

Methods of

Test for electrohydraulic servovalves

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The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

- Association of British Mining Equipment Companies
- British Hydromechanics Research Association
- Institute of Measurement and Control
- Post Office

Amendments issued since publication

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Contents

	Page
Cooperating organizations	Inside front cover
Foreword	ii
1 Scope	1
2 References	1
3 Symbols and units	1
4 Definitions	2
5 Standard test conditions	5
6 Test installation	5
7 Electrical tests	5
8 Steady-state tests	9
9 Dynamic tests	12
10 Endurance test	13
11 Pressure impulse test	13
12 Environmental tests	14
13 Presentation of test results	14
Appendix A Typical plots	16
Appendix B Errors and classes of measurement	22
Figure 1 — Steady-state test circuit	6
Figure 2 — Frequency response test circuit	7
Figure 3 — Transient response test circuit	8
Figure 4 — Servovalve coil impedance test	8
Figure 5 — Voltage vector diagram	9
Figure 6 — Load pressure drop versus input current	17
Figure 7 — No-load flow versus input current	18
Figure 8 — Internal leakage versus input current	19
Figure 9 — Control flow versus load pressure drop	19
Figure 10 — Null bias versus supply pressure	20
Figure 11 — Null bias versus return pressure	20
Figure 12 — Null bias versus temperature	21
Figure 13 — Frequency response	21
Figure 14 — Transient response	22
Table 1 — Symbols and units	1
Table 2 — Permissible systematic errors of measuring instruments as determined during calibration	22
Publications referred to	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Mechanical Engineering Standards Committee. It incorporates the latest proposals (ISO/DP 6404) approved by Technical Committee ISO/TC 131/SC 8 of the International Organization for Standardization (ISO).

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 22, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

1.1 This British Standard describes methods of test for electrohydraulic servovalves, namely production acceptance and type (or qualification) tests.

The standard does not include methods for determining the characteristics associated with external closed-loop control systems.

1.2 The standard has been prepared primarily for electrohydraulic flow control servovalves without interstage electrical feedback but many sections are equally applicable to other types of servovalve such as pressure control servovalves and servovalves with interstage feedback.

2 References

The titles of the publications referred to in this standard are listed on the inside back cover.

3 Symbols and units

The symbols and units listed in Table 1 shall be used in the application of this standard.

Table 1 — Symbols and units

Parameters	Symbol	Unit
Coil impedance	Z	Ω
Coil inductance	L	H
Coil resistance	R	Ω
Dither amplitude	—	mA
Dither frequency	—	Hz
Input current	I	mA
Rated current	I_n	mA
Control flow	Q	litre/min
Flow gain	$K_v (\partial q/\partial I)$	litre/(min mA)
Hysteresis	—	mA
Internal leakage	Q_l	litre/min
Load pressure drop	$p_l = p_a - p_b$	bar
Supply pressure	p_s	bar
Rated pressure	$p_n = p_v + p_l = p_s - p_r$	bar
Return pressure	p_r	bar
Control pressure	p_a or p_b	bar
Servovalve pressure drop	$p_v = p_s - p_r - p_l$	bar
Pressure gain	$S_v (\partial p_e/\partial I)$	bar/mA
Resolution	—	mA
Threshold	—	mA
Amplitude ratio	—	dB
Phase lag	—	degree

NOTE 1 bar = 10^5 N/m² = 10^5 Pa.

4 Definitions

For the purposes of this British Standard, the following definitions apply.

4.1

amplitude ratio

the ratio of the control flow amplitude to sinusoidal input signal amplitude at a particular frequency, normalized by using a specified low frequency as datum at the same input signal

4.2

coil impedance

the complex ratio of coil voltage to coil current at specified conditions, which may vary with signal frequency, amplitude and other operating conditions, e.g. due to back e.m.f. generated by the moving armature

4.3

coil resistance

the d.c. coil resistance at a specified temperature

4.4

control flow

the flow through the servovalve control ports

4.5

control flow, loaded

the flow through the servovalve control ports when there is load pressure drop

4.6

control flow, no load

the flow through the servovalve control ports when there is zero load pressure drop

4.7

dither

a low amplitude, relatively high frequency periodic electrical signal, sometimes superimposed on the servovalve input to improve system resolution. Dither is expressed by the dither frequency and the peak dither current amplitude (mA). Percentage dither is the ratio of dither amplitude to rated signal

4.8

electrical control power

the power dissipation required for operation of the servovalve. Control power is a maximum with full input signal, and is zero with zero input signal. It is independent of the coil connection (series, parallel or differential) for any conventional two-coil operation. For differential operation (push-pull), the control power is the power consumed in excess of the electrical quiescent power. This power change is a result of the differential current change

