



Designation: A1046/A1046M – 22

Standard Specification for Steel Sheet, Zinc-Aluminum-Magnesium Alloy-Coated by the Hot-Dip Process¹

This standard is issued under the fixed designation A1046/A1046M; 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 zinc-aluminum-magnesium alloy-coated steel sheet in coils and cut lengths.

1.2 This product is intended for applications requiring corrosion resistance and paintability.

1.3 The steel sheet is produced in a number of designations, types, grades, and classes designed to be compatible with differing application requirements.

1.4 Product furnished under this specification shall conform to the applicable requirements of the latest issue of Specification A924/A924M, unless otherwise provided herein.

1.5 The text of this specification references notes and footnotes which provide explanatory material. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of the standard.

1.6 *Units*—This specification is applicable to orders in either inch-pound units (as A1046) or SI units (as A1046M). Values in inch-pound and SI units are not necessarily equivalent. Within the text, SI units are shown in brackets. Each system shall be used independently of the other.

1.7 Unless the order specifies the “M” designation (SI units), the product shall be furnished to inch-pound units.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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.

Current edition approved Nov. 1, 2022. Published November 2022. Originally approved in 2006. Last previous edition approved in 2019 as A1046/A1046M – 19. DOI: 10.1520/A1046_A1046M-22.

2. Referenced Documents

2.1 *ASTM Standards*:²

- A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
- A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
- A902 Terminology Relating to Metallic Coated Steel Products
- A924/A924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- A1122/A1122M Test Method for Bend Testing of Metallic-Coated Steel Sheet to Evaluate Coating Adhesion
- E517 Test Method for Plastic Strain Ratio r for Sheet Metal
- E646 Test Method for Tensile Strain-Hardening Exponents (n -Values) of Metallic Sheet Materials

3. Terminology

3.1 *Definitions*—See Terminology A902 for definitions of general terminology relating to metallic-coated hot-dip products.

4. Classification

4.1 The material is available in several designations as follows:

- 4.1.1 Commercial Steel—CS Types A, B, and C,
- 4.1.2 Deep Drawing Steel—DDS,
- 4.1.3 Extra Deep Drawing Steel—EDDS,
- 4.1.4 Forming Steel—FS Types A and B,
- 4.1.5 High Strength Low Alloy Steel—HSLAS,
- 4.1.6 High Strength Low Alloy Steel with Improved Formability—HSLAS-F, and
- 4.1.7 Structural Steel—SS.

4.2 Structural steel and high strength low alloy steel are available in several grades based on mechanical properties. Structural Steel Grade 50 [340] is available in four classes based on tensile strength.

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

TABLE 1 Weight [Mass] of Coating Requirement^A

Coating Designation	Inch-Pound Units	
	Minimum Requirement	
	Triple-Spot Test Total Both Sides, oz/ft ²	Single-Spot Test Total Both Sides, oz/ft ²
ZM20	0.20	0.16
ZM30	0.30	0.25
ZM40	0.40	0.30
ZM50	0.50	0.40
ZM60	0.60	0.50
ZM70	0.70	0.60
ZM75	0.75	0.65
ZM90	0.90	0.80
ZM100	1.00	0.90
ZM115	1.15	1.00
ZM140	1.40	1.20
ZM165	1.65	1.40
ZM210	2.10	1.80

Coating Designation	SI Units	
	Minimum Requirement	
	Triple-Spot Test Total Both Sides, g/m ²	Single-Spot Test Total Both Sides, g/m ²
ZMM60	60	50
ZMM90	90	75
ZMM120	120	90
ZMM150	150	120
ZMM180	180	150
ZMM210	210	180
ZMM220	220	190
ZMM275	275	235
ZMM300	300	270
ZMM350	350	300
ZMM450	450	385
ZMM500	500	425
ZMM600	600	510

^A The coating designation number is the term by which this product is specified. Because of the many variables and changing conditions that are characteristic of continuous hot-dip coating lines, the weight [mass] of the coating is not always evenly divided between the two surfaces of a sheet, nor is the coating evenly distributed from edge to edge. However, it can normally be expected that not less than 40 % of the single-spot test limit will be found on either surface.

4.3 The product is available in several coating weights [masses] with the coating designation in accordance with [Table 1](#).

5. Ordering Information

5.1 Zinc-aluminum-magnesium alloy-coated steel sheet in coils and cut lengths is produced to thickness requirements expressed to 0.001 in. [0.01 mm]. The thickness of the sheet includes the base metal and the coating.

