



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

400 Seventh St., S.W.  
Washington, D.C. 20590

February 14, 2005

In Reply Refer To: HSA-10/B-134

Mr. Barry D. Stephens, P.E.  
Sr. Vice President Engineering  
Energy Absorption Systems, Inc.  
3617 Cincinnati Avenue  
Rocklin, California 95678

Dear Mr. Stephens:

Recently, Mr. Douglas Bernard delivered your letter dated January 7, 2005, to Mr. Richard Powers of my staff. In this letter, you requested formal Federal Highway Administration (FHWA) review and acceptance of a temporary longitudinal barrier called the Vulcan<sup>™</sup> Barrier (Vulcan). To support your request, you supplied a summary report and video prepared by E-Tech Testing Services that describes the Vulcan Barrier as well as the three full-scale crash tests you conducted.

The Vulcan is a longitudinal barrier fabricated from hot-dipped galvanized steel and is intended for use as a portable longitudinal barrier in work zones. Each segment has a nominal length of 4115 mm, a height of 813 mm and a width of 546 mm. The mass of each segment is approximately 395 kg. The upper portion incorporates standard Thrie-beam guardrail panels and the bottom incorporates sheet metal rub rails. Five steel bulkheads tie the sides of the Vulcan together. The end bulkheads incorporate vertically aligned holes to facilitate pinning Vulcan segments together. The center bulkhead incorporates a lifting tab for assembly and transport. A stiffener plate also runs the length of each segment. Vulcan sections are pinned together using 48 mm diameter steel connecting pins. When installed in straight configurations, an optional steel spacer can be installed in the connecting joint to reduce lateral deflection. This spacer was used in the three tests submitted for review. The Vulcan's end bulkheads can also be used to connect an appropriate crash cushion to a Vulcan installation. Enclosure 1 is a schematic drawing of a Vulcan segment.

The Vulcan Barrier was crash tested in two configurations. Two tests were conducted following the guidelines in the National Cooperative Highway Research Program (NCHRP) Report 350 for tests 3-10 and 3-11 with the Vulcan freestanding and unanchored on an asphalt surface. For these two tests, eighteen (18) freestanding Vulcan segments were pinned together and the ends were ballasted with four unanchored 3.0 m long PCMB segments to simulate



longer lengths of upstream and downstream Vulcan Barrier. These concrete segments weighed 8880 kg, which is equal to 23 segments of Vulcan. Consequently, when installed freestanding, the same weight of PCMB segments or a minimum of 23 Vulcan segments (92 m = 302 ft) must be attached to each end of unanchored Vulcan barriers to establish a “beginning of length of need” (BLON) point and to limit the barrier’s dynamic deflection within the length of need to that noted in the crash test. The impact point for these tests was at a point 16.5 m from the connection to the PCMB or the BLON point. The vehicles were smoothly redirected and occupant risk values were acceptable. The lateral dynamic deflection for the 820c test was 1.6 m and for the 2000p test was 4.0 m. Impacts nearer to either end of an unanchored installation may result in significantly greater deflections. Impacts immediately adjacent to either unanchored end may not redirect an impacting vehicle and are likely to result in pocketing or penetration into the area behind the barrier.

A second Vulcan Barrier configuration was also tested per the NCHRP Report 350 Test 3-11 and submitted for evaluation. In this configuration both ends of fourteen (14) Vulcan segments were restrained from moving by connecting the barrier to a QuadGuard CZ crash cushion anchored with DPA anchors (reference the FHWA acceptance letter HSA-10/CC-35G) on the approach end and the QuadGuard base platform on the departure end. The impact point was into the third Vulcan segment at a point 1.2 m downstream from the connection between the second and third segments. The 2000p vehicle was smoothly redirected and the reported occupant risk values were acceptable. The maximum lateral dynamic deflection was reported as 2.1 m. As expected, dynamic deflection was significantly reduced when the Vulcan installation was anchored at both ends and this treatment is acceptable for use in uni-directional applications or where opposite direction impacts immediately adjacent to the QuadGuard are deemed to be unlikely. Since you are connecting a flexible barrier system directly to a rigid crash cushion, further evaluation or a crash test will be required to validate use of QuadGuard systems on both ends in bidirectional traffic applications to make sure there is no snag point when this transition is impacted from the opposing traffic direction. Enclosure 2 includes summary test sheets for the three tests you reported.

You also submitted a drawing (Enclosure 3) depicting Vulcan Barrier ends shielded by your TRITON CET crash cushion (reference the FHWA acceptance letter dated February 6, 2004, HSA-10/CC-47B). I agree that this is an acceptable means of shielding the exposed ends of Vulcan Barrier, but users must be cautioned that impacts into the TRITON CET will likely result in pocketing or penetration into the area beyond the terminal and impacts immediately downstream from this crash cushion will result in greater deflection of the barrier into the work area.

Based upon review of the data you submitted, I agree that the Vulcan Barrier, as tested, meets the NCHRP Report 350 evaluation criteria and may be used on the National Highway System (NHS) as a test level 3 temporary barrier. In its unanchored configuration, at least 8880 kg of mass (23 segments of Vulcan or equivalent weight) must be attached to the ends in advance of the barrier length of need. The freestanding, unshielded end of this design is not crashworthy and requires either shielding with a suitable anchored impact attenuator for uni-directional applications) or introduction outside the appropriate clear zone. I also agree that the ends of the Vulcan can be attached to and shielded by your unanchored TRITON CET crash cushion.

Anticipated lateral deflection of the Vulcan for anchored and unanchored configurations must be communicated to end users so effective field installations can be designed.

Please note also that the following provisions apply to the FHWA letters of acceptance:

- This acceptance is limited to the crashworthiness characteristics of the device and does not cover its structural features or its conformity with the Manual on Uniform Traffic Control Devices.
- Any design changes that may adversely influence the crashworthiness of the device will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, the in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash test, it reserves the right to modify or revoke its acceptance.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for acceptance, and that it will meet the crashworthiness requirements of the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance, designated as number B-134, shall not be reproduced except in full. This letter, and test documentation upon which this letter is based, is public information. All such letters and documentation may be reviewed at our office upon request.
- The Vulcan Barrier is a patented product and is considered proprietary. If proprietary devices are specified by a highway agency for use on a Federal-aid project, except exempt, non-NHS projects, they: (a) must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that they are essential for synchronization with the existing highway facilities or that no equally suitable alternative exists or; (c) they must be used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes. Our regulations concerning proprietary products are contained in Title 23, Code of Federal Regulations, Section 635.411.

