
Draft Jamaican Standard
Specification
for
Motor vehicle brake fluid



BUREAU OF STANDARDS JAMAICA

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Jamaican Standard
Specification
for
Motor vehicle brake fluid

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Amendments

| No. | Date of issue | Remarks | Entered by and date |
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Foreword

This standard is based solely on the Regulations of the United States Department of Transportation (DOT) 571 Standard No. 116 – 1987. The Stroking Test, however, has not been included in this standard. It is felt that the cost of the Stroking Test Apparatus does not justify carrying out this test as most of its requirements are already embodied in the other tests. The exception to this is the lubrication quality of the brake fluid.

This standard is intended to be compulsory.

Committee representation

The preparation of this standard for the Standards Council, established under the Standards Act 1969, was carried out by the Motor Vehicle Standards Committee, which at the time comprised the following members:

Acknowledgement

Acknowledgement is made to the US. Department of Transport for permission to reproduce material from US Code of Federal Regulations Title 49 571.116

Related documents

This standard makes reference to the following:

| | |
|----------------------------------|--|
| 49 CFR 571.116 | Motor vehicle brake fluids |
| ISO 4925 | Road vehicles – Non-petroleum base brake fluid |
| ASTM D 445-86 | Test method for kinematic viscosity of transparent and opaque liquid and the calculations of dynamic viscosity |
| ASTM D 1121-83 | Test method for reserve alkalinity of engine antifreeze anti-rusts and coolants |
| ASTM D 1123-85 | Test method for specific gravity of engine coolant by Karl Fisher reagent method |
| ASTM D 1193-70 | Standard specification for reagent method |
| ASTM D 1415-83 | Test method for rubber property international hardness |
| ASTM D2515 redesignated D446-85a | Specification for operating instruments for glass capillary kinematic viscometers |
| ASTM E 1-68 | Specifications for ASTM thermometers |
| ASTM E 77-84 | Method of verification and calibration of liquid in glass thermometers |
| ASTM E298 | Method of assay of organic peroxides |
| SAE Standard J380 | Specific gravity of brake fluid |
| SAE Standard J527 | Brazed double wall low carbon steel tubing |
| SAE Standard J1703 | Motor vehicle brake fluid |

Jamaican Standard Specification for Motor vehicle brake fluid

1 Scope

This standard specifies requirements for fluids for use in hydraulic brake systems of motor vehicles, containers for these fluids, and labelling of the containers.

2 Definitions

For the purpose of this standard the following definitions apply:

2.1 blister. A cavity or sac on the surface of a brake cup.

2.2 brake fluid. A liquid designed for use in a motor vehicle hydraulic brake system in which it will contact elastomeric components made of styrene and butadiene rubber (SBR), ethylene and propylene rubber (EPR), polychloroprene (CR) brake hose inner tube stock or natural rubber (NR).

2.3 chipping. A condition in which small pieces are missing from the outer surface of a brake cup.

2.4 duplicate samples. Two samples of brake fluid taken from a single packaged lot and tested simultaneously.

2.5 hydraulic system mineral oil. A mineral oil based fluid designed for use in motor vehicle hydraulic brake systems in which the fluid is not in contact with components made of SBR, EPR or NR (see 2.2).

2.6 packager. Any person who fills containers with brake fluid that are subsequently distributed for retail sale.

2.7 packaged lot. That quantity of brake fluid shipped by the manufacturer to the packer in a single container, or that quantity of brake fluid manufactured by a single plant run of 24 h or less, through the same processing equipment and with no change in ingredients.

2.8 scuffing. A visible erosion of a portion of the outer surface of a brake cup.

2.9 sloughing. Degradation of a brake cup as evidenced by the presence of carbon black loosely held on the brake cup surface, such that a visible black streak is produced when the cup, with a 500 ± 10 g deadweight on it, is drawn base down over a sheet of white bond paper placed on a firm flat surface.

2.10 stickiness. A condition on the surface of a brake cup such that fibres will be pulled from a wad of United States Pharmaceutical absorbent cotton when it is drawn across the surface.

3. Requirements

Brake fluids shall conform to the requirements detailed in 3.1 to 3.14 when tested in accordance with the procedures described in 6.1

3.1 Equilibrium reflux boiling point (ERBP). When brake fluid is tested according to the procedures detailed in 1 the ERBP shall not be less than the following values for the grades indicated:

- a) DOT 3: 205°C
- b) DOT 4: 230°C
- c) DOT 5: 260°C

NOTE: DOT – Department of Transport US

3.2 Wet ERBP. When brake fluid is tested according to the procedure detailed in 6.2 the wet ERBP shall not be less than the following values for the grades indicated:

- a) DOT 3: 140°C
- b) DOT 4: 155°C
- c) DOT 5: 180°C

3.3 Kinematic viscosities. When the brake fluid is tested according to the requirements of clause 8 the kinematic viscosity in centistokes (cSt) at stated temperatures shall be neither less than 1.5 cSt at 100°C not more than the following maximum values for the grades indicated:

- a) DOT 3: 1 500 cSt at – 40°C
- b) DOT 4: 1 800 cSt at – 40°C
- c) DOT 5: 1 800 cSt at – 40°C

3.4 pH value. When DOT 3 or DOT 4 brake fluid is tested according to the requirement of 4.4, the pH value shall not be less than 7.0 or more than 11.5

3.5 Brake fluid stability

3.5.1 High-temperature stability. When brake fluid is tested according the procedure detailed in 10.3 the ERBP shall not change by more than 3°C plus 0.05° for each degree that the ERBP of the fluid exceeds 225°C.

3.5.2 Chemical stability. When DOT 3 or DOT 4 brake fluid is tested according to the procedure detailed in 10.4, the change in temperature of the refluxing fluid mixture shall not exceed 3.0°C plus 0.05° for each degree that the ERBP of the fluid exceeds 225°C.

3.6 Corrosion. When brake fluid is tested according to the procedures detailed in clause 11, it shall display the following corrosion characteristics:

- a) the metal test strips shall not show weight changes exceeding the limits given in table 1:

Table 1 Maximum weight change of actual test strips

| Test strip material | Maximum permissible weight change, mg/cm ² of surface |
|-------------------------------|--|
| Steel, tinned iron, cast iron | 0.2 |
| Aluminium | 0.1 |
| Brass, copper | 0.1 |

- b) excluding the area of contact (13 ± 1 mm measured from the bolthole end of the test strip), the metal test strips shall not show pitting or etching to an extent discernible without magnification;
- c) the water-wet brake fluid at the end of the test shall show no gelling at $23 \pm 5^\circ\text{C}$;
- d) crystalline deposit shall not form or adhere to either the glass jar walls or the surface of the metal strips;
- e) sedimentation of the water-wet brake fluid shall not exceed 0.10% by volume at the end of the test.
- f) the pH value of water-wet DOT 3 and DOT 4 brake fluid shall not be less than 7.0 nor more than 11.5 at the end of the test.
- g) the cups shall show no disintegration, as evidenced by blisters or sloughing at the end of the test.
- h) the hardness of the cup shall not decrease by more than 15 International Rubber Hardness Degrees (IRHD); and
- i) the base diameter of the cups shall not increase by more than 1.4 mm

3.7 Fluidity and appearance at low temperature. When brake fluid is tested at the storage temperature and for the storage times given in table 2 it shall:

- a) show no sludging, sedimentation crystallization, or stratification;
- b) upon inversion of the sample bottle not take a time exceeding the bubble flow time given in table 2 for the air bubble to travel to the top of the fluid;
- c) on warming to room temperature, resume the appearance and fluidity that it had before chilling.

Table 2 Fluidity and appearance at low temperature

| Storage temperature | Storage time (h) | Maximum bubble flow time (s) |
|--------------------------------|------------------|------------------------------|
| Minus $40 \pm 2^\circ\text{C}$ | 144 ± 4.0 | 10 |
| Minus $50 \pm 2^\circ\text{C}$ | 6 ± 0.2 | 35 |

3.8 Evaporation. When brake fluid is tested according to the procedure detailed in clause 13, it shall display the following evaporation characteristics:

- a) the loss by evaporation shall not exceed 80% by weight;
- b) the residue from the brake fluid after evaporation shall contain no precipitate that remains gritty or abrasive when rubbed with the fingertip; and
- c) the residue shall have a pour point below -5°C .

3.9 Water tolerance. The water tolerance of brake fluid shall be as follows:

a) at low temperature. When brake fluid is tested according to the procedure given in 14.3 (a):

- (1) the fluid shall show no sludging, sedimentation, crystallization, or stratification;
- (2) upon inversion of the centrifuge tube, the air bubble shall travel to the top of the fluid in not more than 10s;
- (3) if cloudiness has developed, the wet fluid shall regain its original clarity and fluidity when warmed to room temperature;

b) at 60°C. When brake fluid is tested according to the procedure given in 14.3 (b)

- (1) the fluid shall show no stratification;
- (2) sedimentation shall not exceed 0.15% by volume after centrifuging.

3.10 Compatibility

(a) at low temperature. When brake fluid is tested according to the procedure given in 15.3 (a) the test specimen shall show no sludging, sedimentation, or crystallization. In addition DOT 3 and DOT 4 fluids shall show no stratification.

(b) at 60°C. When brake fluid is tested according to the procedure given in 15.3 (b) 3 (b):

- (1) sedimentation shall not exceed 0.05% by volume after centrifuging;
- (2) DOT 3 and DOT 4 fluids shall show no stratification.

3.11 Resistance to oxidation. When brake fluid is tested according to the procedure given in clause 16:

- (a) the metal test strips outside the areas in contact with tinfoil shall not show pitting or etching to an extent discernible without magnification;
- (b) no more than a trace of gum shall be deposited on the test strips outside the areas in contact with the tinfoil;
- (c) the aluminium strips shall not change in weight by more than 0.05 mg/cm²; and
- (d) the cast iron strips shall not change in weight by more than 0.3 mg/cm².

3.12 Effects on cups. When brake cups are subjected to testing with brake fluid in accordance with the procedure given in clause 17:

- (a) the increase in the diameter of the base of the cups shall be not less than 0.15 mm or more than 1.40 mm.
- (b) the decrease in hardness of the cups shall be not more than 10 IRHD at 70°C or more than 15 IRHD at 120°C and there shall be no increase in hardness of the cups;
- (c) the cups shall show no disintegration as evidenced by stickiness, blisters, or sloughing.

