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ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 286

ISO SYSTEM OF LIMITS AND FITS

PART I: GENERAL, TOLERANCES AND DEVIATIONS

1st EDITION

December 1962

For each individual country the only valid standard is the national standard of that country.

Printed in Switzerland

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BRIEF HISTORY

The ISO Recommendation R 286, *ISO System of Limits and Fits — Part I: General, Tolerances and Deviations,* was drawn up by Technical Committee ISO/TC 3, *Limits and Fits,* the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question by the Technical Committee began in 1949, taking into account the studies which had been made by the former International Federation of the National Standardizing Associations (ISA), and led, in 1957, to the adoption of a Draft ISO Recommendation.

In January 1960, this Draft ISO Recommendation (No. 321) was circulated to all the ISO Member Bodies for enquiry. It was approved by the following Member Bodies:

Australia	Finland	Norway
Austria	France	Poland
Belgium	Germany	Romania
Brazil	Hungary	Spain
Bulgaria	India	Sweden
Burma	Italy	Switzerland
Chile	Japan	United Kingdom
Czechoslovakia	New Zealand	Yugoslavia

Three Member Bodies opposed the approval of the Draft:

Netherlands, Portugal, U.S.S.R.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in December 1962, to accept it as an ISO RECOMMENDATION.

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TABLES OF COMMONLY USED SHAFTS AND HOLES

(see detailed summary at the beginning of the Appendix)

INTRODUCTORY NOTE

The values of the ISO System of Limits and Fits are expressed

in metric units, for countries using the metric system of measurement,
in inch units, for countries using the inch system of measurement.

The ISO System ensures complete fit interchangeability of parts manufactured to the same symbol in one or other of these systems of measurement. However, in view of the very slight numerical differences resulting from the conversion from millimetres into inches (see clause 2.4), it is recommended that checking instruments calibrated in the system of measurement in which the parts have been designed should be used, or that agreement should be reached between suppliers and customers on the choice of the system of measurement to be adopted for final inspection.

In the absence of any agreement to the contrary, the *values in metric units* will be taken as authoritative in case of dispute regarding the choice of the system of measurement which ought to have been adopted.

The same remarks apply in those borderline cases, an extremely rare class, in which the nominal size falls within one diameter range in one system of measurement and within the neighbouring range in the other system of measurement.

FOREWORD

The present ISO Recommendation, *ISO System of Limits and Fits, Part I*, is based on the *ISA System of Limits and Fits* published in ISA Bulletin 25 (1940), and on comments included in the Draft Final Report of ISA Committee 3, December 1935.

This ISO Recommendation differs from the ISA System in its lay-out and in the following main items:

1. Inclusion of sizes below 1 mm for grades up to grade 13.
2. Inclusion of the two grades 01 and 0 finer than grade 1.
3. Inclusion of new shaft and hole deviations:

   cd, CD, ef, EF, fg, FG up to 10 mm only . . . . . for fine mechanisms and horology,

   j_s and J_s . . . . . providing a complete range of symmetrical deviations for all diameter steps and all grades,*

   za, ZA, zb, ZB, zc, ZC . . . . . for high interference fits.

4. Amendments of some standard tolerances for fine grades and of some deviations to connect the existing values with those included in the above paragraphs. Numerical values amended with regard to those deriving from the former ISA System are framed in a bold line in Table 7, page 22, Tables 8 and 9, pages 23 to 26, and in the practical tables in the Appendix.
5. Inclusion of Tables 7, 8 and 9, permitting the easy calculations of the deviations corresponding to any symbol through the whole range of diameter steps (upper and lower deviations).

   It should be noted, however, that this possibility does not involve the use of all symbols. Indeed, in addition to the exceptions mentioned above in point 3,

   shafts and holes a A, b B are provided only for sizes above 1 mm;

   shafts j8 are provided only for sizes up to 3 mm;

   holes K, in grades above 8, are provided only for sizes up to 3 mm;

   shafts and holes t T, v V, y Y are provided only for sizes from 24, 14 and 18 mm respectively (since, below those sizes, they would only repeat adjoining symbols).

* The former deviations j and J have not in general been maintained in the fields where they were always symmetrical, since only deviations j_s and J_s are to be recommended for fits, for the sake of homogeneity. However, a few symmetrical deviations j and one symmetrical deviation J have been maintained in grades 6 and 7.

