



Metered Oil Flow Rate (MOFR) of Valve Stem Seals

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. Measure by collected weight, the oil flow rate (Oil leakage rate (grams/5 h) (Q)). The oil flows through the valve stem seal which flows between the valve and the valve guide, and reaches the bottom of the valve guide due to gravity and differential pressure, after 5 h.

1.2 Applicability. Intake (Int) and exhaust (Exh) valve stem seals. After long term engine lab or field testing, leakage can be remeasured.

1.3 Remarks. A function of valve stem seals is to control the passage of oil (flow) between the reciprocating valve stem, valve guide, and the seal lip. Insufficient lubrication leads to abrasion, abnormal valve noise, and in the worst case, valve burnout. Excessive lubrication leads to excessive oil consumption, possible emissions effects, and a puff of smoke at engine startup. Validation of seal design factors is accomplished by precise measurement of oil leakage using actual engine components.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D573	IEEE/ASTM SI 10	ISO/IEC 17025	SAE J946
ATF 16949	ISO 6194-1	Mobil DTE 26	

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Association of Rubber Products Manufacturers (ARPM) OS6, 7321 Shadeland Station Way, Suite 285, Indianapolis, Indiana 46256, (www.arpm.com)
- Product Drawing Specifications

3 Resources

3.1 Facilities. Test laboratory with temperature and humidity control.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Leakage Rate Apparatus. Ahaus Tool and Engineering, Richmond, Indiana or equivalent. Each unit consists of one (1) to two (2) heads, with four (4) test specimens per head. This apparatus can be adapted for push rod or overhead camshaft applications. A pulley, belt, and electric motor drive the camshaft. The oil system includes collection devices, heater, controller, sump, pump and filter. A vacuum pump/boost pressure pump connected to the combustion chamber within the collection cup aids in oil collection and creates the required differential pressure. The machine controls camshaft speed, oil pressure and temperature, and vacuum/boost

pressure. Gauges measure oil temperature, oil pressure and combustion chamber collection cup pressure (vacuum/boost). Head orientation effects are optional. Production heads are optional.

3.2.2 Balance. Single pan analytical with readability to 0.0001 g and repeatability to 0.1 mg. Pan must have a cover or be enclosed.

3.2.3 Calipers. Incremented to 0.02 mm.

3.2.4 Desiccating Cabinet or Desiccator. Sufficiently sized to prevent contact between weighed specimens.

3.2.5 Optical or Video Comparator. Capable of measuring valve stem and seal dimensions per detail drawing, ISO 6194-1, or SAE J946.

3.2.6 Oven. Air circulating oven conforming to ASTM D573, Type IIA.

3.2.7 Profilometer. Capable of measuring valve stem surface finish per detail drawing.

3.2.8 Dial Gauge. Capable of measuring stem stroke (valve lift), incremented to 0.05 mm.

3.3 Test Vehicle/Test Piece. Test only seals compliant with the drawing requirements.

3.3.1 Test Pieces. Randomly select 16 seals to be tested.

3.3.2 Seal. Measure the lip inner diameter (ID) and the lip contact load (LCL) per Association of Rubber Products Manufacturers (ARPM) OS6, and visually inspect the seal for defects. Record these measurements. Confirm the measurements meet the product drawing specifications.

3.3.3 Valve Stems. Obtain production release intent valves. Measure the outside diameter (OD) and stem finish and confirm they meet the product drawing specifications. Customer supplied valves may be used. For each valve stem, measure the outer diameter (OD) in three places which are equal to 7 mm from each end of the guide and in the center of the guide (valve closed). Average these three OD measurements. Valve to be modified as required to adapt to the test fixture (removal of valve head), but at valve closed position the valve must protrude from the bottom of the guide by 5 mm minimum at full diameter. If testing is to be done as development for a program which production release valves are not available, the following part numbers, see Table 1, can be substituted. If using substitute valves, they should have the same surface treatment and key configuration as the planned production valve. See Table 1.

