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Plain bearings — Terms, definitions, classification and symbols —

Part 5:
Application of symbols

Paliers lisses — Termes, définitions, classification et symboles —

Partie 5: Application des symboles

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Contents

Page

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 4378-5 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 6, *Terms and common items*.

This first edition cancels and replaces ISO 4378-4:1997 as well as ISO 7904-2:1995, which have been technically revised.

ISO 4378 consists of the following parts, under the general title *Plain bearings — Terms, definitions, classification and symbols*:

— *Part 1: Design, bearing materials and their properties*

— *Part 2: Friction and wear*

— *Part 3: Lubrication*

— *Part 4: Basic symbols*

— *Part 5: Application of symbols*

Introduction

As there is a large number of multiple designations in the domain of plain bearings, there is a considerable risk of error in the interpretation of standards and technical literature. This uncertainty leads to the continuous addition of supplementary designations, which only serves to increase the misunderstanding.

This part of ISO 4378 specifies pratical applications of the general symbols used in the field of plain bearings.

Plain bearings — Terms, definitions, classification and symbols —

Part 5:
Application of symbols

1 Scope

This part of ISO 4378 specifies practical applications of the general symbols defined in ISO 4378-4, with regard to the calculations, design and testing of plain bearings.

ISO 4378-4 distinguishes between basic characters and additional signs. Additional signs are subscripts and superscripts. The symbols necessary for plain bearing calculations, design, manufacture and testing are just basic characters or combinations of basic characters and additional signs.

This part of ISO 4378 lists symbols which have been found necessary for the calculations, design and testing of plain bearings. They have been defined in accordance with the recommendations given in ISO 4378-4.

Angles and directions of rotation are defined positively as rotating in a left-hand (anticlockwise) direction; the same applies to rotational frequencies, and circumferential and angular velocities.

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 4378-4, *Plain bearings — Terms, definitions, classification and symbols — Part 4: Basic symbols*

3 Symbols and terms

The following listings are not necessarily complete. They may be enlarged, if necessary.

NOTE Some letters of the Roman and Greek alphabet have not yet been used. Therefore, these letters are not listed below.

3.1 Symbols of the Roman alphabet

A heat-emitting surface area (bearing housing), elongation at fracture

A^* heat-emitting surface area parameter [thrust bearing, $A^* = A/(B \times L \times Z_{ax})$]

A_B area of segment or pad

A_G area of groove cross-section

A_i heat-emitting surface area (bearing housing) inside of the machine (flange bearing)

A_{lan} land area

A^*_{lan} relative land area ($A^*_{\mathrm{lan}} = A_{\mathrm{lan}}/(\pi \times D \times B)$ for hydrostatic journal bearings)

A_{o} heat-emitting surface area (bearing housing) outside of the machine (flange bearing)

A_{P} area of lubricant pocket

A_{S} area of cross-section

$\bar{A}_{\mathrm{T}}$ specific area of tube

$A_{\mathrm{T,i}}$ area of tube cross-section flowed through

a distance, acceleration, thermal diffusivity, inertia factor

a_{F} distance between leading edge and pivot position of pad (tilting-pad bearing)

a^*_{F} relative distance between leading edge and pivot position of pad (tilting-pad bearing)

a_{min} minimum distance between two circular thrust pads

a_{T} distance between temperature measuring point and bearing sliding surface

B width parallel to the sliding surface, normal to the direction of motion; bearing width, nominal bearing width, pad width, nominal pad width

B^* relative width, relative bearing width, relative pad width, width ratio ($B^* = B/D$)

B_{ax} width of thrust bearing or thrust pad [$B_{\mathrm{ax}} = (D_{\mathrm{o}} - D_{\mathrm{i}})/2$]

B_{eff} effective bearing width (without grooves, chamfers, etc.), effective pad width

B_{H} outer width of bearing housing in axial direction

B_{tot} total bearing width

b width parallel to the sliding surface, normal to the direction of motion or flow

b_{c} width of circumferential discharge (hydrostatic bearing, $b_{\mathrm{c}} = B - b_{\mathrm{lan}}$)

b_{G} width of lubricant groove, width of lubricant supply groove, width of bleed groove

b_{lan} land width parallel to the sliding surface, normal to the direction of flow

b_{P} width of lubricant pocket, width of lubricant supply pocket

b^*_{P} relative width of lubricant pocket, relative width of lubricant supply pocket

C bearing clearance, nominal bearing clearance, chamfer, concentration

C_{ax} axial bearing clearance (thrust bearing)

$C_{\mathrm{ax,m}}$ mean value of C_{ax} [$C_{\mathrm{ax,m}} = (C_{\mathrm{ax,min}} + C_{\mathrm{ax,max}})/2$]

$C_{\mathrm{ax,max}}$ maximum value of C_{ax}

$C_{\mathrm{ax,min}}$ minimum value of C_{ax}

C_{D} bearing clearance, bearing diametral clearance (difference between bearing bore and journal diameter of a journal bearing, $C_{\mathrm{D}} = D - D_{\mathrm{J}}$)

$C_{\mathrm{D,m}}$ mean value of C_{D} [$C_{\mathrm{D,m}} = (C_{\mathrm{D,min}} + C_{\mathrm{D,max}})/2$]