Sincerely yours,

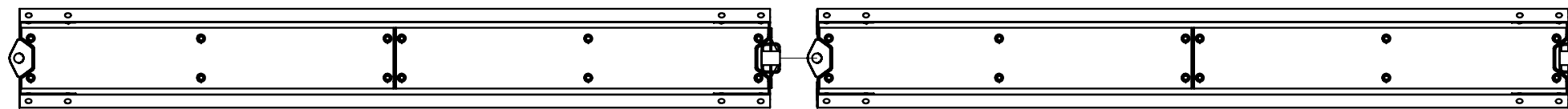
*/Original Signed by Harry W. Taylor/*

*~for~*

John R. Baxter, P.E.  
 Director, Office of Safety Design  
 Office of Safety

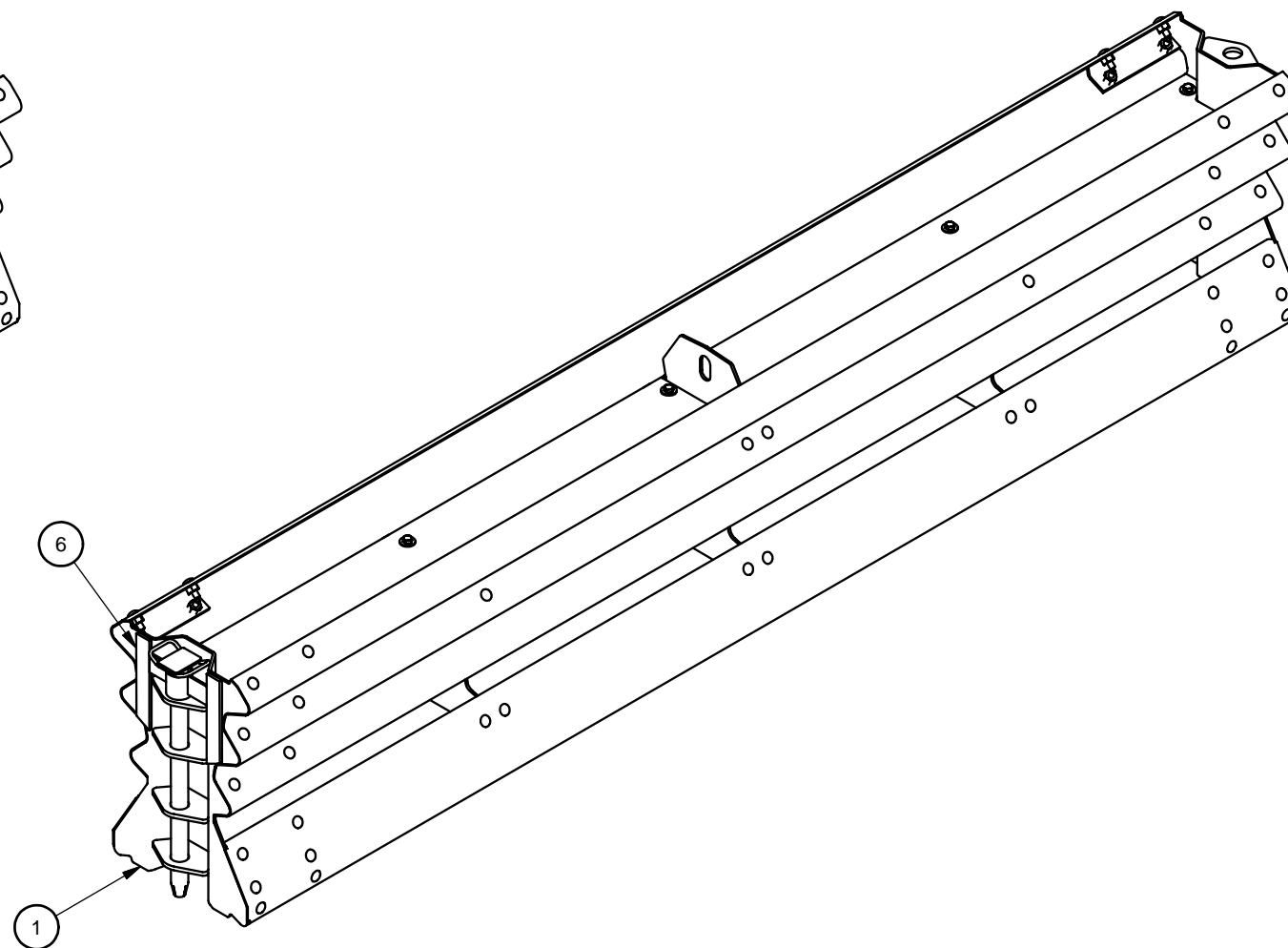
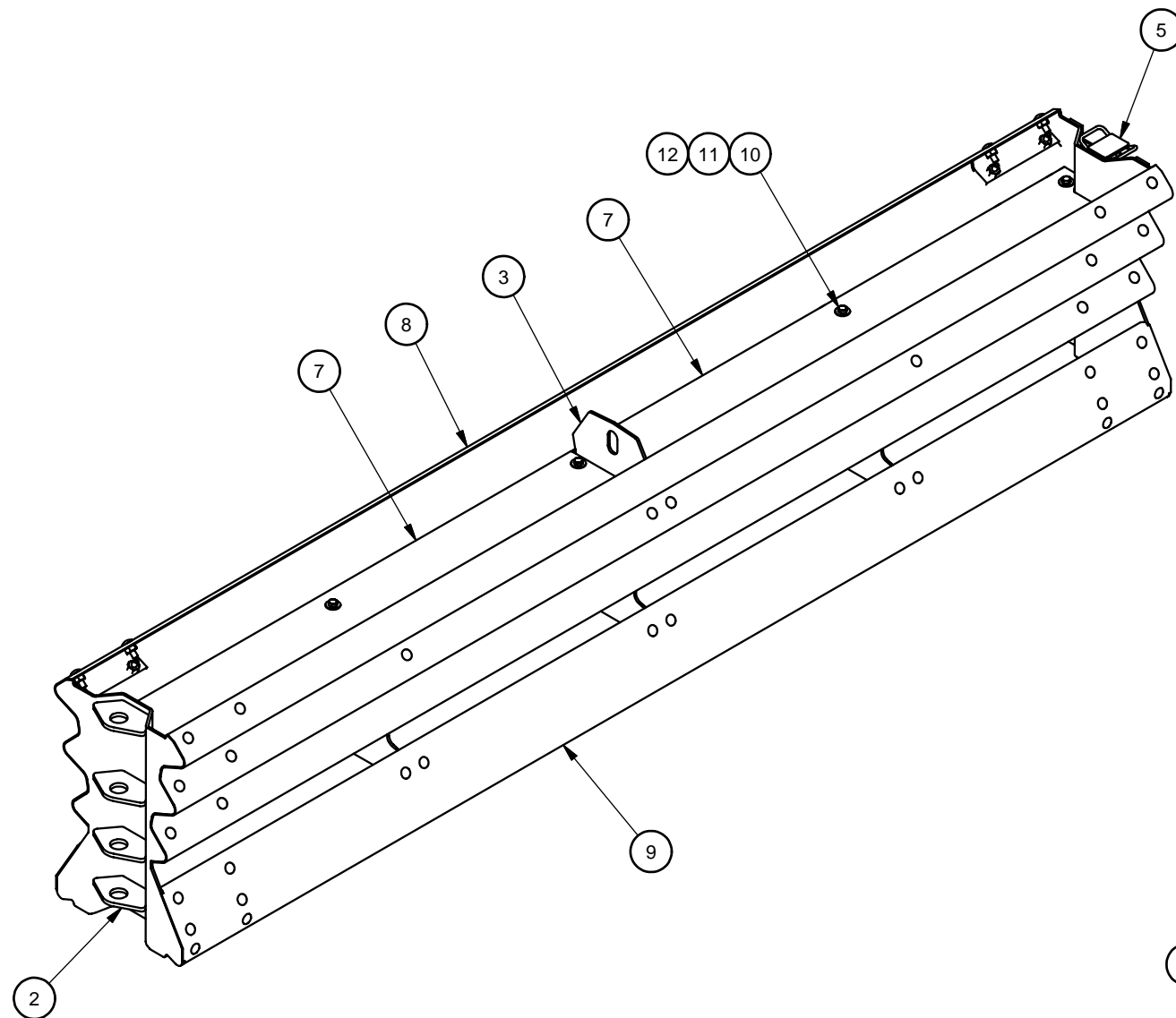
3 Enclosures

