Designation: A228/A228M – 14

Standard Specification for Steel Wire, Music Spring Quality[1]

This standard is issued under the fixed designation A228/A228M; 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.

1. Scope

1.1 This specification covers a high quality, round, cold-drawn steel music spring quality wire, uniform in mechanical properties, intended especially for the manufacture of springs subject to high stresses or requiring good fatigue properties.

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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

A938 Test Method for Torsion Testing of Wire

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

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

E1077 Test Methods for Estimating the Depth of Decarburization of Steel Specimens

2.2 *Federal Standard:*

Fed. Std. No. 123, Marking for Shipment (Civil Agencies)[3]

2.3 *American National Standard:*[4]

B32.4 Preferred Metric Sizes for Round, Square, Rectangle, and Hexagon Metal Products

2.4 *AIAG Standard:*[5]

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A941.

4. Ordering Information

4.1 Orders for steel wire under this specification shall contain the following information:

4.1.1 Quantity (weight in lbs, or mass in kg),

4.1.2 Name of material (music steel spring wire),

4.1.3 Diameter (Table 1 and Section 9),

4.1.4 Finish (see 10.2),

4.1.5 Packaging (Section 15), and

4.1.6 ASTM designation and year of issue.

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

4.2.1 Requirements for certifications, heat, or test reports, (see Section 14),

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

4.2.3 Other special requirements, if any,

NOTE 1—A typical inch-pound units ordering description is as follows: 10 000 lb Music Steel Spring Wire, 0.055 in. diameter, phosphate coated in 1000 lb coils to ASTM A288M_A228M dated _____, or for metric

[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 March 1, 2014. Published April 2014. Originally approved in 1939. Last previous edition approved in 2007 as A228/A228M – 07. DOI: 10.1520/A0228_A0228M-14.

[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 Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111–5098, http://www.dodssp.daps.mil.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, http://www.aiag.org.

TABLE 1 Tensile Requirements

Inch-Pound Units

Diameter, in.[A]	Tensile Strength, ksi		Diameter, in.[A]	Tensile Strength, ksi	
	min	max		min	max
0.004	439	485	0.059	296	327
0.005	426	471	0.063	293	324
0.006	415	459	0.067	290	321
0.007	407	449	0.072	287	317
0.008	399	441	0.076	284	314
0.009	393	434	0.080	282	312
0.010	387	428	0.085	279	308
0.011	382	422	0.090	276	305
0.012	377	417	0.095	274	303
0.013	373	412	0.100	271	300
0.014	369	408	0.102	270	299
0.015	365	404	0.107	268	296
0.016	362	400	0.110	267	295
0.018	356	393	0.112	266	294
0.020	350	387	0.121	263	290
0.022	345	382	0.125	261	288
0.024	341	377	0.130	259	286
0.026	337	373	0.135	258	285
0.028	333	368	0.140	256	283
0.030	330	365	0.145	254	281
0.032	327	361	0.150	253	279
0.034	324	358	0.156	251	277
0.036	321	355	0.162	249	275
0.038	318	352	0.177	245	270
0.040	315	349	0.192	241	267
0.042	313	346	0.207	238	264
0.045	309	342	0.225	235	260
0.048	306	339	0.250	230	255
0.051	303	335	0.262	228	253
0.055	300	331	0.283	223	248

SI Units

Diameter, mm[A]	Tensile Strength, MPa		Diameter, mm[A]	Tensile Strength, MPa	
	min	max		min	max
0.10	3000	3300	1.1	2120	2380
0.11	2950	3250	1.2	2100	2350
0.12	2900	3200	1.4	2050	2300
0.14	2850	3150	1.6	2000	2250
0.16	2800	3100	1.8	1980	2220
0.18	2750	3050	2.0	1950	2200
0.20	2700	3000	2.2	1900	2150
0.22	2680	2980	2.5	1850	2100
0.25	2650	2950	2.8	1820	2050
0.28	2620	2920	3.0	1800	2000
0.30	2600	2900	3.2	1780	1980
0.35	2550	2820	3.5	1750	1950
0.40	2500	2750	3.8	1720	1920
0.45	2450	2700	4.0	1700	1900
0.50	2400	2650	4.5	1680	1880
0.55	2380	2620	5.0	1650	1850
0.60	2350	2600	5.5	1620	1820
0.65	2320	2580	6.0	1600	1800
0.70	2300	2550	6.5	1580	1780
0.80	2250	2500	7.0	1550	1750
0.90	2200	2450	7.2	1540	1740
1.00	2150	2400			

[A] Tensile strength values for intermediate diameters may be interpolated.

units, 5000 kg Music Steel Spring Wire, 1.40 mm diameter, phosphate coated in 500 kg coils to ASTM A288 dated _____.