Table 1: Available Substitute Valve with Part Numbers

Category Diameter	Program	Key	Surface Treatment: Nitrided (Part Number)	Diameter	Surface Treatment: Chrome Plated (Part Number)	Diameter
5	SGE	Triple	12636317	4.965 Int	12636318	4.955 Exh
6	L850	Triple	12622329	5.9625 Int	12615936	5.9425 Exh
6	LGE	Single	12662527	5.965 Int	12627156	5.955 Exh
8	Gen 5 L to 5.3 L	Single	12619825	7.966 Int	12678745	7.966 Exh

Key: Intake (Int), Exhaust (Exh).

3.3.4 Guides. Obtain production release intent valve guides. Measure the outside diameter and confirm it meets the product drawing specifications. Customer supplied guides may be used. Guide inner diameter (ID) size to be machined by valve seal supplier prior to test. Using the average valve stem OD obtained in 3.3.3, add 0.050 mm to this average and finish, machine the ID of the guide to this value ± 0.005 mm. Surface finish of the guide ID should meet Ra1, and concentricity of the machined ID should be 0.1 mm maximum to the OD of the guide. Specific valves and mating guides are to be maintained as a pair for all testing, to ensure valve to guide clearance is tested at $0.050 \text{ mm} \pm 0.005 \text{ mm}$.

3.3.5 Springs. Obtain production release intent springs. Confirm they meet the drawing specifications. Customer supplied springs may be used.

3.3.6 Head. At the requester's option, the intended production part is modified to permit oil collection from each valve. However, valve stem to guide clearance MUST be established as $0.050 \text{ mm} \pm 0.005 \text{ mm}$.

3.3.7 Fixture Build. Using the modified valves from 3.3.3 and the machined guides from 3.3.4 as matched sets, build the fixture using supplied springs from 3.3.5 and supplied valve keys, valve spring retainer, and cylinder head or leak rate apparatus fixture table. Using the test oil (Mobil DTE 26) lubricate the valve stem to valve guide interface and valve stem seal during build. Install these pre-lubricated items in the test unit. Complete the build using supplier camshaft and supplier rocker arms, which should be designed and established to deliver between 9.5 mm and 10.5 mm of valve lift (stem stroke).

3.3.8 Measure Stem Stroke. Using a dial gauge measure valve lift (stem stroke) within ± 0.05 mm. Measure at all valve locations in the test fixture (all locations to be within 0.1 mm of each other). Using the measured stem strokes, take an average of all locations and record this value as "Average Stem Stroke".

3.3.9 Test the Revolutions per Minute (rpm). Calculate test rpm based on the value of "Average Stem Stroke" from 3.3.8. To determine the test rpm divide 15 000 by "Average Stem Stroke" For example, if the value for "Average Stem Stroke" from 3.3.8 is 9.764, then test rpm would be $15\,000/9.764 = 1536$ rpm. This calculation is the methodology used to normalize "Total Swept Distance" of the valve stem. As shown in Table 2, using this methodology will keep variation of "Total Swept Distance" from test to test, stem stroke to stem stroke, and supplier to supplier to within 1.4% variation. Where mean "Total Swept Distance" is equal to 4 500 00 mm $\pm 1.4\%$.

Table 2: Calculation Methodology Examples

	Example 9.5 mm Stem Stroke			Example 10 mm Stem Stroke			Example 10.5 mm Stem Stroke		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Cam Speed (rpm)	1569	1579	1589	1490	1500	1510	1419	1429	1439
Stem Stroke (mm)	9.5	9.5	9.5	10	10	10	10.5	10.5	10.5
Time (minute)	298	300	302	298	300	302	298	300	302
Number of Strokes	467 546	473 684	479 862	444 020	450 000	456 020	422 734	428 571	434 449
Total Swept Length (mm)	4 441 690	4 500 000	4 558 690	4 440 200	4 500 000	4 560 200	4 438 710	4 500 000	4 561 710
Min Swept Length	4 438 710								
Nominal Swept Length	4 500 000								
Max Swept Length	4 561 710								
Percent Error at Min	1.36%								
Percent Error at Max	1.37%								

Key: Minimum (Min), Maximum (Max).