Designation: A1000/A1000M – 17 (Reapproved 2023)

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

This standard is issued under the fixed designation A1000/A1000M; 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 four different grades 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 A401/A401M, A231/A231M, and A229/A229M and the valve spring quality grades such Specifications as A230/A230M, A232/A232M, and A877/A877M. 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 quenched and 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. 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.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A229/A229M Specification for Steel Wire, Quenched and Tempered for Mechanical Springs

A230/A230M Specification for Steel Wire, Carbon Valve Spring Quality

A231/A231M Specification for Chromium-Vanadium Alloy Steel Spring Wire

A232/A232M Specification for Chromium-Vanadium Alloy Steel Valve Spring Quality Wire

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A401/A401M Specification for Steel Wire, Chromium-Silicon Alloy

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A751 Test Methods and Practices for Chemical Analysis of Steel Products

A877/A877M Specification for Steel Wire, Chromium-Silicon Alloys, Chrome-Silicon-Vanadium Alloy Valve Spring Quality

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

E8/E8M Test Methods for Tension Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *European Standard:*

EN 10270-2 Steel Wire for Mechanical Springs Part 2: Oil-Hardened and Tempered Springsteel Wire of Unalloyed and Alloyed Steels[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definition of terms used in this specification, see Terminology A941.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *equivalent round diameter, n*—diameter of a round wire having equivalent cross sectional area to a given shaped wire.

3.2.3 *shape factor, n*—this value is used to obtain cross sectional area for shaped wires when multiplied by measured width and measured thickness.

[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.

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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 European Committee for Standardization, rue de Stassart 36,B-1050 Brussels

3.2.4 *round wire, n*—wire having a circular cross section.

3.2.5 *flat wire, n*—wire having two parallel flats, with either round or square edges.

3.2.6 *shaped wire, n*—wire other than round wire and flat wire.

4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for material under this specification. Such requirements are permitted to 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) and grade (Table 2 and Section 6),

4.1.3 Dimensions (Table 1 and Section 9),

4.1.4 *Condition*—Annealed and Cold Drawn, or Quench and Tempered (Section 7),

4.1.5 Packaging (Section 15), and

4.1.6 ASTM designation and year of issue.

4.2 The purchaser shall have the option to specify additional requirements, including but not limited to:

4.2.1 Requirements for certifications, heat analysis or test reports (see Sections 6.2 and 14),

4.2.2 Special packing, marking, and loading requirements (see Section 15), and

4.2.3 Other special requirements, if any.

NOTE 1—A typical ordering description is as follows: 20 000 kg quenched and tempered chromium-silicon alloy steel specialty spring quality wire, size 6.00 mm in 1500 kg coils to Specification A1000/A1000M, Grade A dated _____, or for inch-pound units, or for inchpound units, 40 000 lb. quenched and tempered chromium-silicon alloy steel specialty spring quality wire, size 0.250 in. in 3000 lb coils to Specification A1000/A1000M, Grade A 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.

TABLE 1 Permissible Variations in Wire Dimensions (Round and Flat)[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)[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 E29.

6.2 *Heat Analysis*—Each heat of steel shall be analyzed by the supplier 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.

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 A751 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

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	. . .	0.35 to 0.60	0.50 to 0.80
Vanadium	. . .	. . .	0.10 to 0.25	0.08 to 0.25

". . ." indicates that there is no requirement and that these elements are not required to be reported.

respond properly to heat treatment. In special cases the tensile strength or hardness, if desired, shall be stated in the purchase order.

7.2 *Quenched and Tempered:*

7.2.1 *Tensile Strength and % Reduction of Area, Round Wire*—When purchased in the quenched and tempered condition, the tensile strength shall conform to the requirements prescribed in Tables 3-6. Minimum percent reduction in area of round wire, sizes 2.34 mm [0.092 in.] and larger shall conform to the requirements prescribed in Tables 3-6.

7.2.2 *Tensile Strength and % Reduction of Area, Shaped and Flat Wire*—Tensile strength of shaped and flat wires shall conform to Tables 3-6 based on the conversion to equivalent round diameter.. Percent reduction of area is not applicable to flat wires. Minimum percent reduction in area of shaped wires with equivalent round wire diameters of 2.50 mm [0.105 in.] and larger shall conform to the requirements prescribed in Tables 3-6.

7.2.3 *Tensile Strength Variation*—The maximum tensile variation in a coil shall be 70 MPa [10 ksi].

