METRIC

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PERFORMANCE SPECIFICATION

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

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

1. SCOPE

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

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of the list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2)

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-E/IE, Warren, MI 48397-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 9150

STANDARDS

FEDERAL

FED-STD-791 - Lubricants, Liquid Fuels, and Related Products; Methods of Testing.

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY OF TESTING MATERIALS (ASTM)

ASTM A624 - Standard Specification for Tin Mill Products, Electrolytic Tin Plate, Single Reduced (DoD adopted).
ASTM B36 - Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar (DoD adopted).
ASTM B152 - Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar (DoD adopted).
ASTM D91 - Standard Test Method for Precipitation Number of Lubricating Oils (DoD adopted).
ASTM D92 - Standard Test Method for Flash and Fire Points by Cleveland Open Cup (DoD adopted).
ASTM D344 - Standard Test Method for Relative Dry Hiding Power of Paints By the Visual Evaluation of Brushouts (DoD adopted).
ASTM D445 - Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity) (DoD adopted).
ASTM D1193 - Standard Specification for Reagent Water (DoD adopted).
ASTM D1415 - Standard Test Method for Rubber Property - International Hardness (DoD adopted).
ASTM E145 - Standard Specification for Gravity-Convection and Forced-Ventilation Ovens (DoD adopted).

(Application for copies should be addressed to the American Society of Testing Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959).

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AMS-QQ-A-250/4	- Aluminum Alloy 2024, Plate and Sheet (DoD adopted).
SAE J403	- Chemical Compositions of SAE Carbon Steels (DoD adopted).
SAE J431	- Automotive Gray Iron Castings (DoD adopted).
SAE J1703	- Motor Vehicle Brake Fluid (DoD adopted).

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

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes 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 that are authorized by the qualifying activity for listing on the applicable qualified product list before contract award (see 4.1.1 and 6.3). Any change in the formulation of a qualified product will necessitate its requalification.

3.2 Design, materials, and manufacturing processes. Unless otherwise specified, the design, materials, and manufacturing process selection is the prerogative of the contractor as long as all articles submitted to the government fully meet the operating, interface, support and ownership, and environmental requirements specified.

3.3 Operating requirements.

3.3.1 Equilibrium reflux boiling point. The equilibrium reflux boiling point of the brake fluid shall be 260 degrees Celsius (°C) minimum (see 4.3.3.1).

3.3.2 Wet boiling point. The wet boiling point of the brake fluid shall be 207°C minimum (see 4.3.3.2).

3.3.3 Flash point. The flash point of the brake fluid shall be 204°C minimum (see 4.3.3.3).

3.3.4 Viscosity.

3.3.4.1 Low temperature (–55°C). The kinematic viscosity of the brake fluid at –55°C shall not be more than 900 square millimeters per second (mm^2/s) (see 4.3.3.4.1).

3.3.4.2 High temperature (100°C). The kinematic viscosity of the brake fluid at 100°C shall not be less than 1.3 mm^2/s (see 4.3.3.4.2).

3.3.5 Stroking performance. The stroking performance of the brake fluid shall be demonstrated by meeting the requirements specified in 3.3.5.1 through 3.3.5.9 (see 4.3.3.5).

3.3.5.1 Cylinder and piston diameter change. The change in the diameter of any cylinder or piston shall not exceed 0.13 millimeter (mm) after completion of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.1).

3.3.5.2 Cup base diameter change. The change in the base diameter of any rubber cup shall not exceed 0.90 mm after completion of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.2).

3.3.5.3 Cup hardness change. The decrease in the hardness of any rubber cup shall not exceed 15 points after completion of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.3).

3.3.5.4 Cup lip interference set. The average lip interference set of the rubber cups shall not exceed 65 percent (%) after completion of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.4).

3.3.5.5 System pressure change. The pressure in the simulated brake system shall not increase more than 241 kilopascals (kPa) or decrease more than 345 kPa from the initial pressure during any 12-hour period of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.5).

3.3.5.6 System fluid loss during test. The volume loss of brake fluid due to leakage and evaporation shall not exceed 36 milliliters (mL) at the end of any 24-hour period of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.6).

3.3.5.7 System fluid loss - end of test. The volume loss of brake fluid shall not exceed 36 mL during the 100 strokes following completion of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.7).

3.3.5.8 Fluid sediment. The brake fluid shall not contain more than 2% sediment by volume after completion of the stroking test as specified in 4.3.3.5 (see 4.3.3.5.8).

3.3.5.9 Piston performance. During the stroking test as specified in 4.3.3.5, the master cylinder piston and wheel cylinder pistons shall show no improper functioning which may be attributed to the brake fluid properties, such as excessive increase in pressure (see 3.3.5.5), seizing of the pistons, or failure of the pistons to permit brake release (see 4.3.3.5.9).

3.4 Interface requirements.

3.4.1 Corrosiveness. The corrosiveness of the brake fluid shall be demonstrated by meeting the requirements specified in 3.4.1.1 through 3.4.1.7 (see 4.3.4.1).

