



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

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

August 22, 2011

In Reply Refer To:
HSST/B-223 and
HSST/CC-119

Mr. Dallas James
Armorflex International Ltd.
8 Paul Matthews Road,
North Harbour 0751
New Zealand.

Dear Mr. James:

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 systems:	ArmorZone™ Plastic Longitudinal Barrier; and, ArmorZone™ Plastic End Treatment
Type of system:	Longitudinal Barrier and End Treatment
Test Level:	NCHRP Report 350 Test Level 2 and MASH Test Level 2
Testing conducted by:	Holmes Solutions Ltd (HSL) and Safe Technologies, Inc (STI).
Date of request:	December 14, 2010
Request initially acknowledged:	December 17, 2010
Task Force 13 Designator:	SWM17 (Barrier) SCI29 (End treatment)

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

Requirements

Roadside safety devices should meet the guidelines contained in the NCHRP Report 350 when tested prior to January 1, 2011, and the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH) if tested after that date. The FHWA Memorandum "Identifying Acceptable Highway Safety Features" of July 25, 1997 provides further guidance on crash testing requirements of longitudinal barriers.



Decision

The following devices are found to be acceptable, with details provided below:

- ArmorZone™ Plastic Longitudinal Barrier Mash TL-2 Design (System “B”)
- ArmorZone™ Plastic End Treatment NCHRP Report 350 Design (System “C”)

The following device was not found acceptable:

- ArmorZone™ Plastic Longitudinal Barrier NCHRP Report 350 Design (System “A”)

Description

ArmorZone™ is a relatively low cost longitudinal barrier designed with an integral end treatment for use in work zone applications. The system will contain or redirect an errant vehicle when impacted beyond the beginning length of need, and is a gating design when impacted at or nearer to the upstream end terminal. Each ArmorZone™ unit is made from High Density Polyethylene (HDPE). It is a one piece roto-molded unit with a fill hole located on the top for internal access and a drain hole, complete with bung, at the bottom. The original design was filled with 520 liters (137 gallons) of water. The modified design, tested with the MASH pickup truck, contained 440 liters (116 gallons). The unit also has a series of ‘through holes’ which provide additional strength to the barrier during impact and also allow the unit to maintain its shape when filled with water. The units tested to MASH specifications each contain a 2152-millimeter (85-inch) galvanized steel bar, 75-millimeter (3-inch) wide by 6-millimeter (½-inch) thick. The steel bar is fitted through each unit, approximately 120-millimeters (5-inches) from the top of the barrier, and has 2 holes at either end which line up with the connection holes at each end of the HDPE unit. The ArmorZone™ unit has a nominal joined length of 2000-millimeters (79-inch), is 450-millimeters (18-inch) wide and 860-millimeters (34-inch) high. When multiple units are connected to each other and filled with water, they form a longitudinal barrier. They are connected with ‘twin pin’ connectors, consisting of two 37-millimeter (1½-inch) diameter by 850-millimeter (33½-inch) long steel pipes complete with internal RHS reinforcement. Enclosure 1 shows the design details for the MASH design. The NCHRP Report 350 design is identical but does not include the steel bar.

The ArmorZone™ end treatment is similar in appearance to the barrier segments, but is not filled with water and has additional holes and slots which reduce the strength of the unit to ensure crashworthiness. It does not include the steel bar found in the MASH barrier units. Enclosure 2 shows these details.

In all ArmorZone™ installations, every unit forming the barrier (except the ArmorZone™ end treatment unit) must be filled with the correct amount of water. Also the individual units must be connected to each other with the ‘twin pin’ connector but not fixed or anchored to the ground in any way.

Crash Testing

I. Testing Summary and Results for the ArmorZone™ longitudinal barrier:

Test 2-10 and 2-11 were conducted by Holmes Solutions Limited in New Zealand. Both tests were run on the original all-plastic barrier design (System “A”) and on 50-meter (164-foot) long installations with the impact points 13.6 meters (45 feet) from the upstream end. Though Test 2-10 met NCHRP Report 350 evaluation criteria, in Test 2-11, the pickup truck was re-directed and came to rest on top of the barrier after very nearly going over the top. Barrier deflection was reported to

be 2.1 meters (83 inches). Because the truck was not contained by the barrier, FHWA considers this result a failure of the NCHRP Report 350 version of the device. Enclosures 3 and 4 are summaries of both tests.

