



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

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

March 30, 2011

In Reply Refer To:
HSST/B-217

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 system:	Armorflex ORION™ Steel Barrier for Standard and Low Deflection Applications
Type of system:	Portable Longitudinal Steel Barrier
Test Level:	NCHRP Report 350 Test Level 3 (TL-3)
Testing conducted by:	Holmes Solutions Ltd and Safe Technologies Inc. Task Force 13
Designator:	SWM16
Date of request:	November 24, 2010
Request initially acknowledged:	December 7, 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 "Recommended Procedures for the Safety Performance Evaluation of Highway Features."

Requirements

Roadside safety devices should meet the guidelines contained in the NCHRP Report 350 or the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH). 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 acceptable, with details provided below:

- Orion™ TL-3 Standard Steel Barrier
- Orion™ TL-3 Low Deflection Steel Barrier



Description

The proprietary ORION™ Standard Steel Barrier (barrier) is a portable barrier for use on edge of road or a median application that is designed to redirect impacting vehicles on the traffic side of the system. This report addresses the following three (3) sets of system drawings and corresponding crash testing.

The first test article consisted of five 12.32 meters (40.4 feet) sections and one 8.4 meter (27.5 feet) section of temporary steel barrier giving a nominal length of 70 meters (230 feet). The first and last sections were pinned into Asphalt Concrete test surface. Test 3-10 with the 820C vehicle is described later.

The barrier is made up of nominal 12 meters (40 feet) long units connected to each other with two steel pins (2 x 32 millimeters (1.25 inches) diameter by 720 millimeters (28 inches) long) and anchored at either end to form a longitudinal barrier. Each side of the barrier is comprised of three (3) thrie-beam and three (3) w-beam standard guardrail panels positively fixed together with standard guardrail splice bolts. The side panels are made of a thrie beam panel located immediately above a w beam panel. These panels are fixed to two (2) internal and two (2) end frames, each of which include feet in contact with the roadway pavement, and three (3) internal horizontal trays which attach directly to the thrie beam only. Each barrier section measures 11.93 meters (470 inches) long x 865 millimeters (34 inches) high with an effective width of 450 millimeters (18 inches). The total width including (protruding) frame feet is 600 millimeters (24 inches).

Assembly of the barrier includes joining each individual section together using the 'twin-pin' connectors (2 x 32 millimeters (1-1/4 inches) diameter by 720 millimeters (28-1/2 inches) long steel pins). Standard anchoring of total barrier length requires anchoring barrier sections at either end using eight (8) hold-down pins at each end. The hold-down pins are 24 millimeters (1-inch) in diameter. The steel pin length is 500 millimeters (20 inches) long, embedded 450 millimeters (18 inches) into asphaltic concrete (AC).

Soil type & anchor pins: 200 millimeters (8 inches) thick AC with 8 x 24 millimeters (1-inch) diameter x 500 millimeters (20 inches) long pins at each end of the system with 450 millimeters (18 inches) embedment. The driven pins have no bonding agent.

Details of this system are provided as enclosure to this correspondence.

The second test article consisted of four 12.32 meters (40.4 feet) sections giving a nominal length of 49.3 meters (161.7 feet). The first and last sections were pinned into Asphalt Concrete test surface. Test 3-11 with the 2000P vehicle is described later.

Typical barrier sections consisted of a 12.32 meters (40.4 feet) long by 0.477 meter (19 inches) wide section of double sided self-supporting steel barrier. Each section has seven steel frames spaced at two meter intervals along the length of the section. Each frame measures 880 millimeters (34.5 inches) high by 315 millimeters (12.4 inches) wide with a 600 millimeters (23.6 inches) wide foot at the base. The frames located at the ends of each section incorporate three horizontal plates for joining to the next section via a vertical pin.

Mild steel angle cross bracing was fixed horizontally and at a height of 510 millimeters (20 inches) and bolted between each frame. The barrier face consisted of three 4.0 meter lengths (13 feet) of standard AASHTO M-180 Class A W-beam guard rail topped with three 4.0 meter (13 feet) lengths of standard AASHTO-M 180 Class A thrie-beam guard rail. The two rails sections combined total section height is 833 millimeters (32.75 inches). Guard rail sections were fixed to the frames with standard FBB01 16 x 35 and FBBO2 50 millimeters (2 inches) galvanized splice bolts.

This test was conducted specifying the following anchorage pattern. The first and last barrier sections were pinned to the asphalt concrete surface with eight pins. Each pin consisted of a M24 diameter x 450 millimeters (18 inches) length of galvanized threaded rod fitted with an M24 nut. Each pin passed through a 28 millimeters (1-inch) diameter hole in the barrier section footing and was adhered into the Asphalt Concrete surface to a depth of 400 millimeters (17.7 inches) using specialized structural concrete adhesive.

Soil type & anchor pins: 200 millimeters (8 inches) thick AC with 8 x 24 millimeters (1-inch) diameter x 500 millimeters (20 inches) long pins at each end of the system with 450 millimeters (18 inches) embedment. The driven pins also specify epoxy glue.

Details of this system are provided as enclosure to this correspondence.

The third test article consisted of the Low Deflection Steel Barrier for applications where a lower deflection is required. The Low Deflection Steel Barrier is anchored at the ends in the same manner as previously described for Standard Anchored applications, with an additional anchor pin every 3.81 meters (12.5 feet) on the traffic-side of the barrier face only. The installation length was 47 meters (154 feet). The critical impact point (CIP) was 23.5 meters (77 feet) from the downstream end (at join between barriers 2 and 3). This CIP area was anchored on Portland Cement Concrete (PCC). Barriers constructed from 3810 millimeters (12.5 feet) beams. The internal frames and horizontal bracing were modified. The total number of frames was decreased from 7 to 4 per barrier section and the horizontal bracing was changed from X-bracing to flat plates.

Specifications for the 24 millimeters (1 inch) diameter anchor pins are as follows:

1. 200 millimeters (8 inches) long pins, embedded 150 millimeters (6 inches) in 200 millimeters (8 inches) thick unreinforced PCC pad.
2. 500 millimeters (20 inches) long pins, embedded 450 millimeters (18 inches) in 75 millimeters (3 inches) thick AC pad.

In regards to crash testing of low deflection PCC anchorages (as per No. 1 listed above), FHWA assumes the worst case is that upon impact, the barrier will separate away from the concrete anchors. Since crash test result indicates this did not happen and the vehicle was redirected, this satisfies the requirements of NCHRP Report 350.