3.4.1.1 Condition of cups. The rubber cups shall show no sloughing, tackiness, blisters, or any other form of disintegration after exposure to the brake fluid as specified in 4.3.4.1 (see 4.3.4.1.1).

3.4.1.2 Cup base diameter change. The change in the base diameter of any rubber cup shall be not less than 0.03 mm and not more than 1.40 mm after exposure to the brake fluid as specified in 4.3.4.1 (see 4.3.4.1.2).

3.4.1.3 Cup hardness change. The decrease in the hardness of any rubber cup shall not exceed 15 points after exposure to the brake fluid as specified in 4.3.4.1 (see 4.3.4.1.3).

3.4.1.4 Condition of metal strips. The metal strips shall not be pitted nor etched after exposure to the brake fluid as specified in 4.3.4.1 (see 4.3.4.1.4).

3.4.1.5 Metal strip weight change. The permissible change in weight of the strips shall be as specified in table I after exposure to the brake fluid as specified in 4.3.4.1 (see 4.3.4.1.5).

3.4.1.6 Condition of brake fluid. The brake fluid shall exhibit no gelling at 25 ± 5°C, and no crystallization deposit shall form, after completion of the corrosiveness test as specified in 4.3.4.1 (see 4.3.4.1.6).

3.4.1.7 Fluid sediment. The brake fluid shall not contain more than 0.10% sediment by volume after completion of the corrosiveness test as specified in 4.3.4.1 (see 4.3.4.1.7).

TABLE I. Permissible metal strip weight changes.

Strip material	Maximum weight change, milligrams per square centimeter (mg/cm^2)
Tinned steel	0.1
Carbon steel	0.1
Aluminum alloy	0.1
Cast iron	0.1
Brass	0.2
Copper	0.2

3.4.2 Effects on rubber. The effects of the brake fluid on rubber shall be demonstrated by meeting the requirements specified in 3.4.2.1 through 3.4.2.4 (see 4.3.4.2).

3.4.2.1 Volume swell. The volume swell of the test specimens shall meet the requirements of table II after exposure to the brake fluid as specified in 4.3.4.2 (see 4.3.4.2.1).

3.4.2.2 Base diameter change. The base diameter change of the test specimens shall meet the requirements of table II after exposure to the brake fluid as specified in 4.3.4.2 (see 4.3.4.2.2).

3.4.2.3 Hardness change. The hardness change of the test specimens shall meet the requirements of table II after exposure to the brake fluid as specified in 4.3.4.2 (see 4.3.4.2.3).

TABLE II. Effects on rubber.

Type	Test specimen	Test temperature, °C	Volume swell, %	Base diameter change, mm	Hardness change, IRHD
SBR	RM-3; SAE wheel cylinder test cup	70 ± 2	+5 to +20	0.15 to 1.40	0 to –10
		120 ± 2	+5 to +20	0.15 to 1.40	0 to –15
EPR	RM-69; EPDM slabstock, 25.4 mm x 25.4 mm	70 ± 2	0 to +10	———	0 to –10
		120 ± 2	0 to +10	———	0 to –10
Natural rubber	NR-X cup	70 ± 2	+5 to +20	0.15 to 1.40	0 to –10

3.4.2.4 Condition of specimens. The test specimens shall show no sloughing, tackiness, blisters, or any other form of disintegration after exposure to the brake fluid as specified in 4.3.4.2 (see 4.3.4.2.4).

3.5 Support and ownership requirements.

3.5.1 Compatibility. The compatibility between the brake fluid to be tested and all other brake fluids qualified under this specification shall be demonstrated by meeting the requirements specified in 3.5.1.1 through 3.5.1.4 (see 4.3.5.1).

3.5.1.1 Fluid mixture transparency at –40°C. A 50/50 mixture of the brake fluid to be tested and a previously qualified brake fluid, as specified in 4.3.5.1, shall be transparent after being subjected to a temperature of –40 ± 2°C for 24 ± 2 hours (see 4.3.5.1.1).

3.5.1.2 Fluid mixture transparency at 60°C. The brake fluid mixture as specified in 3.5.1.1 shall be transparent after being subjected to a temperature of 60 ± 2°C for 24 ± 2 hours (see 4.3.5.1.2).

3.5.1.3 Fluid mixture sediment. The brake fluid mixture as specified in 3.5.1.1 shall not contain more than 0.05% of sediment by volume after being subjected to a temperature of 60 ± 2°C for 24 ± 2 hours (see 4.3.5.1.3).

3.5.1.4 Fluid mixture transparency at 25°C. The brake fluid mixture as specified in 3.5.1.1 shall regain its original degree of clarity after stabilizing at 25 ± 5°C (see 4.3.5.1.4).

3.5.2 Product identification. In addition to the marking requirements specified in the contract, each brake fluid container shall contain the following information (see 4.3.5.2):

a. Military symbol BFS.
b. NATO code number H-547.
c. Eye hazard warning, as follows: "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."

