

ISO system of limits and fits —

Part 1: Bases of tolerances, deviations and fits

The European Standard EN 20286-1:1993 has the status of a British Standard

UDC 621.713.1/2

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Policy Committee (GME/-) to Technical Committee GME/5, upon which the following bodies were represented:

- BCIRA
- BEAMA Ltd.
- British Railways Board
- EBEA (the Electronics and Business Equipment Association)
- Federation of British Engineers' Tool Manufacturers
- Gauge and Tool Makers' Association
- Institution of Production Engineers
- Railway Industry Association of Great Britain
- Society of British Aerospace Companies Limited
- Society of Motor Manufacturers and Traders Limited
- Steel Casting Research and Trade Association
- Zinc Development Association

This British Standard, having been prepared under the direction of the General Mechanical Engineering Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 31 January 1990

© BSI 02-2000

First published as BS 4500-1 July 1969
Second edition as Section 1.1 January 1990

The following BSI references relate to the work on this standard:
Committee reference GME/5
Draft for comment 86/74319 DC

ISBN 0 580 18122 7

Amendments issued since publication

Amd. No.	Date of issue	Comments
7630	August 1993	Indicated by a sideline in the margin

Contents

	Page
Committees responsible	Inside front cover
National foreword	iii
Foreword	2
0 Introduction	3
1 Scope	3
2 Field of application	3
3 References	3
4 Terms and definitions	3
5 Symbols, designation and interpretation of tolerances, deviations and fits	12
6 Graphical representation	16
7 Reference temperature	17
8 Standard tolerances for basic sizes up to 3 150 mm	17
9 Fundamental deviations for basic sizes up to 3 150 mm	18
10 Bibliography	25
Annex A Bases of the ISO system of limits and fits	26
Annex B Examples of the use of ISO 286-1	33
Annex C Equivalent terms	34
Annex ZA (normative) Normative references to international publications with their relevant European publications	41
Figure 1 — Basic size, and maximum and minimum limits of size	5
Figure 2 — Conventional representation of a tolerance zone	6
Figure 3 — Clearance	7
Figure 4 — Clearance fit	8
Figure 5 — Transition fit	8
Figure 6 — Interference	9
Figure 7 — Interference fit	9
Figure 8 — Schematic representation of clearance fits	10
Figure 9 — Schematic representation of interference fits	10
Figure 10 — Schematic representation of transition fits	10
Figure 11 — Shaft-basis system of fits	11
Figure 12 — Hole-basis system of fits	12
Figure 13 — Schematic representation of the positions of fundamental deviations	14
Figure 14 — Deviations for shafts and holes	15
Figure 15 — Graphical representation	17
Figure 16 — Simplified schematic diagram	17
Figure 17 — Deviations for shafts	18
Figure 18 — Deviations for holes	19
Figure 19 — Deviations js and JS	19
Figure 20 — Diagrammatic representation of the rule given in A.4.2 b)	31
Table 1 — Numerical values of standard tolerance grades IT for basic sizes up to 3 150 mm	20
Table 2 — Numerical values of the fundamental deviations of shafts	21
Table 3 — Numerical values of the fundamental deviations of holes	23
Table 4 — Basic size steps	27
Table 5 — Numerical values for standard tolerances in grades IT01 and IT0	28
Table 6 — Formulae for standard tolerances in grades IT01, IT0 and IT1 for basic sizes up to and including 500 mm	28

	Page
Table 7 — Formulae for standard tolerances in grades IT1 to IT18	29
Table 8 — Rounding for IT values up to and including standard tolerance grade IT11	30
Table 9 — Formulae for fundamental deviations for shafts and holes	32
Table 10 — Rounding for fundamental deviations	33
Publications referred to	Inside back cover

National foreword

This Section of BS 4500 has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee and is identical with ISO 286:1988 “ISO system of limits and fits” Part 1 “Bases of tolerances, deviations and fits”, published by the International Organization for Standardization (ISO).

In 1993 the European Committee for Standardization (CEN) accepted ISO 286-1:1988 as European Standard EN 20286-1:1993. As a consequence of implementing the European Standard this British Standard is renumbered as BS EN 20286-1:1993 and any reference to BS 4500-1.1:1990 should be read as a reference to BS EN 20286-1:1993.

