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## Plain bearings — Bearings containing dispersed solid lubricants

*Paliers lisses — Paliers contenant des lubrifiants solides dispersés*

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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.

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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 7, *Special types of plain bearings*.

This second edition cancels and replaces the first edition (ISO 20054:2016), of which it constitutes a minor revision.

The main changes are as follows:

- the titles of 5.2, 7.3.2 and 7.3.3 have been changed to more suitable ones;
- changes in the description in 7.1 have been made due to the above changes.

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](http://www.iso.org/members.html).

# Plain bearings — Bearings containing dispersed solid lubricants

## 1 Scope

This document specifies the characteristics, materials, dimensions, assembly and surface finish for a bearing containing dispersed solid lubricants which is used as a solid lubricant bearing.

NOTE In the solid lubricant bearing among self-lubricating bearings there is a solid type, a coated type, an embedded type and a dispersed type, which is specified by this document.

## 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 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/>

## 4 Symbols and units

See [Table 1](#).

Table 1 — Symbols and units

| Symbol | Description                  | Unit |
|--------|------------------------------|------|
| $B$    | Width of the bush            | mm   |
| $D_i$  | Inside diameter of the bush  | mm   |
| $D_o$  | Outside diameter of the bush | mm   |
| $x$    | Surface roughness            | —    |

## 5 Characteristics

### 5.1 Structure

A bearing containing dispersed solid lubricants is made of sintered composite materials that contain solid lubricants dispersed uniformly in the metal matrix and is manufactured by powder metallurgy (see [Figure 1](#)).

This document includes multi-layered bearings with the sintered layer on a steel backing and both seamless and wrapped bushes (see [Figure 2](#)).

[Figure 3](#) shows a typical microstructure of the bearings containing dispersed solid lubricants. The dispersed solid lubricants in the metal matrix vary in grain size and volume.

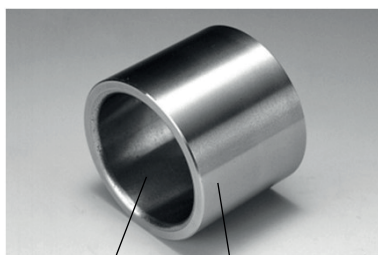


a) Seamless bush — Fine solid lubricants type



b) Seamless bush — Coarse solid lubricants type

Figure 1 — Overview of bearings containing dispersed solid lubricants that are single-layered



1 2

a) Seamless bush



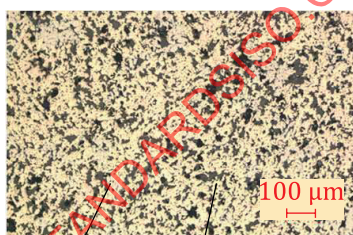
1 2

b) Wrapped bush

**Key**

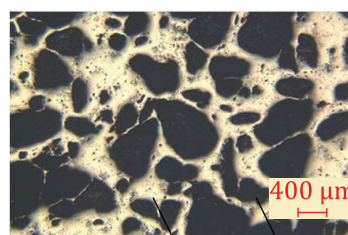
- 1 sintered layer
- 2 steel backing

Figure 2 — Overview of bearings containing dispersed solid lubricants that are multi-layered



1 2

a) Fine solid lubricants type



1 2

b) Coarse solid lubricants type

**Key**

- 1 metal matrix
- 2 dispersed solid lubricant

Figure 3 — Microstructure of a bearing containing dispersed solid lubricants

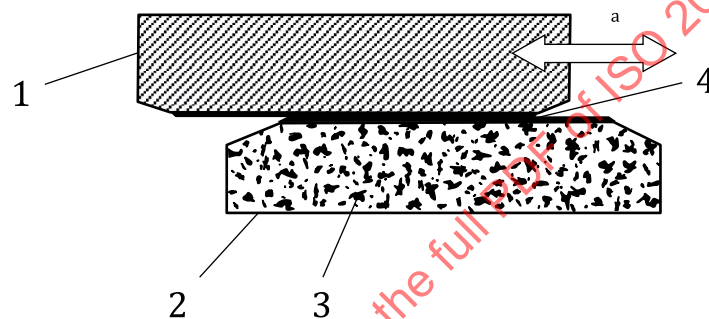
## 5.2 Lubricating mechanism

A bearing containing dispersed solid lubricants obtains its sliding performance from the self-lubricating effects of solid lubricants and the mechanical strength of metal matrix.