ISO Recommendation R 286 December 1962

ISO SYSTEM OF LIMITS AND FITS

PART I: GENERAL, TOLERANCES AND DEVIATIONS *

1. GENERAL — SYMBOLS — DEFINITIONS

1.1 Scope of the ISO System

The ISO System of Limits and Fits relates to tolerances on plain parts or components and to the fits corresponding to their assembly.

For the sake of simplicity, and in view of the particular importance of cylindrical parts with circular section, only these are referred to explicitly. It should be clearly understood however that recommendations for this type of component apply equally well to other plain parts or components; in particular, the general term " hole " or " shaft " can be taken as referring to the space containing or contained by two parallel faces (or tangent planes) of any part, such as the width of a slot, the thickness of a key, etc.

1.2 Reference temperature

As indicated by ISO Recommendation R 1,** the standard reference temperature is 20 °C for industrial measurements and, consequently, for dimensions defined by the System.

1.3 Tolerances of parts

Due mainly to the inevitable inaccuracy of manufacturing methods, a part cannot be made precisely to a given dimension but, in order to meet its purpose, it is sufficient that it should be made so as to lie within two permissible limits of size, the difference of which is the *tolerance*.

For the sake of convenience, a *basic size* is ascribed to the part and each of the two limits is defined by its *deviation* from this basic size. The magnitude and sign of the deviation are obtained by subtracting the basic size from the limit in question.

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* This First Part relates only to the essential bases of the System, giving the prescribed limits of parts; it excludes al matters of inspection or metrology, which will be dealt with in Part II of the System, covered by another ISO Recommendation, at present under preparation.

** ISO Recommendation R 1, *Standard Reference Temperature for Industrial Length Measurements.*

Figure 1, which illustrates these definitions, is in practice replaced by a schematic diagram similar to Figure 2 for the sake of simplicity. In this simplified schematic diagram, the axis of the part, which is not represented, always lies, by convention, below the diagram. (In the example illustrated, the two deviations of the shaft are negative and those of the hole positive.)

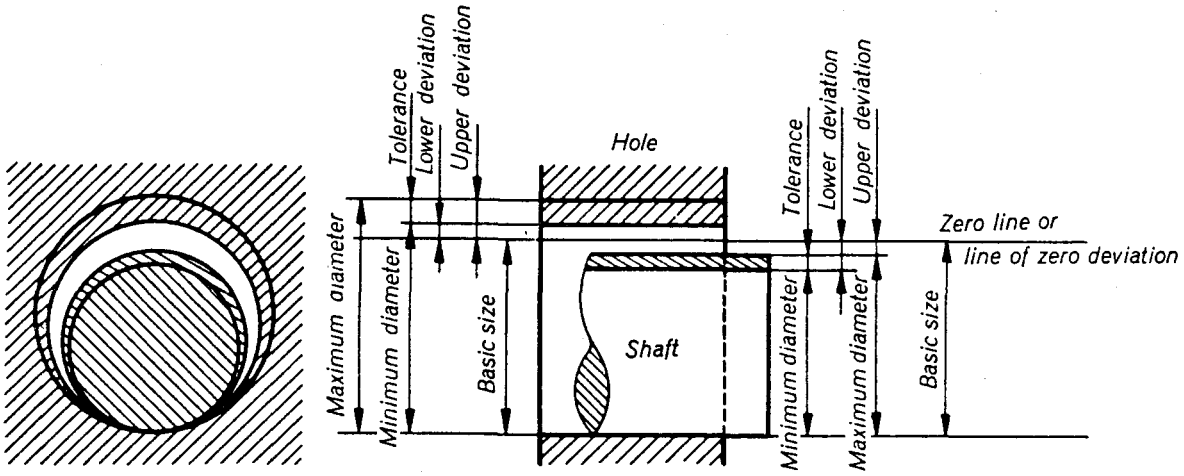


FIG. 1

FIG. 2

1.3.1 *Notation*

The following notation is used in this document: *

Upper deviation of a hole	ES
Lower deviation of a hole	EI
Upper deviation of a shaft	es
Lower deviation of a shaft	ei

1.4 Fits

When two parts are to be assembled, the relation resulting from the difference between their sizes before assembly is called a *fit*.

Depending upon the respective positions of the tolerance zones of the hole or the shaft, the fit may be

a *clearance fit*,
a *transition fit* (i.e. such that the assembly may have either a clearance or an interference), or
an *interference fit*.

