International Standard ISO 4391

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Hydraulic fluid power — Pumps, motors and integral transmissions — Parameter definitions and letter symbols

Transmissions hydrauliques — Pompes, moteurs et variateurs — Définitions des grandeurs et lettres utilisées comme symboles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4391 was developed by Technical Committee ISO/TC 131, *Fluid power systems*.

This second edition was submitted directly to the ISO Council, in accordance with clause 6.11.2 of part 1 of the Directives for the technical work of ISO. It cancels and replaces the first edition (i.e. ISO 4391-1982), which had been approved by the member bodies of the following countries :

Australia	Finland	Netherlands
Austria	France	Norway
Belgium	Germany, F.R.	Poland
Bulgaria	India	Romania
Canada	Italy	Spain
Chile	Japan	Sweden
Czechoslovakia	Libyan Arab Jamahiriya	USSR

The member bodies of the following countries had expressed disapproval of the document on technical grounds :

United Kingdom
USA

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Hydraulic fluid power — Pumps, motors and integral transmissions — Parameter definitions and letter symbols

0 Introduction

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within an enclosed circuit. Pumps are components which convert rotary mechanical power into fluid power. Motors are components which convert fluid power into rotary mechanical power. Transmissions convert a unidirectional variable speed shaft input to a unidirectional or bidirectional variable speed output.

1 Scope

This International Standard describes and systematically defines the principal technical characteristics of hydraulic pumps, motors and integral transmissions.

It allots letter symbols to these characteristics, and indicates how they can be more clearly defined by suffixes corresponding to particular cases. It also lists an analysis of parameter dimensions.

2 Field of application

The determination of exact descriptions with letter symbols, dimensions and definitions should create a single and unambiguous terminology for hydraulic pumps, motors and integral transmissions.

It is not yet possible to define a terminology absolutely valid in all cases concerning life, material fatigue or wear with respect to conditions of operation. This field is to be treated with reserve and should undergo precise study in each particular case.

3 References

ISO 31/0, *General principles concerning quantities, units and symbols.*

ISO 31/1, *Quantities and units of space and time.*

ISO 31/2, *Quantities and units of periodic and related phenomena.*

ISO 31/3, *Quantities and units of mechanics.*

ISO 31/4, *Quantities and units of heat.*

ISO 1219, *Fluid power systems and components — Graphic symbols.*

ISO 5598, *Fluid power systems and components — Vocabulary.*[1)]

4 Definitions

For definitions of terms used, see ISO 5598.

5 Guidelines for the use of letter symbols and suffixes

5.1 Letter symbols

See clause 7 for letter symbols.

5.2 Suffixes for letter symbols

See clause 8 for suffixes for letter symbols.

5.3 Letter symbols and suffixes

The use of symbols is self-explanatory but in combination with suffixes a large variety of possibilities can be developed. Therefore, the following guidelines are required to avoid the creation of too many different symbol-suffix combinations for the same subject.

5.3.1 Only if necessary for clarification are letters to be placed at the top of the symbols (P, M, T) to indicate the unit to be used, i.e. when equations are to be developed and compared for pumps, motors and transmissions.

5.3.2 If two or more suffixes are required, use a comma between them.

5.3.3 First priority : 0, 1, 2

5.3.4 Second priority : 3, b, d, e, g, h, hm, i, m, s, t, v, φ

5.3.5 Third priority : c, dry, ex, f, fi, in, k, p, n

5.3.6 Fourth priority : am, aux, lc, r, st

1) At present at the stage of draft.

5.3.7 Last priority : a, ma, mi, max, min

5.3.8 See clauses 8, 9 and 10 for examples of the use of symbols with suffixes.

5.4 Terms without symbols

See clause 12 for definition of terms without symbols.

6 Identification statement (Reference to this International Standard)

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

"Parameter definitions and letter symbols in accordance with ISO 4391, *Hydraulic fluid power — Pumps, motors and integral transmissions — Parameter definitions and letter symbols*."

