# Life Cycle Analysis of Galvanized Metal Guardrail Elements

*Requested by*
Randy Hiatt, Caltrans Office of Traffic Safety

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*The Caltrans Division of Research and Innovation (DRI) receives and evaluates numerous research problem statements for funding every year. DRI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field.*

# Executive Summary

## Background

Galvanized metal rail elements are commonly used by state departments of transportation (DOTs) in the guardrail installed to increase roadway safety. These guardrail components can be produced using different galvanizing processes, including:

- **Prefabrication galvanization**. In continuous galvanization, the rolled steel used to fabricate guardrail elements is continuously galvanized before the guardrail elements are fabricated. In this process, bolt holes and railing edges are not galvanized.
- **Postfabrication galvanization**. Also referred to as hot-dip galvanization, in this process metal guardrail elements are punched, cut and formed into shape and then subjected to a hot-dip batch galvanizing process.

Caltrans would like to know how the different galvanizing processes affect the design life of guardrail. In support of that inquiry, this Preliminary Investigation examines the following questions:

- How is the issue of galvanizing metal elements addressed in published research and research in progress?
- How is galvanizing addressed in state DOT specifications for guardrail?
- How are state DOTs addressing the issue of galvanized metal rail elements in practice?

## Summary of Findings

In our examination of **Related Research**, we found a dearth of published research that compares the life cycle effects of the different galvanizing processes used for metal guardrail elements (galvanizing before and after fabrication); we located only a 1998 research report published by Michigan DOT. A recently approved research request seeks to address this gap in published research. This project, approved for funding by the AASHTO Standing Committee on Highways, will develop accelerated testing protocols that compare corrosion resistance and permit a life cycle analysis of the two galvanizing methods used for metal guardrail. The project's requestor is awaiting designation of a start date for the study, which is expected to last nine to 12 months.

We also sought information from relevant national committees on research efforts in this area. The AASHTO Standing Committee on Highways has committed funding to researching this topic with the proposed research described above. The TRB staff representative for the TRB Committee on Roadside Safety did not identify any related research associated with that committee, and a search of the TRB database confirmed the lack of research in this area.

The **State Specifications** cited in this report are organized in two categories:

- States permitting galvanizing before fabrication.
- States requiring galvanizing after fabrication.

Two states—Florida and Texas—permit galvanizing of metal guardrail elements before fabrication. In addition to citing the agency's specifications, we also cite a 2002 Florida DOT publication that describes a yearlong verification test of guardrail manufactured using the continuous line method, and summarize discussions with representatives from Florida and Texas DOTs about the agencies' use of guardrail galvanized before fabrication. The two agencies reported differing experiences with using continuously galvanized guardrail in a saltwater or marine environment.

We located specifications for 10 states—Iowa, Maine, Michigan, Missouri, North Carolina, North Dakota, Oregon, Utah, Virginia and Washington—that require galvanizing of metal guardrail elements after fabrication.

## Gaps in Findings

There is a clear lack of published research comparing the long-term effects of galvanizing metal guardrail elements before and after fabrication. Anecdotal evidence is available from some state DOTs, with some conflicting results reported, but we did not discover formal testing protocols that allow for a life cycle analysis of the different galvanizing processes. Research funded by the AASHTO Standing Committee on Highways, soon to be under way, seeks to fill this gap.

At the time of publication of this report, we were unable to connect with a representative from Missouri DOT to learn more about a specification change that appears to have removed a requirement for Type 1 guardrail material to be galvanized by the continuous method.

## Next Steps

Caltrans might consider the following in its evaluation of the galvanizing processes used to manufacture metal guardrail elements:

- Maintaining contact with the submitters of the NCHRP Project 20-7 research "Corrosion Protection Comparison of W Beam Guardrail Using Hot Dip Versus Continuously Galvanized Guardrail Sections" as this research project gets under way.
- Contacting Florida and Texas DOTs to learn more about those states' experiences with guardrail manufactured using differing galvanizing processes.
- Contacting Missouri DOT to identify what led to a specification change with regard to the galvanization processes required for guardrail.

