SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®

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# SAE J1469 JUN88

# Air Brake Actuator Test Procedure, Truck-Tractor, Bus and Trailers

**SAE Recommended Practice**
**Issued June 1988**





**Submitted for Recognition as an American National Standard**

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
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# TRUCK AND BUS PRACTICE

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## AIR BRAKE ACTUATOR TEST PROCEDURE, TRUCK-TRACTOR, BUS AND TRAILERS



1. PURPOSE:

This SAE Recommended Practice provides uniform procedures and methods for laboratory testing of brake actuators used in air brake systems.

2. SCOPE:

This practice provides procedures and methods for testing service, spring applied parking and combination brake actuators with respect to durability, function and environmental performance. A minimum of five test units designated A, B, C, D and E are to be used to perform all tests per paragraphs 2.1 and 2.2.

2.1 Test Procedures:

Leak rate-parking and service chambers
(Section 4)
Chamber volume-parking and service chambers
(Section 5)
Maximum release and hold-off pressure-parking chamber
(Section 6)
Force output and stroke-parking chamber
(Section 7)
Force output and stroke-service chamber
(Section 8)
Low temperature leakage-parking and service chambers
(Section 9)
Low temperature maximum release and hold-off pressure
(Section 10)
Low temperature force output-parking chamber
(Section 11)

2.1 Test Procedures: (Continued)

Low temperature operational test-service chamber
(Section 12)
Corrosion resistance-parking and service chamber
(Section 13)
Mechanical back-off release mechanism
(Section 14)
Proof pressure test-parking and service chambers
(Section 15)
Cycle test-parking chamber
(Section 16)
Cycle test-service chamber
(Section 17)
Elevated temperature cycle test-parking and service chambers
(Section 18)
Vibration test
(Section 19)

2.2 Test Sequence Chart: The test sequence as charted in the "Test Sequence Chart" shall be mandatory. (See page 3.)

3. DEFINITIONS:

3.1 Hold-Off Pressure: A decrease of parking chamber air pressure for parking brake application (extend power spring).

3.2 Release Pressure: An increase of parking chamber air pressure to release the parking brake (compress power spring).

3.3 Parking Chamber Apply: Extend power spring.

3.4 Parking Chamber Release: Compress power spring.

3.5 Full Stroke: Maximum stroke of a unit.

3.6 Rated Stroke: Nominal design stroke of a unit.

3.7 Service Brake Actuator: Air activated actuator for applying the foundation brake.

3.8 Parking Brake Actuator: Mechanically applied actuator for restraining the vehicle.

3.9 Combination Brake Actuator: Combined service and parking section actuator.

3.10 Zero Stroke: Brake actuator push rod must be in retracted position (foundation brake full-off).

3.11 Fully Caged Power Spring: Power spring restrained in its most compressed position within the brake actuator.

Note: This may be accomplished either pneumatically or mechanically per the manufacturer's recommended procedure.

## TEST SEQUENCE CHART

| | | TEST PROCEDURE SECTION NO. | TESTS FOR SERVICE CHAMBER ONLY TEST UNIT DESIGNATION | | | | | TESTS FOR PARK CHAMBER ONLY TEST UNIT DESIGNATION | | | | | TESTS FOR COMBINATIONS TEST UNIT DESIGNATION | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | A | B | C | D | E | A | B | C | D | E |
| Leakage Rate | | 4. | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Chamber Volume | | 5. | X | | | | | X | | | | | X | | | | |
| Max. Release & Hold Off | | 6. | | | | | | X | | | | | X | | | | |
| Force Output and Stroke | Park | 7. | | | | | | X | X | X | X | X | X | X | X | X | X |
| | Service | 8. | X | X | X | X | X | | | | | | X | X | X | X | X |
| Low Temp. Leakage | | 9. | X | | | | | X | | | | | X | | | | |
| Low Temp. Max. Release & Hold Off | | 10. | | | | | | X | | | | | X | | | | |
| Low Temp. Force Output | | 11. | | | | | | X | | | | | X | | | | |
| Low Temp. Operational | | 12. | X | | | | | | | | | | X | | | | |
| Corrosion | | 13. | | X | | | | | X | | | | | X | | | |
| Mech. Back-Off Release (When Applicable) | | 14. | | | | | | X | X | | | | X | X | | | |
| Proof Pressure | | 15. | X | | | | | X | | | | | X | | | | |
| Cycle Test | Park | 16. | | | | | | | X | X | | X | | X | X | | X |
| | Service | 17. | | X | X | | X | | | | | | | X | X | | X |
| Elevated Temp. Cycle | | 18. | | | | X | | | | | X | | | | | X | |
| Vibration | | 19. | | | | X | | | | | X | | | | | X | |

Rev. 2 - 16B & 17B deleted 3 places

4. LEAK RATE-PARKING AND SERVICE CHAMBERS:

4.1 Leakage: Parking chamber.

4.1.1 Conditions:

4.1.1.1 80 ± 20°F (27 ± 11°C) ambient temperature.

