SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1705

NON-CURRENT JUL2007

Issued 1985-03
Noncurrent 2007-07

Superseding J1705 MAY1995

Low Water Tolerant Brake Fluids

1. ***Scope***—This SAE Recommended Practice was prepared by the Motor Vehicle Brake Fluids Subcommittee of the SAE Hydraulic Brake Actuating Systems Committee to provide engineers, designers, and manufacturers of motor vehicles with a set of minimum performance standards in order to assess the suitability of silicone and other low water tolerant type brake fluids (LWTF) for use in motor vehicle brake systems. These fluids are designed for use in braking systems fitted with rubber cups and seals made from natural rubber (NR), styrene-butadiene rubber (SBR), or a terpolymer of ethylene, propylene, and a diene (EPDM).

In the development of the recommended requirements and test procedures contained herein, it is concluded that the LWTFs must be functionally compatible with existing motor vehicle brake fluids conforming to SAE J1703 and with braking systems designed for such fluids. To utilize LWTFs to the fullest advantage, they should not be mixed with other brake fluids. Inadvertent mixtures of LWTFs with fluids meeting SAE J1703 are not known to have any adverse effects on performance, but all combinations have not been tested. Vehicle manufacturer's recommendations should be followed where indicated. These fluids are not necessarily suitable for use in central hydraulic or pumped systems and are not intended for use below temperatures of −50 °C (−58 °F). Brake fluids covered under this document are not required to tolerate water and extreme caution should be exercised to prevent accidental entry of water which might lead to brake failure. Other performance characteristics of these LWTFs not covered in this document are discussed in Appendix A.

1.1 Rationale—This document has been found to be Noncurrent, therefore, it may be in use by some areas of industry but is not the most up-to-date technical information.

2. ***References***

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1703—Motor Vehicle Brake Fluid

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

2.1.2 ASTM PUBLICATIONS—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 91—Test Method for Precipitation Number of Lubricating Oils
ASTM D 445—Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
ASTM D 1120—Test Method for Boiling Point of Engine Coolants
ASTM D 1415—Test Method for Rubber Property—International Hardness
ASTM D 2240—Test Method for Rubber Property—Durometer Hardness
ASTM E 1—Specification for ASTM Thermometers
ASTM E 145—Specification for Gravity Convection and Forced-Ventilation Ovens
ASTM E 203—Test Method for Water Using Karl Fischer Reagent

2.1.3 FEDERAL SPECIFICATION—Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

FMVSS 116—Motor Vehicle Brake Fluids

2.1.4 MILITARY SPECIFICATION—Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-B-46176

2.2 Other Publications

USAMERDC Report 2132 AD A-12849 - Feb. 1975
USAMERDC Report 21264 AD-02618 - Jan. 1976
J. A. Tichy and W. O. Winer, "A Correlation of Bulk Moduli and P-V-T Data for Silicone Fluids at Pressure up to 500,000 PSIF," ASLE Transactions 11338 - 344 (1968)

3. Requirements

3.1 Equilibrium Reflux Boiling Point (ERBP)

3.1.1 When tested by the procedure specified in 4.1, the low water tolerant brake fluid shall have an ERBP of not less than 260 °C (500 °F).

3.1.2 When tested by the procedure specified in 4.1.1, the low water tolerant brake fluid shall have a wet ERBP of not less than 180 °C (356 °F).

3.2 Viscosity—When tested by the procedure specified in 4.2, LWTFs shall have kinematic viscosities as follows:

3.2.1 AT –40 °C (–40 °F)—Not more than 900 mm^2/s (900 cSt).

3.2.2 AT 25 °C (77 °F)—Not more than 50 mm^2/s (50 cSt).

3.2.3 AT 100 °C (212 °F)—Not less than 1.5 mm^2/s (1.5 cSt).

3.3 Corrosion—LWTFs, when tested by the procedure specified in 4.3, shall not cause corrosion exceeding the limits shown in Table 1. The metal strips outside the area of contact shall be neither pitted nor roughened to an extent discernible by the eye without magnification, but staining or discoloration is permitted. Roughening caused during assembly and disassembly shall be disregarded.

TABLE 1—CORROSION TEST STRIPS AND MASS CHANGES

Test Specimens[1]	RM No.	Maximum Permissible Mass Change mg/cm^2 of Surface
Tinned Iron	6A	0.1
Steel	7	0.1
Aluminum	8	0.1
Cast Iron	9	0.1
Brass	10	0.2
Copper	11	0.2
Zinc[2]	ISO-2	0.4

1. Obtainable from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.
2. Added since last publication.

The fluid at the end of the test shall show no gelling at 23 °C ± 5 °C (73 °F ± 9 °F). No crystalline type deposit shall form and adhere to either the glass jar walls or the surface of metal strips. The fluid shall contain no more than 0.10% sediment by volume.

The rubber cup at the end of the test shall show no appreciable disintegration as evidenced by blisters or sloughing as indicated by carbon black separation on the surface of the rubber cup. The hardness of the rubber cup shall not decrease by more than 15 International Rubber Hardness degrees (IRHD) and the base diameter shall not increase by more than 1.40 mm (0.055 in).

3.4 Fluidity and Appearance at Low Temperature

3.4.1 AT –40 °C (–40 °F)—When LWTFs are tested by the procedure specified in 4.4(a), the fluid shall show no stratification, sediment, or crystals. Upon inversion of the sample bottle, the air bubble shall travel to the top of the fluid in not more than 10 s. Cloudiness is permissible, but on warming to room temperature 23 °C ± 5 °C (73 °F ± 9 °F), the fluid shall regain its original uniformity, appearance, and clarity.

3.4.2 AT –50 °C (–58 °F)—When LWTFs are tested by the procedure specified in 4.4(b), the fluid shall show no stratification, sediment, or crystals. Upon inversion of the sample bottle, the air bubble shall travel to the top of the fluid in not more than 35 s. Cloudiness is permissible, but on warming to room temperature 23 °C ± 5 °C (73 °F ± 9 °F), the fluid shall regain its original uniformity, appearance, and clarity.

