Standard Method of Test
for

Testing Epoxy Resin Adhesive

AASHTO DESIGNATION: T 237-73 (1996)

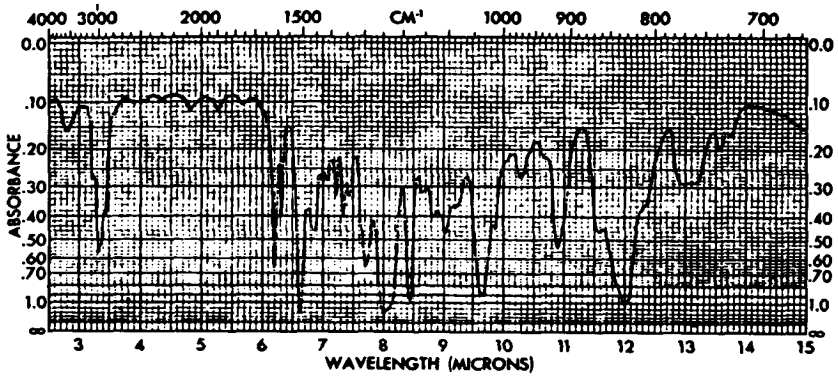
1. SCOPE

1.1 The methods given cover the examination of epoxy resin adhesives for use in bonding traffic markers to pavements, cured concrete to cured concrete, fresh concrete to cured concrete, and are divided into two parts:

1.2 Part I (Sections 2 through 22) covers AASHTO M 235, Class I and II, and AASHTO M 237, Class I adhesives.

1.3 Part II (Sections 23 through 32) covers AASHTO M 235, Class III and AASHTO M 237, Class II adhesives.

1.4 The values stated in SI units are to be regarded as the standard.



A Component

EPOXY ADHESIVE FOR BONDING TRAFFIC MARKERS TO CURED CONCRETE, AASHTO M237—CLASS I
EPOXY ADHESIVE FOR BONDING CURED TO CURED CONCRETE, AASHATO M 235—CLASS II
EPOXY ADHESIVE FOR BONDING FRESH TO CURED CONCRETE, AASHTO M 235—CLASS I

PART I

Pot Life

2. APPARATUS AND MATERIALS

2.1 Unwaxed paper cups, 240 mL (8 oz), 50 ± 6-mm (2 ± $^1/_4$-in.) diameter base.

2.2 Unwaxed paper cups, 60 mL (2 oz), 38-mm ($1^1/_2$-in.) diameter base.

2.3 Wooden tongue depressor with ends cut square.

2.4 Stainless steel spatula with blade 150 by 25 mm (6 × 1 in.), and with the end cut square.

3. PROCEDURE

3.1 Condition both A and B components to 25 ± 1°C (77 ± 2°F).

3.2 Stir the separate components vigorously with a spatula to redisperse any settled material. Use separate spatula for each component.

3.3 Using the 60-mL cups, measure each component, in the proper ratio, into the 240-mL cup.

3.4 Start stopwatch immediately and mix the components for 60 seconds using a wooden tongue depressor and taking care to scrape the sides and bottom of cup periodically.

3.5 Place the sample at 25 ± 1°C (77 ± 2°F) on a wooden bench top which is free of excessive drafts.

3.6 Probe the mixture once with the tongue depressor every 30 seconds, starting 5 minutes prior to the minimum specified pot life.

3.7 The time at which a soft stringy mass forms in the center of the cup is the pot life.

INFRARED SPECTRUM

4. APPARATUS

4.1 Double-beam infrared recording spectrophotometer,[1] 2.5 microns to 15 microns.

4.2 Disk holder for a disk approximately 25 mm in diameter.

4.3 Two sodium chloride crystal disks approximately 25 mm in diameter.

4.4 Superspeed centrifuge able to separate the liquid and solid phases of the adhesive components without previous dilution with solvents.[2]

[1] The Perkin-Elmer Model 137-B Infracord Spectrophotometer has been found satisfactory.

[2] The Sorvall SS-3 Automatic Superspeed Centrifuge has been found satisfactory.

5. PROCEDURE

5.1 Place about 15 g of component A into a stainless steel centrifugal tube.

5.2 Counterbalance with component B in a second centrifuge tube.

5.3 Centrifuge the two components until there is a supernatant liquid layer present in each tube. This takes 20 to 30 minutes at 17000 r/min.

