ISO 17025 LABORATORY
TESTING CERT # 2937.01

Research Project Number TPF-5(193) Supplement #128

CRASH TESTING AND EVALUATION OF THE NEW YORK STATE BOX BEAM TO WEAK-POST W-BEAM TRANSITION

Submitted by

Karla A. Lechtenberg, M.S.M.E.
Research Engineer

Erin Urbank, B.A.
Research Communication Specialist

Ronald K. Faller, Ph.D., P.E.
Research Professor & MwRSF Director

MIDWEST ROADSIDE SAFETY FACILITY
Nebraska Transportation Center
University of Nebraska-Lincoln

Main Office
Prem S. Paul Research Center at Whittier School
Room 130, 2200 Vine Street
Lincoln, Nebraska 68583-0853
(402) 472-0965

Outdoor Test Site
4630 N.W. 36th Street
Lincoln, Nebraska 68524

Submitted to

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
50 Wolf Road, 6th Floor
Albany, New York 12232

MwRSF Research Report No. TRP-03-414-24

February 27, 2024

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. TRP-03-414-24	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Crash Testing and Evaluation of the New York State Box Beam to Weak-Post W-Beam Transition		**5. Report Date** February 27, 2024 **6. Performing Organization code**
7. Author(s) Lechtenberg, K.A., Urbank, E.L., and Faller, R.K.		**8. Performing Organization Report No.** TRP-03-414-24
9. Performing Organization Name and Address Midwest Roadside Safety Facility (MwRSF) Nebraska Transportation Center **University of Nebraska-Lincoln** Main Office: Prem S. Paul Research Center at Whittier School Room 130, 2200 Vine Street Lincoln, Nebraska 68583-0853 Outdoor Test Site: 4630 N.W. 36th Street Lincoln, Nebraska 68524		**10. Work Unit No.** **11. Contract**
12. Sponsoring Agency Name and Address New York State Department of Transportation 50 Wolf Road, 6th Floor Albany, New York 12232		**13. Type of Report and Period Covered** Final Report: 2017 – 2024 **14. Sponsoring Agency Code** TPF-5(193) Supplement #128

15. Supplementary Notes
Prepared in cooperation with U.S. Department of Transportation, Federal Highway Administration.

16. Abstract

The New York State Department of Transportation's (NYSDOT's) box beam to Weak-Post W-beam transition system had not yet been evaluated to the American Association of State Highway and Transportation Officials' (AASHTO's) *Manual for Assessing Safety Hardware, Second Edition* (MASH 2016) safety performance criteria. For its continued use on the National Highway System, the Midwest Roadside Safety Facility (MwRSF) conducted two full-scale crash tests on the box beam to weak-post W-beam transition system. The system consisted of 32-in. (813-mm) tall, 12-gauge (2.6-mm), W-beam, which decreased in height through a transition cover to match the box beam height of 27 in. (686 mm). Each box beam section measured 6 in. (152 mm) x 6 in. (152 mm) x $^{3}/_{16}$ in. (5 mm) thick and was 215½ in. (5,474 mm) long. The box beam to weak-post W-beam transition was evaluated according to MASH 2016 test designation no. 3-21 with 5,139-lb (2,331-kg) and 5,165-lb (2,343-kg) pickup trucks for test nos. NYBWT-2 and NYBWT-3, respectively. In test no. NYBWT-2, the transition was impacted at a speed of 63.5 mph (102.2 km/h) and an impact angle of 25.1 degrees, resulting in moderate system and vehicle damage. The system in test no. NYBWT-3 was identical to test no. NYBWT-2, except the impact occurred in the reverse direction. In test no. NYBWT-3, the transition was impacted at a speed of 62.5 mph (100.5 km/h) and an impact angle of 25.7 degrees, resulting in moderate system and vehicle damage. Both tests successfully met all evaluation criteria in MASH 2016 for test designation no. 3-21. No impact testing was performed using test designation no. 3-20.

17. Key Words Highway Safety, Crash Test, Roadside Appurtenances, Compliance Test, MASH 2016, Box Beam, W-Beam, Weak Post, Transition. Compliance Test		**18. Availability Statement** No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Classification (of this report) Unclassified	**20. Security Classification (of this page)** Unclassified	**21. No. of Pages** 244	**22. Price**

DISCLAIMER STATEMENT

This material is based upon work supported by the New York State Department of Transportation under TPF-5(193) Supplement #128. 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 States of Nebraska and New York do not endorse products or manufacturers.

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 Scott Rosenbaugh, Research Engineer.

ACKNOWLEDGEMENTS

The authors wish to acknowledge several sources that made a contribution to this project: (1) New York State Department of Transportation for sponsoring this project; and (2) MwRSF personnel for constructing the barriers and conducting the crash tests. Acknowledgement is also given to the following individuals who contributed to the completion of this research project.

Midwest Roadside Safety Facility
J.C. Holloway, M.S.C.E., Research Engineer & Assistant Director –Physical Testing Division
R.W. Bielenberg, M.S.M.E., Research Engineer
S.K. Rosenbaugh, M.S.C.E., Research Engineer
C.S. Stolle, Ph.D., Research Assistant Professor
J.S. Steelman, Ph.D., P.E., Associate Professor
M. Asadollahi Pajouh, Ph.D., P.E., Research Assistant Professor
B.J. Perry, M.E.M.E., Research Engineer
A.T. Russell, B.S.B.A., Testing and Maintenance Technician II
E.W. Krier, B.S., Former Engineering Testing Technician II
D.S. Charroin, Engineering Testing Technician II
R.M. Novak, Engineering Testing Technician II
S.M. Tighe, Engineering Testing Technician I
T.C. Donahoo, Engineering Testing Technician I

Midwest Roadside Safety Facility, Cont.
J.T. Jones, Engineering Testing Technician I
C. Charroin, Former Engineering Construction Testing Technician I
T. Shapland, Former Engineering Construction Testing Technician I
Z.Z. Jabr, Engineering Technician
J. Oliver, Solidworks Drafting Coordinator
Undergraduate and Graduate Research Assistants

New York State Department of Transportation
L. Terry Hale III, P.E., Senior Engineer

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background

In 2009, the American Association of State Highway and Transportation Officials (AASHTO) implemented an updated standard for the evaluation of roadside hardware. The 2009 standard, entitled the *Manual for Assessing Safety Hardware* (MASH 2009) [1], improved the criteria for evaluating roadside hardware beyond the previous National Cooperative Highway Research Program (NCHRP) Report 350 [2] standard through updates to the test vehicles, test matrices, and impact conditions. To encourage state departments of transportation and hardware developers to advance their hardware designs, the Federal Highway Administration (FHWA) and AASHTO collaborated to develop a MASH implementation policy that includes sunset dates for various categories of roadside hardware. Further, the MASH 2009 safety criteria was updated in 2016, thus resulting in the MASH 2016 [3] document. The new policy requires that devices installed on federal aid roadways after the sunset dates must have been evaluated to MASH 2016. The proposed MASH 2016 implementation dates for the various hardware categories are listed below.

- December 31, 2017: W-beam barriers and cast-in-place concrete barriers
- June 30, 2018: W-beam terminals
- December 31, 2018: cable barriers, cable barrier terminals, and crash cushions
- December 31, 2019: bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently), all other terminals, sign supports, and all other breakaway hardware
- Temporary work zone devices, including portable barriers, manufactured after December 31, 2019, must have been successfully tested to the 2016 edition of MASH. Such devices manufactured on or before this date, and successfully tested to NCHRP Report 350 or the 2009 edition of MASH, may continue to be used throughout their normal service lives.

The New York State Department of Transportation (NYSDOT) currently uses roadside hardware systems, such as cable, W-beam supported by either weak posts or heavy posts with blockouts, and box beam systems. NYSDOT desires to continue to have access to these systems following the MASH implementation date noted above. However, the increased mass of the MASH 2270P vehicle and kinetic energy of the crash test has been shown to increase impact loading and dynamic deflection of guardrail systems. Thus, a need exists to evaluate the noted systems under the MASH 2016 criteria to determine each system's dynamic deflection, working width, and crashworthiness under MASH 2016 Test Level 3 (TL-3).

1.2 Objective

The objective of this research was to evaluate NYSDOT's box beam to weak-post W-beam transition system. The system was evaluated according to the TL-3 criteria of MASH 2016 [3].

1.3 Scope

The research objective was achieved through the completion of several tasks. Two full-scale crash tests were conducted on the box beam to weak-post W-beam transition system according to MASH 2016 test designation no. 3-21. Next, the full-scale crash test results were analyzed, evaluated, and documented. Conclusions and recommendations were then made pertaining to the safety performance of the box beam to weak-post W-beam transition system.

2 DESIGN DETAILS

The test installation consisted of a 224-ft 1¾-in. (68.3-m) long New York box beam to weak-post W-beam transition, as shown in Figures 1 through 35 for test nos. NYBWT-2 and NYBWT-3. Photographs of the NYBWT-2 and NYBWT-3 test installations are shown in Figures 36 through 40 and Figures 41 through 43, respectively. The installation for test no. NYBWT-3 was identical to the installation for test no. NYBWT-2. The only difference between the two tests was the impact point and direction of travel. The New York Standard sheet for box beam to weak-post W-beam transition is shown in Appendix A. Material specifications, mill certifications, and certificates of conformity for the system materials are shown in Appendix B.

Each ASTM A500 Grade B box beam section, measuring 6 in. x 6 in. x $^{3}/_{16}$ in. (152 x 152 x 5 mm) thick, was 215½ in. (5,474 mm) in length and installed at a height of 27 in. (686 mm). The box beam sections were spliced together with splice plates. For this test series, the splice plate configuration consisted of tack welded nuts as shown in Figures 8 and 30. The cable transition assembly located between post nos. 13 and 19 was attached to the transition anchor assembly 360 in. (9,144 mm) upstream from the downstream end of the box beam. The W-beam guardrail was mounted with a top-rail height of 32 in. (813 mm) from the surface of the roadway. The rails were layered such that the upstream rail section was layered in front of the downstream section.

All posts were 65-in. (1,651-mm) long, ASTM A36 S3x5.7 (S75x8.5) posts with attached soil plates. Post nos. 1 through 18 were spaced 72 in. (1,829 mm) on center and with an embedment depth of 37$^{15}/_{16}$ in. (964 mm) into the soil. Post nos. 19 through 25 were spaced 50 in. (1,270 mm) on center. Post nos. 25 through 28, 32, and 33 were spaced 75 in. (1,905 mm) on center. Post no. 19 was embedded into the soil to a depth of 34⅝ in. (879 mm). Post nos. 28 through 32 were spaced out 150 in. (3,810 mm) on center. Post nos. 20, 21, 23, 24, and 27 were not connected to the rail. Post nos. 20 through 33 were embedded into the soil to a depth of 32⅝ in. (829 mm). The downstream anchorage assembly was attached to post no. 33 and its cable spanned 145$^{3}/_{16}$ in. (3,688 mm). All posts in the critical impact region were placed in 24-in. (610-mm) diameter holes, which were backfilled with well-graded gravel and tamped. Soil details are shown in Appendix C.

Three separate anchor assemblies were contained in this system. The upstream end of the system was anchored using a reverse cable anchorage system to develop the longitudinal resistance in the rail for end-on impacts. The upper ends of the cables were connected to mounting plates bolted to the box beam, while the lower ends of the cables were connected to buried pile end anchors, as shown in Figures 10 and 39. The transition anchor consisted of three cables attached to a concrete block embedded in the soil upstream and behind the transition at an 11-degree offset from the box beam. The anchor cables were attached to the backside of the box beam just downstream from the transition cover. The downstream anchor consisted of the downstream end of the W-beam guard rail attached to a concrete block embedded in the soil behind and downstream from post no. 33 at a 14-degree offset from the front of the system. The end of the W-beam guardrail was attached to the concrete block such that the front of the rail was twisted to face upward. Details for the upstream cable anchor are shown in Figures 10 and 11.

The 12-gauge (2.7-mm) transition cover was bolted to the box beam just upstream from post no. 16. It was also attached to the W-beam, which was bolted to the box beam. The transition anchor cables were bolted through box beam and the W-beam. The downstream end of the transition cover was bent into the W-beam in order to reduce vehicle snag on the transition cover.

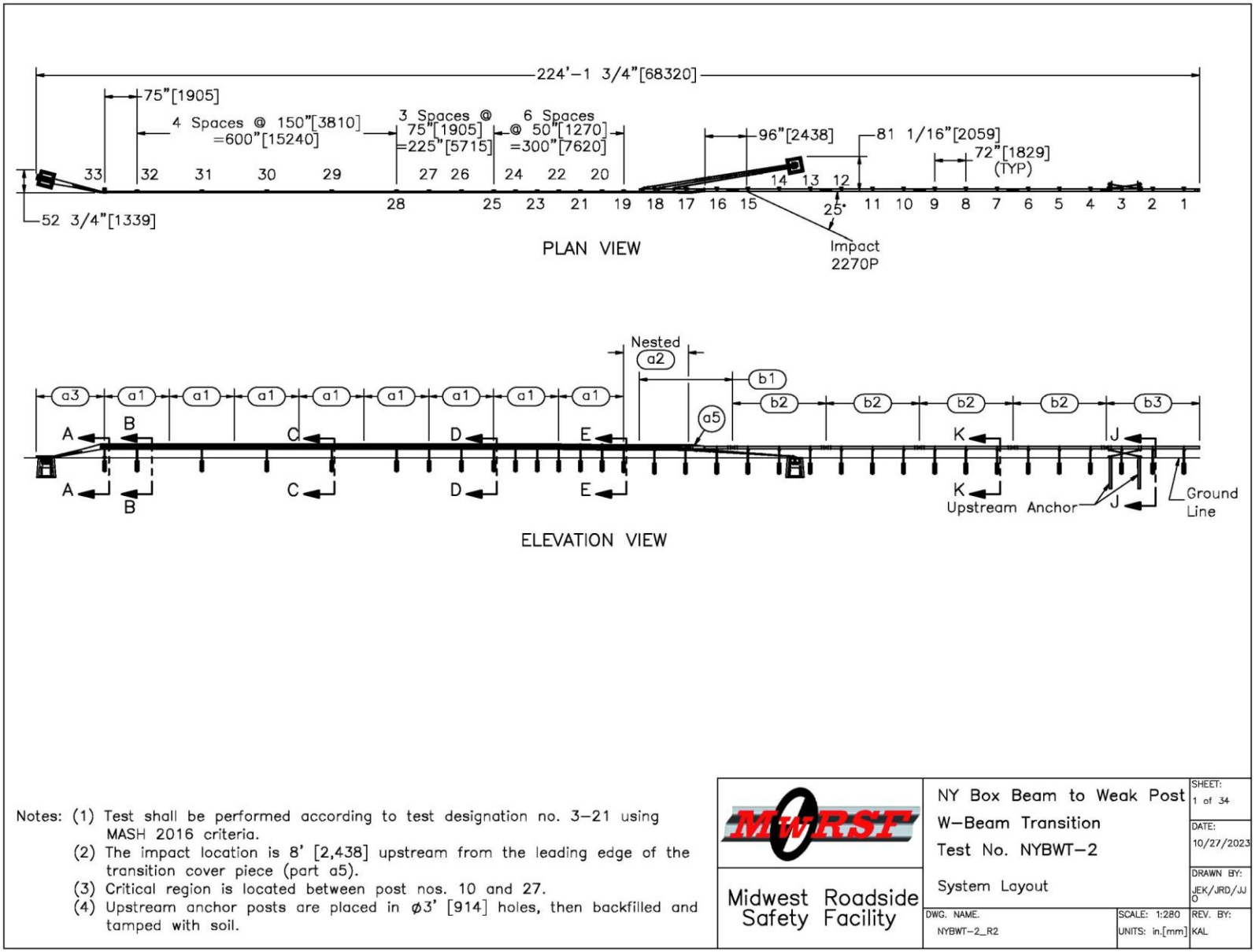


Figure 1. System Layout, Test No. NYBWT-2

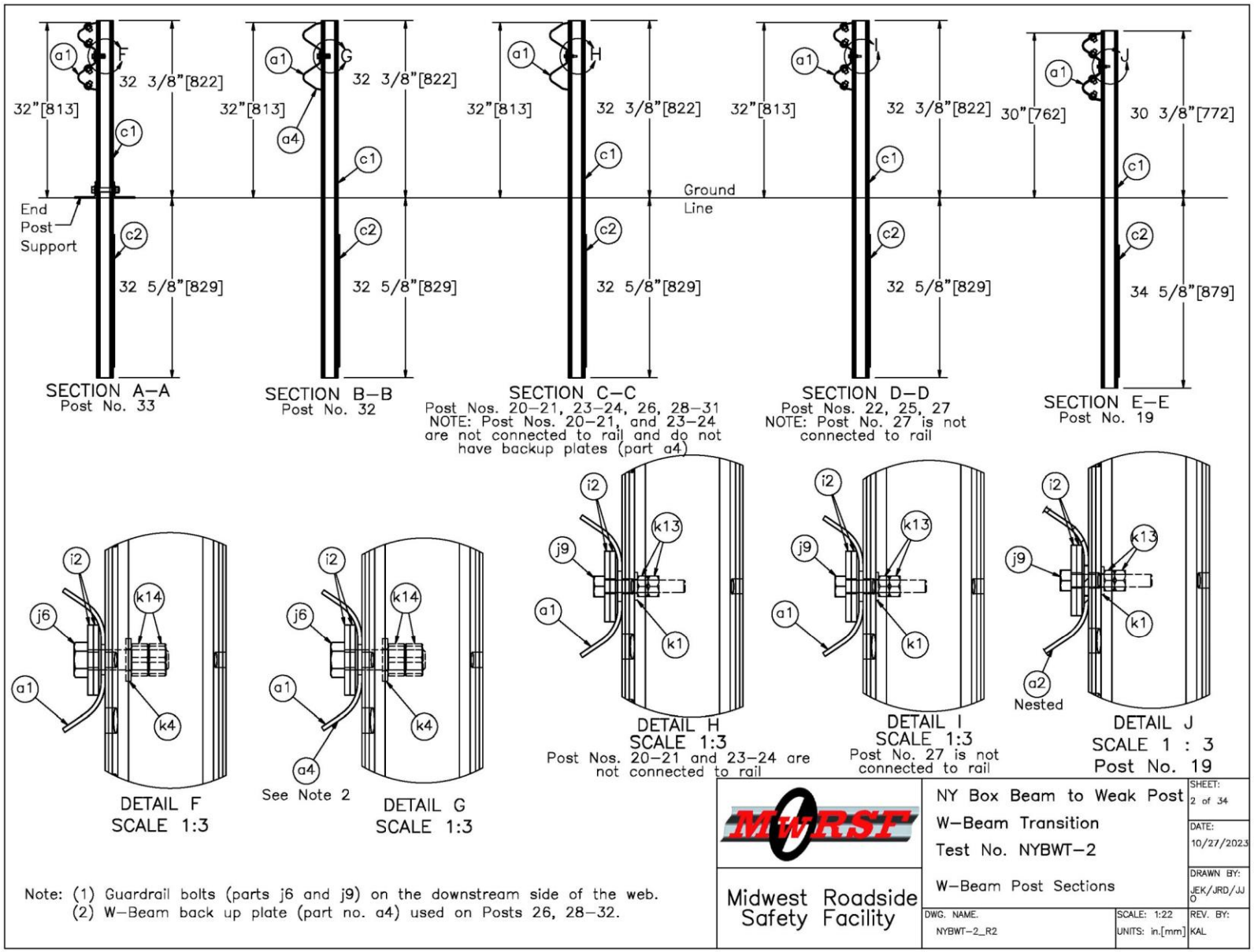


Figure 2. W-Beam Post Section, Test No. NYBWT-2

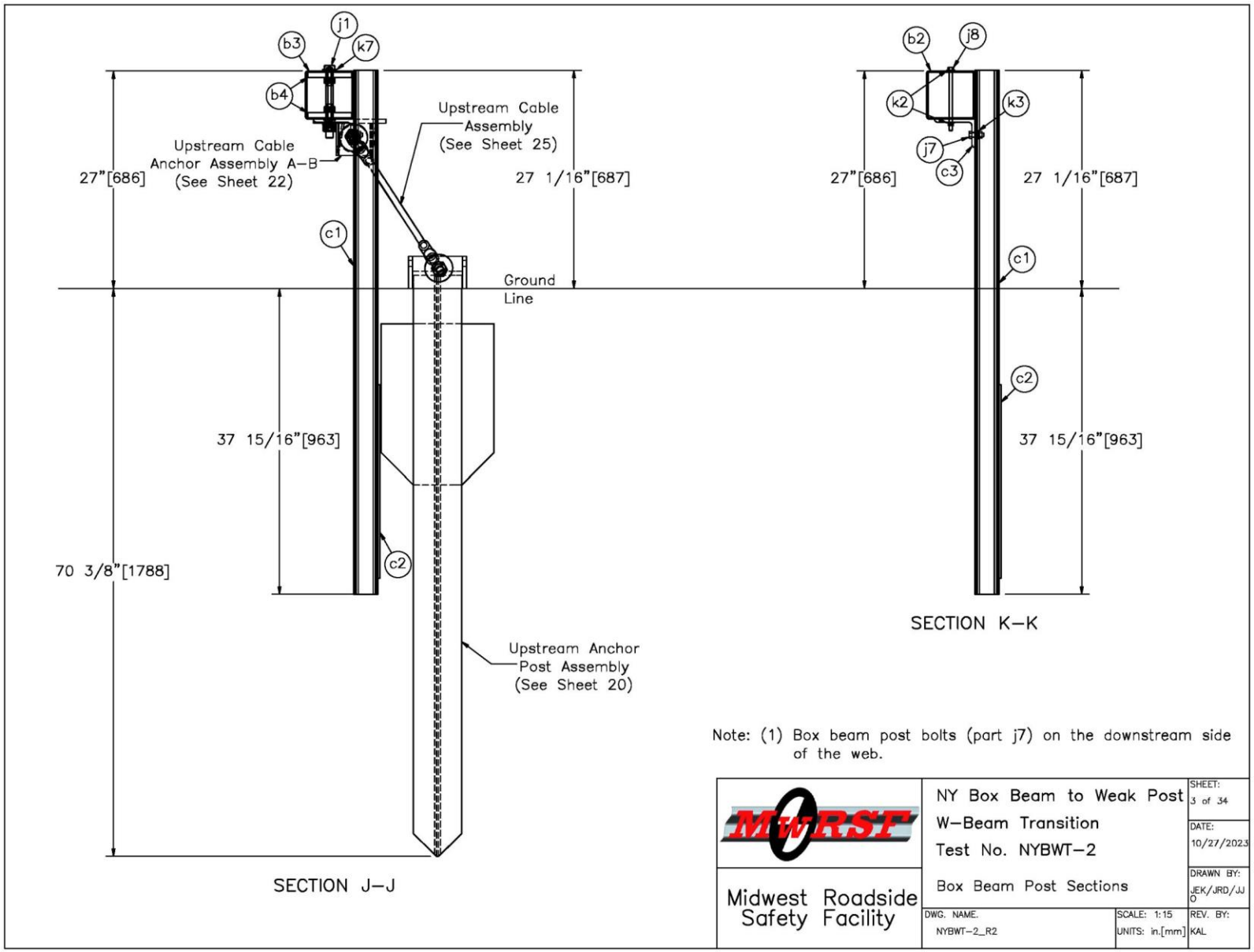


Figure 3. Box Beam Post Section, Test No. NYBWT-2

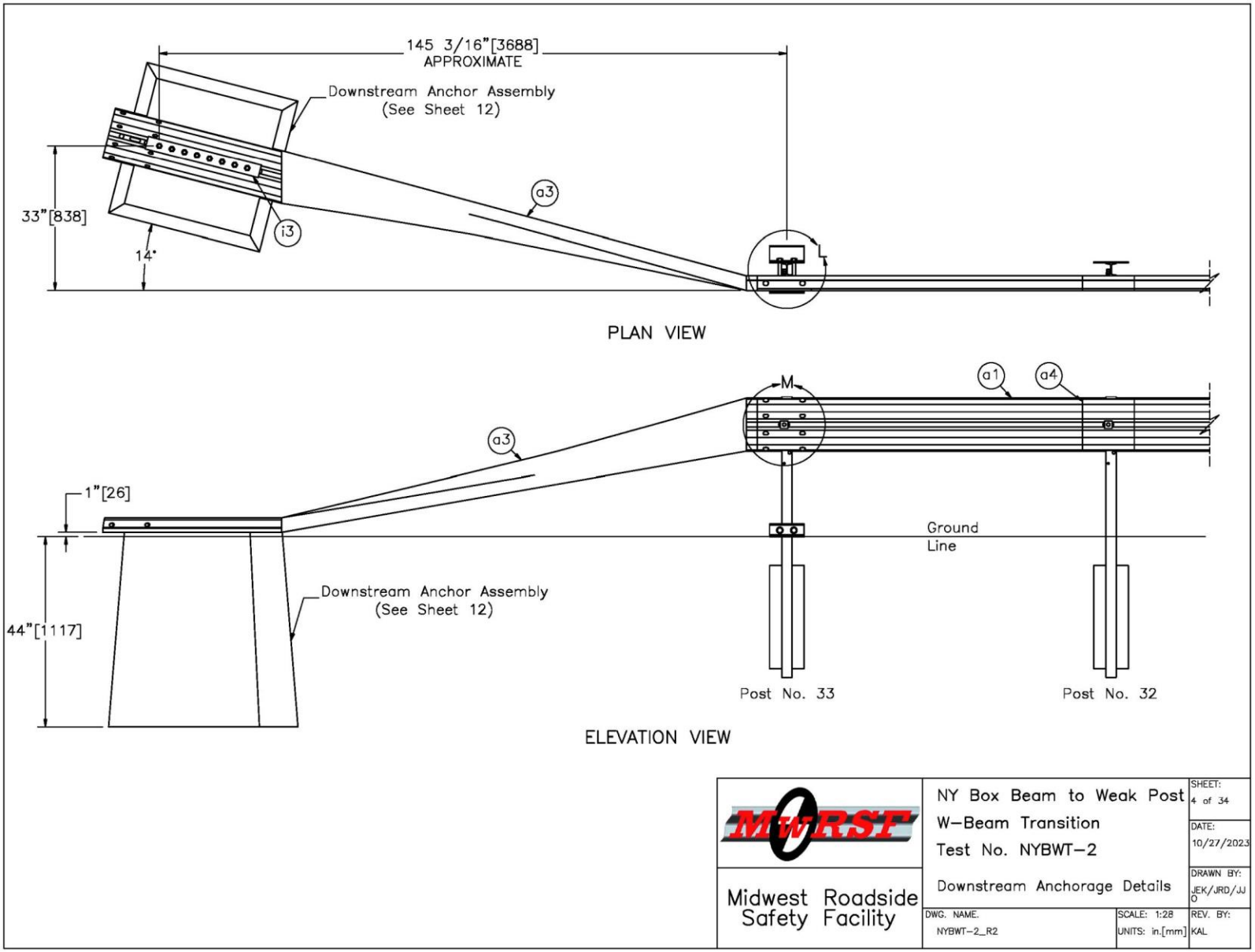


Figure 4. Downstream Anchorage Details, Test No. NYBWT-2

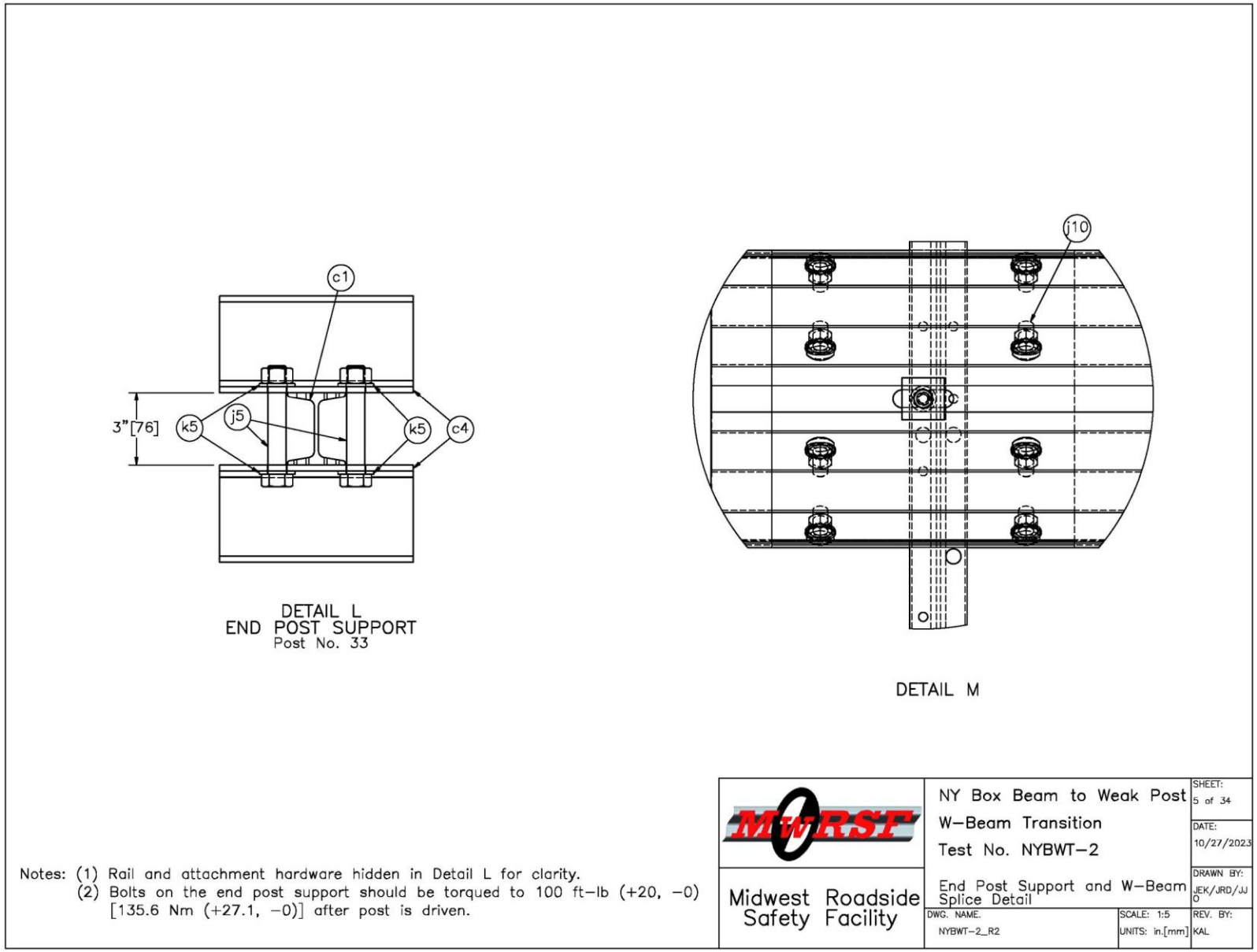


Figure 5. End Post Support and W-beam Splice Detail, Test No. NYBWT-2

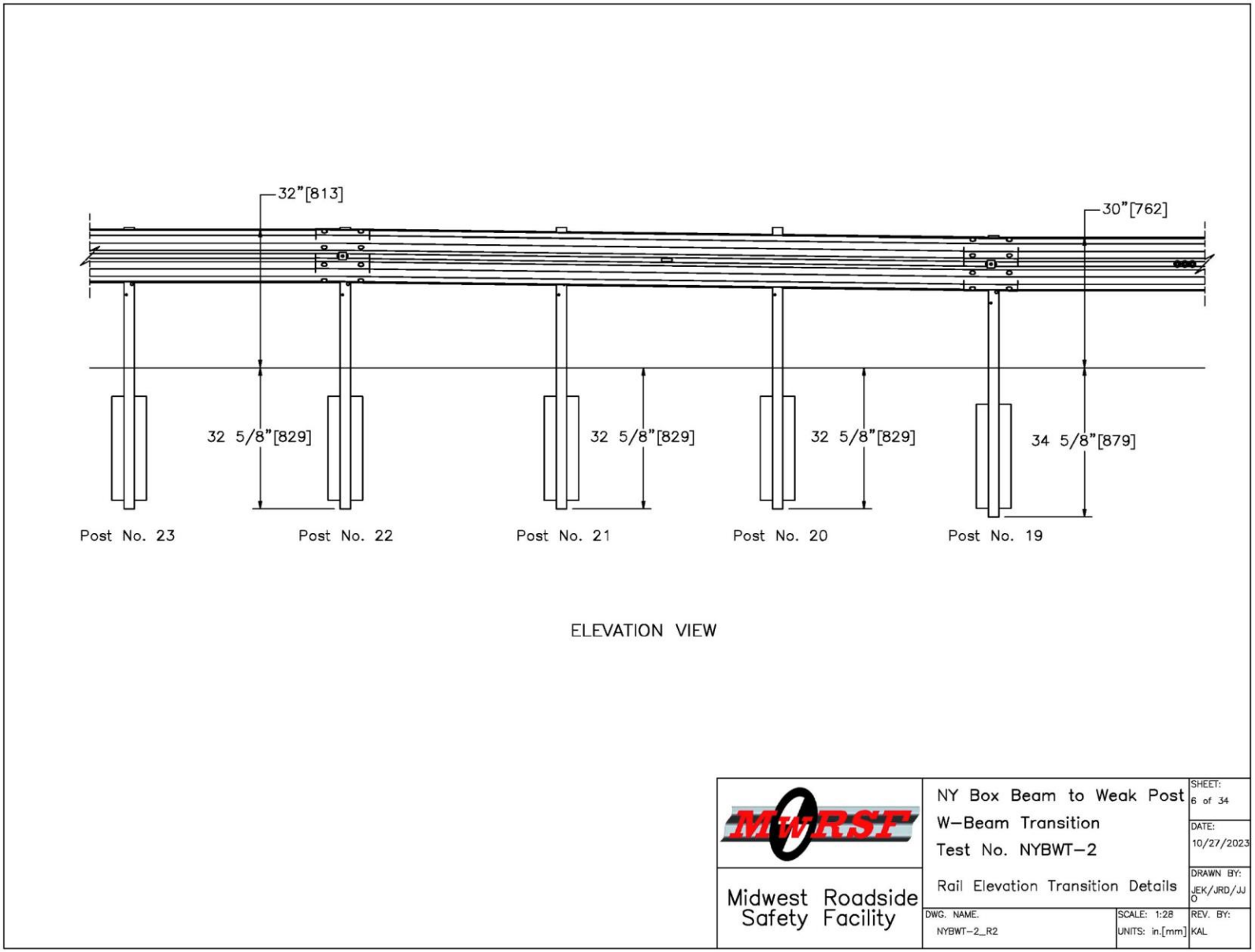


Figure 6. Rail Elevation Transition Details, Test No. NYBWT-2

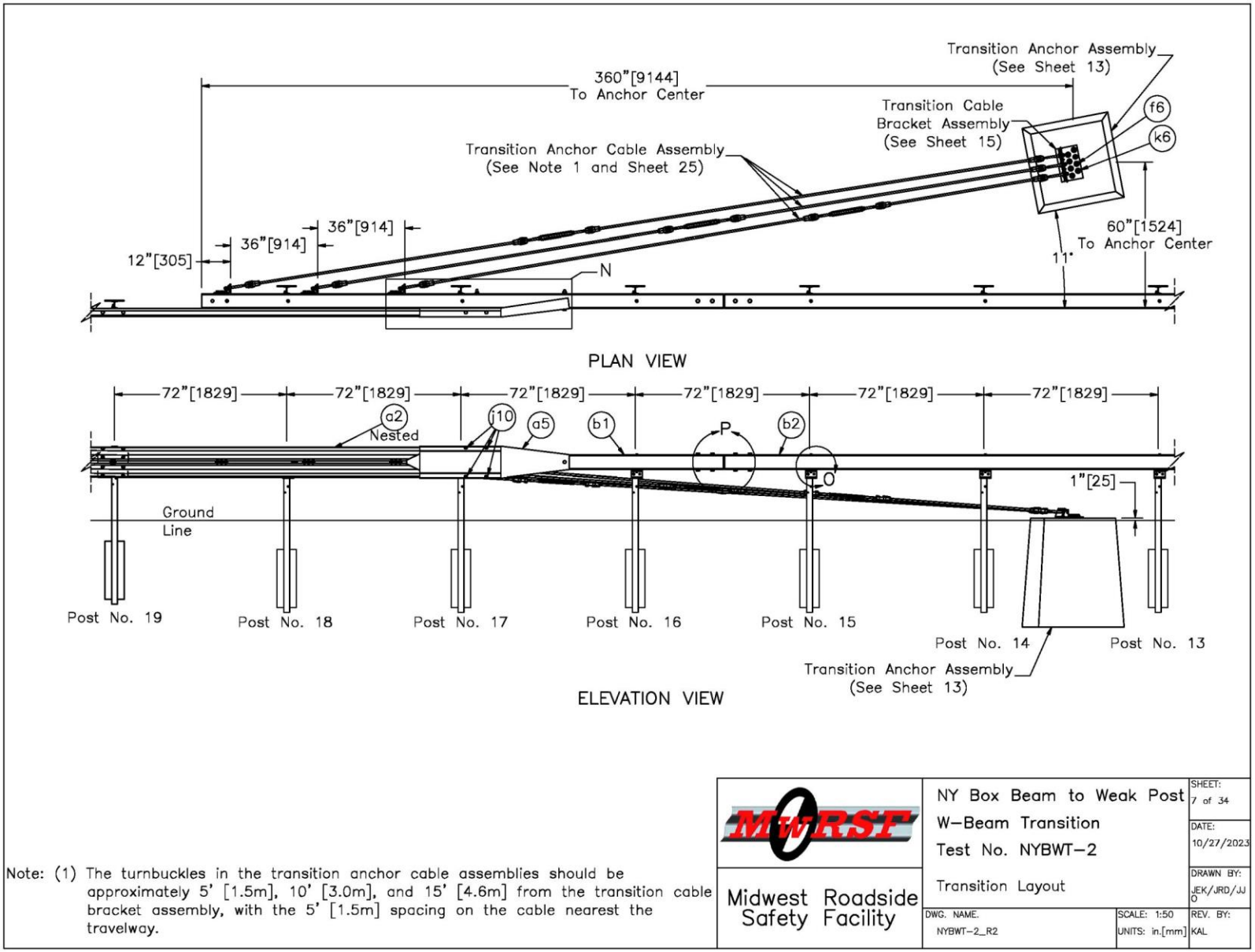


Figure 7. Transition Layout, Test No. NYBWT-2

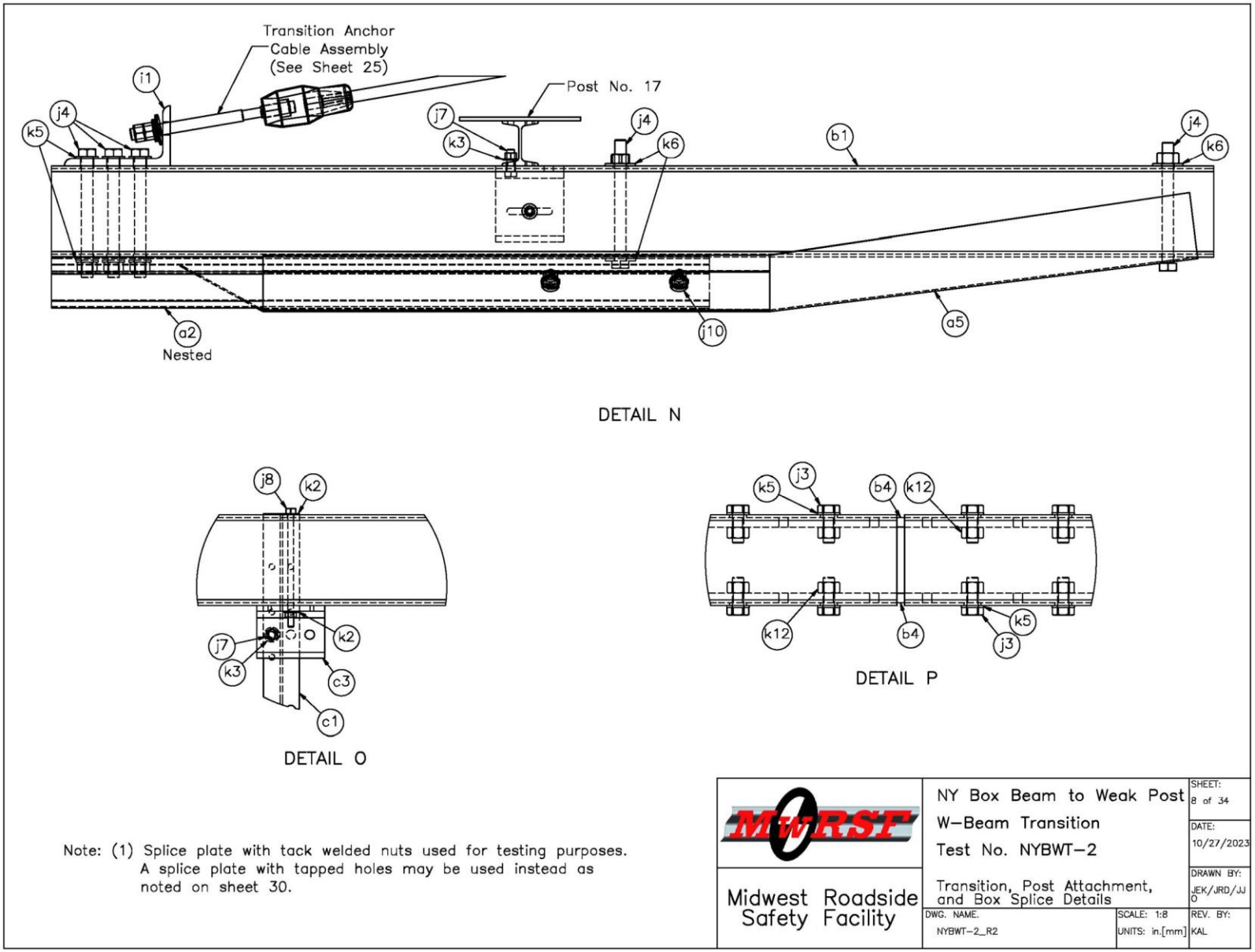


Figure 8. Transition, Post Attachment, and Box Splice Details, Test No. NYBWT-2

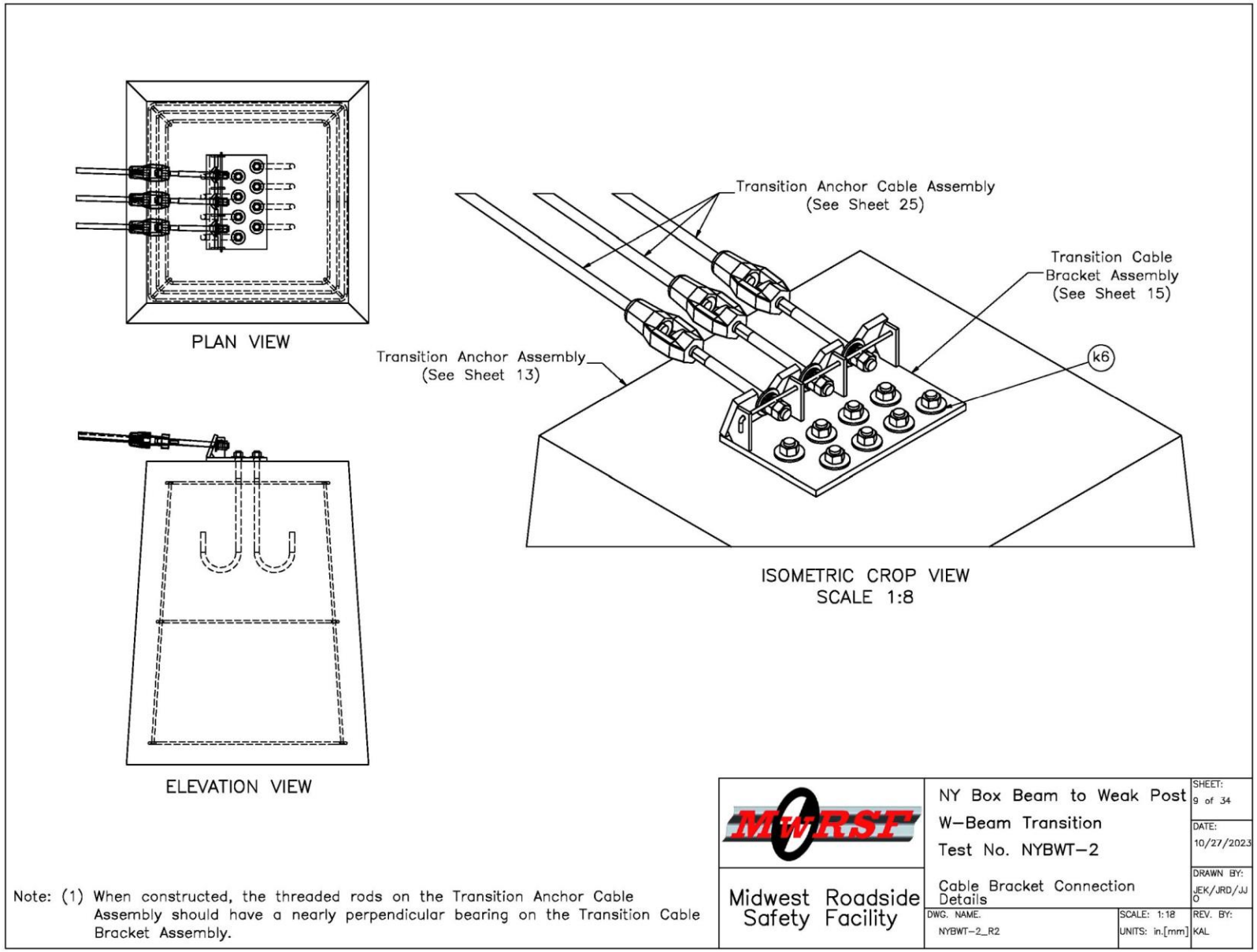


Figure 9. Cable Bracket Connection Details, Test No. NYBWT-2

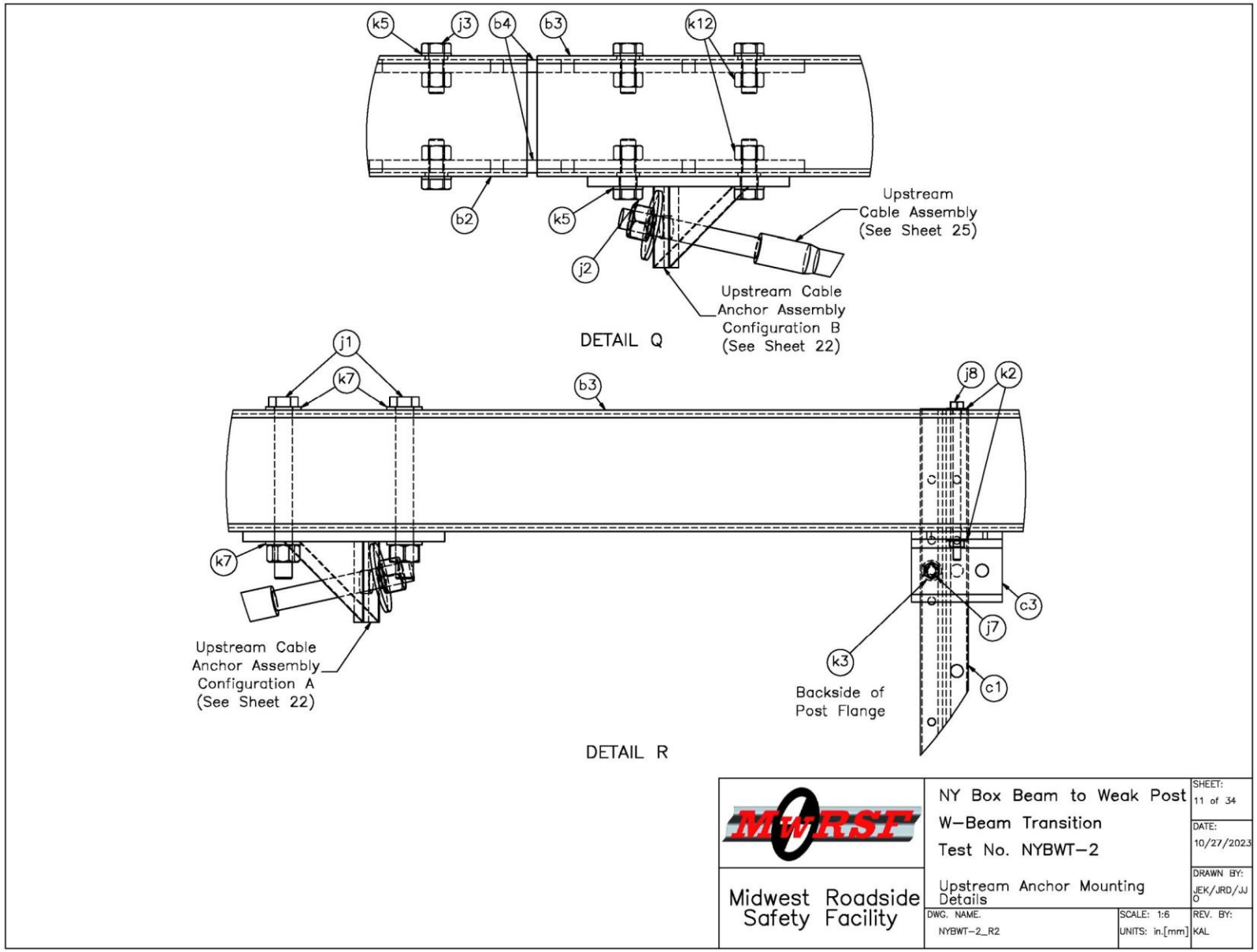


Figure 10. Upstream Anchorage Details, Test No. NYBWT-2

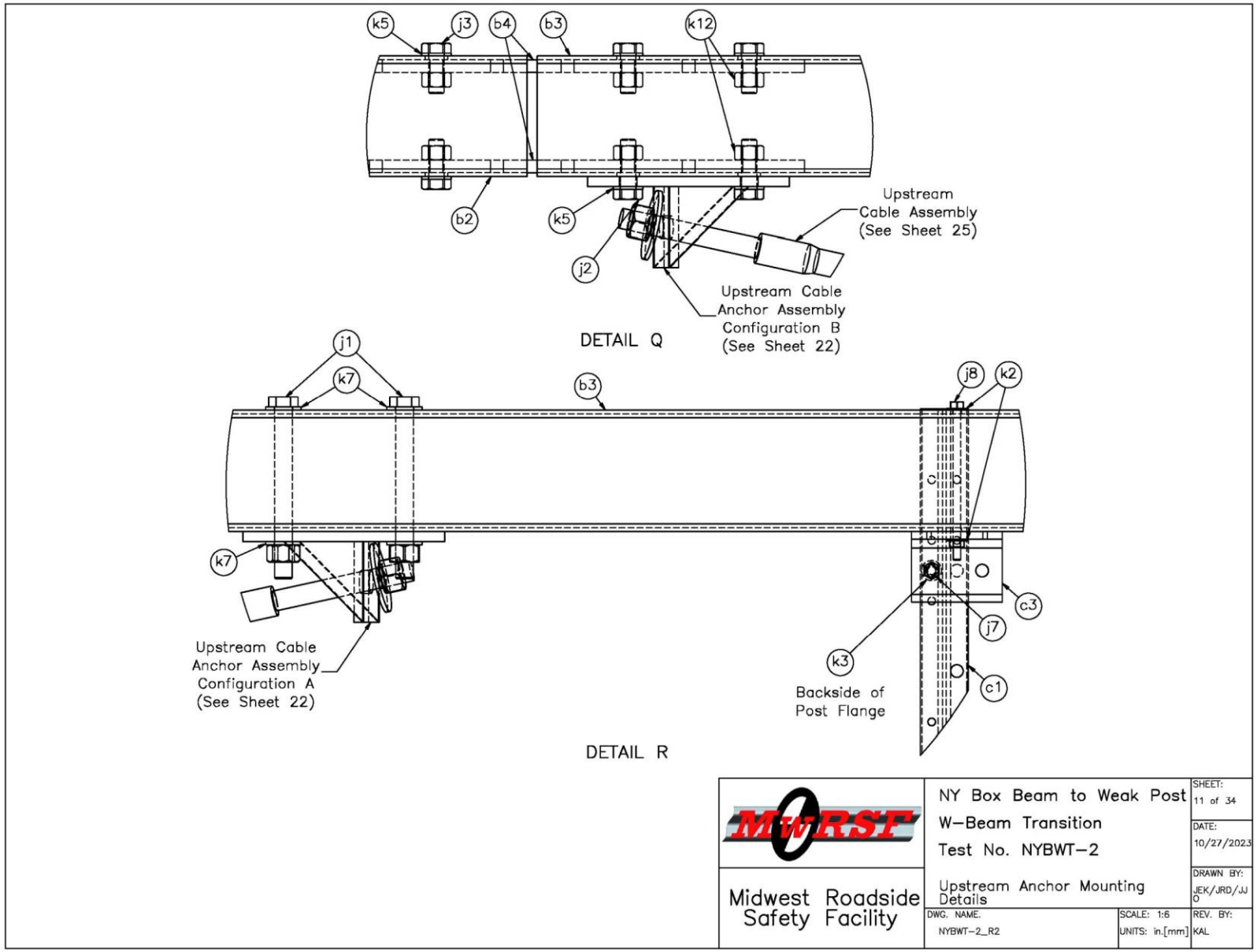
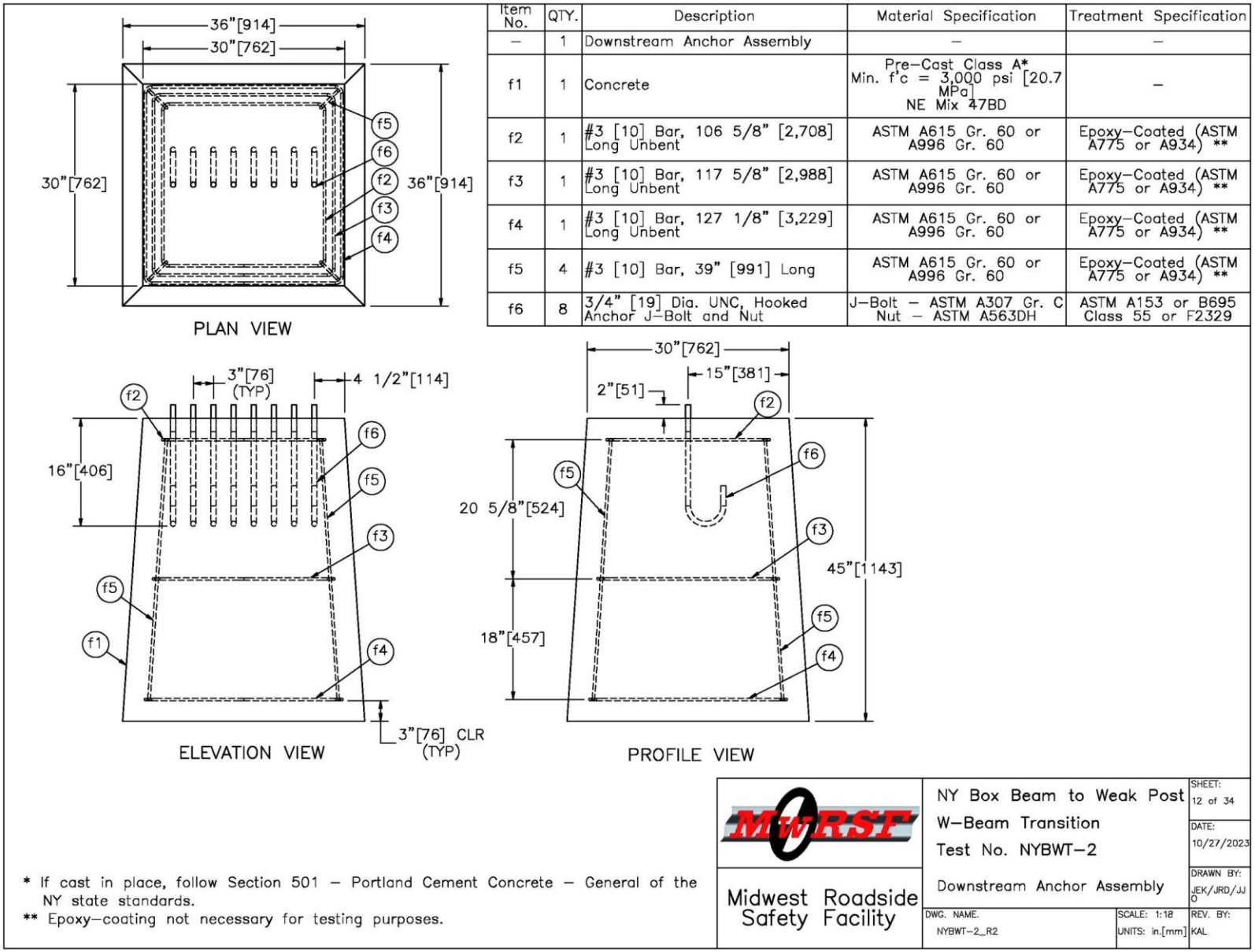
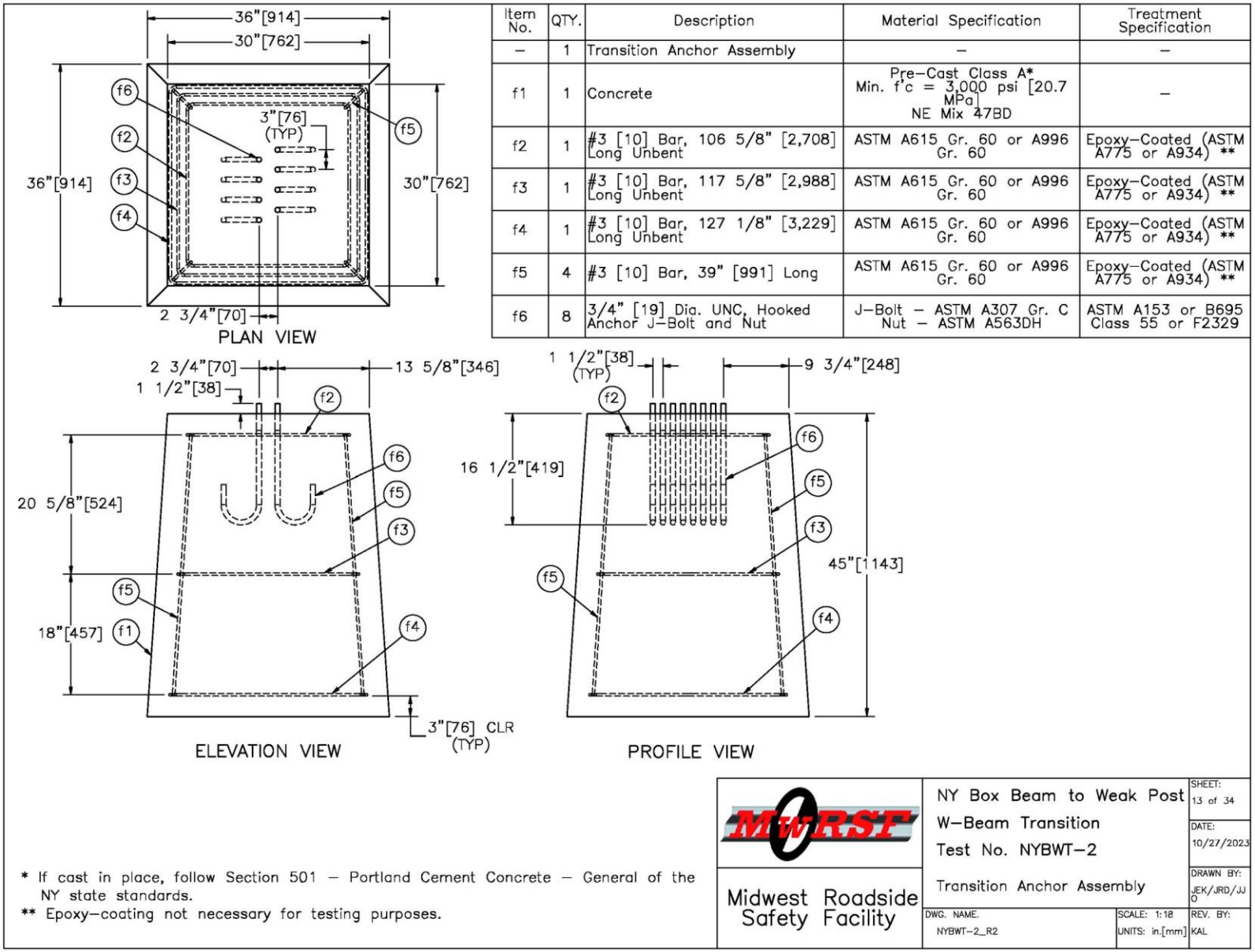


Figure 11. Upstream Anchor Mounting Details, Test No. NYBWT-2



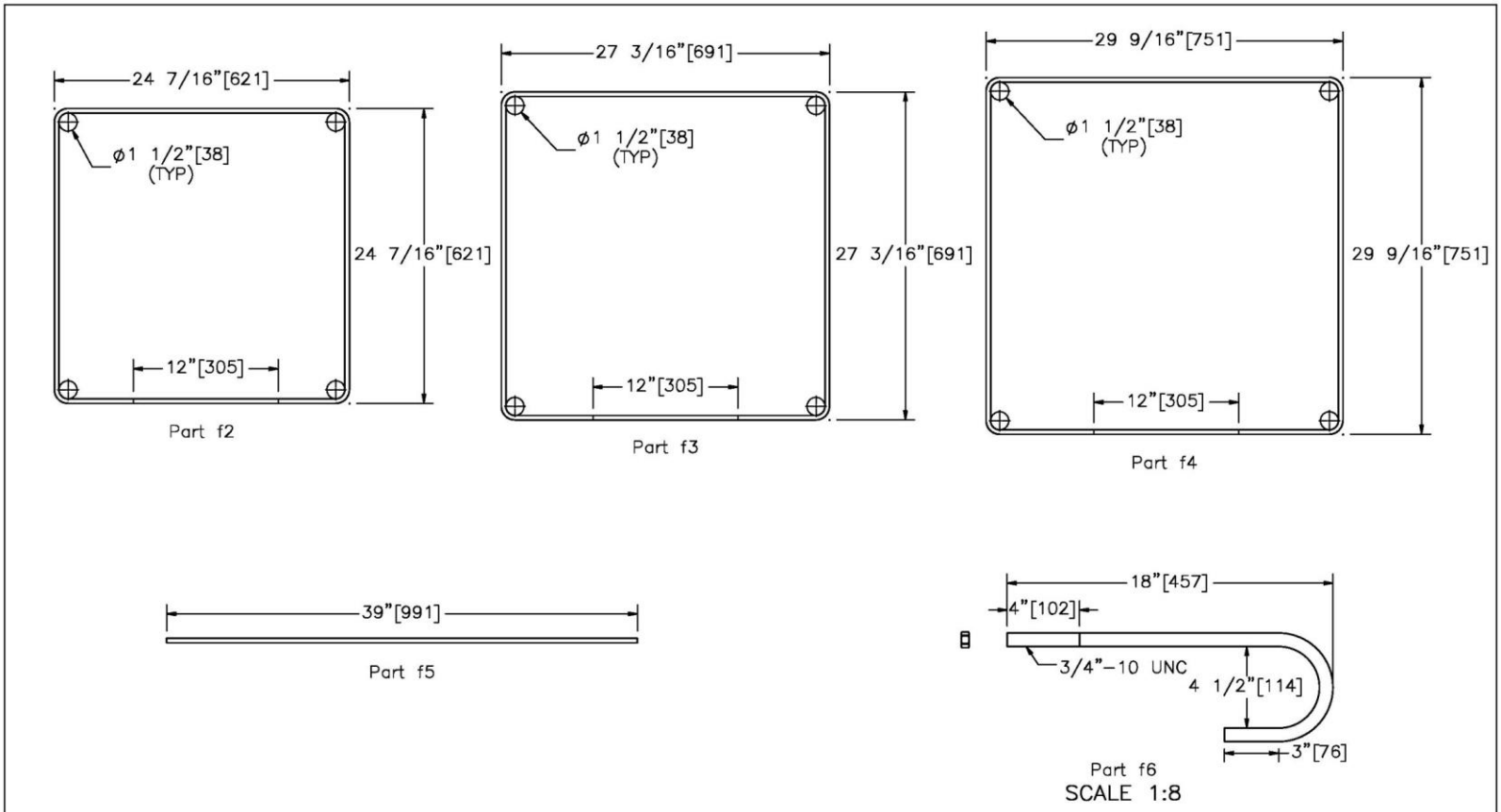
Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Downstream Anchor Assembly	–	–
f1	1	Concrete	Pre–Cast Class A* Min. f'c = 3,000 psi [20.7 MPa] NE Mix 47BD	–
f2	1	#3 [10] Bar, 106 5/8" [2,708] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f3	1	#3 [10] Bar, 117 5/8" [2,988] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f4	1	#3 [10] Bar, 127 1/8" [3,229] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f5	4	#3 [10] Bar, 39" [991] Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f6	8	3/4" [19] Dia. UNC, Hooked Anchor J–Bolt and Nut	J–Bolt – ASTM A307 Gr. C Nut – ASTM A563DH	ASTM A153 or B695 Class 55 or F2329

Figure 12. Downstream Anchor Assembly, Test No. NYBWT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Transition Anchor Assembly	–	–
f1	1	Concrete	Pre–Cast Class A* Min. f'c = 3,000 psi [20.7 MPa] NE Mix 47BD	–
f2	1	#3 [10] Bar, 106 5/8" [2,708] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f3	1	#3 [10] Bar, 117 5/8" [2,988] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f4	1	#3 [10] Bar, 127 1/8" [3,229] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f5	4	#3 [10] Bar, 39" [991] Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **
f6	8	3/4" [19] Dia. UNC, Hooked Anchor J–Bolt and Nut	J–Bolt – ASTM A307 Gr. C Nut – ASTM A563DH	ASTM A153 or B695 Class 55 or F2329

Figure 13. Transition Anchor Assembly, Test No. NYBWT-2



Note: (1) Epoxy–coating not necessary for testing purposes.

Bill of Bars

Bar	QTY. (Per Anchor)	Size	Total Unbent Length	Material	Treatment
f2	1	#3 [10]	106 5/8"[2,708]	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f3	1	#3 [10]	117 5/8"[2,988]	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f4	1	#3 [10]	127 1/8"[3,229]	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f5	4	#3 [10]	39"[991]	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)

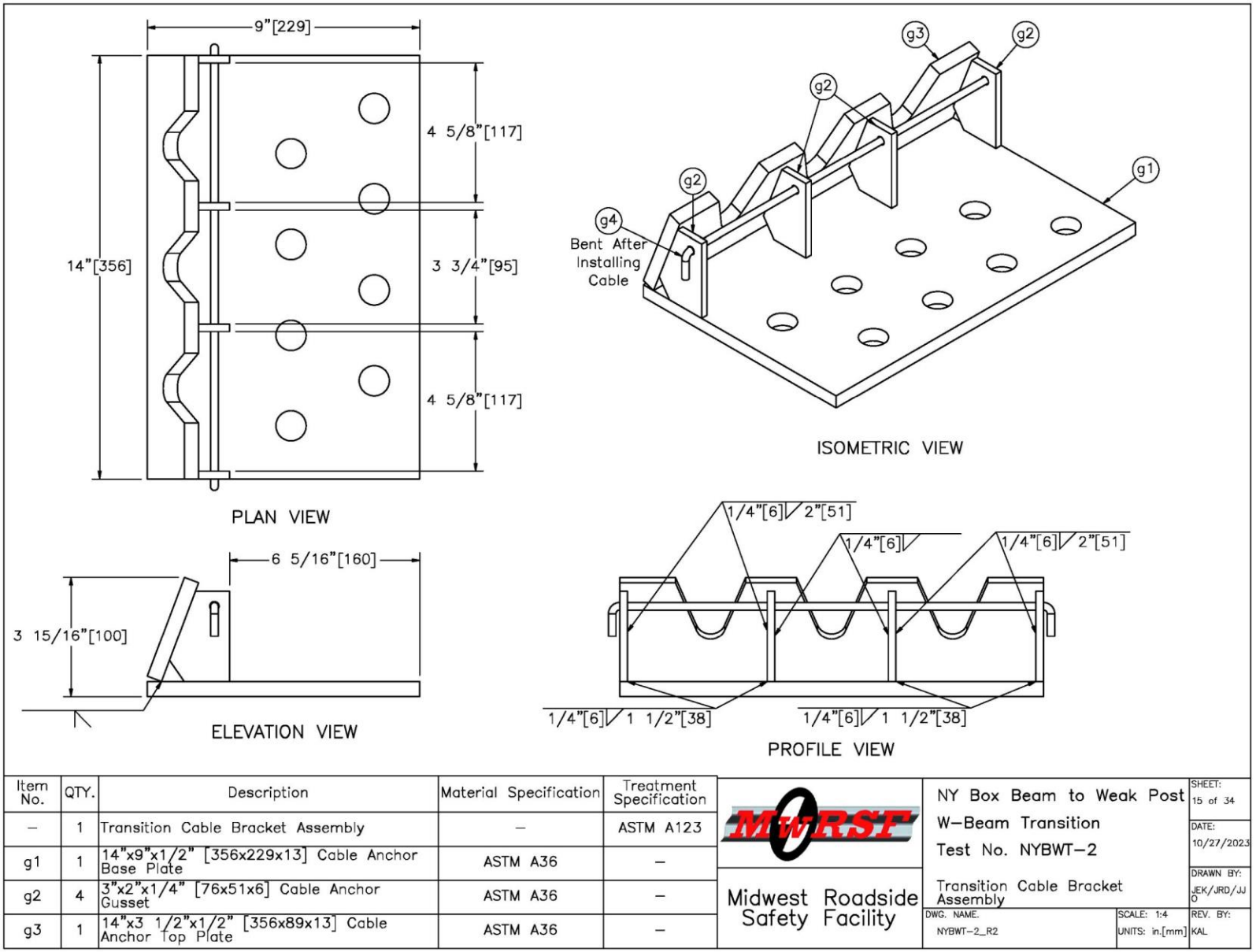
MwRSF

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Concrete Anchor Components

DWG. NAME. NYBWT–2_R2
SCALE: 1:12
UNITS: in.[mm]
REV. BY: KAL
SHEET: 14 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO

Figure 14. Concrete Anchor Components, Test No. NYBWT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Transition Cable Bracket Assembly	–	ASTM A123
g1	1	14"x9"x1/2" [356x229x13] Cable Anchor Base Plate	ASTM A36	–
g2	4	3"x2"x1/4" [76x51x6] Cable Anchor Gusset	ASTM A36	–
g3	1	14"x3 1/2"x1/2" [356x89x13] Cable Anchor Top Plate	ASTM A36	–

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Transition Cable Bracket Assembly

SHEET:	15 of 34
DATE:	10/27/2023
DRAWN BY:	JEK/JRD/JJO
REV. BY:	KAL
DWG. NAME.	NYBWT–2_R2
SCALE: 1:4 UNITS: in.[mm]	

Figure 15. Transition Cable Bracket Assembly, Test No. NYBWT-2

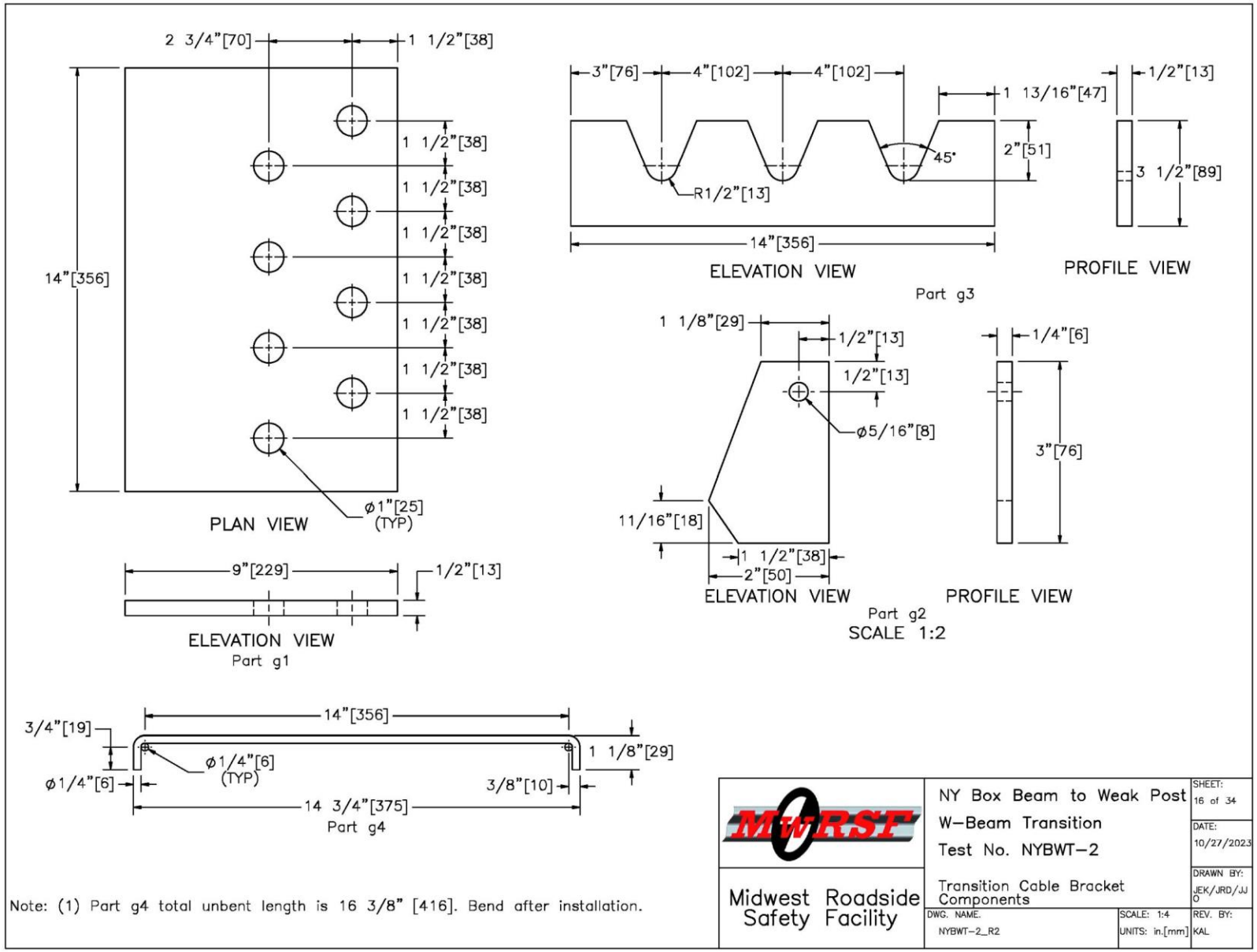
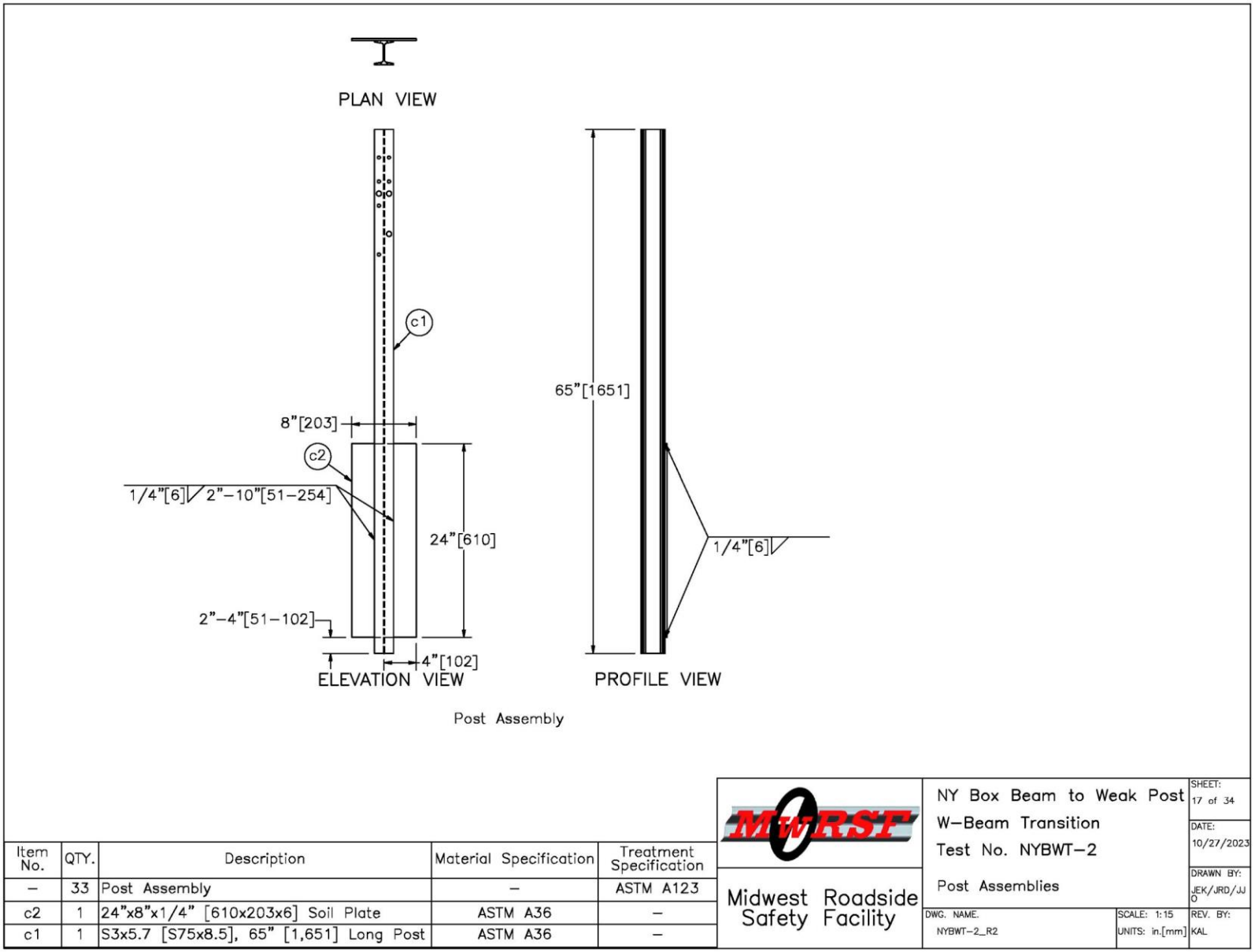


Figure 16. Transition Cable Bracket Components, Test No. NYBWT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	33	Post Assembly	–	ASTM A123
c2	1	24"x8"x1/4" [610x203x6] Soil Plate	ASTM A36	–
c1	1	S3x5.7 [S75x8.5], 65" [1,651] Long Post	ASTM A36	–

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Post Assemblies

SHEET: 17 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME. NYBWT–2_R2
SCALE: 1:15
UNITS: in.[mm]

Figure 17. Post Assemblies, Test No. NYBWT-2

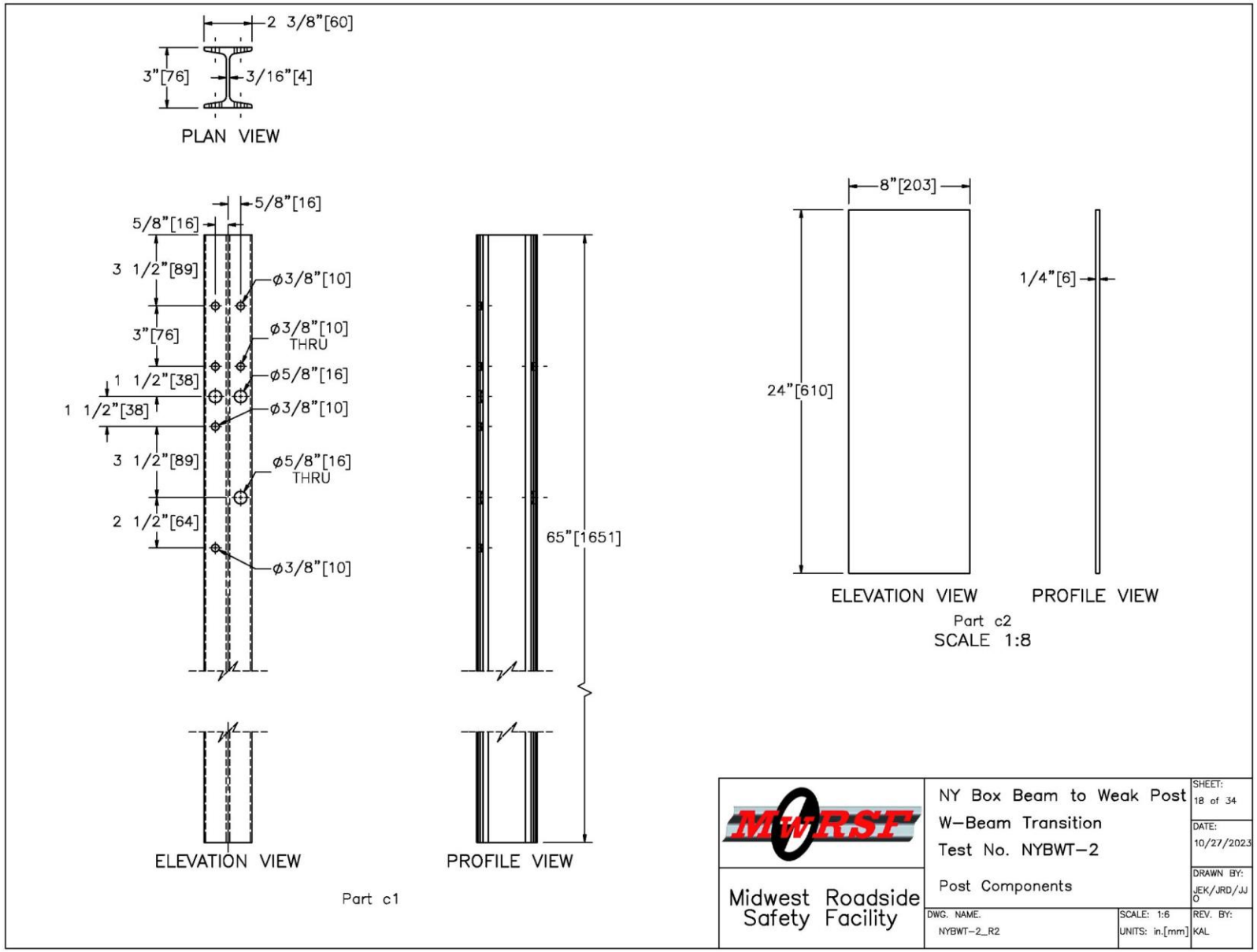


Figure 18. Post Components, Test No. NYBWT-2

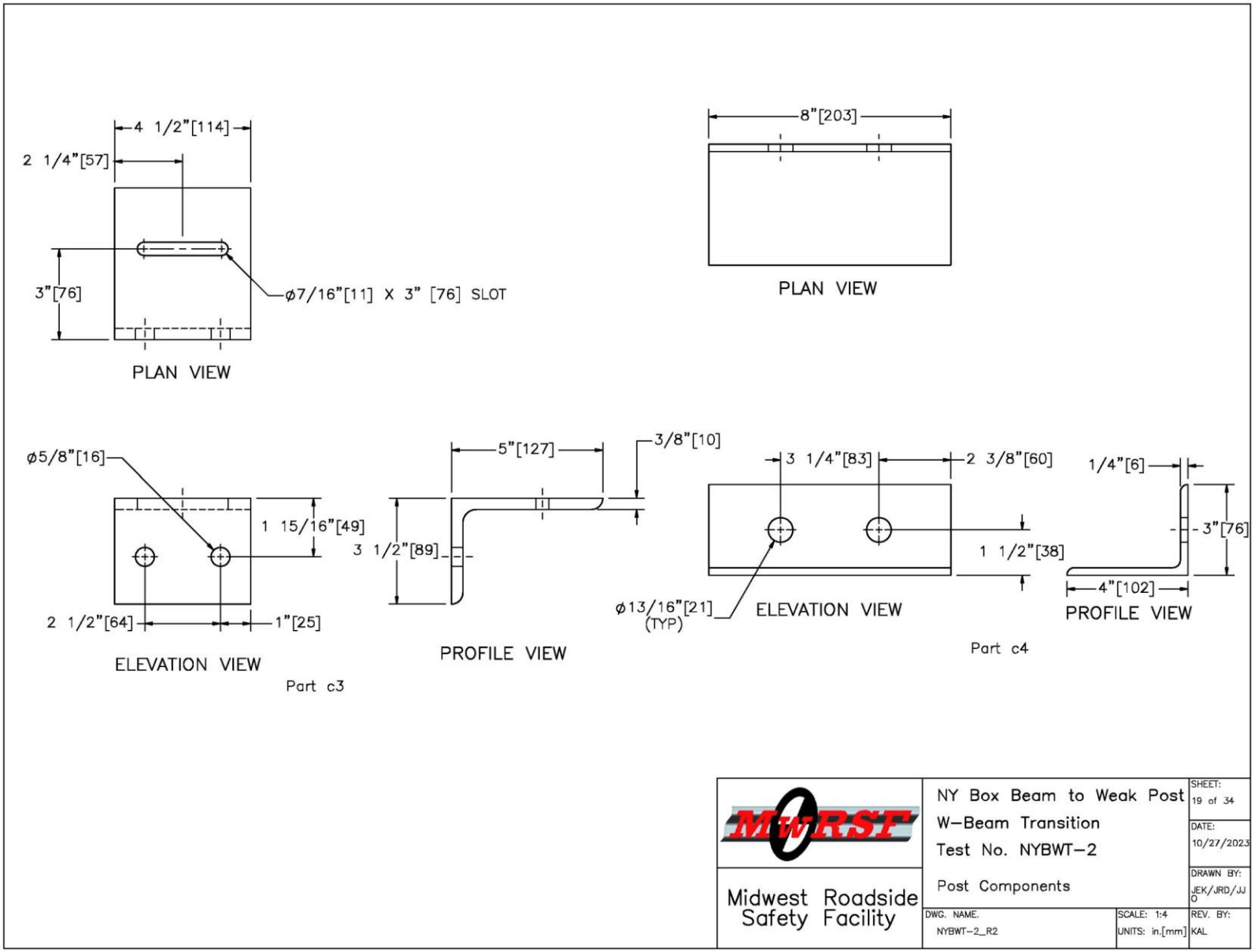
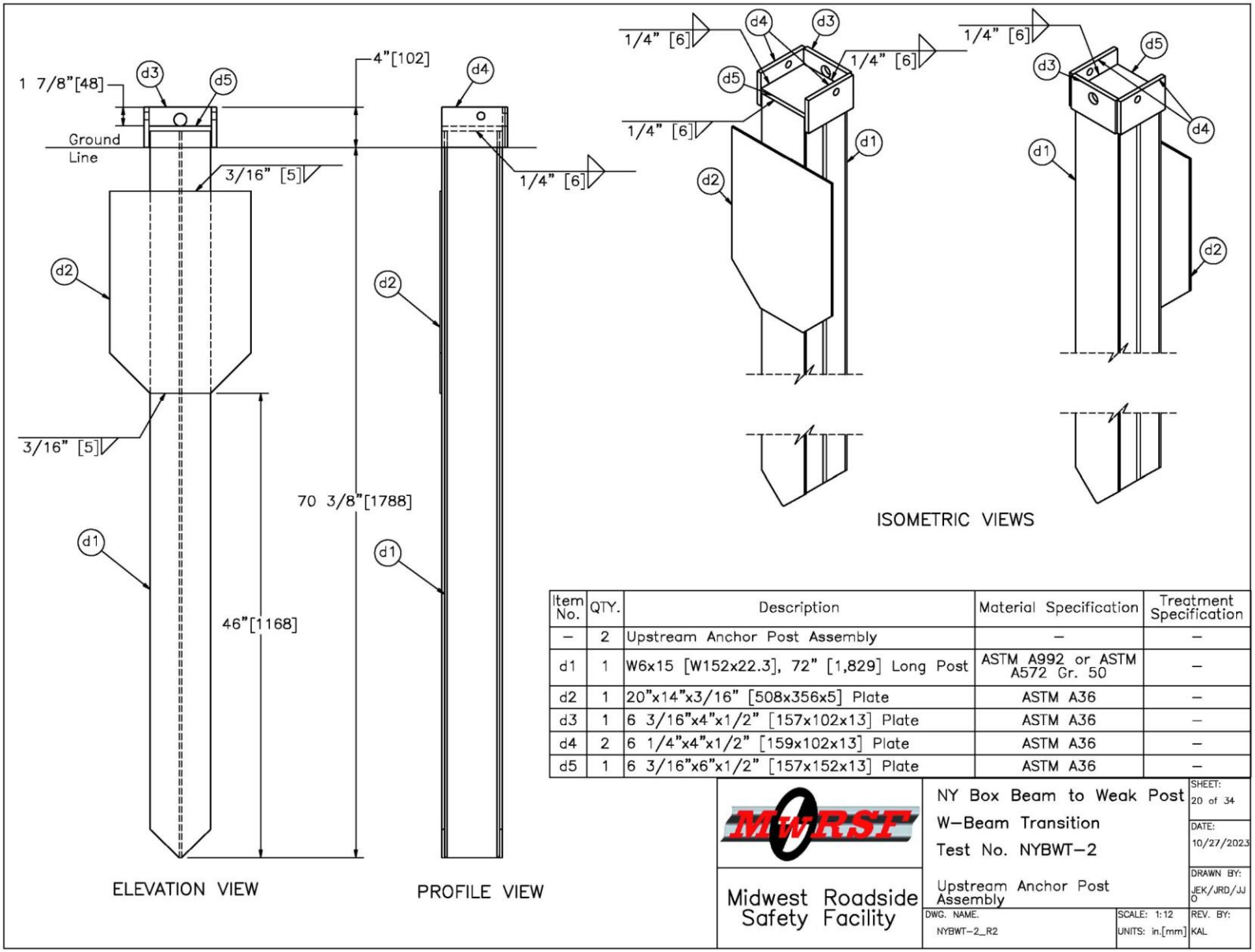


