
**Plain bearings — Hydrodynamic plain
journal bearings under steady-state
conditions —**

Part 2:
**Functions for calculation of multi-
lobed journal bearings**

ITeH STANDARD PREVIEW
(standards.iteh.ai)
Full standard:
<https://standards.iteh.ai/catalog/standards/iso/623fec39-ecd1-402d-a113-e59ef5ca8f34/iso-ts-31657-2-2020>

PROOF / ÉPREUVE



iTeh STANDARD PREVIEW
(standards.iteh.ai)
Full standard:
<https://standards.iteh.ai/catalog/standards/sist/603fec39-ecd1-402d-a113-e59ef5ca8f34/iso-ts-31657-2-2020>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Functions for calculation of multi-lobed journal bearings	1
4.1 General	1
4.2 Two-lobe bearings	4
4.3 Three-lobe bearings	20
4.4 Four-lobe bearings	32
Annex A (informative) Characteristic curves for four-lobe bearings	50
Bibliography	68

iTeh STANDARD PREVIEW
 (standards.iteh.ai)

Full standard:
<https://standards.iteh.ai/catalog/standards/sist/603fec39-eed1-402d-a113-e59ef5ca8f34/iso-ts-31657-2-2020>

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 123, *Plain bearings*, Subcommittee SC 8, *Calculation methods for plain bearings and their applications*.

A list of all parts in the ISO/TS 31657 series can be found on the ISO website.

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.

Plain bearings — Hydrodynamic plain journal bearings under steady-state conditions —

Part 2:

Functions for calculation of multi-lobed journal bearings

1 Scope

This document specifies the characteristic values for selected two-, three- and four-lobe bearings.

The functions plotted and listed in table form below are required for the operationally safe design of hydrodynamic multi-lobed journal bearings according to ISO/TS 31657-1. They are based on the presumptions and boundary conditions indicated there and only apply to stationary operating states. The symbols used are explained in ISO/TS 31657-1; calculation examples are also included there.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Functions for calculation of multi-lobed journal bearings

4.1 General

The characteristic values for two-, three- and four-lobe bearings with relative lubrication pocket widths of $b_p^* = 0,8$ are shown in table form below. The characteristic values were calculated for the geometrical parameters summarised in [Figure 1](#) (angular spans of segment sliding surface, Ω , angular coordinates of lubricant pocket centrelines, $\varphi_{p,1}$, gap ratios, $h_{0,max}^*$, bearing width ratios B^*) in the operating range $0,02 \leq h_{min}^* \leq 1$. The profile factors, K_p , associated with the indicated gap ratios, $h_{0,max}^*$, can be calculated for these bearing types as follows:

$$K_p = h_{0,max}^* \quad \text{for } Z = 2$$

$$K_p = 2 \cdot h_{0,max}^* - 1 \quad \text{for } Z = 3$$

$$K_p = \frac{h_{0,\max}^* - \frac{1}{\sqrt{2}}}{1 - \frac{1}{\sqrt{2}}} \quad \text{for } Z = 4$$

The following (dimensionless) characteristic values are indicated in [Tables 1](#) to [43](#):

a) Static characteristic values

Sommerfeld number:

$$So = \frac{F \cdot \psi_{\text{eff}}^2}{B \cdot D \cdot \eta_{\text{eff}} \cdot \omega}$$

Relative eccentricity:

$$\varepsilon = \frac{e}{C_{R,\text{eff}}}$$

Attitude angle, β , in °

Product of maximum lubricant film pressure parameter and Sommerfeld number:

$$p_{\max}^* \cdot So = \frac{p_{\max} \cdot \psi_{\text{eff}}^2}{\eta_{\text{eff}} \cdot \omega}$$

