ISO 17025 LABORATORY
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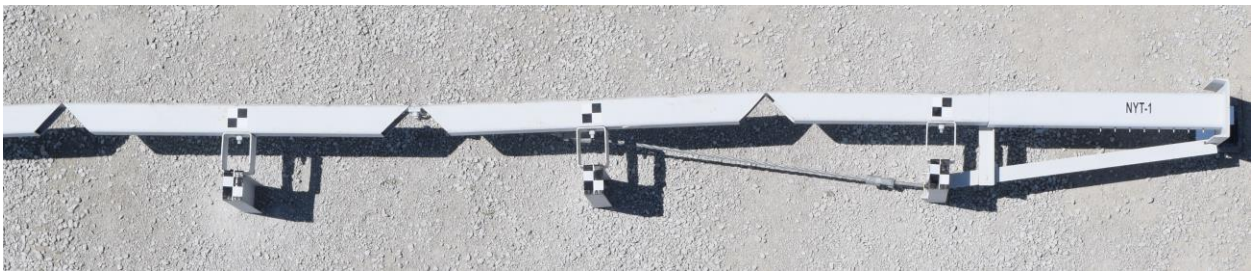
CRASH TEST EVALUATION OF A PROTOTYPE ZIG-ZAG BOX BEAM END TERMINAL: MASH TEST DESIGNATION NO. 3-31



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16. Abstract

The New York State Department of Transportation (NYSDOT) desired to crash test an end terminal connected to box beam in a "zig zag" formation to evaluate its safety performance under the *Manual for Assessing Safety Hardware* (MASH 2016) criteria. Test no. NYT-1 was conducted on the "zig-zag" box beam end terminal according to MASH 2016 test designation no. 3-31. The system consisted of standard box beam guardrail supported by steel posts with a "zig-zag" box beam terminal. The posts were spaced at 72 in. (1,829 mm) at center. The top rail mounting height of the box beam rail was 27 in. (686 mm) from the ground line.

In test no. NYT-1, the vehicle impacted the system at 62.7 mph (101 km/h) at an angle of 0.1 degrees, resulting in a kinetic energy of 655.5 kip-ft (889 kJ). During impact, the vehicle first contacted the end terminal assembly, then travelled through the zig-zag box beam. This action caused rail section nos. 1 through 3 to deflect downstream and the rail section nos. 4 through 13 to deflect to the traffic side of the system. Post nos. 1 through 13 all deflected downstream, and post no. 14 rotated downstream. Once the vehicle made contact with the straight box beam between post nos. 8 and 9, the rail section snagged on the vehicle. This behavior caused the right fender, the right-front door, and the front of the right-rear door to tear away from the frame. The right-front window also shattered as a result of the snag event. As a result, test no. NYT-1 did not successfully meet the evaluation criteria for MASH 2016 test designation no. 3-31. Per guidance from NYSDOT, no further crash tests were conducted on the system.

17. Key Words Highway Safety, Roadside Appurtenances, Longitudinal Barriers, MASH, Box Beam, End Terminal, Crash Test, and Compliance Test		**18. Distribution Statement** No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
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DISCLAIMER STATEMENT

This material is based upon work supported by the Federal Highway Administration, U.S. Department of Transportation and the New York State Department of Transportation. The contents of this report reflect the views and opinions 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 views or policies of the University of Nebraska-Lincoln, New York State Department of Transportation, nor the Federal Highway Administration, U.S. Department of Transportation. This report does not constitute a standard, specification, or regulation. Trade or manufacturers' names, which may appear in this report, are cited only because they are considered essential to the objectives of the report. The United States (U.S.) government and the State of New York do not endorse products or manufacturers.

DISCLOSURE

In accordance with UNL's Conflict of Interest disclosure policy, J. Reid has a financial interest in Safety by Design, developer of the SKT and FLEAT W-beam and BEAT box-beam guardrail terminals.

UNCERTAINTY OF MEASUREMENT STATEMENT

The Midwest Roadside Safety Facility (MwRSF) has determined the uncertainty of measurements for several parameters involved in standard full-scale crash testing and non-standard testing of roadside safety features. Information regarding the uncertainty of measurements for critical parameters is available upon request by the sponsor and the Federal Highway Administration.

INDEPENDENT APPROVING AUTHORITY

The Independent Approving Authority (IAA) for the data contained herein was Dr. Chen Fang, Post-Doctoral Research Associate.

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1 INTRODUCTION

1.1 Background

New York State Department of Transportation (NYSDOT) relies heavily on box beam guide rail along their roadsides and has experienced several penetration impacts with National Cooperative Highway Research Program (NCHRP) Report No. 350 [1] compliant box beam terminals. Further, NYSDOT was facing the prospect of losing their energy-absorbing terminal options, the WyBET and BEAT, for their box beam guide rail system. The WyBET was being discontinued and the manufacturer of the BEAT had indicated that they would "wait until the last minute" to conduct tests according to the *Manual for Assessing Safety Hardware, Second Edition* (MASH 2016) [2]. Consequently, NYSDOT was concerned that a MASH-compliant proprietary energy-absorbing box beam terminal might not be available when the MASH implementation deadline occurred. Therefore, NYSDOT desired to investigate the potential viability of a prototype box beam zig-zag end terminal through preliminary crash testing.

1.2 Objective

The objective of this report included an exploratory evaluation of the safety performance of a prototype box beam zig-zag end terminal through preliminary full-scale vehicle crash testing. The system was to be evaluated according to the Test Level 3 (TL-3) criteria of MASH 2016 [2].

1.3 Scope

The research objective was achieved by conducting one full-scale crash test on the NYSDOT box beam zig-zag end terminal according to MASH 2016 test designation no. 3-31. Next, the full-scale vehicle crash test results were analyzed, evaluated, and documented. Conclusions and recommendations were then made pertaining to the preliminary safety performance of the NYSDOT box beam zig-zag end terminal.

2 TEST REQUIREMENTS AND EVALUATION CRITERIA

2.1 Test Requirements

Historically, guide rail end terminal systems have been required to satisfy impact safety standards to be accepted by the Federal Highway Administration (FHWA) for use on National Highway System (NHS) construction projects or as a replacement for existing designs not meeting current safety standards. According to TL-3 of MASH 2016, gating end terminals must be subjected to nine full-scale vehicle crash tests. The nine full-scale crash tests are as follows:

1. Test designation no. 3-30 consisting of a 2,425-lb (1,100-kg) passenger car impacting at a nominal speed and angle of 62 mph (100 km/h) and 0 degrees, respectively, on the nose of the end terminal with a ¼-point offset.

2. Test designation no. 3-31 consisting of a 5,000-lb (2,268-kg) pickup truck impacting at a nominal speed and angle of 62 mph (100 km/h) and 0 degrees, respectively, on the nose of the end terminal.

3. Test designation no. 3-32 consisting of a 2,425-lb (1,100-kg) passenger car impacting at a nominal speed and angle of 62 mph (100 km/h) and 5 to 15 degrees, respectively, on the nose of the end terminal.

4. Test designation no. 3-33 consisting of a 5,000-lb (2,268-kg) pickup truck impacting at a nominal speed and angle of 62 mph (100 km/h) and 5 to 15 degrees, respectively, on the nose of the end terminal.

5. Test designation no. 3-34 consisting of a 2,425-lb (1,100-kg) passenger car impacting at a nominal speed and angle of 100 km/h (62 mph) and 15 degrees, respectively, and at the Critical Impact Point (CIP) on the end terminal.

6. Test designation no. 3-35 consisting of a 5,000-lb (2,268-kg) pickup truck impacting at a nominal speed and angle of 62 mph (100 km/h) and 25 degrees, respectively, and at the beginning of the Length-of-Need (LON) on the end terminal.

7. Test designation no. 3-36 consisting of a 5,000-lb (2,268-kg) pickup truck impacting at a nominal speed and angle of 62 mph (100 km/h) and 25 degrees, respectively, and at the CIP with respect to the transition to the backup structure.

8. Test designation no. 3-37a consisting of a 5,000-lb (2,268-kg) pickup truck impacting at a nominal speed and angle of 62 mph (100 km/h) and 25 degrees, respectively, and at the CIP for reverse direction impacts on the end terminal. Test designation no. 3-37b consisting of a 2,425-lb (1,100-kg) passenger car impacting at a nominal speed and angle of 62 mph (100 km/h) and 25 degrees, respectively, and at the CIP for reverse direction impacts on the end terminal.

9. Test designation no. 3-38 consisting of a 3,307-lb (1,500-kg) intermediate car impacting at a nominal speed and angle of 62 mph (100 km/h) and 0 degrees,

respectively, on the nose of the end terminal, if it is demonstrated to be necessary following an analysis of selected test results.

The test conditions for TL-3 guide rail end terminals are summarized in Table 1.

Table 1. MASH TL-3 Crash Test Conditions

Test Article	Test Designation	Test Vehicle	Impact Conditions			Evaluation Criteria [1]
			Speed		Angle (degrees)	
			(mph)	(km/h)		
Terminals	3-30	1100C	62	100	0	C,D,F,H,I,N
	3-31	2270P	62	100	0	C,D,F,H,I,N
	3-32	1100C	62	100	5 to 15	C,D,F,H,I,N
	3-33	2270P	62	100	5 to 15	C,D,F,H,I,N
	3-34	1100C	62	100	15	C,D,F,H,I,N
	3-35	2270P	62	100	25	A,D,F,H,I
	3-36	2270P	62	100	25	A,D,F,H,I
	3-37a	2270P	62	100	25	C,D,F,H,I,N
	3-37b	1100C	62	100	25	C,D,F,H,I,N
	3-38	1500A	62	100	0	C,D,F,H,I,N

[1] Evaluation criteria explained in Table 2.

Table 2. MASH 2016 Evaluation Criteria for Terminals and Crash Cushions

<table>
<tr><td>Structural Adequacy</td><td>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.</td></tr>
<tr><td></td><td>C. Acceptable test article performance may be redirection, controlled penetration, or controlled stopping of the vehicle</td></tr>
<tr><td rowspan="4">Occupant Risk</td><td>D. 1. 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.
2. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH 2016.</td></tr>
<tr><td>F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.</td></tr>
<tr><td>H. Occupant Impact Velocity (OIV) (see Appendix A, Section A5.2.2 of MASH 2016 for calculation procedure) should satisfy the following limits:
<table>
<tr><td colspan="3">Occupant Impact Velocity Limits</td></tr>
<tr><td>Component</td><td>Preferred</td><td>Maximum</td></tr>
<tr><td>Longitudinal and Lateral</td><td>30 ft/s
(9.1 m/s)</td><td>40 ft/s
(12.2 m/s)</td></tr>
</table></td></tr>
<tr><td>I. The Occupant Ridedown Acceleration (ORA) (see Appendix A, Section A5.2.2 of MASH 2016 for calculation procedure) should satisfy the following limits:
<table>
<tr><td colspan="3">Occupant Ridedown Acceleration Limits</td></tr>
<tr><td>Component</td><td>Preferred</td><td>Maximum</td></tr>
<tr><td>Longitudinal and Lateral</td><td>15.0 g’s</td><td>20.49 g’s</td></tr>
</table></td></tr>
<tr><td>Post –Impact Vehicular Response</td><td>N. Vehicle Trajectory behind the test article is acceptable.</td></tr>
</table>

2.2 Evaluation Criteria

Evaluation criteria for full-scale vehicle crash testing are based on three appraisal areas: (1) structural adequacy; (2) occupant risk; and (3) vehicle trajectory after collision. Criteria for structural adequacy are intended to evaluate the ability of the box-beam guardrail system to contain and redirect impacting vehicles. In addition, controlled lateral deflection of the test article is acceptable. Occupant risk evaluates the degree of hazard to occupants in the impacting vehicle.

Post-impact vehicle trajectory is a measure of the potential of the vehicle to result in a secondary collision with other vehicles and/or fixed objects, thereby increasing the risk of injury to the occupants of the impacting vehicle and/or other vehicles. These evaluation criteria are summarized in Table 2 and defined in greater detail in MASH 2016. The full-scale vehicle crash test documented herein was conducted and reported in accordance with the procedures provided in MASH 2016.

In addition to the standard occupant risk measures, the Post-Impact Head Deceleration (PHD), the Theoretical Head Impact Velocity (THIV), and the Acceleration Severity Index (ASI) were determined and reported. Additional discussion on PHD, THIV and ASI is provided in MASH 2016.

2.3 Soil Strength Requirements

In accordance with Chapter 3 and Appendix B of MASH 2016, foundation soil strength must be verified before any full-scale crash testing can occur. During the installation of a soil dependent system, W6x16 (W152x23.8) posts are installed near the impact region utilizing the same installation procedures are the system itself. Prior to full-scale testing, a dynamic impact test must be conducted to verify a minimum dynamic soil resistance of 7.5 kips (33.4 kN) at post deflections between 5 in. and 20 in. (127 mm and 508 mm) measured at a height of 25 in. (635 mm) above the ground line. If dynamic testing near the system is not desired, MASH 2016 permits a static test to be conducted instead and compared against the results of a previously established baseline test. In this situation, the soil must provide a resistance of at least 90% of the static baseline test at deflections of 5 in., 10 in., and 15 in. (127 mm, 254 mm, and 381 mm). Further details can be found in Appendix B of MASH 2016.

3 DESIGN DETAILS

The test installation consisted of 158 ft – ¼ in. (48.2 m) of box beam guardrail supported by steel posts with a "zig zag" box beam end terminal, as shown in Figures 1 through 30. All posts were spaced 72 in. (1,829 mm) on their center. The top mounting height of the box beam rail was 27 in. (686 mm) from the ground line. Photographs of the test installation are shown in Figures 31 through 38. Material specifications, mill certifications, and certificates of conformity for the system materials are shown in Appendix A.

Post nos. 1 through 8 were W6x9 (W152x13.4) ASTM A992 steel posts measuring 84 in. (2,134 mm) long with soil plates and embedded 57 in. (1,448 mm) into well-graded soil. The spacing between post nos. 1 through 9 were alternatively spaced 5 ft – 10 in. (1,778 mm) or 6 ft – 2 in. (1,880 mm) apart, starting with 5-ft 10-in. (1.8-m) spacing between post nos. 1 and 2. Post nos. 9 through 26 were S3x5.6 (S75x8.5) ASTM A36 steel posts measuring 63 in. (1,600 mm) long with soil plates and each post had an embedment depth of 36 in. (914 mm). Standard box beam was used between post nos. 9 and 26. Each post between post nos. 9 and 26 was spaced 72 in. (1,829 mm) apart. Splice plates with tapped holes were used at all rail splice locations.

ASTM A500 Grade B steel tube blockouts, 8 in. x 8 in. x 6 in. (203 mm x 203 mm x 152 mm) long, were used to connect the box beam rail to post nos. 1 through 8. ASTM A36 steel L-brackets, 3 in. x 2 in. x 4.8 in. (76 mm x 51 mm x 122 mm) long, were used to connect the box beam to post nos. 9 through 26. Bent rail was placed between post nos. 1 and 9 in alternating zig-zags, as shown in Figure 3. An end terminal assembly, as shown in Figures 1 and 5 was utilized on the upstream end of the system. The downstream anchorage assembly used anchor posts to provide tension resistance, as shown in Figure 7.

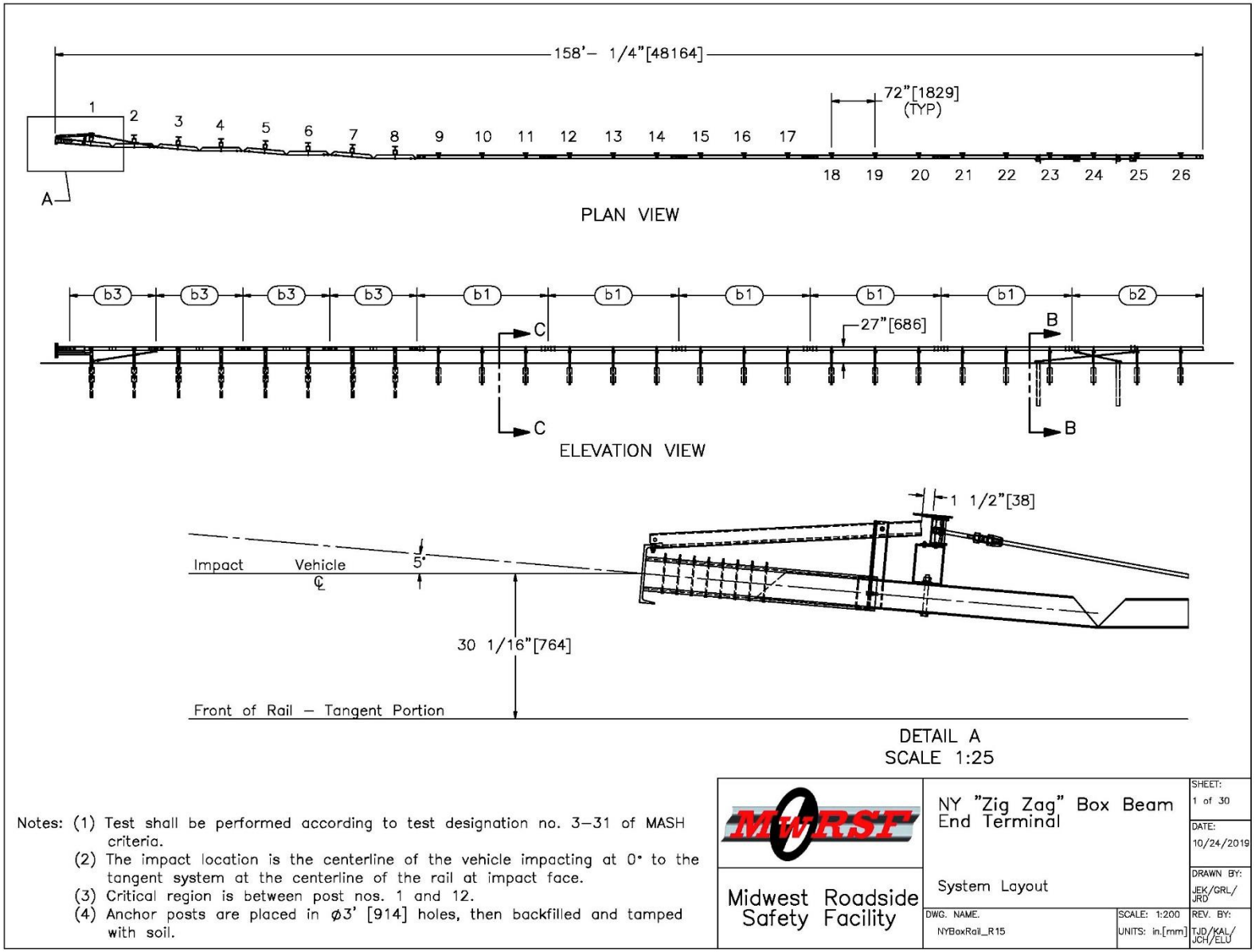


Figure 1. System Layout, Test No. NYT-1

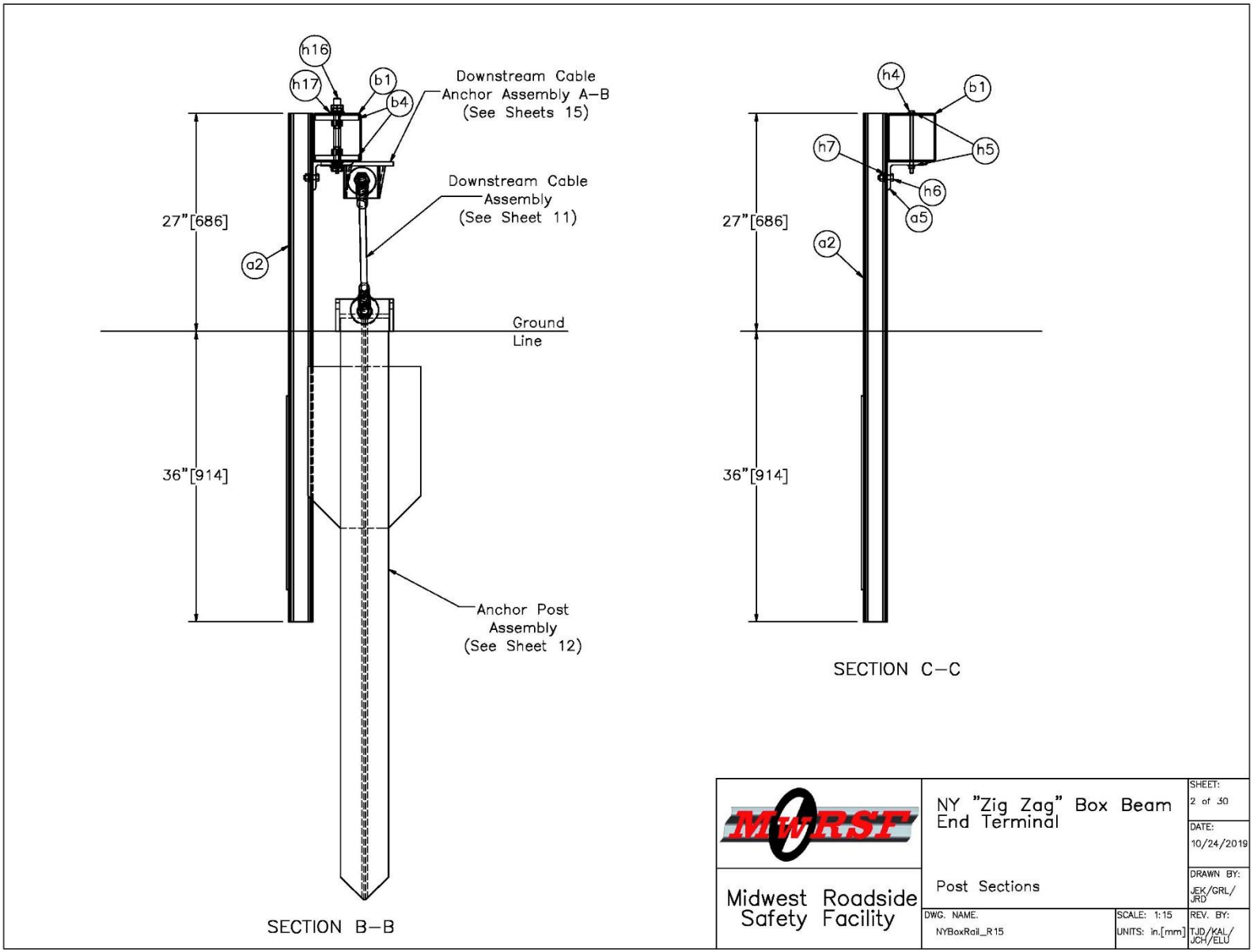
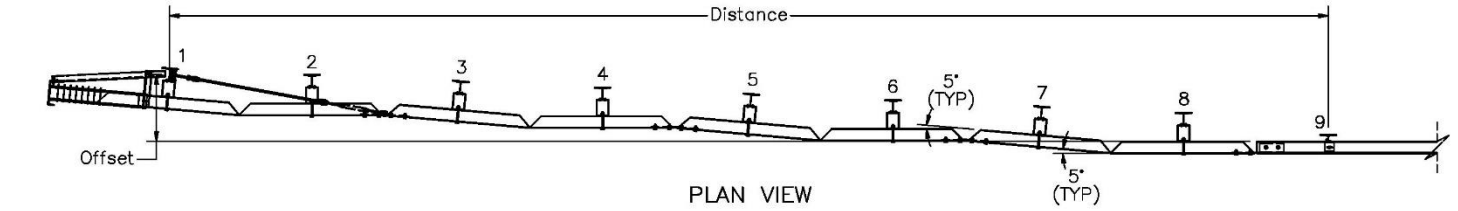


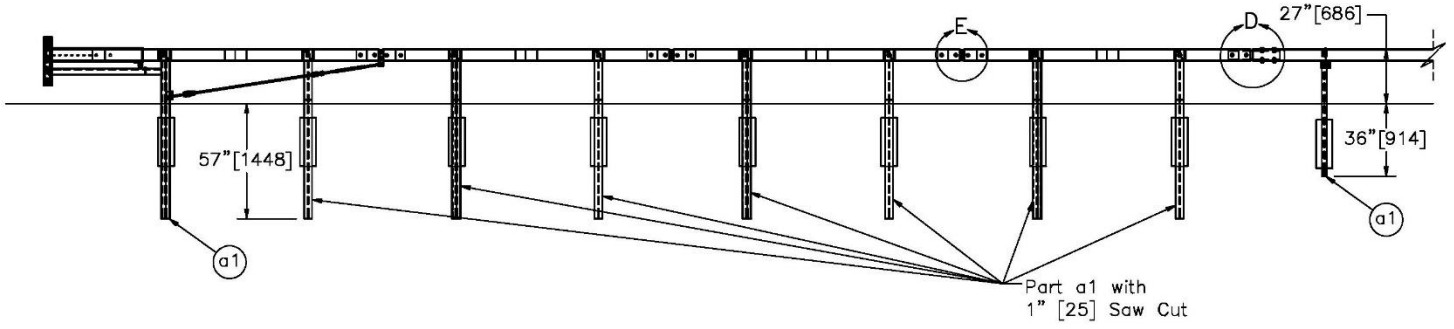
Figure 2. Post Sections, Test No. NYT-1

Post No.	Distance	Offset
1	47'–9 1/8"	2'–8 7/8"
2	41'–10 11/16"	2'–5 3/4"
3	35'–9 3/8"	2'–2 9/16"
4	29'–11"	1'–11 1/2"
5	23'–9 11/16	1'–8 5/16"
6	17'–11 1/4"	1'–5 1/4"
7	11'–10"	1'–2"
8	5'–11 9/16"	10 15/16"

(1) Origin is the middle of the roadside flange of post no. 9.
(2) Distance is measured along the tangent to the run of rail at post no. 9.
(3) Offset is measured from the above tangent to the center of post nos. 1–8.
(4) Post nos. 1, 3, 5, and 7 to be rotated 5° in plan.



PLAN VIEW



ELEVATION VIEW

Midwest Roadside Safety Facility	NY "Zig Zag" Box Beam End Terminal	SHEET: 3 of 30
		DATE: 10/24/2019
	End Assembly	DRAWN BY: JEK/GRL/JRD
	DWG. NAME. NYBoxRail_R15 / SCALE: 1:75 / UNITS: in.[mm]	REV. BY: TJD/KAL/JCH/ELU

