

BS 1916-2:2009



BSI Standards Publication

Limits and fits for engineering

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

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 40, 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This British Standard supersedes BS 1916-2:1953, which is withdrawn.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 1953, 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.

1 Scope

This British Standard gives guidance on the selection of fits given in BS 1916-1.

The recommendations apply, in particular, to fits between cylindrical parts, designated as “holes” and “shafts”, in which case the term “size” refers to the diameter of the mating parts. The recommendations are also applicable to parts other than cylindrical, in which case the term “size” refers to a length, width or other dimension.

Tables of preferred sizes are included to avoid the indiscriminate selection of dimensions, and their use is strongly recommended.

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*

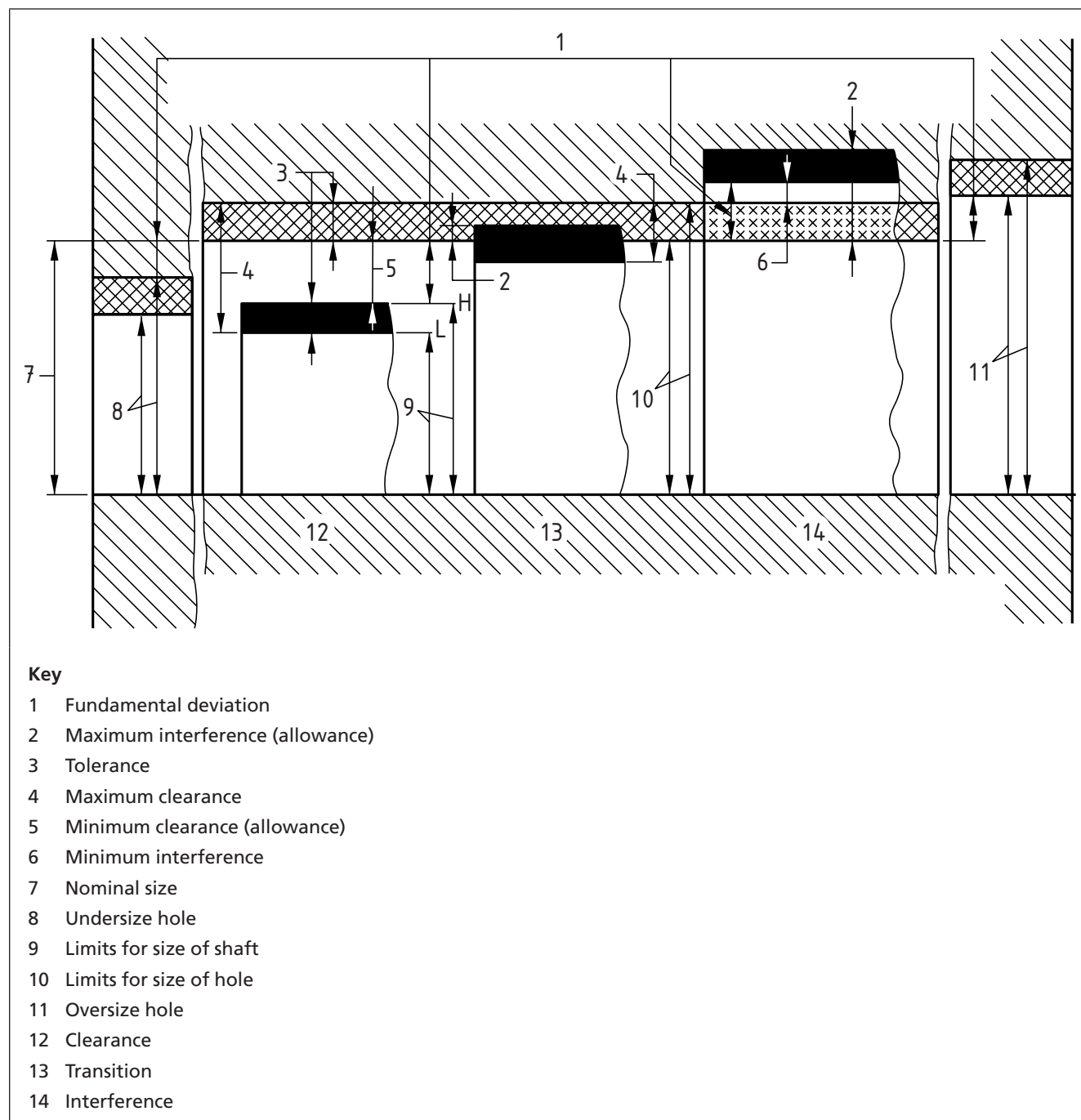
BS 8888, *Technical product specification – Specification*

3 Terms and definitions

For the purposes of this part of BS 1916, the following terms and definitions apply.

