



**International
Standard**

ISO 4378-2

**Plain bearings — Terms, definitions,
classification and symbols —**

**Part 2:
Friction and wear**

Paliers lisses — Termes, définitions, classification et symboles

Partie 2: Frottement et usure

**Fourth edition
2024-11**

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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 document 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).

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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 6, *Terms and common items*.

This fourth edition cancels and replaces the third edition (ISO 4378-2:2017), which has been technically revised.

The main changes are as follows:

- editorial revision of the document; instead of referencing the parts in the figure by subclause number, the part numbers have been used and the names in the key have been shown;
- addition of Bibliography and an alphabetical index.

A list of all parts in the ISO 4378 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.

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 document is an attempt to establish a uniform basic system of designations of friction and wear.

In addition, this document is specifically intended for the field of plain bearings the content can be adopted in general to the field of tribology and being adopted to other machinery elements.

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Plain bearings — Terms, definitions, classification and symbols —

Part 2: Friction and wear

1 Scope

This document specifies the most commonly used terms relating to friction and wear of plain bearings with their definitions and classification.

For some terms and word combinations, their short forms are given, which can be used where they are unambiguous.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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 General terms

3.1.1

external friction

force and its phenomenon of resistance to the relative motion between two bodies, originating at the contact area of their surfaces and directed tangentially to them

3.1.2

internal friction

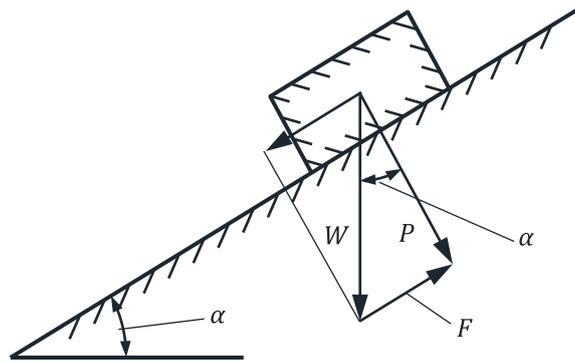
force and its phenomenon of resistance to the relative motion of particles or mass of a body with respect to other particles or mass in the same body

3.1.3

friction

force and its phenomenon of resistance to the relative motion working tangentially with respect to the common boundary between two bodies when, under the action of an external force, one body moves or is at rest relative to the surface of the other

Note 1 to entry: See [Figure 1](#).



Key

- F friction force (3.1.4)
- P normal force
- W weight of material
- α friction angle (3.1.6)

Figure 1 — Friction

3.1.4

friction force

force that resists relative motion between two bodies

Note 1 to entry: See [Figure 1](#).

3.1.5

coefficient of friction

ratio of the *friction force* (3.1.4) between two bodies to the normal force pressing these bodies together

3.1.6

friction angle

angle, the tangent of which is equal to the ratio of the *friction force* (3.1.4) to the normal force, or *coefficient of friction* (3.1.5)

Note 1 to entry: See [Figure 1](#).

3.1.7

wear

phenomenon of a loss of substance from a solid body surface in frictional conditions

3.1.8

wear process

process of a loss of substance from a solid body surface in frictional conditions, which appears as a gradual decrease of body dimensions and/or change of shape

Note 1 to entry: Rarely, in a broader sense, is there a process of permanent increase of body dimensions on the surface without loss of substance.

3.1.9

wear rate

amount of *wear* (3.1.7) per unit sliding distance or per interval of time

Note 1 to entry: A distinction is made between “momentary” (at a definite moment) and “mean” wear rate (during a definite interval of time).

3.1.10

specific wear rate

wear intensity

value of amount of wear (3.1.7) divided by the product of sliding distance (or time) and load; that is, the ratio of wear rate (3.1.9) to the load

Note 1 to entry: Wear can be expressed in the units of length, volume, mass, etc.

Note 2 to entry: Wear intensity is distinguished as “momentary” or as “mean” wear intensity.