5.4 Place a drop of component A liquid layer on a sodium chloride disk.

5.4.1 Place another sodium chloride disk over the drop, rotate and press down until the liquid has flowed into a uniform layer of proper thickness between the two sodium chloride disks.

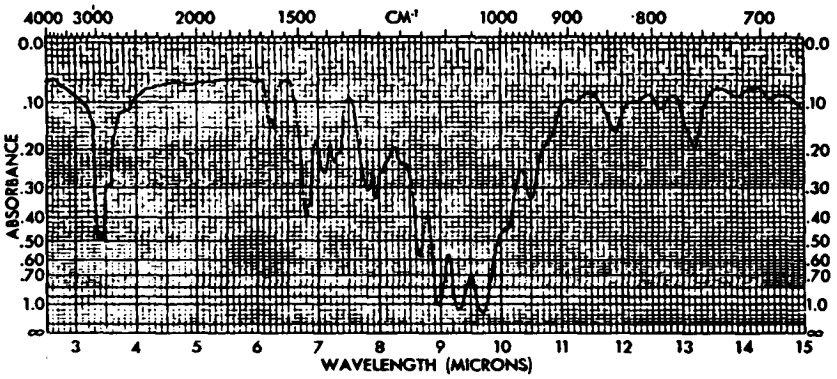
5.4.2 Place the disks in the holder and run an absorption curve with the infrared spectrophotometer.

5.4.2.1 More or less liquid may be used between the disks so as to produce a maximum absorption of 0.7 to 1.0 for the strongest absorption point on the curve.

5.4.3 Clean the disks with toluene and dry.

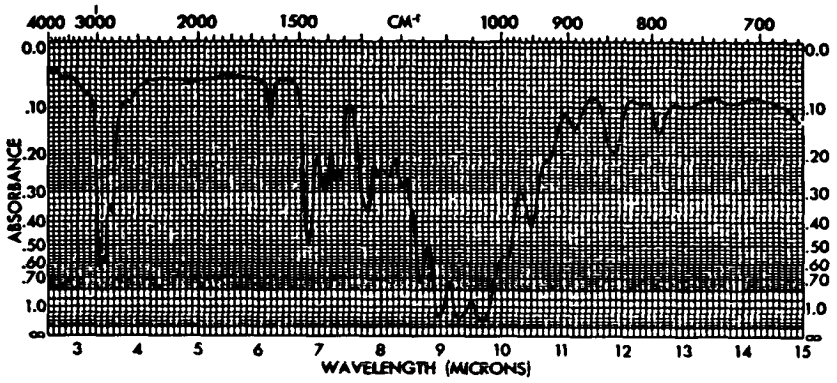
5.4.4 Repeat steps in Sections 5.4 through 5.4.3 with the liquid layer from component B.

5.5 Compare each curve with the appended absorption curves for standard materials. Two materials are considered to be identical if all of the absorption points agree as to wave length and relative magnitude of the peaks in comparison with the other points of absorption.



B Component

EPOXY ADHESIVE FOR BONDING FRESH TO CURED CONCRETE, AASHTO M 235—CLASS I



B Component

EPOXY ADHESIVE FOR BONDING CURED TO CURED CONCRETE, AASHTO M 235—CLASS II

DENSITY

6. APPARATUS AND PROCEDURE

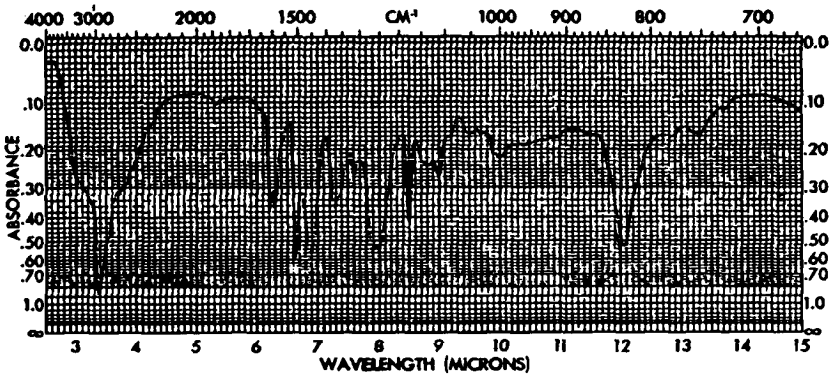
6.1 Follow Federal Test Method Standard No. 141, Method 4184.