Test 2-11 was re-run by Safe Technologies, Inc. using the MASH pickup truck to validate the design changes noted above (the addition of an internal steel bar and another 'through hole', plus reducing the water volume by 80 liters (21 gallons). This test installation was also 50 meters (164 foot) long but the impact point was 23 meters (75 feet) from the upstream end. The pickup truck was smoothly re-directed with a maximum barrier deflection of 4.1 meters (13.5 feet). Enclosure 5 is the test summary sheet (System "B").

II. Testing Summary and Results for the ArmorZone™ end treatment:

Each of the three end treatment tests were conducted by Safe Technologies, Inc. (System "C"). Tests 2-40 and 2-41 were run on 26-meter (85-foot) long installations backed up to free-standing concrete barrier segments. In both tests the vehicles were brought to controlled stops and the occupant risk values were within the preferred limits. However, in Test 2-40, the end treatment and adjacent barrier units slid up and across the hood of the small car, resulting in extensive windshield damage. Enclosures 6 and 7 are summaries of these two tests.

Test 2-43 was run on a 40.2-meter (132-foot) long installation. The vehicle gated through the system as designed and came to rest approximately 30 meters (98 feet) downstream on the backside of the test installation. Enclosure 8 is the test summary sheet.

NCHRP Report 350 requires five tests for a non-redirective, gating terminal or crash cushion. You omitted Test 2-42 from the test matrix for the end treatment because Test 2-40 is a worse case test for occupant risk for the 820C vehicle and Test 2-43 is a worse case test for vehicle trajectory with the 2000P vehicle rather than the small car. The FHWA agrees with your reasoning for omitting Test 2-42.

You also omitted Test 2-44 which is intended to test the crashworthiness of a non-redirective terminal used to shield a rigid object. Because your barrier is not rigid, it is more appropriate to determine the point at which the barrier/terminal combination ceases to be gating but, instead, captures or redirects an impacting vehicle. The FHWA agrees with your analysis that NCHRP Report 350 Test 2-11 is a good substitute for Test 2-44 since that test was run with the impact point 13.6 meters (45 feet) from the upstream end and the vehicle was redirected. Your MASH Test 2-11 was run with the impact point 23 meters (75 feet) from the upstream end of the test installation and the heavier MASH truck was also redirected. Since the Test 2-11 impact angle is 25 degrees and the 2-44 impact angle is only 20 degrees, we agree that test 2-44 can be waived. Based on these two barrier tests, the beginning length of need point should begin approximately 13.6 meters (45 feet) downstream from the nose of the installation for the Report 350 design and 23 meters (75 feet) downstream for the MASH design. Should you wish to establish a length of need closer to the beginning of the barrier, additional testing will be required to determine the point at which containment or redirection can be attained.

Findings

You requested FHWA acceptance of the following two configurations for the ArmorZone™ longitudinal barrier:

- A. NCHRP Report 350 TL-2 design
- B. MASH TL-2 design.

In addition, you requested FHWA acceptance of the following configuration for the ArmorZone™ end treatment:

- C. NCHRP Report 350 TL-2 design

Systems “B” and “C” described above and shown in the Enclosures successfully passed all conducted testing. System “A” failed NCHRP Report 350 Test 2-11 due to vehicle override. The Occupant Impact Velocities (OIV) and Occupant Ridedown Accelerations (ORA) for all other tests were below the preferred limits. However, because your barrier is a “soft” system, deflections can be high and vehicles impacting the terminal at an angle can travel a significant distance behind the barrier. Thus, it is important that all users be aware of deflection distance requirements and of the necessity to keep the area behind and beyond the terminal clear of workers and/or construction materials and equipment.

In summary, with the exception of system “A” above, the remaining systems described above (B & C) and detailed in the enclosed drawings are 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 letter provides an AASHTO/ARTBA/AGC Task Force 13 designator that should be used to create a new or revised Task Force 13 drawing.
- 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 or MASH.
- To prevent misunderstanding by others, this letter of acceptance is designated as number B-223/CC-119 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 ArmorZone™ 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.