3.1.11

mild wear

normal wear

type of adhesive wear (3.3.1.3) characterizing in generation of smooth surface with a little surface damage and minute wear (3.1.7) particles of several microns or less

3.1.12

severe wear

excessive wear

type of adhesive wear (3.3.1.3) characterizing that produces significant transfer and large-sized wear (3.1.7) debris accompanied by intense adhesion (3.4.2) between friction (3.1.3) surfaces

3.2 Terms related to types and characteristics of external friction and classification

3.2.1 Classification according to the presence of relative motion

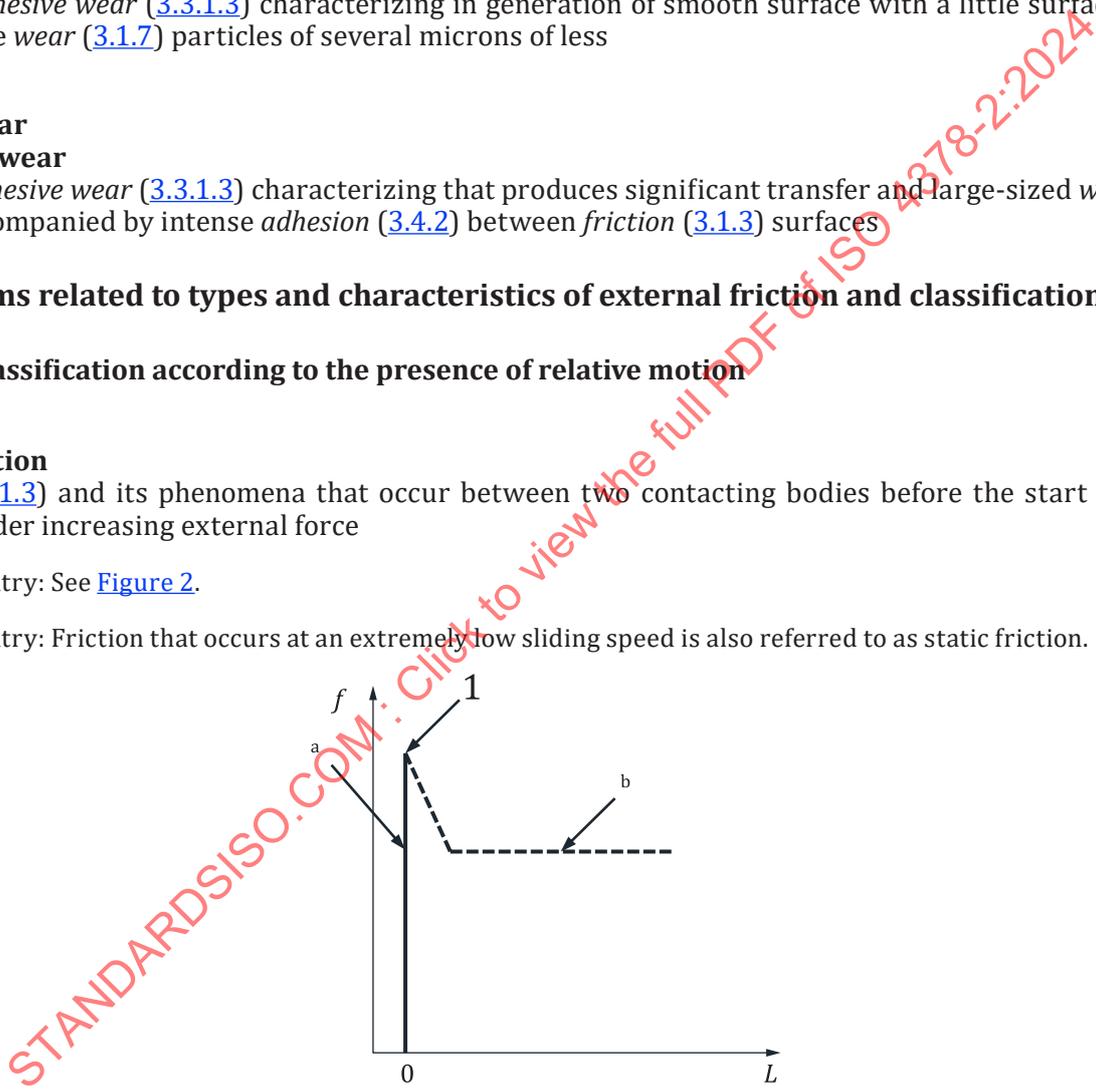
3.2.1.1

static friction

friction (3.1.3) and its phenomena that occur between two contacting bodies before the start of relative motion under increasing external force

Note 1 to entry: See Figure 2.