The sliding performance and mechanical strength vary according to the volume of solid lubricants. Higher sliding performance requires more solid lubricants, while higher mechanical strength requires less solid lubricants.

Since solid lubricants are dispersed over the entire material, the bearings are particularly suitable for extra low speed or micro-motion applications, minimising static friction to achieve smooth sliding at the start of motion.

The solid lubricants are drawn out over both surfaces from the bearing material when it slides against the mating surface, forming a solid lubricant film. As the solid lubricant film is consumed, it is replenished from the bearing material to maintain a continuous film throughout the life of the product (see [Figure 4](#)).



### Key

- |   |                    |   |                           |
|---|--------------------|---|---------------------------|
| 1 | mating member      | 3 | dispersed solid lubricant |
| 2 | metal matrix       | 4 | solid lubricant film      |
| a | Sliding direction. |   |                           |

**Figure 4 — Lubricating mechanism of a bearing containing dispersed solid lubricants**

## 5.3 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. Bearings with appropriate materials are suited to applications with high or low temperature, liquids, gases and in vacuo.

The bearing has been developed to operate satisfactorily without oil or grease lubricants. However, if the application permits, oil or grease may be utilized to improve bearing durability, prevent dust from entering the bearing, flush out wear debris or prevent corrosion of the bearing components.

## 6 Material

### 6.1 Metal matrix

The constituent elements of the metal matrix in the bearing define the physical, chemical and mechanical properties of the bearing. The chemical composition and manufacturing methods (sintering and heat treatment) influence the bearing metal matrix properties.

Metal matrix base materials are principally copper, nickel or iron. [Table 2](#) shows the operating temperature for the alloy types.

**Table 2 — Types of alloy and their operating temperature**

| Alloy type                                                              | Operating temperature <sup>a</sup><br>°C |
|-------------------------------------------------------------------------|------------------------------------------|
| Copper based alloys                                                     | –200 to 450                              |
| Nickel based alloys                                                     | –200 to 600                              |
| Iron based alloys                                                       | 0 to 700                                 |
| <sup>a</sup> Operating temperature varies according to the composition. |                                          |

The most commonly-used, copper-based metal matrix group is Cu-Sn, but Cu-Ni-Sn and Cu-Ni-Fe alloys offer enhanced thermal resistance and strength.

The nickel-based metal matrix group includes Ni-Cu-Fe alloys, which offer high corrosion resistance.

The iron-based metal matrix group includes Fe-Cu alloys, which offer higher thermal resistance than copper-based alloys by forming iron oxide lubricant films. In addition, there are high-heat resistant Fe-Ni-Cu alloys and stainless alloys (Fe-Cr-Ni alloys, etc.).

Metal matrix can contain small additive additions to enhance performance. The surface of metal matrix can have an additional running-in coating.

Guidance for the selection of a bearing metal matrix for bearings containing dispersed solid lubricants is shown in [Figure A.1](#).

## 6.2 Solid lubricant

Many types of solid lubricants are available. They are selected to suit the operating conditions because their friction performances are influenced by the operating environment. The majority of bearings incorporate graphite and molybdenum disulphide as solid lubricants. Other solid lubricants with low friction, suited to demanding environments, include tungsten disulphide, boron nitride and polytetrafluoroethylene (PTFE). [Table 3](#) shows an outline for the operating temperatures and the atmosphere for the solid lubricants.

The size and type of solid lubricants are selected based on the operating conditions.