In regards to non-testing of low deflection AC anchorages (as per number 2 listed above), FHWA assumes these anchors might pull out of an asphalt pavement upon impact. This difference in deflection between AC and PCC anchorages should be addressed by the design of the anchors in asphalt to ensure they remain rigidly fixed as per the concrete anchors.

Details of this system are provided as enclosure to this correspondence.

Crash Testing

The barrier was crash tested at the test facilities at Holmes Solutions Limited testing facility located at the Wigram Airfield, Christchurch New Zealand according to the following NCHRP Report 350 testing criteria for the evaluation of temporary longitudinal barriers used in work and construction zones and as described below.

This report presents findings of the following four (4) tests required for compliance to NCHRP Report 350 TL-3 for this portable barrier. The specified crash testing for the first test article is as follows:

- A. Test 3-10: 820C, Small Car: An 820 kg small car impacting on the test article with a length of 70.0 meters (229 feet 8 inches) at an angle of 20 degrees, at a nominal speed of 100 kph (62 mph). The CIP was located 43 meters (141 feet 1-inch) from the barrier downstream end of the test installation. The purpose of this test is to evaluate the overall performance of the length of need section, in general, and occupant risks, in particular.
- B. Test 3-11: 2000P, Pick-up Truck: A 2000 kg pick-up truck impacting the test article at an angle of 25 degrees and at a nominal speed of 100 kph (62 mph). The CIP was located 43 meters (141 feet 1-inch) from the barrier downstream end. This test is designed to evaluate the strength of the test article section and its ability to contain and redirect a 2000P test vehicle. Two crash tests were conducted, one for each of the following anchorage patterns:
 1. Hold Down Pins: The first and last barrier sections were pinned to the Asphalt Concrete surface with eight mild steel pins per barrier section. Each pin consisted of a 25 millimeters (1-inch) diameter x 500 millimeters (20 inches) long pin with a steel retaining collar located 50 millimeters (2 inches) down from the top. Each pin passed through a hole in the barrier section footing and was driven through the Asphalt Concrete surface to a depth of 450 millimeters (17.7 inches).
 2. Hold Down Pins: Same as above with additional pins at every 3810 millimeters (12.5 feet) using 1 pin on the impact side of the barrier. The install length was 47 meters (154 feet) and the CIP was 23.5 meters (77 feet) from the downstream end (at join between barrier 2 and 3).
- C. Test 3-21: 2000P, Pick-up Truck: A 2000 kg pick-up truck impacting the test article at an angle of 25 degrees and at a nominal speed of 100 kph (62 mph). This test is intended to evaluate the maximum strength of the section in containing and redirecting a 2000P vehicle.

The install length was 49.2 meters (161 feet) and the CIP was 12 meters (40 feet) from the downstream end, 6 meters (20 feet) upstream of the first end anchors. The dynamic deflection was 970 millimeters (38 inches). The barriers are constructed from 4000 millimeters (13 feet) beams.

Findings

The analysis of the NCHRP Report 350 TL-3 testing showed there were no detached elements from the impacting vehicle or gate system that penetrated the occupant compartment of the impacting vehicle or presented hazards to others in the area. There was no significant deformation of the roof, windshield or occupant compartment. The occupant impact velocities and ridedown accelerations were within the recommended limits for the impacting vehicle.

Therefore, the system described in the request 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.

The crash test summary details of this system are provided as enclosure to this correspondence.

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 the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number B-217 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 Armorflex ORION[™] Steel Barrier 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 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 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.