$C_{D,eff}$	effective bearing diametral clearance
$C_{D,max}$	maximum value of C_D
$C_{D,min}$	minimum value of C_D
C_G	circumference of groove cross-section
C_R	bearing radial clearance (difference between bearing bore and journal radius of a journal bearing, $C_R = R - R_J$)
$\Delta C_{R,el}$	elastic change of C_R
$C_{R,eff}$	effective bearing radial clearance
$C_{R,m}$	mean value of C_R [$C_{R,m} = (C_{R,min} + C_{R,max})/2$]
$C_{R,max}$	maximum value of C_R
$C_{R,min}$	minimum value of C_R
$\Delta C_{R,th}$	thermal change of C_R
$\Delta C_{R,tot}$	total change of C_R ($\Delta C_{R,tot} = \Delta C_{R,el} + \Delta C_{R,th}$)
c	specific heat capacity, lubricant specific heat capacity, stiffness
c_{ax}	axial bearing stiffness
$c_{ax,i}$	axial stiffness of the bearing when load is directed into the machine (flange bearing)
$c_{ax,o}$	axial stiffness of the bearing when load is directed out of the machine (flange bearing)
c_{dw}	vertical stiffness of the bearing loaded downwards
c_F	stiffness of pad pivot support in direction of load (tilting-pad bearing)
c_h	horizontal bearing stiffness
c_{ik}	lubricant film stiffness coefficient of journal bearing (i, k = 1, 2)
c^*_{ik}	non-dimensional lubricant film stiffness coefficient of journal bearing $$c^*_{ik} = \frac{\psi^3}{2 \times B \times \eta \times \omega} \times c_{ik} \; (i, k) = (1, 2)$$
$c_{ik,i}$	inner lubricant film stiffness coefficient of journal bearing (i, k = 1, 2)
$c_{ik,o}$	outer lubricant film stiffness coefficient of journal bearing (i, k = 1, 2)
c_{JR}	flexural stiffness of the Jeffcott Rotor
c_p	specific heat capacity of the lubricant (at constant pressure)
$c_{p,cl}$	specific heat capacity of the coolant (at constant pressure)
c_{sh}	flexural stiffness of shaft
c_{sup}	stiffness of isotropic bearing or bearing shell support
$c_{sup,ik}$	stiffness coefficient of anisotropic bearing or bearing shell support (i, k = 1, 2)
c_{up}	vertical stiffness of the bearing loaded upwards

c_v	vertical bearing stiffness
c_ϑ	angular stiffness of pad pivot support (tilting-pad bearing)
D	bearing diameter (inside diameter of journal bearing), nominal bearing diameter
D_B	twice the lobe or pad bore radius of a multi-lobed or tilting-pad journal bearing
$D_\mathrm{B,m}$	mean value of D_B [$D_\mathrm{B,m} = (D_\mathrm{B,min} + D_\mathrm{B,max})/2$]
$D_\mathrm{B,max}$	maximum value of D_B
$D_\mathrm{B,min}$	minimum value of D_B
$D_\mathrm{B,o}$	outside diameter of bearing shell or pad of a fixed-pad or tilting-pad journal bearing
D_fi	(outside) diameter of lubricating ring fixed to the shaft
$D_\mathrm{H,i}$	inside diameter of bearing housing
$D_\mathrm{H,o}$	outside diameter of bearing housing
D_i	inside diameter of thrust bearing sliding surface
D_J	journal diameter (diameter of the shaft section located inside of a journal bearing)
$D_\mathrm{J,m}$	mean value of D_J [$D_\mathrm{J,m} = (D_\mathrm{J,min} + D_\mathrm{J,max})/2$]
$D_\mathrm{J,max}$	maximum value of D_J
$D_\mathrm{J,min}$	minimum value of D_J
D_lo	(outside) diameter of loose lubricating ring
D_m	mean diameter of thrust bearing sliding surface [$D_\mathrm{m} = (D_\mathrm{i} + D_\mathrm{o})/2$]
D_max	maximum value of D
D_min	minimum value of D
D_o	outside diameter of thrust bearing sliding surface
$D_\mathrm{T,i}$	inside diameter of tube
$D_\mathrm{T,o}$	outside diameter of tube
d	diameter, distance, depth, damping
d_B	diameter of circular thrust pad
d_cp	diameter of capillary
d_e	damping of eigenfrequency, system damping
d_F	damping of pad pivot support in direction of load (tilting-pad bearing)
d_G	diameter of groove
$d_\mathrm{G,m}$	mean diameter of groove
d_{ik}	lubricant film damping coefficient of journal bearing (i, k = 1, 2)

d_{ik}^{*} non-dimensional lubricant film damping coefficient of journal bearing

$$\left[d_{ik}^{*} = \frac{\psi^{3}}{2 \times B \times \eta \times \omega} \times \omega \times d_{ik} \left(i, k = 1, 2 \right) \right]$$

d_{L} lubrication hole diameter

$d_{\mathrm{orf,i}}$ inside diameter of orifice

$d_{\mathrm{orf,o}}$ outside diameter of orifice

d_{P} diameter of lubricating pocket

d_{sup} damping of isotropic bearing or bearing shell support

$d_{\mathrm{sup},ik}$ damping coefficient of anisotropic bearing or bearing shell support (i, k = 1, 2)

d_{ϑ} angular damping of pad pivot support (tilting-pad bearing)

E Young's modulus (modulus of elasticity)

E_{B} Young's modulus of bearing material

E_{J} Young's modulus of journal material

E_{res} resultant Young's modulus

E_{sh} Young's modulus of shaft material

e eccentricity (distance between journal and bearing axis)

e_{B} eccentricity of bearing sliding surfaces (segments or pads) of a multi-lobed or tilting-pad journal bearing

$e_{\mathrm{B,h}}$ eccentricity of bearing sliding surfaces (segments) of a multi-lobed journal bearing in the horizontal direction

$e_{\mathrm{B,v}}$ eccentricity of bearing sliding surfaces (segments) of a multi-lobed journal bearing in the vertical direction

e_{CG} eccentricity of centre of gravity (distance between centre of gravity and shaft axis)

e_{x} component of eccentricity normal to direction of load

e_{y} component of eccentricity in direction of load

F bearing force, bearing load, nominal bearing load, load-carrying capacity

F^{*} bearing force parameter

ΔF additional dynamic force

ΔF^{*} additional dynamic force parameter ($\Delta F^{*} = \frac{\Delta F \times \psi^{2}}{B \times D \times \eta \times \omega}$ for journal bearings)

F_{ax} axial bearing force, axial bearing load, thrust bearing load (nominal load)

$F_{\mathrm{ax,lim}}$ maximum admissible thrust bearing load

$F_{\mathrm{ax,lim,i}}$ maximum admissible thrust bearing load directed into the machine (flange bearing)

