International Standard 5166

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

System of cone fits for cones from $C = 1:3$ to $1:500$, lengths from 6 to 630 mm and diameters up to 500 mm

Système d'ajustements coniques pour pièces coniques de conicité $C = 1:3$ *à* $1:500$, *de longueur* 6 *à* 630 mm *et de diamètre jusqu'à* 500 mm

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5166 was developed by Technical Committee ISO/TC 3, *Limits and fits*, and was circulated to the member bodies in June 1981.

It has been approved by the member bodies of the following countries :

Australia	Hungary	Romania
Austria	India	South Africa, Rep. of
Belgium	Italy	Spain
Brazil	Japan	Sweden
Bulgaria	Korea, Rep. of	Switzerland
China	Mexico	United Kingdom
Czechoslovakia	Netherlands	USA
Egypt, Arab Rep. of	New Zealand	USSR
Germany, F. R.	Poland	Yugoslavia

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Canada
France

System of cone fits for cones from C = 1 : 3 to 1 : 500, lengths from 6 to 630 mm and diameters up to 500 mm

0 Introduction

This International Standard is derived from ISO 286, and is a complement to ISO 1947 and ISO 1119.

The annex dealing with the effect on the cone fit of the departures of the internal and external cones, from the basic cone, has been provided for information only, and is not an integral part of this International Standard.

1 Scope and field of application

This International Standard applies to cones which are dimensioned and toleranced according to Method 1, Basic Taper method of ISO 3040; this means that the tolerances limit the variation of penetration of mating surfaces, each surface being within two limiting profiles of the same taper corresponding to the maximum material condition (MMC) and the least material condition (LMC). For dimensioning and tolerancing cones on drawings, see ISO 3040.

2 References

ISO 286, *ISO system of limits and fits — Part 1 : General, tolerances and deviations.*[1]

ISO 1119, *Series of conical tapers and taper angles.*

ISO 1947, *System of cone tolerances for conical workpieces from C* = 1 : 3 *to* 1 : 500 *and lengths from* 6 *to* 630 mm.

ISO 3040, *Technical drawings — Dimensioning and tolerancing cones.*

3 Formation of cone fits

A special feature of cone fits is that clearances and interferences are made by defining the axial position of the assembled internal and external cones with respect to each other. The conical workpieces to be assembled are manufactured separately according to the tolerance zones indicated for their common basic cone diameter. Because of the methods of manufacture *a hole basis system of fits is recommended.*

The axial position of the conical workpieces with respect to each other for obtaining the required clearance or interference of the cone fit in the final position of the assembled conical workpieces can be made by different methods. These are

a) by constructional formation;

b) by dimensional location;

c) by an actual axial displacement;

d) by an actual axial displacement with a defined assembly force.

3.1 Constructional formation

A cone fit resulting from the constructional formation of the workpieces to be assembled (see figure 1).

The axial position of the cones relative to each other in the final position (see 4.5.2) is determined by the form of the conical workpieces. Figure 1 shows a clearance cone fit in which the workpiece with the external cone has a collar which contacts the surface of the workpiece with the internal cone. This type of construction is also valid for an interference cone fit when the workpiece with the internal cone must be pressed on to the workpiece with the external cone in order to make contact at the collar.

3.2 Dimensional location

A cone fit made by the assembly of the conical workpieces to a predetermined axial position relative to each other, irrespective of the actual size of the mating cones (see figure 2).

The final position of the conical workpieces relative to each other is specified on the drawing (see figure 2) and, if need be, marked on the internal cone and on the external cone.

3.3 Axial displacement

A cone fit made by axial displacement of the (actual) cones with respect to each other by a fixed amount, starting from the actual starting position (see 4.5.1.3).

1) At present at the stage of draft. (Revision of ISO/R 286-1962).

In order to reach the required clearances or interferences of the cone fit, the necessary axial displacement (dimension E_a in figure 3 for the example of an interference cone fit) is indicated from the actual starting position.

3.4 Axial displacement with a defined assembly force

A cone fit made by displacement of the actual cones using a defined assembly force from the actual starting position (see figure 4).

For an interference cone fit, the final position of the assembled conical workpieces relative to each other is reached on assembly by a defined axial force (F_s).

4 Definitions

The definitions used for cylindrical fits in ISO 286 are also valid in this International Standard.

Definitions for cones, cone dimensions and cone tolerances are given in ISO 1947.