3.6 Environmental requirements.

3.6.1 High temperature stability. The equilibrium reflux boiling point of the brake fluid, after the brake fluid has been subjected to a temperature of 185 ± 2°C for a minimum of 2 hours, shall not decrease by more than 5°C from the equilibrium reflux boiling point prior to exposure to the high temperature (see 4.3.6.1).

3.6.2 Low temperature. The low temperature properties of the brake fluid shall be demonstrated by meeting the requirements specified in 3.6.2.1 through 3.6.2.3 (see 4.3.6.2).

3.6.2.1 Appearance at –55°C. The brake fluid shall show no stratification, separation, precipitation, or crystallization after being subjected to a temperature of –55 ± 2°C for a minimum of 6 hours (see 4.3.6.2.1).

3.6.2.2 Fluidity at –55°C. The brake fluid shall remain capable of flowing after being subjected to a temperature of –55 ± 2°C for a minimum of 6 hours (see 4.3.6.2.2).

3.6.2.3 Appearance at 25°C. The brake fluid shall regain its original degree of clarity after stabilizing at 25 ± 5°C (see 4.3.6.2.3).

3.6.3 High humidity. The properties of the humidified brake fluid shall be demonstrated by meeting the requirements specified in 3.6.3.1 through 3.6.3.7 (see 4.3.6.3).

3.6.3.1 Water pick-up. The water pick-up of the brake fluid, humidified as specified in 4.3.6.3, shall not exceed 0.35% by weight (see 4.3.6.3.1).

3.6.3.2 Appearance at –40°C. The brake fluid, humidified as specified in 4.3.6.3, shall show no stratification, separation, precipitation, or crystallization after being subjected to a temperature of –40 ± 2°C for 144 ± 4 hours (see 4.3.6.3.2).

3.6.3.3 Fluidity at –40°C. The brake fluid, humidified as specified in 4.3.6.3, shall remain capable of flowing after being subjected to a temperature of –40 ± 2°C for 144 ± 4 hours (see 4.3.6.3.3).

3.6.3.4 Appearance at 25°C. The brake fluid, humidified as specified in 4.3.6.3, shall regain its original degree of clarity after being stabilized at 25 ± 5°C for 4.0 ± 0.5 hours (see 4.3.6.3.4).

3.6.3.5 Appearance at 60°C. The brake fluid, humidified as specified in 4.3.6.3, shall show no stratification, separation, precipitation, or crystallization after being subjected to a temperature of 60 ± 2°C for 22 ± 2 hours (see 4.3.6.3.5).

3.6.3.6 Fluid sediment at 60°C. The brake fluid, humidified as specified in 4.3.6.3, shall not contain more than 0.05% sediment by volume after being subjected to a temperature of 60 ± 2°C for 22 ± 2 hours (see 4.3.6.3.6).

3.6.3.7 Viscosity. The kinematic viscosity of the brake fluid, humidified as specified in 4.3.6.3, shall meet the requirements of 3.3.4 (see 4.3.6.3.7).

4. VERIFICATION

4.1 Classification of Inspection. The inspection requirements specified herein are classified as follow:

a. Qualification Inspection (see 4.1.1).

b. Conformance Inspection (see 4.1.2).

4.1.1 Qualification Inspection. The qualification inspection shall consist of all the tests specified herein.

4.1.2 Conformance Inspection. Conformance inspection shall consist of all tests specified herein except for the stroking test (see 4.3.3.5) and the compatibility test (see 4.3.5.1).

4.2 Order of inspection. The environmental requirement verifications shall be performed first. Unless otherwise specified, the remaining inspections shall be performed in any sequence.

4.3 Verification methods. Acceptable verification methods included in this section are visual inspection, measurement, sample tests, full-scale demonstration tests, simulation, modeling, engineering evaluation, component properties analysis, and similarity to previously-approved or previously-qualified designs.

4.3.1 Verification alternatives. The manufacturer may propose alternative test methods, techniques, or equipment, including the application of statistical process control, tool control, or cost-effective sampling procedures to verify performance. See the contract for alternatives that replace verification methods required by this specification.

4.3.2 Inspection conditions. Unless otherwise specified, all inspections shall be performed at a temperature of 25 ± 3°C and a relative humidity of 50 ± 20%.

4.3.3 Operating requirements verifications.

4.3.3.1 Equilibrium reflux boiling point. Determine the equilibrium reflux boiling point of the brake fluid in accordance with (IAW) SAE J1703 to verify conformance to 3.3.1. An equilibrium reflux boiling point of less than 260°C shall constitute failure of this test.

4.3.3.2 Wet boiling point. Humidify the brake fluid IAW 4.3.6.3. Determine the wet boiling point of the humidified brake fluid IAW SAE J1703 to verify conformance to 3.3.2. A wet boiling point of less than 207°C shall constitute failure of this test.

4.3.3.3 Flash point. Determine the flash point of the brake fluid IAW ASTM D92 to verify conformance to 3.3.3. A flash point of less than 204°C shall constitute failure of this test.