Minimum relative lubricant film thickness:

$$h_{\min}^* = \frac{h_{\min}}{C_{R,\text{eff}}}$$

Friction force parameter:

$$F_f^* = \frac{f}{\psi_{\text{eff}}} \cdot So$$

Lubricant flow rate parameter due to hydrodynamic pressure build-up:

$$Q_3^* = \frac{Q_3}{Q_0}$$

Lubricant flow rate parameter due to supply pressure:

$$Q_p^* = \frac{Q_p}{P_{\text{en}}^* \cdot Q_0}$$

Lubricant flow rate parameter at the exit of the lubrication gap:

$$Q_2^* = \frac{Q_2}{Q_0}$$

Non-dimensional difference between maximum lubricant temperature and lubricant temperature in the lubricant pockets:

$$\Delta T_{\max}^* = \frac{\rho \cdot c_p \cdot \psi_{\text{eff}}}{\bar{p} \cdot f} \cdot \Delta T_{\max}$$

b) Dynamic characteristic values

Non-dimensional lubricant film stiffness coefficients:

$$c_{i,k}^* = \frac{\psi_{\text{eff}}^3}{2 \cdot B \cdot \eta_{\text{eff}} \cdot \omega} \cdot c_{i,k} \quad (i, k = 1, 2)$$

Non-dimensional lubricant film damping coefficients:

$$d_{i,k}^* = \frac{\psi_{\text{eff}}^3}{2 \cdot B \cdot \eta_{\text{eff}} \cdot \omega} \cdot \omega \cdot d_{i,k} \quad (i, k = 1, 2)$$

For some selected four-lobe bearings ($\Omega = 70^\circ$, $\varphi_{p,1} = 315^\circ$), these characteristic values are shown graphically as a function of the Sommerfeld number So , the gap ratio $h_{0,\text{max}}^*$ and the bearing width ratio B^* in [Annex A, Figures A.1 to A.16](#).

Z	Ω [°]	$\varphi_{p,1}$ [°]	$h_{0,\text{max}}^*$	B^*	Load case
2	150	180	3, 5	0,75	
		240	3, 5	0,75	
		270	1, 3, 5	0,5, 0,75, 1	
		300	3, 5	0,75	
3	100	240	3, 5	0,75	
		300	1, 3, 5	0,5, 0,75, 1	
4	70	270	3, 5	0,75	
		315	1, 2, 3, 4, 5	0,5, 0,75, 1	

Figure 1 — Geometrical parameters of selected multi-lobed journal bearings

4.2 Two-lobe bearings

Characteristic values for two-lobe bearings are listed in [Tables 1](#) to [15](#).

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Full standard:
<https://standards.iteh.ai/catalog/standards/sist/603fec39-eed1-402d-a113-e59ef5ca8f34/iso-ts-31657-2-2020>

Table 1 — Characteristic values of a two-lobe bearing with $\Omega = 150^\circ$, $\varphi_{p,1} = 180^\circ$, $h_{0,max}^* = 3$, $B^* = 0,75$

S_o	ε	$\beta [^\circ]$	$p_{max}^* \cdot S_o$	h_{min}^*	F_f^*	Q_3^*	Q_p^*	Q_2^*	ΔT_{max}^*	c_{11}^*	c_{12}^*	c_{21}^*	c_{22}^*	d_{11}^*	d_{12}^*	d_{21}^*	d_{22}^*
0,000	0,000	90,00	0,327	1,000	1,780	0,959	36,868	1,619	1,25	0,364	-0,107	0,174	0,019	0,541	0,168	0,168	0,093
0,014	0,203	15,82	0,364	0,935	1,790	0,971	37,474	1,604	1,35	0,373	-0,106	0,181	0,023	0,548	0,171	0,171	0,099
0,029	0,406	15,38	0,422	0,856	1,822	1,007	39,301	1,560	1,50	0,401	-0,105	0,201	0,035	0,576	0,182	0,182	0,116
0,048	0,607	14,65	0,510	0,768	1,878	1,065	42,339	1,488	1,71	0,455	-0,100	0,241	0,058	0,623	0,202	0,202	0,150
0,073	0,805	13,63	0,639	0,675	1,962	1,145	46,566	1,388	1,99	0,542	-0,089	0,306	0,099	0,699	0,235	0,235	0,206
0,108	1,001	12,36	0,834	0,579	2,083	1,243	52,000	1,265	2,35	0,684	-0,067	0,415	0,174	0,815	0,289	0,289	0,297
0,159	1,195	10,84	1,139	0,485	2,255	1,357	58,643	1,118	2,88	0,916	-0,020	0,599	0,314	0,994	0,376	0,376	0,450
0,241	1,387	9,11	1,645	0,392	2,504	1,482	66,479	0,953	3,64	1,323	0,084	0,932	0,597	1,285	0,525	0,525	0,721
0,384	1,577	7,17	2,569	0,303	2,884	1,616	75,476	0,769	4,80	2,120	0,326	1,599	1,240	1,810	0,801	0,801	1,249
0,677	1,768	5,05	4,546	0,217	3,522	1,755	85,736	0,567	6,73	4,010	1,012	3,194	3,029	2,907	1,371	1,371	2,459
1,478	1,959	2,79	10,341	0,133	4,839	1,898	97,153	0,350	10,97	10,662	3,665	8,585	10,316	6,159	2,978	2,978	6,332
3,840	2,100	1,14	29,250	0,071	7,487	2,003	106,265	0,177	20,77	40,455	15,265	29,531	46,571	17,323	7,373	7,374	20,278
18,558	2,200	0,18	183,912	0,022	16,491	2,079	113,058	0,049	65,04	514,115	142,002	242,523	642,042	124,068	32,520	32,518	154,507
45,130	2,220	0,06	569,417	0,010	26,225	2,095	114,450	0,023	142,08	2 504,109	425,818	779,476	3 114,672	443,694	115,503	115,503	554,368

