Designation: A 1000 – 05

Standard Specification for Steel Wire, Carbon and Alloy Specialty Spring Quality[1]

This standard is issued under the fixed designation A 1000; 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 a quality of round and shaped plain carbon and alloy steel spring wire, uniform in quality and temper, intended for the manufacture of mechanical springs that can withstand moderate fatigue stresses over some relatively low number of cycles. The quality level is between the commercial quality grades of wire such as Specifications A 401/A 401M, A 231/A 231M, and A 229/A 229M and the valve spring quality grades such Specifications as A 230/A 230M, A 232/A 232M, A 877/A 877M and A 878/A 878M. It is similar to the grade TD (referenced in EN 10270-2) intended for medium fatigue levels, such as required for clutch springs. This wire shall be either in the annealed and cold-drawn or oil-tempered condition as specified by purchaser.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, each system must be used independent of the other.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 229/A 229M Specification for Steel Wire, Oil-Tempered for Mechanical Springs

A 230/A 230M Specification for Steel Wire, Oil-Tempered Carbon Valve Spring Quality

A 231/A 231M Specification for Chromium-Vanadium Alloy Steel Spring Wire

A 232/A 232M Specification for Chromium-Vanadium Alloy Steel Valve Spring Quality Wire

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

A 401/A 401M Specification for Steel Wire, Chrome-Silicon Alloy

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment

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

A 877/A 877M Specification for Steel Wire, Chrome-Silicon Alloy Valve Spring Quality

A 878/A 878M Specification for Steel Wire, Modified Chromium Vanadium Valve Spring Quality

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 45 Practice for Determining the Inclusion Content of Steel

2.2 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[3]

2.3 *Military Standard:*

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[3]

2.4 *AIAG Standard:*

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard[4]

2.5 *European Standard:*

EN 10270-2 Steel Wire for Mechanical Springs Part 2: Oil-Hardened and Tempered Springsteel Wire of Unalloyed and Alloyed Steels[5]

3. Terminology

3.1 *Definitions:*

3.1.1 For definition of terms used in this specification, see Terminology A 941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *commercial quality wire*—a grade of wire that is fairly common quality and intended for applications that are primarily static in nature, not involving significant fatigue loading.

4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for material under this

[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 A01.03 on Steel Rod and Wire.

Current edition approved Jan. 1, 2005. Published January 2005. Originally approved in 1999. Last previous edition approved in 1999 as A 1000 – 99.

[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

[4] Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48034.

[5] Available from European Committee for Standardization, rue de Stassart 36,B-1050 Brussels

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

specification. Such requirements may include, but are not limited to the following.

4.1.1 Quantity (mass),

4.1.2 Name of material (chromium-silicon alloy steel specialty spring quality wire),

4.1.3 Dimensions (Table 1 and Section 9)

4.1.4 Condition (Section 7),

4.1.5 Packaging (Section 15),

4.1.6 Heat analysis report, if requested (6.2),

4.1.7 Certification or test report, or both, if specified (Section 14), and

4.1.8 ASTM designation and year of issue.

NOTE 1—A typical ordering description is as follows: 20 000-kg oil-tempered chromium-silicon alloy steel specialty spring quality wire, size 6.00 mm in 1500-kg coils to ASTM ___ dated ___, or for inch-pound units, 40 000-lb, oil-tempered chromium-silicon alloy steel specialty spring quality wire, size 0.250 in. in 3000-lb coils to ASTM___dated ___.

5. Materials and Manufacture

5.1 The steel may be made by any commercially accepted steel making process. The steel may be either ingot cast or strand cast.

5.2 The finished wire shall be free from detrimental pipe and undue segregation.

6. Chemical Composition

6.1 The steel shall conform to the requirements for chemical composition specified in Table 2.

6.2 *Heat Analysis*—Each heat of steel shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 2. This analysis shall be made from a test specimen preferably taken during the pouring of the heat. When requested, this shall be reported to the purchaser and shall conform to the requirements of Table 2.

TABLE 1 Permissible Variations in Wire Dimensions (Round and Shapes)[A]

SI Units		
Dimension, mm	Permissible Variations, mm	Permissible Out-Of-Round, mm
0.5 to 2.0, incl	0.02	0.02
Over 2.0 to 4.0, incl	0.03	0.03
Over 4.0 to 9.5, incl	0.04	0.04
Over 9.5	0.05	0.05
Inch-Pound Units		
Dimension, in.	Permissible Variations, in.	Permissible Out-Of-Round, in.
0.020 to 0.075, incl	0.0008	0.0008
Over 0.075 to 0.148, incl	0.001	0.001
Over 0.148 to 0.375, incl	0.0015	0.0015
Over 0.375	0.002	0.002
Permissible Variations in Wire Dimensions (Flat Rolled)[A]		
SI Units		
Dimension, mm	Thickness Permissible Variations, mm	Width Permissible Variations, mm
All	0.05	0.120
Inch-Pound Units		
Dimension, in.	Thickness Permissible Variations, in.	Width Permissible Variations, in.
All	0.002	0.005

[A] For purposes of determining conformance with this specification, all specified limits are absolute as defined in Practice E 29.

