

Submitted for recognition as an American National Standard

(R) HYDRAULIC WHEEL CYLINDERS FOR AUTOMOTIVE DRUM BRAKES

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. **Scope**—This document specifies minimum performance and durability requirements for satisfactory vehicle usage, and it is applicable to wheel cylinder assemblies from commercial production, after production shipment, shelf storage, and remanufacture (factory rebuild).

2. **References**

2.1 **Related Publications**—The following publications are provided for information purposes only and are not a required part of this document.

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

SAE J1603—Rubber Seals for Hydraulic Disc Brake Cylinders

SAE J1703 OCT88—Motor Vehicle Brake Fluid

2.1.2 ASTM PUBLICATION—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 1149—Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber (Flat Specimens)

3. **Purpose**—This document applies to wheel cylinder assemblies used on hydraulically operated, drum-type brakes of highway vehicles. It covers such cylinders where they are employed in passenger car, truck, bus, and like brake systems utilizing motor vehicle brake fluids that conform to SAE J1703.

4. **Requirements**—A wheel cylinder assembly shall, when tested in accordance with the procedures of Section 7, meet the following requirements:

4.1 **Unrestricted Apply and Release**—Per 7.1.2, the piston(s) must move smoothly throughout full stroke after starting, and must be completely returned to original position on the fifth stroke within 30 s by the force of the piston return spring, or, in the absence of a return spring, by 5 psi (34 kPa) maximum air pressure at inlet port.

4.2 **Ozone Resistance**—Per 7.2, the boot(s) shall not be perforated or cracked through in any areas. (7.2 is a conditioning test of the wheel cylinder for other tests which follow, and the cylinder should be rejected if deterioration of the boot obviously precludes meeting subsequent test requirements.)

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4.3 Applied Leakage

4.3.1 Per 7.3.1, there shall be no drop in pressure in excess of 1 psi (7 kPa) in a 30 s interval.

4.3.2 Per 7.3.2, there shall be no drop in pressure in excess of 50 psi (345 kPa) in a 30 s interval.

4.4 Physical Strength—Per 7.4.1, the gage shall show no abrupt pressure drop and the cylinder shall show no signs of mechanical failure.

4.5 Humidity Operation

4.5.1 Per 7.5.1, the wheel cylinder piston(s) must fully apply the load fixture(s) to its bottom or stop and allow it to return to the full release stop within a stroke cycle of the master cylinder.

4.5.2 Per 7.5.3, see requirements 4.3.1 and 4.3.2.

4.6 High Temperature Durability

4.6.1 Per 7.6.1, see requirement 4.5.1.

4.6.2 Per 7.6.2, there shall be no visible leakage at the wheel cylinder bleed screw or hydraulic connector(s) and leakage at each boot of the wheel cylinder shall not be measurable.

4.6.3 Per 7.6.3, leakage at each boot shall not exceed five drops.

4.6.4 Per 7.6.4, see requirements 4.3.1 and 4.3.2.

4.7 Cold Temperature Operation

4.7.1 Per 7.7.1, see requirement 4.5.1.

4.7.2 Per 7.7.2, there shall be no visible leakage at the wheel cylinder bleed screw or hydraulic connector(s), and leakage at each boot of the wheel cylinder shall not exceed five drops.

4.7.3 Per 7.7.3, see requirements 4.3.1 and 4.3.2.

4.8 Storage Corrosion Resistance

4.8.1 Per 7.8.1, there shall be no visible leakage at the wheel cylinder bleed screw or hydraulic connector(s), and leakage at each boot shall not exceed five drops.

4.8.2 Per 7.8.2, piston(s) must start to move at 40 psi (276 kPa) maximum pressure.

4.8.3 Per 7.8.3, the wheel cylinder piston(s) must fully apply the load fixture to its bottom or stop and return it to full release stop.

