SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

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Categorization and Properties of SAE Cold Rolled Strip Steels

1. ***Scope***—This SAE recommended practice defines and establishes tolerances and attributes of cold rolled strip steels. Differences between cold rolled strip and cold rolled sheet products are discussed so that process designers can make informed material selection decisions.

1.1 Purpose—Cold rolled strip steels are produced to closer dimensional tolerances than cold rolled sheet steels. Cold rolled strip is commercially available over a wider range of thickness and chemical compositions. Cold rolled strip is also available with finishes, tempers and edges that differ from sheet products. Cold rolled strip steels are produced in sizes as follows in Table 1:

TABLE 1—DIMENSIONAL LIMITS FOR COLD ROLLED STRIP STEELS

Width, mm	Thickness, mm
12.5 to 600 mm	7.6 mm and under

Strip tolerance products are available in widths greater than 600 mm, however, these products are technically classified as sheet.

2. ***References***

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE and ASTM publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 19103.

SAE J403—Chemical Compositions of SAE Carbon Steels
SAE J404—Chemical Compositions of SAE Alloy Steels
SAE J409—Product Analysis—Permissible Variations from Specified Chemical Analysis of a Heat or Cast of Steel
SAE J911—Surface Texture Measurement of Cold Rolled Sheet Steel
SAE J2329—Categorization and Properties of Low Carbon Automotive Sheet Steels

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
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SAE WEB ADDRESS: http://www.sae.org

ASTM A109/A109M—Standard Specification for Steel, Strip, Carbon, Cold Rolled
ASTM E 430—Method for Measurement of Gloss of High Gloss Surfaces By Goniophotometry

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this specification.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1058—Standard Steel Sheet Thickness and Tolerances
SAE J1268—Hardenability Bands for Carbon and Alloy H Steels
SAE J2340—Categorization and Properties of Dent Resistant, High Strength, and Ultra High Strength Automotive Sheet Steel

2.2.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 682/A 682M—Standard Specification for Steel, Strip, High - Carbon, Cold - Rolled, Spring Quality, General Requirements For
ASTM A 684/A 684M—Standard Specification for Steel, Strip, High - Carbon, Cold Rolled

2.2.3 OTHER PUBLICATIONS—Available from ISS Book Sales, 410 Commonwealth Drive, Warrendale, PA 19103.

Steel Products Manual, Strip Steel; Carbon, High Strength Low Alloy, and Alloy; Iron and Steel Society Publication, February, 1995

3. Temper Designation

3.1 Low carbon cold rolled strip is often specified to standard tempers. Temper refers to the hardness, or strength of the steel. As hardness increases, formability decreases. In general, the degree of formability increases as the temper number increases, as indicated in Table 2.

TABLE 2—TEMPER DESIGNATORS: LOW CARBON COLD ROLLED STRIP STEELS

Temper Number	Temper Name	Thickness Under	Thickness Through	Hardness Minimum	Hardness Maximum	Approx. Tensile Strength (MPa)	Description
1	Hard	0.6	—	15T90	—	620 ± 70	Very hard and springy intended for flat work not requiring cold forming.
		1.0	0.6	30T76	—		
		1.8	1.0	B90	—		
		7.6	1.8	B84	—		
2	Half Hard	0.6	—	15T83.5	15T88.5	450 ± 70	Moderately hard and springy intended for limited bending defined as 90 degrees across the rolling direction around a radius equal to the thickness.
		1.0	0.6	30T63.5	30T73.5		
		7.6	1.0	B70	B85		
3	Quarter Hard	0.6	—	15T80	15T85	380 ± 70	Medium soft intended for limited amounts of bending, forming and drawing. May be bent 180 degrees across the rolling direction around a radius equal to the thickness.
		1.0	0.6	30T56	30T67		
		7.6	1.0	B60	B75		
4	Skin Rolled	0.6	—	—	15T82	330 ± 40	Soft and ductile intended for deep drawing. May be bent flat upon itself in any direction.
		1.0	0.6	—	30T60		
		7.6	1.0	—	B65		

TABLE 2—TEMPER DESIGNATORS: LOW CARBON COLD ROLLED STRIP STEELS (CONTINUED)

Temper Number	Temper Name	Thickness Under	Thickness Through	Hardness Minimum	Hardness Maximum	Approx. Tensile Strength (MPa)	Description
5	Dead Soft	0.6 1.0 7.6	— 0.6 1.0	— — —	15T78.5 30T53 B55	300 ± 40	Soft and ductile intended for deep drawing applications where stretcher straining and fluting is not objectionable.

