INTERNATIONAL STANDARD

ISO 10770-1

Second edition
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Hydraulic fluid power — Electrically modulated hydraulic control valves —

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

Transmissions hydrauliques — Distributeurs hydrauliques à modulation électrique —

Partie 1: Méthodes d'essai pour distributeurs de commande de débit à quatre voies

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

This second edition cancels and replaces the first edition (ISO 10770-1:1998), which has been technically revised.

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-port directional flow-control valves*

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

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

Introduction

This part of ISO 10770 has been prepared with the intention of improving the uniformity of valve testing and hence the consistency of recorded valve performance data so that these data can be used for system design, regardless of the data source.

Hydraulic fluid power — Electrically modulated hydraulic control valves —

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

1 Scope

This part of ISO 10770 describes methods for determining the performance characteristics of electrically modulated, hydraulic, four-port directional flow-control valves. This type of electrohydraulic valve controls the direction and flow in a hydraulic system.

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 1219-1, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols for conventional use and data-processing applications*

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

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

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

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

ISO 9110-1, *Hydraulic fluid power — Measurement techniques — Part 1: General measurement principles*

ISO 10771-1, *Hydraulic fluid power — Fatigue pressure testing of metal pressure-containing envelopes — Part 1: Test methods*

IEC 60617-DB-12M, *Graphical symbols and diagrams*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

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

3.1.1
electrically modulated, hydraulic directional flow-control valve
valve that provides a degree of proportional flow control in response to a continuously variable electrical input signal

NOTE The flow direction can be changed by the input signal.

3.1.2
input signal deadband
portion of input signal that does not produce a controlled flow

3.1.3
threshold
change of input signal required to produce a reversal in continuous control valve output

NOTE The threshold is expressed as a percentage of rated signal.

3.1.4
rated input signal
that signal defined by the manufacturer to achieve rated output

3.2 Symbols and units

For the purposes of this document, the symbols given in Table 1 apply.

NOTE The graphic symbols in this part of ISO 10770 conform to ISO 1219-1 and IEC 60617-DB-12M.

Table 1 — Symbols and units

Parameter	Symbol	Unit
Inductance	L_c	H
Insulation resistance	R_i	Ω
Insulation test current	I_i	A
Insulation test voltage	U_i	V
Resistance	R_c	Ω
Dither amplitude	—	% (of max. input signal)
Dither frequency	—	Hz
Input signal	I, or U	A, or V
Rated input 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 $K_v = (\Delta q/\Delta U)$	l/min/A, or l/min/V
Hysteresis	—	% (of max. output signal)
Internal leakage	q_l	l/min
Supply pressure	p_P	MPa (bar)
Return pressure	p_T	MPa (bar)

Table 1 (*continued*)

Parameter	Symbol	Unit
Load pressure	p_A or p_B	MPa (bar)
Load pressure difference	$p_L = p_A - p_B$, or $p_L = p_B - p_A$	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	$K_p = (\Delta p_L / \Delta I)$, or $K_p = (\Delta p_L / \Delta U)$	MPa (bar)/A MPa (bar)/V
Threshold	—	% (of max. input signal)
Amplitude (ratio)	—	dB
Phase lag	—	°
Temperature	—	°C
Frequency	f	Hz
Time	t	s
Time constant	t_c	s
Linearity error	q_{err}	l/min

4 Standard test conditions

Unless otherwise specified, tests shall be carried out using the standard test conditions given in Table 2.

Table 2 — Standard test conditions

Parameter	Condition
Ambient temperature	20 °C ± 5 °C
Fluid cleanliness	Solid contaminant code number shall 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 able to operate)
Fluid viscosity	32 cSt ± 8 cSt at valve inlet
Viscosity grade	Grade VG32 or VG46 in accordance with ISO 3448
Pressure drop	Test requirement ± 2,0 %
Return pressure	Shall conform to the manufacturer's recommendations

5 Test installation

A test installation conforming to the requirements of Figure 1 shall be used for testing all valves.

SAFETY PRECAUTIONS — It is essential that consideration be given to the safety of personnel and equipment during the tests.

