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MASH TL-3 EVALUATION OF NYSDOT'S TRANSITION BETWEEN HPBO AND BOX BEAM



Submitted by

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

Seok Hwan Yoo, B.S.C.E.
Former Graduate Research Assistant

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

Christopher Storf
Former Undergraduate Research Assistant

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

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16. Abstract

The New York State Department of Transportation (NYSDOT) desired to evaluate their current roadside hardware systems following the implementation of the *Manual for Assessing Safety Hardware, Second Edition* (MASH). Therefore, the transitions from Heavy-Post Blocked-Out (HPBO) W-Beam to box beam guide rail were evaluated according to MASH Test Level 3 (TL-3) crash test criteria. This transition can be used for both HPBO-to-box beam transitions and box beam-to-HPBO transitions. Test nos. NYHBT-1 and NYHBT-2 were conducted on the HPBO-to-box beam transition using MASH test designation nos. 3-21 and 3-20, respectively. Test nos. NYBHT-1 and NYBHT-2 were conducted on the box beam-to-HPBO transition using MASH test designation nos. 3-21 and 3-20, respectively. The target impact conditions of all four tests were a speed of 62 mph and an angle of 25 degrees. For each test, the critical impact point (CIP) was selected using MASH guidance and prior research data, considering the potential for snag at rail stiffness transitions, hardware failure, and vehicle instability. In all four tests, the vehicle was safely redirected, and all occupant risk values were within the allowable MASH limits. Therefore, test nos. NYHBT-1 and NYHBT-2 on the HPBO-to-box beam transition and test nos. NYBHT-1 and NYBHT-2 on the box beam-to-HPBO transition were deemed successful according to MASH TL-3 safety performance criteria.

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DISCLAIMER STATEMENT

This material is based upon work supported by the New York State Department of Transportation under TPF-5(193) Supplement #152. 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 nor the New York State Department of Transportation. This report does not constitute a standard, specification, or regulation. Trade or manufacturers' names, which may appear in this report, are cited only because they are considered essential to the objectives of the report. The United States (U.S.) government and the State of New York do not endorse products or manufacturers.

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. Uncertainty measurements are not applied to the values contained herein nor during the evaluation against the Manual for Assessing Safety Hardware (MASH) limits.

A2LA ACCREDITATION

The tests reported herein are within the scope of MwRSF's A2LA Accreditation. MwRSF's accreditation documentation can be found in Appendix A.

INDEPENDENT APPROVING AUTHORITY

The Independent Approving Authority for the data contained herein was Mr. Brandon Perry, Research Engineer.

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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 Associate Professor
J.S. Steelman, Ph.D., P.E., Associate Professor
M. Asadollahi Pajouh, Ph.D., P.E., former Research Assistant Professor
B.J. Perry, M.E.M.E., Research Engineer
A.E. Loken, Ph.D., Research Assistant Professor
T.Y. Yosef, Ph.D., Research Assistant Professor
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
T.C. Donahoo, Engineering Testing Technician I
J.T. Jones, Engineering Testing Technician II
E.L. Urbank, Research Communication Specialist
Z.Z. Jabr, Engineering Technician
J.J. Oliver, Solidworks Drafting Coordinator
Undergraduate and Graduate Research Assistants

New York State Department of Transportation
Lyman L. (Terry) Hale III, P.E., Senior Engineer
Pratip Lahiri, P.E., Standards and Specifications Section

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in.	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1,000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short ton (2,000 lb)	0.907	megagrams (or “metric ton”)	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m^2
		FORCE & PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in.
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yard	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliter	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or “metric ton”)	1.103	short ton (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		FORCE & PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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1 INTRODUCTION

1.1 Background

In 2009, the American Association of State Highway 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 included sunset dates for various categories of roadside hardware. Further, the MASH 2009 safety criteria was updated in 2016, thus resulting in the *Manual for Assessing Safety Hardware, Second edition* or MASH 2016 [3]. 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 research objective was to evaluate the NYSDOT's Heavy-Post Blocked-Out (HPBO) W-beam to box beam transition system. The system was to be evaluated according to the TL-3 safety performance criteria of MASH 2016 [3].

1.3 Scope

The research objective was achieved through the completion of several tasks. Four full-scale crash tests were conducted on NYSDOT's HPBO W-beam to box beam transition system according to MASH test designation nos. 3-20 and 3-21. Next, the full-scale crash testing results were analyzed, evaluated, and documented. Conclusions and recommendations were then made pertaining to the safety performance of HPBO W-beam to box beam transition system.

2 TEST REQUIREMENTS AND EVALUATION CRITERIA

2.1 Test Requirements

Longitudinal barriers, such as transitions between HPBO W-beam and box beam, must satisfy impact safety standards to be declared eligible for federal reimbursement by FHWA for use on the National Highway System. For new hardware, these safety standards consist of the guidelines and procedures published in MASH [3]. Note that there is no difference between MASH 2009 [1] and MASH 2016 for longitudinal barriers such as the transition system tested herein, except that additional occupant compartment deformation measurements, photographs, and documentation are required by MASH 2016.

According to TL-3 of MASH, longitudinal barrier transition 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, four 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; (2) MASH 2016 test designation no. 3-20, which evaluates the transition with the 1100C small car vehicle; (3) a reverse-direction impact of test designation no. 3-21 with the 2270P vehicle; (4) a reverse-direction impact of test designation no. 3-20 with the 1100C vehicle. The reverse-direction impact test would be required to evaluate the transition for box beam to HPBO W-beam installations. MASH 2016 also requires that transitions be evaluated adjacent to their connection to rigid barriers and in the stiffness transition region.

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

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

[1] Evaluation criteria are explained in Table 2.

Table 2. MASH Evaluation Criteria for Longitudinal Barrier Transitions

<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="5">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.</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 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</td><td>40 ft/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 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>

2.2 Evaluation Criteria

Evaluation criteria for full-scale vehicle crash testing are based on three factors: (1) structural adequacy, (2) occupant risk, and (3) vehicle trajectory after collision. Criteria for structural adequacy are intended to evaluate the ability of NYSDOT’s HPBO to Box Beam Transition 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 or fixed objects, thereby increasing the risk of injury to the occupants of the impacting vehicle or other vehicles. These evaluation criteria are summarized in Table 2 and defined in greater detail in MASH. The full-scale vehicle crash tests were conducted and reported in accordance with the procedures provided in MASH.

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.

2.3 Soil Strength Requirements

In accordance with Chapter 3 and Appendix B of MASH, foundation soil strength must be verified before any full-scale crash testing can occur. During the installation of a soil dependent system, W6x16 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 at post deflections between 5 and 20 in. measured at a height of 25 in. If dynamic testing near the system is not desired, MASH 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. Further details can be found in Appendix B of MASH.

3 DESIGN DETAILS

The test installation consisted of an approximately 187 ft long New York State's HPBO to box beam transition, as shown in Figures 1 through 38. Photographs of the NYHBT and NYBHT test installations are shown in Figures 39 through 43 and Figures 44 through 46, respectively. The installation for the box beam to HPBO transition (NYBHT) was identical to the installation for HPBO to box beam transition (NYHBT). The only differences between the two systems were the impact points, direction of travel, and the posts were numbered beginning at the upstream end at the box beam instead of the upstream end of the HPBO. The New York Standard sheet for the box beam to HPBO transition is shown in Appendix B. Detailed drawings of the box beam to HPBO transition are shown in Appendix C. Material specifications, mill certifications, and certificates of conformity for the system materials are shown in Appendix D.

The upstream end of the system featured NYSDOT HPBO W-beam rail with a BCT anchor at post nos. 1 and 2. Post nos. 3 through 13 were 72-in. long, W6x8.5 steel posts with timber blockouts. The posts were spaced 75 in. on center and embedded 40 in. in the ground. The 12-gauge W-beam rail had a nominal 31 in. top mounting height. Between post nos. 11 and 13, the rail height transitioned linearly to a 30⅛ in. height and the HPBO post embedment was adjusted accordingly, as shown in Figure 4. The W-beam rails were layered such that the upstream rail section was in front of the downstream section to reduce vehicle snag potential at the splices.

The downstream end of the system featured NYSDOT box beam guide rail with a cable anchorage assembly on the backside of the system near post no. 32. Post nos. 14 through 34 were 65-in. long, S3x5.7 steel posts with soil plates and were embedded 38 in. in the ground. The typical post spacing was 72 in., with a reduced spacing of 36 in. between post nos. 14 through 20. All posts in the critical impact region were placed in 24-in. diameter holes, which were backfilled with well-graded gravel and tamped. Soil details are shown in Appendix E. The TS6x6x3⁄16 box beam rail had a nominal top mounting height of 27 in. top-of-rail height. The rail was bolted to the posts with angle brackets. The box beam rail segments were connected using bolted splices with the splice plates positioned on the inside of the box beam sections.

At the transition from HPBO to box beam guide rail, a 12-ft 6-in. section of nested W-beam rail began at post no. 13. The leading edge of the box beam was behind the nested W-Beam rail at the midspan between post nos. 13 and 14. Post nos. 15, 17, and 19 were not connected to the box beam rail. The front face of the box beam was positioned against the back face of the nested W-beam rail section. To reduce vehicle snag potential, a 12-gauge transition cover plate was shaped to conform to the W-beam and create a smooth transition between the two rail sections. Four ⅝-in. guardrail splice bolts secured the transition cover plate to the end of the nested W-beam rail and one ¾-in. bolt connected the downstream end of the cover plate to the box beam rail.

The transition anchor assembly consisted of three cable assemblies with ¾-in. diameter wire rope. The upper ends of the cables were connected to mounting brackets bolted to the box beam, while the lower ends of the cables were connected to a bracket assembly bolted to a concrete anchor block. The embedded concrete anchor block was positioned with the center of the block 30 ft downstream and 2 ft behind the leading end of the box beam.

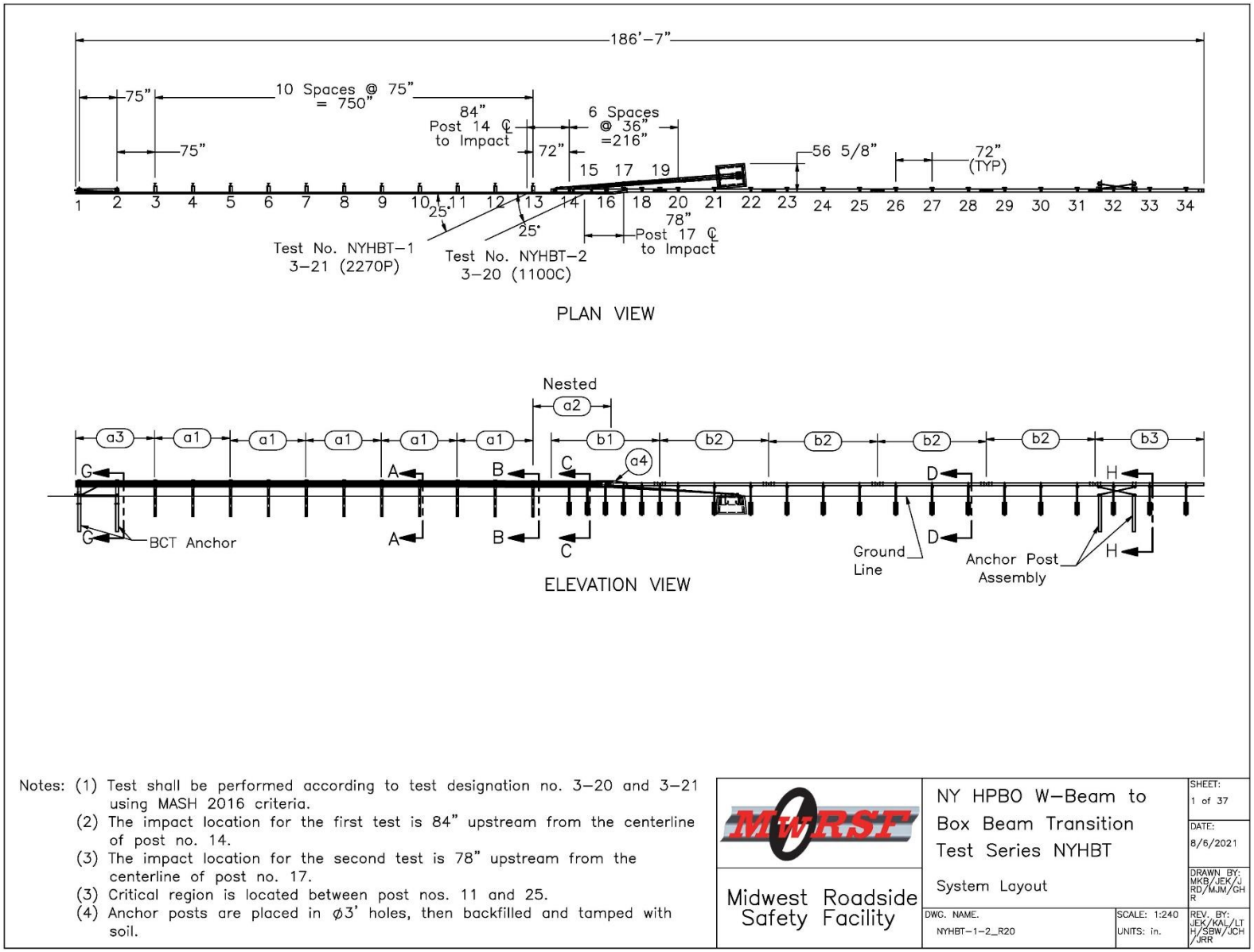


Figure 1. Test Installation Layout, Test Nos. NYHBT-1 and NYHBT-2

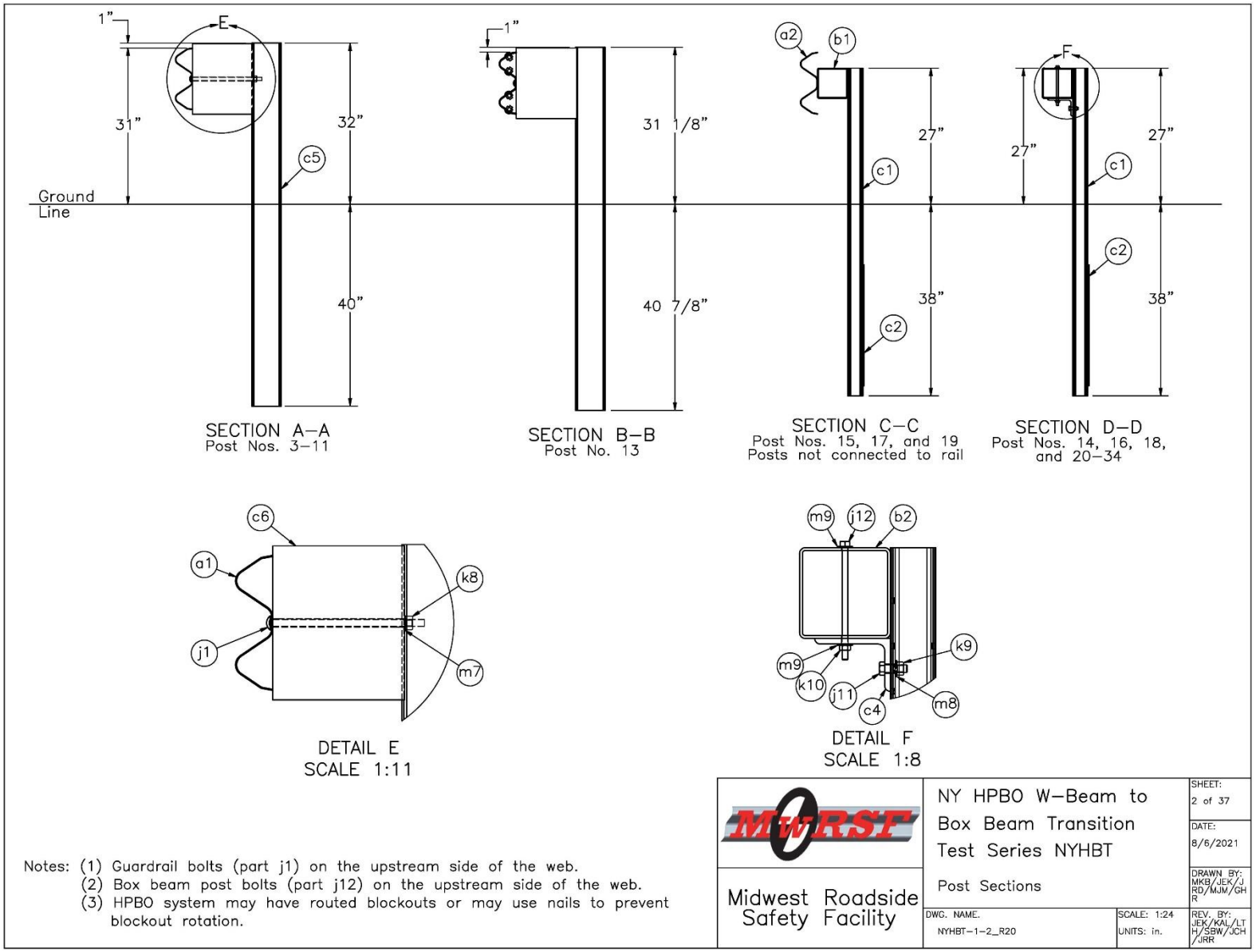


Figure 2. Post Sections, Test Nos. NYHBT-1 and NYHBT-2

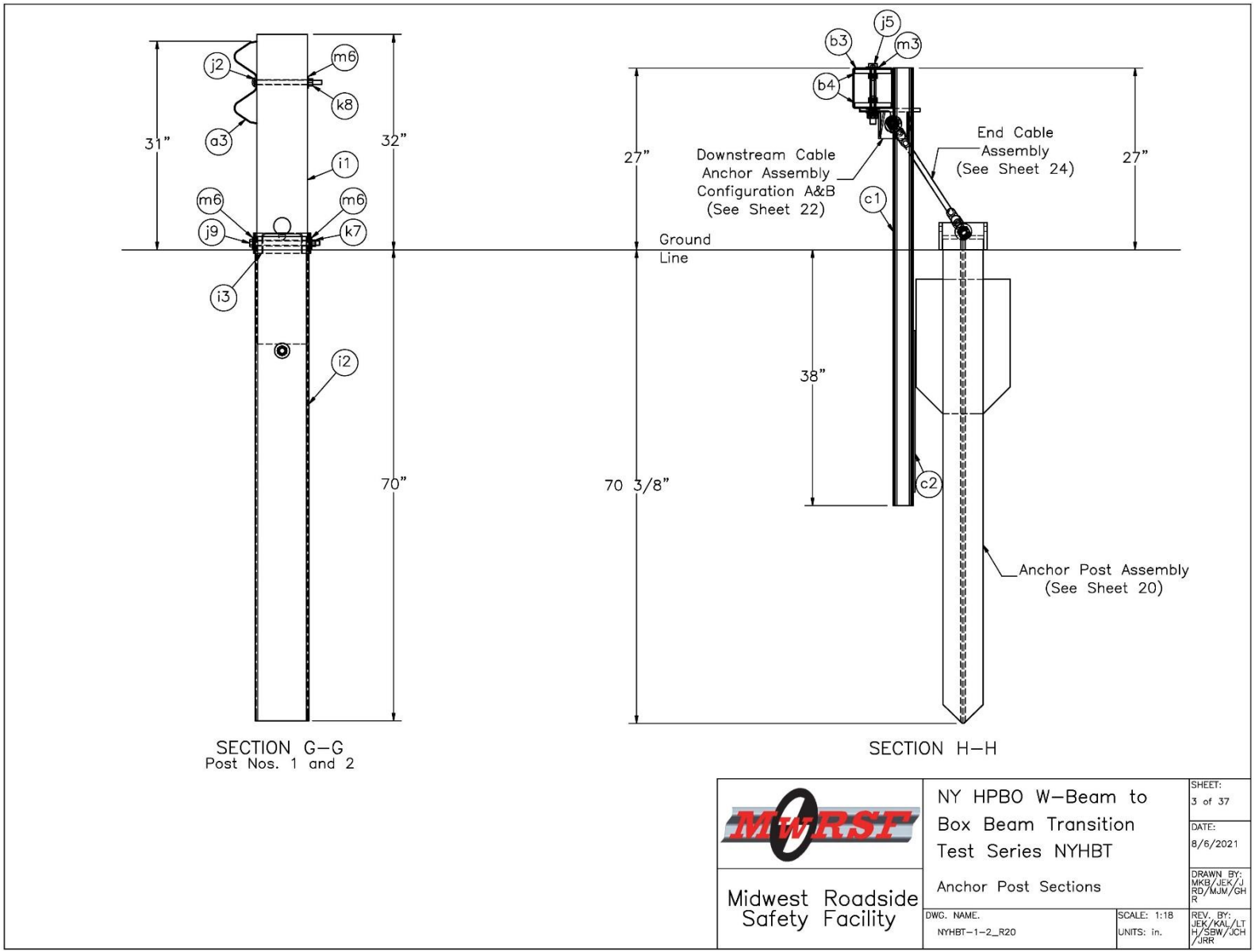


Figure 3. Anchor Post Sections, Test Nos. NYHBT-1 and NYHBT-2

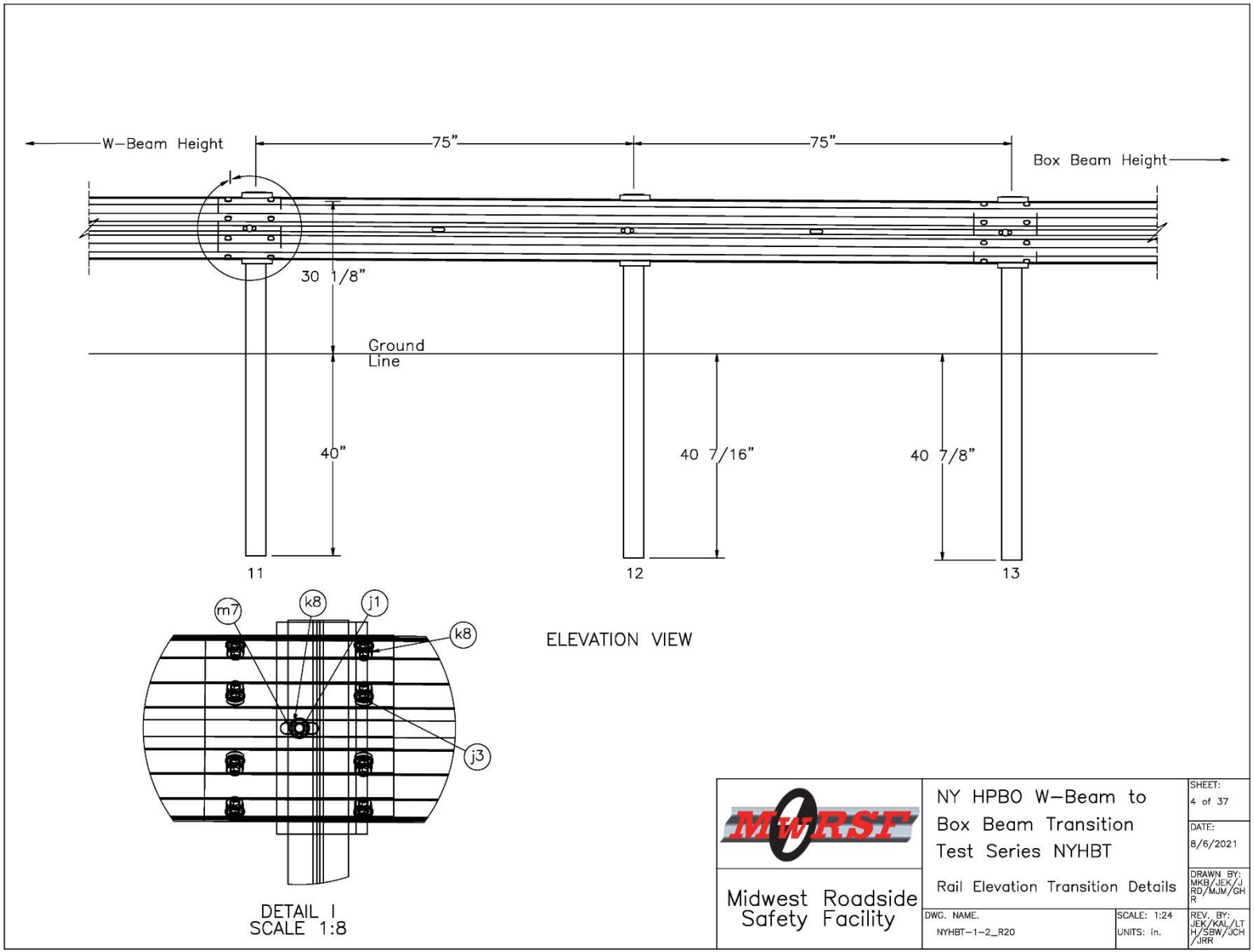


Figure 4. Rail Elevation Transition Details, Test Nos. NYHBT-1 and NYHBT-2

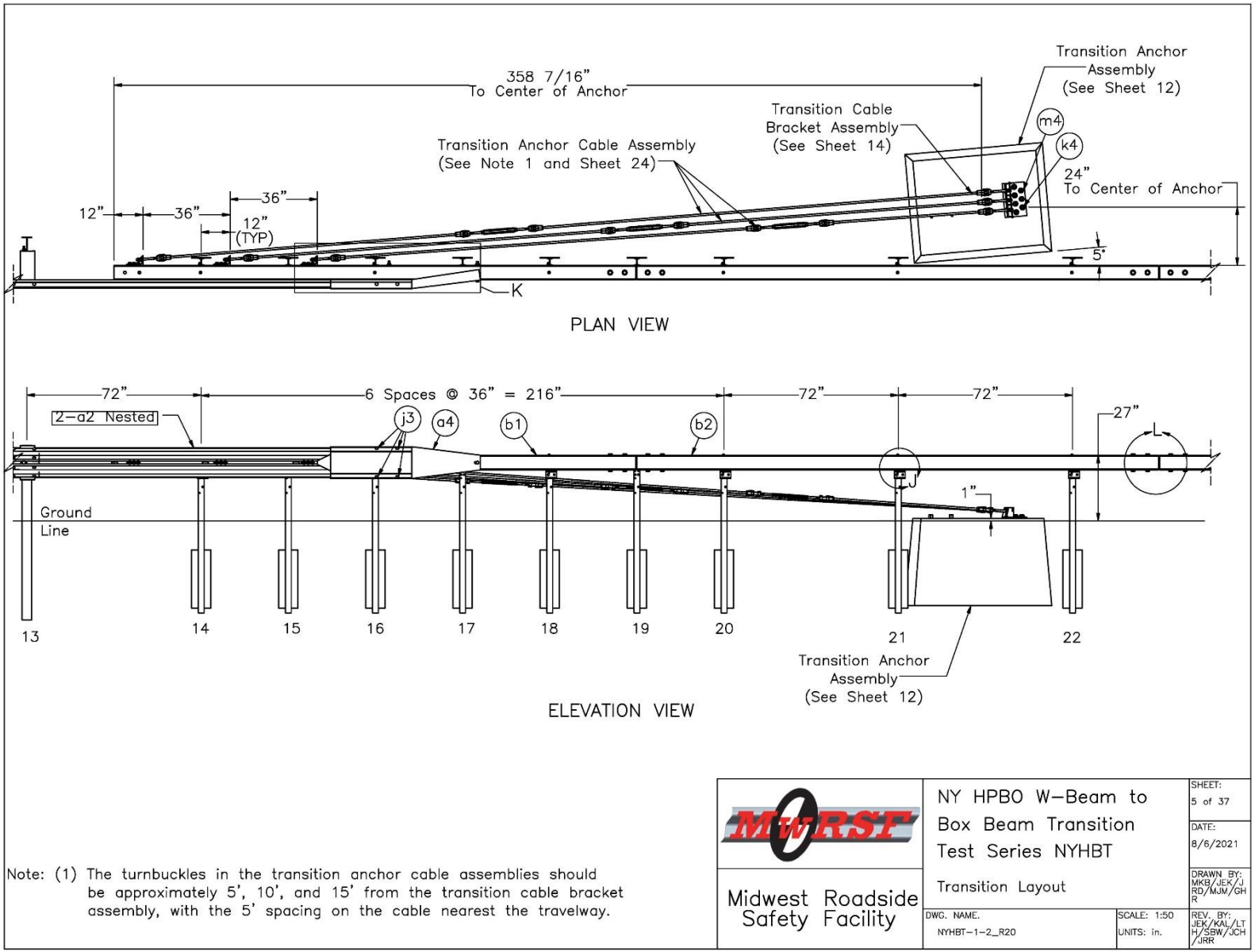


Figure 5. Transition Layout, Test Nos. NYHBT-1 and NYHBT-2

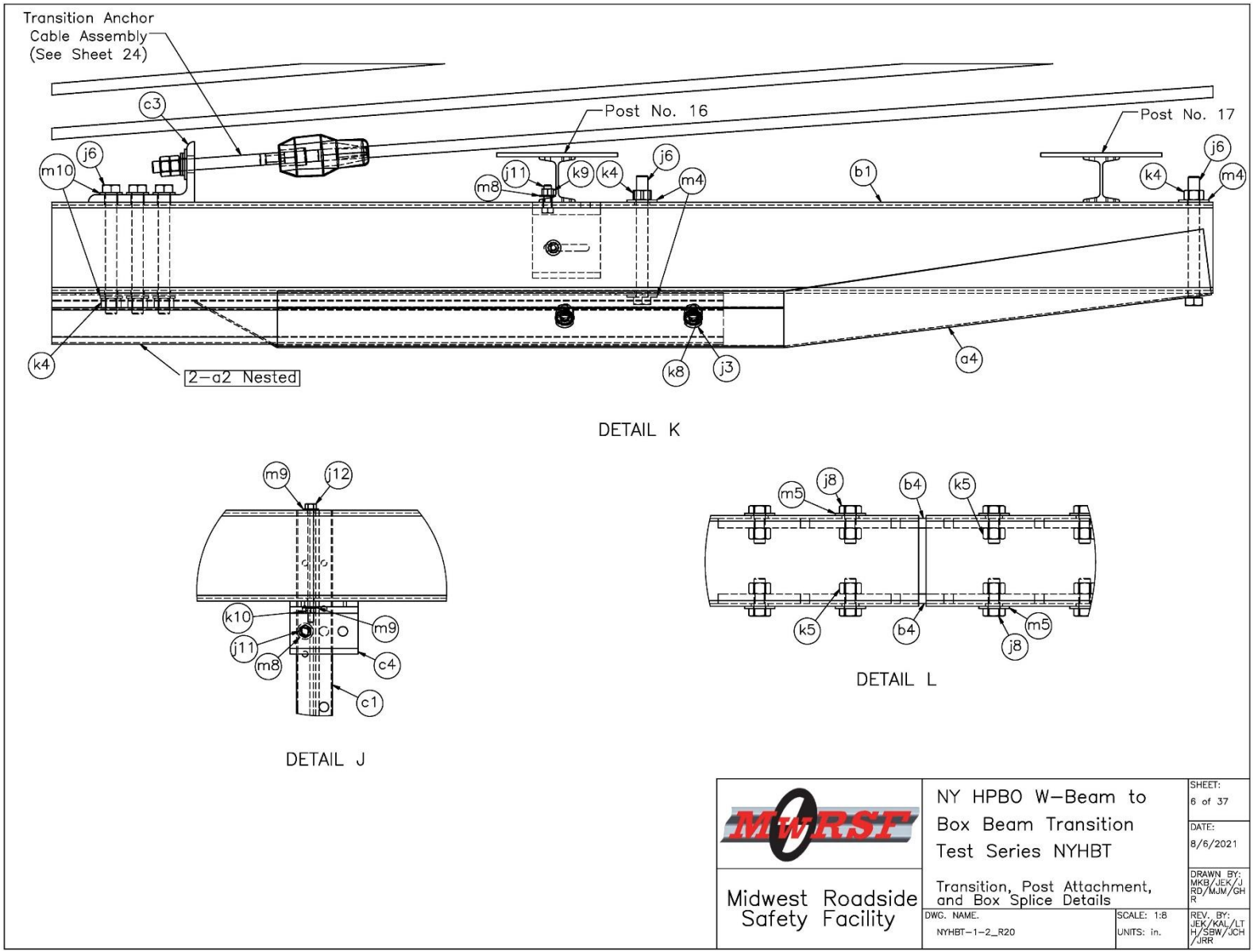


Figure 6. Transition, Post Attachment, and Box Splice Details, Test Nos. NYHBT-1 and NYHBT-2

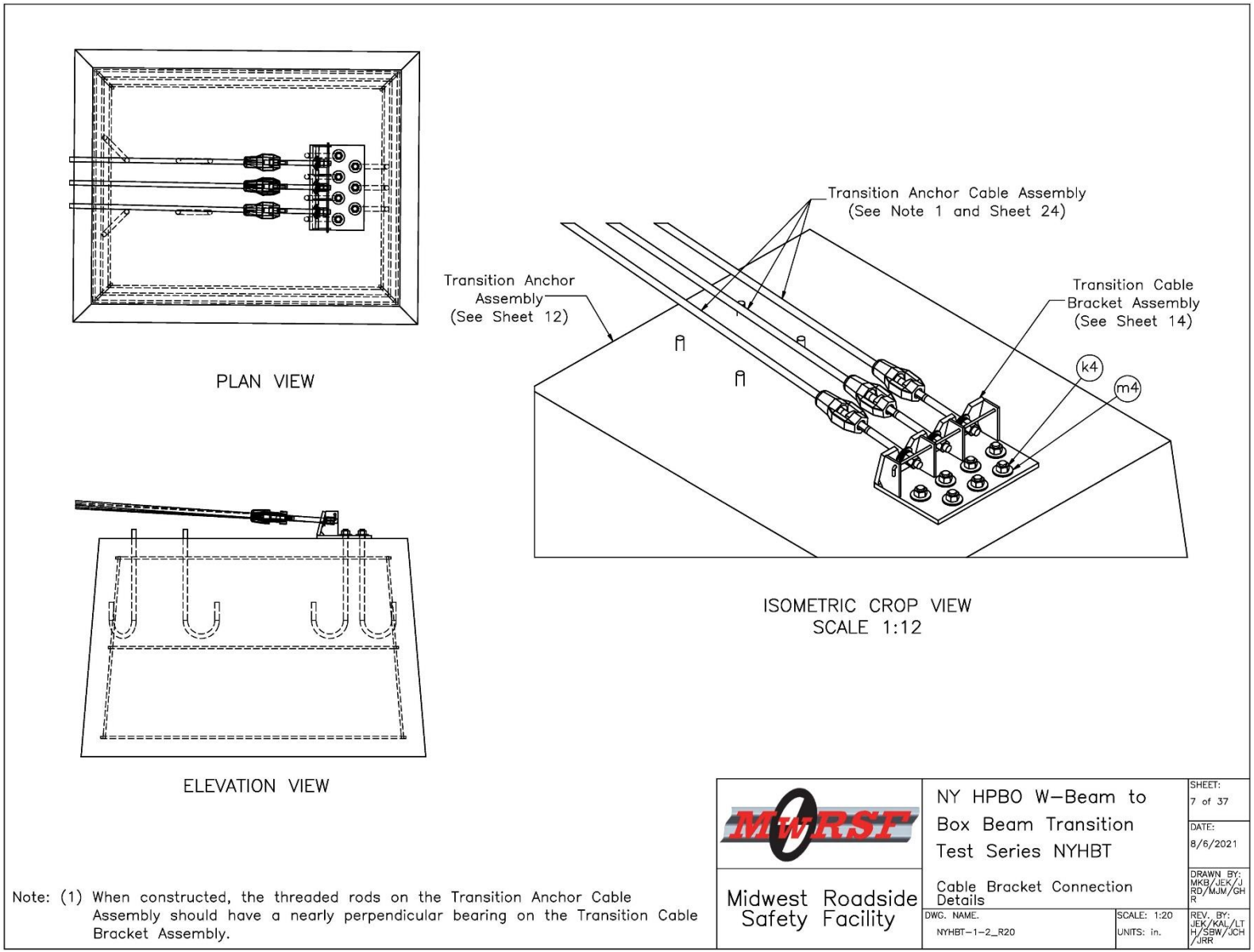


Figure 7. Cable Bracket Connection Details, Test Nos. NYHBT-1 and NYHBT-2

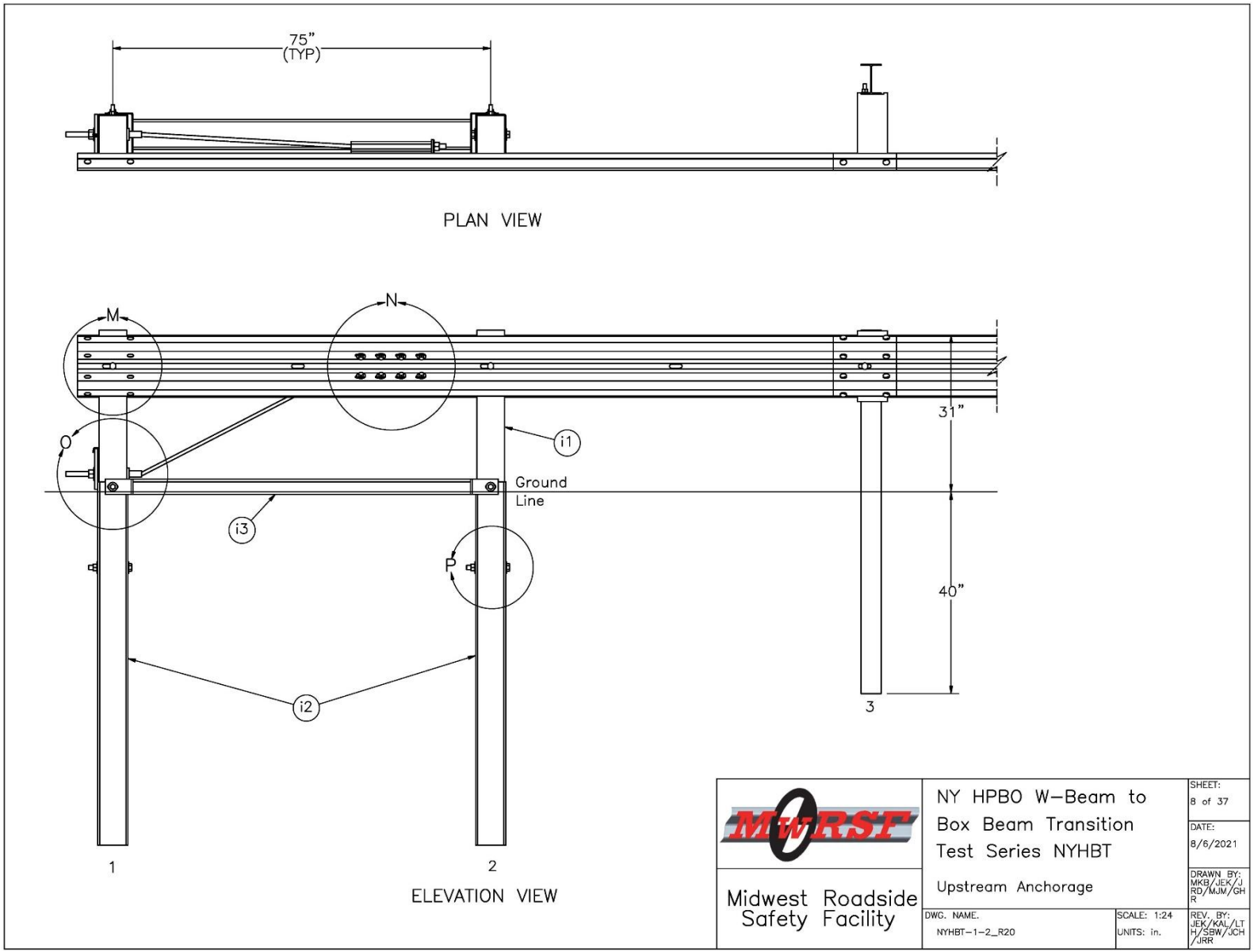


Figure 8. Upstream Anchorage, Test Nos. NYHBT-1 and NYHBT-2

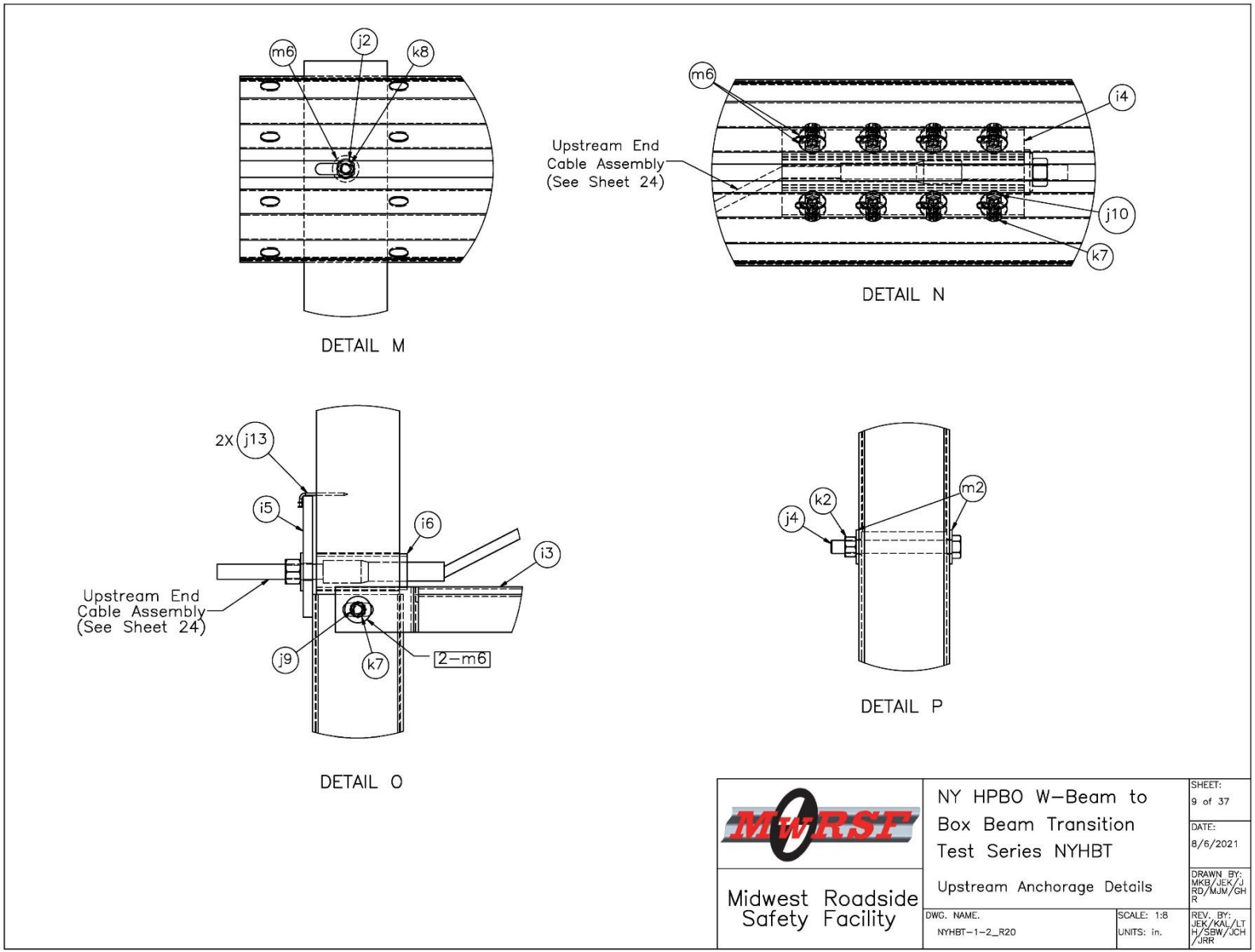


Figure 9. Upstream Anchorage Details, Test Nos. NYHBT-1 and NYHBT-2

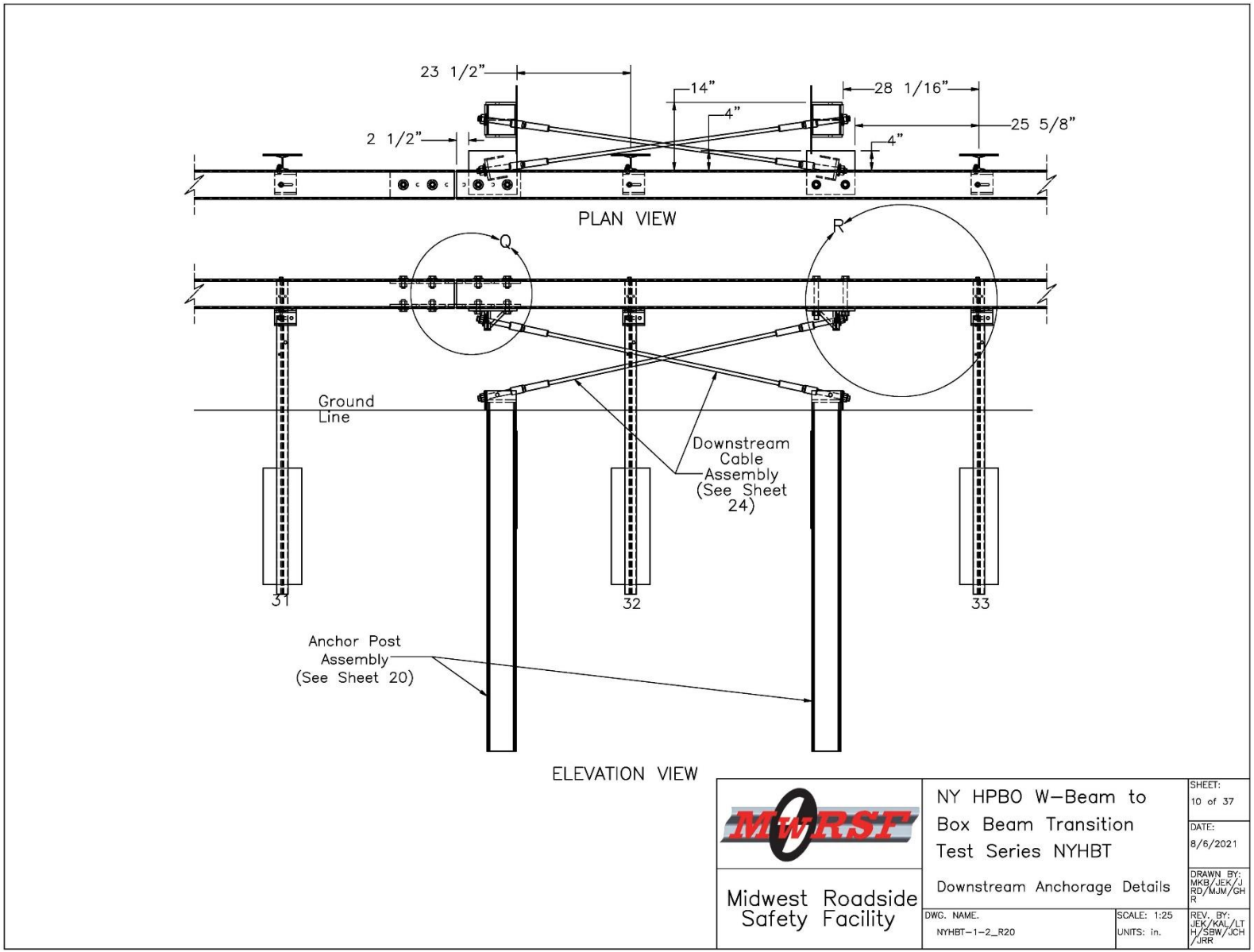


Figure 10. Downstream Anchorage Details, Test Nos. NYHBT-1 and NYHBT-2

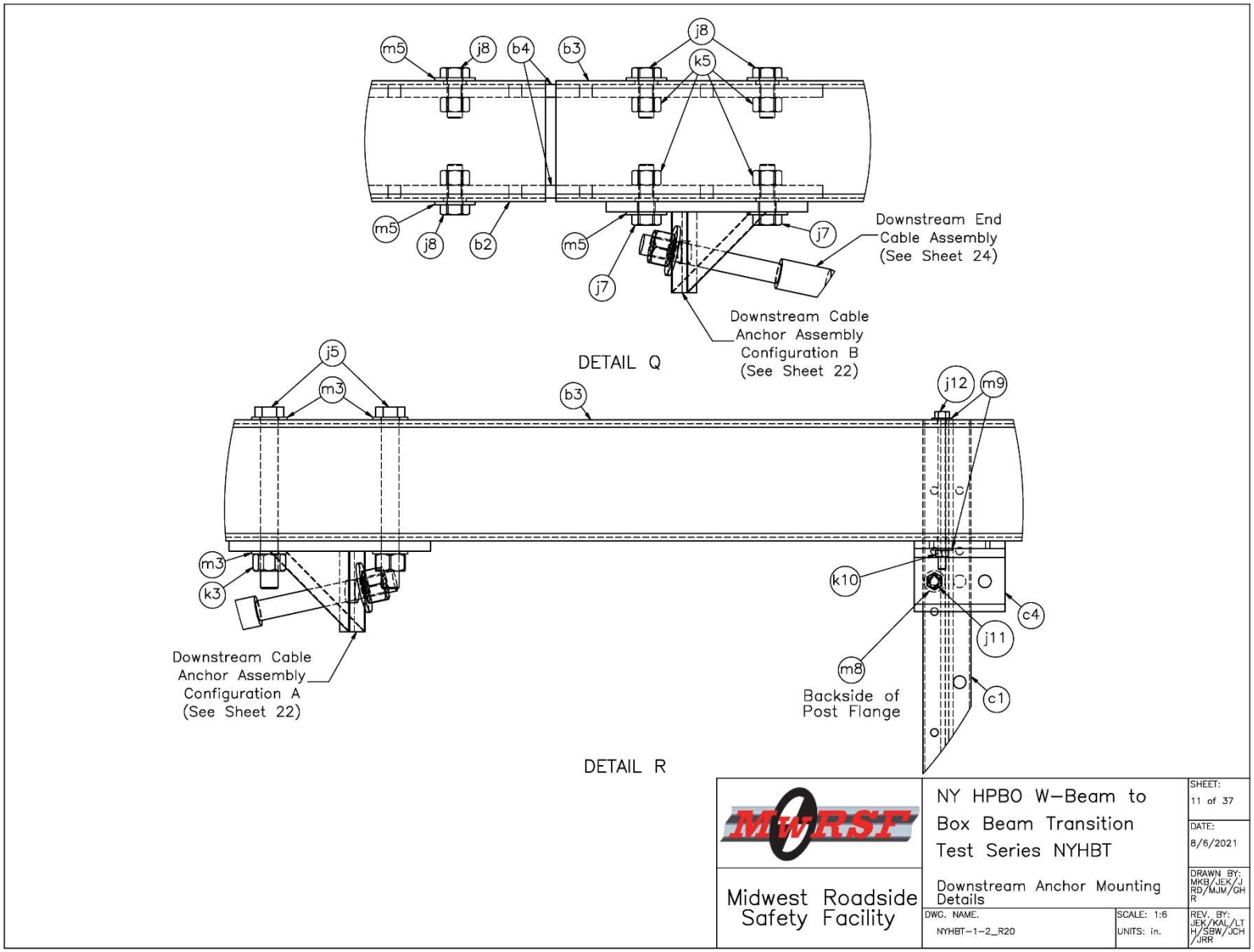


Figure 11. Downstream Anchor Mounting Details, Test Nos. NYHBT-1 and NYHBT-2

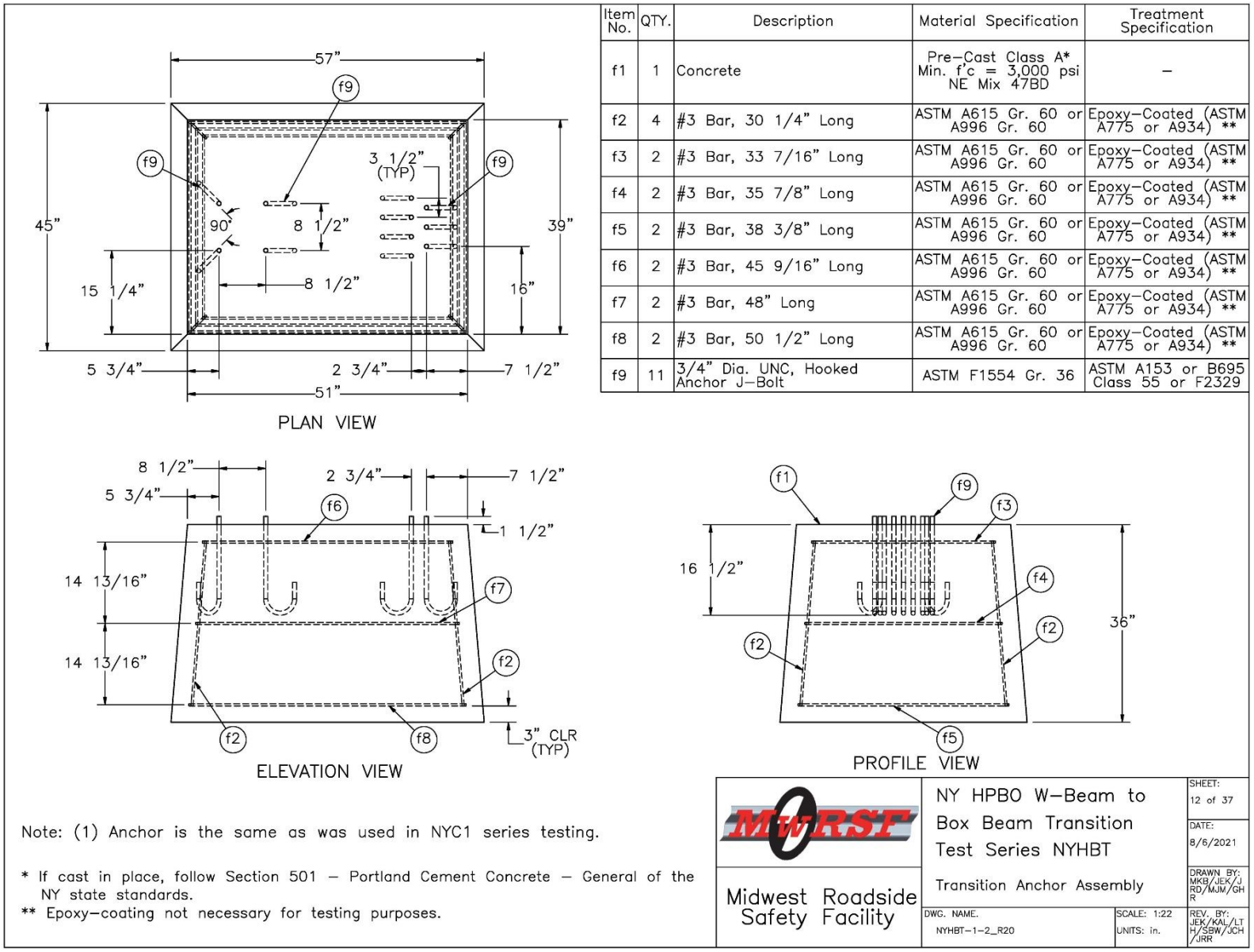
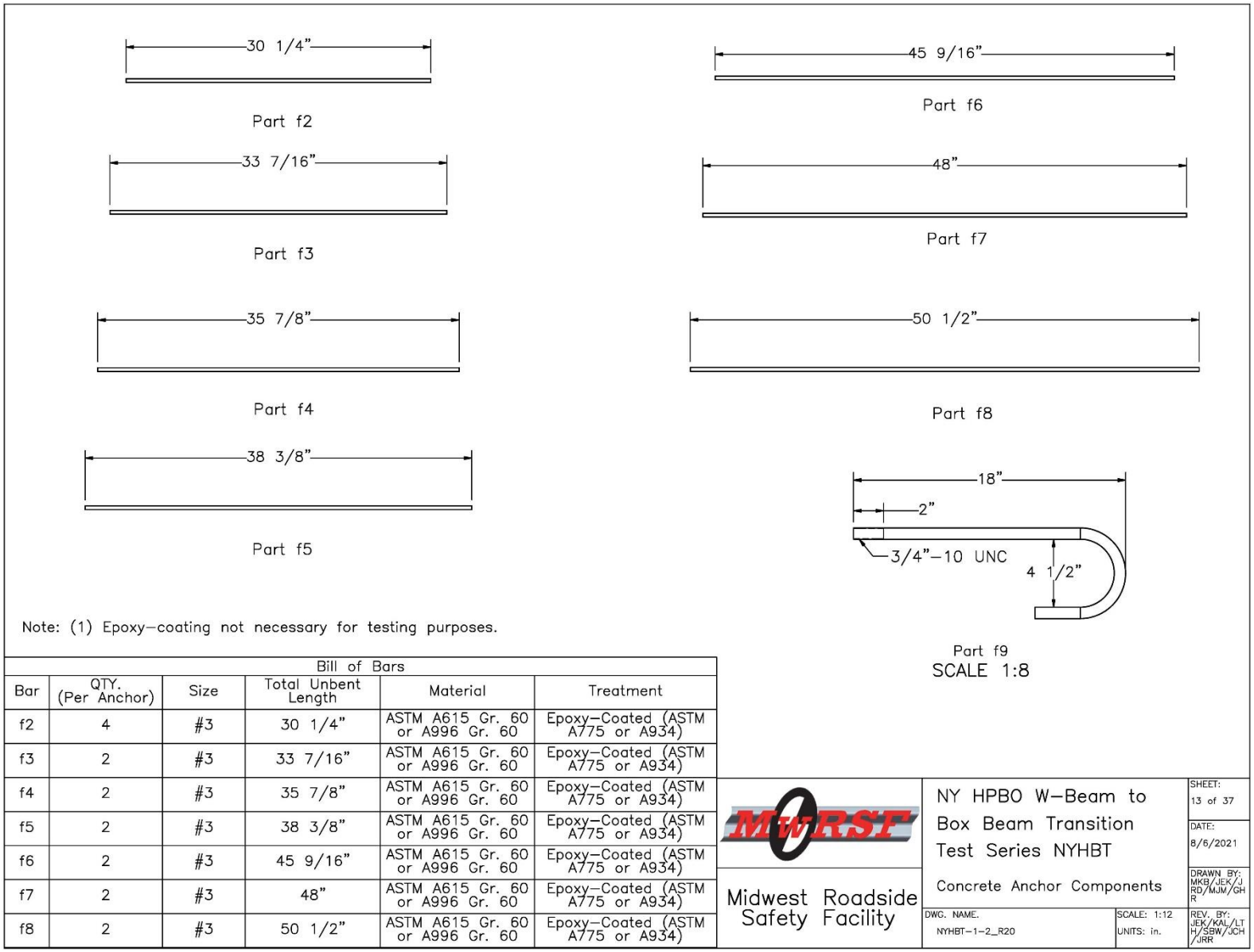


Figure 12. Transition Anchor Assembly, Test Nos. NYHBT-1 and NYHBT-2



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

Bill of Bars

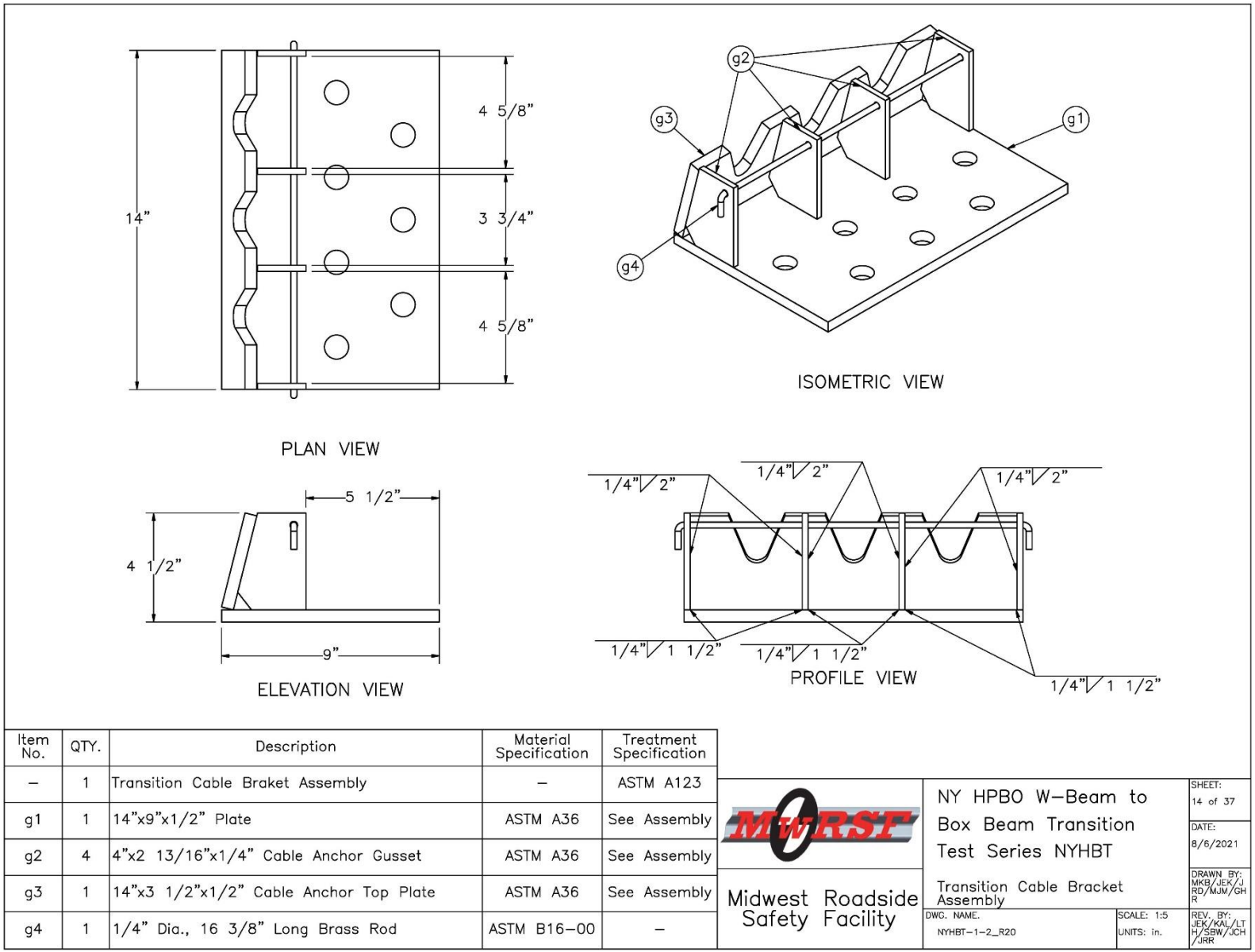
Bar	QTY. (Per Anchor)	Size	Total Unbent Length	Material	Treatment
f2	4	#3	30 1/4"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f3	2	#3	33 7/16"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f4	2	#3	35 7/8"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f5	2	#3	38 3/8"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f6	2	#3	45 9/16"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f7	2	#3	48"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
f8	2	#3	50 1/2"	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934)

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition
Test Series NYHBT
Concrete Anchor Components

SHEET: 13 of 37
DATE: 8/6/2021
DRAWN BY: MKB/JEK/JRD/MJM/GHR
DWG. NAME. NYHBT–1–2_R20
SCALE: 1:12
UNITS: in.
REV. BY: JEK/KAL/LTH/SBW/JCH/JRR

Figure 13. Concrete Anchor Components, Test Nos. NYHBT-1 and NYHBT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Transition Cable Braket Assembly	–	ASTM A123
g1	1	14"x9"x1/2" Plate	ASTM A36	See Assembly
g2	4	4"x2 13/16"x1/4" Cable Anchor Gusset	ASTM A36	See Assembly
g3	1	14"x3 1/2"x1/2" Cable Anchor Top Plate	ASTM A36	See Assembly
g4	1	1/4" Dia., 16 3/8" Long Brass Rod	ASTM B16-00	–

MwRSF

Midwest Roadside Safety Facility

NY HPBO W-Beam to Box Beam Transition Test Series NYHBT

Transition Cable Bracket Assembly

DWG. NAME. NYHBT-1-2_R20

SCALE: 1:5

UNITS: in.

SHEET: 14 of 37

DATE: 8/6/2021

DRAWN BY: MKB/JEK/JRD/MJM/GHR

REV. BY: JEK/KAL/LTH/SBW/JCH/JRR

Figure 14. Transition Cable Bracket Assembly, Test Nos. NYHBT-1 and NYHBT-2

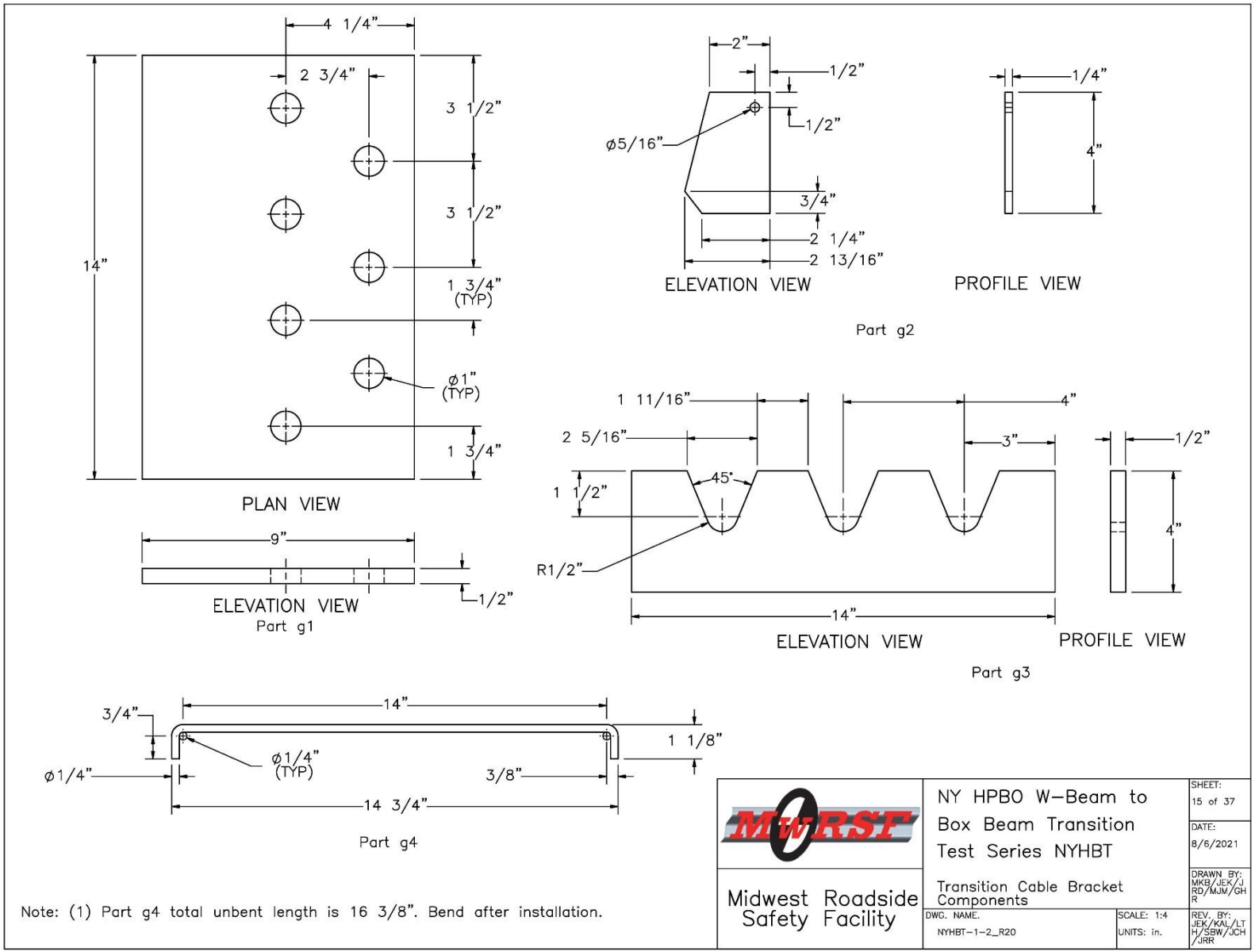
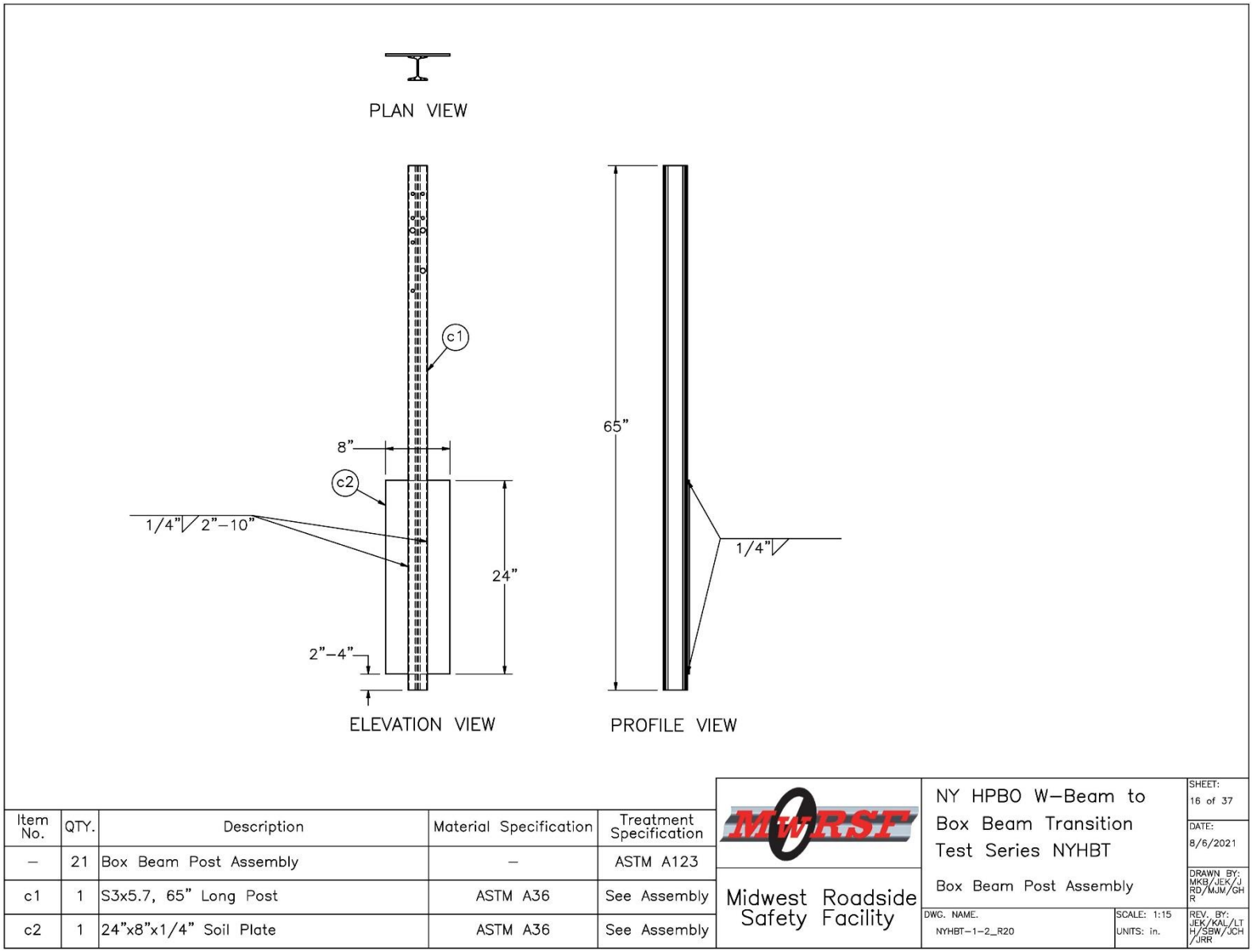


Figure 15. Transition Cable Bracket Components, Test Nos. NYHBT-1 and NYHBT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	21	Box Beam Post Assembly	–	ASTM A123
c1	1	S3x5.7, 65" Long Post	ASTM A36	See Assembly
c2	1	24"x8"x1/4" Soil Plate	ASTM A36	See Assembly

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition Test Series NYHBT

Box Beam Post Assembly

DWG. NAME. NYHBT–1–2_R20 | SCALE: 1:15 | UNITS: in.

SHEET: 16 of 37

DATE: 8/6/2021

DRAWN BY: MKB/JEK/JRD/MJM/GHR

REV. BY: JEK/KAL/LTH/SBW/JCH/JRR

Figure 16. Box Beam Post Assembly, Test Nos. NYHBT-1 and NYHBT-2

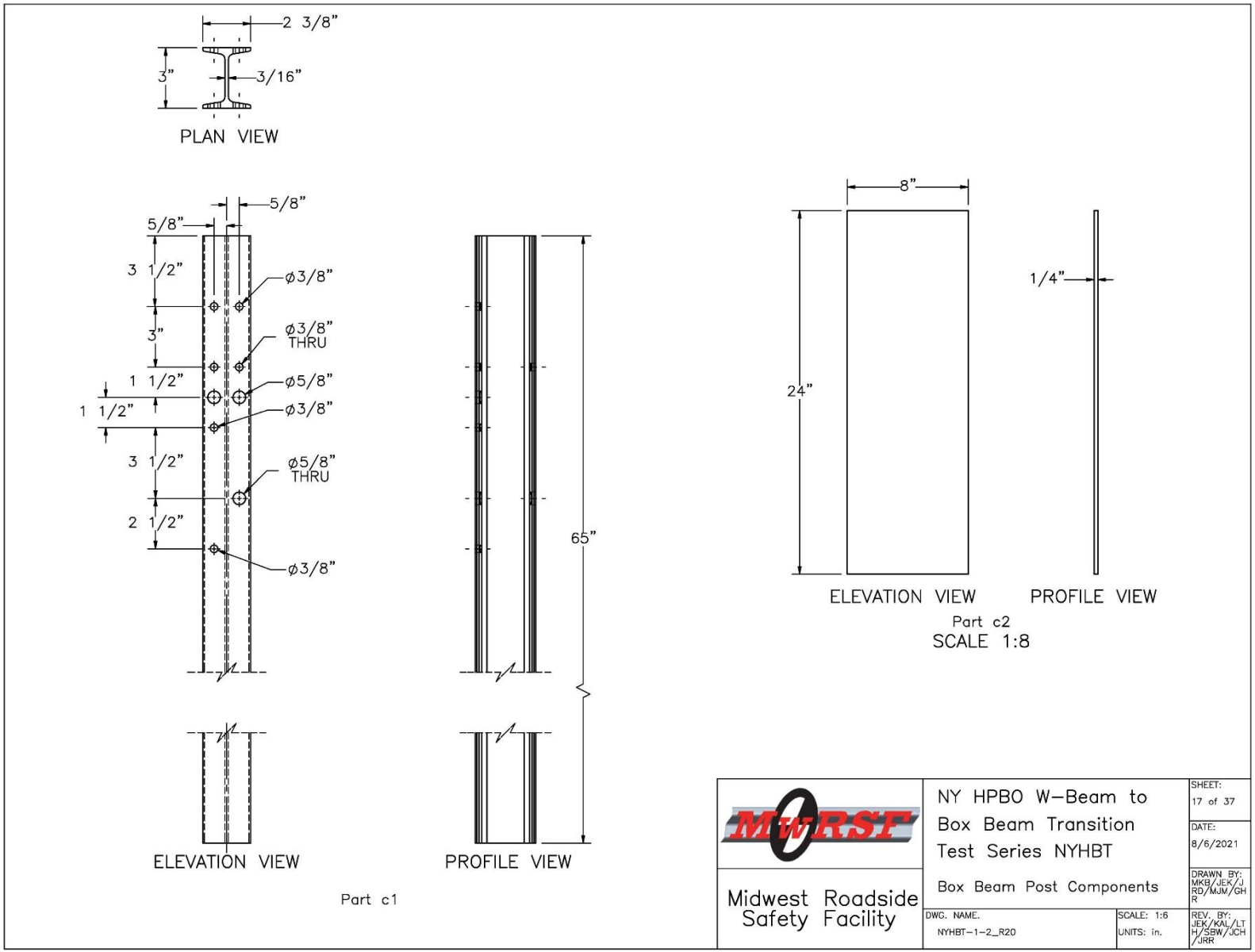


Figure 17. Box Beam Post Components, Test Nos. NYHBT-1 and NYHBT-2

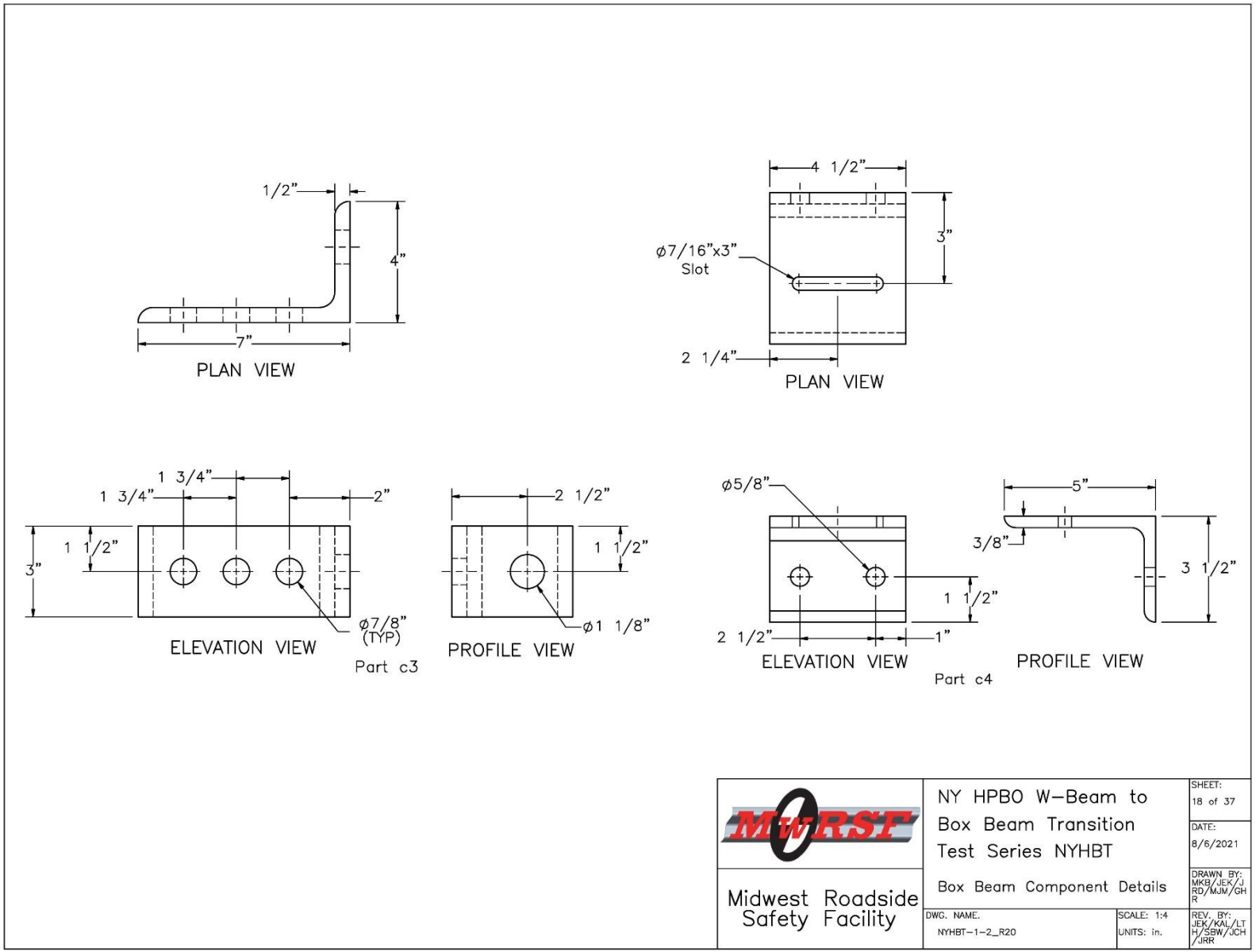


Figure 18. Box Beam Component Details, Test Nos. NYHBT-1 and NYHBT-2

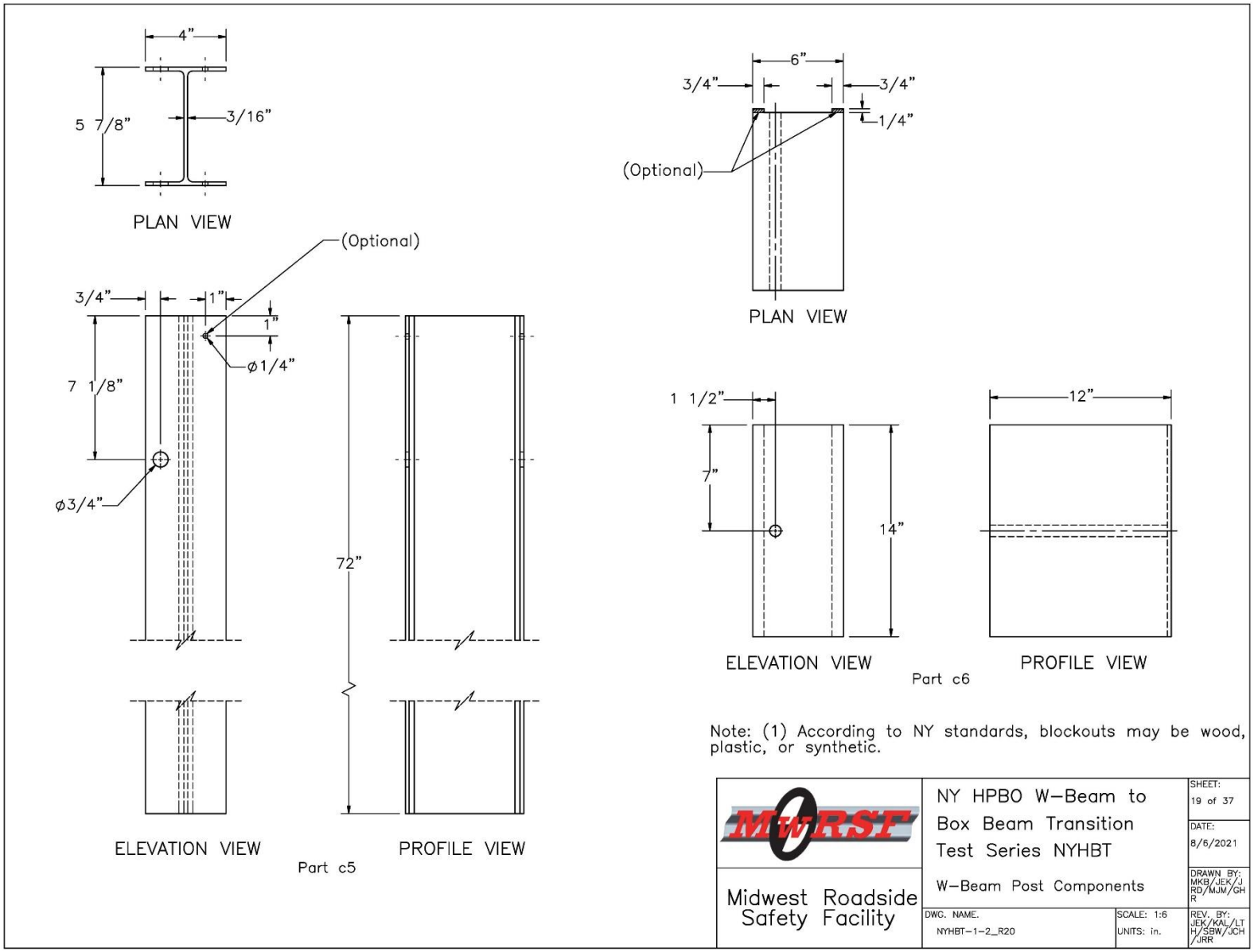
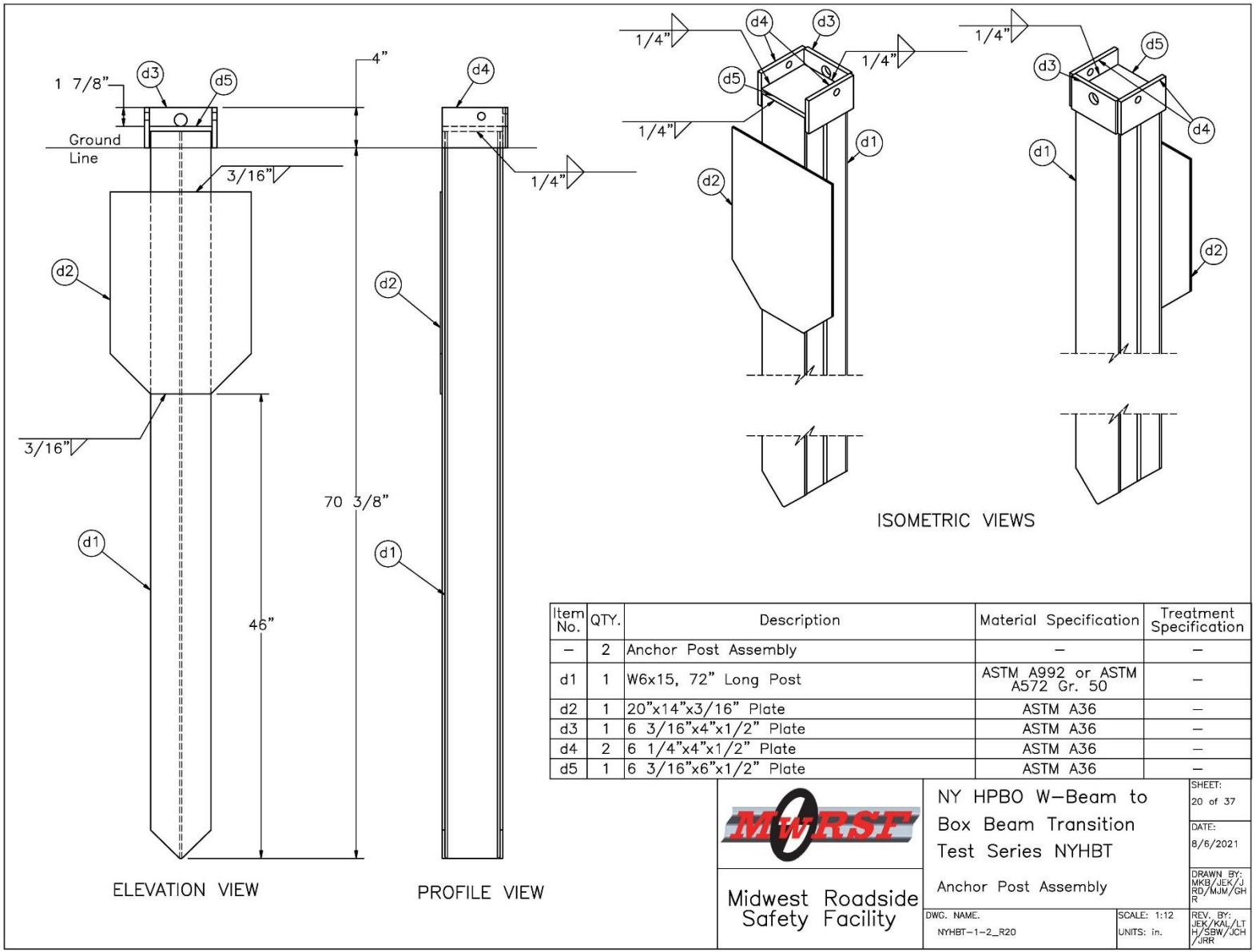


Figure 19. W-Beam Post Components, Test Nos. NYHBT-1 and NYHBT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	2	Anchor Post Assembly	–	–
d1	1	W6x15, 72" Long Post	ASTM A992 or ASTM A572 Gr. 50	–
d2	1	20"x14"x3/16" Plate	ASTM A36	–
d3	1	6 3/16"x4"x1/2" Plate	ASTM A36	–
d4	2	6 1/4"x4"x1/2" Plate	ASTM A36	–
d5	1	6 3/16"x6"x1/2" Plate	ASTM A36	–

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition
Test Series NYHBT
Anchor Post Assembly

SHEET: 20 of 37
DATE: 8/6/2021
DRAWN BY: MKB/JEK/JRD/MJM/GHR
REV. BY: JEK/KAL/LTH/SBW/JCH/JRR
DWG. NAME. NYHBT–1–2_R20
SCALE: 1:12
UNITS: in.

Figure 20. Anchor Post Assembly, Test Nos. NYHBT-1 and NYHBT-2

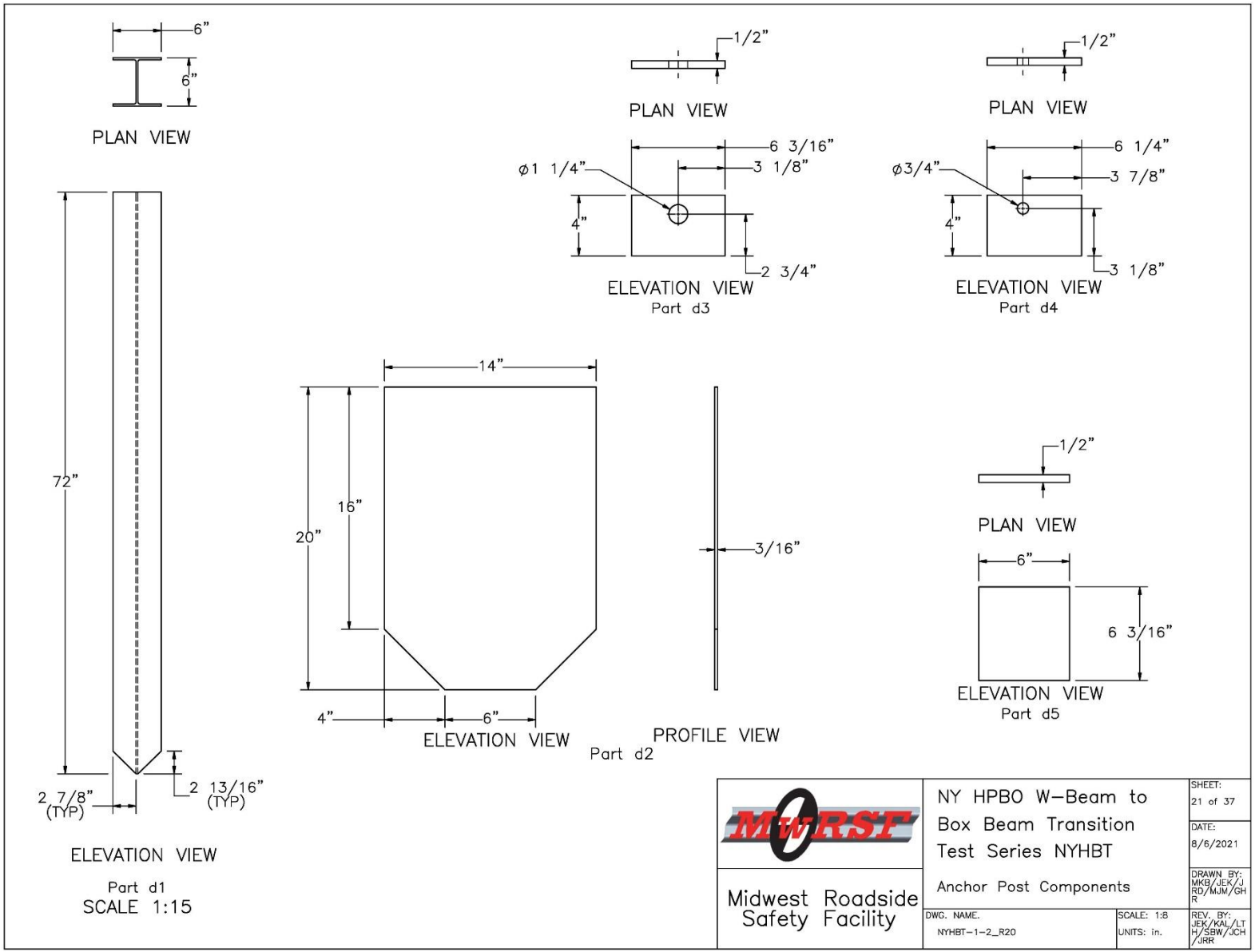


Figure 21. Anchor Post Components, Test Nos. NYHBT-1 and NYHBT-2

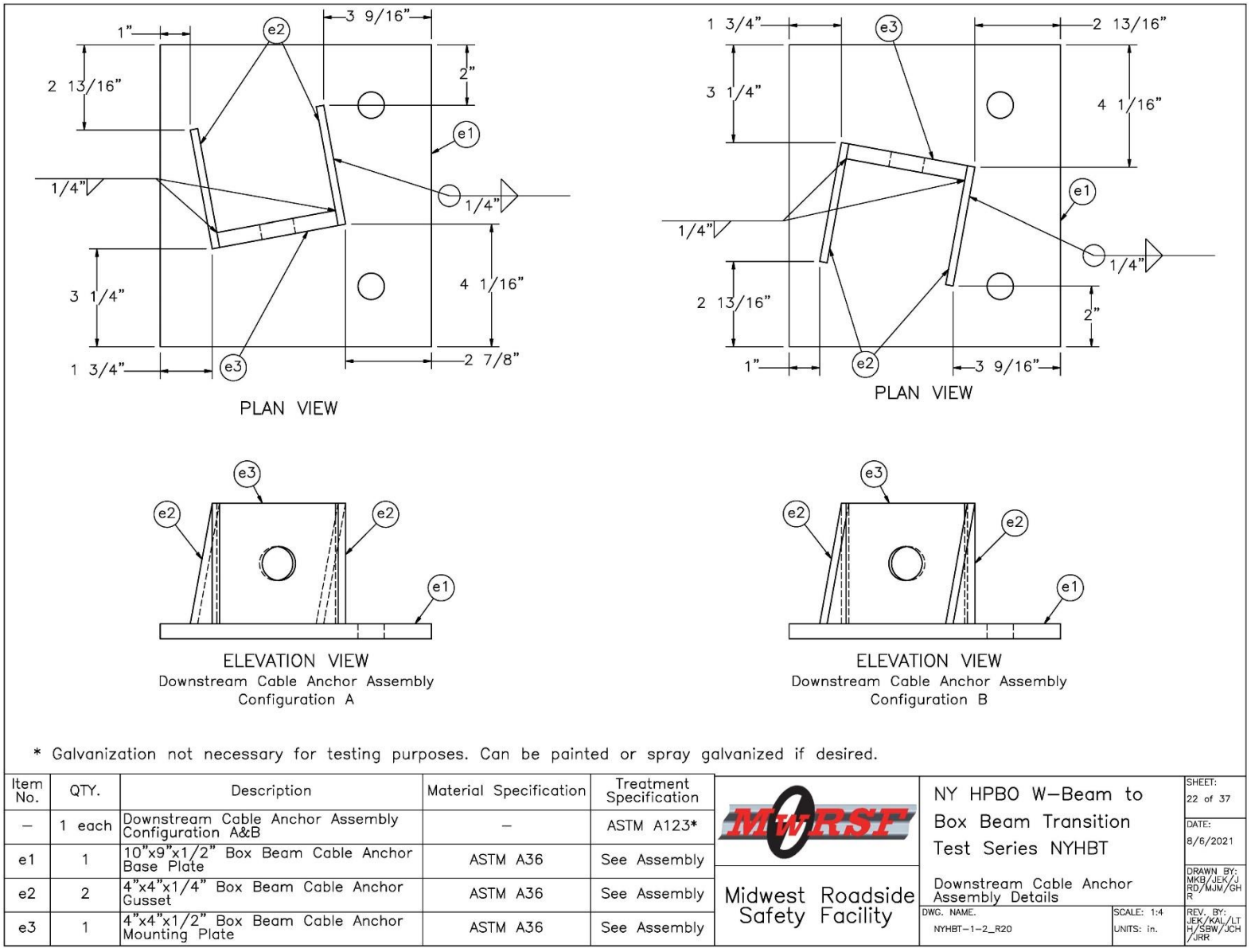


Figure 22. Downstream Cable Anchor Assembly Details, Test Nos. NYHBT-1 and NYHBT-2

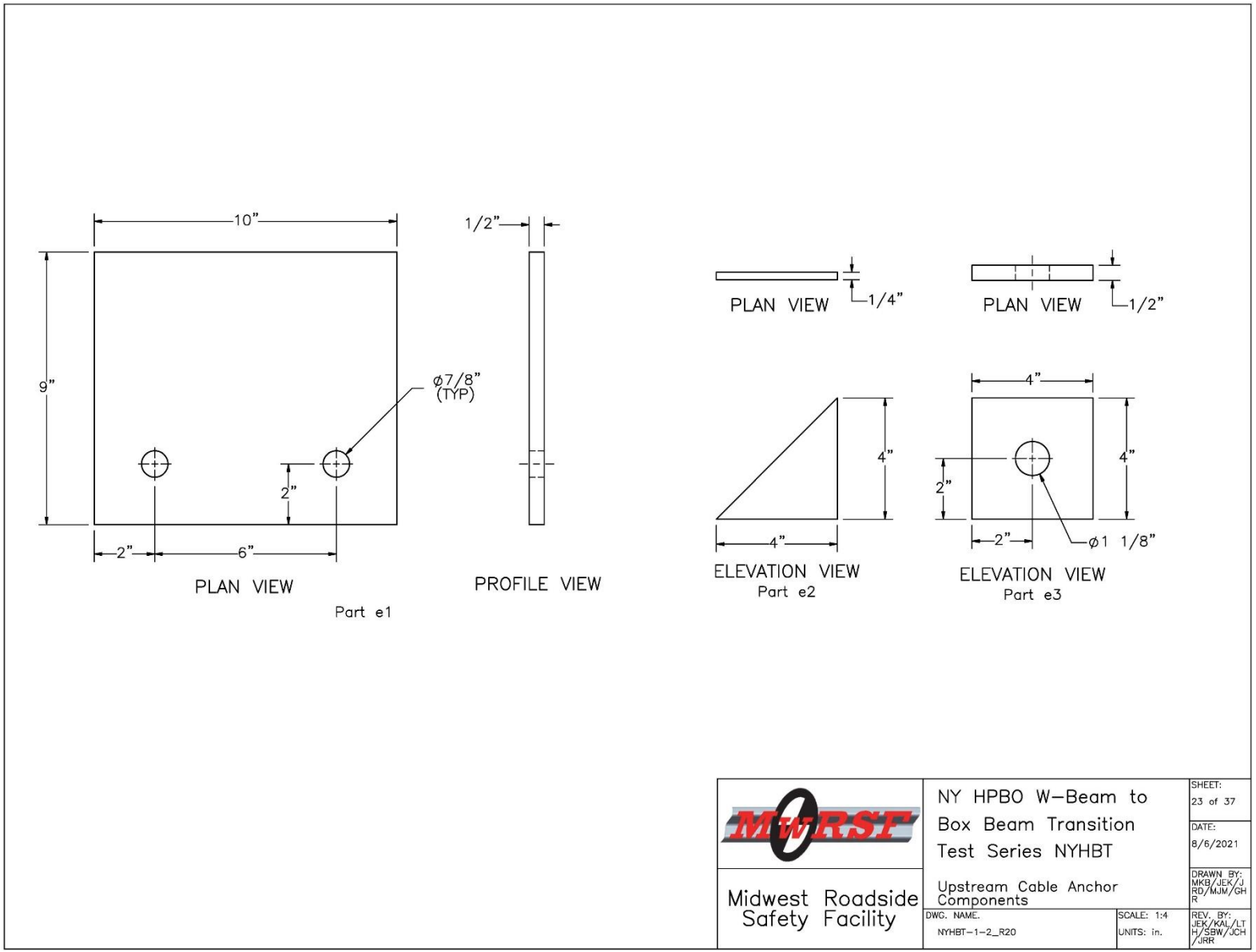
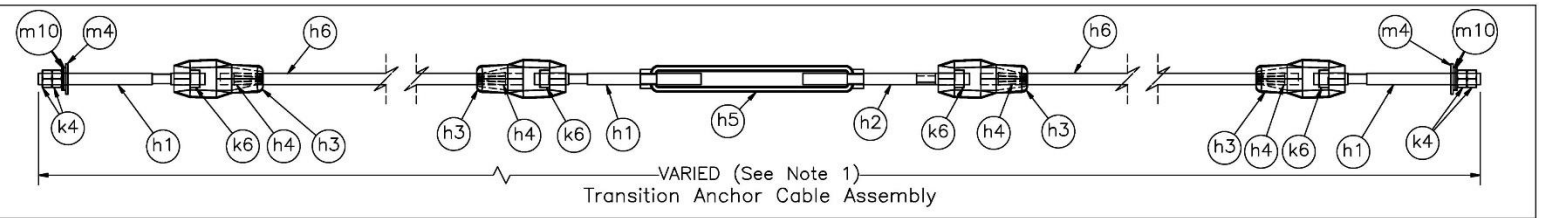
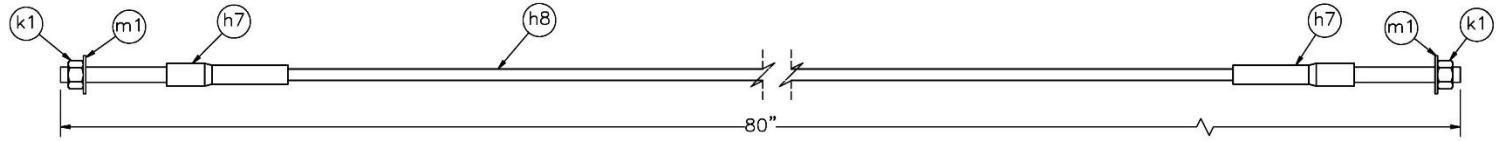


Figure 23. Upstream Cable Anchor Components, Test Nos. NYHBT-1 and NYHBT-2



Transition Anchor Cable Assembly

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	3	Transition Anchor Cable Assembly	–	–	–
h1	3	3/4" Dia. UNC, 11" Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h2	1	3/4" Dia. UNC, 11" Long Left–Hand Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h3	4	Cable End Fitting	ASTM A27 Gr. 70–40 Class 1	ASTM A153 or B695	RCE03
h4	4	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
h5	1	Standard Turnbuckle	ASTM F1145	ASTM A153 or B633	–
h6	2	3/4" Dia. 3x7 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 1	Class A Coating	RCM01
k4	4	3/4"–10 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX20a
k6	4	3/4"–10 UNC Square Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNS20
m4	2	3/4" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC20a
m10	4	3/4" Dia. Hardened SAE Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b



Upstream and Downstream End Cable Assemblies

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	3	Upstream and Downstream End Cable Assemblies	–	–	FCA01
h7	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	–
h8	1	3/4" Dia. 6x19 IWRC IPS Wire Rope	ASTM A741 Type 2	Class A Coating	–
k1	2	1"–8 UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX24b
m1	2	1" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC24a

Notes: (1) Total lengths of the three transition anchor cable assemblies are approximately 282", 317", and 352".

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition
Test Series NYHBT
Anchor Cable Details

SHEET: 24 of 37
DATE: 8/6/2021
DRAWN BY: MKB/JEK/JRD/MJM/GHR
REV. BY: JEK/KAL/LTH/SBW/JCH/JRR
DWG. NAME. NYHBT–1–2_R20
SCALE: 1:10
UNITS: in.

Figure 24. Anchor Cable Details, Test Nos. NYHBT-1 and NYHBT-2

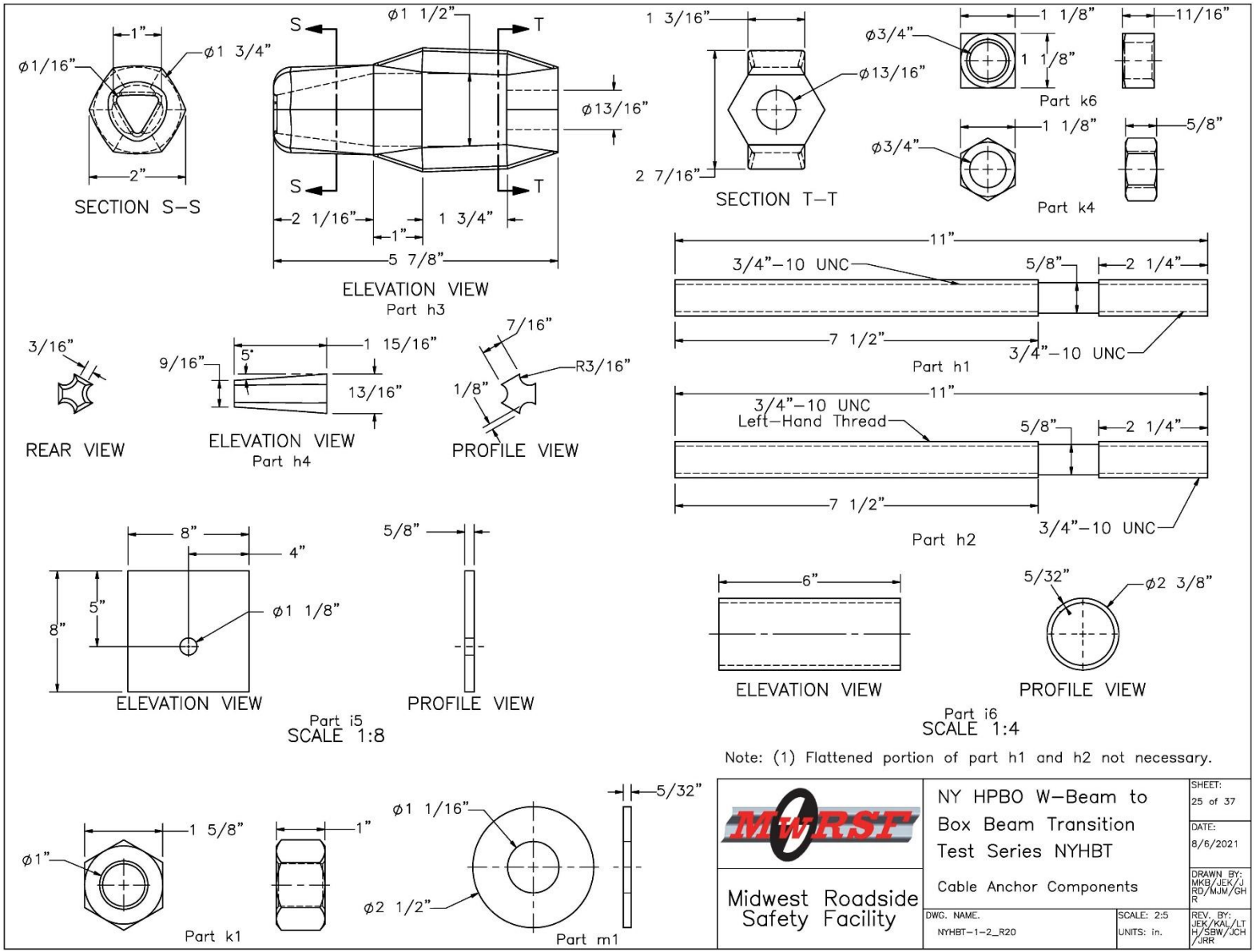


Figure 25. Cable Anchor Components, Test Nos. NYHBT-1 and NYHBT-2

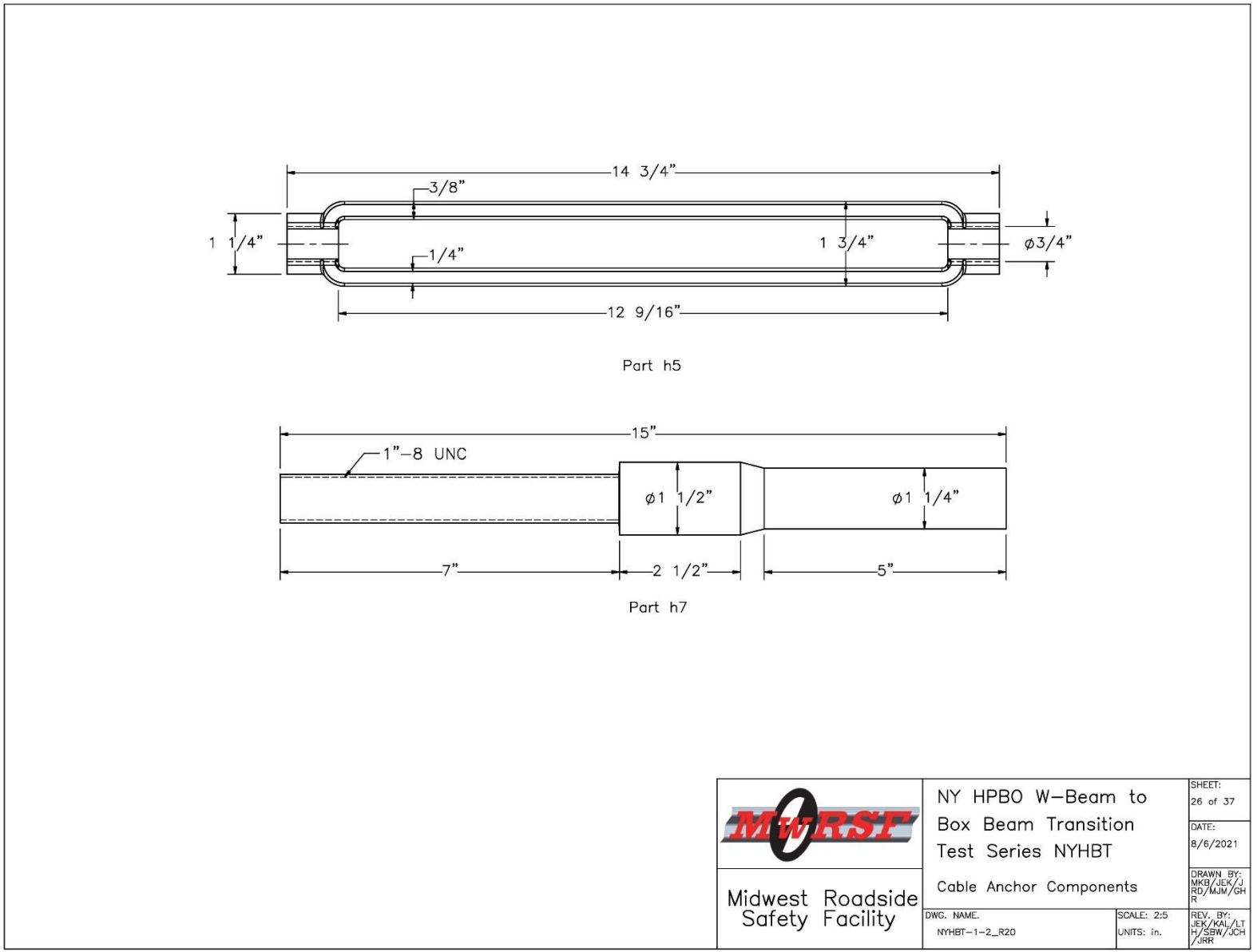


Figure 26. Cable Anchor Components, Test Nos. NYHBT-1 and NYHBT-2

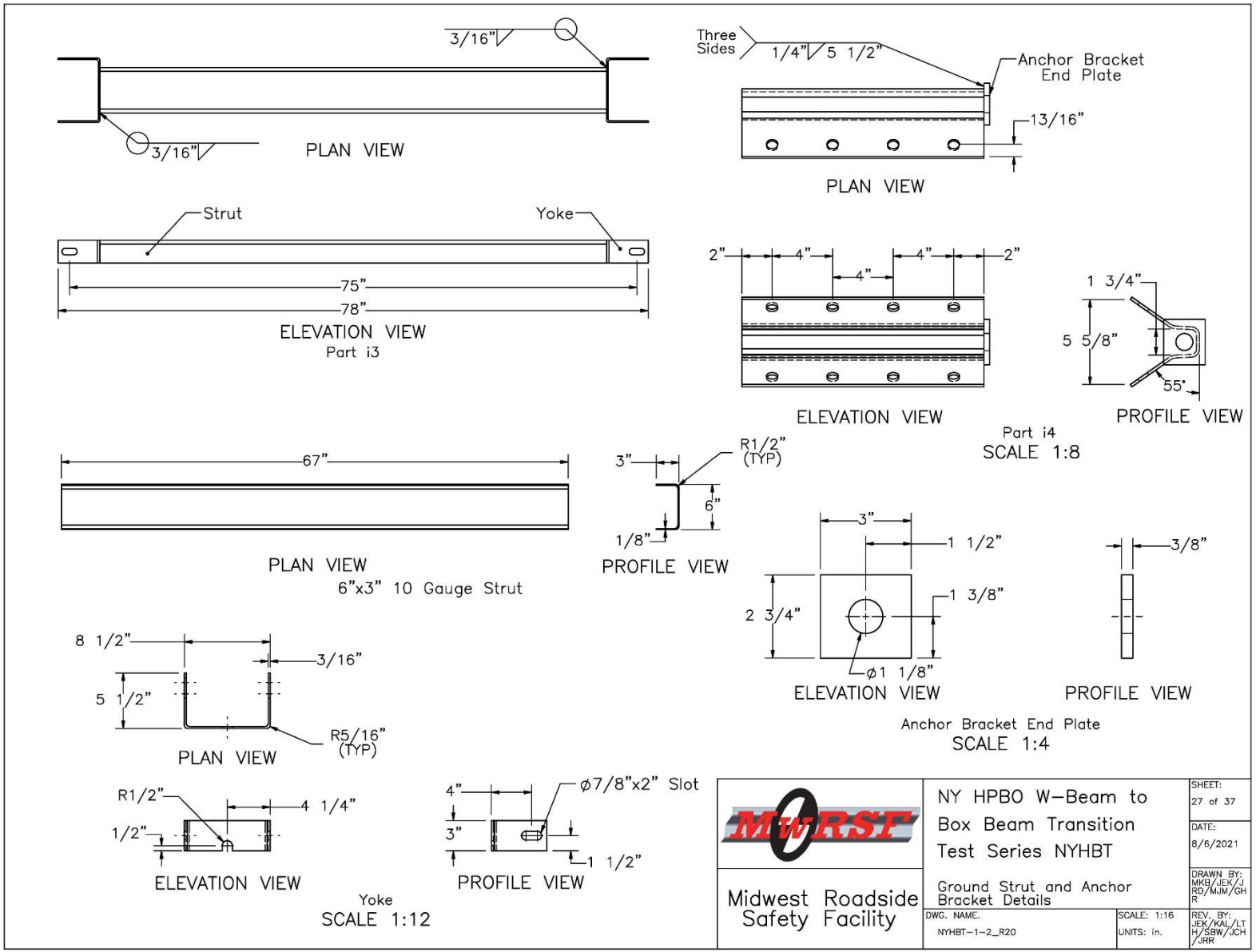


Figure 27. Ground Strut and Anchor Bracket Details, Test Nos. NYHBT-1 and NYHBT-2

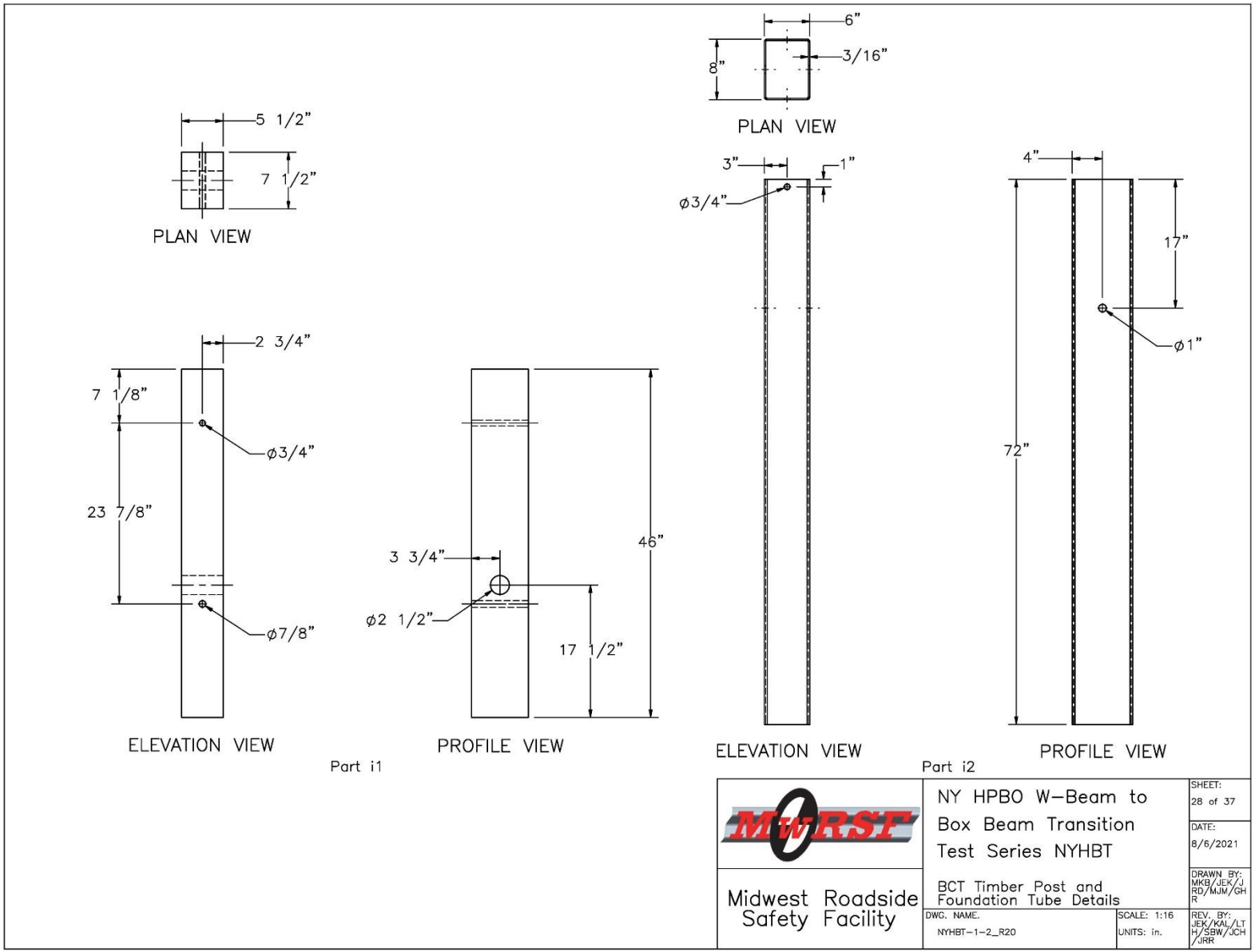


Figure 28. BCT Timber Post and Foundation Tube Details, Test Nos. NYHBT-1 and NYHBT-2

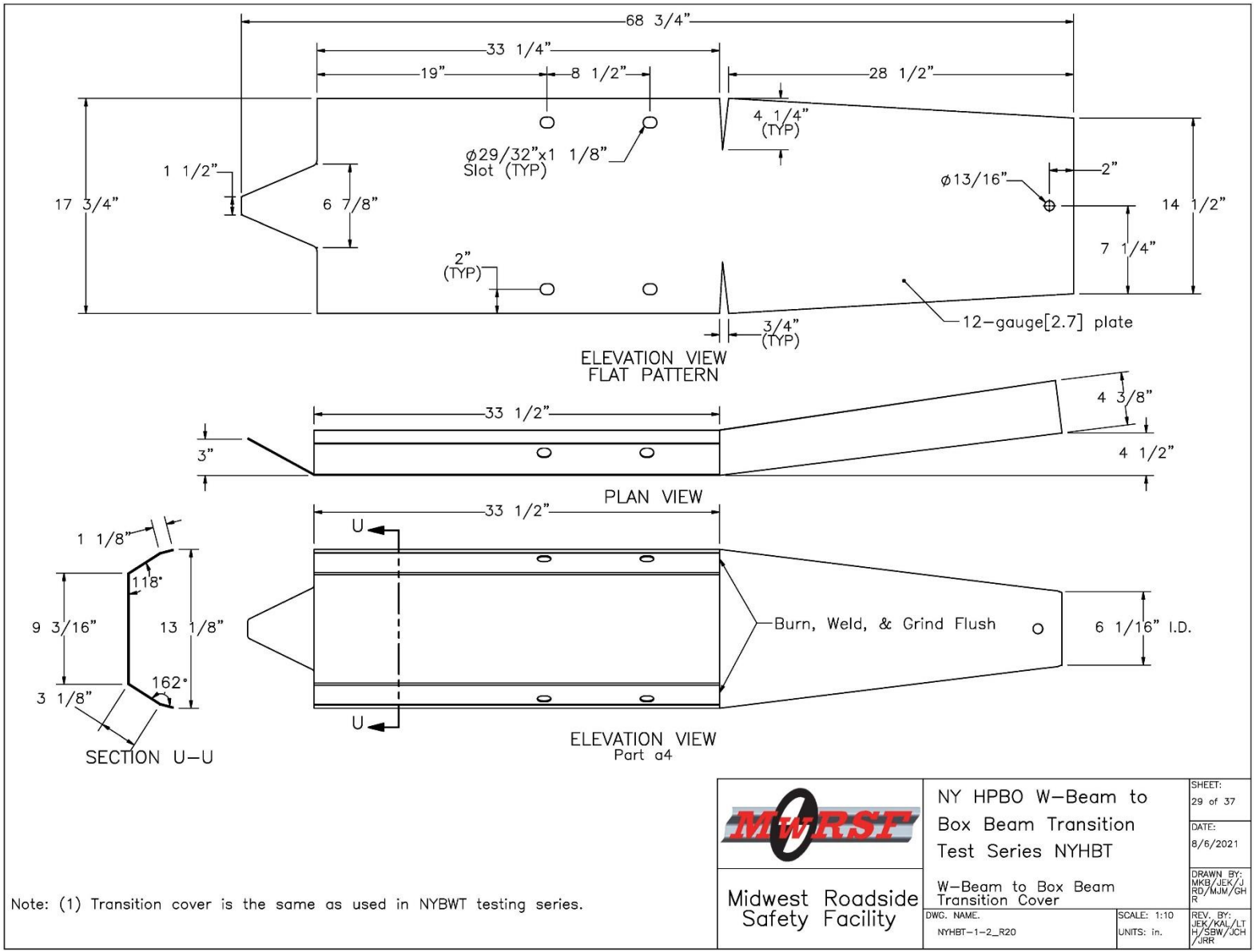


Figure 29. W-Beam to Box Beam Transition Cover, Test Nos. NYHBT-1 and NYHBT-2

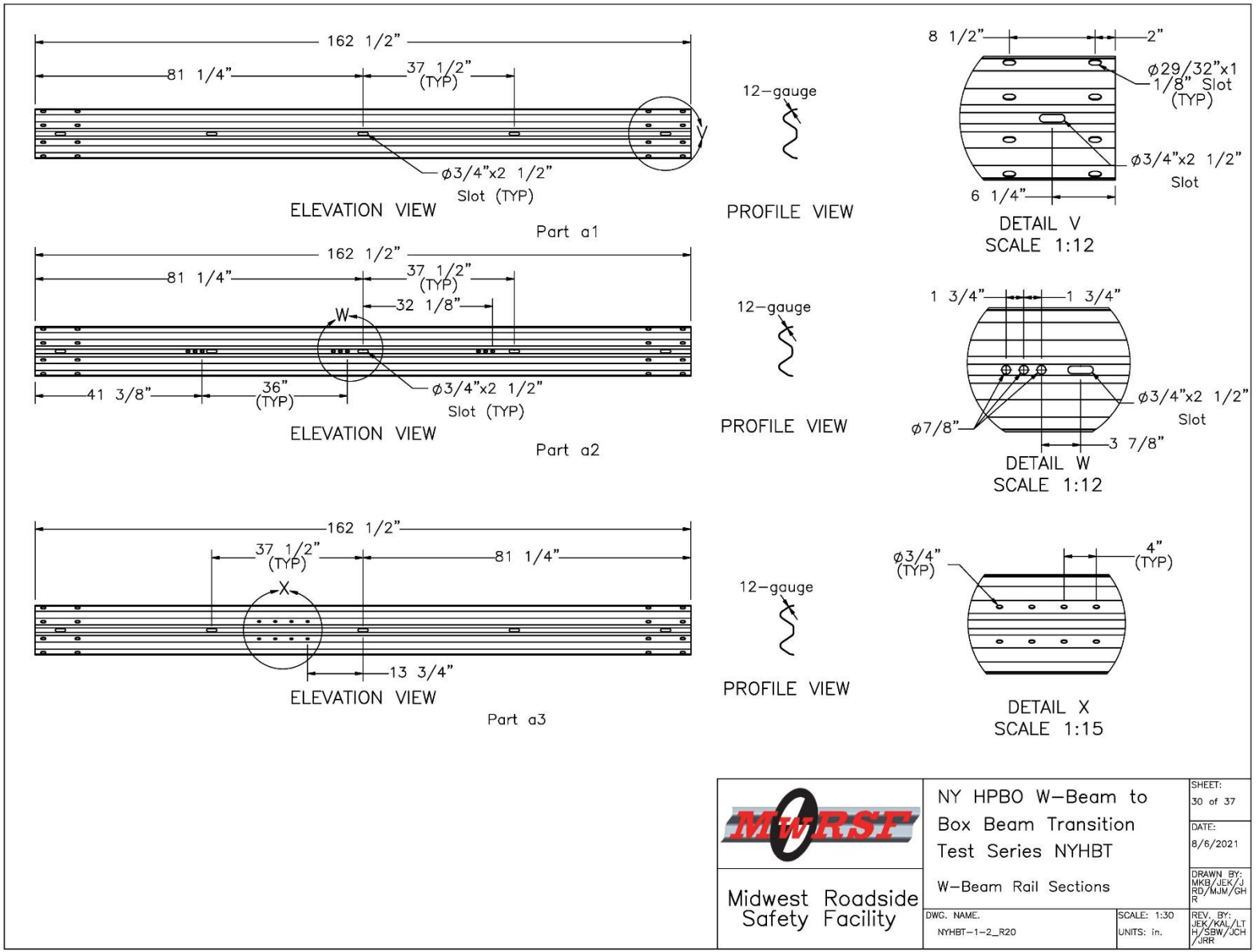


Figure 30. W-Beam Rail Sections, Test Nos. NYHBT-1 and NYHBT-2

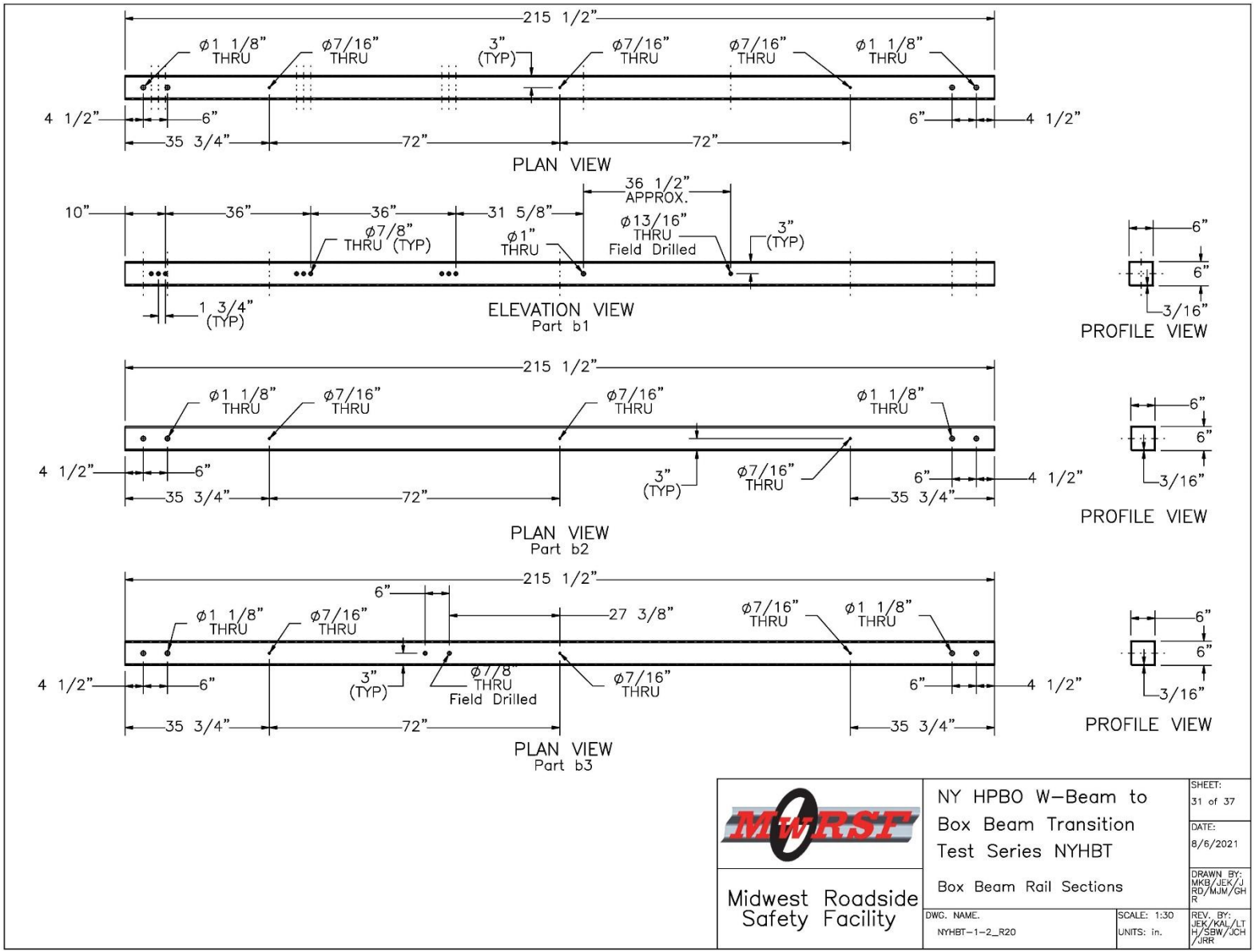
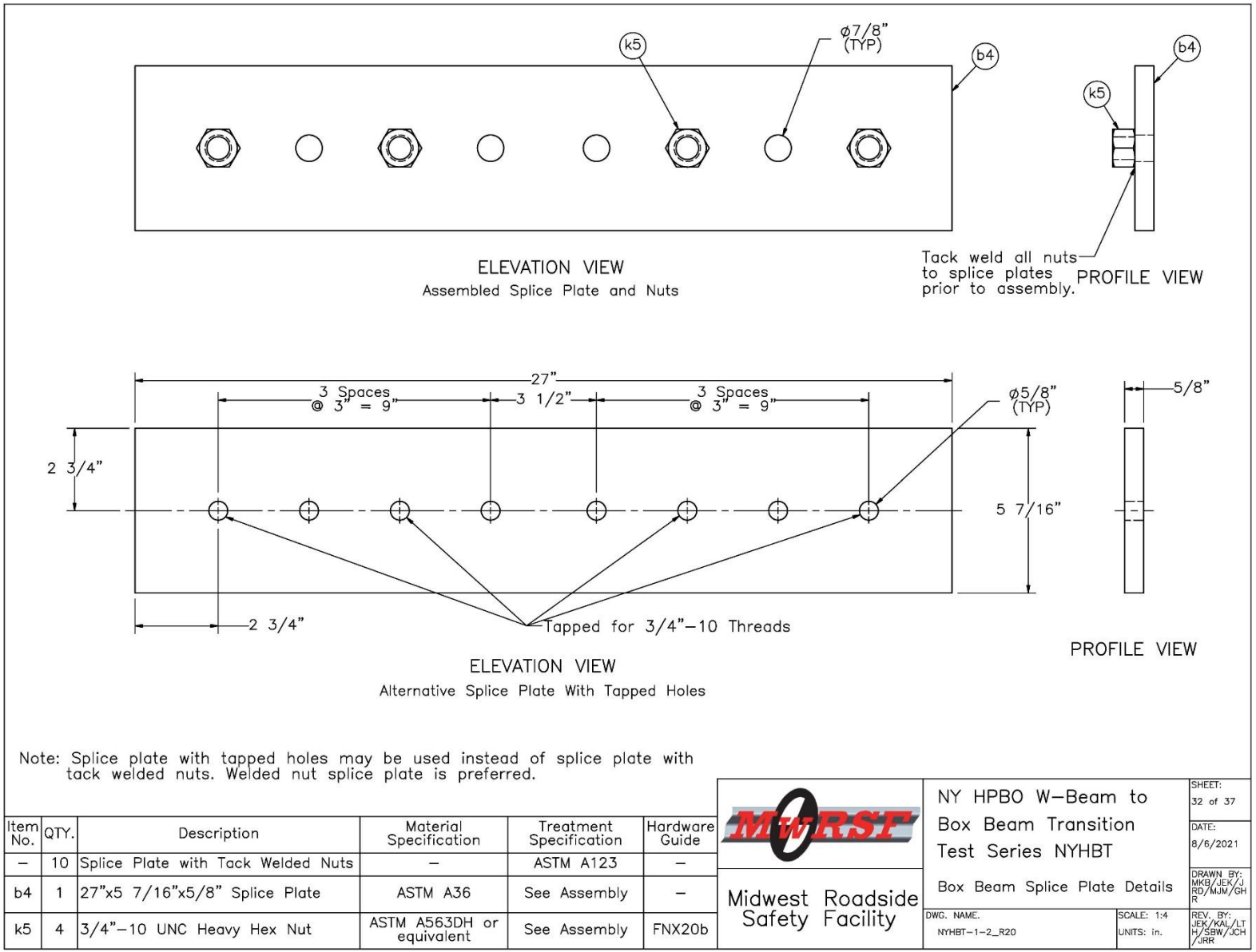


Figure 31. Box Beam Rail Sections, Test Nos. NYHBT-1 and NYHBT-2



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

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" Splice Plate	ASTM A36	See Assembly	–
k5	4	3/4"–10 UNC Heavy Hex Nut	ASTM A563DH or equivalent	See Assembly	FNX20b

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition Test Series NYHBT

Box Beam Splice Plate Details

SHEET: 32 of 37
DATE: 8/6/2021
DRAWN BY: MKB/JEK/JRD/MJM/GHR
DWG. NAME. NYHBT–1–2_R20
SCALE: 1:4
UNITS: in.
REV. BY: JEK/KAL/LTH/SBW/JCH/JRR

Figure 32. Box Beam Splice Plate Details, Test Nos. NYHBT-1 and NYHBT-2

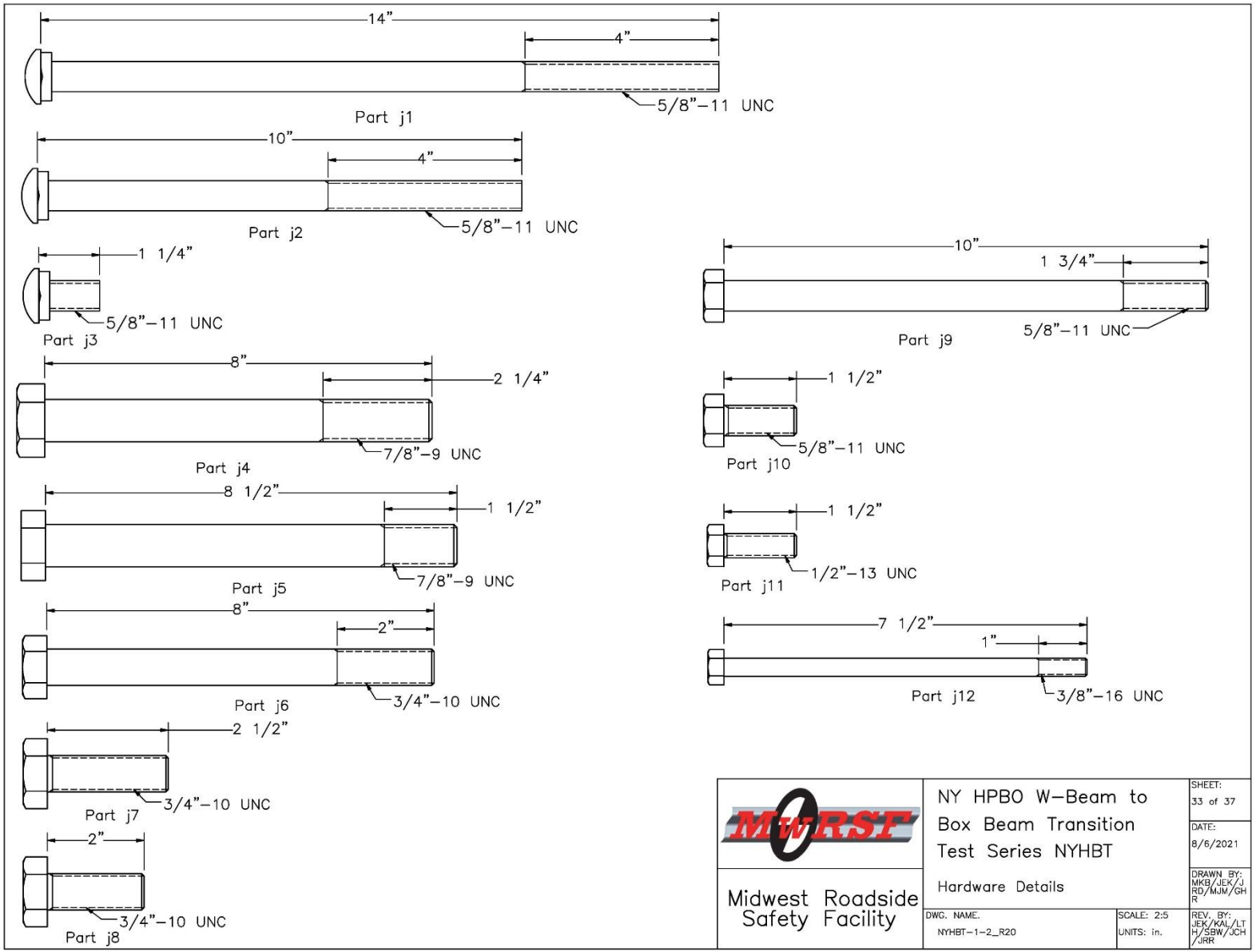


Figure 33. Hardware Details, Test Nos. NYHBT-1 and NYHBT-2

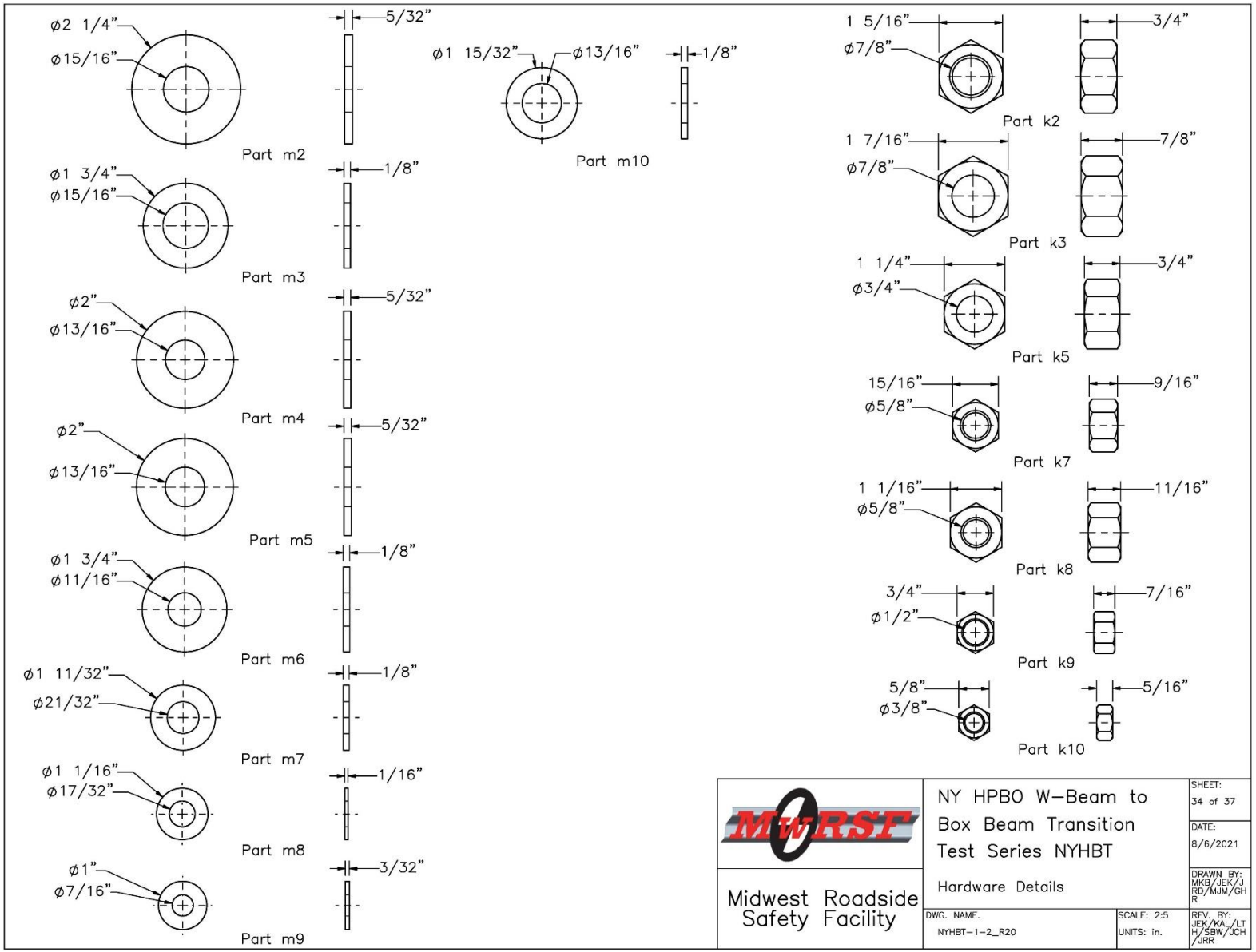


Figure 34. Hardware Details, Test Nos. NYHBT-1 and NYHBT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
a1	5	12'–6" 12–gauge W–Beam Section	AASHTO M180	ASTM A123 or A653	RWM04a
a2	2	12'–6" 12–gauge W–Beam Section	AASHTO M180	ASTM A123 or A653	–
a3	1	12'–6" 12–gauge W–Beam MGS End Section	AASHTO M180	ASTM A123 or A653	RWM14a
a4	1	W–Beam to Box Beam Transition Cover, 12–gauge	ASTM A36	ASTM A123 or A653	–
b1	1	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b2	4	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b3	1	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b4	10	27"x5 7/16"x5/8" Splice Plate	ASTM A36	See Assembly	–
c1	21	S3x5.7, 65" Long Post	ASTM A36	See Assembly	–
c2	21	24"x8"x1/4" Soil Plate	ASTM A36	See Assembly	–
c3	3	7"x4"x1/2", 3" Long L–Bracket	ASTM A36	ASTM A123	–
c4	18	5"x3 1/2"x3/8", 4 1/2" Long L–Bracket	ASTM A36	ASTM A123	–
c5	11	W6x8.5 or W6x9, 72" Long Steel Post	ASTM A36	ASTM A123	–
c6	11	14"x12"x6" Timber Blockout	SYP Grade No. 1 or better	–	–
d1	2	W6x15, 72" Long Post	ASTM A992 or ASTM A572 Gr. 50	–	–
d2	2	20"x14"x3/16" Plate	ASTM A36	–	–
d3	2	6 3/16"x4"x1/2" Plate	ASTM A36	–	–
d4	4	6 1/4"x4"x1/2" Plate	ASTM A36	–	–
d5	2	6 3/16"x6"x1/2" Plate	ASTM A36	–	–
e1	2	10"x9"x1/2" Box Beam Cable Anchor Base Plate	ASTM A36	See Assembly	–
e2	4	4"x4"x1/4" Box Beam Cable Anchor Gusset	ASTM A36	See Assembly	–
e3	2	4"x4"x1/2" Box Beam Cable Anchor Mounting Plate	ASTM A36	See Assembly	–
f1	1	Concrete	Pre–Cast Class A* Min. f'c = 3,000 psi NE Mix 47BD	–	–
f2	4	#3 Bar, 30 1/4" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f3	2	#3 Bar, 33 7/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f4	2	#3 Bar, 35 7/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f5	2	#3 Bar, 38 3/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f6	2	#3 Bar, 45 9/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f7	2	#3 Bar, 48" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f8	2	#3 Bar, 50 1/2" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f9	11	3/4" Dia. UNC, Hooked Anchor J–Bolt	ASTM F1554 Gr. 36	ASTM A153 or B695 Class 55 or F2329	FRH20a

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

Note: (1) According to NY standards, blockouts may be wood, plastic, or synthetic.

