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Plain bearings — Bearings with embedded solid lubricants

Paliers lisses — Paliers avec lubrifiants solide incorporé

Reference number
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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 123, *Plain bearings*, Subcommittee SC 7, *Special types of plain bearings*.

Plain bearings — Bearings with embedded solid lubricants

1 Scope

This International Standard specifies a bearing with embedded solid lubricants which has been widely used as a solid lubricant bearing.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 185, *Grey cast irons — Classification*

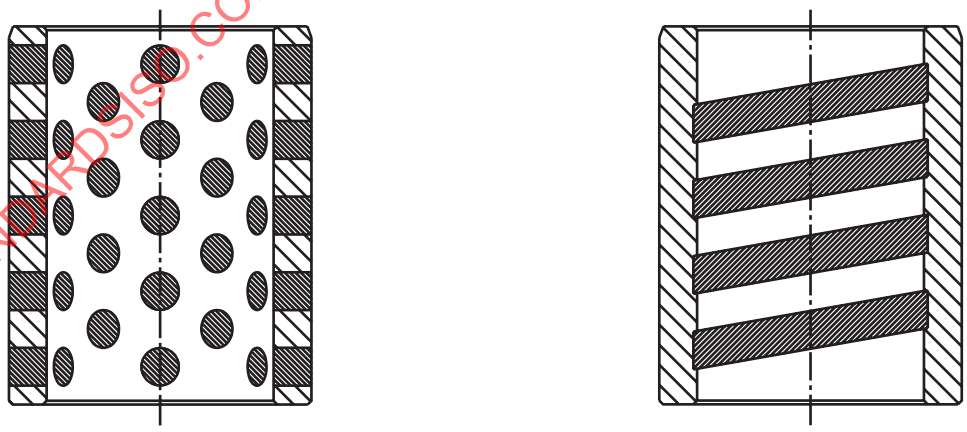
3 Characteristics

3.1 Structure

A bearing with embedded solid lubricants is composed of a metallic base body supporting a load and a solid lubricant embedded in holes or hollows formed on the surface of the metallic base body giving lubricity. As to the embedded state of a solid lubricant, there is a plug type and a spiral type (refer to Figure 1).

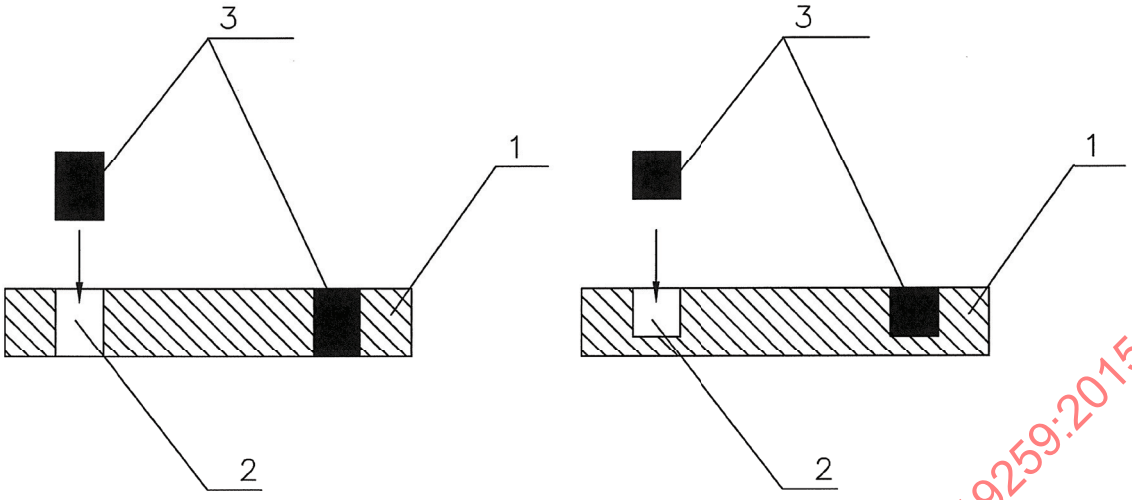
As for hole type, there are "through" or perforated ones and "bottomed" ones (refer to Figure 2).

