RATIONALE

This standard is being revised because the state of the art for vacuum boosters has changed significantly since it was last published.

1. SCOPE

This document applies to direct acting vacuum power assist brake boosters only, exclusive of the master cylinder or other brake system prime mover devices for passenger cars and light trucks [4500 kg GVW (10 000 lb)]. It specifies the test procedure to determine minimum performance and durability characteristics.

1.1 Purpose

This document specifies standards for direct acting vacuum power assist brake boosters of current established designs. It is applicable to assemblies from commercial production, after production shipment, and remanufacture.

2. REFERENCES

2.1 Applicable Publication

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

JASO Standards C452:2005 "Automotive parts – Vacuum servo unit"

2.1.1 SAE Publication

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

3. DEFINITIONS

In order to establish and maintain a continuity of discussion throughout this document, the following definition of terms will be used.

NOTE: Figure 1 for illustration of terms as applied to a typical input-output force curve.

3.1 RELEASED

The unapplied, fully returned state with no force on the input push rod (with or without vacuum).

3.2   POISE

The condition of placing the control valve in a steady state of force equilibrium so that the vacuum power assist brake booster is neither fully applied, nor fully released.

3.3   CUT-IN

The input force required to actuate the valving and produce an output force.

3.4   POWER SLOPE

The ratio of change in output force to change in input force in the area of performance above the initial rise and below the vacuum run-out point.
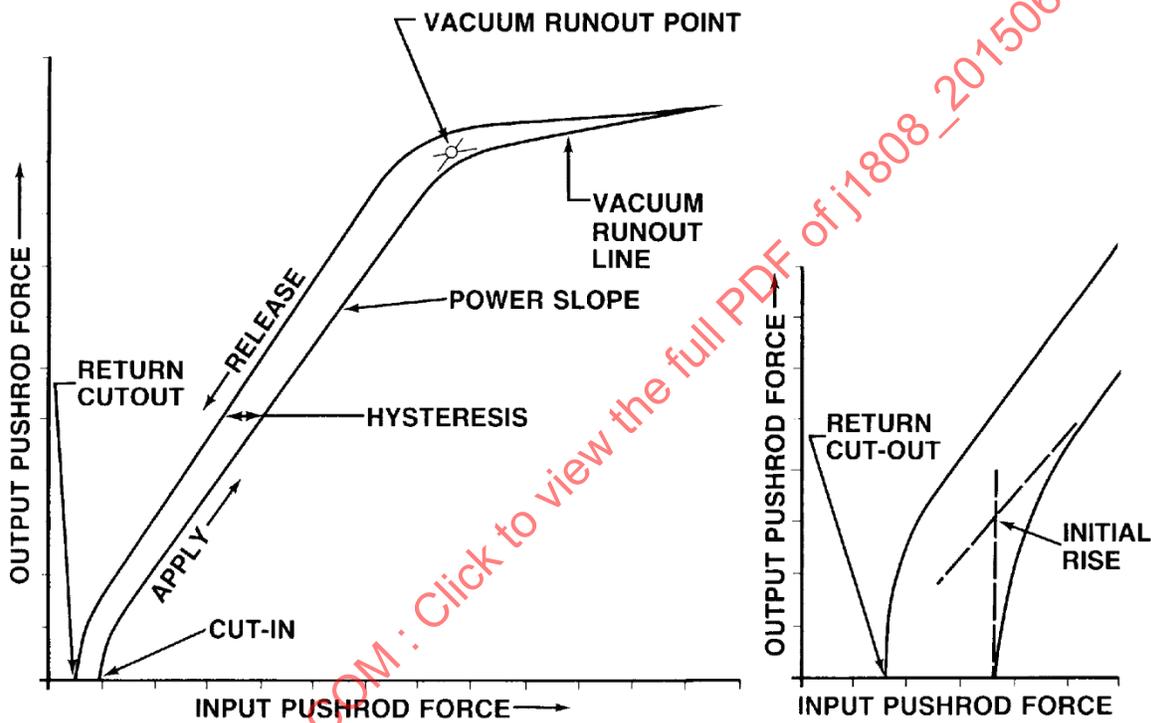

Figure 1 - Typical input-output (X-Y) curve

3.5 POWER BOOST

The output force minus the input force for a given vacuum level and with the maximum available pressure differential across the power piston(s), and at 80% of the usable output stroke of the booster.