Together with BS 4500-1.2, it is a revision of BS 4500-1:1969 which is withdrawn. The major changes incorporated in this Section of BS 4500 are as follows:

- a) The presentation of the information has been modified so that the standard can be used directly in both the design office and the workshop. This has been achieved by separating the material dealing with the bases of the system, and the calculated values of standard tolerances and fundamental deviations, from the tables giving specific limits of the most commonly used tolerances and deviations, which are now in BS 4500-1.2.
- b) The new symbols js and JS replace the former symbols J_s and J_S, i.e. s and S are no longer placed as subscripts, to facilitate the use of symbols on equipment with limited character sets, e.g. computer graphics. The letters “s” and “S” stand for “symmetrical deviation”.
- c) Standards tolerances and fundamental deviations have been included for basic sizes from 500 mm to 3 150 mm as standard requirements (these were previously included on an experimental basis only).
- d) Two additional standard tolerance grades, IT17 and IT18, have been included.
- e) Standard tolerance grades IT01 and IT0 have been deleted from the main body of this Part, although information on these grades is given in Annex A for users who may need such grades.
- f) Inch values have been deleted.
- g) The principles, terminology and symbols have been aligned with those required by contemporary technology.

Cross-references

International Standard	Corresponding British Standard
ISO 286-2:1988	BS 4500 <i>ISO limits and fits</i> Section 1.2:1990 <i>Tables of commonly used tolerance grades and limit deviations for holes and shafts</i> (Identical)
ISO 406:1987	BS 308 <i>Engineering drawing practice</i> Part 2:1985 <i>Recommendations for dimensioning and tolerancing of size</i> (Technically equivalent)
ISO 5166:1982	BS 4500 <i>ISO limits and fits</i> Part 4:1985 <i>Specification for system of cone (taper) fits for cones from C = 1 : 3 to 1 : 500, lengths from 6 mm to 630 mm and diameters up to 500 mm</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 1:1975 and ISO/R 1938:1971 to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to ISO 8015 is BS 308 “*Engineering drawing practice*”, Part 2:1985 “*Recommendations for dimensioning and tolerancing of size*”.

A related British Standard to ISO 1101:1983 is BS 308 “*Engineering drawing practice*”, Part 3:1972 “*Geometrical tolerancing*”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, the EN title page, pages 2 to 42, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

UDC 621.713.1/2

Descriptors: Standard tolerances, fundamental tolerances, fits, definitions, designation, multilingual nomenclature, round shafts, cylindrical bores, dimensions, ratings

English version

ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits

(ISO 286-1:1988)

Système ISO de tolérances et d'ajustements —
Partie 1. Base de tolérances, écarts et
ajustements
(ISO 286-1:1988)

ISO-System für Grenzabmaße und
Passungen —
Teil 1. Grundlagen für Toleranzen, Abmaße
und Passungen
(ISO 286-1:1988)

This European Standard was approved by CEN on 1993-04-15. 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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

© 1993 Copyright reserved to CEN members

Foreword

In 1991, the International Standard ISO 286-1:1988 *ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits* was submitted to the CEN Primary Questionnaire procedure.

Following the positive result of the CEN/CS Proposal, ISO 286-1:1988 was submitted to the Formal Vote.

The result of the Formal Vote was positive.

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 1993, and conflicting national standards shall be withdrawn at the latest by October 1993.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

NOTE The European references to international publications are given in Annex ZA (normative).

0 Introduction

The need for limits and fits for machined workpieces was brought about mainly by the inherent inaccuracy of manufacturing methods, coupled with the fact that “exactness” of size was found to be unnecessary for most workpieces. In order that 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.

Similarly, where a specific fit condition is required between mating workpieces, it is necessary to ascribe an allowance, either positive or negative, to the basic size to achieve the required clearance or interference, i.e. a “deviation”.

With developments in industry and international trade, it became necessary to develop formal systems of limits and fits, firstly at the industrial level, then at the national level and later at the international level. This International Standard therefore gives the internationally accepted system of limits and fits.