This International Standard specifies a type which is most common and has been widely used where a solid lubricant of a plug type is embedded in through holes. The International Standard also specifies a cylindrical bush and a flanged bush (refer to Figure 3).



a) Plug type **b) Spiral type**

Figure 1 — Embedded state of solid lubricants on cylindrical bush



a) Through hole type **b) Bottomed hole type**

Key

1 metallic base body
2 hole
3 solid lubricant plug

Figure 2 — Structure of cross section on a bearing with embedded solid lubricants

a) Cylindrical bush **b) Flanged bush**

Figure 3 — Overview of a bearing with embedded solid lubricants (plug type)

3.2 Friction and wear characteristics

A bearing with embedded solid lubricants falls under the category of a solid lubricant bearing among self-lubricating bearings. In the solid lubricant bearings, there is a solid type, a coated type, a dispersed type, and an embedded type.

A solid type is such where a solid lubricant powder is solidified using pitch, resin or the like as a binder.

A coated type is such where a solid lubricant film is formed on a sliding surface by chemical or physical means such as coating, baking, chemical reaction, or the like.

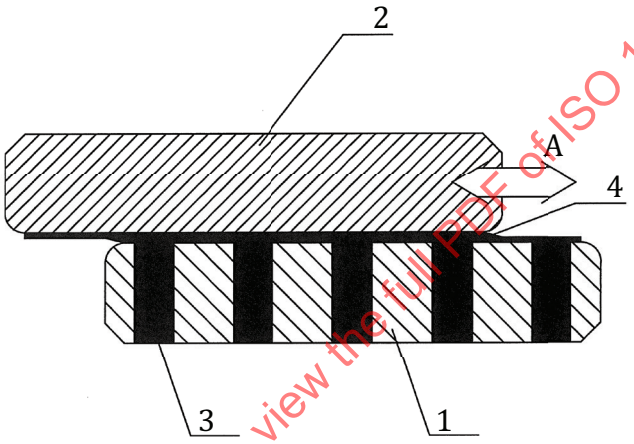
A dispersed type is such where a solid lubricant powder (fine particles) is dispersed into sintered metal matrix or the like.

An embedded type is such as mentioned above where holes or hollows are formed on a sliding surface of a metallic base body and solid lubricants are embedded therein and, since the load is supported by a metallic base body, this type has excellent load carrying capacity.

The embedded solid lubricant supplies solid lubricant to the sliding surface and, when it slides on the mating member, the solid lubricant is properly drawn out and spread over both sliding surfaces whereupon a solid lubricant film is formed.

Further, even when the film is broken, the embedded solid lubricant is drawn out by friction onto the sliding surfaces, so it repairs the film on the sliding surfaces whereby the lubrication is made possible for long periods and long life is achieved (refer to Figure 4).

Since the types of metallic base body and solid lubricant can be appropriately selected depending upon the operating conditions, a wide range of applications is possible. Moreover, bearings ranging from small to large sizes can be manufactured.



Key

1 metallic base body
2 mating member
3 embedded solid lubricant
4 solid lubricant film
A sliding direction

Figure 4 — Lubricating mechanism of a bearing with embedded solid lubricants

3.3 Applicable field

The bearing can be used for rotational motion, reciprocating motion, oscillating motion, and frequent start/stop cycles. The bearing is also used in such applications where no fluid lubrication can be expected because of high load and low speed operation, and where the environment temperature is high.

Principally, the bearing can be used without supplying oil or grease. However, depending upon the actual operating conditions, oil or grease may be supplied for a purpose of enhancement of durability, removal of wear particulate or dust, and prevention of corrosion of the mating member.

