INTERNATIONAL STANDARD

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Hydraulic fluid power — Determination of characteristics of motors —

Part 2: Startability

Transmissions hydrauliques — Détermination des caractéristiques des moteurs —

Partie 2: Essai de démarrage

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 4392 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4392-2 was prepared by Technical Committee ISO/TC 131, *Fluid power systems*, Subcommittee SC 8, *Product testing*.

This third edition cancels and replaces the second edition (ISO 4392-2:1989), of which it constitutes a minor revision.

ISO 4392 consists of the following parts, under the general title *Hydraulic fluid power — Determination of characteristics of motors*:

— *Part 1: At constant low speed and constant pressure*

— *Part 2: Startability*

— *Part 3: At constant flow and at constant torque*

Annexes A, B and C form a normative part of this part of ISO 4392.

Introduction

In hydraulic fluid power systems power is transmitted and controlled through a fluid under pressure within an enclosed circuit.

Hydraulic motors are units which transform hydraulic energy into mechanical energy, usually with a rotary output. Startability, the ability of a motor to start, is an important property of hydraulic motors, when used for specific applications.

Hydraulic fluid power — Determination of characteristics of motors —

Part 2: **Startability**

1 Scope

This part of ISO 4392 specifies two test methods for determining the startability of rotary hydraulic motors. It describes two comparable methods of measurement, namely the constant torque method (see clause 6) and the constant pressure method (see clause 7). Since the results obtained by these two methods are equivalent, no preference is given to either.

Additional physical quantities and their symbols are given in annex A.

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

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 4392. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 4392 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 4391:1983, *Hydraulic fluid power — Pumps, motors and integral transmissions — Parameter definitions and letter symbols*

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 4392, the terms and definitions given in ISO 4391, ISO 5598 and the following apply.

3.1
startability
ability of a hydraulic motor to start against a stated load

3.2
start at constant torque
that point at which there is an abrupt change in the slope of the angular displacement versus pressure characteristic, when the angular displacement of the motor shaft is measured between the motor and the load

3.3
start at constant pressure
that point at which there is an abrupt change in the slope of the angular displacement versus pressure torque characteristic, when the angular displacement of the motor shaft is measured between the motor and the load

4 Symbols

4.1 The physical quantity letter symbols and their suffixes used in this part of ISO 4392 are fully explained either in ISO 4391 or annex A and are given in Table 1.

Table 1 — Symbols and units

Quantity	Symbol	Dimension [a]	SI unit [b]
Pressure, differential pressure	p, Δp	$ML^{-1} T^{-2}$	Pa
Torque	T	ML^2T^{-2}	N·m
Instantaneous displacement	v	L^3	m^3
Time	t	T	s
Swept volume	V	L^3	m^3

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

[b] The practical units which may be used for the presentation of results are given in annex C.

4.2 The graphical symbols used in Figure 1 are in accordance with ISO 1219-1.

5 Test installation

5.1 Hydraulic test circuit

5.1.1 An appropriate hydraulic test circuit similar to that shown in Figure 1 shall be used.

This figure does not incorporate all the safety devices necessary to protect against damage in the event of component failure. It is important that those responsible for carrying out the tests give due consideration to safeguarding both staff and equipment.

NOTE 1 Although Figure 1 illustrates a basic circuit to test a unidirectional motor, a similar, symmetrical, but suitably modified, circuit is acceptable for testing bidirectional motors.