Figure 19. Post Components, Rail Support Bracket and Post Collar, Test No. NYBWT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	2	Upstream Anchor Post Assembly	–	–
d1	1	W6x15 [W152x22.3], 72" [1,829] Long Post	ASTM A992 or ASTM A572 Gr. 50	–
d2	1	20"x14"x3/16" [508x356x5] Plate	ASTM A36	–
d3	1	6 3/16"x4"x1/2" [157x102x13] Plate	ASTM A36	–
d4	2	6 1/4"x4"x1/2" [159x102x13] Plate	ASTM A36	–
d5	1	6 3/16"x6"x1/2" [157x152x13] Plate	ASTM A36	–

MwRSF

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W-Beam Transition
Test No. NYBWT-2
Upstream Anchor Post Assembly

SHEET: 20 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME. NYBWT-2_R2
SCALE: 1:12
UNITS: in.[mm]

Figure 20. HFT Anchor Assembly, Test No. NYBWT-2

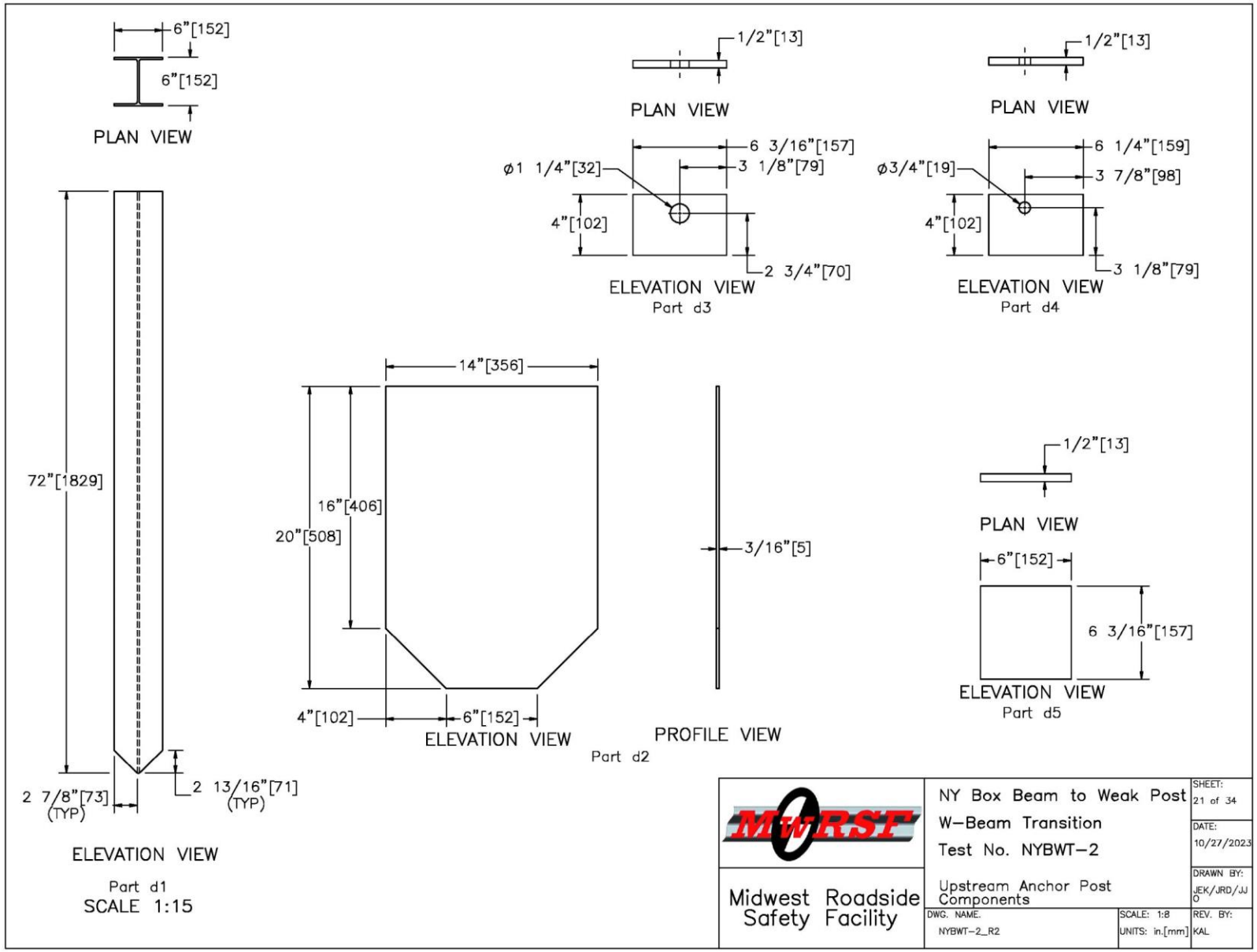


Figure 21. HFT Anchor Assembly Components, Test No. NYBWT-2

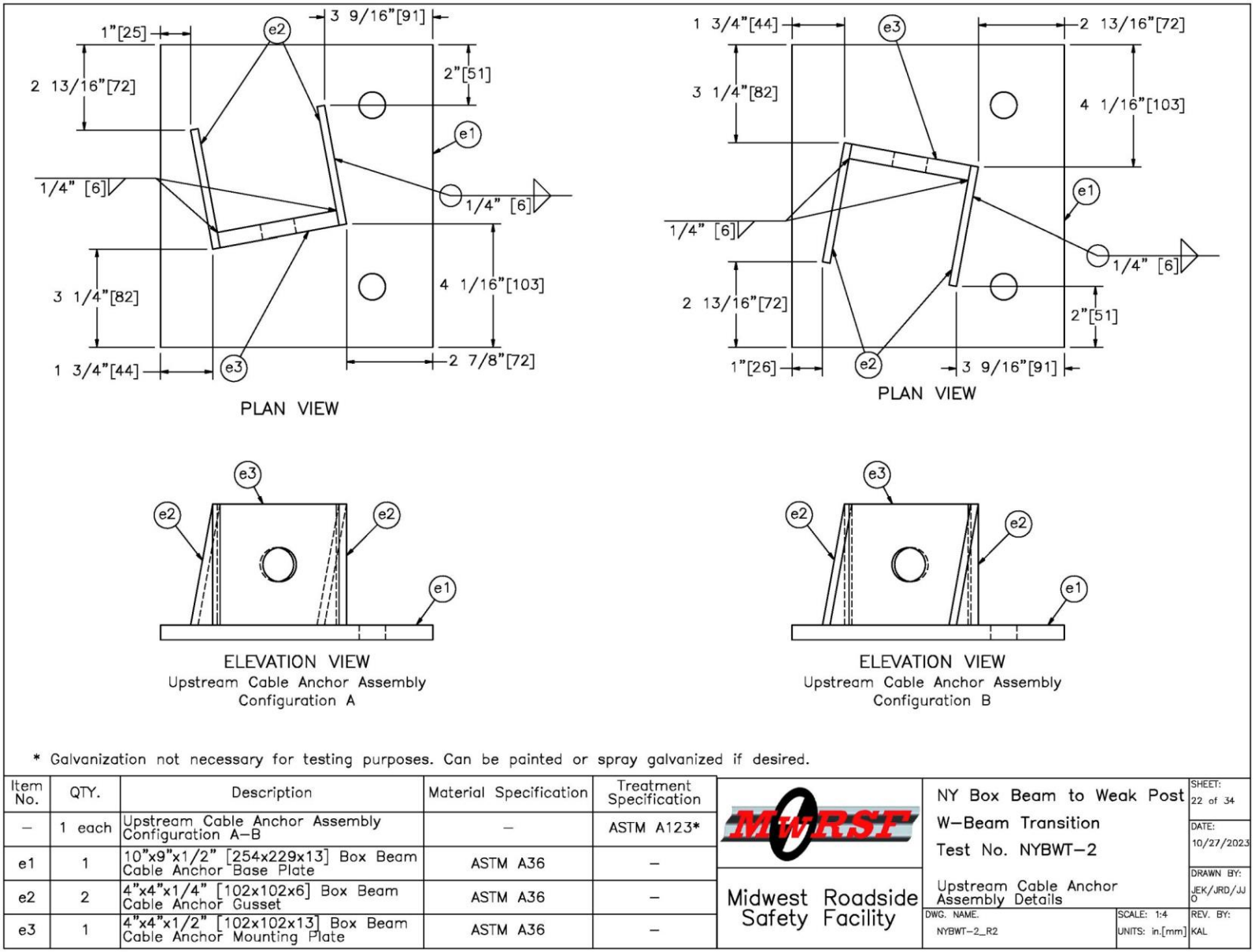


Figure 22. Upstream Cable Anchor Assembly Details Test No. NYBWT-2

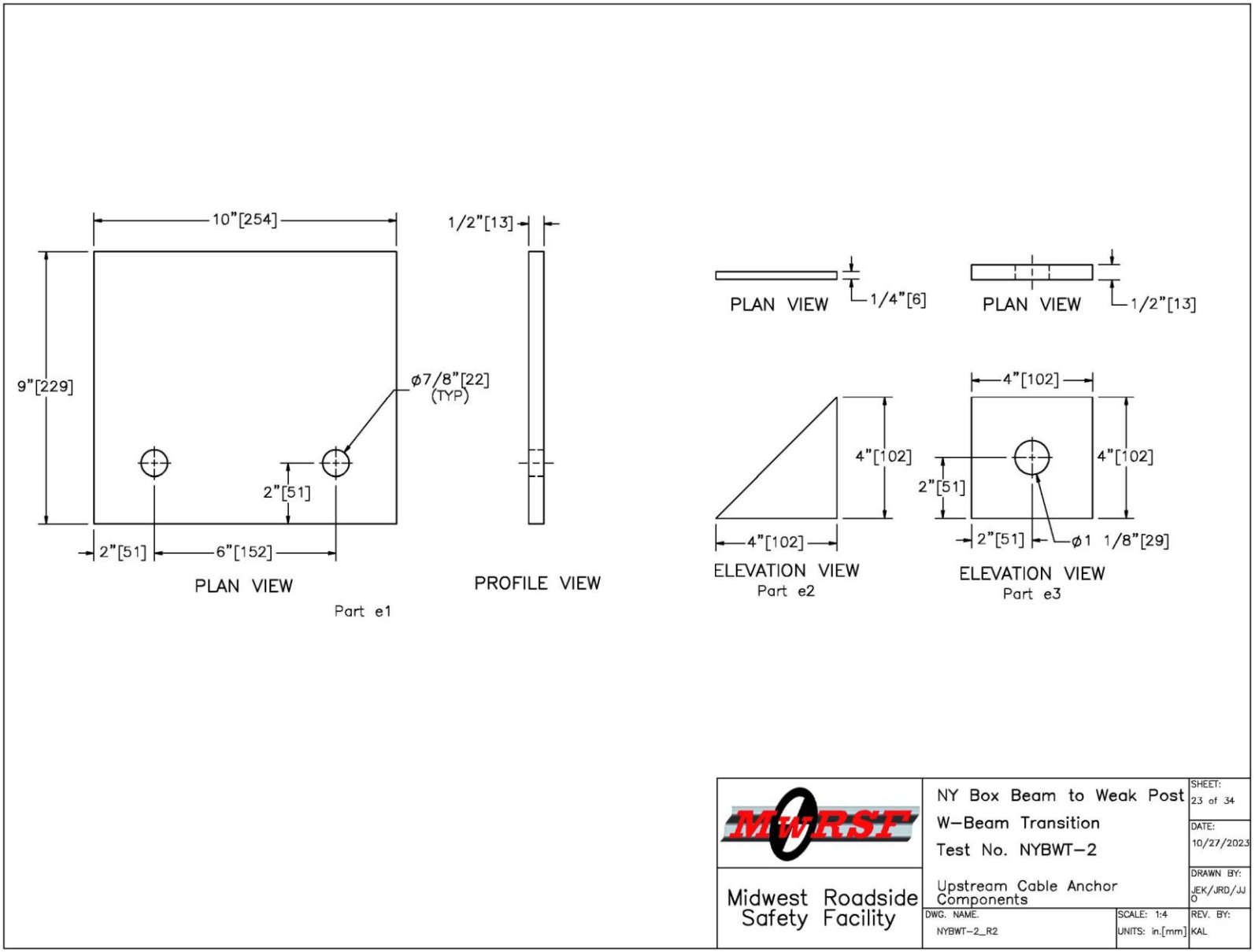


Figure 23. Upstream Cable Anchor Components, Test No. NYBWT-2

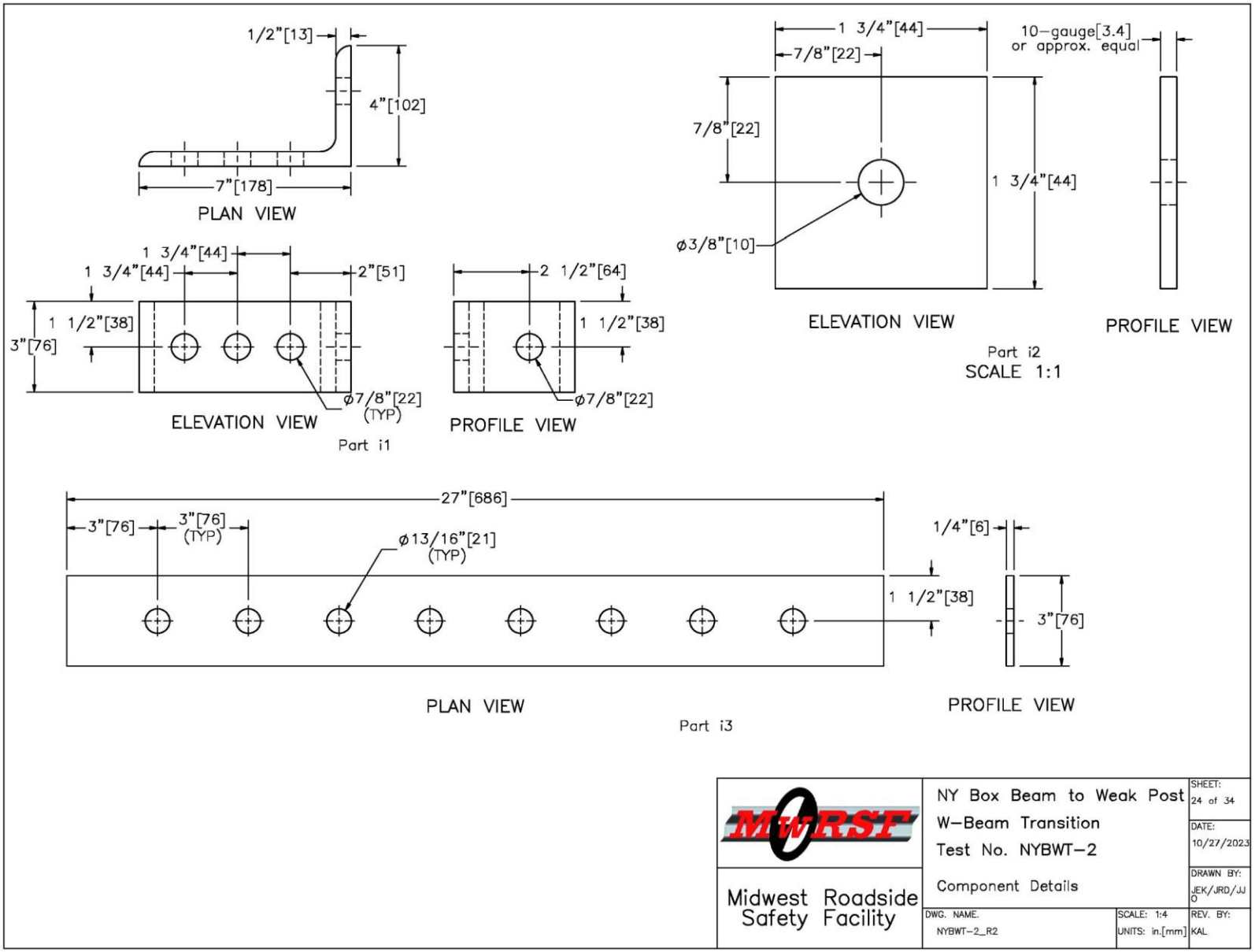
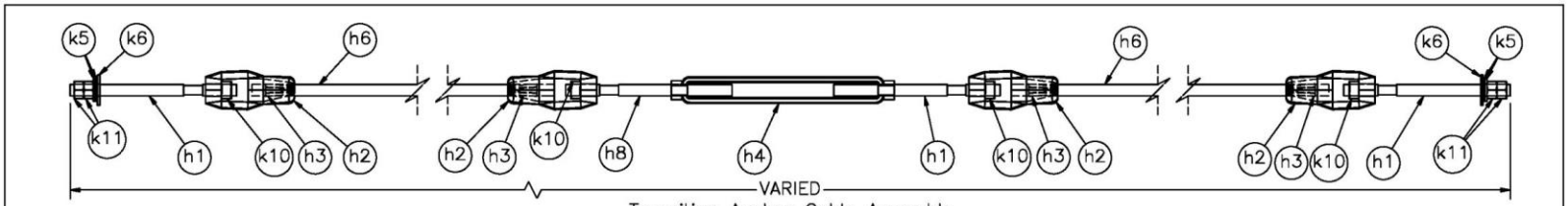
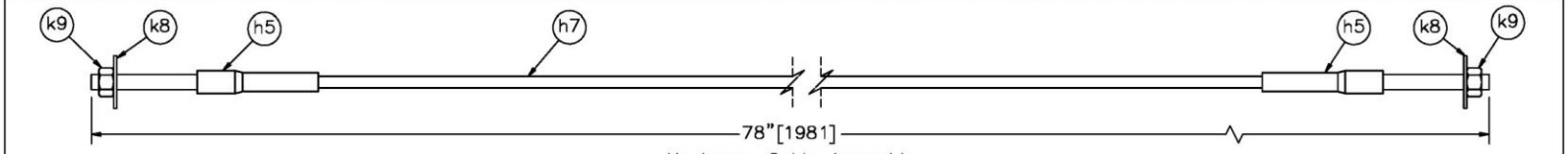


Figure 24. Components Details, Test No. NYBWT-2



Transition Anchor Cable Assembly

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	3	Transition Anchor Cable Assembly	–	–	–
h1	3	3/4" [19] Dia. UNC, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h2	4	Cable End Fitting	ASTM A27 Gr. 70–40 Class 1	ASTM A153 or B695	RCE03
h3	4	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
h4	1	Crosby Threaded Turnbuckle	Stock No. 1034115	As Supplied	–
h6	2	3/4" [19] Dia. 3x7 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 1	Class A Coating	RCM01
h8	1	3/4" [19] Dia. UNC–LH THD, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
k5	4	3/4" [19] Dia. Hardened Flat Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b
k6	2	3/4" [19] Dia. Plain Round Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC20a
k10	4	3/4" [19] Dia. UNC Square Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNS20
k11	4	3/4" [19] Dia. UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX20a



Upstream Cable Assembly

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	2	Upstream Cable Assembly	–	–	–
h5	2	BCT Anchor Cable End Swaged Fitting	Fitting – ASTM A576 Gr. 1035 Stud – ASTM F568 Class C	Fitting – ASTM A153 Stud – ASTM A153 or B695	–
k9	2	1" [25] Dia. UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX24b
k8	2	1" [25] Dia. Plain Round Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC24a
h7	1	3/4" [19] Dia. 6x19 IWRC IPS Wire Rope	ASTM A741 Type 2	Class A Coating	–

Notes: (1) Total lengths of the three transition anchor cable assemblies are approximately 282" [7,163], 317" [8,052], and 352" [8,941].

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Anchor Cable Details

SHEET: 25 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME. NYBWT–2_R2
SCALE: 1:10
UNITS: in.[mm]

Figure 25. Anchor Cable Details, Test No. NYBWT-2

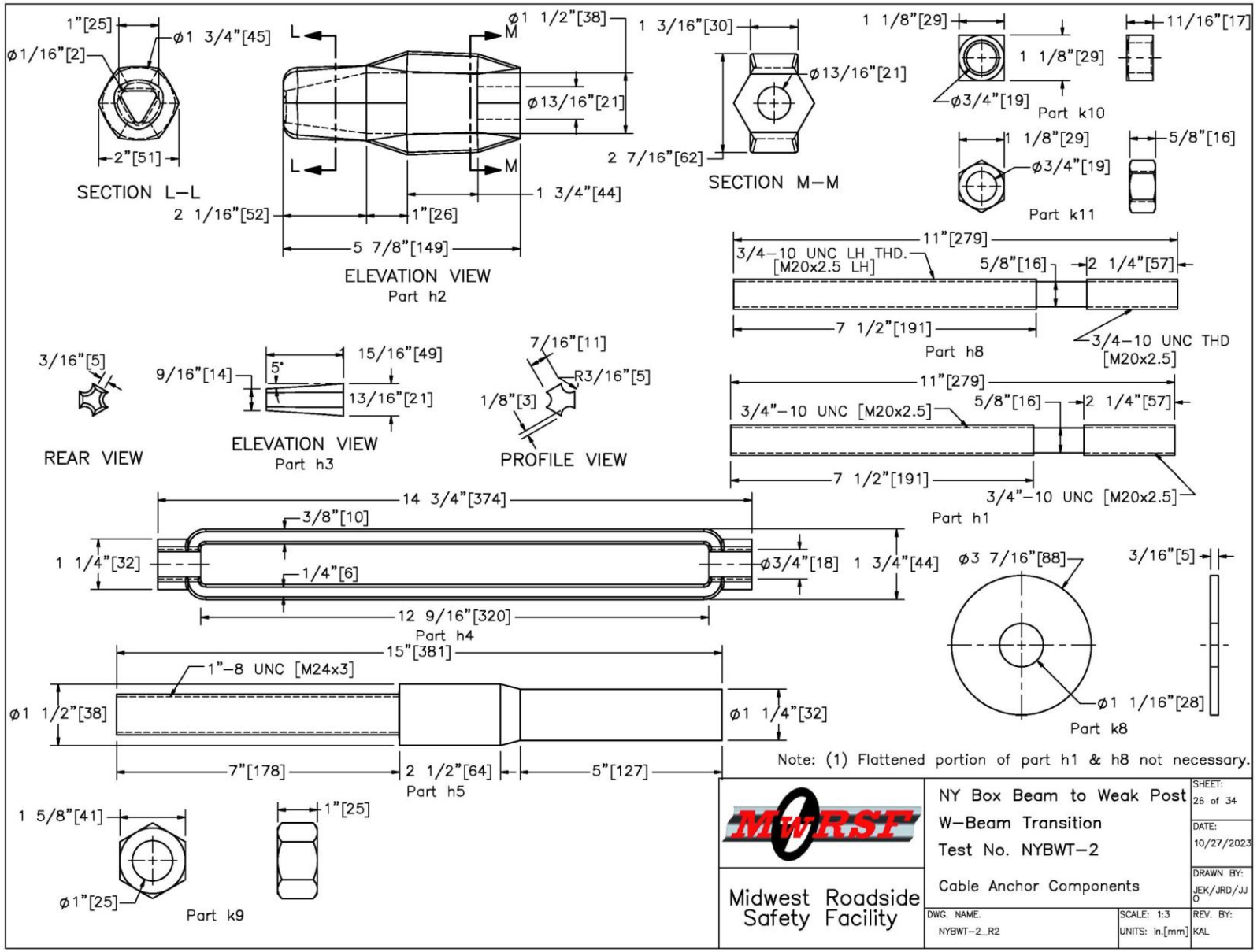


Figure 26. Cable Anchor Components, Test No. NYBWT-2

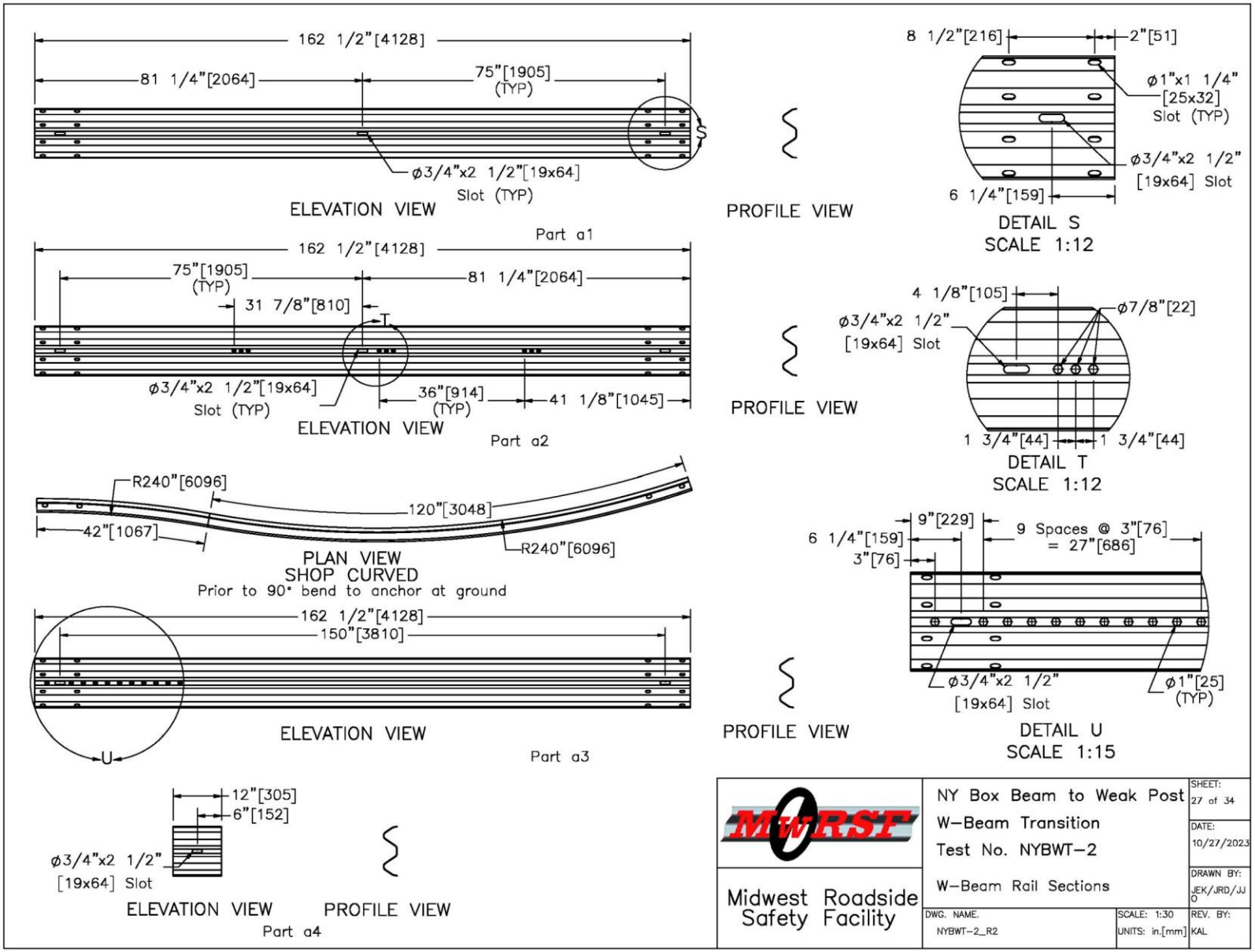


Figure 27. W-Beam Rail Section, Test No. NYBWT-2

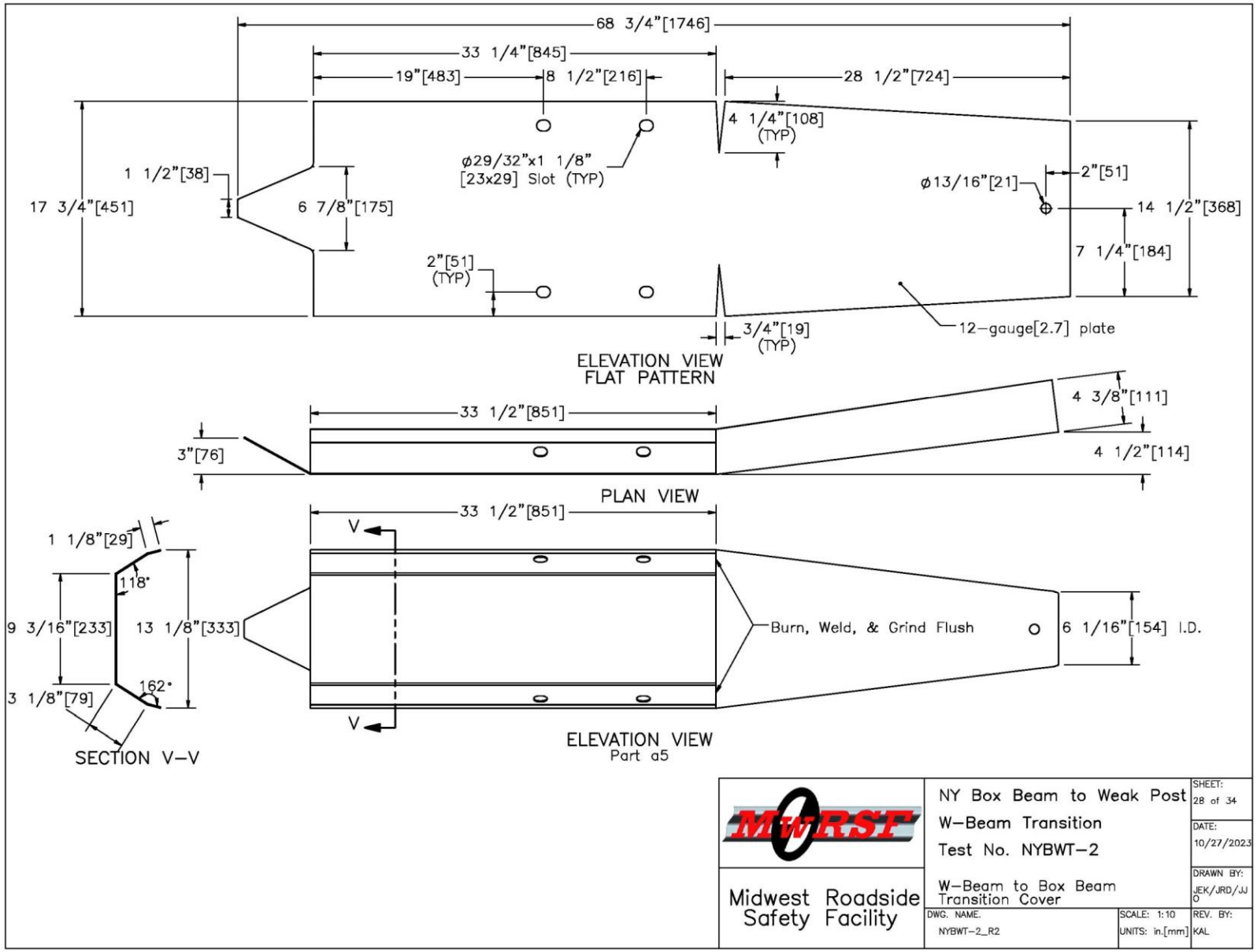


Figure 28. Box Beam to W-Beam Transition Cover, Test No. NYBWT-2

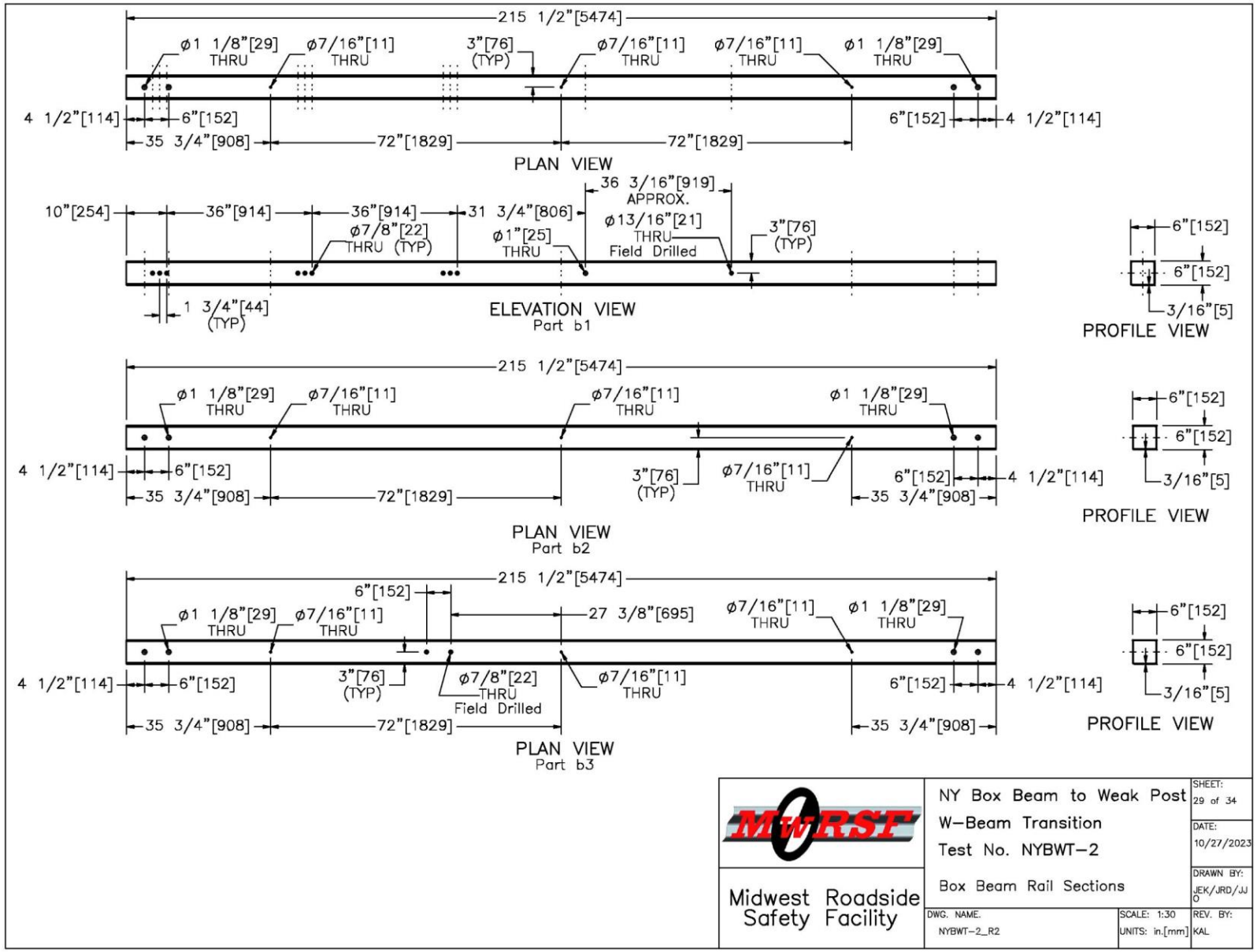
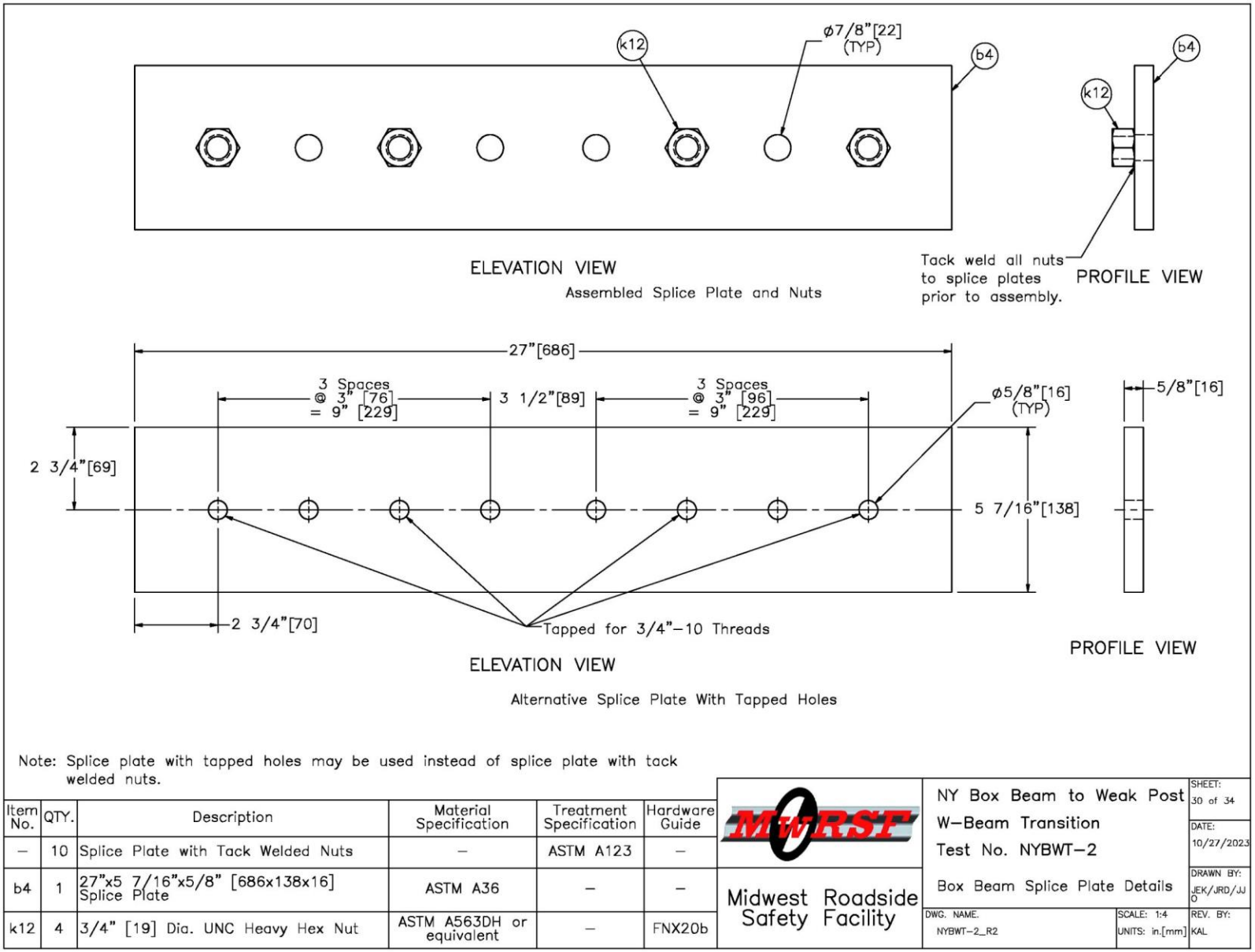


Figure 29. Box Beam Rail Section, Test No. NYBWT-2



Note: Splice plate with tapped holes may be used instead of splice plate with tack welded nuts.

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	10	Splice Plate with Tack Welded Nuts	–	ASTM A123	–
b4	1	27"x5 7/16"x5/8" [686x138x16] Splice Plate	ASTM A36	–	–
k12	4	3/4" [19] Dia. UNC Heavy Hex Nut	ASTM A563DH or equivalent	–	FNX20b

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W-Beam Transition
Test No. NYBWT-2
Box Beam Splice Plate Details

SHEET: 30 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME. NYBWT-2_R2
SCALE: 1:4
UNITS: in.[mm]

Figure 30. Box Beam Splice Plate Details, Test No. NYBWT-2

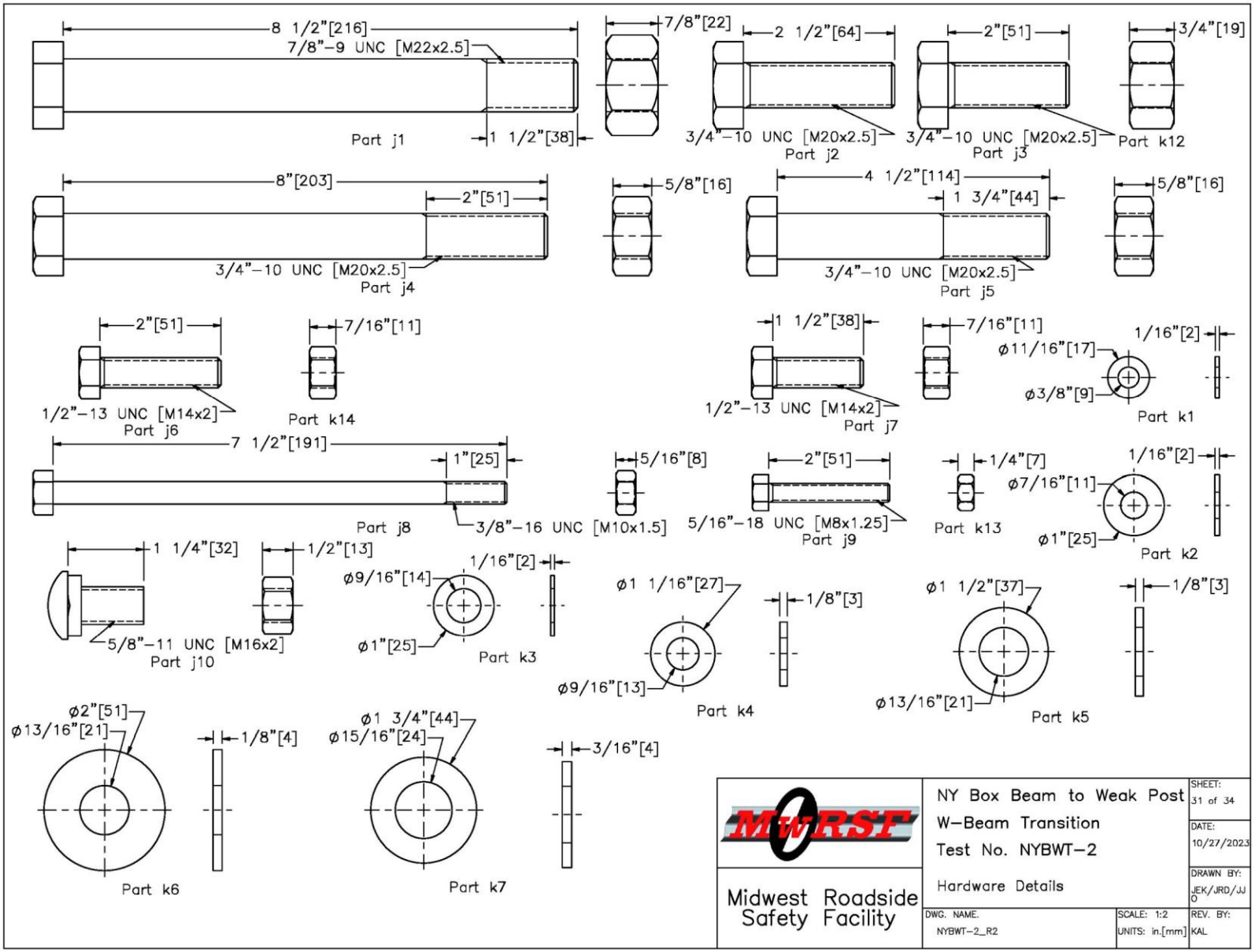


Figure 31. Hardware Details, Test No. NYBWT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
a1	8	12'–6" [3,810] 12–gauge [2.7] W–Beam Section	AASHTO M180	ASTM A123 or A653	RWM02a
a2	2	12'–6" [3,810] 12–gauge [2.7] W–Beam Section	AASHTO M180	ASTM A123 or A653	–
a3	1	12'–6" [3,810] 12–gauge [2.7] W–Beam Curved Section	AASHTO M180	ASTM A123 or A653	RWM11a
a4	6	12" [305] 12–gauge [2.7] W–Beam Backup Plate	AASHTO M180	ASTM A123 or A653	RWB01a
a5	1	W–Beam to Box Beam Transition Cover, 12–gauge [2.7]	ASTM A36	ASTM A123 or A653	–
b1	1	TS6"x6"x3/16" [152x152x5], 215 1/2" [5,474] Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b2	4	TS6"x6"x3/16" [152x152x5], 215 1/2" [5,474] Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b3	1	TS6"x6"x3/16" [152x152x5], 215 1/2" [5,474] Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b4	10	27"x5 7/16"x5/8" [686x138x16] Splice Plate	ASTM A36	–	–
c1	33	S3x5.7 [S75x8.5], 65" [1,651] Long Post	ASTM A36	–	–
c2	33	24"x8"x1/4" [610x203x6] Soil Plate	ASTM A36	–	–
c3	18	5"x3 1/2"x3/8" [127x89x10], 4 1/2" [114] Long L–Bracket	ASTM A36	ASTM A123	–
c4	2	4"x3"x1/4" [102x76x6], 8" [203] Long L–Bracket	ASTM A36	ASTM A123	–
d1	2	W6x15 [W152x22.3], 72" [1,829] Long Post	ASTM A992 or ASTM A572 Gr. 50	–	–
d2	2	20"x14"x3/16" [508x356x5] Plate	ASTM A36	–	–
d3	2	6 3/16"x4"x1/2" [157x102x13] Plate	ASTM A36	–	–
d4	4	6 1/4"x4"x1/2" [159x102x13] Plate	ASTM A36	–	–
d5	2	6 3/16"x6"x1/2" [157x152x13] Plate	ASTM A36	–	–
e1	2	10"x9"x1/2" [254x229x13] Box Beam Cable Anchor Base Plate	ASTM A36	–	–
e2	4	4"x4"x1/4" [102x102x6] Box Beam Cable Anchor Gusset	ASTM A36	–	–
e3	2	4"x4"x1/2" [102x102x13] Box Beam Cable Anchor Mounting Plate	ASTM A36	–	–
f1	2	Concrete	Pre–Cast Class A* Min. f'c = 3,000 psi [20.7 MPa] NE Mix 47BD	–	–
f2	2	#3 [10] Bar, 106 5/8" [2,708] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f3	2	#3 [10] Bar, 117 5/8" [2,988] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f4	2	#3 [10] Bar, 127 1/8" [3,229] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–

* If cast in place, follow Section 501 – Portland Cement Concrete – General of the NY state standards.
** Epoxy–coating not necessary for testing purposes.

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Bill of Materials

SHEET: 32 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME: NYBWT–2_R2
SCALE: None
UNITS: in.[mm]

Figure 32. Bill of Materials, Test No. NYBWT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
f5	8	#3 [10] Bar, 39" [991] Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f6	16	3/4" [19] Dia. UNC, Hooked Anchor J–Bolt and Nut	J–Bolt – ASTM A307 Gr. C Nut – ASTM A563DH	ASTM A153 or B695 Class 55 or F2329	FRH20a
g1	1	14"x9"x1/2" [356x229x13] Cable Anchor Base Plate	ASTM A36	–	–
g2	4	3"x2"x1/4" [76x51x6] Cable Anchor Gusset	ASTM A36	–	–
g3	1	14"x3 1/2"x1/2" [356x89x13] Cable Anchor Top Plate	ASTM A36	–	–
g4	1	1/4" [6] Dia., 16 3/8" [416] Long Brass Rod	ASTM B16–00	–	–
h1	9	3/4" [19] Dia. UNC, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h2	12	Cable End Fitting	ASTM A27 Gr. 70–40 Class 1	ASTM A153 or B695	RCE03
h3	12	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
h4	3	Crosby Threaded Turnbuckle	Stock No. 1034115	As Supplied	–
h5	4	BCT Anchor Cable End Swaged Fitting	Fitting – ASTM A576 Gr. 1035 Stud – ASTM F568 Class C	Fitting – ASTM A153 Stud – ASTM A153 or B695	–
h6	6	3/4" [19] Dia. 3x7 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 1	Class A Coating	RCM01
h7	2	3/4" [19] Dia. 6x19 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 2	Class A Coating	–
h8	3	3/4" [19] Dia. UNC–LH THD, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
i1	3	7"x4"x1/2" [178x102x13], 3" [76] Long L–Bracket	ASTM A36	ASTM A123	–
i2	20	1 3/4"x1 3/4"x10–gauge [44x44x3.4] Square Washer	ASTM A36	ASTM A123	–
i3	1	27"x3"x1/4" [686x76x6] Washer Plate	ASTM A36	ASTM A123	–
j1*	2	7/8"–9 UNC [M22x2.5], 8 1/2" [216] Long Heavy Hex Head Bolt and Nut	Bolt – ASTM F3125 Gr. A325 Type 1 or equivalent Nut – ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX22b
j2*	2	3/4"–10 UNC [M20x2.5], 2 1/2" [64] Long Fully Threaded Heavy Hex Head Bolt	Bolt – ASTM F3125 Gr. A325 Type 1 or equivalent Nut – ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX20b
j3	38	3/4"–10 UNC [M20x2.5], 2" [51] Long Fully Threaded Heavy Hex Head Bolt	Bolt – ASTM F3125 Gr. A325 Type 1 or equivalent Nut – ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX20b
j4	11	3/4"–10 UNC [M20x2.5], 8" [203] Long Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or equivalent Nut – ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX20a
j5	2	3/4"–10 UNC [M20x2.5], 4 1/2" [114] Long Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or equivalent Nut – ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX20a
j6	2	1/2"–13 UNC [M14x2], 2" [51] Fully Threaded Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX14a

* If using the alternate splice plates with tapped holes, these hex bolts can be 1/2" [13] shorter.

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Bill of Materials

SHEET: 33 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME. NYBWT–2_R2
SCALE: None
UNITS: in.[mm]

Figure 33. Bill of Materials, Test No. NYBWT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
j7	18	1/2"–13 UNC [M14x2], 1 1/2" [38] Long Fully Threaded Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or equivalent Nut – ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX14a
j8	18	3/8"–16 UNC [M10x1.5], 7 1/2" [191] Long Hex Head Bolt and Nut	Bolt – ASTM A307 Gr. A or equivalent Nut – ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX10a
j9	8	5/16"–18 UNC [M8x1.25], 2" [51] Long Fully Threaded Hex Head Bolt	Bolt – ASTM A307 Gr. A or equivalent Nut – ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX08a
j10	76	5/8"–11 UNC [M16x2], 1 1/4" [32] Long Guardrail Bolt and Nut	Bolt – ASTM A307 Gr. A Nut – ASTM A563A	ASTM A153 or B695 Class 55 or F2329	FBB01
k1	8	5/16" [8] Dia. Hardened Flat Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	–
k2	36	3/8" [10] Dia. Plain Round Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC10a
k3	18	1/2" [13] Dia. Plain Narrow Round Washer	SAE Low Carbon Gr. 2	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	–
k4	2	1/2" [13] Dia. Hardened Flat Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC14b
k5	74	3/4" [19] Dia. Hardened Flat Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b
k6	17	3/4" [19] Dia. Plain Round Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC20a
k7	4	7/8" [22] Dia. Hardened Flat Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC22b
k8	4	1" [25] Dia. Plain Round Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC24a
k9	4	1" [25] Dia. UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX24b
k10	12	3/4" [19] Dia. UNC Square Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNS20
k11	12	3/4" [19] Dia. UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX20a
k12*	40	3/4" [19] Dia. UNC Heavy Hex Nut	ASTM A563DH or equivalent	–	FNX20b
k13	16	5/16" [8] Dia. UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX08a
k14	4	1/2" [13] Dia. UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX14a

* If using the alternate splice plates with tapped holes, these additional hex nuts are not required.

Washer	Washer Series	Inside Diameter			Outside Diameter			Thickness		
		Basic	Tolerance		Basic	Tolerance		Basic	Max.	Min.
			Plus	Minus		Plus	Minus			
3/4"	Regular (k5)	0.812"	0.03"	0.007"	1.469"	0.03"	0.007"	0.134"	0.16"	0.108"
	Wide (k6)	0.812"	0.03"	0.007"	2"	0.03"	0.007"	0.165"	0.192"	0.136"

Midwest Roadside Safety Facility

NY Box Beam to Weak Post W–Beam Transition
Test No. NYBWT–2
Bill of Materials

SHEET: 34 of 34
DATE: 10/27/2023
DRAWN BY: JEK/JRD/JJO
REV. BY: KAL
DWG. NAME. NYBWT–2_R2
SCALE: None
UNITS: in.[mm]

Figure 34. Bill of Materials, Test No. NYBWT-2

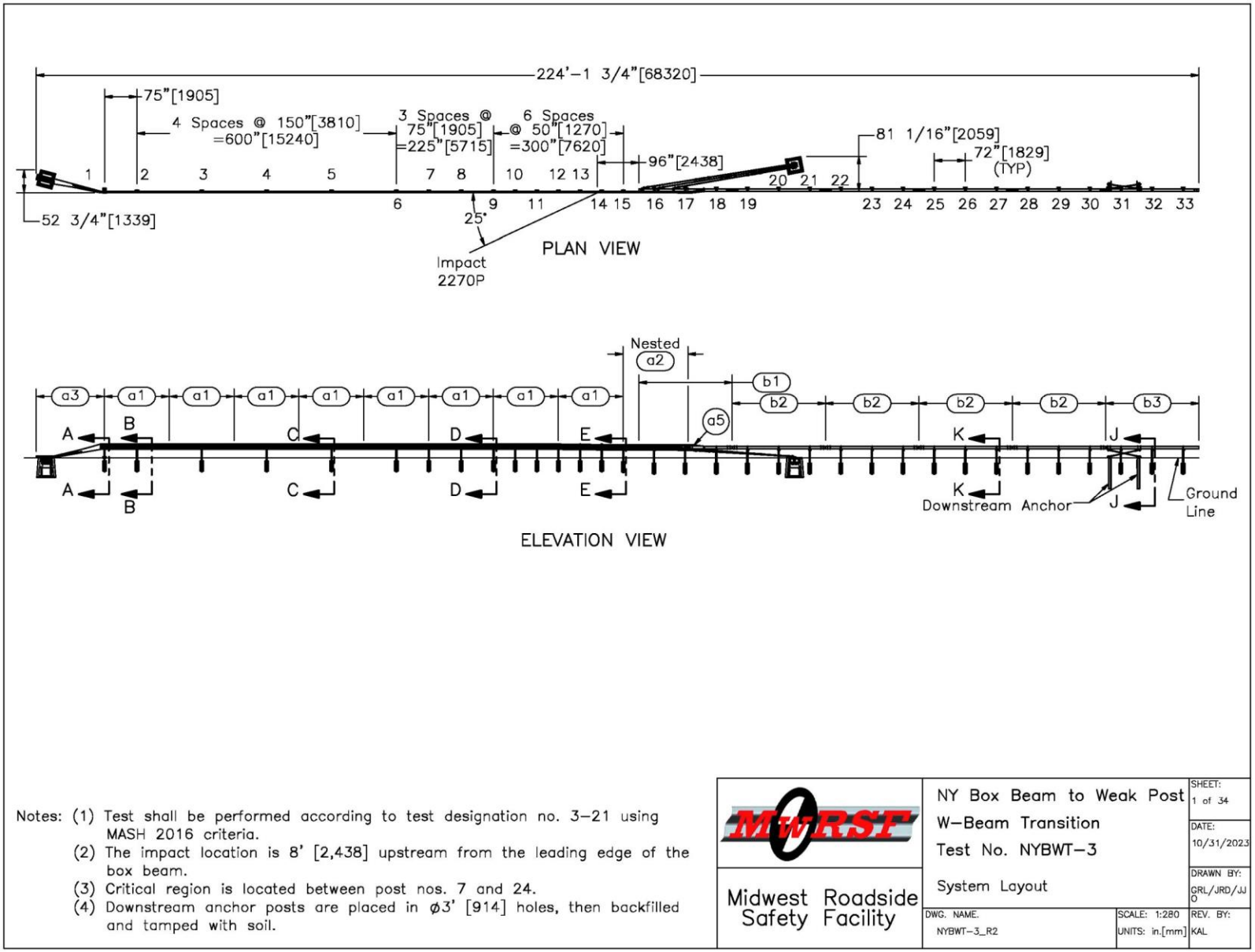


Figure 35. System Layout, Test No. NYBWT-3

Figure 36. System Installation, Test No. NYBWT-2

Figure 37. Box Beam and W-Beam Rails, Test No. NYBWT-2

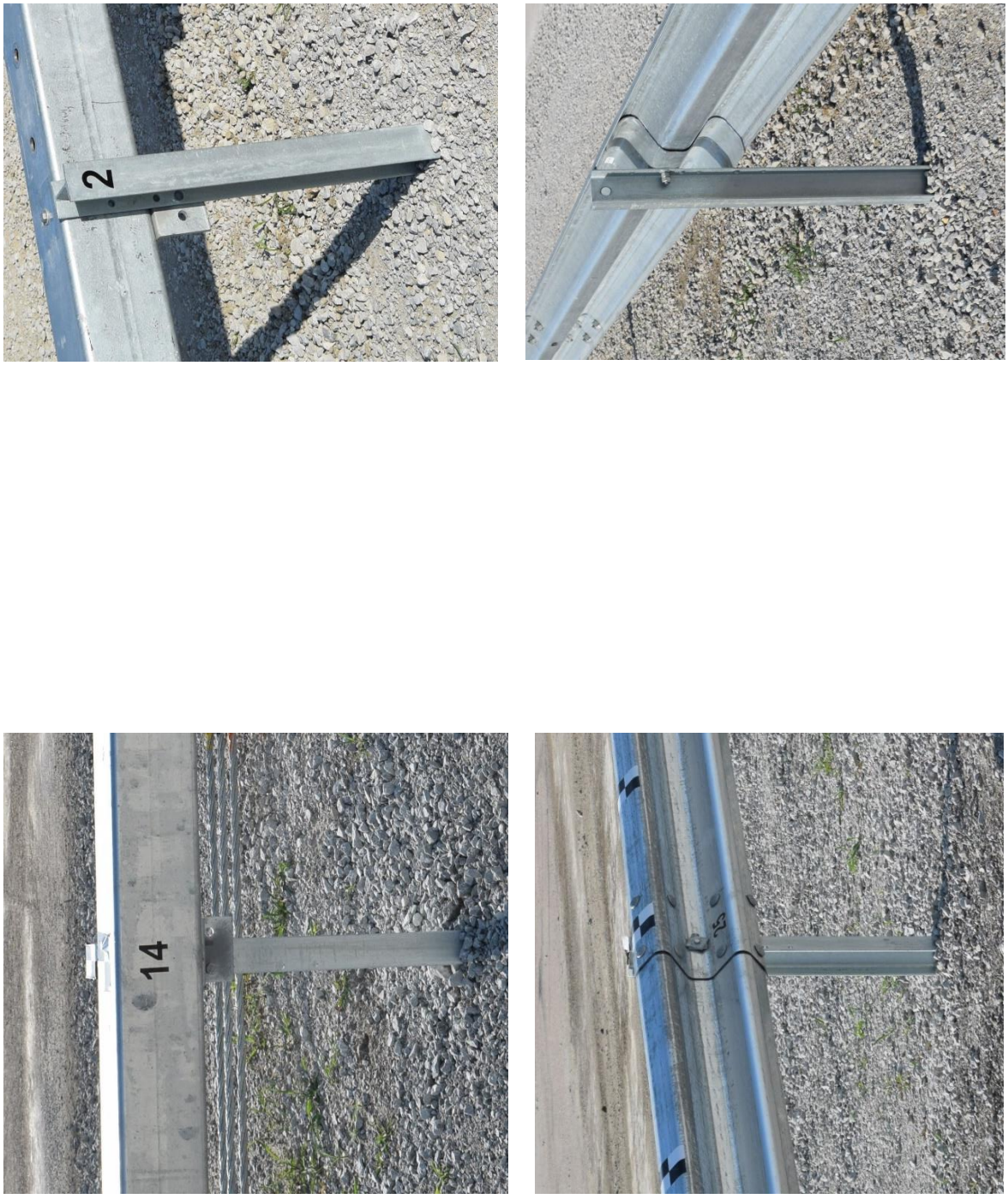


Figure 38. Box Beam and W-Beam Posts, Test No. NYBWT-2

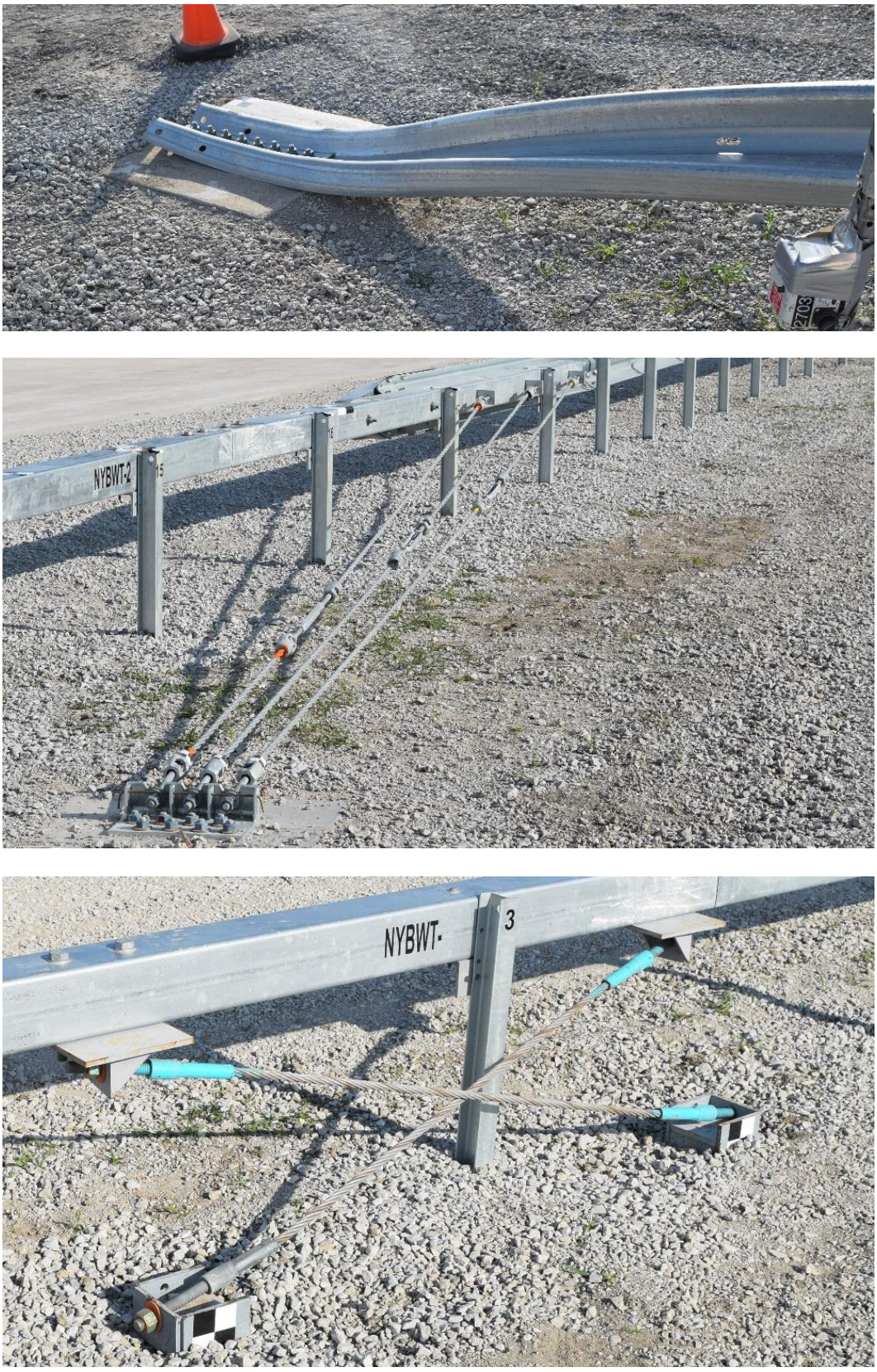


Figure 39. Anchors, Test No. NYBWT-2

Figure 40. Transition Cover Assembly, Test No. NYBWT-2

Figure 41. System Installation, Test No. NYBWT-3

Figure 42. Anchors, Test No. NYBWT-3

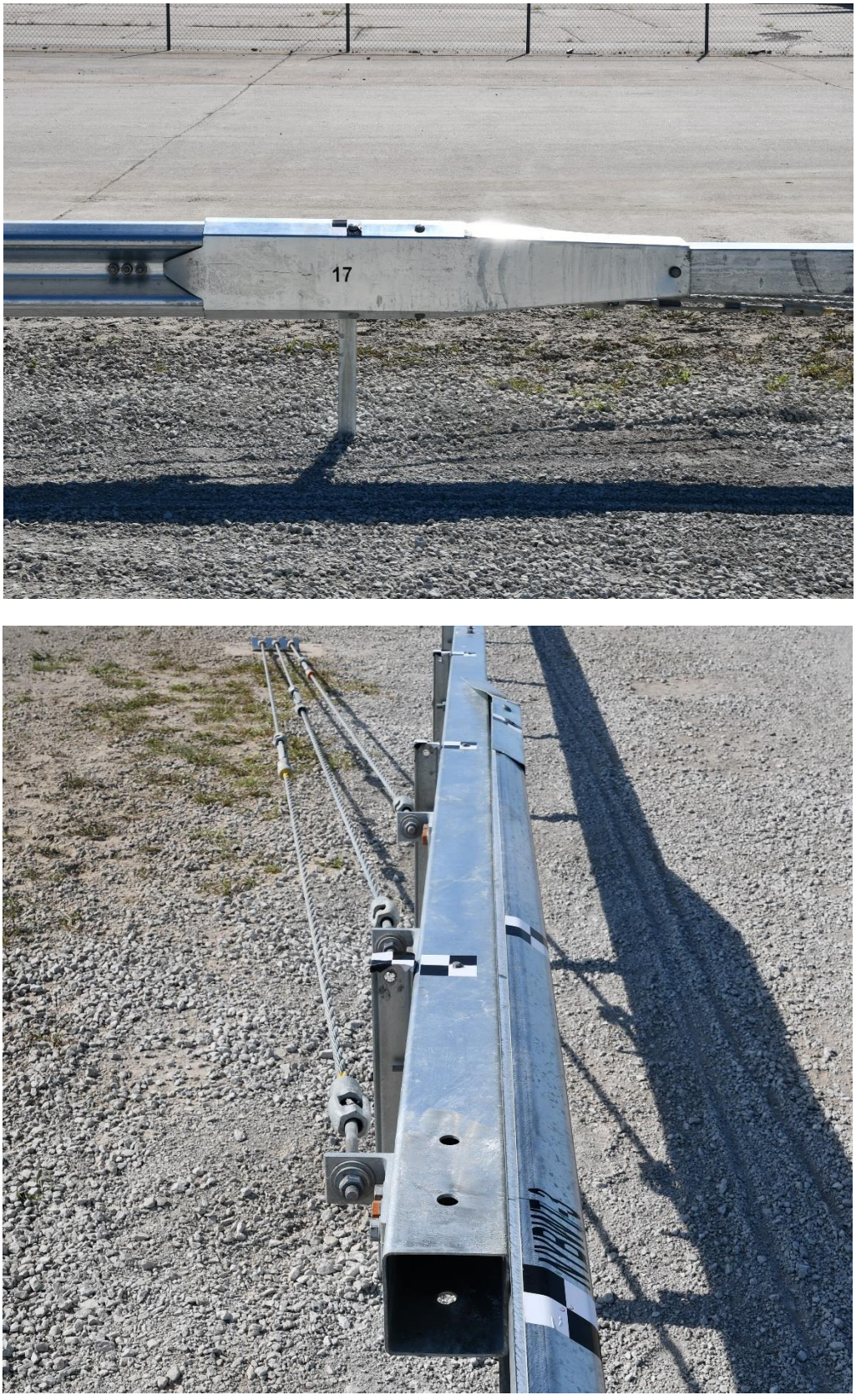


Figure 43. Transition Cover Assembly, Test No. NYBWT-3

3 TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1 Test Requirements

Longitudinal barriers, such as transitions between box beam and W-beam guardrail systems, must satisfy impact safety standards in order to be declared eligible for federal reimbursement by the FHWA for use on the National Highway System. For new hardware, these safety standards consist of the guidelines and procedures published in MASH 2016 [3]. Note that there is no difference between MASH 2009 and MASH 2016 for longitudinal barriers, such as the system tested in this project, except that additional occupant compartment deformation measurements, photographs, and documentation are required by MASH 2016.

According to TL-3 of MASH 2016, longitudinal barrier systems must be subjected to one full-scale vehicle crash test, as summarized in Table 1. Test designation no. 3-20 is an optional test for transitions and is only conducted if there is reasonable uncertainty regarding the impact performance of the system for impacts with small cars. Based on guidance from the sponsor, two full-scale crash tests were deemed necessary to evaluate the transition: (1) MASH 2016 test designation no. 3-21, which evaluates the transition with the 2270P pickup truck vehicle, and (2) a reverse-direction impact of test designation no. 3-21 with the 2270P vehicle. The reverse-direction impact test would be required to evaluate the transition for installations that require two-way traffic adjacent to the barrier. MASH 2016 also requires that transitions be evaluated adjacent to their connection to rigid barriers and in the stiffness transition region.

Table 1. MASH 2016 TL-3 Crash Test Conditions for Longitudinal Barriers - Transitions

Test Article	Test Designation No.	Test Vehicle	Vehicle Weight, lb (kg)	Impact Conditions		Evaluation Criteria [1]
				Speed, mph (km/h)	Angle, deg.	
Longitudinal Barrier-Transition	3-20 (optional)	1100C	2,420 (1,100)	62 (100)	25	A,D,F,H,I
	3-21	2270P	5,000 (2,270)	62 (100)	25	A,D,F,H,I

[1] Evaluation criteria explained in Table 2.

Based on prior research, the small car test was deemed not critical for testing and evaluation of this system. The box beam guardrail system successfully met NCHRP Report 350 test designation no. 3-11 [4]. Similarly, the weak-post W-beam guardrail successfully met NCHRP Report 350 test designation nos. 3-10 and 3-11 [5-6]. Based on recommendations made during NCHRP Project 22-14(03), only pickup truck tests were deemed necessary for the G3 box-beam longitudinal system and the modified G2 weak-post W-beam system with a rail height at 32 in. (813 mm) [7].

Table 2. MASH 2016 Evaluation Criteria for Longitudinal Barrier

<table>
<tr><td>Structural Adequacy</td><td>A.</td><td colspan="3">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 rowspan="4">Occupant Risk</td><td>D.</td><td colspan="3">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. 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.</td><td colspan="3">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.</td><td colspan="3">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.</td><td colspan="3">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>
</table>

During NCHRP Project 22-14(03), in test no. 476460-1-6, the G3 weak-post box-beam system was tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 4.8 ft (1.5 m). During that same research study, in test no. 476460-1-7, the modified G2 weak-post W-beam system was tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 8.6 ft (2.6 m). In addition, in test no. 608221-1, the modified G2 weak-post W-beam guardrail system was successfully tested according to MASH test designation no. 3-10 with no tears or punctures and only small scrapes to the underside of the vehicle [8]. The modified weak-post W-beam guardrail had a dynamic deflection of 6.0 ft (1.8 m) when impacted with the MASH small car.

Weak posts (S3x5.7) rotate minimally and yield at the ground line in the strong soil required by MASH, consequently, the posts behave as if they were in rigid sockets. Using quarter-post spacing with weak-posts in rigid sockets [9] reduced system deflections by almost 60 percent when compared to the modified G2 weak-post W-beam system. Therefore, the deflections of the reduced post spacing of the modified G2 weak-post W-beam system in the transition region should behave similar to the G3 weak-post box beam system.

It was believed that the pickup truck tests noted above would be sufficient to evaluate the transition between two semi-rigid barrier systems that transition to approximately the same stiffness. Therefore, the small car test was deemed not critical based on prior full-scale testing and the guidance in MASH section 2.2.1.2. It should be noted that any tests within the evaluation matrix deemed not critical may eventually need to be evaluated based on additional knowledge gained over time or additional FHWA eligibility letter requirements.

The test matrix detailed herein represents the researchers' best engineering judgement with respect to the MASH 2016 safety requirements and their internal evaluation of critical tests necessary to evaluate the crashworthiness of the barrier system. However, the recent switch to new vehicle types as part of the implementation of the MASH 2016 criteria and the lack of experience and knowledge regarding certain barriers could result in unanticipated barrier performance. Thus, any tests within the evaluation matrix deemed non-critical may eventually need to be evaluated based on additional knowledge gained over time or revisions to the MASH 2016 criteria.

3.2 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 to weak-post W-beam transition 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 detail in MASH 2016 [3]. The full-scale vehicle crash tests documented herein were 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.

3.3 Soil Strength Requirements

In accordance with Chapter 3 and Appendix B of MASH 2016 [3], 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 as 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 and 20 in. (127 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 percent of the static baseline test at deflections of 5, 10, and 15 in. (127, 254, and 381 mm). Further details can be found in Appendix B of MASH 2016.

4 TEST CONDITIONS

4.1 Test Facility

The Outdoor Test Site 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 [10] was used to steer the test vehicle. A guide flag, attached to the left-front wheel for test no. NYBWT-2 and the right-front wheel for test no. NYBWT-3, 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. NYBWT-2, 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 4,931 lb (2,237 kg), 4,969 lb (2,254 kg), and 5,139 lb (2,331 kg), respectively. The test vehicle is shown in Figures 44 and 45, and vehicle dimensions are shown in Figure 46.

For test no. NYBWT-3, a 2012 Dodge Ram 1500 quad cab pickup truck was used as the test vehicle. The curb, test inertial, and gross static vehicle weights were 5,151 lb (2,336 kg), 5,006 lb (2,271 kg), and 5,165 lb (2,343 kg), respectively. The test vehicle is shown in Figures 47 and 48, and vehicle dimensions are shown in Figure 49.

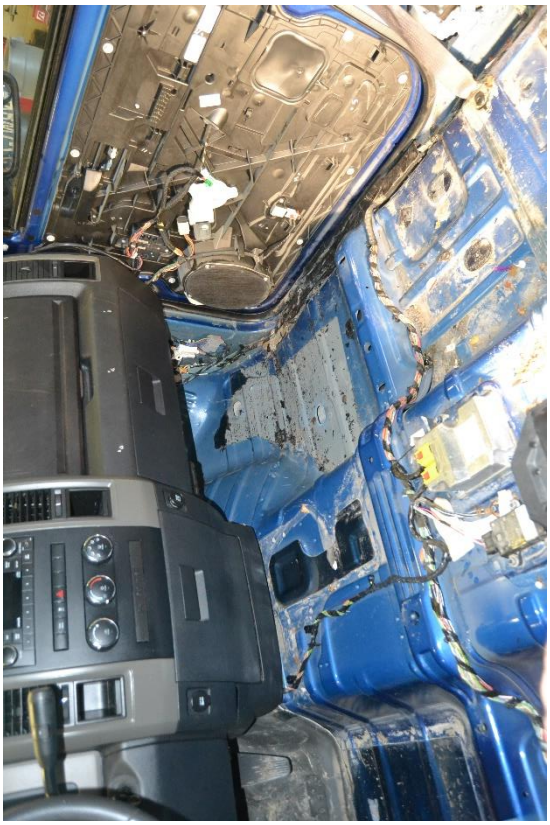
The longitudinal component of the center of gravity (c.g.) was determined using the measured axle weights. The Suspension Method [11] was used to determine the vertical component of the c.g. for the pickup trucks. This method is based on the principle that the c.g. of any freely suspended body is in the vertical plane through the point of suspension. The vehicles were 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. for test no. NYBWT-2 is shown in Figures 46 and 50. The location of the final c.g. for test no. NYBWT-3 is shown in Figures 49 and 51. Data used to calculate the location of the c.g. and ballast information are shown in Appendix D.

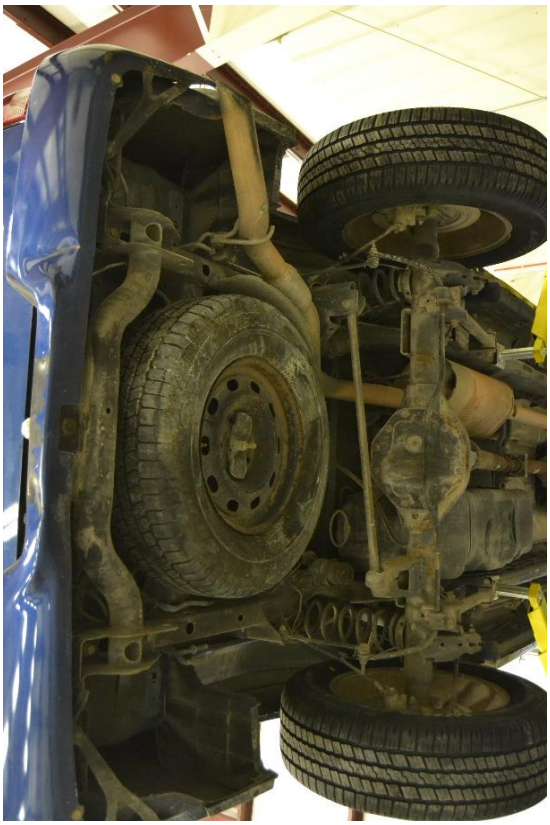
Square, black- and white-checkered targets were placed on the vehicles for reference to be viewed from the high-speed digital video cameras and aid in the video analysis, as shown in

Figures 50 and 51. Round, checkered targets were placed at the c.g. on the left-side door, the right-side door, and the roof of the vehicles.

The front wheels of the test vehicles 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 vehicle's right-side windshield wiper for test no. NYBWT-2 and left-side windshield wiper for test no. NYBWT-3. The flash bulbs were fired by a pressure tape switch mounted at the impact corner of the front 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 vehicles so the vehicles could be brought safely to a stop after the test.

