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# Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement<sup>1</sup>

This standard is issued under the fixed designation A1022/A1022M; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope\*

1.1 This specification covers stainless steel wire and welded wire reinforcement produced from hot-rolled stainless steel rod. The stainless steel wire is cold-worked, drawn or rolled, plain (non-deformed) or deformed or a combination of deformed and plain. It is used as concrete reinforcement for applications requiring resistance to corrosion or controlled magnetic permeability, or both. Common wire sizes and dimensions are found in this specification. Actual wire sizes are not restricted to those shown in the tables.

1.2 A supplementary requirement (S1) is provided and shall apply only when specified by the purchaser. In order to obtain a corrosion tested or controlled magnetic permeability product, steel conforming to Supplementary Requirement S1 should be ordered.

1.3 The chemical composition of the steel (stainless grade) shall be selected for suitability to the application involved by agreement between the manufacturer and the purchaser. Specification **A276** shall be used for chemical requirements. The UNS designations are to be included with the type number and noted in brackets. Examples of austenitic stainless steel designations are Type 304 [S30400], 304L [S30403], 316 [S31600], 316L [S31603], 316N [S31651], 316LN [S31653] and examples of duplex stainless steel designations are Type 2205 [S32205] and 329 [S32900].

NOTE 1—Only austenitic and duplex stainless steels are usually recommended for use as reinforcement in concrete because of their high corrosion resistance. Austenitic stainless steels have good general corrosion resistance, strength characteristics which can be improved by cold working, good toughness and ductility properties at low temperatures, and low magnetic permeability. Duplex stainless steels have generally a corrosion resistance greater than that of most austenitic steels and are magnetic. Other stainless steels with different chemical compositions than the series and types mentioned above, may be used for less restrictive applications.

1.4 Wire for welded wire reinforcement is generally manufactured at 75 ksi [520 MPa] yield strength level. Other strength levels shall be by agreement between the purchaser and manufacturer.

NOTE 2—The term used to refer to yield strength levels are the same as those in ASTM Standards for welded wire reinforcement.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. 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:<sup>2</sup>

**A276** Specification for Stainless Steel Bars and Shapes

**A342/A342M** Test Methods for Permeability of Weakly Magnetic Materials

**A370** Test Methods and Definitions for Mechanical Testing of Steel Products

**A700** Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

**E83** Practice for Verification and Classification of Extensometer Systems

### 2.2 Military Standards:<sup>3</sup>

**MIL-STD-129** Marking for Shipment and Storage

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee **A01** on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee **A01.05** on Steel Reinforcement.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

\*A Summary of Changes section appears at the end of this standard

2.3 *Federal Standard*:<sup>3</sup>

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

2.4 *ACI Standard*:<sup>4</sup>

ACI 318 Building Code Requirements for Structural Concrete

2.5 *Adjuncts*:

Weld Tester Drawing <sup>5</sup>

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

3.1.1 *stainless steel plain wire and welded plain wire reinforcement*—as used within the scope and intent of this specification, designates a material composed of cold-worked stainless steel wire, as cold-drawn or cold-rolled from stainless steel hot-rolled rod.

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<sup>4</sup> Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.aci-int.org>.

<sup>5</sup> Available from ASTM International Headquarters. Order Adjunct No. ADJA0185. Original adjunct produced in 1967.

3.1.1.1 *Discussion*—

The welded intersections provide the bond strength for shear resistance.

3.1.2 *stainless steel deformed wire and welded deformed wire reinforcement*—as used within the scope and intent of this specification, designates a material composed of cold- worked deformed stainless steel wire as cold-drawn or cold-rolled from stainless steel hot-rolled rod.

3.1.2.1 *Discussion*—

Deformations can be indented or raised rib (protrusion) types. As with plain stainless steel welded wire, the welded intersections provide bond strength for shear resistance and the deformations add to the bond strength.

3.1.3 *convoluted wire*—when wire for welded wire reinforcement is formed into a sinusoidal wave shape, it is commonly referred to as convoluted wire.

3.1.3.1 *Discussion*—

The wire is used in the manufacture of cages for certain applications of concrete pipe reinforcement. Only plain wire is normally subject to convolution.

