This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: A955/A955M – 19

# Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement[1]

This standard is issued under the fixed designation A955/A955M; 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 deformed and plain stainless steel bars for concrete reinforcement in cut lengths and coils used in applications requiring resistance to corrosion or controlled magnetic permeability. The standard sizes and dimensions of deformed bars and their numerical designation shall be those listed in Table 1.

1.1.1 A supplementary requirement (S1) is provided for use where a controlled magnetic permeability product is required by the purchaser. Supplementary requirement (S1) applies only when specified in the purchase order.

1.2 The chemical composition of the stainless steel alloy shall be selected for suitability to the application involved by agreement between the manufacturer and the purchaser. This is an important consideration in achieving the desired corrosion resistance or controlled magnetic permeability, or both, because these properties are not provided by all stainless steels.

1.3 Corrosion Resistance requirements are contained in Section 11 and Annex A1 and the test procedures options are Annex A2 (Rapid Macrocell Test) or Annex A3 (Cracked Beam Test).

1.4 The requirements for introduction of new alloys into a mandatory chemical composition requirements table in this specification are given in Annex A5.

1.5 Requirements for the relative deformation area of three-sided deformed bars are contained in Annex A4.

1.6 Bars are of three minimum yield strength levels, namely, 60 000 psi [420 MPa], 75 000 psi [520 MPa], and 80 000 psi [550 MPa], designated as Grade 60 [420], Grade 75 [520], or Grade 80 [550], respectively.

1.7 Plain bars in sizes up to and including 2 in. [50.8 mm] in diameter in coils or cut lengths are furnished in accordance with this specification in Grade 60 [420], Grade 75 [520], and Grade 80 [550], respectively. Mechanical testing, when required, shall be to the nearest nominal deformed bar size. Requirements providing for deformations and marking shall not be applicable to plain bars.

1.8 When stainless steel is to be welded, use a procedure suitable for the chemical composition and intended use or service.

NOTE 1—Welding of stainless steel reinforcement would occur after shipment from the manufacturer. Structural welding should be performed in accordance with the latest edition of AWS D1.6/D1.6M, any other internationally accepted stainless steel welding code, or a procedure suggested by the material manufacturer. AWS D1.6/D1.6M describes the proper selection of the filler metals, temperature control, as well as, performance, procedure qualification and inspection requirements.

1.9 This specification is applicable for orders in either inch-pound units (as Specification A955) or in SI units (as Specification A955M).

1.10 The text of this specification references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.11 The values stated in either inch-pound 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 nonconformance with the specification.

1.12 *This specification does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this specification to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.13 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[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 A01.05 on Steel Reinforcement.

Current edition approved May 15, 2019. Published May 2019. Originally approved in 1996. Last previous edition approved in 2018 as A955/A955M – 18b. DOI: 10.1520/A0955_A0955M-19.

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

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. United States

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

TABLE 1 Deformed Bar Designation Numbers, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements

| Bar Designation No. | Nominal Weight, lb/ft [Nominal Mass, kg/m][A] | | Nominal Dimensions[B] | | | Deformation Requirements, in. [mm] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Maximum Gap per Side[C] | |
| | 400 Series; Duplex Alloys | 300 Series | Diameter, in. [mm] | Cross-Sectional Area, in.$^2$ [mm$^2$] | Perimeter, in. [mm] | Maximum Average Spacing | Minimum Average Height | Two-Sided Bar | Three-Sided Bar |
| 3 [10] | 0.374 [0.556] | 0.378 [0.562] | 0.375 [9.5] | 0.11 [71] | 1.178 [29.9] | 0.262 [6.7] | 0.015 [0.38] | 0.143 [3.6] | 0.097 [2.5] |
| 4 [13] | 0.679 [1.011] | 0.686 [1.021] | 0.500 [12.7] | 0.20 [129] | 1.571 [39.9] | 0.350 [8.9] | 0.020 [0.51] | 0.191 [4.9] | 0.129 [3.3] |
| 5 [16] | 1.048 [1.559] | 1.058 [1.575] | 0.625 [15.9] | 0.31 [199] | 1.963 [49.9] | 0.437 [11.1] | 0.028 [0.71] | 0.239 [6.1] | 0.162 [4.1] |
| 6 [19] | 1.495 [2.225] | 1.511 [2.248] | 0.750 [19.1] | 0.44 [284] | 2.356 [59.8] | 0.525 [13.3] | 0.038 [0.97] | 0.286 [7.3] | 0.194 [4.9] |
| 7 [22] | 2.038 [3.032] | 2.059 [3.064] | 0.875 [22.2] | 0.60 [367] | 2.749 [69.8] | 0.612 [15.5] | 0.044 [1.12] | 0.334 [8.5] | 0.226 [5.8] |
| 8 [25] | 2.685 [3.995] | 2.713 [4.037] | 1.000 [25.4] | 0.79 [510] | 3.142 [79.8] | 0.700 [17.8] | 0.050 [1.27] | 0.383 [9.7] | 0.259 [6.6] |
| 9 [29] | 3.396 [5.053] | 3.441 [5.106] | 1.128 [28.7] | 1.00 [645] | 3.544 [90.0] | 0.790 [20.1] | 0.056 [1.42] | 0.431 [10.9] | 0.292 [7.4] |
| 10 [32] | 4.312 [6.416] | 4.358 [6.484] | 1.270 [32.3] | 1.27 [819] | 3.990 [101.3] | 0.889 [22.6] | 0.064 [1.63] | 0.487 [12.4] | 0.329 [8.3] |
| 11 [36] | 5.296 [7.880] | 5.352 [7.964] | 1.410 [35.8] | 1.56 [1006] | 4.430 [112.5] | 0.987 [25.1] | 0.071 [1.80] | 0.540 [13.7] | 0.365 [9.3] |
| 14 [43] | 7.64 [11.37] | 7.72 [11.49] | 1.693 [43.0] | 2.25 [1452] | 5.32 [135.1] | 1.185 [30.1] | 0.085 [2.16] | 0.648 [16.5] | 0.438 [11.1] |
| 18 [57] | 13.59 [20.22] | 13.72 [20.43] | 2.257 [57.3] | 4.00 [2581] | 7.09 [180.1] | 1.58 [40.1] | 0.102 [2.59] | 0.864 [21.9] | 0.584 [14.8] |

[A] The 400 and Duplex-Alloy Series is based on a density of 489.59 lb/ft$^3$ [7833.4 kg/m$^3$ ]. The 300 Series is based on a density of 494.78 lb/ft$^3$ [7916.5 kg/m$^3$]. Density varies with alloy content which may result in a variation of several percent.

[B] The nominal dimensions of a deformed bar are equivalent to those of a round bar having the same weight [mass] per foot [metre] as the deformed bar.

[C] The maximum gap (measured as a chord) between the ends of the deformations shall not exceed 25 % /*n* of the nominal perimeter of the bar, where n is the number of longitudinal gaps or longitudinal ribs around the perimeter of the bar.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

A342/A342M Test Methods for Permeability of Weakly Magnetic Materials

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

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

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

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

E290 Test Methods for Bend Testing of Material for Ductility

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

G3 Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing

2.2 *U.S. Military Standard:*[3]

MIL-STD-129 Marking for Shipment and Storage

2.3 *U.S. Federal Standard:*[3]

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

2.4 *AWS Standard:*[4]

AWS D1.6/D1.6M Structural Welding Code – Stainless Steel

2.5 *SAE Document:*[5]

SAE J 1086 Recommended Practice for Numbering Metals and Alloys

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to 3.2 and Terminology A941.

