
**Plain bearings — Thermo-
hydrodynamic lubrication design
charts for circular cylindrical bearings
under steady-state conditions**

*Paliers lisses — Diagrammes de conception de la lubrification
thermo-hydrodynamique des paliers cylindriques circulaires dans des
conditions de régime permanent*





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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.

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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.

Introduction

The calculation procedure specified in ISO 7902-1:2020 is useful to calculate the performance of hydrodynamic plain journal bearings with a circular cylindrical shape. This procedure, however, does not specify the maximum bearing temperature, which is one of the most important bearing characteristics. The reason for this is that ISO 7902-1:2020 is based on the Reynolds equation which assumes a constant lubricant film temperature. Therefore, the calculation procedure requires some numerical iteration before the effective dynamic viscosity in the lubricant film is converged.

This document provides a calculation procedure for the maximum bearing temperature and the effective dynamic viscosity in the lubricant film of oil-lubricated and statically loaded hydrodynamic plain journal bearings with a circular cylindrical shape, without any complicated numerical analysis and iterative calculation. The basic formulae contain the energy equation and the formula of temperature-viscosity of the lubricant to obtain the maximum bearing temperature. Since the results already satisfy the energy balance, no iterative calculation is required.

For the reason given above, the effective dynamic viscosity in the lubricant film obtained by the procedure in this document can also be a good input data for ISO 7902-1:2020. [Annex A](#) shows an example of how the calculated results serve to provide input data for ISO 7902-1:2020.

Plain bearings — Thermo-hydrodynamic lubrication design charts for circular cylindrical bearings under steady-state conditions

1 Scope

This document specifies a calculation procedure for the maximum bearing temperature and effective dynamic viscosity in the lubricant film of oil-lubricated and statically loaded hydrodynamic plain journal bearings with a circular cylindrical shape, angular span Ω of 360° and width ratio B^* of 0,5 to 1,5 under fluid lubrication regime. The bearing characteristics are obtained by design charts from four dimensionless numbers which are calculated from bearing dimensions, operating conditions and viscosity characteristics of the lubricant.

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 4378-1, *Plain bearings — Terms, definitions, classification and symbols — Part 1: Design, bearing materials and their properties*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4378-1 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

streamlet

axially separated stream of lubricant flow at bearing clearance where the gap increases in the rotational direction

4 Symbols, units and abbreviated terms

Symbols and units are defined in [Figure 1](#) and [Table 1](#). Abbreviated terms are defined in [Table 2](#).