### 4. Ordering Information

4.1 Orders for stainless steel wire or welded wire reinforcement under this specification shall contain the following information:

4.1.1 Quantity (weight [mass]) or square area for welded wire reinforcement,

4.1.2 Name of material (cold-drawn or rolled stainless steel wire, or welded wire reinforcement, plain or deformed, for concrete),

4.1.3 Wire size number, wire spacing, and sheet or roll width and length for welded wire reinforcement,

4.1.4 Exclusion of over-steeling, if required (see 10.4),

4.1.5 Minimum yield strength or grade,

4.1.6 Type of stainless steel as in accordance with Specification A276,

4.1.7 Report on tests performed on the stainless steel wire or welded wire reinforcement being furnished, if desired (see 16.1),

4.1.8 Packaging (see Section 17),

4.1.9 Supplementary requirements (if desired), and

4.1.10 ASTM designation and year of issue.

NOTE 3—A typical ordering description is as follows: For in-lbs units: (100 000 square feet of welded wire for concrete reinforcement, 12 × 12 – W 10 × W 10 in flat sheets 96-in. wide by 15-ft long) in secured bundles for crane or forklift truck lifts. For metric units: 10 000 square metres of welded wire for concrete reinforcement, 305 × 305 – MW 65 × MW 65, in flat sheets 2438-mm wide by 4.6-m long in secured bundles for crane or forklift truck lifts. Testing shall be in accordance with Test Methods A370.

NOTE 4—Longitudinal wires can be variably spaced. (For example, V × 12 – D 10 × D 10 or V × 305 – MD 65 × MD 65). See the Tables 1 and 2 for wire sizes.

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

4.2.1 Specified corrosion testing requirements,

4.2.2 Magnetic permeability,

4.2.3 Type of stainless steel not listed in Specification A276, and

**TABLE 1 Dimensional Requirements for Plain Wire—SI Units**

Size Number <sup>A</sup>	Nominal Diameter, mm	Nominal Area, mm <sup>2</sup>
MW 5	2.50	5
MW 10	3.60	10
MW 15	4.40	15
MW 20	5.00	20
MW 25	5.60	25
MW 30	6.20	30
MW 35	6.70	35
MW 40	7.10	40
MW 45	7.60	45
MW 50	8.00	50
MW 55	8.40	55
MW 60	8.70	60
MW 65	9.10	65
MW 70	9.40	70
MW 80	10.10	80
MW 90	10.70	90
MW 100	11.30	100
MW 120	12.40	120
MW 130	12.90	130
MW 200	15.95	200
MW 290	19.22	290

<sup>A</sup> This table represents a hard metrication of the most readily available sizes in the welded wire reinforcement industry. Table 1 shall be used in projects that are designed using SI units; Table 2 shall be used on projects designed using inch-pound units. Areas of wire shall be checked with the most efficient and readily available material from manufacturers. Other wire sizes are available and many manufacturers can produce them in 1-mm<sup>2</sup> increments.

**TABLE 2 Dimensional Requirements for Plain Wire—Inch-pound Units**

Size Number <sup>A</sup>	Nominal Diameter, in.	Nominal Area, in <sup>2</sup>
W 0.5	0.080	0.005
W 1.2	0.124	0.012
W 1.4	0.134	0.014
W 2	0.160	0.020
W 2.5	0.178	0.025
W 2.9	0.192	0.029
W 3.5	0.211	0.035
W 4	0.226	0.040
W 4.5	0.239	0.045
W 5	0.252	0.050
W 5.5	0.265	0.055
W 6	0.276	0.060
W 8	0.319	0.080
W 10	0.357	0.100
W 11	0.374	0.110
W 12	0.391	0.120
W 14	0.422	0.140
W 16	0.451	0.160
W 18	0.479	0.180
W 20	0.505	0.200
W 22	0.529	0.220
W 24	0.533	0.240
W 26	0.575	0.260
W 28	0.597	0.280
W 30	0.618	0.300
W 31	0.628	0.310
W 45	0.757	0.450

<sup>A</sup> This table represents the most readily available sizes in the welded wire reinforcement industry in sizes using inch-pound units. Areas of wire shall be checked with the most efficient and readily available material from manufacturers. Other wire sizes are available and many manufacturers can produce them in 0.0015-in.<sup>2</sup> increments.

4.2.4 Special heat treatment or condition.

## 5. Materials

5.1 The stainless steel shall be made by any commercially accepted process.



TABLE 3 Bend Test Requirements—Plain Wire

Size Number Of Wire	Bend Test
W7 [MW 45] and smaller	Bend around a pin the diameter that is equal to the diameter of the specimen
Larger than W7 [MW 45]	Bend around a pin the diameter that is equal to twice the diameter (2d) of the specimen

5.2 Cold-worked wire or rod used in the manufacture of stainless steel welded wire reinforcement shall be in accordance with the chemical and physical requirements of Specification A276.

