



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

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

December 1, 1997

Refer to: HNG-14

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

Dear Mr. Essex:

On November 21, 1997, you and members of your company met with Messrs. James Hatton and Richard Powers of my staff. You delivered a letter addressed to me, dated November 19, which requested the FHWA to accept the QuadGuard - Low Maintenance Cartridge (LMC) System as a National Cooperative Highway Research Program (NCHRP) Report 350 test level 3 (TL-3) crash cushion. You also provided us copies of a report entitled "QuadGuard - LMC System Qualification to NCHRP 350 Engineering Summary" dated November 1997, which included the E-Tech report, "NCHRP Report 350 Crash Test Results for the QuadGuard - LMC System," and a videotape of the tests that were conducted. The QuadGuard - LMC is a reusable, partially self-restoring crash cushion that utilizes the main components of the NCHRP Report 350 - qualified QuadGuard, except for the energy dissipation cartridges, which have been replaced with elastomeric cylinders of the type used in your NCHRP Report 230-qualified Low Maintenance Attenuator (LMA).

The QuadGuard - LMC unit tested was an 11 bay unit, 10 163 mm long and 1220 mm wide. It consisted of a monorail assembly anchored to a concrete pad, steel diaphragms, steel fender panels, a nose assembly, and a steel strut backup. The rear-most nine bays contained energy absorbing elastomeric cylinders as shown in the cutaway view in Enclosure 1. This drawing also identifies the system elements that are identical to those used in the previously-accepted QuadGuard unit.

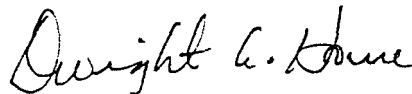
Enclosure 2 is a summary of the tests that were run and the results of each. We noted that some changes were made in the design as testing progressed and agree that these changes were of such a nature that all tests in the series you presented are valid for qualifying the QuadGuard - LMC at TL-3.

We noted also that the QuadGuard - LMC was tested at temperature extremes expected to be seen in service and performed well in both cases. Although my October 29 letter to you suggested that Test 3-30 might be more critical at the reduced *attenuator* temperature of -31.8 degrees C (-25.2 degrees F), you responded-that Test 3-32 would result in higher occupant impact velocities as a result of friction between the monorail and the laterally-loaded front diaphragms. We compared the data from Tests 3-30 and 3-32 that were used to qualify the standard QuadGuard as a Report 350 crash cushion and confirmed that the occupant impact velocity was slightly higher in the angle hit on the nose (Test 3-32) than on the head-on hit (Test 3-30).

My October 29 letter also requested information on and an analysis of your proposed transition designs from the QuadGuard - LMC to a typical concrete safety barrier. You indicated in your report that the tension strut backup was demonstrated to be a rigid structural member by Test 3-38 in the original QuadGuard certification series and that there was no measurable deflection at this point. Figure 9 of your report (Enclosure 3) shows your recommended offset layout when your QuadGuard series attenuators are used to shield the ends of concrete barrier in a bi-directional traffic situation. When used in a gore area, we assume the attenuator will be centered on the barrier, the tension strut backup will be used, and the width of the unit will exceed the bottom width of the concrete to minimize the snagging potential. We further assume that when the QuadGuard - LMC is used to terminate a metal-beam barrier system at bi-directional sites, the transition designs already tested for the original QuadGuard will be specified and used.

Based on our review of the individual test reports and the crash test videos that were provided to us, we agree that the QuadGuard - LMC, as tested, meets the acceptance criteria for an NCHRB Report 350 Test Level 3 (TL-3) crash cushion. Therefore, it may be used on the National Highway System (NHS) when such use is requested by a transportation agency. Since the QuadGuard - LMC is a proprietary device, its use on Federal-aid projects, except exempt, non-NHS projects, is subject to the conditions stated in Title 23, Code of Federal Regulations, Section 635.411, a copy of which is Enclosure 4.

