Dear Mr. Stephens:

Recently, Mr. Douglas Bernard delivered your letter dated January 7, 2005, to Mr. Richard Powers of my staff. In this letter, you requested formal Federal Highway Administration (FHWA) review and acceptance of a temporary longitudinal barrier called the Vulcantm Barrier (Vulcan). To support your request, you supplied a summary report and video prepared by E-Tech Testing Services that describes the Vulcan Barrier as well as the three full-scale crash tests you conducted.

The Vulcan is a longitudinal barrier fabricated from hot-dipped galvanized steel and is intended for use as a portable longitudinal barrier in work zones. Each segment has a nominal length of 4115 mm, a height of 813 mm and a width of 546 mm. The mass of each segment is approximately 395 kg. The upper portion incorporates standard Thrie-beam guardrail panels and the bottom incorporates sheet metal rub rails. Five steel bulkheads tie the sides of the Vulcan together. The end bulkheads incorporate vertically aligned holes to facilitate pinning Vulcan segments together. The center bulkhead incorporates a lifting tab for assembly and transport. A stiffener plate also runs the length of each segment. Vulcan sections are pinned together using 48 mm diameter steel connecting pins. When installed in straight configurations, an optional steel spacer can be installed in the connecting joint to reduce lateral deflection. This spacer was used in the three tests submitted for review. The Vulcan’s end bulkheads can also be used to connect an appropriate crash cushion to a Vulcan installation. Enclosure 1 is a schematic drawing of a Vulcan segment.

The Vulcan Barrier was crash tested in two configurations. Two tests were conducted following the guidelines in the National Cooperative Highway Research Program (NCHRP) Report 350 for tests 3-10 and 3-11 with the Vulcan freestanding and unanchored on an asphalt surface. For these two tests, eighteen (18) freestanding Vulcan segments were pinned together and the ends were ballasted with four unanchored 3.0 m long PCMB segments to simulate...
longer lengths of upstream and downstream Vulcan Barrier. These concrete segments weighed 8880 kg, which is equal to 23 segments of Vulcan. Consequently, when installed freestanding, the same weight of PCMB segments or a minimum of 23 Vulcan segments (92 m = 302 ft) must be attached to each end of unanchored Vulcan barriers to establish a “beginning of length of need” (BLON) point and to limit the barrier’s dynamic deflection within the length of need to that noted in the crash test. The impact point for these tests was at a point 16.5 m from the connection to the PCMB or the BLON point. The vehicles were smoothly redirected and occupant risk values were acceptable. The lateral dynamic deflection for the 820c test was 1.6 m and for the 2000p test was 4.0 m. Impacts nearer to either end of an unanchored installation may result in significantly greater deflections. Impacts immediately adjacent to either unanchored end may not redirect an impacting vehicle and are likely to result in pocketing or penetration into the area behind the barrier.

A second Vulcan Barrier configuration was also tested per the NCHRP Report 350 Test 3-11 and submitted for evaluation. In this configuration both ends of fourteen (14) Vulcan segments were restrained from moving by connecting the barrier to a QuadGuard CZ crash cushion anchored with DPA anchors (reference the FHWA acceptance letter HSA-10/CC-35G) on the approach end and the QuadGuard base platform on the departure end. The impact point was into the third Vulcan segment at a point 1.2 m downstream from the connection between the second and third segments. The 2000p vehicle was smoothly redirected and the reported occupant risk values were acceptable. The maximum lateral dynamic deflection was reported as 2.1 m. As expected, dynamic deflection was significantly reduced when the Vulcan installation was anchored at both ends and this treatment is acceptable for use in uni-directional applications or where opposite direction impacts immediately adjacent to the QuadGuard are deemed to be unlikely. Since you are connecting a flexible barrier system directly to a rigid crash cushion, further evaluation or a crash test will be required to validate use of QuadGuard systems on both ends in bidirectional traffic applications to make sure there is no snag point when this transition is impacted from the opposing traffic direction. Enclosure 2 includes summary test sheets for the three tests you reported.

You also submitted a drawing (Enclosure 3) depicting Vulcan Barrier ends shielded by your TRITON CET crash cushion (reference the FHWA acceptance letter dated February 6, 2004, HSA-10/CC-47B). I agree that this is an acceptable means of shielding the exposed ends of Vulcan Barrier, but users must be cautioned that impacts into the TRITON CET will likely result in pocketing or penetration into the area beyond the terminal and impacts immediately downstream from this crash cushion will result in greater deflection of the barrier into the work area.

Based upon review of the data you submitted, I agree that the Vulcan Barrier, as tested, meets the NCHRP Report 350 evaluation criteria and may be used on the National Highway System (NHS) as a test level 3 temporary barrier. In its unanchored configuration, at least 8880 kg of mass (23 segments of Vulcan or equivalent weight) must be attached to the ends in advance of the barrier length of need. The freestanding, unshielded end of this design is not crashworthy and requires either shielding with a suitable anchored impact attenuator for uni-directional applications) or introduction outside the appropriate clear zone. I also agree that the ends of the Vulcan can be attached to and shielded by your unanchored TRITON CET crash cushion.
Anticipated lateral deflection of the Vulcan for anchored and unanchored configurations must be communicated to end users so effective field installations can be designed.

