June 17, 1999 Refer to: HMHS-CC35C

J.M. Essex, P.E.
Senior Vice President, Sales
Energy Absorption Systems, Inc.
One East Wacker Drive
Chicago, IL 60601

Dear Mr. Essex:

In your May 26 letter to me, you requested the Federal Highway Administration's review and acceptance of a 3-bay QuadGuard unit designed to meet the National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 2 (TL-2). A 6-bay design was accepted as a TL-3 attenuator on June 21, 1996. To support your request, you provided Mr. Richard Powers of my staff a copy of a May 1999 test report entitled "3 bay QuadGuard System Qualification to NCHRP 350 Test Level 2, Engineering Summary," which included the E-TECH Testing Services, Inc. report, also dated May 1999, entitled " NCHRP Report 350 Crash Test Results for the 3 Bay (Test Level 2) QuadGuard System" and a videotape showing the full-scale tests that were conducted.

The TL-2 design differs from your TL-3 unit only in its overall length (4000 mm vs. 6740 mm) and in the arrangement of its energy-absorbing cartridges. The TL-2 design uses Type I cartridges in the nose and in the first two bays and a type II cartridge in the third (or last) bay, as shown in Enclosure 1. Enclosure 2 consists of summaries of the four tests (2-30, 2-31, 2-32, and 2-38) you conducted to demonstrate compliance with Report 350 test and evaluation criteria. We previously agreed to waive test 2-33 and all redirection tests on parallel-sided systems since these were successfully done to certify the QuadGuard at TL-3. Earlier redirection tests on the Wide QuadGuard (run on the 6-bay design) were not directly comparable to a wide TL-2 design due to the significantly greater effective impact angle of a shorter unit having the same back width (2286 mm) as the Wide QuadGuard. However, test 2-38 demonstrated acceptable performance.

Based on our review of the information you submitted, we agree that a 3-bay QuadGuard, with backup widths of 610 mm, 762 mm, 914 mm, 1753 mm, or 2286 mm meets the appropriate evaluation criteria for an NCHRP Report 350 TL-2 crash cushion and that this design may be

used on the National Highway System (NHS) when a TL-2 device is warranted and selected by a transportation agency. Since the QuadGuard is a proprietary device, its use on Federal-aid projects, except exempt, non-NHS projects, is subject to the conditions listed in Title 23, Code of Federal Regulations, Section 635.411.

Sincerely yours,

(original signed by Rudolph M. Umbs)

