Designation: A 385 – 08

# Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)[1]

This standard is issued under the fixed designation A 385; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope*

1.1 This practice covers the precautions that should be taken to obtain high-quality hot-dip galvanized coatings.

1.2 Where experience on a specific product indicates a relaxing of any provision, the mutually acceptable change shall be a matter for agreement between the manufacturer and purchaser.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 143/A 143M Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

A 384/A 384M Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies

A 563 Specification for Carbons and Alloy Steel Nuts

## 3. Steel Selection

3.1 The production of a galvanized coating has as its basis the metallurgical reaction between the steel and the molten zinc, resulting in the formation of several iron-zinc compound layers, for example, gamma (not always visible microscopically), delta, and zeta in Fig. 1. In addition, a layer of the molten zinc adheres to the surface of the compound layers as the steel is withdrawn from the galvanizing bath. Upon solidification, this adherent zinc forms the eta layer.

3.2 It is known that the exact structural nature of the galvanized coating, as typified by Fig. 1, may be modified in accordance with the exact chemical nature of the steel being galvanized. Certain elements found in steels are known to have an influence on the coating structure. The elements carbon in excess of about 0.25 %, phosphorus in excess of 0.04 %, or manganese in excess of about 1.3 % will cause the production of coatings different from the coating typified by Fig. 1. Steels with silicon in the range 0.04 % to 0.15 % or above 0.22 % can produce galvanized coating growth rates much higher than those for steels with silicon levels below 0.04 % and between 0.15 % and 0.22 %. Recent studies have shown that even in cases where the silicon and phosphorous are individually held to desirable limits, a combined effect between them can produce a coating as shown in Fig. 2, which typically would have a mottled or dull gray appearance.

3.3 These elements manifest their structural effect as an accelerated growth of the compound layers, particularly the zeta layer, and the virtual elimination of the eta layer. Cosmetically this accelerated growth is seen as a gray matte finished coating as opposed to the usual bright and smooth appearance of galvanized coatings. Sometimes, a large surface may have adjacent areas of matte finish and bright finish leading to a mottled appearance.

3.4 There is some evidence that the coatings resulting from this accelerated growth are more brittle and less adherent than normal coatings. There is also evidence that these coatings are subject to a premature red staining in atmospheric exposure; however, this staining has been found not to be associated with corrosion of the substrate steel.

3.5 A problem with steel chemistry is not usually apparent until after an item has been galvanized. Not all combinations of silicon, phosphorus, carbon, and manganese can be galvanized successfully. When the steel chemistry is known beforehand, experienced galvanizers can in some, but not all, instances exercise limited control over the coatings as shown in Fig. 2. Also, the combination of two different steel types or thicknesses in one item may result in a nonuniform galvanizing finish. The experience of the steel supplier, designer, manufacturer, and galvanizer should determine the steel selection.

3.6 In general, galvanized coatings are specified because of their corrosion resistance, not because of their appearance. The relative corrosion resistance of the normal and abnormal coatings is, for all practical purposes, equal.

[1] This practice is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

Current edition approved May 1, 2008. Published June 2008. Originally approved in 1955. Last previous edition approved in 2005 as A 385 – 05.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

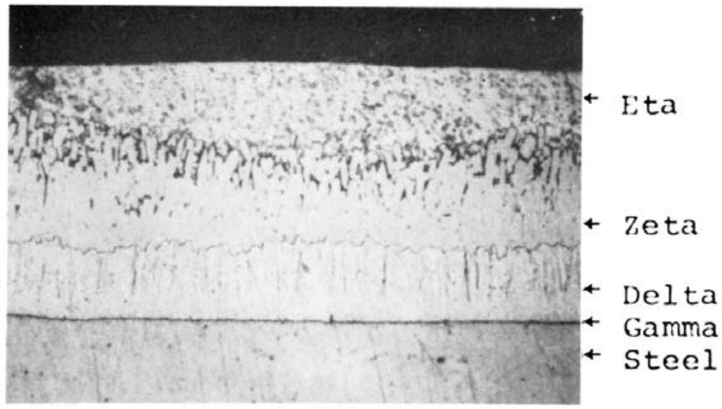


FIG. 1 Photomicrograph of Normal Galvanized Coating (X 400)