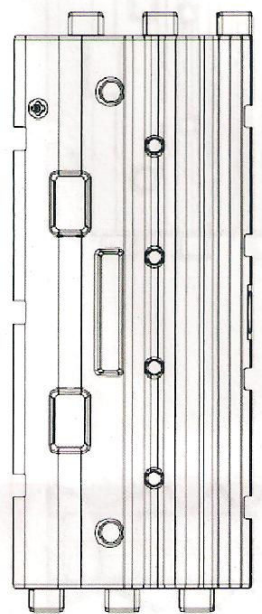
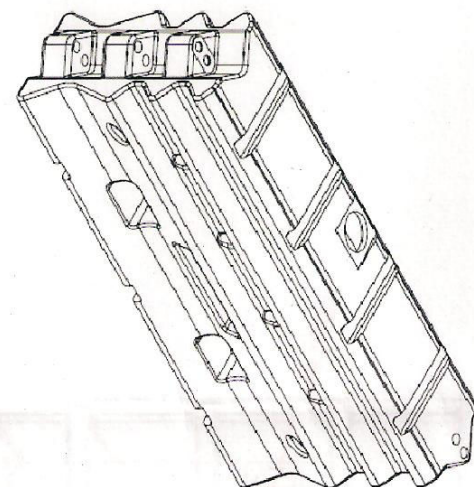
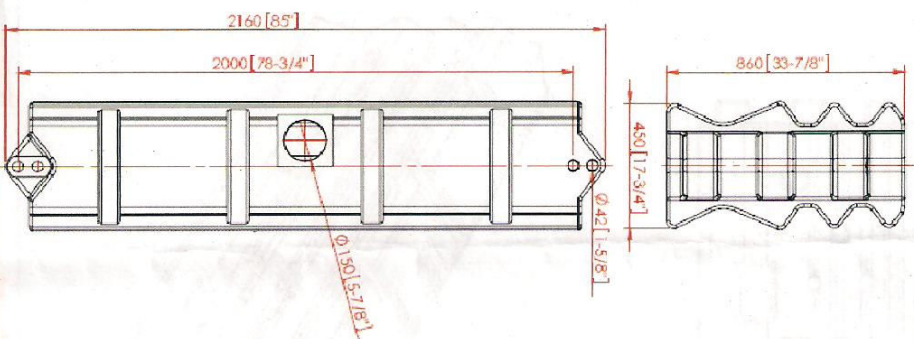
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,

A handwritten signature in blue ink that reads "Michael S. Griffith". The signature is written in a cursive style with a large, stylized "G" at the end.

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

Enclosures



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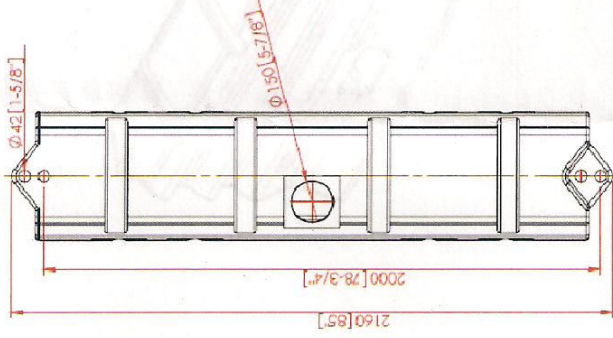
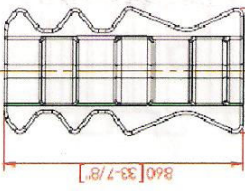
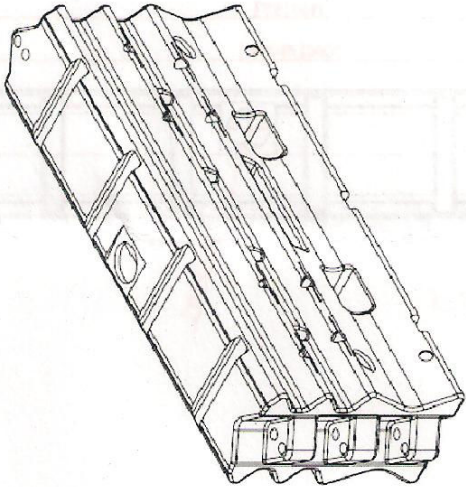
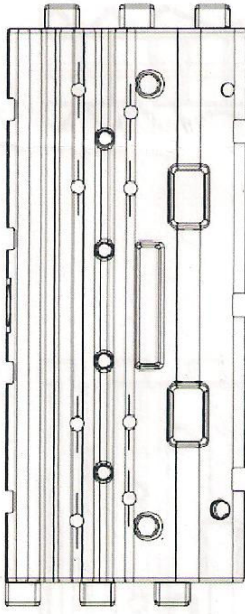
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	20/12/2010	DJ	

