INFORMATION HANDOUT

For Contract No. 05-0R5104
At 05-Mon,SCr-1, 9, 68, 218-Various

Identified by
Project ID 0500000363

MATERIALS INFORMATION

Temporary Alternative Crash Cushion

Water Source Information

BARRIER SYSTEMS INC

TECHNICAL
BRIEF

180 River Road • Rio Vista, CA 94571 • Tel 707-374-6800 • Fax 707-374-6801
Email: info@barriersystemsinc.com • Website: barriersystemsinc.com

Product Specification

ABSORB 350™ TL-3
Non-Redirective, Gating, Crash Cushion
Applied to Permanent and Portable Concrete Barrier

I. General

The ABSORB 350™ TL-3 System is a Non-Redirective, Gating, Crash Cushion in accordance with the definitions in the National Cooperative Highway Research Program Report 350 (NCHRP 350). The system shall be tested and perform in an acceptable manner in accordance with the guidelines of NCHRP 350 at Test Level 3 (100 km/h).

II. Performance

The ABSORB 350 is designed to absorb the impact energy of an errant vehicle in accordance with NCHRP 350 guidelines for Non-Redirective, Gating, Crash Cushions. The system is designed to be attached to Permanent Concrete Barrier and Portable Concrete Barrier with section lengths of at least 3.1 meters (10 feet). When attached in accordance with the manufacturers instructions, the ABSORB 350 system is capable of safely stopping a 2000 kg (4400 pound) pickup truck impacting the system at 100 km/h (62.3 mph) and 0 degrees and an 820 kg (1800 pound) compact vehicle impacting the system at 100 km/h (62.3 mph), 0 degrees and with an offset of the vehicle and system centerlines of one-fourth the vehicle width.

A. When properly installed according to the manufacturer's recommendations the ABSORB 350 system shall be fully tested to and meet the recommended structural adequacy, occupant risk, and vehicle trajectory criteria set forth in NCHRP 350 for Test Level 3 Non-Redirective, Gating Crash Cushions (NCHRP 350 TL-3):

1. Impact at 0 degrees at w/4 offset (centerline of vehicle offset 1/4 width of vehicle from centerline of system) at 100 km/h with an 820C vehicle. This is Test 3-40 of NCHRP 35.

2. Impact at 0 degrees into center nose of device (0 offset from centerline of vehicle) at 100 km/h with a 2000P vehicle. This is Test 3-41 of NCHRP 350.

3. Impact at 15 degrees into center nose of device (0 offset from centerline of vehicle) at 100 km/h with an 820C vehicle unless the Federal Highway Administration, due to acceptable performance in test 3-40, waives this test. This is Test 3-42 of NCHRP 350.

4. Impact at 15 degrees into center nose of device (0 offset from centerline of vehicle) at 100 km/h with a 2000P vehicle. This is Test 3-43 of NCHRP 350.

5. Impact at 20 degrees along the side of the unit (with the centerline of the vehicle aligned with the centerline of the attachment of the barrier and the ABSORB 350™) at 100 km/h with a 2000P vehicle. This is Test 3-44 of NCHRP 350 as modified by the Federal Highway Administration.

B. The impact velocity of a hypothetical front seat passenger against the vehicle interior as calculated from the longitudinal vehicle acceleration and 600 mm [23 5/8 in] forward displacement, and the lateral vehicle acceleration and 300 mm [1 ft] lateral displacement shall be less than 12 m/s (39.3 ft/s] and the highest 10 ms average vehicle acceleration in the longitudinal and lateral directions subsequent to the instant of hypothetical occupant impact shall be less than 20 g's in NCHRP 350 tests 3-40, 41, 42 and 43.

For TL-3 impacts detached debris shall not show potential for penetrating the vehicle occupant compartment or presenting a hazard to other traffic, pedestrians, or workers in a work zone. The vehicle shall remain upright during and after the collision although moderate roll, pitch and yaw may occur.

III. Description of System

A. The ABSORB 350 system shall be made up of the following components and the system shall be fabricated from materials conforming to the following specifications:

1. ABSORB 350 Energy Absorbing Element – Each element of the system shall be composed of a plastic container, steel side bars, end plate/ hinge assemblies, an evaporation prevention cap with tether and appropriate fasteners. The overall dimensions of the assembled element are 610 mm (24 inches) wide, 812 mm (32 inches) tall and 1000 mm (39 1/2 inches) long, as shown in the attached drawing (B000524). Each element of the system shall weigh approximately 50 kg (110 pounds) when empty and 325 kg (717 pounds) when filled. The first element of the assembled system should always be empty of fluid with the evaporation prevention cap installed. All other elements of the system should be filled with fluid in accordance with the installation instructions and the evaporation prevention cap shall be securely installed. All elements shall be attached in accordance with the installation instructions and drawings supplied by the manufacturer.

a. The plastic elements shall be molded from Linear Low Density Polyethylene.

b. All steel sidebars, end plate/hinge assemblies shall be fabricated from mild steel in conformance with ASTM A-36 specifications.

c. The evaporation prevention cap shall be molded from low density polyethylene

2. ABSORB 350 Nose Piece – Each ABSORB 350 system shall contain one Nose Piece at the front of the system. The Nose Piece is approximately 620 mm (24 3/8inches) wide, 825mm (32 1/2inches) tall and 610mm (24 inches) long, as shown in the attached drawing (B000526). The Nose Piece shall weigh approximately 60 kg (132 pounds) and shall be attached to the first Energy Absorbing Element in accordance with the installation instructions and drawings supplied by the manufacturer.

    a. The Nose Piece shall be fabricated from mild steel in conformance with ASTM A-36.

    b. The Nose Piece shall also have an aluminum skin on the front portion to provide an aesthetic cover and a place for attaching traffic control signage, if needed. This skin shall be fabricated from 5052 H32 in conformance with ASTM B209 and shall be attached to the steel portion of the Nose Piece with adhesives and pop rivets.

3. ABSORB 350 Transition Hardware for PCB – The transition configuration is as shown in the attached drawing B000608.

    a. PCB Transition Hardware is fabricated from mild steel in conformance with ASTM A-36 as shown in the attached drawing (B000531). The steel components shall weigh approximately 80 kg (176 pounds).

B. Attachment of the ABSORB 350™ system to PCB systems shall require nine (9) Energy Absorbing Elements. Assembly should be in compliance with the manufactures drawings and written instructions.

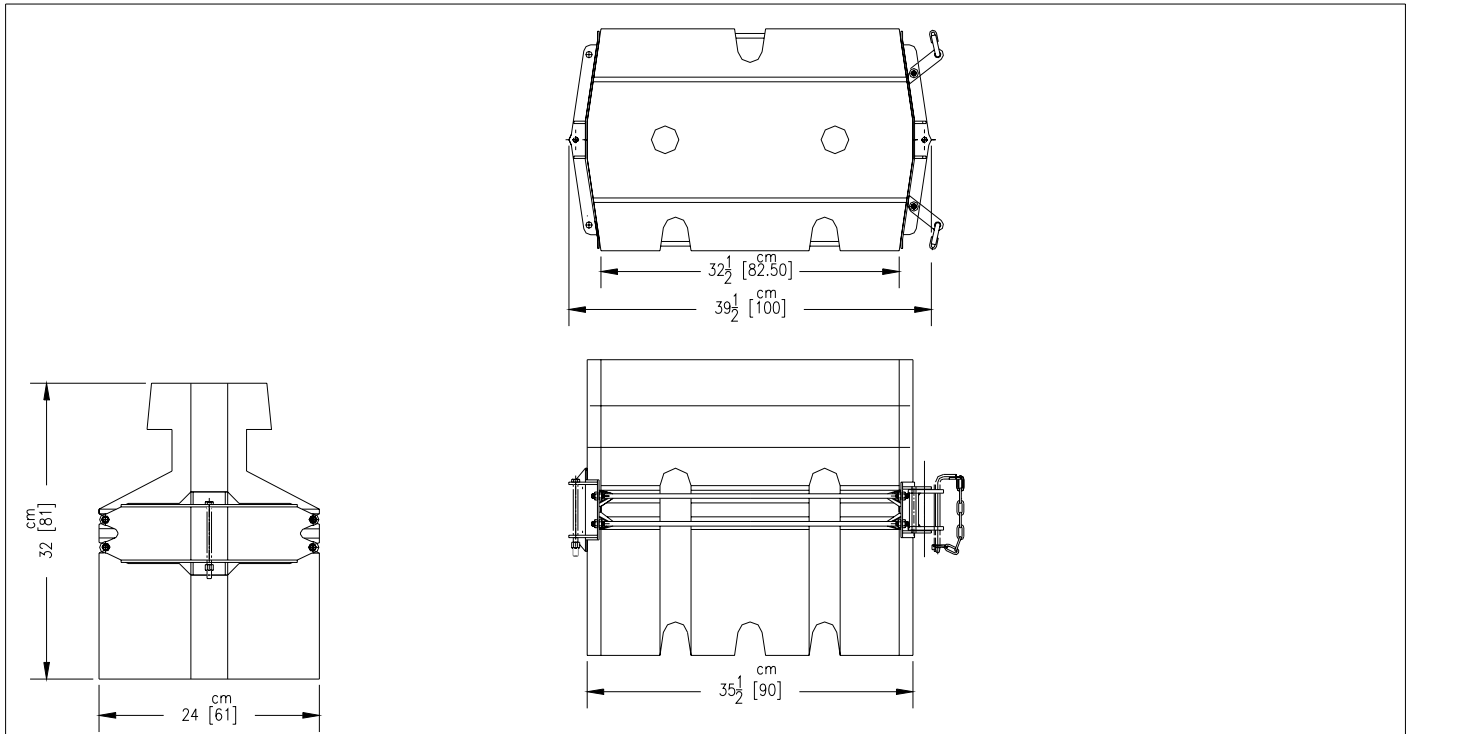
C. The ABSORB 350™ system shall be able to be refurbished after a NCHRP 350 type impact in less than 1 hour with two people, an adequate fluid supply and refurbishment materials.

D. The ABSORB 350™ system shall not require attachment to a foundation. Attachment to the PCB system will require attachment in accordance with the manufacturer's drawings and instructions.

E. The ABSORB 350™ system shall be assembled and filled with fluid in accordance with the manufacturers instructions. If there is a possibility that the fluid in the system could freeze due to low temperatures, proper antifreeze agents should be used in accordance with local standards and environmental regulations.

IV. Application of Safety Appurtenances

Highway safety appurtenances should be applied to hazardous sites in accordance with the guidelines and recommendations in the American Association of State Highway Transportation Officials (AASHTO), "Roadside Design Guide," 1989, and other Federal Highway Administration and State Department of Transportation requirements. Placement and use of the ABSORB 350 system should comply with these specifications and guidelines.



NOTE:
THICKNESS OF WELD TO BE EQUAL TO THE THINNER OF 2 PIECES BEING JOINED. WELD TO BE ALL AROUND UNLESS OTHERWISE NOTED.

REV.	CHANGES	DATE	BY	REQ'D	NEXT ASSY.	ITEM

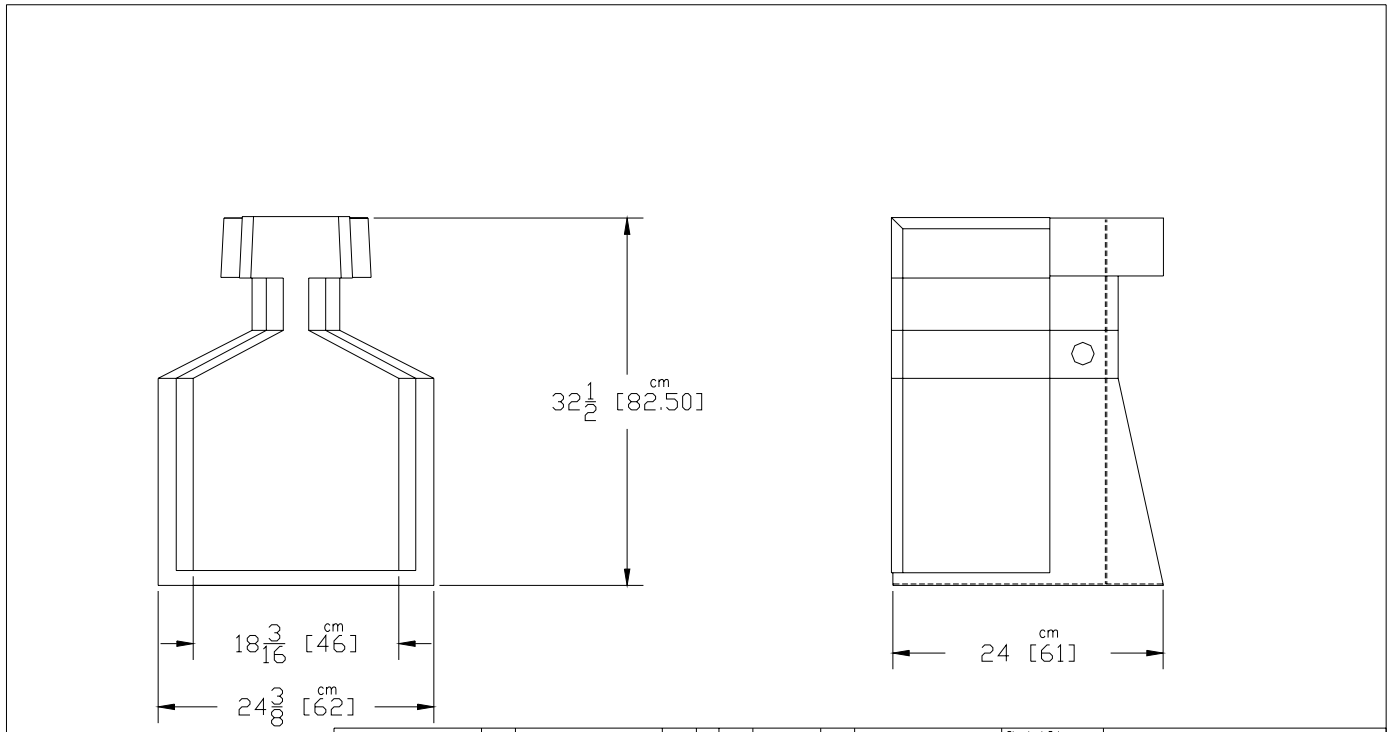
SCALE: 1=10

	DATE	INIT.
DRAWN BY	3/2/00	R.R.C.
APPR'D BY		

Standard Tolerance
Angular ± 1/2°
Fractional ± 1/16
Decimal ± .010

TITLE : ABSORB 350 ELEMENT

MODEL	DRAWING NUMBER	REV.
	B000524	



NOTE:
THICKNESS OF WELD TO BE EQUAL TO THE THINNER OF 2 PIECES BEING JOINED. WELD TO BE ALL AROUND UNLESS OTHERWISE NOTED.

REV.	CHANGES	DATE	BY	REQ'D	NEXT ASSY.	ITEM
						1

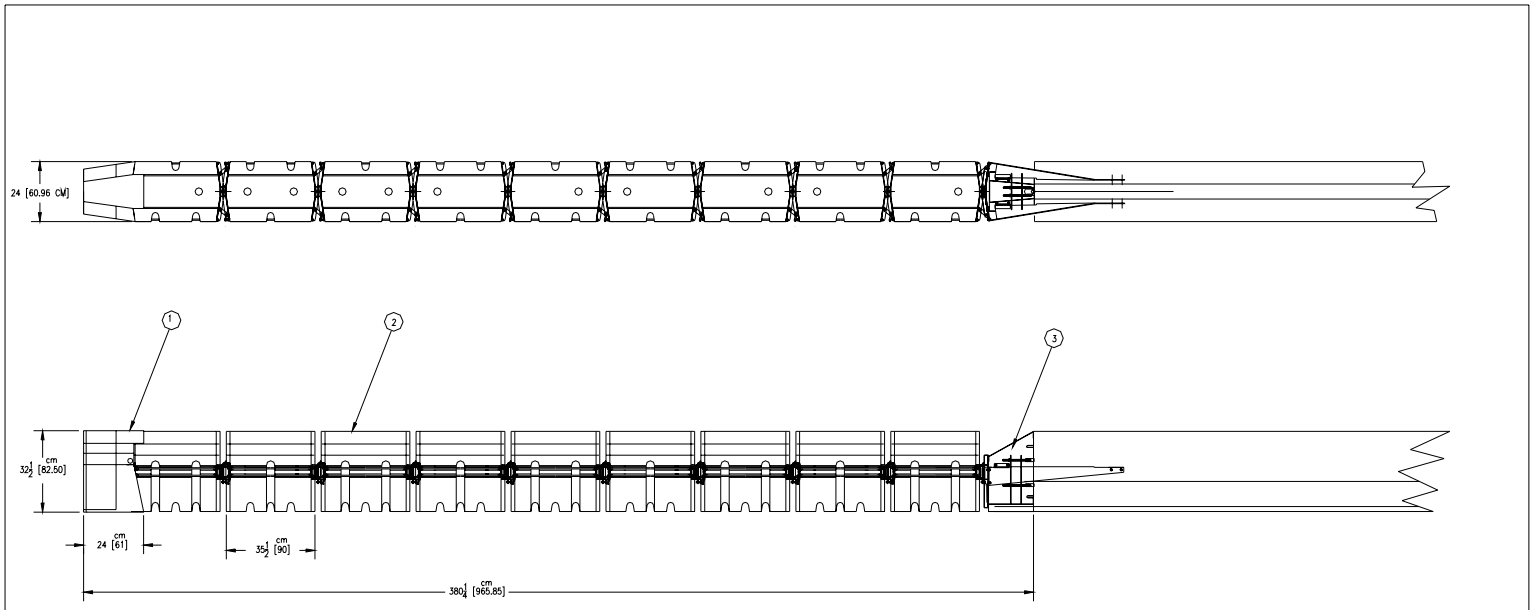
SCALE: EIGHTH

	DATE	INIT.
DRAWN BY	05/24/00	RSS
APPR'D BY		

Standard Tolerance
Angular ± 1/2°
Fractional ± 1/16
Decimal ± .010

TITLE : ABSORB 350
NOSE PIECE

MODEL	DRAWING NUMBER	REV.
	B000526	



SEE B000608.BOM FOR MATERIAL LIST

NOTE:
THICKNESS OF WELD TO BE EQUAL TO THE THINNER OF 2 PIECES BEING JOINED. WELD TO BE ALL AROUND UNLESS OTHERWISE NOTED.