3.13 Stroking properties. When brake fluid is tested according to the procedure detailed in clause 18:

- (a) metal parts of the test system shall show no pitting or etching to an extent discernible without magnification;
- (b) the change in diameter of any cylinder or piston shall not exceed 0.13 mm;
- (c) the average decrease in hardness of seven of the eight cups tested (six wheel cylinder and one master cylinder primary) shall not exceed 15 IRHD. Not more than one of the seven cups shall have a decrease in hardness greater than 17 IRHD.
- (d) none of the eight cups shall be in an unsatisfactory operating condition as evidenced by stickiness, scuffing, blisters, cracking, chipping, or other change in shape from its original appearance;
- (e) none of the eight cups shall show an increase in base diameter greater than 0.90 mm;
- (f) the average lip diameter set of the eight cups shall not be greater than 65%;
- (g) during any period of 24 000 strokes, the volume loss of fluid shall not exceed 33 ml;
- (h) the cylinder pistons shall not freeze or function improperly throughout the test;
- (i) the total loss of fluid during the 100 strokes at the end of the test shall not exceed 36 ml;
- (j) the fluid at the end of the test shall show no formation of gels;
- (k) at the end of the test the amount of sediment shall not exceed 1.5% by volume; and
- (l) brake cylinders shall be free of deposits that are abrasive or that cannot be removed when rubbed moderately with a nonabrasive cloth moistened with ethanol.

3.14 Fluid colour. Brake fluid and hydraulic system mineral oil shall be of the following colours:

- (a) DOT 3 and DOT 4 colourless to amber;
- (b) DOT 5 purple;
- (c) hydraulic system mineral oil green.

4. Packaging and labelling

4.1 Container sealing. Each brake fluid or hydraulic system mineral oil container with a capacity of 170 ml or more shall be provided with a resealable closure that has an inner seal impervious to the packaged brake fluid. The container closure shall include a temper-proof feature that will either be destroyed or substantially altered when the container closure is initially opened.

4.2 Certification, marking, and labelling.

4.2.1 Each manufacturer of a DOT grade brake fluid shall furnish to each packager, distributor, or dealer to whom he delivers brake fluid, the following information:

- (a) a serial number identifying the production lot and the date of manufacture of the brake fluid;

- (b) the grade (DOT 3, DOT 4 or DOT 5) of the brake fluid;
- (c) the minimum wet boiling point in Celsius of the brake fluid;
- (d) certification that the brake fluid conforms to the requirements of JS 1: Part 1 and Part 17.

4.2.2 Each packager of a brake fluid shall furnish the following information clearly and indelibly marked on each brake fluid container, in any location except a removable part such as a lid:

- (a) certification that the brake fluid conforms to the requirements JS 1: Part 1 and Part 17;
- (b) the name of the packager of the brake fluid, which may be in code form;
- (c) the name and complete mailing address of the distributor;
- (d) a serial number identifying the packaged lot and date of packaging;
- (e) designation of the contents as 'DOT – MOTOR VEHICLE BRAKE FLUID' (with '3', '4', or '5' filled in as applicable).
- (f) the minimum wet boiling point in Celsius of the DOT brake fluid in the container;
- (g) the following safety warnings in capitals and lower case letters as given:

(1) FOLLOW VEHICLE MANUFACTURER'S RECOMMENDATIONS WHEN ADDING BRAKE FLUID.

(2) KEEP BRAKE FLUID CLEAN AND DRY. Contamination with dirt, water, petroleum products or other materials may result in brake failure or costly repairs.

(3) STORE BRAKE FLUID ONLY IN ITS ORIGINAL CONTAINER. KEEP CONTAINER CLEAN AND TIGHTLY CLOSED TO PREVENT ABSORPTION OF MOISTURE.

NOTE. The last five words of the second sentence may be omitted from the labelling on DOT 5 CONTAINERS.

(4) CAUTION. DO NOT REFILL CONTAINER, AND DO NOT USE FOR OTHER LIQUID.

NOTE. Not required for containers with a capacity in excess of 2.2 L

4.2.3 Each packager of hydraulic system mineral oil shall furnish the following information clearly and indelibly marked on each container in any location except a removable part such as a lid:

- (a) the name of the packager of the hydraulic system mineral oil, which may be in code form;
- (b) the name and complete mailing address of the distributor;
- (c) a serial number identifying the packaged lot and date of packaging;
- (d) designation of the contents as HYDRAULIC SYSTEM MINERAL OIL in capital letters at least 3.2 mm.
- (e) the following safety warnings in capitals and lower case letters as given:

(1) FOLLOW VEHICLE MANUFACTURER'S RECOMMENDATIONS WHEN ADDING HYDRAULIC SYSTEM MINERAL OIL.

(2) Hydraulic System Mineral Oil is NOT COMPATIBLE with the rubber components of brake systems designed for use with DOT brake fluids.

(3) KEEP HYDRAULIC SYSTEM MINERAL OIL CLEAN. Contamination with dust or other materials may result in brake failure or costly repair.

(4) CAUTION. STORE HYDRAULIC SYSTEM MINERAL OIL ONLY IN ITS ORIGINAL CONTAINER. KEEP CONTAINER CLEAN AND TIGHTLY CLOSED. DO NOT REFILL CONTAINER OR USE OTHER LIQUIDS.

NOTE. The last sentence is not required, for containers with a capacity in excess of 2.2 L.

4.2.4 If a container for brake fluid or hydraulic system mineral oil is not normally visible but designed to be protected by an outer container or carton during use, the outer container or carton rather than the inner container shall meet the appropriate labelling requirements of 4.2.2 or 4.2.3.

5 Motor vehicle requirement

Each passenger car, multipurpose passenger vehicle, truck, bus, trailer, and motorcycle that has a hydraulic brake system, shall be equipped with fluid that has been manufactured and packaged in conformity with the requirements of this standard.

6. Determination of equilibrium reflux boiling point (ERBP)

Determine the ERBP of a brake fluid by running duplicate samples according to the procedure given and averaging the result.

6.1 Summary of procedure. 60 ml of brake fluid are boiled under specified equilibrium conditions (reflux) at atmospheric pressure in a 100-ml flask. The average temperature of the boiling fluid at the end of the reflux period, corrected for variations in barometric pressure if necessary, is the ERBP.

6.2 Apparatus. (see figure 1). The test apparatus shall consist of:

(a) flask. A 100-ml round-bottom, short neck heat-resistant glass flask having a neck with a 19/38 standard taper, female ground-glass joint and a side-entering tube, with an outside diameter of 10 mm, which centres the thermometer bulb in the flask 6.5 mm from the bottom (see figure 2);

NOTE. Not required for containers with a capacity in excess of 2.2 L

(b) condenser. A water-cooled, reflux, glass-tube type condenser, having a jacket 200 mm in length, the bottom end of which has a 19/38 standard-taper, drip-tip, male ground glass joint;

(c) boiling stones. Three clean, unused silicon carbide grains approximately 2 mm in diameter, grit No. 8;

(d) thermometer. Standardized calibrated partial immersion 76-mm solid stem thermometers, conforming to the requirements for an ASTM 2C OR 2F and ASTM 3C or 3F thermometer;

(e) heat source. Variable autotransformer-controlled heating mantle designed to fit the flask or an electric heater with rheostat heat control.

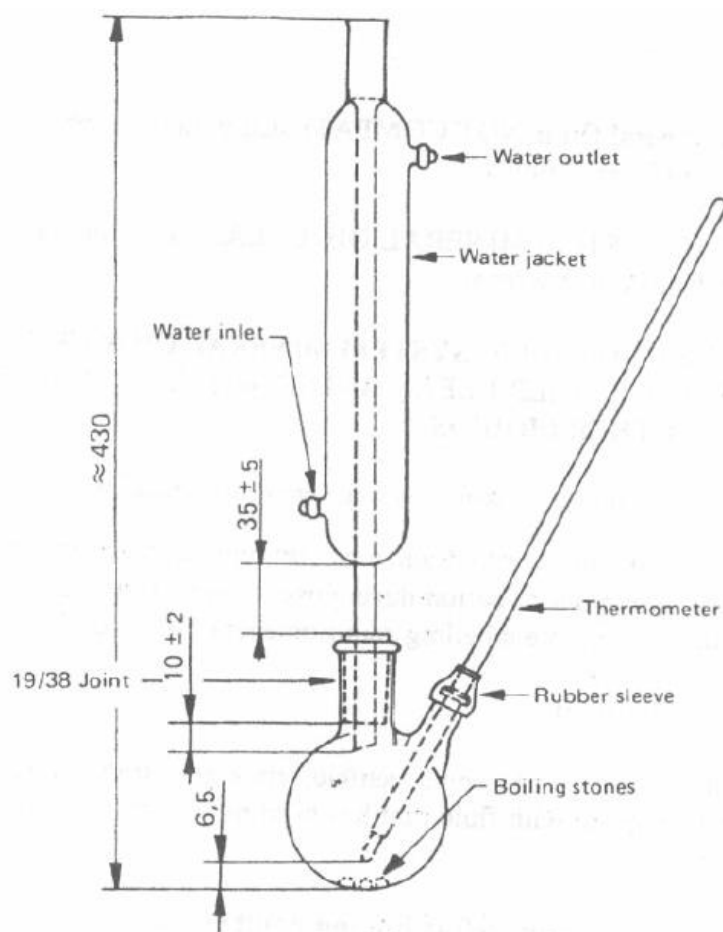


Figure 1. Boiling point test apparatus

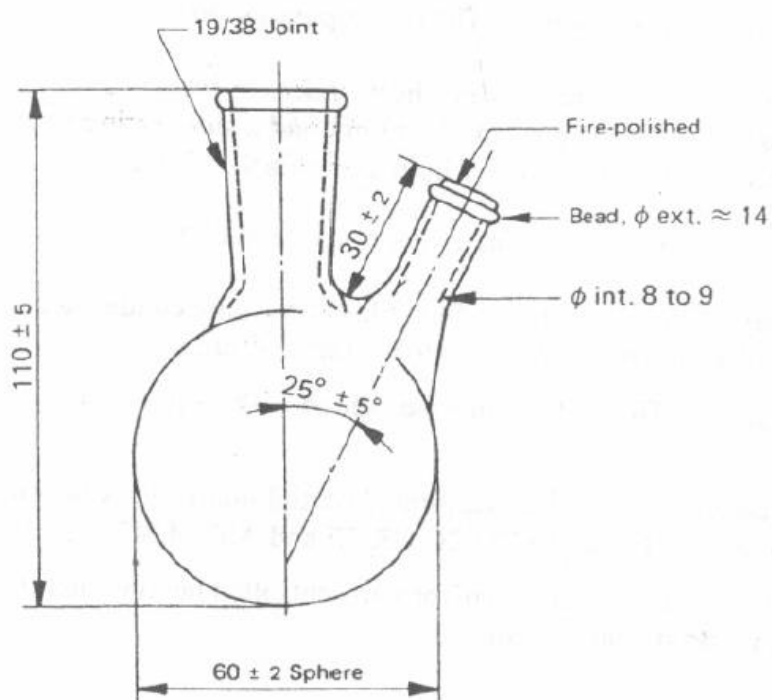


Figure 2. Detail of 100 ml short-neck flask

6.3 Preparation of apparatus.

(a) thoroughly clean and dry all glassware;

(b) insert thermometer through the side tube until the tip of the bulb is 6.3 mm from the bottom centre of the flask. Seal with a short piece of natural rubber ethylene-propylene-diene terpolymer (EPDM), SBR, or butyl tubing;

(c) place 60 ± 1 ml of brake fluid and the silicon carbide grains into the flask;

(d) attach the flask to the condenser. When using a heating mantle, place the mantle under the flask and support it with a ring-clamp and laboratory-type stand, holding the entire assembly in place by a clamp. When using a rheostat-controlled heater, centre a standard porcelain or hard asbestos refractory, having a diameter opening 32 mm to 38 mm over the heating element and mount the flask so that direct heat is applied only through the opening in the refractory. Place the assembly in an area free from drafts or other types of sudden temperature changes. Connect the cooling water inlet and outlet tubes to the condenser. Turn on the cooling water. The water supply temperature shall not exceed 28°C and the temperature rise through the condenser shall not exceed 2°C .

