Designation: A 805 – 08

Standard Specification for Steel, Flat Wire, Carbon, Cold-Rolled[1]

This standard is issued under the fixed designation A 805; 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 Department of Defense.

1. Scope*

1.1 This specification covers carbon steel flat wire in coils or cut lengths. Flat wire is classified as a cold-rolled section, rectangular in shape, 0.500 in. [12.7 mm] or less in width and under 0.250 in. [6.35 mm] in thickness.

1.2 Low-carbon steel flat wire is produced from steel compositions with a maximum carbon content of 0.25 % by cast or heat analysis.

1.3 Carbon spring steel flat wire is produced to a carbon range in which the specified or required maximum is over 0.25 % by cast or heat analysis.

1.3.1 Two types of carbon spring steel flat wire are produced:

1.3.1.1 Untempered cold-rolled carbon spring steel flat wire, produced to several desirable combinations of properties and

1.3.1.2 Hardened and tempered carbon spring steel wire.

1.4 Definite application flat wire is a product developed for a specific application and may be specified only by size and descriptive name.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 510 Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

E 45 Test Methods for Determining the Inclusion Content of Steel

E 112 Test Methods for Determining Average Grain Size

E 140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness

2.2 *Military Standard:*[3]

MIL-STD-129 Marking for Shipment and Storage

2.3 *Federal Standard:*[3]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

2.4 *SAE Standard:*[4]

Recommended Practice SAE J 419 Methods of Measuring Decarburization

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *annealing*—the process of heating to and holding at a suitable temperature and then cooling at a suitable rate, for such purposes as reducing hardness, facilitating cold working, producing a desired microstructure, or obtaining desired mechanical, physical, or other properties.

3.1.2 *batch annealing*—annealing that is generally performed in large cylindrical bell type or large rectangular box or car-type furnaces. The product is protected from scaling and decarburization by the use of a controlled atmosphere that envelops the charge in an inner chamber sealed to prevent the influx of air or products of combustion. The coils or bundles are heated to a temperature in the vicinity of the lower critical temperature for the grade of steel, and held at that temperature for a definite length of time; after which the steel is allowed to cool slowly to room temperature. The time of holding at the annealing temperature varies with the grade of the steel and the desired degree of softness.

3.1.3 *continuous or strand annealing*—annealing that consists of passing a number of individual strands of flat wire continuously through either a muffle furnace or a bath of molten lead or salt, thus heating the flat wire to the desired temperature for a definite time. The hardness obtained by this

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

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

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

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type of annealing, as measured by Rockwell hardness number, is normally somewhat higher than is secured by batch-type annealing. Other characteristics peculiar to strand–annealed steel require this type of annealing for some flat wire products.

3.1.4 *salt annealing*—annealing that is accomplished by immersing bundles or coils of flat wire in a molten salt bath at a desired temperature for a definite time. Following the annealing, the coils are permitted to cool slowly, after which they are immersed in hot water to remove any adhering salts.

3.1.5 *spheroidize annealing*—an operation consisting of prolonged heating and prolonged cooling cycles to produce a globular or spheroidal condition of the carbide for maximum softness.

3.1.6 *cold reduction*—the process of reducing the thickness of the strip at room temperature. The amount of reduction is greater than that used in skin-rolling.

3.1.7 *finish*—the degree of smoothness or lustre of the flat wire. The production of specific finishes requires special preparation and control of the roll surfaces employed.

3.1.8 *hardening and tempering*—a heat treatment for steel over 0.25 % carbon by cast or heat analysis involving continuous strand heating at finish size to an appropriate temperature above the critical temperature range, followed by quenching in oil and finally passing the strands through a tempering bath. This heat treatment is used in the production of such commodities as oil-tempered spring wire for use in certain types of mechanical springs that are not subjected to a final heat treatment after forming. Oil-tempered wire is intended primarily for the manufacture of products that are required to withstand high stresses. The mechanical properties and resiliency of oil-tempered wire provide resistance to permanent set under repeated and continuous stress applications.

3.1.9 *patenting*—a thermal treatment usually confined to steel over 0.25 % carbon. In this process individual strands of rods or wire are heated well above the upper critical temperature followed by comparatively rapid cooling in air, molten salt, or molten lead. This treatment is generally employed to prepare the material for subsequent processing.

3.1.10 *skin-rolled*—a term denoting a relatively light cold-rolling operation following annealing. It serves to reduce the tendency of the steel to flute or stretcher strain during fabrication. It is also used to impart surface finish, or affect hardness or other mechanical properties.

3.1.11 *temper*—a designation by number to indicate the hardness as a minimum, as a maximum, or as a range. The tempers are obtained by the selection and control of chemical composition, by amounts of cold reduction, and by thermal treatment.

4. Ordering Information

4.1 Orders for material to this specification shall include the following information, as necessary, to describe adequately the desired product:

4.1.1 Quantity,
4.1.2 Name of material (flat wire identified by type),
4.1.3 Analysis or grade, if required (Section 6),
4.1.4 Temper of low carbon or type of spring steel (Sections 9, 10, and 11),
4.1.5 Edge (Section 7),
4.1.6 Finish or coating (Sections 14 and 12),
4.1.7 Dimensions,
4.1.8 Coil type and size requirements (Section 17),
4.1.9 Packaging (17.1),
4.1.10 Condition (oiled or not oiled) (14.4),
4.1.11 ASTM designation and date of issue,
4.1.12 Copper-bearing steel, if required,
4.1.13 Application (part identification or description),
4.1.14 Case or heat analysis (request, if desired), and
4.1.15 Exceptions to the specification, if required.

NOTE 1—A typical ordering description is as follows: 18 000 lb Low-Carbon Cold-Rolled Carbon Steel Flat Wire, Temper 4, Edge 4, Finish 2, 0.125 by 0.450-in. vibrated coils, 2000 lb max, coil weight, 16 to 20 in. ID, 36 in. max OD, Face dimension 6 to 10 in., ASTM A 805 – XX, for Stove Frames.