4 Material

4.1 Metallic base body

Principal materials used as a metallic base body in which the solid lubricant is embedded include high strength cast brass, cast bronze, cast aluminium bronze, and grey cast iron.

4.1.1 Copper alloy castings

Chemical compositions of copper alloy castings used as the metallic base body are shown in Table 1.

Table 1 — Chemical composition of copper alloy castings for a bearing with embedded solid lubricants

Chemical element	Chemical composition mass fraction, %			
	High strength brass CuZn25Al6Mn4Fe3	**Bronze I CuSn10Zn2**	**Bronze II CuPb5Sn5Zn5**	**Aluminium bronze CuAl10Fe5Ni5**
Components				
Cu	60,0 to 65,0	86,5 to 89,5	83,0 to 87,0	78,0 to 85,0
Sn		9,0 to 11,0	4,0 to 6,0	
Pb			4,0 to 6,0	
Zn	22,0 to 28,0	1,0 to 3,0	4,0 to 6,0	
Fe	2,0 to 4,0			3,0 to 6,0
Ni				3,0 to 6,0
Al	5,0 to 7,5			8,5 to 10,5
Mn	2,5 to 5,0			0,1 to 1,5
Impurity				
Sn	≤0,2			≤0,1
Pb	≤0,2	≤1,0		≤0,1
Zn				≤0,5
Fe		≤0,2	≤0,3	
Sb		≤0,2	≤0,2	
Ni	≤0,5	≤1,0	≤1,0	
P		≤0,05[a]	≤0,05[a]	
Al		≤0,01	≤0,01	
Si	≤0,1	≤0,01	≤0,01	

[a] For permanent mould castings, centrifugal castings using mould and continuous castings, phosphorus content shall be 0,5 % maximum.

4.1.2 Grey cast irons

Grey cast irons used as the metallic base body should conform to ISO 185.

4.2 Solid lubricant

Table 2 shows outlines of the application and the operating temperature of solid lubricants of a graphite-base type and a fluororesin-base type which are representative ones of the solid lubricant to be embedded in the metallic base body. Besides those, there are sulfide-base type such as molybdenum disulfide and tungsten disulfide used under special and extreme circumstances. Each of them is used as sole component or as a mixed component with other additives. The additives compounded with each of those types are specified by manufacturers.

Table 2 — Types of solid lubricants and their applications

Type	Applications	Operating temperature °C
Graphite-base	General-purpose use High temperature use	−40 to 400
Fluororesin-base	General-purpose use Underwater use	−40 to 80

Generally, a solid lubricant plug is formed in such a manner that the solid lubricant powder comprising the single component or the multiple components is moulded by heating under pressure, for example, by means of injection moulding. The resulting solid lubricant plugs are generally fixed with adhesive into holes in a cylindrical part of the metallic base body. In some cases, they are fixed by means of press fitting. They may also be fixed by injecting a solid lubricant composition having fluidity into a hole, followed by a solidification process.

4.3 Combination of metallic base body and solid lubricant

Since various selections are available for a combination of a metallic base body and a solid lubricant, it is possible to cope with very wide range of applications.

It is important that the metallic base body and the solid lubricant combination are selected to suit the operating conditions. It is also necessary to consider the pattern of the solid lubricant holes on the sliding surface depending upon the motion mode and the environmental conditions.

Table 3 shows a typical combination of metallic base body and solid lubricant together with their applications. Further, a guide for the selection of bearings and examples of actual applications of a bearing with embedded solid lubricants are shown in Figure A.1 and in Table B.1.

