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NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA

ICS 23.100.10

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GB/T 17491-2011

Replacing GB/T 17491-1998

**Hydraulic fluid power - Positive capacity pumps,
motors and integral transmissions - Methods of
testing and presenting basic steady state performance**

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Issued on: June 16, 2011

Implemented on: March 01, 2012

**Issued by: General Administration of Quality Supervision, Inspection and
Quarantine of the People's Republic of China;**

**Standardization Administration of the People's Republic of
China.**

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Foreword

This Standard was drafted in accordance with the rules specified in GB/T 1.1-2009.

This Standard replaces GB/T 17491-1998 "Hydraulic pumps, motors and integral transmissions - Measurement of steady-state performance". As compared with GB/T 17491-1998, the main technical changes are as follows:

- ADD the integral transmission test circuit;
- DELATE the test curves of hydraulic pumps, motors and integral transmission.

Using re-drafting method, this Standard modifies and adopts ISO 4409:2007 "Hydraulic fluid power - Positive capacity pumps, motors and integral transmissions - Methods of testing and presenting basic steady state performance" (English version).

The technical differences between this Standard and ISO 4409:2007 AND their causes are as follows:

- In normative references, this Standard has made adjustments with technical differences to adapt to China's technical conditions. The adjustments are mainly reflected in Chapter 2 "Normative references". The specific adjustments are as follows:
 - USE GB 3102 (all parts) which equivalently adopts international standard to replace ISO 31 (all parts) (see 4).
 - USE GB/T 786.1 which equivalently adopts international standard to replace ISO 1219-1 (see 4).
 - USE GB/T 17446 which equivalently adopts international standard to replace ISO 5598 (see 3).
 - USE GB/T 17485 which equivalently adopts international standard to replace ISO 4391 (see 4).
 - USE JB/T 7033 which adopts international standard through modification to replace ISO 9110-1 (see 5.1.1).
- CORRECT the unit error of "Rotational frequency" in Table 1 of international standard.

Hydraulic fluid power - Positive capacity pumps, motors and integral transmissions - Methods of testing and presenting basic steady state performance

1 Scope

This Standard specifies the measurement method for the steady state performance and efficiency of positive capacity pumps, motors and integral transmissions for the purposes of hydraulic transmission, as well as, under steady state conditions, the expression of the test apparatus, the test program requirements and test results.

This Standard applies to the positive capacity hydraulic pumps, motors and integral transmissions.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this Standard.

GB/T 786.1 Fluid power systems and components - Graphic symbols and circuit diagrams - Part 1: Graphic symbols for conventional use and data-processing applications (GB/T 786.1-2009, ISO 1219-1:2006, IDT)

GB 3102 (all parts), Quantities and units [GB 3102-1993, eqv ISO 31:1992 (all parts)]

GB/T 17446 Fluid power systems and components - Vocabulary (GB/T 17446-1998, idt ISO 5598:1985)

GB/T 17485 Hydraulic fluid power - Pumps, motors and integral transmissions - Parameter definitions and letter symbols (GB/T 17485-1998, idt ISO 4391:1983)

JB/T 7033 Hydraulic fluid power - General measurement principles (JB/T 7033-2007, ISO 9110-1:1990, MOD)

ISO 9110-2 Hydraulic fluid power - Measurement techniques - Part 2:
Measurement of average steady state pressure in a closed conduit

3 Terms and definitions

The terms and definitions as defined in GB/T 17446 as well as the followings apply to this document.

NOTE: When it is no risk of ambiguity, the subscripts P, M and T used to distinguish pumps, motors or integral transmissions can be omitted.

3.1

Volume flow rate q_v

It refers to the volume of fluid flowing through the channel's cross section in unit time.

3.2

Drainage flow rate q_{vd}

It refers to the volume flow rate from the component casing.

3.3

Pump effective outlet flow rate $q_{v2,e}^P$

It refers to, at the temperature of $\theta_{2,e}$ and pressure of $p_{2,e}$, the actual flow rate measured at the pump outlet.

NOTE: If the flow rate is measured at other locations than the pump outlet, then at the temperature of θ and pressure of p , the measured flow rate shall be corrected by the equation (1), so as to obtain the effective outlet flow values.

$$q_{v2,e}^P = q_v \left[1 - \left(\frac{p_{2,e} - p}{K_T} \right) + \alpha (\theta_{2,e} - \theta) \right] \dots\dots\dots (1)$$

3.4

Motor effective inlet flow rate $q_{v1,e}^M$

It refers to, at the temperature of $\theta_{1,e}$ and pressure of $p_{1,e}$, the actual flow rate measured at the motor inlet.