4.1 cone fit : The relationship resulting from the difference on assembly between the cone diameters of conical workpieces (internal cone and external cone) having circular sections and the same basic cone angle α or the same rate of taper C.

The definition for a cone fit with a circular section is also applicable for taper workpieces with other sections, for example, prismatic parts, wedges, etc.

4.2 character of a cone fit : Defined by clearances or interferences measured normal to the cone axis.

The clearances and interferences are effective normal to the conical surfaces, but are indicated and measured normal to the cone axis. The differences between the values shown normal to the cone surface on the one hand and normal to the cone axis on the other are negligible for cones with rates of taper up to 1 : 3 and can be ignored for practical purposes.

4.3 Axial displacement for single conical workpieces

4.3.1 axial displacement (EN) **:** The calculated axial distance of the cone with regard to the basic cone [see figures 5a) to 5d)].

It has importance only for the calculation of the axial displacement for cone assemblies (see 4.4.2).

4.3.1.1 minimum axial displacement (EN_{min}) **:** That displacement relative to the basic cone which is calculated from the fundamental deviation for the basic cone diameter.

4.3.1.2 maximum axial displacement (EN_{max}) **:** That displacement relative to the basic cone which is calculated from the fundamental deviation and the tolerance for the basic cone diameter.

4.4 Definitions for constructional and dimensional location cone fits

4.4.1 variation of cone diameter fit (T_{DP}) **:** The tolerance of the fit; it is the possible variation of the diametral clearance and/or interference between the conical workpieces to be assembled and is the absolute value of the difference between the maximum and minimum clearances and interferences respectively, (see figures 1 to 6).

$$T_{DP} = S_{max} - S_{min} \text{ or } U_{max} - U_{min}$$

where S_{max} and S_{min} are the maximum and minimum diametral clearances respectively and U_{max} and U_{min} are the maximum and minimum diametral interferences respectively.

The variation of cone diameter fit is equal to the sum of the cone diameter tolerances of the internal cone T_{Di} and the external cone T_{De} i.e. :

$$T_{DP} = T_{Di} + T_{De}$$

4.4.2 axial displacement for cone assemblies (EP) **:** The axial displacement of the conical workpieces to be assembled with respect to each other; it is the algebraic sum of the calculated displacements EN_i of the internal cone and EN_e of the external cone (referred to the basic cone).

4.4.2.1 minimum axial displacement for cone assemblies (EP_{min}) **:** The displacement which is calculated from the sum of EN_{imin} of the internal cone and EN_{emin} of the external cone.

$$EP_{min} = EN_{imin} + EN_{emin}$$

NOTE — For the basic hole system, $EN_{imin} = 0$

4.4.2.2 maximum axial displacement for cone assemblies (EP_{max}) **:** is the displacement which is calculated from the sum EN_{imax} of the internal cone and EN_{emax} of the external cone :

$$EP_{max} = EN_{imax} + EN_{emax}$$

NOTE — For the basic hole system, $EN_{imax} = \frac{1}{C} \times IT$

4.5 Definitions for axial displacement type cone fits

4.5.1 starting position (P) : The axial position of the conical workpieces with respect to each other at which the cones contact without force.

4.5.1.1 limit starting positions (P_1 and P_2) : Those extreme axial positions of the conical workpieces to be assembled with respect to each other which are calculated from the limit cones at contact without force, the limit cones being those (extreme) cones having basic cone angle and cone diameter tolerances T_{Di} and T_{De} respectively.

The limit starting positions are calculated from the assembly of the smallest possible internal cone with the largest possible external cone on the one hand, and the largest possible internal cone with the smallest possible external cone on the other hand, (see figure 7).

4.5.1.2 tolerance on the starting positions (T_P) : The maximum axial distance between the reference planes of the internal cone and the external cone relative to each other, resulting from the calculated limit starting positions P_1 and P_2 (see figure 7).

The tolerance T_P of the starting position is calculated from

$$T_P = \frac{1}{C} \times (T_{Di} + T_{De})$$

4.5.1.3 actual starting position (P_a) : The axial position of the actual cones (internal cone and external cone) relative to each other at which they contact without force (see figures 3 and 4).

NOTE — This parameter is important in the production of cone fits and must lie within the limit starting positions P_1 and P_2 (see figure 7).

4.5.2 final position (P_f) : That axial position prescribed for the conical workpieces with respect to each other in the final state in which the required clearances or interferences exist.

