Standard Specification for Steel Wire, Chromium-Silicon Alloy, Chrome-Silicon-Vanadium Alloy Valve Spring Quality

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.

NOTE—Table 4 was editorially corrected in April 2012.

1. Scope

1.1 This specification covers the highest quality of round and shaped chromium-silicon alloy 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.

2. Referenced Documents

2.1 ASTM Standards:
A370 Test Methods and Definitions for Mechanical Testing of Steel Products
A700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment
A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
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 Springsteel Wire of Unalloyed and Alloved Steels.

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—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 may be made by any commercially accepted steel making process. The steel shall be continuously cast.

4.2 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

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

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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 % R.A. shall conform to the requirements prescribed in Table 3 and Table 4.

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 shaped and flat rolled wires.

NOTE 2—Equivalent round definition: The cross sectional area of non-round 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 for each five coils, or fraction thereof, 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. If breakage in the tensile grips prevents conformance to percent reduction in area requirements, conformance to the wrap test (see 6.3) shall suffice.

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

6.2.5 Test Method—The tension test shall be made in accordance with Test Methods and Definitions A370.

6.3 Wrap Test:

6.3.1 Round quenched and tempered or cold drawn wire 4.00 mm [0.157 in.] or smaller 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 The high tensile chrome silicon vanadium grade 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.] shall wrap without breakage on a mandrel twice the diameter without breakage. Larger diameter wire up to and including 8.00 mm [0.315 in.] shall wrap on a mandrel three times the diameter without breakage. Larger diameter wire up to and including 8.00 mm [0.315 in.] shall wrap without breakage on a mandrel twice the diameter without breakage.

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.

6.4 Special Surface Inspection—When specified, the entire length of every coil shall be inspected for surface imperfections with a magnetic or eddy current defect analyzer, or both, or equivalent. The defect depth of this surface inspection shall be agreed upon between the manufacturer and the purchaser. All detected defects shall be properly marked so the purchaser has the ability to identify and discard that length of wire.

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 ina 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 0.025 mm [0.0010 in.] on wire 5.00 mm [0.197 in.] and smaller, or 0.038 mm [0.0015 in.] on larger than 5.00 mm [0.197 in.].

7.2.2 To reveal the decarburization more accurately in untempered wire, the specimen shall be hardened and tempered before microscopic examination. Prior to hardening, the specimen shall be filed flat on one side enough to reduce the diameter at least 20%. The subsequent mounted specimen shall show the flattened section, as well as the original wire edge. Any decarburization on this flattened section shall necessitate a new specimen for examination.

7.2.3 Number of Tests—One test specimen shall be taken for each five coils, or fraction thereof, in a lot.

7.2.4 Location of Tests—Test specimens may be taken from either end of the coil.

7.3 Inclusion Content:

7.3.1 The inclusion content of the wire or wire rod in the worst case shall not exceed the limits shown in Table 5 as described in Test Methods E45, Plate I-r, Method D, except that alternate methodologies are acceptable upon agreement between purchaser and supplier provided minimum requirements are not lower than those of Test Methods E45, Method D.

7.3.1.1 If any coil exceeds the limits listed in Table 5, all coils in the lot will be inspected. Each coil that fails to meet the requirements will be rejected.

7.3.2 Number of Tests—One test specimen shall be taken for each 10 coils, or fraction thereof, in the lot.

7.3.3 Location of Tests—Test specimens may be taken from either end of the coil.

7.3.4 Test Method—A longitudinal section approximately 12.7 mm [0.5 in.] long shall be ground to the centerline and

<table>
<thead>
<tr>
<th>Zone</th>
<th>Thin</th>
<th>Heavy</th>
<th>Thin</th>
<th>Heavy</th>
<th>Thin</th>
<th>Heavy</th>
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<th>Heavy</th>
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<tr>
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<td>1</td>
<td>1</td>
<td>½</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>½</td>
</tr>
<tr>
<td>Core</td>
<td>2</td>
<td>1½</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1½</td>
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NOTE 1—The surface zone is from the wire surface to ½ radius deep. The core is the balance.

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TABLE 4 Tensile and %RA Requirements

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<thead>
<tr>
<th>Diameter, mm</th>
<th>MPa, min</th>
<th>MPa, max</th>
<th>% R.A.</th>
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<tr>
<td>0.5</td>
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<td>2380</td>
<td>β</td>
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<td>2170</td>
<td>2340</td>
<td>β</td>
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<td>1970</td>
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Inch-Pound Units

<table>
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<tr>
<th>Diameter, mm</th>
<th>ksi, min</th>
<th>ksi, max</th>
<th>% R.A.</th>
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<tr>
<td>0.020</td>
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<tr>
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<td>β</td>
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</tr>
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<td>0.148</td>
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</tr>
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<tr>
<td>0.375</td>
<td>270</td>
<td>290</td>
<td>35</td>
</tr>
</tbody>
</table>

TABLE 5 Maximum Inclusion Content

NOTE 1—The surface zone is from the wire surface to ½ radius deep. The core is the balance.
properly mounted and polished. Examination shall be made in
accordance with Test Methods E45.

7.3.5 Upon agreement by the purchaser and supplier, the inclusion requirements may be waived.

8. Dimensions and Permissible Variations

8.1 The permissible variations in the diameter of the wire shall be as specified in Table 1. Any definition of shape wire tolerances shall be agreed upon by the manufacturer and the purchaser.

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

9. Workmanship, Finish, and Appearance

9.1 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.

9.2 Quenched and Tempered—The wire shall be uniform in quality and temper and shall not be wavy or crooked.

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

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

10. Retests

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

11. Inspection

11.1 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 inspections and tests set forth in this specification when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements.

12. Rejection and Rehearing

12.1 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.

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

13. Certification

13.1 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.

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

14. Packaging, Marking, and Loading for Shipment

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

14.2 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.

14.3 Unless otherwise specified in the purchaser’s order, packaging, marking, and loading for shipments shall be in accordance with those procedures recommended by Practices A700.

15. Keywords

15.1 alloy; chromium-silicon; valve spring; wire

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue, A877/A877M – 99, that may impact the use of this standard. (Approved Oct. 1, 2010.)

(1) Changed name of specification – Added Chromium-Silicon-Vanadium alloy.
(2) Scope: Added Chromium-Silicon-Vanadium alloy. Added reference to EN 10270-2 specification.
(3) Deleted 2.2, 2.3, 2.4 referenced standards.
(4) Added 6.2.1, 6.2.2, 6.3.2, and notes 2 and 3.
(5) Deleted 14.4 and 14.5.
(6) Added grade A & B to Table 2 Chemical Requirements.
(7) Added Table 4 for the new steel grade of Chromium-Silicon-Vanadium alloy.
(8) Changed “oil quench” to “quenched and tempered” throughout body of text.