5. Materials and Manufacture

5.1 Low-carbon steel flat wire is normally produced from rimmed, capped, or semi-killed steel. When required, killed steel may be specified, with silicon or aluminum as the deoxidizer.

5.2 Untempered-carbon spring steel flat wire is commonly produced from killed steel, although semi-killed steel is sometimes used.

5.3 Hardened and tempered carbon spring steel flat wire customarily has a carbon content over 0.60 %.

5.4 Flat wire is generally produced from hot-rolled rods or round wire, by one or more cold-rolling operations, primarily for the purpose of obtaining the size and section desired and for improving surface finish, dimensional accuracy, and varying mechanical properties. Flat wire can also be produced from slitting hot- or cold-rolled flat steel to the desired width. The hot-rolled slit flat steel is subsequently cold reduced. The width to thickness ratio and the specified type of edge generally determine the process that is necessary to produce a specific flat-wire item.

5.5 The production of good surface quality flat wire is dependent upon scale-free and clean wire, rod, or hot-rolled steel prior to cold-rolling. Scale removal can be accomplished by chemical or mechanical cleaning.

5.6 Edge rolls, machined with contour grooves, may be used in conjunction with flat-rolling passes to produce the desired edge shape.

5.7 Straightness in flat wire may be controlled by the use of roll straighteners alone or in conjunction with cold-rolling passes.

5.8 Edges of flat wire produced by slitting wider flat-rolled steel can be dressed, depending upon requirements by:

5.8.1 *Deburring*—A process by which burrs are removed by rolling or filing to obtain an approximate square edge;

5.8.2 *Rolling*—A process by which the slit edge is dressed by edge rolling to the desired contour; and

5.8.3 *Filing*—A process by which the slit edge is filed to a specific contour and dimension by passing one or more times against a series of files mounted at various angles.

6. Chemical Composition

6.1 *Limits*:

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6.1.1 When carbon steel flat wire is specified to chemical composition, the compositions are commonly prepared using the ranges and limits shown in Table 1. The elements comprising the desired chemical composition are specified in one of three ways:

6.1.1.1 By a maximum limit, Tables 2-5

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 When carbon steel flat wire is produced from round rods or wire it may be designated by grade number. In such cases the chemical ranges and limits of Table 6, Table 7, Table 8, and Table 9 of Specification A 510 shall apply.

6.2 *Cast or Heat Analysis*:

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

6.2.2 When requested, cast or heat analysis for elements listed or required shall be reported to the purchaser or his representative.

6.3 *Product Analysis* may be made by the purchaser on the finished material.

6.3.1 Capped or rimmed steels are not technologically suited to product analysis due to the nonuniform character of their chemical composition and, therefore, the tolerances in Table 2 do not apply. Product analysis is appropriate on these types of steel only when misapplication is apparent, or for copper when copper steel is specified.

6.3.2 For steels other than rimmed or capped, when product analysis is made by the purchaser, the chemical analysis shall not vary from the limits specified by more than the amounts in Table 2. The several determinations of any element shall not vary both above and below the specified range.

6.3.3 When flat wire is produced from round rods or wire, and when a grade number is used to specify the chemical composition, the values obtained on a product analysis shall not vary from the limits specified by more than the amounts in Table 10 of Specification A 510.

6.4 For referee purposes, if required, Test Methods, Practices and Terminology A 751 shall be used.

TABLE 1 Cast or Heat Analysis

Element	Standard Chemical Ranges and Limits, %	
	When Maximum of Specified Element is	Range
Carbon[A]		
	to 0.15 incl	0.05
	over 0.15 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
Phosphorus[B]		
	to 0.08 incl	0.03
	over 0.08 to 0.15 incl	0.05
Sulfur[B]		
	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[C]		
	to 0.15 incl	0.08
	over 0.15 to 0.30 incl	0.15
	over 0.30 to 0.60 incl	0.30
Copper		
	When copper is required 0.20 minimum is commonly specified.	. . .

[A] *Carbon*—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.

[B] *Phosphorus and Sulfur*—The standard lowest maximum limits for phosphorus and sulfur are 0.030 % and 0.035 % respectively. Certain qualities, descriptions, or specifications are furnished to lower standard maximum limits.

[C] *Silicon*—The standard lowest maximum for silicon is 0.10 %.

TABLE 2 Tolerances for Product Analysis[A]

Element	Limit, or Maximum of Specified Element, %	Tolerance, %	
		Under Minimum Limit	Over Maximum Limit
Carbon	to 0.15 incl	0.02	0.03
	over 0.15 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 incl	0.05	0.05
Copper	. . .	0.02	. . .

[A] When produced from round wire or rod the producer may use the tolerances for product analysis that appear in Specification A 510 (see 6.3.3).

TABLE 3 Thickness Tolerances

Specified Thickness in. [mm]	Tolerances for Specified Thickness, Plus and Minus, in. [mm]
0.005 [0.13] to 0.010 [0.25], excl	0.0005 [0.013]
0.010 [0.25] to 0.029 [0.74], excl	0.001 [0.03]
0.029 [0.74] to 0.0625 [1.59], excl	0.0015 [0.04]
0.0625 [1.59] to 0.250 [6.35], excl	0.002 [0.05]

7. Edge

7.1 The desired edge shall be specified as follows:

7.1.1 *Number 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 the finish of the edge suitable for electroplating is required, or both.

7.1.2 *Number 2 Edge* is not applicable to flat wire products.

7.1.3 *Number 3 Edge* is an approximately square edge produced by slitting.

7.1.4 *Number 4 Edge* is a rounded edge produced either by edge rolling or resulting from the flat rolling of a round section. Width tolerance and edge condition are not as exacting as for a No. 1 Edge.

7.1.5 *Number 5 Edge* is an approximately square edge produced from slit–edge material on which the burr is eliminated by rolling or filing.