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

5.2.1 Name of product (steel sheet, zinc-aluminum-magnesium alloy-coated),

5.2.2 Designation of sheet steel {CS (Type A, B, or C), FS (Type A or B), DDS, EDDS, SS, HSLAS or HSLAS-F},

5.2.2.1 When a CS type is not specified, CS Type B will be furnished. When an FS type is not specified, FS Type B will be furnished.

5.2.2.2 When an SS or HSLAS designation is specified, state the grade or class, or combination thereof.

5.2.2.3 When a class for HSLAS or HSLAS-F is not specified, Class 1 shall be provided.

5.2.3 ASTM designation number and year of issue, such as A1046 -___ for inch-pound units or A1046M -___ for SI units,

5.2.4 Coating designation,

5.2.5 Coating bath composition type (see section [6.2](#)),

5.2.6 Chemically treated or not chemically treated,

5.2.7 Oiled or not oiled,

5.2.8 Dimensions (show thickness, minimum or nominal, width, flatness requirements (if appropriate), and length (if cut length)),

5.2.9 Coil size requirements (specify maximum outside diameter (OD), acceptable inside diameter (ID), and maximum weight [mass]),

5.2.10 Packaging,

5.2.11 Certification, if required, and heat analysis and mechanical property report,

5.2.12 Application (show part identification and description), and

5.2.13 Special requirements (if any).

5.2.13.1 When the purchaser requires thickness tolerances for 3/8-in. [10-mm] minimum edge distance (see Supplementary Requirement in Specification [A924/A924M](#)), this requirement shall be specified in the purchase order or contract.

NOTE 1—Typical ordering descriptions are as follows:
 Steel sheet, zinc-aluminum-magnesium alloy coated, Forming Steel Type B, ASTM A1046 -___, coating designation ZM90, chemical treatment, no oil, minimum 0.034 by 48 in. by coil, 60-in. maximum OD, 24-in. ID, 10,000-lb maximum, for inner door panel, or steel sheet, zinc-aluminum-magnesium alloy coated, Commercial Steel Type B, ASTM A1046M -___, coating designation ZMM275, not chemically treated, oiled, minimum 0.85 by 900 mm by coil, 1200-mm maximum OD, 610-mm ID, 9,000-kg maximum, for building panels.

TABLE 2 Chemical Requirements^A

Designation	Composition, %-Heat Analysis Element, max (unless otherwise shown)												
	C	Mn	P	S	Al, min	Cu	Ni	Cr	Mo	V	Cb/Nb ^J	Ti ^B	N
CS Type A ^{C,D,E}	0.10	0.60	0.030	0.035	^A	0.20	0.20	0.15	0.06	0.008	0.008	0.025	^A
CS Type B ^{C,F}	0.02 to 0.15	0.60	0.030	0.035	^A	0.20	0.20	0.15	0.06	0.008	0.008	0.025	^A
CS Type C ^{C,D,E}	0.08	0.60	0.100	0.035	^A	0.20	0.20	0.15	0.06	0.008	0.008	0.025	^A
FS Type A ^{C,G}	0.10	0.50	0.020	0.035	^A	0.20	0.20	0.15	0.06	0.008	0.008	0.025	^A
FS Type B ^{C,F}	0.02 to 0.10	0.50	0.020	0.030	^A	0.20	0.20	0.15	0.06	0.008	0.008	0.025	^A
DDS ^{D,E,H}	0.06	0.50	0.020	0.025	0.01	0.20	0.20	0.15	0.06	0.008	0.008	0.025	^A
EDDS ^{H,I}	0.02	0.40	0.020	0.020	0.01	0.20	0.20	0.15	0.06	0.10	0.10	0.15	^A

^A There is no requirement, but the analysis shall be reported.

^B For steels containing more than 0.02 % carbon, titanium is permitted to 0.025 % provided the ratio of % titanium to % nitrogen does not exceed 3.4.

^C When a deoxidized steel is required for the application, the purchaser has the option to order CS and FS to a minimum of 0.01 % total aluminum.

^D Steel is permitted to be furnished as a vacuum degassed or chemically stabilized steel, or both, at the producer's option.

