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MILITARY SPECIFICATION

BRAKE FLUID, SILICONE, AUTOMOTIVE, ALL WEATHER, OPERATIONAL AND PRESERVATIVE, METRIC

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers one type and one grade of silicone-based hydraulic brake fluid for use in hydraulic brake systems at ambient temperatures ranging from +55 to -55 °C (see 6.1). The fluid shall be identified by military symbol BFS and NATO code No. H-547 (see 6.1).

1.2 Military part numbers. Silicone-based hydraulic brake fluid furnished under this specification shall be identified by a military part number consisting of the "M" prefix and basic specification number followed by a two-digit number taken from table I indicating unit container type and minimum fluid quantity per unit container followed by the military symbol "BFS" as shown in the following example:

EXAMPLE

M46176-02-BFS

"M" prefix and basic specification number

Dash number from table I indicating 500 milliliter minimum fluid quantity per unit containers; metal can

Military spmbol (see 1.1)

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: USA Belvoir Research, Development, and Engineering Center, ATTN: STRBE-TSE, Fort Belvoir, VA 22060-5606 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 9150

TABLE I. Container type and minimum fluid quantity.

Dash number (see 1.2)	Minimum fluid quantity per unit container	Container type
01	1 point (437 mL)	metal can
02	500 milliliter	metal can
03	1 quart (946 mL)	metal can
04	1 liter	metal can
05	1 gallon (3785 mL)	metal can
06	5 gallons (18927 mL)	metal can
07	208 liter (55 gallon)	metal can

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

QQ-A-250/4 - Aluminum Alloy 2024, Plate and Sheet.
QQ-B-613 - Brass, Leaded and Non-Leaded; Flat Products (Plate, Bar, Sheet, and Strip).
QQ-C-576 - Copper, Flat Products with Slit and Edge Rolled, Sheared, Sawed, or Machine Edged (Plate, Bar, Sheet and Strip).
QQ-T-425 - Tinplate (Electrolytic).

STANDARDS

FEDERAL

FED-STD-141 - Paint, Varnish, Lacquer, and Related Materials, Methods of Inspection, Sampling, and Testing.
FED-STD-313 - Material Safety Data Sheets, Preparation and Submission of.
FED-STD-791 - Lubricants, Liquid Fuels and Related Products; Methods of Testing.

MILITARY

MIL-STD-105 -Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-290 - Packaging, Packing and Marking of Petroleum and Related Products.
MIL-STD-1180 - Safety Standards for Military Ground Vehicles.

2.1.2 Other Government documents, drawings, and publications. The following other Government, documents, drawings, and publications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

DEPARTMENT OF LABOR (DOL)

OSHA 29 CFR 1910.1200 Hazard Communication Interpretation Regarding Lubricating Oils.

(Guideline CPL 2-2.38 may be obtained from OSHA Publication Office, Room S-4203, 200 Constitution Avenue, NW, Washington, DC 20210.)

(Copies of specifications, standards, handbooks, drawings, publications, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following document(s) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 91 - Precipitation Number of Lubricating Oils.
D 92 - Flash and Fire Points by Cleveland Open Cup.
D 344 - Relative Hiding Power of Paints.
D 445 - Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity).
D 1193 - Reagent Water.
D 1415 - Rubber Property - International Hardness.
D 1744 - Water Content in Liquid Petroleum Products by Karl Fischer Reagent.
D 4057 - Manual Sampling of Petroleum and Petroleum Products.
D 4177 - Automatic Sampling of Petroleum and Petroleum Products.
E 145 - Gravity Convection and Forced Ventilation Ovens.

(The ASTM test methods listed above are included in the Annual Book of ASTM Standards and are also available separately. Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.

SAE Standard J1703 - Hydraulic Brake Fluid.
SAE Standard J403 - Chemical Composition of SAE Carbon Steels.

(Application for copies should be addressed to the Society of Automotive Engineers Inc., 400 Commonwealth Drive, Warrendale, PA 15096).

THE BENDIX CORPORATION TEST PROCEDURE

Hydrovac Test Procedure with list of required parts.

(The Hydrovac Test Procedure may be obtained from the Bendix Corporation Automotive Control Systems Group, South Bend, IN 46220).

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, (except for associated detail specifications, specifications sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Silicone brake fluids furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.5.1 and 6.3). Separate qualification shall be conducted for each formulation. The formulation of an approved brake fluid shall not be changed without prior approval of the qualifying activity (see 6.3).

3.2 Material. The material covered by this specification shall contain not less than 70 percent by weight of a diorgano polysiloxane and shall be a bluish-purple color. It shall be furnished in unit containers of the sizes and styles specified (see 6.2). The contractor shall certify that no carcinogenic or potentially carcinogenic constituents are present as defined under the Hazard Communication Standard (RCS) 29 CFR 1910.1200. Certification to this effect shall be made available to the contracting officer or the contracting officer's representative.

3.3 Physical and chemical requirements. The brake fluid shall conform to the respective requirements specified in 3.4 through 3.16.

