August 18, 2011

In Reply Refer To:
HSST/ CC-75D

Mr. Gerrit A. Dyke, P.E.
Vice President of Engineering and R & D
Barrier Systems, Inc.
3333 Vaca Valley Parkway, Suite 800
Vacaville, CA 95688

Dear Mr. Dyke:

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: Universal TAU-IIR Crash Cushion Systems
Type of system: Redirecting Crash Cushion/Impact Attenuator
Test Level: NCHRP Report 350 Test Levels 2 and 3 (TL-2 and TL-3)
Testing conducted by: Safe Technologies, Inc.
Date of request: December 30, 2010
Date initially acknowledged: January 4, 2011
Task Force 13 designator: SCT 01c

You requested that we find this system, in its various configurations, acceptable for use on the NHS under the provisions of the National Cooperative Highway Research Program (NCHRP) Report 350.

Requirements
Roadside safety devices should meet the guidelines contained in NCHRP Report 350 if tested prior to December 31, 2010. Devices tested after that date must follow the guidelines contained in the American Association of State Highway and Transportation Officials’ (AASHTO) Manual for Assessing Safety Hardware (MASH). The FHWA memorandum “ACTION: Identifying Acceptable Highway Safety Features” of July 24, 1997, provides further guidance on crash testing requirements of roadside features, including crash cushions.

Decision
The various configurations of the TAU-IIR crash cushion shown in Enclosure 1 are acceptable for use on the NHS at the impact speeds listed.
Description
The TAU-IIR crash cushion uses the same framework as that used in the TAU-II crash cushion configurations that were accepted by the FHWA in letters CC-75 through CC-75C. Specifically, the structural diaphragms, Thrie-beam side panels, slider bolts, backstop assemblies, cables, and anchoring systems are the same as those originally accepted for use on the NHS. The TAU-IIR design uses different energy absorbing cartridges that can be partially self-restoring after some impacts, thereby reducing the need for immediate repairs. These cartridges are made from proprietary hyperelastic (HE) polyurethane and are identified as Type1, 2, or 3 depending on the wall thickness of the cylindrical elements. Dimensions for each type are shown in Enclosure 2. A typical TL-3 installation is shown in Enclosure 3.

Crash Testing
Since only the energy-absorbing elements were changed from the TAU-II design, it was mutually agreed that only the end-on tests were needed to verify acceptable crash performance. Tests were conducted on specific configurations to determine the occupant risk factors for narrow parallel designs, moderately flared designs and wide designs for TL-2 and TL-3 impact speeds. One test was run with an impact speed of 110 km/h (70 mph). Using finite element analysis (FEA) and the results of the full-scale tests that were run, a report prepared by Roadsafe LLC for Barrier Systems, Inc. concluded that the various configurations shown in Enclosure 1 were likely to produce acceptable compliance with Report 350 evaluation criteria for end-on impacts. The following summaries describe the tests that were conducted by Safe Technologies, Inc. on specific configurations of the TAU-IIR:

Narrow (parallel) at TL-2
NCHRP Report 350 tests 2-30 and 2-31 were conducted on a narrow unit at 70 km/h (42 mph) to assess the capacity and occupant risk factors associated with a lower speed impact by both test vehicles. For test 2-30, the unit was anchored to an AC base; in test 3-31, a concrete base was used. The TAU-IIR design for both tests consisted of a 4-bay unit with one Type 3 element nose piece, two Type 1 elements in bay 1, and two Type 2 elements in both bays 3 and 4. Enclosures 3 and 4 show the crash cushion design and the test summaries for the small car and the pickup truck, respectively.

Narrow (parallel) at TL-3
Tests 3-31 and 3-32 were conducted on a narrow, parallel-sided 8-bay design. The tested configuration consisted of a Type 3 element nose piece, three bays containing two Type 1 elements per bay, and five bays containing two Type 2 elements per bay. Enclosure 5 shows the tested crash cushion design and the summary sheets for both tests. This tested TL-3 configuration does not use any Type 3 elements in its interior bays.

