Designation: A877/A877M – 17 (Reapproved 2023)

Standard Specification for Steel Wire, Chromium-Silicon Alloys, Chrome-Silicon-Vanadium Alloy Valve Spring Quality[1]

This standard is issued under the fixed designation A877/A877M; 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 the highest quality of round and shaped chromium-silicon and chromium-silicon-vanadium alloys of steel valve spring wire, uniform in quality and temper, intended for the manufacture of valve springs and other springs requiring high-fatigue properties when used at moderately elevated temperatures. It is similar to the grade VD (referenced in EN 10270-2) intended for high fatigue levels. 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]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

A751 Test Methods and Practices for Chemical Analysis of Steel Products

E8/E8M Test Methods for Tension Testing of Metallic Materials

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

E45 Test Methods for Determining the Inclusion Content of Steel

2.2 *European Standard:*

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

3. Ordering Information

3.1 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:

3.1.1 Quantity (mass),

3.1.2 Name of material (chromium-silicon alloy steel valve spring quality wire),

3.1.3 Dimensions (Table 1 and Section 8),

3.1.4 Condition (Section 6),

3.1.5 Packaging (Section 14),

3.1.6 Heat analysis report, if requested (5.2),

3.1.7 Certification or test report, or both, if specified (Section 13), and

3.1.8 ASTM designation and year of issue.

NOTE 1—A typical ordering description is as follows: 20 000 kg quenched and tempered chromium-silicon alloy steel valve spring quality wire, size 6.00 mm in 150 kg coils to A877/A877M dated ___, or for inch-pound units, 40 000 lb quenched and tempered chromium-silicon alloy steel valve spring quality wire, size 0.250 in. in 350 lb coils to A877/A877M dated ___ .

4. Materials and Manufacture

4.1 The steel shall be made by a steel making process combined with secondary ladle refining that is capable of satisfying the inclusion content requirements of this specification.

4.2 The steel shall be continuously cast into blooms and rolled into billets.

[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, Belgium.

TABLE 1 Permissible Variations in Wire Diameter[A]

SI Units		
Diameter, 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
Inch-Pound Units		
Diameter, 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

[A] For purposes of determining conformance with this specification, all specified limits are absolute as defined in recommended Practice E29.

4.3 Billet conditioning shall precede wire rod manufacture. The resulting wire rods shall be of sufficient surface quality that when combined with a surface removal operation performed prior to or during the wire manufacturing operation the resulting wire shall satisfy the surface condition and decarburization requirements of this specification.

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

5. Chemical Composition

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

5.2 *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.

5.3 *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. Individual determinations may vary to the extent shown in the product analysis tolerance column, except that the several determinations of a single element in any one heat shall not vary both above and below the specified range.

5.4 For referee purposes, Test Methods, Practices, and Terminology A751 shall be used.

6. Mechanical Properties

6.1 *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.

6.2 *Quenched and Tempered*—When purchased in the quenched and tempered condition, the tensile strength and reduction of area (% R.A.) shall conform to the requirements prescribed in Table 3, Table 4, or Table 5. Percent reduction of the area (% R.A.) is not applicable to wire diameters under 2.0 mm [0.080 in.].

6.2.1 *Tensile Strength of Shaped and Flat Rolled 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 flat rolled wires.

NOTE 2—Equivalent round definition: The cross sectional area of shaped wires converted to the round wire diameter.

6.2.2 *Tensile Strength Variation*—In addition, the maximum tensile variation in a coil shall be 70 MPa [10.15 ksi].

6.2.3 *Number of Tests*—One test specimen shall be taken from each end of every coil in a lot. Each heat in a given lot shall be tested.

NOTE 3—Any specimen breaking in the tensile grips shall be discarded and a new specimen tested if the specified mechanical properties are not achieved.

6.2.4 *Location of Tests*—Test specimens shall be taken from both ends of the coil.

6.2.5 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A370. For shaped wires, cross sectional area shall be calculated by either using the procedure in Test Methods E8/E8M (Subsection 7.2.2) 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.

6.2.5.1 Upon agreement between purchaser and supplier, the shape factor for the 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.

6.3 *Wrap Test:*

6.3.1 *Grade A*—Round quenched and tempered or cold drawn 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.] in diameter 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 rolled wires.

6.3.2 *Grades B, C, or D*—Round of quenched and tempered wire 4.00 mm [0.1575 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 rolled wires.

6.3.3 *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.

6.3.4 *Location of Tests*—Test specimens shall be taken from either end of the coil.

