Designation: A 232/A 232M – 05

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

This standard is issued under the fixed designation A 232/A 232M; 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 the highest quality of round chromium-vanadium 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. 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. Within the text, the inch-pound units are shown in brackets. 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

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

2.2 *ANSI Standard:*[3]

B 32.4 Preferred Metric Sizes for Round, Square, Rectangle, and Hexagon Metal Products

2.3 *Federal Standard:*[4]

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

2.4 *Military Standard:*[4]

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

2.5 *AIAG Standard:*[5]

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard

3. Ordering Information

3.1 Orders for material under this specification should include the following information for each ordered item:

3.1.1 Quantity (mass),

3.1.2 Name of material (chromium-vanadium 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 oil-tempered chromium-vanadium alloy steel valve spring quality wire, size 6.00 mm in 150 kg coils to ASTM A 232/A 232M dated __, or for inch-pound units, 40 000 lb oil-tempered chromium-vanadium alloy steel valve spring quality wire, size 0.250 in. in 350-lb coils to ASTM A 232/A 232M 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 prescribed in Table 2. This analysis shall be made from a test

[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 A1.03 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[A]

SI Units			
Diameter,[B] mm	MPa, min	MPa, max	Reduction of Area, min, %
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
Inch-Pound Units			
Diameter, in.	ksi, min	ksi, max	Reduction of Area, min, %
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 B32.4.
[C] The reduction of area test is not applicable to wire diameters under 0.092 in. [2.34 mm].

TABLE 2 Chemical Requirements

	Analysis, %	Product Analysis Tolerance, %
Carbon	0.48–0.53	±0.02
Manganese	0.70–0.90	±0.03
Phosphorus	0.020 max	+0.005
Sulfur	0.035 max	+0.005
Silicon	0.15–0.35	±0.02
Chromium	0.80–1.10	±0.05
Vanadium	0.15 min	–0.01

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 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, 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 prescribed in Table 1.

6.2.1 *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.

6.2.2 *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 [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 [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 in diameter.

6.3.2 *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.

6.3.3 *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 Test Methods and Definitions A 370.

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*:

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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 100× magnification. Partial decarburization shall not exceed a depth of 0.025 mm [0.001 in.] on wire 5.00 mm [0.192 in.] and smaller or 0.038 mm [0.0015 in.] on larger than 5.00 mm [0.192 in.]. Measure the worst area present excluding decarburization associated with seams or other surface imperfections. Complete decarburization exists when only free ferrite is present. Partial decarburization exists when ferrite is found mixed with pearlite or tempered martensite. Structures of 100 % tempered martensite shall be defined as not decarburized.

7.2.2 To reveal the decarburization more accurately in the untempered wire, the specimen shall be hardened and tempered before microscopical 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. Each in a given lot shall be tested.

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

7.3 *Microstructure*—A longitudinal section shall show a fine homogeneous tempered martensitic structure.

8. Dimensions and Permissible Variations

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

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 *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 and firmly tied.

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

TABLE 3 Permissible Variations in Wire Diameter[A]

SI Units		
Diameter, mm	Permissible Variations, plus and minus, mm	Permissible Out-of-Round, mm
to 2.0, incl	0.02	0.02
Over 2.0 to 4.00, incl	0.03	0.03
Over 4.00 to 9.00, incl	0.04	0.04
Over 9.00	0.05	0.05
Inch-Pound Units		
Diameter, in.	Permissible Variations, plus and minus, 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 to 0.500, incl	0.002	0.002

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

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 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 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.

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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 A 700.

14.4 *For Government Procurement*—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; valve spring; wire

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes made to this standard since the last issue, A 232 A 232M – 99, that may impact the use of this standard. (Approved March 1, 2005.)

(*1*) Removed the ingot cast steel and added continuous cast in 4.1.

(*2*) Removed engine valve spring manufacturer and added statements regarding defect depth and identification in 6.4.

(*3*) Changed the length of time for sample preparation from 1 % to removal of the oxide layer in 7.1.

(*4*) Added Summary of Changes section.

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