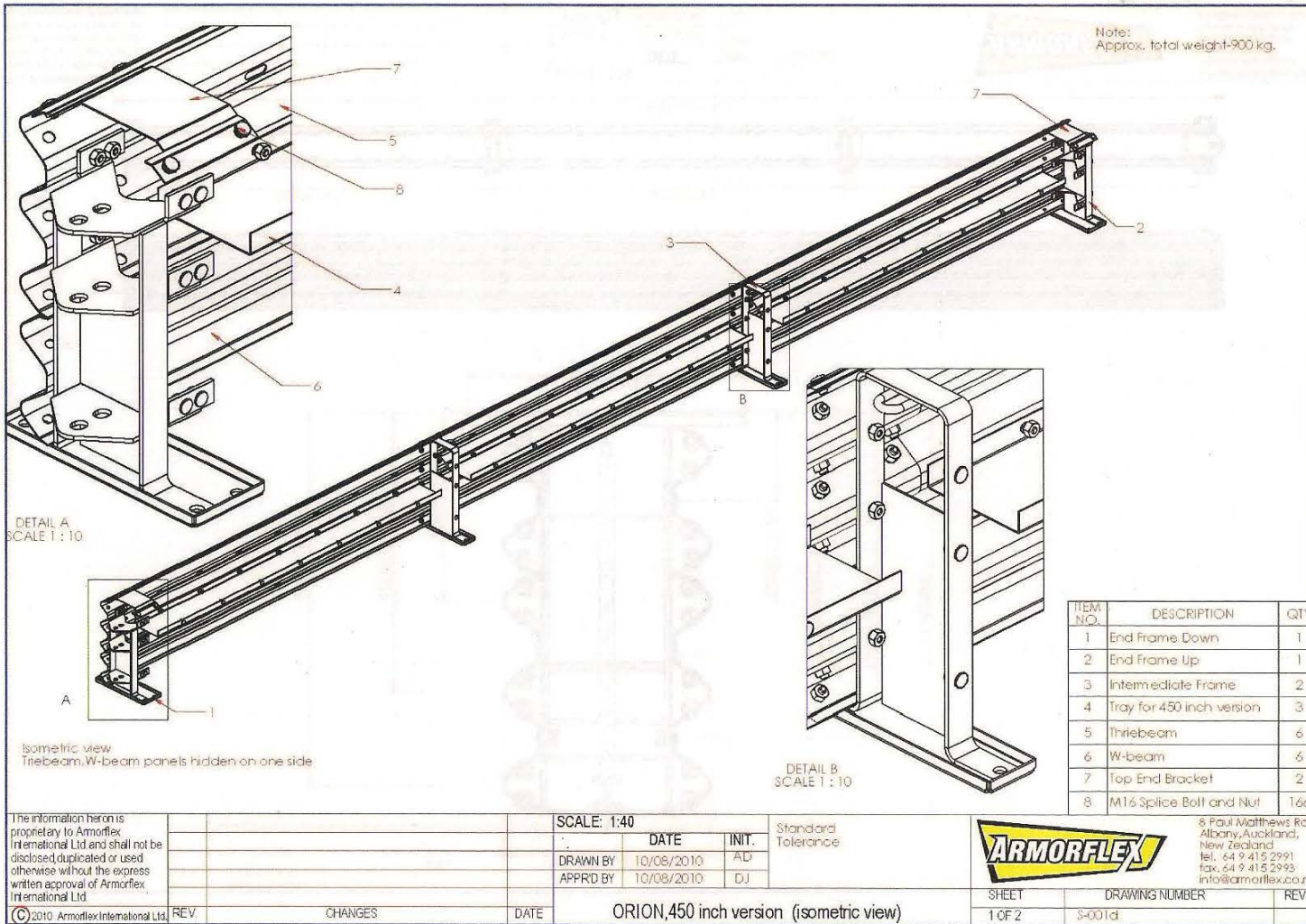
Sincerely yours,

A handwritten signature in cursive script that reads "Michael S. Griffith".

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

Enclosures

Illustration D-1



Appendix D

Appendix D (cont.)

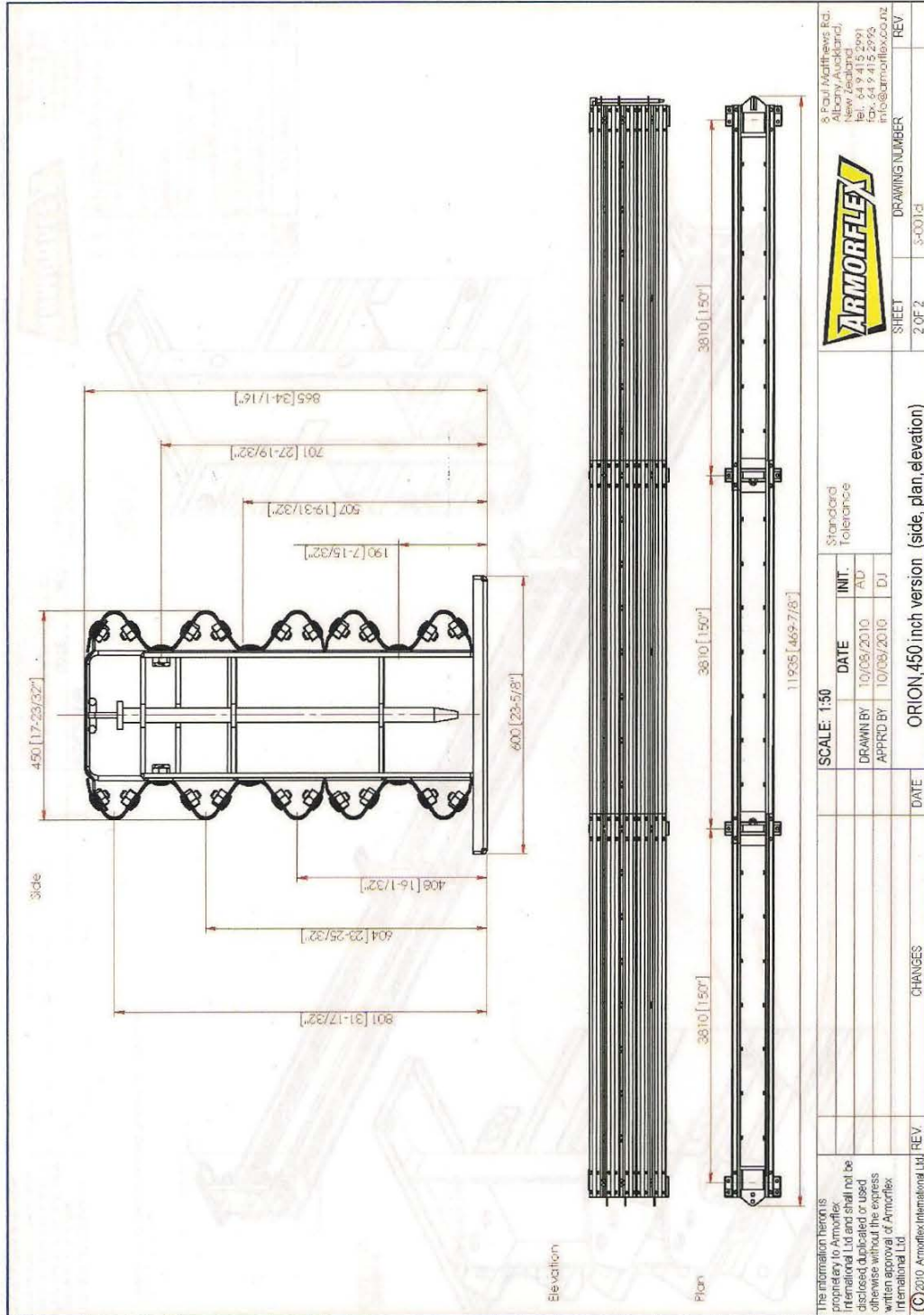
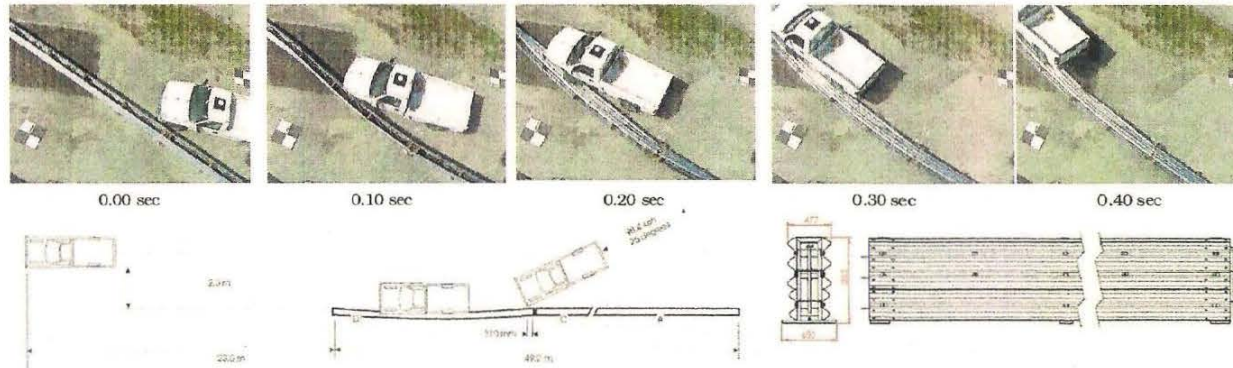