3.2 Low carbon cold rolled strip is available in tempers other than standard by agreement between strip user and strip producer.

4. Chemical Composition

4.1 Cold rolled strip steels are produced from a wide range of hot band alloys. In general, cold rolled strip steel products may be produced from any grade of steel that is available for hot band substrate. With the exception of strip produced to standard tempers (hardness), other public specifications govern the applicable composition limits.

4.2 **Low Carbon Steel Specified To Temper—**When cold rolled strip is specified to a standard temper, chemical composition limits are given by Table 3.

TABLE 3—HEAT ANALYSIS COMPOSITION—WT %

Element	Temper Number 1, 2, 3	Temper Number 4, 5
Carbon, max.	0.25	0.15
Manganese, max.	0.60	0.60
Phosphorus, max.	0.025	0.025
Sulfur, max.	0.025	0.025

4.3 Carbon cold rolled strip steels are available in chemical compositions defined by SAE J403.

4.4 Alloy cold rolled strip steels are available in chemical compositions defined by SAE J404.

4.5 Cold rolled high strength low alloy strip steels are produced to chemical compositions defined by SAE J2340.

4.6 Fully stabilized cold rolled strip steels are available with chemical limits defined by SAE J2329, Grade 5.

4.7 Special chemical compositions and restricted versions of standard SAE grades are available subject to hot band substrate availability. Chemical analysis limits for these grades are defined by agreement between strip user and strip producer.

4.8 Permissible product analysis variations from specified ladle chemical analysis are defined in SAE J409.

5. Thickness Tolerances

5.1 Across the full range of nominal thickness, cold roll strip thickness tolerances range from 58% to 83% of the corresponding thickness tolerances for cold rolled sheet steels.

5.2 Standard cold rolled strip tolerances for carbon, alloy, high strength low alloy, fully stabilized and special alloy steels appear in Table 4.

5.3 Non standard tolerances, either wider or closer, may be specified subject to strip producer capabilities. Such tolerances are by agreement between strip user and strip producer.

TABLE 4—THICKNESS TOLERANCES OF COLD ROLLED STRIP STEELS(1)

Nominal Thickness (mm)	Width (mm) 12.5 to less than 300	Width (mm) 300 to less than 450	Width (mm) 450 to 600
6.40 - 7.60	0.080	0.090	0.100
4.00 - 6.39	0.065	0.080	0.090
3.20 - 3.99	0.055	0.070	0.080
1.80 - 3.19	0.045	0.055	0.070
1.00 - 1.79	0.035	0.045	0.060
0.75 - 0.99	0.030	0.040	0.050
0.50 - 0.74	0.025	0.035	0.040
0.38 - 0.49	0.020	0.025	0.030
0.25 - 0.37	0.013	0.020	0.025
<0.25	0.007	0.015	0.020

1. Measured 10 mm or more in from edge; and on narrower than 25 mm, at any place between edges. (plus and minus, mm)

6. Edges and Width Tolerances

6.1 Cold rolled strip may be specified with many different types of edge conditions produced by rolling, slitting or other mechanical means.

6.2 No. 1 Edge is a prepared edge of a specified contour (round or square), which is produced when a very accurate width is required, or when an edge condition suitable for electroplating is required, or both.

6.3 No. 2 Edge is a natural mill edge carried through the cold rolling from the hot rolled strip without additional processing of the edge.

6.4 No. 3 Edge is an approximately square edge produced by slitting on which the burr is not eliminated. This edge is most frequently specified for cold rolled strip steels.

