INTERNATIONAL STANDARD

ISO 10771-1

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Hydraulic fluid power — Fatigue pressure testing of metal pressure-containing envelopes —

Part 1: **Test method**

Transmissions hydrauliques — Essais de fatigue des enveloppes métalliques sous pression —

Partie 1: Méthode d'essai

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 3.

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 part of ISO 10771 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10771-1 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 8, *Product testing*.

ISO 10771 consists of the following parts, under the general title *Hydraulic fluid power — Fatigue pressure testing of metal pressure-containing envelopes*:

— *Part 1: Test method*

— *Part 2: Test rating* (in preparation)

Annexes A to D form a normative part of this part of ISO 10771.

Introduction

In hydraulic fluid power systems, power is transmitted and controlled under pressure within an enclosed circuit. It is important for the manufacturer and user of hydraulic components to have information on their global reliability because of the importance of the fatigue failure mode and the relationship this has with the functional safety and service life of such components. This part of ISO 10771 provides a method for fatigue testing the pressure-containing envelope provided by hydraulic components.

During operation, components in a system may be subjected to loads that arise from:

— internal pressure;

— external forces;

— inertia and gravitational effects;

— impact or shock;

— temperature changes or gradients.

The nature of these loads can vary from a single static application to continuously varying amplitudes, repetitive loadings and even shocks. It is important to know how a component can withstand these loads, but this part of ISO 10771 addresses only the loading due to internal pressure.

There are many ways in which internal pressure loads are imposed upon a component. This part of ISO 10771 considers a broad range of waveforms within prescribed time limits, temperatures and environmental conditions, and only upon metals. It is expected that these limitations could still provide sufficient common ground for a method of fatigue pressure testing metal pressure-containing envelopes in hydraulic fluid power components. This method, therefore, provides the system designer with certain information to assist in a selection of components for an application. The system designer still has the responsibility of considering the other loading characteristics described above and determining how they could affect the component's pressure-retaining capability.

Hydraulic fluid power — Fatigue pressure testing of metal pressure-containing envelopes —

Part 1: Test method

1 Scope

This part of ISO 10771 specifies a method of fatigue testing the pressure-containing envelopes of components used in hydraulic fluid power systems under sustained steady cyclic internal pressure loads.

This part of ISO 10771 is only applicable to component pressure-containing envelopes that:

— are manufactured from metals;

— are operated at temperatures that exclude creep and low-temperature embrittlement;

— are only subjected to pressure-induced stresses;

— are not subjected to loss of strength due to corrosion or other chemical action;

— may include gaskets, seals and other non-metallic components; however, these are not considered part of the pressure-containing envelope being tested, (see note 3 in 5.5).

This part of ISO 10771 does not apply to piping as defined in ISO 4413 (i.e. connectors, hose, tubing, pipe). See ISO 8434-5, ISO 6803 and ISO 6605 for methods of fatigue testing of piping devices.

This part of ISO 10771 establishes a general test method that is applicable for many hydraulic fluid power components, but additional requirements or more specific methods that may be required for particular components are contained in the annexes or other standards.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitutes provisions of this part of ISO 10771. For dated reference, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10771 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For an undated reference, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 4413:1998, *Hydraulic fluid power — General rules relating to systems*

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

ISO 9110-1:1990, *Hydraulic fluid power — Measurement techniques — Part 1: General measurement principles*

ISO 9110-2:1990, *Hydraulic fluid power — Measurement techniques — Part 2: Measurement of average steady-state pressure in a closed conduit*

3 Terms and definitions

For the purposes of this part of ISO 17701, the terms and definitions given in ISO 5598 and the following apply.

3.1
upper cyclic test pressure
p_U
minimum value of the highest level of the specified test pressure cycle

3.2
lower cyclic test pressure
p_L
maximum value of the lowest level of the specified test pressure cycle

3.3
cyclic test pressure range
Δ_p
difference between the upper and lower cyclic test pressures during a fatigue test

3.4
pressure-containing envelope
elements of a component that contain the pressurized hydraulic fluid, and the means to secure the elements (bolts, welds, etc.)