4.5.3 assembly force (F_s) : The force to be applied axially in the assembly of the conical workpieces starting from the actual starting position in order to reach a defined interference cone fit in the final position of the cones (see figure 4).

4.5.4 axial displacement for assembled cones (E_a) : The algebraic difference measured axially between the separation of the reference planes of the internal and external cones respectively at the actual starting position (P_a), and the separation of the reference planes at the final position (P_f) required for the cone fit (figure 3 gives an example of an interference cone fit).

The amount of the axial displacement E_a depends on the rate of taper C of both conical workpieces to be assembled.

4.5.4.1 minimum axial displacement (E_{amin}) : The axial displacement giving the minimum clearance and the minimum interference respectively in the final position of the conical workpieces (figure 6 gives an example of an interference cone fit).

4.5.4.2 maximum axial displacement (E_{amax}) : The measured axial displacement giving the maximum clearance or the maximum interference respectively in the final position of the conical workpieces (figure 6 gives an example of an interference cone fit).

4.5.4.3 tolerance on the axial displacement (T_E) : The difference between the minimum and maximum axial displacements (see figure 6), i.e.

$$T_E = E_{amax} - E_{amin}$$

5 Calculation of axial displacements for the hole basis system of cone fits

5.1 Axial displacement of the single conical workpiece (*EN*) with regard to the basic cone

For each of the conical workpieces to be assembled, the upper and lower deviation and the ISO symbol respectively is indicated for the basic cone diameter in a reference plane normal to the cone axis. Figures 5a) to 5c) show for the hole basis fit system the possibilities of axial displacements *EN* of the external cones relative to the basic cone for each of the ISO symbols for the cone diameter tolerance zones. Figure 5d) shows the axial displacement for an internal cone with tolerance position *H* (i.e. basic hole).

These displacements *EN* are of importance for the calculation of the axial displacement of two conical workpieces relative to each other. Using the tolerance system of ISO 286, for the basic cone diameter of a cone fit, the following axial displacements (*EN*) result :

a) A displacement EN_T [see figures 5b) and 5d) and table 1] resulting from the standard tolerance *IT*

$$EN_T = \frac{1}{C} \times IT$$

b) Minimum and maximum displacements EN_{emin}, EN_{emax} [see figure 5a) and 5c) and tables 1 and 2], a combination of the fundamental deviation and the standard tolerance

$$EN_{emin} = \frac{1}{C} \times \text{fundamental deviation}$$

$$EN_{emax} = EN_{emin} + EN_{eT}$$

c) Minimum and maximum displacements EN_{imin} and EN_{imax} [see figure 5d) and table 1] for the internal cone resulting from the standard tolerance *IT* only since the fundamental deviation for the basic hole is zero.

$$EN_{imin} = 0$$

$$EN_{imax} = EN_{iT}$$

5.2 Axial displacement type cone fits

5.2.1 Axial displacements (E_a) from the actual starting position (P_a)

From the actual starting position (P_a) the axial displacement of the internal cone relative to the external cone results in a clearance fit (positive displacement, i.e. moving apart) or an interference fit (negative displacement, i.e. forcing together).

For a clearance fit, the minimum axial displacement giving the minimum clearance is

$$E_{amin} = \frac{1}{C} \times S_{min}$$

and the maximum axial displacement giving the maximum clearance is

$$E_{amax} = \frac{1}{C} \times S_{max}$$

For an interference fit, the minimum axial displacement giving the minimum interference (to obtain the necessary securing force) is

$$E_{amin} = \frac{1}{C} \times U_{min}$$

and the maximum axial displacement giving the maximum interference with regard to the strength of the cone fit is

$$E_{amax} = \frac{1}{C} \times U_{max}$$

NOTE — The maximum interference U_{max} can be reduced in order to avoid an excessive maximum displacement E_a in regard to fabrication.

5.2.2 Tolerance (T_E) of the axial displacement (E_a)

Starting from the actual starting position P_a, the displacement to be used in order to reach the required cone fit must lie between E_{amin} and E_{amax} calculated according to 5.2.1, i.e. the tolerance $T_E = E_{amax} - E_{amin}$.

Because of the uncertainties in manufacturing the cones and in measuring the displacement, it is recommended that the calculated displacement E_{amin} be slightly increased, and also E_{amax} slightly reduced. In so doing, the actual tolerance T_E, resulting from $E_{amax} - E_{amin}$ is reduced in practice.