REV.	CHANGES	DATE	BY	REQ'D	NEXT ASSY.	ITEM

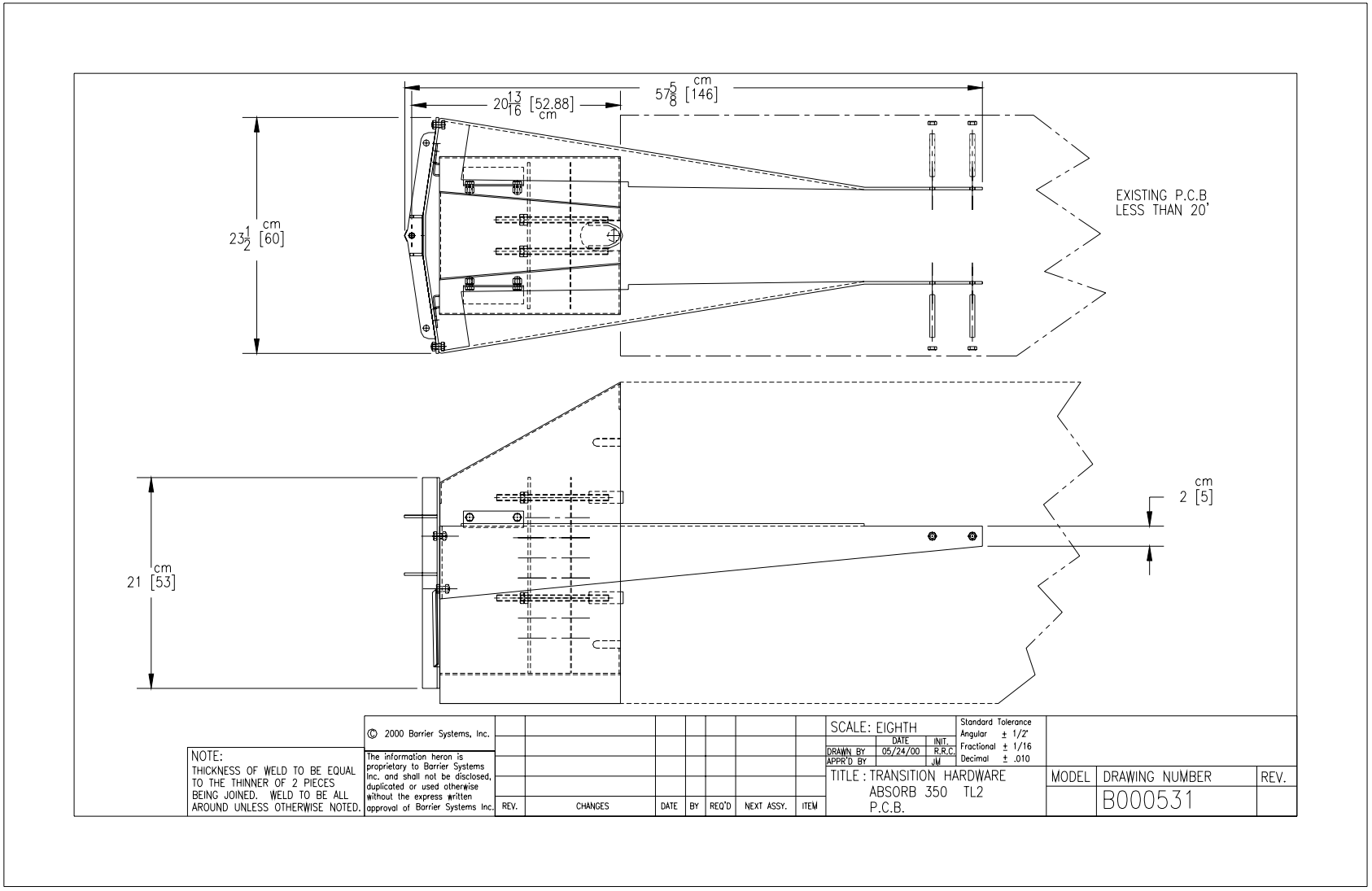
SCALE: 1=40

	DATE	INIT.
DRAWN BY	5/24/00	DGB
APPR'D BY		

Standard Tolerance
Angular ± 1/2°
Fractional ± 1/16
Decimal ± .010

TITLE : ASSEMBLY SYSTEM, ABSORB TL3 P.C.B.

MODEL	DRAWING NUMBER	REV.
	B000608	


20 13/16 [52.88] cm
57 5/8 [146] cm
23 1/2 [60] cm
EXISTING P.C.B
LESS THAN 20'
21 [53] cm
2 [5] cm
NOTE:
THICKNESS OF WELD TO BE EQUAL TO THE THINNER OF 2 PIECES BEING JOINED. WELD TO BE ALL AROUND UNLESS OTHERWISE NOTED.
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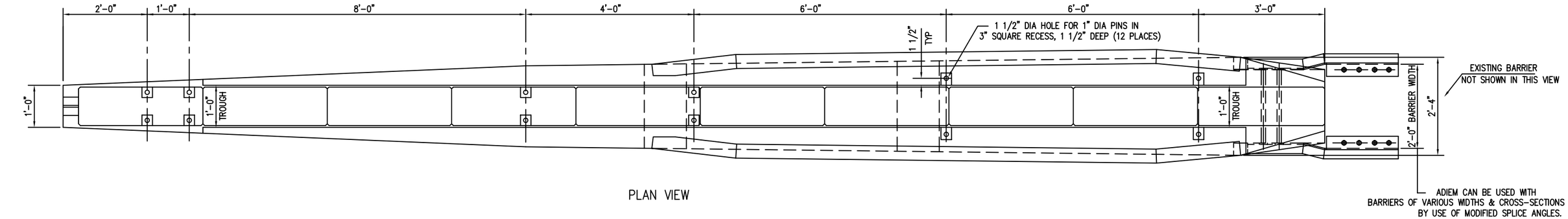
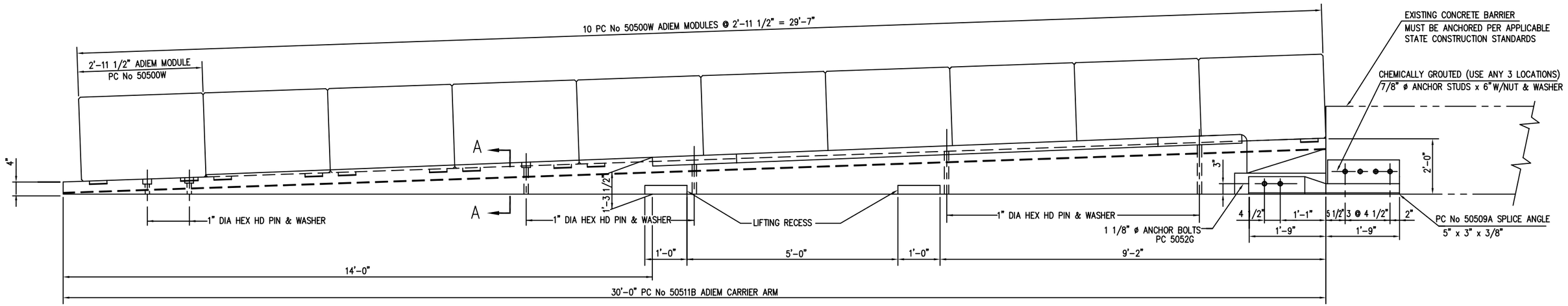
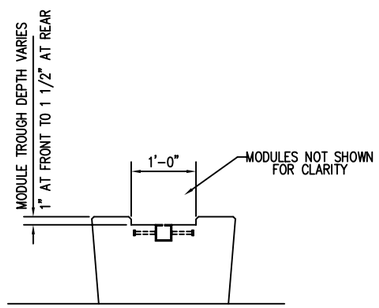
REV. CHANGES DATE BY REQ'D NEXT ASSY. ITEM
SCALE: EIGHTH
DRAWN BY 05/24/00 R.R.C.
APPR'D BY JM
Standard Tolerance
Angular ± 1/2'
Fractional ± 1/16
Decimal ± .010
TITLE : TRANSITION HARDWARE
ABSORB 350 TL2
P.C.B.
MODEL DRAWING NUMBER REV.
B000531



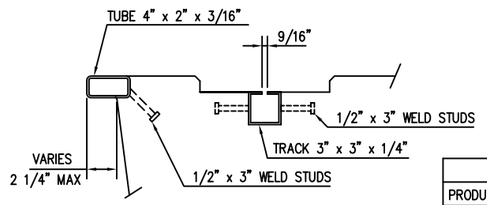
PLAN VIEW



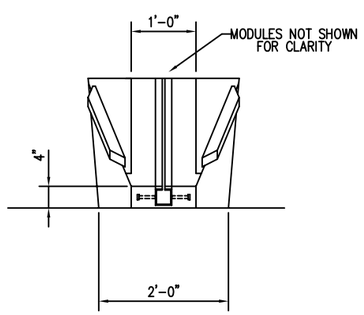
ELEVATION VIEW



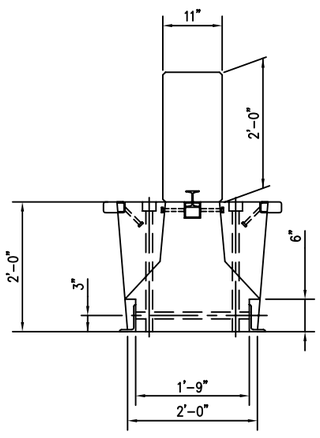
SECTION A-A



TRACK & BUMPER DETAIL



FRONT ELEVATION VIEW



REAR ELEVATION VIEW

BILL OF MATERIAL

PRODUCT CODE	QTY	DESCRIPTION	REMARKS
50500W	10	MODULES x 2'-11 1/2"	
50511B	1	BASE x 30'-0"	
50508A	1	SPLICE ANGLE x 3'-6" RT	
50509A	1	SPLICE ANGLE x 3'-6" LT	
6549W	1	GARNA-THANE COATING (1 GAL)	
5052G	2	1 1/8" ø x 25" HEX HD BOLT	
4963G	4	1 1/8" WASHER	
3976G	2	1 1/8" HEX NUT	
4616G	6	7/8"ø STUD x 6" (FULL THD)	
3725G	6	7/8" WASHER	
3735G	6	7/8" HEX NUT	
☆ 5206B	1	ADHESIVE HY150 CARTRIDGE	
3900G	12	1" WASHER	

PRODUCT CODE	QTY	DESCRIPTION	REMARKS	ANCHOR PIN SCHEDULE PER SURFACE (SEE NOTES 1-5) PCC	ACP	BASE
5665G	SEE SCH	1" ø HEX HD PIN x 48"	SEE NOTES 1-5			4
5642G		1" ø HEX HD PIN x 42"			4	
5650G		1" ø HEX HD PIN x 36"		4		4
5641G		1" ø HEX HD PIN x 30"			4	4
5646G		1" ø HEX HD PIN x 24"		4	4	
5643G		1" ø HEX HD PIN x 18"		4		

☆ EACH CARTRIDGE INCLUDES 1 EACH : MIXER HY 150 CARTDIDGE(NOZZLE)
: FILLER HIT HY 150 (FILLER TUBE)

NOTES:
1) ANCHOR PINS ARE 1" DIA HEX HD, POINTED, GALV RODS (A307)
2) PORTLAND CEMENT CONCRETE (PCC)
3) ASPHALTIC CONCRETE (ACP)
4) BASE AND/OR COMPACTED SOIL (BASE)
5) ADIEM INSTALLATION NOT RECOMMENDED ON LOOSE SOIL.

ADIEM INSTALLATION INSTRUCTIONS

1. The ADIEM base is to be placed on a smooth surface (the same horizontal plane as the concrete barrier) and parallel to the mainline or ramp traveled lane(s).
2. Install anchor rods for ADIEM base by driving in soil or soft asphalt or driving in pre-drilled holes for hard asphalt or concrete (no epoxy required). The base should not be moved after the holes are drilled. The holes should be drilled using, at a mininum, a 35# hammer and minimum 36 inch long drill bit. (A 50# hammer is recommended.)
3. Attach connection brackets to base with two (2) 1 1/8" X 25" hex head bolts provided. Then field drill holes in the existing barrier and attach connection brackets to it with chemically grouted hardware provided.
4. Oil the ADIEM base track. Slide the modules onto the base. Be careful not to damage edges of the modules while sliding onto the base.
5. If the modules are scuffed or nicked, apply GARNA-THANE coating to the affected area.
6. Recommended tools and equipment:
   - 35/50# air hammer/drill
   - 1 3/8" ø x 36" rock drill
   - 1 1/4" ø x 12" rock drill
   - Sledge hammer
   - Oil
   - Wrenches

OPTIONAL ANCHOR ITEMS	
PRODUCT CODE	DESCRIPTION
5205B	ADHESIVE DISPENSER
5207B	MIXER HIT HY150 (NOZZLE)
5208B	FILLER HIT HY150 (FILLER TUBE)
5209B	BIT TE-C+ 11/16-18 (11/16" ø BIT)

ALTERNATE ADIEM INSTALLATION INSTRUCTIONS

1. At a holding site, the modules are slid into the ADIEM base after oiling the base track. Be careful not to damage the edges of the modules while sliding them onto the base.
2. If the modules are scuffed or nicked, apply GARNA-THANE coating to the affected area.
3. The unit is then delivered to the job site. The unit is to be placed on a smooth surface (the same horizontal slope as the concrete barrier) and parallel to the mailine or ramp traveled lane (s).
4. The front module should be removed so the remaining modules can be shifted for easy access for drilling the anchor rod holes.
5. Install anchor rods for ADIEM base by driving in soil or soft asphalt or driving in predrilled holes for hard asphalt or concrete (no epoxy required). The base should not be moved after the holes are drilled. The holes should be drilled using, at a minimum, a 35# hammer and a minimum 36 inch long drilling bit. (A 50# hammer is recommended.)
6. Attach connection brackets to base with two (2) 1 1/8" X 25" hex head bolts provided. Then field drill holes in the existing barrier and attach connection brackets to it with chemically grouted hardware provided.

REV.	CHK'D	BY	DATE	REMARKS
6	B.T.	L.H.	12/10/03	REPLACED GROUT WITH HILTI, UPDATED DWG
5		L.H.	03/12/03	DELETED NOTE #7, REVISED NOTE #3
4	D.D.	L.H.	12/17/99	REVISED COATING, CHANGED TITLE BLOCK
3		BT	3-14-97	DELETED PC 5484, ADDED PC 5052, CHG QTY PC 3976
2		BT	2-14-97	GENERAL UPDATES

ADIEM 30'

ERECTION DETAILS

TRINITY INDUSTRIES, INC.
HIGHWAY SAFETY PRODUCTS
2525 STEMMONS FREEWAY, DALLAS, TX 75207

DRAWN	B.TAKACH
CHECKED	D.D.
APPROVED	
DATE	3/19/96
ENG. FILE #	SS349-01E
SHT.No.	E1 OF 1
DRAWING NO.	SS 349
REV.	6

U.S. Department of Transportation
Federal Highway Administration

1200 New Jersey Avenue, SE.
Washington, DC 20590

March 20, 2009

In Reply Refer To: HSSD/CC-35I

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

Dear Mr. Stephens:

This letter is in response to your request for the Federal Highway Administration (FHWA) acceptance of a roadside safety device for use on the National Highway System (NHS).

Name of device:	5-bay QuadGuard II
	5-bay QuadGuard II Wide
	2-bay QuadGuard II
Type of device:	Impact Attenuators
Test Level:	NCHRP Report 350 Test Levels 2 and 3
Testing conducted by:	E-Tech Testing Services, Inc.
Date of request:	December 8, 2008

You requested that we find this device acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 “Recommended Procedures for the Safety Performance Evaluation of Highway Features.”

Requirements
Roadside safety devices should meet the guidelines contained in the NCHRP Report 350." The FHWA Memorandum “Identifying Acceptable Highway Safety Features” of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description
The QuadGuard® II is a redirective, non-gating crash cushion with a reduced length of 5 bays that is otherwise identical to the previously accepted Test Level 3 (TL-3) 6-bay unit (see FHWA Acceptance Letter CC-35, dated June 21, 1996). The difference is that one bay is removed from the rear of the system and a new sheet metal front nose is used. Likewise, the QuadGuard® II with a reduced length of 2 bays is identical to the previously accepted TL-2 3-bay unit (ref. CC-35C, dated June 17, 1999) with the exception of one of the rear bays being removed plus a new sheet metal front nose.

Features of the 5-bay QuadGuard® II systems (narrow and wide) as well as the 2-bay QuadGuard® II narrow system are depicted in the enclosed drawings for reference. The QuadGuard® II 5-bay narrow system has an overall length of 5830 mm (19' 1") and can be configured with backup widths of 610 mm (24 inches), 762 mm (30 inches), 914 mm (36 inches), 1753 mm (69 inches), and 2286 mm (90 inches). The 2-bay QuadGuard® II system has an overall length of 3080 mm (10' 1") and can be configured with a backup width of 610 mm (24 inches). The system consists of energy absorbing cartridges surrounded by a framework of steel Quad-Beam® guardrail that can telescope rearward during head-on impacts. The system has a center monorail that will resist lateral movement during side angle impacts and a back up structure that will resist movement during head-on impacts. Simply removing a rear Bay from an existing 6-Bay or 3-Bay system will not be adequate to meet TL-3 and TL-2 impact speeds, respectively. As noted in your report, the QuadGuard II system requires an upgraded nose assembly.

Crash Testing

The original 6-bay test data of NCHRP 350 Test 3-31 and 3-32 demonstrated that the 2000P vehicle impacting at 0 degree and a nominal speed of 100km/h (63 mph) resulted in a ridedown g's of -14.52 and Occupant Impact Velocity (ΔV) of 10.55 m/s. An engineering review of this previous data indicated excess capacity in the device and prompted a crash test to be done after removing bay 6. The NCHRP 350 Tests 3-31 and 3-32 were conducted and the results are as follows:

Narrow System 610mm (24 inches) width:
Test 3-31: Impact speed: 101.1 km/h, ridedown of -17.3 g's, and ΔV 9.6 m/s.
Test 3-32: Impact speed: 98.3 km/h, ridedown of -17.4 g's, and ΔV 12.4 m/s.

Wide System 2286mm (90 inches) width:
Test 3-31: Impact speed: 99.7 km/h, ridedown of -17.0 g's, and ΔV 10.0 m/s.
Test 3-32: Impact speed: 97.7 km/h, ridedown of -17.4 g's, and ΔV 11.7 m/s.

Similarly the 3-bay narrow system test data demonstrated that the 2000P vehicle impacting at 0 degree and a nominal speed of 70km/h (43.5 mph) resulted in a ridedown g's of -19.57 and Occupant Impact Velocity (ΔV) of 8.89. Again an engineering review indicated excess capacity in the device and prompted the following crash tests with results as follows:

Test 2-31: Impact speed: 68.3 km/h, ridedown of -19.4 g's, and ΔV 10.7 m/s.
Test 2-32: Impact speed: 67.7 km/h, ridedown of -17.8 g's, and ΔV 10.8 m/s.

Due to the elimination of one bay at the rear of each system we concur that the tests performed provide adequate capacity of head-on impacts for all widths of TL-3 5-bay QuadGuard® II systems. In addition we also concur that the tests performed on the TL-2 2-bay QuadGuard® II system provide adequate capacity for head-on impacts for the 610mm (24 inches) width system. We agree that the front of the system was adequately tested for the 820C vehicle crash

characteristics. Based upon the multiple redirective test impacts into the QuadGuard® and the basic structure of the reduced 5-bay and 2-bay QuadGuard® II being unchanged, redirective tests are not required.

Findings

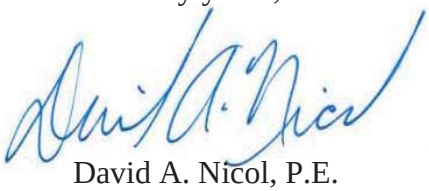
The QuadGuard® II 5-bay and 2-bay systems meet the evaluation criteria for NCHRP Report 350 redirective, non-gating crash cushion at TL-3 and TL-2 impact conditions respectively and are acceptable for use on the NHS when such use is acceptable to the contracting authority. It's further acknowledged that the QuadGuard® II can be installed with existing QuadGuard® Transition hardware (Reference CC-35B, dated October 17, 1996.)

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

- This acceptance is limited to the crashworthiness characteristics of the devices and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any 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, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our 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 FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number CC-35I and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- The QuadGuard and QuadGuard II families of crash cushions are patented products and considered proprietary. If proprietary devices are specified by a highway agency for use on Federal-aid projects, except exempt, non-NHS projects, (a) they 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.
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented device for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate device, and

the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,



David A. Nicol, P.E.
Director, Office of Safety Design
Office of Safety

Enclosures

Table1: Table of TL- 3 Tests (5-Bay System).

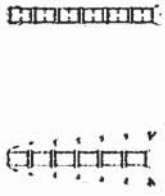
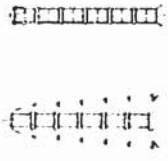
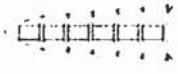
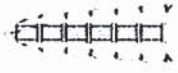
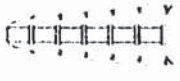
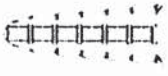
Illustration	Test #	Completed	Notes
	3-31	YES	Passed all ORV's. 5-Bay 24" Wide System was tested and passed all Occupant Risk Values. 5-Bay 90" Wide system was tested and passed all Occupant Risk Values.
	3-32	YES	Passed all ORV's. 5-Bay 24" Wide System was tested. 5-Bay 90" Wide System was tested.
	3-30	NO	Test 3-32 was completed as "Worst Case" for 820c.
	3-33	NO	Test 3-31 tested system capacity for 2000P and is considered worst case.
	3-36	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware therefore performance would remain unchanged.
	3-37	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware – performance remains unchanged.

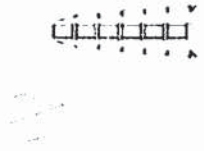
Illustration	Test #	Completed	Notes
	3-38	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware -- performance remains unchanged.
	3-39	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware / performance remains unchanged.