for Dwight A. Horne
Director, Office of Highway Infrastructure

2 Enclosures

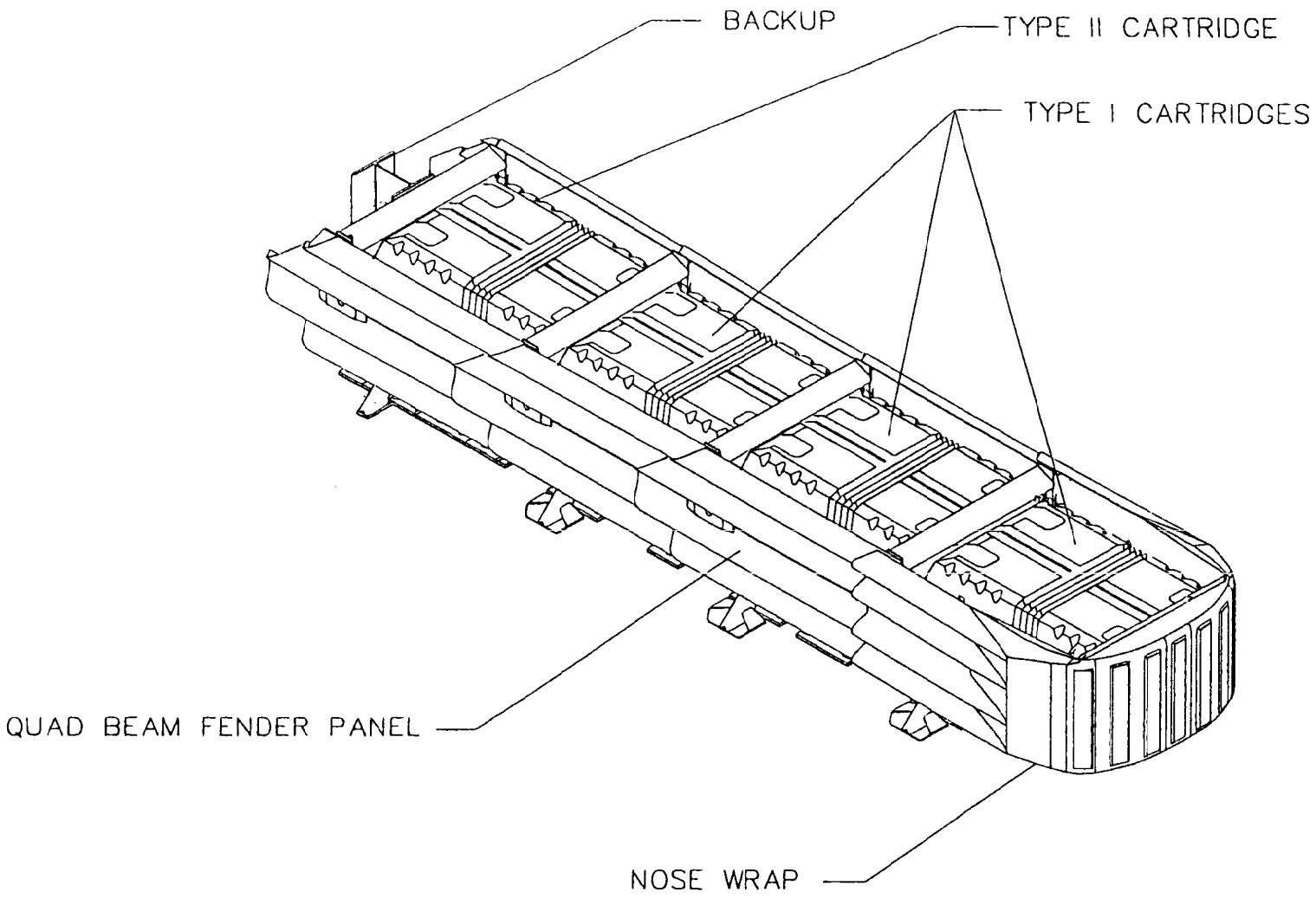


FIGURE 1

ENCLOSURE 1 (1 OF 2)

