Designation: D 3963/D 3963M – 01

Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars[1]

This standard is issued under the fixed designation D 3963/D 3963M; 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 the fabrication and jobsite requirements for deformed and plain steel reinforcing bars with protective epoxy coating applied in accordance with Specification A 775/A 775M.

1.2 This specification is applicable for orders in either SI units (as Specification D 3963M) or inch-pound units (as Specification D 3963).

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound 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 the specification.

1.4 *This standard 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 standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

A 775/A 775M Specification for Epoxy-Coated Reinforcing Steel Bars[2]

B 117 Practice for Operating Salt Spray (Fog) Apparatus[3]

D 374 Test Methods for Thickness of Solid Electrical Insulation[4]

D 2967 Test Method for Edge Coverage of Coating Powders[5]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[6]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[6]

G 20 Test Method for Chemical Resistance of Pipeline Coatings[5]

2.2 *Federal Highway Administration Report*

FHWA-RD-74-18 Nonmetallic Coatings for Concrete Reinforcing Bars[7]

3. Coating Repair Materials

3.1 The patching or repair material shall be compatible with the coating, inert in concrete, and feasible for repairs at the applicator, fabricator, or in the field. This material shall be approved in accordance with Annex A1 prior to use.

3.2 The manufacturer shall specify the method of metal surface preparation, and the patching application procedures to be used in the field.

4. Handling and Identification

4.1 Coated bars shall be transported and handled with care. All systems for handling coated bars shall have padded contact areas. All bundling bands shall be padded, or suitable banding shall be used to prevent damage to the coating. All bundles of coated bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles. The bars or bundles shall not be dropped or dragged.

4.2 The identification (including heat number, mill test results, date and type of coating system used, etc.) of all reinforcing bars shall be maintained throughout the coating and fabrication processes to the point of shipment.

5. Fabrication of Steel Reinforcing Bars After Coating

5.1 The steel reinforcing bars to be fabricated after application of the coating shall meet the requirements of this specification.

5.2 Handling and storage of coated bars at the fabricator's facility shall meet the requirements of Section 4 and 6.3.

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[1] This specification is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.32 on Bridges and Structures.

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[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 03.02.

[4] *Annual Book of ASTM Standards*, Vol 10.01.

[5] *Annual Book of ASTM Standards*, Vol 06.02.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] Available from National Technical Information Service, 5285 Port Royal, Springfield, VA 22161.[5]

5.3 Drive rolls on shear beds, and back-up barrels on benders shall be protected with a suitable covering to minimize damage during the fabrication process.

6. Storage, Handling and Placement at the Jobsite

6.1 The finished, installed coated steel reinforcing bars to be used in the construction shall meet the requirements of this specification.

6.2 All systems for handling the coated bars at the jobsite shall have padded contact areas. Coated bars or bundles shall not be dropped or dragged.

6.3 Coated steel reinforcing bars shall be off-loaded as close as possible to their points of placement or under the crane so that the bars can be hoisted to the area of placement to minimize rehandling.

6.4 Coated bars or bundles shall be stored above the ground on wooden or padded supports with timbers placed between bundles when stacking is necessary. Space the supports sufficiently to prevent sags in the bundles.

6.5 Coated and uncoated steel reinforcing bars shall be stored separately.

6.6 Long-term storage shall be minimized and material delivery scheduled to suit construction progress.

6.7 Coated bars shall be tied with tie wire coated with epoxy, plastic, nylon or other non-conductive material that will not damage or cut the coating.

6.8 Bar supports and spacers shall be coated with or made of a non-conductive material compatible with concrete.

6.9 Placed coated bars shall be covered with opaque polyethylene or other suitable protective material if cumulative environmental exposure of the coated bars, including previous uncovered storage time, of greater than two months prior to concrete embedment is expected. Provisions shall be made for adequate ventilation to minimize condensation under the cover.

NOTE 1—Extended storage of the bars at the job site should be avoided. It is recommended that coated bars be covered immediately upon arrival at the job site.

6.10 After placing, walking on coated steel reinforcing bars shall be minimized. The placement of mobile equipment shall be planned to avoid damage to the coated bars.

NOTE 2—Research has shown that steel-headed vibrators cause damage to epoxy-coated steel reinforcing bars when used to consolidate concrete. When consolidating concrete reinforced with epoxy-coated bars, it is recommended that vibrators with heads made of rubber or other resilient material approved for concrete consolidation be used.

