SURFACE VEHICLE RECOMMENDED PRACTICE	J2902	OCT2014
	Issued 2014-10	

Air Disc Brake Actuator Test Procedure, Truck-Tractor, Bus and Trailer

RATIONALE

This new document has been created to separate the testing for air disc brake actuators from the s-cam drum brake actuator testing outlined in SAE J1469. The air disc brake actuators are similar and do require most of the same testing as the s-cam drum brake actuators but do require some different tests. It is anticipated that development of new testing could take a different direction in some cases.

1. SCOPE

This SAE recommended practice provides procedures and methods for testing service, spring applied parking and combination brake actuators for air disc brake applications. Methods and recommended samples for testing durability, function and environmental performance are listed in 1.1 and 1.2.

1.1 Test Procedures

Leak rate-parking and service chambers (Section 4)
Maximum release and hold-off pressure - parking chamber (Section 5)
Minimum Pressure Response - Service Chambers (Section 6)
Force output and stroke - parking and service chambers (Section 7)
Low temperature leakage (Arctic option included) - parking and service chambers (Section 8)
Low temperature maximum release and hold-off pressure (Section 9)
Low temperature force output - parking chamber (Section 10)
Low temperature operational tests - service chamber (Section 11)
Chamber volume - service chambers (Section 12)
Corrosion resistance - parking and service chamber (Section 13)
Mechanical back-off release mechanism (Section 14)
Elevated temperature cycle test - parking and service chambers (Section 15)
Cycle test - parking and service chambers (Section 16)
Proof pressure test-parking and service chambers (Section 17)
Vibration test (Section 18)

1.2 Test Sequence Chart

The test sequence, as charted in the “Test Sequence Chart”, shall be mandatory except where indicated as optional (see Figure 1).

1.3 Purpose

This document provides uniform procedures and methods for laboratory testing of brake actuators used in heavy duty vehicles equipped with air disc brakes.

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TEST DESCRIPTION		TEST PROCEDURE SECTION NO.	TESTS FOR SERVICE CHAMBERS ONLY						TESTS FOR PARK CHAMBERS ONLY						TESTS FOR COMBINATIONS					
			TEST UNIT DESIGNATION						TEST UNIT DESIGNATION						TEST UNIT DESIGNATION					
			A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
Leakage Rate	Park	4.1							X	X	X	X	X	X	X	X	X	X	X	X
	Service	4.2	X	X	X	X	X	X							X	X	X	X	X	X
	Boot	4.3	X	X	X	X	X	X							X	X	X	X	X	X
Max Relaese and Hold-Off		5							X						X					
Min. Pressure Response		6	X												X					
Force Output and Stroke	Park	7.1							X	X	X	X	X	X	X	X	X	X	X	X
	Service	7.2	X	X	X	X	X	X							X	X	X	X	X	X
Low Temp Leakage	Park	8.1							X						X					
	Service	8.2	X												X					
Low Temp Max Release and Hold-Off		9							O						O					
Low Temp Force Output	Park	10							O						O					
Low Temp Operational		11	X												X					
Chamber Volume	Service	12	X												X					
Corrosion		13						X						X						X
Mechanical Back-Off Release		14							X	X					X	X				
Elevated Temp Test	Park	15.1											X						X	
	Service	15.2					X												X	
Cycle Test	Park	16.1								X	X		X			X	X		X	
	Service	16.2		X	X		X									X	X		X	
Proof Pressure	Park	17.1										X						X		
	Service	17.2				X												X		
Vibration		18	O						X						X					
Items marked with "O" are optional, to be performed only as required by the vehicle manufacturer or customer.																				

FIGURE 1 - TEST SEQUENCE CHART

2. REFERENCES

2.1 Applicable Publication

The following publication forms a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 ASTM Publication

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

ASTM B 117 Method of Salt Spray (Fog) Testing

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

Minimum 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 applying the foundation brake.

3.9 COMBINATION BRAKE ACTUATOR

Combined service and parking section actuator.

3.10 ZERO STROKE

Brake actuator push rod must be in fully retracted position.

3.11 FULLY CAGED POWER SPRING

Power spring retracted in its most compressed position within the brake actuator.

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

4. LEAK RATE - PARKING AND SERVICE CHAMBERS

4.1 Leakage - Parking Chamber

4.1.1 Conditions

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

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

4.1.1.3 Parking chamber is to be uncaged.

4.1.2 Test Procedure

4.1.2.1 Preconditioning Cycle

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

4.1.2.2 Pressurize the parking chamber with air 860 to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage).

4.1.2.3 Stabilize the air pressure for a minimum of 5 minutes.

4.1.2.4 Establish air pressure at 896 kPa ± 7 kPa (130 lbf/in^2 ± 1 lbf/in^2) (gage).

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 4.1.2.1.

4.1.3.2 Connect the parking chamber to a 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank. U.S. 5 Gallon tank is an acceptable alternative.