Figure 44. Test Vehicle, Test No. NYBWT-2





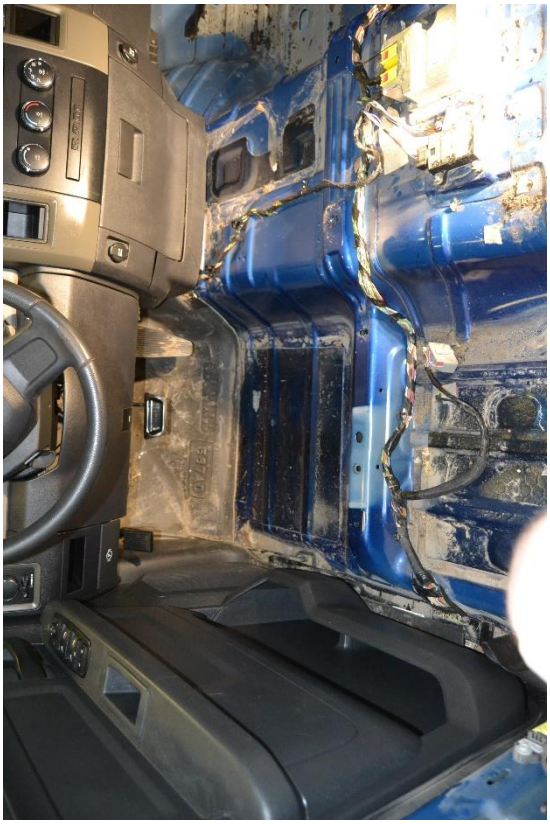
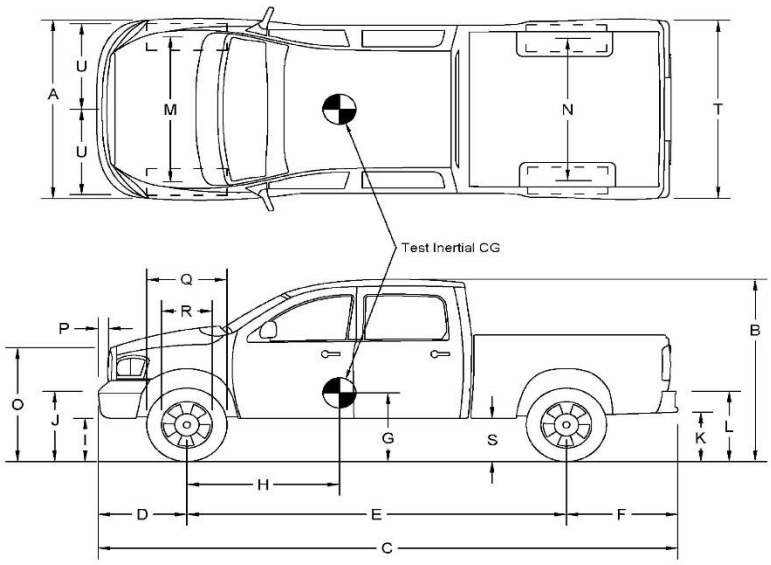


Figure 45. Test Vehicle's Interior Floorboards and Undercarriage, Test No. NYBWT-2

Date:	6/8/2016	**Test Name:**	NYBWT-2	**VIN No:**	1D7RB1GK0BS515074
Year:	2011	**Make:**	Dodge	**Model:**	Ram 1500 Quad Cab
Tire Size:	275/60R20	**Tire Inflation Pressure:**	40 Psi	**Odometer:**	149499



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

A:	76 (1930)	78±2 (1950±50)	**B:**	75 (1905)	
C:	229 1/4 (5823)	237±13 (6020±325)	**D:**	40 1/2 (1029)	39±3 (1000±75)
E:	140 1/2 (3569)	148±12 (3760±300)	**F:**	48 (1219)	
G:	29 1/16 (738)	min: 28 (710)	**H:**	63 11/16 (1618)	63±4 (1575±100)
I:	12 3/4 (324)		**J:**	25 1/5 (640)	
K:	21 1/2 (546)		**L:**	29 3/4 (756)	
M:	66 (1676)	67±1.5 (1700±38)	**N:**	66 (1676)	67±1.5 (1700±38)
O:	45 (1143)	43±4 (1100±75)	**P:**	4 3/4 (121)	
Q:	33 1/2 (851)		**R:**	21 1/2 (546)	
S:	16 (406)		**T:**	75 1/2 (1918)	

U (impact width): 31 (787)

Mass Distribution lb (kg)

Gross Static	**LF**	1441 (654)	**RF**	1382 (627)	**Wheel Center Height (Front):**	24 (610)
	LR	1133 (514)	**RR**	1183 (537)	**Wheel Center Height (Rear):**	24 (610)
					Wheel Well Clearance (Front):	5 1/2 (140)
					Wheel Well Clearance (Rear):	10 (254)

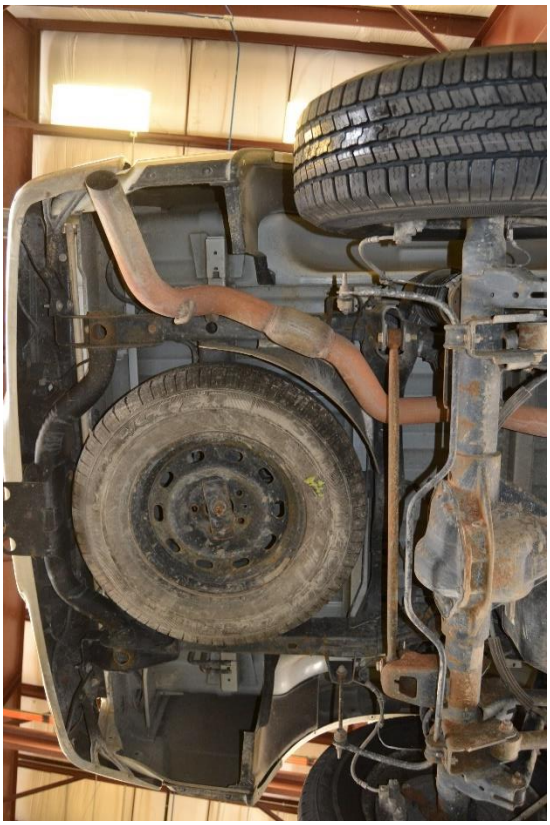
Weights lb (kg)	**Curb**	**Test Inertial**	**Gross Static**	
W-front	2746 (1246)	2717 (1232)	2823 (1280)	**Bottom Frame Height (Front):** 10 3/4 (273)
W-rear	2185 (991)	2252 (1021)	2316 (1051)	**Bottom Frame Height (Rear):** 23 (584)
W-total	4931 (2237)	4969 (2254)	5139 (2331)	**Engine Type:** GAS 6cyl.
		5000±110 (2270±50)	5165±110 (2343±50)	**Engine Size:** 3.6L

GVWR Ratings lb		**Surrogate Occupant Data**			
Front	3700	**Type:**	Hybrid II	**Transmission Type:**	Auto
Rear	3900	**Mass:**	170 lb	**Drive Type:**	RWD
Total	6700	**Seat Position:**	Passenger	**Cab Style:**	Quad Cab
				Bed Length:	67"

Note any damage prior to test: None

Figure 46. Vehicle Dimensions, Test No. NYBWT-2

Figure 47. Test Vehicle, Test No. NYBWT-3



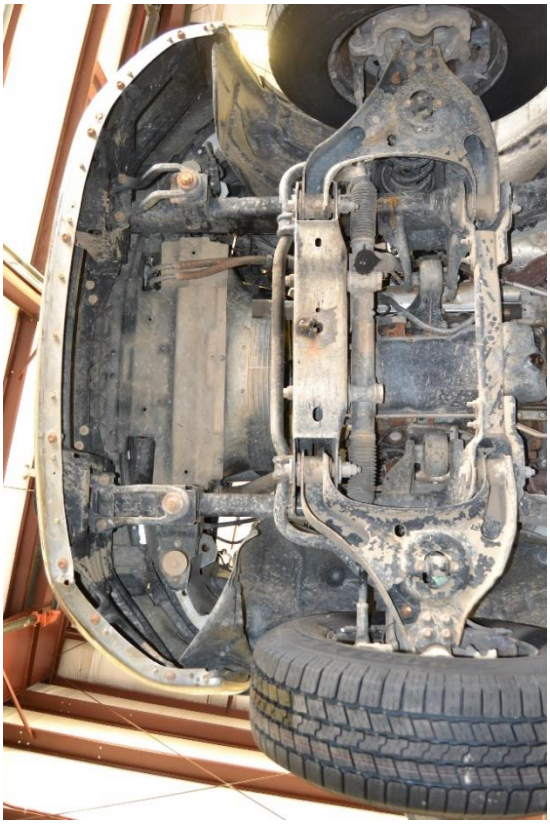
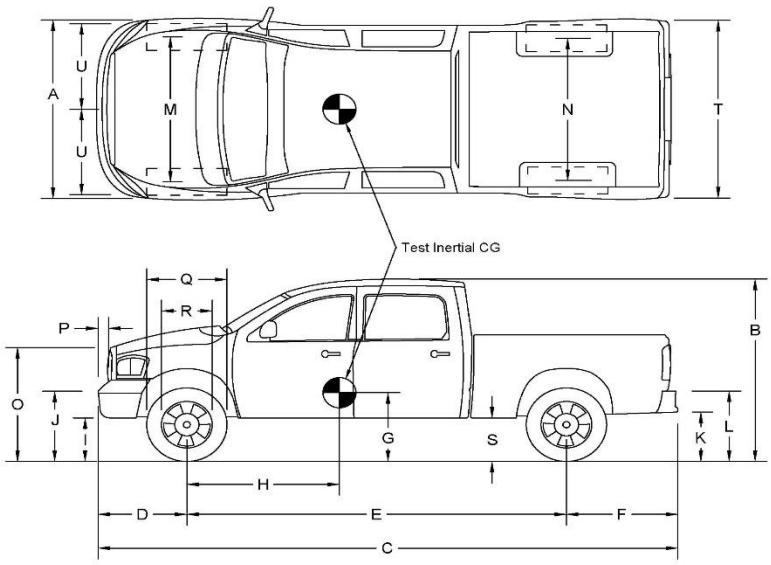


Figure 48. Test Vehicle's Interior Floorboards and Undercarriage, Test No. NYBWT-3

Date:	7/23/2018	**Test Name:**	NYBWT-3	**VIN No:**	1C6RD6FPCS205397
Year:	2012	**Make:**	Dodge	**Model:**	Ram 1500
Tire Size:	P265/70R17	**Tire Inflation Pressure:**	40 Psi	**Odometer:**	210585



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

A:	77 1/4 (1962) 78±2 (1950±50)	**B:**	74 1/4 (1886)
C:	229 3/8 (5826) 237±13 (6020±325)	**D:**	37 1/2 (953) 39±3 (1000±75)
E:	140 1/4 (3562) 148±12 (3760±300)	**F:**	47 3/8 (1203)
G:	28 3/8 (721) min: 28 (710)	**H:**	60 3/4 (1543) 63±4 (1575±100)
I:	12 (305)	**J:**	25 1/8 (638)
K:	21 (533)	**L:**	30 (762)
M:	67 3/8 (1711) 67±1.5 (1700±38)	**N:**	67 3/4 (1721) 67±1.5 (1700±38)
O:	44 1/4 (1124) 43±4 (1100±75)	**P:**	4 7/8 (124)
Q:	30 7/8 (784)	**R:**	18 1/4 (464)
S:	15 1/8 (384)	**T:**	77 (1956)
U (impact width):	75 (1905)		

Mass Distribution lb (kg)

Gross Static	**LF**	1487 (674)	**RF**	1445 (655)
	LR	1107 (502)	**RR**	1126 (511)

Weights lb (kg)	**Curb**	**Test Inertial**	**Gross Static**
W-front	2907 (1319)	2838 (1287)	2932 (1330)
W-rear	2244 (1018)	2168 (983)	2233 (1013)
W-total	5151 (2336)	5006 (2271) 5000±110 (2270±50)	5165 (2343) 5165±110 (2343±50)

GVWR Ratings lb

Front	3700
Rear	3900
Total	6700

Surrogate Occupant Data

Type:	Hybrid II
Mass:	159 lb
Seat Position:	Front Left

Wheel Center Height (Front):	15 (381)
Wheel Center Height (Rear):	15 1/4 (387)
Wheel Well Clearance (Front):	35 1/4 (895)
Wheel Well Clearance (Rear):	38 3/8 (975)
Bottom Frame Height (Front):	21 3/4 (552)
Bottom Frame Height (Rear):	9 3/4 (248)
Engine Type:	Gasoline
Engine Size:	4.7L V8
Transmission Type:	Automatic
Drive Type:	RWD
Cab Style:	Quad Cab
Bed Length:	67"

Note any damage prior to test: mage on the tail gate and driver mirror area. Also, the driver mirror cover has been cracked off

Figure 49. Vehicle Dimensions, Test No. NYBWT-3

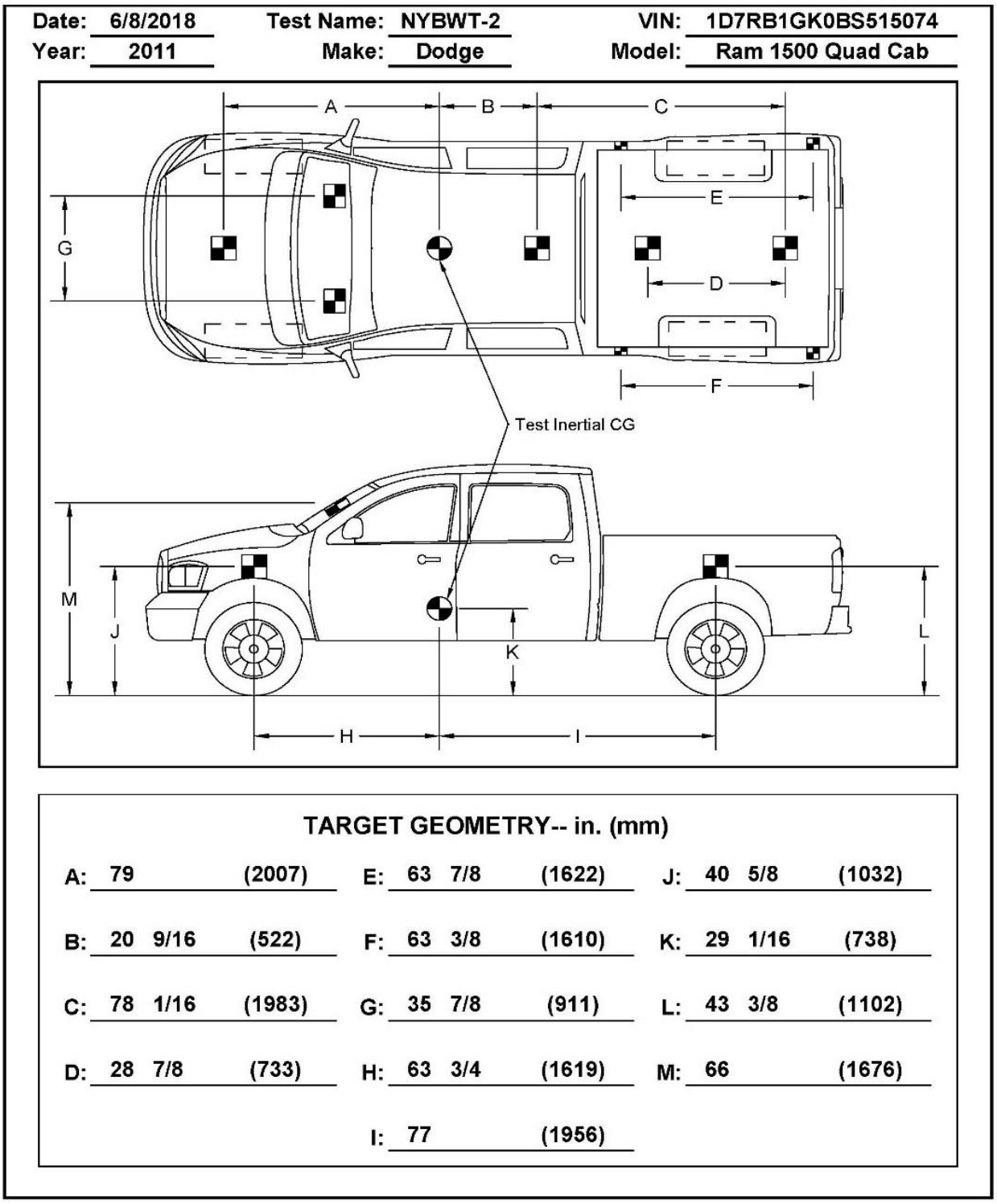


Figure 50. Target Geometry, Test No. NYBWT-2

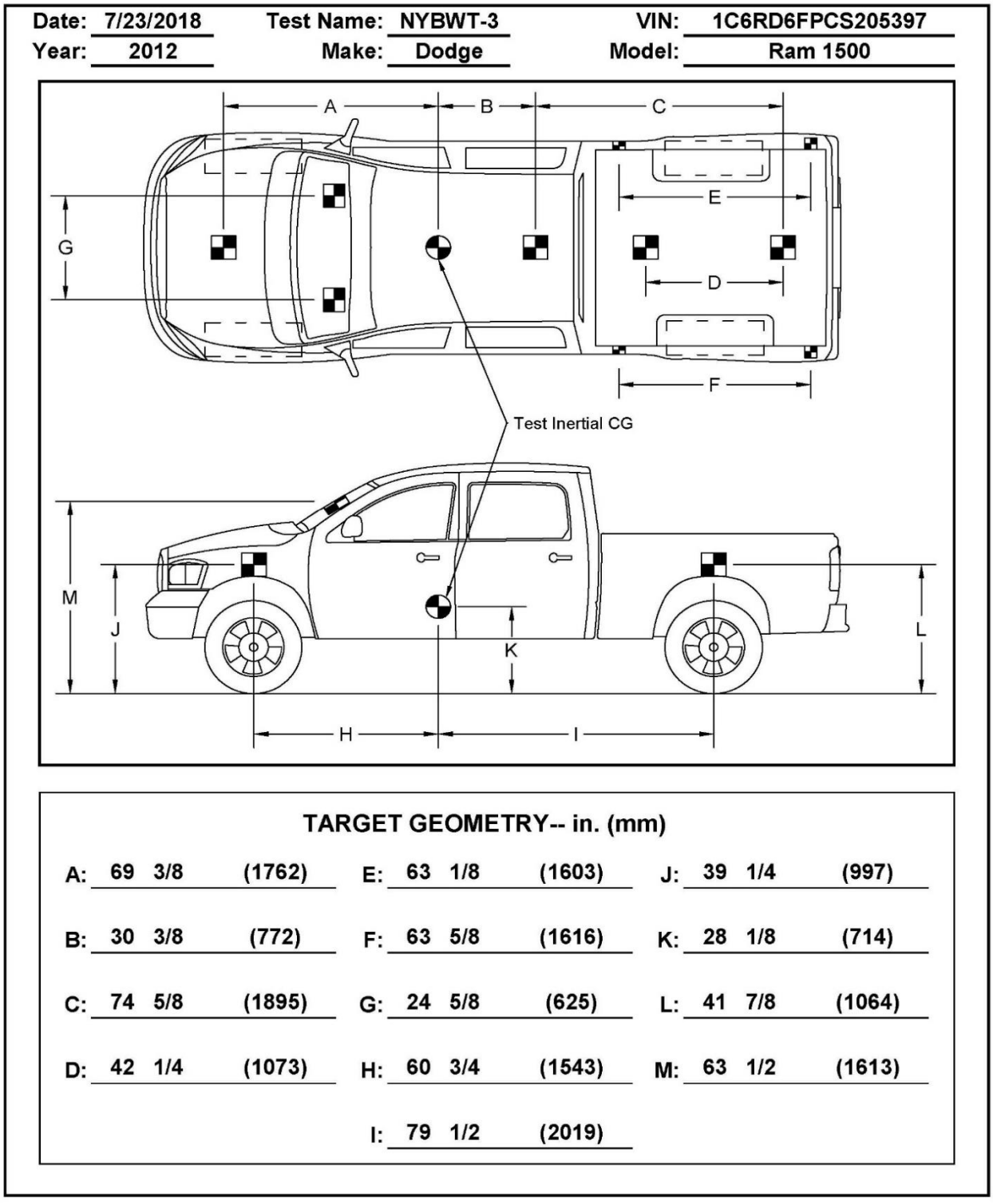


Figure 51. Target Geometry, Test No. NYBWT-3

4.4 Simulated Occupant

For test no. NYBWT-2 and NYBWT-3, a Hybrid II 50th-Percentile, Adult Male Dummy equipped with footwear was placed in the right-front and left-front seats of the test vehicles, respectively, with the seat belt fastened. The simulated occupant had a final weight of 170 lb (77 kg) and 159 lb (72 kg) for test nos. NYBWT-2 and NYBWT-3, respectively. As recommended by MASH 2016, the dummy 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 vehicles. 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 [12].

The two accelerometer 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 for both tests. The acceleration sensors were mounted inside the bodies of a 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 vehicles. 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.

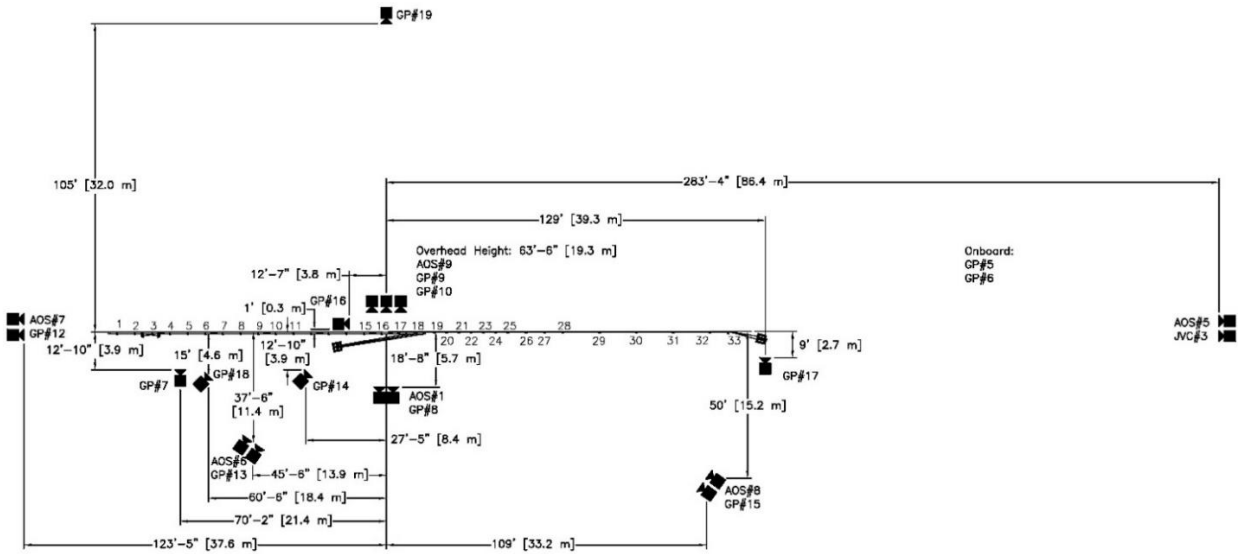
4.5.3 Retroreflective Optic Speed Trap

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

Six AOS high-speed digital video cameras, fourteen GoPro digital video cameras, and one JVC digital video camera were utilized to film test no. NYBWT-2. Five AOS high-speed digital video cameras, twelve GoPro digital video cameras and two Panasonic cameras were utilized to film test no. NYBWT-3. Camera details, camera operating speeds, lens information, and a schematic of the camera locations relative to the system for each test are shown in Figures 52 and 53. Note that GoPro nos. 18 and 8 did not collect data during test nos. NYBWT-2 and NYBWT-3, respectively, due to technical difficulties.

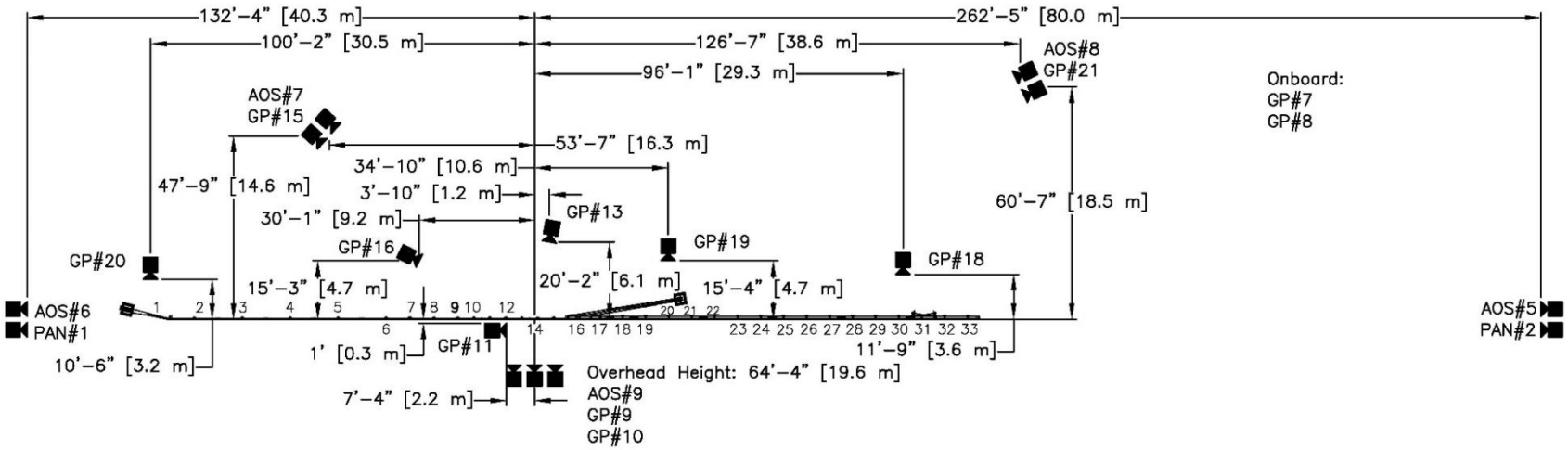
The high-speed videos were analyzed using TEMA Motion and Redlake MotionScope software programs. Actual camera speed and camera divergence factors were considered in the analysis of the high-speed videos. A digital still camera was also used to document pre- and post-test conditions for all tests.



No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
AOS-1	AOS Vitcam CTM	500	Kowa 16mm Fixed	-
AOS-5	AOS X-PRI Gigabit	500	100mm Fixed	-
AOS-6	AOS X-PRI Gigabit	500	Cosmicar 50mm fixed	-
AOS-7	AOS X-PRI Gigabit	500	Fujinon 50mm Fixed	-
AOS-8	AOS S-VIT 1531	500	Fujinon 75mm Fixed	-
AOS-9	AOS TRI-VIT 2236	1000	Kowa 12mm Fixed	-
GP-5	GoPro Hero 3+	120		
GP-6	GoPro Hero 3+	120		
GP-7	GoPro Hero 4	30		
GP-8	GoPro Hero 4	240		
GP-9	GoPro Hero 4	240		
GP-10	GoPro Hero 4	120		
GP-12	GoPro Hero 4	120		
GP-13	GoPro Hero 4	240		
GP-14	GoPro Hero 4	120		
GP-15	GoPro Hero 4	240		
GP-16	GoPro Hero 4	120		
GP-17	GoPro Hero 4	240		
GP-18*	GoPro Hero 6	No View		
GP-19	GoPro Hero 6	120		
JVC-3	JVC – GZ-MC500 (Everio)	30		

*Camera did not record impact event due to technical difficulties.

Figure 52. Camera Locations, Speeds, and Lens Settings, Test No. NYBWT-2



No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
AOS-5	AOS X-PRI Gigabit	500	100mm Fixed	-
AOS-6	AOS X-PRI Gigabit	500	Cosmicar 50mm fixed	-
AOS-7	AOS X-PRI Gigabit	500	Fujinon 50mm Fixed	-
AOS-8	AOS S-VIT 1531	500	Fujinon 75mm Fixed	-
AOS-9	AOS TRI-VIT 2236	1000	Kowa 12mm Fixed	-
GP-7	GoPro Hero 4	30		
GP-8*	GoPro Hero 4	No View		
GP-9	GoPro Hero 4	240		
GP-10	GoPro Hero 4	120		
GP-11	GoPro Hero 4	240		
GP-13	GoPro Hero 4	240		
GP-15	GoPro Hero 4	240		
GP-16	GoPro Hero 4	120		
GP-18	GoPro Hero 6	120		
GP-19	GoPro Hero 6	120		
GP-20	GoPro Hero 6	120		
GP-21	GoPro Hero 6	120		
PAN-1	Panasonic	120		
PAN-2	Panasonic	120		

*Camera did not record impact event due to technical difficulties.

Figure 53. Camera Locations, Speeds, and Lens Settings, Test No. NYBWT-3

5 FULL-SCALE CRASH TEST NO. NYBWT-2

5.1 Static Soil Test

Before full-scale crash test no. NYBWT-2 was conducted, the strength of the foundation soil was evaluated with a static test, as described in MASH 2016 [3]. 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. NYBWT-2 was conducted on June 8, 2018 at approximately 11:45 a.m. The weather conditions as per the National Oceanic and Atmospheric Administration (station 14939/KLNK) were reported and are shown in Table 3.

Table 3. Weather Conditions, Test No. NYBWT-2

Temperature	87° F
Humidity	51%
Wind Speed	9.1 mph
Wind Direction	Variable
Sky Conditions	Sunny
Visibility	10 Statute Miles
Pavement Surface	Dry
Previous 3-Day Precipitation	0.00 in.
Previous 7-Day Precipitation	1.25 in.

5.3 Test Description

Typically, impact points are selected in accordance with Figure 2-17 of MASH 2016 [3] unless computer simulation or analysis indicates that a different impact point is more critical for analyzing system performance. MASH 2016 requires that the upstream end of the stiffer system be used for selecting the impact point. The box beam stiffness was calculated to be M_p = 35.4 kip-ft, compared to the nested W-beam system stiffness of M_p = 16 kip-ft. The nested W-beam overlapped the box beam for approximately 12 ft (3.7 m). Tensile and shear connection between the W-beam and the box beam was accomplished through three sets of three bolts and nuts spaced at 36-in. (914-mm) intervals in the overlap. Therefore, the transition consisted of three consecutive stiffness regions: (1) box beam with 6-ft (1.8-m) post spacing; (2) box beam plus nested W-beam with 6-ft (1.8-m) post spacing; and (3) nested W-beam with 50-in. (1,270-mm) post spacing. Using Figure 2-17 from MASH, the CIP reference distance was approximately 11½ ft (3.5 m) for an impact in the direction of box beam to W-beam.

The upstream end of the W-beam was shielded with a 12-gauge transition cover piece to mitigate potential snag with the nested W-beam. This transition cover piece was connected to the box beam with a single bolt, connected to the upstream end of the nested W-beam section with four bolts, and was shaped to very closely match the external surface of the box beam, as shown

in Figure 43. The transition cover piece connection was weak and when under significant loading, could release from the box beam and expose the upstream end of the nested W-beam. Therefore, the transition cover piece was not included in the calculation of the critical stiffness point, and the upstream end of the nested W-beam was selected as the critical reference point. The critical impact point for test no. NYBWT-2 was selected to be approximately 11½ ft (3.5 m) upstream from the upstream end of the nested W-beam, which resulted in an effective impact location 8 ft (2.4 m) from the upstream end of the transition cover piece, as shown in Figure 54. This also provided a critical evaluation of the snag potential and strength of the transition cover plate. This impact point was selected in discussions with NYSDOT.

The 4,969-lb (2,254-kg) quad cab pickup truck impacted the box beam to weak-post W-beam transition at a speed of 63.5 mph (102.2 km/h) and at an angle of 25.1 degrees. The actual point of impact was 8 ft ─ 5 in. (2.6 m) upstream from the leading edge of the transition cover piece. The vehicle came to rest 171 ft (52.1 m) downstream from the impact point and 1 ft ─ 6 in. (0.5 m) laterally in front of the system after brakes were applied.

A detailed description of the sequential impact events is contained in Table 4, with movement definitions provided in Appendix E. Sequential photographs are shown in Figures 55 and 56. Documentary photographs of the crash test are shown in Figures 57 through 63. The vehicle trajectory and final position are shown in Figure 64.

Figure 54. Impact Location, Test No. NYBWT-2

Table 4. Sequential Description of Impact Events, Test No. NYBWT-2

Time (sec)	Event
0.000	Vehicle's front bumper contacted rail 8 ft ─ 5 in. (2.6 m) upstream from leading edge of transition cover piece (between post nos. 15 and 16).
0.001	Vehicle's front bumper deformed.
0.010	Post no. 16 deflected backward, and vehicle's right-front tire contacted box beam.
0.014	Post no. 15 rotated backward.
0.016	Vehicle's right-front wheel rim contacted box beam.
0.022	Post nos. 14 and 16 rotated backward, and vehicle yawed away from system.
0.030	Post no. 13 deflected backward, and post no. 17 rotated backward.
0.036	Post no. 19 deflected forward.
0.044	Vehicle rolled toward system.
0.056	Post no. 18 rotated backward.
0.058	Post no. 19 deflected backward.
0.062	Post no. 16 rotated counterclockwise.
0.078	Vehicle's front bumper contacted transition cover.
0.080	Vehicle's right-front tire contacted post no. 16.
0.082	Post no. 16 bent downstream.
0.084	L-bracket at post no. 16 disengaged from box-beam connection bolt.
0.086	Post no. 12 deflected backward. Post no. 15 twisted clockwise.
0.102	Post no. 19 rotated backward.
0.106	Post no. 17 rotated counterclockwise, and post no. 14 deflected downstream.
0.114	L-bracket at post no. 17 disengaged from box-beam bolt connection.
0.118	Post no. 17 deflected downstream.
0.134	Post no. 18 rotated counterclockwise, and vehicle's front bumper contacted post no. 17.
0.140	Post no. 20 rotated backward.
0.150	L-bracket at post no. 18 disengaged from box-beam bolt connection.
0.156	Post no. 15 deflected upstream, and vehicle's right-front tire contacted post no. 17.
0.158	Post no. 17 bent downstream.
0.162	Post nos. 21 and 22 deflected backward.
0.178	Post no. 19 deflected downstream.
0.180	Rail disengaged from bolt at post no. 19.
0.194	Vehicle's left-front tire became airborne.
0.213	Vehicle's rear bumper contacted box beam.

Table 5. Sequential Description of Impact Events, Test No. NYBWT-2, Cont.

Time (sec)	Event
0.216	Vehicle's rear bumper deformed, and vehicle's right quarter panel contacted box beam.
0.222	Vehicle's right quarter panel deformed.
0.226	Post no. 18 bent downstream, and top portion of the right-front bumper tore below right-front headlight. Vehicle's right-front tire contacted post no. 18.
0.232	L-bracket at post no. 15 disengaged from box-beam bolt connection.
0.243	Vehicle was parallel to system at a speed of 52.0 mph (83.7 km/h).
0.250	Vehicle pitched downward.
0.260	Post no. 11 deflected backward.
0.272	Post no. 21 rotated backward.
0.294	Vehicle's left-rear tire became airborne.
0.304	Post no. 22 rotated backward. Vehicle's right headlight deformed, and vehicle's right-front tire contacted post no. 19 and deflated.
0.306	Post no. 20 bent backward.
0.310	Vehicle's right-front wheel rim contacted post no. 19.
0.312	Post no. 19 bent downstream, and vehicle's right headlight contacted rail.
0.320	Post no. 20 twisted counterclockwise.
0.324	Vehicle's right fender contacted rail.
0.330	Vehicle's right fender deformed.
0.346	Vehicle's hood deformed.
0.364	Vehicle's right-front tire contacted post no. 20.
0.366	Post no. 20 bent downstream.
0.394	Vehicle's right headlight contacted post no. 21.
0.408	Vehicle's right headlight shattered.
0.464	Vehicle's right-rear tire became airborne.
0.520	Vehicle's right-front door contacted rail.
0.584	Rail disengaged from bolt at post no. 22.
0.702	Vehicle's right-front tire became airborne.
0.726	Vehicle exited system at a speed of 47.3 mph (76.1 km/h) and an angle of 13.6 degrees.
0.828	Vehicle's right-front tire regained contact with ground.
0.970	Vehicle pitched upward.
0.994	Vehicle's right-rear tire regained contact with ground.
1.014	Vehicle rolled away from system.

Table 6. Sequential Description of Impact Events, Test No. NYBWT-2, Cont.

Time (sec)	Event
1.192	Vehicle yawed toward system.
1.268	Vehicle's left-front tire regained contact with ground.
1.270	Vehicle's left-rear tire regained contact with ground.
1.304	Vehicle's right-front tire became airborne.
1.356	Vehicle's mostly detached portion of front bumper contacted ground.
1.418	Vehicle rolled toward system.
1.532	Vehicle pitched downward.
1.544	Vehicle's left-front tire became airborne.
1.632	Vehicle's left-rear tire became airborne.
1.646	Vehicle's right-front tire regained contact with ground.
1.754	Vehicle's right headlight disengaged.


0.000 sec


0.000 sec


0.062 sec


0.114 sec


0.106 sec


0.226


0.156 sec


0.408 sec


0.214 sec


0.726 sec


0.244 sec


1.268 sec

Figure 55. Sequential Photographs, Test No. NYBWT-2


0.000 sec


0.000 sec


0.106 sec


0.062 sec


0.140 sec


0.134 sec


0.272 sec


0.214 sec


0.364 sec


0.272 sec


0.520 sec


0.366 sec

Figure 56. Additional Sequential Photographs, Test No. NYBWT-2

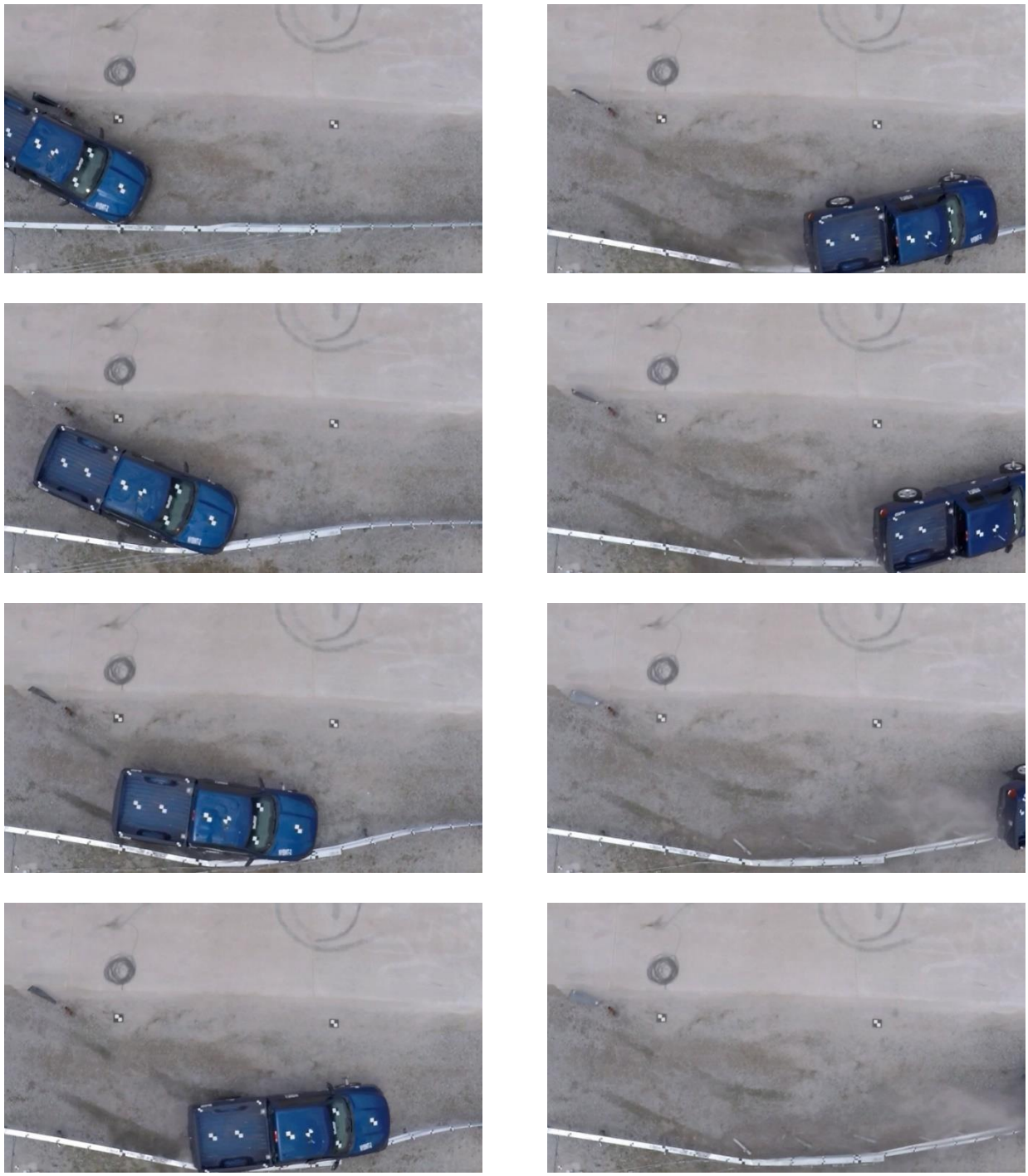


Figure 57. Documentary Photographs, Test No. NYBWT-2

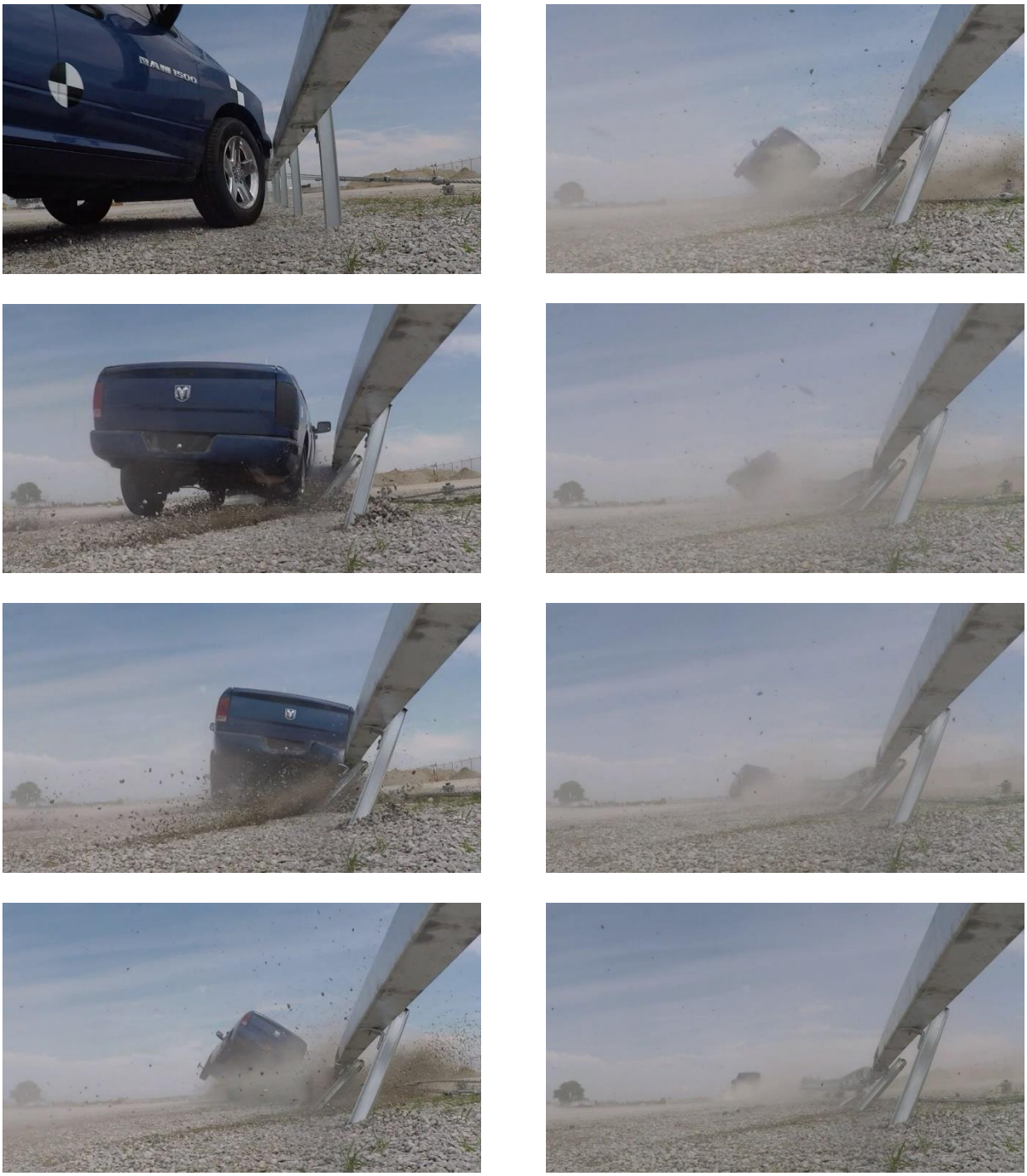


Figure 58. Documentary Photographs, Test No. NYBWT-2

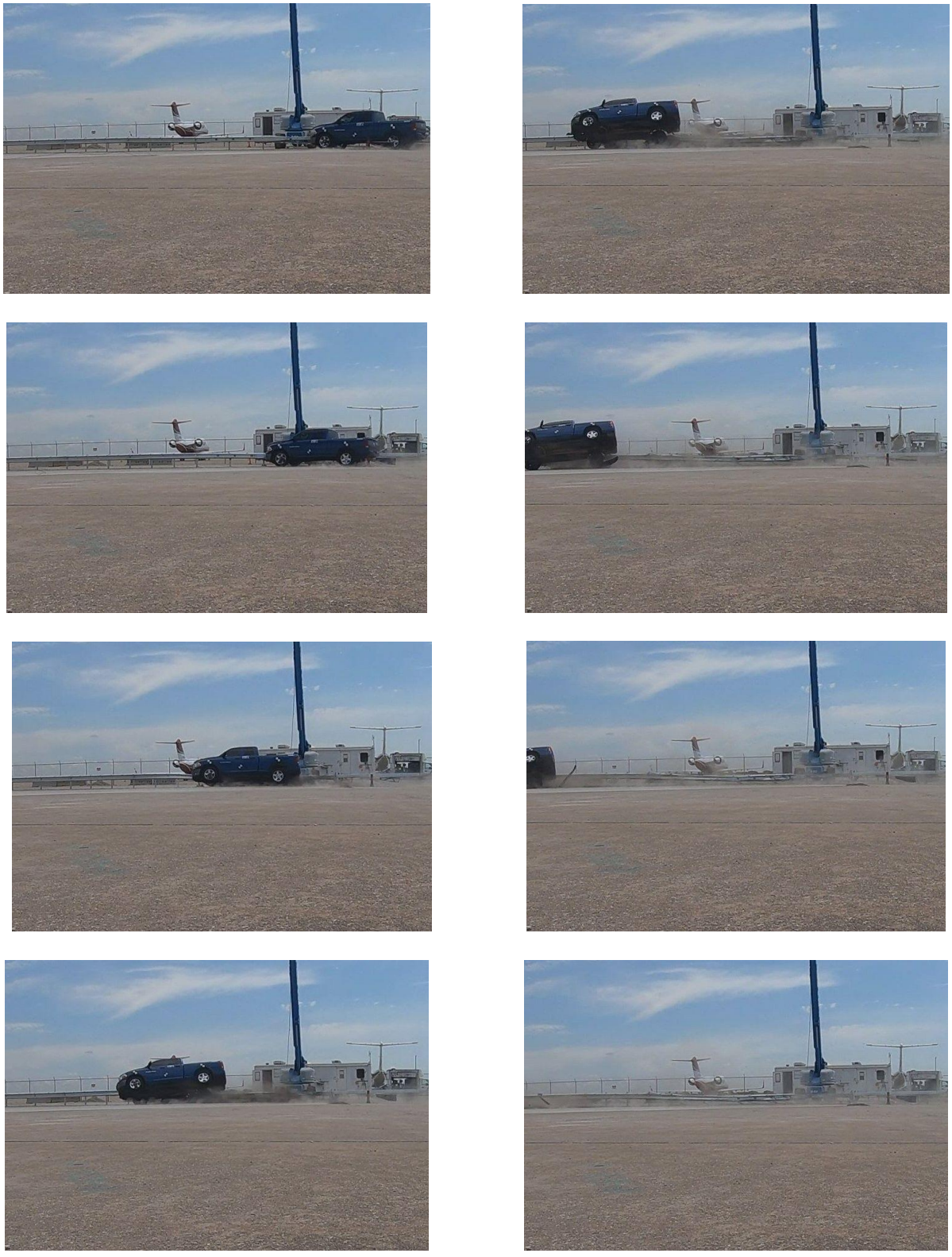


Figure 59. Documentary Photographs, Test No. NYBWT-2

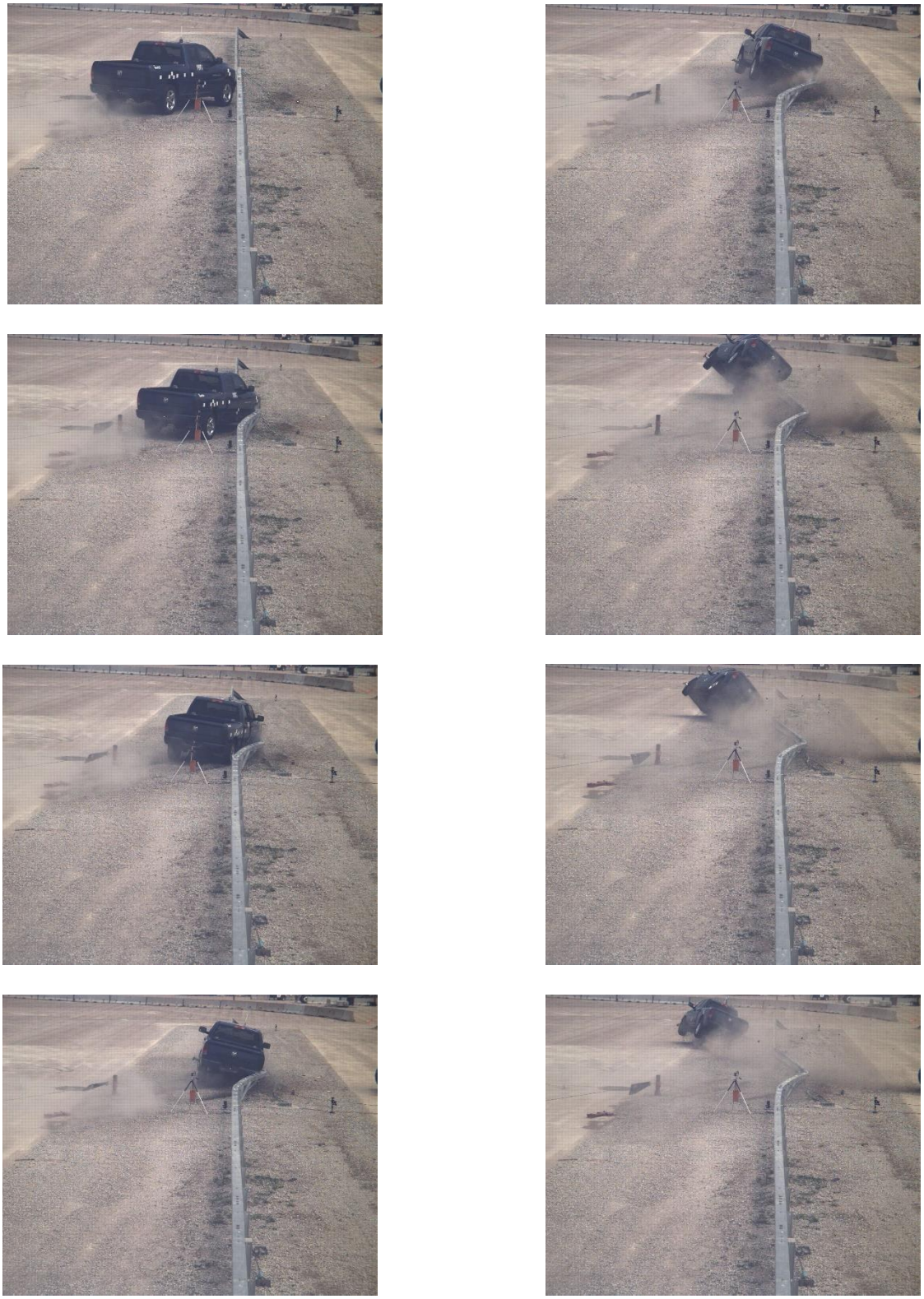


Figure 60. Documentary Photographs, Test No. NYBWT-2

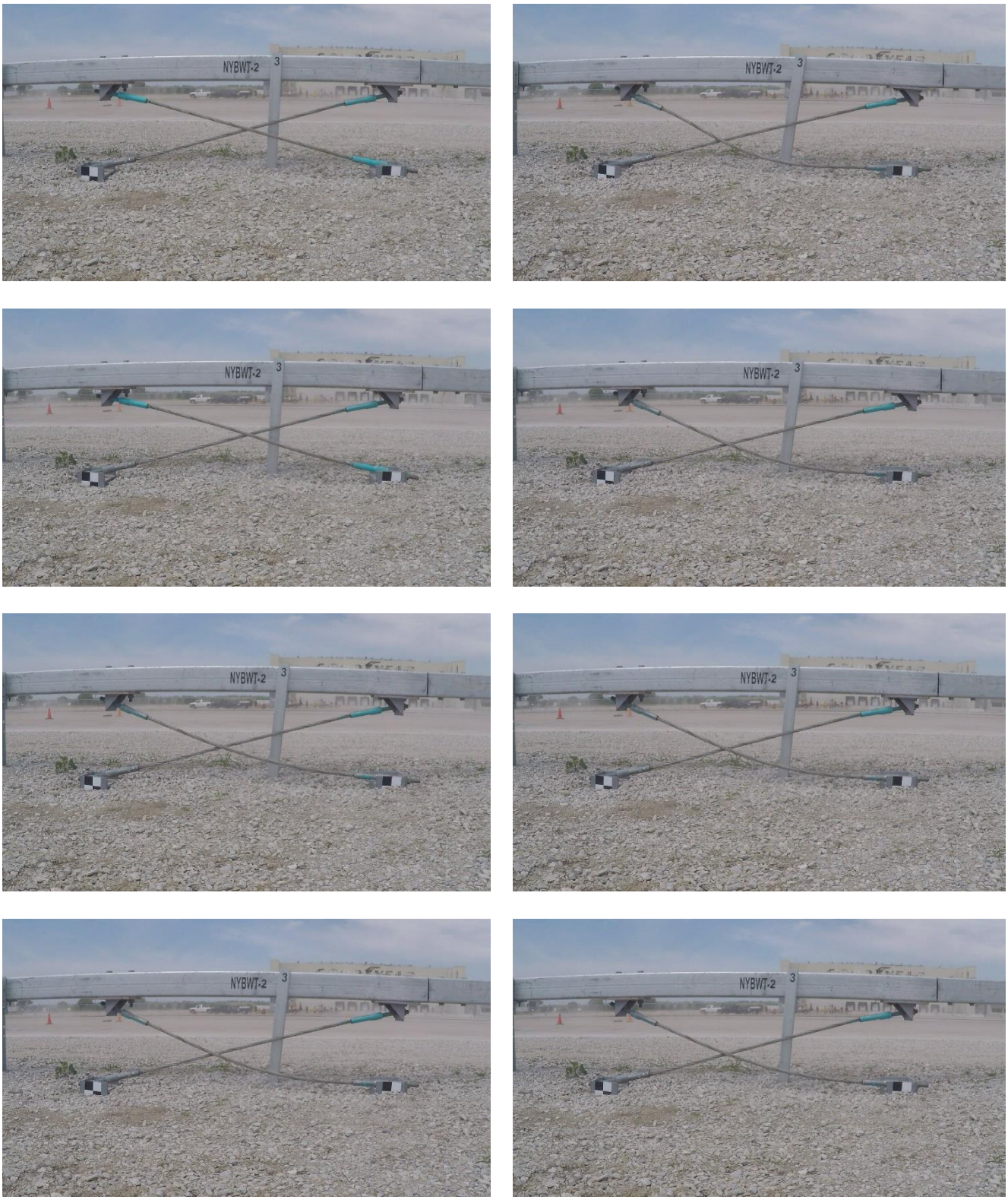


Figure 61. Documentary Photographs, Test No. NYBWT-2

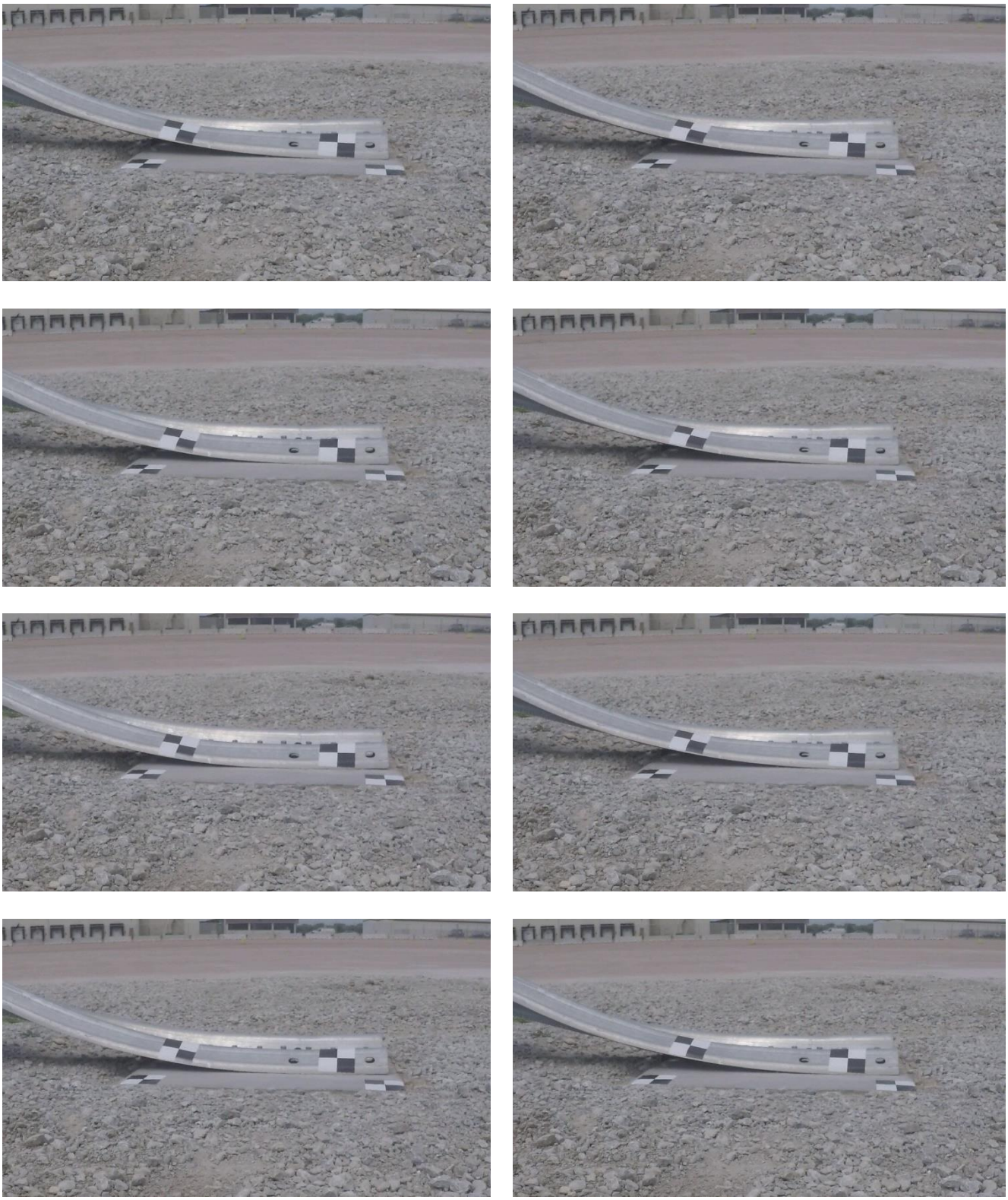


Figure 62. Documentary Photographs, Test No. NYBWT-2

Figure 63. Documentary Photographs, Test No. NYBWT-2

Figure 64. Vehicle Trajectory Marks and Final Position, Test No. NYBWT-2

5.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 65 through 74. Barrier damage consisted of rail deformation, deformed posts, and contact marks on the front faces of the box beam and W-beam rail.

Contact marks were found along the barrier beginning 7 in. (178 mm) upstream from the targeted impact point and ending 6½ in. (165 mm) downstream from the centerline of post no. 22. An outward bend 10 in. (254 mm) long by 4 in. (102 mm) high by 1 in. (25 mm) deep was located 24 in. (610 mm) upstream from post no. 17 on the bottom of the transition plate. A bend 12 in. (305 mm) long by 2 in. (51 mm) deep was found 16 in. upstream from post no. 17 on the bottom of the transition plate. Two smaller bends were found on the bottom and top edges of the rail. One smaller bend was found at the transition plate bolt hole near post no. 17. A 3½-in. (89-mm) long by ½-in. (13-mm) deep kink was found 18 in. (457 mm) upstream from post no. 17 on the top of the transition plate. A 4-in. (102-mm) long by 1½-in. (38-mm) high kink was found 2 in. (51 mm) downstream from post no. 21 on the top edge of the rail. Four other smaller kinks were found on the top and bottom edges of the rail. A 12-in. (305-mm) long tear was found starting 34 in. (864 mm) upstream from post no. 17 on the bottom edge of the transition plate. A 3-in. (76-mm) by ½-in. (13-mm) wide by ½-in. (13-mm) deep tear was found 14 in. (356 mm) upstream from post no. 17 on the front face of the transition plate. Flattening measuring 16 in. (406 mm) long by 6 in. (152 mm) high was found 10 in. (254 mm) upstream from post no. 22 on the top part of the rail.

Post nos. 3, 4, 12, and 13 rotated downstream. Post nos. 12 and 13 also rotated backward. Post nos. 1, 2 and 5 through 15 twisted clockwise. Post nos. 17, 18, 21, 22 twisted counterclockwise. Post nos. 14 through 22 were bent backward. Post nos. 16 through 20 were bent downstream. Post no. 33 bent upstream. The rail-to-bracket bolt pulled out from post nos. 15 through 18. The post-to-rail bolt pulled out from post nos. 19 and 22.

Small soil gaps were found at post nos. 11 through 15, 21, and 22. A 21-in. (533-mm) diameter by 1-in. (25-mm) high soil heave was found at post no. 14. A 19-in. (483-mm) diameter by 1-in. (25-mm) high soil heave was found at post no. 15. A 27-in. (686-mm) diameter by ¾-in. (19-mm) deep soil crater was found at post no. 16. Soil craters 18 in. (457 mm) diameter by 2 in. (51 mm) deep were found at post nos. 17 and 18. A 14-in. (356-mm) diameter by 1½-in. (38-mm) deep soil crater was found at post no. 19. A 16-in. (406-mm) diameter by 1-in. (25-mm) deep soil crater was found at post no. 20.

Figure 65. Overall System Damage, Test No. NYBWT-2

Figure 66. Overall System Damage, Test No. NYBWT-2

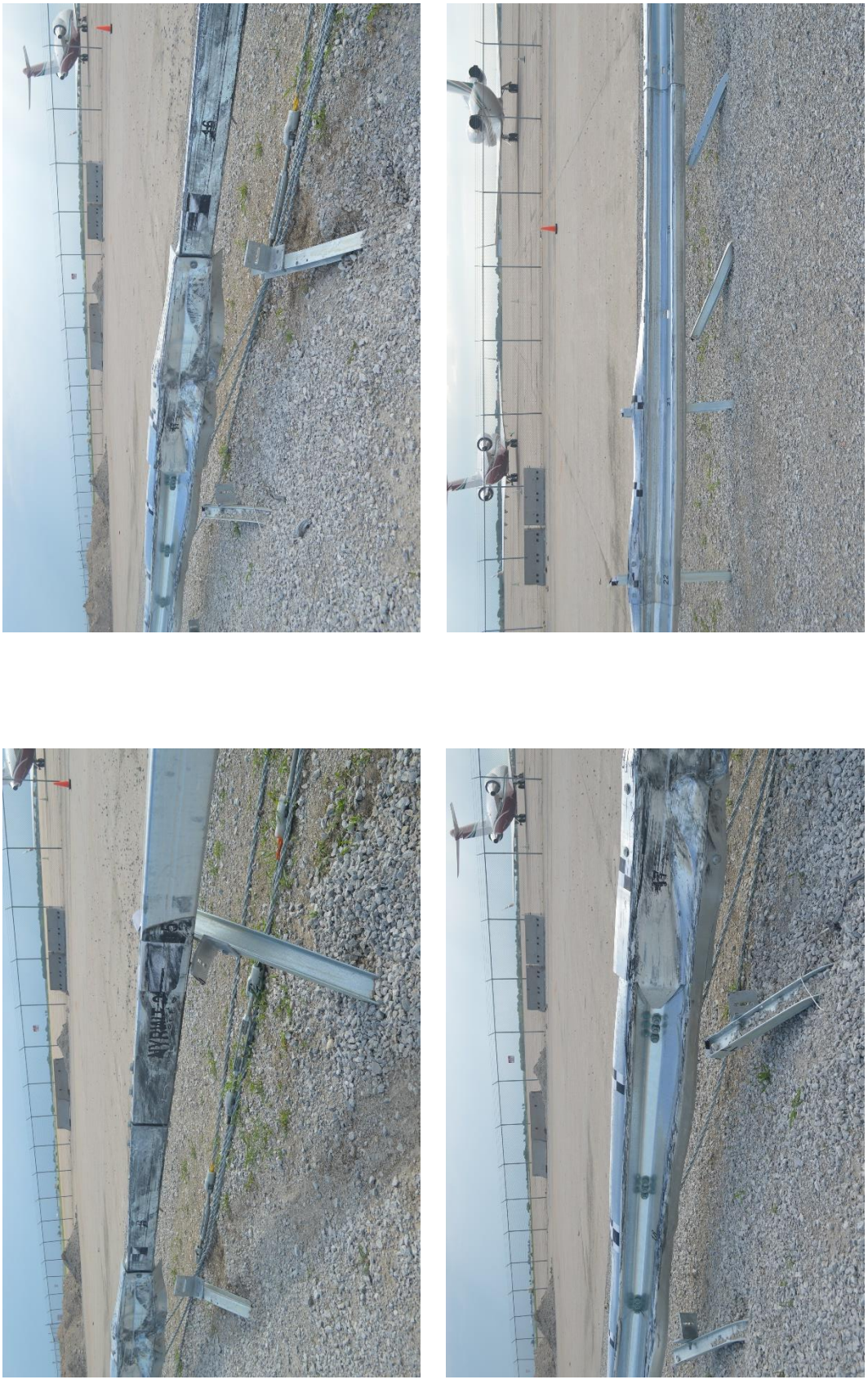


Figure 67. System Damage, Test No. NYBWT-2

Figure 68. Rail and Post Damage, Post Nos. 15 through 18, Test No. NYBWT-2

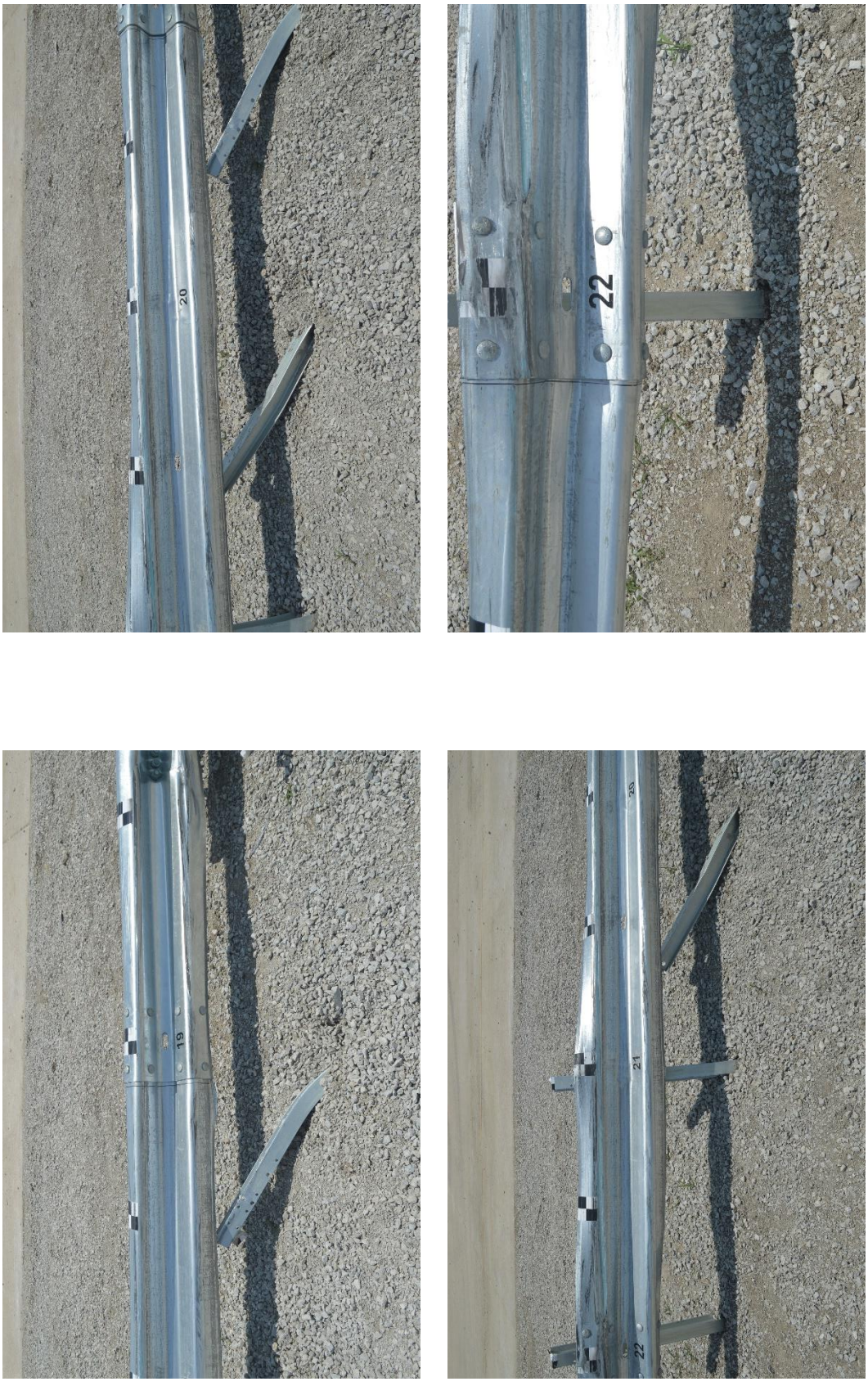


Figure 69. Rail and Post Damage, Post Nos. 19 through 22, Test No. NYBWT-2

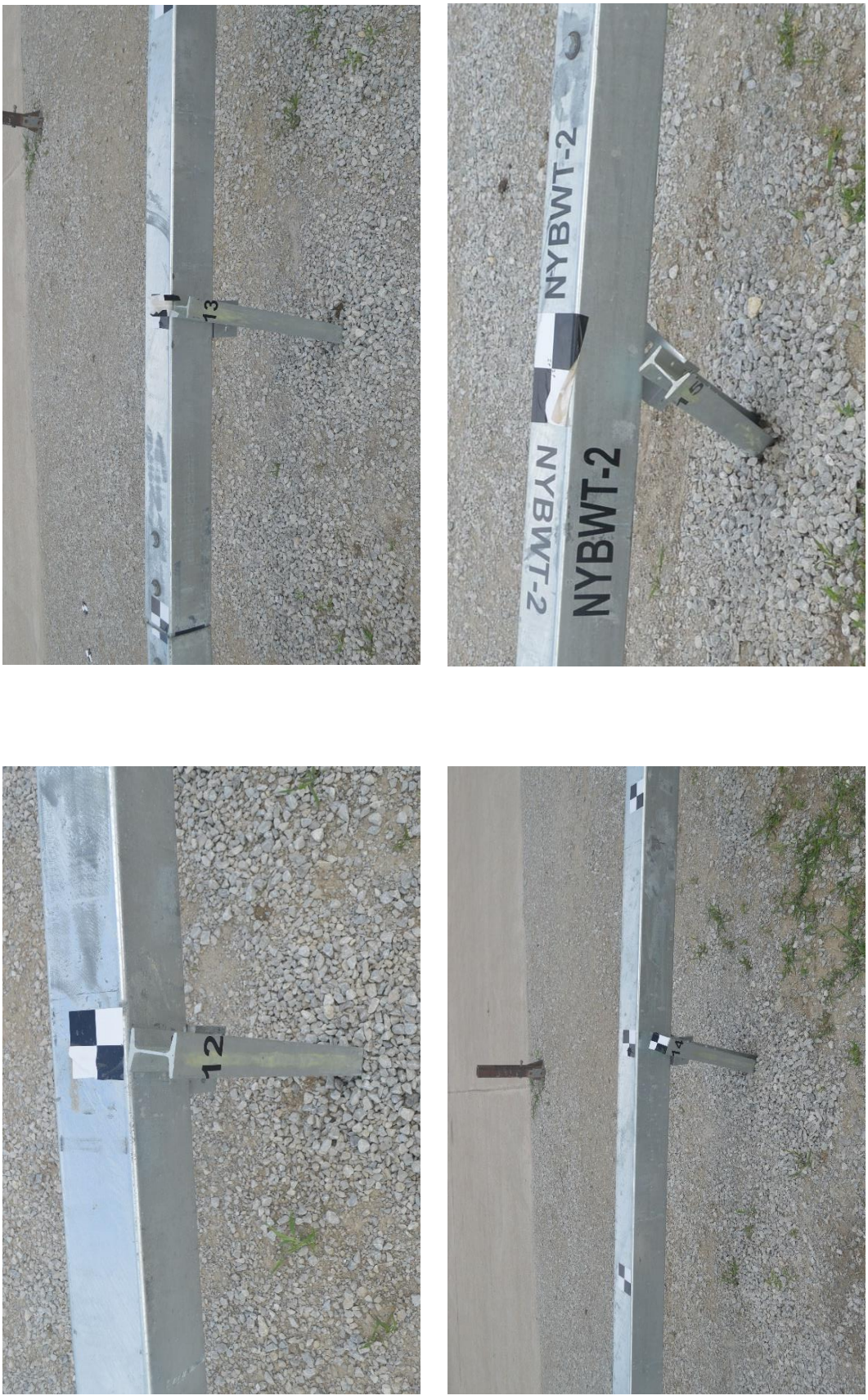


Figure 70. Backside Rail and Post Damage, Post Nos. 12 through 15, Test No. NYBWT-2

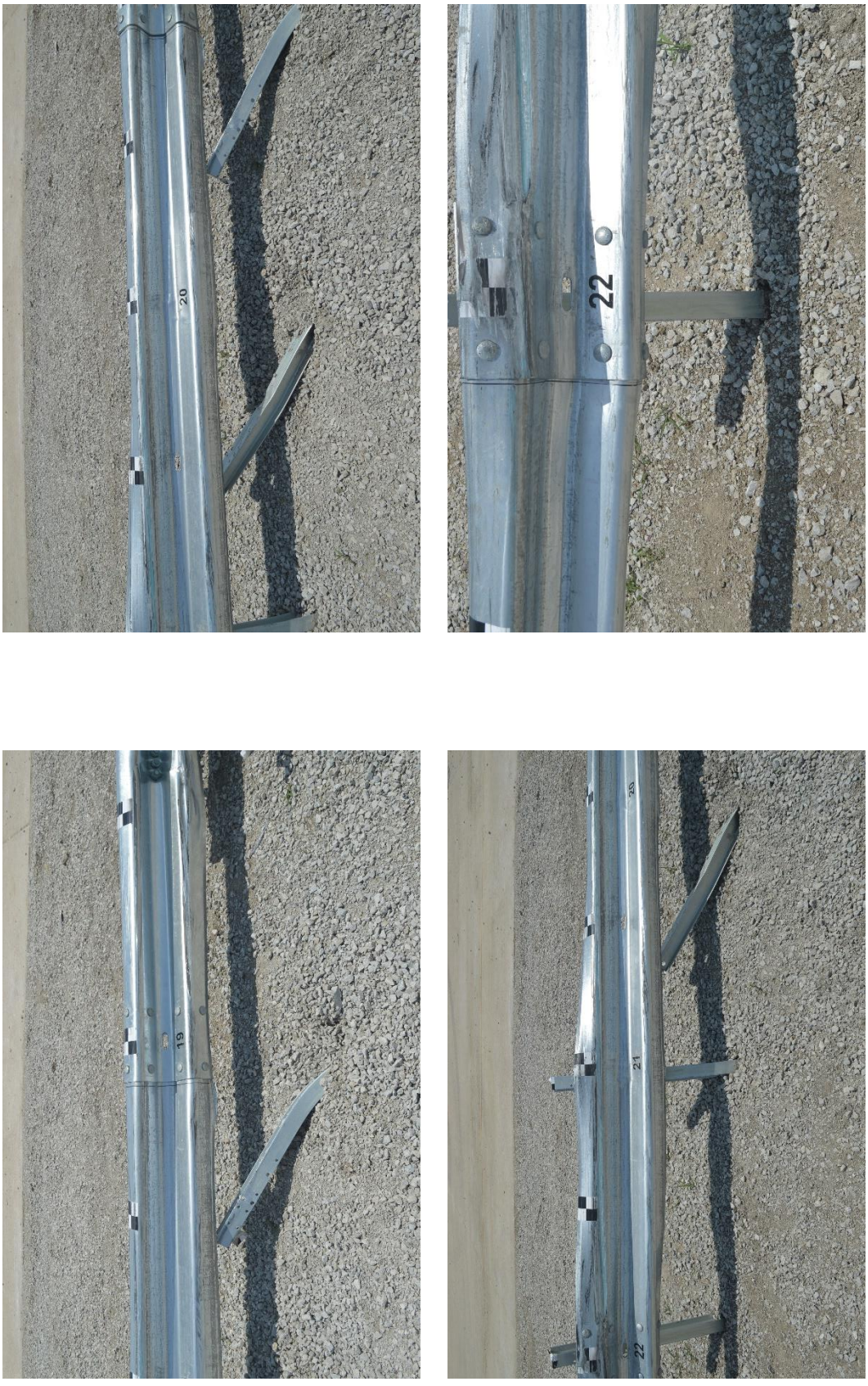


Figure 71. Rail and Post Damage, Post Nos. 19 through 22, Test No. NYBWT-2

Figure 72. Backside Rail and Post Damage, Post Nos. 16 through 19, Test No. NYBWT-2

Figure 73. Backside Rail and Post Damage, Post Nos. 20 through 23, Test No. NYBWT-2

Figure 74 Anchor Damage, Test No. NYBWT-2

The maximum lateral rail and post permanent set was 36½ in. (927 mm) at the rail at post no. 17 and 22⅞ in. (581 mm) at the centerline of post no. 15, as measured in the field, respectively. The maximum lateral dynamic rail and post deflections were 51.6 in. (1,311 mm) at the rail at post no. 17 and 29.0 in. (737 mm) at the centerline post no. 18, respectively. The maximum lateral dynamic deflection values were determined from high-speed digital video analysis. The working width of the system was found to be 63.3 in. (1,608 mm) due to vehicle protrusion over the top of the system, also determined from high-speed video analysis. A schematic of the permanent set, dynamic deflection, and working width is shown in Figure 75.

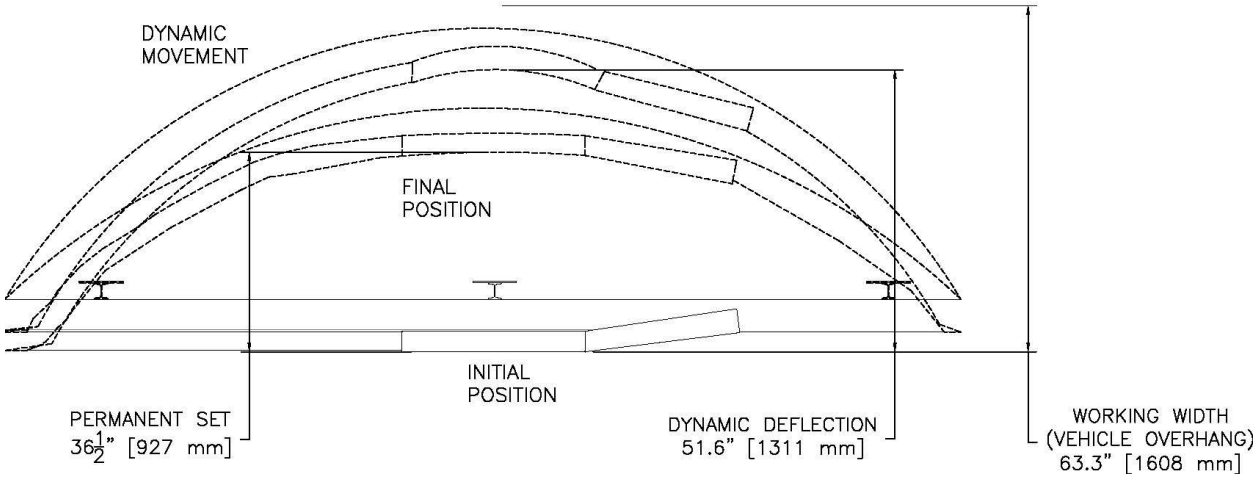


Figure 75. Permanent Set, Dynamic Deflection, and Working Width, Test No. NYBWT-2

5.5 Vehicle Damage

The damage to the vehicle was moderate, as shown in Figures 76 through 79. The maximum occupant compartment intrusion values are listed in Table 7 along with the intrusion limits established in MASH 2016 for various areas of the occupant compartment. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix F. MASH 2016 defines intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. There were no penetrations into the occupant compartment, and none of the established MASH 2016 deformation limits were violated. Outward deformations, which are denoted as negative numbers in Appendix F, are not considered crush toward the occupant, and are not evaluated by MASH 2016 criteria.

Majority of the damage was concentrated on the right-front corner and right side where the impact occurred. The right-side front bumper was bent inward and backward. The right-front quarter panel was bent up to the hood in front of the tire. Behind the tire, the right-front quarter panel was pushed backward and outward and contacted the tire. Scrapes were found along both the right-side doors and the right-rear quarter panel. A 1½-in. (38-mm) long puncture was found 1 in. (25 mm) from the front of the right-rear door. The right-rear quarter panel was peeled backward toward the bumper. The right-rear bumper was deformed outward and buckled upward due to contact with the right-rear quarter panel. The right-rear caliper and right-side headlight were disengaged. The right-side lower control arm bushings and the right-side tie rods were bent. The roof, windows, and left side remained undamaged.

Figure 76. Vehicle Damage, Test No. NYBWT-2

Figure 77. Vehicle Damage, Test No. NYBWT-2

Figure 78. Occupant Compartment Vehicle Damage, Test No. NYBWT-2

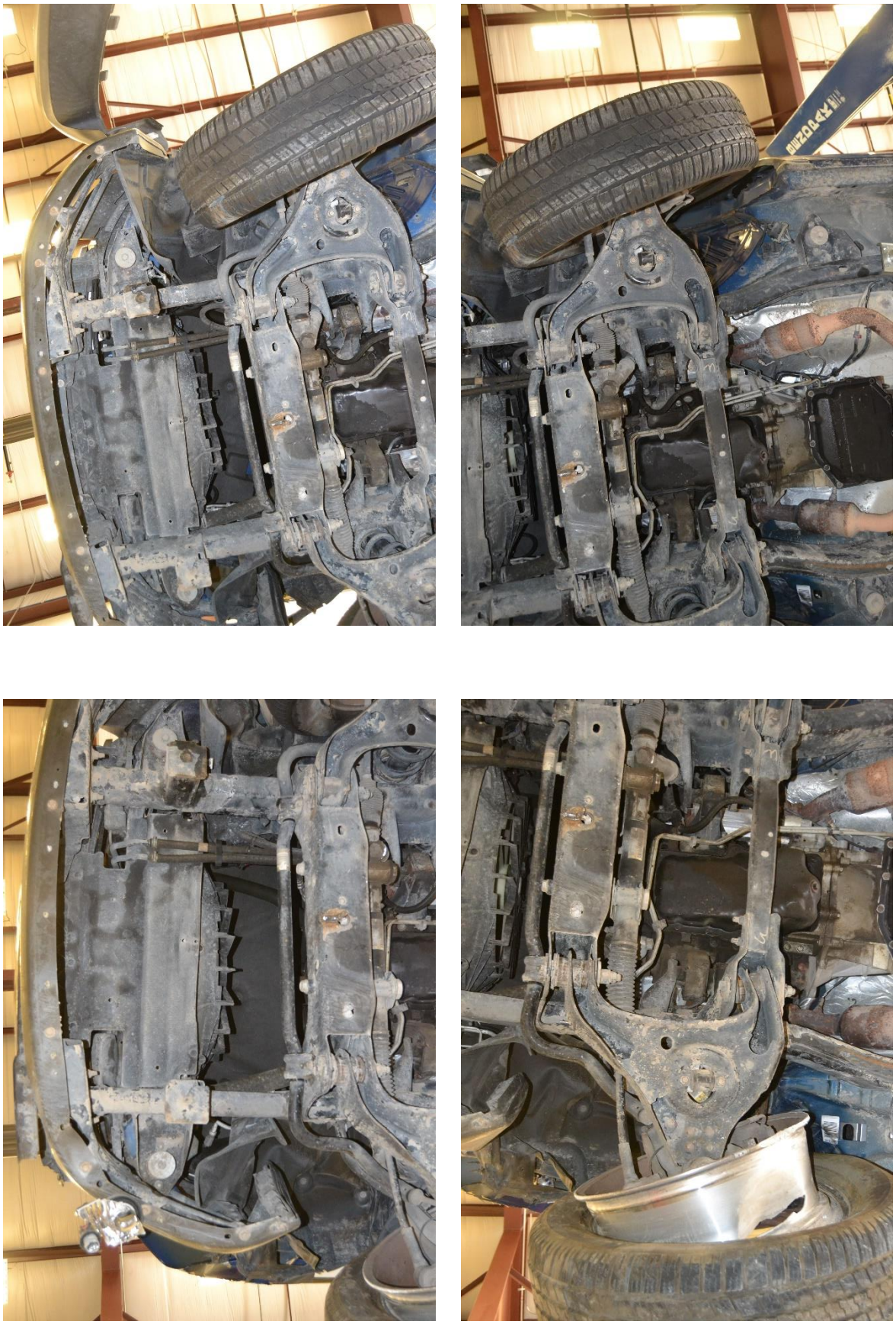


Figure 79. Undercarriage Vehicle Damage, Test No. NYBWT-2

Table 7. Maximum Occupant Compartment Intrusion by Location, Test No. NYBWT-2

Location	Maximum Intrusion in. (mm)	MASH 2016 Allowable Intrusion in. (mm)
Wheel Well & Toe Pan	0.5 (13)	≤ 9 (229)
Floor Pan & Transmission Tunnel	0.1 (3)	≤ 12 (305)
A-Pillar	0.3 (8)	≤ 5 (127)
A-Pillar (Lateral)	0 (0)*	≤ 3 (76)
B-Pillar	0.2 (5)	≤ 5 (127)
B-Pillar (Lateral)	0 (0)*	≤ 3 (76)
Side Front Panel (in Front of A-Pillar)	0.3 (8)	≤ 12 (305)
Side Door (Above Seat)	0.1 (3)	≤ 9 (229)
Side Door (Below Seat)	0.1 (3)	≤ 12 (305)
Roof	0.1 (3)	≤ 4 (102)
Windshield	0.0 (0)	≤ 3 (76)
Side Window	Intact	No shattering resulting from contact with structural member of test article
Dash	0.4 (10)	N/A

N/A – Not applicable
*Negative value reported as 0. See Appendix F for further information.