5.3 Dimensional location type cone fits

5.3.1 Axial displacement (EP) of the conical workpieces to be assembled with each other (fit displacement)

The axial displacement (EP) of the conical workpieces with respect to each other is the algebraic sum of the calculated displacements (EN_i) referred to the basic cone, of the internal cone and (EN_e) of the external cone.

$$\text{Minimum displacement } EP_{min} = EN_{emin}$$

$$\text{Maximum displacement } EP_{max} = EN_{imax} + EN_{emax} = EN_{iT} + EN_{eT} + EN_{emin}$$

The values given in tables 1 and 2 for EN_T and EN_{emin} respectively are derived for cones with a rate of taper $C = 1 : 10$ from the values of IT grades and fundamental deviations given in ISO 286.

For cones with rates of taper other than $C = 1 : 10$, the appropriate axial displacement for the required tolerance class is calculated from tables 1 and 2 and then multiplied by the conversion factor for the required rate of taper given in table 3.

Table 1 gives the axial displacement (EN_T) of the internal and external cones with regard to the basic cone resulting from tolerance grades IT 0 to IT 16 as given in ISO 286. The values apply for cone rates of taper $C = 1 : 10$; they are given in micrometres for tolerance grades up to IT 5 and millimetres for tolerance grades IT 6 to IT 16 inclusive.

Table 2 gives the axial displacement (EN_{emin}) of the external cone with regard to the basic cone resulting from the fundamental deviations a to zc given in ISO 286 for the basic cone diameter of an external cone with a rate of taper $C = 1 : 10$.

Table 3 gives the conversion factors to be applied to the values given in tables 1 and 2 for the axial displacement of all rates of taper (other than $C = 1 : 10$) given in ISO 1119.

6 System of cone fits

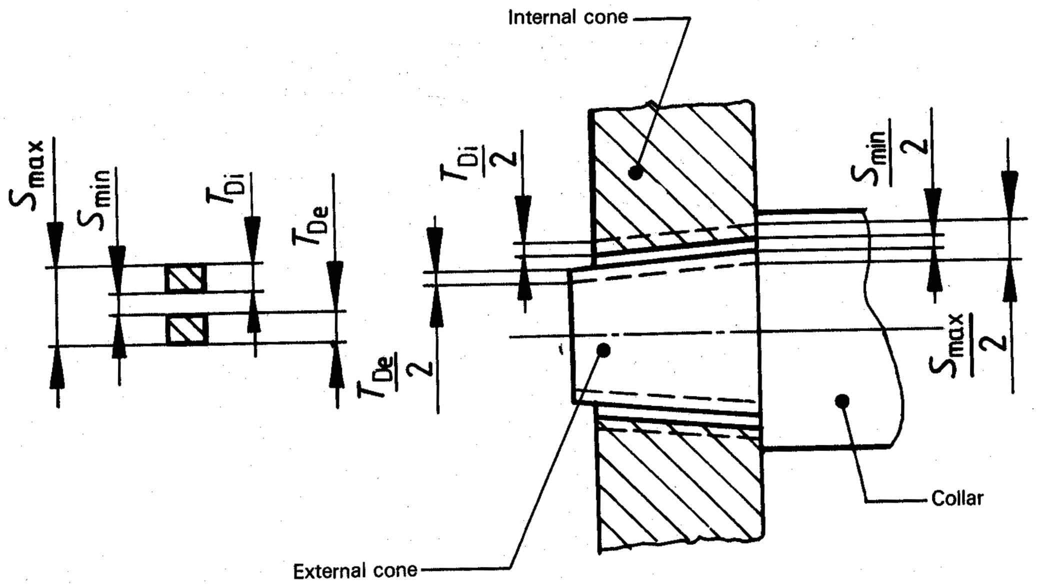


Figure 1 — Cone clearance fit made by constructional formation (Final position P_f fixed by contact at a collar)

