QuadGuard® CEN

The QuadGuard® CEN was tested to meet the requirements and guidelines of the 110km/h, 100km/h, 80km/h and 50km/h performance classes using the CEN criteria described in EN 1317-3 (Crash Cushions).

Assembly Manual

Trinity Highway Products, LLC d.b.a.

Warning: The local highway authority, distributors, owners, contractors, lessors, and lessees are responsible for the assembly, maintenance, and repair of the QuadGuard® CEN system. Failure to fulfill these RESPONSIBILITIES with respect to the assembly, maintenance, and repair of the QuadGuard® CEN system could result in serious injury or death.

Important: These instructions are for standard assembly specified by the appropriate highway authority. In the event the specified system assembly, maintenance, or repair would result in a deviation from these assembly instructions, contact the appropriate highway authority engineer.

This manual must be available to the worker overseeing and/or assembling the product at all times. For additional copies, contact Trinity Highway International at +1 (214) 589-8140 or www.trinityhighway.com.

The instructions contained in this manual supersede all previous information and manuals. All information, illustrations, and specifications in this manual are based on the latest QuadGuard® CEN system information available to Trinity Highway International at the time of printing. We reserve the right to make changes at any time. Please contact Trinity Highway International to confirm that you are referring to the most current instructions.
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Customer Service Contacts

Trinity Highway International is committed to the highest level of customer service. Feedback regarding the QuadGuard® CEN system, its assembly procedures, supporting documentation, and performance is always welcome. Additional information can be obtained from the contact information below:

Trinity Highway International

<table>
<thead>
<tr>
<th>Telephone:</th>
<th>USA:</th>
<th>+1 214 589 8140</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U.K.:</td>
<td>+44 1473 221105</td>
</tr>
<tr>
<td></td>
<td>Singapore:</td>
<td>+65 6276 3398</td>
</tr>
<tr>
<td></td>
<td>Sweden:</td>
<td>+46 709 66 10 55</td>
</tr>
<tr>
<td>E-mail:</td>
<td><a href="mailto:thp.international@trin.net">thp.international@trin.net</a></td>
<td></td>
</tr>
<tr>
<td>Website:</td>
<td><a href="http://www.trinityhighway.com">www.trinityhighway.com</a></td>
<td></td>
</tr>
</tbody>
</table>

Important Introductory Notes

Proper assembly of the QuadGuard® CEN is critical to achieve performance that has been evaluated and accepted per EN 1317-3. These instructions should be read in their entirety and understood before assembling the QuadGuard® CEN. These instructions are to be used strictly in conjunction with the assembly of the QuadGuard® CEN and are for standard assemblies only as specified by the appropriate highway authority. If you need additional information, or have questions about the QuadGuard® CEN, please contact the highway authority that has planned and specified this assembly and, if needed, contact the Trinity Highway Customer Service Department. This product must be assembled in the location specified by the appropriate highway authority. If there are deviations, alterations, or departures from the assembly instructions specified in this manual, the device may not perform as tested.

This manual is intended to provide guidance for new assemblies of the QuadGuard® CEN. It is critical that the QuadGuard® CEN is placed in suitable ground/soil/foundations that will allow the system to fully perform in accordance with the design specification. Should you have any question about this, please contact the appropriate highway authority that specified the QuadGuard® CEN at a particular location for guidance. Trinity Highway International is available for consultation with that authority.

Important: DO NOT use any component part that has not been specifically approved for this system during the assembly or repair of this system.
This product has been specified for use by the appropriate highway authority and has been
provided to that user who has unique knowledge of how this system is to be assembled. No
person should be permitted to assist in the assembly, maintenance, or repair of this system that
does not possess the unique knowledge described above. These instructions are intended for
an individual qualified to both read and accurately interpret them as written. These instructions
are intended only for an individual experienced and skilled in the assembly of highway products
that are specified and selected by the highway authority.

A manufacturer's site drawing package will be supplied by Trinity Highway International upon
request. Each system will be supplied with a specific drawing package unique to that system.
Such drawings take precedence over information in this manual and shall be studied thoroughly
by a qualified individual who is skilled in interpreting them before the start of any product
assembly.

**Important:** Read safety instructions thoroughly and follow the suggested safe
practices before assembling, maintaining, or repairing the QuadGuard® CEN. It is
your responsibility to follow these warnings. Failure to follow warnings can result
in serious injury or death to workers and/or bystanders. Please keep up-to-date
instructions for later use and reference by anyone involved in the assembly of the
product.

**Warning:** Ensure that all of the QuadGuard® CEN system Danger, Warning,
Caution, and Important statements within the QuadGuard® CEN manual are
followed completely. Failure to comply with this warning could result in increased
risk of serious injury or death in the event of a collision.

**Safety Rules for Assembly**

* **Important Safety Instructions** *

This manual must be kept in a location where it is readily available to persons who assemble,
maintain, or repair the QuadGuard® CEN. Additional copies of this manual and the Product
Description Manual are available from Trinity Highway International by calling +44 1473 221105,
emailing thp.international@trin.net, or downloading at www.trinityhighway.com. Please contact
Trinity Highway International if you have any questions concerning the information in this
manual or about the QuadGuard® CEN.

Always use appropriate safety precautions when operating power equipment, mixing chemicals,
and when moving heavy equipment or QuadGuard® CEN components. Safety articles including
but not limited to work gloves, protective eyewear, safety-toe shoes, and back protection should
be used.