4.3.3.4 Viscosity.

4.3.3.4.1 Low temperature (–55°C). Determine the kinematic viscosity of the brake fluid at –55°C IAW ASTM D445 to verify conformance to 3.3.4.1. A kinematic viscosity of more than 900 mm^2/s shall constitute failure of this test.

4.3.3.4.2 High temperature (100°C). Determine the kinematic viscosity of the brake fluid at 100°C IAW ASTM D445 to verify conformance to 3.3.4.2. A kinematic viscosity of less than 1.3 mm^2/s shall constitute failure of this test.

4.3.3.5 Stroking performance. Subject the brake fluid to the stroking test IAW procedure A of method 361 of FED-STD-791, and perform the tests of 4.3.3.5.1 through 4.3.3.5.9 to verify conformance to 3.3.5. Use SAE SBR cups in the master cylinder and wheel cylinders (see 6.4). The brake fluid shall be subjected to the stroking schedule as specified in table III.

TABLE III. Stroking schedule.

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

4.3.3.5.1 Cylinder and piston diameter change. Measure the diameters of the cylinders and pistons IAW method 361 of FED-STD-791 before and after the stroking test to verify conformance to 3.3.5.1. A diameter change of more than 0.13 mm for any cylinder or piston shall constitute failure of this test.

4.3.3.5.2 Cup base diameter change. Measure the base diameters of the rubber cups IAW method 361 of FED-STD-791 before and after the stroking test to verify conformance to 3.3.5.2. An increase in diameter of more than 0.90 mm for any cup shall constitute failure of this test.

4.3.3.5.3 Cup hardness change. Measure the hardness of the rubber cups IAW method 361 of FED-STD-791 before and after the stroking test to verify conformance to 3.3.5.3. A decrease in hardness of more than 15 points for any cup shall constitute failure of this test.

4.3.3.5.4 Cup lip interference set. Measure the lip interference set of the rubber cups IAW method 361 of FED-STD-791 after the stroking test to verify conformance to 3.3.5.4. A lip interference set of more than 65% for any cup shall constitute failure of this test.

4.3.3.5.5 System pressure change. Measure the pressure of the system during the stroking test IAW method 361 of FED-STD-791 to verify conformance to 3.3.5.5. A pressure increase of more than 241 kPa or a pressure decrease of more than 345 kPa shall constitute failure of this test.

4.3.3.5.6 System fluid loss during test. Measure the amount of brake fluid lost due to leakage and evaporation at 24-hour intervals during the stroking test IAW method 361 of FED-STD-791 to verify conformance to 3.3.5.6. A loss of more than 36 mL of brake fluid at the end of any interval shall constitute failure of this test.

4.3.3.5.7 System fluid loss - end of test. Measure the system leakage after completion of the stroking test IAW method 361 of FED-STD-791 to verify conformance to 3.3.5.7. A loss of more than 36 mL of brake fluid shall constitute failure of this test.

4.3.3.5.8 Fluid sediment. After the completion of the stroking test, 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 IAW ASTM D91 to verify conformance to 3.3.5.8. A sediment level of more than 2% by volume shall constitute failure of this test.

4.3.3.5.9 Piston performance. During the stroking test, observe the functioning of the master cylinder piston and the wheel cylinder pistons IAW method 361 of FED-STD-791 to verify conformance to 3.3.5.9. Any improper functioning of the pistons shall constitute failure of this test.

4.3.4 Interface requirements verifications.

4.3.4.1 Corrosiveness. Expose rubber cups and metal strips (see 6.4) to the brake fluid as specified in the following procedure, and perform the tests of 4.3.4.1.1 through 4.3.4.1.7 to verify conformance to 3.4.1:

a. Three SBR wheel brake cylinder cups conforming to SAE J1703 are required. The cups shall be free from lint and dirt, and shall be either within 6 months of the manufacture date if stored between 20°C and 30°C, or within 36 months of the manufacture date if stored below −15°C.

(1) Determine the base diameter of each cup to the nearest 0.03 mm. Using a micrometer, make two diametrical measurements at right angles to each other on each cup. If the two readings differ from each other by more than 0.08 mm, discard the cup. The base diameter shall be the average of these two measurements.
(2) Determine the hardness of each cup IAW ASTM D1415.

b. Three metal strips of each of the materials listed in table IV are required. 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. Each strip shall have a hole, approximately 4.8 mm in diameter, centered 6.4 mm from one end. Clean all strips, with the exception of the tinned steel, by abrading them with No. 320A waterproof silicon carbide paper and 95% ethyl alcohol until all surface scratches, cuts, and pits are removed from all of the strips. Polish with 00 steel wool. Rinse all of the strips in 95% ethyl alcohol, dry them with a clean, lint-free cloth, and condition them to constant weight in a desiccator. Weigh each strip to the nearest 0.1 milligram (mg).

TABLE IV. Corrosiveness test strip materials.