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SHEET	DRAWING NUMBER	REV.
1 OF 1	P-AZ-A1	

CHANGES	DATE



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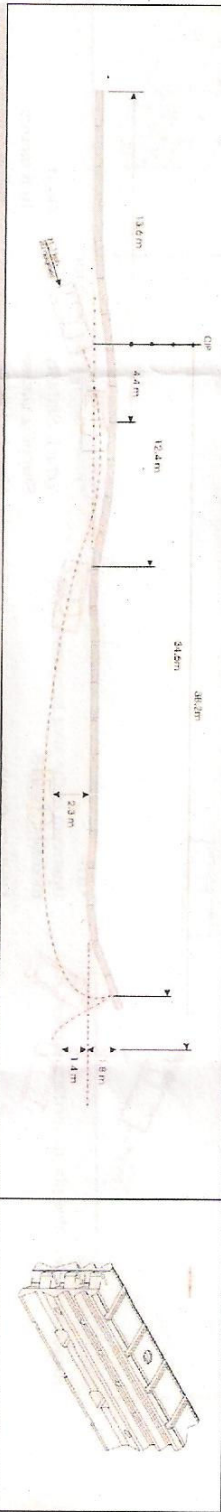
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APPRD BY: DATE: INIT.:
REV. CHANGES DATE

ArmorZone End Treatment

SHEET 1 OF 1 DRAWING NUMBER P-ET-A1 REV.



• TEST ARTICLE
 Armorflex water filled plastic median barrier

• CIP
 13.6 metres from upstream end of barrier

Test Level NCHRP Report 350 Test 2-10

Length..... 49.7 metres (25 x 1980 mm)
 Height..... 870 mm
 Width..... 450 mm
 Section Lengths 1980 mm
 Soil Type..... Asphalt surface

• TEST VEHICLE
 Designation..... 820C
 Make/Model..... Toyota Starlet EP81
 Dimensions (w/h) 3600 x 1595 x 1330 mm
 Test Weight..... 899 kg

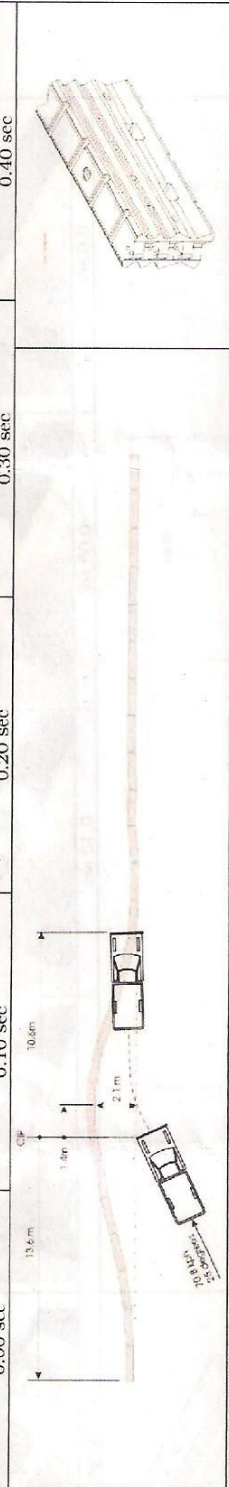
• IMPACT CONDITIONS

Impact Speed 71.7 kph
 Impact Angle 20 degrees
 Exit Speed 55 kph
 Exit Angle 17 degrees
• TEST ARTICLE DEFLECTIONS (METRES)
 Test Article Damage Minor
 Dynamic..... 1050 mm
 Permanent..... 1050 mm
 Working Width..... 1050 mm
• VEHICLE DAMAGE - EXTERIOR
 VDS..... 11-LFG-3
 CDC..... 11-PLLEP2
 Max Deformation 90 mm
• VEHICLE DAMAGE - INTERIOR
 OCCD..... AS 00000000
 Max. Deformation 0 mm