5. Materials and Manufacture

5.1 The steel may be made by any commercially accepted steel-making process. The rod to be used in the manufacture of wire furnished to this specification shall be in accordance with Specification A510/A510M.

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

5.3 The wire shall be cold drawn to produce the desired mechanical properties.

6. Chemical Composition

6.1 The steel shall conform to the requirements for chemical composition prescribed in Table 2.

6.2 *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 in the purchase order, the heat analysis shall be reported to the purchaser.

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 specified in Table 7 of Specification A510/A510M.

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

7. Mechanical Properties

7.1 *Tension Test:*

7.1.1 *Requirements*—The material as represented by tension test specimens shall conform to the requirements prescribed in Table 1.

7.1.2 *Number of Tests*—One test specimen shall be taken from the top or outside end of each coil, reel, or spool, and shall be tested for conformance.

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

7.1.4 For wire diameters over 0.283 in. [7.2 mm], mechanical properties shall be negotiated between purchaser and supplier and shall be included on the order information.

7.2 *Wrap Test:*

7.2.1 *Requirements*—The material shall conform to the requirements prescribed in Table 3. The requirement for conformance to wrap test on wires above 0.283 in. [7.2 mm] in diameter shall be agreed upon between purchaser and producer.

7.2.2 *Number of Tests*—One test specimen shall be taken from the top or outside end of each coil, reel or spool and shall be tested for conformance.

TABLE 2 Chemical Requirements

Element	Composition, %
Carbon	0.70–1.00
Manganese	0.20–0.70
Phosphorus, max	0.025
Sulfur, max	0.030
Silicon	0.10–0.30

TABLE 3 Wrap Test Requirements

Inch-Pound Units	
Diameter, in.	Mandrel Size
Less than 0.028	1×
0.028 to 0.256, incl	2×
Over 0.256 to 0.283, incl	3×
SI Units	
Diameter, mm	Mandrel Size
Less than 0.70	1×
0.70 to 6.5, incl	2×
Over 6.5 to 7.2, incl	3×

7.2.3 *Test Method*—Each test specimen shall be closed wound on an arbor as prescribed in Table 3 for a minimum of four full wraps. Wire so tested shall not show any splits or fractures.

7.3 *Torsion Test:*

7.3.1 *Requirements*—The torsion test shall be applied to wire sizes 0.70 mm [0.028 in.] and larger in diameter. For wire sizes smaller in diameter than 0.70 mm [0.028 in.], the torsion test may be substituted for the wrap test (7.2). In this case, the minimum number of torsions to failure will be equivalent to 25 in a test length of 100*d*.

7.3.2 *Number of tests*—One test specimen shall be taken from the top or outside end of each coil, reel, or spool and shall be tested for conformance.

7.3.3 *Test Method*—Test specimens shall be prepared and tested as shown in A938 with the following exception. The minimum number of torsions (twists) to failure in a test length of 100*d* (where d = the wire diameter being tested) are shown in Table 4.

7.3.4 Following completion of the torsion test, the torsion fracture shall be perpendicular to the longitudinal axis of the test specimen and the surface of the test specimen shall not be split. Secondary (recoil) fractures shall be ignored.

7.3.5 Test lengths other than 100*d* may be utilized. In this case, the minimum number of torsions to failure shall be adjusted in direct proportion to the change in test length as determined by the following formula:

$$T_x = \frac{T_d \times L_x}{L_d} \quad (1)$$

where

TABLE 4 Number of Torsions to Failure for Torsion Test

Inch-Pound Units	
Diameter, in.	Number of Torsions in 100*d*
0.028 to 0.079, incl	25
over 0.079 to 0.138, incl	20
over 0.138 to 0.283, incl	15
SI Units	
Diameter, mm	Number of Torsions in 100*d*
0.70 to 2.0, incl	25
over 2.0 to 3.5, incl	20
over 3.5 to 7.2, incl	15

T_x = minimum number of torsions for new test length,
T_d = minimum number of torsions for 100*d* test length,
L_x = new test length, and
L_d = 100*d* test length

7.3.6 For wire diameters over 0.283 in. [7.2 mm], the requirement for torsion testing shall be negotiated between purchaser and supplier and shall be included on the order information.

8. Metallurgical Requirements

8.1 *Surface Condition:*

8.1.1 The surface of the wire as-received shall be free of rust, excessive scale, die marks, pits, and scratches detrimental to the end application. Seams shall not exceed 2 % of the wire diameter or 0.15 mm [0.006 in.], whichever is less.