4.1.1.2 Parking chamber is to be uncaged.

4.1.2 Test Procedure:

4.1.2.1 Preconditioning Cycles: Pneumatically actuate the parking chamber from fully applied to fully released and back to fully applied three times using 90 - 120 lbf/in$^2$ (gage) (620 - 830 kPa) air pressure.

4.1.2.2 Pressurize the parking chamber with air to 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa).

4.1.2.3 Allow the air pressure in the unit to stabilize for 5 ± 1 minutes.

4.1.2.4 Establish air pressure at 125 ± 1 lbf/in$^2$ (gage) (860 ± 7 kPa).

4.1.2.5 Measure leakage rate with a flow meter.

4.1.2.6 Record leakage rate.

4.1.3 Alternate Test Procedure:

4.1.3.1 Preconditioning Cycles: Per paragraph 4.1.2.1.

4.1.3.2 Connect the parking chamber to a 1250 ± 50 in$^3$ (20 484 ± 820 cm$^3$ air tank.

4.1.3.3 Connect a pressure gage (or equivalent device) to measure pressure change.

4.1.3.4 Pressurize the parking chamber and air tank to 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa) air pressure.

4.1.3.5 Stabilize the air pressure for 5 ± 1 minutes.

4.1.3.6 Establish a pressure of 125 ± 1 lbf/in$^2$ (gage) (860 ± 7 kPa) in the parking chamber and air tank and close shut-off valve at the air tank inlet.

4.1.3.7 Record the pressure change after 10 ± 0.1 minutes.

4.2 Leakage - Service Chamber:

4.2.1 Conditions:

4.2.1.1 80 ± 20°F (27 ± 11°C) ambient temperature.

4.2.1.2 Limit the stroke to 75 ± 5% of rated stroke.

4.2.1.3 Maintain the parking chamber at 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa) - if applicable.

4.2.2 Test Procedure:

4.2.2.1 Precondition Cycles: Cycle the service chamber three times pneumatically, by applying 90 - 120 lbf/in$^2$ (gage) (620 - 830 kPa) from full stroke to zero stroke and back to full stroke position.

4.2.2.2 Pressurize the service chamber with 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa) air pressure.

4.2.2.3 Allow the air pressure in the unit to stabilize for 5 ± 1 minutes.

4.2.2.4 Establish a pressure of 125 ± 1 lbf/in$^2$ (gage) (860 ± 7 kPa) in the service chamber.

4.2.2.5 Measure leakage rate with a flow meter.

4.2.2.6 Record leakage rate.

4.2.3 Alternate Test Procedure:

4.2.3.1 Apply preconditioning cycle per paragraph 4.2.2.1.

4.2.3.2 Connect the service chamber to a 1250 ± 50 in$^3$ (20 485 ± 820 cm$^3$) air tank.

4.2.3.3 Connect a pressure gage (or equivalent device) to measure pressure change.

4.2.3.4 Pressurize the service chamber and air tank to 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa).

4.2.3.5 Stabilize the air pressure in the service chamber and air tank for 5 ± 1 minutes.

4.2.3.6 Establish a pressure of 125 ± 1 lbf/in$^2$ (gage) (860 ± 7 kPa) in the service chamber and air tank and close shut-off valve at the air tank inlet.

4.2.3.7 Record the pressure change after 10 ± 0.1 minutes.

5. CHAMBER VOLUME - PARKING AND SERVICE CHAMBER:

5.1 Parking Chamber:

5.1.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

5.1.2 Test Procedure:

5.1.2.1 Fully cage the power spring in the parking chamber pneumatically.

5.1.2.2 Record the distance from a reference point on the actuator pushrod to a fixed part of the actuator to obtain the zero stroke position.

5.1.2.3 Release the power spring and allow the pushrod to return to its full stroke position or use a stroke limiting device to restrain the pushrod to the required test stroke.

5.1.2.4 Connect the parking chamber air port to the test apparatus as shown in Fig. 1 with the inlet port in the highest position. The fluid reservoir shall be of sufficient capacity to insure an adequate amount of fluid for all bleeding and measurement of chamber volume.

5.1.2.5 Close the drain valve, open the inlet valve and pressurize the fluid reservoir with 100 - 125 lbf/in$^2$ (gage) (690 - 860 kPa). After the actuator rod has moved to its zero stroke position, close the inlet valve, open the drain valve and return the chamber to its test stroke position. Repeat this procedure several times to insure adequate bleeding.

5.1.2.6 Close the drain valve, open the inlet valve and pressurize the fluid reservoir to 100 ± 5 lbf/in$^2$ (gage) (690 ± 35 kPa). Allow the actuator rod to move to the zero stroke position. After 30 s, close the inlet valve, open the drain valve and measure the amount of fluid expelled when the actuator pushrod returns to its test position (rated, full or other specified stroke). Record the distance from the reference point on the actuator pushrod to the fixed point of the actuator used in paragraph 5.1.2.2. The recorded distance measured minus the recorded distance measured in paragraph 5.1.2.2 for zero stroke position is the actuator test stroke.