3.2 *Definitions of Terms Specific to This Specification:*

3.2.1 *deformations, n*—transverse protrusions on a deformed bar.

3.2.2 *deformed bar, n*—steel bar with protrusions; a bar that is intended for use as reinforcement in reinforced concrete construction.

3.2.2.1 *Discussion*—The surface of the bar is provided with protrusions that inhibit longitudinal movement of the bar relative to the concrete surrounding the bar in such construction. The protrusions conform to the provisions of this specification.

3.2.3 *plain bar, n*—steel bar without protrusions.

3.2.4 *relative deformation area, n*—the ratio of the deformation bearing area (projected deformation area normal to the bar axis) to the shearing area (nominal bar perimeter times the average spacing of the deformations.

3.2.5 *rib, n*—longitudinal protrusion on a deformed bar.

3.2.6 *three-sided bar, n*—deformed steel bar with three rows of transverse deformations.

3.2.7 *two-sided bar, n*—deformed steel bar with two rows of transverse deformations.

## 4. Ordering Information

4.1 Orders for stainless steel bars for concrete reinforcement under this specification shall contain the following informaton

4.1.1 Quantity (weight) [mass],

4.1.2 Deformed or plain,

4.1.3 UNS number,

4.1.4 Bar designation number (size) of deformed bars or nominal diameter (size) of plain bars,

4.1.5 Cut lengths or coils,

4.1.6 Grade (strength level), and

4.1.7 ASTM designation A955 [A955M] and year of issue.

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

4.2.1 Requirements for inspection (19.1),

4.2.2 Packaging and package marking (Section 22),

4.2.3 Magnetic permeability supplementary requirement (S1) and

4.2.4 Other special requirements, if any.

## 5. Materials and Manufacture

5.1 The bars shall be processed from properly identified heats of mold-cast or strand-cast steel. The steel shall be made by any commercially acceptable process.

## 6. Chemical Composition

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

6.2 The chemical analysis of each heat of steel shall be determined in accordance with Test Methods, Practices, and Terminology A751. The manufacturer shall make the analysis on test samples taken preferably during the pouring of the heat.

6.3 The steel shall conform to all applicable chemical composition requirements in Specification A484/A484M.

## 7. Requirements for Deformations

7.1 Deformations shall be spaced along the bar at substantially uniform distances. The deformations on all sides of the bar shall be similar in size, shape, and pattern.

7.2 The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45°. Where the line of deformations forms an included angle with the axis of the bar of from 45 to 70° inclusive, the deformations on a two-sided bar shall alternately reverse in direction on each side or those on one side shall be reversed in direction from those on the opposite side. The deformations on three-sided bars

[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 DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

[4] Available from American Welding Society (AWS), 8669 NW 36 St., #130, Miami, FL 33166-6672, http://www.aws.org.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

**TABLE 2 Chemical Composition[A]**

| UNS Designation[B] | Type[C] | Composition % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Carbon | Manganese | Phosphorus | Sulfur | Silicon | Chromium | Nickel | Molybdenum | Nitrogen | Other Elements |
| | | | | | | Austenitic Grades | | | | | |
| S24000 | XM-29[D] | 0.08 | 11.5–14.5 | 0.060 | 0.030 | 1.00 | 17.0–19.0 | 2.3–3.7 | .... | 0.20–0.40 | .... |
| S24100 | XM-28[D] | 0.15 | 11.0–14.0 | 0.045 | 0.030 | 1.00 | 16.5–19.0 | 0.50–2.50 | .... | 0.20–0.45 | .... |
| S31653 | 316LN | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 16.0–18.0 | 10.0–13.0 | 2.00–3.00 | 0.10–0.16 | .... |
| | | | | | | Austenitic-Ferritic (Duplex) Grades | | | | | |
| S31803 | 2205[E] | 0.030 | 2.00 | 0.030 | 0.020 | 1.00 | 21.0–23.0 | 4.5–6.5 | 2.5–3.5 | 0.08–0.20 | .... |
| S32101 | .... | 0.040 | 4.0–6.0 | 0.040 | 0.030 | 1.00 | 21.0–22.0 | 1.35–1.70 | 0.10–0.80 | 0.20–0.25 | Cu 0.10–0.80 |
| S32205 | 2205[D] | 0.030 | 2.00 | 0.030 | 0.020 | 1.00 | 22.0–23.0 | 4.5–6.5 | 3.0–3.5 | 0.14–0.20 | .... |
| S32304 | 2304[D] | 0.030 | 2.50 | 0.040 | 0.030 | 1.00 | 21.5–24.5 | 3.0–5.5 | 0.05–0.60 | 0.05–0.20 | Cu 0.05–0.60 |

[A] Maximum, unless otherwise indicated. Where ellipses (...) appear in this table, there is no requirement and the element need not be determined or reported.

[B] Unified Numbering System, UNS, is the designation for a metal or alloy described and established by Practice E527 and SAE J 1086.

[C] Unless otherwise indicated, a grade designation originally assigned by the American Iron and Steel Institute (AISI).

[D] Naming system developed and applied by ASTM.

[E] Common name, not a trademark, widely used in the concrete industry, not associated with any one manufacturer.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

shall reverse on one of the three sides (see Fig. 1). Where the line of deformation is over 70°, a reversal in direction is not required.

7.3 The average spacing or distance between deformations on each side of the bar shall not exceed seven tenths of the nominal diameter of the bar.

7.4 The overall length of deformations shall be such that the gap (measured as a chord) between the ends of the deformations shall not exceed 25 %/*n*, where *n* is the number of longitudinal gaps or longitudinal ribs, of the nominal perimeter of the bar. Where the ends of the deformations terminate in a longitudinal rib, the width of the longitudinal rib shall be considered as the gap between these ends. The summation of the gaps shall not exceed 25 % of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.1416 times the nominal diameter.

7.5 The spacing, height, and gap of deformations shall conform to the requirements prescribed in Table 1.

## 8. Measurement of Deformations

8.1 The average spacing of deformations shall be determined by measuring the length of a minimum of ten spaces and dividing that length by the number of spaces included in the measurement. The measurement shall begin from a point on a deformation at the beginning of the first space to a corresponding point on a deformation after the last included space. Spacing measurements shall not be made over a bar area containing bar marking symbols.

8.2 The average height of deformations shall be determined from measurements made on not less than two typical deformations. Determinations shall be based on three measurements per deformation, one at the center of the overall length and the other two at the quarter points of the overall length.

8.3 For three-sided bars, the relative deformation area, $R_d$, shall meet the requirements of Annex A4.

**TABLE 3 Tensile Requirements**[A]

| | Grade 60 [420] | Grade 75 [520] | Grade 80 [550] |
|---|---|---|---|
| Tensile strength, min, psi [MPa] | 90 000 [620] | 100 000 [690] | 100 000 [690] |
| Yield strength, min, psi [MPa] | 60 000 [420] | 75 000 [520] | 80 000 [550] |
| Ratio of actual tensile strength to actual yield strength, min | 1.20 | 1.20 | 1.20 |
| Elongation in 8 in. [200 mm], min, % | | | |
| Bar designation no. | | | |
| 3, 4, 5 [10, 13, 16] | 20 | 20 | 16 |
| 6 [19] | 20 | 20 | 16 |
| 7, 8, 9, 10, 11, 14, 18 [22, 25, 29, 32, 36, 43, 57] | 20 | 20 | 16 |

[A] Consult with the manufacturer for availability of grades and bar sizes.

