Designation: ~~A232/A232M – 05 (Reapproved 2011)ε1~~ A232/A232M – 18

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

This standard is issued under the fixed designation A232/A232M; 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.

~~ε[1] NOTE—Units were re-ordered editorially throughout in July 2011.~~

1. Scope*

1.1 This specification covers the highest quality of round and shaped 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. 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 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.

1.3 *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, Practices, and Terminology for Chemical Analysis of Steel Products

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

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 *ANSI Standard:*[3]~~

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

2.2 *Federal Standard:*[3]

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

2.3 ~~*Military*~~*European Standard:*[4]

~~MIL-STD-163~~EN 10270-2 Steel ~~Mill Products, Preparation for Shipment and Storage~~Wire for Mechanical Springs Part 2: Oil-Hardened and Tempered Spring Steel Wire of Unalloyed and Alloyed Steels

~~2.5 *AIAG Standard:*[5]~~

~~AIAG B-5 02.00 Primary Metals Identification Tag Application Standard~~

[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.~~

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

[4] Available from ~~Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48034.~~European Committee for Standardization, CEN-CENELEC Management Centre Avenue Marnix 17-B-1000 Brussels, Belgium.

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

3. Terminology

3.1 *Definitions:*

3.1.1 For definition of terms used in this specification, refer to Terminology A941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *billet, n*—an as-cast or forged section, typically available for transport, inspection, and conditioning, that is used as raw material for wire rod manufacture.

3.2.2 *bloom, n*—an as-cast or forged section used as raw material for billet manufacture.

3.2.3 *equivalent round diameter, n*—diameter of a round wire having equivalent cross sectional area to a given shaped wire.

3.2.4 *round wire, n*—wire having a circular cross section.

3.2.5 *shape factor, n*—a value used to obtain cross sectional area for shaped wires when multiplied by measured width and measured thickness.

3.2.6 *shaped wire, n*—wire having a non-circular cross section.

4. Ordering Information

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

4.1.1 Quantity (mass),

4.1.2 Name of material (chromium-vanadium alloy steel valve spring quality wire),

4.1.3 Dimensions (Section 9),

4.1.4 Condition (Section 7), and

4.1.5 ASTM designation and year of issue.

4.2 ~~Orders for material under this specification should include the following information for each ordered item:~~ The purchaser shall have the option to specify additional requirements, including but not limited to:

~~3.1.1 Quantity (mass),~~

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

4.2.1 ~~Dimensions~~ Requirements for certifications, heat analysis or test reports (~~Table 1~~6.2 and Section ~~8~~14),

~~3.1.4 Condition (Section 6),~~

~~3.1.5 Packaging (Section 14),~~

~~3.1.6 Heat analysis report, if requested (5.2),~~

4.2.2 ~~Certification or test report, or both, if specified~~ Special packing, marking, and loading requirements (Section ~~13~~15), and

4.2.3 ~~ASTM designation and year of issue.~~ Other special requirements, if any.

NOTE 1—A typical ordering description is as follows: For ~~inch-pound~~SI units, ~~40 000 lb~~20 000 kg oil-tempered chromium-vanadium alloy steel valve spring quality wire, size ~~0.250 in. in 350-lb~~ 6.00 mm in 150 kg coils to ASTM A232/A232M dated _____; ~~or for SI units, 20 000 kg~~_____. For inch-pound units, 40 000 lb oil-tempered chromium-vanadium alloy steel valve spring quality wire, size ~~6.00 mm in 150 kg~~ 0.250 in. in 350-lb coils to ASTM A232/A232M dated _____._____.

5. Materials and Manufacture

5.1 The steel ~~may~~shall be made by ~~any commercially accepted steel making process. The steel shall be continuously cast.~~ a steel making process combined with secondary ladle refining that is capable of satisfying the inclusion content requirements of this specification

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

5.3 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.

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

5.5 Alternate manufacturing processes may be used upon agreement between purchaser and supplier provided that the minimum requirements of this standard are met.

6. Chemical Composition

6.1 The steel shall conform to the requirements for chemical composition specified in Table ~~2~~1.

6.2 *Heat Analysis*—Each heat of steel shall be analyzed ~~by the manufacturer~~ to determine the percentage of elements prescribed in Table ~~2~~1. 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~~1.

6.3 *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

TABLE 21 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

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.

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

7. 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.~~

7.1 ~~*Oil Tempered*—~~*Tension Test:* ~~When purchased in the oil-tempered condition, the tensile strength and minimum percent reduction of area, sizes 0.105 in. [2.50 mm] and coarser, of the wire shall conform to the requirements prescribed in Table 1.~~

7.1.1 *Requirements for Annealed and Cold Drawn Wires*—Tension test requirements, if any, shall be stated on the purchase order.

