BS ISO 17559:2003

Hydraulic fluid power — Electrically controlled hydraulic pumps — Test methods to determine performance characteristics

ICS 23.100.10

British Standards

National foreword

This British Standard reproduces verbatim ISO 17559:2003 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee MCE/18, Fluid power systems, to Subcommittee MCE/18/-/8, Product testing, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the ISO title page, pages ii to v, a blank page, pages 1 to 20, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 22 November 2004

ISBN 0 580 44822 3

BS ISO 17559:2003

INTERNATIONAL STANDARD

ISO 17559

First edition
2003-11-15

Hydraulic fluid power — Electrically controlled hydraulic pumps — Test methods to determine performance characteristics

Transmissions hydrauliques — Pompes hydrauliques à commande électrique — Méthodes d'essai pour déterminer les caractéristiques de fonctionnement

Reference number
ISO 17559:2003(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17559 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 8, *Product testing*.

Introduction

This International Standard is intended to unify testing methods of positive-displacement electrically and electronically controlled hydraulic pumps so as to allow comparison of the performance of different components.

Requirements for test installations, procedures and expression of results are described.

blank

Hydraulic fluid power — Electrically controlled hydraulic pumps — Test methods to determine performance characteristics

1 Scope

This International Standard specifies methods for determining the steady-state performance characteristics and dynamic performance characteristics of positive-displacement electrically and electronically controlled hydraulic pumps (hereafter referred to as “pump” or “pumps”), so as to allow comparison of the performance of different components.

Pumps covered by this International Standard have the capacity to affect changes in the output flow or pressure in proportion to the electrical or electronic input signals. These pumps can be of the load-sensing control type, servo-control type, or electrical variable displacement mechanism type, which control output flow and output pressure by feedback using electrical signals.

The accuracy of measurement is divided into three classes, A, B and C, which are explained in Annex A.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3448, *Industrial liquid lubricants — ISO viscosity classification*

ISO 4391, *Hydraulic fluid power — Pumps, motors and integral transmissions — Parameter definitions and letter symbols*

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 4409, *Hydraulic fluid power — Positive displacement pumps, motors and integral transmissions — Determination of steady-state performance*

ISO 5598, *Fluid power systems and components — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5598 and the following apply.

3.1
electrically controlled hydraulic pump
variable displacement pump which is capable of controlling the pressure or flow rate, or the pressure and flow rate corresponding to an input signal

3.2
minimum flow command
minimum input flow command signal needed to maintain the maximum working pressure

3.3
minimum controllable pressure
minimum output pressure when the absolute value of the input pressure command signal is zero and the input flow command signal is maximum (see 7.2.4)

3.4
dead zone
range wherein the output pressure or output flow being controlled by the input signal does not vary when the absolute value of the input signal increases from zero or decreases to zero

3.5
load volume
gross volume of working fluid in the main pipelines from the outlet of the pump to be tested to the inlet of the loading valve

3.6
pressure compensation
condition in which the output flow starts to decrease by the variable displacement control mechanism when the output pressure approaches a set pressure

3.7
deadhead pressure
output pressure without flow

4 Symbols

4.1 The physical quantity letter symbols and their suffixes used in this International Standard (see Table 1), are fully explained in ISO 4391.

Units are given in Table 1 and Annex A.

4.2 Graphical symbols used in Figures 1 and 2, showing test circuit diagrams, conform to ISO 1219-1 and ISO 1219-2.

Table 1 — Symbols and units

Quantity	Symbol	Dimension[a]	SI unit
Power	P	M L^2 T^{-3}	W
Pressure, differential pressure	p, Δp	M L^{-1} T^{-2}	MPa
Flow rate	q	$L^3 T^{-1}$	dm^3/min
Rotational speed	n	T^{-1}	min^{-1}

[a] M = mass, L = length, T = time.

5 Test installation — General requirements

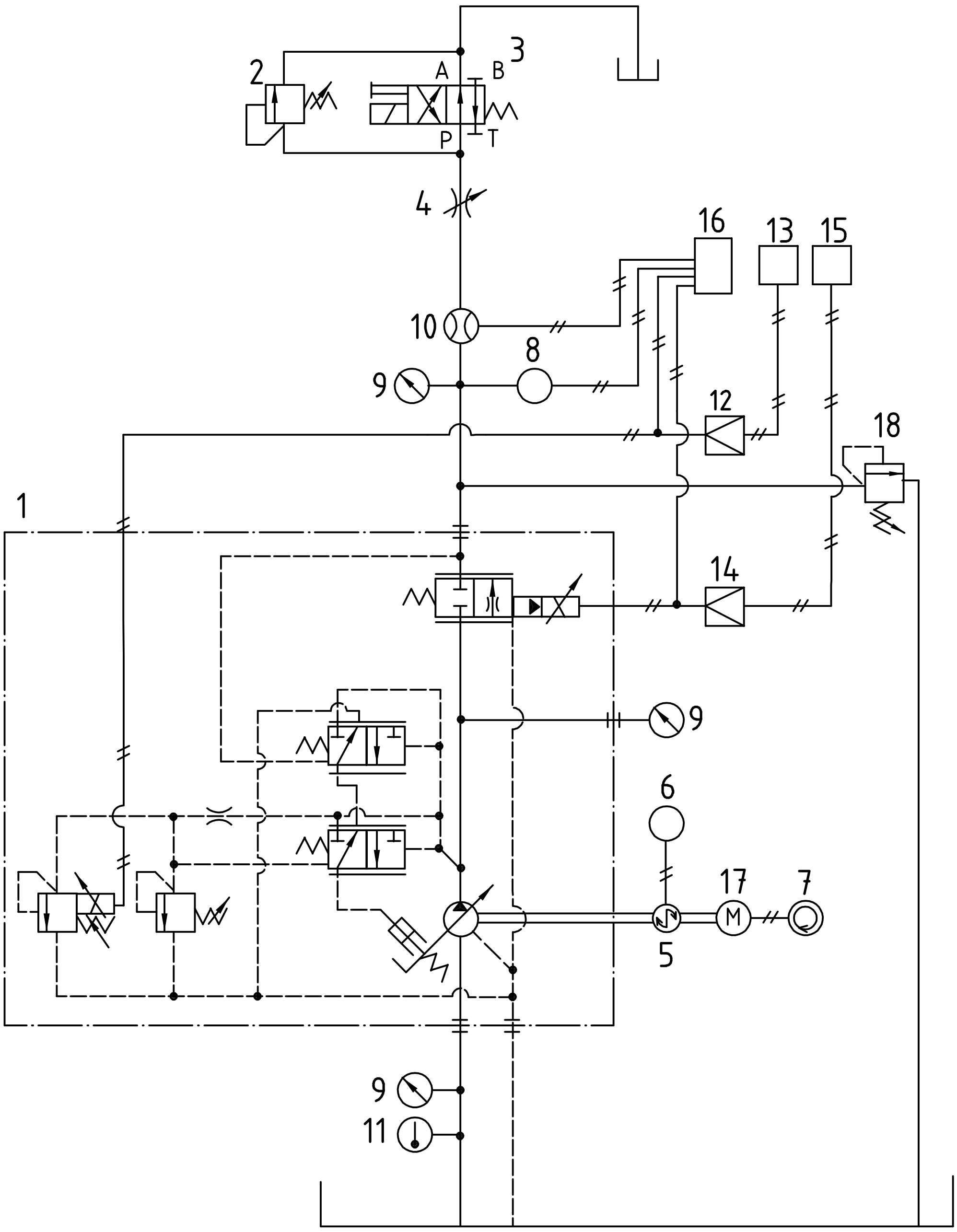
5.1 General

5.1.1 Unless otherwise specified, install the pump with the output shaft horizontal and the drain port facing upwards.

5.1.2 Use a hydraulic test circuit conforming to Figure 1 for test pumps having a pressure control valve to control the pressure in the pressure-compensation state and a flow control valve to control the output flow.