Annex A and Annex B give the basic formulae and rules necessary for establishing the system, and examples in the use of the standard are to be regarded as an integral part of the standard.

Annex C gives a list of equivalent terms used in ISO 286 and other International Standards on tolerances.

1 Scope

This part of ISO 286 gives the bases of the ISO system of limits and fits together with the calculated values of the standard tolerances and fundamental deviations. These values shall be taken as authoritative for the application of the system (see also clause A.1).

This part of ISO 286 also gives terms and definitions together with associated symbols.

2 Field of application

The ISO system of limits and fits provides a system of tolerances and deviations suitable for plain workpieces.

For simplicity and also because of the importance of cylindrical workpieces of circular section, only these are referred to explicitly. It should be clearly understood, however, that the tolerances and deviations given in this International Standard equally apply to workpieces of other than circular section.

In particular, the general term “hole” or “shaft” can be taken as referring to the space contained by (or containing) the two parallel faces (or tangent planes) of any workpiece, such as the width of a slot or the thickness of a key.

The system also provides for fits between mating cylindrical features or fits between workpieces having features with parallel faces, such as the fit between a key and keyway, etc.

NOTE It should be noted that the system is not intended to provide fits for workpieces with features having other than simple geometric forms.

For the purposes of this part of ISO 286, a simple geometric form consists of a cylindrical surface area or two parallel planes.

3 References

NOTE See also clause 10.

ISO 1, *Standard reference temperature for industrial length measurements*.

ISO 286-2, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*.

ISO/R 1938, *ISO system of limits and fits — Inspection of plain workpieces*¹⁾.

ISO 8015, *Technical drawings — Fundamental tolerancing principle*.

4 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply. It should be noted, however, that some of the terms are defined in a more restricted sense than in common usage.

¹⁾ At present under revision.

4.1 shaft

A term used, according to convention, to describe an external feature of a workpiece, including features which are not cylindrical (see also clause 2).

4.1.1 basic shaft

shaft chosen as a basis for a shaft-basis system of fits (see also 4.11.1)

for the purposes of the ISO system of limits and fits, a shaft the upper deviation of which is zero

4.2 hole

A term used, according to convention, to describe an internal feature of a workpiece, including features which are not cylindrical (see also clause 2).

4.2.1 basic hole

hole chosen as a basis for a hole-basis system of fits (see also 4.11.2)

for the purposes of the ISO system of limits and fits, a hole the lower deviation of which is zero

4.3 size

A number expressing, in a particular unit, the numerical value of a linear dimension.

4.3.1 basic size; nominal size

the size from which the limits of size are derived by the application of the upper and lower deviations (see Figure 1)

NOTE The basic size can be a whole number or a decimal number, e.g. 32; 15; 8,75; 0,5; etc.

4.3.2 actual size

The size of a feature, obtained by measurement.

4.3.2.1 actual local size

any individual distance at any cross-section of a feature, i.e. any size measured between any two opposite points

4.3.3 limits of size

The two extreme permissible sizes of a feature, between which the actual size should lie, the limits of size being included.

4.3.3.1 maximum limit of size

the greatest permissible size of a feature (see Figure 1)

4.3.3.2 minimum limit of size

the smallest permissible size of a feature (see Figure 1)

4.4 limit system

a system of standardized tolerances and deviations

4.5 zero line

in a graphical representation of limits and fits, the straight line, representing the basic size, to which the deviations and tolerances are referred (see Figure 1)

according to convention, the zero line is drawn horizontally, with positive deviations shown above and negative deviations below (see Figure 2)

