INTERNATIONAL STANDARD

ISO 10770-1

First edition
1998-05-15

Hydraulic fluid power — Electrically modulated hydraulic control valves —

Part 1:
Test methods for four-way directional flow control valves

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Transmissions hydrauliques — Distributeurs hydrauliques à modulation électrique —

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International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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Annexes

Foreword

ISO (the International Organisation for Standardisation) 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 organisations, 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 standardisation.

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.

International Standard ISO 10770-1 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 8, *Product testing.*

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This first edition of ISO 10770-1 together with ISO 10770-2 cancel and replace ISO 6404:1985, of which they constitute a technical revision. In particular, ISO 10770 is wider-ranging and more comprehensive, covering both servovalves and proportional valves.

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ISO 10770 consists of the following parts, under the general title *Hydraulic fluid power — Electrically modulated hydraulic control valves*:

— *Part 1: Test methods for four-way directional flow control valves*

— *Part 2: Test methods for three-way directional flow control valves*

— *Part 3: Test methods for pressure control valves*

Annex A forms an integral part of this part of ISO 10770. Annexes B and C are for information only.

Introduction

In hydraulic fluid power systems, power is transmitted by a fluid under pressure from a hydraulic power source to one or several loads through electrically modulated hydraulic control valves.

These control valves are components which receive control signals in the form of an electrical signal, receive hydraulic power from a power source, and then, control the direction and amount of hydraulic flow to the load, depending upon the electrical input signal. There are a number of performance characteristics that must be known in order to successfully apply electrically modulated hydraulic control valves.

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Hydraulic fluid power — Electrically modulated hydraulic control valves —

Part 1:
Test methods for four-way directional flow control valves

1 Scope

This part of ISO 10770 describes methods for production acceptance and type (or qualification) testing of electrically modulated hydraulic four-way directional flow control valves.

2 Normative references

The following standards contain provisions, which, through reference in this text, constitute provisions of this part of ISO 10770. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10770 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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ISO 1219-1:1991, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols.*

ISO 3448:1992, *Industrial liquid lubricants — ISO viscosity classification.*

ISO 4406:1987, *Hydraulic fluid power — Fluids — Method for coding level of contamination by solid particles.*

ISO 5598:1985, *Fluid power systems and components — Vocabulary.*

ISO 6743-4:1982, *Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems).*

IEC 617, *Graphical symbols and diagrams.*

3 Definitions

For the purposes of this part of ISO 10770, the definitions given in ISO 5598 and the following definition apply.

3.1 electrically modulated hydraulic flow control valve: Valve that provides a degree of proportional flow control in response to a continuously variable electrical input signal.

4 Symbols and units

The symbols and units for the parameters referred to in this part of ISO 10770 are listed in table 1.

Table 1 — Symbols and units

Parameter	Symbol	Unit
Coil impedance	Z	Ω
Coil inductance	L	H
Coil resistance	R	Ω
Insulation resistance	R_i	Ω
Dither amplitude	—	% of max. input signal
Dither frequency	f_d	Hz
Input signal	I or U	A or V
Rated signal	I_N or U_N	A or V
Output flow	q	l/min
Rated flow	q_N	l/min
Flow gain	$K_v = (\delta q/\delta I$ or $\delta q/\delta U)$	l/min/input signal unit
Hysteresis	—	% of max. input signal
Internal leakage	q_l	l/min
Supply pressure	p_P	MPa (bar)
Return pressure	p_T	MPa (bar)
Load pressure	p_A or p_B	MPa (bar)
Load pressure difference	$p_L = p_A - p_B$ or $p_B - p_A$	MPa (bar)
Valve pressure drop	$p_v = p_P - p_T - p_L$	MPa (bar)
Rated valve pressure drop	p_N	MPa (bar)
Pressure gain	$S_v = (\delta p_L/\delta I$ or $\delta p_L/\delta U)$	MPa (bar)/input signal
Threshold	—	% of max. input signal
Amplitude	—	dB
Phase lag	—	degree
Temperature	—	°C
Frequency	f	Hz
Time	t	s
NOTE — 1 bar = 10^5 N/m^2 = 0,1 MPa		

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5 Standard test conditions

Unless otherwise specified, the standard test conditions given in table 2 shall apply to all tests described in this part of ISO 10770.

Table 2 — Standard test conditions

Ambient temperature	(20 ± 5) °C
Filtration	Solid contaminant code number to be stated in accordance with ISO 4406
Fluid type	Commercially available mineral based hydraulic fluid, i.e. L-HL in accordance with ISO 6743-4 or other fluid with which the valve is capable of operating
Fluid temperature	(40 ± 6) °C at valve inlet
Viscosity grade	Grade VG 32 in accordance with ISO 3448
Supply pressure	In accordance with relevant test requirement ± 2,5 %
Return pressure	In accordance with manufacturer's recommendations
NOTE — Where an alternative hydraulic fluid is used, the fluid type and viscosity grade shall be specified.	

