Designation: A1088 – 13

Standard Specification for Steel, Sheet, Cold-Rolled, Complex Phase (CP), Dual Phase (DP) and Transformation Induced Plasticity (TRIP)[1]

This standard is issued under the fixed designation A1088; 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 cold-rolled, complex phase (CP) grade, dual phase (DP) grade, and transformation induced plasticity (TRIP) grade steel sheet in coils and cut lengths.

1.2 Product furnished under this specification shall conform to the applicable requirements of the latest issue of Specification A568/A568M, unless otherwise provided herein.

1.3 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.

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

1.5 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.

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

1.7 *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. Some specific hazards statements are given in Section 7 on Hazards.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

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

3. Terminology

3.1 *Definitions*—See Terminology A941 for definitions of general terminology relating to cold-rolled steel sheet products.

3.2 *Definitions:*

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.

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.

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

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.19 on Steel Sheet and Strip.

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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.

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

4.2 Cold-rolled steel sheet is supplied for either exposed or unexposed applications. Within the latter category, cold-rolled sheet is specified either "temper rolled" or "annealed last." For details on processing, attributes and limitations, and inspection standards, refer to Specification A568/A568M.

5. Ordering Information

5.1 It is the purchaser's responsibility to specify in the purchase order all ordering information necessary to describe the required material. Examples of such information include, but are not limited to, the following:

5.1.1 ASTM specification number and year of issue;

5.1.2 Name of product (steel sheet, cold-rolled);

5.1.3 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)];

5.1.4 Finish (see 8.1);

5.1.5 Oiled or not oiled (see 8.2);

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

NOTE 1—Not all producers are capable of meeting all the limitations of the thickness tolerance tables in Specification A568/A568M. The purchaser should contact the producer regarding possible limitations prior to placing an order.

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

5.1.8 Quantity;

5.1.9 Packaging;

5.1.10 Certification, if required, heat analysis and mechanical property report;

5.1.11 Application (part identification and description); and

5.1.12 Special requirements (if any).

NOTE 2—Typical ordering descriptions are as follows: steel sheet, cold-rolled, DP Grade 590T/340Y, ASTM A1088, oiled, minimum 1.00 by 1200 mm by coil, 1520 mm maximum OD, 600 mm ID, 10 000 kg maximum, for side reinforcement strut.

6. Chemical Composition

6.1 The heat analysis of the steel shall conform to the requirements shown in Table 1.

6.2 Each of the elements listed in Table 1 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 than 0.008 %, report the analysis as either <0.008 % or the actual determined value.

NOTE 3—Niobium is also known as Columbium.

6.2.1 See Specification A568/A568M for chemical analysis procedures and product analysis tolerances.

7. Mechanical Properties

7.1 All designations and grades shall conform to the mechanical property requirements in Table 2.

7.1.1 All designations and grades shall conform to bake hardening index requirements included in Table 2. 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 min. 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 A568/A568M, 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,

TABLE 1 Chemical Requirements[A] Steel Sheet Designations, CP, DP, and TRIP

	Composition, %—Heat Analysis Element, max (unless otherwise shown)								
Designation/Grade	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).

TABLE 2 Mechanical Property Requirements (Longitudinal), Cold Rolled 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	≥0.10	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.

and base metal microstructure. The table in Appendix X1 lists 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. Finish and Appearance

8.1 *Surface Finish:*

8.1.1 Unless otherwise specified, the sheet shall have a matte finish. When required, specify the appropriate surface texture and condition. For additional information, see the Finish and Condition section of Specification A568/A568M.

8.2 *Oiling:*

8.2.1 Unless otherwise specified, the sheet shall be oiled.

8.2.2 When required, specify the sheet to be furnished not oiled (dry).

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 A568/A568M, 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 A568/A568M.

10. Dimensions and Permissible Variations

10.1 All dimensions and permissible variations shall comply with the requirements of Specification A568/A568M.

11. Keywords

11.1 cold-rolled sheet; complex phase steel; dual phase steel; steel; steel sheet; transformation induced plasticity steel

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 (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 strength (B_L)) after baking at 170°C for 20 min.

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.

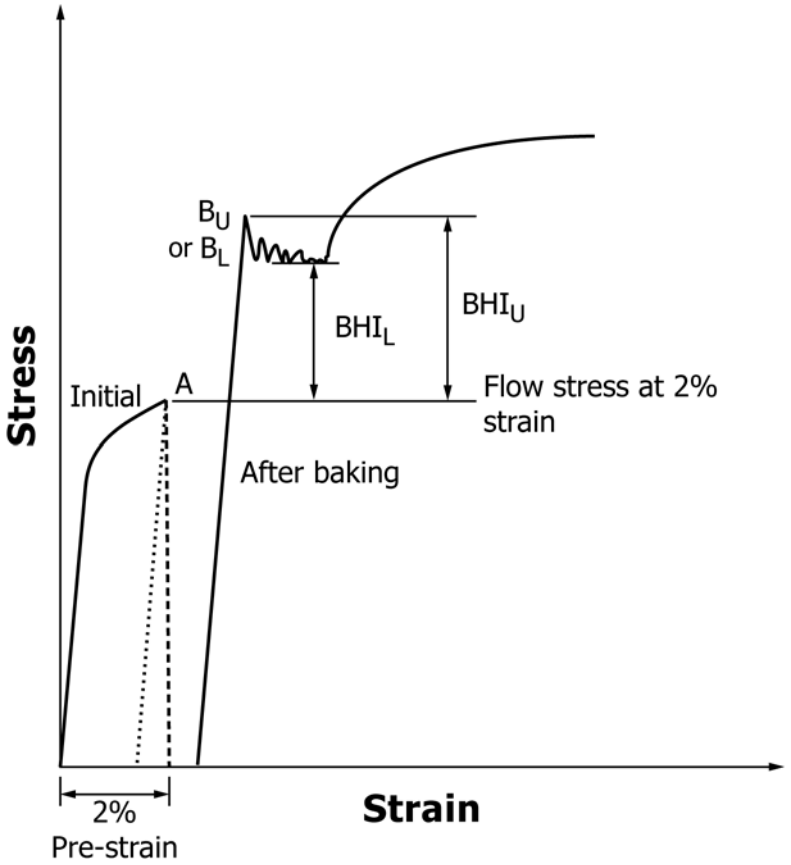

FIG. A1.1 Representation of bake Hardening Index

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/700Y	1½*t*
	490T/290Y	2*t*
	590T/340Y	2*t*
	780T/420Y	2½*t*
	980T/550Y	3*t*
TRIP	690/410Y	2½*t*
	780T/440Y	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.