4.8.4 Per 7.8.4, see requirements 4.3.1 and 4.3.2.

4.9 Static Leakage—Per 7.9.1, there shall be no visible fluid leakage in the trap(s).

4.10 Examination

4.10.1 Per 7.10.1, wheel cylinders up to and including 2 in (50.8 mm) bore diameter shall have 0.080 in (2.03 mm) minimum diameter at the smallest opening of the hydraulic inlet(s).

4.10.2 Because these specifications spell out only minimum requirements, none are called for per 7.10.3.

5. **Test Apparatus**—The basic apparatus shall be that shown and as arranged in Figure 1 or equivalent. All hydraulic lines and fittings shall be of sufficient size as to permit unrestricted fluid flow to and from the test wheel cylinder(s). The apparatus shall operate per the following description and as called for in Section 7.

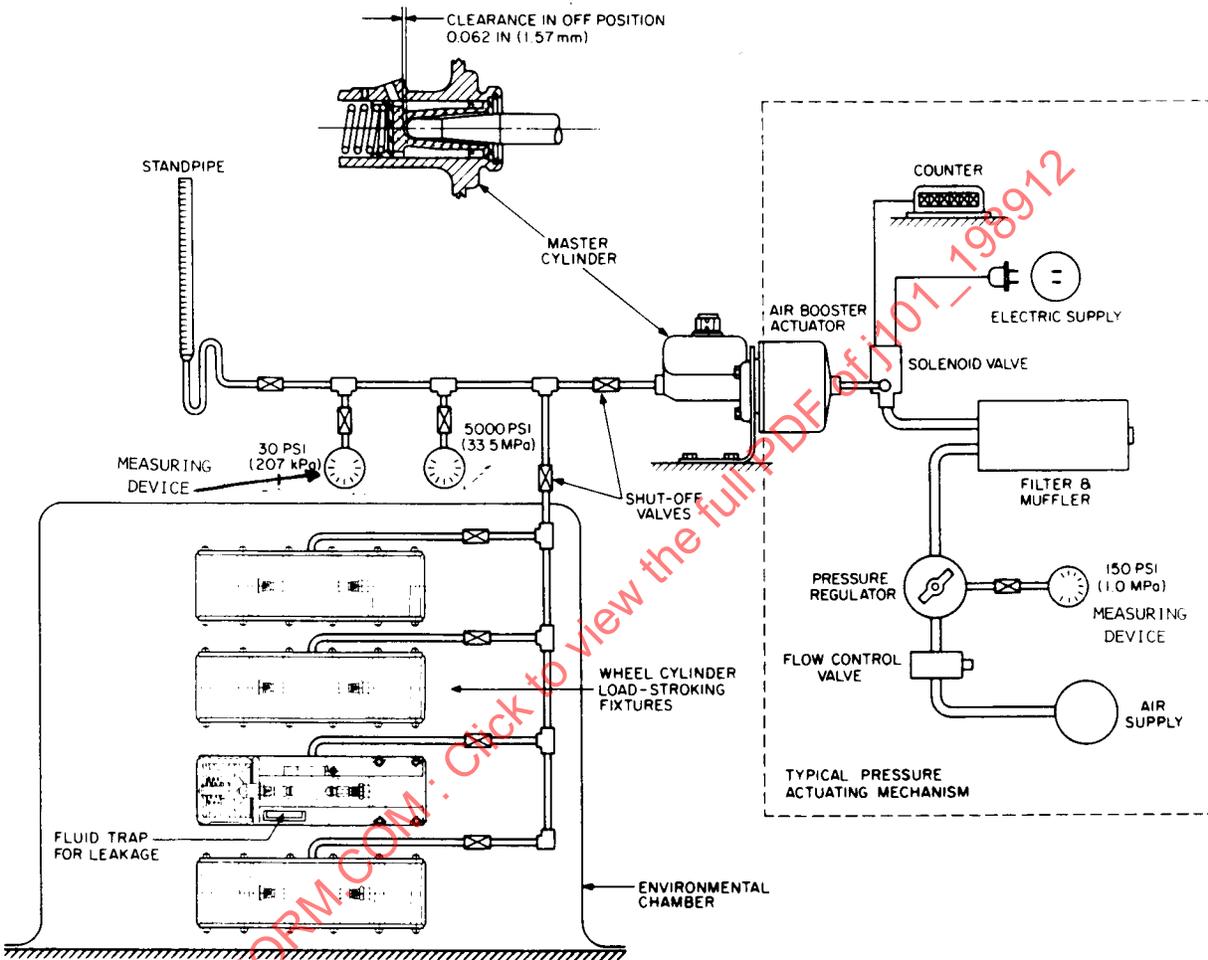


FIGURE 1—TEST APPARATUS

5.1 **Master Cylinder Assembly**—The master cylinder should be one commercially representative of the brake system(s) in which the test wheel cylinder(s) is (are) used. Its bore size and stroke will depend on the numbers and bore sizes of wheel cylinders to be stroke tested simultaneously.

The referee master cylinder of SAE J1703 is one commercially representative.¹ A shutoff valve shall be provided at the hydraulic outlet of the master cylinder.

1. Referee master cylinders, of 1-1/8 in (28.6 mm) diameter bore and 1-7/16 in (36.5 mm) total stroke, may be obtained from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

5.2 Pressure Actuating Mechanism—The pressure actuating mechanism shall apply an axial force to the master cylinder push rod without side thrust, and it shall allow the pressure in the master cylinder to return to 0 psi (0 kPa) when it is in the released position.