3.14**Pump overall efficiency η_t^p**

It refers to the ratio between the power obtained and the input mechanical power when the liquid passes through pump.

$$\eta_t^p = \frac{(q_{V2,e} \cdot p_{2,e}) - (q_{V1,e} \cdot p_{1,e})}{2\pi \cdot n \cdot T} \dots\dots\dots (8)$$

3.15**Pump volumetric efficiency η_v^p**

It refers to, under specified conditions, the ratio between the pump actual output flow rate and the product of derived capacity V_i and shaft speed.

$$\eta_v^p = \frac{(q_{V2,e} \cdot p_{2,e}) - (q_{V1,e} \cdot p_{1,e})}{2\pi \cdot n \cdot T} \dots\dots\dots (8)$$

3.16**Motor overall efficiency η_t^M**

It refers to the ratio between the motor output mechanical power and the input hydraulic power.

$$\eta_t^M = \frac{2\pi \cdot n \cdot T}{(q_{V1,e} \cdot p_{1,e}) - (q_{V2,e} \cdot p_{2,e})} \dots\dots\dots (10)$$

3.17**Motor volumetric efficiency η_v^M**

It refers to, under specified conditions, the ratio between the product of motor derived capacity V_i and shaft speed n and the actual input flow rate.

$$\eta_v^M = \frac{V_i^M \cdot n}{q_{V1,e}} \dots\dots\dots (11)$$

3.18**Motor hydro-mechanical efficiency η_{hm}^M**

It refers to the ratio between motor shaft torque and motor theoretical torque.

$$\eta_{hm}^M = \frac{T}{T_{th}} = \frac{2\pi \cdot n \cdot T}{(p_{1,e} - p_{2,e}) V_i^M} \dots\dots\dots (12)$$

^b 1Pa = 1N/m².

5 Test

5.1 Requirements

5.1.1 Overview

Test equipment shall be designed to prevent air entrainment, AND be able to exclude all free air from the system before testing.

The installation, connection and operation of the test unit in the test circuit shall comply with the manufacturer's requirements, see Appendix C.

It shall record the ambient temperature in the test area.

In the test circuit, it shall equip with filter which complies with the filter criteria as required by the test unit manufacturer, AND it shall indicate the location and quantity of the filters used in the test circuit as well as the model of each filter.

When conducting pressure measurement in the pipelines, it shall meet the requirements of JB/T 7033 and ISO 9110-2.

When conducting temperature measurement in the pipelines, the temperature measurement point shall be kept away from the components AND meanwhile away from the pressure measurement point for 2 times ~ 4 times of the pipeline diameter.

Figure 1 to Figure 4 show the basic circuit, in which the safety device is not equipped to avoid system damage when the system fails. During the test, it shall take safety measures to prevent personnel and equipment from being harmed.

5.1.2 Test unit installation

INSTALL the test unit into the test circuit as shown in Figure 1 to Figure 4.

5.1.3 Test conditions

Before conducting test, the test unit shall be subject to running-in in accordance with the manufacturer's recommendations.

5.1.4 Test fluid

Since the component performance may vary significantly with fluid viscosity, so when it is tested, it shall use the oil which is recommended by the manufacturer.

^a As for the pipe length, see 5.1.1.

Figure 2 Pump test circuit (closed circuit)

5.2.2 Inlet pressure

In each test, it shall, in accordance with the manufacturer's requirements, maintain the inlet pressure at a constant value within the allowable range (see Table 3). If required, CONDUCT test at different inlet pressures.

5.2.3 Test measurement

RECORD the following measurement data:

- a) Input torque;
- b) Outlet flow rate;
- c) Drainage flow rate (if applicable);
- d) Fluid temperature.

At constant rotational frequency (see Table 3) and certain output pressure, MEASURE a set of data, in order to, within the entire range of the outlet pressure, provide the representative indication of pump performance.

At other rotational frequency, REPEAT the measurement from 5.2.3 a) ~ d), in order to, within the entire range of rotational frequency, provide the representative indication of pump performance.

5.2.4 Variable capacity

At the minimum rotational frequency and minimum outlet pressure which are specified by the test, if the pump is a variable capacity type, then with respect to the maximum capacity value and the other required capacity values (such as 75%, 50%, and 25% of the maximum capacity), CONDUCT all tests.

5.2.5 Reverse flow

If the pump flow pattern can be reversed by means of the variable mechanism, then it shall, based on demands, conduct test for the two flow directions.

5.2.6 Non-Integral boost pump

If the testing pump is completed with a boost pump, AND meanwhile the power input can be measured separately, then it shall respectively test each pump, AND respectively express results for each pump.

3, 6, 13, 17 - Thermometer;

4 - Relief valve;

5, 14, 18 - Flowmeter;

7 - Heater;

8 - Cooler;

9 - Filter;

10 - Torque meter;

11 - Tachometer;

15, 19 - Fuel tank;

A - Alternative position;

B - Load;

C - Controlled fluid supply.

^a As for the pipe length, see 5.1.1.

Figure 3 Motor test circuit

5.3.2 Outlet pressure

CONTROL the motor outlet pressure (for example, by pressure control valve), so as to make its variation within the ranges given in Table 3, AND meanwhile keep the outlet pressure constant throughout the testing process.

This outlet pressure shall be in line with the application conditions which are set for this type of motor as well as the manufacturer's recommendations.