Table 2 — Characteristic values of a two-lobe bearing with $\Omega = 150^\circ$, $\varphi_{p,1} = 180^\circ$, $h_{0,max}^* = 5$, $B^* = 0,75$

So	ε	$\beta [^\circ]$	$p_{max}^* \cdot So$	h_{min}^*	F_f^*	Q_3^*	Q_p^*	Q_2^*	ΔT_{max}^*	c_{11}^*	c_{12}^*	c_{21}^*	c_{22}^*	d_{11}^*	d_{12}^*	d_{21}^*	d_{22}^*
0,000	0,000	90,00	0,342	1,000	1,507	1,787	152,625	1,670	1,25	0,284	-0,038	0,110	0,022	0,315	0,081	0,081	0,039
0,011	0,301	7,29	0,370	0,951	1,518	1,801	154,870	1,650	1,33	0,292	-0,038	0,114	0,024	0,321	0,083	0,083	0,041
0,023	0,602	7,02	0,418	0,883	1,551	1,841	161,614	1,598	1,46	0,315	-0,036	0,125	0,031	0,339	0,089	0,089	0,048
0,038	0,902	6,57	0,493	0,800	1,610	1,905	172,838	1,510	1,64	0,359	-0,033	0,147	0,044	0,373	0,099	0,099	0,062
0,058	1,202	5,93	0,609	0,706	1,703	1,994	188,597	1,388	1,88	0,434	-0,026	0,185	0,069	0,427	0,116	0,116	0,085
0,088	1,500	5,14	0,793	0,604	1,841	2,104	208,778	1,235	2,25	0,564	-0,012	0,252	0,116	0,519	0,145	0,145	0,125
0,134	1,798	4,21	1,106	0,496	2,051	2,234	233,495	1,050	2,78	0,805	0,021	0,373	0,212	0,674	0,194	0,194	0,199
0,218	2,095	3,15	1,701	0,384	2,386	2,380	262,650	0,836	3,69	1,311	0,097	0,623	0,435	0,977	0,287	0,287	0,350
0,321	2,293	2,40	2,463	0,307	2,742	2,486	284,578	0,676	4,64	2,042	0,218	0,968	0,784	1,367	0,401	0,402	0,554
0,517	2,491	1,62	3,996	0,228	3,319	2,597	308,482	0,504	6,29	3,737	0,505	1,725	1,650	2,183	0,611	0,611	0,992
1,004	2,690	0,86	8,151	0,146	4,446	2,713	334,471	0,319	9,97	9,508	1,410	3,958	4,721	4,513	1,177	1,177	2,276
3,915	2,900	0,18	40,203	0,052	8,632	2,842	364,011	0,109	28,23	85,684	10,417	24,374	47,054	24,886	4,356	4,355	13,687
8,457	2,950	0,07	107,659	0,027	12,809	2,873	371,364	0,056	54,49	334,928	30,443	71,696	186,580	74,182	9,627	9,627	41,342
14,689	2,970	0,03	224,879	0,017	17,027	2,886	374,341	0,035	89,35	926,933	61,807	152,876	517,668	164,982	19,973	19,972	92,317

ITC/STANDARDS.ITECH.AI PREVIEW
 Full standard:
<https://standards.itech.ai/catalog/standards/sist/603fec39-602b-43-e59ef5ca8f34/iso-ts-31657-2-2020>