Table 3 — Typical combination of metallic base body and solid lubricant

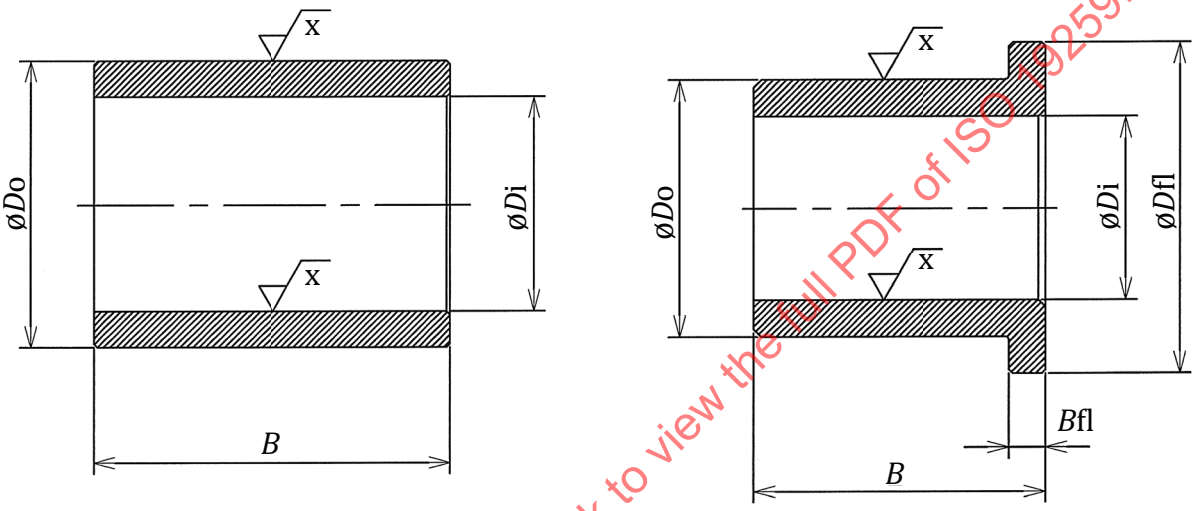
Metallic base body	Solid lubricants	Applications
High-strength brass	Graphite-base	General use for average conditions Applicable for high load
	Fluororesin-base	In freshwater
Bronze	Graphite-base	Conformability with mating member Medium load
Aluminium bronze	Graphite-base	High temperature Medium load
	Fluororesin-base	In seawater
Grey cast iron	Graphite-base	High temperature Low load

5 Dimensions

The wall thickness of the bearing with embedded solid lubricants cannot be too thin or the solid lubricant will not be firmly held. So an appropriate thickness is necessary.

Figure 5 shows cylindrical and flanged bushes. Table 4 shows the preferred nominal dimensions of inside and outside diameters and bush width for cylindrical bushes. Table 5 shows the preferred nominal dimensions for flanged bushes, including flange diameter and flange thickness. Both Table 4 and Table 5 are based on a metallic base body made of high strength cast brass and graphite-based solid lubricant plugs.

Other material combinations with a metallic base body and solid lubricant plugs shall also be in accordance with Table 4 and Table 5. Bearings of sizes outside those shown in Table 4 and Table 5 shall be subject to agreement between the supplier and the user.



