

QuadGuard® CEN



*Set a worldwide standard for crash cushions
reliability and effectiveness.*



**ENERGY ABSORPTION
SYSTEMS, INC.**

**A Quixote Company
Saving Lives By Design**

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Product Manual

QuadGuard® CEN

System Overview

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Important Introductory Notes

Proper placement of the QuadGuard CEN is essential to assure maximum performance. Take the time to review this manual including product limitations thoroughly before using this System at a given site. Do not attempt to install any crash cushion without the proper plans and installation manual from the manufacturer.

If you need additional information, or have questions about the QuadGuard CEN, please call Energy Absorption Systems' Customer Service Department:

USA: 1-888-323-6374

ENGLAND: 44-1473-221-105

The QuadGuard® CEN is a highly efficient, redirective, non-gating crash cushion for hazards ranging from 610 mm [24"] to 2285 mm [90"] in width. It consists of crushable, energy-absorbing cartridges surrounded by a framework of Quad-Beam™ panels. Refer to Table B on page 7 to determine the appropriate length System for a given design speed.

Crash Performance

The QuadGuard CEN has successfully passed the European Standard EN 1317:2000. For a list of the tests, see the Limitations & Warnings section of this manual.

During head-on impacts, the QuadGuard CEN telescopes rearward and crushes to absorb the energy of impact. When impacted from the side, it safely redirects the vehicle back toward its original travel path and away from the hazard.

A wise choice...

because the QuadGuard CEN meets your needs. The System is available in four lengths to meet your design speed criteria and to match the special needs of most sites.

because the QuadGuard CEN is available in several widths. It can fit in places where other crash cushions cannot fit. The QuadGuard CEN is available in the following five widths: 610 mm [24"], 760 mm [30"], 915 mm [36"], 1755 mm [69"] and 2285 mm [90"].

because the QuadGuard CEN is redirective. It is designed to redirect vehicles that hit the System along the side, rather than allowing them to gate through.

because most of the QuadGuard CEN is reusable. After a typical design speed, head-on hit, the majority of the System is reusable. The System usually needs only to be pulled back into place and have the cartridges replaced.

because the QuadGuard CEN is crush efficient. Cartridges offer exceptional energy absorbing efficiency. The QuadGuard CEN is available in four different lengths. Therefore, a System length may be chosen which will offer the best size/efficiency ratio. Thus, the shortest System possible for a given design speed can be installed. This increases driver decision distance and reduces the likelihood of the System being hit.

QuadGuard® CEN

General Product Specifications

I. General

All QuadGuard CENs are produced by Energy Absorption Systems, Inc. of Chicago, Illinois.

II. Description of System

A. General

The QuadGuard CEN consists of energy absorbing cartridges surrounded by a framework of steel Quad-Beam™ guardrail which telescopes rearward during head-on impacts. The QuadGuard CEN has a center monorail, which will resist lateral movement during side angle impacts, and a backup, which will resist movement during head-on impacts. The nose assembly consists of a flexible nose wrap and does not contain an energy-absorbing cartridge. Transitions are available and may be required depending on site conditions.

B. Component Descriptions

1. A bay describes a section of the QuadGuard CEN consisting of an energy absorbing cartridge or bumper assemblies, a diaphragm, two fender panels and fasteners.
 - a. Except for the first and second bays, which contain bumper assemblies and are closest to the nose, each bay contains Type E energy absorbing cartridges. The outside of each cartridge is fabricated from weather resistant plastic. The actual quantity of each will be determined by the System design speed. Refer to the product design manual for more information.
 - b. The diaphragms are made from 10 gauge, steel Quad-Beam sections. Two support legs are welded to the Quad-Beam. Ski-shaped plates are welded to the bottom of the support legs. The diaphragms are designed to lock onto and be guided by a ground-mounted, center monorail support structure.
 - c. The fender panels are fabricated from 10 gauge Quad-Beam sections. The rear of each fender panel (the panel end furthest from the nose of the assembled System) is tapered to help maximize performance during wrong-way, redirective impacts. Each fender panel is drilled and slotted in accordance with the manufacturer's specifications so that when assembled in the field, the front end (the end closest to the nose of the assembled System) is bolted to a diaphragm or hinge plate (depending on the width of the System) by means of 5/8" bolts. The rear of each Quad-Beam fender panel overlaps the next rearward fender panel and is connected to the diaphragm or the hinge plate of the next bay by means of a bolt, and a "mushroom" washer. The bolt and the boss of the mushroom washer fit through the horizontal slot of the fender panel. This permits the movement, front to rear, of one set of fender panels relative to the panels in the underlying, next rearward bay. For QuadGuard CENs with a backup width greater than 915 mm (36"), the mushroom bolt assembly is held in place by a compression spring, which allows limited separation of the fender panels during an impact.