6.5 No. 4 Edge is a rounded edge produced by edge rolling either the natural edge of hot rolled strip or slit strip edge. This edge is produced when the width tolerance and edge condition are not as exacting as for No. 1 edge.

6.6 No. 5 Edge is an approximately square edge produced from slit edge material on which the burr is eliminated usually by rolling or filing.

6.7 No. 6 Edge is a square edge produced by edge rolling the natural edge of hot rolled strip or slit edge strip. This edge is produced when the width tolerance and edge condition are not as exacting as for No. 1 edge.

6.8 Skived edges are custom shaped edges produced by mechanical edge shaving with special tools.

6.9 Some edges are not available over the entire range of cold rolled strip thickness and width.

6.10 Width tolerances for different edges are defined in ASTM A109/A109M.

7. Finish

7.1 Cold rolled strip steels are usually specified to one of the following finishes.

7.1.1 Number 1 or Matte (Dull) Finish is a finish without luster produced by rolling on rolls roughened by mechanical or other means. This finish is especially suitable for paint adhesion and may aid drawing by reducing contact friction between die and steel.

7.1.2 Number 2 or Regular Bright Finish is produced by rolling on moderately smooth rolls.

7.1.3 Number 2-1/2 or Better Bright finish is a smooth finish suitable for those plating applications where high luster is not required.

7.1.4 Number 3 or Best Bright finish is generally of high luster produced by special rolling practices, including the use of specially prepared rolls. It is the highest quality finish commonly produced and is particularly suited for bright plating. The production of this finish requires extreme care in processing and extensive inspection. Paper interleaving is frequently used for protection. In addition to the surface roughness values in Table 5, the user and producer may agree on goniophotometric measurement values (Rs/DI) as defined in ASTM E 430.

TABLE 5—TYPICAL SURFACE ROUGHNESS MEASUREMENT RANGES(1)(2)(3)

Surface	Microinches Maximum
Number 1 or Matte (Dull)	80 Ra
Number 2 or Regular Bright	20 Ra
Number 2-1/2 or Better Bright	10 Ra
Number 3 or Best Bright	4 Ra

1. Due to vagaries in measuring surface roughness, as well as the inherent variability in such rolled surfaces, these values are only typical, and values outside these ranges would not be considered unexpected.
2. Measured either parallel with or across the rolling direction.
3. Tested in accordance with SAE J911.

8. High Carbon and Alloy Cold Rolled Strip Steels

8.1 High carbon steels are those whose maximum specified carbon contents exceed 0.25 weight percent.

8.2 High carbon and alloy cold rolled strip steels are supplied as either untempered or as Hardened and Tempered. Untempered products are supplied as-produced; the end user will often heat treat the part after forming. Hardened and tempered strip is given a quench and temper heat treatment prior to shipment; the end user does not need to heat treat to achieve maximum strength.

8.3 Untempered high carbon and alloy cold rolled strip steels are supplied in four product types.

8.3.1 Spheroidized Annealed is intended for applications requiring maximum formability. It is normally produced to give the lowest maximum hardness for each carbon range. The microstructure of this type consists of spheroidal carbides in a matrix which is essentially free of pearlite.

8.3.2 Annealed is intended for applications requiring moderate cold forming. It is produced to a maximum hardness. The microstructure is mostly a spheroidal structure, but may contain some vestiges of pearlite.

8.3.3 Table 6 shows approximate relationships between steel grade and hardness for spheroidized annealed and annealed high carbon steels. Hardness limits for alloy steels are usually higher than the corresponding high carbon steel and are usually established by agreement between strip user and strip producer.