3.6 VACUUM RUN-OUT LINE

The line defined by two or more points on the input-output curve beyond the input force at which all available pressure differential exists across the power piston(s).

3.7 VACUUM RUN-OUT POINT

The point defined by the intersection of the power slope line and the vacuum run-out line.

3.8 INITIAL RISE

The intersection of a vertical line through the cut-in point and the power slope line.

3.9 HYSTERESIS

The difference between apply and release input forces at a given output force during the power slope.
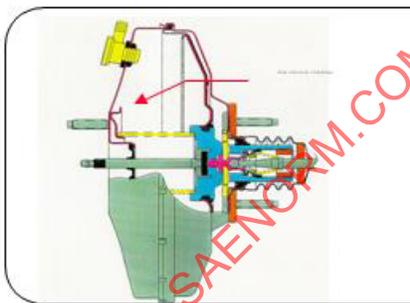
3.10 RETURN CUT-OUT

The input force at which the output force drops to zero or some specified level during release.

3.11 BOOSTER SIZE

Described by the maximum outside diameter, power boost at –80 kPa (23.62 in Hg) vacuum, and at 80% of the usable output stroke, and whether single or tandem.

Single

Tandem
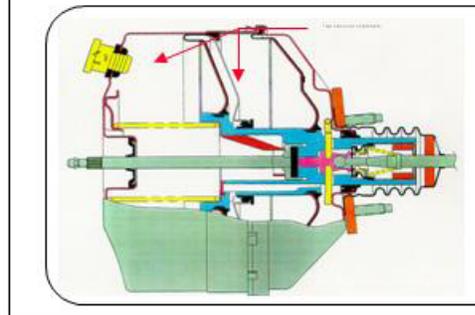
4. TEST APPARATUS

The basic apparatus shall be that shown and as arranged in Figure 2 or equivalent. The apparatus shall operate per Section 4 and as called for in Section 6. It is desirable to have the test apparatus portable to facilitate cold, hot, and room temperature testing.

4.1 Force Absorbing Mechanism

The force absorbing mechanism shall be connected to the vacuum power assist brake booster front housing. This mechanism shall be capable of absorbing a minimum of 150% of booster vacuum run-out point output force, or 9000 N (2000 lb) output force, whichever is greater.

4.1.1   Recommended Output Force and Stroke Relationship

It is recommended that the force absorbing mechanism be capable of restricting the output force and stroke relationship to the shaded are of Figure 3.

4.1.2   Optional Output Force and Stroke Relationship

It is recommended that the force absorbing mechanism is not a rigid fixture, however optionally a rigid fixture which limits output rod stroke to 50% ± 20% of its full travel may be used. Use of a rigid force absorbing fixture will produce lower frictional losses and lower hysteresis values.

4.2   Stroking Mechanism

The stroking mechanism shall contain a mounting plate to which the booster is attached in a manner similar to how it would be mounted in the vehicle. The mounting plate must be sufficiently rigid such that its deflection does not contribute to the input pushrod travel measurements. The actuator shall be compatible with the input push rod(s) of the booster and shall operate coaxially within 3 deg of the longitudinal axis of the booster. The fixture shall be constructed such that full release of the booster is obtained. The stroking mechanism may accommodate multiple boosters if desired, and shall be designed so that it does not apply tensile force to input push rod. Means must be provided for the stroking mechanism to stroke the booster both singly and cyclically.

4.2.1   For single stroke operation, the mechanism shall be capable of generating input push rod forces up to 4500 N (1000 lb) at its maximum travel and holding this position.

4.2.2   For cyclic operation, the stroking mechanism shall be capable of applying the input push rod to generate 80% ± 10 of the vacuum run-out point output force at a rate that can be adjusted from 250 to 1000 apply/release cycles per hour. The input push rod shall be stroked forward at a smooth rate and allowed to return rapidly to its fully released position. The time cycle shall be adjusted to allow maximum time for forward stroking while insuring that the input push rod returns to the fully released position before the start of the next forward stroke.

4.2.3   In 6.11 structural test, utilize a suitable compression test apparatus for performing structural test.

4.3   Instrumentation

4.3.1   A 4 channel data acquisition and recording system compatible with 4.3.2 and 4.3.3. This system must be capable of providing output in standard digital format such as CSV ASCII. If not the system must be able to produce plots of each of the 4 channels vs time base and also any two of the channels against each other.

