



# Standard Specification for Vinyl (PVC) Coated Steel Wire and Welded Wire Fabric for Reinforcement<sup>1</sup>

This standard is issued under the fixed designation A 933/A933M; 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.

## 1. Scope

1.1 This specification covers plain and deformed steel wire and plain and deformed steel welded wire fabric with protective vinyl (PVC, polyvinyl chloride, or polyvinyl chloride powder compound) coating. Class A is intended for use as reinforcement in concrete and Class B as reinforcement in earth.

1.2 Other thermoplastic organic coatings may be used provided they meet the requirements of this specification.

NOTE 1—The coating applicator is identified throughout this specification as the manufacturer.

1.3 Requirements for coatings are contained in Annex A1.

1.4 This specification is applicable for orders in either inch-pound units (as Specification A 933) or in SI units [as Specification A 933M].

1.5 The values stated in either inch-pound or SI units are to be regarded as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- A 82 Specification for Steel Wire, Plain, for Concrete Reinforcement<sup>2</sup>
- A 185 Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement<sup>2</sup>
- A 496 Specification for Steel Wire, Deformed, for Concrete Reinforcement<sup>2</sup>
- A 497 Specification for Welded Deformed Steel Wire Fabric, for Concrete Reinforcement<sup>2</sup>
- D 2240 Test Method for Rubber Property—Durometer Hardness<sup>3</sup>

D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser<sup>4</sup>

G 8 Test Method for Cathodic Disbonding of Pipeline Coatings<sup>5</sup>

G 12 Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel<sup>5</sup>

G 14 Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)<sup>5</sup>

G 20 Test Method for Chemical Resistance of Pipeline Coatings<sup>5</sup>

### 2.2 National Association of Corrosion Engineers Standards:<sup>6</sup>

RP-287-87 Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surface Using a Replica Tape

TM-01-70 Visual Standard for Surfaces of New Steel Air Blast Cleaned with Sand Abrasive (NACE No. 2)

TM-01-75 Visual Standard for Surfaces of New Steel Centrifugally Blast Cleaned with Steel Shot or Steel Grit (NACE No. 2)

### 2.3 Steel Structures Painting Council Specifications:<sup>7</sup>

SSPC-SP 10-85 Near-White Blast Cleaning

SSPC-Vis 1-67T Pictorial Surface Preparation Standards for Painting Steel Surfaces

SSPC-Vis 2-82T Standard Methods of Evaluating Degree of Rusting on Painted Steel Surfaces

## 3. Ordering Information

### 3.1 The purchaser should specify:

3.1.1 Wire or welded wire fabric specification,

3.1.2 Wire size,

3.1.3 Wire spacing and sizes, if welded wire fabric,

3.1.4 Length and width of sheets or rolls,

3.1.5 Quantity, and

3.1.6 Class of coating.

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

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<sup>2</sup> Annual Book of ASTM Standards, Vol 01.04.

<sup>3</sup> Annual Book of ASTM Standards, Vol 09.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 06.01.

<sup>5</sup> Annual Book of ASTM Standards, Vol 06.02.

<sup>6</sup> Available from the National Association of Corrosion Engineers, 1440 South Creek, Houston, TX 77084.

<sup>7</sup> Available from Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213.

3.2 *The purchaser may specify, if desired:*

3.2.1 Requirements for material samples (4.3),

3.2.2 Requirements for patching material (4.4),

3.2.3 Requirements for visual standards for surface cleaning comparison (5.1),

3.2.4 Specific requirements for test frequency (8.1), and

3.2.5 Requirements for inspection of manufacturing plant (11.1).

NOTE 2—A typical ordering description is as follows: 150 sheets, fabric style 6 by 12 – D 7 by D 4 [150 by 300 – MD45 by MD25] vinylcoated steel welded wire fabric, deformed, with Class A coating for use as concrete reinforcement and produced in accordance with A 933/A 933M.

#### 4. Materials

4.1 Plain or deformed steel wire or welded wire fabric to be coated shall meet the requirements of one of the applicable specifications: A 82, A 185, A 496, or A 497, as specified by the purchaser, and shall be free of surface contaminants such as oil, grease, or paint when received at the manufacturer's plant and prior to cleaning and coating.

4.2 The coating material shall meet the requirements listed in Annex A1. In addition to the requirements of Annex A1, the coating material shall have demonstrated long-term stability when embedded in concrete.

