BRITISH STANDARD

BS EN ISO 286-1:2010

*Incorporating corrigendum August 2013*

# Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes

## Part 1: Basis of tolerances, deviations and fits

ICS 17.040.10; 21.020



British Standards

# National foreword

This British Standard is the UK implementation of EN ISO 286-1:2010. It is identical to ISO 286-1:2010, incorporating corrigendum August 2013. It supersedes BS EN 20286-1:1993 which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by ISO corrigendum August 2013 is indicated in the text by [AC1) (AC1].

The UK participation in its preparation was entrusted to Technical Committee TDW/4, Technical Product Realization.

A list of organizations represented on this committee can be obtained on request to its secretary.

The publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2010.



ISBN 978 0 580 84035 7

**Amendments/corrigenda issued since publication**

| Date | Comments |
|---|---|
| 31 August 2013 | Implementation of ISO corrigendum August 2013 |
| | |
| | |
| | |

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN ISO 286-1

April 2010

ICS 17.040.10

Supersedes EN 20286-1:1993

English Version

## Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 1: Basis of tolerances, deviations and fits (ISO 286-1:2010)

Spécification géométrique des produits (GPS) - Système de codification ISO pour les tolérances sur les tailles linéaires - Partie 1: Base des tolérances, écarts et ajustements (ISO 286-1:2010)

Geometrische Produktspezifikation (GPS) - ISO-Toleranzsystem für Längenmaße - Teil 1: Grundlagen für Toleranzen, Abmaße und Passungen (ISO 286-1:2010)

This European Standard was approved by CEN on 6 February 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**Management Centre: Avenue Marnix 17, B-1000 Brussels**



Ref. No. EN ISO 286-1:2010: E

# Foreword

This document (EN ISO 286-1:2010) has been prepared by Technical Committee ISO/TC 213 "Dimensional and geometrical product specifications and verification" in collaboration with Technical Committee CEN/TC 290 “Dimensional and geometrical product specification and verification” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2010, and conflicting national standards shall be withdrawn at the latest by October 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 20286-1:1993.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

**Endorsement notice**

The text of ISO 286-1:2010 has been approved by CEN as a EN ISO 286-1:2010 without any modification.

# Contents

Page

## Introduction

This International Standard is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain links 1 and 2 of the chain of standards on size in the general GPS matrix.

For more detailed information on the relation of this part of ISO 286 to the GPS matrix model, see Annex C.

The need for limits and fits for machined workpieces was brought about mainly by the requirement for interchange ability between mass produced parts and the inherent inaccuracy of manufacturing methods, coupled with the fact that "exactness" of size was found to be unnecessary for the most workpiece features. In order that fit function could be satisfied, it was found sufficient to manufacture a given workpiece so that its size lay within two permissible limits, i.e. a tolerance, this being the variation in size acceptable in manufacture while ensuring the functional fit requirements of the product.

Similarly, where a specific fit condition is required between mating features of two different workpieces, it is necessary to ascribe an allowance, either positive or negative, to the nominal size to achieve the required clearance or interference. This part of ISO 286 gives the internationally accepted code system for tolerances on linear sizes. It provides a system of tolerances and deviations suitable for two features of size types: "cylinder" and "two parallel opposite surfaces". The main intention of this code system is the fulfilment of the function fit.

The terms "hole", "shaft" and "diameter" are used to designate features of size type cylinder (e.g. for the tolerancing of diameter of a hole or shaft). For simplicity, they are also used for two parallel opposite surfaces (e.g. for the tolerancing of thickness of a key or width of a slot).

The pre-condition for the application of the ISO code system for tolerances on linear sizes for the features forming a fit is that the nominal sizes of the hole and the shaft are identical.

The previous edition of ISO 286-1 (published in 1988) had the envelope criterion as the default association criterion for the size of a feature of size; however, ISO 14405-1 changes this default association criterion to the two-point size criterion. This means that form is no longer controlled by the default specification of size.

In many cases, the diameter tolerances according to this part of ISO 286 are not sufficient for an effective control of the intended function of the fit. The envelope criterion according to ISO 14405-1 may be required. In addition, the use of geometrical form tolerances and surface texture requirements may improve the control of the intended function.

# Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes —

# Part 1: Basis of tolerances, deviations and fits

## 1 Scope

This part of ISO 286 establishes the ISO code system for tolerances to be used for linear sizes of features of the following types:

a) cylinder;

b) two parallel opposite surfaces.

It defines the basic concepts and the related terminology for this code system. It provides a standardized selection of tolerance classes for general purposes from amongst the numerous possibilities.

Additionally, it defines the basic terminology for fits between two features of size without constraints of orientation and location and explains the principles of "basic hole" and "basic shaft".

## 2 Normative references

The following referenced documents are indispensable for the application 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.

[AC1) ISO 286-2:2010, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts* (AC1]

ISO 14405-1, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 1: Linear sizes*

ISO 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO 14660-2:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 2: Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14405-1 and ISO 14660-1 and the following apply. It should be noted, however, that some of the terms are defined in a more restricted sense than in common usage.

## 3.1 Basic terminology

**3.1.1**
**feature of size**
geometrical shape defined by a linear or angular dimension which is a size

[ISO 14660-1:1999, definition 2.2]

NOTE 1 The feature of size can be a cylinder, a sphere, two parallel opposite surfaces.

NOTE 2 In former editions of international standards, such as ISO 286-1 and ISO/R 1938, the meanings of the terms “plain workpiece” and “single features” are close to that of “feature of size”.

NOTE 3 For the purpose of ISO 286, only features of size type cylinder as well as type-two parallel opposite surfaces, defined by a linear dimension, apply.

**3.1.2**
**nominal integral feature**
theoretically exact integral feature as defined by a technical drawing or by other means

[ISO 14660-1:1999, definition 2.3]

**3.1.3**
**hole**
internal feature of size of a workpiece, including internal features of size which are not cylindrical

NOTE See also Introduction.

**3.1.4**
**basic hole**
hole chosen as a basis for a hole-basis fit system

NOTE 1 See also 3.4.1.1.

NOTE 2 For the purpose of the ISO code system, a basic hole is a hole for which the lower limit deviation is zero.

**3.1.5**
**shaft**
external feature of size of a workpiece, including external features of size which are not cylindrical

NOTE See also Introduction.

**3.1.6**
**basic shaft**
shaft chosen as a basis for a shaft-basis fit system

NOTE 1 See also 3.4.1.2.

NOTE 2 For the purposes of the ISO code system, a basic shaft is a shaft for which the upper limit deviation is zero.

## 3.2 Terminology related to tolerances and deviations

**3.2.1**
**nominal size**
size of a feature of perfect form as defined by the drawing specification

See Figure 1.

NOTE 1 Nominal size is used for the location of the limits of size by the application of the upper and lower limit deviations.

NOTE 2 In former times, this was referred to as “basic size”.

**3.2.2**
**actual size**
size of the associated integral feature

NOTE 1 "Associated integral feature" is defined in ISO 14660-1:1999, 2.6.

NOTE 2 The actual size is obtained by measurement.

**3.2.3**
**limits of size**
extreme permissible sizes of a feature of size

NOTE To fulfil the requirement, the actual size shall lie between the upper and lower limits of size; the limits of size are also included.

**3.2.3.1**
**upper limit of size**
**ULS**
largest permissible size of a feature of size

See Figure 1.

**3.2.3.2**
**lower limit of size**
**LLS**
smallest permissible size of a feature of size

See Figure 1.

**3.2.4**
**deviation**
value minus its reference value

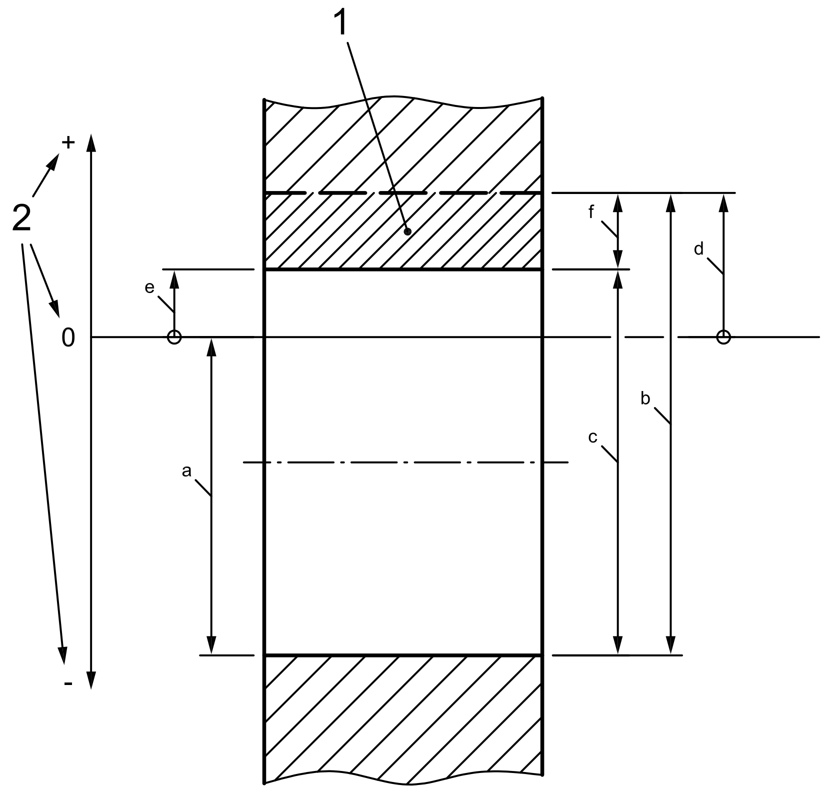
NOTE For size deviations, the reference value is the nominal size and the value is the actual size.

**3.2.5**
**limit deviation**
upper limit deviation or lower limit deviation from nominal size

**3.2.5.1**
**upper limit deviation**
$ES$ (to be used for internal features of size)
$es$ (to be used for external features of size)
upper limit of size minus nominal size

See Figure 1.

NOTE Upper limit deviation is a signed value and may be negative, zero or positive.




**Key**

1 tolerance interval

2 sign convention for deviations

a Nominal size.

b Upper limit of size.

c Lower limit of size.

d Upper limit deviation.

e Lower limit deviation (in this case also fundamental deviation).

f Tolerance.

NOTE The horizontal continuous line, which limits the tolerance interval, represents the fundamental deviations for a hole. The dashed line, which limits the tolerance interval, represents the other limit deviation for a hole.

**Figure 1 — Illustration of definitions (a hole is used in the example)**

**3.2.5.2**
**lower limit deviation**
*EI* (to be used for internal features of size)
*ei* (to be used for external features of size)
lower limit of size minus nominal size

See Figure 1.

NOTE Lower limit deviation is a signed value and may be negative, zero or positive.

**3.2.6**
**fundamental deviation**
limit deviation that defines the placement of the tolerance interval in relation to the nominal size

NOTE 1 The fundamental deviation is that limit deviation, which defines that limit of size which is the nearest to the nominal size (see Figure 1 and 4.1.2.5).

NOTE 2 The fundamental deviation is identified by a letter (e.g. B, d).

**3.2.7**
***Δ* value**
variable value added to a fixed value to obtain the fundamental deviation of an internal feature of size

See Table 3.

**3.2.8**
**tolerance**
difference between the upper limit of size and the lower limit of size

NOTE 1 The tolerance is an absolute quantity without sign.

NOTE 2 The tolerance is also the difference between the upper limit deviation and the lower limit deviation.

**3.2.8.1**
**tolerance limits**
specified values of the characteristic giving upper and/or lower bounds of the permissible value

**3.2.8.2**
**standard tolerance**
**IT**
any tolerance belonging to the ISO code system for tolerances on linear sizes

NOTE The letters in the abbreviated term “IT” stand for “International Tolerance”.

**3.2.8.3**
**standard tolerance grade**
group of tolerances for linear sizes characterized by a common identifier

NOTE 1 In the ISO code system for tolerances on linear sizes, the standard tolerance grade identifier consists of IT followed by a number (e.g. IT7); see 4.1.2.3.

NOTE 2 A specific tolerance grade is considered as corresponding to the same level of accuracy for all nominal sizes.

**3.2.8.4**
**tolerance interval**
variable values of the size between and including the tolerance limits

NOTE 1 The former term “tolerance zone”, which was used in connection with linear dimensioning (according to ISO 286-1:1988), has been changed to “tolerance interval” since an interval refers to a range on a scale whereas a tolerance zone in GPS refers to a space or an area, e.g. tolerancing according to ISO 1101.

NOTE 2 For the purpose of ISO 286, the interval is contained between the upper and the lower limits of size. It is defined by the magnitude of the tolerance and its placement relative to the nominal size (see Figure 1).

NOTE 3 The tolerance interval does not necessarily include the nominal size (see Figure 1). Tolerance limits may be two-sided (values on both sides of the nominal size) or one-sided (both values on one side of the nominal size). The case where the one tolerance limit is on one side, the other limit value being zero, is a special case of a one-sided indication.

**3.2.8.5**
**tolerance class**
combination of a fundamental deviation and a standard tolerance grade

NOTE In the ISO code system for tolerances on linear sizes, the tolerance class consists of the fundamental deviation identifier followed by the tolerance grade number (e.g. D13, h9, etc.), see 4.2.1.

## 3.3 Terminology related to fits

The concepts in this clause relate only to nominal features of size (perfect form). For the model definition of a nominal feature of size, see ISO 17450-1:—, 3.18.

For the determination of a fit, see 5.3.

**3.3.1**
**clearance**
difference between the size of the hole and the size of the shaft when the diameter of the shaft is smaller than the diameter of the hole

NOTE In the calculation of clearance, the obtained values are positive (see B.2).

**3.3.1.1**
**minimum clearance**
⟨in a clearance fit⟩ difference between the lower limit of size of the hole and the upper limit of size of the shaft

See Figure 2.