Table2: Table of TL-2 Tests (2-Bay System)

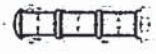
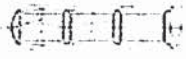
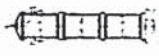
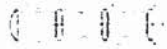
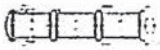
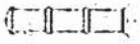
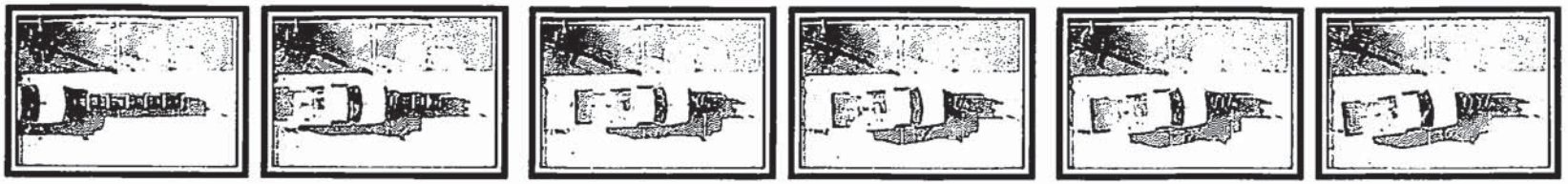
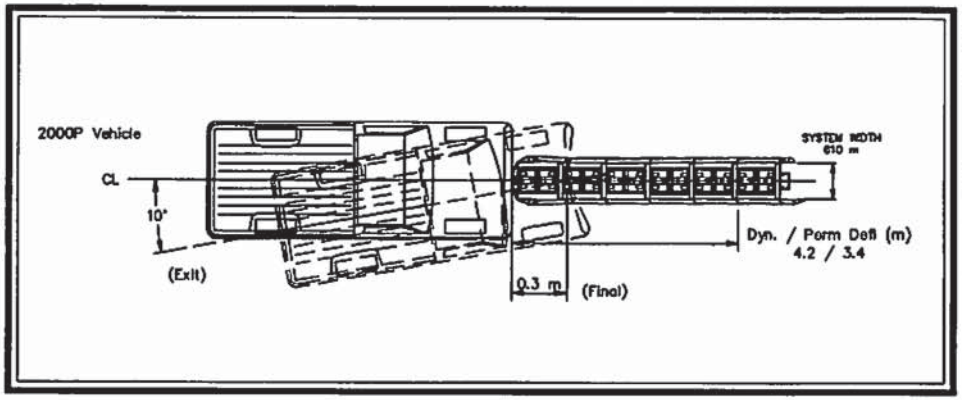
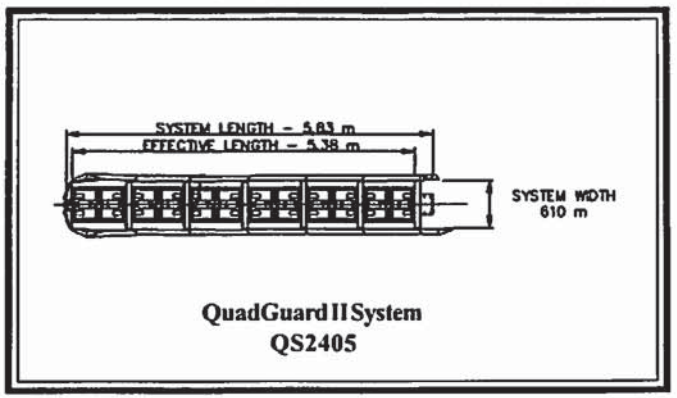
Illustration	Test#	Completed	Notes
	2-30	NO	Test 2-32 was completed as is considered "worst case" scenario for 820c.
	2-31	YES	Passed all ORV's on 2-Bay System.
	2-32	YES	Passed all ORV's on 2-Bay System.
	2-33	NO	Test 2-31 tested system capacity for 2000P and is considered worst case.

Illustration	Test#	Completed	Notes
	2-36	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware – performance remains unchanged.
	2-37	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware – performance remains unchanged.
	2-38	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware – performance remains unchanged.
	2-39	NO	Qualified under the Original QuadGuard Test Matrix. No changes in Structural Hardware – performance remains unchanged.







General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-31
Test No.	01-4309-001
Date	1/5/06

Test Article

Type	Energy Absorption System
	QuadGuard II System QS2405
Installation Length, (mm)	5 bay 5830 mm long 610 mm wide
Material and key elements	5 bay system, 6 energy absorbing cartridges (3) Type II and (3) Type I.
	P.C. Concrete, clean
Foundation Type and Condition	Unreinforced 27.6 Mpa concrete, clean and dry, with (46) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	2000P
Model	1988 Chevrolet Pickup
Mass (kg)	
Curb	1861
Test inertial	1984
Dummy	N/A
Gross Static	1984

Impact Conditions

Speed (km/h)	101.1
Angle (deg)	0
Impact Severity (kJ)	781.6

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	9.6
y-direction	0.5
Ridedown Acceleration (g's)	
x-direction	-17.3
y-direction	3.5

European Committee for Normalization (CEN) Values

THIV (km/h)	34.7
PHD (g's)	17.4
ASI	1.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	3.2
Maximum Pitch Angle	-8.6
Maximum Yaw Angle	-10.2

Test Article Deflections (m)

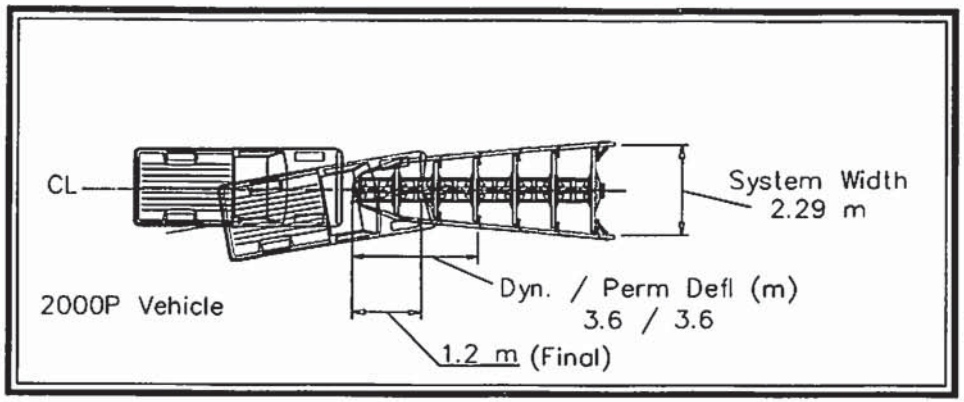
Dynamic	4.2
Permanent	3.4

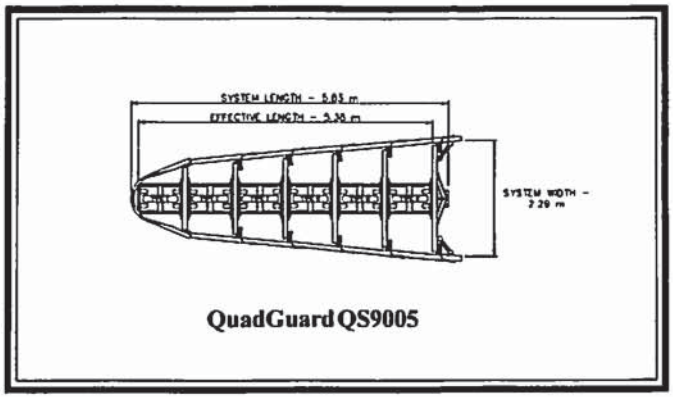
Vehicle Damage (Primary Impact)

Exterior	
VDS	FC-3
CDC	12FCEW3
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 1. Summary of Results - QuadGuard II System Test 01-4309-001

t = 0.000 sec | t = 0.138 sec | t = 0.276 sec | t = 0.414 sec | t = 0.552 sec | t = 0.965 sec





QuadGuard QS9005

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-31
Test No.	01-4309-006
Date	11/04/08

Test Article

Type	Energy Absorption System
	QuadGuard II System QS2405
Installation Length, (mm)	5 bay 5.83 m long 2.29 m wide
Material and key elements	5 bay system, 6 energy absorbing cartridges (3) Type II and (3) Type I.
Foundation Type and Condition	Unreinforced 27.6 Mpa concrete, clean and dry, with (46) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	2000P
Model	1991 GMC C2500
Mass (kg)	
Curb	1840
Test inertial	2000
Dummy	N/A
Gross Static	2000

Impact Conditions

Speed (km/h)	99.7
Angle (deg)	0
Impact Severity (kJ)	766.5

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	10.0
y-direction	0.0
Ridedown Acceleration (g's)	
x-direction	-17.0
y-direction	-3.3

European Committee for Normalization (CEN) Values

THIV (km/h)	36.1
PHD (g's)	17.1
ASI	1.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	-2.6
Maximum Pitch Angle	30.6
Maximum Yaw Angle	-2.3

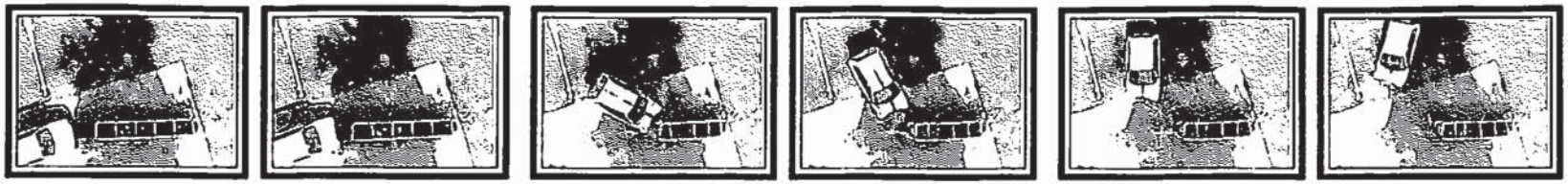
Test Article Deflections (m)

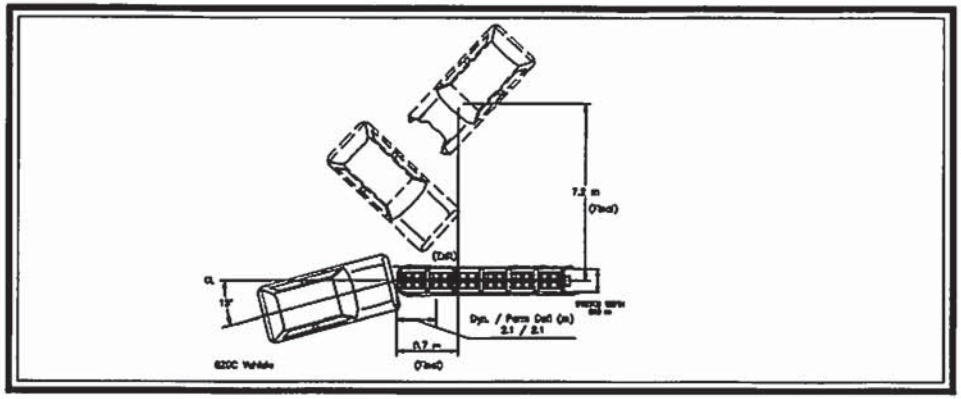
Dynamic	3.6
Permanent	3.6

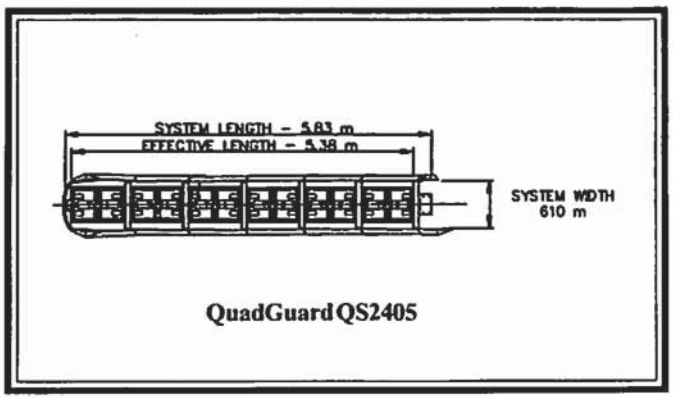
Vehicle Damage (Primary Impact)

Exterior	
VDS	FC-4
CDC	12FCEW4
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 6. Summary of Results - QuadGuard II System Test 01-4309-006







General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-32
Test No.	01-4309-002
Date	6/04/08

Test Article

Type	Energy Absorption System
	QuadGuard System QS2405
Installation Length, (mm)	5 bay 5830 mm long 610 mm wide
Material and key elements	5 bay system, 6 energy absorbing cartridges (3) Type II and (3) Type I.
	P.C. Concrete, clean
Foundation Type and Condition	Unreinforced 27.6 Mpa concrete, clean and dry, with (46) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	820C
Model	1988 Ford Festiva
Mass (kg)	
Curb	818
Test inertial	845
Dummy	75
Gross Static	920

Impact Conditions

Speed (km/h)	98.3
Angle (deg)	15
Impact Severity (kJ)	316.6

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	12.4
y-direction	0.1
Ridedown Acceleration (g's)	
x-direction	-17.4
y-direction	-5.1

European Committee for Normalization (CEN) Values

THIV (km/h)	45.4
PHD (g's)	17.4
ASI	1.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	25.7
Maximum Pitch Angle	-12.1
Maximum Yaw Angle	191.8

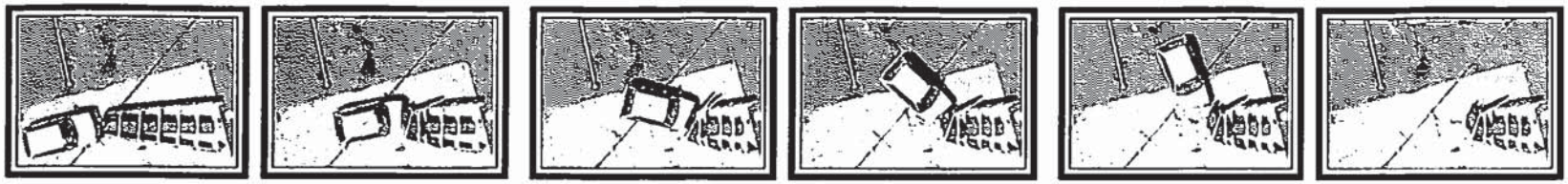
Test Article Deflections (m)

Dynamic	2.1
Permanent	2.1

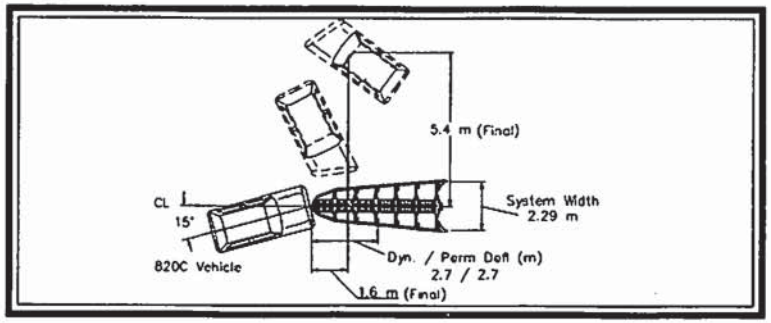
Vehicle Damage (Primary Impact)

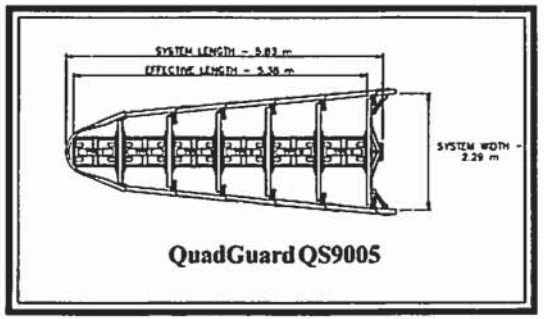
Exterior	
VDS	FC-3
CDC	12FCEW3
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 11. Summary of Results - QuadGuard II System Test 01-4309-002



t = 0.000 sec | t = 0.118 sec | t = 0.236 sec | t = 0.354 sec | t = 0.472 sec | t = 1.295 sec





General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-32
Test No.	01-4309-005
Date	8/13/08

Test Article

Type	Energy Absorption System
	QuadGuard II System QS9005
Installation Length, (mm)	5 bay 5.83 m long 2.29 m wide
Material and key elements	5 bay system, 6 energy absorbing cartridges (3) Type II and (3) Type I.
Foundation Type and Condition	Unreinforced 27.6 Mpa concrete, clean and dry, with (46) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	820C
Model	1990 Ford Festiva
Mass (kg)	
Curb	852
Test inertial	827
Dummy	75
Gross Static	902

Impact Conditions

Speed (km/h)	97.7
Angle (deg)	15
Impact Severity (kJ)	304.3

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	11.7
y-direction	-0.1
Ridedown Acceleration (g's)	
x-direction	-17.4
y-direction	-3.1

European Committee for Normalization (CEN) Values

THIV (km/h)	42.6
PHD (g's)	17.7
ASI	1.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	30.9
Maximum Pitch Angle	13.7
Maximum Yaw Angle	221.1

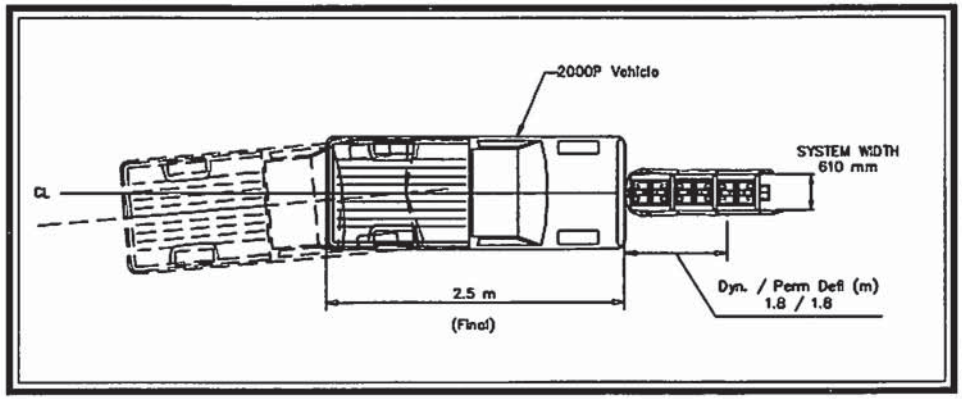
Test Article Deflections (m)

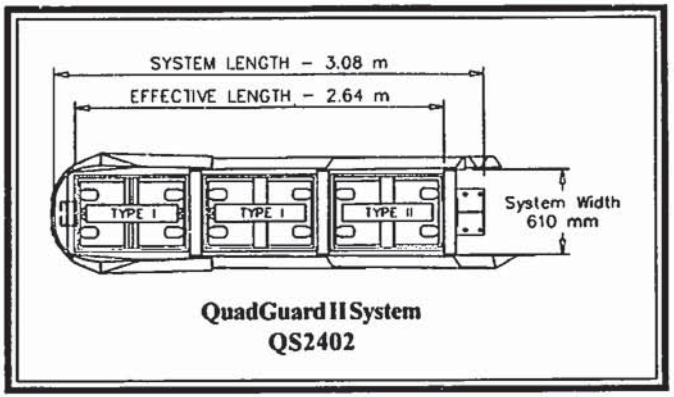
Dynamic	2.7
Permanent	2.7

Vehicle Damage (Primary Impact)

Exterior	
VDS	FC-3
CDC	01FCEW3
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 16. Summary of Results - QuadGuard II System Test 01-4309-005





General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-31
Test No.	01-4309-003
Date	7/16/08

Test Article

Type	Energy Absorption System
	QuadGuard II System QS2402
Installation Length, (mm)	2 bay 3080 mm long 610 mm wide
Material and key elements	2 bay system, 3 energy absorbing cartridges (1) Type II and (2) Type I.
Foundation Type and Condition	Unreinforced 27.6 Mpa concrete, clean and dry, with (26) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	2000P
Model	1989 Chevrolet Pickup
Mass (kg)	
Curb	1961
Test inertial	2005
Dummy	N/A
Gross Static	2005

Impact Conditions

Speed (km/h)	68.3
Angle (deg)	0
Impact Severity (kJ)	361.0

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	10.7
y-direction	-0.7
Ridedown Acceleration (g's)	
x-direction	-19.4
y-direction	5.9