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General Product Specifications (cont'd.)

2. The monorail support structure is made of steel and is to be anchored, per manufacturer's instructions, to a specified rigid surface. The monorail prevents lateral movement, vertical movement and overturning of the diaphragms during design impacts.
3. The nose section contains a nose cover fabricated from a flexible belt and is not counted as a bay. The nose belt attaches to the front diaphragm. Standard nose colors are gray, yellow or black.
4. The backup structure is made of steel and is to be attached to an integral tension strut framework. It is available in nominal widths of 610 mm (24"), 760 mm (30"), 915 mm (36"), 1755 mm (69"), and 2285 mm (90").
5. Several transition panels are available as required by site conditions including: Quad-Beam™ to Concrete Safety Barriers, Quad-Beam to Thrie-Beam, Quad-Beam to W-Beam, Quad-Beam to End Shoe (for attachment to vertical concrete walls). Contact Energy Absorption Systems, Inc. for specific applications.

C. Material Specifications

1. All structural steel elements are fabricated from the specified steel. After fabrication, all metal work is galvanized in accordance with design specifications. All welding is done by or under the direction of a certified welder.
2. All plastic materials in the QuadGuard® CEN are new. All materials are of high quality and conform to applicable Material Specifications.
3. All bolts, nuts, and washers are galvanized. All bolts, nuts, and washers are Commercial Quality "American National Standard," unless otherwise specified.

III. Performance criteria

- A. The QuadGuard CEN is capable of meeting the Impact Test Acceptance Criteria stipulated in European Standard EN 1317:2000, for velocity classes of 110 km/h, 100 km/h, 80 km/h, and 50 km/h for vehicles weighing between 900 kg and 1500 kg. The 8 bay, 6 bay, 5 bay & 3 bay QuadGuard CEN Systems are designed for velocity classes 110 km/h, 100 km/h, 80 km/h & 50 km/h respectively. A properly installed and maintained QuadGuard CEN is capable of performing its functions of stopping or containing and redirecting the test vehicles to the European Standard EN 1317:2000 requirements.
- B. Impact conditions which differ from those described in European Standard EN 1317:2000 may yield results different from those encountered in testing. In particular, impacts conditions in excess of specified impact severity, or existence at the site of the installation of curbs, or cross slopes in excess of 8%, may yield impact performance which does not meet the Impact Test Acceptance Criteria stipulated in European Standard EN 1317:2000.

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General Product Specifications (cont'd.)

IV. Test criteria

The following full-scale crash tests have been conducted on the QuadGuard CEN, and in each test all evaluation criteria specified in European Standard EN 1317:2000 were met. Properly installed and maintained, the QuadGuard CEN is capable of performing its functions of stopping or containing and redirecting impacting vehicles in accordance with European Standard EN 1317:2000 for the impact conditions listed in Table A. The impact conditions tested are intended to represent a wide range of in-service impact conditions, but do not encompass all possible in-service impact conditions.

Table A
Summary of QuadGuard CEN Tests

PERFORMANCE LEVEL	TEST NO.	VEHICLE MASS (KG)	IMPACT SPEED (km/h)	IMPACT ANGLE & IMPACT POINT
110	Parent model at minimum taper/width – QI2408Y			
	TC 1.1.100	900	100	0 deg. Head-on, centre
	TC 1.3.110	1500	110	0 deg. Head-on, centre
	TC 2.1.100	900	100	0 deg. 1/4 vehicle offset
	TC 3.3.110	1500	110	15 deg. Nose, (centre)
	TC 4.3.110	1500	110	15 deg. redirect at L3
	TC 5.3.110	1500	110	165 deg. redirect at L2
	Maximum taper/width model – QI9008Y			
	TC 1.1.100	900	100	0 deg. Head-on, centre
	TC 4.3.110	1500	110	15 deg. redirect at L3
100	Minimum taper/width model – QI2406Y			
	TC 1.2.100	1300	100	0 deg. Head-on, centre
	Maximum taper/width model – QI9006Y			
TC 4.2.100	1300	100	15 deg. redirect at L3	
80	Minimum taper/width model – QI2405Y			
	TC 1.2.80	1300	80	0 deg. Head-on, centre
	Maximum taper/width model – QI9005Y			
TC 4.2.80	1300	80	15 deg. redirect at L3	
50	Minimum taper/width model – QI2403Y			
	TC 1.1.50	900	50	0 deg. Head-on, centre
	Maximum taper/width model – QI9003Y			
TC 4.2.50	1300	50	15 deg. redirect at L3	

V. Design and selection criteria

- A. Placement of Systems should conform to the appropriate European regulations.
- B. Installation of the QuadGuard CEN should be accomplished in accordance with the recommendations of Energy Absorption Systems, Inc.