PARTS LIST			
ITEM	STOCK NO.	DESCRIPTION	QTY.
1	2796004-0000	BULKHEAD,END,RT,VULCAN	1
2	2796003-0000	BULKHEAD,END,LT,VULCAN	1
3	2796005-0000	BULKHEAD,CTR,VULCAN	1
4	2796006-0000	BULKHEAD,QTR,VULCAN	2
5	2796008-0000	PIN,CONNECTING,VULCAN	1
6	2796007-0000	SPACER,VULCAN	1
7	2796001-0000	STIFFNER,VULCAN	2
8	2796000-0000	THRI-BEAM,W/SLOTS,VULCAN	2
9	2796002-0000	RUB RAIL,VULCAN	2
10	2699081-0500	BOLT,HEX-HEAD,5/8 DIA X 1/12,G5,G	12
11	2704141-0000	NUT,HEX,5/8	12
12	2708291-0000	WASHER,FLAT,5/8 X 1 3/4,G	12
13	2699341-0000	BOLT RAIL,5/8 X 2,G	92
14	2704191-0000	NUT,HX,5/8,G,RAIL	92



NOT TO SCALE

NOTE: INSERT PIN AND SPACER (ITEM 5 & 6) TO JOIN LEFT AND RIGHT ENDS OF ADJACENT BARRIER SEGMENTS DURING INSTALLATION.