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 860 kPa to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage) air pressure.

4.1.3.5 Stabilize the air pressure in the parking chamber and tank for a minimum of 5 minutes.

4.1.3.6 Establish a pressure of 896 kPa ± 7 kPa (130 lbf/in^2 ± 1 lbf/in^2) (gage) 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 min ± 0.1 min.

4.2 Leakage - Service Chamber

4.2.1 Conditions

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

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

4.2.1.3 Maintain the parking chamber at 860 kPa to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage) - if applicable.

4.2.2 Test Procedure

4.2.2.1 Precondition Cycles

a. Cycle the service chamber three times pneumatically by applying 620 to 830 kPa (90 lbf/in^2 to 120 lbf/in^2) (gage) from zero stroke to 75% ± 5% stroke and back to zero stroke position.

4.2.2.2 Pressurize the service chamber with 860 kPa to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage) air pressure.

4.2.2.3 Stabilize the air pressure for a minimum of 5 min.

4.2.2.4 Establish a pressure of 896 kPa ± 7 kPa (130 lbf/in^2 ± 1 lbf/in^2) (gage) 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 Preconditioning cycles per 4.2.2.1.

4.2.3.2 Connect the service chamber to a 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank. U.S. 5 Gallon tank is an acceptable alternative.

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 860 kPa to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage).

4.2.3.5 Stabilize the air pressure in the service chamber and tank for a minimum of 5 minutes.

4.2.3.6 Establish a pressure of 896 kPa ± 7 kPa (130 lbf/in^2 ± 1 lbf/in^2) (gage) in the service chamber and air tank then close shut-off valve at the air tank inlet.

4.2.3.7 Record the pressure change after 10 min ± 0.1 min.

4.3 Leakage - Disc Brake Caliper Flange Seal / Pushrod Boot Seal

4.3.1 Conditions

4.3.1.1 27° C ± 11° C (80° F ± 20° F) ambient temperature

4.3.1.2 Maintain the parking chamber at 860 kPa to 896 kPa(125 lbf/in^2 to 130 lbf/in^2) (gage)—if applicable.

4.3.1.3 Caliper flange test fixture should simulate the actual air disc brake caliper with regard to sealing flange of the internal rubber boot, surface conditions, finish and rigidity. See Figure 2. Calipers to be used with the actuator should be considered.

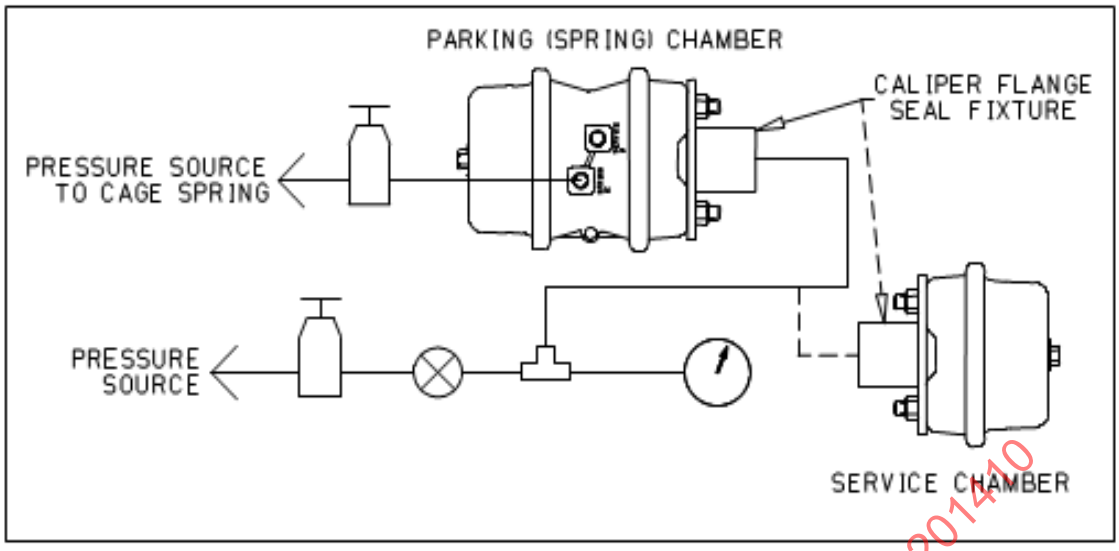


FIGURE 2 - DISC BRAKE CALIPER FLANGE LEAKAGE TEST SCHEMATIC

4.3.2 Test Procedure

4.3.2.1 Apply 21.0 kPa ± 3.0 kPa (3.0 lbf/in^2 ± 0.5 lbf/in^2) (gage) air pressure to the caliper flange test fixture. Allow to stabilize for a minimum of five (5) minutes, then close air valve.