Narrow (parallel) at TL-3
Test 3-30 was conducted on a narrow, parallel-sided crash cushion to determine its crashworthiness at an impact speed of 110 km/h (70 mph). The tested configuration was a 10-bay unit, consisting of a Type 3 nose piece, three bays containing two Type 1 elements per bay, four bays containing two Type 3 elements per bay, and three bays containing two Type 2 elements per bay. Enclosure 6 shows the tested design and the crash test summary sheet.
Flared at TL-3
Test 3-31 was conducted to verify the crashworthiness of a flared side-panel layout. The TAU-IIR configuration tested was a seven bay design consisting of a Type 3 nose piece, three bays containing two Type 1 elements per bay, one bay containing two Type 2 elements, and three bays containing four Type 2 elements per bay. Enclosure 7 shows the tested design and the crash test summary sheet.

Wide (flared) at TL-3
Tests 3-30 and 3-31 were conducted on a wide-flared unit. The tested design was a 7-bay unit with a Type 3 nose piece, three bays containing two Type 1 elements per bay and four bays containing four Type2 elements per bay. Enclosure 8 shows the tested design and the crash test summary sheet.

Findings
Based on our review of the information you submitted, the TAU-IIR designs described above and detailed in the enclosed drawings are acceptable for use on the NHS under the range of conditions tested, when such use is acceptable to a highway agency. In addition, any of the configurations depicted in Enclosure 1 are also acceptable for use on the NHS. The five TAU-IIR configurations that were crash-tested were used to validate the FEA model from which the “family” of designs was created. In comparing the model results to the full-scale crash tests, it was seen that the model predictions were almost always conservative (i.e., they over-predicted the occupant risk factors). Consequently, the non-tested TAU-IIR configurations may be used with confidence that they will perform acceptably under the impact speeds listed.

Transportation agencies specifying the 10-bay 110 km/h (70 mph) design should be advised that this unit met all NCHRP Report 350 evaluation criteria only for a head-on impact with the 2000P pickup truck at that speed. The remaining high-speed configurations were developed through analysis and should be equally acceptable for the head-on crash with the pickup truck. However, no assumption should be made that the remaining Report 350 tests for a crash cushion would meet all appropriate evaluation criteria at a 110 km/h (70 mph) impact speed. There is no federal requirement to specify crash cushions that exceed TL-3 capacity.

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

- This letter includes an AASHTO/ARTBA/AGC Task Force 13 designation that should be used when drafting new or revised Task Force 13 drawings.
- This acceptance is limited to the crashworthiness characteristics of the systems and does not cover their structural features, or 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 NCHRP Report 350.

• To prevent misunderstanding by others, this letter of acceptance is designated as number CC-75D 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 Universal TAU-IIR family of crash cushions are patented products and considered proprietary. If proprietary devices 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 the 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 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
Enclosure 2 (1 of 3)

NOTES:
1. ALTERNATE BOLT PATTERN TOP/BOTTOM BASED ON POSITION IN BAY
2. ENERGY ABSORBING ELEMENT MATERIAL: CE-7820 CASTURETHANE-FORMULATION

APPROVALS

UNIVERSAL TAU-IR SYSTEM
ENERGY ABSORBING ELEMENT ASSY. TYPE-1

BSI-1012069-US

DO NOT SCALE DRAWING
REV. ECH 1 DATE 12/18/10
SCALE 1/8 SHEET 1 OF 1
Enclosure 2 (2 of 3)

NOTES:
1. ALTERNATE BOLT PATTERN TOP/BOTTOM BASED ON POSITION IN BAY
2. ENERGY ABSORBING ELEMENT MATERIAL: CB-762D CAST-URETHANE-FORMULATION

UNIVERSAL TAU-IIR SYSTEM
ENERGY ABSORBING ELEMENT ASSY. TYPE-2

APPROVALS

DRAWN: G. DIXON
DRAWN DATE: 12/18/10
APPROVED: G. DIXON
APPROVED DATE: 12/18/10

BSI-1012070-US
SCAL 1:5
REV 1 OF 1
NOTES:
1. ALTERNATE BOLT PATTERN TOP/BOTTOM BASED ON POSITION IN BAY
2. ENERGY ABSORBING ELEMENT MATERIAL - CRYSTAL CATHERMTRANS FORMULATION

