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1620.01 General

Impact attenuator systems are protective systems that help aid an errant vehicle from impacting an object by either gradually decelerating the vehicle to a stop when hit head-on or by redirecting it away from the feature when struck on the side. These systems are used for rigid objects or other features that cannot be removed, relocated, or made breakaway.

Approved systems are shown in Exhibits [1620-1a](#) and [1620-1b](#) and on the Washington State Department of Transportation (WSDOT) Headquarters (HQ) Design Office web page:

www.wsdot.wa.gov/design/policy/roadsidesafety.htm

Approved systems shall meet standardized testing defined in National Cooperative Highway Research Program (NCHRP) Report 350 or the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware* (MASH). In addition, these devices shall have an acceptance letter from FHWA that certifies that the device meets the appropriate crash test criteria and is eligible for federal-aid reimbursement.

1620.02 Design Criteria

The following design criteria apply to new, existing, or reset permanent and temporary impact attenuators.

Impact attenuators are placed so that they do not present a feature that needs mitigating in relation to opposing traffic. For median and reversible lane locations, the backup structure or attenuator-to-object connection is designed to help in aiding opposing traffic from being snagged.

Avoid placement of curbs between attenuators and traffic. Refer to the specific attenuator manufacturer's instructions if considering placement of curbing between an attenuator and the travelled way. It is desirable that existing curbing be removed and the surface smoothed with asphalt or cement concrete pavement before an impact attenuator is installed. However, mountable curbs 4 inches or less in height may be retained depending on the feasibility of their removal.

In general, attenuators are aligned parallel to the roadway except the inertial barriers.

Consult with the Area Maintenance Superintendent who will be maintaining the system prior to selecting the attenuator systems to include in a construction contract.

1620.03 Selection

To select an appropriate impact attenuator system, the following factors must be assessed:

- Posted speed
- Operating speed
- Average daily traffic (ADT)
- Repair crew exposure
- Proximity to the roadway
- Anticipated number of yearly impacts
- Available space (length and width)
- Maintenance costs
- Initial cost
- Duration (permanent or temporary use)
- Portion of the impact attenuator that is redirective/nonredirective (see [Exhibit 1620-2](#))
- Width of object to be shielded

It is very important for designers to take into account the portion of an impact attenuator that is designed to redirect vehicles during a side impact of the unit. It is crucial that fixed objects, either permanent or temporary (such as construction equipment), are not located behind the nonredirective portion of these devices.

The posted speed is a factor in the selection of many impact attenuators. Use Exhibits [1620-1a](#) and [1620-1b](#) to select the system and configuration appropriate for the posted speed. In the interest of a cost-effective design, selecting a system applicable for the posted speed is recommended (although using a system tested for a higher speed is acceptable). Where there is evidence that the average operating speed of the facility is higher than the posted speed, consider selecting an attenuator system rated at the facility's operating speed. Manufacturer's product information may indicate that a longer system (than what is in Exhibits [1620-1a](#) and [1620-1b](#)) is required for speeds of 70 mph or greater. These models are generally referred to as "high speed" or "70 mph" systems. Use of these systems on facilities with 70 mph posted speeds is not required, and selection of a system rated for at least 60 mph will typically be appropriate for most sites on these facilities. For permanent installations where unusual conditions warrant consideration of a high-speed device, these systems are available and may be used with justification. Contact the HQ Design Office for guidance when selecting one of these systems.

For a comparison summary of space and initial cost information related to impact attenuator systems, see Exhibits [1620-1a](#) and [1620-1b](#).

When maintenance costs are considered, anticipate the average annual impact rate. If few impacts are anticipated, lower-cost devices such as inertial barriers might meet the need. (See [Chapter 301](#) for examples of how to determine lifecycle costs for proposed hardware). Inertial barriers have the lowest initial cost and initial site preparation. However, maintenance will be costly and necessary after each impact. Labor and equipment are needed to clean up the debris and install new containers (barrels). Inertial barriers are not be used where flying debris might be a danger to pedestrians.

In selecting a system, one consideration is the anticipated exposure to traffic that the workers making the repairs may encounter. In areas with high traffic exposure, a low-maintenance system that can be repaired quickly is most desirable. Some systems need nearly total replacement or replacement of critical components (such as cartridges or braking mechanisms) after a head-on impact, while others simply need resetting.

It is very important to consider that each application is unique when selecting impact attenuators for use in particular applications. This applies to both permanent and temporary installations. When specifying the system or systems that can be used at a specific location, the list shown in Exhibits 1620-1a and 1620-1b are to be used as a starting point. As the factors discussed previously are analyzed, inappropriate systems may be identified and eliminated from further consideration. Systems that are not eliminated may be appropriate for the project. When the site conditions vary, it might be necessary to have more than one list of acceptable systems within a contract. Systems are not to be eliminated without documented reasons. Also, wording such as “or equivalent” is not to be used when specifying these systems. If only one system is found to be appropriate, then approval from the Assistant State Design Engineer of a public interest finding for the use of a sole source proprietary item is needed.

When a transition to connect with a concrete barrier, fixed object, or beam guardrail is needed (see impact attenuator descriptions in 1620.04), the transition type and connection may need to be specified. In most cases, the transition type and connection required will be a custom design per the manufacturer (these transitions are included in the cost of the impact attenuator). In a few cases, the transition type and connection to use will be as described in Chapter 1610 and the *Standard Plans* (these transition sections are not included in the cost of the impact attenuator and must be included as a separate bid item in the construction contract). Consult with the Area Maintenance Superintendent who will be maintaining the systems before finalizing the list of attenuators to be included in the contract.

1620.03(1) Low-Maintenance Category

The QuadGuard Elite, SCI100GM/SCI70GM, and REACT 350 are considered low-maintenance devices. These devices have a higher initial cost, requiring substantial site preparation, including a backup or anchor wall in some cases and cable anchorage at the front of the installation. However, repair costs are comparatively low, with labor typically being the main expense. Maintenance might not be needed after minor side impacts with these systems.

Installation of a low-maintenance device is desirable at locations that meet at least one of the following criteria:

- Sites with an ADT of 25,000 or greater
- Sites with a history/anticipation of more than one impact-per year
- Sites with unusually challenging conditions, such as limitations on repair time, a likelihood of frequent night repairs, or narrow gore locations

Document the decision in the DDP to use any device other than a low-maintenance device at locations meeting at least one of the criteria above.

Consider upgrading existing ADIEM, G-R-E-A-T, and Hex-Foam Sandwich impact attenuators to low-maintenance devices when the repair history shows one or more impacts per year over a three- to five-year period.

The HQ Design Office conducts an annual review of maintenance records to consider which devices should be included in the Low-Maintenance category. For a description of requirements that need to be met in order to be included in the Low-Maintenance category, see:

🔗 www.wsdot.wa.gov/publications/fulltext/design/roadsidesafety/low_maint.pdf

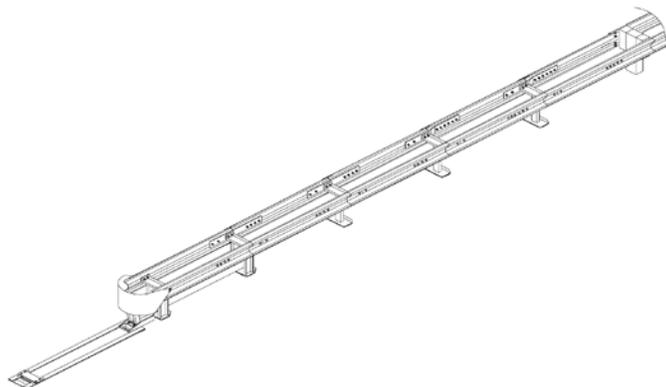
1620.04 Impact Attenuator Systems

1620.04(1) Permanent Installations

For systems used in permanent installations, a description of the system's purpose, parts, and function, as well as transition needs, foundation, and slope requirements are provided as follows and in Exhibits [1620-1a](#) and [1620-1b](#).