4.3.2.2 Record the pressure change after 10 min ± 0.1 min.

4.3.2.3 Apply vacuum of -21.0 kPa ± 3.0 kPa (-3.0 lbf/in^2 ± 0.5 lbf/in^2) (gage) air pressure to the caliper flange test fixture. Allow to stabilize for a minimum of five (5) minutes, then close air valve.

4.3.2.4 Record the pressure change after 10 min ± 0.1 min.

5. MAXIMUM RELEASE AND HOLD-OFF PRESSURE - PARKING CHAMBER

5.1 Conditions

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

5.2 Test Procedure

5.2.1 Power Spring Preset - Parking Brake

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

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

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

5.2.1.4 Apply preconditioning cycles per 4.1.2.1.

5.2.1.5 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 5.0 mm (0.20 in) increments or as otherwise specified.

6. MINIMUM PRESSURE RESPONSE - SERVICE CHAMBERS

6.1 Conditions

6.1.1 27 ± 11 °C (80 ± 20 °F) ambient temperature

6.1.2 Maintain the parking chamber at 860 kPa to 896 kpa (125 lbf/in^2 to 130 lbf/in^2) (gage) - if applicable.

6.2 Test Procedure

6.2.1 Slowly apply air pressure to the Service Chamber port. Measure and record air pressure value at which the pushrod extends to 5 ± 0.5 mm (0.20 ± 0.02 in). This is the Service Chamber Response Pressure. See test apparatus as shown in Figure 3.

6.3 Alternate Test Procedure

6.3.1 Record plot of chamber pressure vs. stroke from fully released to fully applied position. See test apparatus as shown in Figure 3. Pressurize chamber slowly such that the test time is 30 seconds, push rod travel speed should be approximately 152 mm (6”) per minute. Service Chamber Response Pressure shall be the pressure recorded at 5 mm (0.20 in.) stroke.

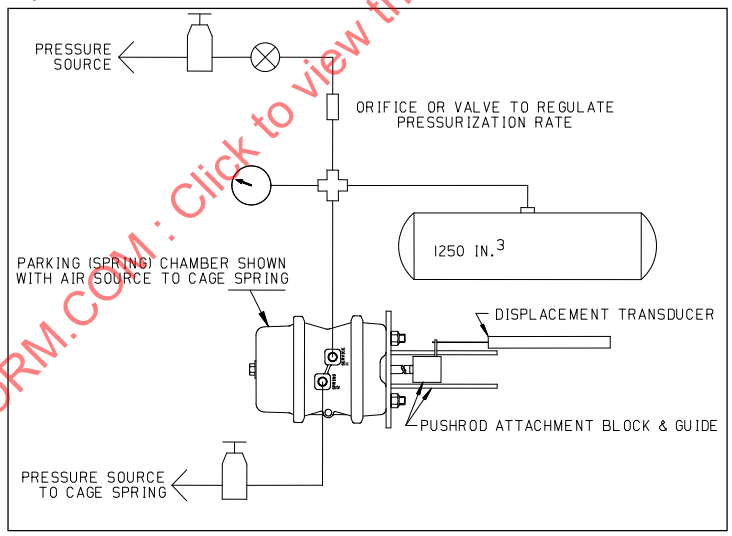


FIGURE 3 - MINIMUM PRESSURE RESPONSE TEST SCHEMATIC

7. FORCE OUTPUT AND STROKE - PARKING AND SERVICE CHAMBERS

7.1 Force Output - Parking Chamber

7.1.1 Conditions

7.1.1.1 27 ± 11 °C (80 ± 20 °F) ambient temperature.

7.1.2 Test Procedure

7.1.2.1 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 (Figure 4). The fixture shall be made to simulate the caliper flange seal boot cavity and contact area profile or a shim may be used for this purpose as shown in Figure 4 (ref. also Figure 6, same shim may be used).

7.1.2.2 Apply preconditioning cycles per 4.1.2.1.

7.1.2.3 Install the test unit and holding fixture in a suitable force versus stroke measuring equipment.

NOTE: 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 degrees ± 1 degree during force output testing (ref. Flat End Rod Adapter Figure 4).

