



# Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process<sup>1</sup>

This standard is issued under the fixed designation A 653/A 653M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification covers steel sheet, zinc-coated (galvanized) or zinc-iron alloy-coated (galvannealed) by the hot-dip process in coils and cut lengths.

1.2 The product is produced in various zinc or zinc-iron alloy-coating weights [masses] or coating designations as shown in Table 1.

3 Product furnished under this specification shall conform to the applicable requirements of the latest issue of Specification A 924/A 924M, unless otherwise provided herein.

1.4 The product is produced in a number of designations, types, grades, and classes pertaining to chemical composition and typical mechanical properties of the steel sheet which are designed to be compatible with differing application requirements.

1.5 This specification is applicable to orders in either inch-pound units (as A 653) or SI units (as A 653M). 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.

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

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

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 and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:

A 90/A 90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings<sup>2</sup>

A 568/A 568M Specification for Steel, Sheet, Carbon, and

High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for<sup>3</sup>

A 902 Terminology Relating to Metallic Coated Steel Products<sup>2</sup>

A 924/A 924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process<sup>2</sup>

D 2092 Guide for Treatment of Zinc-Coated (Galvanized) Steel Surfaces for Painting<sup>4</sup>

E 517 Test Method for Plastic Strain Ratio  $r$  for Sheet Metal<sup>5</sup>

E 646 Test Method for Tensile Strain-Hardening Exponents ( $n$  values) of Metallic Sheet Materials<sup>5</sup>

### 2.2 ISO Standard:

ISO 3575 Continuous Hot-Dip Zinc-Coated Carbon Steel of Commercial and Drawing Qualities<sup>6</sup>

ISO 4998 Continuous Hot-Dip Zinc-Coated Carbon Steel of Structural Quality<sup>6</sup>

## 3. Terminology

3.1 *Definitions*— See Terminology A 902 for definitions of general terminology relating to metallic-coated hot-dip products.

### 3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *differentially coated, n*—galvanized steel sheet having a specified “coating designation” on one surface and a significantly lighter specified “coating designation” on the other surface.

3.2.1.1 *Discussion*—The single side relationship of either specified “coating designation” is the same as shown in the note of Table 1 regarding uniformity of coating.

3.2.2 *high strength low alloy steel, Type A sheet, n*—steel sheet intended for applications where mechanical properties are specified and where improved formability is required compared to structural steel.

3.2.2.1 *Discussion*—Suppliers use one or a combination of microalloying elements as strengthening agents.

3.2.3 *high strength low alloy steel, Type B sheet, n*—steel sheet intended for applications where mechanical properties

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.06.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.03.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 06.02.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>6</sup> Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

**TABLE 1 Weight [Mass] of Coating Requirements<sup>A,B,C</sup>**

NOTE 1— Use the information provided in 8.1.2 to obtain the approximate coating thickness from the coating weight [mass].

		Minimum Requirement <sup>D</sup>			
		Triple-Spot Test		Single-Spot Test	
Inch-Pound Units					
Type	Coating Designation	Total Both Sides, oz/ft <sup>2</sup>	One Side	Total Both Sides, oz/ft <sup>2</sup>	
Zinc	G360	3.60	1.28	3.20	
	G300	3.00	1.04	2.60	
	G235	2.35	0.80	2.00	
	G210	2.10	0.72	1.80	
	G185	1.85	0.64	1.60	
	G165	1.65	0.56	1.40	
	G140	1.40	0.48	1.20	
	G115	1.15	0.40	1.00	
	G90	0.90	0.32	0.80	
	G60	0.60	0.20	0.50	
	G40	0.40	0.12	0.30	
	G30	0.30	0.10	0.25	
	G01	no minimum	no minimum	no minimum	
	Zinc-iron alloy	A60	0.60	0.20	0.50
		A40	0.40	0.12	0.30
A25		0.25	0.08	0.20	
A01		no minimum	no minimum	no minimum	
SI Units					
Type	Coating Designation	Total Both Sides, g/m <sup>2</sup>	One Side	Total Both Sides, g/m <sup>2</sup>	
Zinc	Z1100	1100	390	975	
	Z900	900	316	790	
	Z700	700	238	595	
	Z600	600	204	510	
	Z550	550	190	475	
	Z500	500	170	425	
	Z450	450	154	385	
	Z350	350	120	300	
	Z275	275	94	235	
	Z180	180	60	150	
	Z120	120	36	90	
	Z90	90	30	75	
	Z001	no minimum	no minimum	no minimum	
	Zinc-iron alloy	ZF180	180	60	150
		ZF120	120	36	90
		ZF75	75	24	60
		ZF001	no minimum	no minimum	no minimum