5.1.3 Use a hydraulic test circuit conforming to Figure 2 for test pumps that utilize electrical input signals to control the pressure in the pressure-compensation state and either the position or angle of the mechanism to vary the displacement of the pump.

5.1.4 For applications where the pump will be part of a closed-loop control system it may be necessary to perform a frequency response test. Subclause 8.5 describes a pump test method. The need for the test should be agreed between the customer and manufacturer.

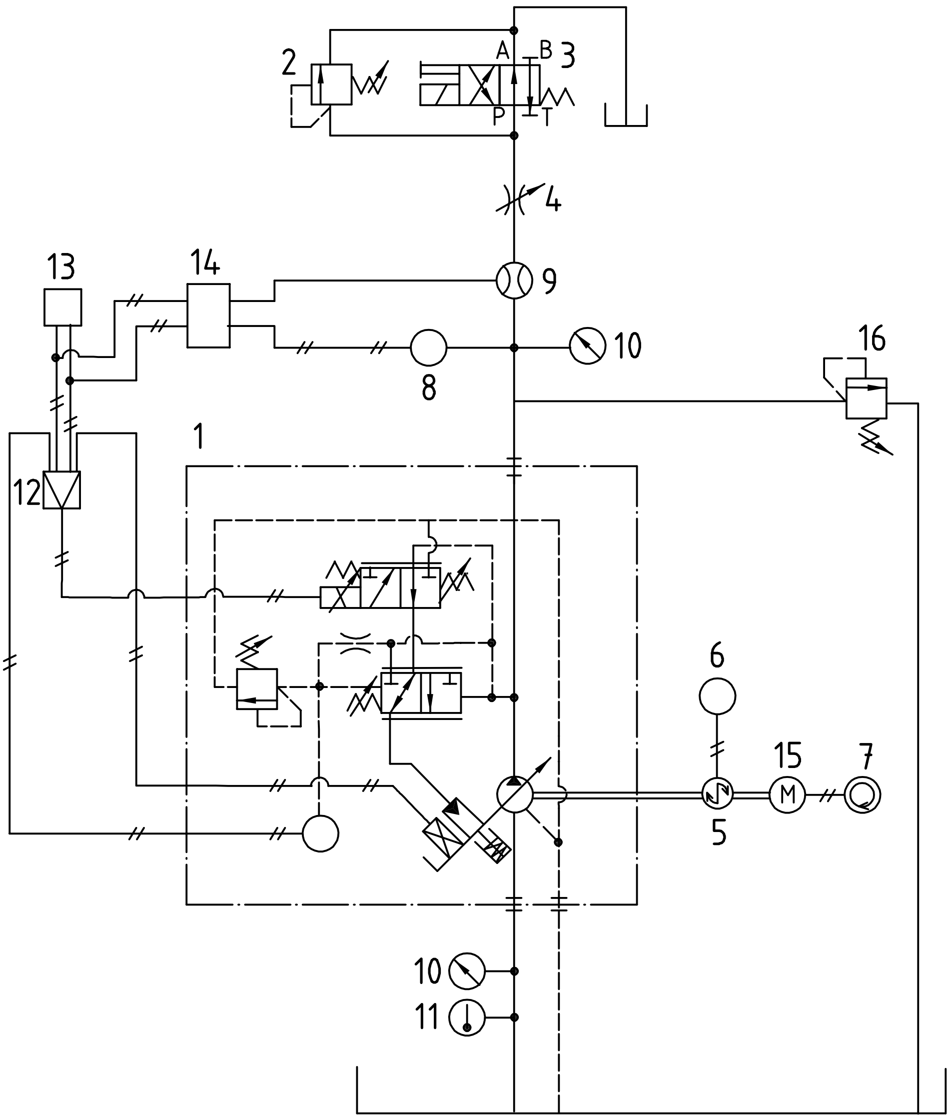


Key

1	pump under test
2	loading valve
3	directional control valve
4	variable restrictor
5	torque meter
6	torque indicator
7	speed meter
8	electrical pressure transducer
9	pressure gauge
10	electrical flow transducer
11	thermometer
12	control device
13	signal source
14	control device
15	signal source
16	recorder
17	electric motor
18	manual relief valve

NOTE Details of the pump control valves are for illustration only.

Figure 1 — Pump with pressure-compensation control valve and flow control valve to control output flow



Key

1 pump under test
2 loading valve
3 directional control value
4 variable restrictor
5 torque meter
6 torque indicator
7 speed meter
8 electrical pressure transducer
9 electrical flow transducer
10 pressure gauge
11 thermometer
12 control device
13 signal source
14 recorder
15 electric motor
16 manual relief valve

NOTE Details of the pump control valves are for illustration only.

Figure 2 — Pump with electrical input signals to control pressure-compensation and either the position or angle of the mechanism to vary displacement

5.2 General test apparatus

5.2.1 Set up a test rig conforming to 5.1.1 to 5.1.3 and Figures 1 and 2 as applicable.

5.2.2 Maintain the loading valve and variable restrictor in the test circuit at no loading and no restriction except for the conditions specified in the test procedure. If the loading valve is operated, open the variable restrictor completely and adjust the directional control valve so that the P port is closed. If the variable restrictor is operated, adjust the directional control valve so that the P port opens to the A port.

5.2.3 Set the manual relief valve integrated with the pump for safety purposes to limit the maximum steady-state pressure to no less than 125 % of the maximum working pressure setting.

6 General test conditions

6.1 Test fluid

6.1.1 The hydraulic fluid type and viscosity shall conform to ISO VG 32 or ISO VG 46 according to ISO 3448.

6.1.2 Maintain the fluid temperature at the pump inlet in the range of 45 °C to 55 °C.

6.1.3 Maintain the fluid contamination class within 19/16 or less according to ISO 4406.

Conditions other than those indicated in this subclause should be agreed between the supplier and purchaser.

6.2 Ambient conditions

The ambient temperature and any variation from still air conditions shall be recorded.

6.3 Steady-state conditions

Take each set of measurements only when the values of the controlled parameters are within the limits given in Table 2.

Table 2 — Limits of permissible variation in the values of controlled parameters

Controlled parameter	Limits of permissible variation in the values of controlled parameters for class of measurement accuracy[a]		
	A	B	C
Temperature, °C	± 0,5	± 1	± 2
Rotational speed, %	± 0,5	± 1	± 2
Input signal, %	± 0,5	± 1,5	± 2,5

[a] See Annex A.

