

December 10, 2003

Refer to: HSA-10/CC-35F

Barry D. Stephens, P.E.
Senior Vice President of Engineering
Energy Absorption Systems, Incorporated
3617 Cincinnati Avenue
Rocklin, California 95765

Dear Mr. Stephens:

In your November 15, 2003, letter to Mr. Richard Powers of my staff, you requested formal Federal Highway Administration acceptance of a parallel-sided QuadGuard CZ mounted on a 42-inch wide A-36 steel plate anchored to the ground. A design in which the QuadGuard CZ was anchored directly to the ground was accepted via Mr. Seppo Sillan's August 5, 1996 letter to your Mr. Roger Egan (acceptance letter CC35A). By mounting the crash cushion on a steel plate, it becomes easier to install, maintain, and eventually remove or relocate on an active construction site. The two-piece steel plate used in the test was 3/8-inch thick and was anchored through 6 inches of asphalt and approximately 8 inches of compacted base course using 30 3/4-inch diameter threaded steel rods (ASTM A193-B7) and a two-part polyester grout. The steel rods were 18-inches long. The tested design is shown in Enclosure 1.

To verify acceptable crash performance of the QuadGuard CZ mounted on steel plates, you ran National Cooperative Highway Research Program (NCHRP) Report 350 test 3-33, which members of my staff had previously agreed would likely place the greatest loading on the plate anchoring system. The crash cushion functioned as designed and the steel plate remained flat with no sign of lifting or bending. Since this test had been successfully run much earlier on a permanent QuadGuard, you did not instrument the truck used in the test so no occupant risk values were recorded or reported. Enclosure 2 is the test summary sheet. You had previously conducted test 3-38 into the side of QuadGuard CZ mounted on a 3/4-inch thick steel plate. In this test, the pickup truck was contained and redirected and, again, the steel plate showed no evidence of distress after the crash.

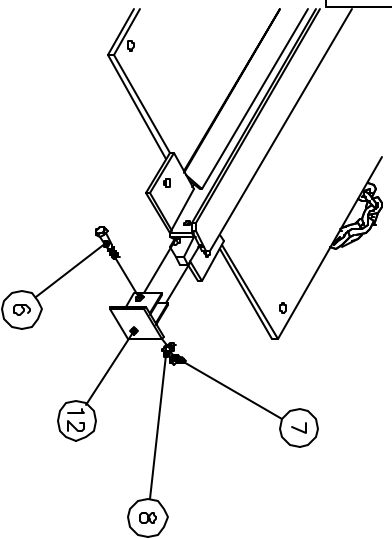
I agree that the QuadGuard CZ, in widths up to 36 inches, may be mounted on a steel plate with a minimum thickness of 3/8 inch, when anchored through asphalt as tested or when anchored as per your specifications through 6 inches (minimum) of concrete. Its NCHRP Report 350 test level rating remains the same as for a permanent installation and is dependent on the number of bays used in a specific application.

Sincerely yours,

(original signed by John R. Baxter)

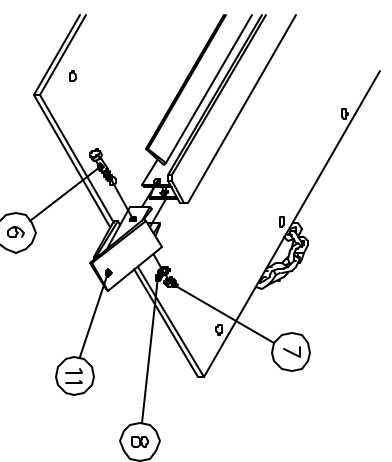
John R. Baxter, P.E.
Director, Office of Safety Design
Office of Safety

