



TEST PROCEDURES FOR BRAKE SHOE AND LINING ADHESIVES AND BONDS — SAE J840c

SAE Recommended Practice

Report of Brake Committee approved November 1962 and last revised May 1971.

1. Scope—This SAE Recommended Practice covers equipment and procedures for qualification of bonded brake shoe and lining assemblies and for quality control on materials and processes used in their manufacture.

2. Qualification Tests

2.1 Scope—The following tests cover equipment and procedures used to verify the structural integrity of the brake shoe, adhesive, and brake lining assembly. The Bond Plane Shear Test and either the Dynamometer Test or the Vehicle Abuse Test are used for qualification.

2.2 Bond Plane Shear Test

2.2.1 PURPOSE—The purpose of this test is to provide actual values of lining-to-brake-shoe shear strength by measuring the load required to cause shear failure on complete shoe and lining assemblies, under both ambient and elevated temperature conditions.

2.2.2 EQUIPMENT—The equipment for performing this test consists of a compression test machine of sufficient capacity to shear the lining from the shoe, a fixture which shall provide means to hold the shoe firmly, and a movable ram through which the shear load is applied to the lining. Additional fixture requirements are:

2.2.2.1 Drum Brake Shoes—Fixture (Fig. 1) shall be so designed

that the ram contacts the edge of the lining for its full length and thickness to within 0.005-0.020 in (0.13-0.51 mm) of the shoe table or rim. Load application on the ram shall be in a direction perpendicular to the plane of the shoe web and the shoe shall be supported to maintain uniform loading along the length of the lining.

2.2.2.2 Disc Brake Shoes—Fixture (Fig. 2) shall be so designed that the ram contacts the edge of the lining within 0.005-0.020 in (0.13-0.51 mm) of the shoe and conforms adequately to the lining edge contour to avoid crushing of the lining edge prior to failure. Normally, the ram shall contact the edge parallel to the long axis of the lining; the edge parallel to the short axis may be used if premature crushing of the lining is not incurred.

2.2.3 PROCEDURE

2.2.3.1 Ambient Destructive Shear Test—The brake shoe and lining assembly shall be placed in the shear test fixture and the load shall be applied at a rate of 1000 ± 100 lb (453 ± 48 kg) per second, or 0.40 ± 0.04 in (10 ± 1 mm) per minute after the ram is in contact with the lining edge. Loading shall be continued until failure has occurred. The load at which observable lining movement or complete shear occurs and the shear pattern (paragraph 2.2.5) shall be recorded. Also, a check shall be made for state of cure using the Cotton Tack Test (paragraph 3.2.5).

2.2.3.2 Hot Destructive Shear Test—The brake shoe and lining assembly shall be placed in a heating fixture or oven that will bring the temperature up to the specified value uniformly throughout the bond line within ± 10 F (± 5.5 C). This specified temperature must be reached within 30 min. When the temperature is reached, the shoe