Figure 1 shows the minimum items required to carry out the tests without any safety devices to protect against damage in the event of component failure. For tests using the test circuit shown in Figure 1, the following apply.

a) Guidance on carrying out the tests is given in Annex A.

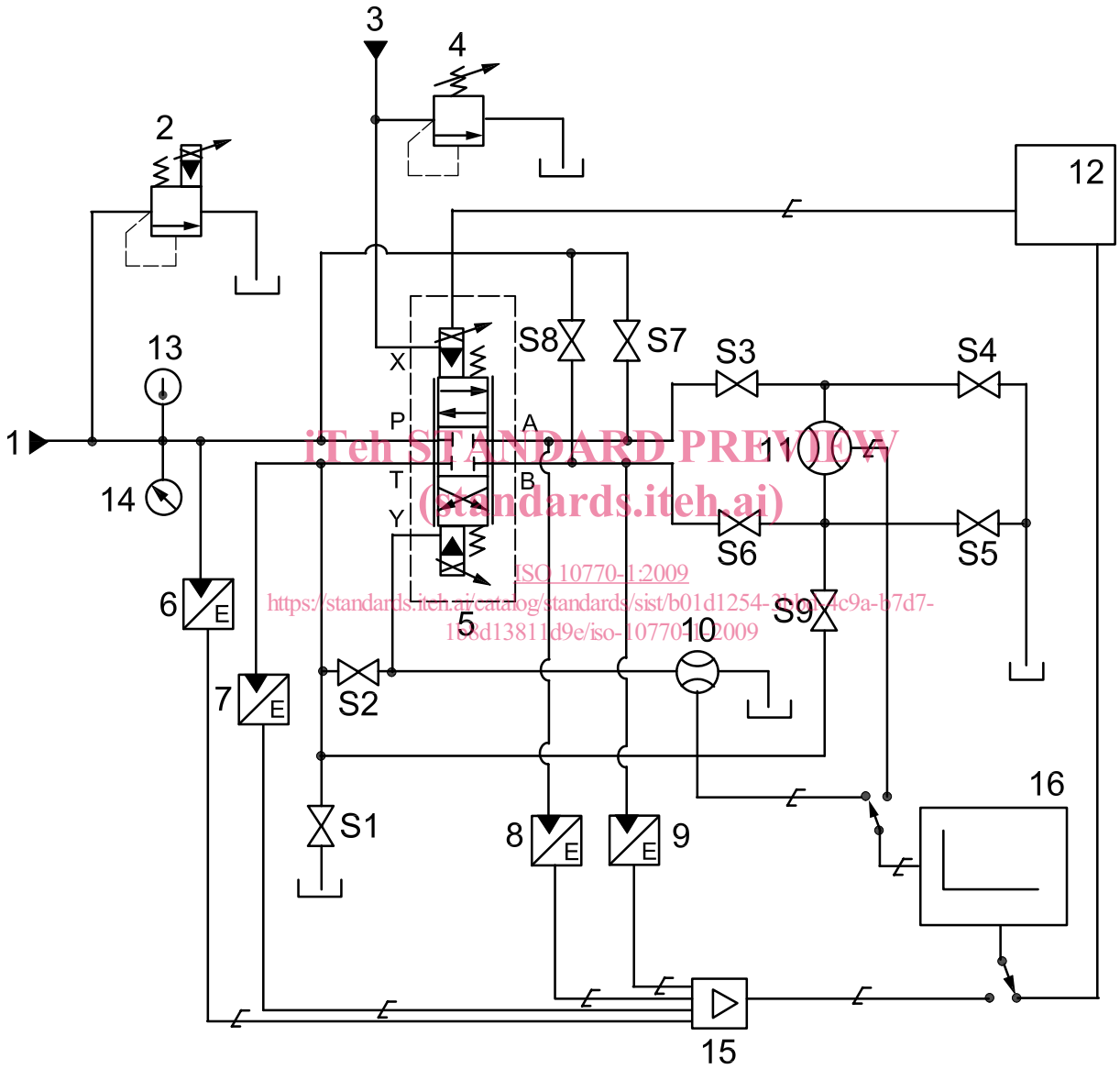
b) A separate circuit may be constructed for each type of test. This can improve the accuracy of test results as it eliminates the possibility of leakage through the shut-off valves.

