# SURFACE VEHICLE STANDARD

**J1704** **AUG2014**

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Superseding J1704 AUG2012

# Motor Vehicle Brake Fluid Based Upon Glycols, Glycol Ethers and the Corresponding Borates

## RATIONAL

SAE J1704 has been edited to correlate Table 1, Test Procedure numbering with the Test Procedure Sections.

## 1. SCOPE

This SAE Standard covers motor vehicle brake fluids of the nonpetroleum type, based upon glycols, glycol ethers, and borates of glycolethers, and appropriate inhibitors, for use in the braking system of any motor vehicle such as a passenger car, truck, bus, or trailer. These fluids are not intended for use under arctic conditions. These fluids are designed for use in braking systems fitted with rubber cups and seals made from styrene-butadiene rubber (SBR), or a terpolymer of ethylene, propylene, and a diene (EPDM).

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

| | |
|---|---|
| SAE J527 | Brazed Double Wall Low-Carbon Steel Tubing |
| SAE J1703 | Motor Vehicle Brake Fluid based upon glycols and glycol ethers |

**TO PLACE A DOCUMENT ORDER:** **Tel: 877-606-7323 (inside USA and Canada)**
**Tel: +1 724-776-4970 (outside USA)**
**Fax: 724-776-0790**
**Email: CustomerService@sae.org**
**SAE WEB ADDRESS:** **http://www.sae.org**

**SAE values your input. To provide feedback on this Technical Report, please visit http://www.sae.org/technical/standards/J1704_201408**

### 2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

| | |
|---|---|
| ASTM D 34-08 | Standard Guide for Chemical Analysis of White Pigments |
| ASTM D 91 | Test Method for Precipitation Number of Lubricating Oils |
| ASTM D 344 | Method of Test for Relative Dry Hiding Power of Paints |
| ASTM D 395 | Test Methods for Rubber Property - Compression Set |
| ASTM D 412 | Test Methods for Rubber Properties in Tension |
| ASTM D 445 | Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity) |
| ASTM D 664 | Test Method for Neutralization Number of Potentiometric Titration |
| ASTM D 2137 | Standard Test Methods for Rubber Property-Brittleness Point of Flexible Polymers and Coated Fabrics |
| ASTM D 865 | Test Method for Rubber - Deterioration by heating in Air (Test Tube Enclosure) |
| ASTM D 1120 | Method of Test for Boiling Point of Engine Coolants |
| ASTM D 1209 | Test Method for Color of Clear Liquids (Platinum-Cobalt Pigments) |
| ASTM D 1364 | Test Method for Water in Volatile Solvents (Fischer Reagent Titration Method) |
| ASTM D 1415 | Method of Test for International Hardness of Vulcanized Natural Rubber and Synthetic Rubbers |
| ASTM D 1613 | Test Method for Acidity in Volatile Solvents and Chemical Intermediates Used in Paint, Varnish, Lacquer, and Related Products |
| ASTM D 2240 | Method of Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer |
| ASTM D 3182 | Recommended Practice for Rubber-Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets |
| ASTM D 3185 | Methods for Rubber-Evaluation of SBR (Styrene-Butadiene Rubber) including Mixtures with Oil |
| ASTM E 1 | Specification for ASTM Thermometers |
| ASTM E 145 | Specification for Gravity-Convection and Forced-Ventilation Ovens |

## 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this document.

### 2.2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

| | |
|---|---|
| ASTM E 260 | Standard Recommended Practice for General Gas Chromatography Procedure |
| ASTM E 298 | Evaluation of Benzoyl Peroxides |

## 3. MATERIALS

The quality of the materials used shall be such that the resulting product will conform to the requirements of this standard and insure uniformity of performance.

## 4. REQUIREMENTS

Requirements are given in Table 1, using the test procedures according to Section 5.

TABLE 1 - SAE J1704 TEST PROCEDURES AND REQUIREMENTS

| **Test Procedure Section** | **Test Description** | **Unit** | **Requirements** | |
|---|---|---|---|---|
| | | | **Standard** | **Low Viscosity** |
| **5.1** | **Equilibrium Reflux BoilingPoint(ERBP)** | °C | ≥230 | ≥250 |
| **5.2** | **Wet Equilibium Reflux Boiling Point (WERBP)** | °C | ≥155 | ≥165 |
| **5.3** | **Viscosity** | | | |
| 5.3.1 | at -40 °C | mm$^2$/s | ≤1500 | ≤750 |
| 5.3.2 | at 100 °C | mm$^2$/s | ≥1.5 | |
| **5.4** | **pH Value** | - | 7.0 to 11.5 | |
| **5.5** | **Fluid Stability** | | | |
| 5.5.1 | High temperature Stability | °C | ±5 | |
| 5.5.2 | Chemical Stability | °C | ±5 | |
| **5.6** | **Metal Corrosion** | | | |
| 5.6 .1 | Wet Corrosion<br>Metal Strip Characteristics, after test<br>Weight Change of Metal Strips | | Maximum | |
| | Tinned Iron | mg/cm$^2$ | ± 0.2 | |
| | Steel | mg/cm$^2$ | ± 0.2 | |
| | Aluminium | mg/cm$^2$ | ± 0.1 | |
| | Cast Iron | mg/cm$^2$ | ± 0.2 | |
| | Brass | mg/cm$^2$ | ± 0.4 | |
| | Copper | mg/cm$^2$ | ± 0.4 | |
| | Appearance | - | No Pitting or roughness outside contact area | |
| | Staining and discoloration | - | Permitted | |
| | Liquid characteristics after test | | | |
| | Appearance | - | No gelling or crystaline deposit | |
| | pH Value | - | 7.0 to 11.5 | |
| | Sediment | % | ≤ 0.1 | |
| | Rubber Characteristics, after test | | | |
| | SBR (RM-03a) | | | |
| | Blisters or sloughing | - | None | |
| | Hardness decrease, maximum | IRHD | 15 | |
| | Base diameter increase, maximum | mm | 1.4 | |
| | EPDM (RM-69) | | | |
| | Blisters or sloughing | - | None | |
| | Hardness decrease, maximum | IRHD | 10 | |
| | Volume increase | % | 0 to 10 | |