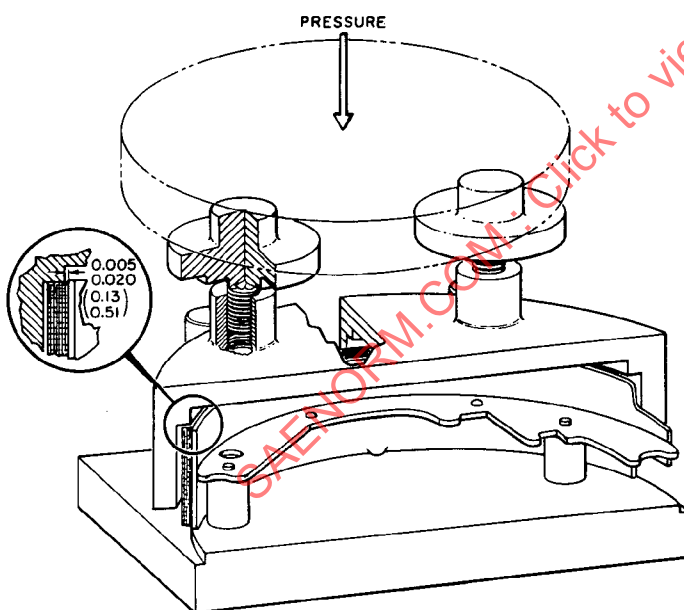


FIG. 1—BOND PLANE SHEAR TEST—DRUM BRAKE

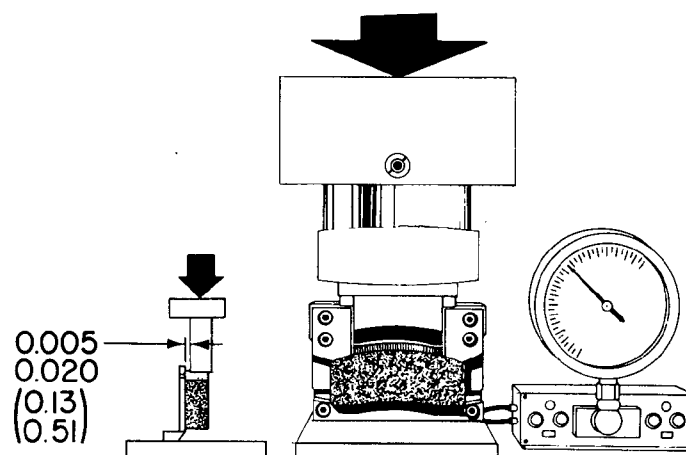
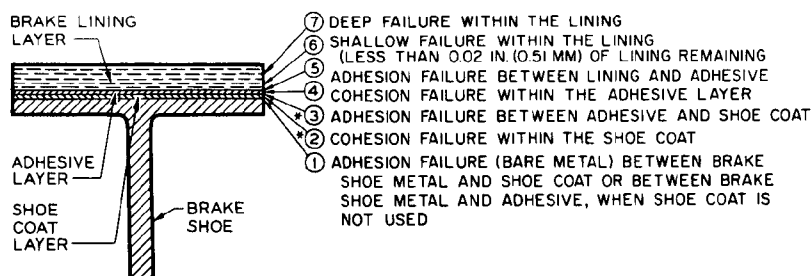


FIG. 2—DISC BRAKE SHEAR TEST FIXTURE



*ELIMINATE WHEN SHOE COAT IS NOT USED.

TO REPORT FRACTURE PATTERN, EXAMINE THE DESTROYED BOND TO DETERMINE EXACTLY WHERE THE FRACTURE TOOK PLACE, IE, BETWEEN THE ADHESIVE AND THE SHOE COAT (3), OR BETWEEN THE LINING AND THE ADHESIVE (5). SHOULD THE EXAMINATION SHOW MORE THAN ONE TYPE OF FRACTURE, REPORT, IN DECREASING ORDER, ALL OF THE DIFFERENT TYPES THAT ARE PRESENT, AND INDICATE THEIR APPROXIMATE PERCENTAGE OF THE TOTAL AREA, IE 60 6, 40 2, OR 50 1, 30 3, 20 4.

FIG. 3—STANDARD METHODS OF BOND FRACTURE

assembly should be placed in the shear test fixture and tested as in paragraph 2.2.3.1. The load at which observable lining movement or complete shear occurs shall be recorded.

NOTE: The heating fixture may be incorporated in the shear test fixture or external to it. If external to it, not more than 15 s should elapse between removal of the shoe assembly from the heating fixture and failure. Temperature of the bond line shall be observed by means of the bond line thermocouple shown in Figs. 4A and 4B.

2.2.3.3 *Resistance to Fluids Test*—This procedure is designed for testing adhesives for resistance to fluids encountered in service, and provides for reporting loss in shear strength after immersion in the test fluids. Individual specimens shall be totally immersed in each test liquid (paragraph 2.2.3.3(a)) in a separate container for 7 days at room temperature. The liquid shall be agitated every 24 h by moderate manual rotation of the container. The individual specimens shall be removed from the containers, blown off or wiped with a clean dry cloth, and tested immediately at room temperature; or, in the event of adverse effect on the lining, longer drying periods may be used. The brake shoe and lining assembly shall be placed in the shear fixture and loaded to destruction at the prescribed loading rate as per paragraph 2.2.3.1.

(a) Immersion Fluids:

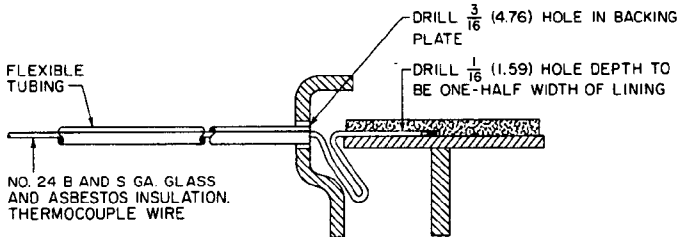


FIG. 4A—DRAWING OF THERMOCOUPLE LOCATION—DRUM BRAKE

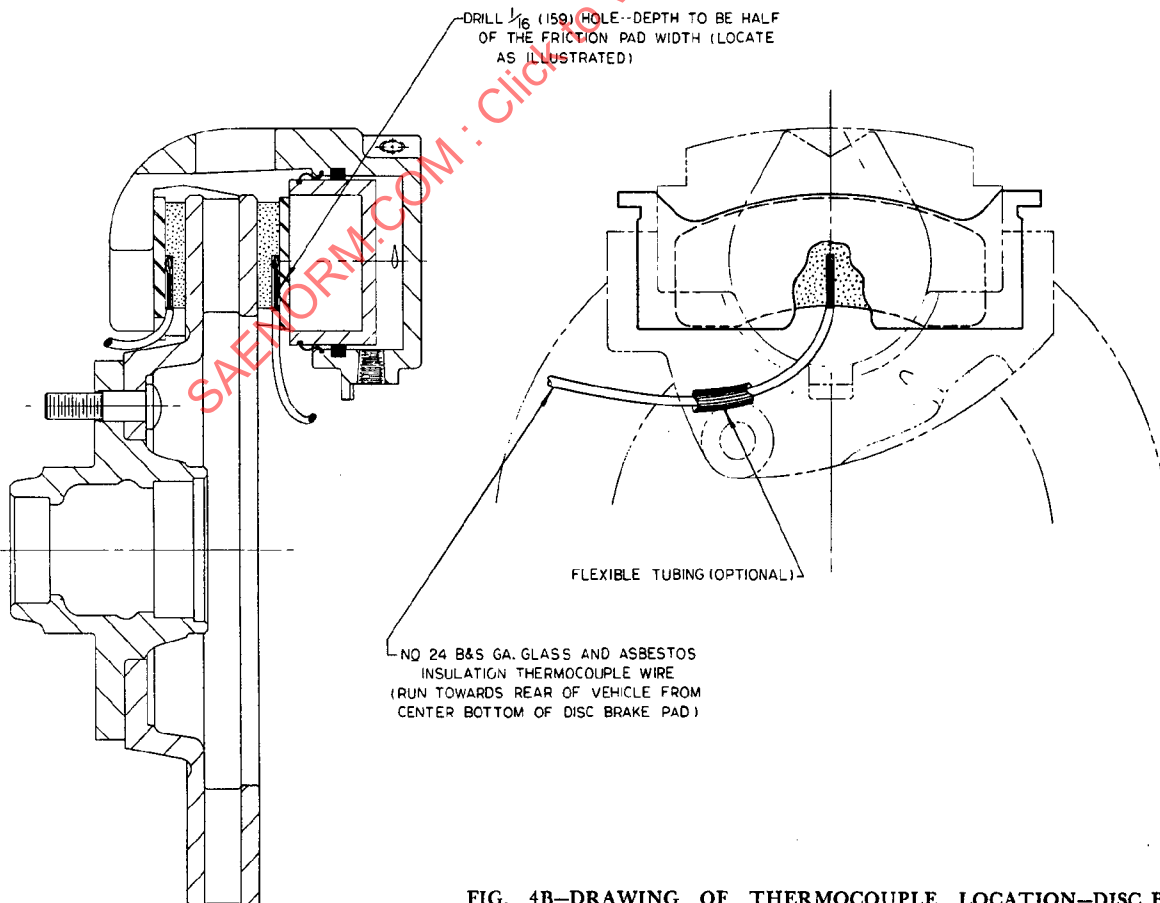


FIG. 4B—DRAWING OF THERMOCOUPLE LOCATION—DISC BRAKE

(1) Reference fuels A and B as specified in ASTM D 471,¹ Tentative Method of Test for Change in Properties of Elastomeric Vulcanizates Resulting from Immersion in Liquids.

(2) ASTM Oil No. 1, as specified in ASTM D 471.

(3) ASTM Oil No. 3, as specified in ASTM D 471.

(4) Calcium chloride 20% solution.

(5) Hypoid oil.

(6) Butyl cellosolve (brake fluid grade).

(7) Tap water.

2.2.4 REPORT

2.2.4.1 *Ambient Destructive Shear Test*

2.2.4.1.1 Record load at which observable movement or complete shear fracture of the lining relative to the shoe occurs.

2.2.4.1.2 Establish and record type of shear fracture pattern. (NOTE: Refer to paragraph 2.2.5.)

2.2.4.1.3 Record results of Cotton Tack Test (paragraph 3.2.5).

2.2.4.2 *Hot Destructive Shear Test*—Record load at which observable movement or complete shear of the lining relative to the shoe occurs.

2.2.4.3 *Resistance to Fluids Test*

2.2.4.3.1 Record load at which observable movement or complete fracture of the lining relative to the shoe occurs.

2.2.4.3.2 Establish and record type of shear fracture.

2.2.4.3.3 Report any visible adverse effects on the adhesive from the immersion fluid.

2.2.5 REPORT, STANDARD METHOD OF REPORTING BOND FRACTURE—Fig. 3 shows the seven possible planes of fracture between the brake lining and the brake shoe. Each of these planes has been assigned a number from 1 to 7. The report should include the type or types of fractures encountered, by indicating the appropriate number from 1 to 7, together with the relative areas of each fracture type expressed as a percentage of the total area in decreasing order. (Example: 60 No. 4, 30 No. 6, 10 No. 7—Note that the percent mark is not used.)