QuadGuard® CEN

Design Criteria

CEN Criteria

The QuadGuard CEN has successfully passed the European Standard EN 1317:2000 tests. For the full test matrix, see the Limitations & Warnings section of this manual.

Establish Basic System Specifications

The specification of a QuadGuard CEN for a particular site must always include System width and System length.

1) Specification of System width

The QuadGuard CEN is available in five nominal widths (see figure 10 on page 12): 610 mm

[24"], 760 mm [30"], 915 mm [36"], 1755 mm [69"] and 2285 mm [90"].

As a general rule, selection of the narrowest width that adequately shields the hazard is recommended.

Impact conditions which differ from those described in the European Standard EN 1317-3:2000 may result in different crash results than those encountered in testing. Furthermore, impacts in excess of design impact severity, or the existence (at the site of the installation) of curbs or cross slopes in excess of 8%, may yield crash performance which does not meet the evaluation criteria of European Standard EN 1317-3:2000.

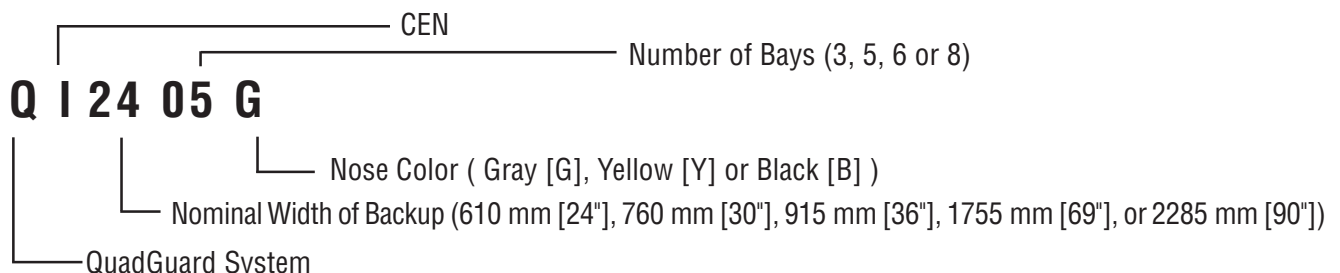
Table B - QuadGuard CEN Design Table

Design Velocity km/h [mph]	Number of Bays	System Length	Effective Length	Average G Deceleration
110 [69]	8	7.97 m [26'-1 1/2"]	7.32 m [24'-0"]	7.7
100 [62]	6	6.13 m [20'-1 1/2"]	5.49 m [18'-0"]	8.4
80 [50]	5	5.22 m [17'-1 1/2"]	4.57 m [15'-0"]	6.5
50 [31]	3	3.39 m [11'-1 1/2"]	2.74 m [9'-0"]	4.3

Above G's are based upon average values calculated for vehicles that stop in a distance equal to 85% of the Systems length.

Table C - QuadGuard Standard System Model Numbers

Number of Bays	Nominal Width				
	610 mm [24"]	760 mm [30"]	915 mm [36"]	1755 mm [69"]	2285 mm [90"]
3	QI2403G, Y or B	QI3003G, Y or B	QI3603G, Y or B	QI6903G, Y or B	QI9003G, Y or B
5	QI2405G, Y or B	QI3005G, Y or B	QI3605G, Y or B	QI6905G, Y or B	QI9005G, Y or B
6	QI2406G, Y or B	QI3006G, Y or B	QI3606G, Y or B	QI6906G, Y or B	QI9006G, Y or B
8	QI2408G, Y or B	QI3008G, Y or B	QI3608G, Y or B	QI6908G, Y or B	QI9008G, Y or B



Model Number Description

QuadGuard® CEN

Design Criteria (cont'd.)

How to Determine Left/Right

To determine left from right when ordering parts, stand in front of the System facing the hazard. Your left is the System's left and your right is the System's right.

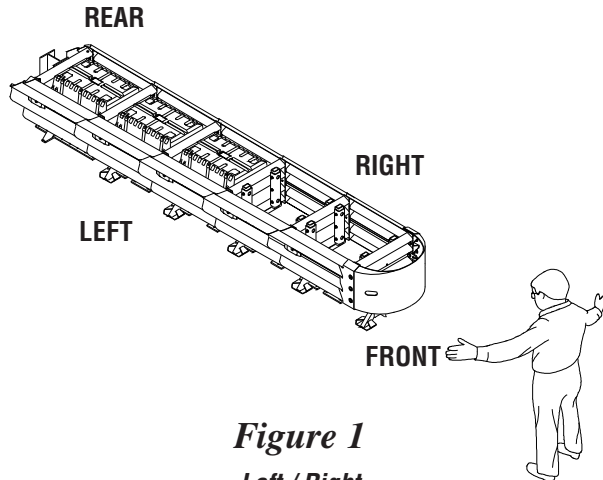


Figure 1
Left / Right

Counting The Number of Bays

One bay consists of one diaphragm and two fender panels. The front two bays contain bumpers. Each of the other bays contains a cartridge. The nose section is not considered a bay. Therefore, the total number of bays will exceed the number of cartridges by two (see figure 2).