7.1.2 *Requirements for Oil Tempered Wires*—The material as represented by tension test specimens shall conform to the requirements in Table 2. Variation in tensile strength within a coil shall not exceed 70 Mpa [10.15 ksi].

7.1.3 *Number of Tests*—~~One~~ For oil-tempered wires, each coil in a lot shall be tested. When specified for annealed and cold drawn wires, 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.

7.1.4 *Location of Tests*—~~Test~~ For oil-tempered wires, test specimens shall be taken from both ends of the coil. For annealed and cold drawn wires, it shall be permissible for test specimens to be taken from either end of the coil.

7.1.5 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A370. Any tensile test specimen breaking in the tensile grips shall be discarded and a new specimen tested if the specified mechanical properties are not achieved. For shaped wires, cross sectional area shall be calculated either using the procedure in Test Methods E8/E8M for uniform but nonsymmetrical cross-sections, or 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.

7.1.5.1 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.

7.2 *Wrap Test:*

7.2.1 Oil-tempered or cold-drawn wire ~~0.162 in. [4.00 mm]~~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 ~~0.312 in. [8.00 mm]~~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 ~~0.312 in. [8.00 mm] in diameter.~~ 8.00 mm [0.312 in.] in diameter. For shaped wires, mandrel size shall be selected based on the equivalent round diameter.

7.2.2 *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.

7.2.3 *Location of Test*—~~Test specimens~~ It shall be ~~taken~~ permissible to take test specimens from either end of the coil.

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

7.3 *Special Surface Inspection*—~~When specified, the~~ The entire length of every coil shall be inspected for surface imperfections with a ~~magnetic or~~ rotating and stationary probe 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~~ equivalent. 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.~~wire; other depths may be agreed upon. Number of allowable marks per coil shall be agreed upon between the manufacturer and purchaser. This test is not applicable to wire diameters or equivalent round diameters below 2.5 mm [0.098 in.].

NOTE 2—Special surface inspection of certain cross sectional shapes may not be technically feasible.

TABLE ~~1~~2 Tensile Requirements[A]

SI Units

Diameter,[B] mm	MPa, min	MPa, max	Reduction of Area, min, %[C,D]
~~0.50~~	~~2060~~	~~2260~~	~~C~~
0.50	2060	2260	. . .
~~0.55~~	~~2050~~	~~2240~~	~~C~~
0.55	2050	2240	. . .
~~0.60~~	~~2030~~	~~2220~~	~~C~~
0.60	2030	2220	. . .
~~0.65~~	~~2010~~	~~2200~~	~~C~~
0.65	2010	2200	. . .
~~0.70~~	~~2000~~	~~2160~~	~~C~~
0.70	2000	2160	. . .
~~0.80~~	~~1980~~	~~2140~~	~~C~~
0.80	1980	2140	. . .
~~0.90~~	~~1960~~	~~2120~~	~~C~~
0.90	1960	2120	. . .
~~1.00~~	~~1940~~	~~2100~~	~~C~~
1.00	1940	2100	. . .
~~1.10~~	~~1920~~	~~2080~~	~~C~~
1.10	1920	2080	. . .
~~1.20~~	~~1900~~	~~2060~~	~~C~~
1.20	1900	2060	. . .
~~1.40~~	~~1860~~	~~2020~~	~~C~~
1.40	1860	2020	. . .
~~1.60~~	~~1820~~	~~1980~~	~~C~~
1.60	1820	1980	. . .
~~1.80~~	~~1800~~	~~1960~~	~~C~~
1.80	1800	1960	. . .
~~2.00~~	~~1780~~	~~1930~~	~~C~~
2.00	1780	1930	. . .
~~2.20~~	~~1750~~	~~1900~~	~~C~~
2.20	1750	1900	. . .
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, %[C,D]
~~0.020~~	~~300~~	~~325~~	~~C~~
0.020	300	325	. . .
~~0.032~~	~~290~~	~~315~~	~~C~~
0.032	290	315	. . .
~~0.041~~	~~280~~	~~305~~	~~C~~
0.041	280	305	. . .
~~0.054~~	~~270~~	~~295~~	~~C~~
0.054	270	295	. . .
~~0.062~~	~~265~~	~~290~~	~~C~~
0.062	265	290	. . .
~~0.080~~	~~255~~	~~275~~	~~C~~
0.080	255	275	. . .
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