TABLE 1 - SAE J1704 TEST PROCEDURES AND REQUIREMENTS (CONTINUED)

| Test Procedure Section | Test Description | Unit | Requirements | |
|---|---|---|---|---|
| | | | **Standard** | **Low Viscosity** |
| 5.6.2 | Dry Fluid (as received) -<br>Metal Strip Characteristics, after test<br>Weight Change of Metal Strips | | Maximum | |
| | Tinned Iron | mg/cm$^2$ | ± 0.2 | |
| | Steel | mg/cm$^2$ | ± 0.2 | |
| | Aluminium | mg/cm$^2$ | ± 0.1 | |
| | Cast Iron | mg/cm$^2$ | ± 0.2 | |
| | Brass | mg/cm$^2$ | ± 0.4 | |
| | Copper | mg/cm$^2$ | ± 0.4 | |
| | Appearance | - | No pitting or roughness outside contact area | |
| | Staining and discoloration | - | Permitted | |
| | Liquid characteristics after test | | | |
| | Appearance | - | No gelling or crystaline deposit | |
| | pH Value | - | 7.0 to 11.5 | |
| | Sediment | % | ≤ 0.1 | |
| | Rubber Characteristics, after test | | | |
| | SBR (RM-03a) | | | |
| | Blister | | None | |
| | Sloughing | | None | |
| | EPDM (RM-69) | | | |
| | Blister | | None | |
| | Sloughing | | None | |
| **5.7** | **Fluidity and Appearance at Low Temperatures** | | | |
| 5.7.1 | At -40 °C | | | |
| | Stratification | - | None | |
| | Sedimentation/ crystalization | - | None | |
| | Bubble Inversion Time | s | ≤ 10 | |
| | Appearance at Room Temperature | - | As original | |
| 5.7.2 | At -50 °C | | | |
| | Stratification | - | None | |
| | Sedimentation/ crystalization | - | None | |
| | Bubble Inversion Time | s | ≤ 35 | |
| | Appearance at Room Temperature | - | As original | |

TABLE 1 - SAE J1704 TEST PROCEDURES AND REQUIREMENTS (CONTINUED)

| | | | |
|---|---|---|---|
| **5.8** | **Water Tolerance** | | |
| 5.8.1 | At -40 °C | | |
| | Stratification | - | None |
| | Sedimentation/ crystalization | - | None |
| | Appearance | - | Contrast lines on hiding power chart to be discernible when viewed through fluid. |
| | Bubble Inversion Time | s | ≤ 10 |
| 5.8.2 | At 60 °C | | |
| | Stratification | - | None |
| | Sedimentation | % vol | ≤ 0.05 |
| | Sediment in Commercial Packaged fluid | % vol | ≤ 0.15 |
| **5.9** | **Compatibility** | | |
| 5.9.1 | At -40 °C | | |
| | Stratification | - | None |
| | Sedimentation/ crystalization | - | None |
| | Appearance | - | Contrast lines on hiding power chart to be discernible when viewed through fluid. |
| 5.9.2 | 60 °C | | |
| | Stratification | - | None |
| | Sedimentation | % vol | ≤ 0.05 |
| **5.10** | **Resistance to Oxidation** | | |
| | Metal Appearance | - | No Pitting or roughness outside contact area. No more than trace of gum. |
| | Staining/ Discoloration | - | Permitted |
| | Weight loss of Aluminium | mg/cm² | ≤ 0.05 |
| | Weight loss of Cast Iron | mg/cm² | ≤ 0.3 |
| **5.11** | **Effect on Rubber** | | |
| 5.11.1 | Styrene Butadiene Rubber ( SBR) RM-03a | | |
| | At 70 °C | | |
| | Hardness decrease | IRHD | 0 to 10 |
| | Base Diameter increase | mm | 0.15 to 1.4 |
| | Blisters | - | None |
| | Sloughing | - | None |
| 5.11.2 | At 120 °C | | |
| | Hardness decrease | IRHD | 0 to 15 |
| | Base Diameter increase | mm | 0.15 to 1.4 |
| | Blisters | - | None |
| | Sloughing | - | None |

TABLE 1 - SAE J1704 TEST PROCEDURES AND REQUIREMENTS (CONTINUED)

| **5.11** | **Effect on Rubber** | | |
|---|---|---|---|
| 5.11.3 | Ethylene Propylene Diene Monomer (EPDM) RM-69 | | |
| | At 70 °C | | |
| | Hardness decrease | IRHD | 0 to 10 |
| | Volume increase | % | 0 to 10 |
| | Blisters | - | None |
| | Sloughing | - | None |
| 5.11.4 | At 120 °C | | |
| | Hardness decrease | IRHD | 0 to 15 |
| | Volume increase | % | 0 to 10 |
| | Blisters | - | None |
| | Sloughing | - | None |

## 5. TEST PROCEDURES

### 5.1 Equilibrium Reflux Boiling Point

Determine the equilibrium reflux boiling point of the brake fluid by ASTM D 1120 with the following exceptions:

### 5.1.1 Apparatus

### 5.1.1.1 Thermometer

ASTM E 1, 76 mm immersion, calibrated. Use ASTM 3C or 3F thermometer. For fluids boiling below 300 °C (572 °F), ASTM 2C or 2F thermometer or other suitable non-mercury containing temperature measuring device, such as a thermocouple, capable of operating in the same temperature range and having equal or better accuracy may be used.

### 5.1.1.2 Heat Source

Heat source, variable autotransformer-controlled heating mantle designed to fit the flask, or an electric heater with rheostat heat control.

### 5.1.1.3 Boiling Point Stones RM-75

Silicon Carbide Boiling Stones #8.

### 5.1.1.4 Preparation of Apparatus

Thoroughly clean and dry all glassware before use. Attach the flask to the condenser. Place the mantle under the flask and support it with a suitable ring clamp and laboratory type stand, holding the whole assembly in place by a clamp.

NOTE: Place the whole assembly in an area free from drafts or other types of sudden temperature changes.

### 5.1.2 Procedure

When everything is in readiness, turn on the condenser water and apply heat to the flask at such a rate that the fluid is refluxing in 10 min ± 2 min at a rate in excess of 1 drop/s.

Immediately adjust heat input to obtain a specified equilibrium reflux rate of 1 to 2 drop/s over the next 5 min ± 2 min period. Maintain a timed and constant equilibrium reflux rate of 1 to 2 drop/s for an additional 2 min; record the average value of four temperature readings taken at 30 s intervals as the equilibrium reflux boiling point.

### 5.1.3 Repeatability (Single Analyst)

The standard deviation of results (each the average of duplicates), obtained by the same analyst on different days, has been estimated to be 0.4 °C (0.88 °F) at 72 degrees of freedom. Two such values should be considered suspect (95% confidence level) if they differ by more than 1.5 °C (2.5 °F).

