Designation: A125 – 96 (Reapproved 2013)$^{\varepsilon 1}$

Standard Specification for Steel Springs, Helical, Heat-Treated[1]

This standard is issued under the fixed designation A125; 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.

ε[1] NOTE—Table references were editorially corrected in November 2013.

1. Scope

1.1 This specification covers hot-coiled, heat-treated helical compression springs with tapered, closed, squared and ground ends made of hot-wrought round steel bars ⅜ in. (9.5 mm) and larger in diameter.

1.2 This specification also serves to inform the user of practical manufacturing limits, mechanical tests, and inspection requirements applicable to the type of spring described in 1.1.

1.3 Supplementary Requirements S1 to S8 inclusive of an optional nature are provided. They shall apply only when specified by the purchaser. Details of these supplementary requirements shall be agreed upon by the manufacturer and purchaser.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A29/A29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for

A689 Specification for Carbon and Alloy Steel Bars for Springs

E10 Test Method for Brinell Hardness of Metallic Materials

E112 Test Methods for Determining Average Grain Size

E709 Guide for Magnetic Particle Testing

3. Ordering Information

3.1 Orders for springs under this specification shall include the following information:

3.1.1 Quantity,

3.1.2 Name of material,

3.1.3 A drawing or list showing required dimensions and loads, and part number,

3.1.4 Packaging, marking and loading, and

3.1.5 End use.

NOTE 1—A typical ordering description is: 500 springs Drawing 3303 Rev. A. to ASTM A125, 1095 steel, for cyclical machine operation. Palletize, maximum weight 4000 lb.

4. Materials and Manufacture

4.1 *Material:*

4.1.1 Unless otherwise specified, the springs shall be made of carbon steel bars conforming to the requirements of Specification A689. Due to hardenability limitations of carbon steel, it is suggested that the bar diameter be limited to 1⅝ in. (41.8 mm) max in order to withstand the maximum test stress requirements of this specification.

4.1.2 If alloy steel is specified, the springs shall be made from alloy steel bars conforming to Specification A689. Any of the alloy steel grades referred to may be used at the option of the spring manufacturer, providing that a minimum as-quenched hardness of Rockwell HRC-50 will be achieved at the center of the bar section representing the spring when quenched in the same media and manner as the spring.

4.1.3 *Springs Made from Bars Over 2 in. (50.8 mm)*—Note that the bias tolerance (reference Specification A29/A29M, Table A1.1 on Permissible Variations in Cross Section for Hot-Wrought Round, Square, and Round-Cornered Square Bars of Steel) of the bar diameter shall be taken into consideration when designing and calculating the solid height, spring rate, solid stress, and solid capacity.

4.2 *Hardness:*

4.2.1 The springs must be quenched and tempered to a sufficiently high hardness (strength) to withstand the stresses

[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 A01.15 on Bars.

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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.

developed in testing the finished spring. The maximum hardness shall not exceed 477 Brinell numbers (2.80 mm indentation diameter).

4.2.2 When hardness limits are specified, the total range or spread may not be less than 0.15 mm difference in indentation diameters. The specified or indicated minimum hardness must be sufficient to develop the required strength to withstand the solid stresses of the spring design involved.

4.2.3 Hardness shall be read on a prepared flat surface in an area not detrimental to the life of the spring at a full section after removal of the decarburized layer. A tungsten-carbide 10-mm ball shall be applied under a 3000-kg load and the indentation diameter converted to Brinell numbers by using Table 1. The values for Table 1 have been taken from Specification E10.

4.3 *Metallurgical Requirements:*

4.3.1 The total depth of decarburization, partial plus complete as measured on the finished spring in the quenched and tempered condition, shall not exceed 0.006 in. (0.15 mm) plus 1 % of the bar diameter. The decarburization shall be examined at 100× on a test specimen suitably etched and cut from a full cross section of the test spring showing at least one lineal inch of original bar circumference.

4.3.2 The structure of the finished spring shall have an average ASTM Grain Size No. 5 or finer as determined by the latest revision of Test Methods E112.

4.4 *End Construction:*

4.4.1 *End Construction-Tapered Squared and Ground*—The end bearing surfaces of the spring shall be ground to produce a firm bearing. The end bearing surfaces shall have a minimum bearing surface of two thirds of the mean coil circumference and a minimum width of two thirds of the hot-tapered surface of the bar. The tip ends of the bar shall be in approximate contact with the adjacent coil, and shall not protrude beyond the maximum permissible outside diameters of the spring as established by Table 2.

4.4.1.1 *End Construction Coil Blunt Squared and Ground (Optional)*—The end bearing surfaces of the spring shall be ground to produce a firm bearing. The end bearing surfaces shall have a minimum ground bearing surface of two thirds of the mean coil circumference and a minimum width of two thirds of the bar diameter. The tip ends of the bar shall be in approximate contact with the adjacent coil and shall not protrude beyond the maximum permissible outside diameters of the spring as established by Table 2.

4.4.2 Springs with ground ends having a free height-to-mean diameter ratio of not less than 1 or more than 5 shall not deviate from the perpendicular more than the number of degrees prescribed in Table 3, as determined by standing the spring on its end and measuring the angular deviation of a straightedge along the outer helix from a perpendicular to the plate on which the spring is standing.