NOTE Figure 1 illustrates the basic definitions used in the text

Figure 1 Diagram showing disposition of limits and tolerances (unilateral hole basis)



4 Terminology

The disposition of the tolerance zone for a hole relative to the nominal size is denoted by a capital letter and the magnitude, or grade, of the tolerance by a suffix number, e.g. H7.

The disposition of the tolerance zone for a shaft relative to the nominal size is denoted by a small letter and the magnitude, or grade, of the tolerance by a suffix number, e.g. p6.

A fit is described by a combination of symbols, e.g. H7–p6 or H7/p6.

NOTE See BS 1916-1:2009, Clauses 6 and 7.

On production drawings, the actual limits for both hole and shaft should be stated by one of the methods recommended in BS 8888, so that the actual size of the part can be ascertained without reference to this standard. There are, however, certain circumstances, for example in general specifications, or on preliminary design drawings, in which it is convenient to state the particular type of fit by symbols only.

5 Hole tolerances

The following is a summary of the uses of the various grades of the unilateral hole H from H5 to H11.

- H5. This grade can normally only be produced by precision boring, fine internal grinding, or honing.
- H6. This grade can be produced by fine grinding or honing, and possibly hand reaming.
- H7. This grade is produced by grinding, broaching or careful reaming.
- H8. This grade is produced by boring or machine reaming.
- H9. This grade is used on high quality products for milled or slotted widths.
- H10. This grade is not normally used for diameter fits, although it can be used for drilled holes. It is used for milled widths on unimportant parts.
- H11. This grade is used for coarse drilled, punched or pressed holes on non-fitting parts.

6 Classification of fits

6.1 General

The whole range of fits is divided into three main classes:

- clearance;
- transition;
- interference.

Each main class, using the unilateral (H) hole, is further sub-divided into several types of fit; for example, clearance fits are divided into six types, from very fine to very coarse clearance. Each type of fit is classified by the letter symbol of the shaft which produces that type, for example: clearance fit, shaft “e”; or clearance fit, shaft “f”.

It is more convenient to refer to a type of fit by the shaft symbol only, e.g. an “e” shaft fit or an “f” shaft fit. The classification is given in Table 1 and those fits using the H7 and H8 holes are illustrated in Figure 2.

