U.S. Department of Transportation
Federal Highway Administration

November 19, 2010

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

In Reply Refer To:
HSSI/CC-35J

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 roadside safety devices for use on the National Highway System (NHS).

| | |
|---|---|
| Name of device: | QuadGuard® and QuadGuard II® various length systems |
| Type of device: | Impact Attenuator |
| Testing Level: | Intermediate speeds other than NCHRP Report 350 Test Level 2 (TL-2), TL-3 |
| Testing Conducted by: | E-Tech Testing Services, Inc. |
| Task Force 13 Designator: | SCT02i |
| Date of Request: | January 15, 2010 |
| Date of Resubmission: | September 20, 2010 |

**Decision:**
The following devices were found acceptable (details below):

- The QG-LS and QGII-LS one-bay and two-bay systems for use at speeds up to 40 km/hr and 60 km/hr.
- The QG-Parallel, QG-Flared, QGII-Parallel and QGII-Flared multiple bay system for use at speeds up to 80 km/hr. and 90 km/hr.
- The QG-HS-Flared 69-inch and 90-inch systems under NCHRP Report 350 TL-3 conditions.

The following device was not found acceptable:

- QG-flared 69-inch, 56mph (90km/hr) crash cushion system.

**Introduction:**
Your request was for FHWA acceptance of the various lengths of the stated devices for use on the NHS. The submission included probable impact speeds other than the three principle speeds as per Recommended Procedures for the Safety Performance Evaluation of Highway Features, National Cooperative Highway Research Project Report 350 (Report 350) in efforts to meet

specific demand of local and state agencies. In addition, your submission also noted your existing request is similar to a previous acceptance letter, CC-75B, dated December 9, 2003. After numerous discussions with the manufacturer and their subsequent diligence in the resubmission of supporting data, FHWA has now received all information required for a concerted review to render findings.

**Requirements**
Roadside safety devices should, as a minimum, meet the guidelines contained in the Report 350. In addition, 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 (QG) and QuadGuard II (QGII) systems are redirective, non-gating crash cushions similar to existing QG, QG-Wide, and QG High Speed (QG-HS) crash cushions previously successfully crash tested and found acceptable as noted in the following FHWA acceptance letters:

| Acceptance Letter No. | Letter Date | Test Level | System Name and Type |
|---|---|---|---|
| CC-35 | June 21, 1996 | TL-3 | QUADGUARD Crash Cushion - unidirectional |
| CC-35A | August 5, 1996 | TL-3 | QUADGUARD CZ - Construction Zone |
| CC-35B | October 17, 1996 | TL-3 | QUADGUARD Crash Cushion – bidirectional |
| CC-35C | June 17, 1999 | TL-2 | 3-bay QUADGUARD at TL-2 |
| CC-35D | October 13, 2000 | TL-3 | Acknowledgment of limited 70 MPH tests |
| CC-35E | October 19, 2001 | TL-3 | QuadGuard HS: Full test matrix at70 mph |
| CC-35F | December 10, 2003 | TL-3 | QuadGuard CZ on steel plate |
| CC-35G | November 1, 2004 | var. | Drivable Pile Anchor for QG CZ on steel plate |
| CC-35H | July 16, 2007 | var. | Change in QuadGuard Cartridge |
| CC-42 | July 16, 1997 | TL-3 | QUADGUARD-WIDE system (6-degree sides) |
| CC-42A | December 10, 2003 | TL-3 | QUADGUARD with 10-degree sides |

All of these letters can be located on the FHWA Web site. As stated in your submission, these systems have a reasonably uniform crush resistance throughout the impact event without excessive or sudden elevation or staging of the ride-down and/or stopping forces. In addition, the amount of staging present is considered minor since it does not create any problems for the full spectrum of passenger vehicle weights for either QG or QG II systems.

**Crash Testing**
No actual crash tests were submitted for this request. Instead, results from previous successful tests of parallel-sided and flared QG (QG and QG-Flared respectively) at TL-2 and TL-3 impact speeds were presented as well as tests into a parallel-sided QG high speed unit at elevated impact speeds of 70 mph (QG-HS). In addition, using the data from those successful tests, engineering logic was presented predicting the results for similar tests into your proposed Low Speed QG & QGII – Parallel (QG-LS& QGII-LS); QG & QGII parallel and flared (QG-Parallel; QG-Flared;

QGII-Parallel; QGII-Flared); and, High Speed QG – Flared Versions (QG-HS). The enclosed System Configuration Charts and Computational Capacity Analysis table provides the brief summary of the Report 350 non-gating crash cushion tests and analysis that were evaluated in your submission.