Figure 1 above shows a clearance fit, and Figure 3, page 7, shows the schematic diagram of tolerance zones in various cases.

* However, it will be left to each country to adopt a notation more in accordance with its own language.

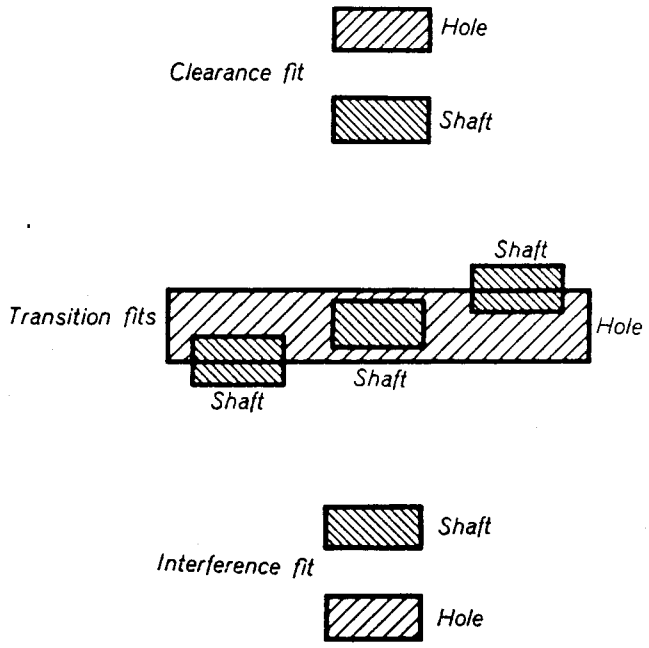


FIG. 3

Two of the most commonly used methods of applying the ISO System are the hole-basis system and the shaft-basis system (defined under No. 1.6.38 and No. 1.6.39 in clause 1.6, " Vocabulary "), which are shown in Figure 4 below.

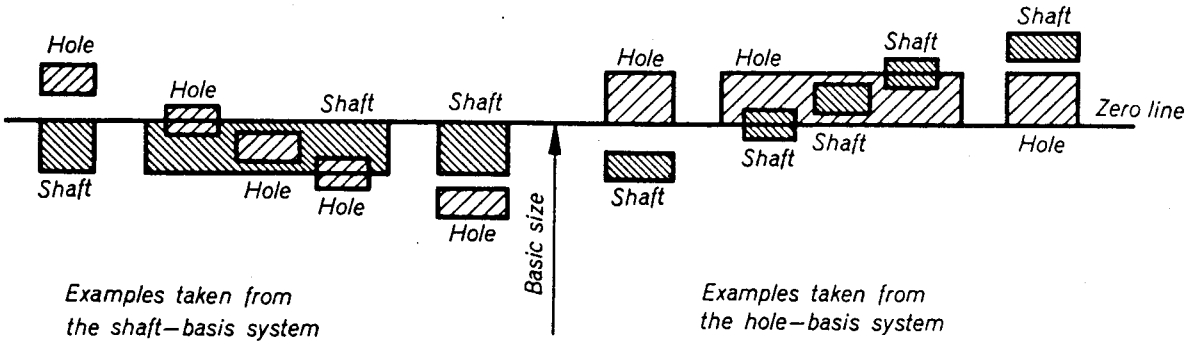


FIG. 4

1.5 Symbols for tolerances and deviations and symbols for fits

In order to satisfy the usual requirements both of individual parts and of fits, the System provides, for any given basic size, a whole range of tolerances together with a whole range of deviations defining the position of these tolerances with respect to the line of zero deviation, called the *zero line*.

The *tolerance*, the value of which is a function of the basic size, is designated by a number symbol, called the *grade*.

The position of the tolerance zone with respect to the zero line, which is a function of the basic size, is indicated by a letter symbol (in some cases, two letters), a capital letter for holes, a small letter for shafts (see Fig. 5).

The toleranced size is thus defined by its basic value followed by a "*symbol*" composed of a letter (in some cases, two letters) and a number.

Example: 45 g7.

A fit is indicated by the basic size common to both components, followed by symbol corresponding to each component, the hole being quoted first.

Example: 45 H8/g7 (possibly 45 H8-g7 or 45 $\frac{H8}{g7}$).