¹Published by American Society for Testing and Materials, 1916 Race St., Philadelphia, Pennsylvania 19103.

2.3 Dynamometer Test—High Temperature Bond Abuse

2.3.1 PURPOSE—The purpose of this test is to determine the effectiveness of the bond of a combination of lining and adhesive when the brake shoe and lining assembly is subjected to high temperature and brake loads, as may be encountered in severe vehicle service reproduced on a dynamometer.

2.3.2 INSTRUMENTATION—The complete brake, assembled with the test set of brake shoes, is mounted in the dynamometer, along with the proper brake drum or rotor. The thermocouple from the bond line of the shoe is connected to the temperature recording instrument. The flywheel loading shall correspond with the work load imposed on the brake as it is used in the specific vehicle. Adjust brake shoe to drum clearance or brake shoe to rotor clearance as recommended by the manufacturer.

2.3.3 PROCEDURE

2.3.3.1 Preparation of Specimens—Sufficient shoes for dynamometer tests shall be prepared. Test shoes and lining assemblies shall be processed over regular production equipment. For the purpose of recording the bond line temperature, drill a $\frac{1}{8}$ in (1.59 mm) diameter hole edgewise in the brake lining and at the bond line to a depth of approximately one-half the lining width, as shown in Fig. 4A for the drum brake or Fig. 4B for the disc brake. The thermocouple must be imbedded in the adhesive layer. When testing a drum brake shoe and lining assembly, locate the hole at approximately the high pressure point of the lining on the shoe which is producing the maximum brake effectiveness and install the thermocouple to the bottom of the hole. For a disc brake shoe and lining assembly, the thermocouple should be located in the bond line at the center of the inboard shoe.

2.3.3.2 Burnish—Turn blower on. Make consecutive stops from a flywheel speed corresponding to 60 mph (96.5 km/h) at an average rate of deceleration of 10 ft/s/s (3.66 m/s/s) allowing the temperature to drop to approximately 200 F (93.5 C) between applications until linings show at least 80% contact.

2.3.3.3 Bond Test, Constant Temperature, 650 F (343.3 C)—Turn blower on at 100 F (37.8 C) below test temperature. Make stops from a flywheel speed corresponding to 70 mph (112.66 km/h) at an average rate of deceleration of 15 ft/s/s (4.57 m/s/s) until the bond line tem-

perature reaches 650 F (343.3 C). Make as many stops as possible, a maximum of 50 or until the lining wears out, at 650 F (343.3 C) at a deceleration rate of 15 ft/s/s. Make applications at time intervals that will result in maintaining the predetermined average temperature throughout the test. If the 15 ft/s/s deceleration rate cannot be maintained, continue the test at the maximum hydraulic line pressure encountered during the previous 15 ft/s/s stops.

2.3.3.4 Bond Test—Ultimate Temperature—Repeat burnish and bond test above except at increased temperature levels in increments of 50 F (27.7 C). Run three tests, each with new samples, at each temperature level until a failure occurs. Bond line temperature at which consistent failures occur in less than 50 stops is considered the ultimate temperature resistance of the adhesive being investigated.

NOTE: This test is generally used as a research evaluation method for adhesive, and is recommended to be used in testing new adhesive formulations to gain comparative values only.

2.3.4 REPORT—Record pertinent data and test results on the form as shown in Fig. 5.

2.4 Vehicle Abuse Test

2.4.1 PURPOSE—The purpose of this test is to determine the effectiveness of the bond for a combination of lining and adhesive when the brake shoes have been subjected to the stresses of shock loading and heat, as may be encountered in severe vehicle service.

2.4.2 EQUIPMENT—The equipment for performing this test shall consist of an appropriate test vehicle modified to receive a thermocouple or thermocouples at the bond line of the brake shoe and lining assembly, a thermocouple or thermocouples, and a pyrometer.

2.4.3 PROCEDURE

2.4.3.1 Select and prepare brake shoe and lining assemblies as in paragraph 2.3.3.1 except that in testing a disc brake shoe and lining assembly, the lining should be ground to 0.100 in (2.54 mm) in thickness before installation to accelerate the heat transfer to the bond line.