Table 1 Classification of types of fits

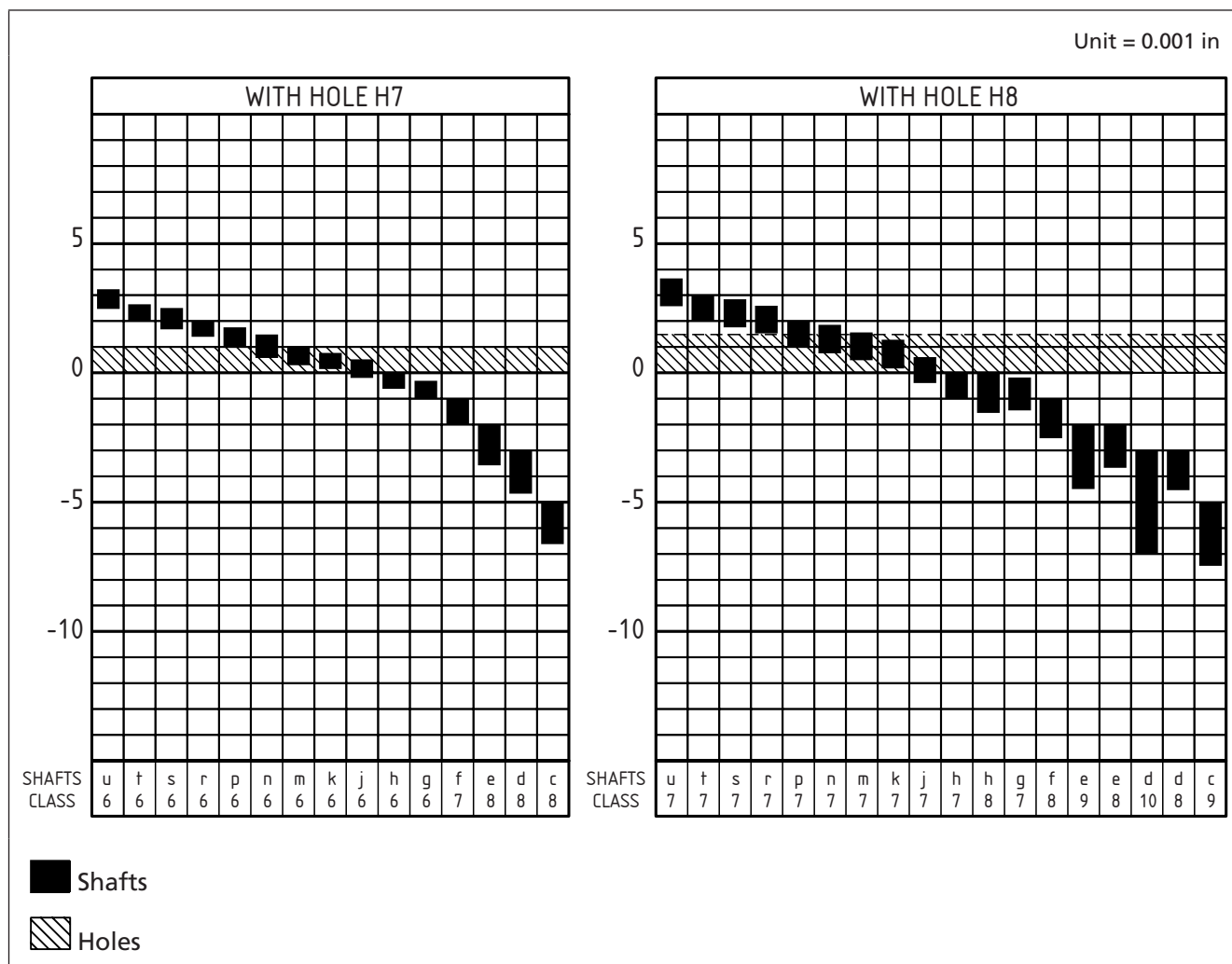
Classification		With holes				Remarks
		H6	H7	H8	H11	
Clearance	Shaft a	—	—	—	—	No general recommendation can be made
	Shaft b	—	—	—	—	
	Shaft c	—	c8	c9	c11	Extra loose running
	Shaft d	—	d8	d8/d10	d11	Loose running
	Shaft e	e7	e8	e8/e9	—	Easy running
	Shaft f	f6	f7	f8	—	Running
	Shaft g	g5	g6	(g7 ^A)	—	Close running
	Shaft h	h5	h6	h7/h8	h11	Slide
Transition	Shaft j	j5	j6	j7	—	Push
	Shaft k	k5	k6	k7	—	Easy keying
	Shaft m	m5	m6	m7	—	Tight keying
	Shaft n	—	n6	n7	—	Drive
		—	—	p7	—	—
		—	—	r7	—	—
Interference		n5	—	—	—	—
	Shaft p	p5	p6	—	—	Light press
	Shaft r	r5	r6	—	—	—
	Shaft s	s5	s6	s7	—	Press
	Shaft t	t5	t6	t7	—	—
	Shaft u	u5	u6	u7	—	Heavy press or shrink
	Shaft v	—	—	—	—	No general recommendations can be made
	Shaft x					
	Shaft y					
	Shaft z					

^{A)} This is a non-standard shaft. If required, the limits for it can be derived by reference to BS 1916-1.

The interference fits are classified on the basis of the hole H7 mated with the various shafts. The combination of these shafts with holes of coarser grades might in some cases result in a different type of fit. For example, in the case of the transition fit using shaft “n”, the fine grade, namely H6–n5, will in fact result in a true interference fit, whereas the combinations H8–p7 and H7–r7 will produce transition fits, not interference fits.

Using the unilateral (H) hole, the resulting fits in combination with the various shafts are as given in 6.2, 6.3 and 6.4.

Figure 2 The disposition of standard shaft fits with H7 and H8 holes for diameter range 1.19 in to 1.97 in



6.2 Clearance fits

6.2.1 Shafts a, b and c

These fits give a large clearance and are not widely used.

6.2.2 Shaft d

This fit is available in grades 8 to 11 and is generally suitable for loose running fits, e.g. plummer block bearings and loose pulleys.