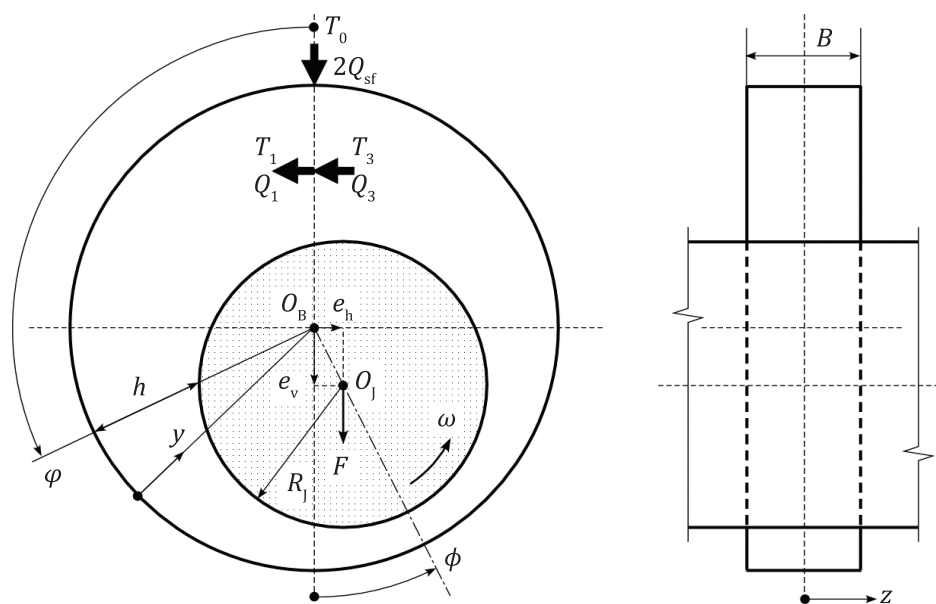


Figure 1 — Illustration of symbols

Table 1 — Symbols and their designations

Symbol	Designation	Unit
B	Bearing width	m
B^*	Width ratio ($B^* = B/D$)	1
C_R	Bearing radial clearance ($C_R = R - R_J$)	m
c_p	Specific heat of the lubricant	J/(kg·K)
D	Inside diameter of journal bearing	m
D_J	Journal diameter	m
E_0	Function of relative dynamic viscosity of the lubricant	1
E_1	Function of relative dynamic viscosity of the lubricant	1
e	Eccentricity between journal and bearing axis	m
e_h	Eccentricity in the horizontal direction between journal and bearing axis	m
e_v	Eccentricity in the vertical direction between journal and bearing axis	m
e_3^*	Relative heat energy of lubricant at the exit of the gap	1
F	Bearing load	N
F_0	Function of relative dynamic viscosity of the lubricant	1
F_1	Function of relative dynamic viscosity of the lubricant	1
F_2	Function of relative dynamic viscosity of the lubricant	1
h	Local lubricant film thickness	m
h^*	Relative local lubricant film thickness ($h^* = h/C_R$)	1
N	Rotational frequency of the rotor	s ⁻¹
O_B	Centerline of circular cylindrical bearing	1
O_J	Centerline of journal	1

NOTE 1 S number is frequently referred to as Sommerfeld number. See References [4] to [6].

NOTE 2 In ISO 4378-5, β is defined as the attitude angle or the temperature viscosity coefficient. In ISO 7902-1:2020, β is defined as the attitude angle. However, in this document, the attitude angle and the temperature viscosity coefficient are represented by ϕ and β , respectively, to avoid confusion due to duplication.

Table 1 (continued)

Symbol	Designation	Unit
Pe	Peclet number ($Pe = C_R^2 \rho c_p \omega / \lambda$)	1
p	Local lubricant film pressure	Pa
p^*	Relative local lubricant film pressure [$p^* = p\psi^2/(\eta_0\omega)$]	1
Q_{sf}	Lubricant side flow rate leaking out of one of the bearing side ends due to hydrodynamic pressure	m ³ /s
Q_{sf}^*	Lubricant side flow rate parameter leaking out of one of the bearing side ends due to hydrodynamic pressure [$Q_{sf}^* = Q_{sf} / (RBC_R \omega)$]	1
Q_1	Lubricant flow rate at the entrance into the gap ($\varphi = \varphi_1$)	m ³ /s
Q_3	Lubricant flow rate at the exit of the gap ($\varphi = \varphi_3$)	m ³ /s
Q_3^*	Lubricant flow rate parameter at the exit of the gap [$Q_3^* = Q_3 / (RBC_R \omega)$]	1
R	Journal bearing inside radius ($R = D/2$)	m
R_j	Journal radius ($R_j = D_j/2$)	m
S_0	S number formed with η_0 and ω [$S_0 = BD\eta_0\omega/(F\psi^2)$]	1
T	Lubricant temperature	°C
T_a	Average temperature of lubricant film	°C
$\Delta T_{a,r}$	Relative difference between average temperature of lubricant film and lubricant supplying temperature [$\Delta T_{a,r} = \psi^2 \rho c_p (T_a - T_0)/(\eta_0\omega)$]	1
T_B	Bearing temperature	°C
$T_{B,max}$	Maximum bearing temperature	°C
$\Delta T_{B,r}$	Relative difference between bearing temperature and lubricant supplying temperature [$\Delta T_{B,r} = \psi^2 \rho c_p (T_B - T_0)/(\eta_0\omega)$]	1
$\Delta T_{B,max,r}$	Relative difference between maximum bearing temperature and lubricant supplying temperature [$\Delta T_{B,max,r} = \psi^2 \rho c_p (T_{B,max} - T_0)/(\eta_0\omega)$]	1
$\widetilde{\Delta T_{B,max,r}}$	Logarithmic modified relative difference between maximum bearing temperature and lubricant supplying temperature [$\Delta T_{B,max,r} = \log_{10} (\Delta T_{B,max,r} B^{*-0,154} Pe^{1,75} \beta^{*8})$]	1
T_{eff}	Effective lubricant film temperature	°C
$T_{ex,0}$	Assumed initial lubricant temperature at bearing exit	°C
$T_{ex,1}$	Calculated lubricant temperature at bearing exit	°C
T_j	Journal surface temperature	°C
$\Delta T_{j,r}$	Relative difference between journal surface temperature and lubricant supplying temperature [$\Delta T_{j,r} = \psi^2 \rho c_p (T_j - T_0)/(\eta_0\omega)$]	1
ΔT_r	Relative difference between lubricant temperature and lubricant supplying temperature [$\Delta T_r = \psi^2 \rho c_p (T - T_0)/(\eta_0\omega)$]	1
T_0	Lubricant supplying temperature	°C
T_1	Lubricant temperature at the entrance into the gap ($\varphi = \varphi_1$)	°C
$\Delta T_{1,r}$	Relative difference between lubricant temperature at the entrance into the gap and lubricant supplying temperature [$\Delta T_{1,r} = \psi^2 \rho c_p (T_1 - T_0)/(\eta_0\omega)$]	1
T_3	Lubricant temperature at the exit of the gap ($\varphi = \varphi_3$)	°C
U_j	Circumferential speed of the journal ($U_j = R_j\omega$)	m/s
u	Velocity component in the circumferential direction	m/s
u^*	Relative velocity component in the circumferential direction ($u^* = u/U_j$)	1

NOTE 1 S number is frequently referred to as Sommerfeld number. See References [4] to [6].