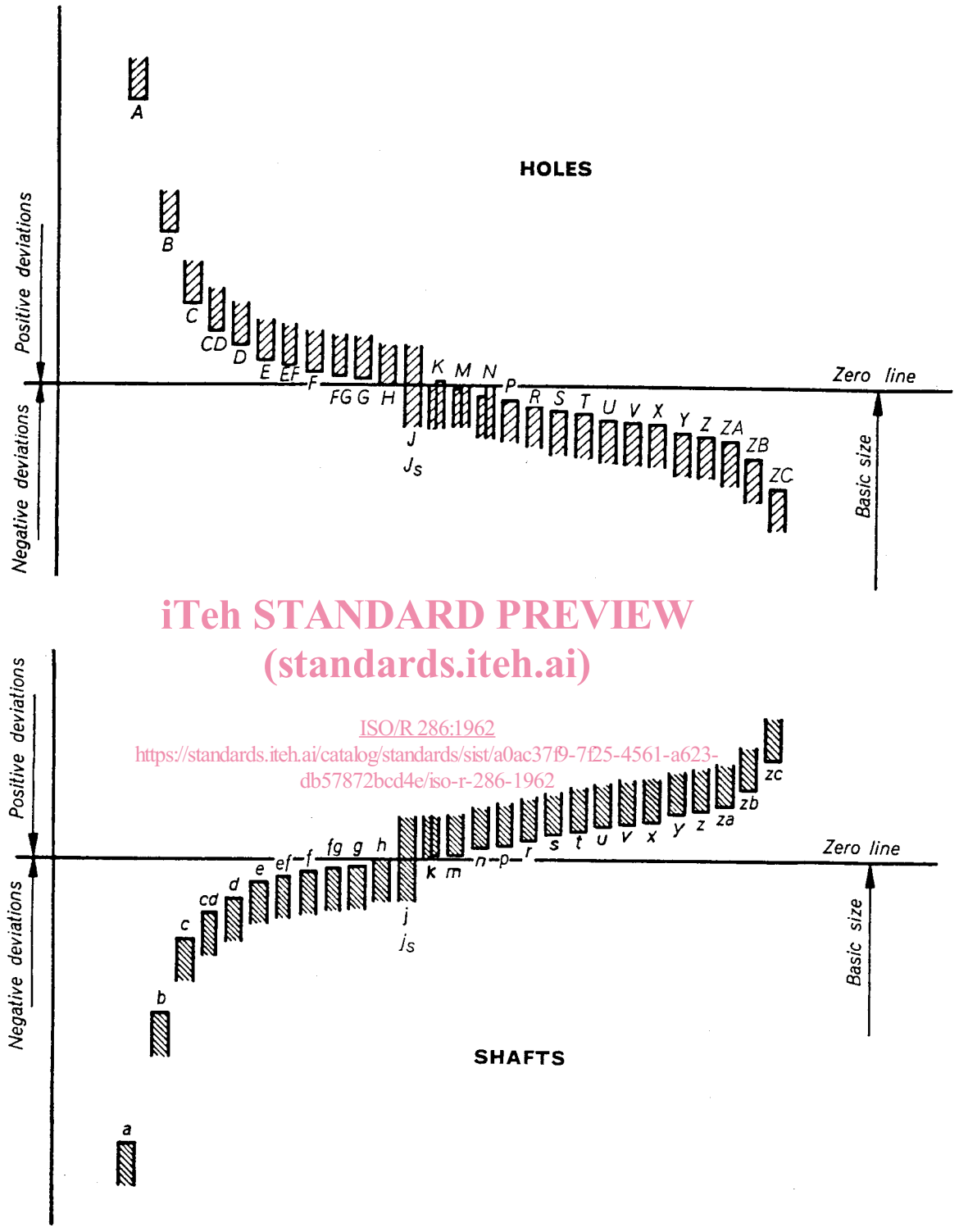


FIG. 5.—Respective positions of the various tolerance zones for a given diameter step

1.6 Vocabulary *

1.6.1 *Size.***—Number expressing in a particular unit the numerical value of a length. (In French, the size is named *cote*, when it is inscribed on a drawing.)

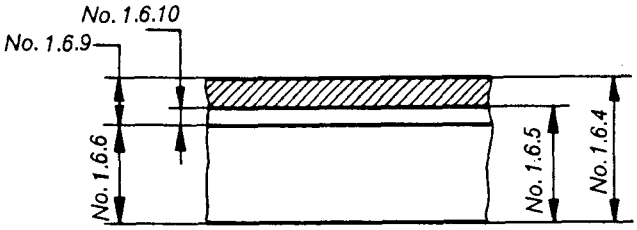
1.6.2 *Actual size (of a part).*—Size as practically obtained (value which may be obtained by measurement; see Part II of ISO System of Limits and Fits).