NOTE 1 Gaskets and seals are not considered as part of the pressure-containing envelope.

NOTE 2 See annexes for component definitions.

4 Test conditions

4.1 Remove entrapped air from the test component and circuit before starting each test.

4.2 The temperature of the hydraulic fluid in the component shall be in the range 15 °C to 80 °C. The temperature of the component shall be a minimum of 15 °C.

5 Test equipment and preparation

5.1 The test equipment and circuit shall be able to generate and repeat the pressure cycle as specified in 7.1.

5.2 Pressure transducer(s) shall be mounted directly into the test component, or as near as possible, so as to record the internal conditions applied to the component. Any restrictions between the transducers and the pressure-containing envelope being tested should be avoided.

5.3 Any non-corrosive hydraulic fluid that has a kinematic viscosity not greater than 60 mm^2/s at the test temperature shall be used as the pressurizing medium.

5.4 Different pressures shall be applied to separate portions of the test components as dictated by design specifications.

5.5 It shall be verified that the ratio of induced stress to pressure, under static loading conditions, is also attained at the test cycling rate, especially when:

— pressures have to penetrate between close-fitting parts;

— large components are tested;

— hysteresis in joints can significantly affect stresses.

NOTE 1 Strain gauges may be used to verify this ratio and, if used, should be located externally in an area of high strain.

NOTE 2 It is permissible to make modifications to the test samples to facilitate cyclic or burst tests, providing such modifications do not increase the pressure capabilities of the pressure-containing envelope.

NOTE 3 It is permissible to replace gaskets and seals that fail during the test, as long as preloads in stressed elements are the same after reassembly as they were before disassembly. It is possible that fastener preloads may decrease during fatigue testing. Fastener preloads should be set to this reduced level when seals or gaskets are replaced.

5.6 Safety procedures shall be followed in order to protect personnel and test equipment during the test (see ISO 4413).

6 Accuracy

6.1 Instrumentation shall be accurate to within the following limits:

— pressure: ± 1,0 % of the upper cyclic test pressure;

— strain: ± 1 % of the value obtained at the upper cyclic test pressure;

— time: ± 0,002 s resolution;

— temperature: ± 2 °C.

6.2 Use pressure transducers, amplifiers and recording devices with a combined system frequency response such that in the frequency range 0 kHz to 2 kHz, the amplitude ratio is within 0 dB and –3 dB.

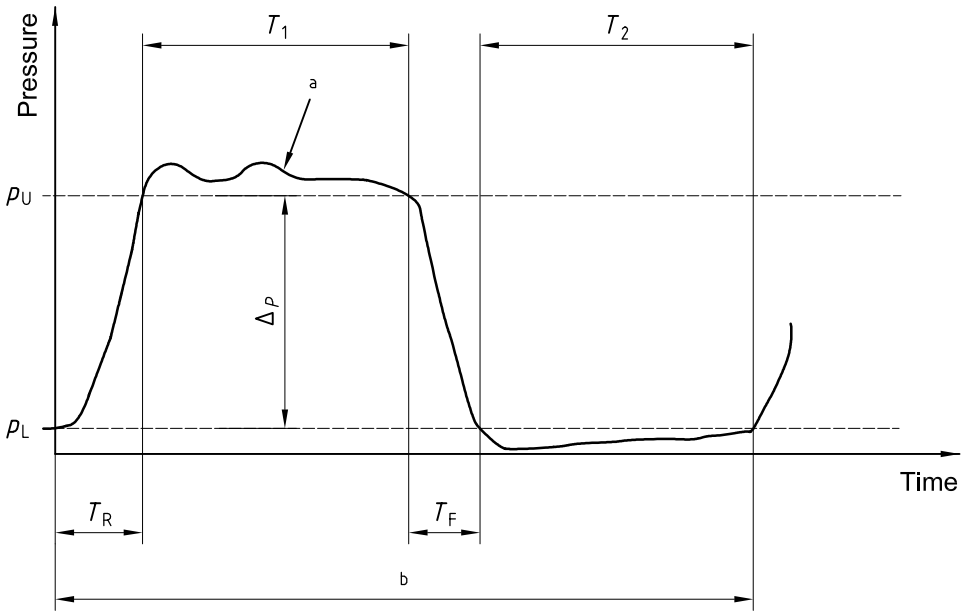
6.3 Instruments and procedures shall conform to ISO 9110-1 and ISO 9110-2.