3.4 Vapor lock temperature (VLT). When tested as specified in 4.6.1, the brake fluid shall have a VLT of not less than 230 °C.

3.5 Wet vapor lock temperature. When tested in accordance with 4.6.2, the brake fluid shall have a wet VLT of not less than 177 °C.

3.6 High temperature stability. The decrease in VLT shall not exceed 5.0 °C when tested according to 4.6.3. If the VLT reported in 3.4 is in excess of 232 °C the observed VLT of 4.6.3 shall not be less than 227 °C.

3.7 Viscosity. The brake fluid when tested by the procedure specified in 4.6.4 shall have kinematic viscosities as follows, both before and after humidification as described in 4.6.11:

a. At -55 °C: Not more than 900 centistokes.
b. At 100 °C: Not less than 1.3 centistokes.

3.8 Corrosiveness. When the brake fluid is tested for corrosiveness, as specified in 4.6.5, the test results shall meet the following requirements.

3.8.1 Disintegration of rubber cups. The rubber cup shall show no sloughing, tackiness, blisters, or any other form of disintegration. The increase in the base diameter of the cup shall be no less than 0.03 mm and no more than 1.4 mm. The hardness of the cup shall not decrease by more than 15 points.

3.8.2 Metal strips. The metal strips shall not be pitted nor etched. The permissible change in weight of the strips shall be as follows:

Metal	Change in weight mg/sq cm max
Tinned steel	0.1
Carbon steel	0.1
Aluminum alloy	0.1
Cast iron	0.1
Brass	0.2
Copper	0.2

3.8.3 Fluid. At the end of the test, the humidified fluid shall show no gelling at 25 ± 5 °C. No crystallization deposit shall form. The fluid shall contain no more than 0.10 percent of sediment of volume.

3.9 Appearance at sub-zero temperatures: -55 °C. When it is tested in accordance with 4.6.6, the brake fluid shall be transparent or slightly cloudy, and shall show no stratification, separation, precipitation, or crystallization. On warming to 25 ± 5 °C, the fluid shall regain its original degree of clarity.

3.10 Fluidity at sub-zero temperatures: -55 °C. When the brake fluid is tested in accordance with 4.6.7, the air bubble shall travel to the top in not more than 10 seconds.

3.11 Compatibility. The brake fluid shall be compatible with all brake fluids qualified under this specification. When it is tested in accordance with 4.6.8.1 and 4.6.8.2, the fluid shall be transparent or

slightly cloudy, and shall contain no more than 0.05 percent of sediment by volume. On warming to 25 ± 5 °C, the fluid shall regain its original degree of clarity.

3.12 Flash point. When the brake fluid is tested in accordance with 4.6.9, the flash point shall not be less than 204 °C.

3.13 Effects on rubber. When the brake fluid is tested for its effect on rubber in accordance with 4.6.10, the test results shall meet the requirements of table II.

TABLE II. Effect on rubber.

Type	Test specimen	Volume swell %	Base diameter change	Change in hardness IRHD	Test temperature °C
SBR	SAE RM-3 Cup	+ 5 to +20	0.15 to 1.40 mm	0 to -10	70 ±2
	”	+ 5 to +20	” ” ”	0 to -15	120 ±2
Polychloroprene	SAE RM-68 Neoprene Slab Stock 2.5 cm sq	-5 to +6	----	+3 to -10	70 ±2
	”	-5 to +10	----	+3 to -10	100 ±2
EPR	SAE RM-69 EPDM slab Stock 2.5 cm sq	0 to +10	----	0 to -10	70 ±2
	”	0 to +10	----	0 to -10	120 ±2
Natural	SAE NR-X Cup	+5 to +20	0.15 to 1.40 mm	0 to -10	70 ±2

3.13.1 Disintegration. The rubber cups and slab stock exposed to the brake fluid shall show no sloughing, tackiness, blisters, nor any other form of disintegration. (Sloughing is indicated by the presence of carbon black on the surface of the rubber at the end of the test.)

3.14 Tolerance to high humidity. When it is tested in accordance with 4.6.11, the fluid shall meet the following requirements:

3.14.1 Appearance at -40 °C. At -40 °C the fluid shall show no stratification, sediment, or crystals. Upon inversion of the centrifuge tube, the air bubble shall travel to the top of the fluid in not more than 10 seconds. Slight cloudiness is permitted, but on warming to 25 ±5 °C the fluid shall regain its original degree of clarity.

3.14.2 Appearance at 60 °C. At 60 °C the fluid shall show no stratification, and the sediment, shall not exceed 0.05 percent by volume after centrifuging.

3.14.3 Water pick-up. The total amount of water pick-up by the test fluid shall be less than 0.30 ±0.05 percent by weight when tested as specified in 4.6.11.