NOTE 2 In ISO 4378-5, [1] β is defined as the attitude angle or the temperature viscosity coefficient. In ISO 7902-1:2020, β is defined as the attitude angle. However, in this document, the attitude angle and the temperature viscosity coefficient are represented by ϕ and β , respectively, to avoid confusion due to duplication.

Table 1 (continued)

Symbol	Designation	Unit
v	Velocity component in the cross-film direction	m/s
v^*	Relative velocity component in the cross-film direction [$v^* = v/(C_R\omega)$]	1
w	Velocity component in the axial direction	m/s
w^*	Relative velocity component in the axial direction [$w^* = w/(B\omega)$]	1
y	Coordinate across the lubricating film	m
y^*	Relative coordinate across the lubricating film ($y^* = y/h$)	1
z	Coordinate in the axial direction	m
z^*	Relative coordinate in the axial direction ($z^* = z/B$)	1
α	Contraction ratio of the lubricant streamlet	1
β	Temperature viscosity coefficient of the lubricant [$\beta = \ln(\eta_{40}/\eta_{100})/60$]	1/°C
β^*	Relative temperature viscosity coefficient of the lubricant [$\beta^* = \eta_0\omega\beta/(\rho c_p\psi^2)$]	1
$\gamma_{\Delta T_{B,\max}}$	The first logarithmic relative coordinate variable in design chart for difference between maximum bearing temperature and lubricant supplying temperature [$\gamma_{\Delta T_{B,\max}} = \log_{10}(S_0 B^{*1,54})$]	1
$\gamma_{\eta_{\text{eff},r}}$	The first logarithmic relative coordinate variable in design chart for effective relative dynamic viscosity in lubricant film [$\gamma_{\eta_{\text{eff},r}} = \log_{10}(S_0 B^{*1,90})$]	1
ε	Relative eccentricity ($\varepsilon = e/C_R$)	1
ε_h	Relative eccentricity in the horizontal direction ($\varepsilon_h = e_h/C_R$)	1
ε_v	Vertical eccentricity in the vertical direction ($\varepsilon_v = e_v/C_R$)	1
η	Dynamic viscosity of the lubricant	Pa·s
η_a	Average dynamic viscosity in lubricant film corresponding to difference ΔT_a between average temperature of lubricant film and lubricant supplying temperature	Pa·s
$\eta_{a,r}$	Relative average dynamic viscosity in lubricant film corresponding to relative difference $\Delta T_{a,r}$ between average temperature of lubricant film and lubricant supplying temperature ($\eta_{a,r} = \eta_a/\eta_0$)	1
η_{eff}	Effective dynamic viscosity in lubricant film	Pa·s
$\eta_{\text{eff},r}$	Effective relative dynamic viscosity in lubricant film ($\eta_{\text{eff},r} = \eta_{\text{eff}}/\eta_0$)	1
η_{rel}	Relative dynamic viscosity of the lubricant ($\eta_{\text{rel}} = \eta/\eta_0$)	1
η_0	Dynamic viscosity at the lubricant supplying temperature	Pa·s
η_{40}	Dynamic viscosity of the lubricant at 40 °C	Pa·s
η_{100}	Dynamic viscosity of the lubricant at 100 °C	Pa·s
$\widetilde{\eta_{\text{eff},r}}$	Logarithmic modified effective relative dynamic viscosity in lubricant film [$\widetilde{\eta_{\text{eff},r}} = \log_{10}(\eta_{\text{eff},r} B^{*-0,01} Pe^{1,10} \beta^{*2,35})$]	1
$\kappa_{\Delta T_{B,\max}}$	The second logarithmic relative coordinate variable in design chart for difference between maximum bearing temperature and lubricant supplying temperature [$\kappa_{\Delta T_{B,\max}} = \log_{10}(Pe \beta^{*4})$]	1
$\kappa_{\eta_{\text{eff},r}}$	The second logarithmic relative coordinate variable in design chart for effective relative dynamic viscosity of lubricant film [$\kappa_{\eta_{\text{eff},r}} = \log_{10}(Pe \beta^{*1,95})$]	1
λ	Thermal conductivity of the lubricant	W/(m·K)

NOTE 1 S number is frequently referred to as Sommerfeld number. See References [4] to [6].

NOTE 2 In ISO 4378-5, [1] β is defined as the attitude angle or the temperature viscosity coefficient. In ISO 7902-1:2020, β is defined as the attitude angle. However, in this document, the attitude angle and the temperature viscosity coefficient are represented by ϕ and β , respectively, to avoid confusion due to duplication.