**Warning:** Safety measures incorporating appropriate traffic control devices
specified by the highway authority must be used to protect all personnel while at
the assembly, maintenance, or repair site.
Safety Symbols
This section describes the safety symbols that appear in this QuadGuard® CEN Assembly Manual. Read the manual for complete safety and assembly information.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
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<tbody>
<tr>
<td>![Safety Alert Symbol]</td>
<td>Safety Alert Symbol: Indicates Danger, Warning, Caution, or Important. Failure to read and follow the Danger, Warning, Caution, or Important indicators could result in serious injury or death to workers and/or bystanders.</td>
</tr>
</tbody>
</table>

Warnings and Cautions
Read all instructions before assembling, maintaining, or repairing the QuadGuard® CEN system.

**Danger:** Failure to comply with these warnings could result in increased risk of serious injury or death in the event of a vehicle impact with a system that is no longer compliant with EN 1317-3.

**Warning:** Do not assemble, maintain, or repair the QuadGuard® CEN system until you have read this manual thoroughly and completely understand it. Ensure that all Danger, Warning, Caution, and Important statements within the manual are completely followed. Please call Trinity Highway International at +44 1473 221105 if you do not understand these instructions.

**Warning:** Do NOT modify the QuadGuard® CEN system in any way.

**Important:** Trinity Highway International makes no recommendation whether use or reuse of any part of the system is appropriate or acceptable following an impact. It is the sole responsibility of the local highway authority and its engineers to make that determination. It is critical that you inspect this product after assembly is complete to make certain that the instructions provided in this manual have been strictly followed.

**Caution:** Ensure that your assembly meets all appropriate local specifications and standards. If you have any questions during the assembly of a QuadGuard® CEN at a particular assembly site, contact the specifying highway authority immediately.
Limitations and Warnings

The QuadGuard® CEN was tested to meet the requirements and guidelines of the 110km/h, 100km/h, 80km/h and 50km/h performance classes using the CEN criteria described in EN 1317-3 (Crash Cushions).

European Standard EN1317-3 tests are not intended to represent the performance of products when impacted by every vehicle type or every impact condition existing on the roadway.

Trinity Highway International expressly disclaims any warranty or liability for injury or damage to persons or property resulting from any impact, collision or harmful contact with products, other vehicles, or nearby hazards or objects by any vehicle, object or person, whether or not the products were assembled in consultation with Trinity Highway International or by third parties.

The QuadGuard® CEN is intended to be assembled, delineated, and maintained in accordance with local guidelines. Trinity Highway International offers a reflective delineator panel for its QuadGuard® CEN line of products.

Note: Consult local transportation authorities for delineation requirements.

It is important for the highway authority specifying the use of a highway product to select the most appropriate product configuration for site specifications. The customer should be careful to properly select, assemble, and maintain the product. Careful evaluation of site layout, traffic speed/type, direction, and visibility are some of the elements that require evaluation by the highway authority in the selection of a highway product. For example, curbs could cause an untested effect on an impacting vehicle.

After an impact occurs, the debris from the impact should be removed from the area immediately and the QuadGuard® CEN should be evaluated and either restored to its original specified condition or replaced as the highway authority determines as soon as possible.
System Overview

The QuadGuard® CEN is a potentially reusable, re-directive, non-gating crash cushion for roadside features ranging in width from 610 mm to 2300 mm (24” to 90”). It consists of energy-absorbing cartridges surrounded by a framework of Quad-Beam™ Panels. The decision as to whether this product is reusable after impact rests within the sound discretion of the trained engineer, experienced in highway products, who is working at the direction of the local highway authority which specified and now owns the product.

The QuadGuard® CEN system utilizes two types of cartridges in a “staged” configuration that are designed and tested to address vehicles as certified and tested by EN 1317-3 for both lighter cars and heavier, high center-of-gravity vehicles. Its modular design allows the system length to be tailored to the design speed of a site.

Impact Performance

The 6 Bay QuadGuard® CEN systems have successfully passed the requirements stipulated in MASH, Test Level 3 tests with both the light car and pickup trucks at speeds of up to 100 km/h [62 mph] at angles up to 25 degrees.

The 3 Bay QuadGuard® CEN systems have successfully passed the requirements stipulated in MASH, Test Level 2 tests with both the light car and pickup trucks at speeds of up to 70 km/h [44 mph] at angles up to 25 degrees.

During head-on impact testing, within EN 1317-3 criteria, the QuadGuard® CEN has been shown to telescope rearward to absorb the energy of impact. When impacted from the side, within the applicable MASH criteria, it has been shown to redirect the vehicle back toward its original travel path and away from the highway feature.
System Components

Below is a list of system components that may be used in your particular QuadGuard® CEN configuration. Verify parts delivered and system details with the BOM (Bill of Materials) and system drawings shipped with your system. Please call Customer Service if you have any system questions (p. 3).

Note: Components are not shown to scale.

<table>
<thead>
<tr>
<th>Narrow Diaphragm</th>
<th>Wide Diaphragm</th>
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<td>625650 24&quot;</td>
<td>607173 - 26.48&quot;</td>
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<td>607148 - 48.53&quot;</td>
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<td>607159 – 68.06&quot;</td>
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| 607162 – 73.73"  | 607163 – 76.88"

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<td>Mushroom Washer</td>
<td>Flat Screw 5/8X8 1/2 Wide</td>
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<th>Rail Nut, Hex, 5/8</th>
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<th>Panel, Fender, QG</th>
<th>Bracket, Cart, Hold Down</th>
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<td>Bracket, Cartridge Support</td>
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<td>Cartridge Assy, Type M-II</td>
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<td>Panel, Side, QG</td>
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<td>Locking Bar, Cartridge Support</td>
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<td>Approved Adhesive *</td>
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<tr>
<td>Washer, Flat, 3/4&quot;</td>
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</table>
QuadGuard® CEN Foundation/Anchoring

Warning: Ensure that this assembly conforms with the guidance provided by EN 1317-3 (Crash Cushions), including, but not limited to, those regarding placement on or adjacent to curbs.