Material	Designation	Temper	Specification
Electrolytic tinned steel	Class 25, Type MR 1/	T-5 2/	ASTM A624
Low carbon steel	UNS G10180	4 or 5	SAE J403
Aluminum	Alloy 2024	0	AMS-QQ-A-250/4
Cast iron 3/	Grade G3000	Not applicable	SAE J431
Brass	UNS C26800	H02	ASTM B36
Copper	UNS C11400	H02	ASTM B152

1/ Base weight: 80lb/base box
2/ Continuously annealed
3/ Strips to be cut from brake wheel cylinders

c. Wet the metal strips with the brake fluid under test. 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. The strips shall be arranged in the same order in which they are listed in table IV. 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 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 (see 4.3.6.3), 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. Allow the jars to cool for 60 to 90 minutes following the test period, then remove the metal strips and rubber cups from the jars. Wash the three rubber cups quickly in isopropyl alcohol and air-dry them. 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 isopropyl alcohol.

4.3.4.1.1 Condition of cups. Visually examine the cups for evidence of sloughing, tackiness, blisters, or any other form of disintegration after the corrosiveness test to verify conformance to 3.4.1.1. Any evidence of these conditions shall constitute failure of this test.

4.3.4.1.2 Cup base diameter change. Determine the base diameters of the rubber cups to the nearest 0.03 mm after the corrosiveness test to verify conformance to 3.4.1.2. An increase in diameter of less than 0.03 mm or more than 1.40 mm from the initial base diameter measurement for any cup shall constitute failure of this test. Diameter measurements shall be made within 15 minutes after removal of the cups from the fluid.

4.3.4.1.3 Cup hardness change. Measure the hardness of the rubber cups IAW ASTM D1415 after the corrosiveness test to verify conformance to 3.4.1.3. A decrease in hardness of more than 15 points from the initial hardness measurement for any cup shall constitute failure of this test. Hardness measurements shall be made within 15 minutes after removal of the cups from the fluid.

4.3.4.1.4 Condition of metal strips. Visually examine the metal strips for evidence of pitting or etching after completion of the corrosiveness test to verify conformance to 3.4.1.4. Any evidence of these conditions shall constitute failure of this test.

4.3.4.1.5 Metal strip weight change. Determine the weight change per unit area of each strip after completion of the corrosiveness test to verify conformance to 3.4.1.5. Bring the metal strips to constant weight in a desiccator and weigh them to the nearest 0.1 mg. These weights shall be compared to the initial weights measured prior to the corrosiveness test. The weight change per unit area shall be calculated by dividing the observed weight change of each strip in milligrams by the surface area of the strip in square centimeters. Determine the average of the three calculations made for each type of metal specimen. An average weight change per unit area in excess of the value listed in table I for the applicable material shall constitute failure of this test.

4.3.4.1.6 Condition of brake fluid. Visually examine the brake fluid at a temperature of 25 ± 5°C for evidence of gelling after completion of the corrosiveness test to verify conformance to 3.4.1.6. Any evidence of gelling shall constitute failure of this test.

4.3.4.1.7 Fluid sediment. Centrifuge 100 mL of the test fluid IAW ASTM D91 after completion of the corrosiveness test to verify conformance to 3.4.1.7. A sediment level of more than 0.10% by volume shall constitute failure of this test.

4.3.4.2 Effects on rubber. Expose rubber specimens to the brake fluid as specified in the following procedure, and perform the tests of 4.3.4.2.1 through 4.3.4.2.4 to verify conformance to 3.4.2:

a. Specimens of each type of rubber listed in table II are required. 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 base diameter, volume and hardness.

   (1) Determine the base diameter for each cup specimen as specified in 4.3.4.1. Exercise care in making these measurements to make sure that the micrometer does not extend more than 0.8 mm beyond the bottom edge of the cup.
   (2) Determine the volume of each specimen. Each specimen shall be weighed, to the nearest milligram, first in air (W_1) then while immersed in water (W_2). The water shall contain not more than 0.2 % of a wetting agent such as Pluronic L-61 (BASF Wyandotte) or an equivalent. The difference between these weights equals the weight of water displaced. The volume can then be calculated by dividing this weight by the standard density of water.
   (3) Determine the hardness of each specimen IAW ASTM D1415.

b. Use a straight-sided, screw-top, round glass jar (RM-51) approximately 50 mm in diameter. Add glass beads 4 to 6 mm in diameter to cover two-thirds of the bottom of the jar. Add 75 mL of the test fluid. Immerse the two specimens in the test fluid and allow them to come to rest on top of the glass beads. 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 temperatures specified in table II for 70 ± 2 hours. At the end of the exposure period, remove the jar from the oven and allow it to cool for 60 to 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.

4.3.4.2.1 Volume swell. Determine the volume swell of each specimen after exposure to the brake fluid to verify conformance to 3.4.2.1. Nonconformance to the requirements specified in table II shall constitute failure of this test. Specimens shall be weighed within one hour after removal from the fluid. Volume swell, as a percentage of the original volume, shall be calculated as follows:

$$\text{Percent Volume Change} = \frac{(W3 - W4) - (W1 - W2)}{W1 - W2} \times 100$$

where:

W1 = initial weight of specimen in air
W2 = initial weight of specimen in water
W3 = final weight of specimen in air
W4 = final weight of specimen in water.