5.6 Occupant Risk

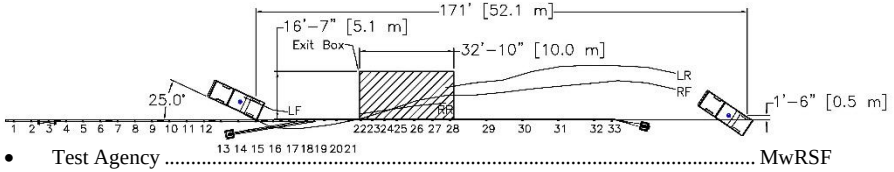
The calculated occupant impact velocities (OIVs) and maximum 0.010-sec average occupant ride down accelerations (ORAs) in both the longitudinal and lateral directions, as determined from the accelerometer data, are shown in Table 8. Note that the OIVs and ORAs were within suggested limits, as provided in MASH 2016. The calculated THIV, PHD, and ASI values are also shown in Table 8. The recorded data from the accelerometers and the rate transducers are shown graphically in Appendix G.

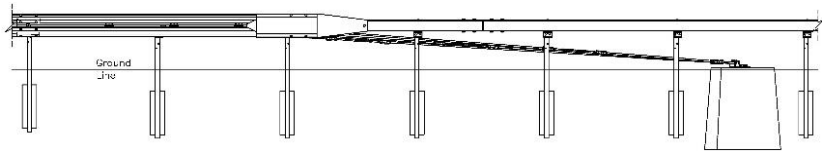
Table 8. Summary of OIV, ORA, THIV, PHD, and ASI Values, Test No. NYBWT-2

Evaluation Criteria		Transducer		MASH 2016 Limits
		SLICE-1	SLICE-2 (primary)	
OIV ft/s (m/s)	Longitudinal	-13.59 (-4.14)	-12.67 (-3.86)	±40 (12.2)
	Lateral	-15.00 (-4.57)	-14.74 (-4.49)	±40 (12.2)
ORA g's	Longitudinal	-6.36	-7.37	±20.49
	Lateral	-8.57	-6.93	±20.49
Maximum Angular Displacement deg.	Roll	48.4	44.0	±75
	Pitch	8.0	6.8	±75
	Yaw	-46.5	-46.1	not required
THIV ft/s (m/s)		18.22 (5.55)	18.29 (5.57)	not required
PHD g's		9.79	9.34	not required
ASI		0.64	0.57	not required

5.7 Discussion

The analysis of the test results for test no. NYBWT-2 showed that the system adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier. A summary of the test results and sequential photographs are shown in Figure 80. Detached elements, fragments, or other debris from the test article did not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or work-zone personnel. Deformations of, or intrusions into, the occupant compartment that could have caused serious injury did not occur. The test vehicle did not penetrate or ride over the barrier and remained upright during and after the collision. Vehicle roll, pitch, and yaw angular displacements, as shown in Appendix G, were deemed acceptable because they did not adversely influence occupant risk nor cause rollover. After impact, the vehicle exited the barrier at an angle of 13.6 degrees, and its trajectory did not violate the bounds of the exit box. Therefore, test no. NYBWT-2 was determined to be acceptable according to the MASH 2016 safety performance criteria for test designation no. 3-21.





- Test Agency ..... MwRSF
- Test Number..... NYBWT-2
- Date 06/08/18
- MASH 2016 Test Designation No..... 3-21
- Test Article..... NYSDOT Box Beam to Weak-Post W-Beam Transition
- Total Length ..... 224 ft – 1¾ in. (68.3 m)
- Key Component – W-Beam Rail
  - Thickness..... 12 gauge (2.6 mm)
  - Mounting Height..... 32 in. (813 mm)
- Key Component – Box Beam
  - Size..... 6 in. x 6 in. x $^{3}/_{16}$ in. (152 mm x 152 mm x 5 mm)
  - Mounting Height..... 27 in. (686 mm)
- Key Component – S3x5.7 (S75x8.5) Steel Posts (nos. 1-33)
  - Size..... 65 in. (1,651 mm) long
  - Embedment Depth (Post nos. 1-12)..... $37^{15}/_{16}$ in. (963 mm)
  - Embedment Depth (Post nos. 13-19)..... 34⅝ in. (879 mm)
  - Embedment Depth (Post nos. 20-33)..... 32⅝ in. (829 mm)
  - Spacing (Post nos. 13-19)..... 72 in. (1,829 mm)
  - Spacing (Post nos. 19-25)..... 50 in. (1,270 mm)
  - Spacing (Post nos. 25-28)..... 75 in. (1,905 mm)
  - Spacing (Post nos. 28-32)..... 150 in. (3,810 mm)
  - Material ..... ASTM A36
- Key Component – Anchors
  - Embedment Depth (Downstream and Transition Anchors)..... 44 in. (1,118 mm)
  - Embedment Depth (Upstream Anchor) ..... 70⅜ in. (1,788 mm)
  - Material (Downstream and Transition Anchors)..... Concrete
  - Material (Upstream Anchor)..... ASTM A992 or ASTM A572 Gr. 50
- Soil Type ..... Coarse, Crushed Limestone (Well-Graded Gravel)
- Vehicle Make /Model ..... 2011 Dodge Ram 1500 Quad Cab Pickup Truck
  - Curb..... 4,931 lb (2,237 kg)
  - Test Inertial ..... 4,969 lb (2,254 kg)
  - Gross Static ..... 5,139 lb (2,331 kg)
- Impact Conditions
  - Speed..... 63.5 mph (102.2 km/h)
  - Angle..... 25.1 deg.
  - Impact Location .....8 ft – 5 in. (2.6 m) US from leading edge of transition cover piece
- Impact Severity ..... 119.7 kip-ft (162.3 kJ) ≥ 106 kip-ft (144 kJ) MASH 2016 Limit
- Exit Conditions
  - Speed..... 47.3 mph (76.1 km/h)
  - Angle ..... 13.6 deg.
- Exit Box Criterion..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance .. 171 ft (52.1 m) downstream, 18 in. (457 mm) laterally in front
- Vehicle Damage ..... Moderate
  - VDS [13] 1-FR-5
  - CDC [14]..... 01-FREK-3
  - Maximum Interior Deformation..... 0.5 in. (13 mm)
- Test Article Damage..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 36½ in. (927 mm)
  - Dynamic..... 51.6 in. (1311 mm)
  - Working Width ..... 63.3 in. (1,608 mm)
- Transducer Data

Evaluation Criteria		Transducer		MASH 2016 Limit
		SLICE-1	SLICE-2 (primary)	
OIV ft/s (m/s)	Longitudinal	-13.59 (-4.14)	-12.67 (-3.86)	±40 (12.2)
	Lateral	-15.00 (-4.57)	-14.74 (-4.49)	±40 (12.2)
ORA g's	Longitudinal	-6.36	-7.37	±20.49
	Lateral	-8.57	-6.93	±20.49
Maximum Angular Displacement deg.	Roll	48.4	44.0	±75
	Pitch	8.0	6.8	±75
	Yaw	-46.5	-46.1	Not required
THIV – ft/s (m/s)		18.22 (5.55)	18.29 (5.57)	Not required
PHD – g's		9.79	9.34	Not required
ASI		0.64	0.57	Not required

Figure 80. Summary of Test Results and Sequential Photographs, Test No. NYBWT-2

6 FULL-SCALE CRASH TEST NO. NYBWT-3

6.1 Static Soil Test

Before full-scale crash test no. NYBWT-3 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.

6.2 Weather Conditions

Test no. NYBWT-3 was conducted on July 24, 2018 at approximately 1:30 p.m. The weather conditions as per the National Oceanic and Atmospheric Administration (station 14939/KLNK) were reported and are shown in Table 9.

Table 9. Weather Conditions, Test No. NYBWT-3

Temperature	89° F
Humidity	55%
Wind Speed	11 mph
Wind Direction	180° from True North
Sky Conditions	Clear
Visibility	10 Statute Miles
Pavement Surface	Dry
Previous 3-Day Precipitation	0.00 in.
Previous 7-Day Precipitation	0.57 in.

6.3 Test Description

Typically, impact points are selected using the CIP plots found in Section 2.3, specifically Figure 2-17, of MASH 2016 [3]. Snag potential exists when the S3x5.7 post spacing transitions from reduced post spacing to standard post spacing. The critical impact point for test no. NYBWT-3 was selected to be approximately 11½ ft (3.5 m) upstream from the centerline of post no. 16, which is the first S3x5.7 post located at standard post spacing within the nested W-beam overlapped with box beam region. This results in an effective impact location of 8 ft (2.4 m) upstream from the leading edge of the box beam, as shown in Figure 81. This impact location maximizes the potential for vehicle snag on the leading edge of the box beam and evaluates the reduced post spacing to standard post spacing transition that occurs at post no. 16. This impact point was selected in discussions with NYSDOT.

The 5,006-lb (2,271-kg) pickup truck impacted the box beam to weak-post W-beam transition at a speed of 62.5 mph (100.5 km/h) and at an angle of 25.7 degrees. The actual point of impact was 8 ft – 2 in. (2.5 m) upstream from the leading edge of the box beam. The vehicle came to rest 95 ft – 11 in. (29.2 m) downstream from and in contact with the system near post no. 30 after the brakes were applied.

A detailed description of the sequential impact events is contained in Table 10, with movement definitions provided in Appendix E. Sequential photographs are shown in Figures 82 and 83. Documentary photographs of the crash test are shown in Figures 84 through 87. The vehicle trajectory and final position are shown in Figure 88.

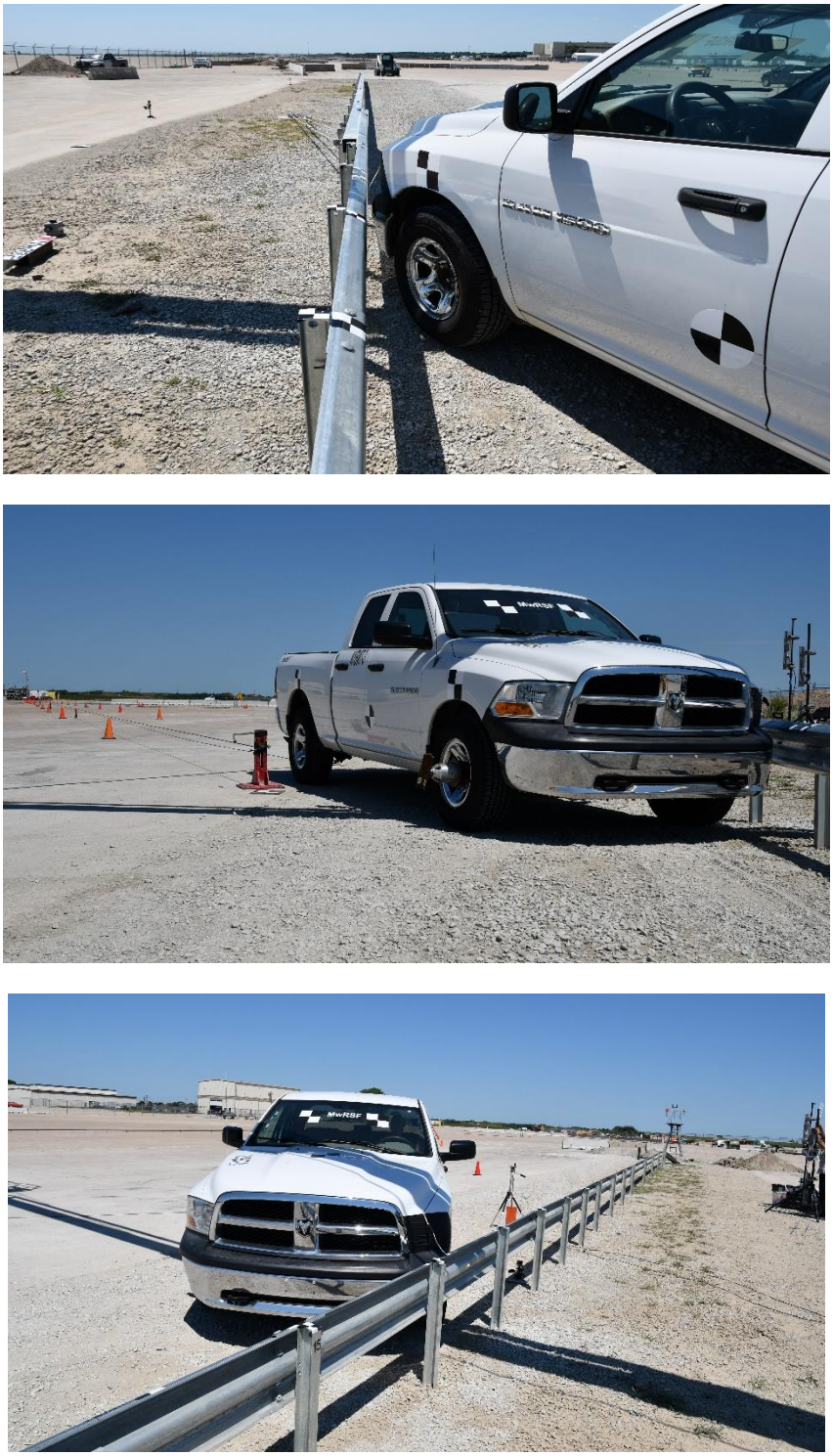


Figure 81. Impact Location, Test No. NYBWT-3

Table 10. Sequential Description of Impact Events, Test No. NYBWT-3

Time (sec)	Event
0.000	Vehicle's front bumper contacted rail 8 ft – 2 in. (2.5 m) upstream from the leading edge of the box beam (between post nos. 13 and 14).
0.004	Vehicle's front bumper deformed and vehicle's left headlight contacted rail.
0.006	Post no. 14 rotated backward, post no. 15 deflected backward, and vehicle's left fender contacted rail.
0.008	Post no. 13 deflected backward.
0.014	Vehicle's left headlight deformed.
0.020	Post no. 15 rotated backward, and vehicle's left fender deformed.
0.022	Vehicle's grille contacted rail.
0.028	Post no. 13 rotated backward.
0.030	Post no. 16 rotated backward.
0.032	Post no. 12 deflected backward.
0.034	Soil heave formed on non-traffic flange of post no. 13.
0.036	Soil heave formed on non-traffic flange of post no. 15.
0.038	Post no. 13 deflected downstream.
0.044	Vehicle yawed away from system.
0.046	Vehicle's front bumper contacted post no. 15.
0.048	Post no. 12 rotated backward, and rail disengaged from bolt at post no. 15.
0.050	Post no. 15 twisted counterclockwise, post no. 17 rotated backward, post no. 15 rotated downstream, and vehicle's grille deformed.
0.053	Post no. 12 deflected downstream.
0.059	Post no. 14 deflected downstream.
0.062	Post no. 18 rotated backward.
0.064	Rail disengaged from bolt at post no. 16.
0.066	Vehicle's left-front tire contacted post no. 15.
0.076	Post no. 16 rotated clockwise, post no. 14 bent backward, and post no. 18 deflected backward.
0.090	Post no. 13 bent backward.
0.094	Rail disengaged from bolt at post no. 17.
0.098	Post no. 20 rotated backward.
0.104	Post no. 19 rotated backward.
0.108	Post no. 16 rotated downstream.
0.114	Post no. 21 and 11 deflected backward.
0.118	Vehicle's left-front tire contacted rail, and vehicle's front bumper contacted post no. 16.
0.122	Vehicle's left-front tire contacted post no. 16.
0.134	Post no. 12 bent backward.

Table 11. Sequential Description of Impact Events, Test No. NYBWT-3, Cont.

Time (sec)	Event
0.138	Post no. 14 rotated counterclockwise.
0.144	Rail disengaged from bolt at post no. 18.
0.155	Vehicle's front bumper contacted transition cover.
0.160	Vehicle rolled away from system.
0.166	Post no. 17 rotated downstream, and vehicle's front bumper contacted post no. 17.
0.180	Rail disengaged from bolt at post no. 19.
0.204	Rail disengaged from bolt at post no. 12.
0.210	Post no. 22 deflected backward.
0.212	Post no. 21 rotated backward.
0.214	Rail disengaged from bolt at post no. 20.
0.218	Post no. 20 twisted clockwise.
0.223	Vehicle's left-front door contacted box beam.
0.224	Vehicle’s left-front tire deflated.
0.234	Vehicle's front bumper contacted box beam.
0.240	Post no. 22 rotated backward, and post no. 23 deflected backward.
0.244	Vehicle's left-front door deformed.
0.248	Rail disengaged from bolt at post no. 21.
0.256	Vehicle's left-rear door deformed.
0.258	Post no. 21 rotated clockwise.
0.264	Post no. 23 rotated backward.
0.272	Vehicle's front bumper contacted post no. 18.
0.274	Post no. 18 rotated downstream.
0.316	Vehicle's left quarter panel contacted rail.
0.318	Vehicle's left headlight became disengaged, and post no. 18 bolt disengaged from L-bracket.
0.328	Vehicle's rear bumper contacted rail.
0.335	Vehicle was parallel to system at a speed of 44.6 mph (71.8 km/h).
0.354	Post no. 19 rotated downstream, and vehicle's front bumper contacted post no. 19.
0.358	Vehicle's left quarter-panel deformed.
0.360	Vehicle rolled toward system.
0.403	Vehicle yawed toward system.
0.426	Vehicle pitched downward.
0.428	Post no. 19 bolt disengaged from L-bracket.
0.444	Vehicle's front bumper contacted post no. 20.
0.446	Post no. 20 rotated downstream.
0.460	Post no. 20 bolt disengaged from L-bracket.
0.464	Post no. 21 deflected downstream.

Table 12. Sequential Description of Impact Events, Test No. NYBWT-3, Cont.

Time (sec)	Event
0.502	Vehicle rolled away from system while in contact with system.
0.554	Vehicle's front bumper contacted post no. 21.
0.556	Post no. 21 rotated downstream.
0.576	Rail disengaged from bolt at post no. 22.
0.582	Post no. 21 bolt disengaged from L-bracket.
0.670	Vehicle pitched upward while in contact with system.
0.748	Post no. 22 rotated downstream, and vehicle's left-front tire contacted post no. 22.
0.782	Post no. 22 bolt disengaged from L-bracket.
0.842	Vehicle pitched downward while in contact with system.
0.888	Vehicle's left-front tire became disengaged.
0.910	Post no. 23 rotated downstream, and vehicle's left-front tire contacted post no. 23.
0.914	Post no. 23 bolt disengaged from L-bracket.
0.936	Vehicle rolled toward system while in contact with system.
1.042	Vehicle pitched upward while in contact with system.
1.230	Vehicle rolled away from system while in contact with system.
1.520	Vehicle rolled toward system while in contact with system.
1.750	Vehicle rolled away from system while in contact with system.
3.125	Vehicle stopped in contact with system.


0.000 sec


0.000 sec


0.100 sec


0.150 sec


0.250 sec


0.250 sec


0.400 sec


0.350 sec


0.550 sec


0.550 sec


0.800 sec


0.700 sec

Figure 82. Sequential Photographs, Test No.NYBWT-3


0.000 sec


0.000 sec


0.100 sec


0.150 sec


0.200 sec


0.300 sec


0.300 sec


0.400 sec


0.400 sec


0.550 sec


0.600 sec


0.750 sec

Figure 83. Additional Sequential Photographs, Test No.NYBWT-3

Figure 84. Documentary Photographs, Test No. NYBWT-3

Figure 85. Documentary Photographs, Test No. NYBWT-3

Figure 86. Documentary Photographs, Test No. NYBWT-3

Figure 87. Documentary Photographs, Test No. NYBWT-3

Figure 88. Vehicle Trajectory Marks and Final Position, Test No. NYBWT-3

6.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 89 through 95. Barrier damage consisted of rail deformation, deformed posts, and contact marks on rail sections. The length of contact along the barrier was approximately 95 ft – 11 in. (29.2 m) which spanned from post no. 14 to post no. 30.

Contact marks were found covering large portions of the barrier. A total of 14 kinks were found along the rail. These included an 18-in. (457-mm) long by 1½-in. (38-mm) high kink was found 1 in. (25 mm) downstream from post no. 13 on the bottom of the rail. An 8-in. (203-mm) long by 1¼-in. (32-mm) high kink was found 1 in. (25 mm) downstream from the centerline of post no. 13 on the top of the rail. A 7-in. (178-mm) long by ½-in. (13-mm) deep kink was found 30 in. (762 mm) downstream from the centerline of post no. 14 on the bottom of the rail. A 12-in. (305-mm) long by ¼-in. (6-mm) high kink was found 43½ in. (1,105 mm) downstream of the centerline of post no. 15 on the top of the rail. Another kink measuring 8 in. (203 mm) long and ¼ in. (6 mm) high was found 29½ in. (749 mm) upstream from post no. 12 on the top of the rail. A 2½-in. (64-mm) long by ¼-in. (6-mm) high kink was found 5⅝ in. (143 mm) downstream from post no. 12 on the top of the rail. Another kink was found 35 in. (889 mm) downstream from post no. 14 at the top of the rail. Measuring 24 in. (610 mm) long by 2½ in. (64 mm) high. A kink measuring 9½ in. (241 mm) long by 1 in. (25 mm) high was found 18 in. (457 mm) downstream from post no. 14 at the bottom of the rail. A kink was found 9 in. (229 mm) upstream from post no. 16 at the top of the rail measuring 11 in. (279 mm) long by ¼ in. (6 mm) high.

Rail flattening was found 10 in. (254 mm) upstream from post no. 14 extending 52 in. (1,321 mm) downstream. Rail flattening measuring 20 in. (508 mm) long by 3 in. (76 mm) high was found 33 in. (838 mm) downstream from post no. 15. Bending measuring 12 in. (305 mm) long by ½ in. (13 mm) deep was found 32 in. (813 mm) downstream from post no. 14. A ¼-in. (6-mm) long by ⅛-in. (3mm) wide gouge was found 1⅛ in. (29 mm) from the top of the transition at the start of the upstream edge. The rail was deformed starting 42 in. (1,067 mm) downstream from post no. 15 extending downstream for 162½ in. (4,128 mm).

Post nos. 1 through 3, 5, 6, and 25 through 29 rotated clockwise. Post nos. 1, 10, 11, and 24 rotated backward. Post no. 1 deflected downstream and rotated backward and clockwise. Post nos. 30 and 31 rotated upstream. Post nos. 12 through 23 bent backward. Post nos. 13 through 23 bent downstream. Post nos. 13, 14, and 23 twisted counterclockwise. Post nos. 16 through 21 twisted clockwise. Post-to-rail bolts pulled out of post nos. 12 and 15 through 23. Soil gaps were found at post nos. 10 through 13, 29, 31, and 32. Soil heaves were found at post nos. 11 through 21 and 23. Soil craters were found at post nos. 13 and 15 through 23.

The maximum lateral rail and post permanent set were 42¾ in. (1,086 mm) at post no.16, and 19½ in. (495 mm) at post no. 13, as measured in the field. The maximum lateral dynamic rail and post deflections were 63.7 in. (1,618 mm) at post no. 16 and 23.3 in. (592 mm) at post no. 14, respectively, as determined from high-speed digital video analysis. The working width of the system was found to be 78.5 in. (1,994 mm), also determined from high-speed digital video analysis. A schematic of the permanent set, dynamic deflection, and working width is shown in Figure 96.

Figure 89. Overview of Damage to System, Test No. NYBWT-3

Figure 90. System Damage, Test No. NYBWT-3

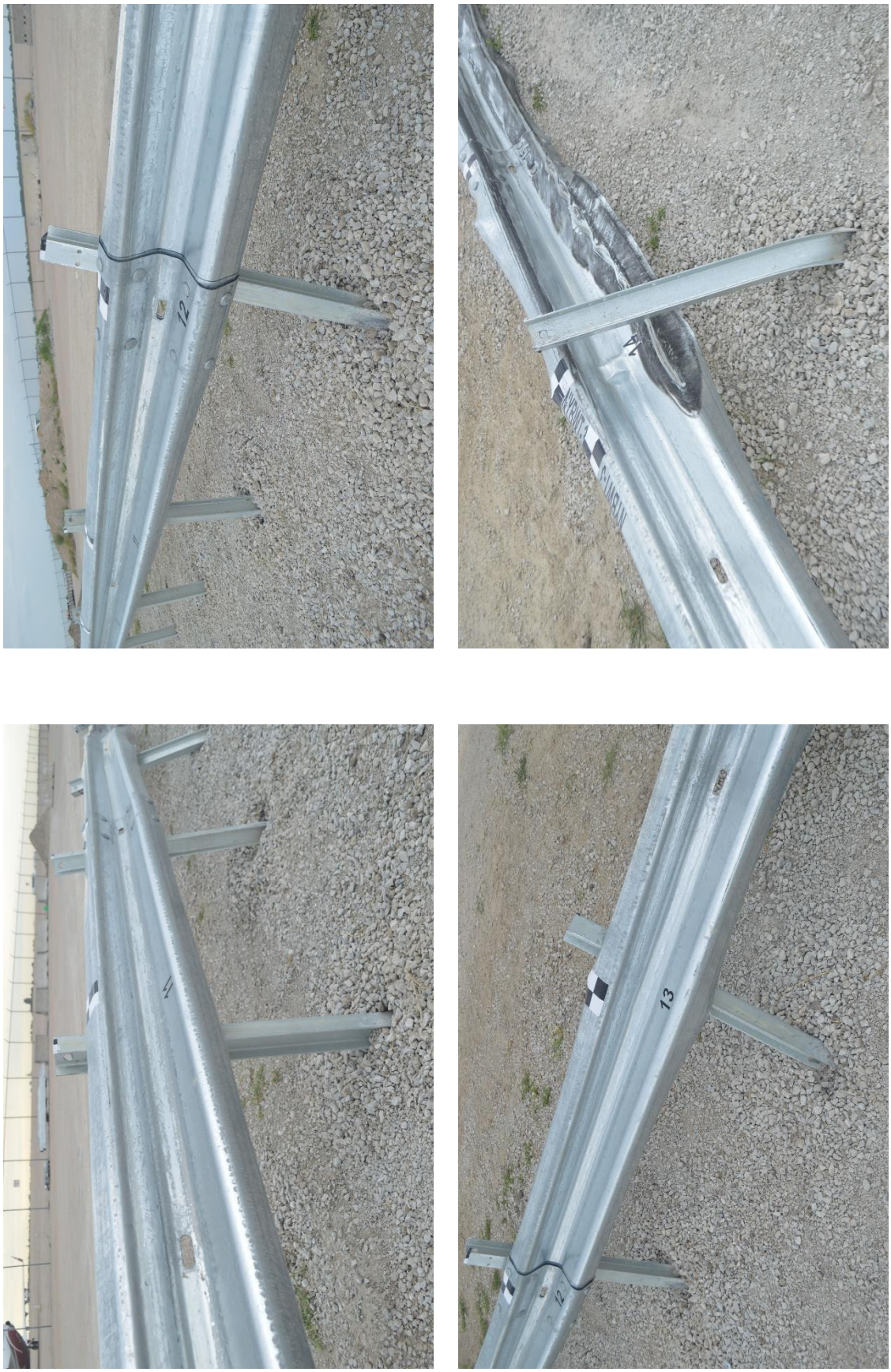


Figure 91. Damage to Post Nos. 11 through 14, Test No. NYBWT-3

Figure 92. Damage to Post Nos. 15 through 18, Test No. NYBWT-3

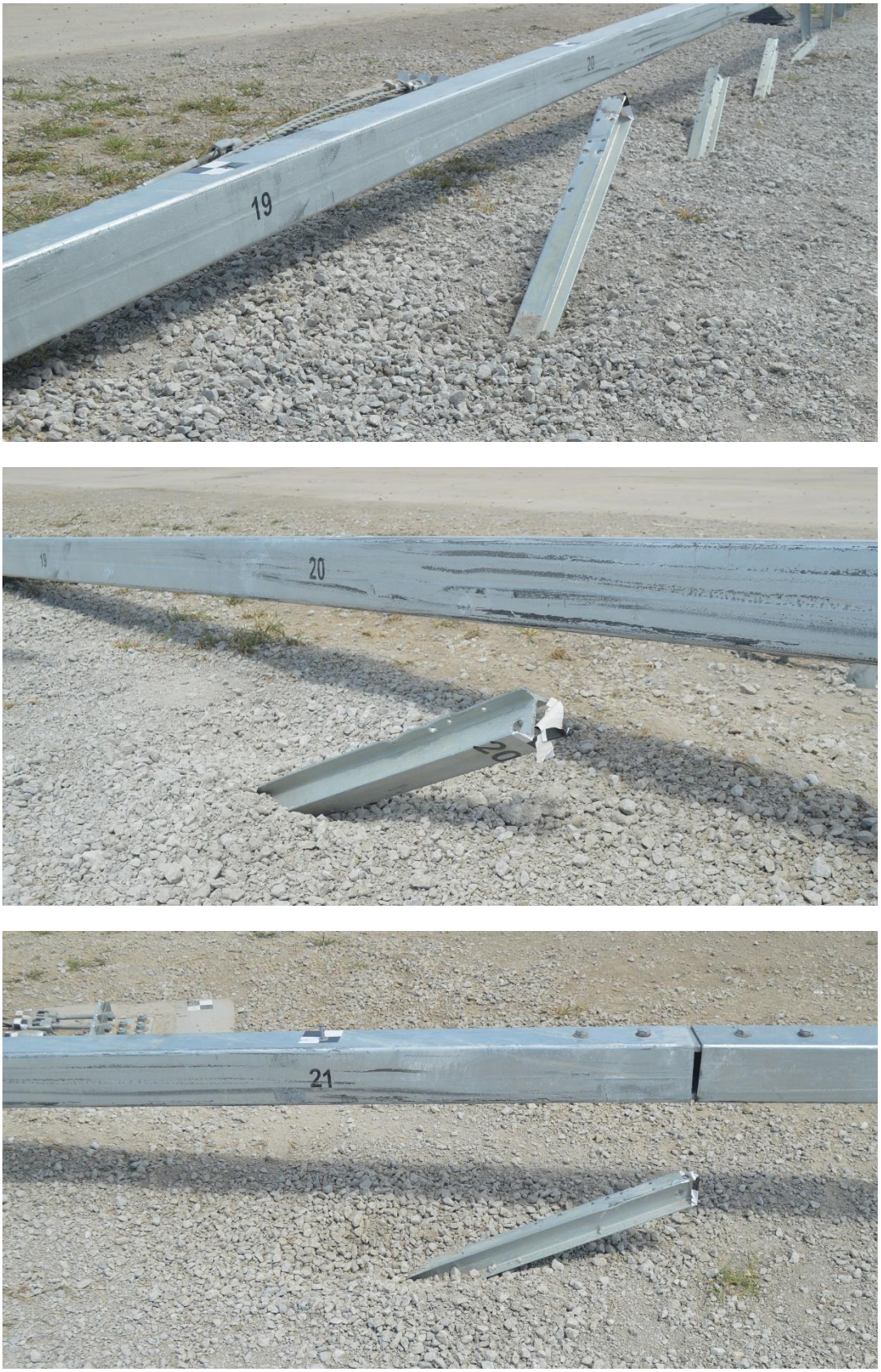


Figure 93. Damage to System at Post Nos. 19 through 21

Figure 94. Damage to System at Post Nos. 22 through 24

Figure 95. Anchor Damage, Test No. NYBWT-3

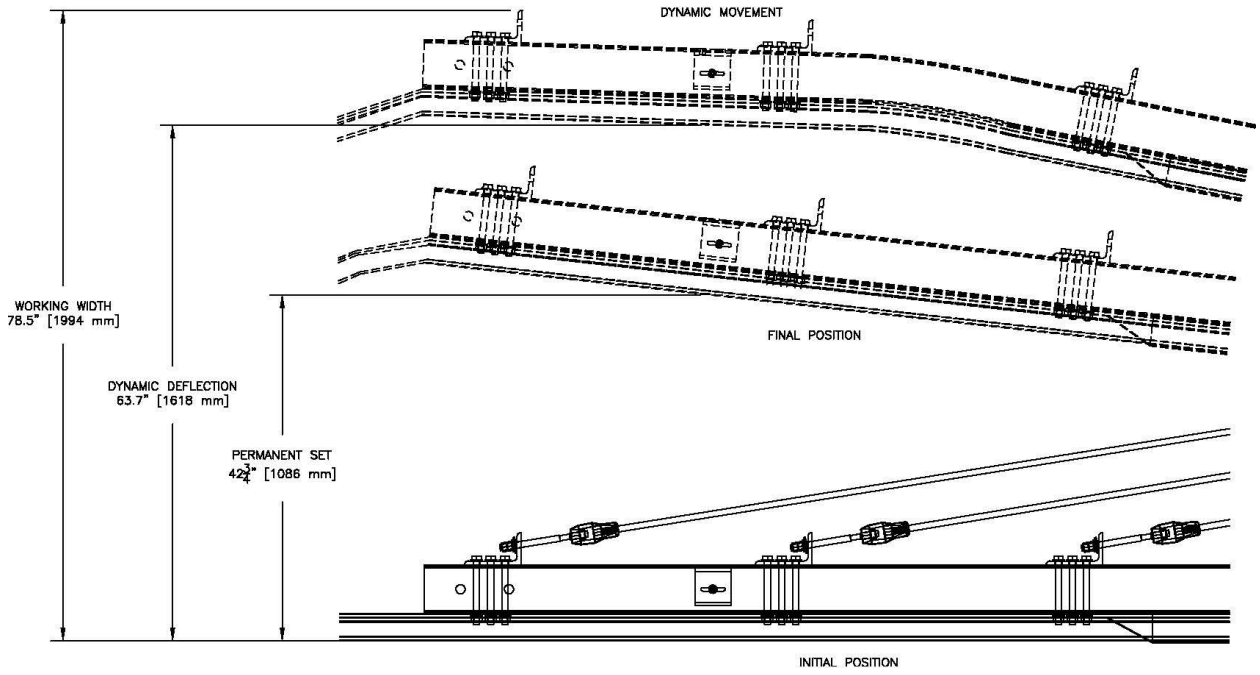


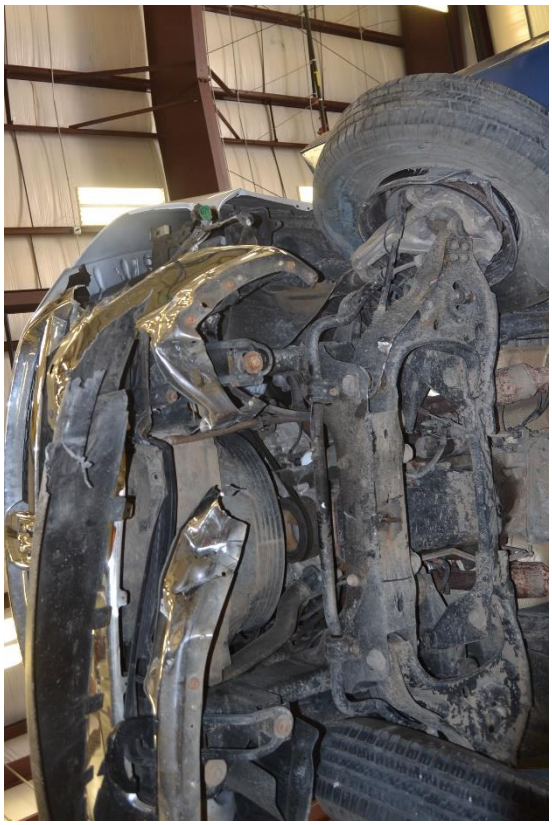
Figure 96. Permanent Set, Dynamic Deflection, and Working Width, Test No. NYBWT-3

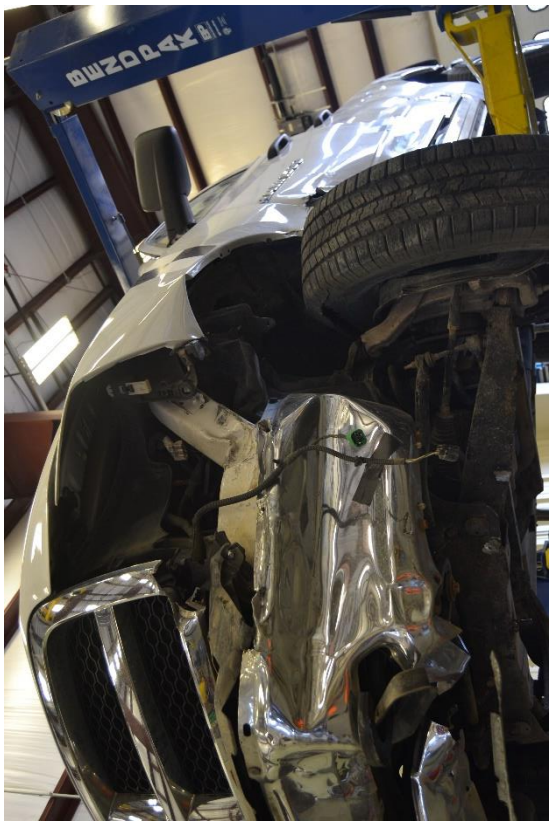
6.5 Vehicle Damage

The damage to the vehicle was moderate, as shown in Figures 97 through 100. The maximum occupant compartment intrusion values are listed in Table 13 along with the intrusion limits established in MASH 2016 for various areas of the occupant compartment. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix F. MASH 2016 defines intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. There were no penetrations into the occupant compartment and none of the established MASH 2016 deformation limits were violated. Outward deformations, which are denoted as negative numbers in Appendix F, are not considered crush toward the occupant, and are not evaluated by MASH 2016 criteria.

Figure 97. Vehicle Damage, Test No. NYBWT-3

Figure 98. Vehicle Damage, Test No. NYBWT-3





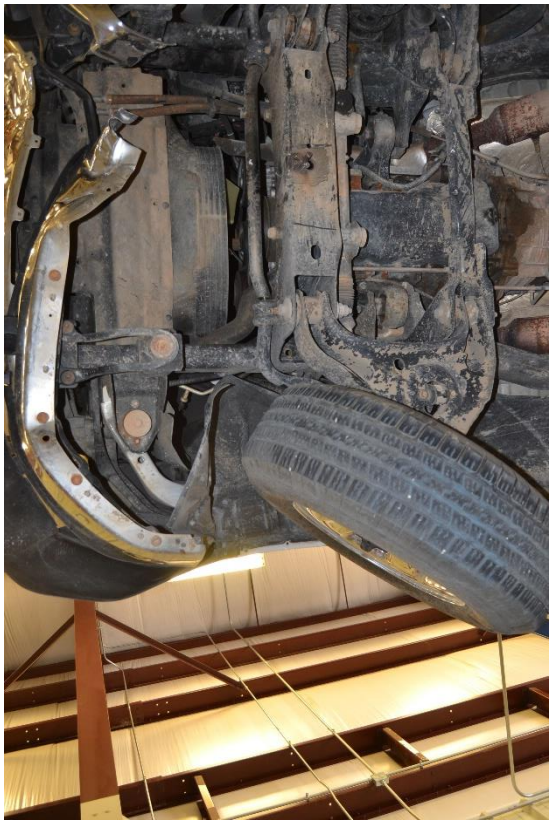


Figure 99. Undercarriage Vehicle Damage, Test No. NYBWT-3

Figure 100. Occupant Compartment Damage, Test No. NYBWT-3

Table 13. Maximum Occupant Compartment Intrusion by Location, Test No. NYBWT-3

Location	Maximum Intrusion in. (mm)	MASH 2016 Allowable Intrusion in. (mm)
Wheel Well & Toe Pan	0.4 (10)	≤ 9 (229)
Floor Pan & Transmission Tunnel	0.4 (10)	≤ 12 (305)
A-Pillar	1.4 (36)	≤ 5 (127)
A-Pillar (Lateral)	0 (0)*	≤ 3 (76)
B-Pillar	1.4 (36)	≤ 5 (127)
B-Pillar (Lateral)	0 (0)*	≤ 3 (76)
Side Front Panel (in Front of A-Pillar)	0 (0)*	≤ 12 (305)
Side Door (Above Seat)	0 (0)*	≤ 9 (229)
Side Door (Below Seat)	0.1 (3)	≤ 12 (305)
Roof	0.2 (5)	≤ 4 (102)
Windshield	0.0 (0.0)	≤ 3 (76)
Side Window	Intact	No shattering resulting from contact with structural member of test article
Dash	1.4 (36)	N/A

N/A – Not applicable
*Negative value reported as 0. See Appendix F for further information.

Majority of the damage was concentrated on the left-front corner and left side of the vehicle where the impact occurred. The left-front quarter panel was deformed inward by the by the door. The left-front door was also dented inward along the bottom of the door. A gouge was found on the bottom-front corner of the door. The front bumper was dented just to the left of center and was deformed into the engine compartment on the left-side, thus bending the body frame. The bottom-left side of the grill was deformed and was partially disengaged. Scrapes and dents were found along the bottom of the left-rear door. The scrapes become tears on the bottom rear corner of the door frame. A dent was found on the left-rear quarter panel in front of the wheel well. A tear was found beginning at the back of the wheel well and extending to the back of the left-rear quarter panel just above the rear bumper. The rear bumper was also dented on the left side.

There was a slight twist on the sway bar link on the left-front side. The lower control arm on the left-front side deformed into the vehicle and knocked off the bushing. The tie rod on the left-front side was deformed inward. The oil pan was scraped on the right side. The engine cross member was dented approximately at the center. The frame horn was deformed inward toward the center. The exhaust located underneath the oil pan had multiple scrapes and dents.

6.6 Occupant Risk

The calculated occupant impact velocities (OIVs) and maximum 0.010-sec average occupant ride down accelerations (ORAs) in both the longitudinal and lateral directions, as

determined from the accelerometer data, are shown in Table 14. 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 14. The recorded data from the accelerometers and the rate transducers are shown graphically in Appendix G.

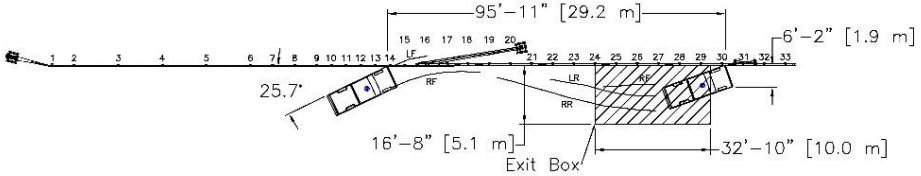
Table 14. Summary of OIV, ORA, THIV, PHD, and ASI Values, Test No. NYBWT-3

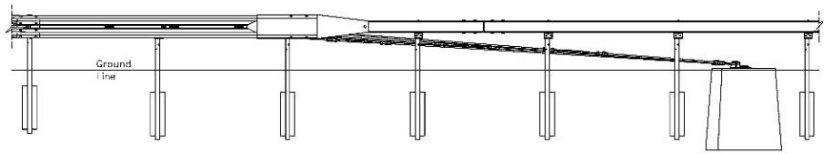
Evaluation Criteria		Transducer		MASH 2016 Limits
		SLICE-1	SLICE-2 (primary)	
OIV ft/s (m/s)	Longitudinal	-17.79 (-5.42)	-15.65 (-4.77)	±40 (12.2)
	Lateral	12.75 (3.89)	13.26 (4.04)	±40 (12.2)
ORA g's	Longitudinal	-6.64	-6.75	±20.49
	Lateral	5.91	5.35	±20.49
Maximum Angular Displacement deg.	Roll	-6.7	6.1	±75
	Pitch	2.4	3.2	±75
	Yaw	30.4	29.8	not required
THIV ft/s (m/s)		19.85 (6.05)	19.69 (6.00)	not required
PHD g's		8.62	8.39	not required
ASI		0.51	0.48	not required

6.7 Discussion

The analysis of the test results for test no. NYBWT-3 showed that the system adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier. A summary of the test results and sequential photographs are shown in Figure 101. Detached elements, fragments, or other debris from the test article did not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or work-zone personnel. Deformations of, or intrusions into, the occupant compartment that could have caused serious injury did not occur. 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 G, were deemed acceptable because they did not adversely influence occupant risk nor cause rollover. After impact, the vehicle did not exit the system, and its trajectory did not violate the bounds of the exit box. Therefore, test no. NYBWT-3 was determined to be acceptable according to the MASH 2016 safety performance criteria for test designation no. 3-21.

0.000 sec 0.050 sec 0.150 sec 0.350 sec 0.650 sec





- Test Agency ..... MwRSF
- Test Number..... NYBWT-3
- Date 07/24/18
- MASH 2016 Test Designation No..... 3-21
- Test Article..... NYSDOT Box Beam to Weak-Post W-Beam Transition
- Total Length ..... 224 ft – 1¾ in. (68.3 m)
- Key Component – W-Beam Rail
  - Thickness..... 12 gauge (2.6 mm)
  - Mounting Height ..... 32 in. (813 mm)
- Key Component – Box Beam
  - Size ..... 6 in. x 6 in. x $^{3}/_{16}$ in. (152 mm x 152 mm x 5 mm)
  - Mounting Height ..... 30 in. (762 mm)
- Key Component –S3x5.7 (S75x8.5) Steel Post (nos.1-33)
  - Size ..... 65 in. (1,651 mm) long
  - Embedment Depth (Post nos. 1-12)..... $37^{15}/_{16}$ in. (963 mm)
  - Embedment Depth (Post nos. 13-19)..... 34⅝ in. (879 mm)
  - Embedment Depth (Post nos. 20-33)..... 32⅝ in. (829 mm)
  - Spacing (Post nos. 13-19) ..... 72 in. (1,829 mm)
  - Spacing (Post nos. 19-25) ..... 50 in. (1,270 mm)
  - Spacing (Post nos. 25-28) ..... 75 in. (1,905 mm)
  - Spacing (Post nos. 28-32) ..... 150 in. (3,810 mm)
  - Material ..... ASTM A36
- Key Component – Anchors
  - Embedment Depth (Downstream and Transition Anchors) ..... 44 in. (1,118 mm)
  - Embedment Depth (Upstream Anchor) ..... 70⅜ in. (1,788 mm)
  - Material (Downstream and Transition Anchors)..... Concrete
  - Material (Upstream Anchor)..... ASTM A992 or ASTM A572 Gr. 50
- Soil Type ..... Coarse, Crushed Limestone (Well-Graded Gravel)
- Vehicle Make /Model..... 2012 Dodge Ram 1500 Quad Cab Pickup Truck
  - Curb..... 5,151 lb (2,336 kg)
  - Test Inertial ..... 5,006 lb (2,271 kg)
  - Gross Static ..... 5,165 lb (2,343 kg)
- Impact Conditions
  - Speed ..... 62.5 mph (100.5 km/h)
  - Angle ..... 25.7 deg.
  - Impact Location ..... 8 ft 2 in. (2.5 m) from the leading edge of the box beam
- Impact Severity..... 122.9 kip-ft (166.7 kJ) ≥ 106 kip-ft (144 kJ) MASH 2016 Limit
- Exit Conditions ..... N/A
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance .....95 ft – 11 in. (29.2 m) downstream in contact with system
- Vehicle Damage ..... Moderate
  - VDS [13] 11-FLQ-10
  - CDC [14]..... 11-FLEW-2
  - Maximum Interior Deformation ..... 1.4 in. (35.5 mm)
- Test Article Damage..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 42¾ in. (1,086 mm)
  - Dynamic..... 63.7 in. (1,618 mm)
  - Working Width ..... 78.5 in. (1,994 mm)
- Transducer Data

Evaluation Criteria		Transducer		MASH 2016 Limit
		SLICE-1	SLICE-2 (primary)	
OIV ft/s (m/s)	Longitudinal	-17.79 (-5.42)	-15.65 (-4.77)	±40 (12.2)
	Lateral	12.75 (3.89)	13.26 (4.04)	±40 (12.2)
ORA g's	Longitudinal	-6.64	-6.75	±20.49
	Lateral	5.91	5.35	±20.49
Maximum Angular Displacement deg.	Roll	-6.7	6.1	±75
	Pitch	2.4	3.2	±75
	Yaw	30.4	29.8	not required
THIV – ft/s (m/s)		19.85 (6.05)	19.69 (6.00)	not required
PHD – g's		8.62	8.39	not required
ASI		0.51	0.48	not required

Figure 101. Summary of Test Results and Sequential Photographs, Test No. NYBWT-3

7 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Test nos. NYBWT-2 and NYBWT-3 were conducted on a New York State box beam to weak-post W-beam transition longitudinal barrier system according to MASH 2016 test designation no. 3-21. Both tests were conducted on identical systems; however, test no. NYBWT-3 utilized a reverse-direction impact. The 1100C vehicle test was deemed unnecessary due to previous testing, as discussed in Section 3.1. The system consisted of standard New York box-beam connected to a W-Beam rail with a transition.

Post nos. 1 through 19 were spaced 72 in. (1,829 mm) on center and with an embedment depth of $37^{15}/_{16}$ in. (964 mm) into the soil. Post nos. 19 through 25 were spaced 50 in. (1,270 mm) apart and post nos. 25 through 28 were spaced 75 in. (1,905 mm) apart, all of which were embedded into the soil to a depth of 32⅝ in. (1,905 mm) except for post no. 19, which was embedded into the soil to a depth of 34⅝ in. (879 mm). The top rail height was 32 in. (813 mm) for the W-beam and 27 in. (687 mm) for the box beam. A summary of the test evaluation is shown in Table 15

In test no. NYBWT-2, the 4,969-lb (2,254-kg) Dodge Ram 1500 Quad Cab pickup truck impacted the box beam to weak-post W-beam transition system at a speed of 63.5 mph (102.2 km/h) and at an angle of 25.1 degrees, resulting in an impact severity of 119.7 kip-ft (162.3 kJ). The critical impact point for test no. NYBWT-2 was selected to be approximately 11½ ft (3.5 m) upstream from the upstream end of the nested W-beam, which resulted in an effective impact location of 8 ft (2.4 m) from the upstream end of the transition cover piece. The actual impact point was at 8 ft – 5 in. (2.6 m) upstream from the leading edge of the transition cover piece. After impacting the barrier system, the vehicle was redirected and exited the system. The vehicle was successfully contained with moderate damage to the vehicle and to the barrier. All vehicle decelerations, ORAs, and OIVs fell within the recommended safety limits established in MASH 2016. Therefore, test no. NYBWT-2 was successful according to the safety criteria of MASH 2016 test designation no. 3-21.

In test no. NYBWT-3, the 5,165-lb (2,343-kg) Dodge Ram 1500 Quad cab pickup truck impacted the box beam to weak-post W-beam transition system at a speed of 62.5 mph (100.5 km/h) and at an angle of 25.7 degrees, resulting in an impact severity of 122.9 kip-ft (166.6 kJ). The critical impact point for test no. NYBWT-3 was selected to be approximately 11½ ft (3.5 m) upstream from the centerline of post no. 16, which is the first S3x5.7 post located at standard post spacing within the nested W-beam overlapped with box beam region. This results in an effective impact location of 8 ft (2.4 m) upstream from the leading edge of the box beam, maximizes the potential for vehicle snag on the leading edge of the box beam, and evaluates the reduced post spacing to standard post spacing transition that occurs at post no. 16. The actual impact point was 8 ft – 2 in. (2.5 m) upstream from the leading edge of the box beam. After impacting the barrier system, the vehicle was redirected but did not exit the system. The vehicle was successfully contained with moderate damage to the vehicle and to the barrier. All vehicle decelerations, ORAs, and OIVs fell within the recommended safety limits established in MASH 2016. Therefore, test no. NYBWT-3 was successful according to the safety criteria of MASH 2016 test designation no. 3-21.

Table 15. Summary of Safety Performance Evaluation

Evaluation Factors	Evaluation Criteria	Test No. NYBWT-2	Test No. NYBWT-3
Structural Adequacy	A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	S	S
Occupant Risk	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.	S	S
	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.	S	S
	F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	S	S
	H. Occupant Impact Velocity (OIV) (see Appendix A, Section A5.2.2 of MASH 2016 for calculation procedure) should satisfy the following limits:	S	S
	Occupant Impact Velocity Limits		
	Component / Preferred / Maximum		
	Longitudinal and Lateral / 30 ft/s (9.1 m/s) / 40 ft/s (12.2 m/s)		
	I. The Occupant Ridedown Acceleration (ORA) (see Appendix A, Section A5.2.2 of MASH 2016 for calculation procedure) should satisfy the following limits:	S	S
	Occupant Ridedown Acceleration Limits		
	Component / Preferred / Maximum		
	Longitudinal and Lateral / 15.0 g's / 20.49 g's		
MASH 2016 Test Designation No.		3-21	3-21
Final Evaluation (Pass or Fail)		Pass	Pass

S – Satisfactory U – Unsatisfactory NA - Not Applicable

8 MASH IMPLMENTATION

The objective of this research was to evaluate the safety performance of NYSDOT's box beam to weak-post W-beam transition system. The system consisted of standard box beam that transitions into a weak-post W-beam. A transition cover plate was located in the region where the two different systems met to mitigate snag potential. A cable anchorage system was also attached in the transition region and terminated at a large concrete anchor block located behind the box beam system. The standard weak-post W-beam system was anchored with a bent turned-down section of W-beam and attached to another concrete anchor block. The W-beam rail height was 32 in. (813 mm) and transitioned gradually to match the box beam height of 27 in. (686 mm).

According to TL-3 of MASH 2016, longitudinal barrier systems must be subjected to one full-scale vehicle crash test: test designation no. 3-21, which is run with a 2270 pickup truck vehicle. Test designation no. 3-20 is an optional test for transitions and only conducted if there is reasonable uncertainty regarding the impact performance of the system with small cars. Based on guidance from the sponsor, two full-scale crash tests were deemed necessary to evaluate the transition: (1) MASH 2016 test designation no. 3-21, which evaluates the transition with the 2270P pickup truck, and (2) a reverse-direction impact of test designation no. 3-21 with the 2270P vehicle. The reverse-direction impact test would be required to evaluate the transition for installations that require two-way traffic adjacent to the barrier. MASH 2016 also requires that transitions be evaluated adjacent to their connection to rigid barriers and in the stiffness transition region.

Based on prior research, the small car test was deemed not critical for evaluation of this system. The box beam guardrail system successfully met NCHRP Report 350 test designation no. 3-11 [4]. Similarly, the weak-post W-beam guardrail successfully met NCHRP Report 350 test designation nos. 3-10 and 3-11 [5-6]. Based on recommendations made during NCHRP Project 22-14(03), only pickup truck tests were deemed necessary for the G3 box-beam longitudinal system and the modified G2 weak-post W-beam system with a rail height at 32 in. (813 mm) [7].

During NCHRP Project 22-14(03), in test no. 476460-1-6, the G3 weak-post box-beam system was tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 4.8 ft (1.5 m). During that same research study, in test no. 476460-1-7, the modified G2 weak-post W-beam system was tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 8.6 ft (2.6 m). In test no. 608221-1, the modified G2 weak-post W-beam guardrail system was successfully tested according to MASH test designation no. 3-10 with no tears or punctures and only small scrapes to the vehicle's underside [8]. The modified weak-post W-beam guardrail had a dynamic deflection of 6.0 ft (1.8 m) when impacted with the 1100C vehicle.

Weak posts (S3x5.7) rotate minimally and yield at the ground line in the strong soil required by MASH, consequently, the posts behave as if they were in rigid sockets. Using quarter-post spacing with weak-posts in rigid sockets [9] reduced system deflections by almost 60 percent when compared to the modified G2 weak-post W-beam system. Therefore, the deflections of the reduced post spacing of the modified G2 weak-post W-beam system in the transition region should behave similar to the G3 weak-post box beam system.

It was believed that the pickup truck tests noted above would be sufficient to evaluate the transition between two semi-rigid barrier systems that transition to approximately the same

stiffness. Therefore, the small car test was deemed not critical based on prior full-scale testing and the guidance in MASH section 2.2.1.2. It should be noted that any tests within the evaluation matrix deemed not critical may eventually need to be evaluated based on additional knowledge gained over time or additional FHWA eligibility letter requirements.

During test no. NYBWT-2, a 4,969-lb (2,254-kg) pickup truck with a simulated occupant seated in the right-front seat impacted the box beam to weak-post W-beam transition at a speed of 63.5 mph (102.2 km/h) and at an angle of 25.1 degrees, resulting in an impact severity of 119.7 kip-ft (162.3 kJ). The point of impact occurred 8 ft – 5 in. (2.6 m) upstream from the leading edge of the transition cover piece. At 0.243 sec after impact, the vehicle became parallel to the system with a speed of 52.0 mph (83.7 km/h). At 0.726 sec, the vehicle was airborne as it exited the system at a speed of 47.3 mph (76.1 km/h) and at an angle of 13.6 degrees. The vehicle was successfully contained and smoothly redirected.

Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal with a maximum of 0.5 in. (13 mm), which did not violate the limits established in MASH 2016. Damage to the barrier was also moderate, consisting of contact marks on the front face of the W-beam and box beam segments, rail deformation, and deformed posts. The maximum dynamic barrier deflection was 51.6 in. (1,311 mm). The working width of the transition system was 63.3 in. (1,643 mm) due to vehicle protrusion over the top of the system. All occupant risk measures were within the recommended limits, and the occupant compartment deformations were also deemed acceptable. Therefore, NYSDOT's box beam to weak-post W-beam transition system successfully met all the safety performance criteria of MASH 2016 test designation no. 3-21.

During test no. NYBWT-3, a 5,006-lb (2,271-kg) pickup truck with a simulated occupant seated in the right-front seat impacted the box beam to weak-post W-beam transition at a speed of 62.5 mph (100.5 km/h) and at an angle of 25.7 degrees, resulting in an impact severity of 122.9 kip-ft (166.7 kJ). The point of impact occurred 8 ft – 2 in. (2.5 m) upstream from the leading edge of the box beam. At 0.335 sec after impact, the vehicle became parallel to the system with a speed of 44.6 mph (71.8 km/h). The vehicle was redirected but did not exit the system before it came to rest. The vehicle was successfully contained.

Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal with a maximum of 1.4 in. (36 mm), which did not violate the limits established in MASH 2016. Damage to the barrier was also moderate, consisting of contact marks on the front face of the W-beam and box beam segments, rail deformation, and deformed posts. The maximum dynamic barrier deflection was 63.7 in. (1,618 mm). The working width of the transition system was 78.5 in. (1,994 mm). All occupant risk measures were within the recommended limits, and the occupant compartment deformations were also deemed acceptable. Therefore, NYSDOT's box beam to weak-post W-beam transition system successfully met all the safety performance criteria of MASH 2016 test designation no. 3-21 in the reverse direction.

The NYSDOT box beam to weak-post W-beam transition system was successfully crash tested and evaluated according to the AASHTO MASH 2016 TL-3 criteria. This barrier successfully met all the requirements of MASH 2016 test designation no. 3-21 as well as the reverse direction test designation no. 3-21. In addition, the researchers consider the system MASH 2016 compliant based on the successful test designation no. 3-21 tests and the previous justification for test designation no. 3-20 being deemed not critical.

9 REFERENCES

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

2. Ross, H.E., Sicking, D.L., Zimmer, R.A., and Michie, J.D., *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, National Cooperative Highway Research Program (NCHRP) Report 350, Transportation Research Board, Washington, D.C., 1993.

3. *Manual for Assessing Safety Hardware*, *Second Edition*, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2016.

4. Mak, K.K., Bligh, R.P., and Menges, W.L., *Volume I: Technical Report, Testing of State Roadside Safety Systems*, Research Report 471470, Texas Transportation Institute, College Station, Texas, September 1996.

5. Buth, C.E., Menges, W.L., Williams, W.F., and Shoeneman, S.K., *NCHRP Report 350 Test 3-10 on the Modified PennDOT Type 2 Guide Rail – Test 4*, Research Report 473750-4, Texas Transportation Institute, College Station, Texas, July 2000.

6. Buth, C.E., Menges, W.L., Williams, W.F., and Shoeneman, S.K., *NCHRP Report 350 Test 3-11 on the Modified PennDOT Type 2 Guide Rail – Test 3*, Research Report 473750-3, Texas Transportation Institute, College Station, Texas, June 2000.

7. National Academies of Sciences, Engineering, and Medicine 2010, *Volume I: Evaluation of Existing Roadside Safety Hardware Using Updated Criteria Technical Report*, Washington, D.C: The National Academies Press. https://doi.org/10.17226/22938.

8. Bullard, D.L., Menges, W.L., and Kuhn, D.L., *MASH Test 3-10 of PennDOT G2 Weak Post W-beam Guardrail*, Research Report 608221-1, Texas Transportation Institute, College Station, Texas, September 2017.

9. Sweigard, M.E., Lechtenberg, K.A., Faller, R.K., Reid, J.D., and Urbank, E.L., *MASH 2016 Test No. 3-10 of MGS Installed in an Asphalt Mow Strip with Nearby Curb (Test No. GAA-1)*, Final Report to the Georgia Institute of Technology, Report No. TRP 03-377-17, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 14, 2017.

10. Hinch, J., Yang, T.L., and Owings, R., *Guidance Systems for Vehicle Testing*, ENSCO, Inc., Springfield, Virginia, 1986.

11. *Center of Gravity Test Code - SAE J874 March 1981*, SAE Handbook Vol. 4, Society of Automotive Engineers, Inc., Warrendale, Pennsylvania, 1986.

12. Society of Automotive Engineers (SAE), *Instrumentation for Impact Test – Part 1 – Electronic Instrumentation*, SAE J211/1 MAR95, New York City, NY, July, 2007.

13. *Vehicle Damage Scale for Traffic Investigators*, Second Edition, Technical Bulletin No. 1, Traffic Accident Data (TAD) Project, National Safety Council, Chicago, Illinois, 1971.

14. *Collision Deformation Classification – Recommended Practice J224 March 1980*, Handbook Volume 4, Society of Automotive Engineers (SAE), Warrendale, Pennsylvania, 1985

15. *Transition: Box – W-Beam (Mod.)*, New York State Standard Sheets, Book 2 of 4: Sheets 606-01 Thru 607-06, New York State Department of Transportation, Albany, NY, September 1, 2017.

10 APPENDICES

Appendix A. NYSDOT Standard Plans

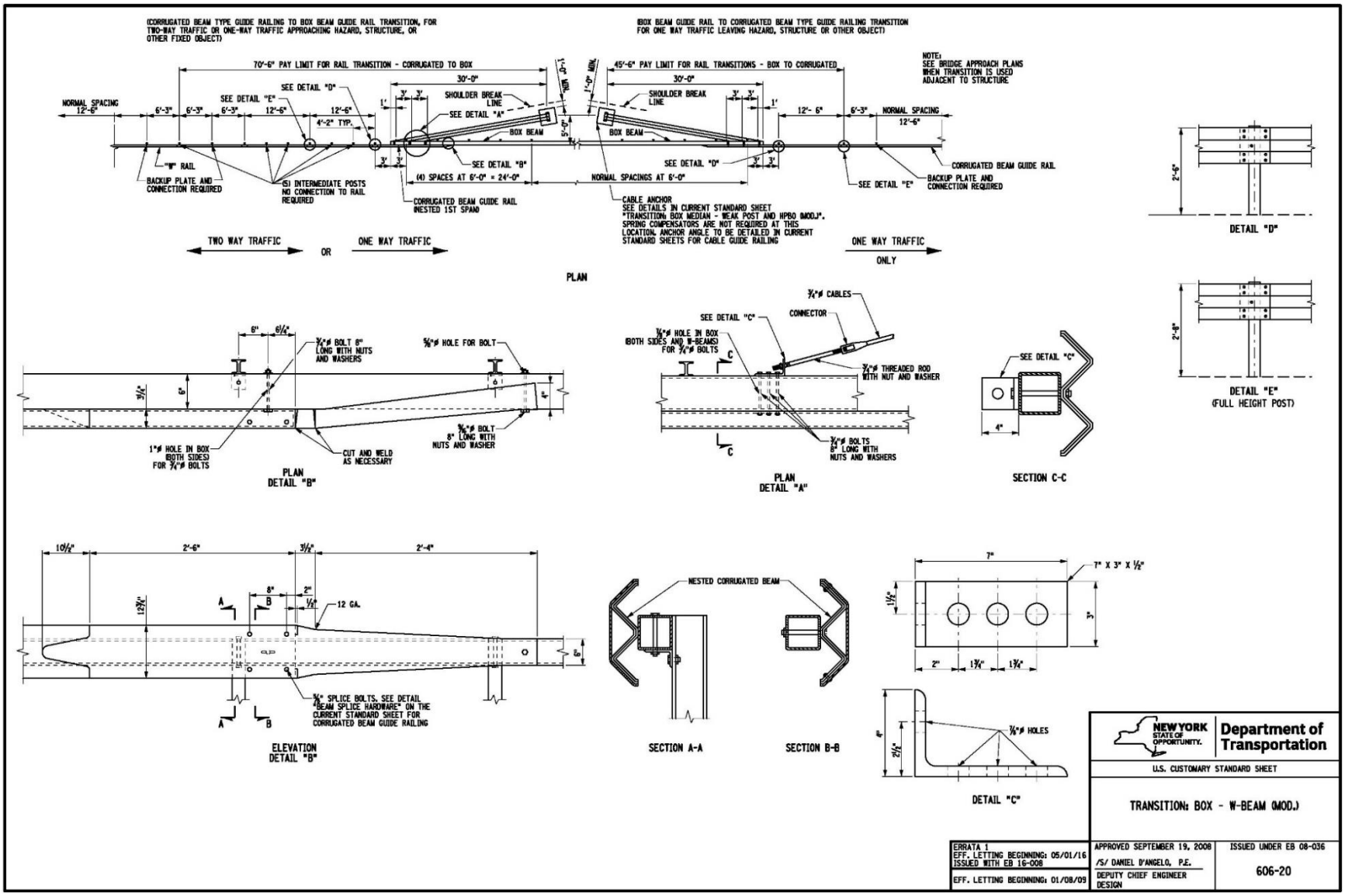


Figure A-1. New York Standard Sheet for Box Beam to Weak-Post W-Beam Transition, Test No. NYBWT-2 [15]

Appendix B. Material Specifications

Table B-1. Bill of Materials, Test Nos. NYBWT-2 and NYBWT-3

Item No.	Description	Material Specification	Reference
a1	12'-6" [3,810] 12-gauge [2.7] W-Beam Section	AASHTO M180	H#USL18L67180
a2	12'-6" [3,810] 12-gauge [2.7] W-Beam Section	AASHTO M180	H#USL18L67180
a3	12'-6" [3,810] 12-gauge [2.7] W-Beam Curved Section	AASHTO M180	H#4120072
a4	12" [305] 12-gauge [2.7] W-Beam Backup Plate	AASHTO M180	H#174700
a5	Box Beam to W-Beam Transition Cover, 12-gauge [2.7]	ASTM A36	H#842W32370
b1	TS6"x6"x3/16" [152x152x5], 215½" [5,474] Long Box Beam	ASTM A500 Gr. B	H#U2133, #U2139, and #U2141
b2	TS6"x6"x3/16" [152x152x5], 215½" [5,474] Long Box Beam	ASTM A500 Gr. B	H#U2133, #U2139, and #U2141
b3	TS6"x6"x3/16" [152x152x5], 215½" [5,474] Long Box Beam	ASTM A500 Gr. B	H#U2133 H#U2139 H#U2141
b4	27"x57/16"x⅝" [686x138x16] Splice Plate	ASTM A36	H#W19665
c1	S3x5.7 [S75x8.5], 65" [1,651] Long Post	ASTM A36	H#12715
c2	24"x8"x¼" [610x203x6] Soil Plate	ASTM A36	H#A87153
c3	5"x3½"x⅜" [127x89x10], 4½" [114] Long L-Bracket	ASTM A36	H#DL16100682
c4	4"x3"x¼" [102x76x6], 8" [203] Long L-Bracket	ASTM A36	H#63173583/04
d1	W6x15 [W152x22.3], 72" [1,829] Long Post	ASTM A992 or ASTM A572 Gr. 50	H#59072980
d2	20"x14"x3/16" [508x356x5] Plate	ASTM A36	H#B610331
d3	63/16"x4"x½" [157x102x13] Plate	ASTM A36	H#A615621
d4	6¼"x4"x½" [159x102x13] Plate	ASTM A36	H#A615621
d5	63/16"x6"x½" [157x152x13] Plate	ASTM A36	H#A615621
e1	10"x9"x½" [254x229x13] Box Beam Cable Anchor Base Plate	ASTM A36	H#17011041
e2	4"x4"x¼" [102x102x6] Box Beam Cable Anchor Gusset	ASTM A36	H#17014221
e3	4"x4"x½" [102x102x13] Box Beam Cable Anchor Mounting Plate	ASTM A36	H#17011041

Table B-2. Bill of Materials, Test Nos. NYBWT-2 and NYBWT-3, Cont.

Item No.	Description	Material Specification	Reference
f1	Concrete	Pre-Cast Class A* Min. f'c = 3,000 psi [20.7 MPa] NE Mix 47BD	Ticket# 4203244
f2	#3 [10] Bar, 106⅝" [2,708] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	H#592415
f3	#3 [10] Bar, 117⅝" [2,988] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	H#592415
f4	#3 [10] Bar, 127⅛" [3,229] Long Unbent	ASTM A615 Gr. 60 or A996 Gr. 60	H#592415
f5	#3 [10] Bar, 39" [991] Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#592415
f6	¾" [19] Dia. UNC, Hooked Anchor J-Bolt and Nut	J-Bolt - ASTM A307 Gr. C Nut - ASTM A563DH	J-Bolts H#357216 Nut H#DL17102699
g1	14"x9"x½" [356x229x13] Cable Anchor Base Plate	ASTM A36	H#812Z45010
g2	3"x2"x¼" [76x51x6] Cable Anchor Gusset	ASTM A36	H#1713253
g3	14"x3½"x½" [356x89x13] Cable Anchor Top Plate	ASTM A36	H#216935
g4	¼" [6] Dia., 16⅜" [416] Long Brass Rod	ASTM B16-00	Fastenal COC
h1	¾" [19] Dia. UNC, 11" [279] Long Threaded Rod	ASTM A307 Gr. A or equivalent	H#AU0810817802
h2	Cable End Fitting	ASTM A153 or ASTM B695	H#BU1
h3	Cable Wedge	ASTM A47 Gr. 32510	H#BR1
h4	Crosby Threaded Turnbuckle	Stock No. 1032714	Edward W Daniels LLC COC
h5	BCT Anchor Cable End Swaged Fitting	Fitting - ASTM A576 Gr. 1035 Stud - ASTM F568 Class C	Assembly Specialty Products INC. COC
h6	¾" [19] Dia. 3x7 IWRC IPS Wire Rope - Various Lengths	ASTM A741 Type 1	H#139015 H#139021
h7	¾" [19] Dia. 6x19 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 2	WireCo WorldGroup COC
i1	7"x4"x½" [178x102x13], 3" [76] Long L-Bracket	ASTM A36	H#1049189
i2	1¾"x1¾"x10-gauge [44x44x3.4] Square Washer	ASTM A36	H#A705763
i3	27"x3"x¼" [686x76x6] Washer Plate	ASTM A36	H#17126641

Table B-3. Bill of Materials, Test Nos. NYBWT-2 and NYBWT-3, Cont.

Item No.	Description	Material Specification	Reference
j1	⅞"-9 UNC [M22x2.5], 8½" [216] Long Heavy Hex Head Bolt and Nut	Bolt - ASTM F3125 Gr. A325 Type 1 or equivalent Nut - ASTM A563DH or equivalent	Bolts: H#NF16102579 Nuts: Lot#23468-75062745
j2	¾"-10 UNC [M20x2.5], 2½" [64] Long Fully Threaded Heavy Hex Head Bolt	Bolt - ASTM F3125 Gr. A325 Type 1 or equivalent Nut - ASTM A563DH or equivalent	H# RR135745
j3	¾"-10 UNC [M20x2.5], 2" [51] Long Fully Threaded Heavy Hex Head Bolt	Bolt - ASTM F3125 Gr. A325 Type 1 or equivalent Nut - ASTM A563DH or equivalent	Fastenal COC
j4	¾"-10 UNC [M20x2.5], 8" [203] Long Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A or equivalent Nut - ASTM A563A or equivalent	Bolts: COC 210158499 Nuts: H#18100738-8
j5	¾"-10 UNC [M20x2.5], 4½" [114] Long Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A or equivalent Nut - ASTM A563A or equivalent	Bolts: H#06307630-4 Nuts: H#16203941-3
j6	½"-13 UNC [M14x2], 2" [51] Fully Threaded Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#182390
j7	½"-13 UNC [M14x2], 1½" [38] Long Fully Threaded Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A or equivalent Nut - ASTM A563A or equivalent	Bolt: H#182390; Nut: H#331703751
j8	⅜"-16 UNC [M10x1.5], 7½" [191] Long Hex Head Bolt and Nut	Bolt - ASTM A307 Gr. A or equivalent Nut - ASTM A563A or equivalent	Bolts: H#817060395 Nuts: H#16211453-3
j9	5/16"-18 UNC [M8x1.25], 2" [51] Long Fully Threaded Hex Head Bolt	Bolt - ASTM A307 Gr. A or equivalent	Bolt: H#817060395
j10	⅝"-11 UNC [M16x2], 1¼" [32] Long Guardrail Bolt and Nut	Bolt - ASTM A307 Gr. A Nut - ASTM A563A	Bolts: H#10435580 Nuts: H#10508780
k1	5/16" [8] Dia. Hardened Flat Washer	ASTM F436	H#14MD2281
k2	⅜" [10] Dia. Plain Round Washer	ASTM F844	L#M-SWE0412035-6

Table B-4. Bill of Materials, Test Nos. NYBWT-2 and NYBWT-3, Cont.

Item No.	Description	Material Specification	Reference
k3	½" [13] Dia. Plain Narrow Round Washer	SAE Low Carbon Gr. 2	L#16H-168236-10
k4	½" [13] Dia. Hardened Flat Washer	ASTM F43k6	H#281051
k5	¾" [19] Dia. Hardened Flat Washer	ASTM F436	H#3XV37 H#176413
k6	¾" [19] Dia. Plain Round Washer	ASTM F844	H#N10746
k7	⅞" [22] Dia. Hardened Flat Washer	ASTM F436	L#16H-168092-9
k8	1" [25] Dia. Plain Round Washer	ASTM F844	L#16H-168236-30
k9	1" [25] Dia. UNC Heavy Hex Nut	ASTM A563DH or equivalent	H#DL15105591
k10	¾" [19] Dia. UNC Square Nut	ASTM A563A or equivalent	H#16302167-4
k11	¾" [19] Dia. UNC Hex Nut	ASTM A563A or equivalent	H#121455
k12	¾" [19] Dia. UNC Heavy Hex Nut	ASTM A563DH or equivalent	H#DL17102699
k13	$^{5}/_{16}$" [8] Dia. UNC Hex Nut	ASTM A563A or equivalent	H#1705030200; Fastenal COC p1222717
k14	½" [13] Dia. UNC Hex Nut	ASTM A563A or equivalent	H#331703751

MWRS.

GREGORY HIGHWAY PRODUCTS, INC.
4100 13th St. SW
Canton, Ohio 44710

Customer: MIDWEST MACHINERY & SUPPLY CO.
P. O. BOX 703

MILFORD,NE,68405

Test Report
Ship Date: 4/11/2018
Customer P O: 3581
Shipped to: MIDWEST MACHINERY & SUPPLY CO.
Project: INVENTORY
GHP Order No.: 682AA

HT # code	Heat #	C.	MN.	P.	S.	SI.	Tensile	Yield	Elong.	Quantity	Class	Type	Description
1483	USL17V55879	0.21	0.61	0.01	0.007	0.017	82026	65956	24.69	29	A	1	12GA 15FT7.5IN WB T13FT1.5IN
1465	USL18L67180	0.21	0.8	0.01	0.014	0.018	76636	64565	26.32	15	A	1	12GA 12FT6IN 6FT3IN WB T1
1609	4120144	0.21	0.75	0.021	0.007	0.01	79900	58000	28	23	A	1	12GA 12FT6IN/3FT1 1/2IN WB T1
1493	USL17V67176	0.21	0.79	0.007	0.011	0.019	79316	65999	25.95	8	A	1	12GA 12FT 6IN / 3FT 1 1/2IN WB T1 RC=140
1431	4159417	0.21	0.76	0.013	0.008	0.01	79500	58100	29	11	A	1	12 GA 12FT6IN WB T1 FLEAT-SKT COMBO PAN
1465	USL18L67180	0.21	0.8	0.01	0.014	0.018	76636	64565	26.32	10	A	1	12 GA 12FT6IN WB T1 FLEAT-SKT COMBO PAN
1465	USL18L67180	0.21	0.8	0.01	0.014	0.018	76636	64565	26.32	11	A	1	12GA 9FT4 1/2IN 3FT1 1/2IN WB T1

Bolts comply with ASTM A-307 specifications and are galvanized in accordance with ASTM A-153, unless otherwise stated.
Nuts comply with ASTM A-563 specifications and are galvanized in accordance with ASTM A-153, unless otherwise stated.
All other galvanized material conforms with ASTM-123 & ASTM-653
All Galvanizing has occurred in the United States
All steel used in the manufacture is of Domestic Origin, "Made and Melted in the United States"
All Steel used meets Title 23CFR 635.410 - Buy America
All Guardrail and Terminal Sections meets AASHTO M-180, All structural steel meets AASHTO M-183 & M270
All Bolts and Nuts are of Domestic Origin
All material fabricated in accordance with Nebraska Department of Transportation
All controlled oxidized/corrosion resistant Guardrail and terminal sections meet ASTM A606, Type 4.

Jeffery S Grover

By:_____
Jeffery Grover, VP of Highway Products Sales & Marketing
Gregory Highway Products, Inc.

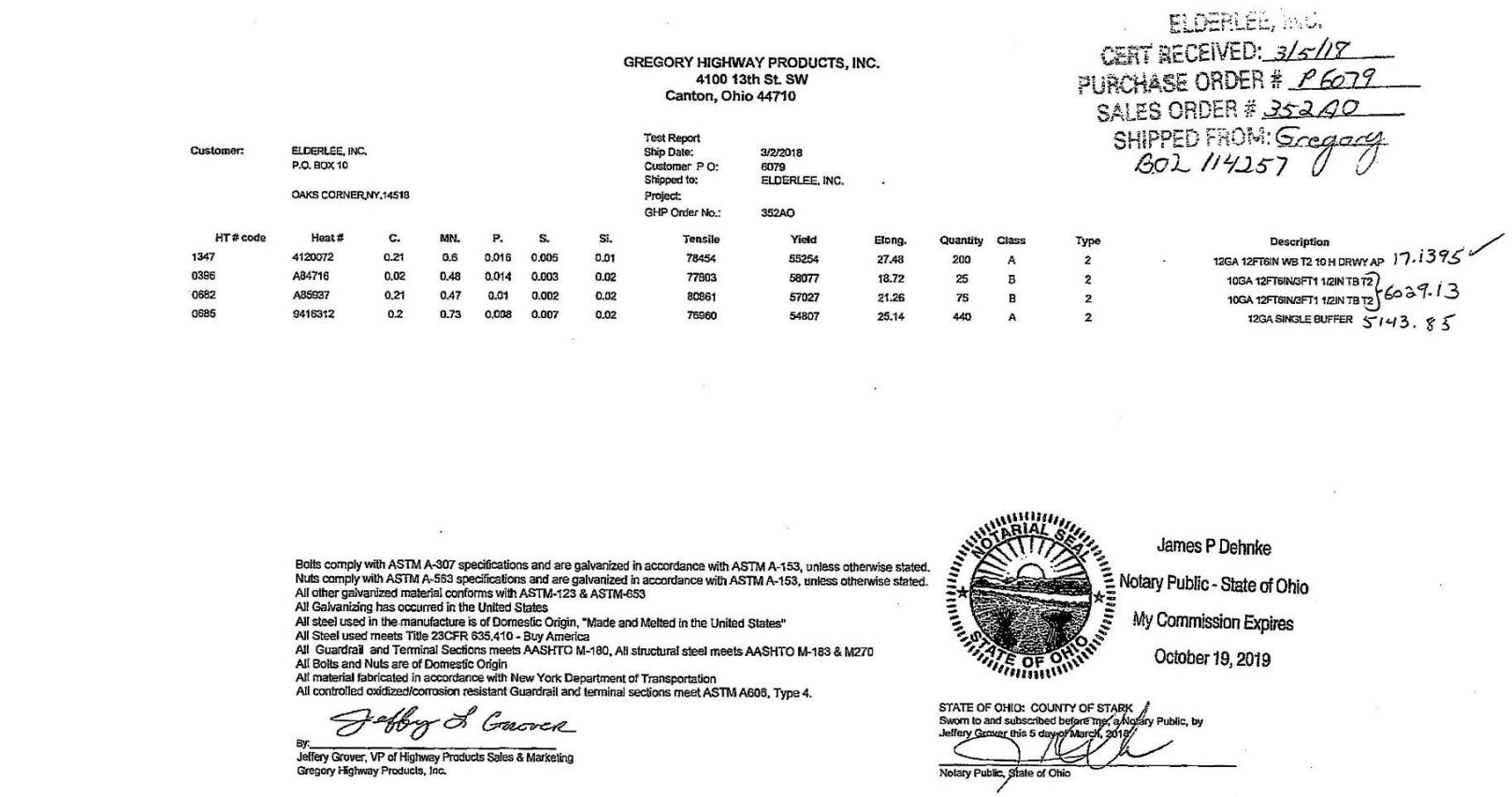
NOTARIAL SEAL
STATE OF OHIO

James P Dehnke
Notary Public - State of Ohio
My Commission Expires
October 19, 2019

STATE OF OHIO, STARK
Sworn to and subscribed before me, a Notary Public, by
Jeffery Grover this 12 day of April, 2018

Notary Public, State of Ohio

Figure B-1. W-Beam Sections, Test Nos. NYBWT-2 and NYBWT-3 (Item Nos. a1 and a2)



GREGORY HIGHWAY PRODUCTS, INC.
4100 13th St. SW
Canton, Ohio 44710

ELDERLEE, INC.
CERT RECEIVED: 3/5/18
PURCHASE ORDER # P6079
SALES ORDER # 352AO
SHIPPED FROM: Gregory
B02 114257

Customer: ELDERLEE, INC.
P.O. BOX 10
OAKS CORNER,NY,14518

Test Report
Ship Date: 3/2/2018
Customer P O: 6079
Shipped to: ELDERLEE, INC.
Project:
GHP Order No.: 352AO

HT # code	Heat #	C.	MN.	P.	S.	Si.	Tensile	Yield	Elong.	Quantity	Class	Type	Description
1347	4120072	0.21	0.6	0.016	0.005	0.01	78454	55254	27.48	200	A	2	12GA 12FT6IN WB T2 10 H DRWY AP 17.1395
0396	A84716	0.02	0.48	0.014	0.003	0.02	77803	58077	18.72	25	B	2	10GA 12FT6IN/3FT1 1/2IN TB T2
0682	A85937	0.21	0.47	0.01	0.002	0.02	80861	57027	21.26	75	B	2	10GA 12FT6IN/3FT1 1/2IN TB T2 6029.13
0695	9416312	0.2	0.73	0.008	0.007	0.02	75960	54807	25.14	440	A	2	12GA SINGLE BUFFER 5143.85

Bolts comply with ASTM A-307 specifications and are galvanized in accordance with ASTM A-153, unless otherwise stated.
Nuts comply with ASTM A-563 specifications and are galvanized in accordance with ASTM A-153, unless otherwise stated.
All other galvanized material conforms with ASTM-123 & ASTM-653
All Galvanizing has occurred in the United States
All steel used in the manufacture is of Domestic Origin, "Made and Melted in the United States"
All Steel used meets Title 23CFR 635.410 - Buy America
All Guardrail and Terminal Sections meets AASHTO M-180, All structural steel meets AASHTO M-183 & M270
All Bolts and Nuts are of Domestic Origin
All material fabricated in accordance with New York Department of Transportation
All controlled oxidized/corrosion resistant Guardrail and terminal sections meet ASTM A606, Type 4.