Asphalt Installations
QuadGuard® CEN Narrow systems with a Tension-Strut Backup may be installed in construction zones on asphalt. Assemblies on Asphalt Concrete (“A.C.”) must provide a minimum of 76 mm [3"] layer of asphalt over a minimum of 76 mm [3"] layer of Portland Cement Concrete (“P.C.C.”), 152 mm [6"] layer of asphalt over 152 mm [6"] layer of subbase, or 203 mm [8"] layer of asphalt with no subbase.

Important: Only 460 mm [18"] threaded rods, utilizing Trinity Highway approved adhesive, can be used with asphalt foundations. Contact Customer Service for a complete list of approved adhesives (p. 3).

Important: QuadGuard® CEN wide systems should not be anchored to asphalt.

Concrete Installations
For concrete installations, the QuadGuard® CEN system should be installed only on an existing or freshly placed and cured concrete base (28 MPa [4000 psi] minimum). Orientation of the concrete base and the attenuator must comply with the project plans or as otherwise determined by the resident project engineer or appropriate highway authority.

Recommended dimension and reinforcement specifications for new concrete pads can be found on the standard drawings.

The QuadGuard® CEN system may be installed on any of the following foundations using the specified anchorage:

Foundation A: Concrete Pad or Roadway
Foundation: 150 mm [6"] minimum depth P.C.C.
Anchorage: Approved adhesive with 180 mm [7"] studs 140 mm [5 1/2"] embedment

Foundation B: Asphalt over P.C.C.
Foundation: 76 mm [3"] minimum A.C. over 76 mm [3"] minimum P.C.C.
Anchorage: Length of anchor required is 460 mm [18"] 420 mm [16 1/2"] embedment

Foundation C: Asphalt over Compacted Subbase (“C.S.”)
Foundation: 150 mm [6"] minimum A.C. over 150 mm [6"] minimum C.S.
Anchorage: Approved adhesive with 460 mm [18"] studs 420 mm [16 1/2"] embedment
Foundation D: Asphalt

Foundation: 200 mm [8"] minimum A.C.

Anchorage: Approved adhesive with 460 mm [18"] studs - 420 mm [16 1/2"] embedment

**Important:** Systems mounted on asphalt must be replaced and mounted on fresh, undisturbed asphalt if more than 10% of anchors are found to be loose, broken, or show signs of pull out. If 10% or fewer anchors are damaged, replace the damaged anchors in the existing asphalt. Anchor bolts used on systems mounted on asphalt must be inspected every six months. See Post Impact Instructions and Maintenance and Repair instructions on pages 59-63.

Foundation Specifications

For Foundations A, B, C and D mentioned above:

A. C. (Asphalt Concrete)

AR-4000 A. C. (per ASTM D3381 '83) 3/4” Maximum, Medium (Type A or B) aggregate

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<th>Operating Range (%) Passing</th>
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<tr>
<td>1&quot;</td>
<td>100</td>
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<tr>
<td>3/4&quot;</td>
<td>95-100</td>
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<td>3/8&quot;</td>
<td>65-80</td>
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<tr>
<td>No. 4</td>
<td>49-54</td>
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<tr>
<td>No. 8</td>
<td>36-40</td>
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<td>No. 30</td>
<td>18-21</td>
</tr>
<tr>
<td>No. 200</td>
<td>3-8</td>
</tr>
</tbody>
</table>

**Caution:** Walk-up inspections are recommended at least once every six months for installations on asphalt.

P.C.C. (Portland Cement Concrete)

Stone aggregate concrete mix

4000 psi minimum compressive strength

(Sampling per ASTM C31-84 or ASTM C42-84a, testing per ASTM C39-84)

C.S.

150 mm [6"] minimum depth 95% compaction

Class 2 aggregate

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<tr>
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<tr>
<td>No. 200</td>
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</table>
Trinity Highway Approved Adhesive Anchoring System

A Trinity Highway approved adhesive anchoring system is required to securely anchor crash cushions. Each approved adhesive kit contains adhesive, studs, nuts, washers and instructions. Both vertical and horizontal assemblies are possible using an approved adhesive anchoring system.

**Important:** Follow adhesive manufacturer’s temperature storage requirements.

Anchor Assemblies

**Note:** Read all Trinity Highway approved adhesive instructions before starting.

1) **Prepare the Concrete Foundation**

**Warning:** Do not allow anchoring adhesive to contact skin or eyes. See material safety data sheet supplied with adhesive kit for first-aid procedures. Use only in well-ventilated area. Do not use near open flame.

**Warning:** Wear gloves and protective eyewear during application.

The anchor bolts (studs) that anchor the QuadGuard® CEN system Backup and/or Monorail sections to the concrete foundation must be those shipped in the kit or of high strength steel (830 MPa [120,000 psi] minimum tensile strength or equal). These studs must be set in minimum 28 MPa [4000 psi] concrete. Allow the concrete to cure a minimum of seven days before applying anchoring adhesive.

2) **Drill Boreholes**

**Important:** Use only double-fluted drill bits with Trinity Highway approved adhesive to achieve optimum tensile strength. Do not use diamond drill bits for anchors as the surface will be too smooth for adhesive.

Use the part that is to be anchored as a drilling template. Use a rotary hammer drill to drill the boreholes 3 mm [1/8"] larger than the stud diameter to the recommended depth. See the approved adhesive instructions provided with your kit. Check to be sure all the boreholes are drilled to the proper depth and aligned with the part to be anchored (Table A).