European Committee for Normalization (CEN) Values

THIV (km/h)	38.7
PHD (g's)	19.9
ASI	1.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	1.5
Maximum Pitch Angle	5.4
Maximum Yaw Angle	-4.7

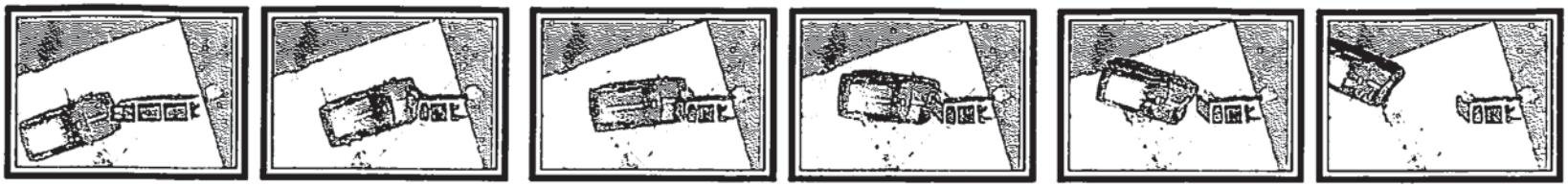
Test Article Deflections (m)

Dynamic	1.8
Permanent	1.8

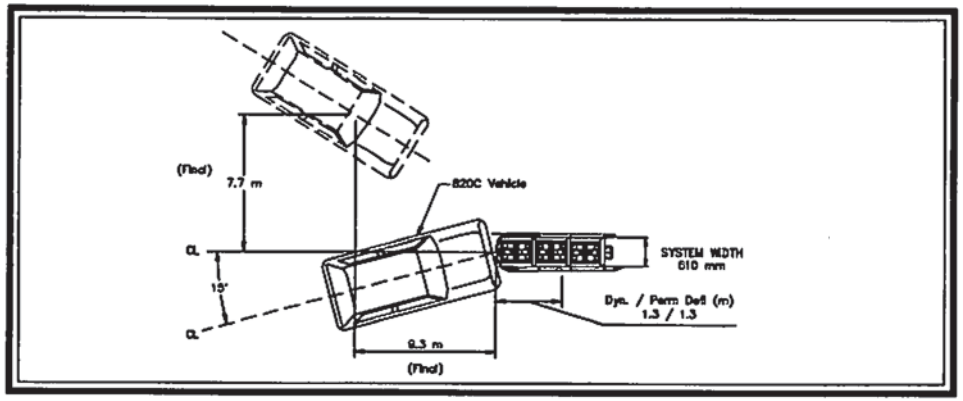
Vehicle Damage (Primary Impact)

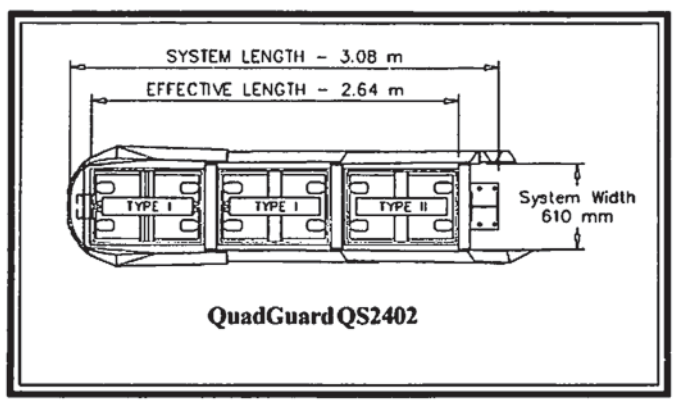
Exterior	
VDS	FC-3
CDC	12FCEW3
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 1. Summary of Results - QuadGuard II System Test 01-4309-003



t = 0.000 sec | t = 0.125 sec | t = 0.250 sec | t = 0.375 sec | t = 0.500 sec | t = 1.285 sec





QuadGuard QS2402

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-32
Test No.	01-4309-004
Date	7/22/08

Test Article

Type	Energy Absorption System
	QuadGuard System QS2402
Installation Length, (mm)	2 bay 3080 mm long 610 mm wide
Material and key elements	2 bay system, 3 energy absorbing cartridges (1) Type II and (2) Type I.
Foundation Type and Condition	Unreinforced 27.6 Mpa concrete, clean and dry, with (26) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	820C
Model	1990 Ford Festiva
Mass (kg)	
Curb	838
Test inertial	818
Dummy	75
Gross Static	993

Impact Conditions

Speed (km/h)	67.7
Angle (deg)	15
Impact Severity (kJ)	144.6

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	10.8
y-direction	-0.5
Ridedown Acceleration (g's)	
x-direction	-17.8
y-direction	-6.2

European Committee for Normalization (CEN) Values

THIV (km/h)	39.0
PHD (g's)	18.0
ASI	1.5

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	7.3
Maximum Pitch Angle	11.3
Maximum Yaw Angle	47.0

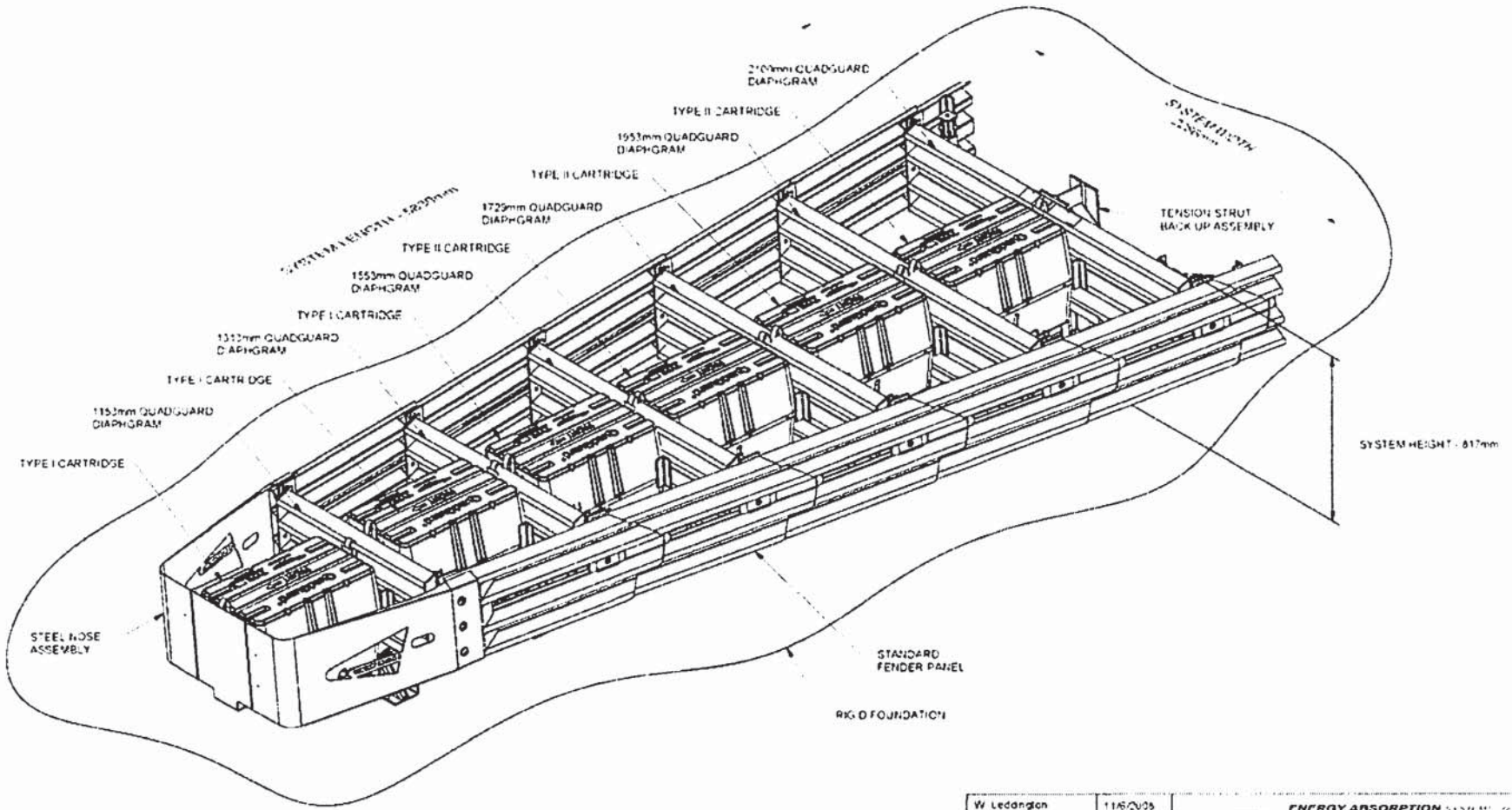
Test Article Deflections (m)

Dynamic	1.3
Permanent	1.3

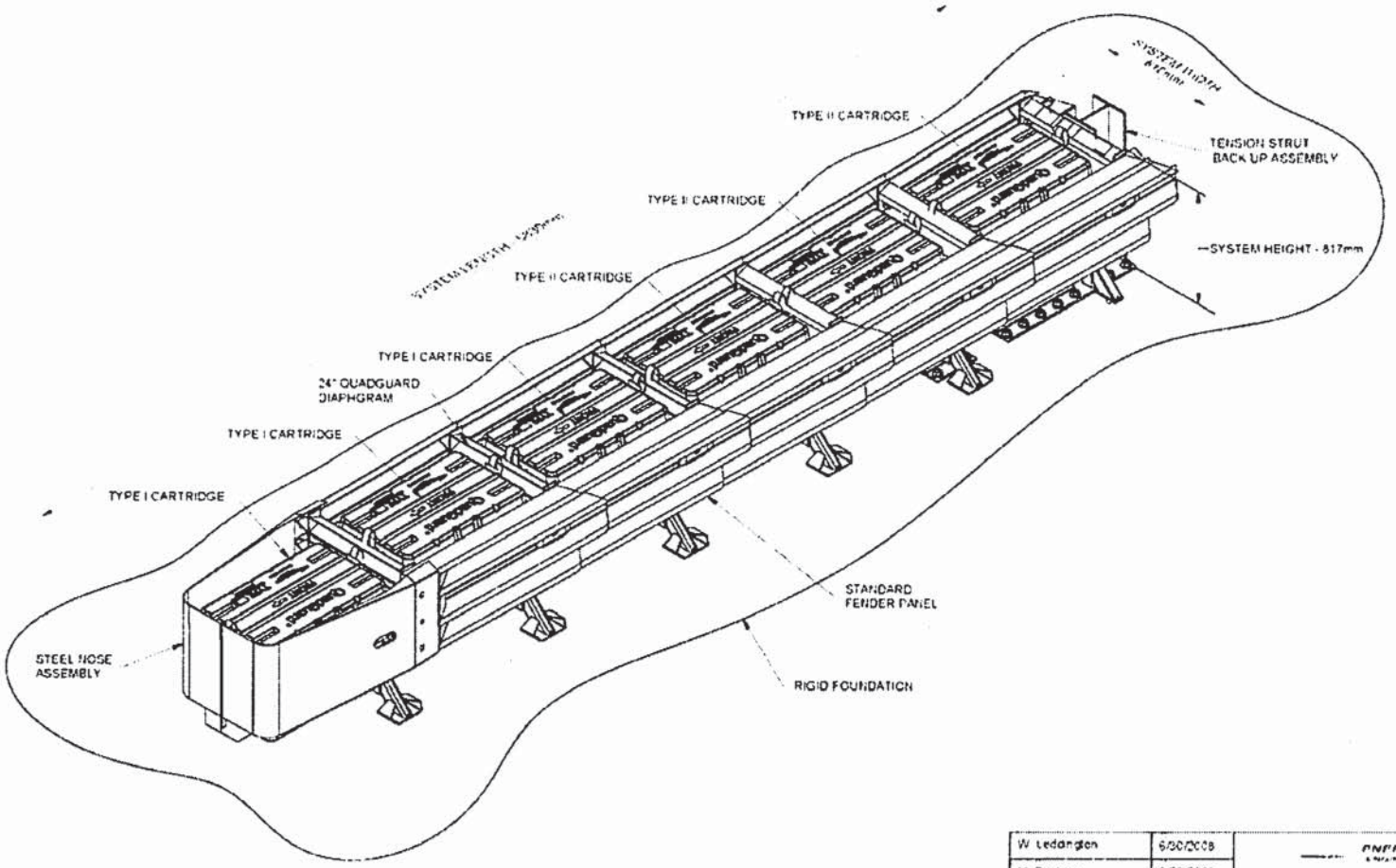
Vehicle Damage (Primary Impact)

Exterior	
VDS	FC-3
CDC	12FCEW3
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 6. Summary of Results - QuadGuard II System Test 01-4309-004



W. Ledbetter	11/5/2008	ENERGY ABSORPTION ENGINEERING AND RESEARCH DEPARTMENT
M. Buehler	11/5/2008	
		5 BAY 90 WIDE QUADGUARD II SYSTEM
		QS90150GII 1 of 1



W. Ledanger	6/30/2008	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT
M. Buehler	6/25/2008	
		5 BAY QUADGUARD II SYSTEM
		1 of 1

U.S. Department
of Transportation
Federal Highway
Administration

1200 New Jersey Avenue, SE.
Washington, DC 20590

February 13, 2009

In Reply Refer To: HSSD/CC-47D

Mr. Barry D. Stephens, P.E.
Senior Vice President of Engineering
Energy Absorption Systems, Inc.
3617 Cincinnati Avenue
Rocklin, CA 95765

Dear Mr. Stephens:

This letter is in response to your request for the Federal Highway Administration (FHWA) acceptance of a roadside safety system for use on the National Highway System (NHS).

Name of system: Mod. TRITON Concrete End Treatment ACZ-350™ System
Type of system: Non-redirecting barrier terminal
Test Level: NCHRP Report 350 TL-3
Testing conducted by: E-TECH Testing Services
Date of request: December 17, 2008

You requested that we find this system acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features."

Requirements
Roadside safety systems should meet the guidelines contained in the NCHRP Report 350. The FHWA Memorandum "Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description
The ACZ-350™ System is designed to perform as a narrow, non-redirecting crash cushion to shield the blunt ends of both permanent and variable length portable concrete median barrier (P/CMB), as well as crashworthy steel median barrier systems such as the Vulcan Barrier.

The ACZ-350™ System consists of a sheet metal nose, four water-filled plastic shell segments, and a steel transition pinned together to act as an end treatment. The nose is constructed of light gauge steel and connects directly to the front-most water filled segment. Each of the four water filled segments is equipped with an external, top-mounted steel stiffener which is rigidly fixed to each respective segment. The front two water filled segments do not contain an internal steel frame or external, side-mounted laminated steel straps. In contrast, the next (or last) two water

filled Triton segments are equipped with an internal steel frame as well as external side-mounted steel laminated straps. A heavy duty non-crushable steel transition completes the system by connecting the last water filled segment to the blunt end of the downstream barrier, be it P/CMB or Vulcan barrier. The total length of the ACZ-350™ System is 9.6 meters (31'-7"). In bi-directional traffic applications, there are no rigid exposed vehicle snag points for traffic traveling from the reverse direction.

Crash Testing

You requested acceptance of the ACZ-350™ System based on the successful results of three NCHRP Report 350 crash tests. The first was Test 3-40 in which an 820C compact car impacted the unit head-on, and with the vehicle offset at w/4. The second test was Test 3-41 in which a 2000P pickup truck impacted the unit head-on. The third test was a modification of Test 3-44 in which a 2000P vehicle impacts the side of the system at 20 degrees with the centerline of the vehicle aligned with the centerline of the rigid hazard. The NCHRP Report 350 states that the intent of Test 3-44 is "...to evaluate the ability of the cushion to safely stop a large passenger car prior to a life-threatening impact with the corner of the hazard object being shielded." Aligning the centerline of the impacting vehicle at the center of the shielded concrete barrier is clearly the critical impact point for the ACZ-350 design and the impact conditions are essentially the same as Test 3-38 for redirecting crash cushions. Report 350 acknowledges that test 3-38 "would be difficult to pass for a nonredirective crash cushion", and thus does not require that the nominal limiting occupant impact velocities and ridedown accelerations be achieved. However, we recognize your newly designed ACZ-350™ System is a nonredirective crash cushion that meets the occupant impact velocities and ridedown accelerations with reported values of 10.5 m/s and 18.4 g's while the impacting vehicle showed no evidence of penetration, climbing or vaulting.

We agree with your conclusions that Tests 3-42 and 3-43 do not require retesting. There has been no significant change in system shape, system height or component weights between the original TRITON CET and the ACZ-350. Individual system sections near the front of the system are designed to articulate in the same fashion as the TRITON Concrete End Treatment. This articulation will allow the errant vehicle to pass through the system as expected for a gating system. Based on these design principals we believe the new ACZ-350™ system will behave with similar results as the TRITON Concrete End Treatment when tested to 3-42 and 3-43 criteria.

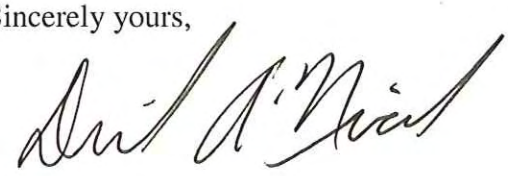
Findings

Based upon the results of the reported Tests 3-40, 3-41, and 3-44, and the discussions above, the FHWA concludes the ACZ-350™ System is acceptable for use on the NHS to act as a narrow, non-redirecting gating crash cushion for permanent and portable concrete median barrier of varying individual lengths as well as steel barrier such as Vulcan. It is acceptable for use on the NHS under the range of conditions tested, when such use is acceptable to a highway agency. The cushion should be used in locations where side impacts are unlikely, penetration behind the barrier is acceptable for angled nose impacts, and where the use of a redirective crash cushion is not feasible for reasons other than cost or convenience.