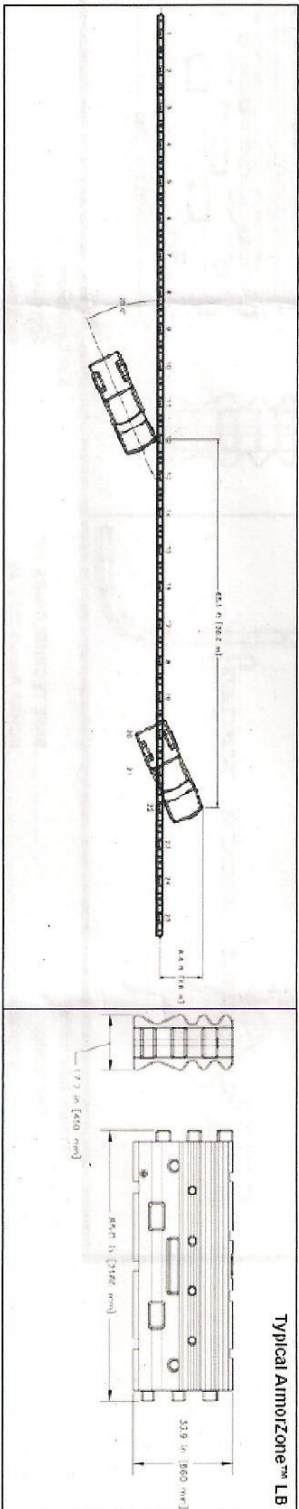
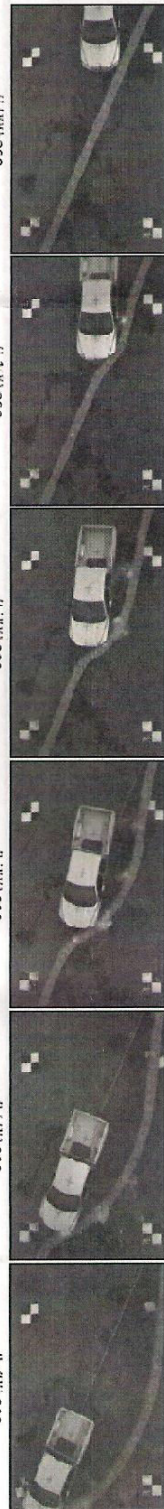
• POST IMPACT BEHAVIOUR

Vehicle Stability..... Good
 Stopping Distance..... 38.2 metres
 Max. Roll angle..... -10.9 ° at 4.0628 sec
 Max. Pitch angle..... -8.9° at 1.6850 sec
 Max. Yaw angle..... 142.7° at 3.9950 sec
• OCCUPANT RISK VALUES
 IMPACT VELOCITY (M/S - ON RIGHT SIDE OF INTERIOR)
 x-direction..... -2.4 m/sec at 0.1380 sec
 y-direction..... 4.0 m/sec at 0.1380 sec
 z-direction..... 5.1 m/sec at 0.1459 sec
 THIV
 RIDEOWN DECELERATIONS (g)
 x-direction..... -3.3 g at 2.6104 - 2.6204 sec
 y-direction..... -4.0 g at 0.2815 - 0.2915 sec
 PHD 4.1 at 0.2814 - 0.2914 sec
 ASI 0.60 at 0.0215 - 0.0715 sec
MAX. 0.050 SECOND AVERAGE (g)
 x-direction..... -2.6 g at 2.5809 - 2.6309 sec
 y-direction..... -5.0 g at 0.0129 - 0.0629 sec
 z-direction..... -1.1 g at 0.1203 - 0.1703 sec





* TEST ARTICLE Armorflex water filled plastic median barrier	* CIP Upstream of the joint between barrier modules 7 and 8.	* POST IMPACT BEHAVIOUR Vehicle Stability..... Stopping Distance..... Max. Roll angle..... Max. Pitch angle..... Max. Yaw angle.....
Test Level	NCHRP Report 350 Test 2-11	Good 10.6 metres 20.7 at 0.4446 sec 18.4 at 8.1498 -20.9 at 8.1498
Length.....	60 metres	* OCCUPANT RISK VALUES
Height.....	880 mm	IMPACT VELOCITY (MS - ON RIGHT SIDE OF INTERIOR)
Width.....	450mm	x-direction..... y-direction..... THIV.....
Section Lengths	12.38 metres	2.4 at 0.2278 sec 6.4 at 0.2553 sec
Soil Type.....	Asphalt surface	RIDEDOWN DECELERATIONS (G) x-direction..... y-direction..... PHD..... ASI..... MAX. 0.050 SECOND AVERAGE (G) x-direction..... y-direction..... z-direction.....
* TEST VEHICLE		-6.1 at 0.9755 - 0.9855 sec- 3.5 at 0.5333 - 0.5433 sec 6.3 at 0.9756 - 0.9856 sec 0.46 at 0.9221 - 0.9721 sec
Designation.....	2000P	
Make/Model.....	Chevrolet Silverado	
Dimensions (lwh).....	5530 x 1950 x 1825	
Test Weight.....	2010 kg	



