

Standard Specification for Chromium-Vanadium Alloy Steel Spring Wire¹

This standard is issued under the fixed designation A231/A231M; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers round and shaped chromiumvanadium alloy steel spring wire having properties and quality intended for the manufacture of springs used at moderately elevated temperatures. This wire shall be either in the annealed and cold-drawn or oil-tempered condition as specified by the 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.

1.2.1 Within the text, the inch-pound units are shown in brackets.

2. Referenced Documents

2.1 ASTM Standards:²

- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A510/A510M Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel, and Alloy Steel
- A700 Guide 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

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 may include, but are not limited to, the following:

3.1.1 Quantity (mass),

3.1.2 Name of material (chromium-vanadium alloy steel wire),

3.1.3 Wire diameter (Table 1 and Section 8),

3.1.4 Packaging (Section 14),

3.1.5 Heat analysis report (if requested) (5.2),

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

3.1.7 ASTM designation and date of issue.

Note 1—A typical ordering description is as follows: 20 000 kg oil-tempered chromium-vanadium alloy steel wire, size 6.00 mm in 150-kg coils to ASTM A231/A231M dated______, or for inch-pound units, 40 000 lb oil-tempered chromium-vanadium alloy steel spring wire, size 0.250 in. in 350-lb coils to ASTM A231/A231M dated______.

4. Materials and Manufacture

4.1 The steel may be made by any commercially accepted steel-making process. The steel may be either ingot cast or strand 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 of Grade 6150 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 chemical composition thus determined, as to elements required or restricted, shall conform to the product analysis requirements specified in Table 4 of Specification A510/A510M.

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

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.

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TABLE 1 Tensile Requirem	nents ^A
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SI Units		Reduction of Areas,	
Diameter, ² mm	MPa, min	MPa, max	— min, %
0.50	2060	2260	C
0.55	2050	2240	C
0.60	2030	2220	C
0.65	2010	2200	С
0.70	2000	2160	C
0.80	1980	2140	C
0.90	1960	2120	C
1.00	1940	2100	C
1.10	1920	2080	C
1.20	1900	2060	С
1.40	1860	2020	C
1.60	1820	1980	С
1.80	1800	1960	С
2.00	1780	1930	С
2.20	1750	1900	С
2.50	1720	1860	45
2.80	1680	1830	45
3.00	1660	1800	45
3.50	1620	1760	45
4.00	1580	1720	40
4.50	1560	1680	40
5.00	1520	1640	40
5.50	1480	1620	40
6.00	1460	1600	40
6.50	1440	1580	40
7.00	1420	1560	40
8.00	1400	1540	40
9.00	1380	1520	40
10.00	1360	1500	40
11.00	1340	1480	40
12.00	1320	1460	40
Diameter, ^B in.	Inch-Pound Units		Reduction of Area, min
	ksi, min.	ksi, max	%
0.020	300	325	С
0.032	290	315	С
0.041	280	305	С
0.054	270	295	С
0.062	265	290	С
0.080	255	275	С
0.105	245	265	45
0.135	235	255	45
0.162	225	245	40
0.192	220	240	40
0.244	210	230	40
0.283	205	225	40
0.312	203	223	40
0.375	200	220	40
0.438	195	215	40
0.500	190	210	40

^A Tensile strength values for intermediate diameters may be interpolated.

^B Preferred sizes. For a complete list, refer to ANSI B 32.4M.

 $^{\it C}$ The reduction of area test is not applicable to wire diameters under 2.34 mm [0.092 in.] in diameter.

TABLE 2 Chemical F	Requirements
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E	Element Analysis, 9	%
Carbon	0.48-0.53	3
Manganese	0.70–0.90)
Phosphorus	0.035 max	х
Sulfur	0.040 max	х
Silicon	0.15–0.35	5
Chromium	0.80–1.10)
Vanadium	0.15 min	

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, or tensile strength, if desired, shall be stated in the purchase order.

6.2 *Oil Tempered*—When purchased in the oil-tempered condition, the tensile strength and minimum percent reduction of area, sizes 2.50 mm [0.105 in.] and coarser, of the wire shall conform to the requirements as shown in Table 1. Tensile strength of shaped and flat rolled wires shall conform to this table 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.

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

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

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

6.3 Wrap Test:

6.3.1 Oil tempered or cold drawn wire 4.00 mm [0.157 in.] and smaller in diameter shall wind 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 or flat rolled wires.

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

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

6.3.4 *Test Method*—The wrap test shall be made in accordance with Supplement A4.7 of Test Methods and Definitions A370.

7. Metallurgical Properties

7.1 Surface Condition:

7.1.1 The surface of the wire as received shall be free of seams, pits, die marks, scratches, and other surface imperfections that are deeper than 3.5 % of the wire diameter, or 0.25 mm [0.010 in.], whichever is the smaller as measured on a transverse section. The wire shall be free of rust and excessive scale.

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

7.1.3 *Location of Test*—Test specimens shall be taken from either or both ends of the coil.

7.1.4 *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 two minutes in order to remove the oxide scale layer from the wire surface. Test ends shall be examined using $10 \times$ magnification. Any specimen showing the presence of a questionable surface imperfection shall have a transverse section taken from the unetched area, properly mounted and polished and examined to measure the depth of the imperfection.

7.2 Decarburization:

7.2.1 The depth of complete decarburization (free ferrite) shall not exceed 0.75 % of the equivalent round wire diameter. The total affected depth (free ferrite plus partial decarburization) shall not exceed 2 % of the equivalent round wire diameter on all sizes of wire.

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

7.2.3 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 diameters may require higher magnification. Measure the worst area present excluding decarburization associated with any surface imperfections. Complete decarburization exists when only free ferrite is present. Partial decarburization exists when ferrite is found mixed with pearlite or tempered martensite, depending on the wire processing.

7.2.4 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 test 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 after heat treatment, evaluate the complete wire section in accordance with 7.2.3.

8. Dimensions and Permissible Variations

8.1 The permissible variations in the diameter of the wire shall be as specified in Table 3.

9. Workmanship 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 flat on itself and not spring up nor show a wavy condition.

9.2 *Oil 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. Welds made prior to cold drawing are permitted. If unmarked welds are unacceptable to the purchaser, special arrangements should be made with the manufacturer at the time of the purchase.

10. Retests

10.1 If any test specimen exhibits obvious imperfections or shows the presence of a weld, 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 assure that the material conforms to prescribed requirements.

TABLE 3 Permissible Variations in Wire Diameter ^A				
Diameter, mm	SI Units Permissible Variations, ± mm	Permissible Out-of Round, mm		
To 0.70, incl	0.02	0.02		
Over 0.70 to 2.00, incl	0.03	0.03		
Over 2.00 to 9.00, incl	0.05	0.05		
Over 9.00	0.08	0.08		
Inch-Pound Units				
Diameter, in.	Permissible	Permissible Out-of-		
	Variations, ± in.	Round, in.		
0.020 to 0.028, incl	0.0008	0.0008		
Over 0.028 to 0.075, incl	0.001	0.001		
Over 0.075 to 0.375, incl	0.002	0.002		
Over 0.375 to 0.500, incl	0.003	0.003		

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



12. Rejection and Rehearing

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

12.2 The material shall 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 as 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, packing, marking, and loading for shipments shall be in accordance with those procedures recommended by Practices A700.

15. Keywords

(3) Revised 5.3.

15.1 alloy; chromium-vanadium; spring; wire

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A231/A231M - 10) that may impact the use of this standard. (Approved Nov. 1, 2015.)

(1) Added Specification A510/A510M to Section 2.(2) Removed Specification A752 from Section 2.

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