6.4 Procedure. Apply heat to the flask so that within 10 ± 2 min the fluid is refluxing in excess of 1 drop per s. The reflux rate shall not exceed 5 drops per s at any time. Immediately adjust the heating rate to obtain an equilibrium reflux rate of 1 to 2 drops per s over the next 5 ± 2 min. Maintain this rate for an additional 2 min, taking four temperature readings at 30 s intervals. Record the average of these as the observed ERBP. If no reflux is evident when the fluid temperature reaches 260°C , discontinue heating and report ERBP as in excess of 260°C .

6.5 Calculation

(a) thermometer inaccuracy. Correct the observed ERBP by applying any correction factor obtained in standardizing the thermometer.

(b) variation from standard barometric pressure. Apply the factor given in table 3 to calculate the barometric pressure correction to the ERBP.

Table 3 – Correction for barometric pressure

| Covered ERBP corrected for thermometer inaccuracy | Correction per 1 mm difference in pressure* |
|---|---|
| | $^{\circ}\text{C}$ |
| 100 $^{\circ}\text{C}$ to 190 $^{\circ}\text{C}$ | 0.039 |
| over 190 $^{\circ}\text{C}$ | 0.04 |

* To be added in case barometric pressure is below 760 mm, to be subtracted in case barometric pressure is above 760 mm.

(c) if the two corrected observed ERBP agree within 2°C (4°C for brake fluids having an ERBP over 230°C), average the duplicate runs as the ERBP; otherwise, repeat the entire test, averaging the four corrected observed values to determine the original ERBP.

7 Determination of wet equilibrium reflux boiling point (ERBP)

Determine the wet ERBP of a brake fluid by running duplicate samples according to the procedure given.

7.1 Summary of the procedure. A 150 ml sample of the brake fluid is humidified under controlled

conditions; 150 ml of SAE trimethylene glycol monomethyl ether, brake fluid grade, referee material (TEGME) as described in appendix E of SAE Standard J1703 is used to establish the end-point for humidification. After humidification the water content and ERBP of the brake fluid are determined.

7.2 apparatus for humidification. The test apparatus (see figure 3) shall consist of:

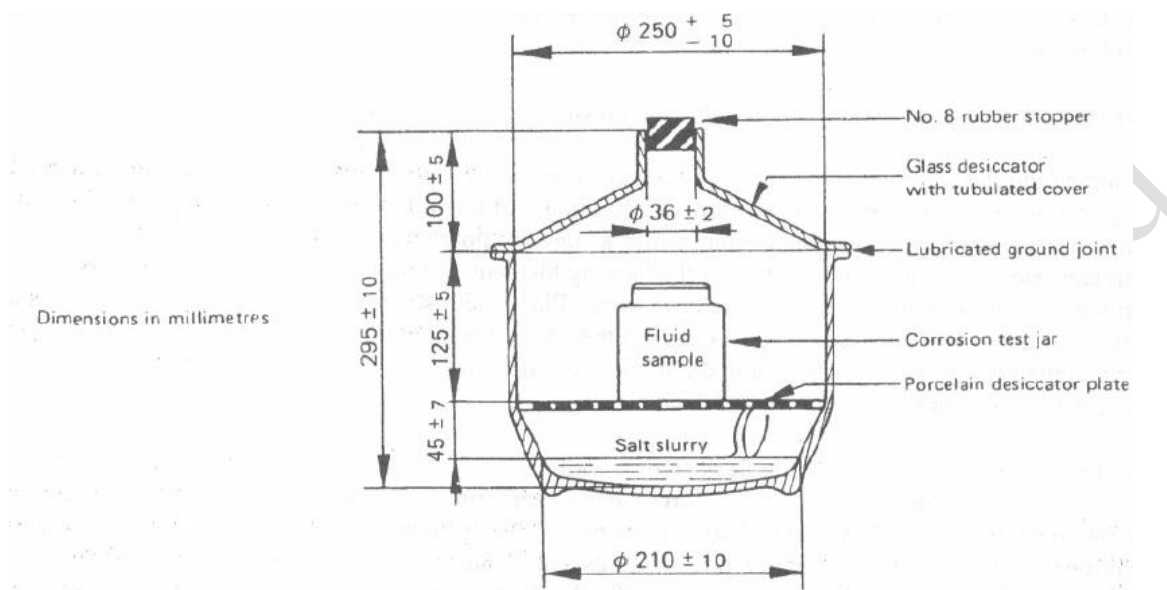


Figure 3. Humidification apparatus

- (a) glass jars. Four SAE RM-49 corrosion test jars or equivalent screw-top, straight-sided, round glass jars each having a capacity of about 475 ml and approximate inner dimensions of 100 mm in height by 75 mm in diameter, with matching lids having new, clean inserts providing water vapour-proof seals;
- (b) desiccator and cover. Four bowl-form glass desiccators, 250 mm inside diameter, having matching tabulated covers fitted with No. 8 rubber stoppers; and
- (c) desiccator plate. Four 230-mm diameter, perforated porcelain desiccator plates, without feet, glazed on one side.

7.3 Reagents and materials. The following materials shall be used:

- (a) brake fluid;
- (b) distilled water (see appendix A)
- (b) SAE TEGME referee material

7.4 Preparation of apparatus. Lubricate the ground glass joint of the desiccator. Pour 450 ± 10 ml of distilled water into each desiccator and insert perforated porcelain desiccator plates. Place the desiccators in an oven with temperature controlled at $50 \pm 1^\circ\text{C}$ throughout the humidification procedure.

7.5 Procedure. Port 150 ± 5 ml of the brake fluid into an open corrosion test jar. Place the jar into a desiccator. Prepare in the same manner a duplicate test fluid sample and two duplicate specimens of the SAE TEGME referee material (150 ± 4 ml of TEGME in each jar). The water content of the SAE TEGME fluid is adjusted to $0.50 \pm 0.05\%$ by weight at the start of the test as detailed in appendix A.2. Place these samples in the desiccators in the 50°C controlled oven and replace desiccator covers. At intervals, during oven humidification, remove the rubber stopper in the top of each desiccator containing SAE TEGME fluid. Using a long needled hypodermic syringe, take a sample of not more than 2 ml from each jar and determine its water content. Remove no more than 10 ml of fluid from each SAE TEGME sample during the humidification procedure.

When the water content of the SAE fluid reaches $3.70 \pm 0.05\%$ by weight (average of the duplicates), remove the two test fluid specimens from their desiccators and promptly cap each jar tightly. Allow the sealed jars to cool for 60 min to 90 min at $23 \pm 5^\circ\text{C}$. Measure the water contents of the test fluid specimens as detailed in appendix A.2 and determine their ERBP (see 6.1). If the two ERBPs agree within 4°C , average them to determine the wet ERBP otherwise repeat and average the four individual ERBP's as the ERBP of the brake fluid.

8. Determination of kinematic viscosity. The kinematic viscosity of a brake fluid is determined in 8.4 centistokes (cSt.) by the procedure given.

8.1 Summary of the procedure. The time is measured for a fixed volume of the brake fluid to flow through a calibrated glass capillary viscometer under an accurately reproducible head and at a closely controlled temperature. The kinematic viscosity is then calculated from the measured flow time and the calibration constant of the viscometer. Run duplicate samples at each of the specified temperatures, making two timed runs on each sample.

8.2 Apparatus. The test apparatus shall consist of:

(a) viscometer. Calibrated glass capillary-type viscometer, conforming to the required ASTM D2515-66. Measure the viscosity within the precision limits given in 8.7. Use suspended level viscometer for viscosity measurements at low temperatures. Use Cannon-Fenske Routine or other modified Ostwald viscometer at ambient temperatures and above.

(b) viscometer holders and frames. Mount a viscometer in the constant-temperature bath so that the mounting tube is held within 1°C of the vertical.

(c) viscometer bath. Use a transparent liquid bath of sufficient depth such that at no time during the measurement will any portion of the sample in the viscometer be less than 2 cm below the surface or less than 2 cm above the bottom. The bath shall be cylindrical in shape, with turbulent agitation sufficient to meet the temperature control requirements. For measurements with 15°C to 100°C the temperature of the bath medium shall not vary by more than 0.10°C over the viscometer, or at the locations of the thermometers. Outside this range, the variation shall not exceed 0.03°C .

(d) thermometers. Use liquid-in-glass kinematic viscosity test thermometers, covering the range of test temperatures given in table 4 and conforming to the requirements of ASTM E1-68 and in the International Practical (IP) requirements for IP standard thermometers. Standardize before use [see 8.3 (b)].

(e) timing device. Stop watch or other timing device graduated in divisions representing not more than 0.2 s, with an accuracy of at least $\pm 0.05\%$ when tested over intervals of 15 min. Electrical timing devices may be used when the current frequency is controlled to an accuracy of 0.01% or better.

Table 4 – Kinematic viscosity thermometers

| Temperature range | For test at | Subdivision | Thermometer # | |
|---------------------|------------------|------------------|---------------|--------|
| $^\circ\text{C}$ | $^\circ\text{C}$ | $^\circ\text{C}$ | ASTM | IP |
| -55.3 to - 52.5 | -55 | 0.05 | 74 F | 69 F/C |
| - 41.4 to - 38.6 | -40 | 0.05 | 73 F | 68 F/C |
| 98.6 to 101.4 | 100 | 0.05 | 30 F | 32 F/C |

* Society of Automotive Engineers (SAE)

8.3 Standardization

(a) for viscometer. Use a viscometer calibrated as detailed in appendix 1 of ASTM D445-86. The calibration constant, C , is dependent upon the gravitational acceleration at the place of calibration. This together with the instrument constant must be supplied by the standardisation laboratory. Where the acceleration of gravity, g , in the two locations differs by more than 0.1%, correct the calibration constant according to the equation:

$C_2 = (g_2/g_1) \times C_1$, where the subscripts 1 and 2 indicate respectively the standardization laboratory and the testing laboratory.

(b) for thermometers. Check liquid-in-glass thermometers to the nearest 0.01°C by direct comparison with a standardized thermometer. Kinematic viscosity test thermometers shall be standardized at 'total immersion'. The ice point of standardized thermometers shall be determined before use and the official corrections shall be adjusted to conform to the changes in ice points. (see ASTM E77-84).