MwRSF

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition Test Series NYHBT

Bill of Materials

SHEET: 35 of 37
DATE: 8/6/2021
DRAWN BY: MKB/JEK/JRD/MJM/GHR
REV. BY: JEK/KAL/LTH/SBW/JCH/JRR
DWG. NAME. NYHBT–1–2_R20
SCALE: None
UNITS: in.

Figure 35. Bill of Materials, Test Nos. NYHBT-1 and NYHBT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
g1	1	14"x9"x1/2" Plate	ASTM A36	See Assembly	–
g2	4	4"x2 13/16"x1/4" Cable Anchor Gusset	ASTM A36	See Assembly	–
g3	1	14"x3 1/2"x1/2" Cable Anchor Top Plate	ASTM A36	See Assembly	–
g4	1	1/4" Dia., 16 3/8" Long Brass Rod	ASTM B16–00	–	–
h1	9	3/4" Dia. UNC, 11" Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h2	3	3/4" Dia. UNC, 11" Long Left–Hand Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h3	6	Cable End Fitting	ASTM A27 Gr. 70–40 Class 1	ASTM A153 or B695	RCE03
h4	6	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
h5	3	Standard Turnbuckle	ASTM F1145	ASTM A153 or B633	–
h6	6	3/4" Dia. 3x7 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 1	Class A Coating	RCM01
h7	6	BCT Anchor Cable End Swaged Fitting	Fitting – ASTM A576 Gr. 1035 Stud – ASTM F568 Class C	Fitting – ASTM A153 Stud – ASTM A153 or B695	–
h7	2	3/4" [19] Dia. 6x19 IWRC IPS Wire Rope	ASTM A741 Type 2	Class A Coating	–
i1	2	BCT Timber Post – MGS Height	SYP Grade No. 1 or better (No knots +/– 9" from weakening hole on tension face)	–	PDF01
i2	2	72" Long Foundation Tube	ASTM A500 Gr. B	ASTM A123	PTE06
i3	1	Ground Strut Assembly	ASTM A36	ASTM A123	PFP01
i4	1	Anchor Bracket Assembly	ASTM A36	ASTM A123	FPA01
i5	1	8"x8"x5/8" Anchor Bearing Plate	ASTM A36	ASTM A123	FPB01
i6	1	2 3/8" O.D. x 6" Long BCT Post Sleeve	ASTM A53 Gr. B Schedule 40	ASTM A123	FMM02
j1	11	5/8"–11 UNC, 14" Long Guardrail Bolt	ASTM A307 Gr. A	ASTM A153 or B695 Class 55 or F2329	FBB06
j2	2	5/8"–11 UNC, 10" Long Guardrail Bolt	ASTM A307 Gr. A	ASTM A153 or B695 Class 55 or F2329	FBB03
j3	52	5/8"–11 UNC, 1 1/4" Long Guardrail Bolt	ASTM A307 Gr. A	ASTM A153 or B695 Class 55 or F2329	FBB01
j4	2	7/8"–9 UNC, 8" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	–
j5	2	7/8"–9 UNC, 8 1/2" Long Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX22b
j6	11	3/4"–10 UNC, 8" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX20a
j7*	2	3/4"–10 UNC, 2 1/2" Long Fully Threaded Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX20b
j8*	38	3/4"–10 UNC, 2" Long Fully Threaded Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX20b
j9	2	5/8"–11 UNC, 10" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX16a
j10	8	5/8"–11 UNC, 1 1/2" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX16a
j11	18	1/2"–13 UNC, 1 1/2" Long Fully Threaded 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" shorter.

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition
Test Series NYHBT
Bill of Materials

SHEET: 36 of 37
DATE: 8/6/2021
DRAWN BY: MKB/JEK/JRD/MJM/GHR
REV. BY: JEK/KAL/LTH/SBW/JCH/JRR
DWG. NAME. NYHBT–1–2_R20
SCALE: None
UNITS: in.

Figure 36. Bill of Materials, Test Nos. NYHBT-1 and NYHBT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
j12	18	3/8"–16 UNC, 7 1/2" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX10a
j13	2	16D Double Head Nail	–	–	–
k1	6	1"–8 UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX24b
k2	2	7/8"–9 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	–
k3	2	7/8 –9 UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX22b
k4	30	3/4"–10 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX20a
k5*	40	3/4"–10 UNC Heavy Hex Nut	ASTM A563DH or equivalent	See Assembly	FNX20b
k6	12	3/4"–10 UNC Square Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNS20
k7	10	5/8"–11 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX16a
k8	65	5/8"–11 UNC Heavy Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX16b
k9	18	1/2"–13 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX14a
k10	18	3/8"–16 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX10a
m1	6	1" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC24a
m2	4	7/8" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	–
m3	4	7/8" Dia. Hardened SAE Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC22b
m4	16	3/4" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC20a
m5	40	3/4" Dia. Hardened USS Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	–
m6	22	5/8" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC16a
m7	11	5/8" Dia. Plain SAE Washer	ASTM F844	ASTM A123 or A153 or F2329	–
m8	18	1/2" Dia. Plain Narrow SAE Washer	SAE Low Carbon Gr. 2	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	–
m9	36	3/8" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC10a
m10	30	3/4" Dia. Hardened SAE Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b

* 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 (m10)	0.812"	0.03"	0.007"	1.469"	0.03"	0.007"	0.134"	0.16"	0.108"
	Wide (m4)	0.812"	0.03"	0.007"	2"	0.03"	0.007"	0.165"	0.192"	0.136"

MwRSF

Midwest Roadside Safety Facility

NY HPBO W–Beam to Box Beam Transition Test Series NYHBT

Bill of Materials

SHEET: 37 of 37

DATE: 8/6/2021

DRAWN BY: MKB/JEK/JRD/MJM/GHR

REV. BY: JEK/KAL/LTH/SBW/JCH/JRR

DWG. NAME. NYHBT–1–2_R20

SCALE: None

UNITS: in.

Figure 37. Bill of Materials, Test Nos. NYHBT-1 and NYHBT-2

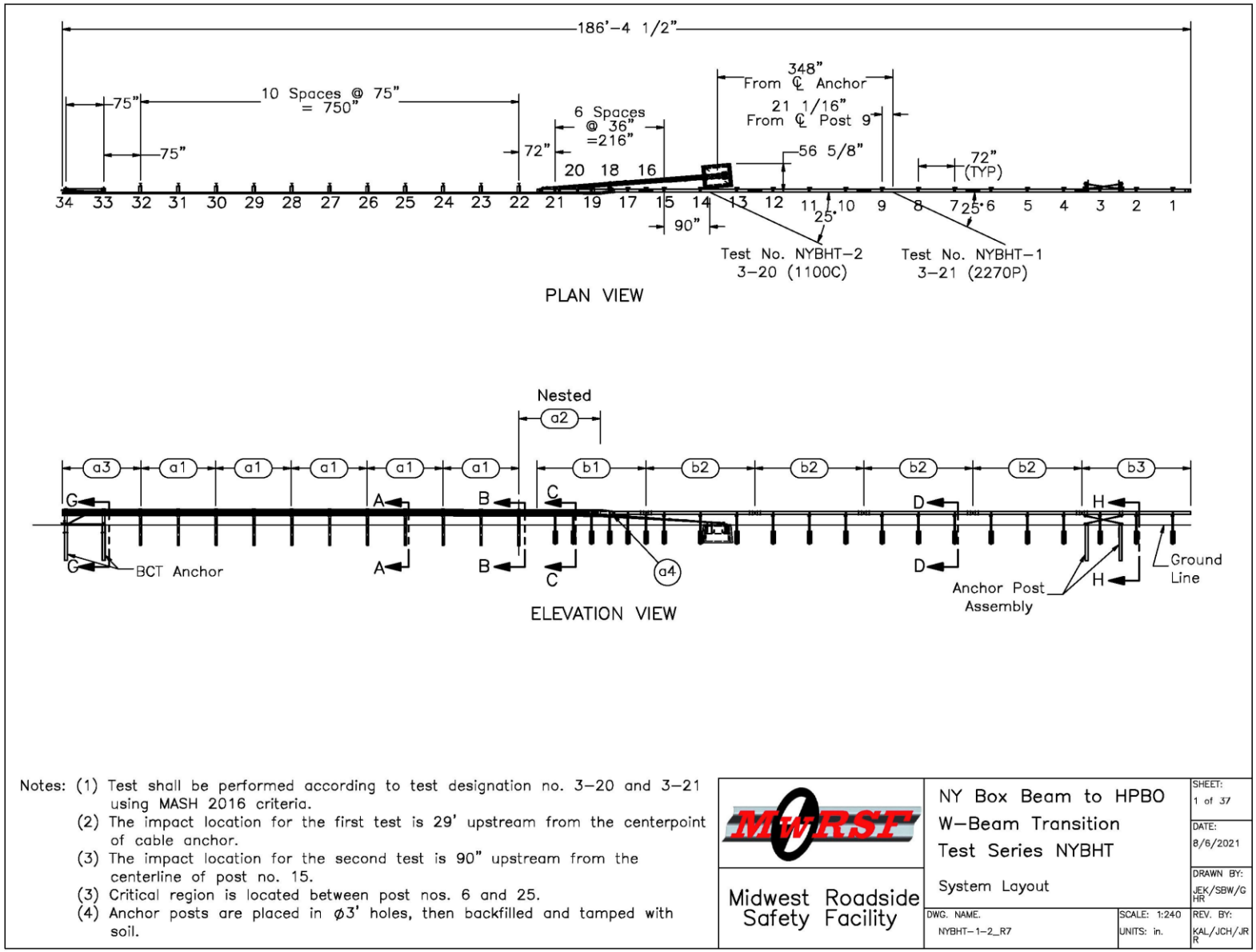


Figure 38. Box Beam to HBPO Transition Test Installation Layout, Test Nos. NYBHT-1 and NYBHT-2

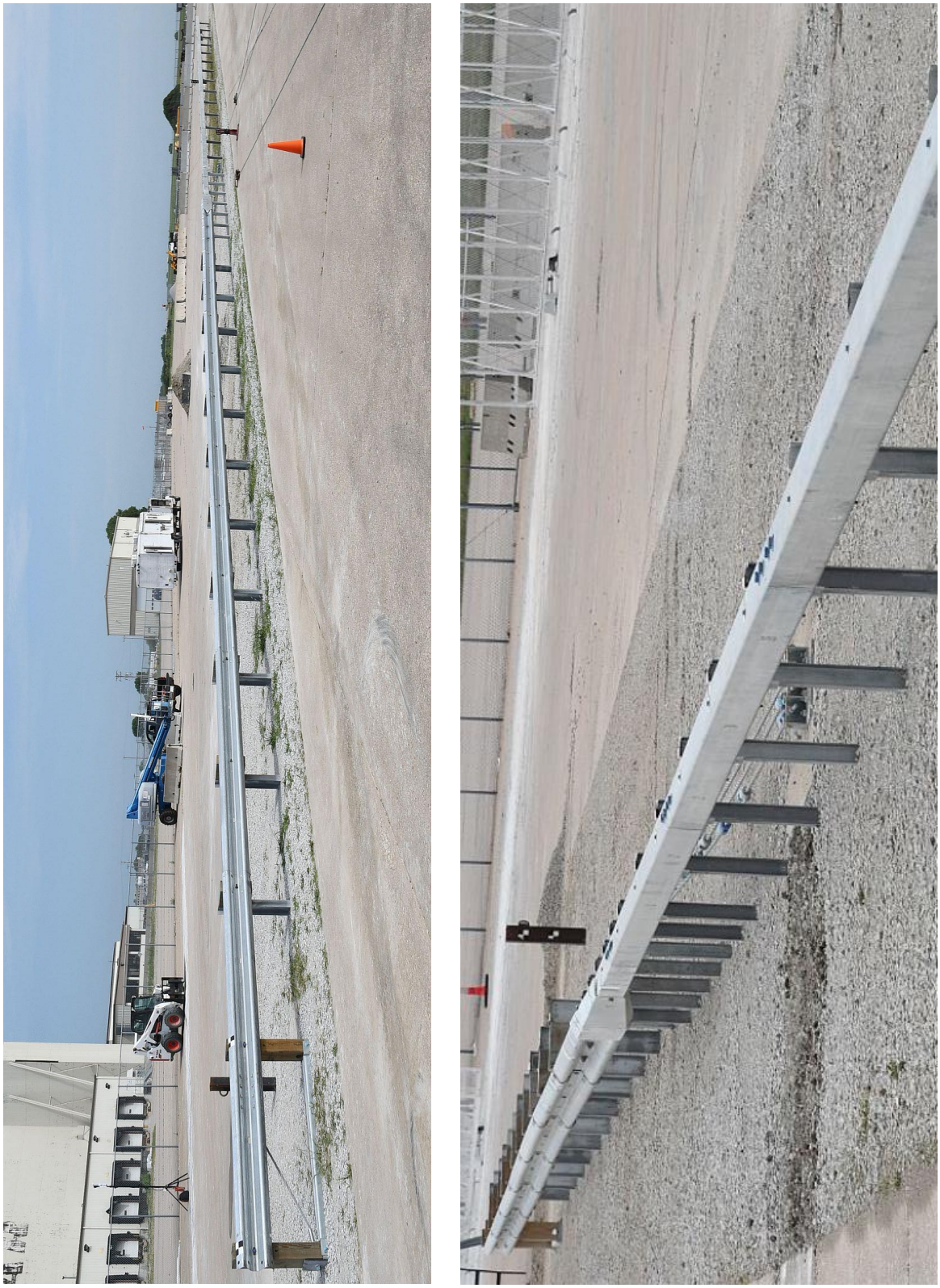


Figure 39. Test Installation Photographs, Test Nos. NYHBT-1 and NYHBT-2

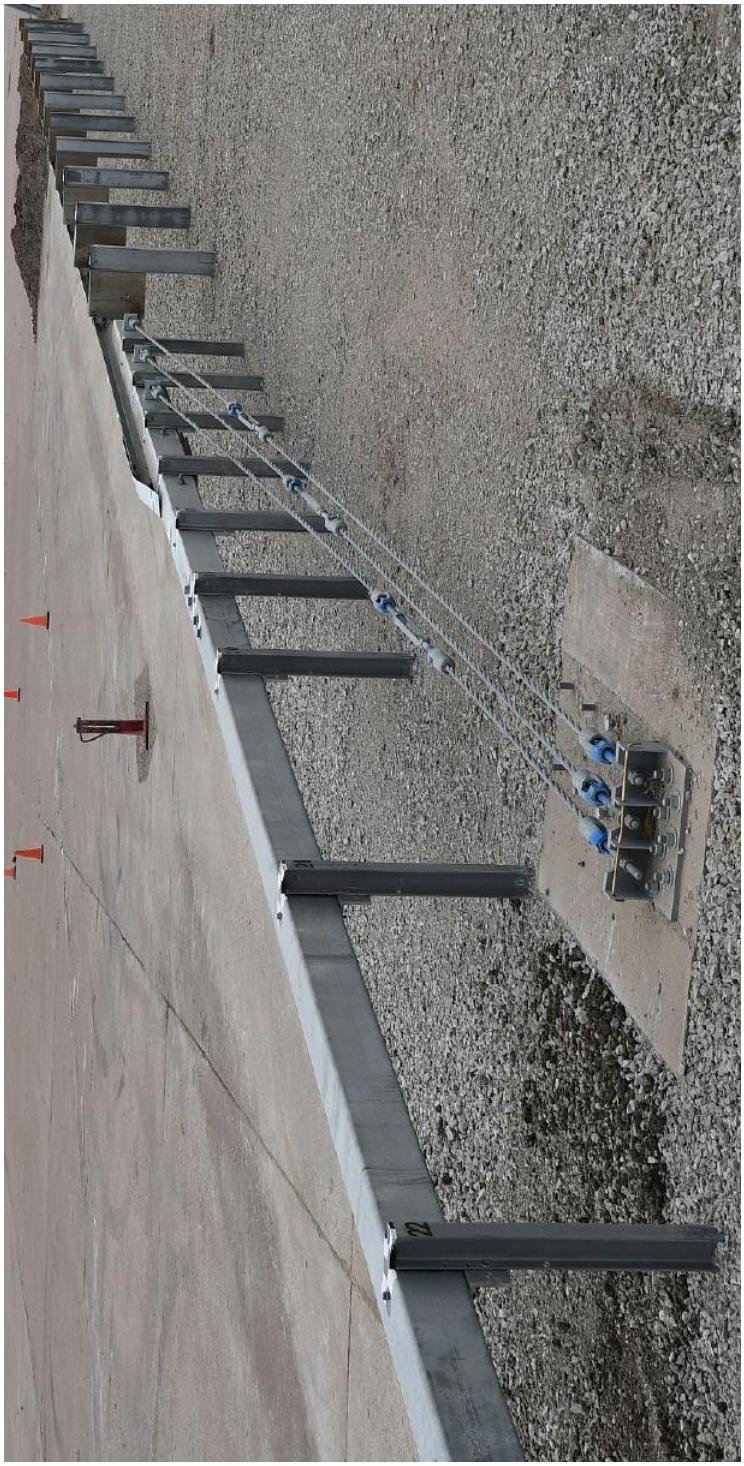




Figure 40. Test Installation Photographs, Test Nos. NYHBT-1 and NYHBT-2



Figure 41. Test Installation Photographs, Transition Section, Test Nos. NYHBT-1 and NYHBT-2

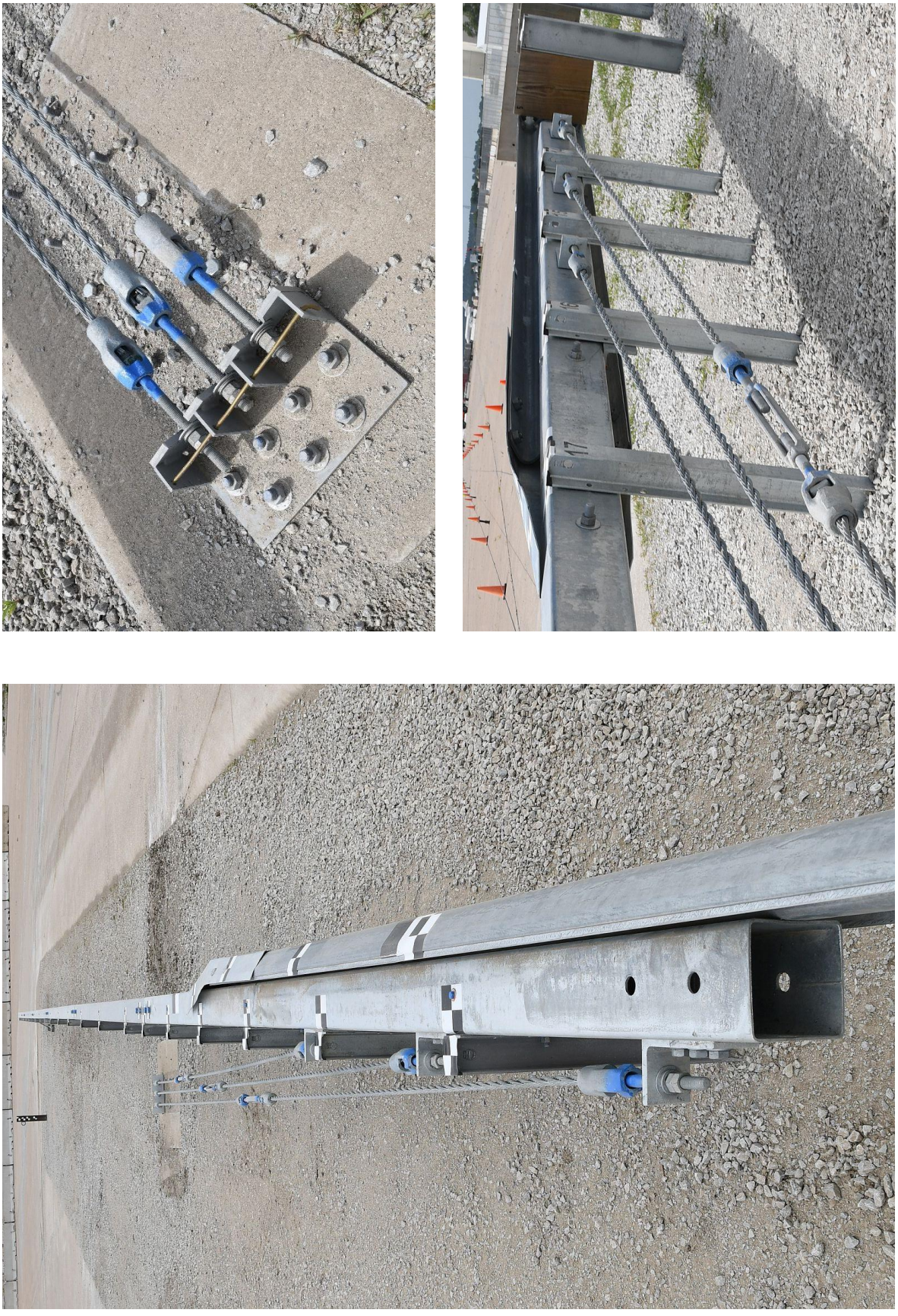


Figure 42. Test Installation Photographs, Transition Anchor, Test Nos. NYHBT-1 and NYHBT-2

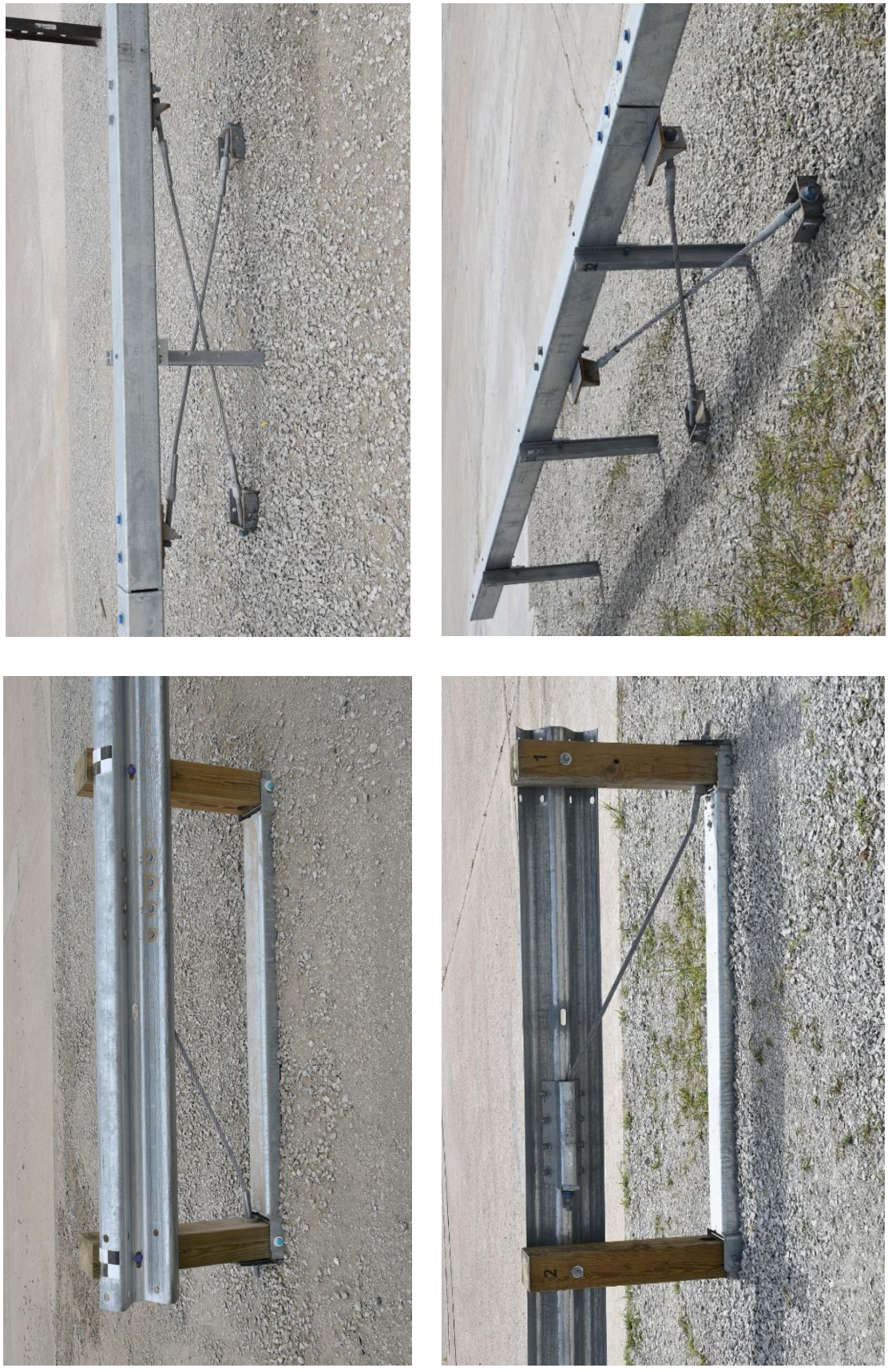


Figure 43. Test Installation Photographs, End Anchorages, Test Nos. NYHBT-1 and NYHBT-2



Figure 44. Test Installation Photographs, Test Nos. NYBHT-1 and NYBHT-2



Figure 45. Test Installation Photographs, Transition Section, Test Nos. NYBHT-1 and NYBHT-2





Figure 46. Test Installation Photographs, Transition Anchor, Test Nos. NYBHT-1 and NYBHT-2

4 CRITICAL IMPACT POINT (CIP) SELECTION

As noted in Chapter 2, full-scale crash test designation nos. 3-20 and 3-21 were deemed necessary for both impact directions: (1) transition from HPBO to box beam guide rail and (2) transition from box beam guide rail to HPBO. Therefore, critical impact points (CIPs) were determined for all four impacts.

4.1 Background

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. 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 [6] .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 [7]. The modified weak-post W-beam guardrail had a dynamic deflection of 6.0 ft when impacted with the MASH small car.

During NCHRP Project 22-14(2), in test no. 2214WB-2, the modified G4(1S) guardrail was tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 3.9 ft [8]. In 2010, the Midwest Guardrail System (MGS) Bridge Rail utilized W-beam guardrail supported by S3x5.7 steel posts at half-post spacing (37½ in. on center) and installed in rigid sockets side-mounted to a concrete bridge deck [9]. In test no. MGSBR-1, the MGS bridge rail was successfully crash tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 4.1 ft. Subsequently, in test no. MGSBR-2, the MGS bridge rail had a dynamic deflection of 2.3 ft when impacted with the MASH small car. In addition, in test no. MGSMS-1, a W-beam guardrail system with weak-posts at half-post spacing installed in rigid sockets was successfully tested according to MASH test designation no. 3-11 criteria and had a dynamic deflection of 3.5 ft [10]

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 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 HPBO strong-post W-beam system and the G3 weak-post box beam system.

4.2 NYSDOT HPBO to Box Beam Transition (System NYHBT)

For both the 2270P and 1100C vehicle impacts, the possible CIPs were determined based on the potential for snag at the transitions between rail stiffness, hardware failure, and vehicle instability.

4.2.1 MASH Test Designation No. 3-21

For the 2270P vehicle impact, three possible CIPs were determined, as shown in Figure 47. As previously noted, a review of previous full-scale crash testing indicate that the effective

stiffness of box beam and W-beam to box beam transition using S3x5.7 steel posts at half-post spacing (3 ft) is similar to the lateral stiffness of the full-post spacing (6 ft-3 in.), heavy post W-beam system in terms of system deflections and vehicle contact length. However, post stiffness is expected to gradually decrease along the longitudinal extent of the transition. Therefore, snag potential could occur at points of stiffness in the rail elements, which include (1) single W-beam to nested W-beam, (2) nested W-beam to nested W-beam overlapped with box beam, and (3) nested W-beam to nested W-beam overlapped with box beam and a transition cover piece.

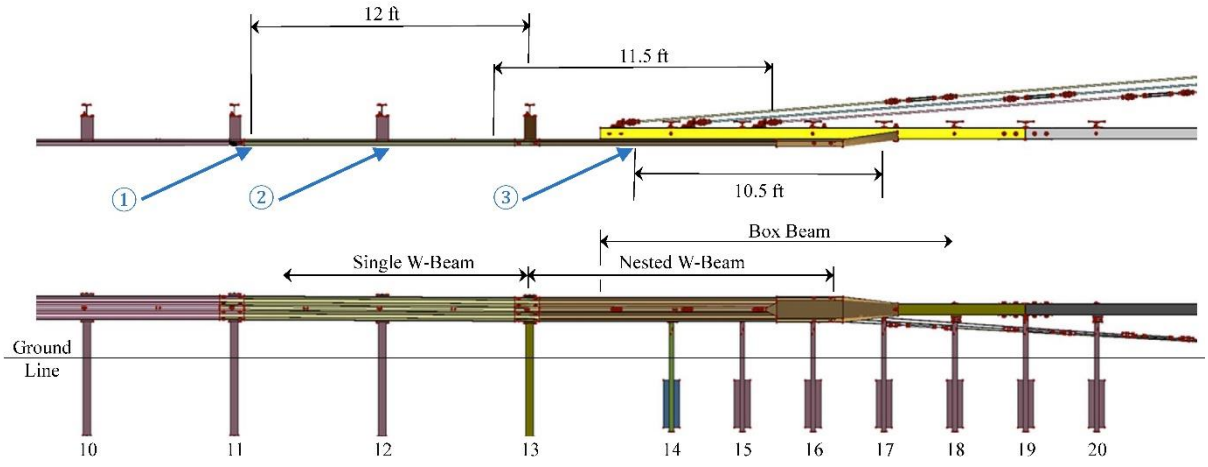


Figure 47. Potential CIPs for HPBO to Box Beam Transition, Test Designation No. 3-21 (2270P)

CIP option no. 1 was intended to maximize vehicle snag at the transition from single W-beam to nested W-beam. An impact 12 ft upstream from post no. 13, which is the last heavy post adjacent to the transition system, would maximize the potential for vehicle snag at this location. This impact location was selected using Figure 2-17 in MASH 2016.

CIP option no. 2 was intended to maximize the potential for vehicle snag on the leading edge of the box beam and evaluates the strong post-to-weak post transition that occurs at post no. 14. An impact 11.5 ft upstream from the centerline of post no. 14, which is the first S3x5.7 weak post located at half-post spacing within the nested W-beam overlapped with box beam region, was determined using Figure 2-17 in MASH 2016. This location was similar to the impact location in test no. NYBWT-3, wherein a weak-post W-beam to box-beam transition system satisfied the safety performance criteria for MASH test designation no. 3-21 [11], but with a propensity for wheel snag on the weak-posts as the vehicle deflected the W-beam and box beam. Based on the vehicle behavior in test no. NYBWT-3 and the added stiffness 4.5 ft downstream from post 14, it was believed that shifting the impact point downstream would maximize the deflections of the transition region when the vehicle was near the cable brackets and consequently the interaction of the vehicle with the half-post spacing weak posts.

CIP option no. 3 was intended to maximize loading on the cable anchor brackets and evaluate vehicle stability when traversing the cable anchorage. Test no. NYBWT-3 was a weak-post W-beam to box beam transition with the cable anchorage attached to the box beam and located 7 ft laterally away from the back side of the system [11]. For the HPBO to box beam transition, the center of the cable anchorage is only 2 ft from the back side of the box beam. Therefore, an

impact of 10.5 ft upstream from post no. 17 was determined using Figure 2-17 in MASH 2016 and observed behavior of test no. NYBWT-3 and similar tests, it is believe one or more wheels of the pickup truck could interact with the cable anchor block and bracket during vehicle redirection.

CIP option no. 2 was recommended for MASH test designation no. 3-21 of the HPBO to box beam transition. This impact point is similar to that used in test no. NYBWT-3, which performed satisfactorily according to MASH test designation no. 3-21. Recall, the cable anchorage system in this transition is positioned much closer to the back side of the box beam which may result in more interaction of the vehicle with the cables or the cable anchorage, especially if wheel snag similar to that observed in test no. NYBWT-3 occurs.

4.2.2 MASH Test Designation No. 3-20

For the 1100C vehicle impact, three possible CIPs were determined, as shown in Figure 48. Again, recall the effective stiffness of box beam and W-beam to box beam transition using S3x5.7 steel posts at half-post spacing is similar to the lateral stiffness of the standard-post spacing, heavy post W-beam system.in terms of system deflections and vehicle contact length and post stiffness is expected to gradually decrease along the longitudinal extent of the transition. Therefore, snag potential could occur at points of stiffness in the rail elements, which include (1) single W-beam to nested W-beam, (2) nested W-beam to nested W-beam overlapped with box beam, and (3) nested W-beam to nested W-beam overlapped with box beam and a transition cover piece.

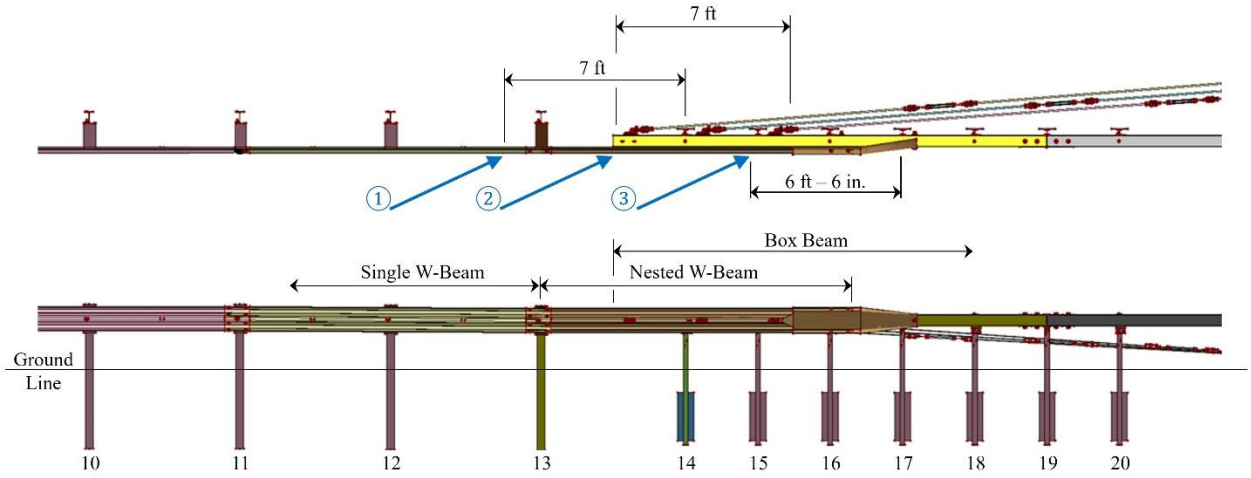


Figure 48. Potential CIPs for HPBO to Box Beam Transition, Test Designation No. 3-20 (1100C)

CIP option no. 1 was intended to maximize the potential for vehicle snag on the leading edge of the box beam and evaluates the strong post-to-weak post transition that occurs at post no. 14. An impact 7 ft upstream from the centerline of post no. 14, which is the first S3x5.7 weak post located at half-post spacing within the nested W-beam overlapped with box beam region, was determined using Figure 2-17 in MASH 2016.

CIP option no. 2 was intended to maximize vehicle interaction and potential snag with the leading edge of the transition cover plate and the upstream end of the cable anchorage attached to

the box beam. An impact of 7 ft upstream from the leading edge of the transition cover plate was determined using Figure 2-17 in MASH 2016 to maximize the snag potential.

CIP option no. 3 was intended to maximize the potential for vehicle snag on the leading edge of the box beam and the weak posts within the transition region. It also was intended to evaluate vehicle stability and interaction with the cables as the approaches the end of the anchorage. In testing of a trailing-end anchorage system, specifically test no. WIDA-2, the small car has the propensity to underride rail elements and snag on anchorage cables before they are released from the tension hardware [5]. An impact of 6.5 ft upstream from post no. 17, which is the first post in the box beam system, was determined using Figure 2-17 in MASH 2016.

CIP option no. 3 was recommended for MASH test designation no. 3-20 of the HPBO to box beam transition. The 2270P vehicle used in test no. NYBWT-3 displayed a propensity for rail underride and vehicle snag. Therefore, this impact will evaluate the propensity for vehicle interaction and snag with system components, specifically weak posts, transition cover plate, and anchorage cables and hardware.

4.3 NYSDOT Box Beam to HPBO Transition (System NYBHT)

For both the 2270P and 1100C vehicle impacts, the possible CIPs were determined based on the potential for snag at the transitions between rail stiffness, hardware failure, and vehicle instability.

4.3.1 MASH Test Designation No. 3-21

For the 2270P vehicle impact, three possible CIPs were determined, as shown in Figure 49.

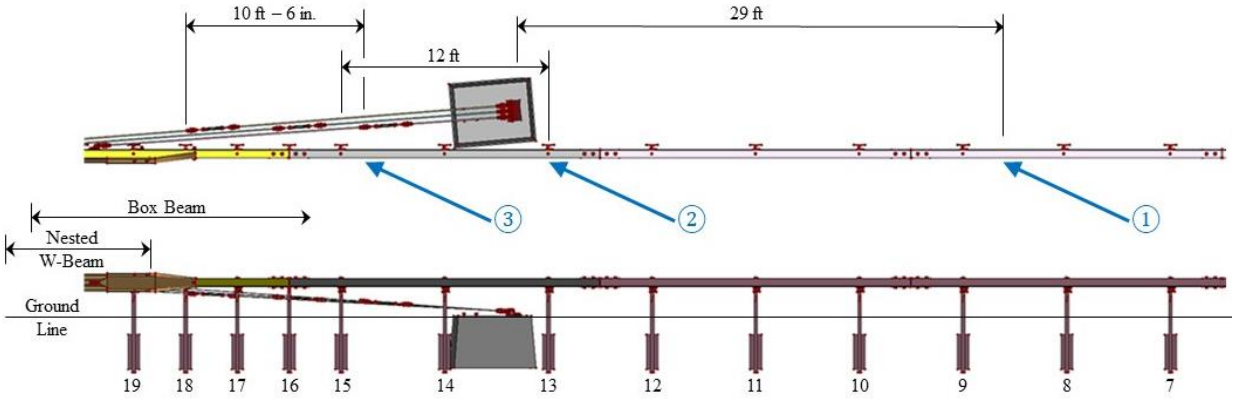


Figure 49. Potential CIPs for Box Beam to HPBO Transition, Test Designation No. 3-21 (2270P)

CIP option no. 1 was intended to maximize the likelihood of the vehicle overriding the cable anchorage assembly and interacting with the cables due to the deflection of the box beam. Recall, in test no. NYBWT-2 [11], a similar transition system had the cable anchorage located 7 ft laterally behind the backside of the box beam. It is desired to evaluate the closer proximity (i.e., 2 ft) used for the cable anchorage in this system. Therefore, an impact of 29.0 ft upstream from the midpoint of the cable anchorage was selected after examination of the trajectory in NCHRP 22-

14(03) test no. 476460-1-6, conducted on a similar box beam system with S3x5.7 posts spaced at 72 in., in which the 2270P test vehicle reached its maximum lateral deflection 29.0 ft downstream of the impact point.

CIP option no. 2 was intended to maximize the possibility of the vehicle's right-front tire to underride the rail, interact with the cables, or partially override the cable anchorage and evaluate the potential for vehicle snag at post no. 15, where post spacing decreases. An impact of 12 ft upstream from post no. 15 was determined using Figure 2-17 in MASH 2016.

CIP option no. 3 was intended to maximize vehicle interaction with the leading edge of the transition cover plate and nested W-beam and evaluate the possibility of the vehicle's right-front tire underriding the box beam or interacting with the cables during vehicle redirection. An impact of 10.5 ft upstream from post no. 18 was determined using Figure 2-17 in MASH 2016. This impact is similar to the one used in test no. NYBWT-2, which successfully met MASH 2016 test designation no. 3-21 safety performance criteria, with the vehicle exhibited a propensity to roll over as it slid along the traffic side of the W-beam [11].

Considering successful MASH crash testing of the similar box-beam to W-beam transition system [11], CIP option no. 1 was recommended for test designation no. 3-21. The relatively close proximity of the cables and cable anchorage to the backside of the box beam increases the likelihood of interaction with the 2270P test vehicle during redirection by the system.

4.3.2 MASH Test Designation No. 3-20

For the 1100C vehicle impact, three possible CIPs were determined, as shown in Figure 50.

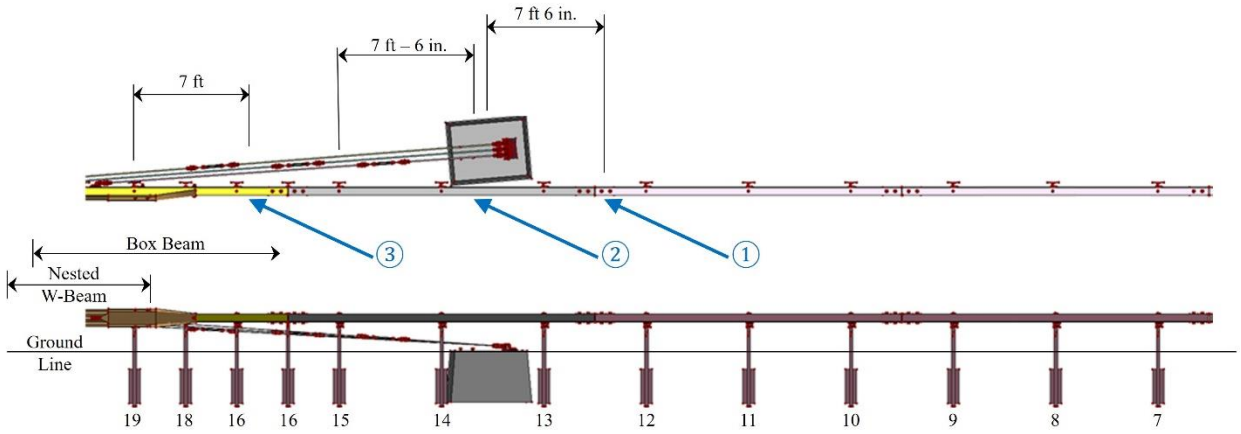


Figure 50. Potential CIPs for Box Beam to HPBO Transition, Test Designation No. 3-20 (1100C)

CIP option no. 1 was intended to maximize the possibility of the vehicle overriding most or all of the cable anchorage or interacting with the cables due to the deflection of the box beam. Previous full-scale crash testing on a similar system, specifically test no. NYBWT-2, used a cable anchorage located 7 ft laterally behind the backside of the box beam. It was desired to evaluate the closer proximity (i.e., 2 ft) used for the cable anchorage in this system. Therefore, an impact 7.5 ft

upstream from the midpoint of the cable anchorage was determined using Figure 2-14 in MASH 2016.

CIP option no. 2 was intended to evaluate the potential for the vehicle's wheels to partially override the cable anchorage or interact with the cables and the possibility of vehicle snag at post no. 15, where post spacing decreases. Thus, an impact of 7.5 ft upstream from post no. 15 was determined using Figure 2-14 in MASH 2016.

CIP option no. 3 was intended to evaluate the potential for hardware failure or vehicle instability at critical points in the system, including the potential for the vehicle's wheels underriding the rail as it interacts with the traffic side of the HPBO. Thus, an impact of 7 ft upstream from post no. 19, which is the first post in the box beam to HPBO transition area, was selected using Figure 2-14 in MASH 2016.

CIP option no. 2 was recommended for MASH test designation no. 3-20 of the box beam to HPBO transition. This impact point evaluates the potential vehicle interaction with the cable anchorage and vehicle snag on the reduced post spacing region.

5 TEST CONDITIONS

5.1 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 five miles northwest of the University of Nebraska-Lincoln.

5.2 Vehicle Tow and Guidance System

A reverse-cable tow system with a 1:2 mechanical advantage was used to propel each 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 [12] was used to steer the test vehicles. A guide flag, attached to the guidance-side (non-impact side) front wheel and the guide cable, was sheared off before impact with the barrier system. The ⅜-in. diameter guide cable was tensioned to approximately 3,500 lb and supported both laterally and vertically every 100 ft 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.

5.3 Test Vehicles

For test no. NYHBT-1, a 2014 Dodge Ram 1500 crew cab pickup truck was used as the test vehicle. The curb, test inertial, and gross static vehicle weights were 5,018 lb, 4,997 lb, and 5,157 lb, respectively. The test vehicle is shown in Figures 51 and 52, and vehicle dimensions are shown in Figure 53.

For test no. NYHBT-2, a 2010 Kia Rio was used as the test vehicle. The curb, test inertial, and gross static vehicle weights were 2,472 lb, 2,421 lb, and 2,584 lb, respectively. The test vehicle is shown in Figures 54 and 55, and vehicle dimensions are shown in Figure 56.

For test no. NYBHT-1, a 2014 Dodge Ram 1500 quad cab pickup truck was used as the test vehicle. The curb, test inertial, and gross static vehicle weights were 5,113 lb, 5,000 lb, and 5,156 lb, respectively. The test vehicle is shown in Figures 57 and 58, and vehicle dimensions are shown in Figure 59.

For test no. NYBHT-2, a 2009 Hyundai Accent was used as the test vehicle. The curb, test inertial, and gross static vehicle weights were 2,483 lb, 2,442 lb, and 2,605 lb, respectively. The test vehicle is shown in Figures 60 and 61, and vehicle dimensions are shown in Figure 62.

MASH requires test vehicles used in crash testing to be no more than six model years old at the time of the test. Older models were used for the 1100C vehicles in test nos. NYHBT-2 and NYBHT-2 because the vehicle geometry of newer models did not comply with the recommended vehicle dimension ranges specified in Table 4.1 of MASH. The use of older test vehicles due to recent small car vehicle properties falling outside of MASH recommendations was allowed by FHWA and AASHTO in MASH implementation guidance dated May of 2018 [13].

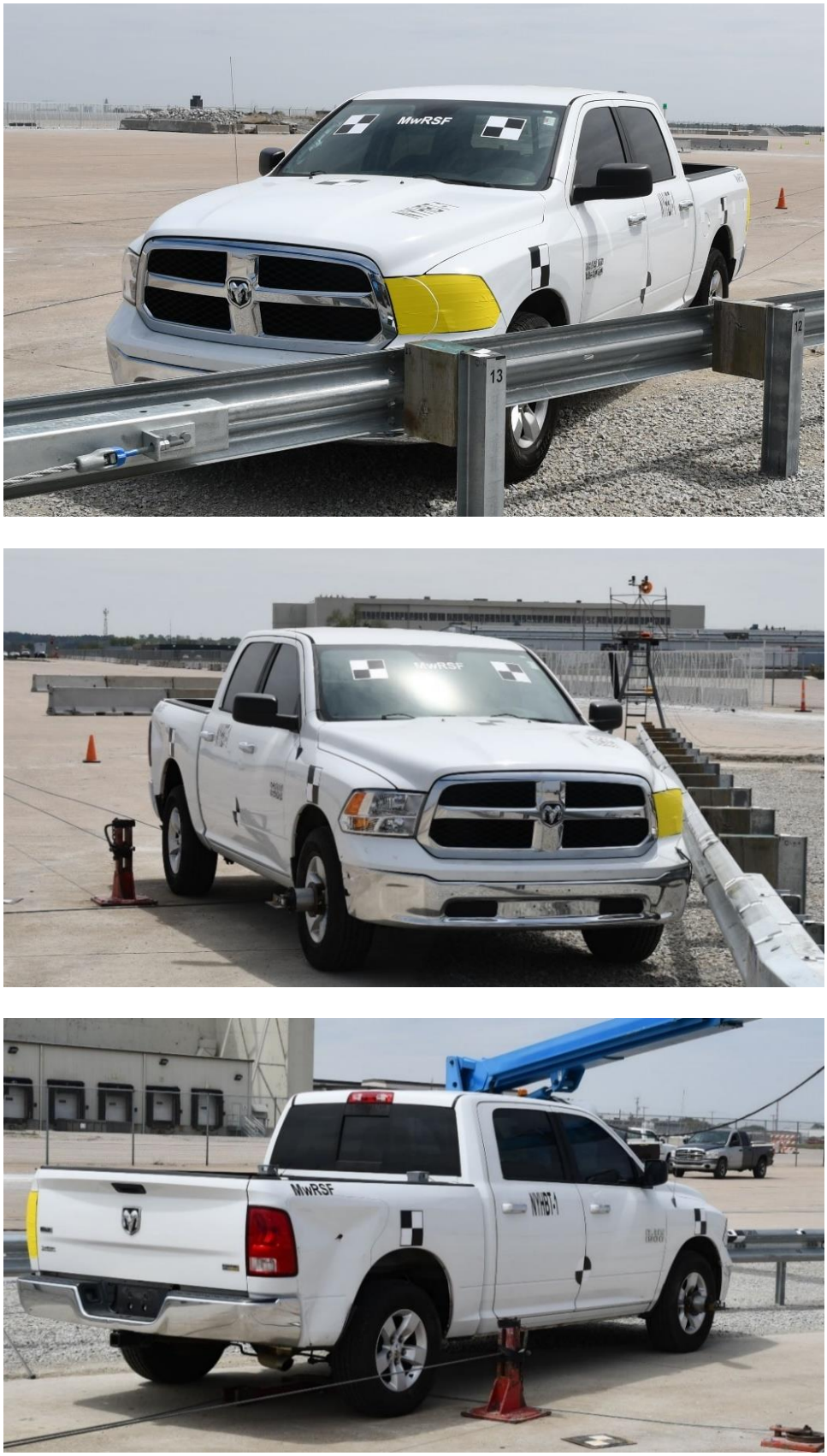


Figure 51. Test Vehicle, Test No. NYHBT-1







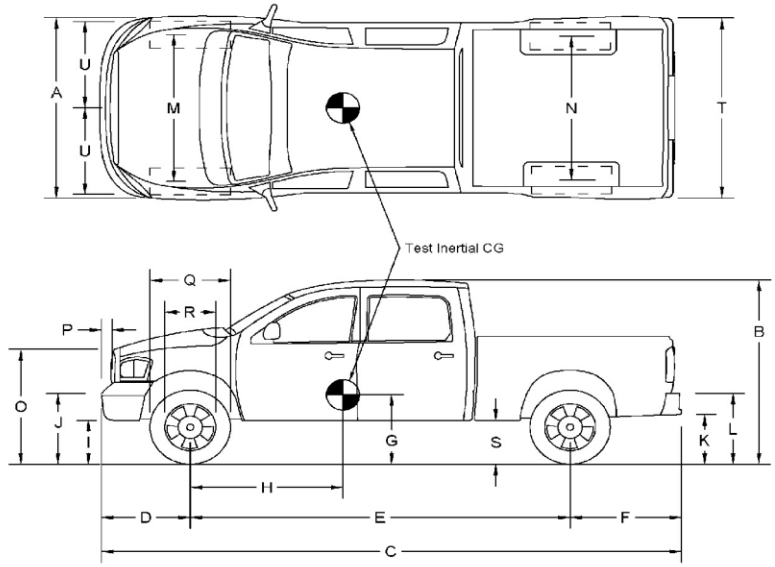


Figure 52. Test Vehicle's Interior Floorboard and Undercarriage, Test No. NYHBT-1

Test Name: NYHBT-1 VIN No: 1C6RR6LG6ES164753

Model Year: 2014 Make: Dodge Model: Ram 1500

Tire Size: 265/70R17 Tire Inflation Pressure: 40 psi Odometer: 195722



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

A:	77 7/8 (1978)	B:	73 3/4 (1873)
	78±2 (1950±50)		
C:	228 3/4 (5810)	D:	39 (991)
	237±13 (6020±325)		39±3 (1000±75)
E:	140 1/4 (3562)	F:	49 (1245)
	148±12 (3760±300)		
G:	28 3/16 (716)	H:	66 1/8 (1680)
	min: 28 (710)		63±4 (1575±100)
I:	12 1/2 (318)	J:	22 5/8 (575)
K:	20 1/8 (511)	L:	29 (737)
M:	67 1/2 (1715)	N:	67 1/2 (1715)
	67±1.5 (1700±38)		67±1.5 (1700±38)
O:	44 1/4 (1124)	P:	4 1/8 (105)
	43±4 (1100±75)		
Q:	30 1/2 (775)	R:	18 1/2 (470)
S:	18 (457)	T:	76 1/8 (1934)

U (impact width): 37 1/8 (943)

Mass Distribution - lb (kg)

Gross Static	LF	1417 (643)	RF	1321 (599)
	LR	1200 (544)	RR	1219 (553)

Weights lb (kg)	Curb	Test Inertial	Gross Static
W-front	2714 (1231)	2640 (1197)	2738 (1242)
W-rear	2304 (1045)	2357 (1069)	2419 (1097)
W-total	5018 (2276)	4997 (2267)	5157 (2339)
		5000±110 (2270±50)	5165±110 (2343±50)

Wheel Center Height (Front):	14 5/8 (371)
Wheel Center Height (Rear):	14 3/4 (375)
Wheel Well Clearance (Front):	35 1/8 (892)
Wheel Well Clearance (Rear):	37 5/8 (956)
Bottom Frame Height (Front):	12 (305)
Bottom Frame Height (Rear):	13 (330)
Engine Type:	Gasoline
Engine Size:	3.6L V6
Transmission Type:	Automatic
Drive Type:	RWD
Cab Style:	Crew Cab
Bed Length:	67"

GVWR Ratings - lb

Front	3700
Rear	3900
Total	6700

Surrogate Occupant Data

Type:	Hybrid II
Mass:	160 lb
Seat Position:	Left/Drivers

Note any damage prior to test: Right/Passenger Bedside is dented behind the wheel well and up to the bodyline.

Figure 53. Vehicle Dimensions, Test No. NYHBT-1



Figure 54. Test Vehicle, Test No. NYHBT-2



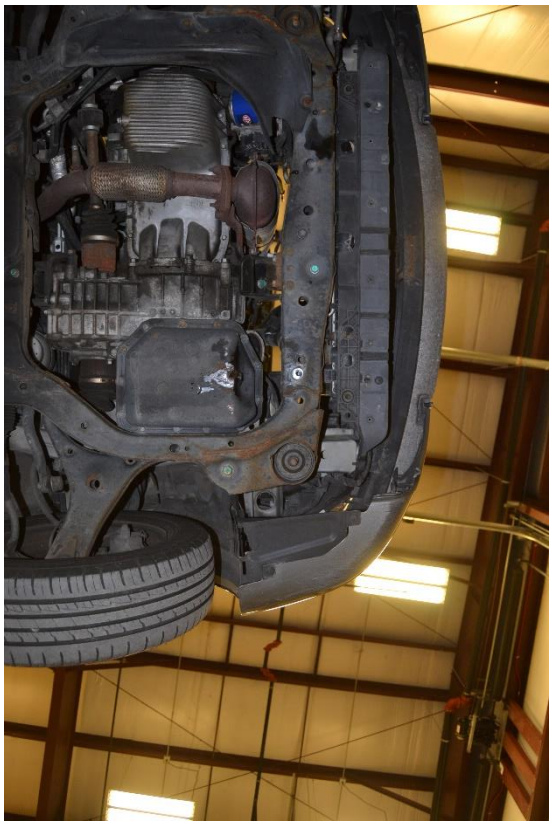
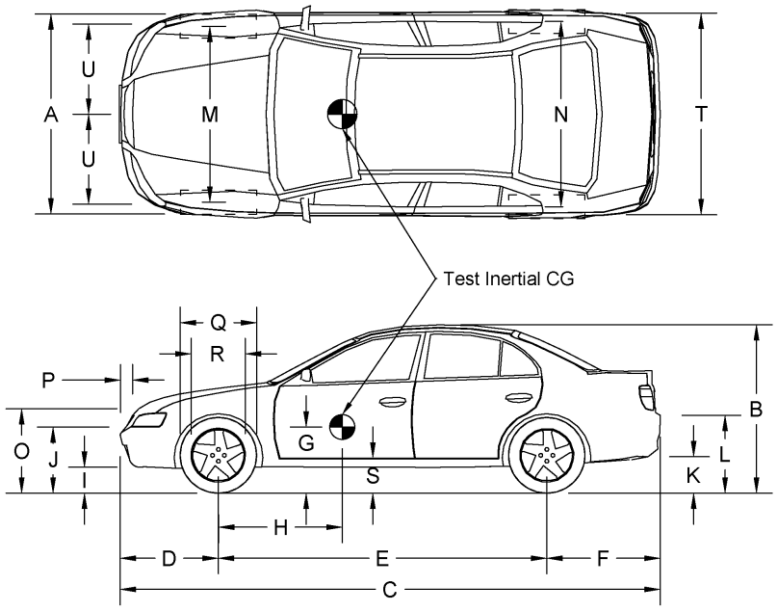






Figure 55. Test Vehicle's Interior Floorboard and Undercarriage, Test No. NYHBT-2

Test Name:	NYHBT-2		**VIN No:**	KNADH4A38A6687587	
Model Year:	2010	**Make:**	Kia	**Model:**	Rio
Tire Size:	185/65/R14	**Tire Inflation Pressure:**	32 psi	**Odometer:**	163286



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

A:	66 1/8 (1680) 65±3 (1650±75)	**B:**	57 (1448)
C:	167 1/8 (4245) 169±8 (4300±200)	**D:**	35 (889) 35±4 (900±100)
E:	98 3/8 (2499) 98±5 (2500±125)	**F:**	33 3/4 (857)
G:	22 1/8 (562)	**H:**	36 1/16 (916) 39±4 (990±100)
I:	15 1/4 (387)	**J:**	19 1/4 (489)
K:	15 3/4 (400)	**L:**	24 (610)
M:	58 3/8 (1483) 56±2 (1425±50)	**N:**	57 9/16 (1462) 56±2 (1425±50)
O:	26 1/4 (667) 24±4 (600±100)	**P:**	3/4 (19)
Q:	23 (584)	**R:**	15 1/3 (389)
S:	11 1/4 (286)	**T:**	65 5/8 (1667)

U (impact width): 29 (737)

Mass Distribution - lb (kg)

Gross Static	**LF**	838 (380)	**RF**	781 (354)
	LR	484 (220)	**RR**	481 (218)

Weights lb (kg)	**Curb**	**Test Inertial**	**Gross Static**
W-front	1588 (720)	1534 (696)	1619 (734)
W-rear	884 (401)	887 (402)	965 (438)
W-total	2472 (1121)	2421 (1098) 2420±55 (1100±25)	2584 (1172) 2585±55 (1175±50)

Top of radiator core support:	28 (711)
Wheel Center Height (Front):	11 1/8 (283)
Wheel Center Height (Rear):	11 1/4 (286)
Wheel Well Clearance (Front):	24 3/4 (629)
Wheel Well Clearance (Rear):	25 (635)
Bottom Frame Height (Front):	5 1/2 (140)
Bottom Frame Height (Rear):	5 1/2 (140)
Engine Type:	Gasoline
Engine Size:	1.4L 4 Cyl
Transmission Type:	Automatic
Drive Type:	FWD

GVWR Ratings lb

Front	1918
Rear	1874
Total	3638

Surrogate Occupant Data

Type:	Hybrid II
Mass:	163 lb
Seat Position:	Left/Driver

Note any damage prior to test: None

Figure 56. Vehicle Dimensions, Test No. NYHBT-2

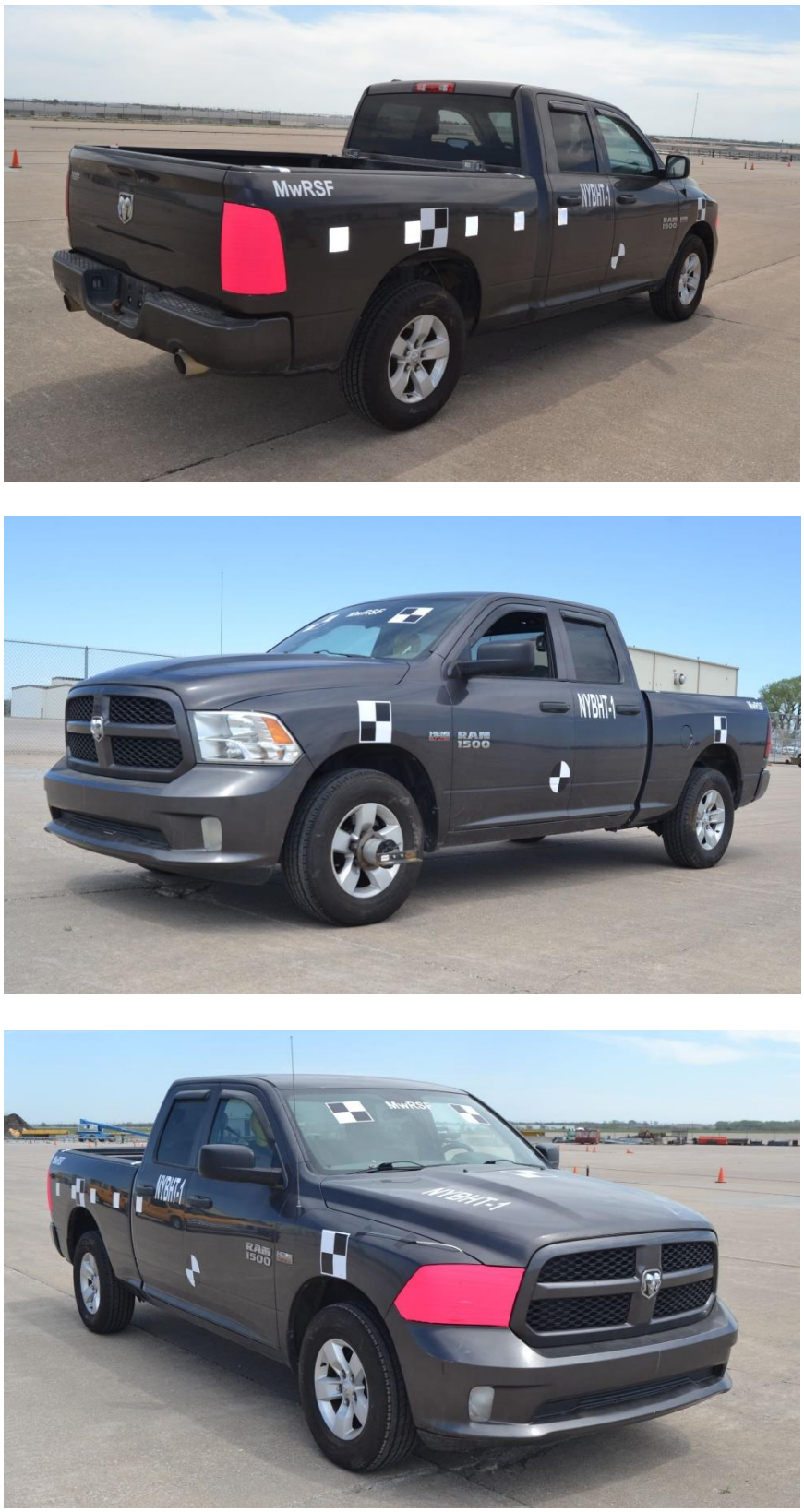


Figure 57. Test Vehicle, Test No. NYBHT-1

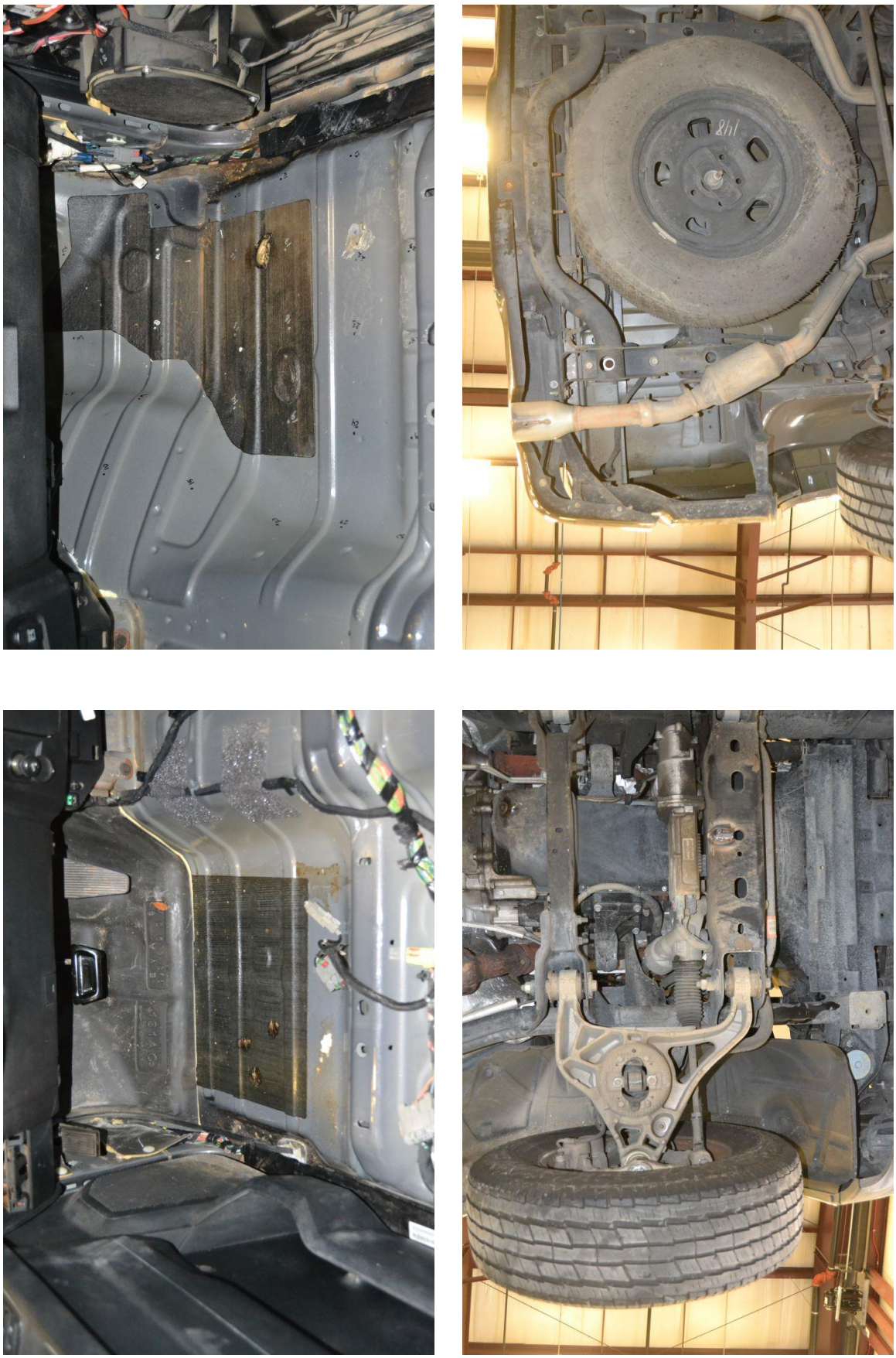
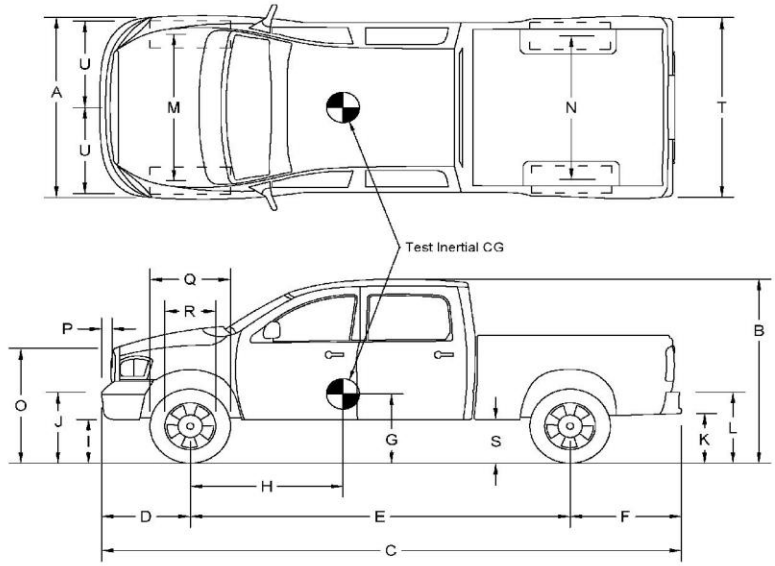


Figure 58. Test Vehicle's Interior Floorboard and Undercarriage, Test No. NYBHT-1

Test Name: NYBHT-1 VIN No: 1C6RR6FT9ES258957

Model Year: 2014 Make: Dodge Model: Ram 1500

Tire Size: 265/70R17 Tire Inflation Pressure: 39 psi Odometer: 214285



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

A:	76 1/4 (1937)	B:	74 7/8 (1902)
	78±2 (1950±50)		
C:	229 (5817)	D:	39 1/4 (997)
	237±13 (6020±325)		39±3 (1000±75)
E:	140 1/2 (3569)	F:	49 1/4 (1251)
	148±12 (3760±300)		
G:	28 13/16 (732)	H:	60 3/8 (1534)
	min: 28 (710)		63±4 (1575±100)
I:	13 (330)	J:	26 3/4 (679)
K:	21 (533)	L:	29 5/8 (752)
M:	68 1/4 (1734)	N:	67 5/8 (1718)
	67±1.5 (1700±38)		67±1.5 (1700±38)
O:	44 7/8 (1140)	P:	4 (102)
	43±4 (1100±75)		
Q:	30 1/4 (768)	R:	18 1/2 (470)
S:	14 1/2 (368)	T:	76 1/2 (1943)

U (impact width): 36 3/4 (933)

Mass Distribution - lb (kg)

Gross Static LF 1463 (664) RF 1487 (674)

LR 1087 (493) RR 1119 (508)

Weights lb (kg)	Curb	Test Inertial	Gross Static
W-front	2925 (1327)	2851 (1293)	2950 (1338)
W-rear	2188 (992)	2149 (975)	2206 (1001)
W-total	5113 (2319)	5000 (2268)	5156 (2339)
		5000±110 (2270±50)	5165±110 (2343±50)

GVWR Ratings - lb

Front 3700

Rear 3900

Total 6900

Surrogate Occupant Data

Type: Hybrid II

Mass: 156 lb

Seat Position: Right/Passenger

Wheel Center Height (Front): 14 3/4 (375)

Wheel Center Height (Rear): 15 1/4 (387)

Wheel Well Clearance (Front): 35 1/2 (902)

Wheel Well Clearance (Rear): 38 1/5 (970)

Bottom Frame Height (Front): 12 1/8 (308)

Bottom Frame Height (Rear): 13 5/8 (346)

Engine Type: Gasoline

Engine Size: 4.7l V8

Transmission Type: Automatic

Drive Type: RWD

Cab Style: Quad Cab

Bed Length: 76"

Note any damage prior to test: None

Figure 59. Vehicle Dimensions, Test No. NYBHT-1



Figure 60. Test Vehicle, Test No. NYBHT-2

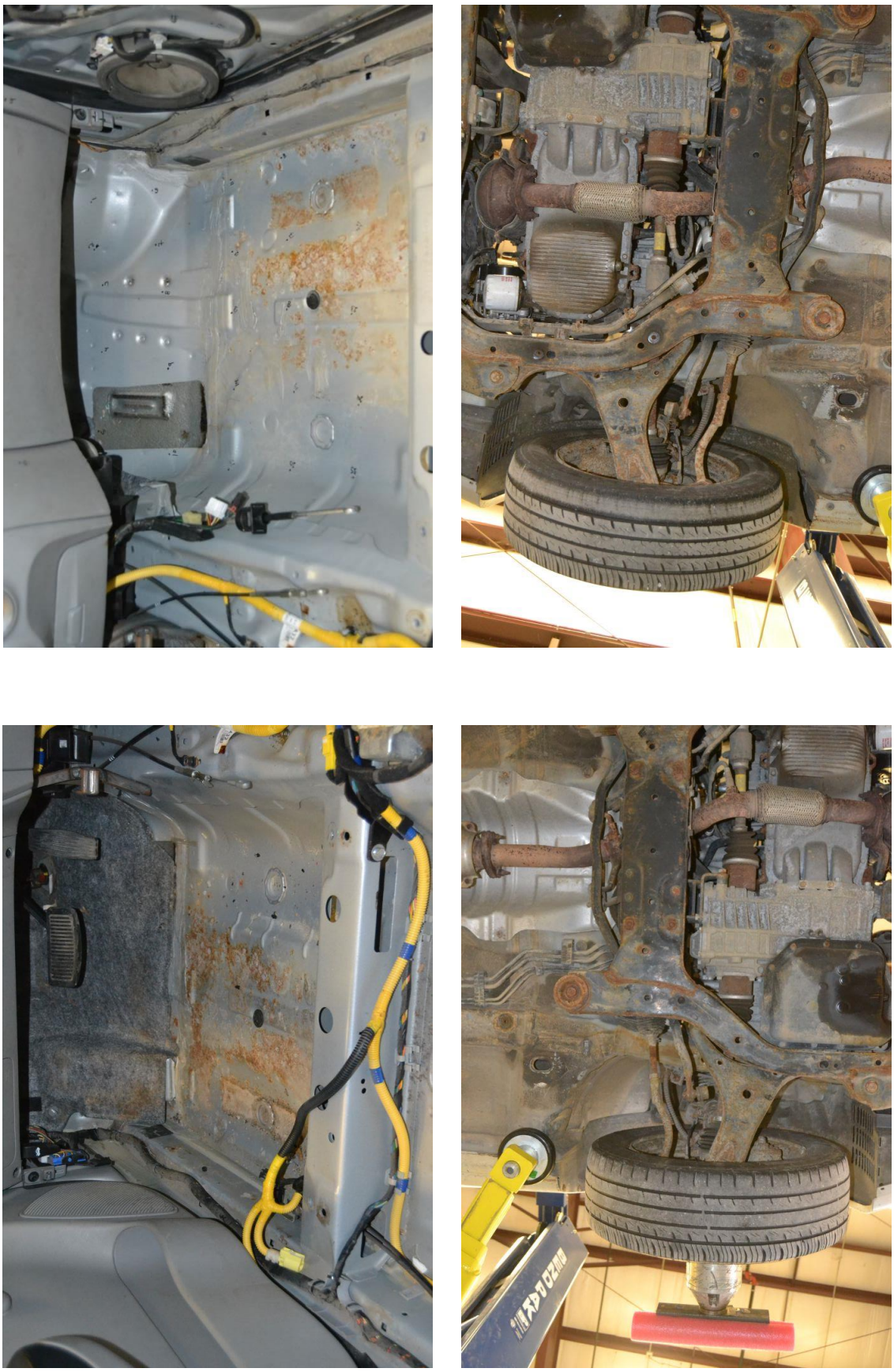
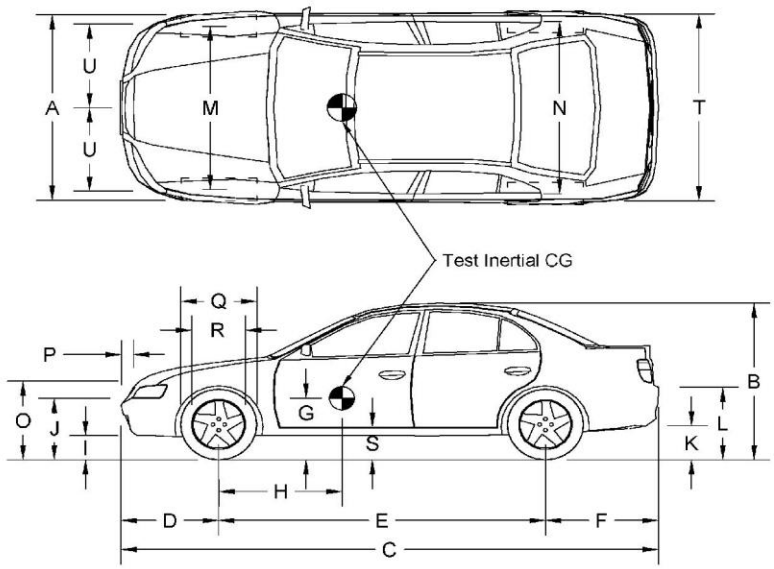


Figure 61. Test Vehicle's Interior Floorboard and Undercarriage, Test No. NYBHT-2

Test Name: NYBHT-2 VIN No: KMHCN46C49U332399

Model Year: 2009 Make: Hyundai Model: Accent

Tire Size: P185/65R14 Tire Inflation Pressure: 32 psi Odometer: 107456



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

A:	62 (1575)	B:	57 1/2 (1461)
	65±3 (1650±75)		
C:	168 1/2 (4280)	D:	33 1/8 (841)
	169±8 (4300±200)		35±4 (900±100)
E:	98 5/8 (2505)	F:	36 3/4 (933)
	98±5 (2500±125)		
G:	22 5/8 (575)	H:	36 3/8 (924)
			39±4 (990±100)
I:	7 7/8 (200)	J:	19 3/4 (502)
K:	11 3/4 (298)	L:	24 1/2 (622)
M:	58 1/8 (1476)	N:	57 1/4 (1454)
	56±2 (1425±50)		56±2 (1425±50)
O:	27 (686)	P:	1 (25)
	24±4 (600±100)		
Q:	22 (559)	R:	15 1/2 (394)
S:	11 1/4 (286)	T:	61 1/4 (1556)

U (impact width): 28 1/2 (724)

Mass Distribution - lb (kg)

Gross Static	LF	807 (366)	RF	819 (371)
	LR	467 (212)	RR	512 (232)

Top of radiator core support:	27 7/8 (708)
Wheel Center Height (Front):	10 1/2 (267)
Wheel Center Height (Rear):	10 7/8 (276)
Wheel Well Clearance (Front):	24 1/2 (622)
Wheel Well Clearance (Rear):	24 3/4 (629)
Bottom Frame Height (Front):	6 1/2 (165)
Bottom Frame Height (Rear):	15 1/2 (394)

Weights lb (kg)	Curb	Test Inertial	Gross Static
W-front	1589 (721)	1542 (699)	1626 (738)
W-rear	894 (406)	900 (408)	979 (444)
W-total	2483 (1126)	2442 (1108)	2605 (1182)
		2420±55 (1100±25)	2585±55 (1175±50)

Engine Type: Gasoline

Engine Size: 1.4L 4 cyl

Transmission Type: Automatic

Drive Type: FWD

GVWR Ratings lb

Front	1918
Rear	1874
Total	3638

Surrogate Occupant Data

Type:	Hybrid II
Mass:	163 lb
Seat Position:	Right/Passenger

Note any damage prior to test: Hail damage concentrated mainly on the hood, roof, and trunk. All other pre-existing damage is circled on vehicle

Figure 62. Vehicle Dimensions, Test No. NYBHT-2

The longitudinal component of the center of gravity (c.g.) was determined using the measured axle weights. The Suspension Method [14] was used to determine the vertical component of the c.g. for the 2270P vehicles. This method is based on the principle that the c.g. of any freely suspended body is in the vertical plane through the point of suspension. The vehicle was suspended successively in three positions, and the respective planes containing the c.g. were established. The intersection of these planes pinpointed the final c.g. location for the test inertial condition. The vertical component of the c.g. for the 1100C vehicles was determined utilizing a procedure published by the Society of Automotive Engineers (SAE) [15]. The final c.g. locations were shown in Figures 53, 56, 59, and 62. Ballast information and data used to calculate the c.g. location are shown in Appendix F.

Square, checkered targets were placed on the vehicles, as shown in Figures 63 through 66, to serve as a reference in the high-speed digital video and aid in video analysis. Round, checkered targets were placed at the c.g. on the left-side door, the right-side door, and the roof of the vehicle.

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 each vehicle's impact-side windshield wiper and was fired by a pressure tape switch mounted at the impact corner of the bumper. The flash bulb was fired upon initial impact with the test article to create a visual indicator of the precise time of impact on the high-speed digital videos. A radio-controlled brake system was installed in the test vehicles so the vehicles could be brought safely to a stop after the test.

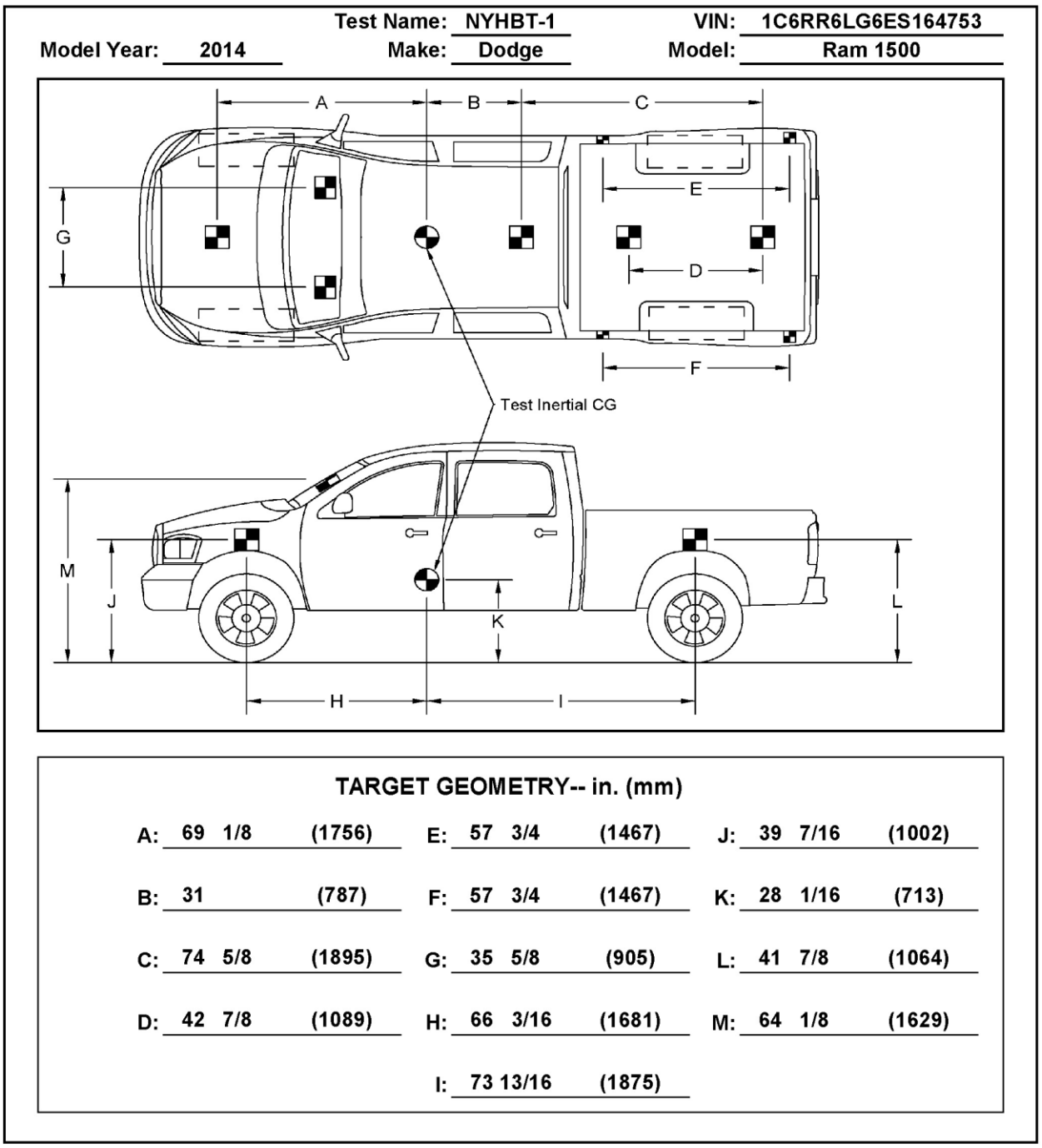


Figure 63. Target Geometry, Test No. NYHBT-1

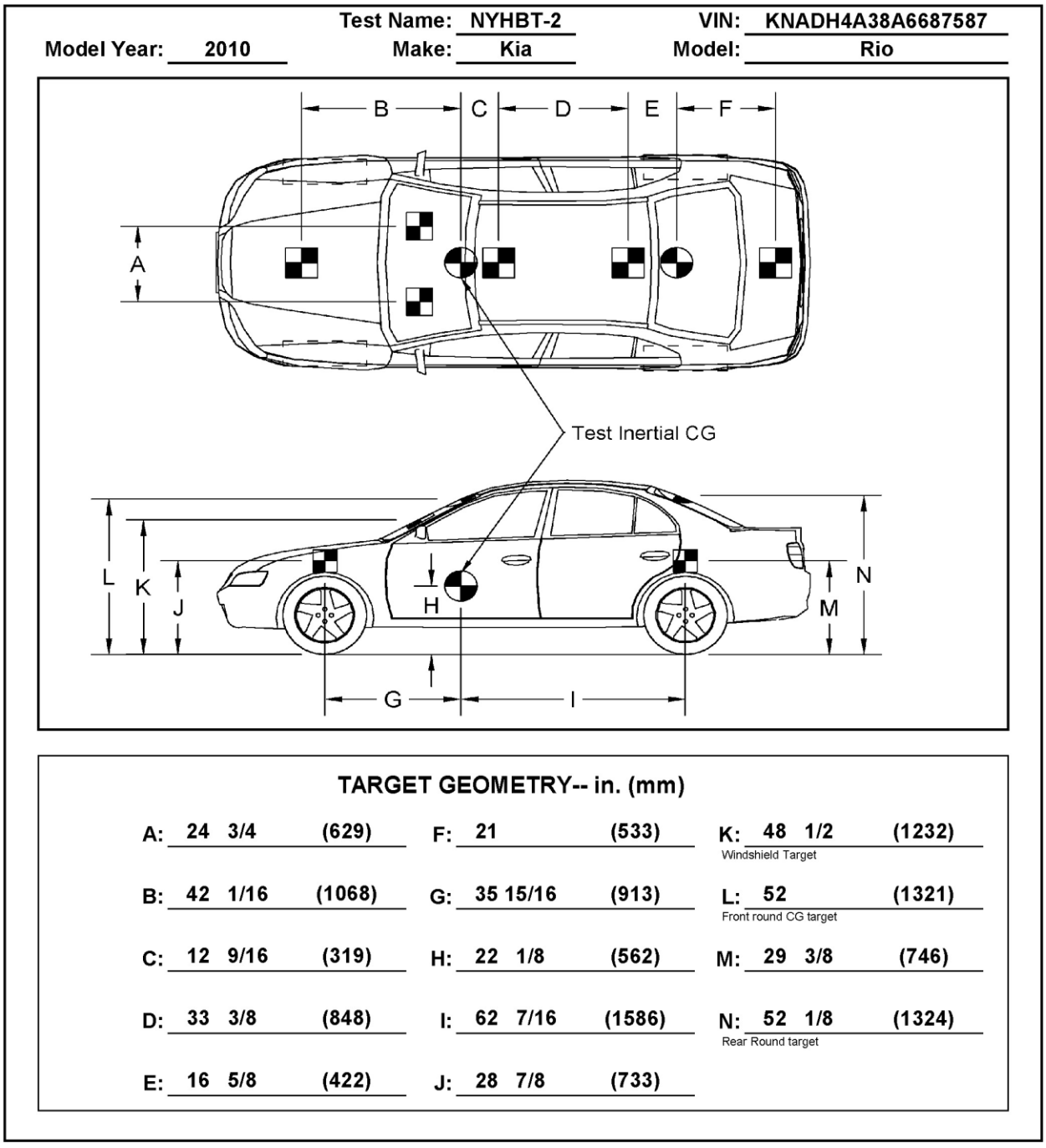


Figure 64. Target Geometry, Test No. NYHBT-2

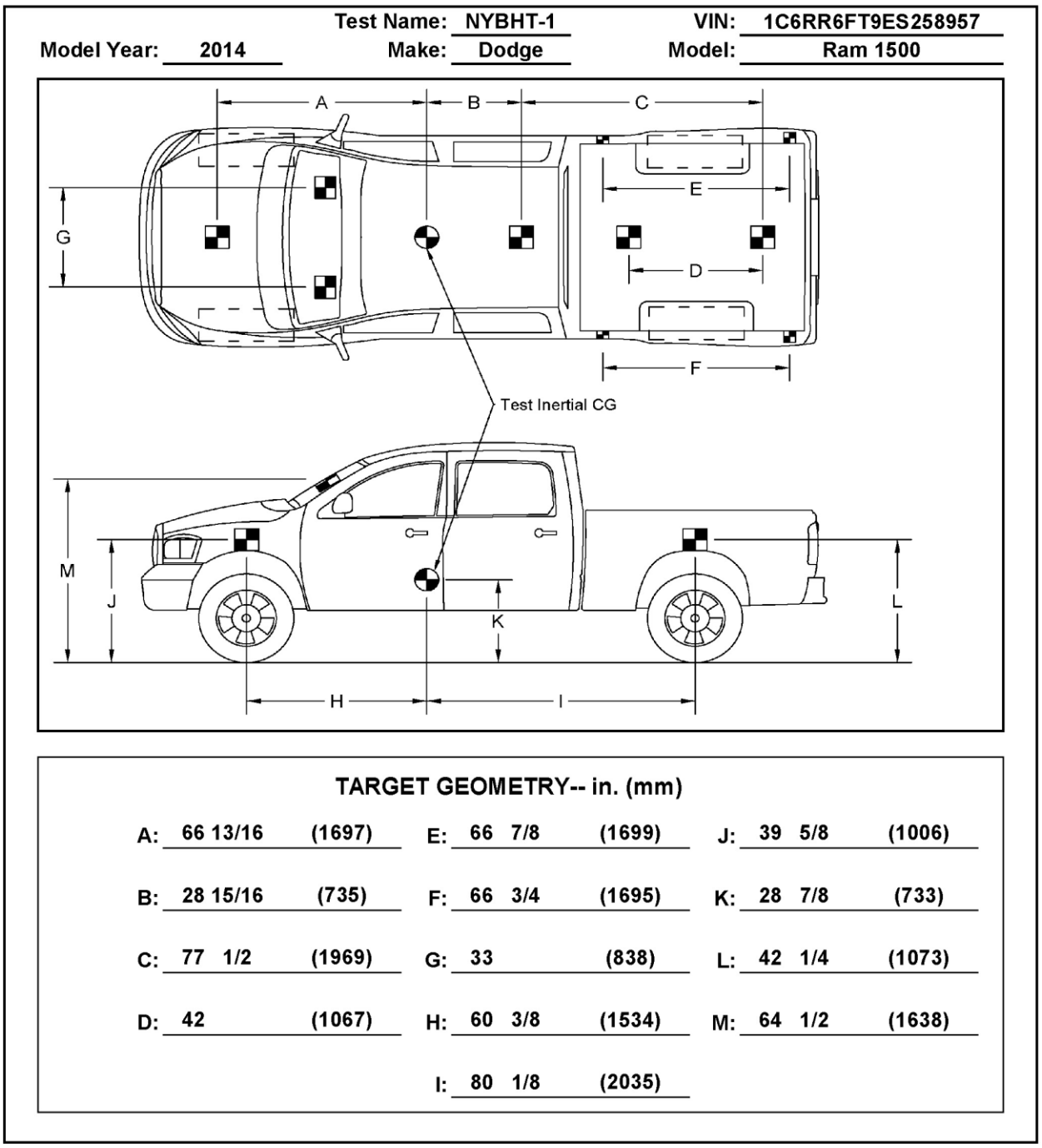


Figure 65. Target Geometry, Test No. NYBHT-1

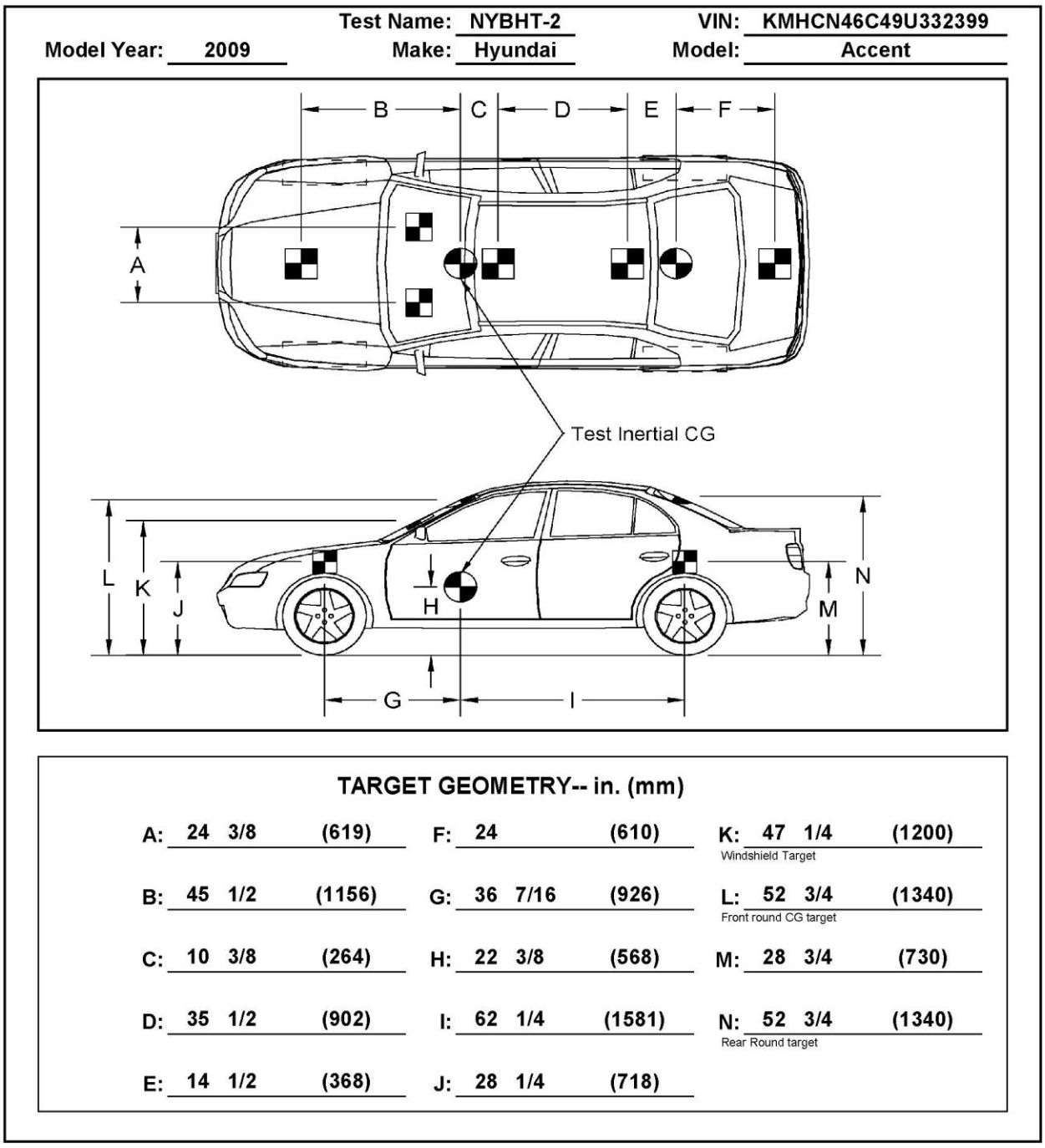


Figure 66. Target Geometry, Test No. NYBHT-2

5.4 Simulated Occupant

For all tests, a Hybrid II 50th-Percentile, Adult Male Dummy equipped with footwear was placed in the impact-side front seat of the test vehicle with the seat belt fastened. The simulated occupant location and final weight for each test are summarized in Table 3. As recommended by MASH, the simulated occupant weight was not included in calculating the c.g. location.

Table 3. Simulated Occupant Location and Weight

Test No.	Location	Weight lb
NYHBT-1	Left-Front Seat	160
NYHBT-2	Left-Front Seat	163
NYBHT-1	Right-Front Seat	156
NYBHT-2	Right-Front Seat	163

5.5 Data Acquisition Systems

5.5.1 Accelerometers and Rate Transducers

The accelerometer and rate transducer systems used in the full-scale crash testing were the SLICE-1, SLICE-2, and TDAS units described below. Unit selection for each test is summarized in Table 4, and all units were positioned near the c.g. of the test vehicle. Data obtained in dynamic testing was filtered using the SAE Class 60 and the SAE Class 180 Butterworth filter conforming to the SAEJ211/1 specifications [16].

Table 4. Accelerometer and Rate Transducer Systems

Test No.	Primary System	Backup System
NYHBT-1	SLICE-2	SLICE-1
NYHBT-2	SLICE-1	SLICE-2
NYBHT-1	SLICE-2	SLICE-1
NYBHT-2	SLICE-1	TDAS*

* Due to technical difficulties, Euler angles could not be determined from the triaxial angular rate data.

The SLICE-1 and SLICE-2 units were modular data acquisition systems manufactured by Diversified Technical Systems, Inc. of Seal Beach, California. Triaxial acceleration and angular rate sensor modules were mounted inside the bodies of custom-built SLICE 6DX event data recorders equipped with 7 GB of non-volatile flash memory and recorded data at 10,000 Hz to the onboard microprocessor. The accelerometers had a range of ±500g's in each of three directions (longitudinal, lateral, and vertical) and a 1,650 Hz (CFC 1000) anti-aliasing filter. Each SLICE unit also contained an angular rate sensor system, the SLICE MICRO Triax ARS, which had a range of 1,500 degrees/sec in each of three directions (roll, pitch, and yaw). The raw angular rate measurements were 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 both the accelerometer and angular rate sensor data.

The TDAS unit was a data acquisition system developed and manufactured by Diversified Technical Systems, Inc. of Seal Beach, California. Sensor data was collected using a DTS Sensor Input Module (SIM), Model TDAS3-SIM-16M mounted on the TDAS3-R4 module rack. The SIM was configured with 16 MB SRAM and eight sensor input channels with 250kB SRAM/channel.

The module rack was configured with isolated power/event/communications, 10BaseT Ethernet and RS232 communication, and an internal backup battery. Both the SIM and module rack were crashworthy. The unit was configured to record one set of triaxial acceleration data and one set of triaxial angular rate data. The two-arm piezoresistive accelerometer module manufactured by Endevco of San Juan Capistrano, California measured longitudinal, lateral, and vertical accelerations independently at a sample rate of 10,000 Hz. The ARS-1500 angular rate sensors with a range of 1,500 degrees/sec measured the rates of rotation of the test vehicle in three directions (roll, pitch, and yaw) and recorded data at 10,000 Hz to the DTS SIM. The "DTS TDAS Control" computer software program and a customized Microsoft Excel worksheet were used to analyze and plot both the accelerometer and angular rate sensor data. Due to technical difficulties with one of the angular rate sensors, in test no. NYBHT-2, Euler angles could not be determined from the raw data measurements. However, the TDAS unit was the backup unit, and the primary unit provided the required data for test evaluation.

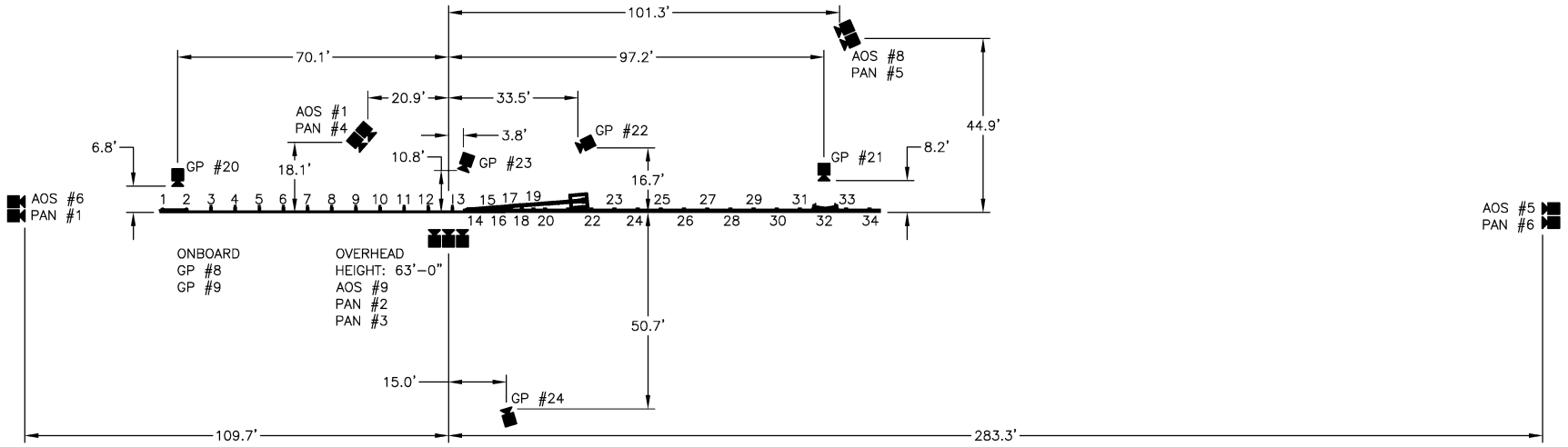
5.5.2 Retroreflective Optic Speed Trap

A retroreflective optic speed trap was used to determine the speed of each test vehicle before impact. Five retroreflective targets, spaced at approximately 18-in. intervals, were applied to the impact side of all test 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, and 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 were used as a backup if vehicle speeds cannot be determined from the electronic data.

5.5.3 Digital Photography

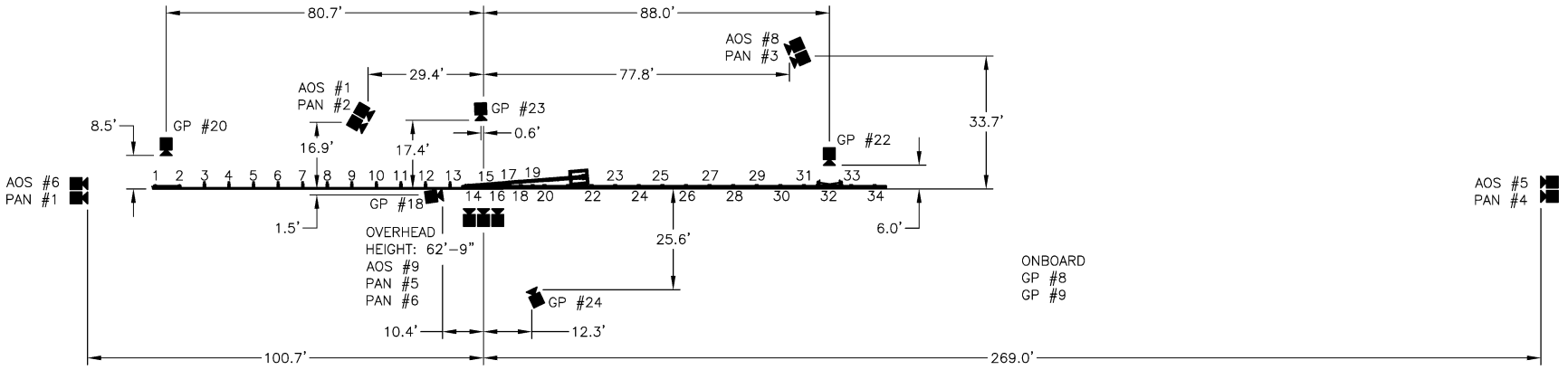
Five AOS high-speed digital video cameras, seven GoPro digital video cameras, and six Panasonic digital video cameras were utilized to film test nos. NYHBT-1, NYHBT-2, and NYBHT-1. Five AOS high-speed digital video cameras, eight GoPro digital video cameras, and six Panasonic digital video cameras were utilized to film test no. NYBHT-2. Camera details, camera operating speeds, lens information, and a schematic of the camera locations relative to the system are shown in Figures 67 through 70. As noted in Figure 68, one of the GoPro cameras did not record the impact event for test no. NYHBT-2.

The high-speed videos were analyzed using AOS, 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	Fujinon 35mm Fixed	-
AOS-5	AOS X-PRI Gigabit	500	100mm Fixed	-
AOS-6	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-8	GoPro Hero 4	120		
GP-9	GoPro Hero 4	120		
GP-20	GoPro Hero 6	240		
GP-21	GoPro Hero 6	240		
GP-22	GoPro Hero 7	240		
GP-23	GoPro Hero 7	240		
GP-24	GoPro Hero 7	240		
PAN-1	Panasonic HC-V770	120		
PAN-2	Panasonic HC-V770	120		
PAN-3	Panasonic HC-V770	120		
PAN-4	Panasonic HC-V770	120		
PAN-5	Panasonic HC-VX981	120		
PAN-6	Panasonic HC-VX981	120		

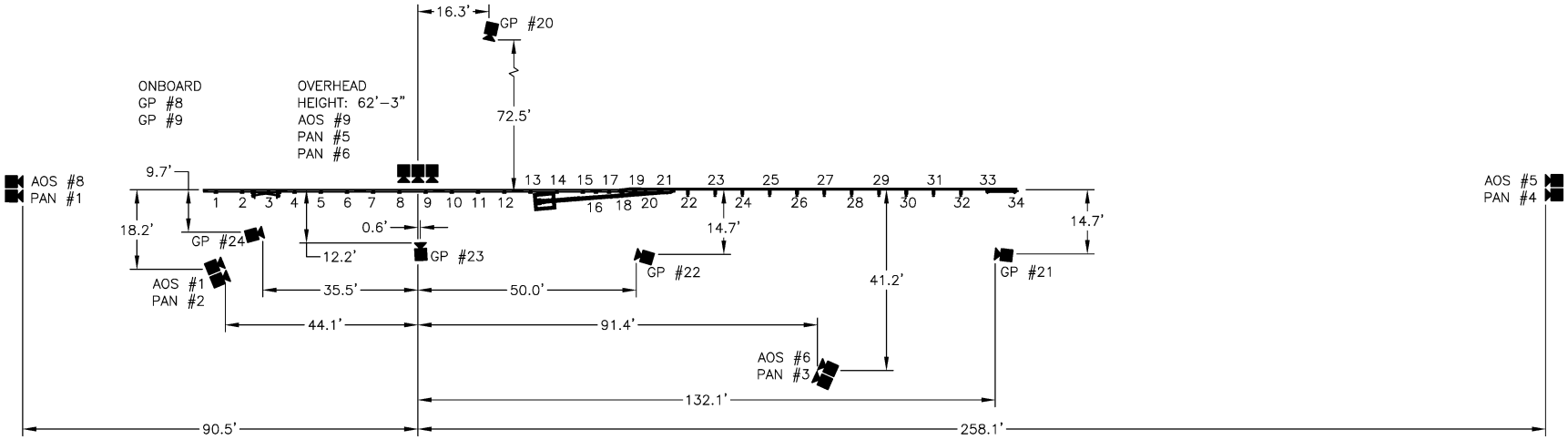
Figure 67. Camera Locations, Speeds, and Lens Settings, Test No. NYHBT-1



No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
AOS-1	AOS Vitcam CTM	500	Fujinon 35mm Fixed	-
AOS-5	AOS X-PRI Gigabit	500	100mm Fixed	-
AOS-6	AOS X-PRI Gigabit	500	Fujinon 50mm Fixed	-
AOS-8	AOS S-VIT 1531	500	Sigma 28-70mm	35mm
AOS-9	AOS TRI-VIT 2236	1000	Kowa 12mm Fixed	-
GP-8	GoPro Hero 4	120		
GP-9	GoPro Hero 4	120		
GP-18	GoPro Hero 6	240		
GP-20*	GoPro Hero 6	240		
GP-22	GoPro Hero 7	240		
GP-23	GoPro Hero 7	240		
GP-24	GoPro Hero 7	240		
PAN-1	Panasonic HC-V770	120		
PAN-2	Panasonic HC-V770	120		
PAN-3	Panasonic HC-V770	120		
PAN-4	Panasonic HC-V770	120		
PAN-5	Panasonic HC-VX981	120		
PAN-6	Panasonic HC-VX981	120		

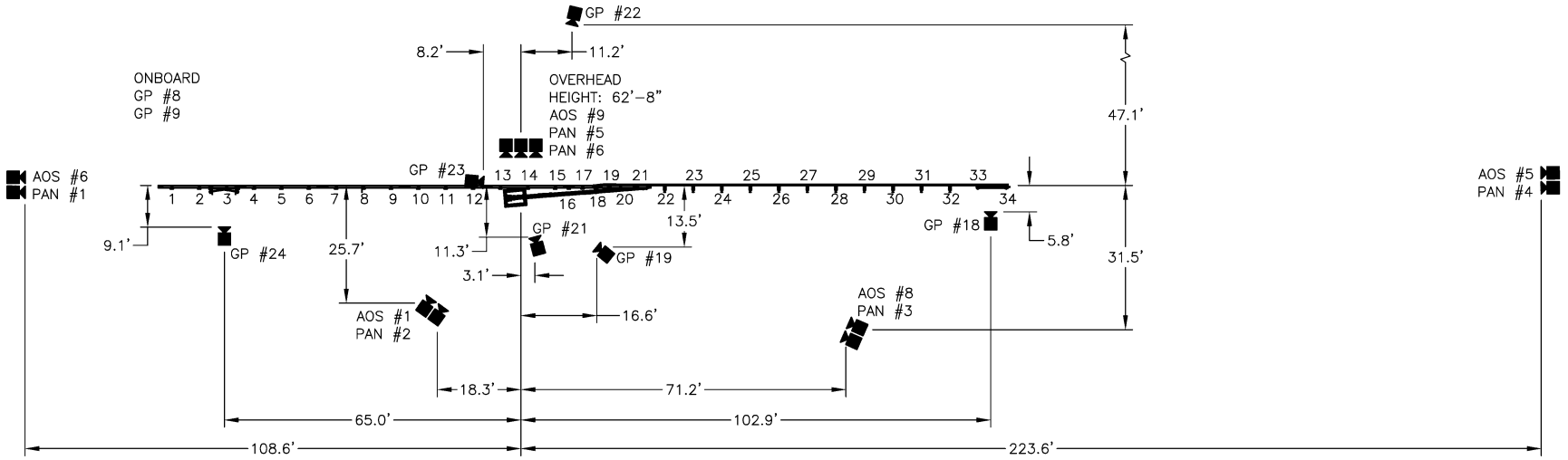
* Due to technical difficulties camera did not record impact event.

Figure 68. Camera Locations, Speeds, and Lens Settings, Test No. NYHBT-2



No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
AOS-1	AOS Vitcam	500	Fujinon 75mm Fixed	-
AOS-5	AOS X-PRI	500	100mm Fixed	-
AOS-6	AOS X-PRI	500	Fujinon 35mm Fixed	-
AOS-8	AOS S-VIT 1531	500	Fujinon 50mm Fixed	-
AOS-9	AOS TRI-VIT 2236	1000	Kowa 12mm Fixed	-
GP-8	GoPro Hero 4	120		
GP-9	GoPro Hero 4	120		
GP-20	GoPro Hero 6	240		
GP-21	GoPro Hero 6	240		
GP-22	GoPro Hero 7	240		
GP-23	GoPro Hero 7	240		
GP-24	GoPro Hero 7	240		
PAN-1	Panasonic HC-V770	120		
PAN-2	Panasonic HC-V770	120		
PAN-3	Panasonic HC-V770	120		
PAN-4	Panasonic HC-V770	120		
PAN-5	Panasonic HC-VX981	120		
PAN-6	Panasonic HC-VX981	120		

Figure 69. Camera Locations, Speeds, and Lens Settings, Test No. NYBHT-1



No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
AOS-1	AOS Vitcam	500	Fujinon 35mm Fixed	-
AOS-5	AOS X-PRI	500	100mm Fixed	-
AOS-6	AOS X-PRI	500	Fujinon 50mm Fixed	-
AOS-8	AOS S-VIT 1531	500	Kowa 25mm Fixed	-
AOS-9	AOS TRI-VIT 2236	1000	Kowa 12mm Fixed	-
GP-8	GoPro Hero 4	120		
GP-9	GoPro Hero 4	120		
GP-18	GoPro Hero 6	240		
GP-19	GoPro Hero 6	240		
GP-21	GoPro Hero 6	240		
GP-22	GoPro Hero 7	240		
GP-23	GoPro Hero 7	240		
GP-24	GoPro Hero 7	240		
PAN-1	Panasonic HC-V770	120		
PAN-2	Panasonic HC-V770	120		
PAN-3	Panasonic HC-V770	120		
PAN-4	Panasonic HC-V770	120		
PAN-5	Panasonic HC-VX981	120		
PAN-6	Panasonic HC-VX981	120		

Figure 70. Camera Locations, Speeds, and Lens Settings, Test No. NYBHT-2

6 FULL-SCALE CRASH TEST NO. NYHBT-1

6.1 Static Soil Test

Before full-scale crash test no. NYHBT-1 was conducted, the strength of the foundation soil was evaluated with a static test, as described in MASH [3]. The static test results, as shown in Appendix E, 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. NYHBT-1 was conducted on May 12, 2020, at approximately 3:15 p.m. The weather conditions as reported by the National Oceanic and Atmospheric Administration (station 14939/KLNK) are shown in Table 5.

Table 5. Weather Conditions, Test No. NYHBT-1

Temperature	60°F
Humidity	35%
Wind Speed	8 mph
Wind Direction	150° from True North
Sky Conditions	Cloudy
Visibility	10 Statute Miles
Pavement Surface	Dry
Previous 3-Day Precipitation	0.03 in.
Previous 7-Day Precipitation	0.63 in.

6.3 Test Description

Initial vehicle impact was to occur 84 in. upstream from the centerline of post no. 14, which is the first S3x5.7 weak post, in the transition as shown in Figure 71. As discussed in Section 4.2.1, the CIP was selected to maximize the potential for vehicle interaction with the anchor cables and anchor brackets. The 4,997-lb crew cab pickup truck impacted the NYSDOT HPBO to Box Beam Guide Rail Transition at a speed of 63.7 mph and an angle of 25.1 degrees. The actual point of impact was 84.3 in. upstream from the centerline of post no. 14. After brakes were applied, the vehicle came to rest facing downstream with the left-front tire positioned 118.5 ft downstream from impact and 0.3 ft in front of the system.

A detailed description of the sequential impact events is contained in Tables 6 and 7 and sequential photographs are shown in Figures 72 through 74, with movement definitions shown in Appendix G. Documentary photographs of the crash test are shown in Figures 75 through 76. The vehicle trajectory and final position are shown in Figure 77. Note, the dirt berm seen in most post-test photographs was placed adjacent to the system following the test to prevent rain water runoff from entering the test pit and compromising the post-test system damage.

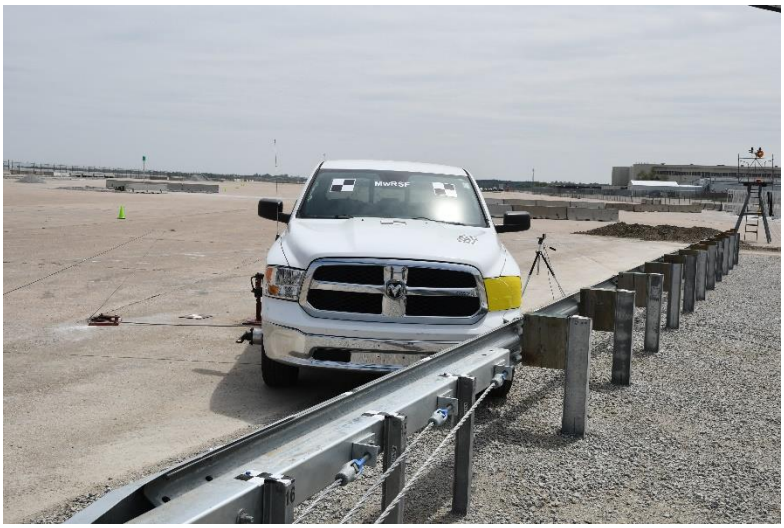






Figure 71. Target Impact Location, Test No. NYHBT-1

Table 6. Sequential Description of Impact Events, Test No. NYHBT-1

Time sec	Event
0.000	Vehicle's front bumper contacted rail at post no. 13 and deformed.
0.004	Post no. 13 deflected backward.
0.010	Vehicle's left fender and headlight contacted rail and deformed.
0.022	Post no. 14 deflected backward. Vehicle's grille contacted rail and deformed.
0.032	Post no. 12 twisted counterclockwise and bent backward. Post no. 15 deflected backward.
0.036	Post no. 16 deflected backward. Post nos. 14 and 15 bent backward.
0.042	Post nos. 18 and 20 deflected forward. Vehicle yawed away from system.
0.048	Post no. 21 deflected forward.
0.052	Vehicle's left-front tire contacted rail. Post no. 16 bent backward and post no. 17 deflected backward.
0.060	Post no. 18 deflected backward. Vehicle's left-front door contacted rail and deformed.
0.062	Post no. 13 twisted counterclockwise.
0.074	Post no. 17 bent backward.
0.082	Post no. 18 bent backward, Post no. 14 L-bracket disengaged from box beam bolt due to bolt pullout.
0.088	Vehicle's left-front tire contacted post no. 14. Post no. 20 deflected backward.
0.094	Post no. 13 bent backward and post no. 14 bent downstream.
0.102	Post no. 19 deflected backward.
0.116	Post no. 21 deflected backward. Post no. 16 L-bracket disengaged from box beam bolt due to bolt fracture. Post no. 19 bent backward.
0.124	Vehicle's left-front tire contacted post no. 15.
0.134	Post no. 15 bent downstream, and post no. 20 bent backward.
0.148	Vehicle's left-front tire disengaged, and vehicle’s right headlight deformed.
0.174	Vehicle's grille disengaged.
0.184	Vehicle's left-front tire contacted post no. 16 and post bent downstream.
0.195	Vehicle's rear bumper and left quarter panel contacted rail and deformed.
0.210	Vehicle pitched downward and rolled toward system.
0.233	Vehicle was parallel to the system at a speed of 45.3 mph.
0.240	Vehicle's left-front tire contacted post no. 17 and post bent downstream.
0.248	Vehicle's left-rear door contacted rail and deformed.
0.258	Post no. 21 bent backward.
0.322	Post no. 18 bent forward.
0.330	Vehicle yawed toward system.
0.334	Post nos. 12 and 19 bent forward.
0.338	Vehicle's right-rear tire became airborne.
0.368	Vehicle's left headlight disengaged.

Table 7. Sequential Description of Impact Events, Test No. NYHBT-1, Cont.

Time sec	Event
0.431	Vehicle exited system at a speed of 40.8 mph and an angle of 11.2 degrees.
0.486	Vehicle's right headlight disengaged.
0.508	Vehicle pitched upward.
0.664	Vehicle's right-front tire became airborne.
0.674	Vehicle's right-rear tire regained contact with ground.
0.700	Vehicle's right-front tire regained contact with ground.
0.756	System came to rest.
3.900	Vehicle came to rest.


0.000 sec


0.000 sec


0.100 sec


0.100 sec


0.200 sec


0.200 sec


0.300 sec


0.300 sec


0.400 sec


0.400 sec


0.500 sec


0.500 sec

Figure 72. Sequential Photographs, Test No. NYHBT-1


0.000 sec


0.600 sec


0.100 sec


0.700 sec


0.200 sec


0.800 sec


0.300 sec


0.900 sec


0.400 sec


1.000 sec


0.500 sec


1.100 sec

Figure 73. Sequential Photographs, Test No. NYHBT-1



Figure 74. Sequential Photographs, Test No. NYHBT-1



Figure 75. Documentary Photographs, Test No. NYHBT-1



Figure 76. Documentary Photographs, Test No. NYHBT-1



Figure 77. Vehicle Final Position and Trajectory Marks, Test No. NYHBT-1

6.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 78 through 85. Barrier damage consisted of contact marks and kinks on the rail, tears on the cover plate, deformation of the W-beam and box beam, deformed steel posts, and disengagement of the box beam from its posts. The length of vehicle contact along the barrier was approximately 20 ft – 9 in., which spanned from 17¾ in. upstream from the centerline of post no. 13 to 21 in. upstream from the centerline of post no. 19.

The W-beam was deformed backward along the length of vehicle contact. Contact marks on the bottom corrugation of the W-beam started 17¾ in. upstream from the centerline of post no. 13 and extended to the leading edge of the transition cover plate. Local deformations of kinking and flattening occurred to the W-beam rail at several locations between post nos. 12 and 14. A splice bolt pulled out at post no. 13.

Two longitudinal tears, 1½-in. and 11 in. long, were found on the transition cover plate near the top W-beam corrugation, and adjacent to the bottom W-beam corrugation, respectively. Both tears originated at the upstream edge of the plate. The upstream end of the transition cover plate deformed, and with the leading triangular portion folded outward and downstream.

Minor contact marks were found on the top edge of the front face of the box beam, starting at the downstream end of the transition cover plate and ending 21 in. upstream from the centerline of post no. 19. The box beam was deformed backward and hinged at the splice at post no. 19. The box beam detached from post nos. 14 and 16 due to rail-to-bracket bolt pullout and fracture, respectively. At post no. 14, the bracket-to-post bolt fractured, and the bracket fully disengaged from the system.

Post deformations, including bending and twisting, were observed at post nos. 12 through 22, with the largest deformations occurring at post nos. 14 through 17. Post nos. 12 and 13 twisted and rotated. Post nos. 14 through 17 bent about their weak axis and rotated through the soil. Post nos. 18 through 22 rotated backward. The upstream edge of the front flange of post nos. 14 through 16 and the back flange of post no. 15 bent and encountered contact marks on the front flange.



Figure 78. System Damage Overview, Test No. NYHBT-1





Figure 79. System Damage, Downstream and Upstream Views, Test No. NYHBT-1



Figure 80. System Damage, Impact, Traffic-side and Backside Views, Test No. NYHBT-1

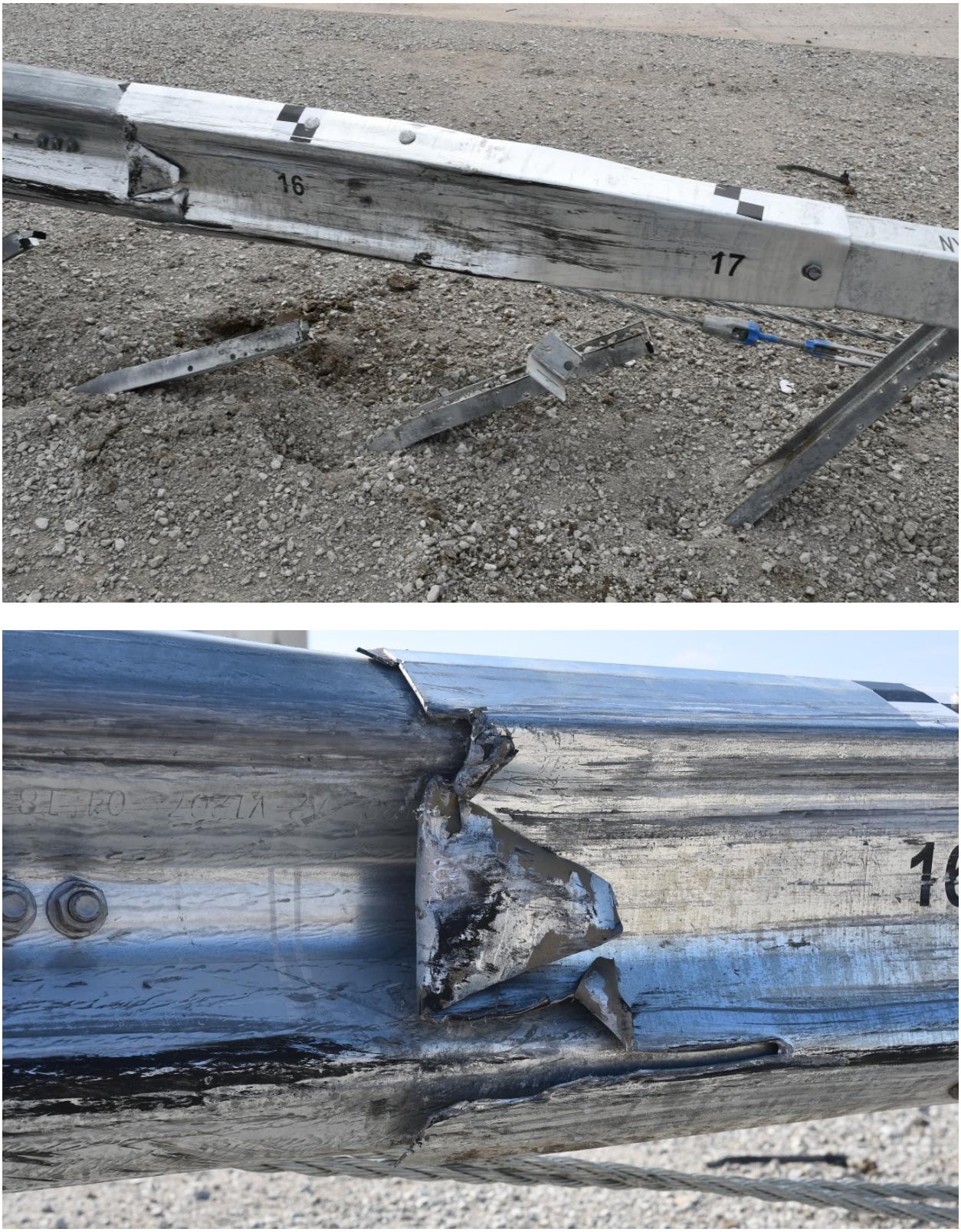


Figure 81. System Damage, Transition Cover Plate, Test No. NYHBT-1



Figure 82. System Damage, Post Nos. 13 through 19, Test No. NYHBT-1



Figure 83. System Damage, Post Nos. 12 through 14



Figure 84. System Damage, Post Nos. 15 through 17

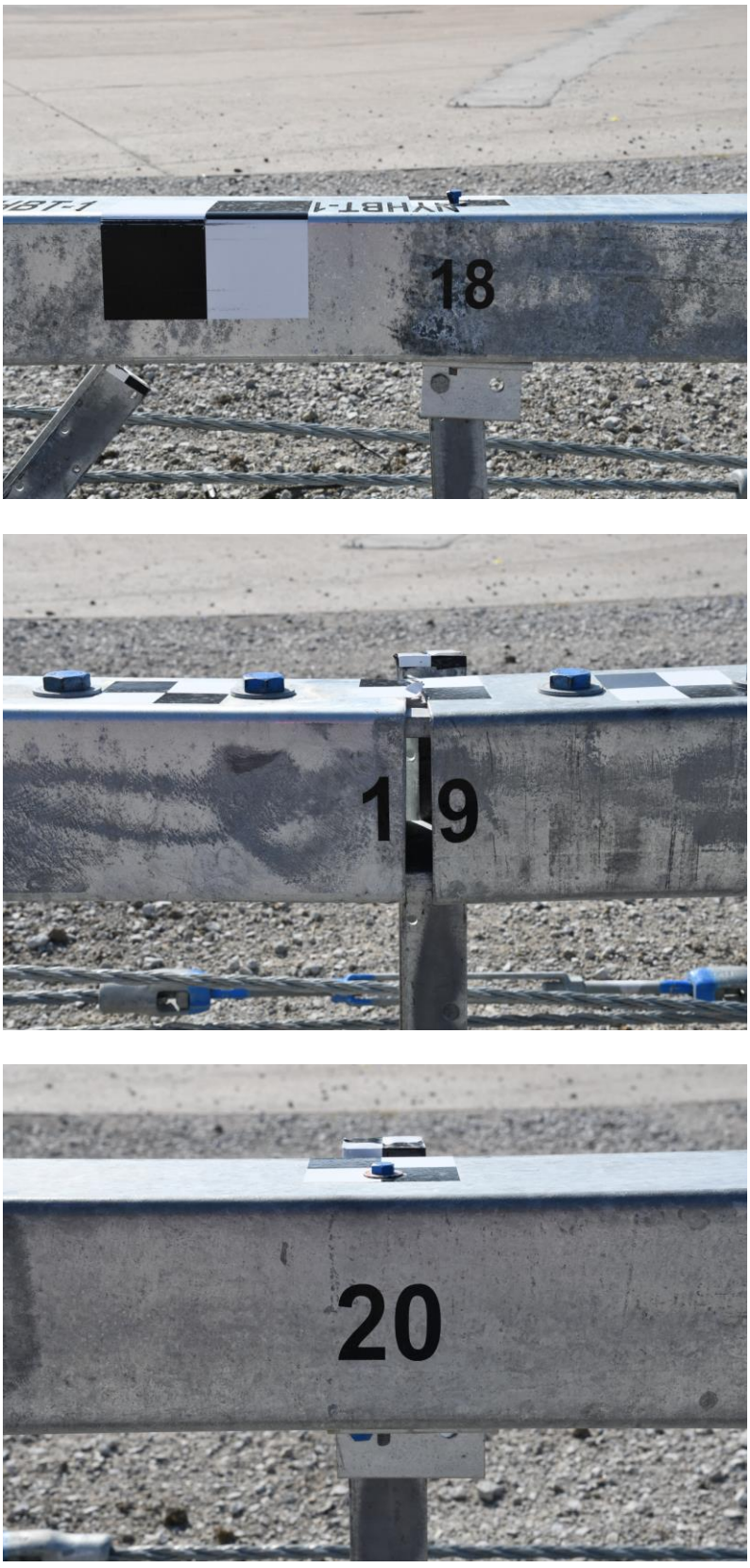


Figure 85. System Damage, Post Nos. 18 through 20

The maximum lateral dynamic rail deflection was 34.1 in. at the upstream end of the box-beam rail, and the maximum lateral post dynamic deflection was 23.3 in at post no. 14, as determined from high-speed digital video analysis. The maximum lateral permanent set of the rail was 19.6 in. between post nos. 14 and 15, and the maximum lateral permanent set of the posts was 19.1 in at post no. 14 as measured in the field using GPS. Based on dynamic deflections, the working width of the system was found to be 43.4 in. determined from high-speed digital video analysis. If the cable anchorage and concrete anchor block are considered, the working width would be 60 in. A schematic of the dynamic deflection, working width, and permanent set deflection is provided in Figure 86.

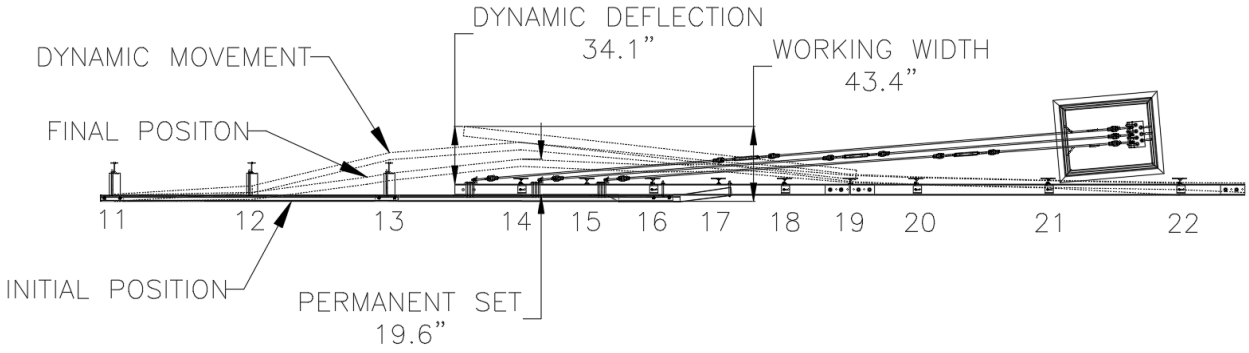
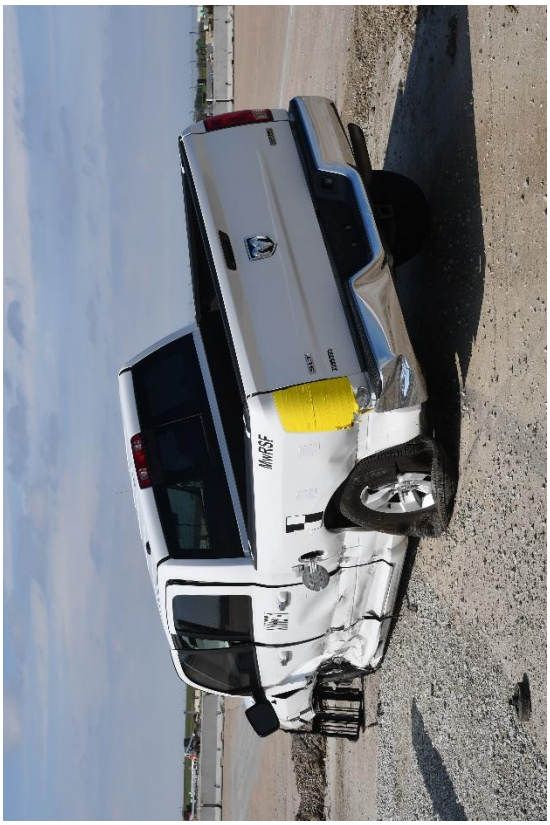


Figure 86. Permanent Set, Dynamic Deflection, and Working Width, Test No. NYHBT-1

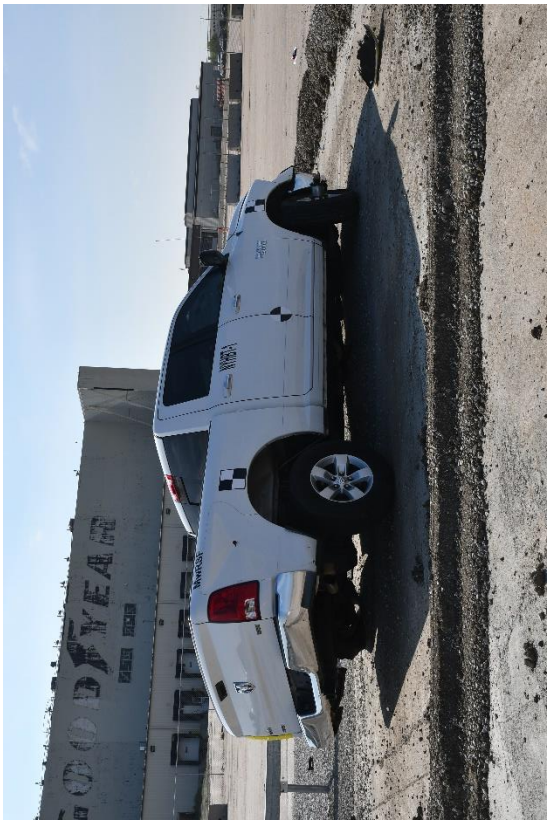
6.5 Vehicle Damage

Damage to the vehicle was moderate, as shown in Figures 87 through 89. The maximum occupant compartment intrusions are listed in Table 8, along with the intrusion limits established in MASH for various areas of the occupant compartment. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix H. MASH defines intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. Outward deformations, which are denoted as negative numbers in Appendix H, are not considered crush toward the occupant, and are not evaluated by MASH criteria. Penetrations into the occupant compartment did not occur, and none of the established MASH deformation limits were violated.

Damage was concentrated on the left-front corner and left side of the vehicle. The front bumper crushed inward and buckled in the center. The left-front wheel assembly, including the lower half of the shock, spring, steering knuckle, lower control arm, tie rod, disengaged from the vehicle, and the left-rear tire was deflated. Both headlights disengaged. The left-front quarter panel crushed inward. The entire length of the vehicle's left side had tears and scrapes. The left-front door was buckled and ajar at the top, and the left-rear door frame was dented. A dent was found on the back of the left-rear door frame. The left-side of the rear bumper was crushed inward. The right-front quarter panel was bent inward. The left-side frame horn was crushed and bent inward. The windshield and all other window glass remained intact and undamaged. The fuel tank also remained intact and undamaged.







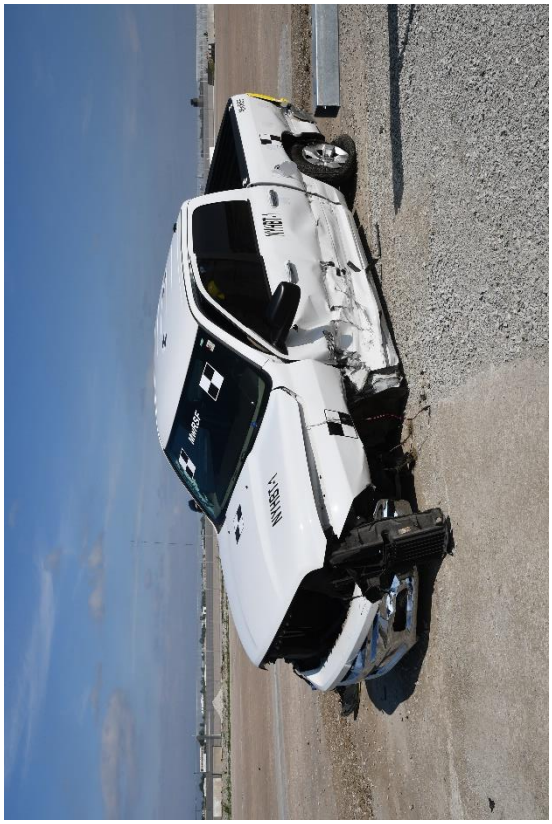


Figure 87. Vehicle Damage, Test No. NYHBT-1



Figure 88. Vehicle Damage, Test No. NYHBT-1



Figure 89. Undercarriage and Occupant Compartment Damage, Test No. NYHBT-1

Table 8. Maximum Occupant Compartment Intrusion by Location, Test No. NYHBT-1

Location	Maximum Intrusion (in.)	MASH Allowable Intrusion (in.)
Wheel Well & Toe Pan	0.0	≤ 9
Floor Pan & Transmission Tunnel	0.2	≤ 12
A-Pillar	0.9	≤ 5
A-Pillar (Lateral)	0.0*	≤ 3
B-Pillar	0.6	≤ 5
B-Pillar (Lateral)	0.0*	≤ 3
Side Front Panel (in Front of A-Pillar)	3.4	≤ 12
Side Door (Above Seat)	0.2	≤ 9
Side Door (Below Seat)	2.1	≤ 12
Roof	0.4	≤ 4
Windshield	0.0	≤ 3
Side Window	Intact	No shattering resulting from contact with structural member of test article
Dash	1.7	N/A

N/A – No MASH criteria exist for this location.
*Negative value reported as 0.0. See Appendix H for further information.

6.6 Occupant Risk

The calculated occupant impact velocities (OIVs) and maximum 0.010-sec average occupant ridedown accelerations (ORAs) in both the longitudinal and lateral directions, as determined from the accelerometer data, are shown in Table 9. Note that the OIVs and ORAs were within suggested limits, as provided in MASH. The calculated THIV, PHD, and ASI values are also shown in Table 9. The recorded data from the accelerometers and the rate transducers are shown graphically in Appendix I.

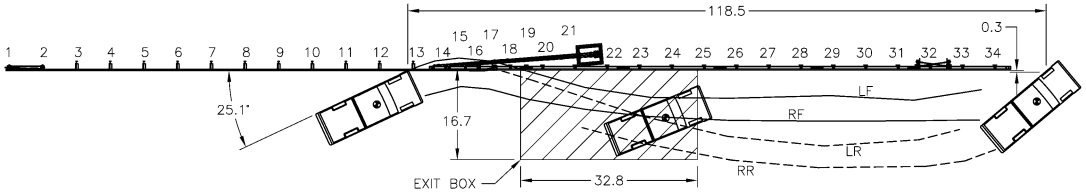
Table 9. Summary of Occupant Risk Values, Test No. NYHBT-1

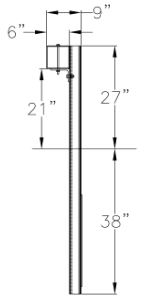
Evaluation Criteria		Transducer		MASH Limits
		SLICE-1	SLICE-2 (primary)	
OIV (ft/s)	Longitudinal	-19.13	-18.84	±40
	Lateral	17.82	19.55	±40
ORA (g's)	Longitudinal	-8.35	-8.96	±20.49
	Lateral	8.60	8.11	±20.49
Maximum Angular Displacement (deg.)	Roll	-15.2	-16.2	±75
	Pitch	-5.9	-4.4	±75
	Yaw	33.9	32.6	not required
THIV – (ft/s)		25.75	25.67	not required
PHD – (g's)		10.45	10.92	not required
ASI		0.83	0.90	not required

6.7 Discussion

Analysis of test no. NYHBT-1 showed that the system adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier. Sequential photographs and a summary of the test results are shown in Figure 90. 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 I, 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 11.2 degrees, and its trajectory did not violate the bounds of the exit box. Therefore, test no. NYHBT-1 satisfied the MASH safety performance criteria for test designation no. 3-21.







- Test Agency ..... MwRSF
- Test Number NYHBT-1
- Date 5/12/2020
- MASH Test Designation No. 3-21
- Test Article ..... NYSDOT HPBO W-Beam to Box Beam Guide Rail Transition
- Total Length ..... 186 ft – 7 in.
- Key Component –W-Beam Rail
  - Thickness ..... 12 gauge
  - Top Mounting Height ..... 31 in.
- Key Component – Box Beam Rail
  - Shape TS6x6x3/16
  - Top Mounting Height ..... 27 in.
- Key Component – Steel Post for W-Beam Rail (Post Nos. 3 through 13)
  - Shape ..... W6x8.5, 72-in. length
  - Typical Embedment ..... 40 in.
  - Spacing ..... 75 in.
- Key Component – Steel Post for Box Beam Rail (Post Nos. 14 through 34)
  - Shape ..... S3x5.7, 65-in. length
  - Typical Embedment ..... 38 in.
  - Spacing ..... 36 in. (post nos. 14 through 20)
    72 in. (post nos. 20 through 34)
- Soil Type ..... Coarse Crushed Limestone (Well-Graded Gravel)
- Vehicle Make /Model ..... 2014 Dodge Ram 1500
  - Curb ..... 5,018 lb
  - Test Inertial ..... 4,997 lb (MASH limit 5,000 ± 110 lb)
  - Gross Static ..... 5,157 lb (MASH limit 5,165 ± 110 lb)
- Impact Conditions
  - Speed ..... 63.7 mph (MASH limit 62 ± 2.5 mph)
  - Angle ..... 25.1 deg. (MASH limit 25 ± 1.5 deg.)
  - Impact Location ..... 84.3 in. upstream from the centerline of post no. 14
- Impact Severity ..... 122.0 kip-ft > 106 kip-ft limit from MASH
- Exit Conditions
  - Speed ..... 40.8 mph
  - Angle ..... 11.2 deg.
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 118.5 ft downstream
  0.3 ft laterally in front
- Vehicle Damage ..... Moderate
  - VDS [17] 11-LFQ-5
  - CDC [18] 11LDEW3
  - Maximum Interior Deformation ..... 3.4 in. at side front panel < 12-in. MASH limit
- Test Article Damage ..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 19.6 in.
  - Dynamic ..... 34.1 in.
  - Working Width ..... 43.4 in.
- Transducer Data

Evaluation Criteria		Transducer		MASH Limits
		SLICE-1	SLICE-2 (primary)	
OIV (ft/s)	Longitudinal	-19.13	-18.84	±40
	Lateral	17.82	19.55	±40
ORA (g's)	Longitudinal	-8.35	-8.96	±20.49
	Lateral	8.60	8.11	±20.49
Maximum Angular Displacement (deg.)	Roll	-15.2	-16.2	±75
	Pitch	-5.9	-4.4	±75
	Yaw	33.9	32.6	not required
THIV – (ft/s)		25.75	25.67	not required
PHD – (g's)		10.45	10.92	not required
ASI		0.83	0.90	not required

Figure 90. Summary of Test Results and Sequential Photographs, Test No. NYHBT-1

7 FULL-SCALE CRASH TEST NO. NYHBT-2

7.1 Static Soil Test

Before full-scale crash test no. NYHBT-2 was conducted, the strength of the foundation soil was evaluated with a static test, as described in MASH [3]. The static test results, as shown in Appendix E, 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.