Illustration D-2



• TEST AGENCY	Holmes Solutions Ltd
• TEST NO.	102350.02-5-10 Test 3-21
• TEST DATE	19 November 2009
• TEST ARTICLE	Freestanding temporary roadside barrier
• INSTALLATION LENGTH	49.2 metres (4 sections)
• SOIL TYPE	Asphalt Concrete (AC) Surface
• KEY ELEMENTS - BARRIER	
Description.....	Steel w-beam barrier (double sided)
Section Lengths.....	4 x 12.3 m
Section Base Width.....	477 mm (600 mm at footing)
Height	883 mm
• TEST VEHICLE	
Designation.....	2000P Pick-up Truck
Make/Model.....	2001 Chevrolet Silverado
Curb Wt.....	2003 kg
Test Inertial Wt.....	2026 kg
Gross Static Wt.....	2026 kg
• IMPACT CONDITIONS	
Speed	99.4 kph
Angle	25 deg
• EXIT CONDITIONS	
Exit speed	84 kph
Exit angle	15 deg

• OCCUPANT IMPACT VELOCITY (MS)	
Longitudinal	3.9 ms (0.1182 s)
Lateral (optional).....	5.6 ms (0.1182 s)
THIV (optional).....	6.4 ms (0.1159 s)
• OCCUPANT RIDE/DOWN ACCELERATION (G)	
x-direction.....	-11.8 g (0.1350 - 0.1450 s)
y-direction.....	-7.4 g (0.1600 - 0.1700 s)
PHD (optional)	12.5 g (0.1158 - 0.1258 s)
ASI (optional)	0.88 (0.0584 - 0.1084 s)
• TEST ARTICLE DAMAGE	Moderate
• TEST ARTICLE DEFLECTIONS (M)	
Dynamic.....	0.97 m
Permanent.....	0.58 m
• VEHICLE DAMAGE - EXTERIOR	
VDS	11-FLQ-3
CDC	11-FLEE-2
Maximum Deformation	200 mm at LF Corner
• VEHICLE DAMAGE - INTERIOR	
OCDI	A5 000000
• POST IMPACT VEHICLE BEHAVIOR	
Max roll angle	25.0° at 1.5368 s
Max pitch angle	14.9° at 0.8482 s
Max yaw angle	43.6° at 1.6076 s