$F_{\mathrm{ax,lim,o}}$ maximum admissible thrust bearing load directed out of the machine (flange bearing)

F_B segment or pad load

F_d damping force

F_{dyn} dynamic bearing force, dynamic bearing load

$F_{dyn,rsn}$ resonance amplitude of dynamic bearing force

$F_{dyn,x}$ component of F_{dyn} in the x-direction

$F_{dyn,y}$ component of F_{dyn} in the y-direction

F_e bearing force considering elasticity

F_e^* bearing force parameter considering elasticity ($F_e^* = K_{el} \times F^*$)

$F_{e,tr}$ bearing force considering elasticity at transition to mixed friction

$F_{e,tr}^*$ bearing force parameter considering elasticity at transition to mixed friction

F_{eff} effective load-carrying capacity

F_{eff}^* effective load-carrying capacity parameter [$F_{eff}^* = F_{hs} / (b_c \times l_{ax} \times Z \times p_{en})$ for hydrostatic journal bearings]

$F_{eff,0}^*$ effective load-carrying capacity parameter at $N = 0$

F_{exc} exciting force

F_f friction force ($F_f = f \times F$)

F_f^* friction force parameter ($F_f^* = \frac{f}{\psi} \times So$ for journal bearings)

$F_{f,ax}$ friction force of thrust bearing ($F_{f,ax} = f_{ax} \times F_{ax}$)

$F_{f,B}$ friction force of thrust bearing segment or pad

$F_{f,B}^*$ friction force parameter of thrust bearing segment or pad ($F_{f,B}^* = \frac{F_{f,B} \times h_{ax,min}}{B_{ax} \times R_m^2 \times \eta \times \omega}$)

$F_{f,G}$ friction force in the area of the lubricant groove

$F_{f,G}^*$ friction force parameter in the area of the lubricant groove

$F_{f,ld}$ friction force in the loaded area of the lubricant film

$F_{f,ld}^*$ friction force parameter in the loaded area of the lubricant film

$F_{f,P}$ friction force in the area of the lubricant pocket

$F_{f,P}^*$ friction force parameter in the area of the lubricant pocket

$F_{f,r}$ friction force of journal bearing ($F_{f,r} = f_r \times F_r$)

$F_{f,uld}$ friction force in the unloaded area of the lubricant film

$F_{f,uld}^*$ friction force parameter in the unloaded area of the lubricant film

F_{lim} maximum admissible bearing load

$F_{lim,dw}$ maximum admissible bearing load in vertical direction downwards

$F_{lim,h}$	maximum admissible bearing load in the horizontal direction
$F_{lim,up}$	maximum admissible bearing load in the vertical direction upwards
F_n	normal force (normal to the sliding surface)
F_r	radial bearing force, radial bearing load, journal bearing load (nominal load)
$F_{r,lim}$	maximum admissible journal bearing load
F_{res}	resulting force, resulting load
F_{rot}	bearing force component due to rotation
F_{sc}	static bearing force, static bearing load
F_{sp}	spring force
F_{sq}	bearing force component due to squeezing
F_{str}	bearing force at start ($N \approx 0$)
F_{stp}	bearing force at stop ($N \approx 0$)
F_{tr}	bearing force at transition to mixed friction
F_{tr}^*	bearing force parameter at transition to mixed friction
F_u	unbalance force
F_0	bearing force at $N = 0$
f	friction factor (coefficient of friction), deflection, function, frequency
f^*	friction parameter
f_{ax}	coefficient of friction of thrust bearing
f_B	downward deflection of segment or pad
f_e	bearing eigenfrequency
f_{hd}	hydrodynamic coefficient of friction
$f_{hd,m}$	hydrodynamic coefficient of friction in the area of mixed friction
f_J	journal deflection
f_{min}	minimum coefficient of friction, coefficient of friction at minimum of Stribeck curve
f_r	coefficient of friction of journal bearing
f_s	solid coefficient of friction
$f_{s,m}$	solid coefficient of friction in the area of mixed friction
f_{tl}^*	friction parameter of taper land thrust bearing ($f_{tl}^* = f^* \times h_{wed}/h_{ax,min}$)
f_{tr}	coefficient of friction at transition to mixed friction
G	shear modulus
g	acceleration due to gravity

H	height, bearing height, nominal bearing height, hardness
H_H	height of bearing housing
h	height, depth, thickness, lubricant film thickness, local lubricant film thickness, gap
h^*	relative lubricant film thickness, relative local lubricant film thickness ($h^* = h/C_R$ for journal bearings)
h_{en}	lubricant film thickness at the entrance gap
h_{ex}	lubricant film thickness at the exit gap
h_G	depth of lubricant groove, depth of lubricant supply groove
h_{lim}	minimum admissible lubricant film thickness during operation
h^*_{lim}	minimum admissible relative lubricant film thickness during operation ($h^*_{lim} = h_{r,lim}/C_R$ for journal bearings)
$h_{lim,tr}$	minimum admissible lubricant film thickness at transition to mixed friction (minimum value of minimum lubricant film thickness still permitting full separation of bearing and shaft sliding surfaces by a lubricant film)
$h^*_{lim,tr}$	minimum admissible relative lubricant film thickness at transition to mixed friction ($h^*_{lim,tr} = h_{lim,tr}/C_R$ for journal bearings)
h_{min}	minimum lubricant film thickness, minimum gap
h^*_{min}	minimum relative lubricant film thickness, minimum relative gap ($h^*_{min} = h_{r,min}/C_R$ for journal bearings, $h^*_{min} = h_{ax, min}/h_{wed}$ for thrust bearings)
$h_{min,tr}$	minimum lubricant film thickness at transition to mixed friction
$h^*_{min,tr}$	minimum relative lubricant film thickness at transition to mixed friction ($h^*_{min,tr} = h_{min,tr}/C_R$ for journal bearings)
$h_{min,0}$	reference value of h_{min}
h_P	depth of lubricant pocket, depth of lubricant supply pocket
$h_{r,lim}$	minimum admissible lubricant film thickness of journal bearing during operation
$h_{r,min}$	minimum lubricant film thickness of journal bearing
h_{wav}	waviness of sliding surface
$h_{wav,eff}$	effective waviness of sliding surface
$h_{wav,eff,lim}$	maximum admissible effective waviness of sliding surface
$h_{wav,lim}$	maximum admissible waviness of sliding surface
h_{wed}	wedge depth (thrust bearing)
h^*_{wed}	relative wedge depth (thrust bearing, $h^*_{wed} = h_{wed}/l_{wed}$)
$h_{wed,r}$	wedge depth in radial direction (thrust bearing)
h_0	local gap at $\varepsilon = 0$ (journal bearing)
h^*_0	relative local gap at $\varepsilon = 0$ ($h^*_0 = h_0/C_R$)