3.5 Tolerance to High Humidity

3.5.1 AT –40 °C (–40 °F)—When LWTFs are tested by the procedure specified in 4.5, the fluid shall show no stratification, sediment, or crystals. Upon inversion of the centrifuge tube, the air bubble shall travel to top of the fluid in not more than 10 s. Cloudiness is permissible, but on warming to room temperature 23 °C ± 5 °C (73 °F ± 9 °F), the fluid shall regain its original uniformity, appearance, and clarity.

3.5.2 AT 60 °C (140 °F)—When LWTFs are tested by the procedure specified in 4.5, the fluid shall show no stratification; sediment shall not exceed 0.05% by volume after centrifuging.

3.6 Effect on Rubber—Rubber specimens, when tested as specified in 4.6, shall show no disintegration as evidenced by blisters or sloughing. Hardness changes, base diameter changes, and volume swell shall lie within the ranges given in Table 2.

TABLE 2—EFFECT ON RUBBER

Type	Test Specimen	Volume Swell %	Base Diameter Change	Change in Hardness	Test Temperature °C	Test Temperature °F	Time Hours
SBR	SAE RM-3a	(+5 to +20)	0.15 to 1.4 mm (0.006 to 0.055 in)	(0 to −10)	25 ± 2	77 ± 4	168 ± 2
		(+5 to +20)	0.15 to 1.4 mm (0.006 to 0.055 in)	(0 to −10)	70 ± 2	158 ± 4	70 ± 2
	SAE RM-3a	(+5 to +20)	0.15 to 1.4 mm (0.006 to 0.055 in)	(0 to −15)	120 ± 2	248 ± 4	70 ± 2
	SAE RM-3a						
EPR	SAE RM-69	(0 to +10)	—	(0 to −10)	25 ± 2	77 ± 4	168 ± 2
		(0 to +10)	—	(0 to −10)	70 ± 2	158 ± 4	70 ± 2
	SAE RM-69	(0 to +10)	—	(0 to −10)	120 ± 2	248 ± 4	70 ± 2
	SAE RM-69						
Natural	SAE NR-X	(+5 to +20)	0.15 to 1.4 mm (0.006 to 0.055 in)	(0 to −10)	25 ± 2	77 ± 4	168 ± 2
	SAE NR-X	(+5 to +20)	0.15 to 1.4 mm (0.006 to 0.055 in)	(0 to −10)	70 ± 2	158 ± 4	70 ± 2

3.7 Compatibility

3.7.1 AT −40 °C (−40 °F)—When LWTFs are tested by the procedure specified in 4.7(a), the fluid shall show no sedimentation or crystallization. Cloudiness is permissible, but on warming to room temperature (23 °C ± 5 °C) (73 °F ± 9 °F), the mixture shall be no more cloudy than the original fluid under test.

3.7.2 AT 60 °C (140 °F)—When LWTFs are tested by the procedure specified in 4.7(b), sedimentation shall not exceed 0.05% by volume after centrifuging.

3.8 Fluid Stability—When the brake fluid is tested according to 4.8, the ERBP shall not be less than 260 °C (500 °F).

3.9 Stroking Test—A LWTF, when tested by the procedure specified in 4.9, shall meet the following performance requirements:

3.9.1 Metal parts shall not show corrosion as evidenced by pitting to an extent discernible to the naked eye, but staining or discoloration shall be permitted.

3.9.2 The initial diameter of any cylinder or piston shall not change by more than 0.13 mm (0.005 in) during test.

3.9.3 Rubber cups shall not decrease in hardness by more than 15 IRHD and shall not be in an unsatisfactory operating condition as evidenced by excessive amounts of scoring, scuffing, blistering, cracking, or change in shape from original appearance.

3.9.4 The base diameter of the rubber cups shall not increase by more than 0.9 mm (0.035 in).

3.9.5 The average lip diameter interference set of the rubber cups shall not be greater than 65%.

3.9.6 During any period of 24 000 strokes, the volume loss of fluid shall not be greater than 36 mL.

3.9.7 The cylinder pistons shall not sieze or function improperly throughout the test.

3.9.8 The volume loss of fluid during the 100 strokes at the end of the test shall not be more than 36 mL.

3.9.9 The fluid at the end of the test shall not be in an unsatisfactory operating condition as evidenced by sludging, gelling, or abrasive grittiness, and sediment in either the master cylinder or the wheel cylinders shall not exceed 1.5% by volume after allowing the fluid to stand 24 h at room temperature and then centrifuging.

3.9.10 Brake cylinder walls and other metal parts shall be free of deposits which are abrasive or which cannot be removed when rubbed with a cloth wetted with isopropyl alcohol.

4. Test Procedure

4.1 Equilibrium Reflux Boiling Point—Determine the equilibrium reflux boiling point of the fluid by ASTM D 1120 with the following exceptions:

a. Apparatus

3(d) 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 may be used.

3(e) Heat Source—Use a suitable Variac-controlled 100 mL heating mantle designed to fit the flask, capable of supplying the heat required to conform to the specified heating and reflux rates. [Supplier: GLAS COL Apparatus Co., Terre Haute, IN. Serial number: 135464, 230 W, 135 V (max).]

b. Preparation of Apparatus

5(d)—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.

c. Procedure

6(c)—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.

The reflux rate shall not exceed 5 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, 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.

If the temperature exceeds 260 °C (500 °F), the test shall be stopped and the temperature recorded as exceeding 260 °C (500 °F).