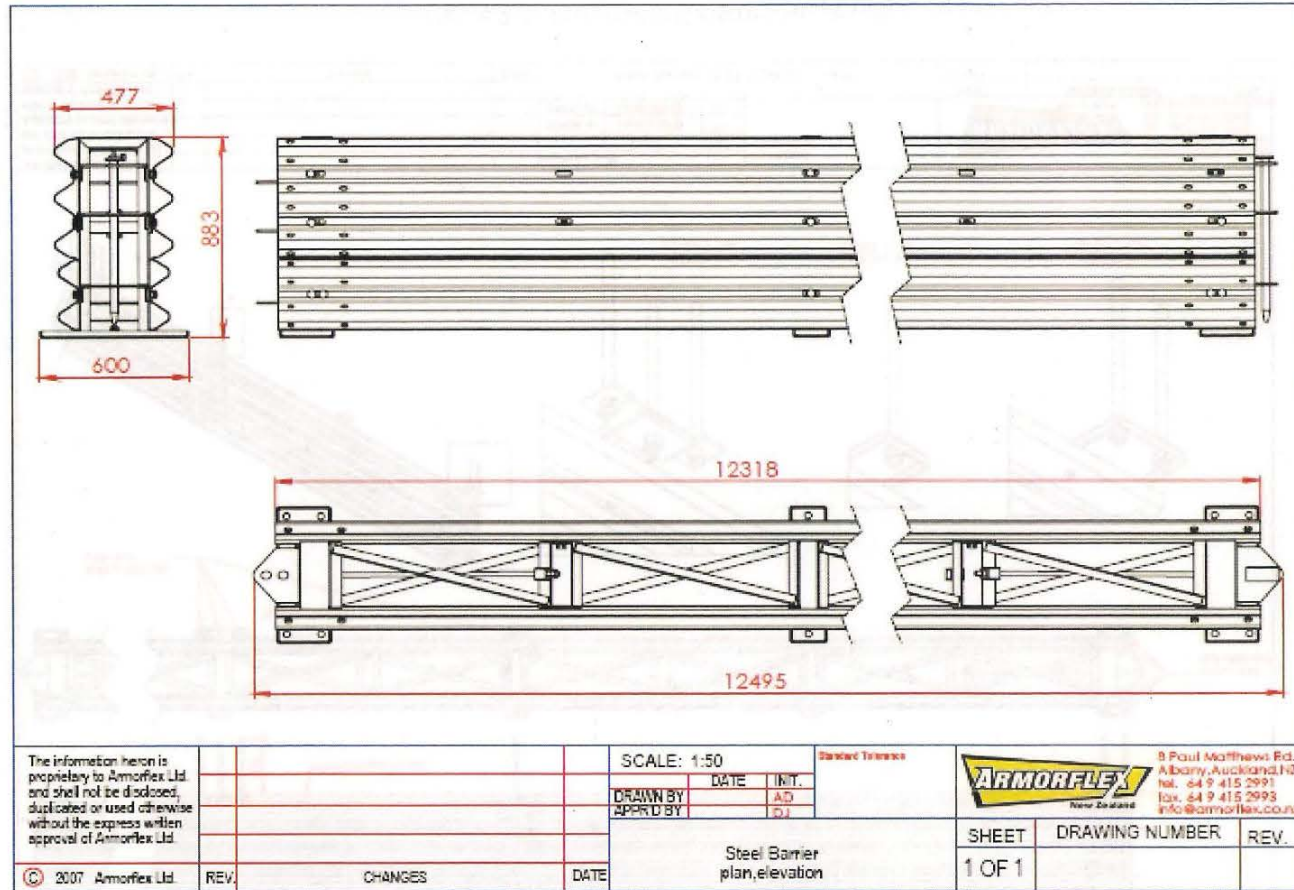


Figure 2-3: Typical Barrier Section

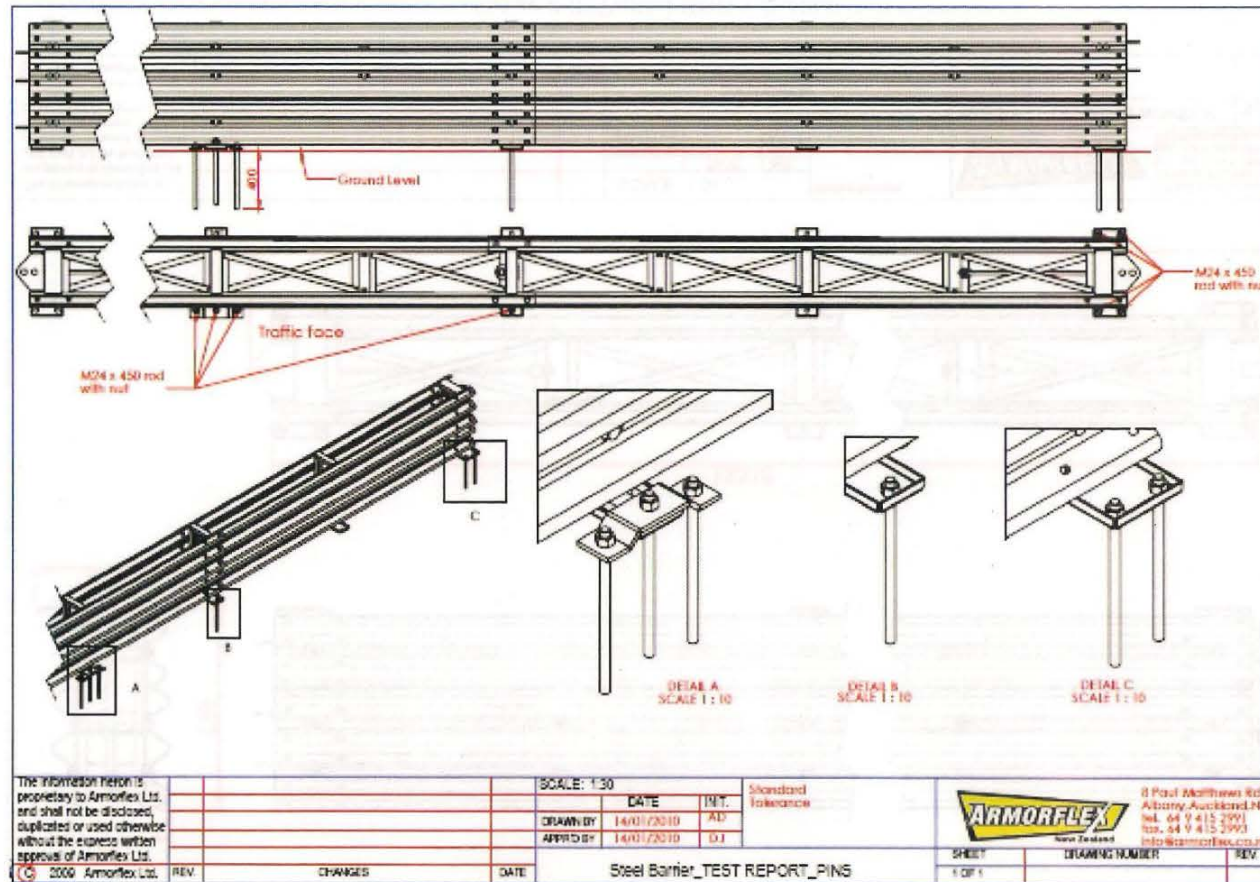


Figure 2-4: Test Article Construction Details

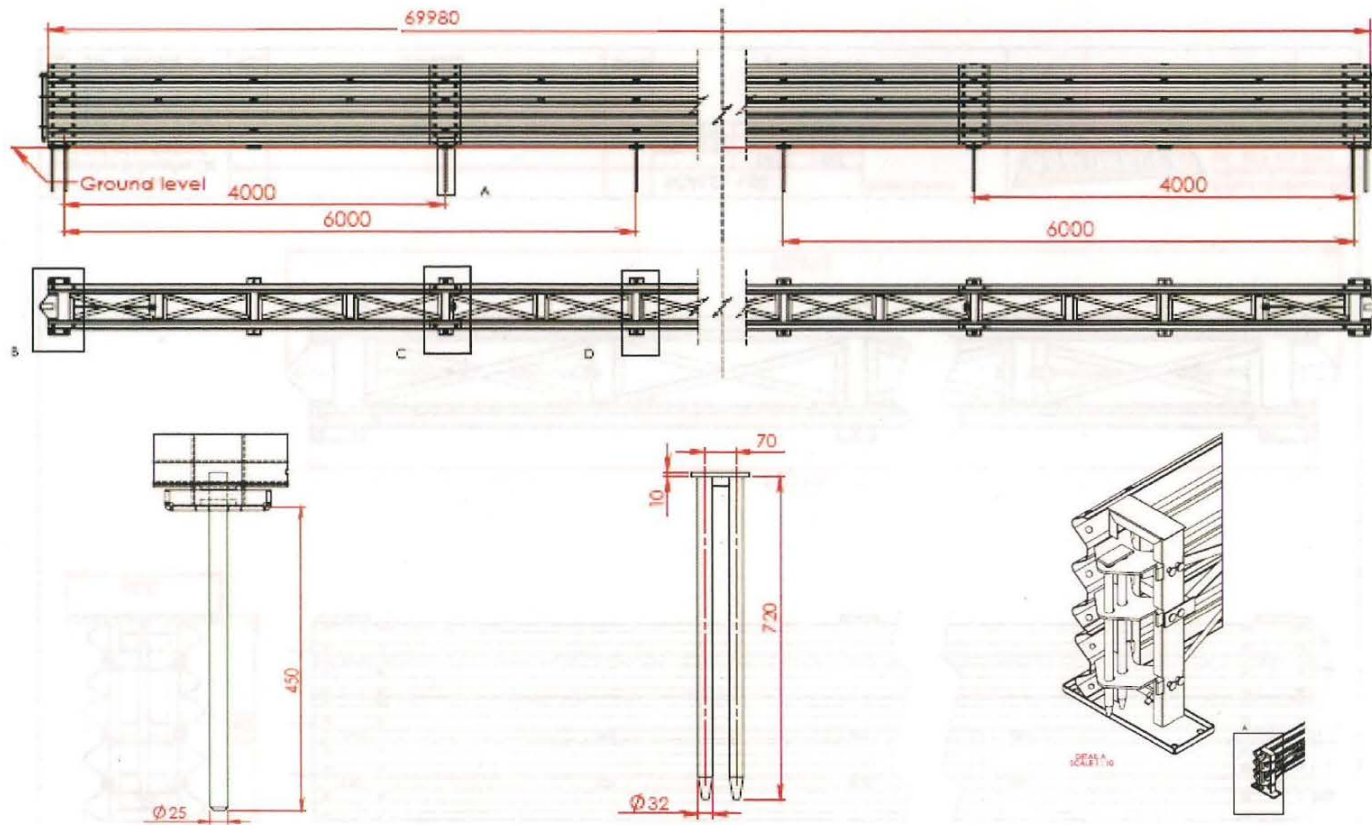
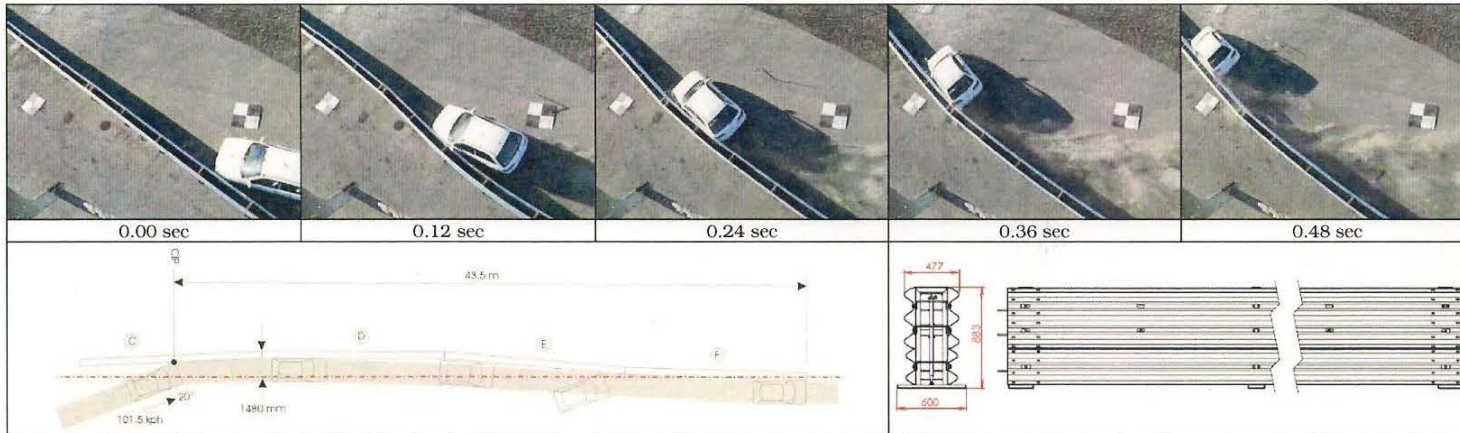


Figure 2-2: Test Article Details



***TEST ARTICLE**

Armorflex temporary steel median barrier

***CIP**

43.2 metres downstream of end of barrier

***POST IMPACT BEHAVIOUR**

Vehicle Stability..... Good
 Stopping Distance..... 32.5 metres
 Max. Roll angle..... 14.5° at 3.7076 sec**
 Max. Pitch angle..... 9.1 ° at 3.5235 sec**
 Max. Yaw angle..... -31.5 ° at 0.4050 sec

Test Level NCHRP Report 350 Test 3-10
 Length..... 70 metres
 Height..... 883 mm
 Width..... 477 mm (600 mm at feet)
 Section Lengths 5 x 12.3, 1 x 8.4
 Soil Type..... Asphalt concrete surface
 Grade AC14
 200 mm thick

***IMPACT CONDITIONS**

Impact Speed 101.5 kph
 Impact Angle 20 degrees
 Exit Speed -
 Exit Angle -

***OCCUPANT RISK VALUES**

IMPACT VELOCITY (MS - ON RIGHT SIDE OF INTERIOR)
 x-direction..... -3.1 ms at 0.1203 sec
 y-direction..... 4.8 ms at 0.1203 sec
 THIV 6.5 ms at 0.1275 sec

***TEST ARTICLE DEFLECTIONS (METRES)**

Test Article Damage moderate
 Dynamic..... 1450 mm
 Permanent..... 1450 mm
 Working Width..... 1450 mm

RIDEDOWN DECELERATIONS (G)

x-direction..... -2.6 g at 0.2340 - 0.2440 sec
 y-direction..... -6.1 g at 0.2278 - 0.2378 sec
 PHD 6.1 g at 0.2279 - 0.2379 sec
 ASI 0.87 at 0.0213 - 0.0713 sec

***TEST VEHICLE**

Designation..... 820C
 Make/Model..... Toyota Starlet EP81
 Dimensions (lwh) 3630 x 1530 x 1380
 Test Weight..... 901 kg