$h_{0,\max}$	maximum gap at $\varepsilon = 0$
$h^*_{0,\max}$	maximum relative gap at $\varepsilon = 0$, gap ratio ($h^*_{0,\max} = h_{0,\max}/C_R$)
I	geometrical moment of inertia
i	$\sqrt{-1}$
J	mass moment of inertia
J_X	bearing mass moment of inertia with reference to the X-axis
J_Y	bearing mass moment of inertia with reference to the Y-axis
J_Z	bearing mass moment of inertia with reference to the Z-axis
j	$\sqrt{-1}$
K	coefficient, constant, factor, parameter, auxiliary variable
K_d	dissipation parameter [$K_d = \eta \times \omega/(\rho \times c_p \times T \times \psi^2)$ for journal bearings]
K_{el}	elasticity influence parameter
K_{fil}	fill factor
K_I	correction factor considering the heat transition resistance of bearing insulation
K_P	profile factor [relative difference between lobe or pad bore radius and journal radius, $K_P = 1/(1 - m)$]
$K_{P,eff}$	effective profile factor
$\Delta K_{P,el}$	elastic change of K_P
$K_{P,T}$	profile factor at temperature T
$\Delta K_{P,th}$	thermal change of K_P
$\Delta K_{P,tot}$	total change of K_P ($\Delta K_{P,tot} = \Delta K_{P,el} + \Delta K_{P,th}$)
K_{rot}	rotational speed influence parameter
K_T	heating parameter ($K_T = \dfrac{\eta_0 \times \omega}{\rho \times c_p \times T_0 \times \psi^2}$ for journal bearings)
K_w	wear coefficient
K_λ	heat conduction parameter ($K_\lambda = \dfrac{1}{Re \times Pr \times \psi}$ for journal bearings)
k	heat transition coefficient
k_{A*}	heat transition coefficient referring to A*
k*	heat transition parameter [$k^* = 2 \times \psi \times k_A \times A/(\lambda \times D)$ for journal bearings]
k_A	heat transition coefficient referring to A
k_B	heat transition coefficient referring to bearing sliding surface (heat transition coefficient at the interface between lubricant film and bearing sliding surface)

k_T heat transition coefficient of tube

L length parallel to the sliding surface, in direction of motion; nominal length, pad length, nominal pad length

L_H length of bearing housing at right angles to the axis

L_T length of tube

l length in the direction of flow, exponent of Falz's formula for the dependency of η on

$$T\left[\frac{\eta}{\eta_0}=\left(\frac{T}{T_0}\right)^{-l}\right]$$

l_{cp} length of capillary

l_G length of lubricant groove (circumferential direction), length of lubricant supply groove, length of drainage groove, length of bleed groove

l_{ax} length of axial discharge [$l_{ax} = \pi \times D/Z_{ax} - (l_{lan} + l_G)$ for hydrostatic journal bearings]

l_{lan} land length in the direction of flow (thrust bearing)

l_P length of lubricant pocket, length of lubricant supply pocket

l_{wed} wedge length (thrust bearing)

M moment, mixing factor

M_F moment of bearing load

M_f friction moment ($M_f = R \times F_{f,r}$ for journal bearings, $M_f = R_m \times F_{f,ax}$ for thrust bearings)

m mass, preload of bearing or pad sliding surface

m_B bearing mass

m_{JR} mass of the Jeffcott Rotor

N rotational speed (rotational frequency) of the rotor (revolutions per time unit)

N_B rotational speed (rotational frequency) of the bearing

N_{cr} critical speed (critical rotational frequency) of the rigidly supported rotor

N_F rotational speed (rotational frequency) of the bearing force

$N_{f,min}$ rotational speed (rotational frequency) at minimum of Stribeck curve

N_{lim} rotational speed (rotational frequency) at the stability speed limit of the rotor supported by plain bearings

N_{max} maximum rotational speed (maximum rotational frequency)

N_{min} minimum rotational speed (minimum rotational frequency)

N_{rsn} resonance speed (resonance rotational frequency) of the rotor supported by plain bearings

N_{tr} rotational speed (rotational frequency) at transition to mixed friction, transition rotational speed, transition rotational frequency

N_0	reference value of N
Nu	Nusselt number
n	number
O	point of origin, centre, centreline, order of magnitude
O_B	centreline of plain bearing
O_i	centreline of sliding surface No. i
O_J	centreline of journal
P	power, heat flow
P^*	power ratio ($P^* = P_f/P_{Pu}$)
$P_{cv,B}$	heat flow discharged from the bearing to the ambient air via convection
$P_{cv,sh}$	heat flow discharged from the shaft to the ambient air via convection
P_f	frictional power
$P_{f,ax}$	frictional power of thrust bearing ($P_{f,ax} = F_{f,ax} \times U_m$)
$P_{f,P}$	frictional power in the lubricant pocket(s)
$P_{f,r}$	frictional power of journal bearing ($P_{f,r} = F_{f,r} \times U_J$)
P_{Pu}	pumping power
P_{pa}	parasitic power loss
$P_{pa,ax}$	parasitic power loss of thrust bearing
$P_{pa,r}$	parasitic power loss of journal bearing
P_{th}	heat flow (quantity of heat transferred by heat or mass transfer per time unit)
$P_{th,amb}$	heat flow to the ambient air
$P_{th,cl}$	heat flow via the cooling system
$P_{th,f}$	heat flow due to frictional power
$P_{th,L}$	heat flow via the lubricant
$P_{th,L,en}$	heat flow supplied to the bearing via the lubricant
$P_{th,L,ex}$	heat flow discharged from the bearing via the lubricant
$P_{th,sf}$	heat flow discharged from the bearing via the lubricant side flow rate
P_{tot}	total power
P_{tot}^*	total power parameter ($P_{tot}^* = \frac{P_{tot}}{F_r \times \omega \times C_R}$ for journal bearings)
$P_{\lambda,sh}$	heat flow discharged from the bearing via heat conduction in the shaft