Table 3 — Characteristic values of a two-lobe bearing with $\Omega = 150^\circ$, $\varphi_{p,1} = 240^\circ$, $h_{0,max}^* = 3$, $B^* = 0,75$

S_o	ε	$\beta [^\circ]$	$p_{max}^* \cdot S_o$	h_{min}^*	F_f^*	Q_3^*	Q_p^*	Q_2^*	Δr_{max}^*	c_{11}^*	c_{12}^*	c_{21}^*	c_{22}^*	d_{11}^*	d_{12}^*	d_{21}^*	d_{22}^*
0,000	0,000	90,00	0,327	1,000	1,780	0,959	36,868	1,619	1,25	0,135	-0,307	-0,025	0,249	0,351	-0,278	-0,278	0,283
0,024	0,300	65,76	0,343	0,948	1,800	0,986	38,272	1,585	1,30	0,144	-0,316	-0,024	0,259	0,360	-0,279	-0,279	0,296
0,053	0,600	64,93	0,388	0,863	1,862	1,065	42,498	1,483	1,39	0,176	-0,345	-0,021	0,296	0,394	-0,286	-0,285	0,339
0,096	0,900	63,58	0,501	0,756	1,983	1,191	49,575	1,320	1,55	0,239	-0,401	-0,010	0,380	0,458	-0,297	-0,297	0,435
0,195	1,255	61,44	0,833	0,612	2,255	1,387	61,648	1,055	2,00	0,395	-0,528	0,031	0,646	0,603	-0,316	-0,316	0,697
0,337	1,488	59,74	1,406	0,502	2,590	1,535	71,722	0,844	2,77	0,602	-0,683	0,128	1,168	0,780	-0,327	-0,326	1,148
0,647	1,698	58,00	2,889	0,331	3,159	1,675	82,206	0,632	4,44	0,968	-0,912	0,463	2,796	1,054	-0,296	-0,296	2,322
1,449	1,860	56,29	7,683	0,182	4,165	1,784	91,126	0,455	9,19	1,578	-1,003	1,986	9,830	1,400	0,010	0,010	6,279
4,655	1,931	53,56	34,941	0,068	6,408	1,816	94,941	0,372	29,85	3,188	2,998	14,895	75,236	1,592	2,566	2,567	30,672
11,520	1,879	50,12	119,413	0,030	9,298	1,747	90,997	0,431	76,95	7,878	21,587	63,226	403,924	1,955	9,260	9,259	113,638
26,368	1,811	46,94	379,970	0,014	13,580	1,670	86,161	0,509	179,60	19,622	83,789	224,646	1 939,293	3,095	25,234	25,233	393,073

Table 4 — Characteristic values of a two-lobe bearing with $\Omega = 150^\circ$, $\varphi_{p1} = 240^\circ$, $h_{0,max}^* = 5$, $B^* = 0,75$

S_o	ε	$\beta [^\circ]$	$p_{max}^* \cdot S_o$	h_{min}^*	F_f^*	Q_3^*	Q_p^*	Q_2^*	ΔT_{max}^*	c_{11}^*	c_{12}^*	c_{21}^*	c_{22}^*	d_{11}^*	d_{12}^*	d_{21}^*	d_{22}^*
0,000	0,000	90,00	0,342	1,000	1,507	1,787	152,625	1,669	1,25	0,119	-0,206	-0,057	0,188	0,178	-0,160	-0,160	0,175
0,013	0,300	59,79	0,356	0,988	1,517	1,801	154,887	1,650	1,27	0,121	-0,209	-0,058	0,193	0,181	-0,162	-0,162	0,180
0,028	0,600	59,61	0,387	0,951	1,548	1,839	161,674	1,597	1,34	0,130	-0,220	-0,060	0,209	0,189	-0,167	-0,167	0,193
0,046	0,900	59,33	0,442	0,890	1,604	1,902	172,982	1,508	1,44	0,148	-0,240	-0,065	0,240	0,203	-0,176	-0,176	0,218
0,074	1,231	58,89	0,549	0,792	1,703	1,998	190,702	1,371	1,64	0,179	-0,279	-0,073	0,305	0,230	-0,194	-0,194	0,269
0,111	1,518	58,43	0,717	0,683	1,837	2,102	210,507	1,220	1,95	0,225	-0,335	-0,083	0,413	0,268	-0,218	-0,218	0,350
0,171	1,797	57,95	1,021	0,556	2,037	2,219	233,701	1,046	2,47	0,300	-0,428	-0,097	0,630	0,324	-0,255	-0,255	0,499
0,281	2,070	57,47	1,659	0,416	2,354	2,348	260,142	0,851	3,45	0,433	-0,601	-0,115	1,150	0,415	-0,318	-0,318	0,815
0,546	2,341	57,09	3,440	0,264	2,940	2,489	290,060	0,633	5,87	0,710	-1,003	-0,110	2,946	0,588	-0,441	-0,441	1,731
1,816	2,625	56,97	15,037	0,101	4,646	2,652	325,394	0,360	17,84	1,631	-2,658	0,683	21,407	1,044	-0,742	-0,742	8,014
3,419	2,702	57,02	34,428	0,058	6,004	2,699	335,693	0,306	34,13	2,381	-4,050	3,505	65,596	1,325	-0,735	-0,735	19,502
13,503	2,757	56,80	224,496	0,017	10,618	2,731	343,151	0,252	136,17	5,394	6,815	53,808	863,057	1,707	2,358	2,358	132,080