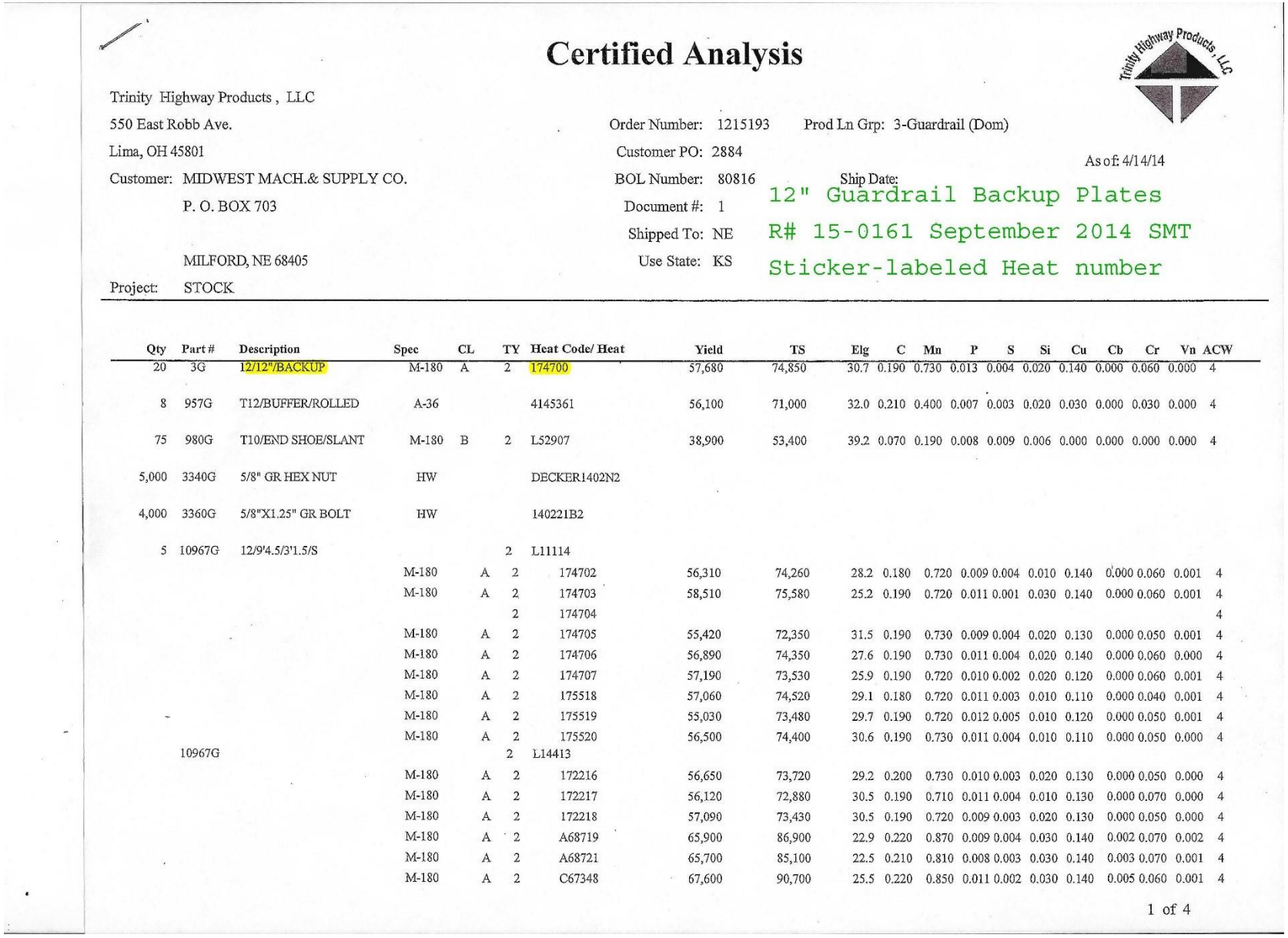
Jeffery L Grover
By:
Jeffery Grover, VP of Highway Products Sales & Marketing
Gregory Highway Products, Inc.

NOTARIAL SEAL STATE OF OHIO

James P Dehnke
Notary Public - State of Ohio
My Commission Expires
October 19, 2019

STATE OF OHIO: COUNTY OF STARK
Sworn to and subscribed before me, a Notary Public, by
Jeffery Grover this 5 day of March, 2018.
Notary Public, State of Ohio

Figure B-2. W-Beam Curved Section, Test Nos. NYBWT-2 and NYBWT-3 (Item No. a3)



Certified Analysis

Trinity Highway Products , LLC
550 East Robb Ave.
Lima, OH 45801
Customer: MIDWEST MACH.& SUPPLY CO.
P. O. BOX 703
MILFORD, NE 68405
Project: STOCK

Order Number: 1215193 Prod Ln Grp: 3-Guardrail (Dom)
Customer PO: 2884
BOL Number: 80816
Document #: 1
Shipped To: NE
Use State: KS

As of: 4/14/14
Ship Date:

12" Guardrail Backup Plates
R# 15-0161 September 2014 SMT
Sticker-labeled Heat number

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn	ACW
20	3G	12/12"/BACKUP	M-180	A	2	174700	57,680	74,850	30.7	0.190	0.730	0.013	0.004	0.020	0.140	0.000	0.060	0.000	4
8	957G	T12/BUFFER/ROLLED	A-36			4145361	56,100	71,000	32.0	0.210	0.400	0.007	0.003	0.020	0.030	0.000	0.030	0.000	4
75	980G	T10/END SHOE/SLANT	M-180	B	2	L52907	38,900	53,400	39.2	0.070	0.190	0.008	0.009	0.006	0.000	0.000	0.000	0.000	4
5,000	3340G	5/8" GR HEX NUT	HW			DECKER1402N2													
4,000	3360G	5/8"X1.25" GR BOLT	HW			140221B2													
5	10967G	12/9'4.5/3'1.5/S			2	L11114													
			M-180	A	2	174702	56,310	74,260	28.2	0.180	0.720	0.009	0.004	0.010	0.140	0.000	0.060	0.001	4
			M-180	A	2	174703	58,510	75,580	25.2	0.190	0.720	0.011	0.001	0.030	0.140	0.000	0.060	0.001	4
					2	174704													4
			M-180	A	2	174705	55,420	72,350	31.5	0.190	0.730	0.009	0.004	0.020	0.130	0.000	0.050	0.001	4
			M-180	A	2	174706	56,890	74,350	27.6	0.190	0.730	0.011	0.004	0.020	0.140	0.000	0.060	0.000	4
			M-180	A	2	174707	57,190	73,530	25.9	0.190	0.720	0.010	0.002	0.020	0.120	0.000	0.060	0.001	4
			M-180	A	2	175518	57,060	74,520	29.1	0.180	0.720	0.011	0.003	0.010	0.110	0.000	0.040	0.001	4
			M-180	A	2	175519	55,030	73,480	29.7	0.190	0.720	0.012	0.005	0.010	0.120	0.000	0.050	0.001	4
			M-180	A	2	175520	56,500	74,400	30.6	0.190	0.730	0.011	0.004	0.010	0.110	0.000	0.050	0.000	4
	10967G				2	L14413													
			M-180	A	2	172216	56,650	73,720	29.2	0.200	0.730	0.010	0.003	0.020	0.130	0.000	0.050	0.000	4
			M-180	A	2	172217	56,120	72,880	30.5	0.190	0.710	0.011	0.004	0.010	0.130	0.000	0.070	0.000	4
			M-180	A	2	172218	57,090	73,430	30.5	0.190	0.720	0.009	0.003	0.020	0.130	0.000	0.050	0.000	4
			M-180	A	2	A68719	65,900	86,900	22.9	0.220	0.870	0.009	0.004	0.030	0.140	0.002	0.070	0.002	4
			M-180	A	2	A68721	65,700	85,100	22.5	0.210	0.810	0.008	0.003	0.030	0.140	0.003	0.070	0.001	4
			M-180	A	2	C67348	67,600	90,700	25.5	0.220	0.850	0.011	0.002	0.030	0.140	0.005	0.060	0.001	4

1 of 4

Figure B-3. W-Beam Backup Plate, Test Nos. NYBWT-2 and NYBWT-3 (Item No. a4)

Customer Name	Customer PO#	Shipper No	Heat Number
Elderlee Inc	PO05930	820439	842W32370

12Ga Sheet
20x70 A1011

CERTIFIED TEST REPORT

*CENTER STEEL SALES, INC.
6645 ROOSEVELT AVENUE
ALLEN PARK, MI 48101
****

DATE: 9/19/17

SOLD TO: KLEIN STEEL SERVICE INC.
105 VANGUARD PKWY
ROCHESTER, NY 14606

SHIP TO: KLEIN STEEL SERVICE INC.
105 VANGUARD PKWY
ROCHESTER, NY 14606
CALL 1-585-328-4000 EXT. 106

Cust P/O# AC7389 Part# (HT# & P
SalesOrdr# 900598 01
SIZE: .104 NOM X 72.00 X 120.00

GRADE: HOT ROLLED ASTM A1011 CS/B MILL EDGE SHEETS

DATE SHPPD: 9/19/17

Wt.Shipped 5260

CHEMICAL ANALYSIS

Heat Number 842W32370

C : .03	Mn: .19	P : .008	S : .007
Si: .007	Ti: .002	Cr: .020	Mo: .002
Cu: .015	Al: .051	Cb: .002	V : .001
			N : .002
B : .004		Ni: .010	

PHYSICAL PROPERTIES

Misc Info
MELTED & MFG IN THE USA
EN10204 3.1
BOL# 17145

WE HEREBY CERTIFY THE ABOVE FIGURES ARE ACCURATELY STATED, MEET YOUR MATERIAL REQUIREMENTS AND ARE TRACEABLE IN OUR RECORDS BACK TO THE PRODUCER AND/OR AN ACCREDITED TEST LABORATORY.

QUALITY CONTROL MANAGER

ELDERLEE, INC.
CERT RECEIVED: 9/21/17
PURCHASE ORDER # P5930
SALES ORDER # 820439
SHIPPED FROM: Klein Steel

Figure B-4. Box Beam to W-Beam Transition Cover, Test Nos. NYBWT-2 and NYBWT-3 (Item No. a5)

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: DKydorst

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 B-5. TS6x6x$^{3}/_{16}$ Box Beams, Test Nos. NYBWT-2 and NYBWT-3 (Item Nos. b1, b2, and b3)

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			Reduction Ratio
A	B	C	D	Q	S	Frequency	Severity	R	C	S	10.4 : 1
				T H T H		MELTED & MANUFACTURED IN THE USA					

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			

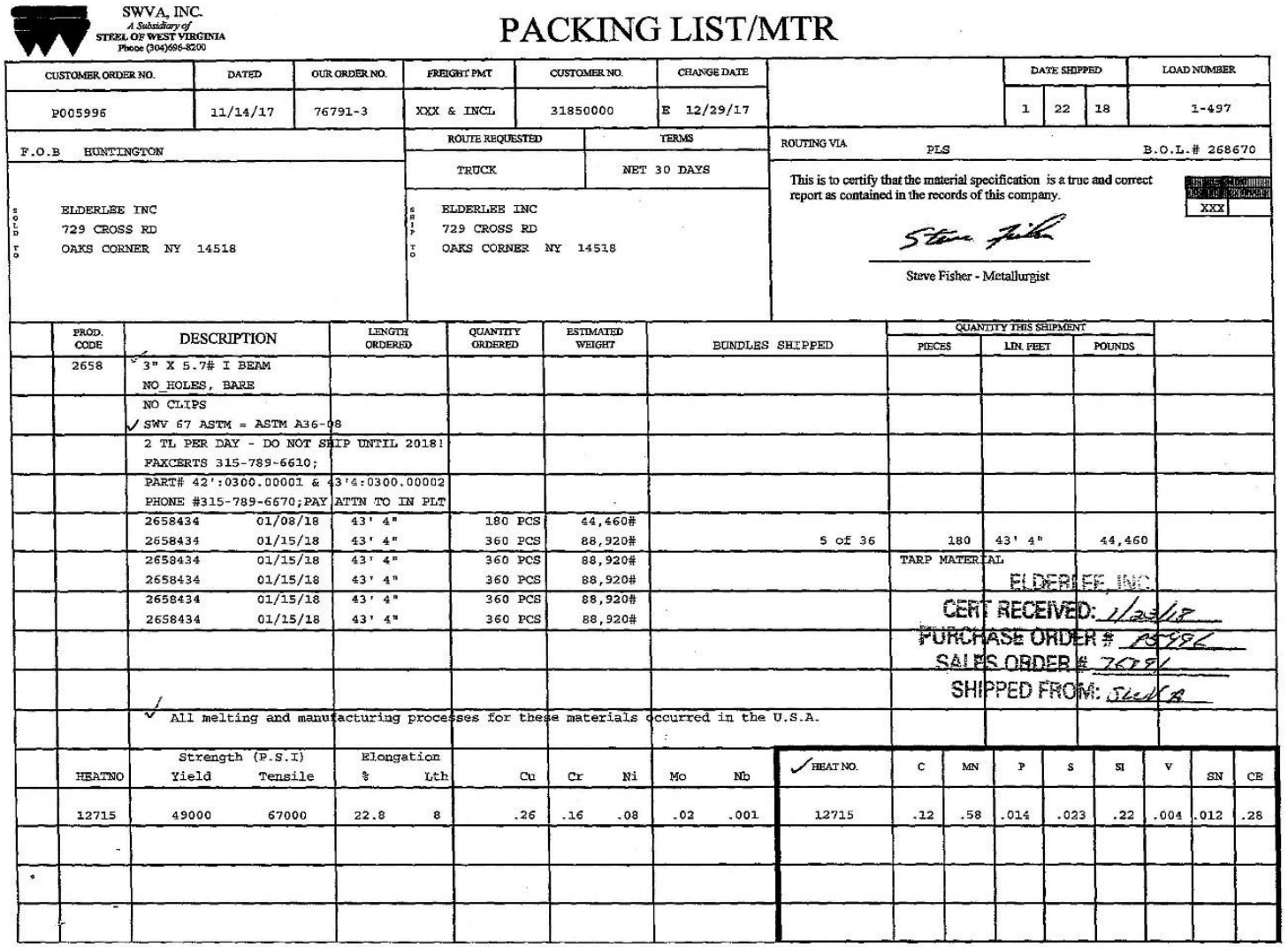
Hardness

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

Charpy

Temp	Size	Longitudinal			Transverse
20	FA	62	64	78	

Figure B-6. Splice Plates, Test Nos. NYBWT-2 and NYBWT-3 (Item No. b4)



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

PACKING LIST/MTR

CUSTOMER ORDER NO.	DATED	OUR ORDER NO.	FREIGHT PMT	CUSTOMER NO.	CHANGE DATE	DATE SHIPPED	LOAD NUMBER
P005996	11/14/17	76791-3	XXX & INCL	31850000	E 12/29/17	1 22 18	1-497

F.O.B HUNTINGTON

ROUTE REQUESTED: TRUCK

TERMS: NET 30 DAYS

ROUTING VIA PLS

B.O.L.# 268670

SOLD TO: ELDERLEE INC
729 CROSS RD
OAKS CORNER NY 14518

SHIP TO: ELDERLEE INC
729 CROSS RD
OAKS CORNER NY 14518

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

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 67 ASTM = ASTM A36-08							
	2 TL PER DAY - DO NOT SHIP UNTIL 2018!							
	FAXCERTS 315-789-6610;							
	PART# 42':0300.00001 & 43'4:0300.00002							
	PHONE #315-789-6670;PAY ATTN TO IN PLT							
	2658434 01/08/18	43' 4"	180 PCS	44,460#				
	2658434 01/15/18	43' 4"	360 PCS	88,920#	5 of 36	180	43' 4"	44,460
	2658434 01/15/18	43' 4"	360 PCS	88,920#		TARP MATERIAL		
	2658434 01/15/18	43' 4"	360 PCS	88,920#				
	2658434 01/15/18	43' 4"	360 PCS	88,920#				
	2658434 01/15/18	43' 4"	360 PCS	88,920#				

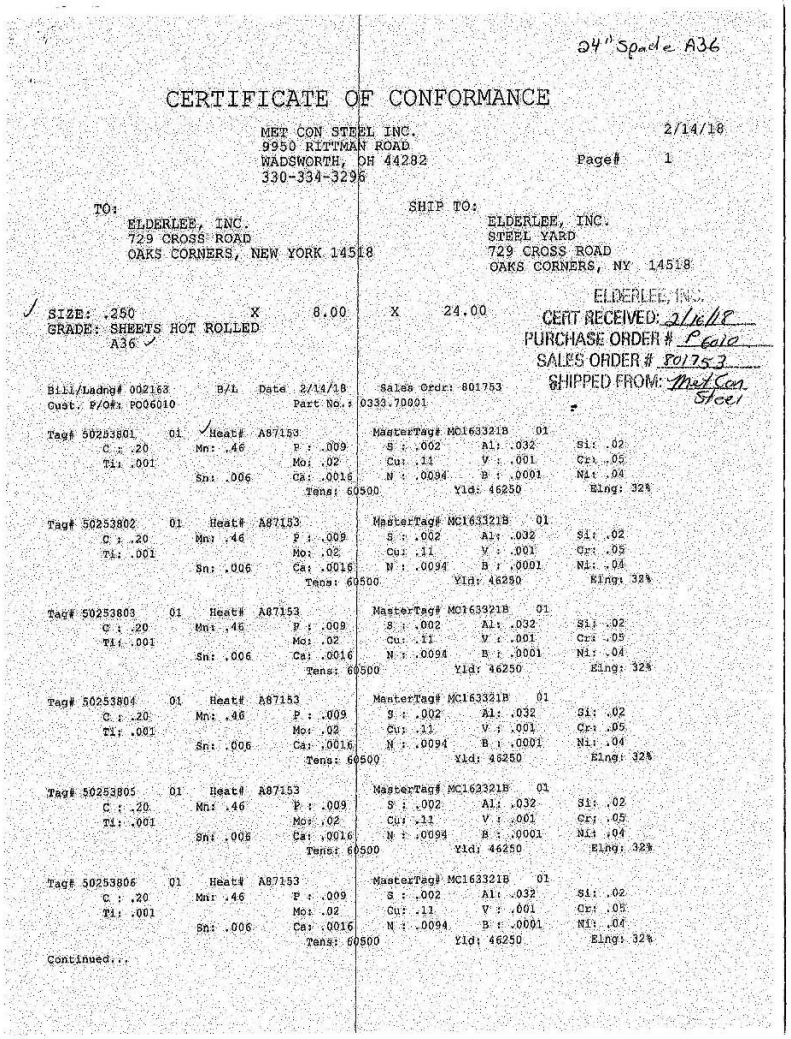
ELDERLEE, INC.
CERT RECEIVED: 1/23/18
PURCHASE ORDER # B598
SALES ORDER # 7078
SHIPPED FROM: Sheet B

All melting and manufacturing processes for these materials occurred in the U.S.A.

HEATNO	Strength (P.S.I) Yield	Tensile	Elongation %	Lth	Cu	Cr	Ni	Mo	Nb
12715	49000	67000	22.8	8	.26	.16	.08	.02	.001

HEAT NO.	C	MN	P	S	SI	V	SN	CE
12715	.12	.58	.014	.023	.22	.004	.012	.28

Figure B-7. S3X5.7 65-in. (1,651-mm) Long Posts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. c1)



24" Spade A36

CERTIFICATE OF CONFORMANCE

MET CON STEEL INC.
9950 RITTMAN ROAD
WADSWORTH, OH 44282
330-334-3296

2/14/18

Page# 1

TO:
ELDERLEE, INC.
729 CROSS ROAD
OAKS CORNERS, NEW YORK 14518

SHIP TO:
ELDERLEE, INC.
STEEL YARD
729 CROSS ROAD
OAKS CORNERS, NY 14518

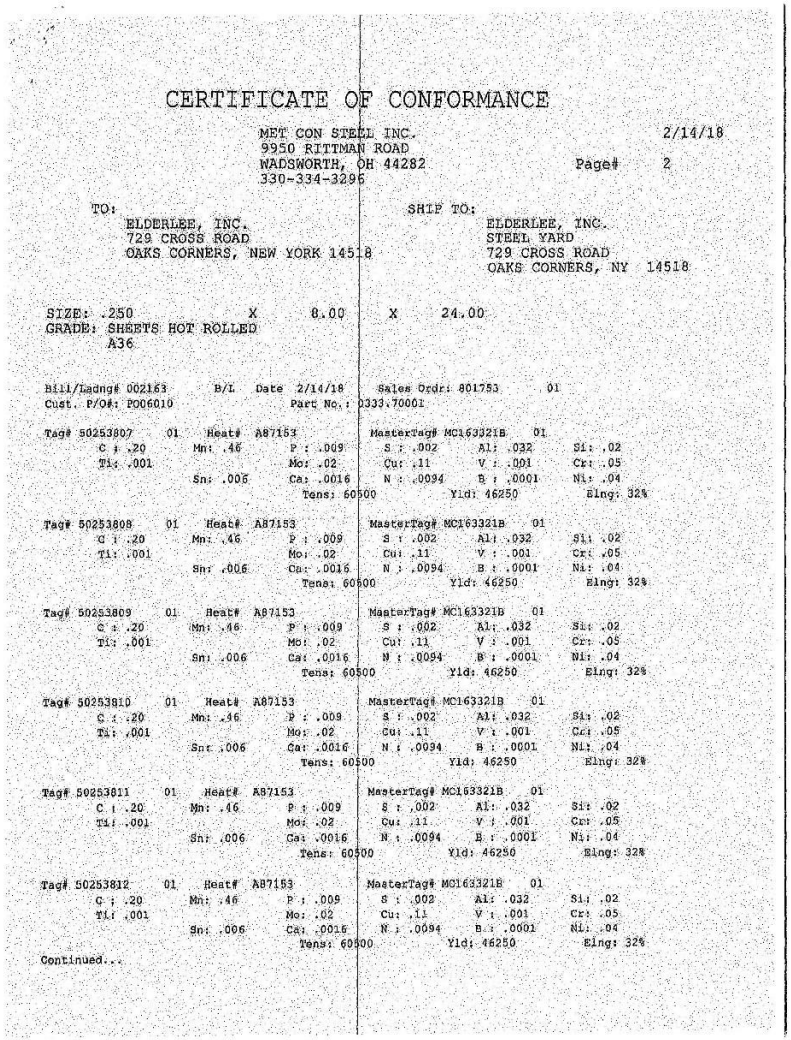
ELDERLEE, INC.
CERT RECEIVED: 2/16/18
PURCHASE ORDER # P6010
SALES ORDER # 801753
SHIPPED FROM: Met Con Steel

SIZE: .250 X 8.00 X 24.00
GRADE: SHEETS HOT ROLLED
A36

Bill/Ladng# 002163 B/L Date 2/14/18 Sales Ordr: 801753
Cust. P/O#: PO06010 Part No.: 0333.70001

Tag# 50253801 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253802 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253803 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253804 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253805 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253806 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	

Continued...



CERTIFICATE OF CONFORMANCE

MET CON STEEL INC.
9950 RITTMAN ROAD
WADSWORTH, OH 44282
330-334-3296

2/14/18

Page# 2

TO:
ELDERLEE, INC.
729 CROSS ROAD
OAKS CORNERS, NEW YORK 14518

SHIP TO:
ELDERLEE, INC.
STEEL YARD
729 CROSS ROAD
OAKS CORNERS, NY 14518

SIZE: .250 X 8.00 X 24.00
GRADE: SHEETS HOT ROLLED
A36

Bill/Ladng# 002163 B/L Date 2/14/18 Sales Ordr: 801753 01
Cust. P/O#: PO06010 Part No.: 0333.70001

Tag# 50253807 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253808 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253809 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253810 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253811 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	
Tag# 50253812 01	Heat# A87153	MasterTag# MC163321B 01				
C : .20	Mn: .46	P : .009	S : .002	Al: .032	Si: .02	
Ti: .001		Mo: .02	Cu: .11	V : .001	Cr: .05	
	Sn: .006	Ca: .0016	N : .0094	B : .0001	Ni: .04	
		Tens: 60500	Yld: 46250		Elng: 32%	

Continued...

Figure B-8. Soil Plates, Test Nos. NYBWT-2 and NYBWT-3 (Item No. c2)

NUCOR
NUCOR CORPORATION
NUCOR STEEL SOUTH CAROLINA

Mill Certification
3/15/2016

MTR #: C1-366424
300 Steel Mill Road
DARLINGTON, SC 29540
(843) 393-6841
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

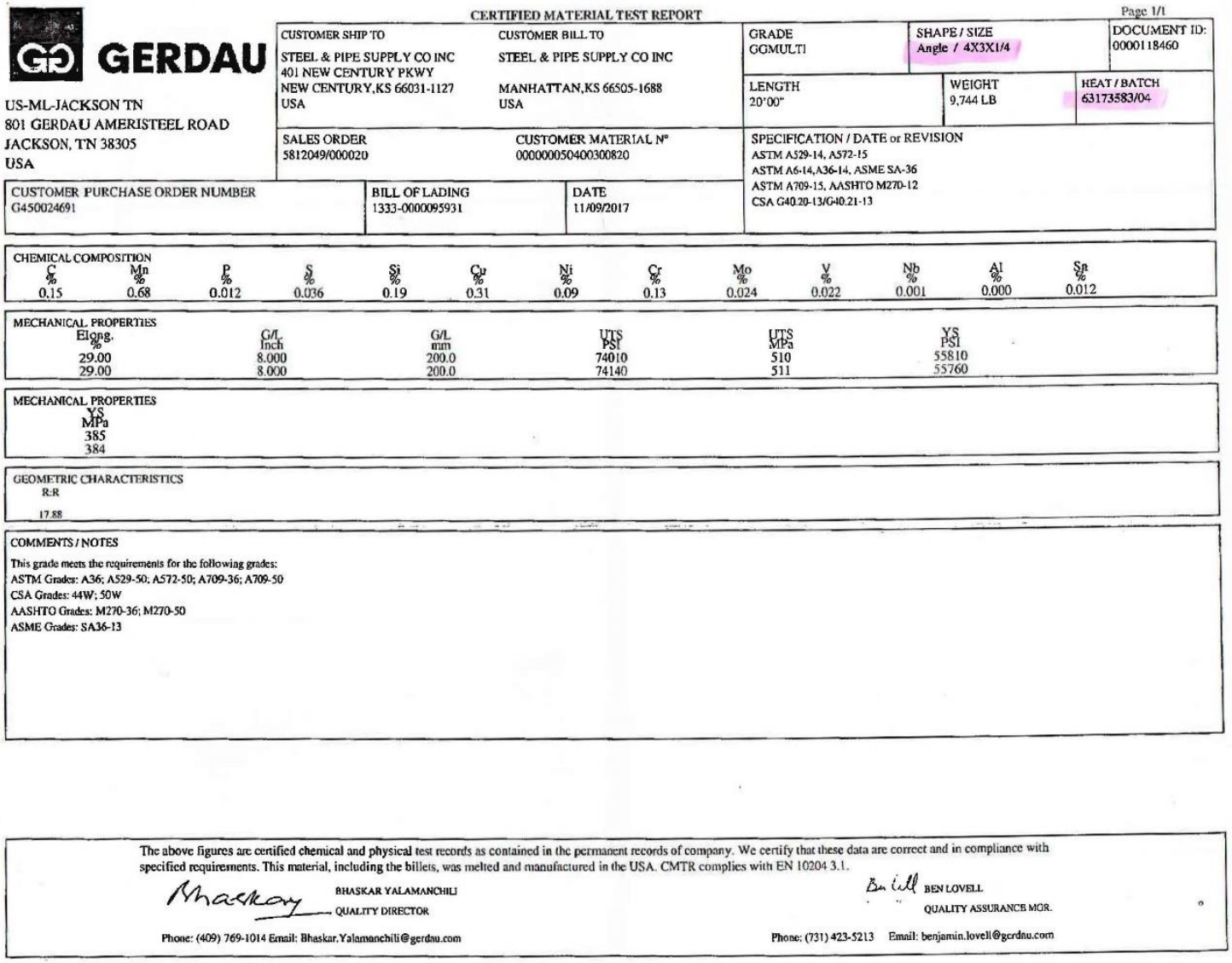
1. WELDING OR WELD REPAIR WAS NOT PERFORMED ON THIS MATERIAL
2. MELTED AND MANUFACTURED IN THE USA
3. MERCURY, RADIUM, OR ALPHA SOURCE MATERIALS IN ANY FORM HAVE NOT BEEN USED IN THE PRODUCTION OF THIS MATERIAL

James H. Blew
Division Metallurgist

NBMG-10 January 1, 2012

Page 1 of 4

Figure B-9. 5 x 3½ x ⅜-in. (127 x 89 x 10-mm), 4½-in. (114-mm) Long L-Brackets, Test Nos. NYBWT-2 and NYBWT-3 (Item No. c3)



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 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 / 4X3X1/4	0000118460

LENGTH	WEIGHT	HEAT / BATCH
20'00"	9,744 LB	63173583/04

SALES ORDER	CUSTOMER MATERIAL Nº
5812049/000020	000000050400300820

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
G450024691	1333-0000095931	11/09/2017

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	V %	Nb %	Al %	Sn %
0.15	0.68	0.012	0.036	0.19	0.31	0.09	0.13	0.024	0.022	0.001	0.000	0.012

MECHANICAL PROPERTIES

Elong. %	G/L Inch	G/L mm	UTS PSI	UTS MPa	YS PSI
29.00	8.000	200.0	74010	510	55810
29.00	8.000	200.0	74140	511	55760

MECHANICAL PROPERTIES

YS MPa
385
384

GEOMETRIC CHARACTERISTICS
R:R
17.88

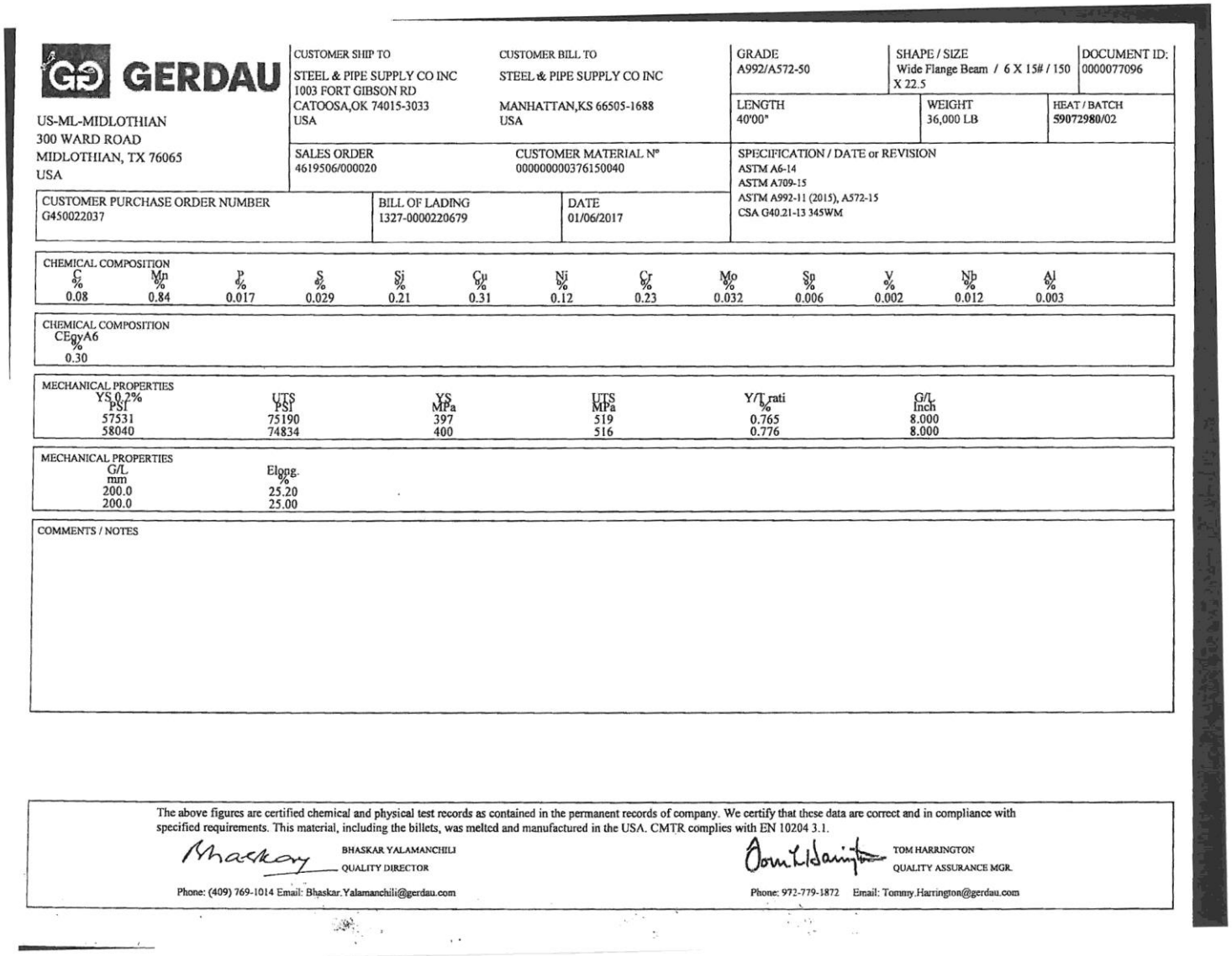
COMMENTS / NOTES
This grade meets the requirements for the following grades:
ASTM Grades: A36; A529-50; A572-50; A709-36; A709-50
CSA Grades: 44W; 50W
AASHTO Grades: M270-36; M270-50
ASME Grades: SA36-13

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 B-10. 4 x 3 x ¼-in. (102 x 76 x 6-mm), 8-in. (203-mm) Long L-Bracket, Test Nos. NYBWT-2 and NYBWT-3 (Item No. c4)



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 B-11. W6X15, 72-in. (1,829-mm) Long Posts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. d1)

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

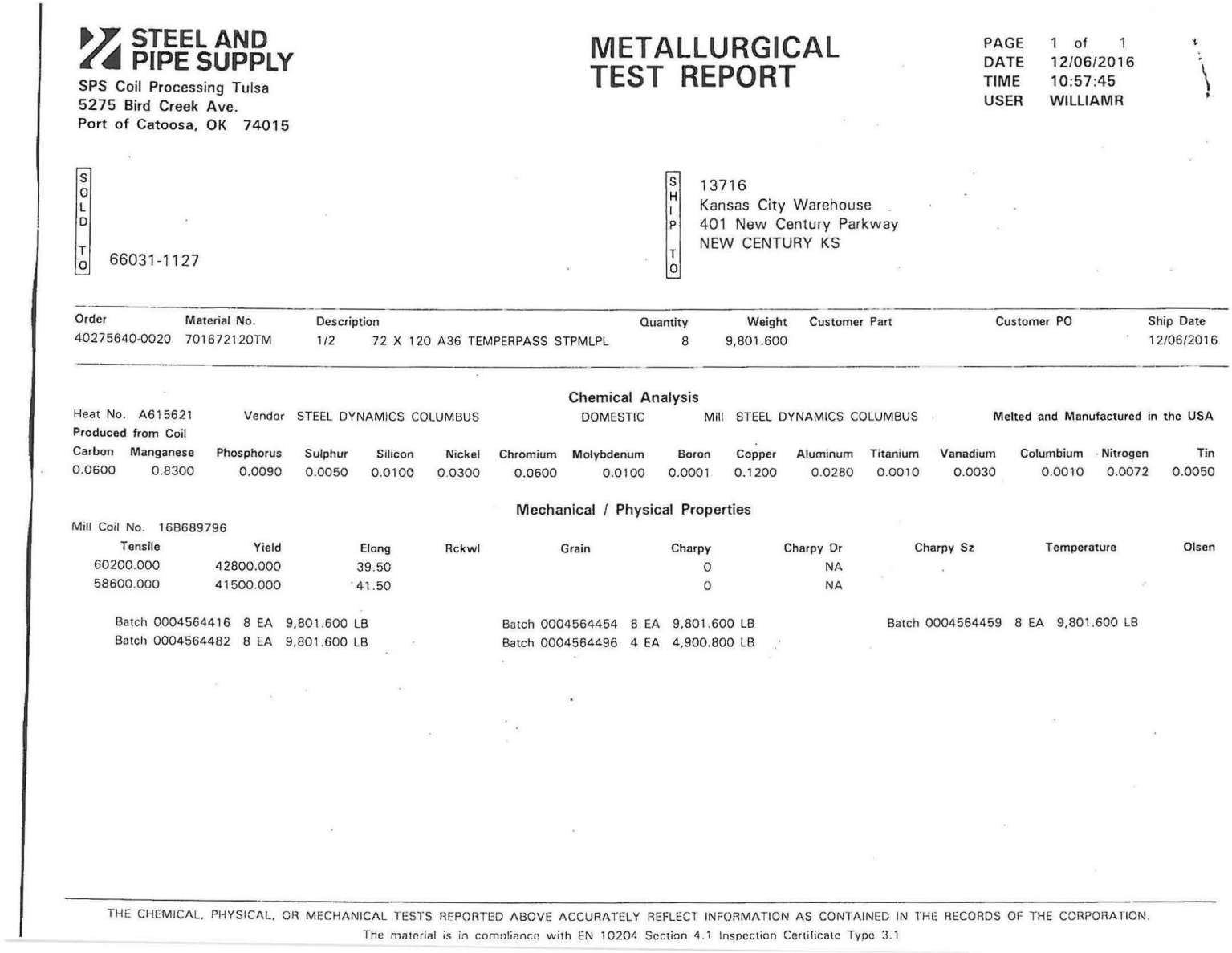
Mill Coil No. 16B651290

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 B-12. 20 x 14 x $^{3}/_{16}$-in. (508 x 356 x 5-mm) Plate, Test Nos. NYBWT-2 and NYBWT-3 (Item No. d2)



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

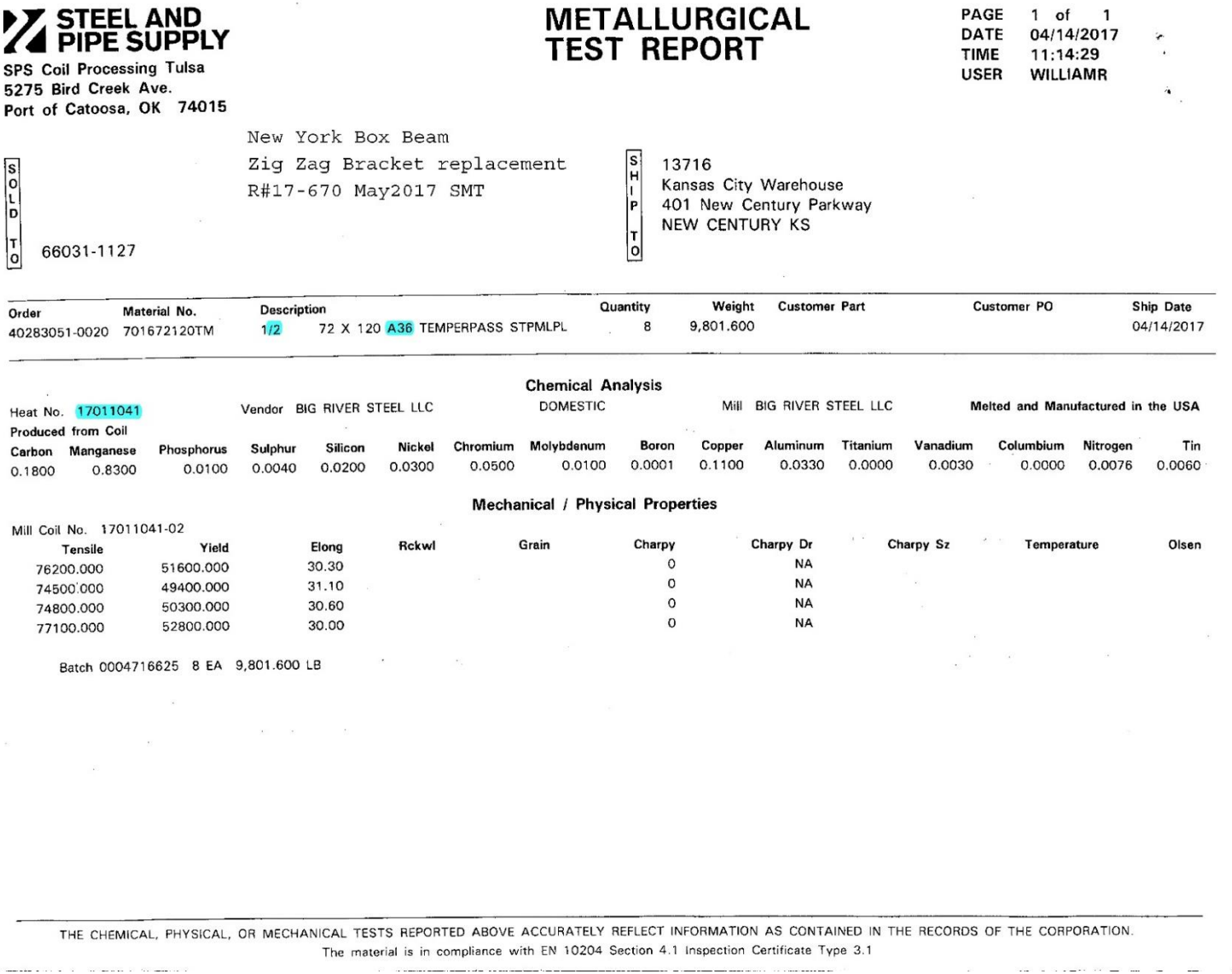
Mill Coil No. 16B689796

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 B-13. Steel Plates, Test Nos. NYBWT-2 and NYBWT-3 (Item Nos. d3, d4, and d5)



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 B-14. Box Beam Cable Anchor Mounting Plate and Base Plate, Test Nos. NYBWT-2 and NYBWT-3 (Item Nos. e1 and e3)

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

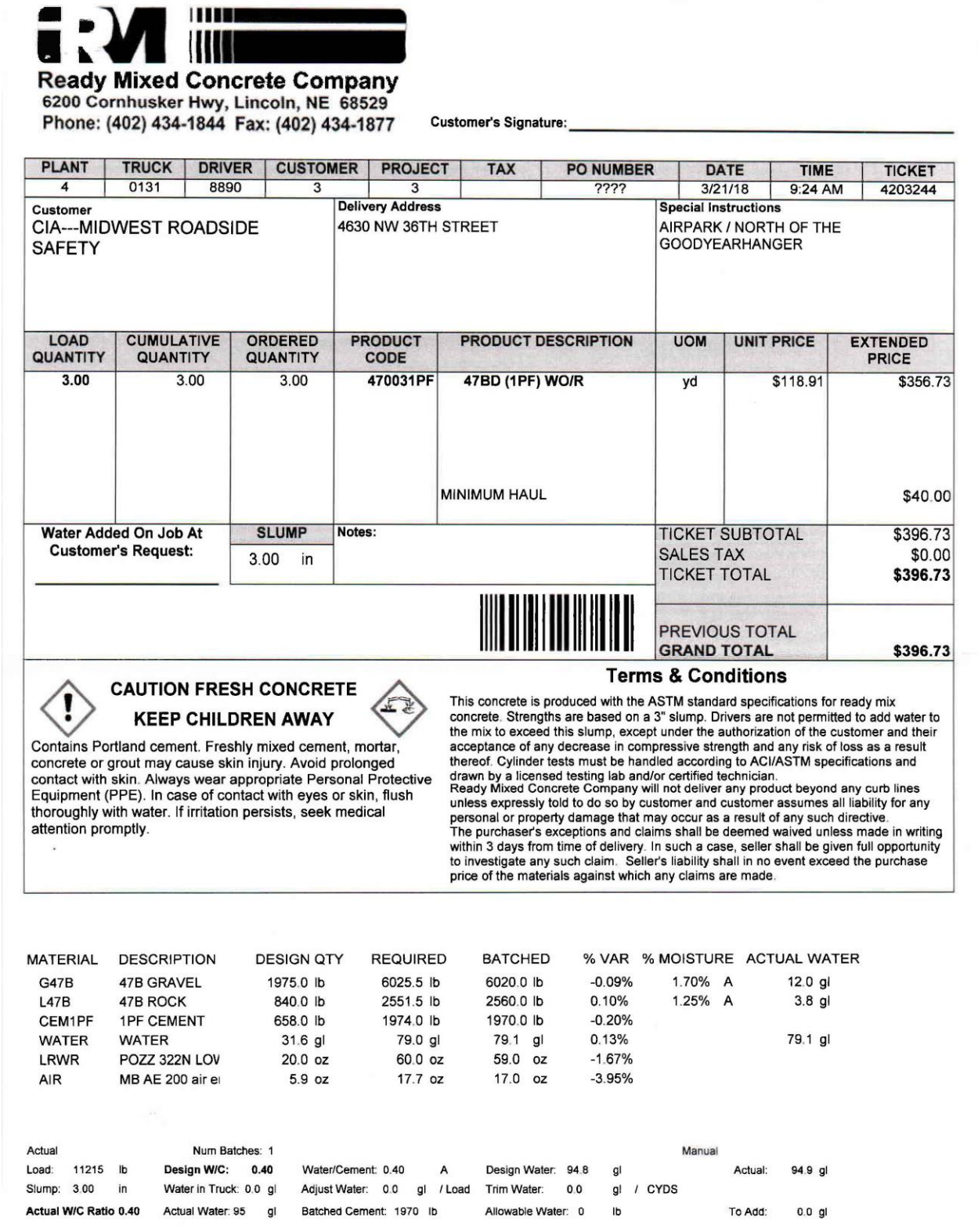
Mill Coil No. 17014221-04

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 B-15. Box Beam Cable Anchor Gusset, Test Nos. NYBWT-2 and NYBWT-3 (Item No. e2)



Ready Mixed Concrete Company
6200 Cornhusker Hwy, Lincoln, NE 68529
Phone: (402) 434-1844 Fax: (402) 434-1877

Customer's Signature: _____

PLANT	TRUCK	DRIVER	CUSTOMER	PROJECT	TAX	PO NUMBER	DATE	TIME	TICKET
4	0131	8890	3	3		????	3/21/18	9:24 AM	4203244

Customer	Delivery Address	Special Instructions
CIA---MIDWEST ROADSIDE SAFETY	4630 NW 36TH STREET	AIRPARK / NORTH OF THE GOODYEARHANGER

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDERED QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	EXTENDED PRICE
3.00	3.00	3.00	470031PF	47BD (1PF) WO/R	yd	$118.91	$356.73
				MINIMUM HAUL			$40.00

Water Added On Job At Customer's Request:	SLUMP	Notes:		
	3.00 in		TICKET SUBTOTAL	$396.73
			SALES TAX	$0.00
			TICKET TOTAL	**$396.73**
			PREVIOUS TOTAL	
			GRAND TOTAL	**$396.73**

CAUTION FRESH CONCRETE
KEEP CHILDREN AWAY

Contains Portland cement. Freshly mixed cement, mortar, concrete or grout may cause skin injury. Avoid prolonged contact with skin. Always wear appropriate Personal Protective Equipment (PPE). In case of contact with eyes or skin, flush thoroughly with water. If irritation persists, seek medical attention promptly.

Terms & Conditions

This concrete is produced with the ASTM standard specifications for ready mix concrete. Strengths are based on a 3" slump. Drivers are not permitted to add water to the mix to exceed this slump, except under the authorization of the customer and their acceptance of any decrease in compressive strength and any risk of loss as a result thereof. Cylinder tests must be handled according to ACI/ASTM specifications and drawn by a licensed testing lab and/or certified technician.
Ready Mixed Concrete Company will not deliver any product beyond any curb lines unless expressly told to do so by customer and customer assumes all liability for any personal or property damage that may occur as a result of any such directive.
The purchaser's exceptions and claims shall be deemed waived unless made in writing within 3 days from time of delivery. In such a case, seller shall be given full opportunity to investigate any such claim. Seller's liability shall in no event exceed the purchase price of the materials against which any claims are made.

MATERIAL	DESCRIPTION	DESIGN QTY	REQUIRED	BATCHED	% VAR	% MOISTURE	ACTUAL WATER
G47B	47B GRAVEL	1975.0 lb	6025.5 lb	6020.0 lb	-0.09%	1.70% A	12.0 gl
L47B	47B ROCK	840.0 lb	2551.5 lb	2560.0 lb	0.10%	1.25% A	3.8 gl
CEM1PF	1PF CEMENT	658.0 lb	1974.0 lb	1970.0 lb	-0.20%		
WATER	WATER	31.6 gl	79.0 gl	79.1 gl	0.13%		79.1 gl
LRWR	POZZ 322N LOV	20.0 oz	60.0 oz	59.0 oz	-1.67%		
AIR	MB AE 200 air e	5.9 oz	17.7 oz	17.0 oz	-3.95%		

Actual — Num Batches: 1 — Manual

Load: 11215 lb | **Design W/C: 0.40** | Water/Cement: 0.40 A | Design Water: 94.8 gl | Actual: 94.9 gl

Slump: 3.00 in | Water in Truck: 0.0 gl | Adjust Water: 0.0 gl / Load | Trim Water: 0.0 gl / CYDS

Actual W/C Ratio 0.40 | Actual Water: 95 gl | Batched Cement: 1970 lb | Allowable Water: 0 lb | To Add: 0.0 gl

Figure B-16. Concrete, Test Nos. NYBWT-2 and NYBWT-3 (Item No. f1)

EVRAZ ROCKY MOUNTAIN STEEL
A DIVISION OF EVRAZ INC. NA

2100 S. Freeway
Pueblo, CO 81004 USA

MATERIAL TEST REPORT

Date Printed: 20-OCT-17

Date Shipped: 20-OCT-17 | Product: DEF #3 (3/8") | Specification: ASTM A706/A615 GR 60

FWIP: 52815347 | Customer: ERMS | Cust. PO:

P.O. BOX 316
PUEBLO, CO 81002

CHEMICAL ANALYSIS (In Weight %, uncertainty of measurement 0.005%)

(Heat cast 04/24/17)

Heat Number	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al	V	B	Cb	Sn	N	Ti
592415	0.26	1.26	0.009	0.024	0.27	0.27	0.08	0.12	0.018	0.003	0.039	0.0005	0.000	0.010	0.0083	0.001

Carbon Equivalent – 0.488

MECHANICAL PROPERTIES (Tensiles test date 04/28/17)

Heat Number	Sample No.		Yield (Psi)	Ultimate (Psi)	Elongation (%)	Reduction (%)	Bend	Wt/ft
592415	01		66902	101000	15.6		OK	0.377
		(MPa)	461.3	696.4				
592415	02		67349	100310	15.8		OK	0.377
		(MPa)	464.4	691.6				

All melting and manufacturing processes of the material subject to this test certificate occurred in the United States of America.
ERMS also certifies this material to be free from Mercury contamination.

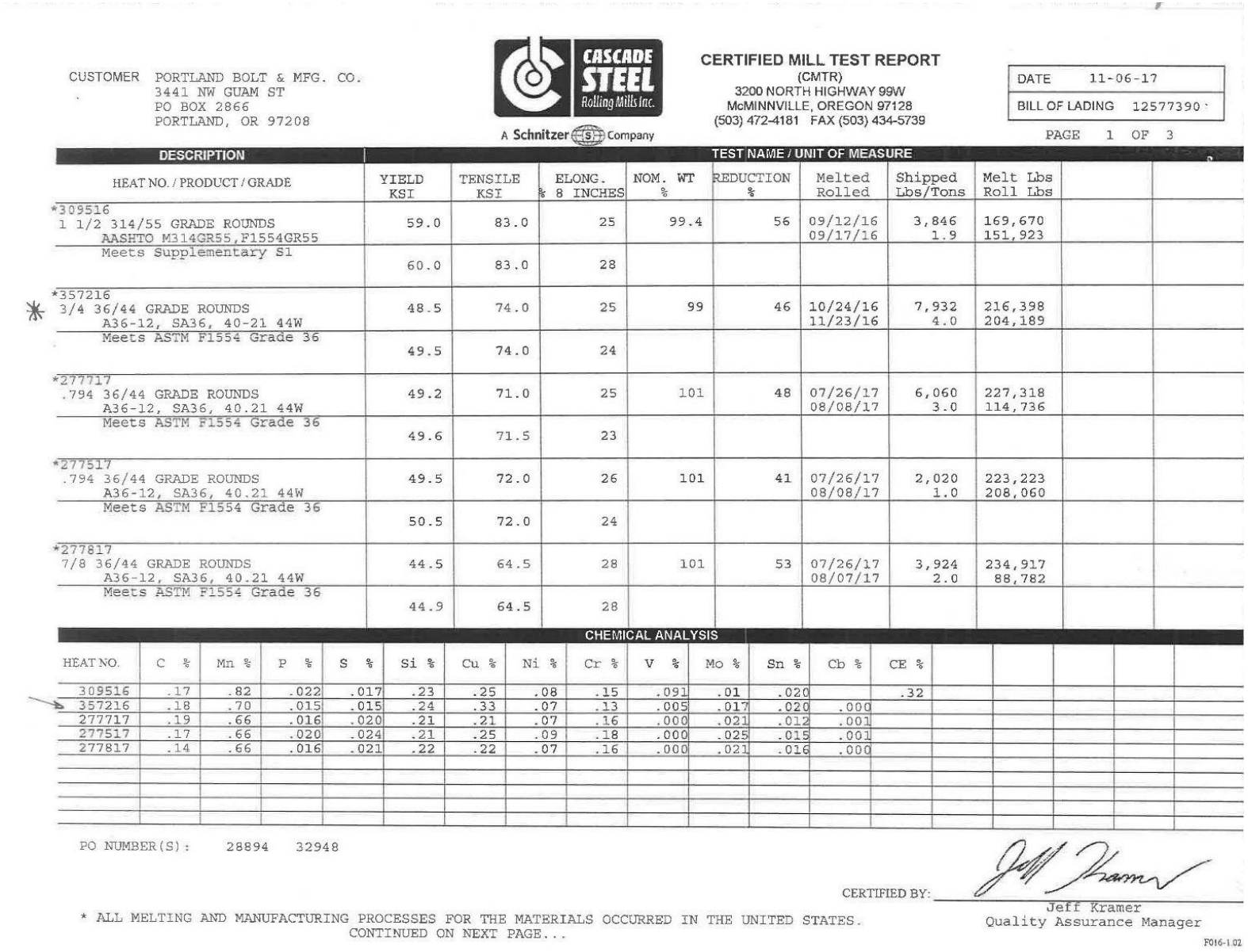
This material has been produced, tested and conforms to the requirements of the applicable specifications. We hereby certify that the above test results represent those contained in the records of the Company.

Methods used: ASTM A370, A510, A615, A706.

Material test report shall not be reproduced except in full, without approval of the company.

Bryce Lakamp
Process Control Engineer

Figure B-17. No. 3 Reinforcement Bar, Test Nos. NYBWT-2 and NYBWT-3 (Item Nos. f2, f3, f4, and f5)



CUSTOMER PORTLAND BOLT & MFG. CO.
3441 NW GUAM ST
PO BOX 2866
PORTLAND, OR 97208

CASCADE STEEL Rolling Mills Inc.
A Schnitzer Company

CERTIFIED MILL TEST REPORT
(CMTR)
3200 NORTH HIGHWAY 99W
McMINNVILLE, OREGON 97128
(503) 472-4181 FAX (503) 434-5739

DATE 11-06-17
BILL OF LADING 12577390

PAGE 1 OF 3

DESCRIPTION	TEST NAME / UNIT OF MEASURE									
HEAT NO. / PRODUCT / GRADE	YIELD KSI	TENSILE KSI	ELONG. % 8 INCHES	NOM. WT %	REDUCTION %	Melted Rolled	Shipped Lbs/Tons	Melt Lbs Roll Lbs		
*309516 1 1/2 314/55 GRADE ROUNDS AASHTO M314GR55,F1554GR55	59.0	83.0	25	99.4	56	09/12/16 09/17/16	3,846 1.9	169,670 151,923		
Meets Supplementary S1	60.0	83.0	28							
*357216 3/4 36/44 GRADE ROUNDS A36-12, SA36, 40-21 44W	48.5	74.0	25	99	46	10/24/16 11/23/16	7,932 4.0	216,398 204,189		
Meets ASTM F1554 Grade 36	49.5	74.0	24							
*277717 .794 36/44 GRADE ROUNDS A36-12, SA36, 40.21 44W	49.2	71.0	25	101	48	07/26/17 08/08/17	6,060 3.0	227,318 114,736		
Meets ASTM F1554 Grade 36	49.6	71.5	23							
*277517 .794 36/44 GRADE ROUNDS A36-12, SA36, 40.21 44W	49.5	72.0	26	101	41	07/26/17 08/08/17	2,020 1.0	223,223 208,060		
Meets ASTM F1554 Grade 36	50.5	72.0	24							
*277817 7/8 36/44 GRADE ROUNDS A36-12, SA36, 40.21 44W	44.5	64.5	28	101	53	07/26/17 08/07/17	3,924 2.0	234,917 88,782		
Meets ASTM F1554 Grade 36	44.9	64.5	28							

CHEMICAL ANALYSIS

HEAT NO.	C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	V %	Mo %	Sn %	Cb %	CE %					
309516	.17	.82	.022	.017	.23	.25	.08	.15	.091	.01	.020		.32					
357216	.18	.70	.015	.015	.24	.33	.07	.13	.005	.017	.020	.000						
277717	.19	.66	.016	.020	.21	.21	.07	.16	.000	.021	.012	.001						
277517	.17	.66	.020	.024	.21	.25	.09	.18	.000	.025	.015	.001						
277817	.14	.66	.016	.021	.22	.22	.07	.16	.000	.021	.016	.000						

PO NUMBER(S): 28894 32948

CERTIFIED BY: Jeff Kramer
Quality Assurance Manager

* ALL MELTING AND MANUFACTURING PROCESSES FOR THE MATERIALS OCCURRED IN THE UNITED STATES.
CONTINUED ON NEXT PAGE...

F016-1.02

Figure B-18. ¾-in. (19-mm) Dia. Anchor J-Bolts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. f6)

NUCOR
FASTENER DIVISION

LOT NO.
394399A

Post Office Box 6100
Saint Joe, Indiana 46785
Telephone 260/337-1600

CUSTOMER NO/NAME
8001 FASTENAL COMPANY-KS
TEST REPORT SERIAL# FB539867
TEST REPORT ISSUE DATE 9/01/17
DATE SHIPPED 1/16/18
NAME OF LAB SAMPLER: RYAN UNGER, LAB TECHNICIAN
NUCOR ORDER # 45399
CUST PART # 38208
CUSTOMER P.O. # 210152338

**********CERTIFIED MATERIAL TEST REPORT**********

NUCOR PART NO	QUANTITY	LOT NO.	DESCRIPTION
175657	9000	394399A	3/4-10 GR DH HV H.D.G.
MANUFACTURE DATE 7/10/17			HEX NUT HDG/GREEN LUBE

--CHEMISTRY MATERIAL GRADE -1045L

MATERIAL NUMBER	HEAT NUMBER	**CHEMISTRY COMPOSITION (WT% HEAT ANALYSIS) BY MATERIAL SUPPLIER C	MN	P	S	SI	NUCOR STEEL - SOUTH CAROL
RM031572	DL17102699	.45	.68	.006	.018	.22	

--MECHANICAL PROPERTIES IN ACCORDANCE WITH ASTM A563-15

SURFACE HARDNESS (R30N)	CORE HARDNESS (RC)	PROOF LOAD 50100 LBS		TENSILE STRENGTH DEG-WEDGE (LBS)	STRESS (PSI)
N/A	30.0	PASS	N/A		N/A
N/A	29.8	PASS	N/A		N/A
N/A	30.3	PASS	N/A		N/A
N/A	30.1	PASS	N/A		N/A
N/A	30.7	PASS	N/A		N/A

AVERAGE VALUES FROM TESTS
30.2
PRODUCTION LOT SIZE 196000 PCS

--VISUAL INSPECTION IN ACCORDANCE WITH ASTM A563-07a 160 PCS. SAMPLED LOT PASSED

--COATING - HOT DIP GALVANIZED TO ASTM F2329-13 - GALVANIZING PERFORMED IN THE U.S.A.

1.	0.00289	2.	0.00330	3.	0.00361	4.	0.00513	5.	0.00505	6.	0.00326	7.	0.00313
8.	0.00227	9.	0.00254	10.	0.00223	11.	0.00232	12.	0.00263	13.	0.00410	14.	0.00495
15.	0.00325												

AVERAGE THICKNESS FROM 15 TESTS .00338
HEAT TREATMENT - AUSTENITIZED, OIL QUENCHED & TEMPERED (MIN 800 DEG F)

--DIMENSIONS PER ASME B18.2.6-2010

CHARACTERISTIC	#SAMPLES TESTED	MINIMUM	MAXIMUM
Width Across Corners	8	1.404	1.408
Thickness	32	0.731	0.745

ALL TESTS ARE IN ACCORDANCE WITH THE LATEST REVISIONS OF THE METHODS PRESCRIBED IN THE APPLICABLE SAE AND ASTM SPECIFICATIONS. THE SAMPLES TESTED CONFORM TO THE SPECIFICATIONS AS DESCRIBED/LISTED ABOVE AND WERE MANUFACTURED FREE OF MERCURY CONTAMINATION. NO INTENTIONAL ADDITIONS OF BISMUTH, SELENIUM, TELLURIUM, OR LEAD WERE USED IN THE STEEL USED TO PRODUCE THIS PRODUCT.
THE STEEL WAS MELTED AND MANUFACTURED IN THE U.S.A. AND THE PRODUCT WAS MANUFACTURED AND TESTED IN THE U.S.A. PRODUCT COMPLIES WITH DFARS 252.225-7014. WE CERTIFY THAT THIS DATA IS A 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.

A2LA ACCREDITED

MECHANICAL FASTENER
CERTIFICATE NO. A2LA 0139.01
EXPIRATION DATE 12/31/17

NUCOR FASTENER
A DIVISION OF NUCOR CORPORATION

BOB HAYWOOD
QUALITY ASSURANCE SUPERVISOR

Page 1 of 1

Figure B-19. ¾-in. (19-mm) Dia. Heavy Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item Nos. f6 and k12)

Customer Name	Customer PO#	Shipper No	Heat Number
Elderlee, Inc.	P006098	387715	812Z45010

ArcelorMittal Burns Harbor Plate

QUALITY ASSURANCE
REPORT OF TEST AND ANALYSES

SHIPMENT NO 804-11862 | DATE SHIPPED 02-04-18 | CAR OR VEHICLE NO. SOU 114230 | PAGE 3

SOLD TO:
METAL TRADERS INC
DBA TRIAD METALS INTERNATIONAL
1 VILLAGE RD STE 2B
HORSHAM PA 19044-3800

SHIP TO:
TRIAD METALS INTERNATIONAL
WASSELL LAND
THEIR SIDING
3507 GRAND AVE
PITTSBURGH PA 15225-1508

NOTE	SERIAL NUMBER	PAT NO	HEAT NUMBER	NO PCS	SIZE AND QUANTITY: THICKNESS	WIDTH OR DIA	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	ELONG.	RED
					INCHES	INCHES	INCHES	POUNDS	PSI	PSI	IN	% %

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.
PLATES - AASHTO M-270-15 GR 36 MOD
MN.80/1.20 NO IMPACTS REQUIRED KLD
FINE GRAIN PRAC CE=.45X PER IIW
FORMULA, ASTM A709-13A GR 36, ASTM
A36-14, ASME SA36 2015 EDITION
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)
MFST - MFST PPI 0073567- 0001 LIFT MAX 15 TON-GAUGES
& GRADES SEP BLK LGWSE-BRG PCS-SEPARATORS- A
MUST.
CO# 119411 GH 405-1132A
MERCURY IN ANY FORM HAS NOT BEEN USED
IN THE PRODUCTION OF THIS ORDER

ELDERLEE, INC.
CERT RECEIVED: 3/1/18
PURCHASE ORDER # P6098
SALES ORDER # 387715
SHIPPED FROM: Triad Metals

812Z45010 15	.5	96	240	49005	43900	68400	8	29
					46400	69300	8	29

(M55)MFST REF#:73567

822Z45010 21	.5	96	240	68607	43900	68400	8	29
					46400	69300	8	29

(M55)MFST REF#:73567

Q-QUENCH TEMPERATURE | T-TEMPER TEMPERATURE | N-NORMALIZE TEMPERATURE

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD BHN	BEND	THICKNESS INCHES	TYPE	SIZE	ORI	TEST TEMP F	CHARPY IMPACT: ENERGY FT LBS 1	2	3	SHEAR(%) 1	2	3	LAT EXP MILS 1	2	3

HEAT NUMBER	CHEMICAL ANALYSIS: C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Cb	N	Sn	MOLIND GRAIN SIZE
812Z45010	.13	1.11	.013	.004	.236	.018	.01	.03	.008	.001	.002	.029	.0002		.002	.004	.004
822Z45010	.13	1.11	.013	.004	.236	.018	.01	.03	.008	.001	.002	.029	.0002		.002	.004	.004

I certify that the above results are a true and correct copy of actual results contained in records maintained by ArcelorMittal Burns Harbor and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be transmitted intact with any subsequent third party test reports, if required.

BHPLTRPT TIF

R. SPANGLER II PER LSS
SUPV. QUALITY ASSURANCE

Figure B-20. Cable Anchor Base Plate, Test Nos. NYBWT-2 and NYBWT-3 (Item No. g1)

NUCOR

Berkeley Division of NUCOR Corporation
ISO/TS 16949 Registered

DELIVER TO: Alex Kanoff
Camden Yards

METALLURGICAL TEST REPORT

P.O. Box 2259
Mt. Pleasant, SC 29465

Nucor Steel - Berkeley
a division of NUCOR corporation

Phone: 843-336-6000
Sales Fax: 843-336-6150

Issuance Date 9/20/17 MTR# 1457821 MTR BER INQUIRIES@NUCOR.COM

Sold M AND A HOLDINGS CO LLC
To: DBA CAMDEN YARDS STEEL CO
2500 BROADWAY DRAWER 14
CAMDEN, NJ 08104

Ship CAMDEN YARDS STEEL CO.
To: 2500 BROADWAY DRAWER 14
CAMDEN, NJ 08104

Ship Date 9/20/17
Bill of Lading # 1292673
Vehicle # CSXT486000

P/O # 007534
Mill Order # 422920-10
Part # NJ .239X60 A36

Total Wgt 180900.00 LB

Gauge x Width .2390 MIN X 60.0000 MIN HR HOT ROLL COIL
CONVERSION TO / ASTM A36 / REV: 2014

SUITABLE FOR CONVERSION TO ASME SA-36

Heat	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	V	Nb	N	Ti	B	Ca
1713253	.19	.47	.005	.003	.03	.07	.03	.04	.01	.003	.027	.002	.000	.007	.001	.000	.002

	YIELD STRENGTH (ksi)		TENSILE STRENGTH (ksi)		ELONGATION (% IN 2")		HARDNESS	N Value	
Heat/Coil#	long.	trans.	long.	trans.	long.	trans.	(Rockwell B)	long.	trans.
1713253-3		52.0		72.3		28	76		.15
1713253-4		47.8		70.5		28	74		.16

Coil (tag) 1713253-4 (46920.00 LB) 1713253-5 (47740.00 LB)

Mill Test Reports according to EN10204 3.1

All material is sold subject to the description, specifications and terms and conditions set forth on the face and reverse side of Nucor Steel - Berkeley's sales order acknowledgment.

Tensile Testing, when applicable, is performed in accordance with ASTM A-370 specifications. Specimen is machined to standard rectangular test configuration (Figure 3 of ASTM A-370) with a 2" gage length. Yield Strength is determined at 0.2% offset.

This material has been produced in compliance with the chemistry and established rolling practices of the ordered specification. If material is ordered to a chemical composition only and if physical testing is not a requirement of the customer's order, testing is not performed by the producer.

We hereby certify the above information is correct as contained in the records of the corporation.
Kevin Skero
Hot Mill Metallurgist
Robert Moses
Chief Metallurgist
** 100% MELTED AND MANUFACTURED IN THE USA **

Figure B-21. Cable Anchor Gusset, Test Nos. NYBWT-2 and NYBWT-3 (Item No. g2)

Customer Name	Customer PO#	Shipper No	Heat Number
Elderlee Inc	PO05901	813973	216935

1/2" Plate A36

CERTIFIED TEST REPORT

*CENTER STEEL SALES, INC.
6645 ROOSEVELT AVENUE
ALLEN PARK, MI 48101
****

DATE: 8/14/17

SOLD TO: KLEIN STEEL SERVICE INC.
105 VANGUARD PKWY
ROCHESTER, NY 14606

SHIP TO: KLEIN STEEL SERVICE INC.
105 VANGUARD PKWY
ROCHESTER, NY 14606
CALL 1-585-328-4000 EXT. 106

Cust P/O# AC7198 Part# (WO#
SalesOrdr# 899910 01
SIZE: .500 NOM X 60.00 X 120.00

GRADE: HOT ROLLED ASTM A36/ASME SA36 MILL EDGE PLATE

DATE SHPPD: 8/14/17

Wt.Shipped 45945

CHEMICAL ANALYSIS

Heat Number 216935

C : .20	Mn: .53	P : .012	S : .003
Si: .020	Ti: .001	Cr: .080	Mo: .020
Cu: .110	Al: .020		V : .001
Pb: .002		Ca: .001	N : .006
		Ni: .070	

PHYSICAL PROPERTIES

Chemistry A-36

Tensile 73990 Yield 53120 Elongation 28.9

Misc Info
MELTED & MFG IN USA
ELONG 28.9% @ 2" EN10204 3.1
BOL# 16704

WE HEREBY CERTIFY THE ABOVE FIGURES ARE ACCURATELY STATED, MEET YOUR MATERIAL REQUIREMENTS AND ARE TRACEABLE IN OUR RECORDS BACK TO THE PRODUCER AND/OR AN ACCREDITED TEST LABORATORY.

QUALITY CONTROL MANAGER

ELDERLEE, INC.
CERT RECEIVED: 8/22/17
PURCHASE ORDER # P5901
SALES ORDER # 813973
SHIPPED FROM: Klein Steel

Figure B-22. Cable Anchor Top Plate, Test Nos. NYBWT-2 and NYBWT-3 (Item No. g3)

FASTENAL®

Certificate of Compliance

Sold To:

UNL TRANSPORTATION

Purchase Order: NYBWT

Job:

Invoice Date: 05/07/2018

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

1 PCS 1/4" x 3' ASTM B16 1/2 Hard 360 Brass Round Stock SUPPLIED UNDER OUR TRACE NUMBER mcneil AND UNDER PART NUMBER 47743

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

Fastenal Account Representative Signature

Ashly Starczyk

Printed Name

5/7/18

Date

Please check current revision to avoid using obsolete copies.

This document was printed on 05/07/2018 and was current at that time.

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 B-23. Brass Rod, Test Nos. NYBWT-2 and NYBWT-3 (Item No. g4)

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

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

NUCOR
NUCOR STEEL AUBURN, INC.

CERTIFIED MILL TEST REPORT

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

Date: 29-Sep-2010
B.L. Number: 383539
Load Number: 132043

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. MERCURY, IN ANY FORM, HAS NOT BEEN USED IN THE PRODUCTION OR TESTING OF THIS MATERIAL.

QUALITY ASSURANCE: Jim Biernat

Figure B-24. ¾-in. (19-mm) Dia. Threaded Rod, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h1)

LG197N-H

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 12/26/12 Form# CERT-7A Rev C 4-21-06

CUSTOMER Bennett Bolt

ORDER NUMBER 60IC942

PATTERN NUMBER BBWT REV. —

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.

Type Material: Malleable Iron

Specifications: ASTM-A220

Grade or Class: 50005

Heat Number: BLL

MECHANICAL PROPERTIES
Tensile Str. PSI 72,152
Yield Str. PSI 56,962
Elongation 11

PHYSICAL PROPERTIES
Brinell Hardness 179
PCS SHIPPED 530

1 of 1

CHEMICAL ANALYSIS
Total Carbon 2.60
Silicon 1.48
Manganese 1.08
Sulfur .098
Phosphorus .014
Chrome .040
Magnesium .001
Copper .478

DATE SHIPPED 12/26/12

Loretta Lopez
Quality Assurance Representative

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

Figure B-25. Cable End Fitting, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h2)

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 12/4/12 Form# CERT-7A Rev C 4-21-06

CUSTOMER Bennett Bolt

ORDER NUMBER 6010328

PATTERN NUMBER W1 Wedge REV Orig

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.

Type Material: Malleable Iron

Specifications: ASTM - A47

Grade or Class: 32510

Heat Number: BR1

MECHANICAL PROPERTIES

Tensile Str. PSI 51,300

Yield Str. PSI 35,200

Elongation 11

PHYSICAL PROPERTIES

Brinell Hardness 126

PCS SHIPPED 5,123

1 of 1

CHEMICAL ANALYSIS

Total Carbon	2.62
Silicon	1.69
Manganese	.84
Sulfur	.125
Phosphorus	.019
Chrome	.038
Magnesium	.001
Copper	.483

DATE SHIPPED 12/3/12

Lolita Lopez
Quality Assurance Representative

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

Figure B-26. Cable Wedge, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h3)

EDWARD W. DANIEL LLC

Certificate Of Origin

Date: 12-23-10

To: Bennett Bolt Works
12 Elbridge Street
Jordan, N.Y. 13080

Purchase Order Number: 6006496
Part No.: D9T-10648-BBW
Description: 3/4 Turnbuckle Bodies
Quantity: 3,000 Pcs.

This is to certify that the parts in this shipment have been melted and manufactured in the U.S.A. in conformance with all applicable specifications and instructions and are mercury free.

FF-T-791b
ASTM F1145

Bill Washington
Quality Manager

11700 Harvard Avenue – Cleveland, Ohio 44105 (216) 295-2750 – (216) 295-2758
Quality First, Service Always

Figure B-27. Crosby Threaded Turnbuckle, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h4)

ASSEMBLY SPECIALTY PRODUCTS INC.
PH 216.676.5600
FX 216.676.6761
www.assemblyspecialty.com
ISO 9001:2008
14700 Brookpark Rd
Cleveland, OH 44135-5166
customerservice@assemblyspecialty.com

Certificate of Conformance

Date: October 10, 2017

To: Gregory Industries, Inc.
Gregory Galv. & Metal Processing
4100 13th St. SW
Canton, OH 44710

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

PURCHASE ORDER #: 38684
DATE SHIPPED: 10/09/17
ASPI SALES ORDER #: 119183
MANUFACTURER: ASSEMBLY SPECIALTY PRODUCTS, INC.

QTY	CUST P/N	ASPI P/N	ASPI LOT#	DESCRIPTION
250	3012G	C-2028	80626	6' 6" BCT Cable Assembly
250	3012G	C-2028	80627	6' 6" BCT Cable Assembly
250	3012G	C-2028	80828	6' 6" BCT Cable Assembly
250	3012G	C-2028	80829	6' 6" BCT Cable Assembly
250	3012G	C-2028	80830	6' 6" BCT Cable Assembly
250	3012G	C-2028	80956	6' 6" BCT Cable Assembly
250	3012G	C-2028	80957	6' 6" BCT Cable Assembly
250	3012G	C-2028	80958	6' 6" BCT Cable Assembly
250	3012G	C-2028	81129	6' 6" BCT Cable Assembly
250	3012G	C-2028	81130	6' 6" BCT Cable Assembly

continued on page 2

REMARKS: NOMINAL BREAKING STRENGTH: 46,000 lbs
WIRE ROPE MANUFACTURED IN ACCORDANCE WITH AASHTO DESIGNATION: M30-02 and ASTM A741 TYPE 2, CLASS A
FITTINGS GALVANIZED IN ACCORDANCE WITH ASTM A-153 CLASS C.

STEEL USED TO MANUFACTURE THESE ITEMS WAS MELTED AND MANUFACTURED IN THE U.S.A
ALL MANUFACTURING PROCESSES SUPPLIED OR PERFORMED BY ASSEMBLY SPECIALTY PRODUCTS, INC. TOOK PLACE IN THE U.S.A.

Signature:
Certification and Compliance Manager

Figure B-28. BCT Anchor Cable End Swaged Fitting, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h5)

Certificate of Quality
BEKAERT CORPORATION Van Buren , Arkansas Date:03/28/2016

Customer : Colorguard Rail Products Our Order No : 4209973815 / 000010
Final Customer : Midwest Machinery & Supply Company Product No : AST3043SE10S02000 3/4 GUIDERAIL 3X7 200

Tag#	Heat#	Lay Length	Breaking Strength	Adherence Appearance of wires	Steel Ductility
		"	lbf		
		3.00	25000		
		7.50			
43383706	139012	6.12	43896	Pass	Pass
	139024				
43383832	139012	6.12	43896	Pass	Pass
	139024				
43383972	139012	6.31	43896	Pass	Pass
	139024				
43383983	139012	6.31	43896	Pass	Pass
	139024				
43384097	139012	6.31	43896	Pass	Pass
	139024				
43384719	139015	6.11	44100	Pass	Pass
	139021				
43384721	139015	6.11	44100	Pass	Pass
	139021				
43384723	139015	6.11	44100	Pass	Pass
	139021				
43384728	139015	6.20	44100	Pass	Pass
	139021				
43384729	139015	6.20	44100	Pass	Pass
	139021				
43384730	139015	6.20	44100	Pass	Pass
	139021				
43384858	139016	6.14	44100	Pass	Pass
43384869	139016	6.14	44100	Pass	Pass
43385035	139016	6.14	44100	Pass	Pass
43385106	139012	6.21	44100	Pass	Pass
	139015				
43385126	139012	6.21	44100	Pass	Pass
	139015				
43385846	139012	6.21	44100	Pass	Pass
	139015				

Made & Melted in USA.

The undersigned certifies that the results are actual results and conform to the standards as contained in the records of this Corporation.

David Berta
Quality Engineer

Notary Public

2 of 2

Figure B-29. ¾-in. (19-mm) Dia. 3x7 Wire Rope, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h6)

WireCo WorldGroup

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

Date: 1/8/18
Sold to: The Commercial Group
12801 Universal Drive
Taylor, MI 48180
Order: 214425

Certificate of Compliance

Report of Chemical Analysis and Physical Tests

Order No. 196002 Reel number 428-724681-2 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	341	278,000	.385	65	17R590203	.81	.54	.011	.009	.20
	.0395	330	269,000	.372	71	17R594359	.80	.58	.015	.010	.24
						17R591720	.82	.53	.008	.009	.18
002	.0460" Galvanized Wire										
	.0460	415	250,000	.417	71	17R591720	.82	.53	.008	.009	.18
003	.0540" Galvanized Wire										
	.054	580	253,000	.416	55	17R590203	.81	.54	.011	.009	.20
						17R591077	.81	.53	.006	.008	.21
						17R593340	.82	.54	.009	.015	.21
						17R591720	.82	.53	.008	.009	.18
						17R594796	.83	.49	.005	.005	.18
004	.0610" Galvanized Wire										
	0.061	751	257,000	.489	45	16R585888	.80	.72	.007	.017	.23
						17R591077	.81	.53	.006	.008	.21
						16KY73253	.84	.61	.006	.013	.24

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.