<sup>A</sup>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 zinc or zinc-iron alloy coating is not always evenly divided between the two surfaces of a coated sheet; nor is it always evenly distributed from edge to edge. However, the minimum triple-spot average coating weight (mass) on any one side shall not be less than 40 % of the single-spot requirement.

<sup>B</sup>As it is an established fact that the atmospheric corrosion resistance of zinc or zinc-iron alloy-coated sheet products is a direct function of coating thickness (weight (mass)), the selection of thinner (lighter) coating designations will result in almost linearly reduced corrosion performance of the coating. For example, heavier galvanized coatings perform adequately in bold atmospheric exposure whereas the lighter coatings are often further coated with paint or a similar barrier coating for increased corrosion resistance. Because of this relationship, products carrying the statement "meets ASTM A 653/A 653M requirements" should also specify the particular coating designation.

<sup>C</sup>International Standard, ISO 3575, continuous hot-dip zinc-coated carbon steel sheet contains Z100 and Z200 designations and does not specify a ZF75 coating.

<sup>D</sup>No minimum means that there are no established minimum requirements for triple- and single-spot tests.

are specified and where improved formability is required compared to high strength low alloy steel; Type A.

3.2.3.1 *Discussion*—Suppliers use one or a combination of microalloying elements as strengthening agents and also treat the steel with additional small alloy additions to effect sulfide inclusion control.

3.2.4 *minimized spangle, n*—the finish produced on hot-dip zinc-coated steel sheet in which the grain pattern is visible to the unaided eye, and is typically smaller and less distinct than the pattern visible on regular spangle.

3.2.4.1 *Discussion*—This finish is produced by one of two methods: either (1) the zinc crystal growth has been started but arrested by special production practices during solidification of the zinc, or (2) the zinc crystal growth is inhibited by a combination of coating-bath chemistry plus cooling during

solidification of the zinc. Minimized spangle is normally produced in coating designations G90 [Z275] and lighter.

3.2.5 *regular spangle, n*—the finish produced on hot-dip zinc-coated steel sheet in which there is a visible multifaceted zinc crystal structure.

3.2.5.1 *Discussion*—Solidification of the zinc coating is typically uncontrolled, which produces the variable grain size associated with this finish.

3.2.6 *spangle-free, n*—the uniform finish produced on hot-dip zinc-coated steel sheet in which the visual spangle pattern, especially the surface irregularities created by spangle formation, is not visible to the unaided eye.

3.2.6.1 *Discussion*—This finish is produced when the zinc crystal growth is inhibited by a combination of coating-bath chemistry and/or cooling during solidification of the zinc.



3.2.7 *zinc-iron alloy, n*—a dull grey coating with no spangle pattern that is produced on hot-dip zinc-coated steel sheet.

3.2.7.1 *Discussion*—Zinc-iron alloy coating is composed entirely of inter-metallic alloys. It is typically produced by subjecting the hot-dip zinc-coated steel sheet to a thermal treatment after it emerges from the molten zinc bath. This type of coating is suitable for immediate painting without further treatment except normal cleaning (refer to Guide D 2092). The lack of ductility of the alloy coating presents a potential for powdering, etc.