ENERGY ABSORPTION SYSTEMS, INC.
ENGINEERING AND RESEARCH DEPARTMENT

24" WIDE, 3 BAY, QuadGuard®

MAJOR SYSTEM COMPONENTS

SCALE	DWG.	SHEET	REV
NTS	TL2-FIG-1	Page 12	

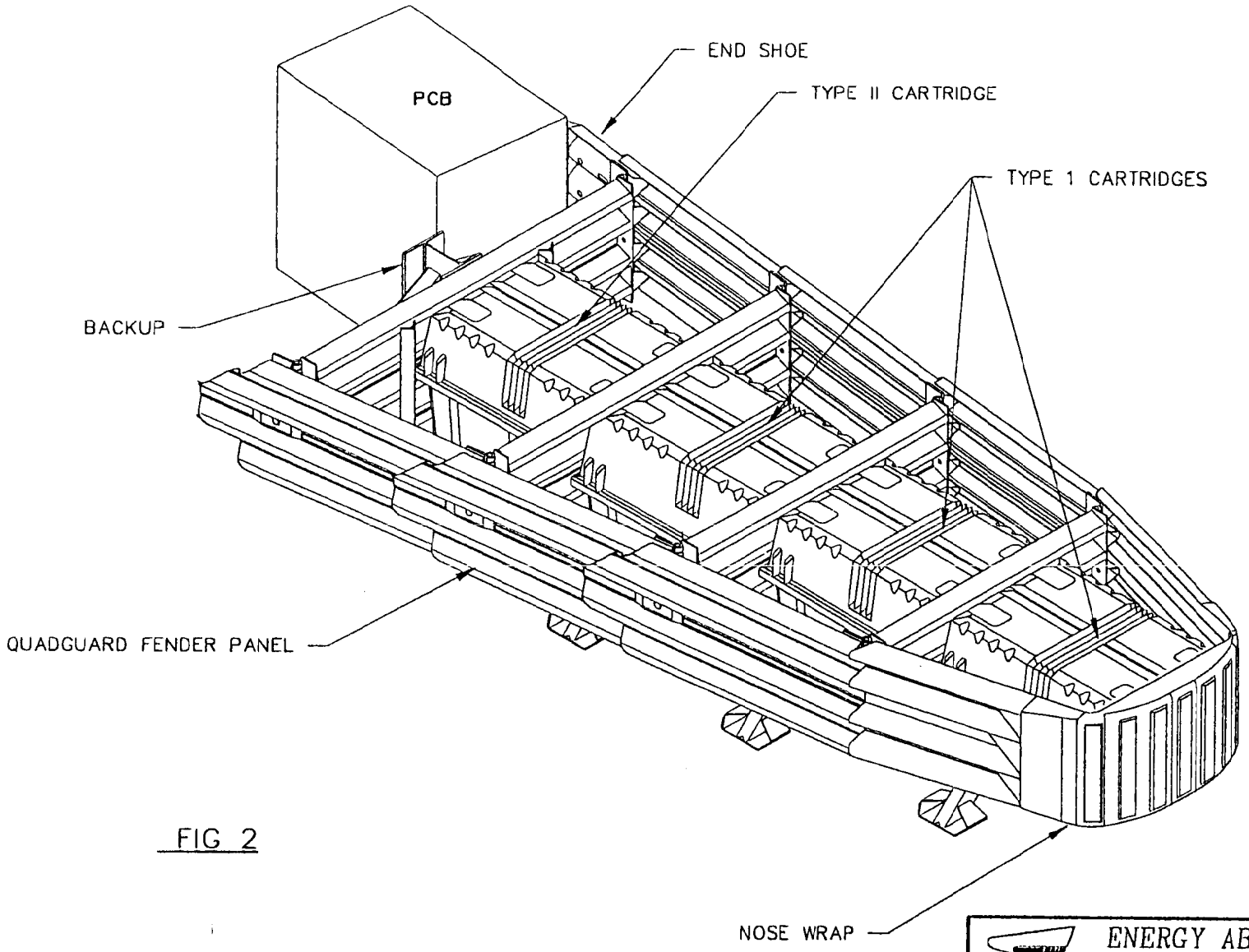


FIG 2

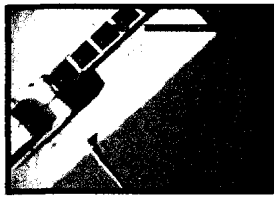
ENCLOSURE 1 (2 OF 2)

ENERGY ABSORPTION SYSTEMS, INC.
ENGINEERING AND RESEARCH DEPARTMENT

90" WIDE, 3 BAY, QuadGuard®

MAJOR SYSTEM COMPONENTS

SCALE	DWG.	SHEET	REV
NTS	TL2-FIG-2	Page 13	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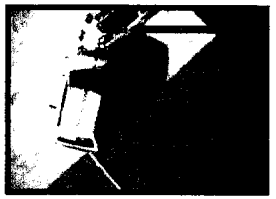
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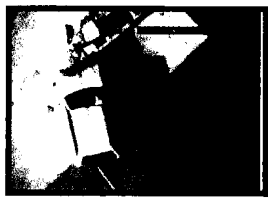
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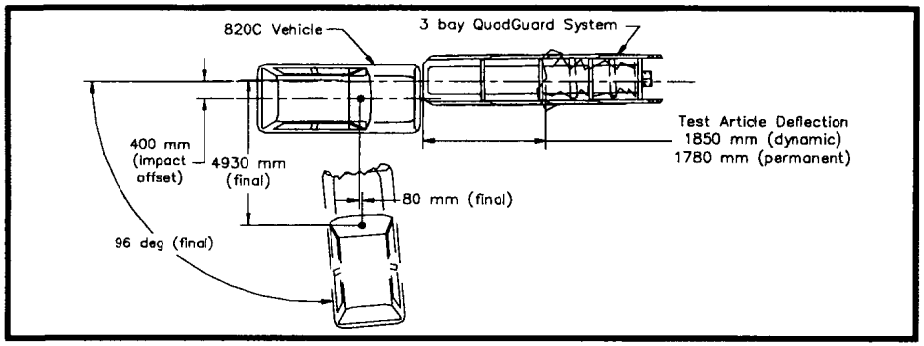