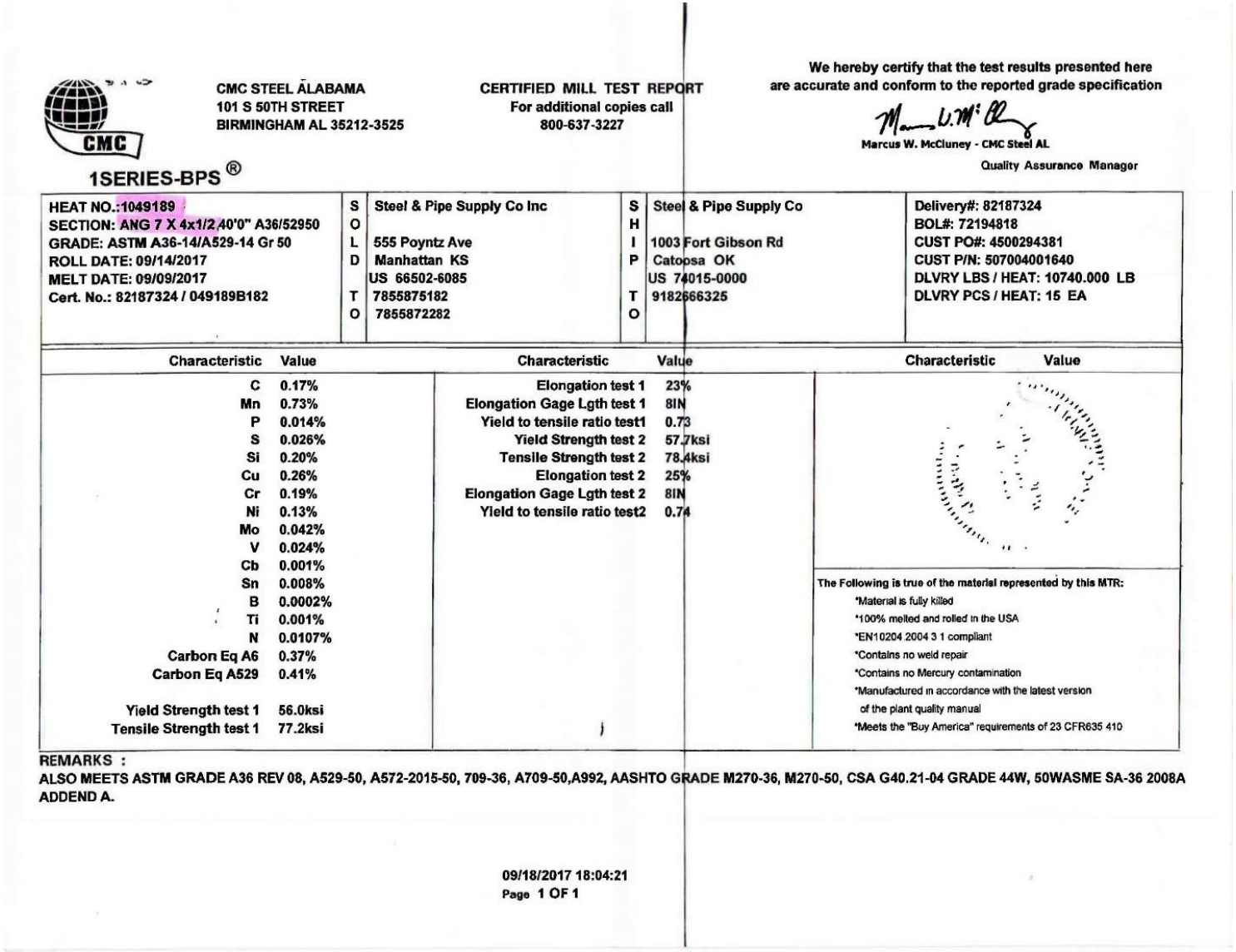
SHEILA DOWDY
Notary Public - Notary Seal
State of Missouri, Pettis County
Commission Number 00464267
My Commission Expires Jun 6, 2020

Sheila Dowdy
January 8, 2018

Signed: Michele Johnson

Page 2 of 2

Figure B-30. ¾-in. (19-mm) Dia. 6x19 Wire Rope, Test Nos. NYBWT-2 and NYBWT-3 (Item No. h7)



CMC STEEL ALABAMA
101 S 50TH STREET
BIRMINGHAM AL 35212-3525

CERTIFIED MILL TEST REPORT
For additional copies call
800-637-3227

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

Marcus W. McCluney - CMC Steel AL
Quality Assurance Manager

1SERIES-BPS ®

HEAT NO.:1049189 SECTION: ANG 7 X 4x1/2 40'0" A36/52950 GRADE: ASTM A36-14/A529-14 Gr 50 ROLL DATE: 09/14/2017 MELT DATE: 09/09/2017 Cert. No.: 82187324 / 049189B182	SOLD TO	Steel & Pipe Supply Co Inc 555 Poyntz Ave Manhattan KS US 66502-6085 7855875182 7855872282	SHIP TO	Steel & Pipe Supply Co 1003 Fort Gibson Rd Catoosa OK US 74015-0000 9182666325	Delivery#: 82187324 BOL#: 72194818 CUST PO#: 4500294381 CUST P/N: 507004001640 DLVRY LBS / HEAT: 10740.000 LB DLVRY PCS / HEAT: 15 EA

Characteristic	Value
C	0.17%
Mn	0.73%
P	0.014%
S	0.026%
Si	0.20%
Cu	0.26%
Cr	0.19%
Ni	0.13%
Mo	0.042%
V	0.024%
Cb	0.001%
Sn	0.008%
B	0.0002%
Ti	0.001%
N	0.0107%
Carbon Eq A6	0.37%
Carbon Eq A529	0.41%
Yield Strength test 1	56.0ksi
Tensile Strength test 1	77.2ksi

Characteristic	Value
Elongation test 1	23%
Elongation Gage Lgth test 1	8IN
Yield to tensile ratio test1	0.73
Yield Strength test 2	57.7ksi
Tensile Strength test 2	78.4ksi
Elongation test 2	25%
Elongation Gage Lgth test 2	8IN
Yield to tensile ratio test2	0.74

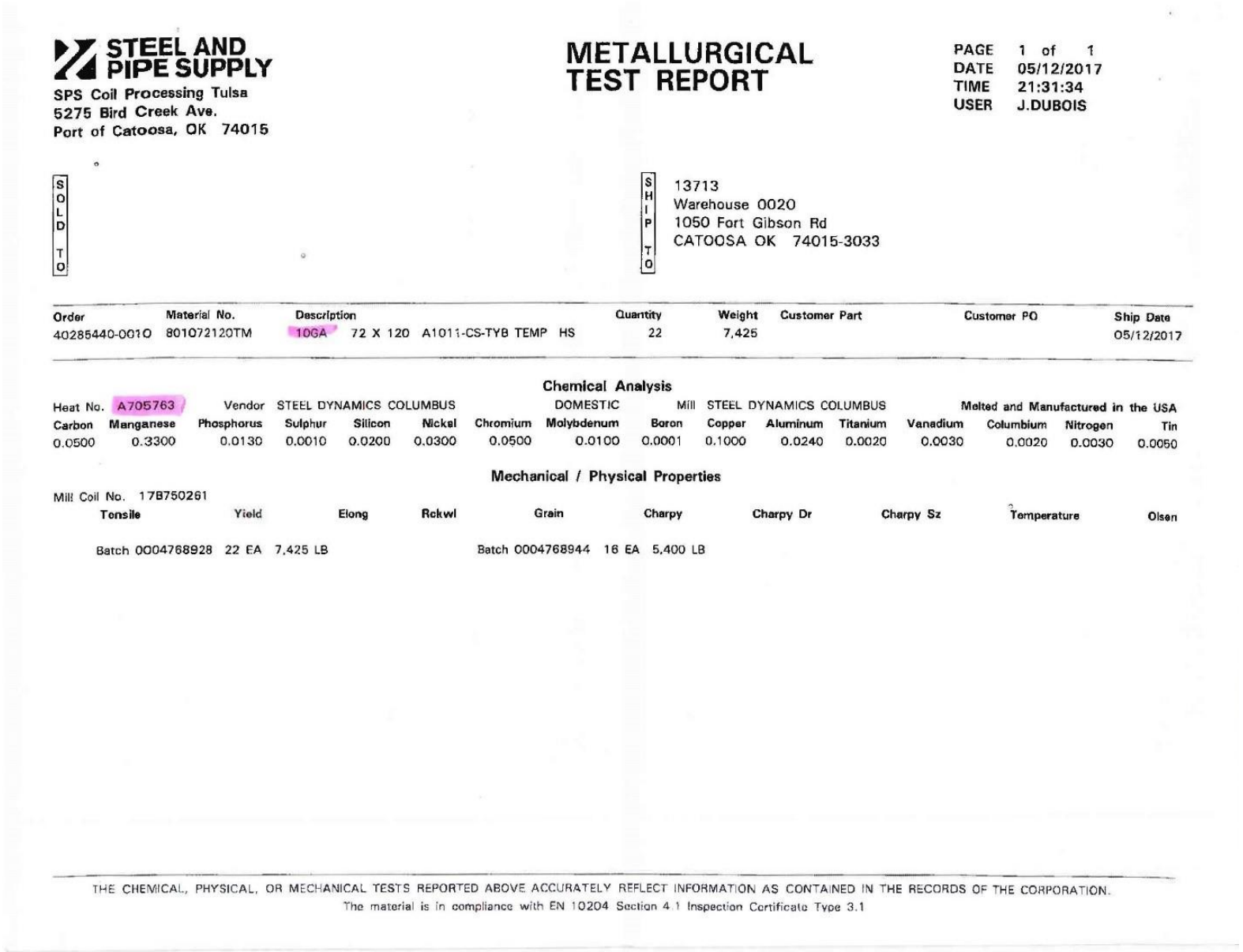
Characteristic	Value

The Following is true of the material represented by this MTR:
*Material is fully killed
*100% melted and rolled in the USA
*EN10204 2004 3 1 compliant
*Contains no weld repair
*Contains no Mercury contamination
*Manufactured in accordance with the latest version of the plant quality manual
*Meets the "Buy America" requirements of 23 CFR635 410

REMARKS :
ALSO MEETS ASTM GRADE A36 REV 08, A529-50, A572-2015-50, 709-36, A709-50,A992, AASHTO GRADE M270-36, M270-50, CSA G40.21-04 GRADE 44W, 50WASME SA-36 2008A ADDEND A.

09/18/2017 18:04:21
Page 1 OF 1

Figure B-31. 7 x 4 x ½-in. (178 x 102 x 13-mm), 3-in. (76-mm) Long L-Brackets, Test Nos. NYBWT-2 and NYBWT-3 (Item No. i1)



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 05/12/2017
TIME 21:31:34
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
40285440-0010	801072120TM	10GA 72 X 120 A1011-CS-TYB TEMP HS	22	7,425			05/12/2017

Chemical Analysis

Heat No. A705763 Vendor STEEL DYNAMICS COLUMBUS DOMESTIC Mill STEEL DYNAMICS COLUMBUS Melted and Manufactured in the USA

Carbon	Manganese	Phosphorus	Sulphur	Silicon	Nickel	Chromium	Molybdenum	Boron	Copper	Aluminum	Titanium	Vanadium	Columbium	Nitrogen	Tin
0.0500	0.3300	0.0130	0.0010	0.0200	0.0300	0.0500	0.0100	0.0001	0.1000	0.0240	0.0020	0.0030	0.0020	0.0030	0.0050

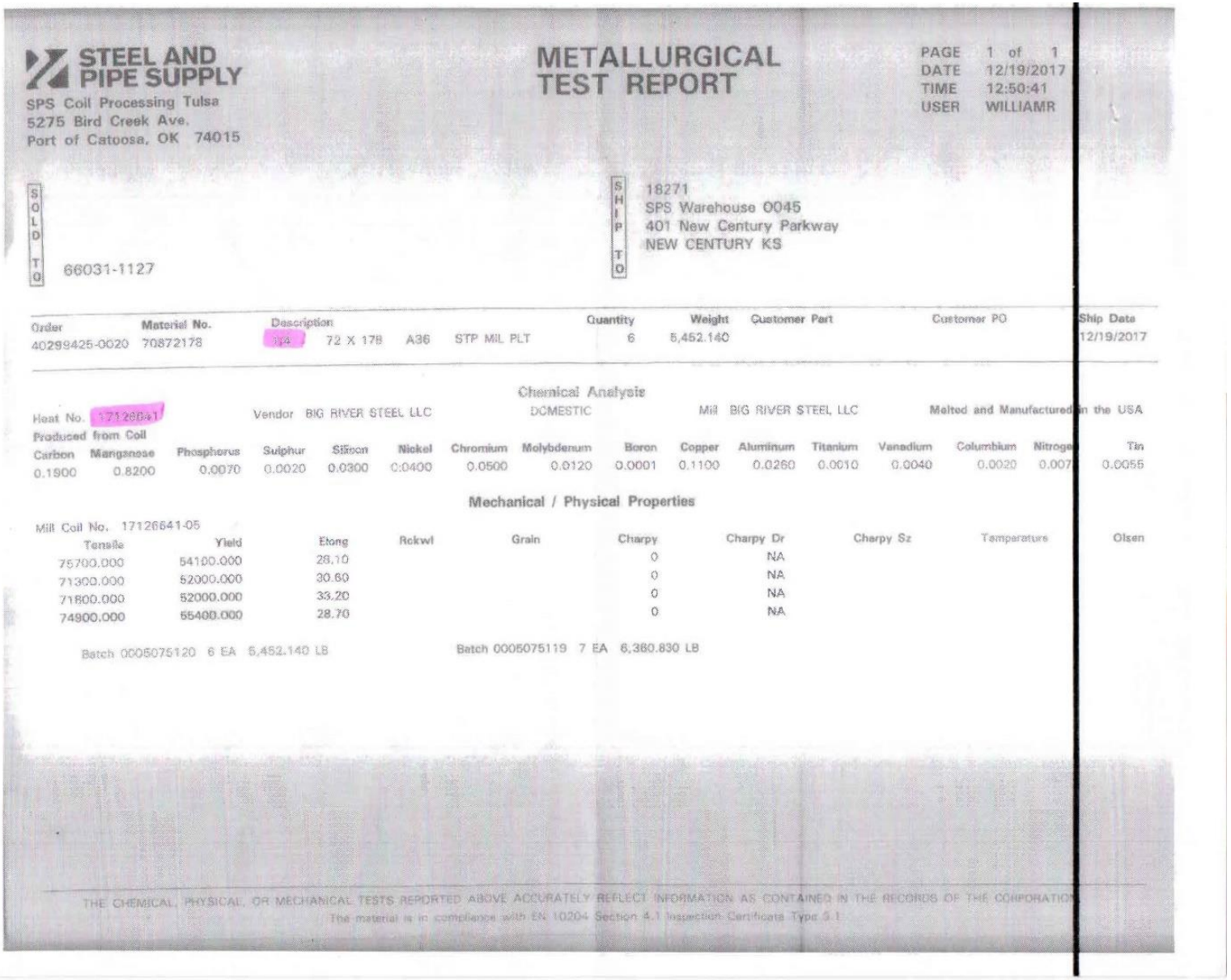
Mechanical / Physical Properties

Mill Coil No. 17B750261

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
Batch 0004768928 22 EA 7,425 LB				Batch 0004768944 16 EA 5,400 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 B-32. 1¾ x 1¾-in. (44 x 44-mm) x 10-gauge Square Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. i2)



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 12/19/2017
TIME 12:50:41
USER WILLIAMR

SOLD TO 66031-1127

SHIP TO 18271
SPS Warehouse 0045
401 New Century Parkway
NEW CENTURY KS

Order	Material No.	Description				Quantity	Weight	Customer Part	Customer PO	Ship Date
40299425-0020	70872178	1/4	72 X 178	A36	STP MIL PLT	6	5,452.140			12/19/2017

Chemical Analysis

Heat No. 17126641 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	Nitroge	Tin
0.1900	0.8200	0.0070	0.0020	0.0300	0.0400	0.0500	0.0120	0.0001	0.1100	0.0260	0.0010	0.0040	0.0020	0.007	0.0055

Mechanical / Physical Properties

Mill Coil No. 17126641-05

Tensile	Yield	Etong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
75700.000	54100.000	28.10			0	NA			
71300.000	52000.000	30.60			0	NA			
71800.000	52000.000	33.20			0	NA			
74900.000	55400.000	28.70			0	NA			

Batch 0005075120 6 EA 5,452.140 LB Batch 0005075119 7 EA 6,380.830 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 B-33. 27 x 3 x ¼-in. (686 x 76 x 6-mm) Washer Plates, Test Nos. NYBWT-2 and NYBWT-3 (Item No. i3)

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

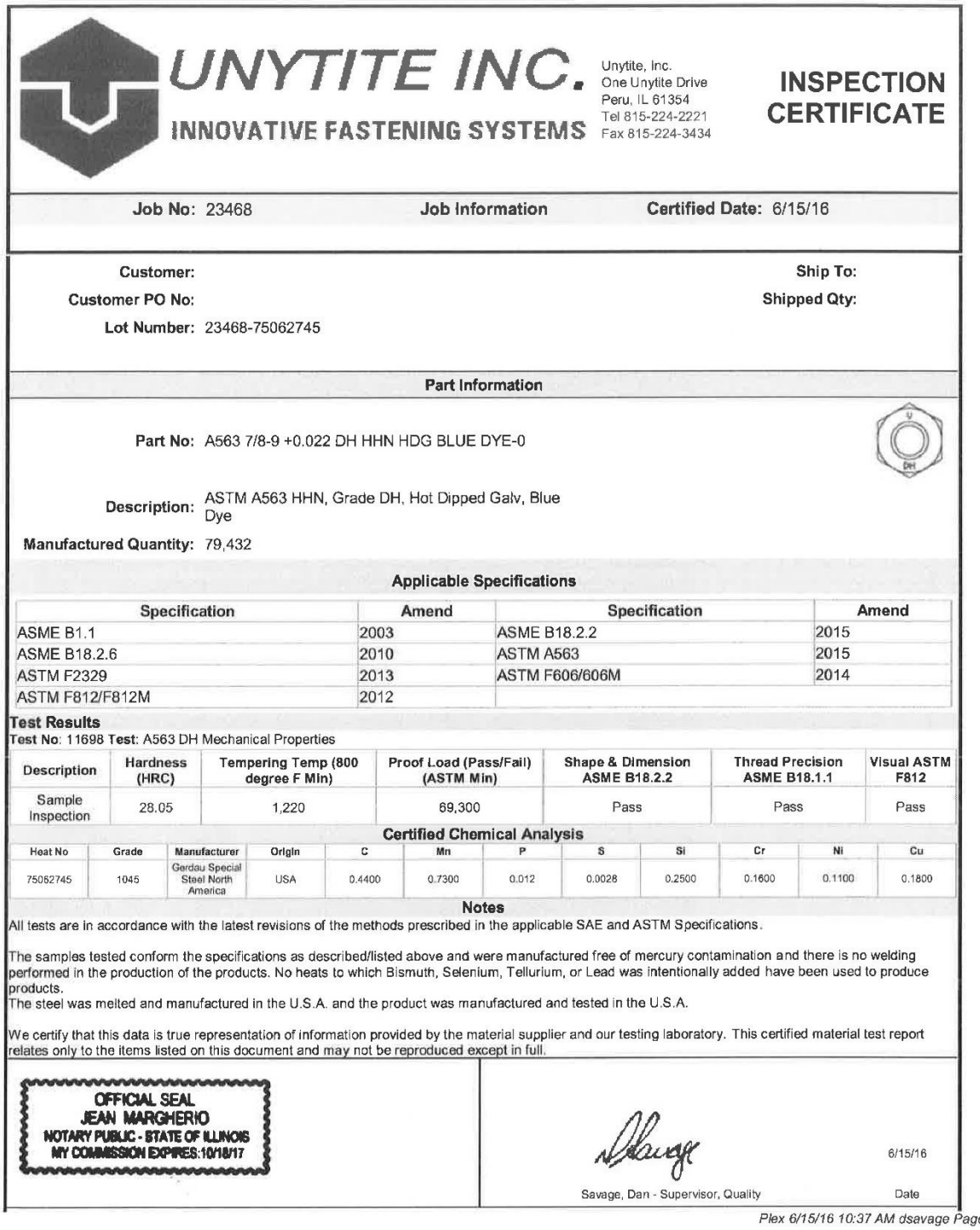
Coatings:
ITEMS HOT DIP GALVANIZED PER ASTM F2329/A153C

Other:
ALL ITEMS MELTED & MANUFACTURED IN THE USA

By: _____
Certification Department Quality Assurance
Dane McKinnon

R#17-414 NY DOT BOX BEAM
7/8" BOLTS AND NUTS

Figure B-34. ⅞-in. (22-mm) Dia., 8½-in. (216-mm) Long Heavy Hex Head Bolts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j1)



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

21394 - 1

Figure B-35. ⅞-in. (22-mm) Heavy Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j1)

NUCOR
FASTENER DIVISION

LOT NO.
160974A

Post Office Box 6100
Saint Joe, Indiana 46785
Telephone 260/337-1600

CUSTOMER NO/NAME
0

NUCOR ORDER # 465235
TEST REPORT SERIAL# FB204482 CUST PART #
TEST REPORT ISSUE DATE 1/28/03
DATE SHIPPED 4/11/03 CUSTOMER P.O. #
NAME OF LAB SAMPLER: SHIRRI STANTZ, LAB TECHNICIAN
**********CERTIFIED MATERIAL TEST REPORT**********

NUCOR PART NO	QUANTITY	LOT NO.	DESCRIPTION
160547	4800	160974A	3/4-10 X 1 1/2 A325-T H.D.G.
MANUFACTURE DATE 1/09/03			STRUC SCREW H.D.G.

A325T

--CHEMISTRY MATERIAL GRADE -1039M

MATERIAL NUMBER	HEAT NUMBER	**CHEMISTRY COMPOSITION (WT% HEAT ANALYSIS) BY MATERIAL SUPPLIER C	MN	P	S	SI
RM020039	RR 135745	.42	.94	.008	.013	.23
	MIN	.30	.60			.10
	MAX	.52		.040	.050	.30

GERDAU-AMERISTEEL
(formly CO-STEEL)
P. O. BOX 313328
TAMPA, FL 33631-3328
A2LA NO: 492.01 EXP: 2004-02-28
FOR CHEMICAL TESTING

--MECHANICAL PROPERTIES IN ACCORDANCE WITH ASTM A325-02

SURFACE HARDNESS (R30N)	CORE HARDNESS (RC)	PROOF LOAD 28400 LBS	TENSILE STRENGTH 0 DEG-WEDGE (LBS)	STRESS (PSI)
N/A	28.2	PASS	48445	145045
N/A	29.8	PASS	48823	146177
N/A	29.0	PASS	48473	145129
N/A	27.8			
AVERAGE VALUES FROM TESTS				
	28.7		48580	145450

PRODUCTION LOT SIZE 5700 PCS

--VISUAL INSPECTION IN ACCORDANCE WITH ASTM A325 32 PCS. SAMPLED LOT PASSED

--COATING - HOT DIP GALVANIZED

1.	0.00332	2.	0.00385	3.	0.00334	4.	0.00346	5.	0.00511	6.	0.00237	7.	0.00267
8.	0.00451	9.	0.00409	10.	0.00486	11.	0.00255	12.	0.00333	13.	0.00354	14.	0.00453
15.	0.00240	16.	0.00821	17.	0.00382	18.	0.00292	19.	0.00233	20.	0.00256		

AVERAGE THICKNESS FROM 20 TESTS .00369

--HEAT TREATMENT - AUSTENITIZED, OIL QUENCHED & TEMPERED (MIN 800 DEG F)

--DIMENSIONS PER ASME B18.2.6-1996

CHARACTERISTIC	#SAMPLES TESTED	MINIMUM	MAXIMUM
Width Across Corners	8	1.4030	1.4100
Head Height	8	0.4630	0.4670
Threads	8	PASS	PASS

ALL TESTS ARE IN ACCORDANCE WITH THE LATEST REVISIONS OF THE METHODS PRESCRIBED IN THE APPLICABLE SAE AND ASTM SPECIFICATIONS. THE SAMPLES TESTED CONFORM TO THE SPECIFICATIONS AS DESCRIBED/LISTED ABOVE AND WERE MANUFACTURED FREE OF MERCURY CONTAMINATION. NO HEATS TO WHICH BISMUTH, SELENIUM, TELLURIUM, OR LEAD WAS INTENTIONALLY ADDED HAVE BEEN USED TO PRODUCE THE BOLTS.
THE STEEL WAS MELTED AND MANUFACTURED IN THE U.S.A. AND THE PRODUCT WAS MANUFACTURED AND TESTED IN THE U.S.A.
PRODUCT COMPLIES WITH DFARS 252.225-7014. WE CERTIFY THAT THIS DATA IS A 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.

A2LA ACCREDITED

MECHANICAL FASTENER
CERTIFICATE NO. A2LA 139-01
EXPIRATION DATE 12/31/03

NUCOR FASTENER
A DIVISION OF NUCOR CORPORATION

CHRIS RAMER
QUALITY ASSURANCE SUPERVISOR

Page 1 of 1

Figure B-36. ¾-in. (19-mm) Dia., 2½-in. (64-mm) Long Fully Threaded Heavy Hex Head Bolts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j2)

FASTENAL®

Certificate of Compliance

Sold To:

UNL TRANSPORTATION

Purchase Order:

Job: NYBWT-1,2

Invoice Date: 05/31/2018

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

50 PCS 3/4"-10 x 2" Grade 5 Hot Dipped Galvanized Hex Cap Screw SUPPLIED UNDER OUR TRACE NUMBER 120328441 AND UNDER PART NUMBER 0189823

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

Fastenal Account Representative Signature

Printed Name

Date

Please check current revision to avoid using obsolete copies.

This document was printed on 05/31/2018 and was current at that time.

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 B-37. ¾-in. (19-mm) Dia. 2-in. (51-mm) Long Fully Threaded Heavy Hex Head Bolts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j3)

FASTENAL®

Certificate of Compliance

Sold To:

UNL TRANSPORTATION

Purchase Order: NYBWT-1,2

Job: NYBWT-1,2

Invoice Date: 05/24/2018

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

24 PCS 3/8"-16 x 7-1/2" ASTM A307 Grade A Hot Dipped Galvanized Hex Bolt SUPPLIED UNDER OUR TRACE NUMBER 120302589 AND UNDER PART NUMBER 91873

84 PCS 3/4"-10 x 2" ASTM F3125 Grade A325 Hot Dipped Galvanized Steel Structural Bolt Only--USA SUPPLIED UNDER OUR TRACE NUMBER 488266 AND UNDER PART NUMBER 19690

48 PCS 1/2"-13 x 2" ASTM A307 Grade A Hot Dipped Galvanized Tap Bolt SUPPLIED UNDER OUR TRACE NUMBER 120295018 AND UNDER PART NUMBER 0189472

50 PCS 1/2"-13 Hot Dip Galvanized Finish Grade A Finished Hex Nut SUPPLIED UNDER OUR TRACE NUMBER 180143778 AND UNDER PART NUMBER 1136709

24 PCS 5/16" x 0.688" OD Thru-Hardened ECOGUARD[REG] Finish Steel SAE General Purpose Flat Washer SUPPLIED UNDER OUR TRACE NUMBER 120109164 AND UNDER PART NUMBER 11137083

48 PCS 5/16"-18 Hot Dip Galvanized Finish Grade A Finished Hex Nut SUPPLIED UNDER OUR TRACE NUMBER p1222717 AND UNDER PART NUMBER 36703

24 PCS 3/4"-10 x 8" ASTM A307 Grade A Hot Dipped Galvanized Hex Bolt SUPPLIED UNDER OUR TRACE NUMBER 210158499 AND UNDER PART NUMBER 91972

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

Fastenal Account Representative Signature

Ashly Stanczyk

Printed Name

5/24/18

Date

Please check current revision to avoid using obsolete copies.

This document was printed on 05/24/2018 and was current at that time.

Fastenal Store Location/Address

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

Page 1 of 2

Figure B-38. ¾-in. (19-mm) Dia. 8-in. (203-mm) Long Hex Head Bolts and Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j4)

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 : 2018/05/25

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210149326
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/4-10 NC O/T 0.51MM
LOT NO : 1N17C0249
SHIP QUANTITY : 6,000 PCS
LOT QUANTITY 159,369 PCS
HEADMARKS :

PACKING NO : GEM180403016
INVOICE NO : GEM/FNL-180415ED-1
PART NO : 1136715
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 18100738-3
MATERIAL : X1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/03/02
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2015

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0400	0.0900	0.3600	0.0100	0.0060	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : WANGYAN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		1.2400-1.2990 inch	1.2730-1.2860 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0230 inch	0.0110-0.0140 inch	15	0
THICKNESS	6 PCS		0.6170-0.6650 inch	0.6390-0.6440 inch	6	0
WIDTH ACROSS FLATS	6 PCS		1.0880-1.1250 inch	1.1070-1.1090 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 A563-2015

SAMPLED BY : GDAN LIAN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	RER	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	67.72-88.37	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:

page 1 of 1

Figure B-39. ¾-in. (19-mm) Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j4)

TÜV CERT
ISO/TS16949:2002
ACCREDITED
NO. 04 111 20051049

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

ACCREDITED
NO:1292-01
VALIDITY:MAY,31,2007

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

TEL : (86-573)4185001~4185048
FAX : (86-573)4184576 4184888
DATE : 2006/11/22

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : PB069306B
COMMODITY : HEX MACHINE BOLT GR-A
SIZE : 3/4-10X4-1/2 NC
LOT NO : B06090726
SHIP QUANTITY : 2,880 PCS
HEADMARKS : CYI & 307A

PACKING NO : GEM061114009
INVOICE NO : GEM/FNL-061124 IN
PART NO : 91965
SAMPLING PLAN : ANSI/ASME B18.18.2M
HEAT NO : 06307630-4
MATERIAL : X1010A
FINISH : HOT DIP GALVANIZED

PERCENTAGE COMPOSITION OF CHEMISTRY :

Chemistry	Al%	C%	Mn%	P%	S%	Si%
Spec. : MIN.	0.0200	0.0800	0.3000			
MAX.		0.1300	0.6000	0.0300	0.0350	0.1000
Test Value	0.0540	0.0900	0.4000	0.0080	0.0100	0.0300

MECHANICAL PROPERTIES : ACCORDING TO ASTM A 307A
TEST DATE : 2006/11/02 SAMPLED BY : FENG LEE SAMPLING DATE : 2006/10/30

INSPECTIONS ITEM	SAMPLE SIZE	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	8	ASTM E18	69-100 HRB	74 HRB	8	0
TENSILE STRENGTH	1	ASTM F606/F606M	Min. 60 KSI	75 KSI	1	0

ALL TESTS ARE IN ACCORDANCE WITH THE METHODS PRESCRIBED IN THE APPLICABLE ASTM/SAE/ASME/MIL-STD-120 SPECIFICATION. WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY.

SIGNATURE : Jim

Figure B-40. ¾-in. (19-mm) Dia. 4½-in. (114-mm) Long Hex Head Bolts and Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j5)

NINGBO DONGXIN HIGH-STRENGTH NUT CO.,LTD
TEST CERTIFICATE
(EN 10204.3.1)

Customer: FASTENAL COMPANY PURCHASING	**Production Lot No.:**	1702DX100-705-1	**Issue Date:**	2017/5/17
	Add.of Customer:	4730 SERVICE DRIVEWINONA MN 55897	**Inv. No.:**	17247DX100-556
	Description:	ANSI B18.2.2 GR.A HEX NUT HDG WITHOUT HT	**Manu. Date:**	2017/2/16
			Manu. Qty:	9270
	PO No.:	210126809	**Shipped Qty:**	9000
	Manufacturer:	Ningbo Dongxin High-strength Nut	**Marking:**	NO MARKS
	Address:	Xijingtang,Luotuo,Ningbo,China	**LOT No.:**	-DX100-705-1
	Tel./Fax:	0574-86533751/86531751	**Sample Plan:**	ASME B18.18-2011(Category.2)/AST M F1470-2012
	Size:	3/4"-10	**Part No.:**	1136715

Chemical Composition

Material type: 35K Φ28 Heat No.: 16203941-3

Chemical Analysis % (items)	**C**	**Mn**	**P**	**S**	**Si**	**Cr**	**Ni**	**Mo**	**Others**
	Min0.58	/	**Max0.13**	/	/	/	/	/	/
Result	0.37	0.68	0.015	0.003	0.18	0. 035	0. 011	/	/
Cert #:	5920160509036			Material supplier:			HUNAN VALIN XIANGTAN		

Dimensions

DIM.SPEC: ASME B18.2.2-2010 INSPECTOR & SAMPER: Ms.Li DATE: 2017/5/17

Item	**Specified**	**Result**	**Sampling**	**Rej.**	**Remark**	**Specification**
Widthacrossflats(inch)	1.088 - 1.125	1.099 - 1.106	4	0	OK	------
Widthacrossangle(inch)	1.24 - 1.299	1.256 - 1.263	4	0	OK	------
Height(inch)	0.617 - 0.644	0.623 - 0.629	4	0	OK	------
Minor diameter(inch)	0.662 - 0.683	0.666 - 0.674	15	0	OK	------
Thread-2B	Thread GO gauge	OK	15	0	OK	ASME B1.1-02
	Thread NO GO gauge	OK	15	0	OK	
Appearance	OK	OK	22	0	OK	ASTM F812-07
FIM	MAX 0.023	0.009 - 0.014	4	0	OK	ASME B18.2.2-2015

Mechanical Properties

MEC,SPEC:ASTM A563-07a INSPECTOR & SAMPLER: Ms.Li DATE: 2017/5/17

ITEM	**Test Method**	**SPECIFIED**	**Sampling**	**Result**	**JUG**
CoreHardness HRC	ASTM F606-2014a	- 32	4	16 - 20	OK
Proof loading KSI	ASTM F606-2014a	68	3	69	OK

Plating

Plating Spec: ASTM F2329-05 Inspector & Sampler : Ms Li Date: 2015/7/6

ITEM	Test Method	SPECIFIED	Sampling	Result	JUG
HDG	ASTM B487	50.8 um Average	15	63 - 99 um	OK

MACROETCH

Division	**Surface Condition**	**Random Condition**	**Center Segregation**	**Test method**
Spec.	S2	R2	C3	ASTM E381-2001
Results	S2	R2	C3	

Figure B-41. ¾-in. (19-mm) Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j5)

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

FACTORY: IFI & MORGAN LTD.
ADDRESS: No.583-28, Chang'an North Road, Wuyuan Town, Haiyan, Zhejiang, China

REPORT DATE:2017/11/13
MANUFACTURE DATE:2017/9/20

CUSTOMER: FASTENAL
MANU QTY: 12300PCS
SAMPE SIZE: ACC.TO Dimension:ASME B18.18-11;Mechanical Properties:ASTM F1470-12
SIZE: 1/2-13X2 HDG
HEADMARKS: 307A PLUS NY

MFG LOT NUMBER:M-2017HT519-2
SHIPPED QTY:12250PCS
PO NUMBER:120295018
PART NO:0189472

STEEL PROPERTIES:
MATERIAL TYPE:Q195

HEAT NUMBER:182390

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:	0.06	0. 32	0.016	0.025

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

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
VISUAL	ASTM F788-2013	PASSED	29	0
THREAD	ASME B1.1-2003,3A GO,2A NOGO	PASSED	15	0
WIDTH FLATS	0.725-0.750	0.732-0.742	4	0
WIDTH A/C	0.826-0.866	0.834-0.860	4	0
HEAD HEIGHT	0.302-0.364	0.312-0.358	4	0
THREAD LENGTH	1.950-2.040	1.968-2.012	15	0
LENGTH	1.950-2.040	1.968-2.012	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	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: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 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD 检验专用章 QUALITY CONTROL

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

Figure B-42. ½-in. (13-mm) Dia. x ½-in. (13-mm) Long Fully Threaded Hex Head Bolts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j6 and j7)

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 : 2018/05/28.

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 180143778
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 1/2-13 NC O/T 0.46MM
LOT NO : 1N1780824
SHIP QUANTITY : 18,750 PCS
LOT QUANTITY 170,225 PCS
HEADMARKS :

PACKING NO : GEM171130002
INVOICE NO : GEM/FNL-171220DE-1
PART NO : 1136709
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 331703751
MATERIAL : ML08
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2017/11/02
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2015

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0330	0.0600	0.4300	0.0180	0.0070	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : WDANDAN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		0.8400-0.8660 inch	0.8540-0.8560 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0110 inch	0.0100-0.0110 inch	15	0
THICKNESS	6 PCS		0.4270-0.4480 inch	0.4430-0.4440 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.7360-0.7500 inch	0.7470-0.7480 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 A563-2015

SAMPLED BY : TANGHAO

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	86-90 HRB	15	0
PROOF LOAD	6 PCS	ASTM F606-2014		Min.9,649 LBF	OK	6	0
PLATING THICKNESS(μm)	6 PCS	ASTM B568-1998		>=53	59.22-80.98	6	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 B-43. ½-in. (13-mm) Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j7)

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

FACTORY: IFI & MORGAN LTD.
ADDRESS: No.583-28, Chang'an North Road, Wuyuan Town, Haiyan, Zhejiang, China

REPORT DATE:2018/1/10

MANUFACTURE DATE:2017/12/28

CUSTOMER: FASTENAL
MFG LOT NUMBER:M-2017HT956-13
SAMPE SIZE: ACC. TO ASME B18.18 CATEGORY 2-2011; ASTM F1470-12 TABLE 3
MANU QTY: 3450PCS
SHIPPED QTY:3400PCS
SIZE: 3/8-16X7 1/2 HDG
HEADMARKS: 307A PLUS NY
PO NUMBER:120302589
PART NO: 91873

STEEL PROPERTIES:
MATERIAL TYPE:Q195
HEAT NUMBER:817060395

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:	0.07	0. 26	0.008	0.006

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 A/F	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 - 14e1 GR.A			
CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS :	ASTM F606/F606M-2016	69-100 HRB	76-80 HRB	4	0
WEDGE TENSILE:	ASTM F606/F606M-2016	Min 60 KSI	65-70 KSI	4	0
CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
COATINGS OF ZINC:		SPECIFIATION: ASTM F2329/F2329M-2015			
HOT DIP GALVANIZED	ASTM B568-98(2014)	Min 0.0017"	0.0018-0.0019"	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 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD. 检验专用章 QUALITY CONTROL

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

Figure B-44. ⅜-in. (10-mm) Dia. 7½-in. (191-mm) Long Hex Head Bolts and Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j8)

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 : 2017/11/09

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 180132801
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/8-16 NC O/T 0.43MM
LOT NO : 1N1710389
SHIP QUANTITY : 45,000 PCS
LOT QUANTITY 317,729 PCS
HEADMARKS :

PACKING NO : GEM170331005
INVOICE NO : GEM/FNL-170419DE
PART NO : 1136705
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 16211453-3
MATERIAL : X1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2017/02/18
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2015

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0220	0.0700	0.3000	0.0200	0.0090	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : WDANDAN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		0.6280-0.6500 inch	0.6380-0.6390 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0170 inch	0.0150-0.0160 inch	15	0
THICKNESS	6 PCS		0.3200-0.3370 inch	0.3310-0.3320 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.5510-0.5630 inch	0.5570-0.5590 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 A563-2015

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	78-82 HRB	15	0
PROOF LOAD	5 PCS	ASTM F606-2014		Min. 90 KSI	OK	5	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	81.75-84.54	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 B-45. ⅜-in. (10-mm) Dia. Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j8)

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

FACTORY: IFI & MORGAN LTD.
ADDRESS: No.583-28, Chang'an North Road, Wuyuan Town, Haiyan, Zhejiang, China

REPORT DATE:2017/10/18
MANUFACTURE DATE:2017/9/5

CUSTOMER: FASTENAL
MANU QTY:72050PCS
SAMPE SIZE: ACC. TO ASME B18.18 CATEGORY 2-2011; ASTM F1470-12 TABLE 3
SIZE: 5/16-18x2 ZP CR3+
HEADMARKS: 307A PLUS NY

MFG LOT NUMBER:M-2017HT690-2
SHIPPED QTY:72000PCS
PO NUMBER:220025503
PART NO:10827

STEEL PROPERTIES:
MATERIAL TYPE:Q195

HEAT NUMBER:817060394

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:	0.07	0. 27	0.011	0.003

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

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
VISUAL	ASTM F788-2013	PASSED	29	0
THREAD	ASME B1.1-2003,3A GO,2A NOGO	PASSED	15	0
WIDTH A/F	0.484-0.500	0.489-0.496	5	0
WIDTH A/C	0.552-0.577	0.564-0.571	5	0
HEAD HEIGHT	0.195-0.235	0.203-0.229	5	0
THREAD LENGTH	1.960-2.020	1.978-2.001	15	0
LENGTH	1.960-2.020	1.978-2.001	15	0

MECHANICAL PROPERTIES: SPECIFICATION: ASTM A307 - 14e1 GR.A

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS :	ASTM F606/F606M-2016	69-100 HRB	75-79	15	0
WEDGE TENSILE:	ASTM F606/F606M-2016	Min 60 KSI	65-70	5	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
COATINGS OF ZINC		SPECIFIATION: ASTM F1941/F1941M-2015 Fe/Zn 3AN			
Coating thickness	ASTM B568-98(2014)	Min 3 μ m	4-5 μ m	5	0
SALT SPRAY TEST	ASTM B117-2016	6 Hr no white rust,12 Hr no red rust	Passed	5	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 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD. 检验专用章 QUALITY CONTROL

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

Figure B-46. $^{5}/_{16}$-in. (8-mm) Dia. 2-in. (51-mm) Long Fully Threaded Hex Head Bolts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j9)

3360

CHARTER STEEL

A Division of Charter Manufacturing Company Inc

FILE

1658 Cold Springs Road
Saukville, Wisconsin 53080
(262) 268-2400
1-800-437 8789
Fax (262) 268 2570

Melted in USA Manufactured in USA

CHARTER STEEL TEST REPORT

Cust P O	106854
Customer Part #	T10167
Charter Sales Order	50039092
Heat #	10435580
Ship Lot #	4412207
Grade	1018 A SK FG RHQ 41/64
Process	HRSA
Finish Size	41/64
Ship date	29-JUN-16

Elgin Fastener Group LLC - Berea Plant
777 West Bagley Road
Berea,OH-44017
Kind Attn :Jeff Leisinger

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed below and that it satisfies these requirements. The recording of false, fictitious and fraudulent statements or entries on this document may be punishable as a felony under federal statute

Test results of Heat Lot # 10435580

Lab Code: 7388

CHEM	C	MN	P	S	SI	NI	CR	MO	CU	SN	V
%Wt	.16	.68	.007	.013	.220	.04	.07	.01	.07	.005	.002
	AL	N	B	TI	NB						
	.023	.0050	.0001	.001	.001						

MACTYP=R
MACRO ETCH SURFACE=1 MACRO ETCH RANDOM=1 MACRO ETCH CENTER=1

Test results of Rolling Lot # 1184012

REDUCTION RATIO=94:1

Test results of Processing Lot #4405557, 4412207

	# of Tests	Min Value	Max Value	Mean Value	
TENSILE (KSI)	2.0	60.3	60.4	60.3	TENSILE LAB = 0358-02
REDUCTION OF AREA (%)	2	72	73	73	RA LAB = 0358-02

NUM DECARB=2 FREE FERRITE DECARB (Inch)=.000 FREE FERR & PARTIAL DECARB (Inch)=.005
NUM SPHERO=2 SPHERODIZATION (%)=85.0 CP SPHERO % LAB=0358-02

Specifications: Manufactured per Charter Steel Quality Manual Rev Date 12/12/13
Charter Steel certifies this product is indistinguishable from background radiation levels by having process radiation detectors in place to measure for the presence of radiation within our process & products.
Meets customer specifications with any applicable Charter Steel exceptions for the following customer documents:
Customer Document = ASTM F2282-03 (Reapproved 2015) Revision = Dated = 01-AUG-15

Additional Comments: MELTED AND MANUFACTURED IN THE U.S.A

Melt Source
Charter Steel
Saukville, WI, USA

Rem Load1,Fax0,Mail0

ACCREDITED
Testing Laboratory

This MTR supersedes all previously dated MTRs for this order

Janice Barnard
Manager of Quality Assurance
Printed Date 06/29/2016

Page 1 of 2

Figure B-47. $^{5}/_{16}$-in. (8-mm) Dia. 1¼-in. (32-mm) Long Guardrail Bolt, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j10)

CHARTER STEEL

A Division of Charter Manufacturing Company, Inc.

Melted in USA Manufactured in USA

EMAIL

1658 Cold Springs Road
Saukville, Wisconsin 53080
(262) 268-2400
1-800-437-8769
Fax (262) 268-2570

CHARTER STEEL TEST REPORT

Cust P.O.	50366-1709
Customer Part #	1.125 1010
Charter Sales Order	30137947
Heat #	10508780
Ship Lot #	4488179
Grade	1010 A AK FG RHQ 1-1/8
Process	HRCC
Finish Size	1-1/8
Ship date	27-AUG-17

Decker Manufacturing Corp.
703 N. Clark St.
Albion, MI-49224

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed below and that it satisfies these requirements. The recording of false, fictitious and fraudulent statements or entries on this document may be punishable as a felony under federal statute.

Test results of Heat Lot # 10508780

Lab Code: 7388

CHEM	C	MN	P	S	SI	NI	CR	MO	CU	SN	V
%Wt	.09	.47	.006	.008	.080	.04	.08	.01	.08	.006	.001
	AL	N	B	TI	NB						
	.022	.0070	.0001	.001	.001						

Test results of Rolling Lot # 1221251

	# of Tests	Min Value	Max Value	Mean Value	
ROCKWELL B (HRBW)	3	59	61	60	RB LAB = 0358-02
ROD SIZE (inch)	16	1.122	1.131	1.127	
ROD OUT OF ROUND (inch)	8	.003	.008	.005	

REDUCTION RATIO=30:1

Specifications: Manufactured per Charter Steel Quality Manual Rev Date 05/12/17
Charter Steel certifies this product is indistinguishable from background radiation levels by having process radiation detectors in place to measure for the presence of radiation within our process & products.
Meets customer specifications with any applicable Charter Steel exceptions for the following customer documents:
Customer Document = ASTM A29/A29M Revision = 16 Dated = 01-DEC-16

Additional Comments:

Melt Source:
Charter Steel
Saukville, WI, USA

Trip: 1166878

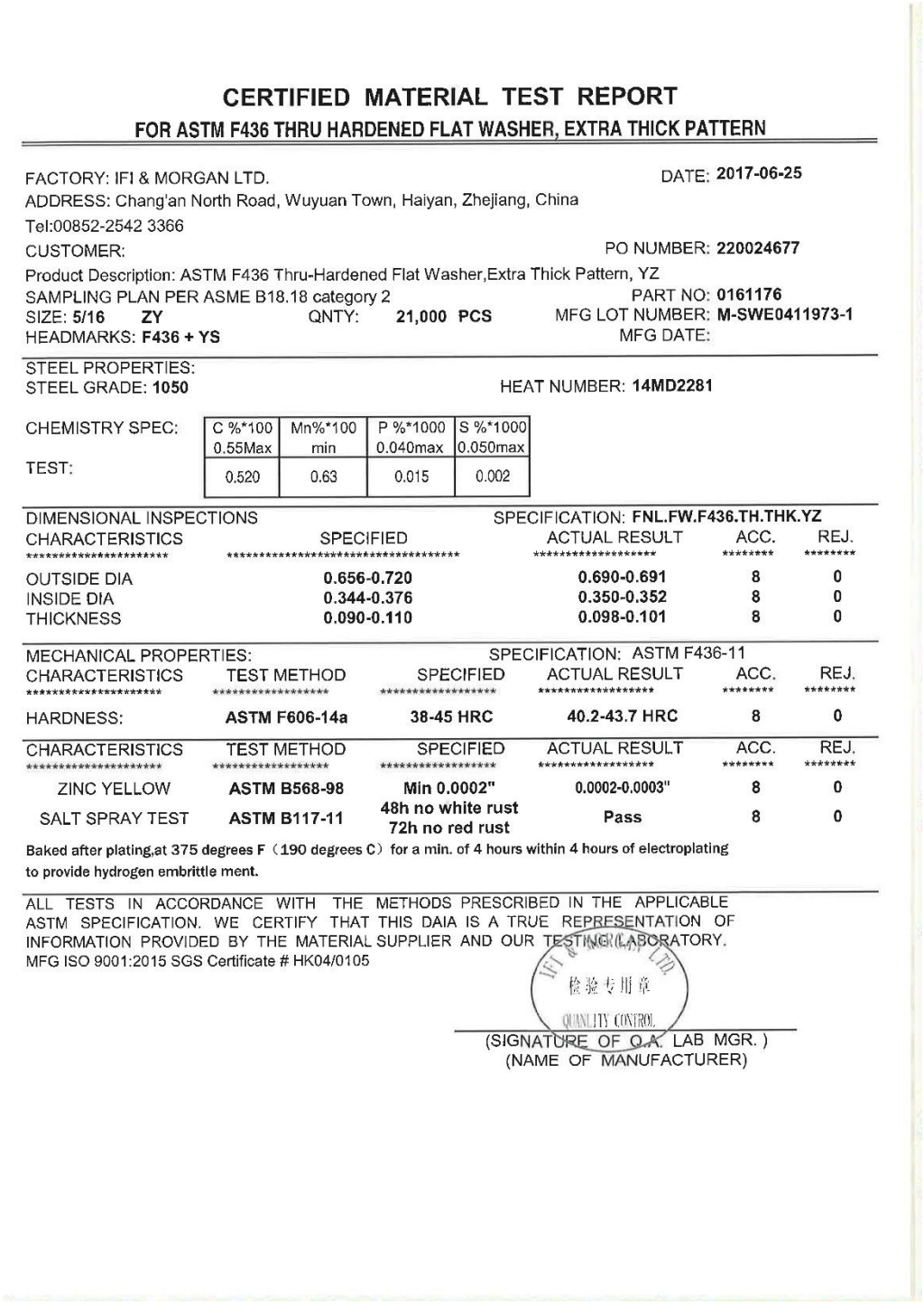
ACCREDITED
Testing Laboratory

This MTR supersedes all previously dated MTRs for this order

Janice Barnard Division Mgr. of Quality Assurance
barnardJ@chartersteel.com
Printed Date : 08/27/2017

Page 1 of 2

Figure B-48. ⅝-in. (16-mm) Dia. Guardrail Nut, Test Nos. NYBWT-2 and NYBWT-3 (Item No. j10)



CERTIFIED MATERIAL TEST REPORT

FOR ASTM F436 THRU HARDENED FLAT WASHER, EXTRA THICK PATTERN

FACTORY: IFI & MORGAN LTD. DATE: **2017-06-25**
ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan, Zhejiang, China
Tel:00852-2542 3366
CUSTOMER: PO NUMBER: **220024677**
Product Description: ASTM F436 Thru-Hardened Flat Washer,Extra Thick Pattern, YZ
SAMPLING PLAN PER ASME B18.18 category 2 PART NO: **0161176**
SIZE: **5/16 ZY** QNTY: **21,000 PCS** MFG LOT NUMBER: **M-SWE0411973-1**
HEADMARKS: **F436 + YS** MFG DATE:

STEEL PROPERTIES:
STEEL GRADE: **1050** HEAT NUMBER: **14MD2281**

CHEMISTRY SPEC:	C %*100 0.55Max	Mn%*100 min	P %*1000 0.040max	S %*1000 0.050max
TEST:	0.520	0.63	0.015	0.002

DIMENSIONAL INSPECTIONS SPECIFICATION: **FNL.FW.F436.TH.THK.YZ**

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
OUTSIDE DIA	**0.656-0.720**	**0.690-0.691**	**8**	**0**
INSIDE DIA	**0.344-0.376**	**0.350-0.352**	**8**	**0**
THICKNESS	**0.090-0.110**	**0.098-0.101**	**8**	**0**

MECHANICAL PROPERTIES: SPECIFICATION: ASTM F436-11

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
HARDNESS:	**ASTM F606-14a**	**38-45 HRC**	**40.2-43.7 HRC**	**8**	**0**

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
ZINC YELLOW	**ASTM B568-98**	**Min 0.0002"**	**0.0002-0.0003"**	**8**	**0**
SALT SPRAY TEST	**ASTM B117-11**	**48h no white rust 72h no red rust**	**Pass**	**8**	**0**

Baked after plating,at 375 degrees F（190 degrees C）for a min. of 4 hours within 4 hours of electroplating to provide hydrogen embrittle ment.

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 ISO 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN (CAY) LTD.
检验专用章
QUANLITY CONTROL

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

Figure B-49. $^{5}/_{16}$-in. (8-mm) Dia. Hardened Flat Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k1)

TEST REPORT

USS FLAT WASHER, HDG

CUSTOMER:

DATE: **2017-10-22**

PO NUMBER: **480006185**

MFG LOT NUMBER: **M-SWE0412035-6**

SIZE: **3/8**

PART NO: **1133182**

HEADMARKS:

QNTY: **420,000 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**	**1.001-1.003**	**8**	**0**
INSIDE DIA	**0.433-0.453**	**0.442-0.446**	**8**	**0**
THICKNESS	**0.064-0.104**	**0.066-0.075**	**8**	**0**

HOT DIP GALVANIZED	**ASTM A153 class C. RoHS Compliant**	**Min 0.0017"**	**Min 0.0018 In**	**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 ISO 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD. 检验专用章 QUANLITY CONTROL

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

IFI & MORGAN LTD. *ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan, Zhejiang, China*

Figure B-50. ⅜-in. (10-mm) Dia. Plain Round Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k2)

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

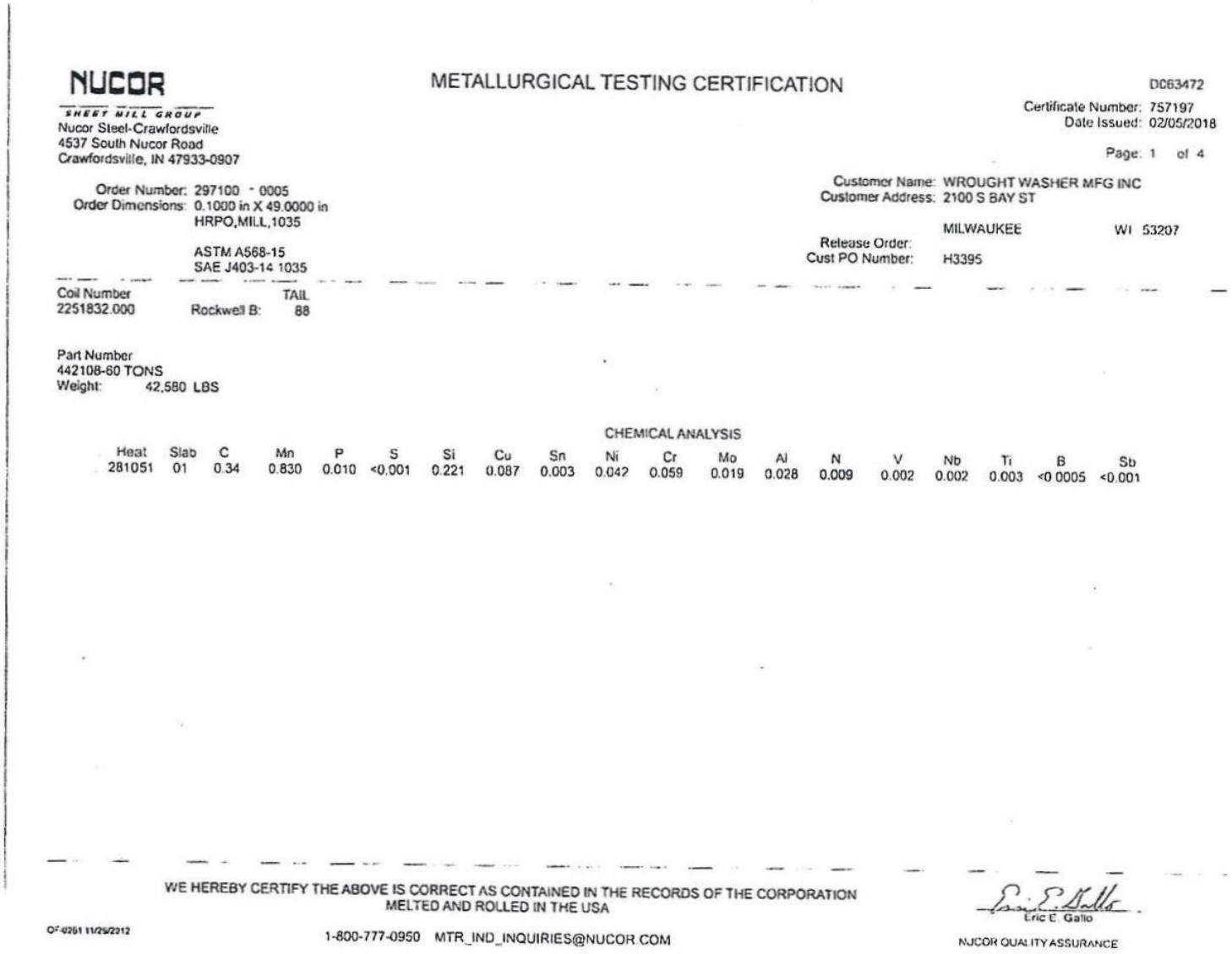
WE HEREBY CERTIFY THAT THIS WAS PRODUCED AS PER CUSTOMER'S REQUIREMENT.

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 B-51. ½-in. (13-mm) Dia. Plain Narrow Round Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k3)



NUCOR

SHEET MILL GROUP

Nucor Steel-Crawfordsville
4537 South Nucor Road
Crawfordsville, IN 47933-0907

METALLURGICAL TESTING CERTIFICATION

DC63472

Certificate Number: 757197
Date Issued: 02/05/2018

Page: 1 of 4

Order Number: 297100 - 0005
Order Dimensions: 0.1000 in X 49.0000 in
HRPO,MILL,1035

ASTM A568-15
SAE J403-14 1035

Customer Name: WROUGHT WASHER MFG INC
Customer Address: 2100 S BAY ST

MILWAUKEE WI 53207

Release Order:
Cust PO Number: H3395

Coil Number
2251832.000

TAIL
Rockwell B: 88

Part Number
442108-60 TONS
Weight: 42,580 LBS

CHEMICAL ANALYSIS

Heat	Slab	C	Mn	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al	N	V	Nb	Ti	B	Sb
281051	01	0.34	0.830	0.010	<0.001	0.221	0.087	0.003	0.042	0.059	0.019	0.028	0.009	0.002	0.002	0.003	<0.0005	<0.001

WE HEREBY CERTIFY THE ABOVE IS CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION
MELTED AND ROLLED IN THE USA

Eric E. Gallo

NUCOR QUALITY ASSURANCE

OF-0261 11/29/2012

1-800-777-0950 MTR_IND_INQUIRIES@NUCOR.COM

Figure B-52. ½-in. (13-mm) Dia. Hardened Flat Washer, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k4)

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 F436

INSPECTION CERTIFICATE

CUSTOMER	**FASTENAL COMPANY**		
PART NAME	FLAT WASHER		
SIZE	3/4 "	DATE	January 20, 2017
PART NO.	W2A6C6000S6JZ5	REPORT NO.	1060120-21
CUST. PART NO.	33174	ORDER NO.	110218950
MATERIAL / DIA.	10B20 / 23 mm	DOCUMENT NO.	10502010
HEAT(COIL) NO.	3XV37	LOT NO.	5A2C6FNB1
LOT QTY	144,000 PCS	MAF. QTY	144,000 PCS

THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH REQUIREMENT OF THE ORDER.

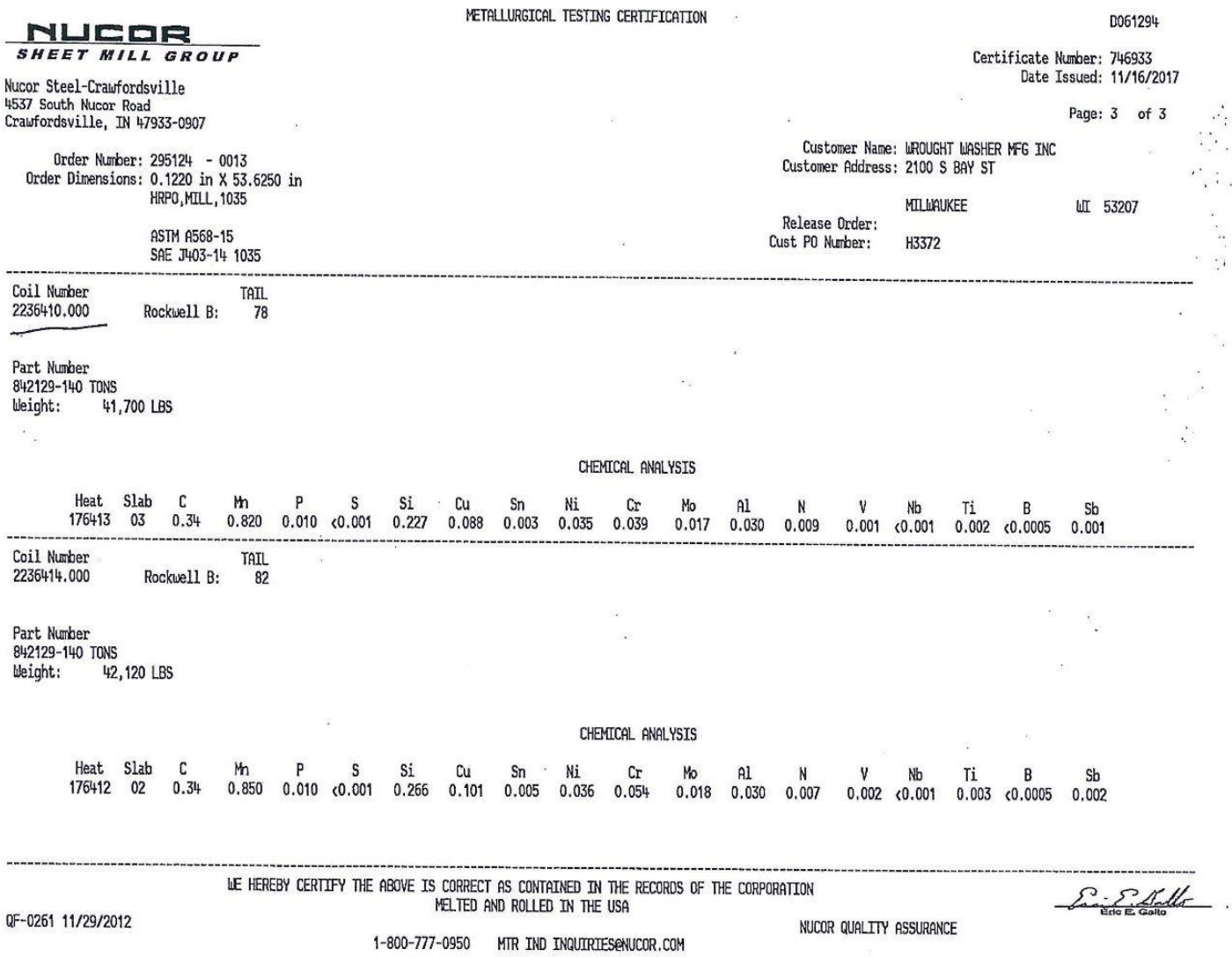
SAMPLING PLAN STANDARD	ASME B18.18-2011
DIMENSION STANDARD	ASTM F436-2011
COATING STANDARD	ASTM B695-R2009
HARDNESS TEST METHOD	ASTM F606-2014
COATING TEST METHOD	ASTM E376-2011
SALT PRAY TEST METHOD	
STANDARD OF INSPECTION REPORT	EN 10204 3.1

DIMENSIONS IN inch

	INSPECTION ITEM	SPECIFICATION	TEST QTY	INSPECTION RESULTS MIN.	INSPECTION RESULTS MAX.	INSPECTION EQUIPMENT
1	OUTSIDE DIAMETER	1.4360 - 1.5000	8	1.4563	1.4764	Caliper
2	INSIDE DIAMETER	0.8130 - 0.8450	8	0.8339	0.8374	Caliper
3	THICKNESS	0.1220 - 0.1770	8	0.1335	0.1394	Caliper
4	HARDNESS	HRC 38 - 45	5	39.1	41.1	Rockwell
5	COATING	MECH. GALV. 0.0021 in.	5	0.0022	0.0032	Magnetic
6	APPEARANCE	VISUAL		OK		

INSPECTOR Yu Tain Lin QC CHIEF Jing Yeh Tsao

Figure B-53. ¾-in. (19-mm) Dia. Hardened Flat Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k5)



METALLURGICAL TESTING CERTIFICATION

D061294

NUCOR
SHEET MILL GROUP

Certificate Number: 746933
Date Issued: 11/16/2017

Page: 3 of 3

Nucor Steel-Crawfordsville
4537 South Nucor Road
Crawfordsville, IN 47933-0907

Customer Name: WROUGHT WASHER MFG INC
Customer Address: 2100 S BAY ST
MILWAUKEE WI 53207

Order Number: 295124 - 0013
Order Dimensions: 0.1220 in X 53.6250 in
HRPO,MILL,1035

ASTM A568-15
SAE J403-14 1035

Release Order:
Cust PO Number: H3372

Coil Number 2236410.000 — Rockwell B: TAIL 78

Part Number
842129-140 TONS
Weight: 41,700 LBS

CHEMICAL ANALYSIS

Heat	Slab	C	Mn	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al	N	V	Nb	Ti	B	Sb
176413	03	0.34	0.820	0.010	<0.001	0.227	0.088	0.003	0.035	0.039	0.017	0.030	0.009	0.001	<0.001	0.002	<0.0005	0.001

Coil Number 2236414.000 — Rockwell B: TAIL 82

Part Number
842129-140 TONS
Weight: 42,120 LBS

CHEMICAL ANALYSIS

Heat	Slab	C	Mn	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al	N	V	Nb	Ti	B	Sb
176412	02	0.34	0.850	0.010	<0.001	0.266	0.101	0.005	0.036	0.054	0.018	0.030	0.007	0.002	<0.001	0.003	<0.0005	0.002

WE HEREBY CERTIFY THE ABOVE IS CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION
MELTED AND ROLLED IN THE USA

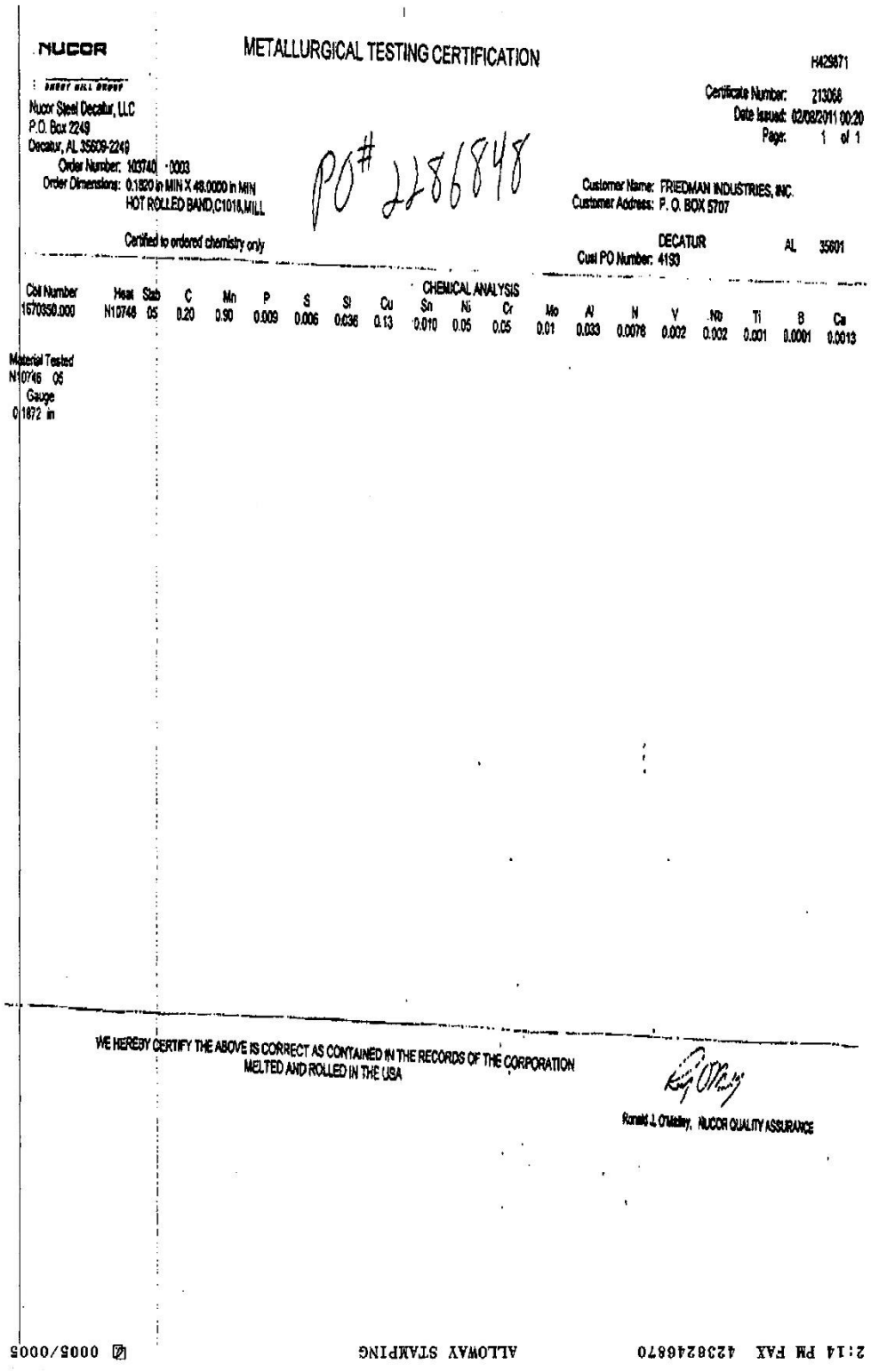
Eric E. Gallo

QF-0261 11/29/2012

NUCOR QUALITY ASSURANCE

1-800-777-0950 MTR IND INQUIRIES@NUCOR.COM

Figure B-54. ¾-in. (19-mm) Dia. Hardened Flat Washer, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k5)



NUCOR

SHEET MILL GROUP

Nucor Steel Decatur, LLC
P.O. Box 2249
Decatur, AL 35609-2249

METALLURGICAL TESTING CERTIFICATION

H429871

Certificate Number: 213068
Date Issued: 02/08/2011 00:20
Page: 1 of 1

Order Number: 103740 - 0003
Order Dimensions: 0.1920 in MIN X 48.0000 in MIN
HOT ROLLED BAND,C1018,MILL

PO# 286848

Customer Name: FRIEDMAN INDUSTRIES, INC.
Customer Address: P. O. BOX 5707
DECATUR AL 35601
Cust PO Number: 4193

Certified to ordered chemistry only

CHEMICAL ANALYSIS

Coil Number	Heat	Slab	C	Mn	P	S	Si	Cu	Sn	Ni	Cr	Mo	Al	N	V	Nb	Ti	B	Ca
1570350.000	N10748	05	0.20	0.90	0.009	0.006	0.036	0.13	0.010	0.05	0.05	0.01	0.033	0.0078	0.002	0.002	0.001	0.0001	0.0013

Material Tested
N10748 05
Gauge
0.1872 in

WE HEREBY CERTIFY THE ABOVE IS CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION
MELTED AND ROLLED IN THE USA

Ronald J. O'Malley, NUCOR QUALITY ASSURANCE

08/01/2012 2:14 PM FAX 4238246870 ALLOWAY STAMPING 0005/0005

Figure B-55. ¾-in. (19-mm) Dia. Plain Round Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k6)

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: 7/8
INVOICE NBR: TD16680100
PART NBR.: 33020
LOT NO.: 16H-168092-9

DATE: 2016-06-12
ORDER NBR. 210107422
QUANTITY:16800PCS

DIMENSIONS (UNIT:INCH)

	STANDARD	RESULT				
		1	2	3	4	5
INSIDE DIA	0.936-0.968	0.942	0.951	0.946	0.948	0.945
OUTSIDE DIA	2.243-2.280	2.251	2.249	2.255	2.258	2.253
THICKNESS	0.136-0.192	0.145	00.148	0.144	0.149	0.143

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	4.0-5.4um	8	0

NOTE

1. QUANTITY OF SAMPLES: 5 PCS

2. JUDGEMENT: GOOD

3. CHIEF INSPECTOR:

Figure B-56. ⅞-in. (22-mm) Dia. Hardened Flat Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k7)

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: IFI & MORGAN LTD.
FACTORY ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan, Zhejiang, China

DESCRIPTION: 1
INVOICE NBR: TD16680155
PART NBR.: 33188
LOT NO.: 16H-168236-30

DATE: 2016-10-08
ORDER NBR. 210114135
QUANTITY:3240PCS

DIMENSIONS (UNIT:INCH)

	STANDARD	RESULT				
		1	2	3	4	5
INSIDE DIA	1.055-1.092	1.068	1.068	1.067	1.069	1.068
OUTSIDE DIA	2.493-2.530	2.514	2.513	2.514	2.514	2.511
THICKNESS	0.136-0.192	0.146	0.149	0.152	0.152	0.147

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	48-64um	8	0

NOTE

1. QUANTITY OF SAMPLES: 5 PCS

2. JUDGEMENT: GOOD

3. CHIEF INSPECTOR:

IFI & MORGAN LTD. 检验专用章 QUANLITY CONTROL

由 扫描全能王 扫描创建

Figure B-57. 1-in. (25-mm) Dia. Plain Round Washers, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k8)

NUCOR
FASTENER DIVISION

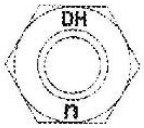
LOT NO.
371123B

Post Office Box 6100
Saint Joe, Indiana 46785
Telephone 260/337-1600

CUSTOMER NO/NAME
8001 FASTENAL COMPANY-KS
TEST REPORT SERIAL# FB488556
TEST REPORT ISSUE DATE 3/04/16
DATE SHIPPED 8/17/16
NAME OF LAB SAMPLER: SANDRA NEUMANN-PLUMMER, LAB TECHNICIAN
NUCOR ORDER # 978943
CUST PART # 38210
CUSTOMER P.O. # 210117217

**********CERTIFIED MATERIAL TEST REPORT**********

NUCOR PART NO	QUANTITY	LOT NO.	DESCRIPTION
175647	3600	371123B 1-8	GR DH HV H.D.G.
MANUFACTURE DATE 1/07/16			HEX NUT H.D.G./GREEN LUBE



--CHEMISTRY MATERIAL GRADE -1045L

MATERIAL NUMBER	HEAT NUMBER	**CHEMISTRY COMPOSITION (WT% HEAT ANALYSIS) BY MATERIAL SUPPLIER C	MN	P	S	SI	NUCOR STEEL - SOUTH CAROL
RM030412	DL15105591	.44	.64	.005	.020	.20	

--MECHANICAL PROPERTIES IN ACCORDANCE WITH ASTM A563-07a

SURFACE HARDNESS (R30N)	CORE HARDNESS (RC)	PROOF LOAD 90900 LBS		TENSILE STRENGTH DEG-WEDGE (LBS)	STRESS (PSI)
N/A	26.6	PASS	N/A		N/A
N/A	27.0	PASS	N/A		N/A
N/A	27.6	PASS	N/A		N/A
N/A	28.9	PASS	N/A		N/A
N/A	26.7	PASS	N/A		N/A
AVERAGE VALUES FROM TESTS	27.4				

PRODUCTION LOT SIZE 90800 PCS

--VISUAL INSPECTION IN ACCORDANCE WITH ASTM A563-07a 80 PCS. SAMPLED LOT PASSED

--COATING - HOT DIP GALVANIZED TO ASTM F2329-13 - GALVANIZING PERFORMED IN THE U.S.A.

1.	0.00294	2.	0.00311	3.	0.00346	4.	0.00235	5.	0.00218	6.	0.00270	7.	0.00353
8.	0.00322	9.	0.00406	10.	0.00269	11.	0.00275	12.	0.00315	13.	0.00487	14.	0.00253
15.	0.00416												

AVERAGE THICKNESS FROM 15 TESTS .00318
HEAT TREATMENT - AUSTENITIZED, OIL QUENCHED & TEMPERED (MIN 800 DEG F)

--DIMENSIONS PER ASME B18.2.6-2010

CHARACTERISTIC	#SAMPLES TESTED	MINIMUM	MAXIMUM
Width Across Corners	8	1.824	1.844
Thickness	32	0.980	1.001

ALL TESTS ARE IN ACCORDANCE WITH THE LATEST REVISIONS OF THE METHODS PRESCRIBED IN THE APPLICABLE SAE AND ASTM SPECIFICATIONS. THE SAMPLES TESTED CONFORM TO THE SPECIFICATIONS AS DESCRIBED/LISTED ABOVE AND WERE MANUFACTURED FREE OF MERCURY CONTAMINATION. NO INTENTIONAL ADDITIONS OF BISMUTH, SELENIUM, TELLURIUM, OR LEAD WERE USED IN THE STEEL USED TO PRODUCE THIS PRODUCT.
THE STEEL WAS MELTED AND MANUFACTURED IN THE U.S.A. AND THE PRODUCT WAS MANUFACTURED AND TESTED IN THE U.S.A.
PRODUCT COMPLIES WITH DFARS 252.225-7014. WE CERTIFY THAT THIS DATA IS A 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.

A2LA ACCREDITED
MECHANICAL FASTENER
CERTIFICATE NO. A2LA 0139.01
EXPIRATION DATE 12/31/17

NUCOR FASTENER
A DIVISION OF NUCOR CORPORATION
John W. Ferguson
JOHN W. FERGUSON
QUALITY ASSURANCE SUPERVISOR

Page 1 of 1

Figure B-58. 1-in. (25-mm) Dia. UNC Heavy Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k9)

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 : 2018/03/29

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 120268938
COMMODITY : REGULAR SQUARE NUTS GR-A
SIZE : 3/4-10 OVER TAP 0.51MM
LOT NO : 1N1670160
SHIP QUANTITY : 10,800 PCS
LOT QUANTITY 13,198 PCS
HEADMARKS :

PACKING NO : GEM160825011
INVOICE NO : GEM/FNL-160913IN-1
PART NO : 0189532
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 16302167-4
MATERIAL : X1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2016/07/15
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2015

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0230	0.0700	0.2900	0.0140	0.0060	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : DWTING

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	4 PCS		1.3820-1.4430 inch	1.4770-1.5510 inch	4	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0290 inch	0.0250-0.0280 inch	15	0
THICKNESS	4 PCS		0.7100-0.7850 inch	0.6370-0.6760 inch	4	0
WIDTH ACROSS FLATS	4 PCS		1.2120-1.2500 inch	1.0930-1.1190 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	REP	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68 -107HRB	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	57.12-72.93	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 B-59. ¾-in. (19-mm) Dia. UNC Square Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k10)

CERTIFIED MILL TEST REPORT

ASI ALTON STEEL INC

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.
One Unytite Drive
Peru, IL 61354

Date	03/22/2012	Customer PO	04051-2	**Specifications**
ASI Ord No.	51041	Customer PT.	B1045SC1.1250	
ASI Ord Line Item	1			SAE 1045

Item Description
Steel Bar, Hot Rolled, 1.1250, 25' 0 "

Strand Cast, RR = 49.29:1

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
121455	0.46	0.74	0.007	0.028	0.23	0.18	0.064	0.105	0.016	0.009	0.001	0.026	0.004	0.0003	0.0007	0.0094	0.0004
121476	0.46	0.75	0.004	0.025	0.23	0.16	0.061	0.067	0.014	0.009	0.001	0.026	0.004	0.0003	0.0006	0.0103	0.0006

JOMINY HARDENABILITY USING ASTM A-255 CALCULATED FROM CHEMICAL DI

Heat Number	GS	DI
121455	7	1.32
121476	7	1.19

SPECIAL TEST RESULTS

	ASTM E-45 Method A:								ASTM E-45 Method C:		SAE J422		ASTM E-381			Mil 12286		Ferritic GS	Hardness		
Heat Number	TA	TB	TC	TD	HA	HB	HC	HD	S	O	S	O	S	R	C	A	B		RC	RB	BHN
121455											3	2	2	2	1						
										Decarb:		0.005									
121476											2	3	2	2	2						
										Decarb:		.005									

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: Rubert Cauley

R Cauley

Figure B-60. ¾-in. (19-mm) Dia. Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k11)

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 : 2018/03/29

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 220025463
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 5/16-18 NC O/T 0.43MM
LOT NO : 1N1760557
SHIP QUANTITY : 139,500 PCS
LOT QUANTITY 162,517 PCS
HEADMARKS :

PACKING NO : GEM170914005
INVOICE NO : GEM/FNL-170928IN-3
PART NO : 36703
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 1705030200
MATERIAL : 1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2017/07/31
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2015

Chemistry	C%	MN%	P%	S%
Spec. : MIN.				
MAX.	0.5800		0.1300	0.2300
Test Value	0.0700	0.2600	0.0160	0.0050

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : LXQING

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		0.5570-0.5770 inch	0.5630-0.5640 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0160 inch	0.0090-0.0130 inch	15	0
THICKNESS	6 PCS		0.2580-0.2730 inch	0.2720-0.2720 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.4890-0.5000 inch	0.4940-0.4970 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 A563-2015

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	85-87 HRB	15	0
PROOF LOAD	5 PCS	ASTM F606-2014		Min. 90 KSI	OK	5	0
PLATING THICKNESS(μm)	29 PCS	ASTM B568-1998		>=53	67.44-71.94	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:

Figure B-61. 5/16-in. (8-mm) Dia. Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k13)

FASTENAL®

Certificate of Compliance

Sold To:

UNL TRANSPORTATION

Purchase Order: NYBWT-1,2

Job: NYBWT-1,2

Invoice Date: 05/24/2018

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

24 PCS 3/8"-16 x 7-1/2" ASTM A307 Grade A Hot Dipped Galvanized Hex Bolt SUPPLIED UNDER OUR TRACE NUMBER 120302589 AND UNDER PART NUMBER 91873

84 PCS 3/4"-10 x 2" ASTM F3125 Grade A325 Hot Dipped Galvanized Steel Structural Bolt Only--USA SUPPLIED UNDER OUR TRACE NUMBER 488266 AND UNDER PART NUMBER 19690

48 PCS 1/2"-13 x 2" ASTM A307 Grade A Hot Dipped Galvanized Tap Bolt SUPPLIED UNDER OUR TRACE NUMBER 120295018 AND UNDER PART NUMBER 0189472

50 PCS 1/2"-13 Hot Dip Galvanized Finish Grade A Finished Hex Nut SUPPLIED UNDER OUR TRACE NUMBER 180143778 AND UNDER PART NUMBER 1136709

24 PCS 5/16" x 0.688" OD Thru-Hardened ECOGUARD[REG] Finish Steel SAE General Purpose Flat Washer SUPPLIED UNDER OUR TRACE NUMBER 120109164 AND UNDER PART NUMBER 11137083

48 PCS 5/16"-18 Hot Dip Galvanized Finish Grade A Finished Hex Nut SUPPLIED UNDER OUR TRACE NUMBER p1222717 AND UNDER PART NUMBER 36703

24 PCS 3/4"-10 x 8" ASTM A307 Grade A Hot Dipped Galvanized Hex Bolt SUPPLIED UNDER OUR TRACE NUMBER 210158499 AND UNDER PART NUMBER 91972

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

Fastenal Account Representative Signature

Ashly Stanczyk

Printed Name

5/24/18

Date

Please check current revision to avoid using obsolete copies.

This document was printed on 05/24/2018 and was current at that time.