#### 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 Forming steel (FS Types A and B),
- 4.1.3 Deep drawing steel (DDS),
- 4.1.4 Extra deep drawing steel (EDDS),
- 4.1.5 Structural steel (SS),
- 4.1.6 High strength low alloy steel (HSLAS Type A), and
- 4.1.7 High strength low alloy steel (HSLAS Type B).

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 three classes based on tensile strength.

4.3 The material is available as either zinc-coated or zinc-iron alloy-coated in several coating weights [masses] or coating designations as shown in Table 1, and

4.3.1 The material is available with the same or different coating designations on each surface.

#### 5. Ordering Information

5.1 Zinc-coated or zinc-iron alloy-coated 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 both 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-coated (galvanized) or zinc-iron alloy-coated (galvannealed)),

5.2.2 Designation of sheet [CS (Types A, B, and C), FS (Types A and B), DDS, EDDS, SS, or HSLAS (Types A and B)].

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

5.2.3 When a SS or HSLAS designation is specified, state the type, grade, or class, or combination thereof.

5.2.4 ASTM designation number and year of issue, as A 653 for inch-pound units or A 653M for SI units.

5.2.5 Coating designation,

5.2.6 Chemically treated or not chemically treated,

5.2.7 Oiled or not oiled,

5.2.8 Minimized spangle (if required),

5.2.9 Extra smooth (if required),

5.2.10 Phosphatized (if required),

5.2.11 Dimensions (show thickness, minimum or nominal, width, flatness requirements, and length, if cut lengths). The

purchaser shall specify the appropriate table of thickness tolerances in Specification A 924/A 924M that applies to the order, that is, the table of thickness tolerances for 3/8-in. [10-mm] edge distance, or the table of thickness tolerances for 1-in. [25-mm] edge distance.

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

5.2.13 Packaging,

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

5.2.15 Application (part identification and description), and

5.2.16 Special requirements (if any).

5.2.16.1 If required, the product may be ordered to a specified base metal thickness (see Supplementary Requirement S1.)

NOTE 1—Typical ordering descriptions are as follows: steel sheet, zinc-coated, commercial steel Type A, ASTM A 653, Coating Designation G 115, chemically treated, oiled, minimum 0.040 by 34 by 117 in., for stock tanks, or steel sheet, zinc-coated, high strength low alloy steel Type A Grade 340, ASTM A 653M, Coating Designation Z275, minimized spangle, not chemically treated, oiled, minimum 1.00 by 920 mm by coil, 1520-mm maximum OD, 600-mm ID, 10 000-kg maximum, for tractor inner fender.

NOTE 2—The purchaser should be aware that there are variations in manufacturing practices among the producers and therefore is advised to establish the producer's standard (or default) procedures for thickness tolerances.

#### 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 and HSLAS (Types A and B).

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 A 924/A 924M for chemical analysis procedures and product analysis tolerances.

6.2 *Zinc Bath Analysis*—The bath metal used in continuous hot-dip galvanizing shall contain not less than 99 % zinc.

NOTE 3—To control alloy formation and promote adhesion of the zinc coating with the steel base metal, the molten coating metal composition normally contains a percentage of aluminum usually in the range from 0.05 to 0.25. This aluminum is purposely supplied to the molten coating bath, either as a specified ingredient in the zinc spelter or by the addition of a master alloy containing aluminum.

#### 7. Mechanical Properties

7.1 Structural steel and high-strength low-alloy steel shall conform to the mechanical property requirements in Table 4 for the type, grade, or class, or all, specified.