5.1.2.7 Close the drain valve and carefully disconnect the actuator from the test apparatus holding the parking chamber inlet up. Drain and measure the fluid remaining in the actuator.

Note: Care must be taken that any fluid expelled from the test apparatus circuit is not included in the measurement of chamber test volume.

5.1.2.8 The volume of the parking chamber for the given test stroke shall consist of the sum of the volumes measured in paragraphs 5.1.2.6 and 5.1.2.7.

5.2 Service Chamber:

5.2.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

5.2.2 Test Procedure:

5.2.2.1 Cage the power spring per paragraph 5.1.2.1 (if applicable). The power spring shall remain caged for this entire procedure.

5.2.2.2 Obtain zero stroke position per paragraph 5.1.2.2.

5.2.2.3 Use a stroke limiting device to restrain the pushrod to the required test stroke.

5.2.2.4 Connect the service chamber air port to the test apparatus as shown in Fig. 1 with the inlet port in the highest position.

5.2.2.5 Close the drain valve, open the inlet valve and pressurize the fluid reservoir with 100 - 125 lbf/in$^2$ (gage) (690 - 860 kPa). After the actuator pushrod has moved to the required test stroke position, close the inlet valve, open the drain valve and return the chamber to its zero stroke position. Repeat this procedure several times to insure adequate bleeding.

5.2.2.6 Close the drain valve, open the inlet valve and pressurize the fluid reservoir to 100 ± 5 lbf/in$^2$ (gage) (690 ± 35 kPa). Allow the actuator pushrod to move to its test stroke position (rated, full or other specified stroke). When at this test stroke position, measure the distance from the reference point on the actuator pushrod to the fixed point of the actuator used in paragraph 5.1.2.2. This recorded distance measured minus the recorded distance measured in paragraph 5.1.2.2 for zero stroke position is the service chamber test stroke. After 30 s of the pushrod in its test stroke position, close the inlet valve, open the drain valve and measure the amount of fluid expelled when the actuator pushrod returns to its zero stroke position.

5.2.2.7 Measure residue chamber fluid per paragraph 5.1.2.7.

NOTE: Care must be taken that any fluid expelled from the test apparatus circuit is not included in the measurement of chamber test volume.

5.2.2.8 The volume of the service chamber for the given test stroke shall consist of the sum of the volumes measured in paragraphs 5.2.2.6 and 5.2.2.7.



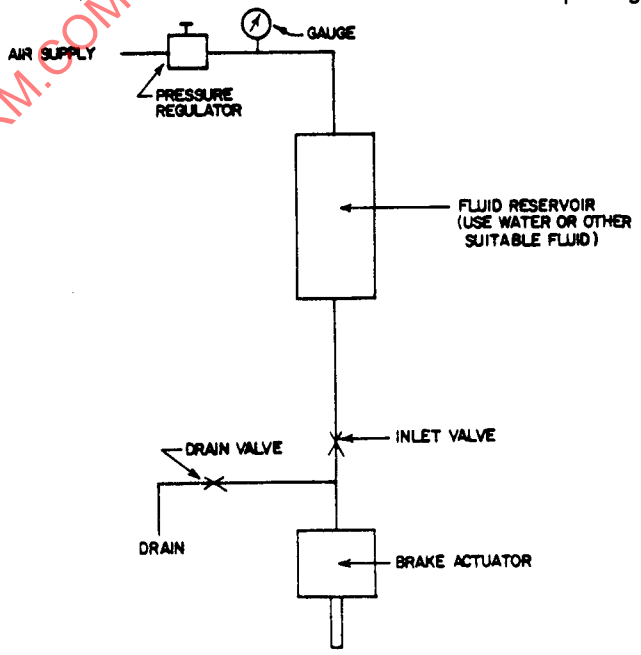


FIGURE 1

6. MAXIMUM RELEASE AND HOLD-OFF PRESSURE - PARKING CHAMBER:

6.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

6.2 Test Procedure:

6.2.1 Power Spring Preset - Parking Brake:

6.2.1.1 Fully cage the power spring in the parking chamber either pneumatically or mechanically as specified by the manufacturer.

6.2.1.2 Maintain the power spring in the caged position for 24 h minimum.

6.2.1.3 Release the power spring to a full stroke position after the required preset period.

6.2.2 Preconditioning Cycles: Apply preconditioning cycles per paragraph 4.1.2.1.

6.2.3 On the third cycle, measure and record stroke versus air pressure in the apply and release direction for the full stroke of the brake actuator. It is recommended measurements be taken in 1/4 in increments or as otherwise specified.

7. FORCE OUTPUT AND STROKE - PARKING CHAMBER:

7.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

7.2 Test Procedure:

7.2.1 Mount Unit To Test Fixture: Mount the test actuator to a holding fixture using mounting hardware specified by the manufacturer and tightened to the manufacturer's recommended torque. The holding fixture shall be constructed with sufficient strength and rigidity to minimize fixture deflection under loading, (see Fig. 2).