6.3 *Product Analysis*—An analysis may be made by the purchaser from finished wire representing each heat of steel. The average of all the separate determinations made shall be within the limits specified in the analysis column.

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

7. Mechanical Properties

7.1 *Annealed and Cold Drawn*—When purchased in the annealed and cold-drawn condition, the wire shall have been given a sufficient amount of cold working to meet the purchaser's coiling requirements and shall be in a suitable condition to respond properly to heat treatment. In special cases the hardness, if desired, shall be stated in the purchase order.

7.2 *Oil Tempered*:

7.2.1 *Tensile Strength and %RA, Round Wire*—When purchased in the oil-tempered condition, the tensile strength and minimum percent reduction in area of round wire, sizes 2.50 mm (0.105 in.) and larger shall conform to the requirements prescribed in Tables 3-6.

7.2.2 *Tensile Strength, Shaped and Flat Wire*—Tensile strength of shaped and flat rolled wires shall conform to these tables based on the conversion to equivalent round dimensions. Percent reduction of area is not applicable to shaped and flat rolled wires.

7.2.3 *Tensile Strength Variation*—In addition, the maximum tensile variation in a coil shall be 70 Mpa (10 KSI).

NOTE 2—Any specimen breaking in the tensile grips shall be discarded and a new specimen tested if the specified mechanical properties are not achieved. If breakage in the tensile grips prevents conformance to percent reduction in area requirements, conformance to the wrap test (see 7.3) shall suffice.

7.2.4 *Number of Tests*—One test specimen shall be taken for each five coils, or fraction thereof, in a lot. Each heat in a given lot shall be tested.

7.2.5 *Location of Tests*—Test specimens shall be taken for each five coils, or fraction thereof, in a lot. Each heat in a given lot shall be tested.

7.2.6 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A 370.

7.3 *Wrap Test*:

7.3.1 Round oil tempered wire 4.00 mm (0.156 in.) or smaller in diameter shall wrap on itself as an arbor without breakage. Larger diameter wire up to and including 8.00 mm (0.312 in.) shall wrap without breakage on a mandrel twice the wire diameter. The wrap test is not applicable to wire over 8.00 mm (0.312 in.) in diameter or to shaped and flat rolled wires.

7.3.2 The special high tensile chrome silicon vanadium grade of round oil tempered wire 4.00 mm (0.156 in.) or smaller in diameter shall wrap on a mandrel twice the diameter without breakage. Larger diameter wire up to and including 8.00 mm (0.312 in.) shall wrap without breakage on a mandrel three times the wire diameter. The wrap test is not applicable to wire over 8.00 mm (0.312 in.) in diameter or to shaped and flat rolled wires.

7.3.3 *Test Method*—The wrap test shall be made in accordance with Test Methods and Definitions A 370.

TABLE 2 Chemical Requirements

	Analysis, %			
	Grade A Chromium-Silicon	Grade B Carbon	Grade C Chromium-Vanadium	Grade D Chromium-Silicon-Vanadium
Carbon	0.51 to 0.59	0.55 to 0.75	0.60 to 0.70	0.55 to 0.68
Manganese	0.50 to 0.80	0.60 to 0.90	0.50 to 0.90	0.50 to 0.90
Phosphorus	0.025 max	0.025 max	0.025 max	0.025 max
Sulfur	0.025 max	0.025 max	0.025 max	0.025 max
Silicon	1.20 to 1.60	0.15 to 0.30	0.15 to 0.30	1.20 to 1.65
Chromium	0.60 to 0.80	[A]	0.35 to 0.60	0.50 to 0.80
Vanadium	[A]	[A]	0.10 to 0.25	0.08 to 0.25

[A] Not required.

TABLE 3 Tensile and % RA Requirements[A] (Chrome Silicon)

SI Units			
Diameter, mm	MPa, min	MPa, max	Reduction of Area
0.5	2100	2280	[B]
1.0	2070	2240	[B]
1.5	2030	2210	[B]
2.0	2000	2140	[B]
2.5	1965	2105	45
3.0	1930	2070	45
4.0	1900	2040	40
4.5	1830	1970	40
5.0	1810	1950	40
5.5	1790	1930	40
6.5	1760	1900	40
8.0	1730	1870	40
9.5	1690	1830	40
11.0	1660	1800	35
12.5	1630	1770	35
14.0	1610	1750	30
16.0	1590	1730	30
Inch-Pound Units			
Diameter, in.	ksi, min	ksi, max	Reduction of area, min %
0.020	305	330	[B]
0.040	300	325	[B]
0.060	295	320	[B]
0.080	290	310	[B]
0.105	284	304	45
0.120	280	300	45
0.156	275	295	40
0.177	265	285	40
0.200	263	283	40
0.218	260	280	40
0.250	255	275	40
0.312	250	270	40
0.375	245	265	40
0.438	240	260	35
0.500	235	255	35
0.562	233	253	30
0.625	231	251	30

[A] Tensile strength values for intermediate diameters may be interpolated.
[B] The reduction of area test is not applicable to wire under 2.5 mm (0.105 in.).