**TABLE 4 Bend Test Requirements**

| Bar Designation No. | Pin Diameter for Bend Test[A] | | |
|---|---|---|---|
| | Grade 60 [420] | Grade 75 [520] | Grade 80 [550] |
| 3, 4, 5 [10, 13, 16] | 3½ *d*[B] | 3½ *d* | 3½ *d* |
| 6 [19] | 5*d* | 5*d* | 5*d* |
| 7, 8 [22, 25] | 5*d* | 5*d* | 5*d* |
| 9, 10, 11 [29, 32, 36] | 7*d* | 7*d* | 7*d* |
| 14, 18 [43, 57] (90°) | 9*d* | 9*d* | 9*d* |

[A] Test bends 180° unless noted otherwise.
[B] *d* = nominal diameter of specimen.

8.4 Insufficient height, insufficient circumferential coverage, or excessive spacing of deformations shall not constitute cause for rejection unless it has been clearly established by determinations on each lot (Note 2) tested that typical deformation height, gap, or spacing does not conform to the

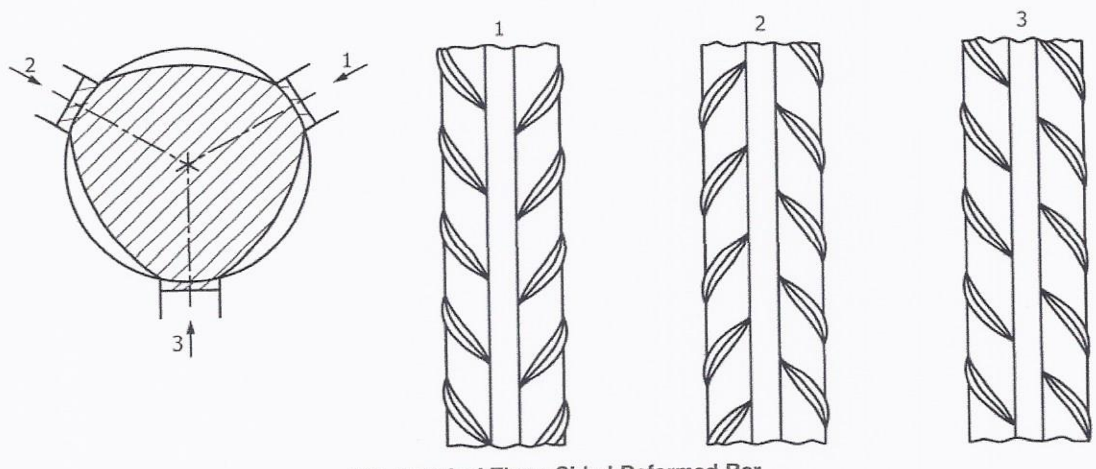


FIG. 1 Typical Three-Sided Deformed Bar

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

minimum requirements prescribed in Section 7. No rejection shall be made on the basis of measurements if fewer than ten adjacent deformations on each side of the bar are measured.

NOTE 2—A lot, *for this purpose*, is defined as all the bars of one bar number and pattern of deformation contained in an individual shipping release or shipping order.

## 9. Tensile Requirements

9.1 The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 3.

9.2 The yield strength shall be determined by the offset method (0.2 % offset), as described in Test Methods and Definitions A370.

9.3 When material is furnished in coils, the test specimen shall be taken from the coil and straightened prior to placing it in the jaws of the tensile test machine. Straightening of the test specimens shall be done carefully to avoid formation of local sharp bends and to minimize cold work. (See Note 3.)

9.3.1 Test specimens taken from post-fabricated material shall not be used to determine conformance to this specification.

NOTE 3—Insufficient straightening prior to attaching the extensometer can result in lower-than-actual yield strength readings. Multiple bending distortion from mechanical straightening and fabricating machines can lead to excessive cold work, resulting in higher magnetic permeability, higher yield strengths, lower elongation values, and a loss in deformation height.

9.4 The percentage of elongation shall be as prescribed in Table 3. When the actual percentage of elongation meets or exceeds 25 %, the bending requirements in Section 10 shall be waived.

## 10. Bending Requirements

10.1 The bend test specimen shall withstand being bent around a pin without cracking on the outside radius of the bent portion. The requirements for degree of bending and sizes of pins are prescribed in Table 4.

10.2 The bend test shall be made on specimens of sufficient length to ensure free bending and with apparatus that provides the following:

10.2.1 Continuous and uniform application of force throughout the duration of the bending operation.

10.2.2 Unrestricted movement of the specimen at points of contact with the apparatus and bending around a pin free to rotate.

10.2.3 Close wrapping of the specimen around the pin during the bending operation.

10.3 It shall be permissible to use other methods of bend testing as described in Test Methods E290, such as placing a specimen across two round bearings free to rotate and applying the bending force with a fixed round-tip mandrel conforming to the specified bend radius, allowing the bar to pass through with sufficient clearance. When failures occur under other methods of bend testing, retests shall be permitted under the bend-test method prescribed in 10.2.

## 11. Corrosion Resistance Requirements

11.1 Corrosion resistance testing shall be performed one time in accordance with Annex A1 for each stainless steel alloy processed as reinforcement by each manufacturer. Corrosion performance for the alloy shall be redemonstrated if the processing method is significantly altered.

## 12. Magnetic Properties

12.1 Controlled magnetic permeability shall be specified by invoking Supplementary Requirement S1.

## 13. Permissible Variation in Weight [Mass]

13.1 Deformed reinforcing bars shall be evaluated on the basis of nominal weight [mass]. The weight [mass] determined using the measured weight [mass] of the test specimen and rounding in accordance with Practice E29, shall be at least 94 % of the applicable weight [mass] per unit prescribed in Table 1. In no case shall overweight [excess mass] of any deformed bar be the cause for rejection. Weight [mass] variation for plain rounds shall be computed on the basis of permissible variation in diameter in accordance with Specifications A6/A6M or A484/A484M.

13.2 The specified limit of variation shall be evaluated in accordance with Practice E29 (rounding method).

## 14. Finish

14.1 The bars shall be free of detrimental surface imperfections. Imperfections shall be considered detrimental when specimens containing them fail to conform to the tensile, bending, weight [mass], dimensions, or cross-sectional area requirements of this specification.

NOTE 4—Deformed reinforcing bars that will be mechanically spliced or butt-spliced by welding may require a certain degree of roundness in order for the splices to adequately achieve strength requirements.

14.2 After rolling, the bars shall be pickled to remove mill scale carbon steel contamination and surface oxidation.

NOTE 5—Pickling improves the corrosion resistance of stainless steel reinforcement. The surface finishes of austenitic and duplex stainless steel may be different in appearance.

## 15. Number of Tests

15.1 One tension test and one bend test, if required (see 9.4), shall be made of each bar size rolled from each heat.

15.2 One set of dimensional property tests including bar weight [mass] and spacing, height, and gap of deformations shall be made of each bar size rolled from each heat.