APPROVALS

DRAWN: 12/16/10
CHECKED: 12/16/10

UNIVERSAL TAU-HIR SYSTEM
ENERGY ABSORBING ELEMENT ASSY. TYPE-3

BSI-1012071-US
1 OF 1
General Information
Test Agency: SAFE TECHNOLOGIES, INC.
Test Designation: NCHRP Report 350-34
Test No.: STI Test # TAR10
Date: 11/29/2010
Test Article
Type: Crash Cushion
Name: TAU-IR
Dimensions: Length: 5.4 m (17.7 ft)
Size and/or dimension and material: Height: 829 mm (32.6 in)
of key elements: Width: 877 mm (34.5 in)

Test Vehicle
Type: Production Model
Designation: 820C
Model: 1985 Honda CRX
Mass (kg): Curb: 772, Test Inertial: 821, Dummy(s): 75, Gross Static: 896

Impact Conditions
Speed (km/h): 71
Angle (deg): 0
Impact Severity (x): 157.4

Exit Conditions
Speed (kph): N/A
Angle (deg): N/A
Occupant Risk Values
Impact Velocity (m/s)
  x-direction: 10
  y-direction: 1
Ride-down Acceleration (g's)
  x-direction: 16
  y-direction: 7

Test Article Deflection (mm)
  Dynamic: N/A
  Permanent: N/A

Vehicle Damage
  Exterior
    VDS: 12-FL-2
    CDC: 12FYEWI
  Interior
    OCDI: FS0000000

Post-Impact Vehicular Behavior (deg - gyro @ c.g)
  Maximum Roll Angle: 8
  Maximum Pitch Angle: 2
  Maximum Yaw Angle: 80
General Information
Test Agency .............................................. SAFE TECHNOLOGIES, INC.
Test Designation ........................................... NCHRP Report 350 3-31
Test No. ...................................................... 3TI Test # TAR11
Date ........................................................... 11/29/2010
Test Article
Type ......................................................... Crash Cushion
Name ......................................................... TAU-IR
Dimensions .................................................. Length: 5.1 m (16.7 ft)
Size and/or dimension and material ........................ Height: 829 mm (32.8 in)
of key elements ........................................... Width: 287 mm (34.5 in)

Test Vehicle
Type ......................................................... Production Model
Designation .................................................. 2000P
Model .......................................................... 2004 Chevrolet 3/4 Tono Pickup
Mass (kg) ..................................................... Curb: 2260
Test Sternal .................................................. 2013
Dummy(s) .................................................... N/A
Gross Static .................................................. 2013

Impact Conditions
Speed (kph) .................................................. 68
Angle (deg) ................................................... 0
Impact Severity (IC) ........................................ 355.9

Exit Conditions
Speed (kph) .................................................. N/A
Angle (deg) ................................................... N/A
Occupant Risk Values
Impact Velocity (m/s)
- x-direction .............................................. 8
- y-direction .............................................. 0
Rideown Acceleration (g's)
- x-direction .............................................. 20
- y-direction .............................................. 3

Test Article Deflection (mm)
- Dynamic .................................................. N/A
- Permanent ............................................... N/A

Vehicle Damage
Exterior
VDS ......................................................... 12-FC-3
COC .......................................................... 12FC6W1
Interior
COCI .......................................................... FS0000000
Post-Impact Vehicular Behavior (deg @ c.g)
- Maximum Roll Angle .................................. 1
- Maximum Pitch Angle .................................. 7
- Maximum Yaw Angle .................................. 7
General Information
Test Agency: SAFETY TECHNOLOGIES, INC.
Test Designation: NCHRP Report 359-32
Test No.: STI Test # TAR04
Date: 11/10/2010
Test Article
Type: Crash Curation
Name: TAU-HIR
Dimensions:
- Length: 8.9 m (29.1 ft)
- Width: 0.77 m (2.5 ft)

Test Vehicle
Type: Production Model
Designation: 820C
Model: 1986 Honda CRX
Mass (kg):
- Curb: 836
- Test Inertial: 829
- Dummy(s): 75
- Gross Statio: 904

Impact Conditions
- Speed (mph): 100
- Angle (deg): 15
- Impact Severity (kJ): 316.6