**3.3.1.2**
**maximum clearance**
⟨in a clearance or transition fit⟩ difference between the upper limit of size of the hole and the lower limit of size of the shaft

See Figures 2 and 4.

**3.3.2**
**interference**
difference before mating between the size of the hole and the size of the shaft when the diameter of the shaft is larger than the diameter of the hole

NOTE In the calculation of an interference, the obtained values are negative (see B.2).

**3.3.2.1**
**minimum interference**
⟨in an interference fit⟩ difference between the upper limit of size of the hole and the lower limit of size of the shaft

See Figure 3.

**3.3.2.2**
**maximum interference**
⟨in an interference or transition fit⟩ difference between the lower limit of size of the hole and the upper limit of size of the shaft

See Figures 3 and 4.

**3.3.3**
**fit**
relationship between an external feature of size and an internal feature of size (the hole and shaft of the same type) which are to be assembled

**3.3.3.1**
**clearance fit**
fit that always provides a clearance between the hole and shaft when assembled, i.e. the lower limit of size of the hole is either larger than or, in the extreme case, equal to the upper limit of size of the shaft

See Figure 2.

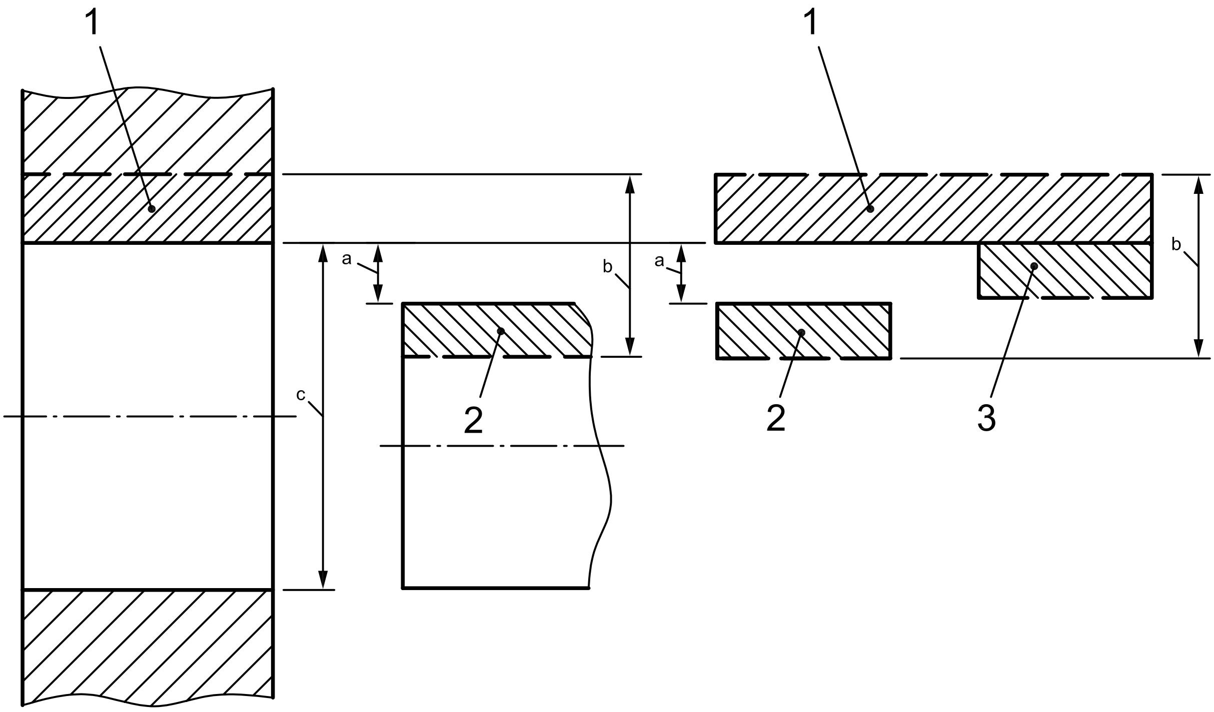
**3.3.3.2**
**interference fit**
fit that always provides an interference between the hole and the shaft when assembled, i.e. the upper limit of size of the hole is either smaller than or, in the extreme case, equal to the lower limit of size of the shaft

See Figure 3.

**3.3.3.3**
**transition fit**
fit which may provide either a clearance or an interference between the hole and the shaft when assembled

See Figure 4.

NOTE In a transition fit, the tolerance intervals of the hole and the shaft overlap either completely or partially; therefore, if there is a clearance or an interference depends on the actual sizes of the hole and the shaft.




**a) Detailed** **b) Simplified**

**Key**

1 tolerance interval of the hole

2 tolerance interval of the shaft, case 1: when the upper limit of size of the shaft is lower than the lower limit of size of the hole, the minimum clearance is larger than zero

3 tolerance interval of the shaft, case 2: when the upper limit of size of the shaft is identical to the lower limit of size of the hole, the minimum clearance is zero

[a] Minimum clearance.

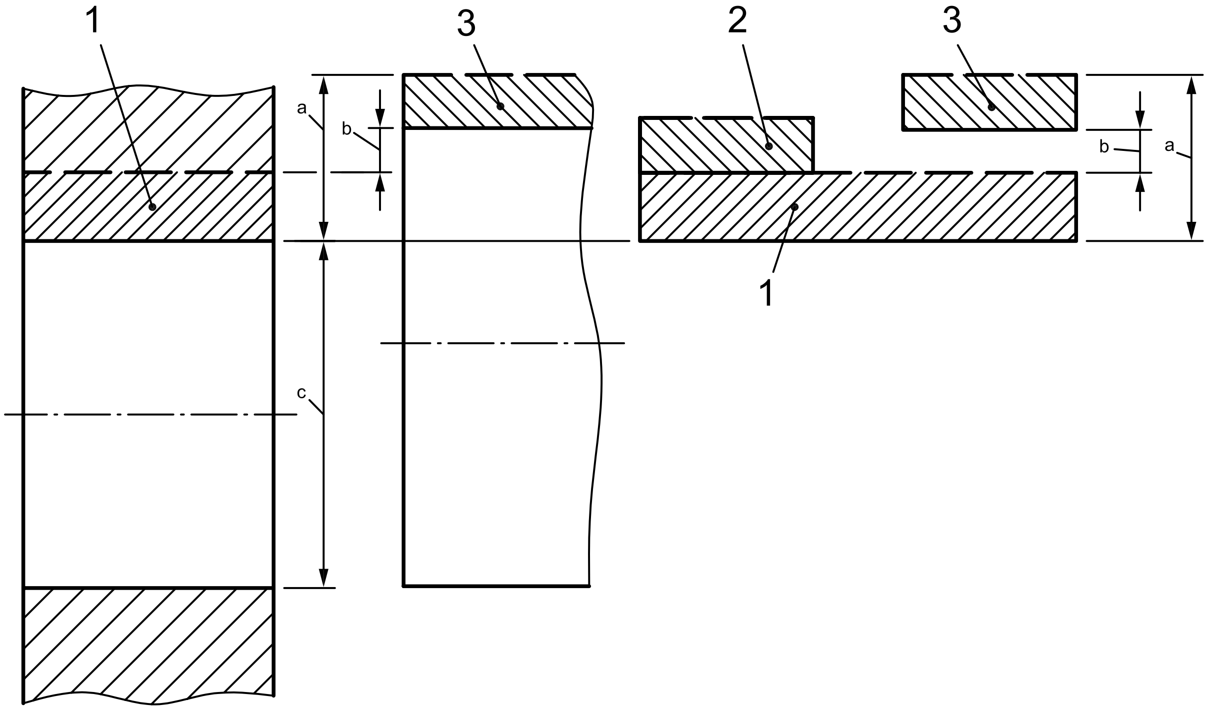
[b] Maximum clearance.

[c] Nominal size = lower limit of size of the hole.

NOTE The horizontal continuous wide lines, which limit the tolerance intervals, represent the fundamental deviations. The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

**Figure 2 — Illustration of definitions of a clearance fit (nominal model)**




**a) Detailed** **b) Simplified**

**Key**

1 tolerance interval of the hole

2 tolerance interval of the shaft, case 1: when the lower limit of size of the shaft is identical to the upper limit of size of the hole, the minimum interference is zero

3 tolerance interval of the shaft, case 2: when the lower limit of size of the shaft is larger than the upper limit of size of the hole, the minimum interference is larger than zero

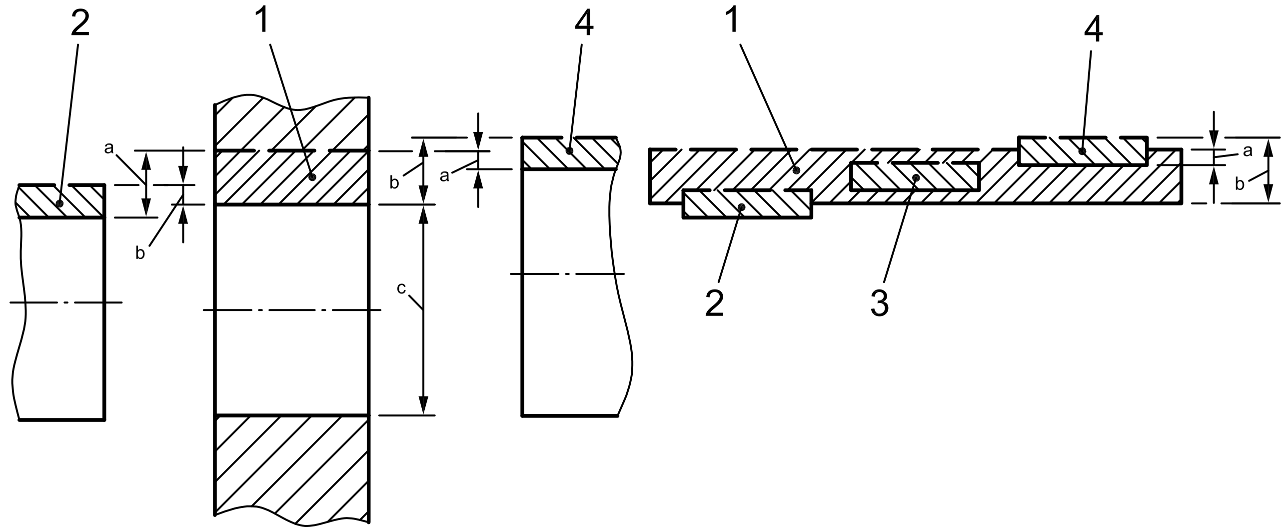
[a] Maximum interference.

[b] Minimum interference.

[c] Nominal size = lower limit of size of the hole.

NOTE The horizontal continuous wide lines, which limit the tolerance intervals, represent the fundamental deviations. The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

**Figure 3 — Illustration of definitions of an interference fit (nominal model)**




**Key**

1 tolerance interval of the hole

2-4 tolerance interval of the shaft (some possible placements are shown)

[a] Maximum clearance.

[b] Maximum interference.

[c] Nominal size = lower limit of size of the hole.

NOTE The horizontal continuous wide lines, which limit the tolerance intervals, represent the fundamental deviations. The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

**Figure 4 — Illustration of definitions of a transition fit (nominal model)**

**3.3.4**
**span of a fit**
arithmetic sum of the size tolerances on two features of size comprising the fit

See Figure B.1.

NOTE 1 The span of a fit is an absolute value without sign and expresses the possible nominal variation of the fit.

NOTE 2 The span of a clearance fit is the difference between the maximum and minimum clearances. The span of an interference fit is the difference between the maximum and minimum interferences. The span of a transition fit is the sum of the maximum clearance and maximum interference (see Annex B).

## 3.4 Terminology related to the ISO fit system

**3.4.1**
**ISO fit system**
system of fits comprising shafts and holes toleranced by the ISO code system for tolerances on linear sizes

NOTE The pre-condition for the application of the ISO code system for tolerances on linear sizes for the features forming a fit is that the nominal sizes of the hole and the shaft are identical.

**3.4.1.1**
**hole-basis fit system**
fits where the fundamental deviation of the hole is zero, i.e. the lower limit deviation is zero

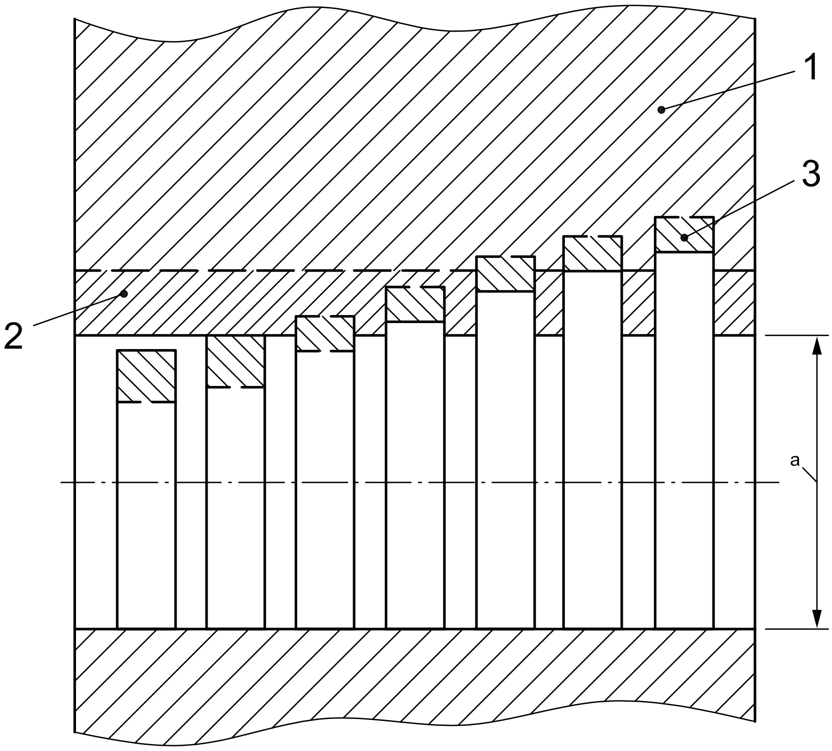
See Figure 5.