7.2 Weather Conditions

Test no. NYHBT-2 was conducted on July 17, 2020, at approximately 2:00 p.m. The weather conditions as reported by the National Oceanic and Atmospheric Administration (station 14939/KLNK) are shown in Table 10.

Table 10. Weather Conditions, Test No. NYHBT-2

Temperature	90°F
Humidity	66%
Wind Speed	13 mph
Wind Direction	170° from True North
Sky Conditions	Partly Cloudy
Visibility	9 Statute Miles
Pavement Surface	Dry
Previous 3-Day Precipitation	0.08 in.
Previous 7-Day Precipitation	0.41 in.

7.3 Test Description

Initial vehicle impact was to occur 78 in. upstream from the centerline of post no. 17, as shown in Figure 91. As discussed in Section 4.2.2, the CIP was selected to maximize the potential for vehicle snag on system posts, anchor cables, and the transition cover plate. The 2,421-lb small car impacted the NYSDOT HPBO to Box Beam Guide Rail Transition at a speed of 61.3 mph and an angle of 25.2 degrees. The actual point of impact was 84.8 in. upstream from the centerline of post no. 17. After brakes were applied, the vehicle came to rest facing downstream, with the left-front tire positioned 153.3 ft downstream from the impact point and 1.6 ft behind the system.

A detailed description of the sequential impact events is contained in Table 11 and sequential photographs are shown in Figures 92 and 93, with movement definitions shown in Appendix G. Documentary photographs of the crash test are shown in Figures 94 and 95. The vehicle trajectory and final position are shown in Figure 96.







Figure 91. Target Impact Location, Test No. NYHBT-2

Table 11. Sequential Description of Impact Events, Test No. NYHBT-2

Time sec	Event
0.000	Vehicle's front bumper contacted rail and deformed.
0.005	Vehicle's left headlight and fender contacted rail and deformed.
0.016	Vehicle's hood contacted rail and deformed.
0.020	Post nos. 14 through 18 deflected backward.
0.030	Post nos. 13 and 19 deflected backward.
0.037	Vehicle yawed away from system.
0.046	Vehicle's left-front door contacted rail and deformed.
0.050	Post nos. 14 through 16 bent backward, and post no. 20 deflected backward.
0.060	Vehicle's left-front tire contacted post no. 16 and vehicle rolled away from system. Post no. 16 bent downstream and post no. 17 bent backward.
0.066	Post no. 16 L-bracket disengaged from box beam bolt.
0.072	Vehicle's left-front tire contacted post no. 17 and post bent downstream. Post no. 18 bent backward.
0.086	Post no. 19 bent backward.
0.110	Vehicle's left-front tire contacted post no. 18 and post bent downstream. Post no. 20 bent backward.
0.116	Post no. 18 L-bracket disengaged from box beam bolt.
0.160	Vehicle's left-front tire contacted post no. 19 and post bent downstream.
0.236	Vehicle's left-front tire contacted post no. 20 and post bent downstream.
0.244	Post no. 20 L-bracket disengaged from box beam bolt.
0.254	Vehicle's right-rear tire became airborne.
0.350	Vehicle exited system at a speed of 30.5 mph and an angle of 5.3 degrees.
0.398	Vehicle became parallel to the system at a speed of 30.5 mph.
0.546	Vehicle's right-rear tire regained contact with ground.
1.444	System came to rest.
4.250	Vehicle came to rest.


0.000 sec


0.000 sec


0.100 sec


0.100 sec


0.200 sec


0.200 sec


0.300 sec


0.300 sec


0.400 sec

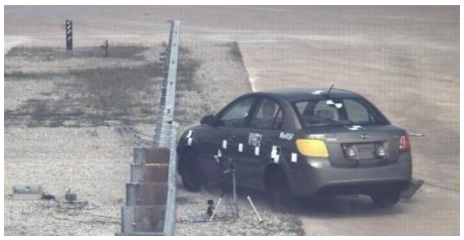

0.400 sec


0.500 sec


0.500 sec

Figure 92. Sequential Photographs, Test No. NYHBT-2


0.000 sec


0.000 sec


0.100 sec


0.100 sec


0.200 sec


0.200 sec


0.300 sec


0.300 sec


0.400 sec


0.400 sec


0.500 sec


0.500 sec

Figure 93. Sequential Photographs, Test No. NYHBT-2



Figure 94. Documentary Photographs, Test No. NYHBT-2

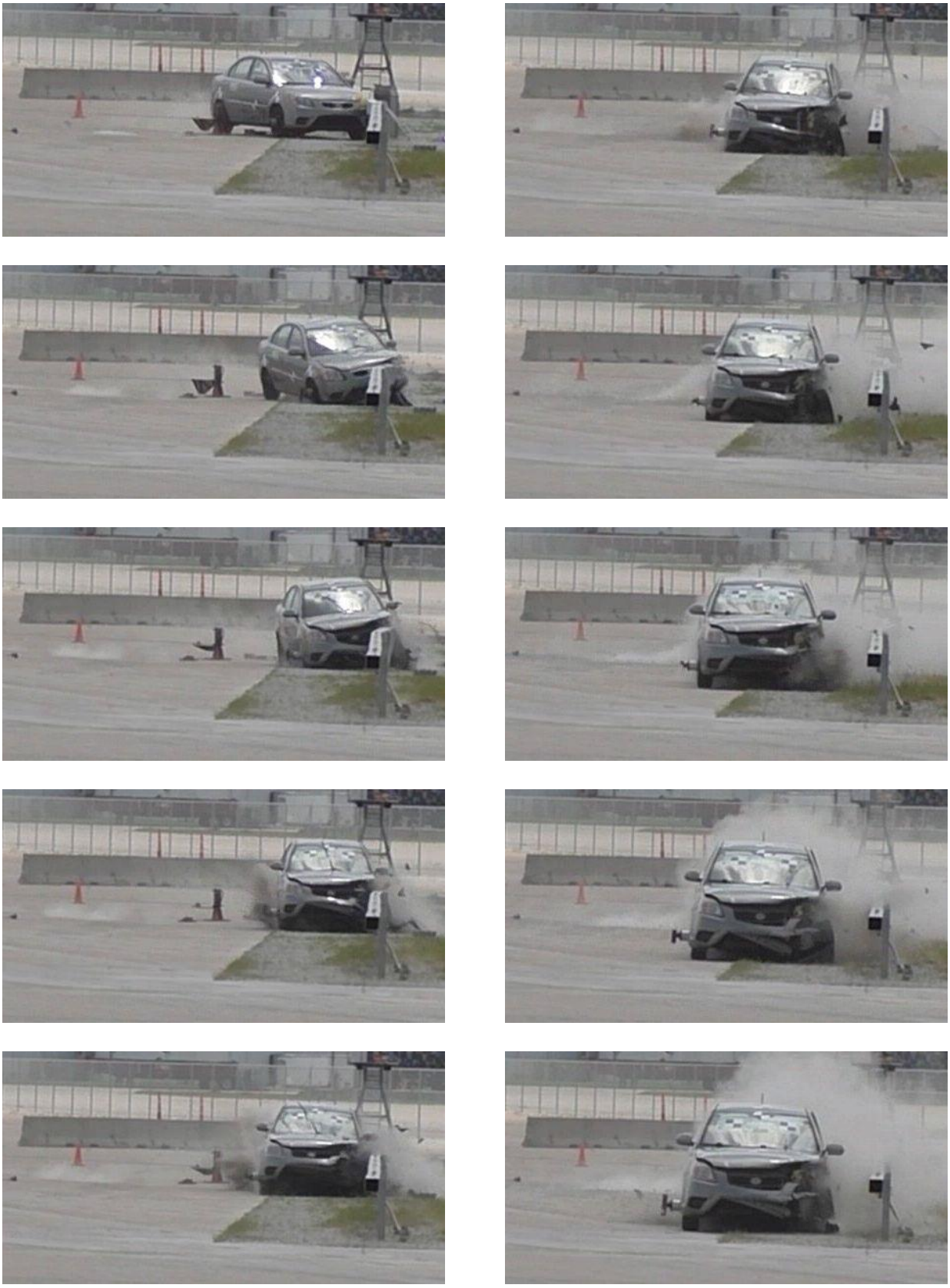


Figure 95. Documentary Photographs, Test No. NYHBT-2



Figure 96. Vehicle Final Position and Trajectory Marks, Test No. NYHBT-2

7.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 97 through 103. Barrier damage consisted of contact marks, kinks, and dents on the rail, deformation of the W-beam, box beam, and steel posts, and disengagement of the box beam from its posts. The overall length of vehicle contact along the barrier was approximately 18 ft – 8 in., which spanned from 16 in. downstream from the centerline of post no. 14 to 24 in. downstream from the centerline of post no. 20.

Multiple contact marks were observed beginning near the impact location and ending roughly 18 in. downstream from post no. 20. The W-beam was dented and kinked at multiple locations between post nos. 16 and 17. The box beam deflected backward and kinked in two places between post nos. 13 and 16. The box beam detached from post nos. 16, 18, and 20 due to bolt pullout and fracture. The L-connection bracket detached from both the post and the rail at post nos. 16, 18, and 20.

The transition cover plate was deformed and contact marks were observed throughout the length of the transition cover plate. Minor bending occurred along the upstream edge of the transition cover plate, and about the vertical axis of the transition cover plate. One bolt bent at the downstream edge of the transition cover plate.

Post deformations, including bending, rotation, and twist, were observed at post nos. 13 through 21. Minor to moderate backward rotation occurred at post nos. 13 through 15 and 21. Significant downstream bending was found at post nos. 16 through 20, and post no. 16 also twisted clockwise.

Contact marks were observed on the upstream edge of both flanges at post nos. 16 through 20, and the front flange deformed outward at post nos. 17 and 18. Additionally, the front flange of post no. 16 tore at one of the bolt hole locations. Post no. 20 had bolt hole ovalization, and bolt pullout.



Figure 97. System Damage, Test No. NYHBT-2





Figure 98. System Damage, Test No. NYHBT-2





Figure 99. System Damage, Test No. NYHBT-2

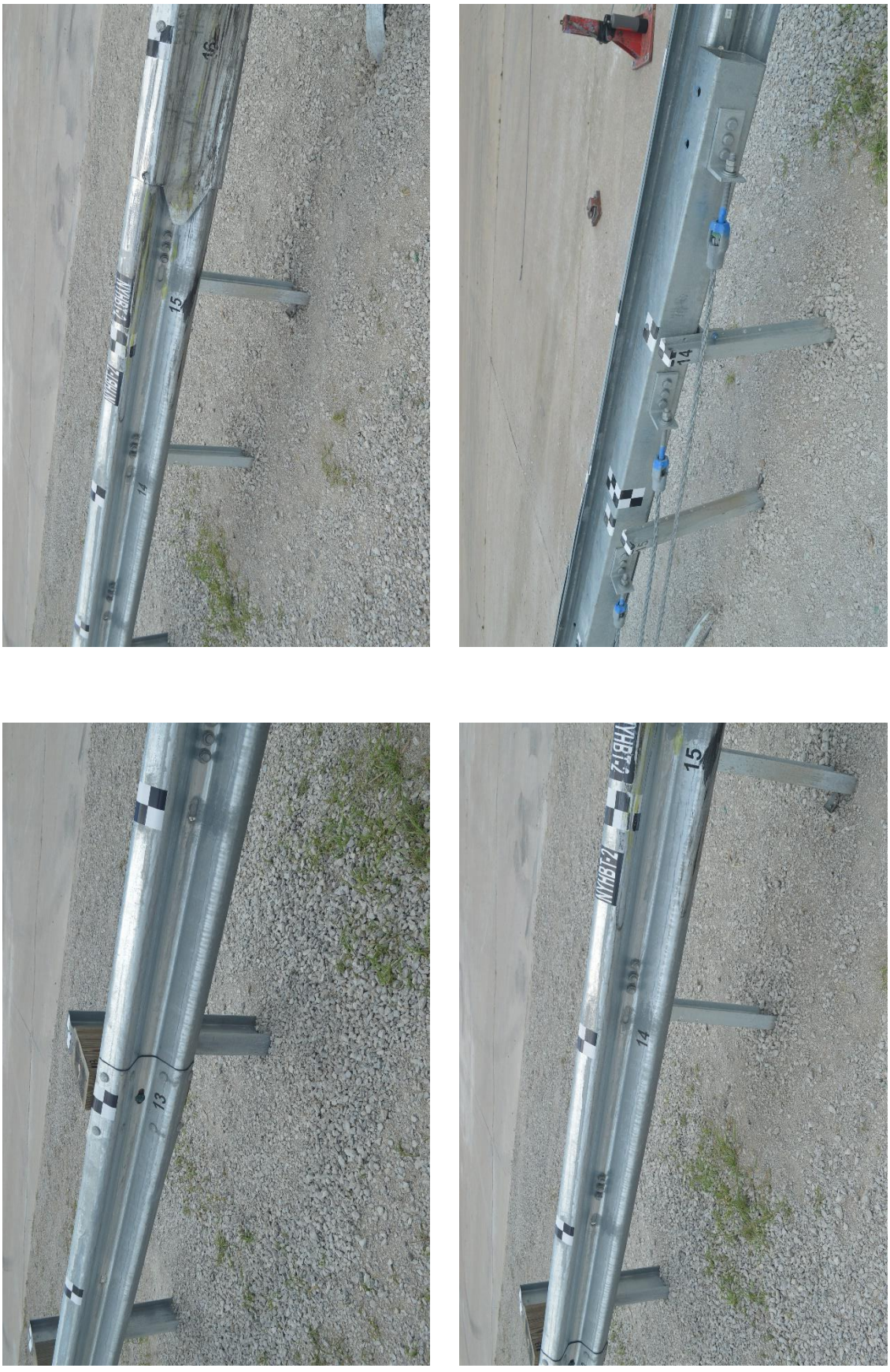


Figure 100. System Damage, Post Nos. 13 through 15, Test No. NYHBT-2



Figure 101. System Damage, Post Nos. 16 through 18, Test No. NYHBT-2

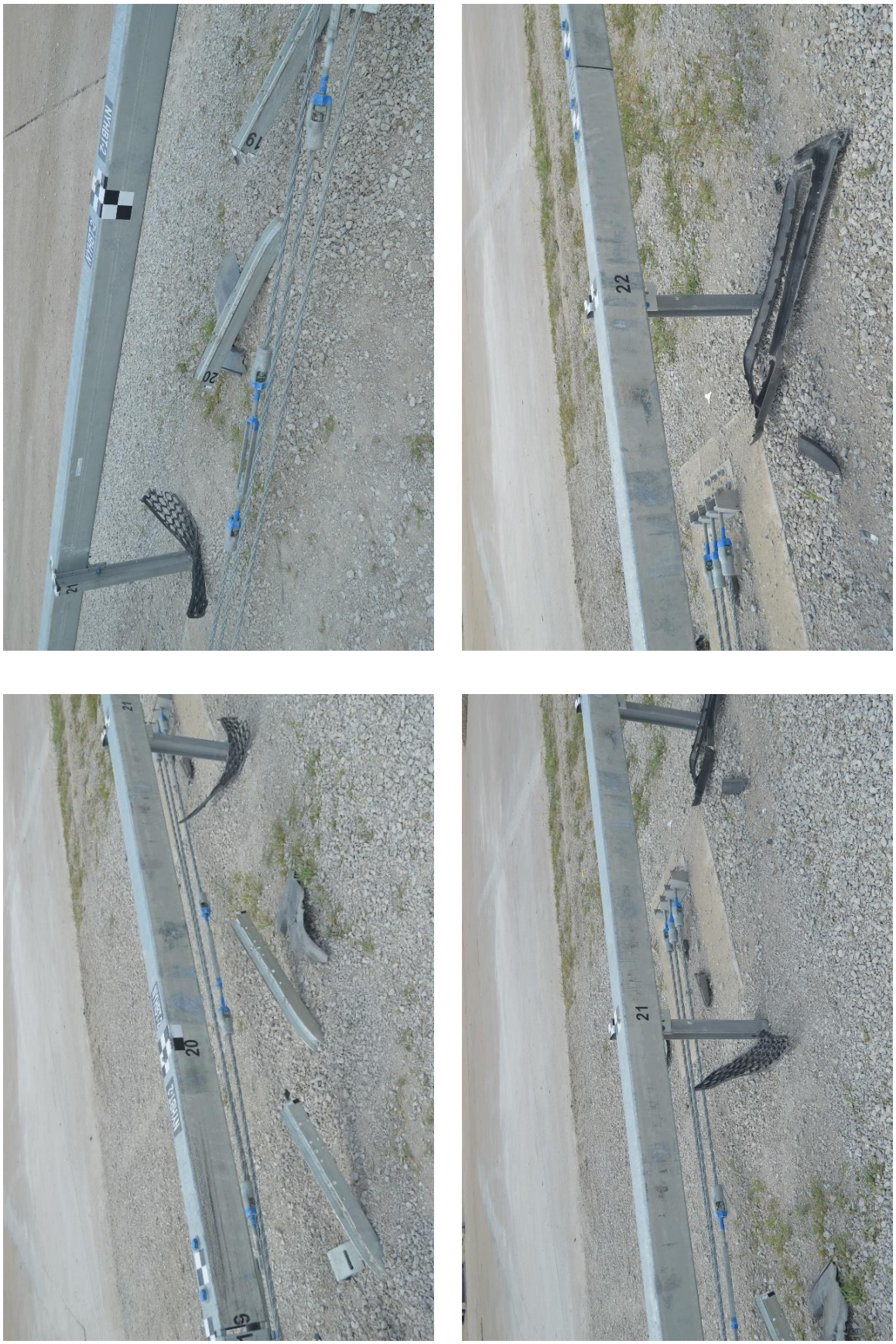


Figure 102. System Damage, Post Nos. 19 through 22, Test No. NYHBT-2



Figure 103. System Damage, Transition Cover Plate, Test No. NYHBT-2

The maximum lateral dynamic rail deflection was 15.7 in. at post no. 16 as determined from high-speed digital video analysis. The maximum lateral permanent set of the rail was 9.5 in. at post no. 16, and the maximum lateral permanent set of the posts was 9.4 in. at post no. 15 as measured in the field using GPS. Based on dynamic deflections, the working width of the system was found to be 28 in., determined from high-speed digital video analysis. If the cable anchorage and concrete anchor block are considered, the working width would be 60 in. A schematic of the dynamic deflection, working width, and permanent set deflection is provided in Figure 104.

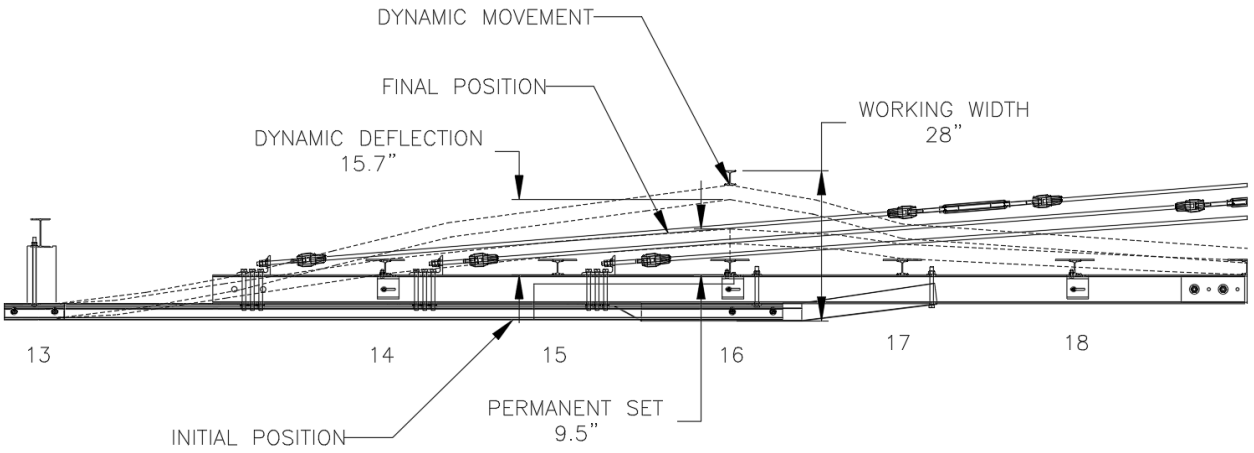


Figure 104. Permanent Set, Dynamic Deflection, and Working Width, Test No. NYHBT-2

7.5 Vehicle Damage

Damage to the vehicle was moderate, as shown in Figures 105 through 107. The maximum occupant compartment intrusions are listed in Table 12, along with the intrusion limits established in MASH for various areas of the occupant compartment. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix H. MASH defines

intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. Outward deformations, which are denoted as negative numbers in Appendix H, are not considered crush toward the occupant, and are not evaluated by MASH criteria. Penetrations into the occupant compartment did not occur, and none of the established MASH deformation limits were violated.

Damage was concentrated on the left-front corner and left side of the vehicle. The front bumper disengaged from the mounts, and the left-side fractured. The left fender and headlight assembly were crushed inward. The left headlight disengaged from the vehicle. The leading edge of the left-front door skin tore and deformed backward, and the door was crushed inward along its full length. The left-rear door encountered a 3-in. long scrape along the bottom edge of the door. The left side of the hood was crushed and deformed downward 2 in. The windshield and all other window glass remained intact and undamaged.

Undercarriage damage was concentrated on the left side of the vehicle. The outermost leading edge of the left-side lower spring bucket and the lower spring bucket attachment to the strut tube were both torn. The left-front lower control arm was bent backward. The left side of the front engine cradle was bent backward and was slightly buckled about the vertical axis. The left side of the frame horn was bent inward toward the center of the vehicle, and the nose of the horn was slightly crushed around the bumper connection. The left-front inner wheel lip was bent and dented, and the left-front tire was deflated.





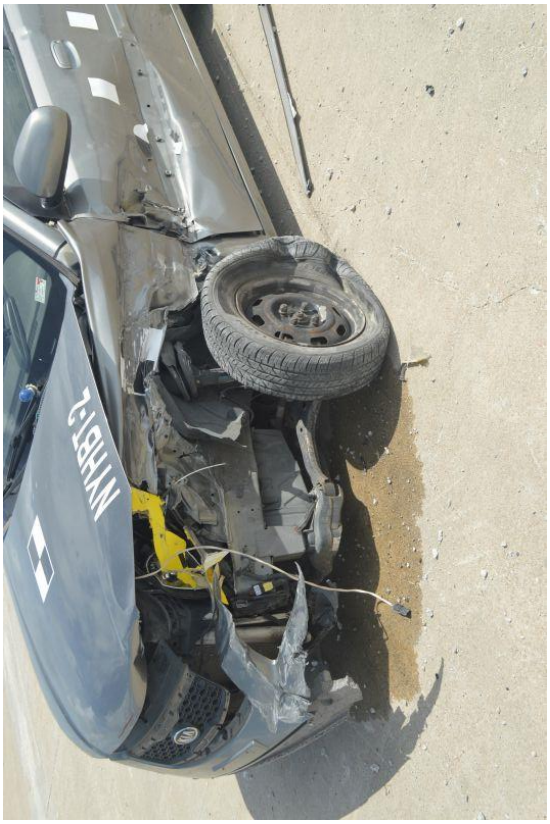




Figure 105. Vehicle Damage, Test No. NYHBT-2







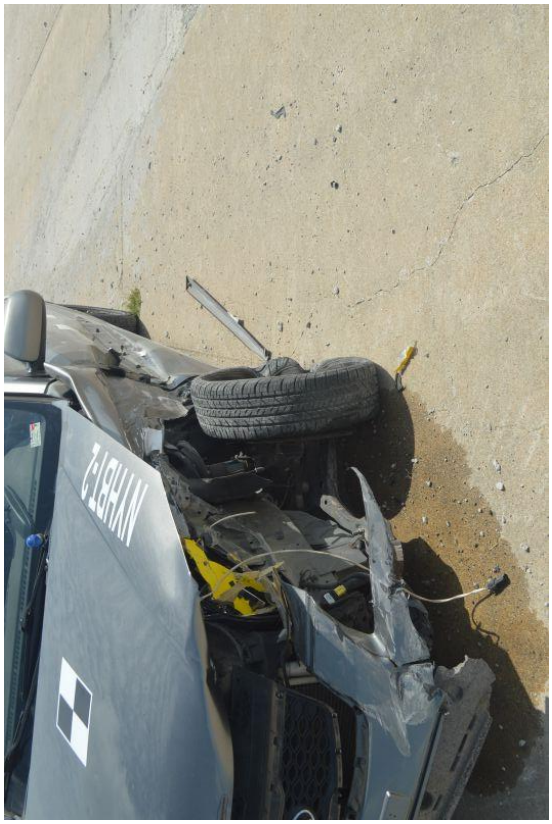


Figure 106. Vehicle Damage, Test No. NYHBT-2

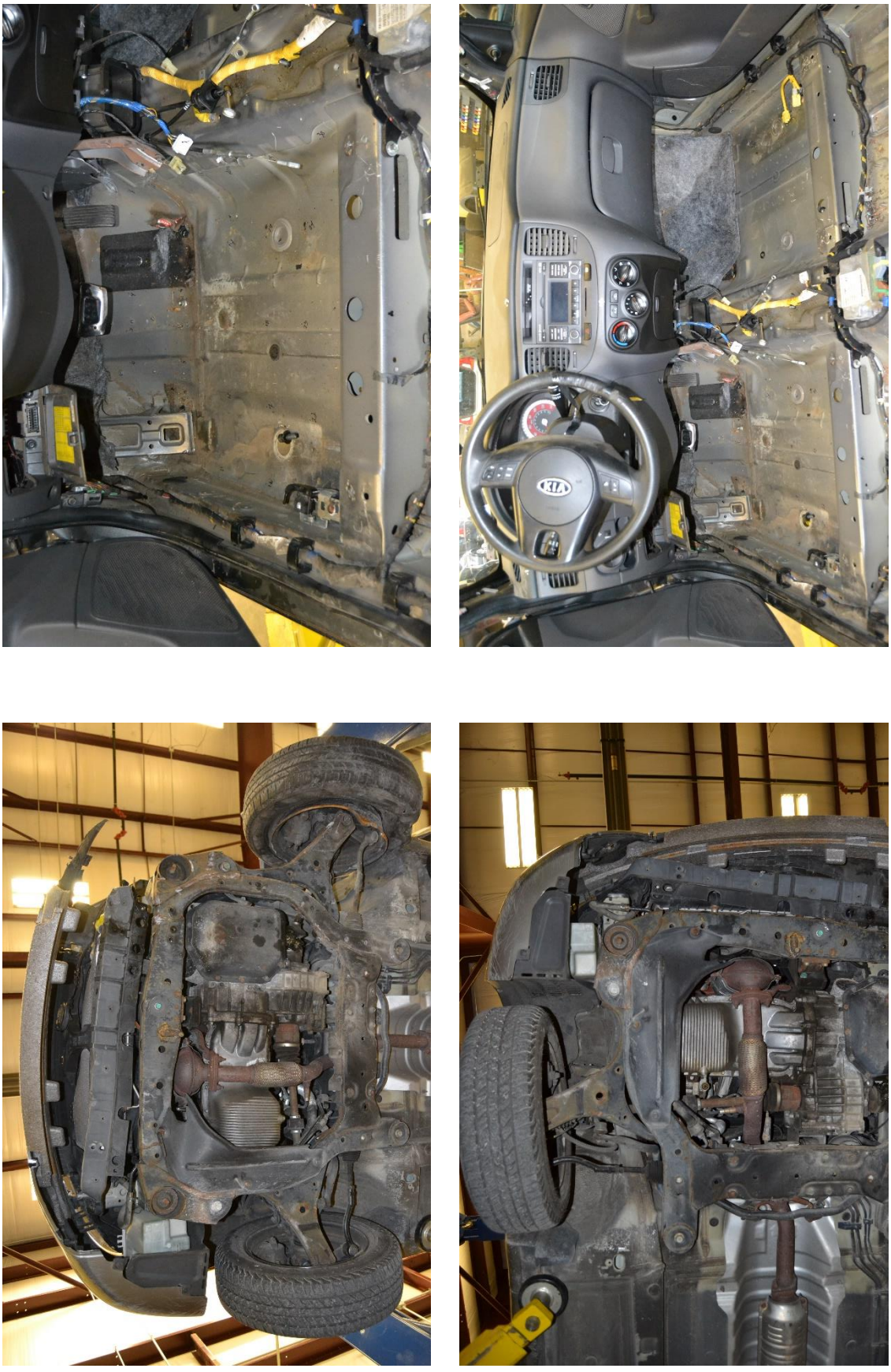


Figure 107. Undercarriage and Occupant Compartment Damage, Test No. NYHBT-2

Table 12. Maximum Occupant Compartment Intrusion by Location, Test No. NYHBT-2

Location	Maximum Intrusion (in.)	MASH 2016 Allowable Intrusion (in.)
Wheel Well & Toe Pan	0.3	≤ 9
Floor Pan & Transmission Tunnel	0.4	≤ 12
A-Pillar	0.3	≤ 5
A-Pillar (Lateral)	0.0	≤ 3
B-Pillar	0.2	≤ 5
B-Pillar (Lateral)	0.0	≤ 3
Side Front Panel (in Front of A-Pillar)	0.7	≤ 12
Side Door (Above Seat)	0.1	≤ 9
Side Door (Below Seat)	0.0*	≤ 12
Roof	0.0*	≤ 4
Windshield	0.0	≤ 3
Side Window	Intact	No shattering resulting from contact with structural member of test article
Dash	0.7	N/A

N/A – No MASH criteria exist for this location.
*Negative value reported as 0.0. See Appendix H for further information.

7.6 Occupant Risk

The calculated OIVs and maximum 0.010-sec average ORAs in both the longitudinal and lateral directions, as determined from the accelerometer data, are shown in Table 13. Note that the OIVs and ORAs were within suggested limits, as provided in MASH. The calculated THIV, PHD, and ASI values are also shown in Table 13. The recorded data from the accelerometers and the rate transducers are shown graphically in Appendix J.

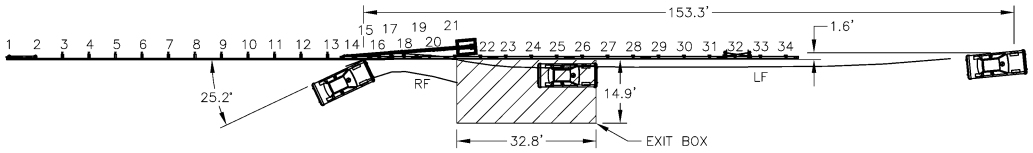
Table 13. Summary of Occupant Risk Values, Test No. NYHBT-2

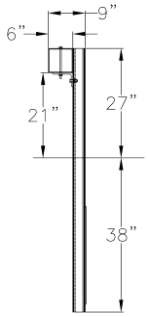
Evaluation Criteria		Transducer		MASH Limits
		SLICE-1 (primary)	SLICE-2	
OIV (ft/s)	Longitudinal	-23.30	-23.16	±40
	Lateral	19.38	19.92	±40
ORA (g's)	Longitudinal	-10.26	-10.39	±20.49
	Lateral	8.49	7.35	±20.49
Maximum Angular Displacement (deg.)	Roll	9.0	10.0	±75
	Pitch	-2.6	-2.5	±75
	Yaw	29.1	28.0	not required
THIV – (ft/s)		30.13	25.14	not required
PHD – (g's)		11.30	11.83	not required
ASI		1.24	1.20	not required

7.7 Discussion

Analysis of test no. NYHBT-2 showed that the system adequately contained and redirected the 1100C vehicle with controlled lateral displacements of the barrier. Sequential photographs and a summary of the test results are shown in Figure 108. 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 J, 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 5.3 degrees, and its trajectory did not violate the bounds of the exit box. Therefore, test no. NYHBT-2 satisfied the MASH safety performance criteria for test designation no. 3-20.







- Test Agency ..... MwRSF
- Test Number NYHBT-2
- Date 7/17/2020
- MASH Test Designation No. 3-20
- Test Article ..... NYSDOT HPBO W-Beam to Box Beam Guide Rail Transition
- Total Length ..... 186 ft – 7 in.
- Key Component –W-Beam Rail
  - Thickness ..... 12 gauge
  - Top Mounting Height ..... 31 in.
- Key Component – Box Beam Rail
  - Shape TS6x6x3/16
  - Top Mounting Height ..... 27 in.
- Key Component – Steel Post for W-Beam Rail (Post Nos. 3 through 13)
  - Shape ..... W6x8.5, 72-in. length
  - Typical Embedment ..... 40 in.
  - Spacing ..... 75 in.
- Key Component – Steel Post for Box Beam Rail (Post Nos. 14 through 34)
  - Shape ..... S3x5.7, 65-in. length
  - Typical Embedment ..... 38 in.
  - Spacing ..... 36 in. (post nos. 14 through 20
72 in. (post nos. 20 through 34)
- Soil Type ..... Coarse Crushed Limestone (Well-Graded Gravel)
- Vehicle Make /Model ..... 2010 Kia Rio
  - Curb ..... 2,472 lb
  - Test Inertial ..... 2,421 lb (MASH limit 2,420 ± 55 lb)
  - Gross Static ..... 2,584 lb (MASH limit 2,585 ± 55 lb)
- Impact Conditions
  - Speed ..... 61.3 mph (MASH limit 62 ± 2.5 mph)
  - Angle ..... 25.2 deg. (MASH limit 25 ± 1.5 deg.)
  - Impact Location ..... 84.8 in. upstream from the centerline of post no. 17
- Impact Severity ..... 55.1 kip-ft > 51 kip-ft limit from MASH
- Exit Conditions
  - Speed ..... 30.5 mph
  - Angle ..... 5.3 deg.
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 153.3 ft downstream, 1.6 ft laterally behind
- Vehicle Damage ..... Moderate
  - VDS [17] 11-LFQ-4
  - CDC [18] 11LYEW2
  - Maximum Interior Deformation ..... 0.7 in. at side front panel < 12-in. MASH limit
- Test Article Damage ..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 9.5 in.
  - Dynamic ..... 15.7 in.
  - Working Width ..... 28 in.
- Transducer Data

Evaluation Criteria		Transducer		MASH Limits
		SLICE-1 (primary)	SLICE-2	
OIV (ft/s)	Longitudinal	-23.30	-23.16	±40
	Lateral	19.38	19.92	±40
ORA (g's)	Longitudinal	-10.26	-10.39	±20.49
	Lateral	8.49	7.35	±20.49
Maximum Angular Displacement (deg.)	Roll	9.0	10.0	±75
	Pitch	-2.6	-2.5	±75
	Yaw	29.1	28.0	not required
THIV – (ft/s)		30.13	25.14	not required
PHD – (g's)		11.30	11.83	not required
ASI		1.24	1.20	not required

Figure 108. Summary of Test Results and Sequential Photographs, Test No. NYHBT-2

8 FULL-SCALE CRASH TEST NO. NYBHT-1

8.1 Static Soil Test

Before full-scale crash test no. NYBHT-1 was conducted, the strength of the foundation soil was evaluated with a static test, as described in MASH [3]. The static test results, as shown in Appendix E, 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.

8.2 Weather Conditions

Test no. NYBHT-1 was conducted on May 1, 2020, at approximately 3:00 p.m. The weather conditions as reported by the National Oceanic and Atmospheric Administration (station 14939/KLNK) are shown in Table 14.

Table 14. Weather Conditions, Test No. NYBHT-1

Temperature	87°F
Humidity	28%
Wind Speed	7 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	0.21 in.

8.3 Test Description

Initial vehicle impact was to occur 29 ft upstream from the center of the cable anchor bracket (21 in. upstream from post no. 9), as shown in Figure 109. As discussed in Section 4.3.1, the CIP was selected to maximize the potential for the vehicle to override the cable anchorage assembly and interaction with the anchor bracket and cables. The 5,000-lb quad cab pickup truck impacted the NYSDOT Box Beam Guide Rail to HPBO Transition at a speed of 63.1 mph and an angle of 25.4 degrees. The actual point of impact was 29.5 ft upstream from the center of the cable anchor bracket. After exiting the system, the vehicle continued traveling downstream and impacted a row of protection portable concrete barriers (PCBs). The vehicle came to rest with the right side of the vehicle against one of the PCB segments and with the right-front tire positioned 259.6 ft downstream of the impact point and 23.4 ft in front of the system.

A detailed description of the sequential impact events is contained in Tables 15 and 16 and sequential photographs are shown in Figures 110 through 112, with movement definitions shown in Appendix G. Documentary photographs of the crash test are shown in Figures 113 through 115. The vehicle trajectory and final position are shown in Figure 116.



Figure 109. Target Impact Location, Test No. NYBHT-1

Table 15. Sequential Description of Impact Events, Test No. NYBHT-1

Time sec	Event
0.000	Vehicle's front bumper contacted rail at post no. 9 and deformed.
0.010	Vehicle's right-front tire contacted rail at post no. 9. Post no. 9 deflected backward.
0.018	Post nos. 8 and 10 deflected backward.
0.028	Post nos. 7 and 11 deflected backward.
0.040	Post no. 12 deflected backward and vehicle yawed away from system.
0.044	Post no. 6 deflected backward.
0.060	Post nos. 13 and 14 deflected backward.
0.070	Post nos. 9 and 10 bent backward. Vehicle rolled toward system.
0.074	Post no. 11 twisted counterclockwise and post no. 10 L-bracket disengaged from box beam bolt.
0.078	Post no. 9 L-bracket disengaged from box beam bolt.
0.088	Post no. 8 bent backward.
0.094	Vehicle's right-front tire contacted post no. 10. Post no. 10 bent downstream.
0.098	Vehicle's right-front fender contacted rail and deformed.
0.100	Post no. 11 bent backward and post no. 11 L-bracket disengaged from box beam bolt.
0.112	Vehicle's right-front door contacted rail and deformed.
0.138	Post no. 15 deflected backward.
0.142	Post no. 12 L-bracket disengaged from box beam bolt.
0.150	Vehicle's right-front tire contacted post no. 11. Post no. 11 bent downstream.
0.160	Vehicle's right-rear door contacted rail and deformed.
0.170	Vehicle's left-front tire became airborne.
0.212	Post no. 13 bent backward.
0.214	Vehicle's right quarter panel and rear bumper contacted rail and deformed. Vehicle's left-rear tire became airborne.
0.218	Post nos. 16 and 17 deflected backward.
0.236	Vehicle's right-front tire contacted post no. 12. Post no. 12 bent downstream.
0.238	Vehicle became parallel to system at a speed of 51.9 mph.
0.246	Post no. 8 L-bracket disengaged from box beam bolt.
0.288	Vehicle pitched downward.
0.298	Post no. 7 bent backward.
0.312	Post no. 14 deflected downstream.
0.324	Post no. 13 bent downstream and post no. 13 L-bracket disengaged from box beam bolt.
0.420	Vehicle's right-rear tire became airborne.
0.508	Vehicle rolled away from system.
0.624	Vehicle exited system at a speed of 49.2 mph and an angle of 16.7 degrees.
0.854	Vehicle's left-front tire regained contact with ground.
0.884	System came to rest.

Table 16. Sequential Description of Impact Events, Test No. NYBHT-1, Cont.

Time sec	Event
0.906	Vehicle pitched upward.
0.970	Vehicle's left-rear tire regained contact with ground.
1.038	Vehicle's right-front tire became airborne.
1.074	Vehicle's right-rear tire regained contact with ground.
1.226	Vehicle's left-front tire became airborne.
1.246	Vehicle pitched downward.
1.362	Vehicle's right-front tire regained contact with ground.
1.388	Vehicle's left-front tire regained contact with ground.
3.925	Vehicle's right-front bumper contacted a row of protection portable concrete barrier at edge of test site.
6.000	Vehicle came to rest



Figure 110. Sequential Photographs, Test No. NYBHT-1


0.000 sec


0.000 sec


0.100 sec


0.150 sec


0.200 sec

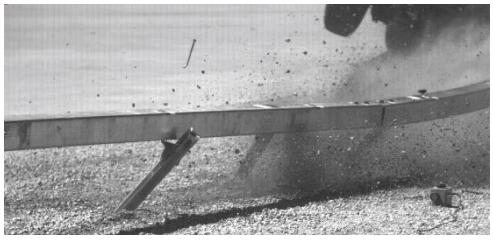

0.300 sec


0.300 sec


0.450 sec


0.400 sec


0.600 sec


0.500 sec


0.750 sec

Figure 111. Sequential Photographs, Test No. NYBHT-1

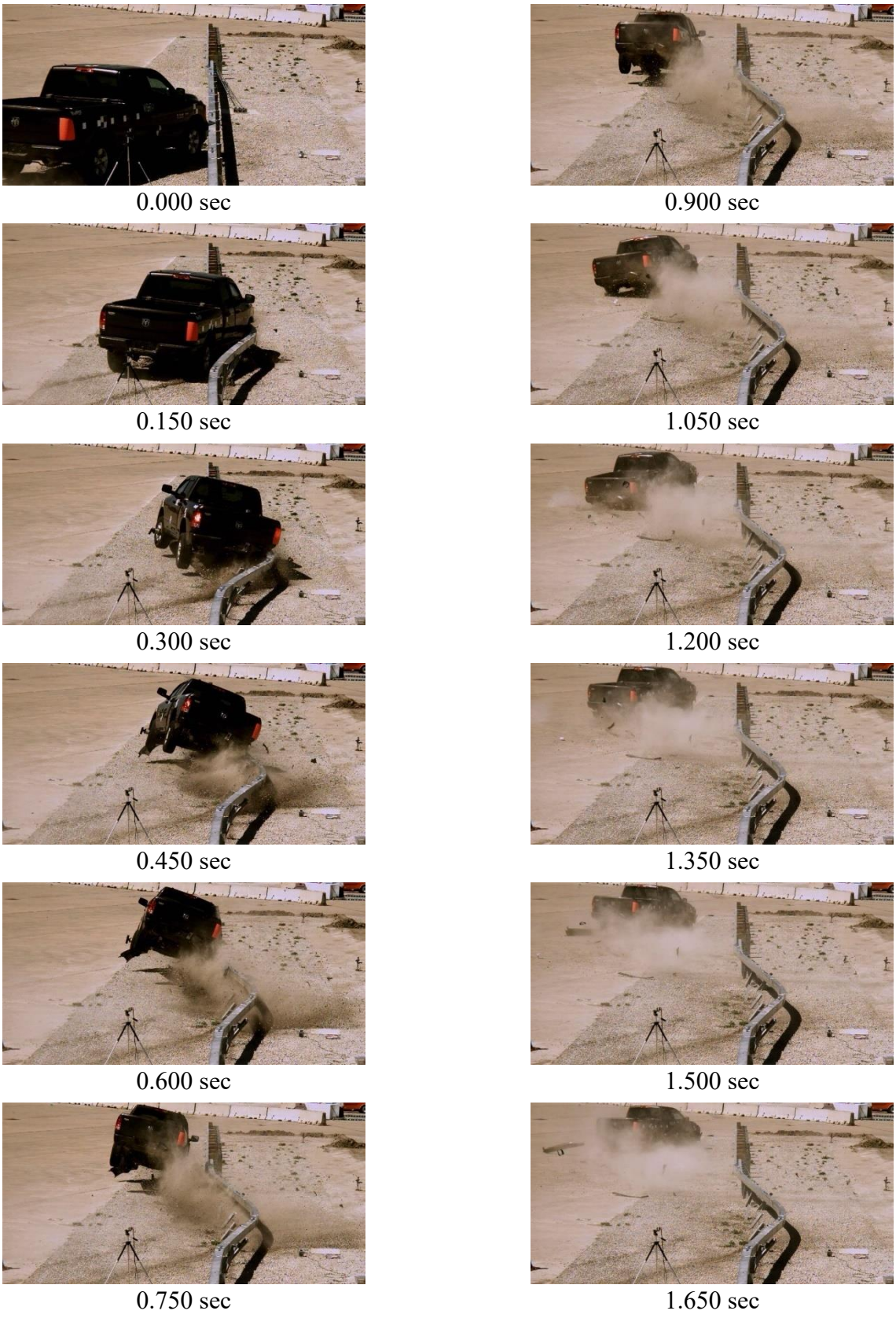


Figure 112. Sequential Photographs, Test No. NYBHT-1

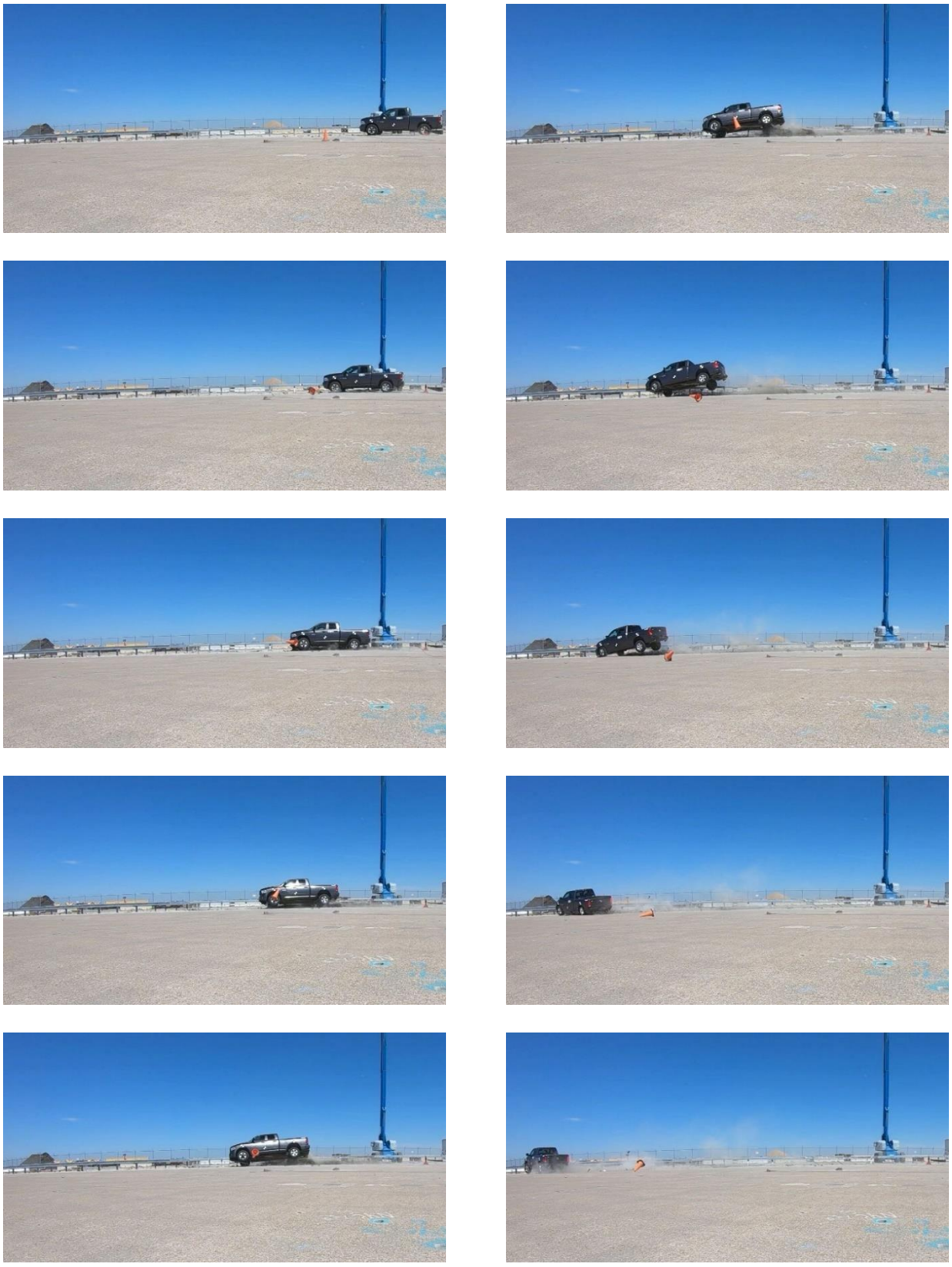


Figure 113. Documentary Photographs, Test No. NYBHT-1

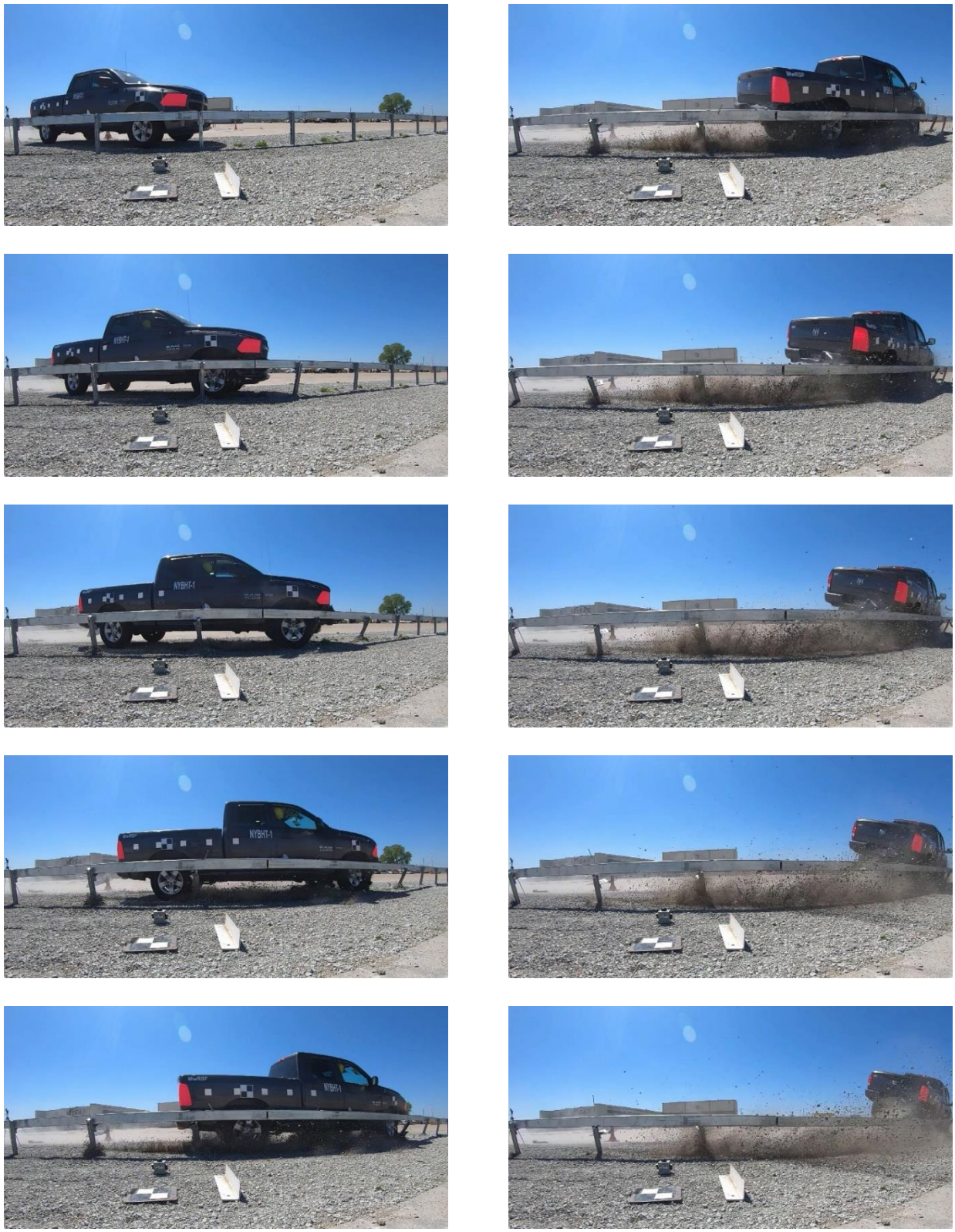


Figure 114. Documentary Photographs, Test No. NYBHT-1

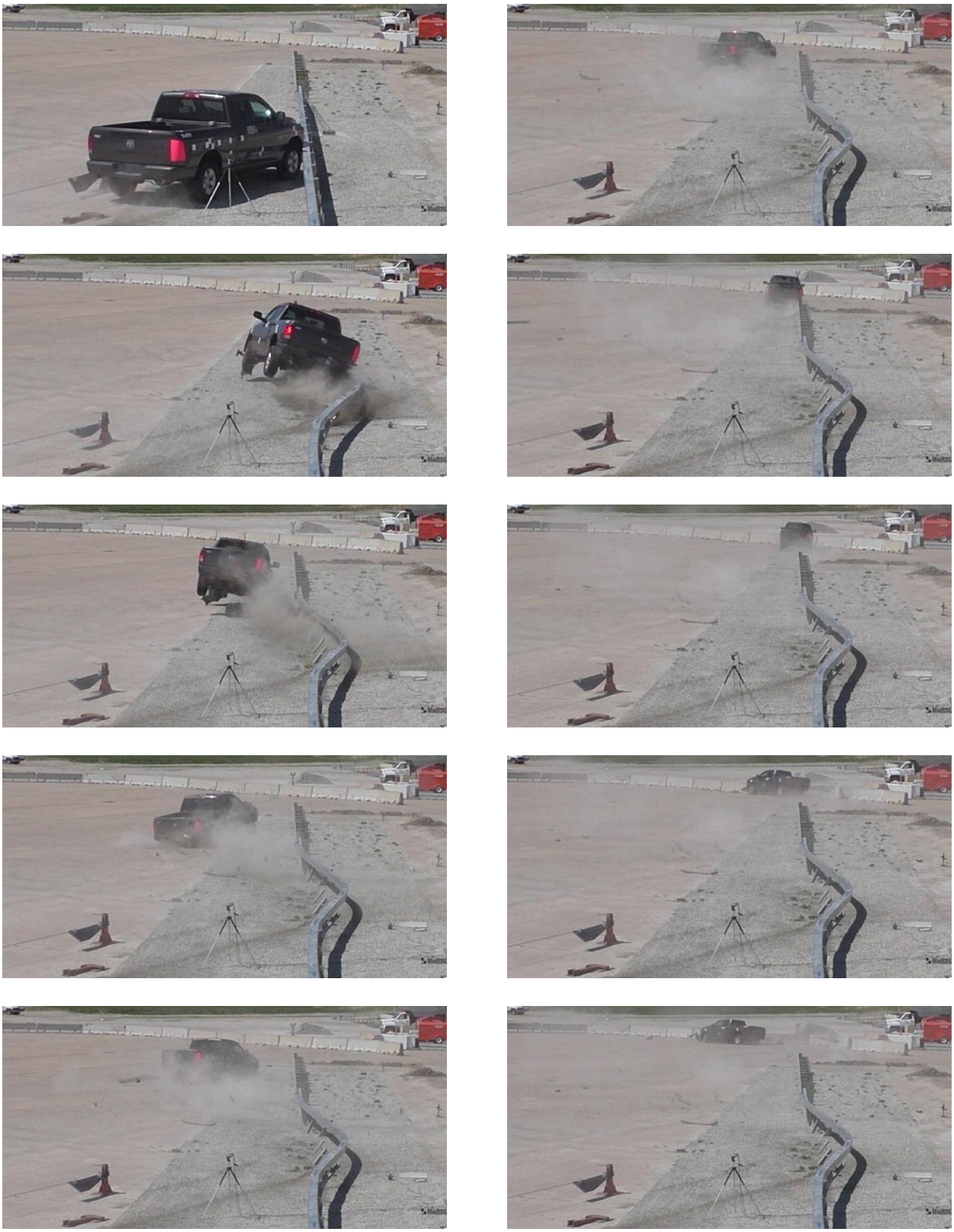
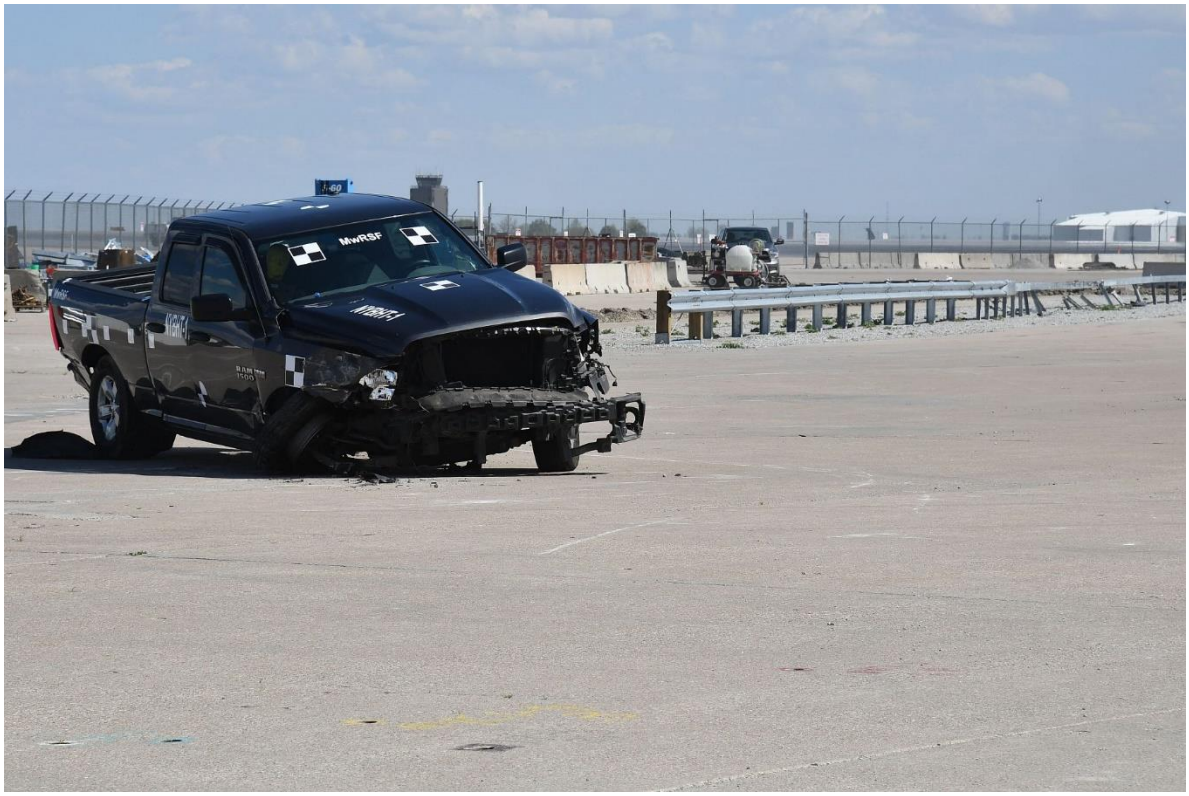


Figure 115. Documentary Photographs, Test No. NYBHT-1



(a) Immediately Following Test



(b) After Removal of Portable Concrete Barriers

Figure 116. Vehicle Final Position and Trajectory Marks, Test No. NYBHT-1

8.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 117 through 121. Barrier damage consisted of contact marks, deformation of the box beam, and disengagement of the box beam from its posts. The length of vehicle contact along the barrier was approximately 41.5 ft extending from 31 in. upstream from the centerline of post no. 9 to the centerline of post no. 16.

The box beam deflected backward between post nos. 6 and 16, with the most severe deflection occurring between splice nos. 9 to 10 and 12 to 13. Between post nos. 10 and 13, the front face of the box beam was dented inward at its mid-height, and the box beam flattened slightly. Contact marks were visible on the front face of the box beam rail beginning 31 in. upstream from post no. 9 through post no. 12 and also from post no. 14 through post no. 16. Contact marks and scrapes on the top face of the box beam rail began 10½ in. downstream from post no. 10 and ended at post no. 13. Minor gouging occurred on the front face of the box beam between post nos. 13 and 16. The maximum splice slip was ⅝ inches. The rail disengaged from post nos. 8 through 13 due to shear or pullout of the rail-to-bracket bolts. At post nos. 10 through 12, the bracket-to-post bolt also fractured, and the L-brackets were fully disengaged from the system.

Post deformations, including bending and rotation, were observed at post nos. 5 through 17. Minor backward rotation occurred at post nos. 5 through 7 and 14 through 17. Clockwise rotation occurred at post no. 7 and counterclockwise rotation at post no. 14. Post nos. 8 through 13 exhibited backward and downstream rotations coupled with counterclockwise rotation at post nos. 9, 10, and 11. Post no. 8 rotated clockwise, and backward bending was visible near the ground line at post no. 11. Contact marks were visible on the front flange of post nos. 9 through 14.



Figure 117. System Damage, Test No. NYBHT-1





Figure 118. System Damage, Test No. NYBHT-1



Figure 119. System Damage, Test No. NYBHT-1



Figure 120. System Damage, Post Nos. 5 through 10, Test No. NYBHT-1









Figure 121. System Damage, Post Nos. 11 through 17, Test No. NYBHT-1

The maximum lateral dynamic rail deflection was 54.4 in. in the box beam at post no. 10, and the maximum lateral post dynamic deflection was 33.1 in. at post no. 9, as determined from high-speed digital video analysis. The maximum lateral permanent set of the rail was 34.9 in. at post no. 10, and the maximum lateral permanent set of the posts was 26.8 in. at post no. 13 as measured in the field using GPS. Based on vehicle extension over the barrier during redirection, the working width of the system was found to be 67.9 in., determined from high-speed digital video analysis. A schematic of the dynamic deflection, working width, and permanent set deflection is provided in Figure 122.

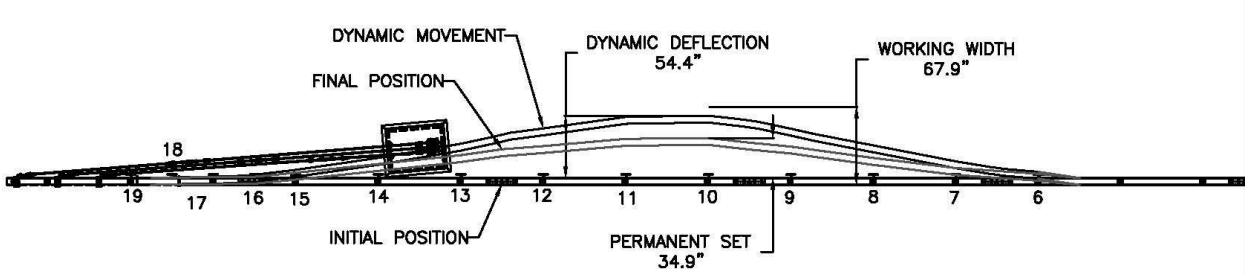


Figure 122. Permanent Set, Dynamic Deflection, and Working Width, Test No. NYBHT-1

8.5 Vehicle Damage

During test no. NYBHT-1, the test vehicle experienced two distinct impacts: (1) impact with the Box Beam Guide Rail to HPBO transition system and (2) a secondary impact with protection PCBs placed to contain the vehicle after exiting the system. The secondary impact was significant and resulted in much of the sustained vehicle damage. It is important to distinguish the damage sustained in each impact, because the secondary impact damage is irrelevant to the evaluation of the barrier system.

In the impact with the Box Beam Guide Rail to HPBO transition, the damage to the vehicle was minimal, as shown in Figure 123. Damage was concentrated on the right-front corner of the vehicle. The right side of the front bumper crushed inward, the right fender was dented, and the right side of the vehicle was scraped. The right-front tire was punctured, but the vehicle was stable and rolled downstream on all four tires following the primary impact. The windshield and all other window glass remained intact and undamaged.



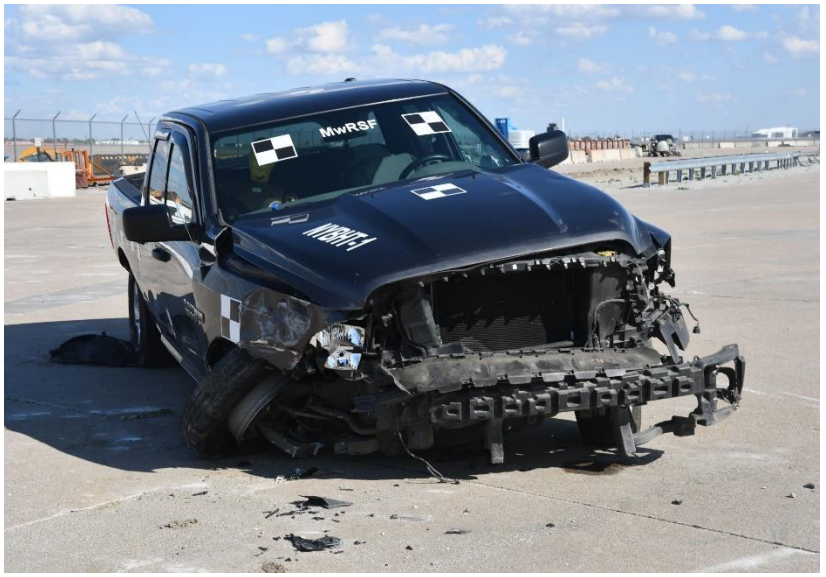
Figure 123. Vehicle Damage after Primary Impact, Test No. NYBHT-1

After exiting the barrier system, the vehicle sustained additional damage in a secondary impact with protection PCBs placed downstream of the barrier installation. The right-front corner of the vehicle impacted a PCB segment and the right side of the vehicle scraped along the concrete barrier before coming to rest against the PCBs. Following this secondary impact, the entire front end of the vehicle was shifted to the left and crushed. The front bumper, left headlight, and grille were disengaged from the vehicle, and the right headlight was crushed. The right-front tire had partially detached from the rim and the rim was deformed. The leading edge of the left fender was crushed. The right fender was crushed, scraped, and bent. The lower edge of the right-front door was torn. Scrapes and dents were visible along the full length of both right-side doors and continued along the quarter panel. The right side of the rear bumper was crushed. On the undercarriage, the right sway bar end link was snapped at the bottom near the control arm. The right-side upper control arm was twisted, and the right-side lower control arm was fractured. The right-side upper ball joint was disengaged. The steering gearbox was cracked. The right-side outer tie rod was bent but remained attached. The frame horn was bent to the left and the right frame horn had approximately 13 in. of lateral movement. Both front cab mounts were deformed rearward and toward the left side. The fuel tank remained intact and undamaged.

The total damage sustained by the vehicle during both test no. NYBHT-1 and the subsequent impact with the arresting PCBs is shown in Figures 124 through 126. Overall, the damage to the vehicle was moderate, even though the damage sustained during the actual impact with the Box Beam Guide Rail to HPBO transition was minimal. The maximum occupant compartment intrusions are listed in Table 17, along with the intrusion limits established in MASH

for various areas of the occupant compartment. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix H. MASH defines intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. Outward deformations, which are denoted as negative numbers in Appendix H, are not considered crush toward the occupant, and are not evaluated by MASH criteria. Penetrations into the occupant compartment did not occur, and none of the established MASH deformation limits were violated.





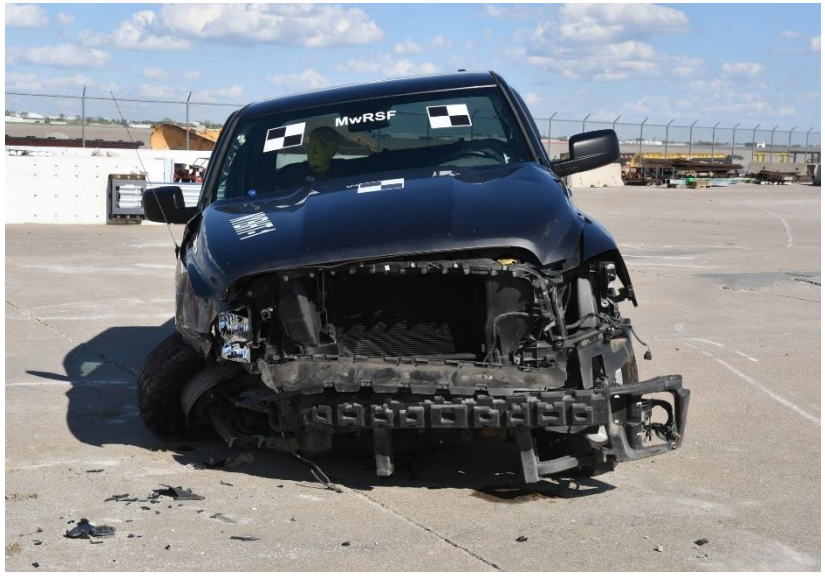




Figure 124. Vehicle Damage, Test No. NYBHT-1



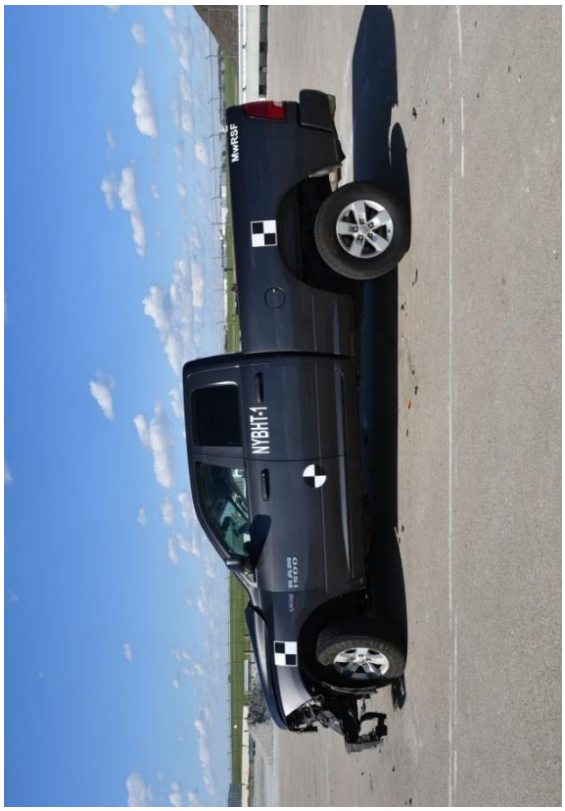






Figure 125. Additional Vehicle Damage, Test No. NYBHT-1

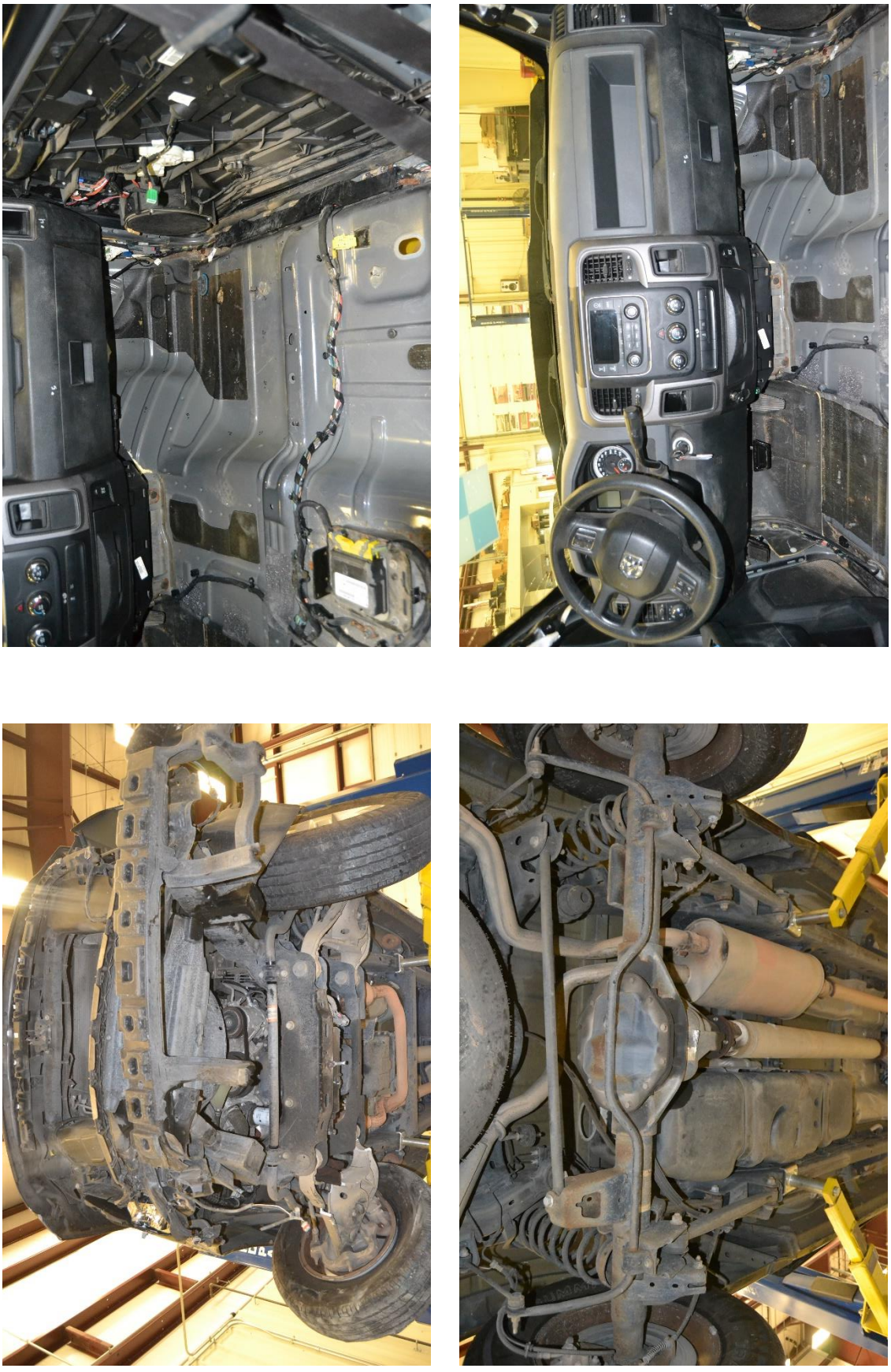


Figure 126. Undercarriage and Occupant Compartment Damage, Test No. NYBHT-1

Table 17. Maximum Occupant Compartment Intrusion by Location, Test No. NYBHT-1

Location	Maximum Intrusion (in.)	MASH Allowable Intrusion (in.)
Wheel Well & Toe Pan	0.7	≤ 9
Floor Pan & Transmission Tunnel	0.0	≤ 12
A-Pillar	0.1	≤ 5
A-Pillar (Lateral)	0.0*	≤ 3
B-Pillar	0.1	≤ 5
B-Pillar (Lateral)	0.0	≤ 3
Side Front Panel (in Front of A-Pillar)	0.2	≤ 12
Side Door (Above Seat)	0.0*	≤ 9
Side Door (Below Seat)	0.1	≤ 12
Roof	0.1	≤ 4
Windshield	0.0	≤ 3
Side Window	Intact	No shattering resulting from contact with structural member of test article
Dash	0.3	N/A

N/A – No MASH criteria exist for this location.
*Negative value reported as 0.0. See Appendix H for further information.

8.6 Occupant Risk

The calculated OIVs and maximum 0.010-sec average ORAs in both the longitudinal and lateral directions, as determined from the accelerometer data, are shown in Table 18. Note that the OIVs and ORAs were within suggested limits, as provided in MASH. The calculated THIV, PHD, and ASI values are also shown in Table 18. The recorded data from the accelerometers and the rate transducers are shown graphically in Appendix K.

Table 18. Summary of Occupant Risk Values, Test No. NYBHT-1

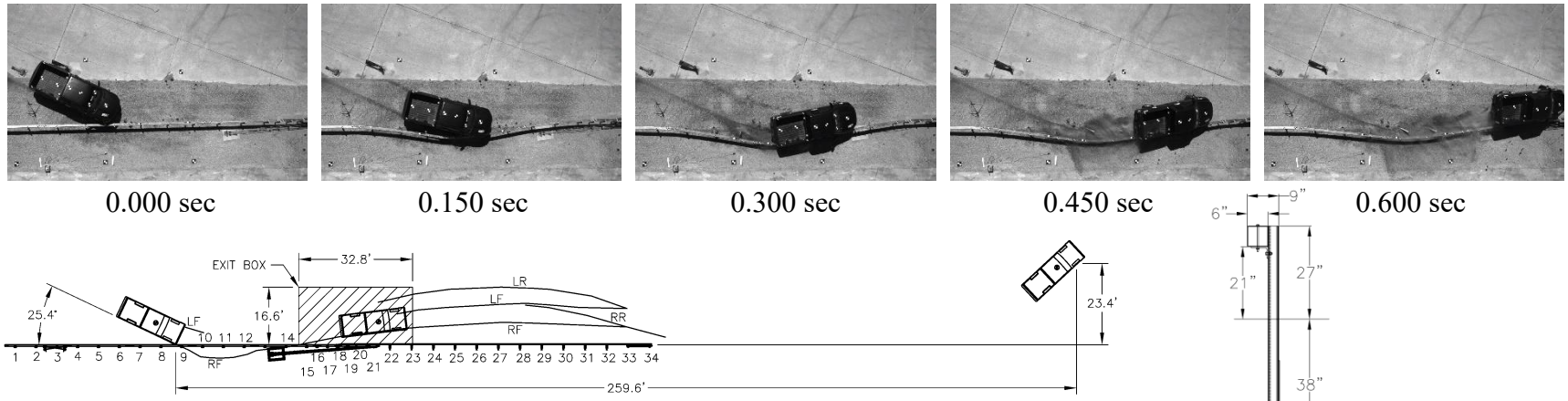
Evaluation Criteria		Transducer		MASH Limits
		SLICE-1	SLICE-2 (primary)	
OIV (ft/s)	Longitudinal	-11.19	-10.94	±40
	Lateral	-14.24	-15.27	±40
ORA (g's)	Longitudinal	5.08	5.26	±20.49
	Lateral	-7.24	-5.90	±20.49
Maximum Angular Displacement (deg.)	Roll	22.1	18.7	±75
	Pitch	-6.9	8.5	±75
	Yaw	-38.1	-37.8	not required
THIV – (ft/s)		17.38	17.76	not required
PHD – (g's)		7.27	7.15	not required
ASI		0.62	0.54	not required

8.7 Discussion

Analysis of test no. NYBHT-1 showed that the system adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier. Sequential photographs and a summary of the test results are shown in Figure 127. 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 K, 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 16.7 degrees, and its trajectory did not violate the bounds of the exit box. Therefore, test no. NYBHT-1 satisfied the MASH safety performance criteria for test designation no. 3-21.

The CIP for test no. NYBHT-1 was selected to maximize vehicle interaction with the cable anchorage during redirection and was based on vehicle trajectory measurements of previous MASH testing into weak-post box beam. However, the 2270P vehicle in test no. NYBHT-1 only traversed over the corner of the concrete anchor block during its exit from the system and did not contact the anchor cables. Upon review of the high-speed test video, it was found that the vehicle was redirected and exited the system more quickly and with less deformation in this test than the previous MASH test on weak-post box beam. The reduction in post spacing from 6 ft to 3 ft in the transition region of the system at the downstream end of the vehicle contact region provided additional stiffness and strength to the barrier, which resulted in the vehicle being redirected more quickly as it approached the reduced post spacing transition region.

The increased strength in the transition region of the test installation greatly reduced the lateral distance over which the vehicle could extend into the guide rail. After further review of the test results, it was believed that the vehicle's interaction with the cables may remain minimal even for impact points further downstream from that tested in NYBHT-1. For impact points closer to the transition region, the overall system behavior would be stiffer, reducing the maximum dynamic deflections relative to those observed in test no. NYBHT-1. Thus, vehicle interaction with the cable anchorage resulting in system failure was unlikely, and further testing was deemed unnecessary.



- Test Agency ..... MwRSF
- Test Number NYBHT-1
- Date 5/1/2020
- MASH Test Designation No. 3-21
- Test Article ..... NYSDOT Box Beam Guide Rail to HPBO W-Beam Transition
- Total Length ..... 186 ft – 4½ in.
- Key Component – Box Beam Rail
  - Shape TS6x6x3/16
  - Top Mounting Height ..... 27 in.
- Key Component –W-Beam Rail
  - Thickness ..... 12 gauge
  - Top Mounting Height ..... 31 in.
- Key Component – Steel Post for Box Beam Rail (Post Nos. 1 through 21)
  - Shape ..... S3x5.7, 65-in. length
  - Typical Embedment ..... 38 in.
  - Spacing ..... 72 in. (post nos. 1 through 15)
    36 in. (post nos. 15 through 21)
- Key Component – Steel Post for W-Beam Rail (Post Nos. 22 through 32)
  - Shape ..... W6x8.5, 72-in. length
  - Typical Embedment ..... 40 in.
  - Spacing ..... 75 in.
- Soil Type ..... Coarse Crushed Limestone (Well-Graded Gravel)
- Vehicle Make /Model ..... 2014 Dodge Ram 1500
  - Curb ..... 5,113 lb
  - Test Inertial ..... 5,000 lb (MASH limit 5,000 ± 110 lb)
  - Gross Static ..... 5,156 lb (MASH limit 5,165 ± 110 lb)
- Impact Conditions
  - Speed ..... 63.1 mph (MASH limit 62 ± 2.5 mph)
  - Angle ..... 25.4 deg. (MASH limit 25 ± 1.5 deg.)
  - Impact Location ..... 354.2 in. upstream from center of transition anchor
- Impact Severity ..... 122.4 kip-ft > 106 kip-ft limit from MASH
- Exit Conditions
  - Speed ..... 49.2 mph
  - Angle ..... 16.7 deg.
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 259.6 ft downstream, 23.4 ft laterally in front
- Vehicle Damage ..... Moderate
  - VDS [17] 1-FR-4
  - CDC [18] 01FDEW1
  - Maximum Interior Deformation ..... 0.7 in. at wheel well/toe pan < 9-in. MASH limit
- Test Article Damage ..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 34.9 in.
  - Dynamic ..... 54.4 in.
  - Working Width ..... 67.9 in.
- Transducer Data

Evaluation Criteria		Transducer		MASH Limits
		SLICE-1	SLICE-2 (primary)	
OIV (ft/s)	Longitudinal	-11.19	-10.94	±40
	Lateral	-14.24	-15.27	±40
ORA (g's)	Longitudinal	5.08	5.26	±20.49
	Lateral	-7.24	-5.90	±20.49
Maximum Angular Displacement (deg.)	Roll	22.1	18.7	±75
	Pitch	-6.9	8.5	±75
	Yaw	-38.1	-37.8	not required
THIV – (ft/s)		17.38	17.76	not required
PHD – (g')s		7.27	7.15	not required
ASI		0.62	0.54	not required

Figure 127. Summary of Test Results and Sequential Photographs, Test No. NYBHT-1

9 FULL-SCALE CRASH TEST NO. NYBHT-2

9.1 Static Soil Test

Before full-scale crash test no. NYBHT-2 was conducted, the strength of the foundation soil was evaluated with a static test, as described in MASH [3]. The static test results, as shown in Appendix E, 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.

9.2 Weather Conditions

Test no. NYBHT-2 was conducted on June 15, 2020, at approximately 12:00 p.m. The weather conditions as reported by the National Oceanic and Atmospheric Administration (station 14939/KLNK) are shown in Table 19.

Table 19. Weather Conditions, Test No. NYBHT-2

Temperature	89°F
Humidity	33%
Wind Speed	20 mph
Wind Direction	200° from True North
Sky Conditions	Clear
Visibility	10 Statute Miles
Pavement Surface	Dry
Previous 3-Day Precipitation	0.00 in.
Previous 7-Day Precipitation	0.16 in.

9.3 Test Description

Initial vehicle impact was to occur 90 in. upstream from the centerline of post no. 15, as shown in Figure 128. As discussed in Section 4.3.2, the CIP was selected to maximize the potential for vehicle snag on the reduced spacing transition posts. The 2,442-lb small car impacted the NYSDOT Box Beam Guide Rail to HPBO Transition at a speed of 66.2 mph and an angle of 25.2 degrees. Note that the impact speed of 66.2 mph exceeded the MASH nominal impact speed tolerance of 62 mph ± 2.5 mph. However, this higher speed resulted in an increased impact severity, and the impact speed exceeding the nominal criteria is acceptable for longitudinal barriers. The actual impact location was 90.3 in. upstream from the centerline of post no. 15. The vehicle was redirected and came to rest facing upstream with the right-front tire positioned 91.6 ft downstream from the impact point and 15.9 ft in front of the system.

A detailed description of the sequential impact events is contained in Tables 20 and 21, and sequential photographs are shown in Figures 129 and 130, with movement definitions shown in Appendix G. Documentary photographs of the crash test are shown in Figures 131 and 132. The vehicle trajectory and final position are shown in Figure 133.



Figure 128. Target Impact Location, Test No. NYBHT-2

Table 20. Sequential Description of Impact Events, Test No. NYBHT-2

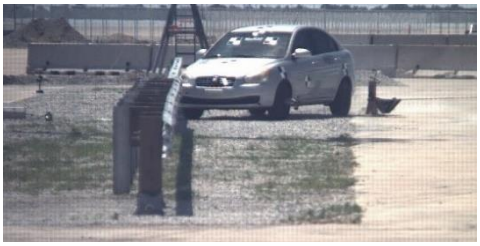
Time sec	Event
0.000	Vehicle's front bumper and right headlight contacted rail and deformed.
0.004	Vehicle's right-front fender contacted rail and deformed. Post no. 14 rotated backward.
0.012	Post nos. 13 and 15 rotated backward.
0.022	Post nos. 12 and 16 rotated backward.
0.030	Vehicle's hood contacted rail and deformed, and vehicle's right headlight shattered. Vehicle's right front tire contacted post no. 14 and post no. 14 bent downstream.
0.034	Vehicle began yawing away from system. Post no. 14 L-bracket disengaged from box beam bolt due to bolt fracture.
0.038	Vehicle's grille deformed and vehicle's right-front corner extended under box beam. Vehicle's right-front door contacted rail, and post no. 17 deflected backward.
0.046	Vehicle rolled away from system.
0.066	Post nos. 18 and 19 rotated backward. Vehicle's right-front tire contacted transition anchor cable no. 1.
0.074	Vehicle's front bumper contacted post no. 15. Post no. 15 bent downstream and L-bracket disengaged from box beam bolt due to bolt fracture. Vehicle's right-front tire traversed over transition anchor cable no. 1.
0.084	Post no. 20 rotated backward. Vehicle's right-front tire traversed over transition anchor cable no. 2.
0.090	Vehicle's right-rear tire became airborne.
0.098	Post no. 21 rotated backward. Vehicle traversed over all three transition anchor cables as the front of the vehicle extended under and lifted box beam rail.
0.106	Vehicle's front bumper contacted post no. 16, and post no. 16 bent downstream.
0.114	Post no. 17 L-bracket disengaged from box beam bolt due to bolt fracture.
0.140	Vehicle's right-front door deformed.
0.148	Vehicle's right-front tire contacted post no. 17, and post no. 17 bent downstream.
0.152	Vehicle's grille disengaged. Vehicle's right-front corner continued to extend under the box beam rail, which continued to lift box beam while the right-front tire continued to traverse over all three transition anchor cables..
0.182	Post no. 19 L-bracket disengaged from box beam bolt due to bolt fracture.
0.196	Vehicle became parallel to the system at a speed of 44.7 mph.
0.202	Vehicle's right-front tire contacted post no. 18, and post no. 18 bent downstream.
0.208	Vehicle's right-rear door contacted rail and deformed.
0.212	Vehicle's rear bumper contacted rail and deformed.
0.240	Vehicle's right-front tire contacted post no. 19, and post no. 19 bent downstream.
0.262	Vehicle right-front tire continued traversing over all three transition cables. Downstream threaded end of transition anchor cable no. 1 sheared and disengaged from box beam L-bracket.
0.286	Upstream end of transition anchor cable no. 1 disengaged from concrete anchor cable bracket assembly.

Table 21. Sequential Description of Impact Events, Test No. NYBHT-2, Cont.

0.289	Vehicle yawed toward the system and continued to yaw.
0.290	Vehicle rolled toward system.
0.302	Downstream threaded end of transition anchor cable no. 2 sheared and disengaged from box beam L-bracket.
0.310	Post no. 20 rotated downstream.
0.332	Upstream end of transition anchor cable no. 2 disengaged from concrete anchor cable bracket assembly.
0.384	Vehicle's right-rear tire regained contact with ground.
0.418	Vehicle exited system at a speed of 34.2 mph and an angle of 7.5 degrees.
0.454	Vehicle's left-rear tire became airborne.
0.472	Vehicle's right taillight disengaged.
0.570	Vehicle rolled away from system and vehicle's left-rear tire regained contact with ground.
0.746	Vehicle's right-front tire became airborne.
0.826	Vehicle rolled toward system.
0.866	Vehicle's right-front tire regained contact with ground.
1.050	System came to rest.
3.088	Vehicle came to rest facing upstream.



0.000 sec


0.000 sec



0.100 sec


0.100 sec


0.200 sec


0.200 sec


0.300 sec


0.300 sec


0.400 sec


0.400 sec


0.500 sec


0.500 sec

Figure 129. Sequential Photographs, Test No. NYBHT-2


0.000 sec


0.000 sec


0.150 sec


0.150 sec


0.300 sec


0.300 sec


0.450 sec


0.450 sec


0.600 sec


0.600 sec


0.750 sec


0.750 sec

Figure 130. Sequential Photographs, Test No. NYBHT-2



Figure 131. Documentary Photographs, Test No. NYBHT-2



Figure 132. Documentary Photographs, Test No. NYBHT-2



Figure 133. Vehicle Final Position and Trajectory Marks, Test No. NYBHT-2

9.4 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 134 through 142. Barrier damage consisted of contact marks, kinks, and dents on the box beam rail, deformed steel posts, and detached box beam rail. The length of vehicle contact along the barrier was approximately 24 ft – 8 in. and began approximately 28 in. upstream from the centerline of post no. 14 and continued to approximately 20 in. upstream of post no. 21.

The box beam deflected upward and backward between splice nos. 12 to 13 and the upstream edge of the transition cover plate. Additionally, the box beam was intermittently dented and kinked throughout the impact region. Contact marks on the top, front, and bottom faces of the box beam rail extended downstream from initial impact through post no. 21. At the transition cover plate, contact marks and a 44-in. long dent extended downstream from the leading edge of the plate. Small kinks were visible at the top of the W-beam rail between post nos. 21 and 23. The box beam rail detached from the L-bracket at post nos. 14, 15, 17, 19, and 21. At post nos. 15 and 19, the L-brackets also detached from the posts. Note that post nos. 16, 18, and 20 did not incorporate a rail-to-post connection.

Post deformations, including bending, rotation, and twisting, were observed at post nos. 11 through 21. At post nos. 11 through 13, 20, and 21, minor backward rotation occurred. Significant downstream bending occurred at post nos. 14 through 19. Post nos. 14 through 18 also encountered backward rotation. Contact marks were observed on the flanges of post nos. 14 through 21.

At the transition anchor assembly, the ends of cable nos. 1 and 2 disengaged from the slotted anchor plate, and the brass rod securing the cables to the anchor plate was bent. The threaded rod ends of the anchor cable nos. 1 and 2 sheered at the box beam L-bracket. Cable no. 3 remained in place in both the anchor plate and the box-beam L-bracket.



Figure 134. System Damage, Test No. NYBHT-2



Figure 135. System Damage, Test No. NYBHT-2



Figure 136. Box Beam Rail Damage, Test No. NYBHT-2





Figure 137. Transition Anchorage Damage, Test No. NYBHT-2

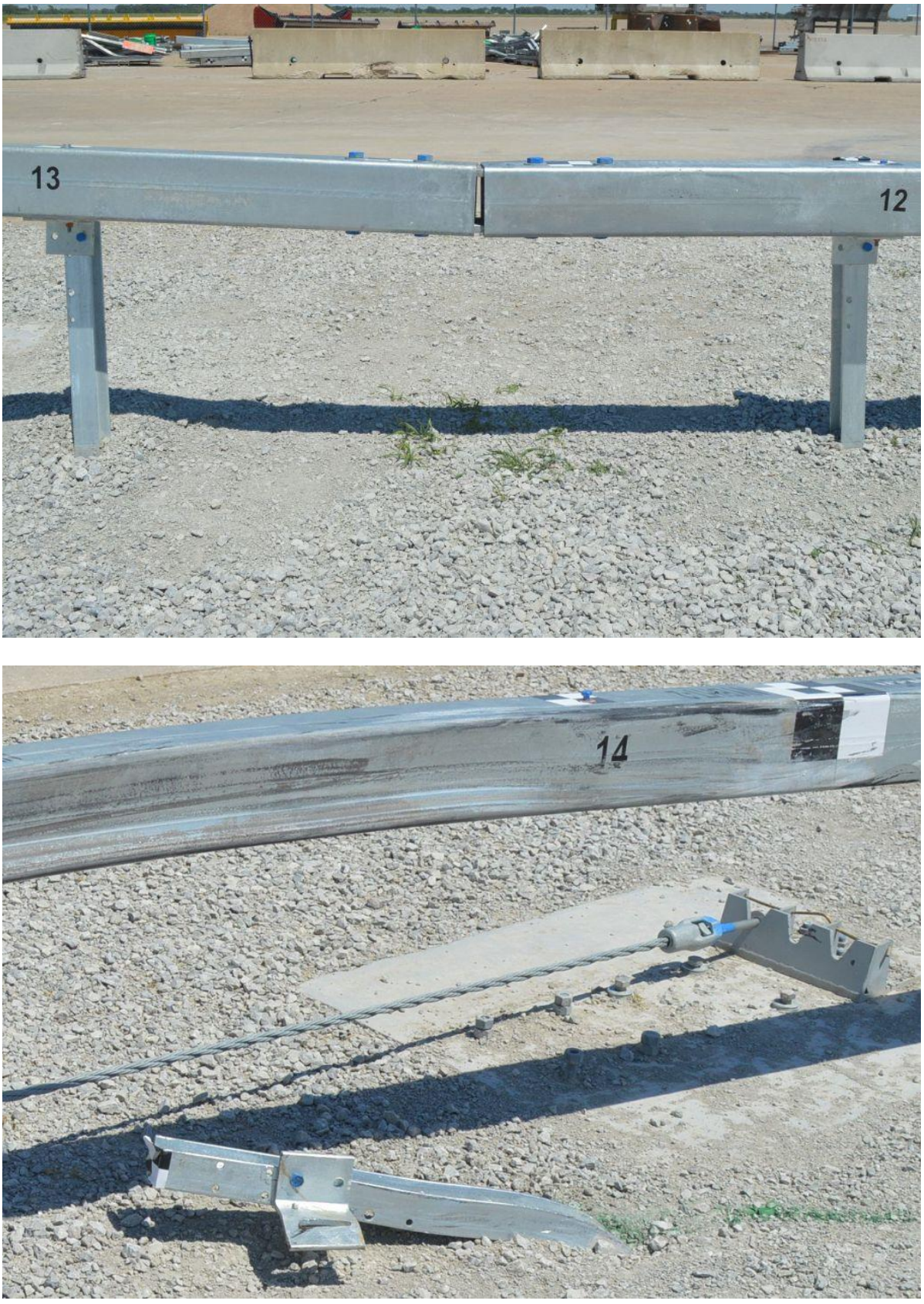


Figure 138. System Damage, Post Nos. 12 through 14, Test No. NYBHT-2



Figure 139. System Damage, Post Nos. 15 through 17, Test No. NYBHT-2

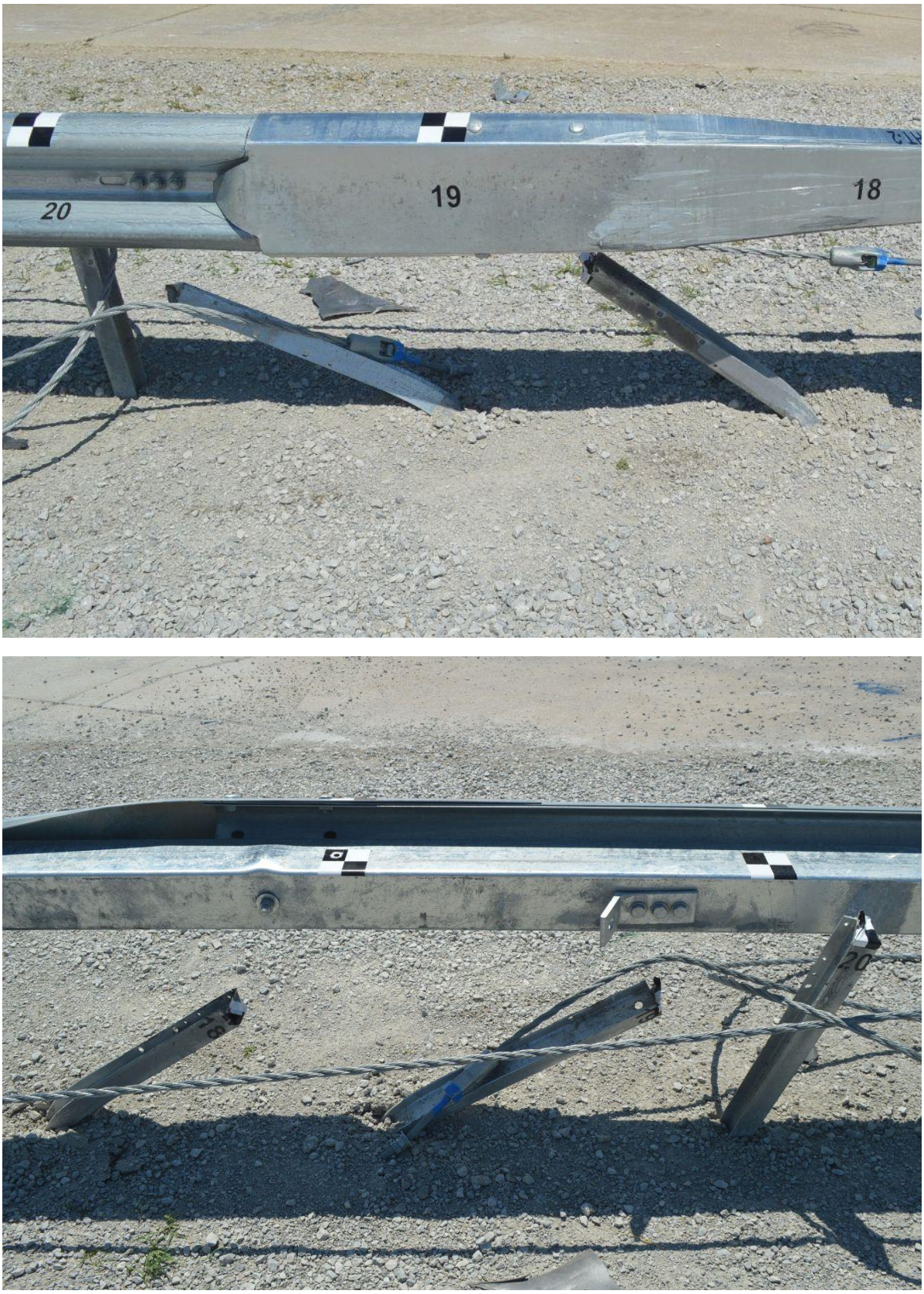


Figure 140. System Damage, Post Nos. 18 through 20, Test No. NYBHT-2

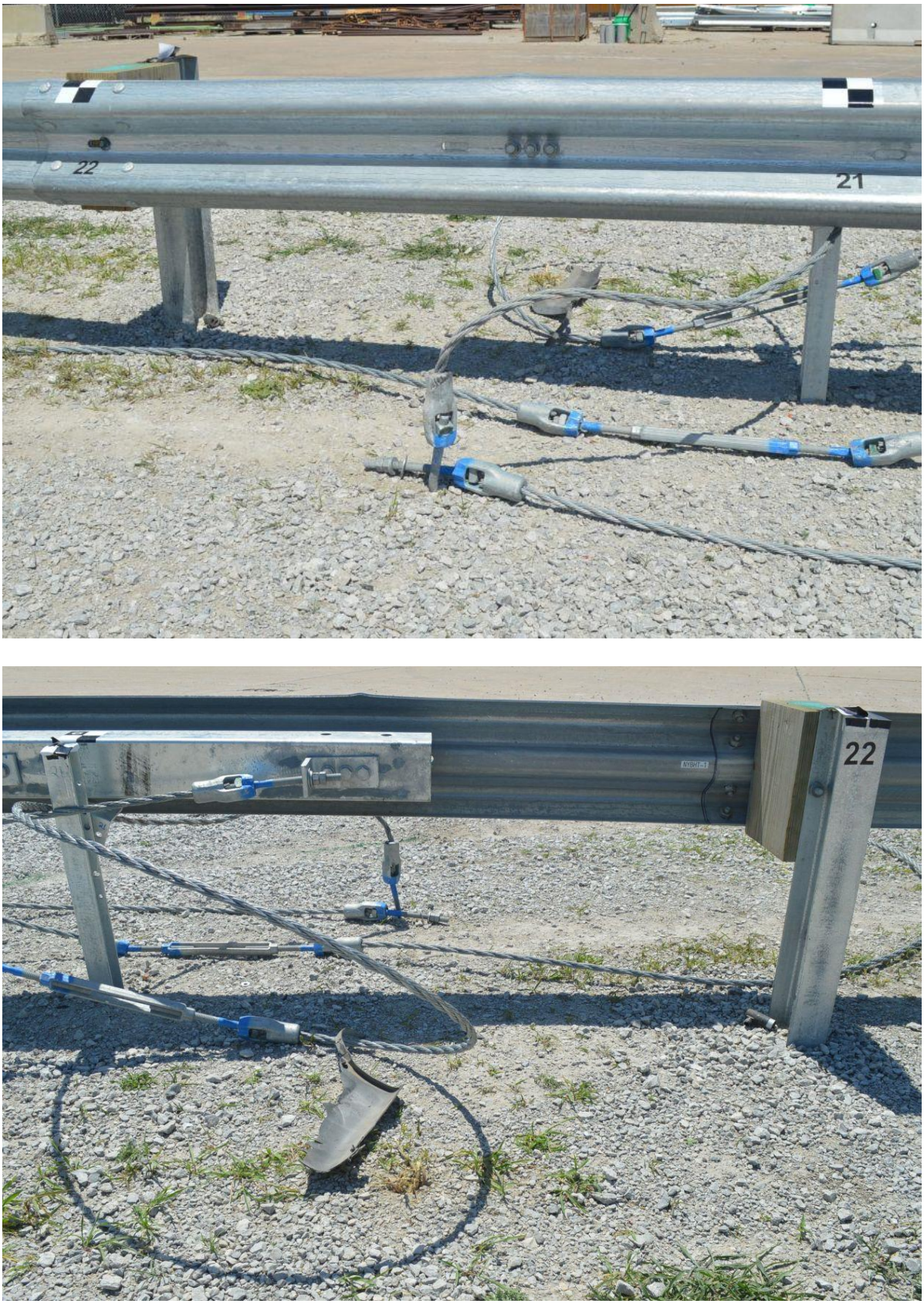


Figure 141. System Damage, Post Nos. 21 and 22, Test No. NYBHT-2

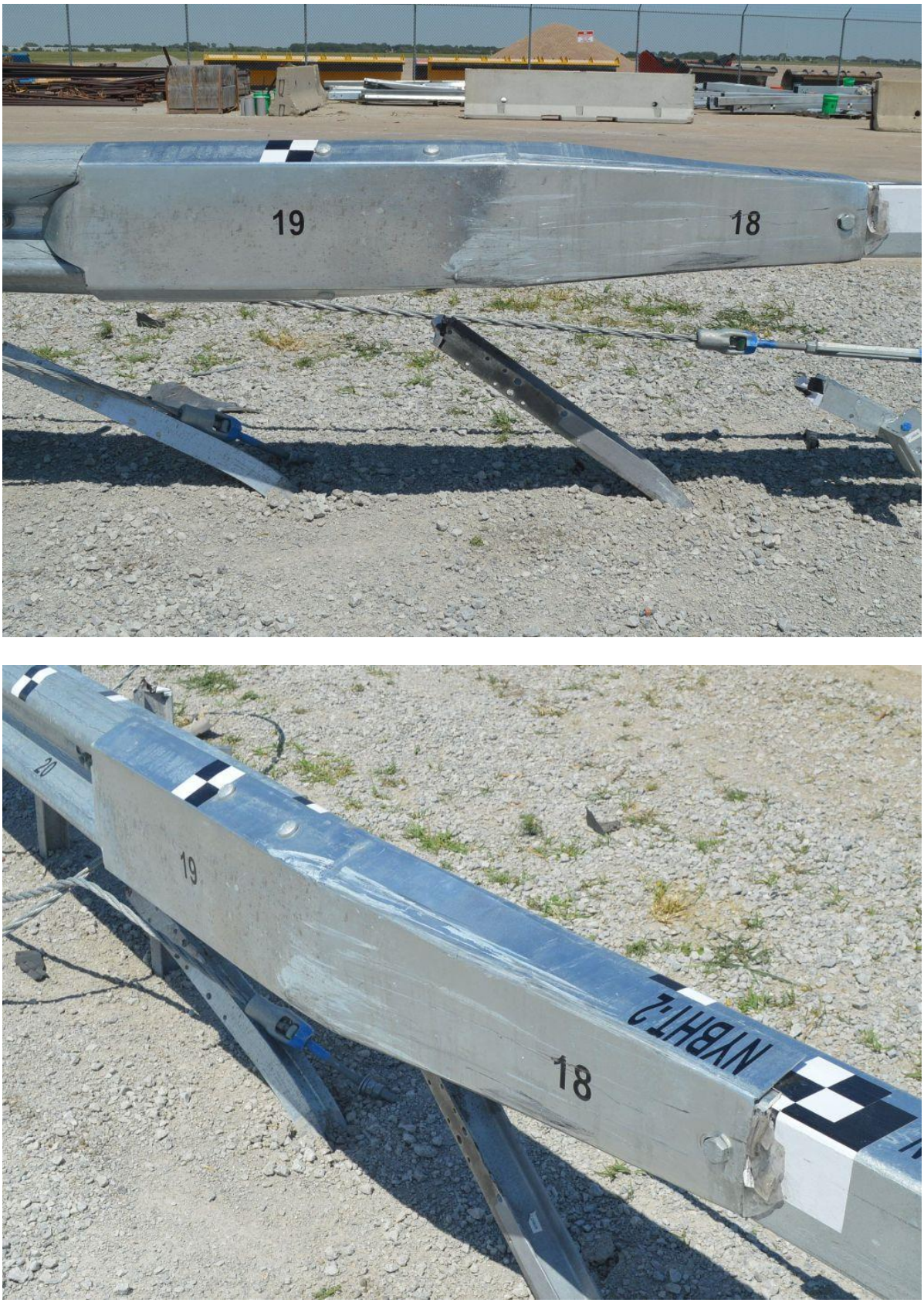


Figure 142. System Damage, Transition Cover Plate, Test No. NYBHT-2

The maximum lateral dynamic rail deflection was 29.3 in. at the midspan between post nos. 14 and 15, and the maximum lateral post deflection was 15.9 in. at post no. 16, as determined from high-speed digital video analysis. The maximum lateral permanent set of the rail was 15.6 in. at the midspan between post nos. 14 and 15, and the maximum lateral permanent set of the posts was 13.8 in. at post no. 14, as measured in the field using GPS. Based on dynamic deflection, the working width of the system was found to be 35.3 in., determined from high-speed digital video analysis. If the cable anchorage and concrete anchor block are considered, the working width would be 60 in. A schematic of the permanent set deflection, dynamic deflection, and working width is shown in Figure 143.

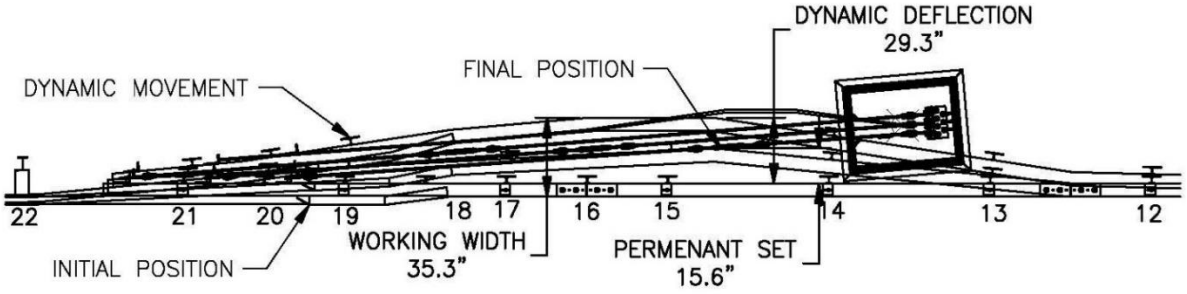


Figure 143. Permanent Set, Dynamic Deflection, and Working Width, Test No. NYBHT-2

9.5 Vehicle Damage

Damage to the vehicle was moderate, as shown in Figures 144 through 146. The maximum occupant compartment intrusions are listed in Table 22, along with the intrusion limits established in MASH for various areas of the occupant compartment. Complete occupant compartment and vehicle deformations and the corresponding locations are provided in Appendix H. MASH defines intrusion or deformation as the occupant compartment being deformed and reduced in size with no observed penetration. Outward deformations, which are denoted as negative numbers in Appendix H, are not considered crush toward the occupant, and are not evaluated by MASH criteria. Penetrations into the occupant compartment did not occur, and none of the established MASH deformation limits were violated.

Damage was concentrated on the right-front corner and right side of the vehicle. The right side of the front bumper was detached, and the right-front fender was crushed inward. The right-front tire was partially disengaged from the rim, and the rim was deformed. The grille and right headlight were disengaged from the vehicle. The right-front edge of the hood was crushed inward. The right-front door was torn and crushed along its mid-height line, jamming the latch. The entire right side of the vehicle was scraped and dented. The rear bumper was scraped on the right side and the right taillight was disengaged from the vehicle. The windshield and all other window glass remained intact and undamaged.

Undercarriage damage was concentrated on the right side of the vehicle. The right side of the frame, right-front shock mount, and right stabilizer link were bent. The right-side frame horn and lower control arm were twisted. The engine cross member was bent and crushed on the right side, and a 4½-in. long by ½-in. wide tear was visible at the connection between the front and rear cross members. The right-side tie rod was snapped at the steering gear box and the lower tie rod was bent. The fuel tank remained intact and undamaged.









Figure 144. Vehicle Damage, Test No. NYBHT-2







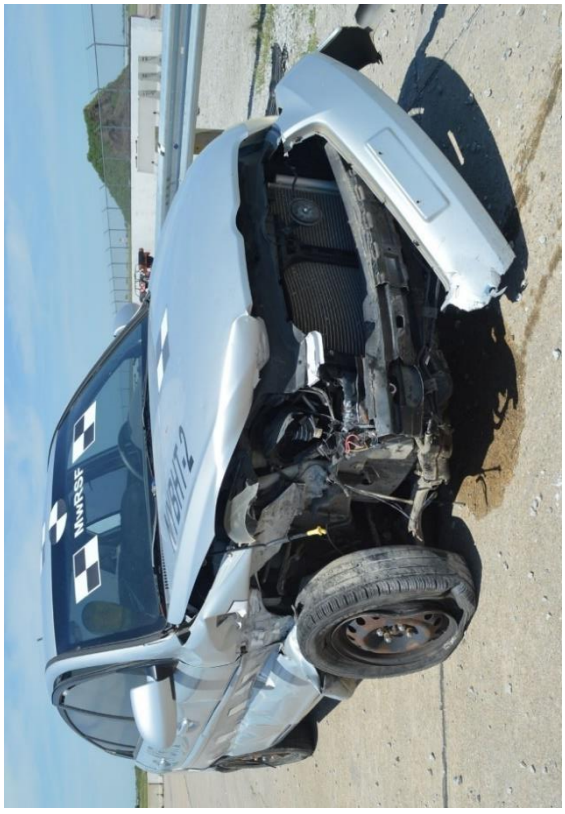


Figure 145. Vehicle Damage, Test No. NYBHT-2






Figure 146. Vehicle Undercarriage Damage and Occupant Compartment Damage, Test No. NYBHT-2

Table 22. Maximum Occupant Compartment Intrusion by Location, Test No. NYBHT-2

Location	Maximum Intrusion (in.)	MASH 2016 Allowable Intrusion (in.)
Wheel Well & Toe Pan	0.9	≤ 9
Floor Pan & Transmission Tunnel	0.7	≤ 12
A-Pillar	0.8	≤ 5
A-Pillar (Lateral)	0.3	≤ 3
B-Pillar	0.7	≤ 5
B-Pillar (Lateral)	0.5	≤ 3
Side Front Panel (in Front of A-Pillar)	0.9	≤ 12
Side Door (Above Seat)	0.4	≤ 9
Side Door (Below Seat)	0.6	≤ 12
Roof	0.0*	≤ 4
Windshield	0.0	≤ 3
Side Window	Intact	No shattering resulting from contact with structural member of test article
Dash	1.3	N/A

N/A – No MASH criteria exist for this location
*Negative value reported as 0.0. See Appendix H for further information.

9.6 Occupant Risk

The calculated OIVs and maximum 0.010-sec average ORAs in both the longitudinal and lateral directions, as determined from the accelerometer data, are shown in Table 23. Note that the OIVs and ORAs were within suggested limits, as provided in MASH. The calculated THIV, PHD, and ASI values are also shown in Table 23. The recorded data from the accelerometers and the rate transducers is shown graphically in Appendix L.

Table 23. Summary of Occupant Risk Values, Test No. NYBHT-2

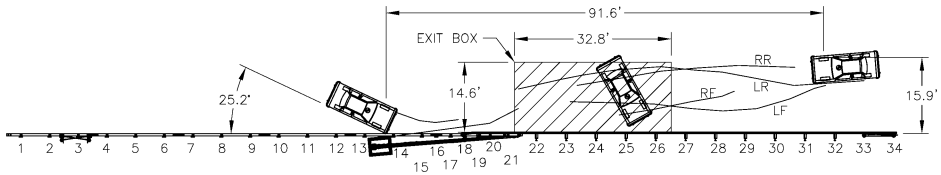
Evaluation Criteria		Transducer		MASH Limits
		SLICE-1 (primary)	TDAS	
OIV (ft/s)	Longitudinal	-19.91	-22.47	±40
	Lateral	-20.38	-18.24	±40
ORA (g's)	Longitudinal	-11.38	-8.83	±20.49
	Lateral	-10.56	-8.66	±20.49
Maximum Angular Displacement (deg.)	Roll	-10.4	not evaluated*	±75
	Pitch	-4.6	not evaluated*	±75
	Yaw	37.1	not evaluated*	not required
THIV – (ft/s)		25.65	not evaluated*	not required
PHD – (g's)		13.19	not evaluated*	not required
ASI		1.05	0.98	not required

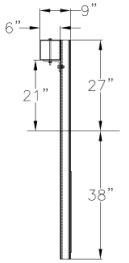
* Not evaluated due to technical difficulties with one of the angular rate sensors.

9.7 Discussion

Analysis of test no. NYBHT-2 showed that the system adequately contained and redirected the 1100C vehicle with controlled lateral displacements of the barrier. Sequential photographs and a summary of the test results are shown in Figure 147. 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 L, 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 7.5 degrees, and its trajectory did not violate the bounds of the exit box. Therefore, test no. NYBHT-2 satisfied the MASH safety performance criteria for test designation no. 3-20.







- Test Agency ..... MwRSF
- Test Number NYBHT-2
- Date 6/15/2020
- MASH Test Designation No. 3-20
- Test Article ..... NYSDOT Box Beam Guide Rail to HPBO W-Beam Transition
- Total Length ..... 186 ft – 4½ in.
- Key Component – Box Beam Rail
  - Shape ..... TS6x6x3⁄16
  - Top Mounting Height ..... 27 in.
- Key Component –W-Beam Rail
  - Thickness ..... 12 gauge
  - Top Mounting Height ..... 31 in.
- Key Component – Steel Post for Box Beam Rail (Post Nos. 1 through 21)
  - Shape ..... S3x5.7, 65-in. length
  - Typical Embedment ..... 38 in.
  - Spacing ..... 72 in. (post nos. 1 through 15); 36 in. (post nos. 15 through 21)
- Key Component – Steel Post for W-Beam Rail (Post Nos. 22 through 32)
  - Shape ..... W6x8.5, 72-in. length
  - Typical Embedment ..... 40 in.
  - Spacing ..... 75 in.
- Soil Type ..... Coarse Crushed Limestone (Well-Graded Gravel)
- Vehicle Make /Model ..... 2009 Hyundai Accent
  - Curb ..... 2,483 lb
  - Test Inertial ..... 2,442 lb (MASH limit 2,420 ± 55 lb)
  - Gross Static ..... 2,605 lb (MASH limit 2,585 ± 55 lb)
- Impact Conditions
  - Speed ..... 66.2 mph (MASH limit 62 ± 2.5 mph)
  - Angle ..... 25.2 deg. (MASH limit 25 ± 1.5 deg.)
  - Impact Location ..... 90.3 in. upstream from post no. 15
- Impact Severity ..... 64.9 kip-ft > 51 kip-ft limit from MASH
- Exit Conditions
  - Speed ..... 34.2 mph
  - Angle ..... 7.5 deg.
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 91.6 ft downstream, 15.9 ft laterally in front
- Vehicle Damage ..... Moderate
  - VDS [17] 1-RFQ-3
  - CDC [18] 01RYEW1
  - Maximum Interior Deformation ..... 0.9 in. at toe pan/wheel well < 9-in. MASH limit
- Test Article Damage ..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 15.6 in.
  - Dynamic ..... 29.3 in.
  - Working Width ..... 35.3 in.
- Transducer Data

Evaluation Criteria		Transducer		MASH Limits
		SLICE-1 (primary)	TDAS	
OIV (ft/s)	Longitudinal	-19.91	-22.47	±40
	Lateral	-20.38	-18.24	±40
ORA (g's)	Longitudinal	-11.38	-8.83	±20.49
	Lateral	-10.56	-8.66	±20.49
Maximum Angular Displacement. (deg.)	Roll	-10.4	*	±75
	Pitch	-4.6	*	±75
	Yaw	37.1	*	not required
THIV – (ft/s)		25.65	*	not required
PHD – (g's)		13.19	*	not required
ASI		1.05	0.98	not required

* Not evaluated due to technical difficulties with one of the angular rate sensors.

Figure 147. Summary of Test Results and Sequential Photographs, Test No. NYBHT-2

10 SUMMARY AND CONCLUSIONS

The NYSDOT HPBO to Box Beam Transition system consists of HPBO W-beam guide rail, box beam guide rail, and an intermediate transition section. The system is designed to be used for both HPBO to box beam and box beam to HPBO transition installations. Test nos. NYHBT-1 and NYHBT-2 assessed the crashworthiness of the HPBO to box beam guide rail transition according to MASH test designation nos. 3-21 and 3-20, respectively. Test nos. NYBHT-1 and NYBHT-2 assessed the crashworthiness of the box beam guide rail to HPBO transition according to MASH test designation nos. 3-21 and 3-20, respectively. Summaries of the test evaluations are shown in Tables 24 and 25.

In test no. NYHBT-1, the 4,997-lb pickup truck impacted the NYSDOT HPBO to box beam guide rail transition at a speed of 63.7 mph and an angle of 25.1 degrees, resulting in an impact severity of 122.0 kip-ft. The impact occurred 84.3 in. upstream from the centerline of post no. 14. After impacting the barrier system, the vehicle exited the system at a speed of 40.8 mph and an angle of 11.2 degrees. The vehicle was successfully contained and smoothly redirected with moderate damage to both the barrier system and the vehicle. All occupant risk values fell within the recommended safety limits established in MASH. Therefore, test no. NYHBT-1 was successful according to the safety criteria of MASH test designation no. 3-21.

In test no. NYHBT-2, the 2,421-lb small car impacted the NYSDOT HPBO to box beam guide rail transition at a speed of 61.3 mph and an angle of 25.2 degrees, resulting in an impact severity of 55.1 kip-ft. The impact occurred 84.8 in. upstream from the centerline of post no. 17. After impacting the barrier system, the vehicle exited the system at a speed of 30.5 mph and an angle of 5.3 degrees. The vehicle was successfully contained and smoothly redirected with moderate damage to both the barrier system and the vehicle. All occupant risk values fell within the recommended safety limits established in MASH. Therefore, test no. NYHBT-2 was successful according to the safety criteria of MASH test designation no. 3-20.

In test no. NYBHT-1, the 5,000-lb pickup truck impacted the box beam guide rail to HPBO transition at a speed of 63.1 mph and an angle of 25.4 degrees, resulting in an impact severity of 122.4 kip-ft. The impact occurred 354 in. upstream from the center of the transition anchor 27 in. upstream from post no. 9. The vehicle exited the system at a speed of 49.2 mph and an angle of 16.7 degrees. The vehicle was successfully contained and smoothly redirected with moderate damage to both the barrier system and the vehicle. All occupant risk values fell within the recommended safety limits established in MASH. Therefore, test no. NYBHT-1 was successful according to the safety criteria of MASH test designation no. 3-21.

In test no. NYBHT-2, the 2,442 lb small car impacted the box beam guide rail to HPBO transition at a speed of 66.2 mph and at an angle of 25.2 degrees, resulting in an impact severity of 64.9 kip-ft. The impact occurred 90.3 in. upstream from the centerline of post no. 15. The vehicle exited the system at a speed of 34.2 mph and at an angle of 7.5 degrees. The vehicle was successfully contained and smoothly redirected with moderate damage to both the barrier system and the vehicle. All occupant risk values fell within the recommended safety limits established in MASH. Therefore, test no. NYBHT-2 was successful according to the safety criteria of MASH test designation no. 3-20.

Table 24. Summary of Safety Performance Evaluation, HPBO-to-Box Beam Guide Rail Transition

Evaluation Factors	Evaluation Criteria	Test No. NYHBT-1	Test No. NYHBT-2
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.	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 for calculation procedure) should satisfy the following limits:	S	S
	Occupant Impact Velocity Limits		
	Component / Preferred / Maximum		
	Longitudinal and Lateral / 30 ft/s / 40 ft/s		
	I. The Occupant Ridedown Acceleration (ORA) (see Appendix A, Section A5.2.2 of MASH 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 Test Designation No.		3-21	3-20
Final Evaluation (Pass or Fail)		Pass	Pass

S – Satisfactory U – Unsatisfactory NA – Not Applicable

Table 25. Summary of Safety Performance Evaluation, Box-to-HPBO Box Beam Guide Rail Transition

Evaluation Factors	Evaluation Criteria	Test No. NYBHT-1	Test No. NYBHT-2
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.	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 for calculation procedure) should satisfy the following limits:	S	S
	Occupant Impact Velocity Limits: Component — Preferred — Maximum; Longitudinal and Lateral — 30 ft/s — 40 ft/s		
	I. The Occupant Ridedown Acceleration (ORA) (see Appendix A, Section A5.2.2 of MASH 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 Test Designation No.		3-21	3-20
Final Evaluation (Pass or Fail)		Pass	Pass

S – Satisfactory U – Unsatisfactory NA – Not Applicable

11 MASH EVALUATION

The objective of this research was to evaluate the safety performance of NYSDOT's HPBO to Box Beam Guide Rail Transition system, which consists of Heavy-Post Blocked-Out (HPBO) W-beam guide rail, box beam guide rail, and an intermediate transition section with half-post spacing. In the transition section, nested W-beam rail is connected to box beam guide rail, which is connected to a cable anchor assembly. A cover plate shaped to match the W-beam profile, and the box beam provides a smooth transition on the rail's traffic face. The system is designed to be used for both HPBO to box beam guide rail transition and box beam guide rail to HPBO transition installations. Thus, the crashworthiness of both configurations was investigated.

According to TL-3 evaluation criteria in MASH, two tests are required for the evaluation of longitudinal barrier transitions: (1) test designation no. 3-20 with an 1100C small car and (2) test designation no. 3-21 with a 2270P pickup truck. Both tests were conducted on the HPBO to box beam and box beam to HPBO transition configurations, for a total of four full-scale crash tests.

During test no. NYHBT-1, a 4,997-lb (1,098-kg) pickup truck with a simulated occupant seated in the left-front seat impacted the NYSDOT HPBO to box beam guide rail transition at a speed of 63.7 mph (102.5 km/h) and at an angle of 25.1 degrees, resulting in an impact severity of 121.9 kip-ft (165.3 kJ). The point of impact occurred 84.3 in. (2.1 m) upstream from the centerline of post no. 14. At 0.233 sec after impact, the vehicle became parallel to the system with a speed of 49.4 mph (79.5 km/h). At 0.431 sec after impact, the vehicle exited the system with a speed of 45.1 mph (72.6 km/h) and at an angle of 11.2 degrees. The vehicle was successfully contained and redirected.

Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal with a maximum of 3.4 in (86 mm), which did not violate the limits established in MASH 2016. Damage to the barrier was also moderate. Barrier damage consisted of contact marks and kinks on the rail, tears on the cover plate, deformation of the W-beam and box beam, deformed steel posts, and disengagement of the box beam from its posts. The maximum dynamic barrier deflection was 34.1 in. (866 mm). The working width of the transition system was 43.4 in (1,102 mm). All occupant risk measures were within the recommended limits, and the occupant compartment deformations were also deemed acceptable. Therefore, NYSDOT's HPBO to box beam guide rail transition system successfully met all the safety performance criteria of MASH 2016 test designation no. 3-21.

During test no. NYHBT-2, a 2,421-lb (2,267-kg) small car with a simulated occupant seated in the left-front seat impacted the NYSDOT HPBO to box beam guide rail transition at a speed of 61.3 mph (98.7 km/h) and at an angle of 25.2 degrees, resulting in an impact severity of 55.1 kip-ft (74.7 kJ). The point of impact occurred 84.8 in. (2.2 m) upstream from the centerline of post no. 17. At 0.350 sec after impact, the vehicle exited the system with a speed of 30.5 mph (58.3 km/h) and at an angle of 5.3 degrees. At 0.398 sec after impact, the vehicle became parallel to the system with a speed of 30.5 mph (59.4 km/h) and not in contact with the system. The vehicle was successfully contained and redirected.

Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal with a maximum of 0.7 in (18 mm), which did not violate the limits established in MASH 2016. Damage to the Barrier was also moderate. Barrier damage consisted of contact marks, kinks,

and dents on the rail, deformation of the W-beam and box beam, deformed steel posts, and disengagement of the box beam from its posts. The maximum dynamic barrier deflection was 15.7 in. (399 mm). The working width of the transition system was 28 in (711 mm). All occupant risk measures were within the recommended limits, and the occupant compartment deformations were also deemed acceptable. Therefore, NYSDOT's HPBO to box beam guide rail transition system successfully met all the safety performance criteria of MASH 2016 test designation no. 3-20.

During test no. NYBHT-1, a 5,000-lb (2,268-kg) pickup truck with a simulated occupant seated in the right-front seat impacted the NYSDOT box beam guide rail to HPBO transition at a speed of 63.1 mph (101.5 km/h) and at an angle of 25.4 degrees, resulting in an impact severity of 122.6 kip-ft (166.2 kJ). The point of impact occurred 354 in. (9 m) upstream from the center of the cable anchor bracket 27 in. upstream from post no. 9. At 0.238 sec after impact, the vehicle became parallel to the system with a speed of 51.9 mph (83.5 km/h). At 0.624 sec after impact, the vehicle exited the system with a speed of 49.2 mph (79.2 km/h) and at an angle of 16.7 degrees. The vehicle was successfully contained and redirected.

Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal with a maximum of 0.7 in (18 mm), which did not violate the limits established in MASH 2016. Damage to the barrier was also moderate. Barrier damage consisted of contact marks, deformation of the box beam, and disengagement of the box beam from its posts. The maximum dynamic barrier deflection was 54.4 in. (1,382 mm). The working width of the transition system was 67.9 in. (1725 mm) due to vehicle extension over the barrier during redirection. All occupant risk measures were within the recommended limits, and the occupant compartment deformations were also deemed acceptable. Therefore, NYSDOT's box beam guide rail to HPBO transition system successfully met all the safety performance criteria of MASH 2016 test designation no. 3-21.

During test no. NYBHT-2, a 2,442-lb (1,108-kg) small car with a simulated occupant seated in the left-front seat impacted the NYSDOT box beam guide rail to HPBO transition system at a speed of 66.2 mph (106.5 km/h) and at an angle of 25.2 degrees, resulting in an impact severity of 64.9 kip-ft (88 kJ). The point of impact occurred 90.3 in. (2.3 m) upstream from the centerline of post no. 15. At 0.196 sec after impact, the vehicle became parallel the system with a speed of 44.7 mph (71.9 km/h). At 0.418 sec after impact, the vehicle exited the system with a speed of 34.2 mph (59.4 km/h) and at an angle of 7.5 degrees. The vehicle was successfully contained and redirected.

Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal with a maximum of 1.3 in (33 mm), which did not violate the limits established in MASH 2016. Damage to the Barrier was also moderate. Barrier damage consisted of contact marks, kinks, and dents on the box beam rail, deformed steel posts, and detached box beam rail. The maximum dynamic barrier deflection was 29.3 in. (744 mm). The working width of the transition system was 35.3 in (897 mm). All occupant risk measures were within the recommended limits, and the occupant compartment deformations were also deemed acceptable. Therefore, NYSDOT's box beam guide rail to transition system successfully met all the safety performance criteria of MASH 2016 test designation no. 3-20.

The NYSDOT HPBO to Box Beam Guide Rail Transition system was successfully crash tested and evaluated according to the AASHTO MASH TL-3 criteria. This barrier successfully

met all the requirements of MASH test designation nos. 3-20 and 3-21 for the HPBO to Box Beam Guide Rail transition configuration as well as the Box Beam Guide Rail to HPBO transition configuration. Therefore, the researchers consider the system MASH compliant based on the successful test matrix.

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13 APPENDICES

Appendix A. A2LA Accreditation Documents



Accredited Laboratory

A2LA has accredited

MIDWEST ROADSIDE SAFETY FACILITY (MwRSF)

Lincoln, NE

for technical competence in the field of

Mechanical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 12th day of February 2020.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2937.01
Valid to November 30, 2021

For the tests to which this accreditation applies, please refer to the laboratory's Mechanical Scope of Accreditation.

Figure A-1. Midwest Roadside Safety Facility A2LA Accreditation Certificate No. 2937.01

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

MIDWEST ROADSIDE SAFETY FACILITY (MwRSF)[1]
University of Nebraska-Lincoln
4630 NW 36th Street
Lincoln, NE 68524
Ms. Karla Lechtenberg Phone: 402 472 9070

MECHANICAL

Valid To: November 30, 2021 Certificate Number: 2937.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests:

Tests	Test Methods[2]
Full-Scale Vehicle Crash Tests of Highway Safety Features	NCHRP Report 350; MASH; EN 1317
Full-Scale Vehicle Crash Tests of Perimeter Protection Systems and Access Control Devices	ASTM F2656; SD-STD-02.01 Revision A
Bogie Dynamic Tests of Highway Safety Features	Non-Standard Test Method: Dynamic Testing of Steel Post and Rigid Foundation; Non-Standard Test Method: Dynamic Testing of Post in Soil; Non-Standard Test Method: Dynamic Testing of Spacer Blocks
Crushable Nose Bogie Testing for Breakaway Supports	Non-Standard Test Method: Dynamic Testing of Breakaway Supports; AASHTO Breakaway Poles and Supports; NCHRP Report 350

On the following types of products, materials, and/or structures:
Metal, Wood, Concrete and Plastic Structures, Components of Structures, Fasteners, and Roadway Pavements.

[1] Administrative office located at: 2200 Vine Street, 130 Whittier Building, Lincoln, NE 68583-0853.

[2] This laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these tests.