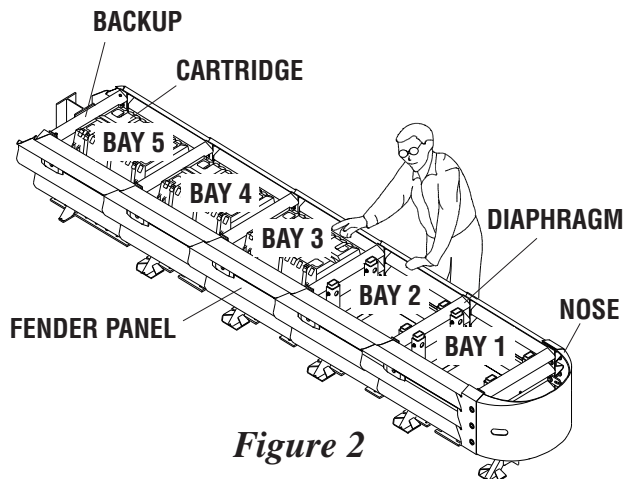


Figure 2
Number of Bays
(5 bay System shown)

Measuring The Width

The QuadGuard® CEN is available in 5 nominal widths:

1. 610 mm [24"]
2. 760 mm [30"]
3. 915 mm [36"]
4. 1755 mm [69"]
5. 2285 mm [90"]

The nominal width of the System is the width between side panels behind the backup (see figure 3).

The outside width of the System is approximately 150-230 mm [6-9"] wider than this measurement.

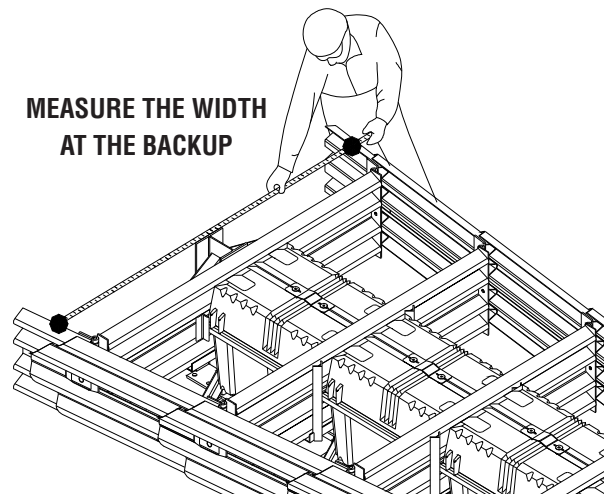


Figure 3
System Width

QuadGuard® CEN

Design Criteria (cont'd.)

Specification of System Length

System length is specified by the number of bays the System includes. The number of bays required is a function of the design speed of the roadway. Refer to Table B on page 7 to correlate the design speed of the roadway with the number of bays which should be specified.

Example of basic System specification:

To shield a 710 mm [28"] hazard on a roadway with a design speed of 100 km/h [62 mph], the designer would call for a 6-bay System with 760 mm [30"] diaphragms. (See Table C on page 7 for model numbers.)

Establish Required System Footing

Note that the System must be anchored. MP-3 polyester anchor bolts will be supplied for all required anchorages in concrete. Refer to the QuadGuard CEN Installation Manual, or MP-3 kits for detailed installation instructions.

1) Is the System to be placed on existing concrete?

Existing concrete

Concrete must be at least 150 mm [6"] thick, reinforced 28 MPa [4000 psi] Portland cement concrete (P.C.C.), or 200 mm [8"] thick non-reinforced. The concrete should be in good condition and be free of major cracks.

New concrete

If existing concrete does not meet these criteria, a new concrete pad must be placed to properly secure the System.

2) Is there a cross slope at the installation site?

Cross slope exists - If there is a cross slope of more than 8% (5 deg.), or if the cross slope varies more than 2% (1 deg.) over the length of the System, a concrete leveling pad may be required. (See figure 4.)

No Cross slope - No additional action is required.

Note: Curb should be mountable and not exceed 100 mm [4"]. Level out as necessary.