General Information

Test Agency: Safe Technologies, Inc.
 Test Number: P2E02
 Test Designation: MASH 2-11
 Date: 11/30/2010
 Test Article Name: ArmorZone
 Type: Longitudinal Barrier
 Installation Length: 50 m (164.0 ft)
 Length: 2167 mm (85.0 in)
 Width: 450 mm (17.7 in)
 Height: 850 mm (33.9 in)
 Test Vehicle Type/Designation: 227ZF
 Make and Model: 2004 Dodge Ram 1500 Quad Cab Pick-up
 Curb Weight: 2151 kg (4742 lbs)
 Test Inertial Weight: 2292 kg (5053 lbs)
 Gross Static Weight: 2292 kg (5053 lbs)
 Impact Conditions
 Speed: 70.3 km/h (43.7 mph)
 Angle: 25.0 degrees
 Location/Orientation: Middle of # 12 barrier

Exit Conditions

Speed: N/A
 Angle: N/A
 Exit EOX Criterion: N/A
 Post-Impact Trajectory: N/A
 Vehicle Stability: Satisfactory
 Stopping Distance: 20.0 m (65.6 ft) downstream
 2.6 m (8.4 ft) laterally behind

Occupant Risk

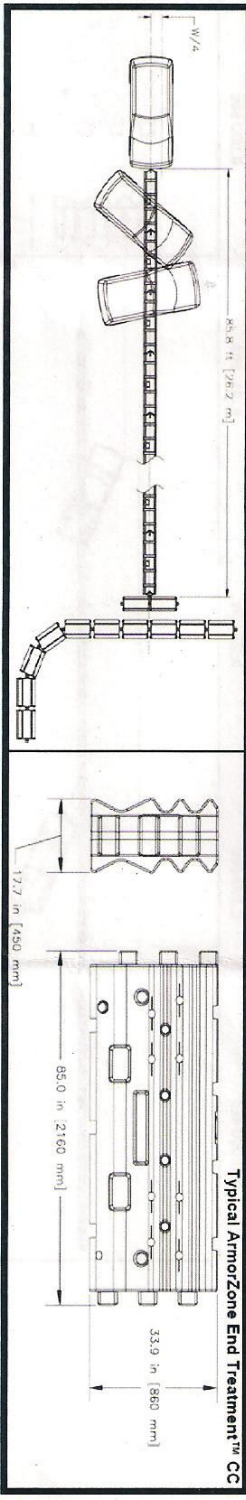
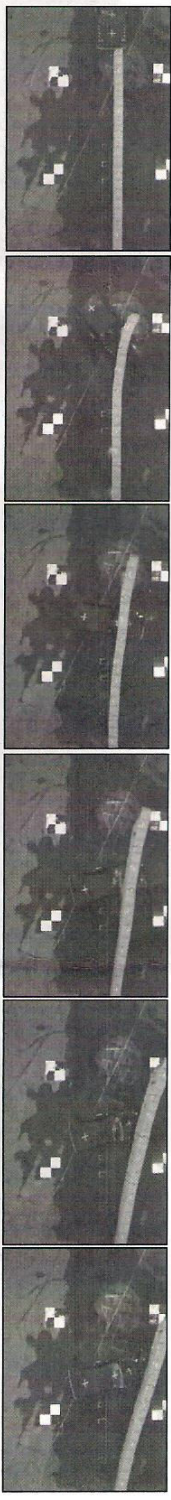
Longitudinal CIV: 4.2 ms (13.8 ft/s)
 Lateral CIV: 2.9 ms (8.9 ft/s)
 Longitudinal RA: 2.9 g's
 Lateral RA: 2.0 g's
 THIV: 4.9 ms (16.1 ft/s)
 PID: 0.3 g's

Test Article Damage:

Permanent Set: Moderate

Dynamic: 4.1 m (13.5 ft)
 Working Width: 4.1 m (13.5 ft)
 Vehicle Damage: 4.0 m (13.1 ft)

VDS: 11_FC_1
 CCC: 11FLEN1
 Maximum Deformation: 11C.0 mm (4.3 in) at front left bumper



General Information

Test Agency: SAFE TECHNOLOGIES, INC.
 Test Designation: NCHRP Report 350 2-40
 Test No.: STI Test # P2B07
 Date: 12/2/2010