ASSEMBLY NO. 3596000-0000

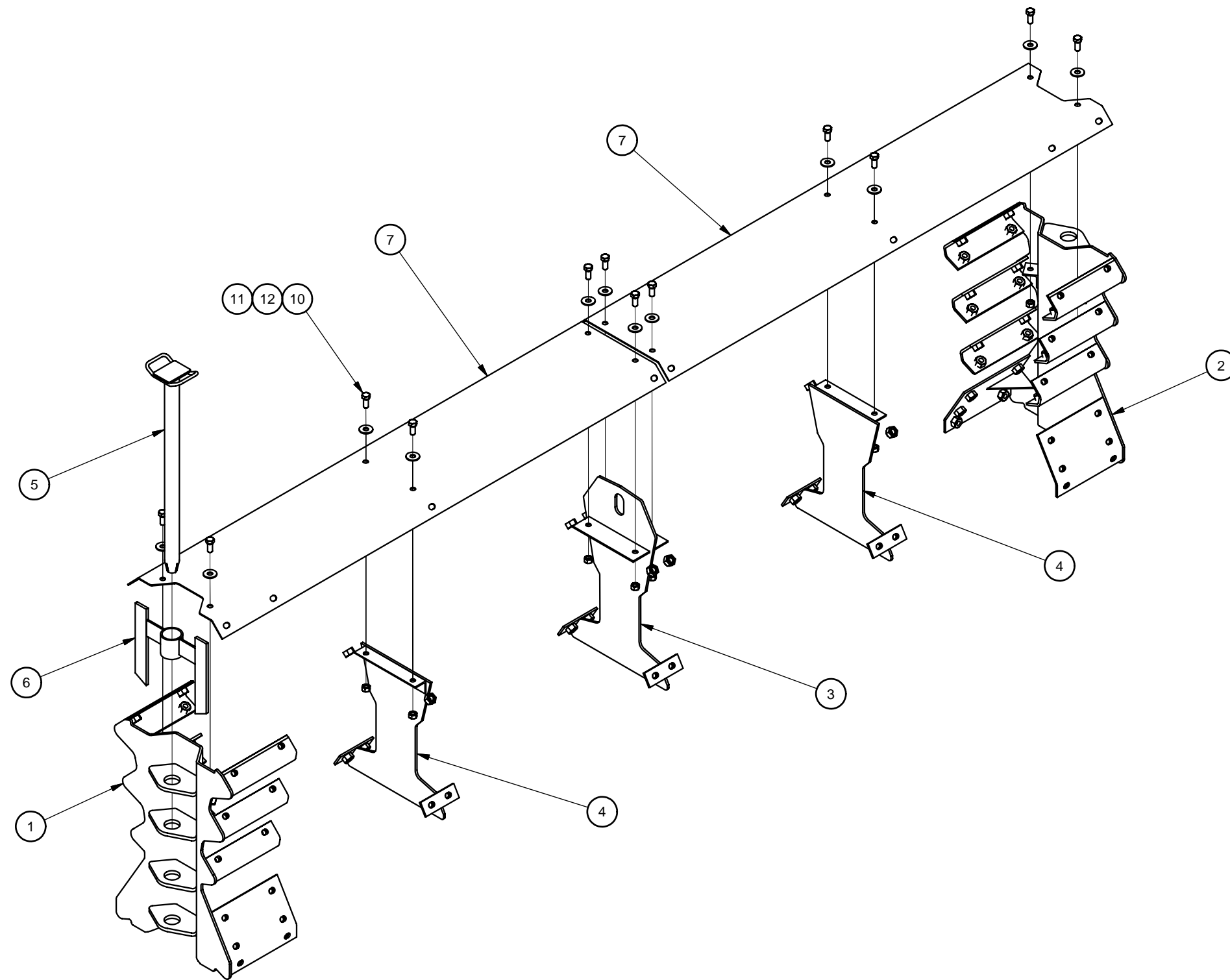


VULCAN

Revision	Date	Rev	By	Chk.	App.
ASSIGNED P/N'S	10/6/04	-	DPH	JME	KWL

DRAWN: D. Hayes Jr.	DATE: 3/3/2004
DESIGNED: D. Wilkinson	DATE: 10/28/2003
CHECKED: J. Espinoza	DATE: 3/5/2004
APPROVED: J. M. Thompson	DATE: 3/5/2004
FILE: 3596000-0000.idw	
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ASSEMBLY NO. 3596000-0000



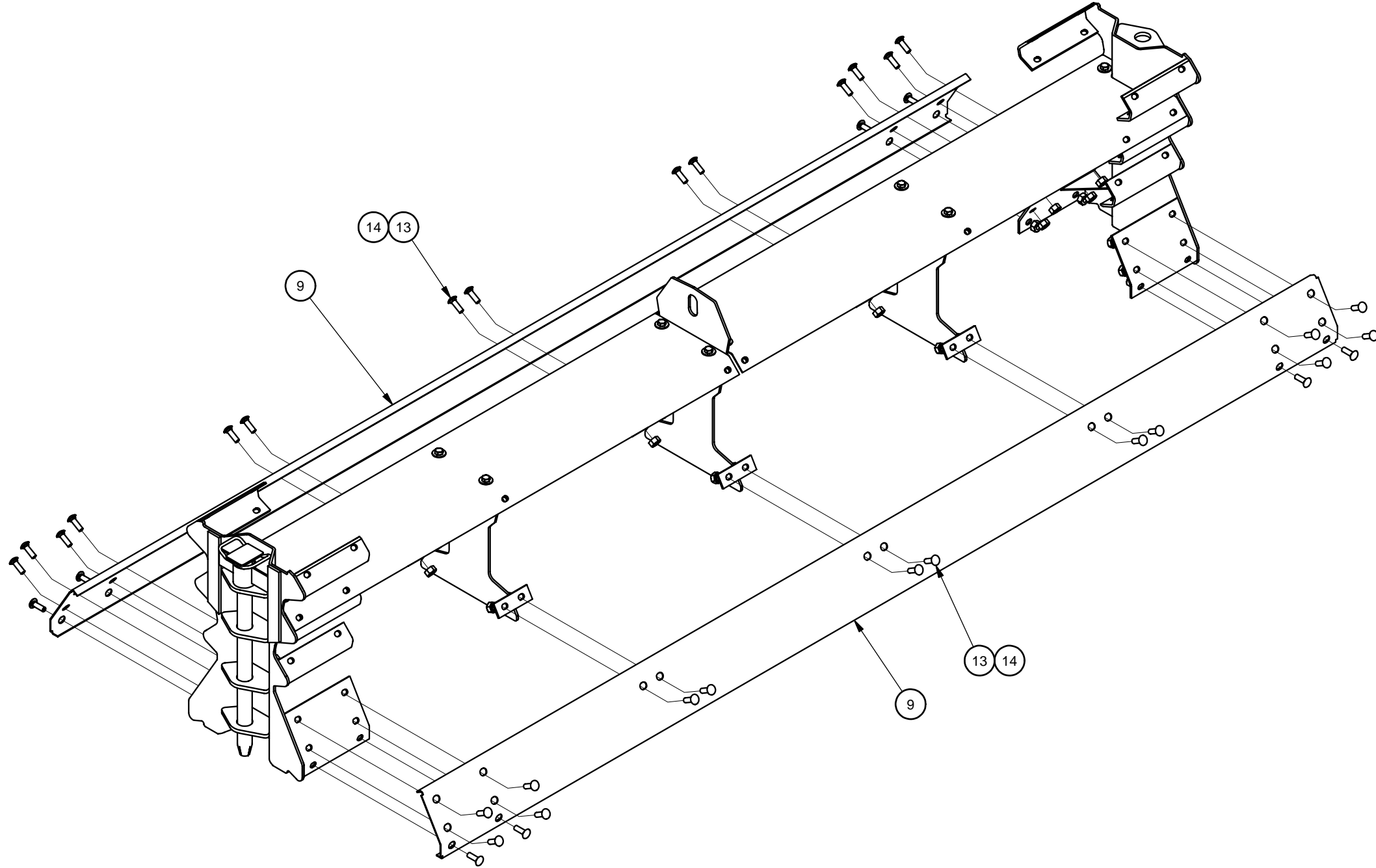
**ENERGY ABSORPTION SYSTEMS, INC.**  
ENGINEERING AND RESEARCH DEPARTMENT

**VULCAN**

DRAWN: D. Hayes Jr.	DATE: 3/3/2004
DESIGNED: D. Wilkinson	DATE: 10/28/2003
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FILE: 3596000-0000.idw	
NEXT ASSEMBLY:	