Means must be provided for the actuating mechanism to stroke the master cylinder both singly and cyclically. For single stroke operation, the means must be capable of generating pressures in the master cylinder up to 3000 psi (20.7 MPa) and it must have adjustment such that pressures of 20, 1000, and 3000 psi (0.14, 6.9, and 20.7 MPa) can be held statically after they are achieved. For cyclic operation, the pressure actuating mechanism must be capable of generating pressures in the master cylinder up to 1000 psi (6.9 MPa) and have adjustments such that pressure can be peaked out at both 500 psi (3.4 MPa) and 1000 psi (6.9 MPa). Further, it must build up both of these pressures uniformly in 1.6 to 2.0 s, and be capable of doing so at any stroke of the master cylinder up to 90% of its total stroke. The pressure actuating mechanism, when releasing, must permit the full retraction of the master cylinder push rod. The means for cycling the pressure actuating mechanism shall permit adjustment of uniform apply/release strokes at rates of both 500 and 1000 cycles/h.

5.3 Load Fixture—The load fixture, such as that shown in Figure 2, must stroke $0.12 \pm 0.0 - 0.5$ in ($3.05 \pm 0.0 - 0.5$ mm) in each load cell at a hydraulic pressure buildup in the wheel cylinder within the limits shown by the curves of Figure 3. It must accommodate both single- and double-ended wheel cylinders and mount them as they would be mounted on their brakes; it must accommodate both insert and socket-type wheel cylinder pistons; it must be capable of placing $4 \text{ deg} \pm 0.5$ angularity on connecting link(s) with respect to the wheel cylinder bore longitudinal axis; and it must accommodate wheel cylinders of $5/8$ to 2 in (15.9 to 50.8 mm) diameter. (This is a composite description of load fixture requirements. At least two load fixtures with appropriate differences in design would be necessary for testing all types and sizes of wheel cylinders.)

