Designation: A1079 – 17

Standard Specification for Steel Sheet, Complex Phase (CP), Dual Phase (DP) and Transformation Induced Plasticity (TRIP), Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process[1]

This standard is issued under the fixed designation A1079; 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, complex phase (CP) grade, dual phase (DP) grade, and transformation induced plasticity (TRIP) grade, 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 masses or coating designations as shown in Table 1.

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

1.4 The product is available in a number of designations and grades with mandatory chemical requirements and mandatory mechanical properties that are achieved through thermal or thermal-mechanical treatments, and are designed to be compatible with automotive application requirements.

1.5 The grade designation nomenclature of the product differs from other hot-dip sheet products having mandatory mechanical properties in that ordering is to tensile, rather than yield strength values.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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:*[2]

A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A902 Terminology Relating to Metallic Coated Steel Products

A924/A924M Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

D7396 Guide for Preparation of New, Continuous Zinc-Coated (Galvanized) Steel Surfaces for Painting

E646 Test Method for Tensile Strain-Hardening Exponents (***n*** -Values) of Metallic Sheet Materials

B6 Specification for Zinc

B852 Specification for Continuous Galvanizing Grade (CGG) Zinc Alloys for Hot-Dip Galvanizing of Sheet Steel

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *complex phase (CP) steel, n*—steel sheet with a ferritic/bainitic matrix containing small amounts of retained austenite, or pearlite, or both where significant grain refinement is caused by retarded crystallization or precipitation of microalloying elements.

3.2.2 *dual phase (DP) steel, n*—steel sheet with a ferritic matrix containing a martensitic phase present in the form of islands.

[1] This test method 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.

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

TABLE 1 Mass of Coating Requirements[A]

NOTE 1—Use the information provided in 8.1.2 to obtain the approximate coating thickness per side from the coating mass.

	Single Spot/Single Side Coating Mass		
	Coating Designation	Minimum, g/m^2	Maximum, g/m^2
Zinc	20G	20	70
	30G	30	80
	40G	40	90
	45G	45	95
	50G	50	100
	55G	55	105
	60G	60	110
	70G	70	120
	90G	90	160
	100G	100	200
Zinc-Iron Alloy	30A	30	60
	40A	40	70
	45A	45	75
	50A	50	80

[A]The coating designation is the term by which the minimum single spot/single side coating mass is specified for each side.

3.2.3 *transformation induced plasticity (TRIP) steel, n*—steel sheet with a mainly ferritic matrix containing retained austenite where, during the forming process, retained austenite can transform to martensite.

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

3.2.4.1 *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 D7396). The lack of ductility of the alloy coating presents a potential for powdering.

4. Classification

4.1 The material is available in several designations and grades as follows:

4.1.1 Complex phase (CP) steel (Grades 600T/350Y, 780T/500Y, and 980T/700Y),

4.1.2 Dual phase (DP) steel (Grades 440T/250Y, 490T/290Y, 590T/340Y, 780T/420Y, and 980T/550Y), and

4.1.3 Transformation induced plasticity (TRIP) steel (Grades 690T/410Y and 780T/440Y).

4.2 The material is available as either zinc-coated or zinc-iron alloy-coated in several coating masses or coating designations as shown in Table 1.

4.2.1 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 0.01 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 [CP (Grades 600T/350Y, 780T/500Y, or 980T/700Y), DP (Grades 440T/250Y, 490T/290Y, 590T/340Y, 780T/420Y, or 980T/550Y), or TRIP (Grades 690T/410Y or 780T/440Y)].

5.2.3 ASTM designation number and year of issue, as A1079.

5.2.4 Coating designation (see 8.1.3),

5.2.5 Minimized spangle (if required),

5.2.6 Chemically treated or not chemically treated,

5.2.7 Oiled or not oiled,

5.2.8 Extra smooth (if required),

5.2.9 Phosphatized (if required),

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

5.2.11 Coil size requirements (specify maximum outside diameter (OD), acceptable inside diameter (ID), and maximum mass),

5.2.12 Packaging,

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

5.2.14 Application (part identification and description), and

5.2.15 Special requirements (if any).

NOTE 1—Typical ordering descriptions are as follows: steel sheet, zinc-iron alloy-coated, DP Grade 590T/340Y, ASTM A1079, Coating Designation 45A45A, not chemically treated, oiled, minimum 1.00 by 1200 mm by coil, 1520 mm maximum OD, 600 mm ID, 10 000 kg maximum, for B side pillar.

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.