4.1.1 WET ERBP—Humidify the fluid as described in 4.5 and determine the boiling point as described in 4.1.

4.2 Viscosity—Determine the kinematic viscosity of the fluid by ASTM D 445.

4.2.1 Report the viscosity to the nearest mm^2/s (centistoke).

4.3 Corrosion—Prepare two sets of strips from each of the metals listed in Table 1, each strip having a surface area of 25 $cm^2 \pm 5$ 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 waterproof carborundum paper (RM-29) 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 clean forceps 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, copper, and zinc, so that the strips are in electrolytic 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. Immerse strip assemblies in isopropanol or ethanol to eliminate fingerprints and then handle only with clean forceps.

Measure the base diameter of two standard SBR cups (RM-3a) 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 0.8 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.

Obtain two straight-sided round glass jars[1] (RM-49) having a capacity of approximately 475 mL and inner dimensions of approximately 100 mm in height and 75 mm in diameter.

To the RM-49 corrosion test jar, apply four wrappings of 3/4 in Teflon tape around the jar threads allowing a 1/8 in height above the top of the jar. Place one rubber cup 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.

Add 400 mL of the humidified fluid to cover the metal strip assembly in each jar to a depth of approximately 10 mm above the tops of the strips. Tighten the lids and place the jars in an oven maintained at 100 °C ± 2 °C (212 ° ± 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 jar. 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 h. Weigh each strip 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 4.6.

1. Obtainable from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001.

Immediately following the cooling period, 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 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 fluid.

Examine the test fluid in the jars for gelling. 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 5(b) of ASTM D 91. Measure the pH value of the corrosion test fluid by the procedure specified in 5.5.

4.4 Fluidity and Appearance of Low Temperatures

4.4.1 AT –40 °C (–40 °F)—Place 100 mL of the test fluid in a screw-top glass sample bottle having a capacity of approximately 125 mL, an outside diameter of about 37 mm, and overall height of about 155 mm. Cap the bottle tightly and place in a cold bath maintained at –40 °C ± 2 °C (–40 °F ± 4 °F) for 144 h ± 4 h. Remove the bottle from the bath, quickly wipe the bottle with a clean lint-free cloth saturated with isopropyl alcohol and/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.

4.4.2 AT –50 °C (–58 °F)—Place 100 mL of fluid in a glass sample bottle (same as in the –40 °F test above). Cap the bottle tightly and place in a cold bath maintained at –50 °C ± 2 °C (–58 °F ± 4 °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 isopropyl alcohol, and examine the fluid for evidence of stratification, sediment, and 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.

4.5 Tolerance for High Humidity

4.5.1 APPARATUS FOR HUMIDIFICATION (SEE FIGURE 7)—Test apparatus shall consist of:

4.5.1.1 *Glass Jars and Lids*—Four SAE RM-49 corrosion test jars. Each shall have a capacity of about 475 mL and approximate inner dimensions of 100 mm in height by 85 mm in diameter. Use matching lids (RM-63) having new, clean inserts, unaffected by the test fluid and providing water-vapor-proof seals.

4.5.1.2 *Desiccator and Cover*—Bowl-form glass desiccators, about 250 mm inside diameter, having matching tabulated covers fitted with No. 8 rubber stoppers. Four are required.

4.5.1.3 *Desiccator Plate*—Porcelain desiccator plates perforated with 5 mm (0.20 in) diameter holes approximately 15 mm on centers. Approximately 230 mm diameter, without feet, glazed one side (Coors 60003 or equal). Four are required.

NOTE—Minor variations in the humidification apparatus will not affect the end results, provided that identical set ups are used for both the reference and test fluids.

4.5.2 REAGENTS AND MATERIALS

4.5.2.1 Ammonium sulfate $(NH_4)_2SO_4$, Reagent or A.C.S. grade.

4.5.2.2 Distilled water.

4.5.2.3 SAE RM-71 reference fluid.

4.5.3 PREPARATION OF APPARATUS—Lubricate ground-glass joint of desiccator with suitable stopcock grease. Load each desiccator with 450 g ± 25 g of ammonium sulfate and add 125 mL ± 10 mL of distilled water. Surface of the salt slurry shall lie within 45 mm ± 7 mm of the top surface of the desiccator plate. Place the desiccators in an area with the temperature controlled at 23 °C ± 5 °C (73 °F ± 9 °F) throughout the humidification procedure. Load the desiccators with the slurry and allow to condition with the desiccator cover on, test jar inside, and stoppers in place, at least 12 h before use. Use a fresh charge of salt slurry for each test.

4.5.4 HUMIDIFICATION PROCEDURE—Pipette 100 mL ± 1 mL of the brake fluid into a test jar through the desiccator cover and replace the rubber stopper. Prepare a duplicate test sample and two duplicate specimens of the RM-71 reference fluid. Adjust water contents of the SAE RM-71 fluid to 0.50% ± 0.05% by weight at start of test. At intervals, remove rubber stopper in the top of each desiccator containing SAE RM-71 fluid. Using a long needled hypodermic syringe, take a sample of not more than 2 mL from each jar and determine its water content by the Karl Fischer procedure (ASTM E 203) or equivalent. Remove no more than 10 mL of fluid from each SAE RM-71 sample during humidification. When the water content of the SAE fluid reaches 3.70% ± 0.05% by weight (average of the duplicates), remove the two test fluid specimens (jars) from their desiccators and promptly cap each tightly. Fill a cone-shaped centrifuge tube (as described in 3.1 of ASTM D 91) with 100 mL of humidified fluid (remainder is available for other tests as required).

4.5.5 ALTERNATE (BULK) HUMIDIFICATION PROCEDURE (SEE NOTES FOLLOWING)—Lubricate the ground-glass joint of a 250 mm ID bowl-form desiccator having matching tubulated glass cover and fitted with a No. 8 rubber stopper. Pour 450 mL ± 10 mL of distilled water into the desiccator and insert a perforated porcelain plate (Coors No. 60003 or equal). Immediately place two open RM-49 corrosion test jars, each containing 350 mL ± 5 mL of the test brake fluid, into the desiccator. Replace the desiccator cover and insert at once into an ASTM E 145, Type IIA, forced-ventilation oven set at 50 °C ± 1 °C (122 °F ± 2 °F). Place an identical desiccator set up having two jars containing Reference Fluid RM-71 in the oven at the same time. The water content of the RM-71 fluid at the start of exposure shall have been adjusted to 0.50% ± 0.05% by weight (Karl Fischer analysis or equivalent).