8.4 Procedure

(a) set and maintain the bath at the appropriate test temperature (see 3.3) within the limits specified in 8.2 (c). Apply the necessary corrections, if any, to all thermometer readings;

(b) select a clean, dry, calibrated viscometer giving a flow time not less than its specified minimum, or 200s whichever is the greater;

(c) charge the viscometer in the manner used when the instrument was calibrated. Do not filter or dry the brake fluid, but protect it from contamination by dirt and moisture during filling and measurements;

1. charge the suspended level viscometer by tilting about 30° from the vertical and pouring sufficient brake fluid through the fill tube into the lower reservoir so that when the viscometer is returned to vertical position the meniscus is between the fill marks. For measurements below 0°C, before placing the filled viscometer into the constant temperature bath, draw the sample into working capillary and timing bulb and insert small rubber stoppers to suspend the fluid in this position, to prevent accumulation of water condensate on the walls of the critical portions of the viscometer. Alternatively, fit loosely packed drying tubes into the open ends of the viscometer to prevent water condensation, but do not restrict the flow of the sample under test by the pressures created in the instrument.

(2) if a Cannon-Fenske routine viscometer is used, charge by inverting and immersing the smaller arm into the brake fluid and applying vacuum to the larger arm. Fill the tube to the upper timing mark, and return the viscometer to an upright position.

(d) mount the viscometer in the bath in a true vertical position [see 8.2 (b)];

(e) the viscometer shall remain in the bath until it reaches the test temperature;

(f) at temperatures below 0°C conduct an untimed preliminary run by allowing the brake fluid to drain through the capillary into the lower reservoir after the test temperature has been established.

(g) adjust the head level of the brake fluid to a position in the capillary arm about 5 mm above the first timing mark.

(h) with brake fluid flowing freely measure to within 0.2 s the time required for the meniscus to pass from the first timing mark to the second. If this flow time is less than the minimum specified for the viscometer, or 200 s, whichever is greater, repeat using a viscometer with a capillary of small diameter.

(i) repeat 4.3.4 (g) and (h). If the two timed runs do not agree within 0.2%, reject and repeat using a fresh sample of brake fluid.

8.5 Cleaning the viscometer

8.5.1 Periodically clean the instrument with chromic acid to remove organic deposits. Rinse thoroughly with distilled water and acetone, and dry with clean dry air.

8.5.2 Between successive samples rinse the viscometer with ethanol (isopropanol when testing DOT 5 fluids) followed by an acetone or ether rinse. Pass a slow stream of filtered dry air through the viscometer until the last trace of solvent is removed.

8.6 Calculation

8.6.1 The following viscometers have a fixed volume charged at an ambient temperature, and as a consequence the calibration constant C varies with test temperature: Cannon-Fenske routine, Penkevitch, Cannon Manning semi-micro, and Cannon Fenske opaque. Calculate C at test temperatures other than the calibration temperature for these viscometers, as given ASTM D2515-66.

8.6.2 Average the four timed runs on the duplicate samples to determine the kinematic viscosities.

8.7 Precision (at 95% confidence level).

If results on duplicate samples by the same operator differ by more than 1% of their mean repeat the tests.

9. Determination of pH value.

The pH value of a brake fluid is determined by running one sample according to the procedure given in 9.5.

9.1 Summary of the procedure. Brake fluid is diluted with an equal volume of an ethanol-water solution. The pH of the resultant mixture is measured with a prescribed pH metre assembly at 23°C.

9.2 Apparatus. The pH assembly consists of the pH metre, glass electrode, and calomel electrode, as detailed in appendices A.1, A1.2 and A1.3 of ASTM D 1121. The glass electrode is a full range type (pH 0 to 14), with low sodium error.

9.3 Reagents. Reagent grade chemicals conforming to the specifications of the Committee on Analytical Reagents of the American Chemical society are required. These shall include:

(a) distilled water. Distilled water (see A.1) shall be boiled for about 15 min to remove carbon dioxide, and protected with a soda-lime tube or its equivalent while cooling and in storage (take precautions to prevent contamination by the materials used for protection against carbon dioxide). The pH of the boiled distilled water shall be between 6.2 and 7.2 at 25°C;

(b) Standard buffer solutions. Prepare buffer solutions for calibrating the pH meter and electrode pair from salts sold specifically for use, either singly or in combination, as pH standards. Dry salts for 1 h at 110°C before use except for borax which shall be used as the decahydrate. Store solutions with pH less than 9.5 in bottles of chemically resistant glass or polyethylene. Store the alkaline phosphate solution in a glass bottle coated inside with paraffin. Do not use a standard with an age exceeding three months. The following buffer solutions may be used:

(1) potassium hydrogen phthalate buffer solution (0.05 M, pH = 4.01 at 25°C). Dissolve 10.21 g of potassium hydrogen phthalate (KHCH_4O_4) in distilled water. Dilute to 1 L.

(2) neutral phosphate buffer solution (0.025 M with respect to each phosphate salt, pH = 6.86 at 25°C). Dissolve 3.40 g of potassium dihydrogen phosphate (KH_2PO_4) and 3.55 g of anhydrous disodium hydrogen phosphate (Na_2HPO_4) in distilled water. Dilute to 1 L.

(3) borax buffer (0.01 M, pH = 9.18 at 25°C). Dissolve 3.81 g of disodium tetraborate decahydrate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$) in distilled water, and dilute to 1 L. Stopper the bottle except when actually in use.

(4) alkaline phosphate buffer solution (0.01 M trisodium phosphate, pH = 11.72 at 25°C). Dissolve in 1.42 g of anhydrous disodium hydrogen phosphate (Na_2HPO_4) in 100 ml of a 0.1 M carbonate-free solution of sodium hydroxide, dilute to 1L with distilled water

(5) potassium chloride electrolyte. Prepare a saturated solution of potassium chloride (KCl) in distilled water.

(c) ethanol- water mixture. To 80 parts by volume of ethanol (see A.3) add 20 parts by volume of distilled water. Adjust the pH of the mixture to 7 ± 0.1 using 0.1 N sodium hydroxide (NaOH) solution. If more than 4 ml of NaOH solution per L of mixture is required for neutralization, discard the mixture.

9.4 Preparation of electrode system

9.4.1 Maintenance of electrodes. Clean the glass electrode before using by immersing in cold chromic acid cleaning solution. Drain the calomel electrode and fill with KCl electrolyte, keeping level above that of the mixture at all times. When not in use, immerse the lower halves of the electrodes in distilled water, and do not immerse in the mixture for any appreciable period of time between determinations.

9.4.2 Preparation of electrodes. Condition new glass electrodes and those that have been stored dry as recommended by the manufacturer. Before and after using, wipe the glass electrode thoroughly with a clean cloth, or a soft absorbent tissue, and rinse with distilled water. Before each pH determination, soak the prepared electrode in distilled water for at least 2 min, Immediately before use remove any excess water from the tips of the electrode.

9.5 Procedure for standardization of the pH assembly and testing of the electrodes.

9.5.1 Immediately before use, standardize the pH assembly with a standard buffer solution. Then use a second standard buffer solution to check the linearity of the response of the electrodes at different pH values, and to detect a faulty glass electrode or incorrect temperature compensation. The two buffer solutions bracket the anticipated pH value of the test brake fluid

9.5.2 Allow instrument to warm up, and adjust according to the manufacturer's instructions. Immerse the tips of the electrodes in a standard buffer solution and allow the temperature of the buffer solution and the electrodes to equalize. Set the temperature knob at the temperature of the buffer solution. Adjust the standardization or asymmetry potential control until the metre registers a scale reading, in pH units, equal to the known pH of the standardizing buffer solution.

9.5.3 Rinse the electrodes with distilled water and remove excess water form the tips. Immerse the electrodes in a second standard buffer solution. The reading of the metre shall agree with the known pH of the second standard buffer solution within ± 0.05 unit without changing the setting of the standardization of asymmetry potential control.

9.5.4 A faulty electrode is indicated by failure to obtain a correct value for the pH of the second buffer solution after the metre has been standardized with the first.

9.6 Procedure. To 50 ± 1 ml of the test brake fluid add 50 ± 1 ml of the ethanol-water [9.3 (c)] and mix thoroughly. Immerse the electrodes in the mixture. Allow the system to come to equilibrium, readjust the temperature compensation if necessary, and take the pH reading.

10. Evaluation of fluid stability

The heat and chemical stability of a brake fluid is evaluated by the procedure given, running duplicate samples for each test and averaging the results.

10.1 Summary of the procedure. The degradation of the brake fluid at elevated temperature, alone or in a mixture with a reference fluid, is evaluated by determining the change in boiling point after a period of heating under reflux conditions.

10.2 Apparatus. Use the apparatus and preparation described in 6.2 and 6.3.

10.3 High temperature stability.

10.3.1 Procedure. Heat a new 60 ± 1 ml sample of the brake fluid to $185 \pm 2^\circ\text{C}$. Hold at this temperature for 120 ± 5 min. Bring to a reflux rate in excess of 1 drop per s within 5 min. The reflux rate should not exceed 5 drops per s at any time. Over the next 5 ± 2 min adjust the heating rate to obtain an equilibrium reflux rate of 1 to 2 drops per s. Maintain this rate for an additional 2 min, taking four temperature readings at 30-s intervals. Average these as the observed ERBP. If no reflux is evident when the fluid temperature reaches 260°C , discontinue heating and report ERBP as in excess of 260°C .

10.3.2 Calculation. Correct the observed ERBP for thermometer and barometric pressure factors according to 6.4 (a) and 6.4 (b). Average the corrected ERBPs of the duplicate samples. The difference between this average and the original ERBP obtained in clause 6 is the change in ERBP of the fluid.

10.4 Chemical stability.

10.4.1 Materials. The materials shall consist of SAE RM –66 –03 Compatibility fluid, as described in appendix A of SAE Standard J1703.

10.4.2 Procedure. Mix 30 ± 1 ml brake fluid with 30 ± 1 ml of SAE RM – 66 – 03 Compatibility fluid in a boiling point flask. Determine the initial ERBP of the mixture by applying heat to the flask so that the fluid is refluxing in 10 ± 2 min at a rate in excess of 1 drop per s, but not more than 5 drops per s. Note the maximum fluid temperature observed during the first minute after the fluid begins refluxing at a rate in excess of 1 drop per s. Over the next 15 ± 1 min, adjust and maintain the reflux rate at 1 to 2 drops per s. Maintain this rate for an additional 2 min, recording the average value of four temperature readings taken at 30 – s intervals as the final ERBP.

Thermometer and barometric corrections are not required.

10.4.3 Calculation. The difference between the initial ERBP and the final average temperature is the change in temperature of the refluxing mixture. Average the results of the duplicates to the nearest 0.5°C .

11. Evaluation of corrosiveness

The corrosiveness of a brake fluid shall be evaluated by running duplicate samples according to the procedure given.