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TABLE 4 Tolerances (Plus and Minus) for Specified Width

Edge Number	Specified Width, in. [mm]	Specified Thickness, in. [mm]		
		Under 0.0625 [1.60]	0.0625 [1.59] to 0.126 [3.20] excl	0.126 [3.20] to 0.250 [6.35] excl
1	Under 0.0625 [1.60]	0.003 [0.08]	. . .	. . .
	0.0625 [1.60] to 0.126 [3.20] excl	0.004 [0.10]	0.004 [0.10]	. . .
	0.126 [3.20] to 0.500 [12.70] incl	0.005 [0.13]	0.005 [0.13]	0.005 [0.13]
4 and 6	Under 0.0625 [1.60]	0.006 [0.15]	. . .	. . .
	0.0625 [1.60] to 0.126 [3.20] excl	0.008 [0.20]	0.008 [0.20]	. . .
	0.126 [3.20] to 0.500 [12.70] incl	0.010 [0.25]	0.010 [0.25]	0.010 [0.25]
3 and 5	0.125 [3.18] to 0.500 [12.70] incl	0.005 [0.13]	0.008 [0.02]	. . .

TABLE 5 Length Tolerances

Specified Length, in. [mm]	Tolerances Over the Specified Length in. [mm]—No Tolerance Under
24 [600] to 60 [1500], incl	1/4 [6.4]
Over 60 [1500] to 120 [3000], incl	1/2 [12.7]
Over 120 [3000] to 240 [6100], incl	3/4 [19.1]

7.1.6 *Number 6 Edge* is a square edge produced by edge rolling when the width tolerance and edge condition are not as exacting as for No. 1 Edge.

8. Dimensional Tolerances

8.1 The dimensional tolerances shall be in accordance with the following:

Tolerances	Table Number
Thickness	3
Width	4
Length	5

8.2 If restricted tolerances closer than those shown in Table 3, Table 4, and Table 5 are required, the degree of restriction should be established between the purchaser and manufacturer.

8.3 Tolerances for camber should be established between the purchaser and manufacturer. Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straight edge.

9. Temper and Bend Test Requirement for Low-Carbon Steel Flat Wire

9.1 Low-carbon steel flat wire specified to temper numbers shall approximate the hardness or tensile strength values shown in Table 6.

9.2 Bend test specimens shall stand being bent at room temperatures as required in Table 7.

9.3 All mechanical tests are to be conducted in accordance with Test Methods and Definitions A 370.

10. Types of Untempered-Carbon Spring Steel Flat Wire

10.1 The following types are produced:

10.1.1 *Hard-Type Carbon Spring Steel Flat Wire* is a very stiff, springy product intended for flat work not requiring ability to withstand cold forming. It is cold reduced with or without preparatory treatment to a minimum Rockwell value of B 98.

10.1.2 *Soft-Type Spring Steel Flat Wire* is intended for application where varying degrees of cold forming are encountered, that necessitates control of both carbon content and hardness. Maximum values for carbon vary from 0.25 to 1.35 %, inclusive. This type also involves one of the following hardness restrictions; a maximum only designated as "soft-type annealed" or a range only designated as "soft-type intermediate hardness."

10.1.2.1 *Soft-Type Annealed Carbon Spring Steel Flat Wire*, intended for moderately severe cold forming, is produced to a specific maximum hardness value. The final anneal is at the finish thickness. Lowest maximum expected hardness values or tensile strength for specific carbon maximums for steel to 0.90 % maximum manganese are shown in Table 8.

10.1.2.2 *Soft-Type Intermediate Carbon Spring Steel Flat Wire* is produced to a specified hardness range, somewhat higher than the category covered in 10.1.2.1. The product is produced by rolling after annealing or by varying the annealing treatment, or both.

10.1.2.3 The Rockwell hardness range which can be produced varies with the carbon content, the required hardness, and the thickness of the material. In Table 9, Table 10, and Table 11 are shown the applicable hardness ranges for various carbon contents and several thickness ranges. If hardness values other than those shown in the tables are required, the applicable ranges should be agreed upon between the purchaser and the manufacturer. Rockwell hardness range is the arithmetical difference between two limits (for example B 82 to B 90 is an eight–point range).

10.1.3 *Spheroidize-Type Carbon Spring Steel Flat Wire* is best suited for the severest cold-forming application, where heat treatment after forming is employed. Spheroidize annealing treatment is employed in its production. Lowest maximum expected hardness values by carbon maximums for steel to 0.90 % maximum manganese are shown in Table 12. For thicknesses under 0.025 in. [0.64 mm] the values for the "Soft-Type Annealed" as contained in Table 8 shall apply.

11. Hardness and Tensile Properties of Hardened and Tempered Carbon Spring Steel Flat Wire

11.1 This product is commonly produced to meet a range of Rockwell hardness as shown in Table 13.

11.2 The hardness scale appropriate to each thickness range is shown in Table 14. Although conversion tables for hardness numbers are available, the recommended practice is to specify the same scale as that to be used in testing. A Rockwell hardness range is the arithmetic difference between two limits

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TABLE 6 Temper, Hardness and Tensile Strength Requirement for Low-Carbon Steel Flat Wire

Temper	Thickness, in. [mm]	Rockwell Hardness		Approximate Tensile Strength, ksi [MPa]	
		min	max (approximate	min	max
No. 1 (hard)	Under 0.010 [0.25]			85 [586]	. . .
	0.010 [0.25] to 0.025 [0.64] excl	15T90	. . .		
	0.025 [0.64] to 0.040 [1.02] excl	30T76	. . .		
	0.040 [1.02] to 0.070 [1.78] excl	B90	. . .		
	0.070 [1.78] and over	B84	. . .		
No. 2 (half-hard)	Under 0.010 [0.25]			65 [448]	90 [621]
	0.010 [0.25] to 0.025 [0.64] excl	15T83.5	15T88		
	0.025 [0.64] to 0.040 [1.02] excl	30T63.5	30T74		
	0.040 [1.02] and over	B70	B85		
No. 3 (quarter-hard)	Under 0.010 [0.25]			55 [379]	80 [552]
	0.010 [0.25] to 0.025 [0.64] excl	15T80	15T85		
	0.025 [0.64] to 0.040 [1.02] excl	30T56.5	30T67		
	0.040 [1.02] and over	B60	B75		
No. 4 (skin-rolled)	Under 0.010 [0.25]			. . .	65 [448]
	0.010 [0.25] to 0.025 [0.64] excl	. . .	15T82		
	0.025 [0.64] to 0.040 [1.02] excl	. . .	30T60		
	0.040 [1.02] and over	. . .	B65		
No. 5 (dead-soft)	Under 0.010 [0.25]			. . .	60 [414]
	0.010 [0.25] to 0.025 [0.64] excl	. . .	15T78.5		
	0.025 [0.64] to 0.040 [1.02] excl	. . .	30T53		
	0.040 [1.02] and over	. . .	B55		