7.2.2 Cycle the parking chamber three times pneumatically from full stroke to zero stroke and back to full stroke using 90 - 120 lbf/in$^2$ (gage) (620 - 830 kPa).

7.2.3 Install the test unit and holding fixture in a suitable force versus stroke measuring equipment. Note: The test fixturing must provide guiding of the test units pushrod which will assure a pushrod angularity with the mounting surface of the chamber of 90 ± 1 deg during force output testing.

7.2.4 Apply 100 - 120 lbf/in$^2$ (gage) (690 - 830 kPa) air pressure to the parking chamber to fully compress the power spring (if applicable).

7.2.5 If an X-Y recorder is used to measure force versus stroke, "zero" the force output on the X-Y recorder at this point in the procedure.

7.2.6 Apply an 8 - 10 lb (35 - 45 N) preload to the end of the test unit's pushrod.

7.2.7 If an X-Y recorder is used, "zero" the linear displacement (pushrod travel) on the X-Y recorder after the 8 - 10 lb (35 - 45 N) preload has been applied.

7.2.8 Gradually release all air pressure from the parking chamber and record the parking chamber force versus stroke from zero to full stroke in the brake application direction (stroke extend) in 1/4 in (0 - 6.4 mm) increments. If an X-Y recorder is used, plot a force versus stroke curve. Force outputs shall be measured at the end of the service chamber pushrod when activated by the parking chamber from zero to full stroke.

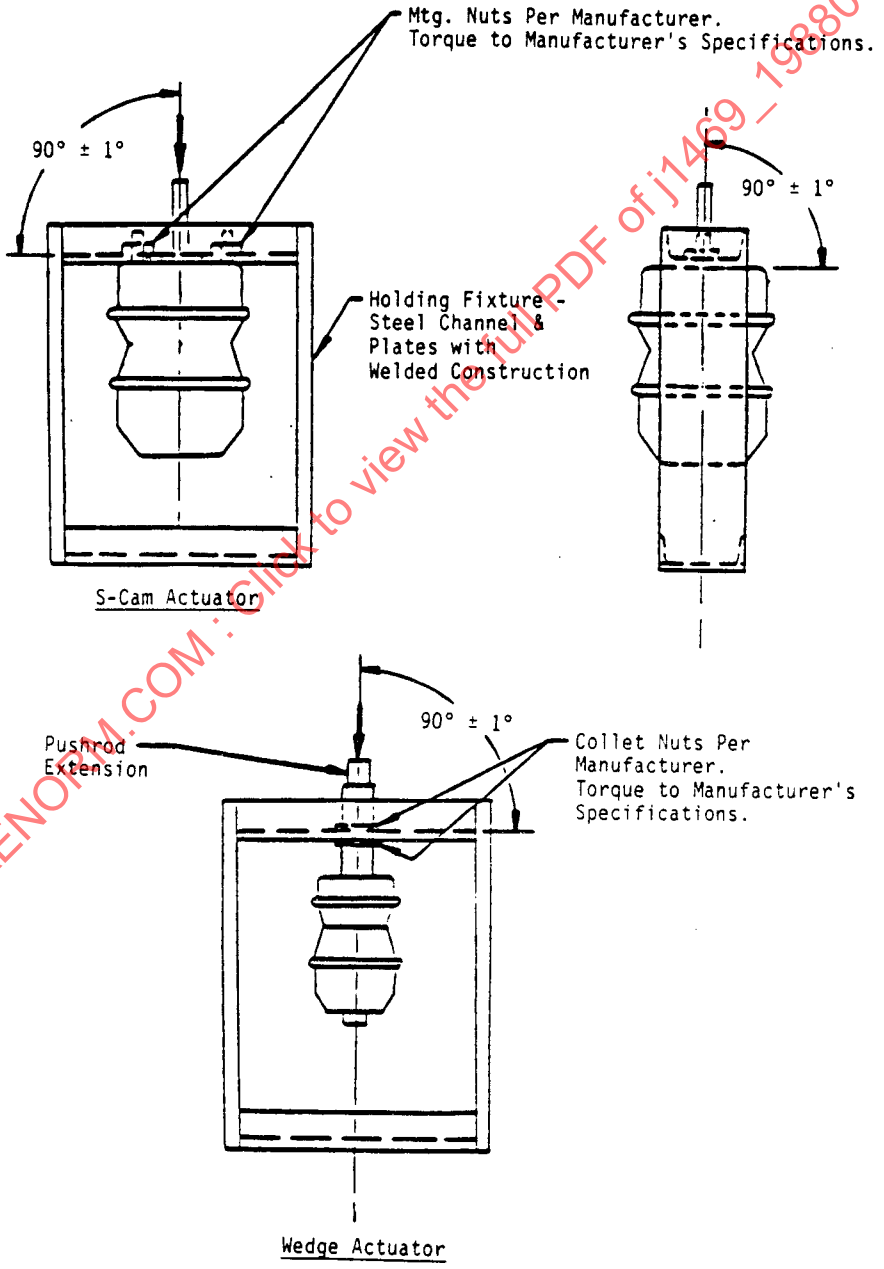


FIGURE 2

8. FORCE OUTPUT AND STROKE - SERVICE CHAMBER:

8.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

8.2 Test Procedure:

8.2.1 Mount Unit To Test Fixture: Same as procedure specified in paragraph 7.2.1.

8.2.2 Cycle the service chamber three times pneumatically from full stroke to zero stroke and back to full stroke using 90 - 120 lbf/in$^2$ (gage) (620 - 830 kPa).