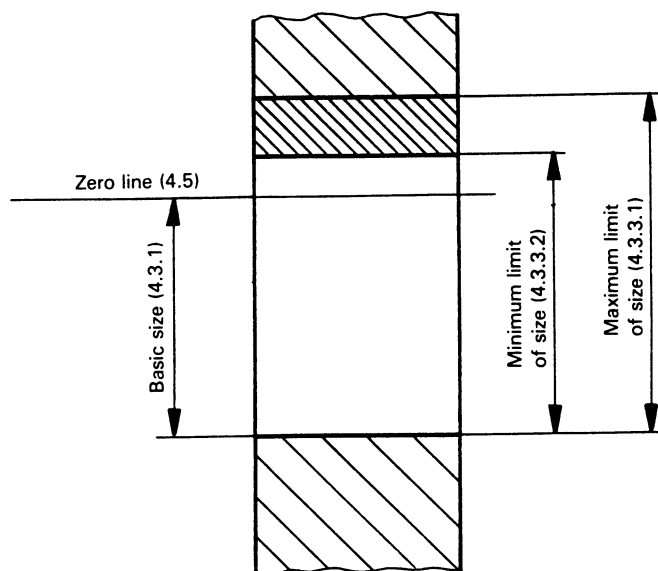


Figure 1 — Basic size, and maximum and minimum limits of size

4.6 deviation

The algebraic difference between a size (actual size, limit of size, etc.) and the corresponding basic size.

NOTE Symbols for shaft deviations are lower case letters (*es*, *ei*) and symbols for hole deviations are upper case letters (*ES*, *EI*) (see Figure 2).

4.6.1 limit deviations

Upper deviation and lower deviation.

4.6.1.1

upper deviation (*ES*, *es*)

the algebraic difference between the maximum limit of size and the corresponding basic size (see Figure 2)

4.6.1.2

lower deviation (*EI*, *ei*)

the algebraic difference between the minimum limit of size and the corresponding basic size (see Figure 2)

4.6.2

fundamental deviation

for the purposes of the ISO system of limits and fits, that deviation which defines the position of the tolerance zone in relation to the zero line (see Figure 2)

NOTE This may be either the upper or lower deviation, but, according to convention, the fundamental deviation is the one nearest the zero line.

4.7 size tolerance

The difference between the maximum limit of size and the minimum limit of size, i.e. the difference between the upper deviation and the lower deviation.

NOTE The tolerance is an absolute value without sign.

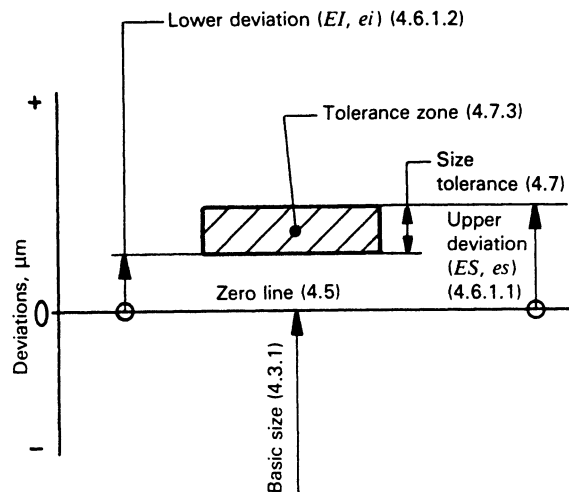


Figure 2 — Conventional representation of a tolerance zone

4.7.1 standard tolerance (IT)

for the purposes of the ISO system of limits and fits, any tolerance belonging to this system

NOTE The letters of the symbol IT stand for “International Tolerance” grade.

4.7.2 standard tolerance grades

for the purposes of the ISO system of limits and fits, a group of tolerances (e.g. IT7), considered as corresponding to the same level of accuracy for all basic sizes

4.7.3 tolerance zone

in a graphical representation of tolerances, the zone, contained between two lines representing the maximum and minimum limits of size, defined by the magnitude of the tolerance and its position relative to the zero line (see Figure 2)

4.7.4 tolerance class

the term used for a combination of fundamental deviation and a tolerance grade, e.g. h9, D13, etc.