# Contacts

During the course of this Preliminary Investigation, we spoke to or corresponded with the following individuals:

## National Associations

**TRB**
Stephen F. Maher
Senior Program Officer
TRB Committee on Roadside Safety
Transportation Research Board
(202) 334-2955, smaher@nas.edu

## State Agencies

**Florida**
Karen Byram
Product Evaluation Administrator
Florida Department of Transportation
(850) 414-4353, karen.byram@dot.state.fl.us

**Michigan**
Jeff Weiler
Transportation Engineer
Bridge Field Services
Michigan Department of Transportation
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**Texas**
Karl Janak
Construction Division
Materials & Pavements Section
Texas Department of Transportation
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**Washington**
Kurt Williams
Construction Materials Engineer
Washington State Department of Transportation
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# Related Research

We found a dearth of published research that examines the life cycle effects of the different galvanizing processes used for metal guardrail elements (galvanizing before and after fabrication); we located only a 1998 Michigan DOT research report. A research request recently approved under NCHRP Project 20-7 seeks to address this gap in published data and analysis.

## Pending Research

**"Corrosion Protection Comparison of W Beam Guardrail Using Hot Dip Versus Continuously Galvanized Guardrail Sections,"** Tom Baker, Kurt Williams, Submission to NCHRP Project 20-7 Panel, March 2012.
http://www.transportation1.org/nchrp/20-7/uploads/SOM%2020-7%20Accelerated%20Testing%20of%20Galvanization%20Processes.doc
The authors of this request for research submitted to the project panel for NCHRP Project 20-7, "Research for the AASHTO Standing Committee on Highways," note that there is no published research that describes an accelerated testing process to compare the effects of hot-dip and continuous galvanization of metal guardrail elements. Such an accelerated process is needed as an alternative to decades-long field tests to allow state DOTs to assess the impact on life cycle of the two galvanizing methods. The project's final report is expected to compare corrosion rates of continuous and hot-dip galvanized samples using multiple tests.

***Interview Summary***

We contacted Kurt Williams of Washington State DOT, one of the authors of this research request, and learned that the request has been approved for funding by the NCHRP Project 20-7 panel; the submitters are awaiting word on when the research will begin and the composition of the panel overseeing the research project. The project is expected to require nine to 12 months to complete.

Contact: Kurt Williams, Construction Materials Engineer, Washington State Department of Transportation, (360) 709-5588, willikr@wsdot.ws.gov.

## Published Research

**"Comparison of Methods Used to Produce Hot-Dipped Galvanized W-Beam Guardrail,"** Michigan Department of Transportation, Research Report No. R-1357, January 1998.
http://www.gregorycorp.com/docpdf/highway/MDOT_Comparison.pdf
This study compared the performance of W-beam guardrail subjected to a hot-dipped galvanization process before and after fabrication. The process used met the requirements of AASHTO M 180, Type II zinc coating. The report notes that at the time of this research, Michigan DOT specifications required galvanizing after fabrication (current MDOT specifications also require galvanizing after fabrication). Researchers used a salt fog tank to accelerate testing of samples, identifying no differences in guardrail corrosion performance after 5,000 hours in the tank. Performance was assessed based on a visual inspection and by recording the nut loosening torque of the bolted, lap-spliced samples.

Page 5 of the PDF describes how the samples were prepared for testing:

> When assembling the guardrail samples for placement in the salt fog tank, the pre-galvanized elements were bolted to pre-galvanized elements and the same was done for the post-galvanized guardrail elements to keep the manufacturing methods spliced together. Edges that were cut for making the splices were coated with zinc rich paint to prevent streaming rust contamination of the samples.

# State Specifications

The state specifications cited below include references to several AASHTO and ASTM specifications.

- AASHTO M 180, Standard Specification for Corrugated Sheet Steel Beams for Highway Guardrail (see http://global.ihs.com/doc_detail.cfm?document_name=AASHTO%20M%20180&item_s_key=00487425). This specification covers corrugated sheet steel prepared for use as beams in highway guardrails. Type I and II beams may be galvanized before or after fabrication, as specified below:

    - Beams galvanized *before* fabrication shall be coated in accordance with ASTM A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process (see http://www.astm.org/Standards/A653.htm).

    - Beams galvanized *after* fabrication shall conform to the requirements of ASTM A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products (see http://www.astm.org/Standards/A123.htm).