4.4.3 The ends of springs shall be parallel within a tolerance of twice that specified for the squareness of ends as determined by standing the spring on its end and measuring the maximum angular deviation of the other end from a plane parallel to the plate on which the spring is standing.

TABLE 1 Brinell Hardness

Indentation Diameter, mm	Brinell Hardness Numbers
2.75	495
2.80	477
2.85	461
2.90	444
2.95	429
3.00	415
3.05	401
3.10	388
3.15	375

5. Physical Requirements

5.1 *Measurements:*

5.1.1 *Solid Height*—The solid height is the perpendicular distance between the plates of the testing machine when the spring is compressed solid with the load specified in 7.3. The solid height thus measured may be less, but shall not exceed the specified nominal solid height by more than the limits given in Table 4.

5.1.2 *Free Height*—The free height is the height of the spring after the load specified in 7.3 has been released, and is determined by placing a straightedge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the bottom of the straightedge at the approximate center of the spring. Tolerances are shown in Table 5.

5.1.3 *Loaded Height*—The loaded height is the perpendicular distance between the plates of the testing machine when the specified working load has been applied in compression. Tolerances are shown in Table 5.

5.1.4 *Permanent Set*—After determining the free height as specified in 5.1.2, the permanent set is the difference between this free height and the height after the spring has been compressed solid three additional times under the test load specified in 7.3, measured at the same point and in the same manner. Tolerances are shown in Table 5.

5.1.5 *Uniformity of Pitch*—The pitch of the coils shall be sufficiently uniform so that when the spring is compressed without lateral support to a height representing a deflection of 85 % of the nominal total travel, none of the coils shall be in contact with one another, excluding the inactive end coils. Under 85 % deflection, the maximum spacing between any two adjacent active coils shall not exceed 40 % of the nominal free coil spacing. The nominal free coil spacing is equivalent to the specified total travel divided by the number of active turns. When the design is such that it cannot be compressed to solid height without lateral support, these requirements do not apply.

5.1.6 *Outside Diameter*—The outside diameter shall be measured on a spring in the free condition and across any full turn excluding the end turns and must be taken approximately perpendicular to the helix axis. The tolerances are shown in Table 2.

5.1.7 *Calculations for Testing Loads and Stresses:*

5.1.7.1 *Solid Capacity*—Calculate the solid capacity of the spring as follows:

$$P = Gd^4F/8\ ND^3 \quad (1)$$

where:

TABLE 2 Permissible Variations in Outside Diameter of Helix (For springs with *D/d* ratio not exceeding 8)

NOTE 1—(For design information). These permissible variations, exclusives of manufacturing taper, should be used as a guide in the design of concentrically-nested helical-spring units for free assembly. The diametrical clearance desired is 1⁄16 in. (1.59 mm) less than the sum of the applicable tolerances of the nested spring units, but in no case should it be less than 1⁄8 in. (3.17 mm).

NOTE 2—In cases where radical clearance on existing concentrically-nested helical-spring units will not accommodate these tolerances, the nominal inside diameters shall be adhered to as closely as practicable, with plus variation on the outer springs and minus variation on the inner springs to guarantee free assembly. Drawings must show reference to the complete nested spring units.

NOTE 3—(For springs with *D/d* ratio not exceeding 8). For *D/d* ratio greater than 8, increase tolerance 50 %.

Nominal Outside Diameter, in. (mm)	Nominal Free Height or Length of Spring, in. (mm)					
	Up to 10 (254) incl, ±	Over 10 to 18 (254 to 457), incl, ±	Over 18 to 26 (457 to 661), incl, ±	Over 26 to 34 (661 to 874), incl, ±	Over 34 to 42 (874 to 1067), incl, ±	Over 42 to 60 (1067 to 1524), incl, ±
Up to 6 (152), incl	1⁄16 (1.59)	3⁄32 (2.38)	1⁄8 (3.17)	5⁄32 (3.97)	3⁄16 (4.76)	. . .
Over 6 to 8 (152 to 203), incl	3⁄32 (2.38)	1⁄8 (3.17)	3⁄16 (4.76)	1⁄4 (6.35)	1⁄4 (6.35)	. . .
Over 8 to 12 (203 to 305), incl	1⁄8 (3.17)	3⁄16 (4.76)	1⁄4 (6.35)	1⁄4 (6.35)	1⁄4 (6.35)	. . .
Over 12 to 16 (305 to 406), incl	. . .	1⁄4 (6.35)	1⁄4 (6.35)	1⁄4 (6.35)	1⁄4 (6.35)	5⁄16 (7.94)
Over 16 to 20 (406 to 508), incl	. . .	. . .	5⁄16 (7.94)	5⁄16 (7.94)	5⁄16 (7.94)	3⁄8 (9.53)
Over 20 to 24 (508 to 610), incl	. . .	. . .	3⁄8 (9.53)	3⁄8 (9.53)	3⁄8 (9.53)	7⁄16 (11.00)
Over 24 to 28 (610 to 701), incl	. . .	. . .	7⁄16	7⁄16	7⁄16	1⁄2
Over 28 (701), incl	. . .	. . .	1⁄2	1⁄2	1⁄2	1⁄2