<table>
<thead>
<tr>
<th>Stud Size:</th>
<th>Concrete Bit Size</th>
<th>Minimum Depth</th>
<th>Recommended Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; x 6 1/2&quot;</td>
<td>22 mm [7/8&quot;]</td>
<td>125 mm [5&quot;]</td>
<td>Consult Adhesive Kit Spec</td>
</tr>
<tr>
<td>3/4&quot; x 7&quot;</td>
<td>22 mm [7/8&quot;]</td>
<td>140 mm [5 3/4&quot;]</td>
<td>Consult Adhesive Kit Spec</td>
</tr>
<tr>
<td>3/4&quot; x 18&quot;</td>
<td>22 mm [7/8&quot;]</td>
<td>420 mm [16 1/2&quot;]</td>
<td>15 N-m [10 ft-lb]</td>
</tr>
</tbody>
</table>

**Important:** When mounting on asphalt, initial torque shall be as shown in Table A. Due to the instability of asphalt, anchors may loosen over time. For this reason Trinity Highway recommends anchoring to asphalt only at temporary locations. It is recommended to re-torque anchors in asphalt every six months to the proper initial torque specified.
3) **Clean the Boreholes**

Blow the concrete dust from the borehole using (90 psi) oil-free compressed air. Thoroughly brush the borehole with a 7/8” diameter steel bristle tube brush and then blow it out again to ensure it is completely dry and debris free.

4) **Apply Approved Adhesive**

Fill the borehole with enough adhesive so when the anchor is inserted a small portion of anchoring adhesive is squeezed out.

**Caution:** Fill the borehole from bottom up to prevent air pockets. Do not overfill or under-fill the borehole. If the borehole is overfilled, there will not be enough adhesive to anchor all of the studs provided in the kit. If borehole is underfilled, the adhesive may not develop the required pull out strength.

5) **Add Nuts to Anchor Studs**

Thread the nut on until flush with the end of the stud (Figure 1).

6) **Insert Studs in Boreholes and Wait for Adhesive to Cure**

Push the stud, nut, and washer assembly down through the part and into the borehole until the washer is seated against the part (Figure 1).

**Warning:** Do not disturb or load the stud until the approved adhesive material has fully cured (consult instructions supplied with the approved adhesive kit).

7) **Torque the Nuts**

Once the adhesive has fully cured, torque the nut to the manufacturer’s recommended values (Table A).

---

**Assembly Cautions**

1) **Steel rebar**

If steel rebar is encountered while drilling an anchor bolt borehole, apply one of the following solutions:

A) Using a diamond core drill bit or rebar drilling tool, drill through the rebar only, then switch back to the concrete bit and drill into the underlying concrete until the proper borehole depth is reached.

**Caution:** Do not drill through rebar without first obtaining permission to do so from the project engineer.

B) Drill a new borehole down at an angle past the rebar to the proper depth. Anchor the stud by completely filling both boreholes with an approved adhesive.
QuadGuard® CEN

KEY
1) CARTRIDGE
2) DIAPHRAGM
3) FENDER PANEL ASSEMBLY
4) NOSE ASSEMBLY
5) MONORAIL
6) BACKUP

Figure 1
Plan & Elevation
How to Determine Left/Right
To determine left from right when ordering parts, stand in front of the system facing the roadside obstacle. Your left is the system's left and your right is the system's right (Figure 2).

Counting the Number of Bays
One bay consists of one Diaphragm, two Fender Panels, etc. The Nose Assembly is not considered a Bay. There are no Cartridges in the front two (2) bays of the system; therefore, there will be two (2) more bays than the number of Cartridges for the system. To determine number of Bays, count Fender Panels on one side (Figure 3).
Measuring the Width

The QuadGuard® CEN is available in five (5) nominal widths:

1. 610 mm [24”]
2. 760 mm [30”]
3. 915 mm [36”]
4. 1753 mm [69”]
5. 2286 mm [90”]

The nominal width of the system is the width between Side Panels behind the Backup (Figure 4).

The outside width of the system is approximately 150 mm to 230 mm [6” to 9”] wider than this measurement.

Figure 4
System Width
**Assembly**

*Warning:* Location of the Backup in relation to nearby objects will affect the operation of the attenuator. Upon impact, the Fender Panels telescope rearward 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 may result in impaired system performance offering motorists less protection and causing component damage.

**Inspect Shipment**

Before deploying the QuadGuard® CEN, check the received parts against the shipping list supplied with the system. Make sure all parts have been received.

*Warning:* Use only Trinity Highway International parts that are specified herein for the QuadGuard® CEN for assembling, maintaining, or repairing the QuadGuard® CEN system. Do not utilize or otherwise comingle parts from other systems even if the systems are other Trinity Highway International systems. Such configurations have not been tested, nor have they been accepted for use. Assembly, maintenance, or repairs using unspecified parts or accessories is strictly prohibited. Failure to follow this warning could result in serious injury or death in the event of a vehicle impact with an UNACCEPTED system.