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6 Test installation

6.1 General

A test installation shall be provided which complies with 6.2 and 6.3 and which is capable of meeting the permissible limits of error stated in annex A. General guidance on conducting the tests is given in annex B.

NOTES

1 Figures 1, 2 and 3 are typical circuits that do not incorporate all the safety devices necessary to protect against damage in the event of component failure. Other circuits which achieve the same purpose may be used. It is important that those responsible for conducting the tests give consideration to safeguarding personnel and equipment.

2 The graphical symbols used in figures 1, 2 and 3 are in accordance with ISO 1219-1 and IEC 617.

6.2 Steady state tests

A typical test circuit is shown in figure 1. This installation allows either point-to-point or continuous plotting methods for

a) recording flow as a function of input signal;

b) recording pressure as a function of input signal;

c) recording flow as a function of valve pressure drop;

d) recording flow as a function of load pressure difference;

e) recording flow as a function of temperature.

6.3 Dynamic tests

A typical test circuit is shown in figure 2. This installation utilizes much of the circuit shown in figure 1. This installation allows

a) frequency response tests;

b) step response tests.

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7 Electrical tests

7.1 General

The tests described in 7.2 to 7.4, as appropriate, shall be carried out on all valves without integrated electronics before proceeding to subsequent tests.

7.2 Coil resistance

The test shall be performed with the coil at the specified ambient temperature. Using an electrical test instrument with an accuracy better than ± 2 % of the measured value, measure the resistance between the two leads of each coil in the valve.

NOTE — The valve under test need not be supplied with pressurized fluid during the measurement of coil resistance.

7.3 Coil inductance

7.3.1 Measure the total coil inductance (corresponding to the series coil connection for a four-lead, two-coil configuration) with the valve operating under the standard test conditions laid down in clause 5.

NOTE — This test measures the apparent inductance, which varies with signal frequency and amplitude due to the back emf (electro-motive force) generated by the moving armature. The result may be used to select the appropriate design of drive amplifier.

7.3.1.1 Connect a suitable oscillator to drive the total valve coil which is in series with a precision non-inductive resistor, as shown in figure 3 a).

7.3.1.2 Set the oscillator frequency, *f*, at either 50 Hz or 60 Hz, so that it is different from the frequency of the electrical power supply to the test equipment.

7.3.1.3 Adjust the valve input current to a peak amplitude equal to the valve rated current.

7.3.1.4 Use an oscillator which is capable of supplying undistorted current to the valve.

7.3.1.5 Using an oscilloscope, monitor the voltage waveform across the resistor *R* to check that the waveform is sinusoidal.

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7.3.1.6 Measure the peak a.c. voltages U_R, U_T and U_V.

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7.3.1.7 Construct the diagram shown in figure 3 b) to show the vectorial relationship of the voltages.

7.3.1.8 Determine the coil impedance characteristics from the following expressions:

— coil impedance, expressed in ohms

$$Z = R \frac{U_V}{U_R} \qquad \text{. . (1)}$$

— apparent inductance, expressed in henry

$$L = \frac{R}{2\pi f} \times \frac{U_L}{U_R} \qquad \text{. . . (2)}$$

7.3.2 Alternative test method: use step response to full current to give time constant t_c of coil and calculate inductance using:

$$L = R_c \times t_c \quad \text{(as indicated at figure 4)} \qquad \text{. . . (3)}$$

7.4 Insulation resistance

Connect together the coil terminations and apply between them and the valve body a d.c. voltage of 500 V. Maintain this for 15 s. With this voltage still applied, use a suitable commercially available insulation tester to measure the insulation resistance. On those testers with a current readout, as opposed to a resistance readout, calculate the resistance, in ohms, from the following equation:

$$R_i = \frac{500\ \mathrm{V}}{I} \quad \ldots (4)$$

where the current measured, I, is expressed in amperes.

This resistance normally exceeds 100 MΩ. In addition, with a four-lead two-coil configuration, similarly determine the resistance between the coils. If internal electrical components are in contact with the fluid (i.e. wet coil), fill the valve with hydraulic fluid before carrying out this test.

8 Performance tests

Conduct all the following tests such that the amplifier specified by the valve manufacturer is included in the test system (when specified).

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If an external pulse width modulating amplifier is used, record the modulation frequency, the dither frequency, and the amplitude.

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In all cases record the amplifier supply voltage.