***VEHICLE DAMAGE - EXTERIOR**

VDS..... 11FL1
 CDC..... 11FLEE1
 Max Deformation 110 mm

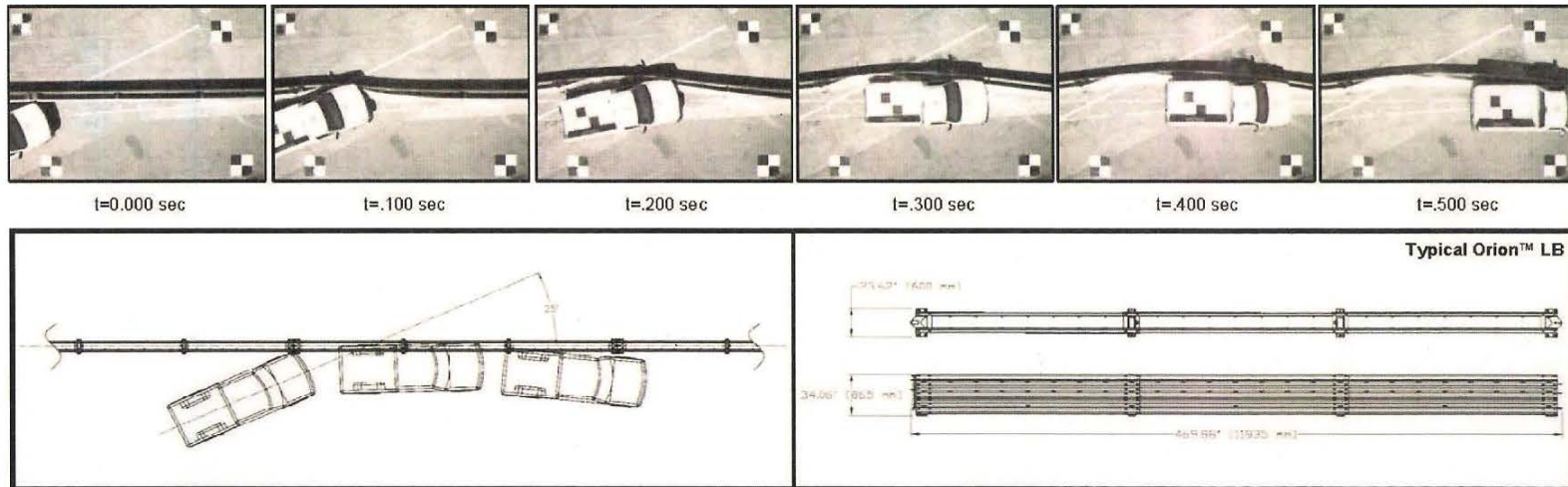
***VEHICLE DAMAGE - INTERIOR**

OCDI..... LF 0101000
 Max. Deformation 50.0 mm

MAX. 0.050 SECOND AVERAGE (G)

x-direction..... -4.2 g at 0.0188 - 0.0688 sec
 y-direction..... -7.1 g at 0.0212 - 0.712 sec
 z-direction..... 0.9 g at 0.3778 - 0.4278 sec

** Max. Roll and pitch values were recorded after the test vehicle had lost contact with the test article.



General Information

Test Agency..... **SAFE TECHNOLOGIES, INC.**
 Test Designation..... **NCHRP Report 360 3-11**
 Test No..... **STI Test # ORB01**
 Date..... **7/30/2010**

Test Article

Type Longitudinal Barrier
 Name Orion Longitudinal Barrier
 Dimensions Length: 11935 mm (469.88")
 Size and/or dimension and material Height: 865 mm (34.06")
 of key elements Width: 600 mm (23.62")

Test Vehicle

Type Production Model
 Designation 2000P
 Model 2001 Chevrolet 3/4 Ton Pickup
 Mass (kg)
 Curb 2134
 Test Inertial 2026
 Dummy(s) N/A
 Gross Static 2026

Impact Conditions

Speed (kph) 100
 Angle (deg) 25
 Impact Severity (kJ) 140.7

Exit Conditions

Speed (kph) 73
 Angle (deg) 7

Occupant Risk Values

Impact velocity (m/s)
 x-direction 6
 y-direction 5
 Ridedown Acceleration (g's)
 x-direction 5
 y-direction 12

Test Article Deflection (mm)

Dynamic 950
 Permanent 600

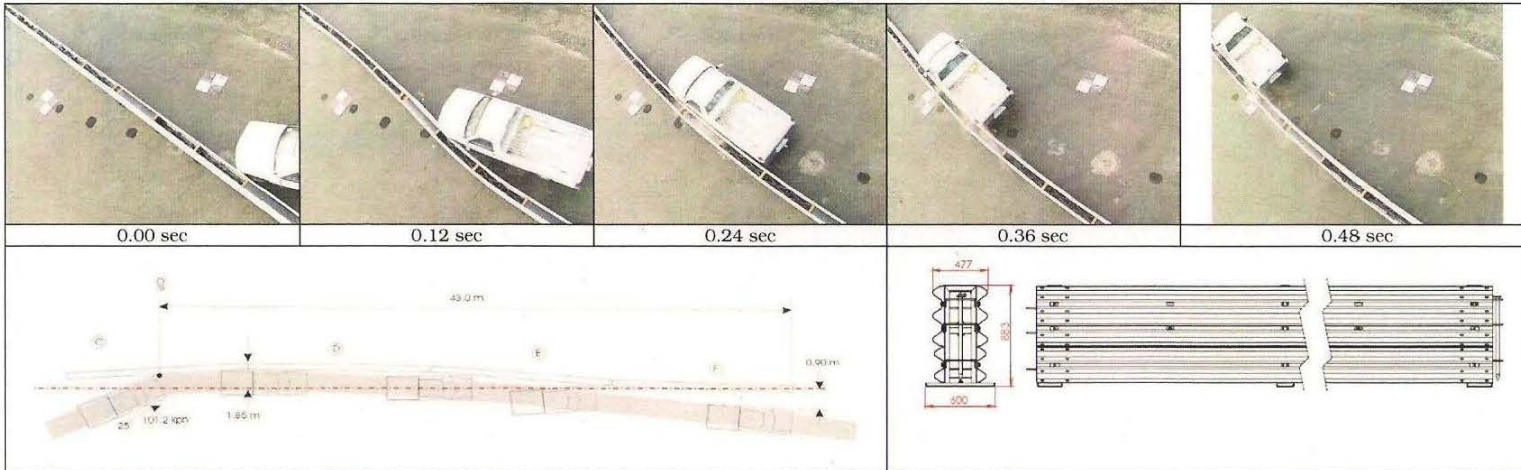
Vehicle Damage

Exterior
 VDS FL-2
 CDC 11FLEN1
 Interior
 OC DI LF0000000

Post-Impact Vehicular behavior (deg - gyro @ c.g)