Periodically during oven humidification, remove the rubber stopper from the desiccator containing the control fluid. Using a hypodermic syringe with a long needle, quickly sample each jar and determine its individual water content. When the average water content of the control fluid has reached 3.70% ± 0.05% by weight, remove desiccator containing the test fluid at once from the oven and seal the test jars promptly, using screw-cap jar lids with suitable vapor-proof liners (RM-63). Allow the sealed jars to cool for 60 to 90 min at 23 °C ± 5 °C (73 °F ± 9 °F).

4.5.5.1 Notes on Alternate Procedure

4.5.5.1.1 The bulk procedure may be run with either one, two, three, or four jars per desiccator, and jars may be filled from 150 to 350 mL as desired.

4.5.5.1.2 Minor variations in equipment used are not critical. However, it is very important that all desiccator set ups in a given run be identical, and that an ASTM Type IIB oven of ample size be used.

4.5.6 PROCEDURE FOR HUMIDITY TOLERANCE DETERMINATION

4.5.6.1 *At −40 °C (−40 °F)*—Pour 100 mL of the humidified fluid into an ASTM cone-shaped centrifuge tube described in 3.1 of ASTM D 91. Seal the tube and place in a cold bath maintained at −40 °C ± 2 °C (−40 °F ± 4 °F) for 144 h ± 4 h. Remove the centrifuge tube from the bath, quickly wipe with a clean, lint-free cloth saturated with isopropyl alcohol or acetone, and examine the fluid for evidence of stratification, sediment, or crystals. 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.) 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 appearance and clarity by comparing it to an as-received sample of the test fluid in an identical container.

4.5.6.2 *At 60 °C (140 °F)*—Place the centrifuge tube from 4.5.6.1 in a gravity convection oven conforming to ASTM E 145 Type IA and maintained at 60 °C ± 2 °C (140 °F ± 4 °F) for 22 h ± 2 h. Then remove tube from oven and immediately examine the fluid for evidence of stratification. Determine percent sediment by volume as described in 5.2 of ASTM D 91.

4.6 Effect on Rubber—Use test specimens for test procedures in 4.6.1 and 4.6.2 (either standard cups or 1 x 1 in test specimens) as described in Table 2. The specimens shall be rinsed in isopropyl alcohol and/or ethanol and quickly air-dried to remove any dirt and packing debris. The specimens shall not remain in the alcohol for more than 30 s. Allow the rubber specimens to stabilize at 23 °C ± 5 °C (73 °F ± 9 °F) prior to measuring volume hardness, also base diameter of cups as described in 4.3. 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 Wyandotte) or equivalent has been found to be acceptable.

4.6.1 EXPOSURE AT ROOM TEMPERATURE—Place two rubber specimens in a straight-sided, screw-top, round glass jar having a capacity of approximately 250 mL, inner dimensions of approximately 125 mm in height and 50 mm in diameter, and containing sufficient glass beads (4 to 6 mm diameter) to cover approximately two-thirds of the jar bottom. Immerse the two specimens in 75 mL of test fluid. Promptly seal the jar, using a steel lid provided with a foil or polytetrafluoroethylene faced cork or pulp insert. Store at 25 °C ± 2 °C for 168 h ± 2 h. Remove rubber specimens from fluid, rinse in isopropyl alcohol and/or ethanol, and quickly air dry. Specimens shall not remain in alcohol for more than 30 s.

After drying, first weigh each specimen in air (M_3) to the nearest milligram, then weigh in distilled water (M_4) at 23 °C ± 5 °C (73 °F ± 9 °F). Next measure base diameter (on cups) and hardness. All measurements must be completed within 60 min after removal from the test fluid.

4.6.2 EXPOSURE AT ELEVATED TEMPERATURE—Place two rubber specimens in a straight-sided, screw-top, round glass jar having a capacity of approximately 250 mL, inner dimensions of approximately 125 mm in height and 50 mm in diameter, and containing sufficient glass beads (4 to 6 mm diameter) to cover approximately two-thirds of the jar bottom. Immerse the two specimens in 75 mL of test fluid. Promptly seal the jar, using a steel lid provided with a foil or polytetrafluoroethylene faced cork or pulp insert. Place in a forced ventilation oven (Type IIA of ASTM E 145) and store at the specified test temperature (see Table 2). After completion of the heating period, remove from oven and allow to cool 60 to 90 min at 23 °C ± 5 °C (73 °F ± 9 °F). Remove rubber specimens from fluid, rinse in isopropyl alcohol and/or ethanol, and quickly air dry. Specimens shall not remain in alcohol for more than 30 s.

After drying, first weigh each specimen in air (M_3) to the nearest milligram, then weigh in distilled water (M_4) at 23 °C ± 5 °C (73 °F ± 9 °F). Next measure base diameter (on cups) and hardness. All measurements must be completed within 60 min after removal from the test fluid.

4.6.3 CALCULATION AND REPORTING—Volume change shall be as a percentage of the original volume, calculated as follows:

$$\text{Percent volume change} = \frac{(M_3 - M) - (M_1 - M_2)}{(M_1 - M_2)} \times 100 \quad \text{(Eq. 1)}$$

where:

M_1 = Initial mass in air
M_2 = Initial mass in water
M_3 = Final mass in air
M_4 = Final mass in water

Calculate and report the change in volume and hardness after exposure. Measure and report the change in base diameter for cups. Examine the exposure rubber specimens for blistering or sloughing. Determine conformance to requirements as set forth in Table 2.