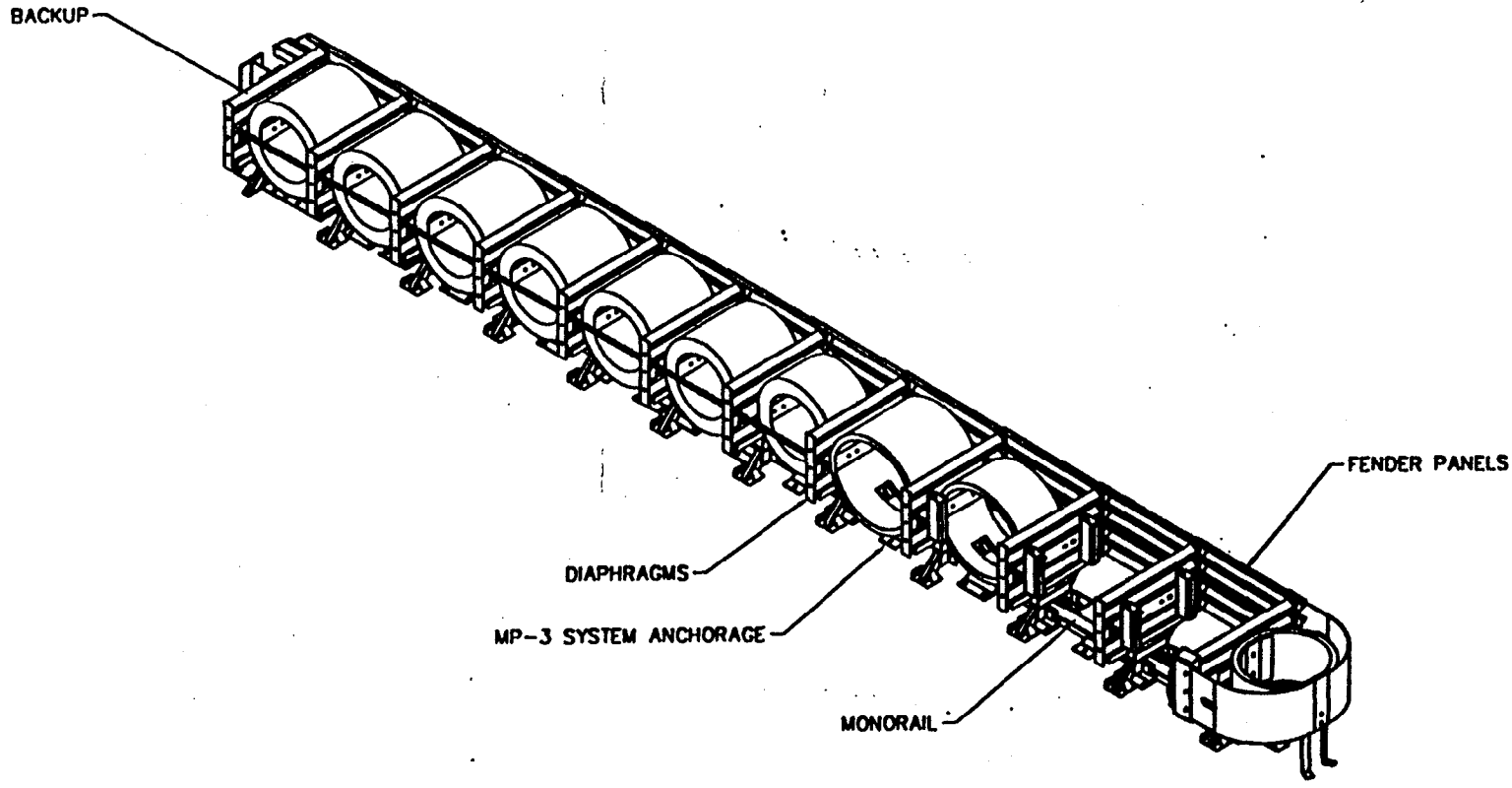
Sincerely yours,



Dwight A. Horne
Chief, Federal-Aid and Design Division


4 Enclosures

| MATERIALS | | PARTS LIST | | |
|-----------|-----------|-------------|-----|------|
| ITEM | STOCK NO. | DESCRIPTION | QTY | RECD |

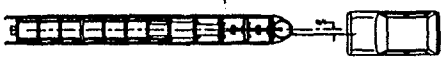



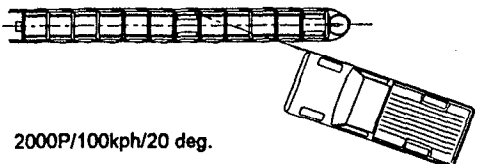


** NOTE: UNIT IS SHOWN WITH LEFT FENDER PANELS REMOVED.

FIG. 2

| | | | |
|-------------|---|--|--------------|
| DESIGNED: | DATE: 10/08/97 |  QuadGuard LMC System Components Retained From the QuadGuard System | |
| REV. ASSY: | | | |
| SCALE: | 1 = 40 | | |
| TOLERANCES: | a. Angular $\pm 1'$ b. Linear ± 1 mm (UNLESS OTHERWISE NOTED) | | |
| FILE: | Fig_2 | REV: | PAGE: 1 of 1 |

