



SURFACE VEHICLE STANDARD

J746™

NOV2024

Issued 1955-12
Reaffirmed 1996-09
Revised 2024-11

Superseding J746 NOV2019

Hydraulic Motor Test Procedures

RATIONALE

Removed imperial unit equivalents from all sections. Updated ISO 4406 cleanliness code in 3.8 to 19/17/14.

1. SCOPE

This test code describes tests for determining characteristics of hydraulic positive displacement motors as used on off-road self-propelled work machines as referenced in SAE J1116.

1.1 Purpose

This test code establishes conditions for motor tests, outlines a procedure for tests, and establishes a method of presenting motor test data.

The procedure covers the following determinations:

- a. SAE volumetric rating
- b. SAE running torque characteristics
- c. SAE stall torque characteristics
- d. Power output
- e. Power loss
- f. SAE power and torque efficiency
- g. Overall efficiency
- h. Required delivery

SAE Executive Standards Committee Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2024 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, or used for text and data mining, AI training, or similar technologies, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: <http://www.sae.org>

For more information on this standard, visit
https://www.sae.org/standards/content/J746_202411/

2. REFERENCES

2.1 Applicable Documents

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

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.

SAE J1116 Categories of Off-Road Self-Propelled Work Machines

2.1.2 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 4406 Hydraulic Fluid Power - Fluids - Method for Coding the Level of Contamination by Solid Particles

3. MATERIAL AND APPARATUS

3.1 Test Fluid

Test fluid shall preferably be a mineral base oil designed for hydraulic service. Fluid viscosity shall be within the limits of 95 to 115 SUS at 49 °C and 50 to 54 SUS at 82 °C.

3.2 Motor Torque and Speed Measuring Apparatus

Torque measurement shall be accurate within $\pm 1\%$ and speed measurement shall be accurate within $\pm 0.5\%$. The test setup shall not impose radial or axial loads upon the driveshaft of the hydraulic motor under test.

3.3 Flow Measurement

Flow measurement shall be accurate within $\pm 2.0\%$.

3.4 Pressure Measurement

Pressure measurement shall be accurate within $\pm 2.0\%$.

3.5 Temperature Measurement and Control

Fluid temperature shall be measured in the motor outlet line by means of a thermometer or thermocouple. Fluid temperature shall be maintained at the prescribed level throughout the test within ± 3 °C.

3.6 Drain Line

Total pressure drop in drain line, if required, shall be as low as possible.

3.7 Motor Outlet Line

Total pressure drop in outlet line shall be as low as possible.

3.8 System Cleanliness

Test system shall have a contamination level not to exceed ISO 4406 Code 19/17/14.

4. GENERAL DEFINITIONS AND TEST CONDITIONS

4.1 Temperature

Shall be expressed in degrees Celsius (°C).

4.2 Pressure

Shall be expressed in kilopascal gauge (kPag).

4.3 SAE Volumetric Rating

The SAE volumetric rating of a hydraulic motor shall be defined as delivery to the motor in liters per minute (L/min) at a speed of 1000 rpm and zero torque on the shaft at a fluid temperature of 49 °C.

4.4 SAE Stall Pressure

Shall be defined as the differential pressure required to maintain a specified motor torque at 1 rpm.

4.5 Delivery (Input Flow)

Shall be defined as the measured flow rate to the motor. It equals the sum of exhaust flow plus drain line flow. It shall be expressed in liters per minute (L/min).

4.6 Required Delivery

Shall be defined as the amount of delivery (input flow) required to maintain a given rpm at a constant known torque.

4.7 Pressure Drop (Δp)

Shall be defined as the pressure differential across motor ports in kilopascal gauge (kPag).

5. WORKING FORMULAS

5.1 SAE Theoretical Torque

$$= \frac{\text{SAE volumetric rating (L/min)} \times \Delta \text{ pressure (kPag)}}{6283} = \text{N}\cdot\text{m} \quad (\text{Eq. 1})$$

5.2 SAE Theoretical Delivery (Flow)

$$= \frac{\text{SAE volumetric rating (L/min)} \times \text{rpm}}{1000} = \text{L/min} \quad (\text{Eq. 2})$$

5.3 SAE Theoretical Hydraulic Power

$$= \frac{\text{SAE theoretical delivery (L/min)} \times \Delta \text{ pressure (kPag)}}{60} = \text{watts (W)} \quad (\text{Eq. 3})$$

5.4 Hydraulic Power

$$= \frac{\text{Delivery (L/min)} \times \Delta \text{ pressure (kPag)}}{60} = \text{watts (W)} \quad (\text{Eq. 4})$$

5.5 Power Output

$$= \frac{\text{Output Torque (N}\cdot\text{m)} \times \text{rpm}}{9.45} = \text{watts (W)} \quad (\text{Eq. 5})$$

5.6 Power Loss

$$= \text{Hydraulic power (W)} - \text{Power output (W)} = \text{watts (W)} \quad (\text{Eq. 6})$$

5.7 Overall Efficiency

$$= \frac{\text{Power output}}{\text{Hydraulic power}} \times 100 = \text{percent (\%)} \quad (\text{Eq. 7})$$

5.8 SAE Power and Torque Efficiency

$$= \frac{\text{Power output}}{\text{SAE theoretical hydraulic power}} \times 100 = \text{percent (\%)} \quad (\text{Eq. 8})$$

$$= \frac{\text{Output torque}}{\text{SAE theoretical torque}} \times 100 = \text{percent (\%)} \quad (\text{Eq. 9})$$

6. TEST PROCEDURES

6.1 Test 1

- Set up the motor as in Figure A2, except uncoupled from load.
- Operate the motor from minimum to maximum speed in suitable increments, one speed being 1000 rpm. If 1000 rpm is too fast, operate at 100 rpm and then convert to 1000 rpm to use the SAE equations. Record inlet and outlet pressure, delivery, rpm, and drain line pressure (if attached).
- Couple the motor to the load and repeat Test 1, step b., at maximum rated torque and at least one intermediate torque. Record inlet and outlet pressure, torque, delivery, rpm, and drain line pressure (if attached).

6.2 Test 2

- Set up the motor as recommended in Figure A3.
- Operate the motor at 1 rpm. Record the inlet and outlet pressure required to maintain the same torques as in Test 1, step c.
- Use the recoded pressures to determine the SAE stall pressures.

7. PRESENTATION OF RESULTS

7.1 Graph of Results

- Use the recorded information and Equations 4 through 7 to create the graphs shown in Figure A1.
- Two sets of data sheets are to be submitted: one at 49 °C and one at 82 °C.

8. NOTES

8.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.