Note 2 to entry: Friction that occurs at an extremely low sliding speed is also referred to as static friction.



Key

- 1 position of the curve corresponding to maximum static friction (3.2.1.2)
- f* friction (3.1.3)
- L* sliding distance
- a The solid line represents static friction.
- b The dotted line represents dynamic friction (3.2.1.3).

Figure 2 — Friction according to relative motion

3.2.1.2

maximum static friction

friction (3.1.3) and its phenomena that occur between two contacting bodies just before the start of relative motion under gradually increasing external force

Note 1 to entry: See [Figure 2](#).

3.2.1.3

dynamic friction

friction (3.1.3) and its phenomena between two bodies in relative motion

Note 1 to entry: See [Figure 2](#).

3.2.2 Classification according to the mode of relative motion

3.2.2.1

sliding motion

relative motion between two bodies in contact when the contact areas of both bodies move with different magnitudes and/or directions of tangential velocity

3.2.2.2

sliding friction

force and its phenomena of resistance to the *sliding motion* (3.2.2.1) between two bodies

Note 1 to entry: See [3.1.3](#).

3.2.2.3

sliding velocity

difference between tangential velocities of two bodies in contact, at their contact point, during sliding

3.2.2.4

sliding surface

body surface subjected to *sliding motion* (3.2.2.1)

3.2.2.5

rolling motion

relative motion between two bodies in contact when the contact areas of both bodies move with the same magnitude and direction of tangential velocity

3.2.2.6

rolling velocity

tangential velocity at the common contact point between bodies that are rolling relative to each other

3.2.2.7

rolling friction

force and its phenomena of resistance to the *rolling motion* (3.2.2.5) between two bodies

3.2.2.8

combined rolling and sliding friction

dynamic friction (3.2.1.3) that occurs between two contacting bodies when *rolling motion* (3.2.2.5) and *sliding motion* (3.2.2.1) take place simultaneously within the contact area

3.2.2.9

traction

force and its phenomena that occur during the *rolling motion* (3.2.2.5) of a body on another body, accompanied by sliding at the contact area in the tangential direction, and which are utilized for power transmission

3.2.2.10

traction force

force that occurs during the *rolling motion* (3.2.2.5) of a body on another body, accompanied by sliding at the contact area in the tangential direction

3.2.2.11

coefficient of traction

dimensionless value obtained by dividing the *traction force* (3.2.2.10) by the normal load on the contact area

3.2.3 Classification according to the presence of lubricant

3.2.3.1

unlubricated friction

dry friction

friction (3.1.3) that occurs between two contacting bodies with no lubricant on the interacting surfaces

3.2.3.2

lubricated friction

friction (3.1.3) that occurs between two contacting bodies with a lubricant applied on the interacting surfaces

3.2.3.3

boundary friction

friction (3.1.3) and its phenomena that occur in a boundary lubrication condition

3.2.3.4

mixed friction

friction (3.1.3) and its phenomena that occur in a mixed-film lubrication

3.2.3.5

fluid friction

friction (3.1.3) and its phenomena of resistance to the relative motion between individual molecules of the fluid or between the fluid and the bounding surfaces of components in contact with the fluid

3.3 Terms related to types and characteristics of wear process and classification

3.3.1 Mechanical wear

3.3.1.1

mechanical wear

wear process (3.1.8) due to mechanical actions

3.3.1.2

abrasive wear

wear process (3.1.8) of a material caused by cutting or scratching actions of hard bodies or hard particles

Note 1 to entry: See [Figure 3](#).