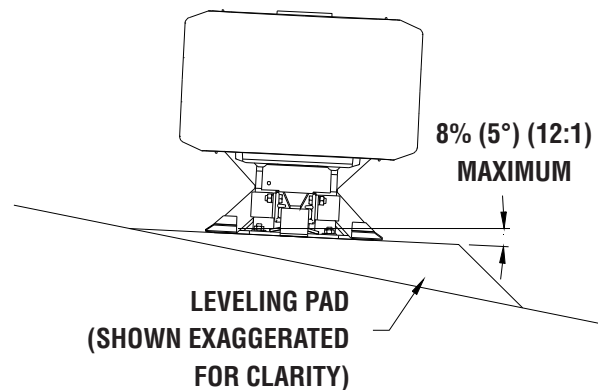


Figure 4
Cross Slope

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Design Criteria (cont'd.)

Special Site Conditions

Contact Energy Absorption Systems Customer Service Department if you would like assistance with your application. You will need to answer the following questions:

1. Are curbs, islands or elevated objects (delineators or signs) present at the site? What height and width are they? All curbs and elevated objects over 100 mm [4"] high should be removed. If possible, curbs under 100 mm [4"] high should be removed approximately 15 m [50'] in front of the QuadGuard® CEN, and as far back as the System's backup. Any curbs that must remain should be 100 mm [4"] maximum and be mountable.
2. If the installation site is a gore area, (place where two roads diverge), what is the angle of divergence?
3. What is the general geometry of the site, including the roadway for 150 m [500'] in front, so traffic patterns can be visualized?
4. When there is an existing guardrail at the site, the backup of the QuadGuard CEN should tie into it when possible.
5. Will there be traffic approaching from the rear of the System? Is the System in a two-way traffic situation, with traffic going in opposite directions on either side of the System? Or, is the System on the side of the road in a location where cross

over traffic is a concern? If so, a transition from the back of the System to the hazard is necessary to prevent vehicle snagging (see page 11).

Note: Transition panels should be angled so the maximum gap from the fender panel overlap does not exceed 20 mm [0.78"] for Narrow Systems and 25 mm [1.00"] for Wide Systems* (see figure 5).*

***Narrow Systems:**

610 mm [24"], 760 mm [30"], 915 mm [36"]

***Wide Systems:**

1755 mm [69"] and 2285 mm [90"]

6. Are there any other unique features at the site that may affect positioning or performance of the QuadGuard CEN? (See next paragraph).

Other Factors That May Affect Your Design:

1. The existence of drain inlets.
2. Junction boxes or other appurtenances located near the hazard.
3. Insufficient space for the length preferred.
4. The location and movement of expansion joints. Contact Energy Absorption Systems Customer Services Department before proceeding with your design. For Customer Service call:
United Kingdom: 44-1473-221-105
United States: 888-323-6374.

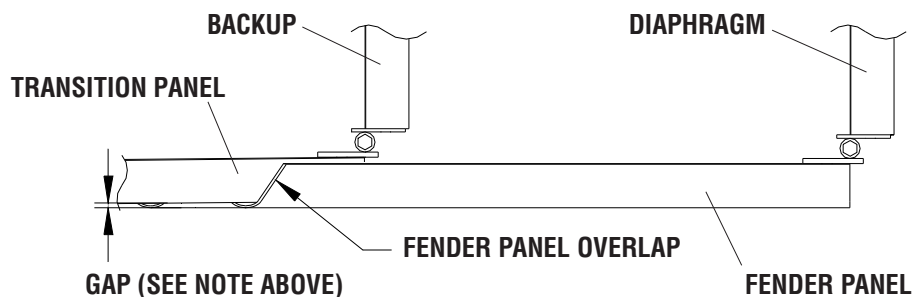


Figure 5
Fender Panel Gap

QuadGuard® CEN

Design Criteria (cont'd.)

Transition Panel Types

If a System is placed in a location where traffic will be approaching from the rear of the System a transition panel is necessary. Figures 6, 7, 8 & 9 show the standard panel

types. There are variations for each panel type. The specific panel needed will depend on System and site conditions. Therefore, it is important to send site specific data to the customer service department for a recommendation for exact panel needed for your application.