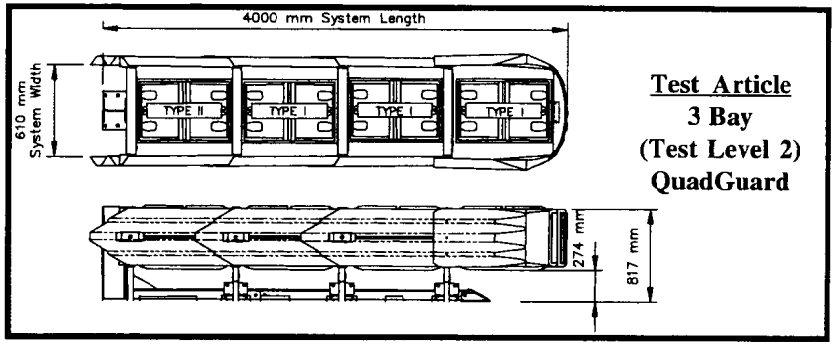

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-30
Test No.	01-7620-018
Date	12/29/98

Test Article

Type	Energy Absorption QuadGuard
	w/tension strut backup
Installation Length, (mm)	4000 (overall 3 Bay system)
Size and/or dimension and material of key elements	3 Bay (Test Level 2) QuadGuard
	w/610 mm wide backup
Foundation Type and Condition	Dry 203 mm deep unreinforced
	Portland Cement Concrete

Test Vehicle

Type	Production Model
Designation	820C
Model	1989 Ford Festiva
	Hatchback
Mass (kg)	
Curb	780.8
Test inertial	844.6
Dummy(s)	75.0
Gross Static	919.6

Impact Conditions

Speed (km/h)	68.64
Angle (deg)	0
Impact Severity (kJ)	153.51

Exit conditions

Speed (km/h)	N/A
Angle (deg)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	9.27
y-direction	0.99
Ridedown Acceleration (g's)	
x-direction	-15.40
y-direction	3.54
THIV (m/s)	9.31
PHD (g's)	13.27
ASI	1.08

Test Article Deflections (mm)

Dynamic	1850
Permanent	1780

Vehicle Damage

Exterior	
VDS	FC-3
CDC	12FCEW2
Interior	
OCDI	AS0000000

Post-Impact Vehicular Behavior (deg - gyro at c.g.)

Maximum Roll Angle	-10.36
Maximum Pitch Angle	-10.17
Maximum Yaw Angle	-96.07

Figure 1. Summary of Results - 3 Bay (Test Level 2) QuadGuard Test 01-7620-018

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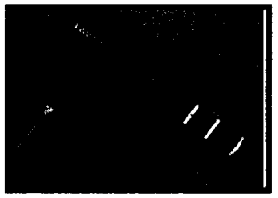

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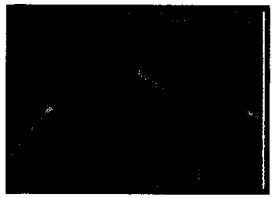

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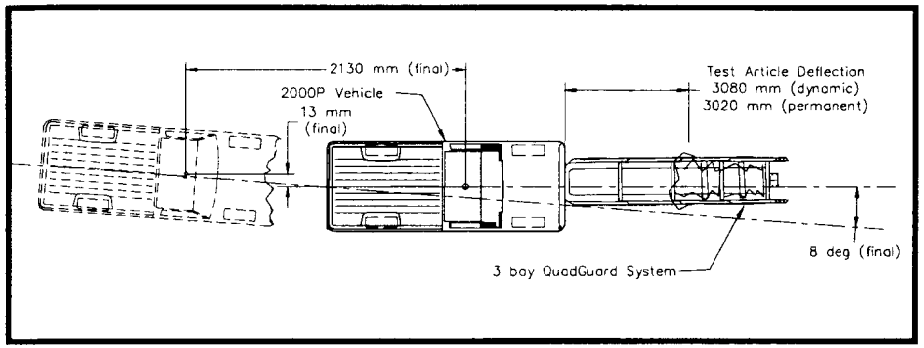
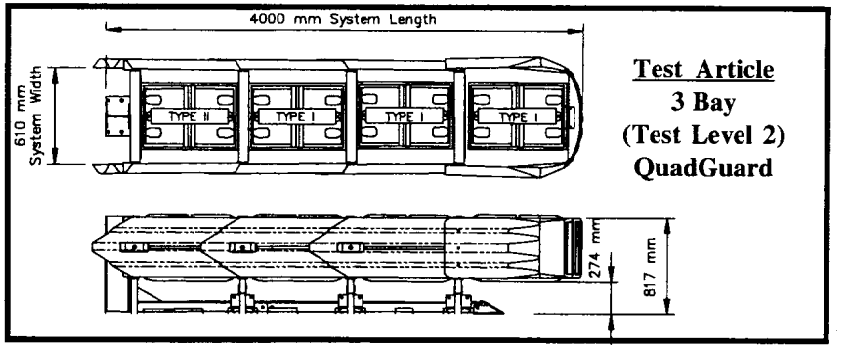