1620.04(1)(a) Brakemaster 350

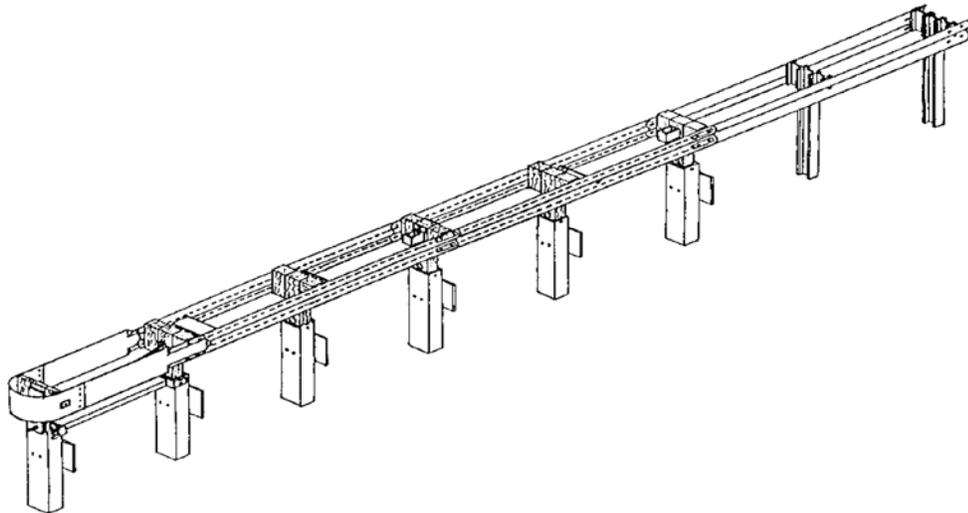
1. **Purpose:** The Brakemaster 350 system is an end treatment for W-beam guardrail and concrete barrier.
2. **Description:** The system contains an embedded anchor assembly, brake cable, W-beam fender panels, steel posts, tension and transition straps, and diaphragms.
3. **Function:** The system uses a brake and cable device for head-on impacts and for redirection. The cable is embedded in a concrete anchor at the end of the system.
4. **Foundation:** A concrete foundation is not needed for this system, but a paved surface is recommended.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** If used as an end treatment for concrete barrier, the system must be connected to the barrier with a transition section (not included in the cost of the attenuator). See [Chapter 1610](#) and the [Standard Plans](#) for the type of transition section and connection required.
7. **Manufacturer/Supplier:** Energy Absorption Systems



Brakemaster 350 – Permanent Installations

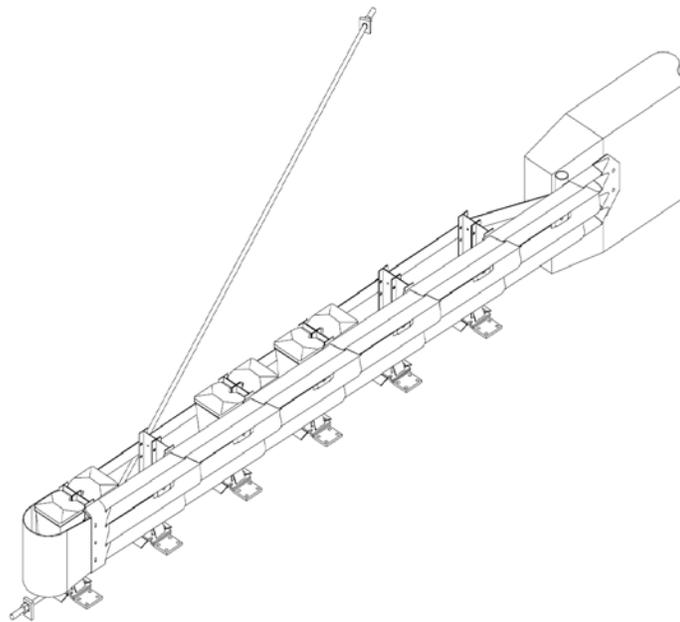
1620.04(1)(b) Crash Cushion Attenuating Terminal (CAT-350)

1. **Purpose:** The CAT-350 is an end treatment for W-beam guardrail and concrete barrier.
2. **Description:** The system consists of slotted W-beam guardrail mounted on both sides of breakaway timber posts. Steel sleeves with soil plates hold the timber posts in place.
3. **Function:** When hit head-on, the slotted guardrail is forced over a pin that shears the steel between the slots. This shearing helps dissipate the energy of the impact.
4. **Foundation:** A concrete foundation or paved surface is not needed. Can be installed in soil.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** If used as an end treatment for concrete barrier, the system must be connected to the barrier with a transition section (not included in the cost of the attenuator). (See [Chapter 1610](#) and the [Standard Plans](#) for the type of transition section and connection required.)
7. **Manufacturer/Supplier:** Trinity Industries, Inc.

**CAT 350 – Permanent Installations**

1620.04(1)(c) QuadTrend 350

1. **Purpose:** The QuadTrend 350 is an end treatment for 2-foot-8-inch-high concrete barriers. The system's short length may allow it to be used at the ends of certain bridges where the installation of a beam guardrail transition and terminal is not feasible and manufacturer's requirements for slope and clear area behind the device can be met.
2. **Description:** This system consists of telescoping quadruple corrugated fender panels mounted on steel posts with slip bases, a tension strap, sand-filled boxes, and a ground-level redirective cable.
3. **Function:** Sand-filled boxes attached to the posts help dissipate a portion of the energy of an impact. In head-on impacts, the anchored ground-level cable installed behind the fender panels directs the vehicle behind and away from the barrier end. Side impacts within the redirective portion of the system, which begins 10.5 ft. from the nose of the system, are redirected toward the roadway.
4. **Foundation:** The system is installed on a concrete foundation to support the steel posts.
5. **Slope:** A 10H:1V or flatter slope is needed on the approaches to the device and to 3 ft. behind the system. A 6H:1V or flatter slope is needed behind the barrier to allow for vehicle recovery.
6. **Transitions:** No transition section is needed for connection to a vertical wall or vertical concrete barrier. A custom transition section per manufacturer's specifications is needed for connection to non-vertical concrete barrier such as New Jersey or F-Shape barrier (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems

**QuadTrend 350 – Permanent Installations**

1620.04(1)(d) Universal TAU-II

1. **Purpose:** The Universal TAU-II crash cushion system is an end treatment for concrete barrier, beam guardrail, and fixed objects up to 8 feet wide.
2. **Description:** The system is made up of overlapping thrie beam panels, structural support diaphragms, supported cables, energy absorbing cartridges, and foundation anchors.
3. **Function:** During a head-on hit, energy-absorbing cartridges and structural support diaphragms help dissipate the energy of the impact as they are guided by high strength galvanized steel cables and overlapping thrie beam panels. In a side impact, the thrie beam rail panels redirect the vehicle back toward the roadway.
4. **Foundation:** The system is installed on either a concrete foundation or an asphalt foundation that conforms to the manufacturer's recommendations.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** A transition section is not needed for concrete barrier or fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for all connections to beam guardrail and for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Barrier Systems, Inc.