7.2 The typical mechanical properties for CS (Types A, B, and C), FS (Types A and B), DDS, and EDDS sheet designations are listed in Table 5. These mechanical property values

**TABLE 2 Chemical Requirements<sup>A</sup>**

Designation	Composition, %—Heat Analysis Element, max (unless otherwise shown)												
	Carbon	Manganese	Phosphorus	Sulfur	Aluminum, min	Cu	Ni	Cr	Mo	V	Cb	Ti <sup>B</sup>	N
CS Type A <sup>C,D,E</sup>	0.10	0.60	0.030	0.035	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
CS Type B <sup>F,C</sup>	0.02 to 0.15	0.60	0.030	0.035	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
CS Type C <sup>G,D,E</sup>	0.08	0.60	0.100	0.035	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
FS Type A <sup>C,G</sup>	0.10	0.50	0.020	0.035	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
FS Type B <sup>F,C</sup>	0.02 to 0.10	0.50	0.020	0.030	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
DDS <sup>D,E</sup>	0.06	0.50	0.020	0.025	0.01	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
EDDS <sup>H</sup>	0.02	0.40	0.020	0.020	0.01	0.20	0.20	0.15	0.06	0.10	0.10	0.15	...

<sup>A</sup> Where an ellipsis (...) appears in this table, there is no requirement, but the analysis shall be reported.

<sup>B</sup> 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.

<sup>C</sup> 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.

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

<sup>E</sup> 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.

<sup>F</sup> For CS and FS, specify Type B to avoid carbon levels below 0.02 %.

<sup>G</sup> Shall not be furnished as a stabilized steel.

<sup>H</sup> Shall be furnished as a stabilized steel.

**TABLE 3 Chemical Requirements<sup>A</sup>**

Designation	Composition, %—Heat Analysis Element, max (unless otherwise shown)												
	Carbon	Manganese	Phosphorus	Sulfur	Cu	Ni	Cr	Mo	V	Cb	Ti <sup>B</sup>	N	
SS Grade													
33 [230]	0.20	...	0.04	0.04	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	
37 [255]	0.20	...	0.10	0.04	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	
40 [275]	0.25	...	0.10	0.04	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	
50 [340] Class 1 and 2	0.25	...	0.20	0.04	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	
50 [340] Class 3	0.25	...	0.04	0.04	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...	
80 [550]	0.20	...	0.04	0.04	0.20	0.20	0.15	0.06	0.008	0.015	0.025	...	
HSLAS Type A <sup>C</sup>													
40 [275]	0.20	1.20	...	0.035	...	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
50 [340]	0.20	1.20	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
60 [410]	0.20	1.35	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
70 [480]	0.20	1.65	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
80 [550]	0.20	1.65	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
HSLAS Type B <sup>C,D</sup>													
40 [275]	0.15	1.20	...	0.035	...	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
50 [340]	0.15	1.20	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
60 [410]	0.15	1.20	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
70 [480]	0.15	1.65	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	
80 [550]	0.15	1.65	...	0.035	0.20	0.20	0.15	0.16	0.01 min	0.005 min	0.01 min	...	

<sup>A</sup> Where an ellipsis (...) appears in this table there is no requirement, but the analysis shall be reported.

<sup>B</sup> Titanium is permitted for SS steels to 0.025% provided the ratio of % titanium to % nitrogen does not exceed 3.4.

<sup>C</sup> HSLAS and HSLAS-F steels commonly contain the strengthening elements columbium, vanadium, and titanium added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.

<sup>D</sup> The producer has the option to treat HSLAS Type B steels by means of small alloy additions to effect sulfide inclusion control.

are nonmandatory. 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 of 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 A 924/A 924M.

7.4 *Bending Properties Minimum Cold Bending Radii*—Structural steel and high-strength low-alloy steel are com-

monly 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. The table in Appendix X1 lists the suggested minimum inside radius for 90° cold bending for structural steel and high-strength low-alloy steel. They presuppose "hard way" bending (bend axis parallel to rolling direction) and reasonably good shop forming



TABLE 4 Mechanical Requirements, Base Metal (Longitudinal)