## 6. Manufacture

6.1 Stainless steel wire for welded wire reinforcement shall be cold worked, either drawn or rolled from steel rod that is rolled from properly identified heats of mold-cast or strand-cast steel.

6.2 The wire or rod shall be assembled into welded wire reinforcement by automatic machines or by other suitable mechanical means which will assure accurate spacing and alignment of all wires of the finished welded wire reinforcement. The finished welded wire reinforcement shall be furnished in flat or bent sheets or in rolls as specified by the purchaser.

6.3 Longitudinal and transverse wires shall be securely connected at every intersection by a process of electrical-resistance welding which employs the principle of fusion combined with pressure.

6.4 Welded wire reinforcement of proper grade and quality shall result in a strong, serviceable product having substantially square or rectangular openings. It shall be fabricated and finished in a quality manner and conform to this specification.

## 7. Mechanical Property Requirements—Wire, Plain and Deformed

### 7.1 General Requirements for Plain Wire:

7.1.1 When plain wire is ordered by size number, the relation between size number, diameter, and area shown in Tables 1 and 2 shall apply.

7.1.2 Specimens for mechanical properties testing shall be full wire sections and shall be obtained from ends of wire coils as drawn. The specimens shall be of sufficient length to perform testing described in Test Methods A370.

7.1.3 If any test specimen exhibits obvious isolated imperfections not representative of the product, it shall be discarded and another specimen substituted.

### 7.1.4 Tension Test:

7.1.4.1 When tested as described in Test Methods and Definitions A370, the material, except as specified in 7.1.4.2 shall conform to the tensile property requirements in Table 5, based on the nominal area of the wire.

7.1.4.2 When required by the purchaser, the yield strength shall be determined as described in Test Methods and Definitions A370 at an extension of 0.5 % of gage length or by the offset method (0.2 %). For determining the yield strength use a Class B-1 extensometer as described in Practice E83.

7.1.4.3 For wire to be used in the manufacture of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 6, based on the nominal area of the wire.

7.1.4.4 Materials shall be measured at extension under load and shall not be required to exhibit a definite yield point as evidenced by a distinct arrest or halt in the load indication gauge of the testing machine prior to reaching ultimate tensile load. The purchaser shall have the option to accept this feature as sufficient evidence of compliance with the specified minimum yield strength tests covered in this specification.

7.1.5 Bond Test—The bend test specimen shall be bent at room temperature through 90° without cracking on the outside of the bent portion, as prescribed in Table 3.

7.1.6 Reduction of Area—Shall be determined as described in Test Methods and Definitions A370. The wire shall conform to the reduction of area requirements in Tables 5 and 6.

### 7.1.7 Permissible Variation in Wire Diameter:

7.1.7.1 The permissible variation in wire diameter shall conform to the requirements in Table 4.

7.1.7.2 The difference between the maximum and minimum diameters, as measured on any given cross section of the wire, shall not exceed the tolerances listed in Table 4 for the given wire size.

### 7.2 General Requirements for Deformed Wire:

7.2.1 When deformed wire is ordered by size number, the relation between size number, diameter, and area shown in Tables 7 and 8 shall apply.

7.2.2 Specimens for mechanical properties testing shall be full wire sections and shall be obtained from ends of wire coils as rolled. The specimens shall be of sufficient length to perform testing described in Test Methods A370.

7.2.3 If any test specimen exhibits obvious isolated imperfections not representative of the product, it shall be discarded and another specimen substituted.



TABLE 4 Permissible Variation in Wire Diameter—Plain Wire

Size Number, in-lbs. [SI]	Nominal Diameter, in. [mm]	Permissible Variation Plus and Minus, in. [mm]	Maximum Permissible Out-of-Round, in. [mm] <sup>A</sup>
Smaller than W 5 [MW 32]	Under 0.252 [6.4]	0.003 [0.08]	0.003 [0.08]
W 5 [MW 32] to W 12 [MW 77], incl	0.252 [6.4] to 0.391 [9.93], incl	0.004 [0.10]	0.004 [0.10]
Over W 12 [MW 77] to W 20 [MW 130], incl	Over 0.391 [9.93] to 0.505 [12.83], incl	0.006 [0.15]	0.006 [0.15]
Over W 20 [MW 130]	Over 0.505 [12.83]	0.008 [0.20]	0.008 [0.20]

<sup>A</sup> Out-of-round is the difference between maximum and minimum diameters of the wire, measured at the same transverse cross section.