2 Enclosures



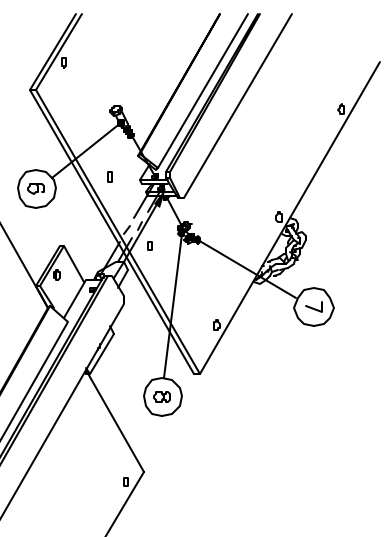
END PLATE ATTACHMENT

SCALE - 1:25
SEE NOTE 7



ENDCAP ATTACHMENT

SCALE - 1:25



MONORAIL ATTACHMENT

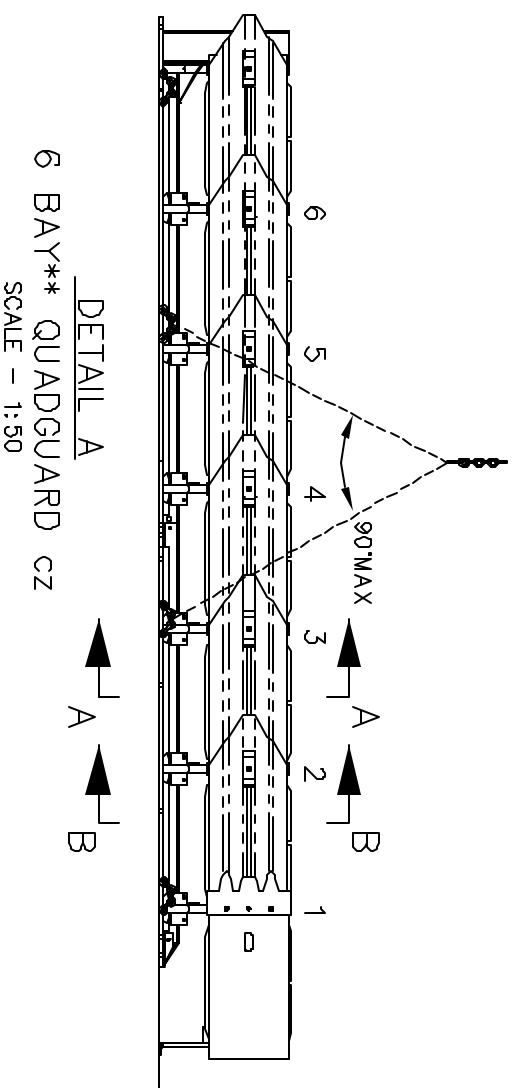
SCALE - 1:25

| PARTS LIST | | | |
|------------|---------------|--------------------------------------|----------|
| ITEM | STOCK NO. | DESCRIPTION | REQ'D |
| | | BAYS → | |
| 1 | 2700731-0500 | ROD, THREADED, 3/4x18, G5, G | 3 6 9 |
| 2 | 2704341-0000 | NU T, HX, 3/4, G, GR DH | 20 30 40 |
| 3 | 2708081-0000 | WASHER, FLAT, 3/4x2, HVY, G | 20 30 40 |
| 4 | 3525100-0000 | MP - 3, QUART PACKAGE | 5 8 10 |
| 6 | 2699571-0000 | BOLT, HX, 5/8x3 1/2, G5, G | 1 2 3 |
| 7 | 2704141-0000 | NU T, HX, 5/8, G | 1 2 3 |
| 8 | 2708231-0000 | WASHER, LOCK, 5/8, G | 1 2 3 |
| 9 | 35440237-0000 | INST. OG PORTABLE CZ ANCHOR/LIFT KIT | 1 1 1 |
| 10 | 2735492-0000 | LABEL, CRATE, OG CZ LIFT KIT | 1 1 1 |
| 11 | 2780040-0000 | ENDCAP, MONORAIL, QPCCZ, G | 1 1 1 |
| 12 | 2760042-0000 | END PLATE, CZ LIFTING KIT | 0 1 1 |

QUADGUARD CZ DECAL

| NO. OF BAYS (DIAPHRAGMS) | ASSEMBLY NUMBER |
|--------------------------|-----------------|
| 3 | 3540233-0000 |
| 6 | 3540236-0000 |
| 9 | 3540239-0000 |

** TO MOVE SYSTEM AS A 9 BAY UNIT PLEASE CONTACT ENERGY ABSORPTION SYSTEMS CUSTOMER SERVICE DEPARTMENT.



6 BAY** QUADGUARD CZ
SCALE - 1:50

ANCHOR SYSTEM:

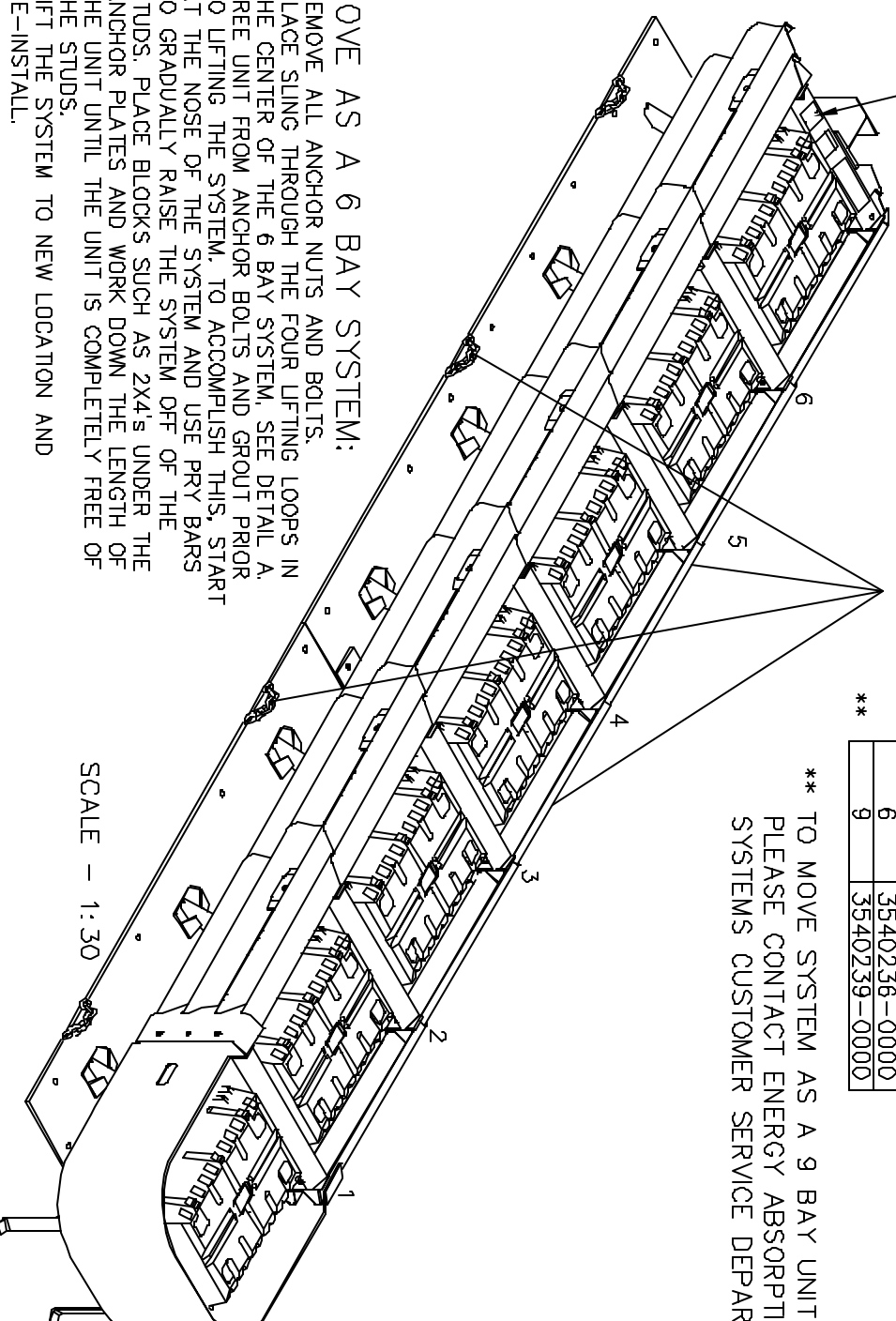
1. CROSS SLOPE OF PLATE SHALL NOT EXCEED 8% AND NOT VARY MORE THAN 2% FROM FRONT TO BACK.
2. USE MP-3 POLYESTER ANCHOR SYSTEM, SUPPLIED BY ENERGY ABSORPTION SYSTEMS, OR APPROVED EQUAL QUADGUARD CZ SYSTEMS INSTALLED ON ASPHALT MUST BE INSPECTED TO ENSURE THE ANCHORS ARE STILL PROPERLY SET FOLLOWING EACH IMPACT. RE-ANCHOR AS NECESSARY.