Inch-Pound Units					
Designation	Type	Grade	Yield Strength, min, ksi	Tensile Strength, min, ksi <sup>A</sup>	Elongation in 2 in., min, % <sup>A</sup>
SS <sup>B</sup>	...	33	33	45	20
		37	37	52	18
		40	40	55	16
		50 Class 1	50	65	12
		50 Class 2	50	...	12
		50 Class 3	50	70	12
HSLAS	Type A	80 <sup>C</sup>	80 <sup>D</sup>	82	...
		40	40	50 <sup>E</sup>	22
		50	50	60 <sup>E</sup>	20
		60	60	70 <sup>E</sup>	16
		70	70	80 <sup>E</sup>	12
		80	80	90 <sup>E</sup>	10
HSLAS	Type B	40	40	50 <sup>E</sup>	24
		50	50	60 <sup>E</sup>	22
		60	60	70 <sup>E</sup>	18
		70	70	80 <sup>E</sup>	14
		80	80	90 <sup>E</sup>	12
		SI Units			
Designation	Type	Grade	Yield Strength, min, MPa	Tensile Strength, min, MPa <sup>A</sup>	Elongation in 50 mm, min, % <sup>A</sup>
SS <sup>B</sup>	...	230	230	310	20
		255	255	360	18
		275	275	380	16
		340 Class 1	340	450	12
		340 Class 2	340	...	12
		340 Class 3	340	480	12
HSLAS	Type A	550 <sup>C</sup>	550 <sup>D</sup>	570	...
		275	275	340 <sup>E</sup>	22
		340	340	410 <sup>E</sup>	20
		410	410	480 <sup>E</sup>	16
		480	480	550 <sup>E</sup>	12
		550	550	620 <sup>E</sup>	10
HSLAS	Type B	275	275	340 <sup>E</sup>	24
		340	340	410 <sup>E</sup>	22
		410	410	480 <sup>E</sup>	18
		480	480	550 <sup>E</sup>	14
		550	550	620 <sup>E</sup>	12

<sup>A</sup>Where an ellipsis ( . . . ) appears in this table there is no requirement.

<sup>B</sup>No type identification is applicable to the SS designation.

<sup>C</sup>For sheet thickness of 0.028 in. [0.71 mm] or thinner, no tension test is required if the hardness result in Rockwell B 85 or higher.

<sup>D</sup>As there is no discontinuous yield curve, the yield strength should be taken as the stress at 0.5 % elongation under load or 0.2 % offset.

<sup>E</sup>If a higher tensile strength is required, the user should consult the producer.

practices. Where possible, the use of larger radii or "easy way" bends are recommended for improved performance.

## 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 following relationships to estimate the coating thickness from the coating weight [mass]:

8.1.2.1 1 oz/ft<sup>2</sup> coating weight = 1.7 mils coating thickness, and

TABLE 5 Typical Ranges of Mechanical Properties<sup>A,B</sup> (Nonmandatory)

Designation	(Longitudinal Direction)		Elongation in 2 in. [50 mm], %	<i>r<sub>m</sub></i> Value <sup>C</sup>	<i>n</i> Value <sup>D</sup>
	Yield Strength				
	ksi	[MPa]			
CS Type A	25/55	[170/380]	≥20	<i>E</i>	<i>E</i>
CS Type B	30/55	[205/380]	≥20	<i>E</i>	<i>E</i>
CS Type C	25/60	[170/410]	≥15	<i>E</i>	<i>E</i>
FS Types A and B	25/45	[170/310]	≥26	1.0/1.4	0.17/0.21
DDS	20/35	[140/240]	≥32	1.4/1.8	0.19/0.24
EDDS <sup>F</sup>	15/25	[105/170]	≥40	1.6/2.1	0.22/0.27

<sup>A</sup>The typical mechanical property values presented here are nonmandatory. 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 of these ranges are to be expected. The purchaser may negotiate with the supplier if a specific range or a more restrictive range is required for the application.

<sup>B</sup>These typical mechanical properties apply to the full range of steel sheet thicknesses. The yield strength tends to increase and some of the formability values tend to decrease as the sheet thickness decreases.

