BS ISO 4409:2019



BSI Standards Publication

Hydraulic fluid power — Positive-displacement pumps, motors and integral transmissions — Methods of testing and presenting basic steady state performance

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National foreword

This British Standard is the UK implementation of ISO 4409:2019. It supersedes BS ISO 4409:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/18, Fluid power systems and components.

A list of organizations represented on this committee can be obtained on request to its secretary.

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© The British Standards Institution 2019
Published by BSI Standards Limited 2019

ISBN 978 0 580 90694 7

ICS 23.100.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 July 2019.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO 4409

Third edition
2019-07

Hydraulic fluid power — Positive-displacement pumps, motors and integral transmissions — Methods of testing and presenting basic steady state performance

Transmissions hydrauliques — Pompes, moteurs et variateurs volumétriques — Méthodes d'essai et de présentation des données de base du fonctionnement en régime permanent

Reference number
ISO 4409:2019(E)

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Published in Switzerland

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document 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 4409:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

— The normative references in Clause 2 have been updated and revised to reflect the changes made to this document.

— The terms and definitions in Clause 3 were updated and correctly referenced to agree with the existing ISO standards.

— Clause 4 now correctly references the appropriate standard for symbols and units and the corresponding table has been revised to display symbols and units correctly.

— The general description of Clause 5 was revised to include various types of conduits. A table with recommendations for the test fluid to be used is now provided, and the circuit diagrams have been revised for technical accuracy.

— The suggested expression of results has been updated in Clause 6 to include meaningful values obtained from the data gathered with the tests.

— The Bibliography has been updated.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. Pumps are components that convert rotary mechanical power into hydraulic fluid power. Motors are components that convert hydraulic fluid power into rotary mechanical power. Integral transmissions (hydraulic drive units) are a combination of one or more hydraulic pumps and motors and appropriate controls forming a component.

With very few exceptions, all hydraulic fluid power pumps and motors are of the positive-displacement type, i.e. they have internal sealing means that make them capable of maintaining a relatively constant ratio between rotational speed and fluid flow over wide pressure ranges. They generally use gears, vanes or pistons. Non-positive displacement components, such as centrifugal or turbine types, are seldom associated with hydraulic fluid power systems.

Pumps and motors are available either as “fixed-” or “variable-displacement” types. Fixed-displacement units have pre-selected internal geometries that maintain a relatively constant volume of liquid passing through the component per revolution of the component's shaft. Variable-displacement components have means for changing the internal geometries so that the volume of liquid passing through the component per revolution of the component's shaft can be changed.

This document is intended to unify testing methods for hydraulic fluid power positive displacement hydraulic pumps, motors and integral transmissions to enable the performance of the different components to be compared.

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Hydraulic fluid power — Positive-displacement pumps, motors and integral transmissions — Methods of testing and presenting basic steady state performance

1 Scope

This document specifies methods for determining the performance and efficiency of hydraulic fluid power positive displacement pumps, motors and integral transmissions. It applies to components having continuously rotating shafts.

This document specifies the requirements for test installations, test procedures under steady-state conditions and the presentation of test results.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4391, *Hydraulic fluid power — Pumps, motors and integral transmissions — Parameter definitions and letter symbols*

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

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

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

ISO 11631, *Measurement of fluid flow — Methods of specifying flowmeter performance*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4391 and ISO 5598 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Symbols and units

The symbols and subscripts listed in Table 1 are as specified in ISO 4391. Units as shown in Table 1 are in accordance with ISO 80000-1 and ISO 80000-4.

The letters and figures shall all be used as subscripts to the symbols listed in Table 1 are as specified in ISO 4391. The graphical symbols used in Figures 1, 2, 3 and 4 shall be used in accordance with ISO 1219-1.