### 5.1.4 Reproducibility (Multilaboratory)

The standard deviation of results (each the average of duplicates), obtained by analysts in different laboratories, has been estimated to be 1.8 °C (3.02 °F) at 17 degrees of freedom. Two such values should be considered suspect (95% confidence level) if they differ by more than 5 °C (9 °F).

## 5.2 Wet Equilibrium Reflux Boiling Point

### 5.2.1 Humidification Procedure

Lubricate the ground-glass joint of a 250 mm (9.89 in) I.D. bowl-form desiccator having matched tubulated glass cover and fitted with a No. 8 rubber stopper. Pour 450 mL ± 10 mL (15.22 oz ± 0.34 oz) of distilled water into the desiccator and insert a perforated porcelain plate (Coors No. 60456 or equivalent). Immediately place one open RM-49 corrosion test jar containing 350 mL ± 5 mL of the test brake fluid into the desiccator. Place a second open RM-49 corrosion test jar containing 350 mL ± 5 mL of TEGME (triethylene glycol monomethyl ether, brake fluid grade-Appendix E) (RM-71) into the same desiccator. The water content of the TEGME control fluid at the start of exposure shall have been adjusted to 0.50% ± 0.05% by weight (Karl Fischer analysis or equivalent). Replace desiccator cover and insert at once into an ASTM E 145, Type II A, forced ventilation oven set at 50 °C ± 1 °C (122 °F ± 1.8 °F).

Periodically, during oven humidification determine water content of the control fluid. When the water content of the control fluid has reached 3.70% ± 0.05% by weight, remove the desiccator from the oven and seal the test sample. Allow the sealed jar to cool for 60 to 90 min at 23 °C ± 5 °C (73.4 °F ± 9 °F).

### 5.2.2 Wet Equilibrium Reflux Boiling Point

Humidify the brake fluid as described in 5.2.1 and determine the boiling point of the humidified brake fluid as described in 5.1.

## 5.3 Viscosity

Determine the kinematic viscosity of the fluid by ASTM D 445.

5.3.1 Report the viscosity to the nearest mm2/s (centistokes). Duplicate runs which agree within 1.2% relative to test result are acceptable for averaging (95% confidence level).

### 5.3.2 Repeatability (Single Analyst)

The coefficient of variation of results (each the average of duplicates), obtained by the same analyst on different days has been estimated to be 0.4% at 47 degrees of freedom. Two such values should be considered suspect (95% confidence level) if they differ by more than 1.2%.

### 5.3.3 Reproducibility (Multilaboratory)

The coefficient of variation of results (each the average of duplicates), obtained by analysts in different laboratories, has been estimated to be 1% at 15 degrees of freedom. Two such values should be considered suspect (95% confidence level) if they differ by more than 3%.

## 5.4 pH Value

Mix the fluid with an equal volume of a mixture of 50% ethanol and 50% distilled water neutralized to a pH of 7.0. Determine the pH of the resulting solution electrometrically at 23 °C ± 5 °C (73.4 °F ± 9 °F), using a pH meter equipped with a calibrated full range (0 to 14) glass electrode and a calomel reference electrode, as specified in ASTM D 664.

## 5.5 Fluid Stability

### 5.5.1 High Temperature Stability

Heat a new sample of the original test brake fluid to a temperature of 185 °C ± 2 °C (365 °F ± 3.6 °F) by the procedure specified in 5.1 and maintain at that temperature for 2 h. Then determine the boiling point of this brake fluid as specified in 5.1. The difference between this observed boiling point and that previously determined in 4.1 shall be considered as the change in boiling point of the brake fluid.

### 5.5.2 Chemical Stability

Mix 30 mL of test brake fluid with 30 mL of SAE Compatibility Fluid described in Appendix B (RM-6606/ISO 4926). Determine the equilibrium reflux boiling point of this fluid mixture by use of the test apparatus specified in 4.1.1, applying heat to the flask at such a rate that the fluid is refluxing in 10 min ± 2 min at a rate in excess of 1 drop/s. The reflux rate shall not exceed 5 drops/s. Record the maximum fluid temperature observed during the first minute after the fluid begins refluxing at a rate in excess of 1 drop/s. Over the next 15 min ± 1 min, adjust and maintain the rate of reflux to 1 to 2 drops/s. Maintain a timed and constant equilibrium reflux rate of 1 to 2 drops/s for an additional 2 min; record the average value of four temperature readings taken at 30 s intervals as the final equilibrium reflux boiling point. Chemical reversion is evidenced by the decrease in temperature between the maximum fluid temperature recorded and the final equilibrium reflux boiling point.

## 5.6 Corrosion

### 5.6.1 Wet Corrosion Test

Prepare two sets of strips from each of the metals listed in Appendix A, each strip having a surface area of 25 $cm^2$ ± 5 $cm^2$ (approximately 8 cm long, 1.3 cm wide, and not more than 0.6 cm thick). Drill a hole between 4 and 5 mm in diameter and about 6 mm from one end of each strip. With the exception of the tinned iron strips, clean the strips by abrading them on all surface areas with 320A (RM-29) or P400 waterproof carborundum paper and isopropanol or ethanol until all surface scratches, cuts, and pits are removed from the strips, using a new piece of carborundum paper for each different type of metal. Wash the strips, including the tinned iron, with isopropanol or ethanol and dry the strips with a clean lint-free cloth and place strips in a desiccator containing desiccant maintained at 23 °C ± 5 °C (73.4 °F ± 9 °F) for at least 1 h.

Handle the strips with gloves, or clean forceps or cotton cloths after polishing to avoid fingerprint contamination.

Weigh each strip to the nearest 0.1 mg and assemble each set of strips on an uncoated steel bolt (RM-61) in the order tinned iron, steel, aluminum, cast iron, brass, and copper, so that the strips are in electrical contact. Bend the strips, other than cast iron, so that there is a separation of at least 3 mm between adjacent strips for a distance of about 6 cm from the free end of the strips.

Use two SBR cups (RM-03a) and two 25.4 mm x 25.4 mm (1 in x 1 in) EPDM rubber slab stock (RM-69) test specimens.

Measure the base diameter of the two standard SBR cups (RM-03A) described in Appendix C, using an optical comparator or micrometer to the nearest 0.02 mm (0.001 in) along the centerline of the SAE and rubber type identifications and at right angles to this centerline. Take the measurements within 0.4 mm (0.015 in) of the bottom edge and parallel to the base of the cup. Discard any cup if the two measured diameters differ by more than 0.08 mm (0.003 in). Average the two readings of each cup. Support the rubber cup on a rubber anvil or cylinder having a flat circular top surface of at least 19 mm in diameter, a thickness of at least 9 mm, and a hardness within 5 IRHD of the hardness of the rubber test cup. Determine the hardness of each cup thus supported by the procedure specified in ASTM D 1415 using the Standard Tester.

