Memorandum

U.S. Department
of Transportation

Federal Highway Administration

**400 Seventh Street, SW
Washington, DC 20590**

Subject: INFORMATION: Design and Materials of Crashworthy Work Zone Traffic Control Devices; Portable Sign Stands, Type III Barricades, and Category IV Devices

Date:

Reply to Attn. of: HSA-10/WZ-85

From: Rudolph M. Umbs
Acting Director, Office of Safety Design

To: Safety Field Staff

Introduction

On September 15, 2000, this office issued a memorandum dealing with various aspects of crashworthy work zone traffic control devices. The topics covered in Acceptance Letter WZ-54 included Generic Type I, Type II, and Type III barricades, Drums with Lights, and Lightweight Warning Lights. This memorandum, WZ-85, distributes additional information on the materials used and the design of crashworthy work zone traffic control devices. It includes guidance on proprietary materials as well as updates some information on generic designs. This information is based upon crash test results, direct comparisons between similar products, and/or extrapolation.

This memorandum consists of two sections. The first will deal with the design and materials of crashworthy devices. The second section includes frequently raised "Questions and Answers" (Q&A's) which will be added to the appropriate page on the Federal Highway Administration (FHWA), Safety Core Business Unit website. (http://safety.fhwa.dot.gov/fourthlevel/qanda.htm)

DESIGN and MATERIALS:

I. Portable Sign Stands

A. Sign Substrates

1. The crash-tested signs of corrugated polypropolylene and polyethylene plastic substrates, with a thickness of 10 mm (0.4 in), going by the names of IntePlast, InteCell, CoroPlast, and SafetyCor are considered interchangeable. Wall thicknesses are approximately 0.9 mm (0.035 in) and cell size is 10 mm (0.4 in). This means that any portable sign stand or other device successfully crash tested with one brand will be acceptable when used with any of the other brands mentioned.

2. The 2 mm (0.079 in) thick aluminum/plastic laminates called Reynalite, Alpolic, and DiBond have been crash tested on certain portable sign stands and are considered equivalent to each other. These aluminum faced composite substrates have thin (0.25 to 0.50 mm, 0.010 to 0.020 in)

aluminum outer layers surrounding a core of polyethylene or other thermoplastic material. As in the case of the plastic substrates discussed above any portable sign stand or other device successfully crash

tested with one brand will be acceptable when used with any of the other brands mentioned.

B. Sign Shapes and Sizes

Most crash tests of portable sign stands have been with 1220 mm x 1220 mm (48 x 48 in) diamond signs on flat and level terrain, which appears to be the most common situation in actual use. However, many square and rectangular signs are also used, and sometimes the sign stands are placed off of the pavement on non-level terrain. National Cooperative Highway Research Program (NCHRP) Report 350 testing represents idealized conditions. We recognize that a test matrix to cover all shapes, sizes, and terrain conditions would be impractical. As many sign stands of various designs and materials have been laboratory crash tested with diamond signs, we believe the safety performance of these same stands when used with rectangular signs will be satisfactory.

Those portable sign stands that have been successfully crash tested with a 1220 mm x 1220 mm (48 x48 in) diamond sign will be considered acceptable with a rectangular sign up to 1525 mm (60 in) wide if:

1. The same lightweight sign substrate is used.
2. The height to the top of the sign remains the same or less for short stands and meets or exceeds the height for tall stands.*
3. The overall area of the sign does not exceed the area of the crash tested sign (approximately 1.5 square meters or 16 square ft.). This would permit a sign up to 1525 x 976 mm or 60 x 36 in.

This acceptability is not extended to rigid aluminum or plywood substrates. These substrates must still be handled on a case-by-case basis.

* In most cases, windshield damage is caused by the top of the sign/mast striking the windshield. If the sign and stand assembly passed the testing, then either the assembly separated and passed harmlessly over the vehicle, or the sign struck the vehicle but the top struck the roof causing little damage. Maintaining the same height to the top of the sign should lead to similar performance. During some tests the stand remained intact but did not deflect enough to come in contact with the test vehicle. For short stands with sign mounting heights of 300 to 450 mm (12 to 18 in) to the bottom, the height to the top of the sign may be any distance equal to or less than that of the tested diamond sign. For tall stands with mounting heights of 1500 mm (60 in) or more to the bottom of the diamond sign, then the height to the top may be any distance exceeding that of the tested diamond sign.