TO MOVE SYSTEM IN 3 BAY SECTIONS:

1. REMOVE CARTRIDGE FROM BAYS THAT HAVE A MONORAIL BOLT CONNECTING SECTIONS TOGETHER BELOW THEM
2. REMOVE MUSHROOM BOLTS FOR THE BAY THAT HAS HAD THE CARTRIDGE REMOVED.
3. REMOVE ALL ANCHOR BOLTS.
4. REMOVE MONORAIL BOLTS THAT CONNECT SECTIONS TOGETHER.
5. LIFT ONLY ONE 3 BAY SECTION AT A TIME. START WITH NOSE SECTION FIRST.
6. PLACE SLING THROUGH THE LIFTING LOOPS ON EACH CORNER OF THE PLATE. THE SLING NEEDS TO BE A MINIMUM OF 9 FEET LONG OUT TO EACH LIFTING LOOP. MAKE SURE THAT THE SLING IS LONG ENOUGH THAT THE ANGLE IS LESS THAN 90° AS SHOWN.
7. FREE UNIT FROM ANCHOR BOLTS AND GROUT PRIOR TO LIFTING THE SYSTEM. TO ACCOMPLISH THIS, START AT THE NOSE OF THE SYSTEM AND USE PRY BARS TO GRADUALLY RAISE THE SYSTEM OFF OF THE STUDS. PLACE BLOCKS SUCH AS 2X4'S UNDER THE ANCHOR PLATES AND WORK DOWN THE LENGTH OF THE UNIT UNTIL THE UNIT IS COMPLETELY FREE OF THE STUDS.
8. INSTALL THE END PLATE (ITEM 12) OR ENDCAP (ITEM 11) ON EACH 3 BAY SECTION OF THE MONORAIL AS SHOWN (ITEM 12 NOT NEEDED FOR THE BACKUP SECTION). IF THE TOTAL UNIT HAS 7 OR MORE BAYS, BOTH THE ENDCAP AND END PLATE WILL NEED TO BE MOVED TO THE SECTION THAT IS BEING LIFTED TO PREVENT THE DIAPHRAGMS FROM SLIPPING OFF THE MONORAIL**.
9. LIFT THE SECTIONS TO NEW LOCATION, REMOVE END PLATE(S) AND RE-INSTALL SYSTEM (START WITH THE BACKUP).

TO MOVE AS A 6 BAY SYSTEM:

1. REMOVE ALL ANCHOR NUTS AND BOLTS.
2. PLACE SLING THROUGH THE FOUR LIFTING LOOPS IN THE CENTER OF THE 6 BAY SYSTEM. SEE DETAIL A.
3. FREE UNIT FROM ANCHOR BOLTS AND GROUT PRIOR TO LIFTING THE SYSTEM. TO ACCOMPLISH THIS, START AT THE NOSE OF THE SYSTEM AND USE PRY BARS TO GRADUALLY RAISE THE SYSTEM OFF OF THE STUDS. PLACE BLOCKS SUCH AS 2X4'S UNDER THE ANCHOR PLATES AND WORK DOWN THE LENGTH OF THE UNIT UNTIL THE UNIT IS COMPLETELY FREE OF THE STUDS.
4. LIFT THE SYSTEM TO NEW LOCATION AND RE-INSTALL.