a) Cylindrical bush **b) Flanged bush**

Key

x surface roughness

Figure 5 — Cylindrical and flanged bush

Table 4 — Preferred nominal dimensions for cylindrical bushes

Dimensions in millimetres

Inside diameter *D*i	**Outside diameter** *D*o	**Width** $B^{-0,1}_{-0,3}$							
8	12	8	10	12					
10	14	8	10	12	15				
12	18	8	10	12	15				
13	19	10	12	15	20				
14	20	10	12	15	20				
15	21	10	12	15	20				
16	22	10	12	15	20	25			
18	24	10	12	15	20	25			
20	28	10	12	15	20	25	30		
20	30	10	12	15	20	25	30		
22	32	12	15	20	25	30			
25	33	12	15	20	25	30	35		
25	35	12	15	20	25	30	35		
28	38	15	20	25	30	35	40		
30	38	15	20	25	30	35	40		
30	40	15	20	25	30	35	40		
32	42	15	20	25	30	35	40		
35	45	20	25	30	35	40	50		
40	50	20	25	30	35	40	50	60	
40	55	20	25	30	35	40	50	60	
45	55	25	30	35	40	50	60	70	
45	60	25	30	35	40	50	60	70	
50	60	30	35	40	50	60	70	80	
50	65	30	35	40	50	60	70	80	
55	70	30	35	40	50	60	70	80	
60	75	30	35	40	50	60	70	80	
65	80	35	40	50	60	70	80		
70	85	35	40	50	60	70	80	100	
70	90	35	40	50	60	70	80	100	
75	90	40	50	60	70	80	100		
75	95	40	50	60	70	80	100		
80	100	40	50	60	70	80	100	120	
90	110	50	60	70	80	90	100	120	
100	120	50	60	70	80	90	100	120	140
110	130	50	60	70	80	90	100	120	140
120	140	70	80	90	100	120	140		
130	150	80	100	130					
140	160	80	100	140					

Table 4 *(continued)*

Inside diameter *Di*	**Outside diameter** *Do*	**Width** $B^{-0,1}_{-0,3}$							
150	170	80	100	150					
160	180	80	100	150					

Table 5 — Preferred nominal dimensions for flanged bushes

Dimensions in millimetres

Inside diameter *Di*	**Outside diameter** *Do*	**Flange diameter** *Dfl*	**Flange thickness** *Bfl*	**Width** $B^{-0,1}_{-0,3}$					
8	12	20	2	10	12				
10	14	22	2	10	12	15			
12	18	25	3	10	12	15	20		
13	19	26	3	10	12	15	20		
14	20	27	3	10	12	15	20		
15	21	28	3	10	12	15	20		
16	22	29	3	12	15	20	25		
18	24	32	3	15	20	25	30		
20	30	40	5	15	20	25	30		
25	35	45	5	15	20	25	30	35	
30	40	50	5	20	25	30	35	40	
35	45	60	5	20	25	30	35	40	50
40	50	65	5	20	25	30	35	40	50
45	55	70	5	30	35	40	50	60	
50	60	75	5	30	35	40	50	60	
55	65	80	5	40	50	60	80		
60	75	90	7,5	40	50	60	80		
65	80	95	7,5	50	60	80			
70	85	105	7,5	50	60	80			
75	90	110	7,5	50	60	80			
80	100	120	10	60	80	100			
90	110	130	10	60	80	100			
100	120	150	10	60	80	100			
120	140	170	10	80	100	120			

6 Assembling

With regard to a cylindrical bush and a flanged bush where solid lubricant plugs are embedded in a metallic base body of high strength brass casting, typical tolerance classes of inside and outside diameters of bush, housing bore diameter and shaft diameter are shown in Table 6. When the metallic base body is other material, Table 6 is also recommended.

Since the optimum fit varies depending upon the bush environments such as at normal or high temperature or in the air or water, discussion between the supplier and the user is recommended for achieving the optimum fit depending upon the operating condition.

Table 6 — Tolerance classes and limit deviations

Fits between bush and housing bore	Inside diameter of bush	Outside diameter of bush	Housing bore diameter	Shaft diameter
Transition fit[a]	F7	m6	H7	d8, e7, or f7[b]
Interference fit	D7 to E7	r6 to r7		

[a] For cylindrical bush only. Recommended to use a set screw to prevent dislocation.

[b] d8: in general case of high-load; e7: in general case of low-load; f7: for high accuracy (less clearance).

Since the bearing with embedded solid lubricants (such as cylindrical bush and flanged bush) is often fitted by means of press-fitting, a mandrel or a press machine is used. In the case of a bearing where the interference is large, the operation of press-fitting can be facilitated by chamfering the outside of the bearing and the inside of the housing. The bearing may be finished after press-fitting.

Besides the above-mentioned method of press-fitting, there is a fitting method by cooling where liquid nitrogen or dry ice is used. This method causes less distortion of the metallic base body and hence results in a more precise fitted bore size and shape.