NOTE A fit system in which the lower limit of size of the hole is identical to the nominal size. The required clearances or interferences are obtained by combining shafts of various tolerance classes with basic holes of a tolerance class with a fundamental deviation of zero.

**3.4.1.2**
**shaft-basis fit system**
fits where the fundamental deviation of the shaft is zero, i.e. the upper limit deviation is zero

See Figure 6.

NOTE A fit system in which the upper limit of size of the shaft is identical to the nominal size. The required clearances or interferences are obtained by combining holes of various tolerance classes with basic shafts of a tolerance class with a fundamental deviation of zero.




**Key**

1 basic hole “H”

2 tolerance interval of the basic hole

3 tolerance interval of the different shafts

a Nominal size.

NOTE 1 The horizontal continuous lines, which limit the tolerance intervals, represent the fundamental deviations for a basic hole and different shafts.

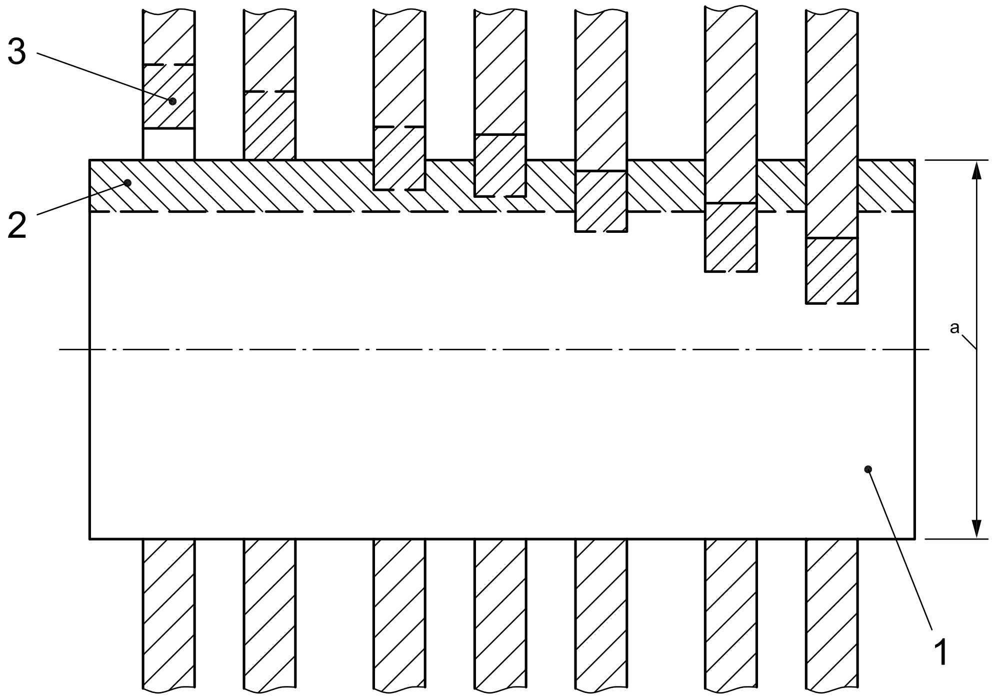
NOTE 2 The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

NOTE 3 The figure shows the possibility of combinations between a basic hole and different shafts, related to their standard tolerance grades.

NOTE 4 Possible examples of hole-basis fits are: H7/h6, H6/k5, H6/p4.

**Figure 5 — Hole-basis fit system**




**Key**

1 basic shaft “h”

2 tolerance interval of the basic shaft

3 tolerance interval of the different holes

[a] Nominal size.

NOTE 1 The horizontal continuous lines, which limit the tolerance intervals, represent the fundamental deviations for a basic shaft and different holes.

NOTE 2 The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

NOTE 3 The figure shows the possibility of combinations between a basic shaft and different holes, related to their standard tolerance grades.

NOTE 4 Possible examples of shaft-basis fits are: h6/G7, h6/H6, h6/M6.

**Figure 6 — Shaft-basis fit system**

# 4 ISO code system for tolerances on linear sizes

## 4.1 Basic concepts and designations

### 4.1.1 Relation to ISO 14405-1

A feature of size may be toleranced by using the ISO code system defined in this part of ISO 286 or by using + and – tolerancing according to ISO 14405-1. Both indications are equivalent.

EXAMPLE 1 $32\,^{x}_{y}$ is equivalent to 32 “code”

where

32 is the nominal size, in millimeters;

x is the upper tolerance limit (x can be positive, zero or negative);

y is the lower tolerance limit (y can be positive, zero or negative);

“code” is the tolerance class according to 4.2.1.

If a fit shall be toleranced, the envelope requirement according to ISO 14405-1 may be indicated (see A.2).

EXAMPLE 2 $32\,{}^{x}_{y}$ Ⓔ is equivalent to 32 “code” Ⓔ

### 4.1.2 Tolerance class

#### 4.1.2.1 General

The tolerance class contains information on the magnitude of the tolerance and the position of the tolerance interval relative to the nominal size of the feature of size.

#### 4.1.2.2 Magnitude of the tolerance

The tolerance class expresses the magnitude of the tolerance. The magnitude of the tolerance is a function of the standard tolerance grade number and the nominal size of the toleranced feature.

#### 4.1.2.3 Standard tolerance grades

The standard tolerance grades are designated by the letters IT followed by the grade number, e.g. IT7.

Values of standardised tolerances are given in Table 1. Each of the columns gives the values of the tolerances for one standard tolerance grade between standard tolerance grades IT01 and IT18 inclusive. Each row in Table 1 is representing one range of sizes. The limits of the ranges of sizes are given in the first column of Table 1.

NOTE 1 When the standard tolerance grade is associated with a letter or letters representing a fundamental deviation to form a tolerance class, the letters IT are omitted, e.g. H7.

NOTE 2 From IT6 to IT18, the standard tolerances are multiplied by the factor 10 at each fifth step. This rule applies to all standard tolerances and may be used to extrapolate values for IT grades not given in Table 1.

EXAMPLE For the nominal size range 120 mm up to and including 180 mm, the value of IT20 is:

IT20 = IT15 × 10 = 1,6 mm × 10 = 16 mm

#### 4.1.2.4 Placement of tolerance interval

The tolerance interval (former term: tolerance zone) is a variable value contained between the upper and the lower limits of size. The tolerance class expresses the position of the tolerance interval relative to the nominal size, by means of the fundamental deviation. The information on the position of the tolerance interval, i.e. on the fundamental deviation, is identified by one or more letters, called the fundamental deviation identifiers:

A graphical overview of the position of the tolerance intervals relative to the nominal sizes and the signs (+ or –) of the fundamental deviations for holes and shafts are given in Figures 7, 8 and 9.

#### 4.1.2.5 Fundamental deviation

The fundamental deviation is that limit deviation, which defines that limit of size, which is the nearest to the nominal size (see Figure 7).

The fundamental deviations are identified and controlled by:

— upper case letter(s) for holes (A . . . ZC), see Tables 2 and 3;

— lower case letter(s) for shafts (a . . . zc), see Tables 4 and 5.

NOTE 1 To avoid confusion, the following letters are not used: I, i; L, l; O, o; Q, q; W, w.

NOTE 2 The fundamental deviations are not defined individually for each specific nominal size, but for ranges of nominal sizes as given in Tables 2 to 5.

The fundamental deviation in micrometres is a function of the identifier (letter) and the nominal size of the toleranced feature.

Tables 2 and 3 contain the signed values of the fundamental deviations for hole tolerances. Tables 4 and 5 contain the signed values of the fundamental deviations for shaft tolerances.

The sign + is used when the tolerance limit identified by the fundamental deviation is above nominal size and the sign – is used when the tolerance limit identified by the fundamental deviation is below nominal size.

Each of the columns in Tables 2 to 5 gives the values of the fundamental deviation for one fundamental deviation identifier letter. Each of the rows is representing one range of sizes. The limits of the ranges of sizes are given in the first column of the tables.

The other limit deviation (upper or lower) is established from the fundamental deviation and the standard tolerance (IT) as shown in Figures 8 and 9.

NOTE 3 The concept of fundamental deviations does not apply to JS and js. Their tolerance limits are distributed symmetrically about the nominal size line (see Figures 8 and 9).

NOTE 4 The ranges of sizes in Tables 2 to 5 are in many cases (for deviations a to c and r to zc or A to C and R to ZC) subdivisions of the main ranges of Table 1.

The last six columns on the right side of Table 3 contain a separate table with $\Delta$-values. $\Delta$ is a function of the tolerance grade and the nominal size of the toleranced feature. It is only relevant for deviations K to ZC and for standard tolerance grades IT3 to IT7/IT8.

The value of $\Delta$ shall be added to the fixed value given in the main table, whenever $+\Delta$ is indicated, to form the correct value of the fundamental deviation.

## 4.2 Designation of the tolerance class (writing rules)

### 4.2.1 General

The tolerance class shall be designated by the combination of an upper-case letter(s) for holes and lower-case letters for shafts identifying the fundamental deviation and by the number representing the standard tolerance grade.

EXAMPLE H7 (holes), h7 (shafts).

### 4.2.2 Size and its tolerance

A size and its tolerance shall be designated by the nominal size followed by the designation of the required tolerance class, or shall be designated by the nominal size followed by + and/or – limit deviations (see ISO 14405-1).

In the following examples the indicated limit deviations are equivalent to the indicated tolerance classes.

EXAMPLE 1

| ISO 286 | | ISO 14405-1 |
|---|---|---|
| 32 H7 | ≡ | $32\,^{+0,025}_{\ \ 0}$ |
| 80 js15 | ≡ | 80 ± 0,6 |
| 100 g6 Ⓔ | ≡ | $100\,^{-0,012}_{-0,034}$ Ⓔ |

NOTE When using + or – tolerancing determined from a tolerance class, the tolerance class may be added in brackets for auxiliary information purposes and vice versa.

EXAMPLE 2 $32\,\mathrm{H7}\left(\begin{array}{l}+0,025\\ \ \ 0\end{array}\right)$ $32\,^{+0,025}_{\ \ 0}$ (H7)

### 4.2.3 Determination of a tolerance class

Determination of a tolerance class is derived from fit requirements (clearances, interferences), see 5.3.4.

## 4.3 Determination of the limit deviations (reading rules)

### 4.3.1 General

The determination of the limit deviations for a given toleranced size, e.g. the transformation of a tolerance class into + and – tolerancing can be performed by the use of:

— the Tables 1 to 5 of this part of ISO 286 (see 4.3.2); or

— the tables of ISO 286-2 (see 4.3.3). Only selected cases are covered.

### 4.3.2 Determination of limit deviations using the tables of this part of ISO 286

#### 4.3.2.1 General

The tolerance class is decomposed into the fundamental deviation identifier and the standard tolerance grade number.

EXAMPLE Toleranced size for a hole 90 F7 Ⓔ and for a shaft 90 f7 Ⓔ

where

| | |
|---|---|
| 90 | is the nominal size in millimetres; |
| F | is the fundamental deviation identifier for a hole; |
| f | is the fundamental deviation identifier for a shaft; |
| 7 | is the standard tolerance grade number; |
| Ⓔ | is the envelope requirement according to ISO 14405-1 (if necessary). |

#### 4.3.2.2 Standard tolerance grade

From the standard tolerance grade number, the standard tolerance grade (IT$x$) is obtained.

From the nominal size and the standard tolerance grade the magnitude of the tolerance, e.g. the standard tolerance value is obtained by the use of Table 1.

EXAMPLE 1 Toleranced size for a hole 90 F7 Ⓔ and for a shaft 90 f7 Ⓔ

The standard tolerance grade number is "7", hence, the standard tolerance grade is IT7.

The standard tolerance value has to be taken from Table 1 in the line of the nominal size range above 80 mm up to and including 120 mm and in the column of the standard tolerance grade IT7.

Consequently, the standard tolerance value is: 35 µm.

EXAMPLE 2 Toleranced size for a hole 28 P9 Ⓔ

The standard tolerance grade number is "9", hence, the standard tolerance grade is IT9.

The standard tolerance value has to be taken from Table 1 in the line of the nominal size range above 18 mm up to and including 30 mm and in the column of the standard tolerance grade IT9.

Consequently the standard tolerance value is: 52 µm.

#### 4.3.2.3 Position of the tolerance interval

From the nominal size and the fundamental deviation identifier the fundamental deviation ( the upper or lower limit deviation) is obtained by use of Tables 2 and 3 for holes (upper-case letters) and Tables 4 and 5 for shafts (lower-case letters).

EXAMPLE 1 Toleranced size for a hole 90 F7 Ⓔ

The fundamental deviation identifier is "F", hence, this is a hole case and Table 2 applies.

From Table 2, line "80 to 100" and column "F", the lower limit deviation $EI$ is: +36 µm.

EXAMPLE 2 Toleranced size for a shaft 90 f7 Ⓔ

The fundamental deviation identifier is "f", hence, this is a shaft case and Table 4 applies.

From Table 4, line "80 to 100" and column "f", the upper limit deviation $es$ is: –36 µm.

EXAMPLE 3 Toleranced size for a hole 28 P9 Ⓔ

The fundamental deviation identifier is "P", hence, this is a hole case and Table 3 applies.

From Table 3, line "24 to 30" and column "P", the upper limit deviation $ES$ is: –22 µm.

#### 4.3.2.4 Establishment of limit deviations

One of the limit deviations (upper or lower) has already been determined in 4.3.2.3. The other limit deviations (upper or lower) are obtained by calculation according to the formulae given in Figures 8 and 9 and using the standard tolerance values of Table 1.