TABLE 7 Temper and Bend Test Requirement for Low-Carbon Steel Flat Wire

Temper	Bend Test Requirement
No. 1 (hard)	Not required to make bends in any direction.
No. 2 (half-hard)	Bend 90° across[A] the direction of rolling around a radius equal to that of the thickness.
No. 3 (quarter-hard)	Bend 180° across[A] the direction of rolling over one thickness of the wire.
No. 4 (skin-rolled)	Bend flat upon itself in any direction.
No. 5 (dead-soft)	Bend flat upon itself in any direction.

[A] To bend "across the direction of rolling" means that the bend axis (crease of the bend) shall be at a right angle to the length of the wire.

(for example C 42 to C 46 is a four-point range). Below a thickness of 0.008 in. [0.20 mm] the Rockwell 15N test becomes inaccurate, and the use of the tensile test is recommended. The values of ultimate tensile strength cited in Fig. 1 apply only to thicknesses less than 0.008 in. [0.20 mm]. When necessary to specify tensile properties for thicknesses of 0.008 in. [0.20 mm] and greater, the manufacturer should be consulted.

11.3 Shown in Fig. 1 is the relationship of thickness and carbon content with Rockwell hardness or tensile strength for hardened and tempered spring steel flat wire appropriate for spring applications. When mechanical properties are specified, they should be compatible with the application.

12. Coatings

12.1 Low-carbon steel flat wire can be produced with various coatings, such as liquor finish, white-liquor finish, lacquer, paint, copper, zinc (galvanized), cadmium, chromium, nickel, and tin. Metallic coatings can be applied by the hot-dip method or by electrodeposition. The flat steel can be coated prior to slitting to wire widths. In this case the slit edges will not be coated.

12.1.1 Copper or liquor coatings consist of thin deposits of either copper or bronze produced by immersion of the material in an acid solution of metallic salts. Because of the nature of liquor coatings no appreciable corrosion protection is afforded by them.

12.1.2 Hot-dipped coatings are produced by passing strands of cleaned flat wire continuously through a molten bath of metal or alloy. Zinc and tin are commonly applied in this manner.

12.1.3 Electrodeposited coatings are produced by passing strands of cleaned flat wire through an electroplating tank containing a solution of a metallic salt, wherein the metal is deposited on the flat wire. Zinc, tin, nickel, cadmium, and copper are applied in this manner.

12.2 Coatings applicable to untempered-carbon spring steel flat wire are the same as those covered in 14.1.

12.3 Metallic coatings are seldom applied to hardened and tempered carbon steel flat wire. If they are required the manufacturer should be consulted.

13. Workmanship

13.1 Cut lengths shall have a workmanlike appearance and shall not have defects of a nature or degree for the product, the grade, and the quality ordered that will be detrimental to the fabrication of the finished part.

13.2 Coils may contain more frequent imperfections that render a portion of the coil unusable since the inspection of coils does not afford the manufacturer the same opportunity to remove portions containing imperfections as in the case with cut lengths.

14. Finish and Condition

14.1 The finish of low-carbon steel flat wire normally specified is one of the following:

14.1.1 *Number 2 or Regular Bright Finish* is produced by rolling on rolls having a moderately smooth finish. It is not generally applicable to plating.

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TABLE 8 Soft-Type Annealed Carbon Spring Steel Flat Wire Lowest Expected Maximum Rockwell Hardness or Tensile Strength

Maximum of Carbon Range, %	Flat Wire Thickness, in. [mm]			
	Under 0.010 [0.25]	0.010 [0.25] to 0.025 [0.64] excl	0.025 [0.64] to 0.040 [1.02] excl	0.040 [1.02] and Over
	Tensile Strength ksi [MPa]	Rockwell Hardness, 15T Scale	Rockwell Hardness, 30T Scale	Rockwell Hardness, B Scale
0.30	66 [455]	84	67	74
0.35	68 [469]	84	68	76
0.40	70 [483]	85	70	78
0.45	72 [496]	85	71	80
0.50	74 [510]	86	72	82
0.55	76 [524]	87	73	84
0.60	78 [538]	87	74	85
0.65	80 [552]	88	75	87
0.70	82 [565]	88	76	88
0.75	83 [572]	88	76	89
0.80	85 [586]	89	77	90
0.85	87 [600]	89	77	91
0.90	88 [607]	89	78	92
0.95 and over	90 [621]	90	78	92

TABLE 9 Rockwell Hardness Ranges for Soft-Type Intermediate Hardness Carbon Spring Steel Flat Wire Thickness Under 0.025 in. [0.64 mm]

Maximum of Carbon Range, %	For Maximum of Specified Rockwell Hardness Range, 15T Scale													
	83.5	84.5	85	85.5	86	86.5	87	87.5	88	88.5	89	89.5	90/92	Over 92[A]
0.26–0.30[B]	. . .	5	5	5	5	5	4	4	4	4	4	4	3	. . .
0.31–0.35[B]	. . .	. . .	5	5	5	5	4	4	4	4	4	4	3	. . .
0.36–0.40[B]	. . .	. . .	. . .	5	5	5	4	4	4	4	4	4	3	. . .
0.41–0.45[B]	. . .	. . .	. . .	. . .	5	5	4	4	4	4	4	4	3	. . .
0.46–0.50[B]	. . .	. . .	. . .	. . .	. . .	5	4	4	4	4	4	4	3	3
0.51–0.55[B]	. . .	. . .	. . .	. . .	. . .	. . .	4	4	4	4	4	4	3	3
0.56–0.60[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	4	4	4	4	3	3
0.61–0.65[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	4	4	4	3	3
0.66–0.70[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	4	4	3	3
0.71–0.75[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	4	4	3	3
0.76–0.80[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	4	3	3
0.81–0.90[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	3	3
0.91–1.35	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3	3

[A] Rockwell 15T Scale is not recommended for values over 15T93.
[B] Indicates soft-type annealed cold-rolled carbon spring steel flat wire which is furnished to a maximum (hardness) shown in Table 8.