2.4.3.2 A complete test for bonded brake shoe and lining assembly shall consist of:

2.4.3.2.1 Shock Test—Cold

2.4.3.2.2 Heat Test

DYNAMOMETER TEST OF BONDED SHOE AND LINING ASSEMBLIES									
GENERAL									
TEST NUMBER _____		PURPOSE _____		DATE _____					
BRAKE TYPE _____		SIZE _____		WHEEL CYLINDER DIAMETER _____					
ADHESIVE									
SOURCE _____		COMPOUND _____		BATCH NO. _____					
LINING									
SOURCE— FIRST OR FORWARD DRUM SHOE OR OUTER DISC SHOE COMPOUND IDENT. _____									
(strike out one)									
SOURCE— SECOND OR REVERSE DRUM SHOE OR INNER DISC SHOE COMPOUND IDENT. _____									
(strike out one)									
DRUM OR DISC (strike out one)									
SOURCE _____		TYPE _____		PART NO. _____					
SAMPLE PREPARATION									
ADHESIVE PATTERN _____		TYPE _____		PART NO. _____					
ROOM TEMP. DRY TIME _____		FORCE DRY TIME _____ F (_____ C)							
BOND CURE _____ MINUTES AT _____ F (_____ C)		AT APPROX. _____ PSI (_____ KG/CM ²)							
DYNAMOMETER FLYWHEEL EQUIVALENT OF _____ FT-LB K.E. AT _____ MPH (_____ KG-M AT _____ KM/HR)									
TEST NO.	BURNISH				BOND TEST				REMARKS
	SPEED	DECEL.	TEMP. MIN	STOPS	SPEED	DECEL.	TEST TEMP. AVERAGE	STOPS	
1									
2									
3									
4									
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FIG. 5—DYNAMOMETER TEST REPORT

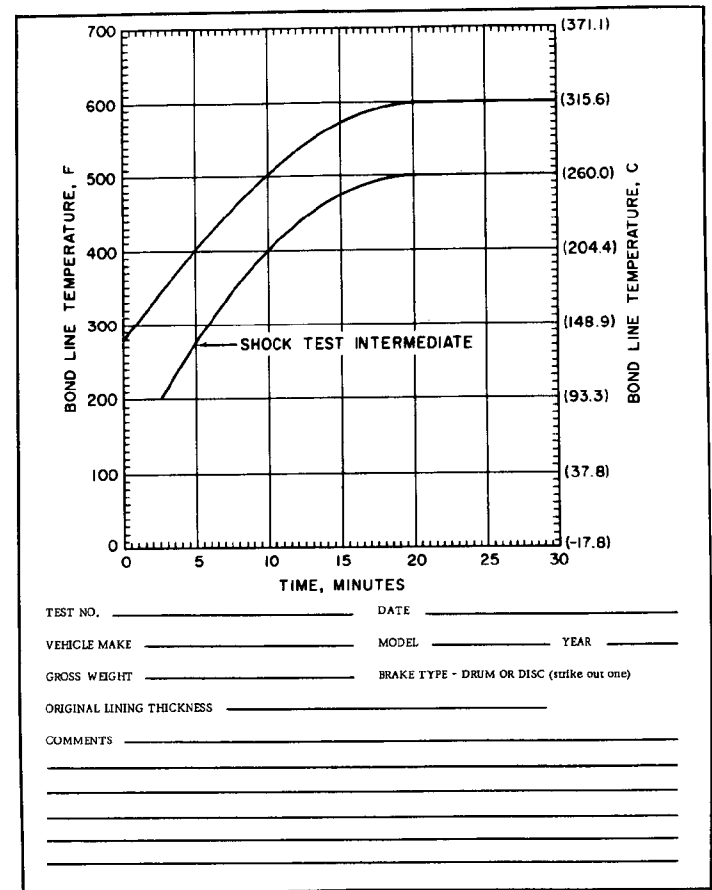


FIG. 6A—ENVELOPE VEHICLE ABUSE TEST

2.4.3.2.3 Repeat Shock Test—Intermediate

2.4.3.2.4 Continued Heat Test

2.4.3.2.5 Repeat Shock Test—Hot

2.4.3.3 *Test Procedure*—Install a set of shoes and adjust brakes according to manufacturer's recommendations.

2.4.3.3.1 Shock Test—Cold—Make one forward and one reverse stop from approximately 15-20 mph (24.1-32.2 km/h) at maximum rate of deceleration and minimum time interval. Repeat two more times. Be alert for wheel drag. A heavy drag or rubbing noise may indicate lining slippage due to bond failure.

2.4.3.3.2 Heat Test at 250-300 F (121-149 C)—In any appropriate gear, drive the vehicle while dragging the service brakes. Continue until a bond line temperature at 250-300 F (121-149 C) is reached within 3-5 min (suggested speed 20-40 mph (32.2-64.4 km/h)).

2.4.3.3.3 Repeat Shock Test—Intermediate—When the bond line temperatures of the shoes are above 250 F (121 C), but not over 300 F (149 C), immediately repeat Shock Test as in paragraph 2.4.3.3.1.

2.4.3.3.4 Continued Heat Test—Immediately continue, dragging the service brakes as in paragraph 2.4.3.3.2 for 30 min. Record bond line temperatures in 2 min intervals and plot on the chart shown in Fig. 6A. During the test, the bond line temperature curve must stay within the limits of the envelope of the two curves shown or the test is not to be considered valid.