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

- This acceptance is limited to the crashworthiness characteristics of the systems and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the system will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the system being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our 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 FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number CC-47D and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- The ACZ-350^{TM} System is a patented product and considered proprietary. If proprietary systems are specified by a highway agency for use on Federal-aid projects, except exempt, non-NHS projects, (a) they 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.
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,



David A. Nicol
Director, Office of Safety Design
Office of Safety

Enclosures

PARTS LIST			
ITEM	STOCK NO.	DESCRIPTION	QTY.
1		ACZ-350 SECTION 2	1
2		ACZ-350 TRANSITION ASSY	1
3		ACZ-350 SECTION 1	1
4		ACZ-350 NOSE ASSY	1

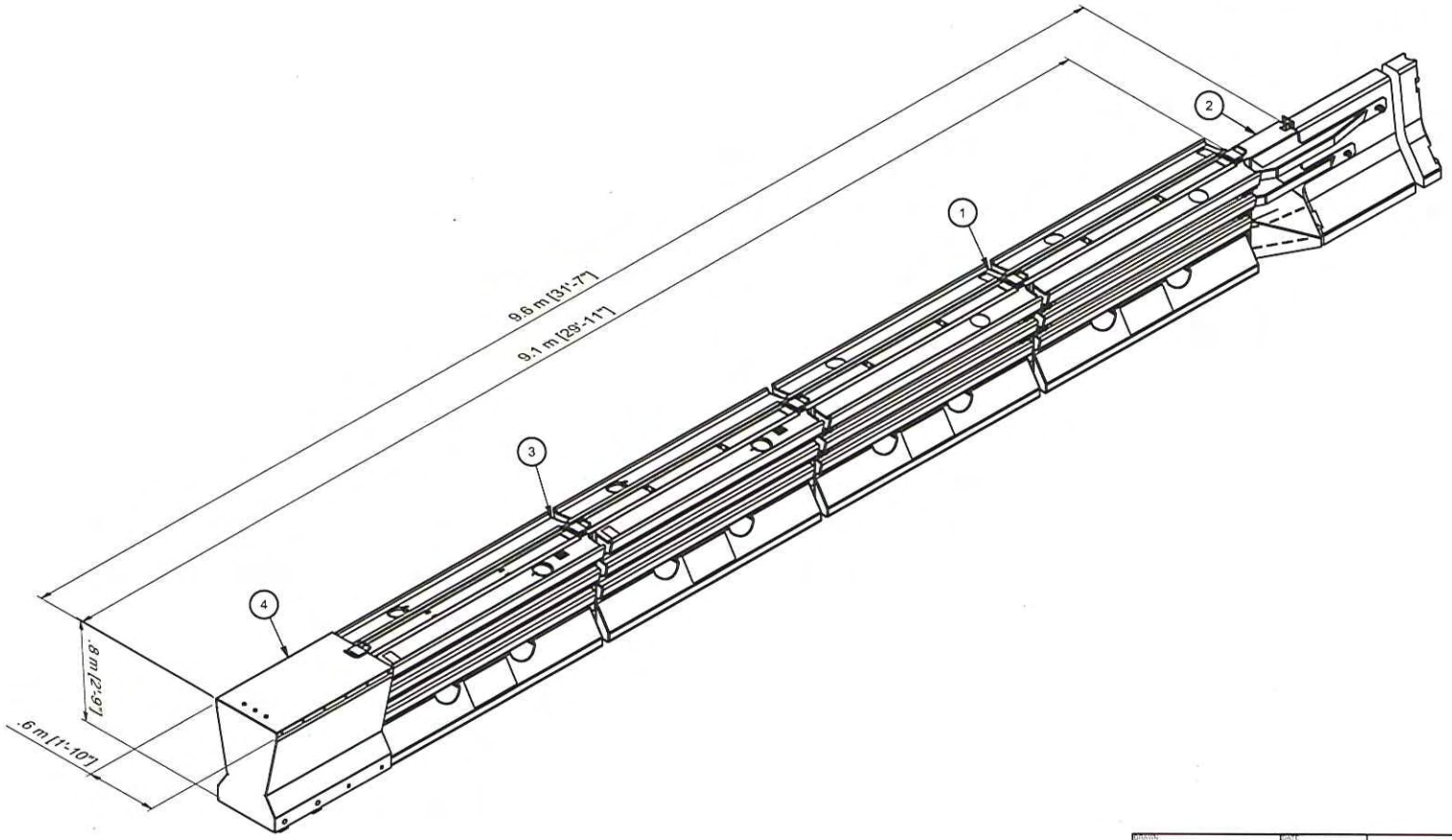
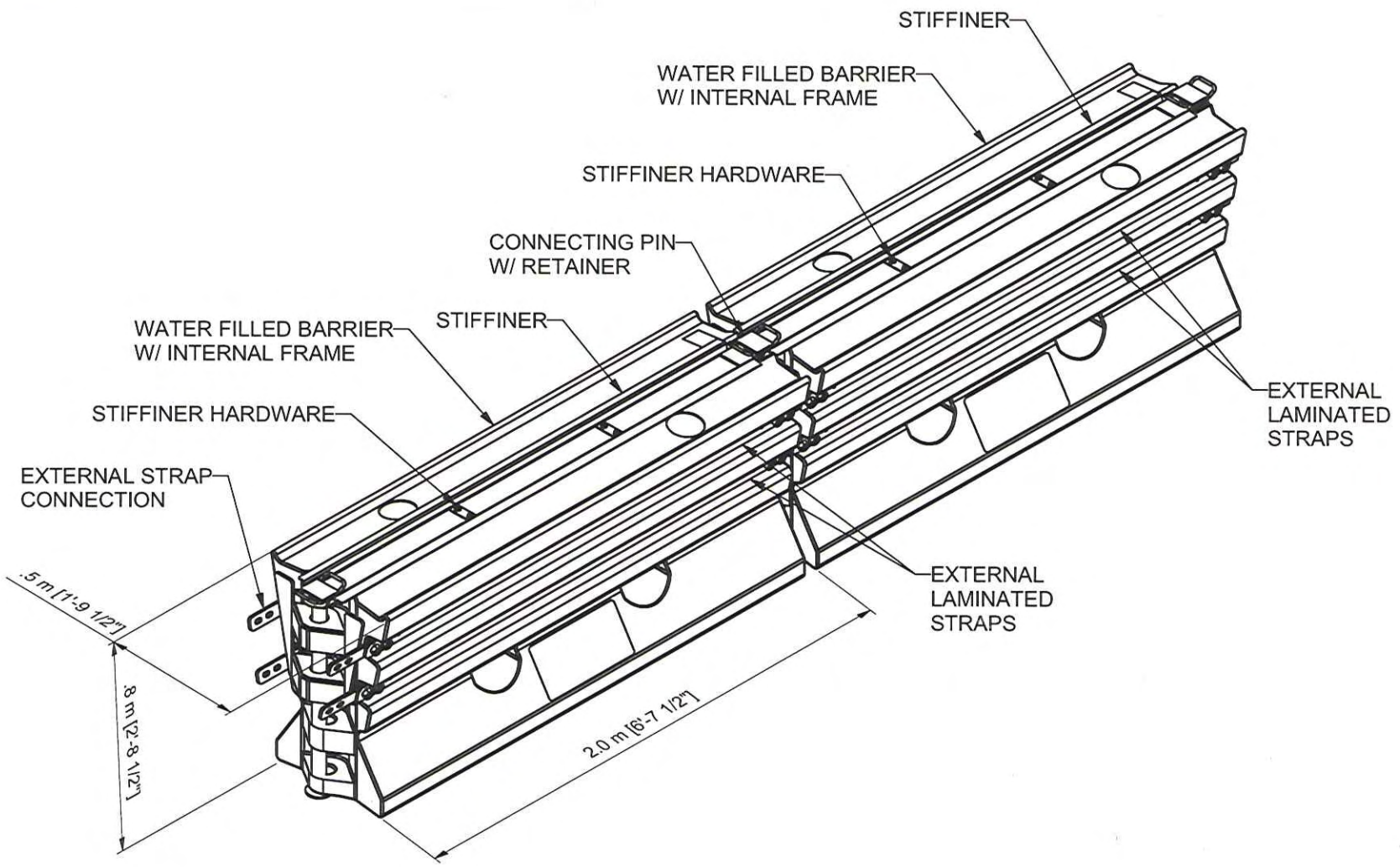


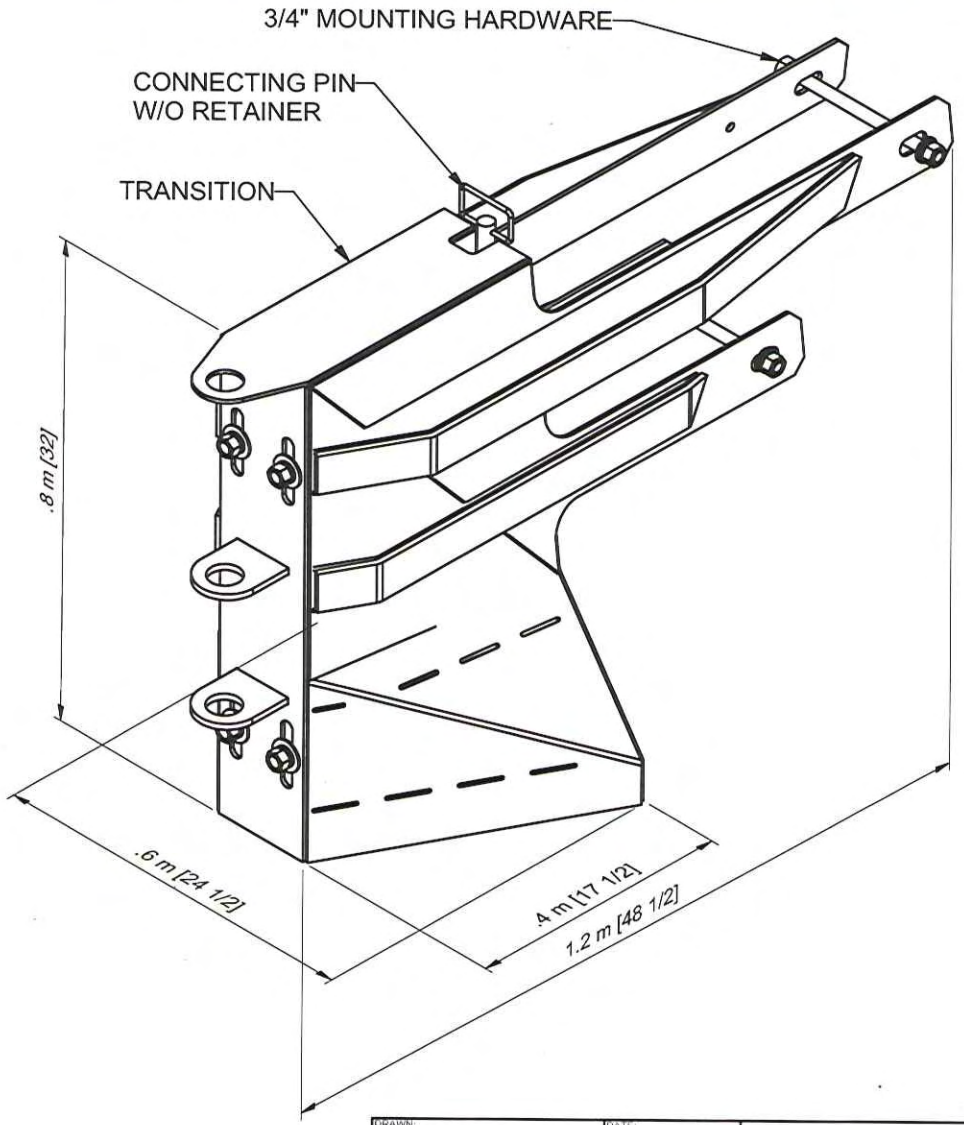
Figure 1

DRAWN: aaron.cox	DATE: 11/12/2008	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT	
DESIGNED: aaron.cox	DATE:		
CHECKED:	DATE:	ACZ-350 TL-3 CRASH CUSHION	
APPROVED:	DATE:		
QA:	DATE:		
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED		DRAWING	SHEET 1 of 1 REV



DRAWN: aaron.cox	DATE: 11/13/2008	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT	
DESIGNED: aaron.cox	DATE:		
CHECKED:	DATE:	ACZ-350 SECTION 2	
APPROVED:	DATE:		
Q.C.	DATE:		
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.		DRAWING:	SHEET: 1 of 1 REV

Figure 4



DRAWN: aaron.cox	DATE: 11/13/2008	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT
DESIGNED: aaron.cox	DATE:	
CHECKED:	DATE:	ACZ-350 TRANSITION ASSY
APPROVED:	DATE:	
Q.C.	DATE:	
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.		DRAWING: / SHEET: 1 of 1 / REV

Figure 3

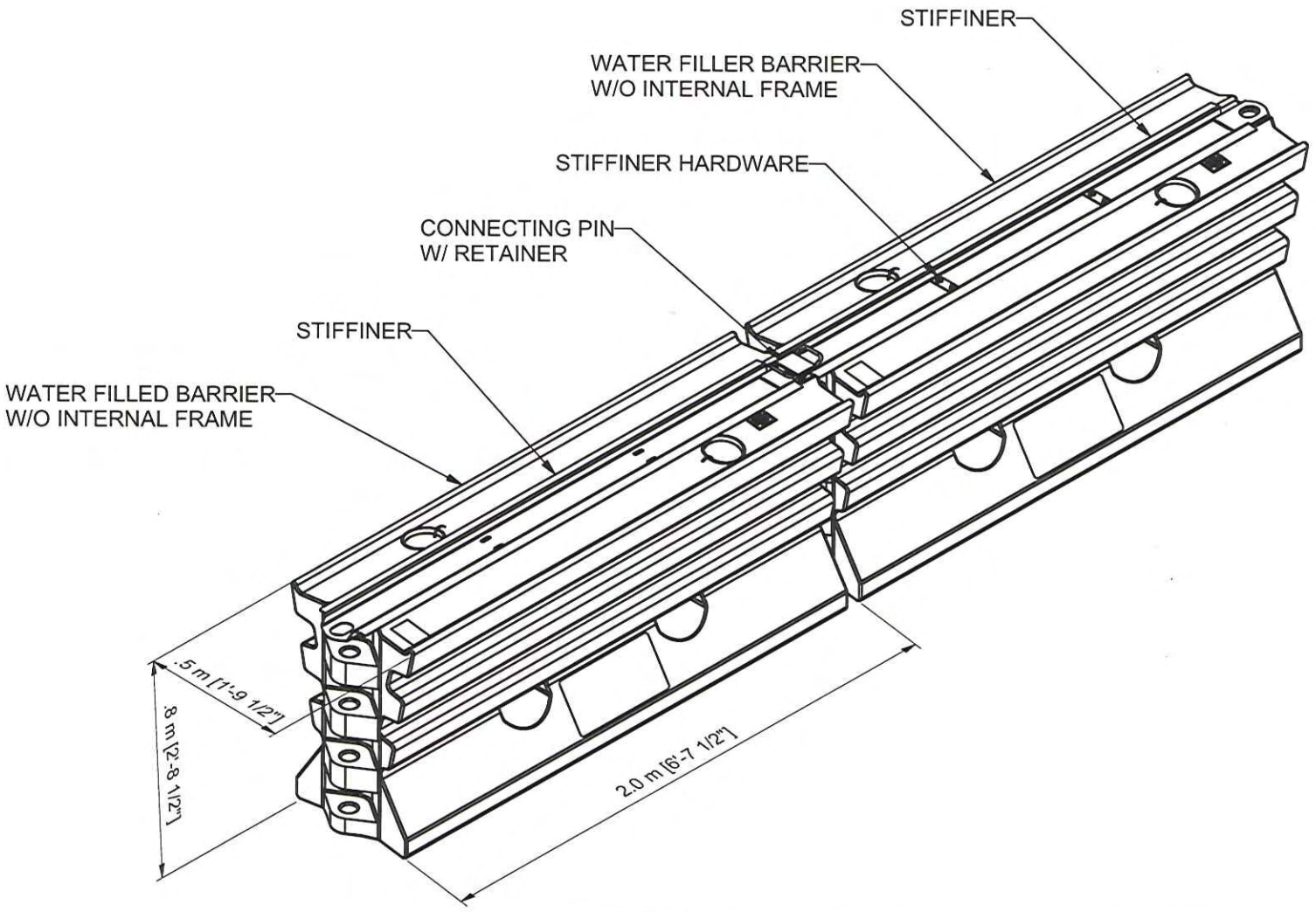
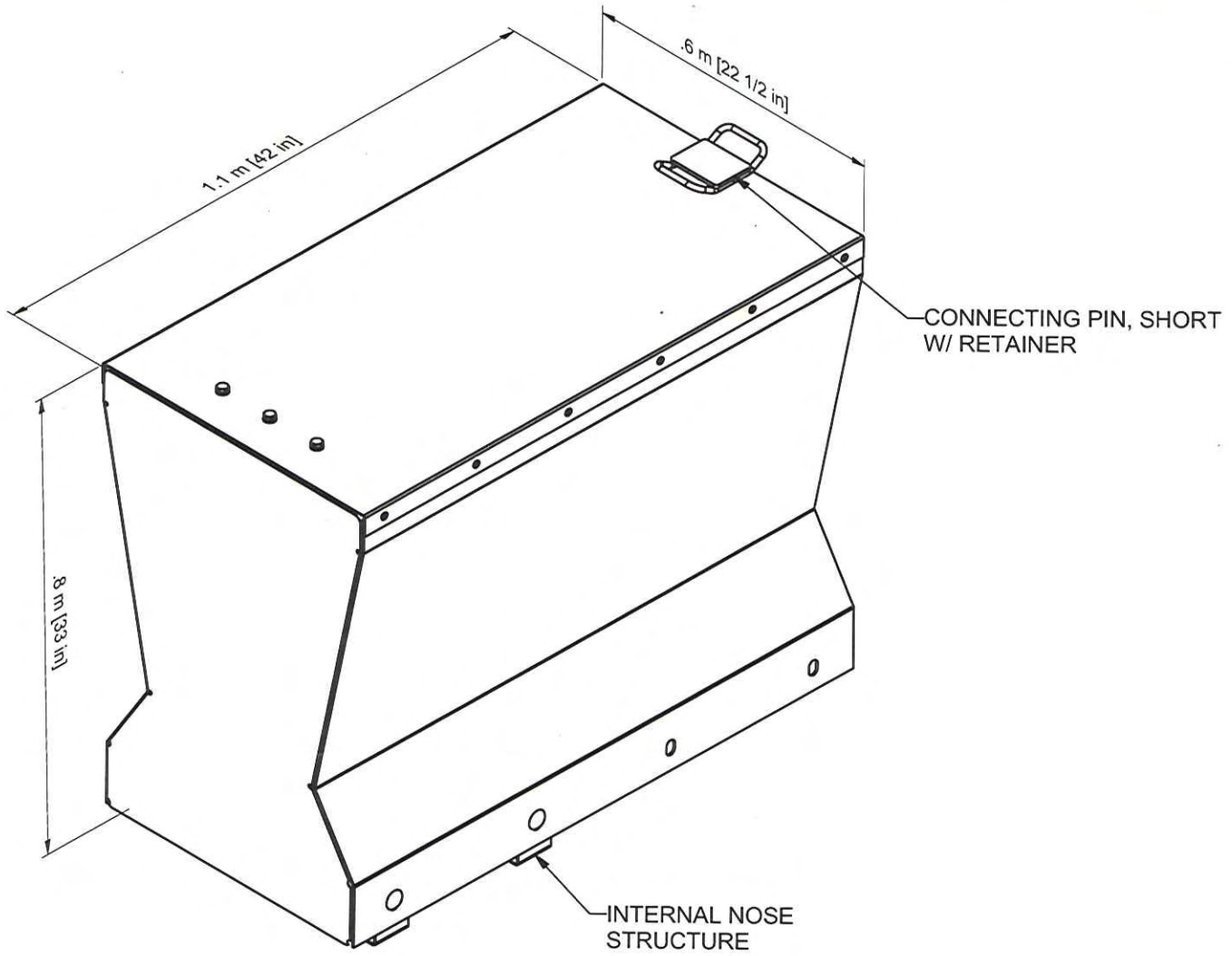


Figure 2

DRAWN: aaron.cox	DATE: 11/12/2008	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT
DESIGNED: aaron.cox	DATE:	
CHECKED:	DATE:	ACZ-350 SECTION 1
APPROVED:	DATE:	
Q.C.	DATE:	
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.		DRAWING: / SHEET: 1 of 1 / REV



DRAWN: aaron.cox	DATE: 11/12/2008	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT
DESIGNED: aaron.cox	DATE:	
CHECKED:	DATE:	ACZ-350 NOSE ASSY
APPROVED:	DATE:	
Q.C.	DATE:	
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.		DRAWING: / SHEET: 1 of 1 / REV

Figure 5

NCHRP 350
TEST MATRIX
TERMINALS & CRASH CUSHIONS
NONREDIRECTIVE GATING

TL-3 (100 km/h = 62.1 mph)

ACZ-350 SYSTEM

← = 820C

← = 2000P

* F FOR TL-2 & TL-3; G FOR TL-1

PASSED

TEST 3-40
820C/100 km/h/0°
C,D,F*,H,I,(J),K,N

PASSED

TEST 3-41
2000P/100km/h/0°
C,D,F*,H,I,(J),K,N

PASSED

TEST 3-44
2000P/100km/h/20°
C,D,F*,K,N

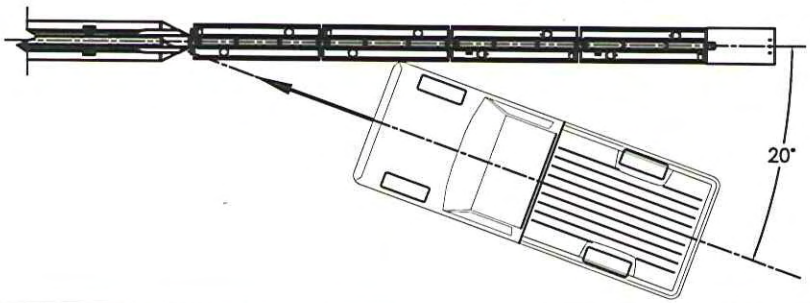
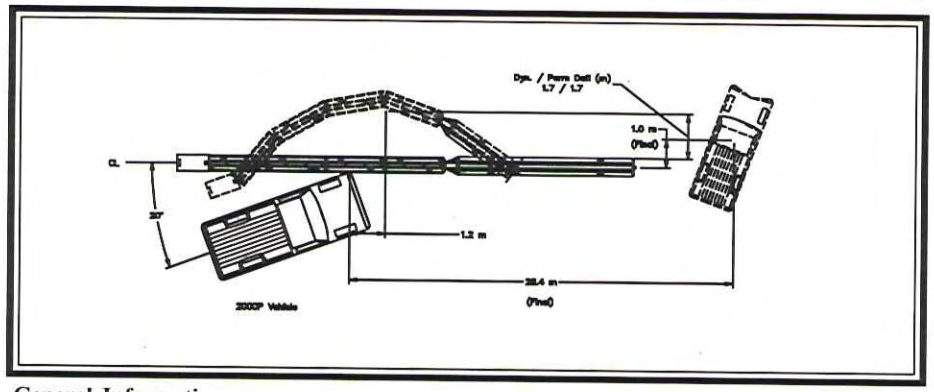
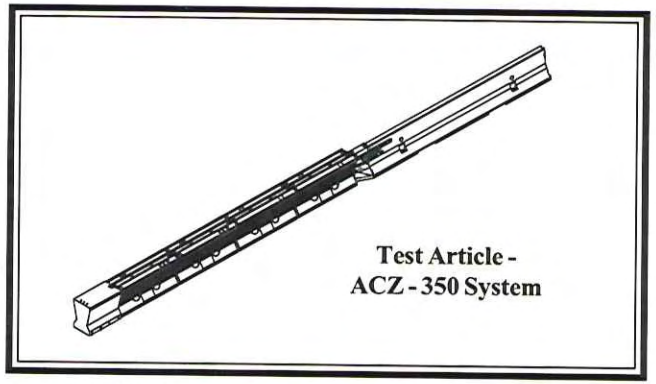