ENCLOSURE 1

| TABLE 1 | | QuadGuard LMC System Crash Test Program | | | | | | | | |
|--|----------------------------------|--|-------------------------------------|------------------------------------|-------------------------------------|----------------------------|-----------------------------------|------------------------|-------------------------------------|-------------------------------|
| NCHRP Evaluation Criteria | E-Tech Test ID. # | Test Conditions | Impact Speed (km/hr) | Impact Angle (deg.) | Occupant Impact Velocity | | Ridedown Accelerations | | Overall Assess- ment | Notes |
| | | | | | Long. (m/sec) | Lateral (m/sec) | Long. (G) | Lateral (G) | | |
| 350-3-30 | 01-7602-004 |  820C/100kph/0 deg., W/4 | 99.76 | 0 | 9.61 | 0.56 | -17.07 | 12.78 | PASS | |
| 350-3-31 | 01-7602-003 |  2000P/100kph/0 deg. | 100.35 | 0 | 8.43 | 0.78 | -13.96 | -3.45 | PASS | Test article at 47.6 deg. C. |
| 350-3-32 | 01-7602-002 |  820C/100kph/15 deg., nose | 99.67 | 14 | 10.50 | 2.28 | -14.94 | -10.08 | PASS | Test article at -31.8 deg. C. |
| 350-3-33 | 01-7602-005 |  2000P/100kph/15 deg., nose | 98.36 | 16 | 8.16 | 1.52 | -11.65 | -5.37 | PASS | |
| 350-3-38 | 01-7602-001 |  2000P/100kph/20 deg. | 95.42 | 21 | 6.36 | 7.81 | -7.44 | -15.31 | PASS | |

Energy Absorption Systems, Inc. Engineering Department

MATERIALS:

PARTS LIST

| ITEM | STOCK NO. | DESCRIPTION | REQ'D |
|------|-----------|-------------|-------|
|------|-----------|-------------|-------|

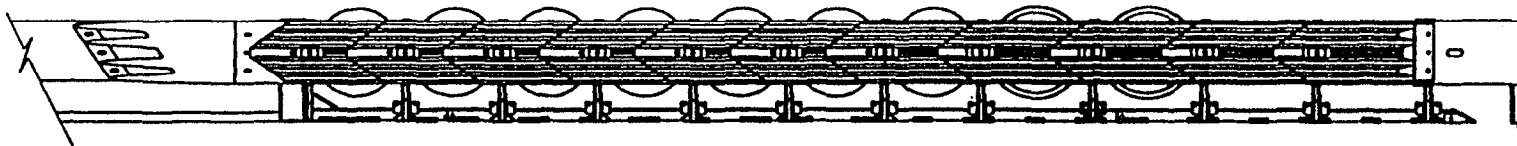
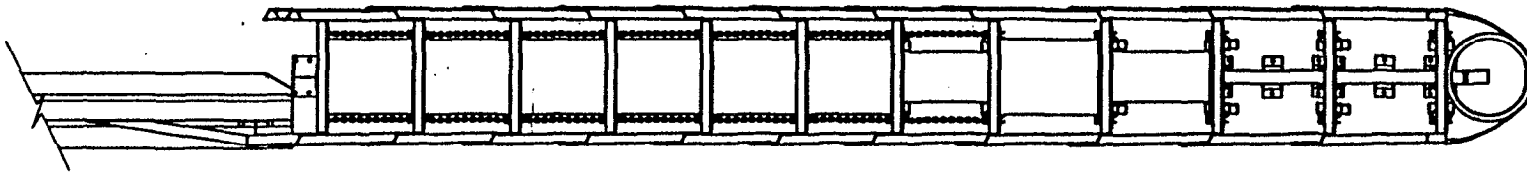



FIG. 9

| | | |
|---|-------------------|---|
| DESIGNER: | DATE: 11-14-97 |  Energy Absorption Systems, Inc. Engineering Design Drawing |
| NEXT ASSY: | | |
| SCALE: 1 = 40 | | |
| TOLERANCES: a. Angular $\pm 1^\circ$ b. Linear ± 1 mm (UNLESS OTHERWISE NOTED) | | |
| FILE: Fig_9 | REV: | DRAWN: 1 of 1 |

ENCLOSURE 3

these materials must occur in the United States.

2) The State has standard contract provisions that require the use of domestic materials and products. Including steel materials, to the same or greater extent as the provisions set forth in this section.

(3) The State elects to include alternate bid provisions for foreign and domestic steel materials which comply with the following requirements. Any procedure for obtaining alternate bids based on furnishing foreign steel materials which is acceptable to the Division Administrator may be used. The contract provisions must (I) require all bidders to submit a bid based on furnishing domestic steel materials, and (II) clearly state that the contract will be awarded to the bidder who submits the lowest total bid based on furnishing domestic steel materials unless such total bid exceeds the lowest total bid based on furnishing foreign steel materials by more than 25 percent.

