

BS 1916-3:2009



BSI Standards Publication

Limits and fits for engineering

Part 3: Guide to tolerances, limits and fits
for large diameters

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 28, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 30 September 2009. It was prepared by Technical Committee TDW/4, *Technical product realization*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 1916-3:1963, which is withdrawn.

Relationship with other publications

This British Standard is published in three parts:

Part 1 – Guide to limits and tolerances;

Part 2 – Guide to the selection of fits in BS 1916-1;

Part 3 – Guide to tolerances, limits and fits for large diameters.

The ISO 286 (BS EN 20286) series establishes the ISO code-system for tolerances of linear sizes and is published in the following parts:

ISO 286-1 (BS EN 20286-1), *ISO system of limits and fits – Part 1: Bases of tolerances, deviations and fits*;

ISO 286-2 (BS EN 20286-2), *ISO system of limits and fits – Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*.

The ISO 286 series covers the metric system of limits and fits; the BS 1916 series provides guidance and recommendations on the equivalent inch system (imperial).

Information about this document

In view of the time elapsed since its original publication in 1963, this British Standard was reviewed in detail in 2009. It was decided that the technical provisions of the previous edition were still generally applicable, but the figures have been redrawn for ease of use, the wording of some guidance updated for clarity, and the opportunity was taken to update references to other standards.

Use of this document

As a guide, this part of BS 1916 takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Contractual and legal considerations

This 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.

Section 1: Introductory

1 Scope

This part of BS 1916 gives guidance on tolerances, limits and fits for large diameters (19.69 in to 125 in).

In many industries, components in large sizes are made to interchangeable as well as to matched fits. There are many practical problems, however, in achieving interchangeable manufacture in large diameters, due mainly to difficulties of measurement.

Clause 4 and Clause 5 in Section 1 discuss the known difficulties which might be encountered and draw attention to those tolerances and fits where the greater difficulties might be expected to arise. Section 2 puts forward tables of tolerances, deviations and limits for shafts and holes.

It is strongly emphasized that these should be regarded as recommendations intended for trial purposes. They are published in the expectation that experience in their use will enable them to be confirmed or modified, and will help to bring to light deficiencies in measuring techniques.

An explanation of the system to which this standard forms an extension is contained in BS 1916-1.

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.

BS 1916-1:2009, *Limits and fits for engineering – Part 1: Guide to limits and tolerances*

3 Terms and definitions

For the purposes of this part of BS 1916, the terms and definitions given in BS 1916-1 apply.

4 A review of the problems

In the manufacture of parts in the size range of 19.69 in to 125 in as covered by this standard, a number of serious manufacturing and measuring problems arise which are not encountered when working in small sizes. This is especially so when it is necessary to produce large components to small tolerances on a universally interchangeable basis.

In the small size range of 0.040 in to 4.000 in, the number associated with the grade of tolerance (known as the fundamental tolerance) tends to be related in practice to a known degree of difficulty in manufacture. In addition, because changes in the size of the component in this size range due to normal fluctuations in temperature are an insignificant proportion of the tolerance, for parts made to IT6 or larger tolerances, they are usually ignored. Those whose main experience lies in the manufacture of parts of up to about 4.0 in might therefore form the opinion that the temperature of the workpiece can be ignored and

because it is known that tolerance increases with size, the manufacture of parts of 100 inches in diameter to IT6 tolerance will present similar but not substantially greater difficulties than the manufacture of smaller parts to this tolerance.

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

Figure 1a and Figure 1b show the relationship between the fundamental tolerances IT4, IT5, IT6, IT7 and IT8 and the change in the size in a steel workpiece due to a change of temperature of 1 °C, 2 °C, 3 °C, 4 °C, 5 °C, 6 °C, 8 °C and 10 °C over the size range of 0 in to 19.69 in and 19.69 in to 125 in. These figures illustrate very clearly that it is possible to manufacture parts of about 2 in diameter to IT6 tolerance and virtually ignore changes of up to five degrees in the temperature of a steel workpiece. The figures also show that a change in temperature of 5 °C on a 120 in steel workpiece absorbs 140% of the IT6 tolerance.

Figure 1a and Figure 1b also show that in the smaller sizes, any of the IT tolerances represent a much larger percentage of the size of the workpiece than in larger sizes. For example, the IT6 tolerance on a 1 in part is 0.000 5 in. For an increase in workpiece size of 120 times to 120 in, the tolerance only increases 10 times to 0.005 in.