Test Article

Type: Crash Cushion
 Name: ArmorZone End Treatment
 Dimensions: Length: 2160 mm (85.0 in)
 Size and/or dimension and material: Height: 450 mm (17.7 in)
 of key elements: Width: 850 mm (33.9 in)

Test Vehicle

Type: Production Model
 Designation: 820C
 Model: 1987 Honda CRX
 Mass (kg):
 Curb: 831
 Test Inertial: 811
 Dummy(s): 75
 Gross Static: 886

Impact Conditions
 Speed (kph): 70
 Angle (deg): 0
 Impact Severity (kJ): 153.3

Exit Conditions

Speed (kph): N/A
 Angle (deg): N/A

Occupant Risk Values

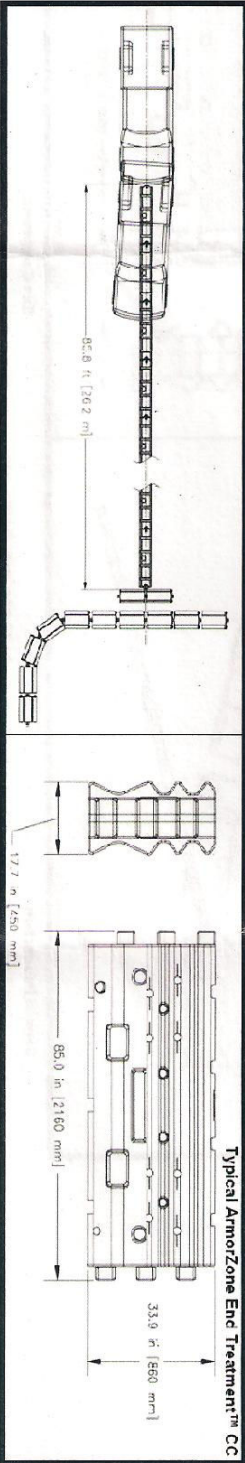
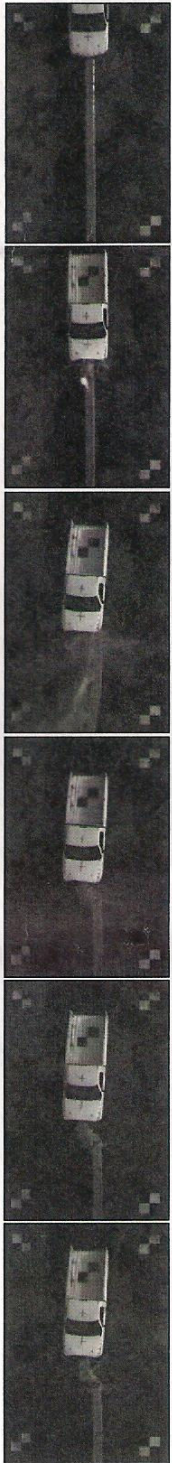
Impact Velocity (m/s):
 x-direction: 9
 y-direction: 1
 Ridedown Acceleration (g/s):
 x-direction: 7
 y-direction: 7

Test Article Deflection (mm)

Dynamic: N/A
 Permanent: N/A

Vehicle Damage

Exterior: VDS: 12-FL-3
 CDC: 12FLEN1
 Interior: OCCDI: LF0000000
Post-Impact Vehicular Behavior (deg - gyro @ c-g)
 Maximum Roll Angle: 7
 Maximum Pitch Angle: 4
 Maximum Yaw Angle: 106



General Information

Test Agency: **SAFE TECHNOLOGIES, INC.**
 Test Designation: **NCHRP Report 350 2-41**
 Test No: **STI Test # P2806**
 Date: **12/1/2010**

Test Article

Type: **Crash Cushion**
 Name: **ArmorZone End Treatment**
 Dimensions: **Length: 2136 mm (86.0 in)**
Size and/or dimension and material: Height: 450 mm (17.7 in)
of key elements: Width: 860 mm (33.9 in)

Test Vehicle

Type: **Production Model**
 Designation: **2000⁺**
 Model: **2000 Chevrolet 3/4 Ton Pickup**
 Mass (kg): **2171**
 Curb: **2113**
 Test Serial: **N/A**
 Dummy(s): **2013**
 Gross Static: **2013**

Impact Conditions
 Speed (kph): **72**
 Angle (deg): **0**
 Impact Severity (ku): **336.6**