Exit Conditions
- Speed (mph): N/A
- Angle (deg): N/A

Occupant Risk Values
- Impact Velocity (m/s):
  - x-direction: 11
  - y-direction: 0
- Ridedown Acceleration (g/s):
  - x-direction: 12
  - y-direction: 3

Test Article Deflection (mm)
- Dynamic: N/A
- Permanent: N/A

Vehicle Damage
- Exterior: 11-FC-3
- CDC: 11FYEN2
- Interior: LF1010000

Post-Impact Vehicular Behavior (deg - g/yra @ c.g.
- Maximum Roll Angle: 14
- Maximum Pitch Angle: 5
- Maximum Yaw Angle: 137
General Information
Test Agency: SAFE TECHNOLOGIES, INC.
Test Designation: NCHRP Report 359-3-31
Test No.: S71 Test 6 TAR03
Date: 11/8/2010

Test Article
Type: Crash Cushion
Name: TAU-IR
Dimensions: Length: 8.9 m (29.1 ft), Height: 829 mm (32.6")

Test Vehicle
Type: Production Model
Designation: 2004P
Model: 2004 Chevrolet 3/4 Ton Pickup
Mass (kg):
- Curb: 2225
- Test Inertial: 2020
- Dummy(s): N/A
- Gross Tons: 2020

Impact Conditions
Speed (kph): 160
Angle (deg): 0
Impact Severity (kJ): 770.0

Exit Conditions
Speed (kph): N/A
Angle (deg): N/A

Occupant Risk Values
Impact Velocity (m/s):
- x-direction: 9
- y-direction: 0

Ride Down Acceleration (g's):
- x-direction: 19
- y-direction: 0

Test Article Deflection (mm)
- Dynamic: N/A
- Permanent: N/A

Vehicle Damage
- Exterior:
  - VDS: 12-FC-2
  - CDC: 12/DEW1
- Interior:
  - OCDI: FS0000000

Post-Impact Vehicle Behavior (deg - gyre @ e.g.)
- Maximum Roll Angle: 4
- Maximum Pitch Angle: 14
- Maximum Yaw Angle: 2

Typical 30" TL-3 Asphalt Anchoring TAU-IR™ OC
### General Information

- **Test Agency:** SAFE TECHNOLOGIES, INC.
- **Test Designation:** NCHRP Report 350.2-31 (Modified 110 kph)
- **Test No.:** STI Test # TAR12
- **Date:** 12/6/2010
- **Test Article Type:** Crash Cushion
- **Name:** TAU-IR
- **Dimensions:** Length: 10.3 m (33.8 ft)
  - Height: 829 mm (32.8 in)
  - Width: 877 mm (34.5 in)
- **Test Vehicle Type:** Production Model
- **Designation:** 2000P
- **Model:** 2000 Chevrolet 3/4 Ton Pickup
- **Mass (kg):**
  - Curb: 2177
  - Test Inertial: 2013
  - Dummy(s): N/A
  - Gross Stato: 2013
- **Impact Conditions:**
  - Speed (kph): 109
  - Angle (deg): 0
  - Impact Severity (kJ): 944.3

### Test Article Deflection (mm)
- **Dynamic:** N/A
- **Permanant:** N/A

### Vehicle Damage
- **Exterior:**
  - VDS: 12-FC-2
  - CDC: 12FCB1
- **Interior:**
  - OD: FS000000

### Exit Conditions
- **Speed (kph):** N/A
- **Angle (deg):** N/A

### Occupant Risk Values
- **Impact Severity (mis):**
  - x-direction: 10
  - y-direction: 0
- **Ride-up Acceleration (g's):**
  - x-direction: 17
  - y-direction: 2

### Post-Impact Vehicular Behavior (deg - gyro @ c-g)
- **Maximum Roll Angle:** 11
- **Maximum Pitch Angle:** 3
- **Maximum Yaw Angle:** 12
General Information
Test Agency: SAFE TECHNOLOGIES, INC.
Test Designation: NCHRP Report 350 3-31
Test No.: STI Test # TAR13
Date: 12/6/2010