EXAMPLE 1 Toleranced size for a hole 90 F7 Ⓔ

| | |
|---|---|
| According to 4.3.2.2 | IT7 = 35 µm |
| According to 4.3.2.3 | Lower limit deviation $EI = +36$ µm |
| According to formula in Figure 8 | Upper limit deviation $ES = EI + \mathrm{IT} = +36 + 35 = +71$ µm |

From that follows: 90 F7 Ⓔ $\equiv 90^{+0{,}071}_{+0{,}036}$ Ⓔ

EXAMPLE 2 Toleranced size for a shaft 90 f7 Ⓔ

| | |
|---|---|
| According to 4.3.2.2 | IT7 = 35 µm |
| According to 4.3.2.3 | Upper limit deviation $es = -36$ µm |
| According to formula in Figure 9 | Lower limit deviation $ei = es - \mathrm{IT} = -36 - 35 = -71$ µm |

From that follows: 90 f7 Ⓔ $\equiv 90^{-0{,}036}_{-0{,}071}$ Ⓔ

EXAMPLE 3 [AC1⟩Toleranced size for a hole 28 P9 Ⓔ⟨AC1]

| | | |
|---|---|---|
| According to 4.3.2.2 | IT7 = 52 µm | |
| According to 4.3.2.3 | Upper limit deviation | $ES$ = –22 µm |
| According to formula in Figure 8 | Lower limit deviation | $EI$ = $ES$ – IT = –22 – 52 = –74 µm |

From that follows: 28 P9 Ⓔ ≡ $28^{-0,022}_{-0,074}$ Ⓔ

#### 4.3.2.5 Establishment of limit deviations using $\Delta$-values

For determining the fundamental deviations K, M and N for standard tolerance grades up to and including IT8 and P to ZC up to and including IT7, the values $\Delta$ from the columns on the right of Table 3 shall be taken into consideration.

EXAMPLE 1 Toleranced size for a hole 20 K7 Ⓔ

Table 1: IT7 in the range above 18 mm up to and including 30 mm IT7 = 21 µm

Table 3: $\Delta$ in the range above 18 mm up to and including 24 mm for IT7 $\Delta$ = 8 µm

For K in the range above 18 mm up to and including 24 mm:

Upper limit deviation $ES$ = –2 + $\Delta$ = –2 + 8 = +6 µm

Lower limit deviation $EI$ = $ES$ – IT = +6 – 21 = –15 µm

From that follows: 20 K7 Ⓔ ≡ $20^{+0,006}_{-0,015}$ Ⓔ

EXAMPLE 2 Toleranced size for a hole 40 U6

Table 1: IT6 in the range above 30 mm up to and including 50 mm IT6 = 16 µm

Table 3: $\Delta$ in the range above 30 mm up to and including 40 mm for IT6 $\Delta$ = 5 µm

For U in the range above 30 mm up to and including 40 mm:

Upper limit deviation $ES$ = –60 + $\Delta$ = –60 + 5 = –55 µm

Lower limit deviation $EI$ = $ES$ – IT = –55 – 16 = –71 µm

From that follows: 40 U6 ≡ $40^{-0,055}_{-0,071}$

NOTE For this interference fit, the envelope requirement has been omitted intentionally. For strong interference fits, it is not necessary to apply the envelope requirement.

### 4.3.3 Determination of limit deviations using the tables of ISO 286-2

The limit deviations for a given toleranced size may be selected from the Tables of ISO 286–2.

EXAMPLE Given toleranced size: 60 M6 Ⓔ

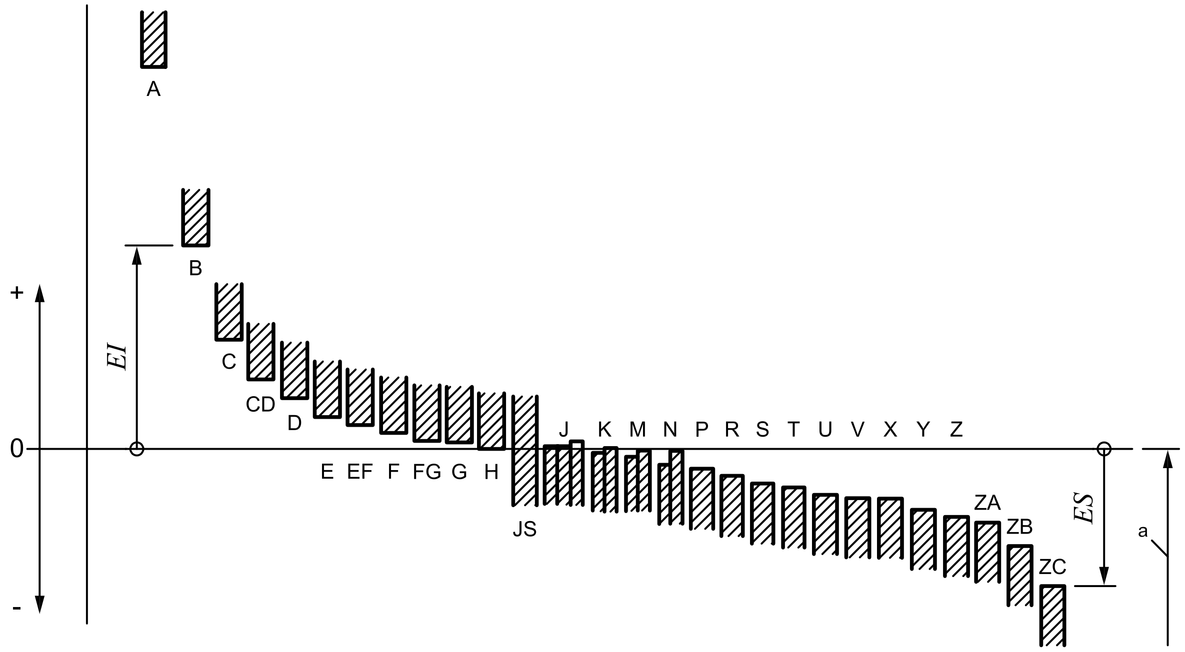
In Table 9 of ISO 286-2:—, the limit deviations have to be taken in the line of the nominal size range above 50 mm up to and including 80 mm and in the column of the standard tolerance grade number 6.

Consequently, the limit deviations are:

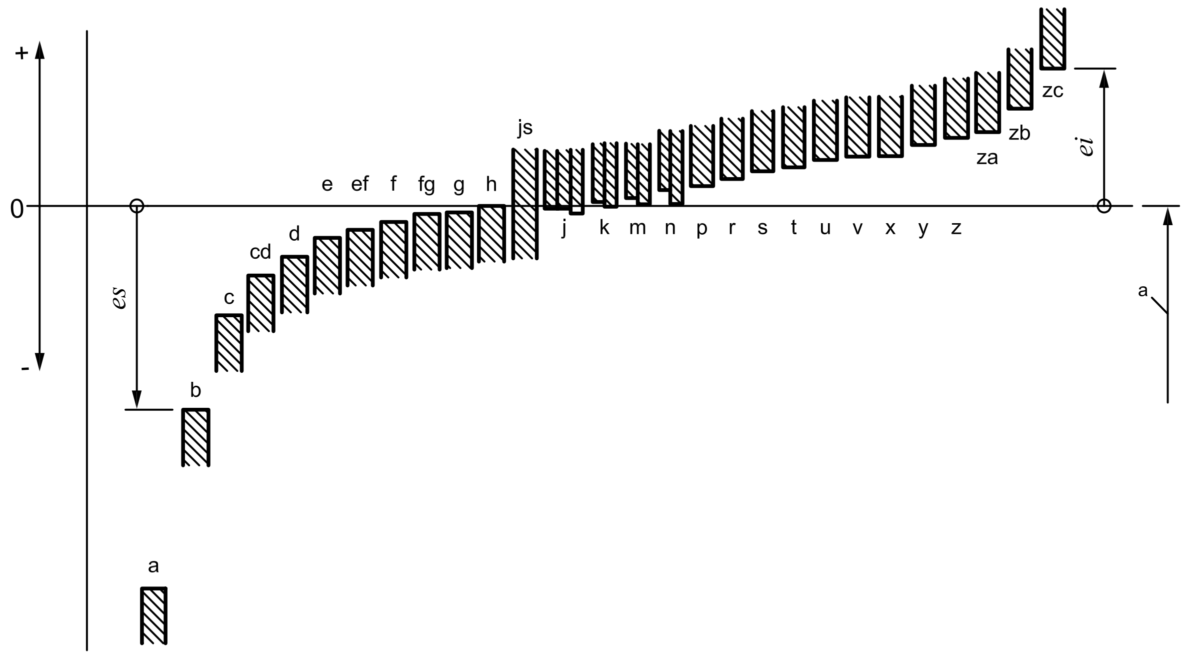
Upper limit deviation $ES$ = –5 µm

Lower limit deviation $EI$ = –24 µm

From that follows: 60 M6 Ⓔ ≡ $60^{-0,005}_{-0,024}$ Ⓔ




a) **Holes** (internal features of size)




b) **Shafts** (external features of size)

**Key**

*EI*, *ES* fundamental deviations of holes (examples)

*ei*, *es* fundamental deviations of shafts (examples)

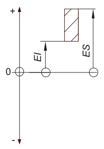
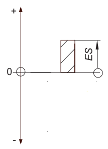
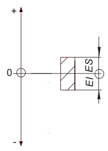
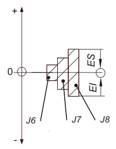
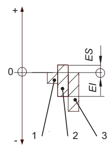
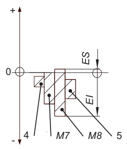
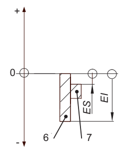
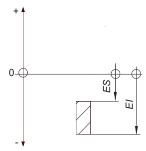
[a] Nominal size.

NOTE 1 According to convention, the fundamental deviation is the one defining the nearest limit to the nominal size.

NOTE 2 For details concerning fundamental deviations for J/j, K/k, M/m and N/n, see Figures 8 and 9.

**Figure 7 — Schematic representation of the placement of the tolerance interval (fundamental deviation) relative to the nominal size**

AC1

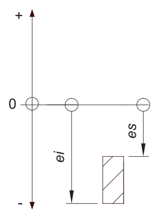
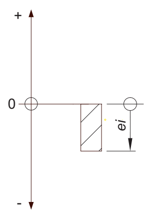
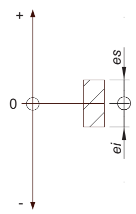
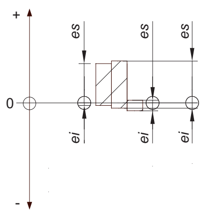
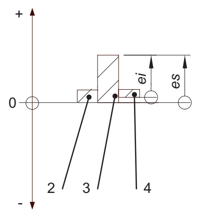
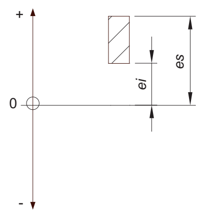
<table>
<tr><th colspan="8">Limit deviation</th></tr>
<tr><th>A to G</th><th>H</th><th>JS</th><th>J</th><th>K</th><th>M</th><th>N</th><th>P to ZC</th></tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr><td>ES = EI + IT</td><td>ES = 0 + IT</td><td>ES =+IT/2</td><td>ES > 0<br>(see<br>Table 2)</td><td colspan="3">ES<br>(see Table 2 and 3)</td><td>ES < 0<br>(see Table 3)</td></tr>
<tr><td>EI > 0<br><br>(see Table 2)</td><td>EI = 0</td><td>EI = - IT/2</td><td colspan="5">EI = ES - IT</td></tr>
<tr><td colspan="8">NOTE 1 IT, see Table 1.<br><br>NOTE 2 The represented tolerance intervals correspond approximately to a nominal size range of above 10 mm up to and including 18 mm.</td></tr>
</table>

**Key**

1 K1 to K3, and also K4 to K8, for nominal size ≤ 3 mm
2 K4 to K8, for sizes for which 3 mm < nominal size ≤ 500 mm
3 K9 to K18, and also K4 to K8 for nominal size > 500 mm
4 M1 to M6
5 M9 to M18, and also M7 to M8 for nominal size > 500 mm
6 N1 to N8 and also N9 to N18 for sizes for which 1 mm < nominal size ≤ 3 mm, as well as nominal size > 500 mm
7 N9 to N18 for sizes for which 3 mm < nominal size ≤ 500 mm AC1

**Figure 8 — Limit deviations for holes**

AC1

| Limit deviation | | | | | |
|---|---|---|---|---|---|
| a to g | h | js | j | k | m to z |
|  |  |  |  |  |  |
| *es* < 0 (see Table 4) | *es* = 0 | *es* = + IT/2 | *es* = *ei* + IT | *es* = *ei* + IT | *es* = *ei* + IT |
| *ei* = *es* - IT | *ei* = 0 – IT | *ei* = - IT/2 | *ei* < 0 (see Table 4) | *ei* = 0 or > 0 (see Table 5) | *ei* > 0 (see Table 5) |

NOTE 1 IT, see Table 1.

NOTE 2 The represented tolerance intervals correspond approximately to a nominal size range of above 10 mm up to and including 18 mm.