8.2.3 Install the test unit and holding fixture in suitable force versus stroke measuring equipment. Note: The test fixturing must provide guiding of the test units pushrod which will assure a pushrod angularity with the mounting surface of the chamber of 90 ± 1 deg during force output testing.

8.2.4 Fully cage the power spring in the parking chamber (if applicable) either pneumatically or mechanically as specified by the manufacturer.

8.2.5 If an X-Y recorder is used to record force versus stroke, "zero" the force output on the X-Y recorder at this point in the procedure.

8.2.6 Apply an 8 - 10 lb (35 - 45 N) preload to the end of the test unit's pushrod.

8.2.7 If an X-Y recorder is used, "zero" the linear displacement (pushrod travel) on the X-Y recorder after the 8 - 10 lb (35 - 45 N) preload has been applied.

8.2.8 Apply 120 ± 2 lbf/in$^2$ (gage) (830 ± 14 kPa) to the service chamber and record the service chamber force output from zero to full stroke in the brake application direction (stroke extend) in 1/4 in (0 - 6.4 mm) increments. If an X-Y recorder is used, plot a force versus stroke curve.

8.2.9 Repeat procedures specified in paragraphs 8.2.3 - 8.2.6 for 100, 80, 60, 40 and 20 lbf/in$^2$ (gage) (690, 550, 415, 275, 140 kPa).

9. LOW TEMPERATURE LEAKAGE - PARKING AND SERVICE CHAMBER:

9.1 Leakage, Low Temperature - Parking Chamber:

9.1.1 Conditions:

9.1.1.1 -40 ± 2°F (-40 ± 1°C).

9.1.1.2 Care must be taken to assure that the test unit is maintained at the specified temperature.

9.1.2 Test Procedure:

9.1.2.1 Connect the parking chamber to a 1250 ± 50 $in^3$ (20 485 ± 820 $cm^3$) air tank. Pressurize the air tank to 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa). Do not pressurize the parking chamber. Parking chamber is to be uncaged.

9.1.2.2 Limit stroke of unit to 75 ± 5% of rated stroke.

9.1.2.3 Soak test unit and pressurized air tank at -40 ± 2°F (-40 ± 1°C) for 16 h minimum.

9.1.2.4 After the low temperature soak is completed, pressurize the parking chamber to 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa) with air from the 1250 $in^3$ (20 485 ± 820 $cm^3$) air tank. If the 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa) air pressure cannot be maintained, it is permissible to apply room temperature make-up air.

9.1.2.5 Stabilize the parking chamber and air tank air pressure for 5 min minimum.

9.1.2.6 Establish air pressure at 125 ± 1 $lbf/in^2$ (gage) (860 ± 7 kPa) and close shut-off valve.

9.1.2.7 Measure leakage rate with a flow meter. Record all results.

9.1.3 Alternate Test Procedure:

9.1.3.1 Connect the parking chamber to a 1250 ± 50 $in^3$ (20 485 ± 820 $cm^3$) air tank.

9.1.3.2 Connect a pressure (gage) (or equivalent device) to measure pressure change.

9.1.3.3 Pressurize the air tank to 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa). Do not pressurize the parking chamber. Parking chamber is to be uncaged. Perform procedures specified in paragraphs 9.1.2.2 - 9.1.2.6.

9.1.3.4 Record the pressure change after 10 ± 0.1 minutes.

9.2 Leakage, Low Temperature Service Chamber:

9.2.1 Conditions: -40 ± 2°F (-40 ± 1°C)

9.2.2 Test Procedure:

9.2.2.1 Connect the service chamber to a 1250 ± 50 $in^3$ (20 485 ± 820 $cm^3$) air tank. Pressurize the air tank to 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa). Do not pressurize the parking chamber.

9.2.2.2 Cage the parking chamber mechanically or pneumatically with 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa) to maintain the power spring in the fully caged position (if applicable).

9.2.2.3 Limit stroke of unit to 75 ± 5% of rated stroke.

9.2.2.4 Soak test unit and pressurized air tank at -40 ± 2°F (-40 ± 1°C) for 16 h minimum.

9.2.2.5 After the low temperature soak is completed, pressurize the service chamber to 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa) with air from the 1250 in$^3$ (20 485 ± 820 cm$^3$) air tank. If the 125 - 130 lbf/in$^2$ (gage) air pressure cannot be maintained, it is permissible to apply room temperature make-up air.