11.1 Summary of the procedure. Six specified metal corrosion test strips are polished, cleaned and weighed, then assembled as described. Assembly is placed on a standard wheel cylinder cup in a corrosion test jar, immersed in the water-wet brake fluid, capped and placed in an oven at 100°C for 120 h. Upon removal and cooling, the strips, fluid, and cups are examined and tested.

11.2 Equipment

(a) balance. An analytical balance having a minimum capacity of 50 g and capable of weighing to the nearest 0.1 mg.

(b) desiccators. Desiccators containing silica gel or other suitable desiccant.

(c) oven. Gravity convection oven capable of maintaining the desired set point within 2°C .

(d) micrometre. A machinist's micrometre 25 mm to 50 mm capacity, or an optical comparator, capable of measuring the diameter of the SBR wheel cylinder (WC) cups to the nearest 0.02 mm.

11.3 Materials

(a) corrosion test strips. Two sets of strips from each of the metals given in appendix C of SAE Standard J1703 (b) Each strip shall be approximately 8 cm long, 1.3 cm wide, not more than 0.6 cm thick, and have a surface area of $25 \pm 15 \text{ cm}^2$ and a hole 4 mm to 5 mm in diameter on the centreline about 6 mm from one end. The hole shall be clean and free from burrs. Tinned iron strips shall not be used. Other strips, if used, shall not be employed if they cannot be polished to a high finish.

(b) SBR cups. Two unused standard SAE and SBR wheel cylinder (WC) cups, as detailed in A.6.

(c) corrosion test jars and lids. Two screw-top straight-sided round glass jars, each having a capacity of approximately 475 ml and inner dimensions of approximately 100 mm in height and 75 mm in diameter, and a tinned steel lid (no insert or organic coating) vented with a hole $0.8 \pm 0.1 \text{ mm}$ in diameter (No. 68 drill).

(d) machine screws and nut. Clean, rust and oil-free, uncoated mild steel round or fillister head machine screws, size 6 or 8-32 of UNC*-class 2A 16 mm or 19 mm, matching uncoated nuts.

(e) supplies for polishing strips. Waterproof silicon carbide paper, grit No. 320 A; grade 00 steel wool, lint-free polishing cloth.

(f) distilled water as detailed in A.1

(g) ethanol as detailed in A.3

(f) isopropanol as detailed in A.7

11.4 Preparation of materials

11.4.1 Corrosion test strips. Except for the tinned iron strips, abrade corrosion test strips on all surface areas with silicon carbide paper wet with ethanol (isopropanol when testing DOT 5 fluids) until all surface scratches, cuts and pits are removed. Use a new piece of paper for each different type of metal. Polish the strips with the 00 grade steel wool. Wash all strips, including the tinned iron and the assembly hardware, with ethanol (isopropanol when testing DOT 5 fluids). Dry the strips and assembly hardware with a clean lint-free cloth or use filtered compressed air and place the strips and hardware in a desiccator containing silica gel or other suitable desiccant and maintained at $23^\circ \pm 5^\circ\text{C}$, for at least 1 h. Handle the strips with forceps after polishing. Weigh and record the weight of each strip to the nearest 0.1 mg.

Assemble the strips on a clean dry machine screw, with matching plain nut, in the order of tinned iron, steel, aluminium, cast iron, brass, and copper. Bend the strips, other than the cast iron, so that there is a separation of

$3 \pm 0.5 \text{ mm}$ between adjacent strips for a distance of about 5 cm from the free end of the strips (see figure 4). Tighten the screw on each test strip assembly so that the strips are in electrolytic contact, and can be lifted by either of the outer strips (tinned iron or copper) without any of the strips moving relative to the others when held horizontally. Immerse the strip assemblies in 90% ethyl alcohol. Dry with dried filtered compressed air, then desiccate at least 1 h before use.

11.4.2 SBR WC cups. Measure the base diameter of the two standard SBR cups, using an optical comparator or micrometre, to the nearest 0.02 mm along the centreline of the SAE and rubber-type identifications and at right angles to this centreline. Take the measurements at least 0.4 mm above the bottom edge parallel to the base of the cup. Discard any cup if the two measured diameters differ by more than 0.08 mm. Average the two readings on each cup. Determine the hardness of the cups as detailed in appendix A.4.

* Unified Course (UNC)

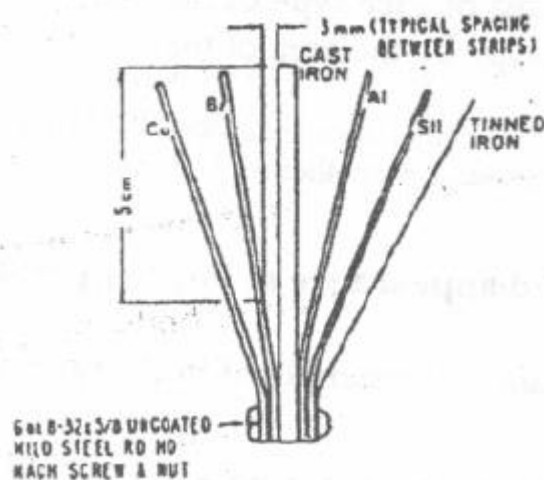


Figure 4. Corrosion strip assembly

11.5 Procedure. Rinse the cups in ethanol (isopropanol when testing DOT 5 fluids) for not more than 30 s and wipe drum with a clean lint-free cloth. Place one cup with lip edge facing up, in each jar. Insert a metal strip assembly inside each cup with the fastened end down and the free end extending upward (see figure 5). When testing DOT 3 and DOT 4 brake fluids, mix 760 ml of brake fluid with 40 ml of distilled water.

When testing DOT 5 brake fluids, humidify 800 ml of brake fluid in accordance with 7.2, eliminating determination of the ERBP; using this water-wet mixture cover each strip assembly to a minimum depth of 10 mm above the tops of the strips. Tighten the lids and place the jars for 120 ± 2 h in an oven maintained at $100^\circ \pm 2^\circ\text{C}$. Allow the jars to cool at $23^\circ \pm 5^\circ\text{C}$ for 60 min to 90 min. Immediately remove the strips from the jars using forceps, agitating the strip assembly in the fluid to remove loose adhering sediment. Examine the test strips and jars for adhering crystalline deposits. Disassemble the metal strips, and remove adhering fluid by flushing with water; clean each strip by wiping with a clean cloth moistened with ethanol (isopropanol when testing DOT 5 fluids). Examine the strips for evidence of corrosion and pitting. Disregard staining or discoloration. Place the strips in a desiccator containing silica gel or other suitable desiccant, maintained at $23^\circ \pm 5^\circ\text{C}$ for at least 1 h. Weigh each strip to the nearest 0.1 mg. Determine the change in weight of each metal strip. Average the results for the two strips of each type of metal.

Immediately following the cooling period, remove the cups from the jars with forceps. Remove loose adhering sediment by agitation of the cups in the mixture. Rinse the cups in ethanol (Isopropanol when testing DOT 5 fluids) and air-dry. Examine the cups for evidence of sloughing, blisters, and other forms of disintegration. Measure the base diameter and hardness of each cup within 15 min after removal from the mixture. Examine the mixture for gelling. Agitate the mixture to suspend and uniformly disperse sediment. From each jar, transfer a 100 ml portion of the mixture to an ASTM cone-shaped centrifuge tube. Determine the percentage sediment after centrifuging as described in A.5. Measure the pH value of the mixture according to 9.6. Measure the pH value of the DOT 3 and DOT 4 test mixture according to 9.6.

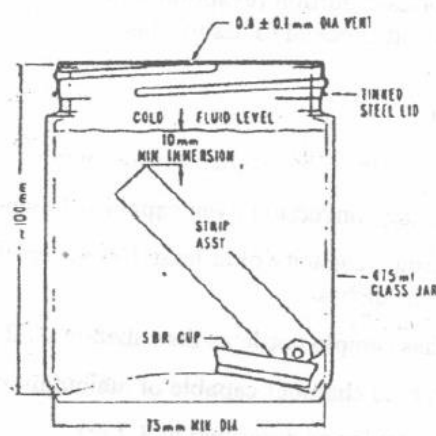


Figure 5. Corrosion test apparatus

11.6 Calculation. Measure the area of each type of test strip to the nearest square centimetre. Divide the average change in weight for each type by the area of that type.

NOTE. Other data and evaluations indicating compliance are given in 3.6. In the event of a marginal pass on inspection by attributes, or of a failure in one of the duplicates, run another set of duplicate samples. Both repeat samples shall meet the requirements of 3.6.

12. Determination of fluidity and appearance at low temperatures

Determine the fluidity and appearance of a sample of brake fluid at each of two selected temperatures according to procedure given.

12.1 Summary of procedure. Brake fluid is chilled to expected minimum exposure temperatures and observed for clarity, gelation, sediment, separation of components, excessive viscosity or thixotropy.

12.2 Apparatus

- (a) oil sample bottle. Two clear flint glass 113.4 g bottles made especially for sampling oil and other liquids with a capacity of approximately 125 ml, an outside diameter of 37 ± 0.05 mm and an overall height of 165 ± 2.5 mm
- (b) cold chamber. An air bath cold chamber capable of maintaining storage temperatures down to -55°C with an accuracy of $\pm 2^{\circ}\text{C}$.
- (c) timing device. A timing device used in accordance with the requirements of 8.2 (e).

12.3 Procedure

- (a) Place 100 ± 1 ml of brake fluid at room temperature in an oil sample bottle. Stopper the bottle with an unused cork and place in the cold chamber at the higher storage temperature given in table 2. After 144 ± 4 h remove the bottle from the chamber, quickly wipe it with a clean, lint-free cloth, saturated with ethanol (isopropanol when testing DOT 5 fluids) or acetone. Examine the fluid for evidence of sludging, sedimentation, crystallization, or stratification. Invert the bottle and determine the number of seconds required for the air bubble to travel to the top of the fluid. Let sample warm to room temperature and examine.
- (b) Repeat 12.3 (a), substituting the lower cold chamber temperature given in table 2, and a storage period of $6 \text{ h} \pm 12 \text{ min}$.

NOTE. Test specimens from either storage temperature may be used for the other temperature.

13 Determination of evaporation residue

The evaporation residue and pour point of the evaporation residue of brake fluid are determined by procedure given. Four replicate samples are run.

13.1 Summary of the Procedure. The volatile diluent portion of a brake fluid is evaporated in an oven at 100°C. The non-volatile lubricant portion (evaporation residue) is measured and examined for grittiness; the residues are then combined and checked to assure fluidity at - 5°C.

13.2 Apparatus

- (a) petri dishes. Four covered glass petri dishes approximately 100 mm in diameter and 15 mm in height.
- (b) oven. A top-vented gravity-convection oven capable of maintaining a temperature of $100^{\circ} \pm 2^{\circ}\text{C}$.
- (c) balance. A balance having a capacity of at least 100 g, capable of weighing to the nearest 0.01 g, and suitable for weighing the petri dishes
- (d) oil sample bottle. A glass sample bottle as described in 12.2 (a).
- (e) cold chamber. Air bath cold chamber capable of maintaining an oil sample bottle at $- 5^{\circ} \pm 1^{\circ}\text{C}$.
- (f) timing device. A timing device as described in 8.2 (e).