NOTE: ASTM D 2240 may be used for quality control and routine tests when a type A durometer is equipped with a fixture for keeping the plane of the pressure foot on the durometer parallel to the plane of the cup face during measurement.

Determine the slab hardnes. Determine the weight of the EPDM rubber slab stock in air ($m_1$) to the nearest 1 mg then determine the apparent weight of the slab stock immersed in distilled water at room temperature ($m_2$). Quickly dip each specimen in alcohol and then blot dry with filter paper free of lint and foreign matter.

Obtain two straight-sided round glass jars, having a capacity of approximately 475 ml and inner dimensions of approximately 100 mm in height and 75 mm in diameter (RM-49). To the RM-49 corrosion test jar, apply four wrappings of 19 mm (3/4 in) Teflon tape around the jar threads allowing a 3 mm (1/8 in) height above the top of the jar. Place one SBR cup (RM-03A) with lip edge facing up, in each of the two glass jars. Use only tinned steel lids vented with a hole 0.8 mm ± 0.1 mm in diameter (RM-64).

Insert a metal strip assembly inside each cup with the bolted end in contact with the concavity of the cup and the free end extending upward in the jar. Place one EPDM rubber slab stock (RM-69) test specimen flat on the bottom of the test jar. Mix 760 mL of test fluid with 40mL of distilled water. Add 400 ml of the test fluid/water mixture to cover the metal strip assembly in each jar. Tighten the lid and place the jars in an oven maintained at 100 °C ± 2 °C (212 °F ± 3.6 °F) for 120 h ± 2 h.

Allow the jars to cool at 23 °C ± 5 °C (73.4 °F ± 9 °F) for 60 to 90 minutes.

Immediately following the cooling period, remove the metal strips from the jars by use of a forceps, removing loose adhering sediment by agitation of the metal strip assembly in the fluid in the jar, and remove the rubber cups from the jars by use of a forceps, removing loose adhering sediment by agitation of the cup in the fluid in jar. Rinse cups in isopropanol or ethanol and air dry cups. Examine test strips and test jars for adhering crystalline deposit, disassemble the metal strips, removing adhering fluid by flushing with water, and clean individual strips by wiping with a cloth wetted with isopropanol or ethanol. Examine the strips for evidence of corrosion and pitting. Place strips in a desiccator containing a desiccant maintained at 23°C ± 5 °C (73.4 °F ± 9 °F) for at least 1 hour.

Within 15 minutes after removal from the fluid, weigh each EPDM rubber slab stock (RM-69) in air ($m_3$), again to the nearest milligram, then reweigh immersed in room temperature distilled water ($m_4$) to determine the volume change after hot fluid immersion. Determine the slab hardness.

Within 15 min after removing the cups from the fluid, visually examine each cup for evidence of sloughing, blisters, and other forms of disintegration. Measure the base diameter and hardness of each cup.

After one hour in the dessicator, metal strips are weighed to the nearest 0.1 mg. Determine the difference in weight of each metal strip and divide the difference by the total surface area of the metal strip measured in square centimeters. Average the measured quantities of the duplicates. In the event of a marginal pass on inspection, or of a failure in only one of the duplicates, another set of duplicate test samples shall be run. Both repeat samples must meet all the requirements of procedure 5.6.

Examine the fluid in the jars for gelling. Agitate the fluid in the jars to suspend and uniformly disperse sediment and transfer a 100 ml portion of this fluid to an ASTM cone-shaped centrifuge tube and determine percent sediment as described in 8.2 of ASTM D 91. Measure the pH value of the corrosion test fluid by the procedure specified in procedure 5.4.

Measure the hardness of each specimen. Volume changes shall be reported as a percentage of the original volume, calculated as follows:

$$\% \text{ change in volume} = \frac{(m_3 - m_4) - (m_1 - m_2)}{(m_1 - m_2)} \times 100 \qquad \text{(Eq. 1)}$$

where:

$m_1$ = the initial mass in grams in air
$m_2$ = the initial mass in grams in water
$m_3$ = the mass in grams in air after immersion in test fluid
$m_4$ = the apparent mass in grams in water after test.

### 5.6.2 Dry Corrosion Test

Prepare and weigh two sets of metal test strips as detailed in procedure 5.6.1.

Use two SBR cups (RM-03a), and two 25.4 mm x 25.4 mm (1 in x 1 in) EPDM rubber slab stock (RM-69) test specimens, as described in Appendix C and Appendix D, respectively.

Obtain two straight-sided round glass jars, having a capacity of approximately 475 ml and inner dimensions of approximately 100 mm in height and 75 mm in diameter (RM-49). To the RM-49 corrosion test jar, apply four wrappings of 19 mm (3/4 in) Teflon tape around the jar threads allowing a 3 mm (1/8 in) height above the top of the jar. Place one SBR cup (RM-3a) with lip edge facing up, in each of the two glass jars. Use only tinned steel lids vented with a hole 0.8 mm ± 0.1 mm in diameter (RM-64).

Insert a metal strip assembly inside each cup with the bolted end in contact with the concavity of the cup and the free end extending upward in the jar. Place one EPDM rubber slab stock (RM-69) test specimen flat on the bottom of the test jar. Add 400 ml of dry test fluid to cover the metal strip assembly in each jar. Tighten the lid and place the jars in an oven maintained at 100 °C ± 2 °C (212 °F ± 3.6 °F) for 120 h ± 2 h.

Allow the jars to cool at 23 °C ± 5 °C (73.4 °F ± 9 °F) for 60 to 90 min.

Immediately following the cooling period, remove the metal strips from the jars by use of a forceps, removing loose adhering sediment by agitation of the metal strip assembly in the fluid in the jar. Rinse cups in isopropanol or ethanol and air dry cups. Examine test strips and test jars for adhering crystalline deposit, disassemble the metal strips, removing adhering fluid by flushing with water, and clean individual strips by wiping with a cloth wetted with isopropanol or ethanol. Examine the strips for evidence of corrosion and pitting. Place strips in a desiccator containing a desiccant maintained at 23°C ± 5 °C (73.4 °F ± 9 °F) for at least 1 hour.