**Key**

1 j5, j6

2 k1 to k3, and also k4 to k7 for nominal size ≤ 3 mm

3 k4 to k7 for sizes where 3 mm < nominal size ≤ 500 mm

4 k8 to k18, and also k4 to k7 for sizes > 500 mm AC1

**Figure 9 — Limit deviations for shafts**

**Table 1 — Values of standard tolerance grades for nominal sizes up to 3 150 mm**

| Nominal size mm | | Standard tolerance grades | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IT01 | IT0 | IT1 | IT2 | IT3 | IT4 | IT5 | IT6 | IT7 | IT8 | IT9 | IT10 | IT11 | IT12 | IT13 | IT14 | IT15 | IT16 | IT17 | IT18 |
| | | Standard tolerance values | | | | | | | | | | | | | | | | | | | |
| Above | Up to and inclu-ding | µm | | | | | | | | | | | | | mm | | | | | | |
| — | 3 | 0,3 | 0,5 | 0,8 | 1,2 | 2 | 3 | 4 | 6 | 10 | 14 | 25 | 40 | 60 | 0,1 | 0,14 | 0,25 | 0,4 | 0,6 | 1 | 1,4 |
| 3 | 6 | 0,4 | 0,6 | 1 | 1,5 | 2,5 | 4 | 5 | 8 | 12 | 18 | 30 | 48 | 75 | 0,12 | 0,18 | 0,3 | 0,48 | 0,75 | 1,2 | 1,8 |
| 6 | 10 | 0,4 | 0,6 | 1 | 1,5 | 2,5 | 4 | 6 | 9 | 15 | 22 | 36 | 58 | 90 | 0,15 | 0,22 | 0,36 | 0,58 | 0,9 | 1,5 | 2,2 |
| 10 | 18 | 0,5 | 0,8 | 1,2 | 2 | 3 | 5 | 8 | 11 | 18 | 27 | 43 | 70 | 110 | 0,18 | 0,27 | 0,43 | 0,7 | 1,1 | 1,8 | 2,7 |
| 18 | 30 | 0,6 | 1 | 1,5 | 2,5 | 4 | 6 | 9 | 13 | 21 | 33 | 52 | 84 | 130 | 0,21 | 0,33 | 0,52 | 0,84 | 1,3 | 2,1 | 3,3 |
| 30 | 50 | 0,6 | 1 | 1,5 | 2,5 | 4 | 7 | 11 | 16 | 25 | 39 | 62 | 100 | 160 | 0,25 | 0,39 | 0,62 | 1 | 1,6 | 2,5 | 3,9 |
| 50 | 80 | 0,8 | 1,2 | 2 | 3 | 5 | 8 | 13 | 19 | 30 | 46 | 74 | 120 | 190 | 0,3 | 0,46 | 0,74 | 1,2 | 1,9 | 3 | 4,6 |
| 80 | 120 | 1 | 1,5 | 2,5 | 4 | 6 | 10 | 15 | 22 | 35 | 54 | 87 | 140 | 220 | 0,35 | 0,54 | 0,87 | 1,4 | 2,2 | 3,5 | 5,4 |
| 120 | 180 | 1,2 | 2 | 3,5 | 5 | 8 | 12 | 18 | 25 | 40 | 63 | 100 | 160 | 250 | 0,4 | 0,63 | 1 | 1,6 | 2,5 | 4 | 6,3 |
| 180 | 250 | 2 | 3 | 4,5 | 7 | 10 | 14 | 20 | 29 | 46 | 72 | 115 | 185 | 290 | 0,46 | 0,72 | 1,15 | 1,85 | 2,9 | 4,6 | 7,2 |
| 250 | 315 | 2,5 | 4 | 6 | 8 | 12 | 16 | 23 | 32 | 52 | 81 | 130 | 210 | 320 | 0,52 | 0,81 | 1,3 | 2,1 | 3,2 | 5,2 | 8,1 |
| 315 | 400 | 3 | 5 | 7 | 9 | 13 | 18 | 25 | 36 | 57 | 89 | 140 | 230 | 360 | 0,57 | 0,89 | 1,4 | 2,3 | 3,6 | 5,7 | 8,9 |
| 400 | 500 | 4 | 6 | 8 | 10 | 15 | 20 | 27 | 40 | 63 | 97 | 155 | 250 | 400 | 0,63 | 0,97 | 1,55 | 2,5 | 4 | 6,3 | 9,7 |
| 500 | 630 | | | 9 | 11 | 16 | 22 | 32 | 44 | 70 | 110 | 175 | 280 | 440 | 0,7 | 1,1 | 1,75 | 2,8 | 4,4 | 7 | 11 |
| 630 | 800 | | | 10 | 13 | 18 | 25 | 36 | 50 | 80 | 125 | 200 | 320 | 500 | 0,8 | 1,25 | 2 | 3,2 | 5 | 8 | 12,5 |
| 800 | 1 000 | | | 11 | 15 | 21 | 28 | 40 | 56 | 90 | 140 | 230 | 360 | 560 | 0,9 | 1,4 | 2,3 | 3,6 | 5,6 | 9 | 14 |
| 1 000 | 1 250 | | | 13 | 18 | 24 | 33 | 47 | 66 | 105 | 165 | 260 | 420 | 660 | 1,05 | 1,65 | 2,6 | 4,2 | 6,6 | 10,5 | 16,5 |
| 1 250 | 1 600 | | | 15 | 21 | 29 | 39 | 55 | 78 | 125 | 195 | 310 | 500 | 780 | 1,25 | 1,95 | 3,1 | 5 | 7,8 | 12,5 | 19,5 |
| 1 600 | 2 000 | | | 18 | 25 | 35 | 46 | 65 | 92 | 150 | 230 | 370 | 600 | 920 | 1,5 | 2,3 | 3,7 | 6 | 9,2 | 15 | 23 |
| 2 000 | 2 500 | | | 22 | 30 | 41 | 55 | 78 | 110 | 175 | 280 | 440 | 700 | 1 100 | 1,75 | 2,8 | 4,4 | 7 | 11 | 17,5 | 28 |
| 2 500 | 3 150 | | | 26 | 36 | 50 | 68 | 96 | 135 | 210 | 330 | 540 | 860 | 1 350 | 2,1 | 3,3 | 5,4 | 8,6 | 13,5 | 21 | 33 |

## Table 2 — Values of the fundamental deviations for holes A to M

Fundamental deviation values in micrometres

| Nominal size mm | | Fundamental deviation values | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lower limit deviation, *EI* | | | | | | | | | | | | Upper limit deviation, *ES* | | | | | | |
| Above | Up to and includ-ing | All standard tolerance grades | | | | | | | | | | | | IT6 | IT7 | IT8 | Up to and includ-ing IT8 | Above IT8 | Up to and includ-ing IT8 | Above IT8 |
| | | A[a] | B[a] | C | CD | D | E | EF | F | FG | G | H | JS | J | | | K[c,d] | | M[b,c,d] | |
| — | 3 | +270 | +140 | +60 | +34 | +20 | +14 | +10 | +6 | +4 | +2 | 0 | Deviations = ± IT*n*/2, where *n* is the standard tolerance grade number | +2 | +4 | +6 | 0 | 0 | –2 | –2 |
| 3 | 6 | +270 | +140 | +70 | +46 | +30 | +20 | +14 | +10 | +6 | +4 | 0 | | +5 | +6 | +10 | –1 + *Δ* | | –4 + *Δ* | –4 |
| 6 | 10 | +280 | +150 | +80 | +56 | +40 | +25 | +18 | +13 | +8 | +5 | 0 | | +5 | +8 | +12 | –1 + *Δ* | | –6 + *Δ* | –6 |
| 10 | 14 | +290 | +150 | +95 | +70 | +50 | +32 | +23 | +16 | +10 | +6 | 0 | | +6 | +10 | +15 | –1 + *Δ* | | –7 + *Δ* | –7 |
| 14 | 18 | | | | | | | | | | | | | | | | | | | |
| 18 | 24 | +300 | +160 | +110 | +85 | +65 | +40 | +28 | +20 | +12 | +7 | 0 | | +8 | +12 | +20 | –2 + *Δ* | | –8 + *Δ* | –8 |
| 24 | 30 | | | | | | | | | | | | | | | | | | | |
| 30 | 40 | +310 | +170 | +120 | +100 | +80 | +50 | +35 | +25 | +15 | +9 | 0 | | +10 | +14 | +24 | –2 + *Δ* | | –9 + *Δ* | –9 |
| 40 | 50 | +320 | +180 | +130 | | | | | | | | | | | | | | | | |
| 50 | 65 | +340 | +190 | +140 | | +100 | +60 | | +30 | | +10 | 0 | | +13 | +18 | +28 | –2 + *Δ* | | –11 + *Δ* | –11 |
| 65 | 80 | +360 | +200 | +150 | | | | | | | | | | | | | | | | |
| 80 | 100 | +380 | +220 | +170 | | +120 | +72 | | +36 | | +12 | 0 | | +16 | +22 | +34 | –3 + *Δ* | | –13 + *Δ* | –13 |
| 100 | 120 | +410 | +240 | +180 | | | | | | | | | | | | | | | | |
| 120 | 140 | +460 | +260 | +200 | | +145 | +85 | | +43 | | +14 | 0 | | +18 | +26 | +41 | –3 + *Δ* | | –15 + *Δ* | –15 |
| 140 | 160 | +520 | +280 | +210 | | | | | | | | | | | | | | | | |
| 160 | 180 | +580 | +310 | +230 | | | | | | | | | | | | | | | | |
| 180 | 200 | +660 | +340 | +240 | | +170 | +100 | | +50 | | +15 | 0 | | +22 | +30 | +47 | –4 + *Δ* | | –17 + *Δ* | –17 |
| 200 | 225 | +740 | +380 | +260 | | | | | | | | | | | | | | | | |
| 225 | 250 | +820 | +420 | +280 | | | | | | | | | | | | | | | | |
| 250 | 280 | +920 | +480 | +300 | | +190 | +110 | | +56 | | +17 | 0 | | +25 | +36 | +55 | –4 + *Δ* | | –20 + *Δ* | –20 |
| 280 | 315 | +1 050 | +540 | +330 | | | | | | | | | | | | | | | | |
| 315 | 355 | +1 200 | +600 | +360 | | +210 | +125 | | +62 | | +18 | 0 | | +29 | +39 | +60 | –4 + *Δ* | | –21 + *Δ* | –21 |
| 355 | 400 | +1 350 | +680 | +400 | | | | | | | | | | | | | | | | |
| 400 | 450 | +1 500 | +760 | +440 | | +230 | +135 | | +68 | | +20 | 0 | | +33 | +43 | +66 | –5 + *Δ* | | –23 + *Δ* | –23 |
| 450 | 500 | +1 650 | +840 | +480 | | | | | | | | | | | | | | | | |
| 500 | 560 | | | | | +260 | +145 | | +76 | | +22 | 0 | | | | | 0 | | –26 | |
| 560 | 630 | | | | | | | | | | | | | | | | | | | |
| 630 | 710 | | | | | +290 | +160 | | +80 | | +24 | 0 | | | | | 0 | | –30 | |
| 710 | 800 | | | | | | | | | | | | | | | | | | | |
| 800 | 900 | | | | | +320 | +170 | | +86 | | +26 | 0 | | | | | 0 | | –34 | |
| 900 | 1 000 | | | | | | | | | | | | | | | | | | | |
| 1 000 | 1 120 | | | | | +350 | +195 | | +98 | | +28 | 0 | | | | | 0 | | –40 | |
| 1 120 | 1 250 | | | | | | | | | | | | | | | | | | | |
| 1 250 | 1 400 | | | | | +390 | +220 | | +110 | | +30 | 0 | | | | | 0 | | –48 | |
| 1 400 | 1 600 | | | | | | | | | | | | | | | | | | | |
| 1 600 | 1 800 | | | | | +430 | +240 | | +120 | | +32 | 0 | | | | | 0 | | –58 | |
| 1 800 | 2 000 | | | | | | | | | | | | | | | | | | | |
| 2 000 | 2 240 | | | | | +480 | +260 | | +130 | | +34 | 0 | | | | | 0 | | –68 | |
| 2 240 | 2 500 | | | | | | | | | | | | | | | | | | | |
| 2 500 | 2 800 | | | | | +520 | +290 | | +145 | | +38 | 0 | | | | | 0 | | –76 | |
| 2 800 | 3 150 | | | | | | | | | | | | | | | | | | | |

[a] Fundamental deviations A and B shall not be used for nominal sizes ⩽ 1 mm.

[b] Special case: for tolerance class M6 in the range above 250 mm up to and including 315 mm, $ES = -9$ µm (instead of –11 µm according to the calculation).

[c] For determining the values K and M, see 4.3.2.5.

[d] For $\Delta$ values, see Table 3.