7. Repairs

7.1 *Repair of Damage Incurred During Fabrication*:

7.1.1 All coating damage due to fabrication or handling at the fabricator's facility shall be repaired with patching material meeting the requirements of 3.1. The patching shall be performed in accordance with the written recommendations of the patching material manufacturer.

7.1.2 Visible cracks, including hairline cracks without bond loss (the coating cannot be easily removed with a peeling action by the fingers of the inspector), and damage to the coating within each fabricated area of the reinforcing bar shall be repaired. All disbonded areas of coating shall be removed, cleaned and repaired. The cleaning shall remove loose or deleterious material, or both. In cases where rust is present, the rust shall be removed by a thorough cleaning prior to the repair. This cleaning shall be done by blast cleaning, filing, power brushing or other method recommended by the patching material manufacturer and approved by the purchaser in a manner that minimizes damage to the sound coating.

7.1.3 When coated bars are sheared, saw-cut or cut by other means during the fabrication process, the cut ends shall be patched.

7.1.4 The repairs shall be performed as soon as possible and before visible oxidation appears on the steel surface and prior to shipment to the jobsite.

7.1.5 The fabricator shall be responsible for repair to the coating due to damage during fabrication and handling at the fabricator's facility.

7.2 *Repair of Damage Incurred During Shipment and Handling at the Jobsite*:

7.2.1 Coating damage, visible to a person with normal or corrected vision, incurred during shipment, storage or placement of epoxy-coated bars at the jobsite shall be repaired with patching material meeting the requirements of 3.1.

7.2.2 The contractor shall be responsible for repair to the coating due to damage during shipment, storage, or placement at the jobsite.

7.2.3 The patching shall be performed in accordance with the written recommendations of the patching material manufacturer. The patching material shall be dry to the touch prior to concrete placement.

7.3 The total damaged surface area (prior to repair with patching material), shall not exceed 2 % in any given 0.3 m [1 ft] section of coated reinforcement. The total bar surface area covered by patching material shall not exceed 5 % in any given 0.3 m [1 ft] section of coated reinforcement. This limit on damaged and repaired area shall not include sheared or cut ends.

8. Rejection

8.1 Coated bars that do not meet the requirements of this specification shall be rejected.

9. Field Sampling

9.1 The purchaser or their representative shall have the right to select samples of the coated reinforcement to be used in the project at the jobsite for testing on site or at the purchaser's facility.

10. Keywords

10.1 coating requirements; concrete reinforcement; corrosion resistance; epoxy coating; fabrication repair; field repair; steel bars

ANNEX

(Mandatory Information)

A1. QUALIFICATION OF PATCHING MATERIAL USED TO REPAIR ORGANIC COATINGS FOR STEEL REINFORCING BARS

A1.1 Scope

A1.1.1 This specification covers qualification requirements for patching materials used to repair barrier organic coatings such as epoxy powder coatings used for protecting steel reinforcing bars from corrosion.

A1.2 Coating Patching Material

A1.2.1 A minimum of 0.5 L [1 pt] of patching material, compatible with the coating and inert in concrete, shall be submitted to the testing agency. The material shall be feasible for repairs to the coated reinforcing bars damaged by handling. The product name and a description of the patching material shall be given in the test report. A complete list of powder coating materials (product names and manufacturers) for which the patching material has been approved for use with shall be provided and included in the test report.

A1.3 Test Specimens

A1.3.1 The following test specimens shall be submitted as a minimum for test:

A1.3.1.1 Four free films of coating patching material with a thickness within ± 25 µm [± 1 mil] of the patching material manufacturer's minimum recommended patching material coating application thickness.

A1.3.1.2 Six 75 by 150 mm [3 by 6 in.] by 3 mm [1/8 in.] flat panels that have been blast cleaned and coated on both sides with 175 to 300 µm [7 to 12 mils] of epoxy powder coating in accordance with the powder coating manufacturer's written instructions. The hanger marks on the panels shall be sealed with silicone or other suitable sealant.

A1.3.2 A description of the sample preparation process for the free films and flat panel samples (for example, the number of coats of patch material applied to the intentional coating defect to achieve the minimum required coating thickness), used in this prequalification evaluation shall be provided in the test report. The patching material manufacturer shall specify the minimum recommended patching material coating application thickness to be used. In addition, the patching material manufacturer shall specify the method of metal surface preparation and the patching application procedures. These procedures and minimum thickness shall be followed by the testing agency to prepare the coated metal specimens for test and shall be listed in the test report.