BROOKFIELD VISCOSITY

7. APPARATUS AND MATERIALS

7.1 Brookfield Syncro-Electric Viscometer, Model RVT, Brookfield Engineering Laboratories, Stroughton, Massachusetts.

7.2 Brookfield Helipath Stand,



B Component

EPOXY ADHESIVE FOR BONDING TRAFFIC MARKERS TO CURED CONCRETE, AASHTO M 237—CLASS I

Model C, with TD spindle and spindle weight.

7.3 Round 475-mL (one-pint) paint cans.

7.4 Stainless steel spatula having a blade 150 by 25 mm (6 by 1 in.) with the end cut square.

8. PROCEDURE

8.1 Fill a 475-mL (one-pint) can within 25 mm (1 in.) of the top with well-mixed component A.

8.2 Condition the material to 25°C (77°F).

8.3 Stir the material vigorously for 30 seconds with a spatula.

8.4 Remove entrained air bubbles by vigorous tapping.

8.5 Insert the spindle and make a viscosity reading at 5 r/min within 10 minutes after stirring.

8.5.1 Make additional readings at 2.5 r/min and 0.5 r/min for use in the Shear Ratio Test (Section 22).

8.6 Repeat to determine viscosity of component B.

9. CALCULATION

9.1 Follow manufacturer's instructions for calculating Brookfield Viscosity.

SAG TEST

10. APPARATUS AND MATERIALS

10.1 Stiff glazed paper 254 by 139 mm (10 by $5^1/_2$ in.).[3]

10.2 Clipboard.

10.3 Metal shims 0.76 ± 0.03 mm (0.030 ± 0.001 in.) thick approximately 25 mm by 250 mm (1 by 10 in.).

10.4 Doctor blade.

[3] Form 2A—Opacity obtained from The Leneta Company, P.O. Box 576, Ho Ho Kus, New Jersey 07428, has proven satisfactory.

11. PROCEDURE

11.1 Place the paper on the clipboard with glazed surface up.

11.2 Place two pieces of metal shim stock on top of the glazed paper so as to produce a space 230 mm long by 64 mm wide (9 by $2^1/_2$ in.). Use the clip to hold the shim stock and chart in place.

11.3 Condition both A and B components to 25°C (77°F).

11.4 Stir the components vigorously for 30 seconds with a spatula.

11.5 Mix for 30 seconds sufficient material in the specified ratio of component A to component B and immediately apply the mixed material to the glazed paper between the shim material.

11.6 Draw the doctor blade over the surface to produce a film 64 mm ($2^1/_2$ in.) wide by 152 mm (6 in.) long, 0.76 ± 0.10 mm (0.03 ± 0.004 in.) thick.

11.7 Release the clip and carefully remove the shims by lifting them upward while holding the glazed paper down.

11.8 Support the paper vertically with the 152 mm (6 in.) side of the strip in a horizontal position.

11.9 After 30 minutes record the sag to the nearest 2.5 mm (0.1 in.).

BOND STRENGTH TO CONCRETE

12. APPARATUS AND MATERIALS

12.1 Stop watch, 1 second or smaller divisions.

12.2 A sandblasted 50 mm (2 in.) diameter steel or aluminum plug approximately 50 mm (2 in.) long, drilled, and threaded on one end to accept a threaded steel rod or hook for insertion into the testing press or apparatus.[4]

12.3 A sandblasted concrete block 305 mm (12 in.) square by 75 mm (3 in.) thick prepared with 390 kg/m^3 (7 sack) concrete and having a tensile strength in excess of 1725 kPa (250 psi).

12.4 Testing press operating at a load rate of 22.2 kN/min (5000 lbs/min.). Alternately, a maximum indicating dynamometer fitted with 25 mm (1 in.) eyes and mounted in a housing allowing application of an upward vertical pull may be used.

[4] Other diameter plugs may be used. However, use of the specified diameter simplifies calculations.