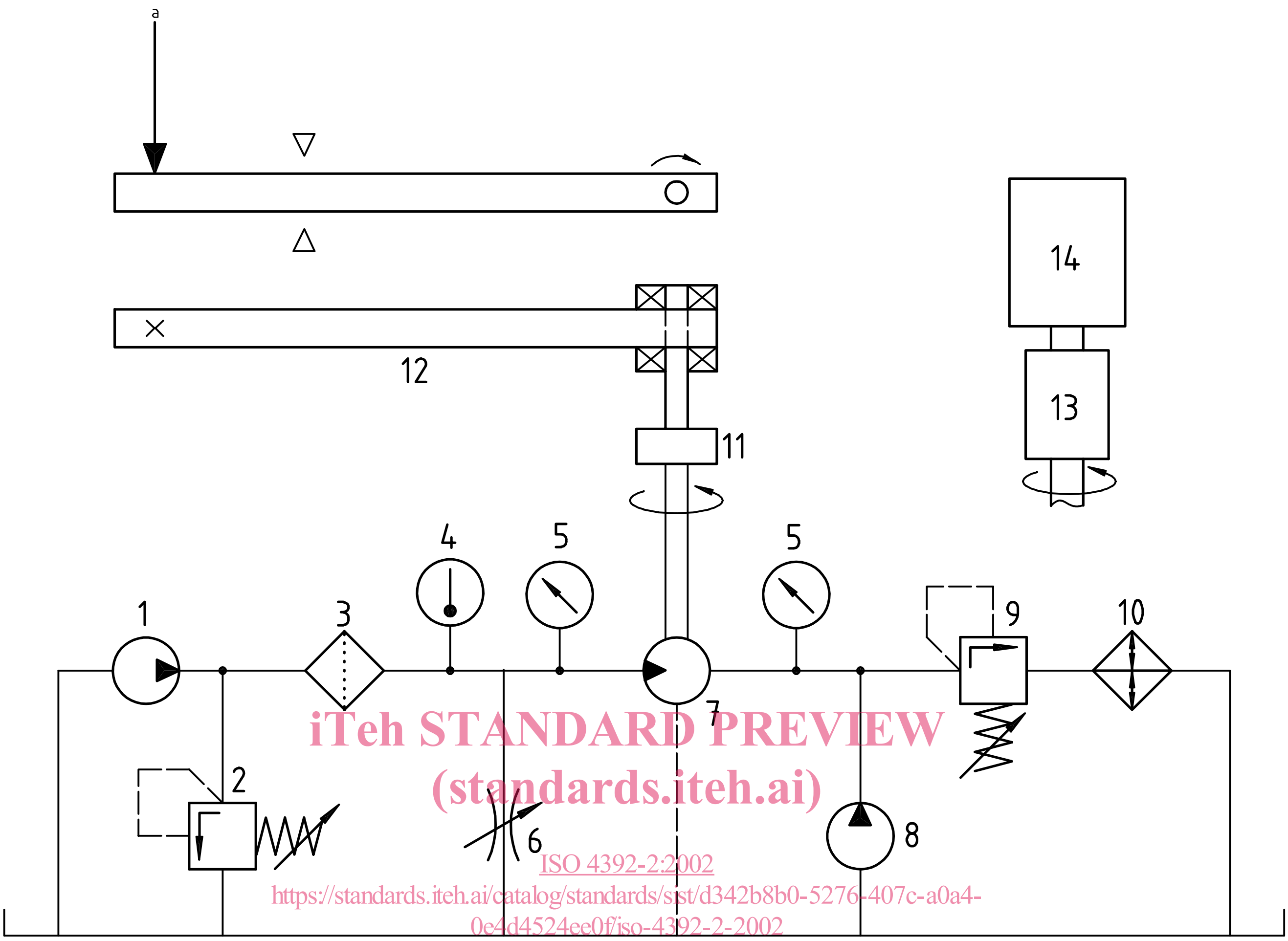
NOTE 2 An additional booster pump circuit may be necessary when testing piston-type motors.

5.1.2 A fluid-conditioning circuit shall be installed which provides the filtration necessary to protect the test motor and the other circuit components, and which will maintain the fluid temperature at the motor inlet at either 50 °C or 80 °C to within ± 2 °C.

5.1.3 The hydraulic ports of the test motor shall be connected to the hydraulic circuit in such a manner that the motor shaft rotation will oppose the torque loading device.

5.1.4 The maximum test pressure shall not exceed that recommended by the motor manufacturer.

Alternative loading devices (see 7.1.2)



Key

1 Supply pump
2 Pressure control valve (manual)
3 Filter
4 Temperature indicator
5 Pressure indicator
6 Variable restrictor
7 Motor under test
8 Back pressure pump
9 Back pressure control valve
10 Heat exchanger
11 Indexing shaft coupling
12 Beam mounted on hydrostatic bearings
13 Torque transducer
14 Electrical torque load

a Variable load.

Figure 1 — Typical hydraulic circuit — Constant torque test on unidirectional motor

5.2 Instrumentation

Instruments shall conform to the requirements of ISO 9110-1 and ISO 9110-2. Measuring instruments shall be selected and installed which provide systematic errors which are consistent with the chosen class of measurement accuracy (see annex B).