TABLE 10 Rockwell Hardness Ranges for Soft-Type Intermediate Hardness Carbon Spring Steel Flat Wire Thickness 0.025 to 0.040 in. [0.64 to 1.02 mm] excl

Maximum of Carbon Range, %	For Maximum of Specified Rockwell Hardness Range, 30T Scale														
	66.5	68	69.5	70.5	71.5	72.5	73.5	74.5	75.5	76	76.5	77.5	78	78.5/80.5	Over 80.5[A]
	Rockwell Hardness Range														
0.26–0.30[B]	. . .	8	8	6	6	6	6	6	6	5	5	5	5	4	. . .
0.31–0.35[B]	. . .	. . .	8	6	6	6	6	6	6	5	5	5	5	4	. . .
0.36–0.40[B]	. . .	. . .	. . .	6	6	6	6	6	6	5	5	5	5	4	. . .
0.41–0.45[B]	. . .	. . .	. . .	. . .	6	6	6	6	6	5	5	5	5	4	. . .
0.46–0.50[B]	. . .	. . .	. . .	. . .	. . .	6	6	6	6	5	5	5	5	4	4
0.51–0.55[B]	. . .	. . .	. . .	. . .	. . .	. . .	6	6	6	5	5	5	5	4	4
0.56–0.60[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6	6	5	5	5	5	4	4
0.61–0.65[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6	5	5	5	5	4	4
0.66–0.70[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5	5	5	5	4	4
0.71–0.75[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5	5	5	4	4
0.76–0.80[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5	5	4	4
0.81–0.90[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5	4	4
0.91–1.35[B]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4	4

[A] Rockwell 30T Scale is not recommended for values over 30T83.
[B] Indicates soft-type annealed cold-rolled carbon spring steel flat wire which is furnished to a maximum hardness as shown in Table 8.

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TABLE 11 Rockwell Hardness Ranges for Soft-Type Intermediate Hardness Carbon Spring Steel Flat Wire Thickness 0.040 in. [1.02 mm] and Over

Maximum of Carbon Range, %	For Maximum of Specified Rockwell Hardness Range, B Scale														
	74	76	78	80	82	83.5	85	86.5	88	89	90	91	92	93/97	Over 97[A]
0.26–0.30[B]	...	12	12	10	10	10	10	10	10	8	8	8	8	6	...
0.31–0.35[B]	...	...	12	10	10	10	10	10	10	8	8	8	8	6	...
0.36–0.40[B]	...	...	...	10	10	10	10	10	10	8	8	8	8	6	...
0.41–0.45[B]	...	...	...	...	10	10	10	10	10	8	8	8	8	6	...
0.46–0.50[B]	...	...	...	...	...	10	10	10	10	8	8	8	8	6	...
0.51–0.55[B]	...	...	...	...	...	...	10	10	10	8	8	8	8	6	...
0.56–0.60[B]	...	...	...	...	...	...	...	10	10	8	8	8	8	6	...
0.61–0.65[B]	...	...	...	...	...	...	...	...	10	8	8	8	8	6	5
0.66–0.70[B]	...	...	...	...	...	...	...	...	...	8	8	8	8	6	5
0.71–0.75[B]	...	...	...	...	...	...	...	...	...	...	8	8	8	6	5
0.76–0.80[B]	...	...	...	...	...	...	...	...	...	...	...	8	8	6	5
0.81–0.90[B]	...	...	...	...	...	...	...	...	...	...	...	...	8	6	5
0.91–1.35[B]	...	...	...	...	...	...	...	...	...	...	...	...	...	6	5

[A] Rockwell B Scale is not recommended for values over B 100.
[B] Indicates soft-type annealed cold-rolled carbon spring steel flat wire which is furnished to a maximum hardness as shown in Table 8.

TABLE 12 Spheroidize Type Carbon Spring Steel Flat Wire Lowest Expected Maximum Rockwell Hardness

Maximum of Carbon Range, %	Flat Wire Thickness, in. [mm]	
	0.025 [0.64] to 0.040 [1.02] excl	0.040 [1.02] and Over
	Rockwell Hardness, 30T Scale	Rockwell Hardness, B Scale
0.30	63	68
0.35	65	70
0.40	66	72
0.45	67	74
0.50	68	77
0.55	69	78
0.60	70	80
0.65	71	82
0.70	72	83
0.75	73	84
0.80	73	86
0.85	74	87
0.90	75	87
0.95 and over	75	88

14.1.2 *Number 3 or Best Bright Finish* is generally of high lustre produced by selective-rolling practices, including the use of specially prepared rolls. Number 3 finish is the highest quality finish produced and is particularly suited for electroplating. The production of this finish requires extreme care in processing and extensive inspection.

14.2 Untempered-carbon spring steel flat wire is commonly supplied in a Number 2 regular bright finish, as in 14.1.1. The manufacturer should be consulted if another finish is required.

14.3 Hardened and tempered spring steel flat wire is usually supplied in one of the following recognized finishes:

14.3.1 *Black-tempered*,

14.3.2 *Scaleless-tempered*,

14.3.3 *Bright-tempered*,

14.3.4 *Tempered and polished*,

14.3.5 *Tempered, polished, and colored* (*blue or straw*), and

14.4 *Oiled*.

14.4.1 Unless otherwise specified, flat wire is coated with oil to minimize scratching and to retard rusting in transit. If the product is not to be oiled, it must be so specified.