7 Letter symbols for characteristics

7.1 Alphabetical sequence of Latin and Greek letters for symbols

Reference	Description	Symbol	Dimension	Definition or explanation
7.1.1	Bulk modulus	K	$ML^{-1}T^{-2}$	The relationship of applied stress and volumetric strain produced when stress is applied uniformly to all sides of a body. It is the reciprocal of compressibility.
7.1.2	Force	F	MLT^{-2}	—
7.1.3	Frequency	f	T^{-1}	—
7.1.4	Moment of inertia	I	ML^2	Value calculated from the moments of inertia of the moving parts
7.1.5	Mass	m	M	—
7.1.6	Rotational frequency (speed)	n	T^{-1}	The number of revolutions of the drive shaft in unit time
7.1.7	Power	P	ML^2T^{-3}	—
7.1.8	Pressure	p	$ML^{-1}T^{-1}$	Static pressure at a stated point
7.1.9	Mass flow rate	q_m	MT^{-1}	The mass of a fluid crossing the transverse plane of a flow path per unit time
7.1.10	Volume flow rate	q_V	L^3T^{-1}	The volume of a fluid crossing the transverse plane of a flow path per unit time
7.1.11	Stiffness	S	ML^2T^{-2}	Ratio of the variation of torque applied to a shaft and the variation of the angular position of the shaft
7.1.12	Torque	T	ML^2T^{-2}	—
7.1.13	Time	t	T	—
7.1.14	Instantaneous displacement	v	L^3	Swept volume at a given shaft position
7.1.15	Swept volume	V	L^3	The volume of a theoretically incompressible fluid that would be displaced by a complete stroke, cycle or revolution $V = \int_0^{2\pi} v \mathrm{d}\varphi$
7.1.16	Speed ratio	Z	1	Ratio of speed of two different units
7.1.17	Volume coefficient of thermal expansion	α	Θ^{-1}	—
7.1.18	Degree of irregularity for parameter X	δX	1	$\delta X = \frac{X_{max} - X_{min}}{X_{mi}}$, where X is any parameter

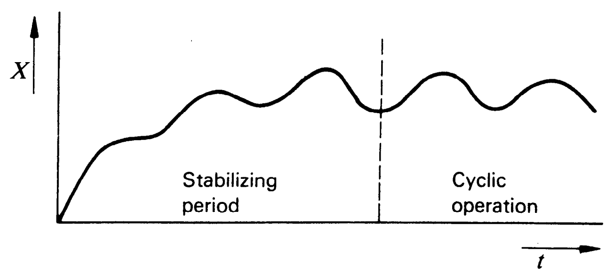
Reference	Description	Symbol	Dimension	Definition or explanation
7.1.19	Position of setting	ϵ	1	For variable units, the position of the control device is defined by the ratio between the theoretical swept volume V_i at a given adjustment and the maximum theoretical swept volume $V_{i, max}$ $\epsilon = \frac{V_i}{V_{i, max}}$
7.1.20	Efficiency	η	1	—
7.1.21	Temperature	θ	Θ	—
7.1.22	Angular velocity	ω	T^{-1}	The number of radians of a shaft in unit time $\omega = 2\pi n$

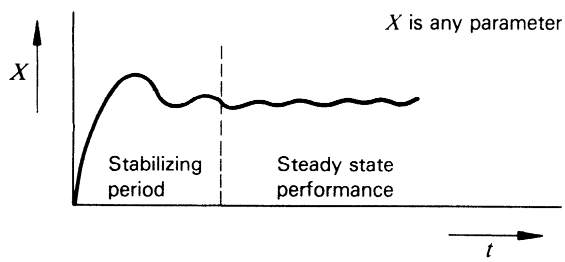
7.2 List of other symbols

Reference	Description	Symbol	Dimension	Definition or explanation
7.2.1	Direction of rotation : — clockwise — anti-clockwise	 R L	 1 1	From the point of view of an observer looking at the end of the shaft

8 Suffixes for symbols for characteristics

8.1 Alphabetical sequence of Latin and Greek letters for suffixes

Reference	Description	Suffix	Definition or explanation and examples
8.1.1	Acceptable conditions	a	Conditions which permit a tolerable standard of performance and life
8.1.2	Ambient	am	Surrounding
8.1.3	Auxiliary	aux	—
8.1.4	Adjustment	b	—
8.1.5	Cyclic stabilized conditions	c	Conditions in which the relevant parameters vary in a repetitive manner, similar conditions repeating at regular intervals 
8.1.6	Drainage	d	—
8.1.7	Indication of dry	dry	For values for which the fluid impact is not to be considered
8.1.8	Measured value	e	Obtained by direct measurement or by calculation based on measurements
8.1.9	External	ex	—
8.1.10	Fluid	f	—
8.1.11	Filling	fi	Indicating values due to imperfect filling of pump

Reference	Description	Suffix	Definition or explanation and examples
8.1.12	Geometric	g	Calculated on the basis of the geometric dimensions
8.1.13	Hydraulic	h	—
8.1.14	Hydraulic mechanical	hm	—
8.1.15	Theoretical	i	—
8.1.16	Internal	in	—
8.1.17	Compressibility related	k	—
8.1.18	Local	lc	—
8.1.19	Mechanical	m	—
8.1.20	Arithmetic mean	ma	$X_{ma} = \frac{X_1 + X_2 + \ldots + X_n}{n}$
8.1.21	Integral mean	mi	Mean value obtained by integration with respect to time. Mean value in the course of one revolution in time t_1 $X_{mi} = \frac{1}{t_1} \int_0^{t_1} X \, dt$
8.1.22	Limiting conditions of operation	min max	These are characterized by the extreme (minimum or maximum) values which each parameter can take; the other parameters being stated
8.1.23	Rated conditions	n	Steady state conditions for which a component or system is recommended as a result of specified testing. The "rated characteristics" are in general shown in catalogues
8.1.24	Peak duty related	p	A peak duty is an impulse during which the quantity exceeds the permitted maximum value. A peak duty is defined by a value which for a short period exceeds average value
8.1.25	Discontinuous conditions of operation	r	Conditions in which the relevant parameters do not attain stabilization as defined in either 8.1.5 or 8.1.27
8.1.26	Losses	s	—
8.1.27	Steady state conditions of operation	st	Conditions in which relevant parameters do not change appreciably after a period for stabilization 
8.1.28	Total value	t	Total value of a parameter where other values are also used
8.1.29	Volumetric value	v	—
8.1.30	Rotational angle	φ	—