**Recommended Tools**

**Documentation**
- Manufacturer’s Assembly Manual
- Manufacturer’s Drawing Package

**Personal Protective equipment**
- Safety Glasses
- Gloves
- Safety-Toe Shoes
- Apron for epoxy anchors (if applicable)

**Cutting equipment**
- Rebar Cutting Bit
- Rotary Hammer Drill
- 22 mm (7/8") Concrete Drill Bits (Double-Fluted)
- Grinder, Hacksaw or Torch (optional)
- Drill Motor
- Drill Bits 1/16” - 7/8”

*Note:* Trinity Highway International recommends using double-fluted drill bits to achieve required tensile strength if assembling with an epoxy anchoring system.
Wrenches
- Heavy Duty Impact Wrench
- 1/2" Drive Sockets: 9/16", 11/16", 3/4", 15/16", 1 1/8", 1 1/4"
- Deep Sockets: 15/16", 1 1/4"
- Ratchet and attachments for the above sockets
- Breaker Bar: 1/2" drive x 24"
- Torque Wrench: min. 135.6 Nm [100 ft-lb]
- Crescent Wrench: 300 mm [12”]
- Allen Wrench: 3/8”
- Impact Wrench: 1/2"
- Pipe Wrench

Hammers
- Sledgehammer
- Standard Hammer

Miscellaneous
- Traffic Control Equipment
- Lifting and Moving Equipment (A lifting device is preferred although a forklift can be used.) Minimum 2,269 kg [5,000 lb.] capacity required.
- Air 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
- Steel Bottle Brush for cleaning drilled holes
- Rags, Water, and Solvent for touch-up
- Chain, 3/8" grade 40, 6 m [20’] with 13 mm [1/2”] hooks.
- Acetylene Torch

Note: The above list of tools is a general recommendation and should not be considered an extensive list. Depending on specific site conditions and the complexity of the assembly specified by the appropriate highway authority the required tools may vary. Decisions as to what tools are needed to perform the job are entirely within the discretion of the specifying highway authority and the authority's selected contractor performing the assembly of the system at the authority's specified assembly site.
Assembly Procedures

**Important:** The Manufacturer's Drawing Package supplied with the QuadGuard® CEN must be used with these instructions for proper assembly and should take precedence over these general instructions.

**Warning:** Safety measures incorporating appropriate traffic control devices specified by the highway authority must be used to protect all personnel while at the assembly, maintenance, or repair site.

1) **Determine Connection Panel Type**

A Connection Panel or Side Panel will be used on each side of the Backup. A Side Panel is not needed when a Connection Panel is used. Several types of Connection Panels are available for use with the QuadGuard® CEN. Refer to Figures 6 through 9 and the drawing package to determine which type of panels are being attached.

**Important:** The proper Connection or Side Panel must be used for optimum impact performance of the system. The correct panel to use will depend on the direction of traffic and what type of barrier or fixed object the QuadGuard® CEN is shielding. Contact the Customer Service Department prior to assembly if you have any questions (p. 3).

![QuadGuard® CEN with Connection Panel](image-url)

**Figure 5**
QuadGuard® CEN with Connection Panel
Connection Panel Types

If a system is placed in a location where traffic will be approaching from the rear of the system, a Connection Panel is necessary. Figures 6 to 9 show standard panel transition 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 Trinity Highway International Customer Service Department for a recommendation of the exact panel needed for your application.

*Note: Wheel Deflectors may be required for this application.
Anchor the System

Cross-slope of assembled location shall not exceed 8% and not vary (twist more than 2% from front to back). For these conditions, a leveling pad is required. The anchors must have a minimum pull out strength of 82.3 kN (18,500 lbs) and a minimum shear strength of 109 kN (24,500 lbs).

**Warning:** Ensure that there is proper site grading for QuadGuard® CEN placement as dictated by the specifying agency.

Test Parameters

The best overall measure of anchor performance is load capacity. Anchor load capacity can be defined by testing static tensile and static shear strengths. Static tensile strength is the maximum force sustained by an anchor when subjected to gradual increases in loading at the exposed end of the anchor and applied in line along its axis. Static shear strength is the maximum force sustained by an anchor when subjected to gradual increases in loading applied at the base of the exposed end of the anchor and applied perpendicular to its axis.

The tensile strength developed will be a function of the strength of the concrete or asphalt surface the anchor is placed in. Embedment depth can also affect anchor tensile strength.

Tensile test of anchors chosen should be tested in compliance with ASTM E488 – Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements (Figure 10).

Recording Test Results

Three pull tests should be conducted on site when the anchoring conditions are different from those described in the reference section of this document with the results recorded. Pictures of the testing should also be taken and stored with the recorded data.

The anchor surface is acceptable if the average of the three pulls is equal or greater than 82.3 kN (18,500 lbs).
1) **Mark System Location**

Locate the centerline of the system by measuring the proper offset from the roadside obstacle. See the drawing package supplied with the system. Place chalk line to mark the centerline of the system. Mark a construction line parallel to the center line and offset 165 mm [6.5"] to one side as shown in Figure 11. The edge of the Monorail will be placed on this line.

**Note:** The concrete pad shall comply with the project plans supplied with the system.

**Warning:** Location of system with respect to the roadside obstacle is critical and dependent on the type of Transition Panel used. See the project plans supplied with the system for details.

![Figure 11](image)

(Top view of concrete pad)

Locating Construction Line

2) **Anchor the Backup and Monorail**

See Figures 12 through 14 (showing Backup and Monorail deployment). For minimum foundation requirements, Consult the Trinity Highway International Customer Service Department (p. 3).

Locate Tension Strut Backup and Monorail on foundation with side of Monorail on the construction line (Figure 13). Verify that any Connection Panels fit properly before anchoring Backup. Drill anchor holes in foundation using the Backup as template. Anchor the Backup to the foundation per the anchor manufacturer’s instructions.

![Figure 12](image)

Anchoring Tension Strut Backup to Foundation
A) Tension Strut Backup Assembly (Figure 13)

Locate the Backup and Monorail on the pad with the side of the Monorail on the construction line (Figure 13). Verify that applicable Connection Panels fit properly before anchoring Backup. Drill anchor holes to appropriate depth in the pad using the Backup as a template. Do not drill through foundation. Anchor the Backup to the foundation per the anchor manufacturer’s instructions.