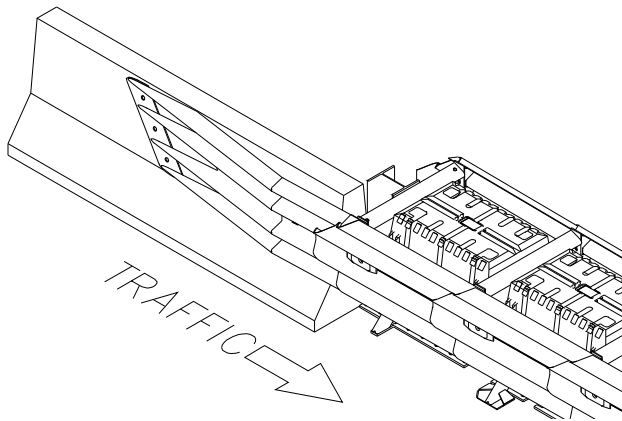


Figure 6
Quad-Beam to Safety Shape Barrier Transition Panel

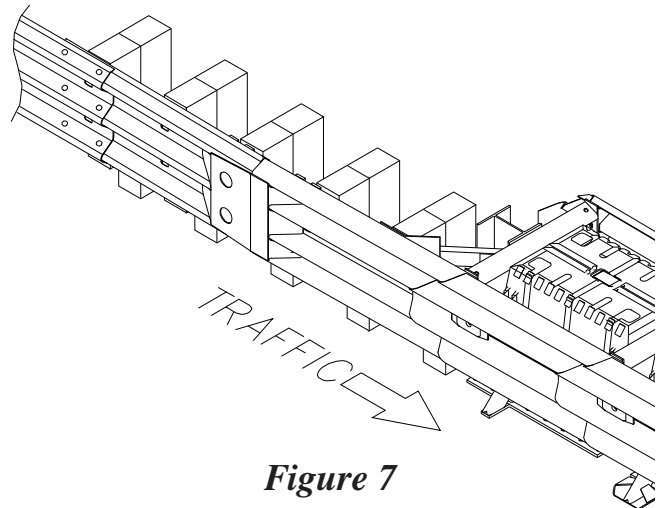


Figure 7
Quad-Beam to Thrie-Beam Transition Panel

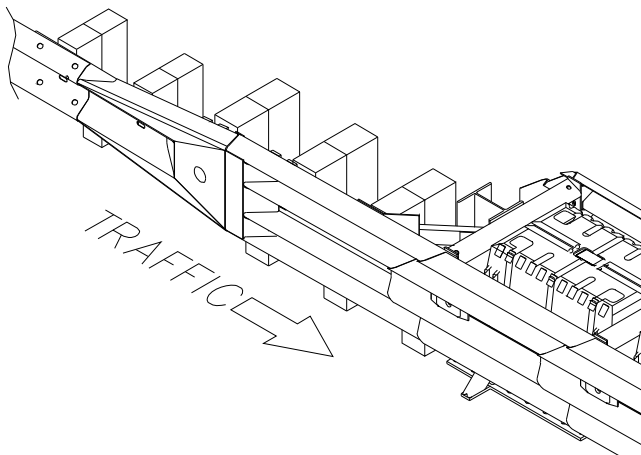


Figure 8
Quad-Beam to W-Beam Transition Panel

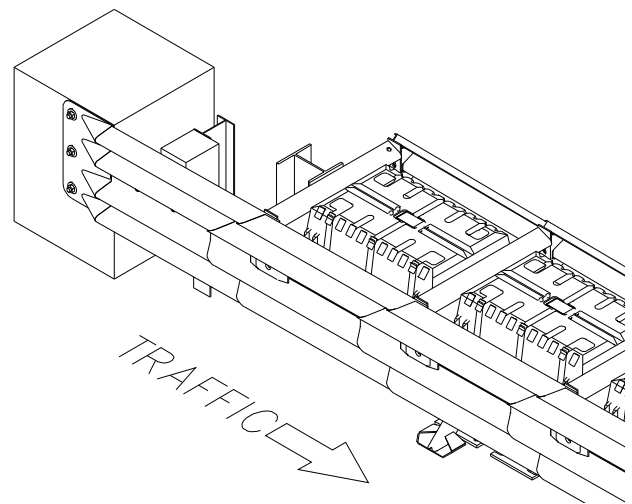
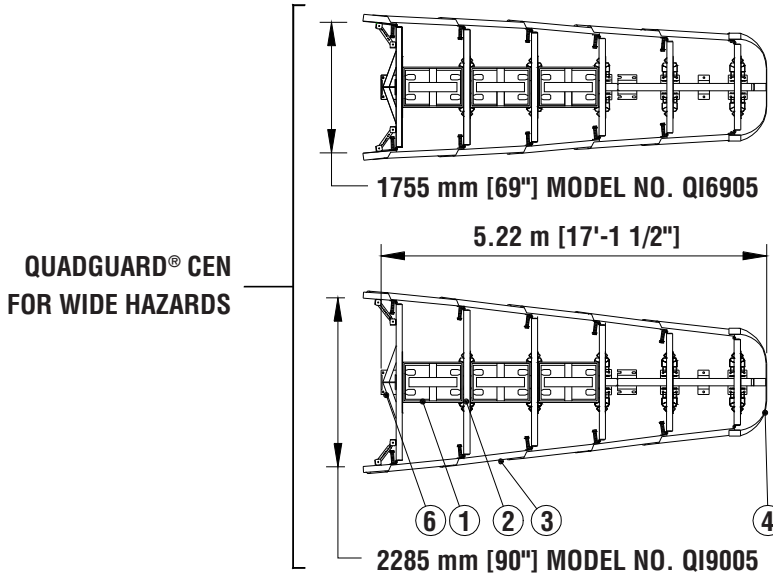
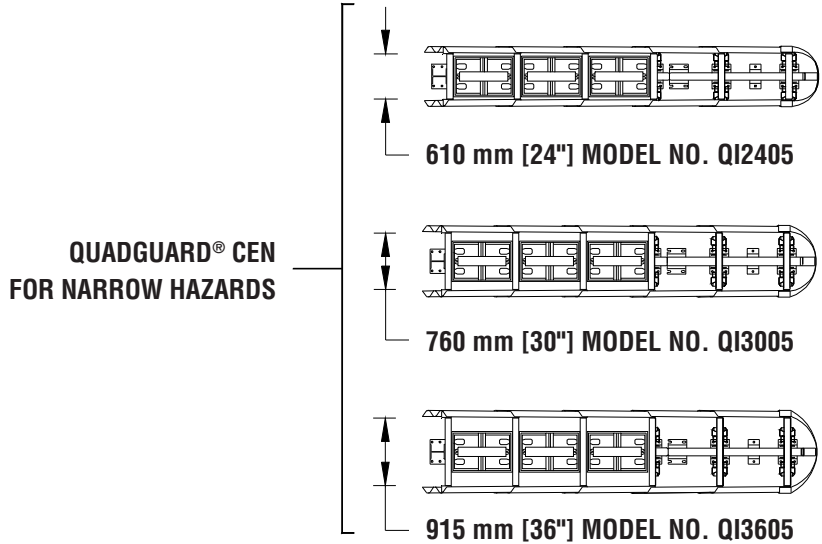