Figure 3. End Assembly, Test No. NYT-1

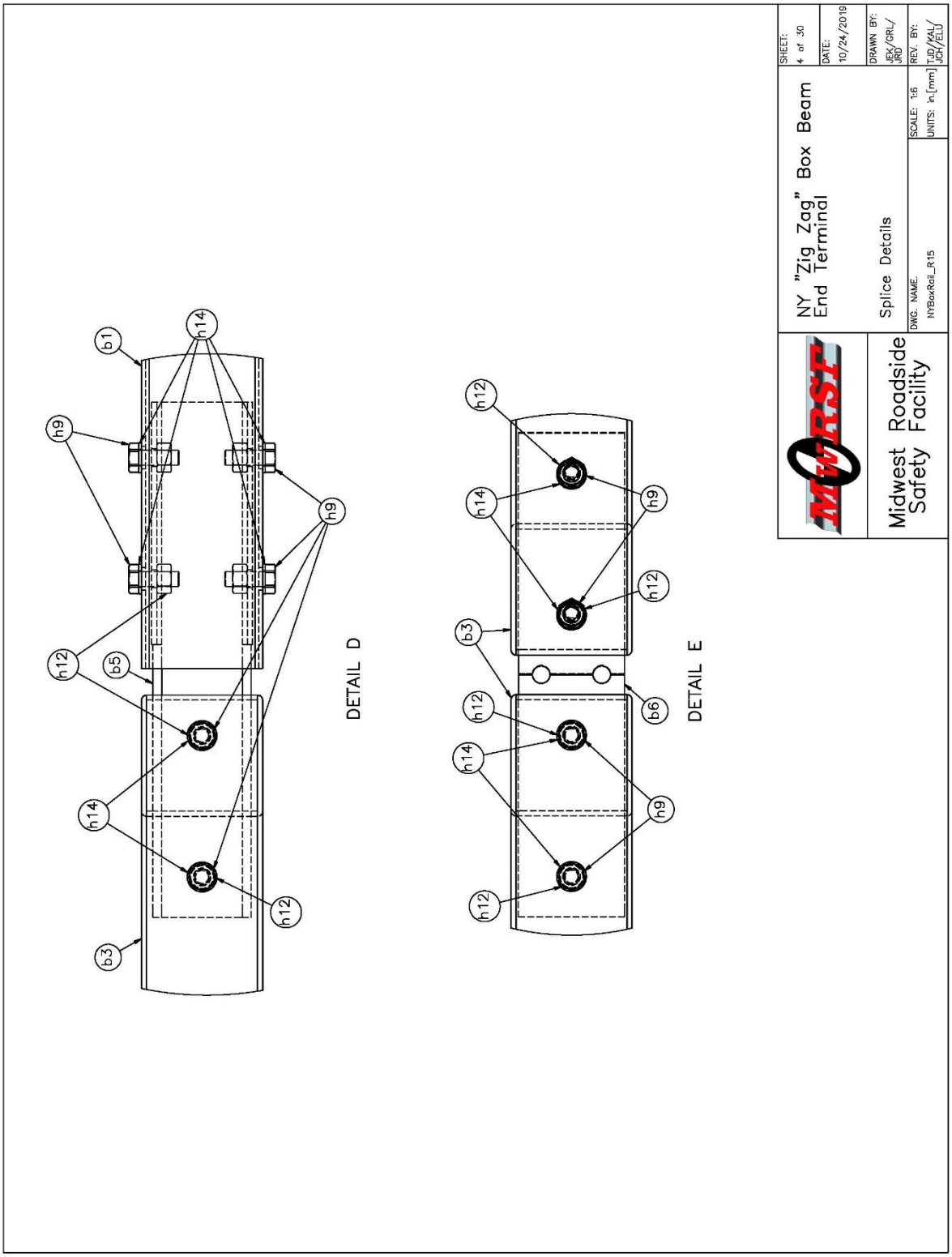


Figure 4. Splice Details, Test No. NYT-1

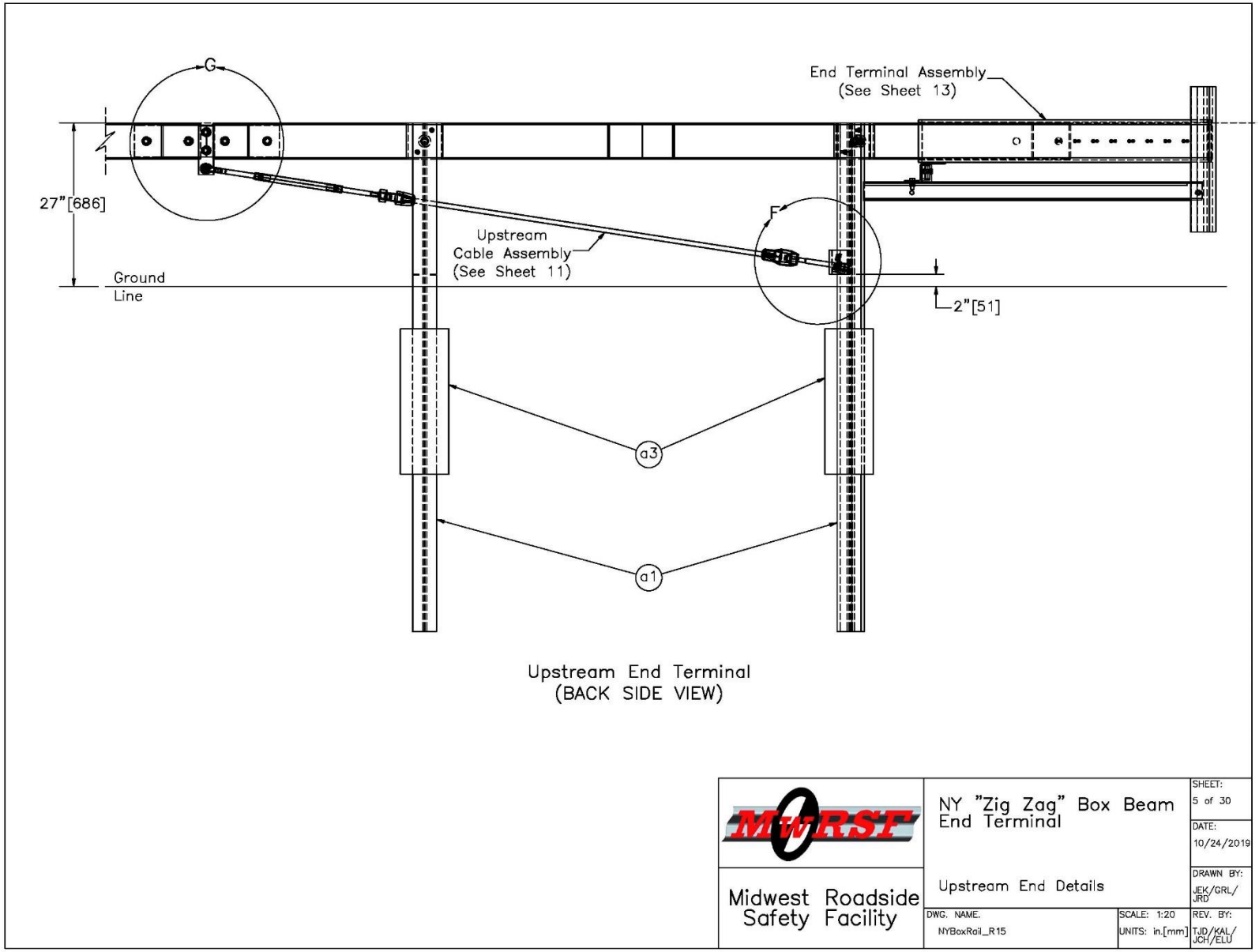


Figure 5. Upstream End Details, Test No. NYT-1

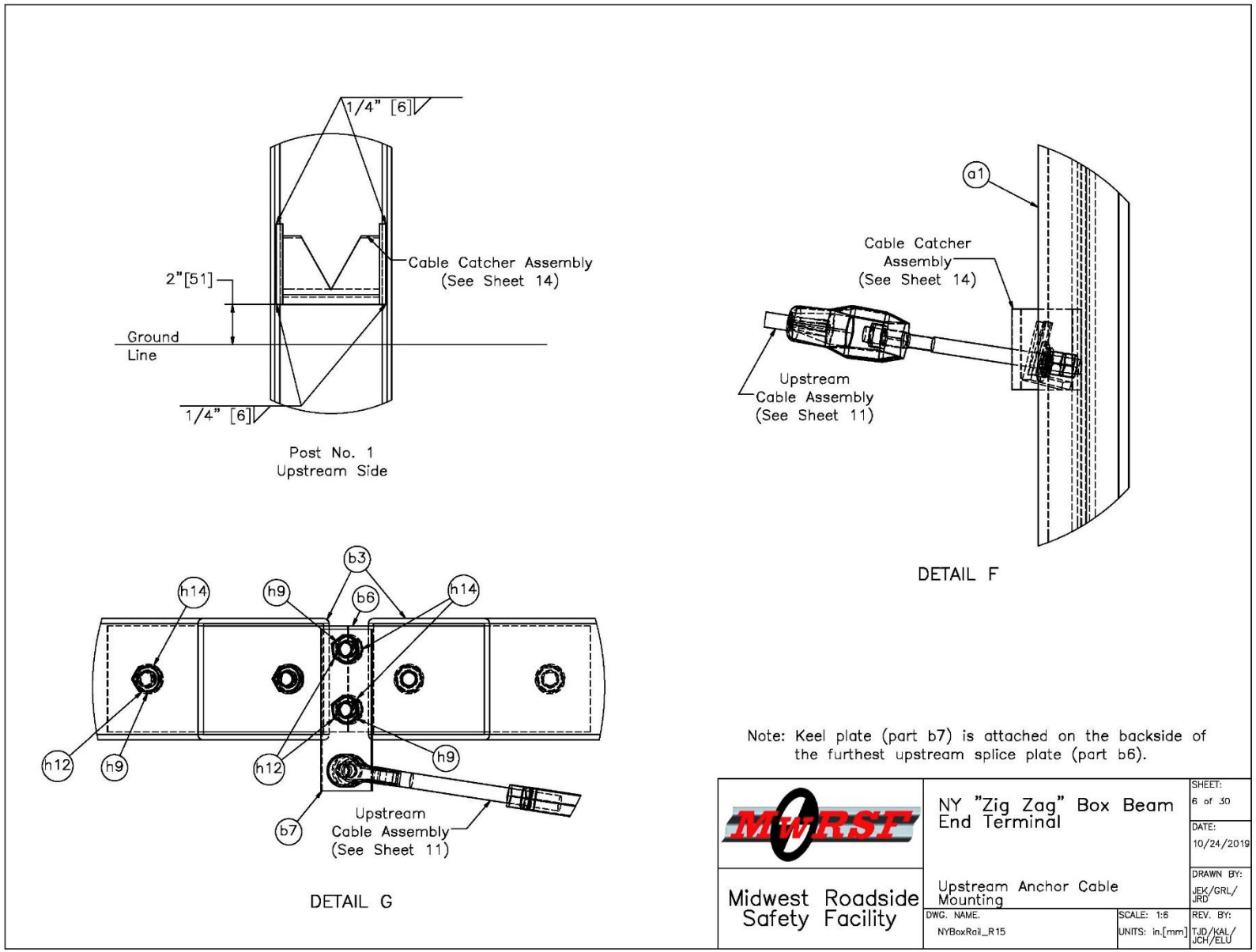


Figure 6. Upstream Anchor Cable Mounting, Test No. NYT-1

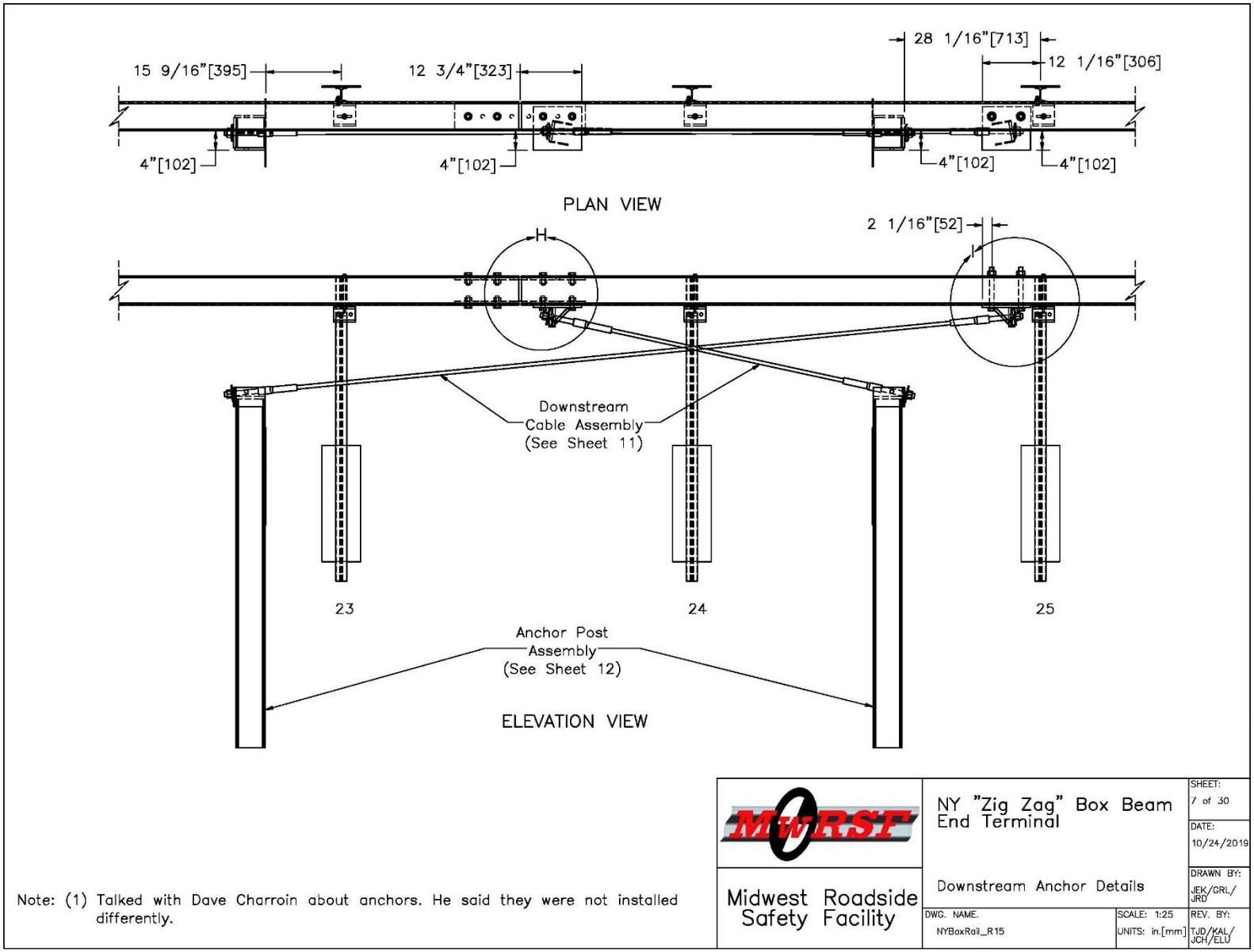


Figure 7. Downstream Anchor Details, Test No. NYT-1

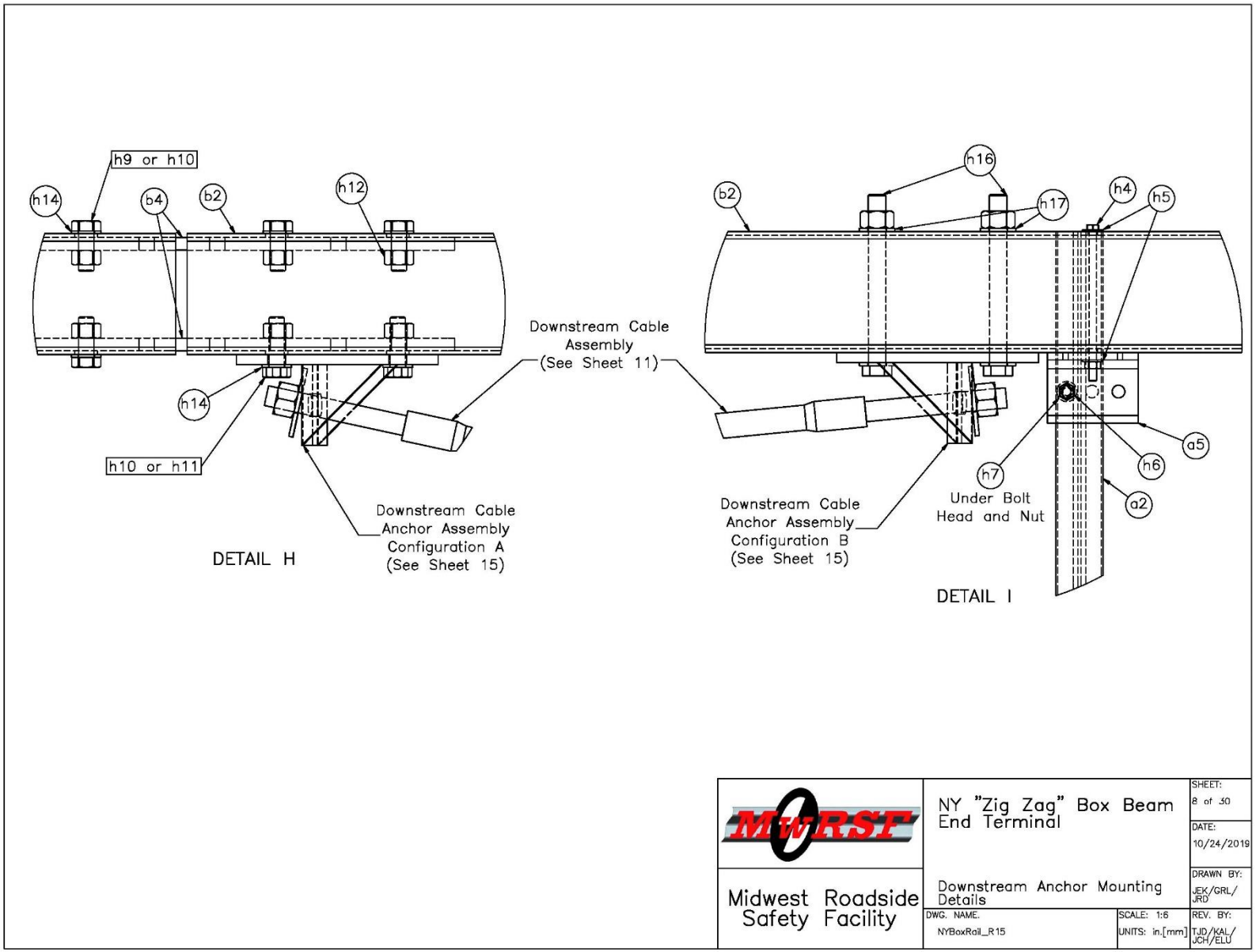


Figure 8. Downstream Anchor Mounting Details, Test No. NYT-1

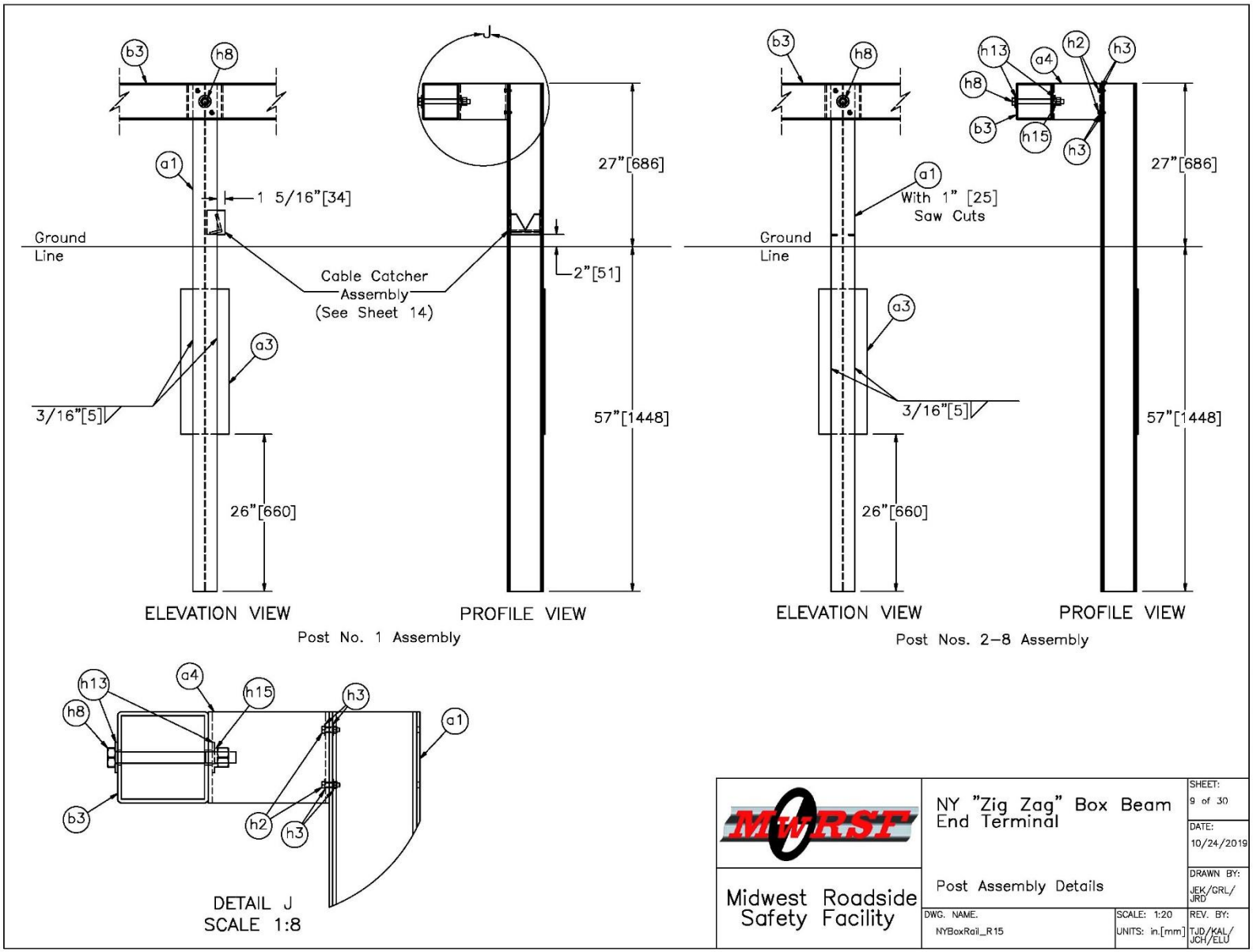


Figure 9. Post Assembly Details, Test No. NYT-1

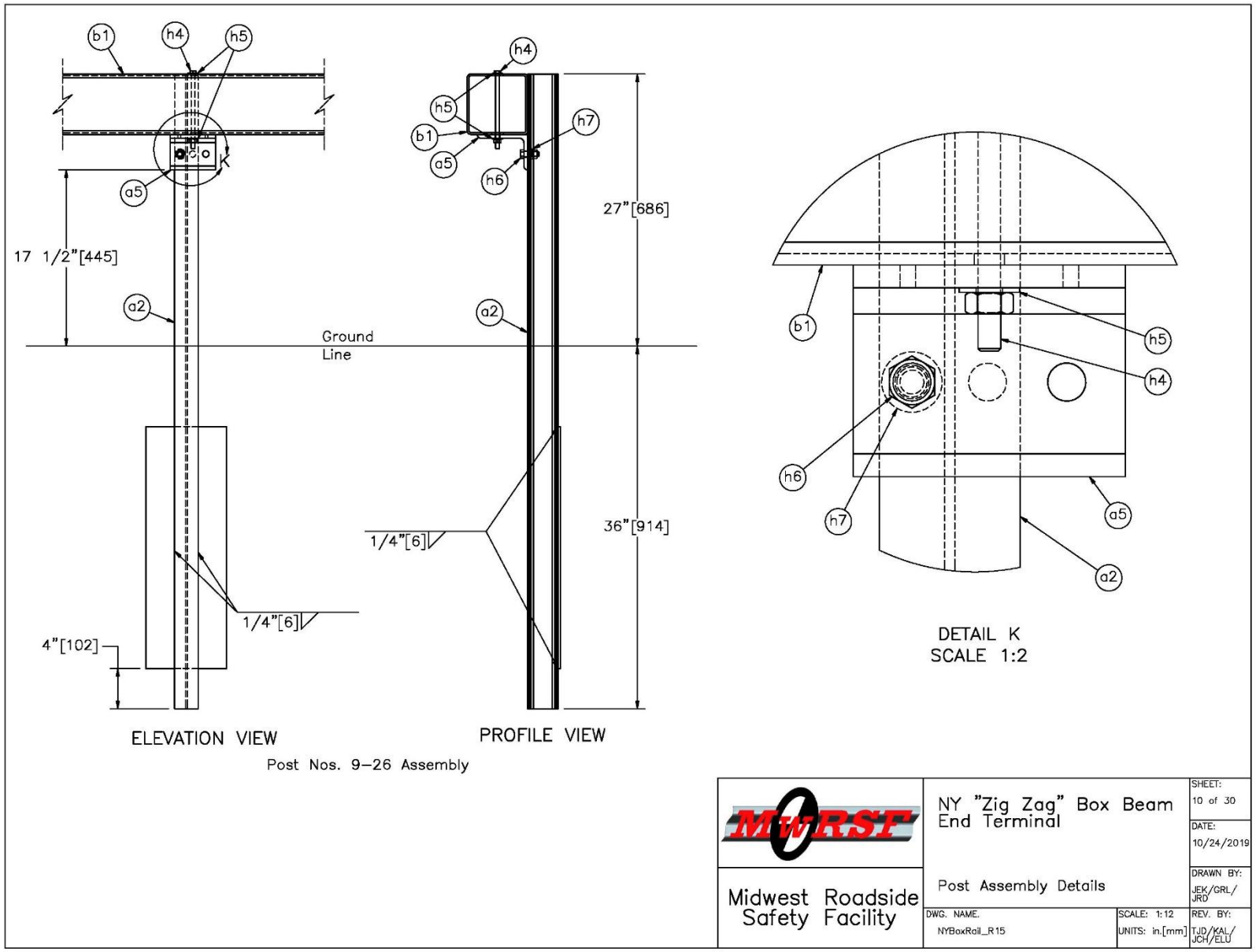


Figure 10. Post Assembly Details, Test No. NYT-1

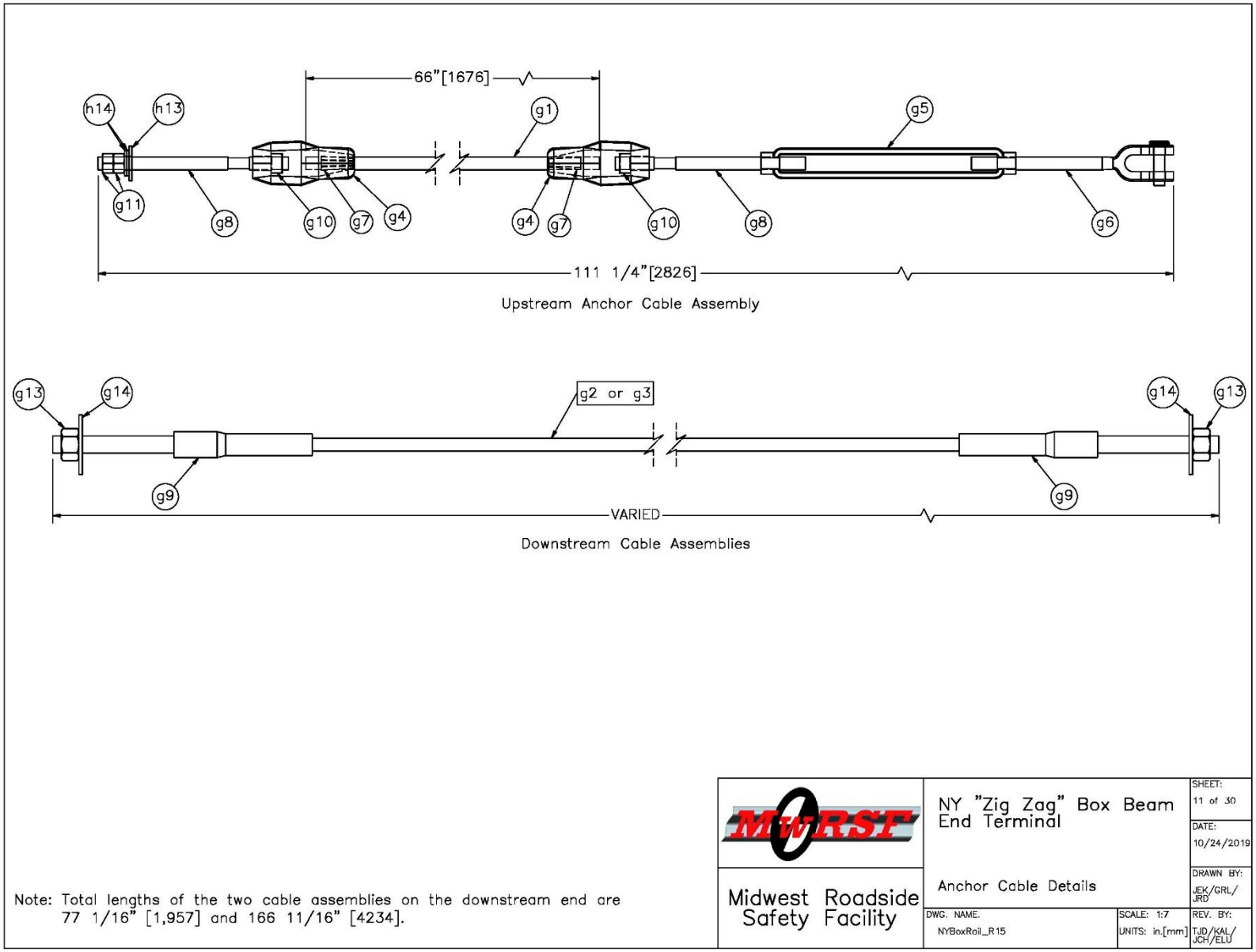


Figure 11. Anchor Cable Details, Test No. NYT-1

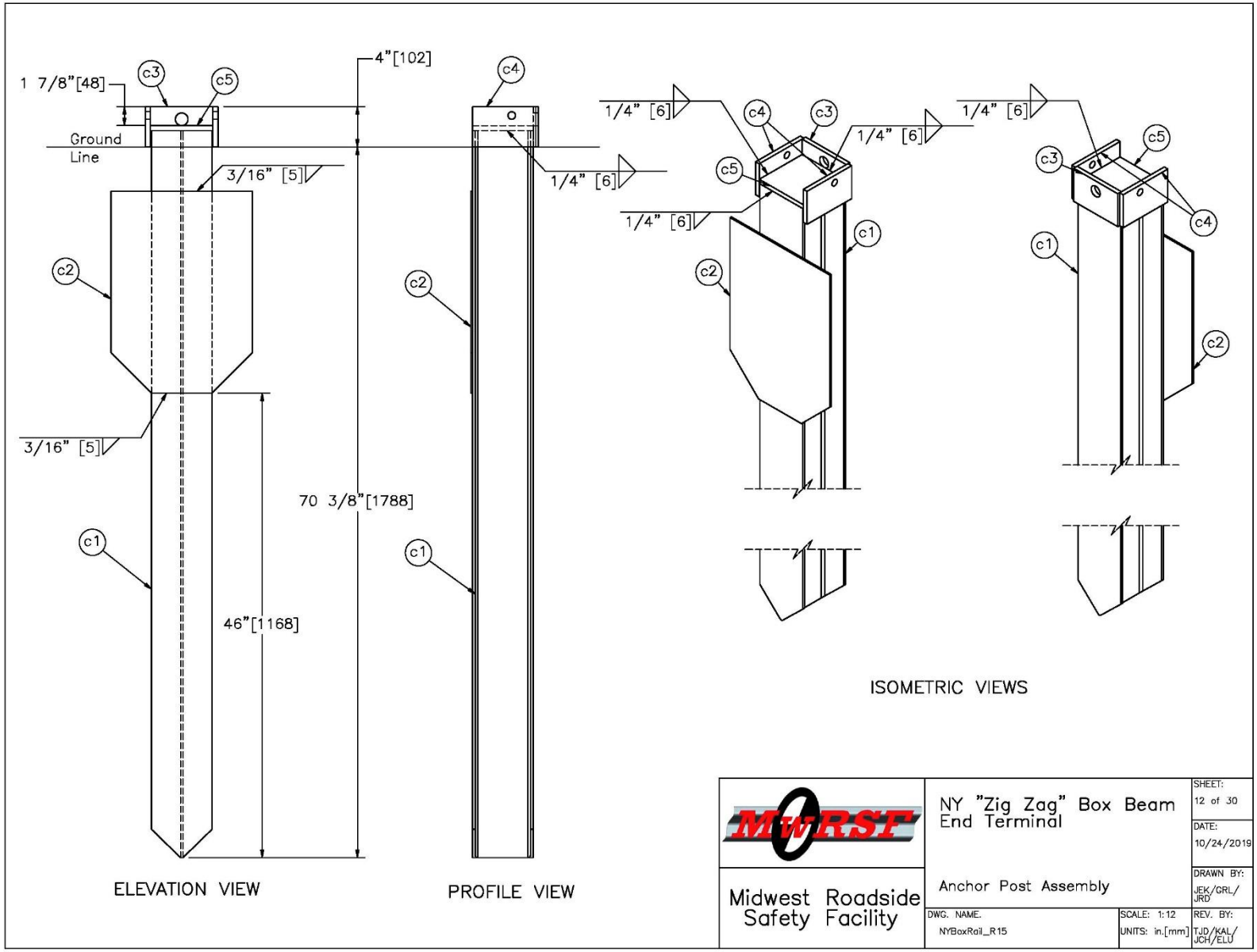


Figure 12. HFT Anchor, Test No. NYT-1

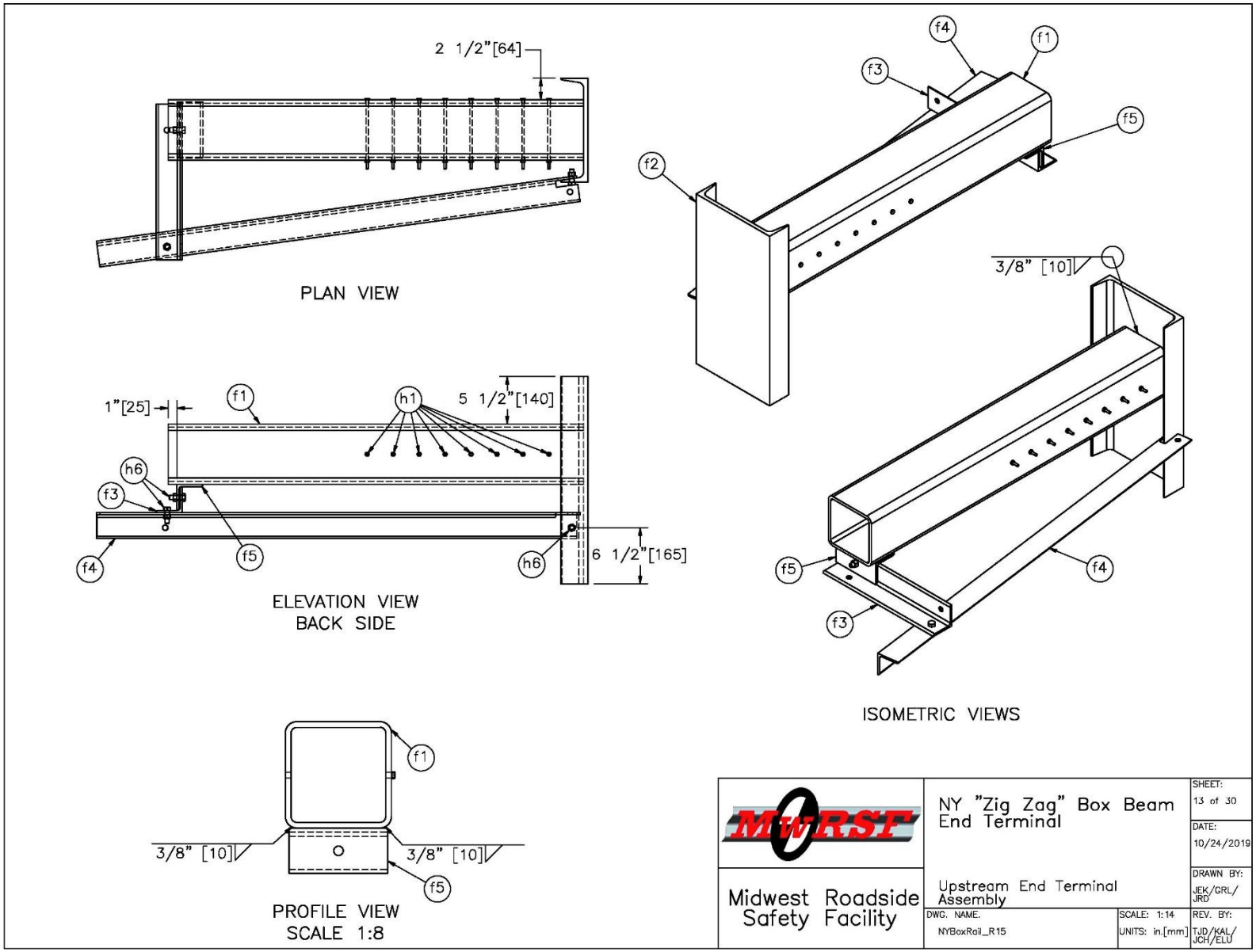


Figure 13. Upstream End Terminal Assembly, Test No. NYT-1

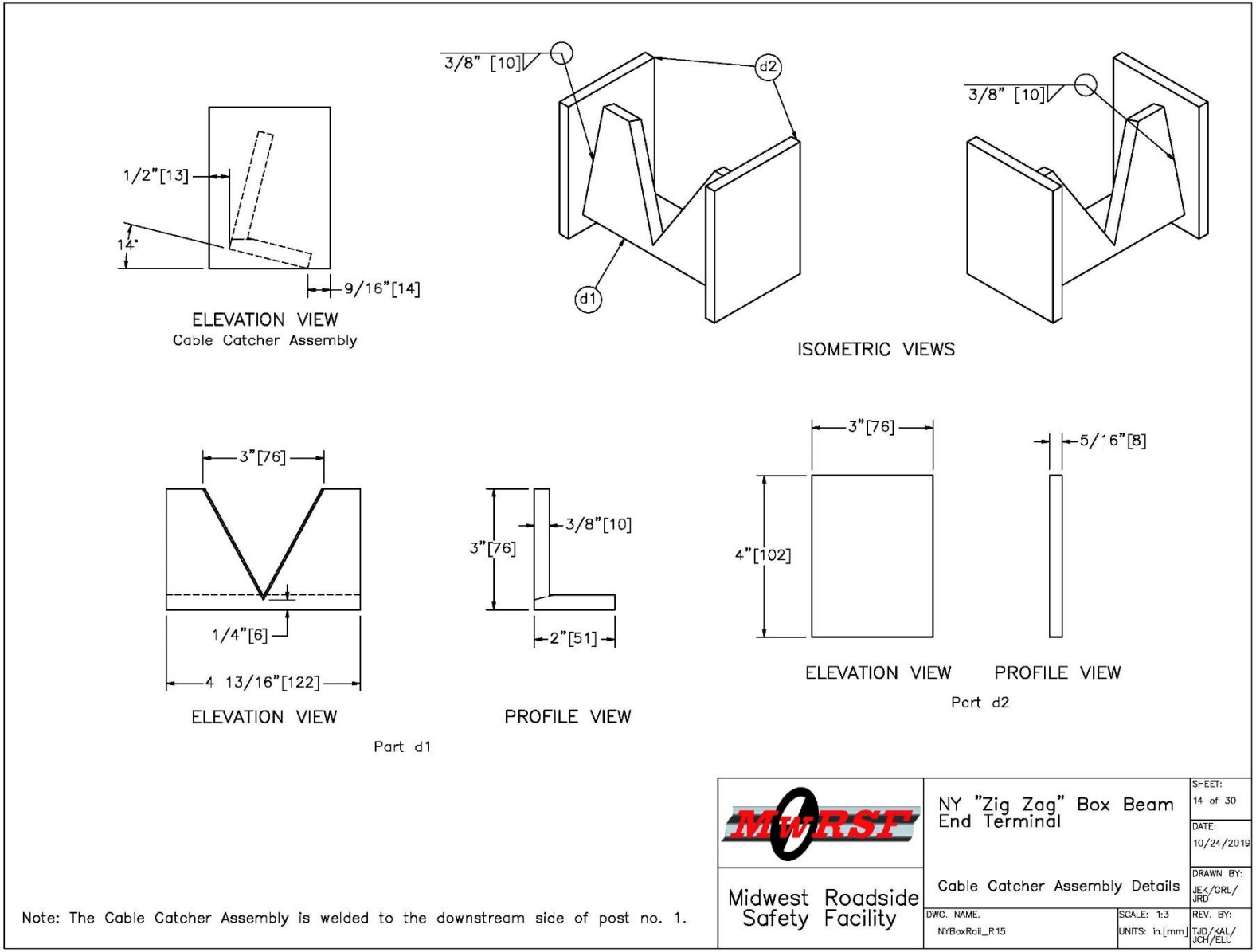


Figure 14. Cable Catcher Assembly Details, Test No. NYT-1

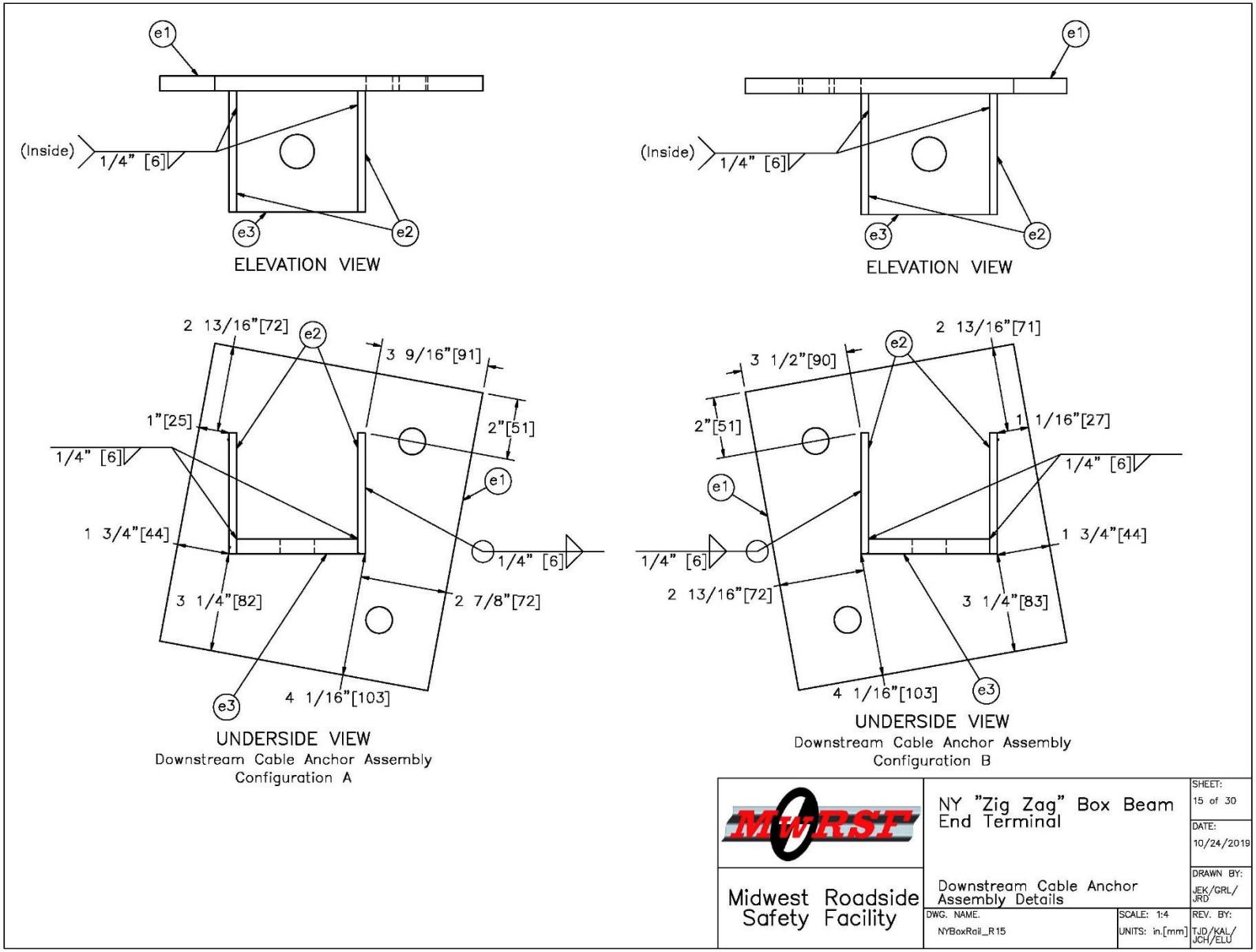


Figure 15. Downstream Cable Anchor Assembly Details, Test No. NYT-1

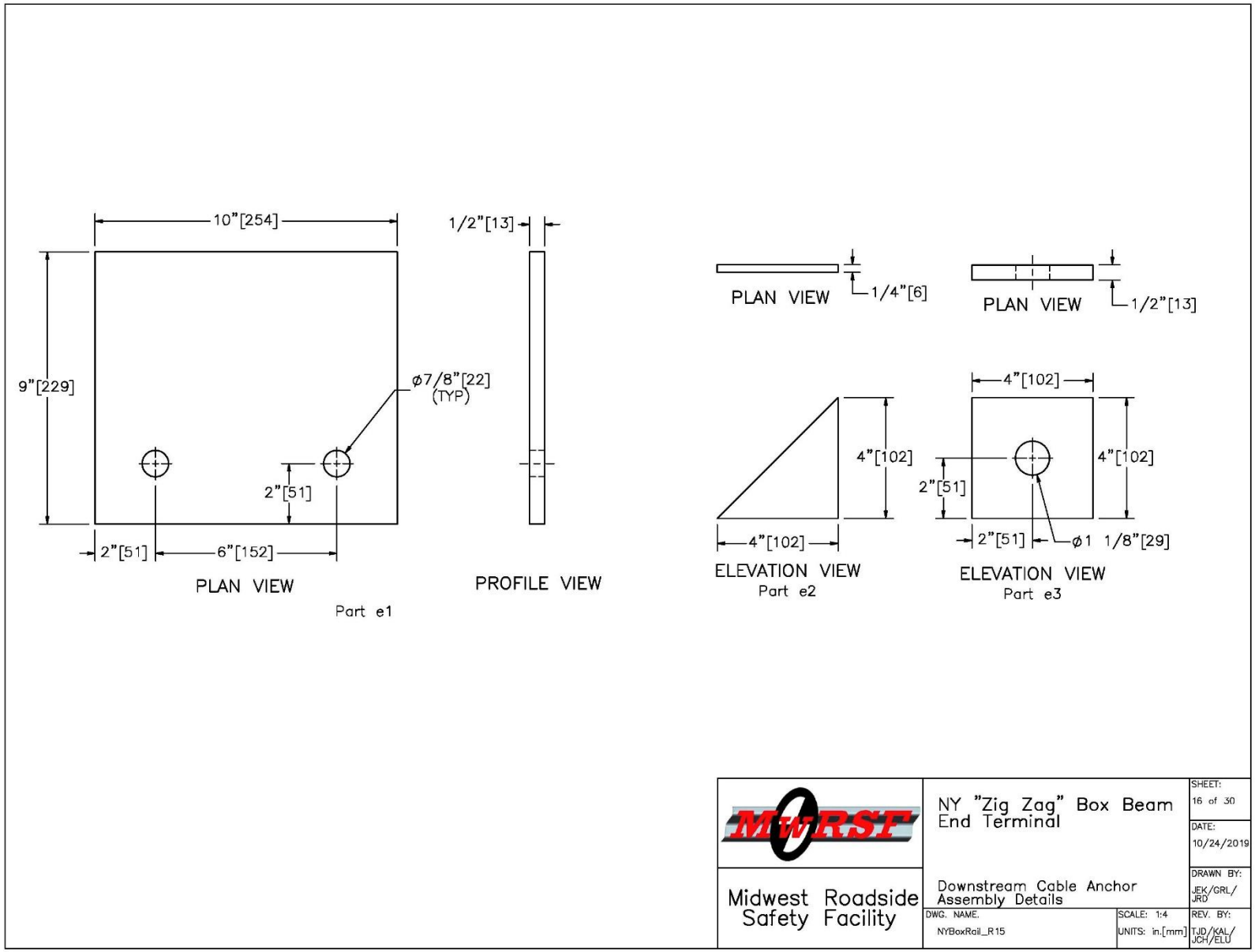


Figure 16. Downstream Cable Anchor Assembly Details, Test No. NYT-1

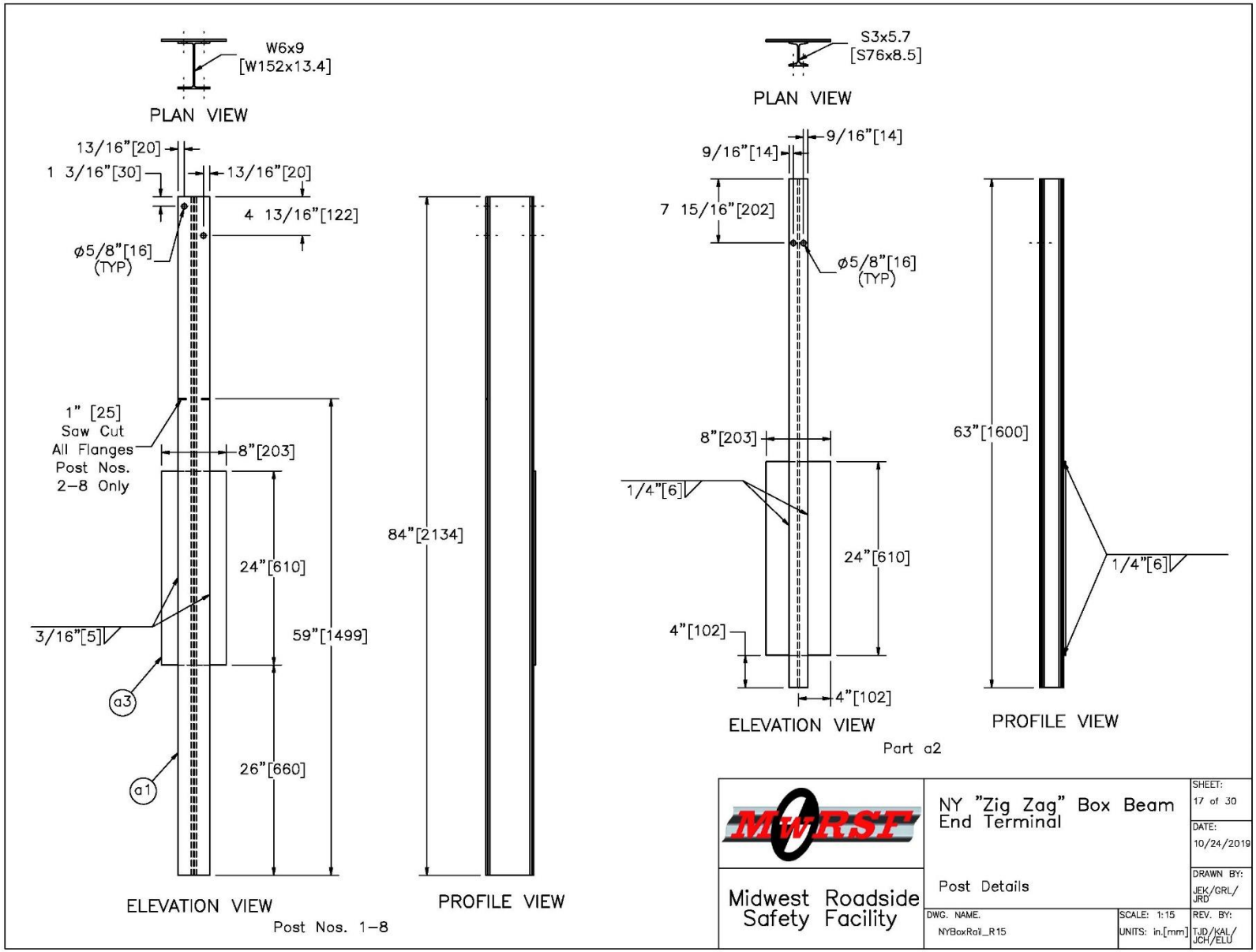


Figure 17. Post Details, Test No. NYT-1

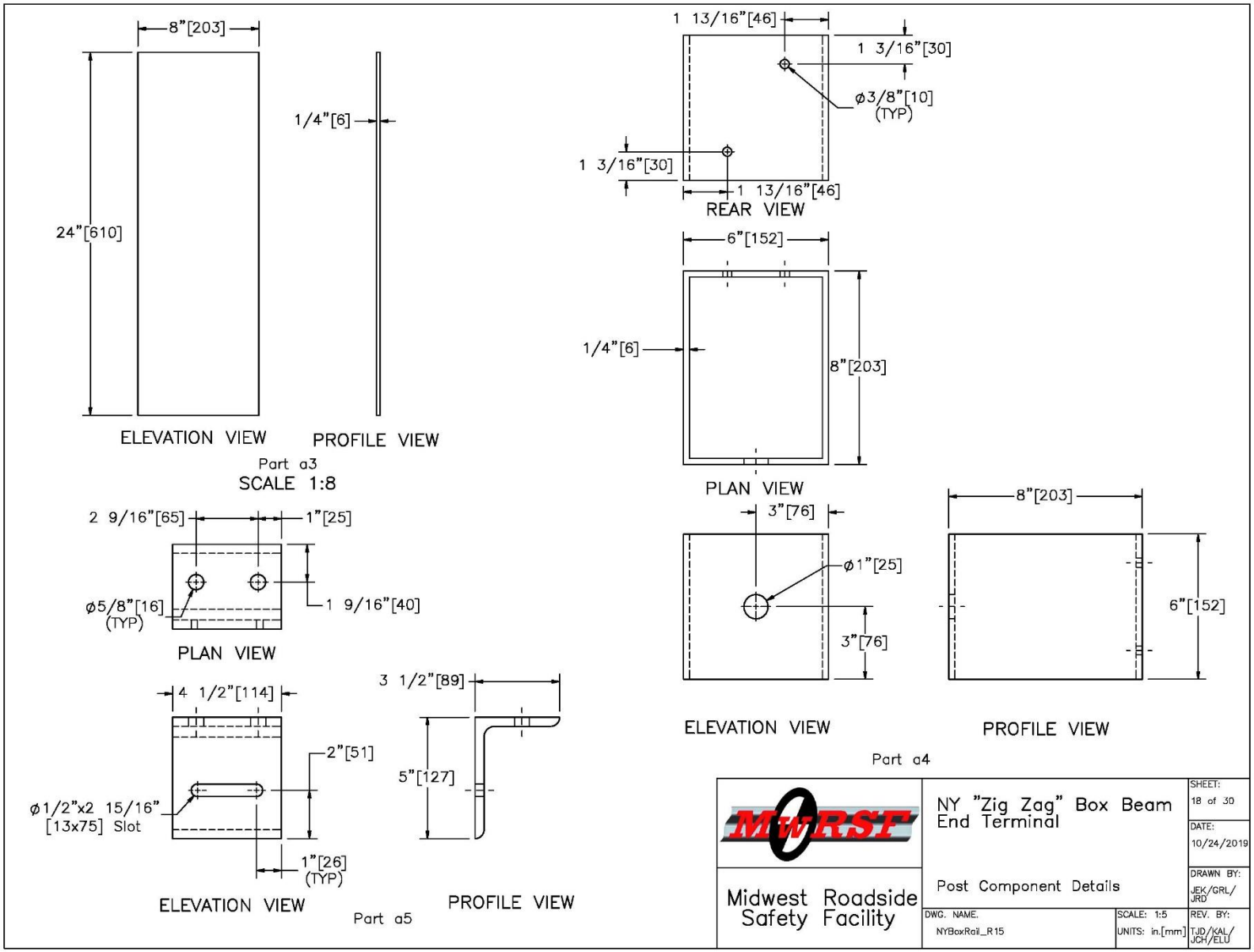


Figure 18. Post Component Details, Test No. NYT-1

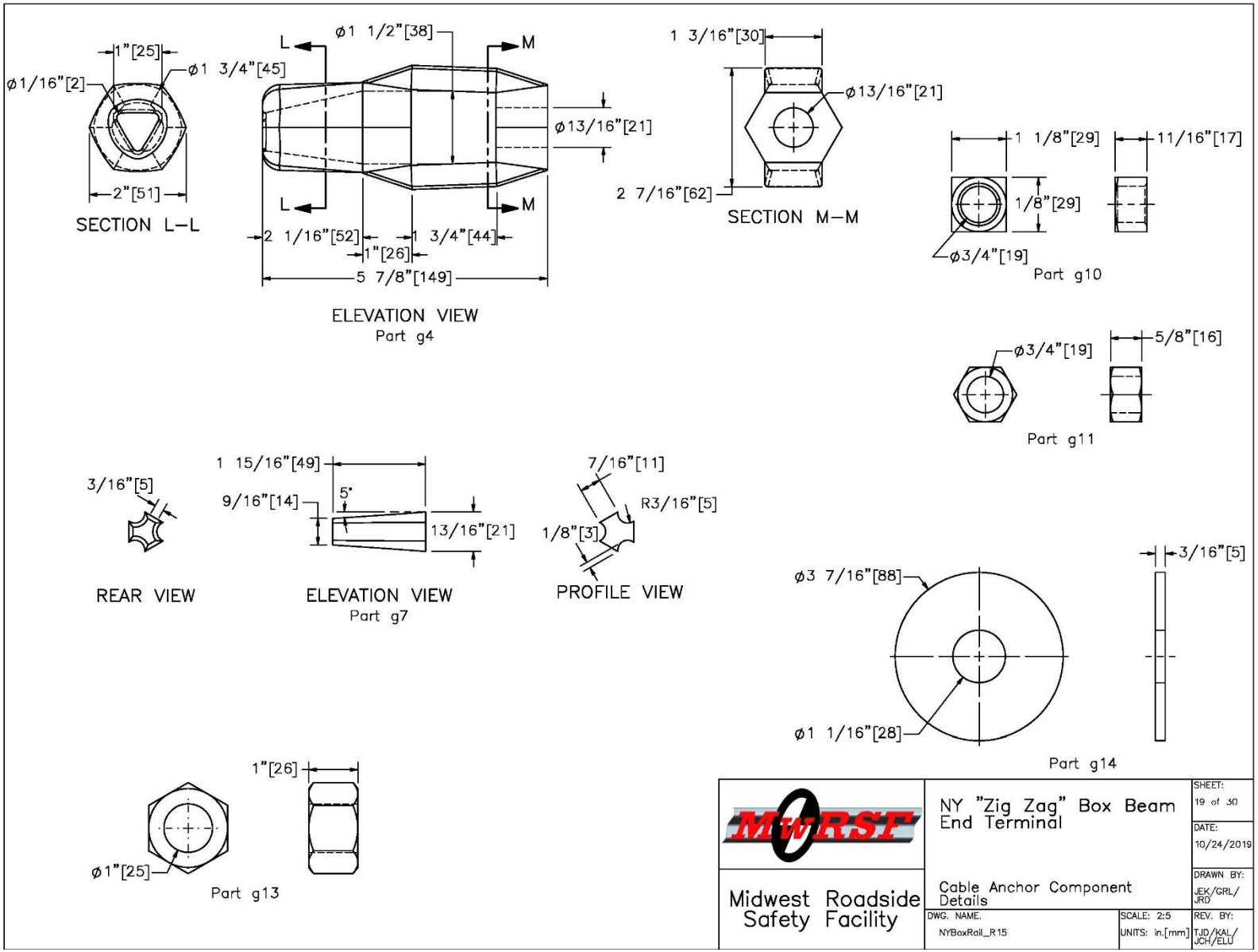


Figure 19. Cable Anchor Component Details, Test No. NYT-1

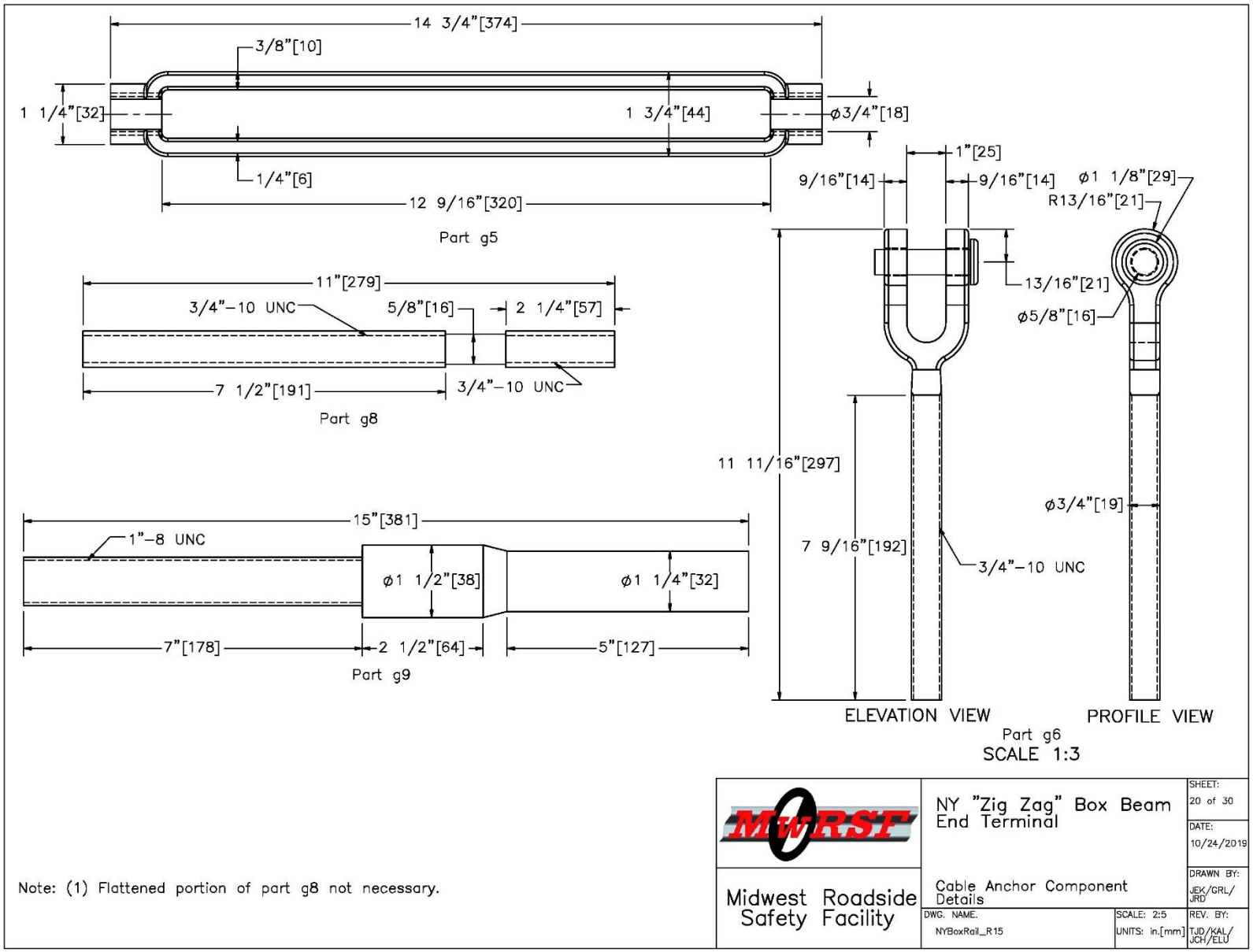


Figure 20. Cable Anchor Component Details, Test No. NYT-1

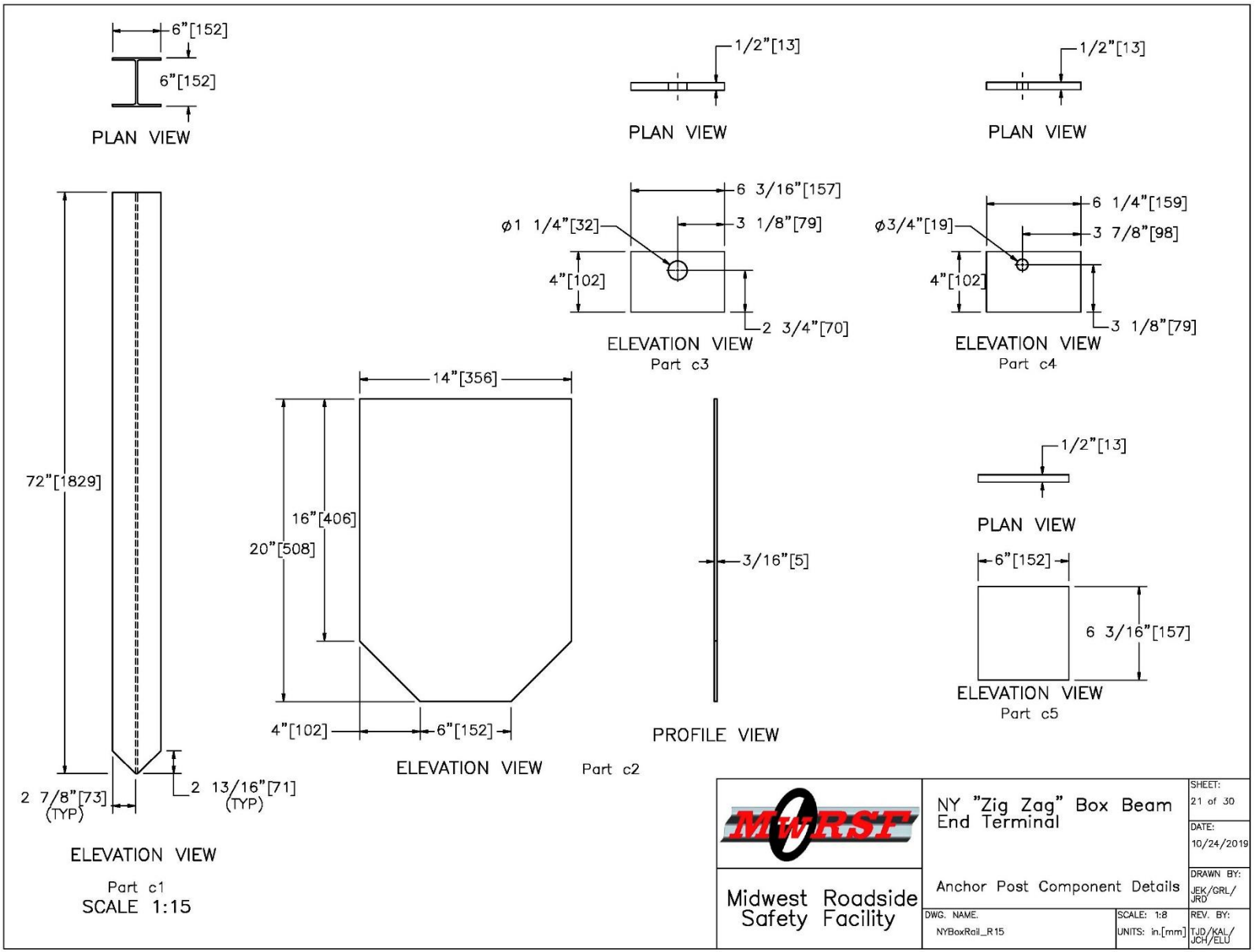


Figure 21. HFT Anchor Component Details, Test No. NYT-1

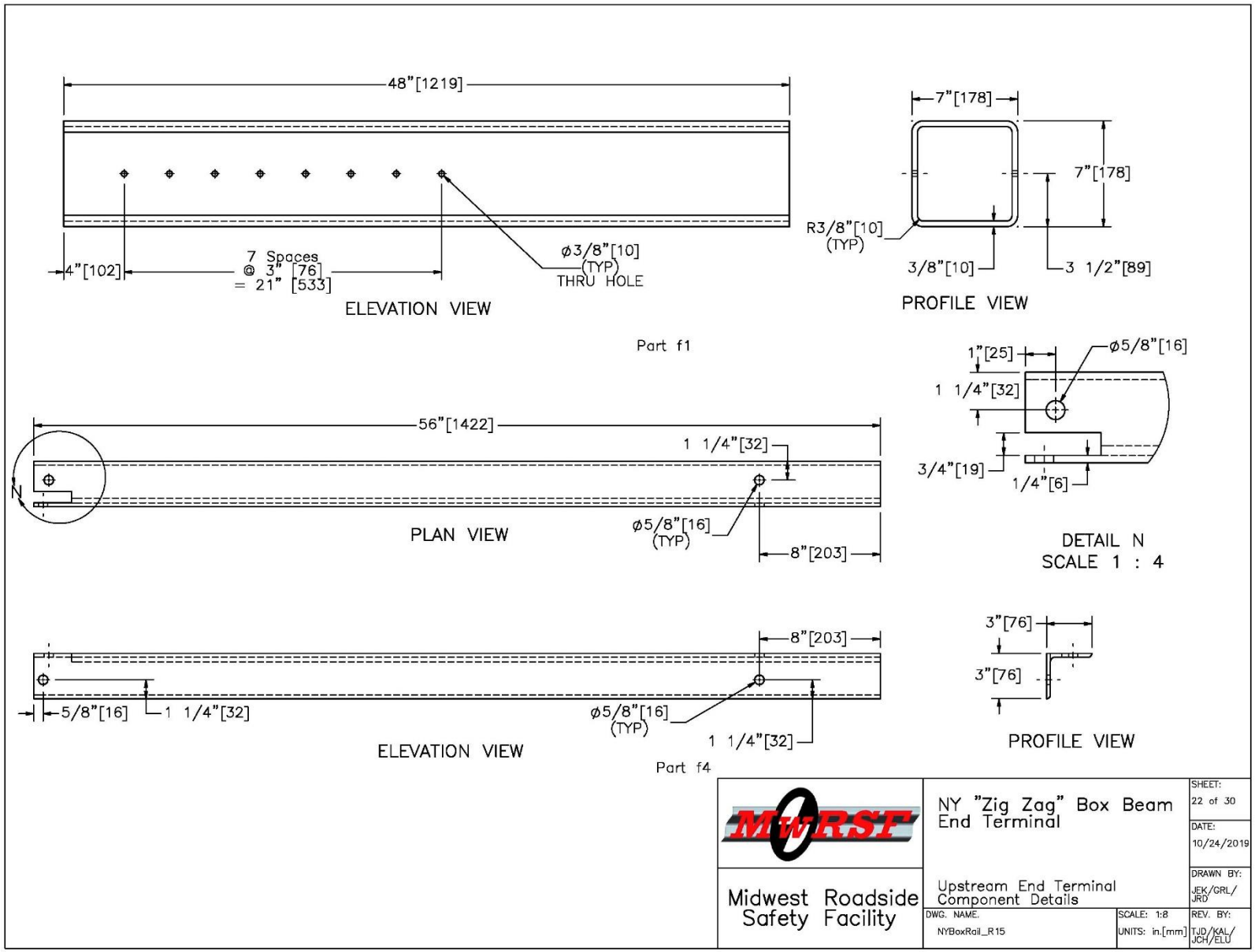


Figure 22. Upstream End Terminal Component Details, Test No. NYT-1

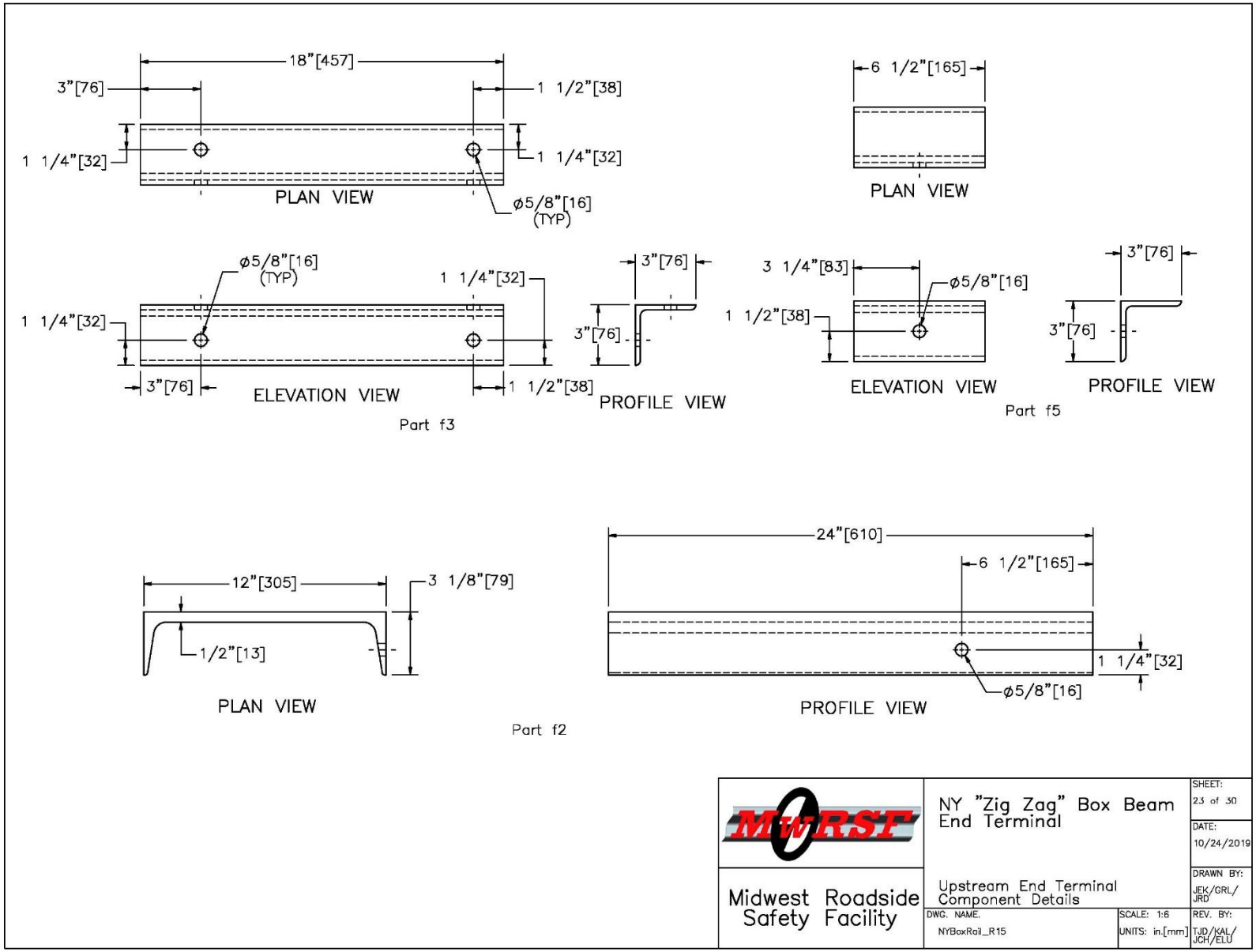


Figure 23. Upstream End Terminal Component Details, Test No. NYT-1

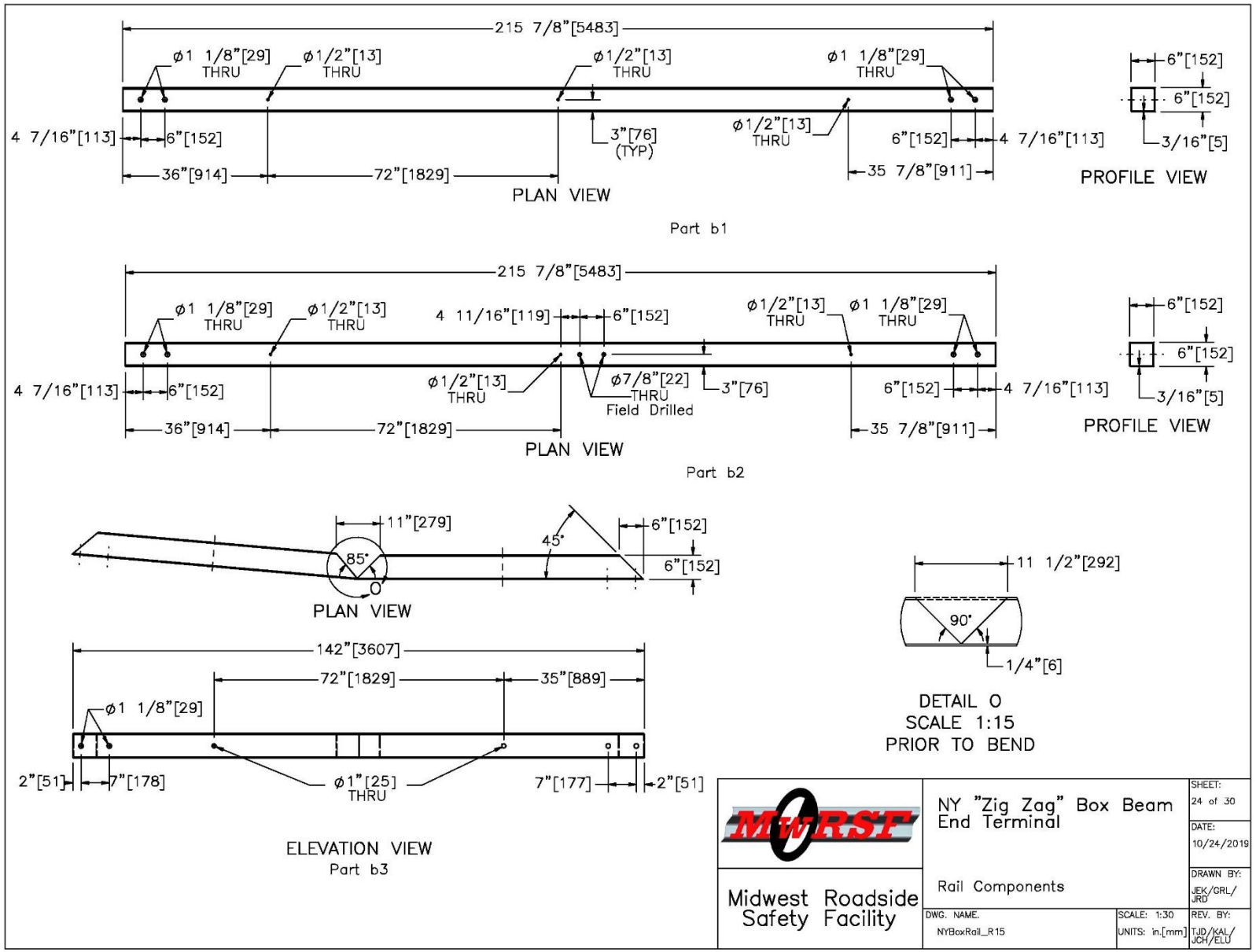


Figure 24. Rail Components, Test No. NYT-1

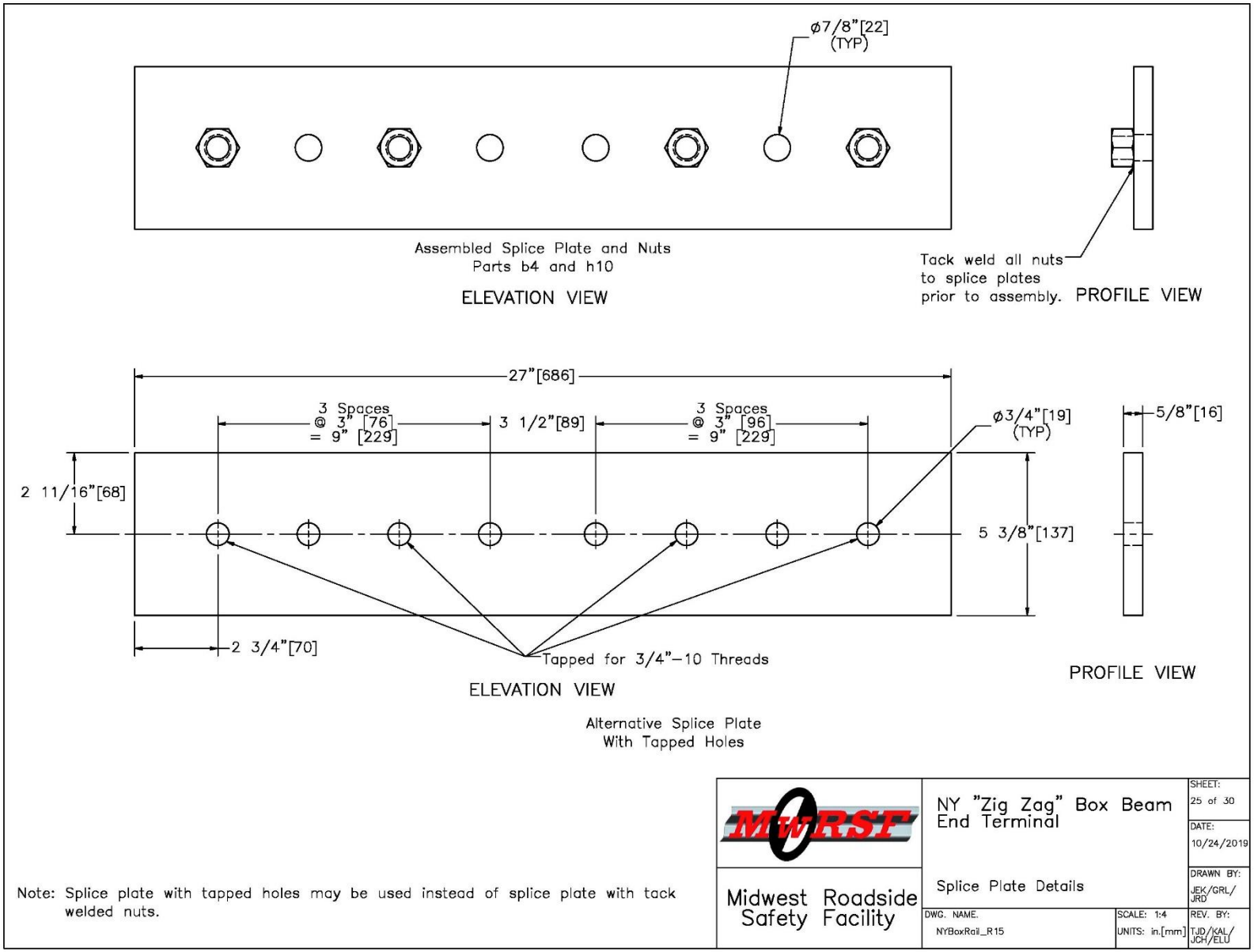


Figure 25. Splice Plate Details, Test No. NYT-1

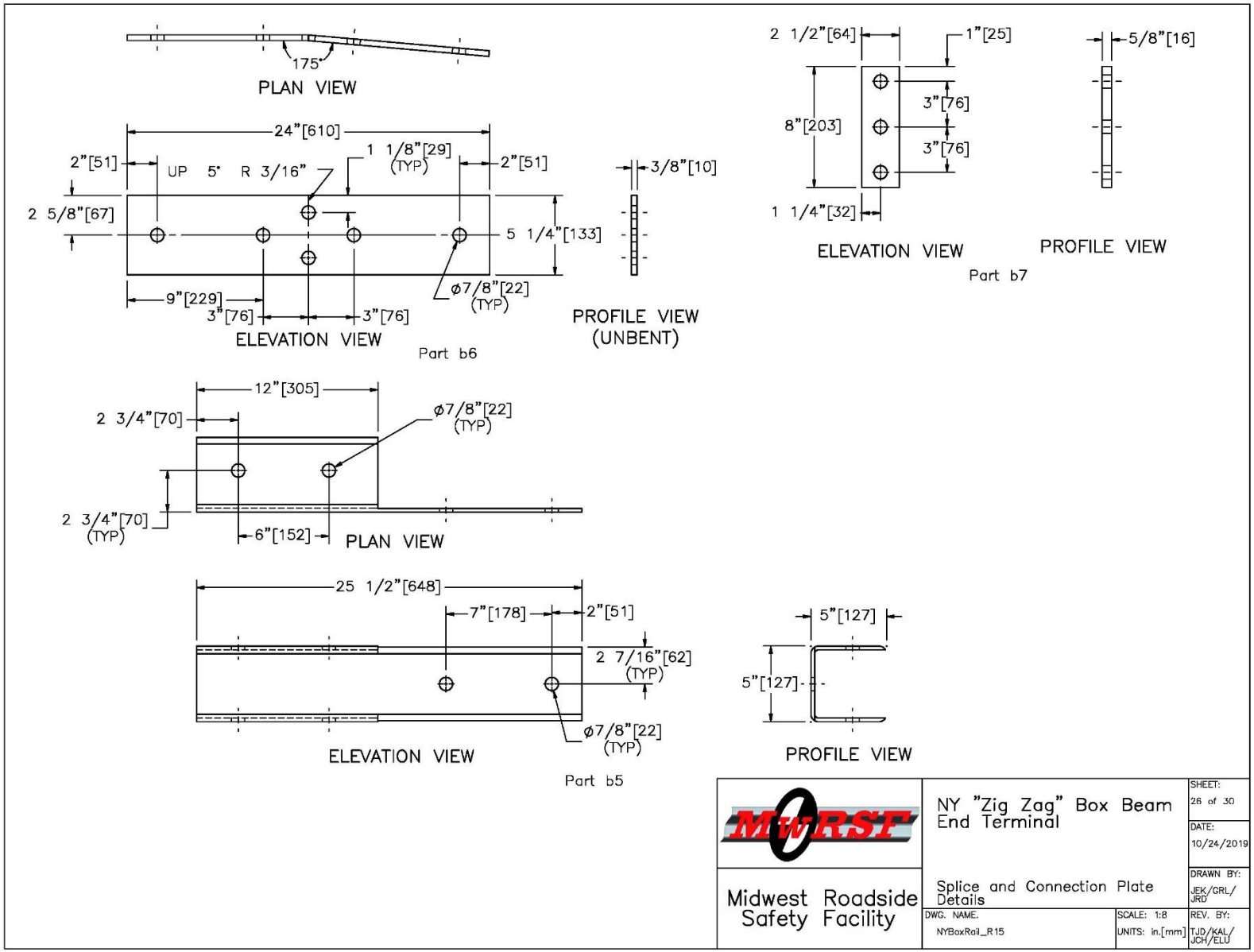


Figure 26. Splice and Connection Plate Details, Test No. NYT-1

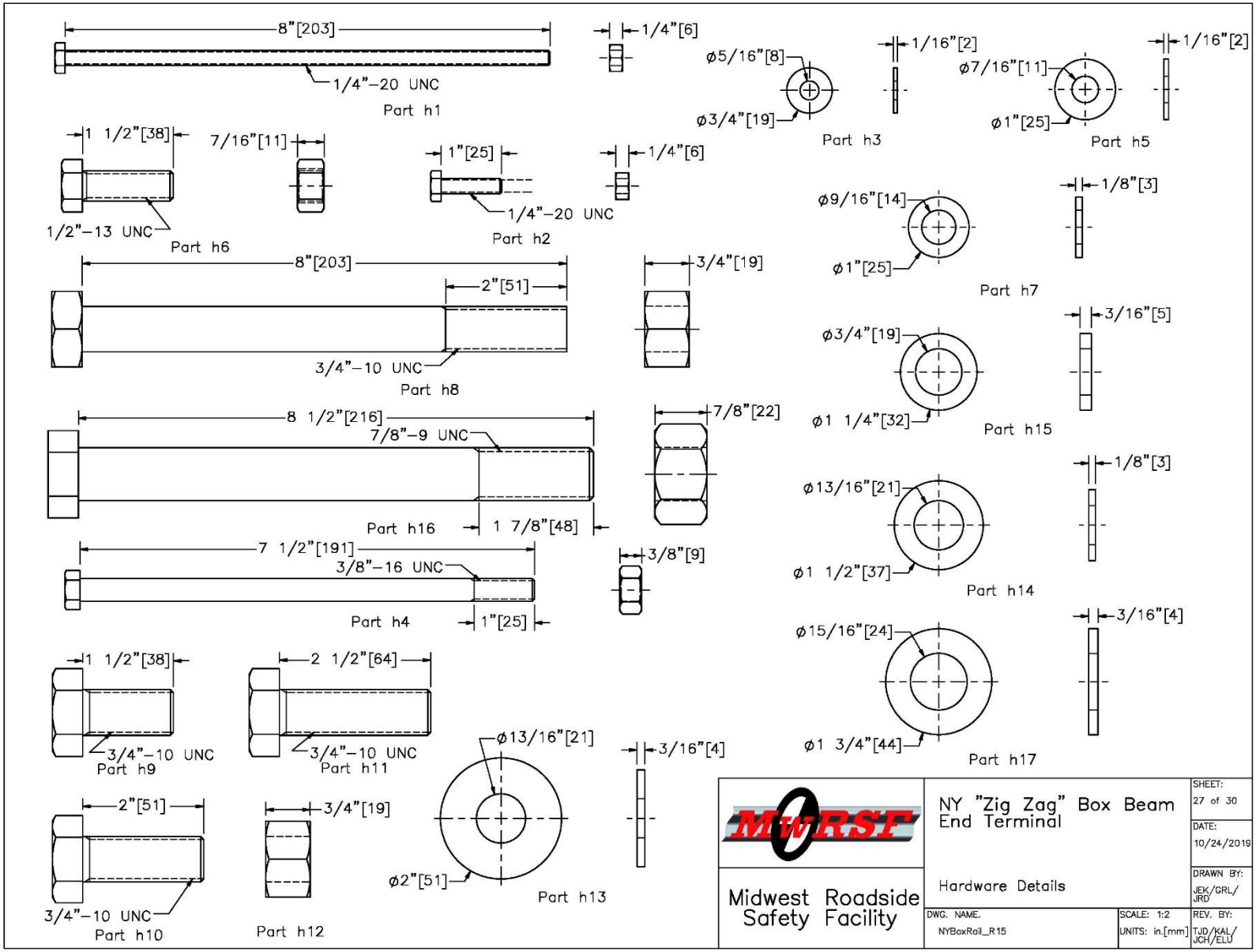


Figure 27. Hardware Details, Test No. NYT-1

Item No.	QTY.	Description	Material Spec	Galv Spec	Hardware Guide
a1	8	W6x8.5 [W152x12.6] or W6x9 [W152x13.4], 84" [2,134] Long Post	ASTM A992 Min. 50 ksi Steel	ASTM A123 (AASHTO M111)	PWE07
a2	18	S3x5.7 [S75x8.5], 63" [1,600] Long Post	ASTM A36	ASTM A123 (AASHTO M111)	PSE08
a3	8	24"x8"x1/4" [610x203x6] Soil Plate	ASTM A36	ASTM A123 (AASHTO M111)	PLS01
a4	8	8"x6"x1/4" [203x152x6], 6" [152] Long Blockout	ASTM A500 Gr. B	ASTM A123 (AASHTO M111)	–
a5	18	5"x3 1/2"x3/8" [127x89x10], 4 1/2" [114] Long L-Bracket	ASTM A36	ASTM A123 (AASHTO M111)	–
b1	5	TS6"x6"x3/16" [152x152x5], 215 7/8" [5,483] Long Box Beam	ASTM A500 Gr. B	ASTM A123 (AASHTO M111)	–
b2	1	TS6"x6"x3/16" [152x152x5], 215 7/8" [5,483] Long Box Beam	ASTM A500 Gr. B	ASTM A123 (AASHTO M111)	–
b3	4	TS6"x6"x1/4" [152x152x6], 142" [3,607] Long Box Beam, Bent	ASTM A500 Gr. B	ASTM A123 (AASHTO M111)	–
b4	10	27"x5 3/8"x5/8" [686x137x16] Splice Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
b5	1	TS5"x5"x1/4" [127x127x6], 25 1/2" [648] Long Box Beam, Cut	ASTM A500 Gr. B	ASTM A123 (AASHTO M111)	–
b6	3	24"x5 1/4"x3/8" [610x133x10] Plate, Bent	ASTM A36	ASTM A123 (AASHTO M111)	–
b7	1	8"x2 1/2"x5/8" [203x64x16] Keel Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
c1	2	W6x15 [W152x22.3], 72" [1,829] Long Post	ASTM A992 or ASTM A572-50	ASTM A123 (AASHTO M111)	–
c2	2	20"x14"x3/16" [508x356x5] Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
c3	2	6 3/16"x4"x1/2" [157x102x13] Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
c4	4	6 1/4"x4"x1/2" [159x102x13] Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
c5	2	6 3/16"x6"x1/2" [159x152x13] Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
d1	1	3"x2"x3/8" [76x51x10], 4.8" [122] Long L-Bracket	ASTM A36	ASTM A123 (AASHTO M111)	–
d2	2	3"x4"x5/16" [76x102x8] Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
e1	2	10"x9"x1/2" [254x229x13] Box Beam Cable Anchor Base Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
e2	4	4"x4"x1/4" [102x102x6] Box Beam Cable Anchor Gusset	ASTM A36	ASTM A123 (AASHTO M111)	–
e3	2	4"x4"x1/2" [102x102x13] Box Beam Cable Anchor Mounting Plate	ASTM A36	ASTM A123 (AASHTO M111)	–
f1	1	TS7"x7"x3/8" [178x178x10], 48" [1,219] Long Box Beam	ASTM A500 Gr. B	ASTM A123 (AASHTO M111)	–
f2	1	C12x30, 24" [610] Long C-Channel	ASTM A36	ASTM A123 (AASHTO M111)	–
f3	1	3"x3"x1/4" [76x76x6], 18" [457] Long L-Bracket	ASTM A36	ASTM A123 (AASHTO M111)	–
f4	1	3"x3"x1/4" [76x76x6], 56" [1,422] Long L-Bracket	ASTM A36	ASTM A123 (AASHTO M111)	–
f5	1	3"x3"x1/4" [76x76x6], 6 1/2" [165] Long L-Bracket	ASTM A36	ASTM A123 (AASHTO M111)	–

Midwest Roadside Safety Facility

NY "Zig Zag" Box Beam End Terminal

Bill of Materials

SHEET: 28 of 30
DATE: 10/24/2019
DRAWN BY: JEK/GRL/JRD
REV. BY: TJD/KAL/JCH/ELU
DWG. NAME. NYBoxRail_R15
SCALE: None
UNITS: in.[mm]

Figure 28. Bill of Materials, Test No. NYT-1

Item No.	QTY.	Description	Material Spec	Galv Spec	Hardware Guide
g1	1	3/4" [19] Dia. 3x7, 66" [1,676] Long IWRC IPS Wire Rope	ASTM A741 Type 1 (AASHTO M30 Type 1)	Class A Coating	RCM01
g2	1	3/4" [19] Dia. 6x19, 56" [1,422] Long IWRC IPS Wire Rope	ASTM A741 Type 2 (AASHTO M30 Type 2)	Class A Coating	–
g3	1	3/4" [19] Dia. 6x19, 145 3/4" [3,702] Long IWRC IPS Wire Rope	ASTM A741 Type 2 (AASHTO M30 Type 2)	Class A Coating	–
g4	2	Cable End Fitting	ASTM A27 (AASHTO M103) Gr. 70-40 Class 1	ASTM A153 or B695 (AASHTO M232 or M298)	RCE03
g5	1	Crosby Threaded Turnbuckle	C1030/C1035 ASTM F1145	ASTM A153	–
g6	1	3/4" [19] Dia. UNJ, Crosby HG 4037 Jaw	ASTM F1145	As Supplied	–
g7	2	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
g8	2	3/4" [19] Dia. UNC, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or SAE Gr. 2	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	RCE03
g9	4	BCT Anchor Cable End Swaged Fitting	Grade 5	Fitting – ASTM A153 (AASHTO M232), Stud – ASTM A153 or B695 (AASHTO M232 or M298)	–
g10	2	3/4" [19] Dia. UNC Square Nut	ASTM A563A	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FNS20
g11	2	3/4" [19] Dia. UNC Hex Nut	ASTM A563A	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FNX20a
g13	4	1" [25] Dia. UNC Heavy Hex Nut	ASTM A563DH	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FNX24b
g14	4	1" [25] Dia. Plain Round Washer	ASTM F844	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FWC24a
h1	8	1/4" [6] Dia. UNC, 8" [203] Long Fully Threaded Hex Head Shear Bolt and Nut	Bolt – ASTM A307 Gr. A or SAE Gr. 2 Nut – ASTM A563A	Both – ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	–
h2	16	1/4" [6] Dia. UNC, 1" [25] Long Fully Threaded Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or SAE Gr. 2 Nut – ASTM A563A	Both – ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FBX06a
h3	32	1/4" [6] Flat Washer	ASTM F844	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FWC06a
h4	18	3/8" [10] Dia. UNC, 7 1/2" [191] Long Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or SAE Gr. 2 Nut – ASTM A563A	Both – ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FBX10a
h5	36	3/8" [10] Dia. Plain Round Washer	ASTM F844	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FWC10a
h6	21	1/2" [13] Dia. UNC, 1 1/2" [38] Long Fully Threaded Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or SAE Gr. 2 Nut – ASTM A563A	Both – ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FBX14b
h7	18	1/2" [13] Dia. Plain Narrow Round Washer	SAE Low Carbon Gr. 2	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	–

MwRSF

Midwest Roadside Safety Facility

NY "Zig Zag" Box Beam End Terminal

Bill of Materials

SHEET: 29 of 30
DATE: 10/24/2019
DRAWN BY: JEK/GRL/JRD
DWG. NAME. NYBoxRail_R15
SCALE: None
UNITS: in.[mm]
REV. BY: TJD/KAL/JCH/ELU

Figure 29. Bill of Materials, Test No. NYT-1

Item No.	QTY.	Description	Material Spec	Galv Spec	Hardware Guide
h8	8	3/4" [19] Dia. UNC, 8" [203] Long Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or SAE Gr. 2 Nut – ASTM A563A	Both – ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FBX20a
h9*	20	3/4" [19] Dia. UNC, 1 1/2" [38] Long Fully Threaded Heavy Hex Head Bolt	Bolt – ASTM F3125 Gr. A325 or ASTM A449 or SAE J429 Gr. 5 Nut – ASTM A563DH or ASTM A194 Gr. 2H	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	–
h10*	38	3/4" [19] Dia. UNC, 2" [51] Long Fully Threaded Heavy Hex Head Bolt	Bolt – ASTM F3125 Gr. A325 or ASTM A449 or SAE J429 Gr. 5 Nut – ASTM A563DH or ASTM A194 Gr. 2H	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FBX20b
h11*	2	3/4" [19] Dia. UNC, 2 1/2" [64] Long Fully Threaded Heavy Hex Head Bolt	Bolt – ASTM F3125 Gr. A325 or ASTM A449 or SAE J429 Gr. 5 Nut – ASTM A563DH or ASTM A194 Gr. 2H	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FBX20b
h12**	60	3/4" [19] Dia. UNC Heavy Hex Nut	ASTM A563DH	ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	FNX20b
h13	17	3/4" [19] Dia. Plain Round Washer	ASTM F844	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FWC20a
h14	62	3/4" [19] Dia. Hardened Flat Washer	ASTM F436	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FWC20b
h15	8	3/4" [19] Dia. Lock Washer	Steel	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	–
h16	2	7/8" [22] Dia. UNC, 8 1/2" [216] Long Heavy Hex Head Bolt and Nut	Bolt – ASTM F3125 Gr. A325 or ASTM A449 or SAE J429 Gr. 5 Nut – ASTM A563DH or ASTM A194 Gr. 2H	Both – ASTM A153 (AASHTO M232) for Class C or ASTM B695 (AASHTO M298) for Class 50	–
h17	4	7/8" [22] Hardened Flat Washer	ASTM F436	ASTM A153 (AASHTO M232) for Class D or ASTM B695 (AASHTO M298) for Class 50	FWC22b

* If using the splice plates with tapped holes instead of tack welded nuts, h9 quantity required will be 58, and h10 quantity will be 2, and h11 will not be required.

** If using the splice plates with tapped holes instead of tack welded nuts, only 20 of part h12 will be required.

Washer	Washer Series	Inside Diameter			Outside Diameter			Thickness		
		Basic	Tolerance		Basic	Tolerance		Basic	Max.	Min.
			Plus	Minus		Plus	Minus			
3/4"	Regular (h14)	0.812"	0.03"	0.007"	1.469"	0.03"	0.007"	0.134"	0.16"	0.108"
	Wide (h13)	0.812"	0.03"	0.007"	2"	0.03"	0.007"	0.165"	0.192"	0.136"

Midwest Roadside Safety Facility

NY "Zig Zag" Box Beam End Terminal

Bill of Materials

SHEET: 30 of 30
DATE: 10/24/2019
DRAWN BY: JEK/GRL/JRD
REV. BY: TJD/KAL/JCH/ELU
DWG. NAME. NYBoxRail_R15
SCALE: None
UNITS: in.[mm]

Figure 30. Bill of Materials, Test No. NYT-1

Figure 31. Test Installation, Test No. NYT-1

Figure 32. Test Installation-End Terminal, Test No. NYT-1

Figure 33. Test Installation Post and Rail Details for Post Nos. 1 through 8, Test No. NYT-1

Figure 34. Test Installation Post and Rail Details for Post Nos. 9 through 26, Test No. NYT-1

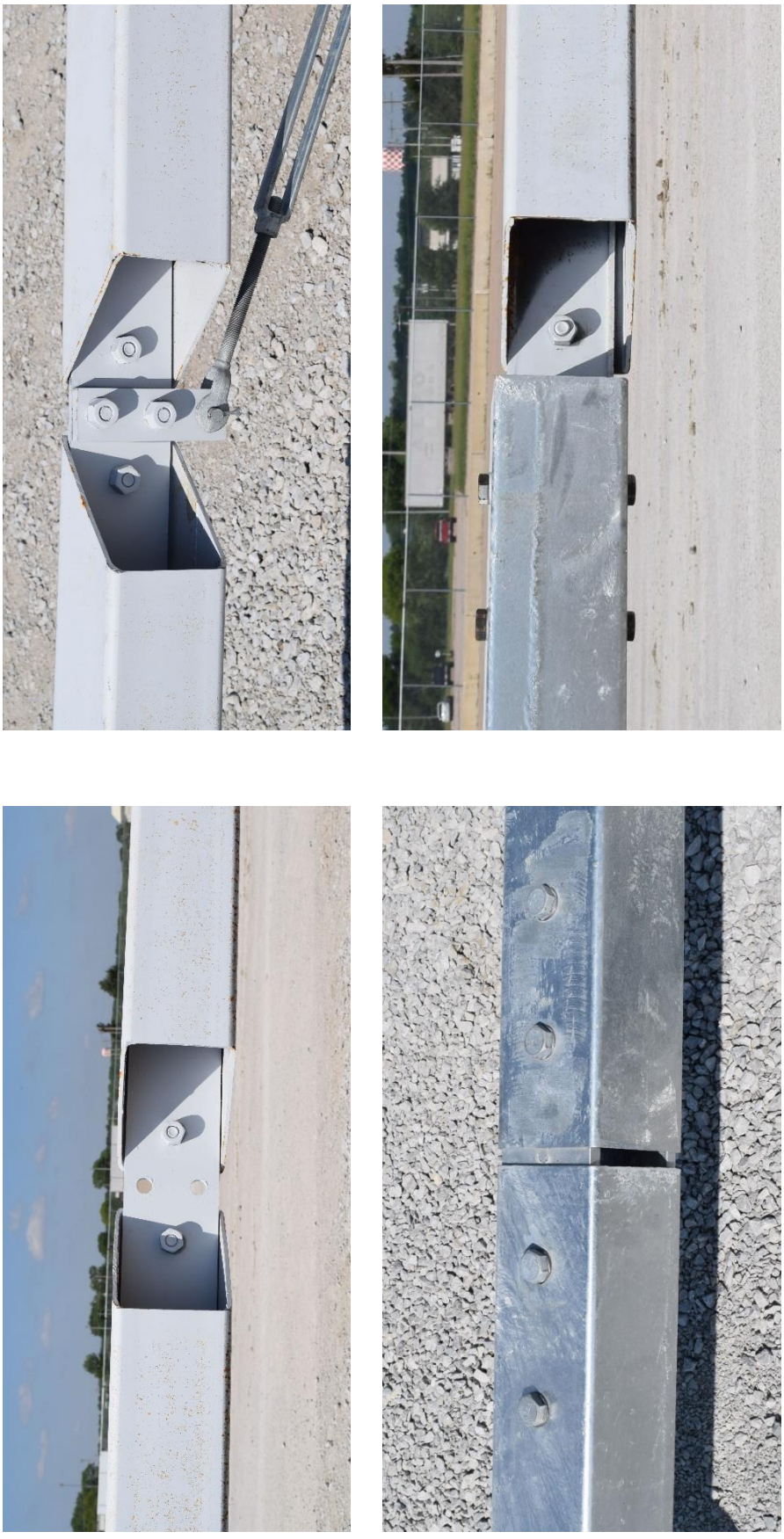
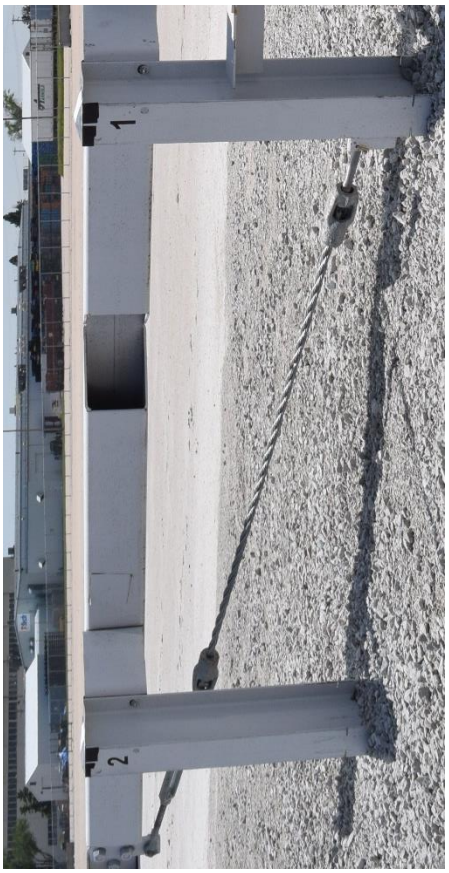
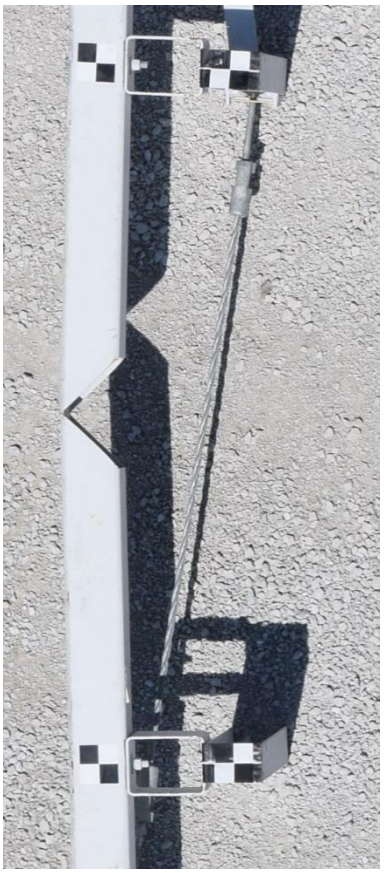


Figure 35. Test Installation, Splice Details, Test No. NYT-1

Figure 36. Test Installation, Splice Details; Test No. NYT-1





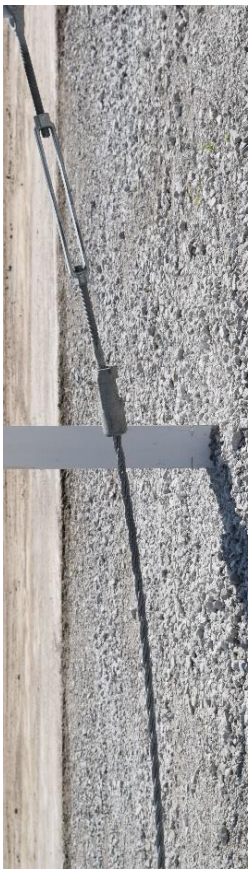


Figure 37. Test Installation, Upstream Anchor Details, Test No. NYT-1

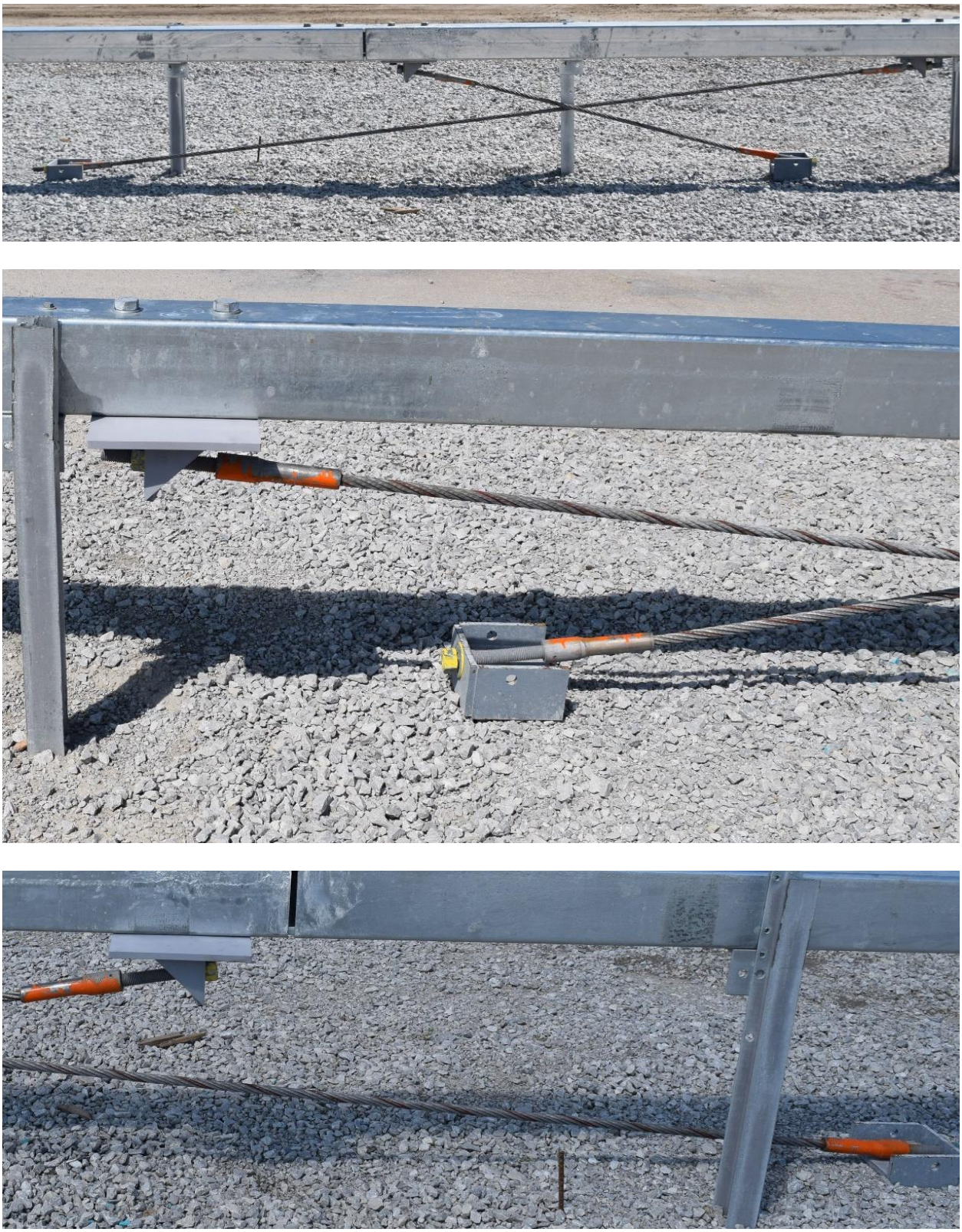


Figure 38. Test Installation, Upstream Anchor Details, Test No. NYT-1

4 TEST CONDITIONS

4.1 Test Facility

The testing facility is located at the Lincoln Air Park on the northwest side of the Lincoln Municipal Airport and is approximately 5 miles (8.0 km) northwest of the University of Nebraska-Lincoln.