Figure 1a and Figure 1b and the preceding explanations demonstrate the increased difficulty which occurs when manufacturing large parts to a tolerance which is considered a simple operation on small components. For this reason, the tolerances in this standard do not go below IT6. In addition, special warning should be given about the very serious and, in some cases, insurmountable difficulties which will be experienced in manufacturing parts to IT6 tolerances in the larger sizes covered in this standard.

When very small fit tolerances are essential on large parts, consideration should be given to the use of a technique known as "Matched fits", which is described in Annex A.

Assuming that particular care is taken, an error of 30 microinches (0.000 03 in) per in of diameter is appropriate. This error is equivalent to a temperature difference of 2.75 °C between a steel workpiece and the gauge.

In terms of measurement, therefore, the practice recommended in BS 1916-1 and BS 1916-2 of associating a hole of wider tolerance with a shaft of a given tolerance is not appropriate to large diameters.

The following conclusions have accordingly been drawn with regard to the measurement of sizes above 19.69 in.

- a) The accuracy of measurement of a size of a part which can be expected from a general precision engineering shop under normal conditions is not better than ± 30 microinches (0.000 03 in) per inch.
- b) The accuracy of measurement of a size of a part which can be expected from a precision engineering shop with very accurate equipment and considerable experience in such measurements is not better than ± 15 microinches (0.000 015 in) per inch.
- c) The accuracy of comparison of the sizes of parts which can be expected from a precision engineering shop under normal conditions is not better than ± 15 microinches (0.000 015 in) per inch.

Figure 1a Relationship between fundamental tolerance and temperature change for sizes up to 19.69 in