After one hour in the dessicator, metal strips are weighed to the nearest 0.1 mg. Determine the difference in weight of each metal strip and divide the difference by the total surface area of the metal strip measured in square centimeters. Average the measured quantities of the duplicates. In the event of a marginal pass on inspection, or of a failure in only one of the duplicates, another set of duplicate test samples shall be run. Both repeat samples must meet all the requirements of 5.6.

Immediately following the cooling period, remove the rubber specimens from the jars by use of a forceps, removing loose adhering sediment by agitation of the cup in the fluid in jar. Visually examine each cup for evidence of sloughing, blisters, and other forms of disintegration.

Examine the fluid in the jars for gelling. Measure the pH value of the corrosion test fluid by the procedure specified in procedure 5.4 Agitate the fluid in jars to suspend and uniformly disperse sediment and transfer a 100 mL portion of this fluid to an ASTM cone-shaped centrifuge tube and determine percent sediment as described in Section 8.2 of ASTM D 91.

## 5.7 Fluidity and Appearance at Low Temperature

### 5.7.1 At –40 °C (–40 °F)

Place 100 mL of the test fluid in a glass sample bottle (RM-59a) having a capacity of approximately 125 mL, an outside diameter of 37 mm ± 0.5 mm, and an overall height of 165 mm ± 3 mm. Stopper or cap the bottle tightly and place in a cold bath maintained at –40 °C ± 2 °C (–40 °F ± 3.6 °F) for 144 h ± 4 h. Remove the bottle from the bath, quickly wipe the bottle with a clean lint-free cloth saturated with isopropanol or ethanol, and examine the fluid for evidence of stratification, sediment, or crystals. Invert the bottle and determine the number of seconds required for the air bubble to travel to the top of the fluid. Allow the fluid to warm to room temperature 23 °C ± 5 °C (73 °F ± 9 °F); if necessary, allow to stand for as long as 4 h. Examine the fluid for clarity and appearance by comparing it to an original sample of the test fluid in an identical container.

### 5.7.2 At –50 °C (–58 °F)

Place 100 mL of fluid in a glass sample bottle (same as in –40 °C test above). Stopper or cap the bottle tightly and place in a cold bath maintained at –50 °C ± 2 °C (–58 °F ± 3.6 °F) for 6 h ± 0.2 h. Remove the bottle from the bath, quickly wipe the bottle with a clean lint-free cloth saturated with isopropanol or ethanol, and examine the fluid for evidence of stratification, sediment, or crystals. Invert the bottle and determine the number of seconds required for the air bubble to travel to the top of the fluid. Allow the fluid to warm to room temperature 23 °C ± 5 °C (73 °F ± 9 °F); if necessary, allow to stand for as long as 4 h. Examine the fluid for clarity and appearance by comparing it to a sample of the original test fluid in an identical container.

## 5.8 Water Tolerance

### 5.8.1 At –40 °C (–40 °F)

Mix 96.5mL of test fluid and 3.5mL of distilled water into an ASTM cone shaped centrifuge tube described in Section 5.1 in ASTM D 91. Stopper the tube with a cork and place in a cold bath maintained at –40 °C ± 2 °C (–40 °F ± 3.6 °F) for 22 h ± 2 h. Remove the centrifuge tube from the bath, quickly wipe the tube with a clean lint-free cloth saturated with isopropanol or ethanol, determine the transparency of the fluid by placing the tube against a hiding power test chart[1] (RM-28) and observing the clarity of the contrast lines on the chart when viewed through the fluid. Examine the fluid for evidence of stratification and sedimentation. 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 shall be considered to have reached the top of the fluid when the top of the bubble reaches the 2 mL graduation of the centrifuge tube.

### 5.8.2 At 60 °C (140 °F)

Place the centrifuge tube from 5.8.1 in an oven maintained at 60 °C ± 2 °C (140 °F ± 3.6 °F) for 22 h ± 2 h. Remove the tube from the oven and immediately examine the contents for evidence of stratification. Determine percent sediment by volume as described in Section 8.2 of ASTM D 91.

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[1] A suitable hiding power chart is described in ASTM D 34, Method of Test for Relative Dry Hiding Power of Paints, published by the American Society for Testing and Materials, or in Method 4112 of Federal Test Method Standard No. 141.

### 5.9 Compatibility

#### 5.9.1 At –40 °C (–40 °F)

Mix 50 mL of fluid with 50 mL of SAE Compatibility Fluid described in Appendix B (RM-6606/ ISO 4926) and pour this mixture into an ASTM cone-shaped centrifuge tube described in Section 5.1 in ASTM D 91 and stopper with a cork. Place centrifuge tube for 22 h ± 2 h in a bath maintained at –40 °C ± 2 °C (–40 °F ± 3.6 °F). Remove the centrifuge tube from the bath, quickly wipe the tube with a clean lint-free cloth saturated with isopropanol or ethanol, determine the transparency of the fluid by placing the tube against a hiding power test chart[1] (ASTM D 34-08, RM-28) and observing the clarity of the contrast lines on the chart when viewed through the fluid. Examine the fluid for stratification and sedimentation.

#### 5.9.2 At 60 °C (140 °F)

Place the centrifuge tube from 5.9.1 in an oven at 60 °C ± 2 °C (140 °F ± 3.6 °F) for 22 h ± 2 h. Remove the tube from the oven and immediately examine the contents for evidence of stratification. Determine percent sediment by volume as described in Section 8.2 of ASTM D 91.

### 5.10 Resistance to Oxidation

Prepare two sets of aluminum and cast iron test strips (RM-08 and RM-09) by the procedure specified in 5.6. Weigh each strip to the nearest 0.1 mg and assemble a strip of each metal on an uncoated steel bolt (RM-62), separating the strips at each end with a piece of tinfoil (RM-27) (min. 99.5% tin, max. 0.5% lead) approximately 12 mm square and between 0.02 and 0.06 mm in thickness.

Place 30 mL ± 1 mL of fluid in a small glass bottle approximately 120 mL in capacity. Add 60 mg ± 2 mg of reagent grade benzoyl peroxide as per ASTM D 298, and 1.5 mL ± 0.05 mL distilled water to bottle. Stopper the bottle and shake the contents, avoiding getting the solution on the stopper. Place bottle in an oven at 70 °C ± 2 °C (158 °F ± 3.6 °F) for 120 min ± 10 min, shaking every 15 minutes to effect solution of the peroxide. Remove the bottle from the oven, do not disturb the stopper, and cool in air at room temperature, 23 °C ± 5 °C (73 °F ± 9 °F).