4.3.2   Force transducers or equivalent measuring devices to measure input and output push rod forces of 0 to 4500 N (0 to 1000 lb) and 0 to 9000 N (0 to 2000 lb) respectively. Overall accuracy ±1/2% of full scale.

4.3.3   Linear transducers or equivalent measuring devices must be provided to measure:

4.3.3.1   Input push rod travel of 0 to 50 mm (0 to 2 in).

4.3.3.2   Output push rod travel of 0 to 50 mm (0 to 2 in).

Overall accuracy of ±1/2% of full scale.

4.3.4   Vacuum gage or equivalent capable of measuring 0 to –100 kPa ±1/2% full scale (0 to 30 in Hg).

4.4   Environmental Equipment

4.4.1   Hot Test Chamber

Shall be provided having sufficient capacity to house test apparatus fixtures. The modulated air source for internal use in the booster shall be at room temperature or at test chamber temperature as specified by the manufacturer. A suitable thermostatically controlled heating system is required to maintain a uniform atmosphere at the desired temperature up to 85 °C ± 3 (185 °F ± 5). Heaters shall be shielded to prevent direct radiation to the booster.

4.4.2   Cold Test Chamber

Shall be provided having sufficient capacity to house test apparatus fixtures. The modulated air source for internal use in the booster shall be at room temperature or at test chamber temperature as specified by the manufacturer. A suitable thermostatically controlled cooling system is required to maintain a uniform atmosphere at the desired temperature down to –40 to –43 °C (–40 to –45 °F).

4.5   Vacuum Source

A vacuum source including all lines and fittings shall be capable of maintaining a set vacuum level of –80 kPa ± 1.7 (23.62 in Hg ± 0.5) during the apply portion of all cyclic tests and as specified for single stroke operation.

5.   TEST SAMPLE

The booster shall come from one of the sources described in Section 1. It shall be new or not used after rebuild, and it shall not be disassembled prior to testing. A single unit should be used for all testing from 6.1 to 6.6.

6.   TEST SETUP AND PROCEDURE

Tests shall be conducted in the sequence shown and at room temperature except where otherwise specified. The booster shall not be disassembled until after all tests are completed or unless testing is discontinued.

6.1   Initial Evaluation

This phase of the test is for the purpose of obtaining a performance profile of the booster without disrupting or otherwise altering its parts or integrity.

6.1.1   Initial Setup

Install the booster on the mounting plate, as shown in Figure 2, and tighten mounting fasteners to the recommended torque. Make certain that the input push rod is properly aligned with the longitudinal axis of the booster within 3 deg. Adjust the apply actuator and/or input push rod to allow the booster to return to a fully released position with zero preload on the input push rod. Attach the force absorbing mechanism to the front housing of the booster and adjust according to Figure 3. Install vacuum line and gage per 6.1.2 from the vacuum port to the vacuum source. Check valve location is optional as it is desirable that it is the same as the actual vehicle system to avoid unexpected restriction effects.
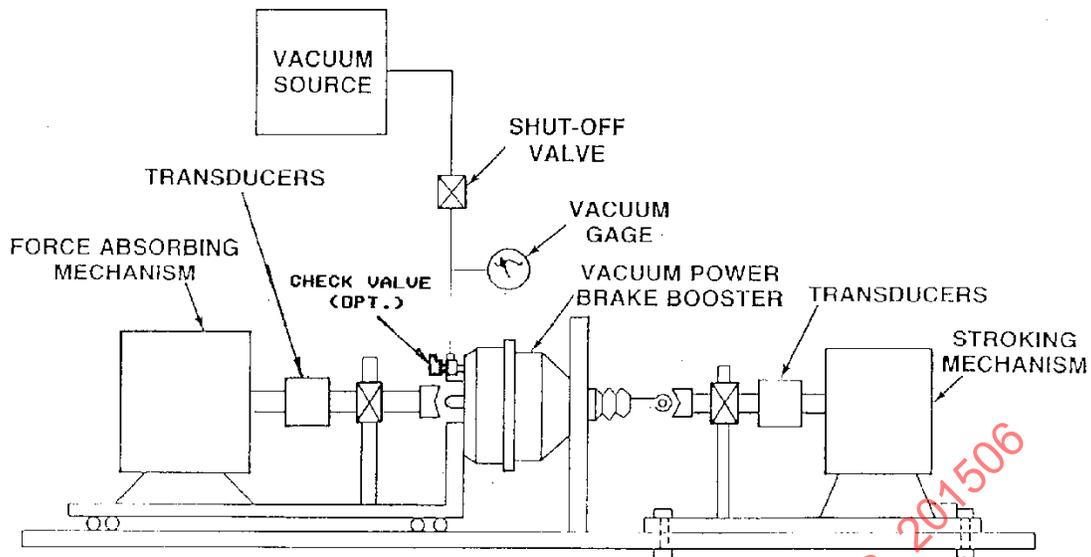
Figure 2 - Schematic of recommended setup