13. PROCEDURE

13.1 Condition the test equipment, materials and epoxy components for 24 hours at the testing temperature specified.

13.2 Stir the separate components vigorously for 30 seconds.

13.3 Measure the components in the proper ratio onto a tin plate and mix with a spatula for 60 ± 5 seconds.

13.4 Place the adhesive on the sandblasted surface of the plug and concrete surface.

13.5 Press the plug firmly in place and remove the excess adhesive.

13.6 Just before the required test time insert the threaded rod or hook into the plug.

13.7 Apply loading at the specified rate until failure and record the maximum load attained before failure.

13.8 Calculate the Bond Strength to concrete attained before failure as follows:

$$\text{Bond Strength, kPa (psi)} \frac{TL}{A}$$

where:

TL = Total load in newtons (lbf), and
A = Area of bond m^2 (in.^{2}).

TENSILE ADHESION AND COHESION

14. APPARATUS AND MATERIALS

14.1 Use the testing apparatus described in Section 12.

14.2 Cold box capable of maintaining −9.5 ± 1.0°C (15 ± 2°F).

14.3 Oven capable of maintaining 60 ± 1°C (140 ± 2°F).

14.4 As specimens, use pavement markers representative of those intended for installation.

15. PROCEDURE

15.1 Stir the separate components vigorously for 30 seconds.

15.2 Measure the components in the proper ratio onto a tin plate and mix with a trowel or spatula for 60 ± 5 seconds.

15.3 Place the adhesive on the plug and the marker surface.

15.4 Press the plug firmly in place and remove excess adhesive.

15.5 Cure all specimens for 24 hours at 25 ± 1°C (77 ± 2°F).

15.6 Proceed according to Sections 13.6 to 13.8.

15.7 Post cure at least one of the specimens further as follows:

15.7.1 48 h at 60°C (140°F).

15.7.2 Return to 25°C and then place in cold box for 24 hours at −9.5°C (15°F).

15.7.3 Return to 25°C and test as in Section 15.6 above.

SLANT SHEAR STRENGTH

16. MATERIALS

16.1 C 109 graded Standard (Ottawa) Sand conforming with Section 3, T 106, Compressive Strength of Hydraulic Cement Mortars.

16.2 Type II portland cement conforming with M 85.

16.3 Water.

17. APPARATUS

17.1 Suitable mold to make diagonal concrete mortar blocks with a square base with 50.8 mm (2 in.) sides and having one diagonal face 50.8 by 101.6 mm (2 in. × 4 in.) standing about 19 mm ($^3/_4$ in.) above the base. After sandblasting, the diagonal faces of two such blocks are bonded together, producing a block 50.8 by 50.8 by 127 mm (2 in. × 2 in. × 5 in.).

17.2 Test blocks are made from the following composition in parts-by-mass.

Standard	20.1
Portland Cement	12.1
Water	4.8

17.3 Suitable testing press.

18. PROCEDURE

18.1 Mix adhesive as described in Section 13.2 and apply a coat to each diagonal surface. Press diagonal surfaces of each block together by hand and remove excess adhesive.

18.2 Align the blocks so that the ends and sides are square and form a block 50.8 by 50.8 mm by 127 mm (2 in. × 2 in. × 5 in.). Use blocks of wood or metal against each end to keep diagonal faces from slipping.

18.3 After the required cure time as specified, apply a suitable capping compound to each end and test by applying a compression load at the rate of 22.2 kN/minute (5000 lbf/minute) until failure.

18.4 For wet shear strength, bond another set of blocks together as described above. Cure 24 hours at 25 ± 1°C (77 ± 2°F) and immerse in water 7 days at 25 ± 1°C (77 ± 2°F), remove and immediately test as described above in Section 18.3.

19. CALCULATIONS

19.1 Calculate the test value of kPa (psi) using the 50.8 by 50.8 mm (2 by 2 in.) dimensions to calculate specimen area:

$$\text{Stress, kPa (psi)} = \frac{TL}{A}$$

where:

TL = Total load in newtons (pounds force) and
A = End area of specimen.

SHEAR RATIO

20. APPARATUS AND MATERIALS

20.1 Same as Section 7.

21. PROCEDURE

21.1 Same as Section 8.

22. CALCULATIONS

22.1 Shear Ratio = (Viscosity in Pa·s (Centipoise) at 0.5 r/min.)/(viscosity in Pa·s (Centipoise) at 2.5 r/min.).

PART II

23. PREPARATION OF SAMPLE

23.1 For all tests on the mixed adhesive, the two components shall be proportioned by mass. The gallon mass of each component shall be determined by Federal Test Standard No. 141, Method 4184. The mass ratio of the components shall be calculated using the gallon masses and the proper volume ratio.