C. Installation conditions

At times signs need to be placed on sloping terrain. As with other roadside safety hardware, portable sign stands should be used on slopes 1:10 or flatter. However, we will use “laboratory testing” of portable signs on level soil to judge the acceptability of the various stands wherever used. Additional crash testing on non-level terrain will not be required unless the stand is specifically designed for non-level terrain. Not all stands successfully crash tested on 1:10 or flatter slopes will perform similarly when placed on slopes steeper than 1:10. However, in those situations where you MUST place a sign on that slope, a crashworthy sign stand should perform better than a stand that has not been tested at all.

Many sign stands have been crash tested on concrete or asphalt pavements rather than on soil. Testing on soil has turned out to be a more critical condition since the device cannot slide as easily on

the ground. Legs of barricades and sign stands tend to dig into the ground, sometimes changing the failure mechanism and behavior of the device. Because we cannot always predict the behavior of devices on unpaved areas when they have been crash tested on concrete, judgement should be used when placing these devices on soil.

In short, if a device was tested on soil it may be used on tranversable slopes subject to the engineer's judgement. If it was tested on concrete or asphalt, its use should be limited to 1:10 slopes or flatter.

II Generic Type III Barricades and Attachments

A. Generic Type III Barricade Designs

1. "Bent Barricade" Angle Iron Framed Type III

The "generic" Type III barricade was covered in Acceptance Letter WZ-54 dated September 15, 2000, (crash tested by Bent Manufacturing.) It is 2440 mm (8 ft) wide and consists of a pair of 1525 mm (5 ft) long, 3.5 mm (10 gage) thick, 38 mm x 38 mm (1 ½ x 1 ½ in) hot rolled-high carbon steel angles as the base. To the center of each of these is welded a 200 mm (8 in) long, 51 mm (2 in) square tube into which are inserted 1600 mm (63 in) tall, 3.5 mm (10 gage) thick, 38 mm x 38 mm (1.5 x 1.5 in) hot rolled high carbon steel angle uprights. The three barricade panels are each 19 mm (3/4 in) ACX plywood and are attached with 9.525 mm (3/8 in) diameter bolts, nuts, and washers to each upright. The Type III barricade is also acceptable with panels that are 1830 mm (6 ft) or 1220 mm (4 ft) long. This Type III barricade is also acceptable with lightweight (1.5 kg or less) warning lights attached with the standard vandal resistant hardware (i.e., using the cupped washer.) The metal legs/frame of these barricades may be either painted or galvanized.

Attached to this memo are detail sheets in Metric and in English units - only the Metric version had been supplied with WZ-54.

An acceptable modification that may be made to the Generic Type III barricade is the use of perforated square steel tube sections, such as 51 mm (2 in) Telespar or equivalent, to fabricate the horizontal base legs.

2. Illinois L-Channel Type III and Minnesota Perforated Square Steel Tube (PSST) Type III

Two additional State-designed Type III barricades have also been successfully crash tested. The Illinois L-channel Type III barricade was found acceptable in WZ-40 dated June 6, 2000. It uses 50 mm (2 in) angle iron of 5 mm (6 gage) thick mild steel. The Minnesota PSST Type III barricade was found acceptable in WZ-55 dated December 18, 2000, and uses 38 mm (1 ½ inch) square, 14 gauge Telespar posts. The rails are extruded aluminum "dog-bone" panels as used in street name signs. See section II B below.

3. Type III Barricade of PSST

There have been many tests run on PSST framed barricades to the extent that we are satisfied that a "generic" Type III PSST barricade can be found acceptable. The PSST sections should be twelve gage ASTM A-653 steel, grade 50. The overall dimensions are similar to the Angle Iron framed Type III:

i. Horizontal legs: 50 mm (2 in) PSST, 1500 to 1800 mm long (60 to 72 in)
i. Base socket: 50 mm (2 in) PSST, 150 mm (6 in) long welded or bolted to the legs.
ii. Vertical supports: 45 mm (1-3/4 in) PSST, 1500 mm (60 in) tall
iv. Horizontal Rails: See the discussion Type III Barricade Rails below. The same variety of rails may be used as long as they are firmly attached to the vertical supports with minimum 10 mm diameter bolts and 25 mm o.d. washers. This generic Type III PSST barricade should be limited to an overall width of 2440 mm (8 ft) unless successfully crash tested with longer rails.

4. Sand Bag Ballast

Sand bag ballast may be used on the legs of the barricades even if they were not included in the crash testing. It is common to use four 20.4 kg (45 pound) bags, one near the end of each leg. The typical precaution of mixing salt with the sand should be followed in freezing weather.

