Fundamentals of Drafting - Tolerances

Objectives:

1. To appreciate the need for tolerances in terms of
   (a) function
   (b) interchangeability
   (c) cost
2. To define the principal terms of limits and fits as specified in BS 4500 Part 1 and to sketch and label diagrams to illustrate them.
3. To differentiate between hole-basis fits and shaft-basis fits.
4. To calculate the maximum and minimum limits for shaft and holes given nominal sizes and classes of fits.

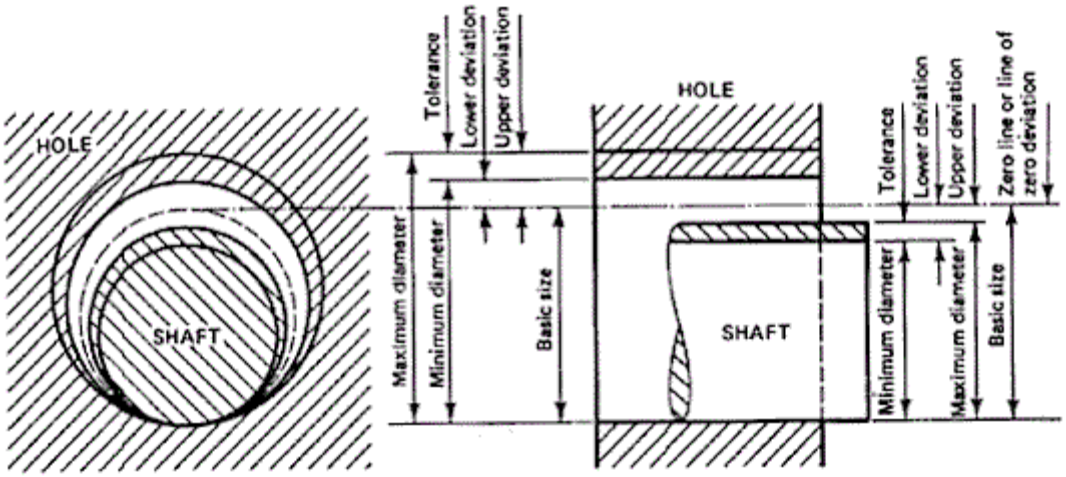
Need for tolerances

Tolerance is the amount of deviation from the given basic design size, or the margin of error, allowable to accommodate reasonable inaccuracy in manufacture. In mechanical drawings, tolerance is indicated by the *maximum and minimum permitted sizes* (limits of sizes).

There are three main considerations in establishing reasonable tolerances.

(a) Function	setting the limits of dimensions closely enough to ensure that the component will perform its function satisfactorily at the extent of the limits, i.e. tolerance must be consistent with the design and function
(b) Interchangeability	setting the limits of dimensions for components so that a component taken at random from a batch should be able to be assembled without modification, i.e. tolerance should be specified for all dimensions affecting interchangeability
(c) Cost	setting the limits of dimensions at no more closely than they need to be in order to minimise the production cost, i.e. tolerance must be as large as the design will permit

Principal terms expressing limits of size

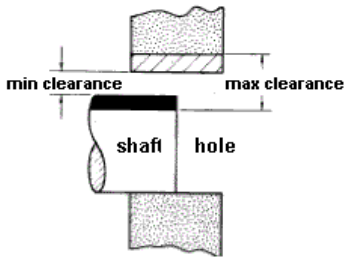


Size	**Size** is a number expressing in a particular unit the numerical value of a length.
Actual size	**Actual size** is the size of a part as obtained by measurement.
Basic size	**Basic size** is the size from which the limits are fixed. It is the same for both members of a fit.
Limits of size	**Limits of size** are the maximum and minimum sizes permitted for a feature.
Maximum limit of size	**Maximum limit of size** is the maximum size permitted for a feature.
Minimum limit of size	**Minimum limit of size** is the minimum size permitted for a feature.
Deviation	**Deviation** is the algebraic difference between the actual size and the corresponding basic size.
Upper deviation	**Upper deviation** is the algebraic difference between the maximum limit of size and the corresponding basic size.
Lower deviation	**Lower deviation** is the algebraic difference between the minimum limit of size and the corresponding basic size.
Zero line	**Zero line** is the line of zero deviation and it represents the basic size.
Shaft	**Shaft** is a term used to designate all external features of a part, including those which are not cylindrical.
Hole	**Hole** is a term used to designate all internal features of a part, including those which are not cylindrical.

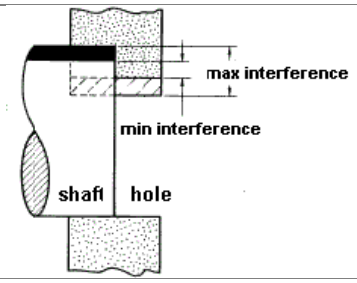
Systems of fits

A fit is the relationship resulting from the difference, before assembly, between the sizes of the two parts which are to be assembled. Engineering fits can be divided into three main types:

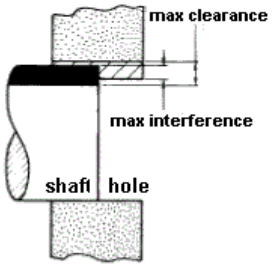
(a) Clearance fit
a fit which always provides a clearance
e.g. a shaft is smaller than the hole into which it fits



(b) Interference fit
a fit which always provides an interference
e.g. a shaft is bigger than the hole into which it fits



(c) Transition fit
a fit which may provide either a clearance or an interferance
e.g. a shaft is bigger, smaller or equal to the hole into which it fits



A system of fits comprises shafts and holes which belong to a limit system. There are two systems of fits:

(a)	Hole-basis fits	this system of fits is based on a single hole, from which the different clearances and interferences are obtained by associating various shafts with the hole
(b)	Shaft-basis fits	this system of fits is based on a single shaft, with which the different clearances and interferences are obtained by associating various holes with the shaft

The hole-basis system of fits is more economical than the shaft-basis system as only one size of drill is used to produce different fits, the shafts being turned and ground to the required sizes, thus making manufacture and measurement much easier.