4.9

electrical quiescent power

the power dissipation required for differential operation when the current through each coil is equal and opposite in polarity

4.10

electrohydraulic servovalve

a hydraulic servovalve in which the input command is electrical

4.11

feedback

the means whereby the state of the controlled element is signalled

4.12

flow curve

the graphical representation of control flow versus input signal. This is usually a continuous plot of a complete cycle between plus and minus rated signal servovalves at a cycle rate which is unaffected by the servovalve dynamic characteristics

4.13

flow curve, normal

the locus of the mid-points of the complete cycle flow curve

4.14

flow gain

the mean slope of the control flow versus input signal curve in any specific operating region. Three operating regions are usually significant with flow control servovalves

the null region

the normal region of flow control, and

the region where flow saturation effects may occur.

where this term is used without qualification, it is assumed to mean normal flow gain

4.15

flow limit

the condition where control flow no longer increases with increasing input signal

4.16

flow linearity

the deviation which exists between the normal flow curve and an idealized flow curve of slope equal to normal flow gain. Linearity is defined as the maximum deviation and expressed as a percentage of rated signal

4.17**frequency response**

the complex ratio of control flow to input signal as the current is varied sinusoidally over a range of frequencies. Frequency response is normally measured with constant input signal amplitude and zero load pressure drop, expressed as amplitude ratio and phase lag. The servovalve frequency response may vary with the input signal amplitude, temperature, supply pressure and other operating conditions

4.18**hydraulic servovalve**

a valve which modulates hydraulic output

4.19**hysteresis**

the difference in the valve input signals required to produce the same valve output during a single cycle of servovalve input signal when cycled at a rate below that at which dynamic effects are important; it is expressed as a percentage of the rated signal. Maximum hysteresis is normally indicated and is the maximum difference in input signal occurring in a cycle shown as a percentage of rated signal

4.20**input current (input signal)**

the effective current to the servovalve which produces a given output

4.21**internal leakage**

the total internal servovalve flow from pressure to return with zero control flow (usually measured with control ports blocked). Leakage flow will vary with input pressure and input signal

4.22**lap**

in a sliding spool valve, the relative axial position relationship between the fixed and movable flow-metering edges with the spool at null

4.23**load pressure drop**

the differential pressure between the control ports. This is denoted as a positive pressure if the higher of the two values is connected to supply pressure and the lower to return. A negative value implies that the higher of the load pressures is connected to return pressure and the lower to supply. Thus a positive pressure drop denotes an opposing load implying a flow of energy to the actuator, while a negative load pressure drop denotes an assisting load implying absorption of energy from the actuator

4.24**null**

this relates to geometric null which is the zero control flow at zero load pressure drop

4.25**null bias**

the input signal required to bring the servovalve to null excluding the effects of valve hysteresis, expressed as a percentage of the rated signal

4.26**null (quiescent) leakage**

total internal leakage from the servovalve in the null (or quiescent) position

4.27**null pressure**

the equalized pressure existing at both control ports at null

4.28**null region**

the region about null where the flow gain is effected by parameters such as lap and internal leakage

4.29**null shift**

a change in null bias expressed as a percentage of the rated signal. Null shift may occur with changes in supply pressure, temperature and other operating conditions

4.30**output stage**

the final stage of hydraulic amplification used in a servovalve

4.31**overlap**

a condition where the fixed and movable flow-metering edges do not coincide with the spool at null in such a way that a relative displacement between the metering edges has to occur before a flow path is created

4.32**phase lag**

a measure of the instantaneous time by which the sinusoidal output follows the sinusoidal input signal at a specified frequency. This is usually expressed in degrees as the vector angle between input and output

4.33**pressure gain**

the change in load pressure drop per unit input signal with zero control flow (control ports blocked). Pressure gain is specified as the average slope of the curve of load pressure drop versus input signal in the defined region

4.34**quiescent current**

a direct current of opposite polarity in each valve coil when using a differential coil connection producing zero output

4.35**rated current (rated signal)**

the specified input current of either polarity to produce rated flow. Rated current must be specified for a particular coil connection (differential, series, or parallel) and does not include null bias current

4.36**rated flow**

the specified control flow corresponding to rated current at a specified servovalve pressure drop. Rated flow is normally specified as no-load flow

4.37**resolution**

the increment of input signal required to produce a change in servovalve output at a specified signal level, expressed as a percentage of the rated signal. Resolution is normally specified as the minimum signal required to cause either an increase or a decrease of valve output. If these signals differ, the larger of the two should be quoted

4.38**response time**

the time lapse between the initiation point of an operation and its point of completion; the initiation point being a given value of the control signal (increasing or decreasing) and the completion point being a given value of the servovalve output

4.39**return pressure (back pressure)**

the pressure at the return port of the servovalve

4.40**servovalve**

a valve which accepts an analogue control signal and provides a corresponding analogue fluid power output

4.41**stage**

a hydraulic amplifier used in a servovalve. Servovalves may be single stage, two stage, three stage, etc.