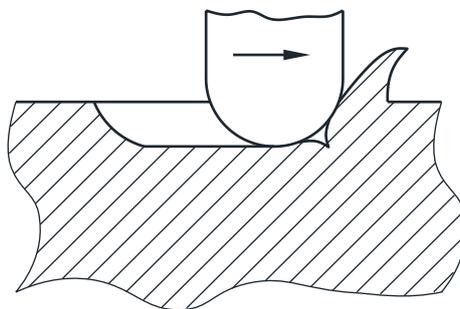


Figure 3 — Abrasive wear

3.3.1.3

adhesive wear

wear process (3.1.8) due to *adhesion* (3.4.2) and extraction of material out of the body surface

Note 1 to entry: See [Figure 4](#).

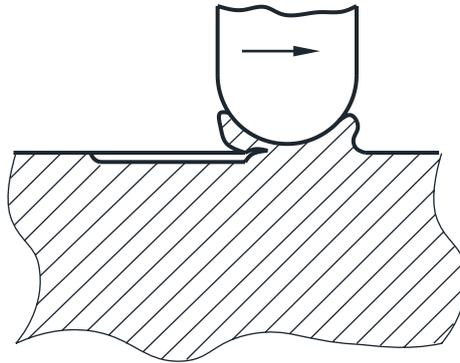


Figure 4 — Adhesive wear

3.3.1.4

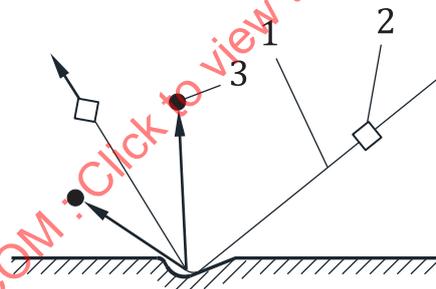
hydro-abrasive wear

fluid-abrasive wear

wear process (3.1.8) due to the action of hard bodies or hard particles carried in a flowing liquid or gas

Note 1 to entry: See [Figure 5](#).

Note 2 to entry: Hydro-abrasive wear is also known as gas-abrasive wear.



Key

- 1 flowing liquid or gas
- 2 hard particles
- 3 wear debris

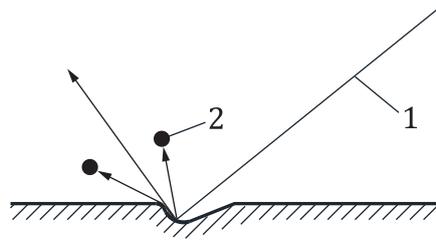
Figure 5 — Hydro abrasive wear

3.3.1.5

fluid erosion

wear process (3.1.8) due to the action of streaming liquid or gas

Note 1 to entry: See [Figure 6](#).



Key

- 1 streaming liquid or gas
- 2 wear debris

Figure 6 — Fluid erosion

3.3.1.6

fatigue wear

wear process (3.1.8) caused by *fatigue* (3.4.5) fracture when micro volumes of the frictional surface material are subjected to repeated stress

Note 1 to entry: Fatigue wear can occur during both sliding and rolling.

3.3.1.7

cavitation wear

cavitation erosion

wear process (3.1.8) when liquid moves along a solid wall or when a solid body moves relatively with respect to liquid in which vapour bubbles generated by reduction of pressure collapse close to the surface, thus, causing locally high impact pressure or high temperature

3.3.1.8

fretting wear

wear process (3.1.8) of the contacting bodies under a condition of oscillatory relative micro-displacement

3.3.2 Mechano-chemical wear

3.3.2.1

mechano-chemical wear

tribo-chemical wear

wear process (3.1.8) due to mechanical action accompanied by chemical and/or electrochemical interaction of the material with the environment

3.3.2.2

fretting corrosion

mechanical and chemical *wear process* (3.1.8) of the contacting bodies under a condition of oscillatory relative micro-displacement

Note 1 to entry: In case of ferrous materials under lubricated conditions, brownish oxidative wear particles are generated.

