Designation: A 401/A 401M – 03

Standard Specification for Steel Wire, Chromium-Silicon Alloy[1]

This standard is issued under the fixed designation A 401/A 401M; 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.

1. Scope*

1.1 This specification covers round chromium-silicon alloy steel spring wire having properties and quality intended for the manufacture of springs resistant to set when used at moderately elevated temperatures. This product is not meant to be used for high cycle fatique applications (see Specification A 877/A 877M). This wire shall be provided 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:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment[3]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[2]

A 752 Specification for General Requirements for Wire Rods and Coarse Round Wire, Alloy Steel[2]

A 877/A 877M Specification for Steel Wire, Chromium-Silicon Alloy Valve Spring Quality[2]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[4]

2.2 *ANSI Standard:*

B 32.4 Preferred Metric Sizes for Round, Square, Rectangle and Hexagon Metal Products[5]

2.3 *Federal Standards:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

2.4 *Military Standard:*

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[6]

2.5 *AIAG Standard:*

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard[7]

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-silicon alloy steel 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-silicon alloy steel wire, size 6.00 mm in 150 kg coils to ASTM A 401/A 401M dated ____, or for inch-pound units, 40 000-lb oil-tempered chromium-silicon alloy steel spring wire, size 0.250 in. in 350-lb coils to ASTM A 401/A 401M 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 9254 for chemical composition specified in Table 2.

[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.

Current edition approved Sept. 10, 2003. Published Sept. 2003. Originally approved in 1956. Last previous edition approved in 1998 as A 401/A 401M – 98.

[2] *Annual Book of ASTM Standards*, Vol 01.03.

[3] *Annual Book of ASTM Standards*, Vol 01.05.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

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

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[7] 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, %
0.80	2080	2260	[C]
0.90	2070	2250	[C]
1.00	2060	2240	[C]
1.10	2040	2220	[C]
1.20	2020	2200	[C]
1.40	2000	2180	[C]
1.60	1980	2160	[C]
1.80	1960	2140	[C]
2.00	1940	2120	[C]
2.20	1920	2100	[C]
2.50	1900	2080	45
2.80	1880	2060	45
3.00	1860	2040	45
3.50	1840	2020	40
4.00	1820	2000	40
4.50	1800	1980	40
5.00	1780	1960	40
5.50	1760	1940	40
6.00	1740	1920	40
6.50	1720	1900	40
7.00	1700	1880	40
8.00	1680	1860	40
9.00	1660	1840	40
10.00	1640	1820	40
11.00	1620	1800	35
12.0	1600	1780	35
13.0	1580	1760	30
14.0	1570	1750	30
15.0	1560	1740	30
16.0	1550	1730	30
17.0	1540	1720	30
18.0	1530	1710	30
Inch-Pound Units			
Diameter, in.	ksi, min	ksi, max	Reduction of Area, min, %
0.032	300	325	[C]
0.041	298	323	[C]
0.054	292	317	[C]
0.062	290	315	[C]
0.080	285	310	[C]
0.092	280	305	45
0.120	275	300	45
0.135	270	295	40
0.162	265	290	40
0.177	260	285	40
0.192	260	283	40
0.219	255	278	40
0.250	250	275	40
0.312	245	270	40
0.375	240	265	40
0.438	235	260	35
0.500	230	255	35
0.562	228	253	30
0.625	226	251	30
0.687	224	249	30

[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 under 2.34 mm [0.092 in.] in diameter.

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.

TABLE 2 Chemical Requirements

UNS Designation G 92540				Grade No. 9254	
Ranges and Limits, %					
Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Chromium
0.51–0.59	0.60–0.80	0.035	0.040	1.20–1.60	0.60–0.80

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 in Table 4 of Specification A 752.

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 [0.105 in.] and coarser, of the wire shall conform to the requirements prescribed in Table 1.

NOTE 2—Any specimen breaking in the grips shall be discarded and a new specimen tested if the specified mechanical properties are not achieved.

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 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 [0.312 in.] in diameter.

6.3.2 *Number of Tests*—One test specimen shall be taken for each 10 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.

7. Metallurgical Requirements

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

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imperfections shall be present. Based upon examination of etched-end specimen, seams shall not exceed 3.5 % of the wire diameter, or 0.25 mm [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 10 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 specimens 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 seam.

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 wire with nital. The entire periphery to be examined should 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 sizes 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. Structures of 100× tempered martensite shall be defined as not decarburized.

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, 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.

TABLE 3 Permissible Variations in Wire Diameter[A]

SI Units		
Diameter	Permissible Variations, ± mm	Permissible Out-of-Round
To 2.00, incl	0.03	0.03
Over 2.00 to 11.0, incl	0.05	0.05
Over 11.00	0.07	0.07
Inch-Pound Units		
Diameter	Permissible Variations, ± in.	Permissible Out-of-Round
0.032 to 0.075, incl	0.001	0.001
Over 0.075 to 0.438, incl	0.002	0.002
Over 0.438	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, 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. 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 defects 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 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.

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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 annealed chromium-silicon alloy; oil; springs; tempered; wire

SUMMARY OF CHANGES

This section identifies the location of selected changes to this standard that have been incorporated since the A 401/A 401M-98 issue. For the convenience of the user, Committee A01 has highlighted those changes that impact the use of this standard. This section may also include descriptions of changes or reasons for changes, or both.

(1) Revised language in Sections 3.1, 6.1, 7.1.1, 7.1.4, and 7.2.3.

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