7 Surface finish

Surface roughness of a bush is in accordance with Table 7.

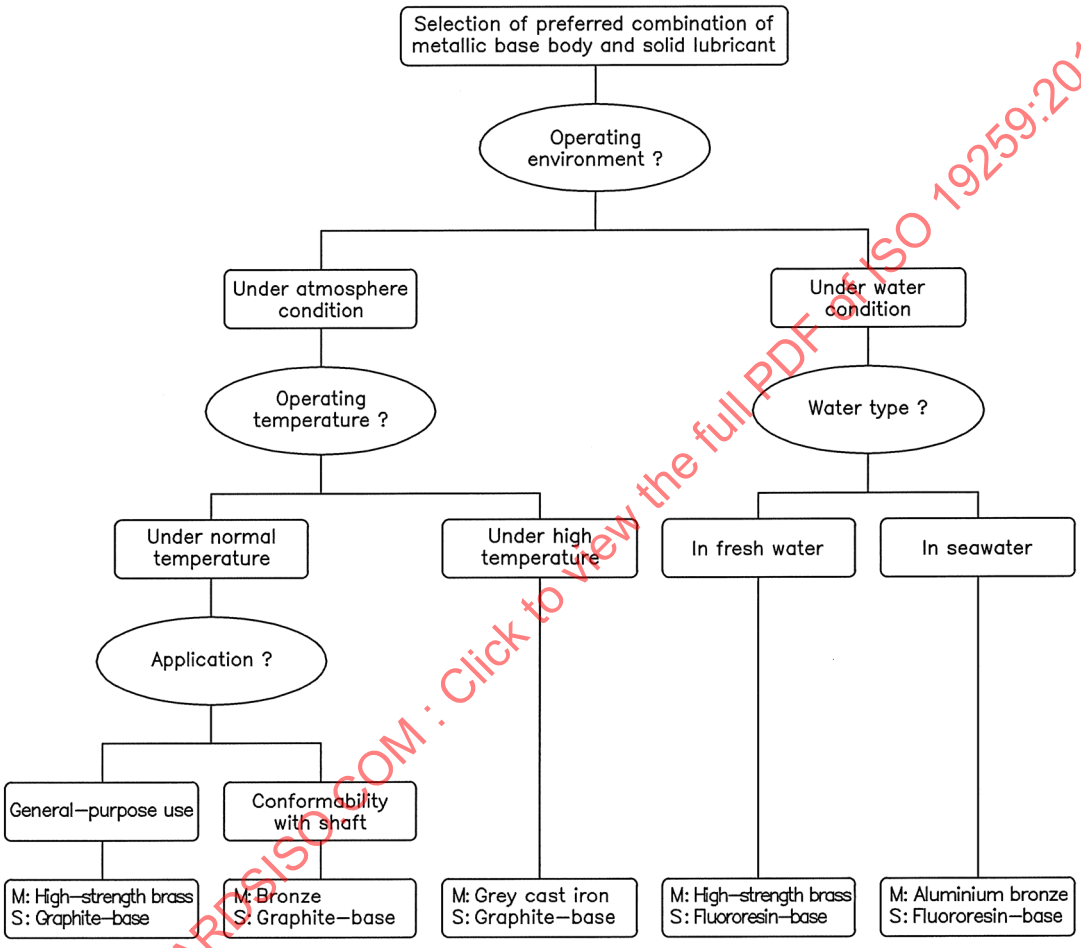
Table 7 — Surface finish of a bush

Surface	Surface roughness x in Figure 5
Inside surface	Ra 1,6
Outside surface	

Annex A
(informative)

Guide for selection of a bearing with embedded solid lubricants

An example of procedures for selection of a bearing with embedded solid lubricants is shown in Figure A.1.



Key

M metallic base body

S solid lubricant

Figure A.1 — Selection procedure of a bearing with embedded solid lubricants