5.3.3 Test measurement

RECORD the following measurement values:

- a) Input flow rate;
- b) Drainage flow rate (if applicable);
- c) Output torque;
- d) Test fluid temperature.

Over the entire rotational frequency range of the motor AND under certain pressure, PROVIDE, over the entire input pressure range, the representative indications of motor performance.

Explanation:

- 1, 6 - Tachometer;
- 2, 7 - Torque meter;
- 3 - Hydraulic motor;
- 4, 10, 23 - Pressure gauge;
- 5, 9, 15, 20, 24 - Thermometer;
- 8 - Hydraulic pump;
- 11, 12 - One way valve;
- 13, 14, 21 - Relief valve;
- 16, 19 - Flowmeter;
- 17 - Heater;
- 18 - Cooler;
- 22 - Boost pump;
- 25 - Filter;
- 26 - Fuel tank.
- A - Load;
- B - Integral transmission case;
- C - Driver.

Figure 4 Integral transmission test circuit

5.4.2 Test measurement

At maximum capacity and specified rotational frequency, CONDUCT test to measure the following items of the integral transmission during running:

- a) Input torque;
- b) Output torque;
- c) Output rotational frequency;
- d) Test fluid pressure;
- e) Test fluid temperature.

At the manufacturer's recommended input rotational frequency, TEST the frequency range.

Within the range specified in Table 3, for different input rotational frequencies, REPEAT the measurement 5.4.2 a) ~ e).

At the maximum capacity of the motor, if the pump is a variable capacity type, REPEAT the measurement 5.4.2 a) ~ e) when the pump's actual capacity is 75%, 50% and 25% of the maximum capacity.

When the motor is at the maximum capacity AND the output shaft has no load, the pump capacity shall be determined based on the ratio between the output rotational frequency at the pump's non-maximum capacity and the output rotational frequency at the pump's maximum capacity.

If the motor is a variable capacity type, when the motor is set to minimum capacity, REPEAT the measurement 5.4.2 a) ~ e).

5.4.3 Boost pump

If the boost pump or other accessories AND this transmission's pump are integrated and driven by same input shaft, then the pump shall be considered as an integral unit AND indicated in the test results of this case.

If the boost pump or other accessories are separately driven, then the power required shall be deducted from the transmission performance, AND indicated in the test results of this case.

5.4.4 Reverse rotation

If the output shaft is needed to work towards both rotational directions, it shall, based on demands, conduct test for the both rotational directions.

6 Result expression

6.1 Overview

All the test measurements and the derived calculation results shall be listed into a Table by the test institute, AND shown in the form of graphics.

6.2 Pump test

6.2.1 Pump test at constant rotational frequency

As for the pump test at constant rotational frequency, it shall draw the relationship curve between the effective outlet pressure ($p_{2,e}$) and the following items:

- a) Volumetric efficiency;

Appendix A

(Informative)

Practical unit application

A.1 Practical unit

The test results recorded in table or graphics can use the practical units as given in Table A.1.

Table A.1 Practical unit

Physical unit	Symbol	Practical unit
Volume flow rate	qv	Lmin ⁻¹
Rotational frequency	n	min ⁻¹
Torque	T	N·m
Pressure	p	bar
Power	P	kW
Mass density	ρ	kgL ⁻¹
Isothermal secant bulk modulus	$\bar{K}_T$	Pa (bar) ^b
Kinematic viscosity	ν	mm ² s ⁻¹ ^c
Temperature	θ	°C
Total efficiency ^a	η	-
a Efficiency can also be expressed as a percentage. b 1 bar = 10 ⁵ Pa. c 1cSt = 1mm ² s ⁻¹ .		

A.2 Calculation

A.2.1 Overview

To use the practical units to express the results (see Table A.1), the equation (4) to (8), (10), (12) and (13) shall be corrected in accordance with A.2.2 ~ A.2.7.

A.2.2 Mechanical power

$$P_m = \frac{2\pi \cdot n \cdot T}{60 \ 000} \text{ kW} \quad \dots\dots\dots (A.1)$$

A.2.3 Hydraulic power

Appendix C

(Informative)

Checklist before test

The following checklist is used to select appropriate items, AND it is recommended for relevant parties to, prior to the test, conduct negotiation on these items, AND make selection based on demands.

- a) Manufacturer's name;
- b) Manufacturer's identification (type number, serial number);
- c) Manufacturer's component name;
- d) Shaft rotation direction;
- e) Test circuit;
- f) Manufacturer's installation and connection requirements;
- g) Filtering device used in the test;
- h) Location of the pressure-tapping point;
- i) Use of pipeline loss in calculation;
- j) Conditions before the test;
- k) Test fluid (name and description);
- l) Test fluid kinematic viscosity at test temperature;
- m) Test fluid mass density at test temperature;
- n) Isothermal secant bulk modulus of test fluid;
- o) Volume coefficient of thermal expansion of Test fluid;
- p) Test fluid temperature;
- q) Allowable maximum pressure of casing;
- r) Pump inlet pressure;

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