(4) When steel materials are used in a project, the requirements of this section do not prevent a minimal use of foreign steel materials, if the cost of such materials used does not exceed one-tenth of one percent (0.1 percent) of the total contract cost or \$2,500, whichever is greater. For purposes of this paragraph, the cost is that shown to be the value of the steel products as they are delivered to the project.

(c)(1) A State may request a waiver of the provisions of this section if:

(I) The application of those provisions would be inconsistent with the public interest; or

(II) Steel materials/products are not produced in the United States in sufficient and reasonably available quantities which are of a satisfactory quality.

(2) A request for waiver, accompanied by supporting information, must be submitted in writing to the Regional Federal Highway Administrator (RFHWA) through the FHWA Division Administrator. A request must be submitted sufficiently in advance of the need for the waiver in order to allow time for proper review and action on the request. The RFHWA will have approval authority on the request.

(3) Requests for waivers may be made for specific projects, or for certain materials or products in specific geographic areas, or for combinations of both, depending on the circumstances.

(4) The denial of the request by the RFHWA may be appealed by the State to the Federal Highway Administrator (Administrator) whose action on the request shall be considered administratively final.

(5) A request for a waiver which involves nationwide public interest or availability issues or more than one FHWA region may be submitted by the RFHWA to the Administrator for action.

(6) A request for waiver and an appeal from a denial of a request must include facts and justification to support the granting of the waiver. The FHWA response to a request or appeal will be in writing and made available to the public upon request. Any request for a nationwide waiver and FHWA's action on such a request may be published in the FEDERAL REGISTER for public comment.

(7) In determining whether the waivers described in paragraph (c)(1) of this section will be granted, the FHWA will consider all appropriate factors including, but not limited to, cost, administrative burden, and delay that would be imposed if the provision were not waived.

(d) Standard State and Federal-aid contract procedures may be used to assure compliance with the requirements of this section.

(23 U.S.C. 315, sec. 10 of Pub. L. 98-229, 98 Stat. 55, sec. 165 of Pub. L. 97-424, 96 Stat. 2136 and 49 CFR 1.48(b))

[48 FR 53104 Nov. 25, 1983, as amended at 49 FR 18821, May 3, 1984]

§ 635.411 Material or product selection.

(a) Federal funds shall not participate, directly or indirectly, in payment for any premium or royalty on any patented or proprietary material, specification, or process specifically set forth in the plans and specifications for a project, unless:

(1) Such patented or proprietary item is purchased or obtained through

competitive bidding with equally suitable unpatented items; or

(2) The State highway agency certifies either that such patented or proprietary item is essential for synchronization with existing highway facilities, or that no equally suitable alternate exists; or

(3) Such patented or proprietary item is used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes.

(b) When there is available for purchase more than one nonpatented, nonproprietary material, semifinished or finished article or product that will fulfill the requirements for an item of work of a project and these available materials or products are judged to be of satisfactory quality and equally acceptable on the basis of engineering analysis and the anticipated prices for the related item(s) of work are estimated to be approximately the same, the PS&E for the project shall either contain or include by reference the specifications for each such material or product that is considered acceptable for incorporation in the work. If the State highway agency wishes to substitute some other acceptable material or product for the material or product designated by the successful bidder or bid as the lowest alternate, and such substitution results in an increase in costs, there will not be Federal-aid participation in any increase in costs.

(c) A State highway agency may require a specific material or product when there are other acceptable materials and products, when such specific choice is approved by the Division Administrator as being in the public interest. When the Division Administrator's approval is not obtained, the item will be nonparticipating unless bidding procedures are used that establish the unit price of each acceptable alternative. In this case Federal-aid participation will be based on the lowest price so established.

(d) Appendix A sets forth the FHWA requirements regarding (1) the specification of alternative types of culvert pipes, and (2) the number and types of such alternatives which must

be set forth in the specifications for various types of drainage installations.

(e) Reference in specifications and on plans to single trade name materials will not be approved on Federal-aid contracts.

§ 635.413 Guaranty and warranty clauses.

(a) Except as provided in paragraph (b) of this section, clauses that require the contractor to guarantee or warrant materials and workmanship or to otherwise maintain the work for a specified period after its satisfactory completion by the contractor and its final acceptance by the State, will not be approved for use in Federal-aid contracts. Work performed and materials replaced under such guaranty or warranty clauses after final acceptance of work are not eligible for Federal participation.

(b) Contracts which involve furnishing and/or installing electrical or mechanical equipment should generally include contract clauses that require:

(1) Manufacturer's warranties or guarantees on all electrical and mechanical equipment consistent with those provided as customary trade practice, or

(2) Contractors' warranties or guarantees providing for satisfactory in-service operation of the mechanical and electrical equipment and related components for a period not to exceed 6 months following project acceptance.