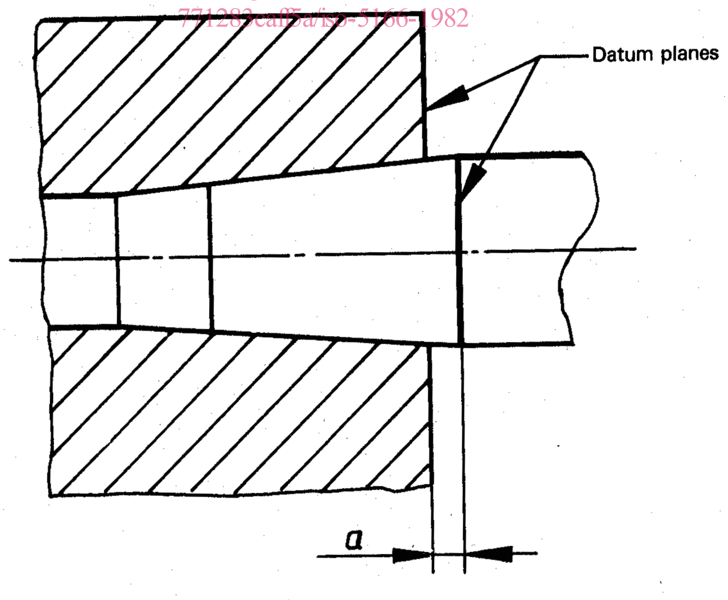


Figure 2 — Cone interference fit made by pressing in to a defined dimension (Final position P_f fixed by distance a)

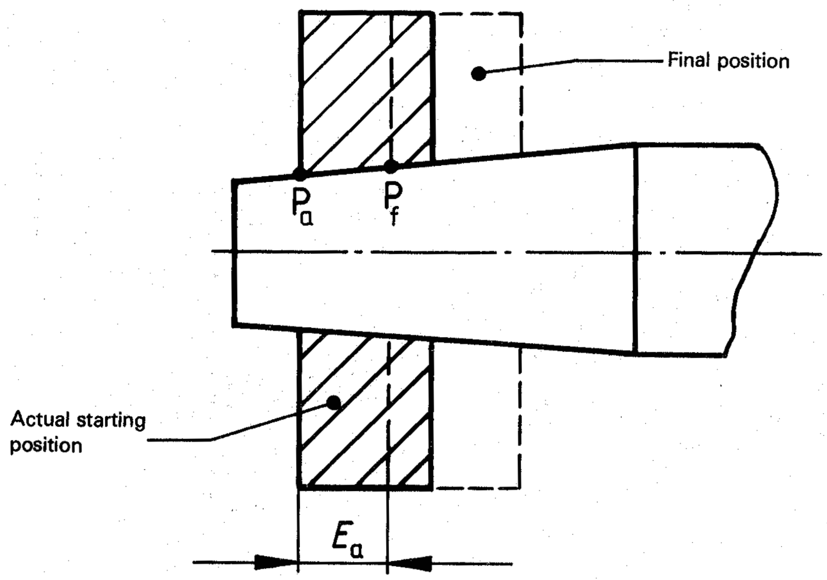


Figure 3 — Cone interference fit made by a defined axial displacement of the cones with respect to each other from the actual starting position P_a (Pressing in and on respectively by a defined displacement E_a)