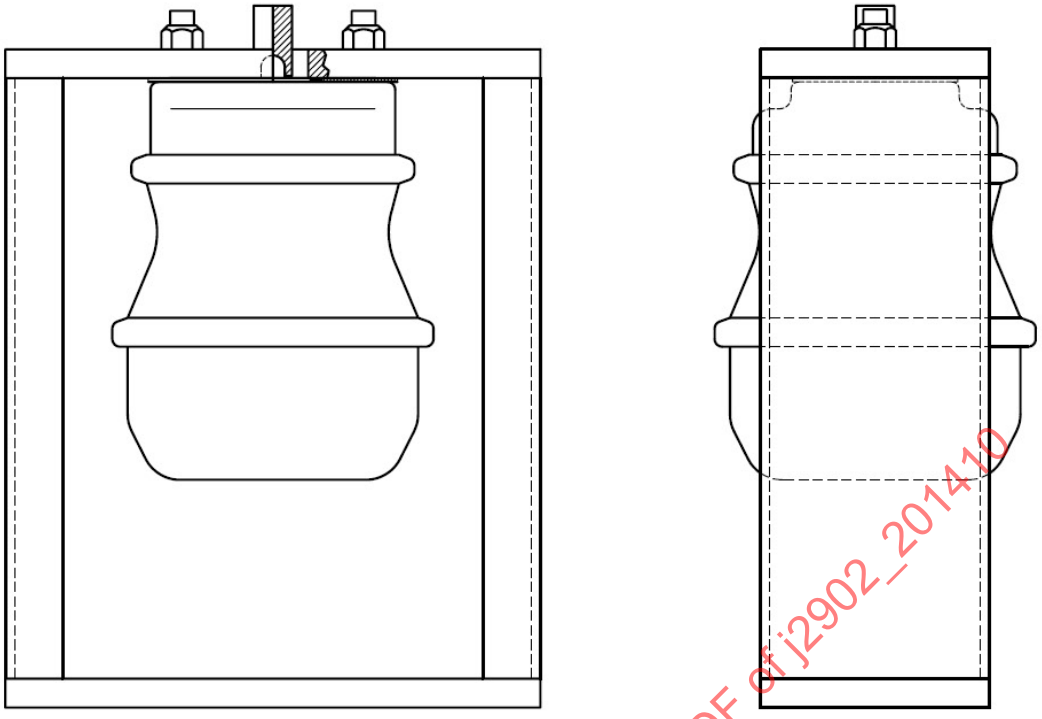
7.1.2.4 Apply 690 kPa to 830 kPa (100 lbf/in^2 to 120 lbf/in^2) (gage) air pressure to the parking chamber to fully compress the power spring (if applicable).

7.1.2.5 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.

7.1.2.6 Apply a 35 N to 45 N (8 lbf to 10 lbf) preload to the end of the test unit's pushrod.

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

7.1.2.8 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 0 mm to 5.0 mm (0 in to 0.20 in) 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.



Recommended Holding Fixture May Be Made From Steel Plate, Channel, Angle, etc. Actuator Mounting Surface Must Be Parallel With Test Machine Load Plate Within 1°.

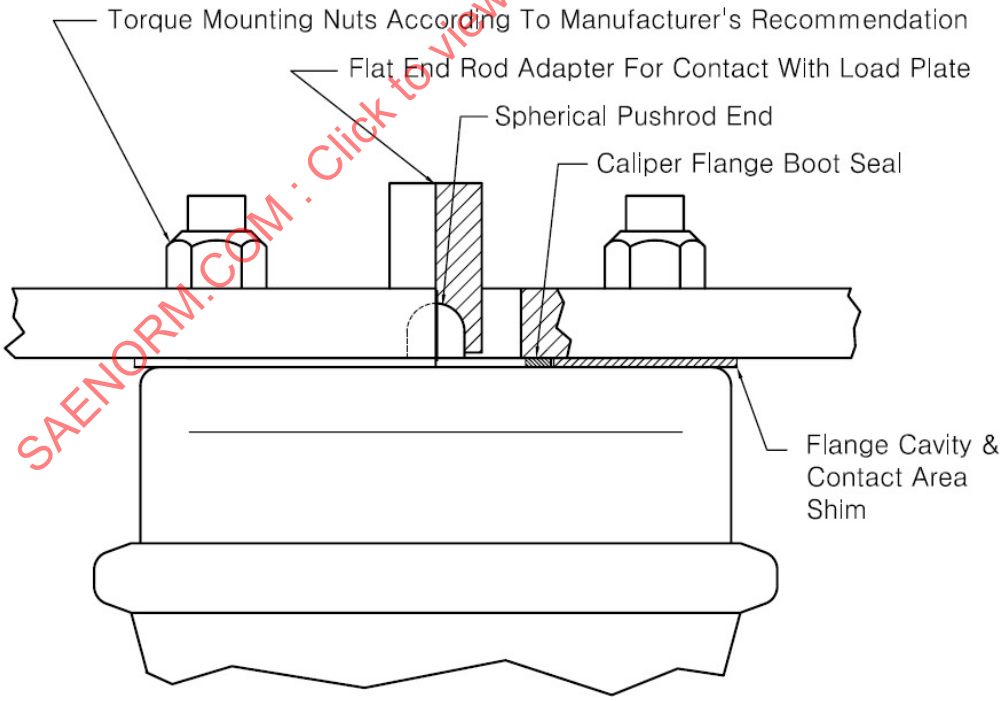


FIGURE 4 - FORCE OUTPUT TEST SCHEMATIC

7.2 Force Output And Stroke - Service Chamber

7.2.1 Conditions

7.2.1.1 27 ± 11 °C (80 ± 20 °F) ambient temperature.