(A2LA Cert. No. 2937.01) 02/12/2020 Page 1 of 1

5202 Presidents Court, Suite 220 | Frederick, MD 21703-8515 | Phone: 301 644 3248 | Fax: 240 454 9449 | www.A2LA.org

Figure A-2. Midwest Roadside Safety Facility Scope of Accreditation to ISO/IEC 17025

Appendix B. New York State Standard Plans

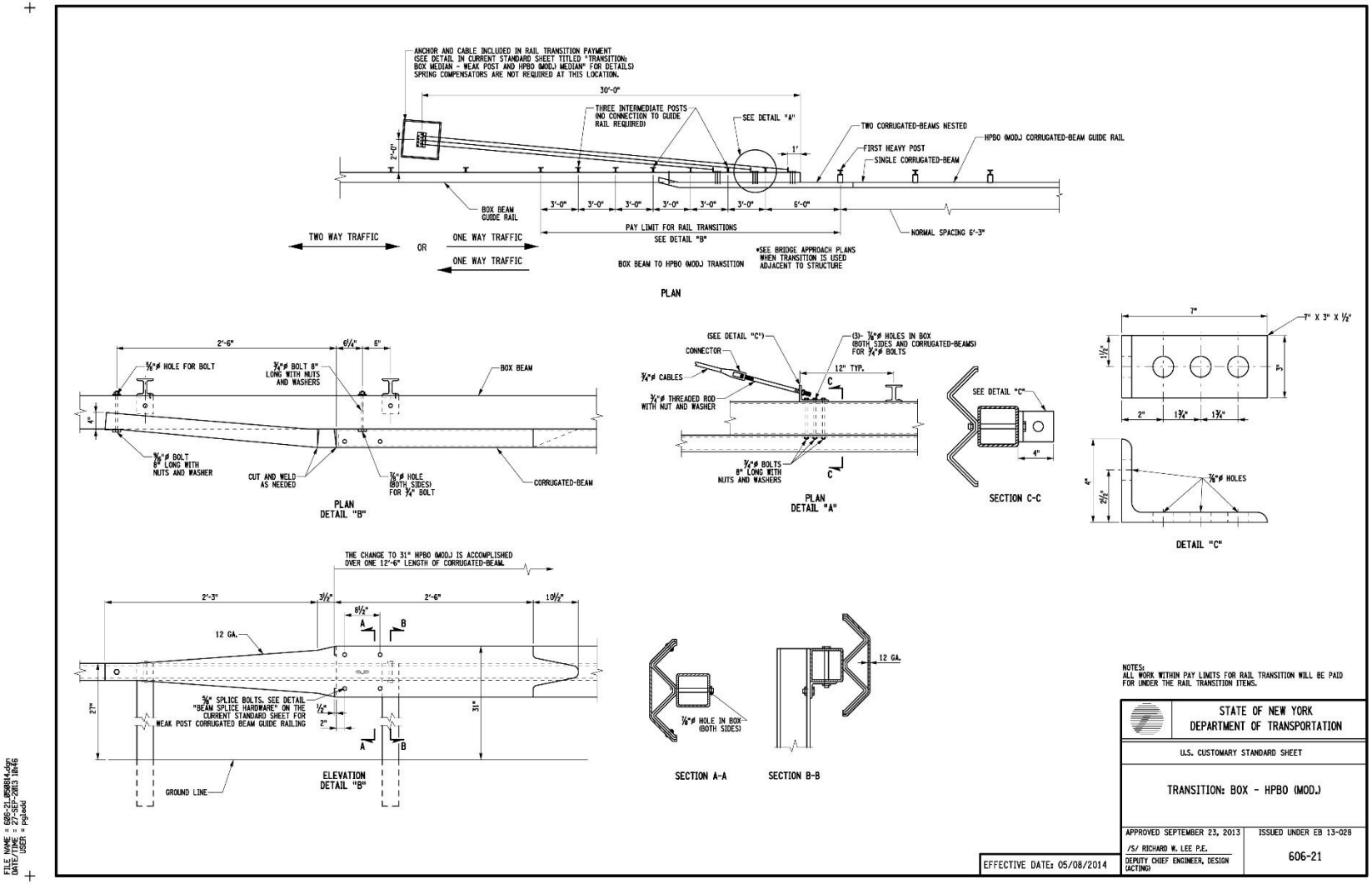


Figure B-1. NYSDOT Standard Plans – Transition Box - HPBO

Appendix C. System Drawing, Test Nos. NYBHT-1 and NYBHT-2

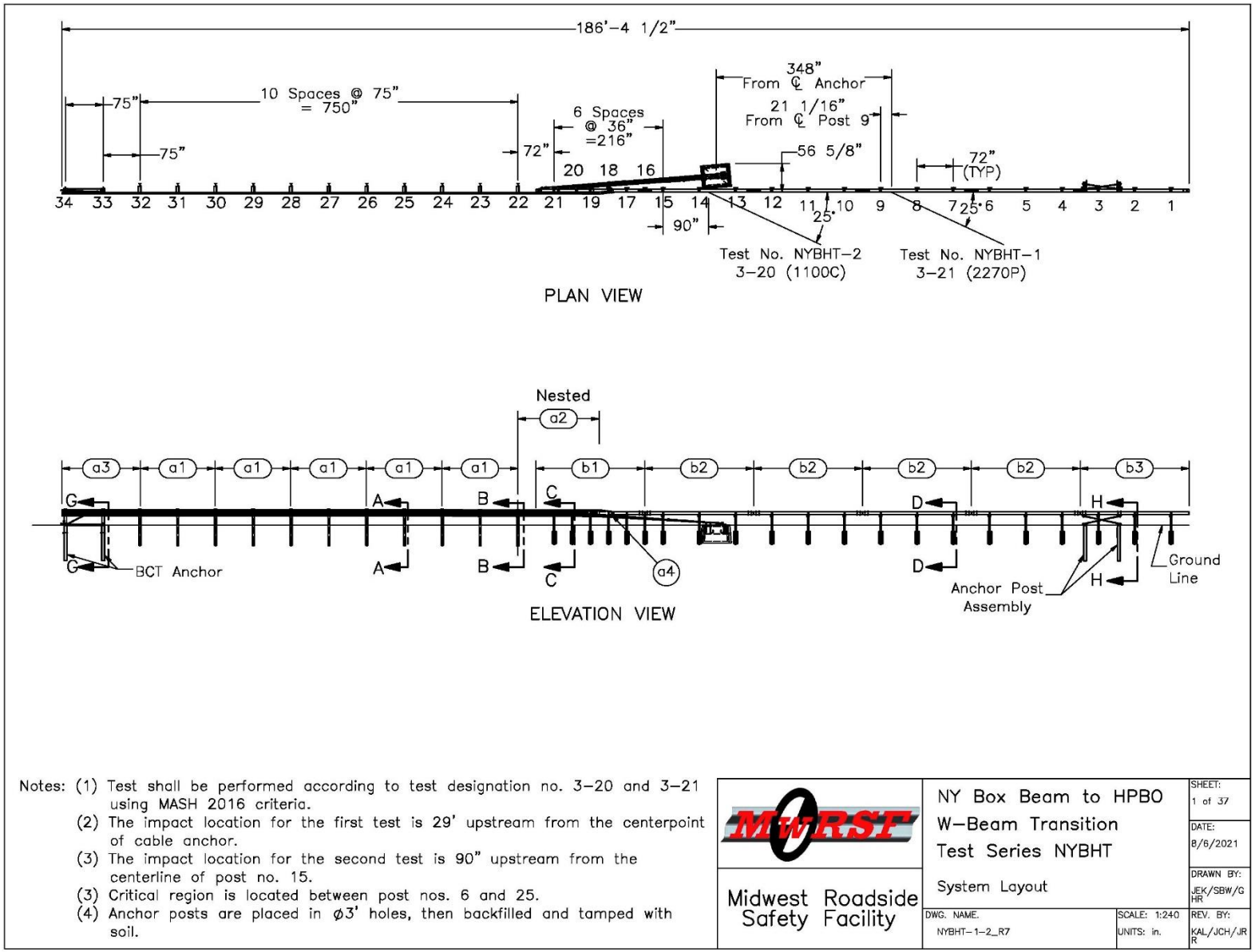


Figure C-1. System Layout, Test Nos. NYBHT-1 and NYBHT-2

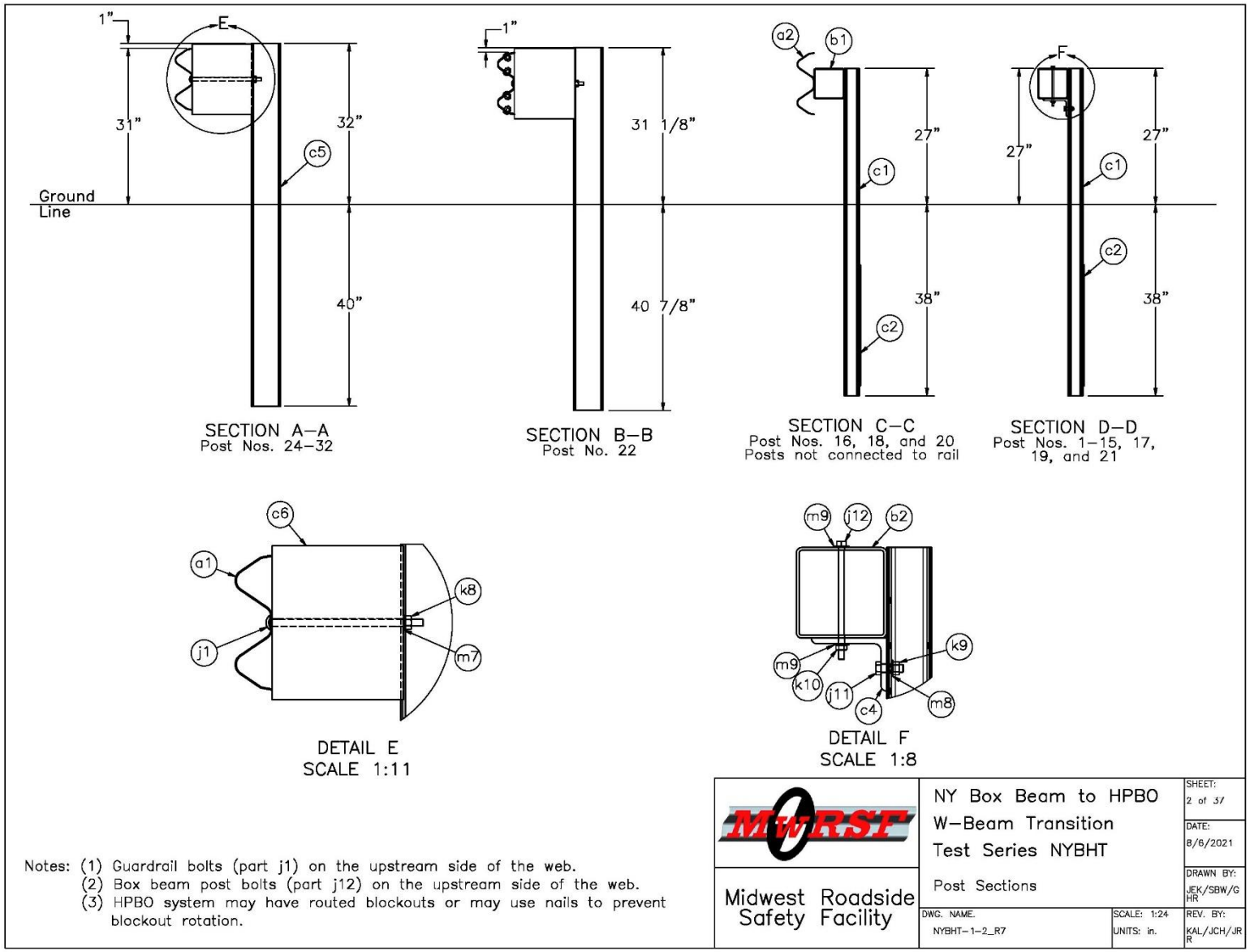


Figure C-2. Post Sections, Test Nos. NYBHT-1 and NYBHT-2

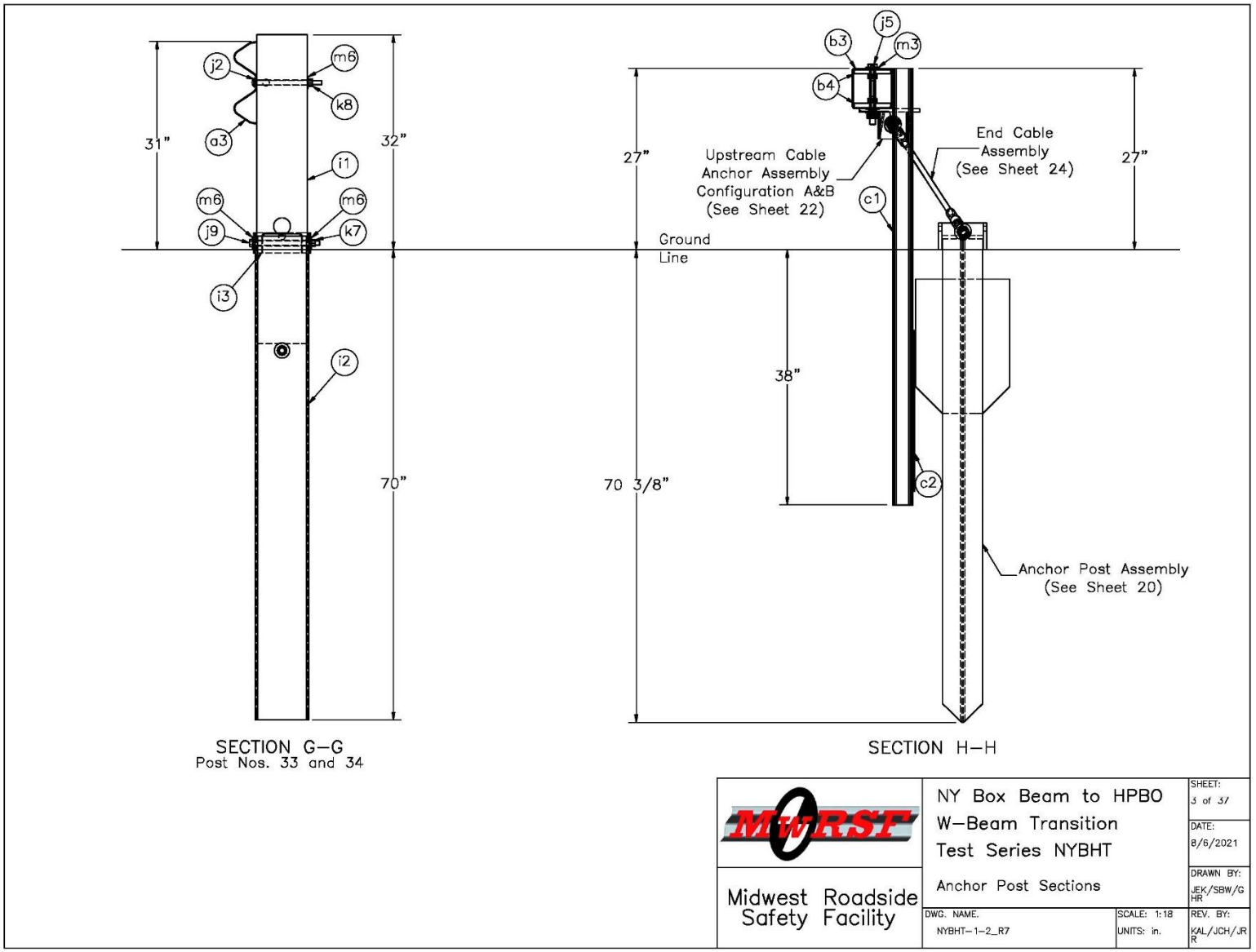


Figure C-3. Anchor Post Sections, Test Nos. NYBHT-1 and NYBHT-2

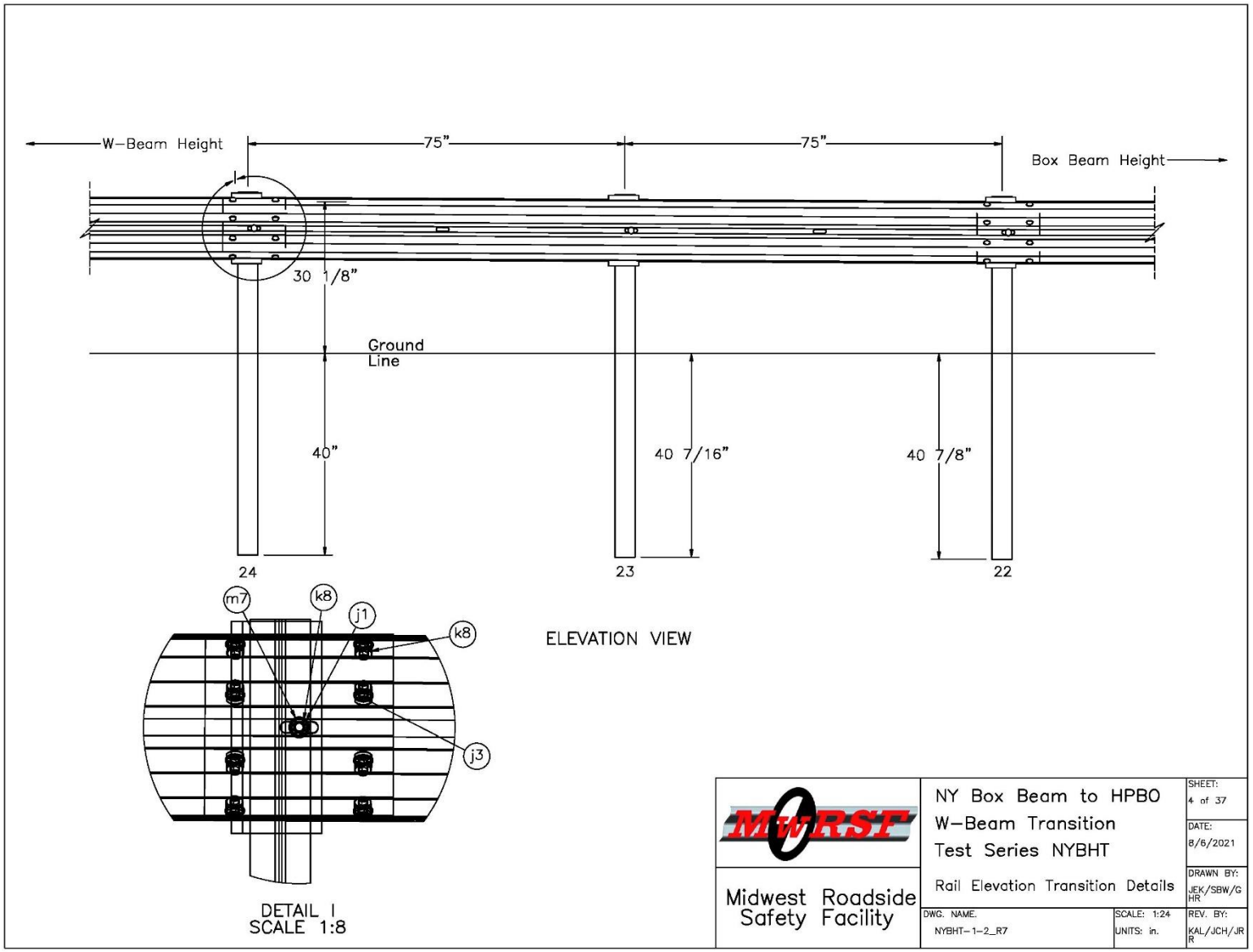


Figure C-4. Rail Elevation Transition Details, Test Nos. NYBHT-1 and NYBHT-2

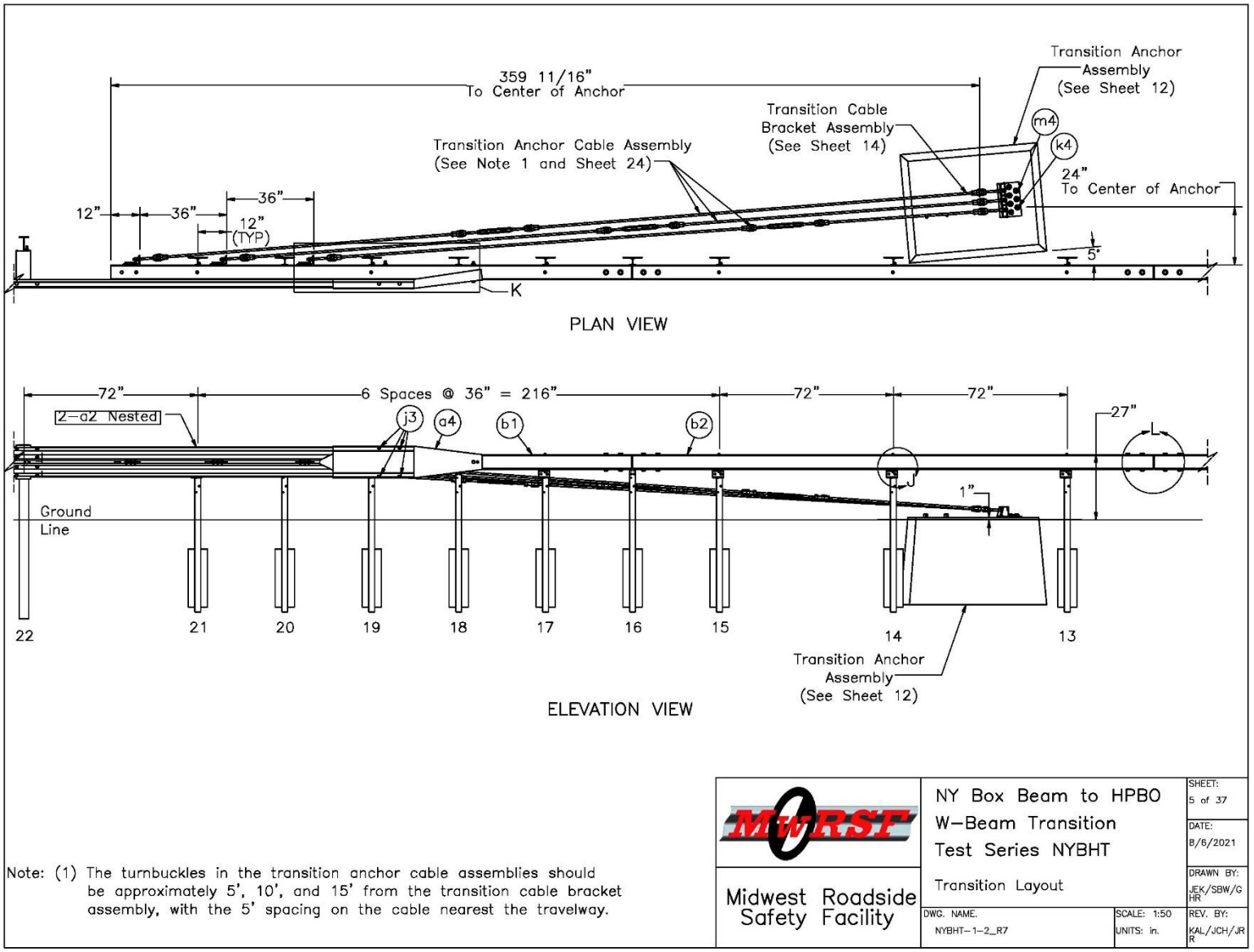


Figure C-5. Transition Layout, Test Nos. NYBHT-1 and NYBHT-2

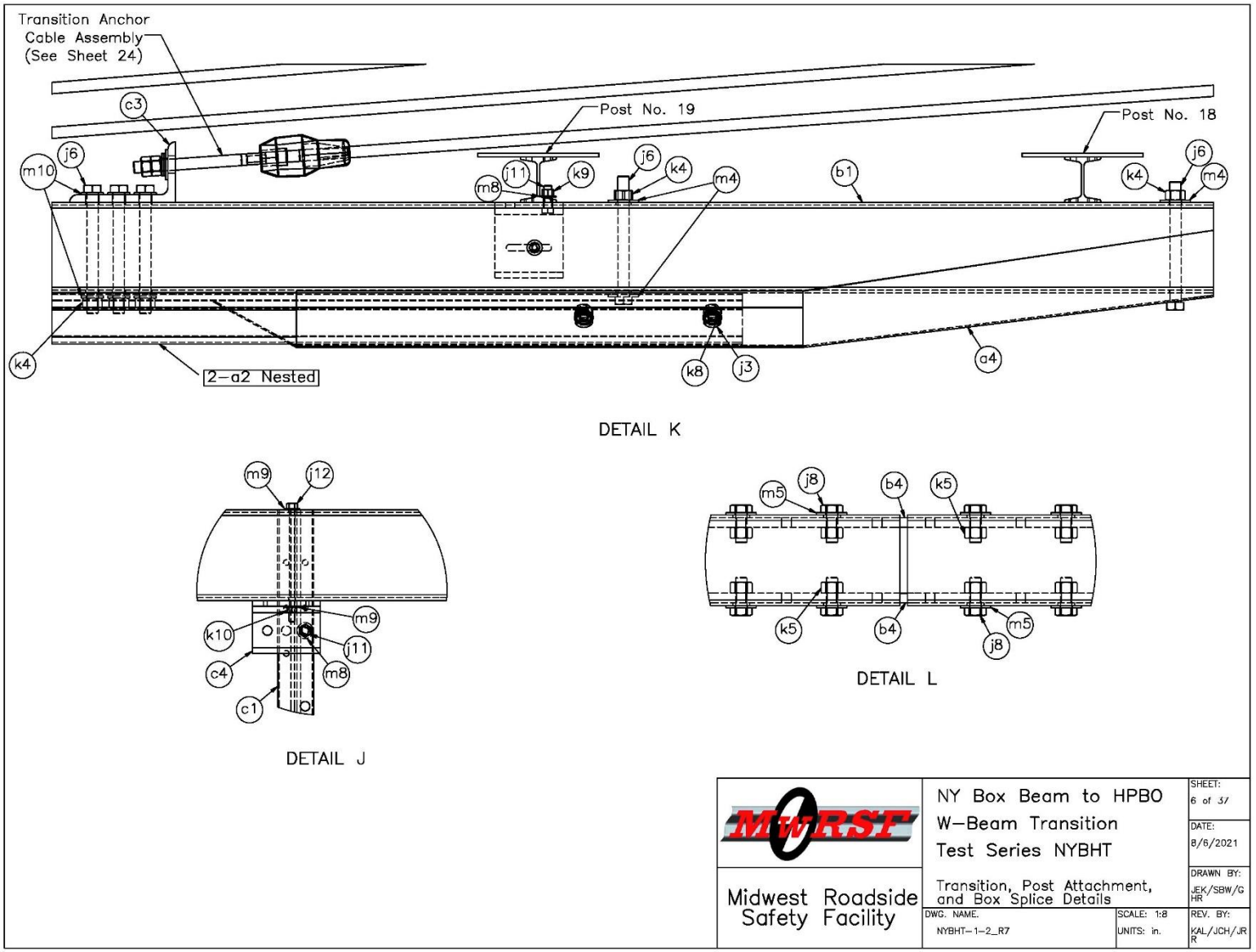


Figure C-6. Transition, Post Attachment, and Box Splice Details, Test Nos. NYBHT-1 and NYBHT-2

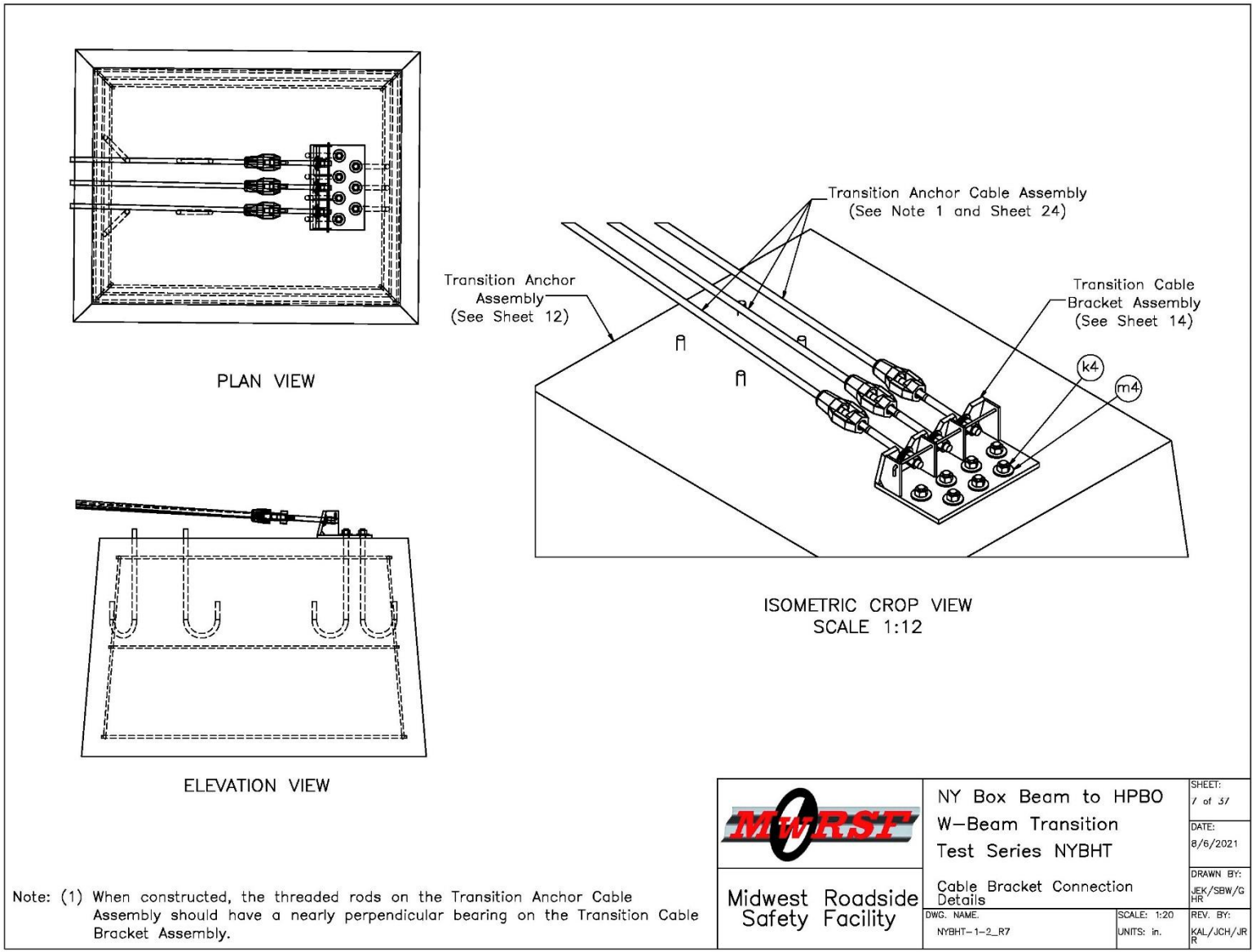


Figure C-7. Cable Bracket Connection Details, Test Nos. NYBHT-1 and NYBHT-2

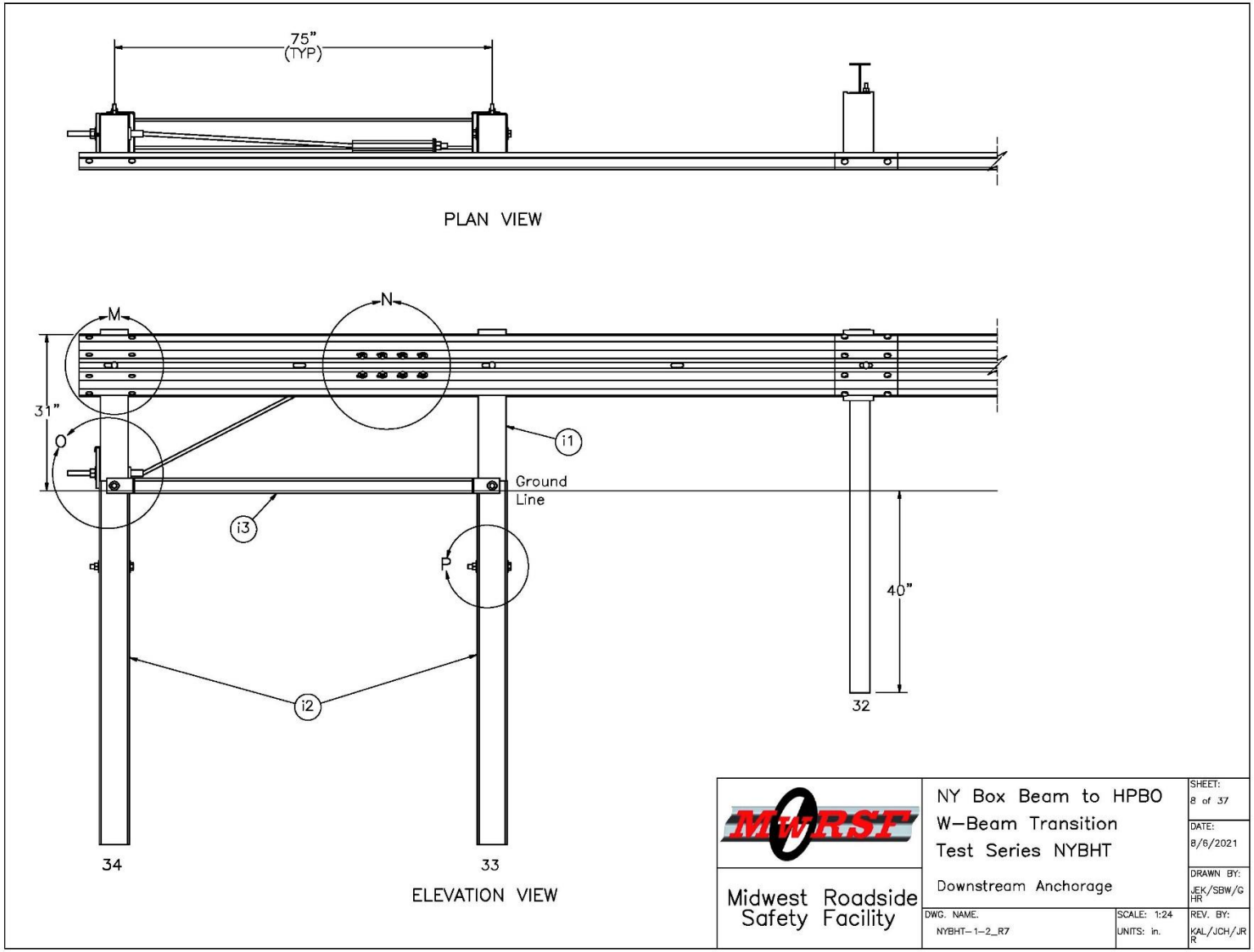


Figure C-8. Downstream Anchorage, Test Nos. NYBHT-1 and NYBHT-2

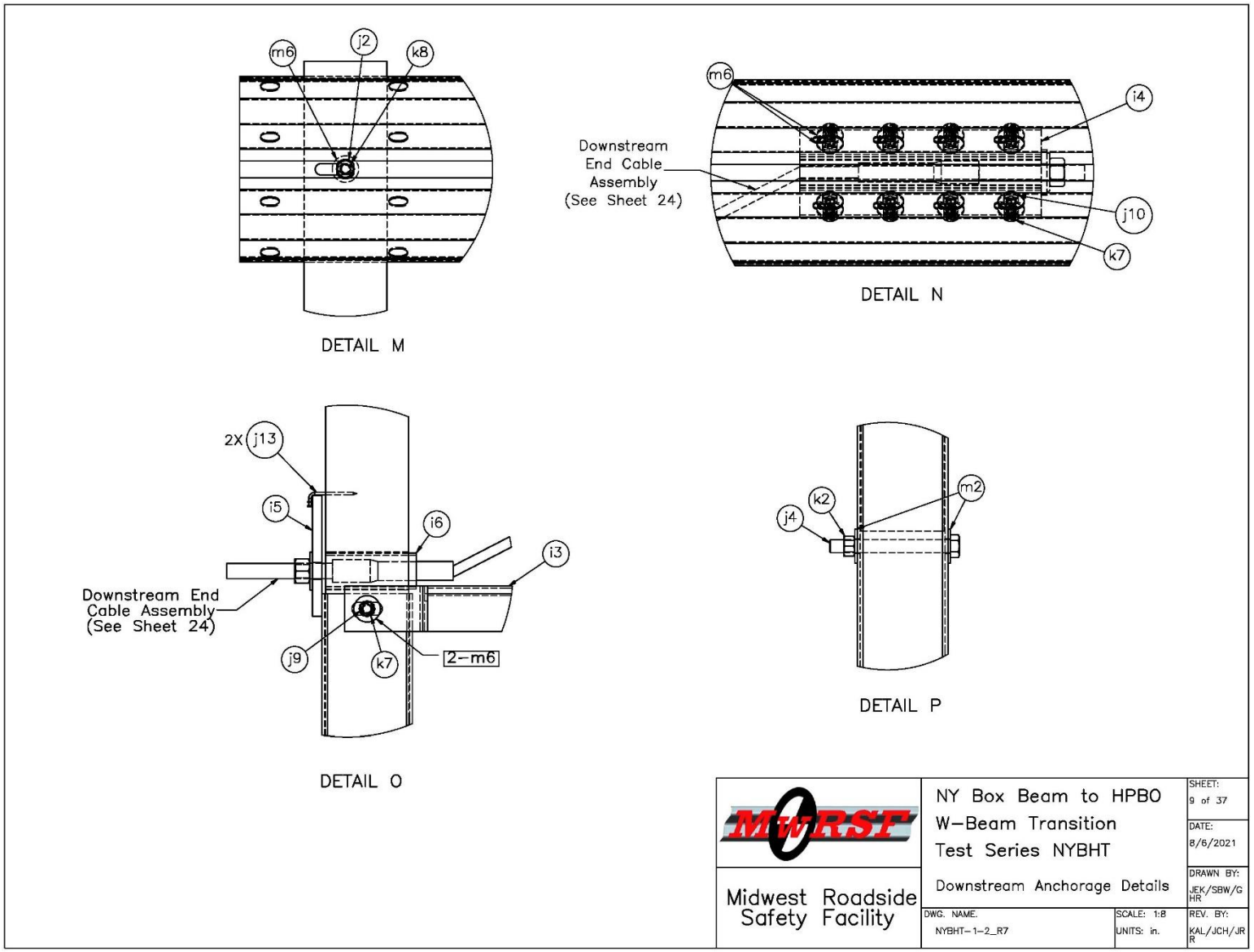


Figure C-9. Downstream Anchorage Details, Test Nos. NYBHT-1 and NYBHT-2

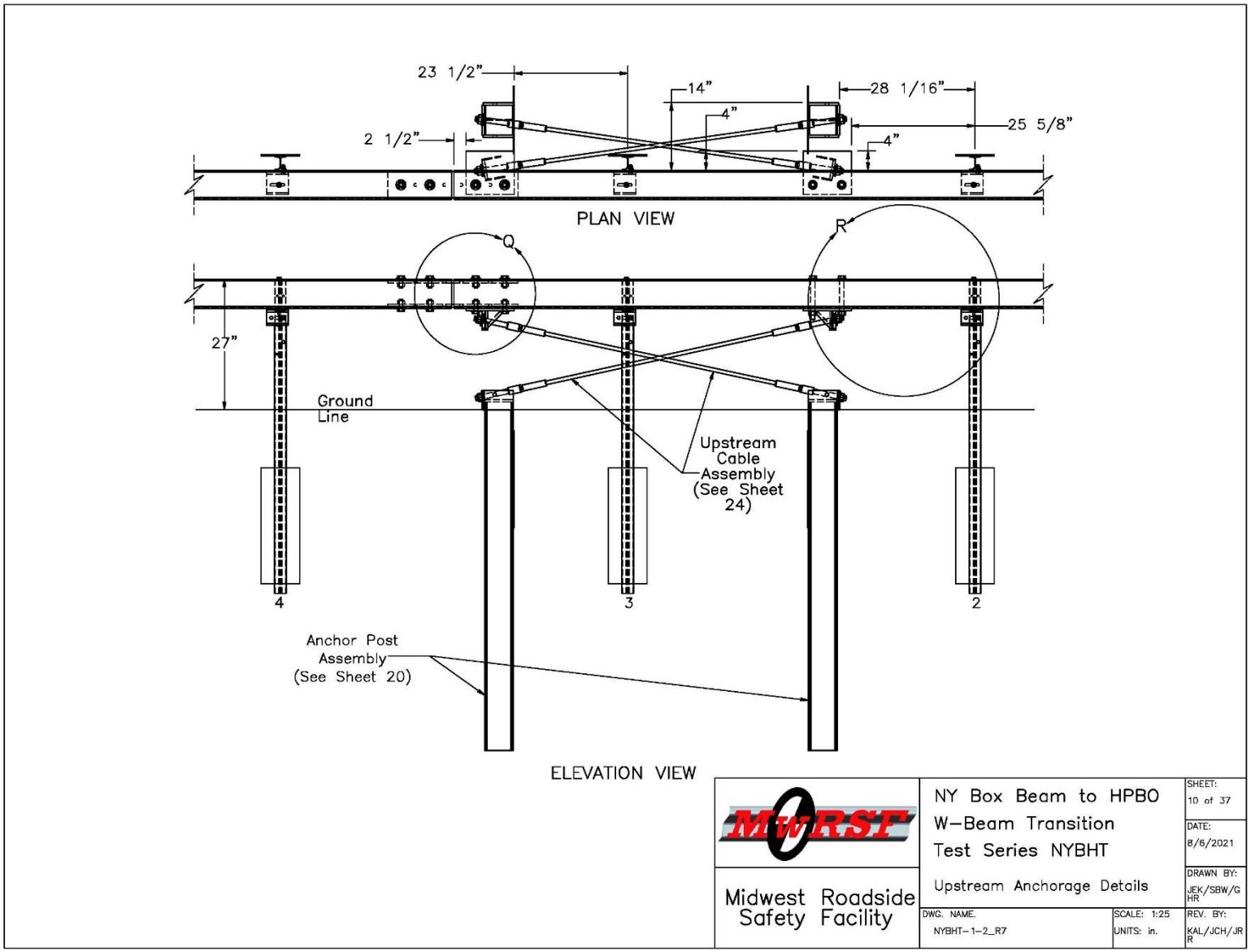


Figure C-10. Upstream Anchorage Details, Test Nos. NYBHT-1 and NYBHT-2

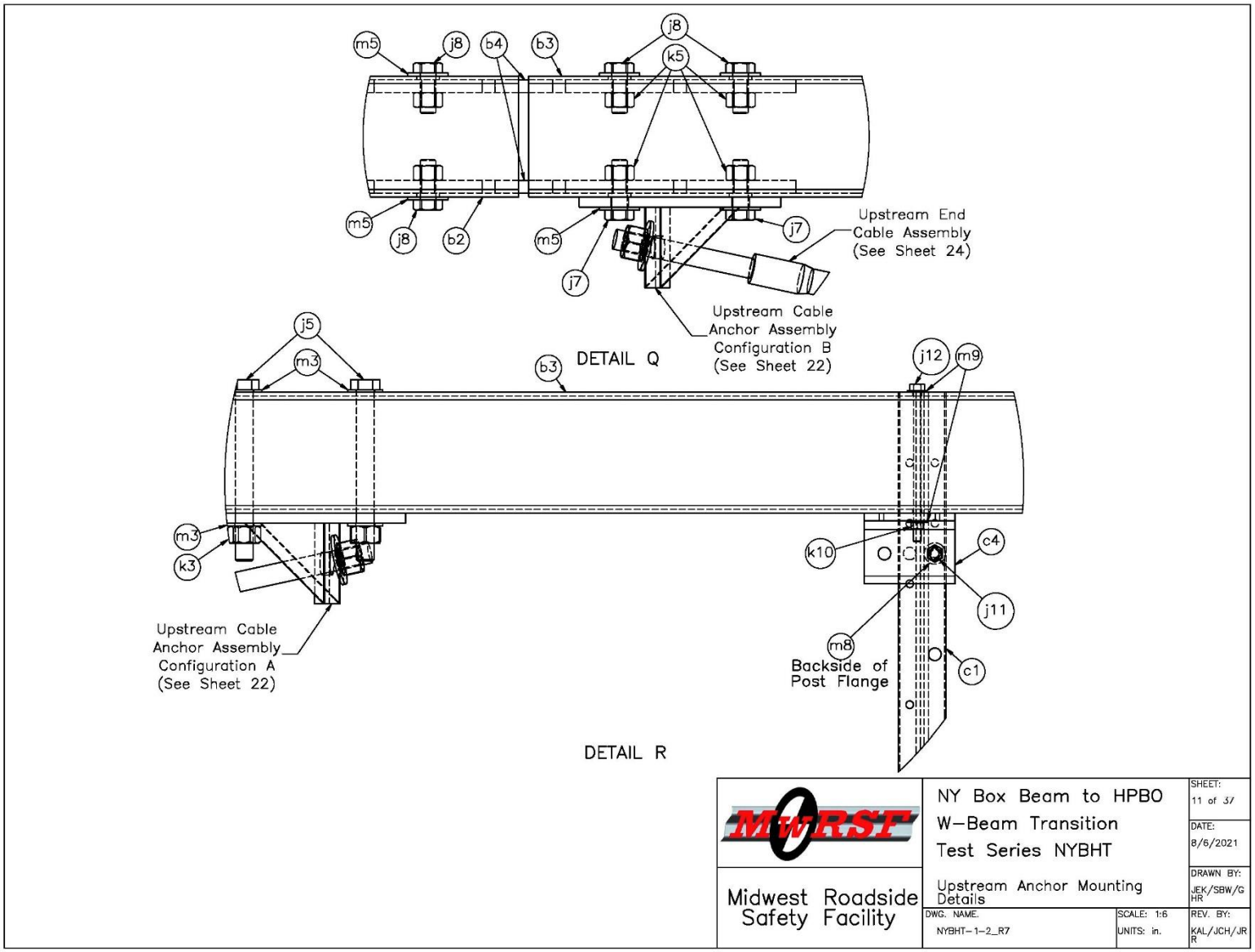
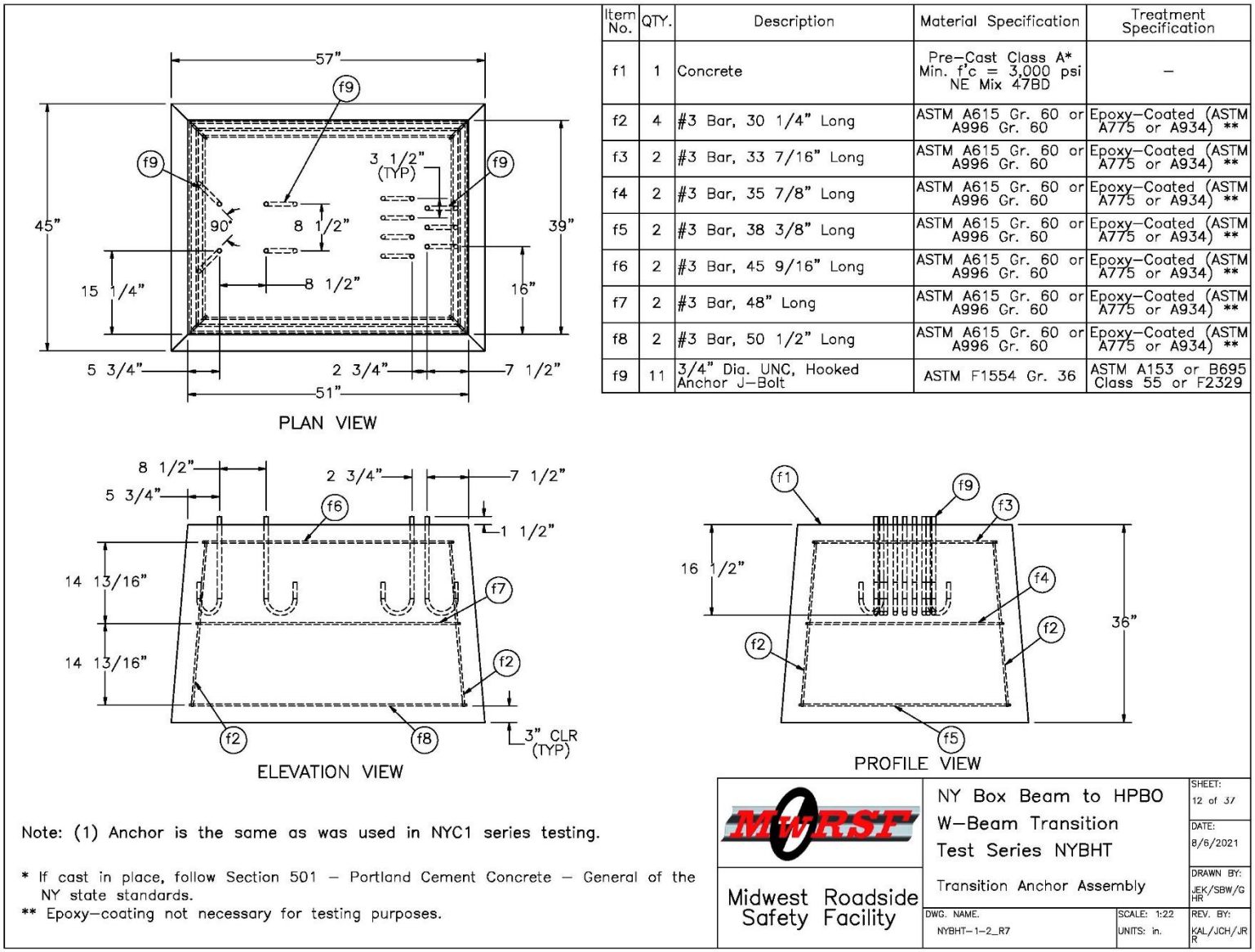


Figure C-11. Upstream Anchor Mounting Details, Test Nos. NYBHT-1 and NYBHT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
f1	1	Concrete	Pre-Cast Class A* Min. f'c = 3,000 psi NE Mix 47BD	–
f2	4	#3 Bar, 30 1/4" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f3	2	#3 Bar, 33 7/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f4	2	#3 Bar, 35 7/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f5	2	#3 Bar, 38 3/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f6	2	#3 Bar, 45 9/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f7	2	#3 Bar, 48" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f8	2	#3 Bar, 50 1/2" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy-Coated (ASTM A775 or A934) **
f9	11	3/4" Dia. UNC, Hooked Anchor J-Bolt	ASTM F1554 Gr. 36	ASTM A153 or B695 Class 55 or F2329

Note: (1) Anchor is the same as was used in NYC1 series testing.

* 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 HPBO W-Beam Transition
Test Series NYBHT
Transition Anchor Assembly

SHEET: 12 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
DWG. NAME. NYBHT-1-2_R7
SCALE: 1:22
UNITS: in.
REV. BY: KAL/JCH/JR

Figure C-12. Transition Anchor Assembly, Test Nos. NYBHT-1 and NYBHT-2

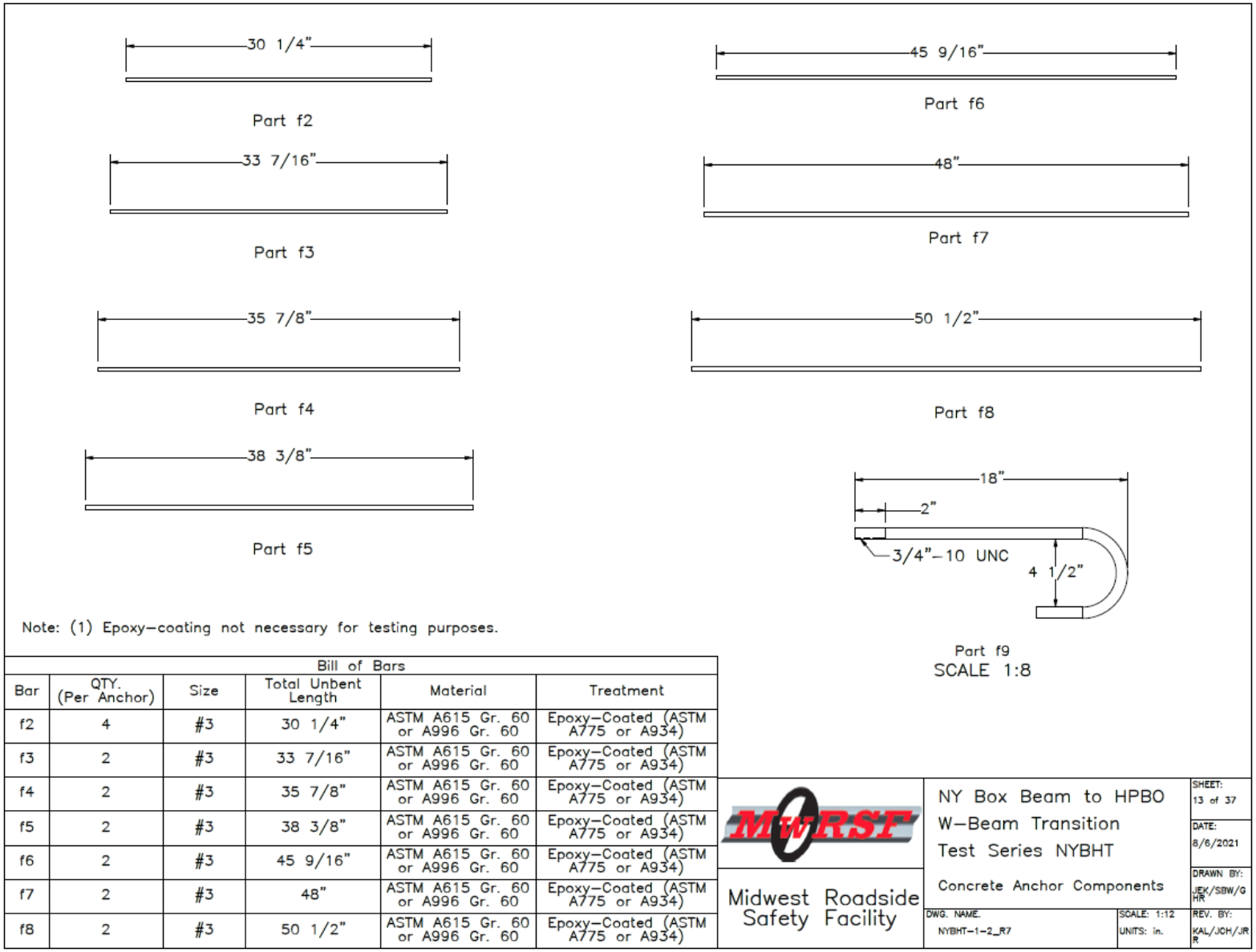
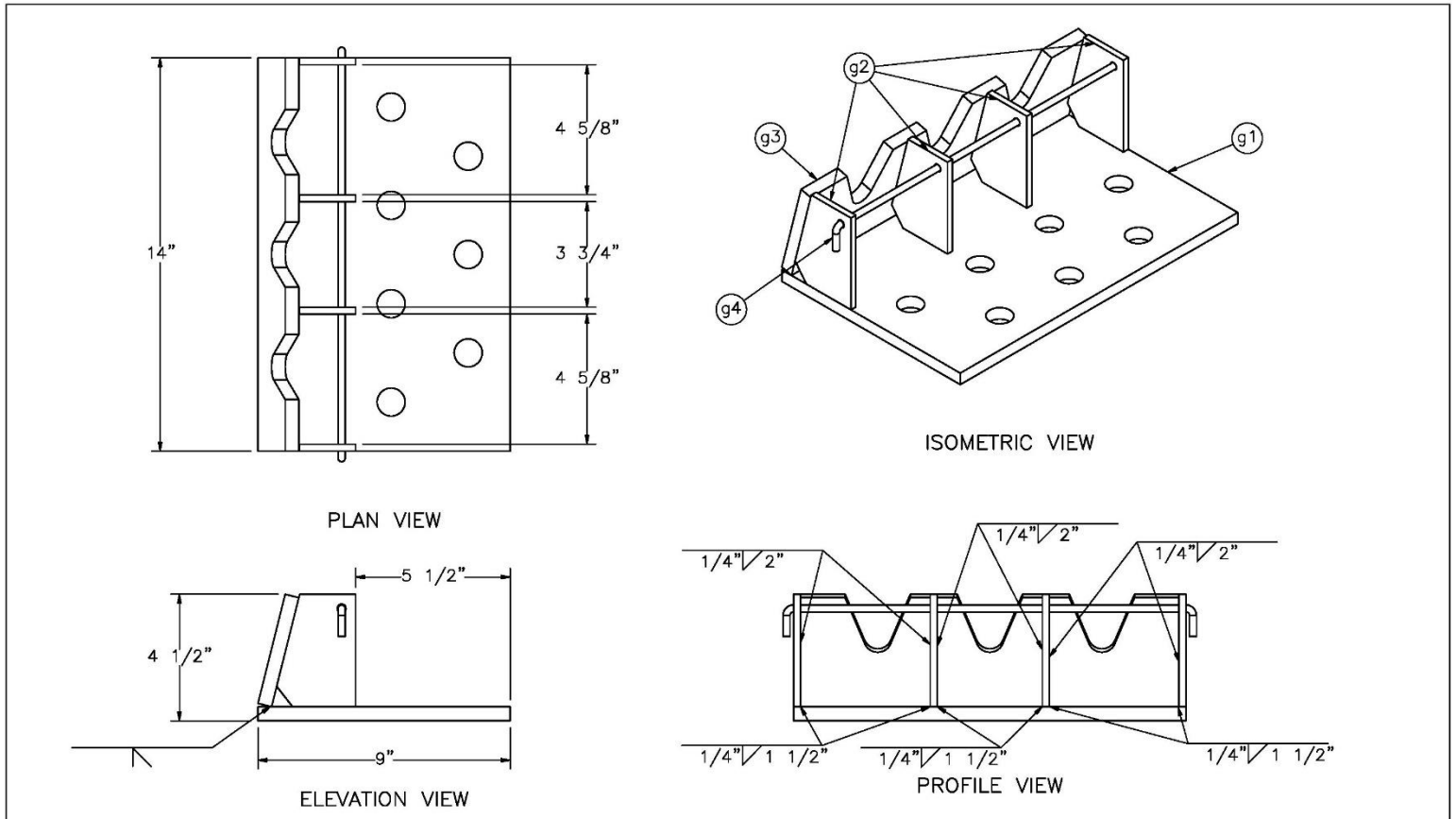


Figure C-13. Concrete Anchor Assembly, Test nos. NYBHT-1 and NYBHT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Transition Cable Braket Assembly	–	ASTM A123
g1	1	14"x9"x1/2" Plate	ASTM A36	See Assembly
g2	4	4"x2 13/16"x1/4" Cable Anchor Gusset	ASTM A36	See Assembly
g3	1	14"x3 1/2"x1/2" Cable Anchor Top Plate	ASTM A36	See Assembly
g4	1	1/4" Dia., 16 3/8" Long Brass Rod	ASTM B16-00	–

MwRSF

Midwest Roadside Safety Facility

NY Box Beam to HPBO W-Beam Transition
Test Series NYBHT
Transition Cable Bracket Assembly

SHEET: 14 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
DWG. NAME. NYBHT-1-2_R7
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UNITS: in.
REV. BY: KAL/JCH/JR

Figure C-14. Transition Cable Bracket Assembly, Test Nos. NYBHT-1 and NYBHT-2

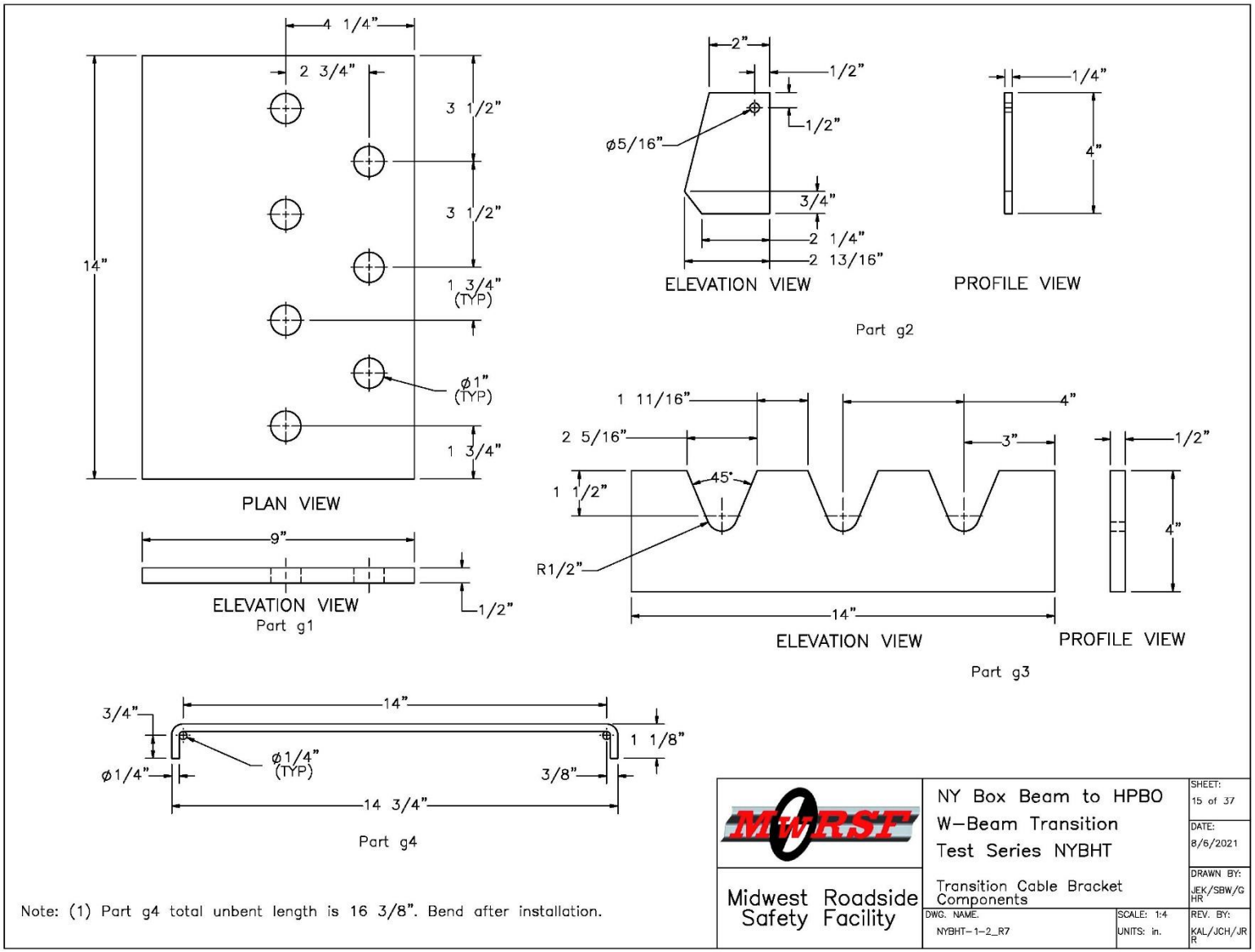
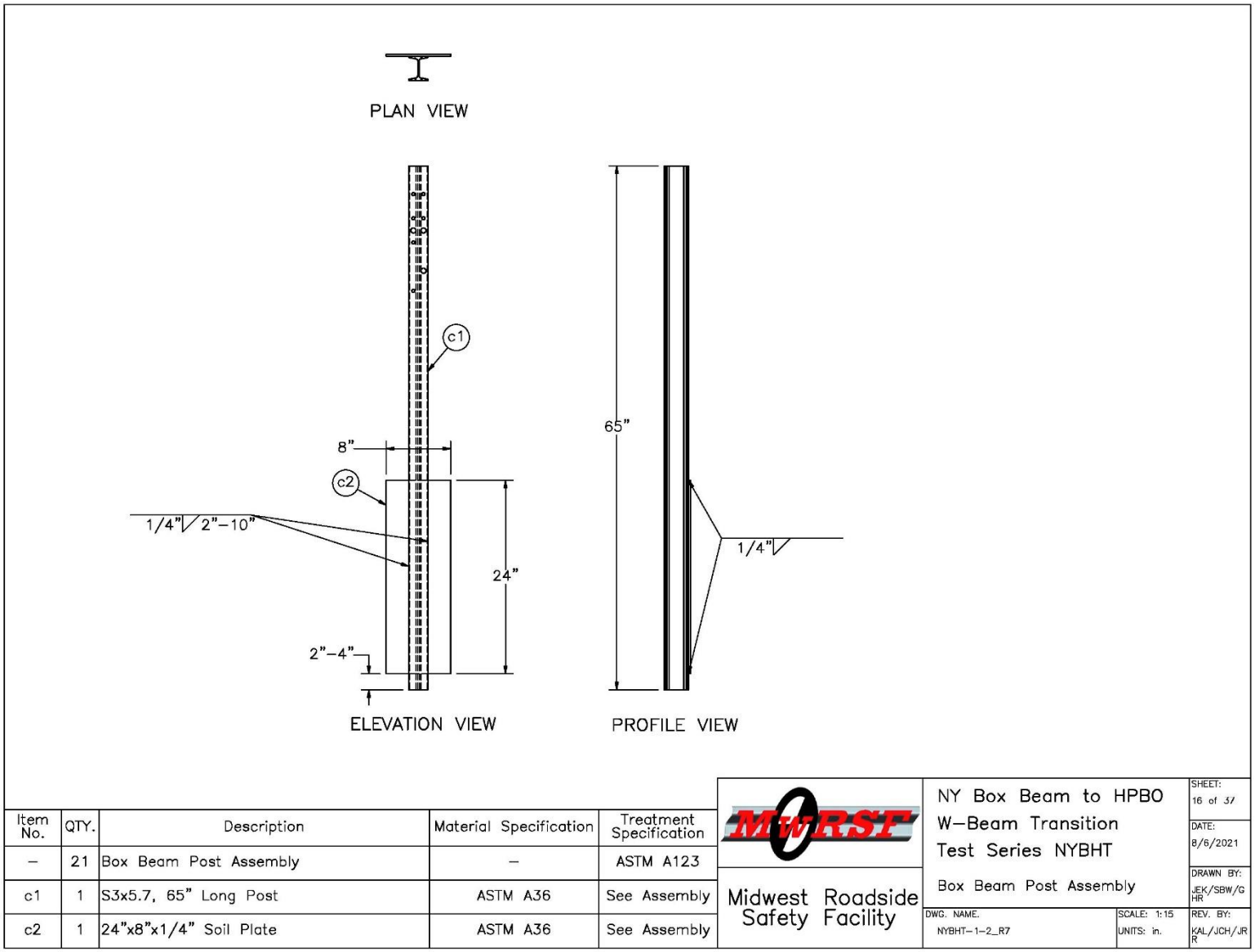


Figure C-15. Transition Cable Bracket Components, Test Nos. NYBHT-1 and NYBHT-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	21	Box Beam Post Assembly	–	ASTM A123
c1	1	S3x5.7, 65" Long Post	ASTM A36	See Assembly
c2	1	24"x8"x1/4" Soil Plate	ASTM A36	See Assembly

Midwest Roadside Safety Facility

NY Box Beam to HPBO W–Beam Transition
Test Series NYBHT
Box Beam Post Assembly

SHEET: 16 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
REV. BY: KAL/JCH/JR
DWG. NAME. NYBHT–1–2_R7
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Figure C-16. Box Beam Post Assembly, Test Nos. NYBHT-1 and NYBHT-2

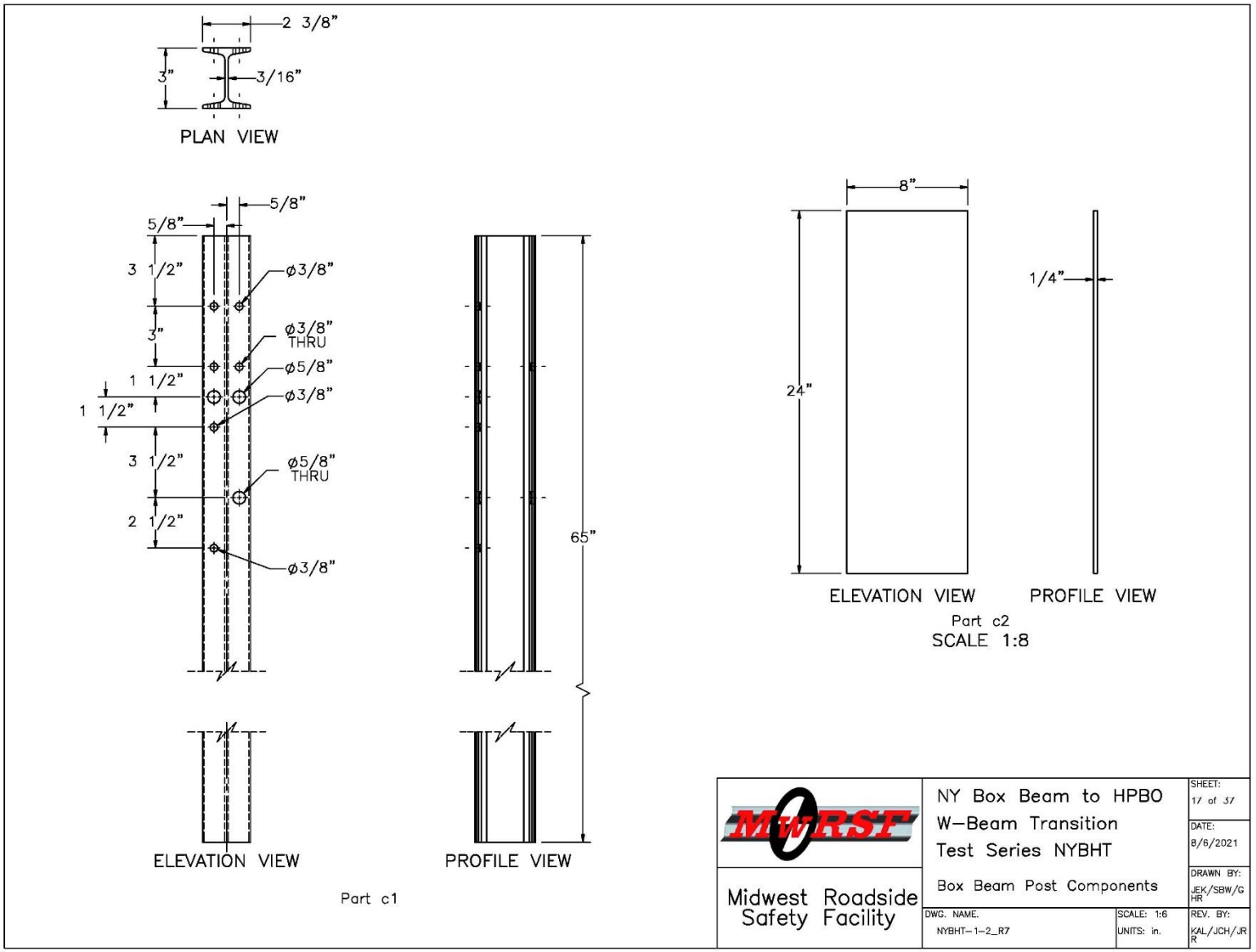


Figure C-17. Box Beam Post Components, Test Nos. NYBHT-1 and NYBHT-2

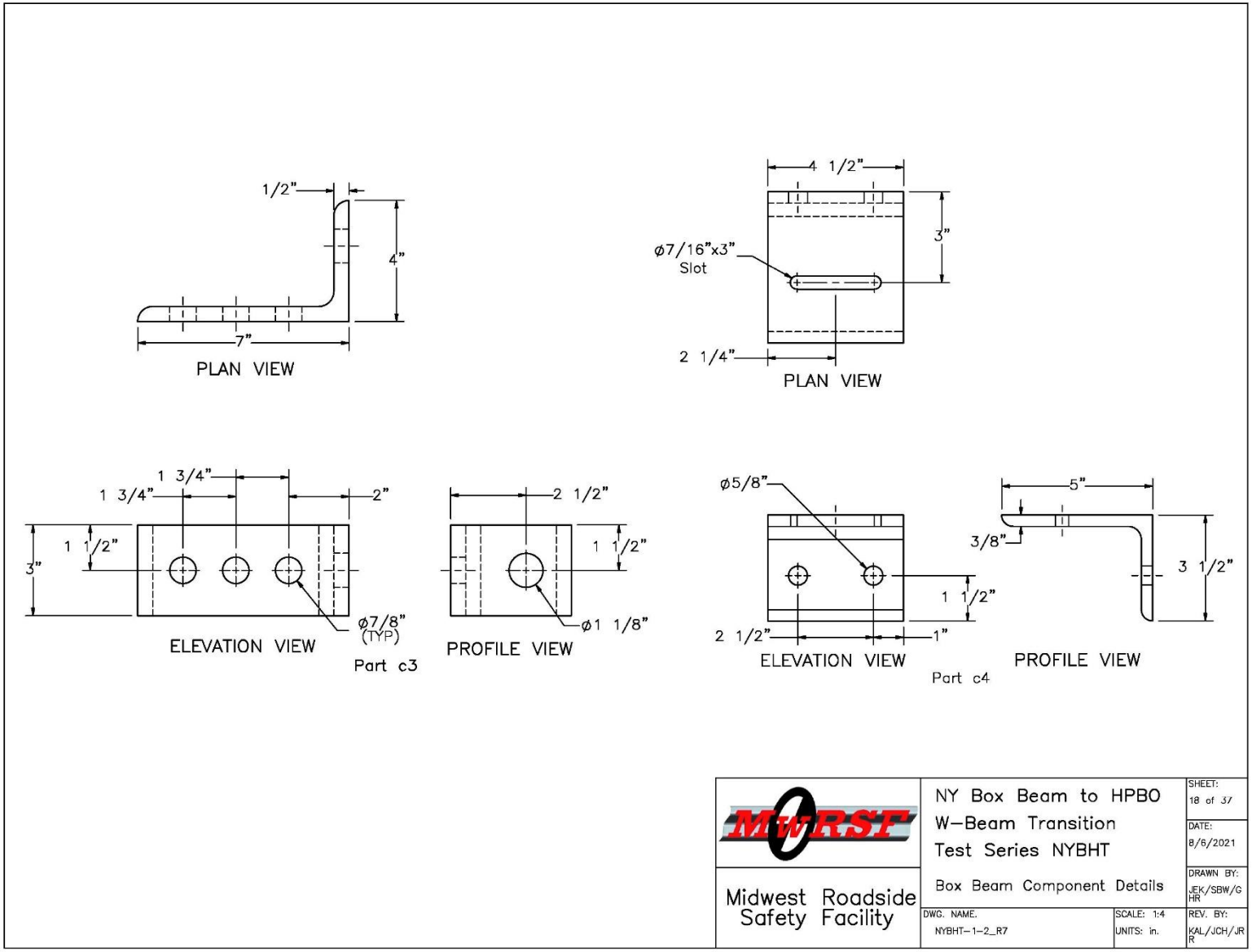


Figure C-18. Box Beam Component Details, Test Nos. NYBHT-1 and NYBHT-2

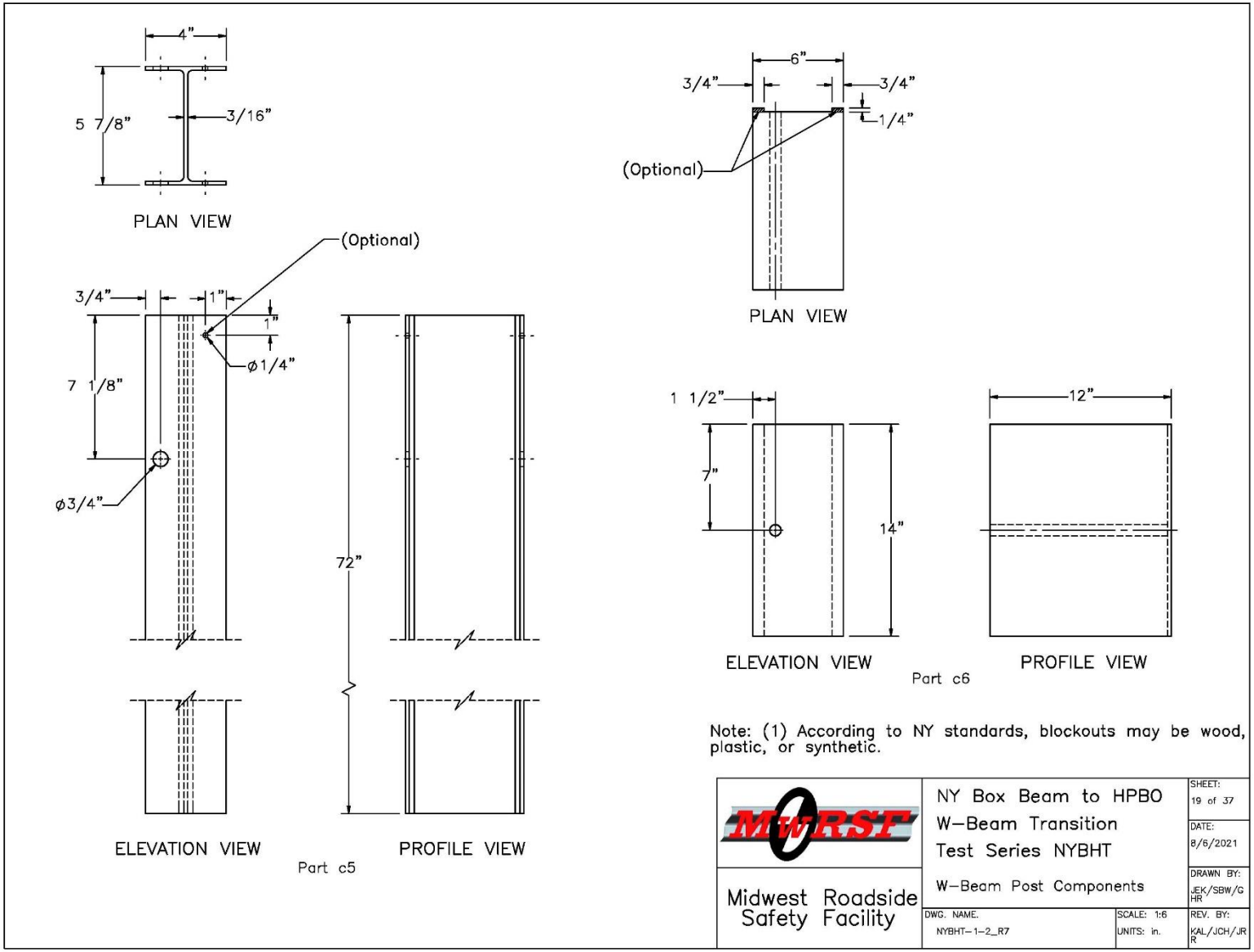


Figure C-19. W-Beam Post Components, Test Nos. NYBHT-1 and NYBHT-2

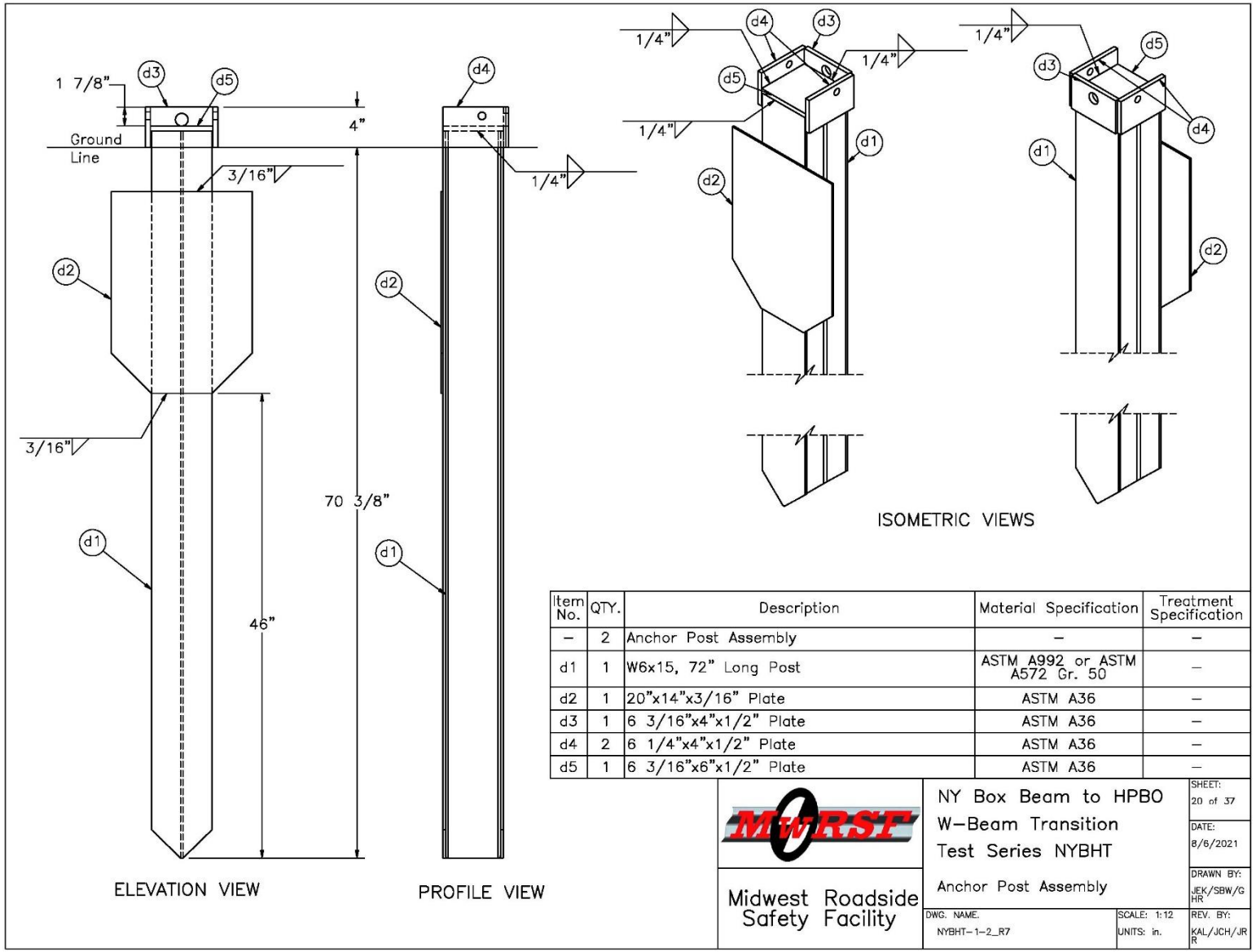


Figure C-20. Anchor Post Assembly, Test Nos. NYBHT-1 and NYBHT-2

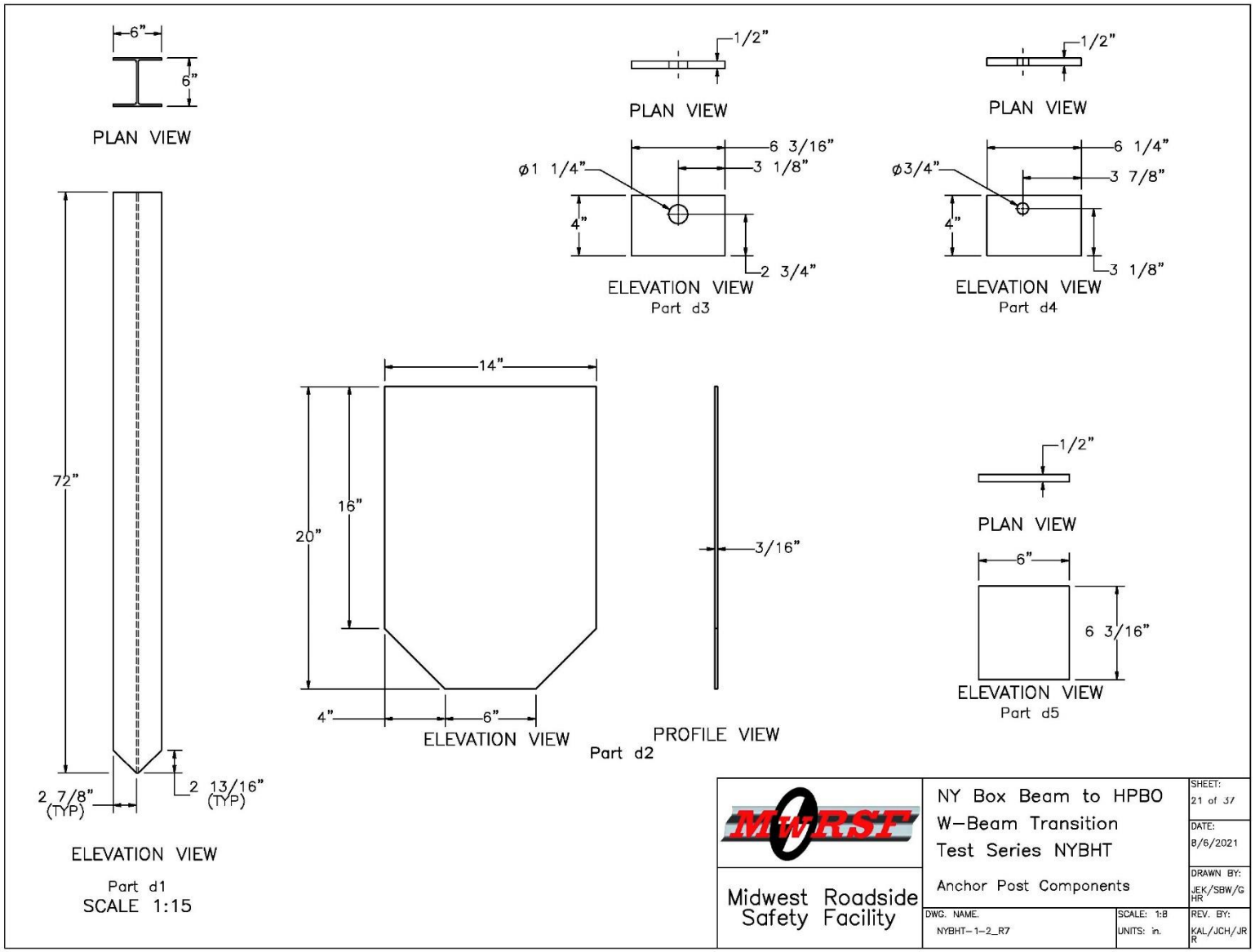


Figure C-21. Anchor Post Components, Test Nos. NYBHT-1 and NYBHT-2

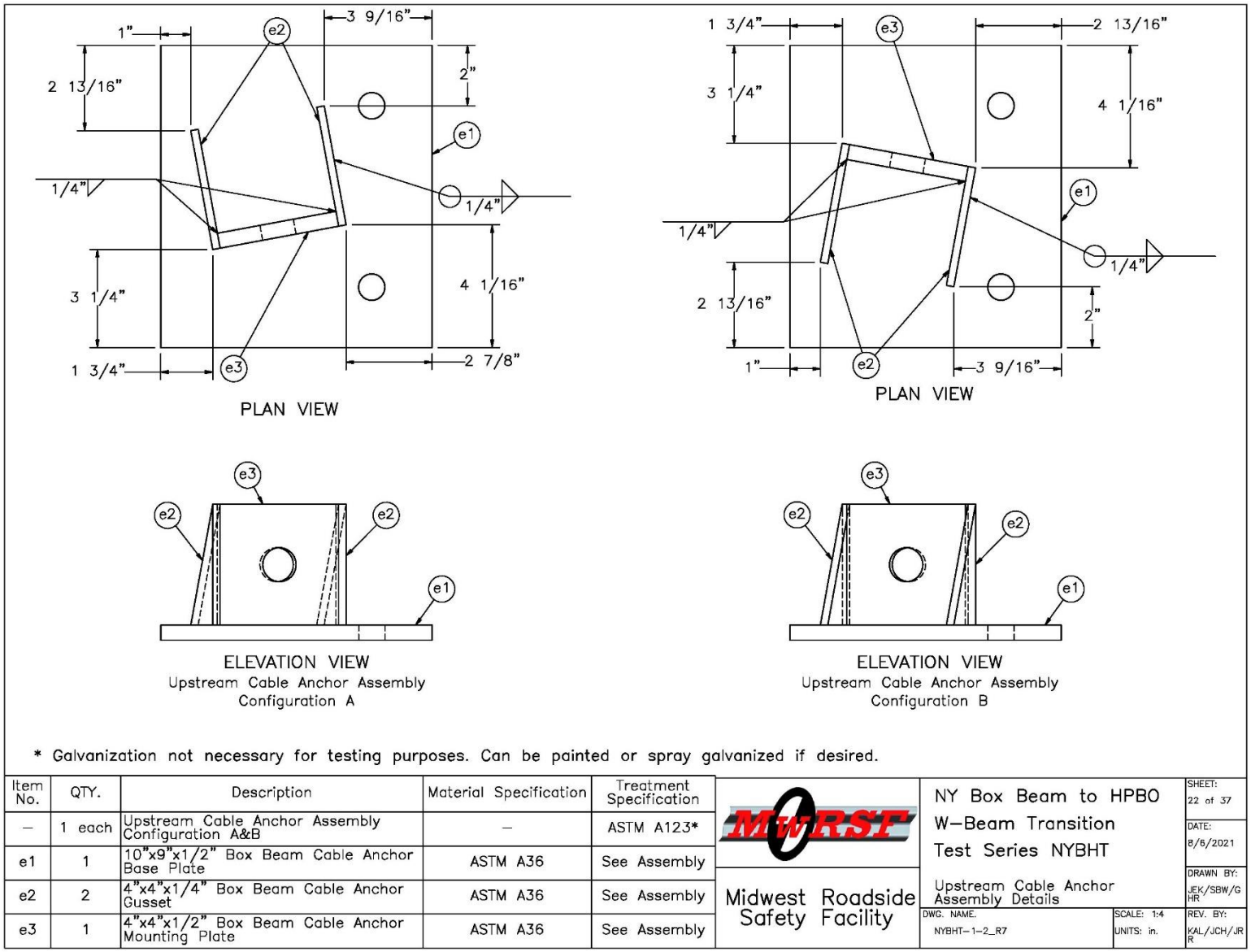


Figure C-22. Upstream Cable Anchor Assembly Details, Test Nos. NYBHT-1 and NYBHT-2

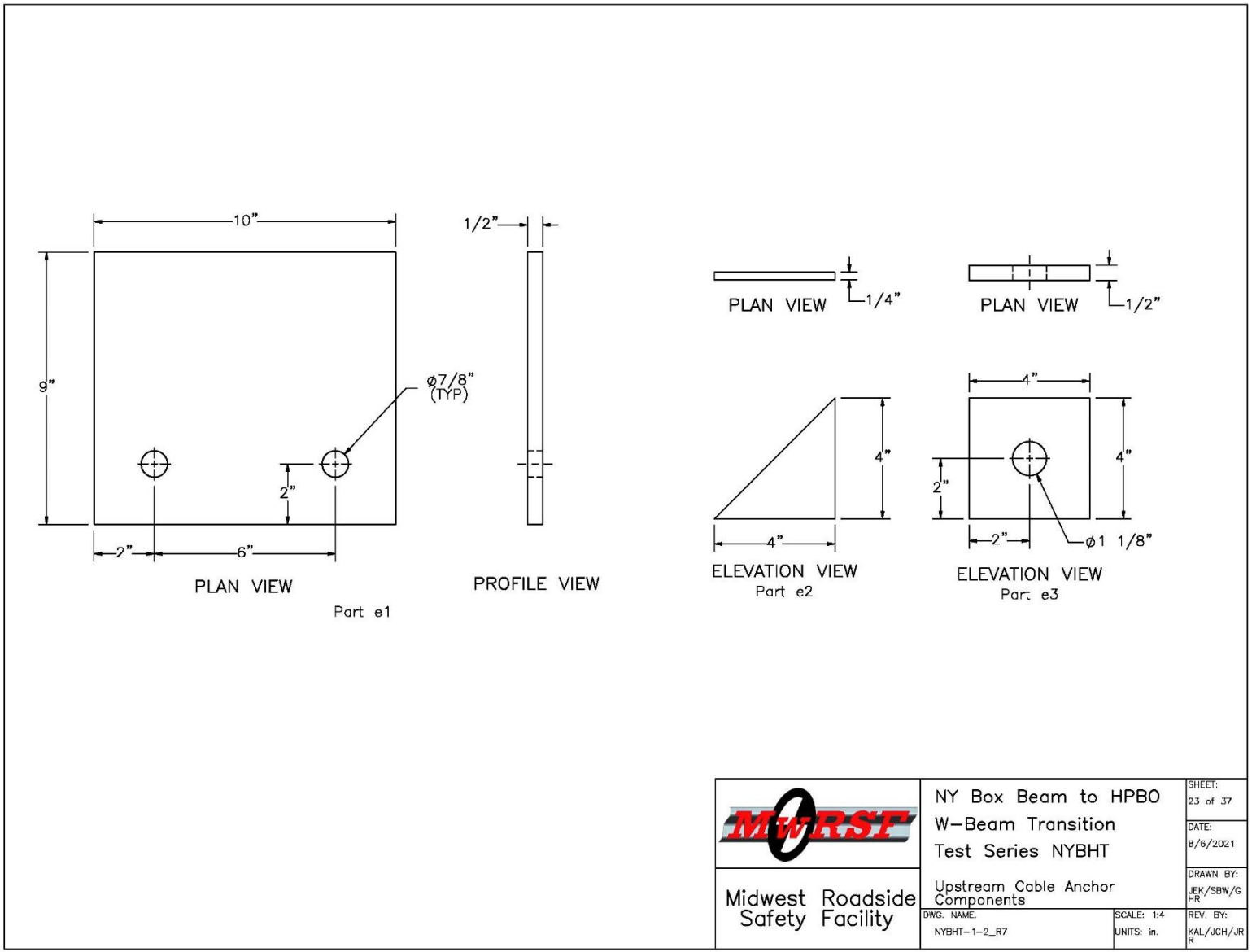
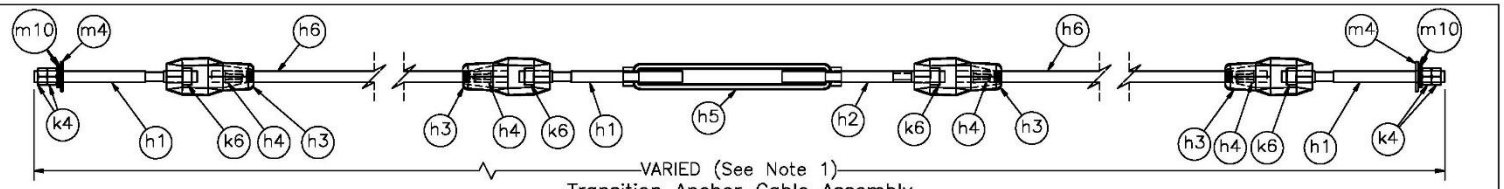
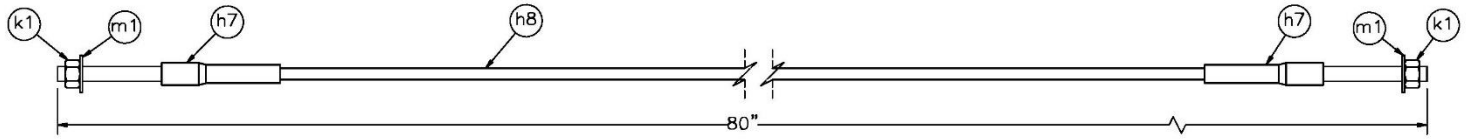


Figure C-23. Upstream Cable Anchor Components, Test Nos. NYBHT-1 and NYBHT-2



Transition Anchor Cable Assembly

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	3	Transition Anchor Cable Assembly	–	–	–
h1	3	3/4" Dia. UNC, 11" Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h2	1	3/4" Dia. UNC, 11" Long Left–Hand Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h3	4	Cable End Fitting	ASTM A27 Gr. 70–40 Class 1	ASTM A153 or B695	RCE03
h4	4	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
h5	1	Standard Turnbuckle	ASTM F1145	ASTM A153 or B633	–
h6	2	3/4" Dia. 3x7 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 1	Class A Coating	RCM01
k4	4	3/4"–10 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX20a
k6	4	3/4"–10 UNC Square Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNS20
m4	2	3/4" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC20a
m10	4	3/4" Dia. Hardened SAE Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b



Upstream and Downstream End Cable Assemblies

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
–	3	Upstream and Downstream End Cable Assemblies	–	–	FCA01
h7	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	–
h8	1	3/4" Dia. 6x19 IWRC IPS Wire Rope	ASTM A741 Type 2	Class A Coating	–
k1	2	1"–8 UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX24b
m1	2	1" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC24a

Notes: (1) Total lengths of the three transition anchor cable assemblies are approximately 282", 317", and 352".

Midwest Roadside Safety Facility

NY Box Beam to HPBO W–Beam Transition
Test Series NYBHT
Anchor Cable Details

DWG. NAME. NYBHT–1–2_R7
SCALE: 1:10
UNITS: in.

SHEET: 24 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
REV. BY: KAL/JCH/JR

Figure C-24. Anchor Cable Details, Test Nos. NYBHT-1 and NYBHT-2

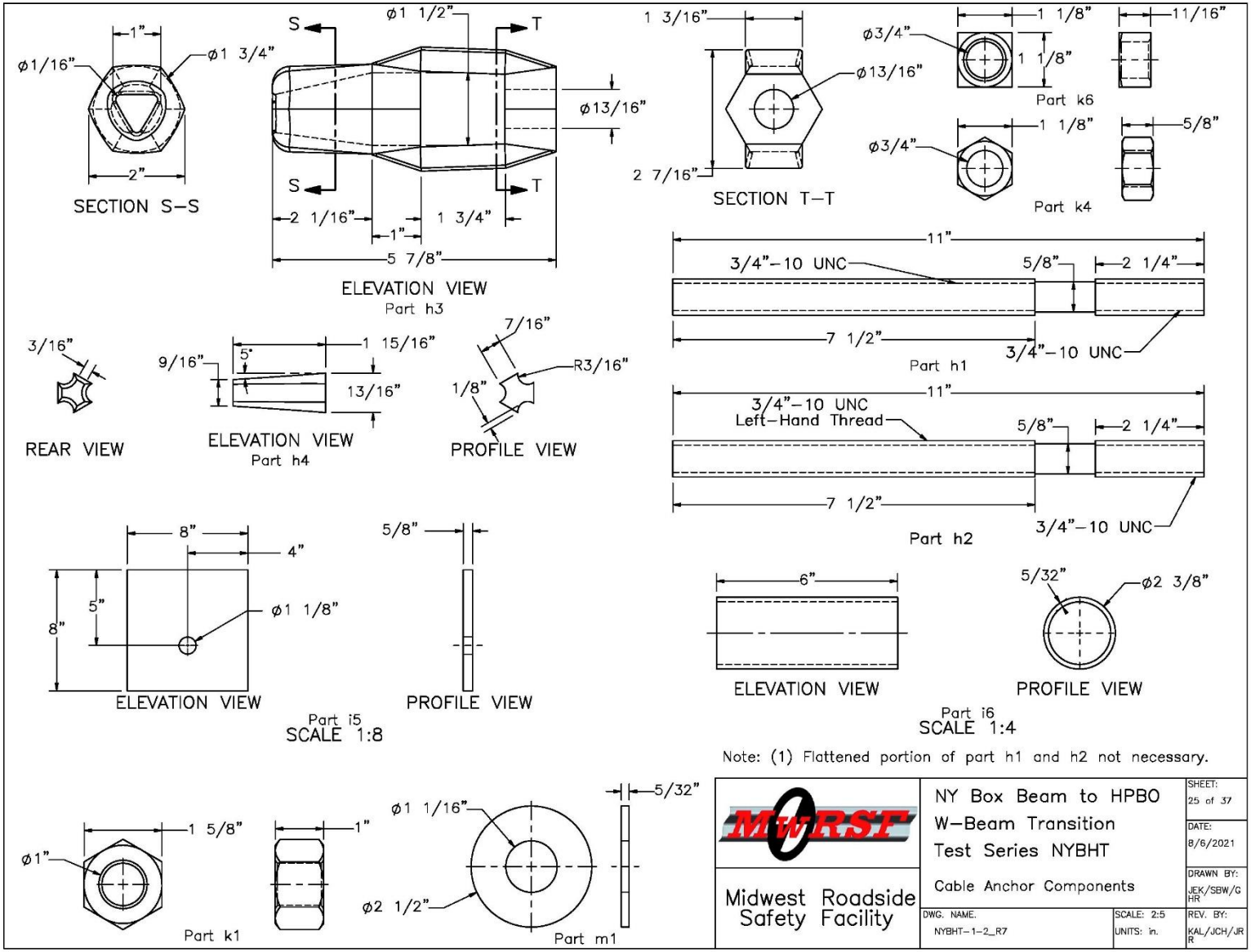


Figure C-25. Cable Anchor Components, Test Nos. NYBHT-1 and NYBHT-2

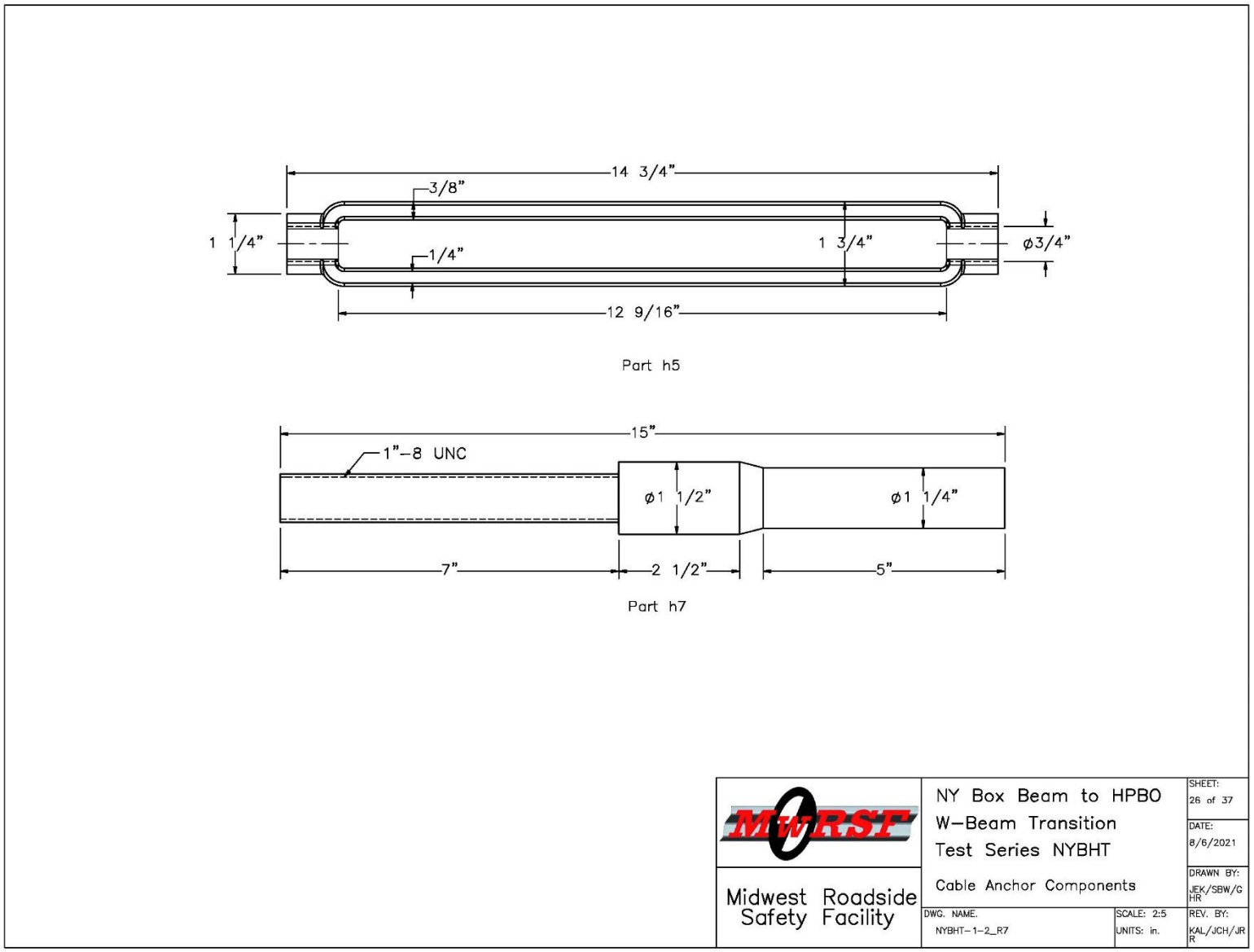


Figure C-26. Cable Anchor Components, Test Nos. NYBHT-1 and NYBHT-2

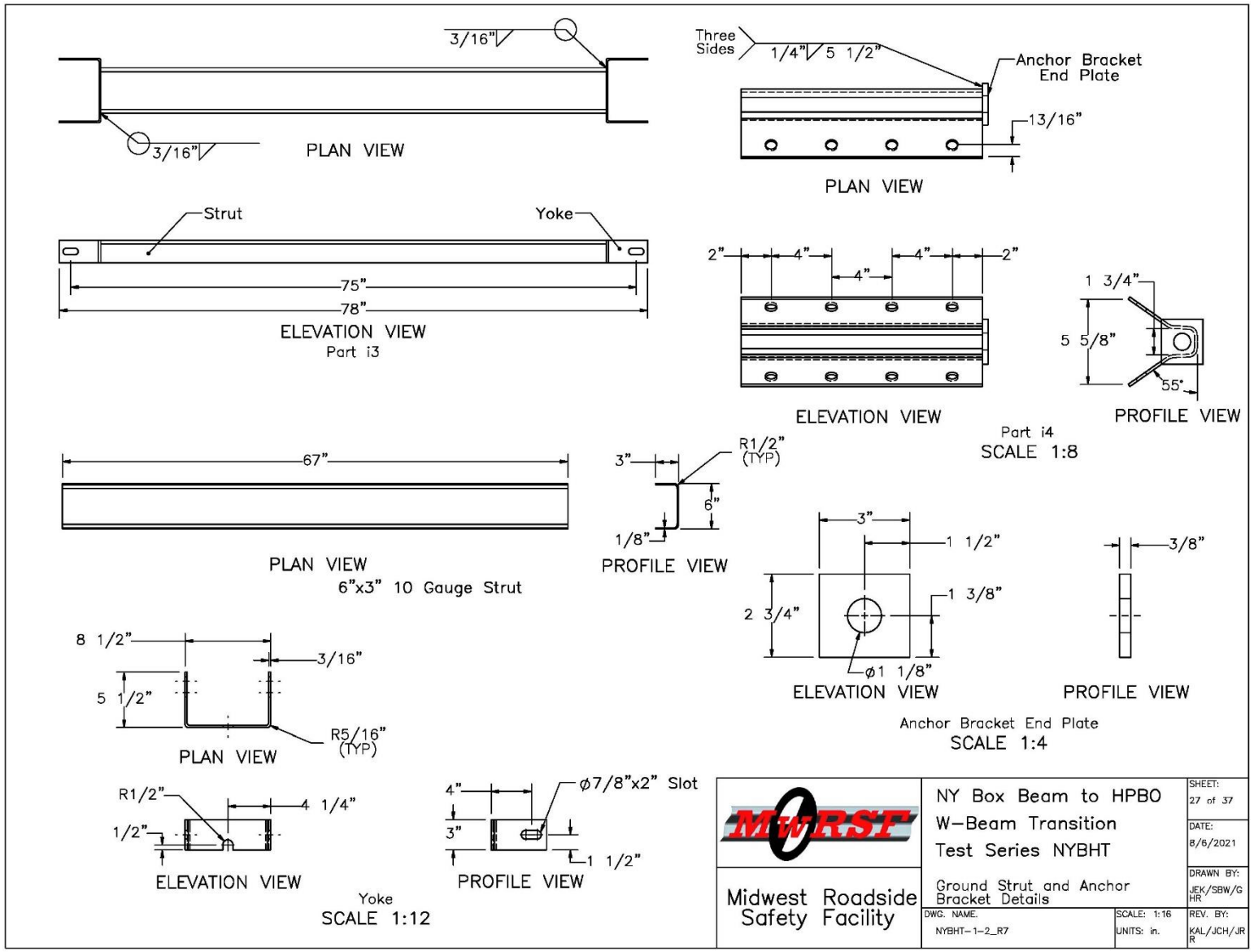


Figure C-27. Ground Strut and Anchor Bracket Details, Test Nos. NYBHT-1 and NYBHT-2

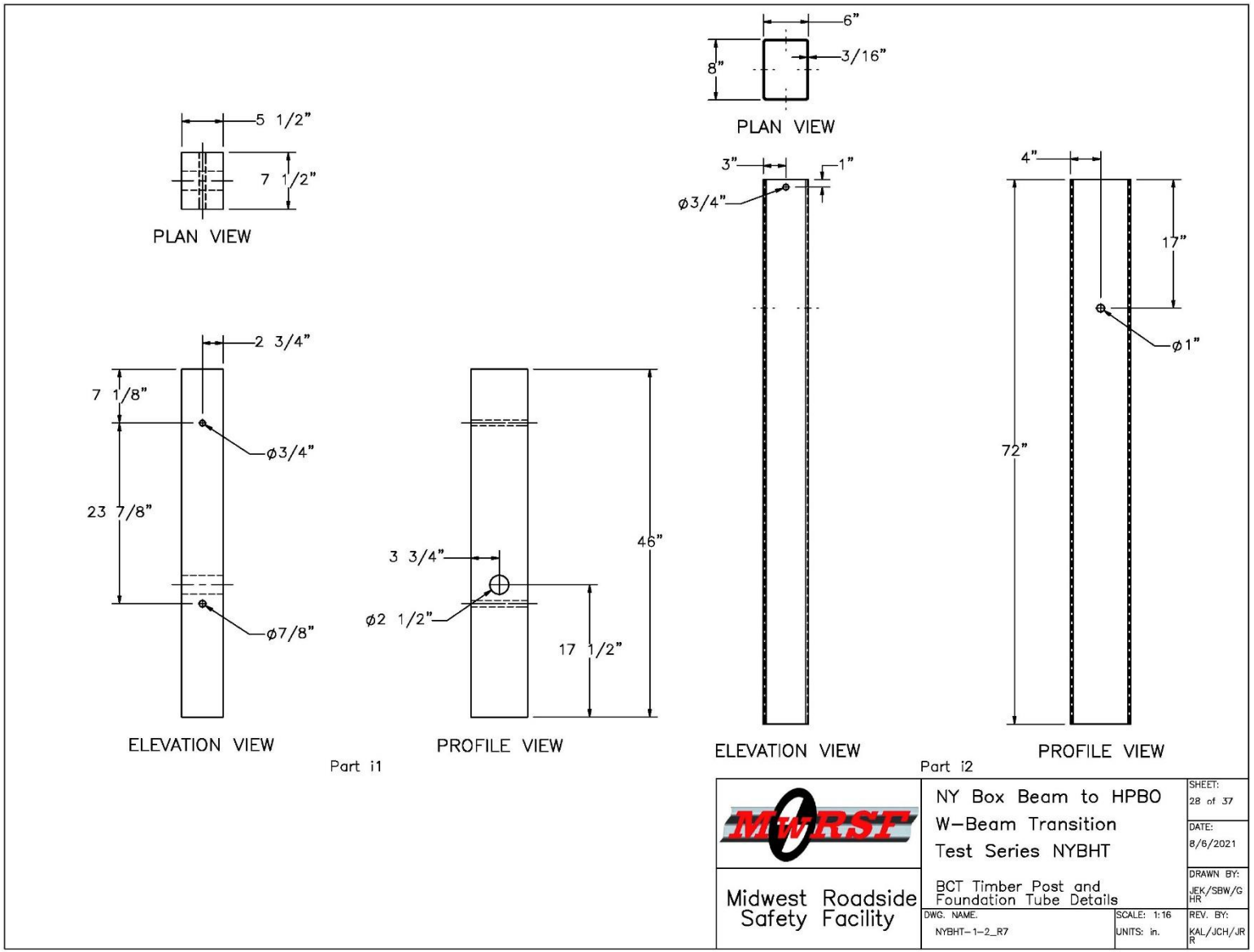


Figure C-28. BCT Timber Post and Foundation Tube Details, Test Nos. NYBHT-1 and NYBHT-2

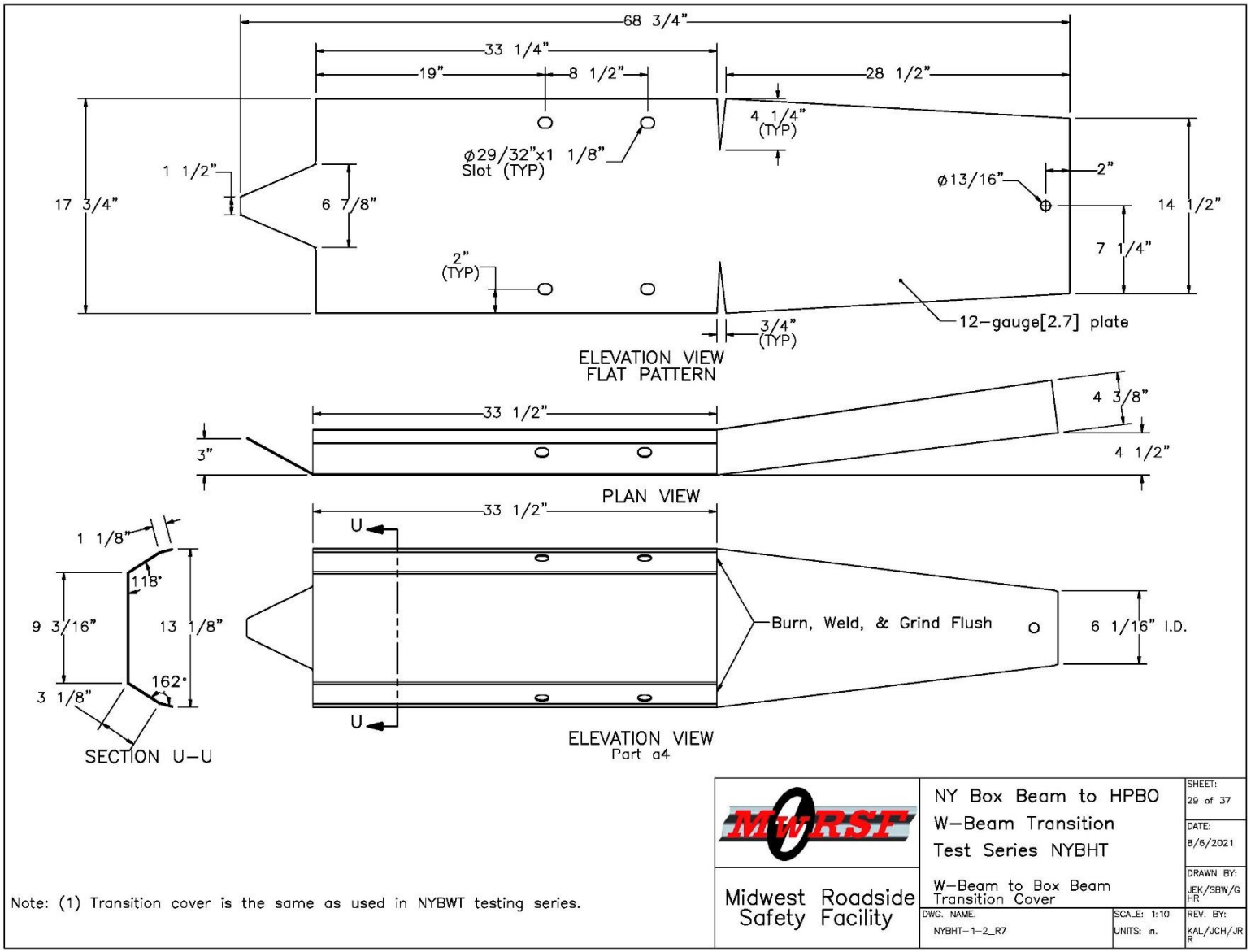


Figure C-29. W-Beam to Box Beam Transition Cover, Test Nos. NYBHT-1 and NYBHT-2

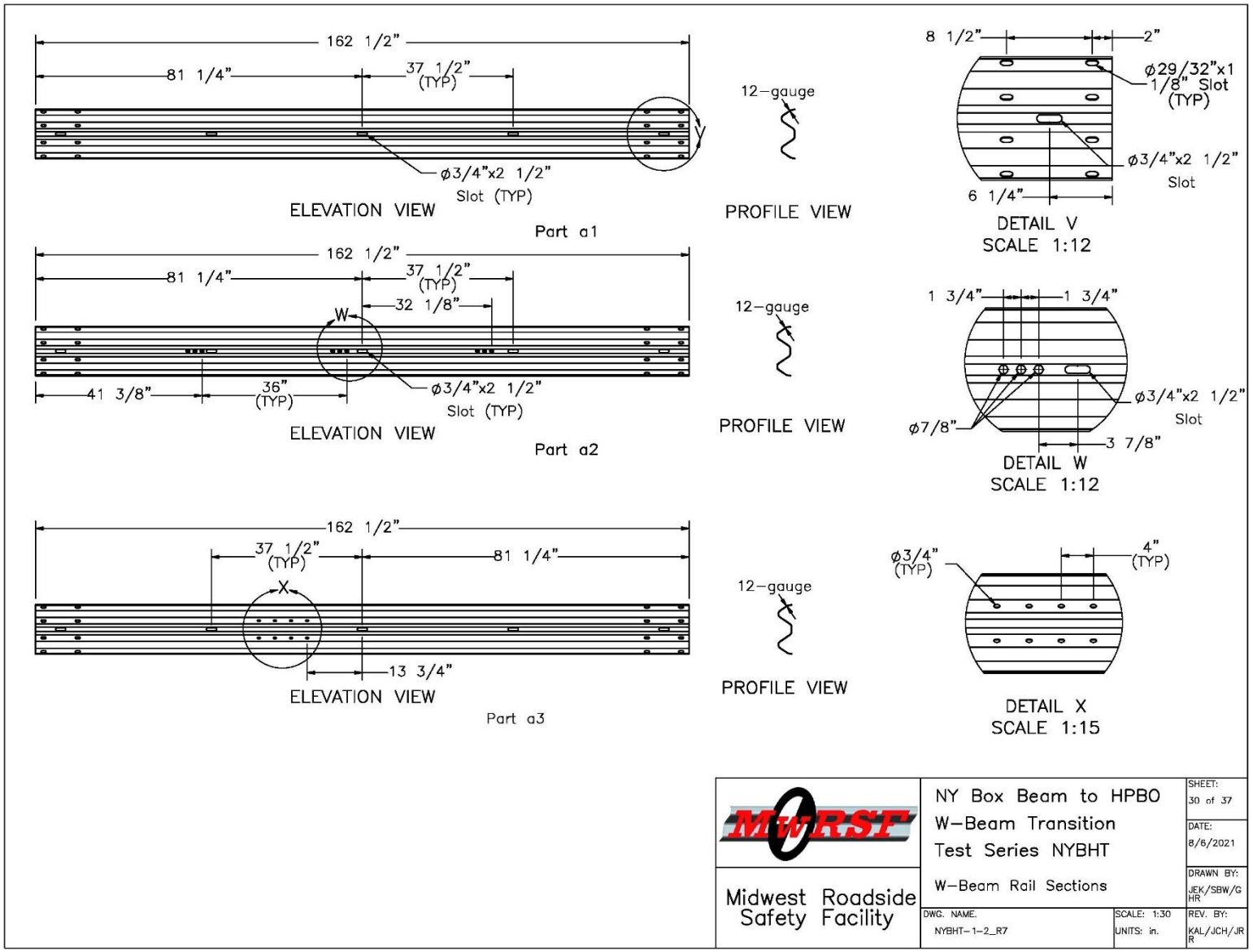


Figure C-30. W-Beam Rail Sections, Test Nos. NYBHT-1 and NYBHT-2

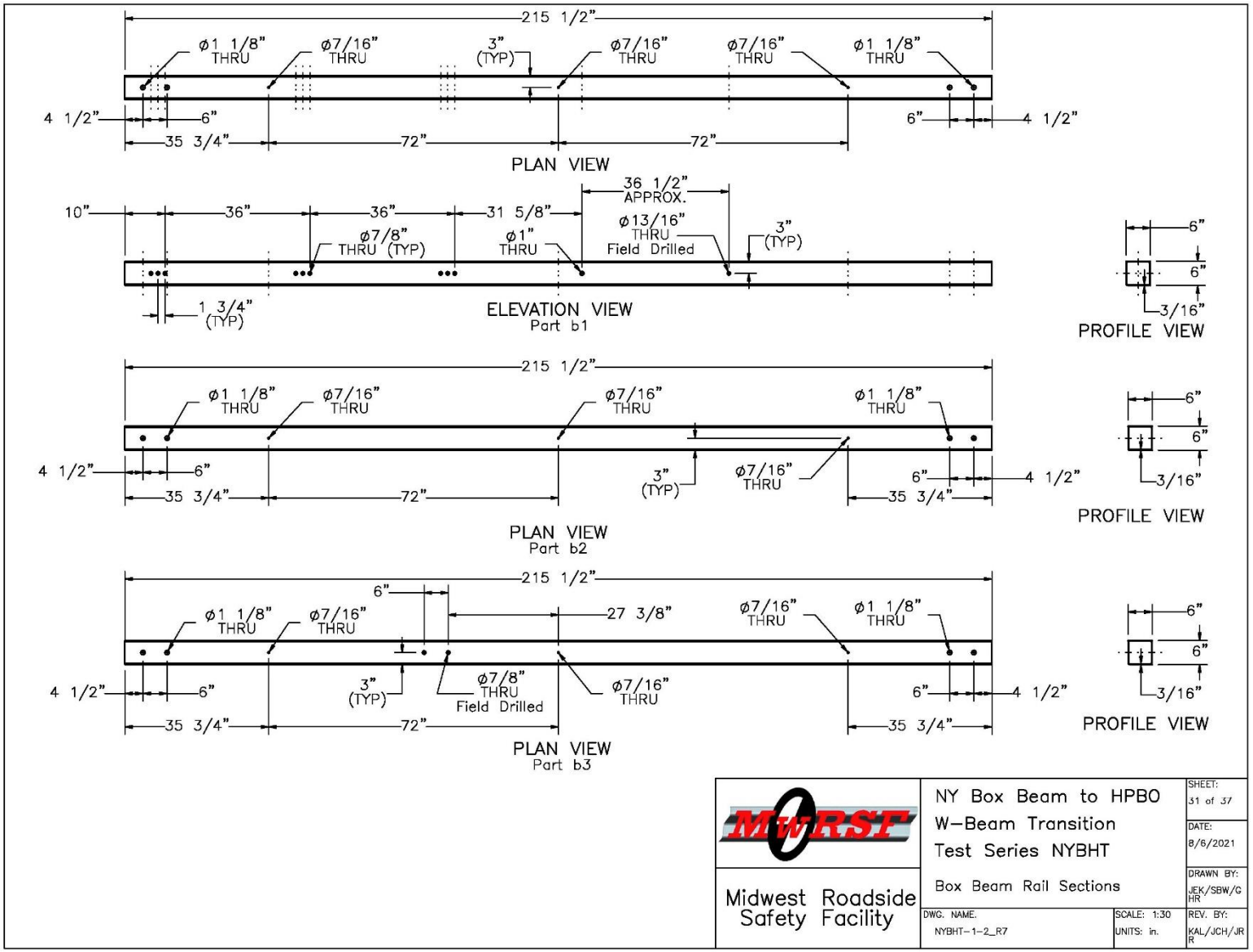
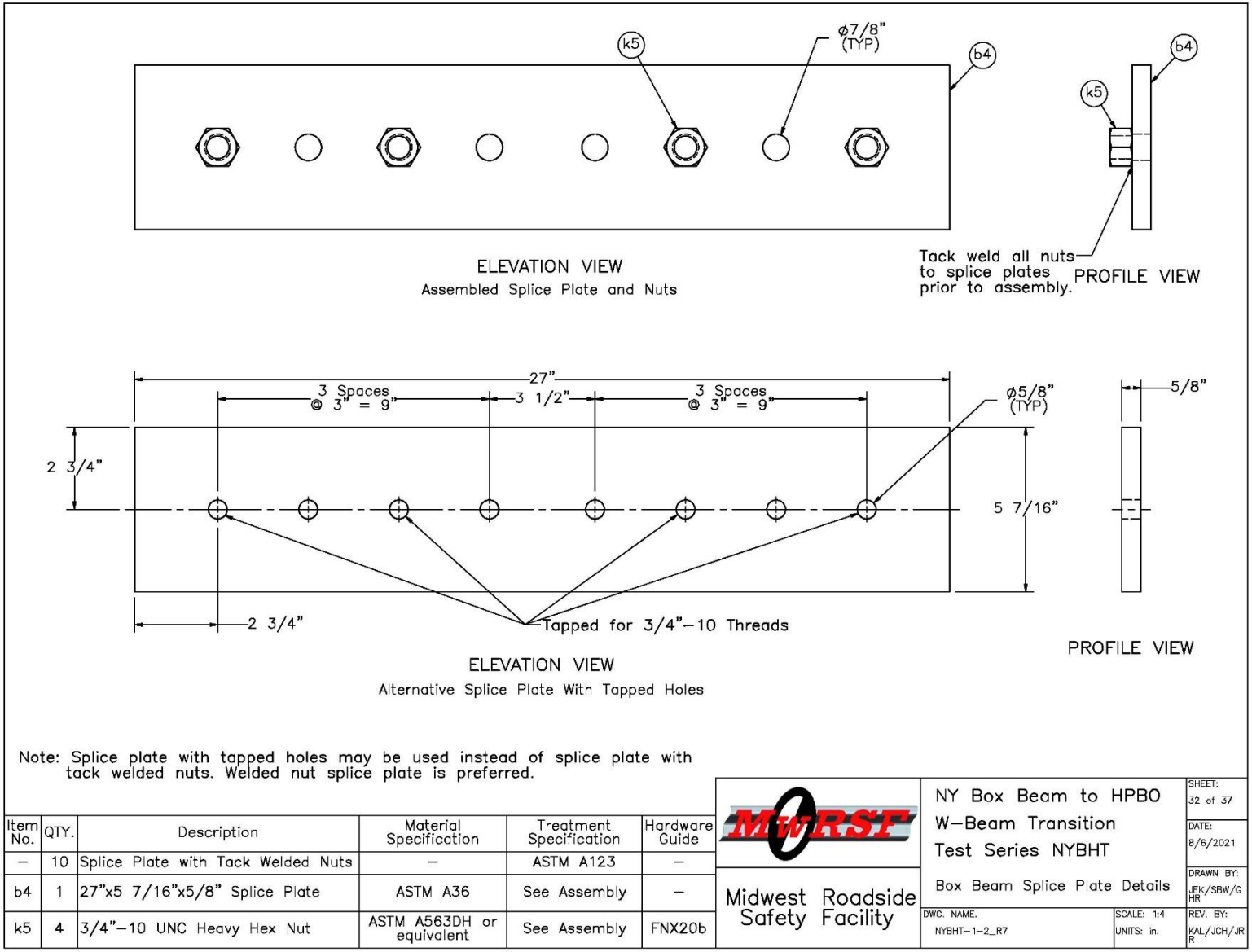


Figure C-31. Box Beam Rail Sections, Test Nos. NYBHT-1 and NYBHT-2



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

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" Splice Plate	ASTM A36	See Assembly	–
k5	4	3/4"–10 UNC Heavy Hex Nut	ASTM A563DH or equivalent	See Assembly	FNX20b

MwRSF
Midwest Roadside Safety Facility

NY Box Beam to HPBO W-Beam Transition
Test Series NYBHT
Box Beam Splice Plate Details

SHEET: 32 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
REV. BY: KAL/JCH/JRR
DWG. NAME. NYBHT-1-2_R7
SCALE: 1:4
UNITS: in.

Figure C-32. Box Beam Splice Plate Details, Test Nos. NYBHT-1 and NYBHT-2

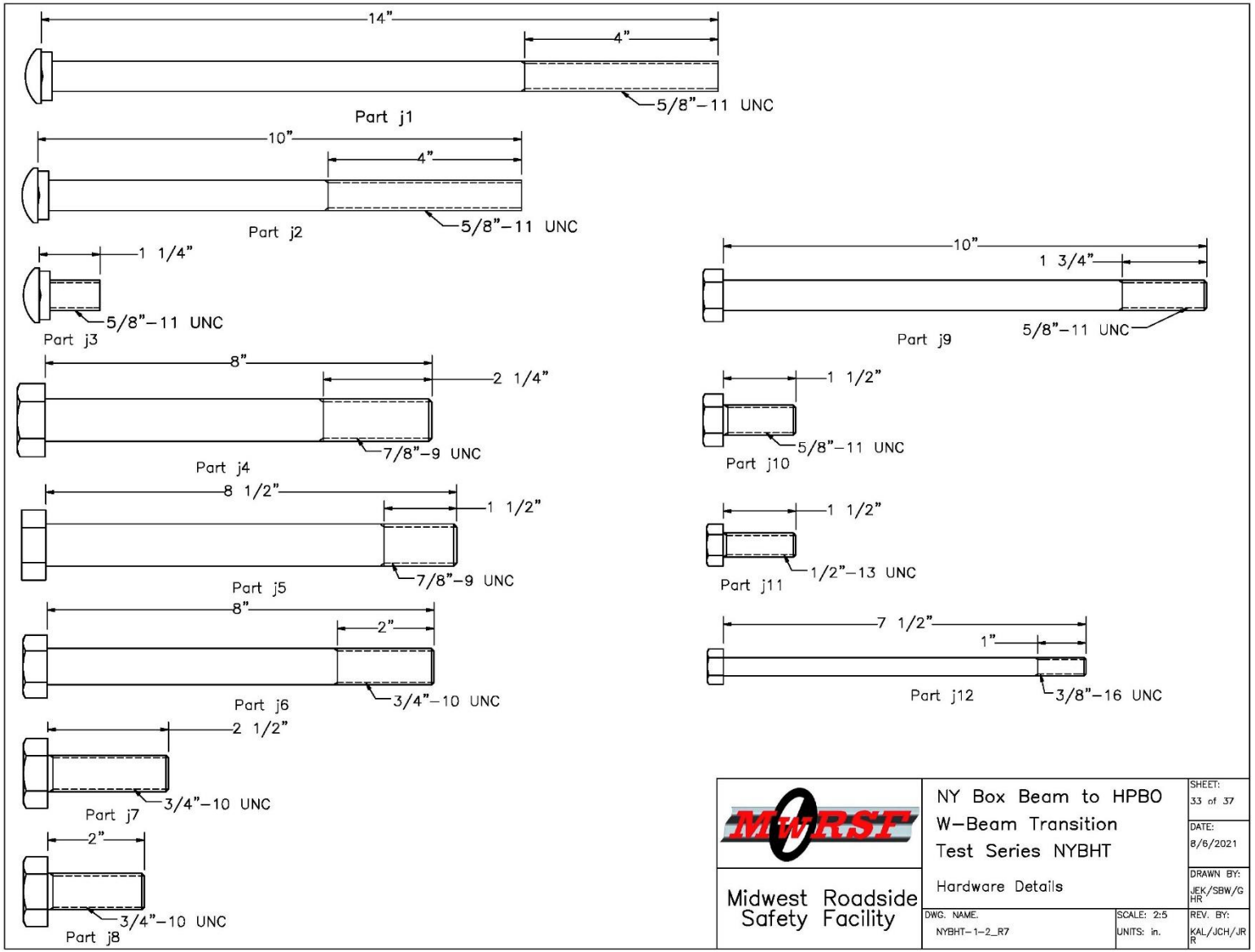


Figure C-33. Hardware Details, Test Nos. NYBHT-1 and NYBHT-2

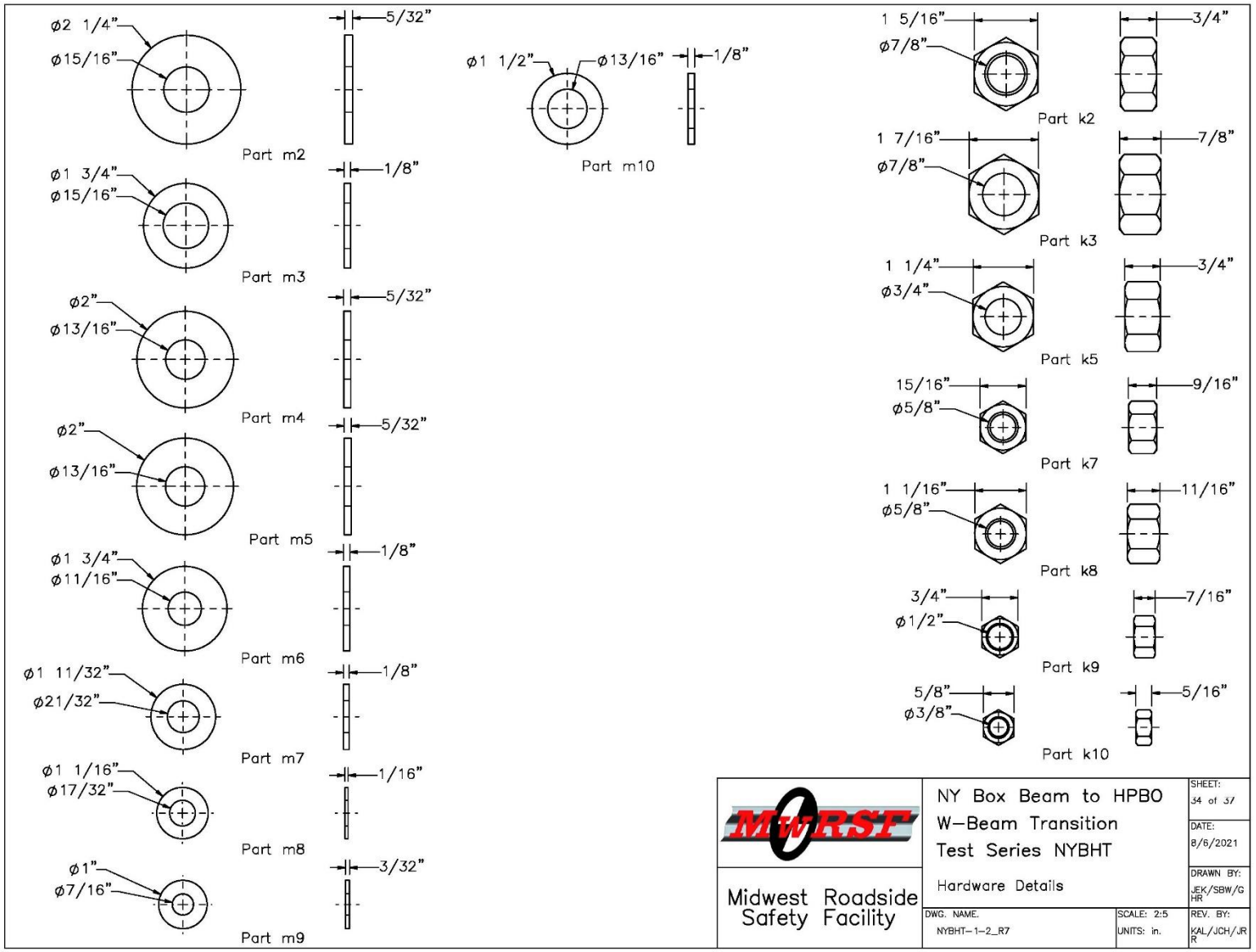


Figure C-34. Hardware Details, Test Nos. NYBHT-1 and NYBHT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
a1	5	12'–6" 12–gauge W–Beam Section	AASHTO M180	ASTM A123 or A653	RWM04a
a2	2	12'–6" 12–gauge W–Beam Section	AASHTO M180	ASTM A123 or A653	–
a3	1	12'–6" 12–gauge W–Beam MGS End Section	AASHTO M180	ASTM A123 or A653	RWM14a
a4	1	W–Beam to Box Beam Transition Cover, 12–gauge	ASTM A36	ASTM A123 or A653	–
b1	1	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b2	4	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b3	1	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	ASTM A123	–
b4	10	27"x5 7/16"x5/8" Splice Plate	ASTM A36	See Assembly	–
c1	21	S3x5.7, 65" Long Post	ASTM A36	See Assembly	–
c2	21	24"x8"x1/4" Soil Plate	ASTM A36	See Assembly	–
c3	3	7"x4"x1/2", 3" Long L–Bracket	ASTM A36	ASTM A123	–
c4	18	5"x3 1/2"x3/8", 4 1/2" Long L–Bracket	ASTM A36	ASTM A123	–
c5	11	W6x8.5 or W6x9, 72" Long Steel Post	ASTM A36	ASTM A123	–
c6	11	14"x12"x6" Timber Blockout	SYP Grade No. 1 or better	–	–
d1	2	W6x15, 72" Long Post	ASTM A992 or ASTM A572 Gr. 50	–	–
d2	2	20"x14"x3/16" Plate	ASTM A36	–	–
d3	2	6 3/16"x4"x1/2" Plate	ASTM A36	–	–
d4	4	6 1/4"x4"x1/2" Plate	ASTM A36	–	–
d5	2	6 3/16"x6"x1/2" Plate	ASTM A36	–	–
e1	2	10"x9"x1/2" Box Beam Cable Anchor Base Plate	ASTM A36	See Assembly	–
e2	4	4"x4"x1/4" Box Beam Cable Anchor Gusset	ASTM A36	See Assembly	–
e3	2	4"x4"x1/2" Box Beam Cable Anchor Mounting Plate	ASTM A36	See Assembly	–
f1	1	Concrete	Pre–Cast Class A* Min. f'c = 3,000 psi NE Mix 47BD	–	–
f2	4	#3 Bar, 30 1/4" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f3	2	#3 Bar, 33 7/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f4	2	#3 Bar, 35 7/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f5	2	#3 Bar, 38 3/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f6	2	#3 Bar, 45 9/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f7	2	#3 Bar, 48" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f8	2	#3 Bar, 50 1/2" Long	ASTM A615 Gr. 60 or A996 Gr. 60	Epoxy–Coated (ASTM A775 or A934) **	–
f9	11	3/4" Dia. UNC, Hooked Anchor J–Bolt	ASTM F1554 Gr. 36	ASTM A153 or B695 Class 55 or F2329	FRH20a

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

Note: (1) According to NY standards, blockouts may be wood, plastic, or synthetic.

Midwest Roadside Safety Facility

NY Box Beam to HPBO W–Beam Transition
Test Series NYBHT
Bill of Materials

SHEET: 35 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
REV. BY: KAL/JCH/JR
DWG. NAME: NYBHT–1–2_R7
SCALE: None
UNITS: in.

Figure C-35. Bill of Materials, Test Nos. NYBHT-1 and NYBHT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
g1	1	14"x9"x1/2" Plate	ASTM A36	See Assembly	–
g2	4	4"x2 13/16"x1/4" Cable Anchor Gusset	ASTM A36	See Assembly	–
g3	1	14"x3 1/2"x1/2" Cable Anchor Top Plate	ASTM A36	See Assembly	–
g4	1	1/4" Dia., 16 3/8" Long Brass Rod	ASTM B16–00	–	–
h1	9	3/4" Dia. UNC, 11" Long Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h2	3	3/4" Dia. UNC, 11" Long Left–Hand Threaded Rod	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	RCE03
h3	6	Cable End Fitting	ASTM A27 Gr. 70–40 Class 1	ASTM A153 or B695	RCE03
h4	6	Cable Wedge	ASTM A47 Gr. 32510	–	FMM01
h5	3	Standard Turnbuckle	ASTM F1145	ASTM A153 or B633	–
h6	6	3/4" Dia. 3x7 IWRC IPS Wire Rope – Various Lengths	ASTM A741 Type 1	Class A Coating	RCM01
h7	6	BCT Anchor Cable End Swaged Fitting	Fitting – ASTM A576 Gr. 1035 Stud – ASTM F568 Class C	Fitting – ASTM A153 Stud – ASTM A153 or B695	–
h7	2	3/4" [19] Dia. 6x19 IWRC IPS Wire Rope	ASTM A741 Type 2	Class A Coating	–
i1	2	BCT Timber Post – MGS Height	SYP Grade No. 1 or better (No knots +/– 9" from weakening hole on tension face)	–	PDF01
i2	2	72" Long Foundation Tube	ASTM A500 Gr. B	ASTM A123	PTE06
i3	1	Ground Strut Assembly	ASTM A36	ASTM A123	PFP01
i4	1	Anchor Bracket Assembly	ASTM A36	ASTM A123	FPA01
i5	1	8"x8"x5/8" Anchor Bearing Plate	ASTM A36	ASTM A123	FPB01
i6	1	2 3/8" O.D. x 6" Long BCT Post Sleeve	ASTM A53 Gr. B Schedule 40	ASTM A123	FMM02
j1	11	5/8"–11 UNC, 14" Long Guardrail Bolt	ASTM A307 Gr. A	ASTM A153 or B695 Class 55 or F2329	FBB06
j2	2	5/8"–11 UNC, 10" Long Guardrail Bolt	ASTM A307 Gr. A	ASTM A153 or B695 Class 55 or F2329	FBB03
j3	52	5/8"–11 UNC, 1 1/4" Long Guardrail Bolt	ASTM A307 Gr. A	ASTM A153 or B695 Class 55 or F2329	FBB01
j4	2	7/8"–9 UNC, 8" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	–
j5	2	7/8"–9 UNC, 8 1/2" Long Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX22b
j6	11	3/4"–10 UNC, 8" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX20a
j7*	2	3/4"–10 UNC, 2 1/2" Long Fully Threaded Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX20b
j8*	38	3/4"–10 UNC, 2" Long Fully Threaded Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329 or F2833 Gr. 1	FBX20b
j9	2	5/8"–11 UNC, 10" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX16a
j10	8	5/8"–11 UNC, 1 1/2" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX16a
j11	18	1/2"–13 UNC, 1 1/2" Long Fully Threaded 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" shorter.

MwRSF

Midwest Roadside Safety Facility

NY Box Beam to HPBO W–Beam Transition
Test Series NYBHT
Bill of Materials

SHEET: 36 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
REV. BY: KAL/JCH/JR
DWG. NAME. NYBHT–1–2_R7
SCALE: None
UNITS: in.

Figure C-36. Bill of Materials, Test Nos. NYBHT-1 and NYBHT-2

Item No.	QTY.	Description	Material Specification	Treatment Specification	Hardware Guide
j12	18	3/8"–16 UNC, 7 1/2" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	ASTM A153 or B695 Class 55 or F2329	FBX10a
j13	2	16D Double Head Nail	–	–	–
k1	6	1"–8 UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX24b
k2	2	7/8"–9 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	–
k3	2	7/8 –9 UNC Heavy Hex Nut	ASTM A563DH or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX22b
k4	30	3/4"–10 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX20a
k5*	40	3/4"–10 UNC Heavy Hex Nut	ASTM A563DH or equivalent	See Assembly	FNX20b
k6	12	3/4"–10 UNC Square Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNS20
k7	10	5/8"–11 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX16a
k8	65	5/8"–11 UNC Heavy Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX16b
k9	18	1/2"–13 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX14a
k10	18	3/8"–16 UNC Hex Nut	ASTM A563A or equivalent	ASTM A153 or B695 Class 55 or F2329	FNX10a
m1	6	1" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC24a
m2	4	7/8" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	–
m3	4	7/8" Dia. Hardened SAE Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC22b
m4	16	3/4" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC20a
m5	40	3/4" Dia. Hardened USS Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b
m6	22	5/8" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC16a
m7	11	5/8" Dia. Plain SAE Washer	ASTM F844	ASTM A123 or A153 or F2329	–
m8	18	1/2" Dia. Plain Narrow SAE Washer	SAE Low Carbon Gr. 2	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	–
m9	36	3/8" Dia. Plain USS Washer	ASTM F844	ASTM A123 or A153 or F2329	FWC10a
m10	30	3/4" Dia. Hardened SAE Washer	ASTM F436	ASTM A153 or B695 Class 55 or F1136 Gr. 3 or F2329	FWC20b

* 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 (m10)	0.812"	0.03"	0.007"	1.469"	0.03"	0.007"	0.134"	0.16"	0.108"
	Wide (m4)	0.812"	0.03"	0.007"	2"	0.03"	0.007"	0.165"	0.192"	0.136"

MwRSF

Midwest Roadside Safety Facility

NY Box Beam to HPBO W-Beam Transition
Test Series NYBHT
Bill of Materials

SHEET: 37 of 37
DATE: 8/6/2021
DRAWN BY: JEK/SBW/GHR
REV. BY: KAL/JCH/JR
DWG. NAME. NYBHT-1-2_R7
SCALE: None
UNITS: in.

Figure C-37. Bill of Materials, Test Nos. NYBHT-1 and NYBHT-2

Appendix D. Material Specifications

Table D-1. Bill of Materials, Test Nos. NYHBT-1, NYHBT-2, NYBHT-1, and NYBHT-2

Item No.	Description	Material Specification	Reference No.			
			Test No NYHBT-1	Test No NYHBT-2	Test No NYBHT-1	Test No NYBHT-2
a1	12'-6" 12-gauge W-Beam Section	AASHTO M180	H#C85187	H#C85187	H#C85187	H#C85187
a2	12'-6" 12-gauge W-Beam Section	AASHTO M180	H#C85187	H#C85187	H#C85187	H#C85187
a3	12'-6" 12-gauge W-Beam MGS End Section	AASHTO M180	H#C85187	H#C85187	H#9411949	H#9411949
a4	W-Beam to Box Beam Transition Cover, 12-gauge	ASTM A36	H#842W32370 H#4125911	H#842W32370 H#4125911	H#842W32370 H#4125911	H#842W32370
b1	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	H#E84376	H#V5411	H#E84376	H#E84376
b2	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	H#V4714	H#V4714	H#V4714	H#V4714 H#V4711 H#V5414
b3	TS6"x6"x3/16", 215 1/2" Long Box Beam	ASTM A500 Gr. B	H#V5411	H#V5411	H#E84376	H#E84376
b4	27"x5 7/16"x5/8" Splice Plate	ASTM A36	H#0600130	H#0600130	H#0600130	H#0600130
c1	S3x5.7, 65" Long Post	ASTM A36	H#14413 H#14007 H#14022 H#14021 H#26120 H#14446	H#14413 H#14007 H#14022 H#14021 H#26120 H#14446	H#14413 H#14007 H#14022 H#14021 H#26120 H#14446	H#14413 H#14007 H#14022 H#14021 H#26120 H#14446 H#27311 H#27666 H#15334 H#15016
c2	24"x8"x1/4" Soil Plate	ASTM A36	H#A91075	H#A91075	H#A91075	H#A91075 H#C90983
c3	7"x4"x1/2", 3" Long L-Bracket	ASTM A36	H#55038700	H#55038700	H#55038700	H#55038700
c4	5"x3 1/2"x3/8", 4 1/2" Long L-Bracket	ASTM A36	H#DL18106642B	H#DL18106642B	H#DL18106642B	H#DL18106642B
c5	W6x8.5 or W6x9, 72" Long Steel Post	ASTM A36	H#14217 H#13790 H#13789	H#14217 H#13790 H#13789	H#14217 H#13790 H#13789	H#14217 H#13790 H#13789
c6	14"x12"x6" Timber Blockout	SYP Grade No. 1 or better	Ch#23422 Ch#21327 Ch#23888	Ch#18379 Ch#21327 Ch#23422 Ch#23888	Ch#23422 Ch#21327 Ch#23888	Ch#23422 Ch#21327 Ch#23888
d1	W6x15, 72" Long Post	ASTM A992 or ASTM A572 Gr. 50	H#59088324	H#59088324	H#59088324	H#59088324

Table D-2. Bill of Materials, Test Nos. NYHBT-1, NYHBT-2, NYBHT-1, and NYBHT-2, Cont.

Item No.	Description	Material Specification	Reference No.			
			Test No NYHBT-1	Test No NYHBT-2	Test No NYBHT-1	Test No NYBHT-2
d2	20"x14"x3/16" Plate	ASTM A36	H#B912008	H#B912008	H#B912008	H#B912008
d3	6 3/16"x4"x1/2" Plate	ASTM A36	H#B916066	H#B916066	H#B916066	H#B916066
d4	6 1/4"x4"x1/2" Plate	ASTM A36	H#B916066	H#B916066	H#B916066	H#B916066
d5	6 3/16"x6"x1/2" Plate	ASTM A36	H#B916066	H#B916066	H#B916066	H#B916066
e1	10"x9"x1/2" Box Beam Cable Anchor Base Plate	ASTM A36	H#B916066	H#B916066	H#B916066	H#B916066
e2	4"x4"x1/4" Box Beam Cable Anchor Gusset	ASTM A36	H#A902127	H#A902127	H#A902127	H#A902127
e3	4"x4"x1/2" Box Beam Cable Anchor Mounting Plate	ASTM A36	H#B916066	H#B916066	H#B916066	H#B916066
f1	Concrete	Pre-Cast Class A* Min. f'c = 3,000 psi NE Mix 47BD	Ticket #2003495 Report# 2147371951	Ticket #2003495 Report# 2147371951	Ticket #2003495 Report# 2147371951	Ticket #2003495 Report# 2147371951
f2	#3 Bar, 30 1/4" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f3	#3 Bar, 33 7/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f4	#3 Bar, 35 7/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f5	#3 Bar, 38 3/8" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f6	#3 Bar, 45 9/16" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f7	#3 Bar, 48" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f8	#3 Bar, 50 1/2" Long	ASTM A615 Gr. 60 or A996 Gr. 60	H#3600002996	H#3600002996	H#3600002996	H#3600002996
f9	3/4" Dia. UNC, Anchor J-Bolt	ASTM F1554 Gr. 36	H#3088555	H#3088555	H#3088555	H#3088555
g1	14"x9"x1/2" Plate	ASTM A36	H#B916072	H#B916072	H#B916072	H#B916072
g2	4"x2 13/16"x1/4" Cable Anchor Gusset	ASTM A36	H#B915258	H#B915258	H#B915258	H#B915258
g3	14"x3.5"x1/2" Cable Anchor Plate	ASTM A36	H#B916072	H#B916072	H#B916072	H#B916072
g4	1/4" Dia., 16 3/8" Long Brass Rod	ASTM B16-00	H#1718206	H#1718206	H#1718206	H#1718206

Table D-3. Bill of Materials, Test Nos. NYHBT-1, NYHBT-2, NYBHT-1, and NYBHT-2, Cont.

Item No.	Description	Material Specification	Reference No.			
			Test No NYHBT-1	Test No NYHBT-2	Test No NYBHT-1	Test No NYBHT-2
h1	3/4" Dia. UNC, 11" Long Threaded Rod	ASTM A307 Gr. A or equivalent	H#188914	H#188914	H#188914	H#188914
h2	3/4" Dia. UNC, 11" Long Left-Hand Threaded Rod	ASTM A307 Gr. A or equivalent	H#188914	H#188914	H#188914	H#188914
h3	Cable End Fitting	ASTM A27 Gr. 70-40 Class 1	H#II7 H#II9	H#II7 H#II9	H#II7 H#II9	H#II7 H#II9
h4	Cable Wedge	ASTM A47 Gr. 32510	H#HZ2	H#HZ2	H#HZ2	H#HZ2
h5	Standard Turnbuckle	ASTM F1145	H#75064032	H#75064032	H#75064032	H#75064032
h6	3/4" Dia. 3x7 IWRC IPS Wire Rope - Various Lengths	ASTM A741 Type 1	H#139015 H#139021	H#139015 H#139021	H#139015 H#139021	H#139015 H#139021 H#5314252604 H#5314398406
h7	BCT Anchor Cable End Swaged Fitting	Fitting - ASTM A576 Gr. 1035 Stud - ASTM F568 Class C	PO#42821	PO#42821	PO#42821	PO#42821
h8	3/4" Dia. 6x19 IWRC IPS Wire Rope	ASTM A741 Type 2	PO#42821	PO#42821	PO#42821	PO#42821
i1	BCT Timber Post - MGS Height	SYP Grade No. 1 or better (No knots +/- 9" from weakening hole on tension face)	CH#652	CH#652	CH#652	CH#652
i2	72" Long Foundation Tube	ASTM A500 Gr. B	H#821T08220	H#821T08220	H#821T08220	H#821T08220
i3	Ground Strut Assembly	ASTM A36	H#163375	H#163375	H#163375	H#163375
i4	Anchor Bracket Assembly	ASTM A36	H#JK16101488	H#JK16101488	H#JK16101488	H#JK16101488
i5	8"x8"x5/8" Anchor Bearing Plate	ASTM A36	H#4181496	H#4181496	H#4181496	H#4181496
i6	2 3/8" O.D. x 6" Long BCT Post Sleeve	ASTM A53 Gr. B Schedule 40	H#B712810	H#B712810	H#B712810	H#B712810
j1	5/8"-11 UNC, 14" Long Guardrail Bolt	ASTM A307 Gr. A	H#DL17100590	H#DL17100590	H#DL17100590	H#DL17100590
j2	5/8"-11 UNC, 10" Long Guardrail Bolt	ASTM A307 Gr. A	H#1721198	H#1721198	H#1721198	H#1721198

Table D-4. Bill of Materials, Test Nos. NYHBT-1, NYHBT-2, NYBHT-1, and NYBHT-2, Cont.