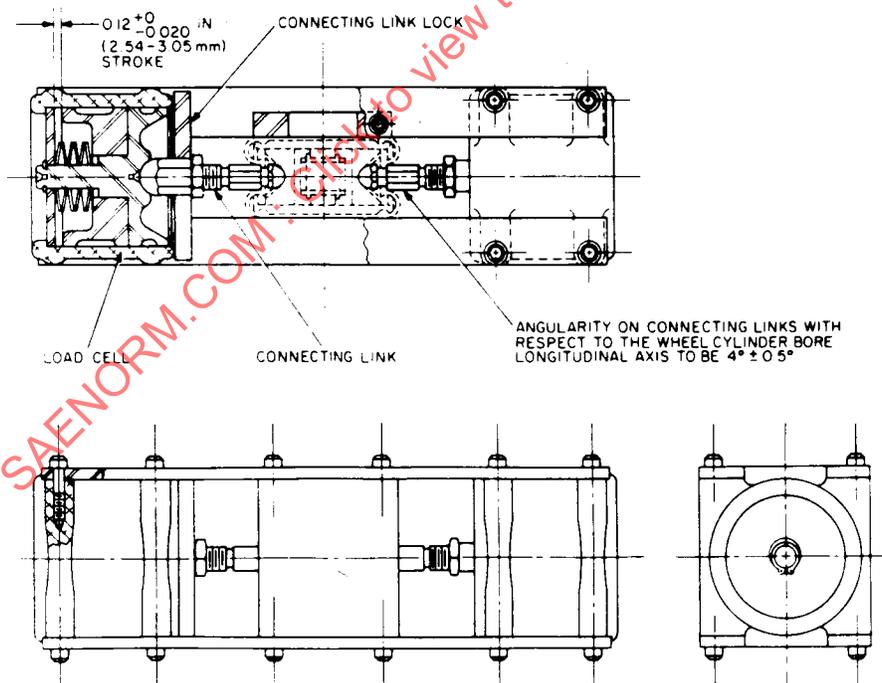


FIGURE 2—WHEEL CYLINDER LOAD FIXTURE

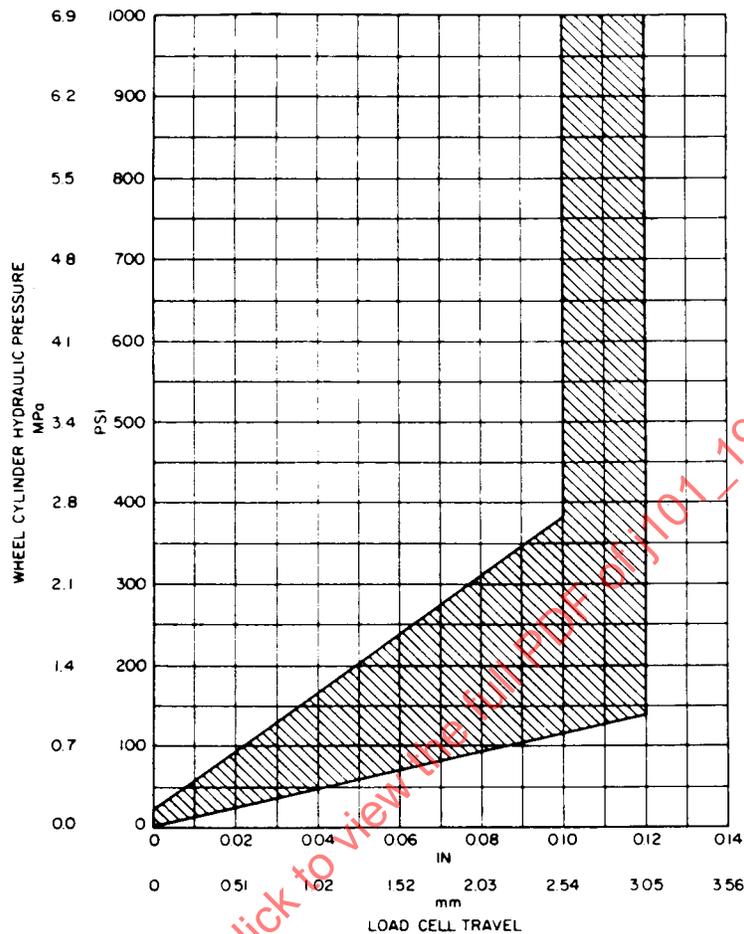


FIGURE 3—LOAD FIXTURE PERFORMANCE CURVES

Ends of connecting links engaging wheel cylinder pistons must be per those links actually used on brakes by the vehicle manufacturer from the standpoint of their piston and boot fits. Locks must be provided for the connecting links at their load cell ends.