3.15 Stroking performance. The brake fluid shall meet the requirements specified in 3.15a through 3.15k when tested in accordance with 4.6.12.

a. There shall be no more than slight pitting, etching, scoring and galling of the metal parts.
b. The change in the diameter of any cylinder or piston shall not exceed 0.13 mm.
c. None of the 10 rubber cups shall show an increase in base diameter of more than 0.90 mm.
d. The decrease in hardness of any of the rubber cups shall not be more than 15 points. The lip edge of the cups shall show no excessive hardening or collapsing.
e. The average lip interference set of the rubber cups shall not be greater than 65 percent.
f. The degree of swelling, tackiness, scoring, scuffing, blistering, cracking, or change in shape shall not be more than moderate. Chipping (heel abrasion) shall not exceed Number 4 in the SAE Wheel Cylinder Base Chipping Standard. Number 5 shall be considered failing.
g. In any 12-hour period during the test, the pressure in the simulated brake system shall not increase more than 241 kPa or decrease more than 345 kPa from the initial pressure.
h. The volume-loss of brake fluid due to leakage and evaporation at the end of any 24 hour period during the test shall not be more than 36 mL.
i. The volume loss of brake fluid during the 100 strokes at the end of the test shall not be more than 36 mL.
j. The fluid, after stroking, shall not contain more than 2 percent sediment by volume when tested as specified in 4.6.12.1.
k. The master cylinder piston and wheel cylinder pistons shall show no improper functioning, such as seizing of the piston in the cylinder, failure of the piston to permit release of the brake, or excessive increase in pressure, which may be attributed to the brake fluid proper (see 3.15.g).

3.16 Hydrovac performance. When tested by the procedure specified in 4.6.13, the fluid shall operate satisfactorily for the duration of the 200,000 strokes at 82.2 °C. The Hydrovac unit shall be capable of raising and holding the pressure within 1380 kPa of the initial setting but the pressure shall not exceed 8964 kPa.

3.17 Material safety data sheets. Material safety data sheets shall be prepared in accordance with FED-STD-313. The form used for submission of data shall be OSHA-20, DD Form 1813, or one essentially similar and approved by OSHA. The completed form shall be submitted to the qualifying activity (see 6.3) when submitting samples for qualification testing.

3.18 Special safety and identification marking and labeling. In addition to the marking requirements specified in 5.1, each brake fluid container shall be marked or labeled in accordance with MIL-STD-1180, requirement 116. Additionally, each container shall be marked with the following information:

Military Symbol BFS
NATO Code NO. H-547

WARNING

Prevent this fluid from coming in contact with the eyes as it may cause irritation. Wash the hands thoroughly after exposure. Upon accidental eye exposure, wash the eyes promptly with water for at least fifteen (15) minutes. Eye hazard is neither severe nor permanent.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Lot.

4.2.1 Bulk lot. A bulk lot is an indefinite quantity of a homogeneous mixture of brake fluid offered for acceptance in a single, isolated container; or manufactured in a single plant run (not exceeding 24 hours), through the same processing equipment, with no change in the ingredient materials.

4.2.2 Packaged lot. A packaged lot is an indefinite number of 208 liter drums or smaller unit containers of identical size and type, offered for acceptance) and filled with a homogeneous mixture of brake fluid manufactured in a single plant run (not exceeding 24 hours), through the same processing equipment, with no change in the ingredient materials.

4.3 Sampling.

4.3.1 Sampling for examination of filled containers. Take a random sample of filled containers from each lot in accordance with MIL-STD-105 at inspection level II. Acceptable quality level (AQL) equals 1.0 percent detective.

4.3.2 Sampling for tests. Take samples for tests from bulk or packaged lots in accordance with ASTM D 4057 or D 4177. The sample shall contain at least 0.95 liter of fluid.

4.4 Inspection. Perform inspection in accordance with method 9601 of FED-STD-791. In addition to the inspection, the manufacturer shall provide certification of noncarcinogenicity (i.e. materials are not considered carcinogenic or potentially carcinogenic).

4.4.1 Examination of filled unit containers. Samples selected in accordance with 4.3.1 shall be examined for compliance with MIL-STD-290 and, as applicable, MIL-STD-1180, with regard to closure, sealing, leakage and marking.

4.5 Classification of tests.

a. Qualification tests (see 4.5.1).
b. Quality conformance tests (see 4.5.2).

4.5.1 Qualification tests. Qualification tests consist of all the tests specified herein.

4.5.2 Quality conformance tests. Quality conformance tests consist of all the tests specified herein except for the compatibility test (see 4.6.8), the stroking test (see 4.6.12) and the hydrovac test (4.6.13).

4.6 Test methods.

4.6.1 Vapor lock temperature. Determine the VLT using the following procedure and the Markey Vapor Lock Instrument. (Information concerning the source of this instrument may be obtained from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096). A VLT of less than 230 °C shall constitute failure of this test.

4.6.1.1 Back heater. Set the back heater (left indicator light) to cut off at 221 °C - 230 °C.

4.6.1.2 Front heater. Adjust the front heater (right indicator light) manually. Set this heater to cut off at about 14 °C below the vapor lock temperature. Check the adjustment during the first run on a sample. Discard the test value from the first run on each sample.