6 Constant torque method

6.1 Test apparatus

6.1.1 A test rig shall be set up which makes use of the test circuit specified in 5.1.1 and which provides the equipment shown in Figure 1 and described in 6.1.2 and 6.1.3.

6.1.2 A suitable torque-loading device, either 12 which will allow limited rotation of the test motor shaft at start-up, for example a lever arm and adjustable mass at one end, or 14 which allows continuous opposing rotation by a controlled electrical variable torque loading device, shall be provided.

6.1.3 A mechanical stop shall also be provided to prevent the torque-loading device rotating the motor shaft in the reverse direction.

6.2 Test conditions

6.2.1 The motor being tested shall be in thermal equilibrium before commencing the test.

6.2.2 The constant outlet pressure shall be maintained at the level recommended by the motor manufacturer.

6.2.3 The rate of increase in inlet pressure per second shall be less than or equal to 20 % of the test pressure and shall not significantly influence the starting pressure.

6.2.4 The differential pressure across the motor shall be reduced to less than 5 % of the maximum test pressure or 10 bar[1)] (1 MPa), whichever is the smaller, before embarking on every subsequent set of measurements.

NOTE This requirement is not applicable to motors for special applications, e.g. winch drives.

6.2.5 The number of measurements at different shaft positions shall be greater than the minimum number necessary for the maximum starting pressure over one revolution to be found with a confidence level of 95 %.

6.2.6 The torque levels shall be kept constant to ± 1 %.

6.3 Test procedure

6.3.1 Adjust the back pressure on the motor outlet to a constant value (see 6.2.2).

6.3.2 Gradually increase the inlet pressure until the motor starts to rotate (see 6.2.3). Simultaneously record the angular displacement of the motor shaft against the inlet pressure.

6.3.3 Produce a graph of the recordings obtained in 6.3.2 and note the pressure at which the motor starts to rotate, i.e. the point at which there is an abrupt change in the slope of the characteristic (see 3.2).

6.3.4 Repeat the steps described in 6.3.2 and 6.3.3 at a number of different shaft positions (see 6.2.5).

6.3.5 Repeat the steps described in 6.3.2 to 6.3.4 at a number of different torque levels (see 6.2.6) in order that the characteristics over a representative range of starting conditions can be obtained.

6.3.6 For bidirectional motors, repeat the steps described in 6.3.2 to 6.3.5 in the reverse direction.

6.4 Expression of results

NOTE Refer to clause 4 for a fuller explanation of letter symbols and suffixes.

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1) 1 bar = 10^5 Pa; 1 Pa = 1 N/m^2.

Calculate the minimum starting efficiency, $\eta_{hm, min}$, for each test torque level, using the following formulae:

$$\eta_{hm, min} = \frac{\Delta p_{i, mi}}{\Delta p_{e, max}}$$

or

$$\eta_{hm, min} = \frac{\Delta p_{g, mi}}{\Delta p_{e, max}}$$

where

$$\Delta p_{i, mi} = \frac{2\pi}{V_i} \times T'$$

$$\Delta p_{g, mi} = \frac{2\pi}{V_g} \times T'$$

T' is the applied test torque;

$\Delta p_{e, max}$ is the highest differential pressure, measured during the test, at a given test torque level.

7 Constant pressure method

7.1 Test apparatus

7.1.1 A test rig shall be set up which makes use of the test circuit in 5.1.1 and which provides the equipment shown in Figure 1 and described in 7.1.2.

7.1.2 A suitable loading device (11 and 12 or 13 and 14) complying with the requirements of 6.1.2 shall be provided.

7.2 Test conditions

7.2.1 The motor being tested shall be in thermal equilibrium before commencing the test.

7.2.2 The constant outlet pressure shall be maintained at the level recommended by the motor manufacturer.

7.2.3 The rate of decrease of the test torque per second shall be less than or equal to 20 % of test torque and shall not significantly influence the starting torque.

7.2.4 The differential pressure across the motor shall be reduced by less than 5 % of the maximum test pressure or 10 bar (1 MPa), whichever is the smaller, before embarking on every subsequent set of measurements.

NOTE This requirement is not applicable to motors for special applications, e.g. winch drives.

7.2.5 The number of measurements at different shaft positions at one torque level shall be sufficient for the minimum starting torque to be found with a confidence level of 95 %.

7.3 Test procedure

7.3.1 Adjust the back pressure on the motor outlet to a constant value (see 7.2.2).