<sup>C</sup>*r<sub>m</sub>* Value—Average plastic strain ratio as determined by Test Method E 517.

<sup>D</sup>*n* Value—Strain-hardening exponent as determined by Test Method E 646.

<sup>E</sup>No typical mechanical properties have been established.

<sup>F</sup>EDDS Sheet will be free from changes in mechanical properties over time, that is, nonaging.

8.1.2.2 7.14 g/m<sup>2</sup> coating mass = 1 μm coating thickness.

### 8.2 Coating Weight [Mass] Tests:

8.2.1 Coating weight [mass] tests shall be performed in accordance with the requirements of Specification A 924/A 924M.

8.2.2 The referee method to be used shall be Test Method A 90/A 90M.

### 8.3 Coating Bend Test:

8.3.1 The bend test specimens of coated sheet designated by prefix "G" ["Z"] shall be capable of being bent through 180° in any direction without flaking of the coating on the outside of the bend only. The coating bend test inside diameter shall have a relation to the thickness of the specimen as shown in Table 6. Flaking of the coating within 0.25 in. [6 mm] of the edge of the bend specimen shall not be cause for rejection.

8.3.2 Because of the characteristics of zinc-iron alloy coatings designated by prefix "A" ["ZF"] as explained in 3.2.6, coating bend tests are not applicable.

## 9. Dimensions and Permissible Variations

9.1 All dimensions and permissible variations shall comply with the requirements of Specification A 924/A 924M, except for flatness of SS and HSLAS, which is specified in Table 7 and Table 8, respectively.

## 10. Keywords

10.1 alloyed coating; high strength low alloy; minimized spangle coating; sheet steel; spangle; steel; steel sheet; zinc; zinc coated (galvanized); zinc iron-alloy; zinc iron-alloy coated

**TABLE 6 Coating Bend Test Requirements**
**Inch-Pound Units**

 Ratio of the Inside Bend Diameter to Thickness of the Specimen (Any Direction)  
 CS, FS, DDS, EDDS

 SS, Grade<sup>A</sup>

## Sheet Thickness

Coating Designation <sup>B</sup>	Sheet Thickness			33	37	40
	Through 0.039 in.	Over 0.039 through 0.079 in.	Over 0.079 in.			
G235	2	3	3	3	3	3
G210	2	2	2	2	2	2½
G185	2	2	2	2	2	2½
G165	2	2	2	2	2	2½
G140	1	1	2	2	2	2½
G115	0	0	1	1½	2	2½
G90	0	0	1	1½	2	2½
G60	0	0	0	1½	2	2½
G40	0	0	0	1½	2	2½
G30	0	0	0	1½	2	2½
G01	0	0	0	1½	2	2½

 HSLAS Type A<sup>A</sup>

## HSLAS Type B

Coating Designation <sup>B</sup>	HSLAS Type A <sup>A</sup>			HSLAS Type B				
	40	50	60	40	50	60	70	80
G115	1½	1½	3	1	1	1	1½	1½
G90	1½	1½	3	1	1	1	1½	1½
G60	1½	1½	3	1	1	1	1½	1½
G40	1½	1½	3	1	1	1	1½	1½
G30	1½	1½	3	1	1	1	1½	1½
G01	1½	1½	3	1	1	1	1½	1½

**SI Units**

 Ratio of the Inside Bend Diameter to Thickness of the Specimen (Any Direction)  
 CS, FS, DDS, EDDS

 SS, Grade<sup>C</sup>

## Sheet Thickness

Coating Designation <sup>B</sup>	Sheet Thickness			230	255	275
	Through 1.0 mm	Over 1.0 mm through 2.0 m	Over 2.0 mm			
Z700	2	3	3	3	3	3
Z600	2	2	2	2	2	2½
Z550	2	2	2	2	2	2½
Z500	2	2	2	2	2	2½
Z450	1	1	2	2	2	2½
Z350	0	0	1	1½	2	2½
Z275	0	0	1	1½	2	2½
Z180	0	0	0	1½	2	2½
Z120	0	0	0	1½	2	2½
Z90	0	0	0	1½	2	2½
Z001	0	0	0	1½	2	2½