7 Tests of steady-state performance characteristics

7.1 General

7.1.1 The test circuit and measuring circuit shall conform to Figures 1 or 2 as applicable.

NOTE In addition to the internal control pressure supply as shown in Figure 2, it is possible to use an external control pressure supply.

7.1.2 Adjust the electric motor to the specified rotational speed.

7.1.3 The steady-state performance shall be determined in accordance with ISO 4409.

7.1.4 For pumps in accordance with Figure 2, the swivel angle or stroke in percent of the maximum value may be used as an alternative to the output flow.

7.2 Flow/pressure characteristics

7.2.1 Use the pump having pressure control and flow control functions.

7.2.2 Determine the minimum flow command by the following procedure:

— set the loading valve to shut-off so that there is no output flow;

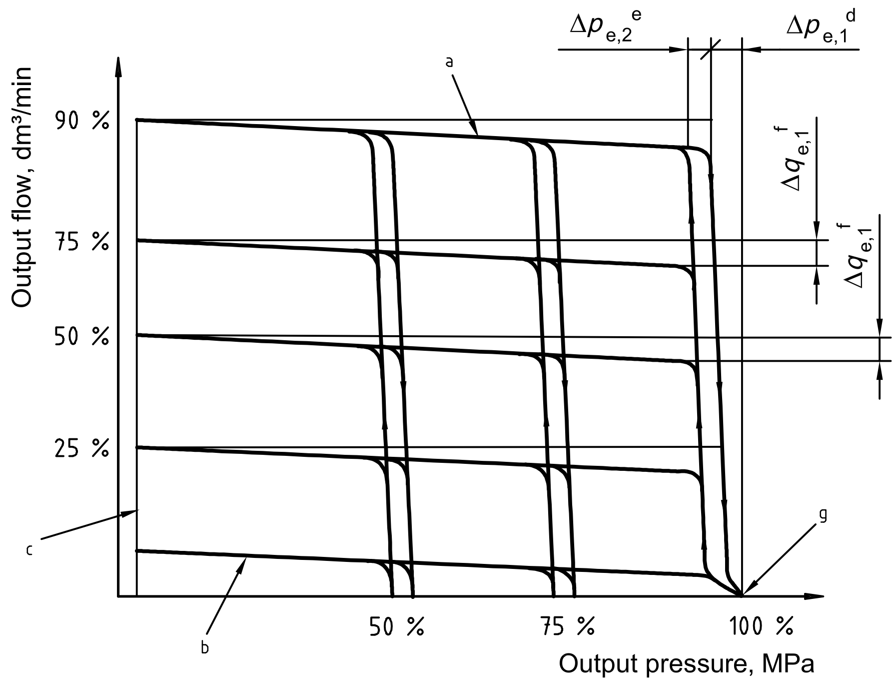
— slowly decrease the input flow command signal until the deadhead pressure can no longer be maintained;

— record the value of the input flow command signal as the minimum flow set point.

7.2.3 Tests should be performed at 100 %, 75 % and 50 % of the maximum working pressure. Tests should also be performed at 90 %, 75 %, 50 % and 25 % of the maximum output flow, and minimum flow command.

7.2.4 Gradually change the output pressure by adjusting the variable restrictor, cycling the pump from the maximum working pressure, through 75 % and 50 % of the maximum working pressure, to the highest minimum controllable pressure and output pressure when the variable restrictor is opened completely, and back again.

7.2.5 Plot a graph of output flow against output pressure (see Figure 3).



[a] Maximum flow command.

[b] Minimum flow command.

[c] Minimum controllable pressure.

[d] Pressure range from starting pressure-compensation state to deadhead pressure.

[e] Hysteresis at pressure-compensation.

[f] Maximum width of the change of the output flow.

[g] Maximum working pressure.

Figure 3 — Output flow versus pressure

7.2.6 Calculate and record the rate of change of adjustable flow rate δq against output pressure using the following formula:

$$\delta q = \frac{\Delta q_{e,1}}{q_0} \times 100$$

where

δq is the rate of change in adjustable flow rate, expressed as a percentage;

$\Delta q_{e,1}$ is the maximum width of the change of output flow (see Figure 3);

q_0 is the output flow at the minimum controllable pressure for each input flow command signal as explained below.

Calculate the values at 75 % and 50 % of the maximum output flow and minimum flow command settings, respectively (these values are the rate of change of adjustable flow rate δq against output pressure). For a pump with pressure-compensation function, $\Delta q_{e,1}$ shall be considered the maximum range of flow rate change immediately before the pump shifts into pressure-compensation mode.

7.2.7 For a pump with pressure-compensation function, calculate and record the following characteristic values for each flow rate setting:

— hysteresis $\Delta p_{e,2}$ of the pressure when controlled by the pressure compensator;

— pressure range $\Delta p_{e,1}$ from commencement of pressure compensation to deadhead condition.

7.3 Characteristic test on output pressure against input pressure command signal: test procedure and presentation of test results

7.3.1 If the pump has pressure control and flow control functions, select input pressure command signal and input flow command signal, and adjust them to their maximum values.

7.3.2 Completely close the loading valve. Increase and decrease input pressure command signal for one cycle, from the minimum controllable pressure of the pump to the maximum working pressure, at a rate that does not subject the pump or measuring equipment to any significant dynamic influence.

7.3.3 Plot a graph of output pressure against input pressure command signal (see Figure 4).

7.3.4 Obtain and record the following characteristic value from the recorded data:

$$\delta p_{hy} = \frac{\Delta p_{max}}{p_{max}} \times 100$$

where

δp_{hy} is the hysteresis of the output pressure, expressed as a percentage;

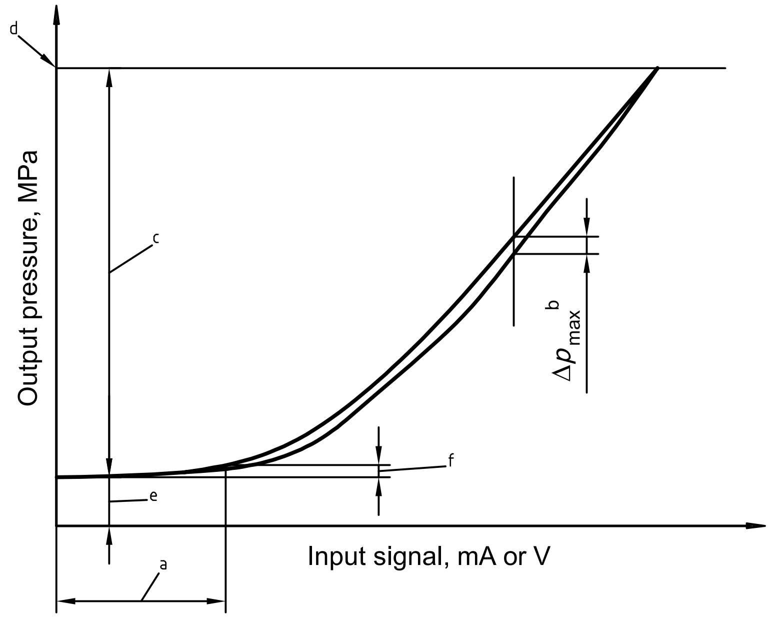
Δp_{max} is the maximum difference in pressure at the same input signal;

p_{max} is the maximum working pressure.