§ 635.417 Convict produced materials.

(a) Materials produced by convict labor may only be incorporated in a Federal-aid highway construction project if such materials have been:

(1) Produced by convicts who are on parole, supervised release, or probation from a prison or

(2) Produced in a qualified prison facility and the cumulative annual production amount of such materials for use in Federal-aid highway construction does not exceed the amount of such materials produced in such facility for use in Federal-aid highway construction during the 12-month period ending July 1, 1987.

(b) *Qualified prison facility* means any prison facility in which convicts,



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MAR 1 9 1998

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

Dear Mr. Essex:

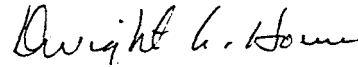
In your March 12 letter to Mr. Henry Rentz, you requested formal acceptance of your QuadGuard 69/90 Low Maintenance Crash Cushion (LMC) as a non-gating redirective attenuator meeting the National Cooperative Highway Research Program (NCHRP) Report 350 evaluation criteria at Test Level 3 (TL-3). To support your request, you also sent us copies of your report entitled "QuadGuard 69/90-LMC System Qualification to the NCHRP 350 TL - 3 Engineering Summary" dated March 1998, which included the full report prepared by E-TECH Testing Services, Inc., entitled "NCHRP Report 350 Crash Test Results for the QuadGuard 69/90-LMC System," also dated March 1998, and a video tape showing the full scale tests that you conducted on the 69/90-LMC system.

We noted that the QuadGuard 69/90-LMC uses the same framework as the QuadGuard-Wide systems that were accepted as TL-3 attenuators in my letter to you dated July 16, 1997, with the only significant changes being the addition of four 20-mm diameter holes in each diaphragm to install the elastomeric energy-absorbing cylinders and four mounting tabs to attach the two indexing chains in each bay which contains a reusable cylinder. Because of the similarity of the designs and the acceptable results of tests 3-31, 3-36, 3-37, 3-38, and 3-39 on the QuadGuard-Wide system, we agreed beforehand to waive these tests on the 69/90-LMC, and to reassess the need for test 3-33 after reviewing the results of test 3-32. Having done so, we agree that test 3-33 may also be waived. Enclosures 1 and 2 summarize the results of tests 3-30 and 3-32, respectively. Enclosure 3 shows the overall dimensions of the two different-width QuadGuard 69/90-LMC units.

Based on our review of the information you provided, we concur that the QuadGuard 69/90-LMC, as tested, meets the acceptance criteria for an NCHRP Report 350 TL-3 crash cushion.

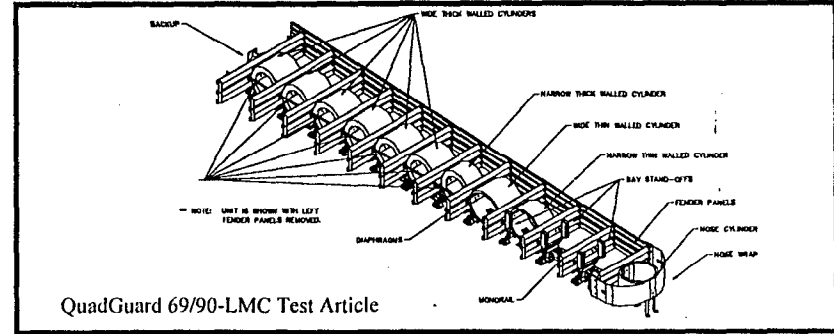
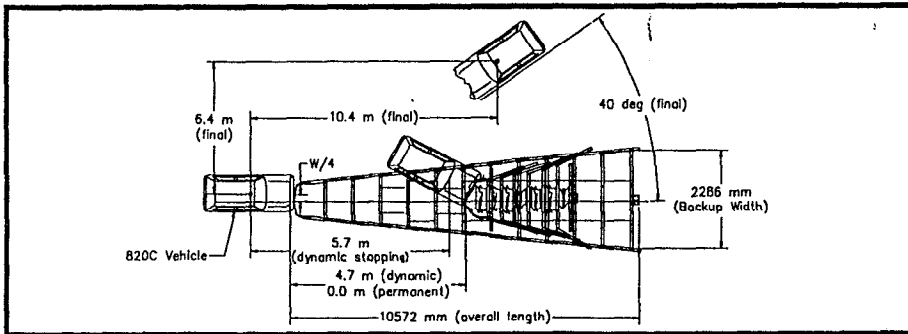
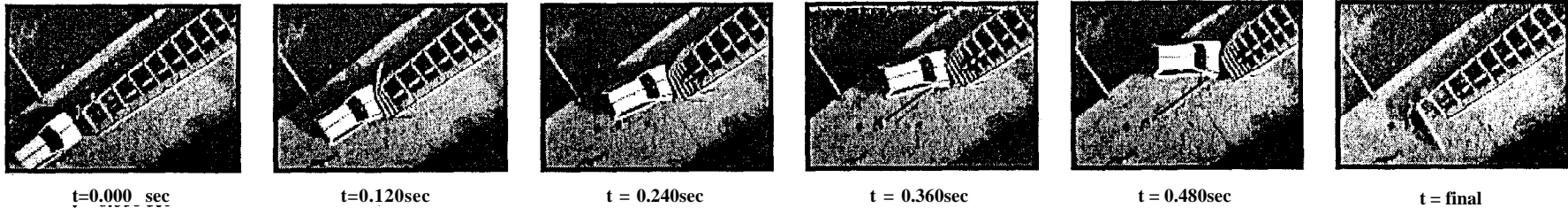
It may be used on the National Highway System (NHS) when such use is requested by a transportation agency. Because it is a proprietary-device, its use on Federal-aid projects, except exempt, non-NHS projects, remains subject to the-conditions listed in Title 23, Code of Federal Regulations, Section 635.411, copies of which have previously been sent to you.