^E For carbon levels less than or equal to 0.02 %, vanadium, columbium, or titanium, or combinations thereof are permitted to be used as stabilizing elements at the producer's option. In such cases, the applicable limit for vanadium and columbium shall be 0.10 % max, and the limit for titanium shall be 0.15 % max.

^F For CS and FS, specify Type B to avoid carbon levels below 0.02 %.

^G Shall not be furnished as a stabilized steel.

^H Minimum Al content is not required if agreed to by purchaser and supplier.

^I Shall be furnished as a stabilized steel.

^J Columbium (Cb) and Niobium (Nb) are considered interchangeable names for Element 41 in the periodic table and both names are acceptable for use.

6. Chemical Composition

6.1 Base Metal:

6.1.1 The heat analysis of the base metal shall conform to the requirements shown in **Table 2** for CS (Types A, B, and C), FS (Types A and B), DDS, and EDDS, and **Table 3** for SS, HSLAS, and HSLAS-F.

6.1.2 Each of the elements listed in **Tables 2 and 3** shall be included in the report of heat analysis. When the amount of copper, nickel, chromium, or molybdenum is less than 0.02 %, report the analysis as either <0.02 % or the actual determined value. When the amount of vanadium, titanium, or columbium is less than 0.008 %, report the analysis as either <0.008 % or the actual determined value.

6.1.3 See Specification **A924/A924M** for chemical analysis procedures and product analysis tolerances.

6.2 **Coating Bath Composition**—The bath metal used for zinc-aluminum-magnesium alloy-coated sheet shall contain 0.5 to 13 % aluminum, 0.4 to 4 % magnesium, up to 1 % total additional alloying elements (except iron) and the balance zinc.

Five types are available, as follows (see **Annex A1** for a visual representation):

Type 1: 5 to 13 % aluminum, 2 to 4 % magnesium,

Type 2: 3 to less than 5 % aluminum, 2 to 4 % magnesium,

Type 3: 3 to 6 % aluminum, 0.4 to less than 2 % magnesium,

Type 4: 0.5 to less than 3 % aluminum, 0.4 to less than 2.6 % magnesium,

Type 5: 0.5 to less than 3 % aluminum, 2.6 to 4 % magnesium.

6.2.1 Due to differences in coating bath chemistry, the properties provided by each type may differ and the user shall specify the type suitable for the application accordingly.

7. Mechanical Properties

7.1 Structural steel and high strength low alloy steel shall conform to the mechanical property requirements of **Table 4** for the grade or class, or combination thereof, specified.

7.2 The typical mechanical properties for CS (Types A, B, and C), FS (Types A and B), DDS, and EDDS steel sheet designations are listed in **Table 5**. These mechanical property values are non-mandatory. They are intended solely to provide

the purchaser with as much information as possible to make an informed decision on the steel to be specified. Values outside these ranges are to be expected.

7.3 When base metal mechanical properties are required, all tests shall be conducted in accordance with the methods specified in Specification **A924/A924M**.

7.4 Bending Properties:

7.4.1 **Minimum Cold Bending Radii**—Structural steel sheet is commonly fabricated by cold bending. There are many interrelated factors that affect the ability of a steel to cold form over a given radius under shop conditions. These factors include: thickness, strength level, degree of restraint, relationship to rolling direction, chemistry and base metal microstructure. **Appendix X1** lists the suggested minimum inside radius for 90° cold bending for these steel sheets. They pre-suppose “hard way” bending (bend axis parallel to rolling direction) and reasonably good shop forming practices. Where possible, the use of larger radii or “easy way” bending is recommended for improved performance.

7.4.2 Fabricators should be aware that cracks may initiate upon bending a sheared edge or cold-worked edge. This is not considered to be a fault of the steel, but is rather a function of the induced localized cold-work zone.

8. Coating Properties

8.1 Coating Weight [Mass]:

8.1.1 Coating weight [mass] shall conform to the requirements as shown in **Table 1** for the specific coating designation.

8.1.2 Use the relationships in **Table 6** to estimate the coating thickness from the coating weight [mass].

8.1.3 Use the following relationship to convert coating weight to coating mass:

8.1.3.1 1.00 oz/ft² coating weight = 305 g/m² coating mass.

8.2 Coating Weight [Mass] Tests:

8.2.1 Coating weight [mass] tests shall be performed in accordance with the requirements stated in Specification **A924/A924M**.

8.2.2 The referee method to be used shall be the dilute hydrochloric acid method, in Test Method **A90/A90M**