        *Note*: The equivalent AASHTO specification for ASTM A123 is AASHTO M 111, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products (see http://engineers.ihs.com/document/abstract/OWHXMCAAAAAAAAAA).

- ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware (see http://www.astm.org/Standards/A153.htm). This specification covers standards for zinc coatings applied through a hot-drip process on iron and steel hardware.

    *Note*: The equivalent AASHTO specification for ASTM A153 is AASHTO M 232, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware (see http://engineers.ihs.com/document/abstract/JIIJJBAAAAAAAAAA).

The specifications below are organized in two categories:

- States permitting galvanizing before fabrication.
- States requiring galvanizing after fabrication.

## States Permitting Galvanizing Before Fabrication

We located specifications for two states—Florida and Texas—that permit galvanizing of metal guardrail elements before fabrication. We also cite below a 2002 Florida DOT publication that describes a yearlong verification test of guardrail manufactured using the continuous line method, and summarize discussions with representatives from Florida and Texas DOTs about the agencies' use of guardrail galvanized before fabrication.

### Florida

**Section 967, Rail Elements for Guardrail,** Standard Specifications for Road and Bridge Construction, Florida Department of Transportation, 2013.
http://www.dot.state.fl.us/specificationsoffice/Implemented/SpecBooks/2013/Files/2013eBook.pdf
From page 1102 of the PDF:

> **967-1 Steel Guardrail.**
> Steel guardrail materials shall meet the requirements of AASHTO M180, (except as specified below), and for either Class shown. Type 2 zinc coating will be required.

> As an exception to the requirements of AASHTO M180, the coating properties, sampling, test methods, inspection, and certification related to galvanizing regardless of the method of galvanization of the rail elements shall meet the requirements of ASTM A123.
>
> All supports, fastenings and other accessories, including bolts, nuts, washers, etc., (and including the steel trailing end-anchorage rods required to be used with aluminum guardrail) shall be galvanized as specified in ASTM A153.
>
> Acceptance of steel guardrail materials shall be based on manufacturer's certified mill analysis of test results meeting the specification limits of the ASTM or AASHTO designation as stated above. Certification of these test values, representing each shipment of guardrail materials, shall be provided to the Engineer for each project.

**Proposed Specifications Change – D9670001 – Rail Elements for Guardrail**, Memorandum to Specification Review Distribution List, Florida Department of Transportation, September 27, 2002. ftp://ftp.dot.state.fl.us/LTS/CO/Specifications/History/Jul03/9670001.pdf
The author of this 2002 specification change request noted that "[s]tandard practice by manufacturers of guardrail is to cut and shape the steel to the desired form and then to galvanize." This proposal sought a change in Florida DOT standard specifications to permit an alternative galvanizing procedure—continuous galvanizing that galvanizes steel coils on a continuous line and then shapes and cuts the steel to the desired form. The author comments that "the two manufacturing methods provide materials that have equal performance."

> *Note*: The 2013 Florida DOT specification cited above reflects the 2002 proposed specification change.

Included in the proposal for specification change is a brief description of a 2001-2002 verification test of the material. From page 2 of the PDF:

> As a verification test of the material, the State Materials Office Chemistry Laboratory installed a sample of the Gregory guardrail, manufactured by the continuous line method, at the test deck on Tea Table Key during March 2001. The installation was designed to mimic an actual installation. The product was on the beach, facing south, and less than 10 yards from the water. On March 29th, 2002, an inspection of the guardrail was performed. Special attention was made to the cut edges and punched out holes. The rail was in excellent condition and showed the typical zinc oxidation on the surface. No rusting, flaking, peeling, staining, streaking, or other failures were noted. Cut edges were free of rusting, pitting, or other signs of degradation.

***Interview Summary***

We contacted Karen Byram, the Florida DOT product evaluation administrator who submitted the 2002 request for specification change, to learn more about Florida DOT's use of guardrail fabricated before galvanizing.

Ms. Byram noted that the guardrail subjected to the verification test was in place for three to four years in a maintenance staging area in the Florida Keys (official testing was conducted during 2001 and 2002). The agency found that the test guardrail manufactured by the continuous line method performed better than guardrail manufactured with the postfabrication hot-dip process and provided better galvanic protection in the saltwater environment of the test deck, perhaps due to the higher zinc content required to keep the product malleable. After three to four years, only tiny, bead-size blossoms of rust appeared in cut areas.