15. Inspection

15.1 When the purchaser's order stipulates that inspection and tests (except product analysis) for acceptance on the steel be made prior to shipment from the mill, the manufacturer shall afford the purchaser's inspector all reasonable facilities to satisfy him that the steel is being produced and furnished in accordance with the specification. Mill inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operation.

16. Rejection and Rehearing

16.1 Unless otherwise specified, any rejection shall be reported to the manufacturer within a reasonable time after receipt of material by the purchaser.

16.2 Material that is reported to be defective subsequent to the acceptance at the manufacturer's works shall be set aside, adequately protected, and correctly identified. The manufacturer shall be notified as soon as possible so that an investigation may be initiated.

16.3 Samples that are representative of the rejected material shall be made available to the manufacturer. In the event that the manufacturer is dissatisfied with the rejection, he may request a rehearing.

17. Packaging and Package Marking

17.1 Flat wire is prepared for shipment in a number of ways. The material may be bare, paper or burlap wrapped, boxed, skidded or palletized, skidded and shrouded, palletized and shrouded, barrelled, or a combination thereof. The purchaser should specify the method desired.

17.2 When coils are ordered it should be specified whether a ribbon or tape wound or a vibrated coil is desired. Since coil diameters and weights vary by the manufacturers, the manufacturer should be consulted for specific capability and limitations. When coil weight is specified for low-carbon steel flat wire or for untempered-carbon spring steel flat wire, it is common practice to ship not more than 10 % of the total weight of an item in short coils, which are those weighing between 25 and 75 % of the maximum coil weight.

17.3 For flat wire in cut lengths, when the specified length is over 36 in. [915 mm], it is permissible to ship up to 10 % of

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TABLE 13 Hardened- and Tempered-Carbon Spring Steel Flat Wire Rockwell Hardness Ranges

NOTE 1— A Rockwell hardness range is the arithmetic difference between two limits (for example, C 42 to C 46 is a four-point range). It is customary to specify Rockwell range requirements within the above ranges for each grade of hardened and tempered carbon spring steel flat wire in accordance with the following:

Rockwell Hardness Scale	Specified Range
C	Any 4 points
30N	Any 4 points
15N	Any 3 points

Thickness in. [mm]	Rockwell Scale	Maximum of Carbon Range, %						
		0.75	0.80	0.85	0.90	0.95	1.00	1.05
		Rockwell Hardness Ranges						
Over 0.005 [0.13] to 0.015 [0.38], incl	15N	78–84	80.5–84.5	81–85	81.5–85.5	82–86	82.5–86.5	83–87
Over 0.015 [0.38] to 0.035 [0.89], incl	30N	57–68	62–69	63–70	64–71	64.5–71.5	65–72	66–73
Over 0.035 [0.89] to 0.055 [1.40], incl	C	37–49	42–50	43–51	44–52	45–53	46–54	47–55
Over 0.055 [1.40] to 0.070 [1.78], incl	C	36–48	41–49	42–50	43–51	44–52	45–53	46–54
Over 0.070 [1.78] to 0.085 [2.16], incl	C	35–47	40–48	41–49	42–50	43–51	44–52	45–53
Over 0.085 [2.16] to 0.100 [2.54], incl	C	34–46	39–47	40–48	41–49	42–50	43–51	44–52
Over 0.100 [2.54] to 0.115 [2.92], incl	C	33–45	38–46	39–47	40–48	41–49	42–50	43–51
Over 0.115 [2.92] to 0.125 [3.17], incl	C	32–44	37–45	38–46	39–47	40–48	41–49	42–50

TABLE 14 Rockwell Hardness Scales for Various Thicknesses (A Guide for Selection of Scales Using the Diamond Penetrator Hardened and Tempered Cold-Rolled Carbon Spring Steel)

NOTE 1—For a given thickness, any hardness greater than that corresponding to that thickness can be tested. For a given hardness, material of any greater thickness than that corresponding to that hardness can be tested on the indicated scale.

Thickness, in. [mm]	Rockwell Scale								
	A		C	15N		30N		45N	
	Dial Reading	Approximate Hardness C-Scale[A]	Dial Reading	Dial Reading	Approximate Hardness C-Scale[A]	Dial Reading	Approximate Hardness C-Scale[A]	Dial Reading	Approximate Hardness C-Scale[A]
0.008[B] [0.20]	...	...	...	90	60	...	...	...	...
0.010 [0.25]	...	...	...	88	55	...	...	...	...
0.012 [0.30]	...	...	...	83	45	82	65	77	69.5
0.014 [0.36]	...	...	...	76	32	78.5	61	74	67
0.016 [0.41]	86	69	...	68	18	74	56	72	65
0.018 [0.46]	84	65	...	...	...	66	47	68	61
0.020 [0.51]	82	61.5	...	...	...	57	37	63	57
0.022 [0.56]	79	56	69	...	...	47	26	58	52.5
0.024 [0.71]	76	50	67	...	...	...	...	51	47
0.026 [0.66]	71	41	65	...	...	...	...	37	35
0.028 [0.71]	67	32	64	...	...	...	...	20	20.5
0.030 [0.76]	60	19	57	...	...	...	...	...	...
0.032 [0.81]	...	...	52	...	...	...	...	...	...
0.034 [0.86]	...	...	45	...	...	...	...	...	...
0.036 [0.91]	...	...	37	...	...	...	...	...	...
0.038 [0.97]	...	...	28	...	...	...	...	...	...
0.040 [1.02]	...	...	20	...	...	...	...	...	...

[A] These approximate hardness numbers are for use in selecting a suitable scale, and should not be used as hardness conversions. If necessary to convert test readings to another scale, refer to the ASTM Standard Hardness Conversion Tables E 140, for Metals (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, and Rockwell Superficial Hardness, and Knoop Hardness).

[B] For thickness less than 0.008 in. [0.20 mm] use of the tension test is recommended.

the item in short lengths, but not shorter than 36 in. [915 mm], unless otherwise agreed upon.