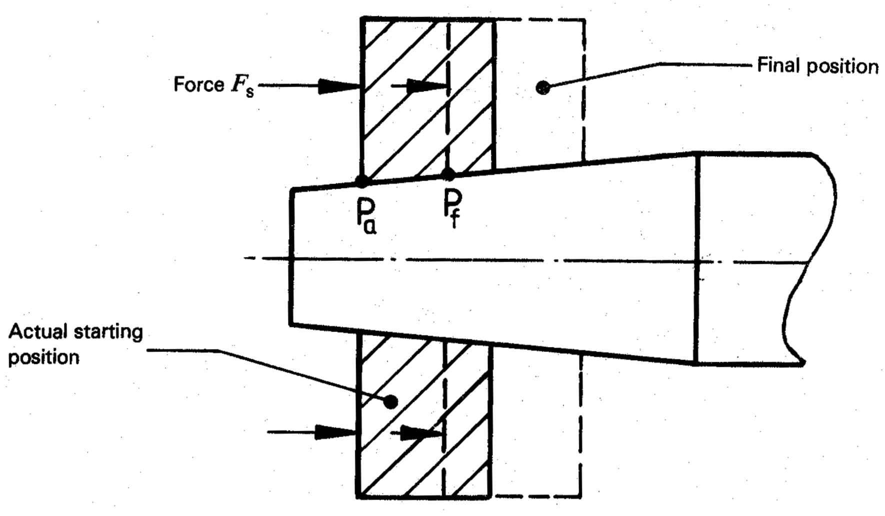
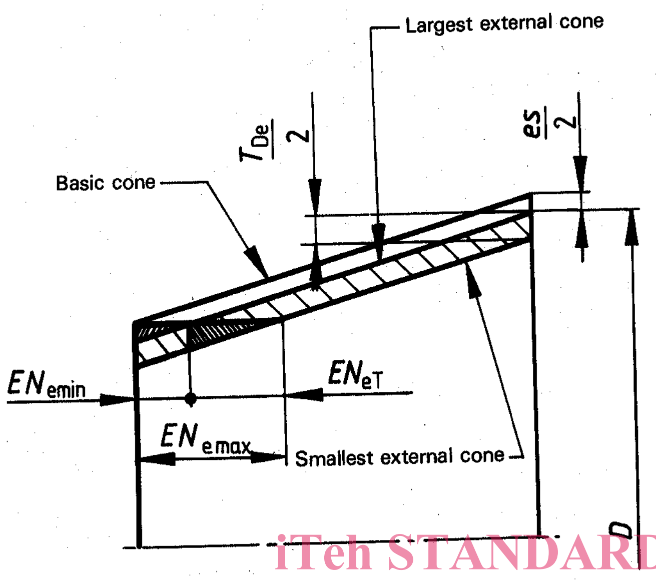
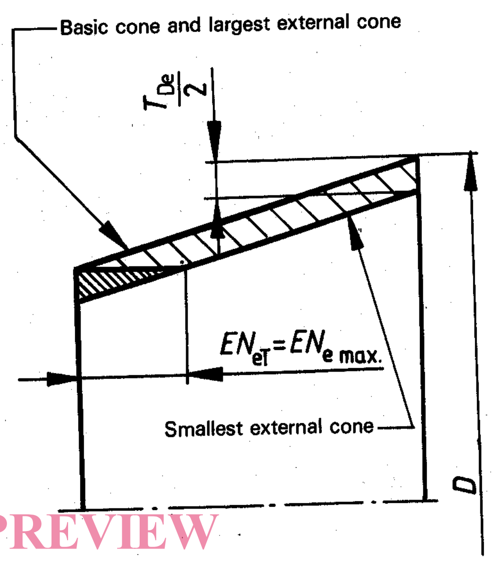


Figure 4 — Cone interference fit made by a defined force of assembly from the actual starting position P_a (Pressing in and on respectively by a defined force of assembly F_s)

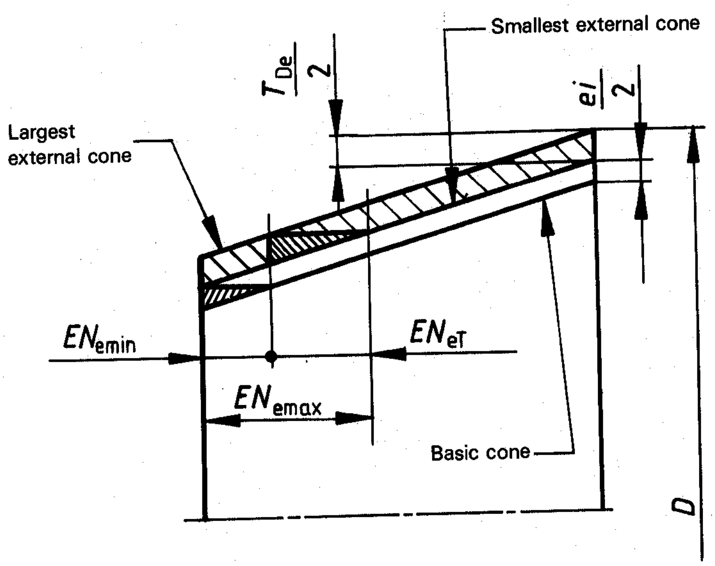
es = upper deviation
ei = lower deviation } fundamental deviations

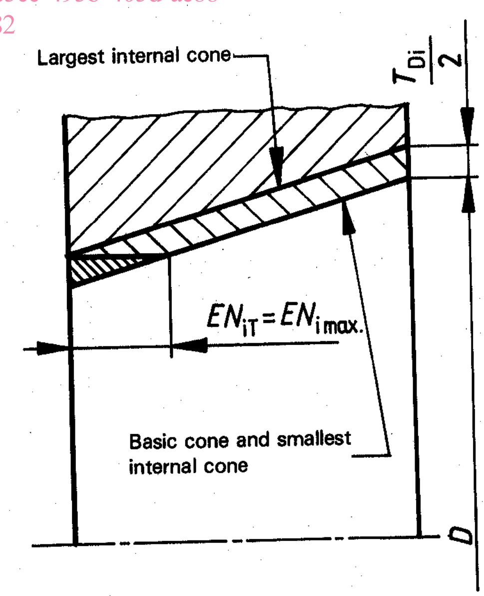




a) External cone — Positions of deviations a to g

b) External cone — Position of deviation h





c) External cone — Positions of deviations n to zc

d) Internal cone — Position of deviation *H*

Figure 5 — Axial displacements *EN* of the single conical workpiece with regard to the basic cone (basic displacement)