9.2.2.6 Stabilize the service chamber and air tank air pressure for 5 min minimum.

9.2.2.7 Establish air pressure at 125 ± 1 lbf/in$^2$ (gage) (860 ± 7 kPa).

9.2.2.8 Measure leakage rate with a flow meter. Record all results.

9.2.3 Alternate Test Procedure:

9.2.3.1 Connect the service chamber to a 1250 ± 50 in$^3$ (20 485 ± 820 cm$^3$) air tank.

9.2.3.2 Connect a pressure gage (or equivalent device) to measure pressure change.

9.2.3.3 Pressurize the air tank to 125 - 130 lbf/in$^2$ (gage) (860 - 900 kPa). Perform procedures specified in paragraphs 9.2.2.2 - 9.2.2.7.

9.2.3.4 Record the pressure change after 10 ± 0.1 minutes.

10. LOW TEMPERATURE MAXIMUM RELEASE AND HOLD-OFF PRESSURE - PARKING CHAMBER:

10.1 Conditions: Same as 9.1. Note: If the test is to be performed outside of the cold box, soak at -45 ± 2°F (-43 ± 1°C) and all testing must be completed within 15 min after removal from the cold box.

10.2 Test Procedure:

10.2.1 Soak test unit and pressurized air tank at test condition temperature for 16 h minimum.

10.2.2 Power spring pre-set per paragraph 6.2.1.

10.2.3 Precondition cycle per paragraph 4.1.2.1.

10.2.4 Measure and record the service chamber pushrod stroke versus air pressure when actuated by the parking chamber in the apply and release direction per paragraph 6.2.3.

11. LOW TEMPERATURE FORCE OUTPUT - PARKING CHAMBER:

11.1 Conditions: Same as 9.1. Note: If the test is to be performed outside of the cold box, soak at -40 ± 2°F (-43 ± 1°C) and all testing must be completed within 15 min after removal from the cold box.

11.2 Test Procedure:

11.2.1 Soak test unit at the test condition temperature for 16 h minimum.

11.2.2 Measure and record force output per paragraph 7.2.

12. LOW TEMPERATURE OPERATIONAL TEST - SERVICE CHAMBER:

12.1 Conditions: -40 ± 2°F (-40 ± 1°C).

12.2 Test Procedure:

12.2.1 Establish zero stroke position of the pushrod relative to a reference surface. Mark the pushrod for stroke measurement required in paragraph 12.2.9.

12.2.2 Limit the pushrod stroke to 75 ± 5% of rated stroke. Note: The test fixturing must guide pushrod, when actuated, to maintain perpendicularity to the chamber mounting surface within ± 1 deg.

12.2.3 Connect the service chamber to a 1250 ± 50 $in^3$ (20 485 ± 820 $cm^3$) air tank with a three way air shut-off valve attached between the air port and air tank to enable cycling of the service chamber.

12.2.4 With the shut-off valve closed, pressurize the air tank to 125 - 130 $lbf/in^2$ (gage) (860 - 900 kPa) air pressure.

12.2.5 Soak the test unit and air tank at -40 ± 2°F (-40 ± 1°C) per paragraph 9.1.1 for 16 h minimum as follows:

12.2.5.1 Combination Actuator: Parking chamber applied (extend power spring) to allow pushrod to stroke per paragraph 12.2.2.

12.2.5.2 Service brake actuator (service chamber) zero pushrod stroke.

12.2.6 After the soak period, pneumatically cage the combination actuator parking chamber power spring. (Room temperature air permissible, do not use air from air tank per paragraph 12.2.3).

12.2.7 Open shut-off valve between air tank and air port and pressurize the service chamber to 90 ± 5 $lbf/in^2$ (gage) (620 ± 35 kPa).

12.2.8 Pneumatically cycle the service chamber, from zero to the pushrod stroke limit (75 ± 5% rated stroke) and back to zero stroke three times. It is permissible to use room temperature make-up air to the air tank to maintain 90 ± 5 $lbf/in^2$ (gage) (620 ± 35 kPa).

12.2.9 On the third release stroke, measure and record the time required for the pushrod to retract to within 1/4 in (0 - 6.4 mm) of its original position after the air pressure is released to 0 $lbf/in^2$ (gage) (0 kPa).

13. CORROSION RESISTANCE - COMBINATION, PARKING AND SERVICE ACTUATORS:

13.1 Service Chamber:

13.1.1 Conditions: The test unit shall be exposed for 96 h to a continuous salt test per ASTM B 117.

13.1.2 The test unit shall cycle at a minimum rate of 48 cycles/h.

13.1.3 After the unit has been air dried, test per the following procedures:

- service chamber leakage per Section 4.2.
- service chamber force output and stroke per Section 8.
- service chamber disassembly and inspection.