4.7 Compatibility

4.7.1 AT –40 °C (–40 °F)—Mix 50 mL of LWTF with 50 mL of SAE RM 70 silicone base compatibility fluid and pour this mixture into an ASTM cone-shaped centrifuge tube described in 3.1 of ASTM D 91, seal. Place the centrifuge tube for 144 h ± 4 h in a cold bath maintained at –40 °C ± 2 °C (–40 °F ± 4 °F). Remove tube from bath, quickly wipe with a clean, lint-free cloth saturated with isopropyl alcohol and/or ethanol, and examine fluid for sedimentation and crystallization. Allow 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 appearance and clarity by comparing it to an as-received sample of the test fluid in an identical container. Repeat the previous procedure using RM 66-04.

4.7.2 AT 60 °C (140 °F)—Place the centrifuge tubes of 3.7 in a gravity convection oven conforming to ASTM E 145 Type IA and maintained at 60 °C ± 2 °C (140 °F ± 4 °F) for 22 h ± 2 h. Remove tube from oven and determine percent sediment by volume as described in 5.2 of ASTM D 91.

4.8 Fluid Stability—Heat a new sample of the original test brake fluid to a temperature 185 °C ± 2 °C (365 °F ± 4 °F) by the procedure specified in 4.1 and maintain at that temperature for 2 h. Then determine the boiling point of this fluid as specified in 4.1. If the temperature exceeds 260 °C (500 °F), the test can be stopped and the value reported as exceeding 260 °C (500 °F).

4.9 Stroking Test Procedure[2]**—**Use the following procedure to evaluate the lubrication quality of the brake fluid.

4.9.1 TEST APPARATUS AND MATERIAL—Use the Figure 2 stroking fixture type apparatus with the following components arranged as shown in Figure 1. The drum and shoe apparatus as described in SAE J1703 may be used as an alternative test system.

4.9.1.1 Master Cylinder Assembly—One cast iron housing hydraulic brake master cylinder having a diameter of approximately 28 mm (1-1/8 in) and fitted with an uncoated steel standpipe. Master cylinder used is SAE RM-15a 28 mm (1-1/8 in) diameter or equivalent.

4.9.1.2 Brake Assemblies—Three cast iron housing straight bore hydraulic brake wheel cylinder assemblies having a diameter approximately 28 mm (1-1/8 in). Wheel cylinder used is SAE RM-14a with stroking adapter mounting plates to hold the brake wheel cylinder assemblies as shown in Figure 2.

4.9.1.3 Braking Pressure Actuating Mechanism—A suitable actuating mechanism for applying a force to the master cylinder push rod without side thrust.

2. This procedure is identical to the one found in SAE J1703.

The amount of force applied by the actuating mechanism shall be adjustable and capable of supplying sufficient stroke and thrust to the master cylinder to create a pressure of at least 70 kg/cm^2 (1000 psi) in the simulated brake system. A hydraulic gauge and pressure recorder, capable of establishing the pressure curve of the system and monitoring the pressure developed, shall be installed on a hydraulic line extending from the master cylinder to the outside of the oven. This line shall be provided with a shut-off valve and a bleeding valve for removing air from the connection tubing.

The actuating mechanism shall be designed to provide a stroking rate of approximately 1000 strokes/h. The pressure buildup rate versus cylinder stroke and time shall correspond to Figure 3.