4.6.1.3 Cleaning. The instrument and sampling syringe shall be clean and dry. If the instrument has been standing for some time, purge it with isopropyl alcohol as specified in the instructions. Heat it to 149 °C - 163 °C and purge it with air, cooling it to 38 °C or less, to drive off any absorbed moisture. The cover must be in place and closely fitted to assure a thorough

purging of the instrument. When the large (50 mm) diameter dial thermometer is used, it must be removed for purging. Cooling from above 149 °C to less than 38 °C will require from 4 to 8 minutes. Avoid breathing the fumes during purging.

4.6.1.4 Sample. Introduce 6.6 mL of the test fluid into the instrument and use the air to relieve any bubbles.

4.6.1.5 Setting. Close the top valve and set the thermostat at 40 °C below the expected vapor lock temperature. The first run will determine the proper setting for the second and third runs.

4.6.1.6 Vapor lock point. Make three determinations on each sample using a fresh specimen each time. Drain, purge, and cool the instrument to less than 38 °C between runs on the same sample. Observe the slow rise of the fluid in the pyrex tube, the throbbing then the fast rise of the fluid until it goes "over the loop" and drips into the fill cup. The temperature at which the fluid starts over the loop is the vapor lock temperature for that fluid. If no vapor lock indication is observed before the fluid reaches 232 °C, discontinue heating and report the vapor lock temperature as “in excess of 232 °C”. Record the average of the last two determinations on a sample as the vapor lock temperature.

4.6.1.7 Calibration. Calibrate the thermometer at least once a mouth using boiling reagent-grade naphthalene with a B. P. of 218 °C, and at least twice a month with boiling reagent-grade water conforming to type II of ASTM D 1193, with a B. P. of 100 °C.

4.6.1.8 Caution. Before starting a new sample, cool the instrument to 40 °C or below. Rinse the instrument twice with reagent-grade toluene, followed by two rinses with reagent-grade acetone or isopropyl alcohol. Heat the instrument to 150 °C - 160 °C and purge it with air once more, then cool it to 40 °C or below. Also, disassemble the sampling syringe and rinse and dry it similarly with compressed air. Avoid toxic fumes. The use of an efficient exhaust hood is recommended.

4.6.2 Wet vapor lock temperature. Humidify the fluid as described in 4.6.11 and test run a vapor lock determination of the humidified fluid as described in 4.6.1. A wet VLT of less than 177 °C shall constitute failure of this test.

4.6.3 High-temperature stability. Using a suitable 100-mL round bottom flask with a water-cooled condenser, heat 60 mL of test fluid to 185 ±2 °C and maintain it at that temperature for 2 hours. At the end of 2 hours attach a drying tube filled with desiccant to the top of the condenser and allow it to cool for 60 to 90 minutes. Determine the VLT of this fluid as specified in 4.6.1. The difference between this observed VLT and that previously determined in 4.6.1 shall be considered the change in VLT of the fluid. A decrease in VLT in excess of that specified in 3.6 shall constitute failure of this test.

4.6.4 Viscosity. Determine the kinematic viscosity of the fluid at 100 °C and -55 °C in accordance with ASTM D 445. Nonconformance to 3.7 shall constitute failure of this test.

4.6.5 Corrosiveness.

4.6.5.1 Rubber cups. Three SBR wheel brake cylinder cups conforming to SAE J1703 are required (see 6.4). Use the cups in testing the brake fluid either within 6 months of the date of manufacture when they are stored between 20 °C and 30 °C, or within 36 months of the date of manufacture when they are stored below -15 °C. The cups shall be free from lint and dirt. Determine the base diameter of each cup with a micrometer to the nearest 0.03 mm and record it. Make two diametrical measurements at right angles to each other. If the two readings differ from each other by more than 0.08 mm, discard the cup. Determine the hardness of each cup in accordance with method 361 of FED-STD-791. Consider the average of the readings taken on each cup as the hardness of the cup. (The standard international rubber hardness tester specified in ASTH D.1415 may be used as an alternate means of determining the hardness of the cup.) Nonconformance to 3.8.1 shall constitute failure of this test.

4.6.5.2 Metal strips. Use three strips of each of the following metals in the test procedure (see 6.4).

METAL	DESCRIPTION
Tinned steel	Steel, Type MR, Temper T-5-CA, Electrolytic, Class 25, base weight 80 lb/base box, conforming to QQ-T-425.
Carbon steel (low carbon)	Temper 4 or 5 of SAE J403 (SAE 1018).
Aluminum alloy	Temper 0 of QQ-A-250/4 (SAE AA2024).
Cast iron	Cut from brake wheel cylinders such as Wagner Electric Corporation FD-373 cylinders or the equivalent (SAE G 3000).
Brass	Copper Alloy No. 268, half-hard temper, of QQ-B-613.
Copper, cold-rolled	Cold-rolled half-hard temper of QQ-C-576 (No. CA 114 of SAE J461).