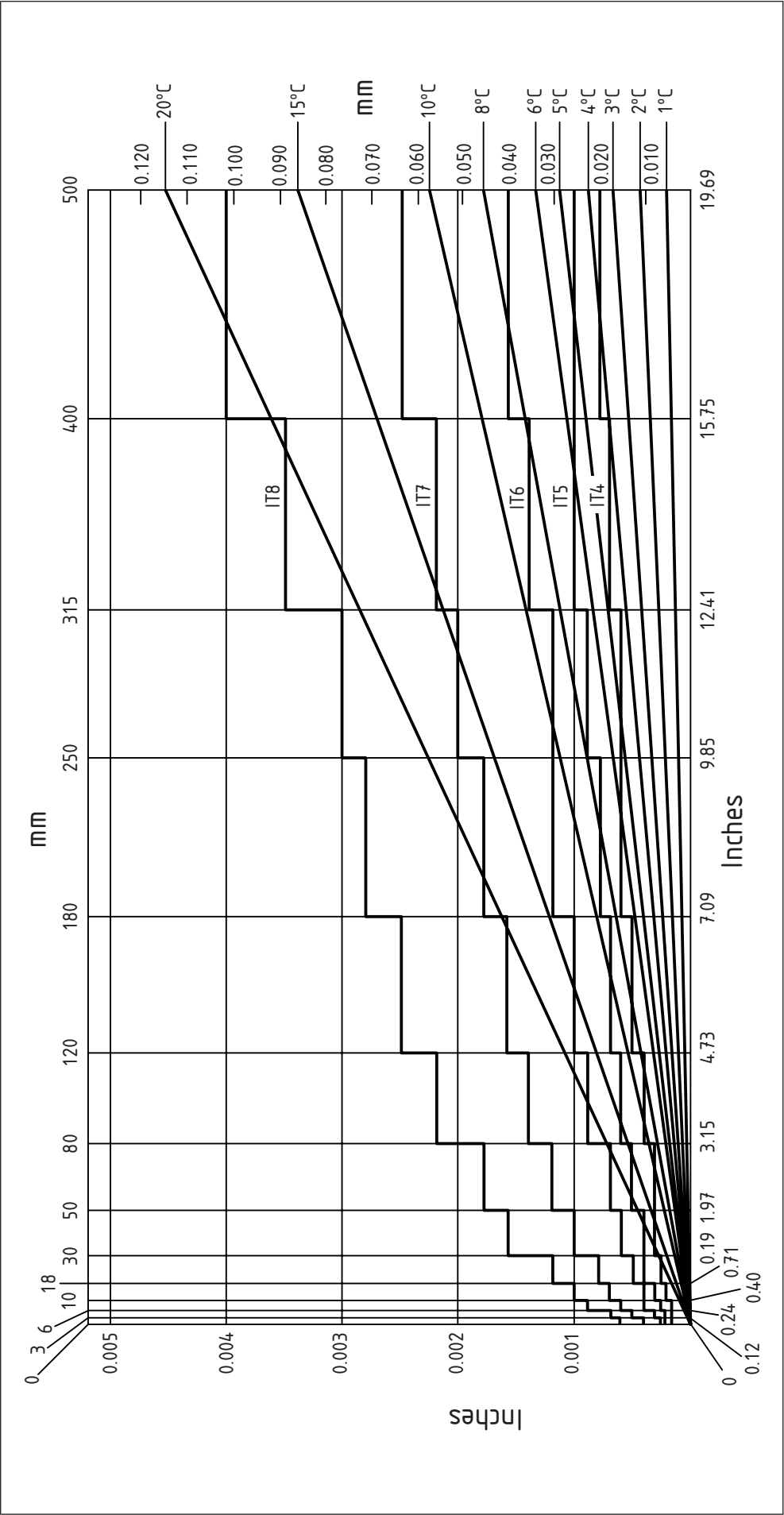
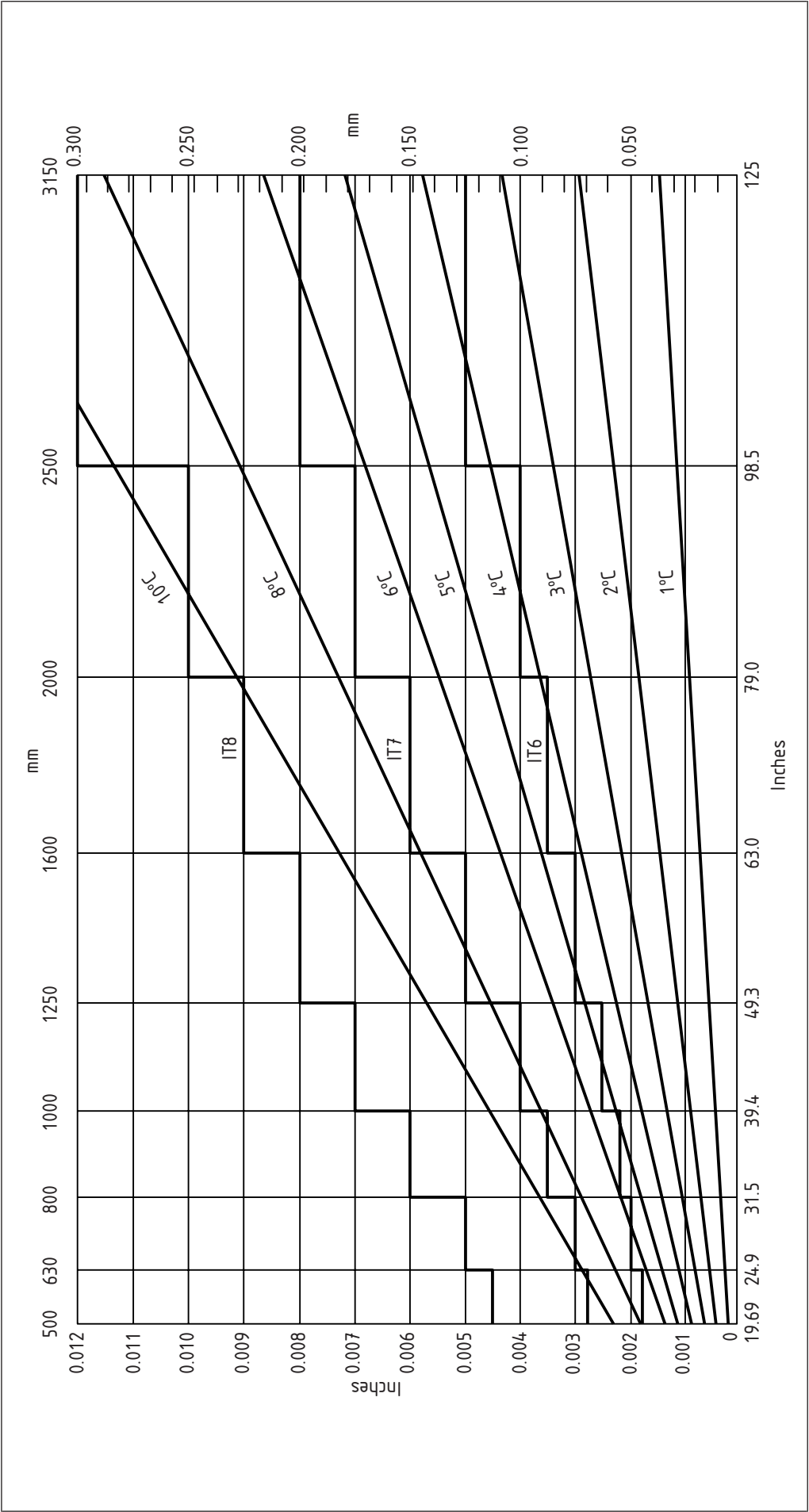


Figure 1b Relationship between fundamental tolerance and temperature change for sizes from 19.69 to 125 in



5 The practical effect of errors on tolerances and fits

The two common methods of mating large parts are to manufacture one to suit the other (matched fits), or to specify interchangeable limits of size. The first practice is carried out in the same shop, presumably using the same master measuring equipment or standards. In the other case, parts could conceivably be made in separate shops using different standards.