1.6.3 *Limits of size.*—The two extreme permissible sizes of a part between which the actual size should lie, the limits of size being included.

1.6.4 *Maximum limit of size.* — The greater of the two limits of size.

1.6.5 *Minimum limit of size.* — The smaller of the two limits of size.

1.6.6 *Basic size.*—Size by reference to which the limits of size are fixed.



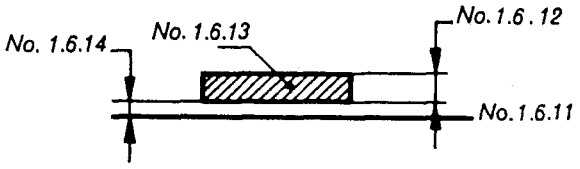
1.6.7 *Deviation.*—Algebraical difference between a size (actual, maximum, etc.) and the corresponding basic size.

1.6.8 *Actual deviation.*—Algebraical difference between the actual size and the corresponding basic size.

1.6.9 *Upper deviation.*—Algebraical difference between the maximum limit of size and the corresponding basic size.

1.6.10 *Lower deviation.*—Algebraical difference between the minimum limit of size and the corresponding basic size.

1.6.11 *Zero line.*—In a graphical representation of limits and fits, straight line to which the deviations are referred. The zero line is the line of zero deviation and represents the basic size.



By convention, when the zero line is drawn horizontally, positive deviations are shown above and negative deviations below it.

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* It should be emphasized that some terms in the present vocabulary are defined, for the purposes of the ISO System of Limits and Fits, in a more restricted sense than that in common use.

** In particular, the word *size* is defined here as "size of a length" ("dimension linéaire" in French), and the corresponding French term "dimension" which, in current speech, has two meanings, corresponding respectively to the English terms "dimension" and "size", is here to be taken in the second sense only, viz. that of a numerical value.

1.6.12 *Tolerance.*—Difference between the maximum limit of size and the minimum limit of size (or, in other words, algebraical difference between the upper deviation and the lower deviation).

The tolerance is an absolute value without sign.

1.6.13 *Tolerance zone.*—In a graphical representation of tolerances, zone comprised between the two lines representing the limits of the tolerance and defined by its magnitude (tolerance) and by its position in relation to the zero line.

1.6.14 *Fundamental deviation.*—That one of the two deviations which is conventionally chosen to define the position of the tolerance zone in relation to the zero line.

1.6.15 *Grade of tolerance.*—In a standardized system of limits and fits, group of tolerances considered as corresponding to the same level of accuracy for all basic sizes.

1.6.16 *Standard tolerance.*—In a standardized system of limits and fits, any tolerance belonging to the system.

1.6.17 *Standard tolerance unit.*—In the ISO System of Limits and Fits, factor expressed only in terms of the basic size and used as a basis for the determination of the standard tolerances of the System. (Each tolerance is equal to the product of the value of the standard tolerance unit, for the considered basic size, by a coefficient corresponding to each grade of tolerance.)

1.6.18 *Shaft.*—Term used by convention to designate all external features of a part, including parts which are not cylindrical.

1.6.19 *Hole.*—Term used by convention to designate all internal features of a part, including parts which are not cylindrical.

1.6.20 *Basic shaft.*—In the ISO System of Limits and Fits, shaft the upper deviation of which is zero.

More generally, shaft chosen as a basis for a shaft-basis system of fits (see No. 1.6.38).

1.6.21 *Basic hole.*—In the ISO System of Limits and Fits, hole the lower deviation of which is zero.

More generally, hole chosen as a basis for a hole-basis system of fits (see No. 1.6.39).

1.6.22 *Go limit.*—Designation applied to that of the two limits of size which corresponds to the maximum material condition, i.e.:

the upper limit of a shaft,
the lower limit of a hole.

(When limit gauges are used, this is the limit of size checked by the GO gauge.)

1.6.23 *NOT GO limit.*—Designation applied to that of the two limits of size which corresponds to the minimum material condition, i.e.:

the lower limit of a shaft,
the upper limit of a hole.