## 16. Retests

16.1 If the results of an original tension specimen fail to meet the specified minimum requirements and are within 2000 psi [14 MPa] of the required tensile strength, within 1000 psi [7 MPa] of the required yield strength, or within two percentage units of the required elongation, a retest shall be permitted on two random specimens for each original tension specimen failure from the lot. Both retest specimens shall meet the requirements of this specification.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

16.2 If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in 16.5.2 and 16.5.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification. The retest shall be performed on test specimens that are at air temperature but not less than 60°F [16°C].

16.3 If a weight [mass] test fails for reasons other than flaws in the specimen as described in 16.5.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

16.4 If a corrosion resistance test fails for reasons other than flaws as described in 16.5.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

16.5 If the original test or any of the random retests fails because of any reasons listed in 16.5.1, 16.5.2, or 16.5.3, the test shall be considered an invalid test. The original results from 16.5.1, 16.5.2, or 16.5.3 shall be discarded and the test shall be repeated on a new specimen from the same lot.

16.5.1 The elongation property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle half of the gage length, as indicated by scribe marks on the specimen before testing,

NOTE 6—Marking specimens with multiple scribe or punch marks can reduce the occurrence of fracture outside or near these marks and the need for declaring the test invalid.

16.5.2 Mechanical reasons such as failure of testing equipment or improper specimen preparation,

16.5.3 Flaws are detected in a test specimen, either before or during the performance of the test.

## 17. Test Specimens

17.1 All mechanical tests shall be conducted in accordance with Test Methods and Definitions A370. In case of any conflict between the requirements in this specification and the requirements of Test Methods and Definitions A370, the requirements in this specification shall prevail.

17.2 Tension test specimens shall be the full section of the bar as rolled. Unit stress determinations for yield and tensile strength shall be based on the nominal bar area.

17.2.1 Tension test specimens shall be long enough to provide for an 8-in. [200-mm] gage length and a distance of at least two bar diameters between each gage mark and the grips.

NOTE 7—It is recommended that sufficient additional length of the test specimen be provided to fill the grips completely, leaving some excess length protruding beyond each grip. The grips should be shimmed so that no more than ½ in. [13 mm] of a grip protrudes from the head of the tensile testing machine.

17.2.2 *Gage Marks*—The 8-in. [200-mm] gage length shall be marked on the specimen using a preset 8-in. [200-mm] punch or, alternately, may be punch marked every 2 in. [50 mm]) along the 8-in. [200-mm] gage length, on one of the longitudinal ribs, if present, or in the clear spaces between transverse deformations. Punch marks shall not be placed on a transverse deformation.

NOTE 8—Light punch marks are desirable because deep marks severely indent the bar and may affect the results.

17.3 The bend test specimens, if required, shall be the full section of the bar rolled.

## 18. Report

18.1 The following information shall be reported on a per heat or per lot basis as is appropriate.

18.1.1 UNS number,
18.1.2 Chemical analysis,
18.1.3 Finish,
18.1.4 Bar size and number of sides,
18.1.5 Tensile properties,
18.1.6 Bend test (if required),
18.1.7 Corrosion test (if appropriate), and
18.1.8 Magnetic permeability (if appropriate).

18.2 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document shall meet the requirements of the invoked ASTM standard(s) and conform to any EDI agreement between the purchaser and the manufaturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 9—The industry definition invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

## 19. Inspection

19.1 Inspection of the stainless steel reinforcing bars shall be agreed upon between the purchaser and the manufacturer as part of the purchase order or contract.

## 20. Rejection and Rehearing

20.1 Any rejection based on testing undertaken by the purchaser shall be promptly reported to the manufacturer.

20.2 Samples tested that represent rejected material shall be preserved for two weeks from the date rejection is reported to the manufacturer. In case of dissatisfaction with the results of the tests, the manufacturer shall have the right to make claim for a rehearing within that time.

## 21. Marking

21.1 When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer's heat or test identification number.

21.2 Each manufacturer shall identify the symbols of his or her marking system.

21.3 All bars produced to this specification, except plain bars, which shall be tagged by grade, shall be identified by distinguishing marks legibly rolled onto the surface of one side of the bar to denote:

21.3.1 *Point of Origin*—Letter or symbol established as the manufacturer's mill designation.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

21.3.2 *Size Designation*—Arabic number corresponding to bar designation number of Table 1.

21.3.3 *Type of Steel*—Either the letters SS or CR indicating that the bar was produced to this specification.

21.3.4 *Minimum Yield Strength Designation*—For Grade 60 [420] bars, one dot or the number 60 [4]. For Grade 75 [520] bars, two dots or the number 75 [5]. For Grade 80 [550] bars, three dots or the number 80 [6].

NOTE 10—Prior to the revision of this specification to require bar markings for Type of Steel and the Minimum Yield Strength Designation, several manufacturers had already voluntarily adopted marking systems. The specific markings used and the order in which they appeared were not consistent. Hence, the phrase "in the following order" was deleted in Section 23.3 of A955/A955M – 11$^{\varepsilon 1}$. As rolls are replaced and redressed, the manufacturers will arrange the markings in the order listed (Point of Origin, Size Designation, Type of Steel and Minimum Yield Strength Designation). At that time, the phrase "in the following order" will be reinstated in Section 23.3 and the two designations for Type of Steel, *CR* and *SS*, will be replaced with *SS*.

NOTE 11—As rolls are replaced and redressed, the manufacturers will transition to numbers. Dots have been traditionally used to identify stainless steel strength grades.

21.3.5 It shall be permissible to substitute a metric size bar of Grade 420 for the corresponding inch-pound size bar of Grade 60, a metric sized bar of 520 for the corresponding inch-pound size bar of Grade 75, and a metric sized bar of 550 for the corresponding inch-pound size bar of Grade 80.

## 22. Packaging and Package Marking

22.1 Packing, marking, and loading for shipment shall be agreed upon between the purchaser and manufacturer.

22.2 When specified in the contract or order, and for direct procurement by or direct shipment to the U.S. Government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for military agencies and with Fed. Std. No. 123 for civil agencies.

## 23. Keywords

23.1 concrete reinforcement; corrosion resistance; deformations (protrusions); magnetic properties; stainless steel bars

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified in the purchase order or contract.

### S1. Magnetic Permeability Testing

S1.1 (See 12.1.) When material of a low permeability is desired, the purchaser shall specify that the material be tested to Test Methods A342/A342M. The specific limits of magnetic permeability shall be a matter of agreement between the manufacturer and the purchaser.

## ANNEXES

**(Mandatory Information)**

### A1. EVALUATION OF CORROSION RESISTANCE

A1.1 The corrosion resistance of the stainless steel reinforcing bars, including the method for removal of mill scale, shall be evaluated based on either A1.2 or A1.3.

A1.2 Using a rapid macrocell test of bars in a simulated concrete pore 15 % sodium chloride solution over a 15-week period, as specified in Annex A2, the average corrosion rate for a minimum of five specimens shall at no time during the test exceed 0.25 µm/year, with no single specimen exceeding a corrosion rate of 0.50 µm/year.

A1.3 Using a cracked beam test, the 24-week test cycle shall be repeated three or four times for a total duration of either 72 or 96 weeks as agreed with the organization requesting the test, as specified in Annex A3, the average corrosion rate for a minimum of five specimens shall at no time during the test exceed 0.20 µm/year, with no single specimen exceeding a corrosion rate of 0.50 µm/year.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019

Downloaded/printed by

## A2. RAPID MACROCELL TEST

### A2.1 Scope

A2.1.1 Annex A2 describes procedures to measure the corrosion rate and corrosion potential of stainless steel reinforcing bars using the rapid macrocell test.