In either case, the important functional characteristic of the fit to be considered in the first place is the minimum clearance or the minimum interference.

In the case of matched fits (explained in greater detail in Annex A), there are two other important factors to be considered.

- a) As already mentioned, a single measuring standard is almost certainly used, so that measurement entails comparison of size rather than absolute determination.
- b) The designer, in specifying a tolerance on the required deviation or allowance, does not have to consider variations of fit resulting from two tolerances, but only from one; they may therefore be more generous with the tolerance they do specify.

Whether matched fits or normal interchangeable limits are chosen, however, the deviation is subject to encroachment from either end by the error of measurement.

Figure 2a and Figure 2b illustrate the practical significance of errors of measurement in the two methods.

Figure 2a Interference fits – interchangeable fits

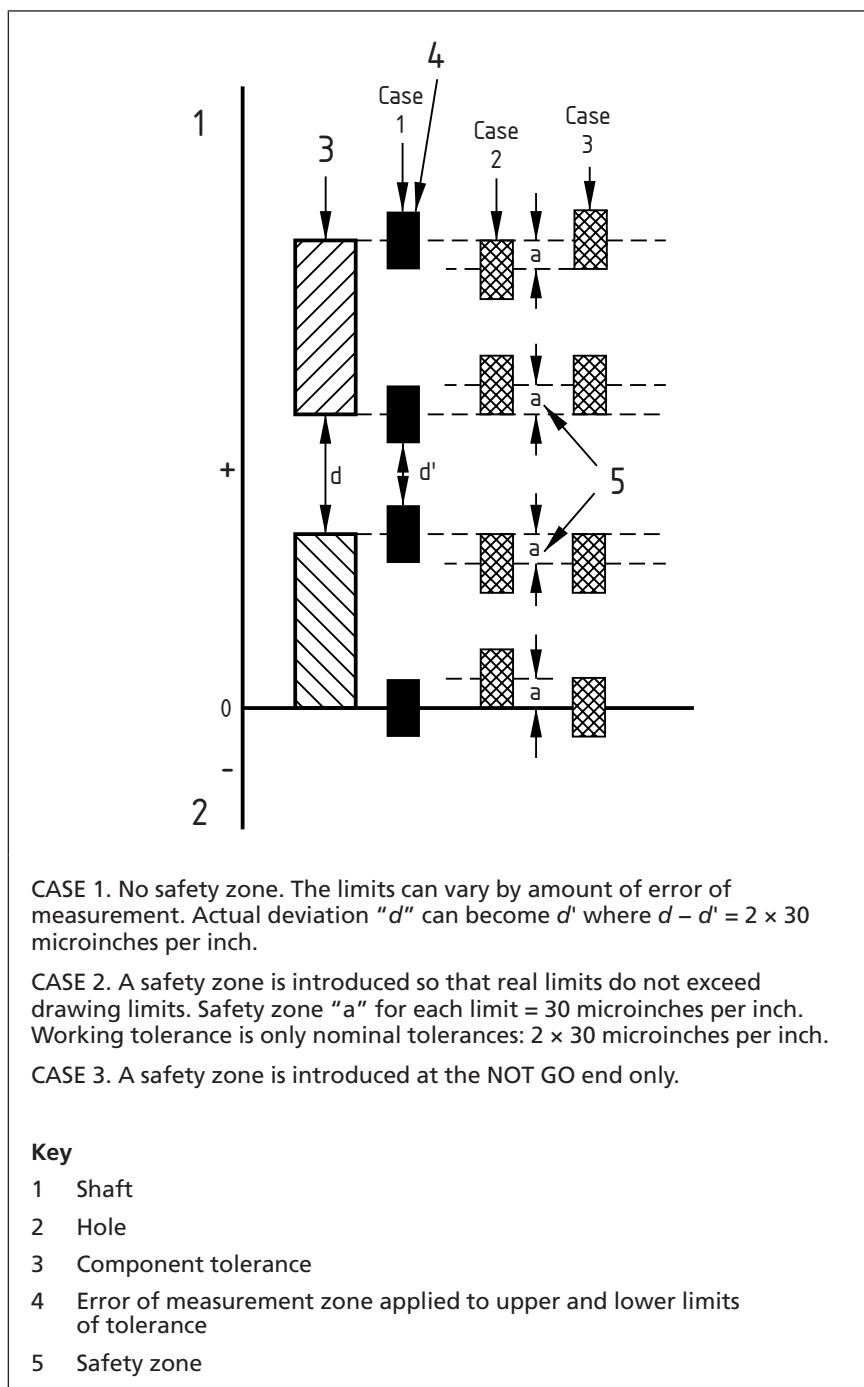
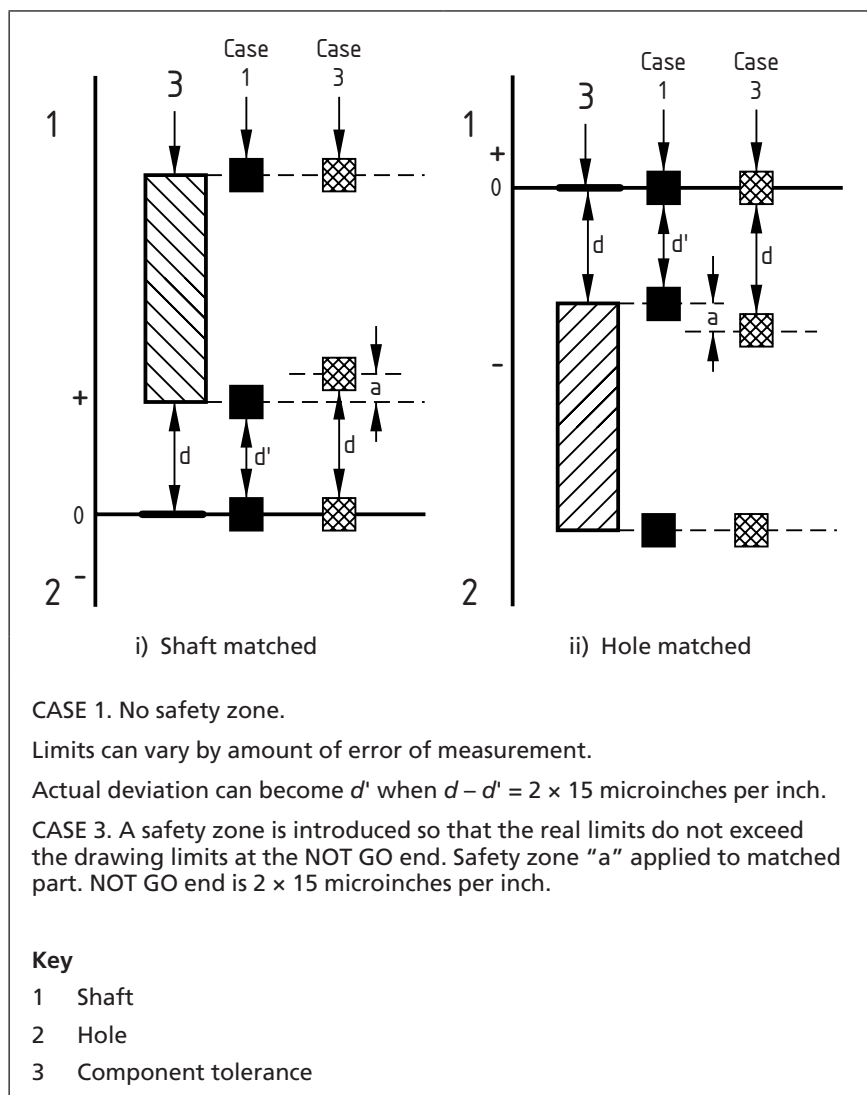


Figure 2b Interference fits – matched fits



In the case of normal interchangeable fits, if no safety zone is introduced, the deviation or allowance between the maximum material limits of the two components may be reduced by 60 microinches (0.000 06 in) per inch.

In many cases it is not unreasonable to allow 20% of the deviation to be absorbed by this error, i.e. the deviation should then be at least 300 microinches (0.000 3 in). If, however, safety zones are introduced to avoid encroaching on the deviation, the working tolerance of each component can be reduced by 60 microinches (0.000 06 in) per in, or half this amount if the often reasonable step is taken of introducing a safety zone only at the GO end.

As a substantial proportion of the tolerance could be involved in either case, tolerance grades of IT7 and finer become impractical. For example, for a diameter of 100 in, the encroachment at the GO end of the tolerance could be 0.006 in with a safety zone and 0.003 in without one, while the tolerance for IT7 is only 0.008 in and that for IT8 is only 0.012 in.

NOTE For an explanation of fundamental tolerance (IT) grades, see BS 1916-1.