General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-31
Test No.	01-7620-016
Date	11/20/98

Test Article

Type	Energy Absorption QuadGuard w/tension strut backup
Installation Length, (mm)	4000 (overall 3 Bay system)
Size and/or dimension and material of key elements	3 Bay (Test Level 2) QuadGuard w/610 mm wide backup
Foundation Type and Condition	Dry 203 mm deep unreinforced Portland Cement Concrete

Test Vehicle

Type	Production Model
Designation	2000P
Model	1990 Chevrolet C2500 3/4 T Pickup
Mass (kg)	
Curb	2094.4
Test inertial	2016.0
Dummy(s)	N/A
Gross Static	2016.0

Impact Conditions

Speed (km/h)	66.75
Angle (deg)	0
Impact Severity (kJ)	346.53

Exit conditions

Speed (km/h)	N/A
Angle (deg)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	8.90
y-direction	-0.25
Ridedown Acceleration (g's)	
x-direction	-19.58
y-direction	-4.41
THIV (m/s)	8.90
PHD (g's)	15.23
ASI	N/A

Test Article Deflections (mm)

Dynamic	3080
Permanent	3020

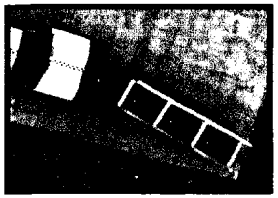
Vehicle Damage

Exterior	
VDS	FC-3
CDC	12FCEW2
Interior	
OCDI	AS0000000

Post-Impact Vehicular Behavior (deg - gyro at c.g.)

Maximum Roll Angle	-4.88
Maximum Pitch Angle	2.34
Maximum Yaw Angle	7.93

Figure 6. Summary of Results - 3 Bay (Test Level 2) QuadGuard Test 01-7620-016



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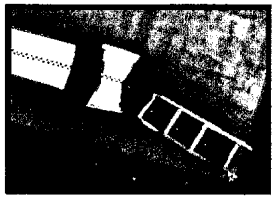

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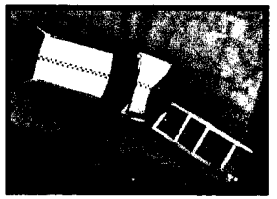

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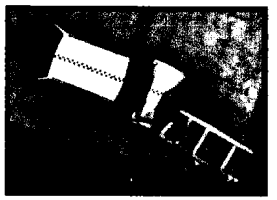

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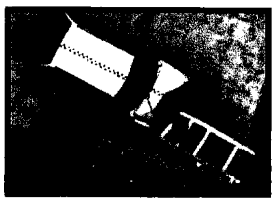

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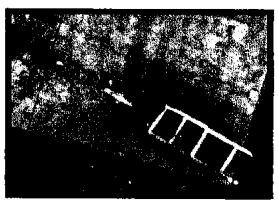