 HSLAS Type A<sup>C</sup>

## HSLAS Type B

Coating Designation <sup>B</sup>	HSLAS Type A <sup>C</sup>			HSLAS Type B				
	275	340	410	275	340	410	480	550
Z350	1½	1½	3	1	1	1	1½	1½
Z275	1½	1½	3	1	1	1	1½	1½
Z180	1½	1½	3	1	1	1	1½	1½
Z120	1½	1½	3	1	1	1	1½	1½
Z90	1½	1½	3	1	1	1	1½	1½
Z001	1½	1½	3	1	1	1	1½	1½

<sup>A</sup>SS Grades 50 and 80 and HSLAS Type A Grades 70 and 80 are not subject to bend test requirements.

<sup>B</sup>If other coatings are required, the user should consult the producer for availability and suitable bend test requirements.

<sup>C</sup>SS Grades 340 and 550 and HSLAS Type A Grades 480 and 550 are not subject to bend test requirements.

**TABLE 7 Structural Steel—Flatness Tolerances  
(Cut Lengths Only)**

NOTE 1—This table also applies to sheets cut to length from coils by the consumer when adequate flattening measures are performed.

NOTE 2—For Grade 50 [340] (Classes 1, 2, and 3) use 1½ times the values given in this table.

NOTE 3—For Grade 80 [550], there are no defined flatness standards.

Specified Thickness, in. [mm]	Specified Width, in. [mm]	Flatness Tolerance (Maximum Devia- tion from a Hori- zontal Flat Sur- face), in. [mm]
Over 0.060 [1.5]	to 60 [1500], inclusive	½ [12]
	over 60 [1500] to 72 [1800], inclusive	¾ [20]
0.060 [1.5] and thinner	to 36 [900], inclusive	½ [12]
	over 36 [900] to 60 [1500], inclusive over 60 [1500] to 72 [1800], inclusive	¾ [20] 1 [25]

**TABLE 8 High-Strength Low-Alloy Steel—Flatness Tolerances  
(Cut Lengths Only)**

NOTE 1—This table also applies to sheets cut to length from coils by the consumer when adequate flattening measures are performed.

		Inch-Pound Units				
Specified Thick- ness, in.	Specified Width, in.	Flatness Tolerances (Maximum Deviation from a Horizontal Flat Surface), in.				
		Grade				
		40	50	60	70	80
Over 0.060	to 60, inclusive	5/8	3/4	7/8	1	1 1/8
	over 60	1	1 1/8	1 1/4	1 3/8	1 1/2
0.060 and thinner	to 36, inclusive	5/8	3/4	7/8	1	1 1/8
	over 36 to 60, inclusive	1	1 1/8	1 1/4	1 3/8	1 1/2
	over 60	1 1/8	1 1/2	1 5/8	1 3/4	1 7/8
		SI Units				
Specified Thickness, mm	Specified Width, mm	Flatness Tolerances (Maximum Deviation from a Horizontal Flat Surface), mm				
		Grade				
		275	340	410	480	550
Over 1.5	to 1500, inclu- sive	15	20	22	25	30
	over 1500	25	30	32	35	38
1.5 and thinner	to 900, inclu- sive	15	20	22	25	30
	over 900 to 1500, inclusive	25	30	32	35	38
	over 1500	35	38	40	45	48

**SUPPLEMENTARY REQUIREMENTS**

The following standardized supplementary requirements are for use when desired by the purchaser. These additional requirements shall apply only when specified on the order.

**S1. Base Metal Thickness**

S1.1 The specified minimum thickness shall apply to the base metal only.

S1.2 The coating designation shown on the order indicates the coating to be applied to the specified minimum base metal thickness.