4.2 Vehicle Tow and Guidance System

A reverse-cable, tow system with a 1:2 mechanical advantage was used to propel the test vehicle. The distance traveled and the speed of the tow vehicle were one-half that of the test vehicle. The test vehicle was released from the tow cable before impact with the barrier system. A digital speedometer on the tow vehicle increased the accuracy of the test vehicle impact speed.

A vehicle guidance system developed by Hinch [3] was used to steer the test vehicle. A guide flag, attached to the right-front wheel and the guide cable, was sheared off before impact with the barrier system. The ⅜-in. (9.5-mm) diameter guide cable was tensioned to approximately 3,500 lb (15.6 kN) and supported both laterally and vertically every 100 ft (30.5 m) by hinged stanchions. The hinged stanchions stood upright while holding up the guide cable, but as the vehicle was towed down the line, the guide flag struck and knocked each stanchion to the ground.

4.3 Test Vehicles

For test no. NYT-1, a 2011 Dodge Ram 1500 quad cab pickup truck was used as the test vehicle. The curb, test inertial, and gross static vehicle weights were 5,071 lb (2,300 kg), 5,000 lb (2,268 kg), and 5,158 lb (2,340 kg), respectively. The test vehicle is shown in Figures 39 and 40, and vehicle dimensions are shown in Figure 41. Pre-test photographs of the vehicle's undercarriage were unavailable.

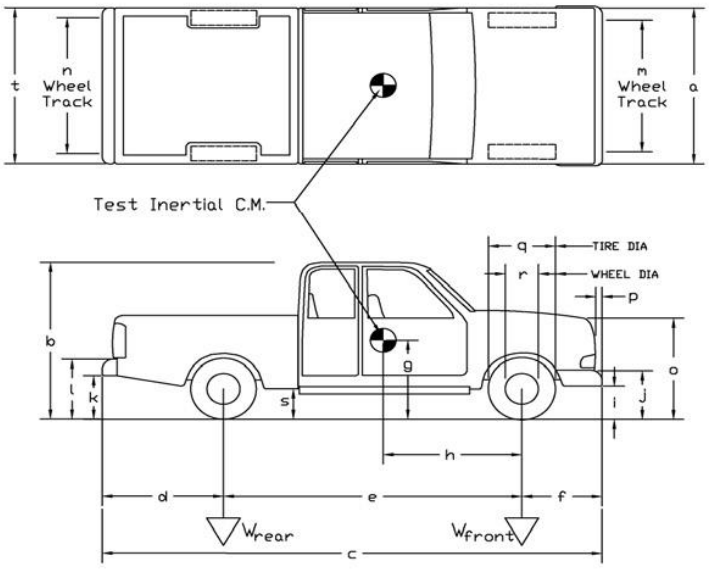
The longitudinal component of the center of gravity (c.g.) was determined using the measured axle weights. The Suspension Method [4] was used to determine the vertical component of the c.g. for the pickup truck. This method is based on the principle that the c.g. of any freely suspended body is in the vertical plane through the point of suspension. The vehicle was suspended successively in three positions, and the respective planes containing the c.g. were established. The intersection of these planes pinpointed the final c.g. location for the test inertial condition. The location of the final c.g. is shown in Figures 41 and 42. Data used to calculate the location of the c.g. and ballast information are shown in Appendix B.

Square, black- and white-checkered targets were placed on the vehicle for reference to be viewed from the high-speed digital video cameras and aid in the video analysis, as shown in Figure 42. Round, checkered targets were placed at the c.g. on the left-side door, the right-side door, and the roof of the vehicle.

Figure 39. Test Vehicle, Test No. NYT-1

Figure 40. Test Vehicle Interior Floorboards, Test No. NYT-1

Date:	5/16/2017	Test Name:	NYT-1	VIN No:	1D7RB1GP3BS553913
Year:	2011	Make:	Dodge	Model:	Ram 1500
Tire Size:	P265/70R17 113R	Tire Inflation Pressure:	40 Psi	Odometer:	217959



Vehicle Geometry - in. (mm)
Target Ranges listed below

a:	78 3/8 (1991)	78±2 (1950±50)	b:	73 3/8 (1864)	
c:	229 1/2 (5829)	237±13 (6020±325)	d:	49 3/8 (1254)	
e:	140 1/4 (3562)	148±12 (3760±300)	f:	38 3/4 (984)	39±3 (1000±75)
g:	28 (711)	min: 28 (710)	h:	61 9/16 (1564)	63±4 (1575±100)
i:	7 (178)		j:	23 3/4 (603)	
k:	19 1/4 (489)		l:	28 3/4 (730)	
m:	66 1/2 (1689)	67±1.5 (1700±38)	n:	67 3/4 (1721)	67±1.5 (1700±38)
o:	45 3/4 (1162)	43±4 (1100±75)	p:	4 5/8 (117)	
q:	31 3/4 (806)		r:	18 1/2 (470)	
s:	14 3/4 (375)		t:	77 5/8 (1972)	

Mass Distribution lb (kg)

Gross Static	LF	1400 (635)	RF	1505 (683)
	LR	1119 (508)	RR	1134 (514)

Weights lb (kg)	Curb	Test Inertial	Gross Static
W-front	2869 (1301)	2805 (1272)	2905 (1318)
W-rear	2202 (999)	2195 (996)	2253 (1022)
W-total	5071 (2300)	5000 (2268) 5000±110 (2270±50)	5158 (2340) 5165±110 (2343±50)

GVWR Ratings lb

Front	3700
Rear	3900
Total	6900

Dummy Data

Type:	Hybrid II
Mass:	158 lb
Seat Position:	Passenger

Wheel Center Height (Front):	14 1/2 (368)
Wheel Center Height (Rear):	15 (381)
Wheel Well Clearance (Front):	34 7/8 (886)
Wheel Well Clearance (Rear):	37 3/8 (949)
Bottom Frame Height (Front):	13 1/4 (337)
Bottom Frame Height (Rear):	24 3/4 (629)
Engine Type:	Gasoline
Engine Size:	4.7L V8
Transmission Type:	Automatic
Drive Type:	RWD
Cab Style:	Quad Cab
Bed Length:	76"

Note any damage prior to test:

Figure 41. Vehicle Dimensions, Test No. NYT-1

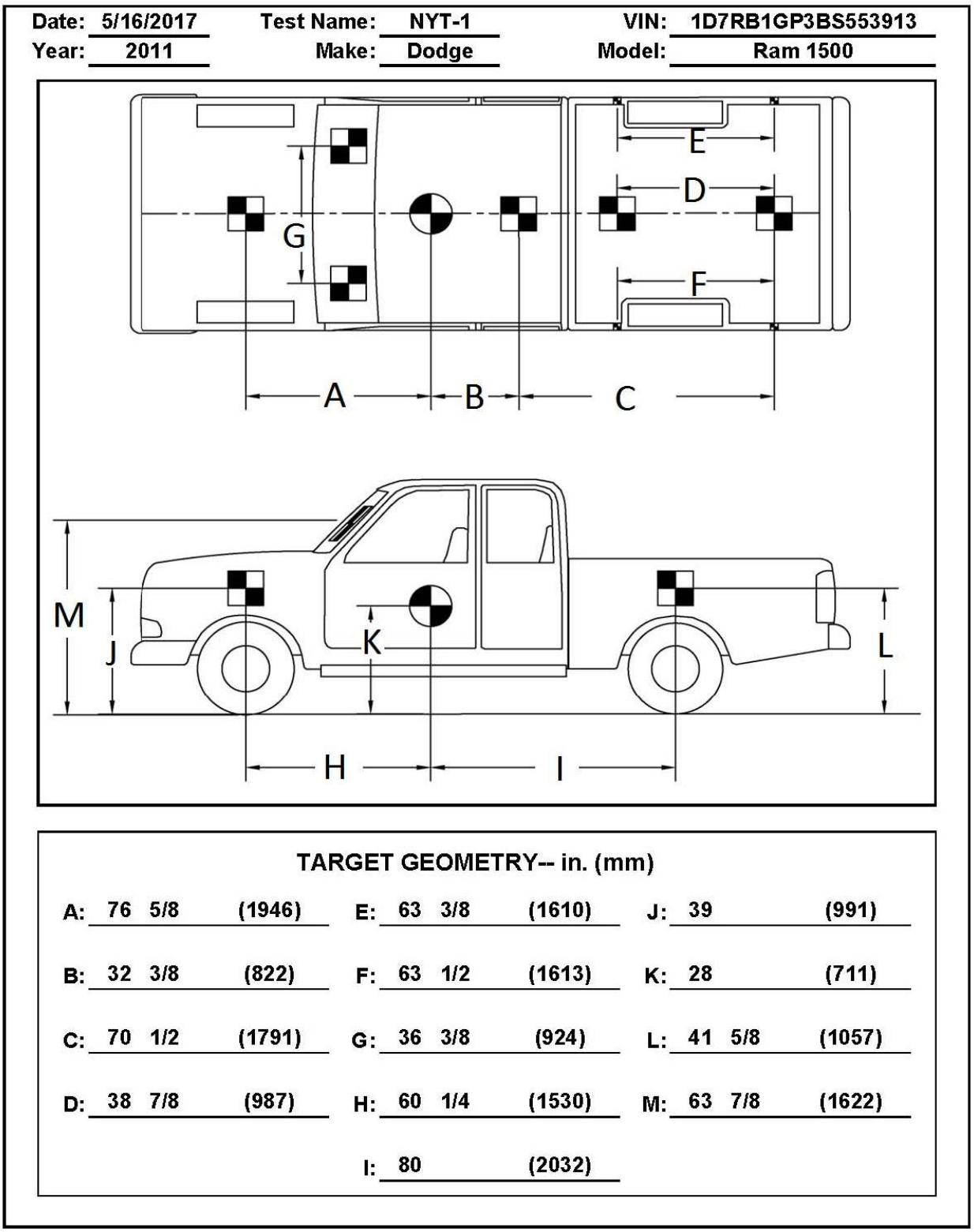


Figure 42. Target Geometry, Test No. NYT-1

The front wheels of the test vehicle were aligned to vehicle standards except the toe-in value was adjusted to zero such that the vehicles would track properly along the guide cable. A 5B flash bulb was mounted under the left windshield wiper and was fired by a pressure tape switch mounted at the impact corner of the bumper. The flash bulb was fired upon initial impact with the test article to create a visual indicator of the precise time of impact on the high-speed digital videos. A radio-controlled brake system was installed in the test vehicle so the vehicle could be brought safely to a stop after the test.

4.4 Simulated Occupant

For test no. NYT-1, a Hybrid II 50th-Percentile, Adult Male Dummy, equipped with clothing and footwear, was placed in the right-front seat of the test vehicle with the seat belt fastened. The simulated occupant had a final weight of 158 lb (72 kg). As recommended by MASH 2016, the simulated occupant was not included in calculating the c.g. location.

4.5 Data Acquisition Systems

4.5.1 Accelerometers

Two environmental shock and vibration sensor/recorder systems were used to measure the accelerations in the longitudinal, lateral, and vertical directions. Both accelerometer systems were mounted near the c.g. of the test vehicle. The electronic accelerometer data obtained in dynamic testing was filtered using the SAE Class 60 and the SAE Class 180 Butterworth filter conforming to the SAE J211/1 specifications [5].

The two systems, the SLICE-1 and SLICE-2 units, were modular data acquisition systems manufactured by Diversified Technical Systems, Inc. (DTS) of Seal Beach, California. The SLICE-2 unit was designated as the primary system. The acceleration sensors were mounted inside the bodies of custom-built, SLICE 6DX event data recorders and recorded data at 10,000 Hz to the onboard microprocessor. Each SLICE 6DX was configured with 7 GB of non-volatile flash memory, a range of ±500 g's, a sample rate of 10,000 Hz, and a 1,650 Hz (CFC 1000) anti-aliasing filter. The "SLICEWare" computer software programs and a customized Microsoft Excel worksheet were used to analyze and plot the accelerometer data.

4.5.2 Rate Transducers

Two identical angular rate sensor systems mounted inside the bodies of the SLICE-1 and SLICE-2 event data recorders were used to measure the rates of rotation of the test vehicle. Each SLICE MICRO Triax ARS had a range of 1,500 degrees/sec in each of the three directions (roll, pitch, and yaw) and recorded data at 10,000 Hz to the onboard microprocessors. The raw data measurements were then downloaded, converted to the proper Euler angles for analysis, and plotted. The "SLICEWare" computer software program and a customized Microsoft Excel worksheet were used to analyze and plot the angular rate sensor data.

4.5.3 Retroreflective Optic Speed Trap

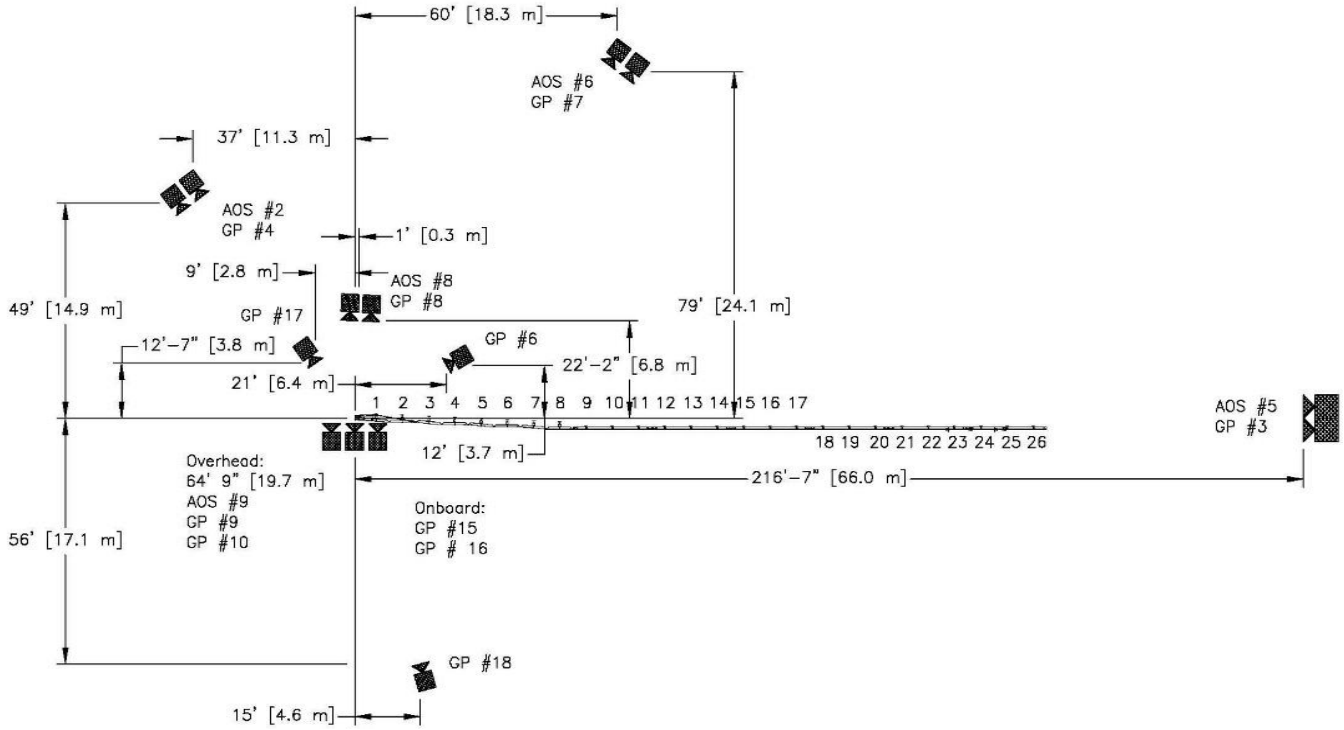
The retroreflective optic speed trap was used to determine the speed of the test vehicle before impact. Five retroreflective targets, spaced at approximately 18-in. (457-mm) intervals,

were applied to the side of the vehicle. When the emitted beam of light was reflected by the targets and returned to the Emitter/Receiver, a signal was sent to the data acquisition computer, recording at 10,000 Hz, as well as the external LED box activating the LED flashes. The speed was then calculated using the spacing between the retroreflective targets and the time between the signals. LED lights and high-speed digital video analysis are only used as a backup in the event that vehicle speeds cannot be determined from the electronic data.

4.5.4 Digital Photography

Five AOS high-speed digital video cameras and eleven GoPro digital video cameras were utilized to film test no. NYT-1. Camera details, camera operating speeds, lens information, and a schematic of the camera locations relative to the system are shown in Figure 43.

The high-speed videos were analyzed using TEMA Motion and Redlake MotionScope software programs. Actual camera speed and camera divergence factors were considered in the analysis of the high-speed videos. A digital still camera was also used to document pre- and post-test conditions for the test.



No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
AOS-2	AOS Vitcam	500	Fujinon 35 mm Fixed	-
AOS-5	AOS X-PRI	500	Vivitar 135 mm Fixed	-
AOS-6	AOS X-PRI	500	Kowa 25 mm Fixed	-
AOS-8	AOS S-VIT 1531	500	Kowa 16 mm Fixed	-
AOS-9	AOS TRI-VIT 2236	500	Kowa 12 mm Fixed	-
GP-3	GoPro Hero 3+	120		
GP-4	GoPro Hero 3+	120		
GP-6	GoPro Hero 3+	120		
GP-7	GoPro Hero 4	240		
GP-8	GoPro Hero 4	240		
GP-9	GoPro Hero 4	120		
GP-10	GoPro Hero 4	240		
GP-15	GoPro Hero 4	120		
GP-16	GoPro Hero 4	120		
GP-17	GoPro Hero 4	240		
GP-18	GoPro Hero 4	240		

Figure 43. Camera Locations, Speeds, and Lens Settings, Test No. NYT-1

5 FULL-SCALE CRASH TEST NO. NYT-1

5.1 Static Soil Test

Before full-scale crash test no. NYT-1 was conducted, the strength of the foundation soil was evaluated with a static test, as described in MASH 2016. The static test results, as shown in Appendix C, demonstrated a soil resistance above the baseline test limits. Thus, the soil provided adequate strength, and full-scale crash testing could be conducted on the barrier system.

5.2 Weather Conditions

Test no. NYT-1 was conducted on May 16, 2017 at approximately 3:00 p.m. The weather conditions as per the National Oceanic and Atmospheric Administration (station 14939/LNK) were reported and are shown in Table 3.

Table 3. Weather Conditions, Test No. NYT-1

Temperature	90° F
Humidity	44%
Wind Speed	18 mph
Wind Direction	190° from True North
Sky Conditions	Partly Cloudy
Visibility	10 Statute Miles
Pavement Surface	Dry
Previous 3-Day Precipitation	0.01 in.
Previous 7-Day Precipitation	0.39 in.

5.3 Test Description

Initial vehicle impact was to occur at the upstream face of the terminal, as shown in Figure 44, which was selected using Table 2-3 of MASH 2016. The 5,000-lb (2,268-kg) quad cab pickup truck impacted the New York zig-zag box-beam terminal at a speed of 62.7 mph (101 km/h) and at an angle of 0.1 degrees. The actual point of impact was on the upstream end of the terminal. The vehicle came to rest 80 ft – 3 in. (24.5 m) downstream from the impact point and 6 in. (152 mm) from the back of the system, facing the system.

A detailed description of the sequential impact events is contained in Table 4. Sequential photographs are shown in Figures 46 and 47. Documentary photographs of the crash test are shown in Figure 48 and Figure 49. The vehicle trajectory and final position are shown in Figure 50.

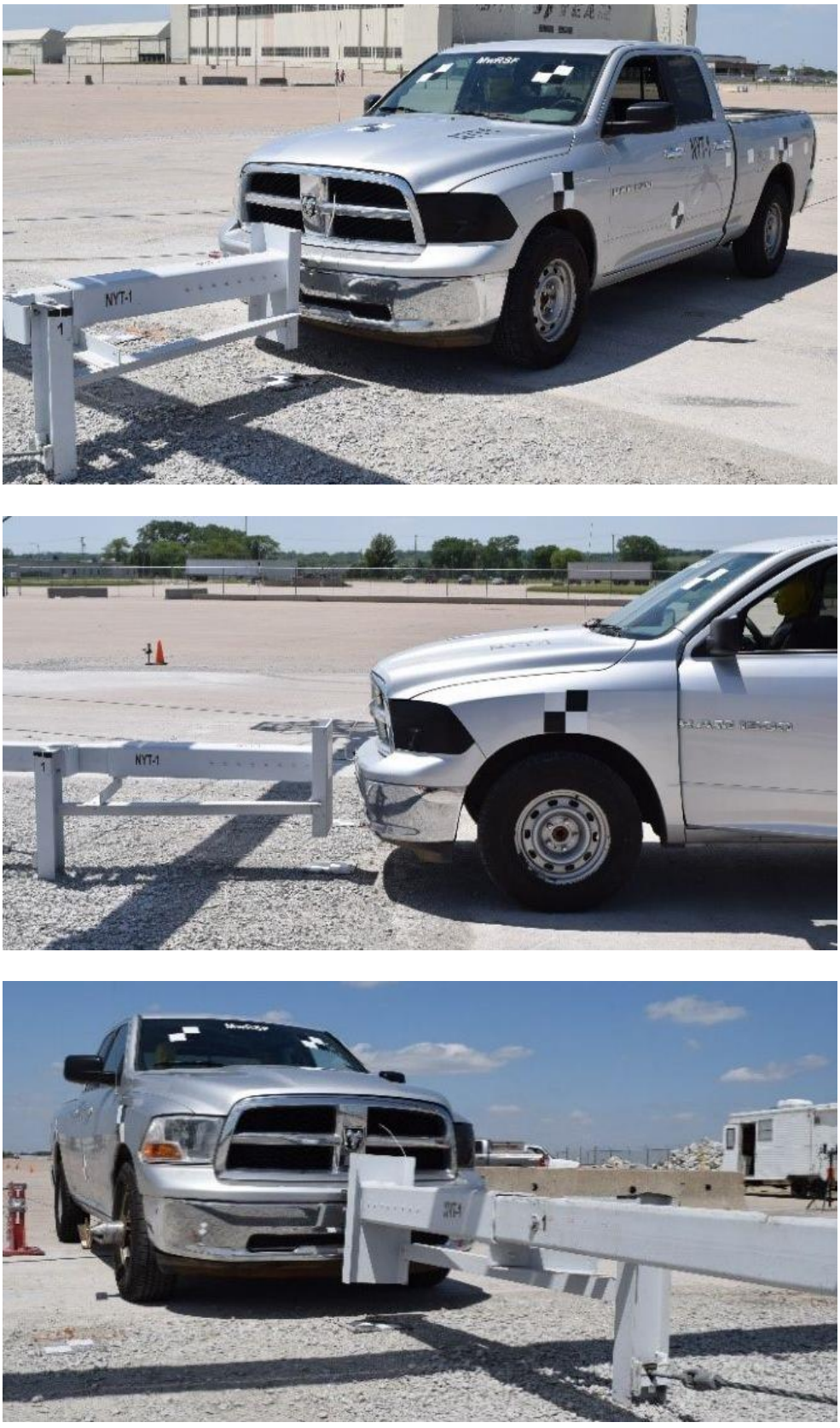


Figure 44. Impact Location, Test No. NYT-1

Table 4. Sequential Description of Impact Events, Test No. NYT-1

TIME (sec)	EVENT
0.000	Vehicle's front bumper impacted end terminal head.
0.002	Vehicle's front bumper deformed. Vehicle's grille contacted end terminal head.
0.004	Vehicle's grille deformed.
0.006	End terminal head assembly deflected downstream.
0.012	Vehicle's right headlight deformed.
0.014	End terminal caused post no. 1 to deflect downstream.
0.016	Blockout no. 1 disengaged from post no. 1.
0.018	Vehicle's hood deformed.
0.022	Post no. 1 bent downstream.
0.024	Vehicle's left fender deformed.
0.026	Vehicle pitched downward.
0.028	Blockout no. 1 disengaged from rail at post no. 1. Vehicle's left headlight deformed.
0.044	Rail bent between post nos. 1 and 2. Rail section no. 1 deflected downstream.
0.046	Vehicle's right fender deformed. Rail bent between post nos. 2 and 3. Rail section no. 2 deflected downstream.
0.048	Post no. 2 rotated counterclockwise. Vehicle yawed toward barrier.
0.050	Anchor cable disengaged from post no. 1. Rail bent between post nos. 3 and 4.
0.052	Post no. 2 deflected downstream. Post no. 3 rotated counterclockwise. Rail bent between post nos. 4 and 5. Rail section no. 3 deflected downstream.
0.054	Post no. 3 deflected downstream. Rail bent between post nos. 5 and 6.
0.056	Post nos. 4 and 5 deflected downstream. Rail bent between post nos. 6 and 7. Rail section no. 4 deflected downstream.
0.058	Blockout no. 4 disengaged from post no. 4. Blockout no. 2 disengaged from post no. 2. Rail bent between post nos. 7 and 8.
0.060	Post no. 7 deflected downstream.
0.062	Blockout no. 6 disengaged from post no. 6.
0.064	Blockout no. 3 disengaged from post no. 3.
0.068	Blockout no. 5 disengaged from post no. 5.
0.072	Blockout no. 8 disengaged from post no. 8.
0.090	Rail section no. 2 contacted post no. 3.
0.098	Vehicle overrode post no. 1.
0.100	Post no. 3 bent downstream.
0.130	Vehicle front bumper contacted post no. 2.
0.138	Post no. 2 bent downstream. Rail section no. 3 rotated counterclockwise.
0.158	Vehicle yawed away from barrier.
0.180	Vehicle overrode post no. 2.
0.200	Post no. 4 bent downstream. Vehicle's right headlight disengaged. Rail section no. 2 contacted post no. 4.
0.236	Rail section no. 3 deflected downstream.

Table 5. Sequential Description of Impact Events, Test No. NYT-1, Cont.

TIME (sec)	EVENT
0.238	Rail section no. 2 tore at notch.
0.258	Vehicle overrode post no. 3.
0.298	Vehicle pitched upward.
0.300	Rail section no. 2 contacted post no. 5. Post no. 5 bent downstream.
0.326	Vehicle overrode post no. 4.
0.372	Rail section no. 2 contacted post no. 6.
0.376	Post no. 6 bent downstream.
0.414	Vehicle overrode post no. 5.
0.422	Upstream end of rail section no. 2 contacted downstream end of rail section no. 3.
0.426	Vehicle's front bumper contacted rail section no. 4.
0.454	Blockout no. 3 contacted post no. 7.
0.458	Blockout no. 7 disengaged from post no. 7.
0.464	Post no. 7 bent downstream.
0.474	Rail section no. 2 contacted post no. 7.
0.486	Rail section no. 4 rotated counterclockwise.
0.502	Vehicle overrode post no. 6.
0.536	Vehicle's grille contacted blockout no. 7. Rail bent between post nos. 8 and 9.
0.542	Vehicle's right-front tire contacted rail section no. 4.
0.550	Vehicle pitched downward.
0.554	Rail section no. 2 contacted post no. 8.
0.556	Vehicle's right fender contacted rail section no. 4.
0.560	Post no. 8 bent downstream.
0.566	Vehicle rolled away from barrier.
0.586	Vehicle overrode post no. 7.
0.658	Vehicle's front bumper contacted tangent rail.
0.660	Vehicle's grille contacted tangent rail.
0.662	Vehicle's right fender contacted tangent rail.
0.690	Vehicle overrode post no. 8.
0.764	Vehicle's right-side mirror deformed.
0.766	Vehicle's right A-pillar and windshield deformed.
0.782	Vehicle's right-front door deformed.
0.786	Vehicle's roof deformed.
0.788	Vehicle's right-front window shattered due to contact with structural member of system.
0.796	Vehicle's windshield separated from right A-pillar.
0.916	Vehicle's grille disengaged.
1.038	Vehicle pitched upward.
1.064	Vehicle rolled toward barrier.
1.512	Vehicle rolled away from barrier.

Figure 45. Vehicle Final Position and Trajectory Marks, Test No. NYT-1


0.000 sec


0.000 sec


0.054 sec


0.474 sec


0.100 sec


1.038 sec


0.180 sec


1.512 sec


0.258 sec


2.166 sec


0.300 sec


2.866 sec

Figure 46. Sequential Photographs, Test No. NYT-1

0.000 sec

0.130 sec

0.302 sec

0.464 sec

0.586 sec

0.788 sec

0.000 sec

0.050 sec

0.100 sec

0.138 sec

0.180 sec

0.258 sec

Figure 47. Additional Sequential Photographs, Test No. NYT-1

Figure 48. Documentary Photographs, Test No. NYT-1

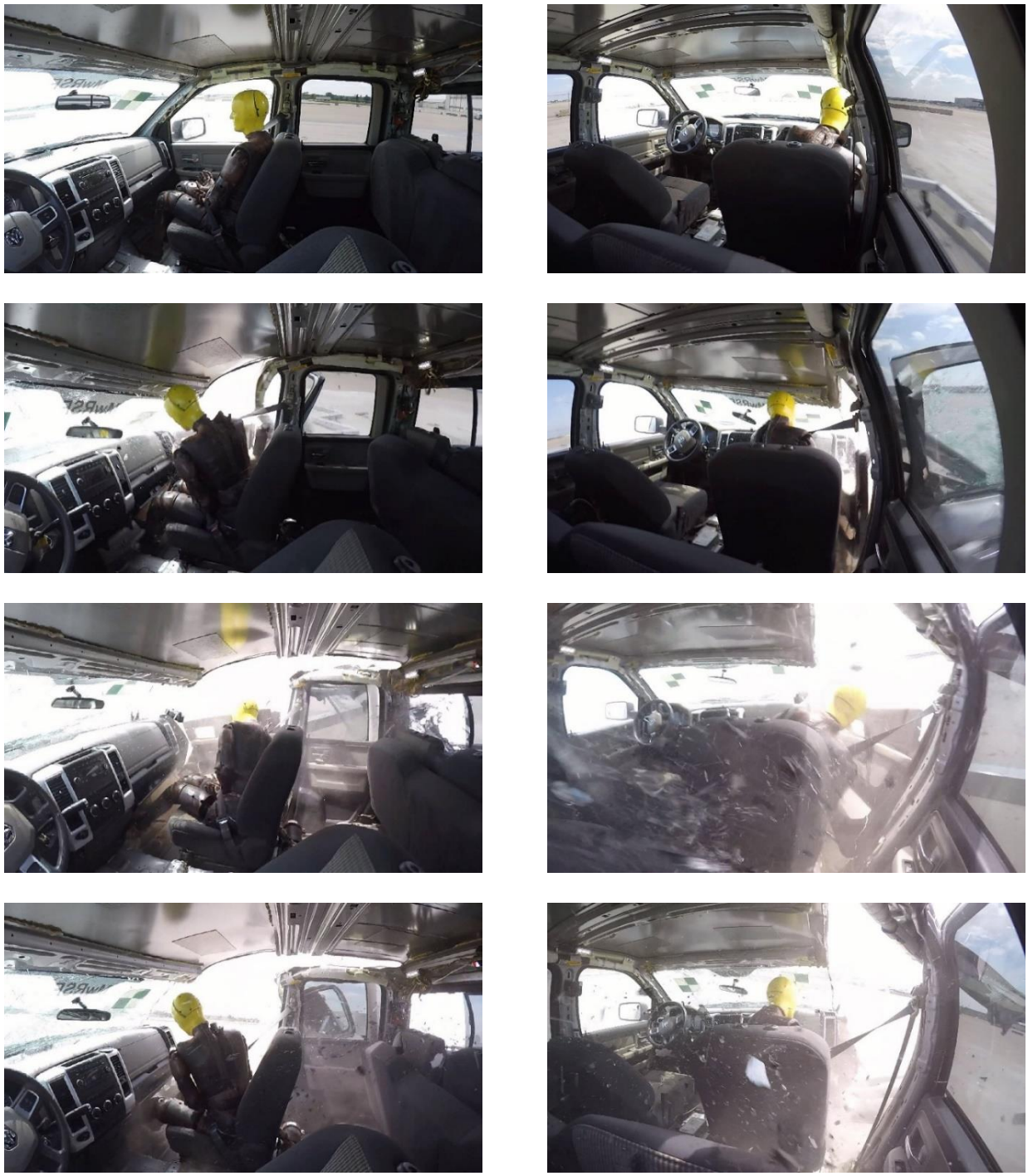


Figure 49. Additional Documentary Photographs, Test No. NYT-1

5.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 50 through 57. Barrier damage consisted of contact marks on the impact head and box beam, vertical tears at the V-shaped sections, deformations to the box beam, and deflection of the posts. The length of vehicle contact along the barrier was approximately 80 ft – 3 in. (24.5 m) beginning at the front of the impact head.

Contact marks found on the front of the impact head measured 35 in. (889 mm), 24 in. (610 mm), and 23 in. (584 mm). An 8-in. high by 3-in. wide (203-mm by 76-mm) contact mark was found at the bottom of the back face of the impact head. A 2½-in. (64-mm) dent was visible on the front face of the impact head box beam. A 4½-in. (114-mm) bend was located at the downstream corner of the vertical plate, which bent ¾ in. (19 mm) backward. Dents were found on the V-shaped section on the rail between post nos. 6 and 7. A 7-in. (178 mm) tear was found on the V-shaped section on the rail between post nos. 6 and 7. Smaller contact marks, bends, tears, and dents were located on the impact head, V-shaped sections, and box beam.

The splice plate on the rail between post nos. 4 and 5 was bent 90 degrees at the splice center. The splice plate connecting rail sections between post nos. 8 and 9 was bent 90 degrees at the splice center. The splice plate on the rail between post nos. 6 and 7 was bent 20 degrees upstream from the splice center, and it was also bent 90 degrees at the splice plate centerline. The splice plate on the rail between post nos. 8 and 9 was bent 90 degrees at the splice centerline.

Soil heaves formed at the bases of post nos. 7, 9, and 11 through 13, and soil craters were found at the bases of post nos. 8 through 10, 13, and 15. Post nos. 1 through 13 were bent downstream at the ground line. For post nos. 1 through 8, four 1-in (25-mm) tears were found at the saw cuts, two on the upstream flange and two on the downstream flange. Dents, gouges, and contact marks were found on post nos. 1 through 14. The box beam disengaged from post nos. 12 and 13. All blockouts from post nos. 2 through 8 disconnected from their respective posts but stayed connected to the box beam. The blockout from post no. 1 disengaged from both the post and the box beam, and was displaced 32 ft – 6 in. (9,906 mm) laterally behind and 152 ft – 7 in. (46,507) downstream from its original position. The blockouts from post nos. 3, 4, and 7 were deformed. The rail-to-post L-brackets remained attached to post nos. 12 through 26. The L-bracket of post no. 14 rotated, but the L-bracket remained intact and fastened to both the post and the box-beam rail. The L-brackets from post nos. 11 through 13 disengaged from the box beam but stayed attached to their respective posts. The L-brackets from post nos. 9 and 10 disengaged from both the box beam and their respective posts. The remaining posts, nos. 15 through 26, appeared to be undamaged.

The maximum lateral permanent set of the barrier system was 266 in. (6,756 mm) which occurred at the rail initially attached to post no. 4, as measured in the field. The maximum lateral dynamic barrier deflection was 326.7 in. (8,299 mm) which occurred at the rail initially attached to post no. 4, as determined from high-speed digital video analysis.

Figure 50. System Damage Overview, Test No. NYT-1

Figure 51. End Terminal Damage, Test No. NYT-1

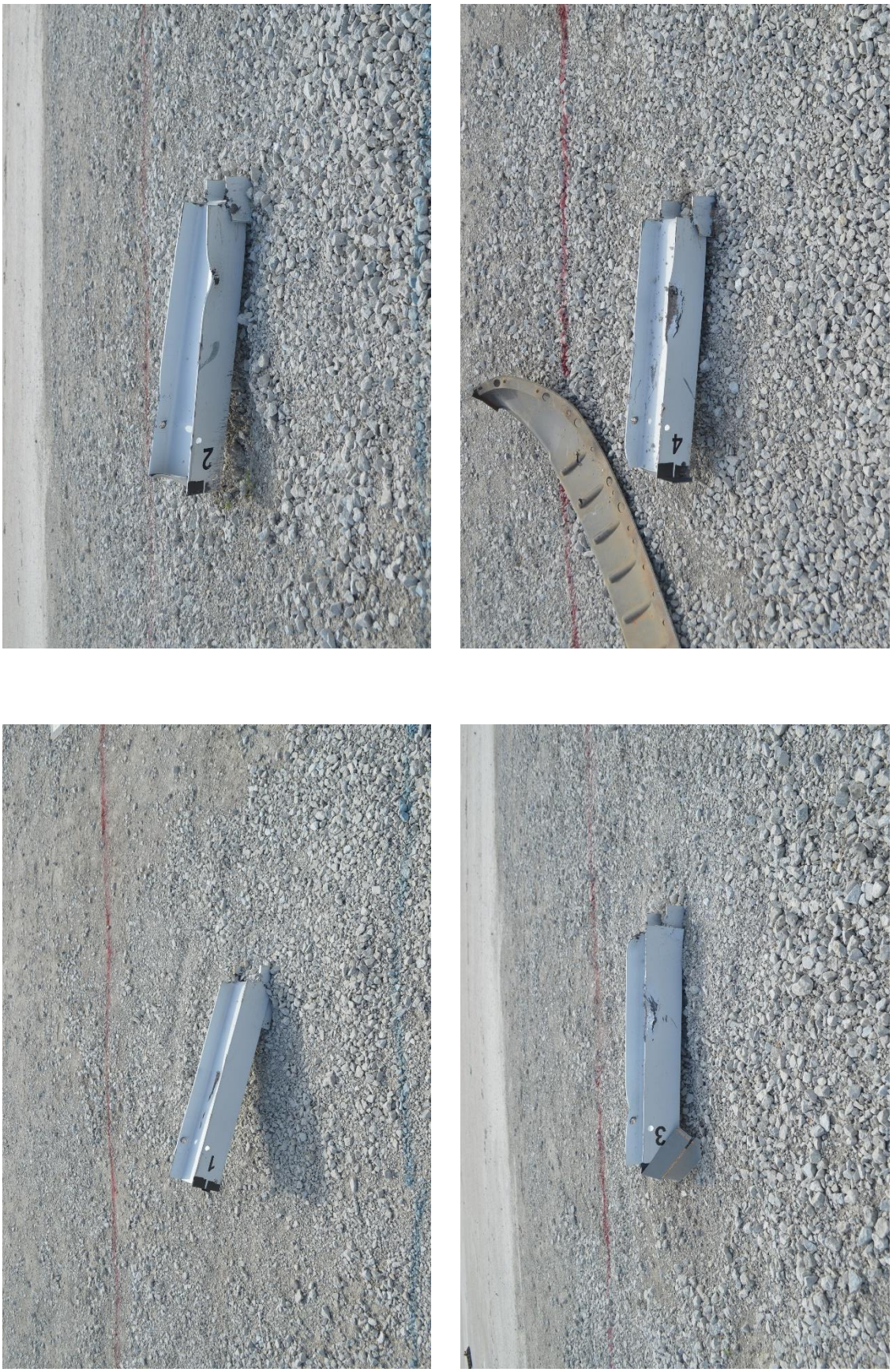


Figure 52. System Damage, Post Nos. 1 through 4, Test No. NYT-1

Figure 53. System Damage, Post Nos. 5 through 8, Test No. NYT-1

Figure 54. System Damage, Post Nos. 9 through 11, Test No. NYT-1

Figure 55. Rail Damage, Test No. NYT-1

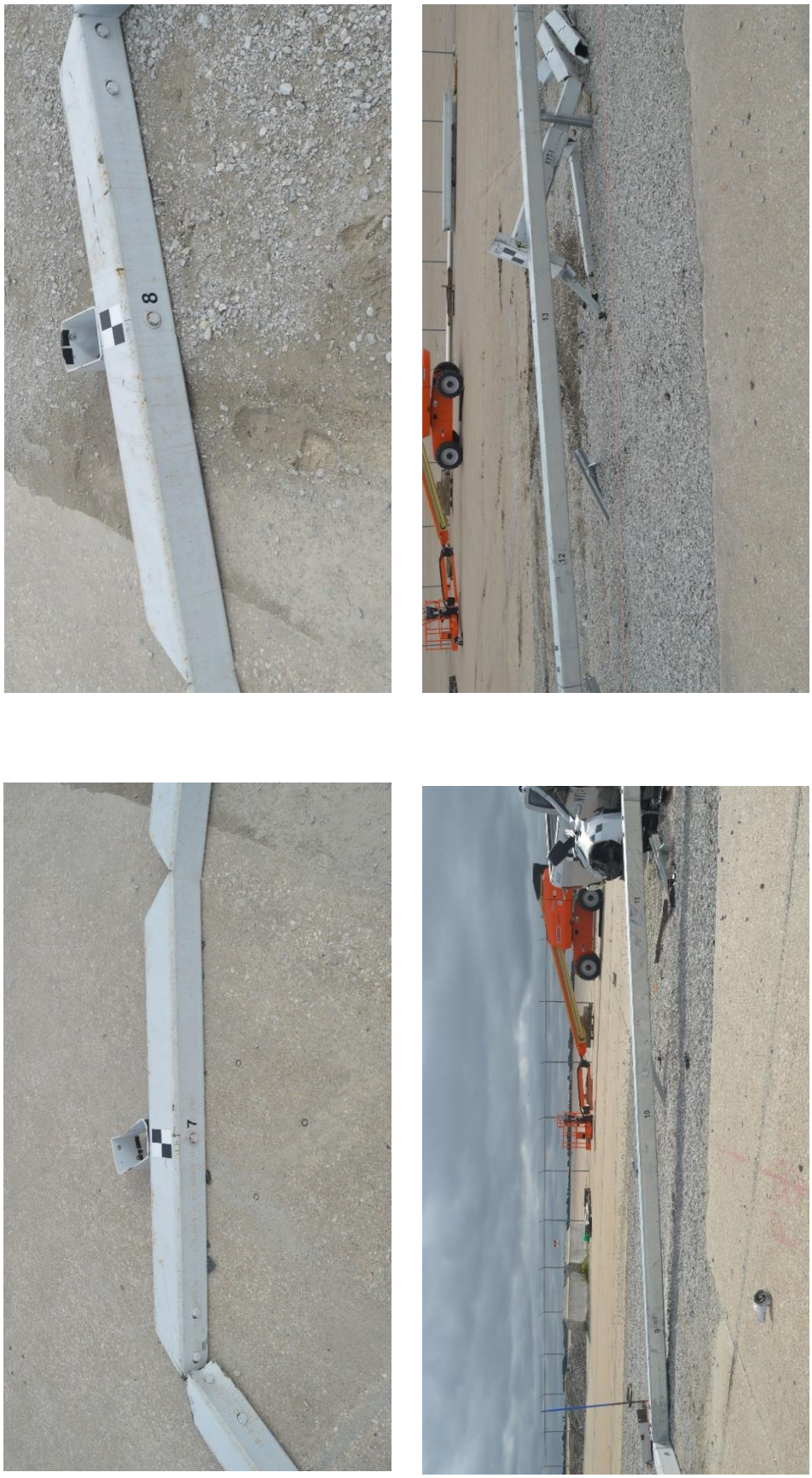


Figure 56. Additional Rail Damage, Test No. NYT-1

Splice 2-3

Splice 4-5

Splice 6-7

Splice 8-9

Figure 57. Splice Damage, Test No. NYT-1

5.5 Vehicle Damage

The damage to the vehicle was extensive, as shown in Figures 58 through 62. The maximum occupant compartment intrusions are listed in Table 6 along with the deformation limits established in MASH 2016 for various areas of the occupant compartment. MASH 2016 defines intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. Note that the side window shattered as a result of contact with a structural member of the system, and thus violated the deformation limits established in MASH 2016. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix D.

Majority of the damage was concentrated on the right-front corner and right side of the vehicle, where 'right' is determined from the rear of the vehicle. The front bumper, headlights, radiator, and grille disengaged from the vehicle. The right-front fender and right-front door were separated from the vehicle's frame, consequently shattering the right-front side window. The right-front wheel assembly deformed and counterclockwise, and the tire tore. Denting and scraping were observed along the vehicle's entire right side. The entire windshield fractured and the top-right corner of the windshield tore from the roof where it was attached. The roof bent downward and buckled.

The vehicle anti-roll bar was dented near the middle-rear. The right-side steering knuckle disengaged from the vehicle. The right-side upper-control arm was severely bent, and the ball joint deflected approximately 3 in. (76 mm) toward the rear of the vehicle. The right-front mounting bracket and lower control arm bent backward. The right-side inner tire rod disengaged. The left-side suspension appeared undamaged. The left-side frame horn bent backward toward the left-side doors, and the right-side frame horn bent inward toward the left side. The first left-side cab mount disengaged from the vehicle while the second left-side cab mount bent inward. The left-front brake line was fractured at the caliper.

Figure 58. Vehicle Damage, Test No. NYT-1

Figure 59. Additional Vehicle Damage, Test No. NYT-1

Figure 60. Vehicle Windshield Damage, Test No. NYT-1

Figure 61. Occupant Compartment Damage, Test No. NYT-1

Figure 62. Vehicle Undercarriage Damage, Test No. NYT-1

Table 6. Maximum Occupant Compartment Intrusions by Location

LOCATION	MAXIMUM INTRUSION in. (mm)	MASH 2016 ALLOWABLE INTRUSION in. (mm)
Wheel Well & Toe Pan	1⅛ (29)	≤ 9 (229)
Floor Pan & Transmission Tunnel	3 (76)	≤ 12 (305)
A-Pillar	1⅜ (35)	≤ 5 (127)
A-Pillar (Lateral)	1⅛ (29)	≤ 3 (76)
B-Pillar	1⅝ (41)	≤ 5 (127)
B-Pillar (Lateral)	1⅜ (35)	≤ 3 (76)
Side Front Panel (in Front of A-Pillar)	1⅛ (29)	≤ 12 (305)
Side Door (Above Seat)	1 (25)	≤ 9 (229)
Side Door (Below Seat)	⅝ (16)	≤ 12 (305)
Roof	4 (102)	≤ 4 (102)
Windshield	N/A[2]	≤ 3 (76)
Side Window	Right-front window shattered due to vehicle contact with a structural member	No shattering resulting from contact with structural member of test article
Dash	3⅜ (86)	N/A[1]

N/A[1] – No MASH criteria exists for this location
N/A[2] – No data available

5.6 Occupant Risk

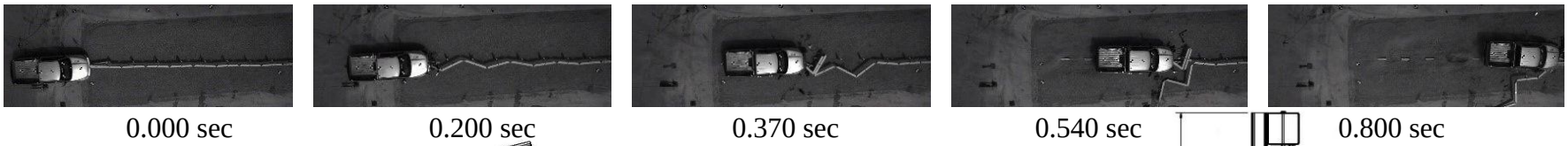
The calculated occupant impact velocities (OIVs) and maximum 0.010-sec average occupant ridedown accelerations (ORAs) in both the longitudinal and lateral directions are shown in Table 7. Note that the OIVs and ORAs were within suggested limits, as provided in MASH 2016. The calculated THIV, PHD, and ASI values are also shown in Table 7. The results of the occupant risk analysis, as determined from the accelerometer data, are summarized in Figure 63. The recorded data from the accelerometers and the rate transducers are shown graphically in Appendix E.

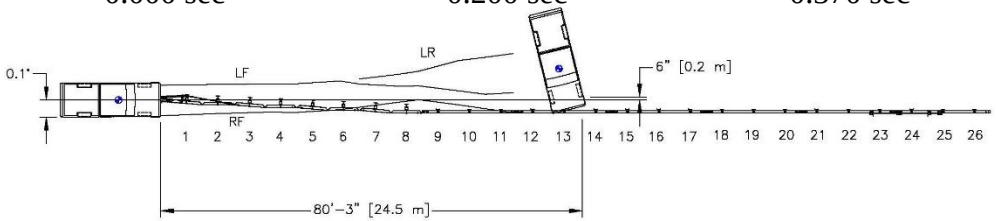
Table 7. Summary of OIV, ORA, THIV, PHD, and ASI Values, Test No. NYT-1

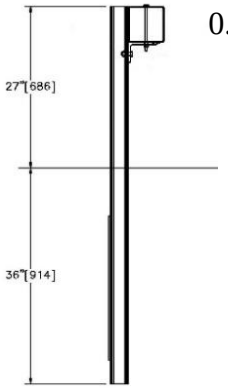
Evaluation Criteria		Transducer		MASH 2016 Limits
		SLICE-1	SLICE-2 (primary)	
OIV ft/s (m/s)	Longitudinal	-13.45 (-4.10)	-13.50 (-4.11)	±40 (12.2)
	Lateral	5.16 (1.57)	4.69 (1.43)	±40 (12.2)
ORA g's	Longitudinal	-13.77	-14.00	±20.49
	Lateral	3.81	3.82	±20.49
MAX. ANGULAR DISPL. deg.	Roll	-13.94	13.90	±75
	Pitch	4.07	-2.97	±75
	Yaw	77.68	75.80	not required
THIV ft/s (m/s)		4.11 (1.25)	4.13 (1.26)	not required
PHD g's		13.81	14.06	not required
ASI		0.52	0.53	not required

5.7 Discussion

The analysis of the test results for test no. NYT-1 showed that the system adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier. A summary of the test results is shown in Figure 63. Deformations of, and intrusions into, the occupant compartment that could have caused serious injury did occur. The right side of the vehicle snagged on the box-beam and separated the right-front door from the vehicle's frame, shattering the right-front window. The test vehicle did not penetrate nor ride over the barrier and remained upright during and after the collision. Vehicle roll, pitch, and yaw angular displacements, as shown in Appendix E, were deemed acceptable, because they did not adversely influence occupant risk nor cause rollover. Therefore, test no. NYT-1 does not satisfy the MASH 2016 safety performance criteria for test designation no. 3-31.







- Test Agency ..... MwRSF
- Test Number NYT-1
- Date 5/16/2017
- MASH 2016 Test Designation No. 3-31
- Test Article ..... New York "Zig-Zag" Box Beam End Terminal
- Total Length ..... 158 ft – ¼ in. (48.164 m)
- Key Component – Zig Zag Rail (between post nos. 1 and 9)
  - Length ..... 142 in. (3607 mm)
  - Top Mounting Height ..... 27 in. (686 mm)
  - End Terminal Assembly ..... Impact head and cable assembly
- Key Component – Post Nos. 1-8 (W6x9) [W152x13.4]
  - Length ..... 84 in. (2,134 mm)
  - Embedment Depth ..... 57 in. (1,448 mm)
  - Spacing ..... 72 in. (1,829 mm)
- Key Component – Post Nos. 9-26 (S3x5.7) [S76x8.5]
  - Length ..... 63 in. (1,600 mm)
  - Embedment Depth ..... 36 in. (914 mm)
  - Spacing ..... 72 in. (1,829 mm)
- Soil Type ..... Coarse Crushed Limestone
- Vehicle Make /Model ..... 2011 Dodge Ram 1500 Quad Cab Pickup Truck
  - Curb ..... 5,071 lb (2,300 kg)
  - Test Inertial ..... 5,000 lb (2,268 kg)
  - Gross Static ..... 5,158 lb (2,340 kg)
- Impact Conditions
  - Speed ..... 62.7 mph (101 km/h)
  - Angle ..... 0.1 degrees
  - Impact Location ..... On end of terminal head
- Kinetic Energy ..... 655.5 kip-ft (889 kJ) > 594 kip-ft (806 kJ) limit from MASH 2016
- Exit Conditions ..... Vehicle did not exit system
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 80 ft – 3 in. (24.5 m) downstream
  6 in. (152 mm) laterally behind impact axis
- Vehicle Damage ..... Extensive
  - VDS [6] 12-FR-5
  - CDC [7] 12-FRAZ-2
  - Maximum Interior Deformation ..... 4 in. (102 mm)
- Test Article Damage ..... Extensive
- Maximum Test Article Deflections
  - Permanent Set ..... 270.25 in. (6,864 mm)
  - Dynamic ..... 326.7 in. (8,299 mm)
- Transducer Data

Evaluation Criteria		Transducer		MASH 2016 Limit
		SLICE-1	SLICE-2 (primary)	
OIV ft/s (m/s)	Longitudinal	-13.45 (-4.10)	-13.50 (-4.11)	±40 (12.2)
	Lateral	5.16 (1.57)	4.69 (1.43)	±40 (12.2)
ORA g's	Longitudinal	-13.77	-14.00	±20.49
	Lateral	3.81	3.82	±20.49
MAX ANGULAR DISP. deg.	Roll	-13.94	13.90	±75
	Pitch	4.07	-2.97	±75
	Yaw	77.68	75.80	not required
THIV – ft/s (m/s)		4.11 (1.25)	4.13 (1.26)	not required
PHD – g's		13.81	14.06	not required
ASI		0.52	0.53	not required

Figure 63. Summary of Test Results and Sequential Photographs, Test No. NYT-1

6 SUMMARY AND CONCLUSIONS

Test no. NYT-1 was conducted on the "zig-zag" box beam end terminal according to MASH 2016 test designation no. 3-31. The system consisted of standard box beam guardrail supported by steel posts with a new box beam terminal concept. The posts were spaced at 72 in. (1,829 mm). The top mounting height of the box beam rail was 27 in. (686 mm) from the ground line. A summary of the test evaluation is shown in Table 8.

During the test, the vehicle impacted the system at 62.7 mph (101 km/h) at an angle of 0.1 degrees resulting in a kinetic energy of 655.5 kip-ft (889 kJ). During impact, the vehicle first contacted the end terminal assembly, then it travelled through the zig-zag box beam. This action caused the rail at post nos. 1 through 6 to deflect downstream and the rail at post nos. 7 through 13 to deflect to the traffic side of the system. Post nos. 1 through 13 all deflected downstream. Deformation and contact marks were found on the rails, posts, and end terminal assembly. Once the vehicle made contact with the straight box beam between post nos. 8 and 9, the rail section snagged on the vehicle. This behavior caused the right fender, the right-front door, and the front of the right-rear door to tear away from the vehicle's frame. The right-front window also shattered as a result of the snag event. A dynamic deflection of 326.7 in. (8,299 mm) was observed at post no. 4. All occupant risk values were found to be within limits, however, not all occupant compartment deformations were deemed acceptable. The right side of the vehicle snagged on the box beam and separated the right-front door from the vehicle's frame, shattering the right-front window and the windshield. Further, the terminal did not absorb sufficient energy before the vehicle reached the tangent portion of the run. Therefore, test no. NYT-1 did not satisfy the safety performance criteria for MASH 2016 test designation no. 3-31.

Table 8. Summary of Safety Performance Evaluation

<table>
<tr><th>Evaluation Factors</th><th colspan="4">Evaluation Criteria</th><th>Test No. NYT-1</th></tr>
<tr><td>Structural Adequacy</td><td colspan="4">C. Acceptable test article performance may be redirection, controlled penetration, or controlled stopping of the vehicle</td><td>S</td></tr>
<tr><td rowspan="4">Occupant Risk</td><td colspan="4">D. 1. 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.</td><td>U</td></tr>
<tr><td colspan="4">2. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH 2016.</td><td>S</td></tr>
<tr><td colspan="4">F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.</td><td>S</td></tr>
<tr><td colspan="4">H. Occupant Impact Velocity (OIV) (see Appendix A, Section A5.2.2 of MASH 2016 for calculation procedure) should satisfy the following limits:
<table>
<tr><th colspan="3">Occupant Impact Velocity Limits</th></tr>
<tr><th>Component</th><th>Preferred</th><th>Maximum</th></tr>
<tr><td>Longitudinal and Lateral</td><td>30 ft/s (9.1 m/s)</td><td>40 ft/s (12.2 m/s)</td></tr>
</table></td><td>S</td></tr>
<tr><td colspan="4">I. The Occupant Ridedown Acceleration (ORA) (see Appendix A, Section A5.2.2 of MASH 2016 for calculation procedure) should satisfy the following limits:
<table>
<tr><th colspan="3">Occupant Ridedown Acceleration Limits</th></tr>
<tr><th>Component</th><th>Preferred</th><th>Maximum</th></tr>
<tr><td>Longitudinal and Lateral</td><td>15.0 g’s</td><td>20.49 g’s</td></tr>
</table></td><td>S</td></tr>
<tr><td>Post – Impact Vehicular Response</td><td colspan="4">N. Vehicle Trajectory behind the test article is acceptable.</td><td>S</td></tr>
<tr><td colspan="5">MASH 2016 Test Designation No.</td><td>3-31</td></tr>
<tr><td colspan="5">Final Evaluation (Pass or Fail)</td><td>Fail</td></tr>
</table>

S – Satisfactory U – Unsatisfactory NA - Not Applicable

7 CRITICAL ANALYSIS OF ZIG ZAG TERMINAL

The NYSDOT "zig zag" box beam end terminal consisted of box beam segments offset from S3x5.7 posts with tubular steel blockouts. The system had a continuous traffic-side face, and the box beam was cut at 45-degree angles toward the backside, as shown in Figures 64 and 65. Each pair of 45-degree cuts were considered a joint, such that the rail was to deflect, rotate, and bend about those cuts. Splices were used when joints occurred at the box beam ends to form a continuous front face. The impact head consisted of a tubular plate steel box, which fit over the end of the last box beam segment such that the box beam slid inside of the terminal head before the system engaged. A series of bolts were placed in the box beam head. When the terminal head moved down the rail, the upstream end of the box beam would fracture the bolts in double shear before it bottomed out on the terminal head.

Figure 64. Plan View of NYSDOT "Zig Zag" Box Beam End Terminal

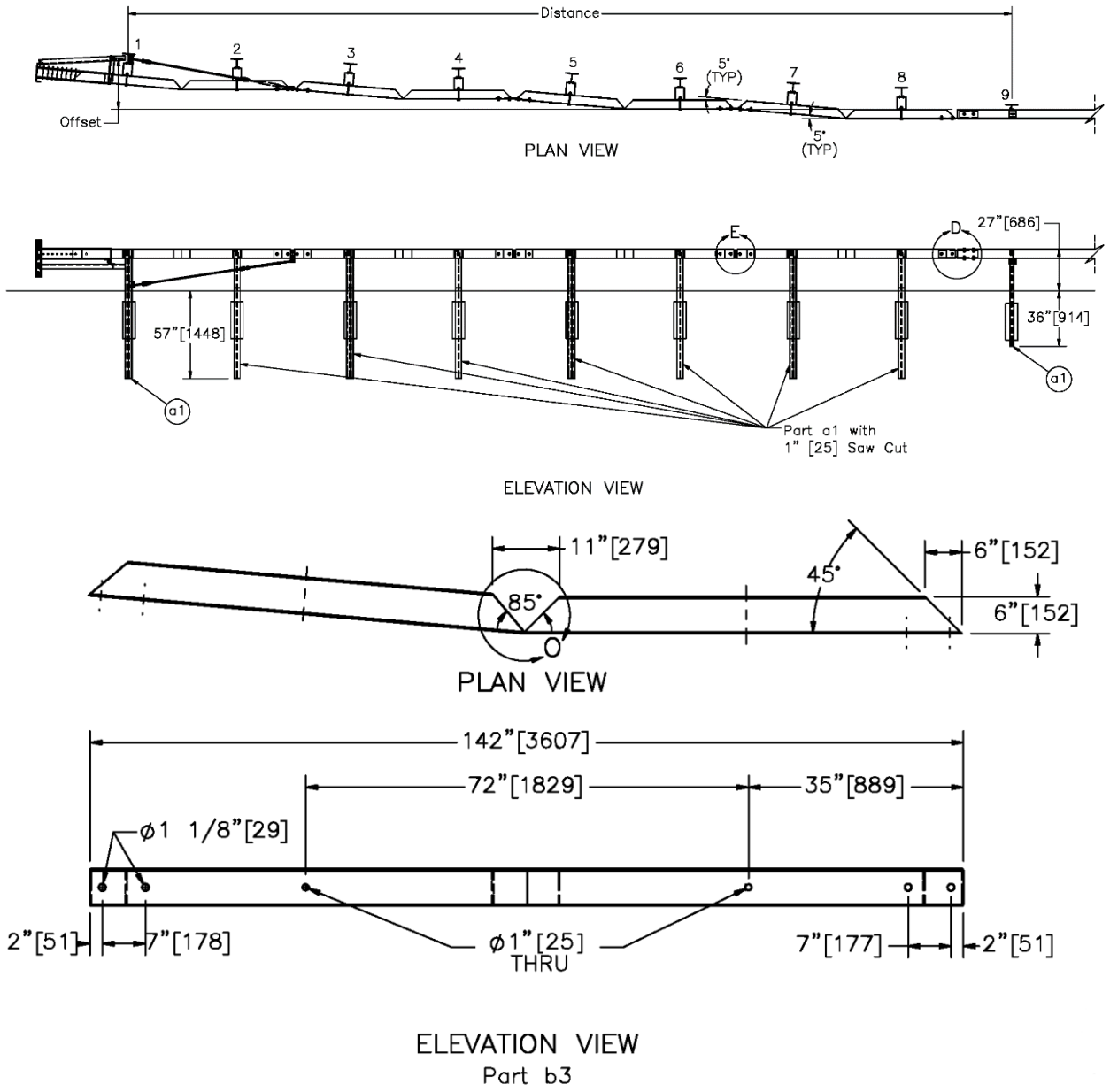


Figure 65. Plan and Elevation Views of Box Beam, Test No. NYT-1

In test no. NYT-1, the vehicle impacted the system at 62.7 mph (101 km/h) and at an angle of 0.1 degrees resulting in a kinetic energy of 655.5 kip-ft (888.7 kN-m). The vehicle displaced the terminal head downstream and caused the rail segments to buckle in a zig-zag pattern. However, the rail failed at the third joint, which resulted in rail spearing on the right-side door and high occupant ride down accelerations. Thus, the terminal did not absorb sufficient energy before the vehicle reached the tangent portion of the run. Following the unsuccessful test of test no. NYT-1, MwRSF researchers analyzed the behavior of the end terminal to determine critical events which contributed to the failure of the terminal system.

7.1 Sequence of Events

Immediately after impact, the impact head displaced downstream, fracturing the steel terminal head shear bolts. When the impact head bottomed out on the first rail segment, all box beam rails between post nos. 1 and 12 deflected downstream. The rail segments attached to post nos. 1 through 6 disengaged from the posts, but remained attached to the blockouts, and displaced laterally to the traffic side of the system.

A zig-zag pattern was formed as the rail deflected about each joint. The front sides of the rail locked when the notched faces collapsed against each other as they deformed. This phenomenon was referred to as "bend-locking". At each bend-locked joint, the compressive force was transmitted from the vehicle through the bend lock and consecutive rail segments, restricting further rotation. This action in turn caused the rail segments to rotate along the inner contact surface and elongated or tear the traffic-side face flange or splice plate. Bend locking occurred at midpoints between post nos. 1 and 2, 3 and 4, and 5 and 6 (joints A, C, and E as shown in Figure 66). The alternating bends caused the thin flanges or splice plates to "open" or bend outward and away from the cut webs, resulting in 180-degree bends (90-degree bends for each consecutive segment). Segments that were not bend locked deflected, such that the backside faces of consecutive box beams would be stacked against each other. Deflections of segments that were not bend locked occurred between post nos. 2 and 3, 4 and 5, and 6 and 7 (joints B, D, and F, respectively, as shown in Figure 66). The alternating sequence of bend-locked and non-bend-locked deflection is shown in Figure 66.

In general, the force required to rotate the box beam segments about joints decreased as the angle of rotation increased (i.e., as longitudinal deflection of the rail segments increased). Thus, as a joint deflected, the joint rotated fully to either 180 degrees (non-bend-locked joints) or 90 degrees (bend-locked joints) before deflecting the rail at the next joint. Therefore, bend-locking at joints A and C and collapse of joint B caused three box beam segments to stack in front of the impacting pickup truck with little reduced deflection downstream. Two consecutive bend-locked segments caused the vehicle to load the flange at joint C in shear instead of in bending, resulting in rail fracture, as shown in Figure 66. Following the fracture of the shear-loaded box beam flange, the rail speared the pickup truck and produced large longitudinal decelerations and occupant compartment deformations.