A1.4 Patching Material Requirements

A1.4.1 *Chloride Permeability*—The chloride permeability characteristics of the patching material shall be measured on two test films and a control film at 24 ± 2°C [75 ± 3.6°F] for 45 days. The permeability cells shall be of the type shown in Fig. 1. Films selected for testing shall be carefully handled and examined for any defects prior to installation in the cell. The cell shall consist of two glass compartments separated by a coating film sandwiched between two glass plates, each having a centered 25-mm [1-in.] hole. One compartment shall contain 175 mL [5.3 oz.] of 3M NaCl and the other 115 mL [3.5 oz] of distilled water. The activity of chloride ions passing through the film shall be measured using a specific ion meter equipped with a chloride electrode and a double junction electrode. Activity measurements shall be converted into concentration values of mole per L [M] with a conversion diagram, constructed by plotting measured chloride ion activities versus known chloride ion concentrations. The accumulative concentration of chloride ions permeating through the film shall be less than $1 \times 10^4 M$.

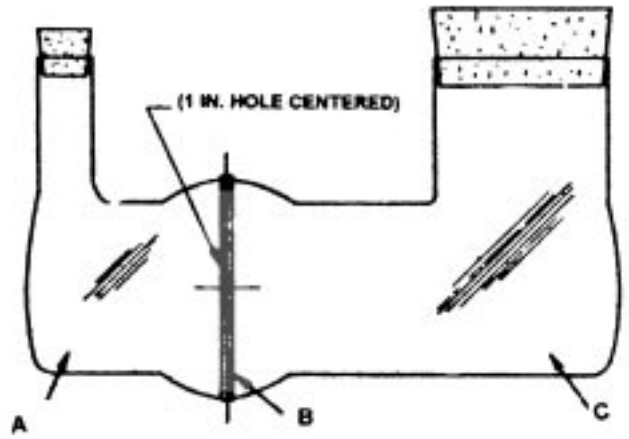

FIG. 1 Chloride Permeability Test Equipment Configuration

Permeability Cell Components
A = Compartment containing distilled water.
B = Epoxy film sandwiched between two glass plates, each having centered one-inch diameter holes.
C = Component containing 3M NaCl.

A1.4.2 *Salt Spray Resistance*—The resistance of the patching material to a hot, wet corrosive environment shall be evaluated in accordance with Practice B 117. Three coated 75 by 150 mm [3 by 6 in.] by 3 mm [1/8 in.] flat panels, with intentional defects repaired with the patching material, shall be exposed to 35 ± 2°C [95 ± 3.6°F] salt spray comprised of 5% NaCl by mass dissolved in distilled water for 400 ± 10 h. Each intentional defect shall be an area of 12 by 25 mm [½ by 1 in.] removed from the center of one side of the coated panel using a grinding wheel or other suitable method. Dust and loose material shall be removed from the intentional defect site with a clean cloth after the coating's removal. The patching material shall be prepared for application in accordance with the written instructions of the patching material manufacturer. The patching material shall be applied with a new paint brush to the

intentional defect to form a patched area of 25 by 37 mm [1 by 1.5 in.] fully covering the intentional defect. The coated panel shall be lying flat on a table during the patching material application and shall remain in such a position until the coating has cured according to the manufacturer's instructions. The patching operation and the patched panels shall be maintained at a temperature of 24 ± 2°C [75 ± 3.6°F]. The patched area coating thickness shall be within ± 25 µm [± 1 mil] of the patching material manufacturer's minimum recommended patching material coating application thickness. The patched panels shall be allowed to cure for a minimum of three days before placement in the salt spray apparatus. Upon examination after completion of the test, the patched areas on each of the three coated panels shall not be observed to have formed blisters nor have developed areas of rust from holes in the patch itself or from the patching material interface with the coated panel.