Test Article
Type: Crash Cushion
Name: TAHI-R
Dimensions: Length: 7.7 m (25.2 ft)
Size and/or dimension and material: Height: 844 mm (33.2 in)
of key elements: Width: 2049 mm (80.7 in)

Test Vehicle
Type: Production Model
Designation: 2000P
Model: 2004 Chevrolet 3/4 Ton Pickup
Mass (kg):
Curv: 2201
Test Inertial: 2009
Dummy(s): N/A
Gross Static: 2009

Impact Conditions
Speed (kph): 102
Angle (deg): 0
Impact Severity (kJ): 808.2

Exit Conditions
Speed (kph): N/A
Angle (deg): N/A

Occupant Risk Values
Impact Velocity (m/s):
x-direction: 9
y-direction: 0
Ridedown Acceleration (g's):
x-direction: 20
y-direction: 3

Test Article Deflection (mm)
Dynamic: N/A
Permanent: N/A

Vehicle Damage
Exterior
VDS: 12-FC-2
GDC: 12FCEW1
Interior
OCDI: FS000000

Post-Impact Vehicular Behavior (deg - gyro @ Cg)
Maximum Roll Angle: 2
Maximum Pitch Angle: 7
Maximum Yaw Angle: 5
General Information
Test Agency ........................................... SAFE TECHNOLOGIES, INC.
Test Designation ...................................... NCHRP Report 359-3-31
Test No. .................................................. STT Test 9 TAR07
Date ...................................................... 1/19/2000
Test Article
Type ...................................................... Crash Cushion
Name ..................................................... TAU-IR
Dimensions ................................................................
Length: 7.4 m (24.4 ft)
Height: 844 mm (33.2 in)
Width: 2808 mm (110.6 in)

Test Vehicle
Type ...................................................... Production Model
Designation ............................................... 2000P
Model ...................................................... 2004 Chevrolet 34 Ton Pickup
Mass (kg) ................................................................
Curb ...................................................... 2213
Test Inertial ............................................... 2004
Dummy(s) ............................................... N/A
Gross Static ............................................... 2004

Impact Conditions
Speed (kph) ............................................. 99
Angle (deg) ............................................. 0
Impact Severity (ft) .................................... 751.7

Test Conditions
Speed (kph) ............................................. N/A
Angle (deg) ............................................. N/A
Occupant Risk Values
Impact Velocity (m/s)
x-direction ........................................... 10
y-direction ............................................. 1
Ride Down Acceleration (g/s)
x-direction ........................................... 17
y-direction ............................................. 3

Impact Vehicle Deflection (mm)
Dynamic ............................................... N/A
Permanent ............................................... N/A
Vehicle Damage
Exterior ................................................. VDS: 12-FC-3
CC: 12FC2W1
Interior ................................................. ODI: FS0000000

Post-Impact Vehicle Behavior (deg - gyro @ e.g)
Maximum Roll Angle ................................. 3
Maximum Pitch Angle ................................. 22
Maximum Yaw Angle ................................. 2
General Information

Test Agency: SAFE TECHNOLOGIES, INC.
Test Designation: NCHRP Report 350 3-30
Test No.: 3-112 Test 1 # TAR06
Date: 1/17/2010

Test Article

Type: Crash Cushion
Name: TALL-IR
Dimensions: Length: 7.4 m (24.4 ft), Width: 2808 mm (110.6 in)

Test Vehicle

Type: Production Model
Designation: 820C
Model: 1998 Honda CRX
Mass (kg): 788
Curb Test Inertial: 817
Dummy(s): 75
Gross Static: 892

Impact Conditions

Speed (kph): 100
Angle (deg): 0
Impact Severity (kU): 315.0

Exit Conditions

Speed (kph): N/A
Angle (deg): N/A
Occupant Risk Values
Impact Velocity (m/s):
  x-direction: 12
  y-direction: 1
Ride-Down Acceleration (g's):
  x-direction: 17
  y-direction: 7

Test Article Deflection (mm)

Dynamic: N/A
Permanent: N/A

Vehicle Damage

Exterior
VDS: 12-FL-6
CDC: 12FYBW3

Interior
OCIDI: LF000000

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

Max. Roll Angle: 14
Max. Pitch Angle: 17
Max. Yaw Angle: 162