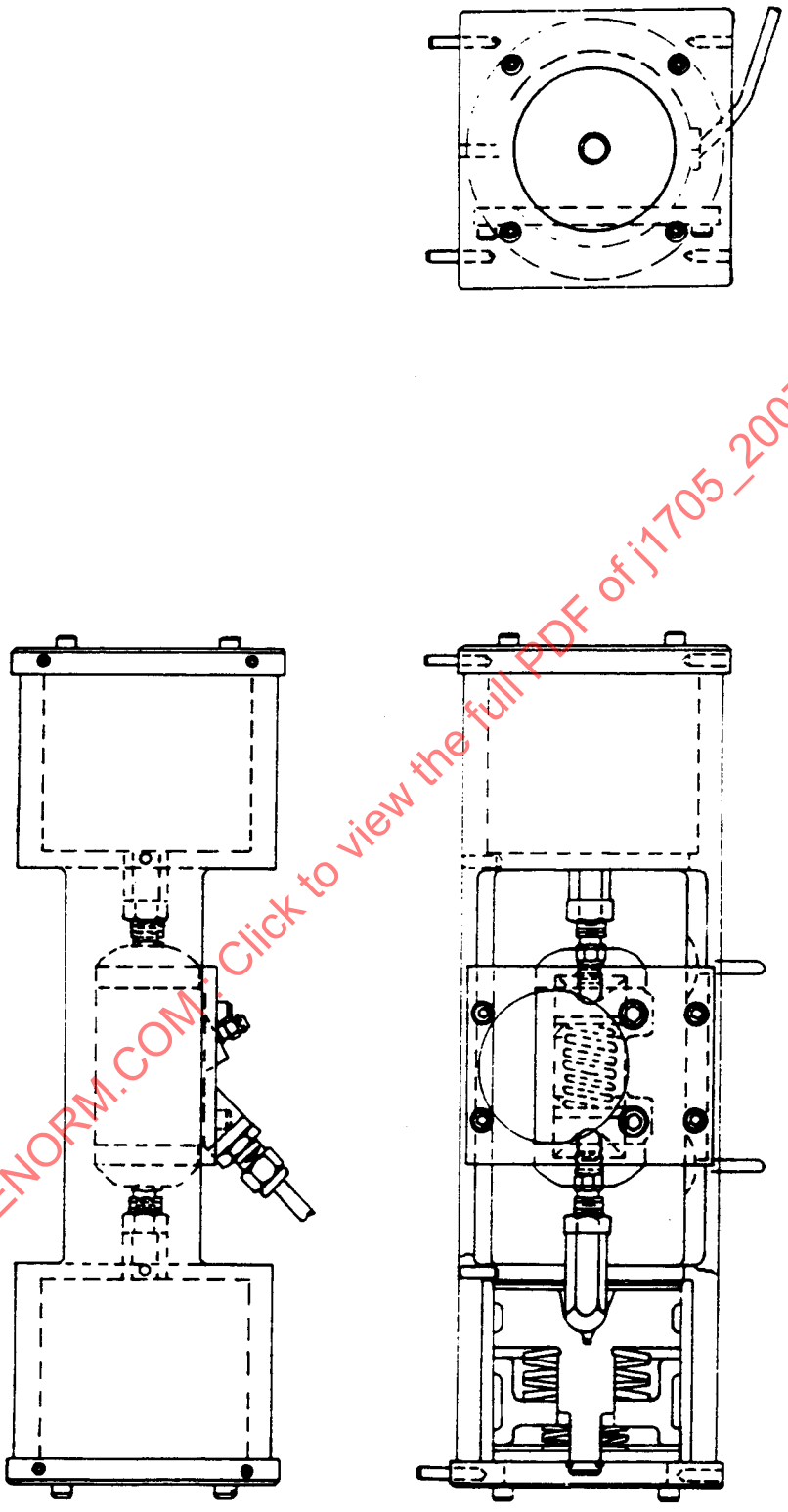

FIGURE 1—STROKING FIXTURE APPARATUS

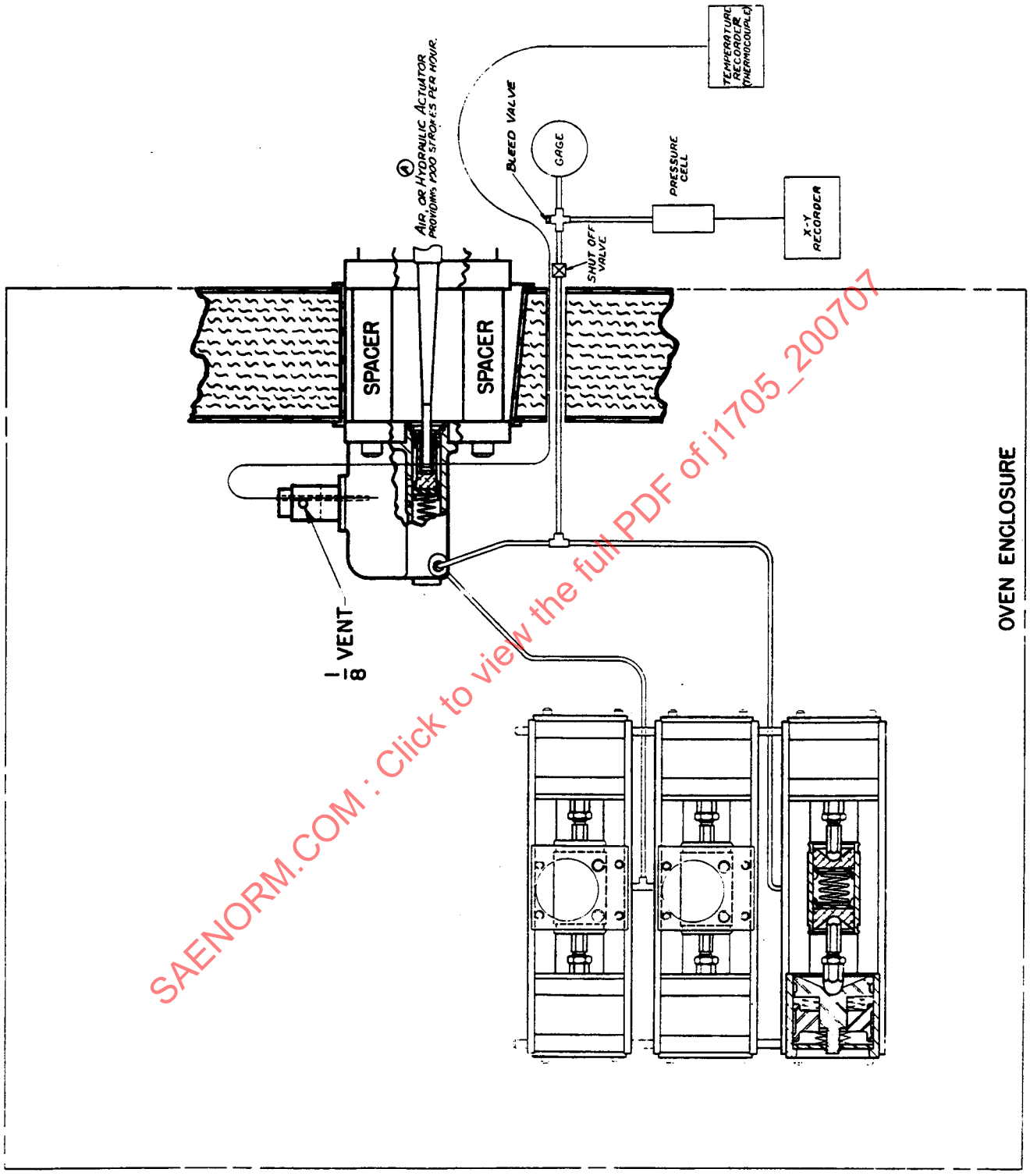

FIGURE 2—STROKING TEST APPARATUS

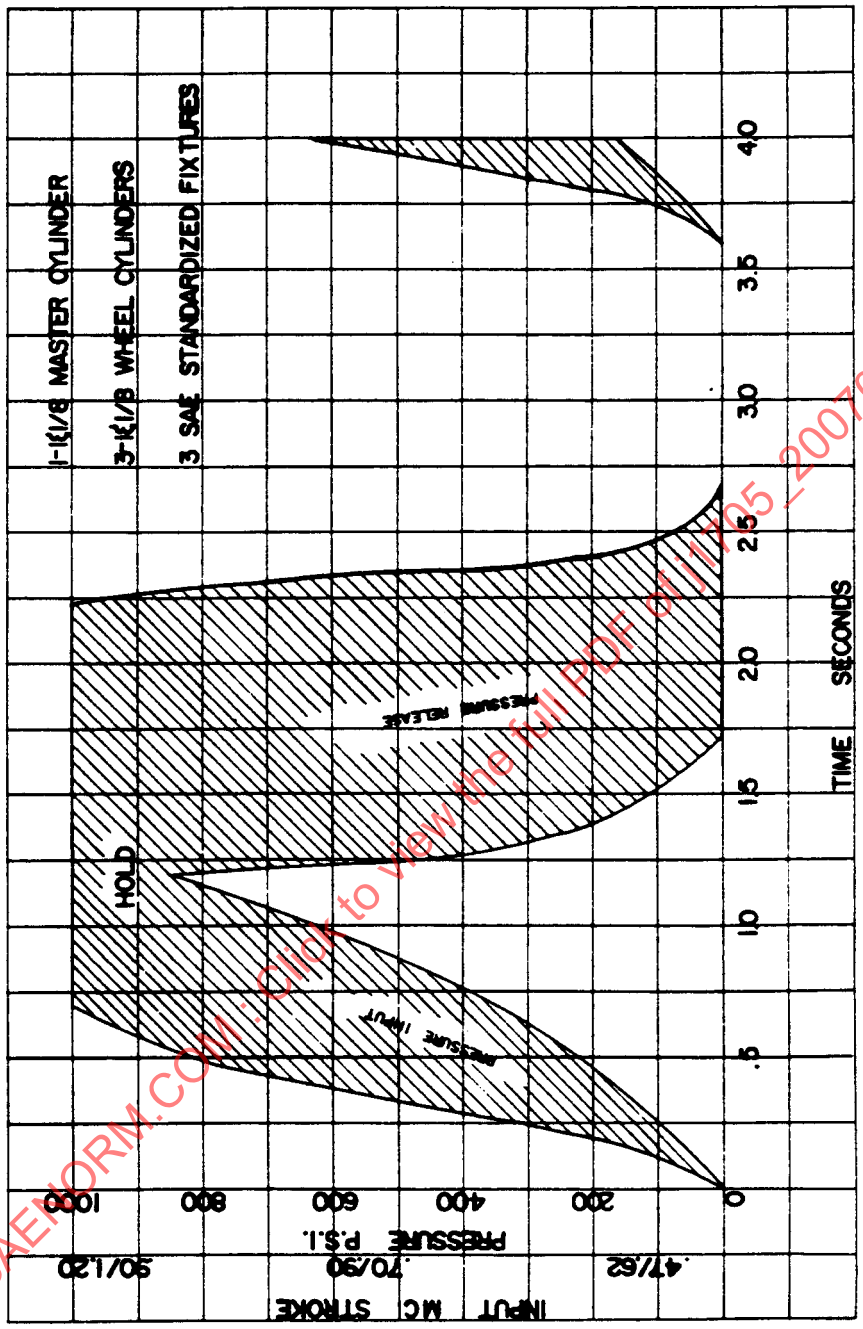

FIGURE 3—MASTER CYLINDER STROKE

4.9.1.4 *Heated Air Bath Cabinet*—An insulated cabinet or oven having sufficient capacity to house the three wheel cylinder fixture assemblies, master cylinder, and necessary connection. A suitable thermostatically-controlled heating system is required to maintain a brake fluid temperature of 120 °C ± 5 °C (248 °F ± 9 °F). Heaters shall be shielded to prevent direct radiation to wheel or master cylinders. Fluid temperature shall be monitored at random intervals during the test at the master cylinder reservoir, using a temperature recording device.

4.9.2 PREPARATION OF TEST APPARATUS

4.9.2.1 Wheel Cylinder Assemblies—Use new wheel cylinder assemblies, SAE RM-14a or equivalent, having diameters as specified in 4.9.1(b). Pistons (SAE RM-12) shall be made from unanodized SAE AA2024 aluminum alloy. Disassemble cylinders and discard rubber cups. Clean all metal parts with isopropanol and dry with clean compressed air. 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 isopropanol and/or ethanol. If stains cannot be removed, discard the cylinder. Measure the internal diameter of each cylinder at locations approximately 19 mm (0.75 in) from each end of the cylinder bore, taking measurements in line with the hydraulic inlet opening and at right angles to the centerline. Discard the cylinder if any of these four readings exceeds maximum or minimum limits