4.3.4.2.2 Base diameter change. Determine the base diameters of the rubber cups after exposure to the brake fluid to verify conformance to 3.4.2.2. Nonconformance to the requirements specified in table II shall constitute failure of this test. Base diameter measurements shall be made within one hour after removal of the specimens from the fluid.

4.3.4.2.3 Hardness change. Measure the hardness of the rubber specimens IAW ASTM D1415 after exposure to the brake fluid to verify conformance to 3.4.2.3. A decrease in hardness from the initial measurement in excess of the values listed in table II for any specimen shall constitute failure of this test. Hardness measurements shall be made within one hour after removal of the specimens from the fluid.

4.3.4.2.4 Condition of specimens. Visually examine the specimens for evidence of sloughing, tackiness, blisters, or any other form of disintegration after exposure to the brake fluid to verify conformance to 3.4.2.4. Any evidence of these conditions shall constitute failure of this test.

4.3.5 Support and ownership requirement verifications.

4.3.5.1 Compatibility. Prepare individual mixtures of the brake fluid under test with all fluids previously qualified under this specification, and perform the tests as specified in 4.3.5.1.1 through 4.3.5.1.4 to verify conformance to 3.5.1. Each mixture shall consist of 50 parts by volume of the test fluid and 50 parts by volume of the previously qualified brake fluid. Place a 100-mL portion of each of the prepared mixtures into separate 125-mL oil sample bottles, approximately 150 mm in height and 35 mm in diameter.

4.3.5.1.1 Fluid mixture transparency at −40°C. Place the bottles in a cold bath maintained at −40 ± 2°C for 24 ± 2 hours. After 24 hours at −40°C, remove the bottles from the cold bath and wipe them quickly with a clean lint-free cloth saturated with alcohol. Visually examine the test mixtures for evidence of stratification, separation, sedimentation, and crystallization to verify conformance to 3.5.1.1. Place the bottles one at a time against a hiding power test chart of the type specified in ASTM D344 (see 6.4). Indiscernible diagonal contrast lines on the chart when viewed through any part of the mixture in each bottle shall constitute failure of this test.

4.3.5.1.2 Fluid mixture transparency at 60°C. Immediately following the examination specified in 4.3.5.1.1, place the bottles in an oven maintained at 60 ± 2°C for 24 ± 2 hours. After 24 hours at 60°C, remove the bottles from the oven, and visually examine the test mixtures for evidence of stratification, separation, sedimentation, and crystallization to verify conformance to 3.5.1.2. Place the bottles one at a time against a hiding power test chart of the type specified in ASTM D344 (see 6.4). Indiscernible diagonal contrast lines on the chart when viewed through any part of the mixture in each bottle shall constitute failure of this test.

4.3.5.1.3 Fluid mixture sediment. Determine the sedimentation of the test mixtures IAW ASTM D91 to verify conformance to 3.5.1.3. A sediment level of more than 0.05% by volume shall constitute failure of this test.

4.3.5.1.4 Fluid mixture transparency at 25°C. Following the verifications specified in 4.3.5.1.1 through 4.3.5.1.3, allow the test mixtures to stabilize at 25 ± 5°C. Visually examine the test mixtures for evidence of stratification, separation, sedimentation, and crystallization to verify conformance to 3.5.1.4. Place the bottles one at a time against a hiding power test chart of the type specified in ASTM D344 (see 6.4). Indiscernible diagonal contrast lines on the chart when viewed through any part of the mixture in each bottle shall constitute failure of this test.

4.3.5.2 Product identification. Visually examine the brake fluid container to verify conformance to 3.5.2. Absence of the military symbol “BFS”, the NATO code number “H-547”, or the eye hazard warning shall constitute failure of this test.

4.3.6 Environmental requirement verifications.

4.3.6.1 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 for a minimum of 2 hours. After 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 equilibrium reflux boiling point of this fluid as specified in 4.3.3.1 to verify conformance to 3.6.1. A decrease of more than 5°C between this observed equilibrium reflux boiling point and that previously determined in 4.3.3.1 shall constitute failure of this test.

4.3.6.2 Low temperature. Place a 100-mL portion of the brake fluid into each of two 125-mL oil sample bottles approximately 150 mm in height and 35 mm in diameter. Place the bottles in a cold bath maintained at –55 ± 2°C for a minimum of 6 hours. Perform the tests of 4.3.6.2.1 through 4.3.6.2.3 to verify conformance to 3.6.2.

4.3.6.2.1 Appearance at –55°C. After 6 hours at –55°C, remove one of the bottles from the cold bath and wipe it quickly with a clean, lint-free cloth saturated with alcohol. Visually examine the brake fluid for evidence of stratification, separation, sedimentation, and crystallization to verify conformance to 3.6.2.1. Place the bottle against a hiding power test chart of the type specified in ASTM D344 (see 6.4). Indiscernible diagonal contrast lines on the chart when viewed through any part of the bottle shall constitute failure of this test.