**Universal TAU-II – Permanent Installations**

1620.04(1)(e) QuadGuard and QuadGuard II

1. **Purpose:** The QuadGuard and QuadGuard II provide end treatments for concrete barrier and beam guardrail. The QuadGuard can be used to mitigate fixed objects up to 10 feet wide and the QuadGuard II can be used to mitigate fixed objects up to 7 feet 6 inches wide.
2. **Description:** These systems consist of a series of Hex-Foam cartridges surrounded by a framework of steel diaphragms and quadruple corrugated fender panels. The QuadGuard and QuadGuard II use the same framework, but the QuadGuard II is shorter in length than the QuadGuard for any given posted speed.
3. **Function:** The internal shearing of the cartridges and the crushing of the energy absorption material dissipates impact energy from end-on hits. The fender panels redirect vehicles impacting the attenuator on the side.
4. **Foundation:** The systems are installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the QuadGuard and QuadGuard II.
6. **Transitions:** A transition section is not needed for concrete barrier and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for all connections to beam guardrail and for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems



QuadGuard – Permanent and Work Zone Installations

1620.04(1)(f) QuadGuard Elite

1. **Purpose:** The QuadGuard Elite is an end treatment for concrete barrier, beam guardrail, and fixed objects up to 7 feet 6 inches wide.
2. **Description:** The system consists of telescoping quadruple corrugated fender panels mounted on both sides of a series of polyethylene cylinders contained within steel diaphragms.
3. **Function:** The cylinders are compressed during a head-on impact and typically return to their original shape, which may provide continued shielding of the fixed object after the impact. The fender panels redirect vehicles impacting the attenuator on the side. It is anticipated that this system will not need many replacement parts or extensive repair following an impact.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the QuadGuard Elite.
6. **Transitions:** A transition section is not needed for concrete barrier and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for all connections to beam guardrail and for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems



QuadGuard Elite – Permanent and Work Zone Installations

1620.04(1)(g) QuadGuard M10

1. **Purpose:** The QuadGuard M10 is an end treatment for concrete barrier, beam guardrail, and fixed objects up to 7 feet 6 inches wide.
2. **Description:** The system consists of a series of energy-absorbing cartridges surrounded by a framework of steel diaphragms and quadruple corrugated fender panels.
3. **Function:** The internal shearing of the cartridges and the crushing of the energy absorption material dissipates impact energy from end-on hits. The fender panels redirect vehicles impacting the attenuator on the side.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the unit in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the QuadGuard M10.
6. **Transitions:** A transition section is not needed for concrete barrier and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for all connections to beam guardrail and for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems



QuadGuard M10 – Permanent and Work Zone Installations

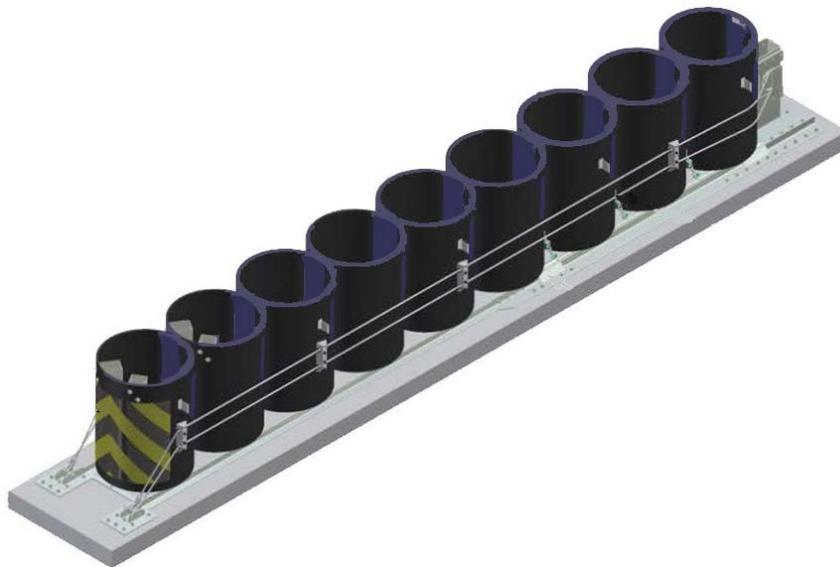
1620.04(1)(h) HEART

1. **Purpose:** The HEART is an end treatment for concrete barriers and fixed objects up to 2 feet wide.
2. **Description:** The system consists of High Density Polyethylene (HDPE) side panels and a rounded nose piece connected to steel diaphragms with tensioning cables that are mounted on a tubular steel track.
3. **Function:** During an end-on impact, the side panels and steel diaphragms help dissipate impact energy as they are pushed toward the rear of the system along the track. In a side impact, the side panels and tensioning cables redirect the vehicle.
4. **Foundation:** The system is installed on a concrete foundation or paved surface conforming to the manufacturer's recommendations.
5. **Slope:** 12H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** A transition section is not needed for concrete barrier and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Other:** The HEART should not be installed behind a curb.
8. **Manufacturer/Supplier:** Trinity Industries, Inc.

**HEART – Permanent and Work Zone Installations**

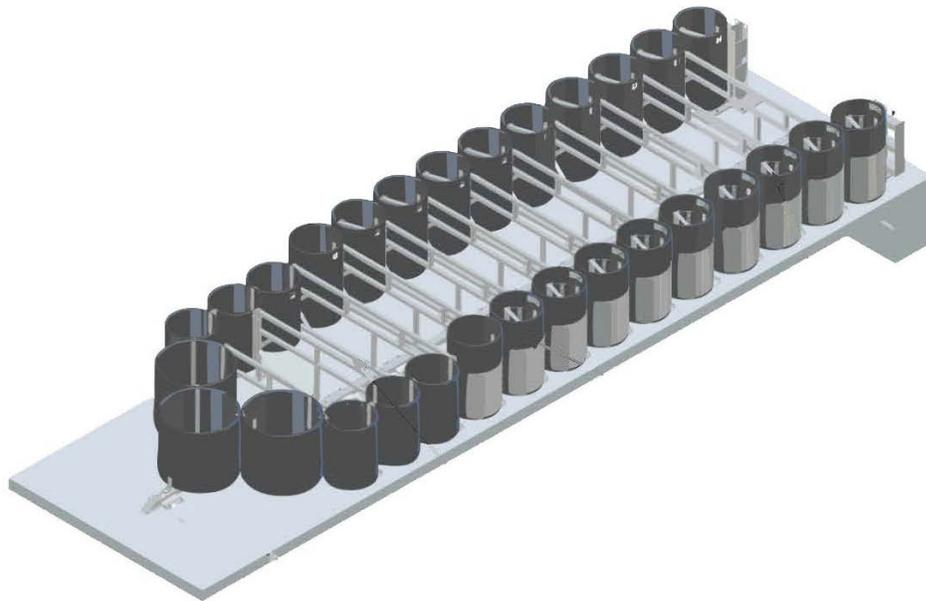
1620.04(1)(i) Reusable Energy Absorbing Crash Terminal (REACT 350)

1. **Purpose:** The REACT 350 is an end treatment for concrete barriers and fixed objects up to 3 feet wide.
2. **Description:** The system consists of polyethylene cylinders with varying wall thicknesses, redirecting cables, a steel frame base, and a backup structure.
3. **Function:** The redirecting cables are anchored in the concrete foundation at the front of the system and in the backup structure at the rear of the system. When hit head-on, the cylinders compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. For side impacts, the cables restrain the system enough to help prevent penetration and redirect the vehicle. It is anticipated that this system will not need many replacement parts or extensive repairs following an impact.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the REACT 350.
6. **Transitions:** Depending on traffic flow directions, the shape of the toe of the concrete barrier, and the ability to offset the system on the site, modifications to the toe of the concrete barrier and/or a custom transition section per manufacturer's specifications may be needed to prevent vehicle snagging (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems

**REACT 350 – Permanent and Work Zone Installations**

1620.04(1)(j) REACT 350 Wide

1. **Purpose:** The REACT 350 Wide is a device that can be used to shield fixed objects with widths up to 10 feet wide.
2. **Description:** The system consists of polyethylene cylinders with varying wall thicknesses, internal struts, space frame diaphragms, and a monorail.
3. **Function:** When hit head-on, the cylinders compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. For side impacts, the system is designed to restrain and redirect the vehicle. It is anticipated that this system will not need many replacement parts or extensive repairs following an impact.
4. **Foundation:** The system is installed on a concrete foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the REACT 350 Wide.
6. **Transitions:** A transition section is not needed for fixed objects exposed to traffic from only one direction. If the attenuator is exposed to bi-directional traffic, modification to the shielded object or a custom transition section per manufacturer's recommendations may be needed if the width of the attenuator's backstop exceeds the width of the shielded object (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems

**REACT 350 Wide – Permanent and Work Zone Installations**

1620.04(1)(k) Compressor

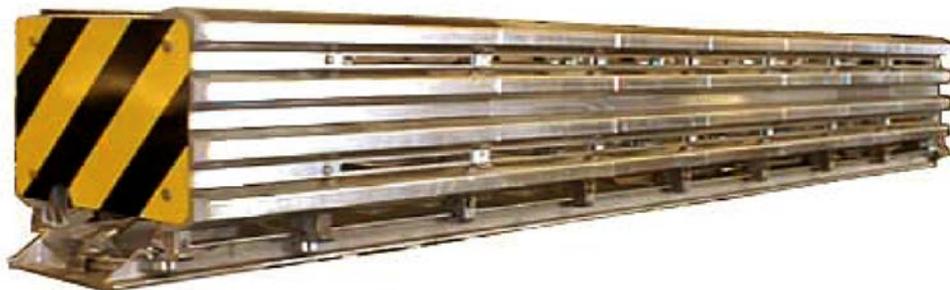
1. **Purpose:** The Compressor is an end treatment for concrete barrier and fixed objects up to 3 feet wide.
2. **Description:** The system consists of High Density Polyethylene (HDPE) modules with varying heights and wall thicknesses, a mounting base, and fender panels.
3. **Function:** When hit head-on, the modules compress, absorb the impact energy, and immediately return to much of their original shape, position, and capabilities. When impacted from the side, the fender panels redirect the vehicle.
4. **Foundation:** The system is installed on a concrete or asphalt foundation.
5. **Slope:** An 8% or flatter slope between the edge of the traveled way and the near face of the unit is required.
6. **Transitions:** A transition section is not needed for concrete barrier and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Traffix Devices



Compressor – Permanent and Work Zone Installations

1620.04(1)(I) Smart Cushion Innovations SCI100GM / SCI70GM

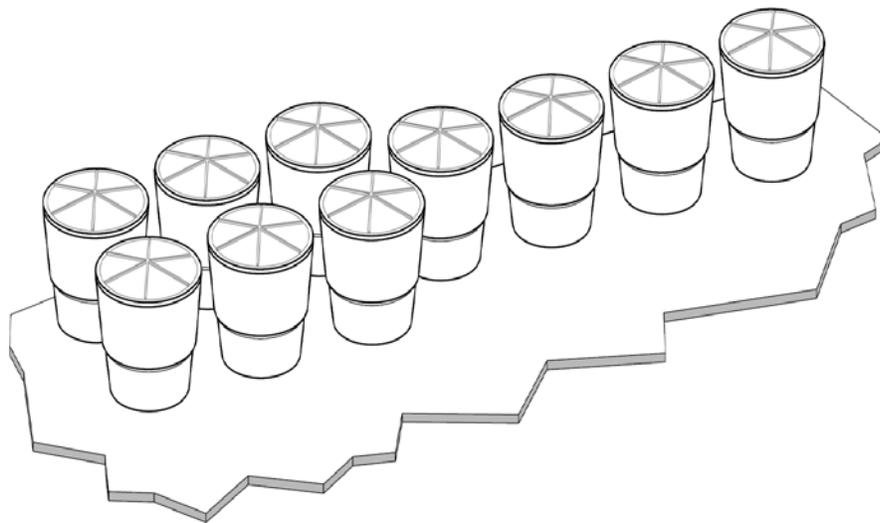
1. **Purpose:** The SCI100GM and SCI70GM are end treatments that can be used for concrete barrier and beam guardrail with widths up to 2 feet.
2. **Description:** The system for both models consists of a front sled assembly, telescoping steel side panels mounted to collapsing steel frames, a shock arresting cylinder, and a steel cable routed around sheave assemblies. It is mounted on a base with a series of tubular steel side frame assemblies.
3. **Function:** During a head-on impact, the system telescopes backwards and dissipates impact energy with a combination of friction between the steel cable and sheaves as well as variable resistance from the shock arresting cylinder. In a side impact, a vehicle is redirected by the steel side panels. It is anticipated that this system will not need many replacement parts or extensive repairs following an impact.
4. **Foundation:** The system is installed on a concrete foundation (see manufacturer's installation information for details).
5. **Slope:** Longitudinal and cross slopes at the installation site must be 10H:1V or flatter.
6. **Transitions:** A transition section is not needed for concrete barrier and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator). If used as an end treatment for beam guardrail, the system must be connected to a transition section (not included in the cost of the attenuator). (See [Chapter 1610](#) and the *Standard Plans* for the type of transition section required.) Connection of the transition section to the attenuator must be per the manufacturer's specifications using custom connection pieces (included in the cost of the attenuator).
7. **Other:** The SCI100GM and SCI70GM should not be installed behind a curb.
8. **Manufacturer/Supplier:** Work Area Protection Corp.

**SCI100GM – Permanent and Work Zone Installations**

1620.04(1)(m) Inertial Barrier

Inertial barrier configurations are shown in the [Standard Plans](#). If a situation is encountered where the configurations in the Standard Plans are not appropriate, contact the HQ Design Office for further information.

1. **Purpose:** Inertial barrier is an end treatment for concrete barrier and is used to mitigate fixed objects. This system does not provide redirection from a side impact.
2. **Description:** This system consists of an array of plastic containers filled with varying weights of sand.
3. **Function:** The inertial barriers slow an impacting vehicle by the transfer of the momentum of the vehicle to the mass of the barrier. This system is not suitable where space is limited to less than the widths shown in the [Standard Plans](#). Whenever possible, align inertial barriers so that an errant vehicle deviating from the roadway by 10° would be on a parallel path with the attenuator alignment (see the [Standard Plans](#)). In addition, inertial barriers do not provide any redirection and are not appropriate where high-angle impacts are likely.
4. **Foundation:** A concrete or paved surface is recommended.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 5% for inertial barriers.
6. **Manufacturer/Supplier:** Approved Inertial Barrier systems (sand barrel arrays) are listed in the [Qualified Products List](#).



Inertial Barrier – Permanent and Work Zone Installations

1620.04(2) Work Zone (Temporary) Installation

Several of the impact attenuators previously listed under the heading “Permanent Installations” are also appropriate for use in work zones or other temporary locations. The following is a list of these devices:

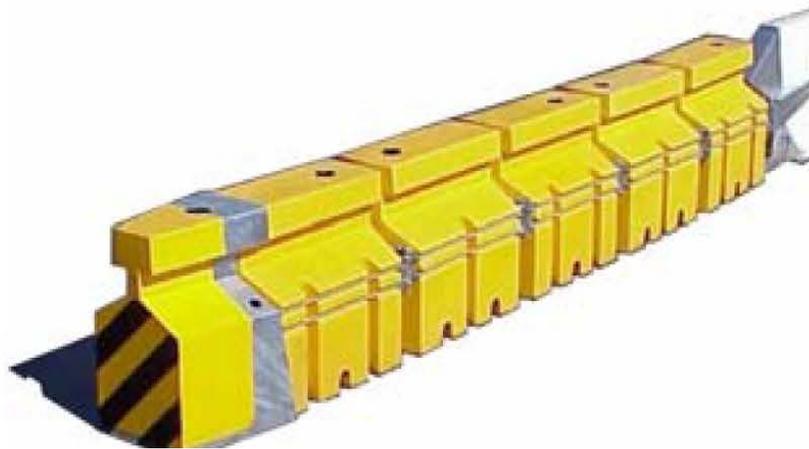
- QuadGuard
- QuadGuard II
- QuadGuard Elite
- QuadGuard M10
- HEART
- REACT 350
- REACT 350 Wide
- Compressor
- SCI100GM
- SCI70GM
- Inertial Barriers

The systems described in the following sections are appropriate only in work zones or other temporary installations. However, the TRACC impact attenuator may be considered for permanent use with the concurrence of the WSDOT Area Maintenance Superintendent who will be maintaining the system.

Descriptions of each work zone (or other temporary) system’s purpose, parts, and functionality, as well as guidance for transition, foundation, and slope, are provided as follows and in Exhibits [1620-1a](#) and [1620-1b](#).