c) Hydraulic performance tests are carried out on a combination of valve and amplifier. Input signals are applied to the amplifier and not directly to the valve. For electrical tests, the signals are applied directly to the valve.

d) If possible, hydraulic tests should be conducted using an amplifier recommended by the valve manufacturer. If not, the type of amplifier used should be recorded, with the operating details (i.e. pulse-width modulation frequency, dither frequency and amplitude).

e) The amplifier supply voltage and magnitude and sign of the voltage applied to the valve during the on and off periods of the pulse-width modulation should be recorded.

f) Electronic test equipment and transducers should have a bandwidth or natural frequency at least ten times greater than the maximum test frequency.



Key

1	main flow source	10, 11	flow transducer	S1 to S9	shut-off valves
2	main relief valve	12	signal generator	A, B	control ports
3	external pilot flow source	13	temperature indicator	P	supply port
4	external pilot relief valve	14	pressure gauge	T	return port
5	unit under test	15	signal conditioner	X	pilot supply port
6 to 9	pressure transducers	16	data acquisition	Y	pilot drain port

Figure 1 — Test circuit

6 Accuracy

6.1 Instrument accuracy

Instrumentation shall be accurate to within the limits shown in Class B of ISO 9110-1:

a) electrical resistance: ± 2 % of the actual measurement;

b) pressure: ± 1 % of the valve's rated pressure drop to achieve rated flow;

c) temperature: ± 2 % of the ambient temperature;

d) flow: ± 2,5 % of the valve's rated flow;

e) input signal: ± 1,5 % of the electrical input signal required to achieve the rated flow.

6.2 Dynamic range

For the dynamic tests, ensure that the measuring equipment, amplifiers and recording devices do not generate any damping, attenuation or phase shift of the output signal being recorded that can affect the measured value by more than 1 % of the measured value.

7 Electrical tests for valves without integrated electronics

7.1 General

As appropriate, perform the tests described in 7.2 to 7.4 on all valves without integrated electronics before proceeding to subsequent tests.

NOTE Tests 7.2 to 7.4 apply only to current-driven valves.

7.2 Coil resistance

7.2.1 Coil resistance — Cold

Carry out the test as follows.

a) Soak the complete, un-energized valve at the specified ambient temperature for at least 2 h.

b) Measure and record the electrical resistance between the two leads or terminals of each coil in the valve.

7.2.2 Coil resistance — Hot

Carry out the test as follows.

a) Soak the complete, energized valve, mounted on a subplate recommended by the manufacturer, at its maximum rated temperature and operate the complete valve, fully energized and without flow, until the coil temperature stabilizes.

b) Measure and record the electrical resistance between the two leads or terminals of each coil in the valve. The resistance value shall be measured within 1 s of removing the supply voltage.

7.3 Coil inductance — Optional test

This test method shall not be construed to determine a definitive value of inductance. The value obtained shall be used for comparison purposes only.

Carry out the test as follows.

a) Connect the coil to a constant voltage supply capable of delivering at least the rated current of the coil.

b) The armature shall be held stationary at 50 % of its working stroke during the test.

c) Monitor the coil current on an oscilloscope or similar equipment.