Sincerely yours,



Dwight A. Horne
Chief, Federal-Aid and Design Division

3 Enclosures



E-TECH Testing Services, Inc.

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-30
 Test No..... 01-7615-001
 Date 2/24/98

Test Article

Type Energy Absorption Systems, Inc.
 11 bay QuadGuard 69/90-LMC System
 Installation Length 10572 mm
 Size and/or dimension and material of key elements 2286 mm Backup Width

Test Vehicle

Type Production Model
 Designation 820C
 Model 1989 Ford Festiva Hatchback
 Mass (kg)
 Curb 805.8
 Test inertial 825.2
 Dummy(s) 75.0
 Gross Static 900.2

Impact Conditions

Speed (km/h) 97.04
 Angle (deg) 0.0
 Impact Severity (kJ) 299.67

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 10.21
 y-direction 1.03
 Ridedown Acceleration (g's)
 x-direction -15.74
 y-direction 13.76
 THIV (m/s) 10.30
 PHD (g's) 13.30
 ASI 1.22

Test Article Deflections (m)

Dynamic 4.7
 Permanent 0.0

Vehicle Damage

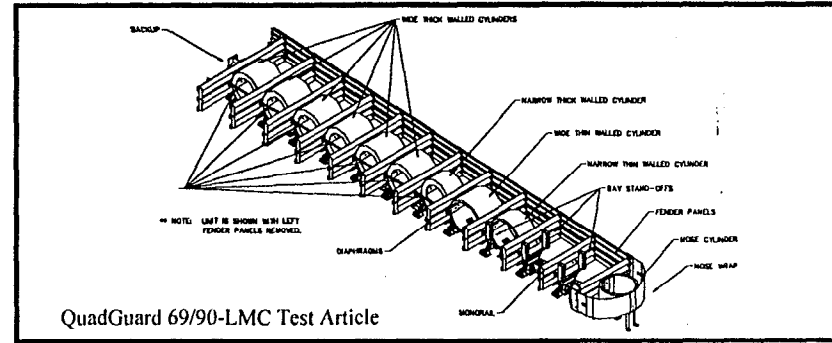
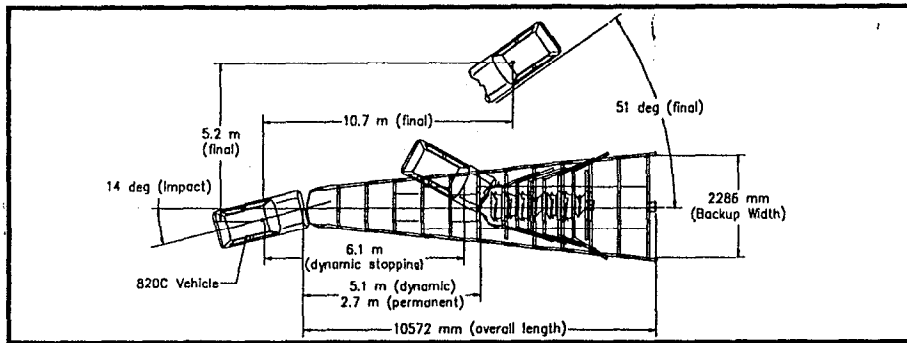
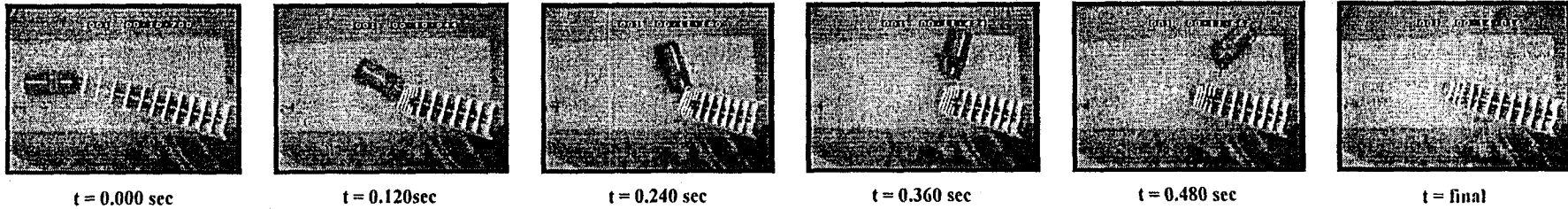
Exterior
 VDS FD-4
 CDC 12FDEW3
 Interior
 ODCI AS0000000