Fastenal Store Location/Address

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

Page 1 of 2

Figure B-62. $^{5}/_{16}$-in. (8-mm) Dia. Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k13)

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 : 2018/05/28

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 180143778
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 1/2-13 NC O/T 0.46MM
LOT NO : 1N1780824
SHIP QUANTITY : 18,750 PCS
LOT QUANTITY 170,225 PCS
HEADMARKS :

PACKING NO : GEM171130002
INVOICE NO : GEM/FNL-171220DE-1
PART NO : 1136709
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 331703751
MATERIAL : ML08
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2017/11/02
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2015

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0330	0.0600	0.4300	0.0180	0.0070	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : WDANDAN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS	ASME B18.2.2-2015	0.8400-0.8660 inch	0.8540-0.8560 inch	6	0
FIM	15 PCS		Max. 0.0110 inch	0.0100-0.0110 inch	15	0
THICKNESS	6 PCS		0.4270-0.4480 inch	0.4430-0.4440 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.7360-0.7500 inch	0.7470-0.7480 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 A563-2015

SAMPLED BY : TANGHAO

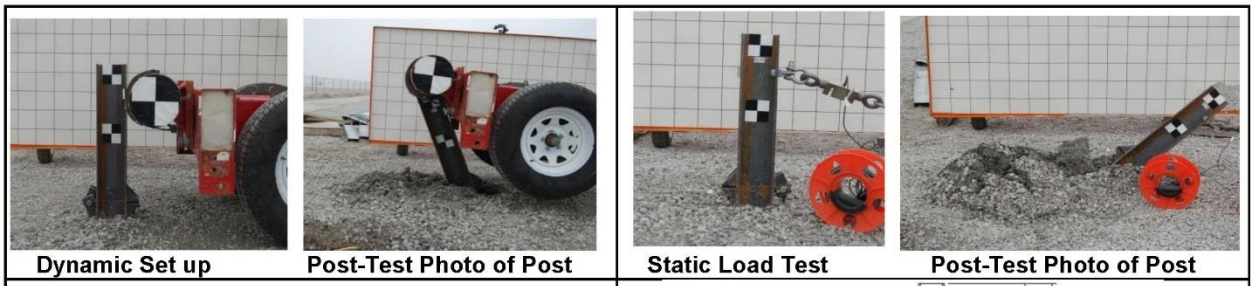
INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	86-90 HRB	15	0
PROOF LOAD	6 PCS	ASTM F606-2014		Min.9,649 LBF	OK	6	0
PLATING THICKNESS(μm)	6 PCS	ASTM B568-1998		>=53	59.22-80.98	6	0

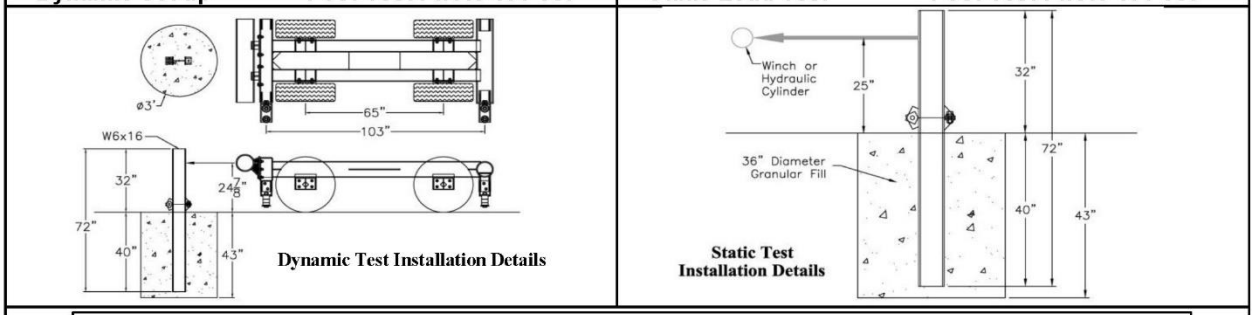
WE CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIAL SUPPLIER AND OUR TESTING LABORATORY .WHICH ACCREDITED BY ISO/IEC17025(CERTIFICATE NUMBER:3358.01)
WE CERTIFY THAT THE PRODUCTS SUPPLIED ARE IN COMPLIANCE WITH THE REQUIREMENTS OF THE ORDER

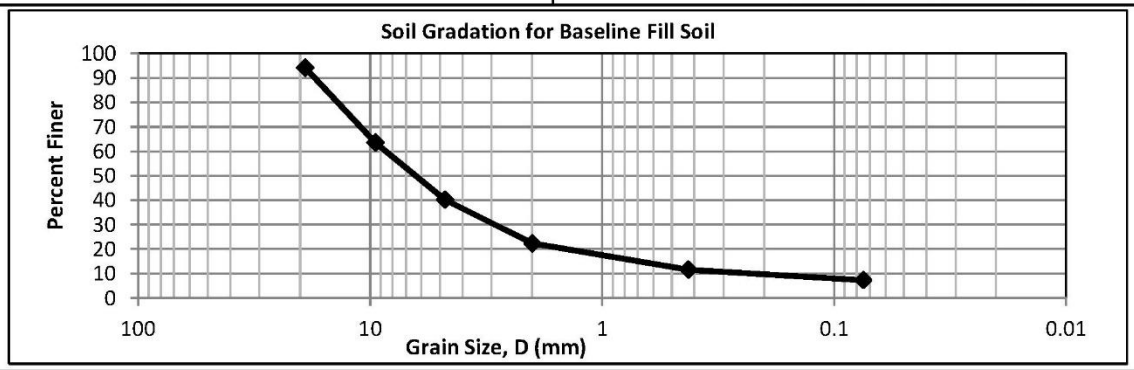
Quality Supervisor:

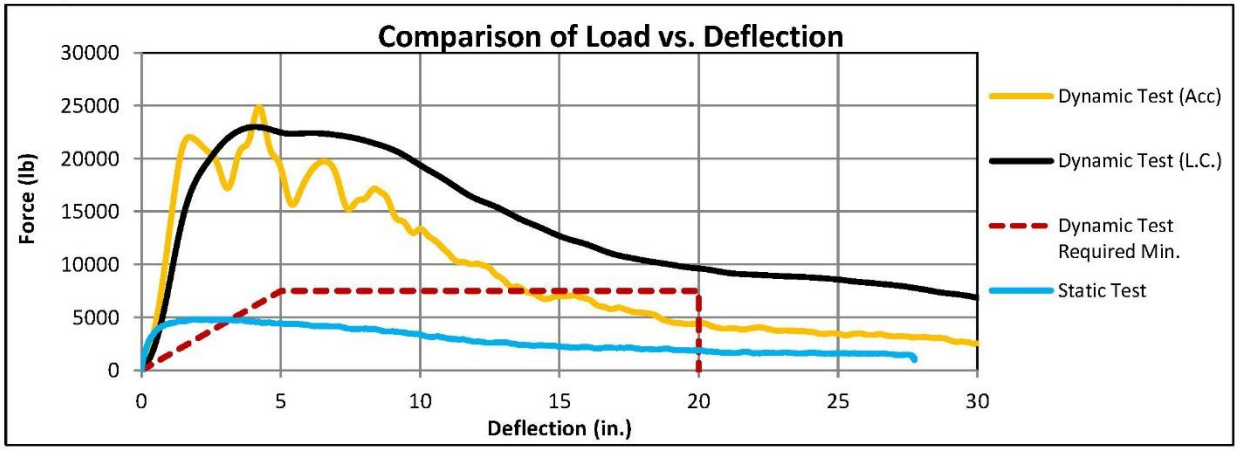
Figure B-63. ½-in. (13-mm) Dia. Hex Nuts, Test Nos. NYBWT-2 and NYBWT-3 (Item No. k14)

Appendix C. Static Soil Tests







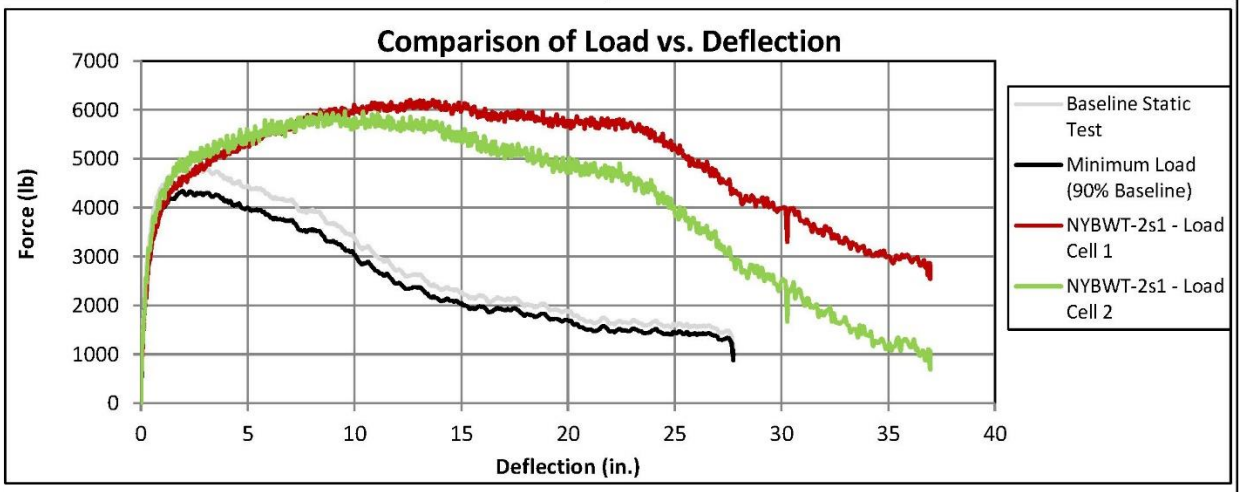


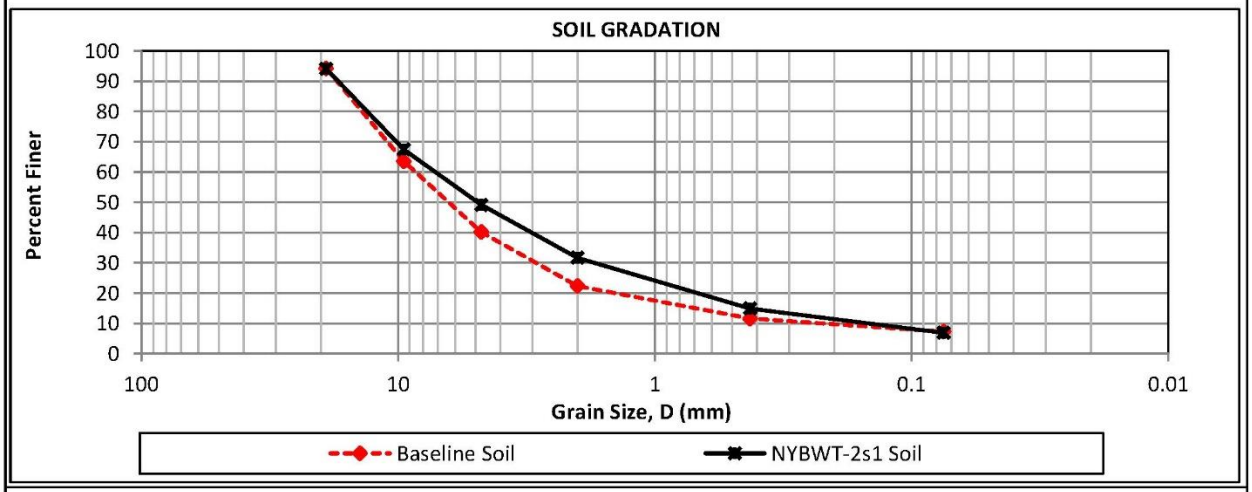
Date	2/16/2018		
Test Facility & Site Location	Midwest Roadside Safety Facility		
In situ soil description (ASTM D2487)	Well-Graded Gravel (GW)		
Fill material description (ASTM D2487)	Well-Graded Gravel (GW) (see sieve analyses above)		
Description of fill placement procedure	H.E.-8		
Bogie Weight	1786	lb	810 kg
Impact Velocity	20.9	mph	33.7 km/h

Figure C-1. Soil Strength, Initial Calibration Tests, Nos. NYBWT-2 and NYBWT-3

Static Load Test Setup

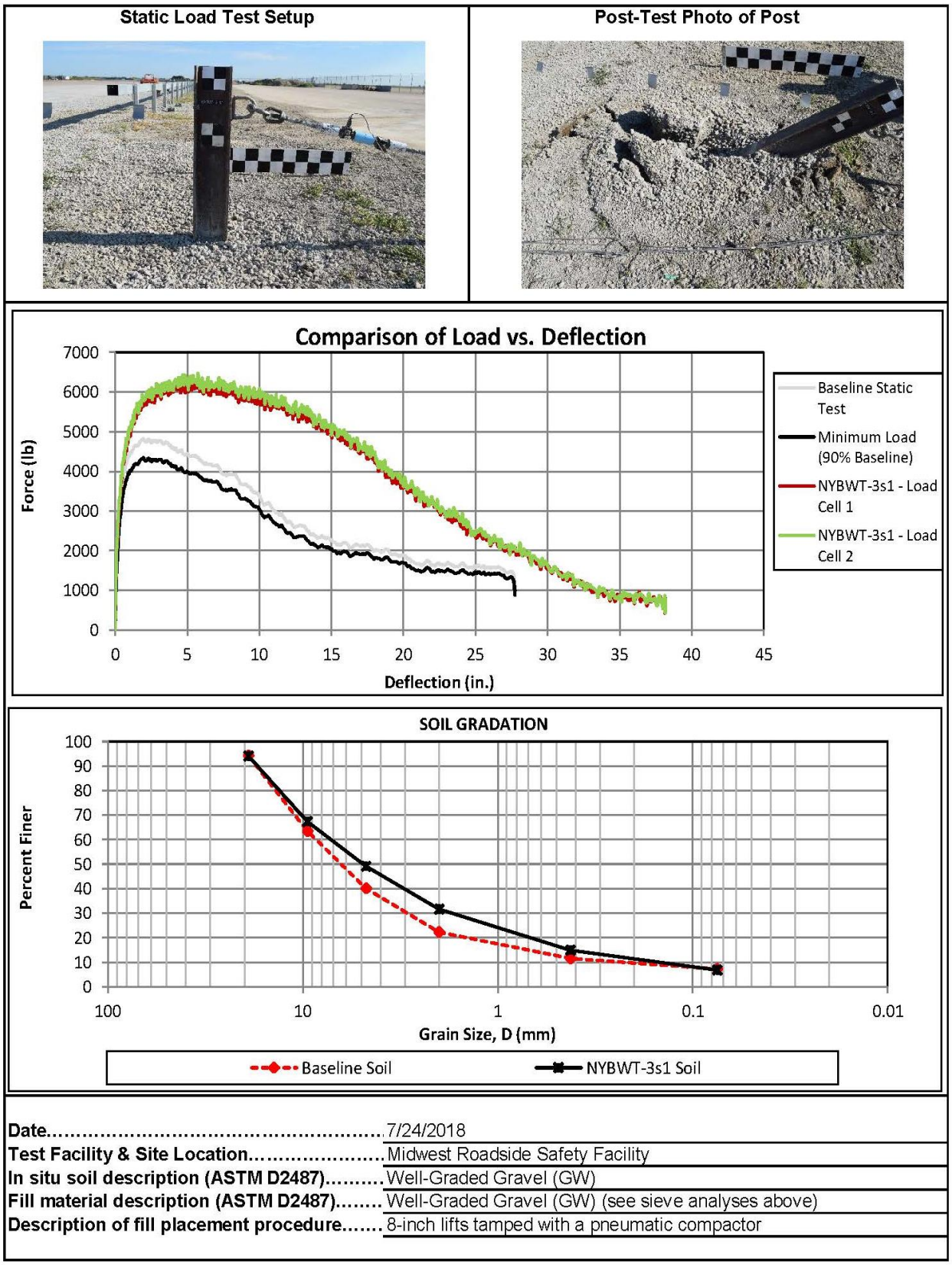
Post-Test Photo of Post





Date	6/8/2018
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. NYBWT-2



Date	7/24/2018
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-3. Static Soil Test, Test No. NYBWT-3

Appendix D. Vehicle Center of Gravity Determination

Date:	6/8/2016	Test Name:	NYBWT-2	VIN:	1D7RB1GK0BS515074
Year:	2011	Make:	Dodge	Model:	Ram 1500 Quad Cab

Vehicle CG Determination

VEHICLE	Equipment	Weight (lb)	Vertical CG (in.)	Vertical M (lb-in.)
+	Unballasted Truck (Curb)	4931	29.322488	144589.19
+	Hub	19	24	456
+	Brake activation cylinder & frame	7	29	203
+	Pneumatic tank (Nitrogen)	27	28	756
+	Strobe/Brake Battery	5	26 1/4	131.25
+	Brake Receiver/Wires	5	54	270
+	CG Plate including DAS	42	32 3/8	1359.75
-	Battery	-47	41	-1927
-	Oil	-8	15 1/2	-124
-	Interior	-93	27	-2511
-	Fuel	-136	20	-2720
-	Coolant	-7	33	-231
-	Washer fluid	-5	-7	35
+	Water Ballast (In Fuel Tank)	207	16 1/2	3415.5
+	Onboard Supplemental Battery	13	26 1/4	341.25
	Smart Barrier Provisions	7	24 1/2	171.5
				0
Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle				144215.44

Estimated Total Weight (lb)	4967
Vertical CG Location (in.)	29.0347

Vehicle Dimensions for C.G. Calculations

Wheel Base: 140.5 in. Front Track Width: 66 in.
Rear Track Width: 66 in.

Center of Gravity	2270P MASH Targets	Test Inertial	Difference
Test Inertial Weight (lb)	5000 ± 110	4969	-31.0
Longitudinal CG (in.)	63 ± 4	63.675991	0.67599
Lateral CG (in.)	NA	-0.816865	NA
Vertical CG (in.)	28 or greater	29.03	1.03472

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	1412	1334	
Rear	1073	1112	
FRONT	2746		lb
REAR	2185		lb
TOTAL	4931		lb

TEST INERTIAL WEIGHT (lb)

	Left	Right	
Front	1433	1284	
Rear	1113	1139	
FRONT	2717		lb
REAR	2252		lb
TOTAL	4969		lb

Figure D-1. Vehicle Mass Distribution, Test No. NYBWT-2

Date:	7/24/2018	Test Name:	NYBWT-3	VIN:	1C6RD6FPCS205397
Year:	2012	Make:	Dodge	Model:	Ram 1500

Vehicle CG Determination

VEHICLE	Equipment	Weight (lb)	Vertical CG (in.)	Vertical M (lb-in.)
+	Unballasted Truck (Curb)	5151	28.43346	146460.75
+	Hub	19	15	285
+	Brake activation cylinder & frame	7	28 3/4	201.25
+	Pneumatic tank (Nitrogen)	31	28	868
+	Strobe/Brake Battery	5	26 1/2	132.5
+	Brake Receiver/Wires	6	51 3/4	310.5
+	CG Plate including DAS	42	31 1/2	1323
-	Battery	-44	38 3/4	-1705
-	Oil	-6	22 5/8	-135.75
-	Interior	-79	41 1/2	-3278.5
-	Fuel	-195	17 1/4	-3363.75
-	Coolant	-9	35 1/8	-316.125
-	Washer fluid	0		0
+	Water Ballast (In Fuel Tank)	59	15	885
+	Onboard Supplemental Battery	0		0
	Smart Barrier Provisions	6	24 1/2	147
				0
Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle				141813.88

Estimated Total Weight (lb)	4993
Vertical CG Location (in.)	28.4025

Vehicle Dimensions for C.G. Calculations

Wheel Base:	140.25	in.	Front Track Width:	67.375	in.
			Rear Track Width:	67.75	in.

Center of Gravity	2270P MASH Targets	Test Inertial	Difference
Test Inertial Weight (lb)	5000 ± 110	5006	6.0
Longitudinal CG (in.)	63 ± 4	60.739513	-2.26049
Lateral CG (in.)	NA	0.6073337	NA
Vertical CG (in.)	28 or greater	28.40	0.40254

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	1478	1429	
Rear	1119	1125	
FRONT	2907		lb
REAR	2244		lb
TOTAL	5151		lb

TEST INERTIAL WEIGHT (lb)

	Left	Right	
Front	1393	1445	
Rear	1065	1103	
FRONT	2838		lb
REAR	2168		lb
TOTAL	5006		lb

Figure D-2. Vehicle Mass Distribution, Test No. NYBWT-3

Appendix E. Post Movement Definitions

Table E-1. Post Movement Definitions

Movement	**Definition**
Deflection	Deflection refers to component translational movement, i.e., lateral or longitudinal displacements. This is linear movement without deformation and without displacing the soil. The deflection direction can be described as upstream, downstream, front, or back. Deflection can also be used as a vague term when it is unclear if a post was bending or rotating during impact.
Bending	Bending refers to plastic deformation of a component due to an applied moment load. The direction of bending can be described as upstream, downstream, front, or back.
Rotation	Rotation refers to a complete component movement with little to no deformation. Soil may be displaced. The direction of rotation can be described as upstream, downstream, front, or back, as well as clockwise or counterclockwise.
Twisting	Twisting refers to rotational displacement along the long axis of a component, e.g., the vertical axis of a post or the longitudinal axis of a rail segment. Twisting does encompass plastic deformations to the component and should be described to explain which direction the front of the component now faces (upstream, downstream, down, up, etc.) or the direction of movement (clockwise or counterclockwise).

Appendix F. Vehicle Deformation Records

Date: 6/8/2016 Test Name: NYBWT-2 VIN: 1D7RB1GK0BS515074
Year: 2011 Make: Dodge Model: Ram 1500 Quad Cab

VEHICLE DEFORMATION
FLOOR PAN - SET 1

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
TOE PAN - WHEEL WELL (X, Z)	1	53.9487	17.7646	-3.3680	53.9307	17.7368	-3.2053	0.0180	0.0278	0.1627	0.1660	0.1637	X, Z
	2	54.7070	20.2759	-1.4738	54.6545	20.1996	-1.3385	0.0525	0.0763	0.1353	0.1640	0.1451	X, Z
	3	55.8209	23.1045	1.0540	55.8225	23.0454	1.2972	-0.0016	0.0591	0.2432	0.2503	0.2432	Z
	4	56.1154	27.7009	0.9003	56.0423	27.6152	1.2473	0.0731	0.0857	0.3470	0.3648	0.3546	X, Z
	5	56.4173	31.4047	-1.0477	56.2566	31.3753	-0.9245	0.1607	0.0294	0.1232	0.2046	0.2025	X, Z
	6	48.0944	16.1886	-0.4601	48.0346	16.1561	-0.2544	0.0598	0.0325	0.2057	0.2167	0.2142	X, Z
	7	48.7306	18.8903	1.4020	48.6637	18.8366	1.6303	0.0669	0.0537	0.2283	0.2439	0.2379	X, Z
	8	49.9582	22.2485	4.2921	49.9370	22.1104	4.5130	0.0212	0.1381	0.2209	0.2614	0.2219	X, Z
	9	50.0170	26.3433	4.3438	49.9737	26.2149	4.5724	0.0433	0.1284	0.2286	0.2657	0.2327	X, Z
	10	49.9023	32.0081	4.4668	49.8912	31.9858	4.6702	0.0111	0.0223	0.2034	0.2049	0.2037	X, Z
FLOOR PAN (Z)	11	43.0803	14.2678	1.5607	43.0272	14.2233	1.7114	0.0531	0.0445	0.1507	0.1659	0.1507	Z
	12	44.2847	17.3954	4.6520	44.2397	17.3673	4.8513	0.0450	0.0281	0.1993	0.2062	0.1993	Z
	13	44.5841	22.6173	5.0134	44.5723	22.5527	5.2029	0.0118	0.0646	0.1895	0.2006	0.1895	Z
	14	44.6530	27.5582	5.0053	44.5889	27.5621	5.1965	0.0641	-0.0039	0.1912	0.2017	0.1912	Z
	15	44.7953	32.6089	5.0299	44.7482	32.4774	5.2207	0.0471	0.1315	0.1908	0.2365	0.1908	Z
	16	37.8151	13.9742	2.9336	37.7546	13.9607	3.0758	0.0605	0.0135	0.1422	0.1551	0.1422	Z
	17	38.5947	17.3343	5.0490	38.5570	17.3741	5.2003	0.0377	-0.0398	0.1513	0.1609	0.1513	Z
	18	38.6925	22.2971	5.0354	38.6806	22.2527	5.1954	0.0119	0.0444	0.1600	0.1665	0.1600	Z
	19	38.7192	26.4289	5.0390	38.7136	26.3784	5.2067	0.0056	0.0505	0.1677	0.1752	0.1677	Z
	20	38.7780	30.9416	5.0512	38.7097	30.8980	5.2244	0.0683	0.0436	0.1732	0.1912	0.1732	Z
	21	35.1265	14.6689	4.6546	35.1043	14.6609	4.8048	0.0222	0.0080	0.1502	0.1520	0.1502	Z
	22	34.7309	18.5904	5.2872	34.6727	18.5558	5.4343	0.0582	0.0346	0.1471	0.1619	0.1471	Z
	23	34.6166	23.6774	5.2745	34.5967	23.6608	5.4326	0.0199	0.0166	0.1581	0.1602	0.1581	Z
	24	34.7557	27.5554	5.2787	34.7391	27.5770	5.4444	0.0166	-0.0216	0.1657	0.1679	0.1657	Z
	25	35.1403	31.9909	5.3069	35.0974	31.9283	5.4706	0.0429	0.0626	0.1637	0.1804	0.1637	Z
	26	32.2242	15.5008	4.5406	32.2484	15.5107	4.6631	-0.0242	-0.0099	0.1225	0.1253	0.1225	Z
	27	32.0863	20.4242	4.5175	32.0628	20.4074	4.6524	0.0235	0.0168	0.1349	0.1380	0.1349	Z
	28	32.2060	24.5343	4.5028	32.1941	24.5483	4.6476	0.0119	-0.0140	0.1448	0.1460	0.1448	Z
	29	32.1513	28.3520	4.2503	32.1570	28.2676	4.4260	-0.0057	0.0844	0.1757	0.1950	0.1757	Z
	30	32.2305	32.1976	4.5162	32.1912	32.2023	4.6678	0.0393	-0.0047	0.1516	0.1567	0.1516	Z

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Pretest Floor Pan	Posttest Floor Pan
	

Figure F-1. Floor Pan Deformation Data – Set 1, Test No. NYBWT-2

Date: 6/8/2016 Test Name: NYBWT-2 VIN: 1D7RB1GK0BS515074
Year: 2011 Make: Dodge Model: Ram 1500 Quad Cab

VEHICLE DEFORMATION
FLOOR PAN - SET 2

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
TOE PAN - WHEEL WELL (X, Z)	1	54.5485	38.0915	-6.9457	54.2079	38.1333	-7.1100	0.3406	-0.0418	-0.1643	0.3805	0.3406	X
	2	55.2453	40.6107	-5.1133	54.8861	40.6123	-5.2474	0.3592	-0.0016	-0.1341	0.3834	0.3592	X
	3	56.2739	43.4644	-2.5414	55.9989	43.4831	-2.6150	0.2750	-0.0187	-0.0736	0.2853	0.2750	X
	4	56.5447	48.0652	-2.7371	56.1523	48.0554	-2.6783	0.3924	0.0098	0.0588	0.3969	0.3968	X, Z
	5	56.7782	51.7830	-4.6532	56.3229	51.8114	-4.8611	0.4553	-0.0284	-0.2079	0.5013	0.4553	X
	6	48.6491	36.4696	-4.0826	48.3204	36.4760	-4.1841	0.3287	-0.0064	-0.1015	0.3441	0.3287	X
	7	49.2144	39.1350	-2.2691	48.9007	39.1713	-2.3049	0.3137	-0.0363	-0.0358	0.3178	0.3137	X
	8	50.3801	42.5343	0.6357	50.1112	42.4724	0.5738	0.2689	0.0619	-0.0619	0.2828	0.2689	X
	9	50.4046	46.6430	0.6574	50.0878	46.5771	0.6203	0.3168	0.0659	-0.0371	0.3257	0.3168	X
	10	50.2048	52.2428	0.7474	49.9206	52.3465	0.6991	0.2842	-0.1037	-0.0483	0.3064	0.2842	X
FLOOR PAN (Z)	11	43.6548	34.4681	-2.1560	43.3316	34.4765	-2.2377	0.3232	-0.0084	-0.0817	0.3335	-0.0817	Z
	12	44.7883	37.7184	0.9842	44.4820	37.6477	0.8983	0.3063	0.0707	-0.0859	0.3259	-0.0859	Z
	13	45.0106	42.8690	1.2917	44.7372	42.8384	1.2349	0.2734	0.0306	-0.0568	0.2809	-0.0568	Z
	14	44.9681	47.8509	1.2561	44.6807	47.8475	1.2126	0.2874	0.0034	-0.0435	0.2907	-0.0435	Z
	15	45.0181	52.8247	1.2516	44.7683	52.7646	1.2218	0.2498	0.0601	-0.0298	0.2587	-0.0298	Z
	16	38.2940	34.1442	-0.7788	38.0565	34.1413	-0.8993	0.2375	0.0029	-0.1205	0.2663	-0.1205	Z
	17	39.0748	37.5911	1.2901	38.7981	37.5726	1.2183	0.2767	0.0185	-0.0718	0.2865	-0.0718	Z
	18	39.0786	42.5433	1.2456	38.8506	42.4524	1.1984	0.2280	0.0909	-0.0472	0.2499	-0.0472	Z
	19	39.0687	46.6330	1.2251	38.8234	46.5782	1.1966	0.2453	0.0548	-0.0285	0.2530	-0.0285	Z
	20	39.0342	51.1359	1.2127	38.7535	51.0973	1.1998	0.2807	0.0386	-0.0129	0.2836	-0.0129	Z
	21	35.7029	34.8088	0.8869	35.3874	34.8081	0.8138	0.3155	0.0007	-0.0731	0.3239	-0.0731	Z
	22	35.2038	38.7268	1.4842	34.8958	38.6983	1.4286	0.3080	0.0285	-0.0556	0.3143	-0.0556	Z
	23	34.9888	43.8256	1.4364	34.7454	43.8016	1.4103	0.2434	0.0240	-0.0261	0.2460	-0.0261	Z
	24	35.0197	47.6976	1.4208	34.8307	47.7195	1.4102	0.1890	-0.0219	-0.0106	0.1906	-0.0106	Z
	25	35.3634	52.1039	1.4250	35.1253	52.0755	1.4243	0.2381	0.0284	-0.0007	0.2398	-0.0007	Z
	26	32.7672	35.6345	0.7211	32.5202	35.6157	0.6549	0.2470	0.0188	-0.0662	0.2564	-0.0662	Z
	27	32.5588	40.5073	0.6691	32.2632	40.5091	0.6276	0.2956	-0.0018	-0.0415	0.2985	-0.0415	Z
	28	32.6159	44.6447	0.6319	32.3342	44.6514	0.6101	0.2817	-0.0067	-0.0218	0.2826	-0.0218	Z
	29	32.5237	48.4357	0.3881	32.2441	48.3691	0.3765	0.2796	0.0666	-0.0116	0.2877	-0.0116	Z
	30	32.4950	52.2393	0.6019	32.2197	52.3046	0.6058	0.2753	-0.0653	0.0039	0.2830	0.0039	Z

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Pretest Floor Pan	Posttest Floor Pan
	

Figure F-2. Floor Pan Deformation Data – Set 2, Test No. NYBWT-2

Date: 6/8/2016 Test Name: NYBWT-2 VIN: 1D7RB1GK0BS515074
Year: 2011 Make: Dodge Model: Ram 1500 Quad Cab

VEHICLE DEFORMATION
INTERIOR CRUSH - SET 1

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
DASH (X, Y, Z)	1	42.5204	28.4543	-24.5726	42.7896	28.6596	-24.3891	-0.2692	-0.2053	0.1835	0.3851	0.3851	X, Y, Z
	2	41.9291	21.5136	-24.7883	42.2199	21.6663	-24.7209	-0.2908	-0.1527	0.0674	0.3353	0.3353	X, Y, Z
	3	41.4783	14.4735	-24.9153	41.6962	14.7486	-24.6565	-0.2179	-0.2751	0.2588	0.4360	0.4360	X, Y, Z
	4	38.6304	14.9686	-16.2262	38.8266	15.1609	-16.1332	-0.1962	-0.1923	0.0930	0.2900	0.2900	X, Y, Z
	5	39.0474	22.3195	-16.4867	39.2593	22.5116	-16.4229	-0.2119	-0.1921	0.0638	0.2930	0.2930	X, Y, Z
	6	39.5358	28.8498	-16.4654	39.7504	29.0840	-16.3893	-0.2146	-0.2342	0.0761	0.3266	0.3266	X, Y, Z
SIDE PANEL (Y)	7	52.9318	35.5034	-1.5829	53.1729	35.5146	-1.2913	-0.2411	-0.0112	0.2916	0.3785	-0.0112	Y
	8	48.7148	35.9079	-4.5681	48.9226	35.7104	-4.4518	-0.2078	0.1975	0.1163	0.3094	0.1975	Y
	9	49.0875	35.8841	0.0468	49.1817	35.8217	0.2240	-0.0942	0.0624	0.1772	0.2102	0.0624	Y
IMPACT SIDE DOOR (Y)	10	37.6063	38.3442	-15.1216	37.6432	38.2928	-15.0081	-0.0369	0.0514	0.1135	0.1299	0.0514	Y
	11	30.3789	39.2071	-14.6484	30.4352	39.3530	-14.5319	-0.0563	-0.1459	0.1165	0.1950	-0.1459	Y
	12	18.8944	38.6051	-14.6576	18.8530	39.1663	-14.7053	0.0414	-0.3612	-0.0477	0.3667	-0.3612	Y
	13	35.0402	39.0473	-0.8931	35.0190	39.0345	-0.6899	0.0212	0.0128	0.2032	0.2047	0.0128	Y
	14	27.9640	39.1859	-1.0591	27.9714	39.2626	-0.9563	-0.0074	-0.0767	0.1028	0.1285	-0.0767	Y
	15	19.7867	38.4247	-0.7403	19.7855	38.6567	-0.6172	0.0012	-0.2320	0.1231	0.2626	-0.2320	Y
ROOF - (Z)	16	33.9082	10.0701	-42.7069	34.1531	10.2495	-42.5974	-0.2449	-0.1794	0.1095	0.3227	0.1095	Z
	17	33.4878	15.0978	-42.6084	33.6677	15.3192	-42.5229	-0.1799	-0.2214	0.0855	0.2978	0.0855	Z
	18	32.5626	20.0931	-42.7649	32.8323	20.2520	-42.6870	-0.2697	-0.1589	0.0779	0.3226	0.0779	Z
	19	31.3866	24.0326	-42.8121	31.6063	24.2988	-42.7272	-0.2197	-0.2662	0.0849	0.3554	0.0849	Z
	20	29.5530	27.0984	-42.3030	29.8354	27.2938	-42.2098	-0.2824	-0.1954	0.0932	0.3558	0.0932	Z
	21	31.1005	6.6701	-43.5227	31.3246	6.8498	-43.4286	-0.2241	-0.1797	0.0941	0.3023	0.0941	Z
	22	30.8437	12.8065	-43.3801	31.1229	13.0440	-43.2798	-0.2792	-0.2375	0.1003	0.3800	0.1003	Z
	23	30.1162	17.8394	-43.2627	30.3779	18.0064	-43.1824	-0.2617	-0.1670	0.0803	0.3207	0.0803	Z
	24	29.0725	22.6818	-43.0298	29.4124	22.8144	-42.9429	-0.3399	-0.1326	0.0869	0.3751	0.0869	Z
	25	27.7927	26.4621	-42.8378	28.0493	26.6627	-42.7646	-0.2566	-0.2006	0.0732	0.3338	0.0732	Z
	26	25.6732	5.7729	-46.0516	25.8356	5.9599	-45.9863	-0.1624	-0.1870	0.0653	0.2561	0.0653	Z
	27	25.1408	11.3217	-46.0369	25.2864	11.5948	-45.9561	-0.1456	-0.2731	0.0808	0.3199	0.0808	Z
	28	25.2022	16.1591	-45.8334	25.4625	16.2975	-45.7505	-0.2603	-0.1384	0.0829	0.3062	0.0829	Z
	29	24.8244	20.7060	-45.6008	25.0312	20.9857	-45.5205	-0.2068	-0.2797	0.0803	0.3570	0.0803	Z
	30	23.8761	25.0450	-45.3638	24.1624	25.2549	-45.2814	-0.2863	-0.2099	0.0824	0.3644	0.0624	Z
A-PILLAR Maximum (X, Y, Z)	31	33.0717	31.5001	-39.4690	33.3299	31.6881	-39.3308	-0.2582	-0.1880	0.1382	0.3480	0.1382	Z
	32	36.4084	32.0701	-37.4418	36.6329	32.2176	-37.2735	-0.2245	-0.1475	0.1683	0.3170	0.1683	Z
	33	39.7657	32.8762	-35.4572	40.0317	33.0380	-35.3176	-0.2660	-0.1618	0.1396	0.3412	0.1396	Z
	34	42.1772	33.3953	-33.8951	42.4171	33.5337	-33.7235	-0.2399	-0.1384	0.1716	0.3258	0.1716	Z
	35	43.9274	33.6595	-32.5357	44.1371	33.7786	-32.3578	-0.2097	-0.1191	0.1779	0.2997	0.1779	Z
	36	46.5900	34.2956	-30.5943	46.8128	34.4065	-30.3863	-0.2228	-0.1109	0.2080	0.3243	0.2080	Z
A-PILLAR Lateral (Y)	31	33.0717	31.5001	-39.4690	33.3299	31.6881	-39.3308	-0.2582	-0.1880	0.1382	0.3480	-0.1880	Y
	32	36.4084	32.0701	-37.4418	36.6329	32.2176	-37.2735	-0.2245	-0.1475	0.1683	0.3170	-0.1475	Y
	33	39.7657	32.8762	-35.4572	40.0317	33.0380	-35.3176	-0.2660	-0.1618	0.1396	0.3412	-0.1618	Y
	34	42.1772	33.3953	-33.8951	42.4171	33.5337	-33.7235	-0.2399	-0.1384	0.1716	0.3258	-0.1384	Y
	35	43.9274	33.6595	-32.5357	44.1371	33.7786	-32.3578	-0.2097	-0.1191	0.1779	0.2997	-0.1191	Y
	36	46.5900	34.2956	-30.5943	46.8128	34.4065	-30.3863	-0.2228	-0.1109	0.2080	0.3243	-0.1109	Y
B-PILLAR Maximum (X, Y, Z)	37	7.3939	31.3419	-41.1360	7.6677	31.5683	-41.1258	-0.2738	-0.2264	0.0102	0.3554	0.0102	Z
	38	7.6625	33.5823	-35.0074	7.8778	33.8104	-34.9532	-0.2153	-0.2281	0.0542	0.3183	0.0542	Z
	39	8.2192	35.2153	-29.8757	8.4258	35.4267	-29.8484	-0.2066	-0.2114	0.0273	0.2968	0.0273	Z
	40	8.4534	35.7628	-26.3837	8.6803	35.9790	-26.2830	-0.2269	-0.2162	0.1007	0.3292	0.1007	Z
B-PILLAR Lateral (Y)	37	7.3939	31.3419	-41.1360	7.6677	31.5683	-41.1258	-0.2738	-0.2264	0.0102	0.3554	-0.2264	Y
	38	7.6625	33.5823	-35.0074	7.8778	33.8104	-34.9532	-0.2153	-0.2281	0.0542	0.3183	-0.2281	Y
	39	8.2192	35.2153	-29.8757	8.4258	35.4267	-29.8484	-0.2066	-0.2114	0.0273	0.2968	-0.2114	Y
	40	8.4534	35.7628	-26.3837	8.6803	35.9790	-26.2830	-0.2269	-0.2162	0.1007	0.3292	-0.2162	Y

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Figure F-3. Occupant Compartment Deformation Data – Set 1, Test No. NYBWT-2

Date: 6/8/2016 Test Name: NYBWT-2 VIN: 1D7RB1GK0BS515074
Year: 2011 Make: Dodge Model: Ram 1500 Quad Cab

VEHICLE DEFORMATION
INTERIOR CRUSH - SET 2

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
DASH (X, Y, Z)	1	43.0300	48.7732	-28.1916	43.0036	48.8489	-28.3714	0.0264	-0.0757	-0.1798	0.1969	0.1969	X, Y, Z
	2	42.5681	41.7902	-28.4251	42.5404	41.8470	-28.6861	0.0277	-0.0568	-0.2610	0.2685	0.2685	X, Y, Z
	3	42.2535	34.7493	-28.5334	42.1200	34.9224	-28.6046	0.1335	-0.1731	-0.0712	0.2299	0.2299	X, Y, Z
	4	39.3016	35.1861	-19.9284	39.2004	35.3155	-20.0974	0.1012	-0.1294	-0.1690	0.2357	0.2357	X, Y, Z
	5	39.5946	42.5185	-20.2310	39.5245	42.6710	-20.4060	0.0701	-0.1525	-0.1750	0.2425	0.2425	X, Y, Z
	6	39.9749	49.1128	-20.1597	39.9169	49.2501	-20.3887	0.0580	-0.1373	-0.2290	0.2732	0.2732	X, Y, Z
SIDE PANEL (Y)	7	53.1855	55.9786	-5.0957	53.1633	55.9232	-5.2403	0.0222	0.0554	-0.1446	0.1564	0.0554	Y
	8	48.9523	56.3423	-8.2274	48.9270	56.0465	-8.4233	0.0253	0.2958	-0.1959	0.3557	0.2958	Y
	9	49.2132	56.3396	-3.5964	49.1601	56.1747	-3.7466	0.0531	0.1649	-0.1502	0.2293	0.1649	Y
IMPACT SIDE DOOR (Y)	10	37.9128	58.5660	-18.8921	37.6651	58.4301	-19.0448	0.2477	0.1359	-0.1527	0.3212	0.1359	Y
	11	30.6829	59.3129	-18.4718	30.4396	59.3835	-18.6087	0.2433	-0.0706	-0.1369	0.2880	-0.0706	Y
	12	19.1405	58.7163	-18.6705	18.8626	59.0229	-18.8411	0.2779	-0.3066	-0.1706	0.4476	-0.3066	Y
	13	35.1220	59.2740	-4.6848	34.9559	59.1724	-4.7424	0.1661	0.1016	-0.0576	0.2031	0.1016	Y
	14	28.1429	59.2887	-4.9686	27.9071	59.2942	-5.0457	0.2358	-0.0055	-0.0771	0.2481	-0.0055	Y
	15	19.9119	58.3923	-4.6801	19.7295	58.5667	-4.7470	0.1824	-0.1744	-0.0669	0.2611	-0.1744	Y
ROOF - (Z)	16	35.0343	30.0954	-46.3980	34.7382	30.2607	-46.5710	0.2961	-0.1653	-0.1730	0.3807	-0.1730	Z
	17	34.4780	35.1876	-46.3309	34.1765	35.3227	-46.5136	0.3015	-0.1351	-0.1827	0.3775	-0.1827	Z
	18	33.4967	40.1562	-46.5164	33.2683	40.2419	-46.6961	0.2284	-0.0857	-0.1797	0.3030	-0.1797	Z
	19	32.2166	44.0435	-46.5984	31.9821	44.2699	-46.7542	0.2345	-0.2264	-0.1558	0.3613	-0.1558	Z
	20	30.3861	47.1087	-46.0997	30.1638	47.2394	-46.2545	0.2223	-0.1307	-0.1548	0.3008	-0.1548	Z
	21	32.2503	26.6452	-47.2472	31.9652	26.8167	-47.4070	0.2851	-0.1715	-0.1598	0.3691	-0.1598	Z
	22	31.8731	32.8004	-47.1361	31.6700	33.0076	-47.2770	0.2031	-0.2072	-0.1409	0.3225	-0.1409	Z
	23	31.0951	37.7801	-47.0416	30.8504	37.9585	-47.1977	0.2447	-0.1784	-0.1561	0.3407	-0.1561	Z
	24	29.9993	42.6479	-46.8246	29.8117	42.7521	-46.9769	0.1876	-0.1042	-0.1523	0.2631	-0.1523	Z
	25	28.5621	46.4087	-46.6878	28.3903	46.5800	-46.8167	0.1718	-0.1713	-0.1289	0.2747	-0.1289	Z
	26	26.8347	25.7074	-49.8582	26.5034	25.8375	-49.9903	0.3313	-0.1301	-0.1321	0.3797	-0.1321	Z
	27	26.2315	31.2962	-49.8455	25.8698	31.4636	-49.9791	0.3617	-0.1674	-0.1336	0.4204	-0.1336	Z
	28	26.1857	36.0513	-49.6657	25.9744	36.1689	-49.7861	0.2113	-0.1176	-0.1204	0.2701	-0.1204	Z
	29	25.7050	40.6244	-49.4549	25.4719	40.8508	-49.5718	0.2331	-0.2264	-0.1169	0.3453	-0.1169	Z
	30	24.7937	44.9195	-49.2307	24.5381	45.1072	-49.3494	0.2556	-0.1877	-0.1187	0.3386	-0.1187	Z
A-PILLAR Maximum (X, Y, Z)	31	33.7675	51.5750	-43.2696	33.5772	51.6936	-43.3703	0.1903	-0.1186	-0.1007	0.2458	0.1903	X
	32	37.0538	52.1918	-41.1718	36.8612	52.2782	-41.2975	0.1926	-0.0864	-0.1257	0.2457	0.1926	X
	33	40.3693	53.0579	-39.1131	40.2372	53.1550	-39.3266	0.1321	-0.0971	-0.2135	0.2692	0.1321	X
	34	42.7205	53.6115	-37.5488	42.6066	53.6908	-37.7216	0.1139	-0.0793	-0.1728	0.2216	0.1139	X
	35	44.5011	53.9326	-36.1744	44.3156	53.9653	-36.3478	0.1855	-0.0327	-0.1734	0.2560	0.1855	X
	36	47.2320	54.6487	-34.1587	46.9714	54.6387	-34.3644	0.2606	0.0100	-0.2057	0.3322	0.2608	X, Y
A-PILLAR Lateral (Y)	31	33.7675	51.5750	-43.2696	33.5772	51.6936	-43.3703	0.1903	-0.1186	-0.1007	0.2458	-0.1186	Y
	32	37.0538	52.1918	-41.1718	36.8612	52.2782	-41.2975	0.1926	-0.0864	-0.1257	0.2457	-0.0864	Y
	33	40.3693	53.0579	-39.1131	40.2372	53.1550	-39.3266	0.1321	-0.0971	-0.2135	0.2692	-0.0971	Y
	34	42.7205	53.6115	-37.5488	42.6066	53.6908	-37.7216	0.1139	-0.0793	-0.1728	0.2216	-0.0793	Y
	35	44.5011	53.9326	-36.1744	44.3156	53.9653	-36.3478	0.1855	-0.0327	-0.1734	0.2560	-0.0327	Y
	36	47.2320	54.6487	-34.1587	46.9714	54.6387	-34.3644	0.2606	0.0100	-0.2057	0.3322	0.0100	Y
B-PILLAR Maximum (X, Y, Z)	37	8.1013	50.9699	-45.1976	7.9293	51.1843	-45.2968	0.1720	-0.2144	-0.0992	0.2922	0.1720	X
	38	8.2753	53.2193	-39.1184	8.0738	53.4466	-39.1297	0.2015	-0.2273	-0.0113	0.3040	0.2015	X
	39	8.7092	54.8838	-33.9797	8.5711	55.0851	-34.0268	0.1381	-0.2013	-0.0471	0.2486	0.1381	X
	40	8.9436	55.4539	-30.4383	8.7988	55.6512	-30.4617	0.1448	-0.1973	-0.0234	0.2458	0.1448	X
B-PILLAR Lateral (Y)	37	8.1013	50.9699	-45.1976	7.9293	51.1843	-45.2968	0.1720	-0.2144	-0.0992	0.2922	-0.2144	Y
	38	8.2753	53.2193	-39.1184	8.0738	53.4466	-39.1297	0.2015	-0.2273	-0.0113	0.3040	-0.2273	Y
	39	8.7092	54.8838	-33.9797	8.5711	55.0851	-34.0268	0.1381	-0.2013	-0.0471	0.2486	-0.2013	Y
	40	8.9436	55.4539	-30.4383	8.7988	55.6512	-30.4617	0.1448	-0.1973	-0.0234	0.2458	-0.1973	Y

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

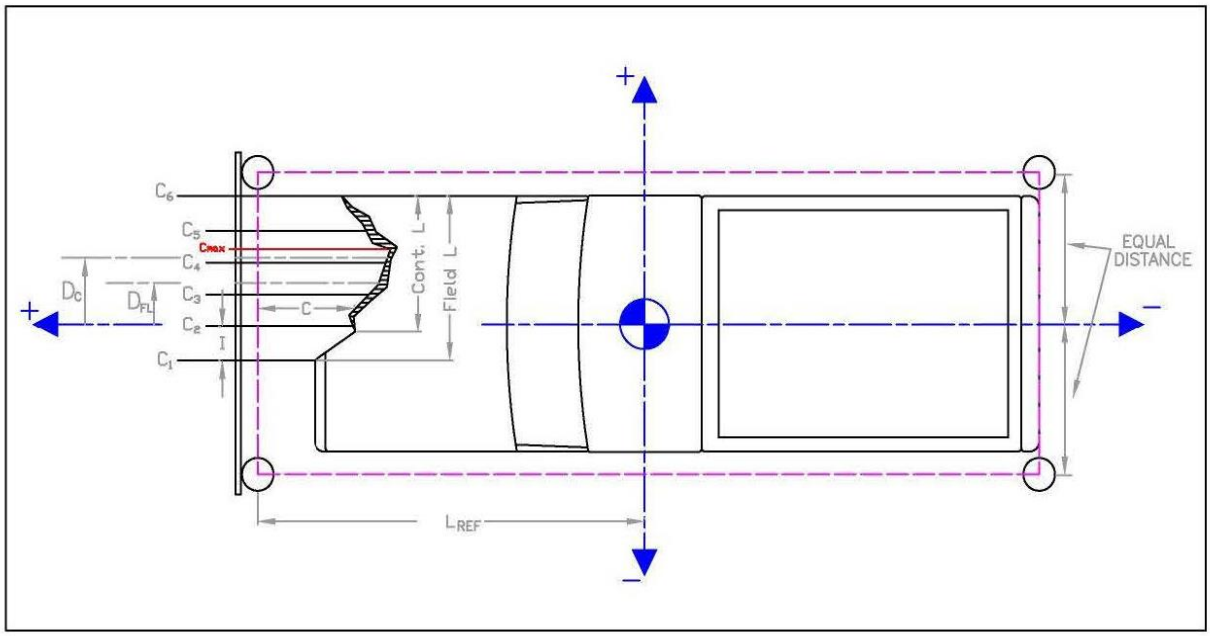
[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Figure F-4. Occupant Compartment Deformation Data – Set 2, Test No. NYBWT-2

Date: 6/12/2018 Test Name: NYBWT-2 VIN: 1D7RB1GK0BS515074

Year: 2011 Make: Dodge Model: Ram 1500 Quad Cab



	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	128	(3251)
Total Vehicle Width:	76	(1930)
Width of contact and induced crush - Field L:	26	(660)
Crush measurement spacing interval (L/5) - I:	5 1/4	(133)
Distance from center of vehicle to center of Field L - D_{FL}:	29 1/2	(749)
Width of Contact Damage:	26	(660)
Distance from center of vehicle to center of contact damage - D_C:	29 1/2	(749)

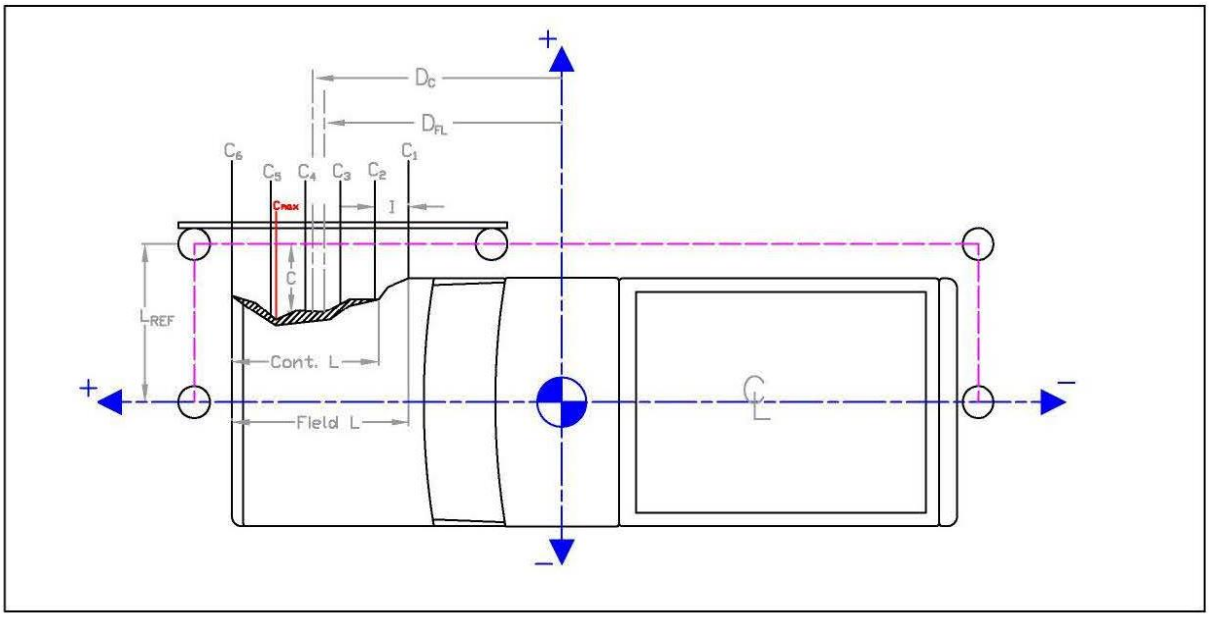
NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., side of vehicle has been pushed inward)

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	25 1/2	(648)	16 1/2	(419)	5 1/8	(130)	20 1/3	(516)	0	(2)
C_2	34	(864)	21 3/4	(552)	5 7/8	(149)			7 4/5	(198)
C_3	42 1/2	(1080)	27	(686)	7 1/2	(191)			14 2/3	(373)
C_4	N/a	#VALUE!	32 1/4	(819)	11 1/8	(283)			#VALUE!	#VALUE!
C_5	n/a	#VALUE!	37 1/2	(953)	19 1/4	(489)			#VALUE!	#VALUE!
C_6	n/a	#VALUE!	42 3/4	(1086)	20 1/2	(521)			#VALUE!	#VALUE!
C_{MAX}	42 1/2	(1080)	27	(686)	7 1/2	(191)			14 2/3	(373)

Figure F-5. Exterior Vehicle Crush (NASS) - Front, Test No. NYBWT-2

Date:	6/12/2018	Test Name:	NYBWT-2	VIN:	1D7RB1GK0BS515074
Year:	2011	Make:	Dodge	Model:	Ram 1500 Quad Cab



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	52 1/2	(1334)
Total Vehicle Length:	229 1/4	(5823)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-3	-(75)
Width of contact and induced crush - Field L:	229 1/4	(5823)
Crush measurement spacing interval (L/5) - I:	45 7/8	(1165)
Distance from vehicle c.g. to center of Field L - D_{FL}:	-10 5/8	-(270)
Width of Contact Damage:	229 1/4	(5823)
Distance from vehicle c.g. to center of contact damage - D_C:	-10 5/8	-(270)

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!	-125 1/4	-(3181)	33 1/2	(851)	8 1/2	(216)	#VALUE!	#VALUE!
C_2	n/a	#VALUE!	-79 3/8	-(2016)	5 1/2	(140)			#VALUE!	#VALUE!
C_3	14 1/2	(368)	-33 1/2	-(851)	5 3/4	(146)			1/4	(6)
C_4	14 3/4	(375)	12 3/8	(314)	5	(127)			1 1/4	(32)
C_5	n/a	#VALUE!	58 1/4	(1480)	5 3/4	(146)			#VALUE!	#VALUE!
C_6	n/a	#VALUE!	104 1/8	(2645)	10 1/8	(257)			#VALUE!	#VALUE!
C_{MAX}	33	(838)	96	(2438)	6 3/8	(162)			18 1/8	(460)

Figure F-6. Exterior Vehicle Crush (NASS) - Side, Test No. NYBWT-2

Date:	7/24/2018	Test Name:	NYBWT-3	VIN: 1C6RD6FPCS205397
Year:	2012	Make:	Dodge	Model: Ram 1500

VEHICLE DEFORMATION
FLOOR PAN - SET 1

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
TOE PAN - WHEEL WELL (X, Z)	1	55.6607	-9.6399	-1.8966	55.6122	-9.9121	-1.7030	0.0485	-0.2722	-0.1936	0.3375	0.0485	X
	2	57.8038	-13.1780	-0.9486	57.6401	-13.4648	-0.6328	0.1637	-0.2868	-0.3158	0.4569	0.1637	X
	3	57.5048	-16.9169	-0.8049	57.4700	-17.2139	-0.5761	0.0348	-0.2970	-0.2288	0.3765	0.0348	X
	4	57.1956	-20.3885	-1.0063	57.1551	-20.6544	-0.7639	0.0405	-0.2659	-0.2424	0.3621	0.0405	X
	5	56.1456	-23.0788	-2.0993	56.1185	-23.2978	-1.8082	0.0271	-0.2190	-0.2911	0.3653	0.0271	X
	6	52.0784	-8.6758	2.2912	52.0414	-8.9767	2.4752	0.0370	-0.3009	-0.1840	0.3546	0.0370	X
	7	52.0256	-11.8408	2.2584	51.9612	-12.0168	2.4848	0.0644	-0.1760	-0.2264	0.2939	0.0644	X
	8	52.2147	-15.6862	2.0294	52.1393	-15.8243	2.2646	0.0754	-0.1381	-0.2352	0.2830	0.0754	X
	9	52.2872	-19.0593	1.8188	52.2294	-19.2714	2.0511	0.0578	-0.2121	-0.2323	0.3198	0.0578	X
	10	52.4937	-22.6321	1.5761	52.5077	-22.8137	1.7840	-0.0140	-0.1816	-0.2079	0.2764	0.0000	NA
FLOOR PAN (Z)	11	45.3813	-7.8236	4.8200	45.3547	-8.0336	4.9636	0.0266	-0.2100	-0.1436	0.2558	-0.1436	Z
	12	45.2373	-12.2521	4.9980	45.1606	-12.4395	5.1535	0.0767	-0.1874	-0.1555	0.2553	-0.1555	Z
	13	45.0428	-15.7344	4.9859	45.0199	-15.9065	5.1557	0.0229	-0.1721	-0.1698	0.2428	-0.1698	Z
	14	44.7816	-19.1578	4.9948	44.6725	-19.3362	5.1891	0.1091	-0.1784	-0.1943	0.2855	-0.1943	Z
	15	44.7182	-23.9794	4.9843	44.6564	-24.1385	5.1989	0.0618	-0.1591	-0.2146	0.2742	-0.2146	Z
	16	40.3947	-7.8381	4.8973	40.3790	-8.0340	5.0286	0.0157	-0.1959	-0.1313	0.2364	-0.1313	Z
	17	40.2905	-11.1546	5.0460	40.3011	-11.3193	5.1912	-0.0106	-0.1647	-0.1452	0.2198	-0.1452	Z
	18	39.9425	-16.5078	5.0237	39.9474	-16.6025	5.1993	-0.0049	-0.0947	-0.1756	0.1996	-0.1756	Z
	19	39.4357	-21.3419	5.0228	39.3626	-21.5433	5.2232	0.0731	-0.2014	-0.2004	0.2934	-0.2004	Z
	20	39.4348	-25.1438	5.0871	39.3948	-25.3412	5.2944	0.0400	-0.1974	-0.2073	0.2890	-0.2073	Z
	21	35.5964	-7.7257	4.8863	35.5120	-7.9300	5.0084	0.0844	-0.2043	-0.1221	0.2525	-0.1221	Z
	22	35.3846	-11.7079	5.0730	35.3185	-11.9473	5.2144	0.0661	-0.2394	-0.1414	0.2858	-0.1414	Z
	23	35.4553	-16.0390	5.0520	35.4374	-16.2120	5.2149	0.0179	-0.1730	-0.1629	0.2383	-0.1629	Z
	24	35.3952	-20.0998	5.0438	35.3598	-20.3042	5.2227	0.0354	-0.2044	-0.1789	0.2739	-0.1789	Z
	25	35.4579	-23.7553	5.0520	35.3741	-23.9372	5.2327	0.0838	-0.1819	-0.1807	0.2697	-0.1807	Z
	26	32.7012	-7.7459	4.8458	32.6302	-8.0106	4.9717	0.0710	-0.2647	-0.1259	0.3016	-0.1259	Z
	27	32.7180	-10.7798	5.1112	32.6588	-10.9946	5.2288	0.0592	-0.2148	-0.1176	0.2519	-0.1176	Z
	28	32.7350	-15.2442	5.1246	32.6654	-15.4460	5.2652	0.0696	-0.2018	-0.1406	0.2556	-0.1406	Z
	29	32.8214	-19.9348	5.1379	32.7982	-20.2069	5.3050	0.0232	-0.2721	-0.1671	0.3202	-0.1671	Z
	30	32.7446	-23.8776	5.1333	32.7242	-24.0192	5.3175	0.0204	-0.1416	-0.1842	0.2332	-0.1842	Z

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Pretest Floor Pan	Posttest Floor Pan
	

Figure F-7. Floor Pan Deformation Data – Set 1, Test No. NYBWT-3

Date: 7/24/2018 Test Name: NYBWT-3 VIN: 1C6RD6FPCS205397
Year: 2012 Make: Dodge Model: Ram 1500

VEHICLE DEFORMATION
FLOOR PAN - SET 2

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
TOE PAN - WHEEL WELL (X, Z)	1	59.3764	-28.4915	-4.8707	59.4346	-28.8725	-5.3148	-0.0582	-0.3810	0.4441	0.5880	0.4441	Z
	2	61.5478	-31.9973	-3.8689	61.4920	-32.4013	-4.2220	0.0558	-0.4040	0.3531	0.5395	0.3575	X, Z
	3	61.2959	-35.7393	-3.7172	61.3639	-36.1520	-4.1644	-0.0680	-0.4127	0.4472	0.6123	0.4472	Z
	4	61.0369	-39.2155	-3.9116	61.0900	-39.5960	-4.3529	-0.0531	-0.3805	0.4413	0.5851	0.4413	Z
	5	60.0440	-41.9232	-5.0145	60.0940	-42.2516	-5.4056	-0.0500	-0.3284	0.3911	0.5131	0.3911	Z
	6	55.7019	-27.5610	-0.7559	55.8120	-27.9754	-1.1728	-0.1101	-0.4144	0.4169	0.5980	0.4169	Z
	7	55.6918	-30.7266	-0.7779	55.7663	-31.0161	-1.1620	-0.0745	-0.2895	0.3841	0.4867	0.3841	Z
	8	55.9365	-34.5698	-0.9891	55.9898	-34.8215	-1.3777	-0.0533	-0.2517	0.3886	0.4661	0.3886	Z
	9	56.0580	-37.9423	-1.1859	56.1212	-38.2675	-1.5879	-0.0632	-0.3252	0.4020	0.5209	0.4020	Z
	10	56.3165	-41.5129	-1.4114	56.4424	-41.8065	-1.8497	-0.1259	-0.2936	0.4383	0.5424	0.4383	Z
FLOOR PAN (Z)	11	48.9468	-26.7898	1.6413	49.0907	-27.1068	1.2485	-0.1439	-0.3170	0.3928	0.5249	0.3928	Z
	12	48.8583	-31.2192	1.8327	48.9448	-31.5146	1.4395	-0.0865	-0.2954	0.3932	0.4993	0.3932	Z
	13	48.7105	-34.7038	1.8298	48.8435	-34.9829	1.4427	-0.1330	-0.2791	0.3871	0.4954	0.3871	Z
	14	48.4948	-38.1304	1.8463	48.5348	-38.4163	1.4751	-0.0400	-0.2859	0.3712	0.4702	0.3712	Z
	15	48.4958	-42.9524	1.8524	48.5732	-43.2185	1.4881	-0.0774	-0.2661	0.3643	0.4577	0.3643	Z
	16	43.9602	-26.8708	1.6231	44.1149	-27.1638	1.2641	-0.1547	-0.2930	0.3590	0.4885	0.3590	Z
	17	43.8973	-30.1878	1.7821	44.0727	-30.4497	1.4283	-0.1754	-0.2619	0.3538	0.4738	0.3538	Z
	18	43.6212	-35.5452	1.7728	43.7791	-35.7365	1.4365	-0.1579	-0.1913	0.3363	0.4179	0.3363	Z
	19	43.1788	-40.3857	1.7800	43.2503	-40.6837	1.4581	-0.0715	-0.2980	0.3219	0.4445	0.3219	Z
	20	43.2273	-44.1870	1.8583	43.3249	-44.4809	1.5323	-0.0976	-0.2939	0.3260	0.4496	0.3260	Z
	21	39.1619	-26.8226	1.5200	39.2475	-27.1152	1.1955	-0.0856	-0.2926	0.3245	0.4452	0.3245	Z
	22	38.9996	-30.8067	1.7172	39.0976	-31.1343	1.4025	-0.0980	-0.3276	0.3147	0.4647	0.3147	Z
	23	39.1284	-35.1364	1.7135	39.2649	-35.3974	1.4071	-0.1365	-0.2610	0.3064	0.4250	0.3064	Z
	24	39.1225	-39.1977	1.7191	39.2338	-39.4902	1.4170	-0.1113	-0.2925	0.3021	0.4350	0.3021	Z
	25	39.2337	-42.8520	1.7421	39.2893	-43.1228	1.4297	-0.0556	-0.2708	0.3124	0.4172	0.3124	Z
	26	36.2687	-26.8817	1.4241	36.3672	-27.2286	1.1304	-0.0985	-0.3469	0.2937	0.4651	0.2937	Z
	27	36.3207	-29.9142	1.7010	36.4273	-30.2119	1.3898	-0.1066	-0.2977	0.3112	0.4437	0.3112	Z
	28	36.3969	-34.3778	1.7312	36.4841	-34.6629	1.4294	-0.0872	-0.2851	0.3018	0.4242	0.3018	Z
	29	36.5455	-39.0668	1.7634	36.6705	-39.4220	1.4738	-0.1250	-0.3552	0.2896	0.4750	0.2896	Z
	30	36.5212	-43.0102	1.7719	36.6398	-43.2349	1.4883	-0.1186	-0.2247	0.2836	0.3808	0.2836	Z

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Pretest Floor Pan	Posttest Floor Pan
	

Figure F-8. Floor Pan Deformation Data – Set 2, Test No. NYBWT-3

Date: 7/24/2018 Test Name: NYBWT-3 VIN: 1C6RD6FPCS205397
Year: 2012 Make: Dodge Model: Ram 1500

VEHICLE DEFORMATION
INTERIOR CRUSH - SET 1

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
DASH (X, Y, Z)	1	41.6013	-19.7724	-29.2934	40.4238	-20.5676	-29.1142	1.1775	-0.7952	0.1792	1.4321	1.4321	X, Y, Z
	2	42.0951	-8.9015	-29.0497	41.1663	-9.8280	-29.0048	0.9288	-0.9265	0.0449	1.3127	1.3127	X, Y, Z
	3	42.8850	4.1804	-28.0226	42.4780	3.2925	-28.0460	0.4070	0.8879	-0.0234	0.9770	0.9770	X, Y, Z
	4	40.0484	-21.9273	-13.5306	38.8325	-22.6308	-13.3138	1.2159	-0.7035	0.2168	1.4214	1.4214	X, Y, Z
	5	39.0039	-8.9605	-13.8577	38.1566	-9.5394	-13.7611	0.8473	-0.5789	0.0966	1.0307	1.0307	X, Y, Z
	6	36.3310	3.8700	-15.3034	35.8534	3.2723	-15.2699	0.4776	0.5977	0.0335	0.7658	0.7658	X, Y, Z
SIDE PANEL (Y)	7	51.5836	-28.4043	-3.0306	50.1775	-29.2532	-2.7959	1.4061	-0.8489	0.2347	1.6592	-0.8489	Y
	8	48.3876	-28.4096	-2.1475	46.9586	-28.8752	-1.9519	1.4290	-0.4656	0.1956	1.5156	-0.4656	Y
	9	48.3981	-28.4191	-4.9155	46.9391	-28.8963	-4.6869	1.4590	-0.4772	0.2286	1.5520	-0.4772	Y
IMPACT SIDE DOOR (Y)	10	38.6592	-30.7241	-16.7638	36.8370	-31.3964	-16.7798	1.8222	-0.6723	-0.0160	1.9423	-0.6723	Y
	11	27.6410	-31.5229	-16.4186	25.8473	-32.2225	-16.3489	1.7937	-0.6996	0.0697	1.9266	-0.6996	Y
	12	16.1873	-31.0216	-17.3413	14.4334	-31.7444	-17.2512	1.7539	-0.7228	0.0901	1.8991	-0.7228	Y
	13	37.3058	-29.3376	-5.1944	35.4582	-29.4135	-5.1645	1.8476	-0.0759	0.0299	1.8494	-0.0759	Y
	14	28.0098	-31.6167	-3.5925	26.2849	-31.7428	-3.5006	1.7249	-0.1261	0.0919	1.7319	-0.1261	Y
	15	17.7778	-30.7759	-2.8599	16.0189	-30.9515	-2.7907	1.7589	-0.1756	0.0692	1.7690	-0.1756	Y
ROOF - (Z)	16	27.8170	-17.9355	-42.9891	26.7868	-18.5807	-42.8407	1.0302	-0.6452	0.1484	1.2246	0.1484	Z
	17	28.7739	-12.5735	-43.3642	27.8154	-13.2664	-43.2540	0.9585	-0.6929	0.1102	1.1878	0.1102	Z
	18	29.8702	-6.4740	-43.5546	29.2229	-7.1414	-43.4286	0.6473	-0.6674	0.1260	0.9382	0.1260	Z
	19	30.6997	-0.1950	-43.6012	30.1401	-0.8864	-43.5146	0.5596	-0.6914	0.0866	0.8937	0.0866	Z
	20	30.6805	4.9794	-43.6449	30.3256	4.3271	-43.5492	0.3549	0.6523	0.0957	0.7487	0.0957	Z
	21	19.8974	-16.6776	-45.9316	18.8758	-17.1621	-45.7524	1.0216	-0.4845	0.1792	1.1448	0.1792	Z
	22	20.0283	-10.1639	-46.3583	19.1127	-10.5694	-46.2189	0.9156	-0.4055	0.1394	1.0110	0.1394	Z
	23	20.3589	-3.6610	-46.5857	19.6696	-4.1813	-46.4566	0.6893	-0.5203	0.1291	0.8732	0.1291	Z
	24	20.6797	0.4445	-46.6409	20.1111	-0.0260	-46.5287	0.5686	0.4705	0.1122	0.7465	0.1122	Z
	25	21.6052	4.5860	-46.5816	20.9756	4.0501	-46.5003	0.6296	0.5359	0.0813	0.8308	0.0813	Z
	26	9.1492	-16.1202	-46.4990	8.0492	-16.2813	-46.3275	1.1000	-0.1611	0.1715	1.1249	0.1715	Z
	27	8.8413	-10.4067	-46.8286	7.8867	-10.5960	-46.6911	0.9546	-0.1893	0.1375	0.9829	0.1375	Z
	28	9.0648	-3.8871	-47.0576	8.3775	-4.0065	-46.9512	0.6873	-0.1194	0.1064	0.7057	0.1064	Z
	29	9.6149	0.8926	-47.1259	8.9909	0.7040	-47.0341	0.6240	0.1886	0.0918	0.6583	0.0918	Z
	30	9.7018	5.6111	-47.1304	9.2172	5.3249	-47.0530	0.4846	0.2862	0.0774	0.5681	0.0774	Z
A-PILLAR Maximum (X, Y, Z)	31	47.7088	-27.0122	-28.8978	46.3623	-28.1191	-28.7078	1.3465	-1.1069	0.1900	1.7534	1.3598	X, Z
	32	45.0217	-26.4613	-31.1185	43.6345	-27.4831	-30.8851	1.3872	-1.0218	0.2334	1.7386	1.4067	X, Z
	33	42.5467	-25.7902	-32.8080	41.2366	-26.7656	-32.5156	1.3101	-0.9754	0.2924	1.6593	1.3423	X, Z
	34	40.0391	-25.2339	-34.5171	38.6447	-26.1344	-34.3337	1.3944	-0.9005	0.1834	1.6700	1.4064	X, Z
	35	37.0351	-24.3264	-36.6352	35.6889	-25.1865	-36.4750	1.3462	-0.8601	0.1602	1.6055	1.3557	X, Z
	36	34.9292	-24.3508	-38.7017	33.6771	-25.1760	-38.4458	1.2521	-0.8252	0.2559	1.5212	1.2780	X, Z
A-PILLAR Lateral (Y)	31	47.7088	-27.0122	-28.8978	46.3623	-28.1191	-28.7078	1.3465	-1.1069	0.1900	1.7534	-1.1069	Y
	32	45.0217	-26.4613	-31.1185	43.6345	-27.4831	-30.8851	1.3872	-1.0218	0.2334	1.7386	-1.0218	Y
	33	42.5467	-25.7902	-32.8080	41.2366	-26.7656	-32.5156	1.3101	-0.9754	0.2924	1.6593	-0.9754	Y
	34	40.0391	-25.2339	-34.5171	38.6447	-26.1344	-34.3337	1.3944	-0.9005	0.1834	1.6700	-0.9005	Y
	35	37.0351	-24.3264	-36.6352	35.6889	-25.1865	-36.4750	1.3462	-0.8601	0.1602	1.6055	-0.8601	Y
	36	34.9292	-24.3508	-38.7017	33.6771	-25.1760	-38.4458	1.2521	-0.8252	0.2559	1.5212	-0.8252	Y
B-PILLAR Maximum (X, Y, Z)	37	3.8709	-23.8402	-39.2369	2.6244	-23.7524	-39.1110	1.2465	0.0878	0.1259	1.2559	1.2559	X, Y, Z
	38	6.8271	-24.7104	-36.9010	5.5079	-24.6848	-36.7777	1.3192	0.0256	0.1233	1.3252	1.3252	X, Y, Z
	39	4.4268	-26.9733	-30.5086	3.0211	-26.8260	-30.3047	1.4057	0.1473	0.2039	1.4280	1.4280	X, Y, Z
	40	7.7909	-27.3103	-28.7775	6.4334	-27.2526	-28.6050	1.3575	0.0577	0.1725	1.3696	1.3696	X, Y, Z
B-PILLAR Lateral (Y)	37	3.8709	-23.8402	-39.2369	2.6244	-23.7524	-39.1110	1.2465	0.0878	0.1259	1.2559	0.0878	Y
	38	6.8271	-24.7104	-36.9010	5.5079	-24.6848	-36.7777	1.3192	0.0256	0.1233	1.3252	0.0256	Y
	39	4.4268	-26.9733	-30.5086	3.0211	-26.8260	-30.3047	1.4057	0.1473	0.2039	1.4280	0.1473	Y
	40	7.7909	-27.3103	-28.7775	6.4334	-27.2526	-28.6050	1.3575	0.0577	0.1725	1.3696	0.0577	Y

[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Figure F-9. Occupant Compartment Deformation Data – Set 1, Test No. NYBWT-3

Date: 7/24/2018 Test Name: NYBWT-3 VIN: 1C6RD6FPCS205397
Year: 2012 Make: Dodge Model: Ram 1500

VEHICLE DEFORMATION
INTERIOR CRUSH - SET 2

	POINT	Pretest X (in.)	Pretest Y (in.)	Pretest Z (in.)	Posttest X (in.)	Posttest Y (in.)	Posttest Z (in.)	ΔX[A] (in.)	ΔY[A] (in.)	ΔZ[A] (in.)	Total Δ (in.)	Crush[B] (in.)	Directions for Crush[C]
DASH (X, Y, Z)	1	44.7914	-39.5520	-32.5131	44.6750	-39.7351	-32.8271	0.1164	-0.1831	-0.3140	0.3817	0.3817	X, Y, Z
	2	45.4318	-28.6881	-32.3011	45.2589	-28.9635	-32.7195	0.1729	-0.2754	-0.4184	0.5299	0.5299	X, Y, Z
	3	46.3844	-15.6143	-31.3087	46.4283	-15.8088	-31.7198	-0.0439	-0.1945	-0.4111	0.4569	0.4569	X, Y, Z
	4	42.9168	-41.6218	-16.7739	42.9696	-41.8344	-16.9919	-0.0528	-0.2126	-0.2180	0.3090	0.3090	X, Y, Z
	5	42.0590	-28.6432	-17.1691	42.1232	-28.7378	-17.4902	-0.0642	-0.0946	-0.3211	0.3408	0.3408	X, Y, Z
	6	39.5922	-15.7829	-18.7125	39.6916	-15.9456	-19.0754	-0.0994	-0.1627	-0.3629	0.4099	0.4099	X, Y, Z
SIDE PANEL (Y)	7	54.1641	-48.2156	-6.0370	54.1811	-48.2728	-6.4281	-0.0170	-0.0572	-0.3911	0.3956	-0.0572	Y
	8	50.9525	-48.1732	-5.2134	50.9771	-47.9345	-5.6013	-0.0246	0.2387	-0.3879	0.4561	0.2387	Y
	9	51.0142	-48.1940	-7.9807	50.9618	-47.9536	-8.3014	0.0524	0.2404	-0.3207	0.4042	0.2404	Y
IMPACT SIDE DOOR (Y)	10	41.4654	-50.4115	-19.9993	40.9930	-50.8811	-20.6126	0.4724	-0.4696	-0.6133	0.9054	-0.4696	Y
	11	30.4327	-51.0563	-19.8559	30.1387	-52.1172	-20.2590	0.2940	-1.0609	-0.4031	1.1724	-1.0609	Y
	12	19.0062	-50.4003	-20.9933	18.6183	-52.1044	-21.4869	0.3879	-1.7041	-0.4936	1.8161	-1.7041	Y
	13	39.9173	-48.9599	-8.4624	39.4316	-48.9011	-9.0764	0.4857	0.0588	-0.6140	0.7851	0.0588	Y
	14	30.5623	-51.1037	-7.0249	30.3254	-51.5819	-7.4803	0.2369	-0.4782	-0.4554	0.7016	-0.4782	Y
	15	20.3312	-50.1184	-6.4858	20.0661	-51.1517	-6.9735	0.2651	-1.0333	-0.4877	1.1730	-1.0333	Y
ROOF - (Z)	16	31.2902	-37.5795	-46.4695	31.1902	-37.9551	-46.6941	0.1000	-0.3756	-0.2246	0.4489	-0.2246	Z
	17	32.3284	-32.2328	-46.8469	32.2546	-32.6178	-47.0592	0.0738	-0.3850	-0.2123	0.4458	-0.2123	Z
	18	33.5129	-26.1499	-47.0398	33.4524	-26.3527	-47.2827	0.0605	-0.2028	-0.2429	0.3222	-0.2429	Z
	19	34.4303	-19.8832	-47.0946	34.3200	-20.1269	-47.3452	0.1103	-0.2437	-0.2506	0.3665	-0.2506	Z
	20	34.4840	-14.7093	-47.1581	34.4212	-14.9553	-47.3946	0.0628	-0.2460	-0.2365	0.3470	-0.2365	Z
	21	23.4448	-36.2239	-49.5634	23.2389	-36.6056	-49.6935	0.2059	-0.3817	-0.1301	0.4528	-0.1301	Z
	22	23.6742	-29.7145	-50.0121	23.4594	-29.9877	-50.1656	0.2148	-0.2732	-0.1535	0.3799	-0.1535	Z
	23	24.0994	-23.2177	-50.2578	23.9726	-23.5398	-50.4156	0.1268	-0.3221	-0.1578	0.3804	-0.1578	Z
	24	24.4783	-19.1173	-50.3225	24.3529	-19.4334	-50.4838	0.1254	-0.3161	-0.1613	0.3764	-0.1613	Z
	25	25.4601	-14.9888	-50.2615	25.2923	-15.2633	-50.4305	0.1678	-0.2745	-0.1690	0.3634	-0.1690	Z
	26	12.7178	-35.5201	-50.3326	12.5313	-35.8091	-50.4161	0.1865	-0.2890	-0.0835	0.3539	-0.0835	Z
	27	12.4956	-29.8043	-50.6894	12.3449	-30.1420	-50.7814	0.1507	-0.3377	-0.0920	0.3811	-0.0920	Z
	28	12.8140	-23.2893	-50.9387	12.6109	-23.4928	-51.0409	0.2031	-0.2035	-0.1022	0.3051	-0.1022	Z
	29	13.4317	-18.5181	-51.0148	13.1698	-18.7444	-51.1212	0.2619	-0.2263	-0.1064	0.3621	-0.1064	Z
	30	13.5843	-13.8013	-51.0354	13.5191	-14.1051	-51.1214	0.0652	-0.3038	-0.0860	0.3224	-0.0860	Z
A-PILLAR Maximum (X, Y, Z)	31	50.7892	-46.8739	-31.9768	50.6505	-47.1738	-32.3290	0.1387	-0.2999	-0.3522	0.4829	0.1387	X
	32	48.1517	-46.2949	-34.2491	48.0182	-46.6055	-34.5278	0.1335	-0.3106	-0.2787	0.4381	0.1335	X
	33	45.7180	-45.5964	-35.9868	45.6084	-45.9054	-36.2039	0.1096	-0.3090	-0.2171	0.3932	0.1096	X
	34	43.2504	-45.0123	-37.7444	43.0392	-45.2995	-38.0082	0.2112	-0.2872	-0.2638	0.4435	0.2112	X
	35	40.2991	-44.0718	-39.9213	40.0852	-44.3396	-40.1624	0.2139	-0.2678	-0.2411	0.4190	0.2139	X
	36	38.2318	-44.0754	-42.0265	38.0307	-44.3884	-42.2424	0.2011	-0.3130	-0.2159	0.4301	0.2011	X
A-PILLAR Lateral (Y)	31	50.7892	-46.8739	-31.9768	50.6505	-47.1738	-32.3290	0.1387	-0.2999	-0.3522	0.4829	-0.2999	Y
	32	48.1517	-46.2949	-34.2491	48.0182	-46.6055	-34.5278	0.1335	-0.3106	-0.2787	0.4381	-0.3106	Y
	33	45.7180	-45.5964	-35.9868	45.6084	-45.9054	-36.2039	0.1096	-0.3090	-0.2171	0.3932	-0.3090	Y
	34	43.2504	-45.0123	-37.7444	43.0392	-45.2995	-38.0082	0.2112	-0.2872	-0.2638	0.4435	-0.2872	Y
	35	40.2991	-44.0718	-39.9213	40.0852	-44.3396	-40.1624	0.2139	-0.2678	-0.2411	0.4190	-0.2678	Y
	36	38.2318	-44.0754	-42.0265	38.0307	-44.3884	-42.2424	0.2011	-0.3130	-0.2159	0.4301	-0.3130	Y
B-PILLAR Maximum (X, Y, Z)	37	7.1988	-43.1371	-43.1409	7.0000	-43.3057	-43.2688	0.1988	-0.1686	-0.1279	0.2904	0.1988	X
	38	10.0988	-44.0387	-40.7472	9.9569	-44.2244	-40.8754	0.1419	-0.1857	-0.1282	0.2666	0.1419	X
	39	7.5492	-46.2425	-34.3921	7.3720	-46.4003	-34.3860	0.1772	-0.1578	0.0061	0.2374	0.1773	X, Z
	40	10.8757	-46.6190	-32.5974	10.7630	-46.7819	-32.6756	0.1127	-0.1629	-0.0782	0.2130	0.1127	X
B-PILLAR Lateral (Y)	37	7.1988	-43.1371	-43.1409	7.0000	-43.3057	-43.2688	0.1988	-0.1686	-0.1279	0.2904	-0.1686	Y
	38	10.0988	-44.0387	-40.7472	9.9569	-44.2244	-40.8754	0.1419	-0.1857	-0.1282	0.2666	-0.1857	Y
	39	7.5492	-46.2425	-34.3921	7.3720	-46.4003	-34.3860	0.1772	-0.1578	0.0061	0.2374	-0.1578	Y
	40	10.8757	-46.6190	-32.5974	10.7630	-46.7819	-32.6756	0.1127	-0.1629	-0.0782	0.2130	-0.1629	Y

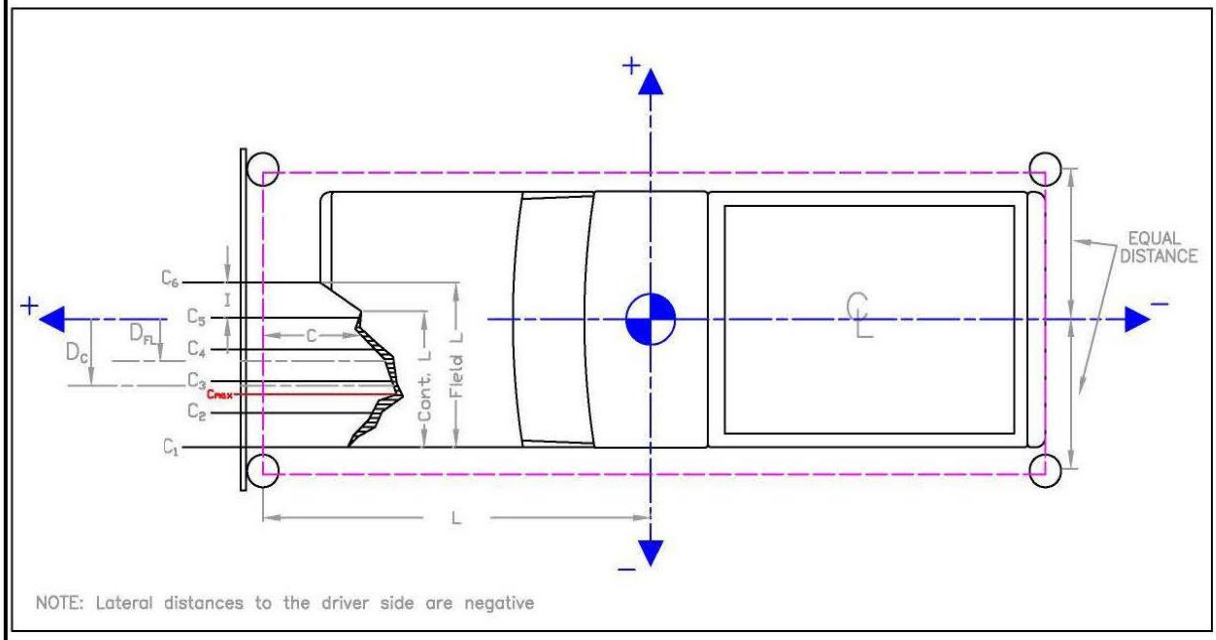
[A] Positive values denote deformation as inward toward the occupant compartment, negative values denote deformations outward away from the occupant compartment.

[B] Crush calculations that use multiple directional components will disregard components that are negative and only include positive values where the component is deforming inward toward the occupant compartment.

[C] Direction for Crush column denotes which directions are included in the crush calculations. If "NA" then no intrusion is recorded, and Crush will be 0.

Figure F-10. Occupant Compartment Deformation Data – Set 2, Test No.NYBWT-3

Date:	7/30/2018	Test Name:	NYBWT-3	VIN:	1C6RD6FPCS205397
Year:	2012	Make:	Dodge	Model:	Ram 1500



	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	122 1/4	(3105)
Total Vehicle Width:	77 1/4	(1962)
Width of contact and induced crush - Field L:	77 1/4	(1962)
Crush measurement spacing interval (L/5) - I:	15 1/2	(394)
Distance from center of vehicle to center of Field L - D_{FL}:	0	()
Width of Contact Damage:	31	(787)
Distance from center of vehicle to center of contact damage - D_C:	20 1/2	(521)

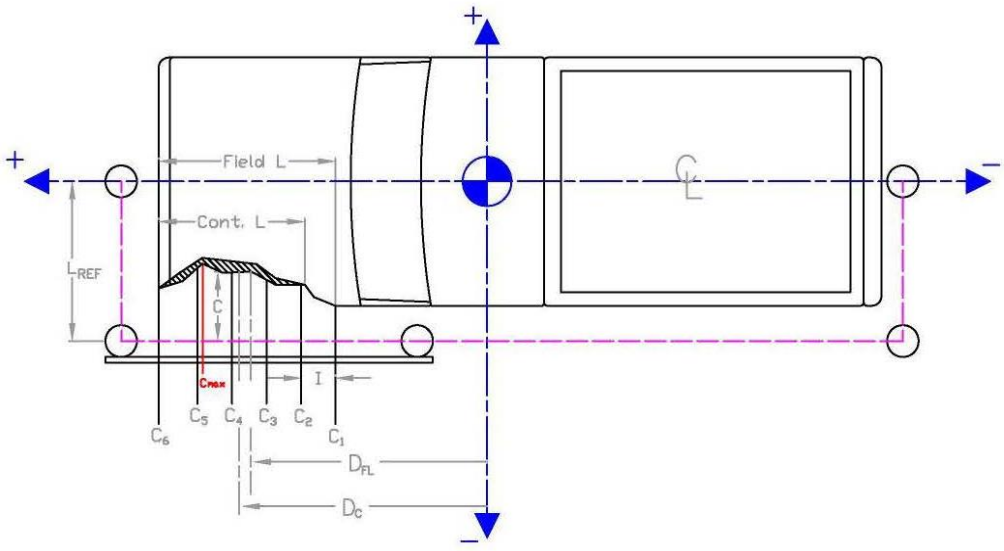
NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., side of vehicle has been pushed inward)
NOTE: All values must be filled out above before crush measurements are filled out.