B. Type III Barricade Rails

Rails for the Generic Angle Iron framed or PSST Type III barricades may be the crash tested plywood detailed above or hollow extruded rigid polyolefin or high density polyethylene panels (i.e., Davidson Plastics, Bunzl Extrusion, Itaska Plastics) fastened in place with 10 mm (3/8 in) diameter hardware including 25 mm [1 in] o.d. washers or better. These extruded plastic elements are approximately 20 mm (3/4 in) thick and have 2 to 3 mm (1/16 to 3/32 in) thick walls. Barricade rails of frangible plastics such as PVC may not be used as they may separate from the frame or may fracture and penetrate the windshield. Without additional end-on crash testing, barricade rails should be limited to a maximum of 2440 mm (8 ft) long. The "overhang" from the uprights to the end of the rail should be kept to a desirable 150 mm (6 in) and may not exceed a maximum of 300 mm (1 ft).

C. Lights on Type III Barricades

The Type III barricades discussed above may be used with one or two lightweight warning lights. The lights should be attached atop the back side of the upright supports. As an alternative, removable head warning lights may be mounted on the supports, with the battery pack located at the base.

III. Type III Barricades as Sign Supports

Rigid sign panels should not be attached to the center of Type III barricades. Certain Type III Barricade designs can support signs as shown in the Millenium Manual on Uniform Traffic Control Devices, figure 6F-2. The Pennsylvania Type III (see WZ-44) and a barricade crash tested for the pooled-fund study (see WZ-40) were both crash tested and accepted with diamond signs mounted on vertical supports above the top rail. The Minnesota Type III barricade (WZ-55, reference above) was crash tested and accepted with a rectangular aluminum sign panel attached to the top rail. This was effective because the rails were of extruded aluminum and had the strength to support the sign during impact.

For other Type III barricade designs, signs on lightweight substrates (as defined in section I A of this memorandum, plus roll-up signs) may be mounted on or above the top rail. The overall height to the top of the sign should be at least 2210 mm (87 in). Any barricade successfully crash tested with a

wood or aluminum sign panel may use signs made of these materials. For barricades that were only tested without signs, wood or solid aluminum substrates should be avoided.

IV. Category IV Devices

As discussed in the September 13, 2000, memorandum "WZ-45" the crashworthiness of Category IV devices will be revisited in 2003. Category IV is limited to the following trailer mounted devices unless specifically authorized by this office.

1. Flashing arrow panels.
2. Changeable message signs
3. Temporary traffic signals
4. Portable work zone lighting devices

This office is seeking documentation on real-world crash experience with these devices. Please ask your State to provide accident reports for crashes with trailer mounted devices and forward them to Mr. Nicholas Artimovich, FHWA, HSA-10, 400 Seventh Street SW, Washington, DC 20590.

Conclusion - Design and Materials

The variations on portable sign stands and Type III barricades described above are similar to crash tested devices and should perform satisfactorily. Therefore, they are acceptable for use on the NHS accordance with the criteria contained in NCHRP Report 350.

Some of the untested devices may be crash tested in the future under pooled-fund studies or by private parties and are, therefore, subject to recall or revision.

The FHWA does not endorse proprietary products. Brand names have been included because the devices have been accepted as crashworthy under certain conditions.

The following questions and answers provide additional guidance on sign substrates and on certain portable sign stands.

QUESTIONS & ANSWERS:

1. Can the new, lightweight substrates that have been crash tested on work zone portable sign stands be used on permanent breakaway sign supports?

   The following substrates may be used on permanent (ground-mounted) breakaway sign supports, without further crash testing, as long as they are attached in such a manner that they will not separate from the supports when impacted:

   a. Corrugated polypropelylene and polyethylene plastic substrates
   b. Aluminum faced composite laminates
   c. Corrugated Lexan plastic signs (e.g., Endurance)

   This may be accomplished if a washer (approximately 25 mm or 1 in o.d.) is used under the head of the bolt.

2. Aren't all compact stands with roll-up signs crashworthy?

   "Compact" sign stands are "X-Footprint" sign stands of steel or aluminum with a short mast. For the purposes of this Q&A, the mounting height of a 1220 mm x 1220 mm (48 x 48 in) diamond sign is

300 mm to 450 mm (12 to 18 in) only. A number of manufacturers have crash tested compact sign stands. These stands have performed well because there are no metal elements at a height that can impact the windshield during a crash.