7.2.2 Test Procedure

7.2.2.1 Mount Unit to Test Fixture - Same as procedure specified in 7.1.2.

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

7.2.2.3 Install the test unit and holding fixture in suitable force versus stroke measuring equipment.

NOTE: Test fixturing must provide guiding of the test unit pushrod which will assure a pushrod angularity with the mounting surface of the chamber of 90 degrees ± 1 degree during force output testing.

7.2.2.4 Fully cage the power spring in the parking chamber (if applicable) pneumatically. 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.

7.2.2.5 Apply a 35 N to 45 N (8 lbf to 10 lbf) preload to the end of the test unit's pushrod.

7.2.2.6 If an X-Y recorder is used, “zero” the linear displacement (pushrod travel) on the X-Y recorder after the 35 N to 45 N (8 lbf to 10 lbf) preload has been applied.

7.2.2.7 Apply 896 kPa ± 7 kPa (130 lbf/in^2 ± 1 lbf/in^2) (gage) to the service chamber and record the service chamber force output from zero to full stroke in the brake application direction (stroke extend); use increments of 5.0 mm (0.20 in) or less. If an X-Y recorder is used, plot a force versus stroke curve.

7.2.2.8 Repeat procedures specified in 7.2.2.5 to 7.2.2.7 for 689 kPa, 415 kPa and 140 kPa (100 lbf/in^2, 60 lbf/in^2 and 20 lbf/in^2) (gage) with the same tolerance of ± 14 kPa (± 2 lbf/in^2).

8. LOW TEMPERATURE LEAKAGE - PARKING AND SERVICE CHAMBER

8.1 Leakage, Low Temperature - Parking Chamber

8.1.1 Conditions

8.1.1.1 -40 ± 1 °C (-40 ± 2 °F) for standard low temperature conditions.

8.1.1.2 -54 ± 1 °C (-65 ± 2 °F) for arctic conditions if required for the application.

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

8.1.2 Test Procedure

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

8.1.2.2 Connect the parking chamber to a 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank with a three-way air shut-off valve attached between the air port and air tank to enable operation of the parking chamber. Install a flow meter between the pressure regulator and the parking chamber. Pressurize the air tank 896 kPa ± 14 kPa (130 lbf/in^2 ± 2 lbf/in^2) (gage). Do not pressurize the parking chamber. Parking chamber is to be uncaged.

8.1.2.3 Soak test unit and pressurized air tank at the appropriate low temperature conditions per 8.1.1.1 or 8.1.1.2 for 16 h minimum.

8.1.2.4 After the low temperature soak is completed, pressurize the parking chamber 860 kPa to 896 kPa ± 14 kPa (130 lbf/in^2 ± 2lbf/in^2) (gage) with air from the 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank. If the 896 kPa ± 14

kPa (130 lbf/in^2 ± 2lbf/in^2) (gage)air pressure cannot be maintained, it is permissible to apply room temperature make-up air. U.S. 5 Gallon tank is an acceptable alternative.

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

8.1.2.6 Establish air pressure at 896 kPa ± 7 kPa (130 lbf/in^2 ± 1lbf/in^2) (gage) and close shut-off valve.

8.1.2.7 Measure leakage rate with the flow meter. Record leakage rate.

8.1.3 Alternate Test Procedure

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

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

8.1.3.3 Pressurize the air tank 896 kPa ± 14 kPa (130 lbf/in^2 ± 2lbf/in^2) (gage). Do not pressurize the parking chamber. Parking chamber is to be uncaged. Perform procedures specified in 8.1.2.2 to 8.1.2.6.

8.1.3.4 Record the pressure change after 10 min ± 0.1 min.

8.2 Leakage, Low Temperature - Service Chamber

8.2.1 Conditions

8.2.1.1 -40 ± 1 °C (-40 ± 2 °F) for standard low temperature conditions.

8.2.1.2 -54 ± 1 °C (-65 ± 2 °F) for arctic conditions if required for the application.

8.2.2 Test Procedure

8.2.2.1 Connect the service chamber to a 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank with a three-way air shut-off valve attached between the air port and air tank to enable operation of the service chamber. Install a flow meter between the pressure regulator and the service chamber. U.S. 5 Gallon tank is an acceptable alternative. Pressurize the air tank to 896 kPa ± 14 kPa (130 lbf/in^2 ± 2lbf/in^2) (gage). Do not pressurize the parking chamber.

8.2.2.2 Cage the parking chamber mechanically or pneumatically with 860 kPa to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage) to maintain the power spring in the fully caged position (if applicable).

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

8.2.2.4 Soak test unit and pressurized air tank at the appropriate low temperature conditions per 8.2.1.1 or 8.2.1.2 for 16 h minimum.

8.2.2.5 After the low temperature soak is completed, pressurize the service chamber 896 kPa ± 14 kPa (130 lbf/in^2 ± 2lbf/in^2) (gage) with air from the 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank. U.S. 5 Gallon tank is an acceptable alternative. If the 896 kPa ± 14 kPa (130 lbf/in^2 ± 2lbf/in^2) (gage) air pressure cannot be maintained, it is permissible to apply room temperature make-up air.