24. CONSISTENCY

24.1 A minimum sample of 475 mL (1 pint) of the mixed adhesive shall be used for viscosity determinations.

24.2 ASTM D 1084, Viscosity of Adhesives, Method B, using a speed of 20 r/min. Initial temperature of samples shall be 25 ± 0.5°C (77 ± 1°F). In the case of marker adhesives, the spindle shall be allowed to rotate for 2 minutes before taking a reading. For the concrete adhesives, a total of 400 g (0.88 lb) of the components shall be weighed into a pint can and stirred together for 5 minutes before determining viscosity. Allow spindle to rotate for 30 seconds before taking reading.

25. POT LIFE

25.1 The initial temperature of the adhesive components and the ambient temperature shall be 25 ± 1°C (77 ± 2°F) for this test. A total of 100 g (0.22 lb) of the adhesive shall be weighed into a 180-mL (6-oz) metal ointment can approximately 70 mm (2.75 in.) in diameter, the time recorded and the two components mixed for 3 minutes with a non-reactive spatula. The sides and bottom of the container should be scraped periodically during the mixing. The container shall then be set on a wooden block and probed with a glass stirring rod. For Type I and I-M through III

and III-M marker adhesives, probe every minute starting 5 minutes from the initiation of mixing. For Type IV and IV-M marker adhesive and the concrete adhesives, probe every 2 minutes, starting 16 minutes from the initiation of mixing. In all cases, the time at which the material becomes unworkable or begins to solidify is recorded as the pot life.

26. SET TIME

26.1 The ambient temperature and the initial temperature of the individual components used in this test shall be either 4.4 ± 1.0°C or 25 ± 1°C (40 ± 2 or 77 ± 2°F).

26.2 Cement mortar briquettes shall be prepared according to 132 (Tensile Strength of Hydraulic Cement Mortars) using Type III cement complying with M 85 and sand complying with M 6 (Fine Aggregate for Portland Cement Concrete). The briquettes shall be cured for a minimum of 7 days and then sawed at the center line perpendicular to the long axis. A diamond tooth saw or other cutting tool capable of producing clean smooth faces on the briquette halves shall be used. The halves shall be allowed to dry before use. Approximately 50 g of the adhesive shall be mixed with a spatula in a 180-mL (6-oz) non-reactive container for 3 minutes. The cut faces of the briquettes shall then be coated with the adhesive and put together with light pressure. The excess adhesive shall be removed from the edges of the bonded area and the briquettes allowed to remain undisturbed until time for testing. No more than 10 minutes after mixing shall elapse during preparation and bonding of the briquettes. A minimum of three briquettes shall be prepared. The briquettes shall be subjected to tensile loading with the Riehle briquette tester and the load at failure recorded.

26.3 This test shall be performed at the specified maximum set time and must yield an average strength of 1240 kPa (180 psi).

27. THIXOTROPY

27.1 This test shall be performed with the initial temperature of the adhesive and materials used in the test at 25 ± 1°C (77 ± 2°F) and also at 49 ± 1.5°C (120 ± 3°F).

27.2 The two components of the epoxy adhesive shall be stirred together for at least one, but not more than 2 minutes and then applied to a smooth, clean steel plate to form a panel of epoxy material 50 mm (2 in.) wide, 100 mm (4 in.) in length, and 2.5 mm (or 100 mL) in thickness. A removable form of the proper dimensions shall be used in placing the epoxy on the steel plate. The epoxy shall be poured into the form and the excess struck off level with the top edge and then the form removed. Immediately after forming the epoxy adhesive the steel panel shall be placed so that the 100-mm (4-in.) dimension of the epoxy panel is vertical. For thixotropy at 25°C (77°F), the panel shall be placed in a room maintained at 25 ± 1°C (77 ± 2°F). For thixotropy at 49°C (120°F), the panel shall be placed in an oven maintained at 49 ± 1.5°C (120 ± 3°F). Not more than 4 minutes shall elapse between the initiation of mixing and placing the panel in the vertical position. After the adhesive has hardened, draw two lines parallel with the 100-mm (4-in.) dimension 13 mm (0.5 in.) from each edge of the epoxy and four lines parallel to the 50 mm (2 in.) dimension spaced 25 mm (1 in.) apart beginning 13 mm (0.5 in.) from the top edge of the panel. Measure the combined thickness of the panel and epoxy adhesive remaining within the original 50 by 100 mm (2 by 4 in.) area by averaging the eight readings and subtracting the thickness of the steel plate.