### A2.2 Test Equipment and Materials

A2.2.1 *Plastic Containers*—Two 4.5-quart [4.5-L] plastic containers per test, approximately 7 in. [180 mm] in diameter by 7.5 in. [190 mm] in depth for each test setup.

A2.2.2 *Voltmeter*—High impedance voltmeter (at least one Mohm) capable of measuring 0.001 mV.

A2.2.3 *Reference Electrode*—A saturated calomel electrode (SCE) or silver-silver chloride electrode, as defined in Practice G3, Appendix X2, Table X2.1.

A2.2.4 *Resistor*—10-ohm (± 0.3 ohm) electrical resistor.

A2.2.5 *Terminal Box*—Terminal boxes are used to make the electrical connections between the test specimens. Each terminal box consists of a project box with a minimum of 6 pairs of binding posts (identified here as red and black). A 10-ohm resistor connects each pair of binding posts in the terminal boxes.

A2.2.6 *Wire*—16-gauge [1.5 $mm^2$] insulated copper wire is used to make the electrical connections to the bars.

A2.2.7 *Epoxy Coating*—A liquid two-part epoxy coating (such as that used as patching material for epoxy-coated reinforcing bars) shall be used to cover the electrical connections. It shall be applied in accordance with manufacturer's recommendations.

A2.2.8 *Concrete Pore Solution*—Simulated concrete pore solution is prepared as follows: One litre of pore solution contains 974.8 g of distilled water, 18.81 g of potassium hydroxide (KOH), 17.87 g of sodium hydroxide (NaOH).

A2.2.9 *Sodium Chloride Solution*—The sodium chloride solution is prepared by adding 172.1 g of sodium chloride (NaCl) to one liter of simulated concrete pore solution to obtain a 15 % (6.04 molal ion) concentration solution.

A2.2.10 *Salt Bridges*—Salt bridges provide an ionic path between the solutions surrounding the cathode and the anode. The salt bridges shall be prepared as follows: A salt bridge consists of a flexible latex tube with an inner diameter of ⅜ in. (9.5 mm), filled with a gel. The gel is made using 4.5 g of agar, 30 g of potassium chloride (KCl), and 100 g of distilled water, enough to produce 4 salt bridges, each with a length of 2 ft [0.6 m]. Salt bridges are prepared by mixing the constituents and heating them over a burner or hotplate for about 1 min or until the solution starts to thicken. The gel is poured into the latex tubes using a funnel. The salt bridges are then placed in boiling water for one hour, keeping the ends of the tubes out of the water. After boiling, the salt bridges are allowed to cool until firm. To provide an adequate ionic path, the gel in the salt bridge must be continuous, without any air bubbles.

A2.2.11 *Air Scrubber*—Air is bubbled into the simulated concrete pore solution surrounding the cathode in the macrocells to provide enough oxygen for the cathodic reaction. An air scrubber is used to minimize carbonation of the pore solution by eliminating the carbon dioxide from the air. To prepare the air scrubber, a 5-gal [20-L] container is partially filled with a 1-*M* sodium hydroxide solution. Compressed air is channeled into the scrubber and out to the specimens through latex tubing. The procedure for preparing the air scrubber is as follows:

*(1)* Two barbed fittings are inserted on the top of the container.

*(2)* A 5-ft [1.5-m] piece of plastic tubing is cut. With a knife, perforate one end of the tubing, 4 ft [1.2 m], making (typically, hundreds of) holes to allow the air to produce small bubbles. The end of the tubing closest to the holes is sealed with a clamp.

*(3)* The tubing end with the holes is coiled at the bottom of the container and trap rock is used to hold down the tubing. The other end of the tubing is connected to the inside part of one of the barbed fittings.

*(4)* The other side of the barbed fitting is connected to a plastic tube, which is connected to the compressed air outlet.

*(5)* Another piece of plastic tubing is connected to the outside of the other barbed fitting. The air is distributed to the solution surrounding the cathodes using 1-ft [0.3-m] lengths of latex tubing and polypropylene T-shaped connectors.

*(6)* Screw clamps are placed to regulate the amount of air bubbled into each container.

*(7)* Distilled water is periodically added to the container to replace water that is lost due to evaporation. NaOH is added, if necessary, to maintain the pH of the solution above 12.5.

NOTE A2.1—Other sources of $CO_2$-free air may also be used.

### A2.3 Test Specimen Preparation

A2.3.1 Stainless steel reinforcing bars used in this test should be prepared in the same manner, including surface treatment, as will be furnished to the purchaser.

A2.3.2 A test bar shall consist of a 5-in. [125-mm] long reinforcing bar. Sharp edges on the bar ends shall be removed with a grinder, and the bar shall be drilled and tapped at one end to receive a ⅜-in. [10-mm] long, 10–24 threaded stainless steel bolt, which is used to connect the copper wire to the bar. The bar shall be then cleaned with acetone to remove oil or dust from the bar surface. A 16-gauge [1.5-$mm^2$] insulated copper wire shall be attached to the top of the bar. The connection shall be covered with two layers of epoxy to prevent crevice corrosion. Each layer should be cured for a minimum of four hours.

NOTE A2.2—Test bars are typically No. 5 [16] reinforcing bars; other bar sizes may be used with the agreement of the organization requesting the test.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

## A2.4 Test Procedure

A2.4.1 The rapid macrocell test, shown in Fig. A2.1, consists of an anode and a cathode. The cathode shall consist of two bars in the simulated concrete pore solution. The anode shall consist of one bar in the simulated concrete pore solution with 15 % NaCl (6.04 molal ion concentration). The solutions shall be changed every five weeks. The test shall be conducted for 15 weeks at room temperature, 68 to 76°F [20 to 24°C].

A2.4.2 At the anode, the simulated concrete pore solution with NaCl shall be placed in a container to a depth of 3 in. [75 mm]. One bar shall be placed in the center of the container, resting on the bottom of the container. The top of the bar shall be supported with the container lid, which shall be placed just above the water level. The free end of a copper wire shall be attached to the specimen and to a black binding post in a terminal box. Another container shall be filled with simulated concrete pore solution without NaCl to a depth of 3 in. [75 mm]. Two bars shall be placed in the container to act as the cathode. The bars shall be fixed in place with the lid. The free ends of copper wires shall be attached to the specimens and to a third wire that has its other end attached to a red binding post in a terminal box. Air, scrubbed to remove carbon dioxide ($CO_2$), shall be bubbled into the solution surrounding the cathode specimens to provide enough oxygen for the cathodic reaction. A salt bridge shall connect the solutions surrounding the cathode and the anode.

A2.4.3 The voltage drop shall be measured across the 10-ohm resistor that completes the macrocell circuit by connecting the black binding post to the red binding post in the terminal box. The negative terminal of the voltmeter shall be connected to the black binding post and the positive terminal of the voltmeter shall be connected to the red binding post. After the voltage drop has been measured, the anodes shall be disconnected from the terminal box. Two hours after being disconnected, the corrosion potentials of the anode shall be measured by placing the reference electrode in the solution surrounding the bar and connecting it to the positive terminal on the voltmeter and the bar to the negative terminal of the voltmeter. After corrosion potentials are obtained, the anodes shall be reconnected to the terminal box. Readings shall be taken once a day for the first seven days of the test and weekly, thereafter.