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

8.2 *Decarburization:*

8.2.1 The maximum affected depth of decarburization shall not exceed 2 % of the wire diameter or 0.15 mm [0.006 in.], whichever is less. The maximum average partial decarburization depth shall not exceed 1.5% of the wire diameter when measured using the test method described in 8.2.3.

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. (See Test Method E1077.)

8.2.3 The entire periphery shall be examined at a magnification of no less than 100× for depth of free ferrite and maximum affected depth. Smaller wire sizes may require higher magnification. Complete decarburization exists when only free ferrite is present. The worst case location shall be used to position perpendicular bisectors as shown in Fig. 1. The depth of decarburization (D) shall be measured at each of the

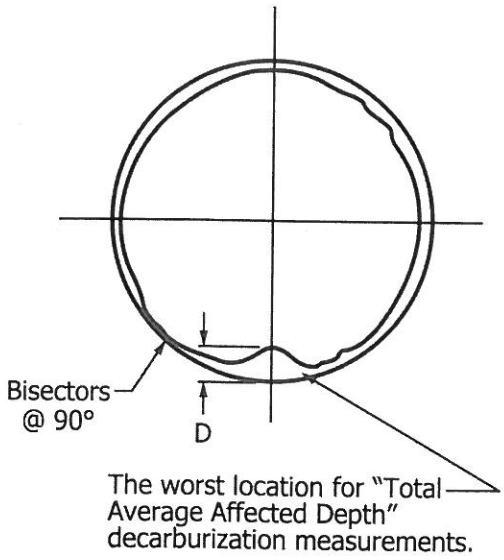

FIG. 1 Positioning of Perpendicular Bisectors

four points where the perpendicular bisectors cross the circumference of the wire. The four readings so obtained shall be averaged, and the average shall not exceed 1.5% of the wire diameter.

8.2.4 The purchaser may specify more restrictive decarburization requirements where necessary for special applications. These requirements shall be negotiated between the purchaser and supplier and must be included in the order information.

8.2.5 There are no decarburization requirements for wire sizes smaller in diameter than 2.0 mm [0.078 in].

9. Dimensions and Permissible Variations

9.1 The permissible variations in the diameter of the wire shall be as specified in Table 5.

10. Workmanship, Finish, and Appearance

10.1 *Workmanship*—The wire shall not be kinked or improperly cast. To test for cast, one convolution of wire shall be cut from the coil, reel, or spool and placed on a flat surface. The wire shall not spring up nor show a wavy condition. Wire below 4.0 mm or 0.156 in. diameter shall lie flat while wire diameters larger than the above shall lie substantially flat.

10.1.1 Each coil, reel, or spool shall be one continuous length of wire, properly coiled and firmly tied.

10.1.2 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 purchase.

10.2 *Finish*—Music wire is supplied with many different types of finish such as bright, phosphate, tin, and others. Finish desired should be specified on purchase orders.

TABLE 5 Permissible Variations in Wire Diameter[A]

SI Units		
Diameter, mm	Permissible Variations, plus and minus, mm	Permissible Out-of-Round, max mm
to 0.25, incl	0.005	0.005
Over 0.25 to 0.70, incl	0.008	0.008
Over 0.70 to 1.50, incl	0.010	0.010
Over 1.50 to 2.00, incl	0.013	0.013
Over 2.00 to 6.00, incl	0.03	0.03
Over 6.00	0.04	0.04
Inch-Pound Units		
Diameter, in.	Permissible Variations, plus and minus, in.	Permissible Out-of-Round, max in.
0.004 to 0.010, incl	0.0002	0.0002
Over 0.010 to 0.028, incl	0.0003	0.0003
Over 0.028 to 0.063, incl	0.0004	0.0004
Over 0.063 to 0.080, incl	0.0005	0.0005
Over 0.080 to 0.250, incl	0.001	0.001
Over 0.250	0.0015	0.0015

[A] For purposes of determining conformance with this specification, all specified limits are absolute as defined in Practice E29.

11. Retests

11.1 If any test specimen exhibits obvious defects or shows the presence of a weld, it shall be discarded and another specimen substituted.

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 shall be adequately protected and identified correctly for the manufacturer to make a proper investigation.

14. Certification

14.1 When specified in the purchase order or contract, a producer'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, reel or spool mass, dimensions, and the method of packaging shall be agreed upon between the manufacturer and purchaser.

15.2 A tag shall be attached securely to each coil of wire with identifying information as agreed upon by the purchaser and manufacturer.

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.

15.4 *For Government Procurement:*

15.4.1 Marking for shipment of material for civil agencies shall be in accordance with Fed. Std No. 123.

15.5 *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 Standard 02.00, Primary Metals Identification Tag Application. The bar code may be applied to a substantially affixed tag.

16. Keywords

16.1 music spring; wire