1620.04(2)(a) ABSORB 350

1. **Purpose:** The ABSORB 350 is an end treatment limited to temporary installations for both concrete barrier and the Quickchange Moveable Barrier (QMB).
2. **Description:** The system contains water-filled Energy Absorbing Elements. Each element is 2 feet wide, 2 feet 8 inches high, and 3 feet 3½ inches long.
3. **Function:** The low-speed (rated for 45 mph or less) system uses five Energy Absorbing Elements, and the high-speed (rated for 60 mph and above) system uses nine elements. The energy of an impact is dissipated as the elements are crushed.
4. **Foundation:** The system does not need a paved foundation.
5. **Slope:** 12H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** A custom transition section per manufacturer's specifications is needed for all connections to concrete barrier or QMB (included in the cost of the attenuator).
7. **Other:** Although manufacturer's information may show configurations using different numbers of Energy Absorbing Elements, use only the five or nine Energy Absorbing Element configurations. Proper antifreeze agents must be used when the Absorb 350 is used in areas where low temperatures can be anticipated.
8. **Manufacturer/Supplier:** Barrier Systems, Inc.

**ABSORB 350 – Work Zone Installations**

1620.04(2)(b) Advanced Dynamic Impact Extension Module 350 (ADIEM 350)

1. **Purpose:** The ADIEM 350 is limited to temporary installations where vehicle speeds are 45 mph or lower. It is generally used as an end treatment for concrete barrier. Currently, there are a few existing permanent units in service. It is permissible to reset these existing devices. However, some of these units may exhibit significant deterioration and replacement may be the appropriate option.
2. **Description:** The system is 30 feet long and consists of ten lightweight concrete modules on an inclined base.
3. **Function:** An inclined base provides a track for placement of the modules and provides redirection for side impacts for roughly half the length. The energy of an impact is dissipated as the concrete modules are crushed.
4. **Foundation:** The system does not need a paved foundation.
5. **Slope:** If the site has excessive grade or cross slope, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed. "Excessive" is defined as steeper than 8% for the ADIEM 350.
6. **Transitions:** Custom bracket attachments per manufacturer's specifications that act as transition sections to prevent snagging are needed for all connections to concrete barrier (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Trinity Industries, Inc.

**ADIEM 350 – Work Zone Installations**

1620.04(2)(c) QuadGuard CZ

This system is similar to the QuadGuard listed for permanent systems above, except that it is mounted on an integral steel plate for ease of transport and resetting and can be installed on a 6-inch-minimum-depth asphalt concrete surface that has a 6-inch-minimum-depth compacted base.

**QuadGuard CZ – Work Zone Installations****1620.04(2)(d) Reusable Energy Absorbing Crash Terminal (REACT 350)**

This is the same system listed for permanent systems above except that it can be installed on a 6-inch-minimum-depth asphalt concrete surface that has a 6-inch-minimum-depth compacted base.

1620.04(2)(e) Non-Redirecting Energy Absorbing Terminal (N-E-A-T)

1. **Purpose:** The N-E-A-T system is an end treatment for temporary concrete barrier where vehicle speeds are 45 mph or lower.
2. **Description:** The N-E-A-T system's cartridge weighs about 300 pounds and is 9 feet 8 inches long. The system consists of aluminum cells encased in an aluminum shell with steel backup, attachment hardware, and transition panels. It can be attached to the ends of New Jersey and F-Shaped portable concrete barrier as well as the Quickchange Moveable Barrier.
3. **Function:** The energy of an impact is dissipated as the aluminum cells are crushed.
4. **Foundation:** The system does not need a paved foundation.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** Custom transition panels per manufacturer's specifications that act as transition sections to prevent snagging are needed for all connections to concrete barrier (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems



N-E-A-T – Work Zone Installations

1620.04(2)(f) Trinity Attenuating Crash Cushion (TRACC)

1. **Purpose:** The TRACC is an end treatment for concrete barriers. It is limited to use in construction or other work zones on a temporary basis.
2. **Description:** The 21.3-foot-long (not including the plastic nosepiece and front end shoes) TRACC includes four major components: a pair of guidance tracks, an impact sled, intermediate steel frames, and 10 gauge W-beam fender panels. The low-speed version (45 mph or less) is called the ShorTRACC and is 14.3 feet long (not including the plastic nosepiece and front end shoes).
3. **Function:** The sled (impact face) is positioned over the upstream end of the guidance tracks and contains a hardened steel blade that cuts the metal plates on the sides of the guidance tracks as it is forced backward when hit head-on, dissipating the impact energy. In a side impact, the fender panels redirect the vehicle.
4. **Foundation:** The system needs a concrete foundation.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** A transition section is not needed for concrete barrier exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for connection to a concrete barrier exposed to bi-directional traffic (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Trinity Industries, Inc.

**TRACC – Work Zone Installations**

1620.04(2)(g) Triton CET

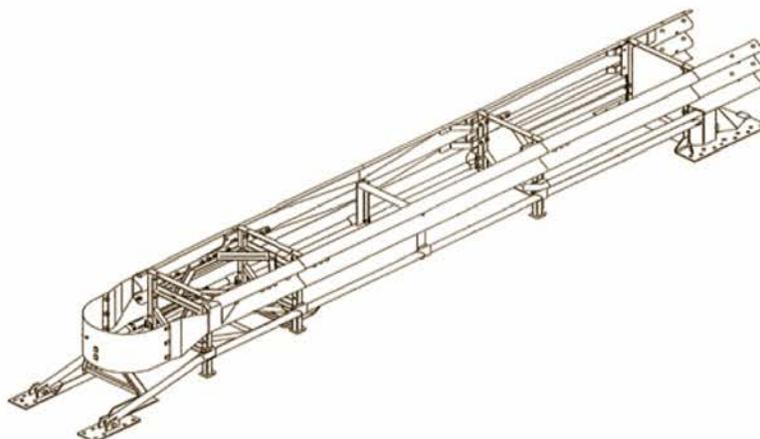
1. **Purpose:** The Triton CET is an end treatment limited to temporary concrete barrier installations.
2. **Description:** The system contains water-filled energy absorbing elements.
3. **Function:** The system uses six energy absorbing elements. The energy of an impact is dissipated as the elements are crushed.
4. **Foundation:** The system does not need a paved foundation.
5. **Slope:** Longitudinal and cross slopes at the installation site must be 20H:1V or flatter.
6. **Transitions:** A custom transition connection per manufacturer's specifications that acts as transition section to prevent snagging is needed for all connections to concrete barrier (included in the cost of the attenuator).
7. **Other:** Proper antifreeze agents must be used when the Triton CET is used in areas where low temperatures can be anticipated.
8. **Manufacturer/Supplier:** Energy Absorption, Inc.



Triton CET– Work Zone Installations

1620.04(2)(h) QUEST

1. **Purpose:** The QUEST is an end treatment for concrete barrier, guardrail, or fixed features and is limited to temporary applications. This system is designed to shield features 3 feet or less in width.
2. **Description:** The system consists of two front anchor assemblies; a nose assembly containing an integrated trigger assembly; two shaper rail assemblies; a support rail assembly with two energy-absorbing tube shapers; a diaphragm assembly; a bridge assembly; two rear rails; a freestanding backup assembly; and W-beam fender panels.
3. **Function:** During head-on impacts, the QUEST system telescopes rearward and energy is absorbed through momentum transfer, friction, and deformation. When impacted from the side, the QUEST system restrains lateral movement by dynamic tension developed between the end restraints.
4. **Foundation:** The system is installed on a concrete or asphalt foundation. (See manufacturer's installation information for details.)
5. **Slope:** 12H:1V (8%) or flatter slope between the edge of the traveled way and the near face of the unit is needed.
6. **Transitions:** A transition section is not needed for concrete barrier, guardrail, and fixed objects exposed to traffic from only one direction. A custom transition section per manufacturer's specifications is needed for connection to a concrete barrier or fixed object exposed to bi-directional traffic (included in the cost of the attenuator). If used as an end treatment for beam guardrail exposed to bi-directional traffic, the system must be connected to a transition section (not included in the cost of the attenuator). (See [Chapter 1610](#) and the *Standard Plans* for the type of transition section required.) Connection of the transition section to the attenuator must be per the manufacturer's specifications and may require custom side panels (included in the cost of the attenuator).
7. **Manufacturer/Supplier:** Energy Absorption Systems, Inc.