Pr Prandtl number ($Pr = \frac{\eta \times c_p}{\lambda}$)

p lubricant film pressure, local lubricant film pressure (pressure built up in the lubricant film of a plain bearing by hydrodynamic or hydrostatic effects)

$\overline{p}$ specific bearing load (bearing load per unit of projected bearing area)

p_{amb} ambient pressure (pressure in the immediate vicinity of bearing shell or pad)

$p_{amb,i}$ ambient pressure at D_i (thrust bearing)

$p_{amb,o}$ ambient pressure at D_o (thrust bearing)

$\overline{p}_{ax}$ specific load of thrust bearing [$\overline{p}_{ax} = F_{ax}/(B \times L \times Z_{ax})$]

p_B profile of bearing or pad sliding surface

$\overline{p}_{dyn}$ dynamic specific bearing force, dynamic specific bearing load ($\overline{p}_{dyn} = F_{dyn}/(B \times D)$ for journal bearings, $\overline{p}_{dyn} = F_{dyn}/(B \times L \times Z_{ax})$ for thrust bearings)

p_{en} lubricant supply pressure (pressure by which the lubricant is supplied to the bearing)

p_{en}^* lubricant supply pressure parameter ($p_{en}^* = \frac{p_{en} \times \psi^2}{\eta \times \omega}$ for journal bearings)

p_{lim} maximum admissible lubricant film pressure

$\overline{p}_{lim}$ maximum admissible specific bearing load (limiting value of specific bearing load; exceeding this value may lead to bearing failure)

$\overline{p}_{lim,tr}$ maximum admissible specific bearing load at transition to mixed friction

p_{max} maximum lubricant film pressure

p_{max}^* maximum lubricant film pressure parameter ($p_{max}^* = p_{max}/\overline{p}$)

p_P lubricant pressure in the lubricant pocket

$p_{P,i}$ lubricant pressure in the lubricant pocket No. i

$p_{P,i,0}$ lubricant pressure in the lubricant pocket No. i at $\varepsilon = 0$ (journal bearing)

$\overline{p}_r$ specific load of journal bearing [$\overline{p}_r = F_r/(B \times D)$]

$\overline{p}_{sc}$ static specific bearing force, static specific bearing load [$\overline{p}_{sc} = F_{sc}/(B \times D)$ for journal bearings, $\overline{p}_{sc} = F_{sc}/(B \times L \times Z_{ax})$ for thrust bearings]

$\overline{p}_{str}$ specific bearing load at start $(N \approx 0)$

$\overline{p}_{stp}$ specific bearing load at stop $(N \approx 0)$

$\overline{p}_{tr}$ specific bearing load at transition to mixed friction [$\overline{p}_{tr} = F_{tr}/(B \times D)$ for journal bearings]

Q lubricant flow rate (volume of lubricant passing through the bearing per time unit, $Q = Q_3 + Q_p$)

Q^* lubricant flow rate parameter, relative lubricant flow rate ($Q^* = Q/Q_0$)

Q_{ax} lubricant flow rate of thrust bearing

$Q_{ax,en}$ lubricant flow rate supplied to the thrust bearing

Q_{le}	lubricant flow rate at leading edge of segment or pad
Q_{sf}	lubricant side flow rate of segment or pad
Q_{te}	lubricant flow rate at trailing edge of segment or pad
Q_{cl}	coolant flow rate
Q_{P}	lubricant flow rate per lubricant pocket
Q_{Pu}	lubricant flow rate at pump
$Q_{Pu,lim}$	maximum admissible lubricant flow rate at pump
Q_{p}	lubricant flow rate due to supply pressure
Q_{p}^{*}	lubricant flow rate parameter due to supply pressure [$Q_{p}^{*} = Q_{p}/(p_{en}^{*} \times Q_{0})$]
$Q_{P,sf}$	lubricant side flow rate of lubricant pocket
Q_{r}	lubricant flow rate of journal bearing
$Q_{r,en}$	lubricant flow rate supplied to the journal bearing
Q_{0}	reference value of Q ($Q_0 = R^3 \times \omega \times \psi$ for hydrodynamic journal bearings, $Q_0 = C_R^3 \times p_{en}/\eta$ for hydrostatic journal bearings, $Q_0 = B_{ax} \times h_{ax,min} \times U_m \times Z_{ax}$ or $Q_0 = h_{ax,min} \times \omega \times R_m^2$ for thrust bearings)
Q_{1}	lubricant flow rate at the entrance into the gap (circumferential direction)
Q_{1}^{*}	lubricant flow rate parameter at the entrance into the gap (circumferential direction, $Q_1^* = Q_1/Q_0$)
Q_{2}	lubricant flow rate at the exit of the gap (circumferential direction, $Q_2 = Q_1 - Q_3$)
Q_{2}^{*}	lubricant flow rate parameter at the exit of the gap (circumferential direction, $Q_2^* = Q_2/Q_0$)
Q_{3}	lubricant flow rate due to hydrodynamic pressure build-up (side flow rate)
Q_{3}^{*}	lubricant flow rate parameter due to hydrodynamic pressure build-up (side flow rate parameter, $Q_3^* = Q_3/Q_0$)
q	lubricant flow rate (lubricant volume flow)
R	journal bearing inside radius ($R = D/2$)
R_{a}	surface finish Centre Line Average (CLA)
$R_{a,B}$	surface finish Centre Line Average (CLA) of bearing sliding surface
$R_{a,J}$	surface finish Centre Line Average (CLA) of journal or thrust collar sliding surface
R_{B}	lobe or pad bore radius of a multi-lobed or tilting-pad journal bearing ($R_B = D_B/2$)
ΔR_{B}	difference between lobe or pad bore radius and journal radius ($\Delta R_B = R_B - R_J$)
R_{cp}	flow resistance of capillary
R_{J}	journal radius (radius of the shaft section located inside of a journal bearing, $R_J = D_J/2$)
$R_{lan,ax}$	flow resistance of land parallel to the sliding surface, normal to the direction of flow