Item No.	Description	Material Specification	Reference No.			
			Test No NYHBT-1	Test No NYHBT-2	Test No NYBHT-1	Test No NYBHT-2
j3	5/8"-11 UNC, 1 1/4" Long Guardrail Bolt	ASTM A307 Gr. A	H#10553090	H#10553090	H#10553090	H#10553090
j4	7/8"-9 UNC, 8" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#489517	H#489517	H#489517	H#489517
j5	7/8"-9 UNC, 8 1/2" Long Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	H#100794352	H#100794352	H#100794352	H#100794352
j6	3/4"-10 UNC, 8" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#1804023300	H#1804023300	H#1804023300	H#1804023300
j7	3/4"-10 UNC, 2 1/2" Long Fully Threaded Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	H#20539460	H#20539460	H#20539460	H#20539460
j8	3/4"-10 UNC, 2" Long Fully Threaded Heavy Hex Head Bolt	ASTM F3125 Gr. A325 Type 1 or equivalent	H#20556060	H#20556060	H#20556060	H#20556060
j9	5/8"-11 UNC, 10" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#JK18104124	H#JK18104124	H#JK18104124	H#JK18104124
j10	5/8"-11 UNC, 1 1/2" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#5-01570	H#5-01570	H#5-01570	H#5-01570
j11	1/2"-13 UNC, 1 1/2" Long Fully Threaded Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#100886004	H#100886004	H#100886004	H#100886004
j12	3/8"-16 UNC, 7 1/2" Long Hex Head Bolt	ASTM A307 Gr. A or equivalent	H#817060395	H#817060395	H#817060395	H#817060395
j13	16D Double Head Nail	-	PO#E000548963	PO#E000548963	PO#E000548963	PO#E000548963
k1	1"-8 UNC Heavy Hex Nut	ASTM A563DH or equivalent	P#38210 C#210157128	P#38210 C#210157128	P#38210 C#210157128	P#38210 C#210157128
k2	7/8"-9 UNC Hex Nut	ASTM A563A or equivalent	H#18108472-3 H#18108473-3	H#18108472-3 H#18108473-3	H#18108472-3 H#18108473-3	H#18108472-3 H#18108473-3
k3	7/8”-9 UNC Heavy Hex Nut	ASTM A563DH or equivalent	H#190518	H#190518	H#190518	H#190518
k4	3/4"-10 UNC Hex Nut	ASTM A563A or equivalent	H#B18000432	H#B18000432	H#B18000432	H#B18000432 H#331502913
k5	3/4"-10 UNC Heavy Hex Nut	ASTM A563DH or equivalent	N/A	N/A	N/A	N/A

Table D-5. Bill of Materials, Test Nos. NYHBT-1, NYHBT-2, NYBHT-1, and NYBHT-2, Cont.

Item No.	Description	Material Specification	Reference No.			
			Test No NYHBT-1	Test No NYHBT-2	Test No NYBHT-1	Test No NYBHT-2
k6	3/4"-10 UNC Square Nut	ASTM A563A or equivalent	Inv#5045356	Inv#5045356	Inv#5045356	Inv#5045356
k7	5/8"-11 UNC Hex Nut	ASTM A563A or equivalent	H#331608011	H#331608011	H#331608011	H#331608011
k8	5/8"-11 UNC Heavy Hex Nut	ASTM A563A or equivalent	H#62144802	H#62144802	H#62144802	H#62144802
k9	1/2"-13 UNC Hex Nut	ASTM A563A or equivalent	H#331610414	H#331610414 H#1804022400	H#331610414	H#331610414 H#1804022400
k10	3/8"-16 UNC Hex Nut	ASTM A563A or equivalent	H#G1712285001	H#G1711323001 H#G171228500	H#G1712285001	H#G1712285001 H#G1711323001
m1	1" Dia. Plain USS Washer	ASTM F844	P#33188 PO#210151571	P#33188 PO#210151571	P#33188 PO#210151571	P#33188 PO#210151571
m2	7/8" Dia. Plain USS Washer	ASTM F844	L#1844804	L#1844804	L#1844804	L#1844804
m3	7/8" Dia. Hardened SAE Washer	ASTM F436	H#63019	H#63019	H#63019	H#63019
m4	3/4" Dia. Plain USS Washer	ASTM F844	P#1133186 PO#210177515	P#1133186 PO#210177515	P#1133186 PO#210177515	P#1133186 PO#210177515
m5	3/4" Dia. Hardened USS Washer	ASTM F436	H#9415738	H#9415738	H#9415738	H#9415738
m6	5/8" Dia. Plain USS Washer	ASTM F844	L#M-SWE0412454-8 L#1845511	L#M-SWE0412454-8 L#1845511	L#M-SWE0412454-8 L#1845511	L#M-SWE0412454-8 L#1845511
m7	5/8" Dia. Plain SAE Washer	ASTM F844	P#0136087 C#110328718	P#0136087 C#110328718	P#0136087 C#110328718	P#0136087 C#110328718
m8	1/2" Dia. Plain Narrow SAE Washer	SAE Low Carbon Gr. 2	L#M-SWE0412034-1	L#M-SWE0412034-1	L#M-SWE0412034-1	L#M-SWE0412034-1 L#M-SWE0412059-1
m9	3/8" Dia. Plain USS Washer	ASTM F844	L#1842301	L#1842301	L#1842301	L#1842301 L#1833609
m10	3/4" Dia. Hardened SAE Washer	ASTM F436	H#1L124	H#1L124	H#1L124	H#1L124

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

Test Report

Customer: UNIVERSITY OF NEBRASKA-LINCOLN
401 CANFIELD ADMIN BLDG
P O BOX 880439
LINCOLN,NE,68588-0439

Ship Date: 1/26/2018
Customer P O: 36263
Shipped to: UNIVERSITY OF NEBRASKA-LINCOLN
Project:
GHP Order No.: 319AA

HT # code	Heat #	C.	MN.	P.	S.	Si.	Tensile	Yield	Elong.	Quanity	Class	Type	Description
1207	C85187	0.2	0.48	0.008	0.003	0.03	80433	59371	16.35	150	A	2	12GA 12FT6IN/3FT1 1/2IN WB T2

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.

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 29 day of January, 2018

Notary Public, State of Ohio

Figure D-1. 12-gauge W-beam Section (Item Nos. a1, a2, and a3)

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

Test Report

Customer: UNIVERSITY OF NEBRASKA-LINCOLN
401 CANFIELD ADMIN BLDG
P O BOX 880439
LINCOLN,NE,68588-0439

Ship Date: 7/9/2015
Customer P.O.: 4500274709/ 07/07/2015
Shipped to: UNIVERSITY OF NEBRASKA-LINCOLN
Project: TESTING COIL
GHP Order No.: 183306

HT # code	Heat #	C.	Mn.	P.	S.	Si.	Tensile	Yield	Elong.	Quantity	Class	Type	Description
8534	9411949	0.21	0.75	0.01	0.006	0.01	75774	56527	27.15	10	A	2	12GA 25FT WB T2 MGS ANCHOR PANEL
8534	9411949	0.21	0.75	0.01	0.006	0.01	75774	56527	27.15	100	A	2	12GA 12FT6IN/3FT1 1/2IN WB T2
8534	9411949	0.21	0.75	0.01	0.006	0.01	75774	56527	27.15	20	A	2	12GA 25FT0IN 3FT1 1/2IN WB T2

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.

By:
Andrew Artar, VP of Sales & Marketing
Gregory Highway Products, Inc.

STATE OF OHIO: COUNTY OF STARK
Sworn to and subscribed before me, a Notary Public, by
Andrew Artar this 17 day of July, 2015

Notary Public, State of Ohio

NOTARIAL SEAL STATE OF OHIO
DAWN R. BATTON
NOTARY PUBLIC
STATE OF OHIO
Comm. Expires
March 03, 2018
Recorded in
Portage County

Figure D-2. 12-gauge W-beam Section (Item No. a3)

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

12Ga Sheet
20x70 9/10/11

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 D-3. Transition Cover (Item No. a4)

Ht# 4125911 Item# 09748
12 GA Plate
A1011

OLYMPIC **STEEL**
5080 RICHMOND ROAD
BEDFORD HEIGHTS, OH 44146 USA
PHONE: 216-292-3800

METALLURGICAL TEST REPORT

>>>>>> CERTIFICATE OF ANALYSIS AND TESTS <<<<<<

Sold To: AMERICAN STEEL & ALUMINUM*LIV*
PO BOX 620
CROWN ROAD
LIVERPOOL, NY 13088

Ship To: AMERICAN STEEL & ALUMINUM*LIV*
PO BOX 620
CROWN ROAD
LIVERPOOL, NY 13088

Sales Order:	549694 - 01	B/L No:	878871	Release:	2
Reference:	HANRAHAN, TIMOTHY	2nd B/L:		Cus Ord #:	M08041344
				Cus Name:	AMERICAN STEEL & ALUMINUM*LIV*

Date: 16-Apr-2019

Description of Material and Specification

✓ MELTED & MFG. IN USA A1011/CSB
.1046IN X 48IN X 96IN

TAG#: 26753880,26753881,26753999
✓ HEAT#: 4125911/ARCELOR MITTAL - CLEVELAND
MC # 26739405

Chem Elem Symbol / Elem Content Value:

<C : .1> <MN : .45> <P : .008> <S : .007> <SI : .01> <AL : .041> <V : .001> <CB : .001> <CU : .04> <NI : .01> <CR : .03> <MO : .01> <N : .0053> <TI : .001> <B : .0001> <CA : .0001> <SN : .006> <SB : .001>

We hereby certify the above is correct as contained in the records of the corporation

Dianna Lowry
Branch Certification Manager

USER: REPORTS@SEMSP01
REPORT: ST_MSR_OSI

16-Apr-2019 4:22 PM
Page 1 of 1

ELDERLEE, INC.
CERT RECEIVED: 3/23/20
PURCHASE ORDER # P6840
SALES ORDER # 08097415
SHIPPED FROM: American Steel

Figure D-4. Transition Cover (Item No. a4)

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

Atlas Tube
A DIVISION OF ZEKELMAN INDUSTRIES

REF.B/L: 80920677
Date: 11/22/2019
Customer: 2293

MATERIAL TEST REPORT

Sold To
DI Highway Sign & Structure
PO Box 128
NEW YORK MILLS NY 13417
USA

Shipped To
DI Highway Sign & Structure
40 Greenman Avenue
NEW YORK MILLS NY 13417
USA

Material: 6.0x6.0x188x23'11"1/2(3x3)NMHCH603NY-21 **Material No:** 60060188 **Made in:** USA **Melted in:** USA

Sales Order: 1417685 **Purchase Order:** 36905

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N	Ca
D82507	0.130	1.120	0.010	0.009	0.011	0.032	0.040	0.006	0.006	0.020	0.040	0.001	0.001	0.0001	0.0060	0.0000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.33
M800902595	9	062820 Psi	079716 Psi	28 %	NY 710-21 GUIDE RAILS	

Heat	MILL	Mill Location	Method	Recycled Content	Post Consumer	Pre-Consumer (Post Industrial)
D82507	USSTEEL	GARY,IN	BOF	36.90%	19.80%	14.40%

Material Note:
Sales Or. Note:

Material: 6.0x6.0x188x35'11"1/2(3x3)NMHCH603NY-21 **Material No:** 60060188 **Made in:** USA **Melted in:** USA

Sales Order: 1417685 **Purchase Order:** 36905

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N	Ca
E84376	0.130	1.130	0.012	0.008	0.010	0.037	0.040	0.006	0.006	0.010	0.040	0.001	0.001	0.0001	0.0010	0.0000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.33
M800902620	9	063525 Psi	078741 Psi	28 %	NY 710-21 GUIDE RAILS	

Heat	MILL	Mill Location	Method	Recycled Content	Post Consumer	Pre-Consumer (Post Industrial)
E84376	USSTEEL	GARY,IN	BOF	36.90%	19.80%	14.40%

Material Note:
Sales Or. Note:

Authorized by Quality Assurance: Jason Richard

The results reported on this report represent the actual attributes of the material furnished and indicate full compliance with all applicable specification and contract requirements.
CE calculated using the AWS D1.1 method.

Steel Tube Institute OF NORTH AMERICA

Metals Service Center Institute

Figure D-5. TS6x6x3⁄16 Box Beam (Item Nos. b1 and b3)

X26 X51 X29

BULL MOOSE TUBE

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

BULL MOOSE TUBE ELKHART FACILITY 05/16/18
CERTIFICATION OF TESTS Page 1 of 2
EN 10204:2004 TYPE 3.1 CERT

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 442739 Ship Via 131_4008

6" SQ X 0.187 HR X 17' 11.5" **Order # 578230**
152.4 mm **Ladle, Physicals, DWTT** **Purchase Order # 35516**
NY Guard Rail 710-21 Rail **Item # 110707 3840**
Customer Item #

Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = V4711 X26 **D NDT**

C	Mn	P	S	Al	Si	Cb	Cu	Cr	Ni	V	Mo	B	Ti	N	Ce	YLD psi	TSN psi	ELN %
.050	.690	.012	.008	.031	.020	.023	.140	.060	.050	.002	.020	0.000	.001	.008	.197	61590	69230	30

6" SQ X 0.187 HR X 17' 11.5" **Order # 578230**
152.4 mm **Ladle, Physicals, DWTT** **Purchase Order # 35516**
NY Guard Rail 710-21 Rail **Item # 110707 3840**
Customer Item #

Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = V5414 X51 **D NDT**

C	Mn	P	S	Al	Si	Cb	Cu	Cr	Ni	V	Mo	B	Ti	N	Ce	YLD psi	TSN psi	ELN %
.060	.670	.014	.007	.036	.020	.023	.150	.090	.050	.002	.020	0.000	.001	.007	.211	60810	69780	30

6" SQ X 0.187 HR X 17' 11.5" **Order # 578230**
152.4 mm **Ladle, Physicals, DWTT** **Purchase Order # 35516**
NY Guard Rail 710-21 Rail **Item # 110707 3840**
Customer Item #

Raw Material is of Domestic Origin - Melted and Manufactured in the USA
Heat # = V4714 X29 **D NDT**

C	Mn	P	S	Al	Si	Cb	Cu	Cr	Ni	V	Mo	B	Ti	N	Ce	YLD psi	TSN psi	ELN %
.060	.680	.014	.003	.035	.030	.023	.150	.080	.060	.002	.020	0.000	.001	.008	.213	66010	72250	29

Quality Manager: Skydeust

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

Figure D-6. TS6x6x3/16 Box Beam (Item No. b2)

BULL MOOSE TUBE

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

BULL MOOSE TUBE - ELKHART FACILITY 08/14/2018
CERTIFICATION OF TESTS Page 7 of 11
EN 10204:2004 TYPE 3.1 CERT

AUG 16 2018

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

SHIP TO : Di Highway - Rail
Ref Contract# NYSW-Q-33126
Route - NS-BUFFCSXT, Utica, NYSW
New York Mills NY 13417

B/L Number 448819 Ship Via TTPX_TTPX80372_TTPX8

6" SQ X 0.187 HR X 17' 11.5" = Order # 578230
152.4 mm Ladle, Physicals, DWTT Purchase Order # 35516
NY Guard Rail 710-21 Rail = Item # 110707 3840
Customer Item #

Raw Material is of Domestic Origin - Melted and Manufactured in the USA

Heat # = V5416

C	Mn	P	S	Al	Si	Cb	Cu	Cr	Ni	V	Mo	B	Ti	N	Ceq	D YLD psi	UT TSN psi	ELN %
.060	.660	.011	.009	.035	.020	.022	.140	.080	.050	.002	.020	.000	.001	.008	.206	61060	69970	30

6" SQ X 0.187 HR X 17' 11.5" = Order # 578230
152.4 mm Ladle, Physicals, DWTT Purchase Order # 35516
NY Guard Rail 710-21 Rail = Item # 110707 3840
Customer Item #

Raw Material is of Domestic Origin - Melted and Manufactured in the USA

Heat # = V5411

C	Mn	P	S	Al	Si	Cb	Cu	Cr	Ni	V	Mo	B	Ti	N	Ceq	D YLD psi	UT TSN psi	ELN %
.050	.660	.014	.007	.030	.020	.022	.160	.080	.060	.002	.020	.000	.001	.008	.198	64920	71660	29

6" SQ X 0.187 HR X 17' 11.5" = Order # 578230
152.4 mm Ladle, Physicals, DWTT Purchase Order # 35516
NY Guard Rail 710-21 Rail = Item # 110707 3840
Customer Item #

Raw Material is of Domestic Origin - Melted and Manufactured in the USA

Heat # = W0822

C	Mn	P	S	Al	Si	Cb	Cu	Cr	Ni	V	Mo	B	Ti	N	Ceq	D YLD psi	UT TSN psi	ELN %
.050	.690	.010	.004	.034	.020	.025	.140	.070	.050	.003	.020	.000	.001	.007	.200	61720	69820	32

Quality Manager: SRydeen

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 D-7. TS6x6x3⁄16 Box Beam (Item Nos. b1 and b3)

NUCOR PLATE MILL
P.O.Box 279
Winton, NC 27986
(252) 356-3700

Mill Test Report

Page 6

1505 River Rd
Cofield, NC 27922
(252) 356-3700
NUCOR It's Our Nature

Issuing Date : 01/08/2020 B/L No. : 551191 Load No. : 563082 Our Order No. : 173393/4 Cust. Order No. : PHL-14166

Vehicle No: NOKL 725161

Specification: 0.6250" x 96.000" x 240.000"
ASTM A36-19 ASTM A709 36-18/ASME SA 36 2015/2017 CSA G40.21-44W/300W-04/-13 AASHTO M270 Gr36

Marking :

Sold To: CHAPEL STEEL CORP
590 N BETHLEHEM PIKE
PO BOX 1000
SPRINGHOUSE,PA 19477

Ship To: CHAPEL STEEL COMPANY
201 S KEIM ST
POTTSTOWN,PA 19464

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
0600130	0.17	0.84	0.007	0.003	0.19	0.20	0.10	0.09	0.02	0.033	0.003	0.001	0.002		0.0056	0.0002	0.009	0.36	0.24

Plate Serial No	Pieces	Tons	Tensile Test Dir.	(psi) Yield	(psi) Tensile	Elong. % in 2"	Elong. % in 8"
0600130-07	7	14.29	T	49,100	72,300		26.2
			T	45,800	69,600		26.3
0600130-08	9	18.37	T	49,100	72,300		26.2
			T	45,800	69,600		26.3

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate as-rolled, unless otherwise noted in Specification. For Mexico shipments:nho-SalesMX@Nucor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
Melted and Manufactured in the USA. ISO 9001:2015 certified (A013354) by SRI Quality System Register (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant
DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate QA-3624366

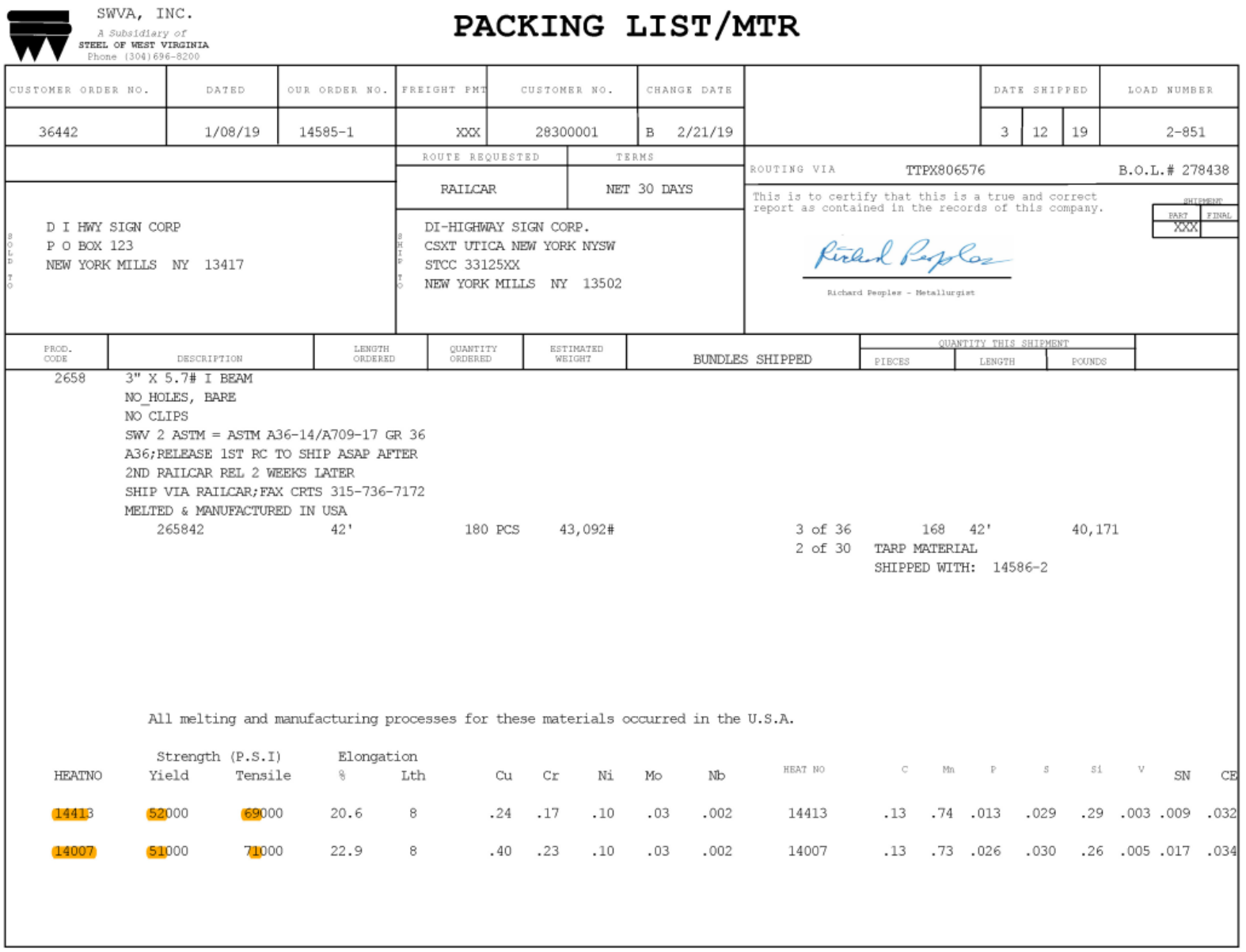
We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A. Depretis

T. A. Depretis, Metallurgist

1/8/2020 10:27:21 AM

Figure D-8. ⅝-in. Splice Plate (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
36442	1/08/19	14585-1	XXX	28300001	B 2/21/19		3	12	19	2-851

ROUTE REQUESTED	TERMS	ROUTING VIA	B.O.L.#
RAILCAR	NET 30 DAYS	TTPX806576	278438

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

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

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

Richard Peoples

Richard Peoples - Metallurgist

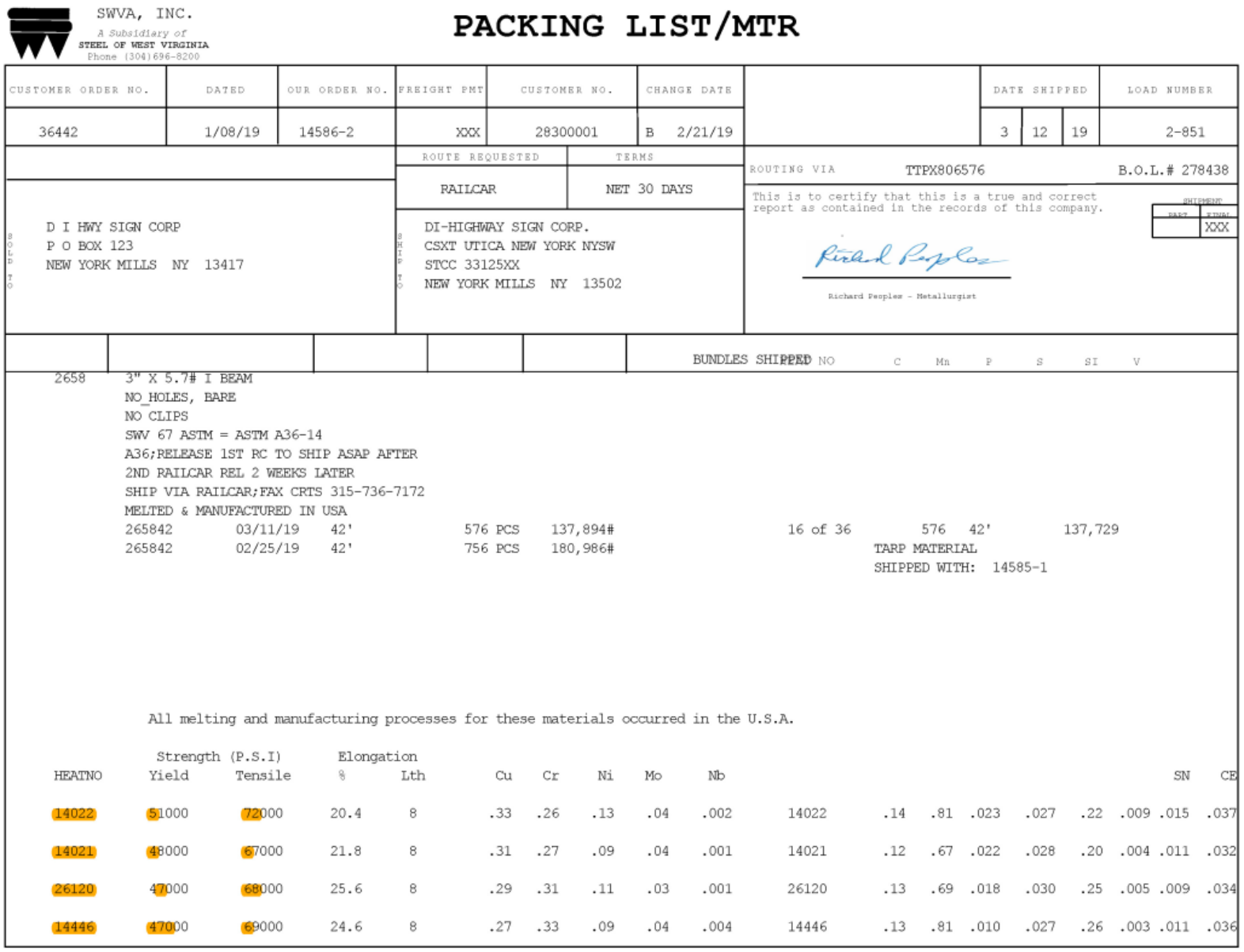
SHIPMENT: PART XXX; FINAL

PROD. CODE	DESCRIPTION	LENGTH ORDERED	QUANTITY ORDERED	ESTIMATED WEIGHT	BUNDLES SHIPPED	QUANTITY THIS SHIPMENT: PIECES	LENGTH	POUNDS
2658	3" X 5.7# I BEAM NO HOLES, BARE NO CLIPS SWV 2 ASTM = ASTM A36-14/A709-17 GR 36 A36;RELEASE 1ST RC TO SHIP ASAP AFTER 2ND RAILCAR REL 2 WEEKS LATER SHIP VIA RAILCAR;FAX CRTS 315-736-7172 MELTED & MANUFACTURED IN USA							
	265842	42'	180 PCS	43,092#	3 of 36 2 of 30	168	42'	40,171
					TARP MATERIAL SHIPPED WITH: 14586-2			

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	HEAT NO	C	Mn	P	S	Si	V	SN	CE
14413	52000	69000	20.6	8	.24	.17	.10	.03	.002	14413	.13	.74	.013	.029	.29	.003	.009	.032
14007	51000	71000	22.9	8	.40	.23	.10	.03	.002	14007	.13	.73	.026	.030	.26	.005	.017	.034

Figure D-9. S3x5.7 Post (Item No. c1)



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
36442	1/08/19	14586-2	XXX	28300001	B 2/21/19	3 12 19	2-851

ROUTE REQUESTED	TERMS	ROUTING VIA	B.O.L.#
RAILCAR	NET 30 DAYS	TTPX806576	278438

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

Richard Peoples – Metallurgist

SHIPMENT PART XXX

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

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

BUNDLES SHIPPED NO C Mn P S SI V

2658 3" X 5.7# I BEAM
NO HOLES, BARE
NO CLIPS
SWV 67 ASTM = ASTM A36-14
A36;RELEASE 1ST RC TO SHIP ASAP AFTER
2ND RAILCAR REL 2 WEEKS LATER
SHIP VIA RAILCAR;FAX CRTS 315-736-7172
MELTED & MANUFACTURED IN USA
265842 03/11/19 42' 576 PCS 137,894# 16 of 36 576 42' 137,729
265842 02/25/19 42' 756 PCS 180,986#
TARP MATERIAL
SHIPPED WITH: 14585-1

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								SN	CE
14022	51000	72000	20.4	8	.33	.26	.13	.04	.002	14022	.14	.81	.023	.027	.22	.009	.015	.037
14021	48000	67000	21.8	8	.31	.27	.09	.04	.001	14021	.12	.67	.022	.028	.20	.004	.011	.032
26120	47000	68000	25.6	8	.29	.31	.11	.03	.001	26120	.13	.69	.018	.030	.25	.005	.009	.034
14446	47000	69000	24.6	8	.27	.33	.09	.04	.004	14446	.13	.81	.010	.027	.26	.003	.011	.036

Figure D-10. S3x5.7 Post, (Item No. c1)

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
P006557	5/15/19	20656-1	XXX & INCL	31850000	

DATE SHIPPED			LOAD NUMBER
5	15	19	5-31

F.O.B HUNTINGTON

ROUTE REQUESTED	TERMS
TRUCK	NET 30 DAYS

ROUTING VIA PLS B.O.L.# 280482

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

Richard Peoples - 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 A36-14							
	ITEM#0300.00001 & 0300.00002							
	FAXCERTS 315-789-6610							
	A36/A709-36;SHIP 2 TRUCKS MAX PER DAY							
	PHONE #315-789-6670;SHIP 42' FIRST!!!!							
	265842	42'	828 PCS	198,223#	3 of 36	108	42'	25,855
	2658434	43' 4"	72 PCS	17,784#	2 of 36	72	43' 4"	17,784
				ELDERLEE INC.				43,639
			CERT RECEIVED:	5/16/19		TARP MATERIAL		
			PURCHASE ORDER #	P6557				
			SALES ORDER #	20656				
			SHIPPED FROM:	SWVA				
	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
27311	52000	73000	21.6	8	.43	.29	.15	.03	.002
27666	51000	65000	24.3	8	.27	.19	.10	.03	.002
15334	49000	66000	24.6	8	.29	.20	.09	.02	.002

HEAT NO.	C	MN	P	S	SI	V	SN	CE
27311	.15	.61	.021	.037	.24	.004	.015	.36
27666	.11	.59	.016	.027	.21	.002	.011	.28
15334	.11	.60	.014	.026	.22	.003	.010	.28

Figure D-11. S3x5.7 Post (Item No. c1)

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
PO06442	4/05/19	18794-1	XXX & INCL	31850000		4 26 19	4-317

F.O.B HUNTINGTON

ROUTE REQUESTED	TERMS
TRUCK	NET 30 DAYS

ROUTING VIA PLS B.O.L.# 280012

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

Richard Peoples

Richard Peoples - 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 2 ASTM = ASTM A36-14/A709-17 GR 36							
	ITEM#0300.00001 & 0300.00002 FAXCERTS 315-789-6610							
	A36/A709-36;SHIP 2 TRUCKS MAX PER DAY PHONE #315-789-6670;SHIP 42' FIRST!!!!							
	2658434	43' 4"	180 PCS	44,460#	1 of 36	36 TARP MATERIAL	43' 4"	8,892

ELDERLEE, INC.
CERT RECEIVED: 4/29/19
PURCHASE ORDER #: P0442
SALES ORDER #: 18794
SHIPPED FROM: Sweda

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
15016	53000	71000	23.5	8	.26	.21	.08	.02	.002

HEAT NO.	C	MN	P	S	SI	V	SN	CE
15016	.15	.79	.023	.027	.26	.007	.010	.35

Figure D-12. S3x5.7 Post (Item No. c1)

CERTIFIED TEST REPORT

UCKEYE METALS INDUSTRIES
238 E. 82ND STREET
LEVELAND, OH 44104
16 663-4300

Spade Plate

DATE: 2/13/19

OLD TO: DI-HIGHWAY SIGN & STRUCTURE
40 GREENMAN AVE. PO BOX 123
NEW YORK MILLS, NY 13417-0123

SHIP TO: DI-HIGHWAY SIGN & STRUCTURE
40 GREENMAN AVE.
NEW YORK MILLS, NY 13417-0123

Cust P/O# 36481

IZE: .245 X 8.00 X 24.00

RADE: A-36

CHEMICAL ANALYSIS

eat Number A91075

C : .05	Mn: .43	P : .011	S : .002
Si: .03	Ti: .002	Cr: .08	Mo: .02
Cu: .13	Al: .025	Cb: Nb: .017	Va: .001
	Sn: .004	Ca: .0018	N : .0071
B : .001		Ni: .05	

PHYSICAL PROPERTIES

Yield: 52500 Tensile: 65000 Elongation 35%

Comment A-36
Comment MADE& MELTED IN U.S.A.

Figure D-13. ¼-in. Soil Plate (Item No. c2)

24" Spade A36

CERTIFICATE OF CONFORMANCE

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

8/13/19

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: 8/14/19
PURCHASE ORDER # P6606
SALES ORDER # 802001
SHIPPED FROM: Met Con Steel

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

Bill/Ladng# 002487 B/L Date 8/13/19 Sales Ordr: 802001
Cust. P/O#: PO06606 Part No.: 0333.70001

Tag# 50292201 01 Heat# C90983 MasterTag# MC153092G 01
C : .22 Mn: 1.12 P : .010 S : .004 Al: .048 Si: .04
Ti: .002 Mo: .02 Cu: .10 V : .001 Cr: .05
Sn: .005 Ca: .0019 N : .0059 B : .0001 Ni: .03
Tens: 63900 Yld: 51050 Elng: 25%

Tag# 50292202 01 Heat# C90983 MasterTag# MC153092G 01
C : .22 Mn: 1.12 P : .010 S : .004 Al: .048 Si: .04
Ti: .002 Mo: .02 Cu: .10 V : .001 Cr: .05
Sn: .005 Ca: .0019 N : .0059 B : .0001 Ni: .03
Tens: 63900 Yld: 51050 Elng: 25%

Tag# 50292203 01 Heat# C90983 MasterTag# MC153092G 01
C : .22 Mn: 1.12 P : .010 S : .004 Al: .048 Si: .04
Ti: .002 Mo: .02 Cu: .10 V : .001 Cr: .05
Sn: .005 Ca: .0019 N : .0059 B : .0001 Ni: .03
Tens: 63900 Yld: 51050 Elng: 25%

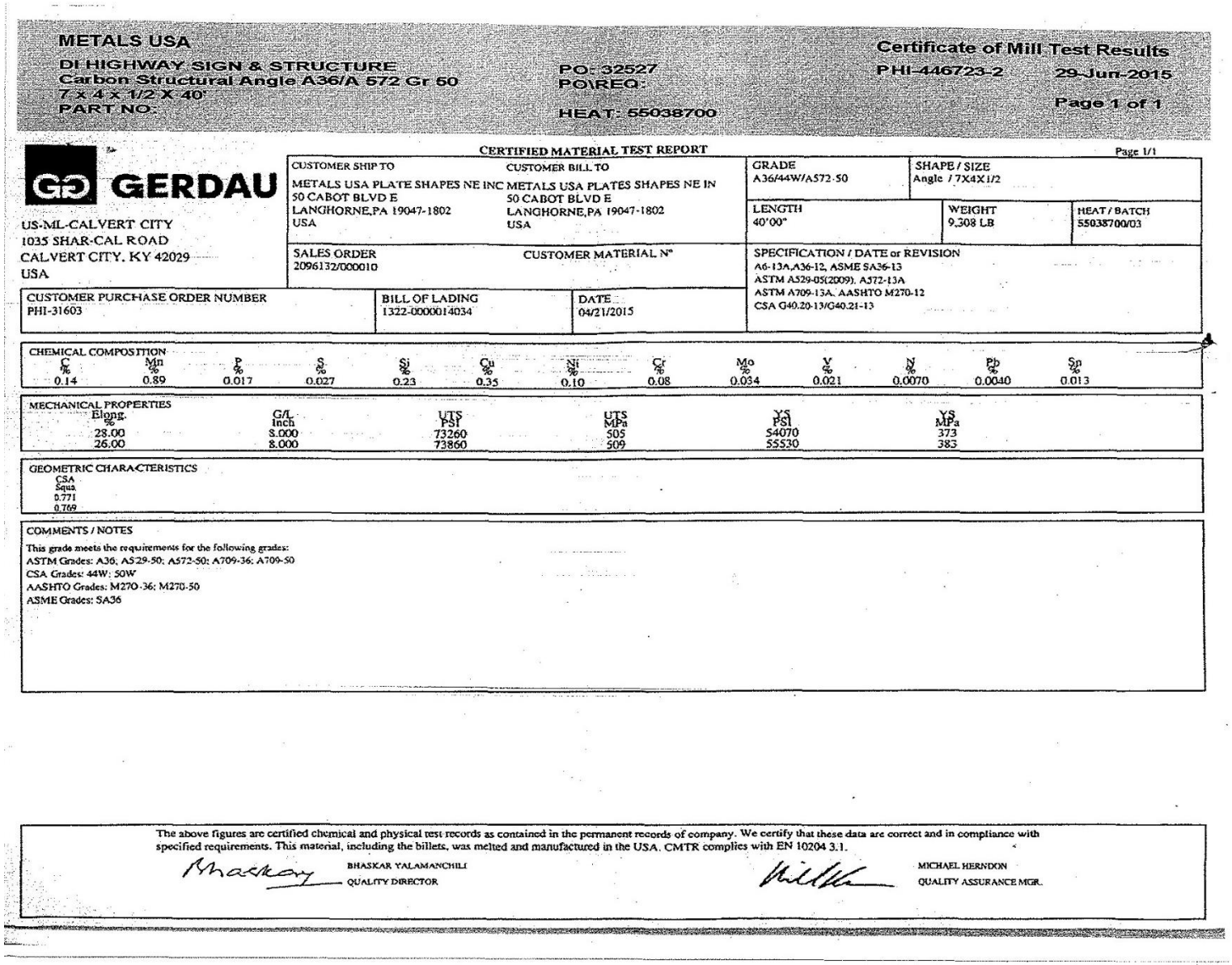
Tag# 50292204 01 Heat# C90983 MasterTag# MC153092G 01
C : .22 Mn: 1.12 P : .010 S : .004 Al: .048 Si: .04
Ti: .002 Mo: .02 Cu: .10 V : .001 Cr: .05
Sn: .005 Ca: .0019 N : .0059 B : .0001 Ni: .03
Tens: 63900 Yld: 51050 Elng: 25%

Tag# 50292205 01 Heat# C90983 MasterTag# MC153092G 01
C : .22 Mn: 1.12 P : .010 S : .004 Al: .048 Si: .04
Ti: .002 Mo: .02 Cu: .10 V : .001 Cr: .05
Sn: .005 Ca: .0019 N : .0059 B : .0001 Ni: .03
Tens: 63900 Yld: 51050 Elng: 25%

Tag# 50292206 01 Heat# C90983 MasterTag# MC153092G 01
C : .22 Mn: 1.12 P : .010 S : .004 Al: .048 Si: .04
Ti: .002 Mo: .02 Cu: .10 V : .001 Cr: .05
Sn: .005 Ca: .0019 N : .0059 B : .0001 Ni: .03
Tens: 63900 Yld: 51050 Elng: 25%

Continued...

Figure D-14. ¼-in. Soil Plate, (Item No. c2)



METALS USA
DI HIGHWAY SIGN & STRUCTURE
Carbon Structural Angle A36/A 572 Gr 60
7 x 4 X 1/2 X 40'
PART NO:

PO: 32527
PO\REQ:
HEAT: 55038700

Certificate of Mill Test Results
PHI-446723-2 29-Jun-2015
Page 1 of 1

GERDAU

US-ML-CALVERT CITY
1035 SHAR-CAL ROAD
CALVERT CITY, KY 42029
USA

CERTIFIED MATERIAL TEST REPORT Page 1/1

CUSTOMER SHIP TO	CUSTOMER BILL TO
METALS USA PLATE SHAPES NE INC 50 CABOT BLVD E LANGHORNE,PA 19047-1802 USA	METALS USA PLATES SHAPES NE IN 50 CABOT BLVD E LANGHORNE,PA 19047-1802 USA

GRADE	SHAPE / SIZE
A36/44W/A572-50	Angle / 7X4X1/2

LENGTH	WEIGHT	HEAT / BATCH
40'00"	9,308 LB	55038700/03

SALES ORDER	CUSTOMER MATERIAL N°
2096132/000010	

SPECIFICATION / DATE or REVISION
A6-13A,A36-12, ASME SA36-13
ASTM A529-05(2009), A572-13A
ASTM A709-13A, AASHTO M270-12
CSA G40.20-13/G40.21-13

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
PHI-31603	1322-0000014034	04/21/2015

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	V %	N %	Pb %	Sn %
0.14	0.89	0.017	0.027	0.23	0.35	0.10	0.08	0.034	0.021	0.0070	0.0040	0.013

MECHANICAL PROPERTIES

Elong. %	G/L Inch	UTS PSI	UTS MPa	YS PSI	YS MPa
28.00	8.000	73260	505	54070	373
26.00	8.000	73860	509	55530	383

GEOMETRIC CHARACTERISTICS

CSA Squa
0.771
0.769

COMMENTS / NOTES
This grade meets the requirements for the following grades:
ASTM Grades: A36; AS29-50; A572-50; A709-36; A709-50
CSA Grades: 44W; 50W
AASHTO Grades: M270-36; M270-50
ASME Grades: SA36

The above figures are certified chemical and physical test records as contained in the permanent records of company. 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

MICHAEL HERNDON
QUALITY ASSURANCE MGR.

Figure D-15. 3-in. Long L-Bracket, (Item No. c3)

NUCOR

Mill Certification
04/23/2019

MTR#:168884-4
Lot #:DL1810664201
25 QUARRY RD
AUBURN, NY 13021 US
315 253 4561
Fax: 315 258 4300

Sold To: DI HIGHWAY SIGN & STRUCTURE
PO BOX 123
NEW YORK MILLS, NY 13417 US

Ship To: DI HIGHWAY SIGN & STRUCTURE
40 GREENMAN AVE
NEW YORK MILLS, NY 13417 US

Customer PO	36611	Sales Order #	31003841 - 5.1
Product Group	Hot Roll - Merchant Bar Quality	Product #	3007306
Grade	Nucor Multigrade	Lot #	DL1810664201
Size	5" x 3.5" x 0.375"	Heat #	DL18106642B
BOL #	BOL-260517	Load #	168884
Description	Hot Roll - Merchant Bar Quality Unequal Angle 5" x 3 1/2" x 3/8" Nucor Multigrade 20' 0" [240"] 2001-6000 lbs	Customer Part #	
Production Date	02/07/2019	Qty Shipped LBS	4992
Product Country Of Origin	United States	Qty Shipped EA	24
Original Item Description		Original Item Number	

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.

Melt Country of Origin : United States — Melting Date: 10/18/2018

C (%)	Mn (%)	P (%)	S (%)	Si (%)	Ni (%)	Cr (%)	Mo (%)	Cu (%)	Ti (%)	Nb (%)	Sn (%)
0.13	0.65	0.016	0.019	0.190	0.11	0.16	0.03	0.44	0.001	0.022	0.013

ASTM A529 S78.2 CE (%) : 0.35

ASTM A992 5.4 CE (%) : 0.31

Other Test Results

Yield (PSI) : 58000 — Yield (PSI) : 54000 — Tensile (PSI) : 73000

Tensile (PSI) : 69000 — Elongation in 8" (%) : 21.0 — Elongation in 8" (%) : 23.0

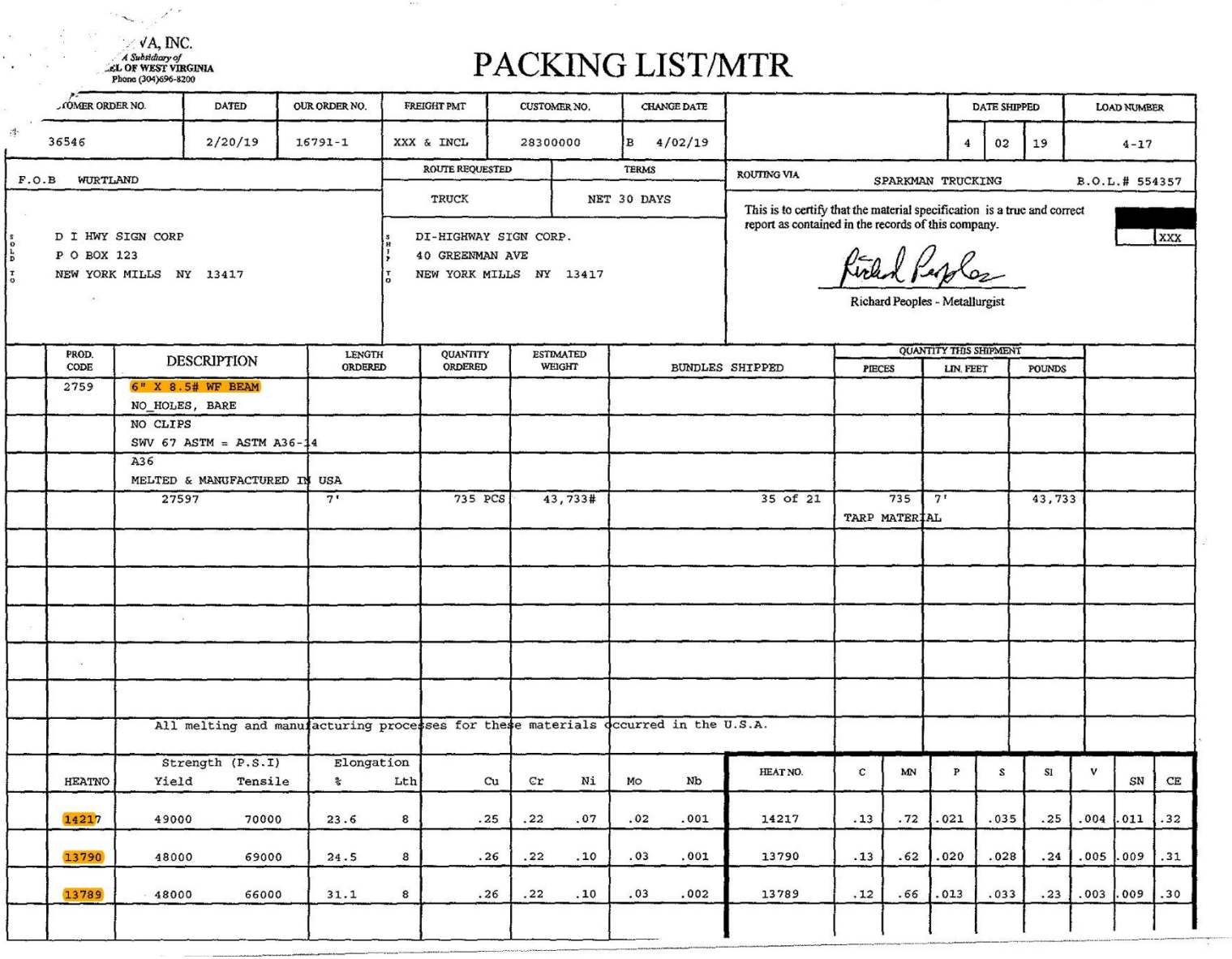
Comments:

NUCOR MULTIGRADE MEETS THE LATEST REVISION OF: ASTM A36/A36M, A529/529M GR50(345), A572/572M GR50(345), A709/709M GR36(250) & GR50(345), CSA G40.21 GR44W(300W) & GR50W, AASHTO M270/M270M GR36(270) & GR50(345), ASME SA36/SA36M. MEETS REPORTING REQUIREMENTS OF EN10204 SEC 3.1 / ISO10474 SEC 3.1 . PRODUCED TO A FULLY KILLED, FINE GRAIN PRACTICE.
ALL MANUFACTURING PROCESS 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.

David Vensel, Division Metallurgist

Page 1 of 1

Figure D-16. 4½-in. Long L-Bracket (Item No. c4)



VA, INC.
A Subsidiary of
CL 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
36546	2/20/19	16791-1	XXX & INCL	28300000	B 4/02/19	4 02 19	4-17

F.O.B WURTLAND

ROUTE REQUESTED: TRUCK

TERMS: NET 30 DAYS

ROUTING VIA: SPARKMAN TRUCKING

B.O.L.# 554357

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

SHIP TO:
DI-HIGHWAY SIGN CORP.
40 GREENMAN AVE
NEW YORK MILLS NY 13417

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

XXX

Richard Peoples - Metallurgist

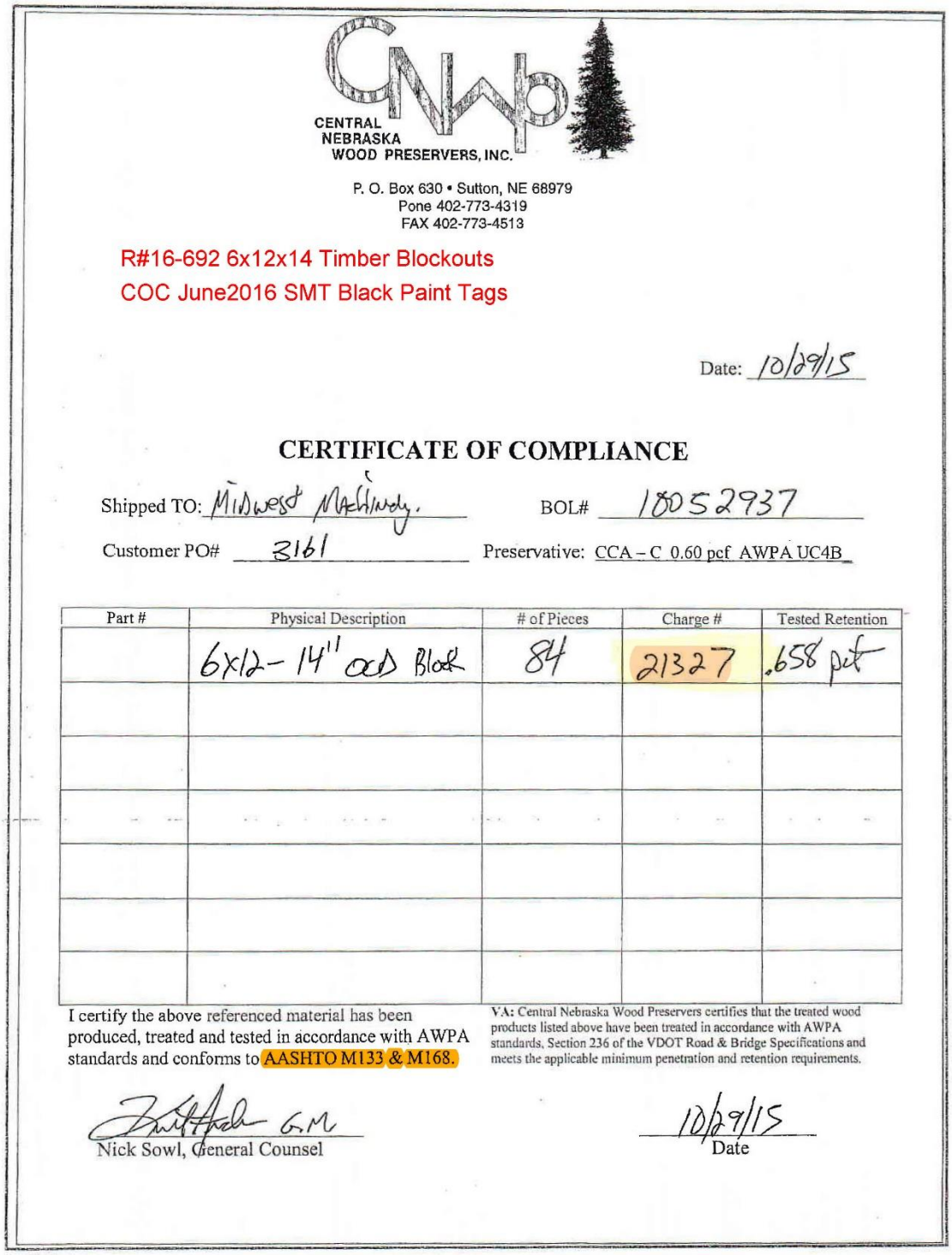
PROD. CODE	DESCRIPTION	LENGTH ORDERED	QUANTITY ORDERED	ESTIMATED WEIGHT	BUNDLES SHIPPED	QUANTITY THIS SHIPMENT PIECES	LIN. FEET	POUNDS
2759	6" X 8.5# WF BEAM							
	NO_HOLES, BARE							
	NO CLIPS							
	SWV 67 ASTM = ASTM A36-14							
	A36							
	MELTED & MANUFACTURED IN USA							
	27597	7'	735 PCS	43,733#	35 of 21	735 TARP MATERIAL	7'	43,733

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
14217	49000	70000	23.6	8	.25	.22	.07	.02	.001
13790	48000	69000	24.5	8	.26	.22	.10	.03	.001
13789	48000	66000	31.1	8	.26	.22	.10	.03	.002

HEAT NO.	C	MN	P	S	SI	V	SN	CE
14217	.13	.72	.021	.035	.25	.004	.011	.32
13790	.13	.62	.020	.028	.24	.005	.009	.31
13789	.12	.66	.013	.033	.23	.003	.009	.30

Figure D-17. W6x8.5 Steel Post (Item No. c5)



CENTRAL
NEBRASKA
WOOD PRESERVERS, INC.

P. O. Box 630 • Sutton, NE 68979
Pone 402-773-4319
FAX 402-773-4513

R#16-692 6x12x14 Timber Blockouts
COC June2016 SMT Black Paint Tags

Date: 10/29/15

CERTIFICATE OF COMPLIANCE

Shipped TO: Midwest Machinery. BOL# 18052937

Customer PO# 3161 Preservative: CCA – C 0.60 pcf AWPA UC4B

Part #	Physical Description	# of Pieces	Charge #	Tested Retention
	6x12 – 14' ocd Block	84	21327	.658 pcf

I certify the above referenced material has been produced, treated and tested in accordance with AWPA standards and conforms to AASHTO M133 & M168.

VA: Central Nebraska Wood Preservers certifies that the treated wood products listed above have been treated in accordance with AWPA standards, Section 236 of the VDOT Road & Bridge Specifications and meets the applicable minimum penetration and retention requirements.

G.M
Nick Sowl, General Counsel

10/29/15
Date

Figure D-18. Timber Blockout (Item No. c6)

CNWP
CENTRAL NEBRASKA WOOD PRESERVERS
1098 East Maple St
Sutton, NE 68979
Phone: 402.773.4319
Email: nick@nebraskawood.com

CERTIFICATE OF COMPLIANCE

Shipped To: Midwest Machinery and Supply
BOL# 10057873
Customer PO# 3475
Preservative: CCA – C 0.60D pcf AWPA UC4B

Part #	Physical Description	# of Pieces	Charge #	Tested Retention
GR61219 BLK	6x12-19" TRANS Hole BLK	56	24245	.616
GR6819 BLK	6x8-19" OCD BLOCK	168	24253	.611
GR61214 BLK	6x12-14" Thrie Hole BLK OCD	84	23422	.660

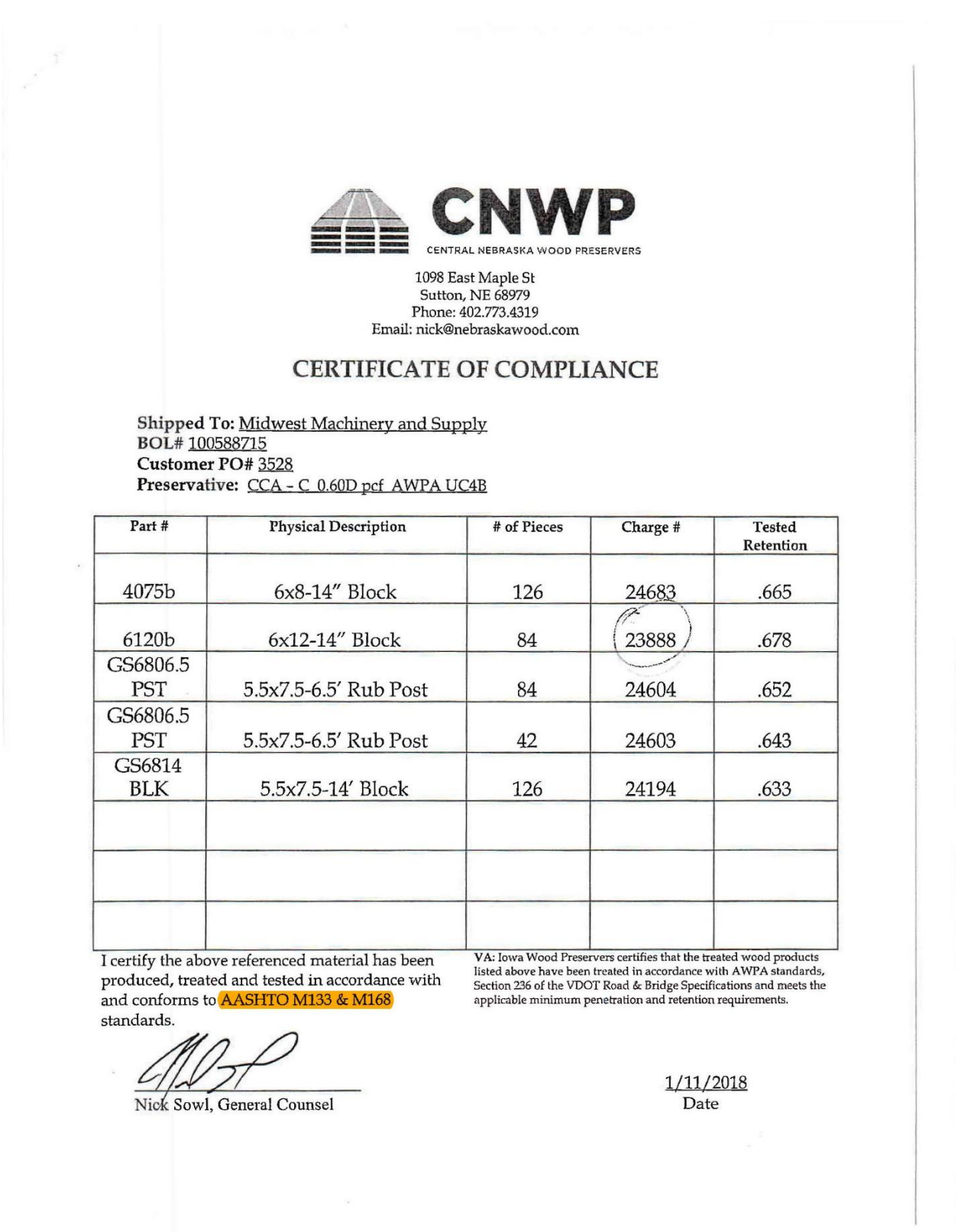
I certify the above referenced material has been produced, treated and tested in accordance with and conforms to AASHTO M133 & M168 standards.

VA: Iowa Wood Preservers certifies that the treated wood products listed above have been treated in accordance with AWPA standards, Section 236 of the VDOT Road & Bridge Specifications and meets the applicable minimum penetration and retention requirements.

Nicholas Sowl, General Counsel

9/1/2017
Date

Figure D-19. Timber Blockout (Item No. c6)



CNWP
CENTRAL NEBRASKA WOOD PRESERVERS

1098 East Maple St
Sutton, NE 68979
Phone: 402.773.4319
Email: nick@nebraskawood.com

CERTIFICATE OF COMPLIANCE

Shipped To: Midwest Machinery and Supply
BOL# 100588715
Customer PO# 3528
Preservative: CCA - C 0.60D pcf AWPA UC4B

Part #	Physical Description	# of Pieces	Charge #	Tested Retention
4075b	6x8-14" Block	126	24683	.665
6120b	6x12-14" Block	84	23888	.678
GS6806.5 PST	5.5x7.5-6.5' Rub Post	84	24604	.652
GS6806.5 PST	5.5x7.5-6.5' Rub Post	42	24603	.643
GS6814 BLK	5.5x7.5-14' Block	126	24194	.633

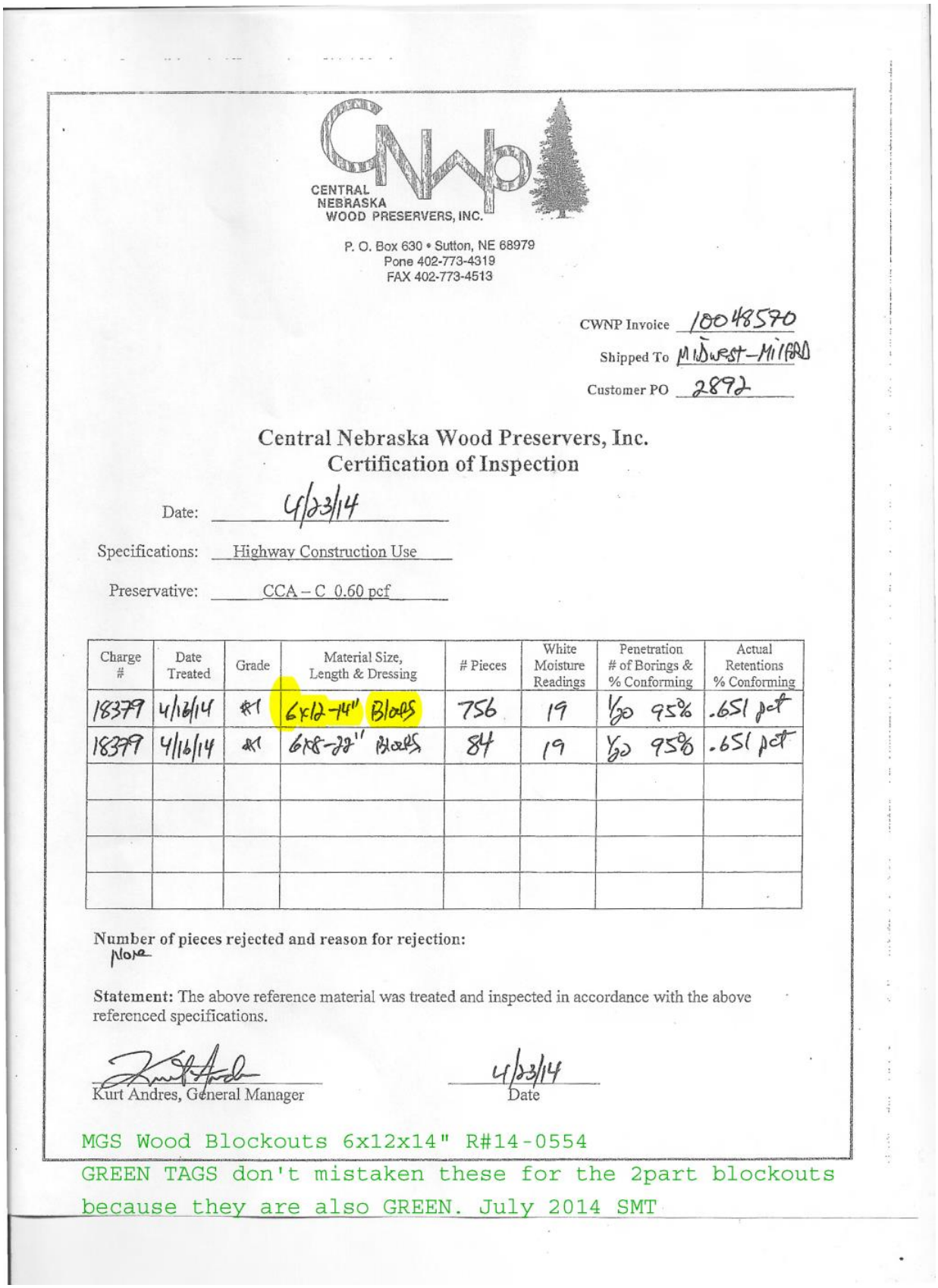
I certify the above referenced material has been produced, treated and tested in accordance with and conforms to AASHTO M133 & M168 standards.

VA: Iowa Wood Preservers certifies that the treated wood products listed above have been treated in accordance with AWPA standards, Section 236 of the VDOT Road & Bridge Specifications and meets the applicable minimum penetration and retention requirements.

Nick Sowl, General Counsel

1/11/2018
Date

Figure D-20. Timber Blockout (Item No. c6)



CENTRAL NEBRASKA WOOD PRESERVERS, INC.

P. O. Box 630 • Sutton, NE 68979
Pone 402-773-4319
FAX 402-773-4513

CWNP Invoice 10048570
Shipped To Midwest-Milford
Customer PO 2892

Central Nebraska Wood Preservers, Inc.
Certification of Inspection

Date: 4/23/14

Specifications: Highway Construction Use

Preservative: CCA – C 0.60 pcf

Charge #	Date Treated	Grade	Material Size, Length & Dressing	# Pieces	White Moisture Readings	Penetration # of Borings & % Conforming	Actual Retentions % Conforming
18379	4/16/14	#1	6x12-14" Blocks	756	19	1/30 95%	.651 pcf
18379	4/16/14	#1	6x8-22" Blocks	84	19	1/30 95%	.651 pcf

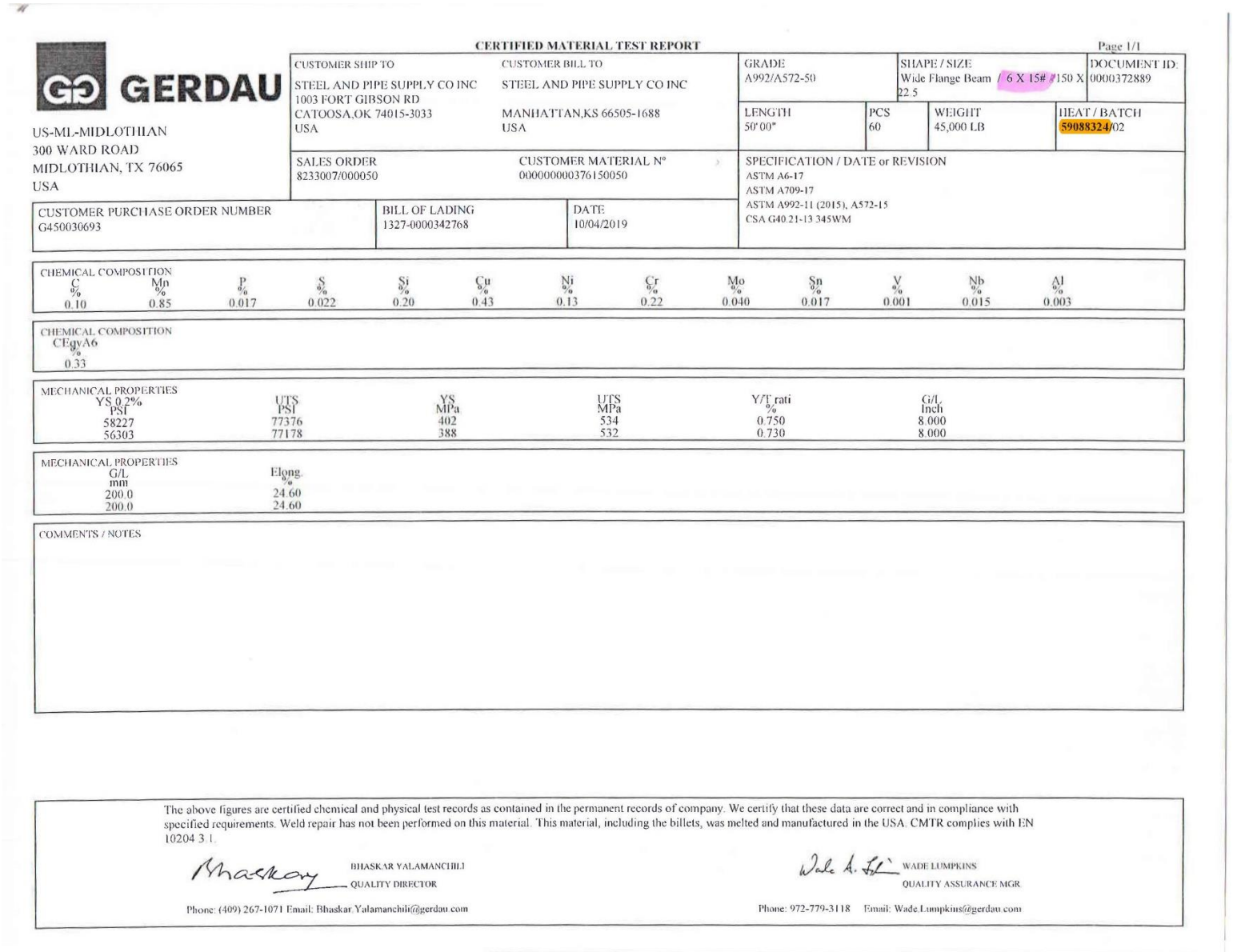
Number of pieces rejected and reason for rejection:
None

Statement: The above reference material was treated and inspected in accordance with the above referenced specifications.

Kurt Andres, General Manager — Date: 4/23/14

MGS Wood Blockouts 6x12x14" R#14-0554
GREEN TAGS don't mistaken these for the 2part blockouts because they are also GREEN. July 2014 SMT

Figure D-21. Timber Blockout (Item No. c6)



CERTIFIED MATERIAL TEST REPORT Page 1/1

GERDAU

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

CUSTOMER SHIP TO	CUSTOMER BILL TO
STEEL AND PIPE SUPPLY CO INC 1003 FORT GIBSON RD CATOOSA,OK 74015-3033 USA	STEEL AND PIPE SUPPLY CO INC MANHATTAN,KS 66505-1688 USA

GRADE	SHAPE / SIZE	DOCUMENT ID
A992/A572-50	Wide Flange Beam / 6 X 15# / 150 X 22.5	0000372889

LENGTH	PCS	WEIGHT	HEAT / BATCH
50' 00"	60	45,000 LB	59088324/02

SALES ORDER	CUSTOMER MATERIAL N°
8233007/000050	000000000376150050

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

CUSTOMER PURCHASE ORDER NUMBER	BILL OF LADING	DATE
G450030693	1327-0000342768	10/04/2019

CHEMICAL COMPOSITION

C %	Mn %	P %	S %	Si %	Cu %	Ni %	Cr %	Mo %	Sn %	V %	Nb %	Al %
0.10	0.85	0.017	0.022	0.20	0.43	0.13	0.22	0.040	0.017	0.001	0.015	0.003

CHEMICAL COMPOSITION

CEgvA6 %
0.33

MECHANICAL PROPERTIES

YS 0.2% PSI	UTS PSI	YS MPa	UTS MPa	Y/T rati %	G/L Inch
58227	77376	402	534	0.750	8.000
56303	77178	388	532	0.730	8.000

MECHANICAL PROPERTIES

G/L mm	Elong. %
200.0	24.60
200.0	24.60

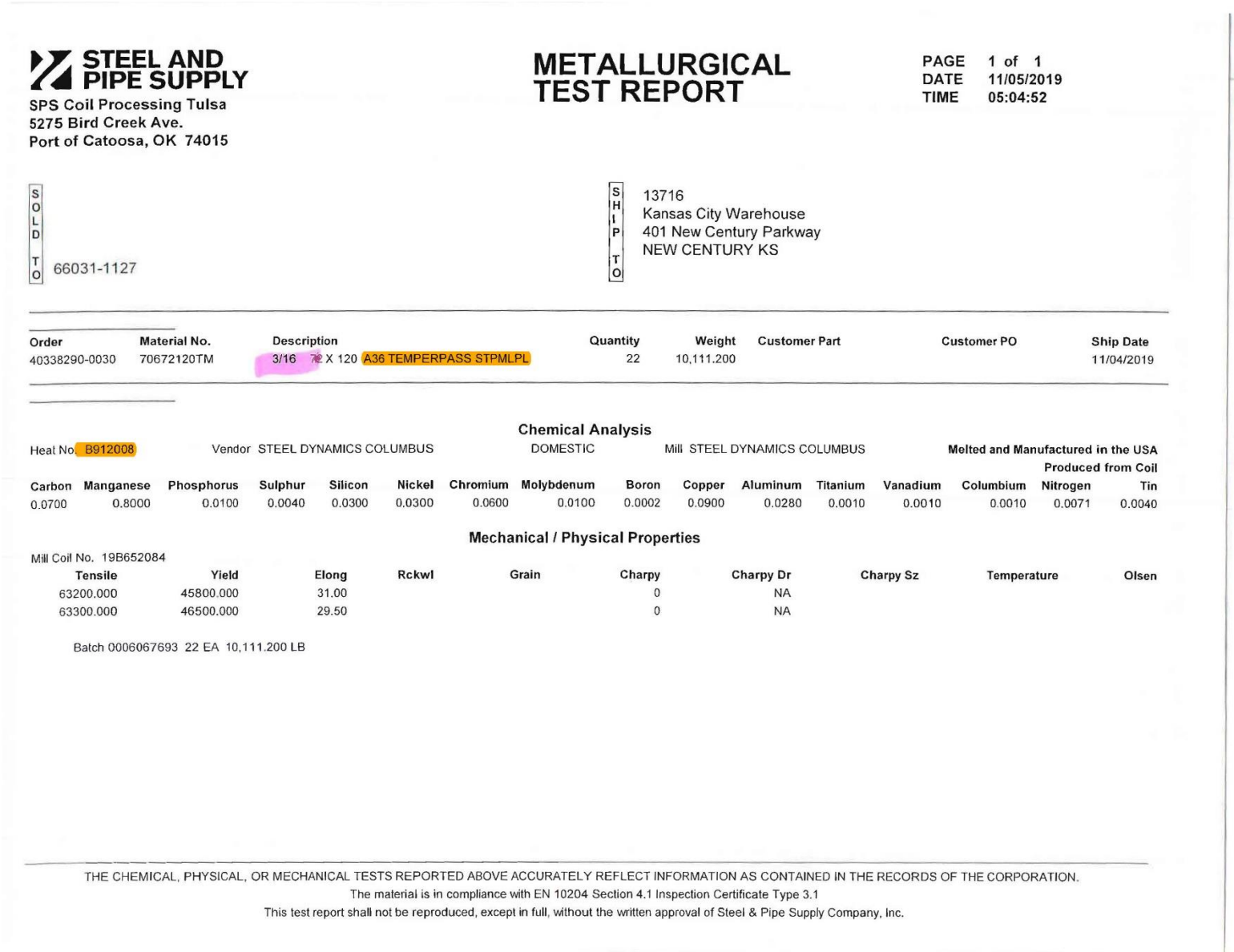
COMMENTS / NOTES

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

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

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

Figure D-22. W6x15 Post (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 11/05/2019
TIME 05:04:52

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
40338290-0030	70672120TM	3/16 7 X 120 A36 TEMPERPASS STPMLPL	22	10,111.200			11/04/2019

Chemical Analysis

Heat No. B912008 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	Produced from Coil Nitrogen	Tin
0.0700	0.8000	0.0100	0.0040	0.0300	0.0300	0.0600	0.0100	0.0002	0.0900	0.0280	0.0010	0.0010	0.0010	0.0071	0.0040

Mechanical / Physical Properties

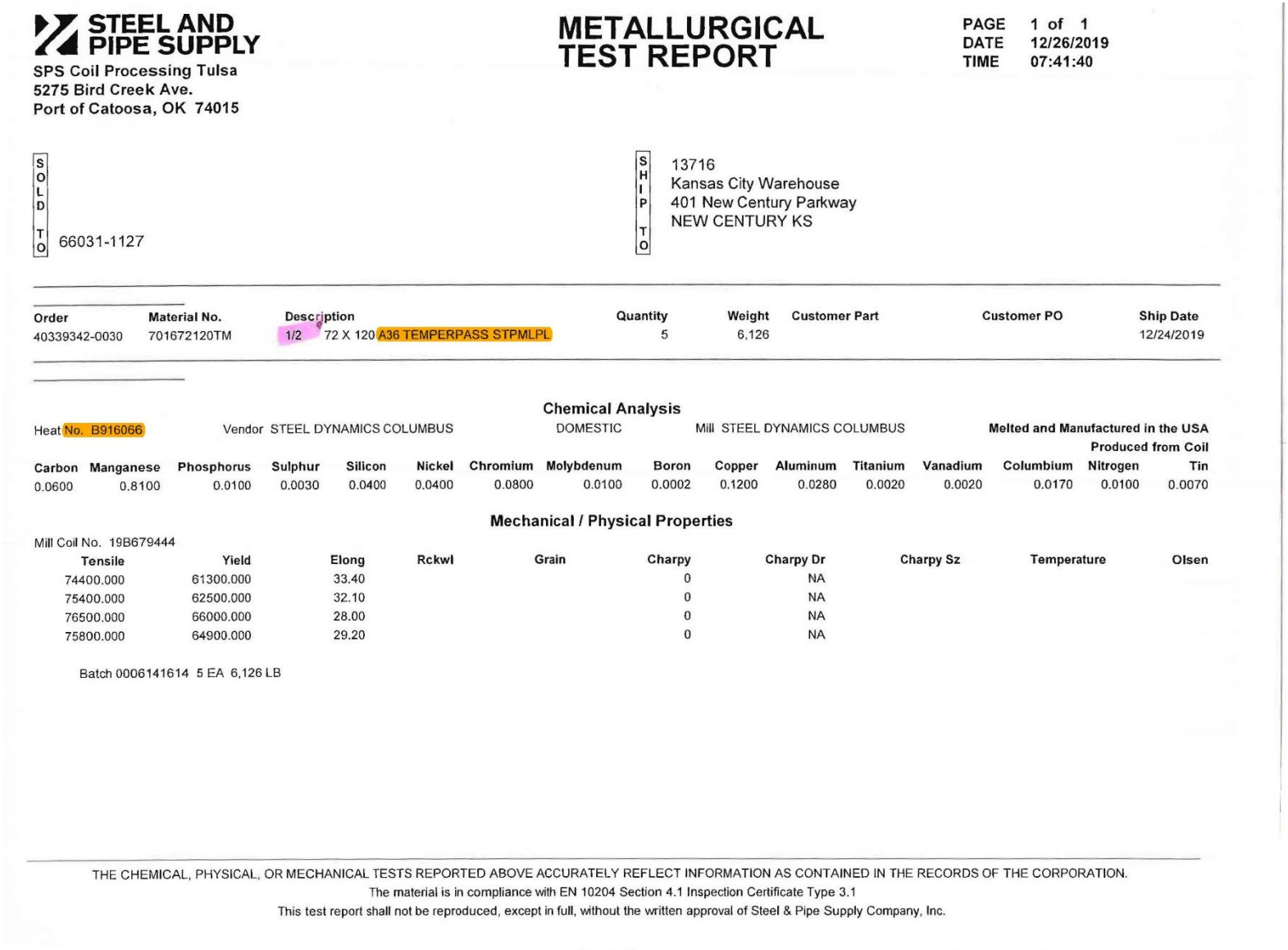
Mill Coil No. 19B652084

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
63200.000	45800.000	31.00			0	NA			
63300.000	46500.000	29.50			0	NA			

Batch 0006067693 22 EA 10,111.200 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
This test report shall not be reproduced, except in full, without the written approval of Steel & Pipe Supply Company, Inc.

Figure D-23. 3⁄16-in. Plate (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 12/26/2019
TIME 07:41:40

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
40339342-0030	701672120TM	1/2 72 X 120 A36 TEMPERPASS STPMLPL	5	6,126			12/24/2019

Chemical Analysis

Heat No. B916066 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	0.8100	0.0100	0.0030	0.0400	0.0400	0.0800	0.0100	0.0002	0.1200	0.0280	0.0020	0.0020	0.0170	0.0100	0.0070

Mechanical / Physical Properties

Mill Coil No. 19B679444

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
74400.000	61300.000	33.40			0	NA			
75400.000	62500.000	32.10			0	NA			
76500.000	66000.000	28.00			0	NA			
75800.000	64900.000	29.20			0	NA			

Batch 0006141614 5 EA 6,126 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
This test report shall not be reproduced, except in full, without the written approval of Steel & Pipe Supply Company, Inc.

Figure D-24. ½-in. Plate (Item Nos. d3, d4, d5, 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 11/04/2019
TIME 14:15:22

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
40337230-0020	70872240TM	1/4" 72 X 240 A36 TEMPERPASS STPMLPL	4	4,900.800			11/02/2019

Chemical Analysis

Heat No. A902127 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	0.8500	0.0090	0.0020	0.0200	0.0400	0.0600	0.0100	0.0001	0.1000	0.0260	0.0010	0.0020	0.0010	0.0078	0.0050

Mechanical / Physical Properties

Mill Coil No. 19B584623

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
64000.000	49700.000	30.30			0	NA			
62500.000	47800.000	33.00			0	NA			
65500.000	50400.000	33.30			0	NA			
64000.000	47600.000	30.00			0	NA			

Batch 0006071178 4 EA 4,900.800 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
This test report shall not be reproduced, except in full, without the written approval of Steel & Pipe Supply Company, Inc.

Figure D-25. ¼-in. Gusset (Item No. e2)

benesch
engineers · scientists · planners

LINCOLN OFFICE
825 "M" Street Suite 100
Lincoln, NE 68508
Phone: (402) 479-2200
Fax: (402) 479-2276

COMPRESSION TEST OF CYLINDRICAL CONCRETE SPECIMENS - 6x12

ASTM Designation: C 39

Client Name: Midwest Roadside Safety Facility
Project Name: Miscellaneous Concrete Testing
Placement Location: NYHBT

Date 07-Jan-20

Mix Designation:

Required Strength:

Laboratory Test Data

Laboratory Identification	Field Identification	Date Cast	Date Received	Date Tested	Days Cured in Field	Days Cured in Laboratory	Age of Test, Days	Length of Specimen, in.	Diameter of Specimen, in.	Cross-Sectional Area, sq.in.	Maximum Load, lbf	Compressive Strength, psi.	Required Strength, psi.	Type of Fracture	ASTM Practice for Capping Specimen
URR-133	A2	12/20/2019	1/3/2020	1/7/2020	14	4	18	12	6.02	28.46	125,714	4,420		5	C 1231
URR-134	B2	12/20/2019	1/3/2020	1/7/2020	14	4	18	12	6.01	28.37	139,495	4,920		5	C 1231

1 cc: Ms. Karla Lechtenberg
Midwest Roadside Safety Facility

Remarks:

All concrete test data in this report was produced by Benesch personnel using ASTM Standard Methods and Practices unless otherwise noted.

Test results presented relate only to the concrete sampled by Benesch personnel as referenced above.

This report shall not be reproduced except in full, without the written approval of Alfred Benesch & Company.

Report Number 2147371951
Page 1

Sketches of Types of Fractures



Type 1: Reasonably well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2: Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3: Columnar vertical cracking through both ends, no well-formed cones

Type 4: Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type 1

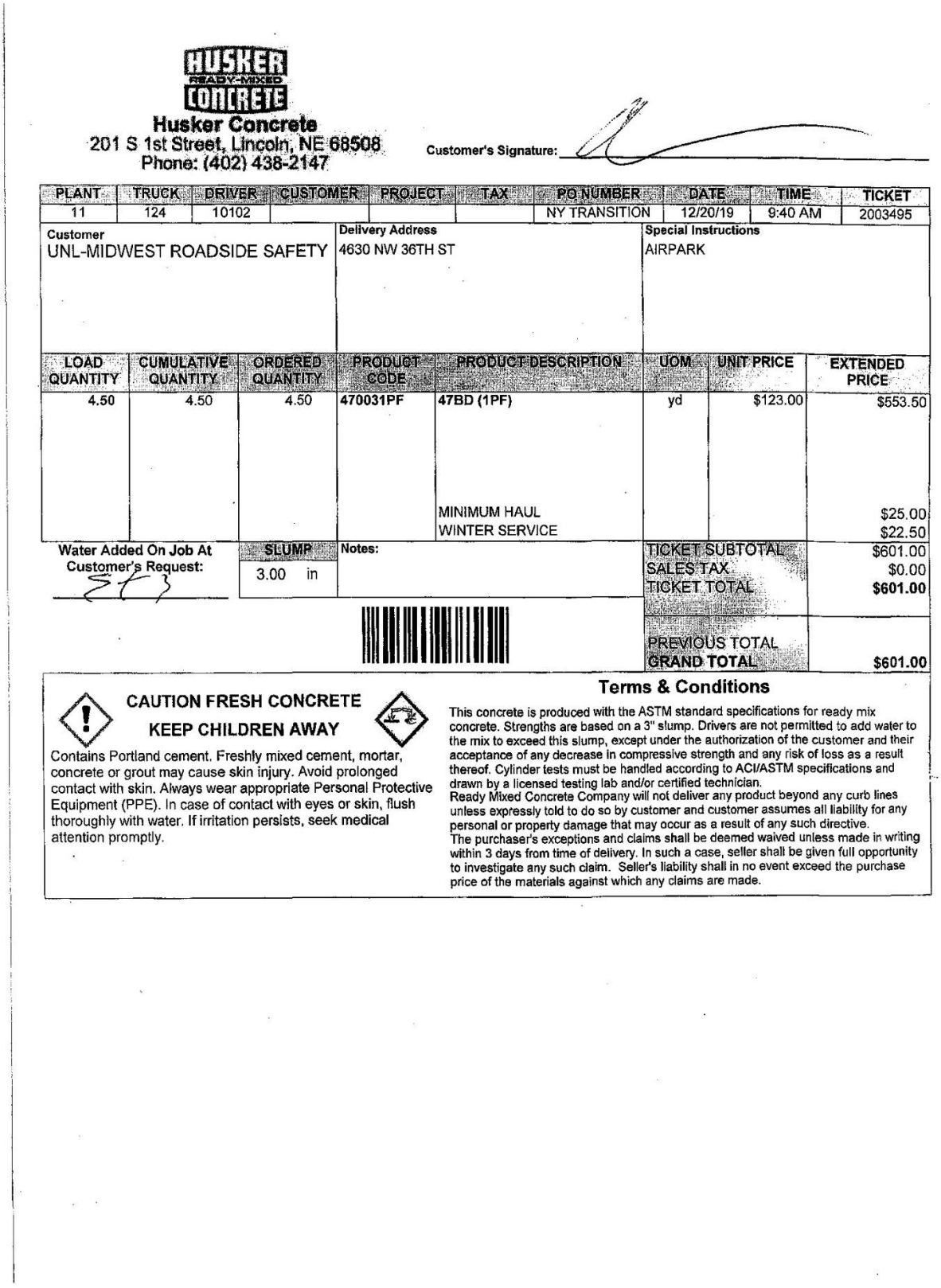
Type 5: Side fractures at top or bottom (occur commonly with unbonded caps)

Type 6: Similar to Type 5 but end of cylinder is pointed

ALFRED BENESCH & COMPANY
CONSTRUCTION MATERIALS LABORATORY

By Matthew Roessler
Matthew Roessler, Laboratory Manager

Figure D-26. Concrete Strength Test (Item No. f1)



HUSKER READY-MIXED CONCRETE

Husker Concrete
201 S 1st Street, Lincoln, NE 68508
Phone: (402) 438-2147

Customer's Signature:

PLANT	TRUCK	DRIVER	CUSTOMER	PROJECT	TAX	PO NUMBER	DATE	TIME	TICKET
11	124	10102				NY TRANSITION	12/20/19	9:40 AM	2003495

Customer	Delivery Address	Special Instructions
UNL-MIDWEST ROADSIDE SAFETY	4630 NW 36TH ST	AIRPARK

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDERED QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	EXTENDED PRICE
4.50	4.50	4.50	470031PF	47BD (1PF)	yd	$123.00	$553.50
				MINIMUM HAUL			$25.00
				WINTER SERVICE			$22.50

Water Added On Job At Customer's Request:

SLUMP	Notes:
3.00 in	

TICKET SUBTOTAL	$601.00
SALES TAX	$0.00
TICKET TOTAL	**$601.00**
PREVIOUS TOTAL	
GRAND TOTAL	**$601.00**

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.

Figure D-27. Concrete (Item No. f1)

NUCOR

Mill Certification
03/20/2019

MTR#:145490-2
Lot #:360000299620
ONE NUCOR WAY
BOURBONNAIS, IL 60914 US
815-937-3131
Fax: 815-939-5599

Sold To: ABC COATING CO INC
PO BOX 9693
TULSA, OK 74157 US

Ship To: ABC COATING CO - MN
2500 W CR B
DOOR 16A
ROSEVILLE, MN 55113 US

Customer PO	022619-MINN	Sales Order #	36002710 - 3.1
Product Group	Rebar	Product #	1053861
Grade	A615 Gr 60/AASHTO M31	Lot #	360000299620
Size	#3	Heat #	3600002996
BOL #	BOL-246097	Load #	145490
Description	Rebar #3/10mm A615 Gr 60/AASHTO M31 40' 0" [480"] 2001-6000 lbs	Customer Part #	
Production Date	03/09/2019	Qty Shipped LBS	39674
Product Country Of Origin	United States	Qty Shipped EA	2638
Original Item Description		Original Item Number	

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.

Melt Country of Origin : United States — Melting Date: 03/05/2019

C (%)	Mn (%)	P (%)	S (%)	Si (%)	Ni (%)	Cr (%)	Mo (%)	Cu (%)	V (%)	Nb (%)
0.37	0.90	0.015	0.056	0.190	0.23	0.15	0.05	0.36	0.003	0.001

Other Test Results

Yield (PSI) : 66600 — Tensile (PSI) : 101100 — Average Deformation Height (IN) : 0.026
Elongation in 8" (%) : 14.5 — Bend Test : Pass — Weight Percent Variance (%) : -0.80

Comments:

All manufacturing processes of the steel materials in this product, including melting, have occurred within the United States. Products produced are weld free. Mercury, in any form, has not been used in the production or testing of this material.

Zachary Sprintz, Process Metallurgist

Page 1 of 1

Figure D-28. #3 Rebar (Item Nos. f2 through f8)

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: MIDWEST ROADSIDE SAFETY FACIL
PB Invoice#: 126388
Cust PO#: SHAUN
Date: 11/18/2019
Shipped: 11/20/2019

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: 3/4 X 17-1/4 X 4-1/2 X 3-1/2 X 2 GALV ASTM F1554G36 J-BOLT

Heat#: 3088555 | **Base Steel:** A36 | **Diam:** 3/4

Source: COMMERCIAL METALS CO | **Proof Load:** 0

C :	.120	**Mn:** .870	**P :** .014	**Hardness:**	163 HBN		
S :	.042	**Si:** .180	**Ni:** .070	**Tensile:**	73,900 PSI	**RA:**	66.00%
Cr:	.110	**Mo:** .021	**Cu:** .300	**Yield:**	56,800 PSI	**Elon:**	22.00%
Pb:	.000	**V :** .009	**Cb:** .000	**Sample Length:**	8 INCH		
N :	.000		**CE:** .2856	**Charpy:**		**CVN Temp:**	

Coatings:
ITEMS HOT DIP GALVANIZED PER ASTM F2329/A153C

By: _____
Certification Department Quality Assurance
Dane McKinnon

Figure D-29. Hooked Anchor J-Bolt (Item No. f9)

STEEL AND PIPE SUPPLY

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

METALLURGICAL TEST REPORT

PAGE 1 of 1
DATE 02/18/2020
TIME 06:23:08

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
40341615-0070	701672144TM	1/2 72 X 144 A36 TEMPERPASS STPMLPL	5	7,351.200			02/14/2020

Chemical Analysis

Heat No. B916072 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	0.8100	0.0060	0.0030	0.0200	0.0400	0.0500	0.0100	0.0002	0.1100	0.0250	0.0010	0.0020	0.0160	0.0065	0.0050

Mechanical / Physical Properties

Mill Coil No. 19B679454

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
70200.000	56500.000	34.20			0	NA			
71500.000	57800.000	33.70			0	NA			

Batch 0006210663 5 EA 7,351.200 LB Batch 0006210657 7 EA 10,291.680 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
This test report shall not be reproduced, except in full, without the written approval of Steel & Pipe Supply Company, Inc.

Figure D-30. ½-in. Plate (Item Nos. g1 and g3)

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 11/20/2019
TIME 11:50:21

SOLD TO

SHIP TO
13715
Warehouse 0030
310 Smith Road
JONESBURG MO 63351-1025

Order	Material No.	Description	Quantity	Weight	Customer Part	Customer PO	Ship Date
40339526-0020	70872120TM	1/4 72 X 120 A36 TEMPERPASS STPMLPL	12	7,351.200			11/19/2019

Chemical Analysis

Heat No. B915258 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	0.8100	0.0100	0.0050	0.0200	0.0400	0.0500	0.0100	0.0001	0.1200	0.0210	0.0010	0.0010	0.0010	0.0076	0.0050

Mechanical / Physical Properties

Mill Coil No. 19B673959

Tensile	Yield	Elong	Rckwl	Grain	Charpy	Charpy Dr	Charpy Sz	Temperature	Olsen
62400.000	45700.000	33.40			0	NA			
62800.000	45800.000	32.00			0	NA			

Batch 0006095838 12 EA 7,351.200 LB
Batch 0006095825 16 EA 9,801.600 LB
Batch 0006095810 16 EA 9,801.600 LB
Batch 0006095827 16 EA 9,801.600 LB
Batch 0006095811 16 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
This test report shall not be reproduced, except in full, without the written approval of Steel & Pipe Supply Company, Inc.

Figure D-31. ¼-in. Cable Anchor Gusset (Item No. g2)

ıstomer Name	Customer PO#	Shipper No	Heat Number
NL-MwRSF	Paid By Visa	1466963	1718206

MUELLER BRASS CO.

LOCATIONS:

2199 LAPEER AVENUE
PORT HURON, MICHIGAN 48060

302 ASHFIELD STREET
BELDING, MICHIGAN 48809

Control No: 1066648

CERTIFIED TEST REPORT

Sold: 00062063
To: COPPER AND BRASS SALES
ATTN ACCOUNTS PAYABLE
P.O.BOX #5116
SOUTHFIELD, MI 48086-5116

Ship: 00060085
To: COPPER & BRASS SALES
3001 ALOUETTE DR
GRAND PRAIRIE, TX 75052

Cust PO: 5400416478
Cust Part: CURD00527
Type/Size: ROD RND 0.2500
Cust Spec: ASTM B16/16M-10
HALF HARD, ROD

MBCo SO: 493449B Ln 50 Cert Lvl: 2
Part Nbr: 3609641 FC
Qty Shpd: 1,080 UM: Lbs
BOL: 50723496 Shpd: 09/28/18
Alloy: 3600
Temper: H020 1/2 H

MECHANICAL PROPERTIES

	YIELD STRENGTH, MIN., KSI	TENSILE STRENGTH, MIN., KSI	ELONGATION MIN., %	ROCKWELL HARDNESS, RB	
To .500" incl.	25	57	7	Rnd	Hex or Oct
.501 to 1.000" incl.	25	55*	10	60 - 80*	55 - 80
1.001 to 2.000" incl.	20	50	15	55 - 75	45 - 80
2.001 to 3.000" incl.	15	45	20	45 - 70	40 - 65
3.001 to 4.000" incl.	15	45	20	40 - 65	35 - 60
4.001" and over	15	40	20	25 min.	25 min.

* If product is specified for thread-rolling applications the minimum for Tensile Strength shall be 52ksi and the Rockwell Hardness shall be 55-75.

Chemical Analysis (%)

	Cu	Pb	Fe	Zn					
ASTM B16/16M-10	60.0-63.0	2.5-3.0	0.35 Max	REM					
LOT Nbr: 1718206	61.6	2.6	0.06	REM.					

TOTAL OTHER ELEMENT MAX: .50

We hereby certify to the chemical and mechanical properties reported herewith and to the fact that they were determined in conformance with the specification noted above or any exceptions to this specification we have granted. We also hereby certify that the material furnished on this order is free from mercury contamination and that no mercury bearing equipment was used in the manufacture of these items.

Melted and Manufactured in USA

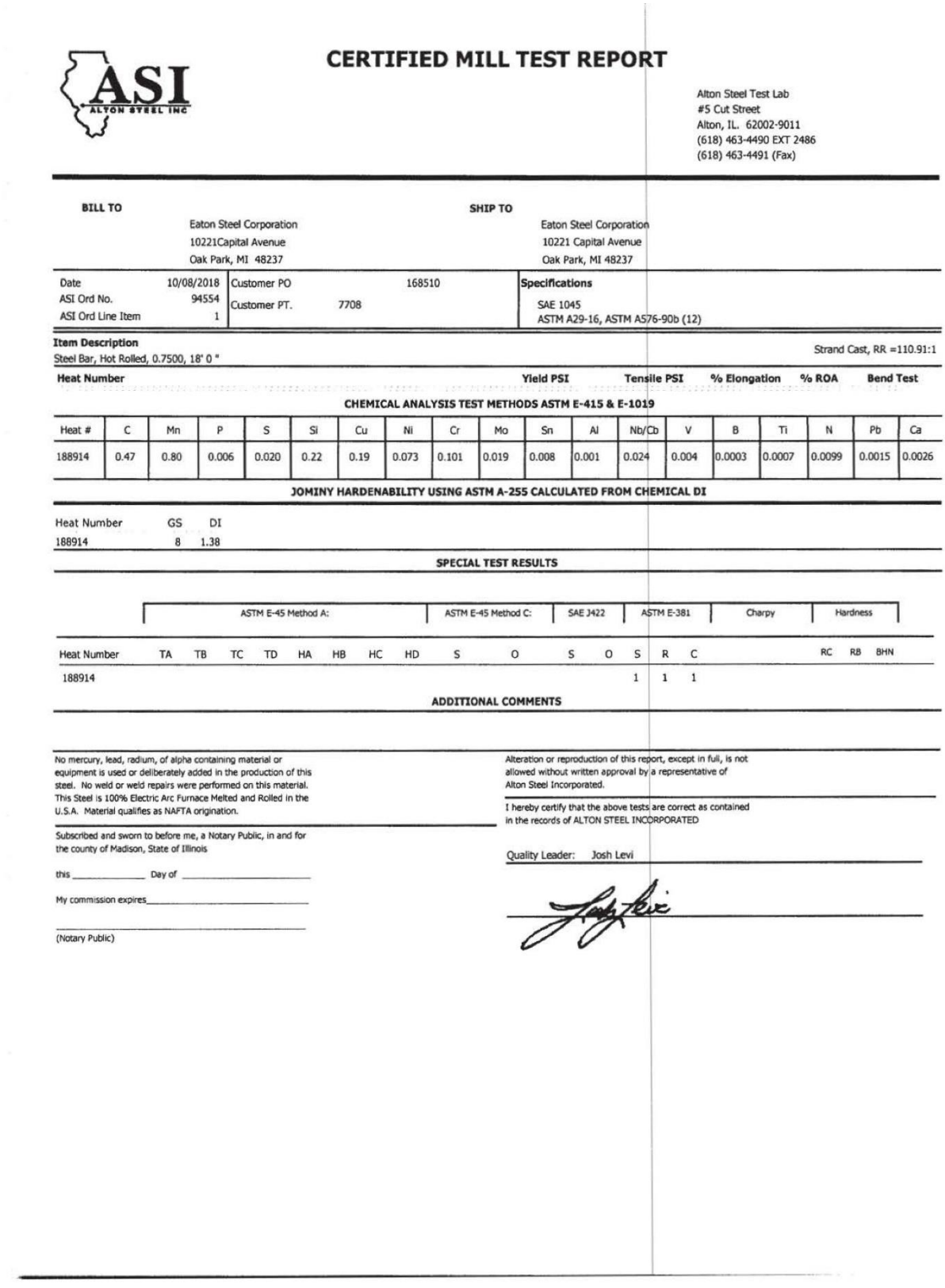
Conflict Minerals Compliant

Produced in Compliance with:
EN10204 3.1
EU Directives:
2011/65/EU (RoHS 2 Compliant)
2000/53/EC

By: 09/28/18
James Tremp
Metallurgist

From: ThyssenKrupp Materials NA
Cust. ONLINE METALS - TX Del.: 2406419138
CstAr 1257 CstOr 108381
Wgt.: 108.600 LB Date 12/07/2018

Figure D-32. ¼-in. Dia., Brass Rod (Item No. g4)



ASI
ALTON STEEL INC

CERTIFIED MILL TEST REPORT

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

BILL TO
Eaton Steel Corporation
10221Capital Avenue
Oak Park, MI 48237

SHIP TO
Eaton Steel Corporation
10221 Capital Avenue
Oak Park, MI 48237

Date	10/08/2018	Customer PO	168510	**Specifications**
ASI Ord No.	94554	Customer PT.	7708	SAE 1045
ASI Ord Line Item	1			ASTM A29-16, ASTM A576-90b (12)

Item Description
Steel Bar, Hot Rolled, 0.7500, 18' 0 "

Strand Cast, RR =110.91:1

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

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

Heat #	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	Nb/Cb	V	B	Ti	N	Pb	Ca
188914	0.47	0.80	0.006	0.020	0.22	0.19	0.073	0.101	0.019	0.008	0.001	0.024	0.004	0.0003	0.0007	0.0099	0.0015	0.0026

JOMINY HARDENABILITY USING ASTM A-255 CALCULATED FROM CHEMICAL DI

Heat Number	GS	DI
188914	8	1.38

SPECIAL TEST RESULTS

	ASTM E-45 Method A:								ASTM E-45 Method C:		SAE J422		ASTM E-381			Charpy	Hardness		
Heat Number	TA	TB	TC	TD	HA	HB	HC	HD	S	O	S	O	S	R	C		RC	RB	BHN
188914													1	1	1				

ADDITIONAL COMMENTS

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

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

this _____ Day of _____

My commission expires_____

_____
(Notary Public)

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

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

Quality Leader: Josh Levi

Figure D-33. ¾-in. Dia. 11-in. Long Threaded Rod (Item Nos. h1 and h2)

Casting Solutions Since 1951

MATERIAL CERTIFICATION

Date 3/11/20 **Form# CERT-7C Rev A 4/21/06**

CUSTOMER: Bennett Bolt

ORDER NUMBER 6017922

PATTERN NUMBER BBWT

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

Type Material: Malleable Iron

Specifications: ASTM-A220

Grade or Class: 50005

Heat Number: II7

MECHANICAL PROPERTIES

Tensile Str. PSI 98,700

Yield Str. PSI 57,500

Elongation 6

PHYSICAL PROPERTIES

Brinell Hardness 228

PCS SHIPPED 726

1 OF 2

CHEMICAL ANALYSIS

Total Carbon	2.61
Silicon	1.76
Manganese	1.39
Sulfur	.093
Phosphorus	.014
Chrome	.059
Magnesium	.001
Copper	.419

DATE SHIPPED 9/23/19

Quality Assurance Representative

BUCK COMPANY, LLC
897 Lancaster Pike
Quarryville, PA 17566
Plant: 717.284.4114
Fax: 717.284.3737
www.buckcompany.com

Aluminum • Brass • Bronze • Ductile Iron • Malleable Iron ISO 9001:2015 Certified

Figure D-34. Cable End Fitting (Item No. h3)

Casting Solutions Since 1951

MATERIAL CERTIFICATION

Date 3/11/20 **Form# CERT-7C Rev A 4/21/06**

CUSTOMER: Bennett Bolt

ORDER NUMBER 6017922

PATTERN NUMBER BBWT

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

Type Material: Malleable Iron

Specifications: ASTM-A220

Grade or Class: 50005

Heat Number: II9

MECHANICAL PROPERTIES

Tensile Str. PSI 101,200

Yield Str. PSI 57,400

Elongation 6

PHYSICAL PROPERTIES

Brinell Hardness 228

PCS SHIPPED 726

2 OF 2

CHEMICAL ANALYSIS

Total Carbon	2.57
Silicon	1.64
Manganese	1.50
Sulfur	.127
Phosphorus	.028
Chrome	.059
Magnesium	.001
Copper	.419

DATE SHIPPED 9/23/19

Loutta Lobs

Quality Assurance Representative

BUCK COMPANY, LLC
897 Lancaster Pike
Quarryville, PA 17566
Plant: 717.284.4114
Fax: 717.284.3737
www.buckcompany.com

Aluminum • Brass • Bronze • Ductile Iron • Malleable Iron ISO 9001:2015 Certified

Figure D-35. Cable End Fitting (Item No. h3)

Casting Solutions Since 1951

MATERIAL CERTIFICATION

Date 5/16/19 Form# CERT-7C Rev A 4/21/06

CUSTOMER: Bennett Bolt

ORDER NUMBER 6018326

PATTERN NUMBER W1WEDGE

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

Type Material: Malleable Iron

Specifications: Astm-A47

Grade or Class: 32510

Heat Number: HZ2

MECHANICAL PROPERTIES

Tensile Str. PSI 53,000

Yield Str. PSI 32,500

Elongation 12

PHYSICAL PROPERTIES

Brinell Hardness 126

PCS SHIPPED 12,154

1 OF 1

CHEMICAL ANALYSIS

Total Carbon	2.60
Silicon	1.38
Manganese	.35
Sulfur	.081
Phosphorus	.010
Chrome	.051
Magnesium	.001
Copper	.397

DATE SHIPPED 5/16/19

Quality Assurance Representative

BUCK COMPANY, LLC
897 Lancaster Pike
Quarryville, PA 17566
Plant: 717.284.4114
Fax: 717.284.3737

www.buckcompany.com

Aluminum • Brass • Bronze • Ductile Iron • Malleable Iron ISO 9001:2015 Certified

Figure D-36. Cable Wedge (Item No. h4)

TTML TENSILE TESTING METALLURGICAL LABORATORY

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

CERTIFIED TEST REPORT

Ken Forging
1049 Griggs Road
Jefferson OH 44047

Attn: Chris Dewey

Job No.: 1709-08-0427
Date: 10-6-17
Cust. PO#: 019022-40

Description: TB108-J-Blank 3/4" x 12" Turnbuckle Body, Blank

Material: 1035 Heat# 75064032 Heat Code: U3

Spec: ASTM A668-16 Class A
235 HBW Max. per Ken Forge DWR-0018
Sulfur 0.05% Max per Ken Forge DWR-0045-TT

TEST RESULTS

	Tensile, ksi	Yield .2%, ksi	Elong., % in 4D	Red. Of Area, %	Hardness, HBW
Requirements (Min.):	47	—	—	—	235 Max.
	106	64.0	19	49	223

Test Method: ASTM A370-17

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

	Actual	Requirements
Carbon	0.34	N/A
Manganese	0.87	1.35 Max.
Phosphorus	0.009	0.050 Max.
Sulfur	0.022	0.050 Max.
Silicon	0.23	N/A
Chromium	0.19	N/A
Nickel	0.11	N/A
Molybdenum	0.04	N/A
Columbium	0.004	N/A
Aluminum	0.004	N/A
Copper	0.15	N/A
Vanadium	0.03	N/A
Titanium	0.002	N/A

The above **conforms** to specifications listed.

Authorized Agent

ACCREDITED

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report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or This Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

Figure D-37. Standard Turnbuckle (Item No. h5), Page 1 of 2

TTML TENSILE TESTING METALLURGICAL LABORATORY

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

CERTIFIED TEST REPORT

Ken Forging
1049 Griggs Road
Jefferson OH 44047

Attn: Chris Dewey

Job No.: 1709-08-0427
Date: 5-8-18
Cust. PO#: 019022-40

Description:	TB108-J-Blank	3/4"-10 x 12" Turnbuckle Body, Blank
Material:	1035 Heat# 75064032	Heat Code: U3
Spec:	ASTM F1145-05(17)	

TEST RESULTS

	Breaking Strength, lbs
Requirements (Min.):	20,000
	21,000

Break Location: No Break

The above **conforms** to specifications listed.

Authorized Agent

This Report May Not Be Reproduced Except In Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test. Unless otherwise noted, all testing reported herein was done at room temperature. All work performed in accordance with TTML QA Manual Rev D 02/15/07.

ACCREDITED

Figure D-38. Standard Turnbuckle (Item No. h5), Page 2 of 2

Bekaert Corporation
1305 South Marietta Pkwy Building 500-Suite 100
Marietta GA 30067
USA
Tel: 1/330/867 3325
Fax: 1/330/867 3424

Page : 2 / 2

Packing List

B/L 4209973815 Ship Date 03/28/2016

Midwest Machinery & Supply Company

Item	Order/Item	Material # Quantity	Net Weight	Tare	Gross weight (LBS)
010	3900168727/010	118647 AST3043SE10S02000 3/4" 3X7 GUIDERAIL 2,000'RLS ASTM A 741			
	25 Units	50,000 FT	42,850	5,346	48,196
	Consisting of :				
	43382894	2,000 FT	1,714	214	1,928
	43383004	2,000 FT	1,714	214	1,928
	43383037	2,000 FT	1,714	214	1,928
	43383285	2,000 FT	1,714	214	1,928
	43383381	2,000 FT	1,714	214	1,928
	43383382	2,000 FT	1,714	214	1,928
	43383547	2,000 FT	1,714	214	1,928
	43383631	2,000 FT	1,714	214	1,928
	43383706	2,000 FT	1,714	214	1,928
	43383832	2,000 FT	1,714	214	1,928
	43383972	2,000 FT	1,714	214	1,928
	43383983	2,000 FT	1,714	214	1,928
	43384097	2,000 FT	1,714	214	1,928
	43384719	2,000 FT	1,714	214	1,928
	43384721	2,000 FT	1,714	214	1,928
	43384723	2,000 FT	1,714	214	1,928
	43384728	2,000 FT	1,714	214	1,928
	43384729	2,000 FT	1,714	214	1,928
	43384730	2,000 FT	1,714	214	1,928
	43384858	2,000 FT	1,714	214	1,928
	43384869	2,000 FT	1,714	214	1,928
	43385035	2,000 FT	1,714	214	1,928
	43385106	2,000 FT	1,714	214	1,928
	43385126	2,000 FT	1,714	214	1,928
	43385846	2,000 FT	1,714	214	1,928

3/4" Guardrail Cable
R#16-503 April 2016 SMT

Figure D-39. ¾-in. Dia. 3x7 IWRC IPS Wire Rope (Item No. h6), Page 1 of 2

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 D-40. ¾-in. Dia. 3x7 IWRC IPS Wire Rope (Item No. h6), Page 2 of 2

Certificate of Quality

Date: 02/28/2018

BEKAERT CORPORATION Van Buren , Arkansas
1881 BEKAERT DRIVE
VAN BUREN, AR 72956
TEL(479)474-5211 FAX(479)474-9075
TELEFAX 537439

Customer	: Colorguard Rail Products	Our Order No	: 4211529087 / 000010
Final Customer	: Midwest Machinery & Supply Company	Product No	: AST3043SE10S02000 3/4 GUIDERAIL 3X7 2000
Customer Order No	: 18-0212-2	QTY	: 42849.975 LBS
Customer Part No.	:	MFG SMP No	: AST3043SE10S02000
Customer Specification	: ASTM A741-98		

Heat#	%C	%Mn	%P	%S	%Si
140734	0.63	0.75	0.026	0.010	0.22
140744	0.66	0.65	0.010	0.008	0.21
5314252604	0.63	0.60	0.009	0.008	0.18
5314341806	0.60	0.79	0.014	0.008	0.20
5314398406	0.66	0.81	0.019	0.007	0.18

Tag#	Heat#	Lay Length " 3.00 7.50	Breaking Strength lbf 25000	Adherence Appearance of wires	Steel Ductility
44629433	140734 140744	6.98	42631	Pass	Pass
44629448	140734 140744	6.98	42631	Pass	Pass
44629850	140734 140744	6.98	42631	Pass	Pass
44629855	140734 140744	6.98	42631	Pass	Pass
44629859	140734 140744	6.98	42631	Pass	Pass
44630041	140734 140744	7.01	41636	Pass	Pass
44755325	5314252604 5314398406	6.25	44213	Pass	Pass
44755329	5314252604 5314398406	6.25	44213	Pass	Pass
44755331	5314252604 5314398406	6.25	44213	Pass	Pass

1 of 2

Figure D-41. ¾-in. Dia. 3x7 IWRC IPS Wire Rope (Item No. h6)

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: September 16, 2019

To: Gregory Industries, Inc.
Highway Finished Goods
4100 13th Street SW
Canton, OH 44710-1464

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 #: 42821
DATE SHIPPED: 09/13/19
ASPI SALES ORDER #: 126520
MANUFACTURER: ASSEMBLY SPECIALTY PRODUCTS, INC.

QTY	CUST P/N	ASPI P/N	ASPI LOT#	DESCRIPTION
250	3012G	C-2028	97742	6' 6" BCT Cable Assembly
250	3012G	C-2028	97743	6' 6" BCT Cable Assembly
250	3012G	C-2028	98073	6' 6" BCT Cable Assembly
250	3012G	C-2028	98095	6' 6" BCT Cable Assembly
250	3012G	C-2028	98097	6' 6" BCT Cable Assembly
250	3012G	C-2028	98098	6' 6" BCT Cable Assembly
250	3012G	C-2028	98099	6' 6" BCT Cable Assembly
250	3012G	C-2028	98100	6' 6" BCT Cable Assembly
250	3012G	C-2028	98101	6' 6" BCT Cable Assembly
250	3012G	C-2028	98102	6' 6" BCT Cable Assembly
250	3012G	C-2028	98103	6' 6" BCT Cable Assembly
250	3012G	C-2028	98105	6' 6" BCT Cable Assembly
250	3012G	C-2028	98318	6' 6" BCT Cable Assembly
250	3012G	C-2028	98320	6' 6" BCT Cable Assembly

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 D-42. BCT Anchor Cable End Swaged Fitting and ¾-in. Dia. 6x19 IWRC IPS Wire Rope (Item Nos. h7 and h8)

CNWP
CENTRAL NEBRASKA WOOD PRESERVERS

1098 East Maple St
Sutton, NE 68979
Phone: 402.773.4319
Email: nick@nebraskawood.com

CERTIFICATE OF COMPLIANCE

Shipped To: Midwest Machinery and Supply
BOL# N18798
Customer PO# 3801
Preservative: CCA – C 0.60D pcf AWPA UC4B

Part #	Physical Description	# Pieces	Charge #	Retention
GR6806 PST	6x8-6' Post	35 35	694 695	.763 .707
GS6846 PST	5.5x7.5-46" BCT	42	652	.608
GR61222 BLK	6x12-22" OCD BLock	56	612	.619

I certify the above referenced material has been produced, treated and tested in accordance with and conforms to AASHTO M133 & M168 standards.

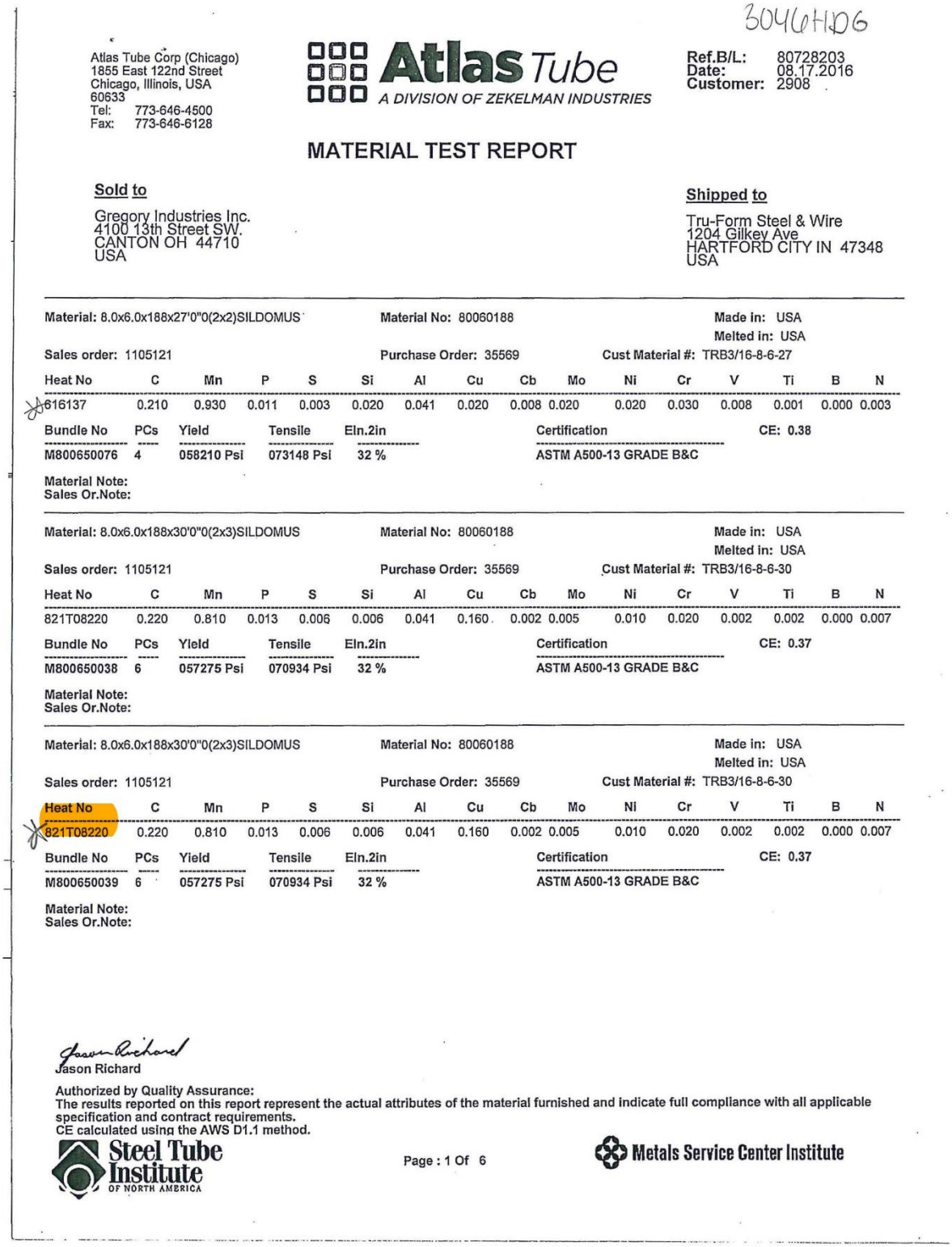
VA: Iowa Wood Preservers certifies that the treated wood products listed above have been treated in accordance with AWPA standards, Section 236 of the VDOT Road & Bridge Specifications and meets the applicable minimum penetration and retention requirements.

Nick Sowl, General Counsel

8/20/19
Date

GENERAL NOTARY - State of Nebraska
LINDA L. SCHROETLIN
My Comm. Exp. May 20, 2020

Figure D-43. BCT Timber Post (Item No. i1)



3046HD6

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

Atlas Tube
A DIVISION OF ZEKELMAN INDUSTRIES

Ref.B/L: 80728203
Date: 08.17.2016
Customer: 2908

MATERIAL TEST REPORT

Sold to

Gregory Industries Inc.
4100 13th Street SW.
CANTON OH 44710
USA

Shipped to

Tru-Form Steel & Wire
1204 Gilkey Ave
HARTFORD CITY IN 47348
USA

Material: 8.0x6.0x188x27'0"0(2x2)SILDOMUS Material No: 80060188 Made in: USA
Melted in: USA
Sales order: 1105121 Purchase Order: 35569 Cust Material #: TRB3/16-8-6-27

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
616137	0.210	0.930	0.011	0.003	0.020	0.041	0.020	0.008	0.020	0.020	0.030	0.008	0.001	0.000	0.003

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.38
M800650076	4	058210 Psi	073148 Psi	32 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 8.0x6.0x188x30'0"0(2x3)SILDOMUS Material No: 80060188 Made in: USA
Melted in: USA
Sales order: 1105121 Purchase Order: 35569 Cust Material #: TRB3/16-8-6-30

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
821T08220	0.220	0.810	0.013	0.006	0.006	0.041	0.160	0.002	0.005	0.010	0.020	0.002	0.002	0.000	0.007

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.37
M800650038	6	057275 Psi	070934 Psi	32 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 8.0x6.0x188x30'0"0(2x3)SILDOMUS Material No: 80060188 Made in: USA
Melted in: USA
Sales order: 1105121 Purchase Order: 35569 Cust Material #: TRB3/16-8-6-30

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
821T08220	0.220	0.810	0.013	0.006	0.006	0.041	0.160	0.002	0.005	0.010	0.020	0.002	0.002	0.000	0.007

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.37
M800650039	6	057275 Psi	070934 Psi	32 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Jason Richard

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

Steel Tube Institute OF NORTH AMERICA

Page : 1 Of 6

Metals Service Center Institute

Figure D-44. Foundation Tube (Item No. i2)

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: 1214903 Prod Ln Grp: 9-End Terminals (Dom)
Customer PO: 2878
BOL Number: 80278 Ship Date:
Document #: 1
Shipped To: NE
Use State: KS

As of: 3/7/14

Qty	Part #	Description	Spec	CL	TY	Heat Code/ Heat	Yield	TS	Elg	C	Mn	P	S	Si	Cu	Cb	Cr	Vn	ACW
36	749G	TS 8X6X3/16X6'-0" SLEEVE	A-500			0173175	55,871	74,495	31.0	0.160	0.610	0.012	0.009	0.010	0.030	0.000	0.030	0.000	4
20	3000G	CBL 3/4X6'6/DBL	HW			98790													
22	9852A	STRUT & YOKE ASSY	A-1011-SS			163375	48,380	64,020	32.9	0.190	0.520	0.011	0.003	0.030	0.110	0.000	0.050	0.000	4
	9852A		A-36			11237730	45,500	70,000	30.0	0.170	0.500	0.010	0.008	0.020	0.080	0.000	0.070	0.001	4

Ground Strut Green Paint
R#15-0157 September 2014 SMT

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

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

ALL COATINGS PROCESSES OF THE STEEL OR IRON ARE PERFORMED IN USA AND COMPLIES WITH THE "BUY AMERICA ACT"
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM-123 (US DOMESTIC SHIPMENTS)
ALL GALVANIZED MATERIAL CONFORMS WITH ASTM A123 & ISO 1461 (INTERNATIONAL SHIPMENTS)

FINISHED GOOD PART NUMBERS ENDING IN SUFFIX B,P, OR S, ARE UNCOATED
BOLTS COMPLY WITH ASTM A-307 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.

NUTS COMPLY WITH ASTM A-563 SPECIFICATIONS AND ARE GALVANIZED IN ACCORDANCE WITH ASTM A-153, UNLESS OTHERWISE STATED.
WASHERS COMPLY WITH ASTM F-436 SPECIFICATION AND/OR F-844 AND ARE GALVANIZED IN ACCORDANCE WITH ASTM F-2329.
3/4" DIA CABLE 6X19 ZINC COATED SWAGED END AISI C-1035 STEEL ANNEALED STUD 1" DIA ASTM 449 AASHTO M30, TYPE II BREAKING STRENGTH – 46000 LB

1 of 2

Figure D-45. Ground Strut Assembly (Item No. i3)

NUCOR
NUCOR STEEL JACKSON, INC.

Mill Certification
7/27/2016

MTR #: M1-150903
NUCOR STEEL JACKSON, INC.
3630 Fourth Street
Flowood, MS 39232
(601) 939-1623
Fax: (601) 936-6202

Sold To: O'NEAL STEEL INC
ATTN ACCOUNTS PAYABLE
PO BOX 98
BIRMINGHAM, AL 35202-0098
(205) 599-8000
Fax: (205) 599-8052

Ship To: O'NEAL STEEL INC
4530 MESSER-AIRPORT HWY
BIRMINGHAM, AL 35222
(205) 599-8000
Fax: (205) 599-8052

Customer P.O.	00771356	Sales Order	343125.5
Product Group	Merchant Bar Quality	Part Number	5350030024010W0
Grade	NUCOR MULTIGRADE	Lot #	JK1610148801
Size	1/2x3" Flat	Heat #	JK16101488
Product	1/2x3" Flat 20' NUCOR MULTIGRADE	B.L. Number	M1-429898
Description	NUCOR MULTIGRADE	Load Number	M1-150903
Customer Spec		Customer Part #	00777557

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: 4/5/2016 Melt Date: 3/30/2016 Qty Shipped LBS: 4,900 Qty Shipped Pcs: 48

Melt Date: 3/30/2016

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Cb	Sn
0.16%	0.78%	0.017%	0.028%	0.20%	0.28%	0.09%	0.14%	0.020%	0.0280%	0.001%	0.010%
CE4020	CEA529										
0.35%	0.39%										

CE4020: C. E., CSA G4020, AASHTO M270
CEA529: A529 CARBON EQUIVALENT

Roll Date: 4/5/2016

Yield 1: 56,172psi Tensile 1: 75,460psi Elongation: 25% in 8"(% in 203.3mm)
Yield 2: 56,126psi Tensile 2: 76,500psi Elongation 25% in 8"(% in 203.3mm)

Specification Comments: NUCOR MULTIGRADE MEETS THE REQUIREMENTS OF: ASTM A36/36M, ASTM A529/529M GR50 ASTM A572/572M GR50 ASTM709/709M GR36/GR50 CSA G40.21 GR44W(300W)/GR50W(350W) AASHTO M270/M270M GR36/GR50 ASME SA36/SA36M MEETS EN10204 SEC 3.1 REPORTING REQUIREMENTS

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.

QA Approved
SI# 777557

Christopher Smith
Division Metallurgist

NBMG-10 January 1, 2012

Page 1 of 1

Figure D-46. Anchor Bracket Assembly (Item No. i4)

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

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

MILFORD,NE,68405

Test Report
Ship Date: 11/17/2017
Customer P.O.: 3515
Shipped to: MIDWEST MACHINERY & SUPPLY CO.
Project:
GHP Order No: 128AA

HT # code	LOT#	C.	Mn.	P.	S.	Si.	Tensile	Yield	Elong.	Quantity	Class	Type	Description
A74070		0.21	0.46	0.012	0.002	0.03	76100	58800	25.2	4	A	2	12GA TB TRANS.
4181496		0.24	0.84	0.014	0.01	0.01	72400	44800	34	4		2	5/8IN X 8IN X 8IN BRG. PL.
4181489		0.09	0.45	0.012	0.004	0.01	58000	43100	27	4		2	350 STRUT & YOKE
196828BM		0.04	0.84	0.014	0.003		76000	74000	25			2	350 STRUT & YOKE
E22985		0.17	0.51	0.013	0.008	0.008	72510	64310	29.5	4		2	2IN X 5 1/2IN PIPE SLEEVE
811T08220		0.22	0.81	0.013	0.006	0.005	71412	56323	35	8		2	3/16IN X 6IN X 8IN X 6FT0IN TUBE SLEEVE

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.

By:

James P. Dehnke
Notary Public, State of Ohio
My Commission Expires 10-19-2019

STATE OF OHIO: COUNTY OF STARK
Sworn to and subscribed before me, a Notary Public, by
Andrew Artar this 21 day of November, 2017

Notary Public, State of Ohio

Figure D-47. ⅝-in. Anchor Bearing Plate (Item No. i5)

Atlas Tube (Alabama), Inc.
171 Cleage Dr
Birmingham, Alabama, USA
35217
Tel:
Fax:

Atlas Tube
A DIVISION OF ZEKELMAN INDUSTRIES

Ref.B/L: 80791452
Date: 11.10.2017
Customer: 179

MATERIAL TEST REPORT

Sold to

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

Shipped to

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

Material: 3.0x2.0x188x40'0"0(5x4). Material No: 0300201884000-B Made in: USA
Melted in: USA
Sales order: 1226976 Purchase Order: 4500296656 Cust Material #: 6630020018840

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
B704212	0.200	0.450	0.010	0.004	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.28
40867002	20	064649 Psi	087652 Psi	24 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 2.375x154x42'0"0(34x1). Material No: R023751544200 Made in: USA
Melted in: USA
Sales order: 1226976 Purchase Order: 4500296656 Cust Material #: 642004042

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
B712810	0.210	0.460	0.012	0.002	0.020	0.024	0.100	0.002	0.020	0.030	0.060	0.004	0.002	0.000	0.008

Bundle No	PCs	Yield	Tensile	Eln.2in	Rb	Certification	CE: 0.32
MC00006947	34	063688 Psi	083220 Psi	25 %	91	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

Material: 2.375x154x42'0"0(34x1). Material No: R023751544200 Made in: USA
Melted in: USA
Sales order: 1226976 Purchase Order: 4500296656 Cust Material #: 642004042

Heat No	C	Mn	P	S	Si	Al	Cu	Cb	Mo	Ni	Cr	V	Ti	B	N
17037261	0.210	0.810	0.005	0.004	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Bundle No	PCs	Yield	Tensile	Eln.2in	Certification	CE: 0.35
41532001	34	066144 Psi	082159 Psi	27 %	ASTM A500-13 GRADE B&C	

Material Note:
Sales Or.Note:

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

Steel Tube Institute

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Metals Service Center Institute

Figure D-48. BCT Post Sleeve (Item No. i6)

CERTIFICATE OF COMPLIANCE

ROCKFORD BOLT & STEEL CO.
126 MILL STREET
ROCKFORD, IL 61101
815-968-0514 FAX# 815-968-3111

CUSTOMER NAME: TRINITY INDUSTRIES

CUSTOMER PO: 187087

SHIPPER #: 061972
DATE SHIPPED: 11/06/2017

LOT#: 30361-P

SPECIFICATION: ASTM A307, GRADE A MILD CARBON STEEL BOLTS

TENSILE:	SPEC:	60,000 psi*min	RESULTS:	66,566 66,832
HARDNESS:		100 max		82.60 82.70

*Pounds Per Square Inch.

COATING: ASTM SPECIFICATION F-2329 HOT DIP GALVANIZE
ROGERS GALVANIZE: 30361-P

CHEMICAL COMPOSITION

MILL	GRADE	HEAT#	C	Mn	P	S	Si
NUCOR	1010	DL17100590	.10	.41	.005	.005	.05

QUANTITY AND DESCRIPTION:

4,825 PCS 5/8" X 14" GUARD RAIL BOLT
P/N 3540G

WE HEREBY CERTIFY THE ABOVE BOLTS HAVE BEEN MANUFACTURED BY ROCKFORD BOLT AND STEEL AT OUR FACILITY IN ROCKFORD, ILLINOIS, USA. THE MATERIAL USED WAS MELTED AND MANUFACTURED IN THE USA. WE FURTHER CERIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIALS SUPPLIER, AND THAT OUR PROCEDURES FOR THE CONTROL OF PRODUCT QUALITY ASSURE THAT ALL ITEMS FURNISHED ON THIS ORDER MEET OR EXCEED ALL APPLICABLE TESTS, PROCESS, AND INSPECTION REQUIREMENT PER ABOVE SPECIFICATION.

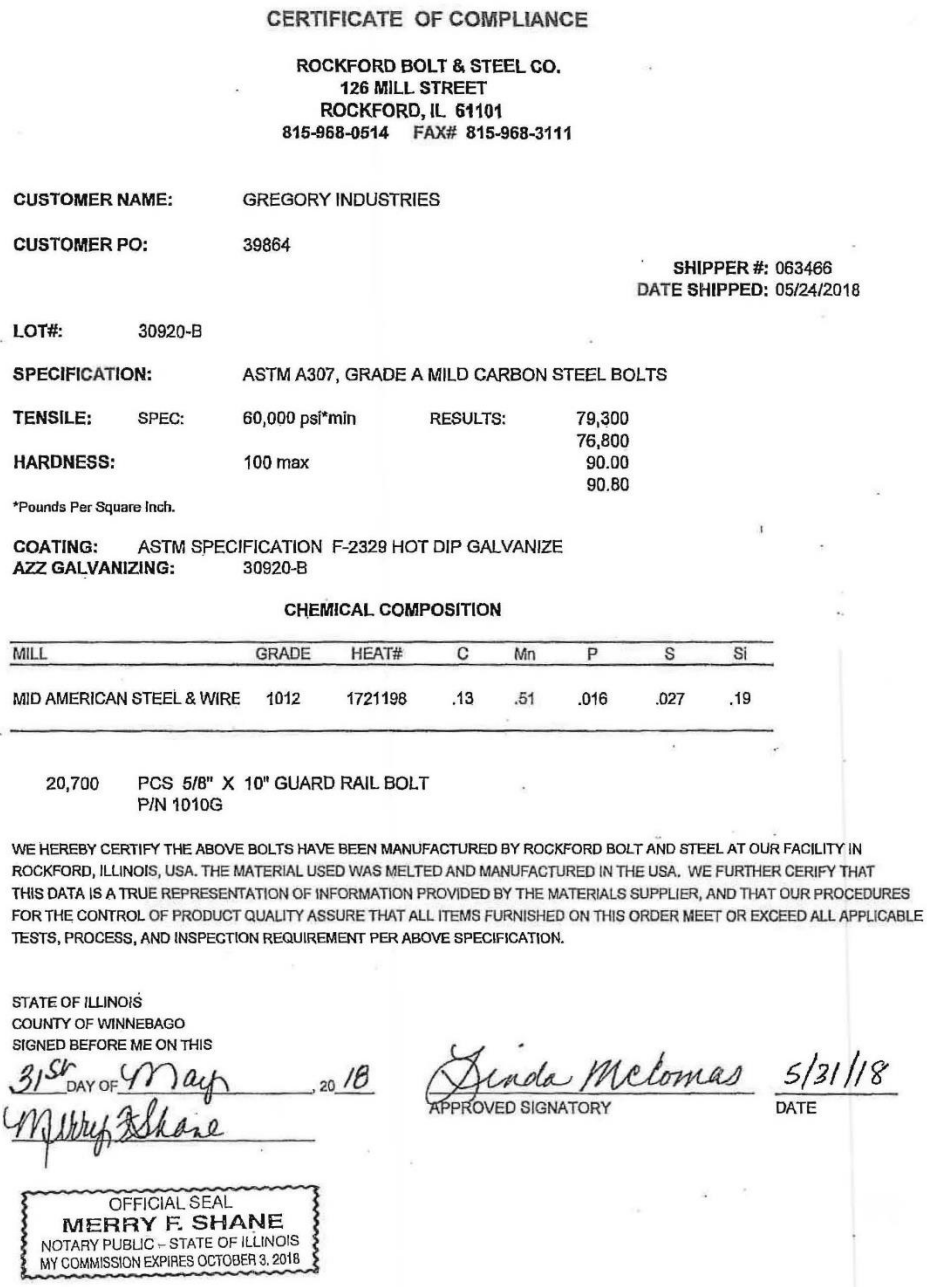
STATE OF ILLINOIS
COUNTY OF WINNEBAGO
SIGNED BEFORE ME ON THIS
6th DAY OF November 2017

Linda McComas — APPROVED SIGNATORY
11/6/17 — DATE

Merry F Shane

OFFICIAL SEAL
MERRY F. SHANE
NOTARY PUBLIC – STATE OF ILLINOIS
MY COMMISSION EXPIRES OCTOBER 3, 2018

Figure D-49. 14-in. Long Guardrail Bolt (Item No. j1)



CERTIFICATE OF COMPLIANCE

ROCKFORD BOLT & STEEL CO.
126 MILL STREET
ROCKFORD, IL 61101
815-968-0514 FAX# 815-968-3111

CUSTOMER NAME: GREGORY INDUSTRIES

CUSTOMER PO: 39864

SHIPPER #: 063466
DATE SHIPPED: 05/24/2018

LOT#: 30920-B

SPECIFICATION: ASTM A307, GRADE A MILD CARBON STEEL BOLTS

TENSILE:	SPEC:	60,000 psi*min	RESULTS:	79,300 76,800
HARDNESS:		100 max		90.00 90.80

*Pounds Per Square Inch.

COATING: ASTM SPECIFICATION F-2329 HOT DIP GALVANIZE
AZZ GALVANIZING: 30920-B

CHEMICAL COMPOSITION

MILL	GRADE	HEAT#	C	Mn	P	S	Si
MID AMERICAN STEEL & WIRE	1012	1721198	.13	.51	.016	.027	.19

20,700 PCS 5/8" X 10" GUARD RAIL BOLT
P/N 1010G

WE HEREBY CERTIFY THE ABOVE BOLTS HAVE BEEN MANUFACTURED BY ROCKFORD BOLT AND STEEL AT OUR FACILITY IN ROCKFORD, ILLINOIS, USA. THE MATERIAL USED WAS MELTED AND MANUFACTURED IN THE USA. WE FURTHER CERIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIALS SUPPLIER, AND THAT OUR PROCEDURES FOR THE CONTROL OF PRODUCT QUALITY ASSURE THAT ALL ITEMS FURNISHED ON THIS ORDER MEET OR EXCEED ALL APPLICABLE TESTS, PROCESS, AND INSPECTION REQUIREMENT PER ABOVE SPECIFICATION.

STATE OF ILLINOIS
COUNTY OF WINNEBAGO
SIGNED BEFORE ME ON THIS
31st DAY OF May, 20 18

Merry F Shane

Linda McComas
APPROVED SIGNATORY

5/31/18
DATE

OFFICIAL SEAL
MERRY F. SHANE
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES OCTOBER 3, 2018

Figure D-50. 10-in. Long Guardrail Bolt (Item No. j2)

CERTIFICATE OF COMPLIANCE

ROCKFORD BOLT & STEEL CO.
126 MILL STREET
ROCKFORD, IL 61101
815-968-0514 FAX# 815-968-3111

CUSTOMER NAME: GREGORY INDUSTRIES

CUSTOMER PO: 40787

SHIPPER #: 063741
DATE SHIPPED: 06/29/2018

LOT#: 30934-B

SPECIFICATION: ASTM A307, GRADE A MILD CARBON STEEL BOLTS

TENSILE:	SPEC:	60,000 psi*min	RESULTS:	66,100 65,400
HARDNESS:		100 max		65.60 65.20

*Pounds Per Square Inch.

COATING: ASTM SPECIFICATION F-2329 HOT DIP GALVANIZE
AZZ GALVANIZING: 30934-B

CHEMICAL COMPOSITION

MILL	GRADE	HEAT#	C	Mn	P	S	Si
CHARTER STEEL	1010	10553090	.08	.38	.005	.011	.090

QUANTITY AND DESCRIPTION:

7,000 PCS 5/8" X 1.25" GUARD RAIL BOLT
P/N 1001G

WE HEREBY CERTIFY THE ABOVE BOLTS HAVE BEEN MANUFACTURED BY ROCKFORD BOLT AND STEEL AT OUR FACILITY IN ROCKFORD, ILLINOIS, USA. THE MATERIAL USED WAS MELTED AND MANUFACTURED IN THE USA. WE FURTHER CERIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMATION PROVIDED BY THE MATERIALS SUPPLIER, AND THAT OUR PROCEDURES FOR THE CONTROL OF PRODUCT QUALITY ASSURE THAT ALL ITEMS FURNISHED ON THIS ORDER MEET OR EXCEED ALL APPLICABLE TESTS, PROCESS, AND INSPECTION REQUIREMENT PER ABOVE SPECIFICATION.

STATE OF ILLINOIS
COUNTY OF WINNEBAGO
SIGNED BEFORE ME ON THIS

3rd DAY OF July, 20 18

Linda Melonas — APPROVED SIGNATORY

7/3/18 — DATE

Merry F Shane

OFFICIAL SEAL
MERRY F. SHANE
NOTARY PUBLIC – STATE OF ILLINOIS
MY COMMISSION EXPIRES OCTOBER 3, 2018

Figure D-51. 1¼-in. Long Guardrail Bolt (Item No. j3)

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: MIDWEST ROADSIDE SAFETY FACIL
PB Invoice#: 119891
Cust PO#: 70ACCT
Date: 4/17/2019
Shipped: 4/25/2019

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 GALV ASTM A307A HEX BOLT

Heat#: 489517 | **Base Steel:** A36 | **Diam:** 7/8

Source: CASCADE STEEL RLG MILL | **Proof Load:** 0

C :	.180	**Mn:** .680	**P :** .013	**Hardness:**	0		
S :	.015	**Si:** .240	**Ni:** .080	**Tensile:**	72,500 PSI	**RA:**	42.00%
Cr:	.130	**Mo:** .028	**Cu:** .240	**Yield:**	48,800 PSI	**Elon:**	24.00%
Pb:	.000	**V :** .000	**Cb:** .000	**Sample Length:**	8 INCH		
N :	.000		**CE:** .3157	**Charpy:**		**CVN Temp:**	

Coatings:
ITEMS HOT DIP GALVANIZED PER ASTM F2329/A153C

By: _____
Certification Department Quality Assurance
Dane McKinnon

Figure D-52. ⅞-in. Dia. Hex Head Bolt (Item No. j4)

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: MIDWEST ROADSIDE SAFETY FACIL
PB Invoice#: 126750
Cust PO#: CHAT
Date: 11/22/2019
Shipped: 11/26/2019

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#: 100794352 **Base Steel:** 4140 **Diam:** 7/8

Source: KREHER STEEL CO LLC **Proof Load:** 39,250 LBF

C :	.420	**Mn:**	.850	**P :**	.007	**Hardness:**	285 HBN
S :	.017	**Si:**	.290	**Ni:**	.060	**Tensile:**	64,180 LBF
Cr:	1.000	**Mo:**	.200	**Cu:**	.150	**Yield:**	0
Pb:	.000	**V :**	.005	**Cb:**	.000	**Sample Length:**	0
N :	.000			**CE:**	.6639	**Charpy:**	

RA: .00%
Elon: .00%
CVN Temp:

LOT#19305

Nuts:
ASTM A563DH HVY HX

Coatings:
ITEMS HOT DIP GALVANIZED PER ASTM F2329/A153C

Other:
ALL ITEMS MELTED & MANUFACTURED IN THE USA

By: _____
Certification Department Quality Assurance
Dane McKinnon

Figure D-53. ⅞-in. Dia., 8½-in. Long Heavy Hex Head Bolt (Item No. j5)

IATF 16949:2016 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 : 2019/11/26

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210165337
COMMODITY : HEX MACHINE BOLT GR-A
SIZE : 3/4-10X8 NC
LOT NO : 1B1882701
SHIP QUANTITY : 1,620 PCS
LOT QUANTITY 2,126 PCS
HEADMARKS : CYI & 307A

PACKING NO : GEM180927008
INVOICE NO : GEM/FNL-181012ED-3
PART NO : 91972
SAMPLING PLAN :
ASME B18.18-2017(Category.2)/ASTM F1470-2018
HEAT NO : 1804023300
MATERIAL : 1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/09/10
COUNTRY OF ORIGIN : CHINA

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A307-14E1

Chemistry	C%	MN%	P%	S%
Spec. : MIN.				
MAX.	0.3300	1.2500	0.0410	
Test Value	0.0700	0.2600	0.0110	0.0070

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.1-2012

SAMPLED BY : FCHUN

INSPECTIONS ITEM	SAMPLE	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
THREAD LENGTH	13 PCS	2.0000 inch	2.2060-2.2220 inch	13	0
MAJOR DIAMETER	13 PCS	0.7350-0.7480 inch	0.7400-0.7460 inch	13	0
BODY DIAMETER	3 PCS	0.7290-0.7680 inch	0.7500-0.7590 inch	3	0
WIDTH ACROSS CORNERS	3 PCS	1.2400-1.2990 inch	1.2810-1.2910 inch	3	0
HEIGHT	3 PCS	0.4550-0.5240 inch	0.4960-0.5100 inch	3	0
NOMINAL LENGTH	13 PCS	7.8200-8.1400 inch	8.0750-8.0950 inch	13	0
WIDTH ACROSS FLATS	3 PCS	1.0880-1.1250 inch	1.1050-1.1170 inch	3	0
SURFACE DISCONTINUITIES	18 PCS	ASTM F788-2013	PASSED	18	0
THREAD	13 PCS	ASME B1.1-2003 nut	PASSED	13	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A307-14E1

SAMPLED BY : GDAN LIAN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	13 PCS	ASTM F606-2016		Max. 100 HRB	81-83 HRB	13	0
TENSILE STRENGTH	3 PCS	ASTM F606-2016		Min. 60 KSI	76-78 KSI	3	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	70.73-76.79	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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

page 1 of 1

Figure D-54. ¾-in. Dia., 8-in. Long Hex Head Bolt (Item No. j6)

61 Barnes Industrial Park North
Wallingford, Connecticut 06492
(203) 284-7023

CERTIFIED MATERIAL TEST REPORT : EN 10204 3.1

Certified Number	:	493262	**Date Issued**	:	February 7, 2019
Customer	:	Fastenal, 4730 Service Drive Winona, MN 57987	**Manufacturing date** **SHOP Part Number** **Purchase Order** **Holo Code**	: : : :	November 28, 2018 19690 N/A N/A
Manufacturer	:	Holo-Krome 61 Barnes Industrial Park North Wallingford, CT 06492	**Grade** **Material** **Finish** **Order Quantity**	: : : :	ASTM F3125-15a GR. A325 Type 1 4137 HOT DIPPED GALVANIZED 13,500 PCS
Customer Part Number	:	19690	**Production Lot Size**	:	13,500 PCS
Description	:	3/4"-10 x 2" ASTM F3125 Grade A325 Hot Dipped Galvanized Steel Structural Bolt Only			
Thread Designation	:	UNRC – 2A	**Marking**	:	H-K ; A325

CHEMISTRY – Heat Number: 20539460
Heat Composition (WT% Heat Analysis)

Element:	C	Mn	P	S	Si
Minimum:	0.30	0.60	-	-	0.15
Maximum:	0.52	-	0.035	0.040	0.30
Result:	0.39	0.79	0.011	0.002	0.210

MACROETCH (if required): ASTM E381 – S1, R1, C1

SURFACE QUALITY: In accordance with ASTM F788/F788M-13	PASS
COATING: HOT DIPPED GALVANIZED	PASS

Heat Treat Method:	N/A				
Mechanical Properties: In accordance with ASTM F3125-15a Gr. A325 Type 1					
Sampling Plan : Per ASTM F1470-18					
Attribute	**Test Method**	**Sample Size**	**Requirement**	**Result**	**Acceptance**
Core Hardness	ASTM F606/F606M-16	4	33 – 38 HRC	28-29 HRC	PASS
6° Wedge Tensile	ASTM F606/F606M-16	3	Min : 120,000 PSI	143,854-145,378 PSI	PASS
Proof Load	ASTM F606/F606M-16	3	Min : 85,000 PSI	PASS	PASS
Decarburization /Carburization	ASTM F2328-17	3	NO COLOR	PASS	PASS

Page 1 of 2 January 6, 2016

This document was printed on 2/7/2019 and was current at that time. Please check current revisions to avoid using obsolete copies.