Based on the results of crash testing of these designs we have identified elements that contribute to the successful crashworthy performance. Based on a declaration of conformity and potential for crashworthiness, FHWA will review requests for acceptance of compact sign stands conforming to the list of conditions below. FHWA will decide whether to accept the stand or require crash testing.

Requests must include:

- Complete drawings and specifications on the stands and roll-up signs (including welds and connecting hardware, and overall weight of sign stand)
- Information on any evaluations (e.g., informal crash testing) that may have been conducted.
- An engineering analysis of the crashworthiness of the stand. This analysis may be performed by the manufacturer or third party, such as a crash test laboratory.
- A declaration from the petitioner that they consider the device to be crashworthy.

The following conditions apply to FHWA's acceptance of these stands based on the petitioner's declaration of conformity:

- Mounting height is between 300 mm to 460 mm (12 to 18 in) from the ground to the bottom of the sign.
- Square tube legs and the short mast should be no larger than 32 mm (1-1/4 in) on a side.
- Maximum vertical mast of steel or aluminum is no taller than necessary to grip the bottom of the vertical fiberglass brace. The mast may not extend to the middle or top of the sign. The grip should be a quick-release type that would allow the vertical fiberglass brace to pull out quickly, releasing the sign.
- Fiberglass bracing of the roll-up sign should be no wider than 32 mm (1-1/4 in).
- The horizontal fiberglass brace should be no thicker than 4.76 mm (3/16 in).
- The vertical fiberglass brace should be no thicker than 6.35 mm (1/4 in).
- No flags or lights may be added.

Compact stands that have been successfully crash tested and found acceptable by FHWA do not need to meet all of the above criteria.

3. Can I substitute a Lexan or fiberglass sign panel for a polyethylene or polypropylene corrugated plastic sign?

The corrugated Lexan plastic substrate that is 16 mm (5/8 in) thick has been successfully crash tested on certain portable sign stands [See WZ-52 dated September 21, 2000, and WZ-69 dated May 9]. However, the material properties of Lexan are significantly different from the lightweight corrugated plastic substrates. Therefore, Lexan is not interchangeable with other substrates. Fiberglass substrates have not been crash tested and are not yet acceptable.

4. What is the procedure for getting an acceptance on a device that is similar to one already accepted, without doing additional crash testing? Can I just "certify" that my device is similar to the accepted device?

This depends on whether you are copying a "generic" design or one that is the property of the company that paid for the crash testing. Any manufacturer or vendor can replicate the "generic"

Type II and Type III barricades that are covered in Acceptance Letters WZ-45 (September 15, 2000) or WZ-85 (this memorandum) and use these Acceptance Letters. The testing of these devices was paid for with public funds (or permission was granted to distribute the design). The manufacturer or vendor must certify their barricades substantially conform to the generic designs, and the devices will be crashworthy.

For devices crash tested at the expense of a private company, a vendor may use the acceptance letter written to the company that had the devices tested only if they: (a) purchase the devices from the company that paid for the testing (or another authorized distributor), or (b) obtain permission from that company to reproduce their design.

For more information on crash testing of work zone traffic control devices please contact Mr. Nicholas Artimovich at (202) 366-1331 or nick.artimovich@fhwa.dot.gov.

2 Attachments

FHWA:HSA-10:NArtimovich:tm:x61331:11/14/01
File: WZ85-Sept.wpd
cc: HSA-10 (Reader, HSA-1; Chron File, HSA-10;
N. Artimovich, HSA-10)

Specifications for Generic Crashworthy Barricades Metric Units WZ-85 Attachment 1

Barricades	Type I or II	Type II	Type III

Frame	1156 mm long, 12 ga steel angle, 31.75 x 31.75 mm "A-Frame" design 12.7 mm fasteners	1156 mm long 12 ga or 14 ga steel angle 31.75 x 31.75 mm "A-Frame" design 12.7 mm fasteners	Two 1525 mm long, 10 ga (3.5 mm thick), 38x38 mm angle bases. Uprights same except 1600 mm tall. All steel to be high-carbon, hot rolled steel.
Panels	13 mm thick plywood	13 mm thick plywood or 13 mm thick waffleboard	19 mm ACX plywood (See "iv" below)
Panel Length	914 mm	914 mm (610 mm also OK)	2440 mm (or shorter: 1830mm or 1220mm)**
Panel Width	203mm to 305mm	203mm to 305mm	203 mm to 305 mm
Fastener Hardware All hardware zinc plated	(Acceptance based on test of Type II barricades.)	1/4"-20 x 1" Steel Carriage Bolt, Class 1 1/4"-20 Steel Hex Lock Nut	3/8"-16 x 1 3/4" Steel Hex Bolt, Class #2 3/8"-16 Steel Hex Nut Steel flat lock washer
Height to top		1200 mm to top of light	1525 mm to top of rails
Mass		13.2 kg	30 kg
Lights	1 lightweight	1 lightweight	2 lightweight

* The tested Type III barricade had a mass of 40.1 kg which included the lights (an acceptable option) and a 48x48-in aluminum sign which is not part of the accepted barricade.
** Rails are not to extend more than 200 mm beyond the uprights.

