Designation: A 929/A 929M – 01 (Reapproved 2007)

# Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe[1]

This standard is issued under the fixed designation A 929/A 929M; 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 This specification covers steel sheet used in the manufacture of corrugated steel pipe for storm sewers, culverts, drains, and similar uses. The sheet is metallic coated by the hot-dip process. Material for this use is furnished in coils, flat in cut lengths, and corrugated in cut lengths. Many metallic coated materials are covered in this material specification. Users must determine which product best serves their needs. Five different metallic coatings are included:

1.1.1 Zinc-coated (galvanized),

1.1.2 Zinc-5 % aluminum-Mischmetal (Zn-5Al-MM) alloy coated,

1.1.3 55 % aluminum-zinc (55Al-Zn) alloy coated,

1.1.4 Aluminum-coated Type 2 (aluminized Type 2), and

1.1.5 Aluminum-coated Type 1 (aluminized Type 1).

1.2 Zinc-coated sheet is available in two coating weights [masses]. Other metallic coatings are available in one coating weight [mass] only.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. The values stated in each system are not equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

## 2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 90/A 90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

A 428/A 428M Test Method for Weight [Mass] of Coating on Aluminum-Coated Iron or Steel Articles

A 902 Terminology Relating to Metallic Coated Steel Products

A 924/A 924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

B 750 Specification for GALFAN (Zinc-5 % Aluminum-Mischmetal) Alloy in Ingot Form for Hot-Dip Coatings

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

## 3. Terminology

3.1 *Definitions:* For definitions of terms used in this specification, refer to Terminology A 902. The following definitions are as stated in that terminology:

3.1.1 *fabricator,*, *n— as related to corrugated metal pipe*, (*1*) the organization that produces the finished pipe; or (*2*) *for structural plate pipe*, the organization that processes flat sheets and other items necessary for the field assembly of finished products.

3.1.2 *manufacturer,*, *n— as related to corrugated metal pipe*, the organization that produces the metal sheet from which pipe is made.

3.1.3 *purchaser,*, *n—as related to corrugated metal pipe*, the person or agency that purchases the finished pipe.

3.1.4 *Discussion*—With regard to this specification for sheet for corrugated steel pipe, the fabricator may also be considered as the purchaser of the sheet, where that term is used in this specification. Such interpretation would not restrict the purchaser of the finished pipe from enforcing any provisions of this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *minimized coating structure,*, *n*—a coating characterized by a finer metallurgical coating structure obtained by a treatment designed to restrict the formation of the normal coarse grain structure formed during solidification of the Zn-5Al-MM coating.

3.2.2 *regular coating structure,*, *n*—the normal coating structure resulting from unrestricted grain growth during normal solidification of the Zn-5Al-MM coating.

3.3 *Abbreviations:Abbreviations:*

3.3.1 Al T2—aluminum-coated Type 2

3.3.2 Al T1—aluminum-coated Type 1

3.3.3 55Al-Zn—55 % aluminum-zinc alloy

[1] This specification is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.11 on Sheet Specifications.

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[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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3.3.4 Zn—zinc

3.3.5 Zn-5Al-MM—zinc-5 % aluminum-Mischmetal alloy

## 4. Classification

4.1 The Zn-5Al-MM coating is available in two coating classes, as follows:

4.1.1 *Class A*—Minimized coating structure, and

4.1.2 *Class B*—Regular coating structure.

## 5. Ordering Information

5.1 All sheet, both flat and formed, covered by this specification shall be ordered only to the specified thicknesses in the table on coated steel sheet thickness requirements.

5.2 All material furnished to this specification shall be chemically treated unless otherwise specified in the purchase order.

5.3 Orders for material to this specification shall include the following information, as necessary, to describe the desired product adequately:

5.3.1 Name of material (steel sheet for corrugated pipe):

5.3.2 ASTM designation and year of issue, as A 929-_____ for inch-pound units, or A 929M-_____ for SI units;

5.3.3 Type of metallic coating (zinc, zinc-5 % aluminum-Mischmetal alloy, 55 % aluminum-zinc alloy, aluminum-coated Type 2, or aluminum-coated Type 1) (Note 1);

5.3.3.1 For zinc-coated sheet, the coating weight [mass] (see Table 3). If the coating weight [mass] is not stated, sheet having 2.00 oz/ft$^2$ [610 g/m$^2$] nominal coating shall be furnished.

5.3.3.2 For Zn-5Al-MM coating the class (coating structure) (see 4.1).

5.3.4 *Quantity and Dimensions*:

5.3.4.1 *Cut Lengths*— Show the number of sheets; thickness; width, either flat or overall corrugated; length; pitch; and depth of corrugations, if corrugated;

5.3.4.2 *Coiled Sheet*— Show the total weight [mass]; thickness; width; coil requirements (maximum outside diameter, acceptable inside diameter, and maximum weight [mass] of individual coils).