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

Maximum Roll Angle 12.50
 Maximum Pitch Angle -12.49
 Maximum Yaw Angle 139.72

QuadGuard 69/90-LMC System Crash Test Results - 5 of 19

Figure 1. Summary of Results - QuadGuard 69/90-LMC System Test 01-7615-001



E-TECH Testing Services, Inc.

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-32
 Test No. 01-7615-002
 Date 3/3/98

Test Article

Type Energy Absorption Systems, Inc.
 11 bay QuadGuard 69/90-LMC
 System

Installation Length..... 10572 mm
 Size and/or dimension and material
 of key elements 2286 mm Backup Width

Test Vehicle

Type Production Model
 Designation 820C
 Model 1988 Ford Festiva
 Hatchback
 Mass (kg)
 Curb 769.0
 Test inertial 825.0
 Dummy(s) 75.0
 Gross Static 900.0

Impact Conditions

Speed (km/h) 101.69
 Angle (deg) 14.0
 Impact Severity (kJ) 329.20

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 10.40
 y-direction 1.40
 Ridedown Acceleration (g's)
 x-direction -15.70
 y-direction 14.60
 THIV (m/s) 10.77
 PHD (g's)
 ASI 1.13

Test Article Deflections (m)

Dynamic 5.1
 Permanent 2.7

Vehicle Damage

Exterior
 VDS FD-4
 CDC 12FDEW3
 Interior
 OCDI AS0000000

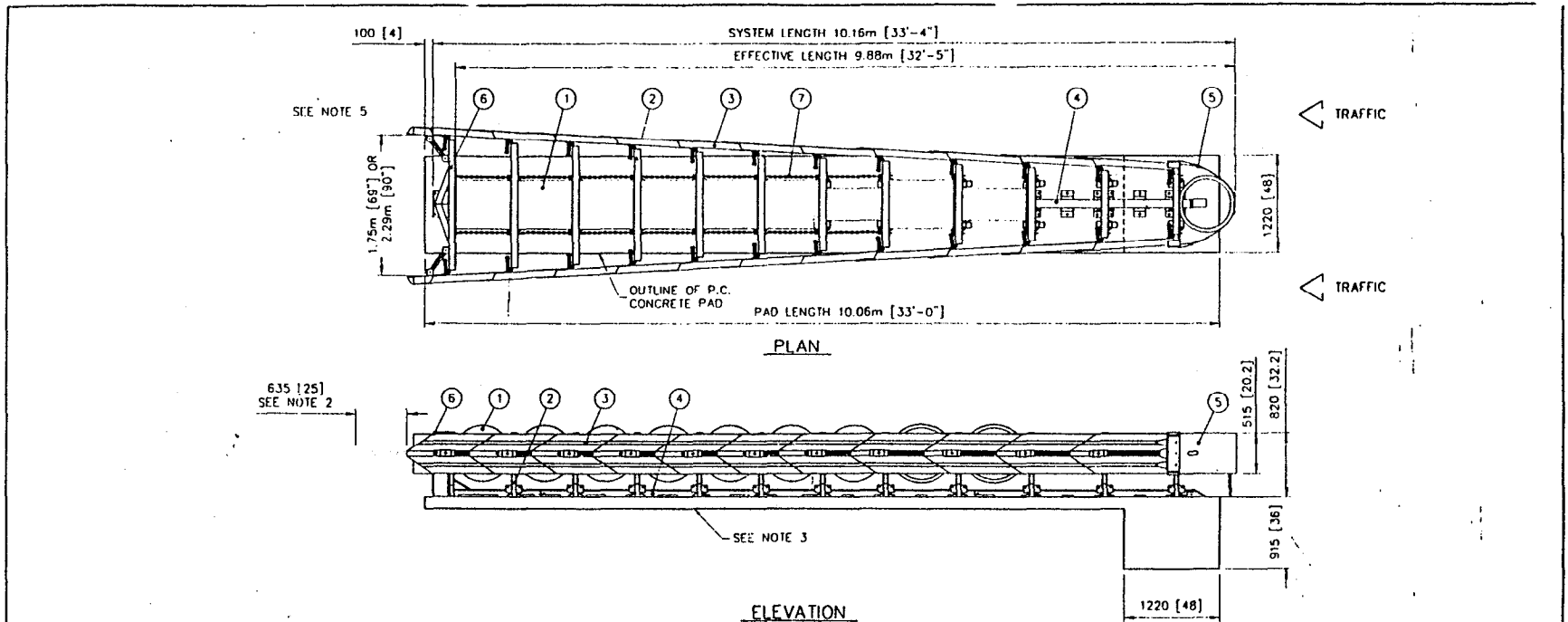
Post-Impact Vehicular Behavior (deg - gyro @ c.g.)