4.3.6.2.2 Fluidity at –55°C. After 6 hours at –55°C, remove the second bottle from the cold bath and immediately invert it. Measure the time required for the air bubble to reach the top of the fluid in the inverted bottle to verify conformance to 3.6.2.2. An elapsed time of greater than 10 seconds shall constitute failure of this test.

4.3.6.2.3 Appearance at 25°C. Following the verification specified in 4.3.6.2.1, allow the brake fluid to stabilize at 25 ± 5°C. Visually examine the brake fluid for evidence of stratification, separation, sedimentation, and crystallization to verify conformance to 3.6.2.3. Place the bottle against a hiding power test chart of the type specified in ASTM D344 (see 6.4). Indiscernible diagonal contrast lines on the chart when viewed through any part of the bottle shall constitute failure of this test.

4.3.6.3 High humidity. The brake fluid shall be humidified IAW either one of the two following procedures:

a. Lubricate the ground-glass joints of four desiccators. In each desiccator, combine 450 ± 25 grams (g) of ammonium sulfate, $(NH_4)_2SO_4$, ACS reagent grade, and 125 ± 10 mL of reagent-grade water conforming to ASTM D1193, type II, and insert a perforated porcelain desiccator plate. The surface of the salt slurry shall lie within 45 ± 7 mm of the top surface of the desiccator plate in each desiccator. Place an open straight-sided, screw-top, round glass jar (RM-49), having a capacity of about 475 mL and approximate inner dimensions of 100 mm in height by 75 mm in diameter, into each desiccator. Place the desiccators in an area where the temperature is maintained at 23 ± 2°C throughout the humidification procedure, and allow them to stand, with covers on, test jars inside and stoppers in place, for at least 12 hours before use. Pipette 100 ± 1 mL of the brake fluid through the desiccator cover into a test jar in each of two desiccators and replace the rubber stopper. Prepare the other two desiccators in the identical manner, except that SAE RM-66-03 compatibility fluid shall be used instead of brake fluid. The water content of the RM-66-03 fluid shall be adjusted to 0.50 ± 0.05% by weight at the start of humidification. Periodically during humidification, remove the rubber stopper from each desiccator containing the RM-66-03 fluid and, using a single-needle hypodermic syringe, quickly take a sample of not more than 2 mL from each jar and determine the water content (Karl Fischer analysis or equivalent). Do not remove more than 10 mL of fluid from each RM-66-03 sample during the humidification procedure. When the water content of the RM-66-03 fluid reaches 3.50 ± 0.05% by weight (average of the two samples), remove the two test fluid samples from their desiccators and determine the water content IAW 4.3.6.3.1. Using matching lids (RM-63) without seals or liners, seal the test jars promptly. Fill a cone-shaped centrifuge tube as described in ASTM D91 with 100 mL of the humidified fluid, and proceed as specified in 4.3.6.3.2. The remainder will be available for other tests as required.

b. Lubricate the ground-glass joint of a bowl-form desiccator with an inside diameter of 250 mm, having a matched tubulated glass cover fitted with a No. 8 rubber stopper. Pour 450 ± 10 mL of reagent grade water conforming to ASTM D1193, type II, into the desiccator and insert a perforated porcelain desiccator plate. Pour 350 ± 5 mL of brake fluid into each of two straight-sided, screw-top, round glass jars (RM-49), each having a capacity of about 475 mL and approximate inner dimensions of 100 mm in height by 75 mm in diameter, and place the open jars into the desiccator. Prepare an identical desiccator set-up, except that the jars shall be filled with 350 ± 5 mL of triethylene glycol monomethyl ether (TEGME), brake fluid grade, stabilized by the addition of 0.25% by weight of 4,4'-isopropylidene-diphenol. The water content of the TEGME control fluid shall be adjusted to 0.50 ± 0.05% by weight at the start of humidification. Place covers on the desiccators, and insert the desiccators immediately into a forced-ventilation oven conforming to ASTM E145, type II, set at 50 ± 1°C. Periodically during humidification, remove the rubber stopper from the desiccator containing the TEGME control fluid and, using a single-needle hypodermic syringe, quickly sample each jar and determine its water content. When the average water content of the TEGME control fluid has reached 3.70 ± 0.05% by weight, remove the desiccator containing the test fluid at once from the oven and determine the water content IAW 4.3.6.3.1. Using matching lids (RM-63) without seals or liners, seal the test jars promptly. Allow the sealed jars to cool for 60 to 90 minutes at 25 ± 5 °C. Fill a cone-shaped centrifuge tube as described in ASTM D91 with 100 mL of the humidified fluid, and proceed as specified in 4.3.6.3.2. The remaining humidified fluid will be available for other tests as required.