7.3.5 Obtain the adjustable range of output pressure from the recorded data.

7.3.6 Obtain the input signal value at the maximum working pressure from the recorded data.

7.3.7 Determine the dead zone by recording the change in input pressure command signal that causes the dead head output pressure to rise by 10 % above the minimum controllable pressure (see Figure 4). Record the dead zone from the recorded data.



a Dead zone.

b Maximum difference in pressure.

c Adjustable range of pressure.

d Maximum working pressure.

e Minimum controllable pressure.

f 10 % of the minimum controllable pressure.

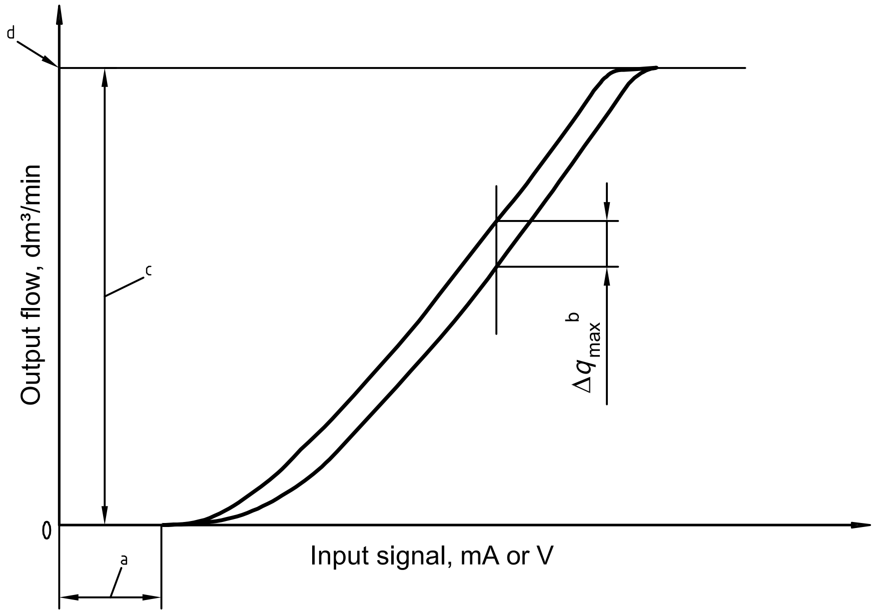
Figure 4 — Output pressure versus input signal

7.4 Characteristic test of output flow against input flow signal — Test procedure and expression of test results

7.4.1 If the pump has pressure control and flow control functions, select the input pressure command signal and input flow command signal and adjust them to their maximum values. Adjust the input pressure command signal to 75 % of the maximum working pressure and the input flow command signal to the maximum, using the loading valve.

7.4.2 Increase and then decrease the flow control input signal for one cycle, from zero output flow to the maximum output flow and back to zero output flow, at a rate that does not subject the pump or measuring equipment to significant dynamic influence.

7.4.3 Plot a graph of output flow against input signal (see Figure 5).



[a] Dead zone.

[b] Maximum difference in output flow.

[c] Adjustable range of output flow.

[d] Maximum output flow.

Figure 5 — Output flow versus input signal at 75 % of maximum working pressure

7.4.4 Obtain and record the following characteristic values from the recorded data:

$$\delta q_{hy} = \frac{\Delta q_{max}}{q_{max}} \times 100$$

where

δq_{hy} is the hysteresis of the output flow, expressed as a percentage;

Δq_{max} is the maximum difference in output flow at the same input signal;

q_{max} is the maximum output flow.

7.4.5 Obtain the adjustable range of the output flow from the recorded data.

7.4.6 Obtain the input signal value at the maximum output flow from the recorded data.

7.4.7 Record the dead zone from the recorded data (see Figure 5).

7.5 Repeatability test

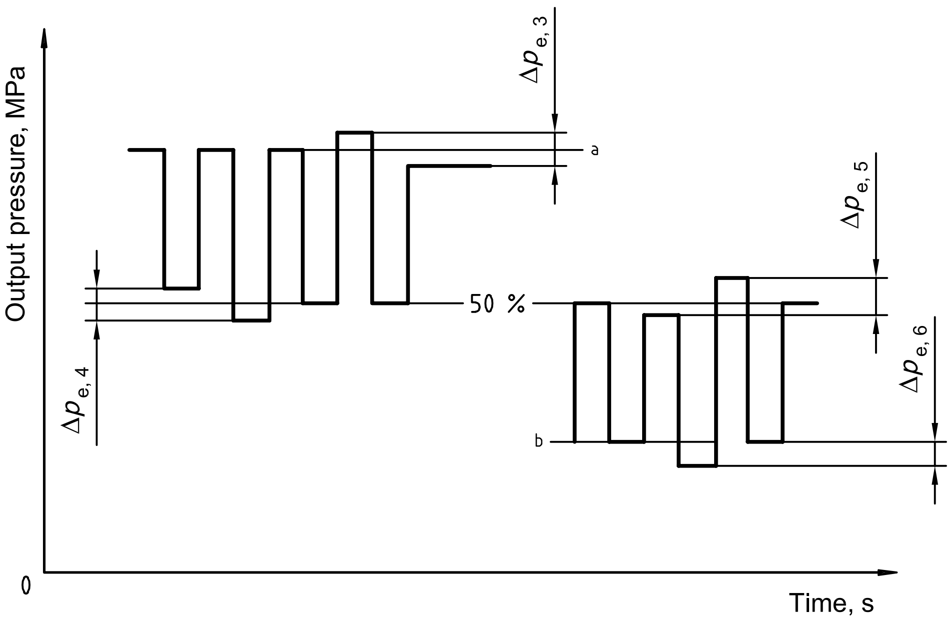
7.5.1 Repeatability of output pressure — Test procedure and presentation of test results

7.5.1.1 If the pump has pressure control and flow control functions, select the input pressure command signal and input flow command signal, and adjust them to their maximum values.

7.5.1.2 Vary the input pressure command signal in accordance with 7.3.2, stepwise for 20 cycles, to attain the maximum working pressure and 50 % of the maximum working pressure.

7.5.1.3 Vary the input pressure command signal in accordance with 7.3.2, stepwise for 20 cycles, to attain 50 % of the maximum working pressure and the minimum controllable pressure.

7.5.1.4 Record graphically the results of the tests in 7.5.1.2 and 7.5.1.3, plotting output pressure against time (see Figure 6).



[a] Signal 100 %.

[b] Signal 0 % minimum adjustable pressure.

Figure 6 — Repeatability of output pressure

7.5.1.5 Obtain and record the ratio of dispersion relative to each pressure setting (see Figure 6), using the following formula:

$$\delta p_{re} = \frac{\Delta p_{e,max}}{p_{max}} \times 100$$

where

δp_{re} is the repeatability of the output pressure, expressed as a percentage;

$\Delta p_{e,max}$ is the maximum value ($\Delta p_{e,3}$ to $\Delta p_{e,6}$);

p_{max} is the maximum working pressure (see Figure 6).