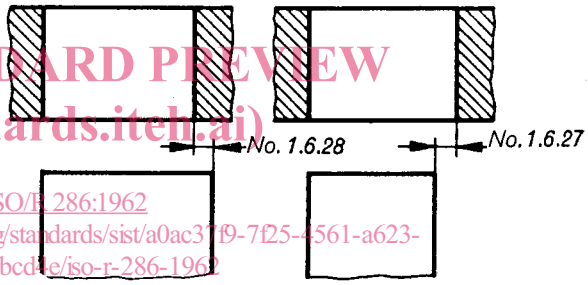
(When limit gauges are used, this is the limit of size checked by the NOT GO gauge.)

1.6.24 *Fit.*—Relationship resulting from the difference, before assembly, between the sizes of the two parts which are to be assembled.

1.6.25 *Basic size (of a fit).*—Common value of the basic size of the two parts of a fit.

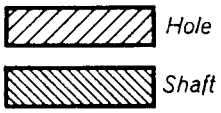
1.6.26 *Variation of fit.*—Arithmetical sum of the tolerances of the two mating parts of a fit.

1.6.27 *Clearance.*—Difference between the sizes of the hole and the shaft, before assembly, when this difference is positive.

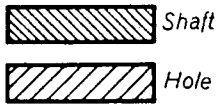


1.6.28 *Interference.*—Magnitude of the difference between the sizes of the hole and the shaft, before assembly, when this difference is negative.

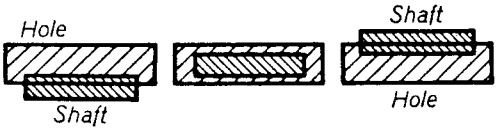
1.6.29 *Clearance fit.*—Fit which always provides a clearance. (The tolerance zone of the hole is entirely above that of the shaft.)



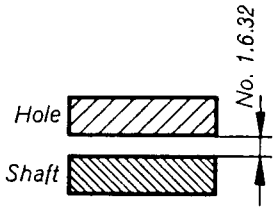
1.6.30 *Interference fit.*—Fit which always provides an interference. (The tolerance zone of the hole is entirely below that of the shaft.)



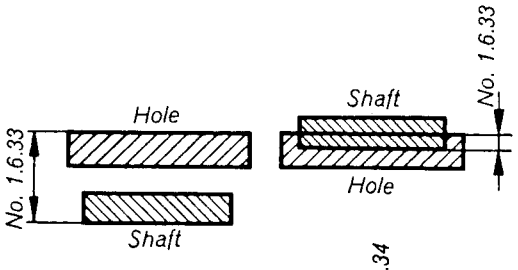
1.6.31 *Transition fit.*—Fit which may provide either a clearance or an interference. (The tolerance zones of the hole and the shaft overlap.)



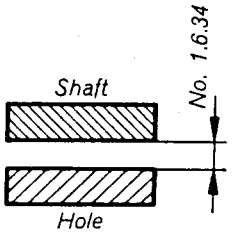
1.6.32 *Minimum clearance.*—In a clearance fit, difference between the minimum size of the hole and the maximum size of the shaft.



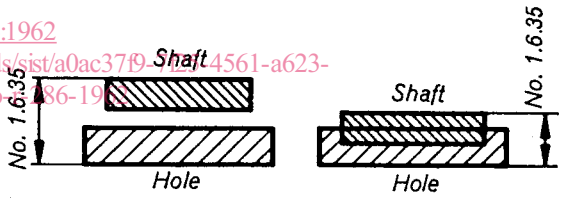
1.6.33 *Maximum clearance.*—In a clearance or a transition fit, difference between the maximum size of the hole and the minimum size of the shaft.



1.6.34 *Minimum interference.*—In an interference fit, magnitude of the (negative) difference between the maximum size of the hole and the minimum size of the shaft, before assembly.



1.6.35 *Maximum interference.*—In an interference or a transition fit, magnitude of the (negative) difference between the minimum size of the hole and the maximum size of the shaft, before assembly.



1.6.36 *Limit system.*—System of standardized tolerances and deviations.

1.6.37 *Fit system.*—System of fits comprising shafts and holes belonging to a limit system.

1.6.38 *Shaft-basis system of fits.*—System of fits in which the different clearances and interferences are obtained in associating various holes with a single shaft (or, possibly, with shafts of different grades, but having the same fundamental deviation).

In the ISO System, the basic shaft is the shaft the upper deviation of which is zero.

1.6.39 *Hole-basis system of fits.*—System of fits in which the different clearances and interferences are obtained in associating various shafts with a single hole (or, possibly, with holes of different grades, but having always the same fundamental deviation).