7 Test procedure

7.1 Cyclic pressure test

7.1.1 Test pressure waveform

The test pressure waveform shall achieve the upper and lower levels for the time periods as specified in 7.1.2. For the purposes of illustration only, a typical test pressure waveform is shown in Figure 1.



a Actual test pressure

b Test period = T = 1/test frequency = $1/f = T_R + T_1 + T_F + T_2$

Figure 1 — Test pressure waveform

7.1.2 Pressure test cycle

a) Upper cyclic test pressure (p_U)

The actual test pressure shall equal, or exceed, the upper cyclic test pressure for a time period T_1 equal to or greater than $0{,}3T$.

b) Time period of pressure rise (T_R)

The actual test pressure shall rise to the upper cyclic test pressure within the time period T_R so that:

$$0{,}4T \leqslant T_R + T_1 \leqslant 0{,}6T$$

c) Lower cyclic test pressure (p_L)

The lower cyclic test pressure shall not exceed 5 % of the upper cyclic test pressure unless specified otherwise in the annexes. The actual test pressure shall not exceed the lower cyclic test pressure in the time period in the cycle T_2, where T_2 is given by:

$$0{,}9T_1 \leqslant T_2 \leqslant 1{,}1T_1$$

7.1.3 Number of test cycles

Select the number of test cycles required in the range 10^5 to 10^7.

7.1.4 Test frequency and time period T_1

Cycle the test pressure at the selected frequency of: $f = 1/T$.

NOTE The fatigue life of hydraulic components depends on the time period T_1 of the pressure variations at a given pressure amplitude. Consequently, the results of the test on a component at a given time period cannot be used to predict the number of cycles that the component will successfully withstand at a different period. For a given test pressure, frequencies (f) of $\leqslant$ 3 Hz or time periods of $T_1 \geqslant$ 100 ms should be used unless there is satisfactory experience of testing at a higher frequency. Such experience should be stated in the test report.

7.2 General

7.2.1 Inspect all of the test components, using non-destructive methods, in order to verify conformity to the manufacturing specification.

7.2.2 If required, place metal balls or other loosely-fitting pieces within the test components in order to reduce the volume of pressurized fluid, ensuring that any such pieces do not prevent the correct pressure from reaching all test areas, and do not affect the fatigue life of the components (e.g. by shot peening the surfaces).

7.2.3 When a hydraulic fluid power component has internal chambers that are designed for different pressure capabilities, the fatigue of the mechanical features forming the separation between these chambers shall also be tested as if it were part of the pressure-containing envelope (see component annexes A, B, C and D).

8 Failure criteria

Criteria for failure are:

— external leakage of any amount caused by fatigue (subject to the requirements of 5.5);

— internal leakage of any amount caused by fatigue (subject to the requirements of 5.5);

— material separation (e.g. cracks).

9 Test report

A test report shall be prepared containing the following data:

a) the number of this part of ISO 10771 and the identification of the annex used;

b) the place of test;

c) the identity of the testing personnel and date of test;

d) a component description (manufacturer, material);

e) the number of components tested;

f) the upper and lower cyclic test pressures (p_U, p_L);

g) the cyclic test frequency (f) and time period (T_1);

h) the number of completed pressure cycles;

i) the type of test fluid;

j) a plot of a typical cycle (pressure/time);

k) the fluid and ambient temperatures;

l) replacement of gaskets and seals, their cyclic life and method of re-establishing the fastener preload;

m) frequency response of the instrumentation systems and transducers;

n) description (either graphical or text) of any modifications to the component that were required in order to complete the test;

o) any other remarks.

10 Test declaration

The conditions of the pressure fatigue test shall be declared by stating the information in a), d), f), g), and h) of clause 9.