NOTE A2.3—The purpose of the corrosion potential measurements is to provide verification for the corrosion rate measurements; generally, an increase in corrosion rate will occur concurrently with or shortly after a drop in corrosion potential.

A2.4.4 The voltage drop obtained from the macrocell readings shall be converted to a corrosion rate (in µm/year) using the following equation:

$$\text{Rate} = 11.6 \cdot i_c = \frac{11600 \cdot V}{A \cdot R} \quad \text{(A2.1)}$$

where:

$i_c$ = corrosion current density (µA/cm$^2$),
$V$ = voltage drop across resistor (mV),
$R$ = resistance of the resistor (ohm), and

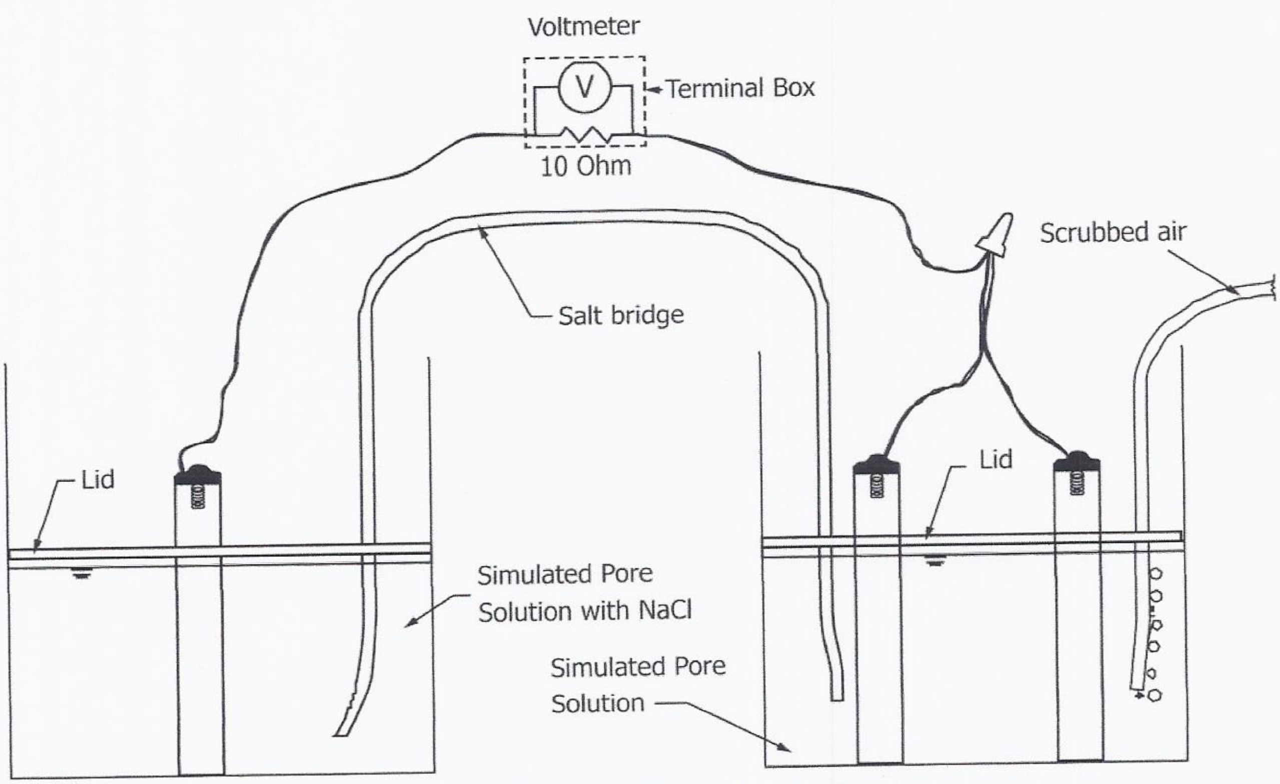


**FIG. A2.1 Schematic of Rapid Macrocell Test**

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

$A$ = surface area of exposed metal at the anode bar ($cm^2$).

### A2.5 Report

A2.5.1 The following information shall be reported for each test setup:

A2.5.2 Type, source, and size of the stainless steel reinforcing bars, and description of the surface preparation.

A2.5.3 Individual readings of voltage drop and the calculated value of corrosion rate.

A2.5.4 Individual readings of corrosion potential for anode and cathode with respect to the reference electrode.

A2.5.5 Identify the specific reference electrode used.

NOTE A2.4—The organization requesting the test may request that photographs of the bars be taken upon completion of the test.

## A3. CRACKED BEAM TEST

### A3.1 Scope

A3.1.1 Annex A3 describes procedures to measure the corrosion rate and corrosion potential of stainless steel reinforcing bars in concrete using the cracked beam test.

### A3.2 Test Equipment and Materials

A3.2.1 *Voltmeter*—High impedance voltmeter (at least one Mohm) capable of measuring 0.001 mV.

A3.2.2 *Reference Electrodes*—For corrosion potential measurements in ponding conditions use a saturated calomel electrode (SCE) or silver-silver chloride electrode, and for corrosion potential measurements after solution removal use a copper-copper sulfate electrode (CSE), as defined in Practice G3, Appendix X2, Table X2.1.

A3.2.3 *Resistor*—10-ohm (±0.3 ohm) electrical resistor.

A3.2.4 *Terminal Box*—Terminal boxes are used to make the electrical connections between the test specimens. Each terminal box consists of a project box with a minimum of 6 pairs of binding posts (identified here as red and black). A 10-ohm resistor connects each pair of binding posts in the terminal boxes.

A3.2.5 *Wire*—16-gauge [1.5 $mm^2$] insulated copper wire is used to make the electrical connections to the bars.

A3.2.6 *Epoxy Sealer*—A two-part epoxy sealer shall be used to cover the sides of the specimens and the electrical connections. It shall be applied in accordance with manufacturer's recommendations.[6]

A3.2.7 *Sodium Chloride Solution*—The 15 % sodium chloride solution is prepared by adding 150 g of NaCl to 850 g of distilled or deionized water.

### A3.3 Test Specimen Preparation

A3.3.1 Preparation of cracked beam specimens (see A3.4.1 and Fig. A3.1) shall be as follows:

A3.3.2 No. 5 [No. 16] bars shall be cut to a length of 12 in. [300 mm].

A3.3.3 Sharp edges on the ends of the bars shall be removed with a grinder.

A3.3.4 The ends of the bars shall be drilled and tapped to receive a ⅜-in. [10-mm] long 10–24 threaded stainless steel bolt. The bolt is used to hold the bars in place during casting of the concrete and to make an electrical connection during the testing period.

A3.3.5 The bars shall be cleaned with acetone to remove dust and oil.

A3.3.6 Mineral oil shall be applied to the forms prior to placing the bars in the forms.

A3.3.7 A 12-mil [0.30-mm] thick, 6-in. [150-mm] long stainless steel shim shall be fixed on to the bottom part of the form so that the shim is located underneath and parallel to the top bar.

A3.3.8 The bars shall be bolted into the forms. The specimens are cast upside down to allow for the integral concrete dam to be cast at the same time.

