Designation: A 228/A 228M – 07

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

This standard is issued under the fixed designation A 228/A 228M; 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 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 (metric) units or inch-pound units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

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

A 510 Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

A 510M Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel [Metric]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

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

A 938 Test Method for Torsion Testing of Wire

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

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

E 1077 Test Methods for Estimating the Depth of Decarburization of Steel Specimens

2.2 *Military Standard:*

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[3]

2.3 *Federal Standard:*

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

2.4 *American National Standard:*[4]

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

2.5 *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 A 941.

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 information:

4.1.1 Quantity (mass),

4.1.2 Name of material (music steel spring wire),

4.1.3 Dimensions (Table 1 and Section 9),

4.1.4 Finish (see 10.2),

4.1.5 Packaging (Section 15),

4.1.6 Heat analysis report, if requested (see 6.2),

4.1.7 Certification or test report, or both, if specified (Section 14), and

4.1.8 ASTM designation and year of issue.

NOTE 1—A typical metric ordering description is as follows: 2500 kg Music Spring Wire, 1.40 mm diameter, phosphate coated in 25 kg coils to ASTM A 288M dated _____, or for inch-pound units, 5000 lb Music Spring Wire, 0.055 in. diameter, phosphate coated in 50 lb coils to ASTM A 288 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. The rod to be used in the manufacture of wire furnished to this specification shall be in accordance with Specification A 510 or A 510M.

[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 Dec. 1, 2007. Published January 2008. Originally approved in 1939. Last previous edition approved in 2002 as A 228/A 228M – 02.

[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.

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TABLE 1 Tensile Requirements

SI Units

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

Inch-Pound Units

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

[A] Tensile strength values for intermediate diameters may be interpolated.
[B] Preferred sizes. For a complete list, refer to ANSI B32.4, Preferred Metric Sizes for Round, Square, Rectangle and Hexagon Metal Products.

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.

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

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 A 510M or A 510.

6.4 For referee purposes, Test Methods, Practices, and Terminology A 751 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 each end of every coil or from the top or outside end of each reel or spool.

7.1.3 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A 370.

7.1.4 For wire diameters over 6.0 mm [0.250 in.], mechanical properties and chemical composition shall be negotiated between purchaser and supplier and shall be included on the order information.

7.2 *Wrap Test*:

7.2.1 *Requirements*—The wrap test shall be applied only to sizes smaller than 0.70 mm [0.028 in.] in diameter.

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.

7.2.3 *Test Method*—Each test specimen shall be closed wound on an arbor of its own diameter 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 A 938 with the following exception. The

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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 3.

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

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

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 E 1077.)

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 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.

TABLE 3 Test Lengths for Torsion Test

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 6.0, incl	15
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 0.250, incl	15

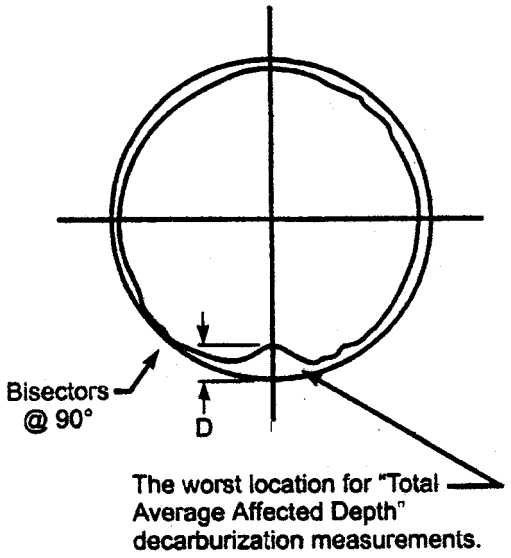


FIG. 1 Positioning of Perpendicular Bisectors

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 4.

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

TABLE 4 Permissible Variations in Wire Diameter[A]

SI Units		
Diameter, mm	Permissible Variations, plus and minus, mm	Permissible Out-of-Round, 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	0.03	0.03
Inch-Pound Units		
Diameter, in.	Permissible Variations, plus and minus, in.	Permissible Out-of-Round, 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

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

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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.

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 A 700.

15.4 *For Government Procurement*:

15.4.1 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.

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

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