EXAMPLE ISO 10771-1 D\\Relief valve (xxx, steel)\\25/0,5 MPa (250/5 bar)\\3 Hz/120 ms\\$10^7$ cycles.

11 Identification statement (reference to this part of ISO 10771)

Use the following statement in test reports, catalogues and sales literature when electing to comply with this International Standard.

“Method for fatigue pressure testing conforms to ISO 10771-1, *Hydraulic fluid power — Fatigue pressure testing of metal pressure-containing envelopes — Part 1: Test method”* .

Annex A
(normative)

Specific requirements for pumps and motors

A.1 General

The requirements specified in this part of ISO 10771 shall apply, subject to the variations given in A.2 and A.3.

Complete assembled units shall be used for the test.

NOTE 1 Inlet ports, drain ports and high-pressure ports may require different cyclic test pressures applied to them during this test.

NOTE 2 An important criterion when conducting this test is whether the driving mechanism of the test unit rotates and produces high pressure itself, or whether it does not rotate and is stressed by a separate pressure source.

A.2 Test procedure

If it is chosen to pressurize more than one port, the phase relationship of the cyclic pressures shall be chosen to achieve the highest fatigue loading.

If the test is conducted with a non-rotating shaft, the angular position of the rotary group is important in determining the load on the pressure-containing envelope and shall be controlled.

The displacement of the unit is important in determining the load on the pressure-containing envelope and should be controlled. For variable displacement units the displacement waveform shall be recorded in addition to the pressure waveform, in the case when displacement is being changed.

A.3 Test report

The following information shall be added to the test report [include notes a) to o) from clause 9]:

a) whether the primary shaft is rotating or non-rotating;

b) if non-rotating, a description of the angular position of the fluid displacement elements;

c) whether the test unit is operated as a pump or a motor;

d) the speed and direction of rotation;

e) for a variable displacement unit report, the displacement waveform and the phase relationship to the pressure waveform;

f) the upper cyclic test pressure p_U and the lower cyclic test pressure p_L for each port pressurized, the phase relationship for each port pressurized and the pressure level applied to any other port.

Annex B
(normative)

Specific requirements for hydraulic cylinders

B.1 General

This annex specifies the method for conducting a fatigue test of the pressure-containing envelope of hydraulic cylinders. It is applicable to cylinders with bores of up to and including 200 mm that conform to ISO design standards, e.g., ISO 6020-1, of the following types:

— the tie rod type;

— the bolted type;

— the welded type;

— types with other fastening methods.

The testing method is not applicable if:

— side loads are applied on the piston rod;

— the piston rod is under load/stress causing buckling.

The pressure-containing envelope for a hydraulic cylinder includes:

— the cylinder body;

— the end heads and caps;

— seal housings;

— the piston;

— piston-to-rod connection;

— any pressurized elements, such as cushioning throttle valves, check valves, air bleed plugs, closure plugs, etc.;

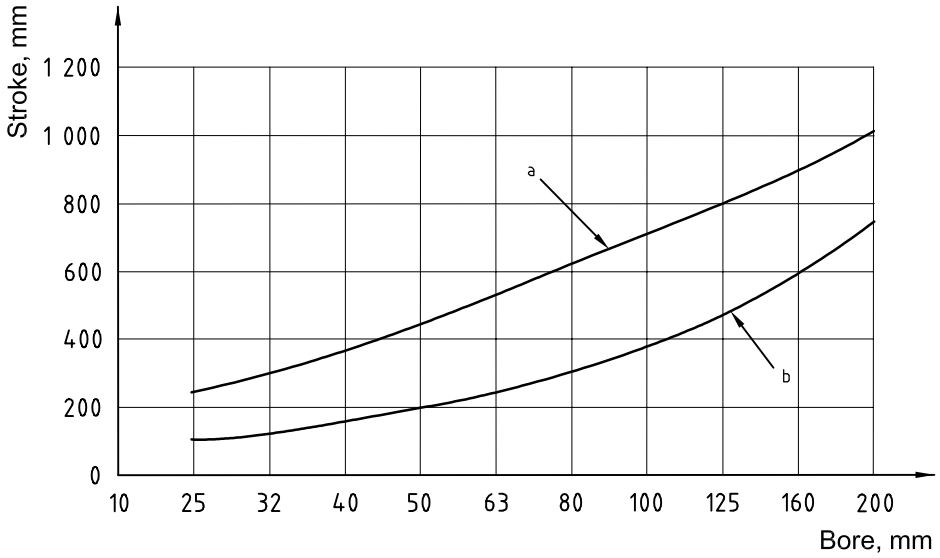
— fasteners (e.g. snap rings, bolts, tie rods, nuts, etc.) that secure end heads/caps, seal housings, piston, and retaining rings.