A3.3.9 The concrete in the test specimens shall be proportioned on a cubic yard [cubic metres] basis with the following constituents: 598 lb [355 kg] of Type I portland cement, 270 lb [160 kg] of water, normalweight fine aggregate constituting 32.5 % of the total concrete volume, normalweight ¾ in. [19 mm] nominal maximum size coarse aggregate constituting 34 % of the total concrete volume, and 6 ± 1 % air content by volume. The concrete shall be cast and cured using the following procedure:

*(1)* The concrete shall be mixed according to Practice C192/C192M.

*(2)* The specimens shall be cast in an inverted position in two layers. Each layer shall be vibrated for 30 s on a vibrating table with an amplitude of 0.0006 in. [0.15 mm] and a frequency of 60 hz.

*(3)* After the second layer is vibrated, the surface of the specimen shall be finished using a wooden float.

*(4)* The specimens shall be cured in the forms for 8 to 24 h.

*(5)* After the initial curing period, the specimens shall be removed from the forms, and the stainless steel shims shall be removed. The specimens shall be placed in a plastic bag with distilled water until 72 h after casting and then removed from the bags and cured in air for 25 days.

NOTE A3.1—It is not necessary or desirable to completely submerge the

[6] Ceilgard 615 made by Ceilcote and Sewer Guard HBS 100 Epoxy Liner made by BASF Construction Chemicals, Inc., have been found to be suitable for this purpose. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

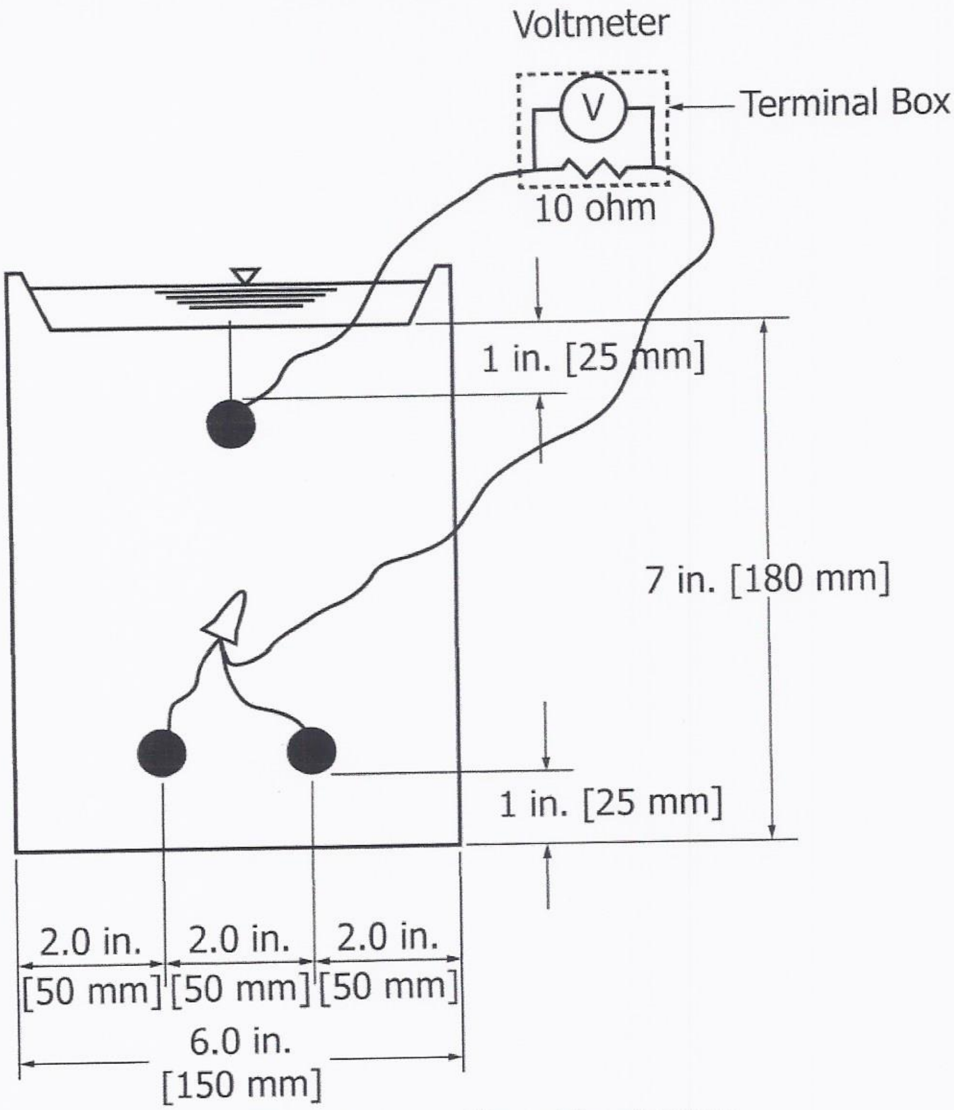


**FIG. A3.1 End View of Cracked Beam Specimen**

specimens in distilled water during curing. Only an amount of water sufficient to maintain a relative humidity near 100 % within the bag is needed.

A3.3.10 Several days before the testing period starts, 16-gauge [1.5 mm$^2$] insulated copper wire shall be attached to the bars in the specimens using ⅜-in. [10-mm] long 10-24 threaded stainless steel bolts. The vertical sides of the specimens shall then be covered with two layers of the epoxy sealer. The electrical connections on the sides shall also be thoroughly coated to prevent crevice corrosion or galvanic corrosion from occurring.

A3.3.11 The top of the specimens shall be lightly sanded with 150-grit sand paper.

A3.3.12 The specimens shall be supported on two pieces of wood, at least 2 in. [50 mm] thick, to allow air to flow under the specimens.

A3.3.13 The top bar shall then be connected to a red binding post on the terminal box, while the bottom bars are connected to a black binding post.

**A3.4 Test Procedure**

A3.4.1 The cracked beam specimen (see Fig. A3.1) shall be 6 in. [150 mm] wide, 7 in. [175 mm] high, and 12 in. [300 mm] long ±0.25 in. [6 mm] for any dimension. It shall contain one No. 5 [No. 16] top bar electrically connected across a 10-ohm (±0.3-ohm) resistor to two No. 5 [No. 16] bottom bars. A crack shall be simulated in the concrete parallel to and above the top bar using a 0.012 ± 0.001 in. [0.30 ± 0.02 mm] thick, 6 ± 0.25 in. [150 ± 6 mm] long stainless steel shim, cast into the concrete and removed 20 to 28 h after casting. The concrete cover to the top and bottom bars shall be 1 ± 0.04 in. [25 ± 1 mm].

A3.4.2 The test procedure for the cracked beam specimens shall proceed as follows beginning 28 days after casting.

*(1)* On the first day of a cycle, the specimens shall be ponded with 300 mL of a 15 % sodium chloride solution at room temperature, 68 to 76°F [20 to 24°C]. This solution shall be left on the specimen for 4 days ±3 h. Evaporation shall be limited by covering the specimens with plastic.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

(2) On the fourth day of a cycle, the voltage drop across the 10-ohm resistor connecting the top and bottom bars shall be recorded for each specimen. The 10-ohm resistor completes the macrocell circuit by connecting the black binding post to the red binding post in the terminal box. The negative terminal of the voltmeter shall be connected to the black binding post and the positive terminal of the voltmeter shall be connected to the red binding post.

(3) The voltage drop obtained from the macrocell readings shall be converted to a corrosion rate (in µm/year) using Eq A2.1.