4.2.1 A written certification shall be furnished to the purchaser that properly identifies the number of each batch of coating material used in the order, material quantity represented, date of manufacture, name and address of manufacturer, and a statement that the supplied coating material meets the requirements of Annex A1.

4.3 If specified in the order, a representative 8-oz [0.20-kg] sample of the coating material shall be supplied to the purchaser from each batch. The sample shall be packaged in an airtight container and identified by batch number.

4.4 If specified in the order, patching material, compatible with the coating and inert in concrete, and recommended by the coating manufacturer, shall be supplied to the purchaser.

NOTE 3—When subjected to temperatures above 392°F [200°C] for a prolonged period of time, PVC is subject to decomposition. One of the products of decomposition is hydrochloric acid, HCl, which can damage concrete and reinforcing steel. Even in small amounts, HCl will accelerate corrosion of steel.

NOTE 4—PVC coated wire has very low bond strength to concrete, and the use of deformed wire provides no advantage over smooth wire. The bond strength of PVC coated welded wire fabric is similar to that of uncoated plain welded wire fabric since the cross wires provide the primary bond.

#### 5. Surface Preparation

5.1 The surface of the steel wire or welded wire fabric to be coated shall be cleaned by abrasive blast cleaning to near-white metal in accordance with SSPC-SP10. Additional surface treatment may be used as indicated in A1.3.3.4. Any of the following visual standards of comparison may be used to define the final surface condition: SSPC-Vis 1, SSPC-Vis 2, NACE TM-01-70, and NACE TM-01-75. Average blast profile maximum roughness depth readings of 1.5 to 4.0 mils [0.04 to 0.10 mm] as determined by replica tape measurements using NACE RP-287-87, shall be considered suitable as an anchor pattern.

NOTE 5—A suitable anchor pattern requires the use of grit in the cleaning media.

#### 6. Application of Coating

6.1 The coating shall be applied to the cleaned surface as soon as possible after cleaning, and before oxidation of the surface discernible to the unaided eye occurs. However, in no case shall application of the coating be delayed more than 4 h after cleaning.

6.2 To achieve a chemical bond of the vinyl coating to metal, the steel wire or welded wire fabric must be primed with appropriate primer as recommended by the manufacturer of the primer and vinyl powder compound.

6.3 The coating shall be applied and fully fused in accordance with the written recommendations of the manufacturer of the coating material.

#### 7. Requirements for Coated Wire or Welded Wire Fabric

##### 7.1 *Thickness of Coating:*

7.1.1 *Class A*—The film thickness of the coating after fusing shall be 7 to 17 mils [175 to 425 μm] for both plain and deformed steel wire and welded wire fabric used for concrete reinforcement. Thickness measurements below 5 mils [125 μm] shall be considered cause for rejection. The upper film thickness limits do not apply to repaired areas of damaged coating.

7.1.2 *Class B*—The film thickness of the coating after fusing shall be a minimum of 18 mils [450 μm], for both plain and deformed steel wire and welded wire fabric used for earth reinforcement, such as mechanically stabilized embankments. Thickness measurements below 16 mils [400 μm] shall be considered cause for rejection.

7.1.3 Measurements shall be made in accordance with Test Method G 12 following the instructions for calibration and use recommended by the thickness gage manufacturer. Pull-off and fixed probe gages may be utilized. Pencil-type pull-off gages that require the operator to observe the reading at the instant the magnet is pulled from the surface are not to be used.

7.1.4 A single recorded coated wire and welded wire fabric thickness measurement is the average of three individual readings obtained between consecutive deformations on the body of the wire. A minimum of five recorded measurements shall be obtained approximately evenly spaced along each side of the test specimen (a minimum of ten recorded measurements per specimen).

7.1.5 For acceptance purposes, at least 90 % of all recorded film thickness measurements shall be within the specified limits.

##### 7.2 *Continuity of Coating:*

7.2.1 After fusing, the coating shall be free of holidays (pinholes not discernible to the unaided eye), holes, voids, cracks, and damaged areas.

7.2.1.1 If any of these deficiencies occur during the coating application process, they shall be patched in accordance with the patching material manufacturer's written recommendations.