## Table 3 — Values of the fundamental deviations for holes N to ZC

Fundamental deviation values and Δ values in micrometres

| Nominal size mm | | Fundamental deviation values<br>Upper limit deviation, *ES* | | | | | | | | | | | | | | | | Values for Δ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Above | Up to and including | Up to and including IT8 | Above IT8 | Up to and including IT7 | Standard tolerance grades above IT7 | | | | | | | | | | | | | Standard tolerance grades | | | | | |
| | | N[a,b] | | P to ZC[a] | P | R | S | T | U | V | X | Y | Z | ZA | ZB | ZC | IT3 | IT4 | IT5 | IT6 | IT7 | IT8 |
| — | 3 | −4 | −4 | Values as for standard tolerance grades above IT7 increased by Δ | −6 | −10 | −14 | | −18 | | −20 | | −26 | −32 | −40 | −60 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 6 | −8 + Δ | 0 | | −12 | −15 | −19 | | −23 | | −28 | | −35 | −42 | −50 | −80 | 1 | 1,5 | 1 | 3 | 4 | 6 |
| 6 | 10 | −10 + Δ | 0 | | −15 | −19 | −23 | | −28 | | −34 | | −42 | −52 | −67 | −97 | 1 | 1,5 | 2 | 3 | 6 | 7 |
| 10 | 14 | −12 + Δ | 0 | | −18 | −23 | −28 | | −33 | | −40 | | −50 | −64 | −90 | −130 | 1 | 2 | 3 | 3 | 7 | 9 |
| 14 | 18 | | | | | | | | | −39 | −45 | | −60 | −77 | −108 | −150 | | | | | | |
| 18 | 24 | −15 + Δ | 0 | | −22 | −28 | −35 | | −41 | −47 | −54 | −63 | −73 | −98 | −136 | −188 | 1,5 | 2 | 3 | 4 | 8 | 12 |
| 24 | 30 | | | | | | | −41 | −48 | −55 | −64 | −75 | −88 | −118 | −160 | −218 | | | | | | |
| 30 | 40 | −17 + Δ | 0 | | −26 | −34 | −43 | −48 | −60 | −68 | −80 | −94 | −112 | −148 | −200 | −274 | 1,5 | 3 | 4 | 5 | 9 | 14 |
| 40 | 50 | | | | | | | −54 | −70 | −81 | −97 | −114 | −136 | −180 | −242 | −325 | | | | | | |
| 50 | 65 | −20 + Δ | 0 | | −32 | −41 | −53 | −66 | −87 | −102 | −122 | −144 | −172 | −226 | −300 | −405 | 2 | 3 | 5 | 6 | 11 | 16 |
| 65 | 80 | | | | | −43 | −59 | −75 | −102 | −120 | −146 | −174 | −210 | −274 | −360 | −480 | | | | | | |
| 80 | 100 | −23 + Δ | 0 | | −37 | −51 | −71 | −91 | −124 | −146 | −178 | −214 | −258 | −335 | −445 | −585 | 2 | 4 | 5 | 7 | 13 | 19 |
| 100 | 120 | | | | | −54 | −79 | −104 | −144 | −172 | −210 | −254 | −310 | −400 | −525 | −690 | | | | | | |
| 120 | 140 | −27 + Δ | 0 | | −43 | −63 | −92 | −122 | −170 | −202 | −248 | −300 | −365 | −470 | −620 | −800 | 3 | 4 | 6 | 7 | 15 | 23 |
| 140 | 160 | | | | | −65 | −100 | −134 | −190 | −228 | −280 | −340 | −415 | −535 | −700 | −900 | | | | | | |
| 160 | 180 | | | | | −68 | −108 | −146 | −210 | −252 | −310 | −380 | −465 | −600 | −780 | −1 000 | | | | | | |
| 180 | 200 | −31 + Δ | 0 | | −50 | −77 | −122 | −166 | −236 | −284 | −350 | −425 | −520 | −670 | −880 | −1 150 | 3 | 4 | 6 | 9 | 17 | 26 |
| 200 | 225 | | | | | −80 | −130 | −180 | −258 | −310 | −385 | −470 | −575 | −740 | −960 | −1 250 | | | | | | |
| 225 | 250 | | | | | −84 | −140 | −196 | −284 | −340 | −425 | −520 | −640 | −820 | −1 050 | −1 350 | | | | | | |
| 250 | 280 | −34 + Δ | 0 | | −56 | −94 | −158 | −218 | −315 | −385 | −475 | −580 | −710 | −920 | −1 200 | −1 550 | 4 | 4 | 7 | 9 | 20 | 29 |
| 280 | 315 | | | | | −98 | −170 | −240 | −350 | −425 | −525 | −650 | −790 | −1 000 | −1 300 | −1 700 | | | | | | |
| 315 | 355 | −37 + Δ | 0 | | −62 | −108 | −190 | −268 | −390 | −475 | −590 | −730 | −900 | −1 150 | −1 500 | −1 900 | 4 | 5 | 7 | 11 | 21 | 32 |
| 355 | 400 | | | | | −114 | −208 | −294 | −435 | −530 | −660 | −820 | −1 000 | −1 300 | −1 650 | −2 100 | | | | | | |
| 400 | 450 | −40 + Δ | 0 | | −68 | −126 | −232 | −330 | −490 | −595 | −740 | −920 | −1 100 | −1 450 | −1 850 | −2 400 | 5 | 5 | 7 | 13 | 23 | 34 |
| 450 | 500 | | | | | −132 | −252 | −360 | −540 | −660 | −820 | −1 000 | −1 250 | −1 600 | −2 100 | −2 600 | | | | | | |

**Table 3** (*continued*)

AC1

| Nominal size mm | | Fundamental deviation values Upper limit deviation, *ES* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Above | Up to and including | Up to and including IT8 | Above IT8 | Up to and including IT7 | Standard tolerance grades above IT7 | | | | |
| | | N[a,b] | | P to ZC[a] | P | R | S | T | U |
| 500 | 560 | −44 | | Values as for standard tolerance grades above IT7 increased by $\Delta$ | −78 | −150 | −280 | −400 | −600 |
| 560 | 630 | | | | | −155 | −310 | −450 | −660 |
| 630 | 710 | −50 | | | −88 | −175 | −340 | −500 | −740 |
| 710 | 800 | | | | | −185 | −380 | −560 | −840 |
| 800 | 900 | −56 | | | −100 | −210 | −430 | −620 | −940 |
| 900 | 1 000 | | | | | −220 | −470 | −680 | −1 050 |
| 1 000 | 1 120 | −66 | | | −120 | −250 | −520 | −780 | −1 150 |
| 1 120 | 1 250 | | | | | −260 | −580 | −840 | −1 300 |
| 1 250 | 1 400 | −78 | | | −140 | −300 | −640 | −960 | −1 450 |
| 1 400 | 1 600 | | | | | −330 | −720 | −1 050 | −1 600 |
| 1 600 | 1 800 | −92 | | | −170 | −370 | −820 | −1 200 | −1 850 |
| 1 800 | 2 000 | | | | | −400 | −920 | −1 350 | −2 000 |
| 2 000 | 2 240 | −110 | | | −195 | −440 | −1 000 | −1 500 | −2 300 |
| 2 240 | 2 500 | | | | | −460 | −1 100 | −1 650 | −2 500 |
| 2 500 | 2 800 | −135 | | | −240 | −550 | −1 250 | −1 900 | −2 900 |
| 2 800 | 3 150 | | | | | −580 | −1 400 | −2 100 | −3 200 |

a For determining the values N and P to ZC, see 4.3.2.5

b Fundamental deviations N for standard tolerance grades above IT8 shall not be used for nominal sizes ≤ 1 mm.

AC1

## Table 4 — Values of the fundamental deviations for shafts a to j

Fundamental deviation values in micrometres

AC1

| Nominal size mm | | Fundamental deviation values | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper limit deviation, *es* | | | | | | | | | | | | Lower deviation, *ei* | | |
| Above | Up to and includ-ing | All standard tolerance grades | | | | | | | | | | | | IT5 and IT6 | IT7 | IT8 |
| | | a[a] | b[a] | c | cd | d | e | ef | f | fg | g | h | js | j | | |
| — | 3 | –270 | –140 | –60 | –34 | –20 | –14 | –10 | –6 | –4 | –2 | 0 | | –2 | –4 | –6 |
| 3 | 6 | –270 | –140 | –70 | –46 | –30 | –20 | –14 | –10 | –6 | –4 | 0 | Deviations = ± IT*n*/2, where *n* is the standard tolerance grade number | –2 | –4 | |
| 6 | 10 | –280 | –150 | –80 | –56 | –40 | –25 | –18 | –13 | –8 | –5 | 0 | | –2 | –5 | |
| 10 | 14 | –290 | –150 | –95 | –70 | –50 | –32 | –23 | –16 | –10 | –6 | 0 | | –3 | –6 | |
| 14 | 18 | | | | | | | | | | | | | | | |
| 18 | 24 | –300 | –160 | –110 | –85 | –65 | –40 | –28 | –20 | –12 | –7 | 0 | | –4 | –8 | |
| 24 | 30 | | | | | | | | | | | | | | | |
| 30 | 40 | –310 | –170 | –120 | –100 | –80 | –50 | –35 | –25 | –15 | –9 | 0 | | –5 | –10 | |
| 40 | 50 | –320 | –180 | –130 | | | | | | | | | | | | |
| 50 | 65 | –340 | –190 | –140 | | –100 | –60 | | –30 | | –10 | 0 | | –7 | –12 | |
| 65 | 80 | –360 | –200 | –150 | | | | | | | | | | | | |
| 80 | 100 | –380 | –220 | –170 | | –120 | –72 | | –36 | | –12 | 0 | | –9 | –15 | |
| 100 | 120 | –410 | –240 | –180 | | | | | | | | | | | | |
| 120 | 140 | –460 | –260 | –200 | | | | | | | | | | | | |
| 140 | 160 | –520 | –280 | –210 | | –145 | –85 | | –43 | | –14 | 0 | | –11 | –18 | |
| 160 | 180 | –580 | –310 | –230 | | | | | | | | | | | | |
| 180 | 200 | –660 | –340 | –240 | | | | | | | | | | | | |
| 200 | 225 | –740 | –380 | –260 | | –170 | –100 | | –50 | | –15 | 0 | | –13 | –21 | |
| 225 | 250 | –820 | –420 | –280 | | | | | | | | | | | | |
| 250 | 280 | –920 | –480 | –300 | | –190 | –110 | | –56 | | –17 | 0 | | –16 | –26 | |
| 280 | 315 | –1 050 | –540 | –330 | | | | | | | | | | | | |
| 315 | 355 | –1 200 | –600 | –360 | | –210 | –125 | | –62 | | –18 | 0 | | –18 | –28 | |
| 355 | 400 | –1 350 | –680 | –400 | | | | | | | | | | | | |
| 400 | 450 | –1 500 | –760 | –440 | | –230 | –135 | | –68 | | –20 | 0 | | –20 | –32 | |
| 450 | 500 | –1 650 | –840 | –480 | | | | | | | | | | | | |
| 500 | 560 | | | | | –260 | –145 | | –76 | | –22 | 0 | | | | |
| 560 | 630 | | | | | | | | | | | | | | | |
| 630 | 710 | | | | | –290 | –160 | | –80 | | –24 | 0 | | | | |
| 710 | 800 | | | | | | | | | | | | | | | |
| 800 | 900 | | | | | –320 | –170 | | –86 | | –26 | 0 | | | | |
| 900 | 1 000 | | | | | | | | | | | | | | | |
| 1 000 | 1 120 | | | | | –350 | –195 | | –98 | | –28 | 0 | | | | |
| 1 120 | 1 250 | | | | | | | | | | | | | | | |
| 1 250 | 1 400 | | | | | –390 | –220 | | –110 | | –30 | 0 | | | | |
| 1 400 | 1 600 | | | | | | | | | | | | | | | |
| 1 600 | 1 800 | | | | | –430 | –240 | | –120 | | –32 | 0 | | | | |
| 1 800 | 2 000 | | | | | | | | | | | | | | | |
| 2 000 | 2 240 | | | | | –480 | –260 | | –130 | | –34 | 0 | | | | |
| 2 240 | 2 500 | | | | | | | | | | | | | | | |
| 2 500 | 2 800 | | | | | –520 | –290 | | –145 | | –38 | 0 | | | | |
| 2 800 | 3 150 | | | | | | | | | | | | | | | |

[a] Fundamental deviations a and b shall not be used for nominal sizes ⩽ 1 mm.

AC1

## Table 5 — Values of the fundamental deviations for shafts k to zc

Fundamental deviation values in micrometres

| Nominal size mm | | Fundamental deviation values<br>Lower limit deviation, *ei* | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Above | Up to and inclu-ding | IT4 to IT7 | Up to and includ-ing IT3 and above IT7 | All standard tolerance grades | | | | | | | | | | | | | |
| | | k | | m | n | p | r | s | t | u | v | x | y | z | za | zb | zc |
| — | 3 | 0 | 0 | +2 | +4 | +6 | +10 | +14 | | +18 | | +20 | | +26 | +32 | +40 | +60 |
| 3 | 6 | +1 | 0 | +4 | +8 | +12 | +15 | +19 | | +23 | | +28 | | +35 | +42 | +50 | +80 |
| 6 | 10 | +1 | 0 | +6 | +10 | +15 | +19 | +23 | | +28 | | +34 | | +42 | +52 | +67 | +97 |
| 10 | 14 | +1 | 0 | +7 | +12 | +18 | +23 | +28 | | +33 | | +40 | | +50 | +64 | +90 | +130 |
| 14 | 18 | | | | | | | | | | +39 | +45 | | +60 | +77 | +108 | +150 |
| 18 | 24 | +2 | 0 | +8 | +15 | +22 | +28 | +35 | | +41 | +47 | +54 | +63 | +73 | +98 | +136 | +188 |
| 24 | 30 | | | | | | | | +41 | +48 | +55 | +64 | +75 | +88 | +118 | +160 | +218 |
| 30 | 40 | +2 | 0 | +9 | +17 | +26 | +34 | +43 | +48 | +60 | +68 | +80 | +94 | +112 | +148 | +200 | +274 |
| 40 | 50 | | | | | | | | +54 | +70 | +81 | +97 | +114 | +136 | +180 | +242 | +325 |
| 50 | 65 | +2 | 0 | +11 | +20 | +32 | +41 | +53 | +66 | +87 | +102 | +122 | +144 | +172 | +226 | +300 | +405 |
| 65 | 80 | | | | | | +43 | +59 | +75 | +102 | +120 | +146 | +174 | +210 | +274 | +360 | +480 |
| 80 | 100 | +3 | 0 | +13 | +23 | +37 | +51 | +71 | +91 | +124 | +146 | +178 | +214 | +258 | +335 | +445 | +585 |
| 100 | 120 | | | | | | +54 | +79 | +104 | +144 | +172 | +210 | +254 | +310 | +400 | +525 | +690 |
| 120 | 140 | +3 | 0 | +15 | +27 | +43 | +63 | +92 | +122 | +170 | +202 | +248 | +300 | +365 | +470 | +620 | +800 |
| 140 | 160 | | | | | | +65 | +100 | +134 | +190 | +228 | +280 | +340 | +415 | +535 | +700 | +900 |
| 160 | 180 | | | | | | +68 | +108 | +146 | +210 | +252 | +310 | +380 | +465 | +600 | +780 | +1 000 |
| 180 | 200 | +4 | 0 | +17 | +31 | +50 | +77 | +122 | +166 | +236 | +284 | +350 | +425 | +520 | +670 | +880 | +1 150 |
| 200 | 225 | | | | | | +80 | +130 | +180 | +258 | +310 | +385 | +470 | +575 | +740 | +960 | +1 250 |
| 225 | 250 | | | | | | +84 | +140 | +196 | +284 | +340 | +425 | +520 | +640 | +820 | +1 050 | +1 350 |
| 250 | 280 | +4 | 0 | +20 | +34 | +56 | +94 | +158 | +218 | +315 | +385 | +475 | +580 | +710 | +920 | +1 200 | +1 550 |
| 280 | 315 | | | | | | +98 | +170 | +240 | +350 | +425 | +525 | +650 | +790 | +1 000 | +1 300 | +1 700 |
| 315 | 355 | +4 | 0 | +21 | +37 | +62 | +108 | +190 | +268 | +390 | +475 | +590 | +730 | +900 | +1 150 | +1 500 | +1 900 |
| 355 | 400 | | | | | | +114 | +208 | +294 | +435 | +530 | +660 | +820 | +1 000 | +1 300 | +1 650 | +2 100 |
| 400 | 450 | +5 | 0 | +23 | +40 | +68 | +126 | +232 | +330 | +490 | +595 | +740 | +920 | +1 100 | +1 450 | +1 850 | +2 400 |
| 450 | 500 | | | | | | +132 | +252 | +360 | +540 | +660 | +820 | +1 000 | +1 250 | +1 600 | +2 100 | +2 600 |
| 500 | 560 | 0 | 0 | +26 | +44 | +78 | +150 | +280 | +400 | +600 | | | | | | | |
| 560 | 630 | | | | | | +155 | +310 | +450 | +660 | | | | | | | |
| 630 | 710 | 0 | 0 | +30 | +50 | +88 | +175 | +340 | +500 | +740 | | | | | | | |
| 710 | 800 | | | | | | +185 | +380 | +560 | +840 | | | | | | | |
| 800 | 900 | 0 | 0 | +34 | +56 | +100 | +210 | +430 | +620 | +940 | | | | | | | |
| 900 | 1 000 | | | | | | +220 | +470 | +680 | +1 050 | | | | | | | |
| 1 000 | 1 120 | 0 | 0 | +40 | +66 | +120 | +250 | +520 | +780 | +1 150 | | | | | | | |
| 1 120 | 1 250 | | | | | | +260 | +580 | +840 | +1 300 | | | | | | | |
| 1 250 | 1 400 | 0 | 0 | +48 | +78 | +140 | +300 | +640 | +960 | +1 450 | | | | | | | |
| 1 400 | 1 600 | | | | | | +330 | +720 | +1 050 | +1 600 | | | | | | | |
| 1 600 | 1 800 | 0 | 0 | +58 | +92 | +170 | +370 | +820 | +1 200 | +1 850 | | | | | | | |
| 1 800 | 2 000 | | | | | | +400 | +920 | +1 350 | +2 000 | | | | | | | |
| 2 000 | 2 240 | 0 | 0 | +68 | +110 | +195 | +440 | +1 000 | +1 500 | +2 300 | | | | | | | |
| 2 240 | 2 500 | | | | | | +460 | +1 100 | +1 650 | +2 500 | | | | | | | |
| 2 500 | 2 800 | 0 | 0 | +76 | +135 | +240 | +550 | +1 250 | +1 900 | +2 900 | | | | | | | |
| 2 800 | 3 150 | | | | | | +580 | +1 400 | +2 100 | +3 200 | | | | | | | |