Place approximately 1/8 section of a standard SBR cup described in Appendix C (RM-03a) in the bottom of each of Place approximately 1/8 section of a standard SBR cup described in Appendix C (RM-03a) in the bottom of each of two test tubes about 22 mm in diameter and 175 mm in length. Add 10 mL of prepared test fluid to each test tube. Place a metal-strip assembly in each tube with the end of the strips resting on the rubber, the solution covering about one-half the length of the strips, and the bolted end remaining out of the solution. Stopper the tubes with corks and store upright for 22 h ± 2 h at 23 °C ± 5 °C (73.4 °F ± 9 °F). Loosen the stoppers and place the tubes for 168 h ± 2 h in an oven maintained at 70 °C ± 2 °C (158 °F ± 3.6 °F). After the heating period, remove from the oven and allow to cool to room temperature for 60-90 minutes. Remove and disassemble the metal strips. Examine the strips for gum deposits. Wipe the strips with a cloth wet with isopropanol or ethanol and examine for pitting or roughening of surface. Place strips in desiccator containing a desiccant maintained at 23 °C ± 5 °C (73.4 °F ± 9 °F) for at least 1 hour. Weigh each strip to the nearest 0.1 mg.

Determine corrosion loss by dividing the difference in weight of each metal strip by the total surface area of each metal strip measured in square centimeters. Average the measured quantities of the duplicates. In the event of a marginal pass on inspection, or of a failure in only one of the duplicates, another set of duplicate test samples shall be run. Both repeat samples must meet all the requirements of procedure 5.6.

### 5.11 Effect on Rubber

For test procedures 5.11.1 and 5.11.2, use standard SBR cups described in Appendix C (RM-03a). Measure the base diameter of all cups and hardness of all specimens as described in 5.6, discarding any cups whose diameters differ by more than 0.08 mm (0.003 in).

For the test procedure 5.11.3 and 5.11.4, cut 25.4 mm x 25.4 mm (1 inch x 1 inch) test specimens from standard EPDM slab stock as described in Appendix D (RM-69). Determine volume of each in the following manner:

Weigh the specimen in air ($M_1$) to the nearest milligram and then weigh the specimens immersed in room temperature distilled water ($M_2$) containing no more than 0.2% of a suitable wetting agent. Pluronic L-61 (BASF) or equivalent has been found to be acceptable.

Determine hardness of each specimen as described in 5.6.

#### 5.11.1 Test at 70 °C (158 °F)

Place two standard SBR cups in a straight-sided round glass jar (RM-51), 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 (RM-52a). Add 75 mL of fluid to the jar and heat for 70 h ± 2 h at 70 °C ± 2 °C (158 °F ± 3.6 °F). Allow the jar to cool at 23 °C ± 5 °C (73.4 °F ± 9 °F) for 60 to 90 min. Remove the cups from the jar, wash quickly with isopropanol or ethanol, and air dry cups. Examine the cups for disintegration as evidenced by blisters or sloughing. Measure the base diameter and hardness of each cup within 15 min after removal from the fluid.

#### 5.11.2 Test at 120 °C (248 °F)

Place two standard SBR cups (RM-03a) in a straight-sided round glass jar (RM-51), 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 (RM-52a). Add 75 mL of fluid to the jar and heat for 70 h ± 2 h at 120 °C ± 2 °C (248 °F ± 3.6 °F). Allow the jar to cool at 23 °C ± 5 °C (73.4 °F ± 9 °F) for 60 to 90 min. Remove the cups from the jar, wash quickly with isopropanol or ethanol, and air dry cups. Examine the cups for disintegration as evidenced by blisters or sloughing. Measure the base diameter and hardness of each cup within 15 min after removal from the fluid.

#### 5.11.3 Test at 70 °C (158 °F)

Place two 25.4 mm x 25.4 mm (1 in x 1 in) standard EPDM test specimens (RM-69) in a straight-sided round glass jar 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 (RM-52a). Add 75 mL of fluid to the jar and heat for 70 h ± 2 h at 70 °C ± 2 °C (158 °F ± 3.6 °F). Allow the jar to cool to 23 °C ± 5 °C (73.4 °F ± 9 °F) for 60 to 90 min. Remove the specimens from the jar, wash quickly with isopropanol or ethanol, and air dry. Examine the specimens for disintegration as evidenced by blisters or sloughing. Weigh each specimen in air ($m_3$), again to the nearest milligram, then reweigh immersed in room temperature distilled water ($m_4$), to determine the volume after hot fluid immersion. Measure the hardness of each specimen. All weighings must be completed within 60 min after removal from the test fluid.

Volume changes shall be reported as a percentage of the original volume, calculated as per Equation 1.

#### 5.11.4 Test at 120 °C (248 °F)

Place two 25.4 mm x 25.4 mm (1 in x 1 in) standard EPDM test specimens (RM-69) in a straight-sided round glass jar having a capacity of approximately 250 mL and inner dimensions of approximately 125 mm in height and 50 mm in diameter, and tinned steel lid (RM-52a). Add 75 mL of fluid to the jar and heat for 70 h ± 2 h at 120 °C ± 2 °C (248 °F ± 3.6 °F). Allow the jar to cool to 23 °C ± 5 °C (73.4 °F ± 9 °F) for 60 to 90 min. Remove the specimens from the jar, wash quickly with isopropanol or ethanol, and air dry. Examine the specimens for disintegration as evidenced by blisters or sloughing. Determine the volume change as in 5.11.3. Measure the hardness of each specimen.

Report the rubber swell to the nearest 0.03 mm (0.001 in). Duplicate results which agree within 0.10 mm (0.004 in) are acceptable for averaging (95% confidence level).

#### 5.11.5 Repeatability for the Base Diameter Increase Measurement (Single Analyst)

The standard deviation of results (each the average of duplicate determinations) obtained by the same analyst on different days has been estimated to be 0.05 mm (0.002 in) at 46 degrees of freedom. Two such values should be considered suspect (95% confidence level) if they differ by more than 0.13 mm (0.005 in).

### 5.11.6 Reproducibility for the Base Diameter Increase Measurement (Multilaboratory)

The standard deviation of results (each the average of duplicates) obtained by analysts in different laboratories has been estimated to be 0.08 mm (0.003 in) at 7 degrees of freedom. Two such values should be considered suspect (95% confidence level) if they differ by more than 0.20 mm (0.008 in).