7.2.2 Holiday checks to determine acceptability of the wire or welded wire fabric shall be made at the manufacturer’s plant with a 67½ -V, 80 000 Ω, wet-sponge-type d-c holiday detector.

NOTE 6—Holiday detection is not intended for use at the job site.

**7.3 Adhesion and Flexibility of Coating:**

7.3.1 The adhesion of the coating shall be evaluated by bending production coated steel wire and welded wire fabric 180° around a mandrel of specified size as prescribed in Table 1. The bend test for adhesion of coating shall be made at a uniform rate and completed within 15 s. The wire or welded wire fabric shall be placed in a plane perpendicular to the mandrel radius. The test specimens shall be at thermal equilibrium of 75 ± 4°F [24 ± 2°C].

7.3.2 Evidence of cracking or disbonding of the coating to the naked eye shall be considered cause for rejection of the coated wire or fabric represented by the bend test sample, except as specified in 9.1.

**8. Number of Tests**

8.1 The purchaser may specify the sampling and test schedule for the number and frequency of tests for coating thickness, adhesion, and continuity.

8.2 If the number and frequency of tests are not specified by the purchaser:

8.2.1 Tests for coating thickness and continuity shall be made at the manufacturer’s plant on a minimum of 1 linear ft [0.3 m] of each size wire or welded wire fabric coated from each 2 h of production.

8.2.2 Bend tests for coating adhesion shall be conducted at the manufacturer’s plant on at least one wire of each size or one style of fabric from each 2 h of production.

**9. Retests**

9.1 If the specimen for coating thickness, continuity, or adhesion fails to meet the specified requirements, two retests on random samples shall be conducted for each failed test. If the results of both retests meet the specified requirements, the coated material represented by the samples shall be accepted.

**10. Handling and Identification**

10.1 All systems for handling coated reinforcement shall have padded contact areas. Bundling bands shall be padded, or suitable banding shall be used to prevent damage to the coating. Bundles of coated reinforcement shall be lifted with a strong back, spreader bar, multiple supports, or a platform

bridge. The bundled reinforcement shall be transported with care and stored off the ground on protective cribbing. The coated reinforcement shall not be dropped or dragged.

10.2 The identification of all reinforcing steel shall be maintained throughout the coating and fabrication process to the point of shipment.

**11. Inspection**

11.1 The inspector representing the purchaser shall have free entry at all times to the parts of the manufacturer’s works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is furnished in accordance with this specification. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. On a random basis, coated specimens may be taken by the purchaser’s representative from the production run for testing.

**12. Permissible Coating Damage Due to Handling and Processing**

12.1 Repairs shall be required on handling damage that occurs at the applicator’s facility. All damage shall be repaired with patching material meeting the requirements of 4.4. The coating applicator shall be responsible for repair to the coating that results from hanging, supporting, or cutting coated wire or welded wire fabric.

12.2 When coated wire and welded wire fabric are sheared, saw-cut, or cut by other means, the cut ends shall be coated within 1 h with the same patching material that is used for the repair of damaged coating.

12.3 Repairs shall be made in accordance with the patching material manufacturer’s written recommendations.

12.4 The total wire surface area covered by patching material shall not exceed 2 %. This does not include cut wire ends.

NOTE 7—All visible damage incurred to the coating during shipping, handling, and installation of the wire and welded wire fabric should be repaired with patching material.

**13. Rejection**

13.1 Coated steel wire and welded wire fabric represented by test samples that do not meet the requirements of this specification shall be rejected. At the manufacturer’s option, such wire or fabric shall be replaced or, alternatively, may be stripped of coating, recleaned, recoated, and resubmitted for acceptance testing in accordance with the requirements of this specification.

**14. Certification**

14.1 The manufacturer shall furnish, at the time of shipment, written certification that the coated steel wire and welded wire fabric meets the requirements of this specification.

**15. Keywords**

15.1 coating requirements; concrete reinforcement; corrosion resistance; steel wire; vinyl coating; welded wire fabric

**TABLE 1 Coating-Adhesion Bend Test Requirements**

Specifications A 82, A 185, A 496, and A 497, Plain or Deformed	
Wire Size No. W or D in <sup>2</sup> × 100 [mm <sup>2</sup> ]	Mandrel Diameter
Up to 6 [40]	Twice the diameter of the tested wire
Larger than 6 [40]	Four times the diameter of the tested wire

**(Mandatory Information)**
**A1. REQUIREMENTS FOR ORGANIC COATINGS FOR PLAIN AND DEFORMED STEEL WIRE AND WELDED WIRE FABRIC**
**A1.1 Coating Material**

A1.1.1 This specification covers qualification requirements for barrier organic coatings for protecting steel wire and welded wire reinforcement from corrosion.

