Designation: A684/A684M – 12

StandardSpecification for Steel, Strip, High-Carbon, Cold-Rolled[1]

This standard is issued under the fixed designation A684/A684M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers cold-rolled, high-carbon strip in coils or cut lengths. Strip is classified as product that is 0.3000 in. [7.6 mm] or less in thickness and over ½ to 23 15⁄16 in. [12.5 to 600 mm] in width, inclusive. Strip tolerance products may be available in widths wider than 23 15⁄16 in. (600 mm) by agreement between purchaser and supplier; however, such products are technically classified as cold-rolled sheet. The maximum of the specified carbon range is over 0.25 to 1.35 %, inclusive. It is furnished in the following types as specified:

1.1.1 Soft spheroidized annealed high-carbon steel is intended for applications requiring maximum cold forming. It is normally produced to give the lowest maximum Rockwell hardness for each grade.

1.1.2 Soft annealed high-carbon steel is intended for applications requiring moderate cold forming. It is produced to a maximum Rockwell hardness.

1.1.3 Intermediate hardness high-carbon steel is intended for applications where cold forming is slight or a stiff, springy product is needed, or both. It is produced to specified Rockwell hardness ranges, the maximum being higher than obtained for the annealed type.

1.1.4 Full hard high-carbon steel is intended for flat applications. It is produced to minimum Rockwell hardness requirements, which vary with grade, microstructure and gauge. Full hard can be produced with either a pearlitic or spheroidized microstructure or a mixture of both. The minimum hardness should be established between the consumer and the producer.

1.2 This specification is applicable for orders in either inch-pound units or SI units.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 The tolerances in this specification are different than those in Specification A568/A568M and Specification A109/A109M.

1.5 For the purpose of determining conformance with this specification, values shall be rounded to the nearest unit in the right hand place of figures used in expressing the limiting values in accordance with the rounding method of Practice E29.

1.6 This specification is expressed in both inch-pound units and SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units. The metric portions of the tables herein list permissible variations in dimensions and mass (see Note 1) in SI (metric) units. The values listed are not exact conversions of the values listed in the inch-pound tables but instead are rounded or rationalized values. Conformance to SI tolerances is mandatory when the "M" specification is used.

NOTE 1—The term *weight* is used when inch-pound units are the standard. However, under SI the preferred term is *mass*.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A109/A109M Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled

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

A700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment (Withdrawn 2014)[3]

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

TABLE 1 Heat (Formerly Ladle) Analysis Chemical Composition, %

Steel Designation No.	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon
1030	0.28 to 0.34	0.60 to 0.90	0.030	0.035	[A]
1035	0.32 to 0.38	0.60 to 0.90	0.030	0.035	[A]
1040	0.37 to 0.44	0.60 to 0.90	0.030	0.035	[A]
1045	0.43 to 0.50	0.60 to 0.90	0.030	0.035	[A]
1050	0.48 to 0.55	0.60 to 0.90	0.030	0.035	[A]
1055	0.50 to 0.60	0.60 to 0.90	0.030	0.035	[A]
1060	0.55 to 0.65	0.60 to 0.90	0.030	0.035	[A]
1064[B]	0.59 to 0.70	0.50 to 0.80	0.030	0.035	[A]
1065	0.60 to 0.70	0.60 to 0.90	0.030	0.035	[A]
1070	0.65 to 0.75	0.60 to 0.90	0.030	0.035	[A]
1074	0.70 to 0.80	0.50 to 0.80	0.030	0.035	[A]
1075	0.70 to 0.80	0.40 to 0.70	0.030	0.035	[A]
1080	0.75 to 0.88	0.60 to 0.90	0.030	0.035	[A]
1085	0.80 to 0.93	0.70 to 1.00	0.030	0.035	[A]
1086	0.80 to 0.93	0.30 to 0.50	0.030	0.035	[A]
1095	0.90 to 1.03	0.30 to 0.50	0.030	0.035	[A]

[A] Silicon composition as one of the following:
Type 1: 0.15 – 0.30
Type 2: 0.10 max
Or other silicon ranges are permissible when agreed upon by purchaser and producer.
[B] 1064 is not an SAE steel grade.