TABLE 5 Tension Test Requirements—Plain Wire

	Grade 70 [485]	Grade 72.5 [500]	Grade 75 [515]	Grade 77.5 [533]	Grade 80 [550]
Tensile strength, min, psi [MPa]	80 000 [550]	82 500 [568]	85 000 [585]	87 500 [603]	90 000 [620]
Yield strength, min, psi [MPa]	70 000 [485]	72 500 [500]	75 000 [515]	77 500 [533]	80 000 [550]
Reduction of area, min, %	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>

<sup>A</sup> For material testing over 100 000 psi [690 MPa] tensile strength, the reduction of area shall be not less than 25 %.

TABLE 6 Tension Test Requirements—Plain Wire for Welded Reinforcement

Size W 1.2 [MW 8] and Larger						
	Grade 65 [450]	Grade 70 [485]	Grade 72.5 [500]	Grade 75 [515]	Grade 77.5 [533]	Grade 80 [550]
Tensile strength, min, psi [MPa]	75 000 [515]	80 000 [550]	82 500 [568]	85 000 [585]	87 500 [603]	90 000 [620]
Yield strength, min, psi [MPa]	65 000 [450]	70 000 [485]	72 500 [500]	75 000 [515]	77 500 [533]	80 000 [550]
Reduction of area, min, %	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>	30 <sup>A</sup>
Smaller than Size W 1.2 [MW 8]						
	Grade 56 [385]					
Tensile strength, min, psi [MPa]	70 000 [485]					
Yield strength, min, psi [MPa]	56 000 [385]					
Reduction of area, min, %	30 <sup>A</sup>					

<sup>A</sup> For material testing over 100 000 psi [690 MPa] tensile strength, the reduction of area shall be not less than 25 %.

#### 7.2.4 Deformation Criteria:

7.2.4.1 Deformations shall be spaced along the wire at a substantially uniform distance and shall be symmetrically disposed around the perimeter. The deformations on all longitudinal lines of the wire shall be similar in size and shape. A minimum of 25 % of the total surface area shall be deformed by measurable deformations.

7.2.4.2 Deformed wire shall have two or more lines of deformations.

7.2.4.3 The average longitudinal spacing of deformations shall be not less than 3.5 nor more than 5.5 deformations per 1 in. [25 mm] in each line of deformations on the wire.

7.2.4.4 The minimum average height of the center of typical deformations based on the nominal wire diameters shown in Tables 7 and 8 shall be as follows:

Wire Sizes	Minimum Average Height of Deformations, Percent of Nominal Wire Diameter
D 3 [MD 19] and smaller	4
Larger than D 3 [MD 19] through D 10 [MD 65]	4½
Larger than D 10 [MD 65]	5

7.2.4.5 The deformations shall be placed with respect to the axis of the wire so that the included angle is not less than 45°; or if deformations are curvilinear, the angle formed by the transverse axis of the deformation and the wire axis shall be not less than 45°. Where the line of deformations forms an included angle with the axis of the wire from 45° to 70° inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the included angle is over 70°, a reversal in direction is not required.

7.2.4.6 The average spacing of deformations shall be determined by dividing a measured length of the wire specimen by the number of individual deformations in any one row of deformations on any side of the wire specimens. A measured length of the wire specimen shall be considered the distance from a point on a deformation to a corresponding point on any other deformation in the same line of deformations on the wire.

7.2.4.7 The minimum average height of deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentations or raised ribs.

#### 7.2.5 Tension Test:

7.2.5.1 When tested as described in Test Methods and Definitions A370, the material, except as specified in 7.2.5.2 shall conform to the tensile property requirements in Table 9, based on nominal area of wire.





TABLE 7 Dimensional Requirements for Deformed Wire for Concrete Reinforcement in SI Units