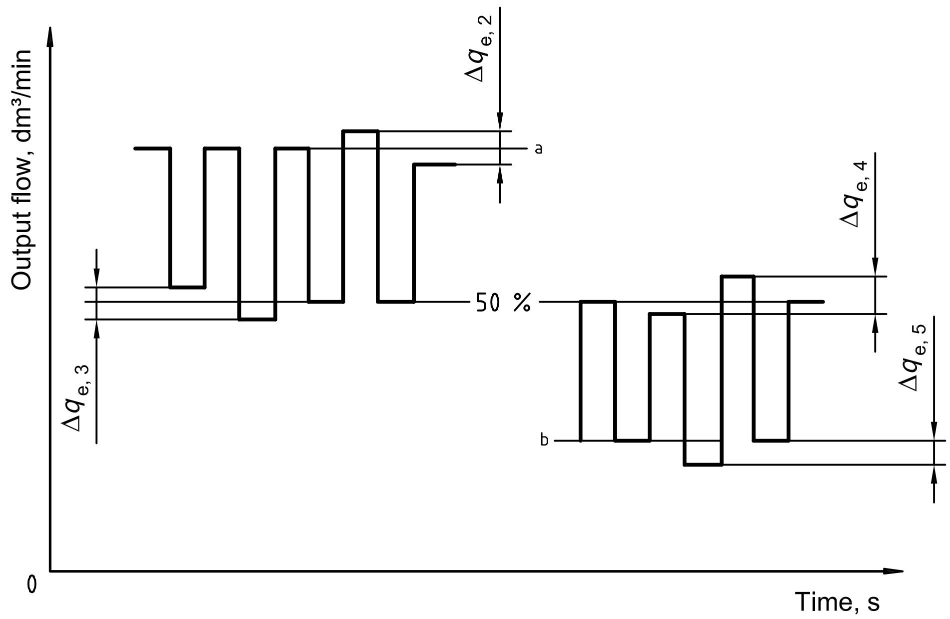
7.5.2 Repeatability of output flow — Test procedure and presentation of test results

7.5.2.1 If the pump has pressure control and flow control functions, select the input pressure command signal and input flow command signal and adjust them to their maximum values. Adjust the input pressure command signal to 75 % of the maximum working pressure and the input flow command signal to the maximum, using the loading valve.

7.5.2.2 With the pump output flow at 90 % of the maximum, adjust the loading valve so that the pressure becomes 75 % of the maximum working pressure. Vary the flow control input signal stepwise for 20 cycles to attain 90 % and 50 % of the maximum output flow at a rate that does not subject the pump or measuring equipment to any dynamic influence.

7.5.2.3 With the pump output flow at 50 % of the maximum, adjust the loading valve so that the pressure becomes 75 % of the maximum working pressure. Vary the input signal in accordance with 7.5.2.2, stepwise for 20 cycles, to attain 50 % of the maximum output flow and the minimum flow command at a rate that does not subject the pump or measuring equipment to any dynamic influence.

7.5.2.4 Record graphically the results of tests in 7.5.2.2 and 7.5.2.3, plotting output flow against time (see Figure 7).



[a] Signal 90 %.

[b] Signal 0 % minimum flow command.

Figure 7 — Repeatability of output flow

7.5.2.5 Obtain and record the ratio of dispersion relative to each flow rate setting (Figure 7), using the following formula:

$$\delta q_{re} = \frac{\Delta q_{e,max}}{q_{max}} \times 100$$

where

δq_{re} is the repeatability of the output flow, expressed as a percentage;

$\Delta q_{e,max}$ is the maximum value ($\Delta q_{e,2}$ to $\Delta q_{e,5}$);

q_{max} is the maximum output flow (see Figure 5).

7.6 Test for change in characteristics against oil temperature

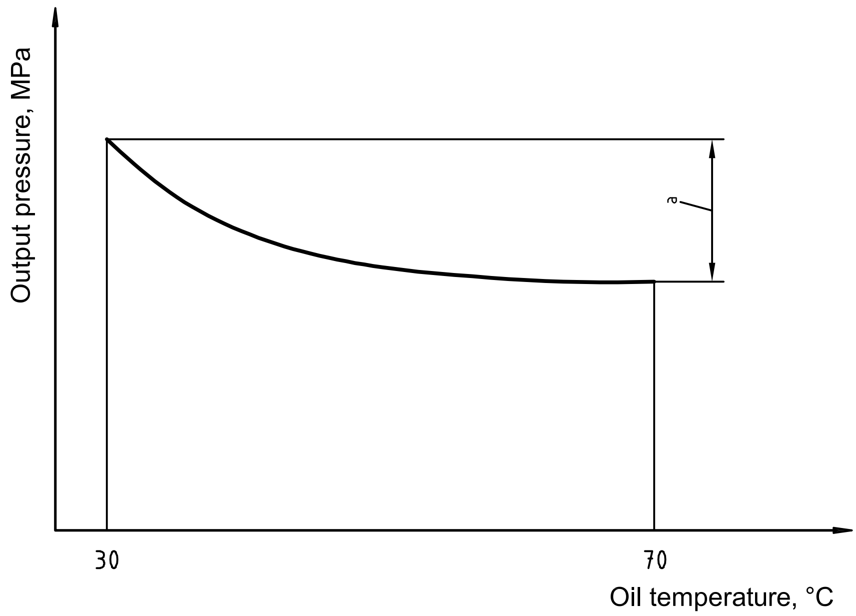
7.6.1 Change in characteristics with respect to pressure — Test procedure and presentation of test results

7.6.1.1 If the pump has a pressure control function, completely close the loading valve and maintain the input pressure command signal to attain the maximum working pressure.

7.6.1.2 Raise the oil temperature from 30 °C to 70 °C at a rate that ensures stable temperatures of the test equipment.

If this range is considered to be too small to have any influence on the control, a temperature range other than that indicated above should be agreed between the parties concerned.

7.6.1.3 Record the results graphically by plotting output pressure against oil temperature (see Figure 8). Record the open-air temperature. If the temperature cannot be recorded continuously, plot at least five points over the range in 10 °C increments within the specified temperature range.



[a] Change in output pressure.