Each strip shall have a surface area of 26 ±5 cm^2, and shall measure 76 mm by 13 mm by less than 6.4 mm. Drill a hole 4.8 mm in diameter, centered 6.4 mm from one end, in each strip. Clean all strips, with the exception of the tinned steel, by abrading them with No. 320A waterproof silicon carbide paper and 95 percent ethyl alcohol until all surface scratches, cuts, and pits are removed from all of the strips. Rinse all of the strips in 95 percent ethyl alcohol, dry them with a clean, lint-free cloth and condition them to constant weight in a desiccator.

4.6.5.3 Procedure. When the strips are ready for testing, weigh them to the nearest 0.1 mg. Fasten one strip of each of the metals together through the holes in the strips, using an uncoated cotter pin or a size No. 6 or 8 uncoated mild steel bolt with nut, to ensure electrolytic contact between the strips.

Wet the strips with the brake fluid under test and arrange them on the pin in the same order in which they are listed in 4.6.5.2. Bend them so as to make a separation of at least 3 mm between the adjacent strips for a distance of approximately 60 mm, measured from the free end of the strips. Place the three sets of assembled strips in separate screw-cap jars of approximately 473 mL capacity (see 6.4). One SBR wheel cylinder cup (see 4.6.5.1) shall also be placed in the container in such a manner that the pinned ends of the strips rest in, and are in contact with, the concavity of the cup. Prepare a sufficient amount of humidified brake fluid in accordance with 4.6.11.3 and pour it into each jar to a depth of 12.7 mm above the tops of the assembled strips. Secure the lids of the jars and place the jars in a gravity convection oven maintained at 100 ±2 °C for 120 ±2 hours. Following the test period, allow the jars to cool for 60 - 90 minutes, then remove the metal strips and rubber cups from the jars. Wash the three rubber cups quickly in isopropyl alcohol and air-dry them. Examine the cups for evidence of sloughing, softening, tackiness, and disintegration. Measure the base diameter and hardness of each cup to determine compliance with 3.8.1. Make these measurements within 15 minutes after removal of the cups from the fluid. Disassemble the metal strips and clean them of all adhering sediment, sludge, and corroded particles by flushing with isopropyl alcohol. Clean the strips individually by wiping them with a cloth wetted with isypropyl alcohol. Examine the strips for evidence of corrosion, pitting, etching, or discoloration. Bring the strips to constant weight in a desiccator and weigh them to the nearest 0.1 mg. Calculate the weight loss per unit area of each strip by dividing the observed loss of weight of each strip in milligrams of its total surface area in square centimeters. Calculate the average of the three determinations made for each type of metal specimen and record it as the average weight loss in milligrams per square centimeter. Centrifuge 100 mL of the test fluid in accordance with ASTM D 91. The centrifuged fluid shall meet the requirements of 3.8.3. Evidence of corrosion, pitting, etching, or discoloration or weight change other than as specified shall constitute failure of this test.

4.6.6 Appearance at sub-zero temperatures: -55 °C.

4.6.6.1 Procedure. Place a 100-mL portion of the brake fluid in a 125-mL oil sample bottle approximately 15 cm in height and 3.5 cm in diameter. Place the bottle and contents in a cold bath maintained at -55 ±2 °C for 6 hours. Following the test period, carefully remove the bottle from the cold bath and wipe it with a clean, lint-free cloth saturated with alcohol or acetone. Place the bottle quickly against a hiding-power test chart of the type specified in method 4121 of FED-STD-141 or in ASTM D 344 (see 6.4). Evidence of stratification, sedimentation, or crystallization shall constitute failure of this test.

4.6.7 Fluidity at sub-zero temperatures: -55 °C. Place a 100-mL portion of the brake fluid in a 125-mL sample bottle approximately 15 cm in height and 3.5 cm in diameter. Place the bottle and contents in a cold bath maintained at -55 ±2 °C for 6 hours. Following the test period, remove the bottle from the bath quickly and invert it immediately. Determine and record the number of seconds required for the air bubble to reach the top of the fluid in the inverted bottle. Failure of the air bubble to reach the top of the fluid within 10 seconds shall constitute failure of this test.

4.6.8 Compatibility. Prepare individual mixtures of the brake fluid under test with all fluids previously qualified under this specification. Each mixture shall consist of 50 parts by volume of the test fluid and 50 parts by volume of a previously qualified brake fluid.

4.6.8.1 Procedure. Place a 100-mL portion of each of the prepared mixtures in separate 125-mL oil sample bottles, approximately 15 cm in height and 3.5 cm in diameter. Place the bottles in a cold bath maintained at -40 ±2 °C for 24 ±2 hours. Following the test period, remove the bottles from the cold bath. Wipe them quickly with a clean lint-free cloth saturated with alcohol, and place them one at a time against a hiding power test chart of the type specified in method 4121 of FED-STD-141 or in ASTM D 344 (see 6.4). The diagonal contrast lines on the chart shall be discernible through every part of the fluid mixture in each bottle. Examine the test mixtures for evidence of stratification, separation, sedimentation, and crystallization.