of 28.66 to 28.60 mm (1.1285 to 1.126 in). Measure the outside diameter of each piston at two points approximately 90 degrees apart. Discard any piston if either reading exceeds maximum or minimum limits of 28.55 to 28.52 mm (1.124 to 1.123 in). Select parts to insure that the clearance between each piston and mating cylinder is within 0.08 to 0.13 mm (0.003 to 0.005 in). Use new standard SAE RM-3 SBR cups as specified in Figure 4 that are free of lint and dirt. Discard any cups showing imperfections such as cuts, tooling marks, molding flaws, or blisters. Measure the lip and base diameters of all test cups with an optical comparator or a micrometer to the nearest 0.025 mm (0.001 in) along the ceterline of SAE and rubber type identifications and right angles to this centerline. Determine base diameter measurements within 0.8 mm (0.032 in) of the bottom edge and parallel to the base of the cup. Discard any cups if the two measured lip or base diameters differ by more than 0.08 mm (0.003 in). Average the lip and base diameters of each cup. Determine the hardness of all cups by the procedure specified in 4.3. Clean rubber parts with isopropanol and a lint-free cloth. Dry with clean compressed air. Dip the rubber and metal parts of the wheel cylinders, except housings, in the fluid to be tested and install them in accordance with manufacturer's instructions. Rubber boots may be retained on the cylinders if a small section is removed on the bottom to observe leakage. Manually stroke the cylinders to insure that they operate easily. Install cylinder in the simulated brake system.