Figure 8 — Output pressure versus oil temperature

7.6.2 Change in characteristics with respect to flow rate — Test procedure and expression of results

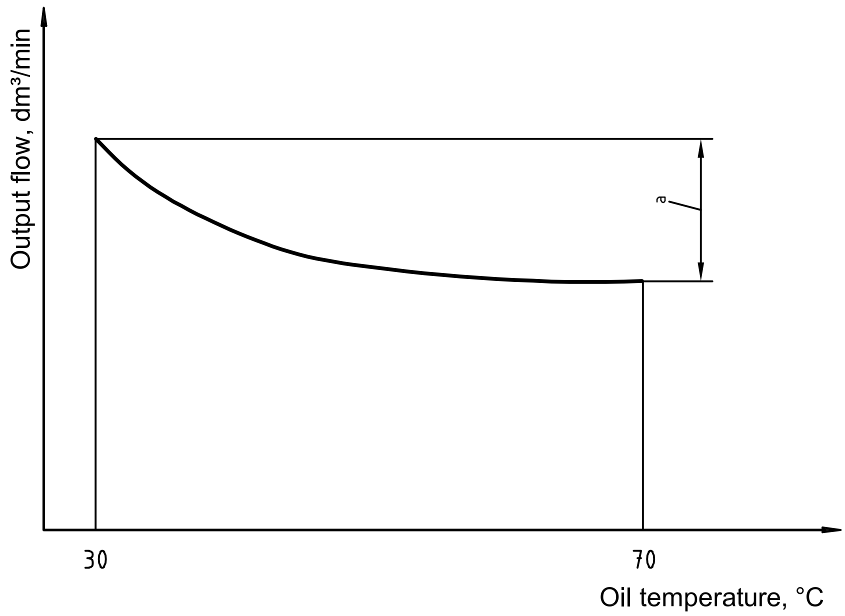
7.6.2.1 If the pump has pressure control and flow control functions, adjust the input flow command signal to 75 % of the maximum, and adjust the loading valve to a pressure of 5 MPa.

7.6.2.2 Raise the oil temperature from 30 °C to 70 °C at a rate that ensures stable temperatures of the test equipment.

If this range is considered to be too small to have any influence on the control, a temperature range other than that indicated above should be agreed between the parties concerned.

7.6.2.3 Record the results graphically by plotting output flow against oil temperature (see Figure 9). Record the open-air temperature. If the temperature cannot be recorded continuously, plot at least five points over the range in 10 °C increments within the specified temperature range.

NOTE Pressure ripple measurement should be carried out in accordance with ISO 10767-1 and ISO 10767-2.



[a] Change in output flow.

Figure 9 — Output flow versus oil temperature

8 Tests of dynamic performance characteristics

8.1 General

8.1.1 The test circuit and measuring circuit shall conform to Figures 1 or 2 as applicable.

NOTE In addition to the internal control pressure supply as shown in Figure 2, it is possible to use an external control pressure supply.

8.1.2 Adjust the electric motor to the specified rotational speed.

8.1.3 For pumps in accordance with Figure 2, the swivel angle or stroke in percent of the maximum value may be used as an alternative to the output flow.

8.2 Pressure compensator response and recovery

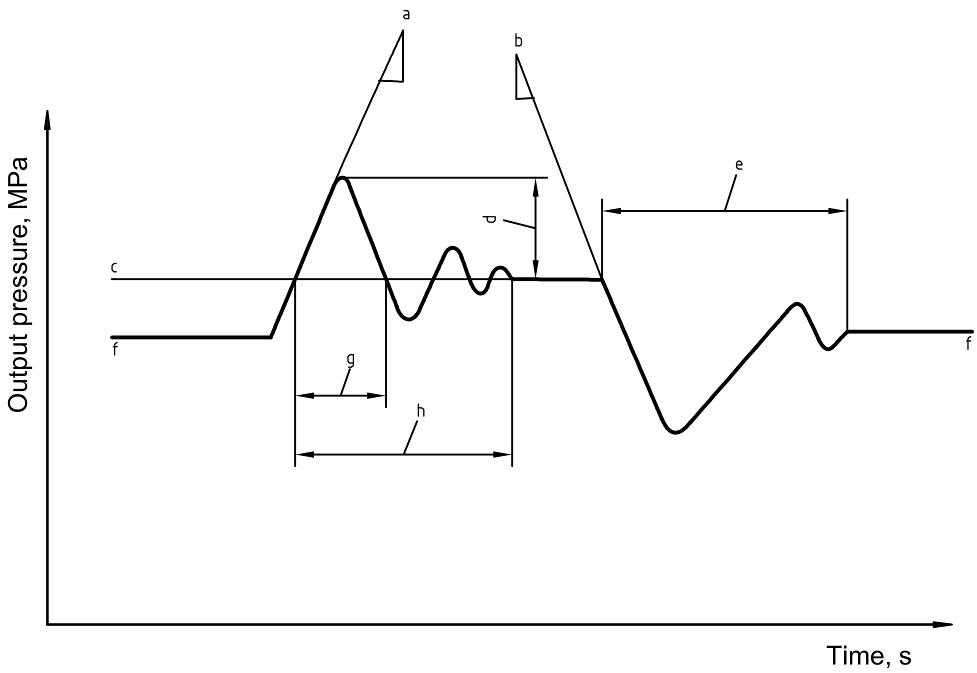
8.2.1 If the pump has pressure and flow rate control functions, select the input pressure command signal and input flow command signal, and adjust them to their maximum values.

8.2.2 Use a directional control valve for rapid shut-off and a pressure transducer in the pump outlet line so that the instantaneous pressure can be recorded against time on an oscilloscope (or oscillograph).

8.2.3 Condition the circuit such that the rate of pressure rise is between 680 MPa/s and 920 MPa/s when the directional control valve is closed. Use 800 MPa/s as the target pressure rise rate [5].

8.2.4 Open the directional control valve, and adjust the variable restrictor valve to maintain 75 % of the maximum working pressure.

8.2.5 Close the directional control valve while recording the instantaneous pressure against time. From this recording, determine the rate of pressure rise in megapascals per second, and the pressure compensator response and settling times in milliseconds, and the overshoot when output pressure approaches each set pressure (see Figure 10). Pressure is considered stabilized when the amplitude of fluctuation falls within the normal band of pressure ripple.



[a] Rate of pressure rise.

[b] Rate of pressure drop.

[c] Deadhead pressure.

[d] Overshoot (rise).

[e] Settling time (descent).

[f] 75 % deadhead pressure.

[g] Response time.

[h] Settling time (rise).

Figure 10 — Pressure compensator response and recovery

8.2.6 Open the directional control valve while recording the instantaneous pressure against time. From this recording, determine the rate of pressure drop in megapascals per second and the pressure compensator response and settling times in milliseconds, and the overshoot when output pressure approaches each set pressure (see Figure 10). Pressure is considered stabilized when the amplitude of fluctuation falls within the normal band of pressure ripple.

8.2.7 Repeat 8.2.4 to 8.2.6 at 50 % and 25 % of the rated flow rate.

8.3 Test of step response versus output pressure — Test procedure and presentation of test results

8.3.1 If the pump has pressure and flow rate control functions, select the input pressure command signal and input flow command signal, and adjust them to their maximum values.