28. ADHESIVE SHEAR STRENGTH

28.1 The adhesive shear strength is to be determined in accordance with ASTM D 1002, Strength Properties of Adhesives in Shear and Tension Loading—Metal to Metal. Steel specimens shall be used. The surfaces of the test specimens used in the adhesive shear strength test shall be prepared by blasting to white metal using a 6.4-mm ($^1/_4$-in.) diameter nozzle and a gun pressure of 345 to 565 kPa (50 to 75 psi). The abrasive used shall be equivalent to Garnet Blasting Abrasive, 250 μm (60 mesh), manufactured by Idaho Garnet Abrasive Company, Kellogg, Idaho. The specimens shall be cured 7 days at 24 ± 3°C (75 ± 5°F).

29. WATER GAIN

29.1 The water gain (24 h emerged at 23°C) shall be determined in accordance with ASTM D 570, Water Absorption of Plastics, with the following modifications. The specimens shall be prepared by casting disks of the epoxy adhesive 70 mm ($2^3/_4$ in.) in diameter and approximately 10 mm ($^3/_8$ in.) thick. Prior to testing, the plane surfaces of the disks shall be ground or machined flat and parallel. The machining or grinding must be done in such a way as to not heat the disks above 48.9°C (120°F). The thickness of the disks after preparing the surfaces shall be 7.6 ± 0.5 mm (0.30 ± 0.02 in.). The specimens shall be cured 7 days at 24 ± 3°C (75 ± 5°F).

30. IMPACT STRENGTH

30.1 The ambient temperature and temperature of equipment shall be 24 ± 3°C (75 ± 5°F). The specimens shall be prepared as outlined in *Water Gain*. The specimens shall be cured 7 days at 24 ± 3°C (75 ± 5°F) before testing. The specimens shall be placed on a smooth concrete slab or a smooth steel plate at least 13 mm ($^1/_2$ in.) thick firmly attached to a concrete slab. A 454-gm (1 lb) steel ball shall be dropped onto the center of the disks from an initial height of 1.5 m (5 ft). The height shall be increased by 0.150 m ($^1/_2$ ft) for each successive drop until the specimen fails by cracking or shattering. The height of drop at which failure occurs shall be recorded as the impact strength in joules (foot-pounds). A minimum of four specimens shall be tested and the average reported to the nearest 0.68 J ($^1/_2$ foot-pound).

31. BONDING OF FRESH PORTLAND CEMENT CONCRETE TO CURED PORTLAND CEMENT CONCRETE

31.1 Approximately 50 grams of the adhesive shall be mixed with a spatula

in a non-reactive container for 3 minutes. The adhesive shall then be applied to the cut faces of briquette halves prepared as described in Section 26.2, *Set Time*. After the adhesive has become tacky, new mortar prepared as described in the Set Time determination shall be molded against it to form a complete briquette. The resulting briquettes shall be cured according to the method set forth in T 132 and then subjected to tensile loading with a briquette tester after 7 days cure.

31.2 A minimum of six briquettes shall be tested. If the average strength of the briquettes tested is less than 2755 kPa (400 psi) and any of these briquettes failed in the mortar at strengths below 2755 kPa (400 psi), an additional set of specimens shall be prepared and tested.

32. WET STRENGTH

32.1 A minimum of three specimens shall be prepared as described under Section 26.2, *Set Time*. The bonded briquettes shall be allowed to cure for 1 day at 24 ± 3°C (75 ± 5°F), followed by 2 days in an oven maintained at 49.0 ± 1.5°C (120 ± 3° F). The cured specimens shall be immersed in distilled water maintained at 38.0 ± 1.5°C (100 ± 3°F) for a total of 7 days. The specimens shall then be removed from the bath, placed in water maintained at 23.0 ± 1.5°C (75 ± 3°F) for 60 minutes, then subjected to tensile loading with a briquette tester and the load at failure recorded. If the average strength of the briquettes tested is less than 2070 kPa (300 psi) and any of these briquettes failed in the mortar at strengths below 2070 kPa (300 psi), an additional set of specimens shall be prepared and tested.