TABLE 6—APPROXIMATE RELATIONSHIP BETWEEN STEEL GRADE, ANNEALING TREATMENT AND HARDNESS FOR COLD ROLLED STRIP STEEL

	Grade	HR15T	HR30T	HRB
Annealed Steel				
	1035	86	68	78
	1045	87	70	80
	1050	87	71	82
	1055/1060	88	72	84
	1065	89	73	85
	1070	89	74	86
	1074	89	74	87
	1080	89	75	88
	1095	90	77	91
Spheriodized Annealed Steel				
	1035	85	66	75
	1045	86	68	77
	1050	86	69	79
	1055/1060	87	70	71
	1065	87	71	72
	1070	88	72	83
	1074	88	72	84
	1080	89	74	86
	1095	89	75	88

8.3.4 Full Hard high carbon and alloy strip steels are hard and springy steels intended for flat applications not requiring cold forming. Full hard is cold rolled, with or without preparatory treatment, to minimum hardness requirements. The prior treatment and amount of cold reduction are varied to produce hardness requirements as established by consumer and producer.

8.4 Hardened and Tempered Cold Rolled High Carbon and Alloy Strip

8.4.1 Hardened and tempered cold rolled high carbon steel strip is produced by continuously heat treating the metal resulting in very high strength and hardness.

8.4.2 Hardened and tempered cold rolled high carbon steel strip customarily has a carbon content over 0.55% and is commonly produced to meet a range of hardness as shown in Table 7. The minimum values for the ranges are normally higher than the maximum values obtainable by cold rolling.

TABLE 7—HARDNESS RANGES(1): HARDENED AND TEMPERED COLD ROLLED HIGH CARBON STEEL STRIP

Thickness, (mm)	Hardness Scale	Hardness Ranges (% Carbon 0.55 - 1.05)
Over 2.90 to 3.20 incl.	C	28 to 50
Over 2.50 to 2.90 incl.	C	29 to 51
Over 2.20 to 2.50 incl.	C	30 to 52
Over 1.80 to 2.20 incl.	C	31 to 53
Over 1.40 to 1.80 incl.	C	32 to 54
Over 0.90 to 1.40 incl.	C	33 to 55
Over 0.40 to 0.90 incl.	30N	53 to 73
Over 0.20 to 0.40 incl.	15N	80 to 87
Over 0.05 to 0.20(2) incl.	DPH	400 to 580

1. By common usage, a hardness range is the arithmetical difference between two limits (for example, HRc 42 to HRc 46 is a four point range). Typical range requirements appear in Table 8.
2. For thickness less than 0.200 mm, use of the tension test is recommended as an alternative to microhardness testing (DPH / Vickers).

TABLE 8—TYPICAL HARDNESS RANGES SPECIFIED FOR HARDENED AND TEMPERED COLD ROLLED HIGH CARBON STEEL STRIP

Hardness Scale	Specific Range
HRc	Any 4 points
HR30N	Any 4 points
HR15N	Any 3 points
DPH (Vickers)	Any 50 points

The specified range to be agreed upon between consumer and supplier.

8.4.3 The hardness scale applicable to each thickness range is shown in Table 9. Although conversion tables for hardness numbers are available, it is recommended that the hardness be specified in the same scale that is to be used in testing. A hardness range is typically specified using a 3, 4 or 5 - point range, based on the scale to be used and as agreed between consumer and producer. In the check testing of hardened and tempered steel strip, a tolerance of a half HRc point below the minimum and above the maximum of the range specified is commonly allowed to compensate for normal differences in testing equipment.

TABLE 9—HARDNESS SCALES FOR VARIOUS THICKNESSES: A GUIDE FOR SELECTION OF HARDNESS SCALES FOR HARDENED AND TEMPERED COLD ROLLED HIGH CARBON STEEL STRIP

Thickness mm	A Dial Reading	A C-Scale(1)	C Dial Reading	15N Dial Reading	15N C-Scale(1)	30N Dial Reading	30N C-Scale(1)	45N Dial Reading	45N C-Scale(1)
0.20	—	—	—	90	60	—	—	—	—
0.25	—	—	—	88	55	—	—	—	—
0.30	—	—	—	83	45	82	65	77	69.5
0.35	—	—	—	76	32	78.5	61	74	67
0.40	86	69	—	68	18	74	56	72	65
0.45	84	65	—	—	—	66	47	68	61
0.50	82	61.5	—	—	—	57	37	63	57
0.55	79	56	69	—	—	47	26	58	52.5
0.60	76	50	67	—	—	—	—	51	47
0.65	71	41	65	—	—	—	—	37	35
0.70	67	32	62	—	—	—	—	20	20.5
0.75	60	19	57	—	—	—	—	—	—
0.80	—	—	52	—	—	—	—	—	—
0.85	—	—	45	—	—	—	—	—	—
0.90	—	—	37	—	—	—	—	—	—
0.95	—	—	28	—	—	—	—	—	—
1.00	—	—	20	—	—	—	—	—	—