**Findings**

As a service to the highway community, the FHWA finds devices meeting Report 350 acceptable for use on the NHS for impact speeds from 50 km/h up to 100 km/hr. You have shown that:

A. The QG-LS and QGII-LS one-bay and two-bay systems plus nose cartridge will likely meet similar evaluation criteria at 40 km/hr and 60 km/hr impact speeds respectively using data from previous successful crash tests and engineering logic derived from submitted computational capacity analysis. The FHWA concurs that these proposed devices described above and detailed within the enclosed tables are acceptable for use on the NHS only when acceptable to a highway agency and only should the agency wish to specify an attenuator with capacity for use at speeds up to 40 km/hr and 60 km/hr.

B. The QG-Parallel, QG-Flared, QGII-Parallel and QGII-Flared multiple bay systems as shown on the enclosed tables will likely meet similar evaluation criteria at 80km/hr and 90km/hr impact speeds using data from previous successful crash test and engineering logic derived from submitted computational capacity analysis. The FHWA concurs that these proposed devices described above and detailed within the enclosed tables are acceptable for use on the NHS only when acceptable to a highway agency and only should the agency wish to specify an attenuator with capacity for use at speeds up to 80 km/hr. and 90 km/hr.

C. The QG-HS-Flared 69-inch and 90-inch will likely meet similar evaluation criteria when tested at 113 km/hr. The FHWA concurs that the device described above and detailed in the enclosed tables is acceptable for use on the NHS under Report 350 TL-3 conditions, when acceptable to a highway agency. Should an agency wish to specify an attenuator with capacity exceeding TL-3 the QG-HS-Flared 69-inch and 90-inch are acceptable for use at speeds up to 113 km/hr.

In addition and after further review and consideration of the presented information, FHWA cannot provide acceptance for proposed QG-flared 69-inch, 56mph (90km/hr) crash cushion system. The FHWA further recommends this system be considered for physical crash testing as per NCHRP Report 350. Please note that any crash test as per Report 350 must be submitted to FHWA for acceptance on or before January 1, 2011. After this date, all crash testing must be conducted as per American Association of State Highway and Transportation Officials Manual of Assessing Safety Hardware.

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.

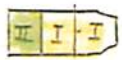
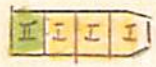
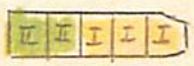
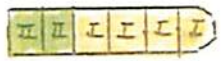
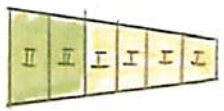
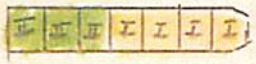
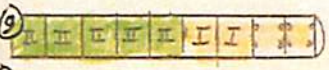
- Any changes that may adversely influence the crashworthiness of the device will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly 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-35J, 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 QG II attenuators are patented products and considered proprietary. If proprietary devices are specified by 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,

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

Enclosures

## QuadGuard System Configuration Chart

| Design Speed/Impact Capacity (km/h) | Backup Width | | | | | |
|---|---|---|---|---|---|---|
| | Parallel - 24",30",36" | | Flared 69" | | Flared 90" | |
| 40 km/h (25 mph) | 820c confirmed by Test 11<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | Unit is too short for flaring..... | | Unit is too short for flaring..... | |
| 60 km/h (37 mph) | 820c confirmed by Test 11<br>2000p confirmed by Test 10 |  | Unit is too short for flaring..... | | Unit is too short for flaring..... | |
| 70 km/h ( 43 mph) | 820c confirmed by 350 Test 1 TEST (2)<br>2000p confirmed by 350 Test 2 TEST (1) |  | | | | |
| 80 km/h (50 mph) | 820c confirmed by Test 13<br>2000p confirmed by 350 Test 3 TEST (3) |  | 820c confirmed by Test 13<br>2000p confirmed by Test 3 |  | 820c confirmed by Test 13<br>2000p confirmed by Test 3 |  |
| 90 km/h (56 mph) | 820c confirmed by Test 5<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | 820c confirmed by Test 5 & 7<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | 820c confirmed by Test 5 & 7<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  |
| 100 km/h (62 mph) | 820c confirmed by 350 Test 5 TEST (5)<br>2000p confirmed by 350 Test 4 TEST (4) |  | | | 820c confirmed by 350 Test 7 TEST (7)<br>2000p confirmed by 350 Test 6 TEST (6) |  |
| 115 km/h (70 mph) | 820c confirmed by Test 9 TEST (9)<br>2000p confirmed by 350 Test 8 TEST (8) |  | 820c confirmed by Test 9<br>2000p confirmed by Test 8 |  | 820c confirmed by Test 9<br>2000p confirmed by Test 8 |  |

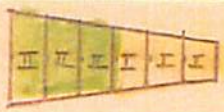
Actual 350 Confirmation Test(s)