**Table 3 — Types of solid lubricants and their properties**

| Type                                                                                   | Operating temperature<br>°C | Atmosphere |            |           |
|----------------------------------------------------------------------------------------|-----------------------------|------------|------------|-----------|
|                                                                                        |                             | In air     | In water   | In vacuum |
| Graphite                                                                               | –120 to 600                 | good       | applicable | poor      |
| MoS <sub>2</sub>                                                                       | –100 to 400                 | good       | poor       | good      |
| WS <sub>2</sub>                                                                        | –180 to 600                 | good       | poor       | good      |
| BN                                                                                     | up to 900 <sup>a</sup>      | good       | —          | —         |
| PTFE                                                                                   | –260 to 260                 | good       | good       | good      |
| <sup>a</sup> BN shows good performance in an oxidising atmosphere at high temperature. |                             |            |            |           |

## 6.3 Combination of metal matrix and solid lubricant

According to a combination of the metal matrix with the solid lubricant types, their grain size, their volume and manufacturing methods permit satisfactory bearing selection for a wide range of applications. Determination of the composition of both metal matrix and solid lubricant is a critical task.

[Table 4](#) shows typical examples of metal matrix and solid lubricant combinations and suitable applications. Further, examples of actual applications of a bearing containing dispersed solid lubricants are shown in [Table B.1](#).

**Table 4 — Typical examples of metal matrix and solid lubricant combinations and suitable applications**

| Alloy type          | Metal matrix <sup>a</sup> | Solid lubricants <sup>a</sup> | Applications                                             |
|---------------------|---------------------------|-------------------------------|----------------------------------------------------------|
| Copper based alloys | Cu-Sn base                | Graphite                      | General use for average conditions (up to 350 °C)        |
|                     |                           | MoS <sub>2</sub>              |                                                          |
|                     |                           | Graphite and MoS <sub>2</sub> | In vacuum and air (up to 350 °C)                         |
|                     | Cu-Ni-Sn base             | Graphite                      | For wear resistance (up to 350 °C)                       |
|                     | Cu-Ni-Fe base             | Graphite                      | For corrosion resistance (up to 450 °C)                  |
| Nickel based alloys | Ni-Cu-Fe base             | Graphite                      | For corrosion resistance (up to 550 °C)                  |
|                     | Ni base                   | Graphite                      | For highest corrosion resistance (up to 600 °C)          |
| Iron based alloys   | Fe-Cu base                | Graphite and MoS <sub>2</sub> | High temperature in air (up to 600 °C)                   |
|                     | Fe-Ni-Cu base             | Graphite and/or BN            | High temperature and corrosion resistance (up to 700 °C) |

<sup>a</sup> It can be processed with oil impregnation. In case that the effect of oil impregnation is necessary, the ambient temperature should be less than 120 °C.

## 7 Dimension

### 7.1 General

The bearing fit (difference between the bearing outside diameter and the housing bore diameter, that is, interference) and bearing clearance (difference between the bearing inside diameter and the diameter of the journal) are important factors to consider when determining the dimensions of a bearing. The many combinations of bearing materials, applications and range of operating conditions do not permit uniform application of tolerances to the bearing component parts (housing, bush and shaft).

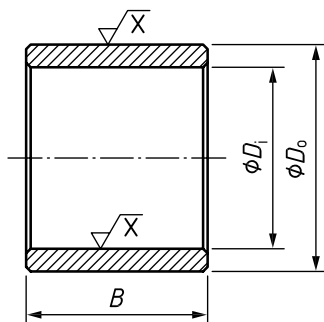
Since the optimum fit varies depending upon the operating environments, discussion is necessary between the supplier and the user to achieve the optimum fit.

### 7.2 General dimension

#### 7.2.1 Seamless bush

Bushes need to have adequate thickness for maintaining the strength.

[Figure 5](#) shows a seamless bush, and [Table 5](#) lists the preferred nominal inside and outside diameters and widths. Bearings of sizes outside those shown in [Table 5](#) shall be subject to agreement between the supplier and the user.