5.4 Certification, if required (see 12.1); and

5.5 Special requirements.

NOTE 1—Abbreviations may be used to describe the coating type (see 3.3).

NOTE 2—A typical ordering description (inch-pound units) is as follows: steel sheet for corrugated pipe in accordance with ASTM A 929-_____, zinc coated, 5000 sheets, 0.064 by 25½ by 60 in. with 2⅔ by ½ in. corrugations, certified.

NOTE 3—A typical ordering description [SI units] is as follows: steel sheet for corrugated pipe in accordance with ASTM A 929M-_____, aluminum coated, Type 2, 45 000 kg, 2.77 by 700 mm by coil, 1500 mm max outside diameter, 600 mm, inside diameter, 7000 kg max, certified.

**TABLE 1 Chemical Composition**

| | Cast Analysis | Product Analysis |
|---|---|---|
| Sulfur, max, % | 0.05 | 0.06 |
| Sum of carbon, manganese, phosphorus, sulfur, and silicon, max, % | 0.70 | 0.74 |

**TABLE 2 Mechanical Requirements (Properties of Flat Sheet Prior to Fabrication)[A]**

| | |
|---|---|
| Tensile strength, min,[B] ksi [MPa] | 45.0 [310] |
| Yield strength, min,[B] ksi [MPa] | 33.0 [230] |
| Elongation in 2 in. [50 mm],[C] min, % | 20 |

[A] To determine conformance with this specification, round each value for tensile strength and yield strength to the nearest 0.1 ksi [1 MPa] and each value for elongation to the nearest 1 %, both in accordance with the rounding method of Practice E 29.

[B] Yield point and tensile strength are based on the thickness of the base metal. If tests are made after coating, determine the base metal thickness after stripping the coating from the ends of the specimen contacting the grips of the tension testing machine prior to tensile testing.

[C] The elongation requirement does not apply to material tested after corrugating.

## 6. Chemical Composition

6.1 *Base Metal Analysis*—The base metal cast or product analyses shall conform to the chemical requirements of Table 1.

6.2 *Coating Bath Composition*:

6.2.1 *Zinc Coating*— The coating bath metal shall contain not less than 99 % zinc.

6.2.2 *Zinc-5 % Aluminum-Mischmetal Alloy Coating*—The ingot used for the coating bath shall conform to Specification B 750.

6.2.3 *55 % Aluminum-Zinc Alloy Coating*—The coating bath metal composition shall be 52 to 58 % aluminum, 2.0 % silicon maximum, and balance zinc.

6.2.4 *Aluminum Coating Type 2*—The coating bath metal composition shall be as follows (all percentages are maximum): Iron, 3.0 %; silicon, 0.35 %; magnesium, 0.50 %; other, each, 0.05 %; other, total, 0.20 %; balance, aluminum.

6.2.5 *Aluminum Coating Type 1*—The coating bath metal composition shall be 5 to 11 % silicon, the balance aluminum.

## 7. Mechanical Properties

7.1 The metallic-coated sheet shall conform to the mechanical requirements listed in Table 2.

7.2 Two tension tests shall be made on random samples of finished material from each cast or heat. One test is sufficient when the finished material from said cast or heat is less than 50 tons [45 Mg]. One tension test shall be made from both the thickest and thinnest material rolled, regardless of the weight represented, when material rolled from one cast or heat differs 0.050 in. [1.25 mm] or more in thickness. The samples shall be prepared and tested in accordance with the method specified in Specification A 924 [A 924M].

## 8. *Coating Requirements* Coating Requirements

8.1 The metallic coating weight [mass] shall conform to the requirements listed in Table 3 for the type of metallic coating specified.

8.2 Adhesion of the coating shall be such that no peeling or flaking occurs while the coated sheet is being corrugated and formed into pipe.

## 9. Dimensions and Tolerances

9.1 *Thickness*—Sheet thickness shall conform to the dimensions prescribed in Table 4. The thickness of the sheet includes both the base steel and the coating.