NOTE—Actual brake assemblies, such as shown in SAE J1703 or equivalent fixtures, such as shown in SAE J1603 may be used in place of the above fixture providing they meet its requirements and those of Section 7. Single-end wheel cylinders, such as those for two leading, floating shoe brakes, and whose reactive loads are taken by brake shoes as well as cylinder mountings, should be tested in pairs as part of a complete brake and drum assembly.

5.4 Instrumentation—Two hydraulic pressure measuring devices shall be employed, each equipped with a shutoff valve. One shall have a range of 0 to 30 psi (0 to 207 kPa) and the other shall have a range of 0 to 5000 psi (0 to 34.5 MPa). Both shall be of a type that requires negligible hydraulic displacement and is equipped with a bleeder.

A mechanical or electrical counter shall be used to record the number of strokes during cyclic operation.

A leak trap shall be provided for each wheel cylinder boot. It shall have minimum exposed area in order to minimize evaporation.

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A 24 to 48 in (610 to 1220 mm) height standpipe shall be provided as shown in Figure 1.

5.5 Environmental Equipment

- 5.5.1 OZONE CHAMBER—An ozone chamber as described in ASTM D 1149-81, Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber (Flat Specimens). It must maintain 50 pphm by volume at $37.7\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($100\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) ozone concentration.
- 5.5.2 HEATED AIR BATH CABINET—An insulated oven or cabinet having sufficient capacity to house the load fixtures of the test apparatus. A suitable thermostatically controlled heating system is required to maintain a temperature of $100\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ($212\text{ }^{\circ}\text{F} \pm 9\text{ }^{\circ}\text{F}$). Heaters shall be shielded to prevent direct radiation to the wheel cylinders.
- 5.5.3 COLD CHAMBER—A cold chamber shall be provided having sufficient capacity to house the load fixtures of the test apparatus. It shall be such that the apparatus can be checked and operated without removal, and it shall be capable of maintaining a uniform atmosphere of cold dry air at $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F} \pm 3.6\text{ }^{\circ}\text{F}$) temperature.
- 5.5.4 HUMIDITY CABINET—A humidity cabinet having sufficient capacity to house the load fixtures of the test apparatus. It shall be capable of maintaining a relative humidity of $95\% \pm 3$ at temperatures of $21\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($70\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) and $46.1\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($115\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$).

- 5.6 Test Fittings and Material—Test hydraulic fluid shall be per SAE J1703. The compatibility fluid of SAE J1703 is recommended.²

Wheel cylinder bolts and their lock washers shall be of types used by the vehicle manufacturer. The hydraulic connector to the wheel cylinder, whether tubing or hose, shall also be of the type used by the vehicle manufacturer.

6. Test Samples—Wheel cylinders for test shall not have been used after manufacture or rebuild, and they shall not be disassembled prior to testing.
7. Test Setup And Procedures—Tests shall be conducted in the sequence shown and at room temperature except where otherwise specified. Wheel cylinders shall not be disassembled until after all tests are completed or unless testing is discontinued.

7.1 Unrestricted Apply and Release

- 7.1.1 Remove the shipping plug from the wheel cylinder hydraulic inlet port(s).
- 7.1.2 Fully stroke the cylinder five times by hand and allow it to return under the piston return spring load. In the absence of a piston return spring, apply 5 psi (34 kPa) air pressure to the inlet port until the cylinder returns to its original position, five times. Record time for return on fifth stroke.

NOTE—Avoid stroking the wheel cylinder cups into the bleed screw and/or hydraulic inlet openings during this test.