17.4 As a minimum requirement, the material shall be identified by having the manufacturer's name, ASTM designation, weight, purchaser's order number, and material identification legibly stenciled on top of each lift or shown on a tag attached to each coil or shipping unit.

17.5 When specified in the contract or order, and for direct procurement by or direct shipment to the government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for military agencies and in accordance with Fed. Std. No. 123 for civil agencies.

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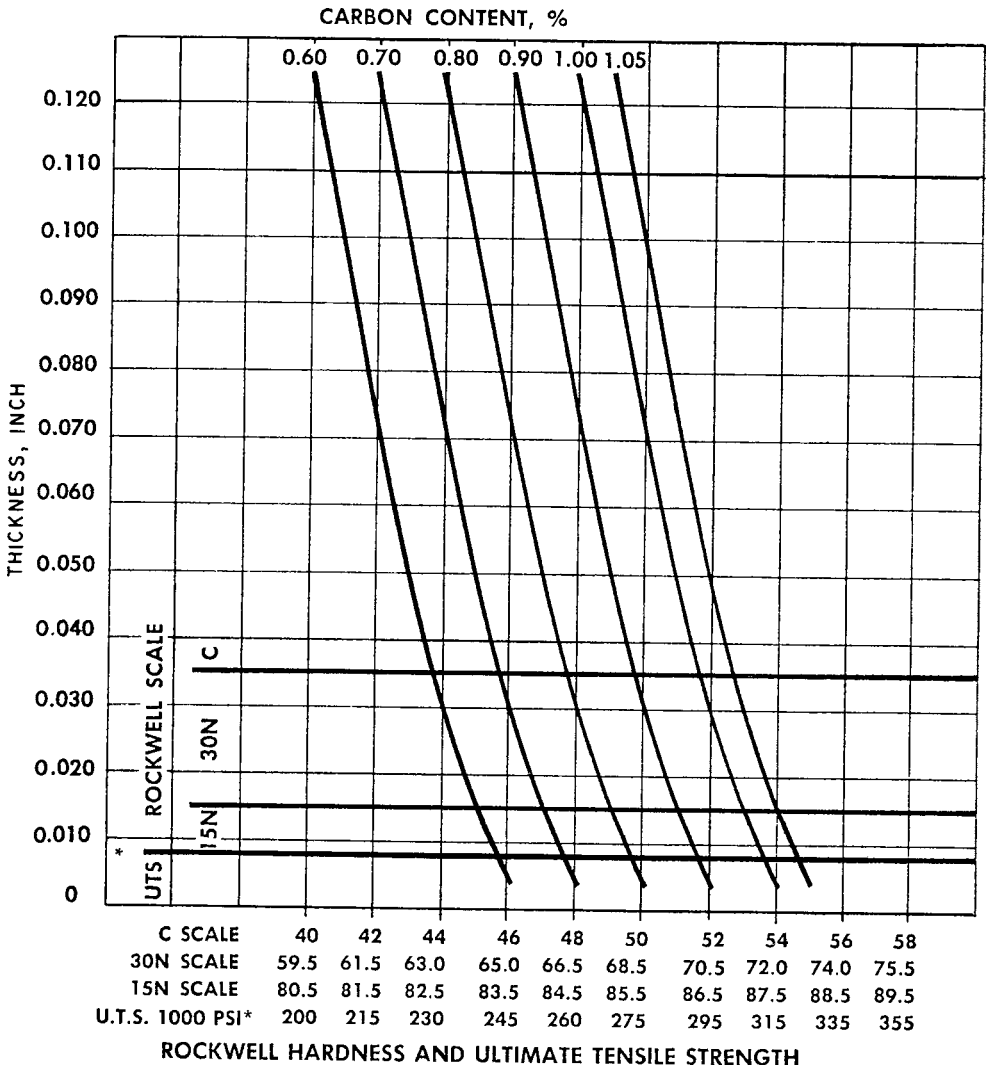

NOTE 1—For thicknesses less than 0.008 in. [0.20 mm] use of the tension test is recommended.

FIG. 1 Approximate Relationship Between Thickness, Carbon Content, Rockwell Hardness, and Tensile Strength for Hardened- and Tempered-Spring Steel Flat Wire Heat-Treated to Combinations of Mechanical Properties Appropriate for Spring Applications

APPENDIX

(Nonmandatory Information)

X1. GENERAL INFORMATION AND METALLURGICAL ASPECTS

X1.1 Aging Phenomenon

X1.1.1 Although the maximum ductility is obtained in low-carbon steel flat wire in its dead-soft (annealed last) condition, such flat wire is unsuited for some forming operations due to its tendency to stretcher strain or flute. A small amount of cold-rolling (skin-rolling) will prevent this tendency, but the effect is only temporary due to a phenomenon called aging. Aging is accompanied by a loss of ductility with an increase in hardness, yield point and tensile strength. For those uses in which stretcher straining, fluting, or breakage due to aging of the steel is likely to occur, the steel should be fabricated as promptly as possible after skin-rolling. When the above aging characteristics are undesirable, special killed (generally aluminum–killed) steel is used.

X1.2 Uncoiling Characteristics of Annealed or Spheroidized Flat Wire

X1.2.1 Carbon spring steel coiled flat wire annealed or spheroidized at finished thickness does not always possess optimum uncoiling characteristics during subsequent forming.

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If uncoiling characteristics are important, it may be necessary for the manufacturer to recoil such material with a concurrent very light skin pass.

X1.3 Definite Application Flat Wire

X1.3.1 Definite application carbon steel flat wire is a product developed for a specific application and is commonly specified only by size and descriptive name. Frequently, the characteristics that measure performance of the product cannot be described in terms of test limits. Satisfactory performance is primarily dependent upon the processing and control developed by the flat wire producer as a result of intensive intimate studies of the purchaser's problems in fabrication.

X1.3.2 Some examples of definite application flat wire are given below:

X1.3.2.1 *Low-Carbon Flat Wire*

Stitching wire, bookbinder's wire, shoe pattern wire, stapling wire.

X1.3.2.2 *Untempered-Carbon Spring Steel Flat Wire*

Umbrella rib wire, metal-band saw steel.