NOTE: It may be possible to stay within this envelope only on either the two front wheels or the two rear wheels but not both (suggested speed 20-40 mph (32.2-64.4 km/h)).

2.4.3.3.5 Repeat Shock Test—Hot—Immediately after completion of Continued Heat Test in paragraph 2.4.3.3.4, repeat paragraph 2.4.3.3.1.

2.4.3.3.6 Lining Test—Shear or chisel lining from test shoes (see paragraphs 3.2.3 and 3.2.4), record failing loads and/or fracture pattern.

2.4.4 Report results on the form shown in Fig. 6B.

3. Quality Control Tests

3.1 Material Tests

3.1.1 SCOPE—These tests are conducted on the adhesive product be-

ing used to determine its consistency within the limits established on a qualified product.

3.1.2 Viscosity Test

3.1.2.1 *Purpose*—This is a quality control test on the bonding agent to determine its viscosity. The viscosity of an adhesive is defined as the internal friction resistance to flow. This viscosity characteristic is important in the development of application techniques.

3.1.2.2 *Equipment*

3.1.2.2.1 Viscometer—Variable speed, spindle type Synchro-electric viscometer.

3.1.2.2.2 Container—One quart (0.94 l) round, friction topped can, 4.5 in (114.5 mm) in diameter and 4.875 in (124 mm) high, with a 3.25 in (82.5 mm) opening.

3.1.2.2.3 Thermometer—Accurate thermometer to read in the 77 ± 1 F (25 ± 0.5 C) range.

3.1.2.2.4 Mixer—High-speed agitator to stir adhesive before testing.

3.1.2.3 *Procedure*

3.1.2.3.1 Agitate sample before testing. Amount and type of mixing to be determined and specified by adhesive supplier.

3.1.2.3.2 Adjust sample to 77 ± 2 F (25 ± 0.5 C).

3.1.2.3.3 Immerse spindle to proper level in adhesive and start motor.

3.1.2.3.4 The reading should be taken when the viscosity reading has stabilized.

3.1.2.4 *Report*—Make and model of the viscometer, the spindle number, spindle speed, temperature, viscosity reading, and scale factor.

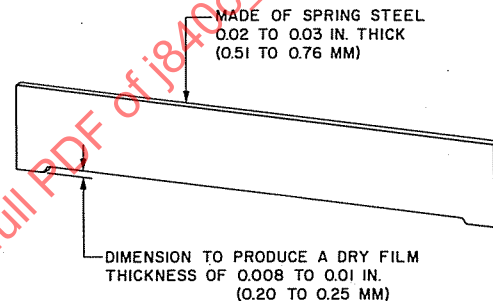


FIG. 7—DOCTOR BLADE

VEHICLE ABUSE TEST OF BRAKE SHOE BOND				
		DATE _____		
		TEST NO. _____		
ADHESIVE MANUFACTURER: _____				
COMPOUND _____ Batch: _____				
SAMPLE PREPARATION: _____				
Wet Film Thickness _____		Dry Film Thickness _____		
Air Dry _____ Minutes _____		Force Dry _____ Minutes at _____ F		
Cure _____ Minutes at _____ F (_____ C)		at approx _____ psi (_____ kg/cm ²)		
VEHICLE DATA:				
DRUM BRAKE OR DISC BRAKE (STRIKE OUT ONE)				
	FRONT (Pri or Fwd) (Outer)	FRONT (Sec or Rev) (Inner)	REAR (Pri or Fwd)	REAR (Sec or Rev)
Size	_____	_____	_____	_____
Lining Manufacturer	_____	_____	_____	_____
Lining Compound	_____	_____	_____	_____
Wheel Cyl Dia	_____	_____	_____	_____
Drum Type	_____	_____	_____	_____
RESULTS:				
	Load at Failure	psi or kg/cm ²	Fracture Pattern Shear Test; or Fracture Pattern Chisel Test	
LF (Pri or Fwd) Outer	_____	_____	_____	
LF (Sec or Rev) Inner	_____	_____	_____	
RF (Pri or Fwd) Outer	_____	_____	_____	
RF (Sec or Rev) Inner	_____	_____	_____	
LR (Pri or Fwd)	_____	_____	_____	
LR (Sec or Rev)	_____	_____	_____	
RR (Pri or Fwd)	_____	_____	_____	
RR (Sec or Rev)	_____	_____	_____	