Figure D-55. ¾-in. Dia., 2½-in. Long Fully Threaded Heavy Hex Head Bolt (Item No. j7)

61 Barnes Industrial Park North
Wallingford, Connecticut 06492
(203) 284-7023

CERTIFIED MATERIAL TEST REPORT : EN 10204 3.1

Certified Number	:	491986	**Date Issued**	:	October 23, 2018
Customer	:	Fastenal Branch	**Manufacturing date**	:	August 23, 2018
Manufacturer	:	Holo-Krome	**Holo Code**	:	N/A
		61 Barnes Industrial Park North	**Grade**	:	A325-15a Type 1
		Wallingford, CT 06492	**Marking**	:	H-K ; A325
Customer Part Number	:	19688	**Material**	:	4137
Customer PO	:	350026924	**Finish**	:	HOT DIPPED GALVANIZED
SHOP Part Number	:	19688	**Order Quantity**	:	6,000 Pcs
Thread Designation	:	UNC-2A	**Production Lot Size**	:	6,000 Pcs
Description	:	3/4"-10 x 1-1/2" ASTM F3125 Steel Structural Bolt Only			

CHEMISTRY – Heat Number: 20556060
Heat Composition (WT% Heat Analysis)

Element:	C	Mn	P	S	Si	B
Minimum:	0.30	0.60	-	-	0.15	-
Maximum:	0.52	-	0.035	0.040	0.30	0.0030
Result:	0.40	0.82	0.009	0.003	0.22	0.0001

MACROETCH (if required): ASTM E381-12 S1, R1, C1

SURFACE QUALITY: In accordance with ASTM F788/F788M-13	PASS
COATING: Per ASTM A123 and ASTM A153	PASS

Heat Treat Method:	Quench and Temper at minimum temperature of 800°F				
Mechanical Properties: In accordance with ASTM F3125-15a Grade A325 Type 1					
SAMPLING PLAN : In accordance with **ASTM F1470-12**					
Attribute	**Test Method**	**Sample Size**	**Requirement**	**Result**	**Acceptance**
Core Hardness	ASTM F606/F606M-16	4	25 – 34 HRC	29 – 30 HRC	PASS
Proof Load	ASTM F606/F606M-16	3	Min: 85,000 PSI	PASS	PASS
10° Wedge Tensile	ASTM F606/F606M-16	3	Min: 120,000 PSI	138,556 – 140,863 PSI	PASS
Decarburization /Carburization	ASTM F2328-17	3	No Color	PASS	PASS

January 6, 2016

This document was printed on 10/23/2018 and was current at that time. Please check current revisions to avoid using obsolete copies.

Figure D-56. ¾-in. Dia., 2-in. Long Heavy Hex Bolt (Item No. j8)

Certificate of Compliance

Birmingham Fastener Manufacturing
PO Box 10323
Birmingham, AL 35202
(205) 595-3512

Customer	Midwest Machinery & Supply	Date Shipped	11/28/2018
Customer Order Number	3664	BFM Order Number	1553751

Item Description

Description	5/8"-11 x 10" Hex Bolt	Qty	298
Lot #	81342	Specification	ASTM A307-14 Gr A
Finish	ASTM F2329		

Raw Material Analysis

Heat# JK18104124

Chemical Composition (wt% Heat Analysis) By Material Supplier

C	Mn	P	S	Si	Cu	Ni	Cr	Mo
0.18	1.19	0.012	0.034	0.20	0.29	0.13	0.11	0.04

Mechanical Properties

Sample #	Hardness	Tensile Strength (lbs)	Tensile Strength (psi)
1	93 HRBW	22,049	99,410
2			
3			
4			
5			

This information represents the most recent analysis of the product supplied on the stated customer order. The samples tested conform to the ASTM standard listed above.
All steel melted and manufactured in the U.S.A.

Authorized Signature: _____ Date: 11/29/2018

Brian Hughes
Quality Assurance

Figure D-57. ⅝ -in Dia., 10-in. Long Hex Head Bolt (Item No. j9)

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:2019/4/2
MANUFACTURE DATE:2019/3/14

CUSTOMER: FASTENAL
SAMPE SIZE: ACC. TO ASME B18.18 CATEGORY 2-2011; ASTM F1470-12 TABLE 3
MANU QTY: 2450PCS
SIZE: 5/8-11X1 1/2 HDG
HEADMARKS: 307A PLUS NY

MFG LOT NUMBER:M-2019HT138-5
SHIPPED QTY:2400PCS
PO NUMBER:210179696
PART NO:1191919

STEEL PROPERTIES:
MATERIAL TYPE:Q195C

HEAT NUMBER:5-01570

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	0.33	0.015	0.022

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

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
VISUAL	ASTM F788-2013	PASSED	18	0
THREAD	ASME B1.1-2003, 3A GO, 2A NO GO	PASSED	13	0
WIDTH A/F	0.906-0.938	0.916-0.928	3	0
WIDTH A/C	1.033-1.083	1.048-1.057	3	0
HEAD HEIGHT	0.378-0.444	0.394-0.428	3	0
BODY DIA.	0.605-0.642	0.617-0.634	3	0
THREAD LENGTH	1.420-1.560	1.436-1.543	13	0
LENGTH	1.420-1.560	1.436-1.543	13	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	75-80 HRB	3	0
WEDGE TENSILE:	ASTM F606/F606M-2016	Min 60 KSI	65-69 KSI	3	0

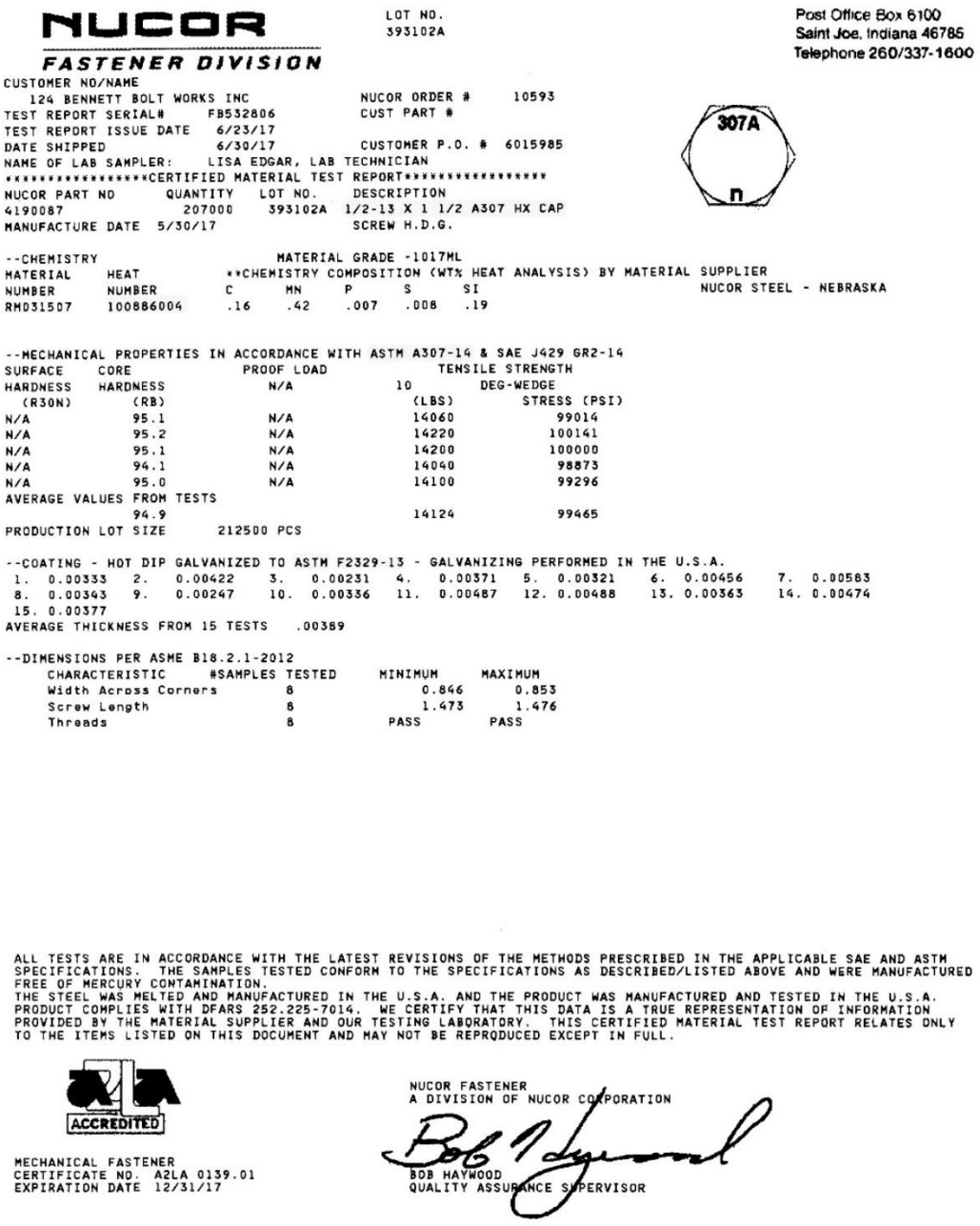
CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
COATINGS OF ZINC:		SPECIFIATION: ASTM F2329/F2329M-2015			
HOT DIP GALVANIZED	ASTM B568-98(2014)	Min 0.0017"	0.0017" -0.0018"	3	0

We hereby certify that above products supplied are in compliance with all the requirements of the order.
We here by certify that this MTR is in compliance to DIN EN 10204 3.1 content.
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 & MORGAT LTD. 检验专用章

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

Figure D-58. ⅝-in. Dia., 1½-in. Long Hex Head Bolt (Item No. j10)



NUCOR
FASTENER DIVISION

LOT NO.
393102A

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

CUSTOMER NO/NAME
124 BENNETT BOLT WORKS INC
TEST REPORT SERIAL# FB532806
TEST REPORT ISSUE DATE 6/23/17
DATE SHIPPED 6/30/17
NAME OF LAB SAMPLER: LISA EDGAR, LAB TECHNICIAN

NUCOR ORDER # 10593
CUST PART #
CUSTOMER P.O. # 6015985

307A
n

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

NUCOR PART NO	QUANTITY	LOT NO.	DESCRIPTION
4190087	207000	393102A	1/2-13 X 1 1/2 A307 HX CAP

MANUFACTURE DATE 5/30/17
SCREW H.D.G.

--CHEMISTRY MATERIAL GRADE -1017ML

MATERIAL NUMBER	HEAT NUMBER	**CHEMISTRY COMPOSITION (WT% HEAT ANALYSIS) BY MATERIAL SUPPLIER C	MN	P	S	SI	NUCOR STEEL - NEBRASKA
RM031507	100886004	.16	.42	.007	.008	.19	

--MECHANICAL PROPERTIES IN ACCORDANCE WITH ASTM A307-14 & SAE J429 GR2-14

SURFACE HARDNESS (R30N)	CORE HARDNESS (RB)	PROOF LOAD N/A	TENSILE STRENGTH 10 DEG-WEDGE (LBS)	STRESS (PSI)
N/A	95.1	N/A	14060	99014
N/A	95.2	N/A	14220	100141
N/A	95.1	N/A	14200	100000
N/A	94.1	N/A	14040	98873
N/A	95.0	N/A	14100	99296
AVERAGE VALUES FROM TESTS				
	94.9		14124	99465

PRODUCTION LOT SIZE 212500 PCS

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

1.	0.00333	2.	0.00422	3.	0.00231	4.	0.00371	5.	0.00321	6.	0.00456	7.	0.00583
8.	0.00343	9.	0.00247	10.	0.00336	11.	0.00487	12.	0.00488	13.	0.00363	14.	0.00474
15.	0.00377												

AVERAGE THICKNESS FROM 15 TESTS .00389

--DIMENSIONS PER ASME B18.2.1-2012

CHARACTERISTIC	#SAMPLES TESTED	MINIMUM	MAXIMUM
Width Across Corners	8	0.846	0.853
Screw Length	8	1.473	1.476
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.
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 D-59. ½-in. Dia., 1½-in. Long Fully Threaded Hex Head Bolt (Item No. j11)

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:
Grade A ASTM A307-12
TEST:

C %*100	Mn%*100	P %*1000	S %*1000
0.29max	1.20 max	0.04max	0.15max
0.07	0. 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.A. LAB MGR.)
(NAME OF MANUFACTURER)

Figure D-60. ⅜-in. Dia., 7½ in. Long Hex Head Bolt (Item No. j12)

McMASTER-CARR

Certificate of Compliance

600 N County Line Rd
Elmhurst IL 60126-2081
630-600-3600
chi.sales@mcmaster.com

University of Nebraska
Midwest Roadside Safety Facility
M W R S F
4630 Nw 36TH St
Lincoln NE 68524-1802
Attention: Shaun M Tighe
Midwest Roadside Safety Facility

Purchase Order
E000548963

Order Placed By
Shaun M Tighe

McMaster-Carr Number
7204107-01

Page 1 of 1

08/02/2018

Line	Product	Ordered	Shipped
1	**97812A109** Raised-Head Removable Nails, 16D Penny Size, 3" Long, Packs of 5	**5 Packs**	**5**

Certificate of compliance

This is to certify that the above items were supplied in accordance with the description and as illustrated in the catalog. Your order is subject only to our terms and conditions, available at www.mcmaster.com or from our Sales Department.

Sarah Weinberg
Compliance Manager

Figure D-61. 16D Double Head Nail (Item No. j13)

Apr. 17. 2019 2:15PM Fastenal-NELIN No. 6648 P. 2

FASTENAL®

Certificate of Compliance

Sold To:

UNL TRANSPORTATION/Midwest Roadside Safe

Purchase Order: 70acct BCTAnchorCableHardware

Job:

Invoice Date: 10/19/2018

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

200 PCS 1" x 2.500" OD Low Carbon Hot Dipped Galvanized Finish Steel USS General Purpose Flat Washer SUPPLIED UNDER OUR TRACE NUMBER 210151571 AND UNDER PART NUMBER 33188

200 PCS 1"-8 Hot Dipped Galvanized A563 Grade DH Heavy Hex Nut Made In USA SUPPLIED UNDER OUR TRACE NUMBER 210157128 AND UNDER PART NUMBER 38210

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

Fastenal Account Representative Signature

Abigail Ferguson

Printed Name

4/17/2019

Date

Please check current revision to avoid using obsolete copies.

This document was printed on 04/17/2019 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 D-62. 1-in. Dia. Heavy Hex Nut (Item No. k1)

IATF 16949:2016 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 : 2019/04/23

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210167591
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 7/8-9 NC O/T 0.56MM
LOT NO : 1N18801113
SHIP QUANTITY : 2,250 PCS
LOT QUANTITY 31,764 PCS
HEADMARKS :

PACKING NO : GEM181128011
INVOICE NO : GEM/FNL-181212ED-1
PART NO : 36717
SAMPLING PLAN :
ASME B18.18-2017(Category.2)/ASTM F1470-2018
HEAT NO : 18108473-3
MATERIAL : X1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/10/12
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	0.0300	0.0600	0.2800	0.0160	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	4 PCS		1.4470-1.5160 inch	1.4650-1.4690 inch	4	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0250 inch	0.0040-0.0060 inch	15	0
THICKNESS	4 PCS		0.7240-0.7760 inch	0.7430-0.7460 inch	4	0
WIDTH ACROSS FLATS	4 PCS		1.2690-1.3120 inch	1.2830-1.2840 inch	4	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0
MINOR DIAMETER	15 PCS		0.7890-0.7970 inch	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	13 PCS	ASTM F606-2014		116-302 HRB	81-82 HRB	13	0
PROOF LOAD	3 PCS	ASTM F606-2014		Min. 90 KSI	OK	3	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	72.03-95.08	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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

page 1 of 1

Figure D-63. ⅞-in. Dia. Hex Nut (Item No. k2)

IATF 16949:2016 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 : 2019/04/23

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210167591
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 7/8-9 NC O/T 0.56MM
LOT NO : 1N18B3C001
SHIP QUANTITY : 2,250 PCS
LOT QUANTITY 3,910 PCS
HEADMARKS :

PACKING NO : GEM181128011
INVOICE NO : GEM/FNL-181212ED-1
PART NO : 36717
SAMPLING PLAN :
ASME B18.18-2017(Category.2)/ASTM F1470-2018
HEAT NO : 18108472-3
MATERIAL : X1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/11/05
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	0.0300	0.0700	0.2700	0.0080	0.0050	0.0300

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : YUQIAN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	4 PCS		1.4470-1.5160 inch	1.4730-1.4770 inch	4	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0250 inch	0.0010-0.0050 inch	15	0
THICKNESS	4 PCS		0.7240-0.7760 inch	0.7280-0.7480 inch	4	0
WIDTH ACROSS FLATS	4 PCS		1.2690-1.3120 inch	1.2840-1.2990 inch	4	0
SURFACE DISCONTINUITIES	22 PCS		ASTM F812-2012	PASSED	22	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0
MINOR DIAMETER	15 PCS		0.7890-0.7970 inch	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A563-2015

SAMPLED BY : GDAN LIAN

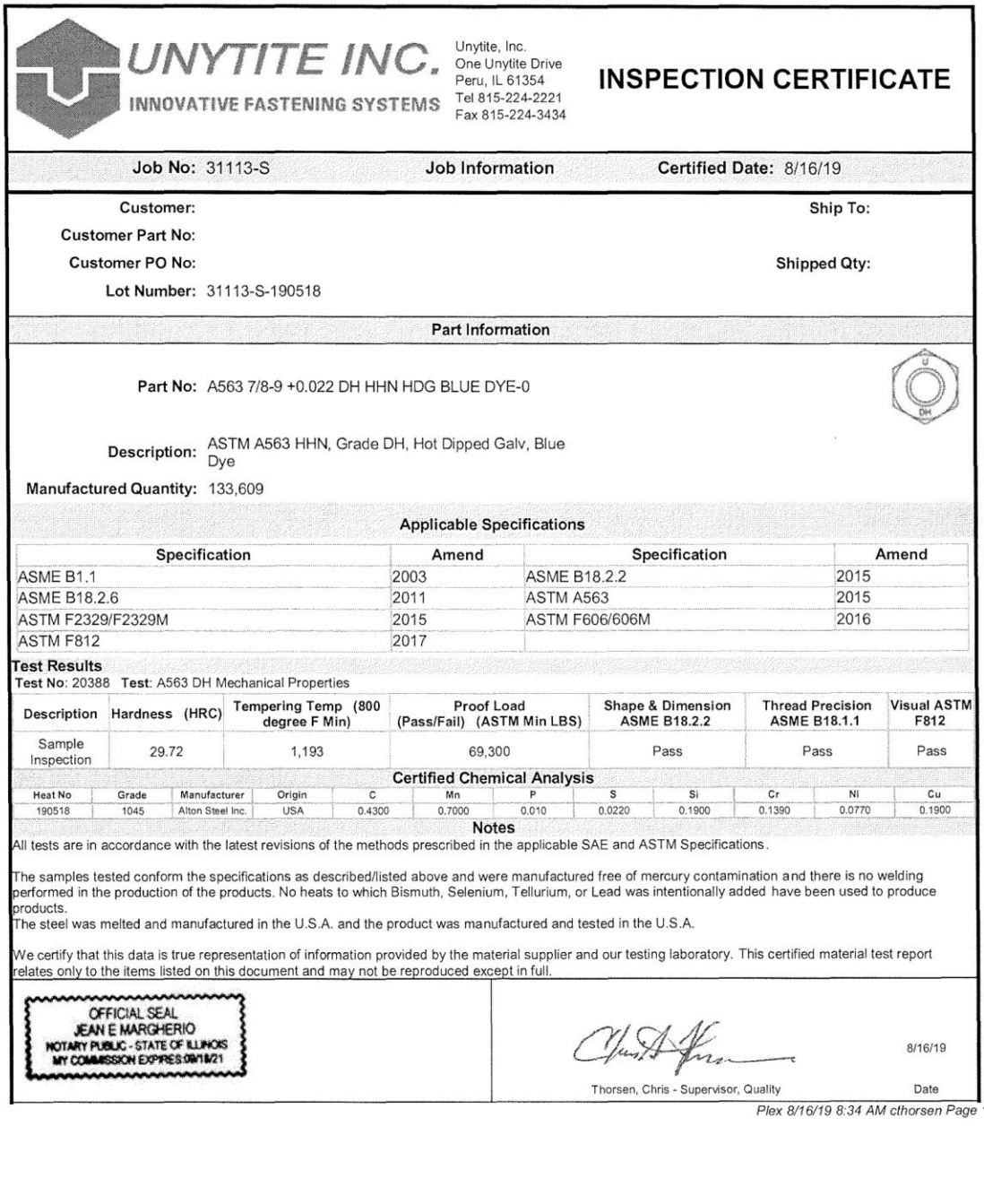
INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	13 PCS	ASTM F606-2014		116-302 HRB	81-82 HRB	13	0
PROOF LOAD	3 PCS	ASTM F606-2014		Min. 90 KSI	OK	3	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	70.22-75.66	5	0

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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

page 1 of 1

Figure D-64. ⅞-in. Dia. Hex Nut (Item No. k2)



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: 31113-S **Job Information** **Certified Date:** 8/16/19

Customer: **Ship To:**
Customer Part No:
Customer PO No: **Shipped Qty:**
Lot Number: 31113-S-190518

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: 133,609

Applicable Specifications

Specification	Amend	Specification	Amend
ASME B1.1	2003	ASME B18.2.2	2015
ASME B18.2.6	2011	ASTM A563	2015
ASTM F2329/F2329M	2015	ASTM F606/606M	2016
ASTM F812	2017		

Test Results
Test No: 20388 **Test**: A563 DH Mechanical Properties

Description	Hardness (HRC)	Tempering Temp (800 degree F Min)	Proof Load (Pass/Fail) (ASTM Min LBS)	Shape & Dimension ASME B18.2.2	Thread Precision ASME B18.1.1	Visual ASTM F812
Sample Inspection	29.72	1,193	69,300	Pass	Pass	Pass

Certified Chemical Analysis

Heat No	Grade	Manufacturer	Origin	C	Mn	P	S	Si	Cr	Ni	Cu
190518	1045	Alton Steel Inc.	USA	0.4300	0.7000	0.010	0.0220	0.1900	0.1390	0.0770	0.1900

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 E MARGHERIO
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES 09/18/21

8/16/19
Thorsen, Chris - Supervisor, Quality Date

Plex 8/16/19 8:34 AM cthorsen Page 1

414435-3

Figure D-65. ⅞-in. Dia. Heavy Hex Nut (Item No. k3)

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

Customer: FASTENAL COMPANY PURCHASING	**Production Lot No.:**	1809DX100-1159-1	**Issue Date:**	2018/12/30
	Add.of Customer:	4730 SERVICE DRIVEWINONA MN 55897	**Inv. No.:**	18944DX100-757
	Description:	ANSI B18.2.2 GR.A HEX NUT HDG WITHOUT HT	**Manu. Date:**	2018/11/2
			Manu. Qty:	6200
	PO No.:	210173106	**Shipped Qty:**	6000
	Manufacturer:	Ningbo Dongxin High-strength Nut	**Marking:**	NO MARKS
	Address:	Xijingtang,Luotuo,Ningbo,China	**LOT No.:**	-DX100-1159-1
	Tel./Fax:	0574-86533751/86531751	**Sample Plan:**	ASME B18.18-2017(Category.2)/ASTM F1470-2018
	Size:	3/4"-10	**Part No.:**	1136715

Chemical Composition

Material type: 35K Φ28 Heat No.: B18000432

Chemical Analysis % (items)	C	Mn	P	S	Si	Cr	Ni	Mo	Others
	Max0.58	/	/	/	/	/	/	/	/
Result	0.35	0.69	0.017	0.005	0.13	0.041	0.016	/	/
Cert #:	0014012			Material supplier:			ZHEJIANG YUANLI		

Dimensions

DIM.SPEC: ASME B18.2.2-2015 INSPECTOR & SAMPER: Ms.Li DATE: 2018/12/30

Item	Specified	Result	Sampling	Rej.	Remark	Specification
Widthacrossflats(inch)	1.088 - 1.125	1.104 - 1.111	4	0	OK	------
Widthacrossangle(inch)	1.24 - 1.299	1.261 - 1.268	4	0	OK	------
Height(inch)	0.617 - 0.644	0.626 - 0.631	4	0	OK	------
Minor diameter(inch)	0.662 - 0.683	0.674 - 0.679	15	0	OK	------
Thread-2B	Thread GO gauge	OK	15	0	OK	ASME B1.1-03
	Thread NO GO gauge	OK	15	0	OK	
Appearance	OK	OK	22	0	OK	ASTM F812-17
FIM	MAX 0.027	0.004 - 0.008	4	0	OK	ASME B18.2.2-2015

Mechanical Properties

MEC,SPEC:ASTM A563-15 INSPECTOR & SAMPLER: Ms.Li DATE: 2018/12/30

ITEM	Test Method	SPECIFIED	Sampling	Result	JUG
CoreHardness HRC	ASTM F606-2016	- 32	15	24 - 26	OK
Proof loading KSI	ASTM F606-2016	68	4	73	OK

Plating

Plating Spec: ASTM F2329-15 Inspector & Sampler : Ms Li Date: 2018/12/30

ITEM	Test Method	SPECIFIED	Sampling	Result	JUG
HDG	ASTM B487	50.8 um Average	22	55 - 86 um	OK

MACROETCH

Division	Surface Condition	Random Condition	Center Segregation	Test method

Figure D-66. ¾-in. Dia. Hex Nut (Item No. k4)

ISO/TS 16949 BUREAU VERITAS Certification

GEM-YEAR TESTING LABORATORY
CERTIFICATE OF INSPECTION

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

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

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

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

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

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2007

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

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2010

SAMPLED BY : FCHUN

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

MECHANICAL PROPERTIES : ACCORDING TO ASTM A563-2007

SAMPLED BY : GYBIN

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

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

Quality Supervisor:

page 1 of 1

Figure D-67. ¾-in. Dia. Hex Nut (Item No. k4)

BENNETT BOLT WORKS, INC.

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

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

CERTIFICATION OF COMPLIANCE

Customer: University of Nebraska-Lincoln
Midwest Roadside Safety Facility
130 Whittier Research Center
Lincoln, NE 68583

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

Customer P.O. No.: NYC1-SQ NUTS

Date Shipped: 05/03/19

Invoice No.: 5045356

Purchase Date: 02/16/16

QUANTITY	DESCRIPTION
50	3/4-10 Heavy Square Nut Import HDG-A153

Kirk Weaver
Manufacturing Manager
Date: 05/03/19

Figure D-68. ¾-in. Dia. Square Nut, ¾-in. Dia. Hex Nut (Item No. k6)

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 : 2017/03/23

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 110216407
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 5/8-11 NC O/T 0.51MM
LOT NO : 1N1680027
SHIP QUANTITY : 23,400 PCS
LOT QUANTITY 170,278 PCS
HEADMARKS :

PACKING NO : GEM160919007
INVOICE NO : GEM/FNL-160929WI
PART NO : 36713
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 331608011
MATERIAL : ML08
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2016/08/26
COUNTRY OF ORIGIN : CHINA

R#17-507 H#331608011
BCT Cable Bracket Nuts

PERCENTAGE COMPOSITION OF CHEMISTRY:ACCORDING TO ASTM A563-2007

Chemistry	AL%	C%	MN%	P%	S%	SI%
Spec. : MIN.						
MAX.		0.5800		0.1300	0.2300	
Test Value	0.0350	0.0700	0.4100	0.0160	0.0060	0.0500

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2010

SAMPLED BY : DWTING

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		1.0510-1.0830 inch	1.0560-1.0690 inch	6	0
FIM	15 PCS	ASME B18.2.2-2010	Max. 0.0210 inch	0.0020-0.0040 inch	15	0
THICKNESS	6 PCS		0.5350-0.5590 inch	0.5390-0.5570 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.9220-0.9380 inch	0.9240-0.9340 inch	6	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A563-2007

SAMPLED BY : GDAN LIAN

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	79-81 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	70.02-75.81	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 D-69. ⅝-in. Dia. Hex Nut, ¾-in. Dia. Hex Nut (Item No. k7)

UNYTITE

CERTIFICATE OF COMPLIANCE

ROCKFORD BOLT & STEEL CO.
126 MILL STREET
ROCKFORD, IL 61101
815-968-0514 FAX# 815-968-3111

CUSTOMER NAME: GREGORY INDUSTRIES

CUSTOMER PO: 39623

SHIPPER #: 062448
DATE SHIPPED: 01/23/2018

RKFD LOT# P37988 R67730
UNYTITE INC.: 27182-6214480205, 27260-6214480205

SPECIFICATION: ASTM 563, GRADE A, REQUIREMENTS FOR CARBON STEEL NUTS

COATING: ASTM SPECIFICATION F-2329 HOT DIP GALVANIZE
ROGERS BROTHERS, INC: 27182-6214480205, 27260-6214480205

CHEMICAL COMPOSITION

MILL	HEAT#	C	Mn	P	S	Si
GERDAU	62144802	.44	.75	.006	.026	.22
GERDAU	62144802	.44	.75	.006	.026	.22

HARDNESS:

SPEC: B68 Min. B:
89.90
86.30

QUANTITY AND DESCRIPTION:

19,110 PCS 5/8" GUARD RAIL NUT .031
P/N 1000G

WE HEREBY CERTIFY THE ABOVE PARTS HAVE BEEN MANUFACTURED IN THE U.S.A. WITH DOMESTIC STEEL. WE FURTHER CERTIFY THAT THIS DATA IS A TRUE REPRESENTATION OF INFORMANTION PROVIDED BY THE MATERIALS SUPPLIER, AND THAT OUR PROCEDURES FOR THE CONTROL OF PRODUCT QUALITY ASSURE THAT ALL ITEMS FURNISHED ON THIS ORDER MEET OR EXCEED ALL APPLICABLE TESTS, PROCESS, AND INSPECTION REQUIREMENTS PER ABOVE SPECIFICATION.

COUNTY OF WINNEBAGO
SIGNED BEFORE ME ON THIS
25th DAY OF January, 20 18
Merry F Shane

Linda Melomas
APPROVED SIGNATORY

1/25/18
DATE

OFFICIAL SEAL
MERRY F. SHANE
NOTARY PUBLIC – STATE OF ILLINOIS
MY COMMISSION EXPIRES OCTOBER 3, 2018

Figure D-70. ⅝-in. Dia. Heavy Hex Nut (Item No. k8)

IATF 16949:2016 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 : 2018/11/15

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 110227020
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 1/2-13 NC O/T 0.46MM
LOT NO : 1N16C0412
SHIP QUANTITY : 401,700 PCS
LOT QUANTITY 307,419 PCS
HEADMARKS :

PACKING NO : GEM170224001
INVOICE NO : GEM/FNL-170316WI-2
PART NO : 36709
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : 331610414
MATERIAL : ML08
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2017/01/24
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	0.0530	0.0700	0.4200	0.0170	0.0040	0.0400

DIMENSIONAL INSPECTIONS :ACCORDING TO ASME B18.2.2-2015

SAMPLED BY : TAO JIA MIN

INSPECTIONS ITEM	SAMPLE	SPECIFIED		ACTUAL RESULT	ACC.	REJ.
WIDTH ACROSS CORNERS	6 PCS		0.8400-0.8660 inch	0.8470-0.8530 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0110 inch	0.0010-0.0020 inch	15	0
THICKNESS	6 PCS		0.4270-0.4480 inch	0.4310-0.4330 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.7360-0.7500 inch	0.7400-0.7420 inch	6	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0
MINOR DIAMETER	15 PCS		0.4430-0.4490 inch	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	82-85 HRB	15	0
PROOF LOAD	6 PCS	ASTM F606-2014		Min. 90 KSI	OK	6	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	71.57-77.95	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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

page 1 of 1

Figure D-71. ½-in. Dia. Hex Nut (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 : 2019/03/15

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210165612
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 1/2-13 NC O/T 0.46MM
LOT NO : 1N1870656
SHIP QUANTITY : 37,500 PCS
LOT QUANTITY 258,182 PCS
HEADMARKS :

PACKING NO : GEM181207006
INVOICE NO : GEM/FNL-181219ED
PART NO : 1136709
SAMPLING PLAN :
ASME B18.18-2017(Category.2)/ASTM F1470-2018
HEAT NO : 1804022400
MATERIAL : 1008A
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/08/29
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	0.0800	0.2600	0.0110	0.0050

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		0.8400-0.8660 inch	0.8490-0.8540 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0110 inch	0.0010-0.0060 inch	15	0
THICKNESS	6 PCS		0.4270-0.4480 inch	0.4330-0.4360 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.7360-0.7500 inch	0.7430-0.7460 inch	6	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0
MINOR DIAMETER	15 PCS		0.4430-0.4490 inch	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	82-85 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	88.34-97.08	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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

page 1 of 1

Figure D-72. ½-in. Dia. Hex Nut (Item No. k9)

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 : 2018/09/25

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 210157366
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/8-16 NC O/T 0.43MM
LOT NO : 1N1830837
SHIP QUANTITY : 54,000 PCS
LOT QUANTITY 452,481 PCS
HEADMARKS :

PACKING NO : GEM180418005
INVOICE NO : GEM/FNL-180503ED
PART NO : 36705
SAMPLING PLAN :
ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : G1712285001
MATERIAL : ML08
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/04/04
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	0.0570	0.0700	0.3800	0.0060	0.0030	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	0.6280-0.6500 inch	0.6300-0.6320 inch	6	0
THICKNESS	6 PCS	0.3200-0.3370 inch	0.3230-0.3240 inch	6	0
WIDTH ACROSS FLATS	6 PCS	0.5510-0.5630 inch	0.5590-0.5610 inch	6	0
SURFACE DISCONTINUITIES	29 PCS	ASTM F812-2012	PASSED	29	0
THREAD	15 PCS	GAGING SYSTEM 21	PASSED	15	0
MINOR DIAMETER	15 PCS	0.3120-0.3180 inch	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A563-2015

SAMPLED BY : LUYI

INSPECTIONS ITEM	SAMPLE	TEST METHOD	REF	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
CORE HARDNESS	15 PCS	ASTM F606-2014		68-107 HRB	86-87 HRB	15	0
PROOF LOAD	5 PCS	ASTM F606-2014		Min. 90 LBF	OK	5	0
PLATING THICKNESS(μm)	5 PCS	ASTM B568-1998		>=53	70.21-97.03	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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

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Figure D-73. ⅜-in. Dia. Hex Nut (Item No. k10)

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 : 2018/10/24

PURCHASER : FASTENAL COMPANY PURCHASING
PO. NUMBER : 120318682
COMMODITY : FINISHED HEX NUT GR-A
SIZE : 3/8-16 NC O/T 0.43MM
LOT NO : 1N1820334
SHIP QUANTITY : 45,000 PCS
LOT QUANTITY 198,752 PCS
HEADMARKS :

PACKING NO : GEM180411009
INVOICE NO : GEM/FNL-180426IN-3
PART NO : 1136705
SAMPLING PLAN : ASME B18.18-2011(Category.2)/ASTM F1470-2012
HEAT NO : G1711323001
MATERIAL : ML08
FINISH : HOT DIP GALVANIZED PER ASTM A153-2009/ASTM F2329-2013

MANUFACTURE DATE : 2018/02/27
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	0.0470	0.0600	0.3800	0.0120	0.0070	0.0200

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		0.6280-0.6500 inch	0.6300-0.6310 inch	6	0
FIM	15 PCS	ASME B18.2.2-2015	Max. 0.0170 inch	0.0070-0.0160 inch	15	0
THICKNESS	6 PCS		0.3200-0.3370 inch	0.3230-0.3240 inch	6	0
WIDTH ACROSS FLATS	6 PCS		0.5510-0.5630 inch	0.5590-0.5610 inch	6	0
SURFACE DISCONTINUITIES	29 PCS		ASTM F812-2012	PASSED	29	0
THREAD	15 PCS		GAGING SYSTEM 21	PASSED	15	0
MINOR DIAMETER	15 PCS		0.3290-0.3350 inch	PASSED	15	0

MECHANICAL PROPERTIES : ACCORDING TO ASTM A 307-2014

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	86-87 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	61.05-94.21	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
WE CERTIFY THAT ALL PRODUCTS WE SUPPLIED ARE IN COMPLIANCE WITH DIN EN 10204 3.1 CONTENT

Quality Supervisor:

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Figure D-74. ⅜-in. Dia. Hex Nut (Item No. k10)

CERTIFIED MATERIAL TEST REPORT
FOR USS FLAT WASHERS HDG

FACTORY: IFI & Morgan Ltd REPORT DATE: 22/10/2018
ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan,Zhejiang, China

SAMPLING PLAN PER ASME B18.18-11 PO NUMBER: 210151571
SIZE: USS 1 HDG QNTY(Lot size): 3240PCS
HEADMARKS: NO MARK PART NO: 33188

DIMENSIONAL INSPECTIONS SPECIFICATION: ASTM B18.21.1-2011

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F844	PASSED	100	0
OUTSIDE DIA	2.492-2.529	2.496-2.504	10	0
INSIDE DIA	1.055-1.092	1.080-1.089	10	0
THICKNESS	0.135-0.192	0.135-0.157	10	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT		ACC.	REJ.
HOT DIP GALVANIZED	ASTM F2329-13	Min 0.0017"	0.0017-0.0020	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.
ISO 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD.
检验专用章
QUANLITY CONTROL

(SIGNATURE OF Q.A. LAB MGR.)

Figure D-75. 1-in. Dia. Plain USS Washer, ⅜-in. Dia. Hex Nut (Item No. m1)

CERTIFIED MATERIAL TEST REPORT
FOR USS FLAT WASHERS HDG

FACTORY: IFI & Morgan Ltd
ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan,Zhejiang, China

REPORT DATE: 23/4/2019

MFG LOT NUMBER: 1844804

SAMPLING PLAN PER ASME B18.18-11
SIZE: USS 7/8 HDG QNTY(Lot size): 7200PCS
HEADMARKS: NO MARK

PO NUMBER: 170089822

PART NO: 33187

DIMENSIONAL INSPECTIONS — SPECIFICATION: ASTM B18.21.1-2011

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F844	PASSED	100	0
OUTSIDE DIA	2.243-2.280	2.246-2.254	10	0
INSIDE DIA	0.931-0.968	0.956-0.965	10	0
THICKNESS	0.136-0.192	0.136-0.157	10	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT		ACC.	REJ.
HOT DIP GALVANIZED	ASTM F2329-13	Min 0.0017"	0.0017-0.0020	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.
ISO 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD.
检验专用章
QUANLITY CONTROL
(SIGNATURE OF Q.A. LAB MGR.)

Figure D-76. ⅞-in. Dia. Plain USS Washer (Item No. m2)



Wrought Washer Mfg., Inc
2100 South Bay Street
Milwaukee, WI 53207
Tel 414-744-0771

Material Certification

Customer:	**Fastenal Company**
Ship To:	**Fastenal - Edwardsville**
Customer PO No:	**210201802**
Wrought Washer Mfg., Inc. Order No:	**1210**
Order Line:	**3**
Wrought Washer Mfg., Inc. Part No:	**017305**
Customer Part No:	**0156031**
Shipped Qty:	**1,500**
Heat:	**63019**
Heat Code:	**63019**
Grade:	**Steel**
Note:	**Lab Date: 1/24/2019**

Material Specification Type	Material Specification	Actual
Chemistry	C	0.34 %
	Mn	0.84 %
	P	0.008 %
	S	0 %
	Si	0.216 %
	Cu	0.133 %
	Ni	0.039 %
	Cr	0.035 %

We hereby certify that chemical analysis and/or physical characteristics shown are a true copy of original test reports on file with us from the producing source covering the heat or lot from which this material was taken.

Plex 11/19/2019 7:46 AM / GPrill.ww *1 of 1*

Figure D-77. ⅞-in. Dia. Hardened SAE Washer (Item No. m3)

FASTWELL INDUSTRY CO., LTD.

TEL:(86)21 53964567 HEAD OFFICE :6TH FLOOR,NO.227.SEC.1. FU-SHENG S.RD.,
64813702 TAIPEI ,TAIPEDI,TAIWAN
FAX: 64811848 SHANGHAI OFFICE:SUITE A,11F,HAILI BUIL DING ,NO.88 DAPU ROAD.
SHANGHAI CHINA ZIP CODE :200023

CERTIFICATE OF INSPECTION

CUSTOMER NAME: FASTENAL COMPANY PURCHASING-IMPORT TRAFFIC

REPORT NO.	:20190414001	HEAT NO.	:/
INSPECTION DATE	: 2019.04.14	LOT. NO.	: /
FINISH	:HDG	MATERIALS	: /
MANUFACTURING DATE	: 2019.02	P.O.NO.	:210177515
DESCRIPTION	:USS FLAT WASHERS	PART NUMBER	: 1133186
SIZE	: 3/4	MANUFACTUREDQUANTITY:3750PCS	
MARK	:/	SHIPQUANTITY	:3750PCS
INVOICE NO .	FS19040017	Sampling plan:	ASME B18.18-2017

1、DIMENSIONS INSPECTION

SPECIFICATION:ASME B18.21.1 - 2009

CHARACTERISTIC	SPECIFICATION	INSPECTION RESULTS	SAMPLING	AC	RE
OUTSIDE DIA.	1.993 - 2.030	1.997 - 2.005	8PCS	8	0
INSIDE DIA.	0.805 - 0.842	0.809 - 0.813	8PCS	8	0
THICKNESS	0.122 - 0.177	0.128 - 0.135	8PCS	8	0

2、MECHANICAL INSPECTION:

SPECIFICATION :

CHARACTERISTIC	TEST METHOD	STANDARD	RESULTS	SAMPLING	AC	RE

3、 FINISH INSPECTION

SPECIFICATION： ASTM F2329-2015

CHARACTERISTIC	TEST METHOD	STANDARD	RESULTS	SAMPLING	AC	RE
THICKNESS OF COATING	ASTM B487	38UM min.	60 - 68	22PCS	22	0

4、APPEARANCE INSPECTION

SPECIFICATION:ASME B18.21.1-2009

CHARACTERISTIC	TEST METHOD	STANDARD	RESULTS	SAMPLING	AC	RE
GENERAL WORKMANSHIP	ASME B18.21.1-2009	VISUAL	OK	22PCS	22	0

5、CHEMICAL ANALYSIS

HEAT NO	C-X100	Mn-x100	P-x1000	S-x1000	Si-x100	Cu-x100	Ni-x100	Cr-x100	Mo-x100	Al-x1000	B-x10000	V-x100
STANDARD												

QC MANAGER

Remark :1.This cortificate is valid with signature of

2.This test report only relates to the items listed and tested ,it's not allowed to be partially used.

3.Samples testing conform to the requirements of specification.

4. This test report is responsible for designated samples only.

5.The above composition is quoted from original mill certs which is not in the scope of Lab Accreditation.

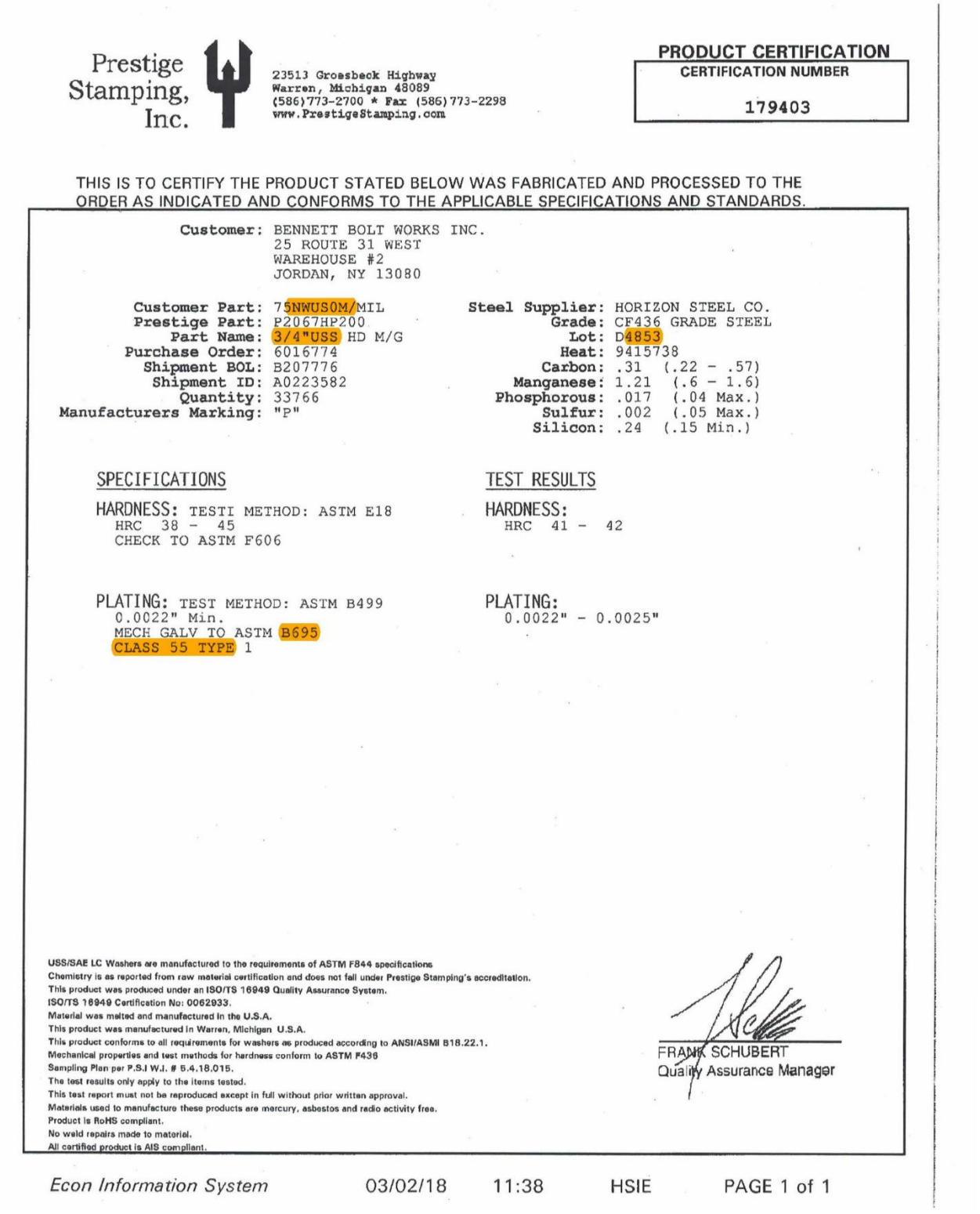
6.Quality System conforms to ISO 9001 requirements.

7.All fasteners meet the requirements of the (FQA)and records of compliance are on file.

8.Sampling Data is according to ASME B18.18.

9.Parts are manufactured and tested according to above specification and compliance with order， we certify that this is a ture representation of information provided by manufacturer and laboratory.

Figure D-78. ¾-in. Dia. Plain USS Washer (Item No. m4)



Prestige Stamping, Inc.

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

PRODUCT CERTIFICATION
CERTIFICATION NUMBER
179403

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

Customer: BENNETT BOLT WORKS INC.
25 ROUTE 31 WEST
WAREHOUSE #2
JORDAN, NY 13080

Customer Part: 75NWUS0M/MIL
Prestige Part: P2067HP200
Part Name: 3/4"USS HD M/G
Purchase Order: 6016774
Shipment BOL: B207776
Shipment ID: A0223582
Quantity: 33766
Manufacturers Marking: "P"

Steel Supplier: HORIZON STEEL CO.
Grade: CF436 GRADE STEEL
Lot: D4853
Heat: 9415738
Carbon: .31 (.22 - .57)
Manganese: 1.21 (.6 - 1.6)
Phosphorous: .017 (.04 Max.)
Sulfur: .002 (.05 Max.)
Silicon: .24 (.15 Min.)

SPECIFICATIONS	TEST RESULTS
HARDNESS: TESTI METHOD: ASTM E18 HRC 38 - 45 CHECK TO ASTM F606	HARDNESS: HRC 41 - 42
PLATING: TEST METHOD: ASTM B499 0.0022" Min. MECH GALV TO ASTM B695 CLASS 55 TYPE 1	PLATING: 0.0022" - 0.0025"

USS/SAE LC Washers are manufactured to the requirements of ASTM F844 specifications
Chemistry is as reported from raw material certification and does not fall under Prestige Stamping's accreditation.
This product was produced under an ISO/TS 16949 Quality Assurance System.
ISO/TS 16949 Certification No: 0062933.
Material was melted and manufactured in the U.S.A.
This product was manufactured in Warren, Michigan U.S.A.
This product conforms to all requirements for washers as produced according to ANSI/ASMI B18.22.1.
Mechanical properties and test methods for hardness conform to ASTM F436
Sampling Plan per P.S.I W.I. # 5.4.18.015.
The test results only apply to the items tested.
This test report must not be reproduced except in full without prior written approval.
Materials used to manufacture these products are mercury, asbestos and radio activity free.
Product is RoHS compliant.
No weld repairs made to material.
All certified product is AIS compliant.

FRANK SCHUBERT
Quality Assurance Manager

Econ Information System 03/02/18 11:38 HSIE PAGE 1 of 1

Figure D-79. ¾-in. Dia. Hardened USS Washer (Item No. m5)

TEST REPORT

USS FLAT WASHER, HDG

CUSTOMER:

DATE: 30/12/2018

PO NUMBER: 180164126

MFG LOT NUMBER: M-SWE0412454-8

SIZE: 5/8

PART NO: 1133185

HEADMARKS:

QNTY: 6,000 PCS

DIMENSIONAL INSPECTIONS

SPECIFICATION: ASME B18.21.1(2009)

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F788-07	PASSED	100	0
OUTSIDE DIA	1.743-1.780	1.752-1.756	8	0
INSIDE DIA	0.681-0.718	0.700-0.707	8	0
THICKNESS	0.108-0.160	0.114-0.119	8	0
HOT DIP GALVANIZED	ASTM A153 class C. RoHS Compliant	Min 0.0017"	Min 0.0019 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

We hereby certify that above products supplied are in compliance with all the requirements of the order.
We here by certify that this MTR is in compliance to DIN EN 10204 3.1 content.

IFI & MORGAN LTD 检验专用章

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

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

Figure D-80. ⅝-in. Dia. Plain USS Washer (Item No. m6)

CERTIFIED MATERIAL TEST REPORT
FOR USS FLAT WASHERS HDG

FACTORY: IFI & Morgan Ltd
ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan,Zhejiang, China

REPORT DATE: 21/5/2019

MFG LOT NUMBER: 1845511

SAMPLING PLAN PER ASME B18.18-11
SIZE: USS 5/8 HDG QNTY(Lot size): 6000PCS
HEADMARKS: NO MARK

PO NUMBER: 210167255

PART NO: 1133185

DIMENSIONAL INSPECTIONS — SPECIFICATION: ASTM B18.21.1-2011

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F844	PASSED	100	0
OUTSIDE DIA	1.743-1.780	1.746-1.754	10	0
INSIDE DIA	0.681-0.718	0.707-0.715	10	0
THICKNESS	0.108-0.160	0.108-0.126	10	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT		ACC.	REJ.
HOT DIP GALVANIZED	ASTM F2329-13	Min 0.0017"	0.0017-0.0020	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.
ISO 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD.
检验专用章
QUANLITY CONTROL
(SIGNATURE OF Q.A. LAB MGR.)

Figure D-81. ⅝-in. Dia. Plain USS Washer (Item No. m6)

Stamping The Future

Wrought Washer Mfg., Inc
1901 Chicory Road
Mount Pleasant, WI 53403

Certificate Of Conformance

Date:
Certification To: Fastenal Company
2001 Theurer Blvd.
Winona, MN 55987
USA

Part Info

PO No Revision:
Customer Part No: 0136087
Part Name: 5/8 SAE GR2 HOT DIP GALV
Quantity: 4,440
Supplier:
Master Unit No(s): M014013

Customer Part Rev Level:
Customer PO No: 110328718
Line No: 1

Piece List:
Wrought Washer Mfg., Inc. Part No: 010389
Shipper No: WW03660
Job No(s): 311759

Revision:

We hereby certify that the subject parts conform to the purchase order and any applicable specification indicated above. We further certify that all hardening and/or plating meet full purchase order specification requirements.

We hereby certify that all statutory requirements as to American Production and Labor Standards and all conditions of purchase applicable to the transaction have been complied with and that the subject parts were manufactured in the USA.

Signature Date

1/20/2020 8:46 AM / GPrill ww 1 of 1

Figure D-82. ⅝-in. Dia. Plain SAE Washer (Item No. m7)

TEST REPORT

SAE FLAT WASHER, HDG

CUSTOMER:

DATE: 2017-10-22

PO NUMBER: 220025400

MFG LOT NUMBER: M-SWE0412034-1

SIZE: 1/2

PART NO: 0136086

HEADMARKS:

QNTY: 180,000 PCS

DIMENSIONAL INSPECTIONS

SPECIFICATION: ASME B18.21.1(2009)

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F788-07	PASSED	100	0
OUTSIDE DIA	1.055-1.092	1.069-1.072	8	0
INSIDE DIA	0.526-0.546	0.538-0.540	8	0
THICKNESS	0.074-0.121	0.076-0.079	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

We hereby certify that above products supplied are in compliance with all the requirements of the order.
We here by certify that this MTR is in compliance to DIN EN 10204 3.1 content.

MORGAN
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 D-83. ½-in. Dia. Plain Narrow SAE Washer (Item No. m8)

TEST REPORT

SAE FLAT WASHER, HDG

CUSTOMER: DATE: **2017-11-12**

PO NUMBER: **220025675** MFG LOT NUMBER: **M-SWE0412059-1**

SIZE: **1/2** PART NO: **0136086**

HEADMARKS: QNTY: **180,000 PCS**

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

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	**ASTM F788-07**	**PASSED**	**100**	**0**
OUTSIDE DIA	**1.055-1.092**	**1.059-1.063**	**8**	**0**
INSIDE DIA	**0.526-0.546**	**0.537-0.539**	**8**	**0**
THICKNESS	**0.074-0.121**	**0.079-0.084**	**8**	**0**
HOT DIP GALVANIZED	**ASTM A153 class C. RoHS Compliant**	**Min 0.0017"**	**Min 0.0018In**	**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

We hereby certify that above products supplied are in compliance with all the requirements of the order.
We here by certify that this MTR is in compliance to DIN EN 10204 3.1 content.

IFI & MORGAN LTD. MORGAN 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 D-84. ½-in. Dia. Plain Narrow SAE Washer (Item No. m8)

CERTIFIED MATERIAL TEST REPORT
FOR USS FLAT WASHERS HDG

FACTORY: IFI & Morgan Ltd
ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan,Zhejiang, China

REPORT DATE: 18/3/2019

MFG LOT NUMBER: 1842301

SAMPLING PLAN PER ASME B18.18-11
SIZE: USS 3/8 HDG QNTY(Lot size): 105000PCS
HEADMARKS: NO MARK

PO NUMBER: 120333159

PART NO: 1133182

DIMENSIONAL INSPECTIONS — SPECIFICATION: ASTM B18.21.1-2011

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F844	PASSED	100	0
OUTSIDE DIA	0.993-1.030	0.996-1.004	10	0
INSIDE DIA	0.433-0.453	0.443-0.450	10	0
THICKNESS	0.064-0.104	0.064-0.079	10	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT		ACC.	REJ.
HOT DIP GALVANIZED	ASTM F2329-13	Min 0.0017"	0.0017-0.0(	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.
ISO 9001:2015 SGS Certificate # HK04/0105

IFI & MORGAN LTD.
检验专用章
QUANLITY CONTROL

(SIGNATURE OF Q.A. LAB MGR.)

Figure D-85. ⅜-in. Dia. Plain USS Washer (Item No. m9)

CERTIFIED MATERIAL TEST REPORT
FOR USS FLAT WASHERS HDG

FACTORY: IFI & Morgan Ltd
ADDRESS: Chang'an North Road, Wuyuan Town, Haiyan,Zhejiang, China
CUSTOMER:

REPORT DATE: 2019/01/10
MANUFACTURE DATE: 2019/01/03
MFG LOT NUMBER: 1833609
PO NUMBER: 2.1E+08
PART NO: 1133182

SAMPLING PLAN PER ASME B18.18-11
SIZE: USS 3/8 HDG QNTY(Lot size): 26250PCS
HEADMARKS: NO MARK

DIMENSIONAL INSPECTIONS SPECIFICATION: ASTM B18.21.1-2011

CHARACTERISTICS	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
APPEARANCE	ASTM F844	PASSED	100	0
OUTSIDE DIA	0.993-1.030	0.996-1.004	10	0
INSIDE DIA	0.433-0.453	0.443-0.450	10	0
THICKNESS	0.064-0.104	0.064-0.079	10	0

CHARACTERISTICS	TEST METHOD	SPECIFIED	ACTUAL RESULT	ACC.	REJ.
HOT DIP GALVANIZED	ASTM F2329-13	Min 0.0017"	0.0017-0.0020 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 ISO9002 CERTIFICATE NO. HK04/0105

IFI & MORGAN LTD. 检验专用章 QUALITY CONTROL

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

Figure D-86. ⅜-in. Dia. Plain USS Washer (Item No. m9)

HEXICO ENTERPRISE CO., LTD.

NO.355-3,SEC. 3,CHUNG SHAN ROAD,KAU-JEN,TAINAN,TAIWAN,R.O.C.
TEL : 886 - 6 - 2390616 FAX : 886 - 6 - 2308947

MARKING

INSPECTION CERTIFICATE

CUSTOMER	**FASTENAL COMPANY**	REPORT DATE	2018/7/24
PART NAME	Flat Washer , SAE , EcoGuard		
SIZE	3/4 "	MAF. DATE	2018/6/26
PART NO.	W2A2C6003S2LK7	REPORT NO.	1070724-14
CUST. PART NO.	11137087	ORDER NO.	120328645
MATERIAL	10B21 / 24 mm	MAT. CER. NO.	10603021
HEAT(COIL) NO.	1L124	LOT NO.	772C6FNN5
LOT QTY	26,880 PCS	MAF. QTY	26,880 PCS

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

THE REPORT IS ISSUED ACCORDING TO EN10204 3.1

SAMPLING PLAN STANDARD	ASME B18.18-2017 / ASTM F1470-2018
DIMENSION STANDARD	ASME B18.21.1-2009
COATING STANDARD	FNL.C.1000
HARDNESS TEST METHOD	ASTM F606-2016
COATING TEST METHOD	ASTM E376-2017
SALT PRAY TEST METHOD	ASTM B117-2016

DIMENSIONS IN inch

	INSPECTION ITEM	SPECIFICATION	TEST QTY	INSPECTION RESULTS		INSPECTION EQUIPMENT
				MIN.	MAX.	
1	OUTSIDE DIAMETER	1.4620 - 1.4990	8	1.4752	1.4945	Caliper
2	INSIDE DIAMETER	0.8050 - 0.8420	8	0.8354	0.8382	Caliper
3	THICKNESS	0.1080 - 0.1600	8	0.1154	0.1185	Caliper
4	HARDNESS	HRC 38 - 45	5	39.8	41.6	Rockwell
5	COATING	GEOMET 21 + PLUS L	5	OK		
6	SALT SPRAY TEST	1000 Hrs No Red Rust	5	OK		S.S.T. tester
7	APPEARANCE	VISUAL	100	OK		

INSPECTOR Yu Tain Lin QC CHIEF Jing Yeh Tsao

Figure D-87. ¾-in. Dia. Hardened SAE Washer (Item No. m10)

Appendix E. Static Soil Tests



Dynamic Set up

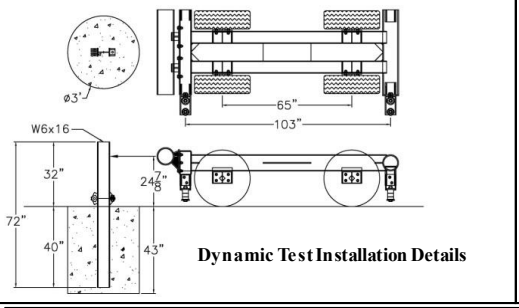
Post-Test Photo of Post



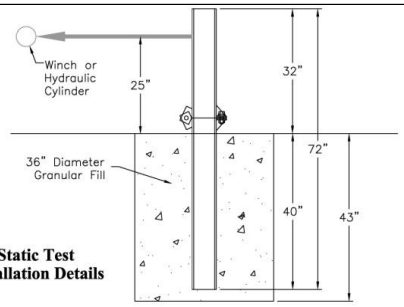
Static Load Test



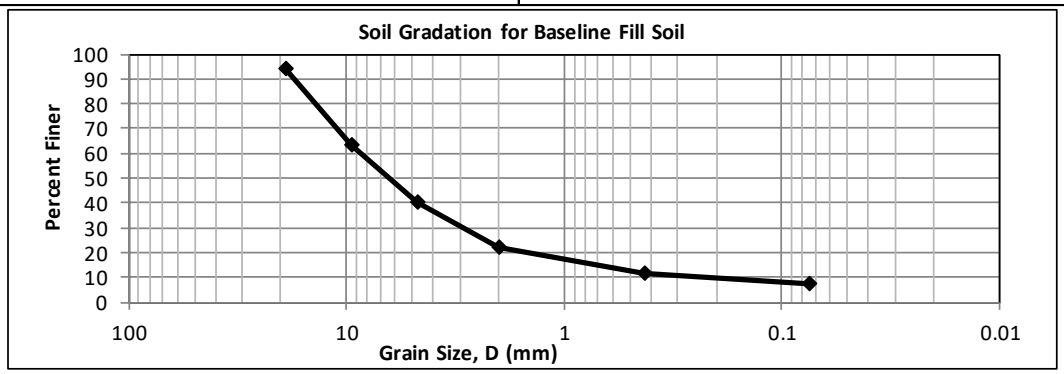
Post-Test Photo of Post

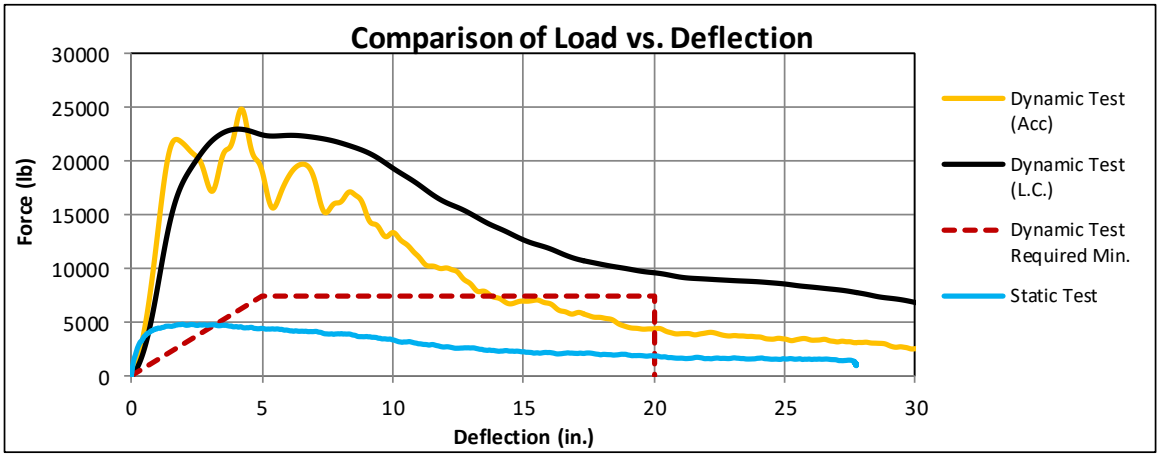


Dynamic Test Installation Details



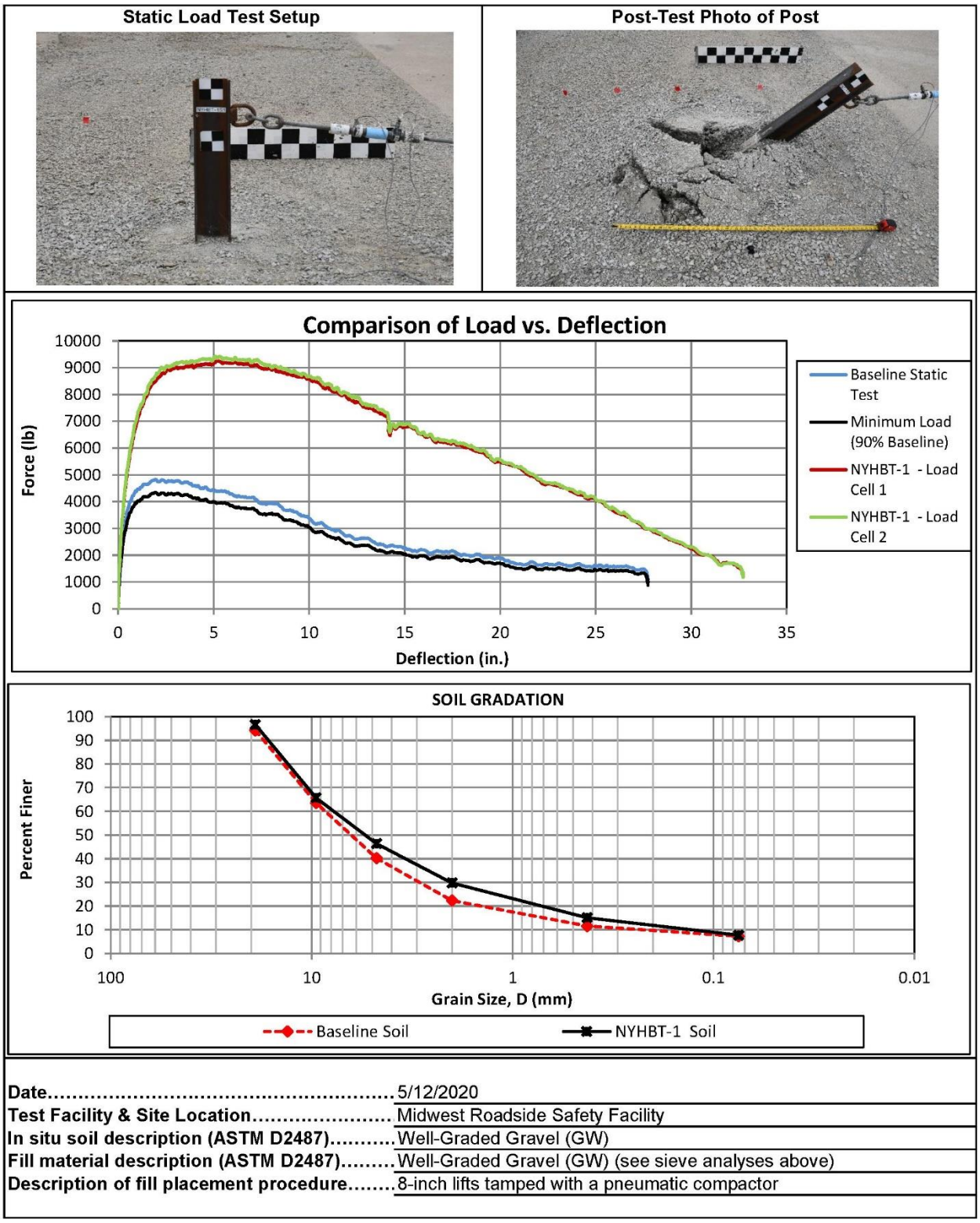
Static Test Installation Details





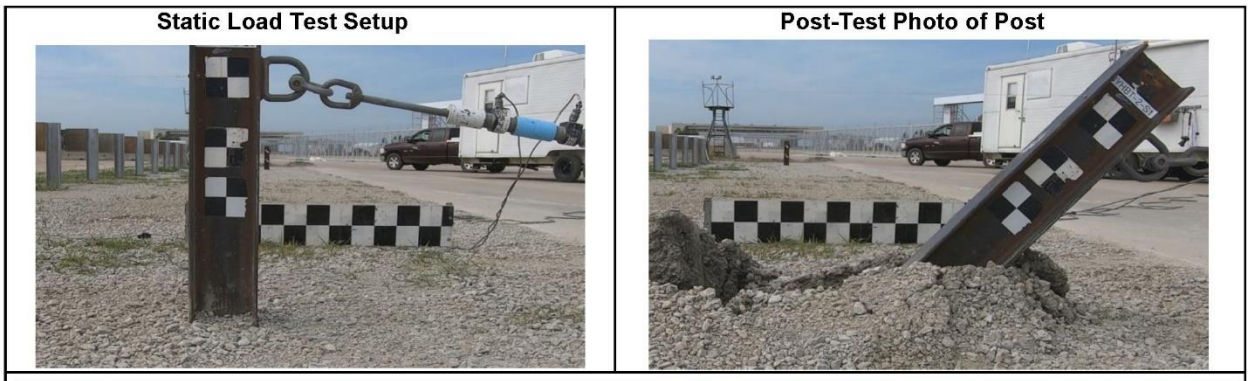
Date	2/16/2018		
Test Facility & Site Location	Midwest Roadside Safety Facility		
In situ soil description (ASTM D2487)	Well-Graded Gravel (GW)		
Fill material description (ASTM D2487)	Well-Graded Gravel (GW) (see sieve analyses above)		
Description of fill placement procedure	H.E.-8		
Bogie Weight	1786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

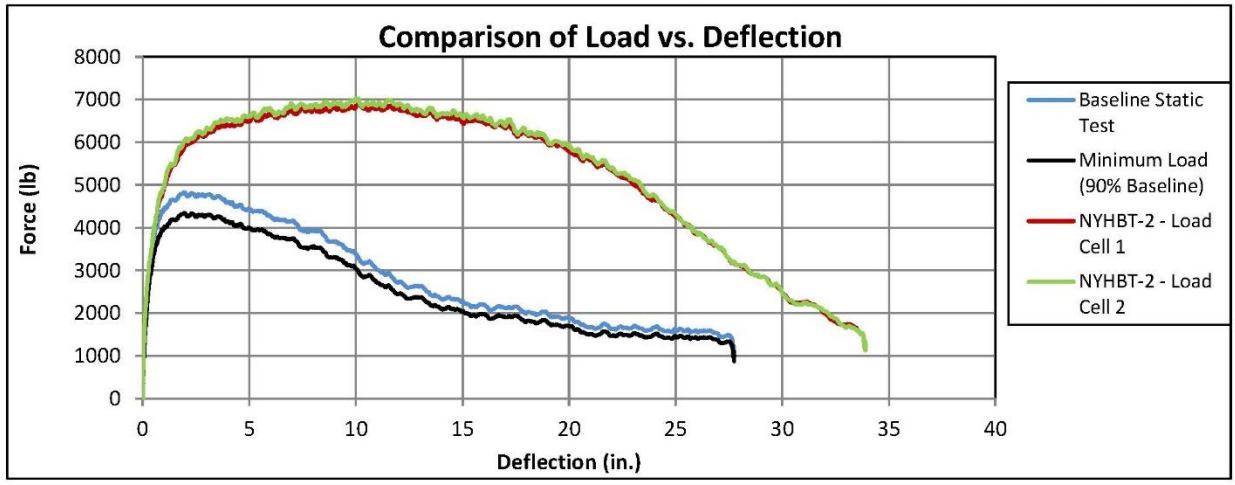
Figure E-1. Soil Strength, Initial Calibration

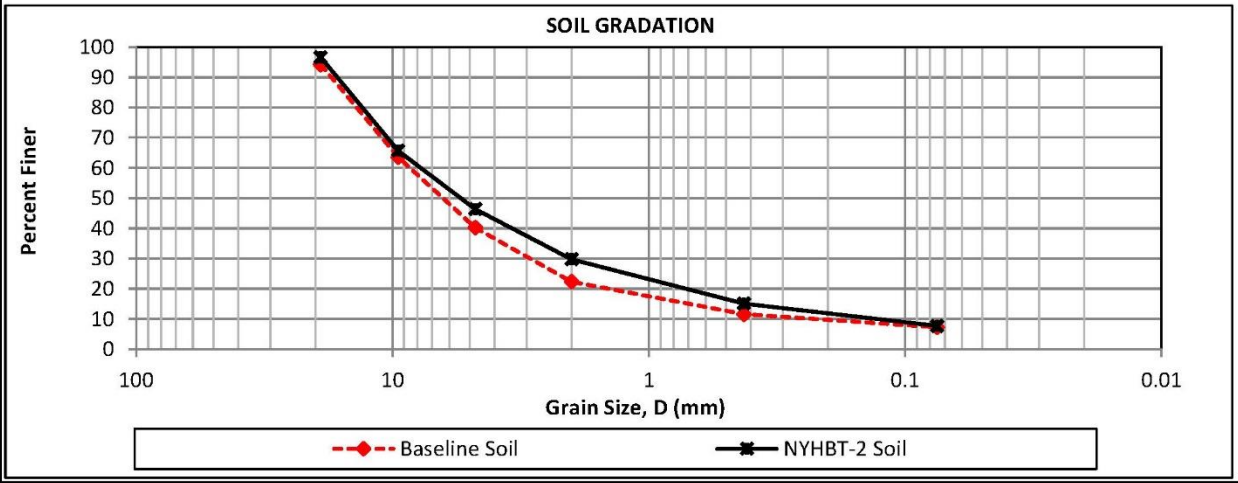


Date	5/12/2020
Test Facility & Site Location	Midwest Roadside Safety Facility
In situ soil description (ASTM D2487)	Well-Graded Gravel (GW)
Fill material description (ASTM D2487)	Well-Graded Gravel (GW) (see sieve analyses above)
Description of fill placement procedure	8-inch lifts tamped with a pneumatic compactor

Figure E-2. Static Soil Test, Test No. NYHBT-1







Date	7/17/2020
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

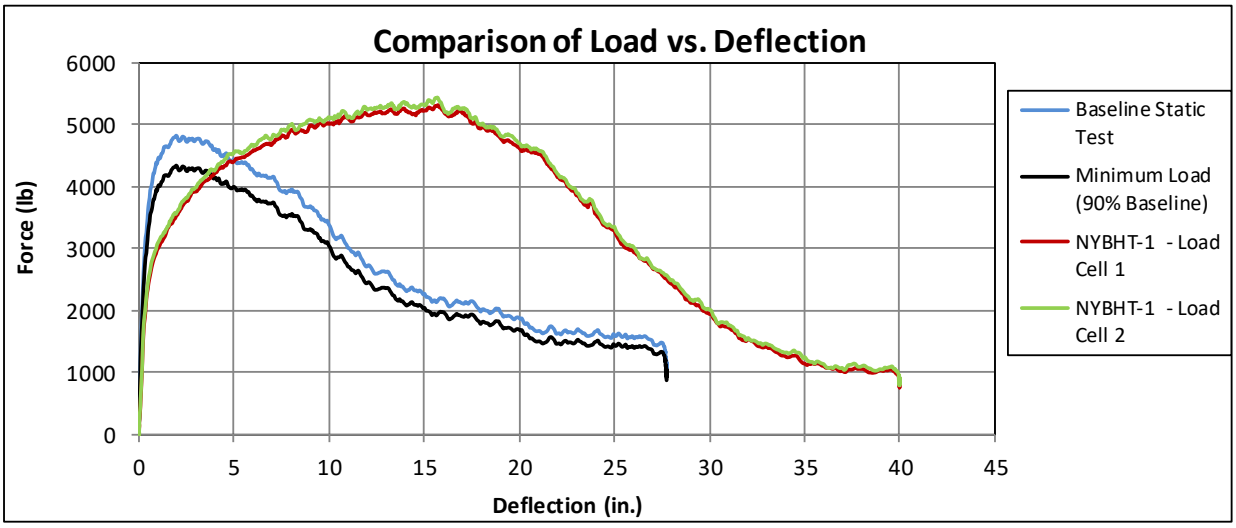
Figure E-3. Static Soil Test, Test No. NYHBT-2

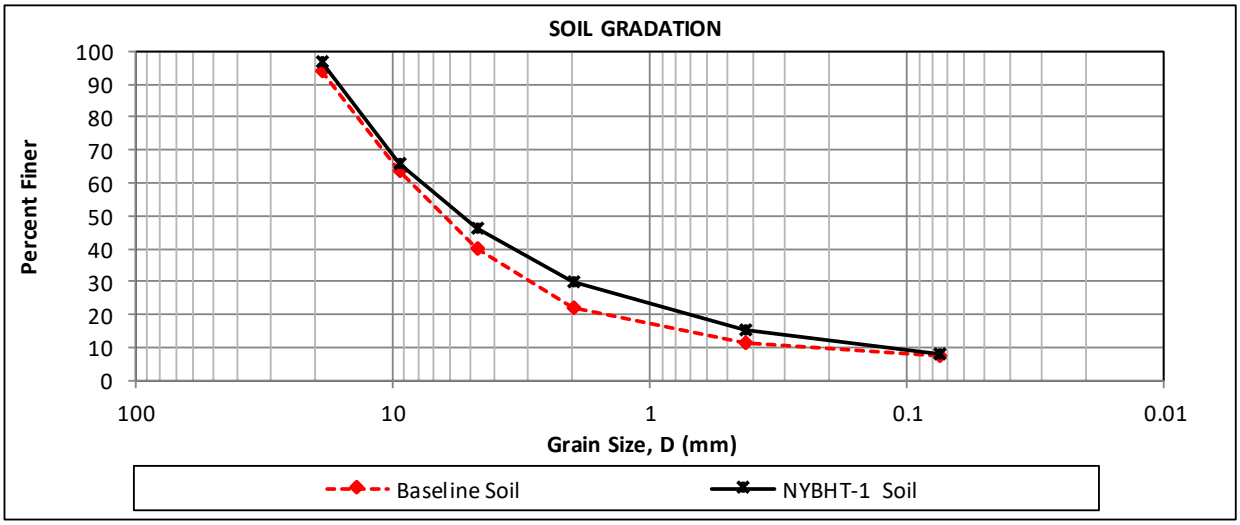
Static Load Test Setup



Post-Test Photo of Post







Date	5/1/2020
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

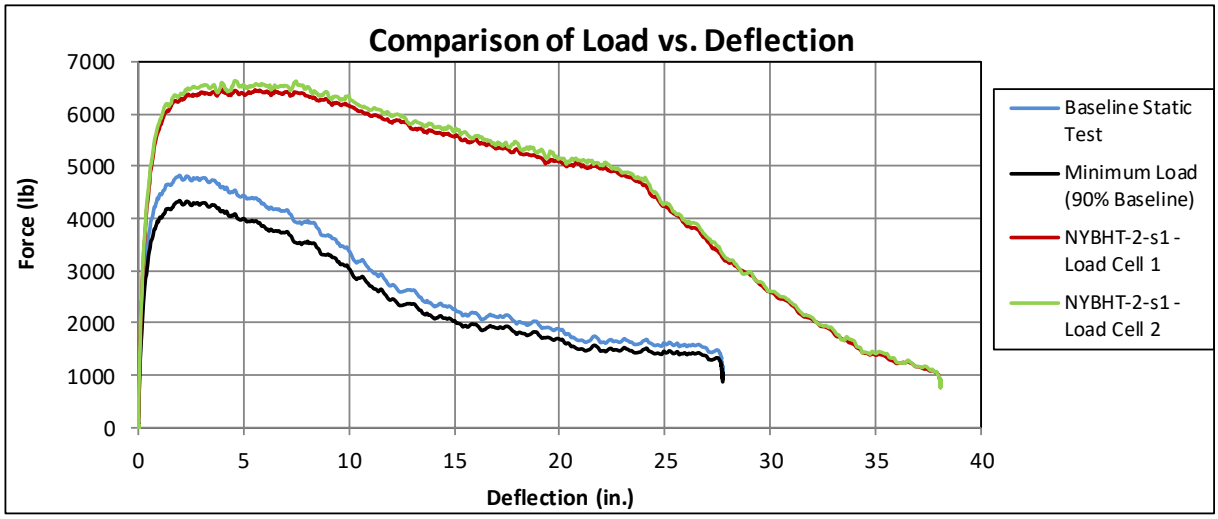
Figure E-4. Static Soil Test, Test No. NYBHT-1

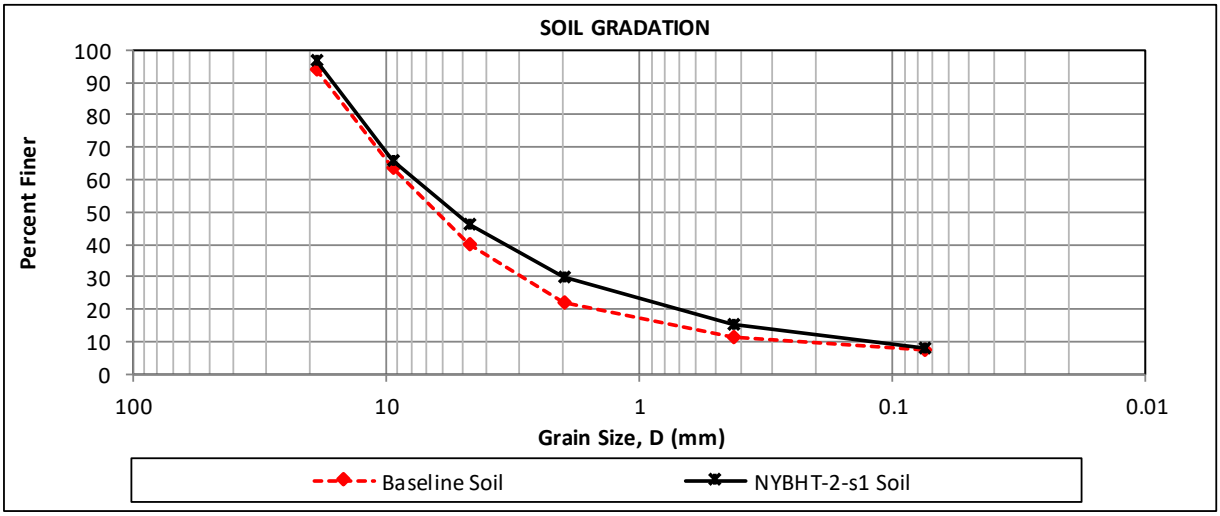
Static Load Test Setup



Post-Test Photo of Post







Date	6/15/2020
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 E-5. Static Soil Test, Test No. NYBHT-2

Appendix F. Vehicle Center of Gravity Determination

		Test Name:	**NYHBT-1**	**VIN:**	**1C6RR6LG6ES164753**
Model Year:	**2014**	**Make:**	**Dodge**	**Model:**	**Ram 1500**

Vehicle CG Determination

	Vehicle Equipment	Weight (lb)	Vertical CG (in.)	Vertical M (lb-in.)
+	Unballasted Truck (Curb)	5018	28.555401	143291
+	Hub	19	14.625	277.875
+	Brake activation cylinder & frame	8	29	232
+	Pneumatic tank (Nitrogen)	22	27 1/4	599.5
+	Strobe/Brake Battery	5	27	135
+	Brake Receiver/Wires	6	53	318
+	CG Plate including DAQ	38	30 3/4	1168.5
-	Battery	-48	39 1/2	-1896
-	Oil	-14	15	-210
-	Interior	-124	35	-4340
-	Fuel	-162	18 3/4	-3037.5
-	Coolant	-11	37	-407
-	Washer fluid	-6	32 1/2	-195
+	Water Ballast (In Fuel Tank)	235	19 1/4	4523.75
+	Onboard Supplemental Battery	5	27	135
				0
				0
Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle				140595.13

Estimated Total Weight (lb)	4991
Vertical CG Location (in.)	28.1697

Vehicle Dimensions for C.G. Calculations

Wheel Base: 140.25 in. Front Track Width: 67.5 in.
Rear Track Width: 67.5 in.

Center of Gravity	**2270P MASH Targets**	**Test Inertial**	**Difference**
Test Inertial Weight (lb)	5000 ± 110	4997	-3.0
Longitudinal CG (in.)	63 ± 4	66.153542	3.15354
Lateral CG (in.)	NA	0.1013108	NA
Vertical CG (in.)	28 or greater	28.17	0.16973

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	1392	1322	
Rear	1142	1162	
FRONT	2714		lb
REAR	2304		lb
TOTAL	5018		lb

TEST INERTIAL WEIGHT (lb)

	Left	Right	
Front	1334	1306	
Rear	1157	1200	
FRONT	2640		lb
REAR	2357		lb
TOTAL	4997		lb

Figure F-1. Vehicle Mass Distribution, Test No. NYHBT-1

		Test Name:	**NYHBT-2**	**VIN:**	**KNADH4A38A6687587**
Model Year:	**2010**	**Make:**	**Kia**	**Model:**	**Rio**

Vehicle CG Determination

	Vehicle Equipment	Weight (lb)
+	Unballasted Car (Curb)	2472
+	Hub	19
+	Brake activation cylinder & frame	8
+	Pneumatic tank (Nitrogen)	30
+	Strobe/Brake Battery	5
+	Brake Receiver/Wires	5
+	CG Plate including DAQ	22
-	Battery	-31
-	Oil	-7
-	Interior	-69
-	Fuel	-17
-	Coolant	-7
-	Washer fluid	-7
+	Water Ballast (In Fuel Tank)	18
+	Onboard Supplemental Battery	

Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle

Estimated Total Weight (lb): 2441

Vehicle Dimensions for C.G. Calculations

Wheel Base:	98.375	in.	Front Track Width:	58.375	in.
Roof Height:	57.0	in.	Rear Track Width:	57.563	in.

Center of Gravity	**1100C MASH Targets**	**Test Inertial**	**Difference**
Test Inertial Weight (lb)	2420 ± 55	2421	1.0
Longitudinal CG (in.)	39 ± 4	36.042	-2.958
Lateral CG (in.)	NA	0.251	NA
Vertical CG (in.)	NA	22.146	NA

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	813	775	
Rear	443	441	
FRONT	1588		lb
REAR	884		lb
TOTAL	2472		lb

TEST INERTIAL WEIGHT (lb)

	Left	Right	
Front	769	765	
Rear	431	456	
FRONT	1534		lb
REAR	887		lb
TOTAL	2421		lb

Figure F-2. Vehicle Mass Distribution, Test No. NYHBT-2

	Test Name:	**NYBHT-1**	**VIN:**	**1C6RR6FT9ES258957**
Model Year:	**2014**	**Make:**	**Dodge**	**Model:** **Ram 1500**

Vehicle CG Determination

	Vehicle Equipment	Weight (lb)	Vertical CG (in.)	Vertical M (lb-in.)
+	Unballasted Truck (Curb)	5113	29.004938	148302.25
+	Hub	19	14.75	280.25
+	Brake activation cylinder & frame	8	28 1/2	228
+	Pneumatic tank (Nitrogen)	31	27	837
+	Strobe/Brake Battery	5	27 1/2	137.5
+	Brake Receiver/Wires	6	53 3/4	322.5
+	CG Plate including DAQ	42	31 1/2	1323
-	Battery	-51	38	-1938
-	Oil	-13	21	-273
-	Interior	-106	37	-3922
-	Fuel	-164	19	-3116
-	Coolant	-13	35	-455
-	Washer fluid	0	36	0
+	Water Ballast (In Fuel Tank)	111	18	1998
+	Onboard Supplemental Battery	5	27 1/2	137.5
				0
				0
Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle				143862

Estimated Total Weight (lb)	4993
Vertical CG Location (in.)	28.8127

Vehicle Dimensions for C.G. Calculations

Wheel Base: 140.5 in. Front Track Width: 68.25 in.
Rear Track Width: 67.625 in.

Center of Gravity	2270P MASH Targets	Test Inertial	Difference
Test Inertial Weight (lb)	5000 ± 110	5000	0.0
Longitudinal CG (in.)	63 ± 4	60.3869	-2.61310
Lateral CG (in.)	NA	-0.394038	NA
Vertical CG (in.)	28 or greater	28.81	0.81274

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	1482	1443	
Rear	1086	1102	
FRONT	2925		lb
REAR	2188		lb
TOTAL	5113		lb

TEST INERTIAL WEIGHT (lb)

	Left	Right	
Front	1449	1402	
Rear	1080	1069	
FRONT	2851		lb
REAR	2149		lb
TOTAL	5000		lb

Figure F-3. Vehicle Mass Distribution, Test No. NYBHT-1

		Test Name:	**NYBHT-2**	**VIN:**	**KMHCN46C49U332399**
Model Year:	**2009**	**Make:**	**Hyundai**	**Model:**	**Accent**

Vehicle CG Determination

	Vehicle Equipment	Weight (lb)
+	Unballasted Car (Curb)	2483
+	Hub	19
+	Brake activation cylinder & frame	7
+	Pneumatic tank (Nitrogen)	31
+	Strobe/Brake Battery	5
+	Brake Receiver/Wires	6
+	CG Plate including DAQ	22
-	Battery	-32
-	Oil	-11
-	Interior	-60
-	Fuel	-3
-	Coolant	-7
-	Washer fluid	-9
+	Water Ballast (In Fuel Tank)	0
+	Onboard Supplemental Battery	5
-	Trunk Contents	-11

Note: (+) is added equipment to vehicle, (-) is removed equipment from vehicle

Estimated Total Weight (lb): 2445

Vehicle Dimensions for C.G. Calculations

Wheel Base:	98.625	in.	Front Track Width:	58.125	in.
Roof Height:	57.5	in.	Rear Track Width:	57.25	in.

Center of Gravity	**1100C MASH Targets**	**Test Inertial**	**Difference**
Test Inertial Weight (lb)	2420 ± 55	2442	22.0
Longitudinal CG (in.)	39 ± 4	36.348	-2.652
Lateral CG (in.)	NA	-0.26	NA
Vertical CG (in.)	NA	22.608	NA

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	812	777	
Rear	440	454	
FRONT	1589		lb
REAR	894		lb
TOTAL	2483		lb

TEST INERTIAL WEIGHT (lb)

	Left	Right	
Front	789	753	
Rear	443	457	
FRONT	1542		lb
REAR	900		lb
TOTAL	2442		lb

Figure F-4. Vehicle Mass Distribution, Test No. NYBHT-2

Appendix G. Post Movement Definitions

Table G-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 H. Vehicle Deformation Records

The following figures and tables describe all occupant compartment measurements taken on the test vehicles used in the full-scale crash testing. MASH defines intrusion as the occupant compartment being deformed and reduced in size with no penetration. Outward deformations, which are denoted as negative numbers within this appendix, are not considered crush toward the occupant, and are not subject to evaluation by MASH criteria.

Model Year: 2014 Test Name: NYHBT-1 Make: Dodge VIN: 1C6RR6LG6ES164753 Model: Ram 1500

VEHICLE DEFORMATION
DRIVER SIDE 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	61.5433	-22.5166	-0.8834	61.7818	-21.7794	0.5002	-0.2385	0.7372	-1.3836	1.5858	0.0000	NA
	2	62.3909	-18.9192	0.5704	62.8548	-18.6849	1.8886	-0.4639	0.2343	-1.3182	1.4170	0.0000	NA
	3	62.0964	-15.3448	0.6544	62.3249	-15.1810	1.6550	-0.2285	0.1638	-1.0006	1.0393	0.0000	NA
	4	61.8649	-10.8785	0.7794	62.0902	-10.6482	1.7491	-0.2253	0.2303	-0.9697	1.0218	0.0000	NA
	5	61.3070	-6.6832	-0.4414	61.3969	-6.5867	0.3212	-0.0899	0.0965	-0.7626	0.7739	0.0000	NA
	6	58.0532	-23.9730	2.7910	58.2542	-23.4972	3.9985	-0.2010	0.4758	-1.2075	1.3133	0.0000	NA
	7	58.1062	-18.4910	2.7745	58.4895	-18.2469	3.6961	-0.3833	0.2441	-0.9216	1.0275	0.0000	NA
	8	58.4990	-14.6127	2.5799	58.7327	-14.4144	3.4722	-0.2337	0.1983	-0.8923	0.9435	0.0000	NA
	9	58.6400	-11.1557	2.5083	58.9269	-10.9615	3.4379	-0.2869	0.1942	-0.9296	0.9921	0.0000	NA
	10	57.9284	-5.3521	2.4094	58.0920	-5.1381	3.1326	-0.1636	0.2140	-0.7232	0.7717	0.0000	NA
FLOOR PAN (Z)	11	51.9253	-24.0221	5.2624	52.2425	-23.7062	5.2169	-0.3172	0.3159	0.0455	0.4500	0.0455	Z
	12	51.7953	-18.7554	5.2198	51.9705	-18.5349	5.7822	-0.1752	0.2205	-0.5624	0.6290	-0.5624	Z
	13	51.7360	-14.3405	5.2538	51.9380	-14.1321	5.9089	-0.2020	0.2084	-0.6551	0.7165	-0.6551	Z
	14	51.5078	-10.2195	5.2799	51.7103	-9.9987	5.9164	-0.2025	0.2208	-0.6365	0.7035	-0.6365	Z
	15	51.3373	-5.3801	3.8849	51.5297	-5.2368	4.4993	-0.1924	0.1433	-0.6144	0.6596	-0.6144	Z
	16	46.7809	-23.5752	5.2859	47.0182	-23.2448	5.0586	-0.2373	0.3304	0.2273	0.4660	0.2273	Z
	17	46.9701	-18.2512	5.2225	47.1689	-18.0285	5.6485	-0.1988	0.2227	-0.4260	0.5202	-0.4260	Z
	18	47.0231	-14.3775	5.2423	47.2311	-14.2355	5.7919	-0.2080	0.1420	-0.5496	0.6046	-0.5496	Z
	19	47.0990	-9.6226	5.2782	47.2711	-9.4850	5.8376	-0.1721	0.1376	-0.5594	0.6012	-0.5594	Z
	20	46.9326	-5.5295	4.1909	47.0417	-5.3889	4.7103	-0.1091	0.1406	-0.5194	0.5490	-0.5194	Z
	21	41.1110	-24.0839	5.3022	41.3374	-23.8978	5.3383	-0.2264	0.1861	-0.0361	0.2953	-0.0361	Z
	22	41.0572	-19.8768	5.2832	41.3240	-19.7139	5.5564	-0.2668	0.1629	-0.2732	0.4152	-0.2732	Z
	23	40.8993	-15.3120	5.3258	41.1277	-15.2503	5.6798	-0.2284	0.0617	-0.3540	0.4258	-0.3540	Z
	24	40.9638	-10.8436	5.3514	41.1510	-10.7469	5.7447	-0.1872	0.0967	-0.3933	0.4462	-0.3933	Z
	25	41.1976	-5.7926	4.5028	41.4019	-5.7024	4.9433	-0.2043	0.0902	-0.4405	0.4939	-0.4405	Z
	26	37.1039	-22.9891	4.5390	37.3421	-22.8153	4.8552	-0.2382	0.1738	-0.3162	0.4324	-0.3162	Z
	27	37.2771	-18.5004	4.5497	37.4429	-18.3884	4.8776	-0.1658	0.1120	-0.3279	0.3841	-0.3279	Z
	28	37.3236	-14.2071	4.5712	37.5637	-14.0647	4.9053	-0.2401	0.1424	-0.3341	0.4354	-0.3341	Z
	29	37.2933	-10.6181	4.3871	37.4836	-10.4943	4.7198	-0.1903	0.1238	-0.3327	0.4028	-0.3327	Z
	30	37.1238	-6.7633	4.1720	37.2738	-6.6209	4.4876	-0.1500	0.1424	-0.3156	0.3773	-0.3156	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 H-1. Floor Pan Deformation Data – Set 1, Test No. NYHBT-1

Model Year: 2014 Test Name: NYHBT-1 Make: Dodge VIN: 1C6RR6LG6ES164753 Model: Ram 1500

VEHICLE DEFORMATION
DRIVER SIDE 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	60.5217	-40.5977	-5.7523	60.5605	-39.8772	-4.3304	-0.0388	0.7205	-1.4219	1.5945	0.0000	NA
	2	61.4711	-37.0291	-4.2905	61.7251	-36.8090	-2.9575	-0.2540	0.2201	-1.3330	1.3747	0.0000	NA
	3	61.2684	-33.4487	-4.1903	61.2820	-33.2931	-3.1917	-0.0136	0.1556	-0.9986	1.0107	0.0000	NA
	4	61.1517	-28.9785	-4.0461	61.1634	-28.7557	-3.1027	-0.0117	0.2228	-0.9434	0.9694	0.0000	NA
	5	60.6922	-24.7654	-5.2463	60.5595	-24.6798	-4.5305	0.1327	0.0856	-0.7158	0.7330	0.1327	X
	6	57.0220	-41.9799	-2.0584	57.0246	-41.5000	-0.7953	-0.0026	0.4799	-1.2631	1.3512	0.0000	NA
	7	57.2146	-36.5010	-2.0538	57.3901	-36.2578	-1.1086	-0.1755	0.2432	-0.9452	0.9916	0.0000	NA
	8	57.7047	-32.6332	-2.2359	57.7283	-32.4331	-1.3411	-0.0236	0.2001	-0.8948	0.9172	0.0000	NA
	9	57.9332	-29.1807	-2.2949	58.0096	-28.9862	-1.3829	-0.0764	0.1945	-0.9120	0.9356	0.0000	NA
	10	57.3691	-23.3605	-2.3658	57.3198	-23.1439	-1.6896	0.0493	0.2166	-0.6762	0.7118	0.0493	X
FLOOR PAN (Z)	11	50.9128	-41.8832	0.4572	51.0216	-41.5546	0.4815	-0.1088	0.3286	-0.0243	0.3470	-0.0243	Z
	12	50.9167	-36.6147	0.4363	50.8864	-36.3773	1.0410	0.0303	0.2374	-0.6047	0.6503	-0.6047	Z
	13	50.9702	-32.2000	0.4882	50.9669	-31.9749	1.1608	0.0033	0.2251	-0.6726	0.7093	-0.6726	Z
	14	50.8472	-28.0746	0.5321	50.8443	-27.8371	1.1638	0.0029	0.2375	-0.6317	0.6749	-0.6317	Z
	15	50.7901	-23.2267	-0.8426	50.7708	-23.0741	-0.2593	0.0193	0.1526	-0.5833	0.6032	-0.5833	Z
	16	45.7817	-41.3056	0.5199	45.8094	-40.9610	0.3730	-0.0277	0.3446	0.1469	0.3756	0.1469	Z
	17	46.1061	-35.9879	0.4760	46.0981	-35.7493	0.9530	0.0080	0.2386	-0.4770	0.5334	-0.4770	Z
	18	46.2578	-32.1169	0.5108	46.2580	-31.9589	1.0896	-0.0002	0.1580	-0.5788	0.6000	-0.5788	Z
	19	46.4552	-27.3657	0.5647	46.4190	-27.2109	1.1271	0.0362	0.1548	-0.5624	0.5844	-0.5624	Z
	20	46.3854	-23.2652	-0.5051	46.2826	-23.1119	-0.0046	0.1028	0.1533	-0.5005	0.5335	-0.5005	Z
	21	40.1010	-41.6699	0.5754	40.1169	-41.4691	0.7087	-0.0159	0.2008	-0.1333	0.2415	-0.1333	Z
	22	40.1543	-37.4627	0.5733	40.2117	-37.2859	0.9202	-0.0574	0.1768	-0.3469	0.3936	-0.3469	Z
	23	40.1131	-32.8956	0.6351	40.1300	-32.8185	1.0382	-0.0169	0.0771	-0.4031	0.4108	-0.4031	Z
	24	40.2915	-28.4305	0.6777	40.2682	-28.3171	1.0955	0.0233	0.1134	-0.4178	0.4335	-0.4178	Z
	25	40.6479	-23.3835	-0.1527	40.6392	-23.2818	0.2835	0.0087	0.1017	-0.4362	0.4480	-0.4362	Z
	26	36.1176	-40.4703	-0.1544	36.1458	-40.2862	0.2626	-0.0282	0.1841	-0.4170	0.4567	-0.4170	Z
	27	36.4053	-35.9875	-0.1272	36.3591	-35.8632	0.2768	0.0462	0.1243	-0.4040	0.4252	-0.4040	Z
	28	36.5614	-31.6969	-0.0892	36.5899	-31.5440	0.2963	-0.0285	0.1529	-0.3855	0.4157	-0.3855	Z
	29	36.6212	-28.1076	-0.2590	36.5986	-27.9729	0.1057	0.0226	0.1347	-0.3647	0.3894	-0.3647	Z
	30	36.5484	-24.2489	-0.4576	36.4849	-24.0958	-0.1308	0.0635	0.1531	-0.3268	0.3664	-0.3268	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 H-2. Floor Pan Deformation Data – Set 2, Test No. NYHBT-1

Model Year: 2014 Test Name: NYHBT-1 Make: Dodge VIN: 1C6RR6LG6ES164753 Model: Ram 1500

VEHICLE DEFORMATION
DRIVER SIDE 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	50.7130	-23.9340	-26.8838	50.4422	-23.5423	-26.1074	0.2708	0.3917	0.7764	0.9108	0.9108	X, Y, Z
	2	48.1661	-11.3074	-29.2909	48.0659	-10.8791	-28.8537	0.1002	0.4283	0.4372	0.6202	0.6202	X, Y, Z
	3	49.6240	4.3914	-27.9916	49.7077	4.8371	-27.6067	-0.0837	-0.4457	0.3849	0.5948	0.5948	X, Y, Z
	4	45.1804	-25.1180	-16.1265	44.8627	-23.7264	-15.2446	0.3177	1.3916	0.8819	1.6779	1.6779	X, Y, Z
	5	43.6907	-12.7701	-14.3666	43.1623	-12.0788	-13.2771	0.5284	0.6913	1.0895	1.3943	1.3943	X, Y, Z
	6	42.3339	4.6561	-20.2724	42.4737	5.1707	-19.8630	-0.1398	-0.5146	0.4094	0.6723	0.6723	X, Y, Z
SIDE PANEL (Y)	7	54.1667	-27.3919	-3.8786	53.9375	-24.0163	-3.0499	0.2292	3.3756	0.8287	3.4834	3.3756	Y
	8	54.0037	-27.4410	1.8429	53.8987	-24.8081	2.9759	0.1050	2.6329	1.1330	2.8683	2.6329	Y
	9	58.2491	-27.4224	-2.4791	57.8844	-24.0903	-1.6149	0.3647	3.3321	0.8642	3.4616	3.3321	Y
IMPACT SIDE DOOR (Y)	10	23.7370	-30.4536	-17.6375	22.9868	-31.1896	-17.4497	0.7502	-0.7360	0.1878	1.0676	-0.7360	Y
	11	33.5781	-29.6046	-18.5888	32.7822	-29.9281	-18.2561	0.7959	-0.3235	0.3327	0.9213	-0.3235	Y
	12	45.0602	-29.6031	-19.3656	44.2282	-29.4334	-18.7430	0.8320	0.1697	0.6226	1.0529	0.1697	Y
	13	22.4074	-30.1580	-2.7090	21.2629	-30.9326	-2.5980	1.1445	-0.7746	0.1110	1.3864	-0.7746	Y
	14	33.4768	-30.8912	-3.6609	32.2449	-29.8267	-3.3518	1.2319	1.0645	0.3091	1.6572	1.0645	Y
	15	41.2455	-30.2728	-2.9094	39.7666	-28.1905	-2.2962	1.4789	2.0823	0.6132	2.6266	2.0823	Y
ROOF - (Z)	16	30.2006	-18.2398	-44.9709	30.4418	-18.3257	-44.6221	-0.2412	-0.0859	0.3488	0.4327	0.3488	Z
	17	30.8852	-11.7986	-45.4812	31.0720	-11.8990	-45.1231	-0.1868	-0.1004	0.3581	0.4162	0.3581	Z
	18	31.5580	-4.9326	-45.7678	31.7256	-5.0151	-45.4099	-0.1676	-0.0825	0.3579	0.4037	0.3579	Z
	19	31.3889	0.9148	-45.9833	31.6532	0.8458	-45.5894	-0.2643	0.0690	0.3939	0.4793	0.3939	Z
	20	30.7661	6.3587	-46.1222	30.9488	6.3348	-45.7288	-0.1827	0.0239	0.3934	0.4344	0.3934	Z
	21	21.4589	-18.7521	-45.6605	21.6320	-18.7797	-45.4309	-0.1731	-0.0276	0.2296	0.2889	0.2296	Z
	22	21.1142	-12.1107	-46.3338	21.3398	-12.2054	-46.0659	-0.2256	-0.0947	0.2679	0.3628	0.2679	Z
	23	20.1605	-3.9334	-46.7914	20.3469	-4.0270	-46.5108	-0.1864	-0.0936	0.2806	0.3496	0.2806	Z
	24	19.6042	2.4970	-46.9715	19.8042	2.4675	-46.6755	-0.2000	0.0295	0.2960	0.3584	0.2960	Z
	25	19.5969	6.6383	-46.9888	19.7680	6.5648	-46.6818	-0.1711	0.0735	0.3070	0.3591	0.3070	Z
	26	14.6289	-18.1010	-46.1361	14.8470	-18.1978	-45.9805	-0.2181	-0.0968	0.1556	0.2849	0.1556	Z
	27	13.9955	-9.5495	-46.7949	14.1888	-9.5498	-46.5837	-0.1933	-0.0003	0.2112	0.2863	0.2112	Z
	28	14.1146	-4.3819	-47.0203	14.3001	-4.4872	-46.7802	-0.1855	-0.1053	0.2401	0.3212	0.2401	Z
	29	14.1307	1.7298	-47.1715	14.3527	1.6622	-46.9196	-0.2220	0.0676	0.2519	0.3425	0.2519	Z
	30	13.9968	6.3117	-47.1895	14.1669	6.2435	-46.9293	-0.1701	0.0682	0.2602	0.3183	0.2602	Z
A-PILLAR Maximum (X, Y, Z)	31	50.5454	-25.4920	-30.3771	50.4646	-25.6348	-29.5258	0.0808	-0.1428	0.8513	0.8670	0.8551	X, Z
	32	47.6575	-24.0449	-32.4171	47.6433	-24.1750	-31.6427	0.0142	-0.1301	0.7744	0.7854	0.7745	X, Z
	33	44.6158	-24.0055	-34.9342	44.6113	-24.1098	-34.2216	0.0045	-0.1043	0.7126	0.7202	0.7126	X, Z
	34	40.3700	-22.3700	-37.1956	40.4779	-22.5364	-36.6670	-0.1079	-0.1664	0.5286	0.5646	0.5286	Z
	35	37.4536	-22.8434	-39.5496	37.6593	-23.0749	-39.0632	-0.2057	-0.2315	0.4864	0.5766	0.4864	Z
	36	35.2910	-21.7683	-40.9471	35.4861	-22.0062	-40.5484	-0.1951	-0.2379	0.3987	0.5036	0.3987	Z
A-PILLAR Lateral (Y)	31	50.5454	-25.4920	-30.3771	50.4646	-25.6348	-29.5258	0.0808	-0.1428	0.8513	0.8670	-0.1428	Y
	32	47.6575	-24.0449	-32.4171	47.6433	-24.1750	-31.6427	0.0142	-0.1301	0.7744	0.7854	-0.1301	Y
	33	44.6158	-24.0055	-34.9342	44.6113	-24.1098	-34.2216	0.0045	-0.1043	0.7126	0.7202	-0.1043	Y
	34	40.3700	-22.3700	-37.1956	40.4779	-22.5364	-36.6670	-0.1079	-0.1664	0.5286	0.5646	-0.1664	Y
	35	37.4536	-22.8434	-39.5496	37.6593	-23.0749	-39.0632	-0.2057	-0.2315	0.4864	0.5766	-0.2315	Y
	36	35.2910	-21.7683	-40.9471	35.4861	-22.0062	-40.5484	-0.1951	-0.2379	0.3987	0.5036	-0.2379	Y
B-PILLAR Maximum (X, Y, Z)	37	9.8371	-23.6846	-38.4736	9.8973	-23.6394	-38.4181	-0.0602	0.0452	0.0555	0.0935	0.0716	Y, Z
	38	13.6732	-26.9983	-27.8553	13.7796	-26.8068	-27.6676	-0.1064	0.1915	0.1877	0.2885	0.2681	Y, Z
	39	10.6918	-27.6775	-17.3886	10.6995	-27.1168	-17.2729	-0.0077	0.5607	0.1157	0.5726	0.5725	Y, Z
	40	15.6071	-27.7477	-10.2527	15.6388	-27.2579	-9.9783	-0.0317	0.4898	0.2744	0.5623	0.5614	Y, Z
B-PILLAR Lateral (Y)	37	9.8371	-23.6846	-38.4736	9.8973	-23.6394	-38.4181	-0.0602	0.0452	0.0555	0.0935	0.0452	Y
	38	13.6732	-26.9983	-27.8553	13.7796	-26.8068	-27.6676	-0.1064	0.1915	0.1877	0.2885	0.1915	Y
	39	10.6918	-27.6775	-17.3886	10.6995	-27.1168	-17.2729	-0.0077	0.5607	0.1157	0.5726	0.5607	Y
	40	15.6071	-27.7477	-10.2527	15.6388	-27.2579	-9.9783	-0.0317	0.4898	0.2744	0.5623	0.4898	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 H-3. Occupant Compartment Deformation Data – Set 1, Test No. NYHBT-1

Model Year: 2014 Test Name: NYHBT-1 Make: Dodge VIN: 1C6RR6LG6ES164753 Model: Ram 1500

VEHICLE DEFORMATION
DRIVER SIDE 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	49.1756	-41.5016	-31.8195	48.9378	-41.3462	-30.8266	0.2378	0.1554	0.9929	1.0327	1.0327	X, Y, Z
	2	46.9159	-28.7996	-34.1140	46.8513	-28.6298	-33.5627	0.0646	0.1698	0.5513	0.5805	0.5805	X, Y, Z
	3	48.7711	-13.1508	-32.7210	48.8955	-12.9585	-32.3468	-0.1244	0.1923	0.3742	0.4387	0.4387	X, Y, Z
	4	43.7208	-42.6266	-21.0163	43.4589	-41.3833	-19.9112	0.2619	1.2433	1.1051	1.6839	1.6839	X, Y, Z
	5	42.5518	-30.2589	-19.1565	42.0676	-29.6955	-17.9392	0.4842	0.5634	1.2173	1.4261	1.4261	X, Y, Z
	6	41.5654	-12.7630	-24.9283	41.7459	-12.4392	-24.5353	-0.1805	0.3238	0.3930	0.5403	0.5403	X, Y, Z
SIDE PANEL (Y)	7	52.7677	-45.2071	-8.8741	52.6391	-41.8898	-7.8028	0.1286	3.3173	1.0713	3.4884	3.3173	Y
	8	52.6593	-45.2931	-3.1518	52.6378	-42.6758	-1.7761	0.0215	2.6173	1.3757	2.9569	2.6173	Y
	9	56.8616	-45.3474	-7.5155	56.5964	-42.0609	-6.4051	0.2652	3.2865	1.1104	3.4791	3.2865	Y
IMPACT SIDE DOOR (Y)	10	22.1393	-47.4251	-22.3511	21.3841	-48.3014	-21.9016	0.7552	-0.8763	0.4495	1.2411	-0.8763	Y
	11	31.9884	-46.8104	-23.3942	31.1998	-47.2847	-22.8020	0.7886	-0.4743	0.5922	1.0943	-0.4743	Y
	12	43.4590	-47.0842	-24.2848	42.6494	-47.0754	-23.3979	0.8096	0.0088	0.8869	1.2009	0.0088	Y
	13	20.9630	-47.2036	-7.4085	19.8082	-47.9904	-7.0345	1.1548	-0.7868	0.3740	1.4465	-0.7868	Y
	14	32.0013	-48.2007	-8.4753	30.8068	-47.1588	-7.8935	1.1945	1.0419	0.5818	1.6885	1.0419	Y
	15	39.7898	-47.7779	-7.7966	38.3765	-45.7095	-6.9108	1.4133	2.0684	0.8858	2.6571	2.0684	Y
ROOF - (Z)	16	28.6336	-35.1784	-49.6624	28.8986	-35.6473	-49.1561	-0.2650	-0.4689	0.5063	0.7392	0.5063	Z
	17	29.4711	-28.7523	-50.1350	29.6837	-29.2387	-49.6694	-0.2126	-0.4864	0.4656	0.7061	0.4656	Z
	18	30.3093	-21.9030	-50.3809	30.5056	-22.3734	-49.9691	-0.1963	-0.4704	0.4118	0.6553	0.4118	Z
	19	30.2816	-16.0518	-50.5544	30.5773	-16.5127	-50.1537	-0.2957	-0.4609	0.4007	0.6785	0.4007	Z
	20	29.7912	-10.5934	-50.6496	30.0084	-11.0079	-50.2918	-0.2172	-0.4145	0.3578	0.5891	0.3578	Z
	21	19.8757	-35.4716	-50.2687	20.0729	-35.8825	-49.8809	-0.1972	-0.4109	0.3878	0.5984	0.3878	Z
	22	19.6875	-28.8192	-50.8927	19.9383	-29.3035	-50.5196	-0.2508	-0.4843	0.3731	0.6608	0.3731	Z
	23	18.9303	-20.6180	-51.2845	19.1450	-21.1033	-50.9631	-0.2147	-0.4853	0.3214	0.6204	0.3214	Z
	24	18.5302	-14.1748	-51.4147	18.7626	-14.5973	-51.1291	-0.2324	-0.4225	0.2856	0.5604	0.2856	Z
	25	18.6243	-10.0345	-51.4033	18.8283	-10.5005	-51.1391	-0.2040	-0.4660	0.2642	0.5732	0.2642	Z
	26	13.0594	-34.6503	-50.6720	13.2995	-35.1324	-50.3669	-0.2401	-0.4821	0.3051	0.6190	0.3051	Z
	27	12.6296	-26.0814	-51.2655	12.8510	-26.4711	-50.9723	-0.2214	-0.3897	0.2932	0.5356	0.2932	Z
	28	12.8732	-20.9167	-51.4564	13.0864	-21.4130	-51.1748	-0.2132	-0.4963	0.2816	0.6092	0.2816	Z
	29	13.0378	-14.8064	-51.5656	13.2907	-15.2669	-51.3208	-0.2529	-0.4605	0.2448	0.5796	0.2448	Z
	30	13.0162	-10.2225	-51.5507	13.2187	-10.6825	-51.3332	-0.2025	-0.4600	0.2175	0.5476	0.2175	Z
A-PILLAR Maximum (X, Y, Z)	31	48.9358	-43.0301	-35.3217	48.8758	-43.4412	-34.2430	0.0600	-0.4111	1.0787	1.1559	1.0804	X, Z
	32	46.0644	-41.4983	-37.3229	46.0717	-41.9133	-36.3345	-0.0073	-0.4150	0.9884	1.0720	0.9884	Z
	33	43.0002	-41.3665	-39.8093	43.0179	-41.7746	-38.8846	-0.0177	-0.4081	0.9247	1.0109	0.9247	Z
	34	38.7740	-39.6115	-42.0171	38.9019	-40.1006	-41.2923	-0.1279	-0.4891	0.7248	0.8837	0.7248	Z
	35	35.8241	-39.9966	-44.3453	36.0481	-40.5706	-43.6611	-0.2240	-0.5740	0.6842	0.9208	0.6842	Z
	36	33.6750	-38.8589	-45.7138	33.8882	-39.4492	-45.1267	-0.2132	-0.5903	0.5871	0.8594	0.5871	Z
A-PILLAR Lateral (Y)	31	48.9358	-43.0301	-35.3217	48.8758	-43.4412	-34.2430	0.0600	-0.4111	1.0787	1.1559	-0.4111	Y
	32	46.0644	-41.4983	-37.3229	46.0717	-41.9133	-36.3345	-0.0073	-0.4150	0.9884	1.0720	-0.4150	Y
	33	43.0002	-41.3665	-39.8093	43.0179	-41.7746	-38.8846	-0.0177	-0.4081	0.9247	1.0109	-0.4081	Y
	34	38.7740	-39.6115	-42.0171	38.9019	-40.1006	-41.2923	-0.1279	-0.4891	0.7248	0.8837	-0.4891	Y
	35	35.8241	-39.9966	-44.3453	36.0481	-40.5706	-43.6611	-0.2240	-0.5740	0.6842	0.9208	-0.5740	Y
	36	33.6750	-38.8589	-45.7138	33.8882	-39.4492	-45.1267	-0.2132	-0.5903	0.5871	0.8594	-0.5903	Y
B-PILLAR Maximum (X, Y, Z)	37	8.2070	-40.1696	-43.0010	8.2880	-40.4435	-42.7525	-0.0810	-0.2739	0.2485	0.3786	0.2485	Z
	38	12.0641	-43.6519	-32.4444	12.1922	-43.6985	-32.0362	-0.1281	-0.0466	0.4082	0.4304	0.4082	Z
	39	9.1692	-44.3325	-21.9535	9.2042	-43.9239	-21.6125	-0.0350	0.4086	0.3410	0.5333	0.5322	Y, Z
	40	14.1506	-44.5739	-14.8675	14.2075	-44.1825	-14.3648	-0.0569	0.3914	0.5027	0.6396	0.6371	Y, Z
B-PILLAR Lateral (Y)	37	8.2070	-40.1696	-43.0010	8.2880	-40.4435	-42.7525	-0.0810	-0.2739	0.2485	0.3786	-0.2739	Y
	38	12.0641	-43.6519	-32.4444	12.1922	-43.6985	-32.0362	-0.1281	-0.0466	0.4082	0.4304	-0.0466	Y
	39	9.1692	-44.3325	-21.9535	9.2042	-43.9239	-21.6125	-0.0350	0.4086	0.3410	0.5333	0.4086	Y
	40	14.1506	-44.5739	-14.8675	14.2075	-44.1825	-14.3648	-0.0569	0.3914	0.5027	0.6396	0.3914	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 H-4. Occupant Compartment Deformation Data – Set 2, Test No. NYHBT-1

Test Name: NYHBT-1 VIN: 1C6RR6LG6ES164753

Model Year: 2014 Make: Dodge Model: Ram 1500

Driver Side Maximum Deformation

Reference Set 1				Reference Set 2			
Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]	Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]
Roof	0.4	≤ 4	Z	Roof	0.5	≤ 4	Z
Windshield[D]	0.0	≤ 3	X, Z	Windshield[D]	NA	≤ 3	X, Z
A-Pillar Maximum	0.9	≤ 5	X, Z	A-Pillar Maximum	1.1	≤ 5	X, Z
A-Pillar Lateral	-0.2	≤ 3	Y	A-Pillar Lateral	-0.6	≤ 3	Y
B-Pillar Maximum	0.6	≤ 5	Y, Z	B-Pillar Maximum	0.6	≤ 5	Y, Z
B-Pillar Lateral	-0.2	≤ 3	Y	B-Pillar Lateral	0.4	≤ 3	Y
Toe Pan - Wheel Well	0.0	≤ 9	NA	Toe Pan - Wheel Well	0.1	≤ 9	X
Side Front Panel	3.4	≤ 12	Y	Side Front Panel	3.3	≤ 12	Y
Side Door (above seat)	0.2	≤ 9	Y	Side Door (above seat)	0.0	≤ 9	Y
Side Door (below seat)	2.1	≤ 12	Y	Side Door (below seat)	2.1	≤ 12	Y
Floor Pan	0.2	≤ 12	Z	Floor Pan	0.1	≤ 12	Z
Dash - no MASH requirement	1.7	NA	X, Y, Z	Dash - no MASH requirement	1.7	NA	X, Y, Z

[A] Items highlighted in red do not meet MASH allowable deformations.

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

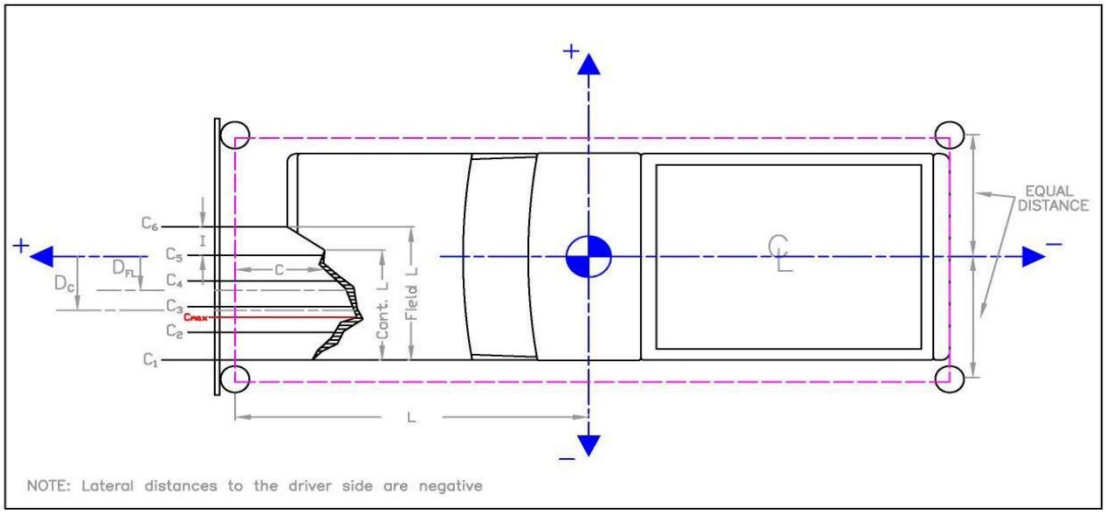
[C] For Toe Pan - Wheel Well the direction of defromation may include X and Z direction. For A-Pillar Maximum and B-Pillar Maximum the direction of deformation may include X, Y, and Z directions. The direction of deformation for Toe Pan -Wheel Well, A-Pillar Maximum, and B-Pillar Maximum only include components where the deformation is positive and intruding into the occupant compartment. If direction of deformation is "NA" then no intrusion is recorded and deformation will be 0.

[D] If deformation is observered for the windshield then the windshield deformation is measured posttest with an examplar vehicle, therefore only one set of reference is measured and recorded.

Notes on vehicle interior crush:

Figure H-5. Maximum Occupant Compartment Deformation by Location, Test No. NYHBT-1

Date Measured:	5/27/2020	Test Name:	NYHBT-1	VIN:	1C6RR6LG6ES164753
Model Year:	2014	Make:	Dodge	Model:	Ram 1500



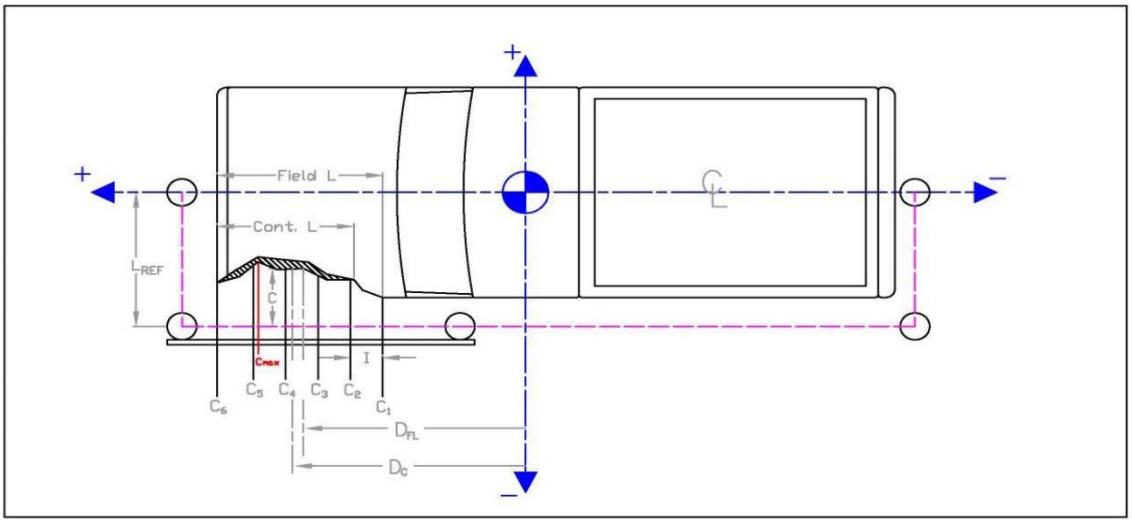
	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	123 1/2	(3137)
Total Vehicle Width:	77 7/8	(1978)
Width of contact and induced crush - Field L:	77 7/8	(1978)
Crush measurement spacing interval (L/5) - I:	15 5/8	(397)
Distance from center of vehicle to center of Field L - D_{FL}:	0	()
Width of Contact Damage:	-27	-(684)
Distance from center of vehicle to center of contact damage - D_C:	-25 4/9	-(646)

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	N/A	-39	-(991)	22 1/2	(572)	13 1/8	(333)	N/A	N/A
C_2	34 1/4	(870)	-23 3/8	-(594)	6 5/8	(168)			14 1/2	(368)
C_3	16 1/2	(419)	-7 3/4	-(197)	4 1/4	(108)			- 7/8	-(22)
C_4	15 3/4	(400)	7 7/8	(200)	4 1/4	(108)			-1 5/8	-(41)
C_5	20 1/2	(521)	23 1/2	(597)	6 1/4	(159)			1 1/8	(29)
C_6	N/a	N/A	39 1/8	(994)	20 1/2	(521)			N/A	N/A
C_{MAX}	38	(965)	-25	-(635)	7	(178)			17 7/8	(454)

Figure H-6. Exterior Vehicle Crush (NASS) – Front, Test No. NYHBT-1

Date Measured:	5/27/2020	Test Name:	NYHBT-1	VIN:	1C6RR6LG6ES164753
Model Year:	2014	Make:	Dodge	Model:	Ram 1500



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	49 1/2	(1257)
Total Vehicle Length:	228 3/4	(5810)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-9 1/4	-(235)
Width of contact and induced crush - Field L:	228 3/4	(5810)
Crush measurement spacing interval (L/5) - I:	45 3/4	(1162)
Distance from vehicle c.g. to center of Field L - D_{FL}:	-9 1/4	-(235)
Width of Contact Damage:	228 3/4	(5810)
Distance from vehicle c.g. to center of contact damage - D_C:	-9 1/4	-(235)

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	N/A	-123 5/8	-(3140)	33 1/2	(851)	5 1/2	(140)	N/A	N/A
C_2	N/a	N/A	-77 7/8	-(1978)	5 1/2	(140)			N/A	N/A
C_3	11 5/8	(295)	-32 1/8	-(816)	5 3/4	(146)			3/8	(10)
C_4	12	(305)	13 5/8	(346)	5	(127)			1 1/2	(38)
C_5	n/a	N/A	59 3/8	(1508)	5 1/2	(140)			N/A	N/A
C_6	n/a	N/A	105 1/8	(2670)	8 3/8	(213)			N/A	N/A
C_{MAX}	28	(711)	95	(2413)	5 7/8	(149)			16 5/8	(422)

Figure H-7. Exterior Vehicle Crush (NASS) – Side, Test No. NYHBT-1

Model Year: 2010 Test Name: NYHBT-2 Make: Kia VIN: KNADH4A38A6687587 Model: Rio

VEHICLE DEFORMATION
DRIVER SIDE 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	61.9703	-10.4122	4.4897	61.7635	-10.5704	4.5992	0.2068	-0.1582	-0.1095	0.2825	0.2068	X
	2	61.9710	-7.5997	4.6487	61.7136	-7.7773	4.5917	0.2574	-0.1776	0.0570	0.3179	0.2636	X, Z
	3	62.2897	-5.1316	4.4788	62.0504	-5.3481	4.3639	0.2393	-0.2165	0.1149	0.3425	0.2655	X, Z
	4	62.1476	-2.2050	4.6123	61.9286	-2.3276	4.4936	0.2190	-0.1226	0.1187	0.2776	0.2491	X, Z
	5	61.1643	5.5053	4.0401	61.0630	5.3400	3.9225	0.1013	0.1653	0.1176	0.2267	0.1552	X, Z
	6	57.8077	-10.5730	7.0219	57.6101	-10.6768	7.0447	0.1976	-0.1038	-0.0228	0.2244	0.1976	X
	7	57.8794	-7.3827	6.8813	57.6662	-7.5070	6.8609	0.2132	-0.1243	0.0204	0.2476	0.2142	X, Z
	8	58.1186	-4.8159	6.8041	57.8823	-4.9628	6.7505	0.2363	-0.1469	0.0536	0.2834	0.2423	X, Z
	9	58.2489	-1.9960	6.8605	58.0355	-2.1395	6.7653	0.2134	-0.1435	0.0952	0.2742	0.2337	X, Z
	10	57.9849	5.5419	4.1985	57.8829	5.3726	4.1469	0.1020	0.1693	0.0516	0.2043	0.1143	X, Z
FLOOR PAN (Z)	11	52.8020	-14.7767	7.4267	52.6182	-14.8574	7.4906	0.1838	-0.0807	-0.0639	0.2107	-0.0639	Z
	12	52.3982	-9.4482	7.3609	52.2353	-9.5465	7.3682	0.1629	-0.0983	-0.0073	0.1904	-0.0073	Z
	13	51.8939	-4.6068	7.2983	51.7093	-4.6823	7.2783	0.1846	-0.0755	0.0200	0.2004	0.0200	Z
	14	52.1485	1.1137	7.6060	51.9598	1.0779	7.2116	0.1887	0.0358	0.3944	0.4387	0.3944	Z
	15	52.1618	5.5470	4.7652	52.0031	5.4490	4.6409	0.1587	0.0980	0.1243	0.2241	0.1243	Z
	16	48.0062	-14.8003	7.7096	47.7971	-14.8753	7.7777	0.2091	-0.0750	-0.0681	0.2323	-0.0681	Z
	17	48.1881	-9.9353	7.7833	47.9729	-10.0147	7.8614	0.2152	-0.0794	-0.0781	0.2423	-0.0781	Z
	18	48.0924	-4.4652	7.4285	47.8906	-4.5323	7.4382	0.2018	-0.0671	-0.0097	0.2129	-0.0097	Z
	19	48.5324	1.2084	8.0387	48.3891	1.1089	7.8881	0.1433	0.0995	0.1506	0.2305	0.1506	Z
	20	49.0388	5.3383	4.8017	48.9329	5.2693	4.6864	0.1059	0.0690	0.1153	0.1711	0.1153	Z
	21	44.1202	-14.7075	7.8148	43.8934	-14.7414	7.8730	0.2268	-0.0339	-0.0582	0.2366	-0.0582	Z
	22	43.9212	-10.2677	7.9814	43.7264	-10.3289	8.0599	0.1948	-0.0612	-0.0785	0.2188	-0.0785	Z
	23	44.2703	-4.3923	7.5362	44.0667	-4.4422	7.5554	0.2036	-0.0499	-0.0192	0.2105	-0.0192	Z
	24	44.3667	1.7907	8.1114	44.2147	1.6854	8.0460	0.1520	0.1053	0.0654	0.1961	0.0654	Z
	25	44.7798	5.4636	5.1537	44.6249	5.4275	5.0774	0.1549	0.0361	0.0763	0.1764	0.0763	Z
	26	39.2751	-12.7451	7.7708	39.0503	-12.8086	7.8310	0.2248	-0.0635	-0.0602	0.2412	-0.0602	Z
	27	39.3914	-9.4685	7.6925	39.1871	-9.4355	7.7525	0.2043	0.0330	-0.0600	0.2155	-0.0600	Z
	28	39.2802	-3.7622	7.6408	39.1351	-3.7820	7.6579	0.1451	-0.0198	-0.0171	0.1474	-0.0171	Z
	29	39.1004	2.4068	7.4797	38.9161	2.3601	7.5063	0.1843	0.0467	-0.0266	0.1920	-0.0266	Z
	30	39.4470	5.4356	4.9955	39.3416	5.3823	4.9220	0.1054	0.0533	0.0735	0.1391	0.0735	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 H-8. Floor Pan Deformation Data – Set 1, Test No. NYHBT-2

Model Year: 2010 Test Name: NYHBT-2 Make: Kia VIN: KNADH4A38A6687587 Model: Rio

VEHICLE DEFORMATION
DRIVER SIDE 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	60.6878	-29.3325	5.2579	60.7677	-28.9327	5.6969	-0.0799	0.3998	-0.4390	0.5991	0.0000	NA
	2	60.7722	-26.5229	5.4442	60.7806	-26.1395	5.7387	-0.0084	0.3834	-0.2945	0.4835	0.0000	NA
	3	61.1689	-24.0644	5.3031	61.1768	-23.7149	5.5625	-0.0079	0.3495	-0.2594	0.4353	0.0000	NA
	4	61.1144	-21.1362	5.4628	61.1197	-20.6952	5.7438	-0.0053	0.4410	-0.2810	0.5229	0.0000	NA
	5	60.3766	-13.3942	4.9508	60.4393	-13.0010	5.2916	-0.0627	0.3932	-0.3408	0.5241	0.0000	NA
	6	56.4838	-29.3886	7.7254	56.5574	-28.9873	8.0451	-0.0736	0.4013	-0.3197	0.5183	0.0000	NA
	7	56.6554	-26.2008	7.6169	56.6887	-25.8168	7.9198	-0.0333	0.3840	-0.3029	0.4902	0.0000	NA
	8	56.9742	-23.6420	7.5682	56.9642	-23.2767	7.8603	0.0100	0.3653	-0.2921	0.4678	0.0100	X
	9	57.1898	-20.8280	7.6539	57.1802	-20.4582	7.9294	0.0096	0.3698	-0.2755	0.4612	0.0096	X
	10	57.1977	-13.2613	5.0615	57.2563	-12.8999	5.4441	-0.0586	0.3614	-0.3826	0.5296	0.0000	NA
FLOOR PAN (Z)	11	51.3461	-33.4398	8.0139	51.4643	-33.0602	8.3019	-0.1182	0.3796	-0.2880	0.4909	-0.2880	Z
	12	51.1068	-28.1011	7.9937	51.2032	-27.7406	8.2666	-0.0964	0.3605	-0.2729	0.4623	-0.2729	Z
	13	50.7520	-23.2460	7.9706	50.7884	-22.8648	8.2525	-0.0364	0.3812	-0.2819	0.4755	-0.2819	Z
	14	51.1768	-17.5392	8.3376	51.1693	-17.1116	8.2954	0.0075	0.4276	0.0422	0.4297	0.0422	Z
	15	51.3695	-13.0823	5.5404	51.3699	-12.6982	5.8056	-0.0004	0.3841	-0.2652	0.4668	-0.2652	Z
	16	46.5481	-33.3185	8.2243	46.6387	-32.9733	8.4789	-0.0906	0.3452	-0.2546	0.4384	-0.2546	Z
	17	46.8777	-28.4623	8.3480	46.9213	-28.1201	8.6543	-0.0436	0.3422	-0.3063	0.4613	-0.3063	Z
	18	46.9550	-22.9888	8.0448	46.9715	-22.6308	8.3282	-0.0165	0.3580	-0.2834	0.4569	-0.2834	Z
	19	47.5591	-17.3373	8.7167	47.5855	-17.0111	8.8910	-0.0264	0.3262	-0.1743	0.3708	-0.1743	Z
	20	48.2414	-13.1952	5.5278	48.2961	-12.8087	5.7780	-0.0547	0.3865	-0.2502	0.4637	-0.2502	Z
	21	42.6656	-33.1072	8.2718	42.7378	-32.7522	8.4878	-0.0722	0.3550	-0.2160	0.4218	-0.2160	Z
	22	42.6001	-28.6651	8.4785	42.6652	-28.3410	8.7505	-0.0651	0.3241	-0.2720	0.4281	-0.2720	Z
	23	43.1357	-22.7994	8.0956	43.1488	-22.4556	8.3600	-0.0131	0.3438	-0.2644	0.4339	-0.2644	Z
	24	43.4126	-16.6278	8.7322	43.4225	-16.3425	8.9643	-0.0099	0.2853	-0.2321	0.3679	-0.2321	Z
	25	43.9833	-12.9421	5.8169	43.9848	-12.5592	6.0738	-0.0015	0.3829	-0.2569	0.4611	-0.2569	Z
	26	37.8841	-30.9963	8.1739	37.9414	-30.7091	8.3706	-0.0573	0.2872	-0.1967	0.3528	-0.1967	Z
	27	38.1019	-27.7243	8.1291	38.1555	-27.3392	8.3561	-0.0536	0.3851	-0.2270	0.4502	-0.2270	Z
	28	38.1662	-22.0170	8.1311	38.2322	-21.6851	8.3622	-0.0660	0.3319	-0.2311	0.4098	-0.2311	Z
	29	38.1779	-15.8442	8.0273	38.1542	-15.5379	8.3166	0.0237	0.3063	-0.2893	0.4220	-0.2893	Z
	30	38.6552	-12.8046	5.5781	38.7069	-12.4814	5.7975	-0.0517	0.3232	-0.2194	0.3940	-0.2194	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 H-9. Floor Pan Deformation Data – Set 2, Test No. NYHBT-2

Model Year: 2010 Test Name: NYHBT-2 Make: Kia VIN: KNADH4A38A6687587 Model: Rio

VEHICLE DEFORMATION
DRIVER SIDE 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	48.8758	-13.6626	-19.9787	48.6035	-13.3933	-19.8392	0.2723	0.2693	0.1395	0.4076	0.4076	X, Y, Z
	2	45.5899	-3.6221	-23.5581	45.3935	-3.4362	-23.5944	0.1964	0.1859	-0.0363	0.2729	0.2729	X, Y, Z
	3	48.4641	10.0304	-21.0647	48.4023	10.3455	-21.2435	0.0618	-0.3151	-0.1788	0.3675	0.3675	X, Y, Z
	4	48.2280	-12.7312	-9.5786	47.8754	-12.2164	-9.4936	0.3526	0.5148	0.0850	0.6297	0.6297	X, Y, Z
	5	47.8800	-2.7249	-9.0236	47.3779	-2.2430	-9.0290	0.5021	0.4819	-0.0054	0.6960	0.6960	X, Y, Z
	6	44.1206	9.5206	-13.5989	44.0285	9.9106	-13.7896	0.0921	-0.3900	-0.1907	0.4438	0.4438	X, Y, Z
SIDE PANEL (Y)	7	53.3520	-17.0813	-0.9176	53.1113	-16.3406	-0.6195	0.2407	0.7407	0.2981	0.8339	0.7407	Y
	8	53.3851	-17.0989	1.7858	53.1730	-16.6221	1.9834	0.2121	0.4768	0.1976	0.5580	0.4768	Y
	9	57.5514	-17.2837	1.9721	57.3541	-16.9164	2.1207	0.1973	0.3673	0.1486	0.4426	0.3673	Y
IMPACT SIDE DOOR (Y)	10	22.3149	-18.4809	-17.2538	21.7245	-18.9776	-17.3404	0.5904	-0.4967	-0.0866	0.7764	-0.4967	Y
	11	31.7148	-18.3785	-17.3584	31.0909	-18.6016	-17.3540	0.6239	-0.2231	0.0044	0.6626	-0.2231	Y
	12	41.6785	-18.6279	-17.0686	41.0923	-18.5045	-16.9834	0.5862	0.1234	0.0852	0.6051	0.1234	Y
	13	23.9108	-18.3039	-9.1946	23.2735	-18.9213	-9.2143	0.6373	-0.6174	-0.0197	0.8875	-0.6174	Y
	14	32.7367	-18.2192	-9.3222	32.0926	-19.0708	-9.2660	0.6441	-0.8516	0.0562	1.0692	-0.8516	Y
	15	41.2443	-18.0537	-9.7097	40.5539	-18.7237	-9.5854	0.6904	-0.6700	0.1243	0.9701	-0.6700	Y
ROOF - (Z)	16	27.9338	-7.6691	-37.7959	27.7861	-7.8202	-37.8842	0.1477	-0.1511	-0.0883	0.2290	-0.0883	Z
	17	28.0683	-3.5766	-38.1656	27.9141	-3.7155	-38.2577	0.1542	-0.1389	-0.0921	0.2271	-0.0921	Z
	18	28.1952	0.1000	-38.4076	28.0602	0.0534	-38.5138	0.1350	0.0466	-0.1062	0.1780	-0.1062	Z
	19	28.5261	4.8405	-38.5703	28.3944	4.7299	-38.6756	0.1317	0.1106	-0.1053	0.2017	-0.1053	Z
	20	28.7709	8.9579	-38.6180	28.6951	8.8670	-38.7132	0.0758	0.0909	-0.0952	0.1519	-0.0952	Z
	21	22.2960	-6.3308	-38.6481	22.1820	-6.4480	-38.7289	0.1140	-0.1172	-0.0808	0.1824	-0.0808	Z
	22	22.3025	-2.8389	-38.9358	22.1393	-2.9328	-39.0308	0.1632	-0.0939	-0.0950	0.2109	-0.0950	Z
	23	22.3229	0.7038	-39.1582	22.2026	0.5603	-39.2546	0.1203	0.1435	-0.0964	0.2106	-0.0964	Z
	24	22.3482	5.0782	-39.3413	22.2231	5.0253	-39.4467	0.1251	0.0529	-0.1054	0.1719	-0.1054	Z
	25	22.4137	8.7531	-39.4105	22.3822	8.6679	-39.5110	0.0315	0.0852	-0.1005	0.1355	-0.1005	Z
	26	17.4568	-6.0773	-38.9684	17.3416	-6.1823	-39.0555	0.1152	-0.1050	-0.0871	0.1786	-0.0871	Z
	27	17.2292	-2.2293	-39.2888	17.0884	-2.2745	-39.3800	0.1408	-0.0452	-0.0912	0.1737	-0.0912	Z
	28	17.1273	1.2596	-39.4860	17.0632	1.1807	-39.5741	0.0641	0.0789	-0.0881	0.1345	-0.0881	Z
	29	17.5987	5.0101	-39.6267	17.5294	4.8884	-39.7292	0.0693	0.1217	-0.1025	0.1736	-0.1025	Z
	30	17.5816	8.5820	-39.7015	17.4613	8.5569	-39.8212	0.1203	0.0251	-0.1197	0.1716	-0.1197	Z
A-PILLAR Maximum (X, Y, Z)	31	52.5466	-15.8931	-23.5923	52.2680	-15.8870	-23.5942	0.2786	0.0061	-0.0019	0.2787	0.2787	X, Y
	32	50.3219	-15.4250	-25.1168	49.9912	-15.4389	-25.1009	0.3307	-0.0139	0.0159	0.3314	0.3311	X, Z
	33	47.9248	-14.9269	-26.5381	47.6766	-14.9519	-26.5400	0.2482	-0.0250	-0.0019	0.2495	0.2482	X
	34	45.8777	-14.5283	-27.5635	45.6740	-14.5496	-27.5658	0.2037	-0.0213	-0.0023	0.2048	0.2037	X
	35	43.3583	-13.9239	-29.0741	43.2094	-13.9596	-29.0661	0.1489	-0.0357	0.0080	0.1533	0.1491	X, Z
	36	41.2529	-13.4587	-30.1637	41.0988	-13.4876	-30.1944	0.1541	-0.0289	-0.0307	0.1598	0.1541	X
A-PILLAR Lateral (Y)	31	52.5466	-15.8931	-23.5923	52.2680	-15.8870	-23.5942	0.2786	0.0061	-0.0019	0.2787	0.0061	Y
	32	50.3219	-15.4250	-25.1168	49.9912	-15.4389	-25.1009	0.3307	-0.0139	0.0159	0.3314	-0.0139	Y
	33	47.9248	-14.9269	-26.5381	47.6766	-14.9519	-26.5400	0.2482	-0.0250	-0.0019	0.2495	-0.0250	Y
	34	45.8777	-14.5283	-27.5635	45.6740	-14.5496	-27.5658	0.2037	-0.0213	-0.0023	0.2048	-0.0213	Y
	35	43.3583	-13.9239	-29.0741	43.2094	-13.9596	-29.0661	0.1489	-0.0357	0.0080	0.1533	-0.0357	Y
	36	41.2529	-13.4587	-30.1637	41.0988	-13.4876	-30.1944	0.1541	-0.0289	-0.0307	0.1598	-0.0289	Y
B-PILLAR Maximum (X, Y, Z)	37	13.9276	-12.1063	-33.3192	13.7216	-12.1732	-33.3824	0.2060	-0.0669	-0.0632	0.2256	0.2060	X
	38	11.7743	-13.8424	-29.5530	11.5808	-13.8653	-29.6695	0.1935	-0.0229	-0.1165	0.2270	0.1935	X
	39	15.9860	-15.3725	-25.4763	15.8286	-15.4243	-25.5372	0.1574	-0.0518	-0.0609	0.1765	0.1574	X
	40	13.0388	-16.4407	-20.2891	12.8639	-16.4619	-20.4056	0.1749	-0.0212	-0.1165	0.2112	0.1749	X
B-PILLAR Lateral (Y)	37	13.9276	-12.1063	-33.3192	13.7216	-12.1732	-33.3824	0.2060	-0.0669	-0.0632	0.2256	-0.0669	Y
	38	11.7743	-13.8424	-29.5530	11.5808	-13.8653	-29.6695	0.1935	-0.0229	-0.1165	0.2270	-0.0229	Y
	39	15.9860	-15.3725	-25.4763	15.8286	-15.4243	-25.5372	0.1574	-0.0518	-0.0609	0.1765	-0.0518	Y
	40	13.0388	-16.4407	-20.2891	12.8639	-16.4619	-20.4056	0.1749	-0.0212	-0.1165	0.2112	-0.0212	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 H-10. Occupant Compartment Deformation Data – Set 1, Test No. NYHBT-2

Model Year: 2010 Test Name: NYHBT-2 Make: Kia VIN: KNADH4A38A6687587 Model: Rio

VEHICLE DEFORMATION
DRIVER SIDE 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	47.7826	-31.9645	-19.6378	46.9535	-31.9754	-19.3020	0.8291	-0.0109	0.3358	0.8946	0.8946	X, Y, Z
	2	44.8371	-21.8036	-23.1732	44.2908	-21.8299	-22.9802	0.5463	-0.0263	0.1930	0.5800	0.5800	X, Y, Z
	3	48.0955	-8.2627	-20.5475	47.9145	-8.2389	-20.3976	0.1810	0.0238	0.1499	0.2362	0.2362	X, Y, Z
	4	47.0572	-31.0901	-9.2378	46.1005	-30.8922	-8.9557	0.9567	0.1979	0.2821	1.0169	1.0169	X, Y, Z
	5	47.0050	-21.0821	-8.6103	46.0732	-20.9128	-8.3687	0.9318	0.1693	0.2416	0.9774	0.9774	X, Y, Z
	6	43.6628	-8.6956	-13.1294	43.3943	-8.5545	-13.0255	0.2685	0.1411	0.1039	0.3206	0.3206	X, Y, Z
SIDE PANEL (Y)	7	51.9594	-35.6560	-0.5596	50.9756	-35.3724	-0.0488	0.9838	0.2836	0.5108	1.1442	0.2836	Y
	8	51.9643	-35.6943	2.1438	50.9779	-35.6886	2.5509	0.9864	0.0057	0.4071	1.0671	0.0057	Y
	9	56.1211	-36.0061	2.3702	55.1371	-36.1854	2.7553	0.9840	-0.1793	0.3851	1.0718	-0.1793	Y
IMPACT SIDE DOOR (Y)	10	21.0622	-35.9988	-17.2144	19.7979	-36.2899	-17.3341	1.2643	-0.2911	-0.1197	1.3029	-0.2911	Y
	11	30.4616	-36.1794	-17.2246	29.1704	-36.3649	-17.1836	1.2912	-0.1855	0.0410	1.3051	-0.1855	Y
	12	40.4098	-36.7315	-16.8374	39.1569	-36.7539	-16.6417	1.2529	-0.0224	0.1957	1.2683	-0.0224	Y
	13	22.5805	-35.9289	-9.1386	21.2045	-36.4081	-9.1828	1.3760	-0.4792	-0.0442	1.4577	-0.4792	Y
	14	31.4059	-36.1098	-9.1776	30.0059	-36.9813	-9.0865	1.4000	-0.8715	0.0911	1.6516	-0.8715	Y
	15	39.9181	-36.1983	-9.4791	38.4784	-37.0379	-9.2574	1.4397	-0.8396	0.2217	1.6813	-0.8396	Y
ROOF - (Z)	16	27.2132	-25.2117	-37.6167	26.7480	-25.1853	-37.6236	0.4652	0.0264	-0.0069	0.4660	-0.0069	Z
	17	27.4746	-21.1225	-37.9538	27.0791	-21.0872	-37.9409	0.3955	0.0353	0.0129	0.3973	0.0129	Z
	18	27.7146	-17.4497	-38.1666	27.4100	-17.3268	-38.1450	0.3046	0.1229	0.0216	0.3292	0.0216	Z
	19	28.1897	-12.7203	-38.2899	27.9708	-12.6701	-38.2396	0.2189	0.0502	0.0503	0.2301	0.0503	Z
	20	28.5589	-8.6119	-38.3038	28.4699	-8.5522	-38.2178	0.0890	0.0597	0.0860	0.1374	0.0860	Z
	21	21.6272	-23.6976	-38.5148	21.2318	-23.5346	-38.5454	0.3954	0.1630	-0.0306	0.4288	-0.0306	Z
	22	21.7417	-20.2055	-38.7758	21.3630	-20.0181	-38.8018	0.3787	0.1874	-0.0260	0.4233	-0.0260	Z
	23	21.8711	-16.6635	-38.9710	21.5975	-16.5295	-38.9786	0.2736	0.1340	-0.0076	0.3047	-0.0076	Z
	24	22.0300	-12.2906	-39.1206	21.8352	-12.0687	-39.1116	0.1948	0.2219	0.0090	0.2954	0.0090	Z
	25	22.2068	-8.6190	-39.1612	22.1697	-8.4374	-39.1254	0.0371	0.1816	0.0358	0.1888	0.0358	Z
	26	16.8013	-23.2959	-38.8813	16.4163	-23.0322	-38.9507	0.3850	0.2637	-0.0694	0.4718	-0.0694	Z
	27	16.6930	-19.4405	-39.1747	16.3563	-19.1131	-39.2281	0.3367	0.3274	-0.0534	0.4727	-0.0534	Z
	28	16.6982	-15.9488	-39.3463	16.5001	-15.6587	-39.3772	0.1981	0.2901	-0.0309	0.3526	-0.0309	Z
	29	17.2837	-12.2133	-39.4538	17.1461	-11.9761	-39.4756	0.1376	0.2372	-0.0218	0.2751	-0.0218	Z
	30	17.3749	-8.6420	-39.5016	17.2554	-8.3077	-39.5206	0.1195	0.3343	-0.0190	0.3555	-0.0190	Z
A-PILLAR Maximum (X, Y, Z)	31	51.4212	-34.2783	-23.2315	50.5598	-34.5961	-23.0265	0.8614	-0.3178	0.2050	0.9408	0.8855	X, Z
	32	49.2273	-33.7322	-24.7745	48.3340	-34.0205	-24.5658	0.8933	-0.2883	0.2087	0.9616	0.9174	X, Z
	33	46.8608	-33.1516	-26.2158	46.0711	-33.4050	-26.0375	0.7897	-0.2534	0.1783	0.8483	0.8096	X, Z
	34	44.8372	-32.6839	-27.2584	44.1085	-32.8942	-27.0918	0.7287	-0.2103	0.1666	0.7765	0.7475	X, Z
	35	42.3527	-31.9927	-28.7895	41.7018	-32.1678	-28.6259	0.6509	-0.1751	0.1636	0.6936	0.6711	X, Z
	36	40.2735	-31.4562	-29.8964	39.6365	-31.5810	-29.7837	0.6370	-0.1248	0.1127	0.6588	0.6469	X, Z
A-PILLAR Lateral (Y)	31	51.4212	-34.2783	-23.2315	50.5598	-34.5961	-23.0265	0.8614	-0.3178	0.2050	0.9408	-0.3178	Y
	32	49.2273	-33.7322	-24.7745	48.3340	-34.0205	-24.5658	0.8933	-0.2883	0.2087	0.9616	-0.2883	Y
	33	46.8608	-33.1516	-26.2158	46.0711	-33.4050	-26.0375	0.7897	-0.2534	0.1783	0.8483	-0.2534	Y
	34	44.8372	-32.6839	-27.2584	44.1085	-32.8942	-27.0918	0.7287	-0.2103	0.1666	0.7765	-0.2103	Y
	35	42.3527	-31.9927	-28.7895	41.7018	-32.1678	-28.6259	0.6509	-0.1751	0.1636	0.6936	-0.1751	Y
	36	40.2735	-31.4562	-29.8964	39.6365	-31.5810	-29.7837	0.6370	-0.1248	0.1127	0.6588	-0.1248	Y
B-PILLAR Maximum (X, Y, Z)	37	13.0348	-29.2567	-33.3137	12.4140	-28.9114	-33.4191	0.6208	0.3453	-0.1054	0.7181	0.7104	X, Y
	38	10.7920	-30.9545	-29.5824	10.1296	-30.5440	-29.7657	0.6624	0.4105	-0.1833	0.8006	0.7793	X, Y
	39	14.9140	-32.6408	-25.4757	14.2244	-32.3563	-25.5826	0.6896	0.2845	-0.1069	0.7536	0.7460	X, Y
	40	11.8832	-33.6574	-20.3264	11.1235	-33.3132	-20.5162	0.7597	0.3442	-0.1898	0.8554	0.8340	X, Y
B-PILLAR Lateral (Y)	37	13.0348	-29.2567	-33.3137	12.4140	-28.9114	-33.4191	0.6208	0.3453	-0.1054	0.7181	0.3453	Y
	38	10.7920	-30.9545	-29.5824	10.1296	-30.5440	-29.7657	0.6624	0.4105	-0.1833	0.8006	0.4105	Y
	39	14.9140	-32.6408	-25.4757	14.2244	-32.3563	-25.5826	0.6896	0.2845	-0.1069	0.7536	0.2845	Y
	40	11.8832	-33.6574	-20.3264	11.1235	-33.3132	-20.5162	0.7597	0.3442	-0.1898	0.8554	0.3442	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 H-11. Occupant Compartment Deformation Data – Set 2, Test No. NYHBT-2

Test Name: NYHBT-2 VIN: KNADH4A38A6687587

Model Year: 2010 Make: Kia Model: Rio

Driver Side Maximum Deformations

Reference Set 1				Reference Set 2			
Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]	Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]
Roof	-0.1	≤ 4	Z	Roof	0.1	≤ 4	Z
Windshield[D]	0.0	≤ 3	X, Z	Windshield[D]	NA	≤ 3	X, Z
A-Pillar Maximum	0.3	≤ 5	X, Z	A-Pillar Maximum	0.9	≤ 5	X, Z
A-Pillar Lateral	0.0	≤ 3	Y	A-Pillar Lateral	-0.3	≤ 3	Y
B-Pillar Maximum	0.2	≤ 5	X	B-Pillar Maximum	0.8	≤ 5	X, Y
B-Pillar Lateral	0.0	≤ 3	Y	B-Pillar Lateral	0.4	≤ 3	Y
Toe Pan - Wheel Well	0.3	≤ 9	X, Z	Toe Pan - Wheel Well	0.0	≤ 9	X
Side Front Panel	0.7	≤ 12	Y	Side Front Panel	0.3	≤ 12	Y
Side Door (above seat)	0.1	≤ 9	Y	Side Door (above seat)	-0.3	≤ 9	Y
Side Door (below seat)	-0.9	≤ 12	Y	Side Door (below seat)	-0.9	≤ 12	Y
Floor Pan	0.4	≤ 12	Z	Floor Pan	0.0	≤ 12	Z
Dash - no MASH requirement	0.7	NA	X, Y, Z	Dash - no MASH requirement	0.7	NA	X, Y, Z

[A] Items highlighted in red do not meet MASH allowable deformations.