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Table 1 — Symbols and units

Description	Symbol	Unit
Volume flow rate	q_V	$m^3\ s^{-1}$
Derived capacity	V_i	$m^3\ r^{-1}$
Rotational frequency	n	s^{-1}
Torque	T	N·m
Pressure	p	Pa[a]
Power	P	W
Mass density	ρ	$kg\ m^{-3}$
Isothermal bulk modulus secant	K_T	Pa[a]
Kinematic viscosity	ν	$m^2\ s^{-1}$[b]
Temperature	θ	K
Volume coefficient of thermal expansion	α	K^{-1}
Overall efficiency [c]	η_τ	—
Volumetric efficiency	η_ς	—
Rotational frequency ratio	Z	—

[a] 1 Pa = 1 N/m^2.

[b] 1 cSt = 1 $mm^2\ s^{-1}$.

[c] Efficiency may also be stated as a percentage.

NOTE When there is no risk of ambiguity (i.e. when a test has been carried out on a pump or a motor), the superscripts "P," "M" and "T" specifying that the quantity concerns, respectively, a pump, a motor or an integral transmission, can be omitted.

5 Tests

5.1 Requirements

5.1.1 General

Installations shall be designed to prevent air entrainment during operation and measures shall be taken to remove all free air from the system before testing.

The unit under test shall be installed and operated in the test circuit in accordance with the manufacturer's instructions; see also Annex B.

The ambient temperature of the test area shall be recorded.

A filter shall be installed in the test circuit to provide the fluid-cleanliness level specified by the manufacturer of the unit under test. The position, number and specific description of each filter used in the test circuit shall be recorded.

Where pressure measurements are made within the piping, the requirements of ISO 9110-1 and ISO 9110-2 shall be met.

Where flow measurements are made, the requirements of ISO 11631 shall be met.

Where temperature measurements are made within the piping, the temperature tapping point shall be positioned between two and four times the internal diameter of the piping from the pressure-tapping point furthest away from the component.

Figures 1, 2, 3 and 4 illustrate basic circuits that do not incorporate all the safety devices necessary to protect against damage in the event of any component fracture or fragmentation. It is important that

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those responsible for carrying out the test give due consideration to safeguarding both personnel and equipment.

NOTE A "run in" procedure before testing can have a positive effect on the test results.

5.1.2 Installation of the unit under test

The unit to be tested in the circuit shall be in accordance with the applicable Figure 1, 2, 3 or 4.

5.1.3 Test fluids

The properties of hydraulic fluids affect pump and motor performance. Any fluid can be used for the test, if agreed between the parties concerned, but its characteristics shall be clearly defined, according to the properties listed in Table 2. In order to compare two components, the same fluid shall be used.

Table 2 — Test fluid specification

Property	Standard	Recommended	
Viscosity grade	ISO 3448	ISO VG 32	ISO VG 46
Fluid classification	ISO 6743-4	HM	
Fluid specification	ISO 11158	(Table 3, ISO 11158)	
Additional constraints			
Density, g/cc	ISO 3675	860 to 880	
Viscosity index	ISO 2909	95 to 115	
Viscosity modification	N/A	The use of additional viscosity modifiers is prohibited.	
Friction modification	N/A	The use of additional friction modifiers is prohibited.	

5.1.4 Temperatures

5.1.4.1 Controlled temperature

Tests shall be carried out at a stated test fluid temperature. The test-fluid temperature shall be measured at the inlet port of the unit under test and be within the range recommended by the manufacturer. It is recommended that measurements are made at two temperature levels, 50 °C and 80 °C.

The test fluid temperature shall be maintained within the limits stated in Table 3.

Table 3 — Indicated test fluid temperature tolerance

Measurement accuracy class (see Annex A)	A	B	C
Temperature tolerance (°C)	±1,0	±2,0	±4,0

5.1.4.2 Other temperatures

The fluid temperature may be measured at the following locations:

a) at the outlet port of the unit under test;

b) at the flow measurement point in the test circuit;

c) in the drainage fluid line (if applicable).

For an integral transmission, it might not be possible to measure all the temperatures required. Temperatures not recorded shall be noted in the test report.

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