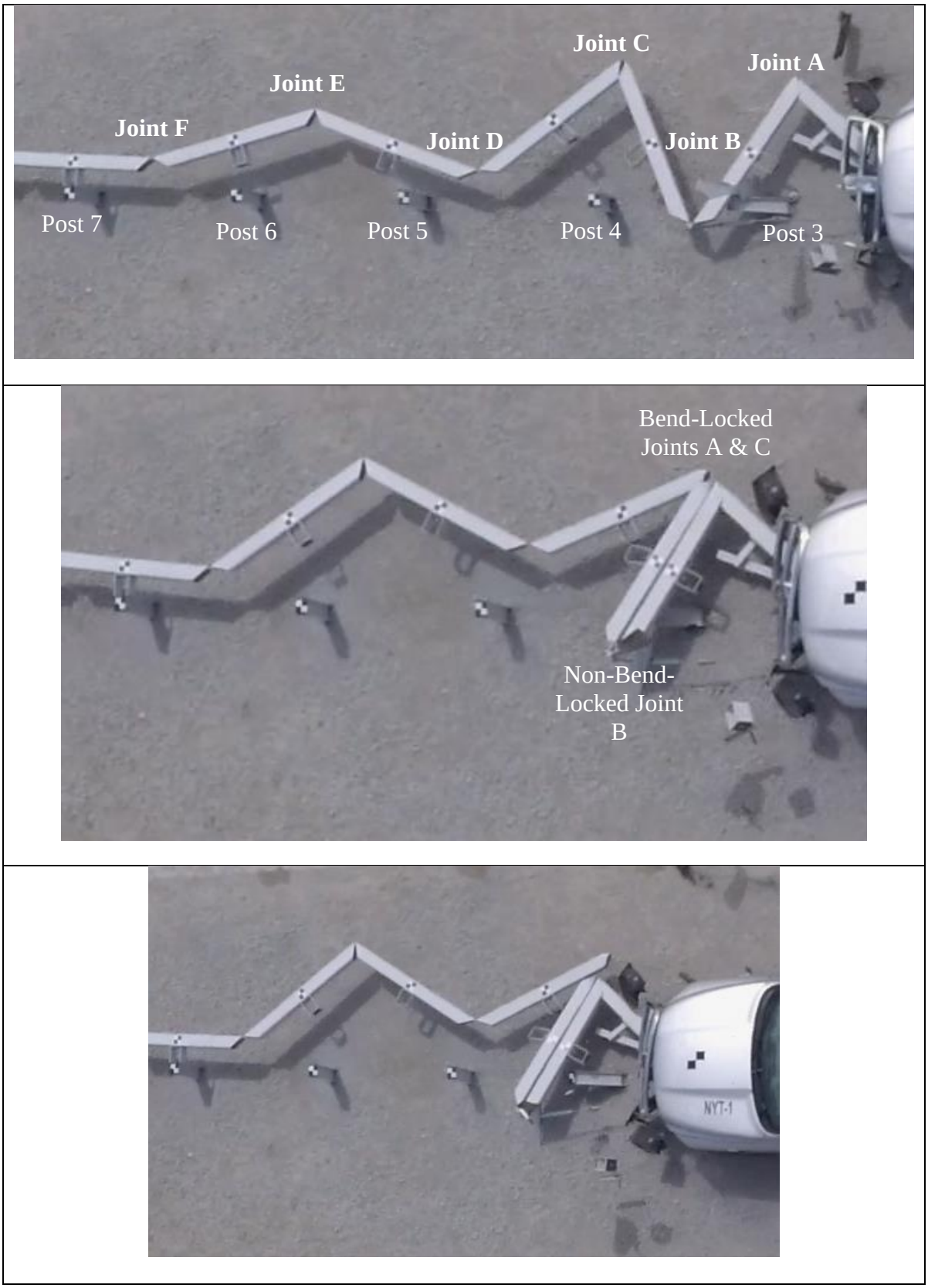


Figure 66. Rail Collapse Sequence and Fracture

7.2 Analysis

All energy-absorbing end terminal systems slow an impacting vehicle by decelerating the vehicle in a controlled manner. Deceleration is produced by a net longitudinal force acting on the vehicle, and the magnitude of the deceleration is based on the ratio of force to vehicle mass. Vehicle velocity is likewise reduced based on the time-integration of the acceleration signal. Therefore, to safely decelerate an impacting vehicle, acceleration must be sustained over a period of time which is within MASH occupant ridedown acceleration limits (e.g., 20 g's). The time corresponding to the acceleration can be plotted against physical position to create a deceleration vs. distance plot. Note that the integration of force acting over a distance is also equivalent to energy:

$$\Delta E = \int \vec{F} \cdot d\vec{r} = \int F_x dx \quad (1)$$

E = Energy
F = Force vector
F_x = Longitudinal force (x-direction)
dr = change in displacement vector
dx = change in longitudinal displacement (x-direction)

During impact, the vehicle is decelerated from the impact force between the vehicle front end and the impact head. After the upstream cable release terminal disengages at post no. 1, the box beam is put into compression and moment-bending by the action of the impact head. The compressive load is transferred through the box beam and becomes a concentrated compression load on the thin flanges at the joint locations. By design, the joints are intended to promote buckling and collapse of the box beam at those locations. Although the beams are constructed with a small eccentric offset to facilitate bending, Euler's formulas for column stability can still be applied to evaluate the limit state of the box beam. The Euler column stability formula is given by:

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2} \quad (2)$$

Where:

P_{cr} = Euler's critical load (longitudinal compression load on column),
E = modulus of elasticity of column material,
I = minimum area moment of inertia of the cross section of the column,
L = unsupported length of column,
K = column effective length factor

The values for K vary based on the boundary conditions, as shown in Figure 67. Because the hinges have very little lateral resistance due to the weakened cut flanges, the boundary conditions for the "zig zag" box beam are most closely associated with cantilever bending. Evaluating the beam through the weakened flange and ignoring the eccentricity of the load, K is nominally equal to 2.0, E is approximatley 30×10^6 psi, I is approximately 0.0033 in.^{4}, L is assumed to be 72 in. which is one segment between joints. Using these parameters, the longitudinal load through the beam to cause axial column collapse is approximately 47 lb.

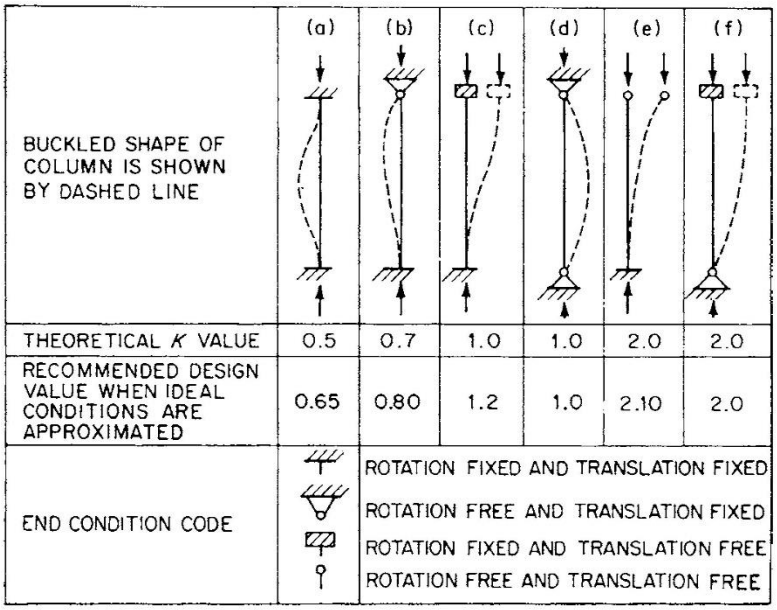


Figure 67. Column Effective Length Factors for Euler's Critical Loads [8]

The Euler column stability calculations are not valid in dynamically-changing loads, because they are derived based on eccentric deflections of the beams, and deflections occur over time. Fast events, such as impact, resist loads with both inertia (translational and rotational) and integration of velocity acting over time. Thus, it is possible to have higher axial loads than the Euler column collapse load over short durations. Nonetheless, the Euler collapse load between adjacent box beam segments indicates that the "zig zag" configuration will quickly experience dynamic collapse after an impact event.

After column collapse, the box beams rotate about joints by plastically deforming the thin flanges or splice plates. The bending of the flanges or splice plates dissipates energy and resists longitudinal vehicle movement based on moment and plastic section. The plastic section modulus of a rectangular cross-section at the weakened joint is given by:

$$Z_p = A_c y_c + A_t y_t \tag{3}$$

Where:

Z_p = plastic section modulus
A_c = plastic compressive section area
y_c = location of centroid of plastic compression area from principal bending axis
A_t = plastic tensile section area
y_t = location of centroid of plastic tensile area from principal bending axis

The effective plastic section of the flange at a weakened joint was approximated using the 6-in. height of the box beam and a total thickness of $^3/_{16}$ in. The resulting plastic section modulus was approximately 0.053 in.^{3}. The splice plates were ⅜ in. thick and 5¼ in. tall, and had two ⅜-in.

diameter holes aligned vertically through the center of the plate, which was at the location of maximum bending. The plastic bending section through the vertical section centered at the vertical holes was also approximately 0.053 in.^{3}.

Using the plastic section modulus and a yield strength of approximately 50 ksi, the estimated bending moment during plastic hinging was 2,635 lb-in. Ignoring plastic hardening, the effective longitudinal load can be estimated as a function of rotation angle between consecutive joints. Using a 72-in. segment length and converting longitudinal impact force into parallel (compressive) and transverse (moment-bending) components in a briefly-steady-state moment rotation, the longitudinal resistance force as a function of lateral offset to the hinge (joint) is shown in Figure 68. The maximum longitudinal resistance at the start of the plastic hinge formation was approximately 420 lb., and the minimum longitudinal resistance at full plastic collapse was approximately 36.5 lb. Note that the hinge angle is approximately half the angle formed between consecutive box beam segments. Therefore, the energy absorbed by rotating the plastic hinge between 5 and 90 degrees was approximately 7.8 kip-in. As a result, to stop the impacting pickup truck during test no. NYT-1, ignoring rolling friction and inertial loads, approximately 84 joints would have to fully collapse before the impacting vehicle would be brought to a stop.

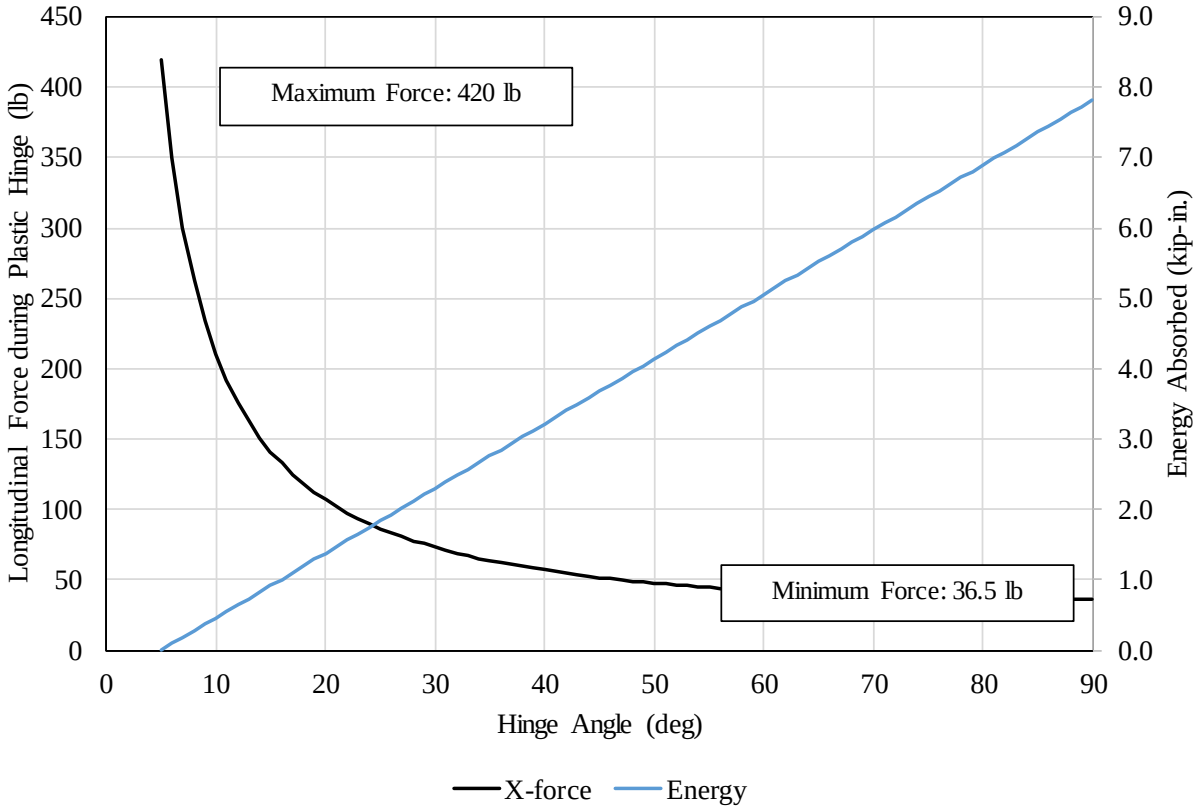


Figure 68. Longitudinal Force During Plastic Hinge Collapse

7.3 Recommendations

Analysis of the collapse of the NYSDOT zig zag box beam end terminal during test no. NYT-1 indicated that the current terminal configuration did not absorb sufficient energy before

the vehicle reached the tangent portion of the run. Therefore, it is necessary that the terminal be modified to be consistent with (1) a non-energy-absorbing, gating terminal or (2) an energy-absorbing, non-gating terminal. Recommendations for both types of terminal configurations are provided below.

7.3.1 Non-Energy Absorbing (Gating Terminal) Design

If the "zig zag" terminal is not intended to absorb the vehicle's energy and bring it to a controlled stop, the terminal should gradually redirect the impacting vehicle such that the vehicle does not spear on the upstream end of the stiff, tangent section of the terminal. Otherwise, the number of cut longitudinal box beam segments required to prevent the stiff end of the box beam from penetrating the vehicle may be very large, spanning as much as 100 ft.

Post-to-rail engagement may need to be modified to change the vehicle path during impact. During test no. NYT-1, the box beam rail segments extended laterally to the traffic-side of the system, and the posts prevented the rail from deflecting backwards. A center-mounted post connection, below the rail, may be necessary to allow the rail to deflect backward upon impact.

Bend-locking was observed when cut faces of box beam interlocked. This behavior prevented the box beam segments from rotating through 180 degrees and stacking in front of the vehicle. Thus, instead of 45-degree V-shaped sections between segments, it may be necessary to redesign the joints between consecutive box beam segments such that the pivot locations permit 180 degrees of box beam rotation. One example of this approach would be to use upper and lower plates with one vertical bolt through each box beam section. The vertical bolts may act as pins facilitating rotation through a virtual point of intersection between two adjacent box beams. Consequently, the initial angular offsets of each box beam segment may be retained to preferentially stack consecutive segments together without bend-locking.

The first box beam segment had an equal length as all subsequent box beam segments. However, longitudinal stacking of segments in the "zig zag" terminal should align along the centerline of the system's line of action. It may be necessary to shorten the first segment to half the length of subsequent segments, such that longitudinal stacking is aligned along the centerline of the line of action.

7.3.2 Energy-Absorbing (Non-Gating Terminal) Design

To safely stop an impacting vehicle engaging the upstream end of a terminal, an energy-absorbing design may be produced which provides consistent longitudinal force sufficient to stop an impacting small car and pickup truck safely within the guidelines provided by MASH. While energy-absorbing designs may be considered, these designs may modify the geometry of the "zig zag" terminal and could result in an entirely different end terminal design. Typical methods of absorbing energy include material shaping (typically plastic deformation), tearing, bolt or stub fracture, friction, or hydraulic resistance.

8 REFERENCES

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9 APPENDICES

Appendix A. Material Specifications

Table A-1. Bill of Materials, Test No. NYT-1

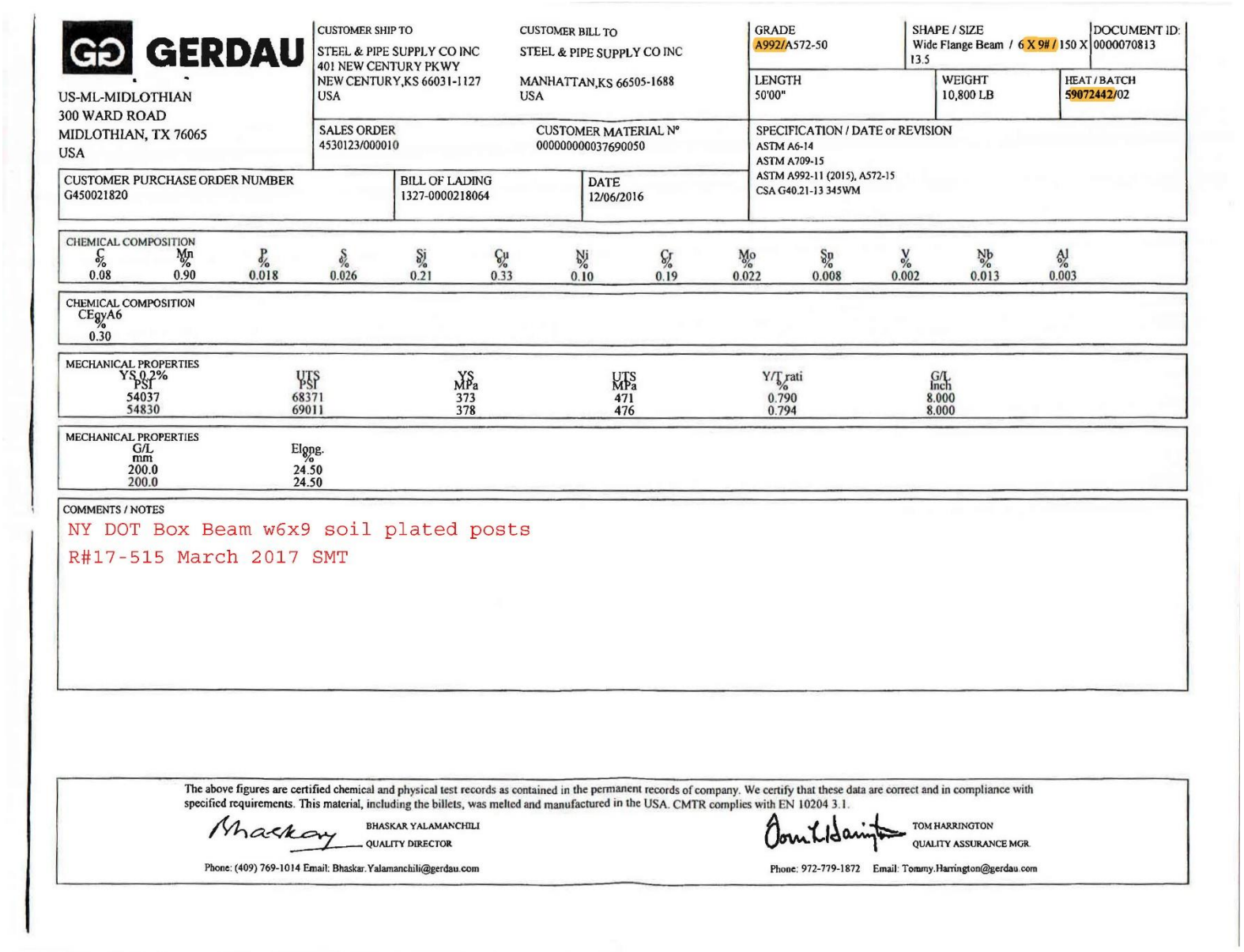
Item No.	Description	Material Specification	Reference
a1	W6x9 [W152x13.4], 84" [2,134] Long Post (Post nos. 1 through 9)	ASTM A992 Min. 50ksi Steel	H#59072442, H#59072444
a2	S3x5.7 [S75x8.5], 63" [1,600] Long Post	ASTM A36	H#21116
a3	24"x8"x1/4" [610x203x6] Soil Plate	ASTM A36	H#1700330
a4	8"x6"x1/4" [203x152x6], 6" [152] Long Blockout	ASTM A500 Gr. B	H#3793C4
a5	5"x3 1/2"x3/8" [127x89x10], 4 1/2" [114] Long L-Bracket	ASTM A36	H#DL16100682
b1	TS6"x 6"x 3/16" [152x152x5], 216" [5,486] Long Box Beam	ASTM A500 Gr. B	H#U2133, H#U2139, H#U2141
b2	TS6"x 6"x 3/16" [152x152x5], 216" [5,486] Long Box Beam	ASTM A500 Gr. B	H#U2133, H#U2139, H#U2141
b3	TS6"x6"x1/4" [152x152x6], 142" [3,607] Long Box Beam, Bent	ASTM A500 Gr. B	H#C79938
b4	27"x5 3/8"x 5/8" [686x137x16] Splice Plate	ASTM A36	H#W19665
b5	TS5"x5"x1/4" [127x127x6], 25 1/2" [648] Long Box Beam, Cut	ASTM A500 Gr. B	H#A612210
b6	24"x5 1/4"x3/8" [610x133x10] Plate, Bent	ASTM A36	H#B607172
b7	8"x2 1/2"x5/8" [203x64x16] Keel Plate	ASTM A36	H#E6I159
c1	W6x15 [W152x22.3], 72" [1,829] Long Post	ASTM A992 or ASTM A572-50	H#59072980
c2	20"x14"x3/16" [508x356x5] Plate	ASTM A36	H#B610331
c3	6 3/16"x4"x1/2" [157x102x13] Plate	ASTM A36	H#A615621
c4	6 1/4"x4"x1/2" [159x102x13] Plate	ASTM A36	H#A615621
c5	6 3/16"x6"x1/2" [159x152x13] Plate	ASTM A36	H#A615621
d1	3"x2"x3/8" [76x51x10], 4.8" [122] Long L-Bracket	ASTM A36	H#63142915
d2	3"x4"x5/16" [76x102x8] Plate	ASTM A36	H#B607172

Table A-2. Bill of Materials, Test No. NYT-1, Cont.

Item No.	Description	Material Specification	Reference
e1	10"x9"x1/2" [254x229x13] Box Beam Cable Anchor Base Plate	ASTM A36	H#17011041
e2	4"x4"x1/4" [102x102x6] Box Beam Cable Anchor Gusset	ASTM A36	H#17014221
e3	4"x4"x1/2" [102x102x13] Box Beam Cable Anchor Mounting Plate	ASTM A36	H#17011041
f1	TS7"x7"x3/8" [178x178x10], 48" [1,219] Long Box Beam	ASTM A500 Gr. B	H#85197PT
f2	C12x30, 24" [610] Long C-Channel	ASTM A36	H#55033620
f3	3"x3"x1/4" [76x76x6], 18" [457] Long L-Bracket	ASTM A36	H#63144478
f4	3"x3"x1/4" [76x76x6], 56" [1,422] Long L-Bracket	ASTM A36	H#63170444
f5	3"x3"x1/4" [76x76x6], 6 1/2" [165] Long L-Bracket	ASTM A36	H#63144478
g1	3/4" [19] Dia. 3x7 Cable, 66 5/16" [1,676] Long IWRC IPS Wire Rope	ASTM A741 Type 1 (AASHTO M30 Type 1)	H#53139015, H#53139021
g2	3/4" [19] Dia. 6x19, 56" [1,422] Long IWRC IPS Wire Rope	ASTM A741 Type 2 (AASHTO M30 Type 2)	COC Inv# 5038896
g3	3/4" [19] Dia. 6x19, 145 3/4" [3,702] Long IWRC IPS Wire Rope	ASTM A741 Type 2 (AASHTO M30 Type 2)	COC Inv# 5038896
g4	Bennet Cable End Fitter	ASTM A27(AASHTO M103) Gr. 70-40 Class 1	H#DA7, H#DA9
g5	Crosby Threaded Turnbuckle	Stock No. 1032714	H#145050
g6	3/4" [19] Dia. UNJ, Crosby HG 4037 Jaw	Stock No. 1073135	COC Certificate#CC1-2017040700802
g7	Cable Wedges	ASTM A47 Gr. 32510	H#DA8
g8	3/4" [19] Dia. UNC, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or SAE Gr .2	H#AU0810817802
g9	BCT Anchor Cable End Swaged Fitting	Grade 5	H#75063022 H#75062074 H#75063075

Table A-3. Bill of Materials, Test No. NYT-1, Cont.

Item No.	Description	Material Specification	Reference
g10	3/4" [19] Dia. UNC Square Nut	ASTM A563A	H#15311340-3
g11	3/4" [19] Dia. UNC Hex Nut	ASTM A563A	COC Only
g13	1" [25] Dia. UNC Heavy Hex Nut	ASTM A563DH	H#166334
g14	1" [25] Dia. Plain Round Washer	ASTM F844	H#0266540
h1	1/4" [6] Dia. UNC, 8" [203] Long Fully Threaded Hex Head Shear Bolt and Nut	Bolt - A307-Gr. A Nut - ASTM A563A	Bolts: H#10201285-3 Nuts: H#184259
h2	1/4" [6] Dia. UNC, 1" [25] Long Fully Threaded Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A Nut - ASTM A563A	Bolts: H#715030091 Nuts: H#184259
h3	1/4" [6] Flat Washer	ASTM F844	16H-168236-9
h4	3/8" [10] Dia. UNC, 7 1/2" [191] Long Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A Nut - ASTM A563A	Bolts: H#715030688 Nuts: H#169D0729
h5	3/8" [10] Dia. Plain Round Washer	ASTM F844	Part#1133182
h6	1/2" [13] Dia. UNC, 1 1/2" [38] Long Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A Nut - ASTM A563A	Bolts: Lot# FAS1638 Nuts: H#180132
h7	1/2" [13] Dia. Plain Round Washer	SAE Low Carbon Gr. 2	L#16H-168236-10
h8	3/4" [19] Dia. UNC, 8" [203] Long Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A Nut - ASTM A563A	Bolts: H#G1607088001 H#1608020500 Nuts: H#331502913
h9	3/4" [19] Dia. UNC, 1 1/2" [38] Long Heavy Hex Head Bolt and Nut	Bolt: ASTM F3125 Gr. A325 Nut: ASTM A563DH	Bolts: L#2010360300 Nuts: H#75062833
h10	3/4" [19] Dia. UNC, 2" [51] Long Heavy Hex Head Bolt	Bolt: ASTM F3125 Gr. A325 Nut: ASTM A563DH	Bolts: H#NF15103298 Nuts: H#75062833
h11	3/4" [19] Dia. UNC, 2 1/2" [64] Long Heavy Hex Head Bolt	Bolt: ASTM F3125 Gr. A325 Nut: ASTM A563DH	NOT REQUIRED
h12	3/4" [19] Dia. UNC Heavy Hex Nut	ASTM A563DH	H#75062833
h13	3/4" [19] Dia. Plain Round Washer	ASTM F844	n/a
h14	3/4" [19] Dia. Hardened Flat Washer	ASTM F436	H#C79696
h15	3/4" [19] Dia. Lock Washer	Steel	H#J510104136
h16	7/8" [22] Dia. UNC, 8 1/2" [216] Long Heavy Hex Head Bolt and Nut	Bolt: ASTM F3125 Gr. A325 Nut: ASTM A563DH	Bolts: H#NF16102579 Nuts: L#23468-75062745
h17	7/8" [22] Hardened Flat Washer	ASTM F436	H#1DR73



GERDAU

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

CUSTOMER SHIP TO
STEEL & PIPE SUPPLY CO INC
401 NEW CENTURY PKWY
NEW CENTURY,KS 66031-1127
USA

CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC
MANHATTAN,KS 66505-1688
USA

GRADE: A992/A572-50
SHAPE / SIZE: Wide Flange Beam / 6 X 9# / 150 X 13.5
DOCUMENT ID: 0000070813
LENGTH: 50'00"
WEIGHT: 10,800 LB
HEAT / BATCH: 59072442/02

SALES ORDER: 4530123/000010
CUSTOMER MATERIAL N°: 000000000037690050
SPECIFICATION / DATE or REVISION:
ASTM A6-14
ASTM A709-15
ASTM A992-11 (2015), A572-15
CSA G40.21-13 345WM

CUSTOMER PURCHASE ORDER NUMBER: G450021820
BILL OF LADING: 1327-0000218064
DATE: 12/06/2016

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.08	0.90	0.018	0.026	0.21	0.33	0.10	0.19	0.022	0.008	0.002	0.013	0.003

CHEMICAL COMPOSITION

CEqvA6 %
0.30

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
54037	68371	373	471	0.790	8.000
54830	69011	378	476	0.794	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	24.50
200.0	24.50

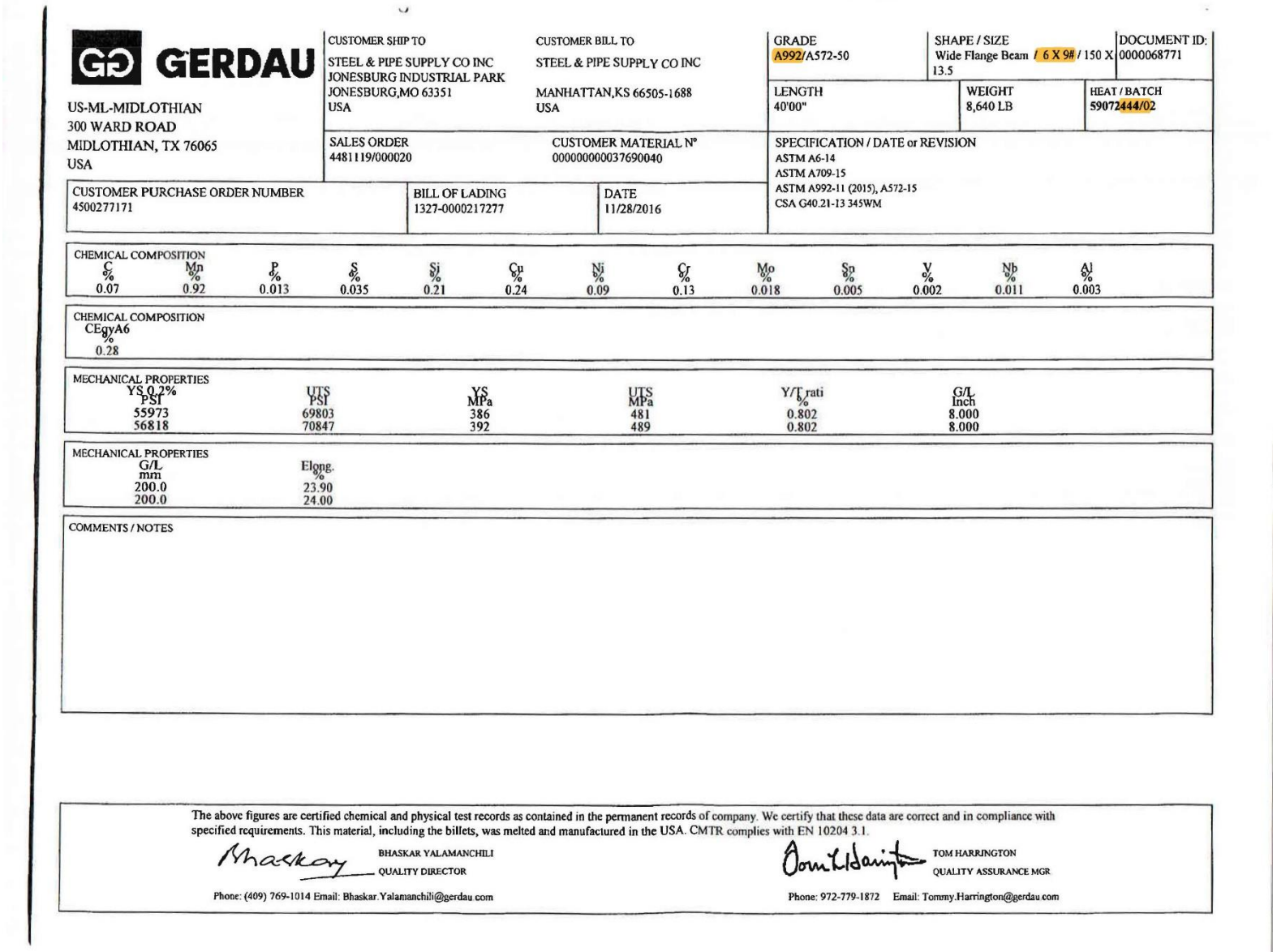
COMMENTS / NOTES
NY DOT Box Beam w6x9 soil plated posts
R#17-515 March 2017 SMT

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 769-1014 Email: Bhaskar.Yalamanchili@gerdau.com

TOM HARRINGTON
QUALITY ASSURANCE MGR.
Phone: 972-779-1872 Email: Tommy.Harrington@gerdau.com

Figure A-1. 84-in. (2,058-mm) Long Post for Post Nos. 1 through 8, Test No. NYT-1



GERDAU

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

CUSTOMER SHIP TO
STEEL & PIPE SUPPLY CO INC
JONESBURG INDUSTRIAL PARK
JONESBURG,MO 63351
USA

CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC
MANHATTAN,KS 66505-1688
USA

GRADE: A992/A572-50
SHAPE / SIZE: Wide Flange Beam / 6 X 9# / 150 X 13.5
DOCUMENT ID: 0000068771
LENGTH: 40'00"
WEIGHT: 8,640 LB
HEAT / BATCH: 59072444/02

SALES ORDER: 4481119/000020
CUSTOMER MATERIAL Nº: 000000000037690040

SPECIFICATION / DATE or REVISION
ASTM A6-14
ASTM A709-15
ASTM A992-11 (2015), A572-15
CSA G40.21-13 345WM

CUSTOMER PURCHASE ORDER NUMBER: 4500277171
BILL OF LADING: 1327-0000217277
DATE: 11/28/2016

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.07	0.92	0.013	0.035	0.21	0.24	0.09	0.13	0.018	0.005	0.002	0.011	0.003

CHEMICAL COMPOSITION

CEqvA6 %
0.28

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
55973	69803	386	481	0.802	8.000
56818	70847	392	489	0.802	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	23.90
200.0	24.00

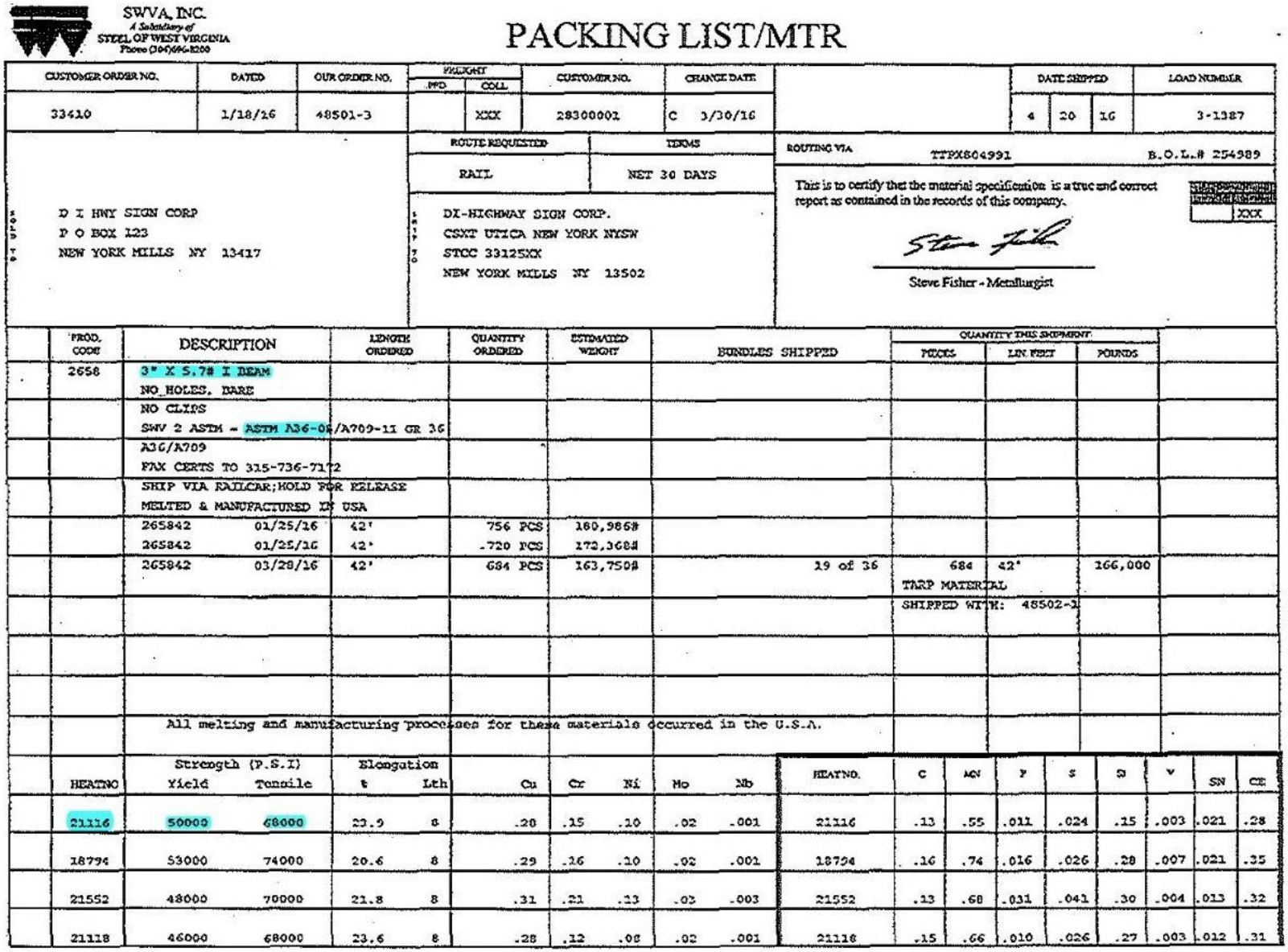
COMMENTS / NOTES

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 769-1014 Email: Bhaskar.Yalamanchili@gerdau.com

TOM HARRINGTON
QUALITY ASSURANCE MGR
Phone: 972-779-1872 Email: Tommy.Harrington@gerdau.com

Figure A-2. 84-in. (2,058-mm) Long Post for Post Nos. 1 through 8, Test No. NYT-1



SWVA, INC.
A Subsidiary of
STEEL OF WEST VIRGINIA
Phone (304)696-8200

PACKING LIST/MTR

CUSTOMER ORDER NO.	DATED	OUR ORDER NO.	FREIGHT PPD	FREIGHT COLL	CUSTOMER NO.	CHANGE DATE	DATE SHIPPED	LOAD NUMBER
33410	1/18/16	48501-3		XXX	28300001	C 3/30/16	4 20 16	3-1387

ROUTE REQUESTED	TERMS
RAIL	NET 30 DAYS

ROUTING VIA TTPX804991 B.O.L.# 254989

This is to certify that the material specification is a true and correct report as contained in the records of this company.

XXX

Steve Fisher - Metallurgist

SOLD TO: D I HWY SIGN CORP
P O BOX 123
NEW YORK MILLS NY 13417

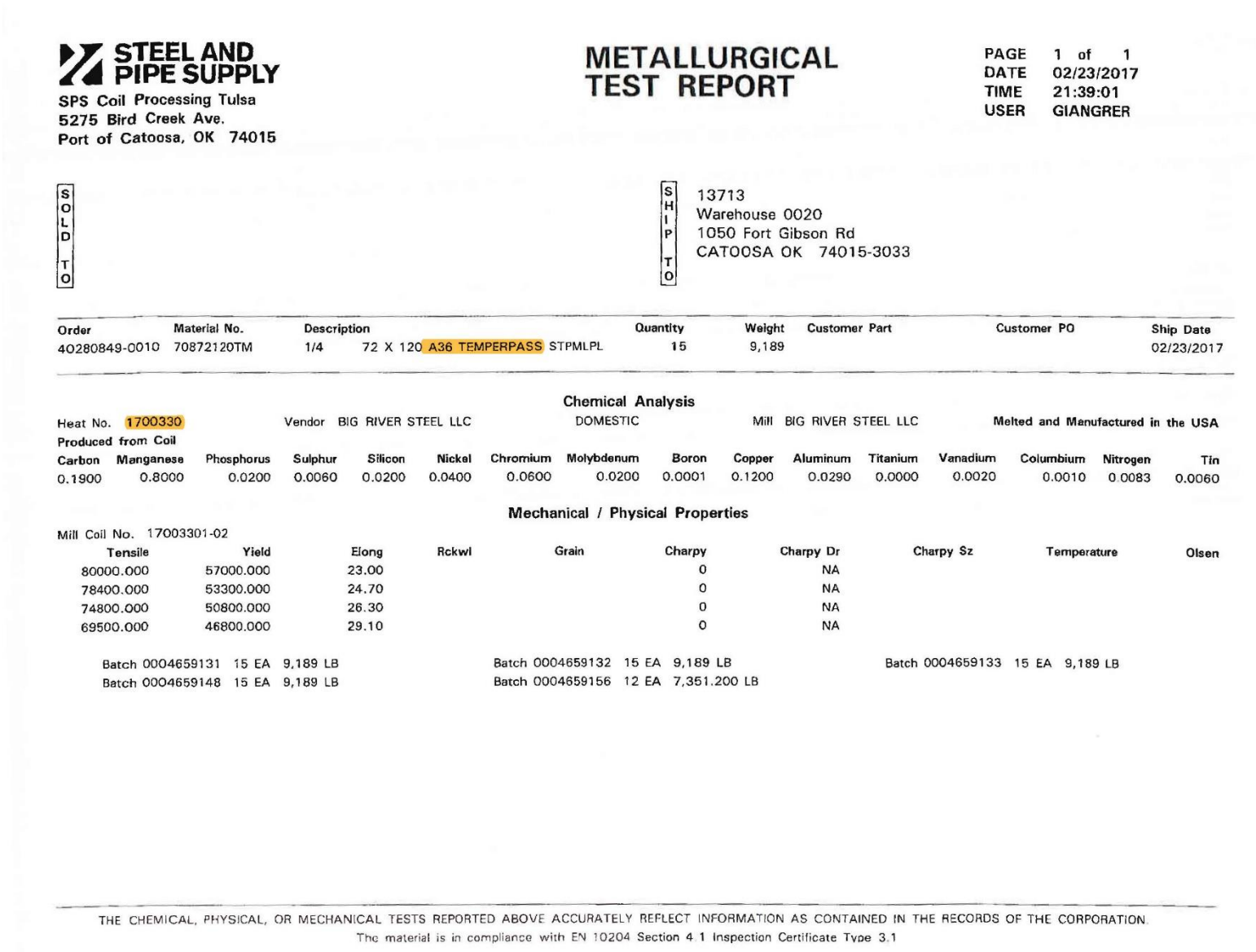
SHIP TO: DI-HIGHWAY SIGN CORP.
CSXT UTICA NEW YORK NYSW
STCC 33125XX
NEW YORK MILLS NY 13502

PROD. CODE	DESCRIPTION	LENGTH ORDERED	QUANTITY ORDERED	ESTIMATED WEIGHT	BUNDLES SHIPPED	QUANTITY THIS SHIPMENT: PIECES	LIN. FEET	POUNDS
2658	3" X 5.7# I BEAM							
	NO HOLES. BARE							
	NO CLIPS							
	SWV 2 ASTM - ASTM A36-08/A709-11 GR 36							
	A36/A709							
	FAX CERTS TO 315-736-7172							
	SHIP VIA RAILCAR;HOLD FOR RELEASE							
	MELTED & MANUFACTURED IN USA							
	265842 01/25/16	42'	756 PCS	180,986#				
	265842 01/25/16	42'	720 PCS	172,368#				
	265842 03/28/16	42'	684 PCS	163,750#	19 of 36	684	42'	166,000
						TARP MATERIAL		
						SHIPPED WITH: 48502-1		
	All melting and manufacturing processes for these materials occurred in the U.S.A.							

HEAT NO	Strength (P.S.I) Yield	Tensile	Elongation %	Lth	Cu	Cr	Ni	Mo	Nb
21116	50000	68000	23.9	8	.20	.15	.10	.02	.001
18794	53000	74000	20.6	8	.29	.16	.10	.02	.001
21552	48000	70000	21.8	8	.31	.21	.13	.03	.003
21118	46000	68000	23.6	8	.28	.12	.08	.02	.001

HEAT NO.	C	MN	P	S	SI	V	SN	CE
21116	.13	.55	.011	.024	.15	.003	.021	.28
18794	.16	.74	.016	.026	.28	.007	.021	.35
21552	.13	.68	.031	.041	.30	.004	.013	.32
21118	.15	.66	.010	.026	.27	.003	.012	.31

Figure A-3. 63-in. (1,600-mm) Long Post for Post Nos. 9 through 26, Test No. NYT-1



STEEL AND PIPE SUPPLY
SPS Coil Processing Tulsa
5275 Bird Creek Ave.
Port of Catoosa, OK 74015

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 02/23/2017
TIME 21:39:01
USER GIANGRER

SOLD TO

SHIP TO
13713
Warehouse 0020
1050 Fort Gibson Rd
CATOOSA OK 74015-3033

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40280849-0010	70872120TM	1/4 72 X 120 A36 TEMPERPASS STPMLPL	15	9,189			02/23/2017

Chemical Analysis

Heat No. 1700330 Vendor BIG RIVER STEEL LLC DOMESTIC Mill BIG RIVER STEEL LLC Melted and Manufactured in the USA
Produced from Coil

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.1900	0.8000	0.0200	0.0060	0.0200	0.0400	0.0600	0.0200	0.0001	0.1200	0.0290	0.0000	0.0020	0.0010	0.0083	0.0060

Mechanical / Physical Properties

Mill Coil No. 17003301-02

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
80000.000	57000.000	23.00			0	NA			
78400.000	53300.000	24.70			0	NA			
74800.000	50800.000	26.30			0	NA			
69500.000	46800.000	29.10			0	NA			

Batch 0004659131 15 EA 9,189 LB
Batch 0004659148 15 EA 9,189 LB
Batch 0004659132 15 EA 9,189 LB
Batch 0004659156 12 EA 7,351.200 LB
Batch 0004659133 15 EA 9,189 LB

THE CHEMICAL, PHYSICAL, OR MECHANICAL TESTS REPORTED ABOVE ACCURATELY REFLECT INFORMATION AS CONTAINED IN THE RECORDS OF THE CORPORATION.
The material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Figure A-4. Soil Plate, Test No. NYT-1

Atlas Tube Corp (Chicago)
1855 East 122nd Street
Chicago, Illinois, USA
60633
Tel: 773-646-4500
Fax: 773-646-6128

Atlas Tube
A DIVISION OF ZEKELMAN INDUSTRIES

Ref.B/L: 80748789
Date: 01.26.2017
Customer: 179

MATERIAL TEST REPORT

Sold to
Steel & Pipe Supply Company
PO Box 1688
MANHATTAN KS 66505
USA

NY DOT BOX BEAM
R#17-515 Steel Tubes Blockouts

Shipped to
Steel & Pipe Supply Company
401 New Century Parkway
NEW CENTURY KS 66031
USA

Material: 8.0x6.0x250x40'0"0(2x3). **Material No:** 800602504000 **Made in:** USA
Melted in: Canada
Sales order: 1151714 **Purchase Order:** C450006295 **Cust Material #:** 6680060025040

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
3793C4	0.190	0.750	0.013	0.005	0.020	0.031	0.030	0.000	0.000	0.020	0.030	0.000	0.001	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.33
M800680527	6	054097 Psi	070624 Psi	35 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 10.0x8.0x375x40'0"0(2x2). **Material No:** 1000803754000 **Made in:** USA
Melted in: Canada
Sales order: 1151715 **Purchase Order:** C450006295 **Cust Material #:** 66100080037540

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
3469C4	0.200	0.730	0.011	0.007	0.030	0.027	0.030	0.000	0.000	0.020	0.020	0.000	0.001	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.33
M900893830	4	058581 Psi	073963 Psi	31 %	ASTM A500-13 GRADE B&C	

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.
Calculated using the AWS D1.1 method.

Steel Tube Institute OF NORTH AMERICA

Page : 3 Of 3

Metals Service Center Institute

Figure A-5. 6-in. (152-mm) Long Blockout, Test No. NYT-1

NUCOR

NUCOR CORPORATION
NUCOR STEEL SOUTH CAROLINA

Mill Certification
3/15/2016

MTR #: C1-366424
300 Steel Mill Road
DARLINGTON, SC 29540
(843) 393-5841
Fax: (843) 395-8701

Sold To: DI HIGHWAY SIGN & STRUCTURE
PO BOX 123
NEW YORK MILLS, NY 13417-0123
(315) 736-8312
Fax: (315) 736-7172

Ship To: DI HIGHWAY SIGN & STRUCTURE
40 GREENMAN AVE
PO BOX 123
NEW YORK MILLS, NY 13417-0000
(315) 736-8312
Fax: (315) 736-7172

Customer P.O.	33537	Sales Order	242841.3
Product Group	Merchant Bar Quality	Part Number	2160363748010W0
Grade	NUCOR MULTIGRADE	Lot #	DL1610068201
Size	5x3-1/2x3/8 Angle	Heat #	DL16100682
Product	5x3-1/2x3/8 Angle 40' NUCOR MULTIGRADE	B.L. Number	C1-686804
Description	NUCOR MULTIGRADE	Load Number	C1-366424
Customer Spec		Customer Part #	

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.

Roll Date: 2/6/2016 Melt Date: 2/1/2016 Qty Shipped LBS: 9,984 Qty Shipped Pcs: 24

Melt Date: 2/1/2016

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Cb	Sn
0.16%	0.66%	0.009%	0.030%	0.20%	0.31%	0.10%	0.16%	0.030%	0.0390%	0.002%	0.015%
Ti	CE4020										
0.001%	0.34%										

CE4020: C. E. CSA G4020, AASHTO M270

Roll Date: 2/6/2016

Yield 1: 54,000psi	Tensile 1: 72,000psi	Elongation: 27% In 8"(% in 203.3mm)
Yield 2: 55,000psi	Tensile 2: 72,000psi	Elongation 26% In 8"(% in 203.3mm)

Specification Comments: NUCOR MULTIGRADE MEETS THE REQUIREMENTS OF: ASTM A36/A36M-08, A529/529M-05(2009) GR50(345), A572/572M-07 GR50(345), A709/709M-10 GR36(250) & GR50(345), CSA G40.21-04 GR44W(300W) & GR50W(350W) AASHTO M270/M270M-10 GR36(270) & GR50(345), ASME SA36/SA36M-07, QQ-S-741D PRODUCED TO A FULLY KILLED, FINE GRAIN PRACTICE

1. WELDING OR WELD REPAIR WAS NOT PERFORMED ON THIS MATERIAL
2. MELTED AND MANUFACTURED IN THE USA
3. MERCURY, RADIUM, OR ALPHA SOURCE MATERIALS IN ANY FORM HAVE NOT BEEN USED IN THE PRODUCTION OF THIS MATERIAL

James H. Blew
Division Metallurgist

NBMG-10 January 1, 2012

Page 1 of 4

Figure A-6. 4½-in. (114-mm) Long L-Bracket, Test No. NYT-1

BULL MOOSE TUBE

1819 Clarkson Rd.
Chesterfield, Missouri 63017
636-537-2600

BULL MOOSE TUBE ELKHART FACILITY 11/01/16
CERTIFICATION OF TESTS Page 1 of 1
EN 10204:2004 TYPE 3.1 CERT

R#17-313 NYDOT
6x6x3/16 Guardrail

BILL TO Di Highway Sign & Structure
P.O. Box 123
New York Mills NY 13417-0123

SHIP TO Di Highway
40 Greenman Ave.
New York Mills NY 13417

B/L Number 395443 Ship Via 14_O2

6" SQ X 0.187 HR X 17' 11.5" Order # 523988
152.4 mm Ladle, Physicals, DWTT Purchase Order # 33610
NY Guard Rail 710-21 Rail Item # 110707 3840
Customer Item #
Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = U2133 D NDT

C	MN	P	S	AL	SI	CB	CU	CR	NI	V	MO	B	TI	N	CE	YLD psi	TSN psi	ELN %
.050	.650	.012	.006	.028	.020	.023	.150	.070	.070	.002	.020	0.000	.002	.008	.195	70240	71530	31

6" SQ X 0.187 HR X 17' 11.5" Order # 523988
152.4 mm Ladle, Physicals, DWTT Purchase Order # 33610
NY Guard Rail 710-21 Rail Item # 110707 3840
Customer Item #
Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = U2139 D NDT

C	MN	P	S	AL	SI	CB	CU	CR	NI	V	MO	B	TI	N	CE	YLD psi	TSN psi	ELN %
.050	.660	.012	.003	.034	.020	.022	.130	.070	.070	.002	.020	0.000	.001	.009	.195	60900	70320	29

6" SQ X 0.187 HR X 17' 11.5" Order # 523988
152.4 mm Ladle, Physicals, DWTT Purchase Order # 33610
NY Guard Rail 710-21 Rail Item # 110707 3840
Customer Item #
Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = U2141 D NDT

C	MN	P	S	AL	SI	CB	CU	CR	NI	V	MO	B	TI	N	CE	YLD psi	TSN psi	ELN %
.050	.620	.013	.005	.032	.020	.022	.130	.060	.060	.002	.020	0.000	.001	.007	.186	62160	69380	33

6" SQ X 0.187 HR X 17' 11.5" Order # 523988
152.4 mm Ladle, Physicals, DWTT Purchase Order # 33610
NY Guard Rail 710-21 Rail Item # 110707 3840
Customer Item #
Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = U2405 D NDT

C	MN	P	S	AL	SI	CB	CU	CR	NI	V	MO	B	TI	N	CE	YLD psi	TSN psi	ELN %
.050	.670	.012	.003	.037	.020	.020	.160	.080	.070	.002	.020	0.000	.001	.008	.201	67050	70750	36

Quality Manager: SKydeust

THIS WELDED STEEL TUBING IS MANUFACTURED IN THE UNITED STATES OF AMERICA AND HAS BEEN PRODUCED IN ACCORDANCE WITH THE STATED SPECIFICATION. LADLE CHEMISTRIES ARE REPORTED FROM DOCUMENTS PROVIDED BY THE SUPPLYING STEEL MILL. ANY PHYSICAL AND MECHANICAL TESTING RESULTS SHOWN ON THIS CERTIFICATION ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

Figure A-7. 216-in. (5,486-mm) Long Box Beam, Test No. NYT-1

EXLTUBE

1000 BURLINGTON STREET, NORTH KANSAS CITY, MO 64116 1-816-474-5210 TOLL FREE 1-800-892-TUBE

STEEL VENTURES, LLC dba EXLTUBE

Certified Test Report

Customer:	Size:	Customer Order No:	Date:
SPS - New Century 401 New Century Parkway NEW CENTURY KS 66031-1127	06.00X06.00	4500277037	12/16/2016
	Gauge: 1/4	Delivery No:82874361 Load No:3826271	
	Specification: ASTM A500-13 Gr.B/C		

Heat No	Yield KSI	Tensile KSI	Elongation % 2 Inch
C79938	60.8	65.4	34.00

Heat No	C	MN	P	S	SI	CU	NI	CR	MO	V
C79938	0.0700	0.8500	0.0100	0.0020	0.0300	0.1600	0.0500	0.0600	0.0200	0.0010

This material was melted & manufactured in the U.S.A.
We hereby certify that all test results shown in this report are correct as contained in the records of our company. All testing and manufacturing is in accordance to A.S.T.M. parameters encompassed within the scope of the specifications denoted in the specification and grade tiles above. This product was manufactured in accordance with your purchase order requirements.

This material has not come into direct contact with mercury, any of its compounds, or any mercury bearing devices during our manufacturing process, testing, or inspections.

This material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Tensile test completed using test specimen with 3/4" reduced area.

STEEL VENTURES, LLC dba EXLTUBE

Jonathan Wolfe
Quality Assurance Manager

Figure A-8. 142-in. (3,607-mm) Long Bent Box Beam, Test No. NYT-1

KES
Kentucky Electric Steel

January 28, 2016

www.kentuckyelectricsteel.com
Phone: (606) 929-1200 Toll Free: (800) 333-3012
Fax: (606) 929-1219

Page:4

Ship To: DI Highway Sign & Structure
40 Greeman Avenue
New York Mills NY 13417

Sold To: DI HIGHWAY SION & STRUCTURE
CORPORATION
P.O. BOX 123
NEW YORK MILLS NY 13417
USA

METALLURGICAL TEST REPORT

We herby certify that these Chemical and/or Test results are correct as contained in the records of Kentucky Electric Steel

By: William L. Compton
William L. Compton Q.C. Manager

Mercury source materials have not been used in the production of this material. No weld repair performed.

Cert #:6164 Grade:A36 CV Size:0.625 X 5.375 FL
Job:K000005409-0 Order:KO00006368-1 Size(MM):15.88 X 136.53
P.O. No:33056 Item: 102706 Cust Item: Length:243.0000
A36 CV,FL SB ,0.625 x 5.375 ,20' 3",20' 3" Length(MM):6172.2

Heat	Furnace	Melted Source	Cast	CE	DI	Sum
W19665	EAF	USA	Bil			0.0000

Ladle Chemistry Analysis

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	V	Nb	B	Ti
0.15	0.60	0.010	0.016	0.27	0.19	0.09	0.13	0.03	0.008	0.005	0.000	0.002	0.0002	0.0004

N	Pb	O	Ca	Bi	Se	Te	As	Sb	Zn	Zr	W	H2	CO	
0.008	0.0004		0.0005				0.005	0.001					0.0070	-

Jominy (ASTM A225)

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J18	J20	J24	J28	J32	Grain Size

Non-Metallic Inclusions (ASTM E45)

Method A					Method C		Magnetic Particle Inspection		ASTM E381			
A	B	C	D		O	S	Frequency	Severity	R	C	S	Reduction Ratio
				T								10.4 : 1
				H								
				T			MELTED & MANUFACTURED IN THE USA					
				H								

Tensile Properties

Tensile	Yield 0.2%	Yield 0.01%	Yield 0.02%	Elong % 2 "	Elong % 8 "	ROA %	Decarb
69200	46600			48.00			
68100	45700			47.00			

Hardness

Type	RC	RB	RA	BHN	HV
Surface					
Mid					
Core					
Surface					
Mid					
Core					

Charpy

Temp	Size	Longitudinal			Transverse
20	FA	62	64	78	

Figure A-9. Splice Plate, Test No. NYT-1

EXLTUBE

1000 BURLINGTON STREET, NORTH KANSAS CITY, MO 64116 1-816-474-5210 TOLL FREE 1-800-892-TUBE

STEEL VENTURES, LLC dba EXLTUBE

Certified Test Report

Customer:	Size:	Customer Order No:	Date:
SPS - New Century 401 New Century Parkway NEW CENTURY KS 66031-1127	05.00X05.00	4500276050	11/30/2016
	Gauge: 1/4	Delivery No: 82863042 Load No: 3817901	
	Specification: ASTM A500-13 Gr.B/C		

Heat No	Yield KSI	Tensile KSI	Elongation % 2 Inch
A612210	61.5	68.9	33.50

NY Box Beam R#17-393

Heat No	C	MN	P	S	SI	CU	NI	CR	MO	V
A612210	0.0600	0.8300	0.0150	0.0050	0.0100	0.1100	0.0400	0.0900	0.0300	0.0030

This material was melted & manufactured in the U.S.A.
We hereby certify that all test results shown in this report are correct as contained in the records of our company. All testing and manufacturing is in accordance to A.S.T.M. parameters encompassed within the scope of the specifications denoted in the specification and grade tiles above. This product was manufactured in accordance with your purchase order requirements.

This material has not come into direct contact with mercury, any of its compounds, or any mercury bearing devices during our manufacturing process, testing, or inspections.

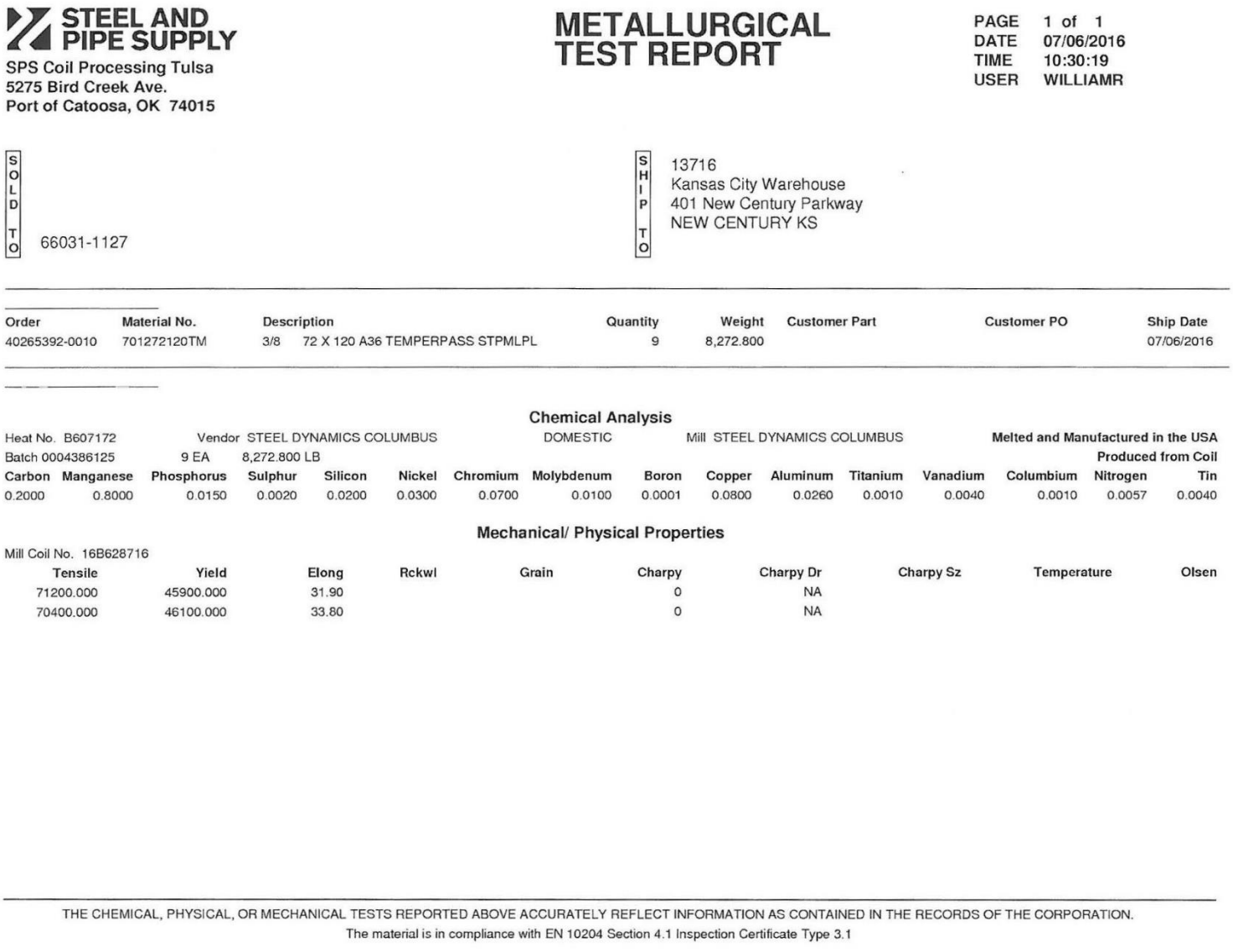
This material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Tensile test completed using test specimen with 3/4" reduced area.