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

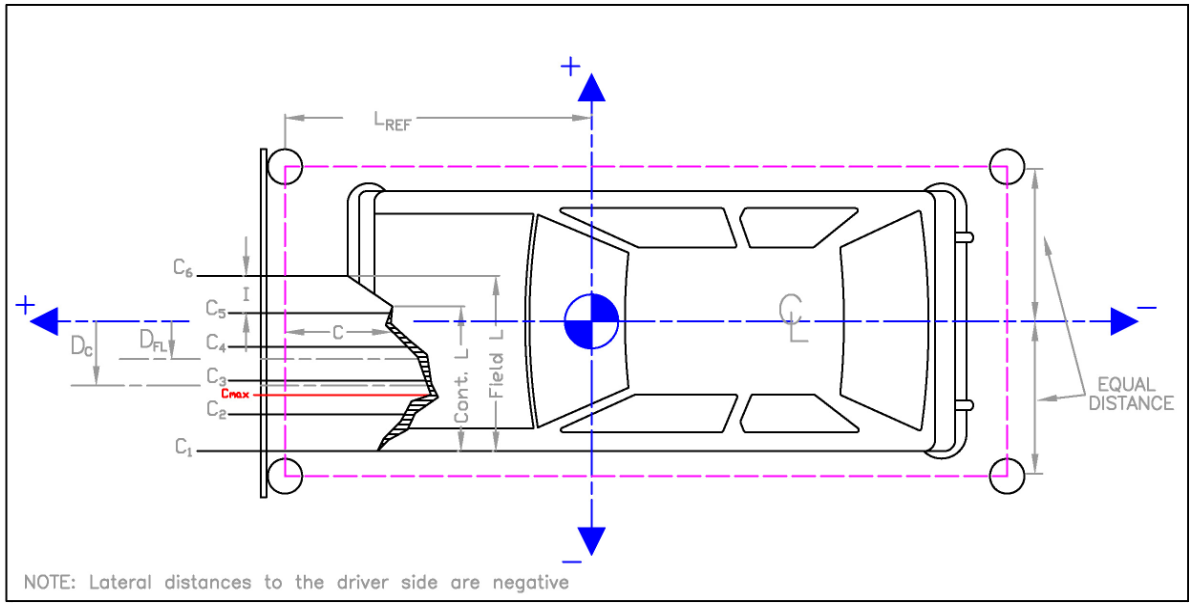
[C] For Toe Pan - Wheel Well the direction of defromation may include X and Z direction. For A-Pillar Maximum and B-Pillar Maximum the direction of deformation may include X, Y, and Z directions. The direction of deformation for Toe Pan -Wheel Well, A-Pillar Maximum, and B-Pillar Maximum only include components where the deformation is positive and intruding into the occupant compartment. If direction of deformation is "NA" then no intrusion is recorded and deformation will be 0.

[D] If deformation is observered for the windshield then the windshield deformation is measured posttest with an examplar vehicle, therefore only one set of reference is measured and recorded.

Notes on vehicle crush:

Figure H-12. Maximum Occupant Compartment Deformation by Location, Test No. NYHBT-2

Date Measured:	7/21/20	Test Name:	NYHBT-2	VIN:	KNADH4A38A6687587
Model Year:	2010	Make:	Kia	Model:	Rio



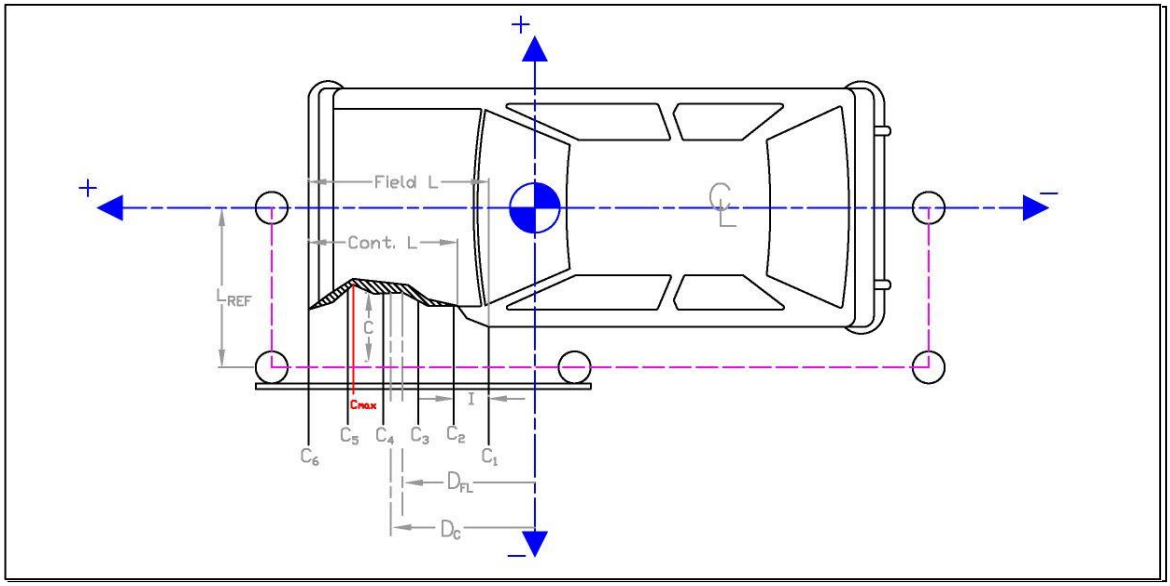
	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	71 1/2	(1816)
Total Width of Vehicle:	66 1/8	(1680)
Width of contact and induced crush - Field L:	23 4/7	(598)
Crush measurement spacing interval (L/5) - I:	4 3/4	(121)
Distance from center of vehicle to center of Field L - D_{FL}:	-21 2/7	-(541)
Width of Contact Damage:	23 4/7	(598)
Distance from center of vehicle to center of contact damage - D_C:	0	()

NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., side of vehicle has been pushed inward)
NOTE: All values must be filled out above before crush measurements are filled out.

Crush Measurement			Lateral Location		Original Profile Measurement		Dist. Between Ref. Lines		Actual Crush	
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
C_1	NA	NA	-33 1/8	-(841)	24	(610)	-3 2/3	-(94)	NA	NA
C_2	NA	NA	-28 3/8	-(721)	13 7/8	(352)			NA	NA
C_3	NA	NA	-23 5/8	-(600)	10 1/4	(260)			NA	NA
C_4	5	(127)	-18 7/8	-(479)	8 3/8	(213)			1/3	(8)
C_5	3 1/8	(79)	-14 1/8	-(359)	7 1/8	(181)			- 1/3	-(8)
C_6	2 1/8	(54)	-9 3/8	-(238)	6 1/2	(165)			- 2/3	-(17)
C_{MAX}	5	(127)	-18 7/8	-(479)	8 3/8	(213)			1/3	(8)

Figure H-13. Exterior Vehicle Crush (NASS) – Front, Test No. NYHBT-2

Date Measured:	7/21/20	Test Name:	NYHBT-2	VIN:	KNADH4A38A6687587
Model Year:	2010	Make:	Kia	Model:	Rio



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	38 1/8	(968)
Total Vehicle Length:	167 1/8	(4245)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-13 3/4	-(349)
Width of contact and induced crush - Field L:	92 4/7	(2351)
Crush measurement spacing interval (L/5) - I:	18 1/2	(470)
Distance from vehicle c.g. to center of Field L - D_{FL}:	24 7/9	(629)
Width of Contact Damage:	92 4/7	(2351)
Distance from vehicle c.g. to center of contact damage - D_C:	24 7/9	(629)

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	4 3/4	(121)	-21 1/2	-(546)	3 5/8	(92)	2 1/8	(54)	-1	-(25)
C_2	5	(127)	-3	-(76)	3 3/4	(95)			- 7/8	-(22)
C_3	6 1/4	(159)	15 1/2	(394)	3 3/4	(95)			3/8	(10)
C_4	NA	NA	34	(864)	3 1/4	(83)			NA	NA
C_5	17 1/2	(445)	52 1/2	(1334)	3 5/8	(92)			11 3/4	(298)
C_6	NA	NA	71	(1803)	20 1/4	(514)			NA	NA
C_{MAX}	17 1/2	(445)	52 1/2	(1334)	3 5/8	(92)			11 3/4	(298)

Figure H-14. Exterior Vehicle Crush (NASS) – Side, Test No. NYHBT-2

Model Year: 2014 Test Name: NYBHT-1 Make: Dodge VIN: 1C6RR6FT9ES258957 Model: Ram 1500

VEHICLE DEFORMATION
PASSENGER SIDE 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	55.1476	34.2542	-2.3669	54.9511	33.9605	-2.4795	0.1965	0.2937	0.1126	0.3709	0.2265	X, Z
	2	56.0437	31.3067	-1.5560	55.5333	31.0091	-2.0976	0.5104	0.2976	0.5416	0.8015	0.7442	X, Z
	3	56.4883	25.8971	-0.6028	56.3868	25.7364	-0.6954	0.1015	0.1607	0.0926	0.2114	0.1374	X, Z
	4	55.4465	22.2240	-1.5924	55.3816	21.9633	-1.6205	0.0649	0.2607	0.0281	0.2701	0.0707	X, Z
	5	53.9300	19.1742	-4.2793	53.8435	18.9828	-4.2281	0.0865	0.1914	-0.0512	0.2162	0.0865	X
	6	51.0367	34.3247	2.3274	51.0538	34.0497	2.2407	-0.0171	0.2750	0.0867	0.2888	0.0867	Z
	7	50.7999	31.3645	2.3314	50.7298	31.0439	2.1972	0.0701	0.3206	0.1342	0.3546	0.1514	X, Z
	8	50.9966	26.3120	2.2319	50.8968	26.0035	2.2427	0.0998	0.3085	-0.0108	0.3244	0.0998	X
	9	50.3566	21.8822	0.6712	50.3391	21.5744	0.7493	0.0175	0.3078	-0.0781	0.3180	0.0175	X
	10	49.1470	17.5004	-2.4609	49.1187	17.2232	-2.4411	0.0283	0.2772	-0.0198	0.2793	0.0283	X
FLOOR PAN (Z)	11	45.6752	34.1623	4.5521	45.6705	33.8631	4.5710	0.0047	0.2992	-0.0189	0.2998	-0.0189	Z
	12	45.4785	30.8386	4.4543	45.5055	30.4988	4.4622	-0.0270	0.3398	-0.0079	0.3410	-0.0079	Z
	13	45.6937	25.6488	4.4601	45.6567	25.3302	4.4426	0.0370	0.3186	0.0175	0.3212	0.0175	Z
	14	45.5889	21.2522	4.3396	45.5552	20.9119	4.3405	0.0337	0.3403	-0.0009	0.3420	-0.0009	Z
	15	45.0247	16.7251	0.9066	45.0543	16.4536	0.8899	-0.0296	0.2715	0.0167	0.2736	0.0167	Z
	16	41.5869	34.4218	4.6409	41.5358	34.1567	4.6638	0.0511	0.2651	-0.0229	0.2709	-0.0229	Z
	17	41.1760	30.2292	4.5445	41.1511	29.8848	4.5801	0.0249	0.3444	-0.0356	0.3471	-0.0356	Z
	18	40.9639	25.6697	4.5534	40.9036	25.4242	4.5389	0.0603	0.2455	0.0145	0.2532	0.0145	Z
	19	41.0775	20.4488	4.5733	41.0297	20.1987	4.5668	0.0478	0.2501	0.0065	0.2547	0.0065	Z
	20	40.4680	15.0132	3.2204	40.4620	14.7333	3.2031	0.0060	0.2799	0.0173	0.2805	0.0173	Z
	21	36.1046	34.5302	4.7211	36.0970	34.2572	4.7437	0.0076	0.2730	-0.0226	0.2740	-0.0226	Z
	22	35.8860	28.9208	4.7344	35.8522	28.6812	4.7817	0.0338	0.2396	-0.0473	0.2466	-0.0473	Z
	23	36.0958	25.0768	4.7348	36.0562	24.7787	4.7597	0.0396	0.2981	-0.0249	0.3017	-0.0249	Z
	24	36.2335	19.9112	4.7607	36.2670	19.6267	4.7623	-0.0335	0.2845	-0.0016	0.2865	-0.0016	Z
	25	36.4716	15.2134	3.9573	36.3748	14.9377	3.9573	0.0968	0.2757	0.0000	0.2922	0.0000	Z
	26	31.2657	33.9060	3.7816	31.2921	33.6372	3.7867	-0.0264	0.2688	-0.0051	0.2701	-0.0051	Z
	27	31.5269	28.6669	3.8037	31.4971	28.4261	3.8126	0.0298	0.2408	-0.0089	0.2428	-0.0089	Z
	28	31.6063	24.2436	3.8131	31.5769	24.0441	3.8244	0.0294	0.1995	-0.0113	0.2020	-0.0113	Z
	29	31.6527	19.7662	3.8306	31.6527	19.5431	3.8379	0.0000	0.2231	-0.0073	0.2232	-0.0073	Z
	30	31.9223	15.2872	3.8815	31.9319	14.9913	3.8582	-0.0096	0.2959	0.0233	0.2970	0.0233	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 H-15. Floor Pan Deformation Data – Set 1, Test No. NYBHT-1

Model Year: 2014 Test Name: NYBHT-1 Make: Dodge VIN: 1C6RR6FT9ES258957 Model: Ram 1500

VEHICLE DEFORMATION
PASSENGER SIDE 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	55.4950	52.8954	-6.4680	55.0608	52.8544	-6.6500	0.4342	0.0410	0.1820	0.4726	0.4708	X, Z
	2	56.3422	49.9329	-5.6591	55.5952	49.8940	-6.2677	0.7470	0.0389	0.6086	0.9643	0.9635	X, Z
	3	56.6972	44.5160	-4.7095	56.3635	44.6085	-4.8648	0.3337	-0.0925	0.1553	0.3795	0.3681	X, Z
	4	55.5949	40.8613	-5.7017	55.2977	40.8519	-5.7895	0.2972	0.0094	0.0878	0.3100	0.3099	X, Z
	5	54.0282	37.8389	-8.3907	53.7120	37.8963	-8.3969	0.3162	-0.0574	0.0062	0.3214	0.3163	X, Z
	6	51.3856	53.0307	-1.7738	51.1650	53.0070	-1.9302	0.2206	0.0237	0.1564	0.2715	0.2704	X, Z
	7	51.0999	50.0747	-1.7718	50.7925	50.0068	-1.9734	0.3074	0.0679	0.2016	0.3738	0.3676	X, Z
	8	51.2130	45.0198	-1.8747	50.8783	44.9644	-1.9273	0.3347	0.0554	0.0526	0.3433	0.3388	X, Z
	9	50.4999	40.6023	-3.4385	50.2494	40.5447	-3.4201	0.2505	0.0576	-0.0184	0.2577	0.2505	X
	10	49.2181	36.2432	-6.5736	48.9593	36.2133	-6.6102	0.2588	0.0299	0.0366	0.2631	0.2614	X, Z
FLOOR PAN (Z)	11	46.0221	52.9554	0.4506	45.7792	52.9075	0.3997	0.2429	0.0479	0.0509	0.2528	0.0509	Z
	12	45.7705	49.6355	0.3506	45.5599	49.5463	0.2913	0.2106	0.0892	0.0593	0.2363	0.0593	Z
	13	45.8998	44.4429	0.3528	45.6278	44.3759	0.2723	0.2720	0.0670	0.0805	0.2915	0.0805	Z
	14	45.7223	40.0487	0.2293	45.4551	39.9599	0.1706	0.2672	0.0888	0.0587	0.2876	0.0587	Z
	15	45.0834	35.5339	-3.2068	44.8827	35.5098	-3.2794	0.2007	0.0241	0.0726	0.2148	0.0726	Z
	16	41.9386	53.2825	0.5394	41.6497	53.2678	0.4920	0.2889	0.0147	0.0474	0.2931	0.0474	Z
	17	41.4585	49.0973	0.4402	41.1962	49.0026	0.4088	0.2623	0.0947	0.0314	0.2806	0.0314	Z
	18	41.1710	44.5419	0.4460	40.8768	44.5466	0.3681	0.2942	-0.0047	0.0779	0.3044	0.0779	Z
	19	41.1981	39.3198	0.4623	40.9186	39.3198	0.3966	0.2795	0.0000	0.0657	0.2871	0.0657	Z
	20	40.4989	33.8959	-0.8944	40.2630	33.8640	-0.9665	0.2359	0.0319	0.0721	0.2487	0.0721	Z
	21	36.4589	53.4815	0.6196	36.2132	53.4560	0.5713	0.2457	0.0255	0.0483	0.2517	0.0483	Z
	22	36.1475	47.8765	0.6290	35.8786	47.8846	0.6101	0.2689	-0.0081	0.0189	0.2697	0.0189	Z
	23	36.2937	44.0295	0.6268	36.0196	43.9794	0.5885	0.2741	0.0501	0.0383	0.2813	0.0383	Z
	24	36.3459	38.8623	0.6492	36.1473	38.8246	0.5918	0.1986	0.0377	0.0574	0.2101	0.0574	Z
	25	36.5063	34.1618	-0.1574	36.1796	34.1344	-0.2127	0.3267	0.0274	0.0553	0.3325	0.0553	Z
	26	31.6103	52.9381	-0.3205	31.3991	52.9134	-0.3860	0.2112	0.0247	0.0655	0.2225	0.0655	Z
	27	31.7848	47.6953	-0.3020	31.5200	47.6996	-0.3595	0.2648	-0.0043	0.0575	0.2710	0.0575	Z
	28	31.7910	43.2713	-0.2956	31.5292	43.3169	-0.3472	0.2618	-0.0456	0.0516	0.2707	0.0516	Z
	29	31.7634	38.7937	-0.2812	31.5323	38.8153	-0.3331	0.2311	-0.0216	0.0519	0.2378	0.0519	Z
	30	31.9589	34.3109	-0.2333	31.7381	34.2596	-0.3123	0.2208	0.0513	0.0790	0.2401	0.0790	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 H-16. Floor Pan Deformation Data – Set 2, Test No. NYBHT-1

Model Year: 2014 Test Name: NYBHT-1 Make: Dodge VIN: 1C6RR6FT9ES258957 Model: Ram 1500

VEHICLE DEFORMATION
PASSENGER SIDE 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	44.2457	32.8250	-27.5551	44.3497	32.9932	-27.3880	-0.1040	-0.1682	0.1671	0.2589	0.2589	X, Y, Z
	2	43.4805	19.5679	-28.2438	43.6030	19.7290	-28.0947	-0.1225	-0.1611	0.1491	0.2514	0.2514	X, Y, Z
	3	43.1981	4.2397	-28.5700	43.2857	4.4427	-28.4584	-0.0876	-0.2030	0.1116	0.2477	0.2477	X, Y, Z
	4	39.0879	34.4750	-16.5053	39.1429	34.7109	-16.3921	-0.0550	-0.2359	0.1132	0.2674	0.2674	X, Y, Z
	5	38.2081	20.2130	-16.2141	38.2993	20.4352	-16.0209	-0.0912	-0.2222	0.1932	0.3082	0.3082	X, Y, Z
	6	36.2010	3.9078	-16.5089	36.2683	4.1176	-16.4003	-0.0673	-0.2098	0.1086	0.2456	0.2456	X, Y, Z
SIDE PANEL (Y)	7	48.3241	36.7565	-4.7903	48.2227	36.5527	-4.6756	0.1014	0.2038	0.1147	0.2549	0.2038	Y
	8	48.2778	36.7548	-0.9345	48.1711	36.5867	-0.8118	0.1067	0.1681	0.1227	0.2339	0.1681	Y
	9	52.6926	36.6936	-0.6388	52.5794	36.7656	-0.5569	0.1132	-0.0720	0.0819	0.1572	-0.0720	Y
IMPACT SIDE DOOR (Y)	10	14.9137	38.7931	-20.0572	14.6046	39.2204	-20.0357	0.3091	-0.4273	0.0215	0.5278	-0.4273	Y
	11	26.2668	38.5238	-20.1595	26.0241	38.8786	-20.1472	0.2427	-0.3548	0.0123	0.4300	-0.3548	Y
	12	38.6916	38.6779	-20.3311	38.4651	38.8487	-20.3627	0.2265	-0.1708	-0.0316	0.2854	-0.1708	Y
	13	16.6306	39.0393	-3.1957	16.3649	39.1589	-3.2486	0.2657	-0.1196	-0.0529	0.2961	-0.1196	Y
	14	29.8697	39.9354	-3.9657	29.5607	40.2480	-3.9870	0.3090	-0.3126	-0.0213	0.4401	-0.3126	Y
	15	39.6838	37.9062	-8.3495	39.2693	37.7966	-8.2596	0.4145	0.1096	0.0899	0.4381	0.1096	Y
ROOF - (Z)	16	24.3593	26.0583	-45.4384	24.3665	26.0419	-45.3807	-0.0072	0.0164	0.0577	0.0604	0.0577	Z
	17	25.5245	20.9319	-45.7256	25.6486	20.9510	-45.6381	-0.1241	-0.0191	0.0875	0.1530	0.0875	Z
	18	26.4516	15.2530	-45.9392	26.4990	15.3003	-45.8659	-0.0474	-0.0473	0.0733	0.0993	0.0733	Z
	19	27.2629	8.9979	-46.0107	27.3127	9.0346	-45.9393	-0.0498	-0.0367	0.0714	0.0945	0.0714	Z
	20	27.6259	5.1673	-45.9895	27.6505	5.1802	-45.9247	-0.0246	-0.0129	0.0648	0.0705	0.0648	Z
	21	15.1634	25.7021	-46.2957	15.2049	25.7276	-46.2542	-0.0415	-0.0255	0.0415	0.0640	0.0415	Z
	22	14.8206	19.9220	-46.7000	14.8226	19.9235	-46.6665	-0.0020	-0.0015	0.0335	0.0336	0.0335	Z
	23	14.8785	15.4856	-46.8352	14.9253	15.4244	-46.8007	-0.0468	0.0612	0.0345	0.0844	0.0345	Z
	24	15.0255	10.9186	-46.9757	15.1178	10.9796	-46.9325	-0.0923	-0.0610	0.0432	0.1188	0.0432	Z
	25	14.9364	6.6454	-47.1079	14.9665	6.6687	-47.0703	-0.0301	-0.0233	0.0376	0.0535	0.0376	Z
	26	7.5479	25.7241	-46.4893	7.5886	25.7439	-46.4673	-0.0407	-0.0198	0.0220	0.0503	0.0220	Z
	27	7.5644	20.1983	-46.8589	7.6113	20.2115	-46.8362	-0.0469	-0.0132	0.0227	0.0538	0.0227	Z
	28	7.5406	16.4755	-47.0410	7.6028	16.4637	-47.0189	-0.0622	0.0118	0.0221	0.0671	0.0221	Z
	29	7.5563	11.9435	-47.1943	7.6110	11.9489	-47.1713	-0.0547	-0.0054	0.0230	0.0596	0.0230	Z
	30	7.6042	8.0952	-47.2613	7.7072	8.1595	-47.2359	-0.1030	-0.0643	0.0254	0.1241	0.0254	Z
A-PILLAR Maximum (X, Y, Z)	31	46.0502	35.1873	-30.9090	45.9817	35.2606	-30.8118	0.0685	-0.0733	0.0972	0.1397	0.1189	X, Z
	32	43.6533	34.6099	-32.5651	43.7167	34.7324	-32.4634	-0.0634	-0.1225	0.1017	0.1714	0.1017	Z
	33	40.6774	33.9656	-34.8204	40.7452	34.0765	-34.7280	-0.0678	-0.1109	0.0924	0.1595	0.0924	Z
	34	37.0807	33.2064	-37.4992	37.1771	33.2941	-37.3902	-0.0964	-0.0877	0.1090	0.1699	0.1090	Z
	35	34.3372	32.6015	-39.1965	34.3909	32.7263	-39.0998	-0.0537	-0.1248	0.0967	0.1668	0.0967	Z
	36	31.3113	31.9419	-40.8925	31.3157	32.0517	-40.8091	-0.0044	-0.1098	0.0834	0.1380	0.0834	Z
A-PILLAR Lateral (Y)	31	46.0502	35.1873	-30.9090	45.9817	35.2606	-30.8118	0.0685	-0.0733	0.0972	0.1397	-0.0733	Y
	32	43.6533	34.6099	-32.5651	43.7167	34.7324	-32.4634	-0.0634	-0.1225	0.1017	0.1714	-0.1225	Y
	33	40.6774	33.9656	-34.8204	40.7452	34.0765	-34.7280	-0.0678	-0.1109	0.0924	0.1595	-0.1109	Y
	34	37.0807	33.2064	-37.4992	37.1771	33.2941	-37.3902	-0.0964	-0.0877	0.1090	0.1699	-0.0877	Y
	35	34.3372	32.6015	-39.1965	34.3909	32.7263	-39.0998	-0.0537	-0.1248	0.0967	0.1668	-0.1248	Y
	36	31.3113	31.9419	-40.8925	31.3157	32.0517	-40.8091	-0.0044	-0.1098	0.0834	0.1380	-0.1098	Y
B-PILLAR Maximum (X, Y, Z)	37	7.1480	34.7510	-31.9482	7.1626	34.7526	-31.9090	-0.0146	-0.0016	0.0392	0.0419	0.0392	Z
	38	4.0945	36.0287	-24.4685	4.0678	36.0117	-24.4267	0.0267	0.0170	0.0418	0.0524	0.0524	X, Y, Z
	39	9.0395	36.4400	-16.1498	8.9790	36.4294	-16.1087	0.0605	0.0106	0.0411	0.0739	0.0739	X, Y, Z
	40	5.0486	36.4395	-11.5088	4.9795	36.4197	-11.4319	0.0691	0.0198	0.0769	0.1053	0.1053	X, Y, Z
B-PILLAR Lateral (Y)	37	7.1480	34.7510	-31.9482	7.1626	34.7526	-31.9090	-0.0146	-0.0016	0.0392	0.0419	-0.0016	Y
	38	4.0945	36.0287	-24.4685	4.0678	36.0117	-24.4267	0.0267	0.0170	0.0418	0.0524	0.0170	Y
	39	9.0395	36.4400	-16.1498	8.9790	36.4294	-16.1087	0.0605	0.0106	0.0411	0.0739	0.0106	Y
	40	5.0486	36.4395	-11.5088	4.9795	36.4197	-11.4319	0.0691	0.0198	0.0769	0.1053	0.0198	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 H-17. Occupant Compartment Deformation Data – Set 1, Test No. NYBHT-1

Model Year: 2014 Test Name: NYBHT-1 Make: Dodge VIN: 1C6RR6FT9ES258957 Model: Ram 1500

VEHICLE DEFORMATION
PASSENGER SIDE 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	44.4771	52.0197	-31.6817	44.3797	52.0251	-31.6501	0.0974	-0.0054	0.0316	0.1025	0.1025	X, Y, Z
	2	43.5291	38.7748	-32.3770	43.4185	38.7737	-32.3365	0.1106	0.0011	0.0405	0.1178	0.1178	X, Y, Z
	3	43.0355	23.4520	-32.7111	42.8545	23.4940	-32.6776	0.1810	-0.0420	0.0335	0.1888	0.1888	X, Y, Z
	4	39.3484	53.7347	-20.6283	39.2176	53.8422	-20.6491	0.1308	-0.1075	-0.0208	0.1706	0.1706	X, Y, Z
	5	38.2726	39.4860	-20.3441	38.1447	39.5824	-20.2560	0.1279	-0.0964	0.0881	0.1828	0.1828	X, Y, Z
	6	36.0410	23.2102	-20.6464	35.8507	23.2991	-20.6088	0.1903	-0.0889	0.0376	0.2134	0.2134	X, Y, Z
SIDE PANEL (Y)	7	48.6214	55.8826	-8.9171	48.3433	55.5541	-8.9486	0.2781	0.3285	-0.0315	0.4316	0.3285	Y
	8	48.5772	55.8795	-5.0613	48.2980	55.5945	-5.0848	0.2792	0.2850	-0.0235	0.3997	0.2850	Y
	9	52.9908	55.7573	-4.7680	52.7090	55.7027	-4.8366	0.2818	0.0546	-0.0686	0.2951	0.0546	Y
IMPACT SIDE DOOR (Y)	10	15.2340	58.3870	-24.1648	14.7497	58.7410	-24.2633	0.4843	-0.3540	-0.0985	0.6079	-0.3540	Y
	11	26.5823	57.9616	-24.2734	26.1621	58.2153	-24.3911	0.4202	-0.2537	-0.1177	0.5048	-0.2537	Y
	12	39.0080	57.9447	-24.4517	38.6006	57.9846	-24.6247	0.4074	-0.0399	-0.1730	0.4444	-0.0399	Y
	13	16.9632	58.6006	-7.3041	16.5337	58.6752	-7.4788	0.4295	-0.0746	-0.1747	0.4696	-0.0746	Y
	14	30.2129	59.3148	-8.0808	29.7442	59.5505	-8.2380	0.4687	-0.2357	-0.1572	0.5477	-0.2357	Y
	15	39.9959	57.1530	-12.4710	39.4058	56.9369	-12.5212	0.5901	0.2161	-0.0502	0.6304	0.2161	Y
ROOF - (Z)	16	24.4899	45.5369	-49.5578	24.2604	45.3710	-49.6035	0.2295	0.1659	-0.0457	0.2868	-0.0457	Z
	17	25.5843	40.3951	-49.8484	25.4600	40.2597	-49.8554	0.1243	0.1354	-0.0070	0.1839	-0.0070	Z
	18	26.4330	34.7041	-50.0654	26.2190	34.5957	-50.0763	0.2140	0.1084	-0.0109	0.2401	-0.0109	Z
	19	27.1580	28.4385	-50.1406	26.9316	28.3176	-50.1418	0.2264	0.1209	-0.0012	0.2567	-0.0012	Z
	20	27.4683	24.6032	-50.1216	27.2073	24.4584	-50.1221	0.2610	0.1448	-0.0005	0.2985	-0.0005	Z
	21	15.2895	45.3078	-50.4103	15.0937	45.2031	-50.4632	0.1958	0.1047	-0.0529	0.2283	-0.0529	Z
	22	14.8669	39.5332	-50.8174	14.6174	39.4052	-50.8665	0.2495	0.1280	-0.0491	0.2847	-0.0491	Z
	23	14.8637	35.0964	-50.9550	14.6474	34.9049	-50.9943	0.2163	0.1915	-0.0393	0.2916	-0.0393	Z
	24	14.9477	30.5279	-51.0980	14.7681	30.4574	-51.1200	0.1796	0.0705	-0.0220	0.1942	-0.0220	Z
	25	14.7997	26.2565	-51.2324	14.5472	26.1493	-51.2513	0.2525	0.1072	-0.0189	0.2750	-0.0189	Z
	26	7.6749	45.4348	-50.5997	7.4784	45.3417	-50.6651	0.1965	0.0931	-0.0654	0.2271	-0.0654	Z
	27	7.6151	39.9095	-50.9723	7.4114	39.8091	-51.0261	0.2037	0.1004	-0.0538	0.2334	-0.0538	Z
	28	7.5400	36.1874	-51.1563	7.3423	36.0617	-51.2034	0.1977	0.1257	-0.0471	0.2390	-0.0471	Z
	29	7.4932	31.6557	-51.3120	7.2775	31.5471	-51.3492	0.2157	0.1086	-0.0372	0.2443	-0.0372	Z
	30	7.4881	27.8072	-51.3811	7.3126	27.7566	-51.4085	0.1755	0.0506	-0.0274	0.1847	-0.0274	Z
A-PILLAR Maximum (X, Y, Z)	31	46.3122	54.3588	-35.0354	46.0430	54.2610	-35.0796	0.2692	0.0978	-0.0442	0.2898	0.2864	X, Y
	32	43.9066	53.8152	-36.6905	43.7672	53.7671	-36.7271	0.1394	0.0481	-0.0366	0.1519	0.1475	X, Y
	33	40.9210	53.2132	-38.9445	40.7822	53.1559	-38.9864	0.1388	0.0573	-0.0419	0.1559	0.1502	X, Y
	34	37.3128	52.5050	-41.6218	37.1980	52.4273	-41.6422	0.1148	0.0777	-0.0204	0.1401	0.1386	X, Y
	35	34.5603	51.9388	-43.3179	34.4005	51.9019	-43.3470	0.1598	0.0369	-0.0291	0.1666	0.1640	X, Y
	36	31.5247	51.3219	-45.0126	31.3123	51.2746	-45.0507	0.2124	0.0473	-0.0381	0.2209	0.2176	X, Y
A-PILLAR Lateral (Y)	31	46.3122	54.3588	-35.0354	46.0430	54.2610	-35.0796	0.2692	0.0978	-0.0442	0.2898	0.0978	Y
	32	43.9066	53.8152	-36.6905	43.7672	53.7671	-36.7271	0.1394	0.0481	-0.0366	0.1519	0.0481	Y
	33	40.9210	53.2132	-38.9445	40.7822	53.1559	-38.9864	0.1388	0.0573	-0.0419	0.1559	0.0573	Y
	34	37.3128	52.5050	-41.6218	37.1980	52.4273	-41.6422	0.1148	0.0777	-0.0204	0.1401	0.0777	Y
	35	34.5603	51.9388	-43.3179	34.4005	51.9019	-43.3470	0.1598	0.0369	-0.0291	0.1666	0.0369	Y
	36	31.5247	51.3219	-45.0126	31.3123	51.2746	-45.0507	0.2124	0.0473	-0.0381	0.2209	0.0473	Y
B-PILLAR Maximum (X, Y, Z)	37	7.4071	54.4586	-36.0538	7.2191	54.3768	-36.1192	0.1880	0.0818	-0.0654	0.2152	0.2050	X, Y
	38	4.3755	55.7742	-28.5717	4.1561	55.6963	-28.6343	0.2194	0.0779	-0.0626	0.2411	0.2328	X, Y
	39	9.3301	56.1129	-20.2554	9.0858	56.0466	-20.3241	0.2443	0.0663	-0.0687	0.2623	0.2531	X, Y
	40	5.3421	56.1649	-15.6124	5.0936	56.1080	-15.6415	0.2485	0.0569	-0.0291	0.2566	0.2549	X, Y
B-PILLAR Lateral (Y)	37	7.4071	54.4586	-36.0538	7.2191	54.3768	-36.1192	0.1880	0.0818	-0.0654	0.2152	0.0818	Y
	38	4.3755	55.7742	-28.5717	4.1561	55.6963	-28.6343	0.2194	0.0779	-0.0626	0.2411	0.0779	Y
	39	9.3301	56.1129	-20.2554	9.0858	56.0466	-20.3241	0.2443	0.0663	-0.0687	0.2623	0.0663	Y
	40	5.3421	56.1649	-15.6124	5.0936	56.1080	-15.6415	0.2485	0.0569	-0.0291	0.2566	0.0569	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 H-18. Occupant Compartment Deformation Data – Set 2, Test No. NYBHT-1

Test Name: NYBHT-1 VIN: 1C6RR6FT9ES258957

Model Year: 2014 Make: Dodge Model: Ram 1500

Passenger Side Maximum Deformation

Reference Set 1				Reference Set 2			
Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]	Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]
Roof	0.1	≤ 4	Z	Roof	-0.1	≤ 4	Z
Windshield[D]	0.0	≤ 3	X, Z	Windshield[D]	NA	≤ 3	X, Z
A-Pillar Maximum	0.1	≤ 5	X, Z	A-Pillar Maximum	0.3	≤ 5	X, Y
A-Pillar Lateral	-0.1	≤ 3	Y	A-Pillar Lateral	0.1	≤ 3	Y
B-Pillar Maximum	0.1	≤ 5	X, Y, Z	B-Pillar Maximum	0.3	≤ 5	X, Y
B-Pillar Lateral	0.0	≤ 3	Y	B-Pillar Lateral	0.1	≤ 3	Y
Toe Pan - Wheel Well	0.7	≤ 9	X, Z	Toe Pan - Wheel Well	1.0	≤ 9	X, Z
Side Front Panel	0.2	≤ 12	Y	Side Front Panel	0.3	≤ 12	Y
Side Door (above seat)	-0.4	≤ 9	Y	Side Door (above seat)	-0.4	≤ 9	Y
Side Door (below seat)	0.1	≤ 12	Y	Side Door (below seat)	0.2	≤ 12	Y
Floor Pan	0.0	≤ 12	Z	Floor Pan	0.1	≤ 12	Z
Dash - no MASH requirement	0.3	NA	X, Y, Z	Dash - no MASH requirement	0.2	NA	X, Y, Z

[A] Items highlighted in red do not meet MASH allowable deformations.

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

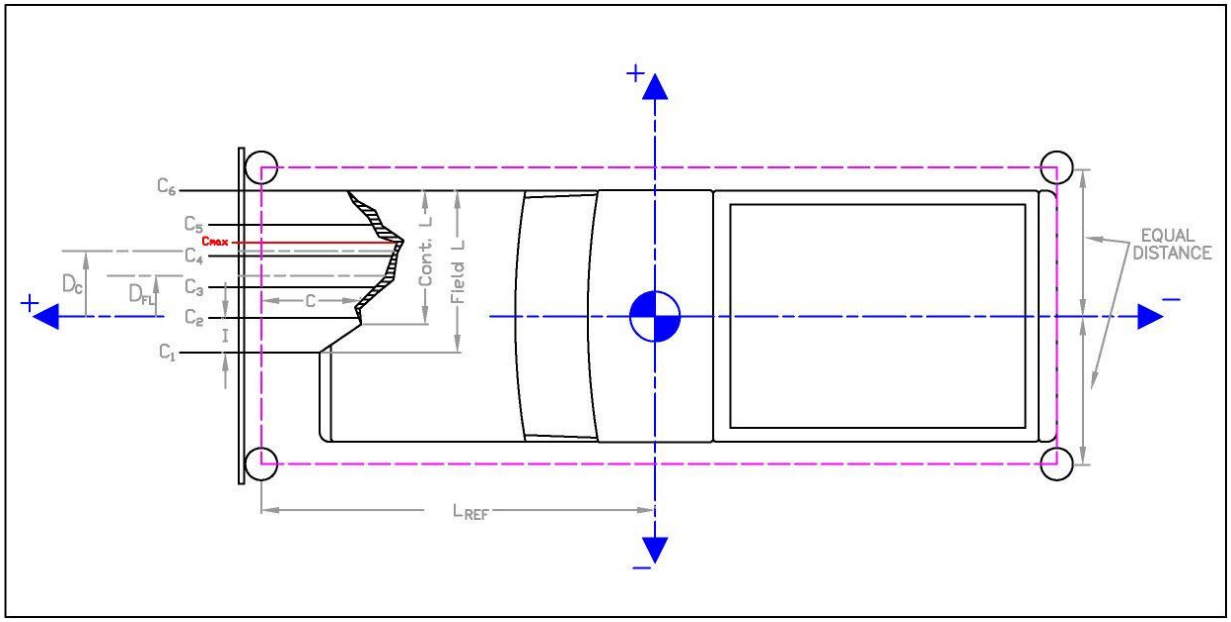
[C] For Toe Pan - Wheel Well the direction of defromation may include X and Z direction. For A-Pillar Maximum and B-Pillar Maximum the direction of deformation may include X, Y, and Z directions. The direction of deformation for Toe Pan -Wheel Well, A-Pillar Maximum, and B-Pillar Maximum only include components where the deformation is positive and intruding into the occupant compartment. If direction of deformation is "NA" then no intrusion is recorded and deformation will be 0.

[D] If deformation is observered for the windshield then the windshield deformation is measured posttest with an examplar vehicle, therefore only one set of reference is measured and recorded.

Notes on vehicle interior crush:

Figure H-19. Maximum Occupant Compartment Deformation by Location, Test No. NYBHT-1

Date Measured:	5/8/2020	**Test Name:**	NYBHT-1	**VIN:**	1C6RR6FT9ES258957
Model Year:	2014	**Make:**	Dodge	**Model:**	Ram 1500



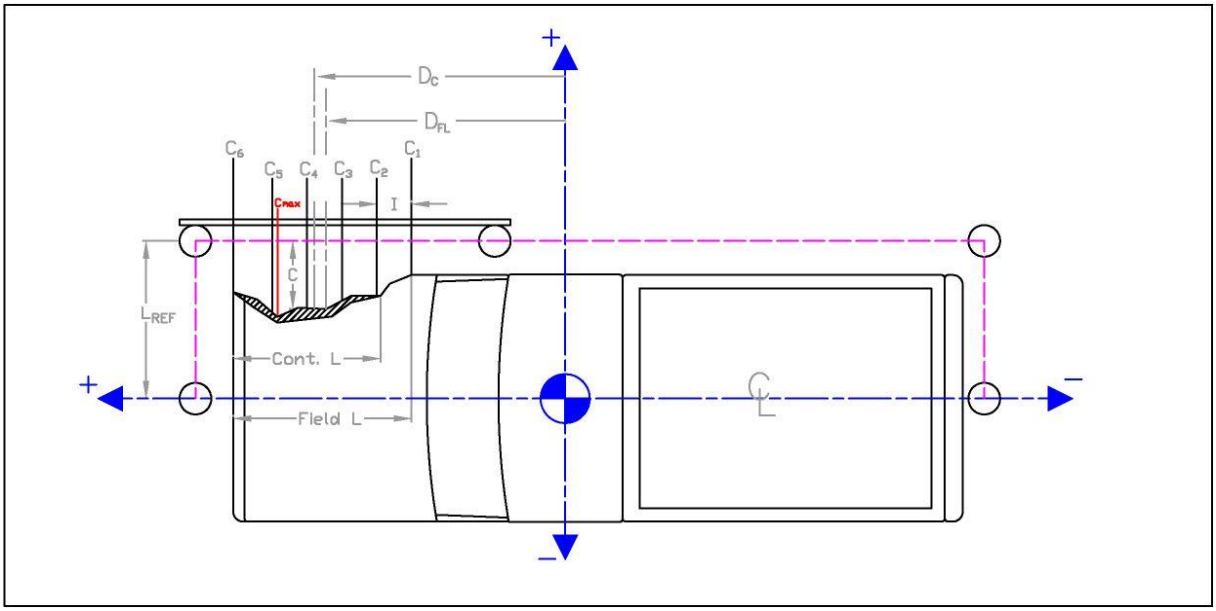
	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	107 1/2	(2731)
Total Vehicle Width:	76 1/4	(1937)
Width of contact and induced crush - Field L:	76 1/4	(1937)
Crush measurement spacing interval (L/5) - I:	15 1/4	(387)
Distance from center of vehicle to center of Field L - D_{FL}:	0	()
Width of Contact Damage:	0	()
Distance from center of vehicle to center of contact damage - D_C:	0	()

NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., side of vehicle has been pushed inward)
NOTE: All values must be filled out above before crush measurements are filled out.

	Crush Measurement		Lateral Location		Original Profile Measurement		Dist. Between Ref. Lines		Actual Crush	
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
C_1	11 3/8	(289)	-38 1/8	-(968)	22 1/2	(572)	3 1/8	(79)	-14 1/4	-(362)
C_2	8 7/8	(225)	-22 7/8	-(581)	6 1/2	(165)			- 3/4	-(19)
C_3	9 1/2	(241)	-7 5/8	-(194)	4 1/4	(108)			2 1/8	(54)
C_4	12	(305)	7 5/8	(194)	4 1/4	(108)			4 5/8	(117)
C_5	19 1/2	(495)	22 7/8	(581)	6 1/8	(156)			10 1/4	(260)
C_6	N/A	N/A	38 1/8	(968)	20 1/2	(521)			N/A	N/A
C_{MAX}	19 1/2	(495)	22 7/8	(581)	6 1/8	(156)			10 1/4	(260)

Figure H-20. Exterior Vehicle Crush (NASS) – Front, Test No. NYBHT-1

Date Measured:	5/8/2020	Test Name:	NYBHT-1	VIN:	1C6RR6FT9ES258957
Model Year:	2014	Make:	Dodge	Model:	Ram 1500



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	49 1/2	(1257)
Total Vehicle Length:	229	(5817)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-4 7/8	-(124)
Width of contact and induced crush - Field L:	229	(5817)
Crush measurement spacing interval (L/5) - I:	45 3/4	(1162)
Distance from vehicle c.g. to center of Field L - D_{FL}:	-14 7/8	-(378)
Width of Contact Damage:	229	(5817)
Distance from vehicle c.g. to center of contact damage - D_C:	-14 7/8	-(378)

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	20	(508)	-129 3/8	-(3286)	33 1/2	(851)	5 1/2	(140)	-19	-(483)
C_2	n/a	N/A	-83 5/8	-(2124)	5 1/2	(140)			N/A	N/A
C_3	10 1/8	(257)	-37 7/8	-(962)	5 3/4	(146)			-1 1/8	-(29)
C_4	9 1/8	(232)	7 7/8	(200)	5	(127)			-1 3/8	-(35)
C_5	n/a	N/A	53 5/8	(1362)	5 1/2	(140)			N/A	N/A
C_6	n/a	N/A	99 3/8	(2524)	8 1/8	(206)			N/A	N/A
C_{MAX}	30 3/4	(781)	79	(2007)	5	(127)			20 1/4	(514)

Figure H-21. Exterior Vehicle Crush (NASS) – Side, Test No. NYBHT-1

Model Year: 2009 Test Name: NYBHT-2 Make: Hyundai VIN: KMHCN46C49U332399 Model: Accent

VEHICLE DEFORMATION
PASSENGER SIDE 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	62.0855	14.9454	2.4603	61.6986	14.7403	1.6043	0.3869	0.2051	0.8560	0.9615	0.9394	X, Z
	2	63.6060	11.8720	3.4499	63.4020	11.8127	2.6856	0.2040	0.0593	0.7643	0.7933	0.7911	X, Z
	3	64.6528	9.5608	4.6146	64.6437	9.4407	3.8364	0.0091	0.1201	0.7782	0.7875	0.7783	X, Z
	4	64.6081	4.6510	4.5714	64.6149	4.6057	3.7918	-0.0068	0.0453	0.7796	0.7809	0.7796	Z
	5	64.5871	-1.0993	4.3815	64.6747	-1.0040	3.6283	-0.0876	0.0953	0.7532	0.7642	0.7532	Z
	6	60.4396	15.9357	6.2375	60.5073	15.8265	5.5615	-0.0677	0.1092	0.6760	0.6881	0.6760	Z
	7	60.9974	12.2570	6.8445	61.0849	12.2622	6.2356	-0.0875	-0.0052	0.6089	0.6152	0.6089	Z
	8	60.4601	8.9195	7.0738	60.4863	9.0218	6.3705	-0.0262	-0.1023	0.7033	0.7112	0.7033	Z
	9	60.0270	3.5837	7.2810	60.1210	3.6244	6.5881	-0.0940	-0.0407	0.6929	0.7004	0.6929	Z
	10	59.7598	-2.2903	7.2382	59.8135	-2.2314	6.6261	-0.0537	0.0589	0.6121	0.6173	0.6121	Z
FLOOR PAN (Z)	11	54.9409	16.1843	8.6992	55.0146	16.2160	8.0465	-0.0737	-0.0317	0.6527	0.6576	0.6527	Z
	12	54.5574	11.4095	8.6059	54.6314	11.4985	7.9438	-0.0740	-0.0890	0.6621	0.6721	0.6621	Z
	13	54.3956	7.4496	8.5143	54.4551	7.5531	7.9033	-0.0595	-0.1035	0.6110	0.6226	0.6110	Z
	14	54.2249	2.5169	8.5686	54.2746	2.5753	7.9010	-0.0497	-0.0584	0.6676	0.6720	0.6676	Z
	15	53.9573	-2.4733	8.0078	54.0639	-2.4618	7.4796	-0.1066	0.0115	0.5282	0.5390	0.5282	Z
	16	50.0518	16.7371	8.8657	50.0624	16.7914	8.2553	-0.0106	-0.0543	0.6104	0.6129	0.6104	Z
	17	49.6878	11.8663	9.0162	49.7037	11.8906	8.4256	-0.0159	-0.0243	0.5906	0.5913	0.5906	Z
	18	49.1611	7.6349	8.5427	49.2793	7.6596	7.9934	-0.1182	-0.0247	0.5493	0.5624	0.5493	Z
	19	48.9540	2.7106	9.0104	48.9738	2.7841	8.3732	-0.0198	-0.0735	0.6372	0.6417	0.6372	Z
	20	48.9553	-1.8083	8.7708	49.0721	-1.7550	8.3064	-0.1168	0.0533	0.4644	0.4818	0.4644	Z
	21	44.2175	16.7349	8.9690	44.2824	16.8686	8.3733	-0.0649	-0.1337	0.5957	0.6140	0.5957	Z
	22	44.0079	11.8696	9.0310	44.0708	12.0081	8.5897	-0.0629	-0.1385	0.4413	0.4668	0.4413	Z
	23	43.9869	7.3134	8.6792	44.0832	7.3664	8.2138	-0.0963	-0.0530	0.4654	0.4782	0.4654	Z
	24	43.8361	2.3413	9.0863	43.9919	2.3872	8.6584	-0.1558	-0.0459	0.4279	0.4577	0.4279	Z
	25	44.0548	-1.5814	8.9172	44.1488	-1.4782	8.5098	-0.0940	0.1032	0.4074	0.4307	0.4074	Z
	26	39.1650	16.6221	8.8613	39.2625	16.6801	8.3791	-0.0975	-0.0580	0.4822	0.4954	0.4822	Z
	27	39.0196	11.8378	8.7221	39.1478	11.8974	8.2899	-0.1282	-0.0596	0.4322	0.4547	0.4322	Z
	28	39.3173	7.1986	8.6985	39.4323	7.3224	8.2938	-0.1150	-0.1238	0.4047	0.4386	0.4047	Z
	29	39.4003	2.0916	8.6531	39.4935	2.1492	8.3235	-0.0932	-0.0576	0.3296	0.3473	0.3296	Z
	30	39.3294	-1.4655	8.3871	39.4677	-1.3717	8.0412	-0.1383	0.0938	0.3459	0.3842	0.3459	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 H-22. Floor Pan Deformation Data – Set 1, Test No. NYBHT-2

Model Year: 2009 Test Name: NYBHT-2 Make: Hyundai VIN: KMHCN46C49U332399 Model: Accent

VEHICLE DEFORMATION
PASSENGER SIDE 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	60.8084	35.4121	1.7292	60.7333	34.6063	1.4554	0.0751	0.8058	0.2738	0.8544	0.2839	X, Z
	2	62.5082	32.4408	2.7389	62.5715	31.7707	2.5608	-0.0633	0.6701	0.1781	0.6962	0.1781	Z
	3	63.6938	30.2061	3.9196	63.9223	29.4689	3.7310	-0.2285	0.7372	0.1886	0.7945	0.1886	Z
	4	63.9247	25.3012	3.9329	64.1206	24.6377	3.7254	-0.1959	0.6635	0.2075	0.7223	0.2075	Z
	5	64.2249	19.5570	3.8090	64.4438	19.0359	3.6071	-0.2189	0.5211	0.2019	0.6002	0.2019	Z
	6	59.1443	36.3536	5.5108	59.4895	35.6671	5.4034	-0.3452	0.6865	0.1074	0.7759	0.1074	Z
	7	59.9134	32.7195	6.1543	60.2333	32.1394	6.1063	-0.3199	0.5801	0.0480	0.6642	0.0480	Z
	8	59.5665	29.3601	6.4270	59.7874	28.8757	6.2671	-0.2209	0.4844	0.1599	0.5559	0.1599	Z
	9	59.4358	24.0113	6.6994	59.6758	23.4690	6.5280	-0.2400	0.5423	0.1714	0.6173	0.1714	Z
	10	59.4987	18.1315	6.7265	59.6434	17.6057	6.6131	-0.1447	0.5258	0.1134	0.5570	0.1134	Z
FLOOR PAN (Z)	11	53.6631	36.3230	8.0235	53.9829	35.8182	7.8833	-0.3198	0.5048	0.1402	0.6138	0.1402	Z
	12	53.5476	31.5335	7.9886	53.8216	31.0873	7.8185	-0.2740	0.4462	0.1701	0.5505	0.1701	Z
	13	53.6077	27.5699	7.9439	53.8307	27.1378	7.8097	-0.2230	0.4321	0.1342	0.5044	0.1342	Z
	14	53.7149	22.6363	8.0562	53.8841	22.1571	7.8474	-0.1692	0.4792	0.2088	0.5494	0.2088	Z
	15	53.7228	17.6327	7.5551	53.9104	17.1124	7.4666	-0.1876	0.5203	0.0885	0.5601	0.0885	Z
	16	48.7524	36.6027	8.2317	49.0090	36.1622	8.0859	-0.2566	0.4405	0.1458	0.5302	0.1458	Z
	17	48.6640	31.7214	8.4415	48.8806	31.2515	8.2955	-0.2166	0.4699	0.1460	0.5376	0.1460	Z
	18	48.3716	27.4618	8.0216	48.6556	27.0019	7.8973	-0.2840	0.4599	0.1243	0.5546	0.1243	Z
	19	48.4457	22.5395	8.5476	48.5791	22.1207	8.3162	-0.1334	0.4188	0.2314	0.4967	0.2314	Z
	20	48.6986	18.0252	8.3597	48.8904	17.5907	8.2861	-0.1918	0.4345	0.0736	0.4806	0.0736	Z
	21	42.9286	36.2747	8.3925	43.2316	35.9689	8.2014	-0.3030	0.3058	0.1911	0.4710	0.1911	Z
	22	42.9933	31.4065	8.5121	43.2482	31.1057	8.4568	-0.2549	0.3008	0.0553	0.3981	0.0553	Z
	23	43.2250	26.8523	8.2126	43.4788	26.4668	8.1183	-0.2538	0.3855	0.0943	0.4711	0.0943	Z
	24	43.3575	21.8848	8.6781	43.6210	21.4926	8.6030	-0.2635	0.3922	0.0751	0.4784	0.0751	Z
	25	43.7947	17.9788	8.5517	43.9593	17.6378	8.4856	-0.1646	0.3410	0.0661	0.3844	0.0661	Z
	26	37.8897	35.8775	8.3358	38.2260	35.5450	8.2070	-0.3363	0.3325	0.1288	0.4901	0.1288	Z
	27	38.0120	31.0913	8.2527	38.3361	30.7616	8.1564	-0.3241	0.3297	0.0963	0.4722	0.0963	Z
	28	38.5696	26.4762	8.2792	38.8351	26.2052	8.1971	-0.2655	0.2710	0.0821	0.3882	0.0821	Z
	29	38.9390	21.3817	8.2915	39.1390	21.0410	8.2685	-0.2000	0.3407	0.0230	0.3957	0.0230	Z
	30	39.0656	17.8232	8.0668	39.2787	17.5205	8.0146	-0.2131	0.3027	0.0522	0.3738	0.0522	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 H-23. Floor Pan Deformation Data – Set 2, Test No. NYBHT-2

Model Year: 2009 Test Name: NYBHT-2 Make: Hyundai VIN: KMHCN46C49U332399 Model: Accent

VEHICLE DEFORMATION
PASSENGER SIDE 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	50.7611	15.6270	-18.9056	50.3635	15.2895	-19.9497	0.3976	0.3375	-1.0441	1.1671	1.1671	X, Y, Z
	2	50.3013	3.7441	-19.4597	49.9341	3.3475	-20.5982	0.3672	0.3966	-1.1385	1.2603	1.2603	X, Y, Z
	3	50.7168	-6.5464	-20.3482	50.3275	-6.8441	-21.3901	0.3893	-0.2977	-1.0419	1.1514	1.1514	X, Y, Z
	4	48.6487	16.8836	-8.2410	48.3741	16.2590	-9.2613	0.2746	0.6246	-1.0203	1.2274	1.2274	X, Y, Z
	5	47.6468	0.5672	-7.9051	47.3479	0.0967	-9.0659	0.2989	0.4705	-1.1608	1.2877	1.2877	X, Y, Z
	6	44.1092	-7.4861	-8.5165	43.7395	-7.8135	-9.5054	0.3697	-0.3274	-0.9889	1.1053	1.1053	X, Y, Z
SIDE PANEL (Y)	7	54.7948	18.7089	0.8062	54.6822	17.8306	-0.2458	0.1126	0.8783	-1.0520	1.3751	0.8783	Y
	8	54.5741	19.5117	4.6018	54.6484	19.1965	3.3798	-0.0743	0.3152	-1.2220	1.2642	0.3152	Y
	9	58.9110	19.0390	4.5314	58.8800	18.7642	3.2244	0.0310	0.2748	-1.3070	1.3359	0.2748	Y
IMPACT SIDE DOOR (Y)	10	46.3803	20.6609	-15.7679	45.7126	20.2769	-16.7187	0.6677	0.3840	-0.9508	1.2236	0.3840	Y
	11	36.0735	20.9654	-16.2839	35.4465	20.7222	-17.0234	0.6270	0.2432	-0.7395	0.9996	0.2432	Y
	12	24.4876	21.1885	-17.2150	23.8716	21.1514	-17.8282	0.6160	0.0371	-0.6132	0.8700	0.0371	Y
	13	43.8644	20.6367	-0.2743	43.5242	20.5228	-1.2819	0.3402	0.1139	-1.0076	1.0696	0.1139	Y
	14	36.7166	20.7730	1.2647	36.4264	20.1548	0.4958	0.2902	0.6182	-0.7689	1.0284	0.6182	Y
	15	26.3618	21.0799	-0.0794	26.0881	20.6972	-0.7537	0.2737	0.3827	-0.6743	0.8222	0.3827	Y
ROOF - (Z)	16	29.2151	10.2706	-36.9899	28.4340	9.9330	-37.6584	0.7811	0.3376	-0.6685	1.0821	-0.6685	Z
	17	29.8228	6.1421	-37.2655	28.9880	5.8455	-37.9068	0.8348	0.2966	-0.6413	1.0937	-0.6413	Z
	18	30.0220	0.9912	-37.5949	29.2458	0.6886	-38.1721	0.7762	0.3026	-0.5772	1.0135	-0.5772	Z
	19	29.7892	-3.2107	-37.8164	28.9217	-3.4627	-38.3605	0.8675	-0.2520	-0.5441	1.0546	-0.5441	Z
	20	29.6707	-6.7230	-37.9056	28.8614	-7.0323	-38.4036	0.8093	-0.3093	-0.4980	0.9993	-0.4980	Z
	21	18.3803	9.5767	-38.4112	17.6417	9.2481	-38.8535	0.7386	0.3286	-0.4423	0.9215	-0.4423	Z
	22	18.6833	5.2867	-38.7999	17.9550	4.9834	-39.1944	0.7283	0.3033	-0.3945	0.8821	-0.3945	Z
	23	18.7361	-0.7732	-39.1718	17.9249	-1.1411	-39.5066	0.8112	-0.3679	-0.3348	0.9516	-0.3348	Z
	24	18.5764	-3.7868	-39.2919	17.8307	-4.1799	-39.5912	0.7457	-0.3931	-0.2993	0.8945	-0.2993	Z
	25	18.6320	-6.6253	-39.3410	17.7961	-7.0129	-39.6143	0.8359	-0.3876	-0.2733	0.9611	-0.2733	Z
	26	8.7480	9.9703	-38.7678	7.8990	9.6053	-39.0226	0.8490	0.3650	-0.2548	0.9586	-0.2548	Z
	27	8.7025	5.9692	-39.1435	7.8311	5.5896	-39.3539	0.8714	0.3796	-0.2104	0.9735	-0.2104	Z
	28	8.5328	0.7380	-39.5087	7.7430	0.3771	-39.6578	0.7898	0.3609	-0.1491	0.8811	-0.1491	Z
	29	8.8291	-3.3221	-39.6759	8.0395	-3.7136	-39.7888	0.7896	-0.3915	-0.1129	0.8885	-0.1129	Z
	30	8.6222	-6.8780	-39.7448	7.8374	-7.2306	-39.8157	0.7848	-0.3526	-0.0709	0.8633	-0.0709	Z
A-PILLAR Maximum (X, Y, Z)	31	53.9373	18.0154	-22.0038	53.3552	17.7382	-23.0797	0.5821	0.2772	-1.0759	1.2543	0.6447	X, Y
	32	50.1634	17.3907	-24.7399	49.5552	17.1284	-25.8080	0.6082	0.2623	-1.0681	1.2568	0.6624	X, Y
	33	47.2121	16.8081	-26.5155	46.5426	16.5290	-27.5078	0.6695	0.2791	-0.9923	1.2291	0.7253	X, Y
	34	44.2815	16.3085	-28.3787	43.6281	16.0152	-29.3793	0.6534	0.2933	-1.0006	1.2305	0.7162	X, Y
	35	40.6629	15.6217	-30.4094	40.0148	15.3238	-31.3080	0.6481	0.2979	-0.8986	1.1473	0.7133	X, Y
	36	36.8605	15.0154	-32.1377	36.1231	14.6920	-32.9927	0.7374	0.3234	-0.8550	1.1745	0.8052	X, Y
A-PILLAR Lateral (Y)	31	53.9373	18.0154	-22.0038	53.3552	17.7382	-23.0797	0.5821	0.2772	-1.0759	1.2543	0.2772	Y
	32	50.1634	17.3907	-24.7399	49.5552	17.1284	-25.8080	0.6082	0.2623	-1.0681	1.2568	0.2623	Y
	33	47.2121	16.8081	-26.5155	46.5426	16.5290	-27.5078	0.6695	0.2791	-0.9923	1.2291	0.2791	Y
	34	44.2815	16.3085	-28.3787	43.6281	16.0152	-29.3793	0.6534	0.2933	-1.0006	1.2305	0.2933	Y
	35	40.6629	15.6217	-30.4094	40.0148	15.3238	-31.3080	0.6481	0.2979	-0.8986	1.1473	0.2979	Y
	36	36.8605	15.0154	-32.1377	36.1231	14.6920	-32.9927	0.7374	0.3234	-0.8550	1.1745	0.3234	Y
B-PILLAR Maximum (X, Y, Z)	37	16.8698	17.3616	-27.9225	16.2910	16.9735	-28.3981	0.5788	0.3881	-0.4756	0.8437	0.6969	X, Y
	38	14.4679	19.4720	-19.7747	14.0058	18.9719	-20.1885	0.4621	0.5001	-0.4138	0.7968	0.6809	X, Y
	39	19.5888	19.5296	-13.2889	19.2654	19.1528	-13.8079	0.3234	0.3768	-0.5190	0.7183	0.4966	X, Y
	40	15.8364	19.5700	-6.0702	15.6244	19.0647	-6.4989	0.2120	0.5053	-0.4287	0.6957	0.5480	X, Y
B-PILLAR Lateral (Y)	37	16.8698	17.3616	-27.9225	16.2910	16.9735	-28.3981	0.5788	0.3881	-0.4756	0.8437	0.3881	Y
	38	14.4679	19.4720	-19.7747	14.0058	18.9719	-20.1885	0.4621	0.5001	-0.4138	0.7968	0.5001	Y
	39	19.5888	19.5296	-13.2889	19.2654	19.1528	-13.8079	0.3234	0.3768	-0.5190	0.7183	0.3768	Y
	40	15.8364	19.5700	-6.0702	15.6244	19.0647	-6.4989	0.2120	0.5053	-0.4287	0.6957	0.5053	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 H-24. Occupant Compartment Deformation Data – Set 1, Test No. NYBHT-2

Model Year: 2009 Test Name: NYBHT-2 Make: Hyundai VIN: KMHCN46C49U332399 Model: Accent

VEHICLE DEFORMATION
PASSENGER SIDE 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	49.1235	35.1166	-19.9490	49.4472	34.3892	-20.0767	-0.3237	0.7274	-0.1277	0.8063	0.8063	X, Y, Z
	2	49.3202	23.2194	-20.3235	49.5727	22.4344	-20.6102	-0.2525	0.7850	-0.2867	0.8730	0.8730	X, Y, Z
	3	50.2958	12.9556	-21.0710	50.4393	12.2648	-21.3026	-0.1435	0.6908	-0.2316	0.7426	0.7426	X, Y, Z
	4	47.1269	36.4174	-9.2674	47.3930	35.3681	-9.4015	-0.2661	1.0493	-0.1341	1.0908	1.0908	X, Y, Z
	5	47.0458	20.0778	-8.6785	47.1159	19.1782	-9.0511	-0.0701	0.8996	-0.3726	0.9762	0.9762	X, Y, Z
	6	43.9547	11.8314	-9.1103	43.8787	11.1055	-9.4198	0.0760	0.7259	-0.3095	0.7928	0.7928	X, Y, Z
SIDE PANEL (Y)	7	53.3152	38.7214	-0.3592	53.6029	37.3168	-0.3914	-0.2877	1.4046	-0.0322	1.4341	1.4046	Y
	8	53.1148	39.5689	3.4278	53.4983	38.7144	3.2206	-0.3835	0.8545	-0.2072	0.9593	0.8545	Y
	9	57.4696	39.3376	3.2864	57.7458	38.4772	3.0763	-0.2762	0.8604	-0.2101	0.9277	0.8604	Y
IMPACT SIDE DOOR (Y)	10	44.5221	39.9463	-16.8060	44.5636	39.1866	-16.9017	-0.0415	0.7597	-0.0957	0.7668	0.7597	Y
	11	34.2070	39.6681	-17.1412	34.2886	39.1528	-17.2274	-0.0816	0.5153	-0.0862	0.5288	0.5153	Y
	12	22.6126	39.2310	-17.8673	22.7079	39.0376	-18.0550	-0.0953	0.1934	-0.1877	0.2859	0.1934	Y
	13	42.2771	40.0203	-1.2710	42.3343	39.4790	-1.4717	-0.0572	0.5413	-0.2007	0.5801	0.5413	Y
	14	35.1602	39.7818	0.3940	35.2575	38.7998	0.2980	-0.0973	0.9820	-0.0960	0.9915	0.9820	Y
	15	24.7830	39.4905	-0.7683	24.9078	38.8505	-0.9734	-0.1248	0.6400	-0.2051	0.6836	0.6400	Y
ROOF - (Z)	16	27.6047	28.2905	-37.5646	27.8259	27.8526	-37.7682	-0.2212	0.4379	-0.2036	0.5312	-0.2036	Z
	17	28.4377	24.1985	-37.7916	28.5691	23.7930	-37.9761	-0.1314	0.4055	-0.1845	0.4645	-0.1845	Z
	18	28.9193	19.0623	-38.0503	29.0660	18.6512	-38.1909	-0.1467	0.4111	-0.1406	0.4586	-0.1406	Z
	19	28.9184	14.8510	-38.2070	28.9350	14.4878	-38.3397	-0.0166	0.3632	-0.1327	0.3870	-0.1327	Z
	20	28.9952	11.3365	-38.2434	29.0401	10.9190	-38.3483	-0.0449	0.4175	-0.1049	0.4328	-0.1049	Z
	21	16.8030	26.9722	-38.7811	17.0794	26.6570	-38.9741	-0.2764	0.3152	-0.1930	0.4615	-0.1930	Z
	22	17.3390	22.7002	-39.1133	17.5906	22.4083	-39.2731	-0.2516	0.2919	-0.1598	0.4172	-0.1598	Z
	23	17.7245	16.6477	-39.3988	17.8448	16.2863	-39.5260	-0.1203	0.3614	-0.1272	0.4016	-0.1272	Z
	24	17.7318	13.6284	-39.4726	17.8916	13.2457	-39.5813	-0.1598	0.3827	-0.1087	0.4287	-0.1087	Z
	25	17.9454	10.7970	-39.4817	17.9883	10.4140	-39.5770	-0.0429	0.3830	-0.0953	0.3970	-0.0953	Z
	26	7.1591	26.8230	-38.9703	7.3311	26.5608	-39.1625	-0.1720	0.2622	-0.1922	0.3678	-0.1922	Z
	27	7.3313	22.8203	-39.2875	7.4499	22.5432	-39.4549	-0.1186	0.2771	-0.1674	0.3448	-0.1674	Z
	28	7.4484	17.5827	-39.5742	7.6039	17.3296	-39.7084	-0.1555	0.2531	-0.1342	0.3260	-0.1342	Z
	29	7.9686	13.5433	-39.6882	8.0898	13.2559	-39.7993	-0.1212	0.2874	-0.1111	0.3311	-0.1111	Z
	30	7.9599	9.9808	-39.7021	8.0508	9.7333	-39.7924	-0.0909	0.2475	-0.0903	0.2787	-0.0903	Z
A-PILLAR Maximum (X, Y, Z)	31	52.1075	37.6303	-23.1378	52.3288	36.9437	-23.2255	-0.2213	0.6866	-0.0877	0.7267	0.6866	Y
	32	48.3282	36.7543	-25.7964	48.5667	36.1323	-25.9539	-0.2385	0.6220	-0.1575	0.6845	0.6220	Y
	33	45.3841	35.9810	-27.5102	45.5886	35.3777	-27.6527	-0.2045	0.6033	-0.1425	0.6528	0.6033	Y
	34	42.4547	35.2902	-29.3131	42.7049	34.7115	-29.5239	-0.2502	0.5787	-0.2108	0.6648	0.5787	Y
	35	38.8459	34.3717	-31.2684	39.1315	33.8349	-31.4516	-0.2856	0.5368	-0.1832	0.6350	0.5368	Y
	36	35.0545	33.5280	-32.9193	35.2767	33.0073	-33.1364	-0.2222	0.5207	-0.2171	0.6063	0.5207	Y
A-PILLAR Lateral (Y)	31	52.1075	37.6303	-23.1378	52.3288	36.9437	-23.2255	-0.2213	0.6866	-0.0877	0.7267	0.6866	Y
	32	48.3282	36.7543	-25.7964	48.5667	36.1323	-25.9539	-0.2385	0.6220	-0.1575	0.6845	0.6220	Y
	33	45.3841	35.9810	-27.5102	45.5886	35.3777	-27.6527	-0.2045	0.6033	-0.1425	0.6528	0.6033	Y
	34	42.4547	35.2902	-29.3131	42.7049	34.7115	-29.5239	-0.2502	0.5787	-0.2108	0.6648	0.5787	Y
	35	38.8459	34.3717	-31.2684	39.1315	33.8349	-31.4516	-0.2856	0.5368	-0.1832	0.6350	0.5368	Y
	36	35.0545	33.5280	-32.9193	35.2767	33.0073	-33.1364	-0.2222	0.5207	-0.2171	0.6063	0.5207	Y
B-PILLAR Maximum (X, Y, Z)	37	15.0388	34.8213	-28.3801	15.3508	34.4116	-28.5962	-0.3120	0.4097	-0.2161	0.5585	0.4097	Y
	38	12.6624	36.9197	-20.2218	12.9585	36.3808	-20.4101	-0.2961	0.5389	-0.1883	0.6431	0.5389	Y
	39	17.8822	37.3623	-13.8305	18.1909	36.8664	-14.0231	-0.3087	0.4959	-0.1926	0.6151	0.4959	Y
	40	14.2576	37.3045	-6.5469	14.5428	36.6799	-6.7195	-0.2852	0.6246	-0.1726	0.7080	0.6246	Y
B-PILLAR Lateral (Y)	37	15.0388	34.8213	-28.3801	15.3508	34.4116	-28.5962	-0.3120	0.4097	-0.2161	0.5585	0.4097	Y
	38	12.6624	36.9197	-20.2218	12.9585	36.3808	-20.4101	-0.2961	0.5389	-0.1883	0.6431	0.5389	Y
	39	17.8822	37.3623	-13.8305	18.1909	36.8664	-14.0231	-0.3087	0.4959	-0.1926	0.6151	0.4959	Y
	40	14.2576	37.3045	-6.5469	14.5428	36.6799	-6.7195	-0.2852	0.6246	-0.1726	0.7080	0.6246	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 H-25. Occupant Compartment Deformation Data – Set 2, Test No. NYBHT-2

Test Name: NYBHT-2 VIN: KMHCN46C49U332399

Model Year: 2009 Make: Hyundai Model: Accent

Passenger Side Maximum Deformations

Reference Set 1				Reference Set 2			
Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]	Location	Maximum Deformation[A,B] (in.)	MASH Allowable Deformation (in.)	Directions of Deformation[C]
Roof	-0.7	≤ 4	Z	Roof	-0.2	≤ 4	Z
Windshield[D]	0.0	≤ 3	X, Z	Windshield[D]	NA	≤ 3	X, Z
A-Pillar Maximum	0.8	≤ 5	X, Y	A-Pillar Maximum	0.7	≤ 5	Y
A-Pillar Lateral	0.3	≤ 3	Y	A-Pillar Lateral	0.7	≤ 3	Y
B-Pillar Maximum	0.7	≤ 5	X, Y	B-Pillar Maximum	0.6	≤ 5	Y
B-Pillar Lateral	0.5	≤ 3	Y	B-Pillar Lateral	0.6	≤ 3	Y
Toe Pan - Wheel Well	0.9	≤ 9	X, Z	Toe Pan - Wheel Well	0.3	≤ 9	X, Z
Side Front Panel	0.9	≤ 12	Y	Side Front Panel	1.4	≤ 12	Y
Side Door (above seat)	0.4	≤ 9	Y	Side Door (above seat)	0.8	≤ 9	Y
Side Door (below seat)	0.6	≤ 12	Y	Side Door (below seat)	1.0	≤ 12	Y
Floor Pan	0.7	≤ 12	Z	Floor Pan	0.2	≤ 12	Z
Dash - no MASH requirement	1.3	NA	X, Y, Z	Dash - no MASH requirement	1.1	NA	X, Y, Z

[A] Items highlighted in red do not meet MASH allowable deformations.

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

[C] For Toe Pan - Wheel Well the direction of defromation may include X and Z direction. For A-Pillar Maximum and B-Pillar Maximum the direction of deformation may include X, Y, and Z directions. The direction of deformation for Toe Pan -Wheel Well, A-Pillar Maximum, and B-Pillar Maximum only include components where the deformation is positive and intruding into the occupant compartment. If direction of deformation is "NA" then no intrusion is recorded and deformation will be 0.

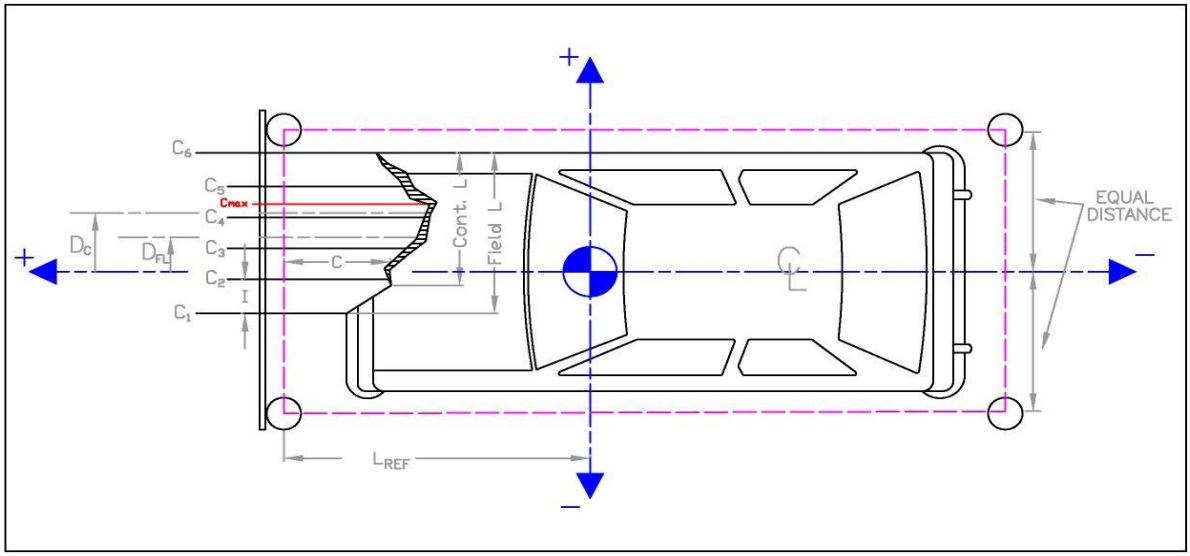
[D] If deformation is observered for the windshield then the windshield deformation is measured posttest with an examplar vehicle, therefore only one set of reference is measured and recorded.

Notes on vehicle crush:

Figure H-26. Maximum Occupant Compartment Deformation by Location, Test No. NYBHT-2

NYBHT-2 VIN: KMHCN46C49U332399

Model Year: 2009 Make: Hyundai Model: Accent



	in.	(mm)
Distance from C.G. to reference line - L_{REF}:	83 3/4	(2127)
Total Width of Vehicle:	62	(1575)
Width of contact and induced crush - Field L:	62	(1575)
Crush measurement spacing interval (L/5) - I:	12 3/8	(314)
Distance from center of vehicle to center of Field L - D_{FL}:	0	()
Width of Contact Damage:	62	(1575)
Distance from center of vehicle to center of contact damage - D_C:	0	()

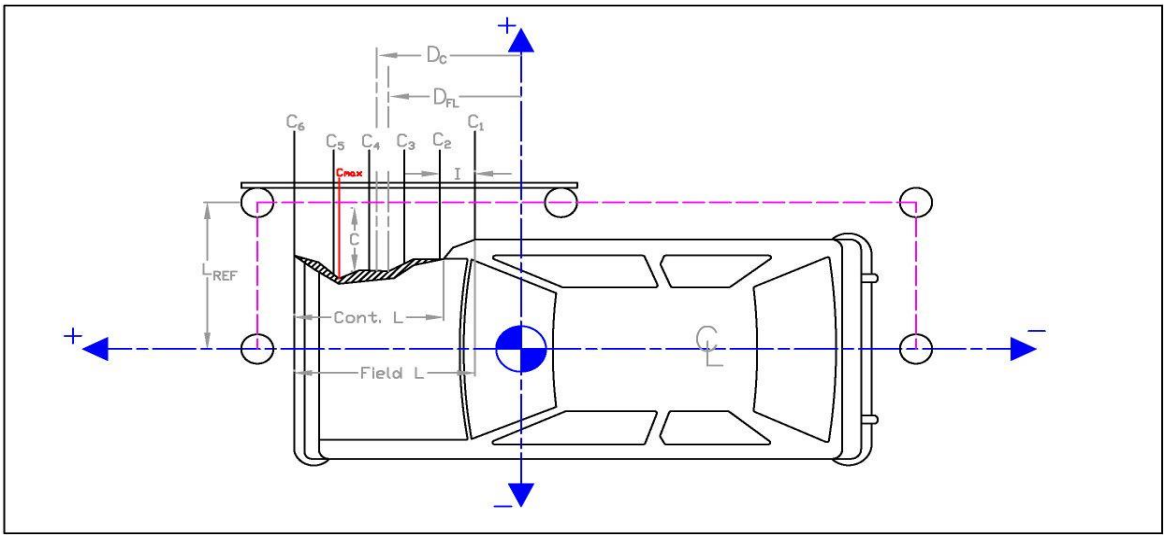
NOTE: Enter "NA" for crush measurement if distance can not be measured (i.e., side of vehicle has been pushed inward)
NOTE: All values must be filled out above before crush measurements are filled out.

	Crush Measurement		Lateral Location		Original Profile Measurement		Dist. Between Ref. Lines		Actual Crush	
	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)	in.	(mm)
C_1	N/a	NA	-31	-(787)	17 1/4	(438)	12 1/4	(311)	NA	NA
C_2	18 1/2	(470)	-18 5/8	-(473)	4 1/2	(114)			1 3/4	(44)
C_3	16 1/3	(414)	-6 1/4	-(159)	2 3/8	(60)			1 2/3	(43)
C_4	17 4/9	(443)	6 1/8	(156)	2 1/4	(57)			3	(75)
C_5	20 5/8	(524)	18 1/2	(470)	4 3/8	(111)			4	(102)
C_6	n/a	NA	30 7/8	(784)	16 5/8	(422)			NA	NA
C_{MAX}	20 5/8	(524)	18 1/2	(470)	4 3/8	(111)			4	(102)

Figure H-27. Exterior Vehicle Crush (NASS) – Front, Test No. NYBHT-2

Test Name: NYBHT-2 VIN: KMHCN46C49U332399

Model Year: 2009 Make: Hyundai Model: Accent



	in.	(mm)
Distance from centerline to reference line - L_{REF}:	40	(1016)
Total Vehicle Length:	168 1/2	(4280)
Distance from vehicle c.g. to 1/2 of Vehicle total length:	-11 1/8	-(283)
Width of contact and induced crush - Field L:	168 1/2	(4280)
Crush measurement spacing interval (L/5) - I:	33 3/4	(857)
Distance from vehicle c.g. to center of Field L - D_{FL}:	-14 3/4	-(375)
Width of Contact Damage:	168 1/2	(4280)
Distance from vehicle c.g. to center of contact damage - D_C:	-14 3/4	-(375)

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	NA	-99	-(2515)	36	(914)	4	(102)	NA	NA
C_2	n/a	NA	-65 1/4	-(1657)	4	(102)			NA	NA
C_3	7 1/2	(191)	-31 1/2	-(800)	3 3/8	(86)			1/8	(3)
C_4	8 1/2	(216)	2 1/4	(57)	3 1/4	(83)			1 1/4	(32)
C_5	n/a	NA	36	(914)	3 1/2	(89)			NA	NA
C_6	n/a	NA	69 3/4	(1772)	36	(914)			NA	NA
C_{MAX}	8 1/2	(216)	45	(1143)	3 7/8	(98)			5/8	(16)