6.2.3 Shaft e

This fit is available in grades 7, 8 and 9, and is recommended for general loose clearance fits, and for properly lubricated bearings requiring appreciable clearance. In the finer grades it can be used for large, high-speed, heavily loaded bearings such as turbo-generator and large electric motor bearings, according to circumstances.

6.2.4 Shaft f

This fit is available in grades 6, 7 and 8 and is recommended for use as a normal running fit. It is widely used as a normal grease-lubricated or oil-lubricated bearing where no substantial temperature differences are encountered. Typical applications are gearbox shaft bearings and the bearings of small electric motors, pumps, etc.

6.2.5 Shaft g

This fit is expensive to manufacture since the clearance is small, and it is not recommended as a running fit except in precision equipment where shaft loadings are very light. Typical applications are the bearings for accurate linkwork, and for piston and slide valves. In addition it is often used for spigot or location fits.

6.2.6 Shaft h

The upper shaft limit of this fit is zero, although in practice a slight clearance will usually be found. It exists in grades 5 to 11, and is widely used for non-running parts. It is useful for normal location and spigot fits and in the finer grades can be used as a precision sliding fit.

6.3 Transition fits

6.3.1 Shaft j

This is a transition fit averaging a slight clearance, and is available in grades 5 to 11. It is recommended for location fits, requiring slightly less clearance than is given with the "h" shaft, and where a slight interference is permissible. Typical applications are coupling spigots and recesses, gear rings clamped to steel hubs, etc.

6.3.2 Shaft k

This is a true transition fit averaging virtually no clearance. It is available in grades 5 to 11, and is recommended for location fits where a slight interference can be tolerated with the object, for example, of eliminating vibration.

6.3.3 Shaft m

This transition fit averages a slight interference, although appreciable assembly force will be required if the extremes are encountered. It is available in grades 5, 6 and 7.

6.3.4 Shaft n

This transition fit averages slightly more interference than the "m" shaft, and gives clearance only on extreme sizes. It is available in grades 5, 6 and 7, and is recommended for generally "tight" assembly fits. The finest grade (n5) is used as a true interference fit with the hole H6.

6.4 Interference fits

NOTE The factors governing the choice of an interference fit are such that only generalized recommendations can be made. Some general guidance is given here and some particular examples are quoted in the fit tables (Table 16 to Table 20), but it is recommended that in every case, careful consideration be given to the factors affecting the fit, i.e. diameter and length of engagement, materials, surface finish, induced stresses, gripping forces, assembly forces and assembly method, before the final choice is made.

6.4.1 Shafts

6.4.1.1 Shaft p

This will give a true interference fit with holes of grades 6 or 7, but with holes of grade 8 a transition fit will be obtained. The amount of interference is not excessive but is sufficient to give non-ferrous parts a light press fit which can be dismantled when required. It is the standard press fit for steel, cast iron or brass-to-steel assemblies. The amount of interference is too small for satisfactory fits to be obtained in very elastic materials, such as light alloys.

6.4.1.2 Shaft r

This combination will give a medium drive fit on ferrous parts, and on non-ferrous parts a light drive fit which can be easily dismantled when required. With the hole H8 an interference fit is obtained with diameters over 3.94 in; with smaller diameters a transition fit results.

6.4.1.3 Shaft s

This is used for the permanent or semi-permanent assembly of steel and cast iron members, the amount of interference being sufficient to provide considerable gripping force. When using elastic materials, e.g. light alloys, it is equivalent to the "p" shaft fit in ferrous materials. Typical applications are collars pressed on to shafts, valve seatings, etc.

6.4.1.4 Shafts t, u, v, x, y and z

These fits involve an increasing degree of interference, and no general recommendations can be made.

6.4.2 Tolerances

When determining the tolerances for an interference fit, it is necessary to check the minimum as well as the maximum interference; the former with regard to the longitudinal forces and torques to be transmitted, the latter with regard to the permissible stresses in the material and the assembling and dismantling forces. Therefore, for interference fits, the lower deviations of the shafts were determined in such a way as to provide a definite amount of minimum interference with reference to the upper deviations of the hole H7.

If D = geometric mean of the diameter size range in inches, the amounts of minimum interference in units of 0.001 in are as follows.