STEEL VENTURES, LLC dba EXLTUBE

Jonathan Wolfe
Quality Assurance Manager

Figure A-10. 25½-in. (648-mm) Long Cut Box Beam, Test No. NYT-



STEEL AND PIPE SUPPLY

SPS Coil Processing Tulsa
5275 Bird Creek Ave.
Port of Catoosa, OK 74015

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 07/06/2016
TIME 10:30:19
USER WILLIAMR

SOLD TO 66031-1127

SHIP TO 13716
Kansas City Warehouse
401 New Century Parkway
NEW CENTURY KS

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40265392-0010	701272120TM	3/8 72 X 120 A36 TEMPERPASS STPMLPL	9	8,272.800			07/06/2016

Chemical Analysis

Heat No. B607172 Vendor STEEL DYNAMICS COLUMBUS DOMESTIC Mill STEEL DYNAMICS COLUMBUS **Melted and Manufactured in the USA**
Batch 0004386125 9 EA 8,272.800 LB **Produced from Coil**

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.2000	0.8000	0.0150	0.0020	0.0200	0.0300	0.0700	0.0100	0.0001	0.0800	0.0260	0.0010	0.0040	0.0010	0.0057	0.0040

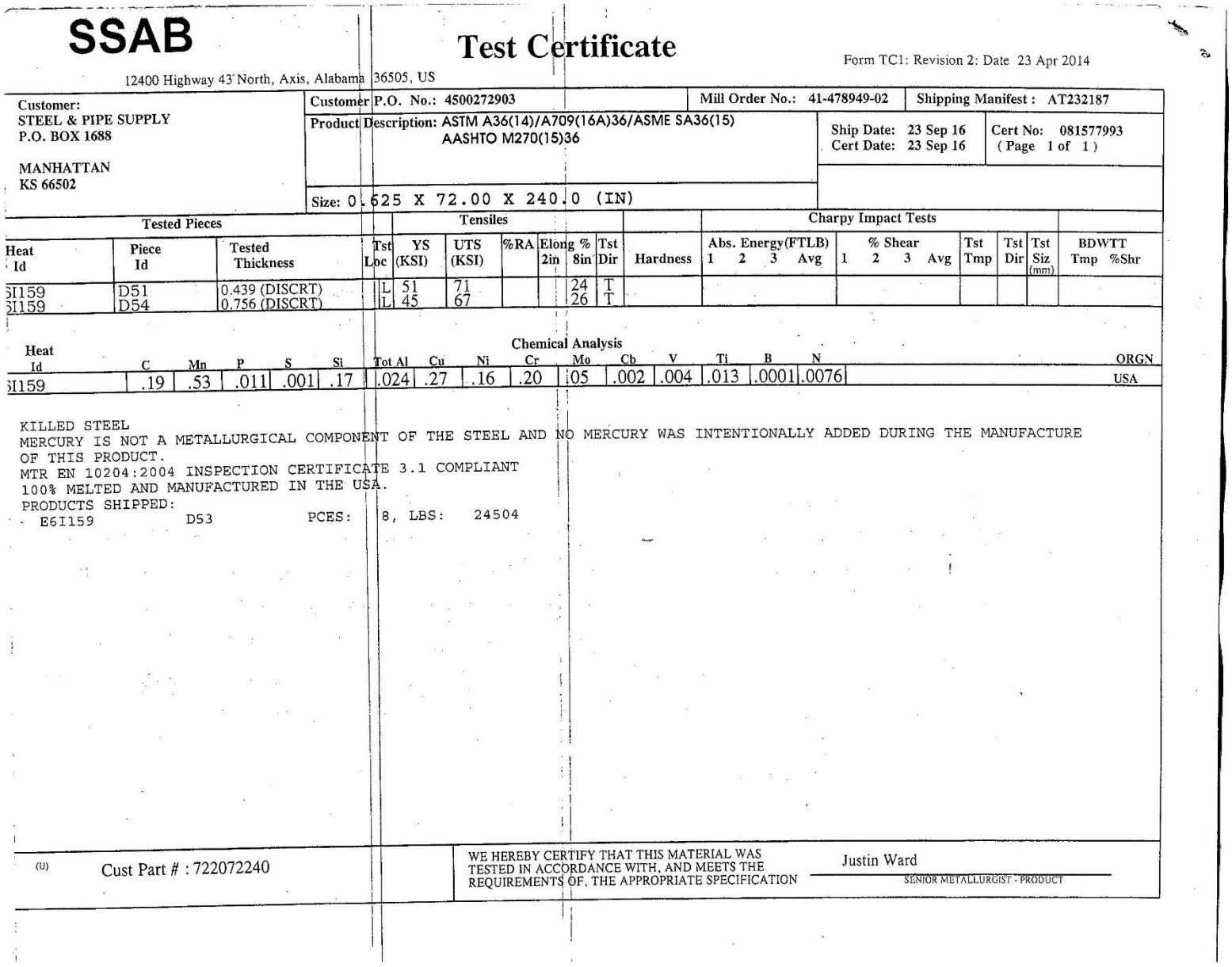
Mechanical/ Physical Properties

Mill Coil No. 16B628716

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
71200.000	45900.000	31.90			0	NA			
70400.000	46100.000	33.80			0	NA			

THE CHEMICAL, PHYSICAL, OR MECHANICAL TESTS REPORTED ABOVE ACCURATELY REFLECT INFORMATION AS CONTAINED IN THE RECORDS OF THE CORPORATION.
The material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Figure A-11. ⅜-in. (9-mm) Bent Plate, Test No. NYT-1



SSAB

12400 Highway 43 North, Axis, Alabama 36505, US

Test Certificate

Form TC1: Revision 2: Date 23 Apr 2014

Customer:
STEEL & PIPE SUPPLY
P.O. BOX 1688

MANHATTAN
KS 66502

Customer P.O. No.: 4500272903 | Mill Order No.: 41-478949-02 | Shipping Manifest : AT232187

Product Description: ASTM A36(14)/A709(16A)36/ASME SA36(15)
AASHTO M270(15)36

Ship Date: 23 Sep 16
Cert Date: 23 Sep 16

Cert No: 081577993
(Page 1 of 1)

Size: 0.625 X 72.00 X 240.0 (IN)

Tested Pieces			Tensiles							Charpy Impact Tests								
Heat Id	Piece Id	Tested Thickness	Tst Loc	YS (KSI)	UTS (KSI)	%RA	Elong % 2in	Elong % 8in	Tst Dir	Hardness	Abs. Energy(FTLB) 1 2 3 Avg	% Shear 1 2 3 Avg	Tst Tmp	Tst Dir	Tst Siz (mm)	BDWTT Tmp %Shr
6I159	D51	0.439 (DISCRT)	L	51	71			24	T							
6I159	D54	0.756 (DISCRT)	L	45	67			26	T							

Chemical Analysis

Heat Id	C	Mn	P	S	Si	Tot Al	Cu	Ni	Cr	Mo	Cb	V	Ti	B	N	ORGN
6I159	.19	.53	.011	.001	.17	.024	.27	.16	.20	.05	.002	.004	.013	.0001	.0076	USA

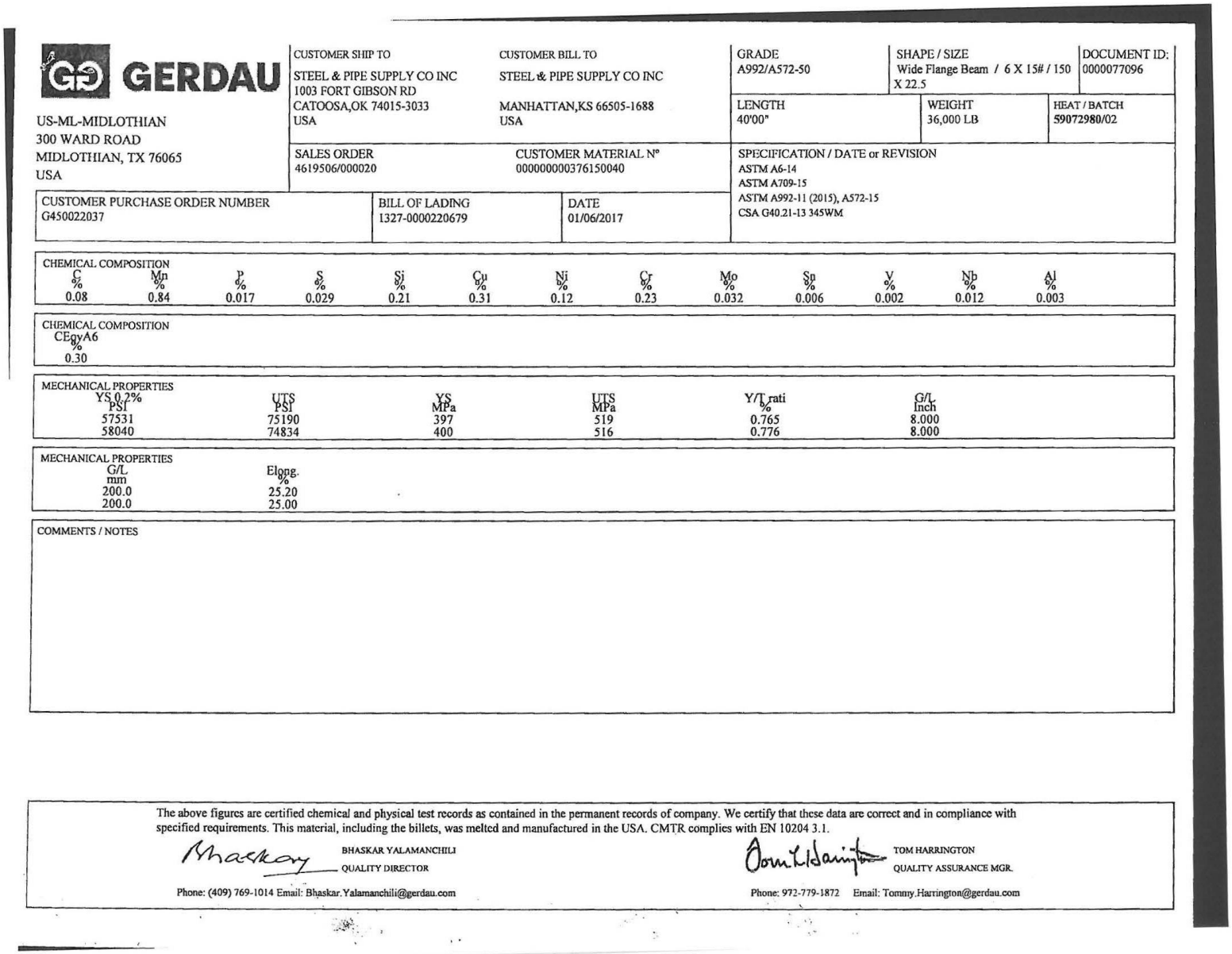
KILLED STEEL
MERCURY IS NOT A METALLURGICAL COMPONENT OF THE STEEL AND NO MERCURY WAS INTENTIONALLY ADDED DURING THE MANUFACTURE OF THIS PRODUCT.
MTR EN 10204:2004 INSPECTION CERTIFICATE 3.1 COMPLIANT
100% MELTED AND MANUFACTURED IN THE USA.
PRODUCTS SHIPPED:
E6I159 D53 PCES: 8, LBS: 24504

(U) Cust Part # : 722072240

WE HEREBY CERTIFY THAT THIS MATERIAL WAS TESTED IN ACCORDANCE WITH, AND MEETS THE REQUIREMENTS OF, THE APPROPRIATE SPECIFICATION

Justin Ward
SENIOR METALLURGIST - PRODUCT

Figure A-12. Keel Plate, Test No. NYT-1



GERDAU

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

CUSTOMER SHIP TO
STEEL & PIPE SUPPLY CO INC
1003 FORT GIBSON RD
CATOOSA,OK 74015-3033
USA

CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC
MANHATTAN,KS 66505-1688
USA

GRADE: A992/A572-50
SHAPE / SIZE: Wide Flange Beam / 6 X 15# / 150 X 22.5
DOCUMENT ID: 0000077096
LENGTH: 40'00"
WEIGHT: 36,000 LB
HEAT / BATCH: 59072980/02

SALES ORDER: 4619506/000020
CUSTOMER MATERIAL N°: 000000000376150040

SPECIFICATION / DATE or REVISION:
ASTM A6-14
ASTM A709-15
ASTM A992-11 (2015), A572-15
CSA G40.21-13 345WM

CUSTOMER PURCHASE ORDER NUMBER: G450022037
BILL OF LADING: 1327-0000220679
DATE: 01/06/2017

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.08	0.84	0.017	0.029	0.21	0.31	0.12	0.23	0.032	0.006	0.002	0.012	0.003

CHEMICAL COMPOSITION

CEqvA6 %
0.30

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
57531	75190	397	519	0.765	8.000
58040	74834	400	516	0.776	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	25.20
200.0	25.00

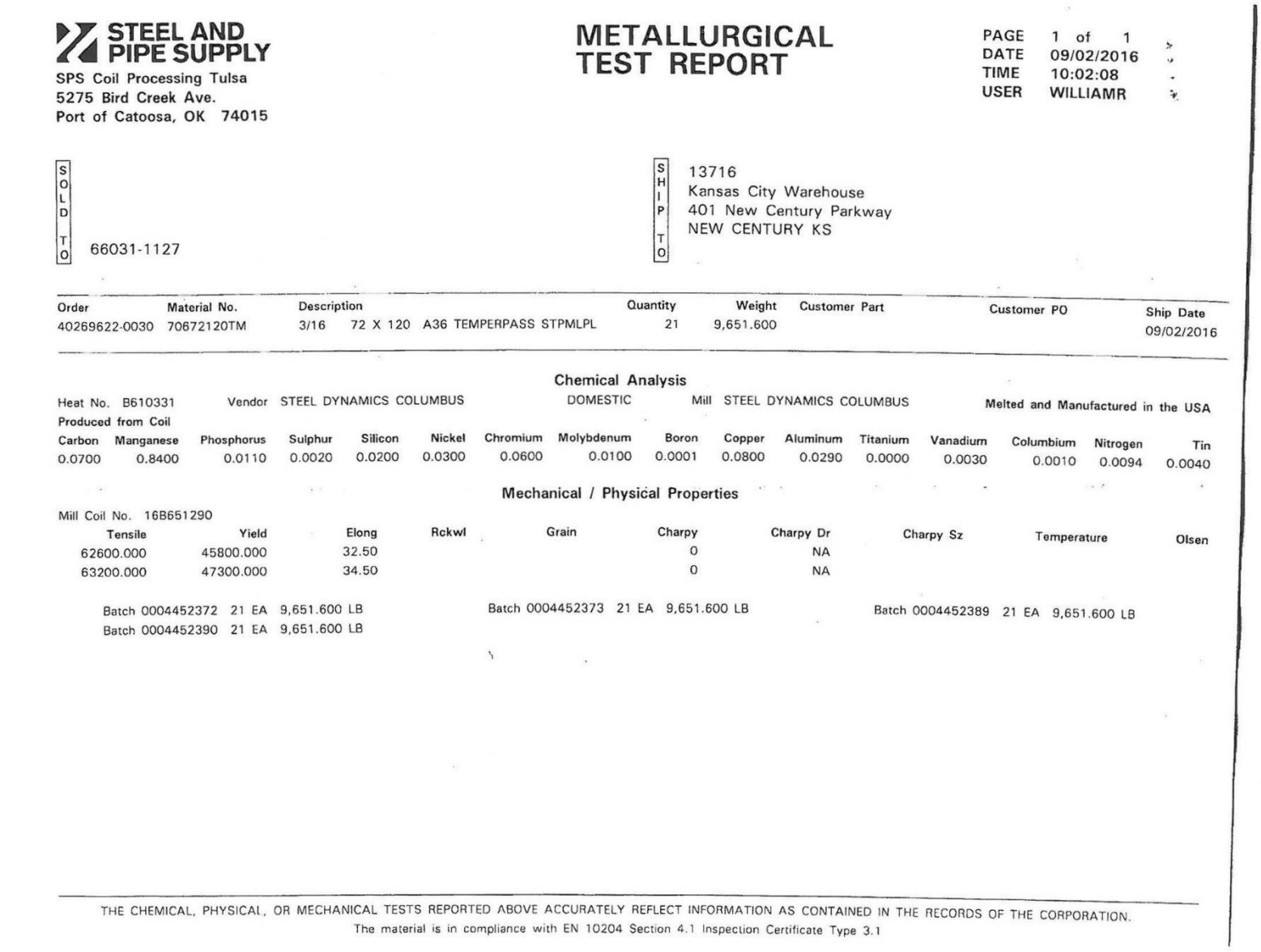
COMMENTS / NOTES

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 769-1014 Email: Bhaskar.Yalamanchili@gerdau.com

TOM HARRINGTON
QUALITY ASSURANCE MGR.
Phone: 972-779-1872 Email: Tommy.Harrington@gerdau.com

Figure A-13. 72½-in. (1,842-mm) Long Post for HFT Anchors, Test No. NYT-1



STEEL AND PIPE SUPPLY

SPS Coil Processing Tulsa
5275 Bird Creek Ave.
Port of Catoosa, OK 74015

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 09/02/2016
TIME 10:02:08
USER WILLIAMR

SOLD TO 66031-1127

SHIP TO 13716
Kansas City Warehouse
401 New Century Parkway
NEW CENTURY KS

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40269622-0030	70672120TM	3/16 72 X 120 A36 TEMPERPASS STPMLPL	21	9,651.600			09/02/2016

Chemical Analysis

Heat No. B610331 Vendor STEEL DYNAMICS COLUMBUS DOMESTIC Mill STEEL DYNAMICS COLUMBUS Melted and Manufactured in the USA
Produced from Coil

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.0700	0.8400	0.0110	0.0020	0.0200	0.0300	0.0600	0.0100	0.0001	0.0800	0.0290	0.0000	0.0030	0.0010	0.0094	0.0040

Mechanical / Physical Properties

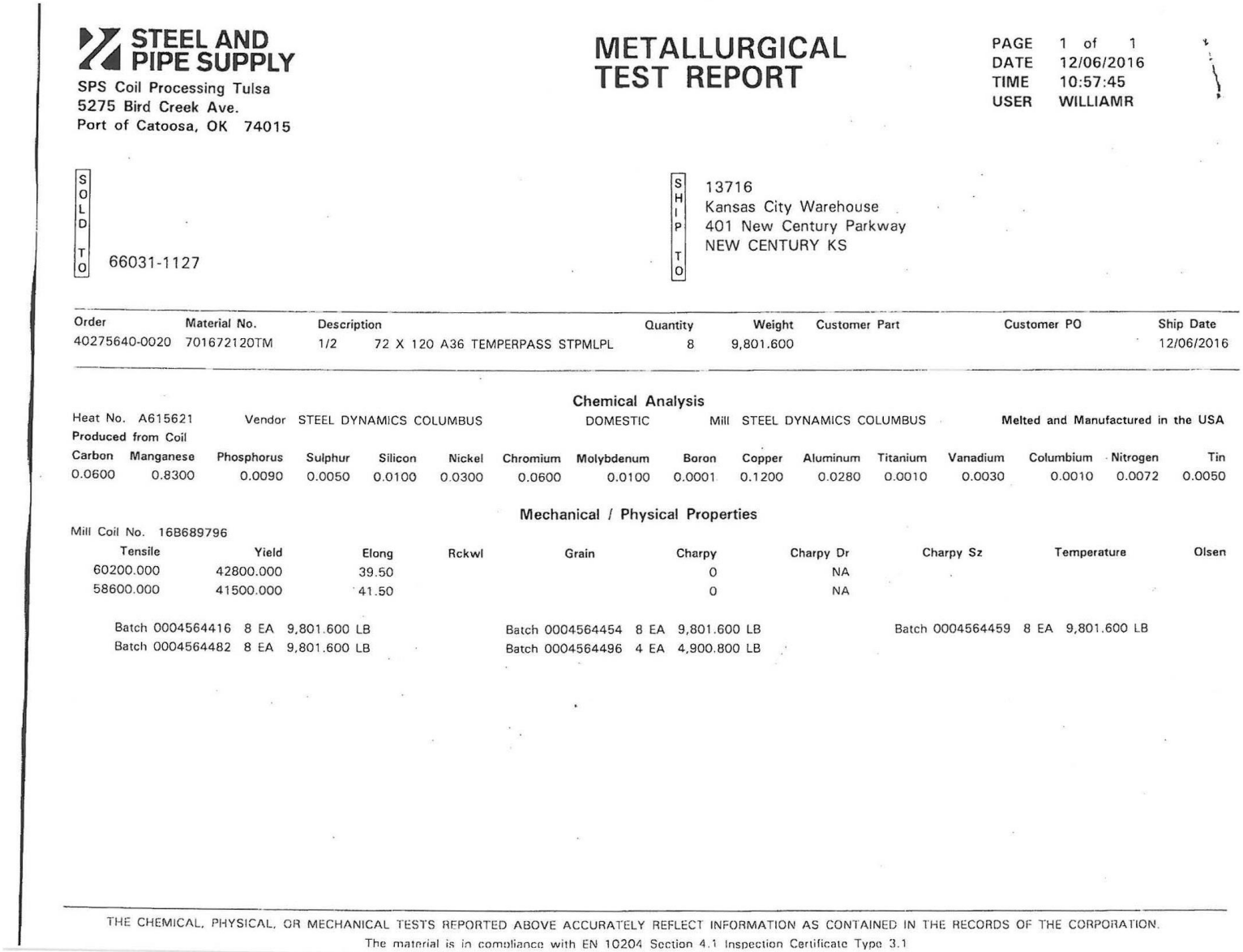
Mill Coil No. 16B651290

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
62600.000	45800.000	32.50			0	NA			
63200.000	47300.000	34.50			0	NA			

Batch 0004452372 21 EA 9,651.600 LB
Batch 0004452373 21 EA 9,651.600 LB
Batch 0004452389 21 EA 9,651.600 LB
Batch 0004452390 21 EA 9,651.600 LB

THE CHEMICAL, PHYSICAL, OR MECHANICAL TESTS REPORTED ABOVE ACCURATELY REFLECT INFORMATION AS CONTAINED IN THE RECORDS OF THE CORPORATION.
The material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Figure A-14. $^{3}/_{16}$-in. (5-mm) Plate, Test No. NYT-1



STEEL AND PIPE SUPPLY

SPS Coil Processing Tulsa
5275 Bird Creek Ave.
Port of Catoosa, OK 74015

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 12/06/2016
TIME 10:57:45
USER WILLIAMR

SOLD TO
66031-1127

SHIP TO
13716
Kansas City Warehouse
401 New Century Parkway
NEW CENTURY KS

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40275640-0020	701672120TM	1/2 72 X 120 A36 TEMPERPASS STPMLPL	8	9,801.600			12/06/2016

Chemical Analysis

Heat No. A615621 Vendor STEEL DYNAMICS COLUMBUS DOMESTIC Mill STEEL DYNAMICS COLUMBUS Melted and Manufactured in the USA
Produced from Coil

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.0600	0.8300	0.0090	0.0050	0.0100	0.0300	0.0600	0.0100	0.0001	0.1200	0.0280	0.0010	0.0030	0.0010	0.0072	0.0050

Mechanical / Physical Properties

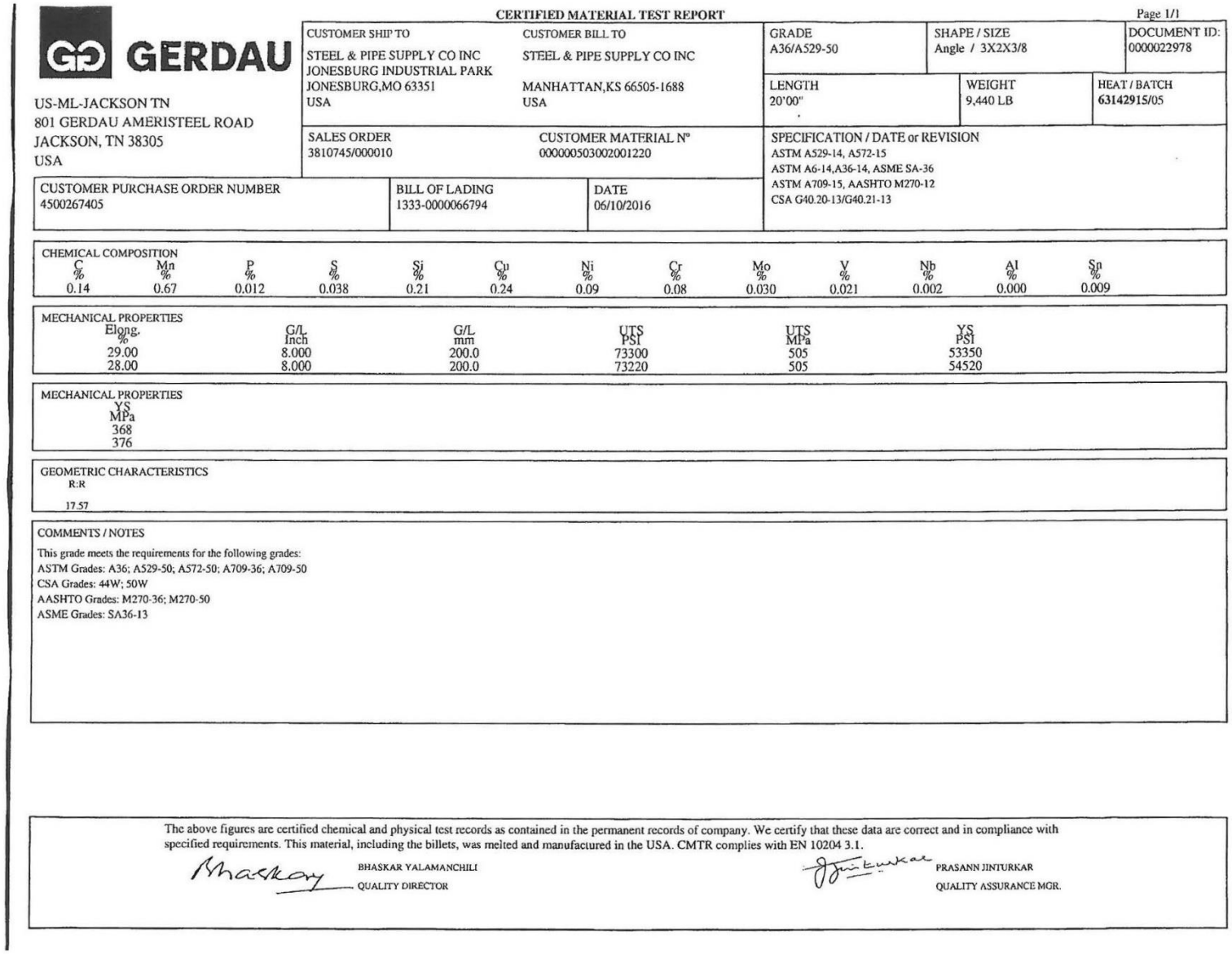
Mill Coil No. 16B689796

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
60200.000	42800.000	39.50			0	NA			
58600.000	41500.000	41.50			0	NA			

Batch 0004564416 8 EA 9,801.600 LB
Batch 0004564482 8 EA 9,801.600 LB
Batch 0004564454 8 EA 9,801.600 LB
Batch 0004564496 4 EA 4,900.800 LB
Batch 0004564459 8 EA 9,801.600 LB

THE CHEMICAL, PHYSICAL, OR MECHANICAL TESTS REPORTED ABOVE ACCURATELY REFLECT INFORMATION AS CONTAINED IN THE RECORDS OF THE CORPORATION.
The material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Figure A-15. ½-in. (12-mm) Plate, Test No. NYT-1



GERDAU

CERTIFIED MATERIAL TEST REPORT

Page 1/1

US-ML-JACKSON TN
801 GERDAU AMERISTEEL ROAD
JACKSON, TN 38305
USA

CUSTOMER SHIP TO	CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC JONESBURG INDUSTRIAL PARK JONESBURG,MO 63351 USA	STEEL & PIPE SUPPLY CO INC MANHATTAN,KS 66505-1688 USA

GRADE	SHAPE / SIZE	DOCUMENT ID:
A36/A529-50	Angle / 3X2X3/8	0000022978

LENGTH	WEIGHT	HEAT / BATCH
20'00"	9,440 LB	63142915/05

SALES ORDER	CUSTOMER MATERIAL Nº
3810745/000010	000000503002001220

SPECIFICATION / DATE or REVISION
ASTM A529-14, A572-15
ASTM A6-14,A36-14, ASME SA-36
ASTM A709-15, AASHTO M270-12
CSA G40.20-13/G40.21-13

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
4500267405	1333-0000066794	06/10/2016

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	V %	Nb %	Al %	Sn %
0.14	0.67	0.012	0.038	0.21	0.24	0.09	0.08	0.030	0.021	0.002	0.000	0.009

MECHANICAL PROPERTIES

Elong. %	G/L Inch	G/L mm	UTS PSI	UTS MPa	YS PSI
29.00	8.000	200.0	73300	505	53350
28.00	8.000	200.0	73220	505	54520

MECHANICAL PROPERTIES

YS MPa
368
376

GEOMETRIC CHARACTERISTICS

R:R
17.57

COMMENTS / NOTES

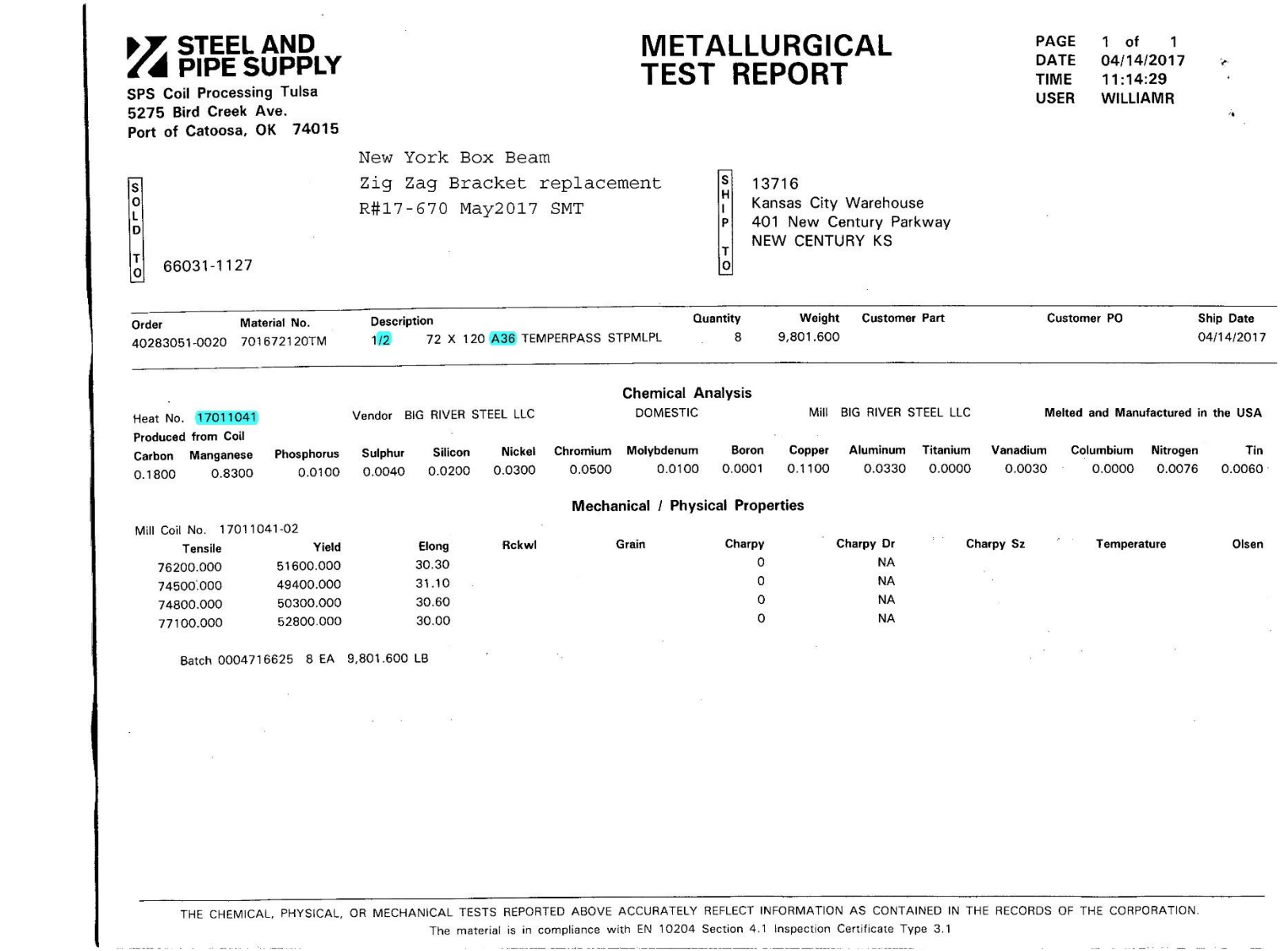
This grade meets the requirements for the following grades:
ASTM Grades: A36; A529-50; A572-50; A709-36; A709-50
CSA Grades: 44W; 50W
AASHTO Grades: M270-36; M270-50
ASME Grades: SA36-13

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR

PRASANN JINTURKAR
QUALITY ASSURANCE MGR.

Figure A-16. 4.8-in. (122-mm) Long L-Bracket, Test No. NYT-1



STEEL AND PIPE SUPPLY

SPS Coil Processing Tulsa
5275 Bird Creek Ave.
Port of Catoosa, OK 74015

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 04/14/2017
TIME 11:14:29
USER WILLIAMR

New York Box Beam
Zig Zag Bracket replacement
R#17-670 May2017 SMT

SOLD TO 66031-1127

SHIP TO 13716
Kansas City Warehouse
401 New Century Parkway
NEW CENTURY KS

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40283051-0020	701672120TM	1/2 72 X 120 A36 TEMPERPASS STPMLPL	8	9,801.600			04/14/2017

Chemical Analysis

Heat No. 17011041 Vendor BIG RIVER STEEL LLC DOMESTIC Mill BIG RIVER STEEL LLC Melted and Manufactured in the USA

Produced from Coil

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.1800	0.8300	0.0100	0.0040	0.0200	0.0300	0.0500	0.0100	0.0001	0.1100	0.0330	0.0000	0.0030	0.0000	0.0076	0.0060

Mechanical / Physical Properties

Mill Coil No. 17011041-02

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
76200.000	51600.000	30.30			0	NA			
74500.000	49400.000	31.10			0	NA			
74800.000	50300.000	30.60			0	NA			
77100.000	52800.000	30.00			0	NA			

Batch 0004716625 8 EA 9,801.600 LB

THE CHEMICAL, PHYSICAL, OR MECHANICAL TESTS REPORTED ABOVE ACCURATELY REFLECT INFORMATION AS CONTAINED IN THE RECORDS OF THE CORPORATION.
The material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Figure A-17. ½-in. (12-mm) Box Beam Cable Anchor Base Plate and Mounting Plate, Test No. NYT-1

STEEL AND PIPE SUPPLY

SPS Coil Processing Tulsa
5275 Bird Creek Ave.
Port of Catoosa, OK 74015

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 04/19/2017
TIME 17:37:34
USER J.DUBOIS

SOLD TO

SHIP TO
13713
Warehouse 0020
1050 Fort Gibson Rd
CATOOSA OK 74015-3033

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40284397-0010	70872120TM	1/4 72 X 120 A36 TEMPERPASS STPMLPL	13	7,963.800			04/19/2017

Chemical Analysis

Heat No. 17014221 Vendor BIG RIVER STEEL LLC DOMESTIC Mill BIG RIVER STEEL LLC **Melted and Manufactured in the USA**

Produced from Coil

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.1700	0.8000	0.0000	0.0020	0.0200	0.0400	0.0300	0.0100	0.0001	0.1100	0.0260	0.0000	0.0010	0.0000	0.0090	0.0060

Mechanical / Physical Properties

Mill Coil No. 17014221-04

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
75900.000	52700.000	28.30			0	NA			
70400.000	49000.000	32.00			0	NA			
74100.000	52500.000	32.20			0	NA			
68300.000	48300.000	33.60			0	NA			

Batch 0004735517 13 EA 7,963.800 LB Batch 0004735520 13 EA 7,963.800 LB

THE CHEMICAL, PHYSICAL, OR MECHANICAL TESTS REPORTED ABOVE ACCURATELY REFLECT INFORMATION AS CONTAINED IN THE RECORDS OF THE CORPORATION.
The material is in compliance with EN 10204 Section 4.1 Inspection Certificate Type 3.1

Figure A-18. ¼-in. (6-mm) Box Beam Cable Anchor Gusset, Test No. NYT-1

Atlas ABC Corp. (Atlas Tube Chicago)
1855 East 122nd Street
Chicago, Illinois, USA
60633
Tel: 773-646-4500
Fax: 773-646-6128

Atlas Tube
JMC STEEL GROUP

Ref.B/L: 80679970
Date: 08.26.2015
Customer: 179

MATERIAL TEST REPORT

Sold to

Steel & Pipe Supply Compan
PO Box 1688
MANHATTAN KS 66505
USA

Shipped to

Steel & Pipe Supply Compan
401 New Century Parkway
NEW CENTURY KS 66031
USA

Material: 7.0x7.0x375x40'0"0(3x2). Material No: 700703754000 Made in: USA
Melted in: United Kingdom
Sales order: 1027837 Purchase Order: C450005244 Cust Material #: 6570037540

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
85197PT	0.154	1.203	0.013	0.008	0.013	0.047	0.040	0.001	0.001	0.019	0.025	0.001	0.001	0.000	0.004

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.37
M800565200	6	062149 Psi	072854 Psi	34 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 7.0x7.0x375x40'0"0(3x2). Material No: 700703754000 Made in: USA
Melted in: United Kingdom
Sales order: 1027837 Purchase Order: C450005244 Cust Material #: 6570037540

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
85197PT	0.154	1.203	0.013	0.008	0.013	0.047	0.040	0.001	0.001	0.019	0.025	0.001	0.001	0.000	0.004

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.37
M800565201	6	062149 Psi	072854 Psi	34 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 10.0x4.0x250x40'0"0(2x4). Material No: 1000402504000 Made in: USA
Melted in: USA
Sales order: 1027838 Purchase Order: C450005244 Cust Material #: 66100040025040

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
W05669	0.190	0.820	0.013	0.008	0.018	0.058	0.020	0.004	0.002	0.010	0.040	0.001	0.001	0.000	0.005

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.34
M800572953	8	067409 Psi	080856 Psi	30 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

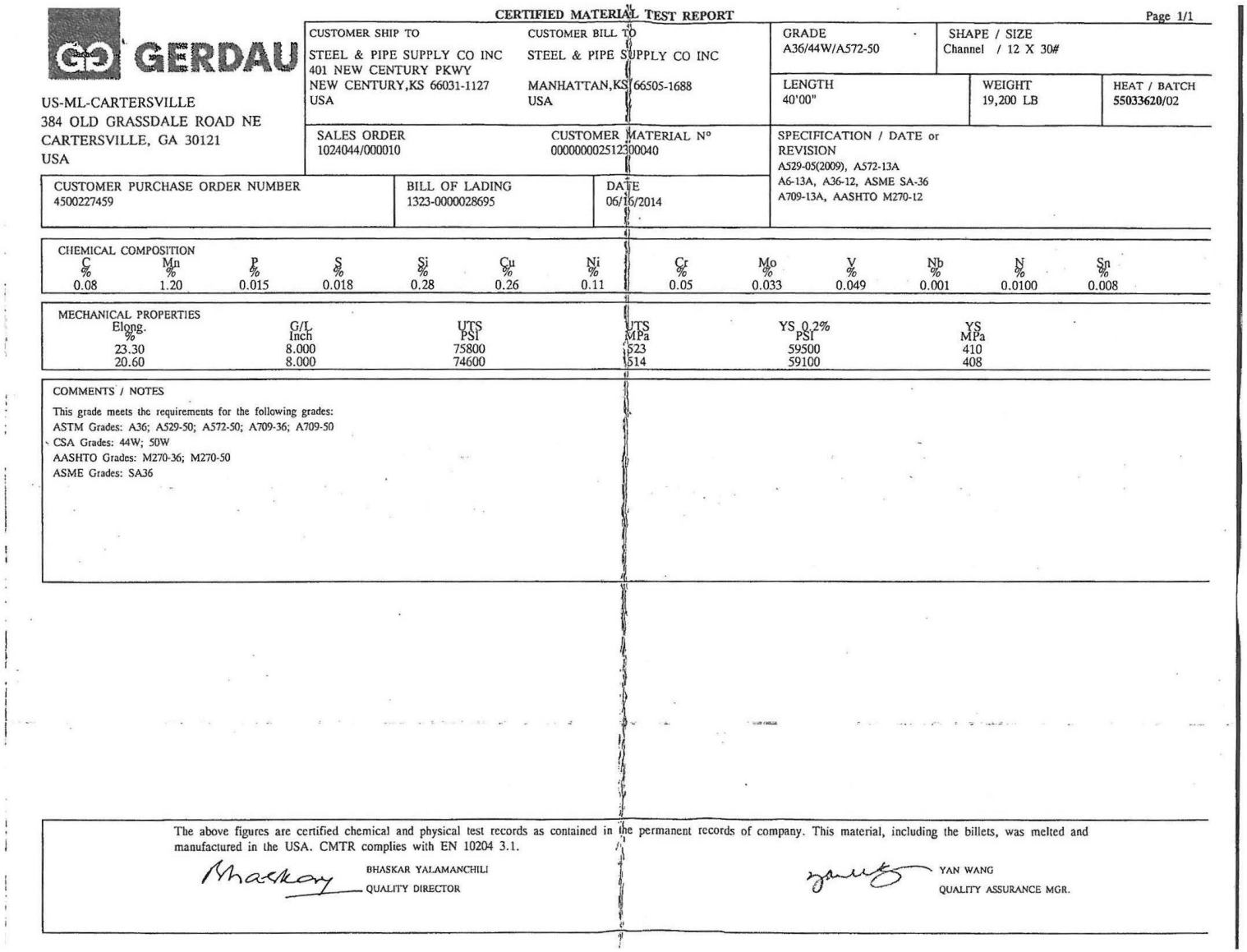
Authorized by Quality Assurance:
The results reported on this report represent the actual attributes of the material furnished and indicate full compliance with all applicable specification and contract requirements.
C[illegible] calculated using the AWS D1.1 method.

Steel Tube Institute OF NORTH AMERICA

Page : 2 Of 3

Metals Service Center Institute

Figure A-19. 48-in. (1219-mm) Long Box Beam, Test No. NYT-1



CERTIFIED MATERIAL TEST REPORT

Page 1/1

GERDAU

US-ML-CARTERSVILLE
384 OLD GRASSDALE ROAD NE
CARTERSVILLE, GA 30121
USA

CUSTOMER SHIP TO	CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC 401 NEW CENTURY PKWY NEW CENTURY,KS 66031-1127 USA	STEEL & PIPE SUPPLY CO INC MANHATTAN,KS 66505-1688 USA

GRADE	SHAPE / SIZE		
A36/44W/A572-50	Channel / 12 X 30#		
LENGTH	WEIGHT	HEAT / BATCH	
40'00"	19,200 LB	55033620/02	

SALES ORDER	CUSTOMER MATERIAL N°	SPECIFICATION / DATE or REVISION
1024044/000010	000000002512300040	A529-05(2009), A572-13A A6-13A, A36-12, ASME SA-36 A709-13A, AASHTO M270-12

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
4500227459	1323-0000028695	06/16/2014

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	V %	Nb %	N %	Sn %
0.08	1.20	0.015	0.018	0.28	0.26	0.11	0.05	0.033	0.049	0.001	0.0100	0.008

MECHANICAL PROPERTIES

Elong. %	G/L Inch	UTS PSI	UTS MPa	YS 0.2% PSI	YS MPa
23.30	8.000	75800	523	59500	410
20.60	8.000	74600	514	59100	408

COMMENTS / NOTES

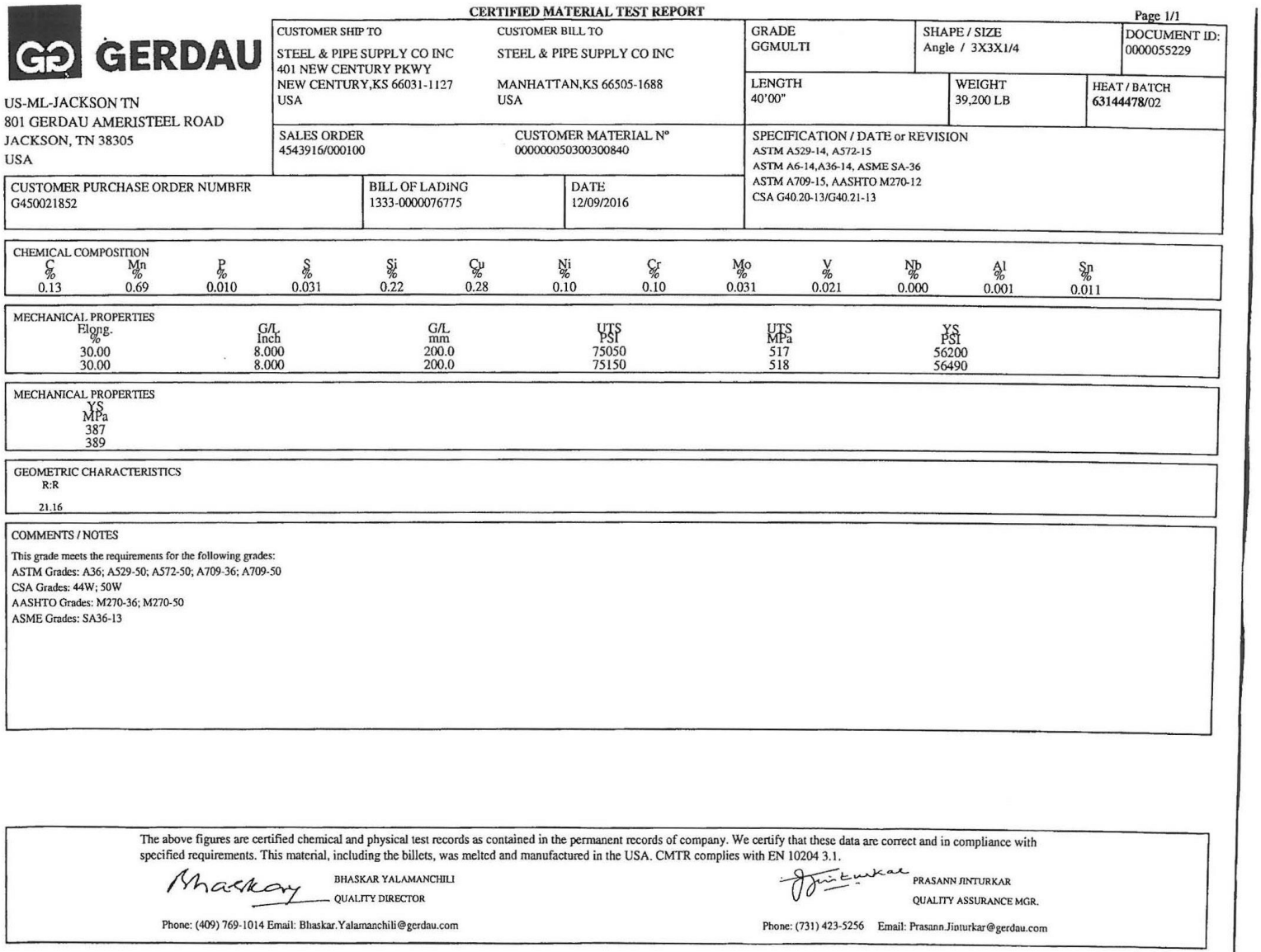
This grade meets the requirements for the following grades:
ASTM Grades: A36; A529-50; A572-50; A709-36; A709-50
CSA Grades: 44W; 50W
AASHTO Grades: M270-36; M270-50
ASME Grades: SA36

The above figures are certified chemical and physical test records as contained in the permanent records of company. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR

YAN WANG
QUALITY ASSURANCE MGR.

Figure A-20. 24-in. (610-mm) Long C-Channel, Test No. NYT-1



CERTIFIED MATERIAL TEST REPORT

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GERDAU

US-ML-JACKSON TN
801 GERDAU AMERISTEEL ROAD
JACKSON, TN 38305
USA

CUSTOMER SHIP TO	CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC 401 NEW CENTURY PKWY NEW CENTURY,KS 66031-1127 USA	STEEL & PIPE SUPPLY CO INC MANHATTAN,KS 66505-1688 USA

GRADE	SHAPE / SIZE	DOCUMENT ID:
GGMULTI	Angle / 3X3X1/4	0000055229

LENGTH	WEIGHT	HEAT / BATCH
40'00"	39,200 LB	63144478/02

SALES ORDER	CUSTOMER MATERIAL N°
4543916/000100	000000050300300840

SPECIFICATION / DATE or REVISION
ASTM A529-14, A572-15
ASTM A6-14,A36-14, ASME SA-36
ASTM A709-15, AASHTO M270-12
CSA G40.20-13/G40.21-13

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
G450021852	1333-0000076775	12/09/2016

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	V %	Nb %	Al %	Sn %
0.13	0.69	0.010	0.031	0.22	0.28	0.10	0.10	0.031	0.021	0.000	0.001	0.011

MECHANICAL PROPERTIES

Elong. %	G/L Inch	G/L mm	UTS PSI	UTS MPa	YS PSI
30.00	8.000	200.0	75050	517	56200
30.00	8.000	200.0	75150	518	56490

MECHANICAL PROPERTIES

YS MPa
387
389

GEOMETRIC CHARACTERISTICS

R:R
21.16

COMMENTS / NOTES

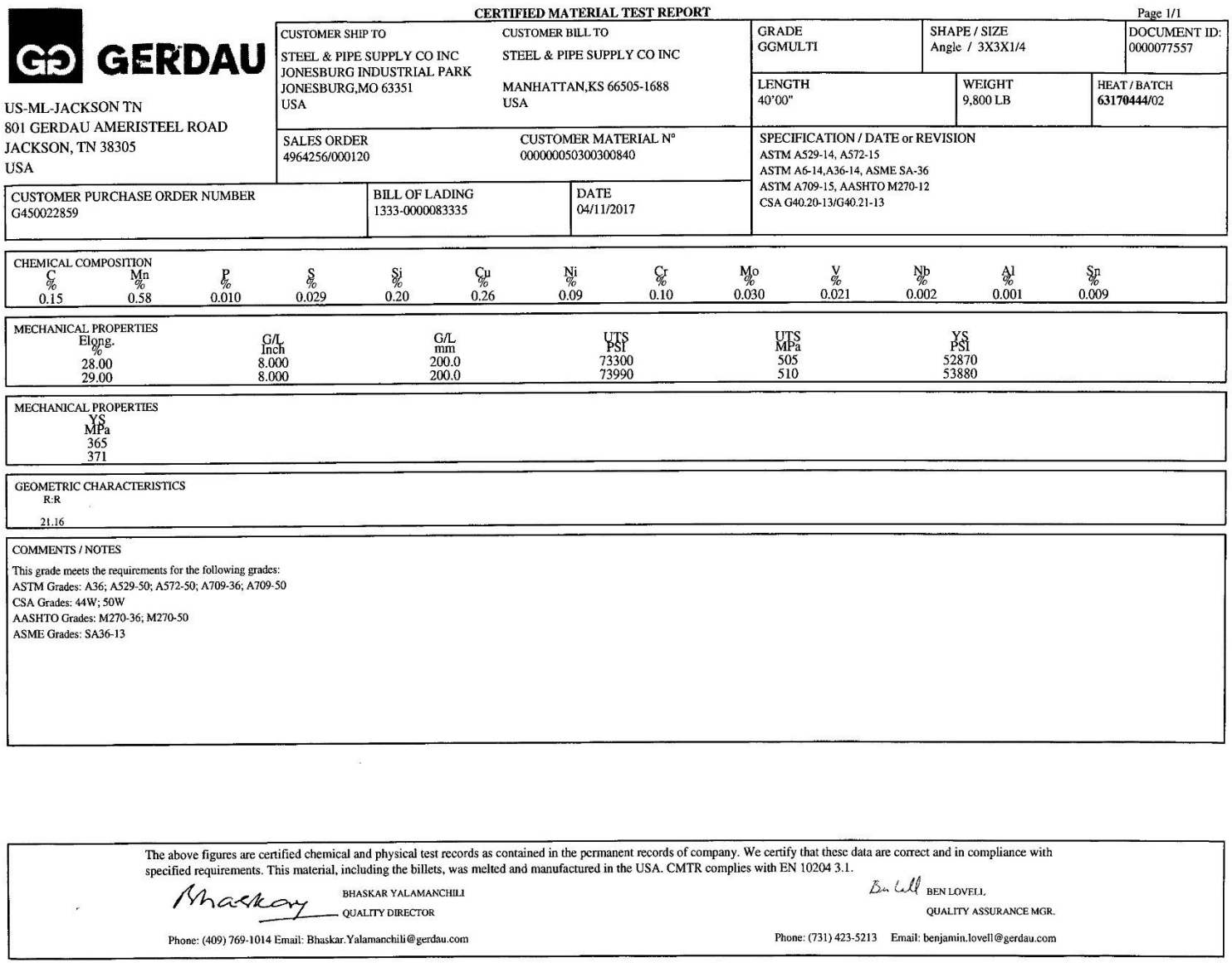
This grade meets the requirements for the following grades:
ASTM Grades: A36; A529-50; A572-50; A709-36; A709-50
CSA Grades: 44W; 50W
AASHTO Grades: M270-36; M270-50
ASME Grades: SA36-13

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 769-1014 Email: Bhaskar.Yalamanchili@gerdau.com

PRASANN JINTURKAR
QUALITY ASSURANCE MGR.
Phone: (731) 423-5256 Email: Prasann.Jinturkar@gerdau.com

Figure A-21. 18-in. (457-mm) Long and 6½-in. (165-mm) Long L-Bracket, Test No. NYT-1



GERDAU

US-ML-JACKSON TN
801 GERDAU AMERISTEEL ROAD
JACKSON, TN 38305
USA

CERTIFIED MATERIAL TEST REPORT Page 1/1

CUSTOMER SHIP TO	CUSTOMER BILL TO
STEEL & PIPE SUPPLY CO INC JONESBURG INDUSTRIAL PARK JONESBURG,MO 63351 USA	STEEL & PIPE SUPPLY CO INC MANHATTAN,KS 66505-1688 USA

GRADE	SHAPE / SIZE	DOCUMENT ID:
GGMULTI	Angle / 3X3X1/4	0000077557

LENGTH	WEIGHT	HEAT / BATCH
40'00"	9,800 LB	**63170444**/02

SALES ORDER	CUSTOMER MATERIAL N°
4964256/000120	000000050300300840

SPECIFICATION / DATE or REVISION
ASTM A529-14, A572-15
ASTM A6-14,A36-14, ASME SA-36
ASTM A709-15, AASHTO M270-12
CSA G40.20-13/G40.21-13

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
G450022859	1333-0000083335	04/11/2017

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	V %	Nb %	Al %	Sn %
0.15	0.58	0.010	0.029	0.20	0.26	0.09	0.10	0.030	0.021	0.002	0.001	0.009

MECHANICAL PROPERTIES

Elong. %	G/L Inch	G/L mm	UTS PSI	UTS MPa	YS PSI
28.00	8.000	200.0	73300	505	52870
29.00	8.000	200.0	73990	510	53880

MECHANICAL PROPERTIES

YS MPa
365
371

GEOMETRIC CHARACTERISTICS

R:R
21.16

COMMENTS / NOTES

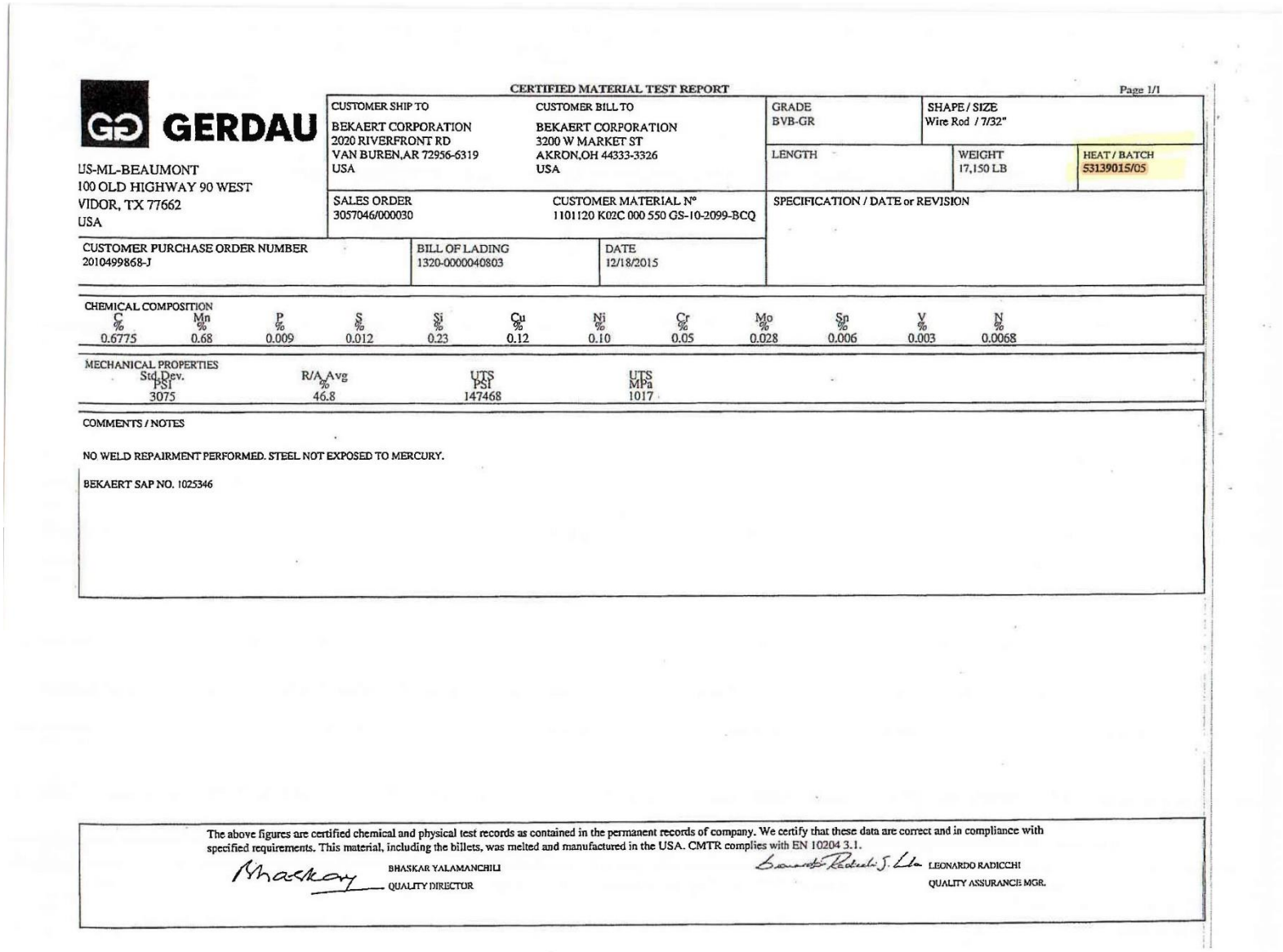
This grade meets the requirements for the following grades:
ASTM Grades: A36; A529-50; A572-50; A709-36; A709-50
CSA Grades: 44W; 50W
AASHTO Grades: M270-36; M270-50
ASME Grades: SA36-13

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR
Phone: (409) 769-1014 Email: Bhaskar.Yalamanchili@gerdau.com

BEN LOVELL
QUALITY ASSURANCE MGR.
Phone: (731) 423-5213 Email: benjamin.lovell@gerdau.com

Figure A-22. 56-in. (1,422-mm) Long L-Bracket, Test No. NYT-1



GERDAU

CERTIFIED MATERIAL TEST REPORT

Page 1/1

US-ML-BEAUMONT
100 OLD HIGHWAY 90 WEST
VIDOR, TX 77662
USA

CUSTOMER SHIP TO	CUSTOMER BILL TO
BEKAERT CORPORATION 2020 RIVERFRONT RD VAN BUREN,AR 72956-6319 USA	BEKAERT CORPORATION 3200 W MARKET ST AKRON,OH 44333-3326 USA

GRADE	SHAPE / SIZE
BVB-GR	Wire Rod / 7/32"

LENGTH	WEIGHT	HEAT / BATCH
	17,150 LB	53139015/05

SALES ORDER	CUSTOMER MATERIAL N°	SPECIFICATION / DATE or REVISION
3057046/000030	1101120 K02C 000 550 GS-10-2099-BCQ	

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
2010499868-J	1320-0000040803	12/18/2015

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	N %
0.6775	0.68	0.009	0.012	0.23	0.12	0.10	0.05	0.028	0.006	0.003	0.0068

MECHANICAL PROPERTIES

Std.Dev. PSI	R/A Avg %	UTS PSI	UTS MPa
3075	46.8	147468	1017

COMMENTS / NOTES

NO WELD REPAIRMENT PERFORMED. STEEL NOT EXPOSED TO MERCURY.

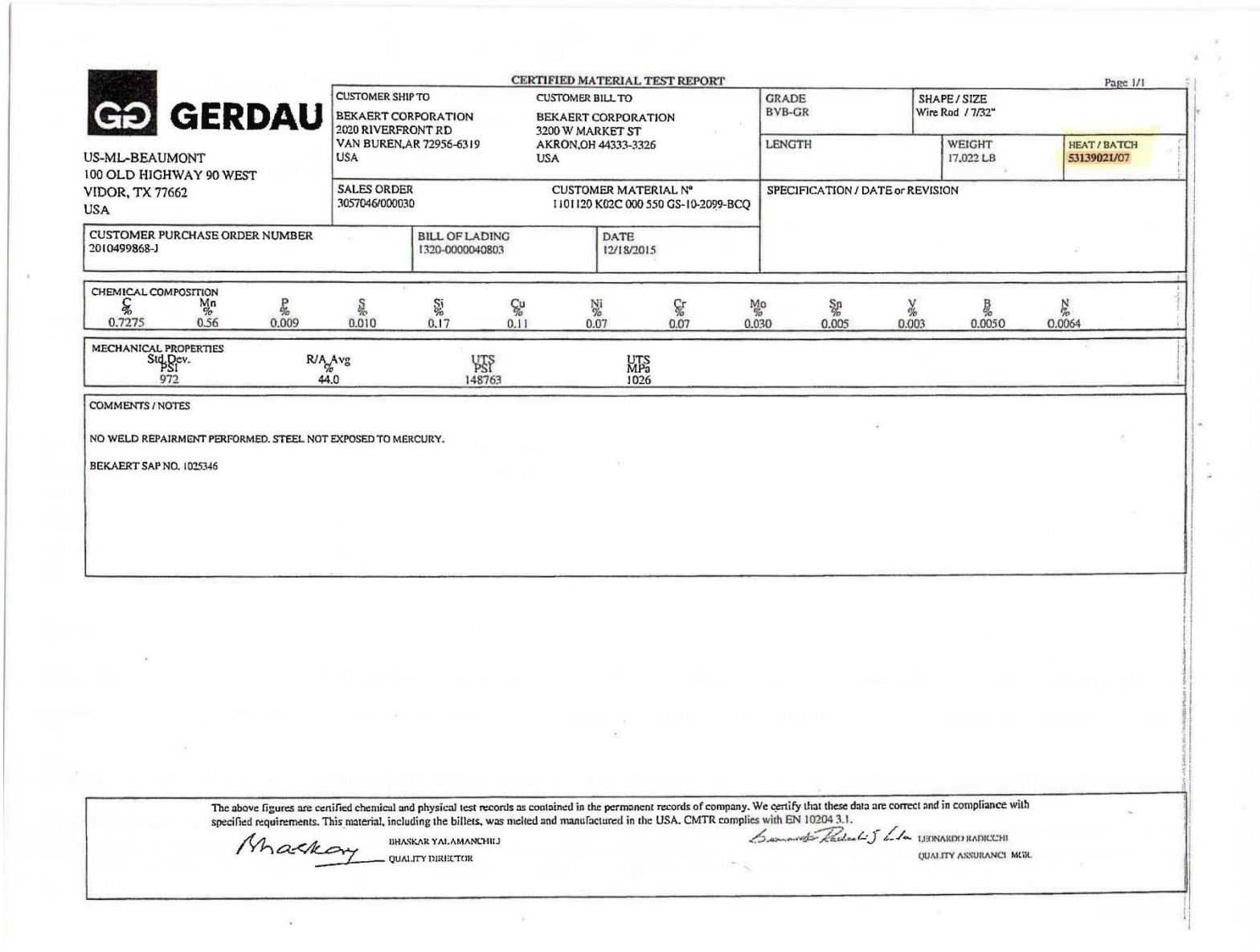
BEKAERT SAP NO. 1025346

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR

LEONARDO RADICCHI
QUALITY ASSURANCE MGR.

Figure A-23. ¾-in. (19-mm) Guardrail Cable, Test No. NYT-1



GERDAU

US-ML-BEAUMONT
100 OLD HIGHWAY 90 WEST
VIDOR, TX 77662
USA

CERTIFIED MATERIAL TEST REPORT

Page 1/1

CUSTOMER SHIP TO	CUSTOMER BILL TO
BEKAERT CORPORATION 2020 RIVERFRONT RD VAN BUREN,AR 72956-6319 USA	BEKAERT CORPORATION 3200 W MARKET ST AKRON,OH 44333-3326 USA

GRADE	SHAPE / SIZE		
BVB-GR	Wire Rod / 7/32"		
LENGTH	WEIGHT	HEAT / BATCH	
	17,022 LB	53139021/07	

SALES ORDER	CUSTOMER MATERIAL Nº	SPECIFICATION / DATE or REVISION
3057046/000030	1101120 K02C 000 550 GS-10-2099-BCQ	

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
2010499868-J	1320-0000040803	12/18/2015

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	B %	N %
0.7275	0.56	0.009	0.010	0.17	0.11	0.07	0.07	0.030	0.005	0.003	0.0050	0.0064

MECHANICAL PROPERTIES

Std Dev. PSI	R/A Avg %	UTS PSI	UTS MPa
972	44.0	148763	1026

COMMENTS / NOTES

NO WELD REPAIRMENT PERFORMED. STEEL NOT EXPOSED TO MERCURY.

BEKAERT SAP NO. 1025346

The above figures are certified chemical and physical test records as contained in the permanent records of company. We certify that these data are correct and in compliance with specified requirements. This material, including the billets, was melted and manufactured in the USA. CMTR complies with EN 10204 3.1.

BHASKAR YALAMANCHILI
QUALITY DIRECTOR

LEONARDO RADICCHI
QUALITY ASSURANCE MGR.

Figure A-24. ¾-in. (19-mm) Guardrail Cable, Test No. NYT-1

BENNETT BOLT WORKS, INC.

12 Elbridge Street
P.O. Box 922
Jordan, New York 13080

PH 315-689-3981
FX 315-689-3999

CERTIFICATION OF COMPLIANCE

Customer: Midwest Machinery & Supply Co
P.O. Box 703
Milford, NE 68405

We certify that our system and procedures for the control of quality assures that all items furnished on the order will meet applicable tests, process requirements, and inspection requirements as required by the purchase order and applicable specifications.

R#17-505
NY Box Beam BCT Cables
Orange Paint March 2017 SMT

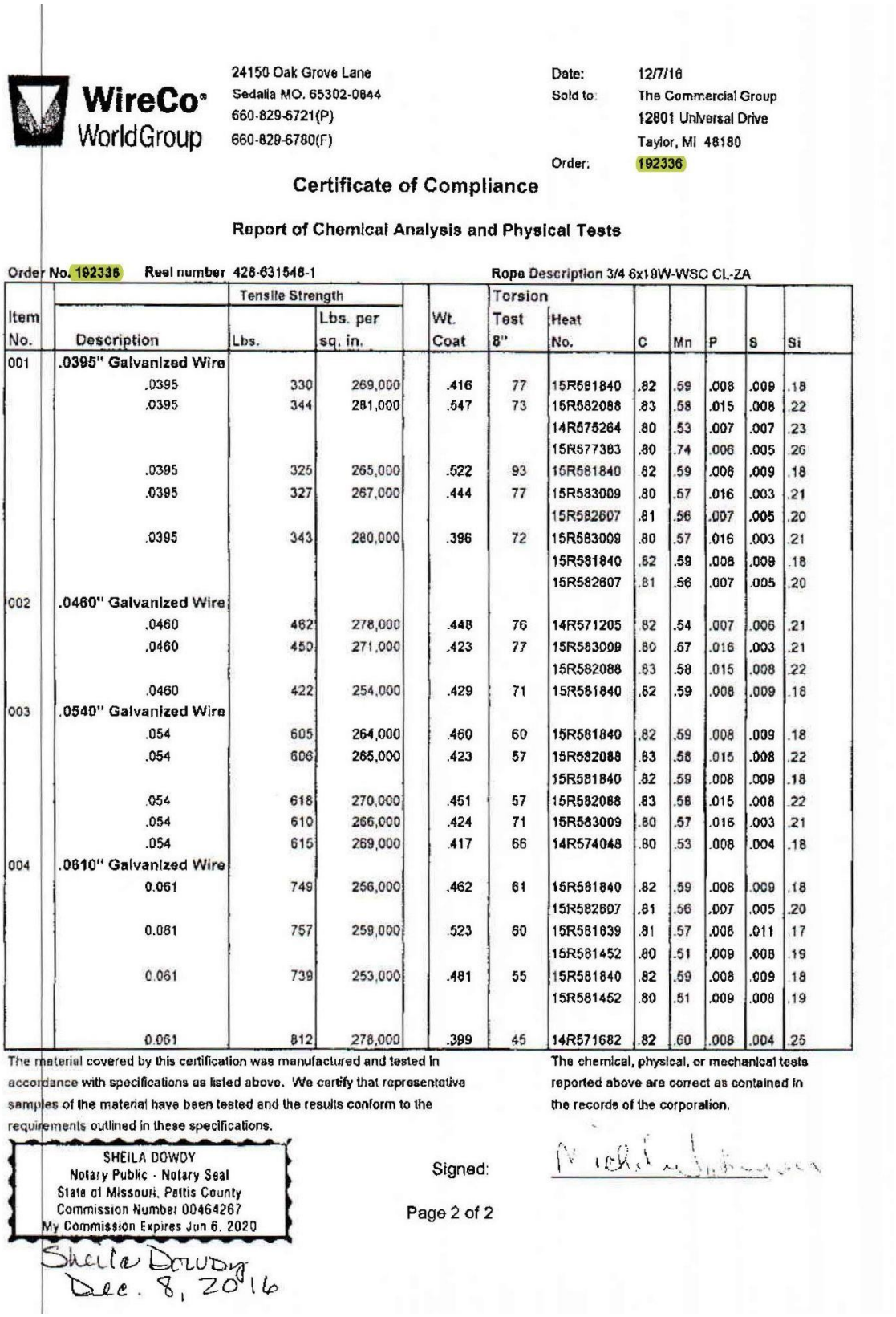
Customer P.O. No.:	3410
Date Shipped:	03/02/17
Invoice No.:	5038896
Purchase Date:	03/06/17

QUANTITY	DESCRIPTION
2	3/4 x 77 1/16" BCT Wire Rope HDG-A153 (Colorguard Rail/AZZ Galv)
2	3/4 x 166 11/16" BCT Wire Rope HDG-A153 (Colorguard Rail/AZZ Galv)

All manufacturing processes for this steel have occurred in the USA. This material is in compliance with domesticity requirements, and conforms to ASTM & AASHTO specifications for standardized highway barrier rail and hardware.

Kirk Weaver
Manufacturing Manager
Date: 03/02/17

Figure A-25. ¾-in. (19-mm) Wire Rope, Test No. NYT-1



WireCo WorldGroup

24150 Oak Grove Lane
Sedalia MO. 65302-0844
660-829-6721(P)
660-829-6780(F)

Date: 12/7/16
Sold to: The Commercial Group
12801 Universal Drive
Taylor, MI 48180
Order: 192336

Certificate of Compliance

Report of Chemical Analysis and Physical Tests

Order No. 192336 Reel number 428-631548-1 Rope Description 3/4 6x19W-WSC CL-ZA

Item No.	Description	Tensile Strength Lbs.	Tensile Strength Lbs. per sq. in.	Wt. Coat	Torsion Test 8"	Heat No.	C	Mn	P	S	Si
001	.0395" Galvanized Wire										
	.0395	330	269,000	.416	77	15R581840	.82	.59	.008	.009	.18
	.0395	344	281,000	.547	73	15R582088	.83	.58	.015	.008	.22
						14R575264	.80	.53	.007	.007	.23
						15R577383	.80	.74	.006	.005	.26
	.0395	325	265,000	.522	93	15R581840	.82	.59	.008	.009	.18
	.0395	327	267,000	.444	77	15R583009	.80	.57	.016	.003	.21
						15R582607	.81	.56	.007	.005	.20
	.0395	343	280,000	.396	72	15R583009	.80	.57	.016	.003	.21
						15R581840	.82	.59	.008	.009	.18
						15R582607	.81	.56	.007	.005	.20
002	.0460" Galvanized Wire										
	.0460	462	278,000	.448	76	14R571205	.82	.54	.007	.006	.21
	.0460	450	271,000	.423	77	15R583009	.80	.57	.016	.003	.21
						15R582088	.83	.58	.015	.008	.22
	.0460	422	254,000	.429	71	15R581840	.82	.59	.008	.009	.18
003	.0540" Galvanized Wire										
	.054	605	264,000	.460	60	15R581840	.82	.59	.008	.009	.18
	.054	606	265,000	.423	57	15R582088	.83	.58	.015	.008	.22
						15R581840	.82	.59	.008	.009	.18
	.054	618	270,000	.451	57	15R582088	.83	.58	.015	.008	.22
	.054	610	266,000	.424	71	15R583009	.80	.57	.016	.003	.21
	.054	615	269,000	.417	66	14R574048	.80	.53	.008	.004	.18
004	.0610" Galvanized Wire										
	0.061	749	256,000	.462	61	15R581840	.82	.59	.008	.009	.18
						15R582607	.81	.56	.007	.005	.20
	0.061	757	259,000	.523	60	15R581839	.81	.57	.008	.011	.17
						15R581452	.80	.51	.009	.008	.19
	0.061	739	253,000	.481	55	15R581840	.82	.59	.008	.009	.18
						15R581452	.80	.51	.009	.008	.19
	0.061	812	278,000	.399	45	14R571682	.82	.60	.008	.004	.25

The material covered by this certification was manufactured and tested in accordance with specifications as listed above. We certify that representative samples of the material have been tested and the results conform to the requirements outlined in these specifications.