A1.4.3 *Chemical Resistance*—The ability of the patching material to resist blistering and corrosion in a solution that simulates concrete pore solution shall be evaluated in accordance with Test Method G 20. Three coated 75 by 150 mm [3 by 6 in.] by 3 mm [1/8 in.] flat panels, with intentional defects repaired with the patching material, shall be immersed in an aqueous solution containing 0.3 *N* KOH and 0.05 *N* NaOH at 55 ± 2°C [132 ± 3.6°F] for 28 days. Each intentional defect shall be an area of 12 by 25 mm [1/2 by 1 in.] removed from the center of one side of the coated panel using a grinding wheel or other suitable method. Dust and loose material shall be removed from the intentional defect site with a clean cloth after the coating's removal. The patching material shall be prepared for application in accordance with the written instructions of the patching material manufacturer. The patching material shall be applied with a new paint brush to the intentional defect to form a patched area of 25 by 37 mm [1 by 1.5 in.] fully covering the intentional defect. The coated panel shall be lying flat on a table during the patching material application and shall remain in such a position until the coating has cured according to the manufacturer's instructions. The patching operation and the patched panels shall be maintained at a temperature of 24 ± 2°C [75 ± 3.6°F]. The patched area coating thickness shall be within ± 25 µm [± 1 mil] of the patching material manufacturer's minimum recommended patching material coating application thickness. The patched panels shall be allowed to cure for a minimum of three days before placement in the simulated concrete pore solution. Upon examination after completion of the test, the patched areas on each of the three coated panels shall not be observed to have formed blisters nor have developed areas of rust from holes in the patch itself or from the patching material interface with the coated panel.

A1.4.4 *Edge Coverage*:

A1.4.4.1 Four precision-finished 13 by 13 by 50 mm [½ by ½ by 2 in.] steel bars, as described in D 2967 section 6.4, with edges having a radius of no more than 0.13 mm [0.005 in.] shall be prepared for the test procedure. The test pieces shall be inspected with a 10x microscope or magnifying glass prior to use to determine that all edges are of the proper sharpness and free from nicks and burrs. The test pieces shall be cleaned in a suitable solvent to remove all oil, grease and foreign matter. The test pieces shall then be air-dried.

A1.4.4.2 A 25-mm [1-in.] micrometer caliper, in accordance with Method C of Test Methods D 374, or other suitable instrument, shall be used to make thickness measurements. Measure and record the distance across both diagonals of each of the four test bars to the nearest 2.5 µm [0.1 mils] at a point 38 mm [1.5 in.] from the end of the specimen to be left uncoated (the top end). Average each uncoated bar's diagonal measurements.

A1.4.4.3 Approximately 0.25 L [0.24 qt] of the patching material shall be prepared in a suitable container in accordance with the written instructions of the patching material manufacturer. The test pieces shall be dipped 25 ± 2 mm [1 ± 0.08 in.] into the patching material for approximately 2 seconds, removed, and allowed to hang undisturbed vertically until the coating is fully cured according to the manufacturer's instructions. The patching material application operation and the patched test pieces shall be maintained at a temperature of 24 ± 2°C [75 ± 3.6°F].

A1.4.4.4 Again measure and record the distance across both diagonals of each of the four now coated test bars to the nearest 2.5 µm [0.1 mils] at the same point 38 mm [1.5 in.] from the uncoated end of the specimen.

A1.4.4.5 Average the distance measurements across the two diagonals of the coated test bars. Subtract the average diagonal measurement of each uncoated bar from that of each coated bar and divide by two (2) to obtain the average edge thickness.

A1.4.4.6 The average of the four averaged edge coating thickness measurements from the four test specimens shall be greater than or equal to the patching material manufacturer's minimum recommended patching material coating application thickness.

A1.4.5 *Precision and Bias*:

A1.4.5.1 *Interlaboratory Test Program*—An interlaboratory study was run in 1999 in which the edge coverage test of A1.4.4, for qualification of patching materials used to repair epoxy-coated steel reinforcing bar, was evaluated. Six laboratories each tested five test specimens using the same lot of patching material. Except for the use of one patching material, Practice E 691 was followed for the design and analysis of the data.[8]

A1.4.5.2 *Test Results*—The precision information given below for average edge coating thickness in percentage points is for the comparison of five test results, each of which is the average of two test determinations.

A1.4.5.3 *Precision*:

95c% repeatability limit (within laboratory)	16.6 %
95 % reproducibility (between laboratories)	12.7 %

A1.4.5.4 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E 177. The respective standard deviations among test results, related to the above numbers by the factor 2.8 are:

repeatability standard deviation	5.9 %
reproducibility standard deviation	4.5 %

[8] Details available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Request RR: D04-1015.

A1.4.5.5 *Bias*—This method has no bias because edge coverage is defined only in terms of this test method.

A1.4.6 *Testing Agency*— Acceptance tests shall be performed by an agency acceptable to the purchaser.