FIG. 6B—REPORT FORM FOR VEHICLE ABUSE TEST

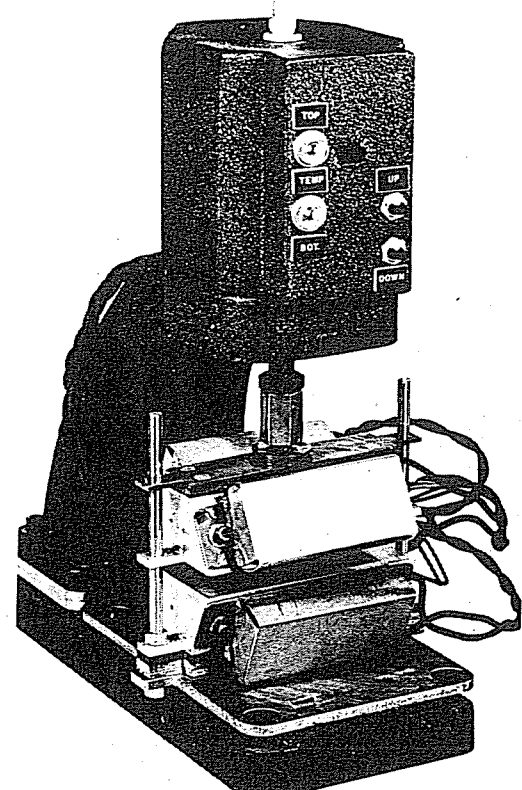


FIG. 8—DISC SHEAR BONDING PRESS

3.1.3 SOLIDS CONTENT TEST

3.1.3.1 *Purpose*—This is a quality control test to determine the nonvolatile content of the adhesive. Dry film coverage is directly proportional to the solids content. The test is performed by evaporating the solvent from a sample of known weight and weighing the residue.

3.1.3.2 Equipment

3.1.3.2.1 Circulating hot air oven or vacuum oven equipped with a thermometer.

3.1.3.2.2 A 3.0 oz (85 g) ointment tin with cover $2\frac{3}{8}$ in (60.5 mm) in diameter.

3.1.3.3 Procedure

3.1.3.3.1 Mix sample thoroughly.

3.1.3.3.2 Weigh empty container and cover to 0.01 g.

3.1.3.3.3 As rapidly as possible, pour approximately 5 g of adhesive into the container. Replace cover on ointment tin at once. Weigh accurately to 0.01 g.

3.1.3.3.4 Remove cover, heat sample in the oven at 220 ± 5 F (105 ± 3 C) for 30 min.

3.1.3.3.5 Reweigh sample, container, and cover to 0.01 g.

3.1.3.3.6 Calculations:

$$\frac{\text{Weight sample after heating}}{\text{Weight sample before heating}} \times 100 = \text{Total solids, \%}$$

3.1.3.4 *Report*—Total solids in percent, time of heating, temperature of heating, and type of oven.

3.1.4 FLOW TEST

3.1.4.1 *Purpose*—This test is used to determine the flow properties of the bonding agent. The flow of the dried adhesive film under bonding or curing conditions indicates its ability to wet the surfaces.

3.1.4.2 Equipment

3.1.4.2.1 Steel discs 0.250 in (6.3 mm) thick, 1.125 in (28.6 mm) in diameter, SAE 1010.

3.1.4.2.2 Steel strip 0.250 \times 1.250 \times 4.250 in (6.3 \times 31.8 \times 110.8 mm), SAE 1010.

3.1.4.2.3 SAE disc shear bonding press.

3.1.4.2.4 Alternate equipment for bonding—use spring loaded fixtures and circulating air oven.

3.1.4.2.5 Micrometer capable of measuring 0.0001 in (0.0025 mm).

3.1.4.2.6 Doctor blade (Fig. 7).

3.1.4.3 Procedure

3.1.4.3.1 If the adhesive is a liquid, a dry film must be cast, if a tape, use as supplied.

3.1.4.3.2 Pour a portion of the liquid adhesive on a clean glass or metal plate covered with a polyethylene film or directly onto a polytetrafluoroethylene coated plate.

3.1.4.3.3 Draw the doctor blade (Fig. 7) across the adhesive, casting a sufficiently thick wet film to give a dry film 0.008-0.010 in (0.20-0.25 mm) thick.

3.1.4.3.4 In lieu of a specific recommendation, dry 3 h minimum at room temperature or as required to obtain a smooth film. Follow by heating for 20 min at an oven air temperature of 175 ± 5 F (80 ± 3 C).

3.1.4.3.5 Using a circular die, cut a 0.75 in (19 mm) diameter circle from the dried film. Remove the polyethylene film. Measure the film thickness to 0.0001 in (0.0025 mm) with the spring micrometer. Use an average of five readings.

3.1.4.3.6 Place a 1.125 in (28.6 mm) diameter circle of heat resistant

cellophane over the center of the 0.250 \times 1.125 \times 4.250 in (6.3 \times 28.6 \times 108.0 mm) steel bar used in the Disc Shear Test. Mount the film specimen in the center of the cellophane. Cover the specimen with a second circle of cellophane 1.125 in (28.6 mm) in diameter. Use the 1.125 in (28.6 mm) steel shear disc to complete the assembly.