## 6. NOTES

### 6.1 Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, neither in documents that contain editorial changes only.

PREPARED BY THE SAE BRAKE FLUIDS STANDARDS COMMITTEE

## APPENDIX A - STANDARD CORROSION TEST STRIPS

A.1

### TABLE A1 - STANDARD CORROSION TEST STRIPS

| Corrosion Test Strip | Material Specification | General Material Data | Dimensions | Surface Requirements |
|---|---|---|---|---|
| Tinned iron<br>RM-06a | ASTM A 624, Federal Specification QQ-T-425A | SR tin plate electrolytic, bright: No. 25, type MR<br>Temper 3, base weight 85 lb<br>Ferrostand and DOS oil | Approx. 8 cm long; 1.3 cm wide<br>Thickness: As purchased<br>Surface area: 25 $cm^2 \pm 5 cm^2$ | As sheared. Clean and uniform tinning. |
| Steel<br>RM-07 | SAE 1018 | Low carbon sheet<br>Cold rolled<br>Hardness: 40 to 72 RB | Approx. 8 cm long; 1.3 cm wide<br>Thickness: Approx. 0.2 cm<br>Surface area: 25 $cm^2 \pm 5 cm^2$ | Edges machined to remove shearing marks. Clean uniform surfaces. |
| Aluminum<br>RM-08 | SAE AA2024 | Wrought aluminum alloy<br>Temper T3<br>Hardness: 75 RB typical | Approx. 8 cm long; 1.3 cm wide<br>Thickness: Approx. 0.2 cm<br>Surface area: 25 $cm^2 \pm 5 cm^2$ | Edges machined to remove shearing marks. Clean uniform surfaces. |
| Cast iron<br>RM-09 | SAE G3000 | Soft automotive cast iron. Must be free from shrinkage cavities, porosity, or any other defects detrimental to specification use of the material.<br>Hardness: 86 to 98 RB | Approx. 8 cm long; 1.3 cm wide<br>Thickness: Approx. 0.4 cm<br>Surface area: 25 $cm^2 \pm 5 cm^2$ | Surface grind 4 sides to dimension using a well-dressed No. 80 Alundum wheel. Clean uniform surfaces. |
| Brass<br>RM-10 | SAE CA260 | Wrought alloy—yellow brass<br>Rolled sheet or strip; half hard temper<br>Hardness: 57 to 74 RB | Approx. 8 cm long; 1.3 cm wide<br>Thickness: Approx. 0.2 cm<br>Surface area: 25 $cm^2 \pm 5 cm^2$ | Edges machined to remove shearing marks. Clean uniform surfaces. |
| Copper<br>RM-11 | SAE CA114 | Cold rolled copper sheet or strip<br>Half-hard temper<br>Hardness: 35 to 56 RB | Approx. 8 cm long; 1.3 cm wide<br>Thickness: Approx. 0.2 cm<br>Surface area: 25 $cm^2 \pm 5 cm^2$ | Edges machined to remove shearing marks. Clean uniform surfaces. |

NOTE: Drill hole between 4 and 5 mm in a diameter and approximately 6 mm from one end of each strip. Holes to be clean and free from burrs. Hardness ranges are commercially for the designated metals. Hardness is not specified for the tinned iron because it is not considered a practical requirement.

## APPENDIX B – RM-6606 /ISO4926 COMPATIBILITY FLUID

### B.1 FORMULATION OF FLUID

| Components | Mass fraction % | Purity [a] |
|---|---|---|
| Triethylene glycol | 19.4 | ≥ 95 % |
| Triethylene glycol monomethyl ether | 25 | ≥ 95 % |
| Polyethylene glycol monobutyl ethers | 35.8 | Diethylene glycol monobutyl ether ≤ 2 %,<br>Triethylene glycol monobutyl ether 60 % ≤ purity ≤ 80 %<br>Tetraethylene glycol + higher glycol monobutyl ethers 20 % ≤ purity ≤ 40 % |
| Borate of triethylene glycol monomethyl ether | 18.6 | Content of boric acid 11.2 % to 11.5 % |
| Diisopropanolamine | 0.85 | ≥ 98 % |
| n-BUTYLDIETHANOLAMINE | 0.1 | ≥ 98 % |
| Bisphenol A | 0.2 | ≥ 97 % |
| Tolyltriazole | 0.025 | ≥ 98 % |
| Benzotriazole | 0.025 | ≥ 98 % |
| [a]. The water content of the reference fluid shall be less than or equal to 0.20 %. | | |

The reference fluid RM-6606 has a minimum shelf life of 5 (five) years when purchased and stored in accordance with SAE J75.

# APPENDIX C - STANDARD STYRENE-BUTADIENE RUBBER (SBR) BRAKE CUPS FOR TESTING SAE MOTOR VEHICLE BRAKE FLUIDS

## C.1 FORMULATION OF RUBBER COMPOUND

TABLE C1 - FORMULATION OF RUBBER COMPOUND

| Ingredient | Parts by Weight |
|---|---|
| SBR type 1502 | 100 |
| N330 Supersacks | 42 |
| BBTS Pellets | 1 |
| St. Acid Pristerine 9429 | 1 |
| Zinc Oxide (210/672) | 5 |
| Polydex E (DCP-R) 40 D | 4.5 |
| Spider Sulfur MC98 | 0.25 |
| AGRTE Stalite S/Octamine | 1 |
| Antiox 58/ZMTI PDR | 0.5 |
| Flexone6H CCPD/*Vanox 6H | 1.5 |
| TOTAL | 156.75 |

## C.2 PROCEDURE FOR MIXING RUBBER COMPOUND

The rubber compound shall be mixed in accordance with the procedure given in ASTM D 3185 for Formula 2B.

## C.3 PROPERTIES OF RUBBER COMPOUND

Vulcanizates cured for 12 min at 180 °C (356 °F) followed by a post cure for 4 h at 100 °C (212 °F) by the procedure described in ASTM D 3182 shall meet the requirements in Table C2.

TABLE C2 - PROPERTIES OF RUBBER COMPOUND

| Property | Requirement | ASTM Method |
|---|---|---|
| Hardness | 63 ± 3 | D 1415 or D 2240 |
| Tensile strength | 17.5 MPa (2500 f-lb/in$^2$, min) | D 412 |
| Ultimate elongation | 350%, min | D 412 |
| Tensile strength after 70 h at 125 °C (257 °F) | 30% decrease, max | D 865 |
| Ultimate elongation after 70 h at 125 °C (257 °F) | 50% decrease, max | D 865 |
| Hardness after 70 h at 125 °C (257 °F) | 0 to 10 increase | D 865 |
| Compression set after 22 h at 125 °C (257 °F) | 10 to 20% | D 395 (Method B) |
| Brittleness temperature | -40 °C (-40 °F), max | D 2137 |

## C.4 BRAKE CUPS PREPARED FROM RUBBER COMPOUND

Brake cups shall be prepared from the rubber compound by vulcanization under the conditions required to obtain the properties given in Section C.3. The dimensions of the cups shall be suitable for the brake cylinders used to determine stroking test procedure in FMVSS 116, as shown in Figure C1. Cups may be used for testing brake fluids within 60 months from date of manufacture when stored at temperatures under 23 °C (73 °F), out of sunlight (storage in dark preferred), and adequately protected from contaminants. Rubber cups should not be stored under any strain and different parts should be stored separately to avoid migration of constituents. Lastly, rubber cups should be stored away from sources of ozone.