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
E3 Guide for Preparation of Metallographic Specimens
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E112 Test Methods for Determining Average Grain Size
E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.2 *Federal Standards:*
Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[4]
Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products[4]

2.3 *Military Standard:*
MIL-STD-129 Marking for Shipping and Storage[4]

2.4 *SAE Standard:*
J 1086 Recommended Practice for Numbering Metals and Alloys (UNS)[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *burr*—metal displaced beyond the plane of the surface by slitting or shearing.

3.1.2 *lot*—quantity of material of the same type, size, and finish produced at one time from the same cast or heat, and heat treated in the same heat-treatment cycle.

3.1.3 *spheroidizing*—the heating and cooling of the strip in controlled conditions (annealing) to produce a spheroidal or globular form of carbide microconstituent.

3.1.4 *stretcher strains*—elongated markings that appear on the surface of the strip when dead soft (fully annealed) material is deformed beyond its yield point (see 5.2).

3.2 Refer to Terminology A941 for additional terms used in this standard.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 ASTM designation and date of issue,

4.1.2 Name, type, and steel grade number,

4.1.3 Hardness (if intermediate or restricted hardness is specified),

4.1.4 Decarburization (if required),

4.1.5 Application,

4.1.6 Dimensions,

4.1.7 Coil size requirements,

4.1.8 Edge (indicate No. 1 round, square, etc.),

4.1.9 Finish (indicate and specify),

4.1.10 Conditions (specify whether material is oiled or dry),

4.1.11 Package (bare coils, skid, etc.),

4.1.12 Cast or heat (formerly ladle) analysis report (if required),

4.1.12.1 The additional chemical composition requirements (heat analysis) for copper, nickel, chromium, and molybdenum shall be specified as Limits L or Limits H. If no limits are specified, Limits L will be provided.

4.1.12.2 Silicon requirement specified (Type 1, Type 2, or other as agreed between purchaser and producer). If no specification is supplied, then Type 1 (see Table 1, Footnote B) will be supplied.

4.1.13 Special requirements (if required).

4.2 Products covered by this specification are produced to decimal thickness only, and decimal thickness tolerances apply.

NOTE 2—A typical ordering description is as follows: ASTM A684

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

TABLE 2 Rockwell Hardness Testing Ranges for Cold-Rolled High-Carbon Steel Strip

Rockwell "B" and "T" Scales		Rockwell "C" and "N" Scales	
Thickness	Scale	Thickness	Scale
Over 0.030 in. [over 0.8 mm]	B	Over 0.040 in. [over 1.0 mm]	C
0.020 to 0.030 in. [0.5 to 0.8 mm]	30T	0.025 to 0.040 in. [0.6 to 1.0 mm]	30N
Under 0.020 in. [under 0.5 mm]	15T	Under 0.025 in. [under 0.6 mm]	15N

dated ______ Cold Rolled, High-Carbon Soft, Strip, Spheroidized 1064, 0.042 in. by 6 in. by coil (16 in. ID by 40 in. OD max), No. 5 Edge, No. 2 Finish, Oiled, Bare Skid or "ASTM A684 dated _______ Cold Rolled, High-Carbon, Soft, Strip, Spheroidized 1064, 0.6 mm by 200 mm by coil (400 mm ID by 7500 mm OD max), No. 3 Edge, No. 2 Finish, Oiled, Bare Skid."

5. Manufacture

5.1 *Condition:*

5.1.1 The strip shall be furnished cold rolled spheroidized annealed, soft annealed, intermediate hardness, or full hard, as specified.

5.1.2 Intermediate hardness may be obtained by either rolling the strip after final annealing or by varying the annealing treatment, or both.

5.2 *Pinch Pass*—Spheroidized annealed and annealed material may be pinch rolled after the final anneal to improve flatness, uniformly oil, modify surface, obtain proper mechanical properties and minimize stretcher strains if required by the purchaser.

6. Chemical Requirements

6.1 *Limits:*

6.1.1 When carbon steel strip is specified to chemical composition, the compositions are commonly prepared using the ranges and limits shown in Table 2. The elements comprising the desired chemical composition are specified in one of three ways:

6.1.1.1 By a maximum limit,

6.1.1.2 By a minimum limit, or

6.1.1.3 By minimum and maximum limits, termed the "range." By common usage, the range is the arithmetical difference between the two limits (for example, 0.60 to 0.71 is 0.11 range).