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13.3 Procedure. Obtain the tare weight of each of the four covered petri dishes to the nearest 0.01 g. Place 25 ± 1 ml of brake fluid in each dish, replace proper covers and re-weigh. Determine the weight of each brake fluid test specimen by the difference. Place the four dishes, each inside its inverted cover, in the oven at $100^{\circ} \pm 2^{\circ}\text{C}$ for 46 ± 2 h. (see NOTE).

Remove the dishes from the oven, allow to cool to $23^{\circ} \pm 5^{\circ}\text{C}$ and weigh. Return to the oven for an additional 24 ± 2 h. If at the end of 72 ± 4 h the average loss by evaporation is less than 60%, discontinue the evaporation procedure and proceed with examination of the residue. Otherwise, continue this procedure either until equilibrium is reached as evidenced by an incremental weight loss of less than 0.25 g in 24 h on all individual dishes or for a maximum of 7 days.

During the heating and weighing operation, if it is necessary to remove the dishes from the oven for a period of longer than 1 h, the dishes shall be stored in a desiccator as soon as cooled to room temperature. Calculate the percentage of fluid evaporated from each dish.

Examine the residue in the dishes at the end of 1 h at $23^{\circ} \pm 5^{\circ}\text{C}$. Rub any sediment with the fingertip to determine grittiness or abrasiveness. Combine the residues from all four dishes in a 113.4 g oil sample bottle and store vertically in a cold chamber at $- 5^{\circ} \pm 1^{\circ}\text{C}$ for 60 ± 10 min. Quickly remove the bottle and place in the horizontal position. The residue must flow at least 5 mm along the tube within 5 s.

NOTE. Do not simultaneously heat more than one fluid in the same oven.

13.4 Calculation. The average of the percentage evaporated from all four dishes is the loss by evaporation.

14. Evaporation of water tolerance

The water tolerance characteristics of a brake fluid are evaluated by running one test specimen according to the procedure given.

14.1 Summary of the procedure. DOT 3 and DOT 4 brake fluid are diluted with 3.5% water, and DOT 5 brake fluid is humidified, then stored at - 40°C for 120 h. The cold, water-wet fluid is first examined for clarity, stratification, and sedimentation, then placed in an oven at 60°C for 24 h. On removal, it is again examined for stratification, and the volume per cent of sediment determined by centrifuging.

14.2 Apparatus

- (a) centrifuge tube [see appendix A.5.1 (a)]
- (b) centrifuge [see appendix A.5.1 (b)]

- (c) cold chamber [see 12.2 (b)]
- (d) oven. Gravity of forced convection oven
- (e) timing device [see 8.2. (e)]

14.3 Procedure

(a) at low temperature. Humidify 100 ± 1 ml of DOT 5 brake fluids, mix 3.5 ± 0.1 ml of distilled water with 100 ± 1 ml of the brake fluid; pour into a centrifuge tube. Stopper the tube with a clean cork and place in the cold chamber maintained at $-40 \pm 2^\circ\text{C}$. After $120 \text{ h} \pm 2\text{h}$ remove the tube, quickly wipe with clean lint-free cloth saturated with ethanol or acetone and examine the fluid for evidence of sludging, sedimentation, crystallization, or stratification. Invert the tube and determine the number of seconds required for the air bubble to travel to the top of the fluid. (The air bubble is considered to have reached the top of the fluid when the top of the bubble reaches the 2 ml graduation of the centrifuge tube). If the wet fluid has become cloudy, warm to $23 \pm 5^\circ\text{C}$ and note appearance and fluidity.

(b) at 60°C . Place tube and brake fluid from 14.3 (a) in an oven maintained at $60^\circ \pm 2^\circ\text{C}$ for 24 ± 2 h. Remove the tube and immediately examine the contents for evidence of stratification. Determine the percentage sediment by centrifuging as detailed in A.5.

15. Evaluation of compatibility

The compatibility of a brake fluid with other brake fluids shall be evaluated by running one test sample according to the procedure given.

15.1 Summary of the procedure. Brake fluid is mixed with an equal volume of SAE-RM-66-03 compatibility fluid, then tested in the same way as for water tolerance (see clause 14) except that the bubble flow time is not measured. This test is an indication of the compatibility of the test fluid with other motor vehicle brake fluids at both high and low temperatures.

15.2 Apparatus and materials

- (a) centrifuge tube [see A.5.1 (a)]
- (b) centrifuge [see A.5.1 (b)]
- (c) cold chamber [see 12.2 (b)]
- (d) oven [see 14.2 (d)]
- (e) except as given in 15.1 SAE RM-66-03. As described in appendix A of SAE Standard JS 1702.

15.3 Procedure

(a) at low temperature. Mix 50 ± 0.5 ml of brake fluid with 50 ± 0.5 ml of SAE RM-66-03 compatibility fluid. Pour this mixture into a centrifuge tube and stopper with a clean dry cork. Place the tube in the cold chamber maintained at $-40^\circ \pm 2^\circ\text{C}$. After 24 ± 2 h, remove tube, quickly wipe with a clean lint-free cloth saturated with ethanol (isopropanol when testing DOT 5 fluids) or acetone. Examine the test specimen for evidence of sludging, sedimentation, or crystallization. DOT 3 and DOT 4 test fluids shall also be examined for stratification.

(b) at 60°C . Place tube and test fluid from 15.3 (a) for 24 ± 2 h in an oven maintained at $60^\circ \pm 2^\circ\text{C}$. Remove the tube and immediately examine the contents of DOT 3 and DOT 4 test mixtures for evidence of stratification. Determine the percentage sediment by centrifuging as detailed in A.5

16. Evaluation of resistance to oxidation

The stability of a brake fluid under oxidative conditions shall be evaluated by running duplicate samples according to the procedure given.

16.1 Summary of the procedure. DOT 3 and DOT 4 brake fluids are activated with a mixture of approximately 0.2% benzoyl peroxide and 5% water. DOT 5 brake fluid is humidified in accordance with the requirement of clause 7 eliminating determination of the ERBP and then approximately 0.2% benzoyl peroxide is added. A corrosion test strip assembly consisting of cast iron and an aluminium strip separated by tinfoil squares at each end is then rested on a piece of SBR WC cup positioned so that the test strip is half immersed in the fluid, and oven-aged at 70°C for 168 h. At the end of this period the metal strips are examined for pitting, etching, and weight loss.

16.2 Equipment

- (a) balance. [see 11.2 (a)]
- (b) desiccators. [see 11.2 (b)]
- (c) oven. [see 11.2 (c)]
- (d) three glass test tubes approximately 22 mm outside diameter by 175 mm in length.

16.3 Reagents and materials

- (a) benzoyl peroxide, reagent grade, 96%. (Benzoyl peroxide that is brownish, or dusty, or has less than 90% purity, must be discarded). Reagent strength may be evaluated by ASTM E298 –84.
- (b) corrosion test strips. Two sets of cast iron and aluminium metal test strips as detailed in appendix C of SAE Standard J1703b.
- (c) tinfoil. Four unused pieces of tinfoil approximately 12 mm square and between 0.02mm and 0.06 mm in thickness. The foil shall be at least 99.9% tin and contain not more than 0.025% lead.
- (d) SBR cups. Two unused, approximately one-eighth sections of a standard SAE SBR WC cup as detailed in A.6
- (e) machine screw and nut. Two clean oil-free, No. 6 or 8 (813 mm x 9.5 mm or 12.7 mm) long, round or fillister head, uncoated mild steel machine screws, with matching plain nuts.

16.4 Preparation.

- (a) corrosion test strips. Prepare two sets of aluminium and cast iron test strips according to 4.6.4 (a) except for assembly. Weigh each strip to the nearest 0.1 mg and assemble a strip of each metal on a machine screw, separating the strips at each end with a piece of tinfoil firmly in place.
- (b) test mixture. Place 30 ± 1 ml of the brake fluid under test in a 22 mm by 175 mm test tube. For DOT 3 and DOT 4 fluids, add 0.060 ± 0.002 g of benzoyl peroxide, and 0.50 ± 0.05 ml of distilled water. For DOT 5 fluids, use test fluid humidified in accordance with clause 7 and add only the benzoyl peroxide. Stopper the tube loosely with a clean dry cork, shake, and place in an oven for 2 h at $70^\circ \pm 2^\circ\text{C}$. Shake every 15 min. to effect solution of the peroxide, but do not wet cork. Remove the tube from the oven and allow to cool to $23 \pm 5^\circ\text{C}$. Begin testing accordance to the requirement of 10.5 not later than 24 h after removal of tube from oven.

16.5 Procedure. Place a one-eighth SBR cup section in the bottom of each tube. Add 10 ml of prepared test mixture to each test tube. Place a metal strip assembly in each, the end of the strip without the screw resting on the rubber, and the solution covering about one-half the length of the strips. Stopper the tube with clean dry corks and store upright for 70 ± 2 h at $23 \pm 5^\circ\text{C}$. Loosen the corks and place the tubes for 168 ± 2 h in an oven maintained at $70 \pm 2^\circ\text{C}$. Afterwards remove and disassemble strips. Examine the strips and note any gum deposits. Wipe the strips with a clean cloth wet with ethanol (Isopropanol when

testing DOT 5 fluids) and note any pitting, etching or roughening of surface disregarding stain or discolouration. Place the strips in a desiccator over silica gel or other suitable desiccant, at $23 \pm 5^\circ\text{C}$ for at least 1 h. Again weigh each strip to the nearest 0.1 mg.

16.6 Calculation. Determine corrosion loss by dividing the change in weight of each metal strip by the total surface area of each strip measured in cm^2 to the nearest cm^2 . Average the results for the two strips of each type of metal, rounding to the nearest 0.05 mg per cm^2 . If only one of the duplicates fails for any reason, run a second set of duplicate samples. Both repeat samples shall conform to the requirements of 3.11.

17. Effect on SBR cups

The effect of a brake fluid in swelling, softening, and otherwise affecting standard SBR WC cups shall be evaluated by the procedure given.

17.1 Summary of the Procedure. Four standard SAE SBR WC cups are measured and their hardness determined. The cups, two to a jar, are immersed in the test brake fluid. One jar is heated for 70 h at 20°C and the other for 70 h at 120°C . Afterwards, the cups are washed, examined for disintegration, as well as measured and their hardness determined.

17.2 Equipment and supplies

(a) oven. [See 11.2 (c)]

(b) glass jars and lids. Two screw top, straight-sided round glass jars, each having a capacity of approximately 250 ml and inner dimensions of approximately 125 mm in height and 50 mm in diameter and a tinned steel lid (no insert or organic coating).