In the ISO System, the basic hole is the hole the lower deviation of which is zero.

2. TOLERANCES AND DEVIATIONS FOR SIZES UP TO 500 mm (19.69 in)

2.1 Formulae for tolerances and deviations

2.1.1 *Nominal diameter steps for metric and inch values*

For the sake of simplicity, the formulae given in clauses 2.1.2 and 2.1.3 for the calculation of standard tolerances and fundamental deviations are applied to suit the diameter steps shown in Table 1 below; the results have been computed on the basis of the geometrical mean D of the extreme diameters of each step and apply to all diameters of this step.

For the whole of the step up to 3 mm (or 0.12 in), the average diameter is taken as the geometrical mean of 1 and 3 mm (or 0.04 and 0.12 in).

TABLE 1. — **Nominal diameter steps**

Nominal diameter steps							
Main steps				Intermediate steps *			
Millimetres		Inches		Millimetres		Inches	
above	up to	above	up to	above	up to	above	up to
—	3	—	0.12				
3	6	0.12	0.24				
6	10	0.24	0.40				
10	18	0.40	0.71	10 14	14 18	0.40 0.56	0.56 0.71
18	30	0.71	1.19	18 24	24 30	0.71 0.95	0.95 1.19
30	50	1.19	1.97	30 40	40 50	1.19 1.58	1.58 1.97
50	80	1.97	3.15	50 65	65 80	1.97 2.56	2.56 3.15
80	120	3.15	4.73	80 100	100 120	3.15 3.94	3.94 4.73
120	180	4.73	7.09	120 140 160	140 160 180	4.73 5.52 6.30	5.52 6.30 7.09
180	250	7.09	9.85	180 200 225	200 225 250	7.09 7.88 8.86	7.88 8.86 9.85
250	315	9.85	12.41	250 280	280 315	9.85 11.03	11.03 12.41
315	400	12.41	15.75	315 355	355 400	12.41 13.98	13.98 15.75
400	500	15.75	19.69	400 450	450 500	15.75 17.72	17.72 19.69

* These are used, in certain cases, when considered as necessary, for the deviations a to c and r to zc or A to C and R to ZC.

2.1.2 *Standard tolerances*

Eighteen grades of tolerance are provided, each corresponding to one of the tolerances, known as the standard tolerances and called IT 01, IT 0, IT 1 to IT 16, the numerical values of which are given, for each nominal diameter step, in Table 7, page 22.

2.1.2.1 FOR GRADES 5 TO 16, the values are determined from the tolerance unit i, as follows:

when i is expressed in microns for D expressed in millimetres,

$$i = 0.45 \sqrt[3]{D} + 0.001 D \text{ *}$$

when i is expressed in 0.001 in for D expressed in inches,

$$i = 0.052 \sqrt[3]{D} + 0.001 D$$

The values of the standard tolerances corresponding to grades 5 to 16 are given in Table 2 below, in terms of the tolerance unit i:

TABLE 2. — **Values of standard tolerances corresponding to grades 5 to 16**

	IT 5	IT 6	IT 7	IT 8	IT 9	IT 10	IT 11	IT 12	IT 13	IT 14	IT 15	IT 16
Values	7 i	10 i	16 i	25 i	40 i	64 i	100 i	160 i	250 i	400 i	640 i	1000 i

NOTE.—Above IT 6, the tolerance is multiplied by 10 at each fifth step. ** This rule applies also, if necessary, beyond IT 16.

2.1.2.2 FOR GRADES BELOW 5, the values are calculated as follows:

TABLE 3. — **Values of standard tolerances corresponding to grades 01, 0 and 1**

	IT 01	IT 0	IT 1
Values in microns for D in millimetres	0.3 $+0.008 D$	0.5 $+0.012 D$	0.8 $+0.020 D$
Values in 0.001 in for D in inches	$0.012+0.008 D$	$0.02+0.012 D$	$0.03+0.020 D$

NOTE.—The values IT 2 to IT 4 have been scaled approximately geometrically between the values of IT 1 and IT 5 (see Table 7, page 22).

* This formula has been empirically calculated on the basis of former national standards and taking account of the fact that, for the same manufacturing conditions, the relationship between the values of the manufacturing errors and the diameter is approximately a parabolic function.

** But for one exception : the value 7.5 is rounded off to 8 for grade 6 in the diameter step above 3 up to 6 mm.