6.1.2 Steel grade numbers indicating chemical composition commonly produced to this specification are shown in Table 3 and may be used. Table 4 shows requirements for additional elements.

6.1.3 Additional elements may be present. Limits on such elements are by agreement between purchaser and supplier.

6.1.3.1 Any additional elements specified shall be included in the report of heat analysis.

6.2 *Heat (Formerly Ladle) Analysis:*

6.2.1 An analysis of each heat of steel shall be made by the manufacturer to determine the percentage of elements specified or restricted by the applicable specification.

TABLE 3 Cold Bending Requirements[A,B] for Spheroidized, Annealed, and Soft-Annealed Cold-Rolled Carbon Steel Strip

Type	Degree of Bend	Inside Radius to Thickness	Relation of Bend Test Specimen to Rolling Direction
Annealed	180°	3*t*	transverse[C]
Spheroidized	180°	2*t*	transverse[C]

[A] Up to 0.100 in. [2.5 mm], incl, thickness maximum. When bend radius for thickness is over 0.100 in. [2.5 mm] the producer should be consulted. These ratios apply to bending performance of the test specimen.
[B] These bend tests apply to the bending performance of test specimens only. Where material is to be bent in fabricating operations a more liberal bend radius may be required and should be based on prior experience or consultation with the steel producer, or both.
[C] If finished strip width prohibits taking a transverse bend test specimen, a longitudinal specimen may be substituted, except the bend radius shall be reduced by 1 *t*.

TABLE 4 Heat (Formerly Ladle) Analysis Limits and Ranges

Element	Standard Chemical Limits and Ranges, Limit or Max of Specified Range	Range, %
Carbon[A]	over 0.25 to 0.30, incl	0.06
	over 0.30 to 0.40, incl	0.07
	over 0.40 to 0.60, incl	0.08
	over 0.60 to 0.80, incl	0.11
	over 0.80 to 1.35, incl	0.14
Manganese	to 0.50, incl	0.20
	over 0.50 to 1.15, incl	0.30
	over 1.15 to 1.65, incl	0.35
Phosphorous	to 0.08, incl	0.03
	over 0.08 to 0.15, incl	0.05
Sulfur	to 0.08, incl	0.03
	over 0.08 to 0.15, incl	0.05
	over 0.15 to 0.23, incl	0.07
	over 0.23 to 0.33, incl	0.10
Silicon	to 0.20, incl	0.10
	over 0.20 to 0.30, incl	0.15
	over 0.30 to 0.60, incl	0.30

[A] The carbon ranges shown in the column headed "Range" apply when the specified maximum limit for manganese does not exceed 1.00 %. When the maximum manganese limit exceeds 1.00 %, add 0.01 to the carbon ranges shown above.

6.2.2 When requested, heat analysis for elements listed or required shall be reported to the purchaser or to his representative. Each of the elements listed in Tables 3 and 4 and additional elements agreed upon by the purchaser and the supplier shall be included in the report of heat analysis. When the amount of copper, nickel, chromium, or molybdenum is less than 0.02 %, the analysis may be reported as <0.02 %. When the amount of vanadium, columbium, or titanium is less than 0.008 %, the analysis may be reported as <0.008 %. The reported heat analysis shall conform to the chemical composition requirements of the appropriate grade in Table 3, if used, the additional elements in Table 4, and the limits of any other elements agreed upon by the purchaser and supplier.

6.3 *Product Analysis*—Product analysis is the chemical analysis of the semi-finished product form. The strip may be subjected to product analysis by the purchaser either for the purpose of verifying that the ordered chemical composition is within specified limits for each element as listed in Table 1

TABLE 5 Additional Chemical Composition Requirements—Heat Analysis

Element	Composition—Weight %	
Aluminum[A]	. . .	
Vanadium[A]	. . .	
Columbium[A]	. . .	
Titanium[A]	. . .	
	Limits	
	L	H
Copper, max[B]	0.30	0.50
Nickel, max[B]	0.30	0.30
Chromium, max[B, C]	0.25	0.30
Molybdenum, max[B]	0.10	0.16

[A] Where an ellipsis (. . .) appears in this table, there is no specified limit, but the analysis shall be reported.
[B] The sum of copper, nickel, chromium, and molybdenum shall not exceed 0.80 % on heat analysis. When one or more of these elements is specified, the sum does not apply, in which case only the individual limits on the remaining elements will apply.
[C] For antigraphitization, the maximum for chromium shall be 1.40 %.