4.6.8.2 Examination. Immediately following the examination for transparency of the mixture, place the bottles in an oven maintained at 60 ±2 °C for 24 ±2 hours. Following the test period, examine the contents of all the bottles for evidence of stratification or separation. Determine sedimentation in accordance with ASTM D 91. Nonconformance to 3.11 shall constitute failure of this test.

4.6.9 Flash point. Determine flash point in accordance with ASTM D 92. A flash point of less than 204 °C shall constitute failure of this test.

4.6.10 Effect on rubber.

4.6.10.1 Material. Use rubber test specimens as specified in table II.

4.6.10.2 Preparation. Expose two specimens of each type of rubber to the test fluid at each specified temperature. Rinse the specimens in alcohol and wipe them dry with a clean, lint-free cloth to remove any dirt or packing debris. Do not allow the specimens to remain in the alcohol for more than 30 seconds. Allow the specimens to become stabilized at 25 ±5 °C for 24 hours before measuring them for hardness, volume, and base diameter of the cups. Determine the base diameter of each cup with a micrometer to the nearest 0.03 mm and record it. Exercise care in making this measurement to make sure that the micrometer does not extend more than 0.8 mm beyond the bottom edge of the cup. Make two diametrical measurements, at right angles to each other, on each of the cups. If the two readings differ from each other by more than 0.08 mm (0.003 in) discard the cup. Consider the average of the two readings as the diameter of the cup.

4.6.10.2.1 Hardness determination. Determine the hardness of each rubber specimen in accordance with method 361 of FED-STD-791, with the average of four readings taken on each sample considered as the hardness. The standard international rubber hardness tester specified in ASTM D 1415 may be used as an alternate means of determining the hardness of the cup.

4.6.10.2.2 Volume determination. Determine the volume of each rubber specimen by weighing it, to the nearest milligram, first in air (W_1) then while immersed in water (W_2) containing no more than

0.2 percent of a wetting agent such as Pluronic L-61 (BASF Wyandotte) or an equivalent. The difference (W_1 - W_2) equals the weight of water displaced and its volume.

4.6.10.3 Procedures. Place two rubber specimens in a straight-aided, screw top, round glass jar TRM-51) approximately 50 mm in diameter. Add a sufficient number of glass beads 4 - 6 mm in diameter to cover two-thirds of the bottom of the jar. Immerse the two specimens in 75 mL of the test fluid. Close the jar promptly with a tinned steel lid free from organic coating and without a gasket or liner (RM-52). Place the jar in an oven with forced ventilation at the temperature specified in table II for 70 ±2 hours. At the end of the exposure period, remove the jar from the oven and slow it to cool for 60 - 90 minutes at 25 ±5 °C. Remove the rubber specimens from the test fluid, rinse them in alcohol and wipe them dry with a clean, lint-free cloth.

4.6.10.3.1 Examination. Measure the base diameters of the cups first, then the volume, and then the hardness. Make all measurements within one hour after removing the specimens from the teat fluid. Nonconformance to the requirements specified in table II shall constitute failure of this test.

4.6.10.4 Calculation. Report volume changes as a percentage of the original volume, calculated as follows:

$$\text{Percent Volume Change} = \frac{(W_3 - W_4) - (W_1 - W_2)}{W_1 - W_2} \text{X } 100$$

Where: W_1 = initial weight in air.
W_2 = initial weight in water.
W_3 = final weight in air.
W_4 = final weight in water.

Calculate and report the change in base diameter of the cups and the change in hardness of all specimens after exposure. Examine the exposed specimens for evidence of blistering or sloughing. Nonconformance to the requirements of table II shall constitute failure of this test.

4.6.11 Tolerance to high humidity.

4.6.11.1 Apparatus. The test apparatus shall consist of 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 RM-63 lids having clean, new inserts providing water-proof seals. Four bowl-form desiccators, having an inside diameter of 250 mm, with matched, tubulated covers fitted with No. 8 rubber stoppers and perforated porcelain desiccator plates are required.

4.6.11.2 Reagents and materials.

Ammonium sulfate, $(NH_4)_2SO_4$, ACS Reagent Grade.

Reagent-grade water conforming to type II of ASTM D 1193.

SAE RM-60-03 Compatibility Fluid.

4.6.11.3 Examination for high humidity tolerance. High humidity tolerance may be determined by either of the following methods.