- 7.2 Ozone Resistance—Seal the hydraulic port(s) from the atmosphere, install connecting link(s) where required to seal the small diameter of the boot, and place the cylinder in the ozone chamber. Subject the cylinder to an ozone concentration of 50 pphm ± 5 by volume at $37.7\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($100\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) for 50 h.

Remove the cylinder from the ozone chamber and visually inspect the boot(s) without disassembling.

2. Compatibility fluid may be obtained from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

7.3 Applied Leakage—Install the wheel cylinder on its load fixture and tighten the mounting bolts by hand. (See Note of 5.3 for single-end wheel cylinders.) Making certain that the piston(s) is (are) not beyond the brake release position and that the connecting link(s) has (have) $4 \text{ deg} \pm 0.5 \text{ deg}$ angularity with the wheel cylinder bore longitudinal axis, tighten the mounting bolts to the nominal torque specified by the vehicle manufacturer. Adjust the connecting link(s) so that the piston(s) is (are) in the release position.

Assemble the hydraulic connector of the test apparatus to the wheel cylinder and tighten to the nominal torque specified by the vehicle manufacturer. Fill the test setup with new hydraulic fluid and bleed at all points in the system as necessary to remove air. Tighten the bleed screw to the nominal torque specified by the vehicle manufacturer.

7.3.1 Drop the connecting link lock(s) in place per Figure 2 and open the valve to the low pressure gage. Apply the master cylinder to build up $20 \text{ psi} \pm 1 \text{ psi}$ ($138 \text{ kPa} \pm 6.9 \text{ kPa}$) pressure in the system, shut off the valve to the master cylinder, and release the master cylinder.

Allow the pressure to the wheel cylinder to stabilize for 15 to 20 s, and then record the pressure at the beginning and end of a $30 \text{ s} \pm 1 \text{ s}$ interval.

7.3.2 Open the valve to the master cylinder, close the valve to the low pressure gage, and open the valve to the high-pressure gage. Apply the master cylinder to build up $1000 \text{ psi} \pm 100 \text{ psi}$ ($6.9 \text{ MPa} \pm 0.7 \text{ MPa}$) pressure in the system, shut off the valve to the master cylinder, and release the master cylinder. Allow the pressure to the wheel cylinder to stabilize for 15 to 20 s, and then record the pressure at the beginning and end of a $30 \text{ s} \pm 1 \text{ s}$ interval.

7.4 Physical Strength—Open the valve to the master cylinder and apply the master cylinder to build up $3000 \text{ psi} \pm 300 \text{ psi}$ ($20.7 \text{ MPa} \pm 2 \text{ MPa}$) pressure in the system. Hold the pressure for $15 \text{ s} \pm 5 \text{ s}$ and then release the master cylinder.

7.4.1 Observe the pressure gage during the test, and visually inspect the wheel cylinder and its mounting afterward for signs of leaks or structural failure.

Remove the connecting link lock(s).

7.5 Humidity Operation—Place the load fixture(s) with the wheel cylinder(s) in the humidity cabinet. Set the pressure actuating mechanism for cyclic operation at $1000 \text{ cycles/h} \pm 100 \text{ cycles/h}$ (3.27 s/cycle to 4.00 of apply and release stroke), and adjust it to build up a master cylinder output pressure of $500 \text{ psi} \pm 50 \text{ psi}$ ($3.4 \text{ MPa} \pm 0.3 \text{ MPa}$). Stroke 8 h at $46.1 \text{ }^\circ\text{C} \pm 3 \text{ }^\circ\text{C}$ ($115 \text{ }^\circ\text{F} \pm 5 \text{ }^\circ\text{F}$) temperature and $95\% \pm 3\%$ relative humidity; and then cease stroking for 16 h while at $21 \text{ }^\circ\text{C} \pm 3 \text{ }^\circ\text{C}$ ($70 \text{ }^\circ\text{F} \pm 5 \text{ }^\circ\text{F}$) temperature and resultant relative humidity. Repeat this sequence.