8.3.2 Completely close the loading valve, and operate the pump at the minimum controllable pressure.

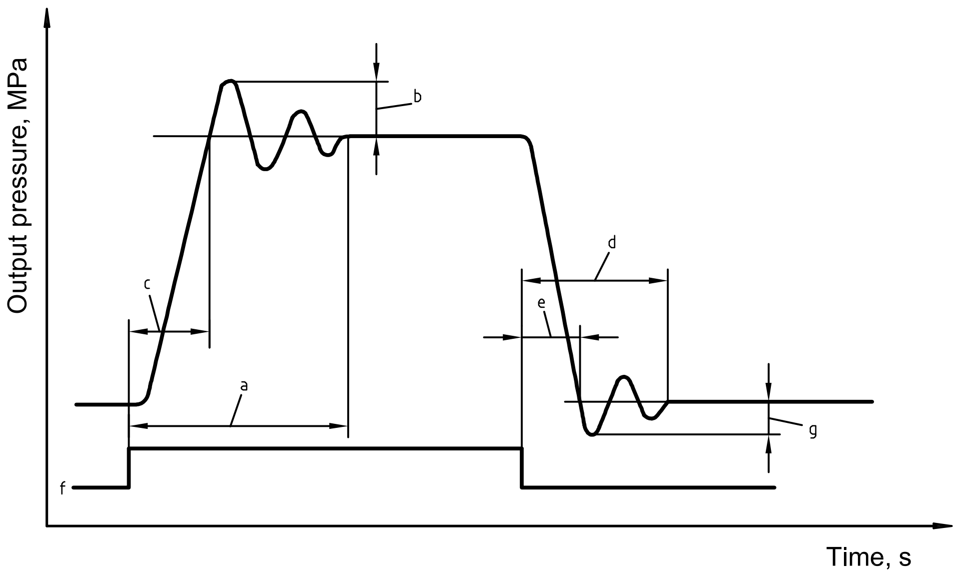
8.3.3 Using a function generator, provide stepped input signals for pressure control to obtain 100 %, 75 % and 50 % of the maximum working pressure.

8.3.4 Using a recorder of sufficiently high response performance compared with the dynamic response characteristics of the pump, simultaneously record the input signal and the output pressure dynamic response waveforms, and graphically present the input signal and output pressure as a function of time (see Figure 11).

NOTE The amplitude ratio of the recorder should be −3 dB at a frequency which is 10 times the maximum signal frequency.

8.3.5 Pressure is considered stabilized when the amplitude of fluctuation falls within the normal band of pressure ripple. From the recorded data, read the pressure compensator response and settling times in milliseconds, and the overshoot when output pressure approaches each set pressure.

8.3.6 Record the load volume, piping length, inside diameter and pipe type.



[a] Settling time (rise).

[b] Overshoot (rise).

[c] Response time (rise).

[d] Settling time (descent).

[e] Response time (descent).

[f] Input signal (mA or V).

[g] Overshoot (descent).

Figure 11 — Step response of output pressure

8.4 Test of step response versus output flow — Test procedure and presentation of test results

8.4.1 If the pump has pressure and flow rate control functions, select the input pressure command signal and adjust it to the maximum working pressure.

8.4.2 Using a function generator, provide stepped input signals for output flow to the pump and vary the output flow from 10 % to 90 %, 75 %, 50 % and 25 % of the maximum output flow.

8.4.3 Set the variable restrictor to obtain 50 % of the maximum working pressure for the respective upper flow rate limits.

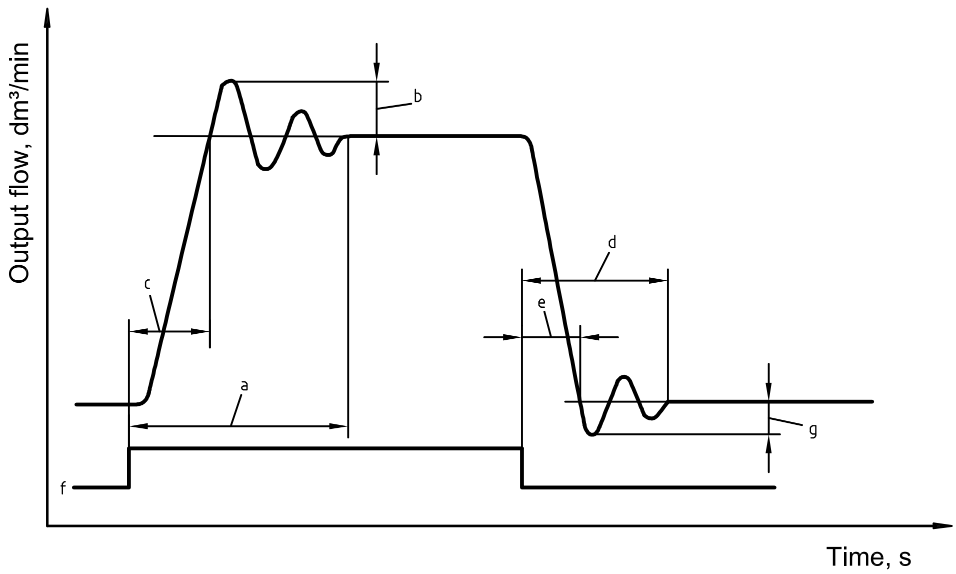
NOTE A loading valve may be used instead of the variable restrictor if the dynamic response performance of the loading valve is sufficiently high compared with the dynamic response characteristics of the pump.

8.4.4 Using a suitable recorder of sufficiently high response performance compared with the dynamic response characteristics of the pump, simultaneously record the output flow dynamic response waveforms, and graphically present the input signal and output flow as a function of time (see Figure 12).

NOTE The amplitude ratio of the recorder should be −3 dB at a frequency which is 10 times the maximum signal frequency.

8.4.5 Flow rate is considered stabilized when fluctuations fall within the ±5 % band of the object flow rate. From the recorded data, read the response and settling times in milliseconds and overshoot when output flow approaches each set flow rate.

8.4.6 Record the load volume, piping length, inside diameter, and pipe type.



[a] Settling time (rise).

[b] Overshoot (rise).

[c] Response time (rise).

[d] Settling time (descent).

[e] Response time (descent).

[f] Input signal (mA or V).

[g] Overshoot (descent).

Figure 12 — Step response of output flow

8.5 Frequency response

8.5.1 Frequency response test on pressure — Test procedure and expression of results

8.5.1.1 For pumps conforming to 8.3.1, completely close the loading valve. Adjust the deadhead pressure to 50 % of the maximum working pressure and, centring on this pressure, apply a sinusoidal input signal of sufficiently low frequency with amplitudes of ± 5 % and ± 12,5 % of the maximum working pressure. Then completely close the loading valve. Adjust the deadhead pressure to 50 % of the maximum working pressure and open the loading valve to obtain 50 % of the maximum output flow. Adjust pressure to 50 % of the maximum working pressure and, centring on this pressure, apply a sinusoidal input signal of sufficiently low frequency with amplitudes of ± 5 % and ± 12,5 % of the maximum working pressure.

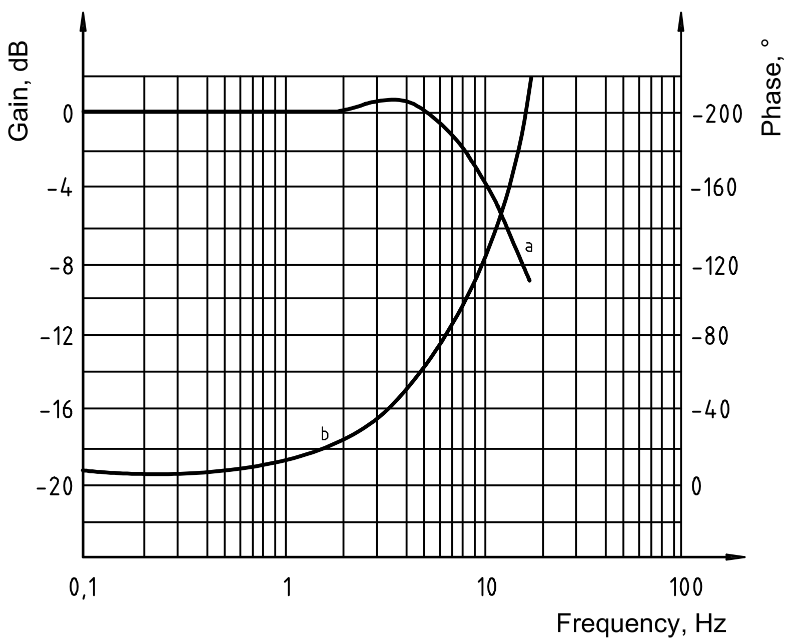
The test shall be performed at two different conditions: one with the loading valve completely closed, and the other with the valve opened by 50 %.