= TYPE I CARTRIDGE

= TYPE II CARTRIDGE

(#) = NUMBERS IN CIRCLES CORRESPOND TO ATTACHED ONE-PAGE TEST SUMMARIES

# QuadGuard II System Configuration Chart

| Design Speed/Impact Capacity (km/h) | Backup Width: Parallel - 24",30",36" | | Flared 69" | | Flared 90" | |
|---|---|---|---|---|---|---|
| 40 km/h (25 mph) | 820c confirmed by Test 11<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | Unit is too short for flaring..... | | Unit is too short for flaring..... | |
| 60 km/h (37 mph) | 820c confirmed by Test 11<br>2000p confirmed by Test 10 |  | Unit is too short for flaring..... | | Unit is too short for flaring..... | |
| 70 km/h ( 43 mph) | 820c confirmed by 350 Test 11 TEST (11)<br>2000p confirmed by 350 Test 10 TEST (10) |  | | | | |
| 80 km/h (50 mph) | 820c confirmed by Test 9<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | 820c confirmed by Test 15<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | 820c confirmed by Test 15<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  |
| 90 km/h (56 mph) | 820c confirmed by Test 13<br>2000p confirmed by K.E. capacity evaluation - see KE Chart |  | 820c confirmed by Test 15<br>2000p confirmed by Test 14 |  | 820c confirmed by Test 15<br>2000p confirmed by Test 14 |  |
| 100 km/h (62 mph) | 820c confirmed by 350 Test 13 TEST (13)<br>2000p confirmed by 350 Test 12 TEST (12) |  | | | 820c confirmed by 350 Test 15 TEST (15)<br>2000p confirmed by 350 Test 14 TEST (14) |  |

| | |
|---|---|
| | Actual 350 Confirmation Test(s) |

(#) – NUMBERS IN CIRCLES CORRESPOND TO ATTACHED ONE-PAGE TEST SUMMARIES.

– TYPE I CARTRIDGE

– TYPE II CARTRIDGE

## QuadGuard & QuadGuard II K.E. Capacity Validation

| Proposed QG Configuration (Nose is not counted as a Bay) | Design Speed (km/h) | Design Capacity =2000p K.E. that must be dissipated (kJ) | No. of Type I Cartridges | Total K.E. that will be dissipated by Type I cartridges* (kJ) | No. of Type II Cartridges | Total K.E. that will be dissipated by Type II cartridges* (kJ) | Estimated K.E. dissipated by crush of 2000p (kJ) | Calculated K.E. dissipated via momentum transfer (acceleration of nose and first Bay) (kJ) | Sum of K.E. that will be dissipated by Type I & II cartridges, momentum transfer and vehicle crush (kJ) | Conclusion on System's Capacity Validation |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposed QuadGuard | | | | | | | | | | |
| Parallel 1-Bay | 40 | 124 | 2 | 174 | 0 | 0 | 80 | 8 | 262 | Adequate Capacity |
| Parallel 5-Bay | 90 | 625 | 4 | 348 | 2 | 300 | 80 | 40 | 768 | Adequate Capacity |
| Flared 69" & 90" 5-Bay | 90 | 625 | 4 | 348 | 2 | 300 | 80 | 40 | 768 | Adequate Capacity |
| 350-Tested Parallel 6-Bay | 100 | 772 | 4 | 348 | 3 | 300 | 80 | 50 | 778 | Actual capacity confirmed by 350 Test 4 |
| Proposed QuadGuard II | | | | | | | | | | |
| Parallel 1-Bay | 40 | 124 | 2 | 174 | 0 | 0 | 80 | 8 | 262 | Adequate Capacity |
| Parallel 3-Bay | 80 | 494 | 2 | 174 | 2 | 300 | 80 | 32 | 586 | Adequate Capacity |
| Flared 69" & 90" 4-Bay | 80 | 494 | 3 | 261 | 2 | 300 | 80 | 32 | 673 | Adequate Capacity |
| Parallel 4-Bay | 90 | 625 | 3 | 261 | 2 | 300 | 80 | 40 | 681 | Adequate Capacity |
| 350-Tested Parallel 5-Bay | 100 | 772 | 3 | 261 | 3 | 425 | 80 | 50 | 816 | Actual capacity confirmed by 350 Test 12 |

| | |
|---|---|
| | Actual 350 confirmation test |
| | Calculated K.E. based on 2000p impacting at given design speed (kJ) |
| | QG did not stroke 100%. Estimate based on % crush of Type II cartridges during Tests 4 and 12 |
| | Sum of K.E. dissipated by cartridge crush, momentum transfer and vehicle crush |