X1.3.2.3 *Hardened and Tempered Carbon Spring Steel Flat Wire*

Tape line, brush wire, heddle wire.

X1.4 Restrictive Requirements

X1.4.1 The requirements that are described below concern characteristics of carbon steel flat wire that are adapted to the particular conditions encountered in the fabrication or use for which the wire is produced. The practices used to meet such requirements necessitate appropriate control and close supervision. These requirements entail one or more of the practices in the manufacture of carbon steel flat wire as follows:

X1.4.1.1 Careful selection of raw materials for melting, which vary with each requirement;

X1.4.1.2 More exacting steelmaking practices;

X1.4.1.3 Selection of heats or portions of heats with consequent higher loss than normal;

X1.4.1.4 Additional discard specified or required;

X1.4.1.5 Special supervision and inspection;

X1.4.1.6 Extensive testing;

X1.4.1.7 Test methods not commonly used for production control; and

X1.4.1.8 Possible processing delays.

X1.4.2 As the application becomes more severe the steel producer is more limited in applying steel for the several requirements described below. The processing methods used to meet these requirements vary among producers because of differences in production facilities.

NOTE X1.1—It is customary to specify only one kind of a mechanical test requirement on any one item.

X1.4.3 Restricted temper requirements for low-carbon steel flat wire are sometimes specified or required and the special properties may include restricted Rockwell ranges or restricted tensile strength ranges.

X1.4.3.1 This type of low-carbon steel flat wire is sometimes required to produce identified parts, within properly established allowances, combined with requirements for Rockwell ranges: 15 points, the minimum of which is not less than B 60; 10 points, the minimum of which is not less than 30T58; or 5 points, the minimum of which is not less than 15T81.

X1.4.3.2 For certain applications, this type of low-carbon steel flat wire is required to meet separate temper restrictions, such as Rockwell ranges of less than 15 points but not less than 10 points, when the minimum of the range is not less than B 60; Rockwell ranges of less than 10 points but not less than 7 points, when the minimum of the range is not less than 30T58; Rockwell ranges of less than 5 points but not less than 3.5 points, when the minimum of the range is not less than 15T81; or tensile strength ranges restricted to less than 25 000 psi [170 MPa].

X1.4.4 *Restricted hardness requirements for carbon spring steel flat wire are sometimes specified or required*:

X1.4.4.1 For certain applications, lower Rockwell hardnesses than shown in Table 8 are required to meet severe forming operations in annealed-carbon spring steel in thicknesses 0.025 in. [0.64 mm] and thicker. In this thickness range, carbon spring steel flat wire must be spheroidize-annealed to produce the lowest possible hardness. In producing spheroidize-annealed carbon spring steel flat wire in thicknesses 0.025 in. [0.64 mm] and thicker, the lowest expected maximum Rockwell hardness is shown in Table 12.

X1.4.4.2 For certain applications, in intermediate-hardness untempered-carbon spring steel flat wire, ranges other than the values shown in Table 9, Table 10, and Table 11 may be required.

X1.4.4.3 For certain applications of hard-type untempered carbon spring steel flat wire minimum Rockwell hardness values over B 98 are required.

X1.4.4.4 For certain applications of hardened and tempered carbon spring steel flat wire, Rockwell hardness ranges closer than or Rockwell values higher than those shown in Table 14 are required.

X1.4.5 *Heat-Treating Requirements*

When heat-treating requirements must be met in the purchaser's end product, all phases of heat treatment procedure and mechanical property requirements should be clearly specified. The specified mechanical properties should be compatible with the nature of the steel involved and the full range of the specified chemical composition when conventional hardening and tempering practices are employed.

X1.4.6 *Testing*

The following tests are not normally made or required except for some special applications:

X1.4.6.1 *Tension Test*

The measurement of tensile properties, such as tensile strength, yield point, and elongation, is not commonly used as a production control for untempered spring steel flat wire in thicknesses 0.010 in. [0.25 mm] and heavier. If, however, a purchaser finds it necessary to specify tensile strength a range of at least 20 000 psi [140 MPa] is commonly used.

X1.4.6.2 *Extensometer Test*

The measurement of elastic properties such as proportional limit, proof stress, yield strength by the offset method, etc., requires the use of special testing equipment and testing procedures such as the use of an extensometer or the plotting of a stress-strain diagram.

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X1.4.6.3 *Specified Austenite Grain Size* is determined in accordance with Test Methods E 112. For any specified fine- or coarse-grain size it is customary that not more than 30 % of the grain structure be outside grain illustrations 5 to 8, inclusive, in the case of fine grain steel, and grain illustrations 1 to 5, inclusive, in the case of coarse grain steel. The foregoing testing procedures involve one or more of the following:

(a) Selection and preparation of special test specimens;

(b) Additional handling and identification of product;

(c) Special testing equipment, unusual testing procedures, or both; and

(d) Possible processing delays due to storage of product while awaiting results of such tests.

X1.4.6.4 *Decarburization*

The loss of carbon at the surface of carbon steel when heated for processing or to modify mechanical properties. Microscopical chemical and hardness test methods are used to determine the extent of decarburization. A definition and method for determination of decarburization is described in the Society of Automotive Engineers Recommended Practice SAE J 419.

X1.4.6.5 *Macroetch Test*

This test consists of immersing a carefully prepared section of the steel in hot acid to evaluate the soundness and homogeneity of the products being tested. Because there are no recognized standards, the location and number of tests, details of testing technique, and interpretation of test results are established in each instance.

X1.4.6.6 *Nonmetallic Inclusion Examination*

(*Microscopical*)—The samples for the determination of the inclusion count are taken longitudinally. The rating is based upon Practice E 45. Because there are no recognized standards, the area to be examined and the interpretation of test results are established in each instance.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 805 – 93 (2002)) that may impact the use of this standard. (Approved March 1, 2008.)

(*1*) Added Section 1.5.

(*2*) Deleted withdrawn MIL-STD-163 from the Referenced Documents and all references within the specification.

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