OUTPUT PUSHROD FORCE – PERCENT OF RUNOUT

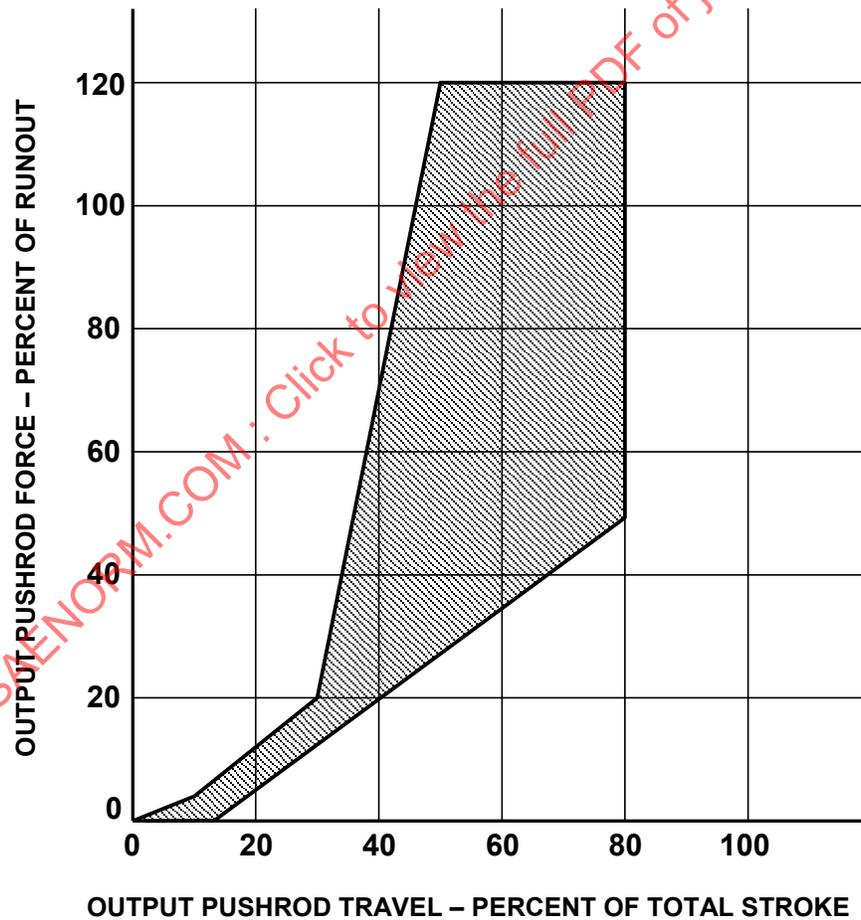OUTPUT PUSHROD TRAVEL – PERCENT OF TOTAL STROKE

Figure 3 - Recommended stroking performance curves for force absorbing mechanism

6.1.2   In cases where the booster is supplied with an integrally mounted check valve at the booster vacuum port or an in-line check valve, the vacuum supply line must be connected between the check valve and the front shell of the booster. This will insure that the vacuum level indicated on the external gage is the actual vacuum level inside the booster shell. In this case, the check valve should be vented to atmosphere.

6.1.3   Data acquisition

Connect the input force, output force, input travel transducers to the data acquisition system.

6.2   Apply-Release

6.2.1   Power

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5). Apply force to the input push rod at a rate of 135 N/s ± 90 (30 lb/s ± 20). After the apply force generates 120 to 150% of the vacuum run-out point output force, release the force to the input push rod at the same rate and allow the booster to return to a fully released condition.