	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!	-38 5/8	-(981)	22 1/2	(572)	17 1/4	(438)	#VALUE!	#VALUE!
C_2	27	(686)	-23 1/8	-(587)	6 1/2	(165)			3 1/4	(83)
C_3	24	(610)	-7 5/8	-(194)	4 1/4	(108)			2 1/2	(64)
C_4	21 1/4	(540)	7 7/8	(200)	4 1/4	(108)			- 1/4	-(6)
C_5	22 3/4	(578)	23 3/8	(594)	6 1/4	(159)			- 3/4	-(19)
C_6	N/A	#VALUE!	38 7/8	(987)	20 1/2	(521)			#VALUE!	#VALUE!
C_{MAX}	45 1/2	(1156)	31 1/8	(791)	10 1/8	(257)			18 1/8	(460)

Figure F-11. Exterior Vehicle Crush (NASS) – Front, Test No. NYBWT-3

Date: 7/30/2018 Test Name: NYBWT-3 VIN: 1C6RD6FPCS205397

Year: 2012 Make: Dodge Model: Ram 1500



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	52	(1321)
Total Vehicle Length:	229 3/8	(5826)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-6 4/7	-(167)
Width of contact and induced crush - Field L:	229 3/8	(5826)
Crush measurement spacing interval (L/5) - I:	45 7/8	(1165)
Distance from vehicle c.g. to center of Field L - D_{FL}:	-16 1/2	-(419)
Width of Contact Damage:	229 3/8	(5826)
Distance from vehicle c.g. to center of contact damage - D_C:	-16 1/2	-(419)

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	na	NA	-131 1/4	-(3334)	33 1/2	(851)	8	(203)	NA	NA
C_2	na	NA	-85 3/8	-(2169)	5 1/2	(140)			NA	NA
C_3	15	(381)	-39 1/2	-(1003)	5 3/4	(146)			1 1/4	(32)
C_4	15 1/4	(387)	6 3/8	(162)	5	(127)			2 1/4	(57)
C_5	na	NA	52 1/4	(1327)	5 1/2	(140)			NA	NA
C_6	33 1/2	(851)	98 1/8	(2492)	8 3/8	(213)			17 1/8	(435)
C_{MAX}	33 1/2	(851)	98 1/8	(2492)	8 3/8	(213)			17 1/8	(435)

Figure F-12. Exterior Vehicle Crush (NASS) – Side, Test No. NYBWT-3

Appendix G. Accelerometer and Rate Transducer Data Plots, Test No. NYBWT-2

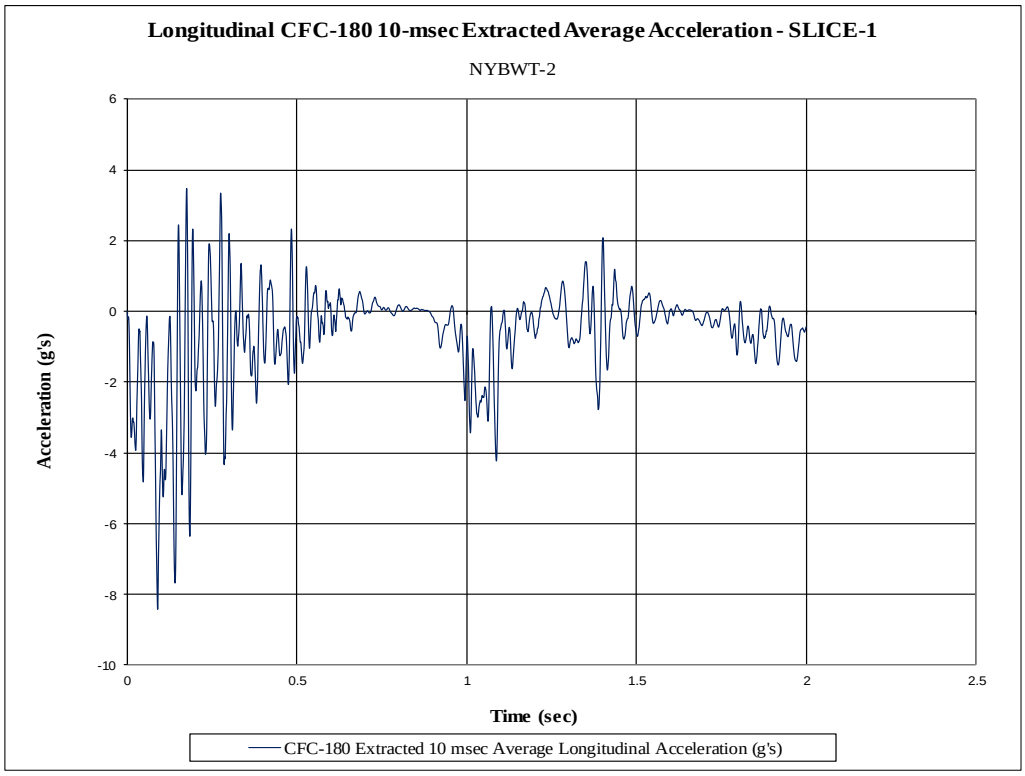


Figure G-1. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYBWT-2

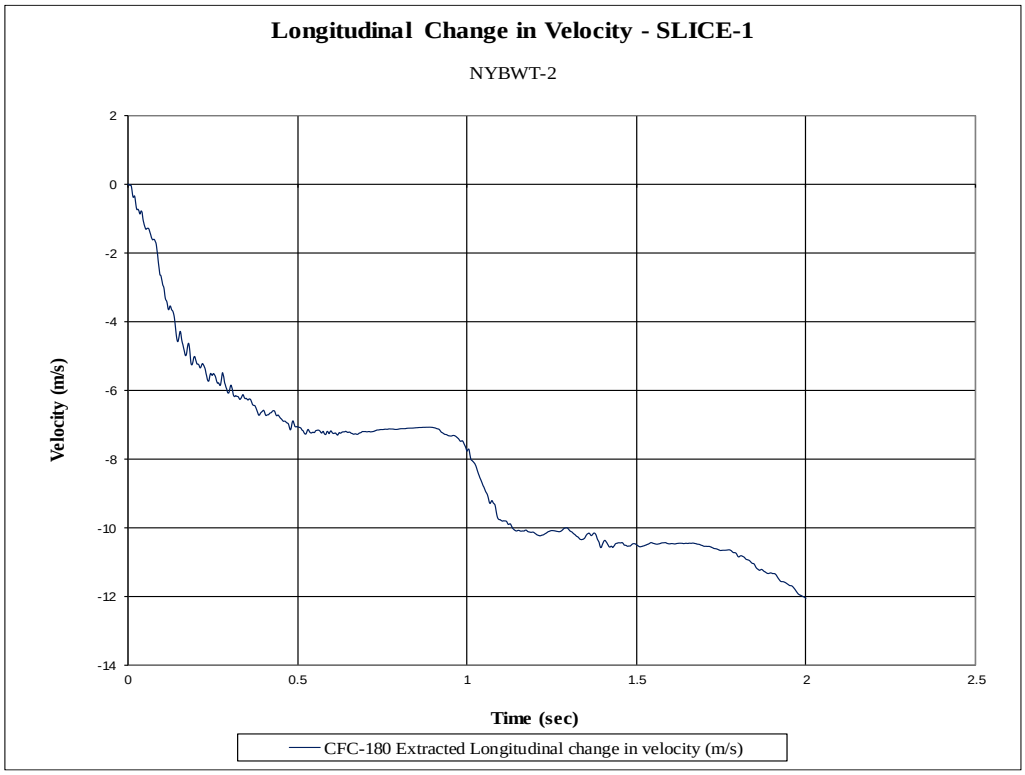


Figure G-2. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYBWT-2

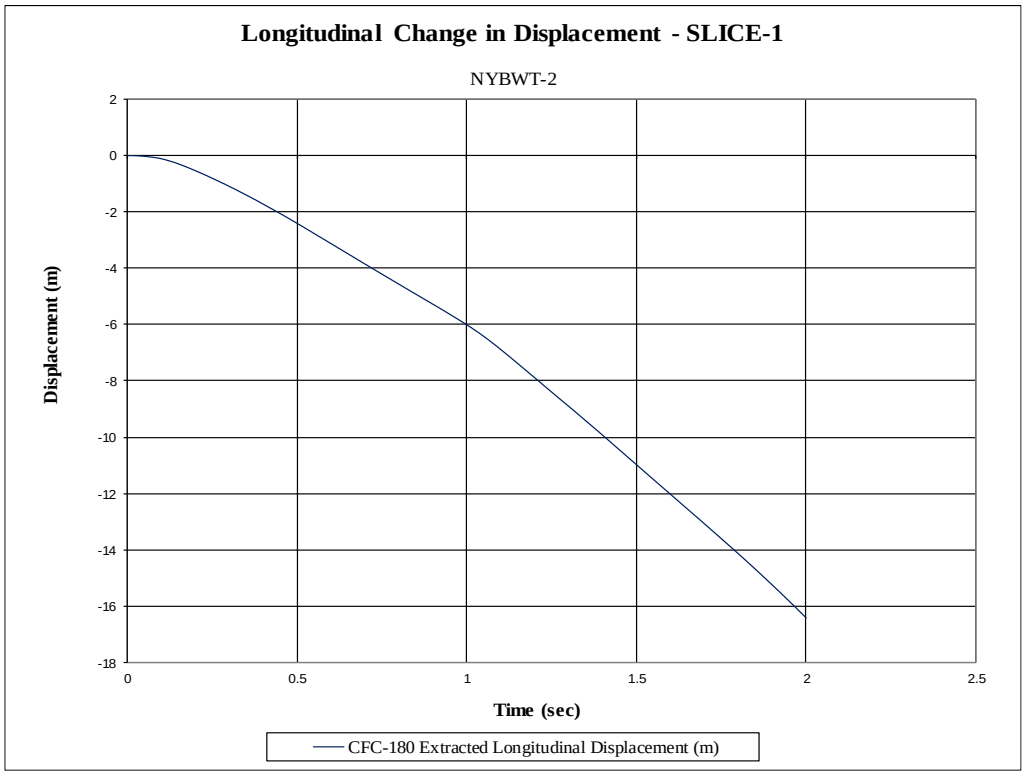


Figure G-3. Longitudinal Occupant Displacement (SLICE-1), Test No. NYBWT-2

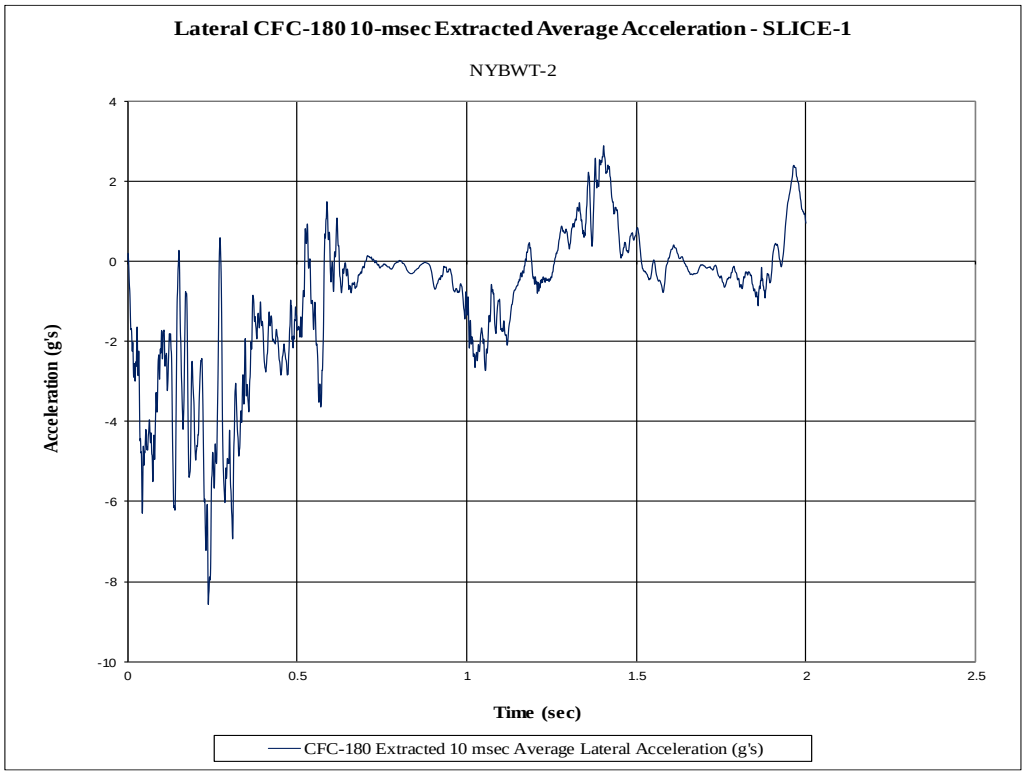


Figure G-4. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYBWT-2

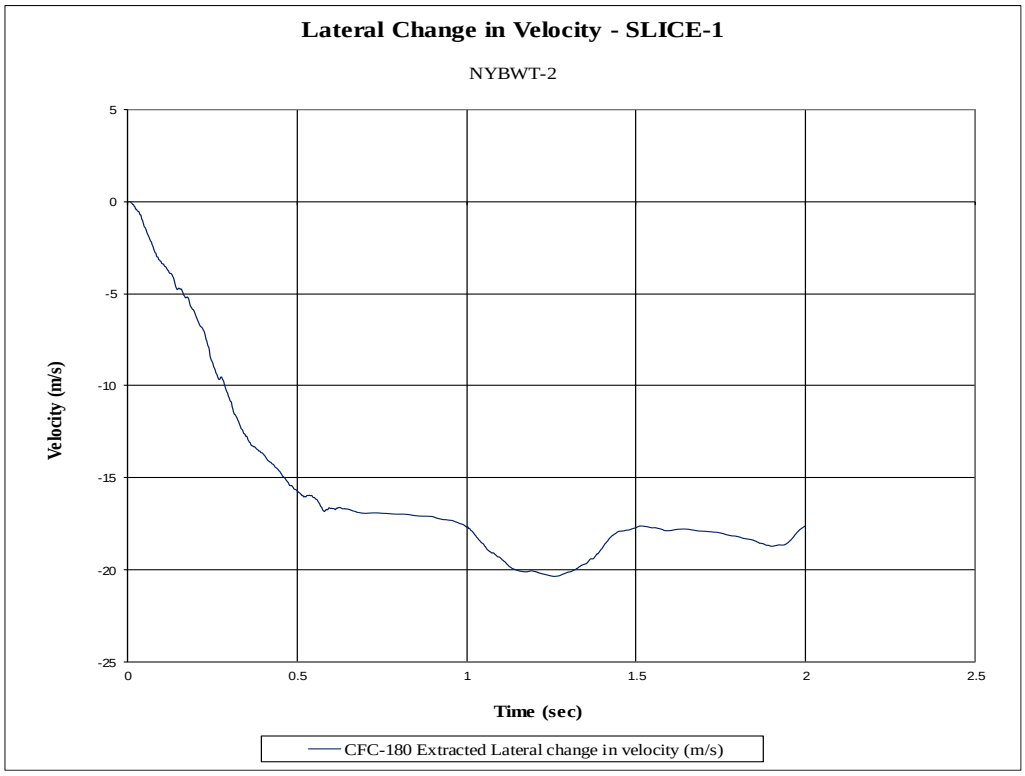


Figure G-5. Lateral Occupant Impact Velocity (SLICE-1), Test No. NYBWT-2

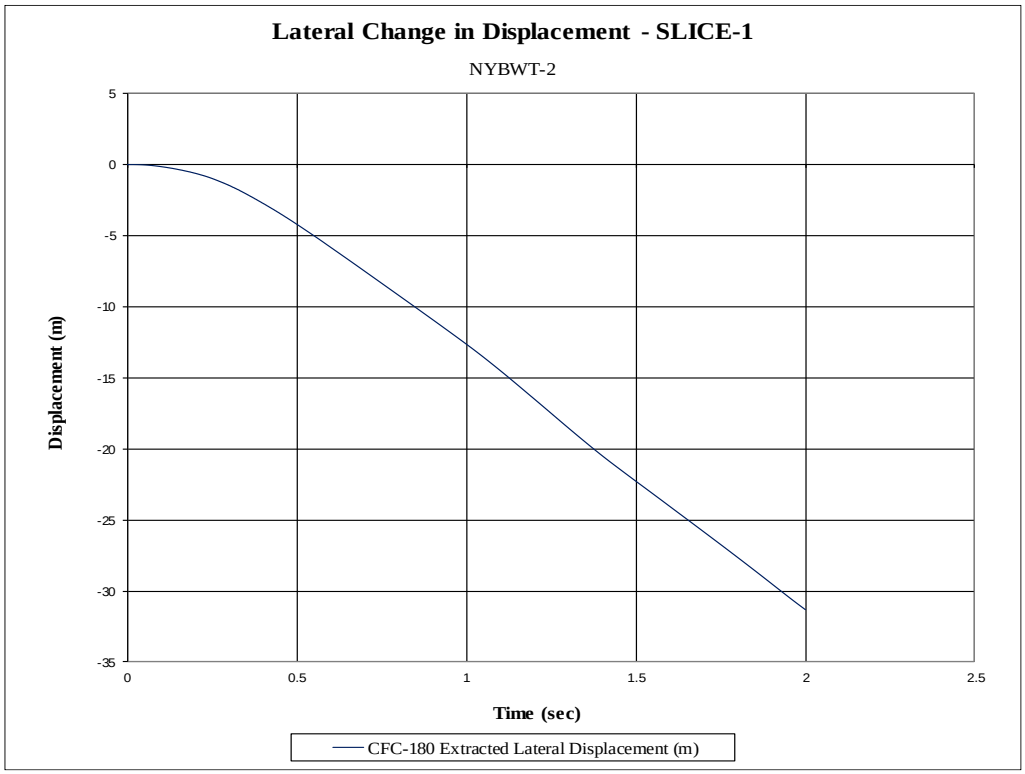


Figure G-6. Lateral Occupant Displacement (SLICE-1), Test No. NYBWT-2

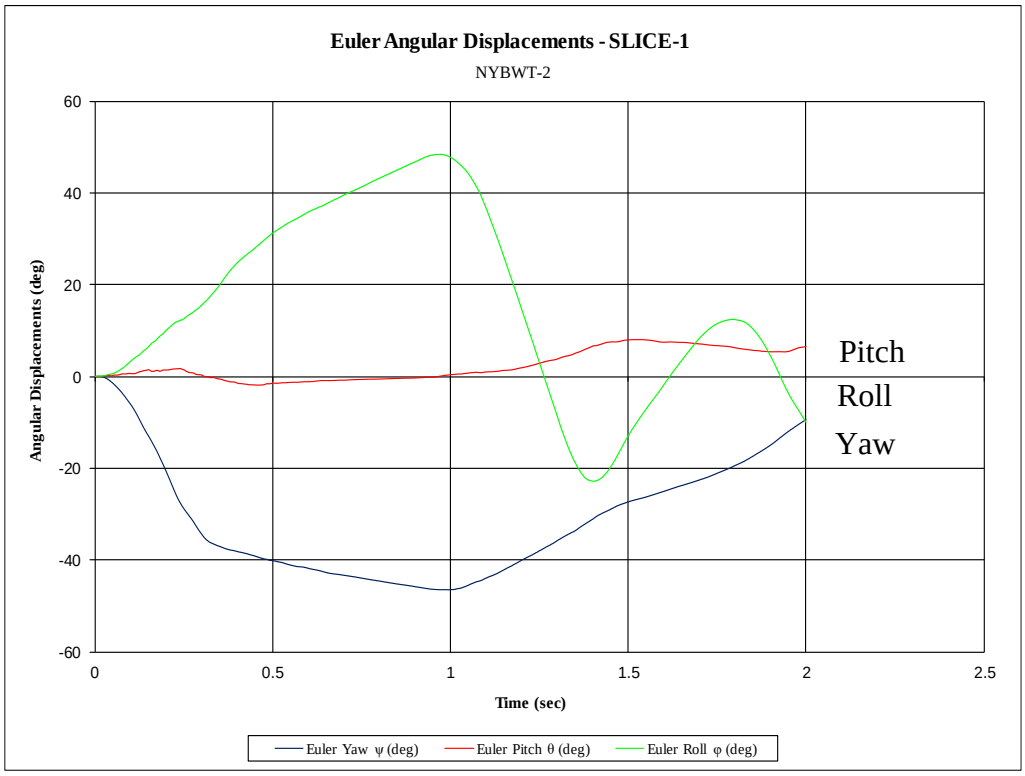


Figure G-7. Vehicle Angular Displacements (SLICE-1), Test No. NYBWT-2

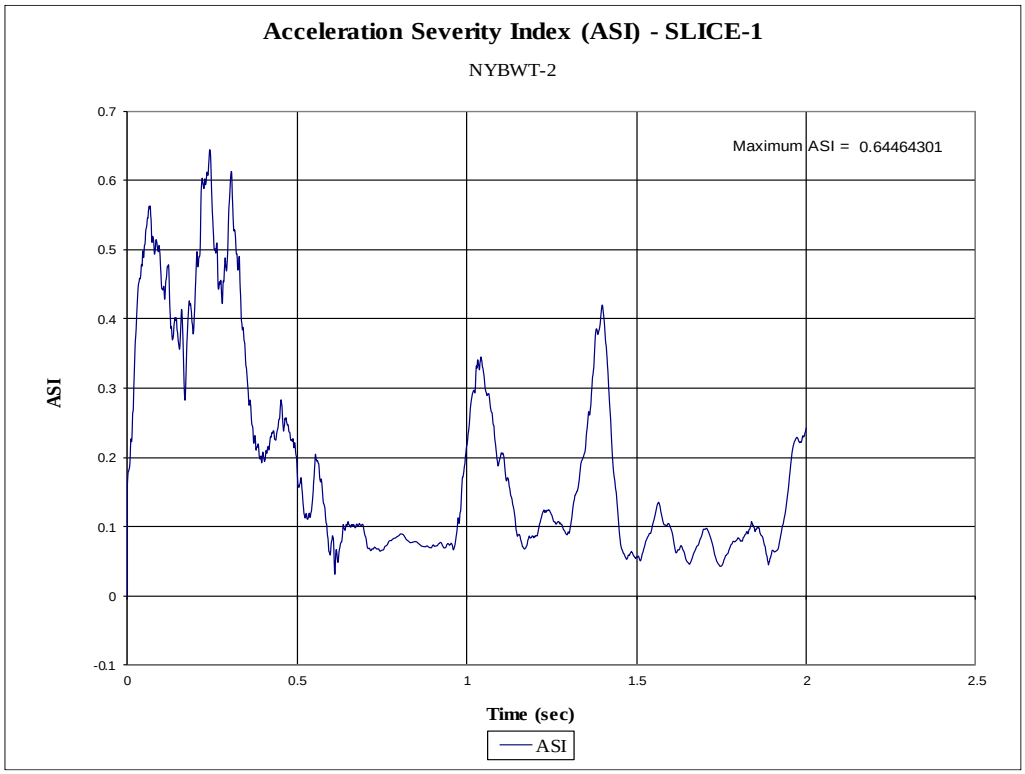


Figure G-8. Acceleration Severity Index (SLICE-1), Test No. NYBWT-2

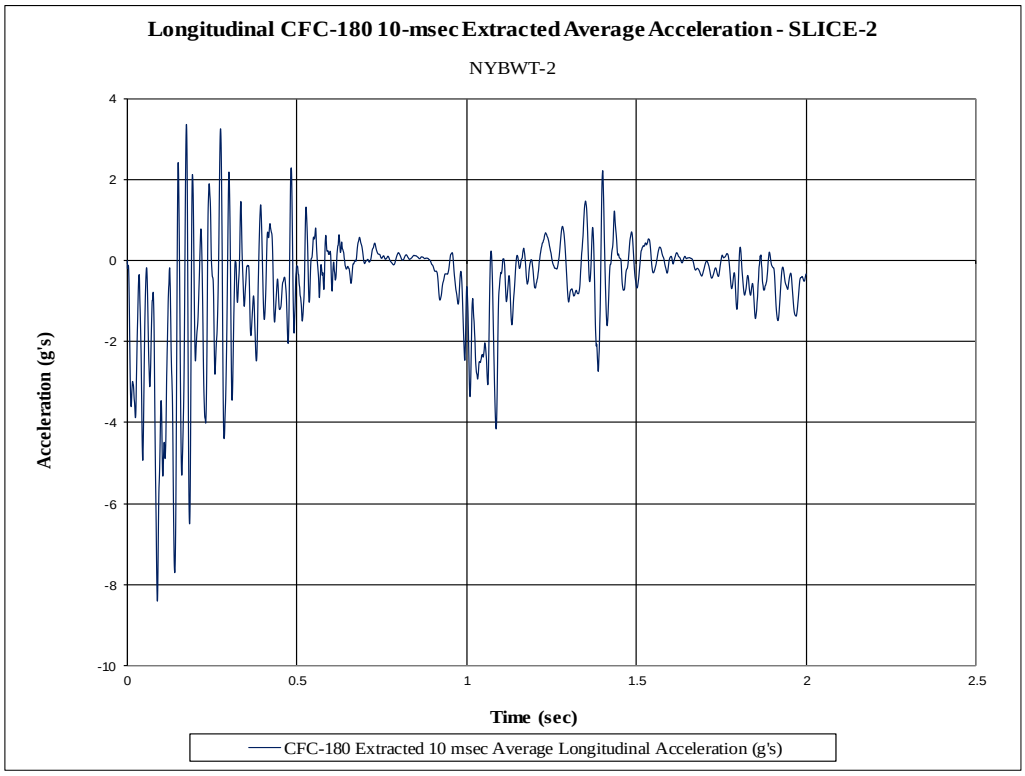


Figure G-9. 10-ms Average Longitudinal Deceleration (SLICE-2), Test No. NYBWT-2

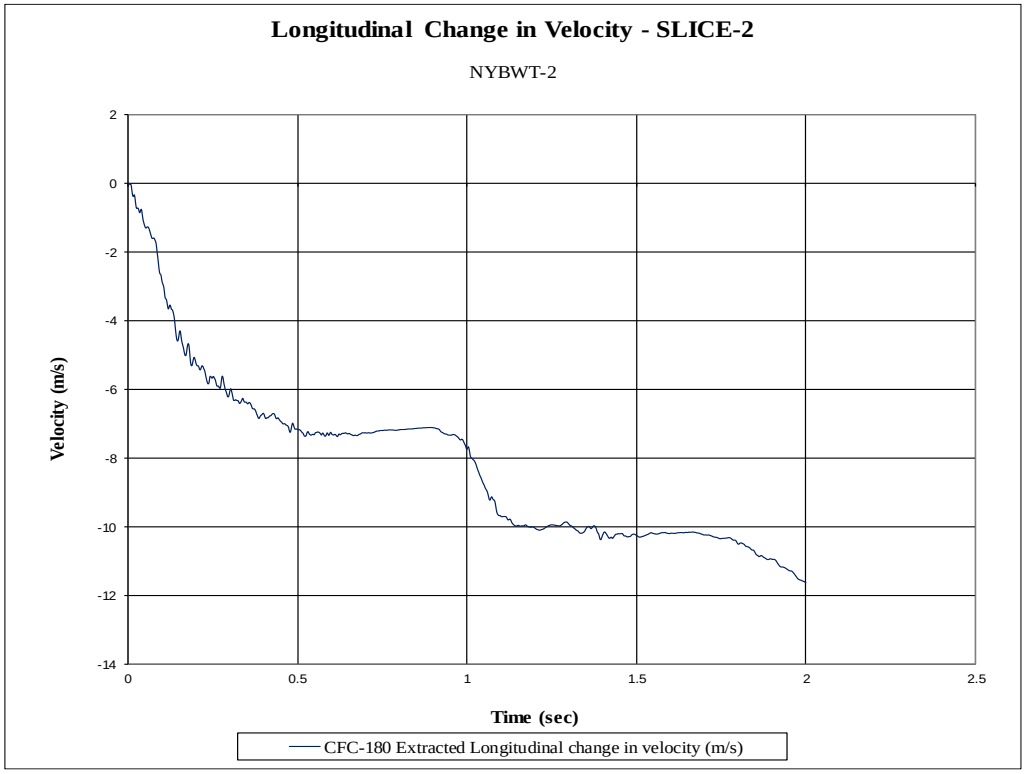


Figure G-10. Longitudinal Occupant Impact Velocity (SLICE-2), Test No. NYBWT-2

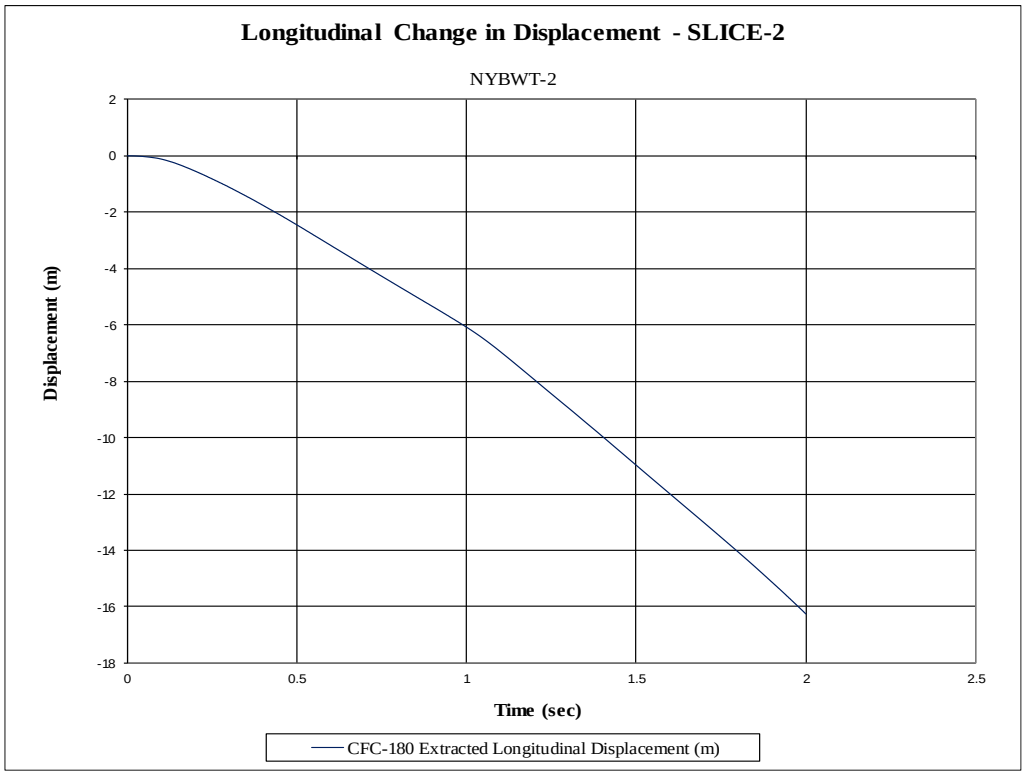


Figure G-11. Longitudinal Occupant Displacement (SLICE-2), Test No. NYBWT-2

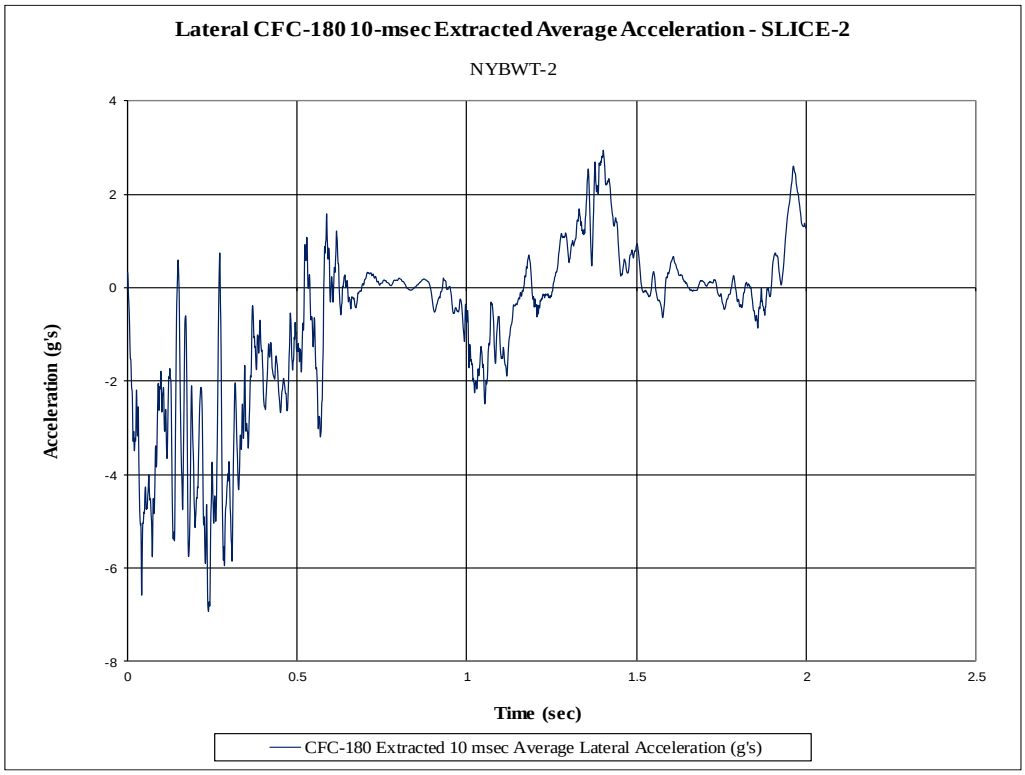


Figure G-12. 10-ms Average Lateral Deceleration (SLICE-2), Test No. NYBWT-2

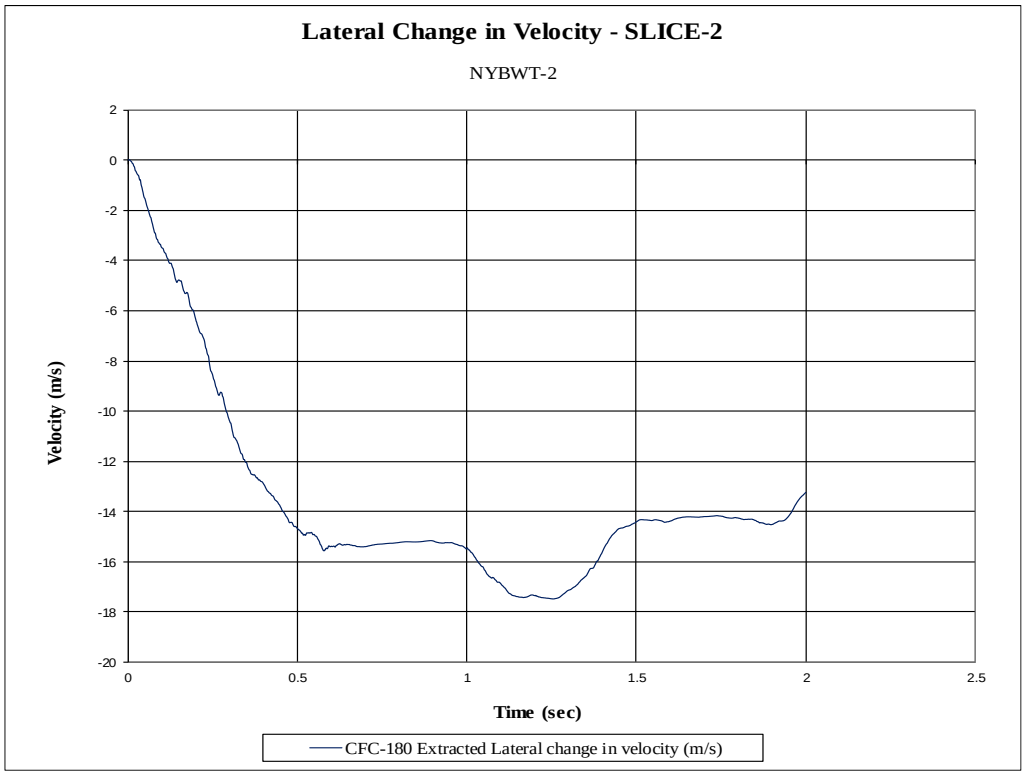


Figure G-13. Lateral Occupant Impact Velocity (SLICE-2), Test No. NYBWT-2

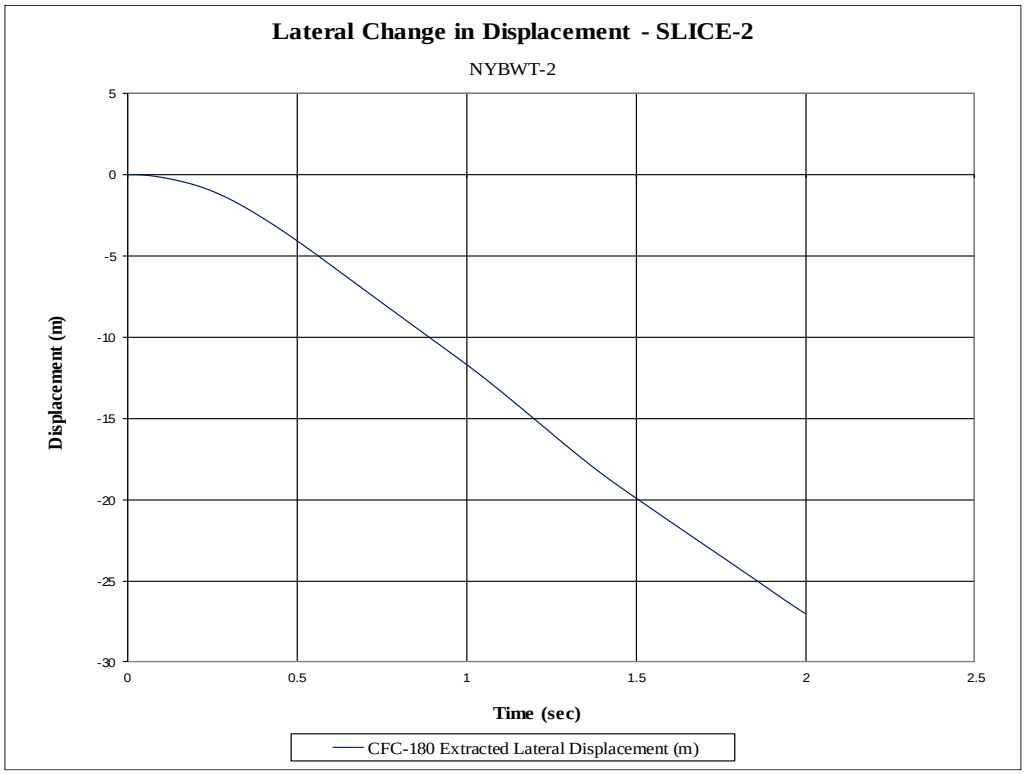


Figure G-14. Lateral Occupant Displacement (SLICE-2), Test No. NYBWT-2

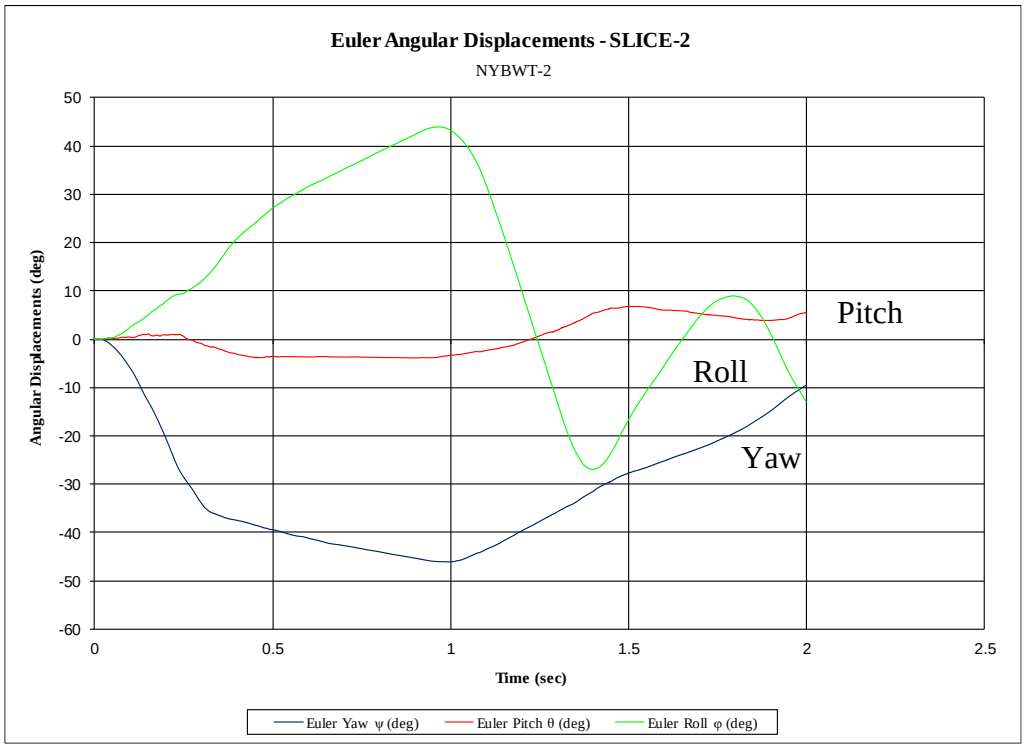


Figure G-15. Vehicle Angular Displacements (SLICE-2), Test No. NYBWT-2

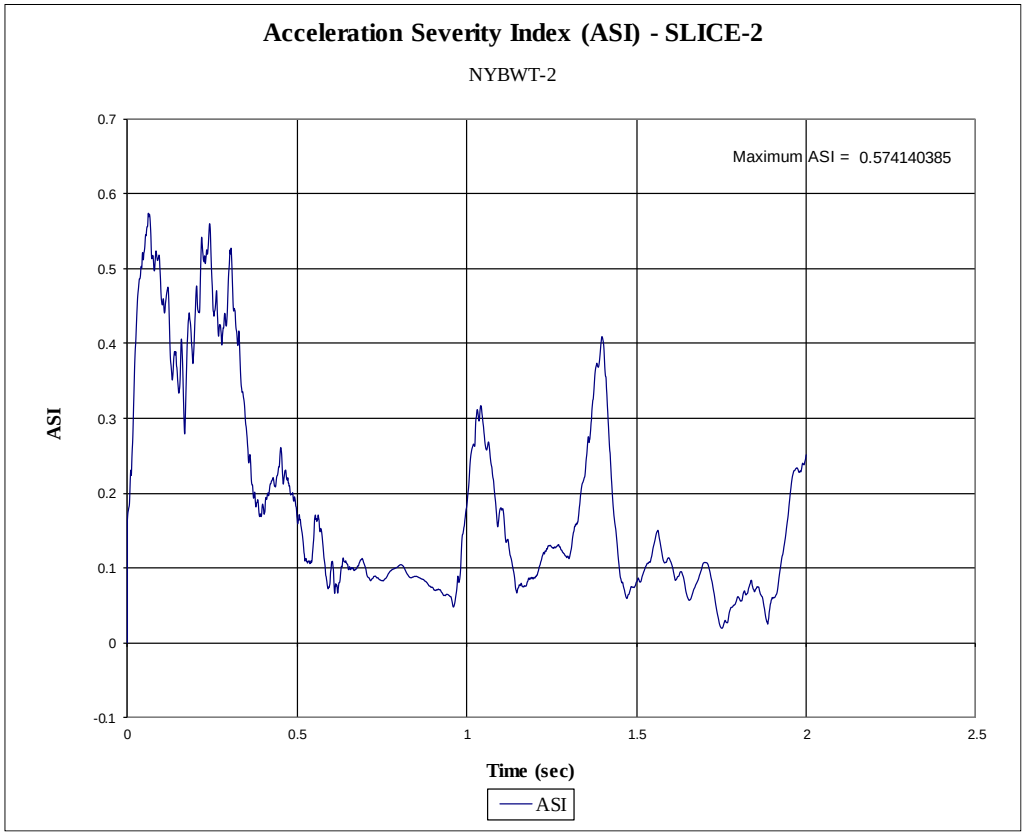


Figure G-16. Acceleration Severity Index (SLICE-2), Test No. NYBWT-2

Appendix H. Accelerometer and Rate Transducer Data Plots, Test No. NYBWT-3

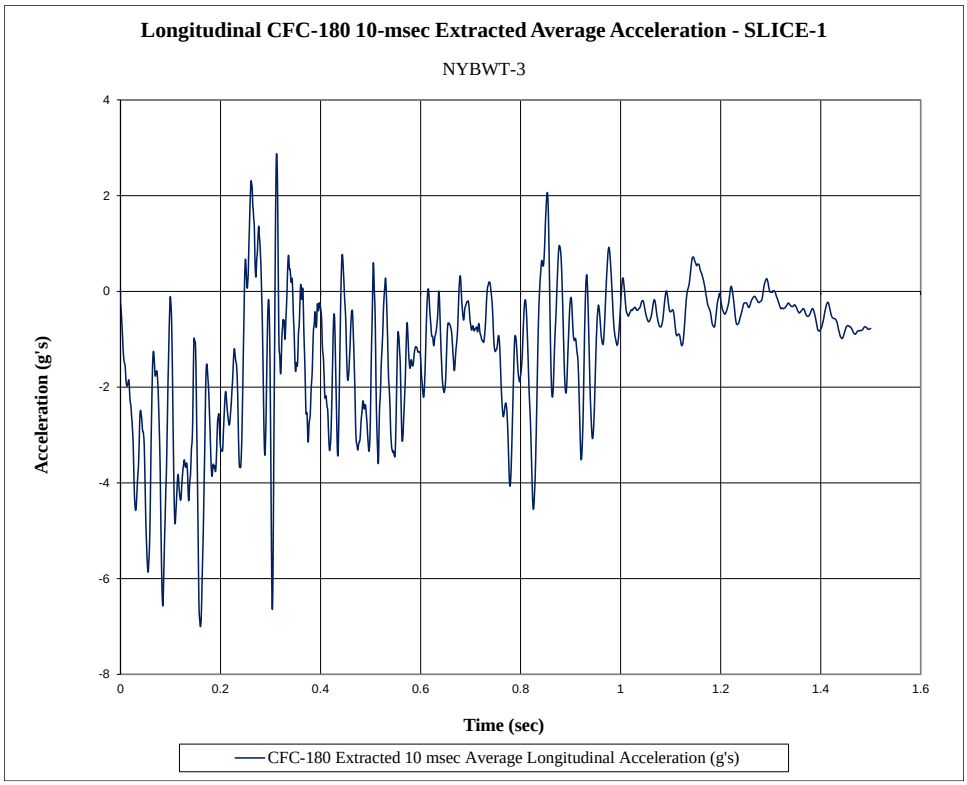


Figure H-1. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYBWT-3

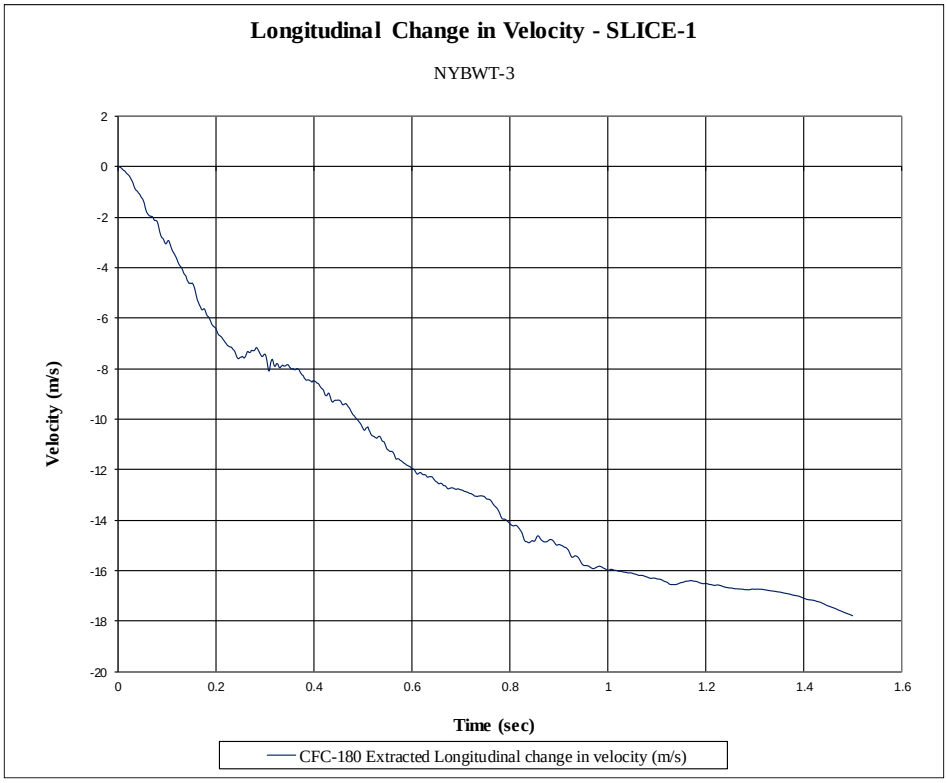


Figure H-2. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYBWT-3

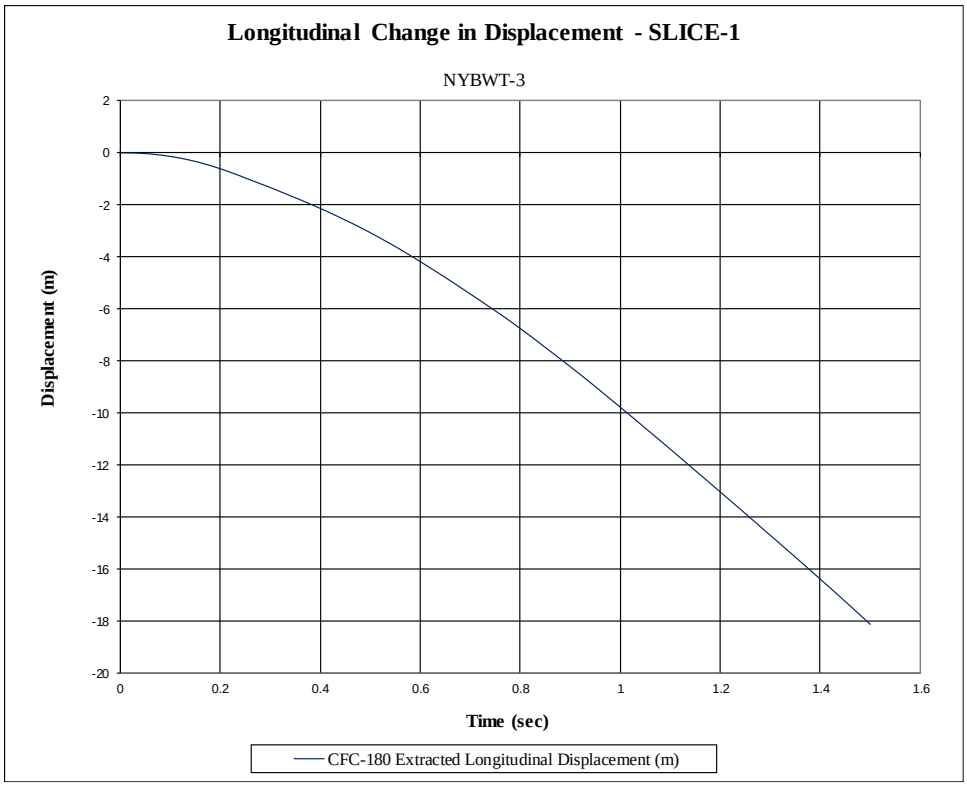


Figure H-3. Longitudinal Occupant Displacement (SLICE-1), Test No. NYBWT-3

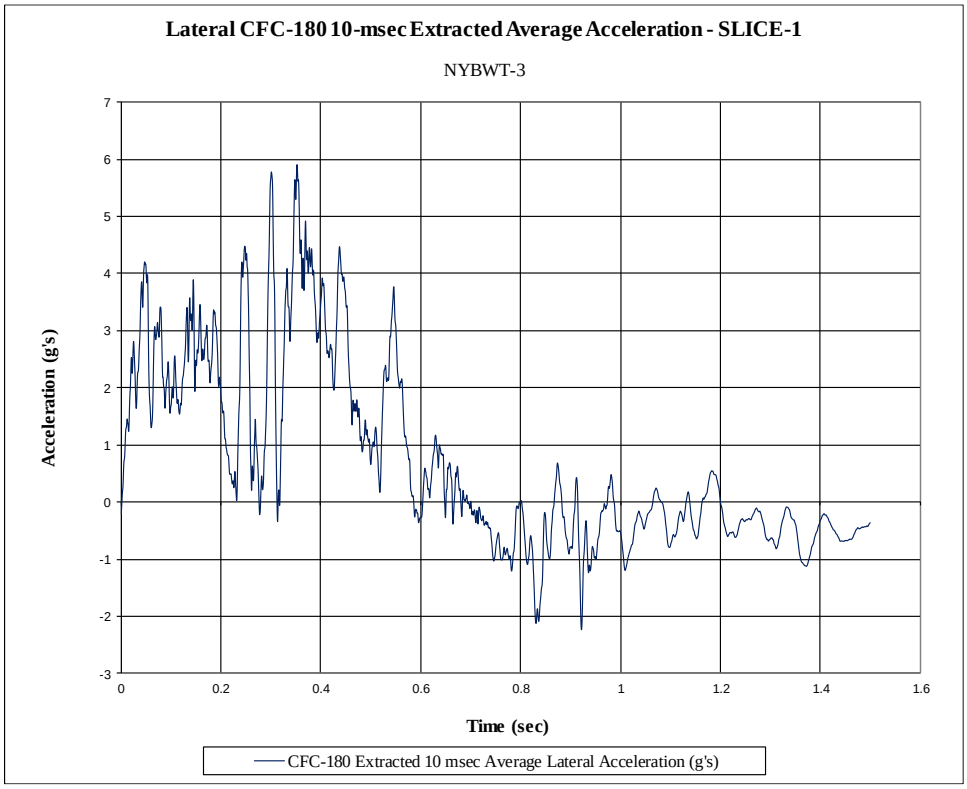


Figure H-4. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYBWT-3

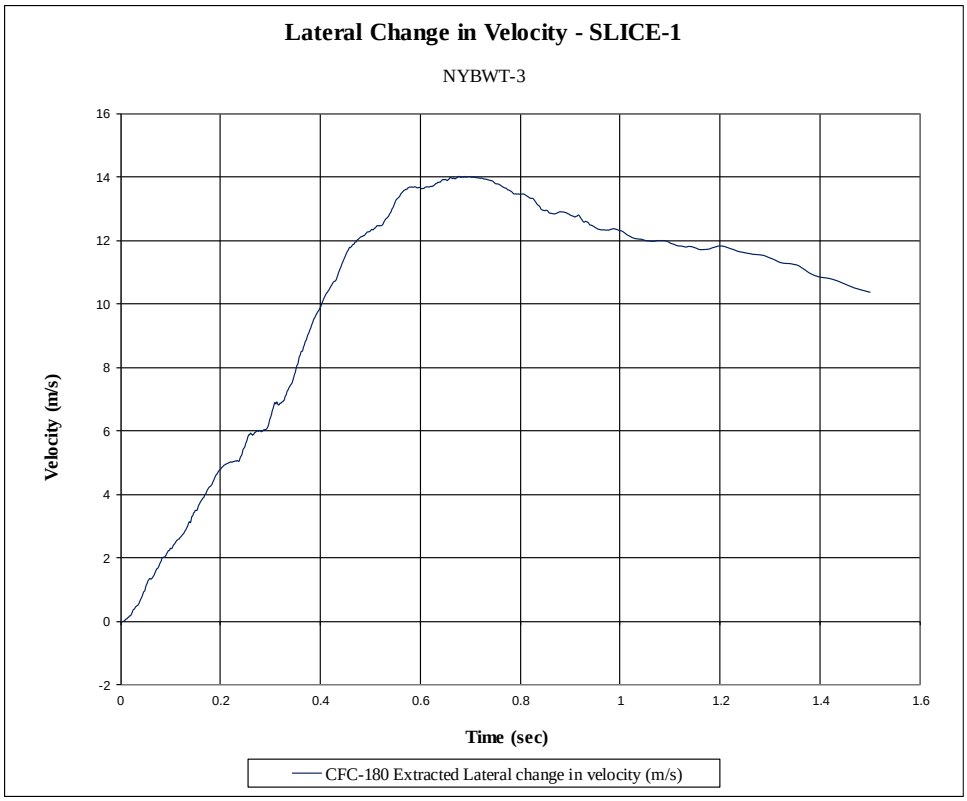


Figure H-5. Lateral Occupant Impact Velocity (SLICE-1), Test No. NYBWT-3

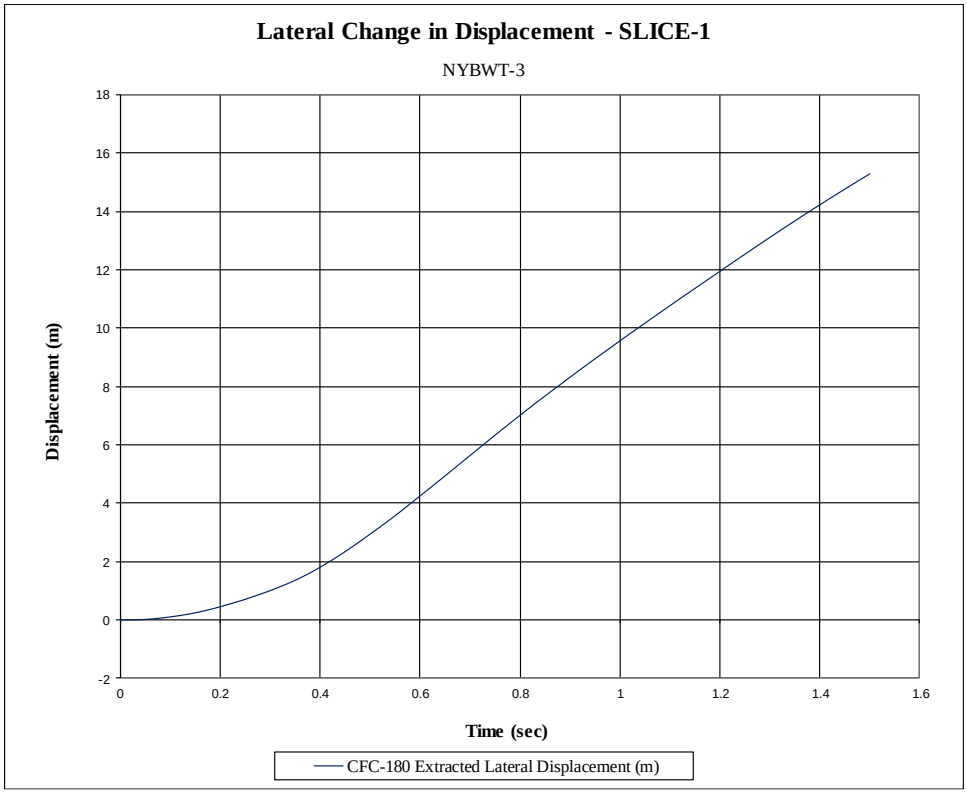


Figure H-6. Lateral Occupant Displacement (SLICE-1), Test No. NYBWT-3

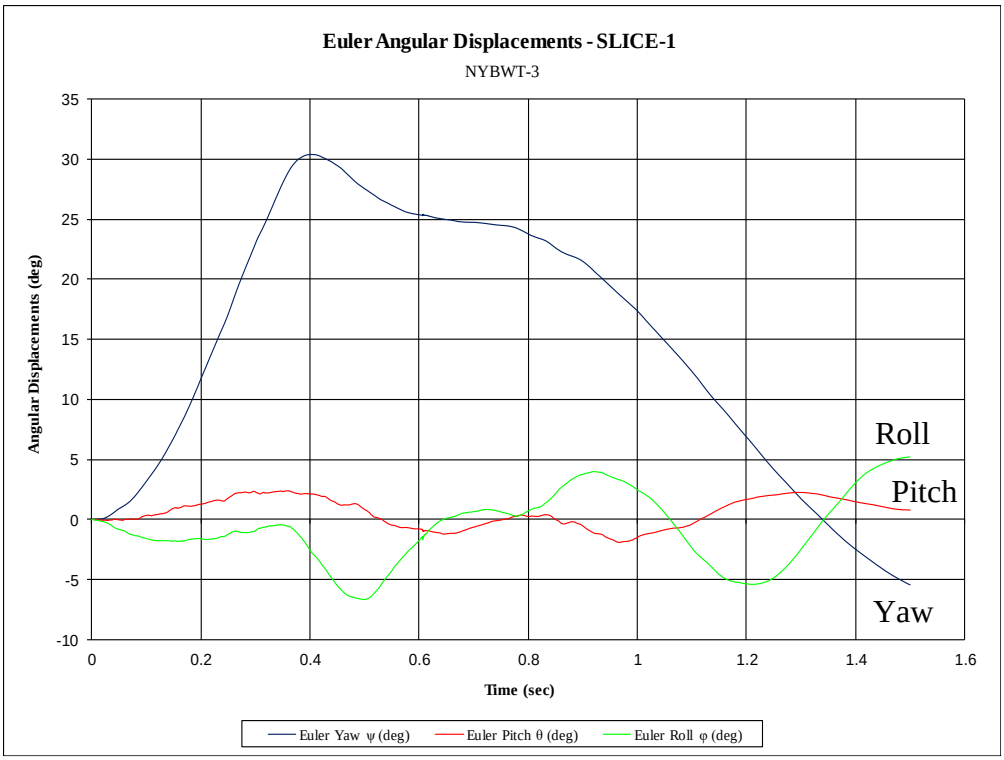


Figure H-7. Vehicle Angular Displacements (SLICE-1), Test No. NYBWT-3

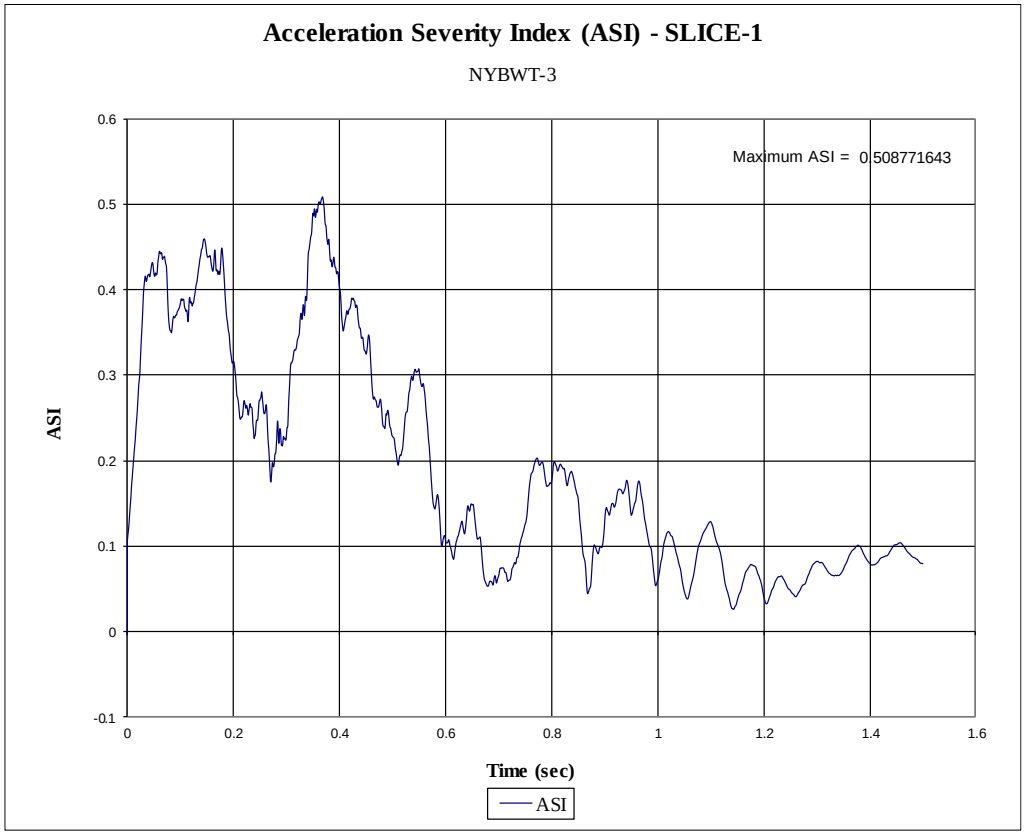


Figure H-8. Acceleration Severity Index (SLICE-1), Test No. NYBWT-3

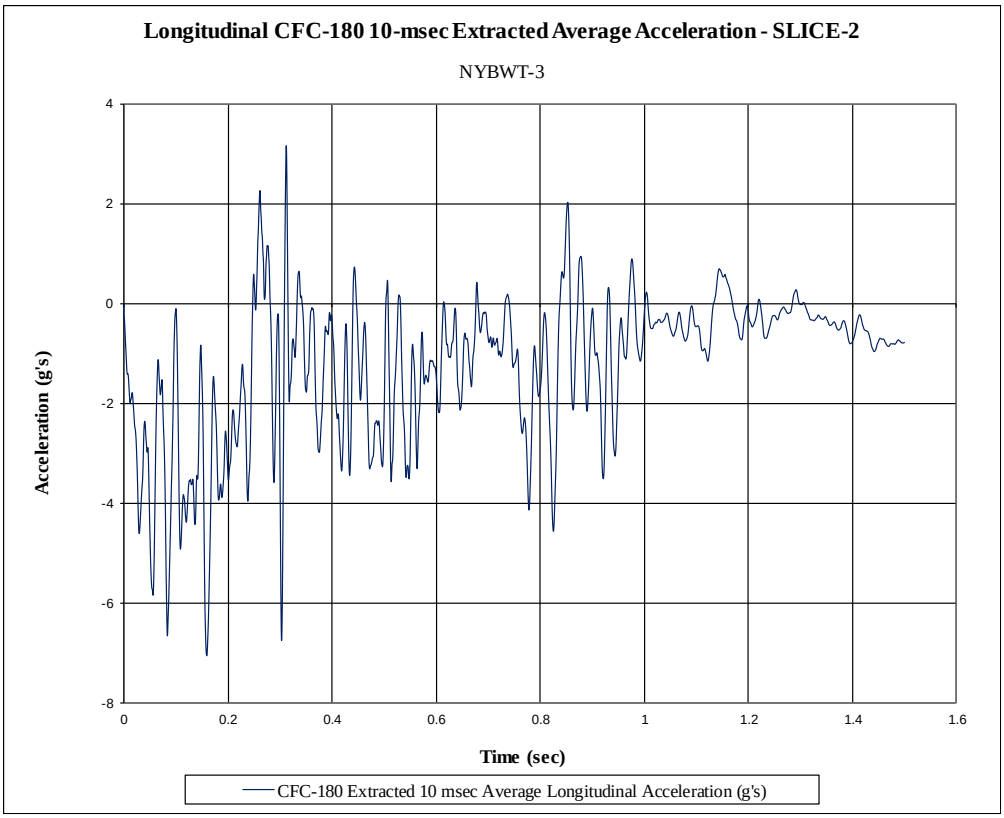


Figure H-9. 10-ms Average Longitudinal Deceleration (SLICE-2), Test No. NYBWT-3

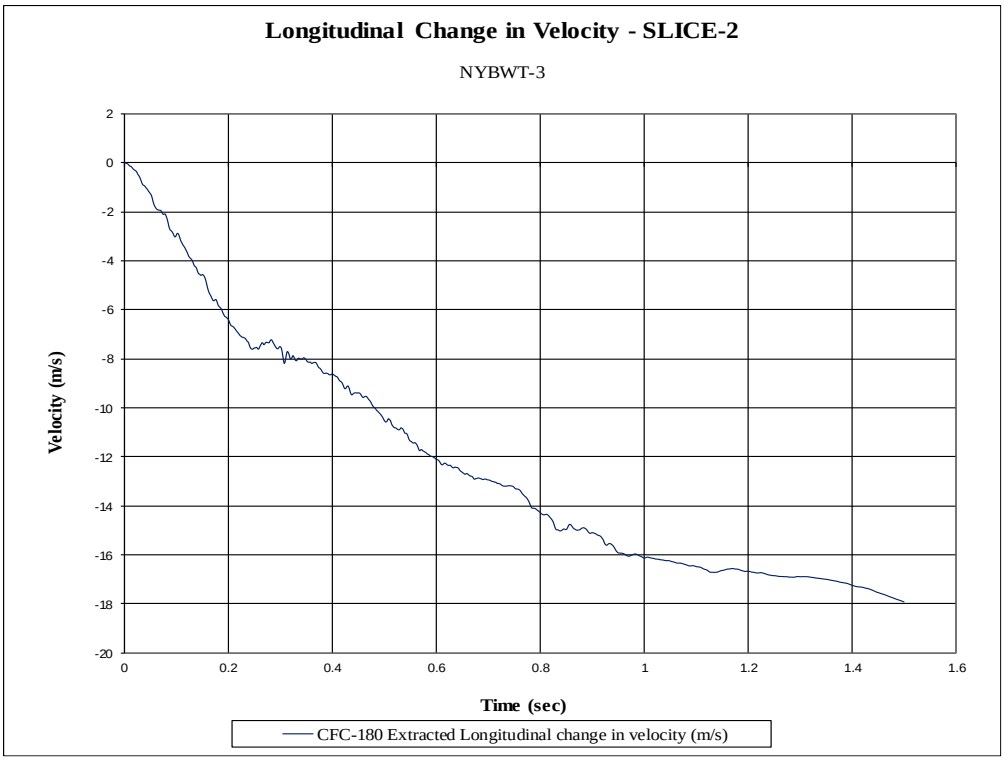


Figure H-10. Longitudinal Occupant Impact Velocity (SLICE-2), Test No. NYBWT-3

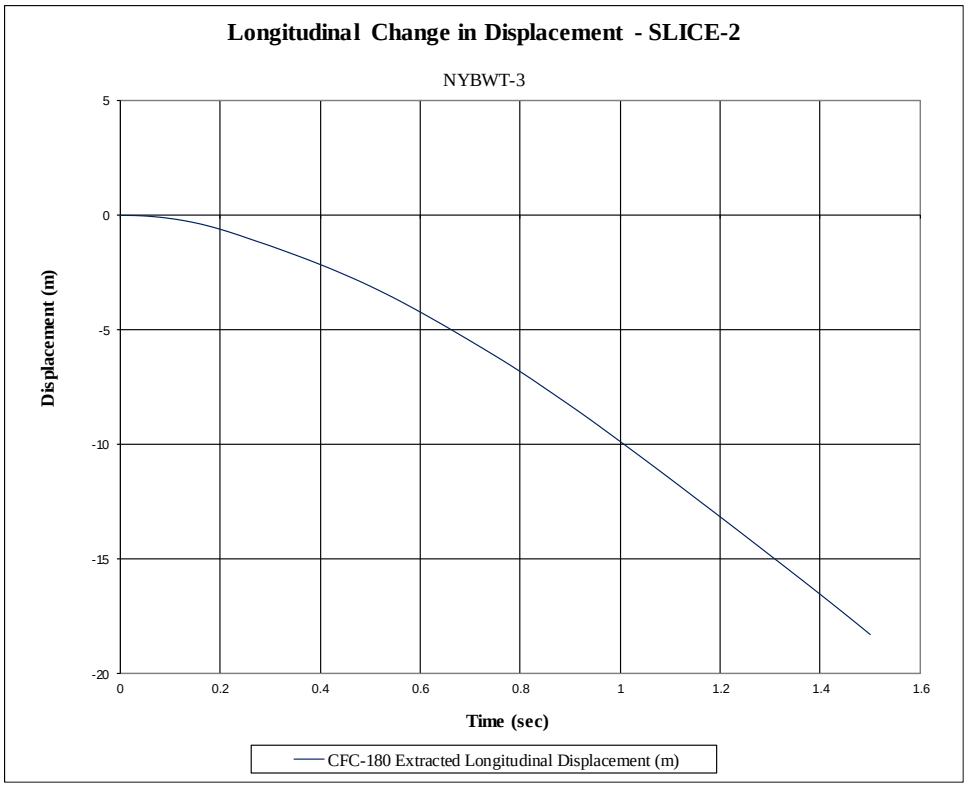


Figure H-11. Longitudinal Occupant Displacement (SLICE-2), Test No. NYBWT-3

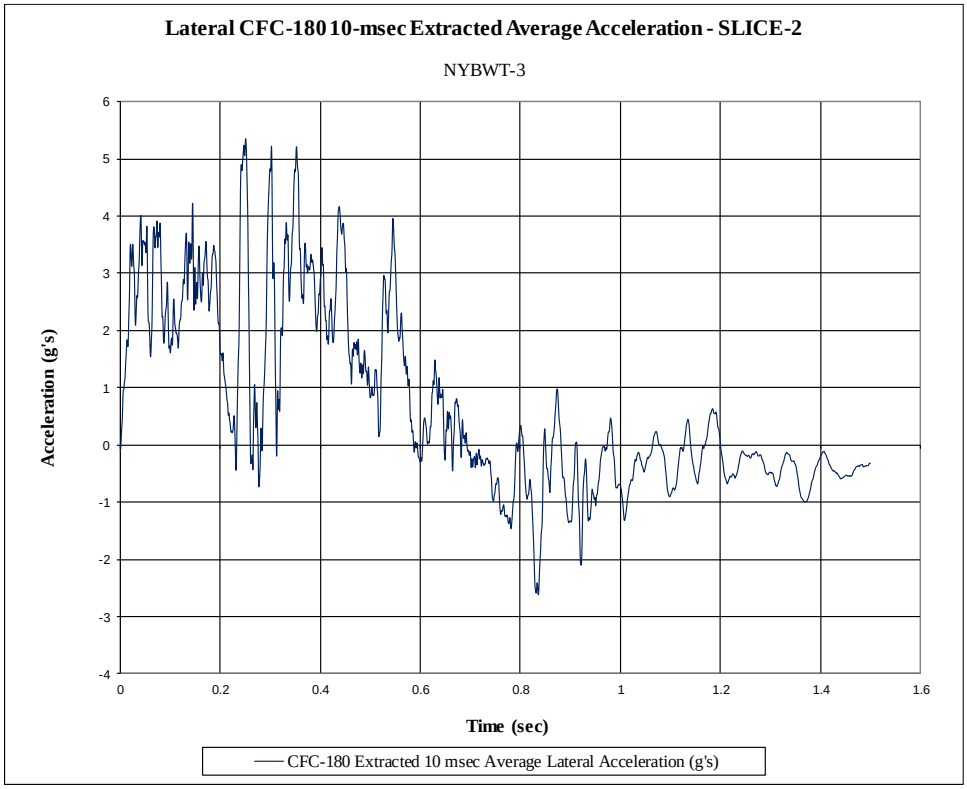


Figure H-12. 10-ms Average Lateral Deceleration (SLICE-2), Test No. NYBWT-3

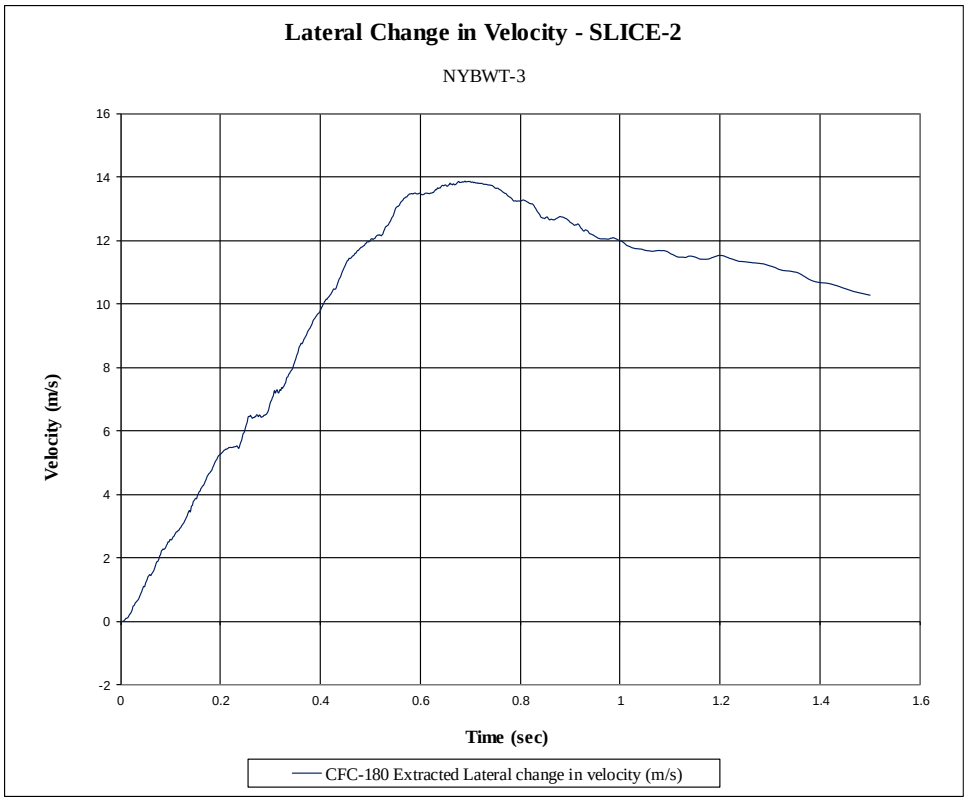


Figure H-13. Lateral Occupant Impact Velocity (SLICE-2), Test No. NYBWT-3

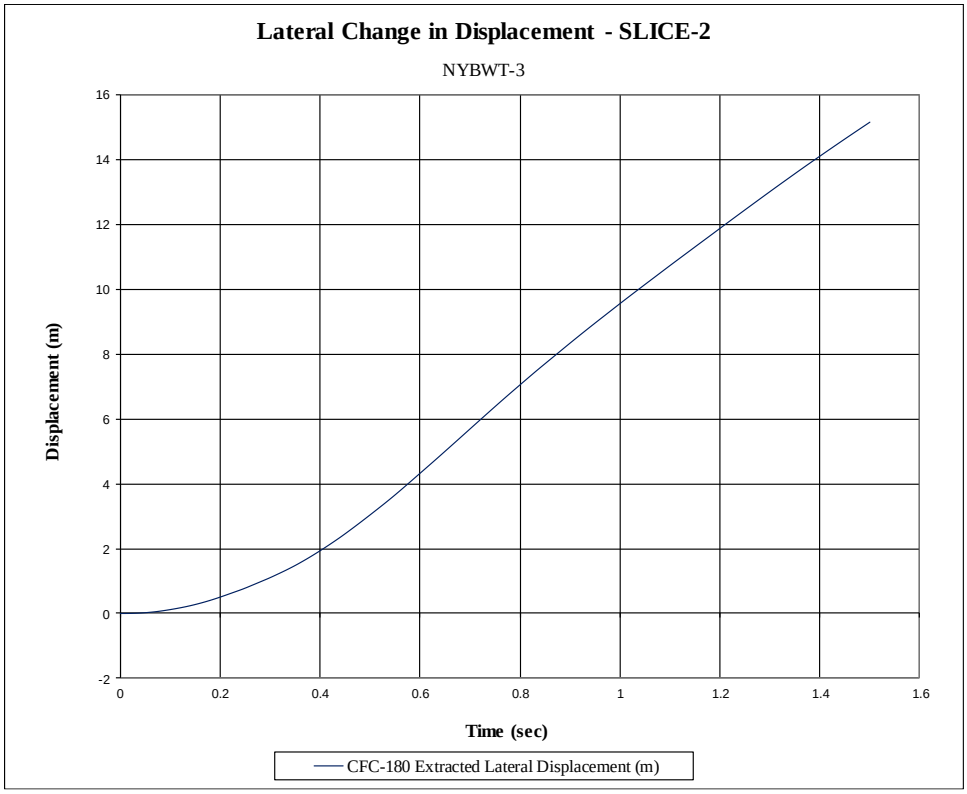


Figure H-14. Lateral Occupant Displacement (SLICE-2), Test No. NYBWT-3

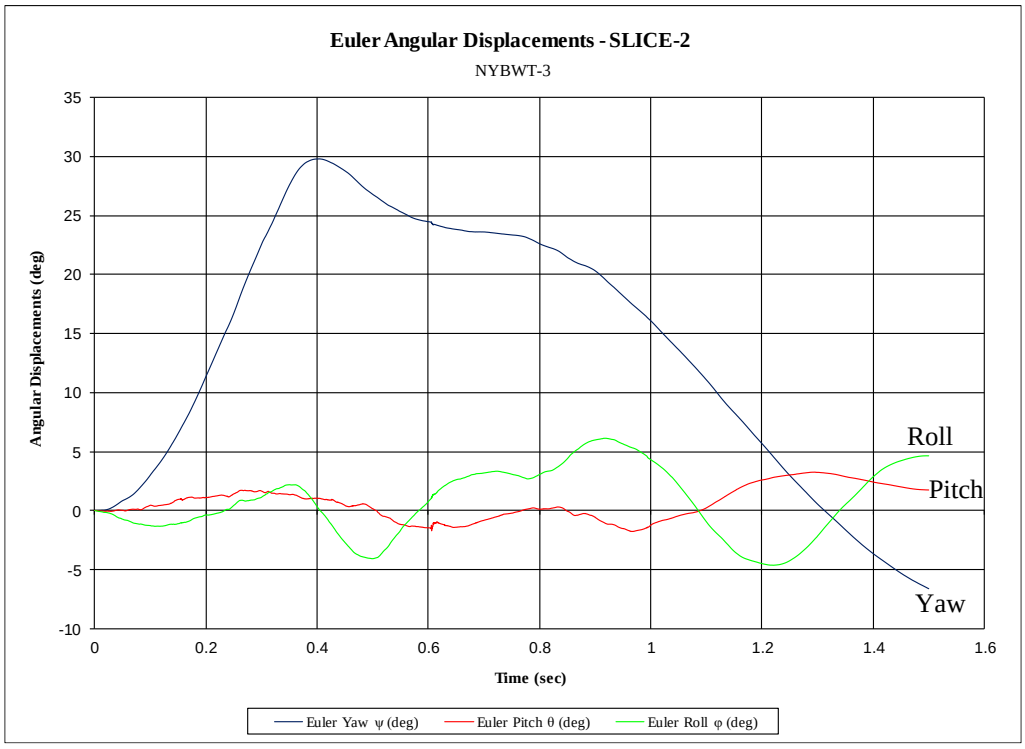


Figure H-15. Vehicle Angular Displacements (SLICE-2), Test No. NYBWT-3

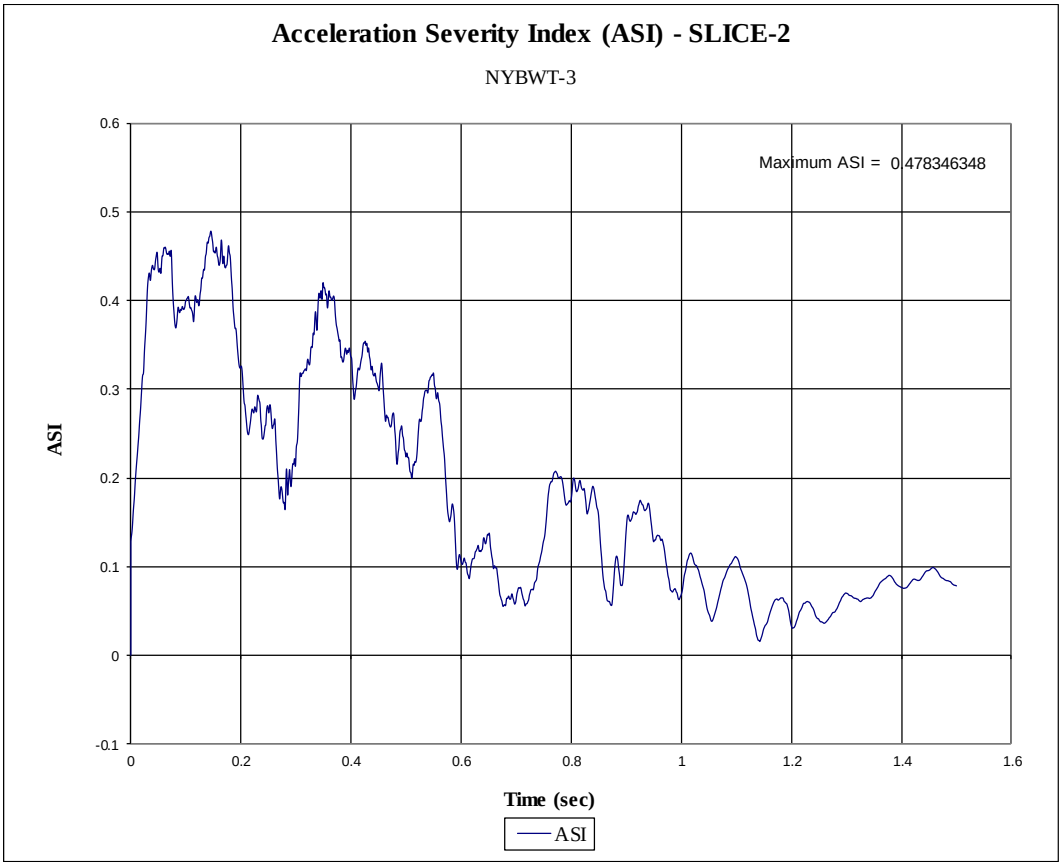


Figure H-16. Acceleration Severity Index (SLICE-2), Test No. NYBWT-3

END OF DOCUMENT