4.7.5 standard tolerance factor (i , I)

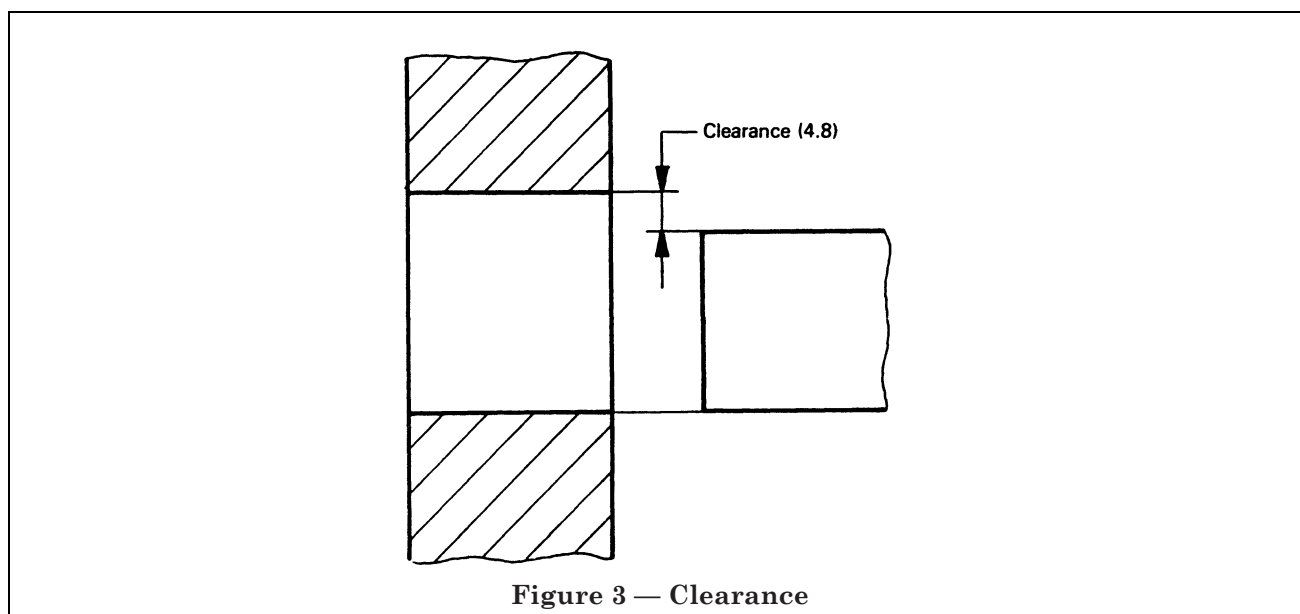
for the purposes of the ISO system of limits and fits, a factor which is a function of the basic size, and which is used as a basis for the determination of the standard tolerances of the system

NOTE 1 The standard tolerance factor i is applied to basic sizes less than or equal to 500 mm.

NOTE 2 The standard tolerance factor I is applied to basic sizes greater than 500 mm.

4.8 clearance

The positive difference between the sizes of the hole and the shaft, before assembly, when the diameter of the shaft is smaller than the diameter of the hole (see Figure 3).



4.8.1

minimum clearance

in a clearance fit, the positive difference between the minimum limit of size of the hole and the maximum limit of size of the shaft (see Figure 4)

4.8.2

maximum clearance

in a clearance or transition fit, the positive difference between the maximum limit of size of the hole and the minimum limit of size of the shaft (see Figure 4 and Figure 5)

4.9 interference

The negative difference between the sizes of the hole and the shaft, before assembly, when the diameter of the shaft is larger than the diameter of the hole (see Figure 6).

4.9.1

minimum interference

in an interference fit, the negative difference, before assembly, between the maximum limit of size of the hole and the minimum limit of size of the shaft (see Figure 7)