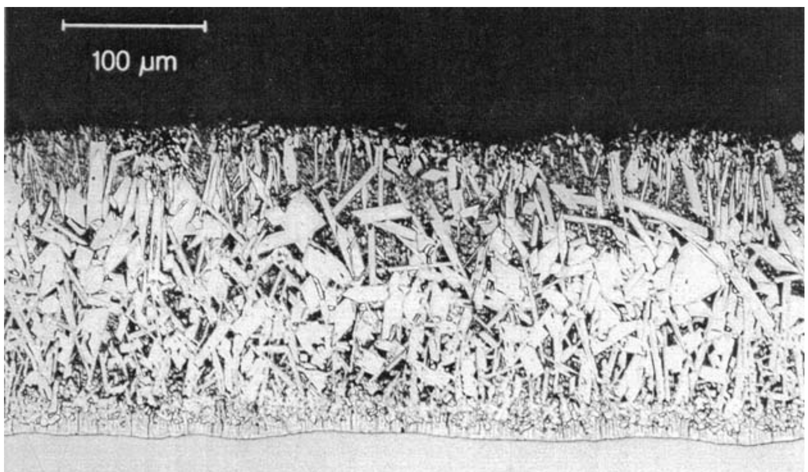


FIG. 2 Photomicrograph of Dull Gray, Thick-Galvanized Coating (X 200)

## 4. Assemblies of Different Materials or Different Surfaces or Both

4.1 Whenever possible, assemblies should consist of elements of similar steel chemistry and surface condition.

4.2 Whenever different analyses of steel or different surfaces of steel are united in an assembly the galvanized finish is not generally uniform in appearance. These differences include:

4.2.1 Excessively rusted surfaces.

4.2.2 Pitted surfaces.

4.2.3 Machined surfaces.

4.2.4 Cast iron (especially with sand inclusion).

4.2.5 Cast steel.

4.2.6 Malleable iron.

4.2.7 Hot-rolled steel.

4.2.8 Cold-rolled steel.

4.2.9 Steel containing chemical elements in excess of those recommended in 3.2.

4.3 Where combinations are unavoidable, thorough abrasive blasting of the entire assembly will normally improve galvanizing quality.

## 5. Overlapping or Contacting Surfaces

5.1 Overlapping or contacting surfaces that have not had all edges seal welded are undesirable.

5.2 When the distance between the overlapping surfaces is less than 3⁄32 in. (2.38 mm), these surfaces will not normally be wet by molten zinc. Furthermore, cleaning solution compounds that remain on these surfaces volatilize during the galvanizing process and may interfere with zinc wetting in adjacent areas. Such uncoated surfaces cause a rust staining after exposure to the environment. Traditionally however, steel grating has been manufactured without seal welding and when properly executed, this manufacturing means has permitted the galvanized coating to satisfy the quality requirements of the applicable ASTM specifications.

5.3 When the overlap surface area is large and the edges have been seal welded, air or moisture or both entrapped therein can develop destructive pressures when the assembly is heated to the galvanizing temperature, which is nominally 850°F (454°C). Vent holes or unwelded area around the adjoining surfaces should be provided through one or both sides into the lapped area per the following tables.

TABLE 1 Vent Holes for Overlapped Areas for Steels ½ in. (12.75 mm) or Less in Thickness

| Overlapped Area in.$^2$(cm$^2$) | Vent Holes | Unwelded Area |
|---|---|---|
| under 16 (103) | None | None |
| 16 (103) to under 64 (413) | One ⅜ in. (1 cm) | 1 in. (2.5 cm) |
| 64 (413) to under 400 (2580) | One ½ in. (1.25 cm) | 2 in. (5.1 cm) |
| 400 (2580) and greater, each 400 (2580) | One ¾ in. (1.91 cm) | 4 in. (10.2 cm) |

TABLE 2 Vent Holes for Overlapped Areas for Steels Greater than ½ in. (12.75 mm) in Thickness

| Overlapped Area in.$^2$(cm$^2$) | Vent Holes | Unwelded Area |
|---|---|---|
| under 16 (103) | None | None |
| 16 (103) to under 64 (413) | None | None |
| 64 (413) to under 400 (2580) | One ½ in. (1.25 cm) | 2 in. (5.1 cm) |
| 400 (2580) and greater, each 400 (2580) | One ¾ in. (1.91 cm) | 4 in. (10.2 cm) |

## 6. Sheet Steel Rolled Over a Wire or Rod Stiffener

6.1 All oil or grease should be removed from both the sheet steel and wire or rod before rolling (Fig. 3). Grease or oil becomes volatile at the galvanizing temperature and will generate gas which will prevent zinc from sealing the contact edges. All steel should be degreased before pickling and in the case of folded assemblies, before folding and assembling (see Fig. 4).