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

8.2.2.7 Establish air pressure at 896 kPa ± 7 kPa (130 lbf/in^2 ± 1 lbf/in^2) (gage) and close shut-off valve.

8.2.2.8 Measure leakage rate with the flow meter. Record leakage rate.

8.2.3 Alternate Test Procedure

8.2.3.1 Connect the service chamber to a 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank. U.S. 5 Gallon tank is an acceptable alternative.

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

8.2.3.3 Pressurize the air tank 896 kPa ± 14 kPa (130 lbf/in^2 ± 2lbf/in^2) (gage). Perform procedures specified in 8.2.2.2 to 8.2.2.7.

8.2.3.4 Record the pressure change after 10 min ± 0.1 min.

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

NOTE: This test is optional and shall be performed only if required by the vehicle manufacturer or customer.

9.1 Conditions

9.1.1 -40 ± 1 °C (-40 ± 2 °F) for standard low temperature conditions.

NOTE: If the test is to be performed outside of the cold box, soak at test conditions per 9.1.1. All testing must be completed within 15 min after removal from the cold box.

9.2 Test Procedure

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

9.2.2 Power spring pre-set and precondition cycle per 5.2.1.2. through 5.2.1.4.

9.2.3 Measure and record the service chamber pushrod stroke versus air pressure when actuated by the parking chamber in the apply and release direction per 5.2.1.5.

10. LOW TEMPERATURE FORCE OUTPUT - PARKING CHAMBER

NOTE: This test is optional and shall be performed only if required by the vehicle manufacturer or customer.

10.1 Conditions

10.1.1 -40 ± 1 °C (-40 ± 2 °F) for standard low temperature conditions.

NOTE: If the test is to be performed outside of the cold box, soak at test conditions per 10.1.1. All testing must be completed within 15 min after removal from the cold box.

10.2 Test Procedure

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

10.2.2 Measure and record force output per 7.1.

11. LOW TEMPERATURE OPERATIONAL TESTS - SERVICE CHAMBER

11.1 Low Temperature Service Return Test - Service Chamber

11.1.2 Conditions

11.1.2.1 -40 ± 1 °C (-40 ± 2 °F) for standard low temperature conditions.

11.1.3 Test Procedure

11.1.3.1 Establish zero stroke position of the pushrod relative to a reference surface. Mark the pushrod for stroke measurement required in 11.1.3.9.

11.1.3.2 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 degree.

11.1.3.3 Connect the service chamber to a 20 485 cm^3 ± 820 cm^3 (1250 in^3 ± 50 in^3) air tank with a three-way air shut-off valve attached between the air port and air tank to enable operation of the service chamber. U.S. 5 Gallon tank is an acceptable alternative.

11.1.3.4 With the shut-off valve closed, pressurize the air tank 860 kPa to 896 kPa (125 lbf/in^2 to 130 lbf/in^2) (gage) air pressure.

11.1.3.5 Soak test unit and pressurized air tank at the appropriate low temperature conditions per 11.1.2.1 for 16 h minimum as follows:

NOTE: Combination Actuator - Parking chamber applied (extend power spring) to allow pushrod to stroke per 11.1.3.2

NOTE: Service brake actuator (service chamber) zero pushrod stroke.

11.1.3.6 After the soak period, pneumatically cage the combination actuator parking chamber power spring. (Room temperature air permissible, air from cold air tank per 11.1.3.3 shall be reserved for use with service chamber).

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

11.1.3.8 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 620 kPa ± 35 kPa (90 lbf/in^2 ± 5 lbf/in^2) (gage).

11.1.3.9 On the third release stroke, measure and record the time required for the pushrod to retract to within 0 mm to 6.4 mm (0.25 in) of its original position after the air pressure is released to 0 kPa (0 lbf/in^2) (gage).

11.2 Low Temperature Minimum Response Pressure - Service Chamber

11.2.2 Conditions

11.2.2.1 -40 ± 1 °C (-40 ± 2 °F) for standard low temperature conditions.

11.2.3 Test Procedure

11.2.3.1 Soak the test unit and air tank per 11.1.3.3 at test conditions per 11.2.2.1 for 16 h minimum as follows:

NOTE: Combination Actuator - Parking chamber applied (extend power spring) to allow pushrod to stroke per 11.1.3.2

NOTE: Service brake actuator (service chamber) zero pushrod stroke.

11.2.3.2 After the soak period, pneumatically cage the combination actuator parking chamber power spring. (Room temperature air permissible, air from cold air tank per 11.1.3.3 shall be reserved for use with service chamber). Allow the service chamber to return to 0 stroke position.

11.2.3.3 Test Procedure

11.2.3.4 Open shut-off valve between air tank and air port and slowly pressurize the service chamber. Measure and record air pressure value at which the pushrod extends to 5 mm ± 0.5 mm (0.20 in ± 0.02 in). This is the Chamber Response Pressure.