Please note also that the following provisions apply to the FHWA letters of acceptance:

- This acceptance is limited to the crashworthiness characteristics of the device and does not cover its structural features or its conformity with the Manual on Uniform Traffic Control Devices.
- Any design 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, the in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash test, it reserves the right to modify or revoke it 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 NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance, designated as number B-134, shall not be reproduced except in full. This letter, and test documentation upon which this letter is based, is public information. All such letters and documentation may be reviewed at our office upon request.
- The Vulcan Barrier is a patented product and is considered proprietary. If proprietary devices are specified by a highway agency for use on a Federal-aid projects, except exempt, non-NHS projects, they: (a) 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.

Sincerely yours,

/Original Signed by Harry W. Taylor/
~for~

John R. Baxter, P.E.
Director, Office of Safety Design
Office of Safety

3 Enclosures
NOTE: INSERT PIN AND SPACER (ITEM 5 & 6) TO JOIN LEFT AND RIGHT ENDS OF ADJACENT BARRIER SEGMENTS DURING INSTALLATION.
ASSEMBLY NO. 3596000-0000

D. Hayes Jr. 3/5/2004
D. Wilkinson 10/28/2003
J. Espinoza 3/5/2004

ASSIGNED P/N'S
10/6/04 - DPH JME KWL

VULCAN

3596000-0000.dwg
General Information
- Test Agency: E-TECH Testing Services, Inc.
- Test Designation: NCHRP 350 Test 3-10
- Test No.: 01-8430-002
- Date: 2/10/04

Test Article
- Type: Vulcan™ Barrier
- Segment: 4115 mm x 813 mm x 546 mm (L x H x W)
- Mass: 395 kg

Installation Length: (18) segments 74.1 m overall
- Length w/o (4) 3.0 m concrete barrier end ballast

Material and key elements
- AASHTO M180 galvanized steel panels, ASTM A53 Pins, and A36 other

Foundation Type and Condition
- Type and Condition: Chip-seal asphalt, dry

Test Vehicle
- Type: Production Model
- Designation: 820C
- Model: 1987 Ford Festiva
- Curb Mass (kg): 823
- Test Inertial Mass: 828
- Dummy Mass: 75
- Gross Mass: 903

Impact Conditions
- Speed (km/h): 103.2
- Angle (deg): 20
- Impact Severity (kJ): 39.8

Exit conditions
- Speed (km/h): 84.0
- Angle (deg - veh. c.g.): 7

Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction: 3.8
  - y-direction: -5.4
- Ridedown Acceleration (g's)
  - x-direction: -5.3
  - y-direction: -4.8

European Committee for Normalization (CEN) Values
- THIV (km/h): 22.8
- PHD (g's): 9.2
- ASI: 0.9

Test Article Deflections (m)
- Dynamic: 1.6
- Permanent: 1.4

Vehicle Damage (Primary Impact)
- Exterior
  - VDS: RFQ-2
  - CDC: 01RFWE1
- Interior
  - VCDI: AS0000000
  - Maximum Deformation (mm): Negligible

Post-Impact Vehicular Behavior (deg - rate gyro)
- Maximum Roll Angle: 6.3
- Maximum Pitch Angle: 1.7
- Maximum Yaw Angle: -27.4

Figure 1. Summary of Results - Vulcan Barrier NCHRP 350 Test 3-10
Figure 6. Summary of Results - Vulcan Barrier NCHRP 350 Test 3-11
Vulcan Barrier Crash Test Results

Exit conditions:
- Speed (km/h): 30
- Angle (deg - veh. c.g.): NA

Occupant Risk Values:
- Impact Velocity (m/s):
  - x-direction: 3.2
  - y-direction: 3.8
- Ridedown Acceleration (g's):
  - x-direction: 4.6
  - y-direction: 9.1

European Committee for Normalization (CEN) Values:
- THIV (km/h): 18.1
- PHD (g's): 9.1
- ASI: 0.7

Test Article Deflections (m):
- Dynamic: 2.1
- Permanent: 2.1

Vehicle Damage (Primary Impact):
- Exterior:
  - VDS: RFQ-2
  - CDC: 01RFWE1
- Interior:
  - VCDI: AS0000000
  - Maximum Deformation (mm): Negligible

Post-Impact Vehicular Behavior (deg - rate gyro):
- Maximum Roll Angle: -10.8
- Maximum Pitch Angle: -4.6
- Maximum Yaw Angle: -36.2

Figure 11. Summary of Results - Vulcan Barrier NCHRP 350 Test 3-11

General Information

Test Agency: E-TECH Testing Services, Inc.
Test Designation: NCHRP 350 Test 3-11
Test No.: 55-8430-003
Date: 10/13/04

Test Article

- Type: Vulcan™ Barrier Segment 4115 mm x 813 mm x 546 mm (L x H x W)
- Mass: 395 kg
- Installation Length: (14) segments 57.6 m length, 67.9 m overall length
- with QuadGuard QZ2406PY end anchorage
- Installation Type and Condition: Chip-seal asphalt over dry soil

Test Vehicle

- Type: Production Model 2000P
- Model: 1995 Chevrolet C-2500
- Mass (kg):
  - Curb: 1858
  - Test Inertial: 2012
  - Dummy: N/A
  - Gross: 2012

Impact Conditions

- Speed (km/h): 100.4
- Angle (deg): 25
- Impact Severity (kJ): 139.6
TRITON CET FOR VULCAN

Standard Triton Pin

DETAIL A
SCALE 0.08 : 1

Triton VET

1 of 1