Designation: A 384/A 384M – 07

Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies[1]

This standard is issued under the fixed designation A 384/A 384M; 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.

1. Scope

1.1 Steel assemblies and subassemblies fabricated by welding, such as composite structural members, sash, weldments, etc., that are to be hot-dip galvanized after fabrication, are subject to warpage and distortion of the material due to the heating and cooling integral to the galvanizing operation, particularly when it is necessary for the assembly to be dipped more than once to coat the entire surface.

1.2 This specification is applicable in either inch pounds or SI units. Inch pounds and SI units are not necessarily exact equivalents. Within the text of this specification and where appropriate, SI units are shown in parentheses.

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 385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)

A 780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

3. Factors in Warpage and Distortion

3.1 One of the most commonly distorted and warped members of assemblies is that of sheets or plates from No. 20 gage [0.812 mm] to ¼ in. [6.35 mm] in thickness which are assembled by welding or riveting to bar-size shapes, angles, channels, tees, etc. The sheets or plates have residual stress from the welding or riveting as well as stress from rolling operations to bring the sheet or plate to its final thickness. As the sheet or plate is heated to galvanizing temperature, 820 to 850°F (438 to 454°C), the stress can be slightly relieved but the constraint of the framing does not allow the stresses to be completely relieved. The stress relief is minimal and, thus, the internal stress level of the sheet or plate compounds because of the addition of the contraction forces. When the fabrication cools after galvanizing, the framing also restricts the contraction of the sheet or plate further increasing internal stresses. If the warpage or distortion is minimal, the fabrication may be acceptable but, if the distortion is significant, the fabrication may need to be reworked with the sheet or plate attached to the frame after hot-dip galvanizing.

3.2 Warpage is accentuated by the use of nonsymmetrical sections such as channels. Regardless of size, channels that are galvanized by themselves often require straightening after galvanizing. This is not true of an I-beam, pipe, H-column, or any other section that is symmetrical about both its major axes. Channels and other nonsymmetrical sections should be avoided for the framework of a sheet metal assembly that is to be hot-dip galvanized whenever it is possible to use symmetrical shapes or sections as framing pieces.

3.2.1 Checkered plate may also warp or distort during galvanizing due to the asymmetry of the plate design. Since all of the deformations are on one side of the plate, the residual stress from fabricating the checkered plate may cause warpage or distortion. This may be accentuated by attaching checkered plate to a frame before hot-dip galvanizing.

3.3 The use of wide radii bends in corners is recommended. In the case of sheet metal, the product that has a right-angle bend in the sheet metal itself will remain flatter and be freer from distortion if the radius of the bend is as large as practical. For extremely tight bends that are integral to the fabrication, stress relieving in accordance with the section on Cold Working and Thermal Treatment of Practice A 143/A 143M is recommended to avoid warpage or distortion.

3.4 Certain welding practices, weld sizes and configurations, and thickness differences between welded components can introduce imbalanced stresses into the weldments. If these stresses are combined with other stresses during hot-dip galvanizing, the stress relieving effect of galvanizing may permit distortion to occur.

NOTE 1—One example of this situation is the bracing of two large pieces in a fabrication by a smaller piece. The smaller piece is welded at

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This practice is based upon the work of the Technical Services Committee of the American Galvanizers Association.

[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.

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both ends and during the cool-down after galvanizing it may experience significant stress as it cools more quickly than the two larger pieces. The resulting stress may cause warpage or distortion of the smaller, bracing piece. Another example of imbalanced stresses is the welding of a fabrication piece on one edge. When this type of fabrication is hot-dip galvanized the welding on one edge causes all of the internal stress in the part to be concentrated at the edge of the weld and during cool down from galvanizing the contraction may cause the part to warp or distort since it cannot move to adjust the internal stresses.

3.5 When two pieces of steel are seal welded in an overlapping joint, the overlapping section must be properly vented per Practice A 385. If the overlapped area is not properly vented or if it is incorrectly sealed, the pressure from the expansion of the trapped gases in the overlapped area can distort the two pieces of steel that are welded together and, in the worst case, can cause an explosion underneath the zinc bath surface destroying the parts and causing a potential safety problem at the hot-dip galvanizing facility.

3.6 When a fabricated assembly is too large for a particular galvanizing kettle and the fabrication must be dipped, repositioned, and dipped again, the thermal stresses on the fabrication due to the temperature differences from the section inside the zinc bath to the section outside the zinc bath can create warpage or distortion of the fabrication.

3.7 Combining any of these potential causes of warpage, or distortion, or both, such as non-symmetrical design with different thickness steel parts increases the potential for warpage and distortion to occur.

4. Suggested Corrections for Panel Fabrication

4.1 The angles selected should be in as perfect alignment as it is practical to obtain.

4.2 The angles should be placed in position without clamping or pulling prior to welding so that the corners of abutting edges will lie in position without restraint. Clamps may be applied to prevent shifting or movement during the welding operation.

4.3 The stiffening angles should be placed in position and held down to prevent their being moved when in contact with the electrode during the welding operation. In welding any intermediate lengths along one side of a common member, care should be taken to prevent warpage of the common member due to the application of high heat on the same side at various intervals along its length.

4.4 All edges of tightly contacting surfaces should be completely sealed by welding unless the area exceeds the recommended size detailed in Practice A 385. This will prevent the rusting of the surfaces that are so connected that molten zinc cannot circulate through the crevices to galvanize the contacting surfaces.

4.5 The sheet steel should not be welded to the angle steel frame prior to galvanizing if the galvanizing kettle is not of sufficient size to permit the total immersion in one dip. If the frame has to be dipped one half at a time, it will be better to have the sheets galvanized, rolled flat after galvanizing, and assembled to the galvanized frame by the use of galvanized rivets. These rivets can be countersunk or flat head if the protruding head of the ordinary button or round head rivet is objectionable. If the angle steel frame and sheets are punched prior to galvanizing (the recommended procedure), the use of drift pins to bring the holes into alignment should be avoided as far as possible at the time the sheets and frame are assembled.

4.6 If the galvanizing kettle is of sufficient size to permit total immersion of the assembly in one dip, the riveting of fabricated parts prior to galvanizing is not recommended because contacting surfaces will not be coated and rusting will occur due to entrapped pickling acid.

4.7 Unequal thickness of metal should be avoided wherever possible due to the different rates of heating and cooling during the galvanizing operation and the effect of unequal expansion and contraction.

4.8 If the fabrication is non-symmetrical and all other attempts to minimize the warpage and distortion have failed, two fabrications may be temporarily connected to make a symmetrical assembly for the hot-dip galvanizing process. This can minimize the warpage and distortion during the thermal cycle of the hot-dip galvanizing. After galvanizing, the temporary bracing to make the symmetrical assembly can be removed and the areas of contact can be repaired or touched-up as described in Practice A 780.

5. Embrittlement

5.1 Cold working before galvanizing (straightening, springing into position, reforming, etc.) of various steel parts in making up an assembly, or in the cold working of the individual members of an assembly, punching, cutting, etc., may result in embrittlement of the base metal following the hot galvanizing operation. Necessary precautions to fabricate properly and prepare the material for galvanizing to prevent embrittlement are described in Practice A 143/A 143M.

NOTE 2—Welding, if improperly performed, may induce embrittlement. It is recommended that welding procedures be carried out in conformance with the pertinent specifications of the American Welding Society.

6. Keywords

6.1 coatings-zinc; galvanized coatings; steel products-metallic coated; zinc coatings-steel products

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