Figure H-28. Exterior Vehicle Crush (NASS) – Side, Test No. NYBHT-2

Appendix I. Accelerometer and Rate Transducer Data Plots, Test No. NYHBT-1

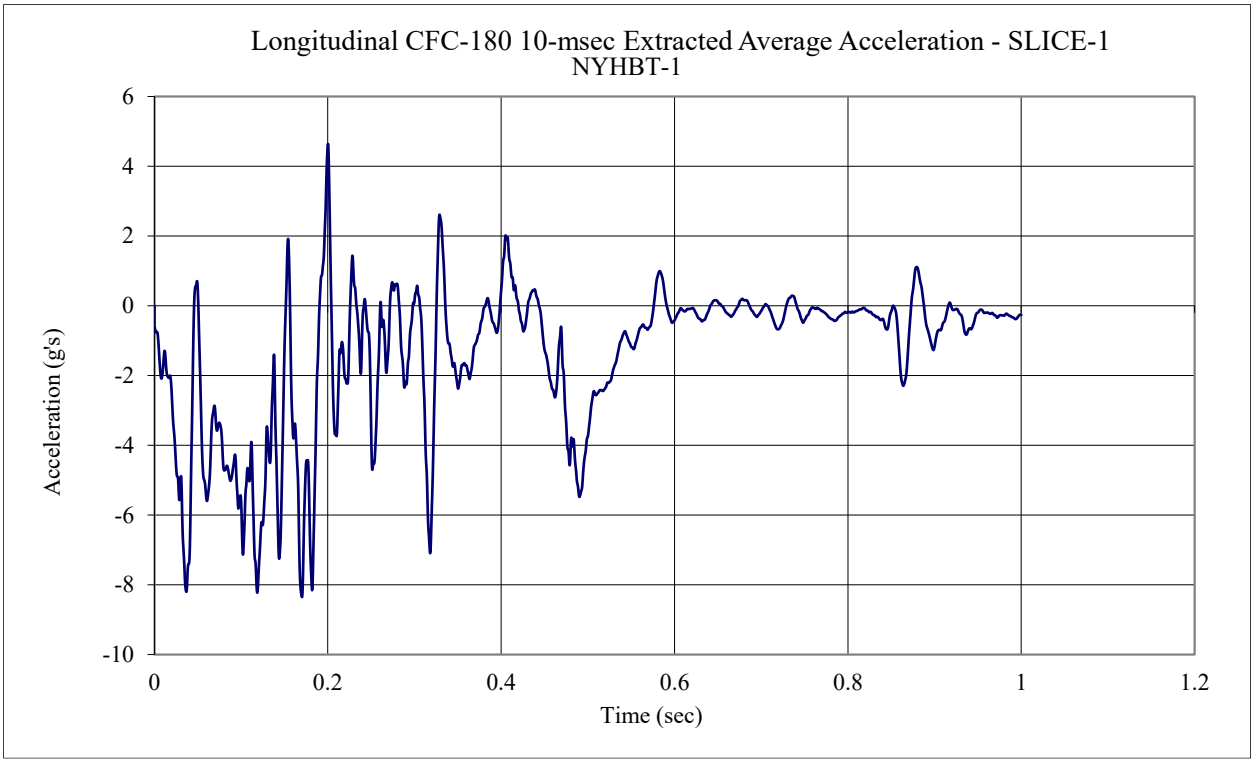


Figure I-1. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYHBT-1

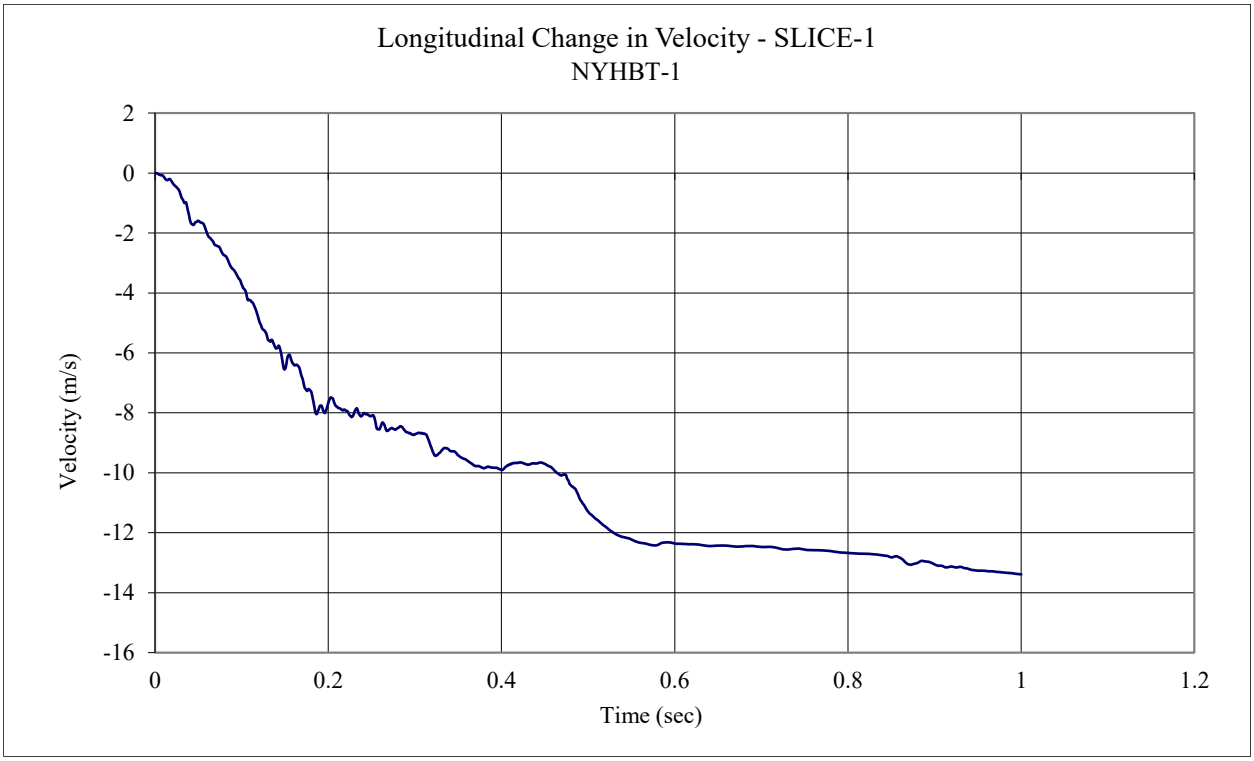


Figure I-2. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYHBT-1

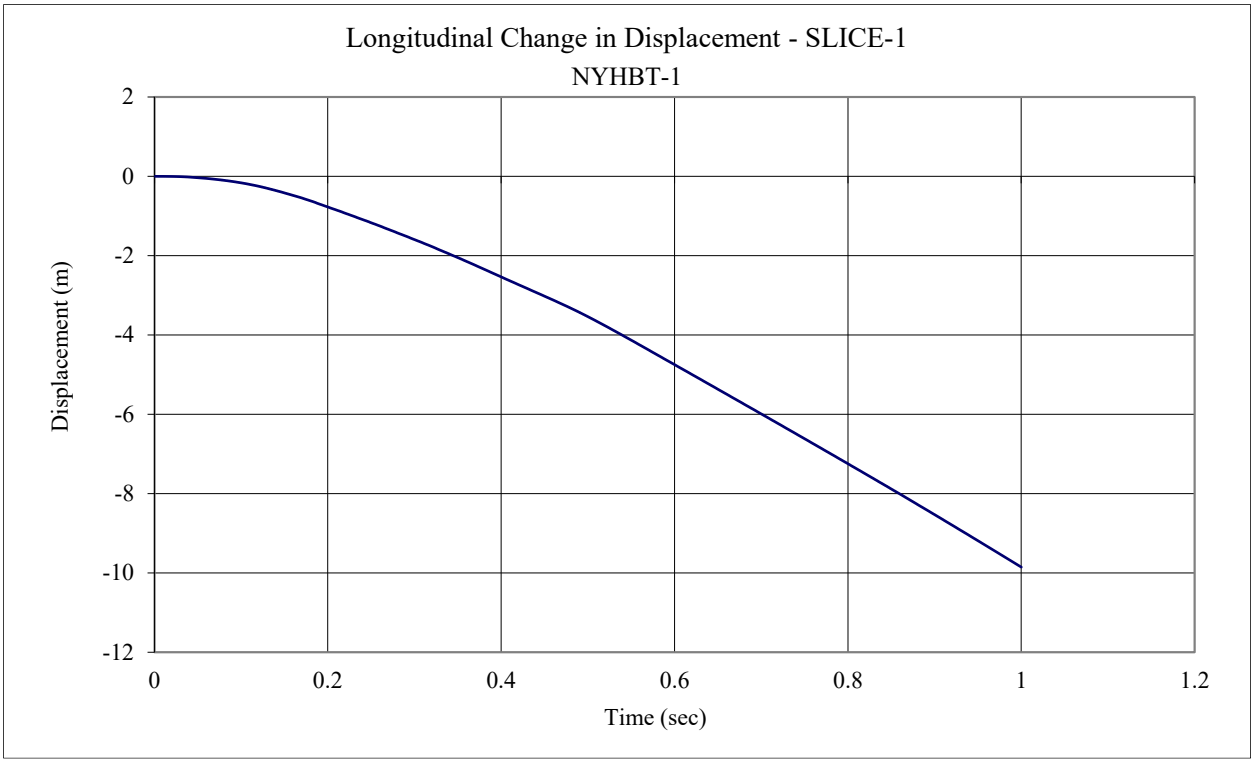


Figure I-3. Longitudinal Occupant Displacement (SLICE-1), Test No. NYHBT-1

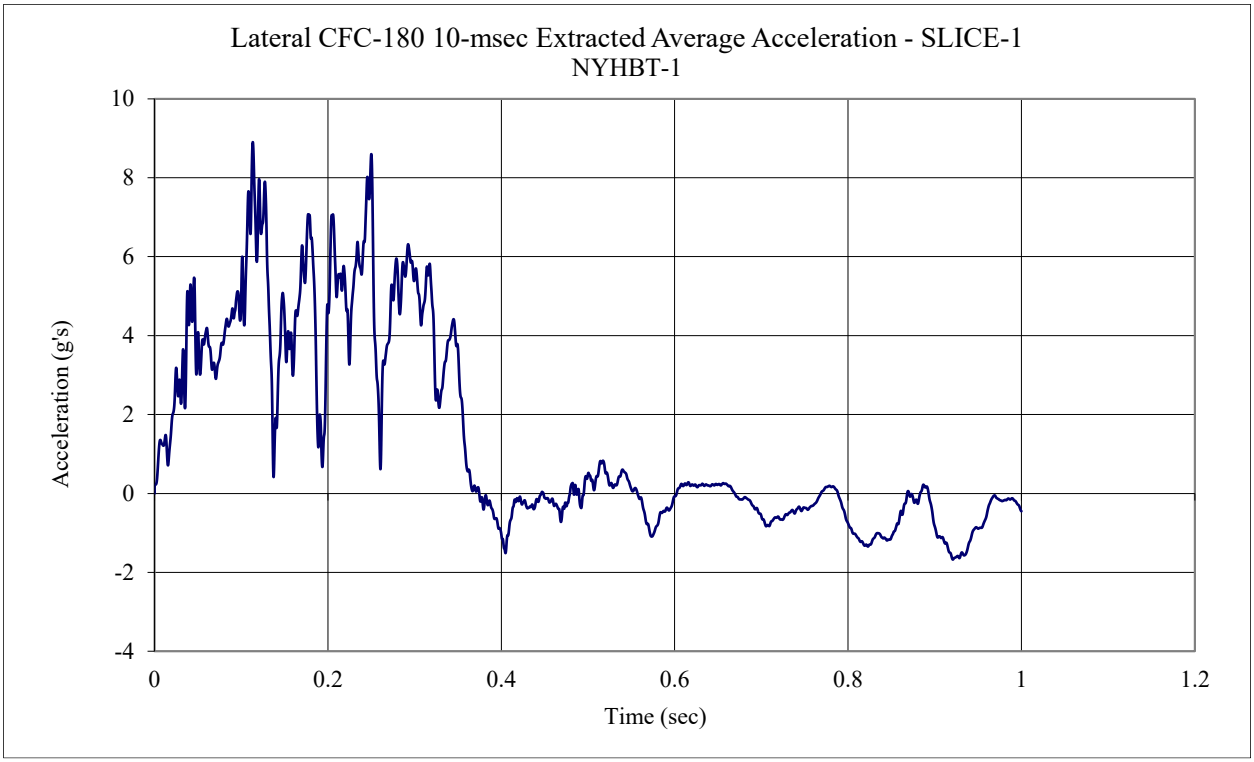


Figure I-4. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYHBT-1

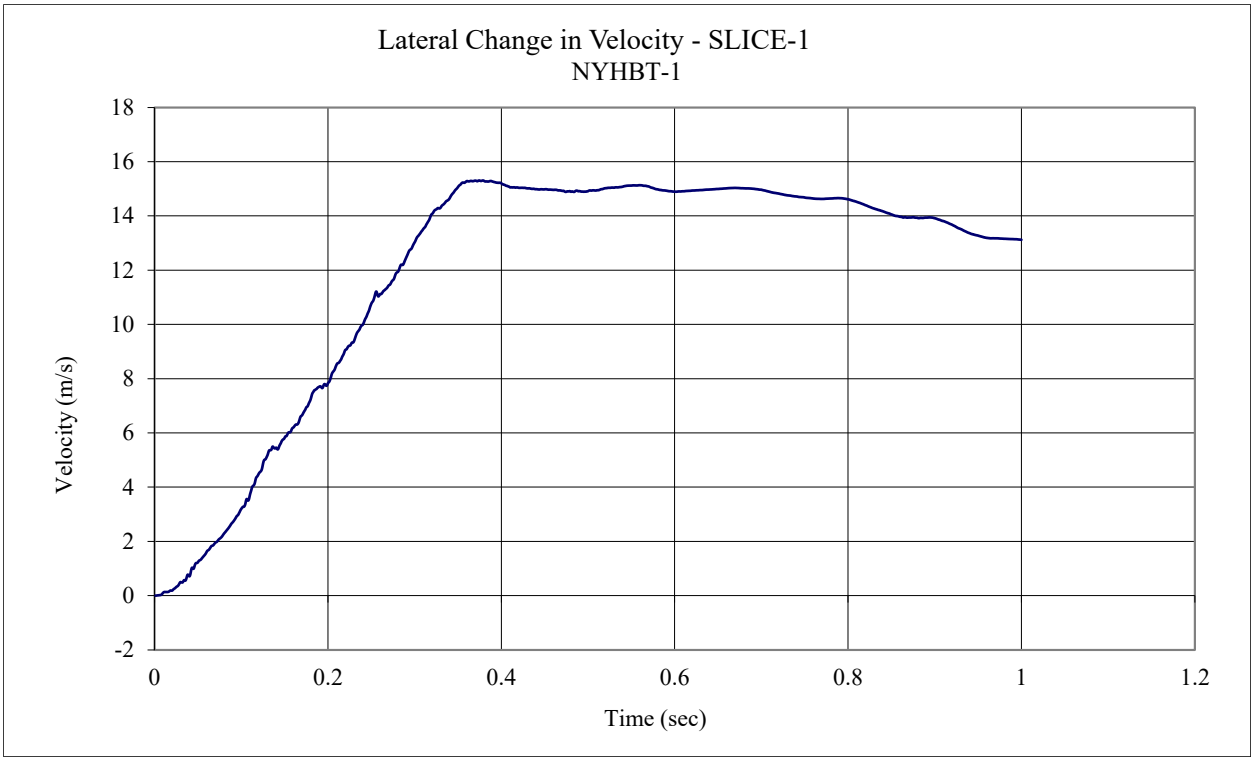


Figure I-5. Lateral Occupant Impact Velocity (SLICE-1), Test No. NYHBT-1

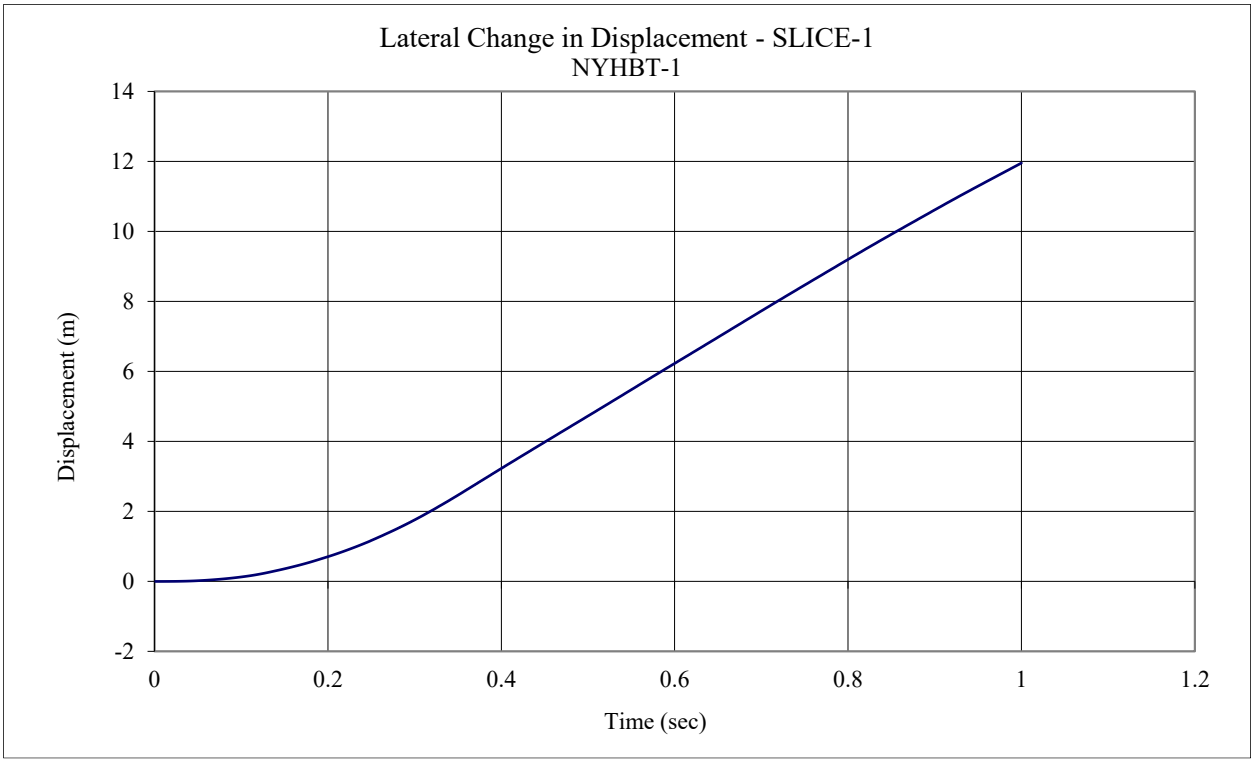


Figure I-6. Lateral Occupant Displacement (SLICE-1), Test No. NYHBT-1

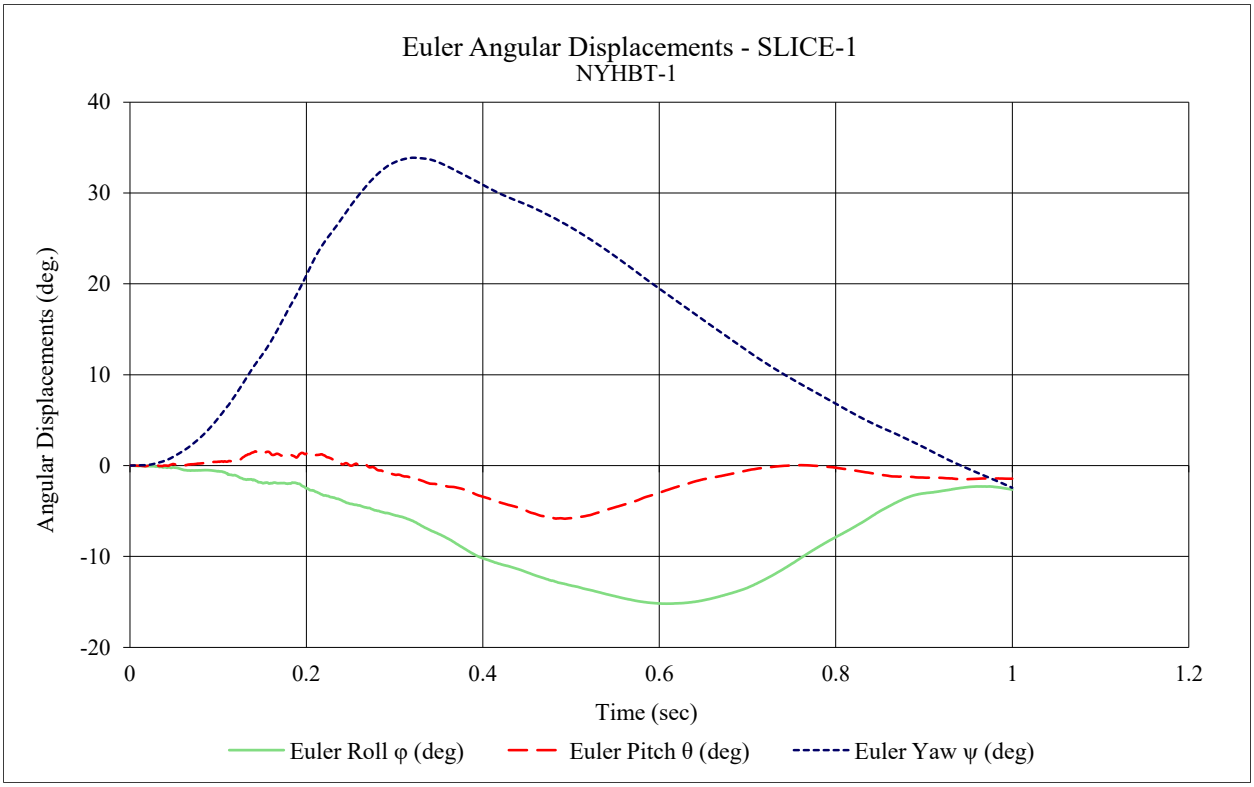


Figure I-7. Vehicle Angular Displacements (SLICE-1), Test No. NYHBT-1

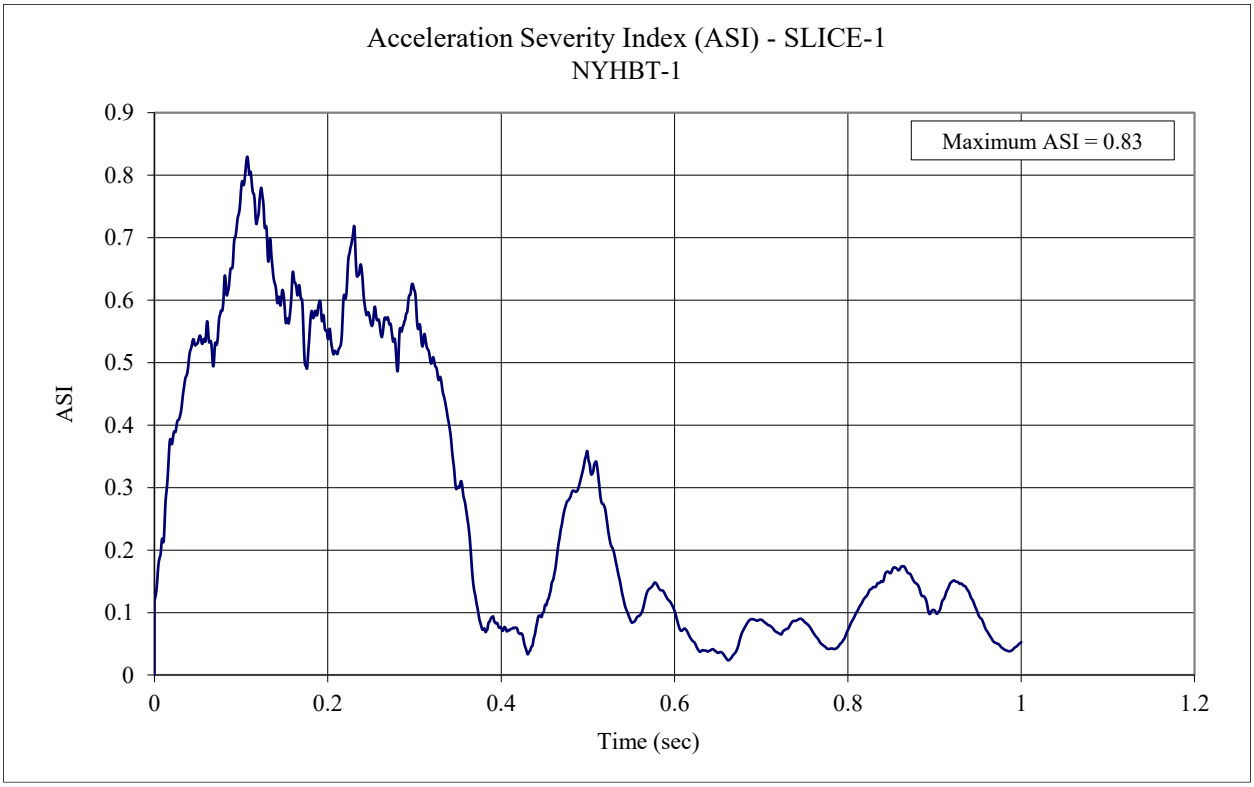


Figure I-8. Acceleration Severity Index (SLICE-1), Test No. NYHBT-1

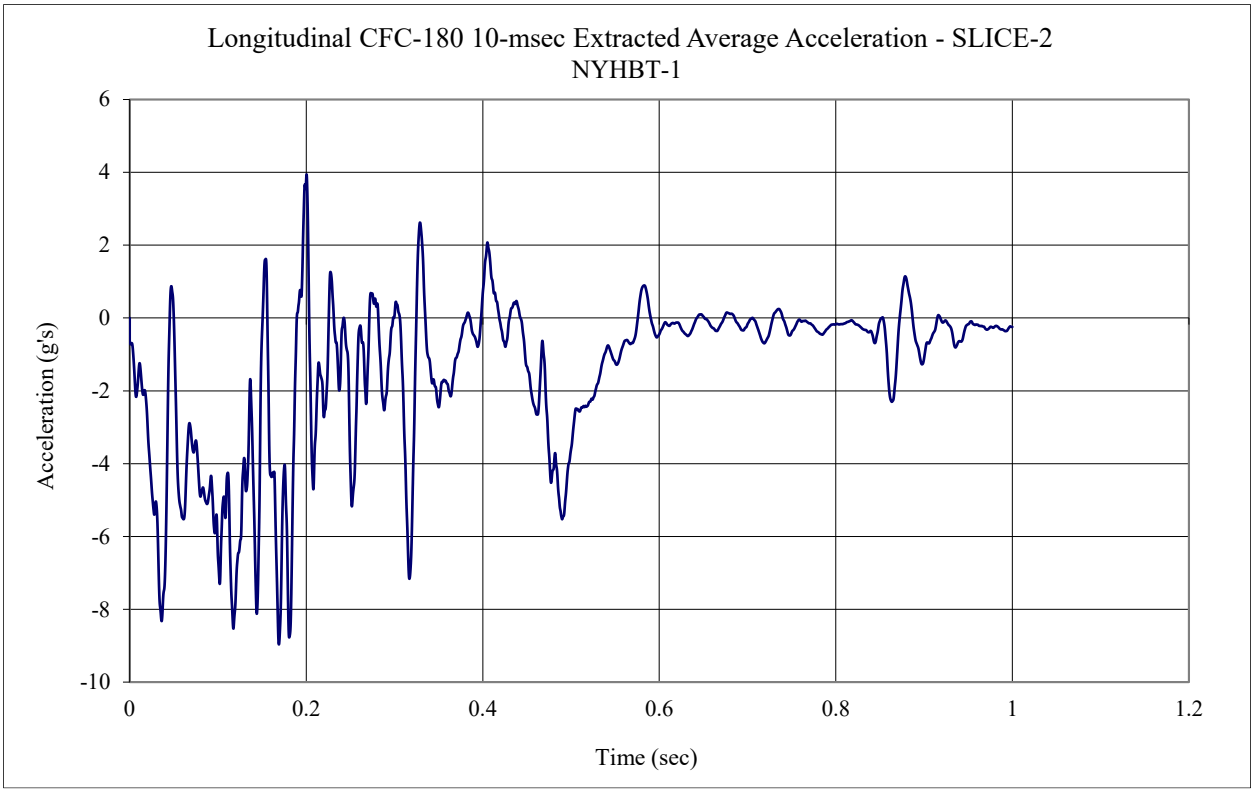


Figure I-9. 10-ms Average Longitudinal Deceleration (SLICE-2), Test No. NYHBT-1

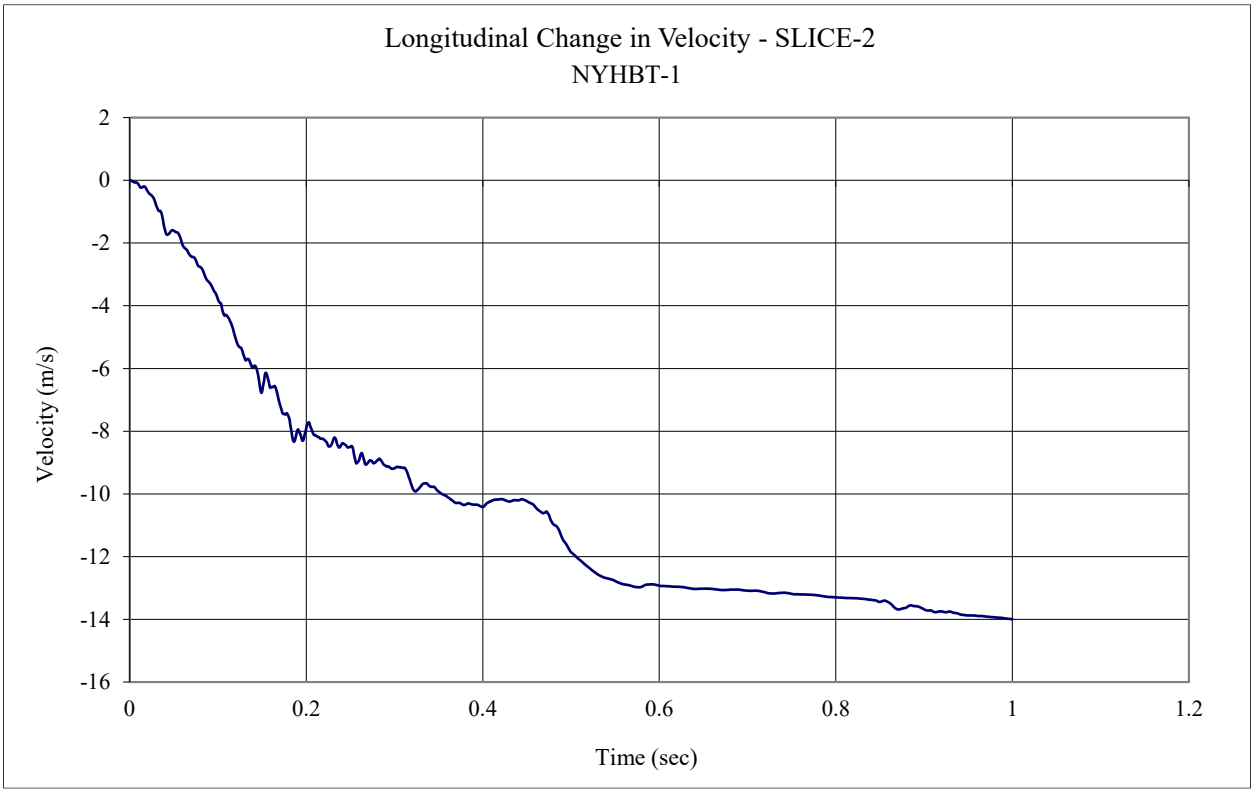


Figure I-10. Longitudinal Occupant Impact Velocity (SLICE-2), Test No. NYHBT-1

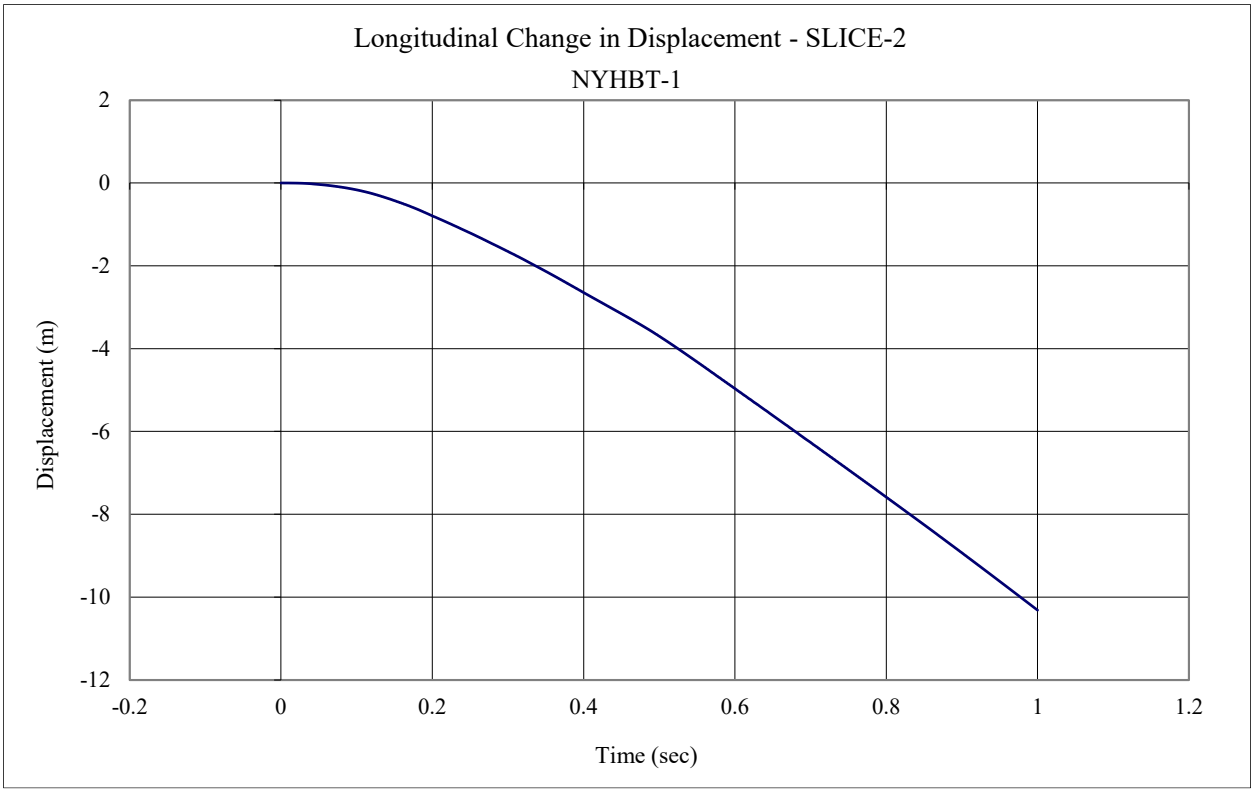


Figure I-11. Longitudinal Occupant Displacement (SLICE-2), Test No. NYHBT-1

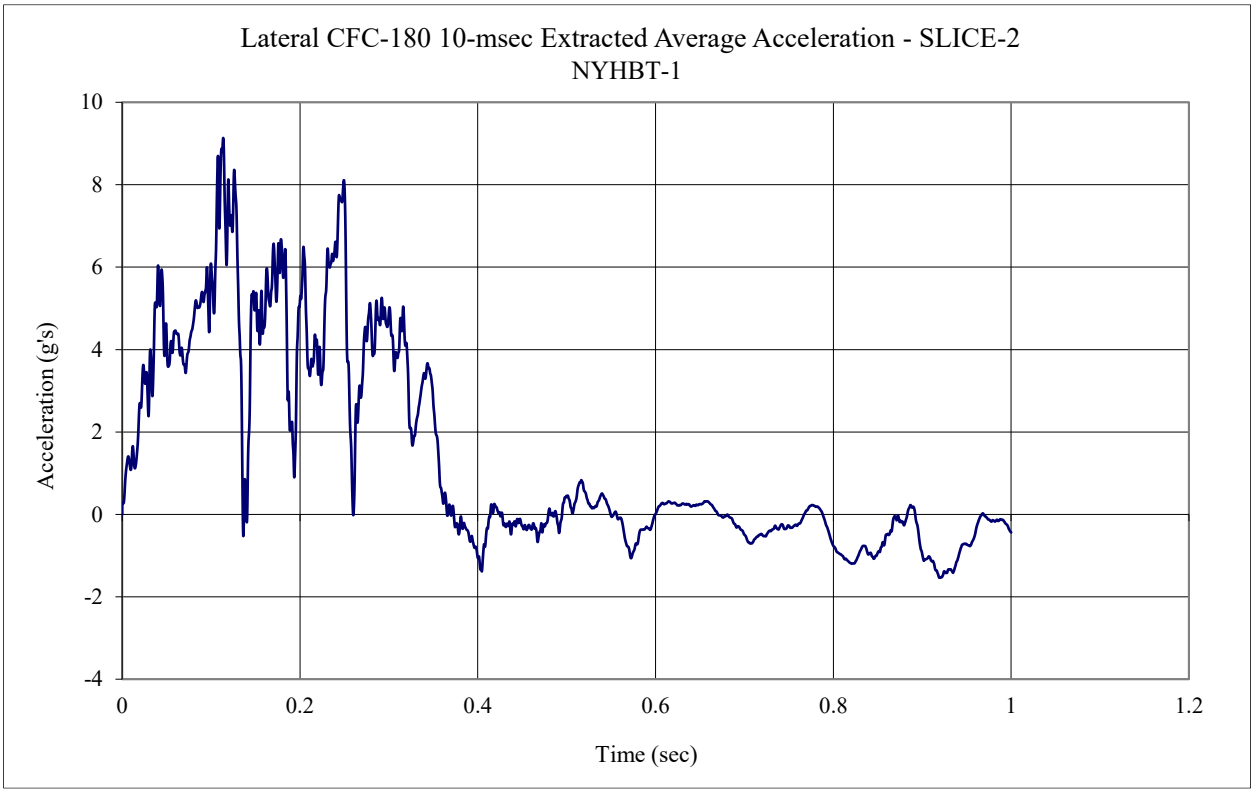


Figure I-12. 10-ms Average Lateral Deceleration (SLICE-2), Test No. NYHBT-1

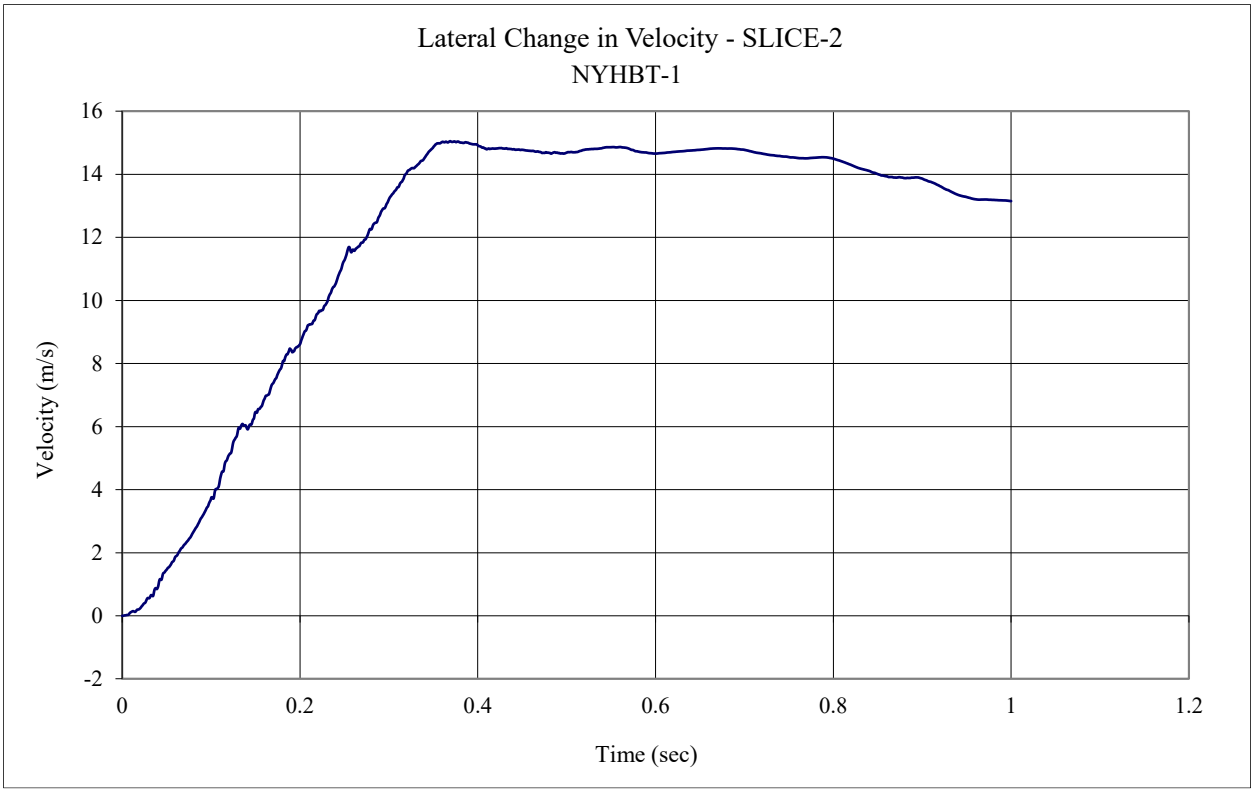


Figure I-13. Lateral Occupant Impact Velocity (SLICE-2), Test No. NYHBT-1



Figure I-14. Lateral Occupant Displacement (SLICE-2), Test No. NYHBT-1

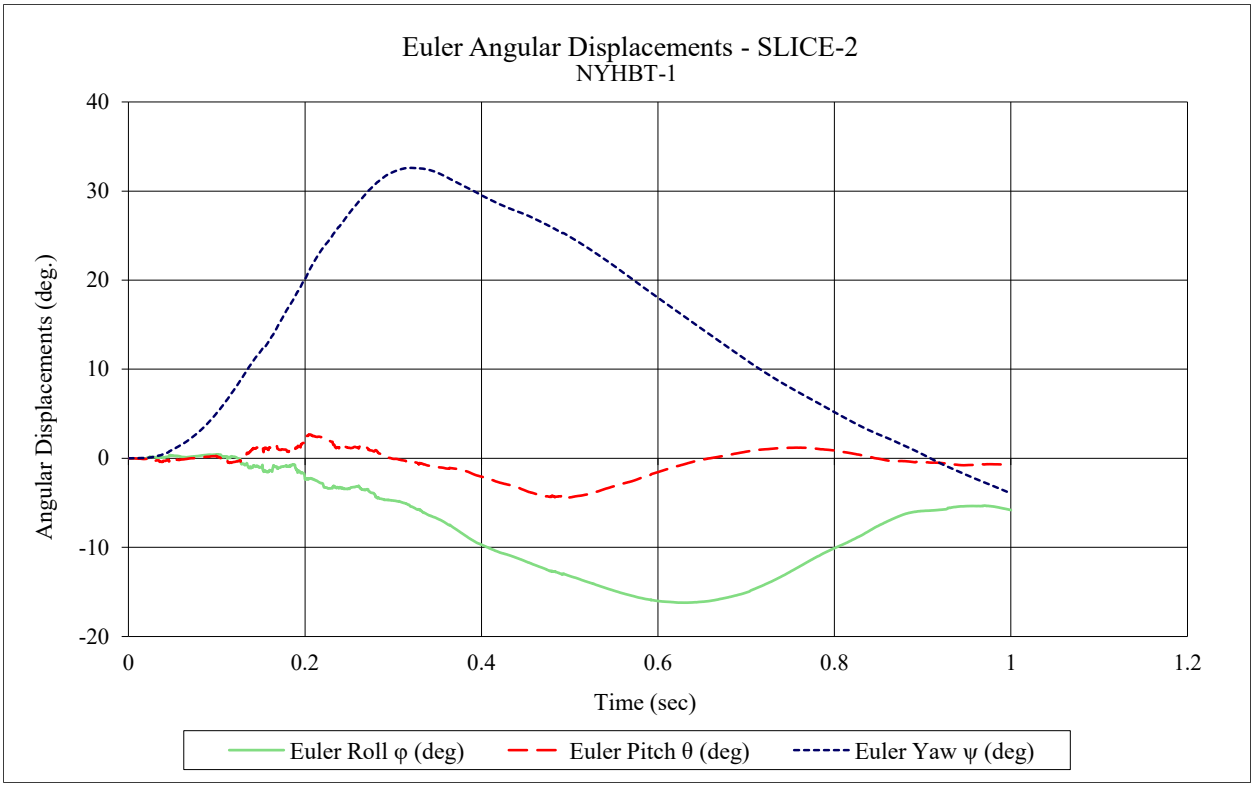


Figure I-15. Vehicle Angular Displacements (SLICE-2), Test No. NYHBT-1

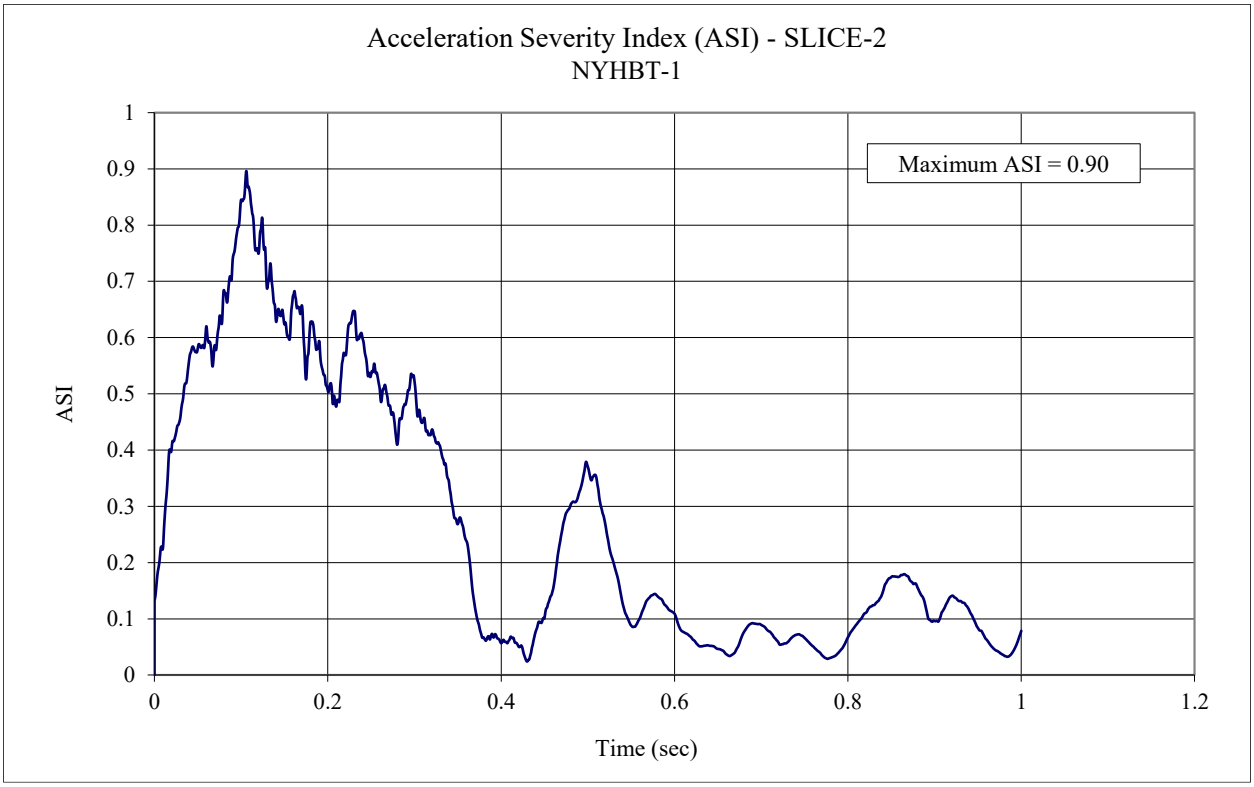


Figure I-16. Acceleration Severity Index (SLICE-2), Test No. NYHBT-1

Appendix J. Accelerometer and Rate Transducer Data Plots, Test No. NYHBT-2

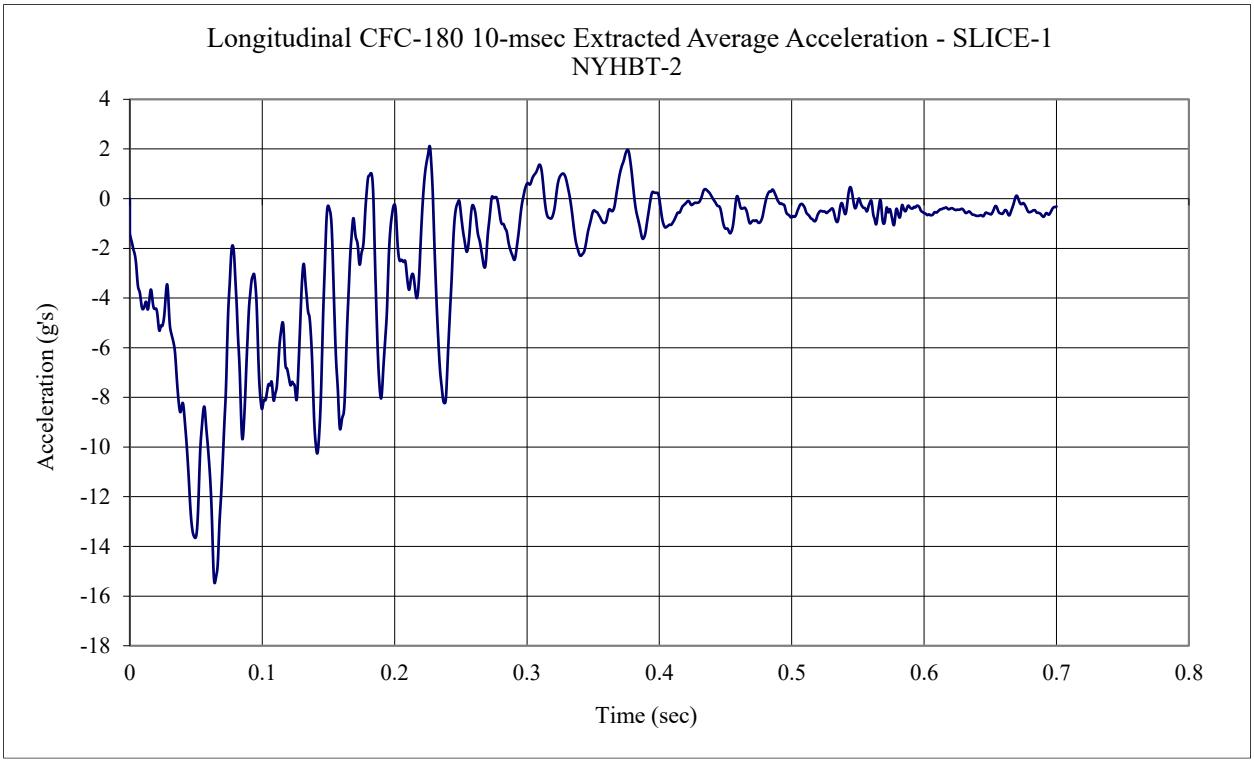


Figure J-1. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYHBT-2

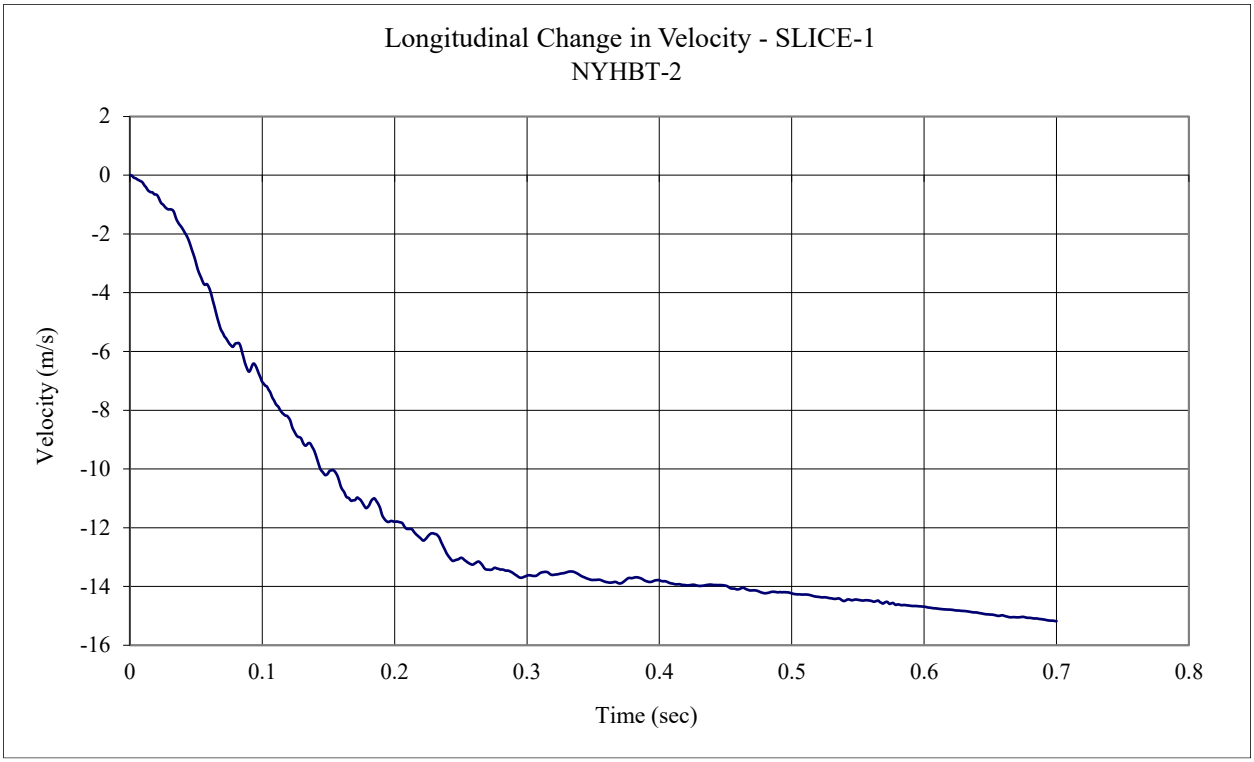


Figure J-2. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYHBT-2

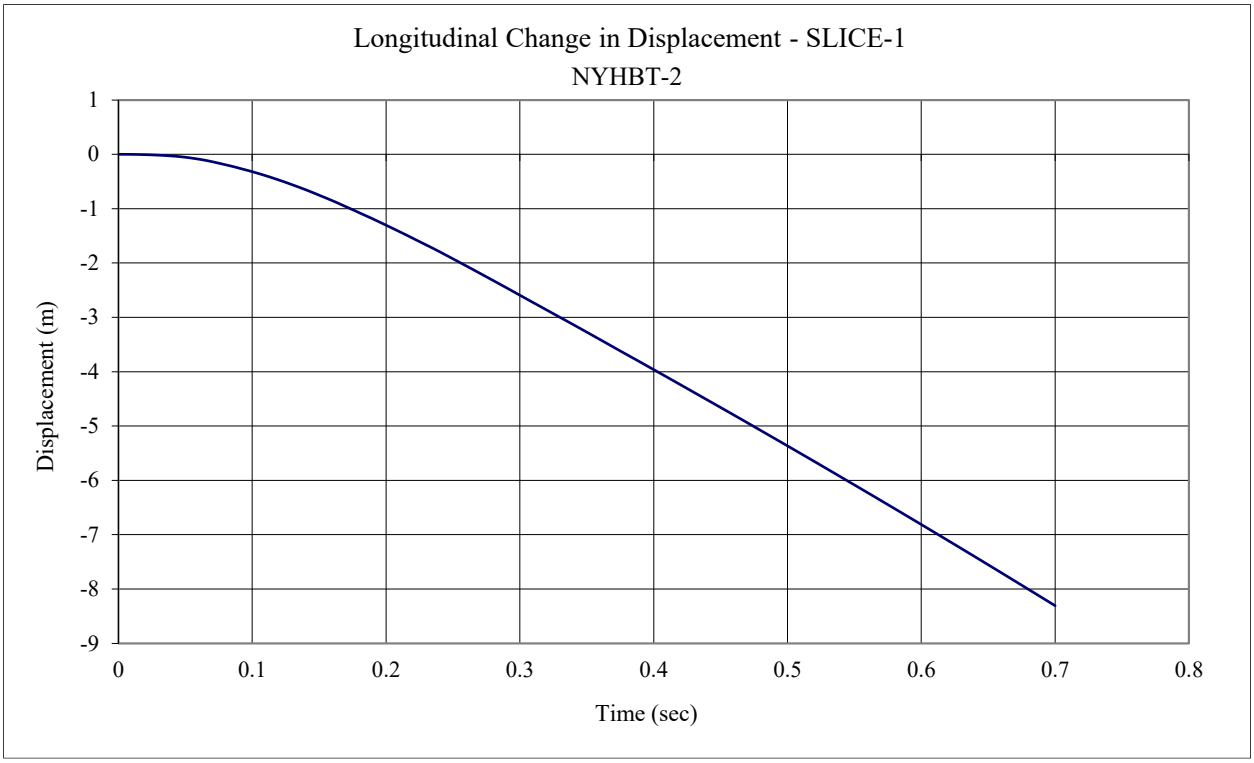


Figure J-3. Longitudinal Occupant Displacement (SLICE-1), Test No. NYHBT-2

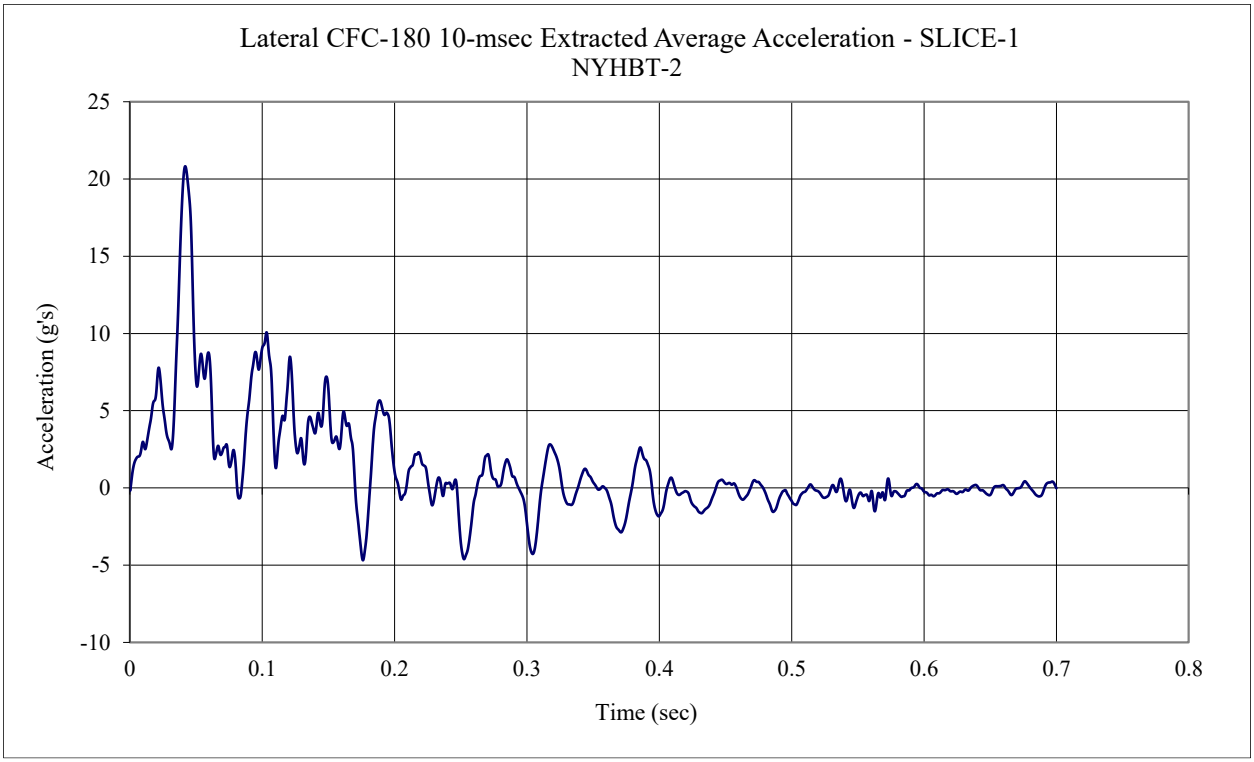


Figure J-4. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYHBT-2

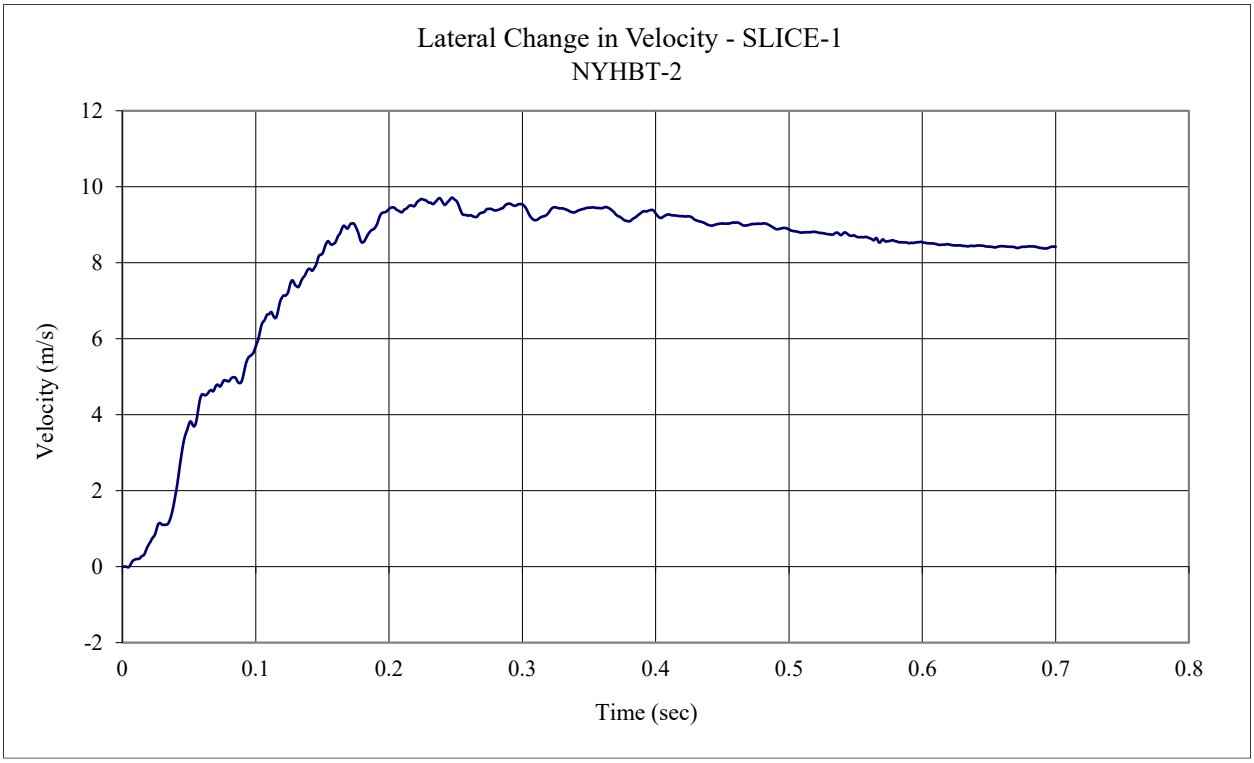


Figure J-5. Lateral Occupant Impact Velocity (SLICE-1), Test No. NYHBT-2

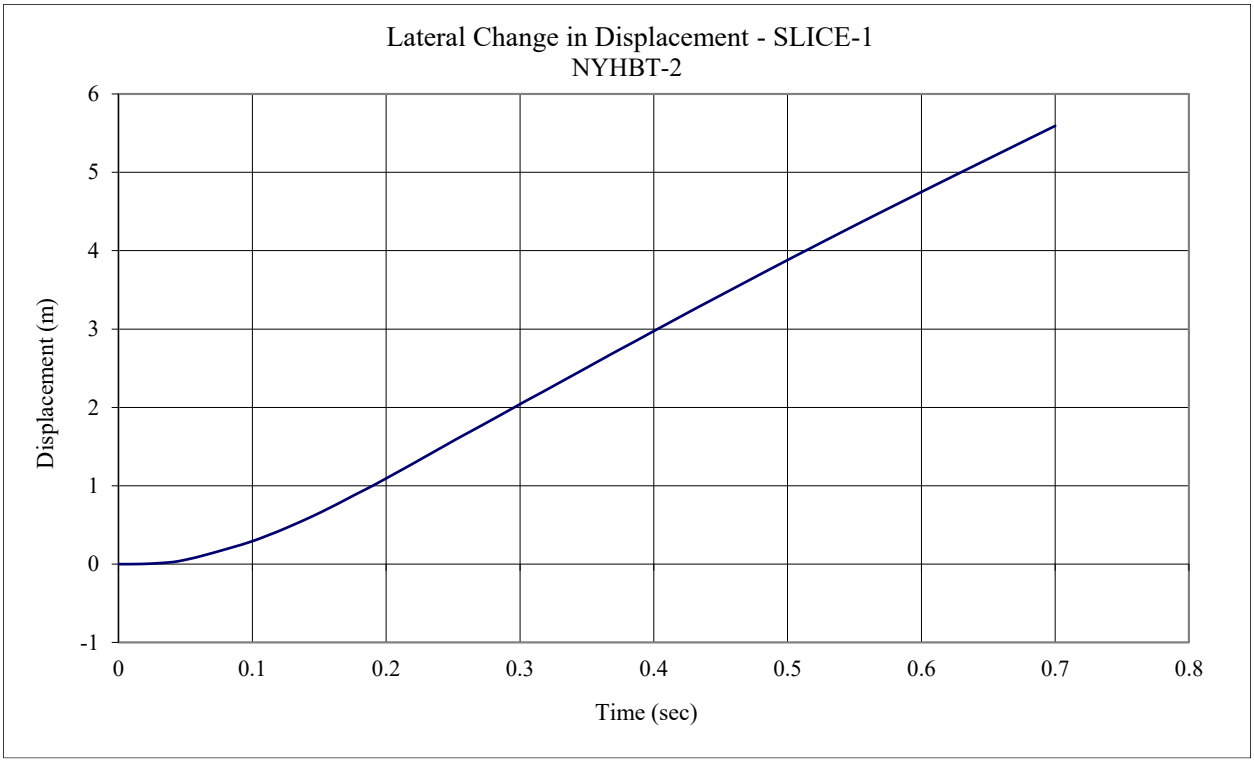


Figure J-6. Lateral Occupant Displacement (SLICE-1), Test No. NYHBT-2

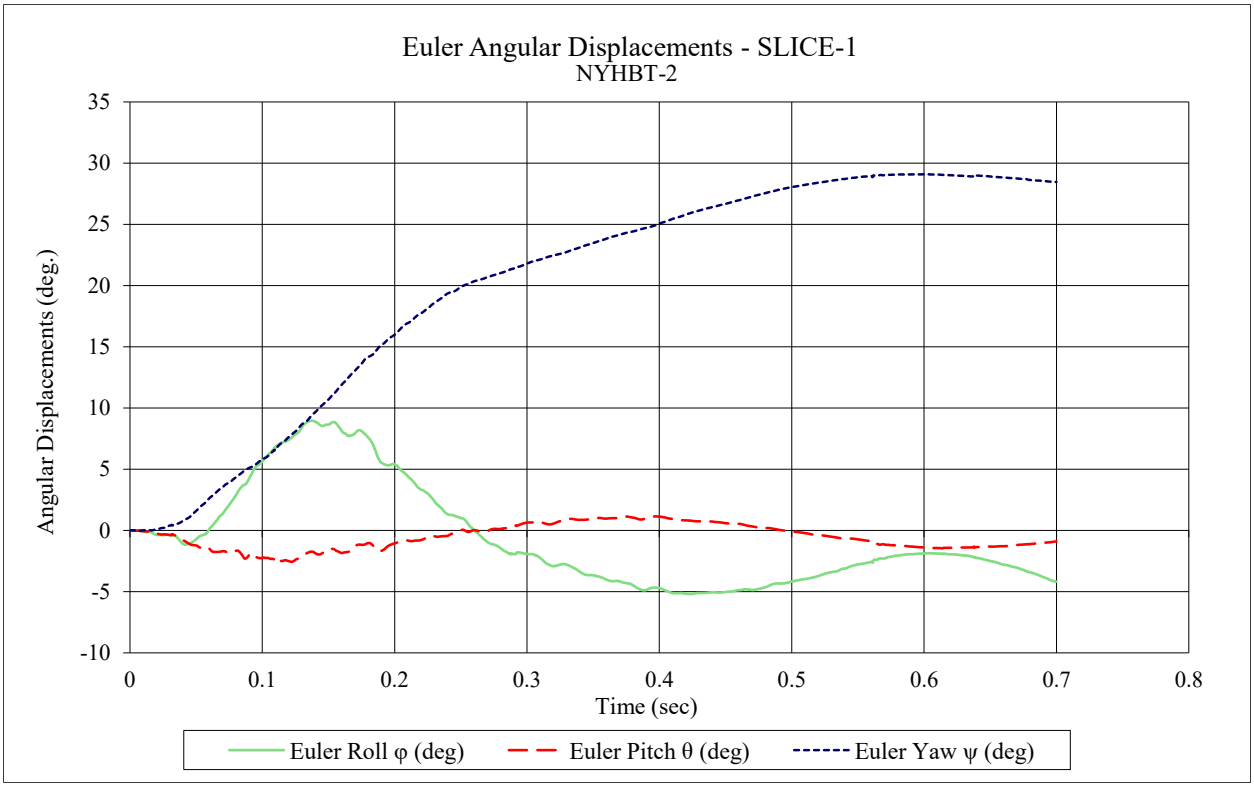


Figure J-7. Vehicle Angular Displacements (SLICE-1), Test No. NYHBT-2

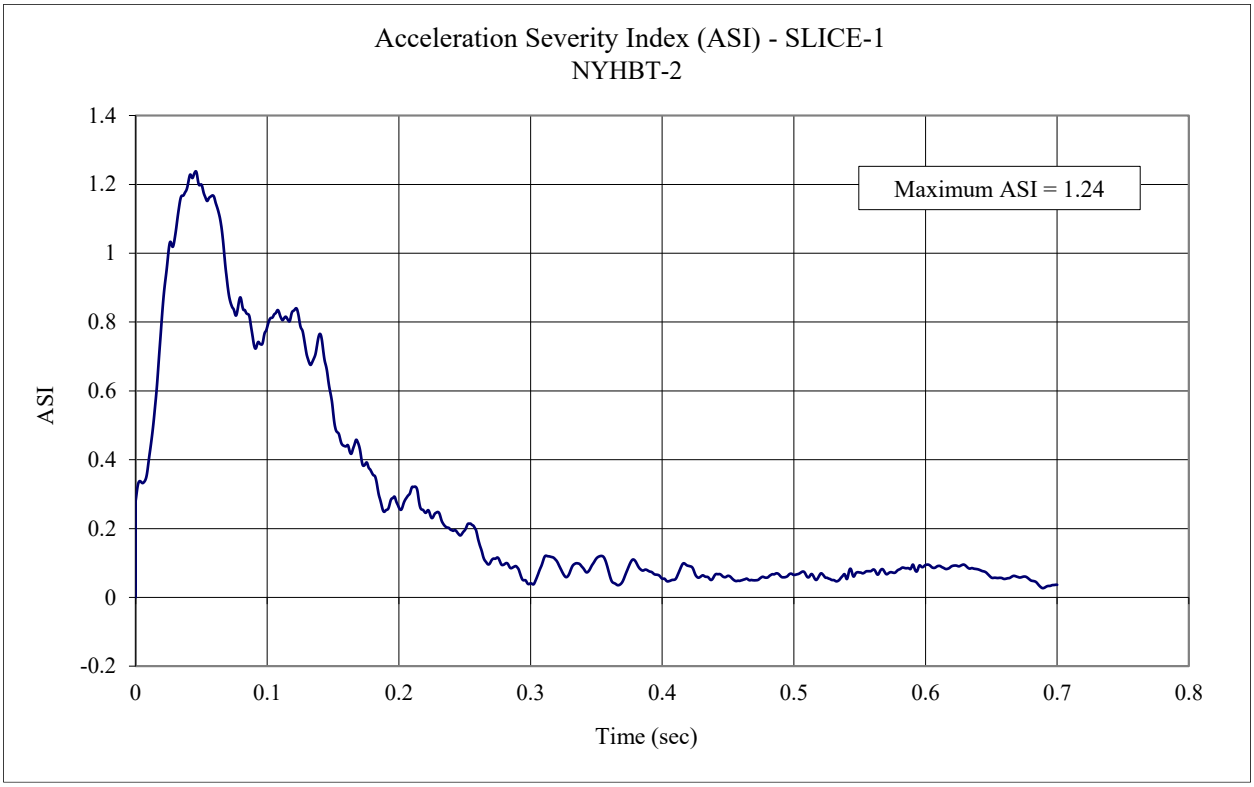


Figure J-8. Acceleration Severity Index (SLICE-1), Test No. NYHBT-2

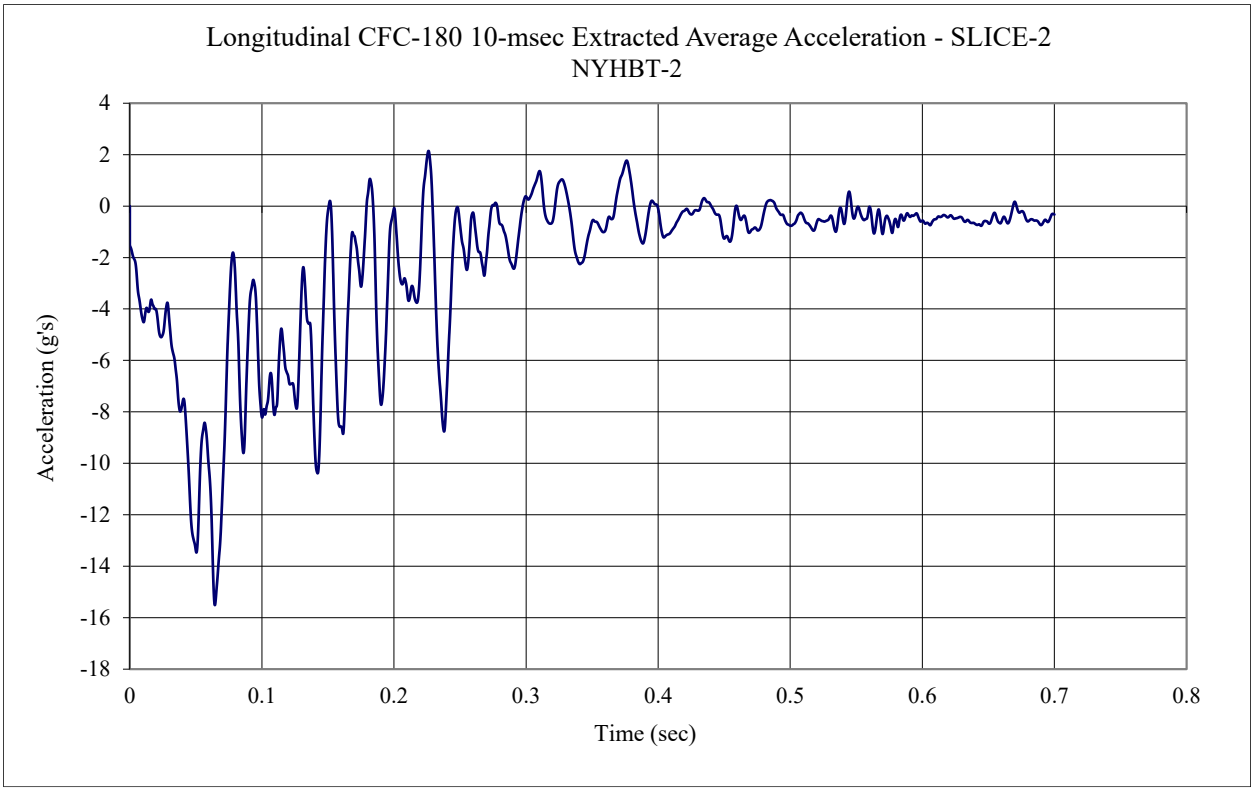


Figure J-9. 10-ms Average Longitudinal Deceleration (SLICE-2), Test No. NYHBT-2

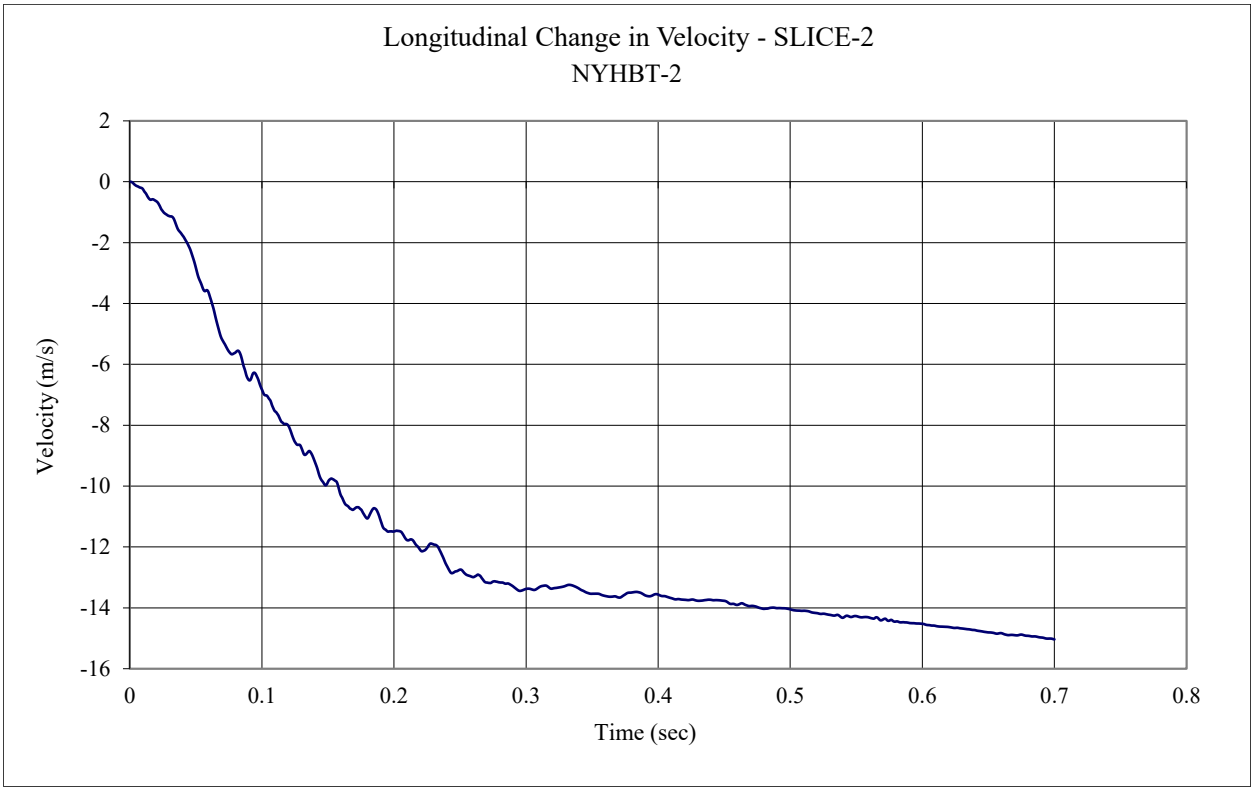


Figure J-10. Longitudinal Occupant Impact Velocity (SLICE-2), Test No. NYHBT-2



Figure J-11. Longitudinal Occupant Displacement (SLICE-2), Test No. NYHBT-2

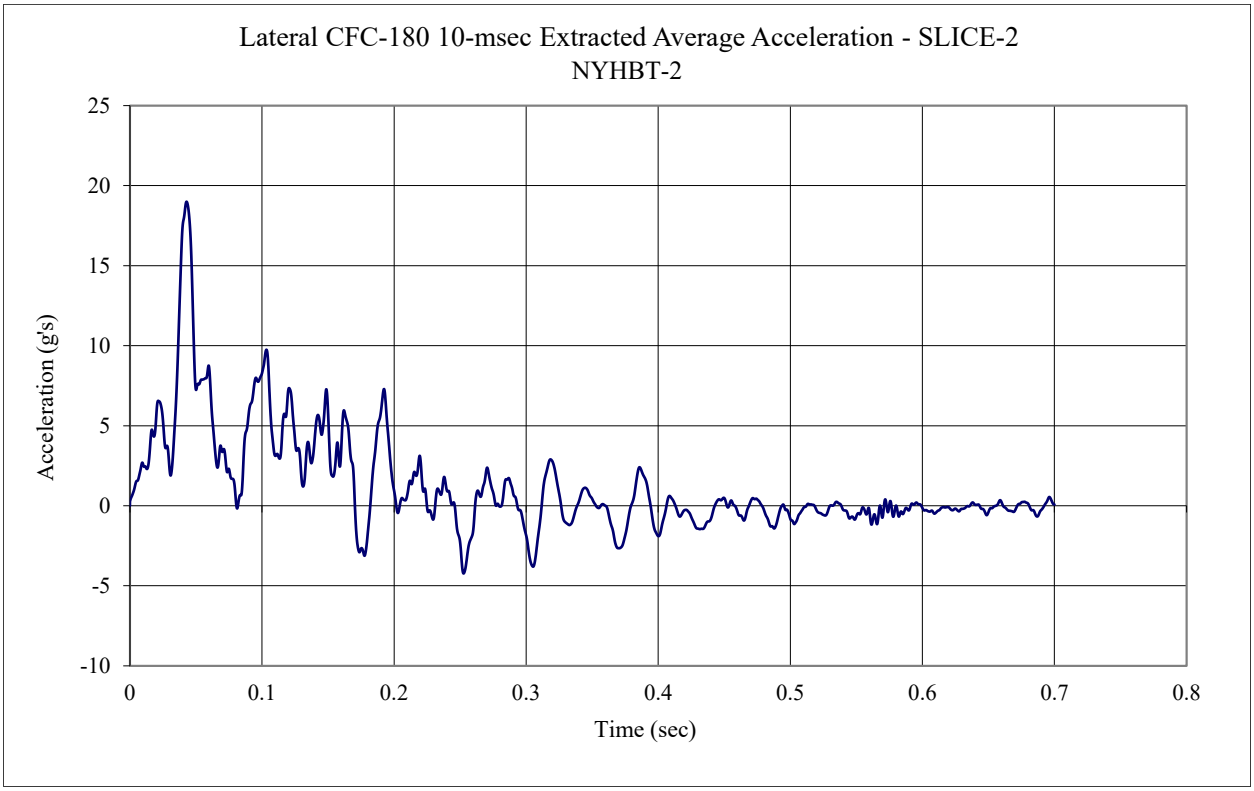


Figure J-12. 10-ms Average Lateral Deceleration (SLICE-2), Test No. NYHBT-2

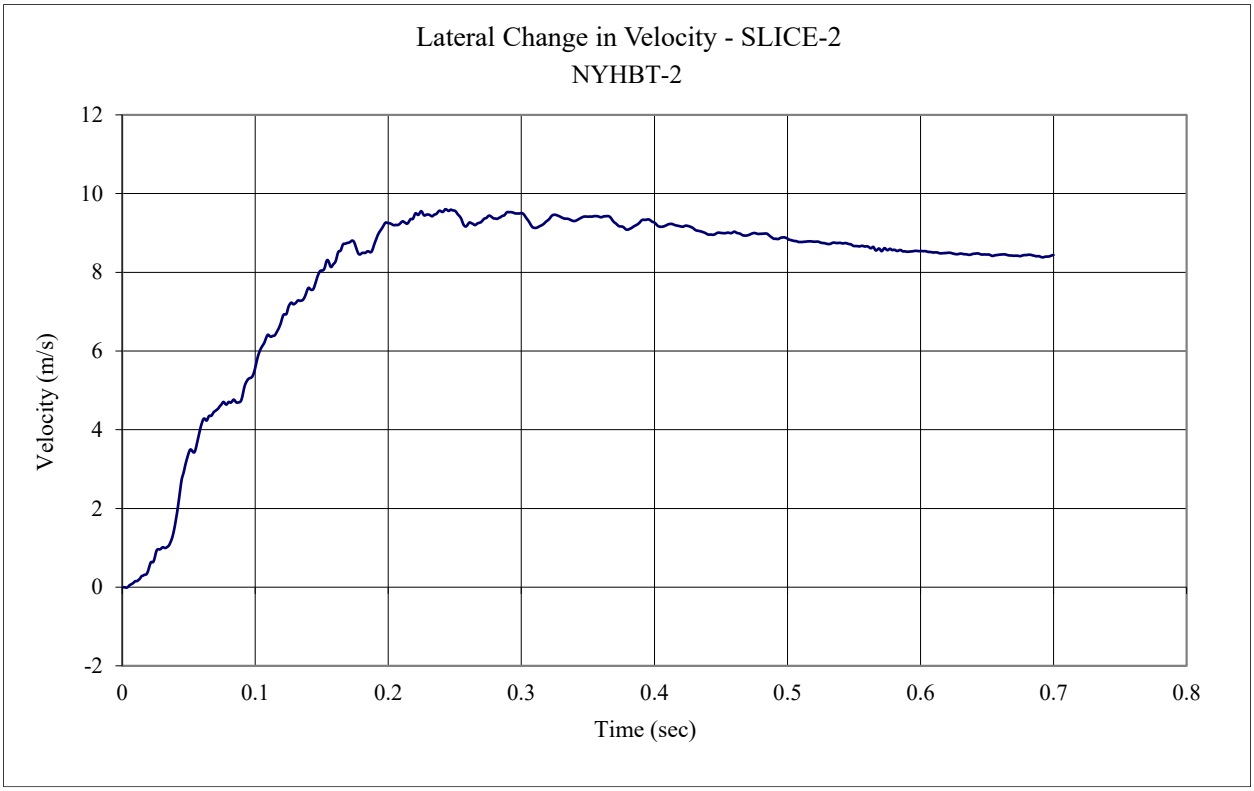


Figure J-13. Lateral Occupant Impact Velocity (SLICE-2), Test No. NYHBT-2



Figure J-14. Lateral Occupant Displacement (SLICE-2), Test No. NYHBT-2

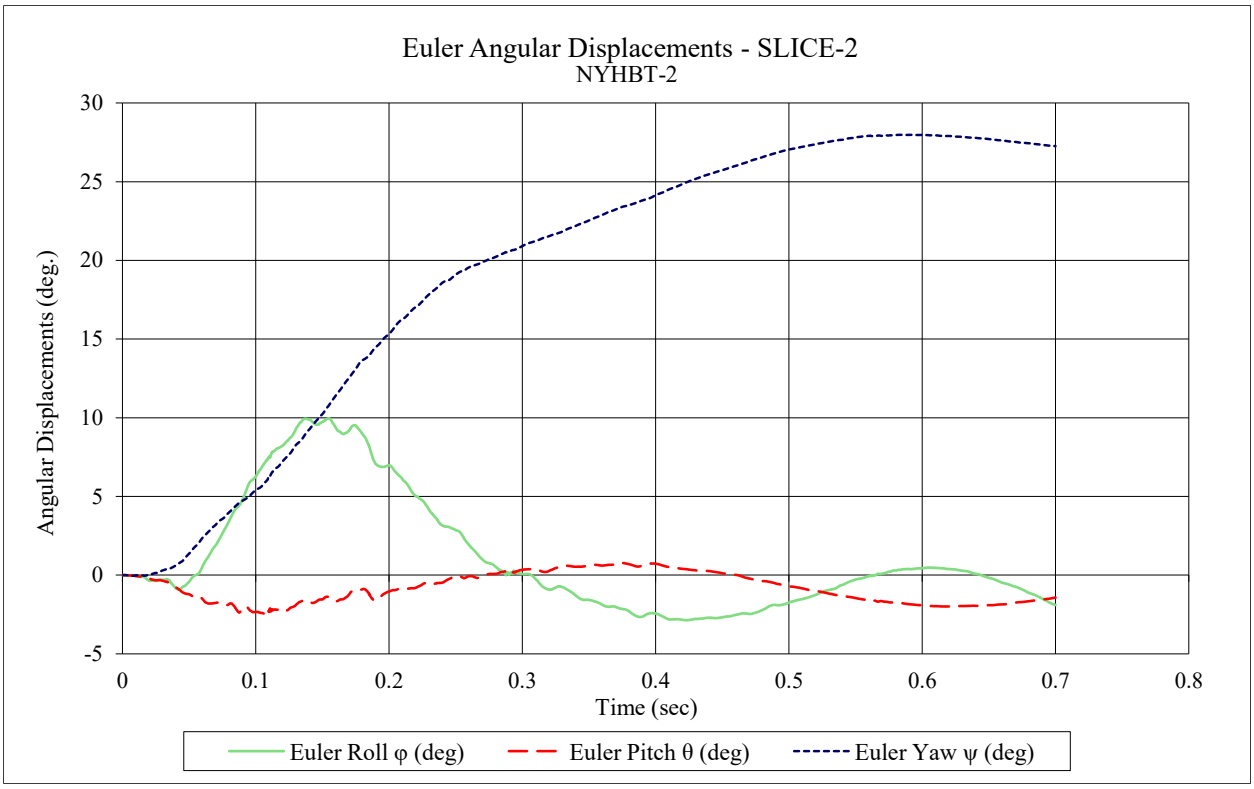


Figure J-15. Vehicle Angular Displacements (SLICE-2), Test No. NYHBT-2

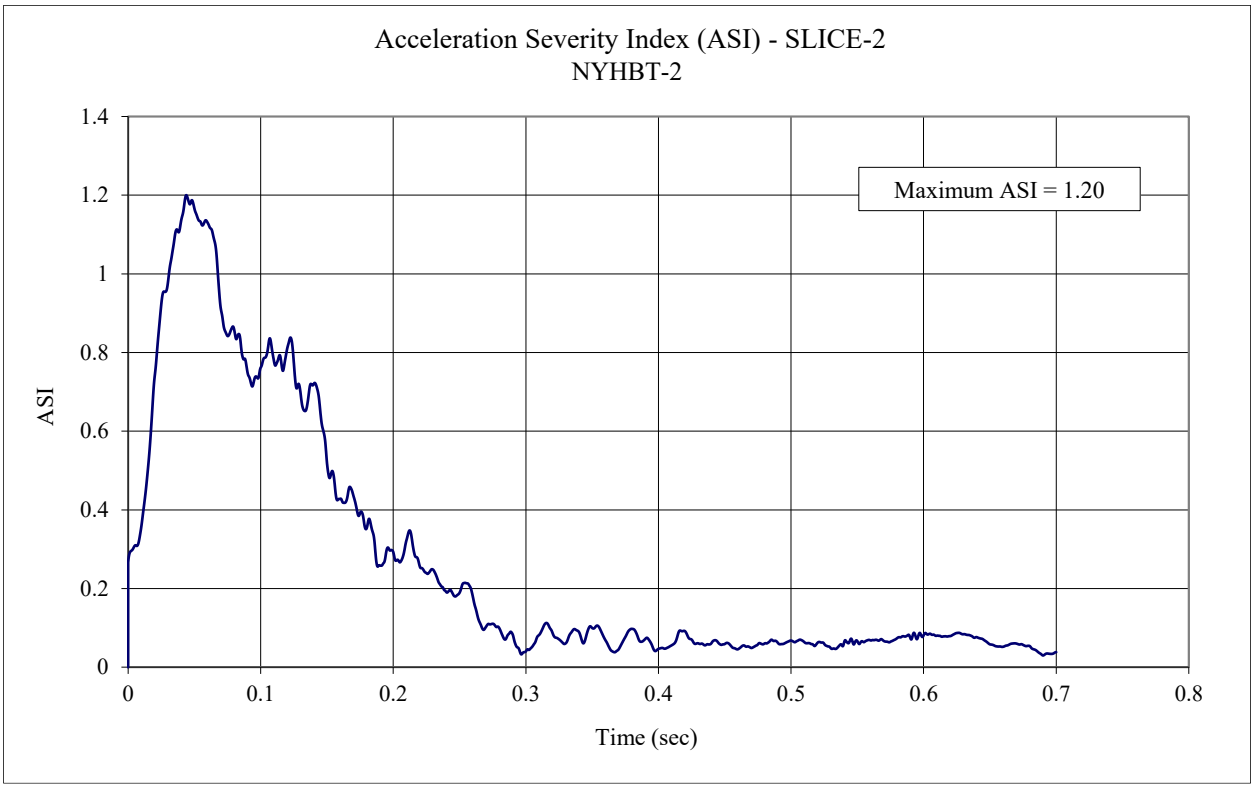


Figure J-16. Acceleration Severity Index (SLICE-2), Test No. NYHBT-2

Appendix K. Accelerometer and Rate Transducer Data Plots, Test No. NYBHT-1

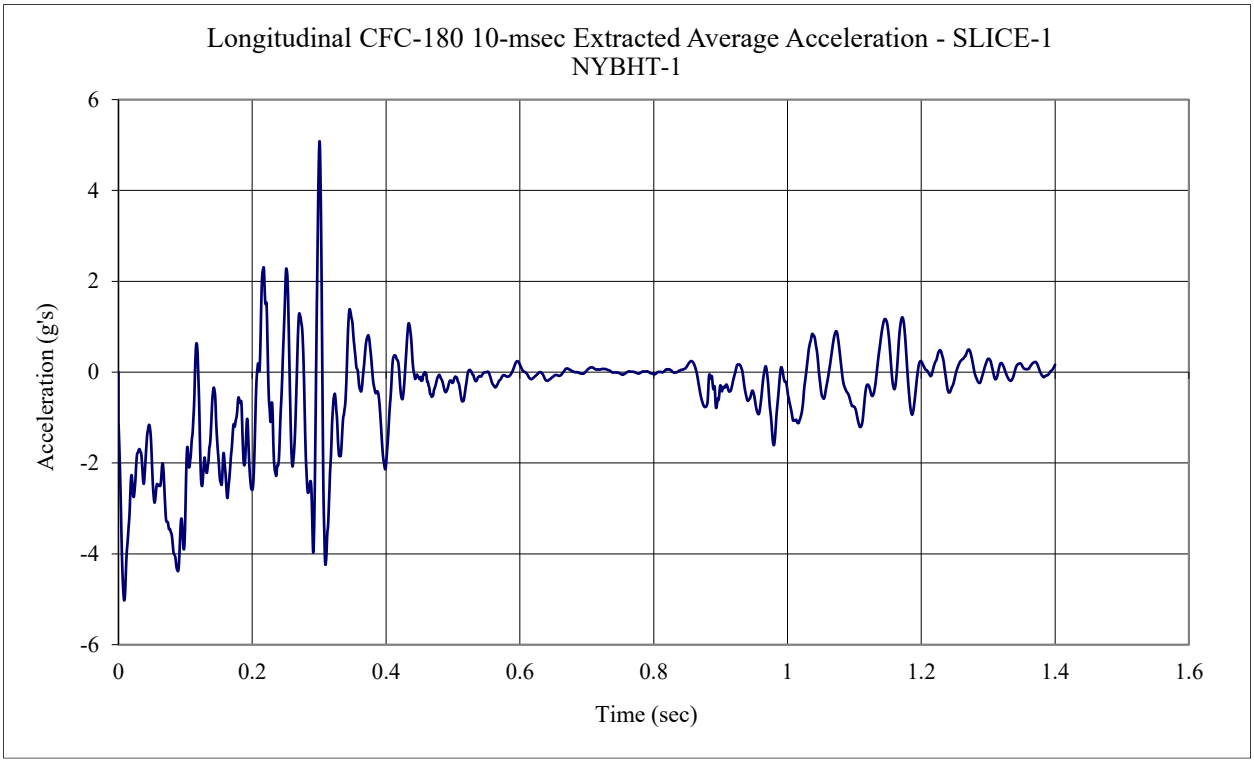


Figure K-1. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYBHT-1

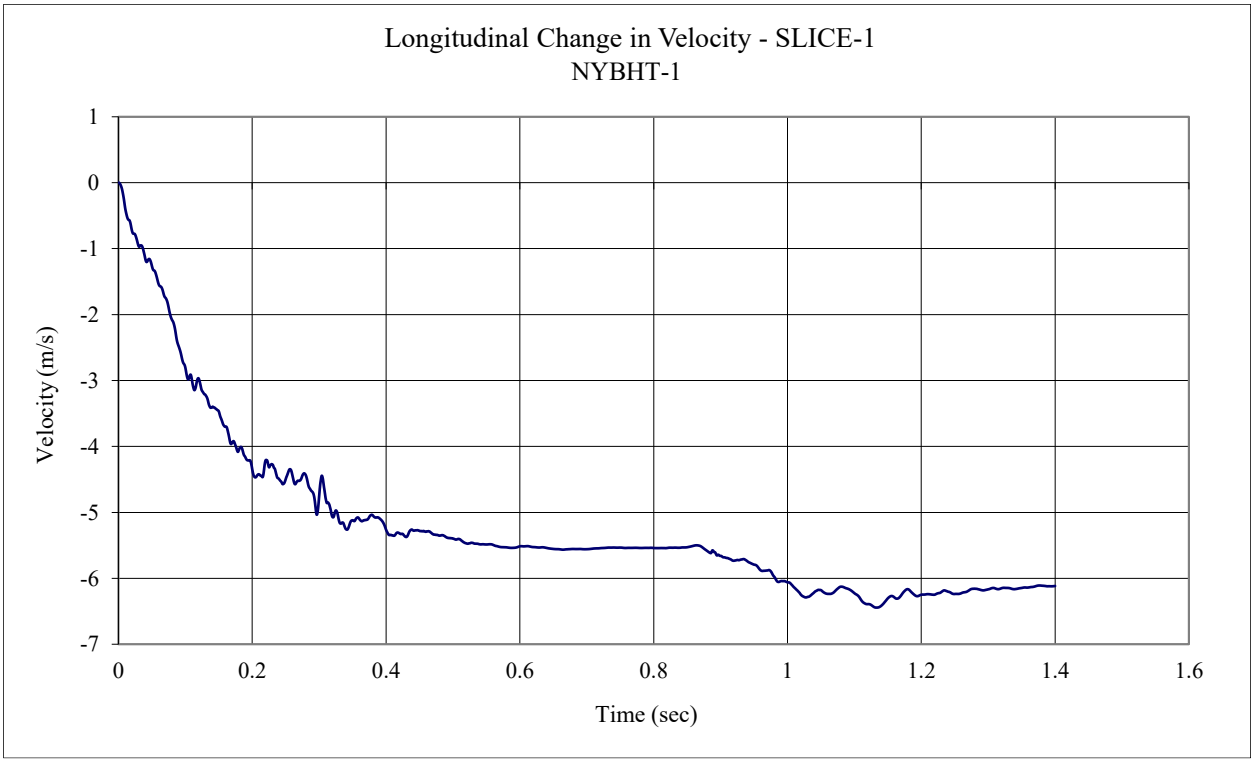


Figure K-2. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYBHT-1

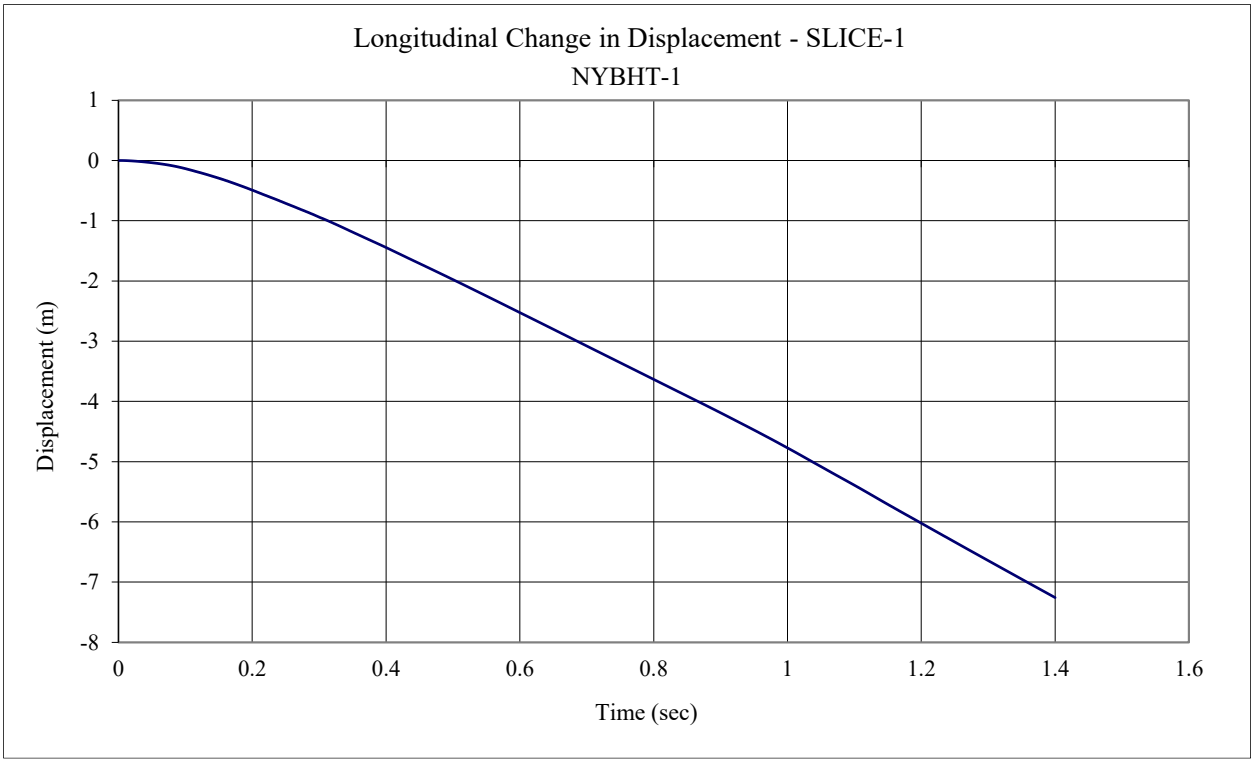


Figure K-3. Longitudinal Occupant Displacement (SLICE-1), Test No. NYBHT-1

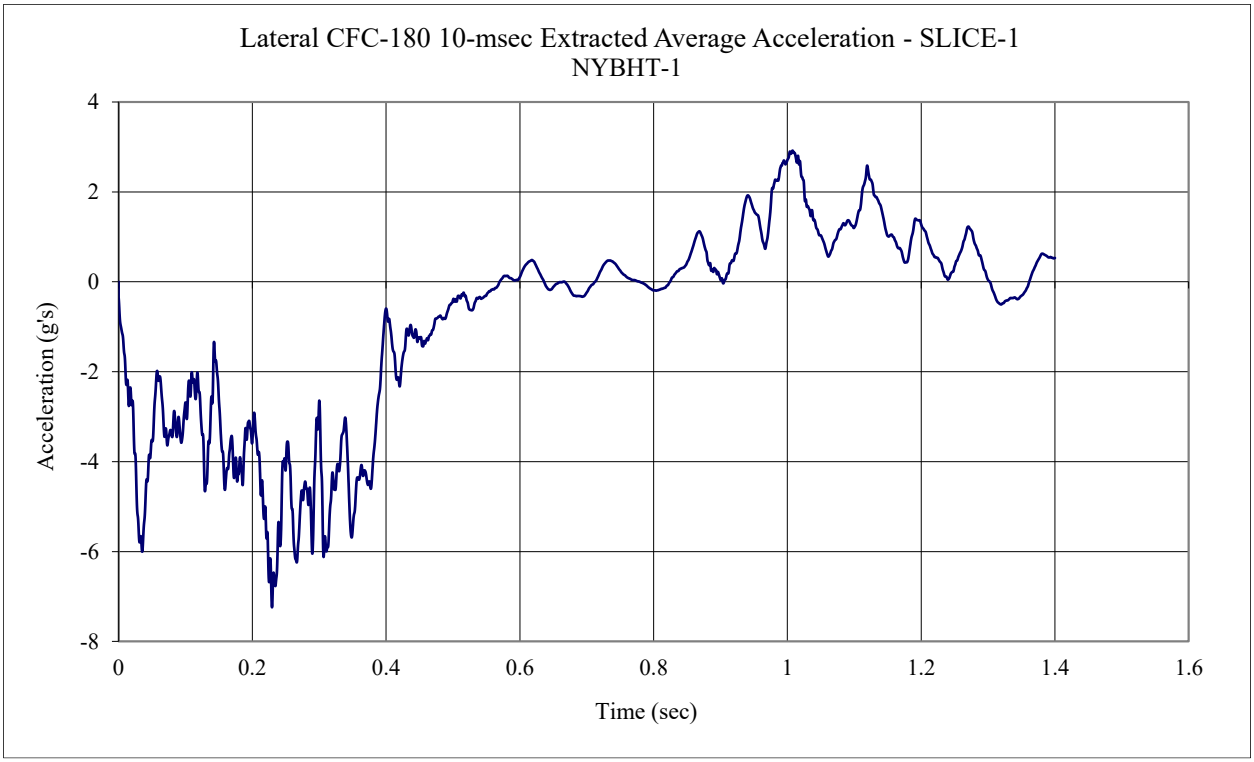


Figure K-4. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYBHT-1

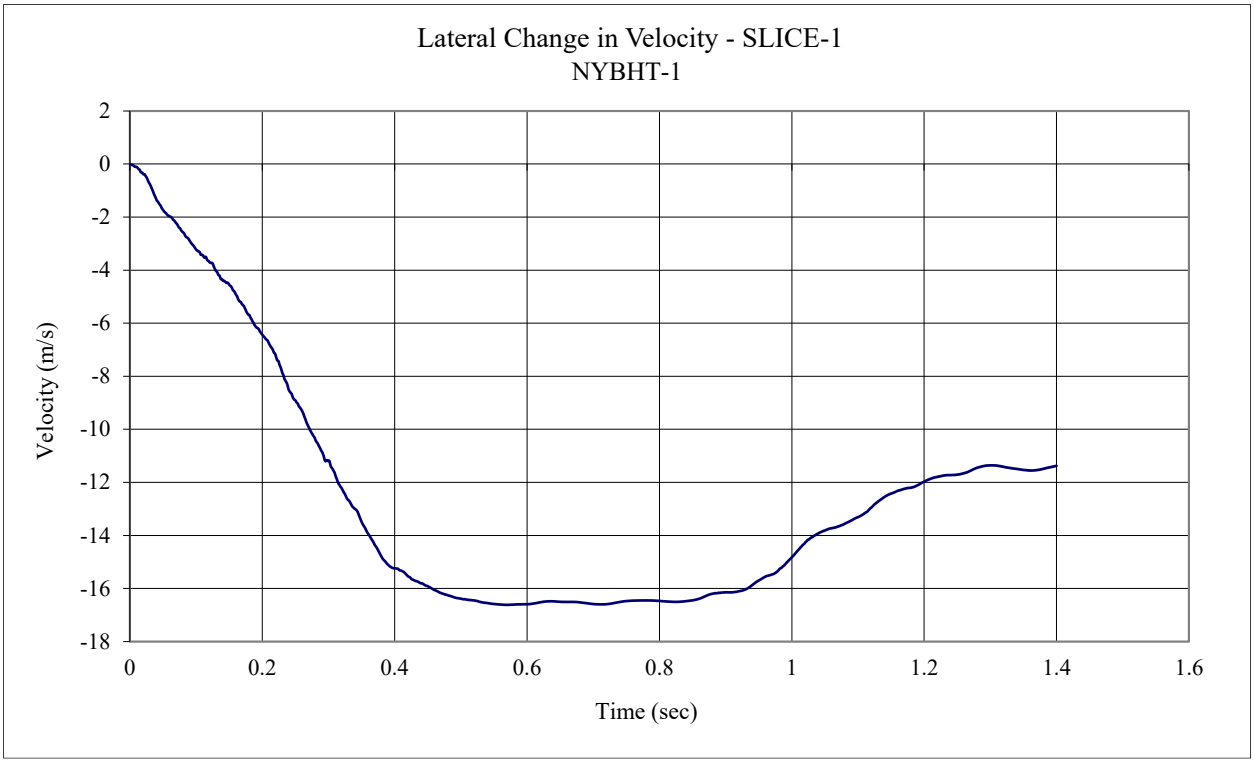


Figure K-5. Lateral Occupant Impact Velocity (SLICE-1), Test No. NYBHT-1

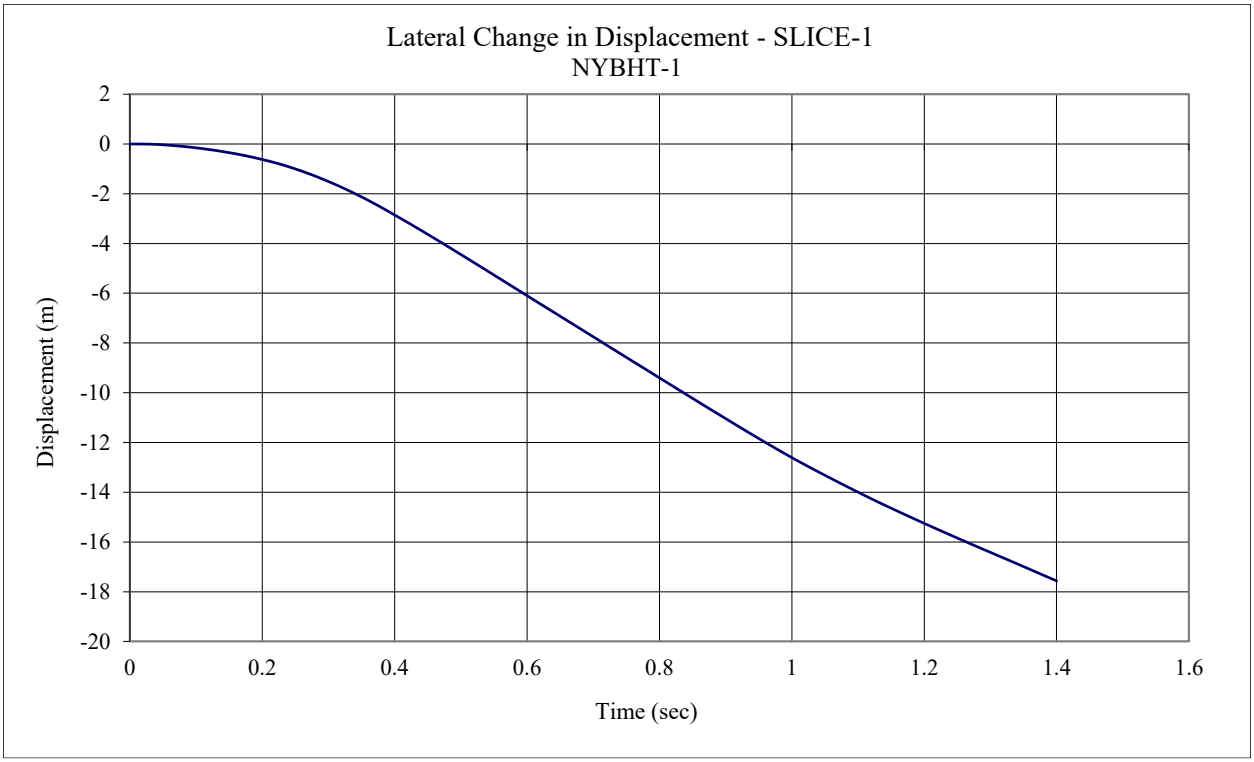


Figure K-6. Lateral Occupant Displacement (SLICE-1), Test No. NYBHT-1

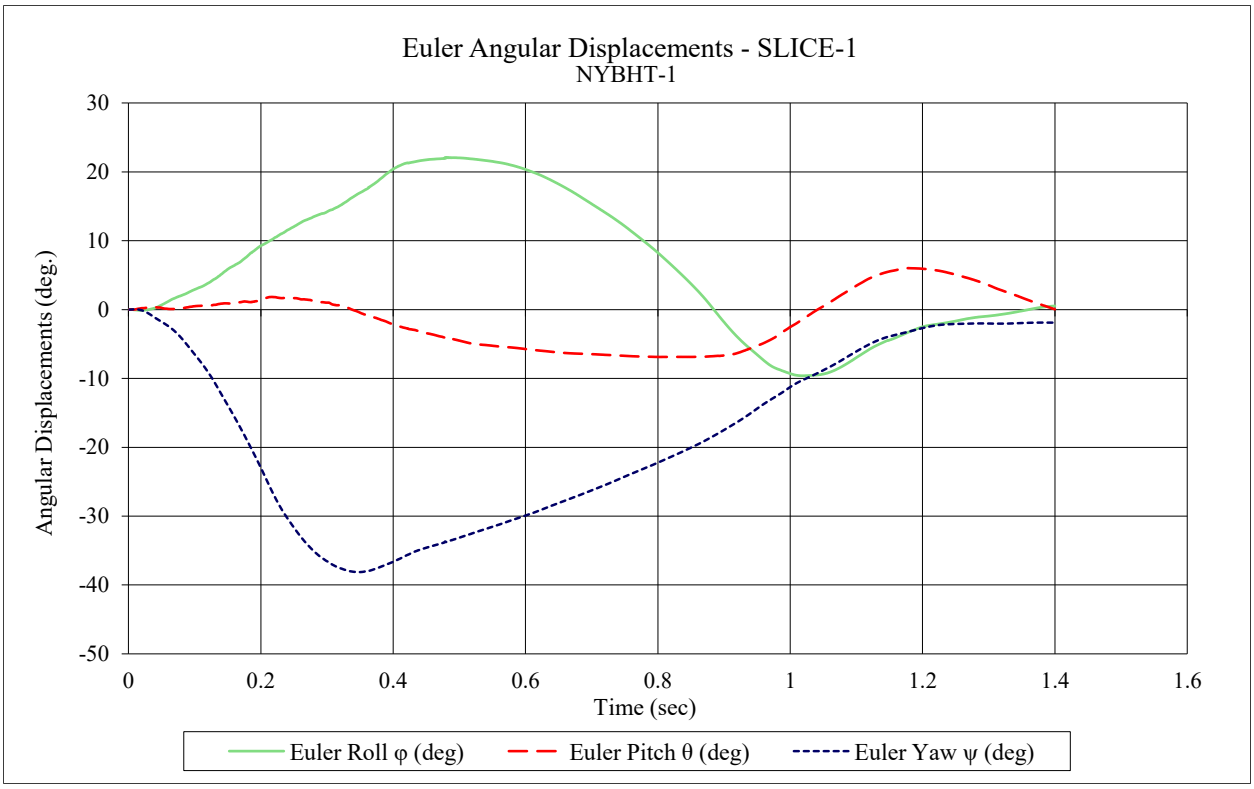


Figure K-7. Vehicle Angular Displacements (SLICE-1), Test No. NYBHT-1

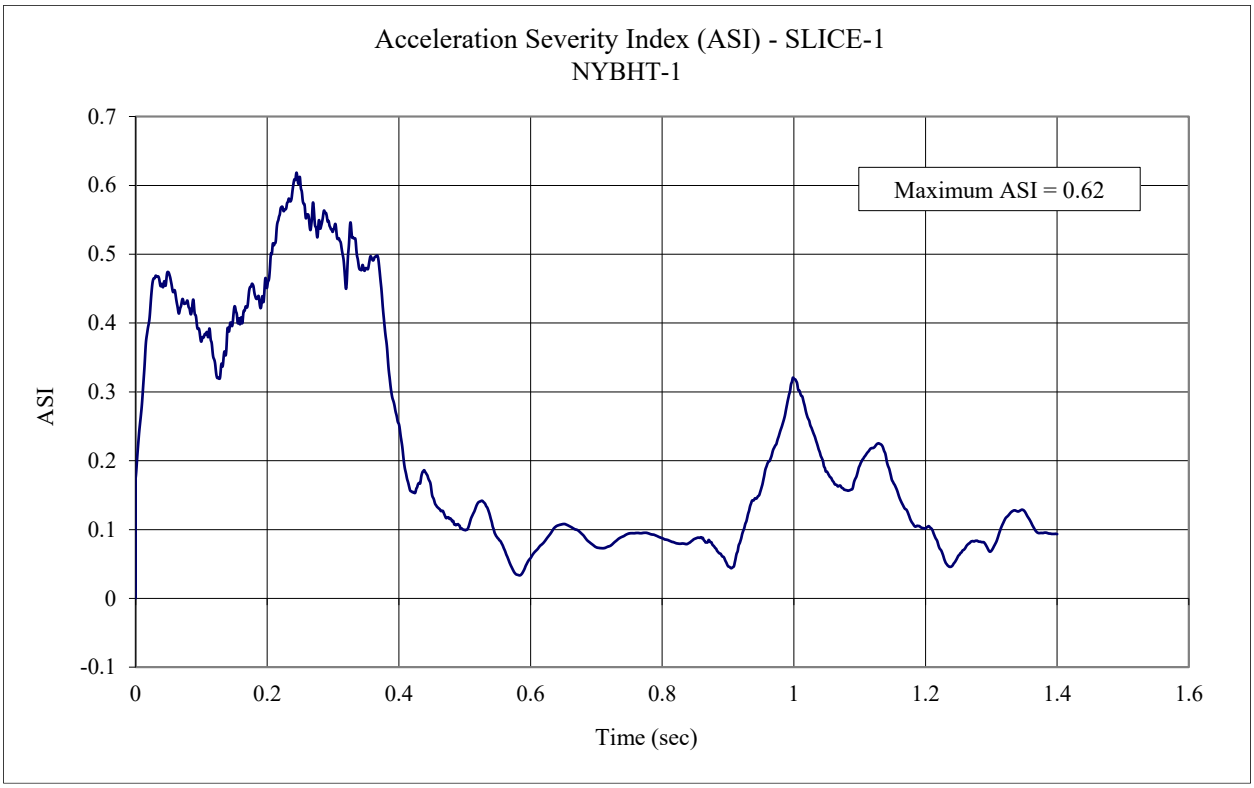


Figure K-8. Acceleration Severity Index (SLICE-1), Test No. NYBHT-1

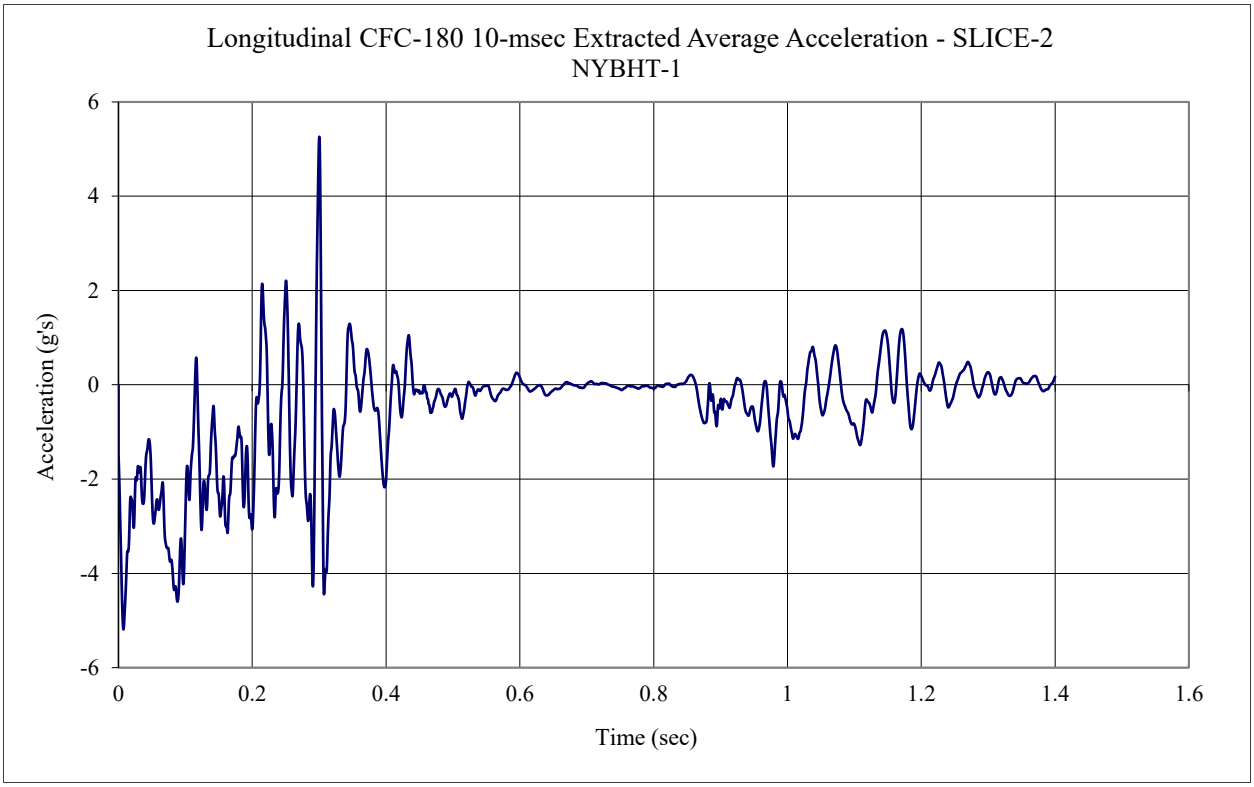


Figure K-9. 10-ms Average Longitudinal Deceleration (SLICE-2), Test No. NYBHT-1

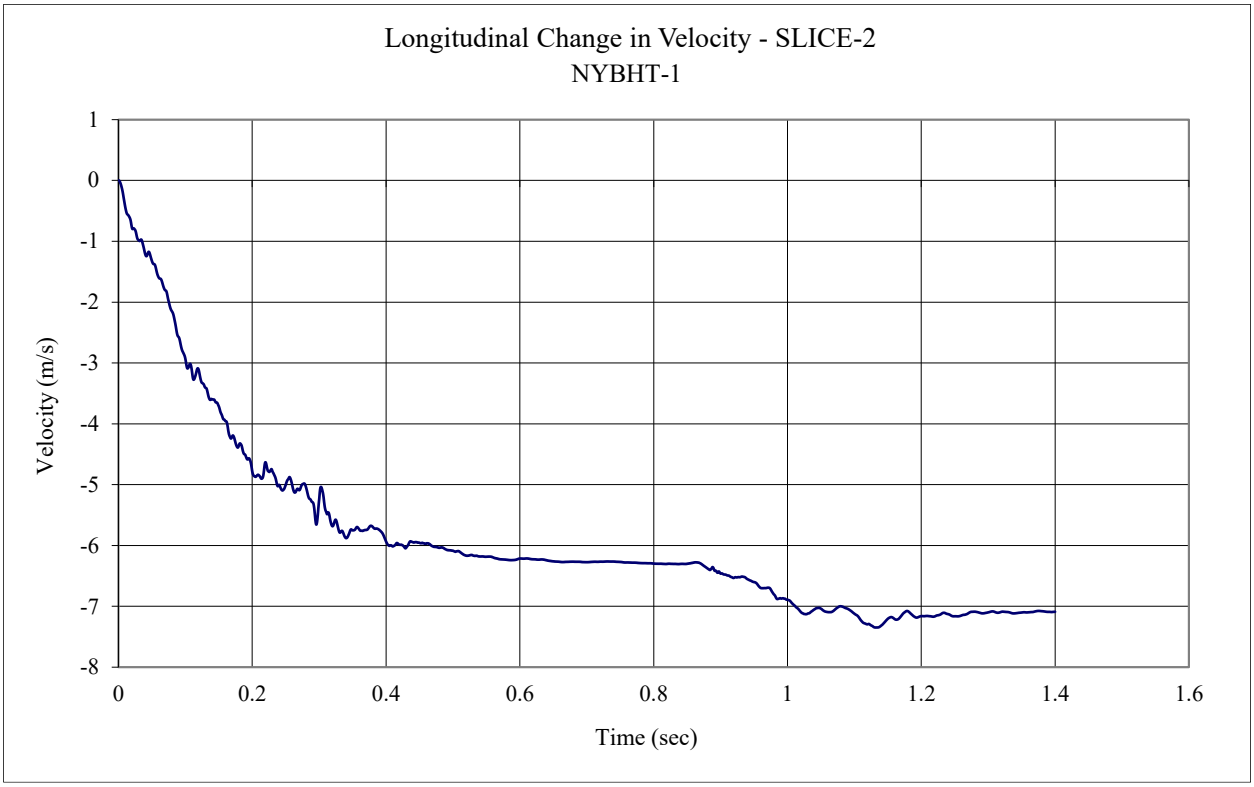


Figure K-10. Longitudinal Occupant Impact Velocity (SLICE-2), Test No. NYBHT-1

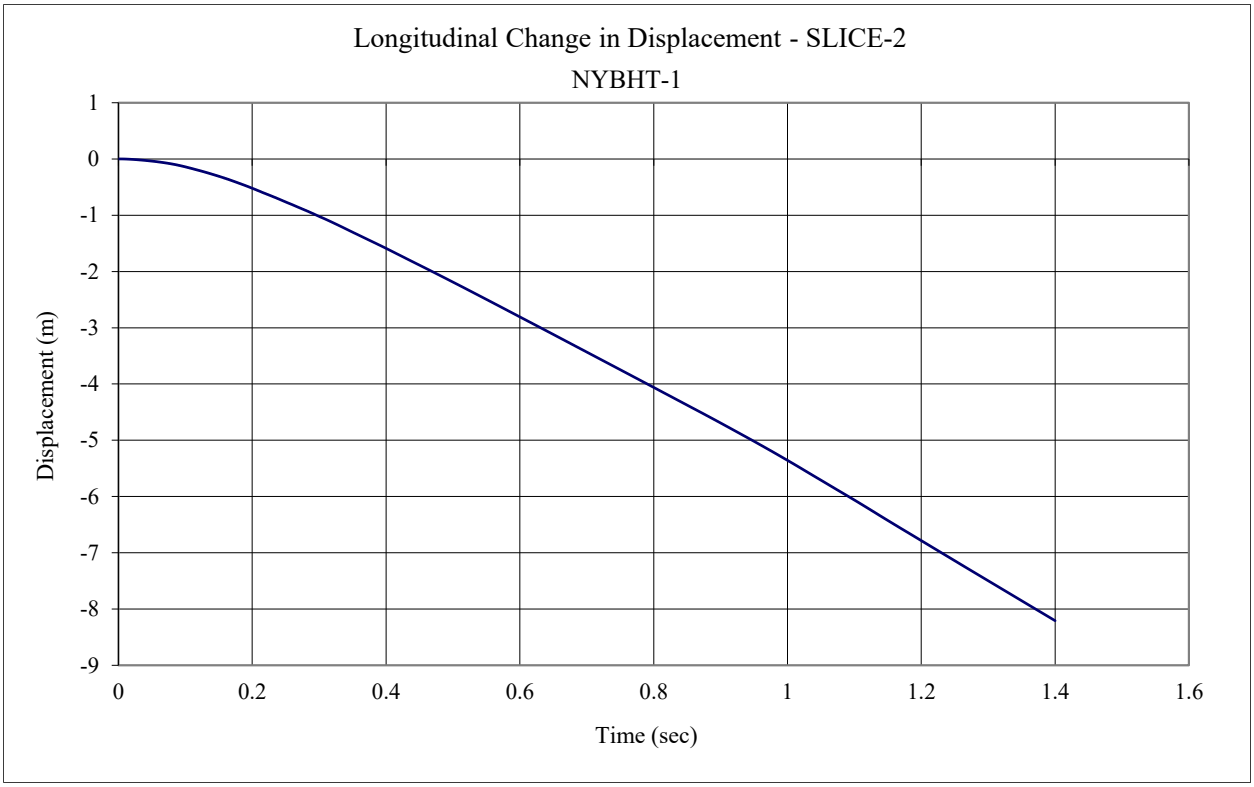


Figure K-11. Longitudinal Occupant Displacement (SLICE-2), Test No. NYBHT-1

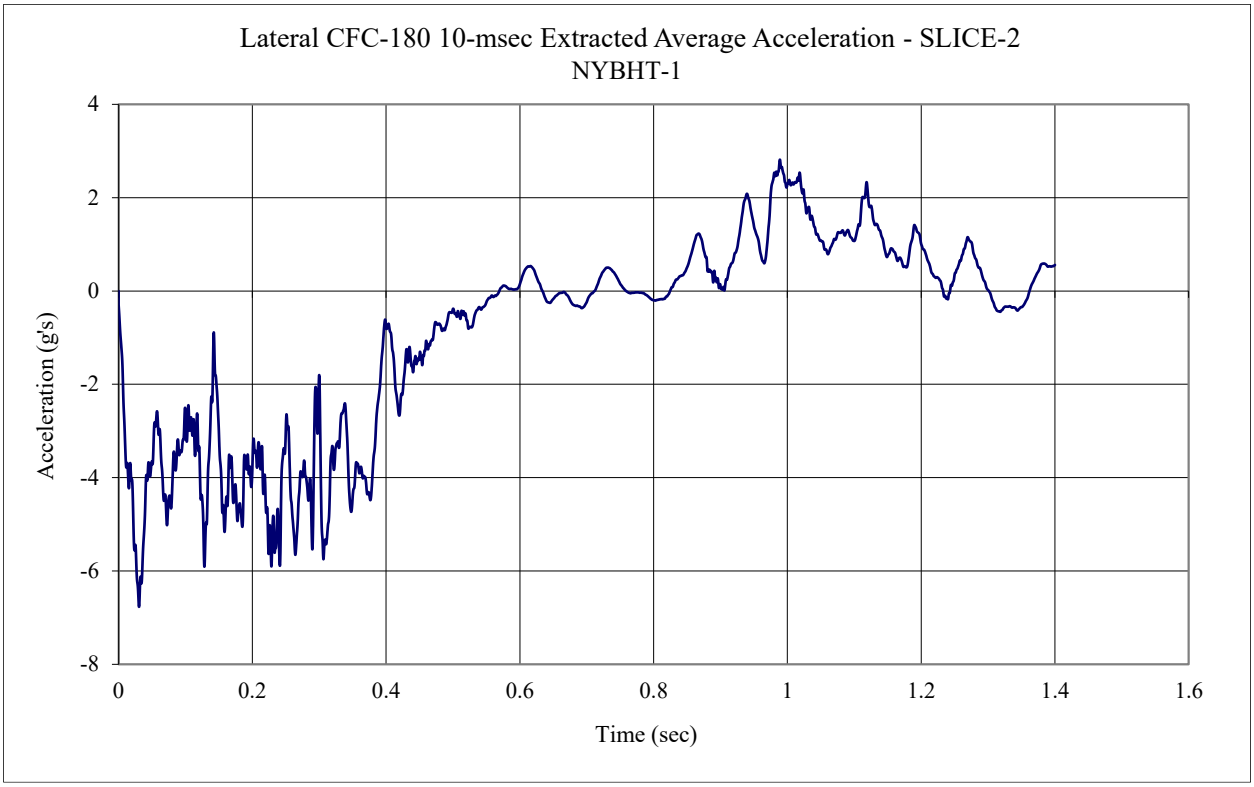


Figure K-12. 10-ms Average Lateral Deceleration (SLICE-2), Test No. NYBHT-1

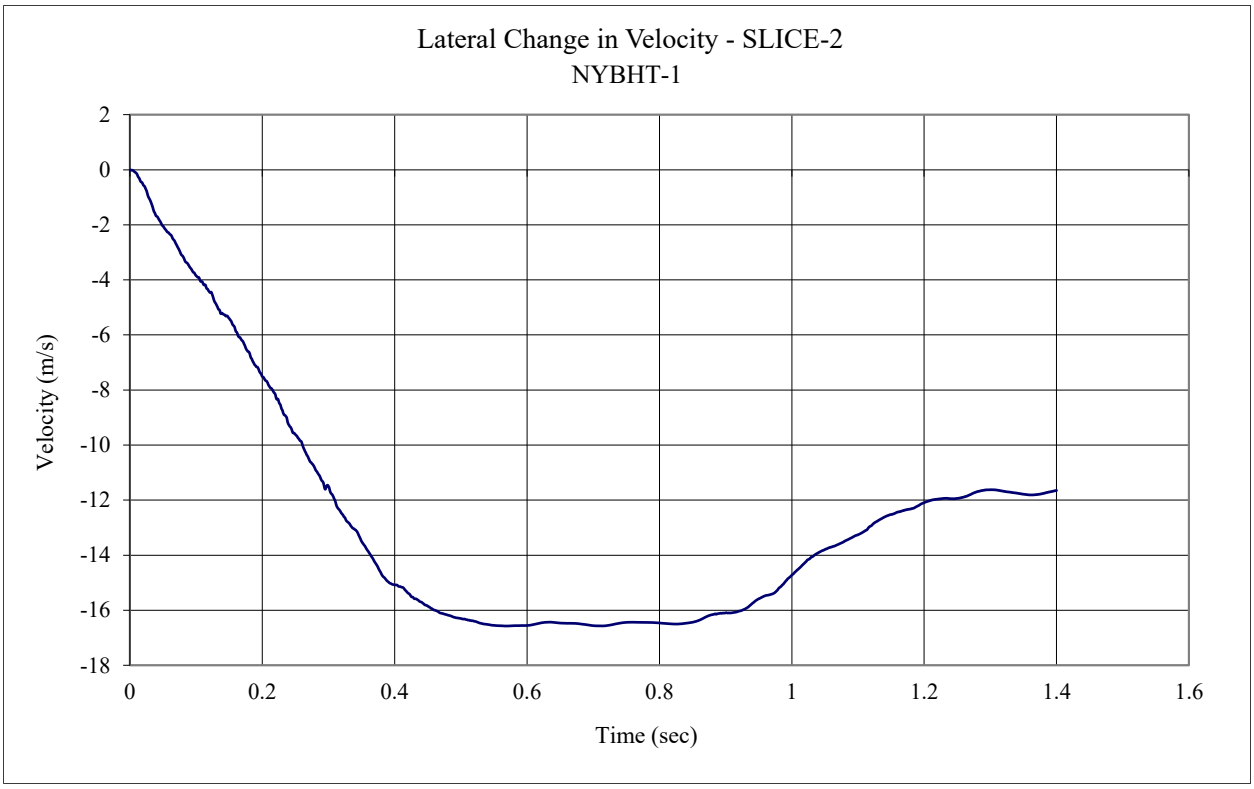


Figure K-13. Lateral Occupant Impact Velocity (SLICE-2), Test No. NYBHT-1



Figure K-14. Lateral Occupant Displacement (SLICE-2), Test No. NYBHT-1

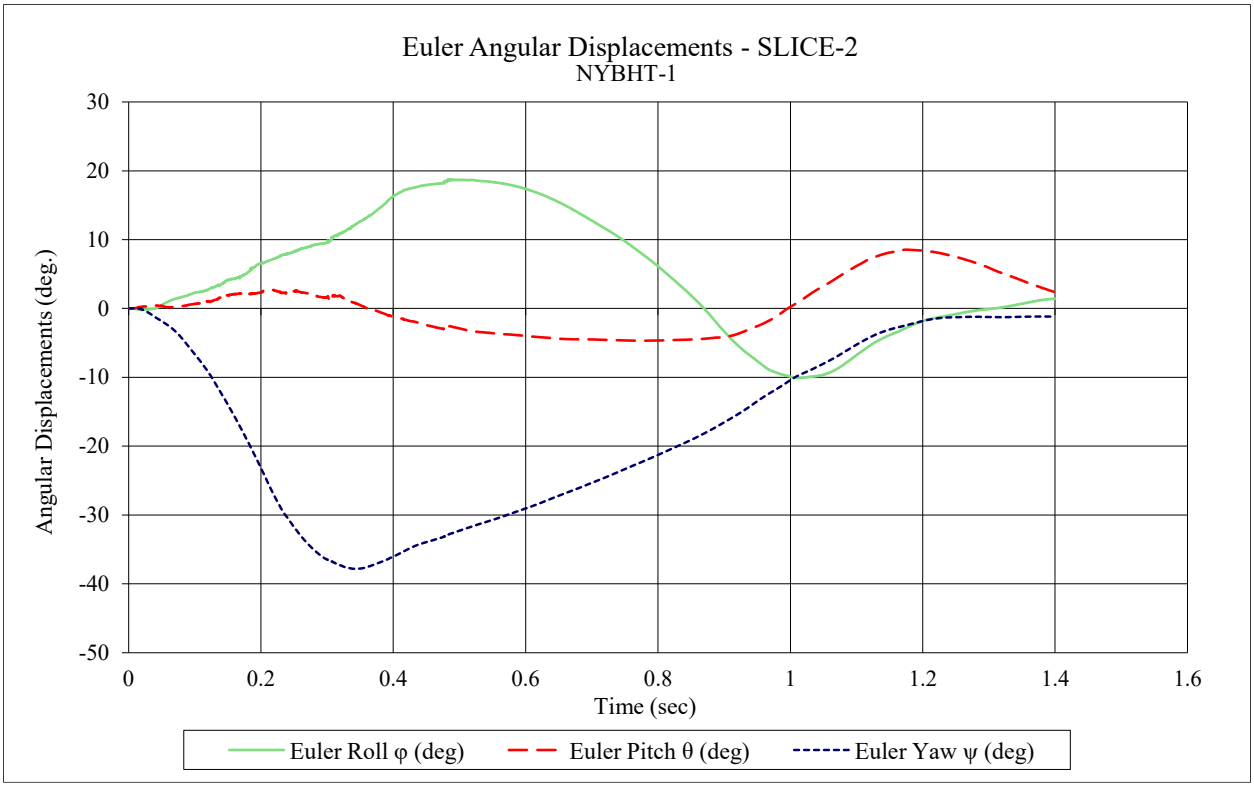


Figure K-15. Vehicle Angular Displacements (SLICE-2), Test No. NYBHT-1

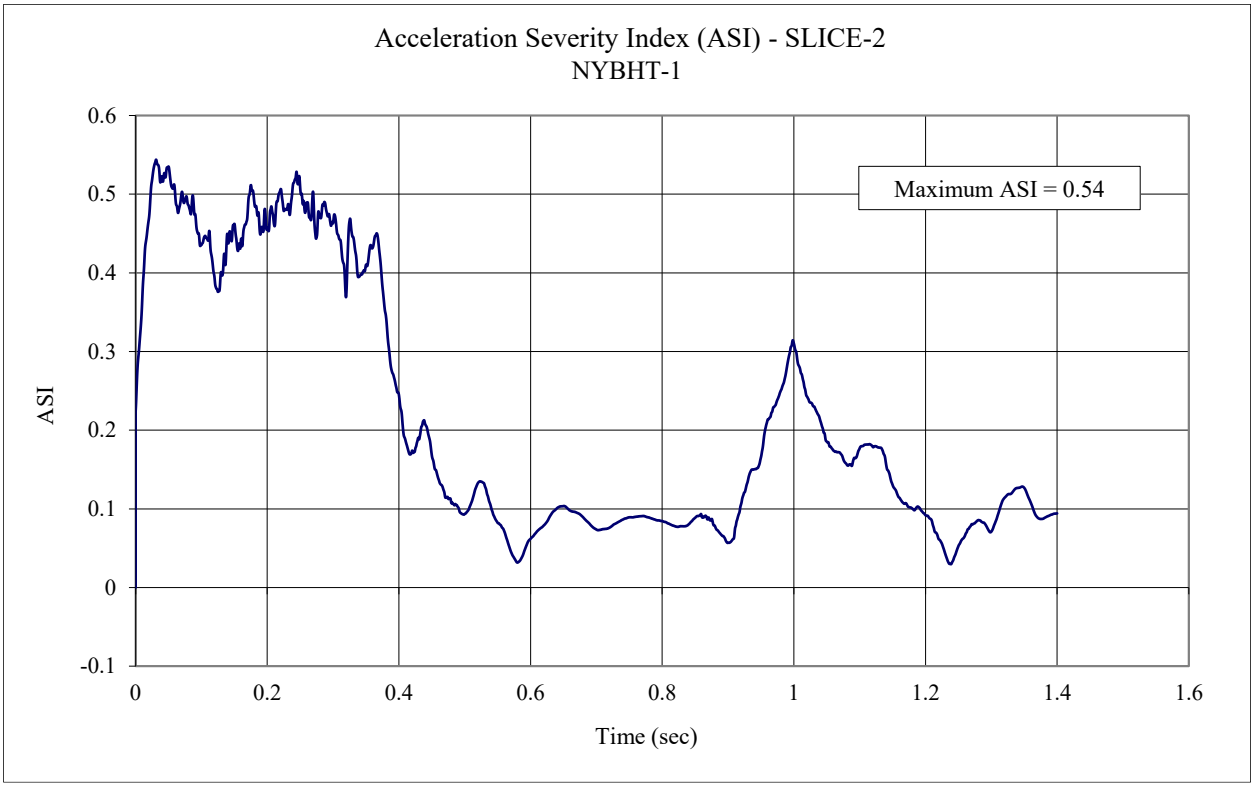


Figure K-16. Acceleration Severity Index (SLICE-2), Test No. NYBHT-1

Appendix L. Accelerometer and Rate Transducer Data Plots, Test No. NYBHT-2

For test no. NYBHT-2, the SLICE-1 unit was primary and the TDAS unit was used as a backup. Due to technical difficulties with one of the angular rate sensors in the TDAS unit, Euler angles could not be calculated from the raw data and are, therefore, not reported in this appendix.

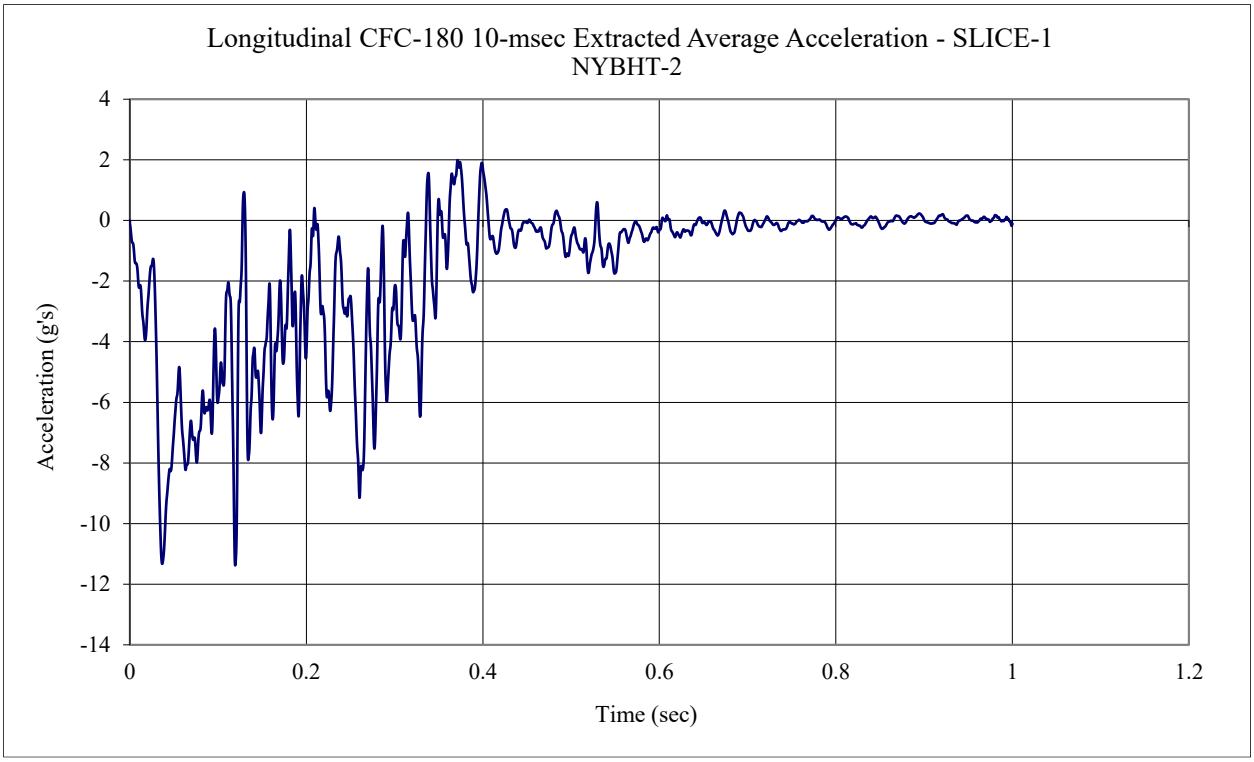


Figure L-1. 10-ms Average Longitudinal Deceleration (SLICE-1), Test No. NYBHT-2

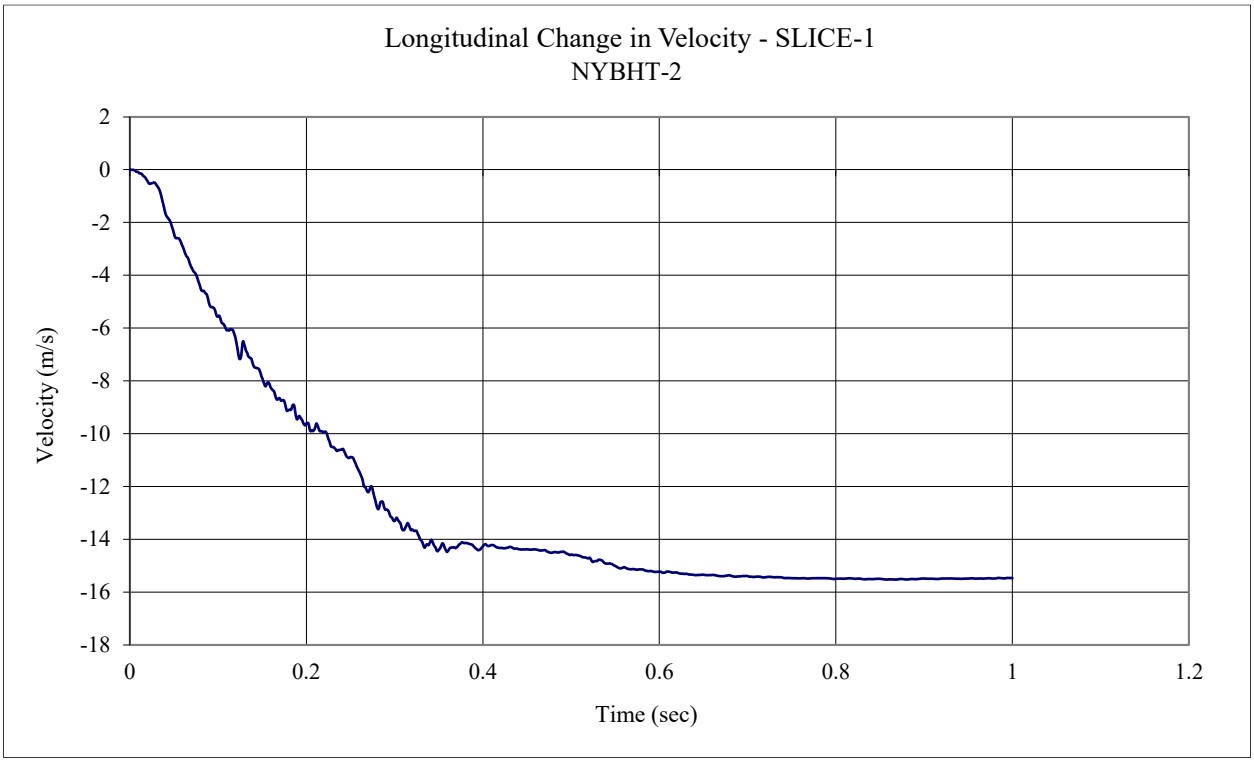


Figure L-2. Longitudinal Occupant Impact Velocity (SLICE-1), Test No. NYBHT-2

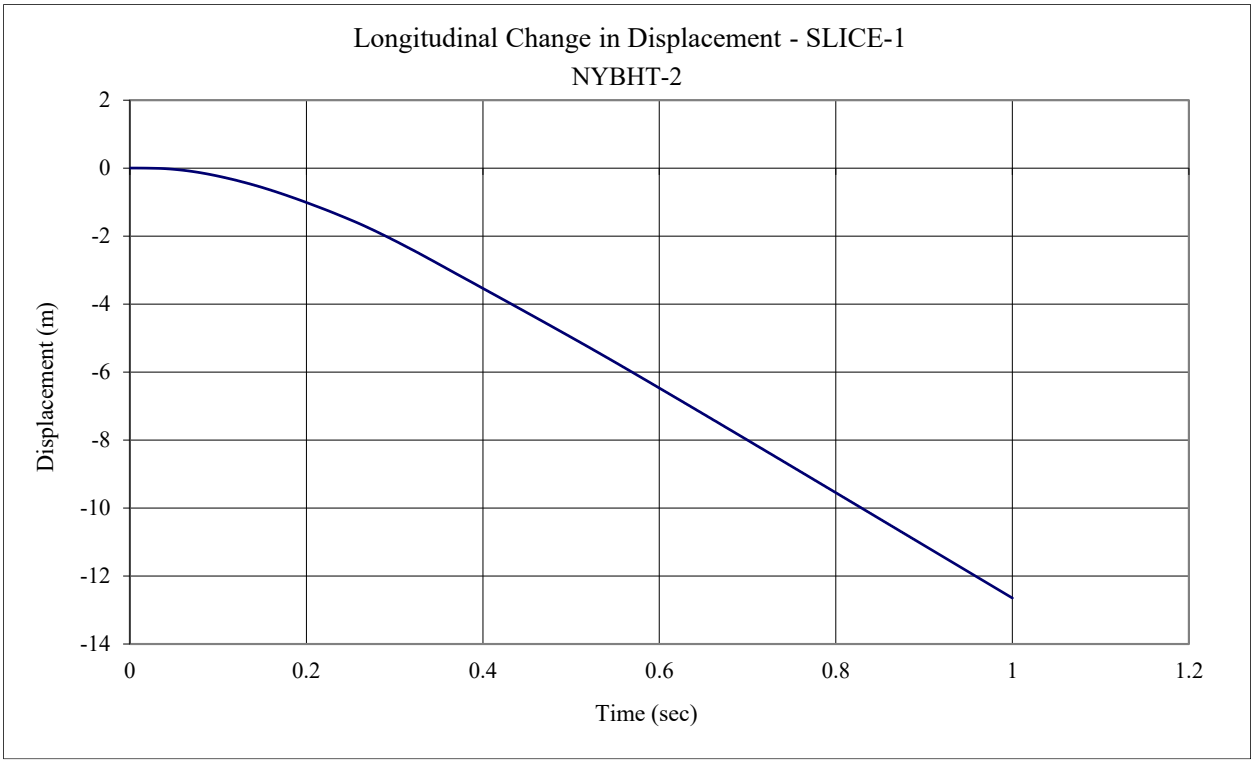


Figure L-3. Longitudinal Occupant Displacement (SLICE-1), Test No. NYBHT-2

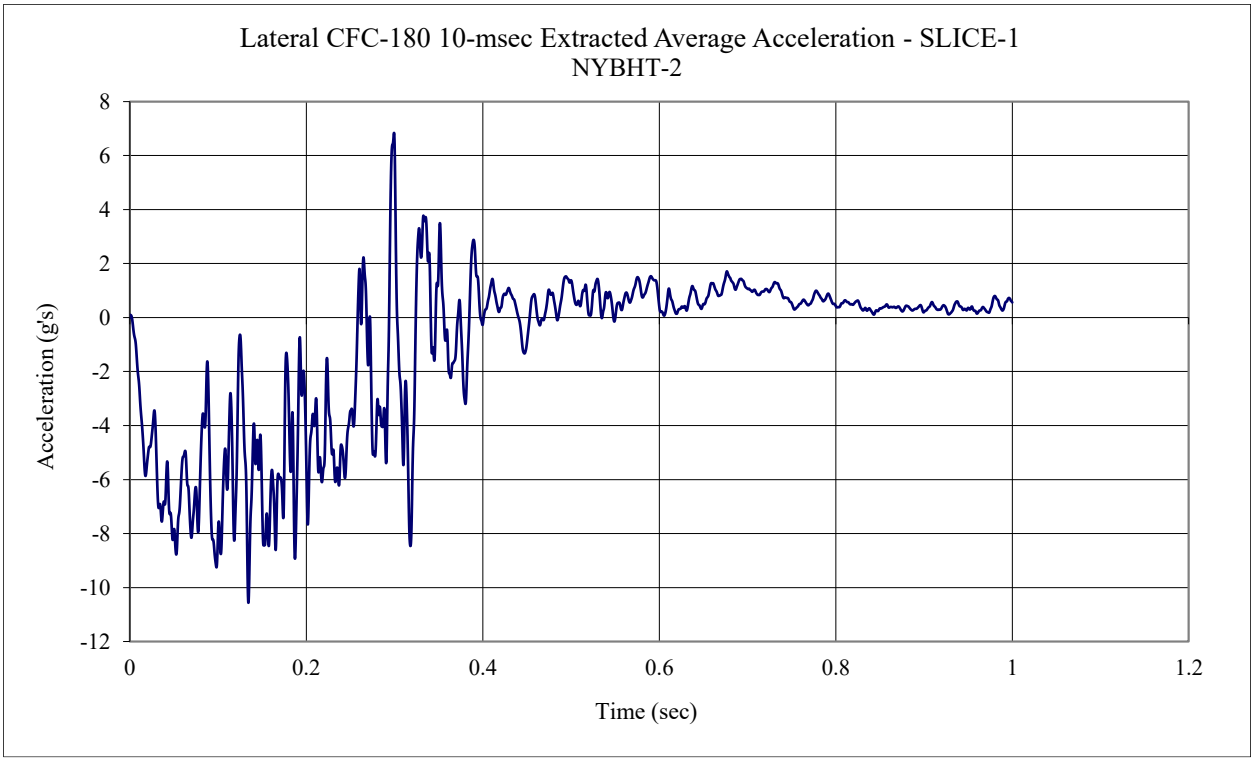


Figure L-4. 10-ms Average Lateral Deceleration (SLICE-1), Test No. NYBHT-2

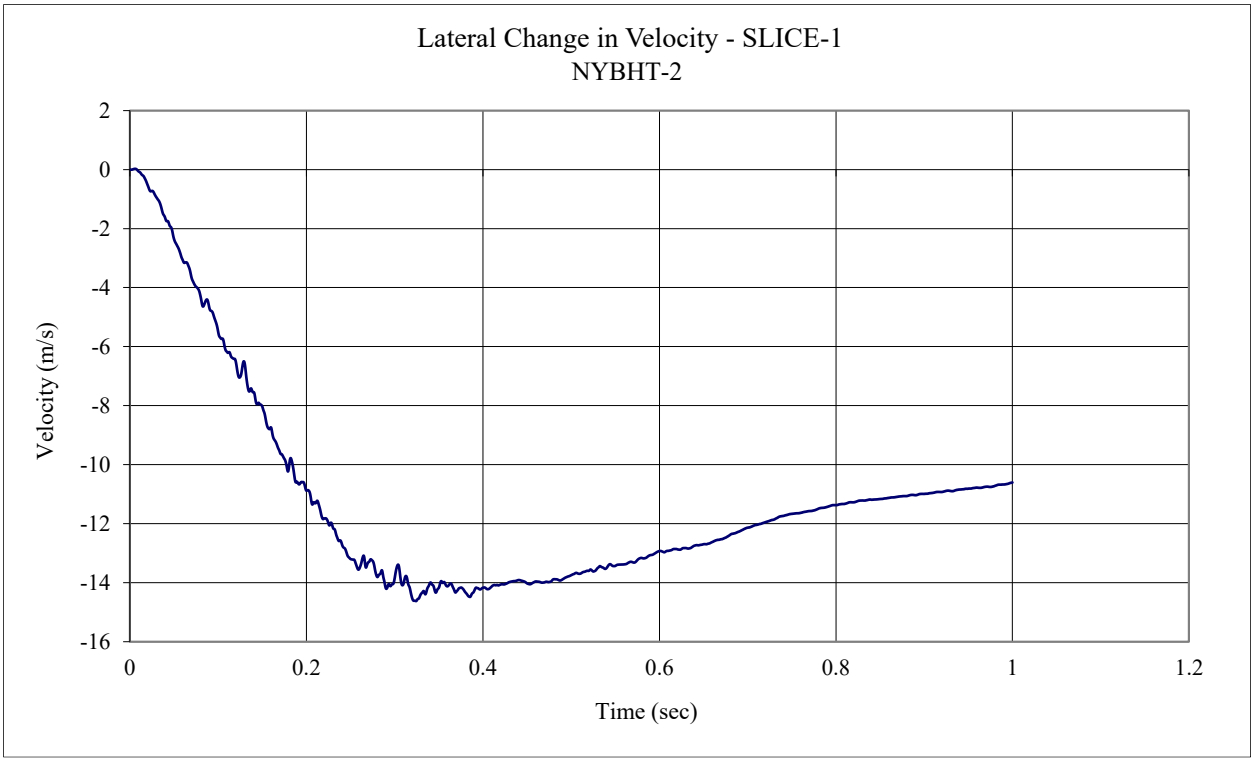


Figure L-5. Lateral Occupant Impact Velocity (SLICE-1), Test No. NYBHT-2

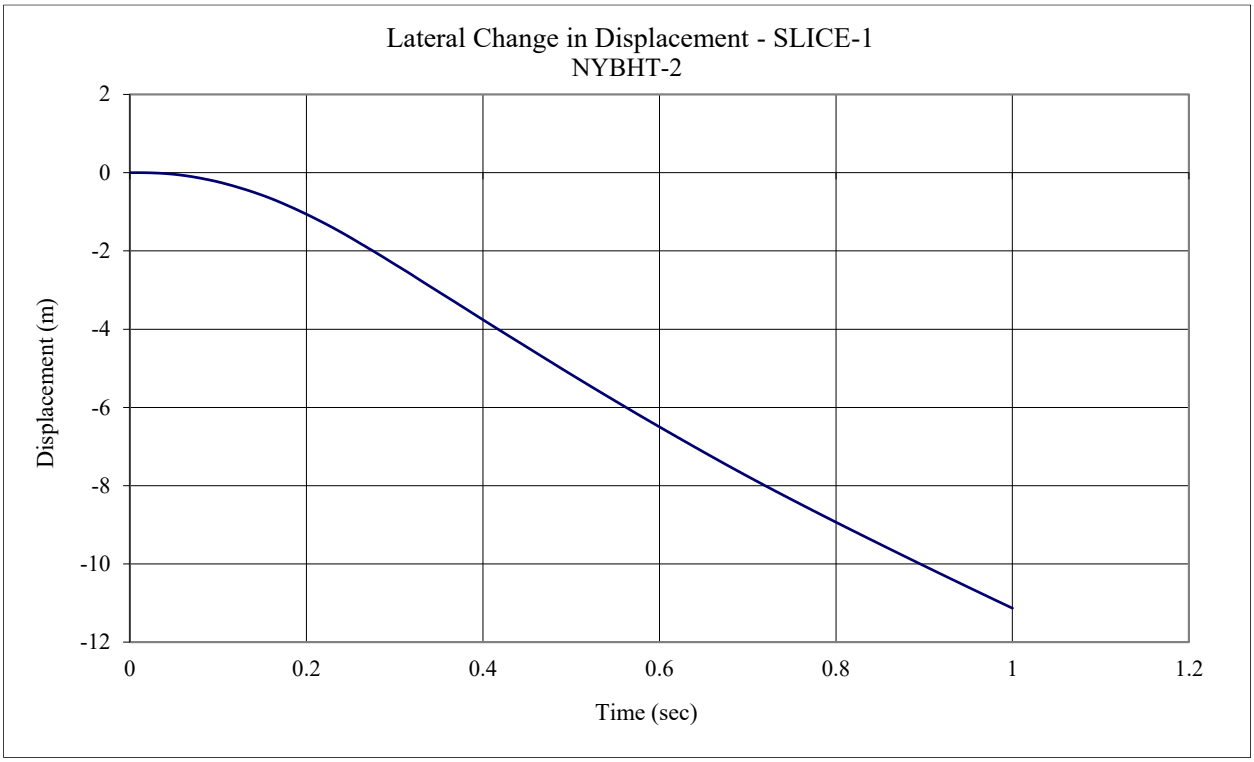


Figure L-6. Lateral Occupant Displacement (SLICE-1), Test No. NYBHT-2

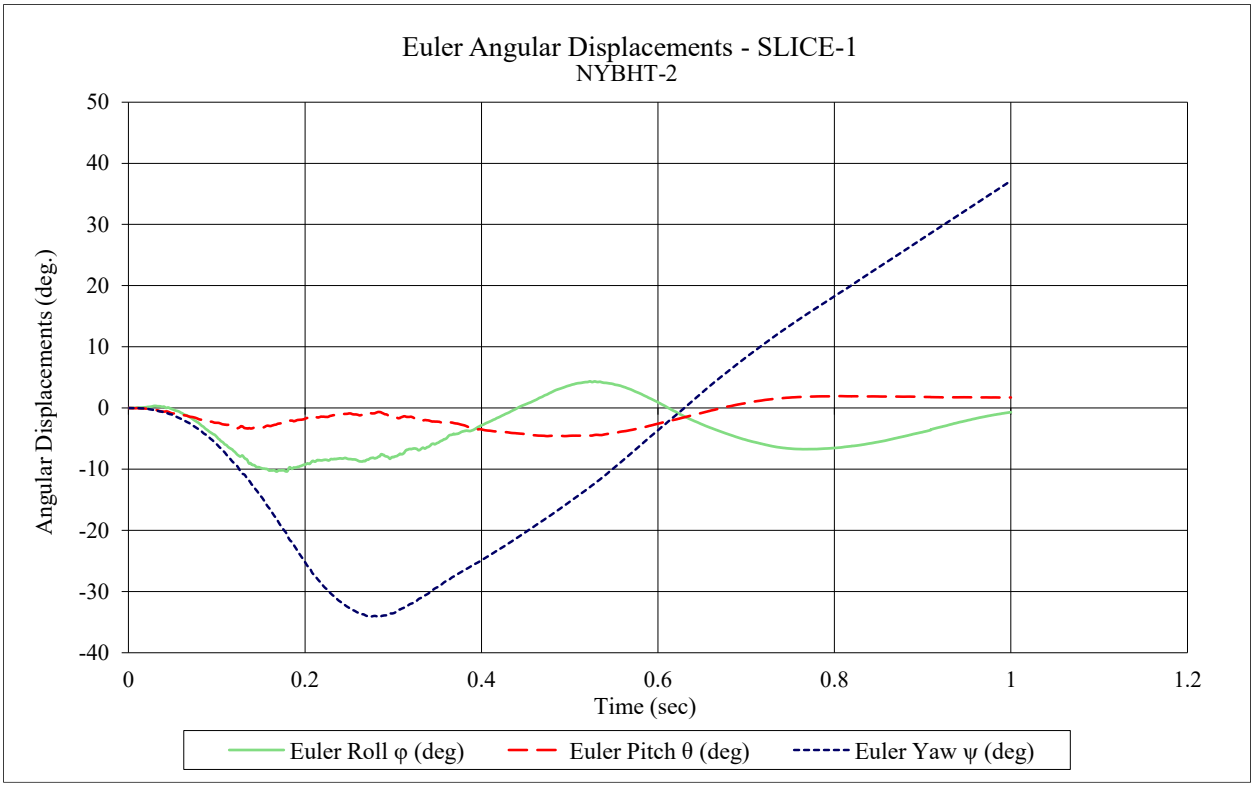


Figure L-7. Vehicle Angular Displacements (SLICE-1), Test No. NYBHT-2

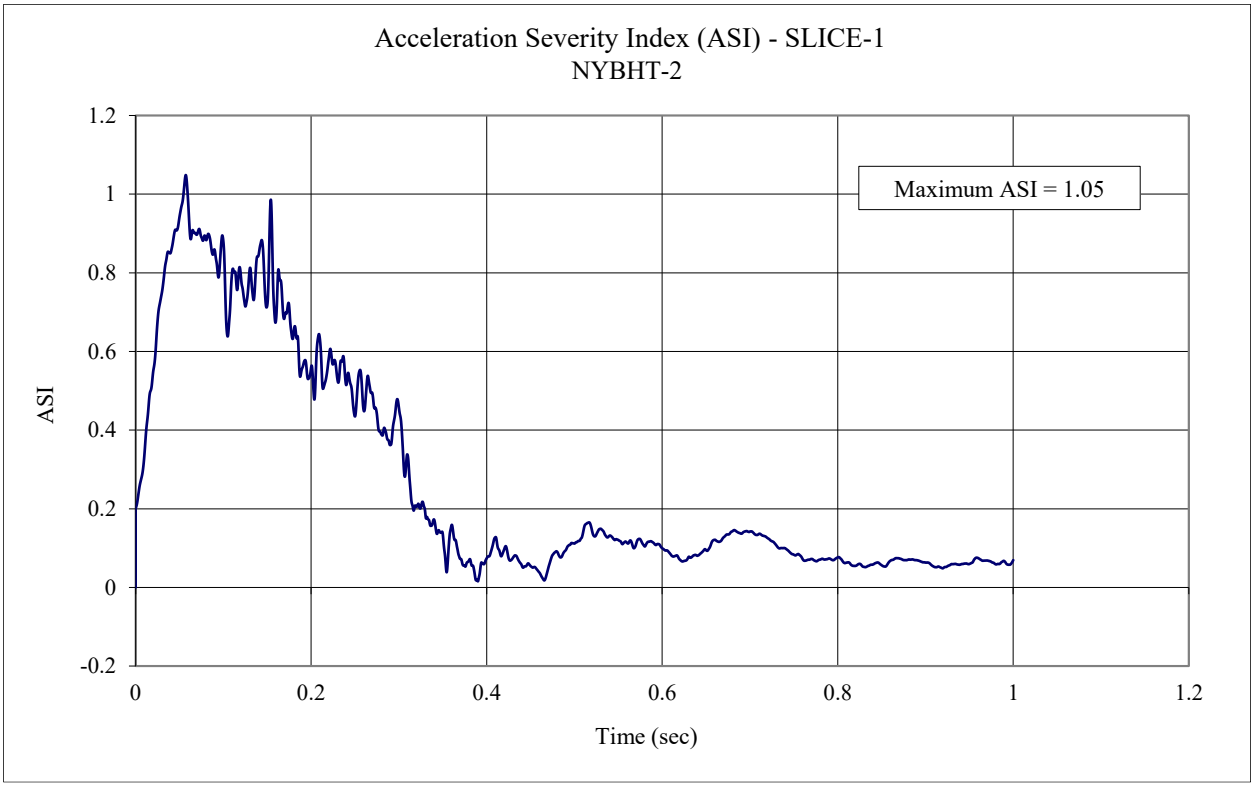


Figure L-8. Acceleration Severity Index (SLICE-1), Test No. NYBHT-2

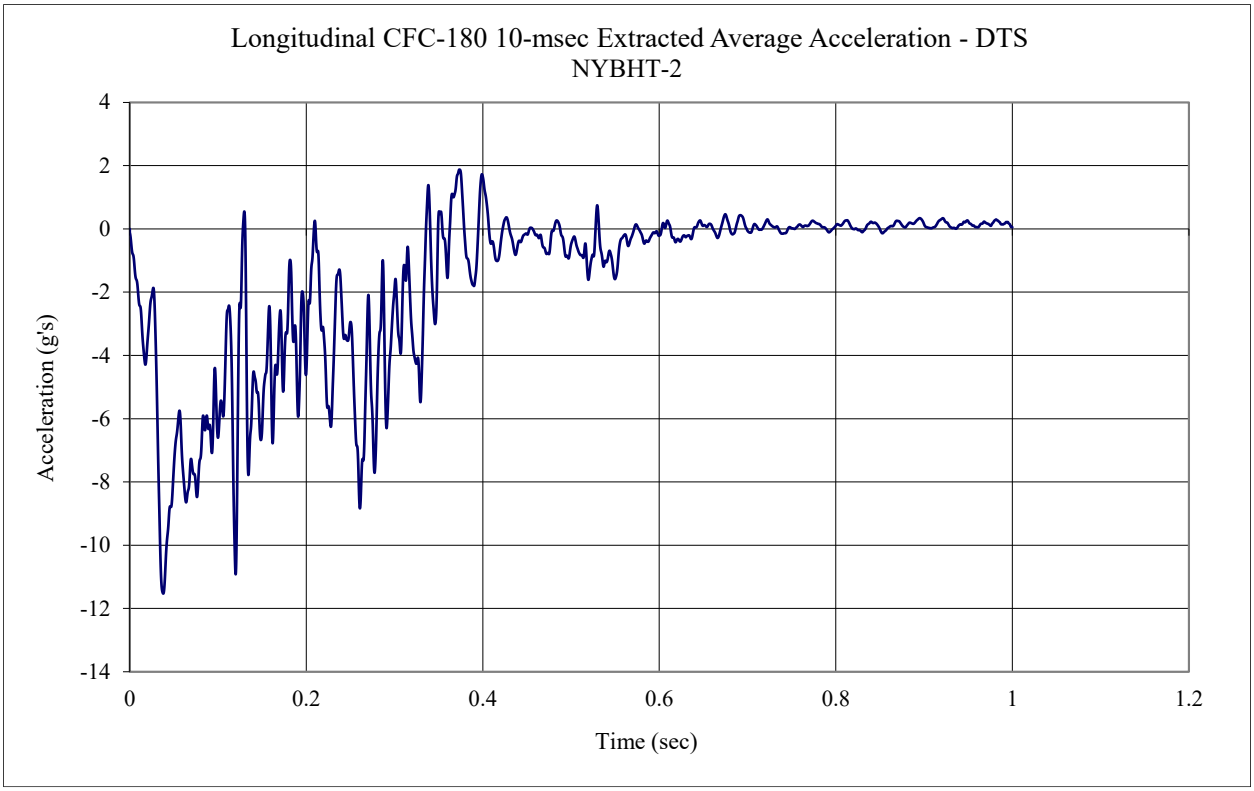


Figure L-9. 10-ms Average Longitudinal Deceleration (TDAS), Test No. NYBHT-2

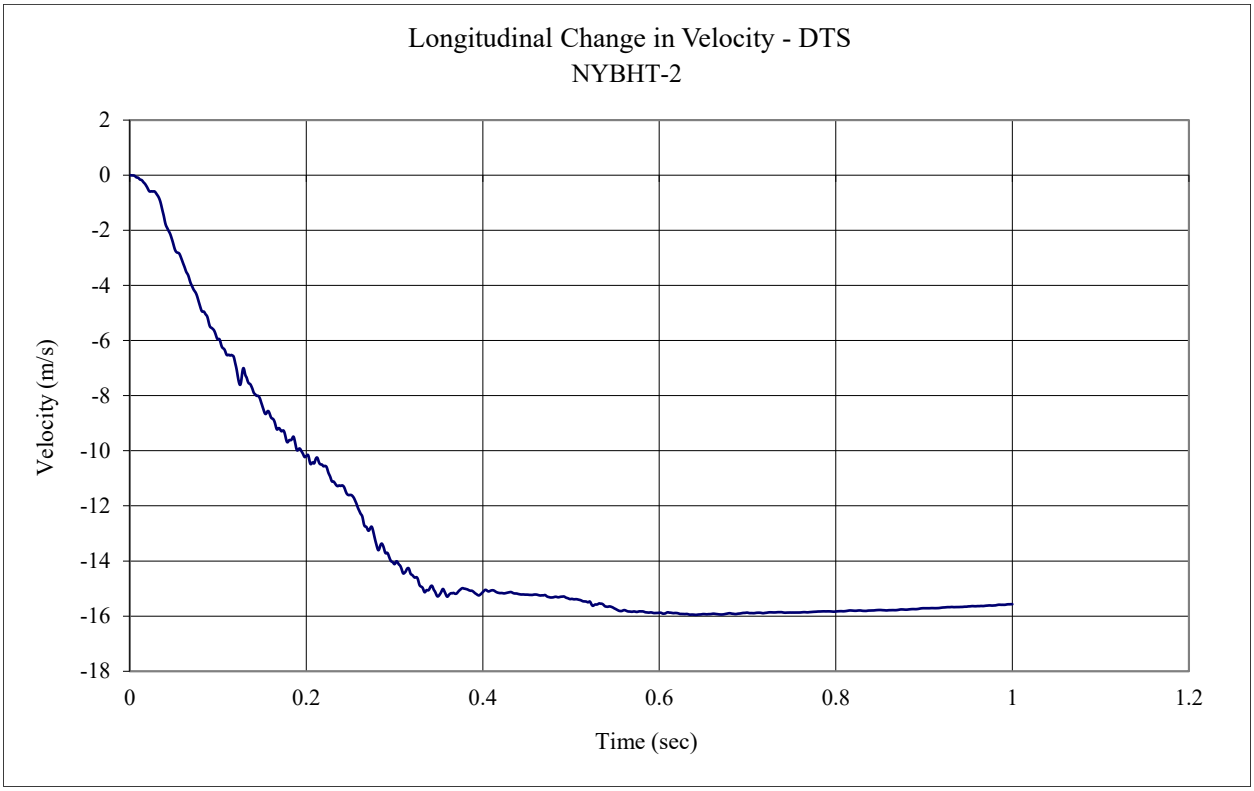


Figure L-10. Longitudinal Occupant Impact Velocity (TDAS), Test No. NYBHT-2

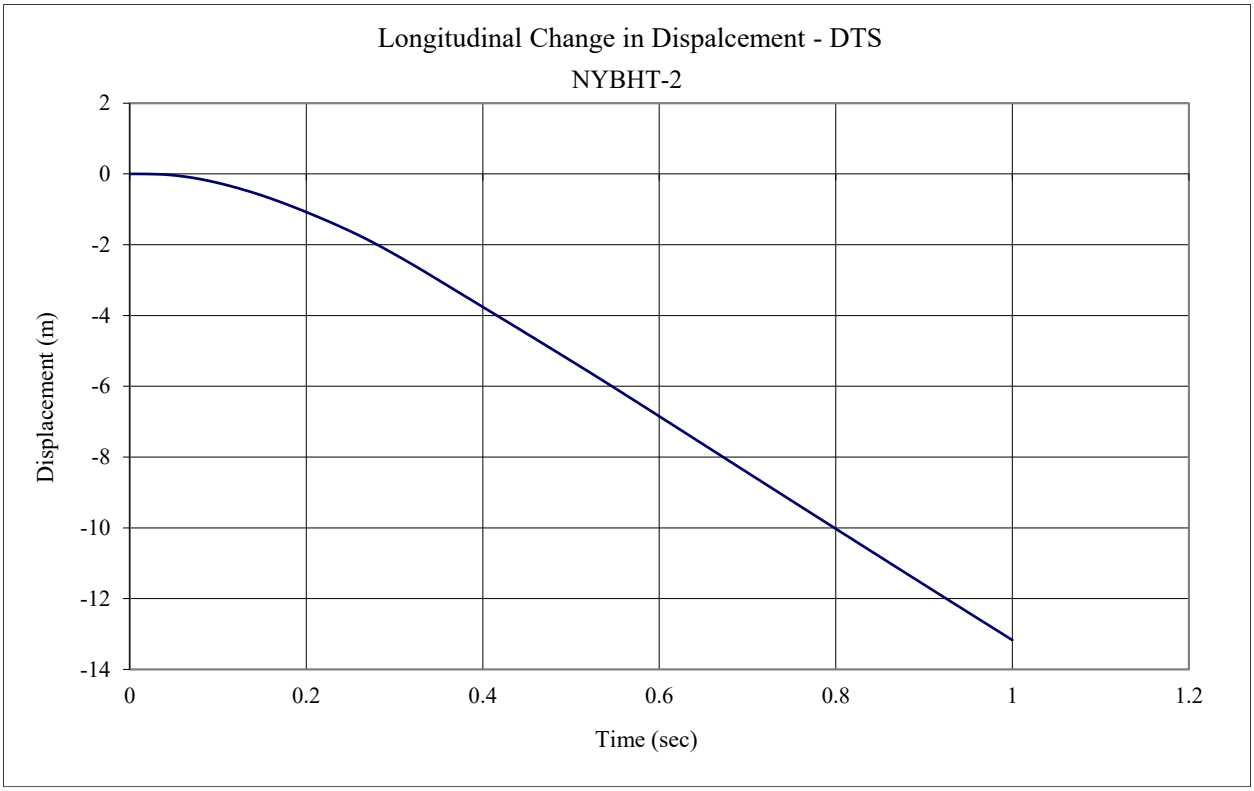


Figure L-11. Longitudinal Occupant Displacement (TDAS), Test No. NYBHT-2

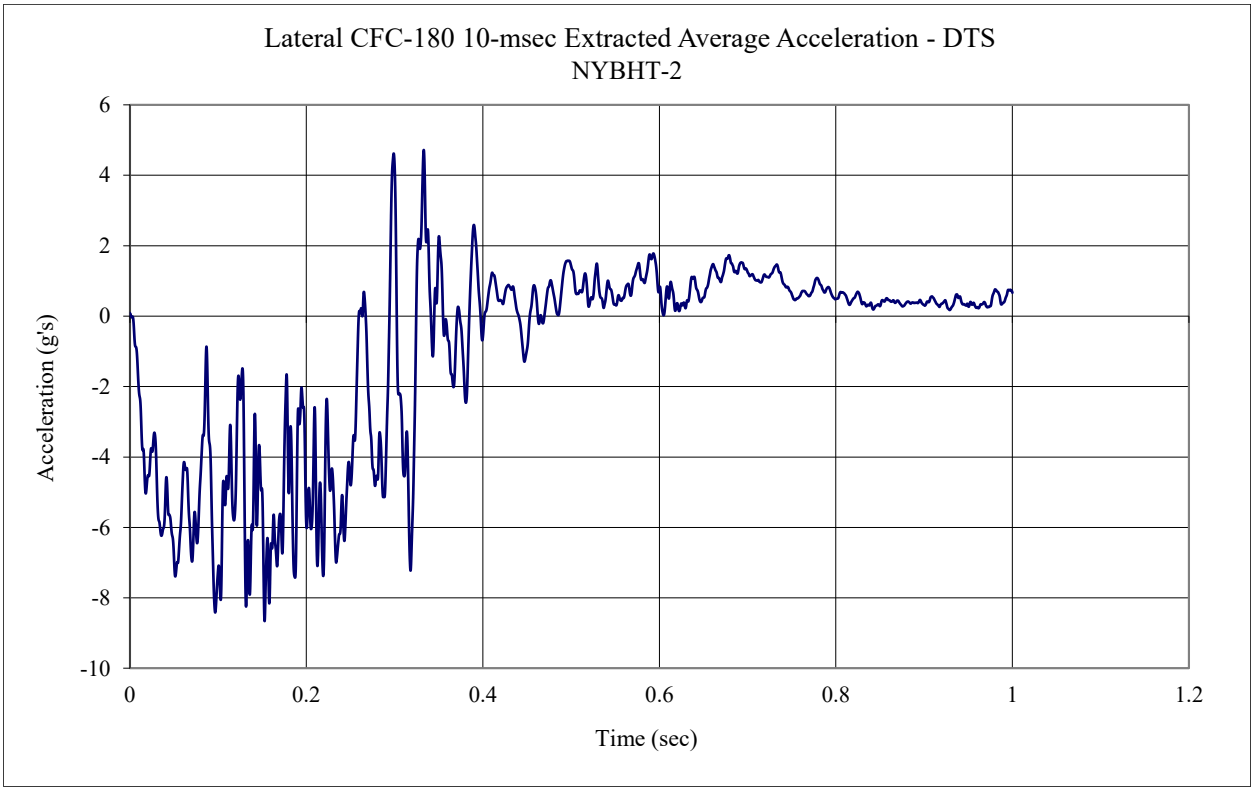


Figure L-12. 10-ms Average Lateral Deceleration (TDAS), Test No. NYBHT-2

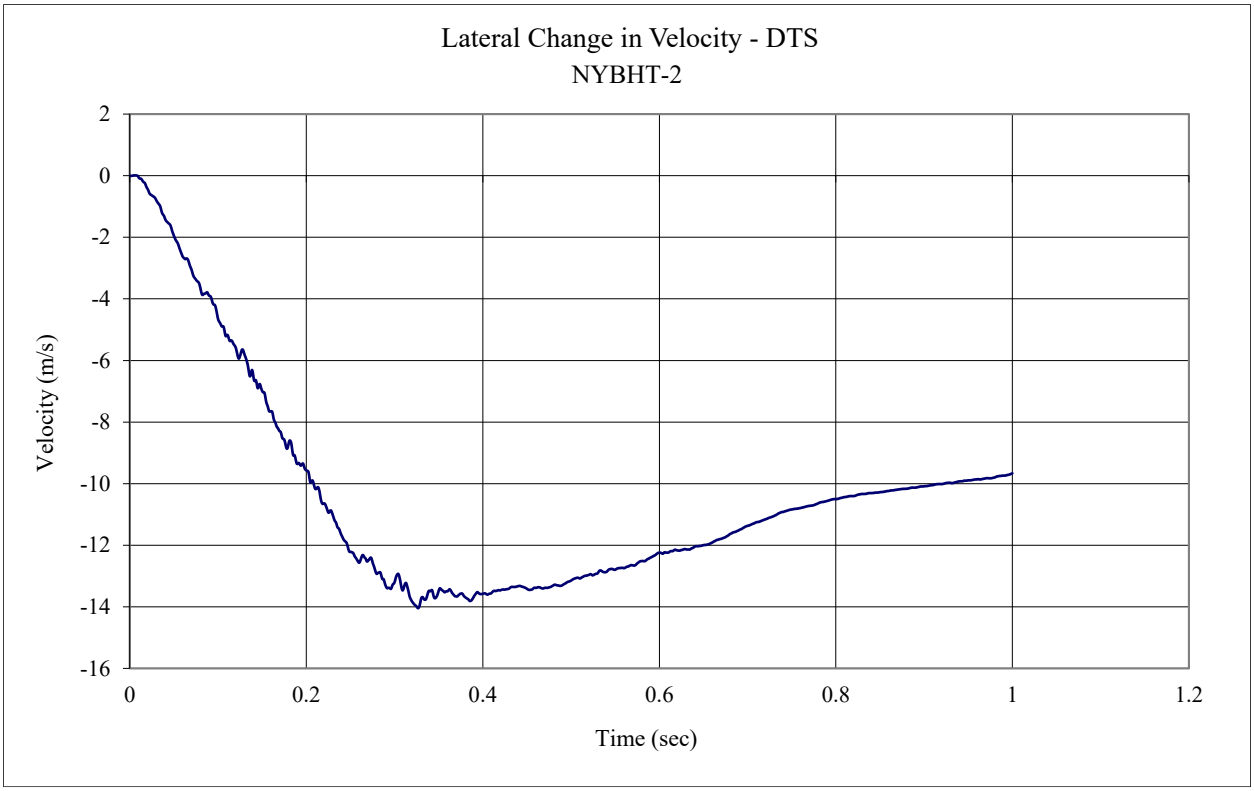


Figure L-13. Lateral Occupant Impact Velocity (TDAS), Test No. NYBHT-2

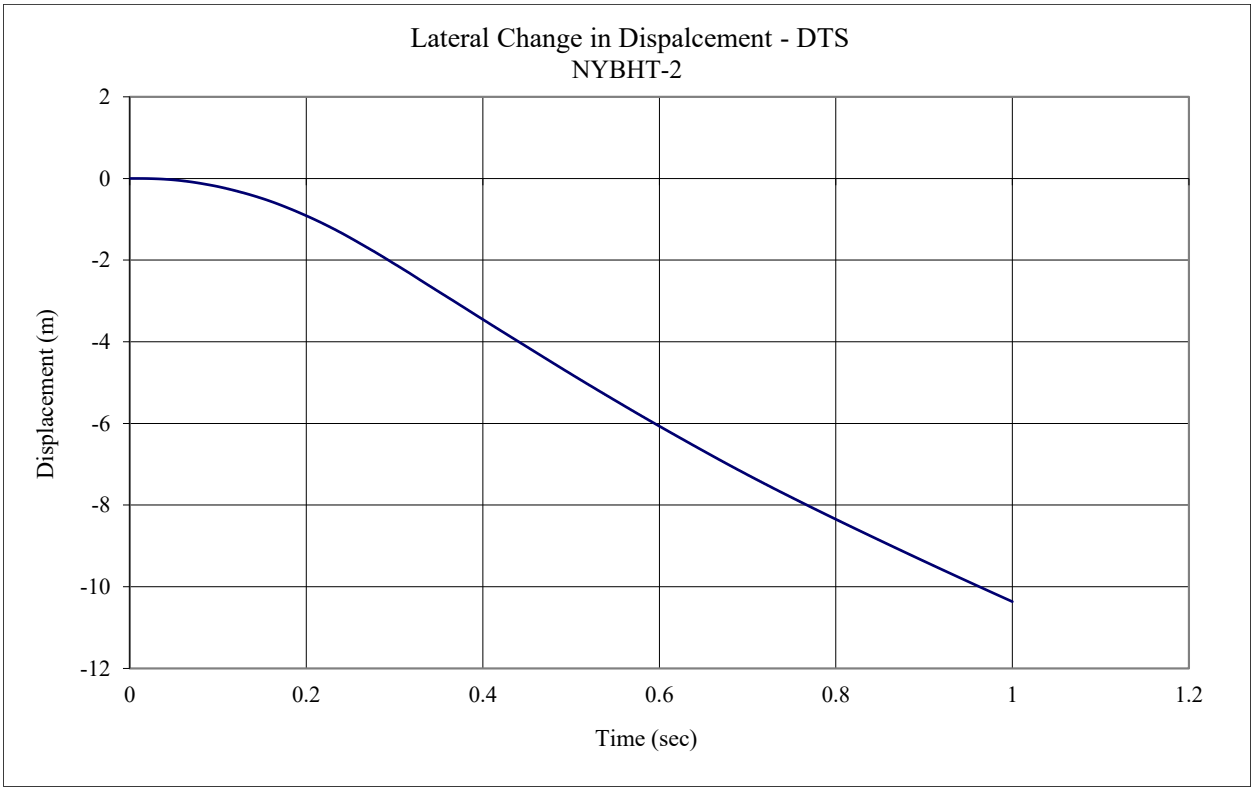


Figure L-14. Lateral Occupant Displacement (TDAS), Test No. NYBHT-2

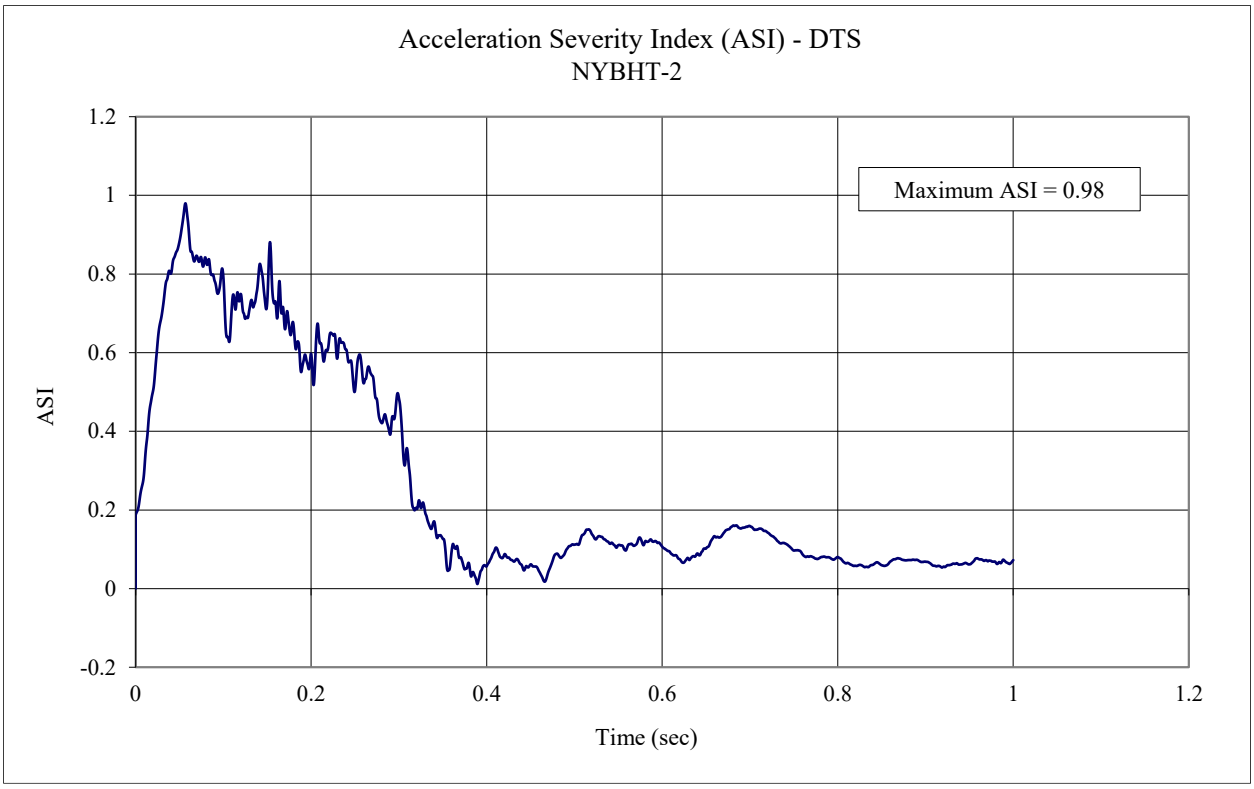


Figure L-15. Acceleration Severity Index (TDAS), Test No. NYBHT-2

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