Revision	Date	Rev	By	Chk.	App.
ASSIGNED P/N'S	10/6/04	-	DPH	JME	KWL

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ASSEMBLY NO. 3596000-0000



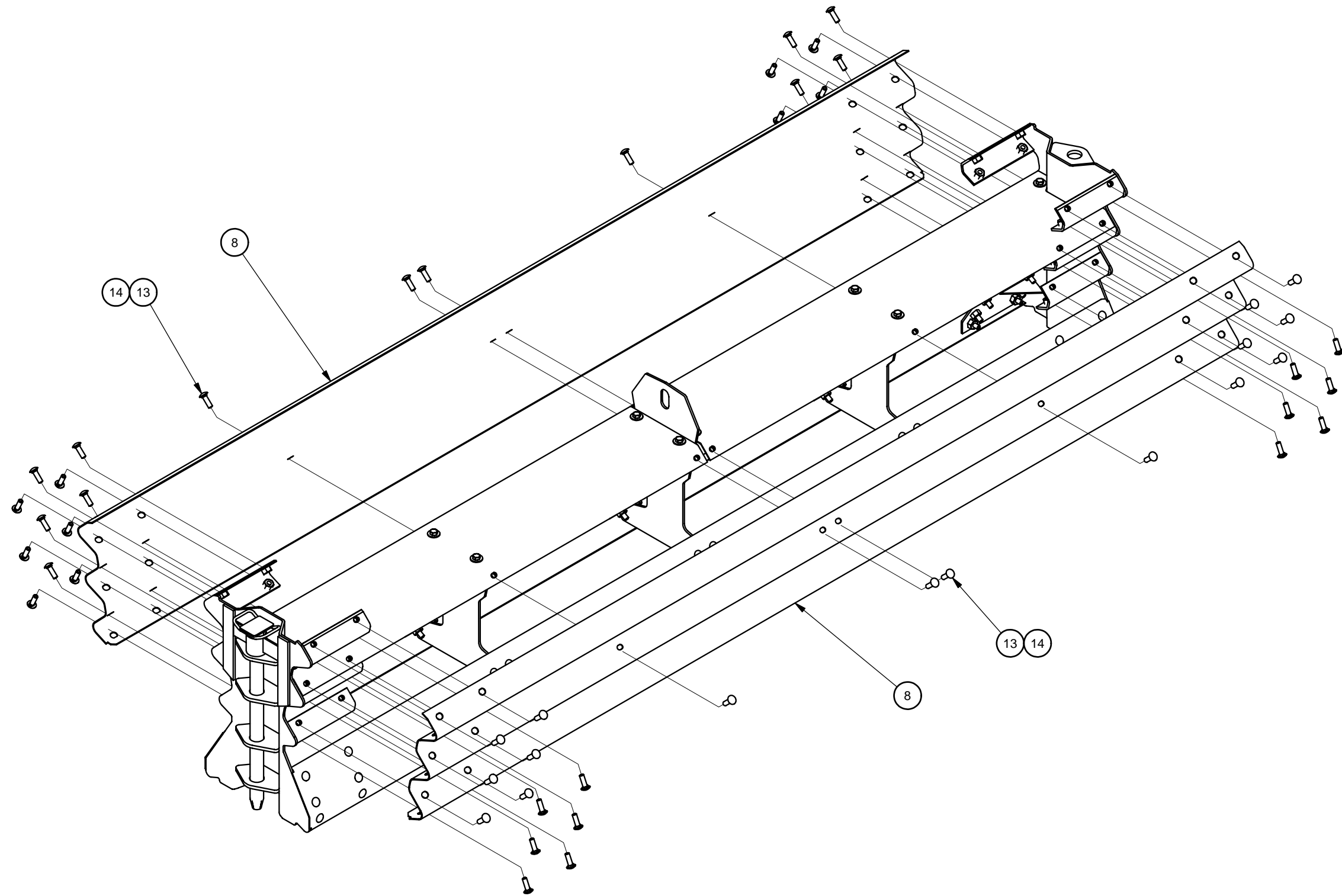
**ENERGY ABSORPTION SYSTEMS, INC.**  
ENGINEERING AND RESEARCH DEPARTMENT

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APPROVED: J. M. Thompson	DATE: 3/5/2004
FILE: 3596000-0000.idw	
NEXT ASSEMBLY:	

SCALE: 1:16	DRAWING: 3596000-0000	SHEET: 3 of 4	REV: -
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ASSEMBLY NO. 3596000-0000



**ENERGY ABSORPTION SYSTEMS, INC.**  
ENGINEERING AND RESEARCH DEPARTMENT

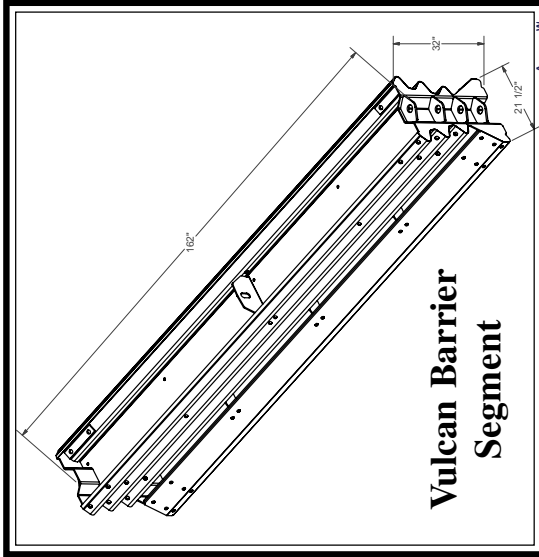
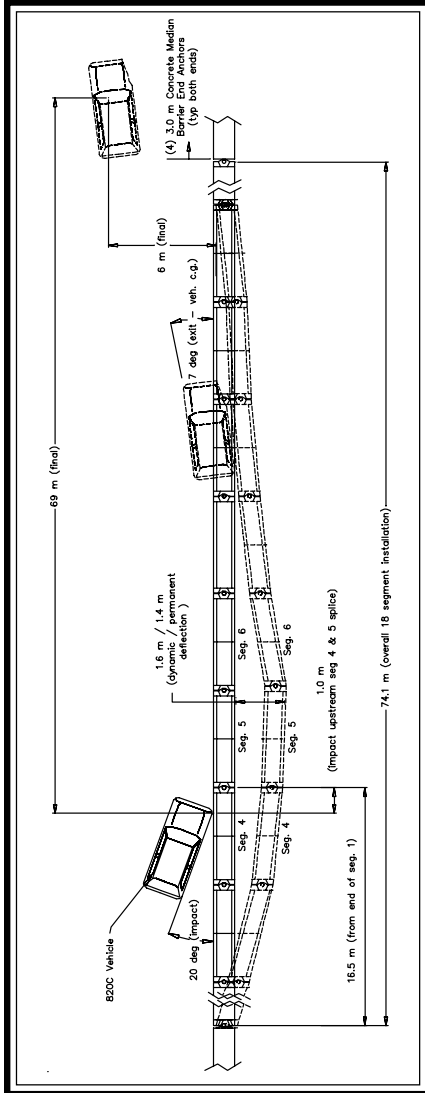
**VULCAN**