Figure 9
Quad-Beam End Shoe Transition Panel

Note: Wheel Deflectors may be required for this application (see drawing 35-40-20 in the back of this manual).

QuadGuard® CEN

Design Criteria (cont'd.)



KEY

- ① CARTRIDGE
- ② DIAPHRAGM
- ③ QUAD BEAM FENDER PANEL
- ④ NOSE COVER
- ⑤ MONORAIL
- ⑥ BACKUP

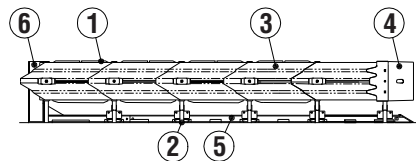


Figure 10

Plan & Elevation (5 bay System shown)

QuadGuard® CEN

General Installation Information

Required Tools

Documentation

- Manufacturer's installation manual
- Manufacturer's drawing package

Cutting equipment

- Rebar cutting bit
- 22 mm (7/8") concrete drill bits (*Two Fluted)
- Grinder, Hacksaw or Torch (optional)
- Drill motor
- Drill Bits: 1/16" through 7/8"

* Energy Absorption Systems recommends using two fluted drills to achieve optimum tensile strength when installing the MP-3 anchoring system.

Hammers

- Rotohammer
- Sledgehammer
- Standard hammer

Wrenches

- Heavy duty impact wrench
- Standard adjustable wrench
- 1/2" drive sockets: 9/16", 11/16", 3/4", 15/16", 1 1/8", 1 1/4"
- Deep sockets: 5/16", 1 1/4"
- Ratchet and attachments for the above sockets
- Breaker bar: 1/2" x 24"

- Torque wrench: 200 ft-lbs.
- Crescent wrench: 300 mm [12"]
- Allen wrench: 3/8" (may be ordered through EASI, P/N 2727317-0038)
- Impact Wrench: 1/2"

Personal protective equipment

- Protective eyewear
- Gloves

Miscellaneous

- Traffic control equipment
- Lifting and moving equipment (A lifting device is preferred although a forklift can be used.) Minimum 5,000 lb. capacity required.
- Compressor (100 psi) and Generator (5 KW)
- Long pry bar
- Drift pin 300 mm [12"]
- Center punch
- Tape measure 7.5 m (25')
- Chalk line
- Concrete marking pencil
- Nylon bottle brush for cleaning 7/8" drilled holes
- Rags, water, and solvent for touch-up

Note: The above list of tools is a general recommendation. The actual number of tools required will depend on specific site conditions and the complexity of the installation.

QuadGuard® CEN

General Installation Information (cont'd.)

Caution: The installation/maintenance information provided here is for planning and System selection purposes only. Do not attempt to install or maintain the QuadGuard CEN without the proper plans and Installation/Maintenance Manual from the manufacturer.