TABLE 3 Tensile and % Reduction of Area Requirements[A] (Chrome Silicon) Grade A

SI Units			
Diameter, mm	MPa, min	MPa, max	% Reduction of Area, min[B]
0.5	2100	2280	. . .
1.0	2070	2240	. . .
1.5	2030	2210	. . .
2.0	2000	2140	. . .
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[B]
0.020	305	330	. . .
0.040	300	325	. . .
0.060	295	320	. . .
0.080	290	310	. . .
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 shall be interpolated.
[B] The reduction of area test is not applicable to wire under 2.34 mm (0.092 in.). For intermediate diameters, the reduction of area. requirement shall be that of the next larger wire.
". . ." indicates that there is no requirement.

TABLE 4 Tensile and % Reduction of Area Requirements[A] (Carbon) Grade B

SI Units			
Diameter, mm	MPa, min	MPa, max	% Reduction of area, min[B]
0.5	1900	2070	. . .
1.0	1860	2030	. . .
2.0	1790	1960	. . .
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[B]
0.020	275	300	. . .
0.040	270	295	. . .
0.080	260	285	. . .
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 shall be interpolated.
[B] The reduction of area test is not applicable to wire under 2.34 mm (0.092 in.). For intermediate diameters, the reduction of area requirement shall be that of the next larger wire.
". . ." indicates that there is no requirement.

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*—It shall be permissible to take test specimens from either end of the coil.

7.2.6 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A370. Any tensile test specimen breaking in the tensile grips shall be discarded and a new specimen tested if the specified mechanical properties are not achieved. For shaped wires, cross sectional area shall be calculated either by using the procedure in Test Methods E8/E8M for uniform but nonsymmetrical cross-sections, or by measuring width and thickness and multiplying by a shape factor. Reduction of area for shaped wires shall be calculated by using this shape factor. Measure the maximum and minimum dimension on the necked down section and multiply by the shape factor to estimate the cross sectional area for use in the standard reduction of area calculation.

7.2.6.1 Upon agreement between purchaser and supplier, the shape factor for the cross section design provided by the wire mill shall be permissible to be adopted for use. In other situations if the shape factor is not available from the wire mill, the shape factor shall be calculated by measuring the cross sectional area in accordance with Test Methods E8/E8M and dividing by the width and thickness.

TABLE 5 Tensile and % Reduction of Area Requirements[A] (Chrome Vanadium) Grade C

SI Units			
Diameter, mm	MPa, min	MPa, max	% Reduction of Area, min[B]
1.0	1860	2030	. . .
2.0	1760	1930	. . .
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[B]
0.040	270	295	. . .
0.080	255	280	. . .
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 shall be interpolated.
[B] The reduction of area test is not applicable to wire under 2.34 mm (0.092 in.). For intermediate diameters, the reduction of area requirement shall be that of the next larger wire.
". . ." indicates that there is no requirement.

TABLE 6 Tensile and % Reduction of Area Requirements[A] (Chromium Silicon Vanadium) Grade D

SI Units			
Diameter, mm	MPa, min	MPa, max	% Reduction of Area, min[B]
1.0	2200	2370	. . .
1.5	2170	2340	. . .
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[B]
0.040	320	345	. . .
0.060	315	340	. . .
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 shall be interpolated.
[B] The reduction of area test is not applicable to wire under 2.34 mm (0.092 in.). For intermediate diameters, the reduction of area requirement shall be that of the next larger wire.
". . ." indicates that there is no requirement.

7.3 *Wrap Test:*

7.3.1 *Grades A, B, and C*—Round quenched and tempered wire 4.00 mm [0.157 in.] or smaller in diameter shall wrap on itself as an arbor without breakage. Larger diameter wire up to and including 8.00 mm [0.315 in.] shall wrap without breakage on a mandrel twice the wire diameter. The wrap test is not applicable to wire over 8.00 mm [0.315 in.] in diameter or to shaped and flat wires.

7.3.2 *Grade D*—The special high tensile chrome silicon vanadium grade of round quench and tempered wire 4.00 mm [0.157 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 [0.315 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 [0.315 in.] in diameter or to shaped and flat wires.

7.3.3 *Test Method*—The wrap test shall be made in accordance with Test Methods and Definitions A370.

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 1.0 % of the wire diameter for round wire or 1.0 % of the equivalent round diameter for shaped and flat 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 supplier and the purchaser, round, flat, and shaped wire 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 supplier and the 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.

NOTE 2—Inspection of certain cross sectional shapes may not be technically feasible.

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 diameter for shaped and flat 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 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