**QUEST – Work Zone Installations**

1620.04(2)(i) ACZ 350

1. **Purpose:** The ACZ 350 is an end treatment limited to temporary concrete barrier installations.
2. **Description:** The system consists of water-filled plastic sections and an integrated steel nose section. The low-speed (rated for 45 mph and below) system uses two water-filled sections, and the high-speed (rated for 60 mph and above) system uses four.
3. **Function:** The energy of an impact is dissipated as the water-filled sections are crushed.
4. **Foundation:** The system does not need a paved foundation.
5. **Slope:** If the site has excessive cross slope, additional site preparation in accordance with the manufacturer's literature is needed. Excessive is defined as steeper than 5% for the ACZ 350.
6. **Transitions:** A custom transition connection per manufacturer's specifications that acts as a transition section to prevent snagging is needed for all connections to concrete barrier (included in the cost of the attenuator).
7. **Other:** Proper antifreeze agents must be used when the ACZ 350 is used in areas where low temperatures can be anticipated.
8. **Manufacturer/Supplier:** Energy Absorption Systems, Inc.



ACZ 350 – Work Zone Installations

1620.04(2)(j) Sentry Longitudinal Energy Dissipater (SLED)

1. **Purpose:** The SLED is an end treatment limited to temporary concrete barrier installations.
2. **Description:** The system contains energy absorbing modules, some filled with water. The low-speed (rated for 45 mph and below) system uses three energy absorbing modules, and the high-speed (rated for 60 mph and above) system uses four.
3. **Function:** The energy of an impact is dissipated as the modules are crushed.
4. **Foundation:** The system does not need a paved foundation.
5. **Slope:** 10H:1V or flatter slope between the edge of the traveled way and the near face of the unit.
6. **Transitions:** A custom transition section per manufacturer's specifications is needed for all connections to concrete barrier (included in the cost of the attenuator).
7. **Other:** Proper antifreeze agents must be used when the SLED is used in areas where low temperatures can be anticipated.
8. **Manufacturer/Supplier:** Traffix Devices Inc.



SLED – Work Zone Installations

1620.04(2)(k) Transportable Attenuators (Truck-Mounted and Trailer-Mounted)

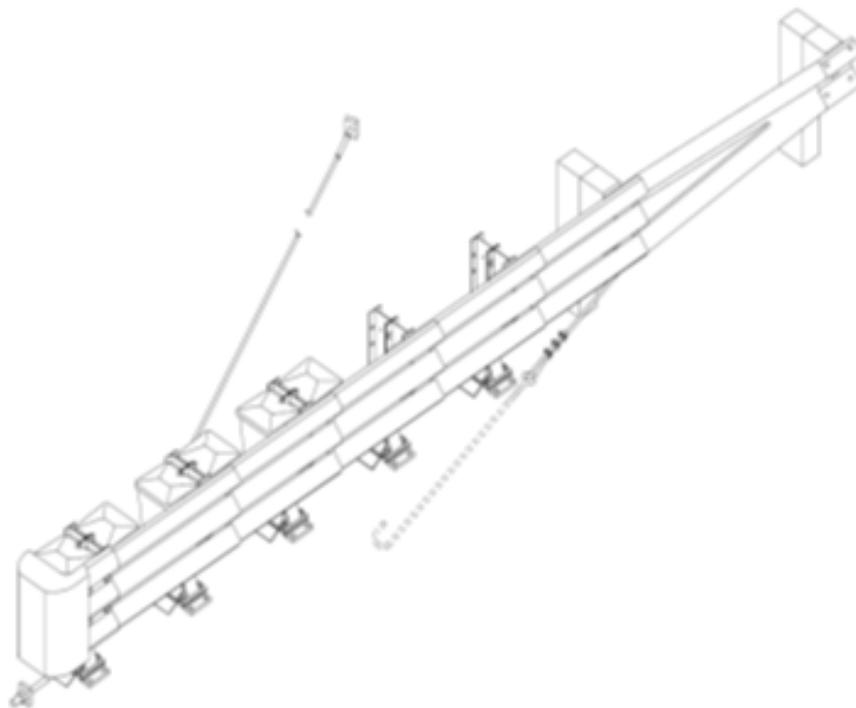
Truck Mounted Attenuators and Trailer-Mounted Attenuators are portable systems mounted on trucks or trailers. They are intended for use in work zones and for temporary applications.

1620.04(3) Older Systems

The following systems are in use on Washington State highways and may be left in place or reset with concurrence of the WSDOT Area Maintenance Superintendent who maintains the system. New installations of these systems need approval from the HQ Design Office.

1620.04(3)(a) Sentre

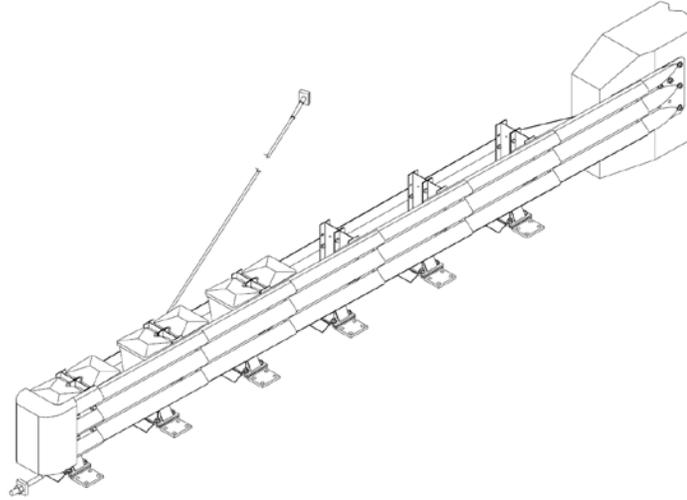
The Sentre is a guardrail end treatment. Its overall length of 17 feet allowed it to be used where space was not available for a guardrail transition and terminal. The system is very similar to the QuadTrend 350 in both appearance and function except that it uses three beam fender panels instead of the quadruple corrugated panels. This system needs a transition when used to terminate rigid barriers.



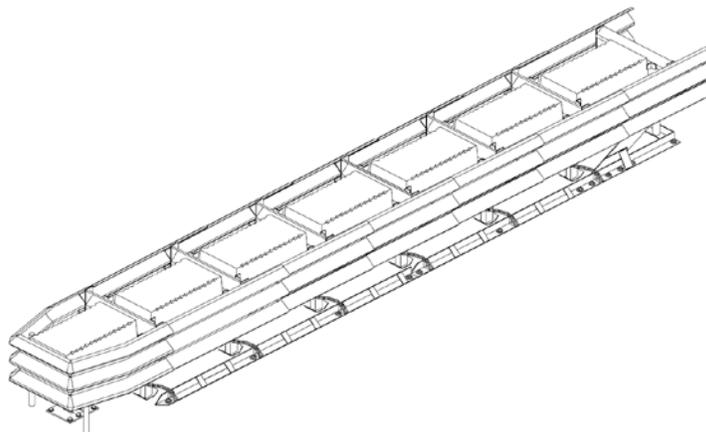
Sentre

1620.04(3)(b) TREND

The TREND is an end treatment with a built-in transition and was used at the end of rigid barriers including bridge rails. The system is similar to the QuadTrend 350 except that it uses three beam fender panels.

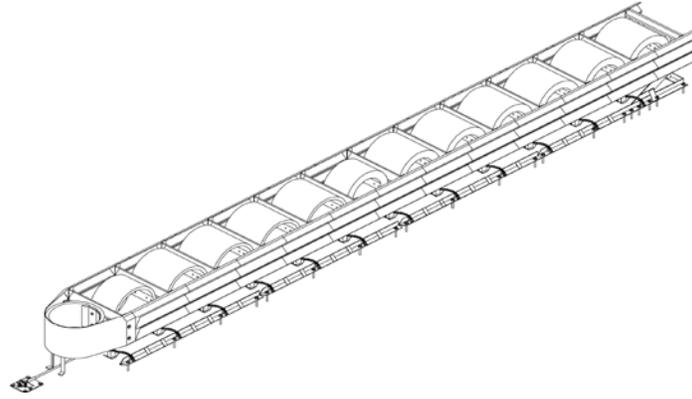
**TREND****1620.04(3)(c) Guard Rail Energy Absorption Terminal (G-R-E-A-T)**

This system was primarily used as an end treatment for concrete barrier. It is similar to the QuadGuard except that it uses three beam fender panels.