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

TABLE 2 Chemical Requirements

	Analysis, %				
	Grade A Chromium-Silicon	Grade B Chromium-Silicon-Vanadium	Grade C Chrome-Silicon-Nickel-Vanadium	Grade D Chrome-Silicon- Molybdenum-Vanadium	Product Analysis Tolerance, %
Carbon	0.51–0.59	0.55–0.70	0.50–0.70	0.50–0.70	±0.02
Manganese	0.50–0.80	0.50–0.80	0.70–1.00	0.30–0.60	±0.04
Phosphorus	0.025 max	0.025 max	0.020 max	0.020 max	±0.005
Sulfur	0.025 max	0.025 max	0.020 max	0.020 max	±0.005
Silicon	1.20–1.60	1.20–1.65	1.80–2.20	1.80–2.20	±0.05
Chromium	0.60–0.80	0.50–0.80	0.85–1.05	0.80–1.00	±0.03[A] / ±0.05[B]
Vanadium	. . .	0.08–0.25	0.05–0.15	0.05–0.15	±0.02
Nickel	. . .	. . .	0.20–0.40	. . .	±0.03
Molybdenum	. . .	. . .	. . .	0.05–0.15	±0.01

[A] Product Analysis Tolerance for Grade A and B is ±0.03 %.
[B] Product Analysis Tolerance for Grade C & D is ±0.05 %.
“. . .” indicates that there is no requirement and that these elements are not required to be reported.

TABLE 3 Tensile[A] and % R.A. Requirements

Grade A (Chrome Silicon)			
SI Units			
Diameter, mm	MPa, min	MPa, max	Min % R.A.[BC]
0.5	2100	2280	. . .
1.0	2070	2240	. . .
1.5	2030	2210	. . .
2.0	2000	2140	45
3.0	1930	2070	45
3.75	1900	2030	40
4.5	1830	1970	40
5.0	1810	1950	40
5.7	1800	1930	40
6.3	1760	1900	40
7.9	1730	1860	40
9.5	1690	1830	40
Inch-Pound Units			
Diameter, in.	ksi, min	ksi, max	Min % R.A.[BC]
0.020	305	330	. . .
0.040	300	325	. . .
0.060	295	320	. . .
0.080	290	310	45
0.120	280	300	45
0.148	275	295	40
0.177	265	285	40
0.200	263	283	40
0.225	260	280	40
0.250	255	275	40
0.312	250	270	40
0.375	245	265	40

[A] Tensile strength values for intermediate diameters shall be interpolated.
[B] For intermediate diameters, the % R.A. requirement shall be that of the next larger wire diameter.
[C] “. . .” indicates that there is no requirement.

TABLE 4 Tensile[A] and % R.A. Requirements

Grade B (Chrome Silicon Vanadium)			
SI Units			
Diameter, mm	MPa, min	MPa, max	Min % R.A.[BC]
0.5	2200	2380	. . .
1.0	2170	2340	. . .
1.5	2140	2300	. . .
2.0	2100	2240	40
3.0	2070	2200	40
3.75	2030	2170	35
4.5	2000	2140	35
5.0	1970	2100	35
5.7	1930	2070	35
6.3	1900	2030	35
7.9	1860	2000	35
9.5	1830	1970	35
Inch-Pound Units			
Diameter, in.	ksi, min	ksi, max	Min % R.A.[BC]
0.020	320	345	. . .
0.040	315	340	. . .
0.060	310	335	. . .
0.080	305	325	40
0.120	300	320	40
0.148	295	315	35
0.177	290	310	35
0.200	285	305	35
0.225	280	300	35
0.250	275	295	35
0.312	270	290	35
0.375	265	285	35

[A] Tensile strength values for intermediate diameters shall be interpolated.
[B] For intermediate diameters, the % R.A. requirement shall be that of the next larger wire diameter.
[C] “. . .” indicates that there is no requirement.

6.4 *Special Surface Inspection*—The entire length of every coil shall be inspected for surface imperfections with a rotating and stationary probe eddy current defect analyzer, or equivalent system. Imperfections deeper than 0.04 mm [0.0016 in.] shall be properly marked so the purchaser has the ability to identify and discard that length of wire; other depths may be agreed upon. Number of allowable marks per coil, shall be agreed upon between the manufacturer and the purchaser. This test is not applicable to wire sizes below 2.5 mm [0.098 in.].

NOTE 4—Inspection of certain cross sectional shapes may not be technically feasible.

7. Metallurgical Requirements

7.1 *Surface Condition:*

7.1.1 The surface of the wire as received shall be free of imperfections such as pits, die marks, scratches, seams, and other defects tending to impair the fatigue value of the springs.

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

7.1.3 *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 up to 2 min in order to remove the oxide scale layer from the wire surface. Test ends shall be examined using 10× magnification.

7.2 *Decarburization:*

7.2.1 Transverse sections of the wire properly mounted, polished, and etched shall show no completely decarburized (carbon-free) areas when examined at a magnification of 100 diameters. Partial decarburization shall not exceed a depth of