(c) SBR cups. (See A.6)

17.3 Preparation. Measure the base diameters of the SBR cups as described in 11.4.2 and the hardness of each as detailed in A.4

17.4 Procedure. Wash the cups in 90% ethanol (isopropanol when testing DOT 5 fluids) (see A.3) for not longer than 30 s and quickly dry with a clean, lint-free cloth. Using forceps, place two cups into each of the two jars; add 75 ml of brake fluid to each jar and cap tightly. Place one jar in an oven held at $70 \pm 2^\circ\text{C}$ for 70 ± 2 h. Place the other jar in an oven held at $120 \pm 2^\circ\text{C}$ for 70 ± 2 h. Allow each jar to cool for 60 min to 90 min at $23 \pm 5^\circ\text{C}$. Remove cups, wash with ethanol (isopropanol when testing DOT 5 fluids) for not longer than 30 s and quickly dry. Examine the cups for disintegration as evidenced by stickiness, blisters or sloughing. Measure the base diameter and hardness of each cup within 15 min after removal from the fluid.

17.5 Calculation

(a) calculate the change in base diameter for each cup. If the two values, at each temperature, do not differ by more than 0.10 mm, average them to the nearest 0.02 mm. If the two values differ by more than 0.10 mm repeat the test at the appropriate temperature and average the four values as the change in base diameter.

(b) calculate the change in hardness for each cup. The average of the two values for each pair is the change in hardness.

(c) note disintegration as evidenced by stickiness, blisters, or sloughing.

18 Stroking properties

Evaluate the lubricating properties, component compatibility, resistance to leakage, and related qualities of

a brake fluid by running one sample according to the procedures given.

18.1 Summary of the procedure. Brake fluid is stroked under controlled conditions at an elevated temperature in a simulated motor vehicle hydraulic braking system consisting of three slave wheel cylinders and an actuating master cylinder connected by steel tubing. Referee standard parts are used. All parts shall be carefully cleaned, examined and certain measurements made immediately prior to assembly for test. During the test, temperature, rate of pressure rise, maximum pressure and rate of stroking are specified and controlled. The system is examined periodically during stroking to assure that excessive leakage of fluid is not occurring. Afterwards, the system is torn down. Metal parts and SBR cups are examined and measured again. The brake fluid and any resultant sludge and debris are collected, examined, and tested.

18.2 Apparatus and equipment. Either the drum and shoe type of stroking apparatus [See figure 1 of SAE standard J1703 (b)] except those using only three sets of drum and shoe assemblies, or the stroking fixture type apparatus as shown in figure 2 of SAE J1703 with the components arranged as shown in figure 1 of SAE. The following components are required:

- (a) brake assemblies. With the drum and shoes apparatus three drum and shoe assembly units (See SAE RM-29a) consisting of three forward brake shoes and three reverse brake shoes with linings and three from wheel brake drum assemblies with assembly component parts. With stroking fixture type apparatus, three fixture units including appropriate adapter mounting plates to hold brake wheel cylinder assemblies.
- (b) braking pressure actuation mechanism. An actuating mechanism for applying force to the master cylinder pushrod without side thrust. The amount of force applied by the actuating mechanism shall be adjustable and capable of applying sufficient thrust to the master cylinder to create a pressure of at least 70 kg per cm² in the simulated brake system. A hydraulic gauge or pressure recorder having range of at least 0 kg cm² to 70 kg cm² shall be installed between the master cylinder and the brake assemblies and shall be provided with a shutoff valve and with a bleeding valve for removing air from the connecting tubing. The actuating mechanism shall be designed to permit adjustable stroking rates of approximately 1.00 strokes per h. Use a mechanical or electrical counter to record the total number of strokes.
- (c) heated air bath cabinet. An insulated cabinet or oven having sufficient capacity to house the three mounted brake assemblies, master cylinder, and necessary connections. A thermostatically controlled heating system is required to maintain a temperature of $70 \pm 5^{\circ}\text{C}$ or $120 \pm 5^{\circ}\text{C}$. Heaters shall be shielded to prevent direct radiation to wheel or master cylinder.
- (d) master cylinder (MC) assembly (See SAE RM-15a). One cast iron housing hydraulic brake system cylinder having a diameter of approximately 28 mm and fitted for a filler cap and standpipe [See 18.2 (e)]. The master cylinder piston shall be made from SAE CA 380 copper-based alloy (half -hard). A new (MC) assembly is required for each test.
- (e) filler cup and standpipe. Master cylinder (MC) filler cap provided with a glass or uncoated steel standpipe. Standpipe must provide adequate volume for thermal expansion, yet permit measurement and adjustment of the fluid level in the system to 3 ml. Cap and standpipe may be cleaned and reused.
- (f) wheel cylinder (WC) assemblies (see SAE RM-14a). Three unused cast iron housing straight bore hydraulic brake WC assemblies having diameters of approximately 28 mm for each test. Pistons shall be made from unanodized SAE AA 2024 aluminium alloy.
- (g) micrometre as given in 11.2 (d)

18.3 Materials

- (a) standard SBR brake cups. Six standard SAE SBR wheel cylinder test cups, one primary MC test cup and one secondary MC test cup, as described in A.6 for each test.

(b) steel tubing. Double wall steel tubing meeting the requirement of SAE standard specification J527. A complete replacement of tubing is essential when visual inspection indicates any corrosion or deposits on inner surface of tubing. Tubing from master cylinder to one wheel cylinder shall be replaced for each test (minimum length 915 mm). Uniformity in tubing size is required between master cylinder and wheel cylinder. The standard master cylinder has two outlets for tubing, both of which shall be used.

18.4 Preparation of test apparatus.

18.4.1 wheel cylinder assemblies. Use unused wheel cylinder assemblies. Disassemble cylinders and discard cups. Clean all metal parts with ethanol (isopropanol when testing DOT 5 fluids). Inspect the working surfaces of all metal parts for scoring, galling, or pitting and cylinder bore roughness; and discard all defective parts. Remove any stains on cylinder walls with crocus cloth and ethanol (isopropanol when testing DOT 5 fluids). If stains cannot be removed, discard the cylinder. Measure the internal diameter of each cylinder bore, taking measurements in line with the hydraulic inlet opening and at right angles to this centreline. Discard the cylinder if any of these four readings exceeds the maximum or minimum limits of 28.66 mm to 28.60 mm.

Measure the outside diameter of each piston at two points approximately 90° apart. Discard any piston if either reading exceeds the maximum or minimum limits of 28.55 mm to 28.52 mm. Select parts to insure that the clearance between washer piston and mating cylinder is within 0.08 mm to 0.13 mm. Use unused SBR cups. To remove dirt and debris, rinse the cups in 90% ethyl alcohol for not more than 30 s and wipe dry with a clean lint-free cloth. Discard any cups showing defects such as cuts, moulding flaws, or blisters.

Measure the lip and base diameters of all cups with an optical comparator or micrometre to the nearest 0.02 mm along the centreline of the SAE and rubber type identifications and at right angles to this centreline. Determine base diameter measurements at least 0.4 mm above the bottom edge and parallel to the base of the cup.

Discard any cup if the two measured lip or base diameters differ by more than 0.08 mm. Average the lip and base diameters of each cup. Determine the hardness of all cups as detailed in A.4. Dip the rubber and metal parts of wheel cylinders, except housing and rubber boots, in the fluid to be tested and install them in accordance with the manufacturer's instructions. Manually stroke the cylinders to insure that they operate easily. Install cylinders in the simulated brake system.

18.4.2 master cylinder assembly. Use an unused master cylinder and unused standard SBR primary and secondary MC cups which have been inspected, measured and cleaned in the manner given in 18.4.1, omitting hardness of the secondary (MC) cup. However, prior to determining the lip and base diameters of the secondary cup, dip the cup in the test brake fluid, assemble on the MC piston and maintain the assembly in a vertical position at $23 \pm 5^\circ\text{C}$ for at least 12 h. Inspect the relief and supply ports of the master cylinder; discard the cylinder if ports have burrs or wire edges. Measure the internal diameter of the cylinder at two locations (approximately midway between the relief and supply ports and approximately 19 mm beyond the relief port toward the bottom or discharge end of the bore), taking measurements at each location on the vertical and horizontal centreline of the bore. Discard the cylinder if any reading exceeds the maximum or minimum limits of 28.65 mm to 28.57 mm. Measure the outside diameter of each end of the master cylinder piston at two points approximately 90° apart. Discard the piston if any of these four readings exceed the maximum or minimum limits of 28.52 mm. Dip the rubber and metal parts of the master cylinder, except the housing and push rod-boot assembly, in the brake fluid and install in accordance with manufacturer's instructions. Manually stroke the master cylinder in the simulated brake system.

18.4.3 assembly and adjustment of test apparatus.

18.4.3.1 When using a shoe and drum type apparatus, adjust the brake shoe toe clearance to 1.0 ± 0.1 mm. Fill the cylinder with brake fluid, bleeding all wheel cylinders and the pressure gauge to remove entrapped air. Operate the actuator manually to apply a pressure greater than the required operating pressure and inspect the system for leaks. Adjust the actuator and/or pressure relief valve to obtain a pressure of 70 ± 3.5 kg per cm². A smooth pressure-stroke pattern is required when using a shoe and drum type apparatus. The

pressure is relatively low during the first part of the stroke and then builds up smoothly to the maximum stroking pressure at the end of the stroke, to permit the primary cup to pass the compensating hole at a relatively low pressure. Using stroking fixtures, adjust the actuator and/or pressure relief valve to obtain a pressure of 70 ± 3.5 kg per cm^2 .

18.4.3.2 adjust the stroking rate to $1\,000 \pm 100$ strokes per h. Record the fluid level in the master cylinder standpipe.

18.5 Procedure. Operate the system for $16\,000 \pm 1\,000$ cycles at $25 \pm 5^\circ\text{C}$. Repair any leakage, readjust the brake shoe clearances, and add fluid to the master cylinder standpipe to bring to the level originally recorded, if necessary. Start the test again and raise the temperature of the cabinet within 6 ± 2 h to $120 \pm 5^\circ\text{C}$. During the test observe operation of wheel cylinders for improper functioning and record the amount of fluid required to replenish any loss at intervals of 24 000 strokes. Stop the test at the end of 85 000 total recorded strokes. These totals shall include the number of strokes during operation at $23 \pm 5^\circ\text{C}$ and the number of strokes required to bring the system to the operating temperature. Allow equipment to cool to room temperature. Examine the wheel cylinders for leakage. Stroke the assembly 100 times more, examine wheel cylinders for leakage and record volume loss of fluid.

Within 16 h after stopping the test, remove the master and wheel cylinders from the system, retaining the fluid in the cylinders by immediately capping or plugging the ports. Disassemble the cylinders, collecting the fluid from the master cylinder and wheel cylinders in a glass jar. When collecting the stroked fluid, remove all residue, which has deposited on rubber and metal internal parts by rinsing and agitating such in the stroked fluid and using a soft brush to assure that all loose adhering sediment is collected. Clean SBR cups in ethanol (isopropanol when testing DOT 5 fluids) and dry. Inspect the cups for stickiness, scuffing, blistering, cracking, chipping and change in shape from original appearance.