ITChe STANDARD PREVIEW
 (standards.iteh.ai)
 Full standard:
<https://standards.iteh.ai/catalog/standards/sist/603fec39-402d-a113-e59ef5ca8f34/iso-ts-31657-2-2020>

Table 5 — Characteristic values of a two-lobe bearing with $\Omega = 150^\circ$, $\varphi_{p,1} = 270^\circ$, $h_{0,\max}^* = 1$, $B^* = 0,5$

S_o	ε	$\beta [^\circ]$	$p_{\max}^* \cdot S_o$	h_{\min}^*	F_f^*	Q_3^*	Q_p^*	Q_2^*	ΔT_{\max}^*	c_{11}^*	c_{12}^*	c_{21}^*	c_{22}^*	d_{11}^*	d_{12}^*	d_{21}^*	d_{22}^*
0,000	0,000	90,00	0,000	1,000	2,614	0,000	3,008	1,000	2,00	0,000	-0,262	0,671	0,000	0,523	0,000	0,000	1,342
0,090	0,236	64,91	0,192	0,764	2,430	0,175	3,394	0,796	2,71	0,160	-0,171	0,469	0,163	0,372	0,174	0,174	0,923
0,163	0,361	56,42	0,373	0,639	2,471	0,245	3,784	0,706	3,34	0,292	-0,210	0,674	0,345	0,510	0,339	0,338	1,309
0,260	0,467	50,13	0,643	0,533	2,607	0,291	4,131	0,639	3,93	0,438	-0,204	0,976	0,690	0,599	0,501	0,501	1,868
0,401	0,562	44,64	1,081	0,438	2,833	0,323	4,403	0,588	4,66	0,650	-0,180	1,473	1,332	0,730	0,740	0,740	2,783
0,626	0,649	39,58	1,849	0,351	3,168	0,342	4,584	0,548	5,68	0,983	-0,107	2,338	2,622	0,926	1,120	1,120	4,383
1,011	0,729	34,71	3,317	0,271	3,649	0,351	4,663	0,520	7,20	1,570	0,093	4,007	5,477	1,241	1,791	1,793	7,460
1,783	0,805	29,68	6,656	0,195	4,392	0,350	4,633	0,502	9,89	2,748	0,706	7,804	13,213	1,799	3,154	3,155	14,473
3,709	0,877	24,15	16,512	0,123	5,714	0,335	4,477	0,497	15,89	5,805	3,052	19,273	41,921	3,039	6,768	6,767	35,742
11,175	0,943	17,40	66,166	0,057	8,914	0,303	4,174	0,511	36,26	18,352	19,280	80,457	252,403	6,810	21,690	21,697	148,293
30,369	0,974	12,58	238,937	0,026	13,981	0,273	3,946	0,534	85,56	53,612	93,221	315,937	1 384,251	14,455	64,581	64,585	574,742
59,033	0,985	9,96	568,507	0,015	19,196	0,255	3,837	0,550	155,16	109,469	267,165	805,560	4 501,754	23,051	130,675	130,663	1 433,334