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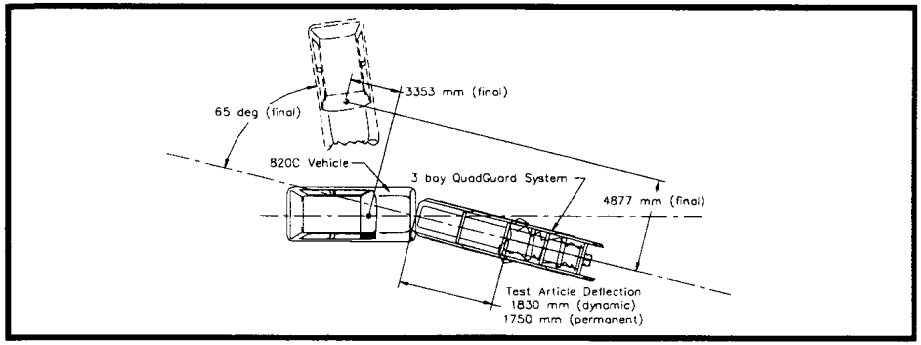
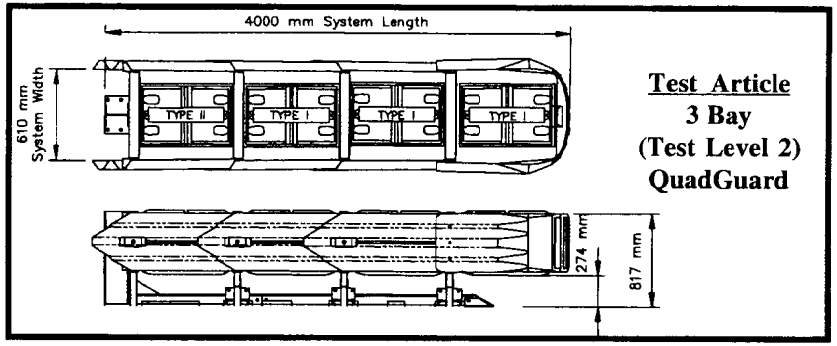




General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-32
Test No.	01-7620-017
Date	12/11/98

Test Article

Type	Energy Absorption QuadGuard
	w/tension strut backup
Installation Length, (mm)	4000 (overall 3 Bay system)
Size and/or dimension and material of key elements	3 Bay (Test Level 2) QuadGuard
	w/610 mm wide backup
Foundation Type and Condition	Dry 203 mm deep unreinforced
	Portland Cement Concrete

Test Vehicle

Type	Production Model
Designation	820C
Model	1988 Ford Festiva
	Hatchback
Mass (kg)	
Curb	797.4
Test inertial	813.2
Dummy(s)	75.0
Gross Static	888.2

Impact Conditions

Speed (km/h)	68.64
Angle (deg)	15
Impact Severity (kJ)	147.81

Exit conditions

Speed (km/h)	N/A
Angle (deg)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	9.54
y-direction	0.56
Ridedown Acceleration (g's)	
x-direction	-15.76
y-direction	-4.85
THIV (m/s)	9.62
PHD (g's)	12.88
ASI	1.08

Test Article Deflections (mm)

Dynamic	1830
Permanent	1750

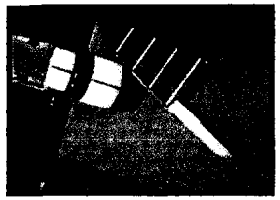
Vehicle Damage

Exterior	
VDS	FC-3
CDC	12FCEW2
Interior	
OCDI	AS0000000

Post-Impact Vehicular Behavior (deg - gyro at c.g.)