8.2 List of other suffixes

Reference	Description	Suffix	Definition or explanation and examples
8.2.1 8.2.2 8.2.3	Position in unit	0 1 } * 2	Neutral condition Inlet or input Outlet or output
8.2.4 8.2.5 8.2.6	Type of unit	P M T	Pump Motor } Placed at the top of the symbols Integral transmission

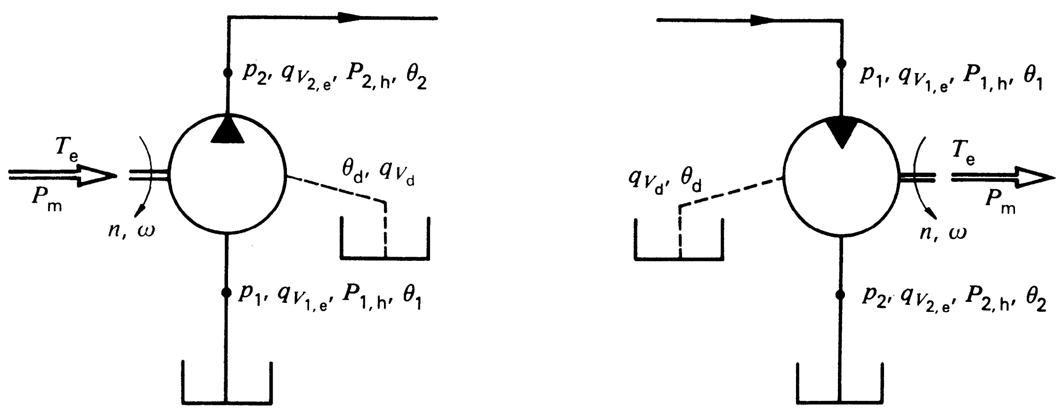
* Where the suffixes 0, 1 and 2 are not sufficient for specific description, identify inlets by odd numbers and outlets by even numbers.

9 Examples for the use of symbols with suffix for general characteristics

Reference	Description	Symbol	Dimension	Definition or explanation
9.1	Dry mass	m_{dry}	M	Mass of unit without fluid
9.2	Fluid mass	m_f	M	Mass of fluid contained in unit when ready to operate
9.3	Total (working) mass	m_t	M	Mass of unit ready to operate $m_t = m_{dry} + m_f$
9.4	Volumetric loss	q_{V_s}	L^3T^{-1}	—
9.5	Torque loss	T_s	ML^2T^{-2}	$T_s^P = T_e - T_i$ or $T_s^M = T_i - T_e$
9.6	Differential temperature	$\Delta\theta$	Θ	*
9.7	Ambient temperature	θ_{am}	Θ	The temperature of the environment in which the apparatus is working
9.8	Fluid drainage temperature	$\theta_{d,f}$	Θ	Temperature of the fluid at an external drainage point
9.9	Fluid temperature	θ_f	Θ	The temperature of the fluid measured at a specified point
9.10	Fluid inlet temperature	$\theta_{1,f}$	Θ	Temperature of the fluid measured at the inlet of the unit
9.11	Fluid outlet temperature	$\theta_{2,f}$	Θ	Temperature of the fluid measured at the outlet of the unit
9.12	Local temperature	θ_{lc}	Θ	Temperature of the equipment at a defined point

10 Examples for the use of symbols with suffix for pumps and motors

Reference	Description	Symbol	Dimension	Definition or explanation
10.1	Transformation of energy	—	—	General



Pump : $\Delta p = p_2 - p_1$

$$P_{1,h} = p_1 \cdot q_{V_{1,e}}$$

$$P_{2,h} = p_2 \cdot q_{V_{2,e}}$$

$$P_m = T_e \cdot \omega$$

$$\eta_t = \frac{P_{2,h} - P_{1,h}}{P_m} = \frac{P_{2,h} - P_{1,h}}{T_e \cdot \omega}$$

Motor : $\Delta p = p_1 - p_2$

$$P_{1,h} = p_1 \cdot q_{V_{1,e}}$$

$$P_{2,h} = p_2 \cdot q_{V_{2,e}}$$

$$P_m = T_e \cdot \omega$$

$$\eta_t = \frac{P_m}{P_{1,h} - P_{2,h}} = \frac{T_e \cdot \omega}{P_{1,h} - P_{2,h}}$$

* Δ is an indication of a differential value.