Designation: A 231/A 231M – 04

Standard Specification for Chromium-Vanadium Alloy Steel Spring Wire[1]

This standard is issued under the fixed designation A 231/A 231M; 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 Department of Defense.

1. Scope*

1.1 This specification covers round chromium-vanadium 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 (metric) units or inch-pound units are to be regarded separately as standard. 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 370 Test Methods and Definitions for Mechanical Testing of Steel Products

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 752 Specification for General Requirements for Wire Rods and Coarse Round Wire, Alloy Steel

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

2.2 *ANSI Standard:*

B 32.4M Preferred Metric Sizes for Round, Square, Rectangle, and Hexagon Metal Products[3]

2.3 *Military Standard:*

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[4]

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[4]

2.5 *AIAG Standard:*

AIAGB-5 02.00 Primary Metals Identification Tag Application Standard[5]

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 Table 2),

3.1.4 Packaging (Section 14),

3.1.5 Cast or 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 A 231M 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 A 231 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 as to chemical composition specified in Table 3.

5.2 *Cast or Heat Analysis*—Each cast or heat of steel shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 3. This analysis shall be made from a test specimen preferably taken during the pouring of the

[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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

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

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

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TABLE 1 Tensile Requirements, SI Units[A]

Diameter,[B] mm	Tensile Strength, MPa		Reduction of Areas, min, %
	min	max	
0.50	2060	2260	[C]
0.55	2050	2240	[C]
0.60	2030	2220	[C]
0.65	2010	2200	[C]
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	[C]
1.40	1860	2020	[C]
1.60	1820	1980	[C]
1.80	1800	1960	[C]
2.00	1780	1930	[C]
2.20	1750	1900	[C]
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

[A] Tensile strength values for intermediate diameters may be interpolated.
[B] Preferred sizes. For a complete list, refer to ANSI B 32.4M, Preferred Metric Sizes for Round, Square, Rectangle, and Hexagon Metal Products.
[C] The reduction of area test is not applicable to wire diameters under 2.34 mm.

TABLE 2 Tensile Requirements, Inch-Pound Units[A]

Diameter,[B] in.	Tensile Strength, ksi		Reduction of Area, min, %
	min	max	
0.020	300	325	[C]
0.032	290	315	[C]
0.041	280	305	[C]
0.054	270	295	[C]
0.062	265	290	[C]
0.080	255	275	[C]
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, Preferred Metric Sizes for Round, Square, Rectangle, and Hexagon Metal Products.
[C] The reduction of area test is not applicable to wire diameters under 0.092 in.

cast or heat. When requested, this shall be reported to the purchaser and shall conform to the requirements of Table 3.

5.3 *Product Analysis*—An analysis may be made by the purchaser from finished wire representing each cast or heat of steel. The chemical composition thus determined, as to elements required or restricted, shall conform to the product analysis requirements specified in Table 5 of Specification A 752.

TABLE 3 Chemical Requirements

Element	Analysis, %
Carbon	0.48–0.53
Manganese	0.70–0.90
Phosphorus	0.040 max
Sulfur	0.040 max
Silicon	0.15–0.35
Chromium	0.80–1.10
Vanadium	0.15 min

5.4 For referee purposes, Test Methods, Practices, and Terminology A 751 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, 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 or 0.105 in. and coarser, of the wire shall conform to the requirements as shown in Table 1 or Table 2.

6.2.1 *Number of Tests*—One test specimen shall be taken for each ten coils, or fraction thereof, in a lot. Each cast or 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 A 370.

6.3 *Wrap Test*:

6.3.1 Oil tempered or cold drawn wire 4.00 mm or 0.162 in. and smaller in diameter shall wind on itself as an arbor without breakage. Larger diameter wire up to and including 8.00 mm or 0.312 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 or 0.312 in. in diameter.

6.3.2 *Number of Tests*—One test specimen shall be taken for each ten coils, or fraction thereof, in a lot. Each cast or 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 IV of Test Methods and Definitions A 370.

7. Metallurgical Properties

7.1 *Surface Condition*:

7.1.1 The surface of the wire as received shall be free of rust and excessive scale. No serious die marks, scratches, or surface imperfections shall be present. Based upon examination of

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etched end specimen, surface imperfections shall not exceed 3.5 % of the wire diameter, or 0.25 mm or 0.010 in., whichever is the smaller as measured on a transverse section.

7.1.2 *Number of Tests*—One test specimen shall be taken for each ten coils, or fraction thereof, in a lot. Each cast or 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. Test ends shall be examined using 10× magnification. Any specimen which shows questionable surface imperfections of borderline depth 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 wire diameter. The total affected depth (free ferrite plus partial decarburization) shall not exceed 2 % of the 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 4 or Table 5.

TABLE 4 Permissible Variations in Wire Diameter, SI Units[A]

Diameter, mm	Permissible Variations, plus and minus, 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

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

TABLE 5 Permissible Variations in Wire Diameter, Inch-Pound Units[A]

Diameter, in.	Permissible Variations, plus and minus, in.	Permissible Out-of-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 E 29.

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.

9.4 *Appearance*—The surface shall be smooth and free of pits, die marks, and other imperfections tending to impair the use of the wire for springs. Any additional surface requirements shall be negotiated at the time of entry of the order.

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.

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

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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 A 700.

14.4 *For Government Procurement*:

14.4.1 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.

14.5 *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 B-5 02.00, Primary Metals Identification Tag Application. The bar code may be applied to a substantially affixed tag.

15. Keywords

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, A 231/A 231M –96 (2002), that may impact the use of this standard. (Approved Sept. 1, 2004.)

(*1*) Revised 3.1 to include mandatory language.
(*2*) Deleted reference to "check analysis" in 5.3.
(*3*) Revised 6.1 to include tensile strength.
(*4*) Updated terminology in 7.1.1, 7.1.4, 9.4, and 10.1.
(*5*) Added 7.2 on Decarburization.
(*6*) Revised 12.2.

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