Contact: Karen Byram, Product Evaluation Administrator, Florida Department of Transportation, (850) 414-4353, karen.byram@dot.state.fl.us.

## Texas

**Item 445, Galvanizing**, Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, Texas Department of Transportation, June 1, 2004.
ftp://ftp.dot.state.tx.us/pub/txdot-info/des/specs/specbook.pdf
From page 690 of the PDF:

**445.1. Description.** Galvanize or repair galvanizing on metal items. Table 1.

**445.2. Materials.** Provide galvanized metal items that meet the standards in Table 1.

**Table 1**

**Galvanizing Standards**

| Item | Standard |
|---|---|
| Fabricated items, rolled, pressed or forged steel shapes, plates, pipes, tubular items, and bars | ASTM A 123 |
| Steel or iron castings | ASTM A 153, Class A |
| Bolts, nuts, screws, washers, and other miscellaneous hardware | ASTM A 153, Class C or D or ASTM B 695, Class 50 |
| Miscellaneous fasteners | ASTM B 633, Class Fe/Zn 8 |
| Rail elements for metal beam guard fence or bridge railing | AASHTO M 180 |
| Permanent metal deck forms, supporting angles and incidental items | ASTM A 653, Coating Designation G165 |

TxDOT allows both AASHTO M180 Type I and Type II coated W-beam rail element for its metal beam guardrail. Karl Janak of TxDOT describes the differences between the two types of guardrail:

> A continuous galvanizing hot-dipped coating process of coiled steel is applied to the Type I rail element that requires only 1.80 oz/sq ft (total both sides) of Zn [zinc] galvanizing coating. This equates to about 1.5 mils minimum required Zn coating thickness. By comparison, the Type II requires twice the coating (3.60 oz/sq ft) which is comparable to the minimum required coating thickness of 2.6 mils under ASTM A 123 for 12 gauge thickness steel. The galvanizing is also performed after fabrication leaving no bare steel edges.
>
> We have seen the Type I rail element corrode at a faster rate than the Type II rail element in marine environments. We therefore suggest (not require) our designers to specify Type II in these environments.

Contact: Karl Janak, Construction Division, Materials & Pavements Section, Texas Department of Transportation, (512) 506-5922, Karl.Janak@txdot.gov.

## States Requiring Galvanizing After Fabrication

We located specifications for 10 states—Iowa, Maine, Michigan, Missouri, North Carolina, North Dakota, Oregon, Utah, Virginia and Washington—that require galvanizing of metal guardrail elements after fabrication.

### Iowa

**Section 4155, Guardrail**, Standard Specifications with GS-12001, Iowa Department of Transportation, October 16, 2012.
http://www.iowadot.gov/erl/current/GS/content/4155.pdf
From page 2 of the PDF:

> **4155.04 Posts**
> **B. Steel Posts.**
> 1. Use steel posts of the dimensions shown in the contract documents and that meet the requirements of ASTM A 36/A 36M structural steel.
> 2. Ensure bolt holes comply with Article 2408.03, S, 2.
> 3. Ensure steel posts and blocks are galvanized according to the requirements of ASTM A 123. Ensure galvanizing is done after fabrication and after all bolt holes have been drilled.

### Maine

**Section 710, Fence and Guardrail**, Standard Specifications, Maine Department of Transportation, December 2002.
http://www.state.me.us/mdot/contractor-consultant-information/ss_division_700.pdf
From page 26 of the PDF:

> 710.04 Metal Beam Rail. The rails shall conform to the requirements of AASHTO M180, Class A, Type I, or Type IV as designated.

From page 28 of the PDF:

> 710.07 Guardrail Posts. Posts shall be of wood or steel.
>
> b. Galvanized steel posts shall conform to the requirements of AASHTO M183/M183M if a rolled section or ASTM A769/A769M Grade 36 if a welded section. Fabrication will be in accordance with Section 504 - Structural Steel. Galvanizing shall be in accordance with AASHTO M111.
>
> 710.08 Guardrail Hardware. Guardrail hardware shall conform to the applicable standards contained in the latest ARTBA Bulletin No. 268B, "A Guide to Standardized Highway Barrier Rail Hardware," approved by the AASHTO-ARTBA-AGC Joint Cooperative Committee, Technical Bulletin Number 268-B.
>
> All galvanized fittings, bolts, washers, twisted end section anchors and other accessories shall be in accordance with the requirements of AASHTO M111, M232 or AASHTO M298, Class 50, Type I, whichever applies. All galvanizing shall be done after fabrication.