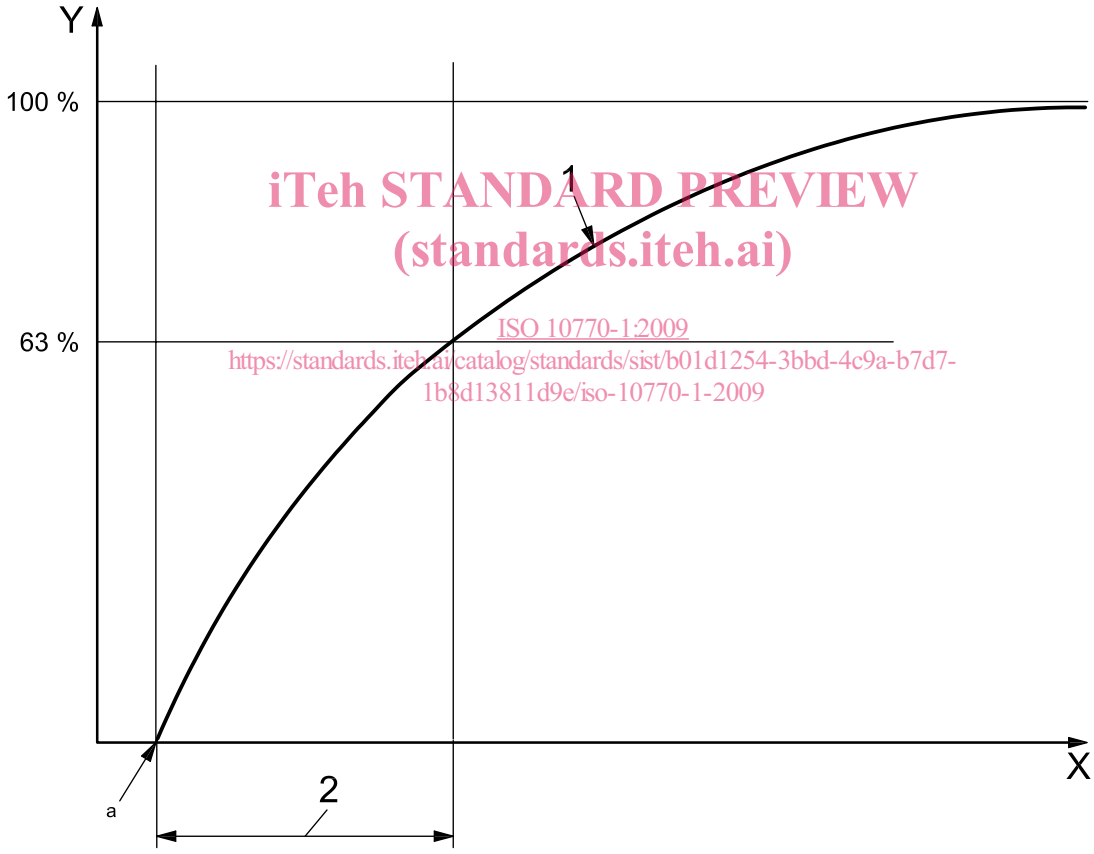
d) Adjust the voltage so that the steady-state current equals the rated current of the coil.

e) Switch the voltage off then on and record the current transient behaviour.

f) Determine the time constant, t_c, of the coil (see Figure 2) and calculate the inductance, L_c, using Equation (1):

$$L_c = R_c t_c \tag{1}$$

where R_c is the coil resistance in ohms.



Key

X time
Y current

1 DC current trace
2 time constant, t_c

a Initiation.

Figure 2 — Coil inductance measurement

7.4 Insulation resistance

Establish the insulation resistance of the coil as follows.

a) If internal electrical components are in contact with the fluid (i.e. the coil is wet), fill the valve with hydraulic fluid before carrying out the test.

b) Connect the valve coil terminals together and apply voltage, U_i, of 500 V d.c. between them and the valve body for 15 s.

c) Using a suitable insulation tester, record the insulation resistance, R_i.

d) For testers with a current (ampere, A) readout, I_i, calculate the insulation resistance using Equation (2).

$$R_i = \frac{U_i}{I_i} \tag{2}$$

8 Performance tests

All performance tests should be conducted on a combination of valve and amplifier, as input signals are applied to the amplifier and not directly to the valve.

For multi-stage valves, configure the valve to be an external pilot supply and external pilot drain, where possible.

Before commencing any test, make any mechanical/electrical adjustments that are normally carried out, such as nulling, deadband adjustment and gain adjustment.

8.1 Steady state tests

Care should be taken to exclude dynamic effects during steady state tests.

8.1.1 General

Steady-state tests shall be performed in the following order:

a) optional proof pressure tests (8.1.2);

b) internal leakage test (8.1.3);

c) metering output flow versus input signal at constant valve pressure drop (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;