8.5.1.2 Sweep the sinusoidal wave input signal frequency over a range of approximately 1/20th to 10 times the break-point frequency of the tested pump. The speed of the sweep should be appropriate for the measurements.

8.5.1.3 Using a true frequency response analyser of sufficiently high response performance compared to the dynamic response characteristics of the pump, simultaneously show a graphical representation with time on the horizontal axis, and input signal and output pressure on the vertical axis.

8.5.1.4 Read the amplitude ratio and phase lag in correlation to frequency from the recorded data and express the relationship as a Bode diagram (see Figure 13). Frequency response test results shall be presented in the Bode format, that is, amplitude in decibels referenced to the zero-frequency amplitude, and phase lag in degrees versus log frequency. The use of single-point benchmarks such as 3 dB down points and 90° phase lag points shall be discouraged.

8.5.1.5 Record the load volume, piping length, inside diameter, and pipe type.



[a] Gain curve.

[b] Phase curve.

Figure 13 — Bode diagram of frequency response on output pressure

8.5.2 Frequency response test on output flow — Test procedure and expression of results

8.5.2.1 For pumps conforming to 8.4.1, connect a simple, passive load that allows adjustment of the instantaneous output pressure so that the working pressure of the pump is not exceeded at any test amplitude or frequency. Adjust the pressure to 50 % of the maximum working pressure and, centring on this pressure, apply a sinusoidal input signal in accordance with 8.5.2.2 and 8.5.2.3.

8.5.2.2 Adjust the output flow to 50 % of the maximum output flow and, centring on this output flow, apply a sinusoidal input signal of sufficiently low frequency with amplitudes of $\pm$ 5 % and $\pm$ 12,5 % of the maximum output flow.

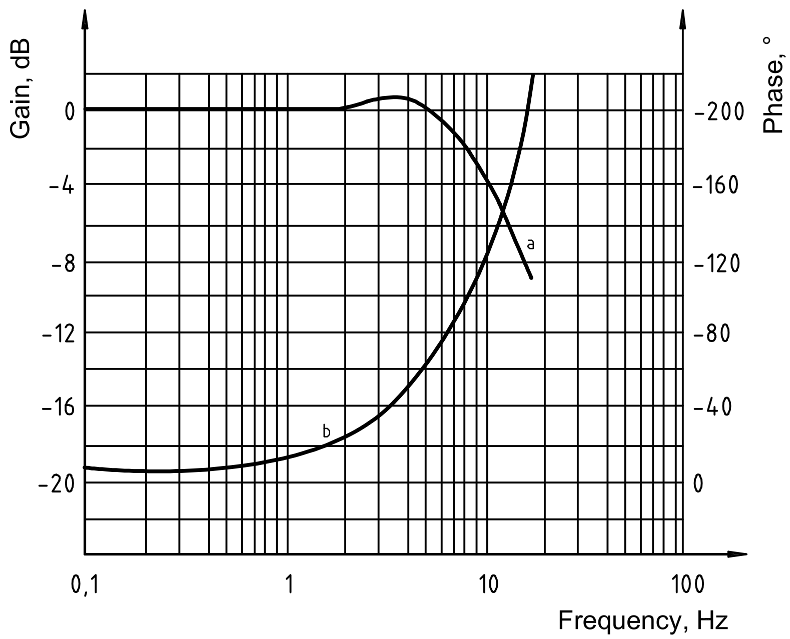
8.5.2.3 The preferred method is to use a transducer at a suitable position to measure the pump's output response as the position of the pump's cam or swash plate, as applicable. However, if it is known that the flow transducer used has been demonstrated to be at least 10 times faster than that required by the highest test frequency of interest, then such a flow transducer may be used as an alternative to measuring the cam/swash plate position.

8.5.2.4 Sweep the sinusoidal input signal in accordance with 8.5.1.2.

8.5.2.5 Using a true frequency response analyser of sufficiently high response performance compared to the dynamic response characteristics of the pump, simultaneously show a graphical representation with time on the horizontal axis and input signal and output flow on the vertical axis.

8.5.2.6 Obtain the Bode diagram (see Figure 14) from the record in accordance with 8.5.1.4.

8.5.2.7 Record the load volume, piping length, inside diameter, and pipe type.



[a] Gain curve.

[b] Phase curve.

Figure 14 — Bode diagram of frequency response on output flow

Annex A
(normative)

Classes of measurement accuracy

A.1 Classes of measurement accuracy

Tests shall be carried out to one of three classes of measurement accuracy, A, B or C, as agreed by the parties concerned.

NOTE 1 Classes A and B are intended for special cases where a higher precision is required.

NOTE 2 Classes A and B tests require more accurate apparatus and methods that can increase costs.

A.2 Errors

Systematic errors of any and all means of measurement to be made according to this International Standard shall not exceed the limits given in Table A.1, when they are calibrated or otherwise examined in accordance with the relevant International Standard.

Table A.1 — Permissible systematic errors of measuring instruments as determined during calibration

Parameter of measuring instrument	Permissible systematic errors measurement accuracy		
	A	B	C
Pressure, Pa; where $p < 2 \times 10^5$ Pa gauge	$\pm 1 \times 10^3$	$\pm 3 \times 10^3$	$\pm 5 \times 10^5$
Pressure, %; where $p \geqslant 2 \times 10^5$ Pa gauge	± 0,5	± 1,5	± 2,5
Temperature, °C	± 0,5	± 1	± 2
Flow rate, %	± 0,5	± 1,5	± 2,5
Rotational speed, %	± 0,5	± 1	± 2
Input signal, %	± 0,5	± 1,5	± 2,5

Bibliography

[1] ISO 1219-1, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols*

[2] ISO 1219-2, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 2: Circuit diagrams*

[3] ISO 10767-1, *Hydraulic fluid power — Determination of pressure ripple levels generated in systems and components — Part 1: Precision method for pumps*

[4] ISO 10767-2, *Hydraulic fluid power — Determination of pressure ripple levels generated in systems and components — Part 2: Simplified method for pumps*

[5] SAE Recommended Practice — SAE J745, *Hydraulic Power Pump Test Procedure*, Sept. 1996

blank

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

Details and advice can be obtained from the Copyright & Licensing Manager. Tel: +44 (0)20 8996 7070. Fax: +44 (0)20 8996 7553. Email: copyright@bsi-global.com.

BSI
389 Chiswick High Road
London
W4 4AL