13.2 Parking Chamber:

13.2.1 Conditions: The test unit shall be exposed for 96 h to a continuous salt spray test per ASTM B 117.

13.2.2 Test Procedure:

13.2.2.1 Limit the piston rod stroke to 75 ± 5% of rated stroke.

13.2.2.2 The test unit shall cycle at a minimum rate of 12 cycles/h.

Note: Parking chamber may be tested in tandem as a combination unit.

13.2.2.3 After the unit has been air dried, test per the following procedures:

- parking chamber leakage per Section 4.1.

13.3 Combination Actuator:

13.3.1 Conditions: The test unit shall be exposed for 96 h to a continuous salt spray test per ASTM B 117.

13.3.2 Test Procedure:

13.3.2.1 Limit the piston rod stroke to 75 ± 5% of rated stroke.

13.3.2.2 The test unit cycle sequence shall consist of eight service chamber cycles followed by two parking chamber cycles and repeated at a minimum rate of 60 cycles/h.

13.3.2.3 After the unit has been air dried, test per the following procedures:

- parking chamber leakage per Section 4.1
- service chamber leakage per Section 4.2
- service chamber force output and stroke per Section 8
- service chamber disassembly and inspection.

14. MECHANICAL BACK-OFF RELEASE MECHANISM:

14.1 Exceptions: This test applies only to actuators designed with mechanical back-off (release) mechanisms.

14.2 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

14.3 Test Procedure: Establish zero stroke position of the pushrod per paragraph 12.2.1. Apply the parking chamber mechanical back-off mechanism per the manufacturer's instructions to manually cage (compress) the parking chamber power spring. Manually compress and release the power spring to within 1/4 in (0 - 6.4 mm) of full release five times. Record the maximum running torque for each application.

15. PROOF PRESSURE TEST - PARKING AND SERVICE CHAMBER:

15.1 Parking Chamber:

15.1.1 Conditions:

15.1.1.1 80 ± 20°F (27 ± 11°C) ambient temperature.

15.1.1.2 Limit actuator stroke to 75 ± 5% of rated stroke.

15.1.2 Test Procedure:

15.1.2.1 Place test unit in a burst chamber and connect parking chamber air port to a hydraulic pressurizing means.

Warning: In the event a pressurized unit explodes, the burst chamber must prevent injury to personnel in the area.

15.1.2.2 Pressurize the parking chamber to 300 ± 10 lbf/in$^2$ (gage) (2070 ± 70 kPa) hydrostatic pressure (oil or water) for a minimum of 15 seconds.

15.1.2.3 Release the pressure and purge the unit of liquid medium.

15.1.2.4 Leak test the parking chamber per Section 4.1.

15.1.2.5 After all testing is completed, disassemble the parking chamber, using manufacturer's recommended procedures and inspect components for structural damage.

15.2 Service Chamber:

15.2.1 Conditions:

15.2.1.1 80 ± 20°F (27 ± 11°C) ambient temperature.

15.2.1.2 Limit actuator stroke to 75 ± 5% of rated stroke.

15.2.1.3 Cage the power spring per paragraph 6.2.1.1 if applicable.

15.2.2 Test Procedure:

15.2.2.1 Place test unit in a burst chamber and connect the service chamber air port to a hydrostatic pressurizing means.

Warning: In the event a pressurized unit explodes, the burst chamber must prevent injury to persons in the area.

15.2.2.2 Pressurize the service chamber to 300 ± 10 lbf/in$^2$ (gage) (2070 ± 70 kPa) hydrostatic pressure (oil or water) for a minimum of 15 seconds.

15.2.2.3 Release the pressure and purge the unit of liquid medium.

15.2.2.4 Leak test the service chamber per Section 4.2.

15.2.2.5 After all testing is completed, disassemble the service chamber and inspect components for structural damage.

16. CYCLE TEST - PARKING CHAMBER:

16.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

16.2 Test Procedure:

16.2.1 A complete parking and service chamber assembly, when applicable, will be tested.

16.2.2 Preset power spring per Section 6.2.1.

16.2.3 Pneumatically cycle the test unit from its compressed position (zero stroke) to 75 ± 5% of rated stroke by pressurizing the parking chamber with air from 0 - 100 lbf/in$^2$ (gage) (0 - 690 kPa) at a rate of 20 ± 10 cycles per minute. The test unit shall be cycled against a resisting service chamber of equivalent size (that is, a type 30 test unit opposed by a type 30 resisting service chamber). At zero stroke of the test unit, the resisting service chamber shall have 15 ± 5 lbf/in$^2$ (gage) (105 ± 35 kPa) and the pressure shall be allowed to increase to the maximum attainable pressure when the test unit reaches 75 ± 5% of its rated stroke. At this position, the test unit shall exert a force in the extend direction against a positive stop.

16.2.4 Pressure must dwell at 0 - 2 lbf/in$^2$ (gage) (0 - 14 kPa) and 100 ± 5 lbf/in$^2$ (gage) (690 ± 35 kPa) for a minimum of 0.1 second.