- Shaft s: Minimum interference = $0.4 \times D$ = (0.000 4 in per in of diameter).
- Shaft t: Minimum interference = $0.63 \times D$ = (0.000 63 in per in of diameter).
- Shaft u: Minimum interference = $1.0 \times D$ = (0.001 in per in of diameter).
- Shaft v: Minimum interference = $1.25 \times D$ = (0.001 25 in per in of diameter).
- Shaft x: Minimum interference = $1.6 \times D$ = (0.001 6 in per in of diameter).
- Shaft y: Minimum interference = $2.0 \times D$ = (0.002 in per in of diameter).
- Shaft z: Minimum interference = $2.5 \times D$ = (0.002 5 in per in of diameter).

7 Choice of fit

The tables of recommended fits are compiled on the unilateral (H) hole basis system, but if unilateral (h) shaft basis fits are required, the same maximum and minimum amounts of clearance or interference are provided by the equivalent shaft basis fits. For transition and interference fits, this condition is only satisfied if the holes are mated with a shaft of the next finer quality, e.g.:

- hole basis clearance fit H7–g6 = shaft basis clearance fit G7–h6;
- hole basis transition fit H7–m6 = shaft basis transition fit M7–h6.

A complete list of interchangeable fits is given in Table 2.

Table 2 Equivalent fits on the hole basis and shaft basis

Clearance		Transition		Interference	
Hole basis	Shaft basis	Hole basis	Shaft basis	Hole basis	Shaft basis
H7–c8	C8–h7	H6–j5	J6–h5	H6–n5	N6–h5
H8–c9	C9–h8	H7–j6	J7–h6		
H11–c11	C11–h11	H8–j7	J8–h7		
H7–d8	D8–h7	H6–k5	K6–h5	H6–p5	P6–h5
H8–d9	D9–h8	H7–k6	K7–h6	H7–p6	P7–h6
H11–d11	D11–h11	H8–k7	K8–h7	H6–r5	R6–h5
				H7–r6	R7–h6
H6–e7	E7–h6	H6–m5	M6–h5	H6–s5	S6–h5
H7–e8	E8–h7	H7–m6	M7–h6	H7–s6	S7–h6
H8–e8	E8–h8	H8–m7	M8–h7	H8–s7	S8–h7
H6–f6	F6–h6	H7–n6	N7–h6	H6–t5	T6–h5
H7–f7	F7–h7	H8–n7	N8–h7	H7–t6	T7–h6
H8–f8	F8–h8	H8–p7	P8–h7	H8–t7	T8–h7
H6–g5	G6–h5			H6–u5	U6–h5
H7–g6	G7–h6	H8–r7	R8–h7	H7–u6	U7–h6
H8–g7	G8–h7			H8–u7	U8–h7

The use of the unilateral hole basis is strongly recommended, but there is still a need for oversize and undersize holes for special applications, e.g. in the case of two different fits on the same shaft diameter. The system makes provision for this by a series of oversize holes (A to G), and a series of undersize holes (K to Z), which will be useful for outside diameter fits for ball bearings.

NOTE Tolerances for these holes are in BS 1916-1:2009, Table 2.

The tolerance symbols given in the tables of recommended fits (Table 6 to Table 20) are equally suitable for inch or metric measure (see BS EN 20286 for metric units of measurement).

8 Choice of tolerance

In the selection of the grade (i.e. magnitude) of the tolerance as applied to the mating parts of a particular fit, in order to obtain the most economic manufacture consistent with satisfactory performance, the tolerances should be as wide as possible. Figure 3 illustrates the degree of accuracy which can reasonably be expected from various machine and manufacturing processes under average conditions.

In the allocation of tolerances to the hole and shaft members of a fit, it is generally advisable, owing to the greater difficulty of producing a hole (in diameters of about 0.25 in and over), to allocate to it a slightly larger tolerance than to the shaft. In the tables of recommended fits, it is assumed that in general the hole member will be allocated a tolerance one grade coarser than the shaft member, e.g. that holes H7 will be mated with shafts of grade 6.

NOTE See BS 1916-3 for guidance on tolerances, limits and fits for large diameters.

9 Preferred sizes

The dimensions of manufactured products are determined from design calculations or from considerations of appearance and economy. In each instance, the size may vary within certain limits and the designer, having established a theoretical size, rounds it off to a convenient value. In rounding off, designers should refer to Table 3 and Table 4 and if possible select sizes from the "first choice" columns. If a finer division of size is required, reference should be made to Table 5, which lists a complete series of preferred inch sizes.

Figure 3 The degree of accuracy which can reasonably be expected from various manufacturing processes under average conditions