4.6.11.3.1 Procedure I.

a. Lubricate the ground-glass joint of the desiccator. Load each desiccator with 450 ±25 grams of the ammonium sulfate and add 125 ±10 mL of reagent-grade water. The surface of the salt slurry shall lie within 45 ±7 mm of the top surface of the desiccator plate. Place the desiccator in an area where the temperature is maintained at 23 ±2 °C throughout the humidification procedure. Load the desiccator with the slurry and allow it to stand for at least 12 hours before use with the cover on, the test jar inside and the stoppers in place. Use a fresh charge of salt slurry for each test.
b. Pipette 100 ±1 mL of the brake fluid into a test jar through the desiccator cover and replace the rubber stopper. Prepare duplicate test samples and two duplicate samples of SAE RM-60-03 compatibility fluid. Adjust the water content of the RM-60-03 fluid to 0.50 ±0.05 percent by weight at the start of the test. At intervals, remove the rubber stopper in the top of each desiccator containing the RM-60-03 fluid. Using a long-needled hypodermic syringe, take a sample of not more than 2 mL from each jar and determine the water content by the Karl Fischer method. Do not remove more than 10 mL of fluid from each RM-60-03 sample during the humidifiction procedure. When the water content of the RM-60-03 fluid reaches 3.50 ±0.05 percent by weight (average of the duplicate samples), remove the two test fluid samples from their desiccators and determine the water content by the Karl Fischer method in accordance with ASTM D 1744. Cap each jar promptly and tightly. Fill a cone-shaped centrifuge tube, as described in 3.1 of ASTM D 91, with 100 mL of the humidified fluid. The remainder will be available for other tests as required. A water pick-up in excess of 0.03 ±0.05 percent by weight shall constitute failure of this test.

4.6.11.3.2 Alternate bulk humidification procedure. Lubricate the ground glass joint of a 250 mm I.D. bowl-form desiccator having a matched tubulated glass cover and fitted with a No. 8 rubber stopper. Pour 450 ±10 mL of reagent grade water into the desiccator and insert a perforated porcelain plate. Immediately place two open RM-49 corrosion test jars, each containing 350 ±5 mL of the test fluid, into the desiccator, replace the cover, and insert it at once, into a forced ventilation oven, conforming to ASTM E 145, type II, and set at 50 ±1 °C. Place an identical desiccator set up, having two jars of triethylene glycol monomethyl ether, brake fluid grade, stabilized by the addition of 0.25 percent by weight of 4.4 isopropylidene diphenol in the oven at the same time. Adjust the water content of the TEGME control fluid to 0.50 ±0.005 percent by weight at the start of exposure by the Carl Fischer method.

4.6.11.3.2.1 Examination. Periodically during oven humidification remove the rubber stopper from the desiccator containing the control fluid and, using a single-needle hypodermic syringe, 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 percent by weight, remove the desiccator containing the test fluid at once from the oven and determine the water content by the Karl Fischer method in accordance with ASTM D 1744. Seal the test jars promptly. Allow the sealed jars to cool for 60 - 90 minutes at 25 ±5 °C, then proceed as in 4.6.11.4. The remaining humidified fluid will be available for other tests as required. A water pick-up greater than 0.30 ±0.05 percent by weight shall constitute failure of this test.

4.6.11.4 Humidity tolerance at -40 °C. Stopper the centrifuge tube with a cork and place the tube in a cold bath maintained at -40 ±2 °C for 144 ±4 hours. Remove the centrifuge tube from the bath, quickly wipe the tube with a clean, lint-free cloth saturated with alcohol or acetone, and examine the fluid for evidence of stratification, sedimentation, or crystallization. Invert the tube 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 25 ±5 °C for 4 ±0.5 hours and examine the fluid for clarity by comparing it with an as-received sample of the test fluid in an identical container. Nonconformance to 3.14.1 shall constitute failure of this test.

4.6.11.5 Humidity tolerance at 60 °C. Place the centrifuge tube used in the procedure of 4.6.11.4 in a gravity-convection oven maintained at 60 ±2 °C. After 22 ±2 hours, remove the tube from the oven and immediately examine the contents for evidence of stratification. Determine the percent of sediment by volume in accordance with 5.2 of ASTM D 91. Any evidence of stratification or sediment in excess of 0.05 percent by volume shall constitute failure of this test.

4.6.12 Stroking test. Determine the stroking properties of the brake fluid in accordance with procedure A of method 361 of FED-STD-791. Use SAE SBR cups in the master cylinder and wheel cylinders. Subject the fluid to the following stroking schedule:

Temperature	Percent stroke Ratio	Pressure kPa	Strokes per hour	Number of strokes
+25 °C	60/40	3448	1000	16000
+25 °C to -30 °C	40/60	3448	720	17000
-30 °C to 55 °C	25/75	3448	180	1500
-55 °C	25/75	3448	180	13000
-55 °C to +25 °C	25/75	3448	180	3000
+25 °C to +120 °C	50/50	6896	1000	8000
+120 °C	50/50	6896	1000	44000

4.6.12.1 Sediment after stroking. After the completion of stroking, collect the fluid from the master cylinder and wheel cylinders in separate glass jars. Remove all of the test fluid from the cups, springs, pistons, and internal areas of the cylinders, using a soft brush to aid in the collection of loose residue.