SCALE - 1:30

* SEE CHART

ASSEMBLY NO. 3524023*-0000



QuadGuard® SYSTEM

CZ, PORTABLE, ANCHOR/LIFTING KIT, OG, 3 BAY B/U, 3 BAY ADAPTER PLATES

| Revisions | Date | Rev. | By | Chk'd. | App. | Q.C. |
|---|----------|------|-----|--------|------|------|
| ITEM 11 WAS 2760041-0000, REM. 4, 5, 7 & 8 BAYS | 05/09/03 | A | LWC | BK | RCB | STI |

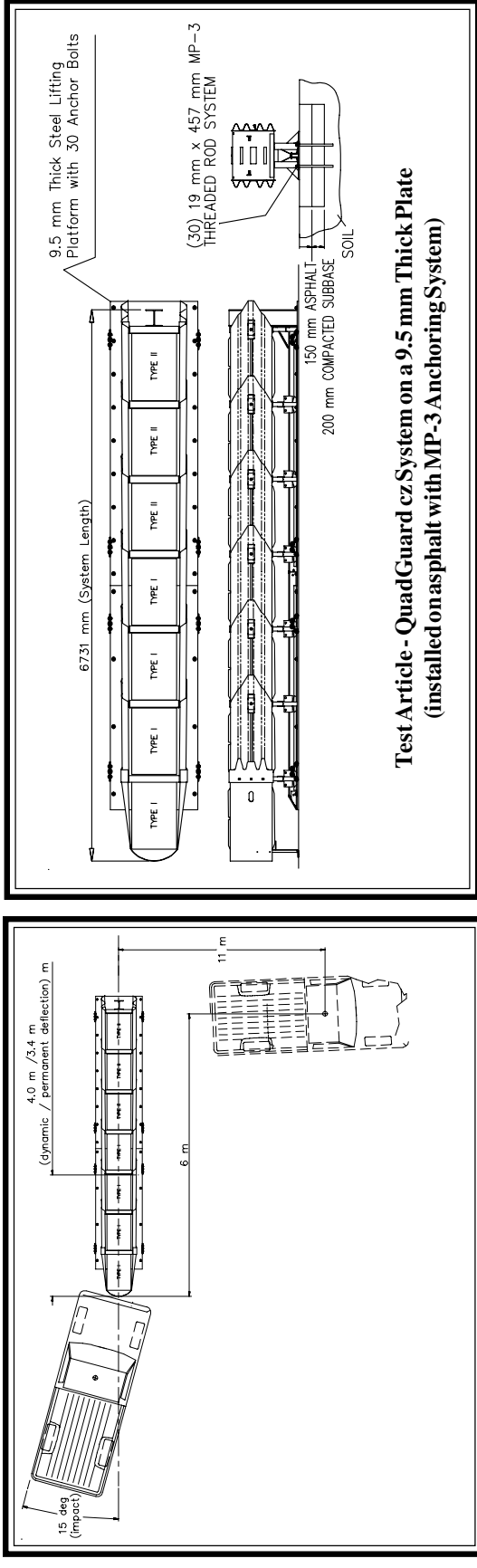
| DATE | DATE | DATE | DATE |
|----------|----------|----------|----------|
| 03/21/03 | 03/28/03 | 03/28/03 | 03/28/03 |

| DESIGNED | APPROVED | DATE | DATE |
|--------------|-------------|----------|----------|
| R. Brougher | R. Brougher | 12/17/01 | 03/28/03 |
| K. Mortensen | R. Brougher | 03/28/03 | 03/28/03 |
| J. Espinoza | J. Espinoza | 03/28/03 | 03/28/03 |

| NAME | DATE |
|--------------|----------|
| L. Corker | 03/21/03 |
| R. Brougher | 12/17/01 |
| K. Mortensen | 03/28/03 |
| R. Brougher | 03/28/03 |
| J. Espinoza | 03/28/03 |

Instruction No. 3540237-0000

SCALE AS NOTED



Test Article - QuadGuard cz System on a 9.5 mm Thick Plate
 (installed on asphalt with MP-3 Anchoring System)