3.1.4.3.7 Place the assembly in the standard SAE disc bonding press (Fig. 8) or in a spring loaded fixture if an oven is to be used for heating. Load to 100 psi (7.0 kg/cm²). Heat at the recommended temperature and time cycle. In lieu of a specific recommendation, use rate as shown in Fig. 9. As a supplemental test, the pressure and rate of heating could be the same as that used in paragraph 2.2.

3.1.4.3.8 Remove the assembly from the press or oven and cool to room temperature. Remove the adhesive disc from the plate.

3.1.4.3.9 Soak the disc in water to remove the cellophane.

3.1.4.3.10 Measure the new film thickness with a micrometer to the nearest 0.0001 in (0.0025 mm). Use average of five readings. As an alternate method, measure the area using a planimeter.

3.1.4.3.11 Calculate flow by:

$$\text{Flow, \%} = \frac{\text{Original thickness} - \text{New thickness}}{\text{Original thickness}} \times 100$$

3.1.4.3.12 Alternate calculation:

$$\text{Flow, \%} = \frac{\text{New area} - \text{Original area}}{\text{Original area}} \times 100$$

3.1.4.4. *Report*—Percent flow and method of measurement and calculation (based on thickness or area change).

3.1.5 DISC SHEAR TEST

3.1.5.1 *Purpose*—This test is used to determine the shear strength of an adhesive intended for bonding brake linings to brake shoes. Disc shear specimens are tested at room temperature and at elevated temperature.

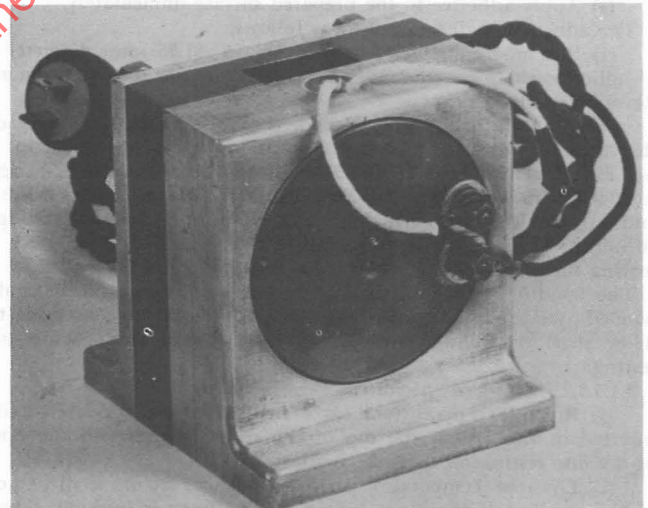


FIG. 10—STEEL DISC AND STRIP

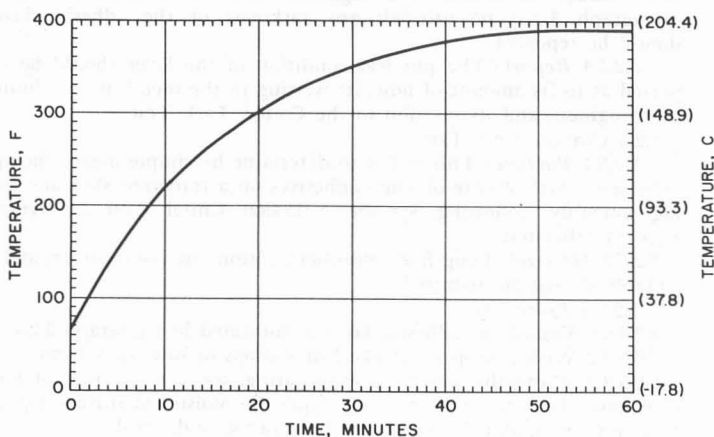


FIG. 9—RATE OF HEATING CURVE

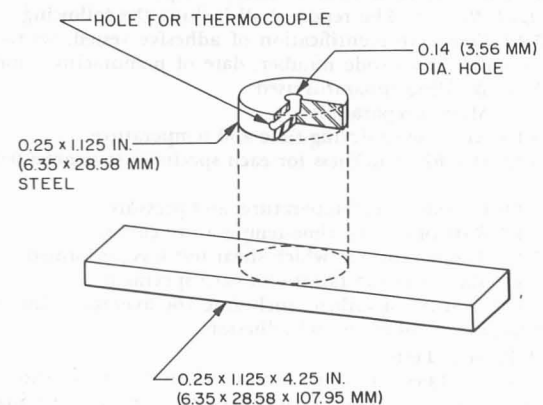


FIG. 11—DISC SHEAR FIXTURE