B) Monorail Assembly

Locate the Monorail using the Monorail Assembly drawings. Drill anchor holes to appropriate depth using the Monorail as a template (Figure 13). Do not drill through foundation. Anchor each Monorail section per the anchor manufacturer’s instructions. It is important to attach each segment of Monorail in alignment from the back to the front of the system (± 6 mm [1/4”]).

**Warning:** Improper alignment at the Monorail Splice Joints will prevent proper system collapse during an impact.

**Warning:** Every hole and slot in Backup and Monorail must have an appropriate ground anchor attaching the Backup and Monorail to the foundation.
3) **Attach Side Panels / Connection Panels to Backup Assembly**

Attach the Connection Panel or Side Panel as appropriate to each side of the Backup. See Figures 15 & 17 and the drawing package for more information.

**Note:** A Side Panel is not needed when a Connection Panel is used.

---

**Figure 15**
Side Panel/Connection Panel Attachment for Narrow Applications

**Figure 16**
Rail Nuts are Oversize

**Figure 17**
Side Panel/Connection Panel Attachment for Wide Applications
4) **Attach Monorail Guides**

Attach Monorail Guides to Diaphragms as shown in Figure 18 and the Diaphragm Assembly drawing.

5) **Attach Diaphragms (Narrow Systems)**

Orient a Diaphragm so that the front face of the Fender Panel Assembly faces toward the nose of the system (Figure 19).

---

**Important:** Slide one Diaphragm onto the Monorail and all the way to the Backup to **ensure the system is able to collapse properly during impact.** Once this has been verified, slide the Diaphragm forward 915 mm [36"] in front of the Backup (Figure 20).

---

Orient and slide all other Diaphragms onto the Monorail and position each (Figure 20). The Diaphragm spacing shown in Figure 20 allows the system to be assembled. Once the system is assembled, the Diaphragms will be moved to their final locations.

6) **Attach Diaphragms (Wide Systems)**

Orient Diaphragms so that the front face of the Fender Panel Assembly faces toward the nose of the system (Figure 19). The widest Diaphragm should be assembled closest to the Backup with each subsequent Diaphragm being progressively narrower.

---

**Important:** Slide the widest Diaphragm onto the Monorail and all the way to the Backup to **ensure system is able to collapse properly during impact.** Once this has been verified then slide the Diaphragm forward to approximately 915 mm [36"] in front of the Backup (Figure 20).

---

Orient and slide all other Diaphragms onto the Monorail and position each as shown approximately 915 mm [36"] in front of the previous Diaphragm (Figure 20).
Figure 19
Diaphragm Orientation

Figure 20
Initial Diaphragm Spacing
7) **Attach Bumper Assemblies**

Bays 1 and 2 of all systems are outfitted with Bumper Assemblies as shown in Figures 21a and 21b.

**First Diaphragm**

On the first Diaphragm, the Bumper Assemblies are attached to the rear of the Diaphragm only.

Attach Bumper Assemblies to the first Diaphragm by orienting each Bumper Assembly with the small holes facing the rear of the Diaphragm as shown below. Next, insert 1/2” x 5” hex bolts through the front of first Diaphragm and small hole on each Bumper Assembly. Fasten with 1/2” x 1 3/8” flat washers and nuts. Tighten all assembly fasteners to a snug position.

![Figure 21a](image1)

*Figure 21a  
Bumper Assemblies (except 3 Bay Systems)*

![Figure 21b](image2)

*Figure 21b  
Bumper Assemblies (3 Bay Systems)*

![Figure 22](image3)

*Figure 22  
First Diaphragm Bumper Assembly for Narrow Systems*

![Figure 23](image4)

*Figure 23  
First Diaphragm Bumper Assembly for Wide Systems*
Second Diaphragm (*except 3 Bay Systems)

On the second Diaphragm, the Bumper Assemblies are attached to the front and rear of the Diaphragm.

Orient Bumper Assemblies front and rear with the small holes facing the second Diaphragm and fasten with 1/2" x 5" hex bolts, 1/2" x 1 3/8" flat washers, and 1/2" nuts (Figures 24 and 25). Tighten all assembly fasteners to a snug position.

![Diagram of Second Diaphragm Bumper Assembly for Narrow Systems](image1)

![Diagram of Second Diaphragm Bumper Assembly for Wide Systems](image2)

**Figure 24**
Second Diaphragm Bumper Assembly for Narrow Systems

**Figure 25**
Second Diaphragm Bumper Assembly for Wide Systems
Third Diaphragm

(*Second Diaphragm for 3 Bay Systems)

On the third Diaphragm*, the Bumper Assemblies are on the front side of the Diaphragm only.

Orient Bumper Assemblies with the small holes facing the front of the third Diaphragm and, using the top holes, fasten with 1/2" x 3" long hex bolts, 1/2" x 1 3/8" flat washers, and 1/2" nuts as shown in Figures 26 and 27.

The Cartridge Support Bracket and Nose Clamp Shims must be placed against the rear of the third Diaphragm and over the lower holes as shown. Fasten to the Diaphragm and Bumper Assemblies with 1/2" x 3" long hex bolts, 1/2" x 1 3/8" flat washers, and 1/2" nuts. Tighten all assembly fasteners to a snug position.

*Note: This bracket is not necessary for 610 mm [24"] systems.*
8) **Attach Fender Panels** *(Narrow Systems)*

**Caution:** Do not mix the 5/8” hex nuts (small) with the 5/8” rail nuts (large). The rail nuts are oversize (Figure 31 on p. 24).