16.2.5 Test unit for 200 000 cycles minimum.

16.2.6 After cycling, test the unit per the following procedures:

- Parking chamber leakage per Section 4.1.
- Parking chamber force output per Section 7.
- Maximum release and hold-off per Section 6.

17. CYCLE TEST - SERVICE CHAMBER:

17.1 Conditions: 80 ± 20°F (27 ± 11°C) ambient temperature.

17.2 Test Procedure:

17.2.1 Cage the power spring per paragraph 6.2.1.1 (if applicable).

17.2.2 Pneumatically cycle the service chamber from zero stroke to 75 ± 5% of rated stroke. The test unit shall be cycled against a resisting service chamber of equivalent size (that is, a type 30 test unit opposed by a type 30 resisting service chamber). At zero stroke of the test unit, the resisting service chamber shall have 15 ± 5 lbf/in$^2$ (gage) (105 ± 35 kPa) and it shall increase to 45 ± 5 lbf/in$^2$ (gage) (310 ± 35 kPa) when the test unit reaches 75 ± 5% of its rated stroke. At this position, the test unit shall exert a force in the extend direction against a positive stop.

17.2.3 To cycle service chamber, apply air pressure from 0 - 75 ± 5 lbf/in$^2$ (gage) (0 - 515 ± kPa).

17.2.4 Cycle test unit at a rate of 20 ± 10 cycles/minute.

17.2.5 Pressure must dwell at 0 - 2 lbf/in$^2$ (gage) (0 - 14 kPa) and 75 ± 5 lbf/in$^2$ (gage) (515 ± 35 kPa) for 0.1 s minimum.

17.2.6 Test unit must complete 1 000 000 cycles minimum.

17.2.7 After cycling, the unit shall be leak tested per Section 4.

18. ELEVATED TEMPERATURE CYCLE TEST - PARKING AND SERVICE:

18.1 Parking Chamber:

18.1.1 Conditions: 158 ± 5°F (70 ± 3°C).

18.1.2 Test Equipment:

18.1.2.1 An environmental chamber capable of maintaining 158 ± 5°F (70 ± 3°C).

18.1.2.2 A minimum of 100 lbf/in$^2$ (gage) (690 kPa) air supply.

18.1.2.3 Pneumatic circuit to cycle test unit in environmental chamber.

18.1.3 Test Procedure:

18.1.3.1 Connect parking brake air port to the pneumatic circuit.

18.1.3.2 Soak test unit for 2 h at 158 ± 5°F (70 ± 3°C); then pneumatically cycle the parking chamber from the fully released to the fully applied position (full stroke to zero stroke and back to full stroke position) while maintaining 158 ± 5°F (70 ± 3°C) by applying 0 - 100 ± 5 to 0 lbf/in$^2$ (gage) (0 - 690 ± 35 - 0 kPa) air pressure at a rate of 6 cycles/min minimum for 22 hours.

18.1.3.3 Repeat procedure specified in paragraph 18.1.3.2 four times to accumulate a total of 96 h and a minimum of 30 000 cycles.

18.1.3.4 After cycling, leak test the parking chamber per Section 4.1.

18.2 Service Chamber:

18.2.1 Conditions: Same as those set forth in paragraph 18.1.1 except the test unit's spring chamber is to be caged pneumatically or mechanically during testing (if applicable).

18.2.2 Test Equipment: Same as specified in paragraph 18.1.2.

18.2.3 Test Procedure:

18.2.3.1 Connect the service chamber air port to the pneumatic circuit.

18.2.3.2 Soak test unit for 2 h at 158 ± 5°F (70 ± 3°C), then pneumatically cycle the service chamber from the fully released to the fully applied position (full stroke to zero stroke and back to full stroke position) while maintaining 158 ± 5°F (70 ± 3°C) by applying 0 - 100 ± 5 to 0 lbf/in$^2$ (gage) (0 - 690 ± 35 - kPa) air pressure at a rate of six cycles/min minimum.

18.2.3.3 Repeat procedure specified in paragraph 8.2.3.2 four times to accumulate a total of 96 h and minimum of 30 000 cycles.

18.2.3.4 After cycling, leak test the service chamber per Section 4.2.

19. VIBRATION TEST:

This procedure provides uniform test methods for evaluating "Service" and "Combination" air brake actuators for resistance to vibration fatigue damage.

19.1 Conditions:

19.1.1 80 ± 20°F (27 ± 11°C) ambient temperature.

19.1.2 Pneumatically or mechanically cage the test unit's spring chamber (if applicable).

19.1.3 The brake actuator may be tested with its "pushrod" and "service chamber return spring" removed from the assembly.

19.1.4 If the unit is tested with the "pushrod" and "service chamber return spring" installed, pushrod "tie-down" fixturing shall be employed (see Figs. 3 and 4).

19.2 Test Equipment:

19.2.1 Warning: Adequate shielding and/or isolation of the test unit shall be provided during vibration testing to protect operators and all personnel and property in the area of testing.

19.2.2 Vibration equipment capable of providing a sinusoidal acceleration input.