NOTE — All performance tests should be conducted on a combination of valve and amplifier. Input signals are applied to the amplifier and not directly to the valve.

8.1 Steady state tests

8.1.1 General

When conducting these tests, care should be taken to exclude dynamic effects.

Test a) shall be performed prior to carrying out any other tests.

a) Proof pressure tests, in accordance with 8.1.2.

b) Internal leakage test, in accordance with 8.1.3.

c) Test for output flow versus input signal at constant valve pressure drop, in accordance with 8.1.4 and 8.1.5 to determine

   1) rated flow;

   2) flow gain;

3) flow linearity;

4) flow hysteresis;

5) flow symmetry;

6) flow polarity;

7) spool lap condition;

8) threshold.

d) Flows across lands versus input signal in accordance with 8.1.6.

e) Output flow versus load pressure difference in accordance with 8.1.7.

f) Output flow versus valve pressure drop in accordance with 8.1.8.

g) Limiting output flow versus valve pressure drop in accordance with 8.1.9.

h) Output flow versus fluid temperature in accordance with 8.1.10.

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i) Pressure difference versus fluid temperature in accordance with 8.1.11.

j) Pressure gain versus input signal in accordance with 8.1.12.

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k) Pressure null shift in accordance with 8.1.13

l) Fail-safe function test in accordance with 8.1.14

8.1.2 Proof pressure tests

8.1.2.1 General

Proof pressure tests shall be carried out to examine the integrity of the valve before conducting any further tests.

A simplified high pressure test rig may be used for these tests in place of that shown in figure 1.

8.1.2.2 Supply proof pressure

In the test, a proof pressure is supplied to the pressure and control ports of the valve with the return port open. The test shall be carried out as follows.

8.1.2.2.1 Test circuit

Set up the hydraulic test circuit shown in figure 1, with valves g and j open and all other valves closed.

8.1.2.2. Set up

Adjust the valve supply pressure to achieve 1,3 times the maximum rated supply pressure or 35 MPa (350 bar), whichever is the lower.

8.1.2.2.3 Procedure

Maintain the supply pressure for a minimum of 30 s.

For approximately half of this period apply the maximum positive input signal and for the remainder of the test apply the maximum negative input signal.

Examine the valve for evidence of external leakage or permanent deformation during the test.

8.1.2.3 Return port proof pressure

In the test, a proof pressure is supplied to the pressure port, control ports and the return port of the valve. The test shall be carried out as follows.

8.1.2.3.1 Test circuit

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Set up the hydraulic test circuit shown in figure 1, with valves c, e and h open and all other valves closed.

8.1.2.3.2 Set up

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Adjust the valve supply pressure to achieve 1,3 times the maximum return port pressure.

8.1.2.3.3 Procedure

Maintain this pressure for a minimum of 30 s.

For approximately half of this period apply the maximum positive input signal and for the remainder of the test apply the maximum negative input signal.

There shall be no external leakage or permanent deformation during the test.

8.1.3 Internal leakage test (control ports blocked)

8.1.3.1 General

Before commencing the test, any mechanical/electrical adjustments necessary shall be made, such as nulling the valve, and then the test shall be carried out to determine the total internal leakage, including any pilot control flow, in the following manner.

8.1.3.2 Test circuit

Set up the hydraulic test circuit shown in figure 1, with valve g open and all other valves closed.

8.1.3.3 Set up

Adjust the valve supply pressure to 10 MPa (100 bar) above return pressure, and pilot pressure where applicable.

8.1.3.4 Procedure

Proceed as follows:

a) Immediately before the leakage measurements are to be taken, operate the valve over its full input signal range several times.

b) Record the leakage flow from the T and y ports over a range from maximum positive to maximum negative input signal (see figure 5).

These tests may, if required, be repeated at additional pressures up to the maximum supply pressure of the valve under test.

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NOTE — For spools with special features, it may be necessary to determine the pilot flow independently and to determine the rate of leakage between the ports. See 8.1.6.

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8.1.4 Output flow versus input signal characteristics at constant valve pressure drop (open control ports)

8.1.4.1 General

The test shall be carried out to obtain the flow versus input signal curve and to deduce the steady-state valve characteristics.

8.1.4.2 Test circuit

8.1.4.2.1 For multi-stage valves with integral pilot supply, use an appropriate modified circuit configuration, incorporating, for example, either:

a) a pressure compensator inserted between the valve and the test manifold, or

b) using a loading valve as shown in figure 1, to load the valve under test, which operates under open or closed loop conditions, to maintain constant valve pressure drop.

8.1.4.2.2 Set up the hydraulic test circuit shown in figure 1, with valves a, b, c, d, g, j open and all other valves closed.