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SAE J745 MAR86

Hydraulic Power Pump Test Procedure

SAE Recommended Practice
Reaffirmed March 1986

Submitted for Recognition as an American National Standard

This standard is indexed in the Standards Search Database

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RATIONALE:

This SAE Recommended Practice is currently under revision by Subcommittee 4, Hydraulic Fluid Power Systems and Components of the Off-Road Machinery Technical Committee.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

SAE J916, Rules for SAE Use of SI (Metric) Units

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

APPLICATION:

This test code describes tests for determining characteristics of hydraulic positive displacement pumps as used on construction and industrial machinery as referenced in SAE J1116. In this code, metric equivalents are established according to SAE J916. These characteristics are to be recorded on data sheets similar to the ones shown herein. Two sets of data sheets are to be submitted: one at 120°F (49°C) and one at 180°F (82°C).

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

The procedure covers the following determinations:

1. SAE volumetric rating.
2. Power input.
3. Delivery characteristics.
4. Power loss.
5. Overall efficiency.

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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

OFF-HIGHWAY MACHINERY PRACTICE

Submitted for recognition as an American National Standard

SAE J745

Issued January 1955
Reaffirmed March 1986

Reaffirms J745 OCT80

HYDRAULIC POWER PUMP TEST PROCEDURE

CONSTANT AND VARIABLE POSITIVE DISPLACEMENT HYDRAULIC PUMPS

1. SCOPE: This test code describes tests for determining characteristics of hydraulic positive displacement pumps as used on construction and industrial machinery as referenced in SAE J1116. In this code, metric equivalents are established according to SAE J916. These characteristics are to be recorded on data sheets similar to the ones shown herein. Two sets of data sheets are to be submitted: one at 120°F (49°C) and one at 180°F (82°C).

2. PURPOSE: This test code establishes conditions for pump tests, outlines a procedure for tests, and establishes a method of presenting pump test data.

   The procedure covers the following determinations:

   1. SAE volumetric rating.
   2. Power input.
   3. Delivery characteristics.
   4. Power loss.
   5. Overall efficiency.

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 95-115 SUS at 120°F (49°C) and 50-54 SUS at 180°F (82°C).

3.2 Pump Torque and Speed Measuring Apparatus: Torque measurement must be accurate within ±1% and speed measurement must be accurate within ±0.5%. The test setup shall not impose radial or axial loads upon the drive shaft of the hydraulic pump under test.

3.3 Flow Measurement: Flow measurement shall be accurate within ±2.0%.

3.4 Pressure Measurement: Pressure measurement shall be accurate within ±2.0%.

3.5 Temperature Measurement and Control: Fluid temperature shall be measured in the reservoir at the entrance to the pump supply line by means of a thermometer or thermocouple. Fluid temperatures shall be maintained at the prescribed level throughout the test within 5°F (2.8°C).

3.6 Pump Inlet Line: Total pressure drop from the reservoir to the pump inlet shall not exceed 5 in (127 mm) Hg. Unless otherwise requested, the pump inlet pressure at the inlet fitting shall be maintained within 1 in (25.4 mm) Hg of atmospheric pressure by control of the reservoir fluid level and/or reservoir pressure. A shutoff valve shall be installed at least 20 diameters upstream from the pump in the inlet line.

3.7 Reservoir: To minimize aeration, the return fluid shall enter the reservoir at a point below the surface of the fluid. Return fluid shall be diffused in such a manner as to minimize turbulence in the reservoir and to prevent the return fluid short circuiting to the pump inlet. Provision shall be made to prevent settlings entering the inlet line.

4. GENERAL DEFINITIONS AND TEST CONDITIONS:

4.1 Temperature: Shall be expressed in degrees Fahrenheit (F) or Centigrade (C).

4.2 Delivery: Shall be expressed in gallons per minute (gpm) or liters per minute (lpm).

4.3 Outlet Pressure: Shall be expressed in pounds per square inch gage (psig) or newtons per square centimeter gage (N/cm^2g).

4.4 Inlet Pressure: Shall be expressed in inches of mercury absolute (in Hg abs) or millimeters of mercury absolute (mm Hg abs).

4.5 Deadhead Pressure: Is pressure psig (N/cm^2g) developed by a pressure compensated pump when delivery is zero.

4.6 SAE Volumetric Rating of a hydraulic pump shall be defined as the pump delivery in gallons per minute or liters per minute at a speed of 1000 rpm and a pressure differential across the pump of 100 psi (68.95 N/cm^2) at a fluid temperature of 120°F (49°C).

4.7 Torque: Shall be expressed in pounds-inch (lb-in) or newton-meters (N-m).

4.8 Response Time: Shall be defined as time in milliseconds between instantaneous pressure reaching deadhead pressure on the pressure rise and again reaching deadhead pressure on the pressure drop when tested according to Test 5 of this procedure. (See Fig. 3.)

4.9 Recovery Time: Shall be defined as time in milliseconds between start of the pressure drop and when instantaneous pressure reaches 75% of the deadhead pressure on the first rise of the curve when tested according to Test 5 of this procedure. (See Fig. 4.)