6.1.2 Each of the elements listed in Table 2 shall be included in the report of heat analysis, including each element in columns with grouped elements. 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 niobium is less

TABLE 2 Chemical Requirements[A] Steel Sheet Designations CP, DP, and TRIP

Designation/ Grade	Composition, %—Heat Analysis Element, max (unless otherwise shown)								
	C	Mn+Al+Si[C]	P	S	Cu[B]	Ni	Cr+Mo[C]	V+Nb[D] +Ti[C]	N
CP									
600T/350Y	0.18	5.30	0.080	0.015	0.20	0.50	1.00	0.35	...
780T/500Y	0.18	5.50	0.080	0.015	0.20	0.50	1.00	0.35	...
980T/700Y	0.25	5.20	0.080	0.015	0.20	0.50	1.00	0.35	...
DP									
450T/250Y	0.15	3.00	0.080	0.015	0.20	0.50	1.00	0.35	...
490T/290Y	0.15	3.40	0.080	0.015	0.20	0.50	1.00	0.35	...
590T/340Y	0.17	4.75	0.080	0.015	0.20	0.50	1.40	0.35	...
780T/420Y	0.18	5.40	0.080	0.015	0.20	0.50	1.40	0.35	...
980T/550Y	0.23	6.00	0.080	0.015	0.20	0.50	1.40	0.35	...
TRIP									
690T/410Y	0.32	6.20	0.12	0.015	0.20	0.50	0.60	0.40	...
780T/440Y	0.32	6.70	0.12	0.015	0.20	0.50	0.60	0.40	...

[A]Where an ellipsis (...) appears in the table, there is no requirement but, the analysis shall be reported.
[B]When copper is specified, the copper limit is a minimum requirement. When copper steel is not specified, the copper limit is a maximum requirement.
[C]The producer shall report the individual composition of each element in the grouping.
[D]Niobium (Nb) is also known as Columbium (Cb).

than 0.008 %, report the analysis as either <0.008 % or the actual determined value.

NOTE 3—Niobium is also known as Columbium.

6.1.3 See Specification A924/A924M 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, with a lead level not exceeding 0.009 %.

NOTE 4—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. Specification B852 specifies continuous galvanizing grade (CGG) zinc alloys, including multiple zinc alloys, that enable the molten coating metal to be controlled within 0.05 to 0.25 % aluminum and to not exceed 0.009 % lead. Specification B6 specifies certain grades of zinc that do not exceed 0.009 % lead but contain lower levels of aluminum.

NOTE 5—The producer can demonstrate compliance to the maximum lead level through reference to the chemical test certificates received from the zinc supplier.

7. Mechanical Properties

7.1 All designations and grades shall conform to the mechanical property requirements in Table 3.

7.1.1 All designations and grades shall conform to bake hardening index requirements included in Table 3. The minimum increase in yield strength is based on the lower yield stress, after a prestrained specimen has been exposed to a standard bake cycle of 170°C for 20 minutes. The method for measuring the bake hardening index is described in the Annex A1.

7.2 Mechanical property tests shall be conducted in accordance with the methods specified in Specification A924/A924M, or those prescribed by the purchaser.

7.3 *Bending Properties Minimum Cold Bending Radii*—High-strength sheet steels are 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. The table in Appendix X1 lists

TABLE 3 Mechanical Property Requirements, Base Metal (Longitudinal) Steel Sheet Designations CP, DP, and TRIP[A]

Designation	Grade	Yield Strength, min, MPa	Tensile Strength, min, MPa	Elongation in 50 mm, min, %	*n* Value[B]	Bake Hardening Index, min, MPa Lower Yield
CP	600T/350Y	350	600	16	...	30
	780T/500Y	500	780	10	...	30
	980T/700Y	700	980	7	...	30
DP	450T/250Y	250	450	27	≥0.16	30
	490T/290Y	290	490	25	≥0.15	30
	590T/340Y	340	590	21	≥0.14	30
	780T/420Y	420	780	14	≥0.11	30
	980T/550Y	550	980	8	...	30
TRIP	690T/410Y	410	690	21	≥0.19	30
	780T/440Y	440	780	19	≥0.16	30

[A]Where an ellipsis (. . .) appears in this table, there is no requirement.
[B]*n* Value—Strain-hardening exponent as determined by Test Method E646, 10-20 % strain.

the suggested minimum inside radius for 90° cold bending for the grades of steel in this specification. They presuppose "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" bends is recommended for improved performance.

8. Coating Properties

8.1 *Coating Mass:*

8.1.1 Coating 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 mass:

8.1.2.1 7.14 g/m^2 coating mass = 1.00 µm coating thickness.

8.1.3 The ordering format for specifying the coating for each surface shall be, for instance, 45A45A. In the case of differentially coated product, the thicker (heavier) coating mass side shall be specified first, for instance 50A30A.

8.2 *Coating Mass Tests:*

8.2.1 Coating mass tests shall be performed in accordance with the requirements of Specification A924/A924M.

8.2.2 The referee method to be used shall be Test Method A90/A90M.

8.3 *Coating Bend Test:*

8.3.1 The designations and grades in this specification are not subject to coating bend tests.

9. Retests and Disposition of Non-Conforming Material

9.1 Retests, conducted in accordance with the requirements of the section on Retests and Disposition of Non-Conforming Material of Specification A924/A924M, are permitted when an unsatisfactory test result is suspected to be the consequence of the test method procedure.