$R_{lan,c}$	flow resistance of land in the direction of flow
R_m	mean radius of thrust bearing sliding surface ($R_m = D_m/2$)
R_P	flow resistance of lubricant pocket (hydrostatic bearing)
$R_{P,0}$	flow resistance of lubricant pocket at $\varepsilon = 0$ (hydrostatic journal bearing)
$\mathrm{R_z}$	surface finish ten-point average
$\mathrm{R_{z,B}}$	surface finish ten-point average of bearing sliding surface
$R_{z,J}$	surface finish ten-point average of journal or thrust collar sliding surface
Re	Reynolds number [$Re = (\rho \times \omega \times R \times C_R)/\eta$ for journal bearings, $Re = \rho \times \omega \times R_m \times h_{min}/\eta$ for thrust bearings]
Re_{cp}	Reynolds number in the capillary ($Re_{cp} = \rho \times \bar{v}_{cp} \times d_{cp}/\eta_{cp}$)
Re_{cr}	critical Reynolds number
Re_P	Reynolds number in the lubricant pocket ($Re_P = \rho \times U \times h_P/\eta$)
r	radius, coordinate in the radial direction
r_F	coordinate of pivot position of pad in the radial direction (tilting-pad bearing)
r_T	coordinate of temperature measuring point in the radial direction
S	safety factor, displacement amplitude of rotor (mechanical oscillation), S number (special form of reciprocal Sommerfeld number So, $S = \frac{1}{2 \times \pi \times So} = \frac{B \times D \times \eta \times \omega}{2 \times \pi \times F_r \times \psi^2}$)
S_F	safety factor against mixed friction due to overload
S_N	safety factor against mixed friction due to rotational underspeed
S_{rsn}	displacement amplitude of rotor at resonance
So	Sommerfeld number (special form of bearing force parameter F^*; $So = \frac{F_r \times \psi^2}{B \times D \times \eta \times \omega}$ for journal bearings, $So = \frac{F_{ax} \times h_{ax,min}^2}{Z_{ax} \times B_{ax} \times R_m^3 \times \eta \times \omega}$ for thrust bearings)
So_{cr}	Sommerfeld number formed with ω_{cr} (journal bearing, $So_{cr} = \frac{F_r \times \psi^2}{B \times D \times \eta \times \omega_{cr}}$)
So_m	Sommerfeld number formed with η_m ($So_m = \frac{F_r \times \psi^2}{B \times D \times \eta_m \times \omega}$ for journal bearings)
So_{rot}	Sommerfeld number of bearing force component due to rotation ($So_{rot} = \frac{F_{rot} \times \psi^2}{B \times D \times \eta \times \omega}$ for journal bearings)
So_{sq}	Sommerfeld number of bearing force component due to squeezing ($So_{sq} = \frac{F_{sq} \times \psi^2}{B \times D \times \eta \times \dot{\varepsilon}}$ for journal bearings)
So_{tr}	Sommerfeld number at transition to mixed friction
So_0	Sommerfeld number formed with η_0 ($So_0 = \frac{F_r \times \psi^2}{B \times D \times \eta_0 \times \omega}$ for journal bearings)

SP	switching period
s	displacement
s_y	journal displacement against the direction of load
T	temperature, lubricant temperature
ΔT	difference between lubricant temperature at the bearing exit and lubricant temperature at the bearing entrance ($\Delta T = T_{ex} - T_{en}$)
T_{amb}	ambient temperature (temperature in the immediate vicinity of the bearing)
$T_{amb,B}$	bearing shell or pad ambient temperature
$T_{amb,C}$	thrust collar ambient temperature (thrust bearing)
$T_{amb,sh}$	shaft ambient temperature
T_B	bearing temperature
$T_{B,max}$	maximum bearing or pad sliding surface temperature
$T_{B,lim}$	maximum admissible bearing sliding surface temperature (maximum temperature of bearing sliding surface material; exceeding this value leads to deterioration of the material)
T_C	thrust collar temperature (thrust bearing)
ΔT_{cl}	difference between coolant temperature at the heat exchanger exit and coolant temperature at the heat exchanger entrance ($\Delta T_{cl} = T_{cl,ex} - T_{cl,en}$)
$T_{cl,en}$	coolant temperature at the heat exchanger entrance
$T_{cl,ex}$	coolant temperature at the heat exchanger exit
T_{cp}	lubricant temperature in the capillary (hydrostatic bearing)
T_{eff}	effective temperature of lubricant film (temperature defined on the basis of heat balance)
$T_{eff,ax}$	effective temperature of lubricant film of thrust bearing
$T_{eff,lim}$	maximum admissible effective temperature of lubricant film
$T_{eff,r}$	effective temperature of lubricant film of journal bearing
$T_{eff,tr}$	effective temperature of lubricant film at transition to mixed friction
T_{en}	lubricant temperature at the bearing entrance (temperature at which the lubricant is supplied to the bearing, measured immediately before entering the bearing)
T_{ex}	lubricant temperature at the bearing exit
T_{gl}	glass transition temperature (testing of plastics)
T_J	journal temperature
$T_{le,m}$	mean lubricant temperature at leading edge of segment or pad
T_{lim}	maximum admissible bearing temperature
T_{max}	maximum temperature of lubricant film

ΔT_{max} difference between maximum temperature of lubricant film and lubricant temperature in the lubricant pocket ($\Delta T_{max} = T_{max} - T_1$)