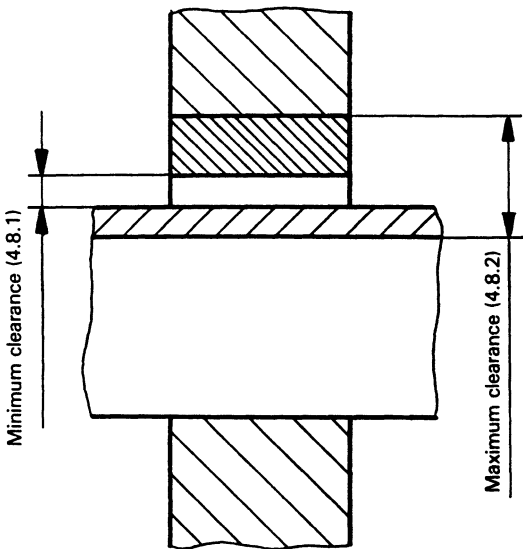


Figure 4 — Clearance fit

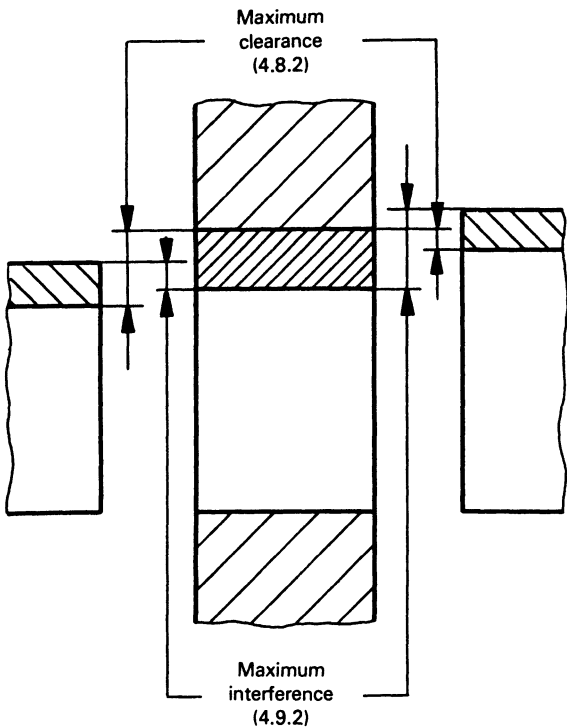


Figure 5 — Transition fit

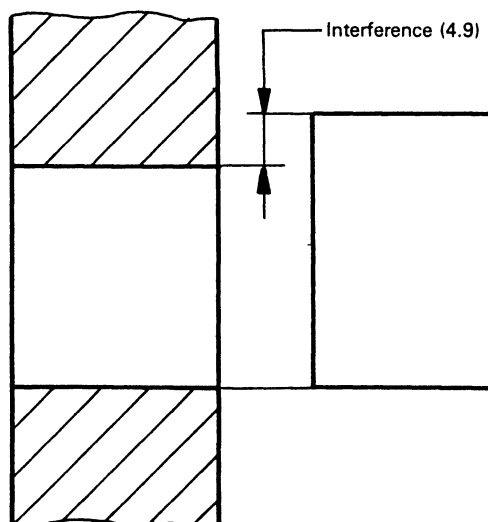


Figure 6 — Interference

4.9.2**maximum interference**

in an interference or transition fit, the negative difference, before assembly, between the minimum limit of size of the hole and the maximum limit of size of the shaft (see Figure 5 and Figure 7)

4.10 fit

The relationship resulting from the difference, before assembly, between the sizes of the two features (the hole and the shaft) which are to be assembled.

NOTE The two mating parts of a fit have a common basic size.

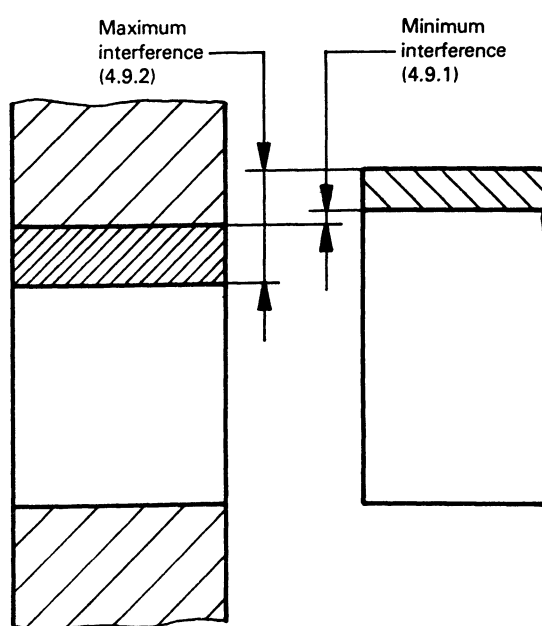


Figure 7 — Interference fit