Deformed Wire Size <sup>A,B,C</sup>	Nominal Dimensions				Deformation Requirements	
	D [in <sup>2</sup> X 100]	Unit Mass, kg/m	Diameter, mm <sup>D</sup>	Cross-Sectional Area, mm <sup>2E</sup>	Minimum Average Height of Deformations, mm <sup>F,G,H</sup>	
MD 25	[D 3.9]	0.1962	5.60	25	0.25	
MD 30	[D 4.6]	0.2355	6.20	30	0.28	
MD 35	[D 5.4]	0.2747	6.70	35	0.30	
MD 40	[D 6.2]	0.3140	7.10	40	0.32	
MD 45	[D 7.0]	0.3532	7.60	45	0.34	
MD 50	[D 7.7]	0.3925	8.00	50	0.36	
MD 55	[D 8.5]	0.4317	8.40	55	0.38	
MD 60	[D 9.3]	0.4709	8.70	60	0.39	
MD 65	[D 10.1]	0.5102	9.10	65	0.46	
MD 70	[D 10.8]	0.5494	9.40	70	0.47	
MD 80	[D 12.4]	0.6279	10.10	80	0.50	
MD 90	[D 13.9]	0.7065	10.70	90	0.54	
MD 100	[D 15.5]	0.7849	11.30	100	0.57	
MD 120	[D 18.6]	0.9419	12.40	120	0.62	
MD 130	[D 20.1]	1.0204	12.90	130	0.64	
MD 200	[D 31.0]	1.5700	15.95	200	0.80	
MD 290	[D 45.0]	2.2700	19.22	290	0.96	

<sup>A</sup> The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square millimetres.

<sup>B</sup> For sizes other than those shown above, the Size Number shall be the number of square millimetres in the nominal area of the deformed wire cross section, prefixed by the letters MD.

<sup>C</sup> These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 1 mm<sup>2</sup> increments.

<sup>D</sup> The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same mass per metre as the deformed wire.

<sup>E</sup> The cross-sectional area is based on the nominal diameter. The area in square millimetres may be calculated by dividing the unit mass in kg/mm by  $7.849 \times 10^{-6}$  (mass of 1 mm<sup>3</sup> of steel) or by dividing the unit mass in kg/m by 0.007849 (mass of steel 1 mm square and 1 m long).

<sup>F</sup> The minimum average height of the deformations shall be determined from measurements made on not less than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentation as described in 7.2.4.7.

<sup>G</sup> Spacing of deformations shall not be greater than 7.24 mm nor less than 4.62 mm for all wire sizes.

<sup>H</sup> See 7.2.4.6 for average longitudinal number of deformations per unit length.

7.2.5.2 When required by the purchaser, the yield strength shall be determined as described in Test Methods and Definitions A370 at an extension of 0.5 % of gage length or by the offset method (0.2 %). For determining the yield strength use a Class B-1 extensometer as described in Practice E83.

7.2.5.3 For wire to be used in the manufacture of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 10, based on the nominal area of the wire.

7.2.5.4 Materials shall be measured at extension under load and shall not be required to exhibit a definite yield point as evidenced by a distinct arrest or halt in the load indication gauge of the testing machine prior to reaching ultimate tensile load. The purchaser shall have the option to accept this feature as sufficient evidence of compliance with the specified minimum yield strength tests covered in this specification.

7.2.6 *Bend Test*—The bend test specimen shall be bent at room temperature through 90° without cracking on the outside of the bent portion, as prescribed in Table 11.

7.2.7 *Permissible Variation in Weight [Mass]:*

7.2.7.1 The permissible variation in weight [mass] of any deformed wire is  $\pm 6$  % of its nominal weight [mass]. The nominal weights [mass] shown in Table 7 and Table 8, or similar calculations on unlisted sizes, shall be used to establish the variation.

7.3 *Number of Tests*—One tension and one bend test shall be made from each 10 tons [9000 kg] or less of each size of wire or fraction thereof.

7.4 *Quality, Finish, and Appearance:*

7.4.1 The wire shall be free of detrimental imperfections and shall have a smooth surface of 125  $\mu\text{m}$ . [3.2  $\mu\text{m}$ ] or better. See 11.1 also.

## 8. Mechanical Property Requirements—Welded Wire Reinforcement

8.1 *Tensile*—Wire for the production of welded wire, deformed, is described in Section 6. Tensile tests shall be made on wire cut from the welded wire and tested either across or between the welds; no less than 50 % shall be across welds. Tensile tests across a weld shall have the welded joint located approximately at the center of the wire being tested and the cross wire forming the welded joint shall extend approximately 1 in. [25 mm] beyond each side of the welded joint.

8.1.1 The yield strength shall be determined as described in Test Methods and Definitions A370 at an extension of 0.5 % of gage length or by the offset method (0.2 %). The manufacturer is not required to test for yield strength, but is responsible for supplying a product that will meet the stipulated limit when tested in conformance with the provisions of 14.3. For determining the yield strength use a Class B-1 extensometer as described in Practice E83. It shall be permissible to remove the extensometer after the yield strength has been determined.