| | |
|---|---|
| General Information | |
| Test Agency | E-TECH Testing Services, Inc. |
| Test Designation | NCHRP 350 Test 3-33 |
| Test No. | 01-5500-006 |
| Date | 11/11/2003 |
| Test Article | |
| Type | Energy Absorption Systems, Inc. |
| ..... | QuadGuard cz System on a 9.5 mm Plate |
| ..... | Model QZ2406P |
| Installation Length | 6 bay 6.73 m (system length) |
| Material and key elements | (4) Type I cartridges |
| ..... | (3) Type II cartridges |
| Foundation Type and Condition | 150 mm thick asphalt over 200 mm |
| ..... | aggregate base with (30) 19 mm x 457 mm |
| ..... | ASTMA193 B7 threaded rods |
| ..... | MP-3 Anchoring System |
| Test Vehicle | |
| Type | Production Model |
| Designation | 2000P |
| Model | 1988 Chevrolet |
| ..... | C2500 Pickup |
| Mass (kg) | |
| Curb | 1898 |
| Test inertial | 2009 |
| Impact Conditions | |
| Speed (km/h) | 101.8 |
| Angle (deg) | 15 |
| Impact Severity (kJ) | 802.6 |
| Exit conditions | |
| Speed (km/h) | N/A |
| Angle (deg - veh. c.g.) | N/A |
| Occupant Risk Values | |
| ..... | N/A * |
| European Committee for Normalization (CEN) Values | |
| ..... | N/A * |
| Post-Impact Vehicular Behavior (deg - rate gyro) | |
| ..... | N/A * |
| Test Article Deflections (m) | |
| Dynamic | 4.0 |
| Permanent | 3.4 |

* Vehicle un-instrumented at request of client.

Figure 1. Summary of Results - QuadGuard cz System on a 9.5 mm Thick Plate Test 01-5500-006

The results of this report relate only to the QuadGuard QZ2406P configuration tested. This report may not be reproduced except in full, without the prior written approval of E-TECH Testing Services, Inc. Prepared by: John F. LaTurner, P.E. - Manager, Report 226 - Issued 11/03



U.S. Department
of Transportation

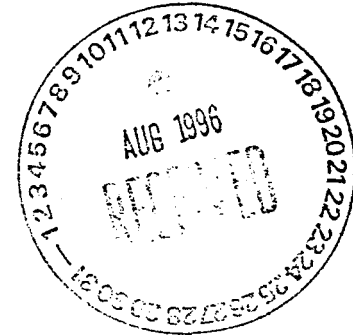
Federal Highway
Administration

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

AUG 5 1996

Refer to: HNG-14

Mr. Roger N. Egan
Senior Vice President
Sales & Marketing
Energy Absorption Systems, Inc.
One East Wacker Drive
Chicago, Illinois 60601



Dear Mr. Egan:

In your June 24 letter to Mr. Gerald L. Eller, you requested the Federal Highway Administration's (FHWA) acceptance of the QuadGuard CZ for use as a temporary crash cushion in work zones. You stated that the QuadGuard CZ is essentially identical to that used in a permanent installation except for its anchoring system. Based on an analysis of the full-scale crash tests conducted to certify the permanent QuadGuard as a National Cooperative Highway Research Program Report 350 TL-3 attenuator, you concluded that test 3-37 (2000-kg pickup truck at 100 km/h impacting at 20 degrees at the beginning of the attenuator length of need) would be the most severe test of the anchoring system. The test 3-37 was successfully run and reported in "Quad Guard CZ Anchoring Test" prepared by Mr. John V. Machado and dated June 17, Revision A. The specific anchoring system used was the "MP-3 Longbolt System," which uses a two-part polyester grout to anchor 20-mm diameter x 460-mm long threaded rods to a foundation of 150-mm deep asphalt over a 150-mm deep compacted subbase. The rods are to be embedded to a minimum depth of 410 mm in 22-mm diameter drilled holes. A total of 50 anchors are needed. The anchor system is shown in Figure 1 and the summary test results are shown in Figure 2.

Based on the test results, we conclude that the QuadGuard CZ qualifies as a TL-3 attenuator *when anchored as tested*. When used in a location subject to reverse-direction impacts, a crash-tested transition design should be used to prevent snagging on the back end of the QuadGuard unit. Subject to the foregoing, the QuadGuard CZ may be used on projects on the National Highway System (NHS) when requested by a State agency. Since the QuadGuard CZ 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.

