

# SPECIFICATION FOR STEEL WIRE, CHROMIUM-SILICON ALLOY



**SA-401/SA-401M**



(23)

(Identical with ASTM Specification A401/A401M-18.)

# Specification for Steel Wire, Chromium-Silicon Alloy

## 1. Scope

1.1 This specification covers round and shaped 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 non-static applications involving moderate fatigue stresses (see Specification A1000/A1000M) or high cycle fatigue applications (see Specification A877/A877M). This wire shall be provided either in the annealed and cold-drawn or quench and 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.

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:

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

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

A877/A877M Specification for Steel Wire, Chromium-Silicon Alloys, Chrome-Silicon-Vanadium Alloy Valve Spring Quality

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

A1000/A1000M Specification for Steel Wire, Carbon and Alloy Specialty Spring Quality

E8/E8M Test Methods for Tension Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions of terms used in this specification, see Terminology A941.

### 3.2 Definitions of Terms Specific to This Standard:

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

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

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

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

## 4. Ordering Information

4.1 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:

4.1.1 Quantity (mass),

4.1.2 Name of material (chromium-silicon alloy steel wire),

4.1.3 Dimensions (Table 1 and Section 9),

4.1.4 Condition (Section 7), and

4.1.5 ASTM designation and year of issue.

4.2 The purchaser shall have the option to specify additional requirements, including but not limited to:

TABLE 1 Tensile Requirements<sup>A</sup>

SI Units			
Diameter, <sup>B</sup> mm	MPa, min	MPa, max	Reduction of Area, min, % <sup>C,D</sup>
0.80	2080	2260	...
0.90	2070	2250	...
1.00	2060	2240	...
1.10	2040	2220	...
1.20	2020	2200	...
1.40	2000	2180	...
1.60	1980	2160	...
1.80	1960	2140	...
2.00	1940	2120	...
2.20	1920	2100	...
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, % <sup>C,D</sup>
0.032	300	325	...
0.041	298	323	...
0.054	292	317	...
0.062	290	315	...
0.080	285	310	...
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

<sup>A</sup> Tensile strength values for intermediate diameters shall be interpolated.

<sup>B</sup> Preferred sizes.

<sup>C</sup> The reduction of area test is not applicable to wire under 2.34 mm [0.092 in.] in diameter. For intermediate wire diameters, the reduction of area requirement shall be that of the next larger wire.

<sup>D</sup> "..." Indicates no minimum requirement.

4.2.1 Requirements for certifications, heat analysis or test reports (6.2 and Section 14),

4.2.2 Special packing, marking, and loading requirements (Section 15), and

4.2.3 Other special requirements, if any.

NOTE 1—A typical ordering description is as follows: 20 000-kg, quench and tempered chromium-silicon alloy steel wire, size 6.00 mm in 150 kg coils to ASTM A401/A401M dated \_\_\_\_\_, or for inch-pound units, 40 000-lb quench and tempered chromium-silicon alloy steel spring wire, size 0.250 in. in 350-lb coils to ASTM A401/A401M dated \_\_\_\_\_.

## 5. Materials and Manufacture

5.1 The steel may be made by any commercially accepted steel making process. The steel may be either ingot cast or strand cast.

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

## 6. Chemical Composition

6.1 The steel shall conform to the requirements of Grade 9254 for chemical composition specified in Table 2.

6.2 *Heat Analysis*—Each heat of steel shall be analyzed 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.

6.3 *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 A510/A510M.

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

## 7. Mechanical Properties

7.1 *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.

7.2 *Quench and Tempered*—When purchased in the quench and tempered condition, the tensile strength and minimum percent reduction of area shall conform to the requirements prescribed in Table 1. Tensile strength of shaped wires shall conform to this table based on the conversion to equivalent round dimensions.

7.2.1 *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.

TABLE 2 Chemical Requirements

UNS Designation G92540		Grade No. 9254			
Ranges and Limits, %					
Carbon	Manga- nese	Phosphorus, max	Sulfur, max	Silicon	Chro- mium
0.51–0.59	0.60–0.80	0.035	0.040	1.20–1.60	0.60–0.80

7.2.2 *Location of Tests*—It shall be permissible to take test specimens from either end of the coil.

7.2.3 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A370. For shaped wires, cross sectional area shall be calculated either by using the procedure in Test Methods E8/E8M for uniform but nonsymmetrical cross-sections, or by 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.

7.2.4 Upon agreement between purchaser and supplier, the shape factor for the cross section 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.

### 7.3 *Wrap Test:*

7.3.1 Quench and 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 and flat rolled wires.

7.3.2 *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.

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

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

## 8. Metallurgical Requirements

### 8.1 *Surface Condition:*

8.1.1 On the whole, the surface of the wire as received shall be free of rust and excessive scale. Based upon examination of end specimens, no serious die marks, scratches, or other continuous surface 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.

8.1.2 *Number of Tests*—For the purpose of examination of etched-end specimens, 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.

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

8.1.4 *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× 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 surface imperfection.

### 8.2 *Decarburization:*

8.2.1 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 2.0 % of the equivalent round wire diameter on all sizes of wire.

8.2.2 *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.

8.2.3 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.

8.2.4 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 8.2.3.

## 9. Dimensions and Permissible Variations

9.1 The permissible variations in the diameter of the wire shall be as specified in Table 3. Any definition of shaped tolerances shall be agreed upon by the producer and the purchaser.

## 10. Workmanship, Finish, and Appearance

10.1 *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

TABLE 3 Permissible Variations in Wire Diameter<sup>A</sup>

SI Units		
Diameter	Permissible Variations, ±mm	Permissible Out-of-Round
0.80 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

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

surface. The wire shall lie substantially flat on itself and not spring up nor show a wavy condition.

10.2 *Quench and Tempered*—The wire shall be uniform in quality and temper and shall not be wavy or crooked.

10.3 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.

### 11. Retests

11.1 If any tested specimen exhibits an obvious defect or condition of non-conformance that is not representative of the coil from which it was collected, or shows the presence of a weld, it shall be discarded and another specimen substituted.

11.2 If any tested specimen exhibits an obvious defect or condition of non-conformance that is representative of a portion of the coil from which it was collected, the manufacturer shall remove from the coil the portion containing the obvious defect or condition of non-conformance before collecting another test specimen from the coil for the purpose of retesting.

### 12. Inspection

12.1 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.

### 13. Rejection and Rehearing

13.1 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.

13.2 The material must be adequately protected and correctly identified in order that the manufacturer may make a proper investigation.

### 14. Certification

14.1 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.

14.2 The certification shall include the specification number, year date of issue, and revision letter, if any.

### 15. Packaging, Marking, and Loading for Shipment

15.1 The coil mass, dimensions, and the method of packaging shall be agreed upon between the manufacturer and purchaser.

15.2 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.

15.3 Unless otherwise specified in the purchaser's order, packaging, marking, and loading for shipments shall be in accordance with those procedures recommended by Practices A700.

### 16. Keywords

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

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