9.2 Disposition of non-conforming material shall be subject to the requirements of Specification A924/A924M.

10. Dimensions and Permissible Variations

10.1 All dimensions and permissible variations shall comply with the requirements of Specification A924/A924M.

11. Keywords

11.1 alloyed coating; complex phase steel; dual phase steel; minimized spangle coating; sheet steel; spangle; steel; steel sheet; transformation induced plasticity steel; zinc; zinc iron-alloy; zinc coated (galvanized); zinc iron-alloy coated (galvannealed)

ANNEX

(Mandatory Information)

A1. BAKE HARDENABLE INDEX

A1.1 Determination of Bake Hardening Index

A1.1.1 The bake hardening index (BHI) is determined by a two-step procedure using a standard longitudinal (rolling direction) tensile-test specimen, prepared in accordance with Test Methods A370. The test specimen is first strained in tension. The magnitude of this tensile "pre-strain" shall be 2 % (extension under load). The test specimen is then removed from the test machine and baked at a temperature of 170°C for a period of 20 minutes. Referring to Fig. A1.1, the bake hardening index (BHI) of the material is calculated as follows:

$$BHI = B - A \quad \text{(A1.1)}$$

where:

A = flow stress at 2 % extension under load.

B = yield strength [upper yield strength (B_U) or lower yield stress (B_L)] after baking at 170°C for 20 minutes.

A1.1.2 The original test specimen cross section (width and thickness) is used in the calculation of all engineering strengths in this test.

A1.1.3 The pre-straining of 2 % in tension is intended to simulate a modest degree of forming strain, while the subsequent baking is intended to simulate a paint-curing or similar treatment. In the production of actual parts, forming strains and baking treatments can differ from those employed here and, as a result; final properties can differ from the values obtained under these controlled conditions.

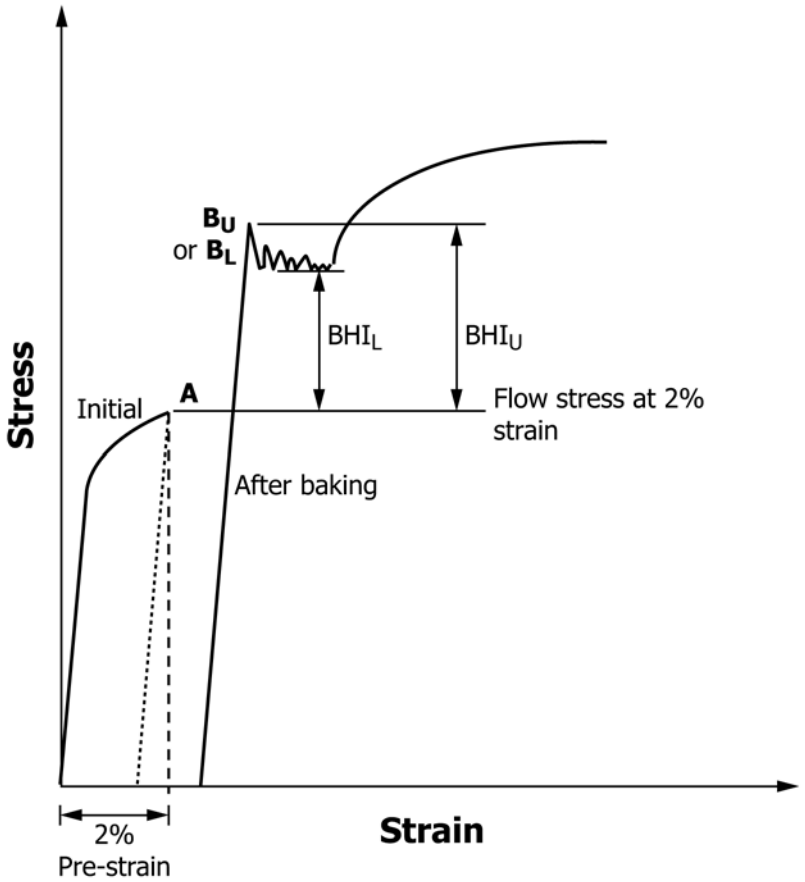

FIG. A1.1 Representation of Bake Hardening Index

APPENDIX

(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[A]

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.

Designation	Grade	Minimum Inside Radius for Cold Bending[B]
CP	600T/350Y	2*t*
	780T/500Y	3*t*
	980T/700Y	4*t*
DP	450T/250Y	1½ *t*
	490T/290Y	2*t*
	590T/340Y	2*t*
	780T/420Y	2½ *t*
	980T/550Y	3*t*
TRIP	690T/410Y	2½ *t*
	780T440Y	2½ *t*

[A]Material that does not perform satisfactorily, when fabricated in accordance with the requirements in this table may be subject to rejection pending negotiation with the steel supplier.
[B]Bending capability may be limited by coating designation.

SUMMARY OF CHANGES

Committee A05 has identified the location of selected changes to this standard since the last issue (A1079 - 13$^{\varepsilon 2}$) that may impact the use of this standard. (January 1, 2017)

(1) Added Specification B6 and Specification B852 references to Section 2.
(2) Added lead restriction in 6.2 and references to Specification B6 and Specification B852 in Note 4.
(3) Added Note 5.