4.3.6.3.1 Water pick-up. After the humidifying process as specified in 4.3.6.3, determine the water content (Karl Fischer analysis or equivalent) of the brake fluid to verify conformance to 3.6.3.1. A water pick-up of more than 0.35% by weight shall constitute failure of this test.

4.3.6.3.2 Appearance 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. After 144 hours at –40°C, remove the centrifuge tube from the bath, and quickly wipe it with a clean, lint-free cloth saturated with alcohol. Visually examine the brake fluid for evidence of stratification, sedimentation, or crystallization to verify conformance to 3.6.3.2. Any evidence of these conditions shall constitute failure of this test shall constitute failure of this test.

4.3.6.3.3 Fluidity at –40°C. Following the verification specified in 4.3.6.3.2, invert the tube and measure the time required for the air bubble to reach the top of the fluid in the inverted tube to verify conformance to 3.6.3.3. An elapsed time of greater than 10 seconds shall constitute failure of this test.

4.3.6.3.4 Appearance at 25°C. Following the verification specified in 4.3.6.3.3, allow the humidified brake fluid to stabilize at 25 ± 5°C for 4.0 ± 0.5 hours. Visually compare the test fluid to an as-received sample of the test fluid in an identical container to verify conformance to 3.6.3.4. A stabilized test sample that does not regain its original clarity shall constitute failure of this test.

4.3.6.3.5 Appearance at 60°C. Following the verification specified in 4.3.6.3.4, place the centrifuge tube in a gravity-convection oven maintained at 60 ± 2°C for 22 ± 2 hours. After 22 hours at 60°C, remove the tube from the oven and immediately visually examine the brake fluid for evidence of stratification, sedimentation, or crystallization to verify conformance to 3.6.3.5. Any evidence of these conditions shall constitute failure of this test shall constitute failure of this test.

4.3.6.3.6 Fluid sediment at 60°C. Determine the sedimentation of the humidified brake fluid IAW ASTM D91 to verify conformance to 3.6.3.6. A sediment level of more than 0.05% by volume shall constitute failure of this test.

4.3.6.3.7 Viscosity. Determine the viscosity of the humidified brake fluid as specified in 4.3.3.4.1 and 4.3.3.4.2 to verify conformance to 3.6.3.7. Nonconformance to the requirements of 3.3.4 shall constitute failure of this test.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory).

6.1 Intended use. The brake fluid covered by this specification is military unique due to the requirement that it perform at a minimum ambient temperature of –55°C, whereas commercial silicone-based brake fluids are rated at a minimum ambient temperature of –40°C. It 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.

6.1.1 Replacement of brake fluid. If brake fluid IAW this specification is used to replace another type of brake fluid, adequate flushing of the brake system must be accomplished to remove all traces of the brake fluid that is to be replaced. If these fluids are not completely removed, the corrosion-protective and preservative properties of the silicone fluid will be negated.

6.2 Acquisition requirements. Acquisition documents must 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).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 46176 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from US Army Tank-automotive and Armaments Command, AMSTA-TR-E/IE, Warren, MI 48397-5000. Products will not be considered for inclusion in QPL-46176 until such time as appropriate departmental medical activity has reviewed all pertinent material safety data sheets (FED-STD-313).

6.4 Test materials. Rubber cups, metal strips, tin foil, steel bolts and nuts, hiding power charts specified in ASTM D344, corrosiveness test jars, and the SAE compatibility fluid can be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

6.5 Interchangeability. Brake fluid covered by this specification can be used in the same equipment and systems as the brake fluids covered by VV-B-680. However, all VV-B-680 or other non-silicone fluid should be removed and flushed from the brake system before using MIL-PRF-46176 fluid.

6.6 International standardization. Certain provisions of this specification are the subject of international standardization agreement NATO STANAG 1135. When amendment, revision or cancellation of this specification is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

6.7 Material Safety Data Sheets (MSDS). Contracting officers should identify those activities requiring copies of MSDS's prepared IAW FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313; and 29 CFR 1910.1200 requires that the MSDS for each hazardous chemical used in an operation must be readily available to personnel using the material. Contracting officers should identify the activities requiring copies of the MSDS.

6.8 Subject term (key word) listing.

Hydraulic
NATO STANAG 1135
Viscosity

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

Custodians:
Army – AT
Navy – AS
Air Force – 68

Review Activities:
Army – AR, MI
Navy – OS, SA
Air Force – 03, 11
DLA – GS, PS
GSA – 6FET

Preparing Activity:
Army – AT

Project 9150-1249

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-PRF-46176B	2. DOCUMENT DATE *(YYYYMMDD)* 20010110

3. DOCUMENT TITLE

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

4. NATURE OF CHANGE ***(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)***

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) DSN *(If applicable)*	7. DATE SUBMITTED *(YYYYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)* (1) Commercial (2) DSN
c. ADDRESS *(Include Zip Code)* Commander U.S. Army Tank-automotive and Armaments Command ATTN: AMSTA-TR-E/IE Warren, MI 48397-5000	(810) 574-8745 786-8745 IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888