4.42**supply pressure**

the pressure (frequently at nominally constant value) at the supply port of the servovalve

4.43**symmetry**

the degree of equality between the servovalve normal flow gain of one polarity and that of the reversed polarity. Symmetry is measured as the difference in normal flow gain of each polarity, expressed as a percentage of the greater

4.44**threshold**

the change of input signal required to produce a reversal in valve output at null expressed as a percentage of rated signal

4.45**torque motor**

a type of electromechanical transducer, having rotary motion, which is used in the input stages of a servovalve

4.46**total electrical power**

the sum of the instantaneous control power and the quiescent power

4.47**transfer function**

a differential equation in Carson notation or using the Laplace operator, which uniquely describes the relationship of the controlled flow to the input signal at zero load

4.48**travel**

the displacement of the servovalve spool in either direction relative to the geometric null

4.49**underlap**

a condition where the fixed and movable flow-metering edges do not coincide with the spool at null in such a way that a flow path exists across two or more metering edges with the spool at null

4.50**valve polarity**

the relationship between the direction of control flow and the direction of input current

4.51**valve pressure drop**

the sum of the differential pressures across the control orifices of the output stage. The valve pressure drop will equal the supply pressure minus the return pressure minus the load pressure drop

4.52

zero lap

a condition where the fixed and movable flow-metering edges coincide with the spool at null, giving rise to constant flow gain over the null and operational regions

5 Standard test conditions

Unless otherwise specified, the following standard test conditions shall apply to all tests specified in this standard.

Ambient temperature:	20 ± 5 °C
Filtration:	solid contaminant code to be stated (in accordance with BS ^a)
Fluid type:	commercially available mineral based hydraulic fluid
Fluid temperature:	40 ± 6 °C servovalve inlet temperature
Viscosity grade:	VG 32 as described in BS 4231
Supply pressure:	rated pressure + return pressure
Return pressure:	not to exceed 5 % of rated pressure

^a In course of preparation.

6 Test installation

A suitable test installation shall be provided. However, the suitability of any particular installation will be dependent upon its ability to meet the permissible limits of error stated in Appendix B.

The circuit of a typical steady-state test installation is shown in Figure 1. This installation allows:

- either point-to-point or continuous plotting methods for recording the results;
- a single differential pressure transducer to be substituted for the two absolute transducers.

The circuits of typical dynamic test installations are shown in Figure 2 and Figure 3. These installations utilize much of the circuit shown in Figure 1.

NOTE The graphical symbols used in Figure 1 to Figure 3 are in accordance with BS 2917 and BS 3939.

7 Electrical tests

7.1 Insulation resistance. The insulation resistance of the servovalve coil and connection shall be measured as follows. Servovalves need not be pressurized for this test, however, if internal electrical components are in contact with the fluid (i.e. wet-coil servovalve) the valve shall be filled with hydraulic fluid.

Connect together the coil terminations and apply, between them and the servovalve body, a d.c. voltage of five times the maximum anticipated coil voltage or 500 V, whichever is the greater. Maintain this voltage for a period of 60 s and then, with the voltage still applied, using a suitable commercially available insulation tester, measure the current flowing. From the ratio of the applied voltage to current flowing, calculate the insulation resistance (this should normally exceed 100 MΩ). With a four-lead, two-coil configuration, this test should also be performed between the coils.

7.2 Coil resistance. Since the resistance of a servovalve coil is temperature dependent, time shall be allowed for stabilization to room temperature. Using an electrical test instrument having an accuracy of ± 2 %, measure the resistance of the servovalve coil, or each coil separately if the servovalve has more than one. The servovalve need not be supplied with pressurized fluid during the measurement of coil resistance.

7.3 Coil inductance. The total coil inductance (corresponding to the series coil connection for a four-lead, two-coil configuration) shall be measured with the servovalve operating under the standard test conditions of clause 5. This test measures the apparent inductance, which varies with signal frequency and amplitude due to the back e.m.f. generated by the moving armature. The result may be used to select the appropriate design of drive amplifier.

Connect a suitable oscillator to drive the total servovalve coil which is in series with a precision non-inductive resistor, as shown in Figure 4. Set the oscillator frequency f at 50 Hz or 60 Hz, whichever is different from the frequency of the electrical power supply to the test equipment, and adjust the servovalve input current to a peak amplitude equal to the servovalve rated current. The oscillator shall be capable of supplying undistorted current to the servovalve.

NOTE To check that undistorted current is being supplied, the voltage waveform across the resistor, R , should be monitored with an oscilloscope.