(4) After the voltage drop has been measured, the circuit shall then be disconnected. Two hours after disconnecting the specimens, the solution on top of the specimens shall be removed with a vacuum cleaner, and the corrosion potentials with respect to a copper-copper sulfate electrode (CSE) of the top and bottom bars recorded. After corrosion potentials are obtained, the circuit shall be reconnected.

(5) After the readings have been taken, a heat tent shall be placed over the specimens to maintain a temperature of 100 ± 3°F [38 ± 2°C]. The specimens shall remain under the heat tent for 3 days ±3 h.

(6) After 3 days, the tent shall be removed and the specimens shall again be ponded with 300 mL of a 15 % sodium chloride solution and the cycle started again.

(7) The wet-dry cycle shall be repeated for 12 weeks. The specimens shall then be subjected to 12 weeks of continuous ponding. During this period the solution shall not be removed and the specimens shall not be placed under the heat tents. The solution depth shall be maintained by adding additional sodium chloride solution. The voltage drop across the 10-ohm resistor and corrosion potential shall be taken once a week as described in A3.4.2(2) and A3.4.2(4).

(8) After 12 weeks of continuous ponding, the drying and ponding cycle shall be repeated for 12 weeks, followed by 12 weeks of continuous ponding. The 24-week cycle shall be repeated as agreed with the organization requesting the test.

NOTE A3.2—Because the specimens are ponded, the corrosion potential during this period should be taken with respect to a saturated calomel reference electrode (SCE) or silver-silver chloride reference electrode instead of a copper-copper sulfate electrode (CSE), since the SCE or silver/silver chloride is more convenient when the electrode has to be immersed in solution. Each type of electrode has a different standard potential. As potentials are only used as an indication of corrosion activity, it is only important to know and report the standard potential for the specific electrodes used.

NOTE A3.3—The purpose of the corrosion potential measurements is to provide verification for the corrosion rate measurements; generally, an increase in corrosion rate will occur concurrently with or shortly after a drop in corrosion potential.

### A3.5 Report

A3.5.1 Type and source of reinforcing bars, and description of surface preparation.

A3.5.2 Individual readings of voltage drop and calculated value of corrosion rate.

A3.5.3 Individual readings of corrosion potential for anode and cathode with respect to the reference electrode.

A3.5.4 Identify the specific reference electrodes used.

NOTE A3.4—The organization requesting the test may request that photographs of the bars be taken upon completion of the test.

## A4. RELATIVE DEFORMATION AREA REQUIREMENTS FOR THREE-SIDED DEFORMED BARS

A4.1 Annex A4 prescribes the requirements for the relative deformation area of three-sided deformed reinforcing bars.

A4.2 The relative deformation area, $R_d$, shall be determined once for each bar size and shall meet or exceed a relative deformation area of 0.06.

A4.3 Measurements of deformations shall be made on as-rolled deformed bars.

A4.4 The relative deformation area, $R_d$, shall be calculated by the following equation:

$$R_d = \left(\frac{h_d}{s_d}\right)\left(1 - \frac{\sum gaps}{p}\right) \qquad (A4.1)$$

where:

$h_d$ = average height of deformations, in. or mm,
$s_d$ = average spacing of deformations, in. or mm,
$\sum gaps$ = summation of the gaps or chord between ends of deformations, in. or mm, and
$p$ = nominal perimeter of the bar, in. or mm.

NOTE A4.1—The term "relative deformation area," which has been adopted in this specification, is defined in 3.2.4 and is calculated by Eq A4.1. Some national standards for deformed (ribbed) reinforcing bars and technical documents use the analogous term "relative rib area." Further information on "relative rib area" is presented in a technical report by ACI Committee 408.[7]

A4.5 *Measurement of Deformation Height*—The average height of deformations, $h_d$, shall be based on measurements made on not less than two typical deformations on each side of the bar. Determinations shall be based on five measurements per deformation, one at the center of the overall length, two at the ends of the overall length, and two located halfway between the center and the ends. The measurements at the ends of the overall length shall be averaged to obtain a single value, and that value shall be combined with the other three measurements to obtain the average deformation height $h_d$. Deformation measurements shall be made using a depth gage with a knife-edge support that spans not more than two adjacent deformations. A knife edge is required to allow measurements

[7] "Bond and Development of Straight Reinforcing Bars in Tension (ACI 408R-03)." The report is available from the American Concrete Institute, 38000 International Way, P.O. Box 9094, Farmington Hills, Michigan 48333-9094, www.concrete.org.

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

to be made at the ends of the overall length of deformations, usually adjacent to a longitudinal rib. The calculation of $h_d$ is based on a knife edge that spans only two deformations because measurements made with a longer knife edge result in higher average deformation heights and, thus, an overestimate of the relative deformation area of some three-sided deformed bars.

## A5. REQUIREMENTS FOR THE INTRODUCTION OF NEW ALLOYS

A5.1 New alloys may be proposed for inclusion in this specification, subject to the following conditions:

A5.1.1 The application for the addition of a new alloy to this specification shall be made to the chair of the Subcommittee A01.05.

A5.1.2 The application shall be accompanied by a document from at least one user indicating that there a need for the new alloy to be included in this specification.

A5.1.3 The application shall be accompanied by test data as required by this specification. Test data from a minimum of three test lots, as defined by this specification, shall be furnished.

A5.1.4 The application shall provide recommended values for all requirements appearing in this specification and a copy of the corrosion resistance testing report.

A5.1.5 The application shall state whether the new alloy is covered by patent.

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A955/A955M – 18b) that may impact the use of this standard. (Approved May 1, 2019.)

*(1)* Revised Sections 1, 2, 3, 4, 5, 6, 9, 15, 16, 17, 18, and 21.
*(2)* Revised Table 2.
*(3)* Deleted 3.1.6, *stainless steel*.
*(4)* Deleted Section 11 (Hardness Requirements) and renumbered subsequent sections accordingly.
*(5)* Combined and revised Section 21 (Rejection) and Section 22 (Rehearing) into Section 20 (Rejection and Rehearing).

Committee A01 has identified the location of selected changes to this standard since the last issue (A955/A955M – 18a) that may impact the use of this standard. (Approved Nov. 15, 2018.)

*(1)* Revised A2.3.2, A2.4.4, and A2.5.2.
*(2)* Added Note A2.2.

Committee A01 has identified the location of selected changes to this standard since the last issue (A955/A955M – 18) that may impact the use of this standard. (Approved Nov. 1, 2018.)

*(1)* Revised 1.6, 1.7, 21.3.4, Table 3, and Table 4.

Committee A01 has identified the location of selected changes to this standard since the last issue (A955/A955M – 17a) that may impact the use of this standard. (Approved Jan. 1, 2018.)

*(1)* Revised the term 'stainless-steel' to 'stainless steel' throughout.
*(2)* Revised Note 1, added 1.4, and added Annex A5.
*(3)* Removed references A510 and A510M throughout.
*(4)* Replaced reference G15 with G3 throughout.
*(5)* Added reference A484/A484M throughout.
*(6)* Revised 6.3 and 13.1.
*(7)* Added Note A2.1, Note A2.4, Note A3.1, and Note A3.4.
*(8)* Revised A3.3.1 and A3.4.2(*1*) and A3.4.2(*6*).

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019
Downloaded/printed by

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, Tel: (978) 646-2600; http://www.copyright.com/*

Copyright by ASTM Int'l (all rights reserved); Tue Jun 4 13:29:01 EDT 2019 
Downloaded/printed by