6.2.2   Reserve Apply-Release Capability

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5) and close the vacuum shut-off valve. Apply force to the input push rod at a rate of 135 N/s ± 90 (30 lb/s ± 20) to generate 25 to 30% of the vacuum run-out point output force and 25 to 35% of the usable output stroke (note the input force used). Hold for 15 s, and return and input push rod force to zero. Repeat this apply-release cycle, using the same input force, and record, to the nearest cycle, the number of cycles until power assist is reduced to zero.

6.2.2.1   "No Power" Apply-Release

With vacuum supply disconnected and vacuum port vented to atmosphere, stroke booster until all internal vacuum is depleted. Repeat procedure 6.2.1 using the same input values.

6.3   Vacuum Leak Check

Install vacuum gage at the vacuum port to measure vacuum level in the booster. The volume of the vacuum lines between the booster and the shutoff valve including the vacuum gage, should not exceed 100 cm^3 (6 in^3).

6.3.1   Fully Released

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5), and allow to stabilize for a minimum of 15 s. With zero force on the input push rod, close the vacuum shutoff valve and measure the drop in vacuum level in the unit after 15 s.

6.3.2   Poise

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5). Apply and maintain a steady force to the input push rod to generate 25 to 30% of the vacuum run-out point output force, and allow to stabilize for 15 s minimum. Close the vacuum shutoff valve and measure the drop in vacuum level in the unit after 15 s.

6.3.3   Run-Out

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5). Apply and maintain a steady force to the input push rod to generate 120 to 150% of the vacuum run-out point output force and allow to stabilize for 15 s minimum. Close the vacuum shutoff valve and measure the drop in vacuum level in the booster after 15 s.

6.4   Apply and Release Response

Adjust the output force absorbing mechanism to provide 65 to 75% of the usable output stroke at 125 to 135% of vacuum run-out point output force. Maintain the vacuum level at –80 kPa ± 1.7 (23.62 in Hg ± 0.5).

6.4.1   Apply Response

Apply an input force to generate 150% minimum of vacuum run-out point output force at a rate that 130% minimum of input run-out force is obtained in 0.25 s or less. Maintain the output force above 150% for a minimum of 2 s.

6.4.2   Release Response

Release the input force so that the applying device retracts faster than the input rod.

6.4.3   Record the input and output forces versus time for the respective apply and release tests.

6.5   Usable Output Stroke and Input Travel Loss

6.5.1   Usable Output Stroke

It is the intent of this phase of the test to measure the usable output stroke of the booster. It is the lesser of 6.5.1.1 or 6.5.1.2 results.

6.5.1.1   Power

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5). With linear transducers connected to measure the output push rod travel relative to the front housing mounting surface, remove the force absorbing mechanism and stroke the booster its full usable output stroke with 670 N ± 90 (150 lb ± 20) applied to the input push rod. Record the output stroke of the booster.

CAUTION: If excessive force is applied to obtain full stroke, internal damage to the booster could result.

6.5.1.2   No Power

Vent the vacuum port to atmosphere and stroke the booster a minimum of five times or until all vacuum is exhausted from inside the unit. Repeat the procedure given in 6.2.1.1.

6.6   Input Travel Loss

It is the intent of this phase of the test to measure the input push rod travel loss and, thereby, determine the required input stroke of the booster.

The input travel loss is the greater of either6.6.1 or 6.6.2.

The amount of input push rod stroke required for a given output stroke is the sum of the input travel loss and the given output stroke.

6.6.1   Power

Evacuate the booster to –80 kPa ± 1.7 (23.62 in Hg ± 0.5). Set, block, and record the output push rod at 65 to 75% of the usable output stroke (6.2.1) with a rigid fixture simulating a master cylinder mounted to the front shell of the booster so that the axial motion of the front housing is not restricted.

With a linear transducer connected to measure the input push rod travel relative to the rear housing mounting surface, stroke the booster from 65 to 75% of its usable output stroke with 670 N ± 90 (150 lb ± 20) applied to the input push rod. Record the input stroke of the booster. Input stroke measured minus the set output stroke is the amount of input travel loss.

6.6.2   No Power

Vent the vacuum port to atmosphere and stroke the booster a minimum of five times or until all vacuum is exhausted from inside the unit. Repeat the procedure given in 6.6.1.