ΔT^*_{max} non-dimensional difference between maximum temperature of lubricant film and lubricant temperature in the lubricant pocket ($\Delta T^*_{max} = \frac{\rho \times c_p \times \psi}{\bar{p}_r \times f_r} \times \Delta T_{max}$ for journal bearings)

T_{ms} measured temperature

$T_{P,m}$ mean temperature in the lubricant pocket(s)

$T_{P,sf,m}$ mean temperature of the lubricant side flow rate of lubricant pocket

$T_{sf,m}$ mean temperature of the lubricant side flow rate of segment or pad

T_{sh} shaft temperature

$T_{te,m}$ mean lubricant temperature at trailing edge of segment or pad

T_0 lower reference temperature

T_1 lubricant temperature at the entrance into the gap (circumferential direction), upper reference temperature

ΔT_1 difference between lubricant temperature at the entrance into the gap and lubricant temperature at the bearing entrance ($\Delta T_1 = T_1 - T_{en}$)

T_2 lubricant temperature at pressure trailing edge (circumferential direction)

ΔT_2 difference between lubricant temperature at pressure trailing edge and lubricant temperature at the entrance into the gap ($\Delta T_2 = T_2 - T_1$)

Ta Taylor number ($Ta = Re \times \sqrt{\psi}$ for journal bearings)

Ta_{cr} critical Taylor number (Ta_{cr} = 41,3 for journal bearings)

t time, thickness, wall thickness, lining thickness

t_B thickness of bearing shell or segment or pad

t_C thickness of thrust collar (thrust bearing)

U surface velocity in the x- or φ-direction, sliding velocity, circumferential speed

U_B circumferential speed of the bearing

U_J circumferential speed of the journal, sliding velocity ($U_J = \omega \times R_J$)

$U_{lim,tr}$ minimum admissible circumferential speed at transition to mixed friction

U_m mean circumferential speed of the thrust collar sliding surface, sliding velocity ($U_m = \omega \times R_m$)

U_{tr} circumferential speed at transition to mixed friction

u velocity component in the x- or φ-direction, deformation in x-direction

$\bar{u}$ average velocity component in the x- or φ-direction

V volume, surface velocity in the y-direction

V_L lubricant volume of the bearing

VG	viscosity grade of the lubricant
VI	viscosity index of the lubricant
v	velocity component in y-direction, deformation in the y-direction
$\overline{v}$	average velocity component in the y-direction
$v_{ax,el}$	elastic deformation of thrust bearing or segment or pad in the y-direction
$v_{ax,th}$	thermal deformation of thrust bearing or segment or pad in the y-direction
$v_{ax,tot}$	total deformation of thrust bearing or segment or pad in the y-direction ($v_{ax,tot} = v_{ax,el} + v_{ax,th}$)
$\overline{v}_{cl}$	average flow velocity of the coolant
$\overline{v}_{cp}$	average flow velocity in the capillary
W	surface velocity in the z-direction, work (energy)
w	velocity component in z-direction, deformation in the z-direction
$\overline{w}$	average velocity component in the z-direction
w_{amb}	velocity of ambient air surrounding the bearing housing
X	Cartesian coordinate
X_{CG}	coordinate of the bearing centre of gravity in the x-direction
x	coordinate parallel to sliding surface, in direction of motion (circumferential direction); coordinate of journal radial motion, normal to direction of load
$\dot{x}$	velocity of journal radial motion, normal to direction of load
x^*	relative coordinate of journal radial motion, normal to direction of load ($x^* = x/C_R$)
$x_{F,f,B}$	coordinate of $F_{f,B}$ in the x-direction
$x_{F,res}$	coordinate of F_{res} in the x-direction
Y	Cartesian coordinate
Y_{CG}	coordinate of the bearing centre of gravity in the y-direction
y	coordinate normal to sliding surface (across the lubricating film, for journal bearings in the radial direction, for thrust bearings in the axial direction); coordinate of journal radial motion, in direction of load
$\dot{y}$	velocity of journal radial motion, in direction of load
y^*	relative coordinate of journal radial motion, in direction of load ($y^* = y/C_R$)
y_h	coordinate normal to sliding surface (across the lubricating film)
Z	Cartesian coordinate, number of sliding surfaces (pads), number of pockets per bearing, necking after fracture
Z_{ax}	number of sliding surfaces (pads) of thrust bearing
Z_{cl}	number of coolers, number of heat exchangers

Z_{CG} coordinate of the bearing centre of gravity in the z-direction

Z_P number of lubricant pockets

Z_r number of sliding surfaces (pads) of journal bearing

Z_T number of tubes

z coordinate parallel to the sliding surface, normal to the direction of motion (normal to circumferential direction; for journal bearings in the axial direction, for thrust bearings in the radial direction); coordinate in the axial direction

$z_{F,res}$ coordinate of F_{res} in the z-direction

z_T coordinate of temperature measuring point in axial direction

3.2 Symbols of the Greek alphabet

NOTE As there is a risk of confusion with the corresponding Roman letters, the following Greek letters have not been specified: *A*, *B*, *E*, *Z*, *H*, *I*, *K*, *M*, *N*, *O*, *o*, *P*, *T*, *Y*, *X*.