NOTE 1 Other items, such as mountings, mounting accessories, and cushion parts, are not considered part of the pressure-containing envelope.

NOTE 2 Although the mountings are not pressure-containing elements, they may be fatigue tested for endurance using the test methods described in this annex.

B.2 Test arrangement for the basic cylinder pressure-containing envelope

The cylinder stroke length shall be at least as long as that determined in Figure B.1.



a Tie rod cylinders

b All other cylinders

Figure B.1 — Shortest stroke as a function of bore diameter

Provide a test arrangement that attaches to the external end of the piston rod and fastens to the rod end head in a concentric manner to the piston rod (modifications to the rod end head to accomplish this are permissible). The test arrangement shall position the piston approximately so that the length L (see Figure B.2) is within 3 mm to 6 mm from the cap end for tie rod cylinders, and approximately in the middle of the cylinder body length for non-tie rod cylinders.

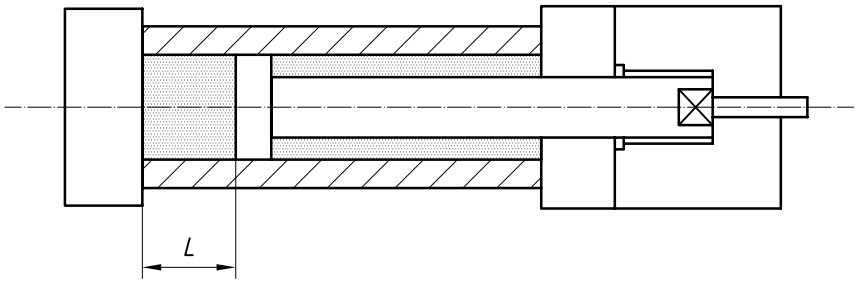


Figure B.2 — Cylinder test arrangement

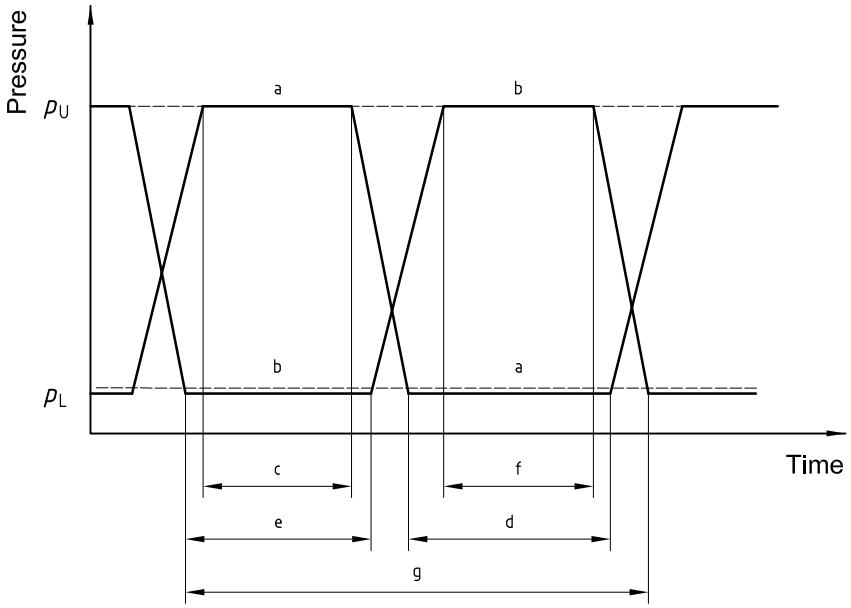
A filler material (e.g. steel shot, spacers, etc.) may be used in the pressure-containing envelope in order to reduce the volume pressurized, but the filler material shall not restrict application of the pressure to the test components.