If you need additional information, or have questions about the QuadGuard CEN, please call: Energy Absorption Systems, Inc. Customer Service Department at +44-1473-221-105.

Site Preparation/Foundation

The QuadGuard® CEN should be installed only on an existing or freshly placed and cured concrete base (28 MPa [4000 psi] minimum). Location and orientation of the concrete base and attenuator must comply with project plans or as otherwise determined by the resident project engineer.

Recommended dimension and reinforcement specifications for new concrete pads are provided in Energy Absorption Systems, Inc. concrete pad drawings, supplied with the System. System may be installed on concrete roadway (minimum 200 mm [8"] thick). Installation cross slope shall not exceed 8% and should not vary more than 2% over the length of the System; the pad surface shall have a light broom finish.

Caution: Accurate placement of all steel rebar is critical to avoid interference with the concrete Anchor Bolts.

WARNING!

Location of the backup in relation to nearby objects will affect the operation of the attenuator. Upon impact, the fender panels telescope toward and extend beyond the rigid backup as much as 760 mm [30"] from their pre-impact location. Position the backup so that the rear ends of the last fender panels are a minimum of 760 mm [30"] forward of objects that would otherwise interfere with movement of the panels. Failure to comply with this requirement will result in impaired System performance offering motorists less protection and cause component damage.

Estimated Time for Installation

With the use of proper tools and trained crew of 3 workers, the estimated time for installation on a fully cured pad is 2 to 4 hours depending on site conditions, traffic, size and experience of work crew, and quality of tools.

General Maintenance and Repair

The QuadGuard CEN is considered to be a reusable System. After most design impacts, you can expect to reuse 65 - 70% of the System. The System must be inspected after each impact and must be manually pulled out to its original length. Depending on the impact, components may get damaged and need replacement.

Estimated time for Maintenance

An experienced two person crew with the proper tools and spare parts should be able to complete the work in one to 3 hours depending on the damage done to the System.

IMPORTANT: After an impact, always follow the "Post-Impact Instructions" in the maintenance and repair section of the installation manual.

Recycling Information

When parts need to be replaced, it is recommended that the old parts be recycled as follows:

Steel should be sold as scrap to a local metal recycler.

Plastic from the cartridges should be sold to a plastic recycler if available. If a recycler is unavailable, dispose of the material as plastic refuse.

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Limitations and Warnings

The QuadGuard CEN has been tested and evaluated in accordance with European Standard EN 1317:2000. The impact conditions tested are intended to represent a wide range of in-service impact conditions, but do not encompass all possible in-service impact conditions.

The following full-scale crash tests have been conducted on the QuadGuard CEN, and in each test all evaluation criteria specified in European Standard EN 1317:2000 were met. Properly installed and maintained, the QuadGuard CEN is capable of performing its functions of stopping or containing and redirecting impacting vehicles in accordance with European Standard EN 1317:2000 for the impact conditions listed in Table A.

Table A
Summary of QuadGuard CEN Tests

PERFORMANCE LEVEL	TEST NO.	VEHICLE MASS (KG)	IMPACT SPEED (km/h)	IMPACT ANGLE & IMPACT POINT
110	Parent model at minimum taper/width – QI2408Y			
	TC 1.1.100	900	100	0 deg. Head-on, centre
	TC 1.3.110	1500	110	0 deg. Head-on, centre
	TC 2.1.100	900	100	0 deg. 1/4 vehicle offset
	TC 3.3.110	1500	110	15 deg. Nose, (centre)
	TC 4.3.110	1500	110	15 deg. redirect at L3
	TC 5.3.110	1500	110	165 deg. redirect at L2
	Maximum taper/width model – QI9008Y			
	TC 1.1.100	900	100	0 deg. Head-on, centre
	TC 4.3.110	1500	110	15 deg. redirect at L3
100	Minimum taper/width model – QI2406Y			
	TC 1.2.100	1300	100	0 deg. Head-on, centre
	Maximum taper/width model – QI9006Y			
	TC 4.2.100	1300	100	15 deg. redirect at L3
80	Minimum taper/width model – QI2405Y			
	TC 1.2.80	1300	80	0 deg. Head-on, centre
	Maximum taper/width model – QI9005Y			
	TC 4.2.80	1300	80	15 deg. redirect at L3
50	Minimum taper/width model – QI2403Y			
	TC 1.1.50	900	50	0 deg. Head-on, centre
	Maximum taper/width model – QI9003Y			
	TC 4.2.50	1300	50	15 deg. redirect at L3

Impact conditions which differ from those described in European Standard EN 1317:2000 may yield results different from those encountered in testing. In particular, impact conditions in excess of specified impact severity, or existence at the site of curbs or cross slopes in excess of 8%, may yield impact performance which does not meet the evaluation criteria of European Standard EN 1317:2000.