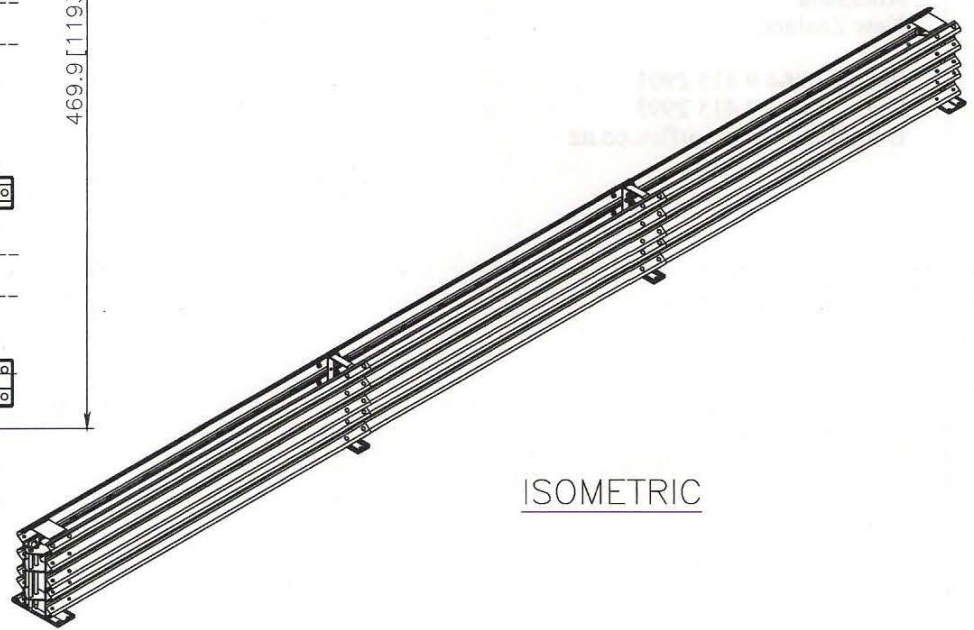
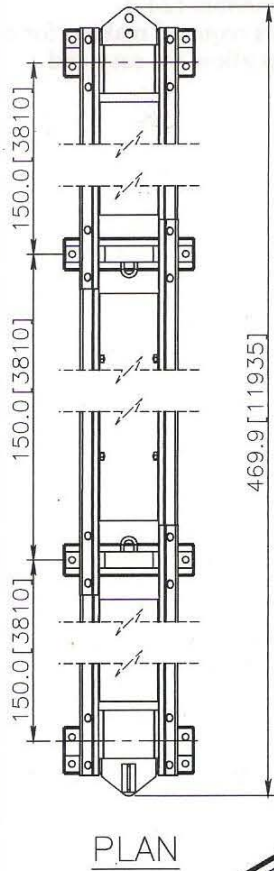
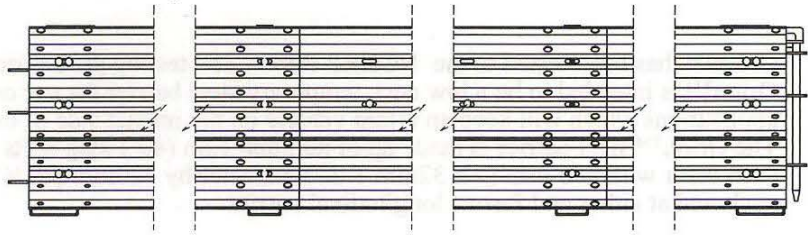
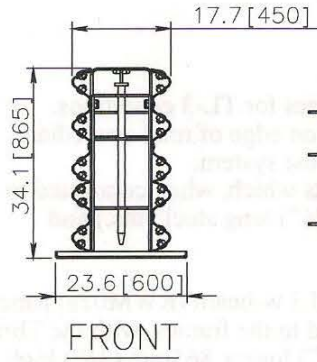
Maximum Roll Angle 11
 Maximum Pitch angle 20
 Maximum Yaw Angle 38

Figure 1. Summary of Results, Orion™ Test # ORB01



*TEST ARTICLE Armorflex temporary steel median barrier		*CIP 43.0 metres downstream of end of barrier		*POST IMPACT BEHAVIOUR	
Test Level NCHRP Report 350 Test 3-11		*IMPACT CONDITIONS		Vehicle Stability..... Good	
Length..... 69.98 metres		Impact Speed 101.2 kph		Stopping Distance..... 98 metres	
Height..... 883 mm		Impact Angle 25 degrees		Max. Roll angle..... 5.1° at 0.307 seconds	
Width..... 477 mm (600 mm at feet)		Exit Speed 51.4 kph		Max. Pitch angle..... 5.4° at 0.48 seconds	
Section Lengths 5 x 12.3, 1 x 8.4		Exit Angle 5°		Max. Yaw angle..... -34.8° at 1.783 seconds	
Soil Type..... Asphalt concrete surface		*TEST ARTICLE DEFLECTIONS (METRES)		*OCCUPANT RISK VALUES	
Grade AC14		Test Article Damage moderate		IMPACT VELOCITY (MS - ON RIGHT SIDE OF INTERIOR)	
200 mm thick		Dynamic..... 1850 mm		x-direction..... -	
		Permanent..... 1850 mm		y-direction..... -	
		Working Width..... 1850 mm		THIV -	
		*VEHICLE DAMAGE - EXTERIOR		RIDEDOWN DECELERATIONS (G)	
*TEST VEHICLE		VDS..... 11-FL-1		x-direction..... -1.24 g at 0.0 to 1.10 sec**	
Designation..... 2000P		CDC..... 11-FLEE-1		y-direction..... -	
Make/Model..... Chevrolet Silverado 2500		Max Deformation 80 mm		PHD -	
Dimensions (lwh) 5550 x 1950 x 1830		*VEHICLE DAMAGE - INTERIOR		ASI -	
Test Weight..... 2025.5 kg		OCDI..... AS0000000		MAX. 0.050 SECOND AVERAGE (G)	
		Max. Deformation 0.0 mm		x-direction..... -	
				y-direction..... -	
				z-direction..... -	

** Ridedown calculated as an average of impact and exit velocities, measured on time spent in contact with the test article.



2010

ORION

SHEET NO.	DATE:
1 of 2	23/11/2010

SPECIFICATIONS

Orion™ has been tested to the NCHRP Report 350 testing procedures for TL-3 conditions. Orion™ is intended to be a low cost, temporary steel barrier for use on edge of road or median applications which will keep an errant vehicle on the impact side of the system. The Orion™ steel barrier is made up of nominal 12m (40') long units which, when connected to each other with two pins (2 x 32mm 1 ¼") diameter by 720mm (28 ½") long steel pins.) and anchored at either end form a longitudinal barrier.

Each side of the barrier is comprised of 3 Thrie beam (RTM08a) and 3 w-beam (RWM02a) panels fixed together with standard guardrail splice bolts (FBB01) and fixed to the frames, with the Thrie beam immediately above the w beams. Each barrier is 11.93 m (470") long x 865mm (34") high and its effective width is 450mm (18") with the feet protruding to a width of 600mm (24") The Orion™ units are identical which means there are no special end units required making for easy installation. In addition the standard Thrie and W beam panels and fixings allow for easy and economical maintenance if required.

CONTACT INFORMATION

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2010

ORION

SHEET NO.	DATE:
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