**Key** $x$  surface roughness (see Table 7) $B$  width $D_1$  inside diameter $D_0$  outside diameter**Figure 5 — Seamless bush****Table 5 — Preferred nominal dimensions for seamless bushes**

Dimensions in millimetres

| Inside diameter<br>$D_1$ | Outside diameter<br>$D_0$ | Width <sup>a</sup><br>$B$ |    |    |    |    |    |    |   |
|--------------------------|---------------------------|---------------------------|----|----|----|----|----|----|---|
|                          |                           | 8                         | 10 | 12 | 15 | 20 | 25 | 30 | — |
| 8                        | 12                        | 8                         | 10 | 12 | 15 | —  | —  | —  | — |
| 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 | — |

<sup>a</sup> The width  $B$  can be achieved with multiple connected bushes.

Table 5 (continued)

| Inside diameter<br>$D_i$ | Outside diameter<br>$D_o$ | Width <sup>a</sup><br>$B$ |    |    |    |    |     |     |     |
|--------------------------|---------------------------|---------------------------|----|----|----|----|-----|-----|-----|
|                          |                           | 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 |

<sup>a</sup> The width  $B$  can be achieved with multiple connected bushes.

### 7.2.2 Wrapped bush

The preferred dimensions for wrapped bushes with a steel backing are based on ISO 3547-1.

The large diameter wrapped bushes with the steel backing can use wall thickness 3 mm for inside diameter  $\geq 75$  mm, and can use wall thickness 3 mm or 5 mm for inside diameter  $\geq 250$  mm to get higher rigidity.

## 7.3 Tolerance classes and limit deviations

### 7.3.1 General

Table 6 shows the preferred tolerance classes and limit deviations for operations at ambient temperature.

### 7.3.2 Bearing fit

In general, an interference fit is preferable. A wide range of operating temperatures can make it difficult to maintain the correct interference when bush and housing have dissimilar materials due to differential thermal expansion between the bush and housing. Furthermore, high temperature operation can cause stress relaxation, or high alternating load operation can reduce or eliminate interference. Under such operating conditions, mechanical retention using screws or dowel pins should be applied.

### 7.3.3 Bearing clearance

Notes on the clearance between a bush and a shaft are as follows.

- Interference between housing bore and bush outside diameter causes the bush inside diameter to reduce during fitting.
- Thermal expansion or contraction should be considered if the bush is subjected to a wide temperature operating range. Higher bush-to-shaft clearances are recommended for high-temperature applications.

Table 6 — Preferred tolerance classes and limit deviations

| Inside diameter of bush                          | Outside diameter of bush | Housing bore diameter | Shaft diameter  |
|--------------------------------------------------|--------------------------|-----------------------|-----------------|
| C7 <sup>a</sup>                                  | r6                       | H7                    | h7 <sup>a</sup> |
| <sup>a</sup> In general case.                    |                          |                       |                 |
| <sup>b</sup> For high accuracy (less clearance). |                          |                       |                 |

**Table 6** (continued)

| Inside diameter of bush                          | Outside diameter of bush | Housing bore diameter | Shaft diameter  |
|--------------------------------------------------|--------------------------|-----------------------|-----------------|
| D6 to E6 <sup>b</sup>                            | r6                       | H7                    | g6 <sup>b</sup> |
| <sup>a</sup> In general case.                    |                          |                       |                 |
| <sup>b</sup> For high accuracy (less clearance). |                          |                       |                 |

## 8 Assembling

Since the bush of a bearing containing dispersed solid lubricants 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 fit is large, the operation of press-fitting can be facilitated by chamfering the outside of the bush and the inside of the housing.

Seamless bushes can be cooled using liquid nitrogen or dry ice (CO<sub>2</sub>) to facilitate fitting. This method causes less distortion of the material and hence results in a more precise fitted bore size and shape.

Discussion is recommended between the supplier and the user as some metal matrix materials are unsuitable for freeze-fitting.

## 9 Surface finish

Surface roughness of the bush shall be in accordance with [Table 7](#).

**Table 7 — Surface finish of a bush**

| Surface                                                                                                                       | Surface roughness <sup>a</sup> |
|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
|                                                                                                                               | <i>x</i>                       |
| Inside surface                                                                                                                | Ra 1,6                         |
| Outside surface                                                                                                               | Ra 3,2                         |
| <sup>a</sup> Surface roughness is measured across the metal matrix, excluding surface depressions at solid lubricant islands. |                                |