B.3 Application of test pressure

Both end heads/caps should have two sets of ports; one to connect to the pressure-generating source, and one to facilitate connection of the pressure-measuring equipment.

Apply the test pressure at a level above the cyclic test pressure (p_U) first to one side of the piston with the test pressure at a level below the lower cyclic test pressure (p_L) on the other side; then reverse the pressures, generating one pressure cycle, as shown in Figure B.3.

The time period T_2 for the unpressurized side of the piston shall be longer than T_1. In order to achieve this, the time period T_1 for each side of the piston shall not begin until the pressure on the other side has dropped to below p_L. The time period T_1 for each side of the piston shall end before the pressure on the other side begins to rise above p_L.



a side 1

b side 2

c T_1 side 1

d T_2 side 1

e T_2 side 2

f T_1 side 2

g 1 cycle

Figure B.3 — Test pressure waveform

Annex C
(normative)

Specific requirements for gas-loaded accumulators

C.1 General

This annex shall apply to gas-loaded accumulators in addition to the requirements specified in the main document. It covers the pressure-containing envelope of the following accumulator types:

— piston;

— bladder;

— diaphragm.

This annex also covers gas bottles for use as additional gas capacity for transfer accumulators.

C.2 Test sample(s)

C.2.1 Bladder accumulators shall consist of:

— shell;

— hydraulic port valve assembly;

— gas port valve assembly.

C.2.2 Piston accumulators shall consist of:

— body;

— end caps;

— gas port valve assembly.

C.2.3 Diaphragm accumulators shall consist of:

— body with integral ports;

— gas port valve assembly.

C.2.4 Gas bottles, depending on their construction, shall consist of:

— body;

— valve assemblies;

— end caps.

If test sample(s) contain a fluid separator such as a piston, bladder or diaphragm, fluid shall be on both sides of the separator.

NOTE Fittings connected to the accumulator (e.g. gas valves) may be tested separately if the fixation is the same as when mounted on the accumulator.

C.3 Test procedure

If more than one test sample of the component is required, the samples may be connected in series or parallel provided that the test pressure waveform is present and measured in all test samples (see 5.1 and 5.2).

It is permissible for the lower cyclic test pressure p_L to be higher than 5 % of the upper cyclic test pressure p_U, but the test pressure waveform shall conform to Figure 1.

Annex D
(normative)

Specific requirements for valves

D.1 General

In general, valves consist of several chambers. Each of these can experience different pressures (e.g. system pressure, the pressures at the service port connections, control pressures and return line pressure).

D.2 Guide for the test procedure

Valves should be tested as complete assemblies. Attachments (e.g. solenoid tubes, body end covers, etc.) can be tested as an integral part of the valve or as independent components.

If internal walls or boundaries of the chamber can experience a reversal of pressure loading in service (which may be the case for internal sections between the pressure and service ports of a directional valve), then one cycle shall consist of the maximum pressure difference applied alternately to each side of the wall or boundary.

NOTE A pressure pulse may be applied to several chambers simultaneously if the chambers are not adjacent.

Bibliography

[1] ISO 6020-1:1998, *Hydraulic fluid power — Mounting dimensions for single rod cylinders, 16 MPa (160 bar) series — Part 1: Medium series*

[2] ISO 6605:—[1)], *Hydraulic fluid power — Hoses and hose assemblies — Method of test*

[3] ISO 6803:1994, *Rubber or plastics hoses and hose assemblies — Hydraulic-pressure impulse test without flexing*

[4] ISO 8434-5:1995, *Metallic tube connections for fluid power and general use — Part 5: Test methods for threaded hydraulic fluid power connections*

1) To be published. (Revision of ISO 6605:1986)

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