**GREAT**

1620.04(3)(d) Low-Maintenance Attenuator System (LMA)

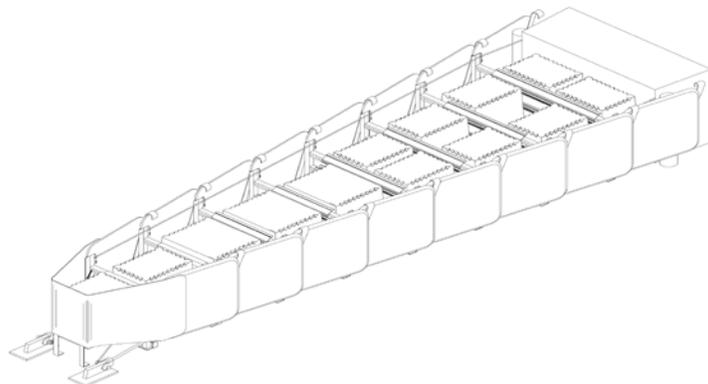
The LMA is an end treatment for concrete barrier and beam guardrail and was used for fixed objects up to 3 feet wide. The system is similar to the QuadGuard Elite except that it uses three beam fender panels and rubber cylinders.



LMA

1620.04(3)(e) Hex-Foam Sandwich

The Hex-Foam Sandwich system is an end treatment for beam guardrail and concrete barrier and was also used for fixed objects 3 feet or more in width. This system consists of a number of Hex-Foam cartridges containing an energy absorption material separated by a series of diaphragms and restrained by anchor cables. It is installed on a concrete slab. Impact energy is absorbed by the internal shearing of the cartridges and crushing of the energy absorption material. The lapped panels on the perimeter serve to redirect vehicles for side impacts. If the site has grade or cross slope in excess of 5%, additional site preparation or modification to the units in accordance with the manufacturer's literature is needed.



Hex-Foam Sandwich

Exhibit 1620-1a Impact Attenuator System Comparison

System ⁽¹⁾	Permanent (P), Temporary (T), or Both (B)	Posted Speed (mph) ⁽⁴⁾	Approximate Outside Width	Maximum Shielded Object Width	Approximate System Length ⁽¹⁰⁾	Distance Beyond Length of Need (See Exhibit 1620-2)	Initial Cost Category ⁽¹¹⁾
Brakemaster 350 ⁽²⁾	P	≥ 60	2.1	2	31.5	15.8	A
CAT 350 ⁽²⁾	P	≥ 60	2.5	2	31.3	18.8	A
QuadTrend 350 ⁽⁶⁾	P	≥ 60	1.3	2	20	10.5	A
Universal Tau-II ⁽⁷⁾	P	See Note 7	4.4 to 8.9	3.9 to 8.4	14.5 to 27.1	3	C,D ⁽⁷⁾
QuadGuard ⁽⁷⁾	B	See Note 7	2.5 to 10.5	2.0 to 10	13.1 to 22.1	3.3	B,C ⁽⁷⁾
QuadGuard II ⁽⁷⁾	B	See Note 7	2.5 to 8.0	2.0 to 7.5	10.0 to 19.1	3.3	B,C ⁽⁷⁾
QuadGuard Elite ⁽⁷⁾	B	See Note 7	2.5 to 8.0	2.0 to 7.5	18 to 27.1	3.3	C ⁽⁷⁾
QuadGuard M10 ⁽⁷⁾	B	See Note 7	2.5 to 8.0	2.0 to 7.5	13.1 to 22.1	3.3	C,D ⁽⁷⁾
HEART	B	≥ 60	3	2	26	5	D
REACT 350 (9-Bay)	B	≥ 60	4	3	30.5	4.3	D
REACT 350 (6-Bay)	B	≤ 55	4	3	20	4.3	D
REACT 350 (4-Bay)	B	≤ 45	4	3	15.5	4.3	D
REACT 350 Wide TL-3 (60"/96"/120" widths)	B	≥ 60	5.2/8.2/10.2	5.0/8.0/10.0	32.8/36.8/36.8	4.3	D
REACT 350 Wide TL-2 (60"/96" widths)	B	≤ 45	5.2/8.2/10.2	5.0/8.0/10.0	21	4.3	D
Compressor	B	≥ 60	4.1	3.0	21.3	3	D
SCI100GM	B	≥ 60	3.1	2.0/2.5/3.0	21.5/24.4/25.9	3	C
SCI70GM	B	≤ 45	2.8	2.0/2.5/3.1	13.5/15.4/16.9	3	C
INERTIAL BARRIERS	B	See Note 5	See Note 5	See Note 5	See Note 5	See Note 3	A
ABSORB 350 TL-3 ⁽⁸⁾	T	≥ 60	2	2	32	See Note 3	B
ABSORB 350 TL-2	T	≤ 45	2	2	19.3	See Note 3	B
ADIEM 350	T	≤ 45	2.7	2	30	14.1	B
QuadGuard CZ ⁽⁷⁾	T	See Note 7	2.5 to 8.0	2.0 to 7.5	13 to 22.1	3.3	C,D ⁽⁷⁾
N-E-A-T	T	≤ 45	1.9	2	10	See Note 3	B
TRACC	T ⁽⁹⁾	≥ 60	2.6	2	21.3	8	B
ShorTRACC	T ⁽⁹⁾	≤ 45	2.6	2	14.3	8	B
Triton CET TL-3 ⁽⁸⁾	T	≥ 60	1.8	2	40	See Note 3	A
Triton CET TL-2	T	≤ 45	1.8	2	40	See Note 3	A
QUEST TL-3 (24"/30"/36" widths)	T	≥ 60	3.0/3.5/4.0	2.0/2.5/3.0	28	3.5	B
QUEST TL-2 (24"/30"/36" widths)	T	≤ 45	3.0/3.5/4.0	2.0/2.5/3.0	22	3.5	B
ACZ-350 TL-3 ⁽⁸⁾	T	≥ 60	1.7	2	31.6	See Note 3	A
ACZ-350 TL-2	T	≤ 45	1.7	2	18.4	See Note 3	A
SLED TL-3 ⁽⁸⁾	T	≥ 60	2	2	26	See Note 3	B
SLED TL-2	T	≤ 45	2	2	19	See Note 3	B

For table notes, see the following page.

Exhibit 1620-1a Impact Attenuator System Comparison (continued)

Notes:

- [1] See system descriptions in [1620.04](#) for additional information regarding slopes, transitions, and other factors that may influence the appropriateness of an attenuator selection for a specific site.
- [2] Generally for use with double-sided beam guardrail
- [3] The N-E-A-T, Inertial Barriers, Triton CET, ACZ 350, SLED and ABSORB 350 may only be used beyond the length of need.
- [4] It is acceptable to use an attenuator rated for a higher posted speed on a roadway with a lower posted speed. For example: an attenuator rated for ≥ 60 mph may be used on a roadway with posted speed of 50 mph (see [1620.03](#)).
- [5] Varies; see the [Standard Plans](#).
- [6] See manufacturer's requirements for slope and clear area behind the device.
- [7] Numerous speed, length, and width combinations are available (see [Exhibit 1620-1b](#)).
- [8] Test Level 3 version on high-speed facilities should be limited to locations where the likelihood of being hit is low.
- [9] May be considered for permanent installations with concurrence of the Area Maintenance Superintendent.
- [10] The given dimension is the approximate system length. The effective length may vary depending on such factors as the physical design and type of anchorage used. To verify the total length needed, refer to the manufacturer's specifications and drawings.
- [11] A (\$5,000 to \$10,000); B (\$10,000 to \$15,000); C (\$15,000 to \$25,000); D (\$25,000 to \$50,000). These are rough initial cost estimates; verify actual costs through manufacturers/suppliers. Some products are priced very close to the margin between cost categories.