TABLE 4 Tensile and % RA Requirements[A] (Carbon)

SI Units			
Diameter, mm	MPa, min	MPa, max	Reduction of area
0.5	2100	2070	[B]
1.0	1860	2030	[B]
2.0	1790	1960	[B]
2.5	1760	1900	45
3.0	1720	1860	45
4.0	1650	1790	40
4.5	1580	1720	40
5.5	1510	1650	40
6.5	1480	1620	40
8.0	1450	1590	40
9.5	1410	1550	40
12.5	1380	1520	35
16.0	1350	1490	30
Inch-Pound Units			
Diameter, in.	kSI, min	kSI, max	Reduction of area, min %
0.020	275	300	[B]
0.040	270	295	[B]
0.080	260	285	[B]
0.105	255	275	45
0.120	250	270	45
0.156	240	260	40
0.177	235	255	40
0.218	225	245	40
0.250	215	235	40
0.312	210	230	40
0.375	205	225	40
0.500	200	220	35
0.625	195	215	30

[A] Tensile strength values for intermediate diameters may be interpolated.
[B] The reduction of area test is not applicable to wire under 2.5 mm (.105 in.).

8. Metallurgical Requirements

8.1 *Surface Condition*:

8.1.1 The surface of the wire as received shall be free of imperfections such as seams, pits, die marks, scratches, and other surface defects that are deeper than 1 % of the wire diameter for round wire or 1 % of the equivalent round diameter for shaped and flat rolled wire.

8.1.2 *Number of Tests*—One test specimen shall be taken from each end of every coil.

8.1.3 *Test Method*—The surface shall be examined after etching in a solution of equal parts of hydrochloric acid and water that has been heated to approximately 80°C for a sufficient length of time to remove up to approximately 1 % of the diameter of the wire. Test ends shall be examined using 10× magnification.

8.1.4 *Eddy Current Testing*—Upon the agreement of the producer and the purchaser, round wire 3.0 mm (0.120 in.) and larger shall be 100 % eddy current tested with a rotary probe or a stationary coil, or both. The depth of surface defects to be detected shall also be agreed upon by the producer and purchaser. Defects equal to or deeper than this depth shall be marked with some means of identification, such as ink or paint, to facilitate removal at a later stage in the processing.

8.2 *Decarburization*:

8.2.1 Transverse sections of the wire when properly mounted, polished and etched shall show maximum complete decarburization of 0.3 % of the wire diameter for round wires and 0.3 % of the equivalent round for shaped and flat rolled

TABLE 5 Tensile and % RA Requirements[A] (Chrome Vanadium)

SI Units			
Diameter, mm	MPa, min	MPa, max	Reduction Of area
1.0	1860	2030	[B]
2.0	1760	1930	[B]
3.0	1650	1790	45
4.0	1620	1760	40
4.5	1590	1730	40
5.5	1520	1660	40
6.5	1480	1620	40
8.0	1450	1590	40
Inch-Pound Units			
Diameter, in.	kSI, min	kSI, max	Reduction of area, min %
0.040	270	295	[B]
0.080	255	280	[B]
0.120	240	260	45
0.156	235	255	40
0.177	230	250	40
0.218	220	240	40
0.250	215	235	40
0.312	210	230	40

[A] Tensile strength values for intermediate diameters may be interpolated.
[B] The reduction of area test is not applicable to wire under 2.5 mm (0.105 in.).

TABLE 6 Tensile and % RA Requirements[A] (Chromium Silicon Vanadium)

SI Units			
Diameter, mm	MPa, min	MPa, max	Reduction Of area
1.0	2200	2370	[B]
1.5	2170	2340	[B]
2.5	2100	2270	40
3.0	2070	2210	40
4.0	2030	2170	40
4.5	2000	2140	35
5.0	1960	2100	35
5.5	1930	2070	35
6.5	1900	2040	35
8.0	1860	2000	30
9.5	1830	1970	30
11.0	1790	1930	30
12.5	1760	1900	30
14.0	1720	1860	30
16.0	1690	1830	30
Inch-Pound Units			
Diameter, in.	kSI, min	kSI, max	Reduction of area, min %
0.040	320	345	[B]
0.060	315	340	[B]
0.105	305	330	40
0.120	300	320	40
0.156	295	315	40
0.177	290	310	35
0.200	285	305	35
0.218	280	300	35
0.250	275	295	35
0.312	270	290	30
0.375	265	285	30
0.438	260	280	30
0.500	255	275	30
0.562	250	270	30
0.625	245	265	30

[A] Tensile strength values for intermediate diameters may be interpolated.
[B] The reduction of area test is not applicable to wire under 2.5 mm (0.105 in.).

wire. Partial decarburization should not exceed a depth of 1.5 % of the diameter for round wires and 1.5 % of the equivalent round diameter for shaped and flat rolled wire.