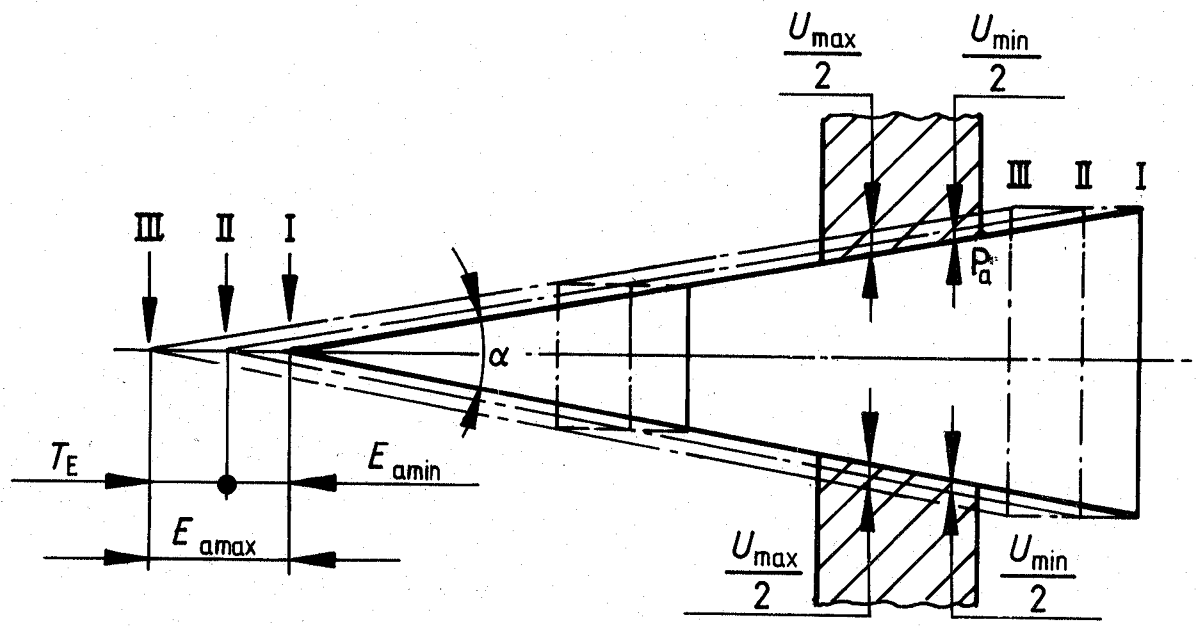


Figure 6 — Maximum and minimum interference of a cone interference fit made by a defined axial displacement of the cones with respect to each other from the actual starting position P_a (Pressing in and on respectively by displacement E_{amin} and E_{amax} respectively)