Determine the percent of residue in accordance with ASTM D 91. Nonconformance to 3.15 shall constitute failure of this test.

4.6.13 Hydrovac performance (Hydrovac Life Test). Determine the performance of the silicone brake fluid in accordance with the procedure specified in the Bendix Corporation Procedures for Life Testing of Hydrovac with silicone brake fluid at 82.2 °C. Nonconformance to 3.16 shall constitute failure of this test.

4.7 Inspection of packaging.

4.7.1 Quality conformance inspection of packaging.

4.7.1.1 Unit of product. For the purpose of inspection, a complete pack prepared for shipment shall be considered a unit of product.

4.7.1.2 Inspection lot. The inspection lot shall be as defined in 4.2, packed for shipment.

4.7.1.3 Sampling. Samples for examination of packaging shall be selected at random from each inspection lot in accordance with procedure prescribed in MIL-STD-105.

4.7.1.4 Examination. Samples selected in accordance with 4.7.1.3 shall be examined for the defects listed below. The AQL shall be 1.0 percent defective.

No.	Defect	Paragraph
101.	Unit containers not of size or style specified.	3.2
102.	Special safety and identification marking and labeling not as specified.	3.18
103.	Sealing of unit containers of 177 mL and greater not as specified.	5.1
104.	Unit containers not in accordance with the requirements of MIL-STD-290.	5.1
105.	Intermediate containers specified in MIL-STD-290 not furnished for unit containers with a capacity of 237 mL or less.	5.1
106.	Quantity and arrangement of unit containers in furnished intermediate containers not in accordance with MIL-STD-290.	5.1
107.	Furnished intermediate containers not of the quantity nor arranged in the exterior container in accordance with MIL-STD-290.	5.1
108.	Exterior container not in accordance with MIL-STD-290.	5.1
109.	Marking not as specified.	5.1
110.	Palletization, when specified (see 6.2), not in accordance with MIL-STD-290.	5.2

5. PACKAGING

5.1 Packing and marking. The unit containers of the sizes and styles specified in 3.2, the intermediate containers when required of the unit container sizes and styles specified in 3.2, the exterior

containers and the marking shall comply with the applicable requirements of MIL-STD-290. The level of preservation and packing shall be level B or level C as specified (see 6.2), and shall comply with the requirements of MIL-STD-290. Additionally, closure of unit containers of 6 fluid ounces or greater shall be as specified in MIL-STD-1180, requirement 116.

5.2 Palletization. When specified (see 6.2), the packed brake fluid shall be palletized in accordance with MIL-STD-290.

6 NOTES

6.1 Intended use. This brake fluid is intended for use as an operational fluid and preservative fluid in automotive hydraulic brake systems at ambient temperatures ranging from 55 °C to -55 °C and fluid temperatures ranging from 205 °C to -55 °C.

Caution: Adequate flushing of the brake system must be accomplished to remove all traces of the previous types of brake fluid. If these fluids are not completely removed, the corrosion-protective and preservative properties of the silicone fluid will be negated.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number and date of this specification.
b. Date of qualification of the fluid (see 3.1).
c. Types, styles, and sizes of containers required (see 3.2).
d. Quantity required. Material should be purchased by volume.
e. Level of preservation and packing required (see 5.1).
f. Marking requirements (see 5.1).
g. When palletization is required (see 5.2).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of contractors is called to this requirement, and manufacturers are urged to arrange to have the products they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the quality products list is the US Army Belvoir Research, Development and Engineering Center, ATTN: STRBE-VF, Fort Belvoir, VA 22060-5606 and information pertaining to the qualification of products may be obtained from that activity.

6.4 Test materials. Rubber cups, metal strips, tin foil, steel bolts and nuts, biding power charts specified in ASTM D 344, corrosiveness test jars, and the SAE compatibility fluid can be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096. Hiding power charts conforming to method 4121 of FED-STD-141 can be obtained from the Morest Co., 211 Center Street, New York, NY 10013 (Form No. 03-B) or from the International Photo Co., 570 Seventh Avenue, New York, NY 10018.

6.5 Interchangeability. Brake fluid covered by this specification is interchangeable with brake fluids covered by VV-B-680. However, all VV-B-680 or other non-silicones fluid should be removed and flushed from the brake system before using MIL-B-46176 fluid.

6.6 International standardization. Certain provisions of this specification are the subject of international standardization (NATO STANAG 1135). When amendment, revision or cancellation of this specification is proposed which would affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization offices, if required.

6.7 Material safety data sheets. A copy of the data sheet must be forwarded with the application for qualification to the qualifying activity listed in 6.3. In addition, upon approval for listing on the qualified products list, a copy of the data sheet must be sent to address in FED-STD-313.

6.8 Changes from previous issue. Asterisks (or vertical lines) are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - ME
Navy - YD
Air Force - 68

Preparing activity:
Army - ME

Project 9150-0735

Review activities:
Army - AR
DLA - GS

User activities:
Army - AT
Navy - OS, AS