### Michigan

**Section 908, Miscellaneous Metal Products**, Standard Specifications for Construction, Michigan Department of Transportation, 2012.
http://mdotwas1.mdot.state.mi.us/public/specbook/files/2012/908%20Misc%20Metal%20Products.pdf
From page 3 of the PDF:

> **908.11. Steel Beam Guardrail Elements, Hardware, and Steel Sleeves.**

**A. Steel Beam Elements and End Sections.** Steel beam sections, backup elements, buffered end sections, terminal end shoes, and special end shoes must meet the requirements of AASHTO M 180, for Class A guardrail. Thrie beam elements for bridge railing retrofit, and special end shoes for bridge barrier railing connections must meet the requirements of AASHTO M 180, for Class B guardrail.

Provide steel beam elements, back-up elements, and end sections in the required shape. Steel beam elements, back-up elements, and end sections must be hot-dip zinc coated after fabrication in accordance with AASHTO M 180, for Type II zinc coatings. Guardrail Type A, Type B, and Type BD beam elements and corresponding back-up elements may be hot-dip zinc coated before, or after fabrication.

***Interview Summary***

We contacted Michigan DOT to determine if the agency had conducted further research on the corrosion performance of guardrail galvanized before and after fabrication as a follow-up to MDOT's 1998 study on this topic. Jeff Weiler, MDOT transportation engineer, confirmed that no additional research had been undertaken. He noted that MDOT specifications—both current and previous editions—do not permit galvanizing before fabrication, and the agency requires hot-stick galvanizing repairs of guardrail drilled in the field.

Contact: Jeff Weiler, Transportation Engineer, Bridge Field Services, Michigan Department of Transportation, (517) 322-1235, WeilerJ@michigan.gov.

## Missouri

**Section 1040, Guardrail, End Terminals, One-Strand Access Restraint Cable and Three-Strand Guard Cable Material**, Missouri Standard Specifications for Highway Construction, Missouri Department of Transportation, 2011.
http://www.modot.org/business/standards_and_specs/Sec1040.pdf
From page 1 of the PDF:

**1040.2.2 Steel Posts, Plates and Rails.** Steel posts, anchor plates, bearing plates, soil plates, plate washers and channel rail shall be structural steel in accordance with AASHTO M 270, Grade 36, shall be of the dimensions and weights shown on the plans and shall be galvanized in accordance with AASHTO M 111. Bolts, nuts and washers shall be in accordance with the dimensions shown on the plans and shall be galvanized in accordance with AASHTO M 232, or may be mechanically galvanized. If mechanically galvanized, the coating thickness, adherence and quality requirements shall be in accordance with AASHTO M 232, Class C. Any dimensional defects and structural discontinuities will be cause for rejection. The material to be welded shall be preheated in accordance with good welding practice, and welds shall be full-section and sound throughout. All welds shall be mechanically cleaned before galvanizing. No punching, drilling, cutting or welding will be permitted after galvanizing.

**1040.3 Steel Beam Guardrail.** Guardrail beams shall be of the class and type shown on the plans. Guardrail beams shall be in accordance with AASHTO M 180, Type 1 or Type 2.

A previous edition of Missouri DOT's specifications (see http://www.modot.org/business/standards_and_specs/2004%20Spec%20Book%20Archive/Sec1040.pdf for the *2004 Missouri Standard Specification Book for Highway Construction*) included this on page 1 of the PDF (emphasis added):

**1040.3 Steel Beam Guardrail.** Guardrail beams shall be of the class and type shown on the plans. Guardrail beams shall be in accordance with AASHTO M 180, Type 1 or Type 2, except as noted herein. *Type 1 material shall be galvanized by the continuous method.*

## North Carolina

**Section 1046, Guardrail Materials**, Standard Specifications for Roads and Structures, North Carolina Department of Transportation, 2012.
http://www.ncdot.gov/doh/preconstruct/ps/specifications/2012StdSpec.pdf
From page 465 of the PDF:

**1046-2 Rail Elements**
The rail element and terminal sections shall meet AASHTO M 180 for Class A, Type 2.

From page 466 of the PDF:

**1046-3 Posts and Offset Blocks.**

**(B) Structural Steel Posts**
Fabricate steel posts for guardrail of the size and weight shown in the plans from structural steel complying with Section 1072. Metal from which C-shape posts are fabricated shall meet ASTM A1011 for any grade of steel except that mechanical requirements that shall meet ASTM A36. Punch or drill the holes for connecting bolts. Burning will not be permitted. After fabrication the posts shall be galvanized in accordance with Section 1076.

**Section 1076, Galvanizing**, Standard Specifications for Roads and Structures, North Carolina Department of Transportation, 2012.
http://www.ncdot.gov/doh/preconstruct/ps/specifications/2012StdSpec.pdf
From page 518 of the PDF:

**1076-1 Galvanizing**
Wherever galvanizing is required, perform the galvanizing in accordance with this section except where other requirements for galvanizing are included in other sections of the *Standard Specifications*.

**1076-3 Fabricated Products**
Galvanize products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips 1/8" thick and heavier in accordance with AASHTO M 111. Fabricate products into the largest unit that is practicable to galvanize before the galvanizing is done. Fabrication includes all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, welding and riveting. Galvanize components of bolted or riveted assemblies separately before assembly. When it is necessary to straighten any sections after galvanizing, perform such work without damage to the zinc coating.

## North Dakota

**Section 854**, **Guardrail and Posts**, Standard Specifications for Road and Bridge Construction, Volume 1 of 2, North Dakota Department of Transportation, October 2008.
http://www.dot.nd.gov/manuals/environmental/2008-Vol01.pdf
From page 585 of the PDF:

**862.01 General.**
All steel components of the various types of guardrail shall be galvanized.

No burning, cutting, or welding will be permitted after galvanizing unless the item is regalvanized according to Section 854.

From page 588 of the PDF:

> **862.05 Steel Guardrail Post.**
> Steel posts, adjustment blocks, blockouts, attachment angles, and base plates shall meet AASHTO 270 Grade 36 and shall be galvanized after fabrication according to AASHTO M 111. Welding shall meet the current AWS D1.1.

## Oregon

**Section 02820 - Metal Guardrail**, Standard Specifications, Oregon Department of Transportation, 2008.
http://www.oregon.gov/ODOT/HWY/SPECS/docs/08book/08_02000.pdf
From page 95 of the PDF:

> **Section 02820 - Metal Guardrail**
>
> **02820.10 Metal Beam Rail** - Form metal beam rail from galvanized steel. Galvanized steel beam rail shall conform to the requirements of AASHTO M 180, Class A. The zinc coating shall conform to the requirements of AASHTO M 180, Type II, applied after fabrication and subject to the single spot test. Backup plates will be accepted with ungalvanized edges and boltholes, provided these areas are field-coated with an approved galvanizing substitute.
>
> **02820.20 Metal Guardrail and Median Barrier Posts** - Metal posts shall be of structural steel conforming to the requirements of ASTM A 36 and galvanized according to AASHTO M 111 (ASTM A 123).
>
> **02820.30 Guardrail Hardware** - All bolts, nuts, washers and other fittings for beam type guardrail shall be galvanized steel meeting the requirements of AASHTO M 180.
>
> All bolts, nuts, and washers shall be as detailed, with nuts tapped oversize not to exceed 1/32 inch.
>
> **02820.40 Guardrail Anchor Hardware** - Provide cable and fittings for guardrail anchors that conform to the requirements of AASHTO M 30, Class C, for Type II cable. Galvanize all fittings according to AASHTO M 111 (ASTM A 123).
>
> For steel anchors, the steel tubing shall meet the requirements of ASTM A 500, Grade B, ASTM A 501 or ASTM A 618. The soil plate shall meet the requirements of ASTM A 36. After fabrication galvanize tubing and plate according to AASHTO M 111 (ASTM A 123).