S1.3 The applicable tolerances for base metal thickness are shown in Tables 16 and Tables 17, Thickness Tolerance of Cold-Rolled Sheet (Carbon and High-Strength, Low-Alloy Steel), of Specification A 568/A 568M.



## APPENDIXES

(Nonmandatory Information)

## X1. BENDING PROPERTIES

X1.1 Table X1.1 lists suggested minimum inside radii for cold bending.

TABLE X1.1 Suggested Minimum Inside Radii for Cold Bending<sup>A</sup>

NOTE 1—(*t*) equals a radius equivalent to the steel thickness.

NOTE 2—The suggested radii should be used as minimums for 90° bends in actual shop practice.

Quality	Type	Grade	Minimum Inside Radius for Cold Bending <sup>B</sup>
SS		33 [230]	1½ <i>t</i>
		37 [255]	2 <i>t</i>
		40 [275]	2 <i>t</i>
		50 [340] Class 1	not applicable
		50 [340] Class 2	not applicable
HSLAS	Type A	50 [340] Class 3	not applicable
		80 [550]	not applicable
		40 [275]	2 <i>t</i>
		50 [340]	2½ <i>t</i>
		60 [410]	3 <i>t</i>
HSLAS	Type B	70 [480]	4 <i>t</i>
		80 [550]	4½ <i>t</i>
		40 [275]	1½ <i>t</i>
		50 [340]	2 <i>t</i>
		60 [410]	2 <i>t</i>
		70 [480]	3 <i>t</i>
		80 [550]	3 <i>t</i>

<sup>A</sup>Material that does not perform satisfactorily, when fabricated in accordance with the requirements in Table X1.1, may be subject to rejection pending negotiation with the steel supplier.

<sup>B</sup>Bending capability may be limited by coating designation.

## X2. RATIONALE FOR CHANGES IN PRODUCT DESIGNATIONS

X2.1 Subcommittee A05.11 has revised the designations used to classify the various products available in each hot-dip coated specification. The previous "quality" designations have been replaced with designations and descriptions more closely related with product characteristics. Many of the former "quality" specifications described the steel only in terms of limited chemical composition, which in some cases was identical for two or more qualities. The former designations also did not reflect the availability of new steels which are the result of the use of new technologies such as vacuum degassing and steel ladle treatments.

X2.2 The former "quality" designators, defined in very broad qualitative terms, did not provide the user with all the information needed to select the appropriate steel for an application. The new designations are defined with technical information such as specific chemical composition limits and typical nonmandatory mechanical properties. These steel characteristics are important to users concerned with the weldability and formability of the coated steel products. The typical mechanical properties included in the new designation system are those indicated by the tension test. These properties are more predictive of steel formability than other tests such as the hardness test which may not compensate adequately for

product variables such as substrate thickness and coating weight.

X2.3 The new designations also provide the user with the flexibility to restrict the steels applied on any order. For example, a user can restrict the application of ultra low carbon steels on an application through the selection of an appropriate "type" designator.

X2.4 There is a limited relationship between the former and current systems of designation. Some of the reasons for this limited relationship are: addition of steels not previously described in ASTM specifications, restrictions placed on ranges of chemical composition, the addition of typical mechanical properties, and the enhanced capability of steel producers to combine chemical composition and processing methods to achieve properties tailored to specific applications.

X2.5 The changes in designation are significant which may create transition issues that will have to be resolved. Continued dialogue between users and producers will have to be maintained to assist with the transition to the new system of designations. A user with concerns about the appropriate coated steel to order for a specific application should consult with a steel supplier or producer.



### X3. RELATIONSHIP BETWEEN SPECIFICATIONS THAT DESCRIBE REQUIREMENTS FOR A COMMON PRODUCT

X3.1 ISO 3575 and ISO 4998 may be reviewed for comparison with this standard. The relationship between the standards may only be approximate; therefore, the respective

documents should be consulted for actual requirements. Those who use these documents must determine which specifications address their needs.

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