4.9.2.2 Master Cylinder Assembly—Use a new SAE RM-15b master cylinder having an SAE RM-13-02 aluminum alloy piston and new standard SAE RM-4a and RM-5a SBR cups as specified in Figures 5 and 6. Inspect and clean all parts as specified in 4.9.2(a). Measure each end of the master cylinder piston at two points approximately 90 degrees apart. Discard the piston if any of these readings exceeds maximum or minimum limits of 28.55 to 28.52 mm (1.124 to 1.123 in). Dip the secondary cup in the test brake fluid, assemble on the piston, and maintain the assembly in a vertical position at 23 °C ± 5 °C (73 °F ± 9 °F) for at least 2 h. Determine the lip and base diameter of the secondary cup as installed on the piston and the primary cup at locations shown in Figure 5. Inspect the relief and supply ports of the master cylinder and discard the cylinder if these 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 (0.75 in) beyond the relief port toward the bottom or discharge end of the bore, taking measurements at each location in the vertical and horizontal centerlines of the bore. Discard the cylinder if any reading exceeds maximum or minimum limits of 28.65 to 28.58 mm (1.128 to 1.125 in). Dip the rubber and metal parts of the master cylinder, except the housing, in the fluid to be tested and install them in accordance with manufacturer's instructions. Discard boot and push rod assembly. Manually stroke the master cylinder to insure that it operates easily. Install the master cylinder in the simulated brake system.

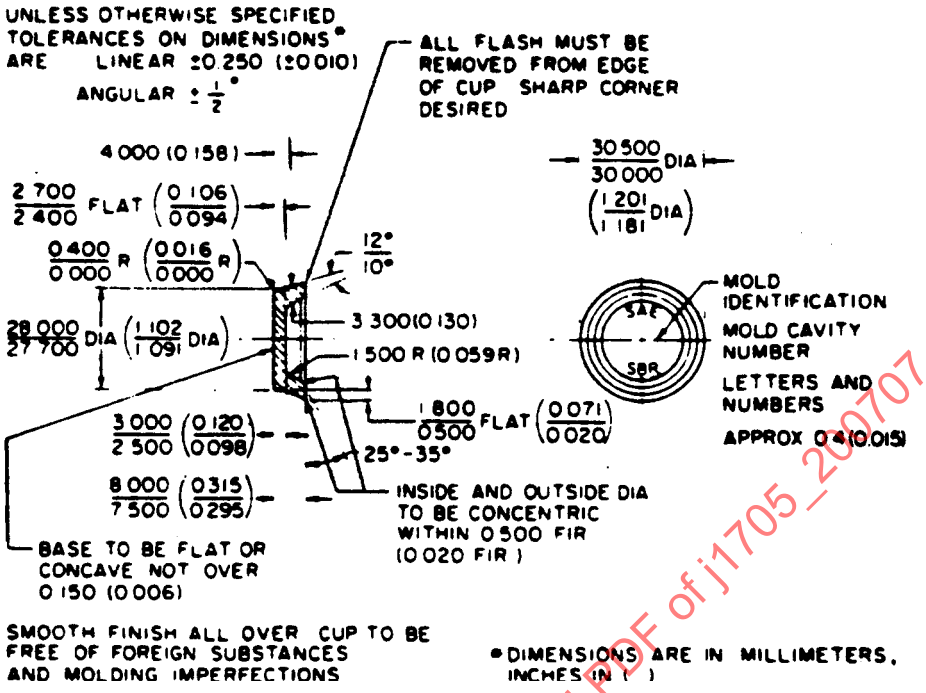

FIGURE 4—SAE TEST CUP WHEEL CYLINDER

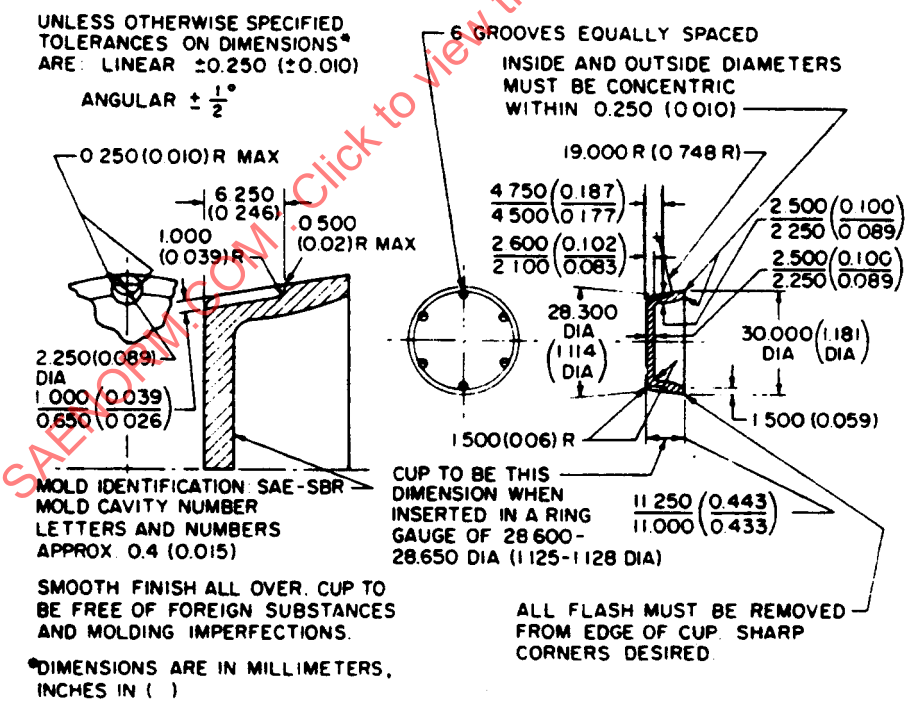

FIGURE 5—SAE TEST CUP—PRIMARY MASTER CYLINDER