Sincerely yours,

David A. Prici

for

Seppo I. Sillan, Acting Chief
Federal-Aid and Design Division

2 Enclosures

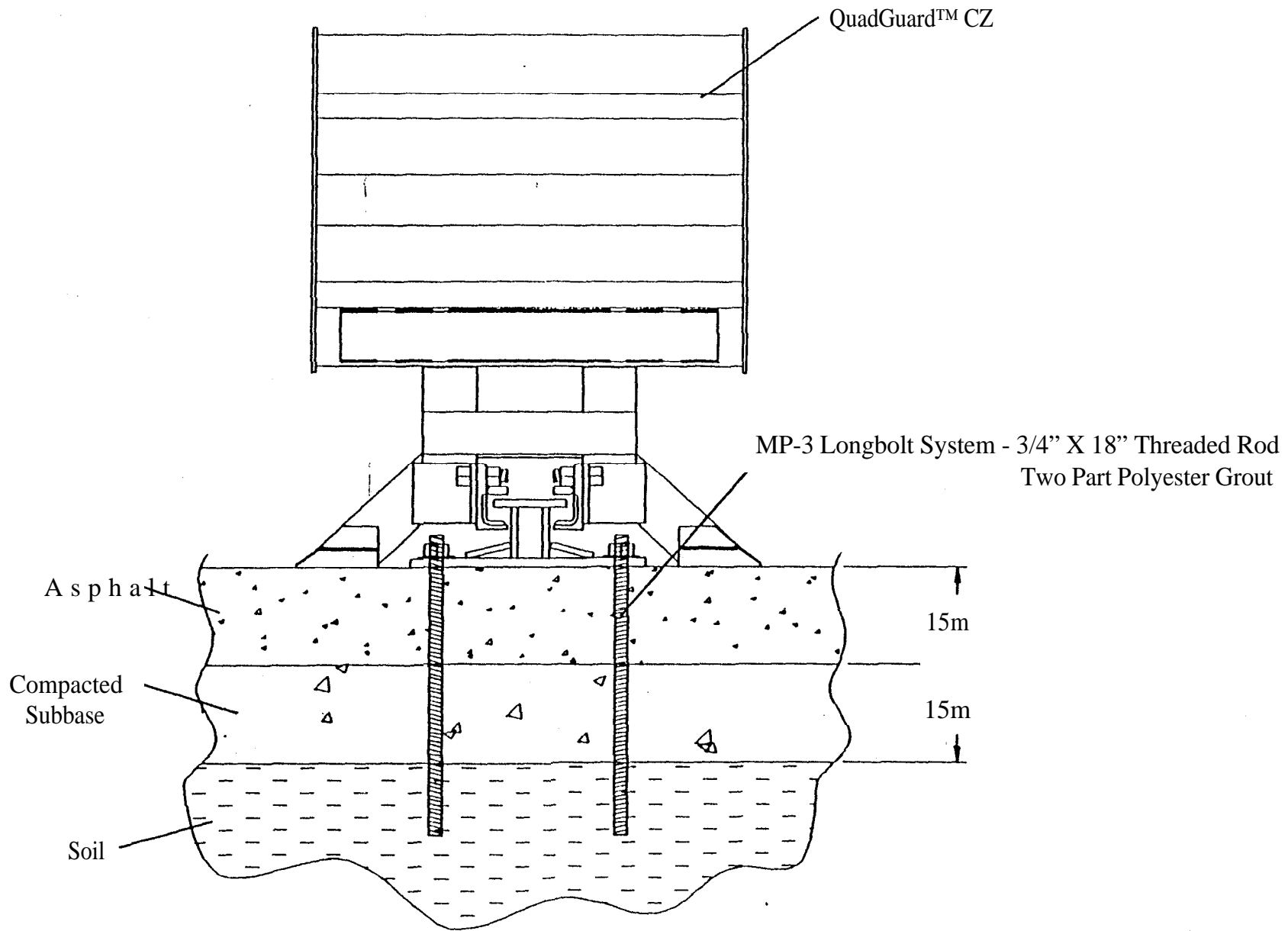
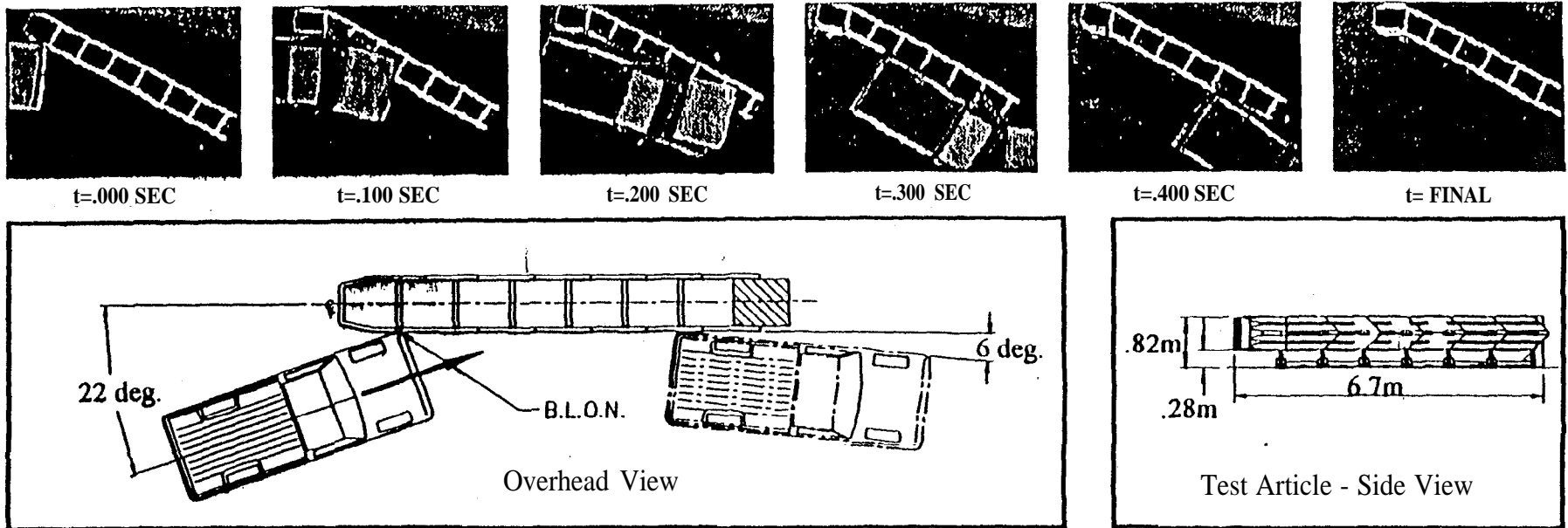