Figure 6

t = 0.000 sec | t = 0.160 sec | t = 0.320 sec | t = 0.480 sec | t = 0.640 sec | t = 0.800 sec





General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-44 modified
Test No.	01-4317-003
Date	12/4/08

Test Article

Type	Energy Absorption System
	ACZ - 350 System
Installation Length,	9.0 m - (4) segment total,
	pinned and freestanding
	w/ steel nose
Material and key elements	Polyethylene plastic segments
	(4 water filled), first two w/o frame and
	steel side straps, last two with, 14 ga
	hollow steel nose, transition to (3) 3 m
	freestanding PCMB with last section
	anchored
	Segment Length x Width x Height:
	(2021 mm x 533 mm x 813 mm)
Foundation Type and Condition	Portland Cement Concrete,
	clean and dry, unanchored

Test Vehicle

Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500 Pickup
Mass (kg)	
Curb	1907
Test inertial	2000
Dummy	N/A
Gross Static	2000

Impact Conditions

Speed (km/h)	96.4
Angle (deg)	20
Impact Severity (kJ)	717.0

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	10.5
y-direction	6.9
Ridedown Acceleration (g's)	
x-direction	-18.4
y-direction	-12.0

European Committee for Normalization (CEN) Values

THIV (km/h)	43.3
PHD (g's)	31.0
ASI	1.8

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	-17.5
Maximum Pitch Angle	24.9
Maximum Yaw Angle	-59.5

Test Article Deflections (m)

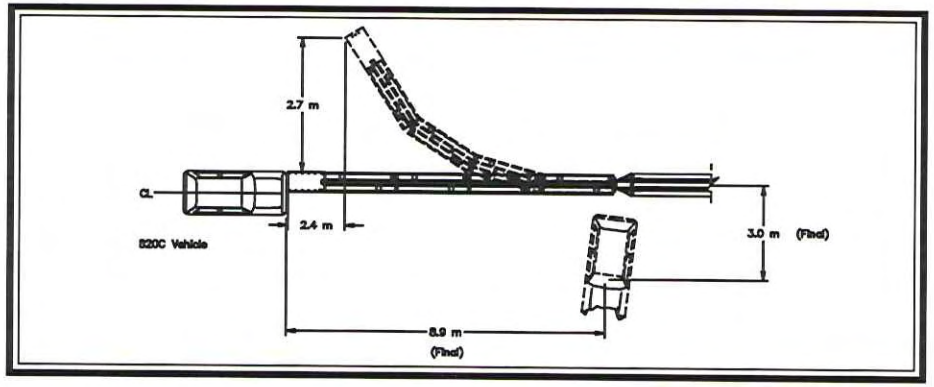
Dynamic	1.7
Permanent	1.7

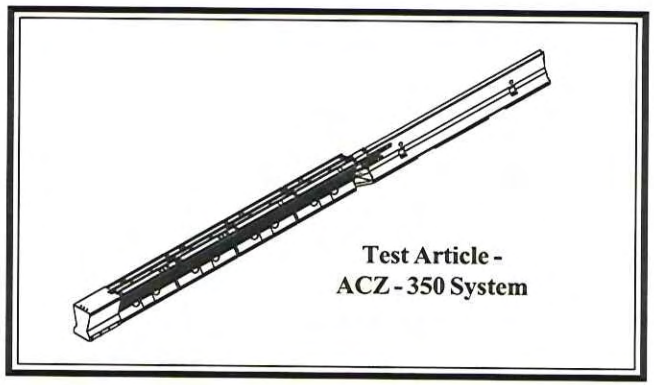
Vehicle Damage (Primary Impact)

Exterior	
VDS	FL-4
CDC	11FLEW4
Interior	
VCDI	AS1020000
Maximum Deformation (mm)	195

Figure 11. Summary of Results - ACZ - 350 System Test 01-4317-003

t = 0.0.0 sec | t = 0.129 sec | t = 0.258 sec | t = 0.387 sec | t = 0.516 sec | t = 0.968 sec





General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-40
Test No.	01-4317-002
Date	11/6/08

Test Article

Type	Energy Absorption System
	ACZ - 350 System
Installation Length,	9.0 m - (4) segment total,
	pinned and freestanding
	w/ steel nose
Material and key elements	Polyethylene plastic segments
	(4 water filled), first two w/o frame and
	steel side straps, last two with, 14 ga
	hollow steel nose, transition to (3) 3 m
	freestanding PCMB with last section
	anchored
	Segment Length x Width x Height:
	(2021 mm x 533 mm x 813 mm)
Foundation Type and Condition	Portland Cement Concrete,
	clean and dry, unanchored

Test Vehicle

Type	Production Model
Designation	820C
Model	1993 Ford Festiva
Mass (kg)	
Curb	821
Test inertial	816
Dummy	75
Gross Static	891

Impact Conditions

Speed (km/h)	99.0
Angle (deg)	0
Impact Severity (kJ)	308.5

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	11.9
y-direction	-0.6
Ridedown Acceleration (g's)	
x-direction	-12.5
y-direction	-3.6

European Committee for Normalization (CEN) Values

THIV (km/h)	44.2
PHD (g's)	12.5
ASI	1.1

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	20.1
Maximum Pitch Angle	-43.5
Maximum Yaw Angle	-244.9

Test Article Deflections (m)

Dynamic	2.7
Permanent	2.7

Vehicle Damage (Primary Impact)

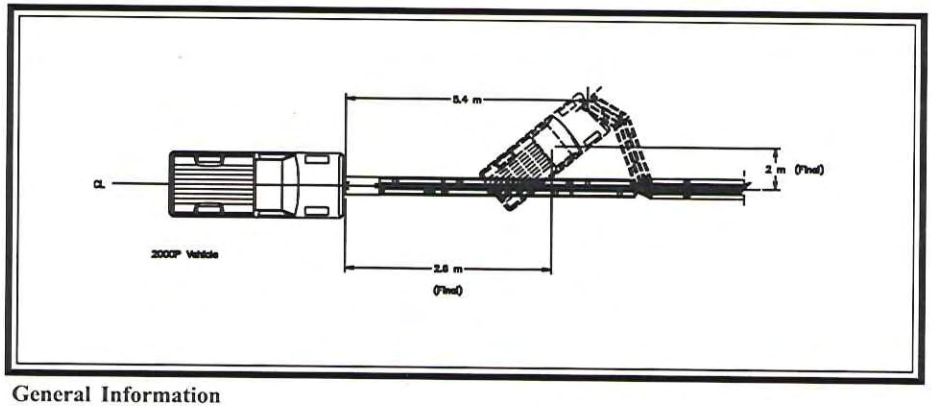
Exterior	
VDS	FD-4
CDC	12FDEW4
Interior	
VCDI	AS0001000
Maximum Deformation (mm)	21 mm

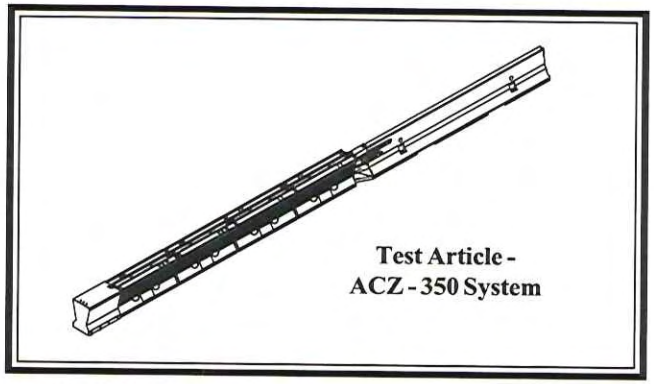
Figure 1. Summary of Results - ACZ - 350 System Test 01-4317-002






t = 0.000 sec | t = 0.210 sec | t = 0.420 sec | t = 0.630 sec | t = 0.840 sec | t = 1.260 sec





General Information	
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-41
Test No.	01-4317-001
Date	10/30/08
Test Article Type	Energy Absorption System
	ACZ - 350 System
Installation Length,	9.0 m - (4) segment total,
	pinned and freestanding
	w/ steel nose
Material and key elements	Polyethylene plastic segments
	(4 water filled), first two w/o frame and
	steel side straps, last two with, 14 ga
	hollow steel nose, transition to (3) 3 m
	freestanding PCMB with last section
	anchored
	Segment Length x Width x Height:
	(2021 mm x 533 mm x 813 mm)
Foundation Type and Condition	Portland Cement Concrete,
	clean and dry, unanchored
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500 Pickup
Mass (kg)	
Curb	1853
Test inertial	1995
Dummy	N/A
Gross Static	1995

Impact Conditions	
Speed (km/h)	98.3
Angle (deg)	0
Impact Severity (kJ)	744.0
Exit conditions	
Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	9.9
y-direction	-0.3
Ridedown Acceleration (g's)	
x-direction	-11.1
y-direction	-5.7
European Committee for Normalization (CEN) Values	
THIV (km/h)	35.6
PHD (g's)	11.2
ASI	0.9
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	-7.6
Maximum Pitch Angle	20.0
Maximum Yaw Angle	-39.2
Test Article Deflections (m)	
Dynamic	5.4
Permanent	5.4
Vehicle Damage (Primary Impact)	
Exterior	
VDS	FD-4
CDC	12FDEW4
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	14

Figure 6. Summary of Results - ACZ - 350 System Test 01-4317-001

U.S. Department of Transportation
Federal Highway Administration

1200 New Jersey Ave., SE
Washington, D.C. 20590

February 9, 2011

In Reply Refer To:
HSST/CC-114

Mr. Geoff Maus
Chief Design Engineer
TrafFix Devices, Inc.
160 Avenida La Pata
San Clemente, California 92673

Dear Mr. Maus:

This letter is in response to your request for the Federal Highway Administration (FHWA) acceptance of a roadside safety system for use on the National Highway System (NHS).

Name of system:	SLED – Sentry Longitudinal Energy Dissipater
Type of system:	Gating Crash Cushion/Impact Attenuator
Test Level:	NCHRP Report 350 Test Level 3 (TL-3)
Testing conducted by:	KARCO Engineering
Date of request:	August 31, 2010
Date initially acknowledged:	August 31, 2010

You requested that we find this system acceptable for use on the NHS under the provisions of the National Cooperative Highway Research Program (NCHRP) Report 350.

Requirements
Roadside safety devices should meet the guidelines contained in the Report 350. The FHWA memorandum "ACTION: Identifying Acceptable Highway Safety Features" of July 24, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Decision
The following device was found acceptable, with details provided below:

- TL-3 SLED – Sentry Longitudinal Energy Dissipater

Description
The SLED End Treatment is a high-density polyethylene (HDPE) water filled crash cushion designed to shield the end of permanent and portable barrier shapes including concrete, steel, and plastic. The SLED End Treatment modules are designed for uni- and bi-directional traffic applications where a gating device is acceptable to the road authority.

FHWA:HSST:NArtimovich:ms:x61331:2/9/11
File: s://directory folder/HSST/Artimovich CC114_Sled_TL3.dotx
cc: HSST (NArtimovich; JDewar)

The SLED End Treatment modules are designated by their yellow color, each module has overall dimensions of approximately 6.3 ft (1.93 m) x 1.875 ft (.57 m) x 3.8 ft (1.16 m) and weighs approximately 160 lbs empty and 2000 lbs filled. Each module has eleven connecting lugs, five on one end and six on the opposite end. The four upper lugs on every module contain an independent corrosion resistant wire rope. A 1.125 inch (28.6 mm) diameter steel t-pin drops through the 1.5 inch (38 mm) diameter holes in the lugs linking the sections together.
At the front of the end treatment, pinned directly to module #1 is the Containment Impact Sled (CIS). The CIS is made of all steel construction with a flat bottom, a curved sheet metal nose, and support frames made of structural rectangular steel tubes. The CIS is designed to attach to either the five or six knuckle ends of module #1. The CIS has a curved impact face to fit over the curved knuckle contour of module #1. The vertical t-pin connects the CIS to module #1 through the series of vertical knuckles and the internal molded-in cables. Module #1 is designed to be an empty module. To prevent module #1 from being filled, six holes are designed into the lower edge of the side walls. Modules 2, 3, and 4 are filled entirely and weigh approximately 2000lbs (907 kg) each when filled.

When the Sentry SLED End Treatment is used to shield an end of an array of Sentry Water Cable Barriers, one CIS, and one module #1 is attached. For TL-3 applications, the SLED End Treatment is attached to a minimum of ten (unlimited maximum number) Sentry Water Cable Barriers.

For shielding all permanent and portable barriers, an adjustable steel transition has been designed. This transition securely attaches the rear of the Sentry SLED End Treatment to the shielded object. The transition is designed to accommodate assorted safety barrier shapes and sizes by using hinged outboard transition panels. The transition panels are made of 0.188 inch (4.8 mm) thick steel, which when attached to the barrier, conforms to the contour of the barrier. The combination of hinging, and contouring, allow the panels allows the SLED End Treatment to be attached to narrow and wide and profile shapes with either converging, or diverging angles, up to 10 degrees. For testing, the contoured hinged panels were anchored to the barriers using a minimum of eight 1 inch diameter anchor bolts with expansion sleeves, minimum four per side.

Crash Testing

A non-redirective gating crash cushion requires the following tests be conducted:
3-40, 3-41, 3-42, 3-43, and 3-44. The following full-scale tests were conducted on the SLED:

Tests for Shielding Sentry Water Cable Barrier

NCHRP-350 Test Number	Test Vehicle Weight (kg)	Impact Speed (kph)	Impact Condition	Occ. Imp Velocity (m/s)	Ridedown Acceleration (G)
3-40	820	99.6	¼ offset	10.6	15.7
3-41	2000	102	0°	11.1	11.0
3-43	2000	102.4	15°	8.0	4.8

Tests for Shielding F-Shape CMB Unpinned and Permanently Anchored

NCHRP-350 Test Number	Test Vehicle Weight (kg)	Impact Speed (kph)	Impact Angle Degree	Occ. Imp Velocity (m/s)	Ridedown Acceleration (G)
3-41 Free Standing	2000	101.5	0°	9.2	9.6
3-41 Anchored	2000	99.1	0°	9.7	12.3
3-44 Anchored	2000	103.1	20°	9.8	10.6
3-44M Anchored	2000	96.2	15°	8.4	15.6

You requested waivers of the following tests:

Test 3-40 -Shielding permanent and portable concrete barriers.
Test 3-42 -Shielding Sentry Water Cable Barrier and permanent and portable concrete barriers.
Test 3-43- Shielding permanent and portable concrete barriers.
Test 3-44 -Shielding Sentry Water Cable Barrier.

You detailed your reasoning behind the waiver requests as follows:

Test 3-40 Shielding Permanent and Portable Concrete Barriers
The Sentry SLED End Treatment shielding Sentry Water Cable Barrier recorded an OIV of 10.6 m/s and a ridedown acceleration of 15.7 g's. These values are below accepted levels, and were recorded prior to movement of the fourth Sentry module. You expect little or no change in performance with the SLED End Treatment attached to a fixed object.

Tests 3-42 Shielding Sentry Water Cable Barrier and Permanent and Portable Concrete Barriers
You expect the impacting car to push the sled and first empty module aside, allowing the end treatment to act as a gating device, similar to the 3-43 test performed. Just as the 3-43 test had lower measured values than the 3-41 test, we would expect the 3-42 test would have lower values than the 3-40 test.

Test 3-43 Shielding Permanent and Portable Concrete Barriers
As tested, shielding the Sentry Water Cable Barrier, the trajectory of the impacting vehicle carried past the angled barrier and remained upright during and after the collision with only moderate, roll pitch, and yaw. It would be expected that the impacting vehicle would have similar test results regardless of the type of barrier that is being shielded.

Test 3-44 Shielding Sentry Water Cable Barriers
The SLED End Treatment was tested twice in the most severe condition, attached to rigid anchored F-shape safety concrete barrier, in test 3-44 and 3-44M parameters. In these tests, all specified evaluation criteria (C,D,F,K, and N) were met. In addition, evaluation criteria H and I (OIV and Ridedown) were well below the maximum accepted values. Based on the 3-11 performance of Sentry Water Cable Barriers, and the products ability to deflect, you expect equal or better performance for evaluation criteria C,D,F,K and N with the SLED End Treatment attached to Sentry Water Cable Barriers.

All physical crash test summaries are included as enclosures to this correspondence.

Findings
Because the SLED is a non-redirecting, gating cash cushion, it should be applied to hazards that are not likely to be impacted at an angle on the side at any significant velocity. We note also that proper antifreezing agents must be used as filler when the SLED and Sentry products are used in areas where low temperatures can be anticipated. All users of this device should be made aware of the factors that contribute to its proper performance.

Therefore, the system described in the requests above and detailed in the enclosed drawings is acceptable for use on the NHS under the range of conditions tested, when such use is acceptable to a highway agency.

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

- This acceptance is limited to the crashworthiness characteristics of the systems and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the system will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the system being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our 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 FHWA and NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number CC-114 and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- The Sentry and SLED are patented products and considered proprietary. If proprietary devices are specified by a highway agency for use on Federal-aid projects, except exempt, non-NHS projects, (a) they 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.
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder.

The acceptance letter is limited to the crashworthiness characteristics of the candidate system, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely,

Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety

Enclosures

U.S. Department of Transportation
Federal Highway Administration

1200 New Jersey Ave., SE
Washington, D.C. 20590

February 9, 2011

In Reply Refer To:
HSST/CC-114

Mr. Geoff Maus
Chief Design Engineer
TrafFix Devices, Inc.
160 Avenida La Pata
San Clemente, California 92673

Dear Mr. Maus:

This letter is in response to your request for the Federal Highway Administration (FHWA) acceptance of a roadside safety system for use on the National Highway System (NHS).

Name of system:	SLED – Sentry Longitudinal Energy Dissipater
Type of system:	Gating Crash Cushion/Impact Attenuator
Test Level:	NCHRP Report 350 Test Level 3 (TL-3)
Testing conducted by:	KARCO Engineering
Date of request:	August 31, 2010
Date initially acknowledged:	August 31, 2010

You requested that we find this system acceptable for use on the NHS under the provisions of the National Cooperative Highway Research Program (NCHRP) Report 350.

Requirements
Roadside safety devices should meet the guidelines contained in the Report 350. The FHWA memorandum "ACTION: Identifying Acceptable Highway Safety Features" of July 24, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Decision
The following device was found acceptable, with details provided below:

- TL-3 SLED – Sentry Longitudinal Energy Dissipater

Description
The SLED End Treatment is a high-density polyethylene (HDPE) water filled crash cushion designed to shield the end of permanent and portable barrier shapes including concrete, steel, and plastic. The SLED End Treatment modules are designed for uni- and bi-directional traffic applications where a gating device is acceptable to the road authority.