### 4.4 Selection of tolerance classes

Whenever possible, the tolerance classes should be chosen from those corresponding to the classes for holes and shafts given in Figures 10 and 11, respectively. The first choice should preferably be made from the tolerance classes, shown in the frames.

NOTE 1 The tolerance system of limits and fits gives the possibility of a very wide choice among the various tolerance classes (see Tables 2 to 5), even if this choice is limited only to those shown in ISO 286-2. By restricting the selection of tolerance classes, an unnecessary multiplicity of tools and gauges can be avoided.

NOTE 2 The tolerance classes of Figures 10 and 11 apply only to general purposes which do not require a more specific selection of tolerance classes. Keyways, for example, require a more specific selection.

NOTE 3 Deviations js and JS may be replaced by the corresponding deviations j and J if necessary in a specific application.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | G6 | H6 | JS6 | K6 | M6 | N6 | P6 | R6 | S6 | T6 | | |
| | | | | | F7 | G7 | H7 | JS7 | K7 | M7 | N7 | P7 | R7 | S7 | T7 | U7 | X7 |
| | | | | E8 | F8 | | H8 | JS8 | K8 | M8 | N8 | P8 | R8 | | | | |
| | | | D9 | E9 | F9 | | H9 | | | | | | | | | | |
| | | C10 | D10 | E10 | | | H10 | | | | | | | | | | |
| A11 | B11 | C11 | D11 | | | | H11 | | | | | | | | | | |

**Figure 10 — Holes**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | g5 | h5 | js5 | k5 | m5 | n5 | p5 | r5 | s5 | t5 | | |
| | | | | | f6 | g6 | h6 | js6 | k6 | m6 | n6 | p6 | r6 | s6 | t6 | u6 | x6 |
| | | | | e7 | f7 | | h7 | js7 | k7 | m7 | n7 | p7 | r7 | s7 | t7 | u7 | |
| | | | d8 | e8 | f8 | | h8 | | | | | | | | | | |
| | b9 | c9 | d9 | e9 | | | h9 | | | | | | | | | | |
| | | | d10 | | | | h10 | | | | | | | | | | |
| a11 | b11 | c11 | | | | | h11 | | | | | | | | | | |

**Figure 11 — Shafts**

## 5 ISO fit system

### 5.1 General

The ISO fit system is based on the “ISO code system for tolerances on linear sizes” for the size of a feature of size. The tolerance classes for the two mating parts in the fit should preferably be chosen in accordance with the advice given in 4.4 and 5.2.

## 5.2 Generics of fits

### 5.2.1 Designation of fits (writing rules)

A fit between mating features shall be designated by

— the common nominal size;

— the tolerance class for the hole;

— the tolerance class for the shaft.

EXAMPLE 52 H7/g6 Ⓔ or $52\frac{H7}{g6}$ Ⓔ

### 5.2.2 Determination of the limit deviations (reading rules)

To read the fit designation (e.g. 52H7/g6 Ⓔ), apply the rules described in 4.3. To determine the clearances and interferences, see Annex B.

## 5.3 Determination of a fit

### 5.3.1 General

There are two possibilities to determine a fit. Determination of a fit either by experience (see 5.3.4) or by calculating the permissible clearances and/or interferences derived from the functional requirements and the production possibilities of the mating parts (see 5.3.5).

### 5.3.2 Practical recommendations for determining a fit

There are more characteristics than the sizes of the mating parts and their tolerances, which influence the function of a fit. In order to give a complete technical definition of a fit, further influences shall be taken into consideration.

Further influences may be, for example, form, orientation and location deviations, surface texture, density of the material, operating temperatures, heat treatment and material of the mating parts.

Form, orientation and location tolerances may be needed as a supplement to the size tolerances on the mating features of size in order to control the intended function of the fit.

For more information about selecting a fit, see Annex B.

### 5.3.3 Selection of the fit system

The first decision to be made is whether to adopt the “hole-basis fit system” (hole H) or the “shaft-basis fit system” (shaft h). However, it has to be noted, that there are no technical differences regarding the function of the parts. Therefore the choice of the system should be based on economic reasons.

The “**hole-basis fit system**” should be chosen for general use. This choice would avoid an unnecessary multiplicity of tools (e.g. reamers) and gauges.

The “**shaft-basis fit system**” should only be used where it will convey unquestionable economical advantages (e.g. where it is necessary to be able to mount several parts with holes having different deviations on a single shaft of drawn steel bar without machining the latter).

### 5.3.4 Determination of a specific fit by experience

Based on the decision taken, the tolerance grades and the fundamental deviation (placement of tolerance interval) should then be chosen for the hole and the shaft to give the corresponding minimum and maximum clearances or interferences that best meet the required conditions of use.

For normal ordinary engineering purposes, only a small number of the many possible fits is required. Figures 12 and 13 indicate those fits which will be found to meet many of the needs of an average engineering organization. For economic reasons, the first choice for a fit should, whenever possible, be made from the tolerance classes shown in the frames (see Figures 12 and 13).

Satisfactory fits are obtained by the following combinations of basic holes system (see Figure 12) or for special applications the combinations of basic shafts system (see Figure 13).

| Basic hole | Tolerance classes for shafts | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clearance fits | | | | | | | Transition fits | | | | Interference fits | | | | | | |
| H 6 | | | | | | g5 | h5 | js5 | k5 | m5 | | n5 | p5 | | | | | |
| **H 7** | | | | | f6 | **g6** | **h6** | **js6** | **k6** | m6 | **n6** | | **p6** | **r6** | **s6** | t6 | u6 | x6 |
| **H 8** | | | | e7 | **f7** | | **h7** | js7 | k7 | m7 | | | | | s7 | | u7 | |
| | | | d8 | **e8** | f8 | | h8 | | | | | | | | | | | |
| **H 9** | | | d8 | **e8** | f8 | | h8 | | | | | | | | | | | |
| H10 | b9 | c9 | d9 | e9 | | | h9 | | | | | | | | | | | |
| **H 11** | **b11** | **c11** | d10 | | | | h10 | | | | | | | | | | | |

**Figure 12 — Preferable fits of the hole-basis system**

| Basic shaft | Tolerance classes for holes | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clearance fits | | | | | | | Transition fits | | | | Interference fits | | | | | | |
| h 5 | | | | | | G6 | H6 | JS6 | K6 | M6 | | N6 | P6 | | | | | |
| **h 6** | | | | | F7 | **G7** | **H7** | **JS7** | **K7** | M7 | **N7** | | **P7** | **R7** | **S7** | T7 | U7 | X7 |
| **h 7** | | | | E8 | **F8** | | **H8** | | | | | | | | | | | |
| h 8 | | | D9 | E9 | F9 | | H9 | | | | | | | | | | | |
| **h 9** | | | | E8 | **F8** | | **H8** | | | | | | | | | | | |
| | | | D9 | **E9** | F9 | | **H9** | | | | | | | | | | | |
| | **B11** | C10 | **D10** | | | | H10 | | | | | | | | | | | |

**Figure 13 — Preferable fits of the shaft-basis system**

### 5.3.5 Determination of a specific fit by calculation

In certain special functional cases, it is necessary to calculate the permissible clearances and/or interferences derived from the functional requirements of the mating parts (see literature). The clearances and/or interferences and the span of the fit obtained from that calculation have to be transformed into limit deviations and if possible into tolerance classes.

For more information about determining tolerance classes, see Annex B.3.

# Annex A
(informative)

# Further information about the ISO system of limits and fits and former practice

## A.1 Former practice of default definition of linear size

In ISO 286-1:1988, the default definition of diameters toleranced with ISO-tolerance classes (e.g. ∅ 30 H6) was the Taylor principle (mating size at maximum material limit and local diameter at least material limit) as stated in ISO/R 1938:1971.

That meant that for any features of size toleranced with ISO-tolerance classes the envelope requirement was valid without indicating the latter, even if the toleranced feature of size was not part of a fit.

EXAMPLE ∅ 24 h13 for head diameters of round head screws according to ISO 4759-1, the envelope requirement was valid automatically.

## A.2 Detailed interpretation of a toleranced size

The interpretation of a toleranced size according to ISO 286-1:1988 and ISO/R 1938:1971 was made in the following ways within the stipulated length.

a) **for holes**

   The diameter of the largest perfect imaginary cylinder, which can be inscribed within the hole so that it just contacts the highest points of the surface, should not be smaller than the maximum material limit of size.

   The maximum local diameter at any position in the hole shall not exceed the least material limit of size.

b) **for shafts**

   The diameter of the smallest perfect imaginary cylinder, which can be circumscribed about the shaft so that it just contacts the highest points of the surface, should not be larger than the maximum material limit of size.

   The minimum local diameter at any position on the shaft shall not be less than the least material limit of size.

These interpretations mean that if a feature of size is everywhere at its maximum material limit, that feature should be perfectly round and straight, i.e. a perfect cylinder.

This interpretation is in future only valid when the envelope requirement according to ISO 14405-1 (symbol Ⓔ) is indicated on the drawing in addition to the size and the tolerance.

## A.3 Change of default definition of linear size

The default definition for a toleranced linear size is changed according to ISO 14405-1 to local size between two opposite points. For the local size of an extracted feature, see ISO 14660-2:1999, 4.2.

To state exactly the same requirement (Taylor principle according to ISO/R 1938:1971) on the drawing, the tolerance statement shall according to ISO 14405-1 be followed by the modifier for mating size, e.g. the envelope requirement.

EXAMPLE ∅ 30 H6 Ⓔ

# Annex B
(informative)

# Examples of the use of ISO 286-1 to determine fits and tolerance classes

## B.1 General

This annex gives examples in the use of the ISO system of limits and fits in determining the clearances and/or interferences of fits. Furthermore, it contains examples for determining tolerance classes out of fits.

## B.2 Determination of fits from the limit deviations

From the definitions of the clearances and the interferences, the calculation of the minimum clearances and the maximum interferences is made using the same formula:

lower limit of size of the hole – upper limit of size of the shaft.

and for the calculation of the maximum clearances and the minimum interferences:

upper limit of size of the hole – lower limit of size of the shaft.

The result of the calculation is a positive or a negative value. From the definitions follows that clearances are positive and interferences are negative. That means a “+ sign” for clearances and a “– sign” for interferences.

After interpreting the results of the calculation the absolute values are taken to communicate and describe the clearances and interferences.