**A1.2 Coating Requirements**

A1.2.1 *Chemical Resistance*—The chemical resistance of the coating shall be evaluated in accordance with Test Method G 20 by immersing coated reinforcing bars in each of the following: distilled water, a 3M aqueous solution of  $\text{CaCl}_2$ , a 3M aqueous solution of  $\text{NaOH}$ , and a solution saturated with  $\text{Ca}(\text{OH})_2$ . Specimens without holidays and specimens with intentional holes drilled through the coating 0.25 in. [6 mm] in diameter shall be tested. The temperature of the test solutions shall be  $75 \pm 3.6^\circ\text{F}$  [ $24 \pm 2^\circ\text{C}$ ]. Minimum test time shall be 45 days. The coating must not blister, soften, lose bond, nor develop holidays during this period. The coating surrounding the intentionally made holes shall exhibit no undercutting during the 45-day period.

A1.2.2 *Resistance to Applied Voltage (Type of Accelerated Corrosion Test)*:

A1.2.2.1 The effects of electrical and electrochemical stresses on the bond of the coating to steel and on the film integrity of the coating shall be assessed. Method A of Test Method G 8 shall be followed, except:

- (1) The cathode and anode shall be reinforcing bars coated with the proposed material,
- (2) The electrolyte shall be an aqueous solution of 7 %  $\text{NaCl}$ ,
- (3) A potential of 2V shall be applied, and
- (4) No intentional holes in the coating shall be made.

A1.2.2.2 No film failures, as evidenced by evolution of hydrogen gas at the cathode or appearance of corrosion products of iron at the anode, shall take place during the first hour of testing.

A1.2.2.3 The test shall be continued for 30 days and the elapsed time for development of the first holidays recorded. No undercutting of the coating shall occur at any holidays that develop during the test. If no holidays have developed after 30 days, then single intentional holes 0.25 in. [6 mm] in diameter shall be made in both the anode and cathode. The test shall be continued for an additional 24 h in which time no undercutting of the coating shall occur.

A1.2.3 *Chloride Permeability*—The chloride permeability characteristics of the films of fused coating having the minimum thickness proposed for use shall be measured by the method outlined in FHWA-RD-74-18.<sup>8</sup> The test shall be performed at  $75 \pm 3.6^\circ\text{F}$  [ $24 \pm 2^\circ\text{C}$ ] for 45 days. The

accumulative concentration of chloride ions permeating through the film shall be less than 1 by  $10^{-4}\text{M}$ .

A1.2.4 *Adhesion and Flexibility of Coating*:

A1.2.4.1 The adhesion of the coating shall be evaluated by bending three coated reinforcing bars, as specified in A1.3.3.1 (1),  $180^\circ$  (after rebound) around a 6-in. [150-mm] diameter mandrel. The bends shall be made at a uniform rate and completed within a 15-s time period. The two longitudinal deformations should be placed in a plane perpendicular to the mandrel radius. The specimens shall be at thermal equilibrium of  $75 \pm 4^\circ\text{F}$  [ $24 \pm 2^\circ\text{C}$ ].

A1.2.4.2 No cracking or disbonding of the coating shall be visible on the outside radius of any of the three bent bars when examined in a well-lit area.

A1.2.5 *Abrasion Resistance*—The resistance of a coating on each of the steel panels to abrasion by a Taber abraser (see Test Method D 4060) or its equivalent, using CS-10 wheels and a 2.2-lb [1-kg] load per wheel, shall be such that the weight loss shall not exceed 0.00355 oz [100 mg] per 1000 cycles.

A1.2.6 *Impact Test*—The resistance of the coating to mechanical damage shall be determined by the falling weight test. A test apparatus similar to that described in Test Method G 14 shall be used along with a 1.8-kg (4-lb) tup, having a nose diameter of 16 mm ( $\frac{5}{8}$  in.). Impact shall occur on a coated steel test panel in accordance with A1.3.3.1(4). The test shall be performed at  $24 \pm 2^\circ\text{C}$  ( $75 \pm 3.6^\circ\text{F}$ ). With an impact of 9Nm (80 in.-lb), no shattering, cracking, or bond loss of the coating shall occur except at the impact area, that is, the area permanently deformed by the tup.