5. WORKING FORMULAS:

5.1 SAE Theoretical Delivery

$$= \frac{\text{SAE volumetric rating (gpm) x rpm}}{1000} = \text{gpm}$$

$$= \frac{\text{SAE volumetric rating (lpm) x rpm}}{1000} = \text{lpm}$$

5.2 SAE Theoretical Hydraulic Power

$$= \frac{\text{SAE theoretical delivery (gpm) x psig}}{1714} = \text{horsepower (hp)}$$

$$= \frac{\text{SAE theoretical delivery (lpm) x N/cm}^2\text{g}}{6} = \text{watts (W)}$$

5.3 Hydraulic Power

$$= \frac{\text{Delivery (gpm) x psig}}{1714} = \text{horsepower (hp)}$$

$$= \frac{\text{Delivery (lpm) x N/cm}^2\text{g}}{6} = \text{watts (W)}$$

5.4 Power Input

$$= \frac{\text{Torque (lb-in.) x rpm}}{63{,}025} = \text{horsepower (hp)}$$

$$= \text{Torque (N-m) x rpm x } 0.105 = \text{watts (W)}$$

5.5 Torque Efficiency

$$= \frac{\text{Theoretical hydraulic power}}{\text{Power input}} \times 100 = \text{percent (\%)}$$

5.6 Overall Efficiency

$$= \frac{\text{Hydraulic power}}{\text{Power input}} \times 100 = \text{percent (\%)}$$

5.7 Power Loss

= Power input (hp) - Hydraulic power (hp) = horsepower (hp)

= Power input (W) - Hydraulic power (W) = watts (W)

5.8 **Rate of Pressure Change**

$$= \frac{1}{\text{milliseconds (ms)}} \frac{\Delta p \times 1000}{} = \frac{\text{psig}}{\text{sec}}$$

$$= \frac{\text{N/cm}^2\text{g}}{\text{sec}}$$

POSITIVE DISPLACEMENT HYDRAULIC PUMPS

Test 1--SAE Volumetric Rating:

1. Set up pump as recommended in Fig. 1.
2. Operate pump at 1000 rpm with 100 psi (68.95 N/cm^2) differential pressure using fluid at 120°F (49°C).
3. Record delivery.

Test 2--Performance Characteristics:

1. Set up pump as recommended in Fig. 1.
2. With discharge pressure adjusted to 100 psi maximum (68.95 N/cm^2), operate pump from minimum to maximum speed in a suitable number of steps using fluid at 120°F (49°C). Record input torque and delivery.
3. Repeat step 2 at maximum and at least one intermediate discharge pressure.
4. Repeat steps 2 and 3 with the inlet at 5 in (127 mm) Hg below atmospheric by adjusting the shutoff valve in the inlet line.

Test 3--Performance Characteristics:

1. Repeat Test 2, steps 1, 2, and 3 with fluid temperature at 180°F (82°C).

The performance of constant displacement pumps shall be presented as shown on Work Sheet 1.

VARIABLE POSITIVE DISPLACEMENT PUMP PRESSURE COMPENSATED

Perform Test 1, 2, and 3. Maximum pressure can be 5-20% below deadhead pressure.

Test 4--Performance Charactersitics Compensator Range:

1. At the minimum, maximum, and one intermediate speed used in Test 2 and deadhead pressure set at recommended maximum, reduce pump delivery from maximum to zero in adequate steps to define performance curves. Record input torque, pressure, and delivery.
2. Repeat step 1 at recommended minimum and one intermediate deadhead setting.

[1]See Figs. 3 and 4.

Test 5--Response Time and Recovery Time:

1. Add a rapid shutoff valve (such as a direct solenoid operated valve) in series with the manual shutoff valve and connect a pressure transducer into the pump outlet line so that instantaneous pressure can be recorded against time on an oscilloscope (or oscillograph). See circuit drawing in Fig. 2.

2. With pump running at a selected speed, deadhead pressure set at recommended maximum pressure, relief valve set to limit maximum pressure to 125% minimum of deadhead pressure setting, and shutoff valve open, adjust manual shutoff valve to maintain 75% of deadhead pressure.

   (a) Close shutoff valve as quickly as possible while making a recording of instantaneous pressure against time. From this recording, determine the rate of pressure rise in psi/sec ($N/cm^2/sec$) and response time in milliseconds. Rate of pressure rise is determined from the slope of the pressure line when instantaneous pressure equals deadhead pressure. (See Fig. 3.)

   (b) Open shutoff valve as quickly as possible while making a recording of instantaneous pressure against time. From this recording, determine the rate of pressure drop in psi/sec ($N/cm^2/sec$) and recovery time in milliseconds. Rate of pressure drop is determined from the slope of pressure line when instantaneous pressure equals 75% of deadhead pressure. (See Fig. 4.)

3. Repeat step 2 at any other condition as agreed to by manufacturer and user.

Performance of pressure compensated variable positive displacement pumps shall be presented as shown on Work Sheet 1 for Tests 1, 2, and 3 and on Work Sheet 2 for Tests 4 and 5.