EXAMPLE 1 Calculation of the fit: ∅ 36 H8/f7

From the tables of ISO 286-2 for the hole 36 H8 results:

$ES = +0{,}039$ mm hence it follows: upper limit of size = 36,039 mm

$EI = 0$ lower limit of size = 36,000 mm

and for the shaft 36 f7 results:

$es = -0{,}025$ mm hence it follows: upper limit of size = 35,975 mm

$ei = -0{,}050$ mm lower limit of size = 35,950 mm

Therefore:

lower limit of size of the hole – upper limit of size of the shaft = 36,000 − 35,975 = 0,025 mm

upper limit of size of the hole – lower limit of size of the shaft = 36,039 − 35,950 = 0,089 mm

The calculation results in two positive values. That means the fit has a maximum clearance of 0,089 mm and a minimum clearance of 0,025 mm and it is a **clearance fit.**

EXAMPLE 2 Calculation of the fit: ∅ 36 H7/n6

From the tables of ISO 286-2 for the hole 36 H7 results:

$ES = +0{,}025$ mm hence it follows: upper limit of size = 36,025 mm

$EI = 0$ lower limit of size = 36,000 mm

and for the shaft 36 n6 results:

$es = +0{,}033$ mm hence it follows: upper limit of size = 36,033 mm

$ei = +0{,}017$ mm lower limit of size = 36,017 mm

Therefore:

lower limit of size of the hole – upper limit of size of the shaft = 36,000 − 36,033 = –0,033 mm

upper limit of size of the hole – lower limit of size of the shaft = 36,025 − 36,017 = +0,008 mm

The calculation results in a positive and a negative value. That means the fit has a clearance of 0,008 mm and an interference of 0,033 mm and is a **transition fit**.

EXAMPLE 3 Calculation of the fit: ∅ 36 H7/s6

From the tables of ISO 286-2 for the hole 36 H7 results:

$ES = +0{,}025$ mm hence it follows: upper limit of size = 36,025 mm

$EI = 0$ lower limit of size = 36,000 mm

and for the shaft 36 s6 results:

$es = +0{,}059$ mm hence it follows: upper limit of size = 36,059 mm

$ei = +0{,}043$ mm lower limit of size = 36,043 mm

Therefore:

lower limit of size of the hole – upper limit of size of the shaft = 36,000 − 36,059 = –0,059 mm

upper limit of size of the hole – lower limit of size of the shaft = 36,025 − 36,043 = –0,018 mm

The calculation results in two negative values. That means the fit has a maximum interference of 0,059 mm and a minimum interference of 0,018 mm and is an **interference fit.**

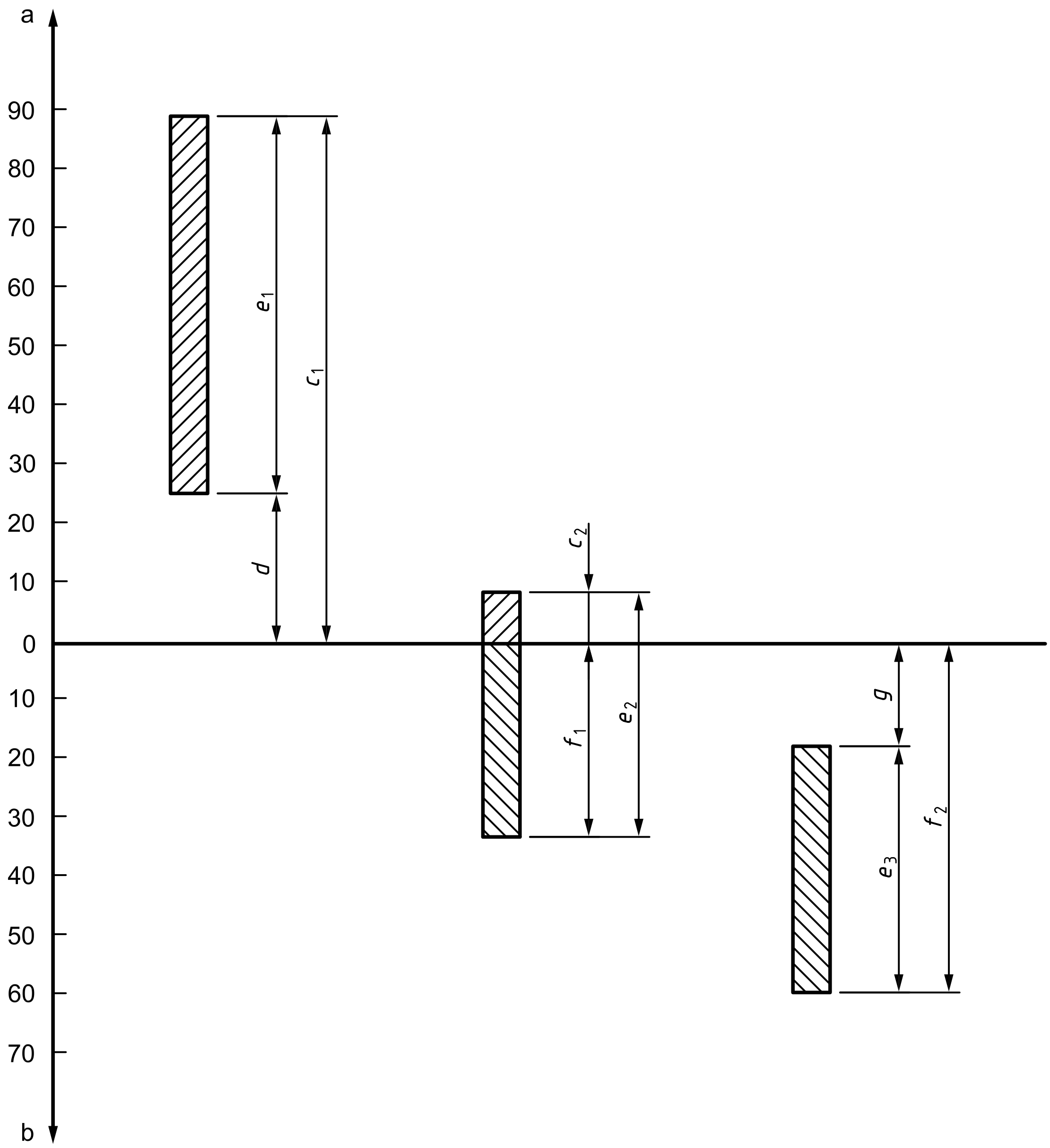
## B.3 Determination of the span of a fit

To determine the span of a fit, use the interpreted results of the calculation.

The span of the clearance fit is by definition: maximum clearances – minimum clearances
0,089 mm − 0,025 mm = 0,064 mm (see Figure B.1).

The span of the transition fit is by definition: maximum clearance + maximum interferences
0,008 mm + 0,033 mm = 0,041 mm (see Figure B.1).

The span of the interference fit is by definition: maximum interferences – minimum interferences
0,059 mm − 0,018 mm = 0,041 mm (see Figure B.1).




**Key**

| | | |
|---|---|---|
| maximum clearance | $c_1$ = 0,089 mm | $c_2$ = 0,008 mm |
| minimum clearance | $d$ = 0,025 mm | |
| span of a clearance fit | $e_1$ = 0,064 mm | |
| span of a transition fit | $e_2$ = 0,041 mm | |
| span of an interference fit | $e_3$ = 0,041 mm | |
| maximum interference | $f_1$ = 0,033 mm | $f_2$ = 0,059 mm |
| minimum interference | $g$ = 0,018 mm | |

[a] Clearances.

[b] Interferences.

**Figure B.1 — Span of fits**

## B.4 Determination of a specific tolerance class from calculated fits

### B.4.1 Magnitude of the tolerance

For the transformation of a calculated fit into limit deviations, and if possible into tolerance classes, first the magnitudes of the tolerances have to be determined by using Table 1 of this part of ISO 286 according to the following formula:

Span of the calculated fit ⩾ IT-value for the hole + IT-value for the shaft

| | | | |
|---|---|---|---|
| EXAMPLE | Calculated fit: | Nominal size | 40 mm |
| | (see 5.3.5) | Minimum clearance | 24 µm |
| | | Maximum clearance | 92 µm |
| | | Span of the clearance fit | 68 µm |

The sum of two selected standard tolerance values has to be equal or smaller than the span of the calculated fit.

Half of the span of the fit is 34 µm. In Table 1, in the line of the nominal size range above 30 up to and including 50 mm, the value 34 µm is situated between 25 µm and 39 µm. The sum of the table values is 64 µm which is smaller than 68 µm.

Hence, it follows: One standard tolerance is 25 µm and the standard tolerance grade is IT7.

The second standard tolerance is 39 µm and the standard tolerance grade is IT8.

### B.4.2 Determination of the deviations and the tolerance class

Then the decision has to be made whether to adopt the hole-basis fit system (hole H) or the shaft-basis fit system (shaft h) or another combination of fundamental deviations, see 5.3.3.

For the example below, the hole-basis fit system has been chosen according to 5.3.3. Therefore, the tolerance class identifier is H and Table 2 applies for the determination of the tolerance class.

EXAMPLE Nominal size (from Example B.4.1) 40 mm

Chosen fit system hole H

**a) Determination of the tolerance class for the hole**

Chosen standard tolerance grade for the hole (from Example B.4.1): IT8

In Table 2, the fundamental deviation can be chosen in the column H

the lower limit deviation $EI = 0$
the upper limit deviation follows from $ES = EI + \text{IT} = 0 + 39$ (IT8) $= +\,39$ µm

Hence, it follows: lower limit of size of the hole is 40 mm
upper limit of size of the hole is 40,039 mm
tolerance class for the hole is H8 and the size of the feature is 40 H8.

**b) Determination of the tolerance class for the shaft**

From the definition of the minimum clearance (see 3.3.1.1), it follows:

minimum clearances = lower limit of size of the hole – upper limit of size of the shaft

Calculated minimum clearance (from Example B.4.1) 24 µm = 0,024 mm

lower limit of size of the hole 40 mm

Hence, it follows:

0,024 mm = 40 mm – upper limit of size of the shaft
and
upper limit of size of the shaft = 40 mm − 0,024 mm = 39,976 mm

From the definition of the upper limit deviation (see 3.2.5.1), it follows:

$es$ = upper limit of size – nominal size

$es$ = 39,976 – 40 = – 0,024 mm = – 24 µm

In Table 4, in the line of the nominal size range above 30 mm up to and including 50 mm, the value – 25 µm can be found for $es$.

Hence, it follows: for $es$ = – 25 µm the tolerance class identifier is “f”, and

lower deviation $ei = es$ – IT7 = –25 – 25 = –50 µm

and tolerance class for the shaft is f7 and the size of the feature is 40 f7.

c) **Control of the fit**

The designation of the fit is 40 H8/f7.

From the calculation similar to B.2, Example 1 follows:

minimum clearance 25 µm

maximum clearance 89 µm

From the functional requirement was calculated:

actual calculated minimum clearance 24 µm

actual calculated maximum clearance 92 µm

The person who is responsible for the function of the mating parts has to decide if the deviations from the original calculated fit can be tolerated or if the exact minimum and maximum clearances have to be observed.

In any case, for the part with the hole, the toleranced dimension “40 H8” will be chosen. For the part with the shaft, the size 40, the tolerance class “f7 (–0,025/–0,050)” or the individual deviations “–0,024/–0,053” will be chosen.

# Annex C
(informative)

# Relationship to the GPS matrix model

## C.1 General

For full details about the GPS matrix model, see ISO/TR 14638.

## C.2 Information about this International Standard and its use

This part of ISO 286 establishes a code-system for tolerances to be used for sizes of nominal integral features of size. It also defines the basic concepts and the related terminology for this code system. Furthermore it defines the basic terminology for fits and explains the principles of “basic hole” and “basic shaft”.

## C.3 Position in the GPS matrix model

This part of ISO 286 is a GPS standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain links 1 and 2 of the chains of standards on size in the general GPS matrix, as graphically illustrated in Figure C.1.

**Fundamental GPS standards**

**Global GPS-standards**

| **General GPS-standards** | | | | | | |
|---|---|---|---|---|---|---|
| **Chain link number** | **1** | **2** | **3** | **4** | **5** | **6** |
| Size | | | | | | |
| Distance | | | | | | |
| Radius | | | | | | |
| Angle | | | | | | |
| Form of a line independent of datum | | | | | | |
| Form of a line dependent of datum | | | | | | |
| Form of a surface independent of datum | | | | | | |
| Form of a surface dependent of datum | | | | | | |
| Orientation | | | | | | |
| Location | | | | | | |
| Circular run-out | | | | | | |
| Total run-out | | | | | | |
| Datums | | | | | | |
| Roughness profile | | | | | | |
| Waviness profile | | | | | | |
| Primary profile | | | | | | |
| Surface imperfections | | | | | | |
| Edges | | | | | | |

**Figure C.1 — Position in the GPS matrix model**

## C.4 Related International Standards

The related International Standards are those of the chains of standards indicated in Figure C.1.

# Bibliography

[1] ISO 1:2002, *Geometrical Product Specifications (GPS) — Standard reference temperature for geometrical product specification and verification*

[2] ISO 1101:2004, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

[3] ISO 1302:2002, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

[4] ISO/R 1938:1971, *ISO system of limits and fits — Part II : Inspection of plain workpieces*

[5] ISO 2692:2006, *Geometrical product specifications (GPS) — Geometrical tolerancing — Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)*

[6] ISO 2768-1:1989, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

[7] ISO 3534-1:2006, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

[8] ISO 3534-2:2006, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

[9] ISO 4759-1, *Tolerances for fasteners — Part 1: Bolts, screws, studs and nuts — Product grades A, B and C*

[10] ISO 14253-1:1998, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for proving conformance or non-conformance with specifications*

[11] ISO/TR 14638:1995, *Geometrical product specifications (GPS) — Masterplan*

[12] ISO 17450-1:—[2], *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

[13] ISO/TS 17450-2:2002, *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

2) To be published. (Revision of ISO/TS 17450-1:2005)

# BSI - British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

**Revisions**

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

**Buying standards**

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

**Information on standards**

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact Information Centre. Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048 Email: info@bsigroup.com

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001 Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at http://www.bsigroup.com.

**Copyright**



BSI Group
Headquarters 389
Chiswick High Road,
London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/
standards