Generic" Type III PSST barricade should be framed with12 gage ASTM A-653 steel, grade 50. The overall dimensions re similar to the Angle Iron barricade:

. Horizontal legs: 50 mm PSST, 1500 to 1800 mm long.
i. Base socket: 50 mm PSST, 150 mm long welded or bolted to the legs.
ii. Vertical supports: 45 mm PSST, 1500 mm tall.
v. Horizontal Rails: Rails for the Generic Angle Iron or PSST Type III barricades may be the crash tested plywood detailed above or hollow extruded rigid polyolefin or high density polyethylene (HDPE) panels (i.e. Davidson Plastics, Bunzl Extrusion, Itaska Plastics) fastened in place with 10 mm diameter hardware including 25 mm o.d. washers or better. These extruded plastic elements are approximately 20 mm thick and have 2 to 3 mm thick walls. Barricade rails of frangible plastics such as PVC may not be used as they may separate from the frame or may fracture and penetrate the windshield. Without additional end-on crash testing, barricade rails should be limited to a maximum of 2440 mm long. The "overhang" from the uprights to the end of the rail should be kept to a desirable 150 mm and may not exceed a maximum of 300 mm.

Barricades	Type I or II	Type II	Type III
Frame	45.5 in long, 12 ga steel angle, 1.25 x 1.25 in "A-Frame" design ½ in fasteners	45.5 in long, 12 gage or 14 gage steel angle, 1.25 x 1.25 in "A-Frame" design ½ in fasteners	Two 60 in long, 10 gage (0.14 in thick), 1.25 x 1.25 in angle bases. Uprights same except 60 in tall. Steel to be high-carbon, hot rolled steel.
Panels	½ in thick plywood	½ in thick plywood or ½ in waffleboard	3/4 in thick ACX plywood (see "iv" below)
Panel Length	36 in (24 in also OK)	36 in (24 in also OK)	96 in (or shorter: 72 in or 48 in mm)**
Panel Width	8 to 12 in	8 to 12 in	8 to 12 in
Fastener Hardware All hardware zinc plated	(Acceptance based on test of Type II barricades.)	1/4"-20 x 1" Steel Carriage Bolt, Class 1 1/4"-20 Steel Hex Lock Nut	3/8"-16 x 1 3/4" Steel Hex Bolt, Class #2 3/8"-16 Steel Hex Nut Steel flat lock washer
Height to top		48 in to top of light	60 in to top of rails
Mass		30 pounds	66 pounds
Lights (Optional)	1 lightweight	1 lightweight	2 lightweight

* The tested Type III barricade had a mass of 88.4 pounds which included the lights (an acceptable option) and a 48x48 inch aluminum sign which is not part of the accepted barricade.
** Rails are not to extend more than 8 inches beyond the uprights.

Generic" Type III PSST barricade should be framed with12 gage ASTM A-653 steel, grade 50. The overall dimensions re similar to the Angle Iron barricade:

. Horizontal legs: 2 in PSST, 60 to 72 in long.
i. Base socket: 2 in PSST, 6 in long welded or bolted to the legs.
ii. Vertical supports: 1-3/4 in PSST, 60 in tall.
v. Horizontal Rails: Rails for the Generic Angle Iron or PSST Type III barricades may be the crash tested plywood detailed above or hollow extruded rigid polyolefin or HDPE panels (i.e. Davidson Plastics, Bunzl Extrusion, Itaska Plastics) fastened in place with 3/8 in diameter hardware including 1 in o.d. washers or better. These extruded plastic elements are approximately 3/4 in thick and have 1/16- to 3/32 in thick walls. Barricade rails of frangible plastics such as PVC may not be used as they may separate from the frame or may fracture and penetrate the windshield. Without additional end-on crash testing, barricade rails should be limited to a maximum of 8 ft long. The "overhang" from the uprights to the end of the rail should be kept to a desirable 6 in and may not exceed a maximum of 1 ft.