Exit Conditions

Speed (kph): **N/A**
 Angle (deg): **N/A**
 Occupant Risk Values
 Impact Velocity (m/s): **9**
 X-direction: **1**
 Y-direction: **1**
 Ride-down Acceleration (g's): **10**
 X-direction: **1**
 Y-direction: **1**

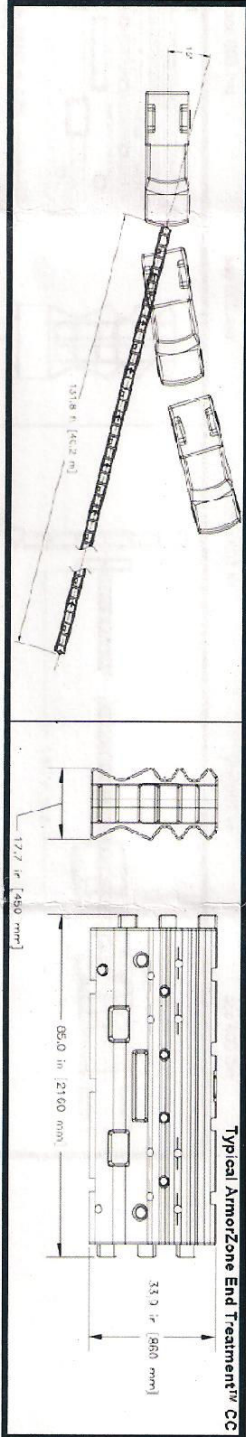
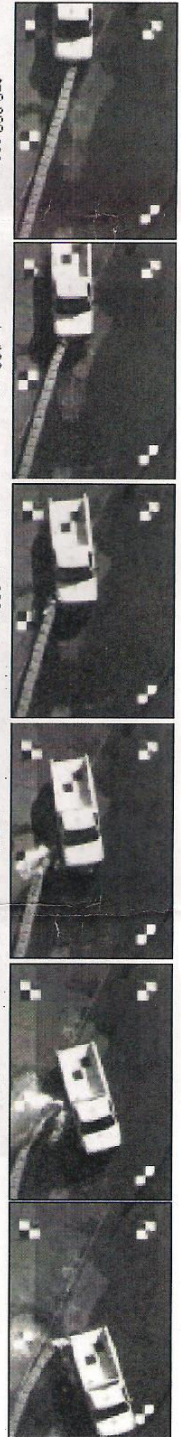
Test Article Deflection (mm)

Dynamic: **N/A**
 Permanent: **N/A**

Vehicle Damage

Exterior: **12 F-C 1**
 VDS: **12FCEN**
 Interior: **12FCEN**
 OCCU: **1-S0000000**

Post-Impact Vehicular Behavior (deg - gyro @ c.g.)
 Maximum Roll Angle: **5**
 Maximum Pitch Angle: **4**
 Maximum Yaw Angle: **4**



General Information

Test Agency: SAFE TECHNOLOGIES, INC.
 Test Designation: NCHRP Report 350 2-43
 Test No.: STI Test # P2B06
 Date: 12/1/2010

Test Article

Type: Crash Cushion
 Name: ArmorZone End Treatment
 Dimensions: Length: 2180 mm (85.0 in)
 Height: 450 mm (17.7 in)
 Size and/or dimension and material of key elements: Width: 850 mm (33.9 in)

Test Vehicle

Type: Production Model
 Designation: 2000+
 Model: 2001 Chevrolet 3/4 Ton Pickup
 Mass (kg): 2136
 Curb: 2024
 Test Inertial: N/A
 Durability(s): 2024
 Gross Static: 2024

Impact Conditions

Speed (mph): 89
 Angle (deg): 15
 Impact Severity (k.i): 368.4

Exit Conditions

Speed (mph): 26
 Angle (deg): 30

Occupant Risk Values

Impact Velocity (m/s):
 x-direction: 7
 v-direction: 3
 Riddown Acceleration (g's):
 x-direction: 3
 y-direction: 6

Test Article Deflector (mm)

Dynamic: N/A
 Permanent: N/A

Vehicle Damage

Exterior: VDS
 Interior: CDC
 OCCDI: 12-FC-1
 12-FCENI

Post-Impact Vehicular Behavior (deg - gwro @ 5-g)

Maximum Roll Angle: 4
 Maximum Pitch Angle: 7
 Maximum Yaw Angle: 14

FS0000000