Starting at the last bay, assemble left and right Fender Panels (Figure 28). Attach the front of each Fender Panel to the Diaphragm in front using two rail bolts and rail nuts (large) per side. Use only the top and bottom holes; leave the center hole open until the next Fender Panel is attached.

Attach Mushroom Washer Assemblies as shown in Figure 28 but do not tighten at this time.

**Warning:** Maximum Fender Panel gap allowed for narrow systems: 20 mm [0.78"] (Figure 30).

**Note:** Reference QuadGuard CEN Product Manual drawing 608238.
Be sure Mushroom Washer lays flat against the Fender Panel (Figure 29). Standoff on Washer must be seated completely through slot.

**Figure 29**  
Mushroom Washer Orientation

**Figure 30**  
Fender Panel Gap for Narrow Systems

**Caution:** Do not mix the 5/8” hex nuts (small) with the 5/8” rail nuts (large). The rail nuts are oversize (Figure 31).

**Figure 31**  
Rail Nuts are Oversize

9) **Attach Fender Panels (Wide Systems)**

**Note:** For proper impact performance, systems for wide roadside features must have Hinge Plates.

Attach Hinge Plates on each Fender Panel as shown in Figure 32.

**Figure 32**  
Fender Panel Assembly for Wide Systems
Starting at the last bay, attach left and right Fender Panel (Figure 35). Attach the Hinge Plate at the front of the Fender Panels to the Diaphragm in front using three (3) 5/8" hex bolts, nuts and washers.

Attach Mushroom Washer Assembly as shown in Figures 34 and 35 but do not tighten at this time.

Be sure Mushroom Washer lays flat against the Fender Panel as shown in Figure 29. Standoff on washer must be seated completely through slot.

**Warning:** Maximum Fender Panel gap allowed for wide systems: 25 mm [1.00"] (Figure 33).
Check diaphragm spacing to ensure 915 mm [36"] between rear face of consecutive Diaphragms (Figures 36 and 37).

Once the proper spacing has been achieved, tighten the nut to compress the spring. The spring must be compressed a minimum of 1 mm and a maximum where the nut reaches the end of the bolt threads.

Attach the remaining Diaphragms and Fender Panels following the same procedure.
10) Attach End Cap

Using 5/8" x 3 1/2" G5 hex bolt, 5/8" hex nut, and 5/8" lock washer, attach the End Cap to the front of the first Monorail segment (Figure 38).
11) Side Support Brackets

Note: 610 mm [24"] wide Diaphragms do not have Side Support Brackets. Only 760 mm [30"] and wider Diaphragms have Side Support Brackets welded onto the assembly.

![Image of 610 mm [24"] wide Diaphragm with Side Support Brackets](Figure 39)

12) Cartridge Support Brackets

Attach Cartridge Support Bracket to Backup and all diaphragms that support Cartridges as shown in Figures 41 - 43 and the Diaphragm Assembly drawing.

![Image of Cartridge Support Bracket Attachment](Figure 41)

![Image of Cartridge Support Bracket Attachment (Side View)](Figure 42)
13) Attach Nose

Attach the Nose Belt to the Fender Panels using six (6) 5/8” x 5” long hex bolts, twenty (20) 5/8” flat washers, and eighteen (18) 5/8” hex nuts through the Belt Clamps as shown in Figures 44 - 45 and the Nose Assembly drawing.
Attach the flat washers so they are flush with the outside humps of the Fender Panels (Figure 45).

14) Checking the System Assembly

At this point recheck to ensure that all fasteners are properly tightened throughout the system per table below (anchor bolts, etc.). Check all Fender Panels. If they do not fit tightly against the underlying panel, system realignment may be necessary. See Figure 30 for narrow systems and Figure 33 for wide systems.

![Warning]

<table>
<thead>
<tr>
<th>Anchor Studs</th>
<th>Torqued to 135.6 Nm [100 ft-lb] May slightly protrude above nuts (Figure 14 on p. 16).</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Other Bolts</td>
<td>Tightened</td>
</tr>
<tr>
<td>Fender Panel</td>
<td>Maximum gap allowed:</td>
</tr>
<tr>
<td></td>
<td>Narrow – 20 mm [0.78”]</td>
</tr>
<tr>
<td></td>
<td>Wide – 25 mm [1.00”]</td>
</tr>
</tbody>
</table>
15) Cartridge Placement

To complete the assembly of a QuadGuard® CEN, place a Type E Cartridge in each Bay except the first Bay and second Bay for 5, 6, & 8 Bay systems (Figures 46 through 48).

**Warning:** Placing Cartridges in the Nose or first Bay (and second Bay for 5, 6, & 8 Bay systems) may result in unacceptable crash performance as described in EN 1317-3.

**Warning:** Ensure that the QuadGuard® CEN system and delineation used meet all local specifications.

Figure 46

Typical Cartridge Placement
Figure 47
Completed QuadGuard® CEN for narrow roadside obstacles (6 Bay system shown)

Figure 48
Completed QuadGuard® CEN for wide roadside obstacles (6 Bay system shown)
Maintenance and Repair

The QuadGuard® CEN is considered to be a potentially reusable 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.

**Important:** After an impact, always follow the “Post-Impact Instructions” in the maintenance and repair section of this manual (p. 34).

Inspection Frequency

Inspections by the appropriate highway authority are recommended as needed based upon volume of traffic and impact history. Visual drive-by inspections are recommended as often as possible and at least once every month. Walk-up inspections are recommended as often as possible and at least twice a year.