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**TABLE 3 Coating Weight [Mass] Requirements**

| Type | Coating Weight [Mass], Total Both Sides | | Equivalent Coating Thickness, Total Both Sides[A] | |
|---|---|---|---|---|
| | Triple Spot, Average, min oz/ft² [g/m²] | Single Spot, min oz/ft² [g/m²] | Triple Spot Average, min in. [µm] | Single Spot, min in. [µm] |
| Zn | 2.00 [610] | 1.80 [550] | 0.0034 [86] | 0.0031 [78] |
| Zn | 4.00 [1220] | 3.60 [1100] | 0.0068 [172] | 0.0062 [156] |
| Zn-5Al-MM | 2.10 [640] | 1.80 [550] | 0.0037 [93] | 0.0032 [80] |
| 55Al-Zn | 0.70 [210] | 0.60 [180] | 0.0022 [56] | 0.0019 [48] |
| Al Type 2[B] | 1.00 [305] | 0.90 [275] | 0.0037 [95] | 0.0034 [86] |
| Al Type 1 | 1.00 [305] | 0.90 [275] | 0.0040 [101] | 0.0036 [91] |

[A] Coating thicknesses are approximate, for information only (see 10.5.1). Conversions are based on the following relationships: (*1*) Zn coating: 1 oz/ft² = 0.0017 in.; 1 g/m²= 0.1415 µm; (*2*) Zn-5Al-MM coating: 1 oz/ft²= 0.001754 in., 1 g/m²= 0.1460 µm; (*3*) 55Al-Zn coating: 1 oz/ft ²= 0.0032 in.; 1 g/m²= 0.26636 µm; ( *4*) Al T2 coating: 1 oz/ft²= 0.00374 in.; 1 g/m² = 0.31131 µm and (*5*) Al T1 coating: 1 oz/ft ²= 0.00398 in.; 1 g/m²= 0.33128 µm.
[B] Aluminum coating Types 2 and 1 include both free and alloy layers.

**TABLE 4 Coated Steel Sheet Thickness Requirements**

NOTE—Thickness is measured not less than ⅜ in. [10 mm] from an edge. On corrugated sheet, thickness is measured on the tangents of corrugations.

| Specified Thickness, in. [mm][A] | Minimum Thickness, in. [mm][A] |
|---|---|
| 0.040 [1.02][B] | 0.036 [0.91] |
| 0.052 [1.32] | 0.046 [1.17] |
| 0.064 [1.63] | 0.057 [1.45] |
| 0.079 [2.01] | 0.072 [1.83] |
| 0.109 [2.77] | 0.101 [2.57] |
| 0.138 [3.51] | 0.129 [3.28] |
| 0.168 [4.27][B] | 0.159 [4.04] |

[A] For 4 oz/ft² [1220 g/m²] zinc coating, the specified thickness and the minimum thickness shall be increased by 0.003 in. [0.076 mm] to account for the greater coating thickness as compared to the 2 oz/ft² [610 g/m²] zinc coating thickness.
[B] Aluminum-coated sheet is not furnished in these thicknesses.

9.2 *Length*—Permissible variations in the length of cut-length sheets, both flat and corrugated, shall be in accordance with Specification A 924 [A 924M].

9.3 *Flat Sheet*—Permissible variations in the width and camber of flat materials shall be in accordance with Specification A 924 [A 924M]. The flatness tolerances are given in Table 5.

9.4 *Corrugated Sheet*:

9.4.1 *Corrugations*— Corrugations shall form smooth continuous curves and tangents. The dimensions of the corrugations shall be in accordance with Table 6.

9.4.2 *Covering Width and Lip Dimension*—The covering width of corrugated sheet shall be in accordance with Table 7. The covering width is the distance between the crests of the extreme corrugations. The lip dimension of corrugated sheet shall be in accordance with Table 8 and is measured along the radial curvature from the crest of the corrugation to the edge of the sheet. There is no established tolerance for overall width since the covering width and lip dimensions are the governing factors for the formed product.

**TABLE 5 Flatness Tolerances (Cut Lengths Only)**

NOTE—This table also applies to sheets cut to length from coils by the fabricator when adequate flattening measures are performed.

| Specified Thickness, in. [mm] | Specified Width, in. [mm] | Flatness Toler-ance (Maximum Deviation from a Horizontal Flat Surface), in. [mm] |
|---|---|---|
| 0.064 [1.63] and thicker | to 60 [1500], incl | ½ [13] |
| 0.052 [1.32] and thinner | to 36 [900], incl | ½ [13] |
| | over 36 [900] to 60 [1500], incl | ¾ [19] |

**TABLE 6 Corrugation Size**

| Nominal Size, in. [mm] | Maximum Pitch,[A] in. [mm] | Minimum Depth,[B] in. [mm] | Radius of Curvature, in. [mm] | |
|---|---|---|---|---|
| | | | nominal | minimum |
| 2⅔ by ½ [68 by 13] | 2⅞ [73] | 0.48 [12] | 11/16 [17] | 0.5 [13] |
| 3 by 1 [75 by 25] | 3¼ [83] | 0.95 [24] | 9/16 [14] | 0.5 [13] |
| 5 by 1 [125 by 25] | 5 5/16 [135] | 0.95 [24] | 1 37/64 [40] | 1.4 [36] |

[A] Pitch is measured from crest of corrugations, at 90° to the direction of the corrugations.
[B] Depth is measured as the vertical distance from a straight edge resting on the corrugation crests to the bottom of the intervening valley.