Revision	Date	Rev	By	Chk.	App.
ASSIGNED P/N'S	10/6/04	-	DPH	JME	KWL

DRAWN: D. Hayes Jr.	DATE: 3/3/2004
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APPROVED: J. M. Thompson	DATE: 3/5/2004
FILE: 3596000-0000.idw	
NEXT ASSEMBLY:	

SCALE: 1:16	DRAWING: 3596000-0000	SHEET: 4 of 4	REV -
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**General Information**

Test Agency .....  
 Test Designation .....  
 Test No. ....  
 Date .....

E-TECH Testing Services, Inc.  
 NCHRP 350 Test 3-10  
 01-8430-002  
 2/10/04

**Test Article**

Type .....  
 Installation Length .....  
 Material and key elements .....

Vulcan™ Barrier  
 Segment 4115 mm x 813 mm x 546 mm (L x H x W)  
 395 kg mass  
 (18) segments 74.1 m overall length w/o (4) 3.0 m concrete barrier end ballast  
 AASHTO M180 galvanized steel panels, ASTM A53 Pins, and A36 other  
 Chip-seal asphalt, dry

**Foundation Type and Condition**

Type .....  
 Designation .....  
 Model .....

Production Model  
 820C  
 1987 Ford Festiva

**Impact Conditions**

Speed (km/h) .....  
 Angle (deg) .....  
 Impact Severity (kJ) .....

823  
 828  
 75  
 903  
 103.2  
 20  
 39.8

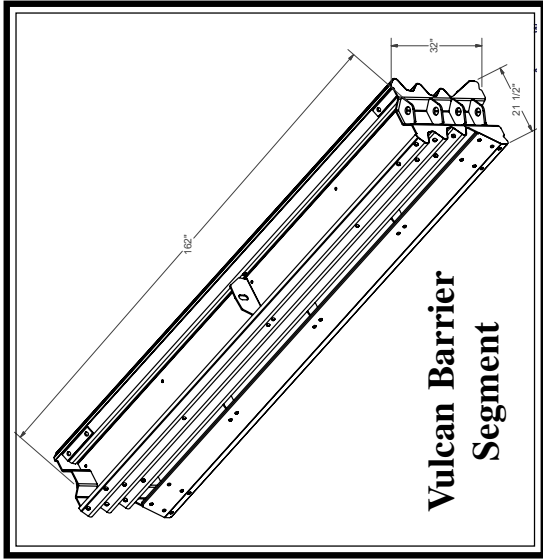
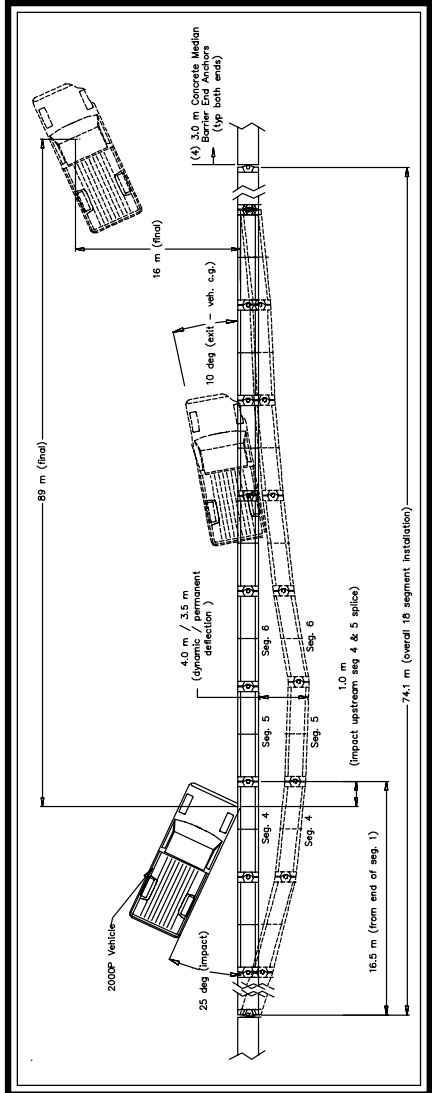
Exit conditions	Speed (km/h) .....	84.0
	Angle (deg - veh. c.g.) .....	7
Occupant Risk Values	Impact Velocity (m/s)	
	x-direction .....	3.8
	y-direction .....	-5.4
Ridedown Acceleration (g's)	x-direction .....	-5.3
	y-direction .....	-4.8
European Committee for Normalization (CEN) Values	THIV (km/h) .....	22.8
	PHD (g/s) .....	9.2
	ASI .....	0.9
Test Article Deflections (m)	Dynamic .....	1.6
	Permanent .....	1.4
Vehicle Damage (Primary Impact)	Exterior	
	VDS .....	RFQ-2
	CDC .....	01RFWEI
	Interior	
	VCDI .....	AS0000000
	Maximum Deformation (mm) .....	Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)	Maximum Roll Angle .....	6.3
	Maximum Pitch Angle .....	1.7
	Maximum Yaw Angle .....	-27.4

Figure 1. Summary of Results - Vulcan Barrier NCHRP 350 Test 3-10





t = 0.000 sec      t = 0.120 sec      t = 0.240 sec      t = 0.360 sec      t = 0.480 sec      t = 0.600



**General Information**

Test Agency ..... E-TECH Testing Services, Inc.  
 Test Designation ..... NCHRP 350 Test 3-11  
 Test No. .... 01-8430-001  
 Date ..... 1/21/04

Test Article Type .....