The chemical, physical, or mechanical tests reported above are correct as contained in the records of the corporation.

SHEILA DOWDY
Notary Public - Notary Seal
State of Missouri, Pettis County
Commission Number 00464267
My Commission Expires Jun 6, 2020

Sheila Dowdy
Dec. 8, 2016

Signed:

Page 2 of 2

Figure A-26. ¾-in. (19-mm) Wire Rope, Test No. NYT-1, Cont.

BUCK COMPANY, INC.

897 Lancaster Pike, Quarryville, PA 17566-9738
Phone (717) 284-4114 Fax (717) 284-4321
www.buckcompany.com greatcastings@buckcompany.com

MATERIAL CERTIFICATION

Date 4/30/14 Form# CERT-7C Rev A 4/21/06

CUSTOMER: Bennett Bolt

ORDER NUMBER 0011934

PATTERN NUMBER GG1W482

This is to certify that the castings listed conform to the following specifications and comply in all respects with the drawing or ordered requirements. All Quality Assurance provisions and / or Quality Assurance requirements and / or supplementary Quality Assurance provisions have been completed and accepted. SPC data is on file and available upon request. Melted & Manufactured in the USA.

Type Material: Ductile Iron

Specifications: ASTM-A536

Grade or Class: 65-45-12

Heat Number: DA9

MECHANICAL PROPERTIES

Tensile Str. PSI 86,800

Yield Str. PSI 50,700

Elongation 12

PHYSICAL PROPERTIES

Brinell Hardness 196

CHEMICAL ANALYSIS

Total Carbon	3.80
Silicon	2.69
Manganese	.32
Sulfur	.012
Phosphorus	.022
Chrome	.035
Magnesium	.028
Copper	.256

PCS SHIPPED 2,376

DATE SHIPPED 4/29/14

1 OF 1

Quality Assurance Representative

Quality Castings
ISO 9001: 2008 CERTIFIED
Ferritic and Pearlitic Malleable Iron, Gray and Ductile Iron, Brass, Aluminum

Figure A-27. Bennett Cable End Fitter, Test No. NYT-1

BUCK COMPANY, INC.
897 Lancaster Pike, Quarryville, PA 17566-9738
Phone (717) 284-4114 Fax (717) 284-4321
www.buckcompany.com greatcastings@buckcompany.com

MATERIAL CERTIFICATION

Form# CERT-7C Rev A 4/21/06

Date 4/30/14

CUSTOMER: Bennett Bolt

ORDER NUMBER 0011934

PATTERN NUMBER CG1W484

This is to certify that the castings listed conform to the following specifications and comply in all respects with the drawing or ordered requirements. All Quality Assurance provisions and / or Quality Assurance requirements and / or supplementary Quality Assurance provisions have been completed and accepted. SPC data is on file and available upon request. Melted & Manufactured in the USA.

Type Material: Ductile Iron

Specifications: ASTM-A536

Grade or Class: 65-45-12

Heat Number: DA7

MECHANICAL PROPERTIES

Tensile Str. PSI 76,600

Yield Str. PSI 46,600

Elongation 18

PHYSICAL PROPERTIES

Brinell Hardness 179

PCS SHIPPED 1,892

1 OF 1

CHEMICAL ANALYSIS

Total Carbon	3.54
Silicon	2.73
Manganese	.37
Sulfur	.013
Phosphorus	.019
Chrome	.036
Magnesium	.043
Copper	.227

DATE SHIPPED 4/29/14

Quality Assurance Representative

Quality Castings
ISO 9001: 2008 CERTIFIED
Ferritic and Pearlitic Malleable Iron, Gray and Ductile Iron, Brass, Aluminum

Figure A-28. Bennett Cable End Fitter, Test No. NYT-1

TTML TENSILE TESTING METALLURGICAL LABORATORY

A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

Ken Forging
1049 Griggs Road
Jefferson OH 44047

Attn: Chris Dewey

Job No.: 1507-14-0723
Date: 8-21-15
Cust. PO#: 013384-40

Description:	TB108-J-Blank	3/4"-10 x 12" Turnbuckle Body Blank	
Material:	1035	Heat# 145050	Heat Code: S1
Spec:	ASTM A668-04(09) Class A 235 HBW Max. per Ken Forge DWR-0018		

TEST RESULTS

	Tensile, ksi	Yield, .2% ksi	Elong., % in 4D	Red. Of Area, %	*Hardness, HBW
Requirements (Min.):	47	—	—	—	235 Max.
	111	71.5	20	48	223

Test Method: ASTM A370-14, *Converted from HRBW

Product Analysis of Elements in % (OES per TTML C-01J):

	Actual	Requirements
Carbon	0.34	0.32-0.38
Manganese	0.77	0.60-0.90
Phosphorus	0.012	0.030 Max.
Sulfur	0.032	0.050 Max.
Silicon	0.25	N/A
Chromium	0.15	N/A
Nickel	0.08	N/A
Molybdenum	0.02	N/A
Columbium	0.005	N/A
Aluminum	<0.002	N/A
Copper	0.27	N/A
Vanadium	0.04	N/A
Titanium	0.002	N/A

The above **conforms** to specifications listed.

Authorized Agent

Figure A-29. Bennet Threaded Turnbuckle, Test No. NYT-1

TTML TENSILE TESTING METALLURGICAL LABORATORY

A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

Ken Forging
1049 Griggs Road
Jefferson OH 44047

Attn: Chris Dewey

Job No.: 1507-14-0723
Date: 8-21-15
Cust. PO#: 013384-40

Description:	TB108-J-Blank	3/4"-10 x 12 Turnbuckle Body Blank	
Material:	1035	Heat# 145050	Heat Code: S1
Spec:	ASTM F1145-05(11)		

TEST RESULTS

	Breaking Strength, lbs
Requirements (Min.):	20,000
	40,000

Break Location: No Fracture

The above **conforms** to specifications listed.

Authorized Agent

Figure A-30. Bennet Threaded Turnbuckle, Test No. NYT-1, Cont.

COMPANY WITH QUALITY SYSTEM CERTIFIED BY DNV = ISO 9001:2008 =

Crosby®
2801 Dawson Rd
Tulsa, OK 74110
www.thecrosbygroup.com

Certificate of Conformance

Certificate Number: CC1-2017040700802
Location of Issue: Crosby
2801 Dawson Rd
Tulsa, OK 74110 USA
Phone: 918-834-4611 Fax: 918-832-0940

Stock No: 1032714
Description of Gear: HG228 3/4X12 Jaw & Jaw Turnbuckle
Working Load Limit: 5,200 lbs | Max. Allowed Proof Load: 13,000 lbs
Comments: Ultimate load is 5 times the WLL
Note: Meets the performance requirements of Federal Specification ASTM F-1145, except for those provisions required of the contractor.
Meets or exceeds all requirements of ASME B30.26
Has not been contaminated by Mercury or Asbestos in the manufacturing process.
Number of Pieces: 2
Generic certificate based on item being the Crosby product described above.

We hereby certify that the above described material was manufactured and processed in a manner compatible to meeting the load ratings when used under normal and proper applications.

Mentioned products are in conformity to the Crosby literature available at time of manufacturing, including the following trademarked features:

QT Fatigue Rated CE

For Product Delivered To: MIDWEST UNLIMITED
1750 W. O Street
LINCOLN, NE 68528 USA

Date: April 07, 2017
Date of Issuance

Signature: Donna DeWitt
Donna DeWitt, Crosby Director of Quality

Figure A-31. Crosby Jaw, Test No. NYT-1

BUCK COMPANY, INC.
897 Lancaster Pike, Quarryville, PA 17566-9738
Phone (717) 284-4114 Fax (717) 284-4321
www.buckcompany.com greatcastings@buckcompany.com

MATERIAL CERTIFICATION

Date 4/28/14 Form# CERT-7C Rev A 4/21/06

CUSTOMER: Bennett Built

ORDER NUMBER 6011934

PATTERN NUMBER W1 Wedge

This is to certify that the castings listed conform to the following specifications and comply in all respects with the drawing or ordered requirements. All Quality Assurance provisions and / or Quality Assurance requirements and / or supplementary Quality Assurance provisions have been completed and accepted. SPC data is on file and available upon request. Melted & Manufactured in the USA.

Type Material: Malleable Iron

Specifications: ASTM - A47

Grade or Class: 32510

Heat Number: DA8

MECHANICAL PROPERTIES

Tensile Str. PSI 53,665

Yield Str. PSI 35,031

Elongation 14

PHYSICAL PROPERTIES

Brinell Hardness 126

CHEMICAL ANALYSIS

Total Carbon	2.61
Silicon	1.56
Manganese	.38
Sulfur	.113
Phosphorus	.014
Chrome	.039
Magnesium	.001
Copper	.373

PCS SHIPPED 9,698

DATE SHIPPED 4/25/14

1 OF 1

Quality Assurance Representative

Quality Castings
ISO 9001: 2008 CERTIFIED
Ferritic and Pearlitic Malleable Iron, Gray and Ductile Iron, Brass, Aluminum

Figure A-32. Cable Wedges, Test No. NYT-1

SOLD TO: BENNETT BOLT WORKS INC
12 ELBRIDGE ST
JORDAN, NY 13080-0000

NUCOR
BAR MILL GROUP
NUCOR STEEL AUBURN, INC.

CERTIFIED MILL TEST REPORT

Ship from:
Nucor Steel - Auburn
25 Quarry Road
Auburn, NY 13021
315-253-4561

SHIP TO: BENNETT BOLT WORKS INC
CUSTOMER PICK-UP
JORDAN, NY 13080-0000

Date: 3-Aug-2009
B.L. Number: 365821
Load Number: 115335

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

NBMG-08 March 24, 2009

HEAT NUM. *	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	75989												
AU0810817802	Nucor Steel - Auburn Inc						.49	.77	.009	.031	.22	.35	
AU08108178A	3/4 Rd 20						.09	.10	.025 0	.00	.001		
	A576 GR 1045												
	ASTM A576-90b(2006) GR 1045												

I HEREBY CERTIFY THAT THE ABOVE FIGURES ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION.

ALL MANUFACTURING PROCESSES OF THE STEEL MATERIALS IN THIS PRODUCT, INCLUDING MELTING, HAVE OCCURRED WITHIN THE UNITED STATES. ALL PRODUCTS PRODUCED ARE WELD FREE.

QUALITY ASSURANCE: Jim Biernat

Figure A-33. 11-in. (279-mm) Long Threaded Rod, Test No. NYT-1

GERDAU

GERDAU SPECIAL STEEL NORTH AMERICA
5591 MORRILL ROAD
JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
297134	H1625RCH2000MOD2	75063022	303022 101	5/31/16

210mm Billet

REPORT TO
ROB
NEW DIMENSION METALS CORP
3050 DRYDEN RD
ATTN PHIL RUSTON

DAYTON , OH 45439

SHIP TO
NEW DIMENSION METALS CORP

3050 DRYDEN ROAD

DAYTON , OH 45439

ORDERED

GRADE	SIZE	LENGTH
1035	1 5/8" RND	20'

CUSTOMER SPECIFICATIONS
ASTM A576; VD; ALUM FG

CHEMICAL ANALYSIS

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Sn	Al
0.34	0.88	0.012	0.025	0.22	0.13	0.13	0.04	0.11	0.008	0.024

V	Nb
0.000	0.002

GRAIN SIZE SPECIFICATION ASTM E 112 FINE GRAIN 5-8

HARDNESS SPECIFICATION ASTM E10 AS ROLLED

SURFACE
186.0

MICROCLEANLINESS SPECIFICATION ASTM E45 METH A

	A		B		C		D	
	T	H	T	H	T	H	T	H
AVERAGE	1.6	0.6	1.0	0.0	0.5	0.0	1.0	0.5

PAGE 1
We certify that these data are correct and in compliance with specified requirements.

Gerdau Monroe
3000 East Front Street
Monroe, MI 48161

Quality Assurance Representative

CONTINUED ON PAGE 2

Figure A-34. BCT Anchor Cable End Swaged Fitting, Test No. NYT-1

GERDAU

GERDAU SPECIAL STEEL NORTH AMERICA
5591 MORRILL ROAD
JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
297134	H1625RCH2000MOD2	75063022	303022 101	5/31/16

210mm Billet

REPORT TO
ROB
NEW DIMENSION METALS CORP
3050 DRYDEN RD
ATTN PHIL HUSTON

DAYTON , OH 45439

SHIP TO
NEW DIMENSION METALS CORP
3050 DRYDEN ROAD

DAYTON , OH 45439

ORDERED

GRADE	SIZE	LENGTH
1035	1 5/8" RND	20'

CUSTOMER SPECIFICATIONS
ASTM A576; VD; ALUM FG

PHYSICALS SPECIFICATION ASTM E8/370 AS ROLLED

02.0 IN

TENSILE KSI	YIELD KSI	% ELONGATION	REDUCTION OF AREA
92.0	50.5	21.0	37.0

DI CALCULATION SPECIFICATION CAT 1B24

1.30

DECARB SPECIFICATION ASTM E1077

F TOTAL= 0.014

REDUCTION RATIO

RATIO= 32.8 TO 1.0

** MATERIAL 100% MELTED AND MANUFACTURED IN THE U.S.A. BY THE ELECTRIC ARC FURNACE AND CONTINUOUS CASTING METHOD. THE PRODUCT HAS NOT BEEN REPAIRED BY WELDING AND THIS MATERIAL HAS NOT BEEN EXPOSED TO MERCURY OR TO ANY OTHER METAL ALLOY THAT IS LIQUID AT AMBIENT TEMPERATURES DURING PROCESSING OR WHILE IN OUR POSSESSION.
GERDAU MONITORS ALL INCOMING SCRAP AND ALL HEATS OF STEEL TO ENSURE THAT

PAGE 2

We certify that these data are correct and in compliance with specified requirements.

Gerdau Monroe
3000 East Front Street
Monroe, MI 48161

Quality Assurance Representative

CONTINUED ON PAGE 3

Figure A-35. BCT Anchor Cable End Swaged Fitting, Test No. NYT-1, Cont.

GERDAU

GERDAU SPECIAL STEEL NORTH AMERICA
5591 MORRILL ROAD
JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
29217	H0968RSA3200	75062074	300927 101	3/16/16
		210mm Billet		

REPORT TO
ROB
NEW DIMENSION METALS CORP
3050 DRYDEN RD
ATTN PHIL HUSTON

DAYTON , OH 45439

SHIP TO
NEW DIMENSION METALS CORP
3050 DRYDEN ROAD

DAYTON , OH 45439

ORDERED

GRADE	SIZE	LENGTH
15V41	0 31/32" RND	32'

CUSTOMER SPECIFICATIONS
PER STANDARD LOAD HIGH- UBOLT 8 SPEC. DTD 8/16/13

CHEMICAL ANALYSIS

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Sn	Al
0.43	1.49	0.010	0.024	0.33	0.11	0.08	0.02	0.16	0.010	0.024

V	Ti	Nb	N
0.069	0.014	0.002	0.0100

GRAIN SIZE SPECIFICATION ASTM E112 FINE GRAIN 5-8

HARDNESS SPECIFICATION ASTM E10 AS ROLLED

SURFACE
286.0

MICROCLEANLINESS SPECIFICATION ASTM E45 METH A

	A		B		C		D	
	T	H	T	H	T	H	T	H
AVERAGE	1.0	0.3	1.0	0.0	0.1	0.0	1.0	0.5

PAGE 1

We certify that these data are correct and in compliance with specified requirements.

Gerdau Monroe
3000 East Front Street
Monroe, MI 48161

Gabriela Felipe
Quality Assurance Representative

CONTINUED ON PAGE 2

Figure A-36. BCT Anchor Cable End Swaged Fitting, Test No. NYT-1

GERDAU

GERDAU SPECIAL STEEL NORTH AMERICA
5591 MORRILL ROAD
JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
29217	H0968RSA3200	75062074	300927 101	3/16/16
		210mm Billet		

REPORT TO
ROB
NEW DIMENSION METALS CORP
3050 DRYDEN RD
ATTN PHIL HUSTON

DAYTON , OH 45439

SHIP TO
NEW DIMENSION METALS CORP
3050 DRYDEN ROAD

DAYTON , OH 45439

ORDERED

GRADE	SIZE	LENGTH
15V41	0 31/32" RND	32'

CUSTOMER SPECIFICATIONS
PER STANDARD LOAD HIGH- UBOLT 8 SPEC. DTD 8/16/13

PHYSICALS SPECIFICATION ASTM E8/A370 AS ROLLED

0.0 IN

TENSILE KSI	YIELD KSI	% ELONGATION	REDUCTION OF AREA
131.1	89.4	15.0	41.1

DI CALCULATION SPECIFICATION CAT 1E0024

2.69

DECARB SPECIFICATION ASTM E1077

F TOTAL= 0.008

REDUCTION RATIO

RATIO= 92.5 TO 1.0

** MATERIAL 100% MELTED AND MANUFACTURED IN THE U.S.A. BY THE ELECTRIC ARC FURNACE AND CONTINUOUS CASTING METHOD. THE PRODUCT HAS NOT BEEN REPAIRED BY WELDING AND THIS MATERIAL HAS NOT BEEN EXPOSED TO MERCURY OR TO ANY OTHER METAL ALLOY THAT IS LIQUID AT AMBIENT TEMPERATURES DURING PROCESSING OR WHILE IN OUR POSSESSION.
GERDAU MONITORS ALL INCOMING SCRAP AND ALL HEATS OF STEEL TO ENSURE THAT

PAGE 2

We certify that these data are correct and in compliance with specified requirements.

Gerdau Monroe
3000 East Front Street
Monroe, MI 48161

Quality Assurance Representative

Figure A-37. BCT Anchor Cable End Swaged Fitting, Test No. NYT-1, Cont.

GERDAU

GERDAU SPECIAL STEEL NORTH AMERICA
5591 MORRILL ROAD
JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
29644	H0968RSA3200	75063075 210mm Billet	302684 101	6/30/16

REPORT TO
ROB
NEW DIMENSION METALS CORP
3050 DRYDEN RD
ATTN PHIL HUSTON

DAYTON , OH 45439

SHIP TO
NEW DIMENSION METALS CORP
3050 DRYDEN ROAD

DAYTON , OH 45439

ORDERED

GRADE	SIZE	LENGTH
15V41	0 31/32" RND	32'

CUSTOMER SPECIFICATIONS
PER STANDARD LOAD HIGH- UBOLT 8 SPEC. DTD 8/16/13

CHEMICAL ANALYSIS

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Sn	Al
0.41	1.49	0.009	0.022	0.33	0.10	0.08	0.03	0.09	0.010	0.020

V	Ti	Nb	N
0.064	0.013	0.002	0.0090

GRAIN SIZE SPECIFICATION ASTM E112 FINE GRAIN 5-8

HARDNESS SPECIFICATION ASTM E10 AS ROLLED

SURFACE
266.0

MICROCLEANLINESS SPECIFICATION ASTM E45 METH A

	A		B		C		D	
	T	H	T	H	T	H	T	H
AVERAGE	0.8	0.1	0.9	0.0	0.2	0.0	1.0	0.5

PAGE 1

We certify that these data are correct and in compliance with specified requirements.

Gerdau Monroe
3000 East Front Street
Monroe, MI 48161

Quality Assurance Representative

CONTINUED ON PAGE 2

Figure A-38. BCT Anchor Cable End Swaged Fitting, Test No. NYT-1

GERDAU

GERDAU SPECIAL STEEL NORTH AMERICA
6591 MORRILL ROAD
JACKSON, MICHIGAN 49201

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
29644	H0968RSA3200	75063075	302684 101	6/30/16

210mm Billet

REPORT TO
ROB
NEW DIMENSION METALS CORP
3050 DRYDEN RD
ATTN PHIL HUSTON

DAYTON , OH 45439

SHIP TO
NEW DIMENSION METALS CORP
3050 DRYDEN ROAD

DAYTON , OH 45439

ORDERED

GRADE	SIZE	LENGTH
15V41	0 31/32" RND	32'

CUSTOMER SPECIFICATIONS
PER STANDARD LOAD HIGH- UBOLT 8 SPEC. DTD 8/16/13

PHYSICALS SPECIFICATION ASTM E8/A370 AS ROLLED

0.0 IN

TENSILE KSI	YIELD KSI	% ELONGATION	REDUCTION OF AREA
131.8	90.0	14.8	49.9

DI CALCULATION SPECIFICATION CAT 1E0024

2.62

DECARB SPECIFICATION ASTM E1077

F TOTAL= 0.015

REDUCTION RATIO

RATIO= 92.5 TO 1.0

** MATERIAL 100% MELTED AND MANUFACTURED IN THE U.S.A. BY THE ELECTRIC ARC FURNACE AND CONTINUOUS CASTING METHOD. THE PRODUCT HAS NOT BEEN REPAIRED BY WELDING AND THIS MATERIAL HAS NOT BEEN EXPOSED TO MERCURY OR TO ANY OTHER METAL ALLOY THAT IS LIQUID AT AMBIENT TEMPERATURES DURING PROCESSING OR WHILE IN OUR POSSESSION. GERDAU MONITORS ALL INCOMING SCRAP AND ALL HEATS OF STEEL TO ENSURE THAT

PAGE 2

We certify that these data are correct and in compliance with specified requirements.

Gerdau Monroe
3000 East Front Street
Monroe, MI 48161

Quality Assurance Representative

CONTINUED ON PAGE 3

Figure A-39. BCT Anchor Cable End Swaged Fitting, Test No. NYT-1, Cont.

ISO/TS 16949 BUREAU VERITAS Certification

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

MANUFACTURER :GEM-YEAR INDUSTRIAL CO., LTD.
ADDRESS : NO.8 GEM-YEAR ROAD,E.D.Z.,JIASHAN,ZHEJIANG,P.R.CHINA

Tel: (0573)84185001(48Lines)
Fax: (0573)84184488 84184567
DATE : 2017/05/10

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 480003368
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/4-10 NC O/T 0.51MM
LOT NO : 1N1610043
SHIP QUANTITY : 7,000 PCS
LOT QUANTITY 27,011 PCS
HEADMARKS :

PACKING NO : GEM160303010
INVOICE NO : GEM/FNL-160324IN-4
PART NO : 1136715
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 15311340-3
MATERIAL : X1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2016/02/22
COUNTRY OF ORIGIN : CHINA

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0290	0.0600	0.2700	0.0150	0.0090	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY: TAO JIA MIN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	4 PCS		1.2400-1.2990 inch	1.2780-1.2830 inch	4	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0180 inch	0.0150-0.0170 inch	15	0
THICKNESS	4 PCS		0.6170-0.6650 inch	0.6220-0.6220 inch	4	0
WIDTH ACROSS FLATS	4 PCS		1.0880-1.1250 inch	1.1080-1.1110 inch	4	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A563-2015

SAMPLED BY: GDAN LIAN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	80-82 HRB	15	0
PROOF LOAD	4 PCS	ASTM F606-2014		Min. 90 KSI	OK	4	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	79.11-86.37	5	0

WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

Quality Supervisor:

Figure A-40. ¾-in. (19-mm) Square Nut, Test No. NYT-1

FASTENAL®

Certificate of Compliance

Sold To:

UNL TRANSPORTATION

Purchase Order:

Job:

Invoice Date: 05/09/2017

THIS IS TO CERTIFY THAT WE HAVE SUPPLIED YOU WITH THE FOLLOWING PARTS.
THESE PARTS WERE PURCHASED TO THE FOLLOWING SPECIFICATIONS.

6 PCS 3/4"-10 Hot Dip Galvanized Finish Grade A Finished Hex Nut SUPPLIED UNDER OUR TRACE NUMBER 480003368 AND UNDER PART NUMBER 1136715

6 PCS 3/4"-10 Grade A Hot Dipped Galvanized Finish Steel Regular Square Nut SUPPLIED UNDER OUR TRACE NUMBER 120265730 AND UNDER PART NUMBER 0189532

This is to certify that the above document is true and accurate to the best of my knowledge.

Please check current revision to avoid using obsolete copies.

This document was printed on 05/15/2017 and was current at that time.

Fastenal Account Representative Signature

Printed Name

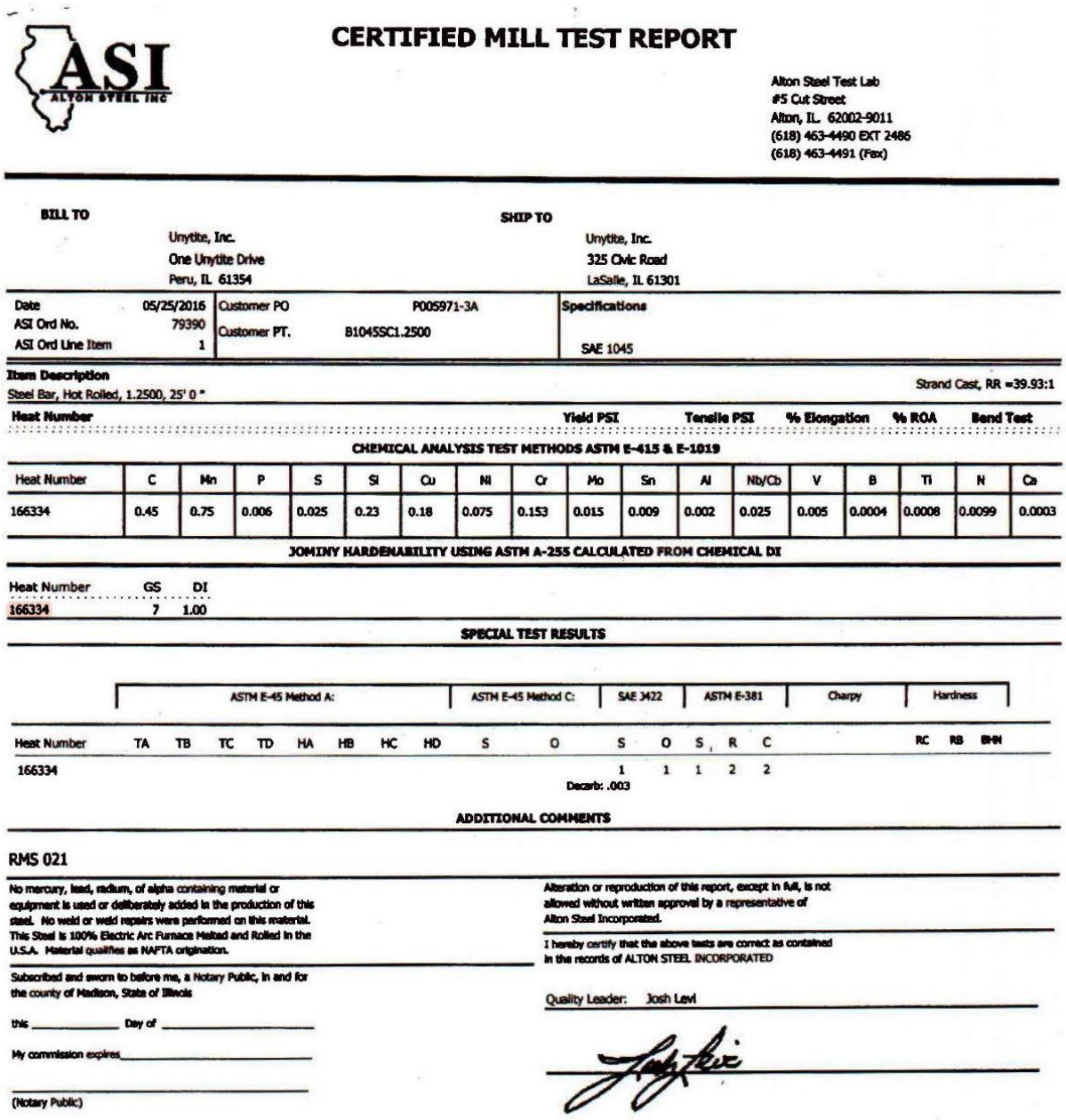
Date

Fastenal Store Location/Address

3201 N. 23rd Street STE 1
LINCOLN, NE 68521
Phone #: (402)476-7900
Fax #: 402/476-7958

Page 1 of 1

Figure A-41. ¾-in. (19-mm) Square and Hex Nut, Test No. NYT-1



CERTIFIED MILL TEST REPORT

Alton Steel Test Lab
#5 Cut Street
Alton, IL 62002-9011
(618) 463-4490 EXT 2486
(618) 463-4491 (Fax)

BILL TO
Unytite, Inc.
One Unytite Drive
Peru, IL 61354

SHIP TO
Unytite, Inc.
325 Civic Road
LaSalle, IL 61301

Date	05/25/2016	Customer PO	P005971-3A	Specifications
ASI Ord No.	79390	Customer PT.	B1045SC1.2500	SAE 1045
ASI Ord Line Item	1			

Item Description
Steel Bar, Hot Rolled, 1.2500, 25' 0 "
Strand Cast, RR =39.93:1

Heat Number | **Yield PSI** | **Tensile PSI** | **% Elongation** | **% ROA** | **Bend Test**

CHEMICAL ANALYSIS TEST METHODS ASTM E-415 & E-1019

Heat Number	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	Nb/Cb	V	B	Ti	N	Ca
166334	0.45	0.75	0.006	0.025	0.23	0.18	0.075	0.153	0.015	0.009	0.002	0.025	0.005	0.0004	0.0008	0.0099	0.0003

JOMINY HARDENABILITY USING ASTM A-255 CALCULATED FROM CHEMICAL DI

Heat Number	GS	DI
166334	7	1.00

SPECIAL TEST RESULTS

	ASTM E-45 Method A:								ASTM E-45 Method C:		SAE J422		ASTM E-381		Charpy	Hardness		
Heat Number	TA	TB	TC	TD	HA	HB	HC	HD	S	O	S	O	S	R	C	RC	RB	BHN
166334											1	1	1	2	2			

Decarb: .003

ADDITIONAL COMMENTS

RMS 021

No mercury, lead, radium, of alpha containing material or equipment is used or deliberately added in the production of this steel. No weld or weld repairs were performed on this material. This Steel is 100% Electric Arc Furnace Melted and Rolled in the U.S.A. Material qualifies as NAFTA origination.

Subscribed and sworn to before me, a Notary Public, in and for the county of Madison, State of Illinois

this _____ Day of _____

My commission expires_____

_____
(Notary Public)

Alteration or reproduction of this report, except in full, is not allowed without written approval by a representative of Alton Steel Incorporated.

I hereby certify that the above tests are correct as contained in the records of ALTON STEEL INCORPORATED

Quality Leader: Josh Levi

Figure A-42. 1-in. (25-mm) Diameter Heavy Hex Nut for Downstream Cable Assembly, Test No. NYT-1

R#17-411 NY Box Rail
BCT Nuts and Washers
Feb2017 SMT Yellow Paint

Prestige Stamping, Inc.

23513 Groesbeck Highway
Warren, Michigan 48089
(586)773-2700 * Fax (586)773-2298
www.PrestigeStamping.com

PRODUCT CERTIFICATION
CERTIFICATION NUMBER
111237

THIS IS TO CERTIFY THE PRODUCT STATED BELOW WAS FABRICATED AND PROCESSED TO THE ORDER AS INDICATED AND CONFORMS TO THE APPLICABLE SPECIFICATIONS AND STANDARDS.

Customer: BENNETT BOLT WORKS INC
12 ELBRIDGE ST
JORDAN, NY 13080

Customer Part:	100NWUS0H/BOX	Steel Supplier:	MARATHON METALS, LLC
Prestige Part:	F2523MP300	Grade:	CSECONDARY STEEL
Part Name:	1"USS LOW CARBON H/DIP	Lot:	C6992
Purchase Order:	6011096-1	Heat:	0266540
Shipment BOL:	B167276	Carbon:	.051 (2.13 Max.)
Shipment ID:	A0177562	Manganese:	.3794 (2.6 Max.)
Quantity:	16365	Phosphorous:	.0225 (2.04 Max.)
Manufacturers Marking:	"P"	Sulfur:	.0064 (2.05 Max.)
		Silicon:	.0089

SPECIFICATIONS	TEST RESULTS
:	:
PLATING: TEST METHOD: ASTM B499 0.0017" Min. HOT DIP GLAV ASTM F-2329	PLATING: 0.0020" - 0.0025"

Chemistry is as reported from raw material certification and does not fall under Prestige Stamping's accreditation.
This product was produced under an ISO/TS 16949 Quality Assurance System.
ISO/TS 16949 Certification No: 0062833.
Material was melted and manufactured in the U.S.A.
This product was manufactured in Warren, Michigan U.S.A.
This product conforms to all requirements for washers as produced according to ANSI/ASMI B18.22.1.
Mechanical properties and test methods for hardness conform to ASTM F436
Sampling Plan per P.S.I W.I. # 5.4.18.015.
The test results only apply to the items tested.
This test report must not be reproduced except in full without prior written approval.
Materials used to manufacture these products are mercury, asbestos and radio activity free.
No weld repairs made to material.

FRANK SCHUBERT
Quality Assurance Manager

Econ Information System 07/29/13 11:07 SLEW PAGE 1 of 1

Figure A-43. 1-in. (25-mm) Diameter Plain Round Washer, Test No. NYT-1

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

MANUFACTURER GEM-YEAR INDUSTRIAL CO., LTD.
ADDRESS : NO.8 GEM-YEAR ROAD,E.D.Z.,JIASHAN,ZHEJIANG,P.R.CHINA
Tel: (0573)84185001(48Lines)
Fax: (0573)84184488 84184567
DATE : 2017/03/20

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 120094419
COMMODITY : HEX MACHINE BOLT GR-A
SIZE : 1/4-20X8 NC
LOT NO : 1B1092640
SHIP QUANTITY : 7,200 PCS
LOT QUANTITY 7,252 PCS
HEADMARKS : CYI & 307A

PACKING NO : GEM101213009
INVOICE NO : GEM/FNL-101221 IN-1
PART NO : 91824
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 10201285-3
MATERIAL : X1010A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2010/10/15
COUNTRY OF ORIGIN : CHINA

R#17-510
NY DOT BOX BEAM

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A307-2014

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.3300	1.2500	0.0410		
Test Value	0.0430	0.1000	0.3900	0.0100	0.0060	0.0200

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.1-2012

SAMPLED BY : ZHANG HUI JING

INSPECTIONS ITEM	SAMPLE	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
THREAD LENGTH	15 PCS	1.0000 inch	1.1310-1.1600 inch	15	0
MAJOR DIAMETER	15 PCS	0.2420-0.2500 inch	0.2420-0.2450 inch	15	0
BODY DIAMETER	4 PCS	0.2370-0.2600 inch	0.2460-0.2480 inch	4	0
WIDTH ACROSS CORNERS	4 PCS	0.4840-0.5050 inch	0.4950-0.4950 inch	4	0
HEIGHT	4 PCS	0.1500-0.1880 inch	0.1520-0.1590 inch	4	0
NOMINAL LENGTH	15 PCS	7.8200-8.1000 inch	7.9020-7.9200 inch	15	0
WIDTH ACROSS FLATS	4 PCS	0.4250-0.4380 inch	0.4300-0.4370 inch	4	0
SURFACE DISCONTINUITIES	22 PCS	ASTM F788-2013	PASSED	22	0
THREAD	15 PCS	ASME B1.1-2003 nut	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A 307-2014

SAMPLED BY : TANGHAO

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		Max. 100 HRB	86-89 HRB	15	0
TENSILE STRENGTH	4 PCS	ASTM F606-2014		Min. 60 KSI	66-69 KSI	4	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	55.5-77.9	5	0

WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

Quality Supervisor:

Figure A-44. ½-in. (6-mm) Diameter Hex Head Shear Bolt, Test No. NYT-1

Certified Material Test Report to BS EN 10204-2004 3.1
FOR ASTM A563, GRADE A HEX FIN NUTS

FACTORY: IFI & Morgan Ltd. Haiyan Office
ADDRESS: Haiyan, Zhejiang, China

REPORT DATE:05 Dec,2016

R#17-510
NY DOT BOX BEAM
1/4" NUTS USED FOR
H1 AND H2 BOLTS

CUSTOMER:

MFG LOT NUMBER: GL16263-1

SAMPLE SIZE: ACC. TO ASME B18.18-11;ASTM F1470-12
SIZE: 1/4-20 HDG
QTY: 150000 PCS

PO NUMBER:220022810

PART NO: 1136701

STEEL PROPERTIES
STEEL GRADE: Q195

HEAT NUMBER: 184259

CHEMISTRY SPEC:
ASTM A563 GRADE A
TEST:

C %*100 0.55max	Mn%*100 min	P %*1000 0.12max	S %*1000 0.15max
0.08	0.34	0.022	0.022

DIMENSIONAL INSPECTIONS — SPECIFICATION: ASME-B18.2.2-2010

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F812-2013		PASSED	29	0
THREAD	ASME B1.3-2003 2B		PASSED	15	0
WIDTH A/F	0.438-0.428		0.435-0.432	5	0
WIDTH A/C	0.505-0.488		0.498-0.496	3	0
HEIGHT	0.226-0.212		0.220-0.218	4	0

MECHANICAL PROPERTIES: 1/4" to 1 1/2" — SPECIFICATION: ASTM A563-07a GR-A

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
HARDNESS :	ASTM F606-2014	B68-C32 Max(107HRB)	C25-27	15	0
PROOF LOAD :	ASTM F606-2014	Min 68 Ksi	72 Ksi	5	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
HOT DIP GALVANIZED	ASTM F2329-05	MIN 2.10miu	2.50miu	4	0

ALL TESTS IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE ASTM OR SAE SPECIFICATION. WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY.

(SIGNATURE OF Q.A. LAB MGR.)
(NAME OF MANUFACTURER)

Figure A-45. ¼-in. (6-mm) Diameter Nuts, Test No. NYT-1

CERTIFIED MATERIAL TEST REPORT
FOR ASTM A307, GRADE A FULLY THREADED HEX BOLTS

FACTORY: NINGBO ECONOMIC & TECHNICAL DEVELOPMENT ZONE YONGGANG FASTENERS CO., LTD.
REPORT DATE:2015/11/11
ADDRESS: FuShan South Road No.17,BeiLun NingBo China
NY DOT Box Beam Item H2
H#715030091
MANUFACTURE DATE:2015/10/14
CUSTOMER: FASTENAL
MFG LOT NUMBER:M-2015HT909-3
MANU QTY: 89250PCS
SHIPPED QTY: 89250PCS
SAMPE SIZE: ACC.TO Dimension:ASME B18.18-11;Mechanical Properties:ASTM F1470-12
SIZE: 1/4-20X1 ZP CR3+
HEADMARKS: 307A PLUS NY
PO NUMBER:220019936
PART NO:10803

STEEL PROPERTIES:
MATERIAL TYPE:Q195
HEAT NUMBER:715030091

CHEMISTRY SPEC:
Grade A ASTM A307-12
TEST:

C %*100	Mn%*100	P %*1000	S %*1000
0.29max	1.20 max	0.04max	0.15max
0.07	0.31	0.016	0.004

DIMENSIONAL INSPECTIONS CHARACTERISTICS	Unit:inch SPECIFIED	SPECIFICATION: ASME B18.2.1 - 2012 ACTUAL RESULT	ACC.	REJ.
VISUAL	ASTM F788-2013	PASSED	22	0
THREAD	ASME B1.1-2003,3A GO,2A NOGO	PASSED	15	0
WIDTH FLATS	0.425-0.438	0.430-0.435	4	0
WIDTH A/C	0.484-0.505	0.494-0.500	4	0
HEAD HEIGHT	0.150-0.188	0.168-0.181	4	0
THREAD LENGTH	0.970-1.020	0.987-1.010	15	0
LENGTH	0.970-1.020	0.987-1.010	15	0

MECHANICAL PROPERTIES: CHARACTERISTICS	TEST METHOD	SPECIFICATION: ASTM A307-2012 GR-A SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS :	ASTM F606-2014	69-100 HRB	75-78	15	0
WEDGE TENSILE:	ASTM F606-2014	Min 60 KSI	66-70	4	0
CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
COATINGS OF ZINC		SPECIFIATION: Fe/Zn 3AT ASTM F1941-2015			
Coating thickness	ASTM B568-98(2104)	Min 0.0001"	0.0004" -0.0006"	4	0
SALT SPRAY TEST	ASTM B117-11	6 Hr no white rust,12 Hr no red rust	Passed	15	0

ZINC ELECTROPLATING WITH TRIVALENT CHROMATE(CR+3) IN COMPLIANCE WITH ROHS REQUTREMENTS.

ALL TESTS IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE ASTM SPECIFICATION. WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY.
Maker's ISO# 00109Q16722R3M/3302

(SIGNATURE OF Q.A. & LAB. MGR.)
(NAME OF MANUFACTURER)

Figure A-46. ¼-in. (6-mm) Diameter Hex Head Bolt, Test No. NYT-1

Certified Material Test Report to BS EN ISO 10204-2004 3.1

FOR USS FLAT WASHER ZP

COUNTRY OF ORIGIN: CHINA
CUSTOMER: FASTENAL
FACTORY NAME: TIANJIN JIGE HARDWARD MANUFACTURE CO.LTD.
FACTORY ADDRESS: 1146 KAIXUAN STREET DAGANG TIANJIN, CHINA

DESCRIPTION: 1/4 DATE: 2016-10-10
INVOICE NBR: TD16680155 ORDER NBR. 210114135
PART NBR.: 1133004 QUANTITY:8250PCS
LOT NO.: 16H-168236-9

DIMENSIONS (UNIT:INCH)

	STANDARD	RESULT				
		1	2	3	4	5
INSIDE DIA	0.307-0.327	0.317	0.316	0.313	0.324	0.316
OUTSIDE DIA	0.727-0.749	0.741	0.738	0.740	0.739	0.739
THICKNESS	0.051-0.080	0.063	0.065	0.055	0.059	0.060

WE HEREBY CERTIFY THAT THIS WAS PRODUCED AS PER CUSTOMER'S REQUIREMENT.

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
ZINC PLATED ASTM 1941	FE/ZN 3AT			
	Min 3 um	3.6-6.0um	8	0

NOTE

1. QUANTITY OF SAMPLES: 5 PCS
2. JUDGEMENT: GOOD
3. CHIEF INSPECTOR:

Figure A-47. ¼-in. (6-mm) Flat Washer, Test No. NYT-1

CERTIFIED MATERIAL TEST REPORT
FOR ASTM A307, GRADE A - MACHINE BOLTS

FACTORY: NINGBO ECONOMIC & TECHNICAL DEVELOPMENT ZONE YONGGANG FASTENER CO., LTD.
ADDRESS: FuShan South Road No.17,BeiLun NingBo China

REPORT DATE:2015/12/1

MANUFACTURE DATE:2015/11/18

CUSTOMER: FASTENAL
SAMPE SIZE: ACC.TO Dimension:ASME B18.18-11;Mechanical Properties:ASTM F1470-12
MANU QTY: 8800PCS
SIZE: 3/8-16X7 1/2 HDG
HEADMARKS: 307A PLUS NY

MFG LOT NUMBER:M-2014HT1244-2
SHIPPED QTY:8800PCS

PO NUMBER:160100588
PART NO: 91873

STEEL PROPERTIES:
MATERIAL TYPE:Q195

HEAT NUMBER:715030688

CHEMISTRY SPEC:	C %*100	Mn%*100	P %*1000	S %*1000
Grade A ASTM A307-12	0.29max	1.20 max	0.04max	0.15max
TEST:	0.08	0.31	0.028	0.021

DIMENSIONAL INSPECTIONS Unit:inch SPECIFICATION: ASME B18.2.1 - 2012

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
VISUAL	ASTM F788-2013	PASSED	22	0
THREAD	ASME B1.1-2003,3A GO,2A NOGO	PASSED	15	0
WIDTH FLATS	0.544-0.562	0.549-0.558	4	0
WIDTH A/C	0.620-0.650	0.631-0.641	4	0
HEAD HEIGHT	0.226-0.268	0.234-0.258	4	0
BODY DIA.	0.360-0.388	0.369-0.371	4	0
THREAD LENGTH	1.25Min	1.262-1.275	15	0
LENGTH	7.320-7.600	7.339-7.581	15	0

MECHANICAL PROPERTIES: SPECIFICATION: ASTM A307-2012 GR-A

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS :	ASTM F606-2014	69-100 HRB	76-80 HRB	4	0
WEDGE TENSILE:	ASTM F606-2014	Min 60 KSI	66-69 KSI	4	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
COATINGS OF ZINC:		SPECIFIATION:ASTM F2329-2013			
HOT DIP GALVANIZED	ASTM B568-98(2104)	Min 0.0017"	0.0017" -0.0018"	4	0

ALL TESTS IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE ASTM SPECIFICATION. WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY.

Maker's ISO# 00109Q16722R3M/3302

NINGBO ECONOMIC & TECHNICAL DEVELOPMENT ZONE YONGGANG FASTENER CO., LTD

(SIGNATURE OF Q.A.V.LAB MGR.)
(NAME OF MANUFACTURER)

Figure A-48. ⅜-in. (10-mm) Diameter Hex Head Bolt, Test No. NYT-1

ISO/TS 16949 BUREAU VERITAS Certification

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

MANUFACTURER GEM-YEAR INDUSTRIAL CO., LTD.
ADDRESS : NO.8 GEM-YEAR ROAD,E.D.Z.,JIASHAN,ZHEJIANG,P.R.CHINA

Tel: (0573)84185001(48Lines)
Fax: (0573)84184488 84184567
DATE : 2017/02/04

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 120261713
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/8-16 NC O/T 0.43MM
LOT NO : 1N1640033
SHIP QUANTITY : 67,500 PCS
LOT 356,291 PCS
HEADMARKS :

PACKING NO : GEM160602034
INVOICE NO : GEM/FNL-160616IN-3
PART NO : 1136705
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 169D0729
MATERIAL : 1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2016/04/05
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2007

Chemistry	C%	MN%	P%	S%
Spec. : MIN.				
MAX.	0.5800		0.1300	0.2300
Test Value	0.0800	0.2600	0.0120	0.0070

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2010

SAMPLED BY : ZHANG XIA

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		0.6280-0.6500 inch	0.6310-0.6350 inch	6	0
FIM	15 PCS	ASME B18.2.2-2010	Max. 0.0170 inch	0.0150-0.0150 inch	15	0
THICKNESS	6 PCS		0.3200-0.3370 inch	0.3270-0.3290 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.5510-0.5630 inch	0.5560-0.5580 inch	6	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0

MECHANICAL PROPERTIES : ASTM A563-2007

SAMPLED BY : GYBIN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	81-86 HRB	15	0
PROOF LOAD	6 PCS	ASTM F606-2014		Min. 90 KSI	OK	6	0
PLATING THICKNESS(μm)	29 PCS	ASTM B568-1998		>=53	60.18-96.18	29	0

WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

Quality Supervisor:

page 1 of 1

Figure A-49. ⅜-in. (10-mm) Diameter Nuts, Test No. NYT-1

TEST REPORT

USS FLAT WASHER, HDG

CUSTOMER:

DATE: **2015-12-02**

PO NUMBER: **110194766**

MFG LOT NUMBER: **M-SWE0411325-6**

SIZE: **3/8**

PART NO: **1133182**

HEADMARKS:

QNTY: **52,500 PCS**

DIMENSIONAL INSPECTIONS — SPECIFICATION: **ASME B18.21.1(2009)**

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	**ASTM F788-07**	**PASSED**	**100**	**0**
OUTSIDE DIA	**0.993-1.030**	**0.998-1.000**	**8**	**0**
INSIDE DIA	**0.433-0.453**	**0.446-0.447**	**8**	**0**
THICKNESS	**0.064-0.104**	**0.065-0.069**	**8**	**0**
HOT DIP GALVANIZED	**ASTM A153 class C. RoHS Compliant**	**Min 0.0017"**	**0.0021-0.0024In**	**8**	**0**

ALL TESTS IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE ASTM SPECIFICATION. WE CERTIFY THAT THIS DAIA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY.

MFG ISO9002 CERTIFICATE NO. ***03614Q20007R0M***

嘉善永鑫紧固件有限公司
Jiashan Yongxin Fasteners CO., Ltd.
检验专用章
QC PASS

(SIGNATURE OF QA LAB MGR.)
(NAME OF MANUFACTURER)

Jiashan Yongxin Fasteners CO., Ltd. *ADDRESS: No.357,Fenhu South Road,Taozhuang Town,Jia Shan,Zhe Jiang Province,PRC.*
嘉善永鑫紧固件有限公司 ***浙江省嘉善县陶庄镇汾湖南路357号***

Figure A-50. ⅜-in. (10-mm) Plain Round Washer, Test No. NYT-1

JINAN STAR FASTENER CO., LTD
NO.75 CUIPING STREET PINGYIN JINAN CHINA
TEL: 0086 531 87896380 FAX: 0086 531 87871032
E-mail: zhangyuhua@star-fastener.com

CERTIFICATE OF INSPECTION HY0380.1.3-12

HY0380.1.3-12

Manufacturering Date:2016-3-18 **DATE: 2016-3-24**

Customer Part Number客户产品代号	10884							
Customer Control (PO) Number客户订单号	120253605							
Product Description产品描述	1/2-13 X 1 1/2 Tap Z							
Surface Condition表面处理	$ZnCr^{3+}$							
Head Marking头部标记	307A and 01RL							
Lot Size (Manufactured QTY):生产数量	8080pcs							
Lot Size (QTY Shipped):装运数量	8270pcs							
Lot Number订单号	FAS1638							
Mechanical properties机械性能要求	ASTM A307-2014 Gr307A							
Material type:	Q235			Heat Number			G4601173	
	C%	Mn%	Si%	S%	P%	Ni%	Cr%	Cu%
Chemical composition化学成份:标准	max0.33	max1.25		max0.15	max0.041			
Chemical composition化学成份:实测	0.16	0.43	0.16	0.020	0.030	0.002	0.031	0.006
Sampling Plan Used 使用的抽样方案	**Dimensional as per ASME B18.18-2011/Mechanical Property as per F1470-2012**							

Specification技术要求:	Specification 檢測标准	Test method 檢測方法	Specified 标准要求	单位	Test value 实测值	Sampling Plan 抽样方案	ACC 合格	REJ 不合格
Width across Flat对边尺寸	ASME B18.2.1-2012		0.725-0.750	in	0.744-0.748	5/0	5	0
Width across Corners对角尺寸	ASME B18.2.1-2012		0.826-0.866	in	0.842-0.848	5/0	5	0
Height高度	ASME B18.2.1-2012		0.302-0.364	in	0.339-0.345	5/0	5	0
Length总长度	ASME B18.2.1-2012		1.44-1.54	in	1.495-1.498	15/0	15	0
Radius under head头下R角	ASME B18.2.1-2012		0.01-0.03	in	0.017-0.019	15/0	15	0
Max Distance from under head to thread 头下间距	ASME B18.2.1-2012		0.154max	in	0.126-0.129	15/0	15	0
Major 大径	ANSI B1.1-2003		0.488-0.498	in	0.492-0.493	15/0	15	0
Thread 螺纹	ANSI B1.1-2003		3A GO		3A GO	15/0	15	0
	ANSI B1.1-2003		2A NO GO		2A NO GO	15/0	15	0
Core Hardness芯部硬度	ASTM A307-2014	ASTM F606-2014	69-100	HRB	92-95	15/0	15	0
Tensile Strength抗拉强度	ASTM A307-2014	ASTM F606-2014	min60	KSI	82.7-83.6	5/0	5	0
Proof Load保证载荷	ASTM A307-2014	ASTM F606-2014		in		5/0	5	0
Plating thickness镀层厚度	ASTM F1941-2015	ASTM B568-1998	min0.0001	in	0.00202-0.000212	29/0	29	0
盐雾试验结果（salt spray test result）	ASTM F1941-2015	ASTM B117-2011	6h without white rust 12h without red rust		6h without white rust 12h without red rust	15/0	15	0
Appearance外观	ASTM F788-2013		Visual		OK	29/0	29	0

Parts are manufactured and tested according to above specification, we certify that this is a true representation of information provided by manufacturer
产品是按照上述要求进行生产和检测的，我们证明厂家提供的信息是真实的

Signature: Fu Yan Jun
Title: Quality Manager

The requirements are fulfilled
Inspector（终检员）:马付彬

Figure A-51. ½-in. (13-mm) Long Hex Head Bolt, Test No. NYT-1

Certified Material Test Report to BS EN 10204-2004 3.1
FOR ASTM A563, GRADE A HEX FIN NUTS

FACTORY: IFI & Morgan Ltd. Haiyan Office
ADDRESS: Haiyan, Zhejiang, China

REPORT DATE:05 APRIL,2016

R#17-513 1/2" Nuts A563 Grade A
NY DOT Box Beam

CUSTOMER: FASTENAL

MFG LOT NUMBER: GL16052-2

SAMPLE SIZE: ACC. TO ASME B18.18-11;ASTM F1470-12
SIZE: 1/2-13 ZP QTY: 28125PCS

PO NUMBER : 210104867

PART NO: 1136110

STEEL PROPERTIES
STEEL GRADE: Q195

HEAT NUMBER: 180132

CHEMISTRY SPEC:
ASTM A563 GRADE A
TEST:

C %*100 0.55max	Mn%*100 min	P %*1000 0.12max	S %*1000 0.15max
0.08	0.35	0.012	0.037

DIMENSIONAL INSPECTIONS — SPECIFICATION: ASME-B18.2.2-2010

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F812-2013		PASSED	29	0
THREAD	ASME B1.3-2003 2B		PASSED	15	0
WIDTH A/F	0.750-0.736		0.740-0.738	5	0
WIDTH A/C	0.866-0.840		0.858-0.855	3	0
HEIGHT	0.448-0.427		0.440-0.438	4	0

MECHANICAL PROPERTIES: 1/4" to 1 1/2" — SPECIFICATION: ASTM A563-07a GR-A

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
HARDNESS :	ASTM F606-2014	B68-C32 Max(107HRB)	C25-27	15	0
PROOF LOAD :	ASTM F606-2014	Min 68 Ksi	72 Ksi	5	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
ZINC PLATED	ASTM F1941-2010	Min 3 μm	5.5 μm	5	0

ZINC ELECTROPLATINGWITHTRIVALENTCHROMATE(CR+3) INCOMPLIANCEWITH ROHSREQUIREMENTS
ALL TESTS IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE ASTM OR SAE SPECIFICATION. WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY.

(SIGNATURE OF Q.A. LAB MGR.)
(NAME OF MANUFACTURER)

Figure A-52. ½-in. (12-mm) Nuts, Test No. NYT-1

Certified Material Test Report to BS EN ISO 10204-2004 3.1

FOR USS FLAT WASHER HDG

COUNTRY OF ORIGIN: CHINA
CUSTOMER: FASTENAL
FACTORY NAME: TIANJIN JIGE HARDWARD MANUFACTURE CO.LTD.
FACTORY ADDRESS: 1146 KAIXUAN STREET DAGANG TIANJIN, CHINA

DESCRIPTION: 1/2
INVOICE NBR: TD16680155
PART NBR.: 1133184
LOT NO.: 16H-168236-10

DATE: 2016-10-10
ORDER NBR. 210114135
QUANTITY:11250PCS

DIMENSIONS (UNIT:INCH)

	STANDARD	RESULT				
		1	2	3	4	5
INSIDE DIA	0.557-0.577	0.563	0.562	0.561	0.560	0.562
OUTSIDE DIA	1.368-1.405	1.395	1.397	1.396	1.399	1.398
THICKNESS	0.086-0.132	0.095	0.106	0.101	0.094	0.100

WE HEREBY CERTIFY THAT THIS WAS PRODUCED AS PER CUSTOMER'S REQUIREMENT.

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
HOT DIP GALVANIZED ASTM F2329	Min 43 um	52-78um	8	0

NOTE

1. QUANTITY OF SAMPLES: 5 PCS
2. JUDGEMENT: GOOD
3. CHIEF INSPECTOR:

Figure A-53. ½-in. (12-mm) Diameter Plain Round Washer, Test No. NYT-1

ISO/TS 16949 BUREAU VERITAS Certification

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

MANUFACTURER GEM-YEAR INDUSTRIAL CO., LTD.
ADDRESS : NO.8 GEM-YEAR ROAD,E.D.Z.,JIASHAN,ZHEJIANG,P.R.CHINA
Tel: (0573)84185001(48Lines)
Fax: (0573)84184488 84184567
DATE : 2017/02/04

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 120274323
COMMODITY : HEX MACHINE BOLT GR-A
SIZE : 3/4-10X8 NC
LOT NO : 1B16A1385
SHIP QUANTITY : 1,080 PCS
LOT 5,572 PCS
HEADMARKS : CYI & 307A

PACKING NO : GEM161201013
INVOICE NO : GEM/FNL-161218IN-1
PART NO : 91972
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : G1607088001
MATERIAL : 1015A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2016/11/23
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A307-2014

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.3300	1.2500	0.0410		
Test Value	0.0460	0.1600	0.4200	0.0090	0.0060	0.0400

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.1-2012

SAMPLED BY : ZHANG HUI JING

INSPECTIONS ITEM	SAMPLE	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
THREAD LENGTH	15 PCS	2.0000 inch	2.0630-2.0810 inch	15	0
MAJOR DIAMETER	15 PCS	0.7370-0.7500 inch	0.7400-0.7480 inch	15	0
BODY DIAMETER	4 PCS	0.7290-0.7680 inch	0.7400-0.7480 inch	4	0
WIDTH ACROSS CORNERS	4 PCS	1.2400-1.2990 inch	1.2790-1.2840 inch	4	0
HEIGHT	4 PCS	0.4550-0.5240 inch	0.4750-0.4810 inch	4	0
NOMINAL LENGTH	15 PCS	7.8200-8.1400 inch	7.9290-7.9470 inch	15	0
WIDTH ACROSS FLATS	4 PCS	1.0880-1.1250 inch	1.1090-1.1240 inch	4	0
SURFACE DISCONTINUITIES	22 PCS	ASTM F788-2013	PASSED	22	0
THREAD	15 PCS	ASME B1.1-2003 nut	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A 307-2014

SAMPLED BY : GYBIN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	13 PCS	ASTM F606-2014		Max. 100 HRB	79-83 HRB	13	0
TENSILE STRENGTH	3 PCS	ASTM F606-2014		Min. 60 KSI	62-65 KSI	3	0
PLATING THICKNESS(μm)	18 PCS	ASTM B568-1998		>=53	55.83-74.11	18	0

WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

Quality Supervisor:

page 1 of 1

Figure A-54. ¾-in. (19-mm) Diameter, 8-in. (203-mm) Long Hex Bolt, Test No. NYT-1

ISO/TS 16949 BUREAU VERITAS Certification

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

MANUFACTURER GEM-YEAR INDUSTRIAL CO., LTD.
ADDRESS : NO.8 GEM-YEAR ROAD,E.D.Z.,JIASHAN,ZHEJIANG,P.R.CHINA

Tel: (0573)84185001(48Lines)
Fax: (0573)84184488 84184567
DATE : 2017/02/04

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 120274323
COMMODITY : HEX MACHINE BOLT GR-A
SIZE : 3/4-10X8 NC
LOT NO : 1B16A1385
SHIP QUANTITY : 1,530 PCS
LOT 2,246 PCS
HEADMARKS : CYI & 307A

PACKING NO : GEM161201013
INVOICE NO : GEM/FNL-161218IN-1
PART NO : 91972
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 1608020500
MATERIAL : 1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2016/11/24
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A307-2014

Chemistry	C%	MN%	P%	S%
Spec. : MIN.				
MAX.	0.3300	1.2500	0.0410	
Test Value	0.0900	0.3300	0.0190	0.0060

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.1-2012

SAMPLED BY : LXQING

INSPECTIONS ITEM	SAMPLE	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
THREAD LENGTH	13 PCS	2.0000 inch	2.2060-2.2130 inch	13	0
MAJOR DIAMETER	13 PCS	0.7370-0.7500 inch	0.7370-0.7450 inch	13	0
BODY DIAMETER	3 PCS	0.7290-0.7680 inch	0.7330-0.7510 inch	3	0
WIDTH ACROSS CORNERS	3 PCS	1.2400-1.2990 inch	1.2500-1.2680 inch	3	0
HEIGHT	3 PCS	0.4550-0.5240 inch	0.4660-0.5080 inch	3	0
NOMINAL LENGTH	13 PCS	7.8200-8.1400 inch	7.8520-8.1190 inch	13	0
WIDTH ACROSS FLATS	3 PCS	1.0880-1.1250 inch	1.0920-1.1000 inch	3	0
SURFACE DISCONTINUITIES	18 PCS	ASTM F788-2013	PASSED	18	0
THREAD	13 PCS	ASME B1.1-2003 nut	PASSED	13	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A 307-2014

SAMPLED BY : GYBIN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	13 PCS	ASTM F606-2014		Max. 100 HRB	81-85 HRB	13	0
TENSILE STRENGTH	3 PCS	ASTM F606-2014		Min. 60 KSI	63-64 KSI	3	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	70.22-72.58	5	0

WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

Quality Supervisor:

page 1 of 1

Figure A-55. ¾-in. (19-mm) Diameter, 8-in. (203-mm) Long Hex Bolt, Test No. NYT-1

ISO/TS 16949 BUREAU VERITAS Certification

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

MANUFACTURER GEM-YEAR INDUSTRIAL CO., LTD.
ADDRESS : NO.8 GEM-YEAR ROAD,E.D.Z.,JIASHAN,ZHEJIANG,P.R.CHINA
Tel: (0573)84185001(48Lines)
Fax: (0573)84184488 84184567
DATE : 2017/02/04

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210100834
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/4-10 NC O/T 0.51MM
LOT NO : 1N1580463
SHIP QUANTITY : 3,000 PCS
LOT 150,457 PCS
HEADMARKS :

PACKING NO : GEM160214004
INVOICE NO : GEM/FNL-160125ED
PART NO : 1136715
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 331502913
MATERIAL : 1010A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2015/09/29
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2007

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0390	0.0900	0.4200	0.0220	0.0060	0.0400

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2010

SAMPLED BY : FCHUN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		1.2400-1.2990 inch	1.2480-1.2910 inch	6	0
FIM	15 PCS	ASME B18.2.2-2010	Max. 0.0180 inch	0.0130-0.0130 inch	15	0
THICKNESS	6 PCS		0.6170-0.6650 inch	0.6220-0.6500 inch	6	0
WIDTH ACROSS FLATS	6 PCS		1.0880-1.1250 inch	1.0950-1.1190 inch	6	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A563-2007

SAMPLED BY : GYBIN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	79-83 HRB	15	0
PROOF LOAD	6 PCS	ASTM F606-2014		Min. 90 KSI	OK	6	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	61.32-74.53	5	0

WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

Quality Supervisor:

page 1 of 1

Figure A-56. ¾-in. (19-mm) Diameter Hex Nut, Test No. NYT-1

INSPECTION CERTIFICATE

Certificate No. : J420160227009
P/O No. : 110198305
L/C No. : FASTENAL(WINONA 활성)
Date issued : 2016.02.27
Date Shipped : 2016.02.10
Date Tested : 2015.12.24
Date Manufactured : 2015.12.14
Specifications : Set : ASME B18.2.6 - 2010
Bolt : ASTM A325 - 14
Nut : ASTM A563 - 07a(R.2014)
Washer :

Customer : FASTENAL COMPANY PURCHASING
Description : STR H/H B N I A325 TY1 DH HDG_B
Size : 3/4-10UNCx1 1/2
Surface Condition : HDG-BLUE/WAX
Set Lot No. : 2010360400
Q'ty Shipped : 7,200 SETS
Marking : Bolt : A325,KPF LOGO
Nut : DH,KPF LOGO
Washer :

KPF FACTORY : 50, CHUNGJUSANDAN 5-RO, CHUNGJU-SI
CHUNGCHEONGBUK-DO, KOREA 380-250
TEL : (043)849 - 1114 FAX : (043)849 - 1234

FIELD OF TESTING : MECHANCICAL TESTING
LAB. ID. : 111983
CERT. NO. : 0882.01

STANDARD OF CERTIFIED : ISO/TS 16949, ISO 9001, ISO 14001
CERTIFICAT NO. : TS-01899, AC-01899, EAC-01899

CE STANDARD OF CERTIFIED : EN 14399-1,2,3,4,5,6,10
CERTIFICAT NO. : 1020 - CPR - 070038467

CE STANDARD OF CERTIFIED : EN 15048-1
CERTIFICAT NO. : 1020 - CPR - 070048404

1. Chemical Composition (%)

Division			C x100	Si x100	Mn x100	P x1000	S x1000	Cr x100	Mo x100	Ni x100	B x10000	Cu X100
Bolt	Spec.	Min.	30	10	60						5	
		Max.	52	30		40	50				30	
Heat No.	HH49003		32	18	77	14	4	17	4	5	20	1
Nut	Spec.	Min.	20		60							
		Max.	55			40	50					
Heat No.	HB01435		46	21	72	11	3	22		2	17	4
Washer	Spec.	Min.										
		Max.										
Heat No.												

2. Mechanical Properties
2.1 Bolt
- Lot No : 2010360300
- Grade : A325 TY1

Division		Hardness		Specimen Tensile				Proof Load		Wedge Tensile Load
			n= 4					n= 3		
		Surface	Core	Yield Strength	Tensile Strength	Elongation	Reduction of Area	Load	Elongation	n= 3
Unit	Min.							LBF		LBF
	Max.		HRC						in	
Spec.	Min.							28,400		40,100
	Max.		34						0.0005	
Results	Min.		HRC 29					28,400	0.0004	45,399
	Max.		30					28,400	0.0005	45,812
	Avg.		30					28,400	0.0004	45,579
	Wedge Angele									6 °
Tested By			D.H.KIM					D.H.KIM		D.H.KIM
Spec. of Test Method			ASTM F606/F606M-14a					ASTM F606/F606M-14a		ASTM F606/F606M-14a

2.2 Nut
- Lot No : 1005024001
- Grade : GR.DH

Division		Hardness	Proof Load	
		n= 5	n= 5	
Unit	Min.	HRC	LBF	
	Max.	HRC		
Spec.	Min.	24	50,100	
	Max.	38		
Results	Min.	HRC 31	50,100	
	Max.	32	50,100	
	Avg.	32	50,100	GOOD
Tested By		B.S.KANG	B.S.KANG	
Spec. of Test Method		ASTM F606/F606M-14a	ASTM F606/F606M-14a	

2.3 Washer
- Lot No :
- Grade :

Division		Hardness
Unit	Min.	
	Max.	
Spec.	Min.	
	Max.	
Results	Min.	
	Max.	
	Avg.	
Tested By		
Spec. of Test Method		

3. Assembly Lot Tension Test

Division		Axial Tension
Unit	Min.	
	Max.	
Spec.	Min.	
	Max.	
Results	Min.	
	Max.	
	Avg.	
Tested By		
Spec. of Test Method		

4. Visual & Thread Inspection

Division	Appearance	Thread
Bolt	OK	OK
Nut	OK	OK
Washer	-	-

Reference : 1.PART NO : 0123453M 2.Mechanical Sampling Plan - ASTM F1470-2012
3.ROTATIONAL CAPACITY TEST (Long Bolt Test Method : tension measureing device) (ROTATIONAL Test Method : ASTM F3125 - 2015)
1)Load (28Kips) 2)Torque (437ft-lb Max) Result : 233, 231, 229, 334
3)After load (32Kips Min) Result : 36, 36, 35, 36 4)Nut Rotation Total degrees(240°) Results - GOOD
4.Nut lubrication : OK 5.BOLT STEEL GRADE : 10B33 / NUT STEEL GRADE : S45C
6.ALL FASTENERS MEET THE REQUIREMENTS OF THE (FQA)AND RECORDS OF COMPLIANCE ARE ON FILE
7.The products supplied are in compliance with the requirements of the order
8.EN10204-3.1 9.Heats have the elements listed in 5.4 intentionally added were not used

This is to certify that the above results are true and correct in every details

DAE - HO LEE
Chief of Quality Management Dept.