11.2.4 Alternate Test Procedure

11.2.4.1 Record plot of chamber pressure vs. stroke from fully released to fully applied position. Pressurize chamber slowly such that the test time is 30 seconds, push rod travel speed should be approximately 152 mm (6”) per minute.

12. CHAMBER VOLUME - SERVICE CHAMBER

12.1 Conditions

12.2 27 ± 11 °C (80 ± 20 °F) ambient temperature.

12.3 Test Procedure

12.4 Fully cage the power spring pneumatically (if applicable). The power spring shall remain caged for this entire procedure.

12.5 Obtain zero stroke position..

12.6 Service chamber volume may be measured at rated, full, or other specified stroke position. A stroke limiting device may be used to restrain the pushrod to any required test stroke. The distance traveled by the pushrod end from the zero stroke position to the test stroke position shall be recorded as the actuator test stroke. Test stroke shall be reported with the volume measurement.

12.7 Connect the service chamber air port to the test apparatus as shown in Figure 5 with the inlet port in the highest position.

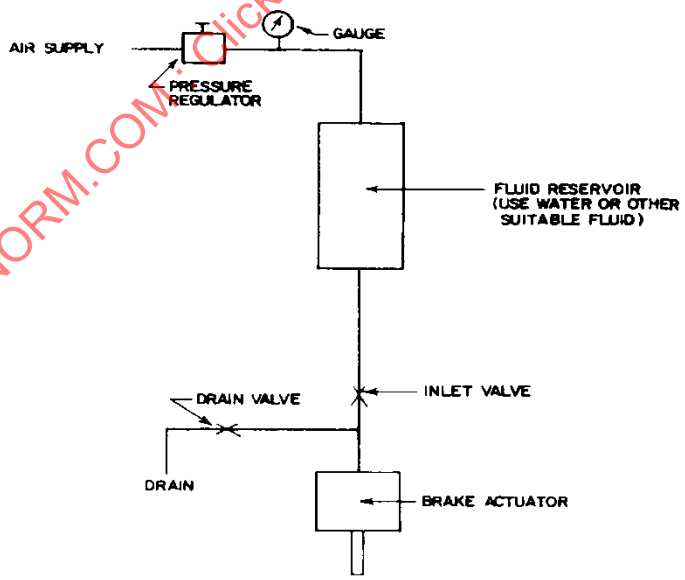


FIGURE 5 - VOLUME TEST SCHEMATIC

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

12.7.2 Close the drain valve, open the inlet valve, and pressurize the fluid reservoir to 690 kPa ± 35 kPa (100 lbf/in^2 ± 5 lbf/in^2) (gage). Allow the actuator pushrod to move to its test stroke position. After 30 seconds with 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. This is the swept volume or active volume.

12.7.3 Close the drain valve and carefully disconnect the actuator from the test apparatus holding the actuator service chamber inlet up. Drain and measure the fluid remaining in the service chamber. This is the dead volume.

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

12.7.4 The volume of the service chamber for the given test stroke shall consist of the sum of the swept volume and dead volume as measured in 12.7.2 and 12.7.3 respectively.

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

13.1 Corrosion Resistance - Parking Chamber Only

13.1.1 Conditions

13.1.1.1 The test unit shall be exposed for 240 h to a continuous salt spray test per ASTM B 117.

13.1.2 Test Procedure

13.1.2.1 Limit the pushrod stroke to 75% ± 5% of rated stroke.

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

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

a. Parking chamber leakage per 4.1

b. Parking chamber force output and stroke per 7.1

13.2 Corrosion Resistance - Service Chamber Only

13.2.1 Conditions

13.2.1.1 The test unit shall be exposed for 240 h to a continuous salt test per ASTM B 117.

13.2.1.2 Test Procedure

13.2.1.3 Limit the pushrod stroke to 75% ± 5% of rated stroke.

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

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

a. Service chamber leakage per 4.2

b. Service chamber force output and stroke per 7.2

c. Leakage - Disc Brake Caliper Flange Seal / Pushrod Boot Seal per 4.3

13.3 Corrosion Resistance - Combination Actuator

13.3.1 Conditions

13.3.1.1 The test unit shall be exposed for 240 h to a continuous salt spray test per ASTM B 117.

13.3.2 Test Procedure

13.3.2.1 Limit the pushrod 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. The cycle sequence shall be repeated at a minimum rate of 6 times/h.

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

a. Parking chamber leakage per 4.1 and force output per 7.1

b. Service chamber leakage per 4.2 and force output per 7.2

c. Leakage - Disc Brake Caliper Flange Seal / Pushrod Boot Seal per 4.3

14. MECHANICAL BACK-OFF RELEASE MECHANISM

14.1 Exceptions

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

14.2 Conditions

14.2.1 27 ± 11 °C (80 ± 20 °F) ambient temperature.