A1.2.7 *Hardness Test*—The hardness of the coating shall be determined in accordance with Test Method D 2240, on durometer hardness. The average of five individual (15-s) hardness measurements shall be made and shall be equal to or exceed Shore D of 40.

**A1.3 Acceptance Testing**

A1.3.1 *Testing Agency*—Acceptance tests shall be performed by an agency acceptable to the purchaser.

A1.3.2 *Test Materials*:

A1.3.2.1 A 1-lb [0.45-kg] sample of the coating material with its generic description and fingerprint (including the method such as infrared spectroscopy or thermal analysis) shall be submitted to the testing agency. The fingerprint and generic description shall become an integral part of the qualification test report.

A1.3.2.2 A 1-pt [0.5-L] sample of liquid patching material that hardens to a solid on drying or curing, compatible with the coating and inert in concrete, shall be submitted to the testing agency. The material must be useable for repairs to the coated reinforcing steel bars damaged by handling. The product name and a description of the patching material shall be given in the test report.

<sup>8</sup> Available from National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

### A1.3.3 Test Specimens:

A1.3.3.1 The following specimens shall be submitted as a minimum for test:

((1) Six 4-ft [1.2-m] long No. 6 [20-mm] deformed reinforcing steel bars, Grade 60 [400], coated with a film thickness of 7 to 12 mils [175 to 300  $\mu\text{m}$ ] for bend and impact tests.

((2) Two 4-ft [1.2 m] long, cleaned but uncoated No. 6 [20-mm], deformed reinforcing bars, Grade 60 [400], from the same lot of steel and subject to the same cleaning process as the coated bars for instrument calibration.

(3) Twelve-10 in. [0.25-m] long, No. 6 [20-mm] deformed reinforcing steel bars, Grade 60 [400], coated with a film thickness of 7 to 12 mils [175 to 300  $\mu\text{m}$ ], for chemical resistance and applied voltage tests. Seal the ends of the coated bars with patching material.

(4) Four 4 by 4 by 0.05-in. [100 by 100 by 1.3-mm] steel plates with center holes for Taber abrasers coated with a coating thickness of  $10 \pm 2$  mils [ $250 \pm 50 \mu\text{m}$ ].

(5) Four free film samples of coating material 4 by 4 in. [100 by 100 mm] with a film thickness of approximately 7 mils [175  $\mu\text{m}$ ], for the chloride permeability test.

(6) Four free films of coating material, 4 by 4 in. [100 by 100 mm], approximately 30 mils [760  $\mu\text{m}$ ] thick, for durometer hardness testing.

A1.3.3.2 After fusion, the coating shall be free of holidays (pinholes not visible to the unaided eye), holes, voids, contamination, cracks, and damaged areas discernible to the

unaided eye. The coatings shall be checked for holidays using a 67½ -V, 80 000  $\Omega$ , wet-sponge-type d-c holiday detector, and patched accordingly. The number of holidays shall be reported.

A1.3.3.3 The reinforcing steel bars shall be uniformly coated with a deviation not exceeding  $\pm 2$  mils [ $\pm 50 \mu\text{m}$ ] from the average thickness. The thickness of the coating shall be measured on the body of the bar between the deformations or ribs.

A1.3.3.4 The manufacturer shall specify the method and grade of metal surface preparation and the coating application procedures for the test specimens and for contract production of coated wire and welded wire fabric. These procedures shall be listed in the test report.

#### A1.3.4 Test Procedures:

A1.3.4.1 Thickness measurements shall be made in accordance with Test Method G 12 as described in 7.1.3 of this specification.

A1.3.4.2 The specified number of thickness measurement readings on steel reinforcing bars shall be taken between consecutive deformations as described in 7.1.4 of this specification.

NOTE A1.1—Material qualification tests prescribe the use of reinforcing bars and steel substrates other than wire and welded wire fabric for convenient comparison to preestablished test procedures and standards developed for plastic-coated reinforcing steel products.

A1.3.5 Certification—Reports summarizing the results of all tests and bearing the signature of the testing laboratory shall be furnished to the manufacturer.

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