TABLE 3 Permissible Out-of-Squareness, Springs with Ground Ends

Total Travel, in. (mm)	Mean Diameter, in. (mm)									
	2 (51) and under	Over 2 to 4 (51 to 102), incl	Over 4 to 6 (102 to 152), incl	Over 6 to 8 (152 to 203), incl	Over 8 to 10 (203 to 254), incl	Over 10 to 12 (254 to 305), incl	Over 12 to 14 (305 to 356), incl	Over 14 to 16 (356 to 406), incl	Over 16 to 18 (406 to 457), incl	Over 18 to 20 (457 to 508), incl
	Degree									
2 (51) and under	1¼	1¼	1	1	1	1	. . .	. . .	. . .	. . .
Over 2 to 4 (51 to 102), incl	1¾	1½	1¼	1¼	1	1	1	. . .	. . .	. . .
Over 4 to 6 (102 to 152), incl	2¼	1¾	1½	1¼	1¼	1	1	. . .	. . .	. . .
Over 6 to 8 (152 to 203), incl	2½	2¼	1¾	1½	1¼	1¼	1	1	. . .	. . .
Over 8 to 10 (203 to 254), incl	2¾	2½	2	1½	1½	1¼	1¼	1	. . .	. . .
Over 10 to 12 (254 to 305), incl	3	2¾	2¼	1¾	1½	1½	1¼	1¼	1	. . .
Over 12 to 14 (305 to 356), incl	. . .	3	2½	2	1¾	1¾	1½	1½	1¼	1¼
Over 14 to 16 (356 to 406), incl	. . .	. . .	2¾	2¼	2	2	1¾	1¾	1½	1½
Over 16 to 18 (406 to 457), incl	. . .	. . .	3	2½	2¼	2	2	1¾	1¾	1½
Over 18 to 20 (457 to 508), incl	. . .	. . .	3	2¾	2½	2¼	2¼	2	2	1¾
Over 20 to 22 (508 to 559), incl	. . .	. . .	. . .	3	2¾	2¼	2¼	2	2	1¾
Over 22 to 24 (559 to 610), incl	. . .	. . .	. . .	. . .	3	2¼	2¼	2	2	1¾
Over 24 to 26 (610 to 660), incl	. . .	. . .	. . .	. . .	. . .	2½	2½	2¼	2¼	2
Over 26 to 28 (660 to 701), incl	. . .	. . .	. . .	. . .	. . .	2½	2½	2¼	2¼	2
Over 28 to 30 (702 to 762), incl	. . .	. . .	. . .	. . .	. . .	2¾	2½	2¼	2¼	2
Over 30 to 32 (762 to 813), incl	. . .	. . .	. . .	. . .	. . .	2¾	2¾	2½	2½	. . .
Over 32 to 34 (813 to 864), incl	. . .	. . .	. . .	. . .	. . .	2¾	2¾	2½	2½	. . .
Over 34 to 38 (864 to 914), incl	. . .	. . .	. . .	. . .	. . .	3	2¾	2¾	2¾	. . .
Over 36 to 38 (914 to 965), incl	. . .	. . .	. . .	. . .	. . .	. . .	3	2¾	2¾	. . .
Over 38 to 42 (965 to 1016), incl	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3	3	. . .

G = 11×10^6 psi = effective torsional modulus of elasticity,
d = nominal bar diameter, in.,
D = mean coil or helix diameter, in.,
F = spring deflection = free to solid, in.,
N = active turns = (solid height)/bar diameter) − 1.5, and
P = solid capacity, lb.

5.1.7.2 *Uncorrected Solid Stress*—Calculate the uncorrected solid stress as follows: (**Warning**—Bar nominal diameter may not be the same as the specified diameter, due to biased tolerances on hot-rolled bars 2 in. (50.8 mm) and over.)

$$S = 8PD/3.1416\,d^3 \qquad (2)$$

6. Workmanship, Finish, and Appearance

6.1 *Finish:*

TABLE 4 Permissible Variations in Solid Height

Nominal Solid Height, in. (mm)	Deviation Above Nominal Solid Height, max, in.[A] (mm)
Up to 7 (178), incl	1⁄16 (1.59)
Over 7 to 10 (178 to 254), incl	3⁄32 (2.38)
Over 10 to 13 (254 to 330), incl	1⁄8 (3.17)
Over 13 to 16 (330 to 406), incl	5⁄32 (3.97)
Over 16 to 19 (406 to 483), incl	3⁄16 (4.76)
Over 19 to 22 (483 to 559), incl	7⁄32 (5.56)
Over 22 to 25 (559 to 635), incl	1⁄4 (6.35)
Over 25 to 28 (635 to 711), incl	9⁄32 (7.14)
Over 28 to 31 (711 to 787), incl	5⁄16 (7.94)

[A] For additional 3-in. (76-mm) increase in solid height, the deviation shown should be increased by 1⁄32 in. (0.79 mm).