Within 1 h after disassembly, measure the lip and base diameters of each cylinder cup by the procedures given in 18.4.1 and 18.4.2 with the exception that lip or base diameters of each cylinder cups by the procedures given in 18.4.1 and 18.4.2 with the exception that the lip or base diameters of cups may now differ by more than 0.08 mm. Determine the hardness of each cup according to A.4. Note any sludge or gel present in the test fluid. Within 1 h after draining the cylinders, agitate the fluid in a glass jar to suspend and uniformly disperse sediment and transfer a 100 ml portion of this fluid to a centrifuge tube and determine per cent sediment recovered. Inspect cylinder parts, note any gumming or any pitting on pistons and cylinder walls. Disregard staining or discolouration. Rub any deposits adhering to cylinder walls with a clean soft cloth moistened with ethanol (isopropanol when testing DOT 5 fluids) and dry. Measure and record diameters of pistons and cylinders according to 18.4.1 and 18.4.2. Repeat the test if mechanical failure occurs that may affect the evaluation of the brake fluid.

18.6 Calculation

(a) calculate the changes in diameters of cylinders and pistons [see 3.13 (b)]

(b) calculate the average decrease in hardness of the seven cups tested, as well as the individual values [see 3.13 (c)]

(c) calculate the increases in base diameters of the eight cups [see 3.13 (c)]

(d) calculate the lip diameter interference set for each of the eight cups by the following formula and average the eight values [see 3.13 (f)]

$$[(D_1 - D_2)/(D_1 - D_2)] \times 100 = \text{percentage lip diameter interference set}$$

where:

D_1 = Original lip diameter

D_2 = Final lip diameter

Appendix A

Auxiliary test methods and reagent standards

A.1 Distilled water. Non referee reagent water as specified in ASTM D1193-70, or water of equal purity should be used.

A.2 Water content of motor vehicle brake fluids. Use analytical methods based on ASTM D1123-82, for determining the water content of brake fluids, or other methods of analysis yielding comparable results. To be acceptable for use, such other method must measure the weight of water added to samples of the SAE RM-66-03 and TEGME compatibility fluids within $\pm 15\%$ of the water added for additions up to 0.8% by weight, and within $\pm 5\%$ of the water added for additions greater than 0.8% by weight. The SAE RM –66-03 compatibility fluid used to prepare the samples must have an original ERBP of not less than 205°C when tested in accordance with 4.1. The SAE TEGME fluid used to prepare the samples shall have an original ERBP of not less than 240°C when tested in accordance with the requirement of clause 6.

A.3 Ethanol. 95% (190 proof) ethyl alcohol, United States Pharmacopoeial (USP) or American Chemical Society (ACS), or Formula 3-A (specially denatured alcohol of the same concentration). For pre-test washings of equipment used approximately 90% of ethyl alcohol, obtained by adding 5 parts of distilled water to 95 parts of ethanol.

A.4 Measuring the hardness of SBA brake cups. Hardness measurements on SBR wheel cylinder cups and master cylinder primary cups shall be made by using the following apparatus and the procedure given.

A.4.1 Apparatus

- (a) anvil. A rubber anvil having a flat circular top 20 ± 1 mm in diameter, a thickness of at least 9 mm and a hardness within 5 IRHDs of the SBR test cup.
- (b) hardness tester. A hardness tester, meeting the requirements of ASTM D1415 and graduated directly in IRHD units.

A.4.2 Procedure. Make hardness measurements at $23 \pm 2^\circ\text{C}$. Equilibrate the tester and anvils at this temperature prior to use. Centre brake cups lip side down on an anvil of appropriate hardness. Following the manufacturer's operating instructions for the hardness tester, make one measurement at each of four points 6.3 mm from the centre of the cup and spaced 90° apart. Average the four values and round off to the nearest IRHD

A.5 Sediment by centrifuging. The amount of sediment in the test fluid shall be determined by the procedure given.

A.5.1 Apparatus

- (a) centrifuge tube. Cone-shaped centrifuge tubes conforming to the dimensions given in figure 6 and made of thoroughly annealed glass. The graduations shall be numbered as shown in figure 6, and shall be clear and distinct. Scale-error tolerances and smallest graduations between various calibration marks are given in table 5 and apply to calibrations made within air-free water at 20°C .

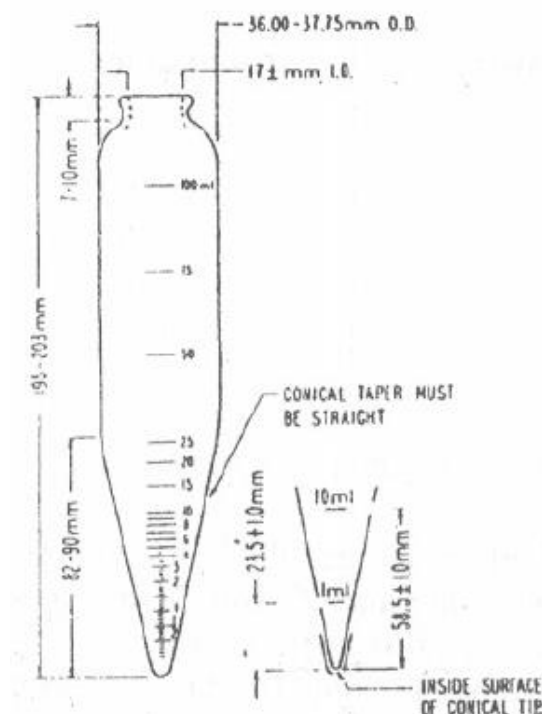


Figure 6. ASTM 203 mm centrifuge tube

Table 5 Calibration tolerances for 203 mm centrifuge tube

| Range (ml) | Subdivision (ml) | Volume tolerance (ml) |
|------------------|---------------------|--------------------------|
| 0 to 0.1 | 0.05 | ± 0.02 |
| above 0.1 to 0.3 | 0.05 | ± 0.03 |
| above 0.3 to 0.5 | 0.05 | ± 0.05 |
| above 0.5 to 1 | 0.10 | ± 0.05 |
| above 1 to 2 | 0.10 | ± 0.10 |
| above 2 to 3 | 0.20 | ± 0.10 |
| above 3 to 5 | 0.50 | ± 0.20 |
| above 5 to 10 | 1.00 | ± 0.50 |
| above 10 to 25 | 5.00 | ± 1.00 |
| above 25 to 100 | 25.00 | ± 1.00 |

(b) centrifuge. A centrifuge capable of whirling two or more filled centrifuge tubes at a speed which can be controlled to give a relative centrifugal force (r.c.f) between 600 and 700 at the tip of the tubes. The revolving head, trunnion rings, and trunnion cups, including the rubber cushion, shall withstand the maximum centrifugal force cable of being delivered by the power source. The trunnion cups and cushions shall firmly support the tubes when the centrifuge is in motion. Calculate the speed of the rotating head using this equation:

$$r.p.m = 265 [\sqrt{r.c.f/d}]$$

Where:

r.c.f. = Relative centrifugal force, and

d = Diameter of swing, in inches, measured between tips of opposite tubes when in rotating position.

Table 6 gives the relationship between diameter swing, relative centrifugal force (r.c.f) and revolutions per minute.

Table 6 Rotation speeds for centrifuges of various diameters

| Diameter of swing (inches) | r.p.m at 600 r.c.f | r.p.m at 700 r.c.f |
|-------------------------------|--------------------|--------------------|
| 19 | 1490 | 1610 |
| 20 | 1450 | 1570 |
| 21 | 1420 | 1530 |
| 22 | 1390 | 1500 |

* Measured in inches between tips and opposite tubes when in rotating position.

A.5.2 Procedure. Balance the corked centrifuge tubes with their respective trunnion cups in pairs by weight on a scale, according to the centrifuge manufacturer's instructions, and place them on opposite sides of the centrifuge head. Use a dummy assembly when one sample is tested. Then whirl them for 10 min., at a rate sufficient to produce a.r.c.f. between 600 and 700 at the tips of the whirling tubes. Repeat until the volume of sediment in each tube remains constant for three consecutive readings.

A.5.3 Calculation. Read the volume of the solid sediment at the bottom of the centrifuge tube and report the percentage sediment by volume. Where replicate determinations are specified, report the average volume

A.6 Standard styrene-butadiene rubber (SBR) brake cups. SBR brake cups for testing motor vehicle brake fluids shall be manufactured using the formulation given in table 7.

Table 7 Formulation of rubber compound

| Ingredient | Parts by weight |
|---|-----------------|
| SBR type 1503* | 100 |
| Oil furnace black (NBS 378) | 40 |
| Zinc oxide (NBS 370) | 5 |
| Sulphur (NBS 371) | 0.25 |
| Stearic acid (NBS 372) | 1 |
| n-tertiary butyl –2-benzothiazole sulfenamide (NBS 384)..... | 1 |
| Symmetrical dibethanaphthyl-p-phenylenediamine | 1.5 |
| Dicumyl peroxide (40% on precipitated CaCO ₃) +.... | 4.5 |
| Total | 153.25 |

* Philprene 1503 has been found suitable.

+ Use only within 90 days of manufacture and store at temperature below 27°C.

NOTE. The ingredients labelled (NBS) shall have properties identical with those supplied by the Bureau of Standards.

Compounding, vulcanization, physical properties, size of the finished cups, and other details shall be as detailed in appendix B of SAE J 1703b. The cups shall be used in testing brake fluids either within 6 m from date of manufacture when stored at room temperature below 30°C or within 36 m from date of manufacture when soaked at temperatures below – 15°C. After removal of cups from refrigeration they shall be conditioned base down on a flat surface for at least 12h at room temperature in order to allow cups to reach their true configuration before measurement.

A.7 Isopropanol. ACS or reagent grade.

Draft Jamaican Standard

Standards Council

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The following is an outline of the procedure, which must be followed in the preparation of documents:

1. The preparation of standards documents is undertaken upon the Standard Council's authorisation. This may arise out of representation from national organisations or existing Bureau of Standards' Committees of Bureau staff. If the project is approved it is referred to the appropriate sectional committee or if none exists a new committee is formed, or the project is allotted to the Bureau's staff.
2. If necessary, when the final draft of a standard is ready, the Council authorises an approach to the Minister in order to obtain the formal concurrence of any other Minister who may be responsible for any area, which the standard may affect.
3. The draft document is made available to the general public for comments. All interested parties, by means of a notice in the Press, are invited to comment. In addition, copies are forwarded to those known, interested in the subject.
4. The Committee considers all the comments received and recommends a final document to the Standards Council
5. The Standards Council recommends the document to the Minister for publication.
6. The Minister approves the recommendation of the Standards Council.
7. The declaration of the standard is gazetted and copies placed on sale.
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9. Amendments to and revisions of standards normally require the same procedure as is applied to the preparation of the original standard.

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