Maximum Roll Angle	6.08
Maximum Pitch Angle	-6.17
Maximum Yaw Angle	80.28

Figure 11. Summary of Results - 3 Bay (Test Level 2) QuadGuard Test 01-7620-017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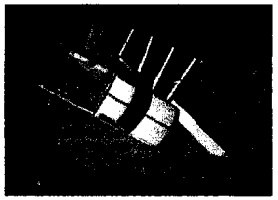
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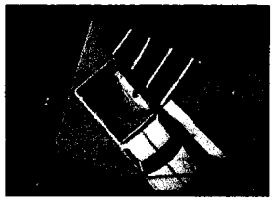
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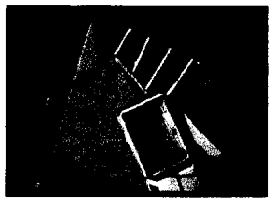
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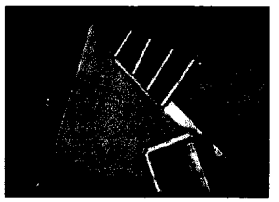
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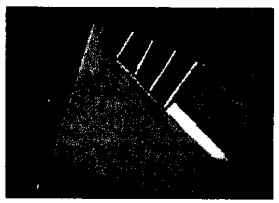
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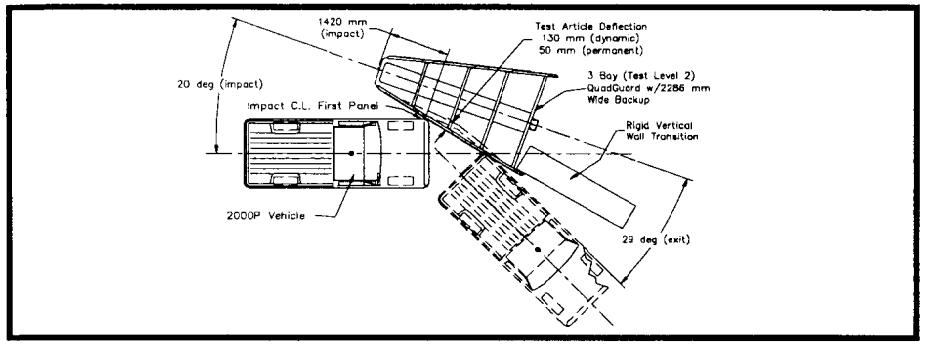

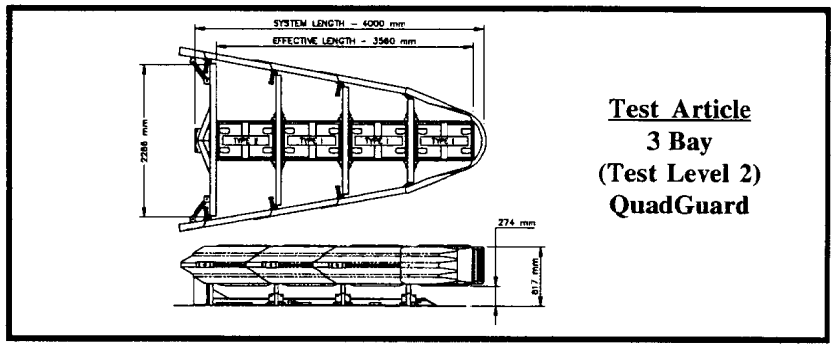

Test Article
3 Bay
(Test Level 2)
QuadGuard

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-38
Test No.	01-7620-019
Date	3/17/99

Test Article

Type	Energy Absorption QuadGuard w/tension strut backup
Installation Length, (mm)	4000 (overall 3 Bay system)
Size and/or dimension and material of key elements	3 Bay (Test Level 2) QuadGuard w/2286 mm wide backup
Foundation Type and Condition	Dry 203 mm deep unreinforced Portland Cement Concrete

Test Vehicle

Type	Production Model
Designation	2000P
Model	1989 Chevrolet C2500 3/4 T Pickup
Mass (kg)	
Curb	2073.4
Test inertial	2005.8
Dummy(s)	N/A
Gross Static	2005.8

Impact Conditions

Speed (km/h)	71.33
Angle (deg)	20
Impact Severity (kJ)	46.06

Exit conditions

Speed (km/h)	35.64
Angle (deg)	29

Occupant Risk Values	Primary (cab)	Backup (bed)
Impact Velocity (m/s)		
x-direction	6.80	7.17
y-direction	6.58	5.59
Ridedown Acceleration (g's)		
x-direction	-7.19	-4.22
y-direction	6.05	11.21
THIV (m/s)	9.37	8.72
PHD (g's)	13.23	8.19
ASI	N/A	0.89

Test Article Deflections (mm)

Dynamic	130
Permanent	50

Vehicle Damage

Exterior	
VDS	LFQ-3
CDC	11LDEW3
Interior	
OCDI	AS0000000

Post-Impact Vehicular Behavior (deg - gyro at c.g.)

Maximum Roll Angle	10.27
Maximum Pitch Angle	-14.20
Maximum Yaw Angle	64.94

Figure 16. Summary of Results - 3 Bay (Test Level 2) QuadGuard Test 01-7620-019