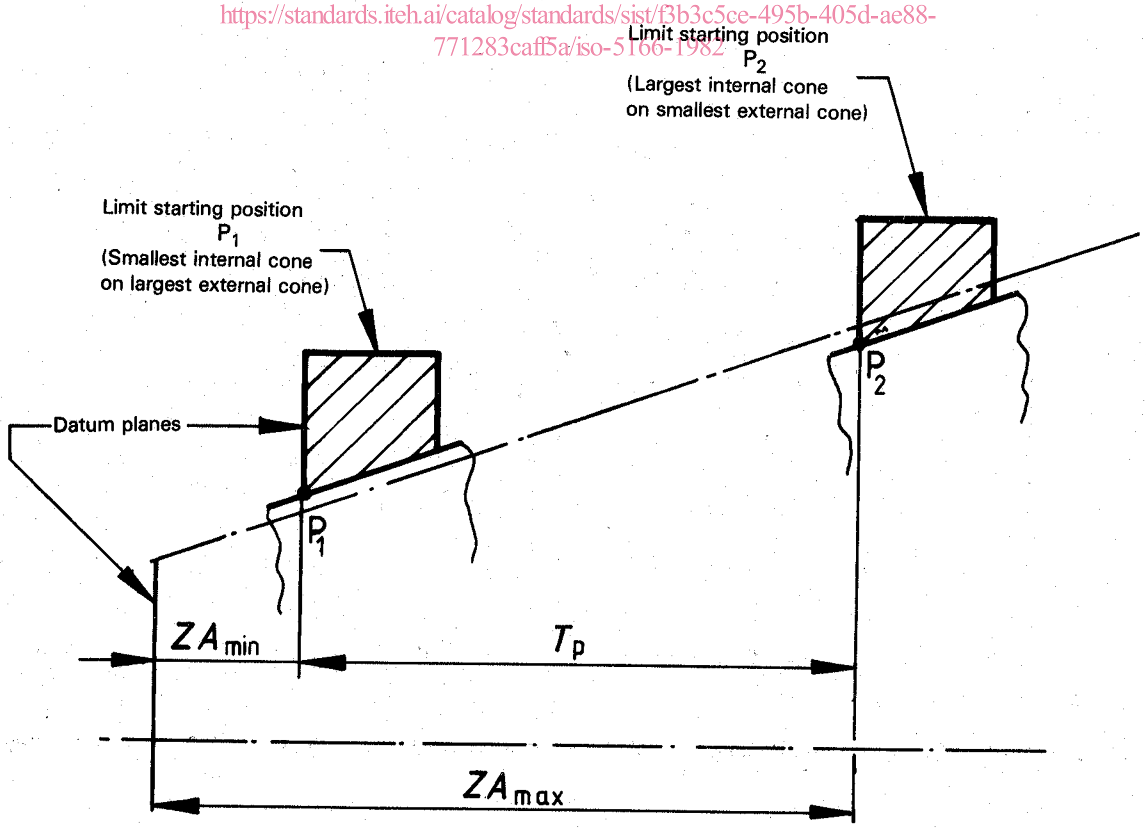


Figure 7 — Limit starting positions

Table 1 — Axial displacement EN_T of the internal cone and the external cone respectively, with regard to the basic cone resulting from the standard tolerances IT 01 to IT 16 according to ISO 286 for the basic cone diameter — For rate of taper $C = 1 : 10$[1)]

Cone diameter range mm		Values for EN_T in micrometres for							Values for EN_T in millimetres for										
from	to	IT 01	IT 0	IT 1	IT 2	IT 3	IT 4	IT 5	IT 6	IT 7	IT 8	IT 9	IT 10	IT 11	IT 12	IT 13	IT 14	IT 15	IT 16
	3	3	5	8	12	20	30	40	0,06	0,10	0,14	0,25	0,40	0,60	1	1,4	2,5	4	6
3	6	4	6	10	15	25	40	50	0,08	0,12	0,18	0,30	0,48	0,75	1,2	1,8	3	4,8	7,5
6	10	4	6	10	15	25	40	60	0,09	0,15	0,22	0,36	0,58	0,90	1,5	2,2	3,6	5,8	9
10	18	5	8	12	20	30	50	80	0,11	0,18	0,27	0,43	0,70	1,1	1,8	2,7	4,3	7	11
18	30	6	10	15	25	40	60	90	0,13	0,21	0,33	0,52	0,84	1,3	2,1	3,3	5,2	8,4	13
30	50	6	10	15	25	40	70	110	0,16	0,25	0,39	0,62	1	1,6	2,5	3,9	6,2	10	16
50	80	8	12	20	30	50	80	130	0,19	0,30	0,46	0,74	1,2	1,9	3	4,6	7,4	12	19
80	120	10	15	25	40	60	100	150	0,22	0,35	0,54	0,87	1,4	2,2	3,5	5,4	8,7	14	22
120	180	12	20	35	50	80	120	180	0,25	0,40	0,63	1	1,6	2,5	4	6,3	10	16	25
180	250	20	30	45	70	100	140	200	0,29	0,46	0,72	1,15	1,85	2,9	4,6	7,2	11,5	18,5	29
250	315	25	40	60	80	120	160	230	0,32	0,52	0,81	1,3	2,1	3,2	5,2	8,1	13	21	32
315	400	30	50	70	90	130	180	250	0,36	0,57	0,89	1,4	2,3	3,6	5,7	8,9	14	23	36
400	500	40	60	80	100	150	200	270	0,40	0,63	0,97	1,55	2,5	4	6,3	9,7	15,5	25	40

1) For cones other than $C = 1 : 10$, the above values for the respective IT grades should be multiplied by the appropriate conversion factor given in table 3.