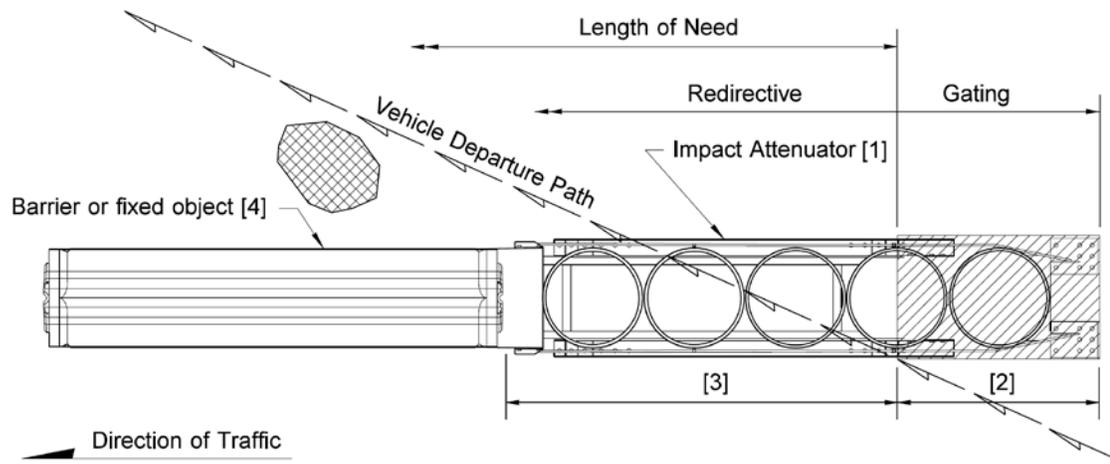
Exhibit 1620-1b Impact Attenuator Systems: Universal TAU II and QuadGuard Configurations

System ⁽¹⁾	Permanent (P), Temporary (T), or Both	Posted Speed (mph) ⁽²⁾	Approximate Outside Width	Maximum Shielded Object Width	Approximate System Length ⁽³⁾	Initial Cost Category ⁽⁴⁾
Universal Tau-II (8-Bay, 30" width)	P	≥ 60	2.9	2.5	25.4	D
Universal Tau-II (8-Bay, 42"/48"/54"/60" widths)	P	≥ 60	4.4/4.9/5.4/5.9	3.9/4.4/4.9/5.4	27.1	D
Universal Tau-II (7-Bay, 66"/72"/78"/84"/90"/96" widths)	P	≥ 60	6.4/6.9/7.4/7.9/8.4/8.9	5.9/6.4/6.9/7.4/7.9/8.4	24.2	D
Universal Tau-II (7-Bay, 30" width)	P	≤ 55	2.9	2.5	22.7	C
Universal Tau-II (7-Bay, 42"/48"/54"/60" widths)	P	≤ 55	4.4/4.9/5.4/5.9	3.9/4.4/4.9/5.4	24.2	D
Universal Tau-II (5-Bay, 72"/78"/84"/90"/96" widths)	P	≤ 55	6.9/7.4/7.9/8.4/8.9	6.4/6.9/7.4/7.9/8.4	18.6	D
Universal Tau-II (5-Bay, 30" width)	P	≤ 50	2.9	2.5	16.9	C
Universal Tau-II (5-Bay, 42"/48"/54"/60" widths)	P	≤ 50	4.4/4.9/5.4/5.9	3.9/4.4/4.9/5.4	18.6	D
Universal Tau-II (4-Bay, 66"/72"/78"/84"/90"/96" widths)	P	≤ 50	6.4/6.9/7.4/7.9/8.4/8.9	5.9/6.4/6.9/7.4/7.9/8.4	16	D
Universal Tau-II (4-Bay, 30" width)	P	≤ 45	2.9	2.5	14.5	C
Universal Tau-II (4-Bay, 42"/48"/54"/60" widths)	P	≤ 45	4.4/4.9/5.4/5.9	3.9/4.4/4.9/5.4	16	C
QuadGuard (6-Bay, 24"/30"/36"/90"/120" widths)	B	≥ 60	2.5/3.0/3.5/8.0/10.5	2.0/2.5/3.0/7.5/10	22.1	C
QuadGuard (5-Bay, 24"/30"/36"/90" widths)	B	≤ 55	2.5/3.0/3.5/8.0	2.0/2.5/3.0/7.5	19.1	C
QuadGuard (4-Bay, 24"/30"/36"/69"/90" widths)	B	≤ 50	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.7/7.5	16.1	C
QuadGuard (3-Bay, 24"/30"/36"/69"/90" widths)	B	≤ 45	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.7/7.5	13.1	B
QuadGuard II (5-Bay, 24"/30"/36"/90" widths)	B	≥ 60	2.5/3.0/3.5/8.0	2.0/2.5/3.0/7.5	19.1	C
QuadGuard II (4-Bay, 24"/30"/36"/69"/90" widths)	B	≤ 55	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.8/7.5	16.1	C
QuadGuard II (3-Bay, 24"/30"/36"/69"/90" widths)	B	≤ 50	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.8/7.5	13.1	B
QuadGuard II (2-Bay, 24"/30"/36" widths)	B	≤ 45	2.5/3.0/3.5	2.0/2.5/3.0	10	B
QuadGuard Elite (8-Bay, 24"/30"/36"/69"/90" widths)	B	≥ 60	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.8/7.5	27.1	C
QuadGuard Elite (5-Bay, 24"/30"/36"/69"/90" widths)	B	≤ 45	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.8/7.5	18	C
QuadGuard M10 (6-Bay, 24"/30"/36"/69"/90" widths)	B	≥ 60	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.8/7.5	22.1	D
QuadGuard M10 (3-Bay, 24"/30"/36"/69"/90" widths)	B	≤ 45	2.5/3.0/3.5/6.3/8.0	2.0/2.5/3.0/5.8/7.5	13.1	C
QuadGuard CZ (6-Bay, 24"/30"/36" widths)	T	≥ 60	2.5/3.0/3.5	2.0/2.5/3.0	22.1	D
QuadGuard CZ (5-Bay, 24"/30"/36" widths)	T	≤ 55	2.5/3.0/3.5	2.0/2.5/3.0	19.1	D
QuadGuard CZ (4-Bay, 24"/30"/36" widths)	T	≤ 50	2.5/3.0/3.5	2.0/2.5/3.0	16.1	C
QuadGuard CZ (3-Bay, 24"/30"/36" widths)	T	≤ 45	2.5/3.0/3.5	2.0/2.5/3.0	13.1	C

Notes:

- [1] See system descriptions in [1620.04](#) for additional information regarding slopes, transitions, and other factors that may influence the appropriateness of an attenuator selection for a specific site.
- [2] It is acceptable to use an attenuator rated for a higher posted speed on a roadway with a lower posted speed. For example, an attenuator rated for ≥ 60 mph may be used on a roadway with posted speed of 50 mph (see [1620.03](#)).
- [3] The given dimension is the approximate system length. The effective length may vary depending on such factors as the physical design and type of anchorage used. To verify the total length needed, refer to the manufacturer's specifications and drawings.
- [4] A (\$5,000 to \$10,000); B (\$10,000 to \$15,000); C (\$15,000 to \$25,000); D (\$25,000 to \$50,000). These are rough initial cost estimates; verify actual costs through manufacturers/suppliers. Some products are priced very close to the margin between cost categories.

Exhibit 1620-2 Impact Attenuator Distance Beyond Length of Need

**Notes:**

- [1] Impact attenuator type and manufacturer varies with application (see [Exhibit 1620-1a](#)).
- [2] Distance beyond the length of need (see [Exhibit 1620-1a](#)). This portion is nonredirective (gating).
- [3] This portion is redirective (nongating) and can be included as part of the barrier needed to satisfy length of need.
- [4] Concrete barrier shown for illustration purposes only. Type of object varies.

1620.05 Documentation

Refer to [Chapter 300](#) for design documentation requirements.