**Visual Drive-By Inspection**

1) Check to see if there is evidence of a hit. If so, a walk-up inspection will be necessary.
2) Check to see if the Cartridges appear to be off the Support Brackets. Any damaged Cartridges will need to be replaced.

**Warning:** See Cartridge placement instructions on pages 31 and 32.

3) Verify the Nose Belt is in place.
4) Note the location and condition of the QuadGuard® CEN and the visual drive-by inspection date.

**Walk-Up Inspection**

1) Clear and dispose of any debris on site.
2) Ensure all bolts are tight and rust free.
3) Verify concrete anchor bolts are securely anchored.
4) Check to ensure system Diaphragm legs are straight.
5) Verify all Mushroom Washer Assemblies are properly aligned and positioned (p. 24).
6) Fender Panels and Transition Panels should nest tightly against the system. The maximum gap allowed for narrow systems is 20 mm [0.78"] (Figure 30). For wide systems, the maximum gap allowed is 25 mm [1.0"] (Figure 33).
7) Ensure all Cartridges have not been damaged and are properly positioned on their Support Brackets. Replace crushed or sagging Cartridges. To ensure 100% of the intended speed characteristics, any partially crushed Cartridges (due to low speed impacts) should be replaced.

**Warning:** See Cartridge placement instructions on pages 31 and 32.
8) Make all necessary repairs as described above. Refer to Post-Impact Instructions for more information.

9) Note the location and condition of the QuadGuard® CEN system and any work done in the Impact Attenuator Inspection Logbook under the date of this inspection. If further repair is necessary, note repair request date in logbook. Refer to Post-Impact Instructions and assembly section of this manual for more information.

**Post-Impact Instructions**

1) Deploy appropriate traffic-control devices.

2) Check to see that all anchor bolts have remained firmly anchored in the roadway surface. Replace any that are loose, broken, or pulled out. Proper performance of the system depends on the Monorail anchors being properly deployed.

**Warning:** If the system is anchored to asphalt, it must be relocated to fresh, undisturbed asphalt after each impact to insure adequate future impact performance. The ground anchors should be deployed.

**Important:** The proper performance of the system during an angle impact depends on the Monorail anchors being properly anchored.

3) Clear and dispose of any debris on site.

4) Check the system to ensure all Mushroom Washer Assemblies holding the Fender Panels together are still intact, properly positioned, and that the system has not been deformed in a way that would prevent pulling it back into its original position for reuse.

5) Ensure all Diaphragm Support Legs are properly attached to the Monorail.

6) Attach 10 mm [3/8"] grade 40 chain to pullout Brackets on first Diaphragm (Figure 49). Attach both ends of chain to a heavy vehicle (such as a 1 ton pickup).

**Warning:** Stand clear in case the chain breaks or becomes disconnected.

![Figure 49 Pullout Bracket Locations (Nose Belt not shown for clarity)](image-url)
7) Pull the QuadGuard® CEN forward slowly until the system reaches its original length. Have someone watch the system during repositioning to be certain previously undetected damage does not cause the Diaphragms to bind or pull out improperly.

8) Remove all crushed Cartridges from within the system.

9) Check to see that the Diaphragms are in usable condition. Diaphragms which are bowed or have bent legs must be replaced.

10) Check that the Fender Panels are properly attached with the Mushroom Washer Assemblies. Damaged Fender Panels and Connection Panels must be replaced. Cartridge Support Brackets with minor damage can usually be straightened and reused by doing the following:
   
   A. Remove damaged Cartridge Support Bracket from Diaphragm.
   
   B. Clamp Cartridge Support Bracket to Backup and begin bending using pipe wrench as shown in Figure 50.

   ![Figure 50]
   
   **Figure 50**
   
   Straighten Cartridge Support Bracket

   C. Then, using a sledge hammer and Quad-Beam™ shape on Backup as an anvil, form Cartridge Support Bracket back into 90° shape (Figure 51).

   ![Figure 51]
   
   **Figure 51**
   
   Form Cartridge Support Bracket
11) Check gaps between Fender Panels. On the bidirectional side of the system, the maximum gap allowed for these overlapping parts (including Fender Panels overlapping panels behind the system) is 20 mm [0.78"] for narrow systems and 25 mm [1.0"] for wide systems (Figure 30 & 33).

If the gaps between the Fender Panels are too large, it may be necessary to replace bent parts.

12) Replace all crushed Cartridges (p. 31 & 32 for proper Cartridge Placement).

13) Check to ensure all bolts are tightened per table below.

14) Check to be certain that the site is free from any debris. The QuadGuard® CEN is once again ready for use.

<table>
<thead>
<tr>
<th></th>
<th>Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor Studs….</td>
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<td>Maximum Gap Allowed</td>
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<td><strong>Narrow Systems</strong></td>
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</tr>
<tr>
<td><strong>Wide Systems</strong></td>
<td>25 mm [1.0&quot;]</td>
</tr>
</tbody>
</table>
Parts Ordering Procedure

Make a list of all damaged parts using part descriptions shown on next page.

Circle the appropriate system attributes below. This information is necessary to receive the proper parts.

**System width:** 610 mm [24"], 760 mm [30"], 915 mm [36"], 1753 mm [69"], 2286 mm [90"

**Backup type:** Tension Strut

**Connection Panel(s) on which side?** Left, Right, Both, None

**Connecting to:** W-beam guardrail, Thrie beam guardrail, Safety shape barrier, Vertical face wall
Figure 52
QuadGuard® CEN Components
(for narrow roadside obstacles)

Figure 53
QuadGuard® CEN Components
(for wide roadside obstacles)