Vulcan™ Barrier  
 Segment 4115 mm x 813 mm x  
 546 mm (L x H x W)  
 395 kg mass  
 (18) segments 74.1 m overall  
 length w/o (4) 3.0 m concrete  
 barrier end ballast  
 AASHTO M180 galvanized steel  
 panels, ASTM A53 Pins, and A36  
 other  
 Chip-seal asphalt, dry

Foundation Type and Condition .....

Test Vehicle Type .....  
 Designation .....  
 Model .....  
 Mass (kg) .....  
 Curb .....  
 Test inertial .....  
 Dummy .....  
 Gross .....

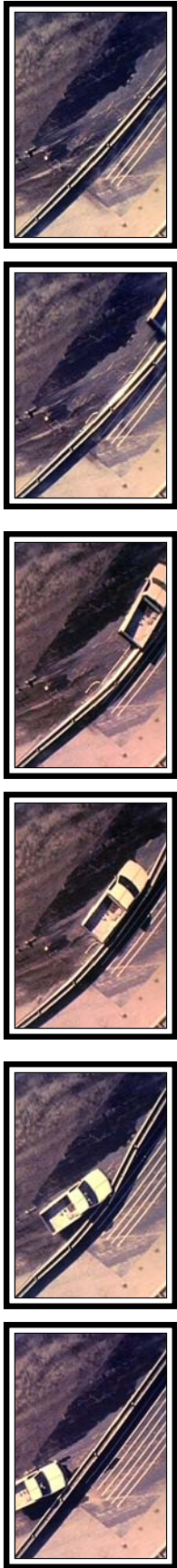
1879  
 2008  
 N/A  
 2008

Impact Conditions  
 Speed (km/h) .....  
 Angle (deg) .....  
 Impact Severity (kJ) .....

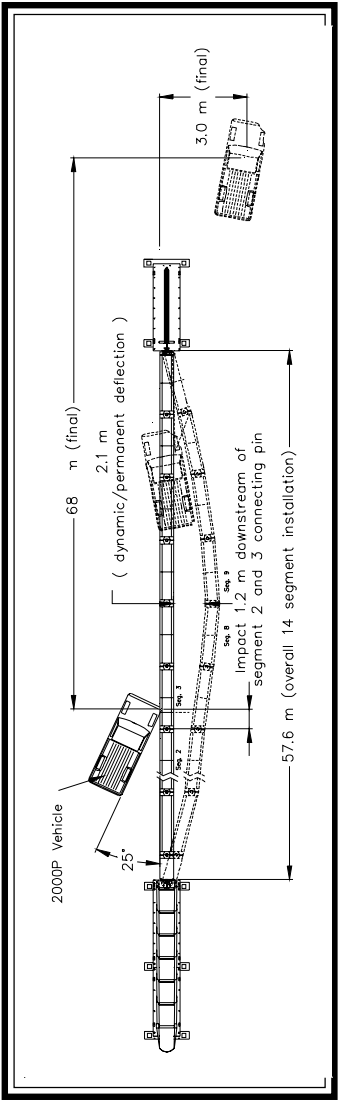
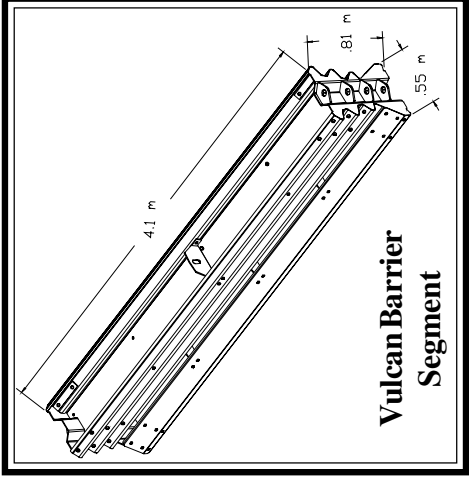
102.5  
 25  
 145.3

Exit conditions  
 Speed (km/h) ..... 80.0  
 Angle (deg - veh. c.g.) ..... 10  
 Occupant Risk Values  
 Impact Velocity (m/s)  
   x-direction ..... 3.8  
   y-direction ..... -4.3  
 Ridedown Acceleration (g's)  
   x-direction ..... -3.7  
   y-direction ..... -5.5  
 European Committee for Normalization (CEN) Values  
 THIV (km/h) ..... 19.9  
 PHD (g's) ..... 5.5  
 ASI ..... 0.6  
 Test Article Deflections (m)  
 Dynamic ..... 4.0  
 Permanent ..... 3.5  
 Vehicle Damage (Primary Impact)  
 Exterior  
   VDS ..... RFQ-3  
   CDC ..... 01RFWE1  
 Interior  
   VCDI ..... AS0000000  
   Maximum Deformation (mm) ..... Negligible  
 Post-Impact Vehicular Behavior (deg - rate gyro)  
 Maximum Roll Angle ..... -8.0  
 Maximum Pitch Angle ..... -6.5  
 Maximum Yaw Angle ..... -42.2