Maximum Roll Angle 13.08
 Maximum Pitch Angle -19.56
 Maximum Yaw Angle 143.00

QuadGuard 69/90-LMC System Crash Test Results -11 of 19.

Figure 6. Summary of Results - QuadGuard 69/90-LMC System Test 01-7615~002

Enclosure 2



NOTES:

- IN COMPLIANCE WITH THE AASHTO 1996 ROADSIDE DESIGN GUIDE, MANUFACTURER RECOMMENDS REMOVAL OF ALL CURBS AND ISLANDS TO ENSURE PROPER IMPACT PERFORMANCE.
- PROVISION SHALL BE MADE FOR REAR FENDER PANELS TO SLIDE REARWARD UPON IMPACT 635 [25.00] MIN.
- 150 [6.00] MIN REINFORCED 28 MPa [4000 PSI] P.C. CONCRETE PAD OR 200 [8.00] MIN NON-REINFORCED 28 MPa [4000 PSI] P.C. CONCRETE ROADWAY.
- SEE THE "QUADGUARD LMC SYSTEM DESIGN MANUAL" CODED FOR A DESCRIPTION OF ITS IMPACT PERFORMANCE CHARACTERISTICS AND DESIGN LIMITATIONS BEFORE PLACING A SYSTEM AT A GIVEN SITE. INFORMATION AND COPIES OF ABOVE MANUAL ARE AVAILABLE BY CALLING CUSTOMER SERVICE DEPARTMENT AT 1-888-32-ENERG.
- WHERE NECESSARY, THE CUSTOMER SHALL SUPPLY A TRANSITION FROM THE QUADGUARD SYSTEM TO THE OBJECT BEING SHIELDED.
- UNITS OF MEASUREMENT ARE MILLIMETERS [INCHES] UNLESS OTHERWISE NOTED.
- BACKUP ASSEMBLY NOT INCLUDED IN MODEL NUMBER.

REFERENCES

| | | |
|-----------------|-------------------|--------------|
| SERIAL # | DIAPHRAGM ASSY | 3540342-0000 |
| SALES ORDER # | NOSE ASSY | 3540452-0000 |
| EH PROJECT # | FENDER PANEL ASSY | 3540370-0000 |
| DESIGN SPEED | BACKUP ASSY | 3540393-0000 |
| NOSE COLOR | RAIL ASSY | 35-40-46 |
| NUMBER OF UNITS | CONCRETE PAD | 35-40-47 |
| | CYLINDER ASSY | 35-09-54 |
| | BAY ASSY | 3540456-0000 |
| | CHAIN ASSY | 3540455-0000 |

| | | |
|------|-------------|--------|
| DATE | D. Staus | 3/5/98 |
| BY | R. Blowski | 3/5/98 |
| DATE | KRM | 7-6-98 |
| DATE | AL | 7-6-98 |
| DATE | OLF TSCVR-U | dwg |



UNIDIRECTIONAL
MODEL NO. OF6911L
MODEL NO. OF9011L

ENERGY ABSORPTION SYSTEMS, INC.
ENGINEERING AND RESEARCH DEPARTMENT

QUADGUARD® 69/90 LMC SYSTEM
W/ 69° or 90° TENSION STRUT BACKUP

1-50 OLF TSCVR-U 1 of 1

| | | | | | |
|-----------|-------------------------|-----------------|------------------|-----|-----|
| KEY | ① ELASTOMERIC CYLINDERS | ④ MONORAIL | ⑦ CHAIN ASSEMBLY | | |
| | ② DIAPHRAGM | ⑤ NOSE ASSEMBLY | | | |
| | ③ FENDER PANEL | ⑥ BACKUP | | | |
| Revisions | Date | Rev | By | Ckd | App |
| | | | | | |