Figure 1. Anchoring Details - QuadGuard™ CZ Test 159-058



| | | | |
|-------------------------------------|-------------------------------|---|-----------|
| General Information | | Exit conditions | |
| Test Agency | E-TECH Testing Services, Inc. | Speed (km/h) | 64.80 |
| Test No. | 159-058 | Angle (deg) | 6 |
| Date | 5/14/96 | Occupant Risk Values | |
| Test Article | | Impact Velocity (m/s) | |
| Type..... | Energy Absorption Systems | x-direction | 7.15 |
| ..... | Quad Guard CZ system | y-direction | 7.62 |
| Installation Length (m) | 6.4 | Ridedown Acceleration (g's) | |
| Size and/or dimension and material | | x-direction | -6.72 |
| of key elements | 6 bay system, 7 energy | y-direction | 8.54 |
| ..... | absorbing cartridges | THIV (optional) | 10.91 |
| Foundation Type and Condition | .15m Asphalt Concrete, .15 m | PHD (optional) | 13.59 |
| ..... | Compacted Subbase | ASI (optional) | 1.48 |
| Test Vehicle | | Test Article Deflections (m) | |
| Type | Production Model | Dynamic | N/A |
| Designation | 2000P | Permanent | N/A |
| Model | 1974 Chevrolet | Vehicle Damage | |
| ..... | 3/4 Ton Pickup | Exterior | |
| Mass (kg) | | VDS | LFQ-6 |
| Curb | 2036 | CDC | 11LDEW2 |
| Test Inertial | 2037 | Interior | |
| Dummy(r) | N/A | OCDI | LF0010000 |
| Gross Static | 2037 | Post-Impact Vehicular Behavior (deg) | |
| Impact Conditions | | Maximum Roll Angle..... | -7.29 |
| Speed(km/h) | 96.97 | Maximum Pitch Angle | 3.35 |
| Angle (deg) | 22 | Maximum Yaw Angle | 32.07 |
| Impact Severity(kJ) | 107.73 | | |

Figure 2. Summary of Results - QuadGuard™ CZ Test 159-058