14.2.2 Limit the pushrod stroke to 75% ± 5% of rated stroke.

14.3 Test Procedure

14.3.1 Establish zero stroke position of the pushrod relative to a reference surface. Mark the pushrod for stroke measurement required in 14.3.2.

14.3.2 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 0 to 6.4 mm (0 in 0.25 in) of full release two times. Record the maximum running torque for each application. Cooling time from 0 to 15 minutes is allowed between sequential test cycles.

15. ELEVATED TEMPERATURE CYCLE TEST - PARKING AND SERVICE

15.1 Cycle Test, elevated Temperature - Parking Chamber

15.1.1 Conditions

15.1.1.1 70 ± 3 °C (158 ± 5 °F).

15.1.2 Test Equipment

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

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

15.1.2.3 Pneumatic circuit to cycle test unit in environmental chamber.

15.1.3 Test Procedure

15.1.3.1 Connect parking brake air port to the pneumatic circuit.

15.1.3.2 Soak test unit for 2 h at 70 ± 3 °C (158 ± 5 °F).

15.1.3.3 Pneumatically cycle the parking chamber from the fully released to 75% ± 5% of its rated stroke (75% ± 5% stroke to zero stroke and back to 75% ± 5% stroke position) while maintaining 70 ± 3 °C (158 ± 5 °F) by applying 0 kPa to 690 kPa ± 35 kPa (0 lbf/in^2 to 100 lbf/in^2 ± 5 lbf/in^2) (gage) air pressure at a rate of 6 cycles/min minimum for 22 h.

15.1.3.4 Repeat procedure specified in 15.1.3.3 four times to accumulate a total of 96 h and a minimum of 30 000 cycles. A cool down period between cycle sets is optional.

15.1.3.5 When both chambers in a combination actuator are tested, the parking chamber and service chamber shall be cycled together such that the complete procedures for both chambers are completed within the same total 96 h exposure period (ref. 15.1.3.4 and 15.2.2.5). Cycling of the parking and service chambers may be performed in two ways as best suits equipment available in the test lab:

a. Cycles may be interspersed and combined throughout the entire period with both chambers cycling at a rate of 6 cycles/min alternating.

b. Cycle periods for both chambers may be separated and sequential at a rate of 12 cycles/min.

15.1.3.6 After cycling, leak test the parking chamber and service chamber as applicable per 4.1 or 4.2.

15.2 Cycle Test, Elevated Temperature - Service Chamber

15.2.1 Conditions

15.2.1.1 Same as those set forth in 15.1.1 except when testing the service chamber only in a combination actuator the test unit's spring chamber is to be caged pneumatically or mechanically during testing.

15.2.2 Test Equipment

15.2.2.1 Same as specified in 15.1.2.1 through 15.1.2.3 Test Procedure

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

15.2.2.3 Soak test unit for 2 h at 70 ± 3 °C (158 ± 5 °F).

15.2.2.4 Pneumatically cycle the service chamber from the zero stroke to 75% ± 5% of its rated stroke (75% ± 5% stroke to zero stroke and back to 75% ± 5% stroke position) while maintaining 70 ± 3 °C (158 ± 5 °F) by applying 0 kPa to 690 kPa ± 35 kPa (0 lbf/in^2 to 100 lbf/in^2 ± 5 lbf/in^2) (gage) air pressure at a rate of 6 cycles/min minimum for 22 h.

15.2.2.5 Repeat procedure specified in 15.2.2.4 four times to accumulate a total of 96 h and a minimum of 30 000 cycles. A cool down period between cycle sets is optional.

15.2.2.6 After cycling, leak test the service chamber per 4.2.

16. CYCLE TEST - PARKING AND SERVICE CHAMBER

16.1 Cycle Test - Parking chamber

16.1.1 Conditions

16.1.1.1 27 ± 11 °C (80 ± 20 °F) ambient temperature.

16.1.1.2 Limit the pushrod stroke to 75% ± 5% of rated stroke.

16.1.2 Test Procedure

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

16.1.2.2 Preset power spring per 5.2.1.

16.1.2.3 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 kPa to 690 kPa (0 lbf/in^2 to 100 lbf/in^2) (gage) at a rate of 20 cycles/min ± 10 cycles/min. 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 105 kPa ± 35 kPa (15 lbf/in^2 ± 5 lbf/in^2) (gage) 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.

16.1.2.4 Pressure must dwell at 0 kPa to 14 kPa (0 lbf/in^2 to 2 lbf/in^2) (gage) and 690 kPa ± 35 kPa (100 lbf/in^2 ± 5 lbf/in^2) (gage) for a minimum of 0.1 s.

16.1.2.5 Test unit for 200 000 cycles minimum.

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

a. Parking chamber leakage per 4.1

b. Parking chamber force output per 7.1

c. Maximum release and hold-off per Section 5

d. Disassemble and inspect for damage if testing parking chamber only