After removal of cups from storage, they shall be conditioned base down on a flat surface for at least 12 h at room temperature in order to allow cups to reach their true configuration before measurement.

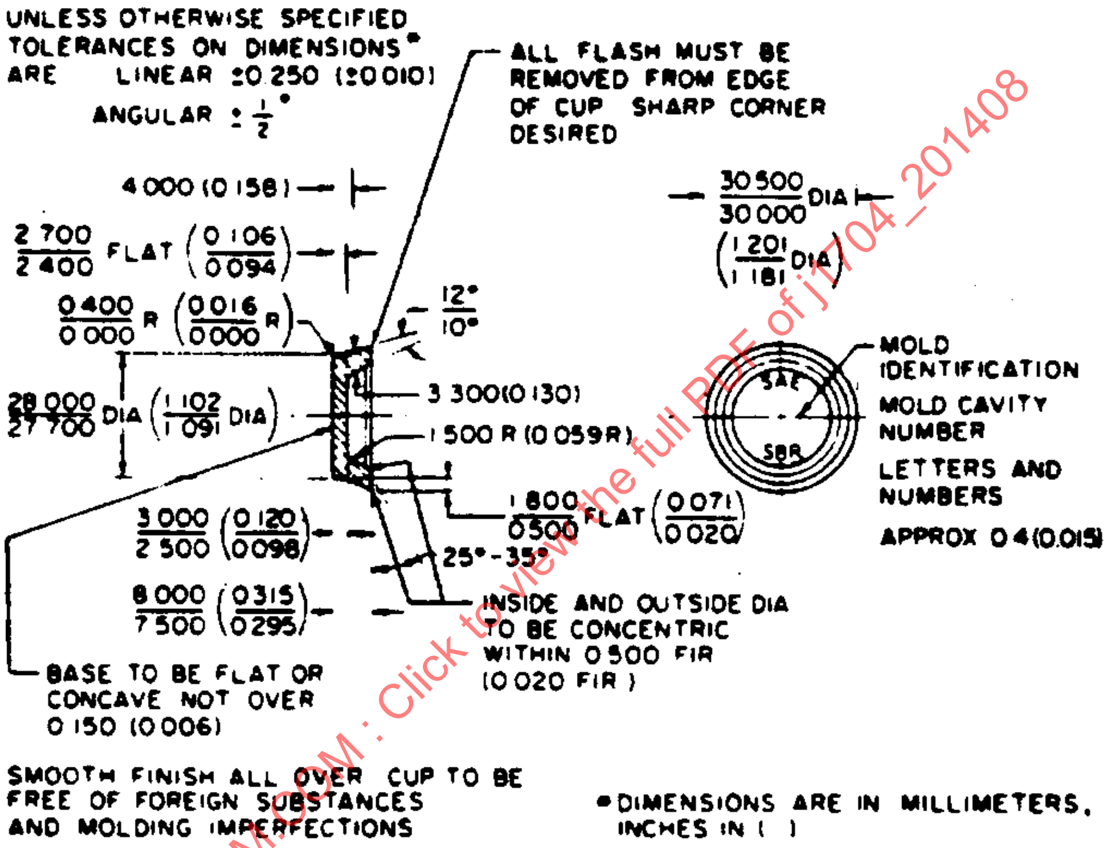

FIGURE C1 – SAE TEST CUP

# APPENDIX D - STANDARD ETHYLENE, PROPYLENE, AND DIENE (EPDM) TERPOLYMER RUBBER SLABSTOCK (RM-69)

## D.1 FORMULATION OF RUBBER COMPOUND

TABLE D1 - FORMULATION OF RUBBER COMPOUND

| Ingredient | Parts by Weight |
|---|---|
| Vistalon 2504 | 100 |
| N330 Supersacks | 47 |
| Zinc Oxide (210/672) | 5 |
| Liandox DCP 99 (BC FF) | 3.2 |
| TMQ/AK DQ Pellets | 2 |
| Total | 157.2 |

## D.2 PROCEDURE FOR MIXING RUBBER COMPOUND

The rubber compound shall be mixed in accordance with the procedures given in ASTM D 3182.

## D.3 PROPERTIES OF RUBBER COMPOUND

Vulcanizates cured for 12 min at 180 °C (356 °F) followed by a post cure for 4 h at 120 °C (248 °F) by the procedure described in ASTM D 3182 shall meet the requirements in Table D2.

TABLE D2 - PROPERTIES OF RUBBER COMPOUND

| Property | Requirement | ASTM Method |
|---|---|---|
| Hardness, IRHD | 70 ± 3 | D 1415 |
| Tensile strength, min | 13.8 MPa (2000 lbf/in$^2$) | D 412 |
| Ultimate elongation, min | 225% | D 412 |
| Tensile strength, decrease after 22 h at 175 °C (347 °F), max | 15% | D 865 |
| Ultimate elongation, decrease after 22 h at 175 °C (347 °F), max | 30% | D 865 |
| Hardness, increase after 22 h at 175 °C (347 °F) | 0 to 10 | D 865 |
| Compression set after 22 h at 175 °C (347 °F) | 20% max | D 395 (Method B) |
| Brittleness temperature, max | -54 °C (-65°F), | D 2137 |

## D.4 SLABSTOCK PREPARED FROM RUBBER COMPOUND

Test slabs approximately 150 mm x 150 mm x 1.9 mm (6 in x 6 in x 0.075 in) shall be prepared from the rubber compound by vulcanization under the conditions stated in Section D.3. These slabs may be used in testing brake fluids within 36 months from their date of manufacture, when stored in the dark at ambient temperatures not exceeding 38 °C (100 °F) and adequately protected from atmospheric or other contaminants. When stored at other than 23 °C ± 5 °C (73.4 °F ± 9 °F), the material shall be allowed to stabilize at laboratory temperature prior to measurements.