KPF

Figure A-57. ¾-in (19-mm) Diameter, 1½-in. (38-mm) Long Heavy Hex Head Bolt, Test No. NYT-1

UNYTITE INC.
INNOVATIVE FASTENING SYSTEMS

Unytite, Inc.
One Unytite Drive
Peru, IL 61354
Tel 815-224-2221
Fax 815-224-3434

INSPECTION CERTIFICATE

Job No: 24256 **Job Information** **Certified Date:** 11/15/16

Customer: FASTENAL COMPANY
SHIP TO FASTENAL
Customer PO No: 210126221 FNL P/N: 38208 **Shipped Qty:** 1,000
Lot Number: 24256-75062833

Part Information

Part No: A563 3/4-10 +0.020 DH HHN HDG BLUE DYE

Description: ASTM A563 Heavy Hex Nut, Grade DH, Hot Dipped Galv, Blue Dye

Manufactured Quantity: 123,490

Applicable Specifications

Specification	Amend	Specification	Amend
ASME B1.1	2003	ASME B18.2.2	2015
ASME B18.2.6	2010	ASTM A563	2015
ASTM F2329	2013	ASTM F606/606M	2014
ASTM F812/F812M	2012		

Test Results

Test No: 13297 **Test**: A563 DH Mechanical Properties

Description	Hardness (HRC)	Tempering Temp (800 degree F Min)	Proof Load (Pass/Fail) (ASTM Min)	Shape & Dimension ASME B18.2.2	Thread Precision ASME B18.1.1	Visual ASTM F812
Sample Inspection	28.20	1,229	50,100	Pass	Pass	Pass

Certified Chemical Analysis

Heat No	Grade	Manufacturer	Origin	C	Mn	P	S	Si	Cr	Ni	Cu
75062833	1045	Gerdau Special Steel North America	USA	0.4500	0.7400	0.009	0.0250	0.2300	0.1100	0.1000	0.1400

Notes

All tests are in accordance with the latest revisions of the methods prescribed in the applicable SAE and ASTM Specifications.

The samples tested conform the specifications as described/listed above and were manufactured free of mercury contamination and there is no welding performed in the production of the products. No heats to which Bismuth, Selenium, Tellurium, or Lead was intentionally added have been used to produce products.
The steel was melted and manufactured in the U.S.A. and the product was manufactured and tested in the U.S.A.

We certify that this data is true representation of information provided by the material supplier and our testing laboratory. This certified material test report relates only to the items listed on this document and may not be reproduced except in full.

OFFICIAL SEAL
JEAN MARGHERIO
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:10/18/17

Sobkowiak, Bill - Supervisor, Quality — 11/15/16 Date

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Figure A-58. ¾-in. (19-mm) Heavy Hex Nut, Test No. NYT-1

30369

NUCOR
NUCOR CORPORATION
NUCOR STEEL NEBRASKA

Mill Certification
10/14/2015

MTR #: 0000140866
2911 East Nucor Road
NORFOLK, NE 68701
(402) 644-0200
Fax: (402) 644-0329

Sold To: NUCOR FASTENER INDIANA
PO BOX 6100
6730 COUNTY RD 60
ST JOE, IN 46785-0000
(260) 337-1600
Fax: (435) 734-4581

Ship To: NUCOR FASTENER INDIANA
COUNTY RD 60
ST JOE, IN 46785-0000

Customer P.O.	155994	Sales Order	144113.8
Product Group	Special Bar Quality	Part Number	31000765000T770
Grade	1039ML1	Lot #	NF1510329811
Size	49/64" (.7656) Round Coil	Heat #	NF15103298
Product	49/64" (.7656) Round Coil 1039ML1	B.L. Number	N1-312641
Description	1039ML1	Load Number	N1-255778
Customer Spec		Customer Part #	005012

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.

Roll Date: 10/9/2015 Melt Date: 9/30/2015 Qty Shipped LBS: 48,485 Qty Shipped Pcs: 9

Melt Date: 9/30/2015

C	Mn	V	Si	S	P	Cu	Cr	Ni	Mo	Al	Cb
0.42%	0.92%	0.004%	0.26%	0.013%	0.015%	0.09%	0.10%	0.04%	0.02%	0.003%	0.004%

Pb	Sn	Ca	B	Ti	N
0.000%	0.006%	0.0013%	0.0003%	0.002%	51 ppm

Roll Date: 10/9/2015

Reduction Ratio 95 :1

Specification Comments: Coarse Grain Practice

Selenium,Tellurium,Lead,Bismuth or Boron were not intentionally added to this heat.

1. All manufacturing processes of the steel materials in this product, including melting, have been performed in the United States.
2. All products produced are weld free.
3. Mercury, in any form, has not been used in the production or testing of this material.
4. Test conform to ASTM A29-12, ASTM E415 and ASTM E1019-resulphurized grades or applicable customer requirements.
5. All material melted at Nucor Steel Nebraska is produced in an Electric Arc Furnace
6. Strand Cast
7. ISO-17025 LAB accreditation cert available upon request
8. Exporting Country-USA
9. Sales@nucorne.com

Chemistry Verification Checks

Part# 5012 **RM#** 30369

	Checked By	Date
Receiving OK:	JJ7	10-16-15
Certifications OK:	375	10-16-15

Jim Hill
Division Metallurgist

Page 1 of 1

NBMG-10 January 1, 2012

Figure A-59. ¾-in. (19-mm) Diameter, 2-in. (51-mm) Long Heavy Hex Head Bolt, Test No. NYT-1

UNYTITE INC.
INNOVATIVE FASTENING SYSTEMS

Unytite, Inc.
One Unytite Drive
Peru, IL 61354
Tel 815-224-2221
Fax 815-224-3434

INSPECTION CERTIFICATE

Job No: 24256 **Job Information** **Certified Date:** 11/15/16

Customer: FASTENAL COMPANY
SHIP TO FASTENAL
Customer PO No: 210126221 FNL P/N: 38208 **Shipped Qty:** 1,000
Lot Number: 24256-75062833

Part Information

Part No: A563 3/4-10 +0.020 DH HHN HDG BLUE DYE

Description: ASTM A563 Heavy Hex Nut, Grade DH, Hot Dipped Galv, Blue Dye

Manufactured Quantity: 123,490

Applicable Specifications

Specification	Amend	Specification	Amend
ASME B1.1	2003	ASME B18.2.2	2015
ASME B18.2.6	2010	ASTM A563	2015
ASTM F2329	2013	ASTM F606/606M	2014
ASTM F812/F812M	2012		

Test Results

Test No: 13297 **Test**: A563 DH Mechanical Properties

Description	Hardness (HRC)	Tempering Temp (800 degree F Min)	Proof Load (Pass/Fail) (ASTM Min)	Shape & Dimension ASME B18.2.2	Thread Precision ASME B18.1.1	Visual ASTM F812
Sample Inspection	28.20	1,229	50,100	Pass	Pass	Pass

Certified Chemical Analysis

Heat No	Grade	Manufacturer	Origin	C	Mn	P	S	Si	Cr	Ni	Cu
75062833	1045	Gerdau Special Steel North America	USA	0.4500	0.7400	0.009	0.0250	0.2300	0.1100	0.1000	0.1400

Notes

All tests are in accordance with the latest revisions of the methods prescribed in the applicable SAE and ASTM Specifications.

The samples tested conform the specifications as described/listed above and were manufactured free of mercury contamination and there is no welding performed in the production of the products. No heats to which Bismuth, Selenium, Tellurium, or Lead was intentionally added have been used to produce products.
The steel was melted and manufactured in the U.S.A. and the product was manufactured and tested in the U.S.A.

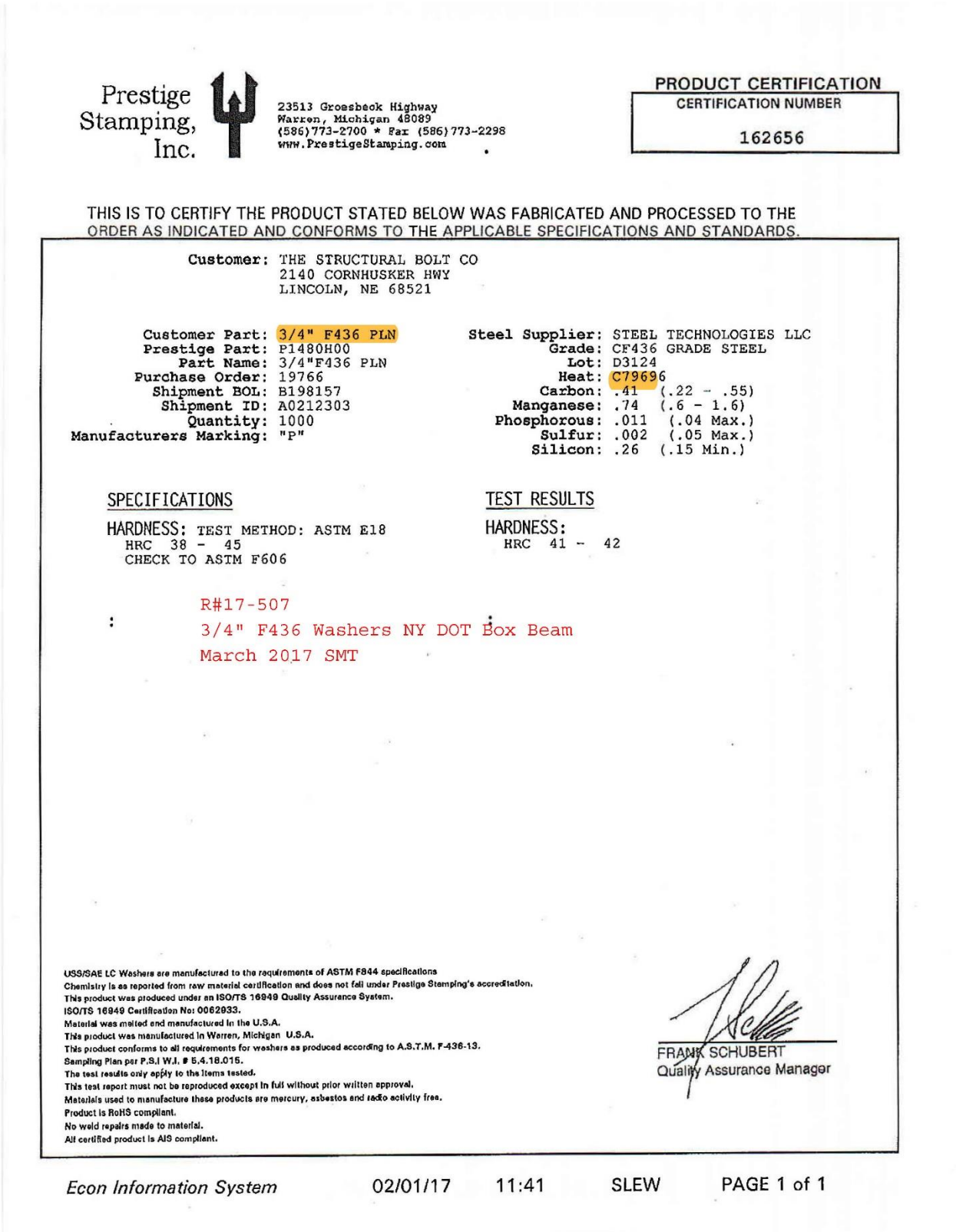
We certify that this data is true representation of information provided by the material supplier and our testing laboratory. This certified material test report relates only to the items listed on this document and may not be reproduced except in full.

OFFICIAL SEAL
JEAN MARGHERIO
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:10/18/17

Sobkowiak, Bill - Supervisor, Quality 11/15/16 Date

Plex 11/15/16 9:34 AM bsobkowiak Page 1

Figure A-60. ¾-in. (19-mm) Heavy Hex Nut, Test No. NYT-1



Prestige Stamping, Inc.

23513 Groesbeck Highway
Warren, Michigan 48089
(586)773-2700 * Fax (586)773-2298
www.PrestigeStamping.com

PRODUCT CERTIFICATION

CERTIFICATION NUMBER

162656

THIS IS TO CERTIFY THE PRODUCT STATED BELOW WAS FABRICATED AND PROCESSED TO THE ORDER AS INDICATED AND CONFORMS TO THE APPLICABLE SPECIFICATIONS AND STANDARDS.

Customer: THE STRUCTURAL BOLT CO
2140 CORNHUSKER HWY
LINCOLN, NE 68521

Customer Part: 3/4" F436 PLN
Prestige Part: P1480H00
Part Name: 3/4"F436 PLN
Purchase Order: 19766
Shipment BOL: B198157
Shipment ID: A0212303
Quantity: 1000
Manufacturers Marking: "P"

Steel Supplier: STEEL TECHNOLOGIES LLC
Grade: CF436 GRADE STEEL
Lot: D3124
Heat: C79696
Carbon: .41 (.22 - .55)
Manganese: .74 (.6 - 1.6)
Phosphorous: .011 (.04 Max.)
Sulfur: .002 (.05 Max.)
Silicon: .26 (.15 Min.)

SPECIFICATIONS

HARDNESS: TEST METHOD: ASTM E18
HRC 38 - 45
CHECK TO ASTM F606

TEST RESULTS

HARDNESS:
HRC 41 - 42

R#17-507
3/4" F436 Washers NY DOT Box Beam
March 2017 SMT

USS/SAE LC Washers are manufactured to the requirements of ASTM F844 specifications
Chemistry is as reported from raw material certification and does not fall under Prestige Stamping's accreditation.
This product was produced under an ISO/TS 16949 Quality Assurance System.
ISO/TS 16949 Certification No: 0062933.
Material was melted and manufactured in the U.S.A.
This product was manufactured in Warren, Michigan U.S.A.
This product conforms to all requirements for washers as produced according to A.S.T.M. F-436-13.
Sampling Plan per P.S.I W.I. # 5.4.18.015.
The test results only apply to the items tested.
This test report must not be reproduced except in full without prior written approval.
Materials used to manufacture these products are mercury, asbestos and radio activity free.
Product is RoHS compliant.
No weld repairs made to material.
All certified product is AIS compliant.

FRANK SCHUBERT
Quality Assurance Manager

Econ Information System 02/01/17 11:41 SLEW PAGE 1 of 1

Figure A-61. ¾-in. (19-mm) Diameter Hardened Flat Washer, Test No. NYT-1

HANGZHOU SPRING WASHER CO.,LTD

QUALITY TEST CERTIFICATE OF SPRING LOCK WASHER

Standard: ASME B 18.21.1-2009 Contract No.: 16HZW04195

Order No.: PO 220021738 Invoice No.: 16SHD307

Chemical Composition (%)	C	Si	Mn	P	S	Cr	Ni	Cu
	0.63	0.22	0.55	0.015	0.007	0.06	0.06	0.08
Heat No.	J510104136							

Specification	3/4" GALV	
Quantity	18 M	
Lot No.	1605291	
Part No.	1133786	

Testing Item	Ac/n	Norm	Result	Reject	Norm	Result	Reject
Inside Diameter	2/100	19.33-19.86	19.36-19.71	0			
Outside Diameter	1/32	Max32.93	Max31.95	0			
Width	1/32	Min6.04	Min6.08	0			
Thickness	1/32	4.88-5.33	4.9-5.16	0			
Height							
Section							
Surface Defects	2/100	None	None	0			
Hardness	0/8	HRC38-46	HRC38-40	0			
Springing							
Toughness	0/8	Qualified	Qualified	0			

General:

The spring lock washers are conformed with the standard of ASME B 18.21.1-2009. QUALIFI

Inspector: Zhaojianfei Quality Inspection Chief: Date: 2020.12.04

Figure A-62. ¾-in. (19-mm) Diameter Lock Washer, Test No. NYT-1

Portland Bolt & MANUFACTURING COMPANY

Phone: 800-547-6758 | Fax: 503-227-4634
3441 NW Guam Street, Portland, OR 97210
Web: www.portlandbolt.com | Email: sales@portlandbolt.com

CERTIFICATE OF CONFORMANCE

For: CASH SALE
PB Invoice#: 96359
Cust PO#: MIDWEST ROADSIDE
Date: 2/08/2017
Shipped: 2/10/2017

We certify that the following items were manufactured and tested in accordance with the chemical, mechanical, dimensional and thread fit requirements of the specifications referenced.

Description: 7/8 X 8-1/2 GALV ASTM F3125 GRADE A325 HEAVY HEX BOLT

Heat#: NF16102579 **Base Steel:** 4140 **Diam:** 7/8

Source: KREHER STEEL CO LLC **Proof Load:** 39,250 LBF

C :	.420	**Mn:** .930	**P :** .013	**Hardness:**	269 HBN		
S :	.025	**Si:** .250	**Ni:** .080	**Tensile:**	57,700 LBF	**RA:**	.00%
Cr:	.910	**Mo:** .180	**Cu:** .190	**Yield:**	0	**Elon:**	.00%
Pb:	.000	**V :** .009	**Cb:** .000	**Sample Length:**	0		
N :	.000		**CE:** .6702	**Charpy:**		**CVN Temp:**	

LOT#18344

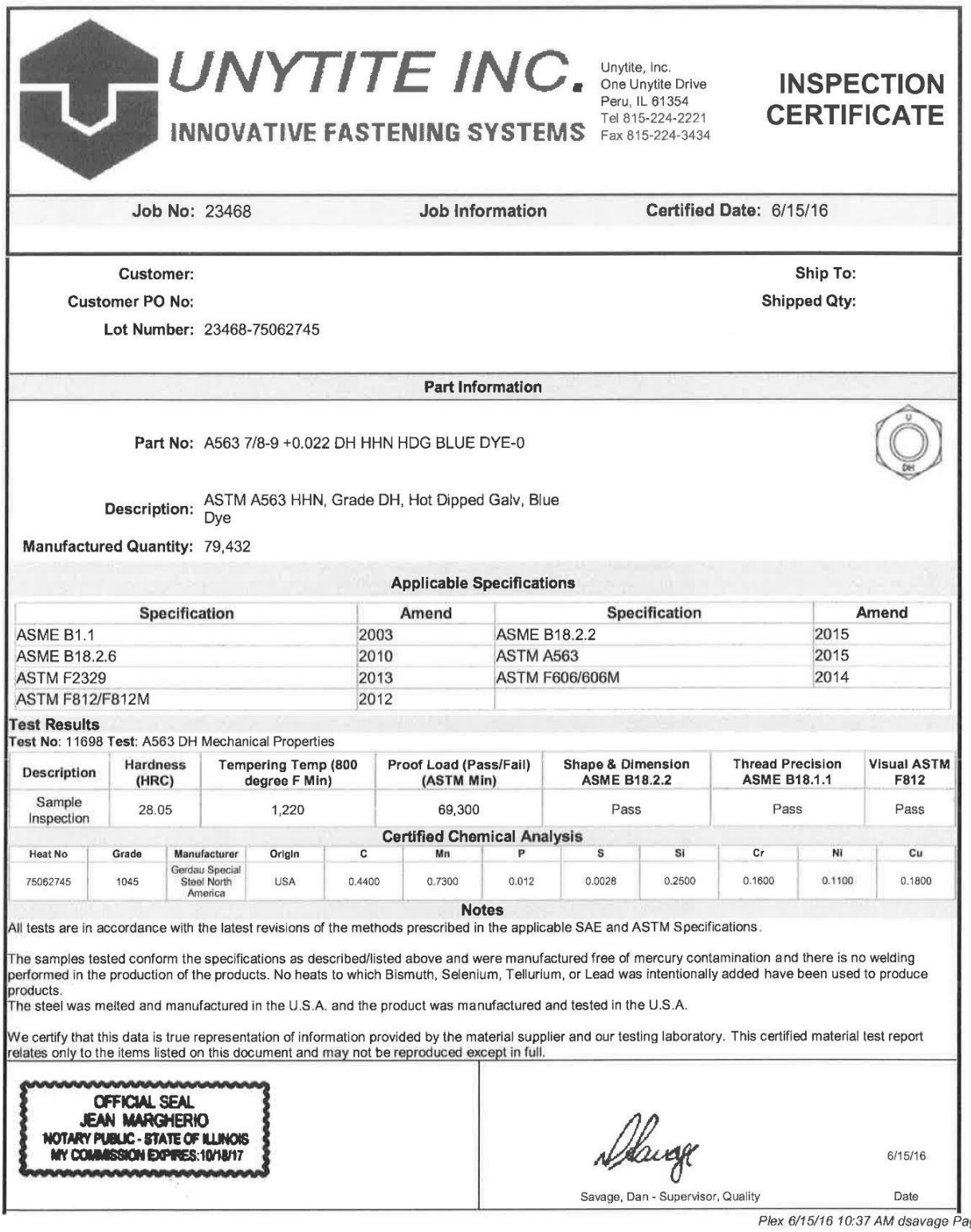
Nuts:
ASTM A563DH HVY HX

Coatings:
ITEMS HOT DIP GALVANIZED PER ASTM F2329/A153C

Other:
ALL ITEMS MELTED & MANUFACTURED IN THE USA

By: _____
Certification Department Quality Assurance
Dane McKinnon

Figure A-63. ⅞-in. (22-mm) Diameter, 8½-in. (216-mm) Long Heavy Hex Head Bolt, Test No. NYT-1



UNYTITE INC.
INNOVATIVE FASTENING SYSTEMS

Unytite, Inc.
One Unytite Drive
Peru, IL 61354
Tel 815-224-2221
Fax 815-224-3434

INSPECTION CERTIFICATE

Job No: 23468 **Job Information** **Certified Date:** 6/15/16

Customer:
Customer PO No:
Lot Number: 23468-75062745

Ship To:
Shipped Qty:

Part Information

Part No: A563 7/8-9 +0.022 DH HHN HDG BLUE DYE-0

Description: ASTM A563 HHN, Grade DH, Hot Dipped Galv, Blue Dye

Manufactured Quantity: 79,432

Applicable Specifications

Specification	Amend	Specification	Amend
ASME B1.1	2003	ASME B18.2.2	2015
ASME B18.2.6	2010	ASTM A563	2015
ASTM F2329	2013	ASTM F606/606M	2014
ASTM F812/F812M	2012		

Test Results
Test No: 11698 **Test**: A563 DH Mechanical Properties

Description	Hardness (HRC)	Tempering Temp (800 degree F Min)	Proof Load (Pass/Fail) (ASTM Min)	Shape & Dimension ASME B18.2.2	Thread Precision ASME B18.1.1	Visual ASTM F812
Sample Inspection	28.05	1,220	69,300	Pass	Pass	Pass

Certified Chemical Analysis

Heat No	Grade	Manufacturer	Origin	C	Mn	P	S	Si	Cr	Ni	Cu
75062745	1045	Gerdau Special Steel North America	USA	0.4400	0.7300	0.012	0.0028	0.2500	0.1600	0.1100	0.1800

Notes

All tests are in accordance with the latest revisions of the methods prescribed in the applicable SAE and ASTM Specifications.

The samples tested conform the specifications as described/listed above and were manufactured free of mercury contamination and there is no welding performed in the production of the products. No heats to which Bismuth, Selenium, Tellurium, or Lead was intentionally added have been used to produce products.
The steel was melted and manufactured in the U.S.A. and the product was manufactured and tested in the U.S.A.

We certify that this data is true representation of information provided by the material supplier and our testing laboratory. This certified material test report relates only to the items listed on this document and may not be reproduced except in full.

OFFICIAL SEAL
JEAN MARGHERIO
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:10/18/17

Savage, Dan - Supervisor, Quality — 6/15/16 Date

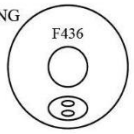
Plex 6/15/16 10:37 AM dsavage Page 1

Figure A-64. ⅞-in. (22-mm) Diameter Nuts, Test No. NYT-1

HEXICO ENTERPRISE CO., LTD.

NO.355-3,SEC. 3,CHUNG SHAN ROAD,KAU-JEN,TAINAN,TAIWAN,R.O.C.
TEL : 886 - 6 - 2390616 FAX : 886 - 6 - 2308947

MARKING



INSPECTION CERTIFICATE

CUSTOMER	**FASTENAL COMPANY**		
PART NAME	ASTM F436 - 11 TYPE 1 WASHERS		
SIZE	7/8 "	DATE	March 18, 2015
PART NO. - Mfr.	W2A6C7000S6JZ2	REPORT NO.	1040318-26
PART NO. - Cust.	1133175	SHIPPING NO.	
MATERIAL / DIA.	10B20 / 25 mm	ORDER NO.	220018262
HEAT(COIL) NO.	1DR73	DOCUMENT NO.	10310009
LOT QTY	16,800 PCS	LOT NO.	432C7FNG1
STANDARD OF SAMPLING SCHEME	ANSI / ASME B18.18-2011		
HARDNESS TEST METHOD	ASTM F606-2010		
COATING TEST METHOD	ASTM B499-2009		

DIMENSIONS IN inch

	INSPECTION ITEM	SPECIFICATION	TEST QTY	INSPECTION RESULTS		INSPECTION EQUIPMENT
				MIN.	MAX.	
1	OUTSIDE DIAMETER	1.7180 - 1.7820	8	1.7394	1.7472	Caliper
2	INSIDE DIAMETER	0.9380 - 0.9700	8	0.9539	0.9567	Caliper
3	THICKNESS	0.1360 - 0.1770	8	0.1488	0.1520	Caliper
4	HARDNESS	HRC 38 - 45	5	40.0	41.4	Rockwell
5	COATING	MECH. GALV. 53 μm	5	57.6	64.5	Magnetic
6	APPEARANCE	VISUAL	100	OK		

INSPECTOR Yu Tain Lin QC CHIEF Jing Yeh Tsao

Figure A-65. ⅞-in (22-mm) Hardened Flat Washer, Test No. NYT-1

Appendix B. Vehicle Center of Gravity Determination

Date:	5/11/2017	Test Name:	NYT-1	VIN:	1D7RB1GP3BS553913
Year:	2011	Make:	Dodge	Model:	Ram 1500

Vehicle CG Determination

VEHICLE	Equipment	Weight (lb)	Vertical CG (in.)	Vertical M (lb-in.)
+	Unballasted Truck (Curb)	5071	28	141988
+	Hub	19	14 1/2	275.5
+	Brake activation cylinder & frame	7	24 1/4	169.75
+	Pneumatic tank (Nitrogen)	27	26 1/2	715.5
+	Strobe/Brake Battery	5	23 1/2	117.5
+	Brake Receiver/Wires	5	51 3/4	258.75
+	CG Plate including DAS	42	29 1/2	1239
-	Battery	-43	40	-1720
-	Oil	-11	26	-286
-	Interior	-94	26 3/4	-2514.5
-	Fuel	-169	19 3/4	-3337.75
-	Coolant	-16	29	-464
-	Washer fluid	-3	34	-102
+	Water Ballast (In Fuel Tank)	99	19 3/4	1955.25
+	Onboard Supplemental Battery	12	24	288
		33	33 1/2	1105.5
				139688.5

Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle

Estimated Total Weight (lb)	4984
Vertical CG Location (in.)	28.0274

Vehicle Dimensions for C.G. Calculations

Wheel Base: 140 1/4 in. Front Track Width: 66 1/2 in.
Rear Track Width: 67 3/4 in.

Center of Gravity	2270P MASH Targets	Test Inertial	Difference
Test Inertial Weight (lb)	5000 ± 110	5000	0.0
Longitudinal CG (in.)	63 ± 4	61.56975	-1.43025
Lateral CG (in.)	NA	0.18795	NA
Vertical CG (in.)	28 or greater	28.03	0.02739

Note: Long. CG is measured from front axle of test vehicle

Note: Lateral CG measured from centerline - positive to vehicle right (passenger) side

CURB WEIGHT (lb)

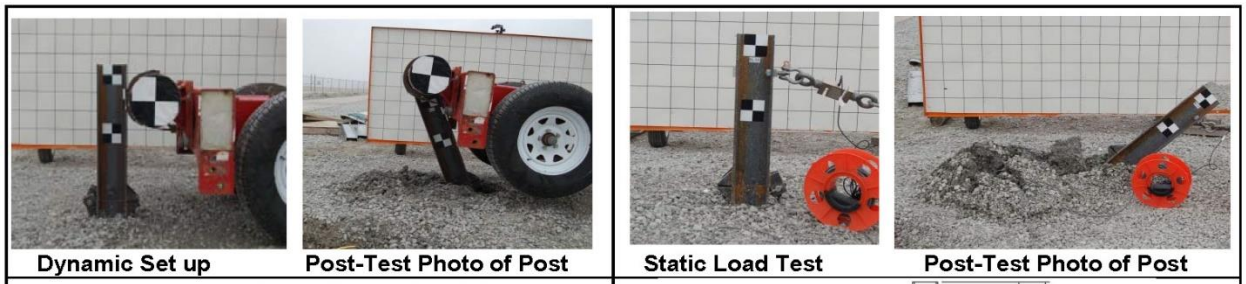
	Left	Right	
Front	1481	1388	
Rear	1099	1103	
FRONT	2869		lb
REAR	2202		lb
TOTAL	5071		lb

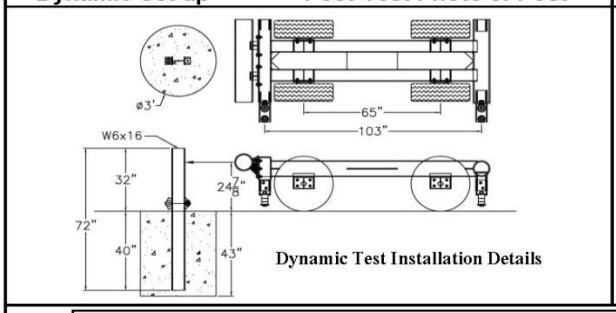
TEST INERTIAL WEIGHT (lb)

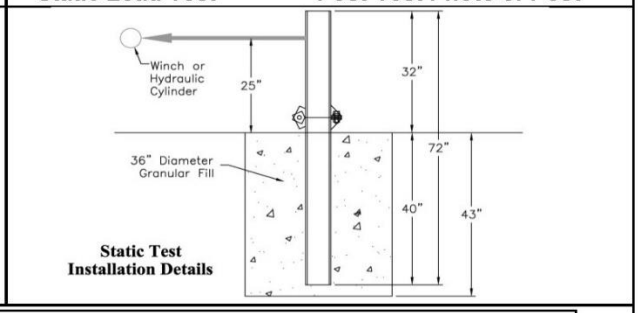
	Left	Right	
Front	1386	1419	
Rear	1100	1095	
FRONT	2805		lb
REAR	2195		lb
TOTAL	5000		lb

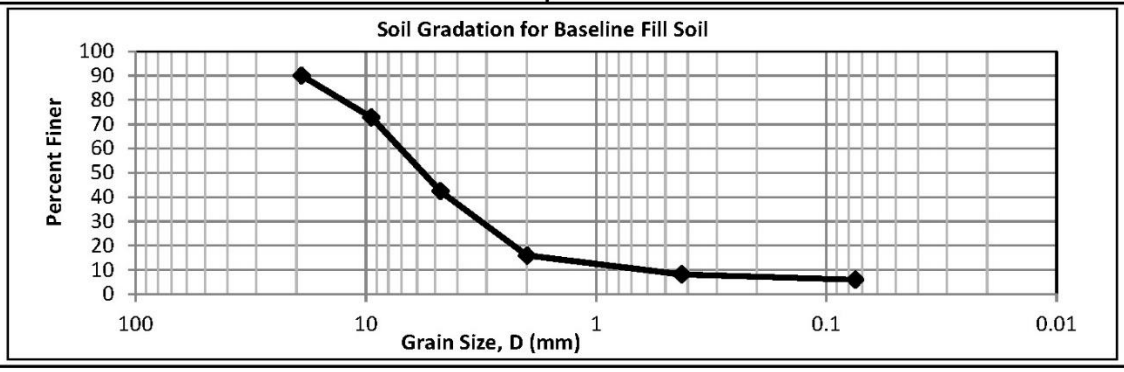
Figure B-1. Vehicle Mass Distribution, Test No. NYT-1

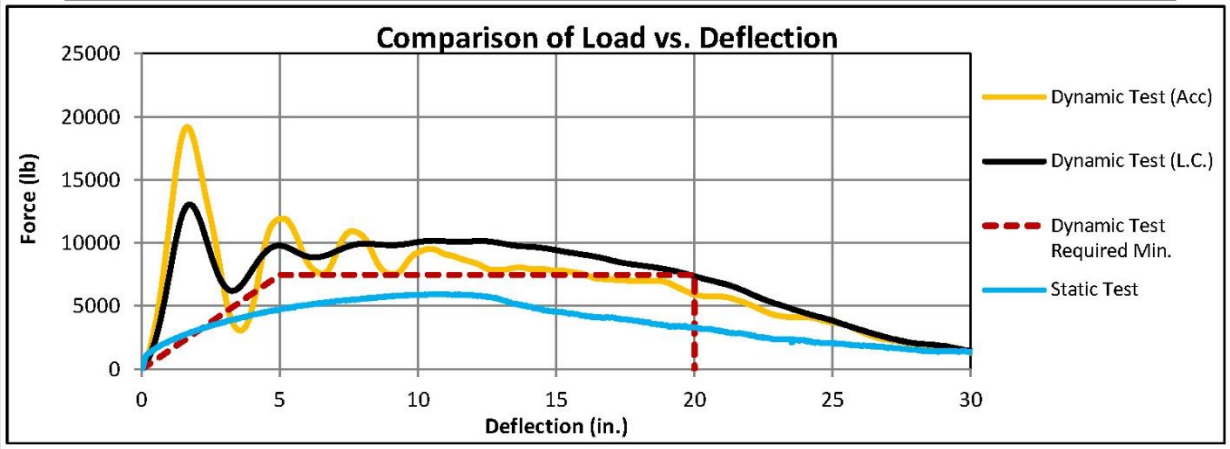
Appendix C. Static Soil Tests





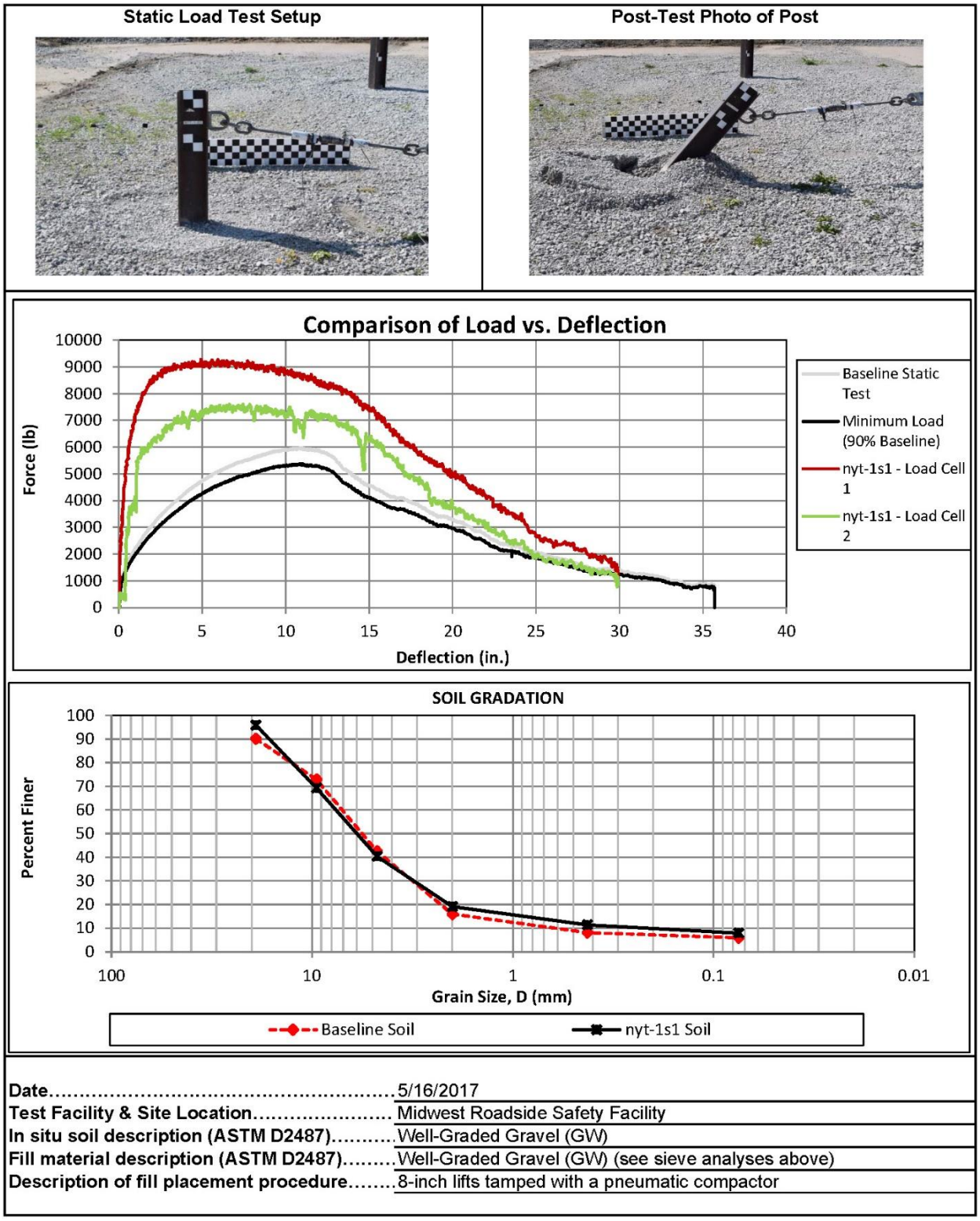






Date	3/20/2012		
Test Facility & Site Location	Midwest Roadside Safety Facility		
In situ soil description (ASTM D2487)	Well-Graded Gravel (GW)		
Fill material description (ASTM D2487)	Well-Graded Gravel (GW) (see sieve analyses above)		
Description of fill placement procedure	8" lift 3-4 passes		
Bogie Weight	1843	lb	836 kg
Impact Velocity	20.0	mph	32.2 km/h

Figure C-1. Soil Strength, Initial Calibration Tests



Date	5/16/2017
Test Facility & Site Location	Midwest Roadside Safety Facility
In situ soil description (ASTM D2487)	Well-Graded Gravel (GW)
Fill material description (ASTM D2487)	Well-Graded Gravel (GW) (see sieve analyses above)
Description of fill placement procedure	8-inch lifts tamped with a pneumatic compactor

Figure C-2. Static Soil Test, Test No. NYT-1

Appendix D. Vehicle Deformation Records

The following figures and tables describe all occupant compartment measurements taken on the test vehicle used in full-scale crash testing herein. MASH 2016 defines intrusion as the occupant compartment being deformed and reduced in size with no penetration. Outward deformations, which are denoted as negative numbers within this Appendix, are not considered as crush toward the occupant, and are not subject to evaluation by MASH 2016 criteria.

Date: 5/11/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913
Year: 2011 Make: Dodge Model: Ram 1500

VEHICLE PRE/POST CRUSH
FLOORPAN - SET 1

POINT	X (in.)	Y (in.)	Z (in.)	X' (in.)	Y' (in.)	Z' (in.)	ΔX (in.)	ΔY (in.)	ΔZ (in.)	Total Δ (in.)
1	28.884	-25.284	-4.312	28.723	-25.809	-3.276	-0.162	-0.525	1.036	1.173
2	28.607	-18.434	-4.836	28.530	-18.914	-3.887	-0.077	-0.481	0.949	1.067
3	27.633	-12.477	-3.000	27.580	-13.047	-2.298	-0.053	-0.570	0.702	0.906
4	19.592	-24.752	-10.683	19.560	-25.240	-9.898	-0.031	-0.488	0.785	0.925
5	19.690	-18.104	-9.367	19.794	-18.668	-8.656	0.104	-0.565	0.711	0.914
6	19.592	-12.280	-8.305	19.614	-12.723	-7.720	0.022	-0.442	0.586	0.734
7	12.557	-25.674	-11.299	12.574	-26.120	-10.661	0.018	-0.447	0.637	0.779
8	12.387	-18.707	-9.962	12.449	-19.144	-9.428	0.062	-0.437	0.534	0.693
9	12.194	-10.774	-8.563	12.289	-11.158	-8.158	0.094	-0.384	0.406	0.566
10	7.645	-25.800	-11.502	7.756	-26.258	-10.999	0.111	-0.459	0.503	0.689
11	7.425	-19.019	-10.192	7.508	-19.427	-9.740	0.084	-0.408	0.452	0.615
12	7.381	-12.326	-8.953	7.426	-12.693	-8.639	0.044	-0.367	0.314	0.485
13	-0.101	-22.610	-6.999	-0.270	-22.953	-6.749	-0.169	-0.343	0.250	0.456
14	-0.281	-15.468	-5.671	-0.267	-15.801	-5.500	0.014	-0.333	0.170	0.374
15	27.043	15.735	4.654	26.703	15.371	6.135	-0.340	-0.364	1.481	1.562
16	30.502	21.603	4.284	28.871	21.346	6.788	-1.631	-0.257	2.503	2.999
17	27.886	26.736	5.298	25.231	25.793	6.040	-2.655	-0.942	0.742	2.913
18	19.778	12.677	1.882	19.632	12.168	2.856	-0.146	-0.509	0.974	1.109
19	21.462	21.576	-1.107	21.537	21.174	-0.010	0.076	-0.401	1.096	1.170
20	21.470	29.130	0.295	21.513	28.833	1.151	0.043	-0.297	0.856	0.907
21	13.748	10.860	-1.598	13.826	10.454	-0.958	0.078	-0.406	0.640	0.762
22	14.824	21.343	-2.223	15.009	21.012	-1.687	0.185	-0.331	0.537	0.657
23	15.078	29.155	-0.787	15.254	28.926	-0.329	0.176	-0.230	0.458	0.542
24	5.731	12.979	-4.032	5.934	12.680	-3.760	0.203	-0.299	0.272	0.452
25	6.563	20.888	-2.536	6.678	20.616	-2.292	0.115	-0.272	0.244	0.383
26	7.120	29.011	-0.987	7.243	28.725	-0.750	0.123	-0.286	0.237	0.391
27	-0.260	15.231	0.218	-0.176	15.093	0.258	0.083	-0.137	0.039	0.165
28	-0.046	23.081	1.762	0.015	22.826	1.876	0.061	-0.254	0.114	0.285

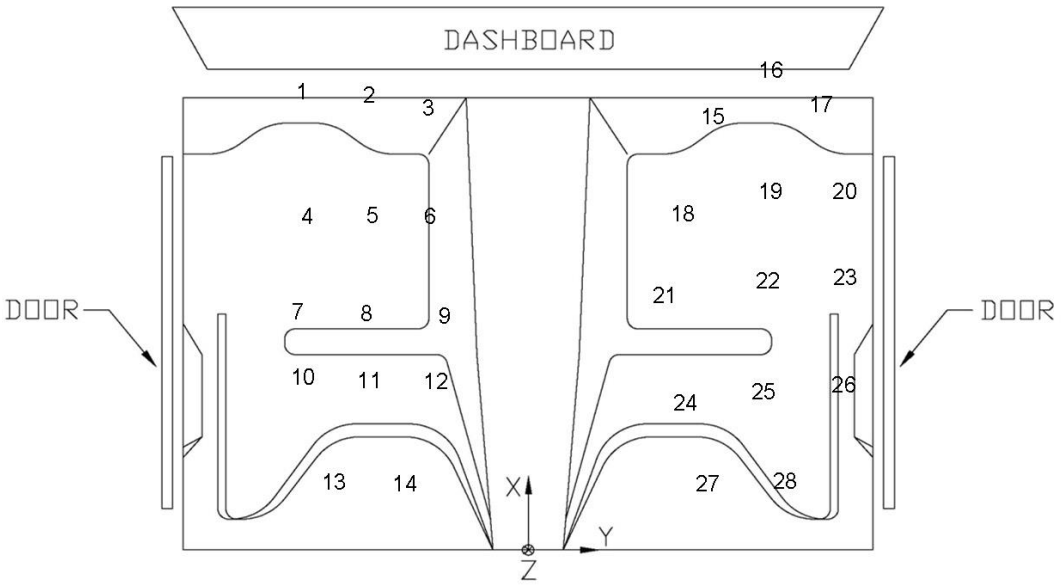


Figure D-1. Floor Pan Deformation Data – Set 1, Test No. NYT-1

Date: 5/11/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913
Year: 2011 Make: Dodge Model: Ram 1500

VEHICLE PRE/POST CRUSH
FLOORPAN - SET 2

POINT	X (in.)	Y (in.)	Z (in.)	X' (in.)	Y' (in.)	Z' (in.)	ΔX (in.)	ΔY (in.)	ΔZ (in.)	Total Δ (in.)
1	51.896	-23.898	1.508	51.869	-24.048	1.701	-0.027	-0.150	0.193	0.246
2	51.678	-17.245	-0.286	51.633	-17.418	-0.127	-0.045	-0.173	0.160	0.240
3	50.792	-11.132	0.381	50.750	-11.282	0.416	-0.042	-0.150	0.035	0.159
4	42.393	-24.535	-4.615	42.419	-24.716	-4.399	0.026	-0.181	0.217	0.283
5	42.662	-17.612	-4.581	42.653	-17.848	-4.442	-0.009	-0.236	0.138	0.274
6	42.536	-11.748	-4.668	42.505	-11.999	-4.604	-0.031	-0.251	0.064	0.261
7	35.326	-25.438	-4.859	35.395	-25.592	-4.650	0.069	-0.155	0.209	0.269
8	35.242	-18.377	-4.876	35.283	-18.569	-4.728	0.041	-0.192	0.148	0.246
9	35.188	-10.290	-5.017	35.165	-10.455	-4.958	-0.023	-0.166	0.059	0.177
10	30.517	-25.599	-4.912	30.521	-25.785	-4.721	0.003	-0.186	0.190	0.266
11	30.303	-18.630	-4.920	30.319	-18.873	-4.735	0.016	-0.243	0.185	0.305
12	30.336	-11.787	-4.983	30.381	-12.009	-4.906	0.045	-0.223	0.077	0.240
13	22.717	-21.490	-0.928	22.760	-21.664	-0.774	0.043	-0.173	0.154	0.236
14	22.742	-14.249	-0.975	22.810	-14.439	-0.877	0.068	-0.190	0.098	0.224
15	50.585	18.084	2.546	50.246	18.175	3.393	-0.338	0.091	0.847	0.916
16	54.011	23.756	0.929	52.437	24.073	2.781	-1.575	0.316	1.851	2.451
17	51.480	28.978	1.004	48.693	28.354	1.480	-2.787	-0.625	0.476	2.896
18	43.273	14.634	0.631	42.995	14.463	1.097	-0.278	-0.171	0.467	0.569
19	44.921	22.791	-4.077	44.704	22.806	-3.487	-0.217	0.015	0.590	0.629
20	45.000	30.472	-4.149	44.769	30.510	-3.749	-0.231	0.038	0.400	0.464
21	37.094	12.273	-2.354	37.093	12.168	-2.107	-0.001	-0.105	0.247	0.268
22	38.234	22.395	-4.999	38.187	22.338	-4.742	-0.047	-0.057	0.257	0.268
23	38.616	30.384	-5.090	38.439	30.268	-4.896	-0.177	-0.116	0.194	0.287
24	29.046	13.933	-4.951	29.036	13.803	-4.774	-0.011	-0.130	0.177	0.220
25	29.898	22.030	-5.018	29.858	21.884	-4.849	-0.040	-0.146	0.168	0.226
26	30.558	30.262	-5.062	30.413	30.227	-4.870	-0.146	-0.035	0.192	0.244
27	23.154	17.105	-1.064	23.139	16.920	-0.974	-0.015	-0.185	0.089	0.206
28	23.473	25.011	-1.053	23.405	24.848	-0.835	-0.067	-0.163	0.218	0.280

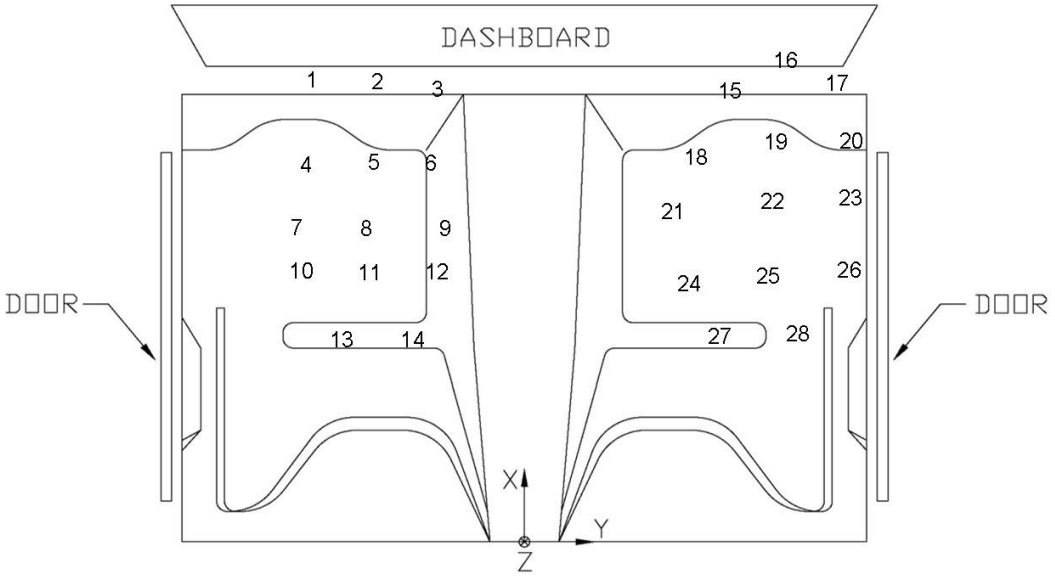


Figure D-2. Floor Pan Deformation Data – Set 2, Test No. NYT-1

Date: 5/11/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913
Year: 2011 Make: Dodge Model: Ram 1500

VEHICLE PRE/POST CRUSH
INTERIOR CRUSH - SET 1

	POINT	X (in.)	Y (in.)	Z (in.)	X' (in.)	Y' (in.)	Z' (in.)	ΔX (in.)	ΔY (in.)	ΔZ (in.)	Total Δ (in.)
DASH	1	11.503	-22.780	24.219	10.400	-23.775	24.930	-1.103	-0.995	0.712	1.647
	2	10.481	-4.351	25.110	8.631	-5.538	25.624	-1.850	-1.187	0.515	2.258
	3	13.827	13.335	28.147	11.080	12.071	29.580	-2.747	-1.264	1.434	3.346
	4	9.180	-20.747	10.299	8.042	-21.443	10.522	-1.138	-0.695	0.223	1.352
	5	8.007	-2.502	14.015	6.424	-3.439	14.521	-1.583	-0.937	0.507	1.908
	6	10.192	14.644	18.655	7.663	13.394	20.175	-2.530	-1.249	1.520	3.205
SIDE PANEL	7	21.337	-32.571	-0.465	21.072	-33.064	0.408	-0.264	-0.493	0.873	1.037
	8	24.819	-32.513	-0.793	24.622	-32.990	0.182	-0.198	-0.477	0.975	1.103
	9	21.871	-31.681	-4.519	21.715	-32.181	-3.582	-0.156	-0.500	0.936	1.073
IMPACT SIDE DOOR	10	-12.993	-37.095	14.560	-13.563	-36.879	14.761	-0.570	0.216	0.201	0.642
	11	-1.351	-36.941	14.747	-1.836	-36.947	15.232	-0.485	-0.006	0.485	0.686
	12	9.569	-36.785	14.841	8.969	-36.994	15.544	-0.600	-0.209	0.703	0.947
	13	-7.043	-34.956	-3.873	-7.259	-35.003	-3.463	-0.216	-0.047	0.410	0.466
	14	-0.903	-35.170	-3.985	-1.057	-35.285	-3.631	-0.154	-0.115	0.355	0.403
	15	5.925	-34.766	-3.717	5.742	-35.035	-3.172	-0.184	-0.269	0.545	0.635
ROOF	16	2.825	-29.540	36.097	1.920	-28.193	36.066	-0.905	1.347	-0.031	1.623
	17	5.537	-18.463	38.540	4.476	-16.879	37.613	-1.061	1.584	-0.927	2.120
	18	6.329	-8.085	40.650	5.100	-6.431	38.927	-1.229	1.654	-1.722	2.686
	19	5.284	4.653	43.066	3.927	6.494	40.447	-1.357	1.840	-2.619	3.476
	20	2.857	14.848	44.515	1.271	16.726	41.408	-1.586	1.879	-3.107	3.962
	21	-4.679	-28.408	39.330	-5.588	-26.839	39.210	-0.909	1.569	-0.120	1.817
	22	-3.161	-17.509	41.956	-4.094	-15.920	41.227	-0.933	1.589	-0.729	1.981
	23	-2.155	-8.140	43.787	-3.212	-6.461	42.577	-1.057	1.679	-1.211	2.324
	24	-2.145	2.474	45.541	-3.057	4.274	43.825	-0.912	1.800	-1.716	2.649
	25	-3.928	11.613	46.908	-4.927	13.338	45.078	-0.999	1.725	-1.829	2.705
	26	-8.150	-27.945	39.777	-9.064	-26.367	39.625	-0.914	1.578	-0.152	1.830
	27	-7.815	-17.557	42.357	-8.757	-15.930	41.769	-0.943	1.627	-0.588	1.970
	28	-7.178	-7.994	44.372	-8.177	-6.246	43.402	-0.999	1.748	-0.969	2.234
	29	-6.153	2.279	45.962	-7.164	4.143	44.527	-1.012	1.864	-1.436	2.561
	30	-7.342	10.940	47.254	-8.347	12.770	45.494	-1.005	1.830	-1.761	2.731
A PILLAR	31	2.229	-33.847	33.098	1.425	-32.740	33.317	-0.804	1.107	0.219	1.386
	32	8.777	-34.741	29.828	7.913	-34.057	30.328	-0.864	0.684	0.500	1.210
	33	14.208	-35.241	26.085	13.456	-34.923	26.689	-0.752	0.318	0.604	1.015
	34	18.066	-35.590	23.283	17.203	-35.459	24.037	-0.863	0.130	0.754	1.153
B PILLAR	35	-20.563	-35.232	16.004	-20.965	-34.484	16.043	-0.402	0.747	0.039	0.850
	36	-23.935	-35.282	16.220	-24.390	-34.479	16.153	-0.455	0.803	-0.067	0.926
	37	-24.214	-35.536	23.083	-24.826	-34.494	23.110	-0.612	1.042	0.027	1.209
	38	-21.248	-35.518	23.065	-21.940	-34.524	23.054	-0.692	0.994	-0.011	1.211
	39	-25.114	-34.046	32.478	-25.839	-32.671	32.338	-0.725	1.375	-0.140	1.561
	40	-22.136	-33.984	32.895	-22.923	-32.627	32.850	-0.787	1.357	-0.045	1.569

Figure D-3. Occupant Compartment Deformation Data – Set 1, Driver, Test No. NYT-1

Date: 5/11/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913
Year: 2011 Make: Dodge Model: Ram 1500

VEHICLE PRE/POST CRUSH
INTERIOR CRUSH - SET 1

	POINT	X (in.)	Y (in.)	Z (in.)	X' (in.)	Y' (in.)	Z' (in.)	ΔX (in.)	ΔY (in.)	ΔZ (in.)	Total Δ (in.)
DASH	1	11.477	-22.761	24.291	10.420	-23.825	25.010	-1.057	-1.063	0.719	1.663
	2	10.481	-4.363	25.134	8.608	-5.420	25.608	-1.874	-1.057	0.474	2.203
	3	13.852	13.319	28.220	11.089	12.150	29.569	-2.763	-1.169	1.350	3.290
	4	9.192	-20.701	10.260	8.082	-21.434	10.437	-1.110	-0.732	0.178	1.342
	5	7.995	-2.472	14.005	6.458	-3.405	14.388	-1.537	-0.933	0.382	1.838
	6	10.180	14.662	18.732	7.696	13.478	19.998	-2.484	-1.184	1.267	3.030
SIDE PANEL	7	25.556	31.155	9.291	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	8	20.663	32.429	2.714	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	9	20.333	31.222	9.565	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
IMPACT SIDE DOOR	10	-13.563	29.470	27.481	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	11	-3.008	29.315	27.498	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	12	7.833	29.204	27.348	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	13	-8.313	34.367	9.400	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	14	0.083	34.543	9.331	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	15	6.805	34.126	8.619	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
ROOF	16	2.867	-29.539	36.087	1.912	-28.192	36.071	-0.956	1.348	-0.016	1.652
	17	5.511	-18.389	38.584	4.445	-16.885	37.634	-1.066	1.504	-0.950	2.074
	18	6.306	-8.127	40.661	5.117	-6.448	38.937	-1.190	1.678	-1.724	2.684
	19	5.294	4.718	43.076	3.877	6.523	40.501	-1.417	1.805	-2.575	3.449
	20	2.868	14.892	44.516	1.264	16.704	41.413	-1.605	1.812	-3.103	3.936
	21	-4.618	-28.444	39.298	-5.509	-27.003	39.171	-0.891	1.441	-0.127	1.699
	22	-3.123	-17.595	41.920	-4.155	-15.978	41.233	-1.031	1.617	-0.687	2.037
	23	-2.148	-8.175	43.774	-3.152	-6.443	42.578	-1.004	1.732	-1.196	2.332
	24	-2.075	2.569	45.555	-3.095	4.328	43.850	-1.020	1.759	-1.705	2.654
	25	-3.993	11.622	46.929	-5.003	13.417	45.095	-1.010	1.795	-1.835	2.758
	26	-8.181	-27.927	39.786	-9.083	-26.318	39.648	-0.901	1.609	-0.138	1.849
	27	-7.804	-17.565	42.369	-8.747	-15.909	41.779	-0.942	1.656	-0.590	1.995
	28	-7.205	-7.966	44.393	-8.172	-6.235	43.416	-0.967	1.731	-0.977	2.211
	29	-6.236	2.326	45.989	-7.157	4.016	44.543	-0.921	1.691	-1.446	2.408
	30	-7.353	11.065	47.282	-8.382	12.757	45.560	-1.029	1.692	-1.722	2.624
A PILLAR	31	3.416	20.111	43.025	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	32	8.976	21.859	40.296	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	33	14.076	23.580	37.129	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	34	20.238	25.730	32.780	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
B PILLAR	35	-20.321	27.329	27.995	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	36	-23.583	27.447	27.613	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	37	-21.333	24.281	35.985	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	38	-24.299	24.351	35.835	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	39	-22.067	20.204	42.731	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	40	-24.953	20.173	42.801	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Passenger A Pillar, B Pillar, Side Panel, and Door are disengaged. Points could not be taken.

Figure D-4. Occupant Compartment Deformation Data – Set 1, Passenger, Test No. NYT-1

Date: 5/11/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913
Year: 2011 Make: Dodge Model: Ram 1500

VEHICLE PRE/POST CRUSH
INTERIOR CRUSH - SET 2

	POINT	X (in.)	Y (in.)	Z (in.)	X' (in.)	Y' (in.)	Z' (in.)	ΔX (in.)	ΔY (in.)	ΔZ (in.)	Total Δ (in.)
DASH	1	35.312	-15.800	29.493	34.981	-16.735	29.978	-0.331	-0.935	0.484	1.104
	2	34.384	2.512	26.846	33.195	1.349	27.346	-1.189	-1.163	0.500	1.737
	3	37.957	20.468	26.402	35.778	19.383	27.847	-2.179	-1.085	1.445	2.831
	4	32.623	-16.431	15.485	31.925	-17.132	15.469	-0.698	-0.700	-0.016	0.989
	5	31.664	2.223	15.612	30.451	1.381	16.091	-1.213	-0.842	0.480	1.552
	6	34.063	19.859	16.917	31.918	18.919	18.448	-2.146	-0.941	1.531	2.799
SIDE PANEL	7	44.460	-30.258	6.828	44.502	-30.490	7.103	0.042	-0.232	0.275	0.362
	8	47.844	-30.274	6.415	47.964	-30.472	6.644	0.120	-0.198	0.230	0.326
	9	44.834	-30.137	2.746	44.924	-30.355	2.963	0.090	-0.218	0.217	0.321
IMPACT SIDE DOOR	10	10.425	-31.417	23.354	10.596	-31.334	23.630	0.172	0.083	0.277	0.336
	11	22.174	-31.367	23.170	22.317	-31.391	23.477	0.144	-0.024	0.307	0.340
	12	33.091	-31.319	22.981	33.227	-31.448	23.264	0.135	-0.129	0.284	0.340
	13	15.928	-32.897	4.731	16.047	-32.910	4.991	0.119	-0.013	0.260	0.286
	14	22.018	-33.191	4.380	22.127	-33.252	4.614	0.109	-0.061	0.234	0.265
	15	28.886	-32.827	4.495	29.007	-32.976	4.706	0.120	-0.149	0.211	0.285
ROOF	16	26.931	-20.063	42.623	27.071	-18.982	42.110	0.139	1.081	-0.513	1.204
	17	29.696	-8.636	42.900	29.629	-7.547	41.431	-0.068	1.089	-1.468	1.829
	18	30.617	1.815	42.932	30.346	2.941	40.714	-0.271	1.126	-2.218	2.502
	19	29.769	14.878	42.848	29.214	15.940	39.860	-0.554	1.062	-2.987	3.218
	20	27.397	25.110	42.406	26.577	26.148	39.038	-0.820	1.038	-3.369	3.619
	21	19.497	-18.320	45.742	19.892	-16.975	45.264	0.395	1.346	-0.478	1.482
	22	21.129	-7.109	46.209	21.341	-5.861	45.183	0.212	1.247	-1.026	1.629
	23	22.254	2.461	46.192	22.312	3.715	44.700	0.058	1.255	-1.492	1.950
	24	22.378	13.273	45.880	22.340	14.471	43.955	-0.038	1.198	-1.925	2.268
	25	20.692	22.484	45.529	20.473	23.667	43.569	-0.219	1.183	-1.960	2.300
	26	15.961	-17.688	46.196	16.289	-16.435	45.814	0.328	1.253	-0.381	1.351
	27	16.536	-7.048	46.722	16.667	-5.780	45.961	0.131	1.268	-0.761	1.484
	28	17.275	2.807	46.860	17.340	4.033	45.739	0.065	1.226	-1.120	1.662
	29	18.322	13.201	46.455	18.281	14.396	44.894	-0.040	1.195	-1.561	1.966
	30	17.262	21.993	46.084	17.219	23.178	44.297	-0.043	1.185	-1.787	2.144
A PILLAR	31	26.237	-24.858	40.500	26.474	-23.920	40.353	0.237	0.938	-0.147	0.979
	32	32.591	-26.417	37.361	32.864	-25.838	37.252	0.273	0.578	-0.108	0.649
	33	38.000	-27.711	33.621	38.113	-27.372	33.625	0.112	0.339	0.004	0.357
	34	41.755	-28.604	30.824	41.797	-28.465	30.901	0.042	0.139	0.077	0.165
B PILLAR	35	2.979	-29.246	24.565	3.155	-28.725	24.708	0.177	0.520	0.143	0.568
	36	-0.426	-29.218	24.820	-0.227	-28.673	25.033	0.199	0.544	0.213	0.617
	37	-0.506	-28.150	31.660	-0.367	-27.404	31.847	0.139	0.745	0.187	0.781
	38	2.473	-28.186	31.507	2.656	-27.445	31.700	0.183	0.741	0.193	0.787
	39	-1.104	-24.892	40.605	-0.830	-23.879	40.658	0.274	1.013	0.052	1.051
	40	1.860	-24.772	40.976	2.036	-23.748	41.045	0.176	1.023	0.069	1.041

Figure D-5. Occupant Compartment Deformation Data – Set 2, Driver, Test No. NYT-1

Date: 5/11/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913
Year: 2011 Make: Dodge Model: Ram 1500

VEHICLE PRE/POST CRUSH
INTERIOR CRUSH - SET 2

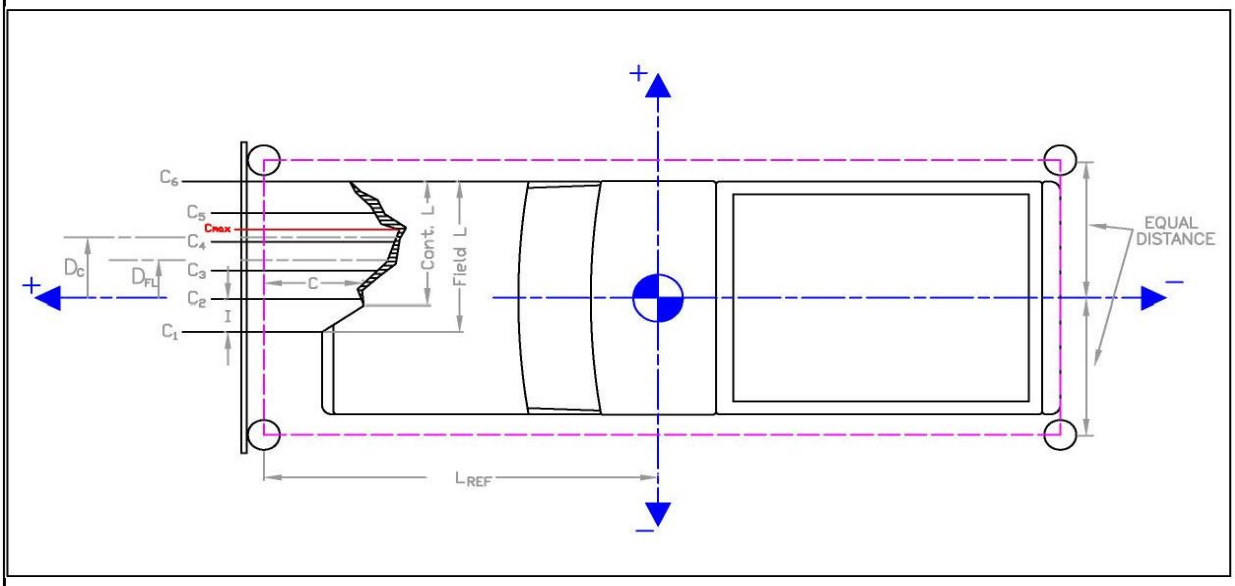
	POINT	X (in.)	Y (in.)	Z (in.)	X' (in.)	Y' (in.)	Z' (in.)	ΔX (in.)	ΔY (in.)	ΔZ (in.)	Total Δ (in.)
DASH	1	35.315	-15.855	29.485	34.988	-16.840	29.951	-0.327	-0.985	0.467	1.138
	2	34.389	2.456	26.824	33.144	1.383	27.285	-1.244	-1.073	0.461	1.706
	3	37.914	20.362	26.386	35.782	19.333	27.842	-2.133	-1.029	1.456	2.780
	4	32.631	-16.383	15.463	31.923	-17.122	15.464	-0.708	-0.739	0.001	1.023
	5	31.665	2.202	15.618	30.456	1.402	16.114	-1.209	-0.800	0.496	1.532
	6	34.062	19.881	16.848	31.921	19.004	18.395	-2.141	-0.878	1.547	2.783
SIDE PANEL	7	49.233	34.139	4.144	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	8	44.164	34.183	-2.455	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	9	44.067	34.313	4.521	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
IMPACT SIDE DOOR	10	10.675	36.387	23.299	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	11	21.264	36.126	23.055	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	12	32.029	35.864	22.687	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	13	15.474	37.675	4.489	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	14	23.849	37.740	4.167	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	15	30.520	37.126	3.403	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
ROOF	16	26.925	-20.089	42.607	27.053	-18.962	42.130	0.128	1.127	-0.478	1.230
	17	29.736	-8.705	42.848	29.672	-7.591	41.415	-0.064	1.114	-1.433	1.816
	18	30.619	1.754	42.924	30.334	2.913	40.731	-0.285	1.160	-2.193	2.497
	19	29.733	14.862	42.861	29.204	15.936	39.879	-0.529	1.074	-2.982	3.214
	20	27.375	25.195	42.401	26.573	26.133	39.056	-0.802	0.938	-3.344	3.565
	21	19.582	-18.314	45.716	19.782	-17.058	45.301	0.200	1.256	-0.415	1.338
	22	21.196	-7.177	46.189	21.301	-5.869	45.184	0.105	1.308	-1.005	1.653
	23	22.270	2.510	46.187	22.307	3.727	44.676	0.037	1.218	-1.511	1.941
	24	22.371	13.294	45.880	22.307	14.484	43.935	-0.065	1.191	-1.945	2.281
	25	20.644	22.391	45.534	20.537	23.707	43.499	-0.107	1.316	-2.035	2.426
	26	16.074	-17.613	46.180	16.225	-16.336	45.818	0.150	1.276	-0.362	1.335
	27	16.529	-7.013	46.724	16.704	-5.754	45.947	0.175	1.259	-0.776	1.489
	28	17.178	2.786	46.863	17.355	4.062	45.705	0.178	1.276	-1.159	1.733
	29	18.302	13.122	46.439	18.276	14.426	44.866	-0.026	1.305	-1.573	2.044
	30	17.225	21.928	46.078	17.171	23.165	44.247	-0.054	1.237	-1.831	2.210
A PILLAR	31	27.947	29.978	39.932	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	32	33.441	31.119	36.803	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	33	38.461	32.125	33.157	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	34	44.550	33.354	28.359	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
B PILLAR	35	3.991	34.445	24.457	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	36	0.524	34.533	24.065	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	37	3.118	33.005	32.782	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	38	0.084	33.111	32.676	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	39	2.453	30.288	40.238	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!
	40	-0.484	30.289	40.428	N/A	N/A	N/A	#VALUE!	#VALUE!	#VALUE!	#VALUE!