TABLE 6 Tolerances for Product Analysis

Element	Limit or Max of Specification, %	Variations Over Max Limit or Under Min Limit	
		Under Min Limit	Over Max Limit
Carbon	over 0.25 to 0.40, incl	0.03	0.04
	over 0.40 to 0.80, incl	0.03	0.05
	over 0.80	0.03	0.06
Manganese	to 0.60, incl	0.03	0.03
	over 0.60 to 1.15, incl	0.04	0.04
	over 1.15 to 1.65, incl	0.05	0.05
Phosphorus	. . .	. . .	0.01
Sulfur	. . .	. . .	0.01
Silicon	to 0.30, incl	0.02	0.03
	over 0.30 to 0.60	0.05	0.05

including applicable tolerance for product analysis, or to determine variations in compositions within a cast or heat. Table 5 lists additional chemical composition requirements. The results of analyses taken from different pieces within a heat may differ from each other and from the cast analysis. The chemical composition thus determined shall not vary from the limits specified by more than the amounts shown in Table 6.

6.4 *Methods of Analysis*—Test Methods, Practices, and Terminology A751 shall be used for referee purposes.

7. Metallurgical Structure

7.1 *Grain Size:*

7.1.1 Unless otherwise specified, the steel strip shall be manufactured to a fine grain (austenitic and ferritic) practice.

7.1.2 Pearlite is the normal structure of cold rolled high-carbon strip unless it has had an intermediate anneal.

7.2 *Decarburization:*

7.2.1 When specified, the steel strip shall have a maximum permissible depth of complete plus partial decarburization of 0.001 in. [0.025 mm] or 1.5 % of the thickness of the strip, whichever is greater, except that strip less than 0.011 in. [0.279 mm] thick shall show no complete decarburization.

7.3 Annealed is mostly a spheroidized structure, but may contain some vestiges of pearlite.

7.4 Spheroidized annealed is essentially free of pearlite.

7.5 At least one specimen shall be taken from each lot for microexamination.

7.5.1 The specimens shall be prepared for microscopic examination in accordance with Guide E3.

8. Mechanical Requirements

8.1 Unless otherwise specified in the applicable product specification, test specimens must be prepared in accordance with Test Methods and Definitions A370.

8.2 Mechanical tests shall be conducted in accordance with Test Methods and Definitions A370.

8.3 *Hardness:*

8.3.1 *Spheroidized Annealed and Annealed Types*—When furnished spheroidized annealed or annealed, the hardness of the strip shall not exceed the maximum values specified in Figs. 1 and 2 for the applicable carbon range and type.

8.3.2 *Intermediate Hardness Type*—When furnished as intermediate hardness, the hardness of the strip shall conform to the range specified on the purchase order. The maximum hardness limit and the corresponding minimum shall be specified by the purchaser. If the maximum temper is under Rockwell B 100 (15T93 or 30T82), that scale should be used exclusively. If the minimum temper is over Rockwell C 20 (15N69.5 or 30N41.5), that scale should be used exclusively. For accuracy in testing, the hardness scales should not overlap. On either hardness scale, a range of ten points arithmetic difference is required. Refer to Table 2 for appropriate scale testing requirements.

8.3.3 Full hard is specified to a minimum hardness value. Refer to Table 2 for appropriate scale testing requirements.

8.3.4 At least one specimen shall be taken from each lot.

8.3.5 The sample shall be tested in accordance with Test Methods and Definitions A370.

8.4 *Bend Test:*

8.4.1 The steel strip produced as spheroidized, or the annealed type shall meet the cold bend requirement in Table 3. Any visible cracking on the tension side of the bend portion shall be cause for rejection.

8.4.2 At least one specimen shall be taken from each lot.

8.4.3 The specimen shall be the full thickness and shall be taken transverse to the rolling direction as described in Test Methods and Definitions A370. The edges of the bend test specimens shall be rounded and free of burrs; filing or machining is permissible.

9. Dimensions, Mass, and Permissible Variations

9.1 The thickness, width, camber, and length tolerances shall conform to the requirements specified in Tables 5-10.

9.2 *Flatness*—It is not practical to formulate flatness tolerances for cold-rolled carbon spring steel strip to represent the range of widths and thicknesses in coils and cut lengths.