1. Approximate Hardness

8.4.4 Below a thickness of 0.2 mm., the HR15N test becomes inaccurate and the use of a tension test or microhardness test is recommended. The Diamond Pyramid Hardness (DPH) test, also known as Vickers, is typically specified for a stated indenter load using a 50 - point range. An ultimate tensile strength is usually specified with a 210 MPa range.

8.4.5 The desired mechanical properties for a given application are achieved by quenching and tempering to obtain the proper combination of hardness, toughness and formability. In the as-quenched condition, the steel lacks ductility and therefore is tempered using a lower temperature stress relief cycle. By varying the carbon and manganese content and the conditions of quenching and tempering, the required combination of strength, hardness, toughness and ductility can be produced.

8.4.6 The variation of hardness and ultimate tensile strength with carbon content and thicknesses for hardened and tempered cold rolled high carbon strip steel, heat treated to combinations of mechanical properties appropriate for spring applications, is shown in Tables 10A and 10B. Each ten point (0.10%) increase in carbon content is accompanied by an average increase of about two points HRc hardness and an equivalent increase in HR30N, HR15N, DPH, and ultimate tensile strength. The mechanical properties specified should be compatible with the fabricating requirements involved in making the part.

TABLE 10A—APPROXIMATE RELATIONSHIP BETWEEN THICKNESS, CARBON CONTENT, HARDNESS, AND UTS OF HARDENED AND TEMPERED STRIP FOR SPRING APPLICATIONS

Thickness (mm)	0.55% Carbon Hardness	0.55% Carbon UTS MPa (ksi)	0.65% Carbon Hardness	0.65% Carbon UTS MPa (ksi)	0.75% Carbon Hardness	0.75% Carbon UTS MPa (ksi)
0.15[1]	450	1650 (240)	475	1760 (255)	500	1860 (270)
0.25[2]	82.8	1620 (235)	84.0	1720 (250)	85.0	1830 (265)
0.40[2]	82.6	1600 (232)	83.8	1700 (247)	84.6	1810 (262)
0.50[3]	62.8	1570 (228)	64.8	1670 (243)	66.3	1780 (258)
0.65[3]	62.5	1550 (225)	64.4	1650 (240)	68.0	1760 (255)
0.75[3]	62.2	1530 (222)	64.0	1630 (237)	65.8	1740 (252)
0.90[3]	62.0	1520 (220)	63.7	1620 (235)	65.5	1720 (250)
1.00[4]	42.5	1500 (218)	44.5	1600 (232)	46.5	1700 (247)
1.25[4]	42.0	1480 (215)	44.0	1590 (230)	46.0	1690 (245)
1.50[4]	41.5	1460 (212)	43.5	1560 (227)	45.5	1690 (242)
1.75[4]	41.0	1440 (209)	43.0	1540 (224)	45.0	1650 (239)
2.00[4]	40.7	1420 (206)	42.7	1520 (221)	44.7	1630 (236)
2.25[4]	40.3	1400 (203)	42.3	1500 (218)	44.3	1610 (233)
2.50[4]	40.0	1380 (200)	42.0	1480 (215)	44.0	1590 (230)
2.75[4]	39.6	1360 (197)	41.6	1460 (212)	43.6	1560 (227)
3.00[4]	39.2	1340 (194)	41.2	1440 (209)	43.2	1540 (224)

1. For thicknesses less then 0.200 mm, use of the tension test is recommended as an alternative to microhardness testing (DPH/Vickers).
2. 15N Hardness Scale
3. 30N Hardness Scale
4. C-Scale