7.5.1 Periodically observe the wheel cylinder action during stroking.

7.5.2 Remove the load fixture(s) with the wheel cylinder(s) from the humidity cabinet at the end of the second day (16 000 cycles stroking and 32 h static).

DO NOT DISTURB WHEEL CYLINDER BOOT(S).

7.5.3 Repeat Procedures 7.3.1 and 7.3.2.

Open the valve to the master cylinder and remove the connecting link lock(s).

7.6 High Temperature Durability—Set the pressure actuating mechanism for cyclic operation at 1000 cycles/h \pm 100 cycles/h (3.27 to 4.00 s/cycle of apply and release stroke). Empty the leak trap(s) and place the load fixture(s) with the cylinder(s) in the heat cabinet. Adjust the pressure actuating mechanism to build up a master cylinder output pressure of 1000 psi \pm 100 psi (6.9 MPa \pm 0.7 MPa). Place the leak trap under each wheel cylinder boot and commence stroking while raising the temperature of the cabinet to 100 °C \pm 5 °C (212 °F \pm 9 °F) within 6 h.

7.6.1 Periodically observe the wheel cylinder action during stroking.

7.6.2 Discontinue stroking at the end of 100 000 cycles. Inspect the wheel cylinder for external leakage. Measure and record the fluid in each leak trap.

7.6.3 Empty the leak trap(s), shut off the valve to the master cylinder, and open the valve from the wheel cylinder(s) to the standpipe. Place the leak trap under each wheel cylinder boot and let the system stand idle for 12 to 18 h, during which the cabinet shall be allowed to cool to room temperature. Measure and record leakage.

7.6.4 Shut off the valve to the standpipe, open the valve to the master cylinder, and repeat 7.3.1 and 7.3.2.

Open the valve to the master cylinder, remove the connecting link lock(s), and remove the load fixture(s) from the heat cabinet.

7.7 Cold Temperature Operation—Empty the leak trap(s) and place the load fixture(s) with the wheel cylinder(s) in the cold chamber. Set the pressure actuating mechanism for cyclic operation at 500 cycles/h \pm 50 cycles/h (6.55 to 8.00 s/cycle of apply and release stroke), and adjust it to build up a master cylinder output pressure of 500 psi \pm 50 psi (3.4 MPa \pm 0.3 MPa). Place the leak trap under each wheel cylinder boot and lower the temperature of the chamber to -40 ± 2 , -5 °C (-40 ± 3.6 , -9 °F) within 18 h. Commence stroking after a minimum of 4 h soak at the test temperature.

7.7.1 Observe the wheel cylinder action during stroking.

7.7.2 Discontinue stroking at the end of 20 cycles and allow the load fixture(s) to come to room temperature. Inspect the wheel cylinder for external leakage. Measure and record the fluid in each leak trap.

7.7.3 Repeat 7.3.1 and 7.3.2.

Open the valve to the master cylinder and remove the connecting link lock(s), and remove the load fixture from the cold chamber.

7.8 Storage Corrosion Resistance—Remove the wheel cylinder connector at its juncture with the line to the master cylinder, and then, taking care not to empty fluid from the wheel cylinder or its connecting tubing/hose, install a vented plug in the open end of connecting tubing/hose. With the wheel cylinder on its load fixture or a like device that holds the piston(s) in release position, place empty leak trap(s) under the cylinder boot(s) and store the cylinder for seven days at room temperature.

7.8.1 At the end of seven days, examine the cylinder for visible leakage. Measure the amount of fluid in the leak trap(s).

7.8.2 Remove the piston clamps, if used, and remount the cylinder on the load fixture or like device allowing equivalent piston stroke. Reattach the cylinder to the test apparatus or equivalent and build up hydraulic pressure gradually until the piston(s) starts to move, measure and record this pressure.

7.8.3 Continue the pressure buildup until 500 psi \pm 50 psi (3.4 MPa \pm 0.3 MPa) is achieved and release it, meanwhile observing the wheel cylinder action.