The SLED End Treatment modules are designated by their yellow color, each module has overall dimensions of approximately 6.3 ft (1.93 m) x 1.875 ft (.57 m) x 3.8 ft (1.16 m) and weighs approximately 160 lbs empty and 2000 lbs filled. Each module has eleven connecting lugs, five on one end and six on the opposite end. The four upper lugs on every module contain an independent corrosion resistant wire rope. A 1.125 inch (28.6 mm) diameter steel t-pin drops through the 1.5 inch (38 mm) diameter holes in the lugs linking the sections together.
At the front of the end treatment, pinned directly to module #1 is the Containment Impact Sled (CIS). The CIS is made of all steel construction with a flat bottom, a curved sheet metal nose, and support frames made of structural rectangular steel tubes. The CIS is designed to attach to either the five or six knuckle ends of module #1. The CIS has a curved impact face to fit over the curved knuckle contour of module #1. The vertical t-pin connects the CIS to module #1 through the series of vertical knuckles and the internal molded-in cables. Module #1 is designed to be an empty module. To prevent module #1 from being filled, six holes are designed into the lower edge of the side walls. Modules 2, 3, and 4 are filled entirely and weigh approximately 2000lbs (907 kg) each when filled.

When the Sentry SLED End Treatment is used to shield an end of an array of Sentry Water Cable Barriers, one CIS, and one module #1 is attached. For TL-3 applications, the SLED End Treatment is attached to a minimum of ten (unlimited maximum number) Sentry Water Cable Barriers.

For shielding all permanent and portable barriers, an adjustable steel transition has been designed. This transition securely attaches the rear of the Sentry SLED End Treatment to the shielded object. The transition is designed to accommodate assorted safety barrier shapes and sizes by using hinged outboard transition panels. The transition panels are made of 0.188 inch (4.8 mm) thick steel, which when attached to the barrier, conforms to the contour of the barrier. The combination of hinging, and contouring, allow the panels allows the SLED End Treatment to be attached to narrow and wide and profile shapes with either converging, or diverging angles, up to 10 degrees. For testing, the contoured hinged panels were anchored to the barriers using a minimum of eight 1 inch diameter anchor bolts with expansion sleeves, minimum four per side.

Crash Testing

A non-redirective gating crash cushion requires the following tests be conducted:
3-40, 3-41, 3-42, 3-43, and 3-44. The following full-scale tests were conducted on the SLED:

Tests for Shielding Sentry Water Cable Barrier

NCHRP-350 Test Number	Test Vehicle Weight (kg)	Impact Speed (kph)	Impact Condition	Occ. Imp Velocity (m/s)	Ridedown Acceleration (G)
3-40	820	99.6	¼ offset	10.6	15.7
3-41	2000	102	0°	11.1	11.0
3-43	2000	102.4	15°	8.0	4.8

Tests for Shielding F-Shape CMB Unpinned and Permanently Anchored

NCHRP-350 Test Number	Test Vehicle Weight (kg)	Impact Speed (kph)	Impact Angle Degree	Occ. Imp Velocity (m/s)	Ridedown Acceleration (G)
3-41 Free Standing	2000	101.5	0°	9.2	9.6
3-41 Anchored	2000	99.1	0°	9.7	12.3
3-44 Anchored	2000	103.1	20°	9.8	10.6
3-44M Anchored	2000	96.2	15°	8.4	15.6

You requested waivers of the following tests:

Test 3-40 -Shielding permanent and portable concrete barriers.
Test 3-42 -Shielding Sentry Water Cable Barrier and permanent and portable concrete barriers.
Test 3-43- Shielding permanent and portable concrete barriers.
Test 3-44 -Shielding Sentry Water Cable Barrier.

You detailed your reasoning behind the waiver requests as follows:

Test 3-40 Shielding Permanent and Portable Concrete Barriers
The Sentry SLED End Treatment shielding Sentry Water Cable Barrier recorded an OIV of 10.6 m/s and a ridedown acceleration of 15.7 g's. These values are below accepted levels, and were recorded prior to movement of the fourth Sentry module. You expect little or no change in performance with the SLED End Treatment attached to a fixed object.

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You expect the impacting car to push the sled and first empty module aside, allowing the end treatment to act as a gating device, similar to the 3-43 test performed. Just as the 3-43 test had lower measured values than the 3-41 test, we would expect the 3-42 test would have lower values than the 3-40 test.

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As tested, shielding the Sentry Water Cable Barrier, the trajectory of the impacting vehicle carried past the angled barrier and remained upright during and after the collision with only moderate, roll pitch, and yaw. It would be expected that the impacting vehicle would have similar test results regardless of the type of barrier that is being shielded.

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The SLED End Treatment was tested twice in the most severe condition, attached to rigid anchored F-shape safety concrete barrier, in test 3-44 and 3-44M parameters. In these tests, all specified evaluation criteria (C,D,F,K, and N) were met. In addition, evaluation criteria H and I (OIV and Ridedown) were well below the maximum accepted values. Based on the 3-11 performance of Sentry Water Cable Barriers, and the products ability to deflect, you expect equal or better performance for evaluation criteria C,D,F,K and N with the SLED End Treatment attached to Sentry Water Cable Barriers.

All physical crash test summaries are included as enclosures to this correspondence.

Findings
Because the SLED is a non-redirecting, gating cash cushion, it should be applied to hazards that are not likely to be impacted at an angle on the side at any significant velocity. We note also that proper antifreezing agents must be used as filler when the SLED and Sentry products are used in areas where low temperatures can be anticipated. All users of this device should be made aware of the factors that contribute to its proper performance.

Therefore, the system described in the requests above and detailed in the enclosed drawings is acceptable for use on the NHS under the range of conditions tested, when such use is acceptable to a highway agency.

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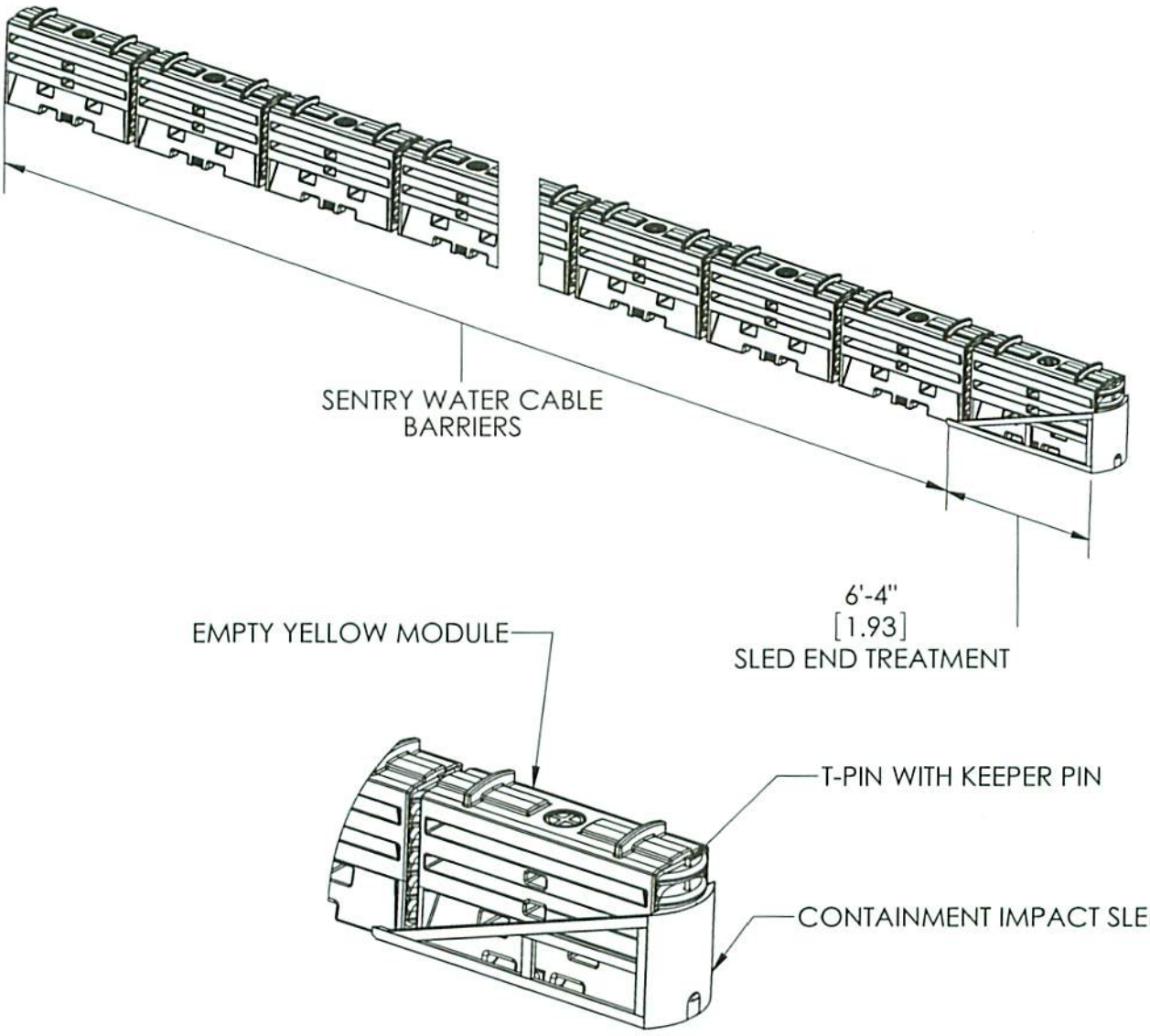
The acceptance letter is limited to the crashworthiness characteristics of the candidate system, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely,

Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety

Enclosures



SLED END TREATMENT

TrafFix Devices Inc.

SER##

SHEET NO.	DATE:
1 OF 2	08/27/2010

INTENDED USE

The Sentry Longitudinal Energy Dissipater (**SLED**) End Treatment is a narrow water filled non-redirective, gating crash cushion designed to shield the Sentry Water Cable Barrier. Like the Sentry Water Cable Barrier the SLED End Treatment does not require foundation anchor bolts to be attached to road surface. The complete end treatment can be installed on firm soil, asphalt, and concrete.

The SLED End Treatment meets NCHRP-350 TL-3, TL-2, and TL-1 crashworthy test criteria as a non-redirective crash cushion. The complete end treatment consists of one yellow empty module and a Containment Impact Sled (CIS).

SLED End Treatment
Length: 75-3/4 in (1.93 m)
Height: 42-11/16 in (1.09 m)
Width: 22-1/2 in (0.57 m)

The SLED End Treatment has been fully tested to the recommended procedures of Report NCHRP-350.

ACCEPTANCE

FHWA Acceptance Letters:

CONTACT INFORMATION

TrafFix Devices, Inc.
Corporate Headquarters
160 Avenida La Pata
San Clemente, CA 92673
www.traffixdevices.com

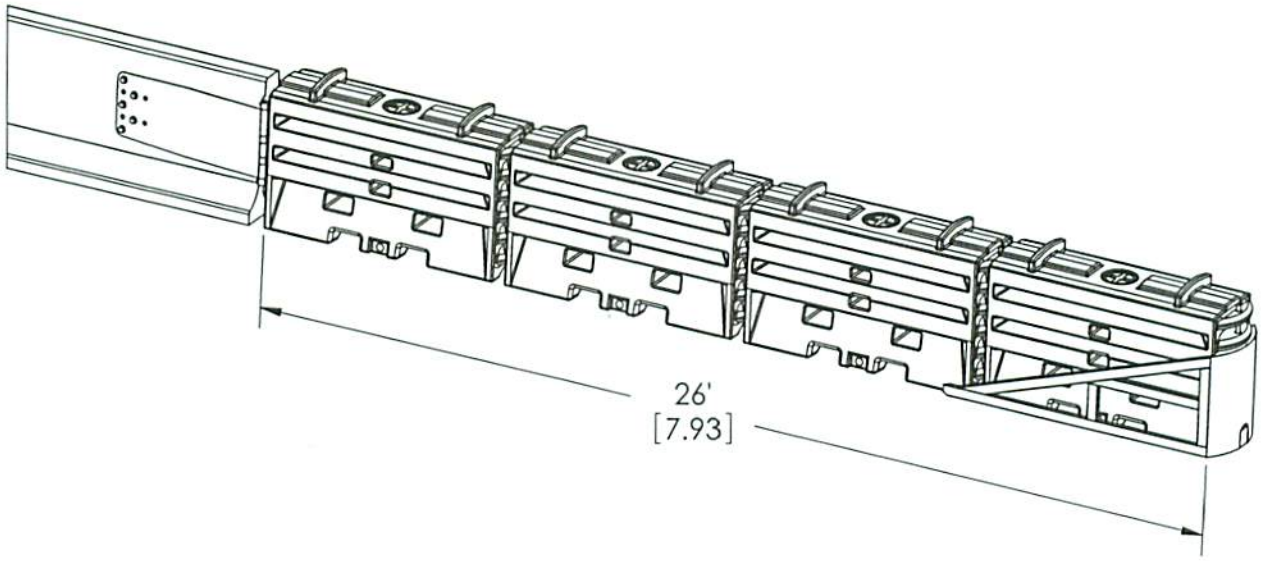
Phone: +1(949)-361-5663
Fax: +1(949)-361-9205
Email: info@traffixdevices.com

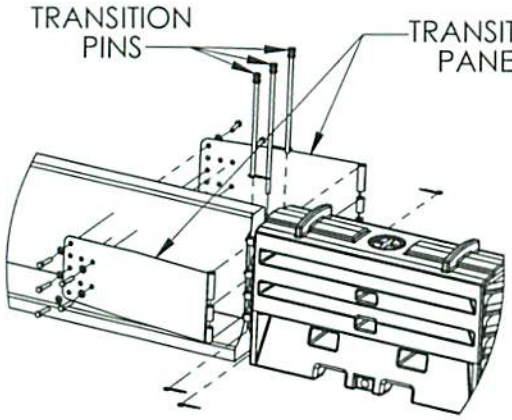
SLED END TREATMENT

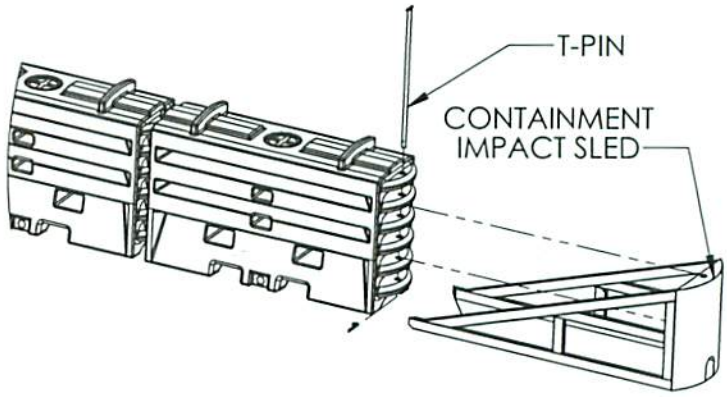
SER##

SHEET NO.	DATE:
2 OF 2	08/27/2010

TrafFix Devices Inc.







SLED END TREATMENT

TrafFix Devices Inc.

SER##

SHEET NO.	DATE:
1 OF 2	08/27/2010

INTENDED USE

The Sentry Longitudinal Energy Dissipater (SLED) End Treatment is a narrow water-filled non-redirective, gating crash cushion designed to shield the end of all permanent and portable barrier shapes including concrete, steel, and plastic. The SLED End Treatment does not require foundation anchor bolts to be attached to the road surface. The complete crash cushion can be installed on firm soil, asphalt, and concrete.

The SLED End Treatment meets NCHRP-350 TL-3, TL-2, and TL-1 crashworthy test requirements as a non-redirective crash cushion. Four yellow modules make up the complete crash cushion assembly. Front module 1 is left empty and weighs 160 lbs. [75.6 kg]. Modules 2, 3, and 4 are filled and weigh approximately 2000 lbs [907.2 kg]. The Containment Impact Sled is attached to the front of Module 1 and the Transition is attached to the rear of Module 4.

SLED End Treatment
Length: 26 ft (7.93 m) Four (4) Modules
Height: 42-11/16 in (1.09 m)
Width: 22-1/2 in (0.57 m)

The SLED End Treatment has been fully tested to the recommended procedures of NCHRP-350.

ACCEPTANCE

FHWA Acceptance Letters:

CONTACT INFORMATION

TrafFix Devices, Inc.
Corporate Headquarters
160 Avenida La Pata
San Clemente, CA 92673
www.traffixdevices.com

Phone: +1(949)-361-5663
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SLED END TREATMENT

SER##

SHEET NO.	DATE:
2 OF 2	08/27/2010

TrafFix Devices Inc.

DATA SHEET 4

SUMMARY OF RESULTS

Test Article:	TrafFix Devices Sentry End Treatment	Project No.:	P30061-01
Test Program:	NCHRP 350 3-40	Test Date:	05/14/10
Test Vehicle:	1995 Geo Metro		

GENERAL INFORMATION		OCCUPANT RISK VALUES	
TEST AGENCY	KARCO Engineering, LLC	FLAIL SPACE VELOCITY (m/sec)	
TEST NO.	3-40	X DIRECTION	10.6
DATE	5/14/2010	Y DIRECTION	0.4
TEST ARTICLE		THIV (Optional)	
TYPE	Crash Cushion	RIDEDOWN ACCELERATION (g's)	
INSTALLATION LENGTH	25.0 m (82.1 ft.)	X DIRECTION	-15.7
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 79.4 kg (175 lbs)	Y DIRECTION	2.2
SOIL TYPE AND CONDITION	Concrete	PHD (Optional)	
TEST VEHICLE		ASI (Optional)	
TYPE	Production Model	**TEST ARTICLE DEFLECTIONS (m)**	
DESIGNATION	820C	DYNAMIC	
MODEL	1995 Geo Metro	PERMANENT	
MASS (CURB)	807.0 kg (1779 lbs)	**VEHICLE DAMAGE**	
MASS (TEST INERTIAL)	806.5 kg (1778 lbs)	EXTERIOR	
DUMMY MASS	75.0 kg (165 lbs)	VDS	12-FR-5
MASS (GROSS STATIC)	885.5 kg (1952 lbs)	CDC	12FREW2
IMPACT CONDITIONS		INTERIOR	
VELOCITY (km/h)	99.6 km/h (61.9 mi/h)	OCDI	FS0000000
ANGLE (°)	0.1		
IMPACT SEVERITY (kJ)	337.9	**POST-IMPACT VEHICULAR BEHAVIOR**	
EXIT CONDITIONS		MAXIMUM ROLL ANGLE (°)	-7.0
VELOCITY (km/h)		MAXIMUM PITCH ANGLE (°)	-7.4
ANGLE (°)		MAXIMUM YAW ANGLE (°)	-165.3

DATA SHEET 4

SUMMARY OF RESULTS

Test Article:	TrafFix Devices Sentry End Treatment	Project No.:	P30040-01
Test Program:	NCHRP 350 3-41	Test Date:	04/15/10
Test Vehicle:	1998 Chevrolet 2500 Cheyenne		

GENERAL INFORMATION		OCCUPANT RISK VALUES	
TEST AGENCY	KARCO Engineering, LLC	FLAIL SPACE VELOCITY (m/sec)	
TEST NO.	3-41	X DIRECTION	11.1
DATE	4/15/2010	Y DIRECTION	0.1
TEST ARTICLE		THIV (Optional)	
TYPE	Crash Cushion	RIDEDOWN ACCELERATION (g's)	
INSTALLATION LENGTH	25.0 m (82.1 ft.)	X DIRECTION	-11.0
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 79.4 kg (175 lbs)	Y DIRECTION	-2.7
SOIL TYPE AND CONDITION	Concrete	PHD (Optional)	
TEST VEHICLE		ASI (Optional)	
TYPE	Production Model	**TEST ARTICLE DEFLECTIONS (m)**	
DESIGNATION	2000P	DYNAMIC	
MODEL	1998 Chevrolet 2500 Cheyenne	PERMANENT	
MASS (CURB)	2155 kg (4752 lbs)	**VEHICLE DAMAGE**	
MASS (TEST INERTIAL)	2034 kg (4484 lbs)	EXTERIOR	
DUMMY MASS	N/A	VDS	12-FC-5
MASS (GROSS STATIC)	2034 kg (4484 lbs)	CDC	12FCEN2
IMPACT CONDITIONS		INTERIOR	
VELOCITY (km/h)	102.0 km/h (63.3 mi/h)	OCDI	FS0000000
ANGLE (°)	0.1		
IMPACT SEVERITY (kJ)	815.9	**POST-IMPACT VEHICULAR BEHAVIOR**	
EXIT CONDITIONS		MAXIMUM ROLL ANGLE (°)	-6.0
VELOCITY (km/h)		MAXIMUM PITCH ANGLE (°)	3.4
ANGLE (°)		MAXIMUM YAW ANGLE (°)	-6.6