## 7. Weld Flux Removal and Welding Rods

7.1 Welding flux residues are chemically inert in normal pickling solutions. Thus, they will not be removed by standard galvanizing cleaning techniques and are best removed at the time of fabrication by grit or sand-blasting or by a wire needle gun.

7.2 It is desirable to choose a welding rod with a chemical composition as close as possible to the parent metal.

7.3 Welding rods high in silicon may cause excessively thick or darkened coatings or both to form in the welded area.

## 8. Flame Cut Cope Edges Preparation

8.1 Flame cut copes on beams can be extremely sensitive to residual stresses in the steel beam and, with the rough surface from the flame cutting operation, can be sources of cracking during the thermal cycling of the hot-dip galvanizing process. The steel beams start near ambient temperature then are immersed in the molten zinc and heated to above 800°F for usually 5 to 10 minutes. The steel beams are then cooled back to ambient temperature so the thermal cycling can create thermal stresses in the area of the cope.

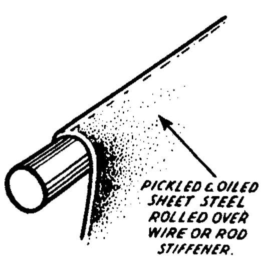


FIG. 3 Rolled Surfaces

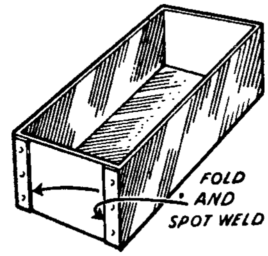


FIG. 4 Folded Surfaces

8.2 One method that has had fairly good success at minimizing the cracking at the edges of the flame cut cope is to weld a bead along the sides of the cope in the area where the flame cutting was done before hot-dip galvanizing. This welding operation will reheat the area and may relieve some of the residual stress near the cope edges. The weld bead will not eliminate all incidents of cracking but will greatly reduce the likelihood of cracking.

8.3 The weld rod material should be chosen as described in Section 7.

## 9. Cold Forming Before Galvanizing

9.1 Refer to the latest revision of Practice A 143/A 143M.

## 10. Shearing, Cutting and Punching Before Galvanizing

10.1 Refer to the latest revision of Practice A 143/A 143M.

## 11. Warpage and Distortion

11.1 Refer to the latest revision of Practice A 384.

## 12. Design Recommendations for Providing for the Free Flow of Cleaning Solutions, Fluxes, Air, and Zinc

12.1 All fabricated assemblies shall be so designed with vent and drain holes such that no air is trapped during the immersion of the assemblies into cleaning solutions or molten zinc. Similarly these holes shall allow all solutions and molten zinc to drain freely from the assemblies. Failure to follow this practice will result in areas that will not galvanize properly, or that may retain entrapped flux or excessive amounts of zinc.

12.2 Free flow of cleaning solutions and molten zinc shall also be provided for in assemblies of hot-rolled shapes. This is accomplished by cropping the corner to provide an opening with a minimum area of 0.3 in.$^2$ (1.9 cm$^2$) at the corners of all stiffeners (Fig. 5), gussets, or bracing (Fig. 6).

12.3 Air or moisture, or both, entrapped within closed fabricated pipework, such as handrail, can develop destructive pressures when heated to the galvanizing temperature. Pipe handrail shall preferably be vented full open internally, as shown in Fig. 7. In addition, there shall be one ⅜-in. (9.5-mm) minimum diameter external hole at each intersection to prevent any possible explosions in the event that the fabricator neglects to provide internal venting. Where internal venting is not possible, external vents shall be provided with one vent hole in each side of each intersection. The vent openings shall be a minimum of ⅜ in. in diameter or 25 % of the diameter of the pipe that is used, whichever is larger (see Fig. 8).

12.4 Figs. 9-12 show most of the conditions encountered with tubular product assemblies. The venting shall open