**TABLE 7 Covering Width Tolerance for Corrugated Sheet**

| Covering Width, in. [mm] | Tolerance, Over and Under, in. [mm] |
|---|---|
| To 24 [600], incl | ¼ [6] |
| Over 24 [600] to 36 [900], incl | ⅜ [10] |
| Over 36 [900] to 48 [1200], incl | ½ [13] |

**TABLE 8 Corrugated Sheet Lip Dimensions**

| Nominal Corrugation Size, in. [mm] | For Riveted Pipe Construction,[A] in. [mm] | For Spot-Welded Pipe Construction, min in. [mm] |
|---|---|---|
| 2⅔ by ½ [68 by 13] | ¾ [19] | 7/16 [11] |
| 3 by 1 [75 by 25] | ⅞ [22] | ½ [13] |
| 5 by 1 [125 by 25] | ⅞ [22] | ½ [13] |

[A] Tolerances, +3/16 in. [+5 mm], –0.

## 10. Testing

10.1 The manufacturer shall make such tests and measurements as deemed necessary to ensure that the coated sheet produced complies with this specification.

10.2 The purchaser may make tests and measurements, as determined to be necessary, to confirm conformance with this specification.

10.3 *Chemical Analyses of Steel*—Cast analysis (by the manufacturer) and product analysis (by the purchaser) shall be in accordance with Specification A 924 [A 924M].

10.4 *Mechanical Testing*—Mechanical property tests shall be conducted on the sheet prior to corrugating or other fabrication, when possible, and shall be in accordance with Specification A 924 [A 924M]. If the tests are made after



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corrugating, the specimens shall be taken on the tangents of corrugations and used for the determination of tensile and yield strengths only.

10.5 *Coating Weight [Mass]*:

10.5.1 Sampling for coating weight [mass] determinations shall be in accordance with Specification A 924 [A 924M]. The coating thickness may be determined by the procedures described in Specification A 924 [A 924M], but the weigh-strip-weigh procedures described in 10.5.2 shall apply in case of dispute.

10.5.2 Test for coating weight [mass] using the following procedures:

10.5.2.1 *Zinc Coatings*— Test Method A 90 [A 90M].

10.5.2.2 *Zn-5Al-MM Coatings*—Test Method A 90 [A 90M].

10.5.2.3 *55Al-Zn Coatings*— Test Method A 90 [A 90M] using the dilute hydrochloric acid method.

10.5.2.4 *Aluminum Coatings*—Test Method A 428 [A 428M].

## 11. Rejection and Rehearing

11.1 Material tested by the purchaser and found not conforming to this specification may be rejected, subject to the rejection and rehearing provisions of Specification A 924 [A 924M].

## 12. Certification

12.1 A manufacturer's certification shall be furnished to the purchaser when specified in the purchase order or contract. The certification shall be in accordance with the provisions of Specification A 924 [A 924M] and shall include reference to this product specification designation and the coating type.

12.2 The test results, including chemical composition, mechanical properties, coating type, and coating weight [mass] for each heat and coating lot, shall be maintained by the manufacturer for seven years without regard to whether a certification was furnished. The test results shall be made available to the fabricator and purchaser upon request.

## 13. Product Marking

13.1 Each 2 to 5 ft [0.5 to 1.5 m] of sheet in coils or cut lengths shall be identified by showing the following:

13.1.1 Name of manufacturer,

13.1.2 Brand name,

13.1.3 Specified thickness,

13.1.4 Coating type (Zn, Zn-5Al-MM, 55Al-Zn, Al T2, or Al T1), including class for Zn-5Al-MM sheet,

13.1.5 Specified coating weight [mass],

13.1.6 Identification symbols relating to a specific heat number and coating lot number, and

13.1.7 ASTM designation number.

13.2 The brand shall be removed, obliterated, or the sheet rebranded "nonspecification" on each 2 to 5 ft [0.5 to 1.5 m] of sheet in a coating lot or heat for which control tests, as prescribed herein, show nonconformance to this specification.

## 14. Keywords

14.1 coatings—aluminum; coatings—metallic; coatings—zinc; coatings—zinc-5 % aluminum-Mischmetal; coatings—55 % aluminum-zinc alloy; corrugated steel pipe; pipe—corrugated steel; steel sheet—aluminum coated; steel sheet—hot-dip coated; steel sheet—metallic coated; steel sheet—zinc coated; steel sheet—zinc-5 % aluminum-Mischmetal alloy coated; steel sheet—55 % aluminum-zinc alloy coated

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