3.3.2.3

oxidative wear

wear process (3.1.8) in which chemical reaction of material with oxygen or oxidizing media predominates

3.3.3 Other wear

3.3.3.1

electroerosive wear

wear process (3.1.8) caused by electrical discharge that occurs at the contact surfaces of two bodies when electric current flows between them

3.3.3.2

thermal wear

wear process (3.1.8) due to softening and melting of the friction area caused by the heating of the surroundings and *friction* (3.1.3)

3.4 Terms related to phenomena and processes in friction and wear

3.4.1

stick-slip motion

phenomenon of alternation of relative sliding and relative state of rest or alternately increasing and decreasing relative *sliding velocity* (3.2.2.3) developing spontaneously during *dynamic friction* (3.2.1.3)

Note 1 to entry: As an example of stick-slip motion, self-excited vibration occurs when the friction coefficient decreases with the increase of relative sliding velocity.

3.4.2

adhesion in friction

adhesion

phenomenon of local attraction of two bodies in relative sliding due to the action of molecular forces

3.4.3

transfer of material

phenomenon developed during *friction* (3.1.3) when the material of one body adheres to another body and, being detached from the first, remains on the surface of the second body

3.4.4

seizure

process of formation and developing of damage on *sliding surfaces* (3.2.2.4) due to *adhesion* (3.4.2) and *transfer of material* (3.4.3)

Note 1 to entry: Seizure can result in rapid stopping of relative motion.

3.4.5

fatigue

damage and fracture due to the repetition of stress produced by external load

3.4.6

scoring

damage of surface(s) in relative sliding in the form of severe scratches in the direction of sliding

3.4.7

scratching

formation of fine scratches on the surface in the direction of sliding due to irregularities on the harder *sliding surface* (3.2.2.4) or due to hard particles

3.4.8

spalling

flaking

separation of material from a surface in the form of flakes due to *fatigue wear* (3.3.1.6)

Note 1 to entry: This phenomenon is observed mainly in rolling bearings and gears.

3.4.9

pitting

process of pit formation on the surface(s) in relative sliding due to detaching of particles of material during *fatigue wear* (3.3.1.6)

Note 1 to entry: This phenomenon is observed mainly in rolling bearings and gears.

3.4.10

running-in

process of changing the geometry of surface(s) in relative sliding as well as physical and mechanical properties of material surface layers during the initial period of *friction* (3.1.3) usually displayed as decrease of *friction force* (3.1.4), temperature and *wear intensity* (3.1.10) under constant outside conditions

3.4.11

initial running-in

running-in (3.4.10) that occurs in the initial stage of a running-in period

3.4.12

edge loading

condition in which the shaft and the bearing come extremely close to, or in contact with, each other at an end or both ends of the bearing due to bending or tilting of the shaft or improper installation of the bearing and in which brinelling or wear occurs on the bearing as a result

3.5 Terms related to vibration and vibration-related terms regarding a rotating shaft supported by plain bearings

3.5.1

oil whip

phenomenon of the static equilibrium state of an elastic rotating shaft supported by journal bearings becoming unstable when the rotational speed exceeds the limit speed determined by the characteristics of lubricant film force, the shaft weight and the rigidity of bending of the shaft, which starts a whirling motion at high amplitude at the frequency closely corresponding to the minimum bending frequency

Note 1 to entry: This phenomenon leads to catastrophic breakdown of machines.

3.5.2

oil whirl

phenomenon of the static equilibrium state of a rigid rotating shaft supported by journal bearings becoming unstable and starting a whirling motion at a frequency corresponding to a little less than half of the rotational speed, ω , when the rotational speed exceeds the limit speed determined by the characteristics of lubricant film force and the shaft weight

3.5.3

friction whirl

phenomenon of a rotating shaft making a whirling motion in a journal bearing while intermittently making solid contact

3.5.4

stiffness coefficient of lubricant film

spring constant of lubricant film in a journal bearing, determined by the ratio of increase of lubricant film force with the increase of displacement of the shaft centre

3.5.5

damping coefficient of lubricant film

damping constant of lubricant film in a journal bearing, determined by the ratio of increase of lubricant film force with the increase in the rate of shaft centre displacement

3.5.6

creep of bearing

phenomenon of the plain bearing under rotating load sliding slowly in the housing in the opposite direction to that of shaft rotation, resulting in damage such as *wear* (3.1.7), *seizure* (3.4.4) or deformation on the fitting surfaces

Bibliography

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