α angle, heat transfer coefficient

α_B heat transfer coefficient of bearing or bearing shell or pad

α_{Bu} Bunsen coefficient

α_C heat transfer coefficient of thrust collar (thrust bearing)

α_l linear thermal expansion coefficient

$\alpha_{l,B}$ linear thermal expansion coefficient of bearing material

$\alpha_{l,J}$ linear thermal expansion coefficient of journal material

$\alpha_{l,sh}$ linear thermal expansion coefficient of shaft material

α_{mnt} mounting angle

α_p pressure viscosity coefficient

$\alpha_{p,T}$ pressure-temperature viscosity coefficient

α_{sh} heat transfer coefficient of shaft

α_V cubic thermal expansion coefficient

β attitude angle (angular position of journal eccentricity related to the direction of load), temperature viscosity coefficient

$\beta_{h,min}$ angle between direction of load and position of minimum lubricant film thickness

β_0 initial value of β

γ angular direction of bearing load, load angle

Δ difference, tolerance, change

δ angle

δ_B bearing misalignment angle (angular deviation of bearing)

$\delta_{B,h}$	bearing misalignment angle in the horizontal direction
$\delta_{B,v}$	bearing misalignment angle in the vertical direction
$\delta_{h,min}$	angular position of minimum lubricant film thickness
δ_J	journal misalignment angle (angular deviation of journal)
$\delta_{J,h}$	journal misalignment angle in the horizontal direction
$\delta_{J,v}$	journal misalignment angle in the vertical direction
ε	relative eccentricity ($\varepsilon = e/C_R$), relative strain
ε_0	initial value of ε
ζ	hydraulic resistance coefficient, nozzle coefficient
ζ_P	hydraulic resistance coefficient of the lubricant pocket
η	dynamic viscosity of the lubricant
η_B	dynamic viscosity of the lubricant at T_B
η_{cp}	dynamic viscosity of the lubricant at T_{cp}
η_{eff}	effective dynamic viscosity in lubricant film
$\eta_{eff,ax}$	effective dynamic viscosity in lubricant film of thrust bearing
$\eta_{eff,r}$	effective dynamic viscosity in lubricant film of journal bearing
η_m	mean dynamic viscosity in lubricant film of journal bearing
η_0	dynamic viscosity of the lubricant at T_0
η_1	dynamic viscosity of the lubricant at T_1
ϑ	angle, angular coordinate, tilting angle (tilting-pad bearing)
κ	resistance ratio (hydrostatic bearing, $\kappa = \frac{R_{lan,ax}}{R_{lan,c}}$)
λ	thermal conductivity of the lubricant
λ_B	thermal conductivity of bearing or bearing shell or pad material
λ_C	thermal conductivity of thrust collar material (thrust bearing)
λ_{sh}	thermal conductivity of shaft material
μ	relative bearing stiffness, relative shaft flexibility (Jeffcott Rotor, $\mu = \frac{F_r / C_R}{c_{JR} / 2} = \frac{g}{C_R \times \omega_{cr}^2}$); friction factor (coefficient of friction), dynamic viscosity
ν	kinematic viscosity of the lubricant, Poisson's ratio
ν_B	Poisson's ratio of bearing material
ν_J	Poisson's ratio of journal material
ν_{sh}	Poisson's ratio of shaft material
ξ	restrictor ratio ($\xi = R_{cp}/R_{P,0}$ for hydrostatic journal bearings)

π	circular constant (Ludolph's number) ($\pi = 3{,}141\,592$ ...)
ρ	density of the lubricant
ρ_{cl}	density of the coolant
σ	normal stress, standard deviation
τ	shearing stress
Φ	dissipation function, sliding surface utilization ratio ($0 < \Phi < 1$)
φ	angular coordinate in circumferential direction
φ_{ct}	angular coordinate of contact line between journal and bearing at $N = 0$
φ_F	angular coordinate of pivot position of pad (tilting-pad bearing)
φ_{le}	angular coordinate of pressure leading edge
φ_P	angular coordinate of lubricant pocket centreline
φ_T	angular coordinate of temperature measuring point
φ_{te}	angular coordinate of pressure trailing edge
$\varphi_{wed,ex}$	angular coordinate at the exit of the wedge face
φ_0	angular coordinate of bearing sliding surface (segment or pad) centreline at multi-lobed or tilting-pad journal bearings (with non-tilted pads)
φ_1	angular coordinate at the entrance into the gap
φ_2	angular coordinate at the end of the hydrodynamic pressure build-up
φ_3	angular coordinate at the exit of the gap
ψ	relative bearing clearance (ratio of bearing diametral clearance to nominal bearing diameter of a journal bearing, $\psi = C_R/R$)
$\Delta\psi$	tolerance of ψ ($\Delta\psi = \psi_{max} - \psi_{min}$)
$\bar{\psi}$	mean value of ψ
ψ_{eff}	effective relative bearing clearance
$\Delta\psi_{el}$	elastic change of ψ
ψ_{max}	maximum value of ψ
ψ_{min}	minimum value of ψ
$\Delta\psi_{th}$	thermal change of ψ
$\Delta\psi_{tot}$	total change of ψ ($\Delta\psi_{tot} = \Delta\psi_{el} + \Delta\psi_{th}$)
ψ_0	reference value of ψ
ψ_{20}	relative bearing clearance at 20 °C
Ω	angular span of bearing sliding surface (segment or pad, $\Omega = \varphi_3 - \varphi_1$)

Ω_{ax}	angular span of thrust bearing sliding surface (segment or pad)
Ω_F	angular distance between leading edge and pivot position of pad (tilting-pad bearing, $\Omega_F = \varphi_F - \varphi_1$)
Ω_F^*	relative angular distance between leading edge and pivot position of pad (tilting-pad bearing, $\Omega_F^* = \Omega_F/\Omega$)
Ω_G	angular span of lubricant groove
Ω_{lan}	angular span of land face (thrust bearing)
Ω_P	angular span of lubricant pocket ($\Omega_P = 360°/Z - \Omega$)
Ω_r	angular span of journal bearing sliding surface (segment or pad)
Ω_{wed}	angular span of wedge face (thrust bearing)
ω	angular speed of the rotor ($\omega = 2 \times \pi \times N$)
ω_B	angular speed of the bearing ($\omega_B = 2 \times \pi \times N_B$)
ω_{cr}	critical angular speed of the rigidly supported rotor ($\omega_{cr} = 2 \times \pi \times N_{cr}$)
ω_{hd}	hydrodynamic angular speed
ω_{lim}	angular speed at the stability speed limit of the rotor supported by plain bearings ($\omega_{lim} = 2 \times \pi \times N_{lim}$)
ω_{osc}	angular frequency of oscillation
ω_{rel}	relative angular speed
ω_{tr}	angular speed at transition to mixed friction

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