8.2.2 *Test Method*—Decarburization shall be determined by etching a suitably polished transverse section of wire with nital. The entire periphery to be examined should be in a single plane with no edge rounding.

8.2.3 The entire periphery shall be examined at a magnification of no less than 100□ for depth of free ferrite and total affected depth. Smaller wire sizes may require higher magnification. Measure the worst area present excluding decarburization associated with seams or other surface imperfections. Complete decarburization exists when only free ferrite is present. Partial decarburization exists when ferrite is found mixed with pearlite or tempered martensite. Structures of 100 % tempered martensite shall be defined as not decarburized.

8.2.4 Decarburization shall be checked on annealed wire by giving a wire sample an austenitize, oil quench and temper heat treatment. A flat shall be ground on the sample prior to heat treatment. The flat shall have a minimum width equal to one half of the wire diameter. Any decarburization visible on this ground section shall necessitate a retest with new samples. If no decarburization is visible on the ground flat, evaluate the complete wire section in accordance with 8.2.3.

8.3 *Inclusion Content*:

8.3.1 Restrictions on inclusion content may be agreed upon by the producer and the purchaser. It is recommended that methods be used that are relevant for spring wire applications such as maximum thickness (Max '*t*') and inclusion count techniques (Swedish Method). These should concentrate on non-deformable inclusions, the thickness (transverse to the longitudinal wire axis) of inclusions and the condition in areas near to the wire surface. The application of Practice E 45 to this requirement is not recommended.

9. Dimensions and Permissible Variations

9.1 The permissible variations in the dimensions of the wire shall be as specified in Table 1.

9.2 *Number of Tests*—One test specimen shall be taken from each end of every coil.

10. Workmanship, Finish and Appearance

10.1 *Annealed and Cold Drawn*—The wire shall not be kinked or improperly cast. To test for cast, a few convolutions of wire shall be cut loose from the coil and placed on a flat surface. The wire shall lie substantially flat on itself and not spring up nor show a wavy condition.

10.2 *Oil Tempered*—The wire shall be uniform in quality and temper and shall not be wavy or crooked.

10.3 Each coil shall be one continuous length of wire properly coiled and firmly tied.

10.4 No welds are permitted in the finished product and any welds made during processing must be removed.

11. Retests

11.1 If any test specimen exhibits obvious defects it may be discarded and another specimen substituted.

12. Inspection

12.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of

all inspection and test requirements specified in this specification. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspection and tests set forth in this specification when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements.

13. Rejection and Rehearing

13.1 Unless otherwise specified, any rejection based on tests made in accordance with these specifications shall be reported to the manufacturer as soon as possible so that an investigation may be initiated.

13.2 The material must be adequately protected and correctly identified in order that the manufacturer may make a proper investigation.

14. Certification

14.1 When specified in the purchase order or contract, a manufacturer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

14.2 The certification shall include the specification number, year date of issue, and revision letter, if any.

15. Packaging, Marking, and Loading for Shipment

15.1 The coil mass, dimensions, and the method of packaging shall be agreed upon between the manufacturer and purchaser.

15.2 The size of the wire, purchaser's order number, ASTM specification number, heat number, and name or mark of the manufacturer shall be marked on a tag securely attached to each coil of wire.

15.3 Unless otherwise specified in the purchaser's order, packaging, marking, and loading for shipments shall be in accordance with those procedures recommended by Practices A 700.

15.4 *For Government Procurement*—Packaging, packing, and marking of material for military procurement shall be in accordance with the requirements of MIL-STD-163, Level A, Level C, or commercial as specified in the contract or purchase order. Marking for shipment of material for civil agencies shall be in accordance with Fed. Std. No. 123.

15.5 *Bar Coding*—In addition to the previously stated identification requirements, bar coding is acceptable as a supplementary identification method. Bar coding should be consistent with AIAG Standard 02.00, Primary Metals Identification Tag Application. The bar code may be applied to a substantially affixed tag.

16. Keywords

16.1 alloy; eddy current; flat rolled; inclusion content; oil-tempered; shaped wire

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue, A 1000 – 99, that may impact the use of this standard. (Approved Jan. 1, 2005.)

(*1*) Revised chemical composition for Grade D in Table 2.