DATA SHEET 4

SUMMARY OF RESULTS

Test Article: TrafFix Devices Sentry End Treatment

Project No.: P30075-01

Test Program: NCHRP 350 3-43

Test Date: 06/17/10

Test Vehicle: 1998 Chevrolet Silverado 2500

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC
TEST NO.	3-43
DATE	6/17/2010
TEST ARTICLE	
TYPE	Crash Cushion
INSTALLATION LENGTH	25.1 m (82.4 ft.)
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 79.4 kg (175 lbs)
SOIL TYPE AND CONDITION	Concrete
TEST VEHICLE	
TYPE	Production Model
DESIGNATION	2000P
MODEL	1998 Chevrolet Silverado 2500
MASS (CURB)	2122.5 kg (4679 lbs)
MASS (TEST INERTIAL)	2044.0 kg (4506 lbs)
DUMMY MASS	N/A
MASS (GROSS STATIC)	2044.0 kg (4506 lbs)
IMPACT CONDITIONS	
VELOCITY (km/h)	102.4 km/h (63.6 mi/h)
ANGLE (°)	15.5
IMPACT SEVERITY (kJ)	826.8
EXIT CONDITIONS	
VELOCITY (km/h)	
ANGLE (°)	23.0

OCCUPANT RISK VALUES	
FLAIL SPACE VELOCITY (m/sec)	
X DIRECTION	8.0
Y DIRECTION	1.9
THIV (Optional)	
RIDEDOWN ACCELERATION (g's)	
X DIRECTION	-4.8
Y DIRECTION	3.7
PHD (Optional)	
ASI (Optional)	
TEST ARTICLE DEFLECTIONS (m)	
DYNAMIC	
PERMANENT	
VEHICLE DAMAGE	
EXTERIOR	
VDS	11-FL-4
CDC	11FLEN2
INTERIOR	
OCDI	FS0000000
POST-IMPACT VEHICULAR BEHAVIOR	
MAXIMUM ROLL ANGLE (°)	6.3
MAXIMUM PITCH ANGLE (°)	-2.7
MAXIMUM YAW ANGLE (°)	-14.3

DATA SHEET 4

SUMMARY OF RESULTS

Test Article: TrafFix Devices Sentry End Treatment

Project No.: P30043-01

Test Program: NCHRP 350 3-41

Test Date: 05/27/10

Test Vehicle: 1994 GMC Sierra 2500

GENERAL INFORMATION		OCCUPANT RISK VALUES	
TEST AGENCY	KARCO Engineering, LLC	FLAIL SPACE VELOCITY (m/sec)	
TEST NO.	3-41	X DIRECTION	9.2
DATE	5/27/2010	Y DIRECTION	0.1
TEST ARTICLE		THIV (Optional)	
TYPE	Crash Cushion	RIDEDOWN ACCELERATION (g's)	
INSTALLATION LENGTH	20.1 m (65.9 ft.)	X DIRECTION	-9.6
END TREATMENT LENGTH	7.9 m (25.9 ft.)	Y DIRECTION	-3.4
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 79.4 kg (175 lbs)	PHD (Optional)	
SOIL TYPE AND CONDITION	Concrete	ASI (Optional)	
TEST VEHICLE		**TEST ARTICLE DEFLECTIONS (m)**	
TYPE	Production Model	DYNAMIC	
DESIGNATION	2000P	PERMANENT	
MODEL	1994 GMC Sierra 2500		
MASS (CURB)	2092.5 kg (4614 lbs)	**VEHICLE DAMAGE**	
MASS (TEST INERTIAL)	2016 kg (4445 lbs)	EXTERIOR	
DUMMY MASS	N/A	VDS	12-FC-5
MASS (GROSS STATIC)	2016 kg (4445 lbs)	CDC	12FCEN2
IMPACT CONDITIONS		INTERIOR	
VELOCITY (km/h)	101.5 km/h (63.1 mi/h)	OCDI	FS0000000
ANGLE (°)	0.2		
IMPACT SEVERITY (kJ)	801.9	**POST-IMPACT VEHICULAR BEHAVIOR**	
EXIT CONDITIONS		MAXIMUM ROLL ANGLE (°)	-2.8
VELOCITY (km/h)		MAXIMUM PITCH ANGLE (°)	3.6
ANGLE (°)		MAXIMUM YAW ANGLE (°)	3.6

DATA SHEET 4

SUMMARY OF RESULTS

Test Article: TrafFix Devices Sentry End Treatment Project No.: P30072-01

Test Program: NCHRP 350 3-41 Test Date: 06/15/10

Test Vehicle: 1992 Chevrolet Silverado 2500

GENERAL INFORMATION		OCCUPANT RISK VALUES	
TEST AGENCY	KARCO Engineering, LLC	FLAIL SPACE VELOCITY (m/sec)	
TEST NO.	3-41	X DIRECTION	9.7
DATE	6/15/2010	Y DIRECTION	0.3
TEST ARTICLE		THIV (Optional)	
TYPE	Crash Cushion	RIDEDOWN ACCELERATION (g's)	
INSTALLATION LENGTH	20.3 m (66.6 ft.)	X DIRECTION	-12.3
END TREATMENT LENGTH	8.0 m (26.2 ft.)	Y DIRECTION	3.5
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 79.4 kg (175 lbs)	PHD (Optional)	
SOIL TYPE AND CONDITION	Concrete	ASI (Optional)	
TEST VEHICLE		**TEST ARTICLE DEFLECTIONS (m)**	
TYPE	Production Model	DYNAMIC	
DESIGNATION	2000P	PERMANENT	
MODEL	1992 Chevrolet Silverado 2500		
MASS (CURB)	2130 kg (4696 lbs)	**VEHICLE DAMAGE**	
MASS (TEST INERTIAL)	2013.5 kg (4439 lbs)	EXTERIOR	
DUMMY MASS	N/A	VDS	12-FC-5
MASS (GROSS STATIC)	2013.5 kg (4439 lbs)	CDC	12FCEN2
IMPACT CONDITIONS		INTERIOR	
VELOCITY (km/h)	99.1 km/h (61.5 mi/h)	OCDI	FS0000000
ANGLE (°)	0.1		
IMPACT SEVERITY (kJ)	762.6	**POST-IMPACT VEHICULAR BEHAVIOR**	
EXIT CONDITIONS		MAXIMUM ROLL ANGLE (°)	-5.6
VELOCITY (km/h)		MAXIMUM PITCH ANGLE (°)	-2.6
ANGLE (°)		MAXIMUM YAW ANGLE (°)	-4.1

DATA SHEET 4

SUMMARY OF RESULTS

Test Article: TrafFix Devices Sentry End Treatment CMB

Project No.: P30077-01

Test Program: NCHRP 350 3-44

Test Date: 06/28/10

Test Vehicle: 1996 Chevrolet Cheyenne 2500

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC
TEST NO.	3-44
DATE	6/28/2010
TEST ARTICLE	
TYPE	Crash Cushion
INSTALLATION LENGTH	20.3 m (66.6 ft)
END TREATMENT LENGTH	8.0 m (26.2 ft)
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 66.5 kg (146 lbs)
SOIL TYPE AND CONDITION	Concrete
TEST VEHICLE	
TYPE	Production Model
DESIGNATION	2000P
MODEL	1996 Chevrolet Cheyenne 2500
MASS (CURB)	2087.0 kg (4601 lbs)
MASS (TEST INERTIAL)	2044.5 kg (4507 lbs)
DUMMY MASS	N/A
MASS (GROSS STATIC)	2044.5 kg (4507 lbs)
IMPACT CONDITIONS	
VELOCITY (km/h)	103.1 km/h (64.1 mi/h)
ANGLE (°)	20.1
IMPACT SEVERITY (kJ)	99.0
EXIT CONDITIONS	
VELOCITY (km/h)	
ANGLE (°)	

OCCUPANT RISK VALUES	
FLAIL SPACE VELOCITY (m/sec)	
X DIRECTION	9.8
Y DIRECTION	2.2
THIV (Optional)	
RIDEDOWN ACCELERATION (g's)	
X DIRECTION	-10.6
Y DIRECTION	4.3
PHD (Optional)	
ASI (Optional)	
TEST ARTICLE DEFLECTIONS (m)	
DYNAMIC	
PERMANENT	
VEHICLE DAMAGE	
EXTERIOR	
VDS	1-FR-5
CDC	01FREW2
INTERIOR	
OCDI	FS0000000
POST-IMPACT VEHICULAR BEHAVIOR	
MAXIMUM ROLL ANGLE (°)	-35.7
MAXIMUM PITCH ANGLE (°)	-5.2
MAXIMUM YAW ANGLE (°)	-15.2

DATA SHEET 4

SUMMARY OF RESULTS

Test Article:	TrafFix Devices Sentry End Treatment CMB	Project No.:	P30074-01
Test Program:	NCHRP 350 3-44 (Modified)	Test Date:	06/16/10
Test Vehicle:	1990 Chevrolet Silverado		

GENERAL INFORMATION	
TEST AGENCY	KARCO Engineering, LLC
TEST NO.	NCHRP 350 3-44 (Modified)
DATE	6/16/2010
TEST ARTICLE	
TYPE	Crash Cushion
INSTALLATION LENGTH	20.3 m (66.5 ft)
END TREATMENT LENGTH	8.0 m (26.2 ft)
SIZE AND/OR DIMENSION OF KEY ELEMENTS	Nominal Mass 71.7 kg (158 lbs)
SOIL TYPE AND CONDITION	Concrete
TEST VEHICLE	
TYPE	Production Model
DESIGNATION	2000P
MODEL	1990 Chevrolet Silverado
MASS (CURB)	2020.5 kg (4454 lbs)
MASS (TEST INERTIAL)	1983.0 kg (4372 lbs)
DUMMY MASS	N/A
MASS (GROSS STATIC)	1983.0 kg (4372 lbs)
IMPACT CONDITIONS	
VELOCITY (km/h)	96.2 km/h (59.8 mi/h)
ANGLE (°)	15.0
IMPACT SEVERITY (kJ)	47.4
EXIT CONDITIONS	
VELOCITY (km/h)	
ANGLE (°)	

OCCUPANT RISK VALUES	
FLAIL SPACE VELOCITY (m/sec)	
X DIRECTION	8.4
Y DIRECTION	2.0
THIV (Optional)	
RIDEDOWN ACCELERATION (g's)	
X DIRECTION	-15.6
Y DIRECTION	7.4
PHD (Optional)	
ASI (Optional)	
TEST ARTICLE DEFLECTIONS (m)	
DYNAMIC	
PERMANENT	
VEHICLE DAMAGE	
EXTERIOR	
VDS	1-FR-5
CDC	01FREW2
INTERIOR	
OCDI	FS0000000
POST-IMPACT VEHICULAR BEHAVIOR	
MAXIMUM ROLL ANGLE (°)	-19.3
MAXIMUM PITCH ANGLE (°)	10.7
MAXIMUM YAW ANGLE (°)	4.0

WATER SOURCE INFORMATION:

Monterey Peninsula Water Management District

Gabby Ayala
Address: 5 Harris Court, Building G, Monterey, CA 93940
Mail: P.O. Box 85, Monterey, CA 93942-0085
Tel (831) 658-5601
Fax (831) 644-9558
e-mail: Gabby@mpwmd.net
Website: www.montereywaterinfo.org

San Lorenzo Valley Water District

Rick Rogers, Director of Operations
Address: 13060 Highway 9, Boulder Creek, CA 95006
Tel (831) 430-4624
Fax (831) 338-8002
e-mail: rrogers@slvwd.com

Soquel Creek Water District

Christine Mead, Operations and Maintenance Manager
Address: 5180 Soquel Drive, Soquel, CA 95073
Tel (831) 475-8501 ext 129 office
(831)359-1386 cell
e-mail: christinem@soquelcreekwater.org

Retrieved from Monterey Peninsula

Atanda, Rasaq L@DOT WATER AVAILABILITY DOCUMENTATION

From: Gabby Ayala <Gabby@mpwmd.net>
Sent: Monday, February 02, 2015 10:48 AM
To: Atanda, Rasaq L@DOT; Stephanie Locke
Cc: Sengmany, Anonh@DOT
Subject: RE: Caltrans Requesting for Water availability during construction activities
Attachments: Mobile Water Distribution Hydrant Meter Permit Application_REV_20140812.pdf

Good Morning Rasaq,

The MPWMD (District) will issue Hydrant Meter Permits (HMP) (a.k.a construction meter) for the construction and upgrade curb ramps and sidewalks project. A HMP is valid for 60 days from date of issuance, the District will allow two extensions of 60 additional days. A $70 fee is required for issuance of the initial permit (attached is a copy of the application). A separate permit is required for each jurisdiction.

It is important to note that the information provided in this email is based on District's current Rules and Regulations. The District's Rules and Regulations are subject to change by action of the Board of Directors. Applications are subject to the rules in effect at the time an application is received.

Gabby Ayala
MPWMD
831-658-5601

From: Atanda, Rasaq L@DOT [mailto:rasaq.atanda@dot.ca.gov]
Sent: Monday, February 02, 2015 9:23 AM
To: Stephanie Locke; Gabby Ayala
Cc: Sengmany, Anonh@DOT; Atanda, Rasaq L@DOT
Subject: Caltrans Requesting for Water availability during construction activities

Good Morning everybody,
Caltrans is preparing Plans, Specifications and Estimate for a project and construction of this project will start in September of 2015. This project will construct and upgrade curb ramps and sidewalks in compliance with the American Disabilities Act. Some of the curb ramps identified for upgrading are located in Monterey county. Please go through the locations and the intersections below where the curb ramps and the sidewalks will be constructed.

We have studied your websites and that of Association of California Water Agencies (ACWA). The two websites indicated that our project is in Monterey Peninsular Water District which is one of the Mandatory Water Restrictions districts in California. The estimated total of water required for this project is 11000 gallons.

I had tried to send you the locations of our constructions and I have made several fruitless attempts to send our plans to you as an attachment through e-mail with no success. The following are the locations identified for our ADA curb ramps and sidewalks; Route 1 @ Rio Rd, Route 1 @ Ocean Avenue, Route 1 @ Carpenter St., Route 1 @ Soledad Dr., Route 1 @ Aguajito Rd, Route 1 @ English Avenue. Also Route 68 @ 17 Mile Dr., Route 68 @ Grove Acre Avenue, Route 68 @ Piedmont, Route 68 @ Fairground, Route 68 @ Josselyn Cannyon Rd., Route 68 @ Route 218, Route 68 @ York Road, Route 68 @ Pasadera Dr., Route 218 @ Harcourt Rd, Route 218 @ Carlton Dr., and Route 218 @ Pheasant Ridge Rd.

We would like to know (1) if the locations are in your Water District Area. Most importantly (2) if there will be water available for use during construction activities of this project from Monterey Peninsular Water District. We would appreciate your effort in finding out and letting us know this information.

Thank you.

Rasaq Atanda
Transportation Engineer,
Caltrans Design Office,
Fresno, CA
559 244 2940

2 SAN LORENZO VALLEY WATER DISTRICT
SANTA CRUZ COUNTY

Atanda, Rasaq L@DOT

From: Rick Rogers <rrogers@slvwd.com>
Sent: Friday, February 06, 2015 6:45 AM
To: Atanda, Rasaq L@DOT
Cc: Stephanie Hill; Brian Lee; James Furtado
Subject: Caltrans Requesting for Water Usage clearance during construction activities

Rasaq,
In review of your projects two of the three projects are in the Districts service area. The Route 1 @ Freedom project is not in the Districts service area (not sure of District). At this time it is unknown the severity of the drought and water available for construction activities. The amount of water projected (4500 gallons) is not significant and the District will work with the selected contractor for construction water. To be on the safe side I would check back with the District two months prior to construction. The District understands the importance of these projects and will work with Cal-Tans to provide water if possible. If I can answer any questions please do not hesitate to contact me.

Thanks,

Rick

Rick Rogers
Director of Operations
San Lorenzo Valley Water District
13060 Highway 9
Boulder Creek CA 95006

Office 831-430-4624
Fax 831-338-8002
e-mail rrogers@slvwd.com

From: Stephanie Hill
Sent: Wednesday, February 04, 2015 8:16 AM
To: Rick Rogers
Cc: Brian Lee
Subject: FW: Caltrans Requesting for Water Usage clearance during construction activities

Believe this is something you handle? Let me know?

From: Atanda, Rasaq L@DOT [mailto:rasaq.atanda@dot.ca.gov]
Sent: Wednesday, February 04, 2015 8:11 AM
To: Stephanie Hill; Customer Service
Cc: Sengmany, Anonh@DOT
Subject: Caltrans Requesting for Water Usage clearance during construction activities

Good morning,

Caltrans is preparing Plans, Specifications and Estimate for a project and construction of this project will start in September of 2015. This project will construct and upgrade curb ramps and sidewalks in compliance with the American Disabilities Act. Some of the curb ramps identified for upgrading are located in Santa Cruz county. The specific locations are Route 9 @ San Lorenzo Valley High School, intersections of Route 9 @ Graham Hill Rd. and lastly Route 1 @ Freedom Boulevard.

We have studied your websites and that of Association of California Water Agencies (ACWA). The two websites indicated that our project is partly in San Lorenzo Water District and SLWD is one of the Mandatory Water Restrictions districts in California. The estimated total water required for these locations on the project mentioned above is 4500 gallons.

Please go through the attached Plans and the locations identified on the plans. We would like to know (1) if the locations are in your Water District Area. Most importantly (2) if there will be water available for use during construction activities of this project from San Lorenzo Water District. We would appreciate your effort in finding out and letting us know this information.

Thank you.

Rasaq Atanda
Transportation Engineer,
Caltrans Design Office,
Fresno, CA
559 244 2940

Atanda, Rasaq L@DOT

Response from Soquel Creek water District

From: Christine Mead <christinem@soquelcreekwater.org>
Sent: Friday, January 30, 2015 12:32 PM
To: Atanda, Rasaq L@DOT; rond@soquelcreekwater.org
Cc: Sengmany, Anonh@DOT
Subject: RE: Caltrans Requesting for Water Usage clearance for its upcoming project.

Rasaq –

I can only answer for the location of Hwy 1 @ Freedom Blvd. The area south of Hwy 1 in this area is in Soquel Creek Water District, but the area north of Hwy 1 is in Central Water District.

For the work @ Freedom Boulevard, you may purchase water from one of our bulk water stations. However, this water cannot be used outside of our District.

Let me know if you have any other questions.

Christine Mead
Operations and Maintenance Manager
Soquel Creek Water District
5180 Soquel Drive
Soquel, California 95073
831-475-8501 x129 office
831-359-1386 cell

From: Atanda, Rasaq L@DOT [mailto:rasaq.atanda@dot.ca.gov]
Sent: Thursday, January 29, 2015 2:05 PM
To: Ron Duncan; Christine Mead
Cc: Sengmany, Anonh@DOT; Atanda, Rasaq L@DOT
Subject: Caltrans Requesting for Water Usage clearance for its upcoming project.

Hello,
Caltrans is preparing Plans, Specifications and Estimate for a project and construction of this project will start in September of 2015. This project will construct and upgrade curb ramps and sidewalks in compliance with the American Disabilities Act. Some of the curb ramps identified for upgrading are located in Santa Cruz county. The specific locations are Route 9 @ San Lorenzo High School, intersections of Route 9 @ Graham Hill Rd. and lastly Route 1 @ Freedom Boulevard.

We have studied your websites and that of Association of California Water Agencies (ACWA). The two websites indicated that our project is partly in San Lorenzo Water District and SLWD is one of the Mandatory Water Restrictions districts in California. The estimated total water required for these locations on the project mentioned above is 4500 gallons.

Please go through the attached Plans and the locations identified on the plans. We would like to know (1) if the locations are in your Water District Area. Most importantly (2) if there will be water available for use during construction activities of this project from San Lorenzo Water District. We would appreciate your effort in finding out and letting us know this information.

ank you.

Rasaq Atanda
Transportation Engineer,