Figure 6. Summary of Results - Vulcan Barrier NCHRP 350 Test 3-11



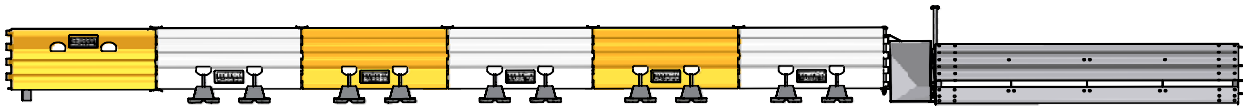
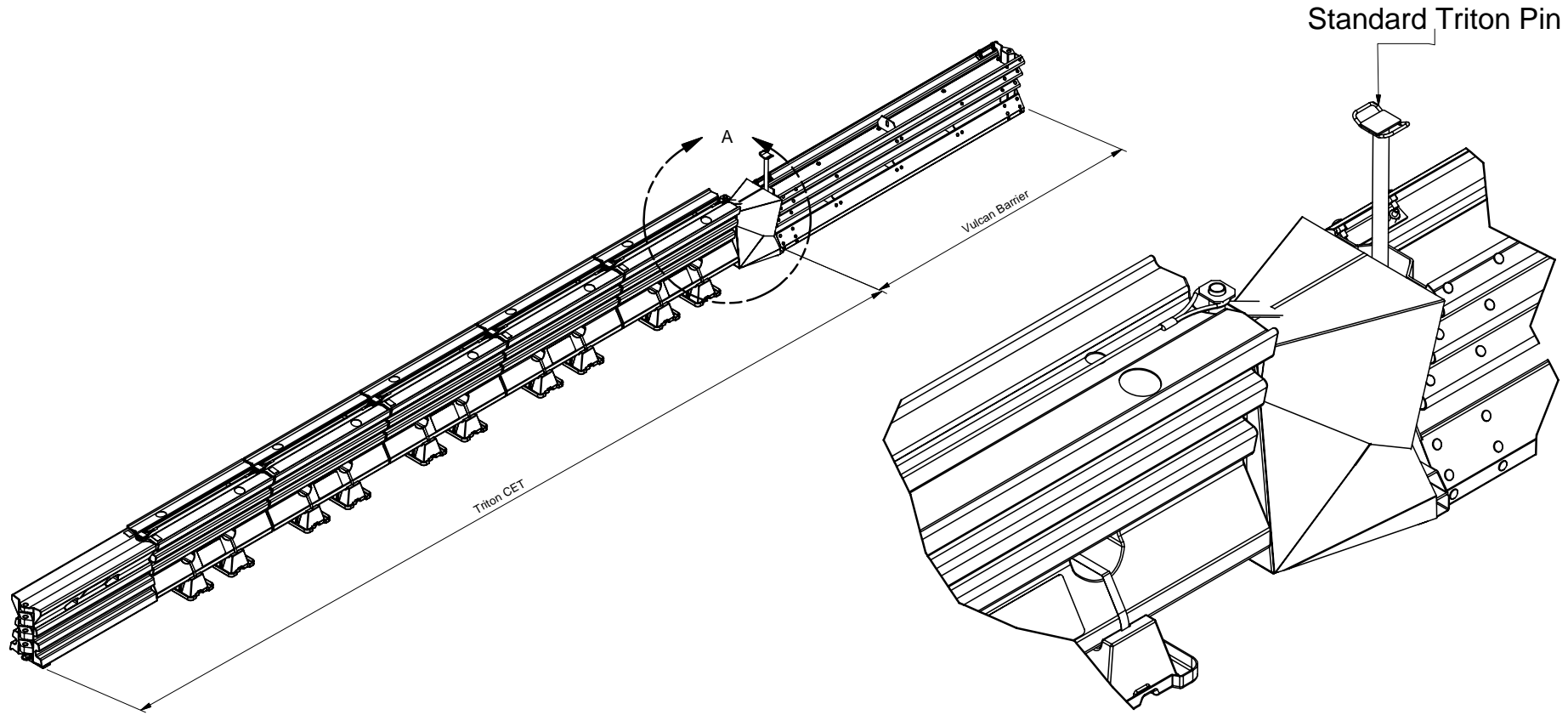
t = 0.000 sec                      t = 0.120 sec                      t = 0.240 sec                      t = 0.360 sec                      Final



**General Information**  
 Test Agency ..... E-TECH Testing Services, Inc.  
 Test Designation ..... NCHRP 350 Test 3-11  
 Test No. .... 55-8430-003  
 Date ..... 10/13/04

Test Article .....	Vulcan™ Barrier	Exit conditions	Speed (km/h) .....	30
Type .....	Segment 4115 mm x 813 mm x 546 mm (L x H x W) 395 kg mass with QuadGuard QZ2406PY end anchorage	Occupant Risk Values	Angle (deg - veh. c.g.) .....	N/A
Installation Length .....	(14) segments 57.6 m length with QuadGuard Drivable Pile end anchorage (6) upstream and (4) downstream	Impact Velocity (m/s)	x-direction .....	3.2
Material and key elements .....	AASHTOM180 galvanized steel panels, ASTM A53 Pins, and A36 other	Ridedown Acceleration (g's)	y-direction .....	-3.8
Foundation Type and Condition .....	Chip-seal asphalt over dry soil	x-direction .....	Ridedown Acceleration (g's)	4.6
Test Vehicle	Production Model	y-direction .....	European Committee for Normalization (CEN) Values	-9.1
Type .....	2000P	THV (km/h) .....	THV (km/h) .....	18.1
Designation .....	1995 Chevrolet C-2500	PHD (g's) .....	PHD (g's) .....	9.1
Model .....		ASI .....	ASI .....	0.7
Mass (kg)	1858	Test Article Deflections (m)	Dynamic .....	2.1
Curb .....	2012	Permanent .....	Permanent .....	2.1
Test inertial .....	N/A	Vehicle Damage (Primary Impact)	Exterior .....	RFQ-2
Dummy .....	2012	Interior .....	VDS .....	01RFWE1
Gross .....		VCDI .....	VCDI .....	AS0000000
Impact Conditions		Maximum Deformation (mm) .....	Maximum Deformation (mm) .....	Negligible
Speed (km/h) .....	100.4	Post-Impact Vehicular Behavior (deg - rategyro)	Maximum Roll Angle .....	-10.8
Angle (deg) .....	25	Maximum Pitch Angle .....	Maximum Pitch Angle .....	-4.6
Impact Severity (kJ) .....	139.6	Maximum Yaw Angle .....	Maximum Yaw Angle .....	-36.2

Figure 11. Summary of Results - Vulcan Barrier NCHRP 350 Test 3-11



DETAIL A  
SCALE 0.08 : 1

DRAWN: klooney	DATE: 1/6/2005
DESIGNED: klooney	DATE:
CHECKED:	DATE:
APPROVED:	DATE:
Q.C.:	DATE:



TRITON CET FOR VULCAN

FILE: Triton VET	SCALE:	DRAWING: Triton VET	SHEET: 1 of 1	REV:
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