## Utah

**Section 02841,W-Beam Guardrail**, 2012 Standard Specifications for Road and Bridge Construction, Utah Department of Transportation, January 1, 2012.
http://www.udot.utah.gov/main/uconowner.gf?n=7569028183854784
From page 571 of the PDF:

> **2.1 W-Beam Guardrail and Hardware**
>
> A. W-Beam Rail – Refer to BA Series Standard Drawings.
>  1. Minimum galvanizing requirement: Refer to AASHTO M 180, Type 1, Class A.
>
> B. Bottom W-Beam rail or steel rub rail – Refer to BA Series Standard Drawings.
>  1. W-Beam – Refer to requirements of this Section.
>  2. Channel rub rail – Refer to AASHTO M 160 and AASHTO M 270.
>  a. Refer to AASHTO M 111 after all punching and cutting is complete.
>
> C. Hardware – Refer to BA Series Standard Drawings.

1. Manufacturer – Refer to AASHTO M 180. 2. Coatings – Refer to AASHTO M 232 or M 298.

**2.2 W-Beam Guardrail Posts and Offset Blocks**

A. All elements according to BA Series Standard Drawings.
   1. Steel post – Refer to AASHTO M 270 and AASHTO M 160.
      a. Refer to AASHTO M 111 after all punching and cutting is complete.
   2. Wood Post and wood blocks – Refer to Section 06055.
   3. Composite or plastic offset blocks for steel post installations.
      a. Certify according to NCHRP 350 test requirements.
   4. Visually inspected and accepted by the Engineer.

## Virginia

**Section 221, Guardrail**, Road and Bridge Specifications, Virginia Department of Transportation, 2007.
http://www.virginiadot.org/business/resources/const/2007SpecBook.pdf
From page 197 of the PDF:

> **221.02—Detail Requirements**
> Guardrail shall consist of rail or cable elements and fastenings fabricated to develop continuous beam or cable strength when installed.
>
> (a) **Steel beam guardrail** shall conform to the requirements of AASHTO M180, Class A, Type 1. Where guardrail is to be constructed on curves that have a radius of 150 feet or less, rail elements shall be shop curved to the proper radius, with the roadside of the rail either concave or convex as required.
>
> (e) **Steel posts** shall be galvanized in accordance with the requirements of AASHTO M111.

Related resource:

> **Section 223, Galvanizing**, Road and Bridge Specifications, Virginia Department of Transportation, 2007.
> http://www.virginiadot.org/business/resources/const/2007SpecBook.pdf
> From page 221 of the PDF:
>
> **233.01—Description**
> These specifications cover the use and repair of zinc coatings (galvanizing) on a variety of materials.
>
> **233.02—Detail Requirements**
> Galvanizing of fabricated items shall be performed after fabrication.
>
> Galvanized items shall be stored off the ground in a manner that will allow free drainage of water from galvanized surfaces.
>
> (a) **Galvanizing of iron and steel hardware** shall conform to the requirements of ASTM A153 for the hot-dip process or ASTM B695, Class 50, for the mechanical process.
>
> (b) **Galvanizing of rolled, pressed, and forged steel shapes, plates, bars, and strips** shall conform to the requirements of ASTM A123.

## Washington

**9-16, Fence and Guardrail**, Standard Specifications for Road, Bridge and Municipal Construction, Washington State Department of Transportation, 2012.
http://www.wsdot.wa.gov/publications/manuals/fulltext/M41-10/SS2012.pdf
From page 9-103 of the publication (page 837 of the PDF):

> **9-16.3(3) Galvanizing**
> W-beam or thrie beam rail elements and terminal sections shall be galvanized in accordance with AASHTO M 180, Class A, Type 2, except that the rail shall be galvanized after fabrication, with fabrication to include forming, cutting, shearing, punching, drilling, bending, welding, and riveting. In addition, the minimum average mass of zinc coating shall be 2 ounces per square foot of surface (not sheet), the average to be determined on the basis of three individual tests, no one of which may be less than 1.8 ounces per square foot of surface (not sheet). The aluminum content of the zinc bath during actual galvanizing operations shall not exceed 0.01 percent. Channel rails, splice plates, WF steel posts, and base plates shall be galvanized in accordance with ASTM A 123. Anchor cables shall be galvanized in accordance with Federal Specification RR-W-410, Table II, galvanized at finished size. Bolts, nuts, washers, plates, rods, and other hardware shall be galvanized in accordance with ASTM A 153.