A Pillar, B Pillar, Side Panel, and Door are disengaged. Points could not be taken.

Figure D-6. Occupant Compartment Deformation Data – Set 2, Passenger, Test No. NYT-1

Date: 5/16/2017 Test Name: NYT-1 VIN: 1D7RB1GP3BS553913

Year: 2011 Make: Dodge Model: Ram 1500



	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	119 1/2	(3035)
Total Vehicle Width:	78 3/8	(1991)
Width of contact and induced crush - Field L:	78 3/8	(1991)
Crush measurement spacing interval (L/5) - I:	15 5/8	(397)
Distance from center of vehicle to center of Field L - D_{FL}:	0	()
Width of Contact Damage:	78 3/8	(1991)
Distance from center of vehicle to center of contact damage - D_C:	0	()

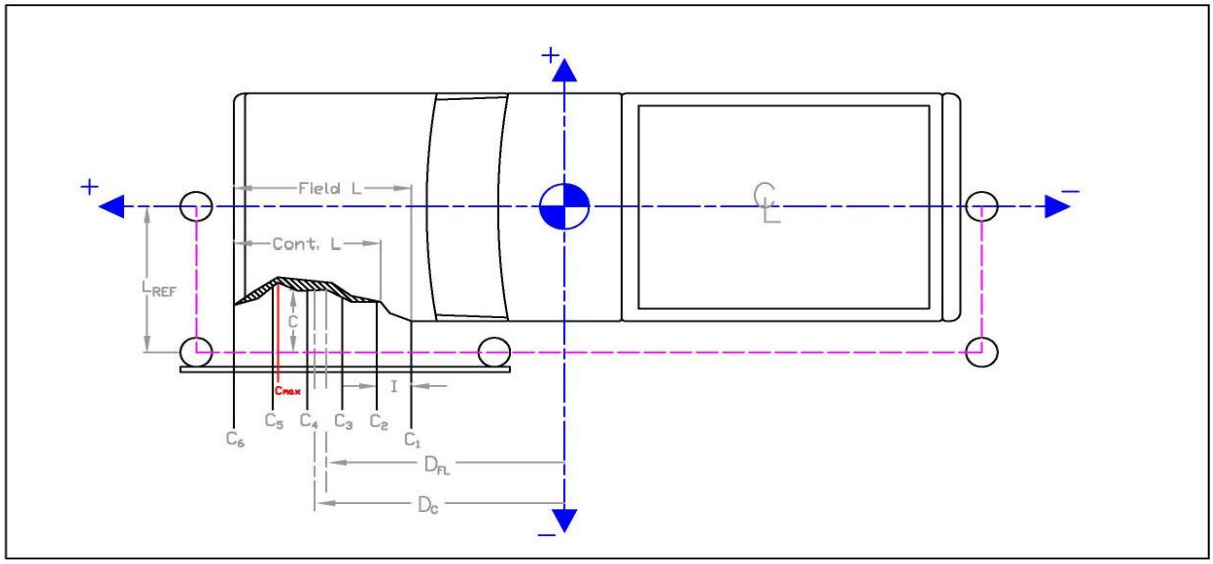
NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., side of vehicle has been pushed inward)

NOTE: All values must be filled out above before crush measurements are filled out.

	Crush Measurement		Lateral Location		Original Profile Measurement		Dist. Between Ref. Lines		Actual Crush	
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
C_1	N/A	#VALUE!	-39 1/4	-(997)	22 1/2	(572)	13 2/3	(348)	#VALUE!	#VALUE!
C_2	13 1/2	(343)	-23 5/8	-(600)	6 3/4	(171)			-7	-(176)
C_3	41 1/4	(1048)	-8	-(203)	4 1/4	(108)			23 1/3	(592)
C_4	11 1/4	(286)	7 5/8	(194)	4 1/4	(108)			-6 2/3	-(170)
C_5	N/A	#VALUE!	23 1/4	(591)	6 1/4	(159)			#VALUE!	#VALUE!
C_6	N/A	#VALUE!	38 7/8	(987)	20 1/2	(521)			#VALUE!	#VALUE!
C_{MAX}	44 3/4	(1137)	-3 3/8	-(86)	4	(102)			27	(687)

Figure D-7. Exterior Vehicle Crush (NASS) - Front, Test No. NYT-1

Date:	5/16/2017	**Test Name:**	NYT-1	**VIN:**	1D7RB1GP3BS553913
Year:	2011	**Make:**	Dodge	**Model:**	Ram 1500



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	43 1/8	(1095)
Total Vehicle Length:	229 1/2	(5829)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-14 4/9	-(367)
Width of contact and induced crush - Field L:	35	(889)
Crush measurement spacing interval (L/5) - I:	7	(178)
Distance from vehicle c.g. to center of Field L - D_{FL}:	92 1/4	(2343)
Width of Contact Damage:	25 4/7	(649)
Distance from vehicle c.g. to center of contact damage - D_C:	87 1/2	(2223)

NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., front of vehicle has been pushed inward or tire has been removed)
NOTE: All values must be filled out above before crush measurements are filled out.

	Crush Measurement		Longitudinal Location		Original Profile Measurement		Dist. Between Ref. Lines		Actual	Crush
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
C_1	N/A	#VALUE!	74 3/4	(1899)	5 5/8	(143)	- 7/8	-(22)	#VALUE!	#VALUE!
C_2	15 3/4	(400)	81 3/4	(2076)	6	(152)			10 5/8	(270)
C_3	19 1/4	(489)	88 3/4	(2254)	7 1/4	(184)			12 7/8	(327)
C_4	20 1/4	(514)	95 3/4	(2432)	14	(356)			7 1/8	(181)
C_5	5 3/4	(146)	102 3/4	(2610)	33 1/2	(851)			-26 7/8	-(683)
C_6	8 1/2	(216)	109 3/4	(2788)	33 1/2	(851)			-24 1/8	-(613)
C_{MAX}	36 7/8	(937)	76 3/8	(1940)	5 3/4	(146)			32	(813)

Figure D-8. Exterior Vehicle Crush (NASS) - Side, Test No. NYT-1

Appendix E. Accelerometer and Rate Transducer Data Plots, Test No. NYT-1

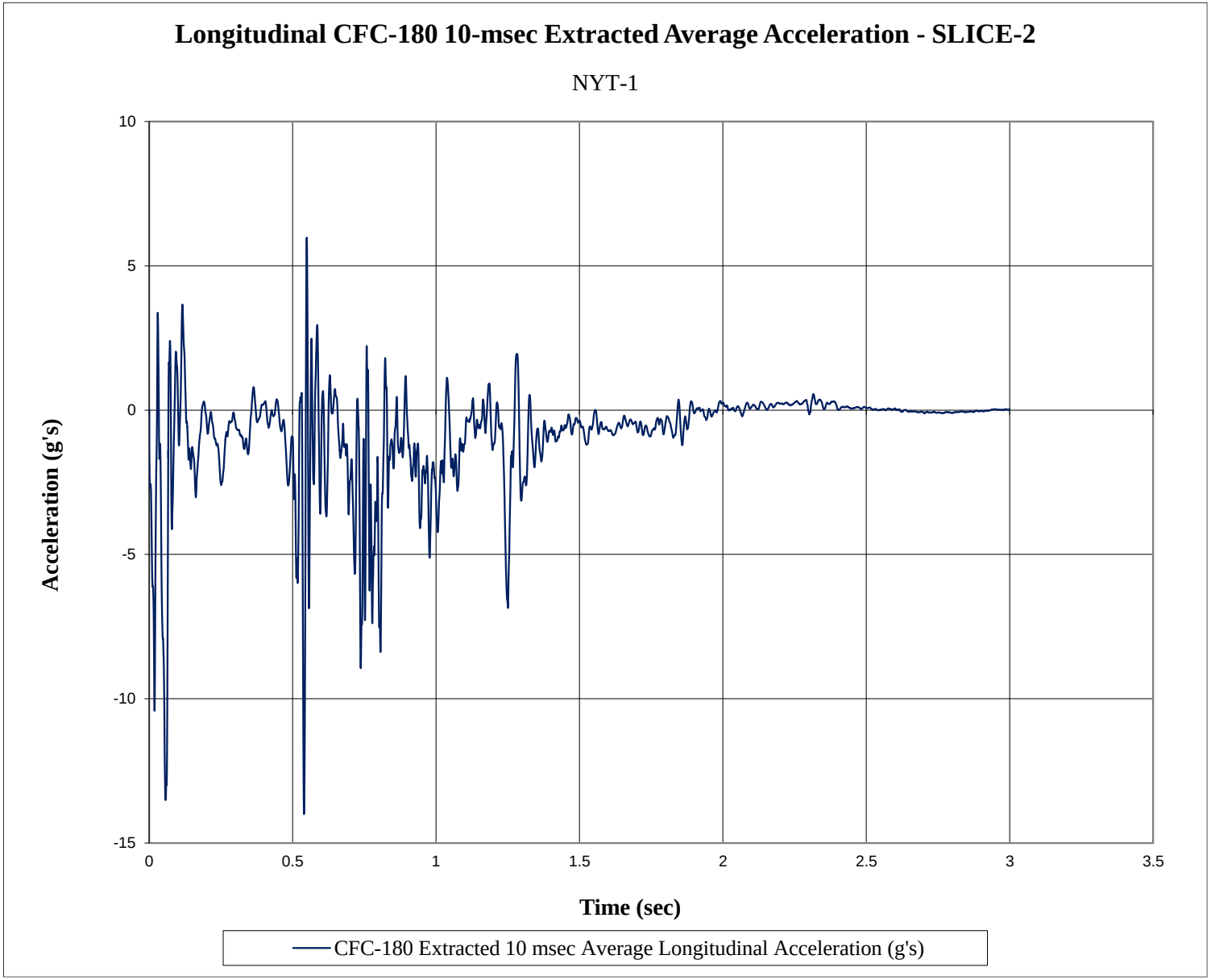


Figure E-1. 10-ms Average Longitudinal Deceleration (SLICE-2), Test No. NYT-1

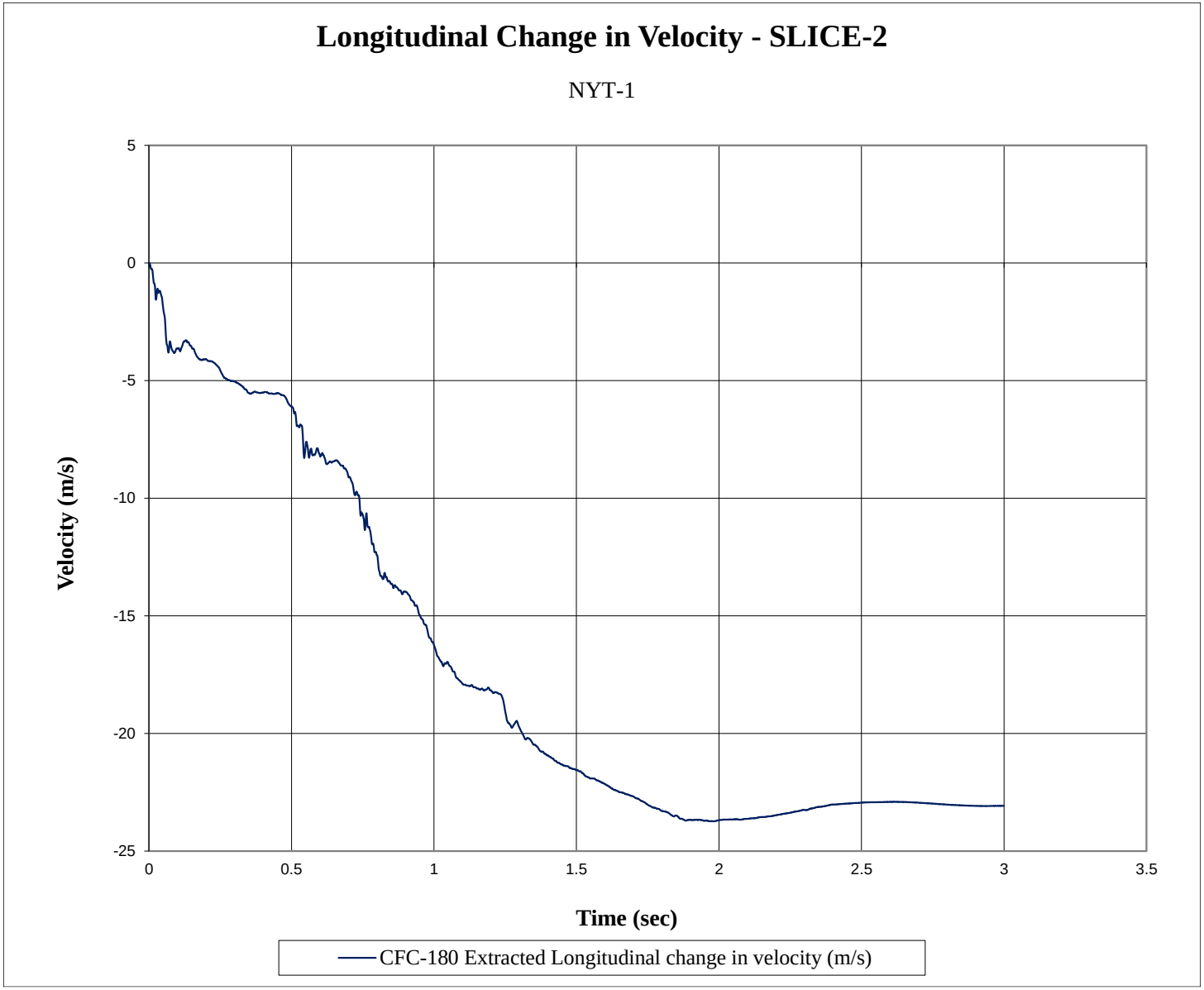


Figure E-2. Longitudinal Occupant Velocity (SLICE-2), Test No. NYT-1

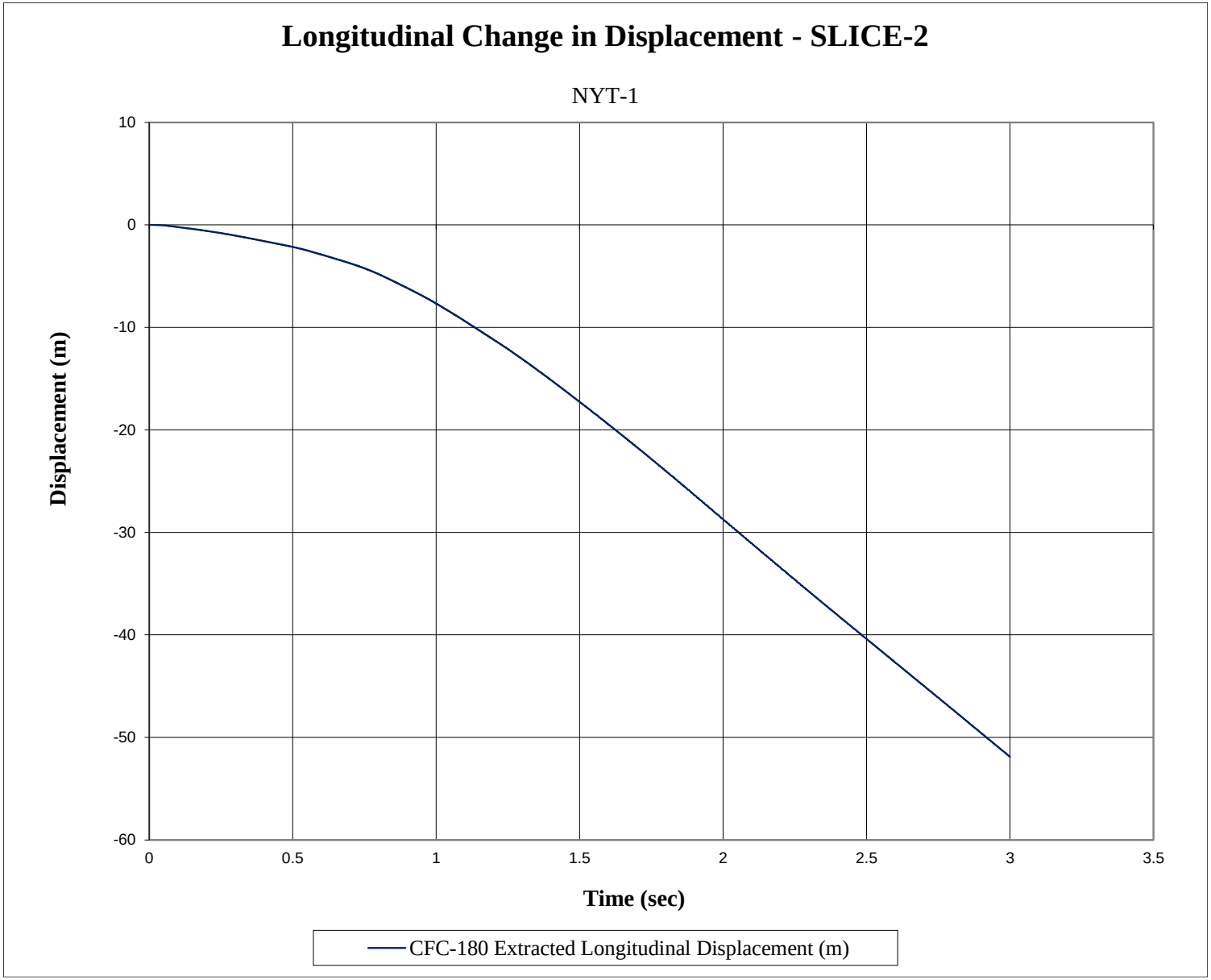


Figure E-3. Longitudinal Occupant Displacement (SLICE-2), Test No. NYT-1

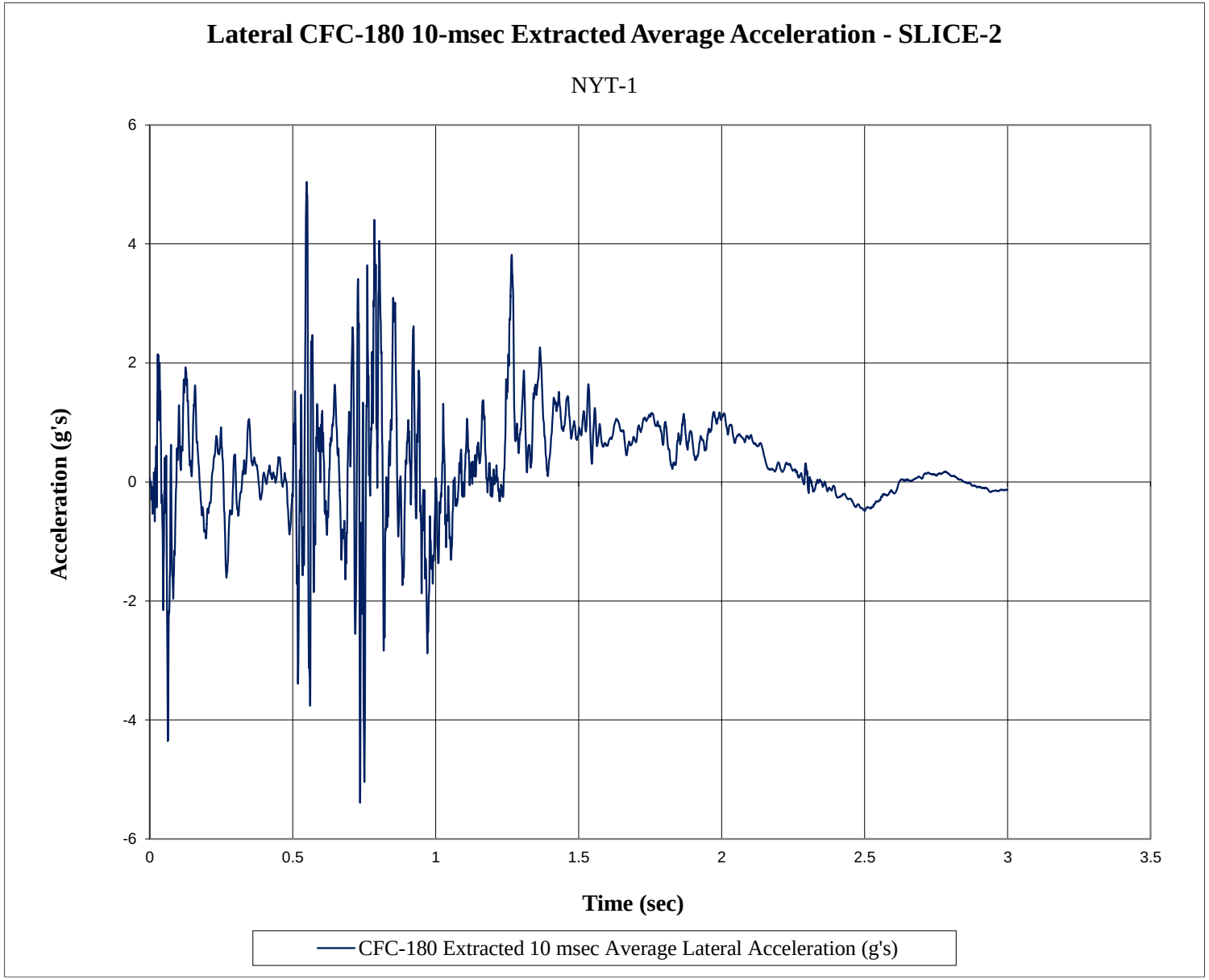


Figure E-4. 10-ms Average Lateral Deceleration (SLICE-2), Test No. NYT-1

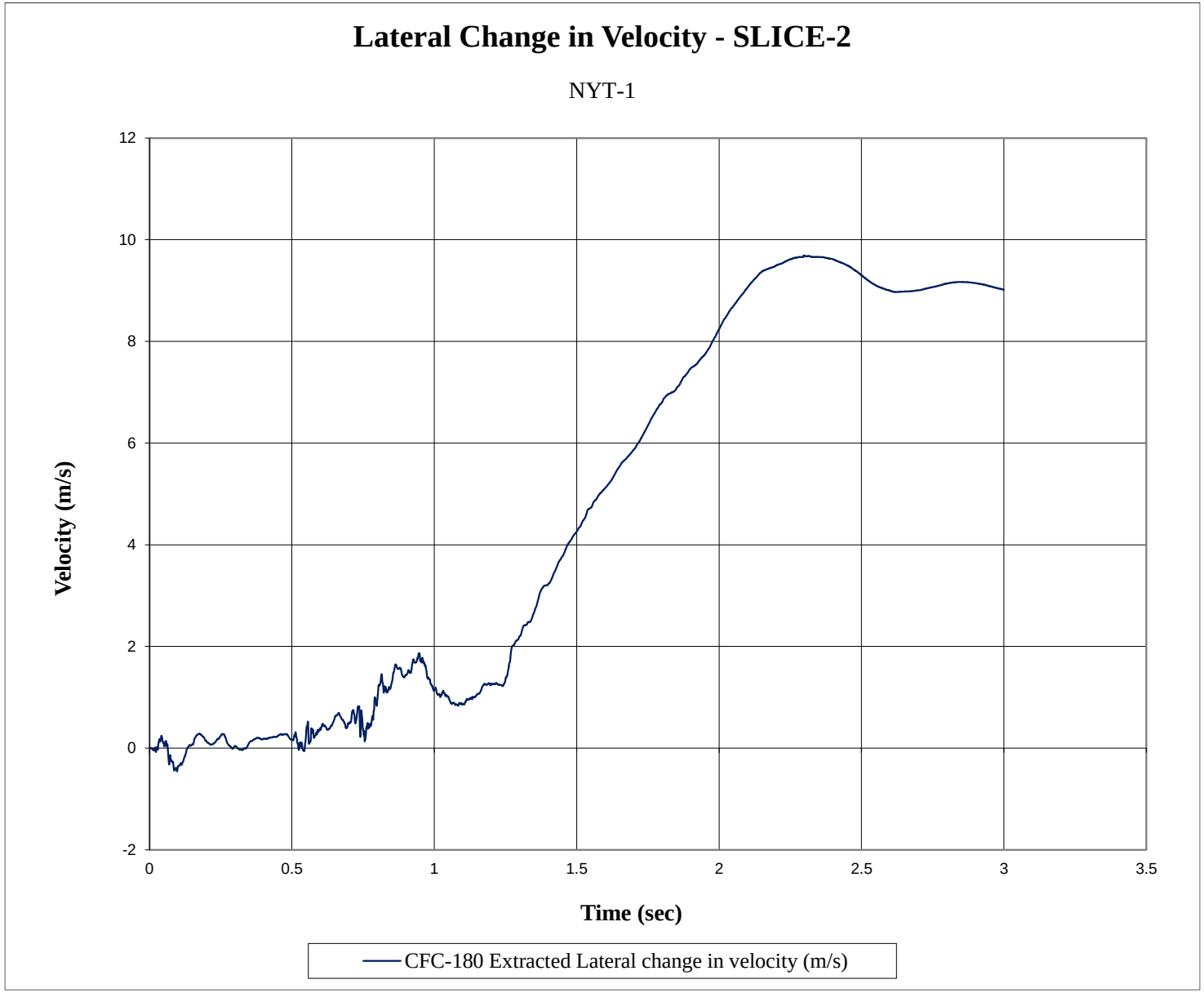


Figure E-5. Lateral Occupant Velocity (SLICE-2), Test No. NYT-1

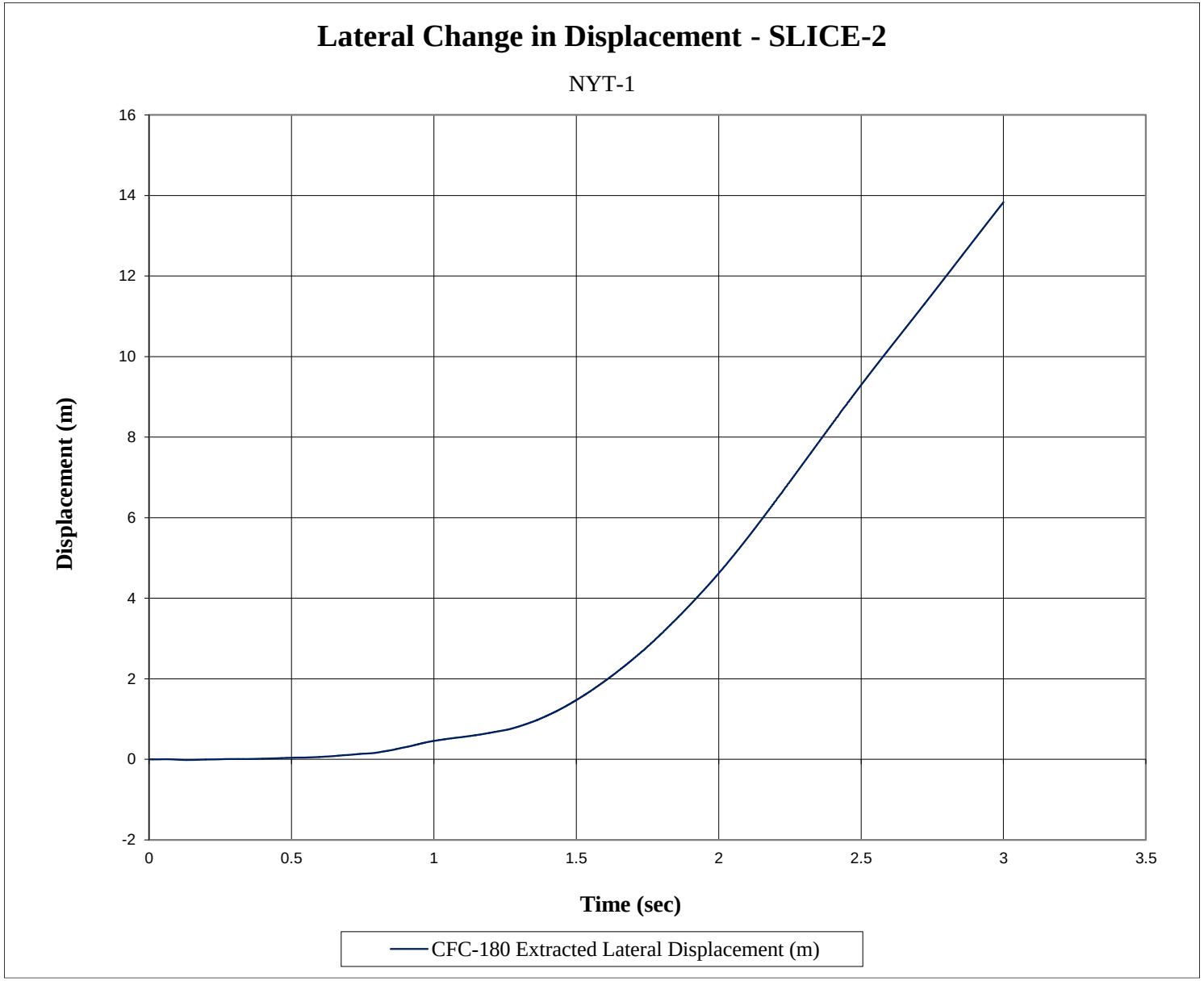


Figure E-6. Lateral Occupant Displacement (SLICE-2), Test No. NYT-1

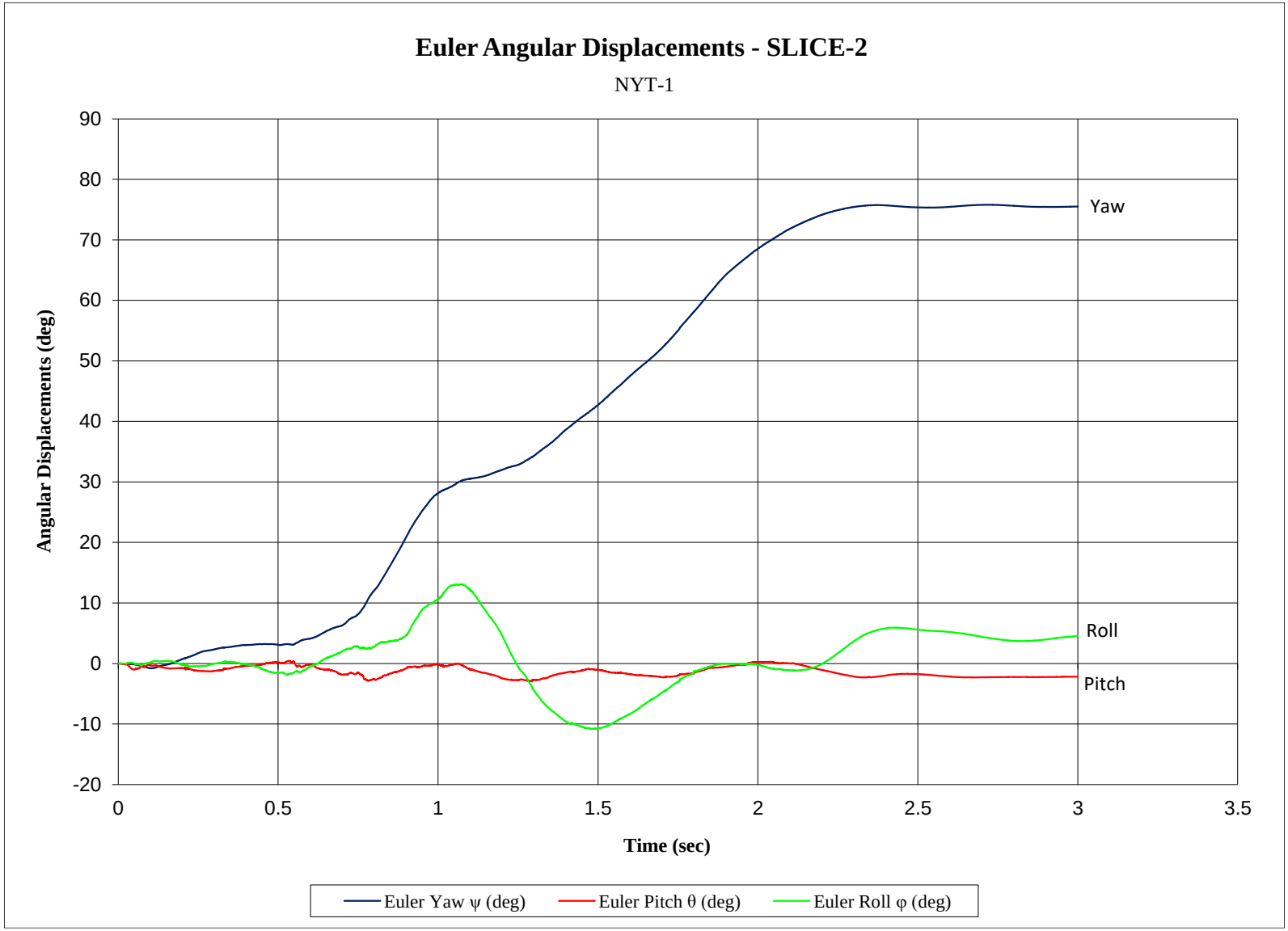


Figure E-7. Vehicle Angular Displacements (SLICE-2), Test No. NYT-1

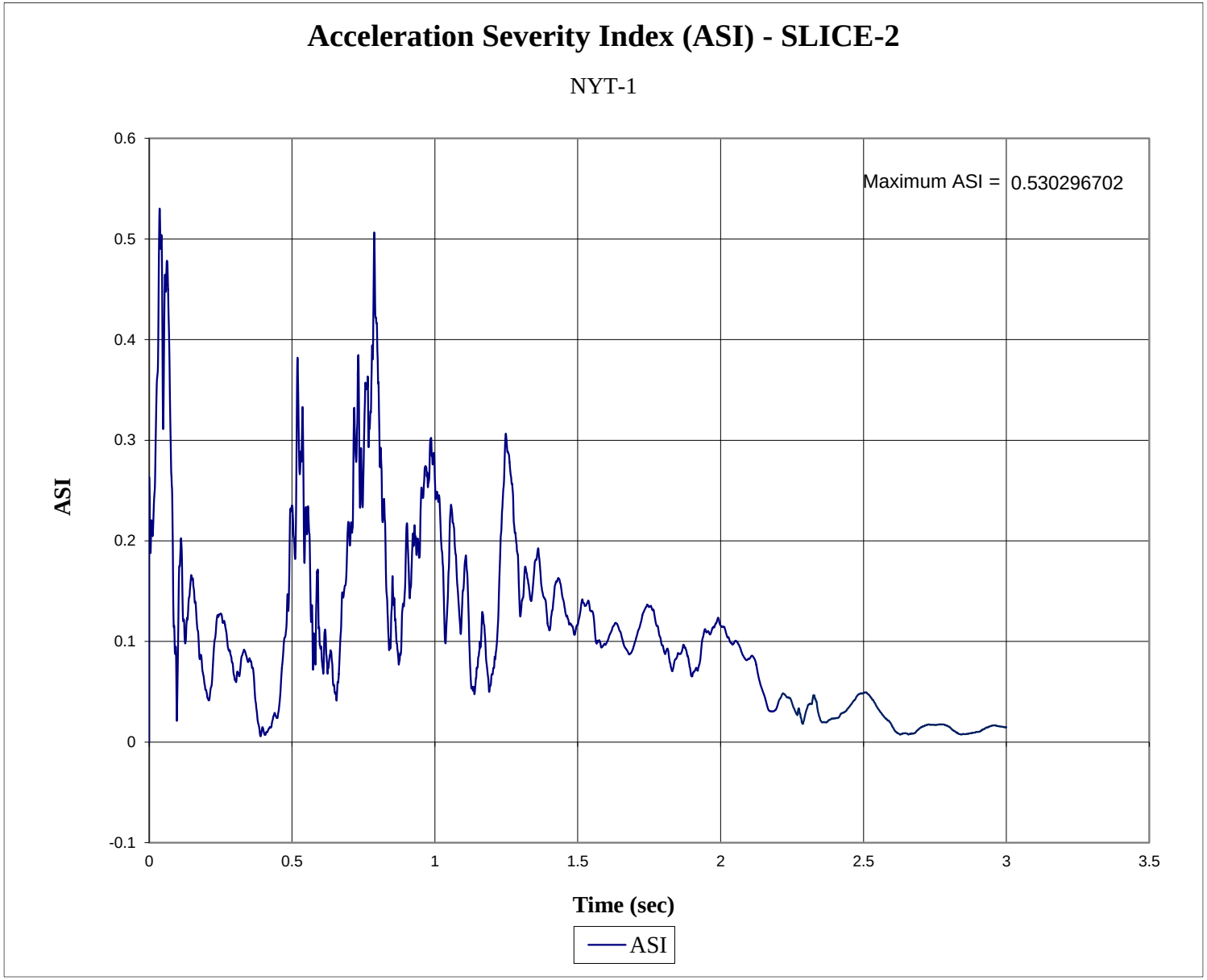


Figure E-8. Acceleration Severity Index (SLICE-2), Test No. NYT-1

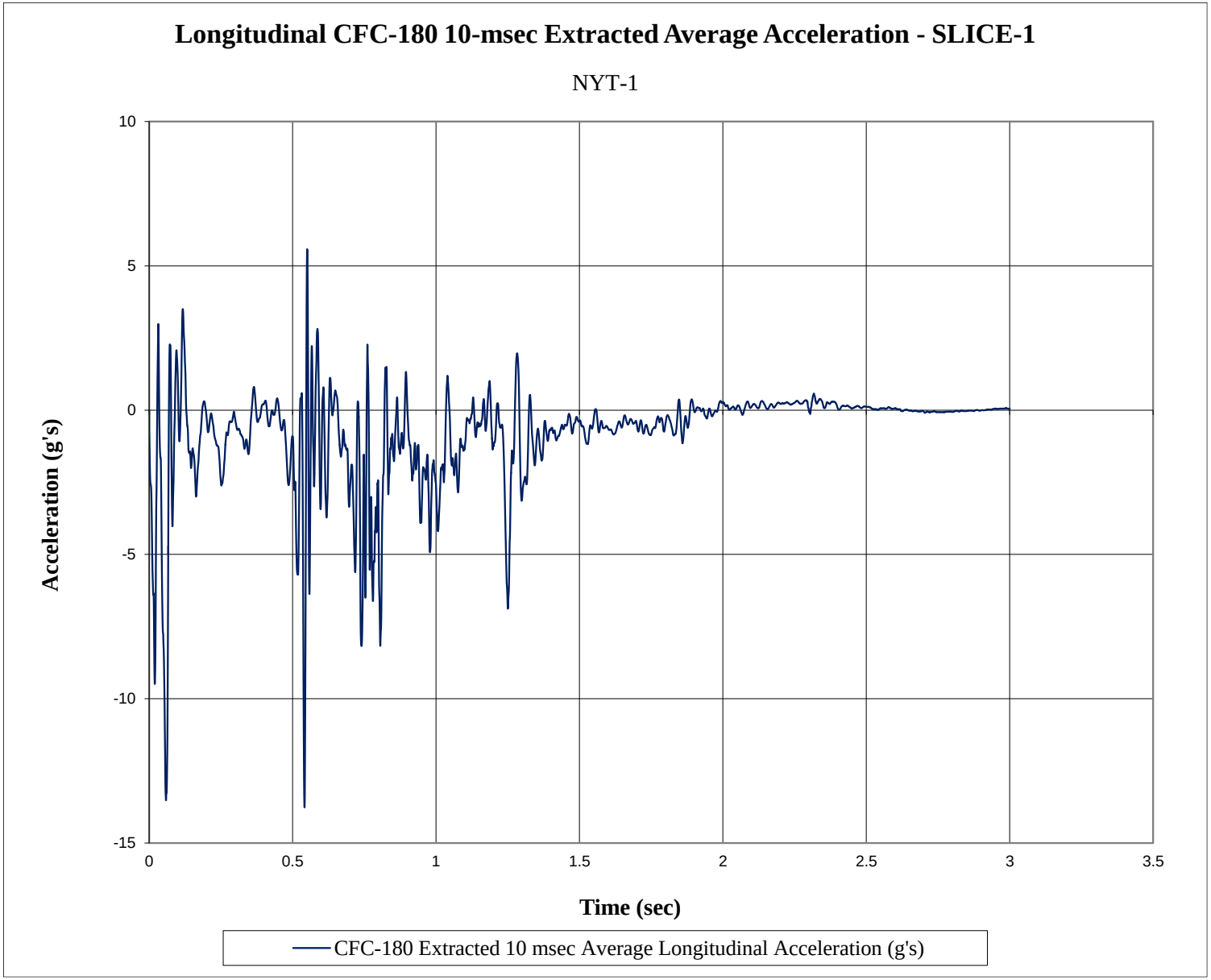


Figure E-9. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYT-1

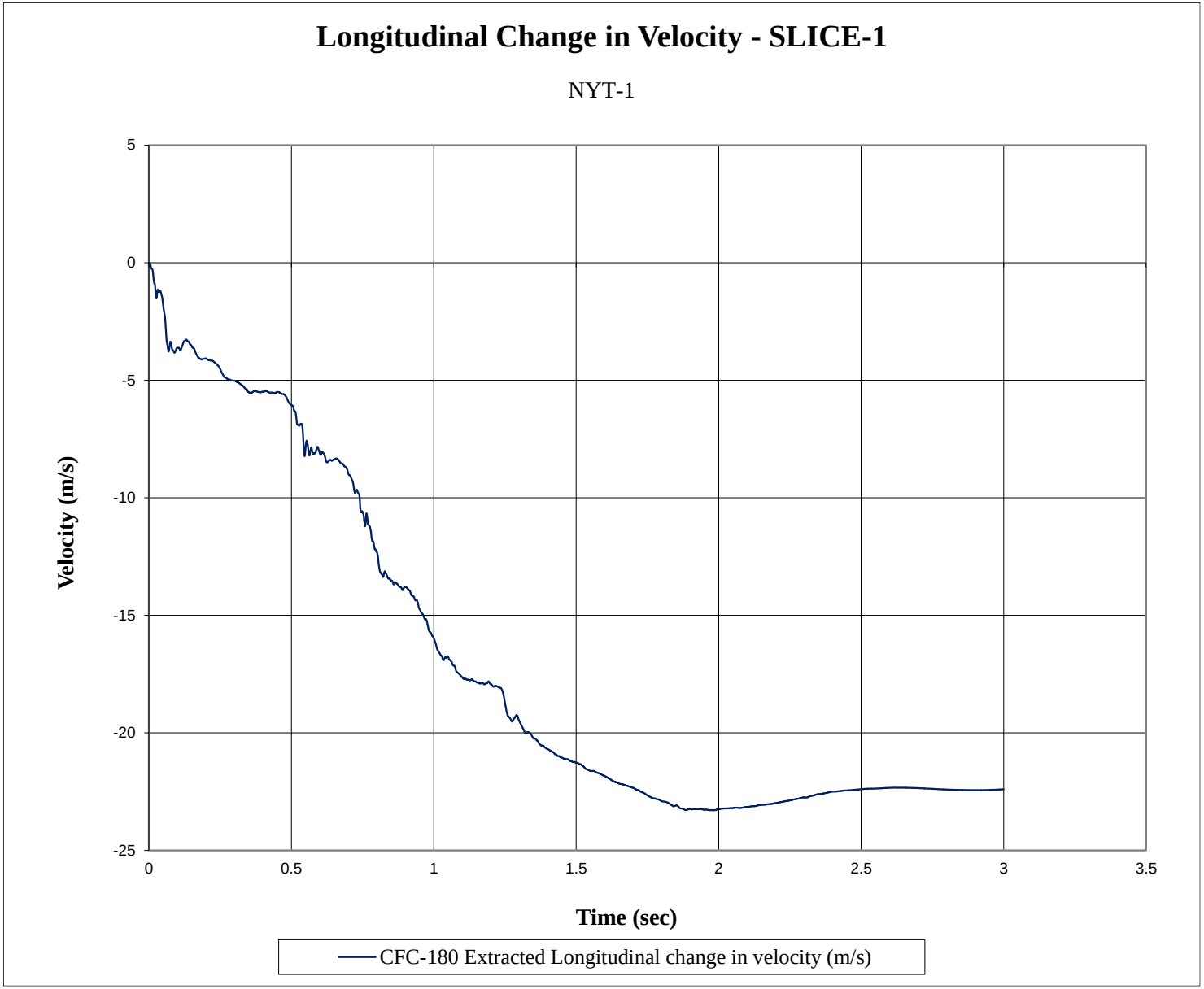


Figure E-10. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYT-1

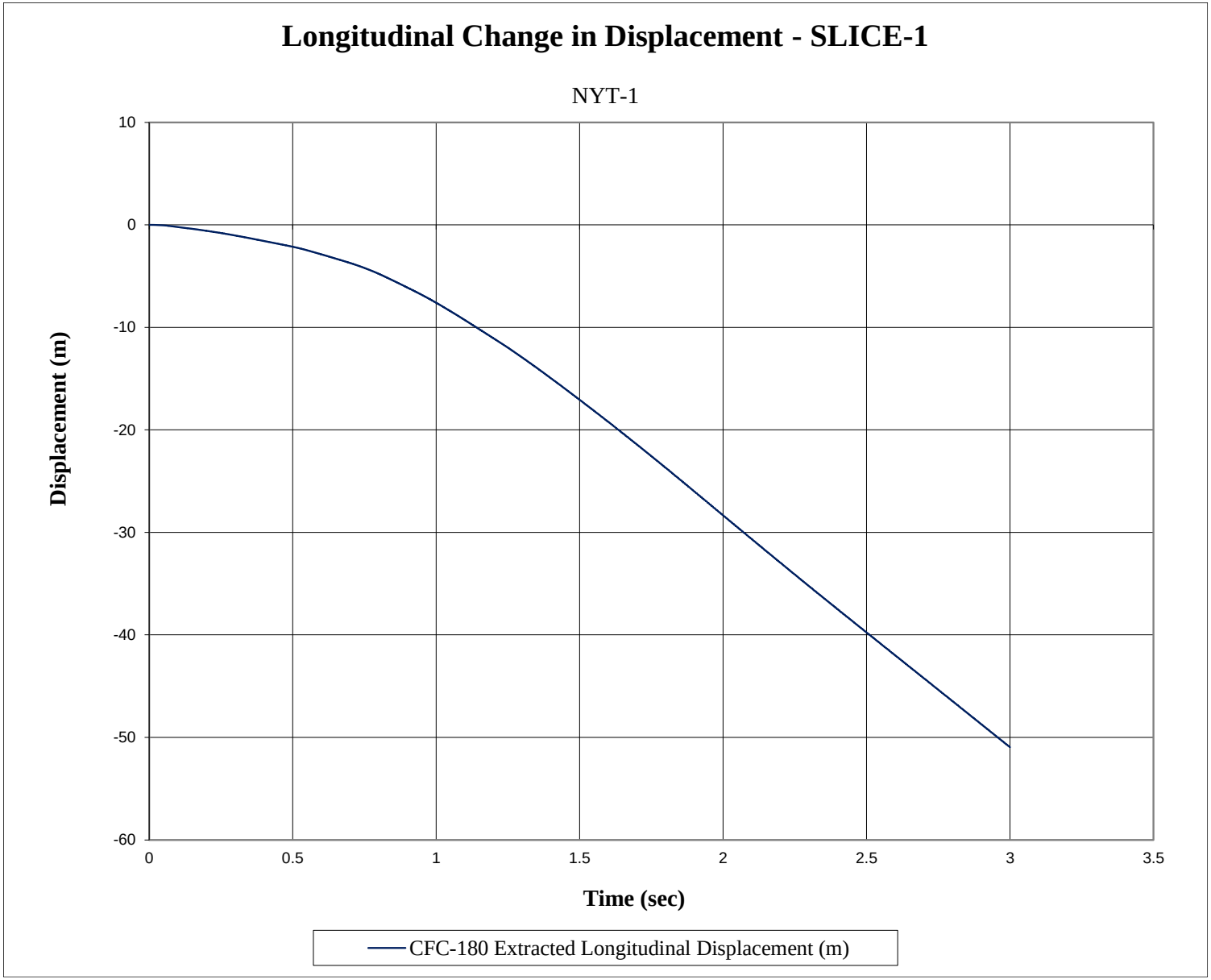


Figure E-11. Longitudinal Occupant Displacement (SLICE-1), Test No. NYT-1

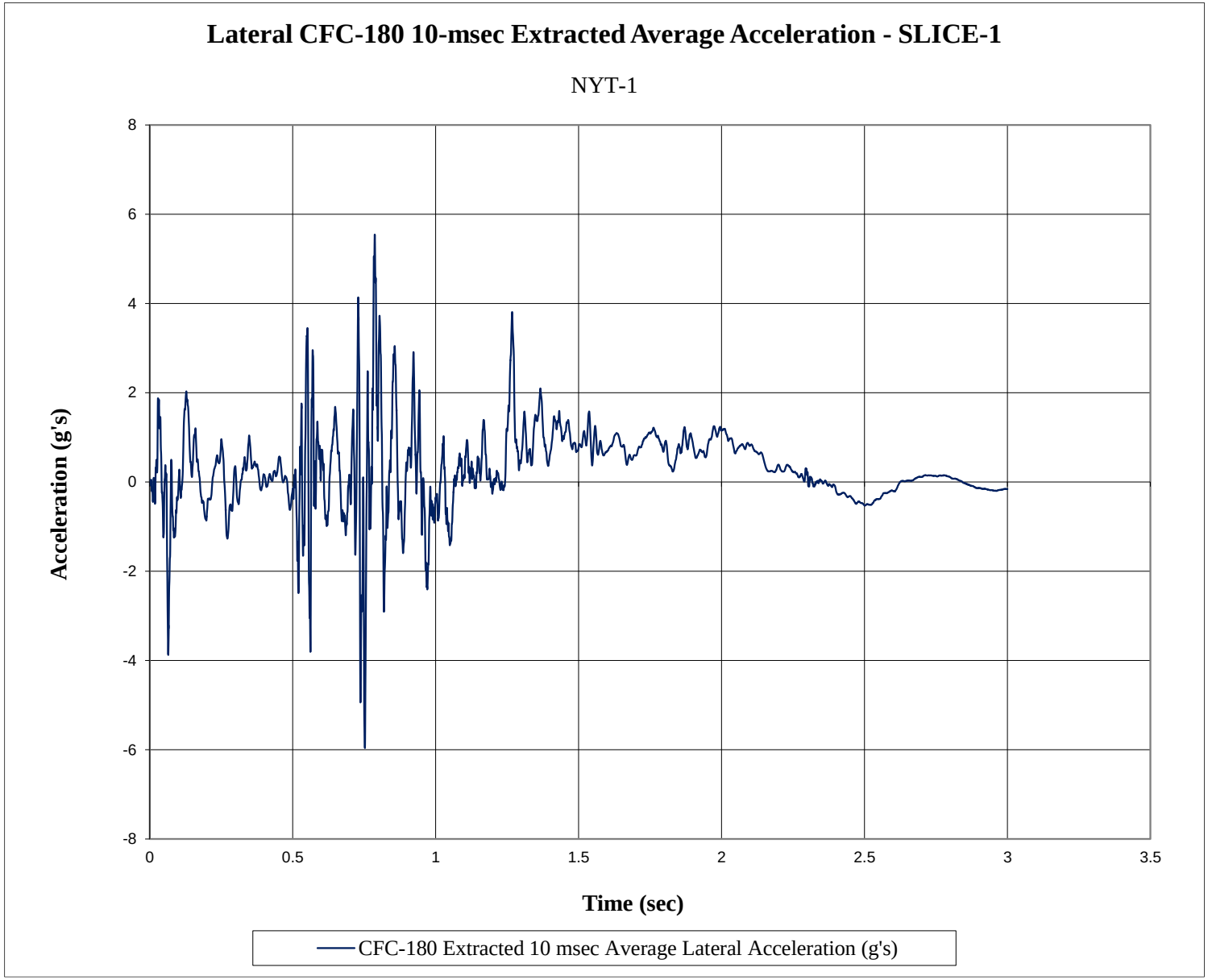


Figure E-12. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYT-1

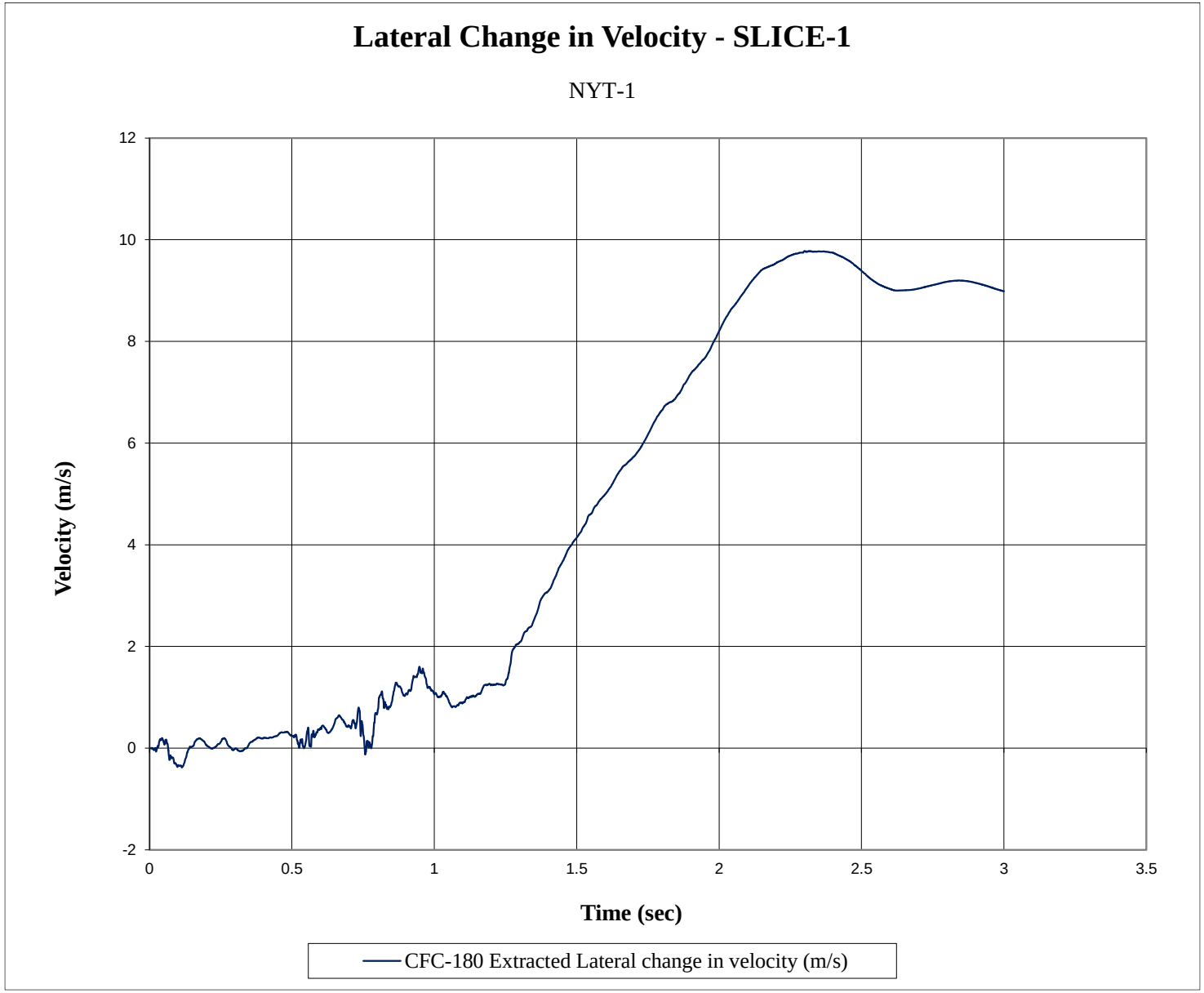


Figure E-13. Lateral Occupant Velocity (SLICE-1), Test No. NYT-1

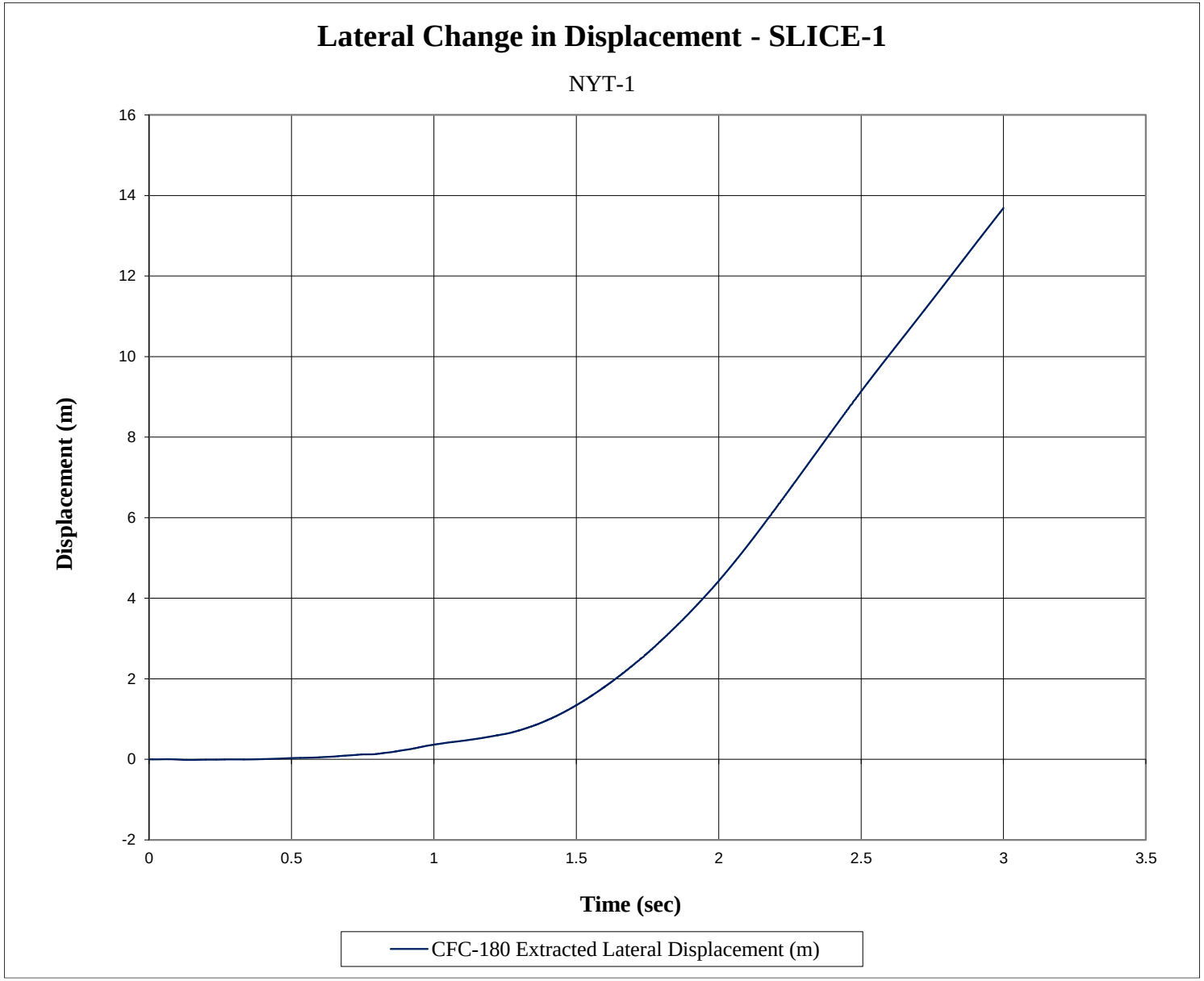


Figure E-14. Lateral Occupant Displacement (SLICE-1), Test No. NYT-1

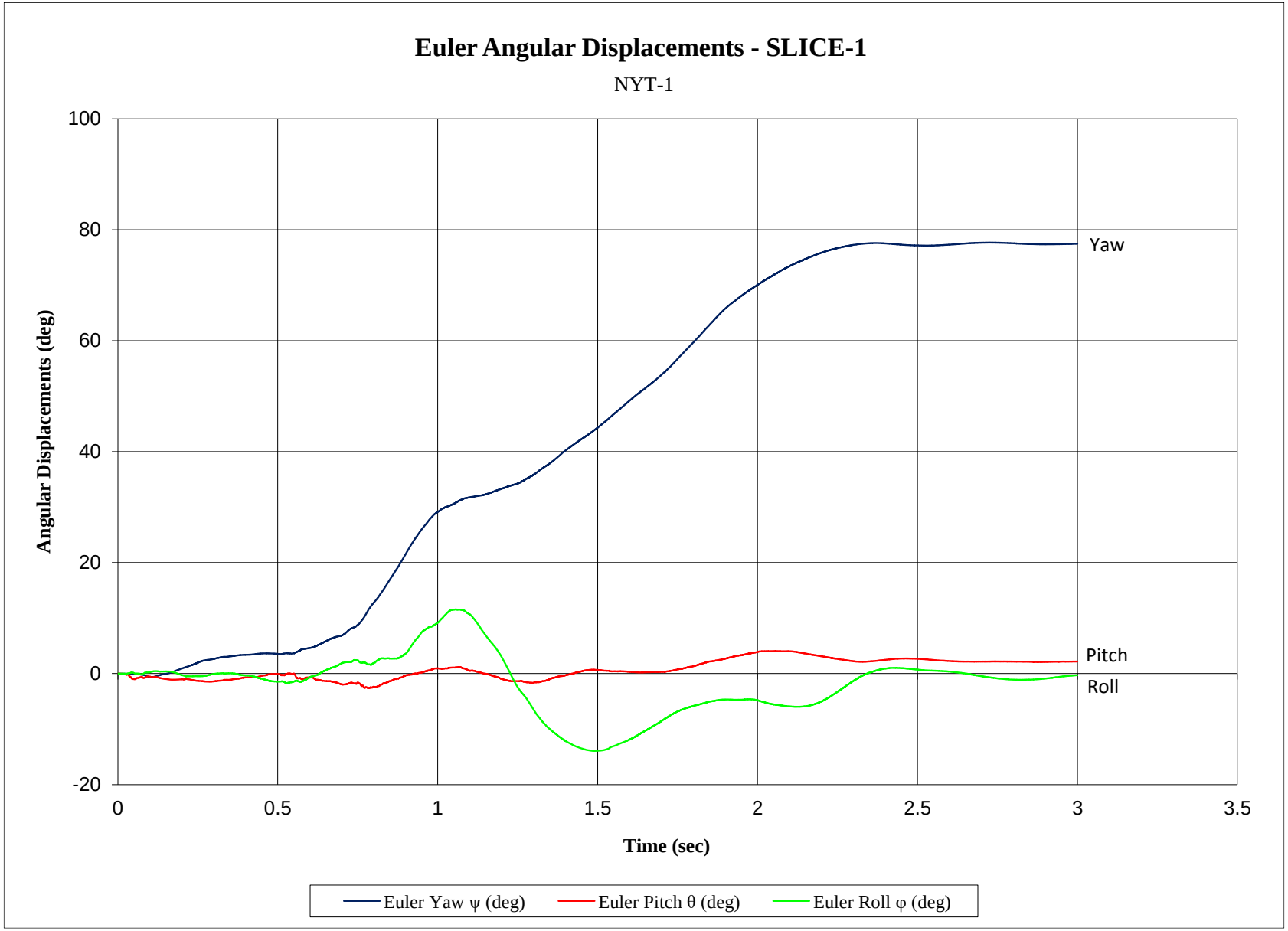


Figure E-15. Vehicle Angular Displacements (SLICE-1), Test No. NYT-1

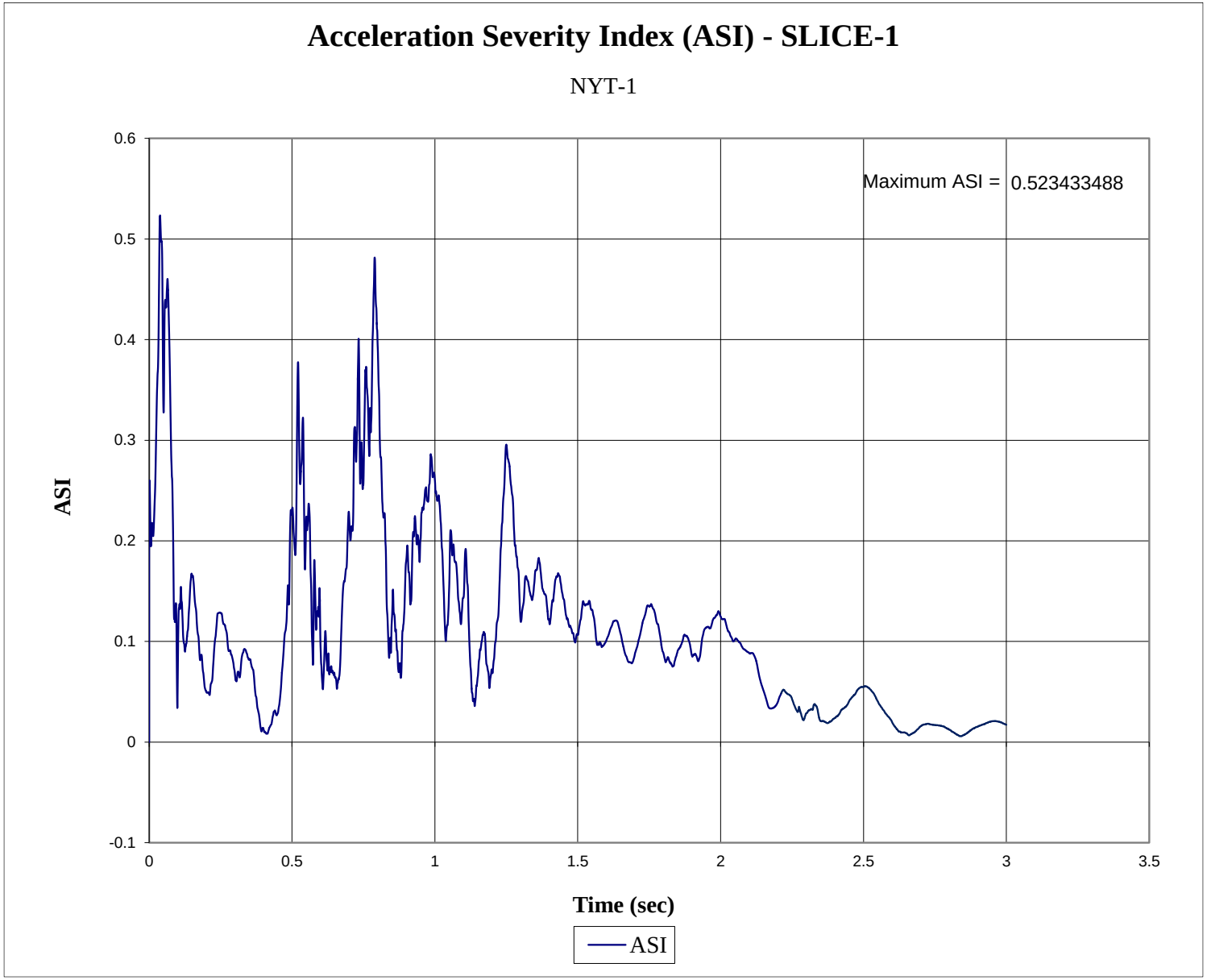


Figure E-16. Acceleration Severity Index (SLICE-1), Test No. NYT-1

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