Selected fits

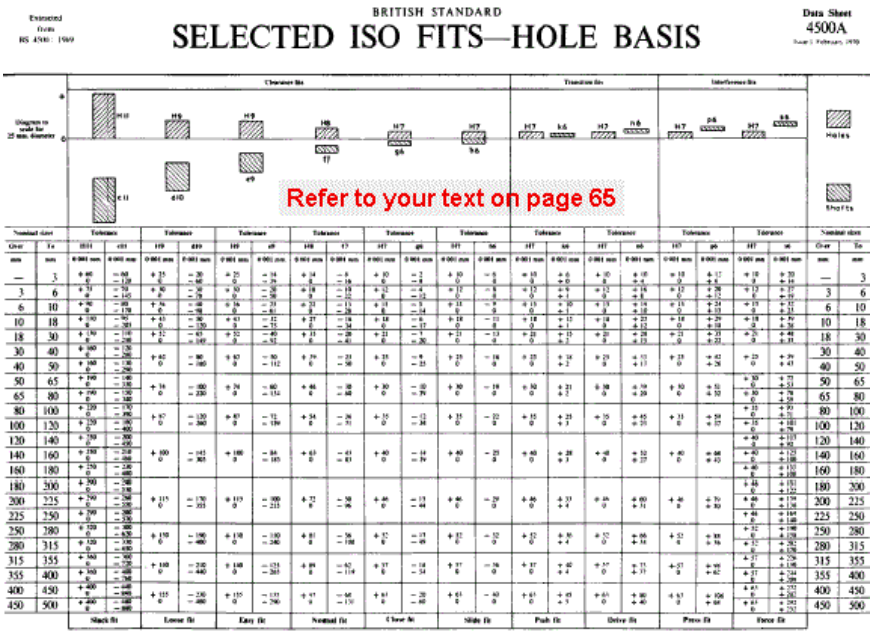
BS 4500 Part 1 provides a selection of hole and shaft tolerances to cover a wide range of engineering applications. The following selected hole and shaft tolerances have been found to be commonly applied:

(a)	Selected hole tolerances	H7; H8; H9; H11
(b)	Selected shaft tolerances	c11; d10; e9; f7; g6; h6; k6; n6; p6; s6

Tolerance is designated by a letter and a figure. A hole tolerance is designed by a capital letter indicating the fundamental deviation, following by a figure denoting the grade (e.g. H7). Shaft fundamental deviations are indicated by small letters, followed by a tolerance grade (e.g. p6). The hole limits are always quoted first, e.g. H7/p6 stands for a press fit.

Data sheets showing a selected range of fits can be derived from the hole tolerances and shaft tolerances. Data sheet BS 4500A gives a range of hole-basis fits derived from the selected hole and shaft tolerances given in BS 4500 Part 1. It covers fits from loose clearance to heavy interference and is suitable for most normal requirements.

Data sheet BS 4500B shows the shaft-basis equivalents of the hole-basis fits in BS 4500A.



BRITISH STANDARD

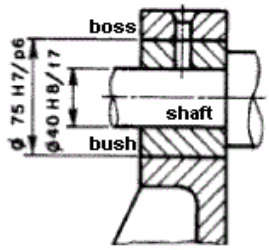
SELECTED ISO FITS—HOLE BASIS

Data Sheet 4500A

Refer to your text on page 65

`Use of data sheet

Data sheet can be used to determine the working limits of an assembly. The following example demonstrates how the limits of sizes are calculated using the data sheet BS 4500A.

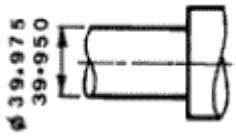
The assembly	Sub-assembly	Desirable fit	Nominal dia
	shaft + bush	H8/f7 normal fit	40
	bush + boss	H7/p6 press fit	75

Extracting data from BS 4500A,

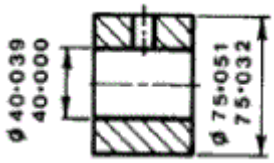
	Nominal size	Fit	Tolerance	Max limit	Min limit
shaft	40	f7	-25, -50	40-0.025=39.975	40-0.05=39.950
bush id	40	H8	+39, 0	40+0.039=40.039	40+0=40.000
bush od	75	p6	+51, +32	75+0.051=75.051	75+0.032=75.032
boss	75	H7	+30, 0	75+0.030=75.030	75+0=75.000

Dimensioning the parts,

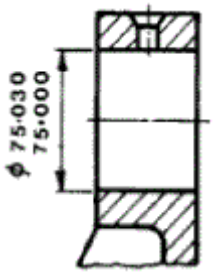
shaft



bush



boss



Assignment 8

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Question No. 35 (Referring to Figure 7.19)

The belt-pulley unit shown in Fig. 7.19 consists of a belt pulley (2), a mounting bracket (1), a fitted bolt (3), and two bushes (4). (The following figure is extracted from textbook.)

Draw full size in third angle projection with all parts assembled, including a suitable nut with locking device. Take all fillets to be R2

(a) a sectional front view on YY,
(b) a sectional end view on XX,
(c) a plan view.

Insert a title block and add a parts list.

Hidden details are not required for all views

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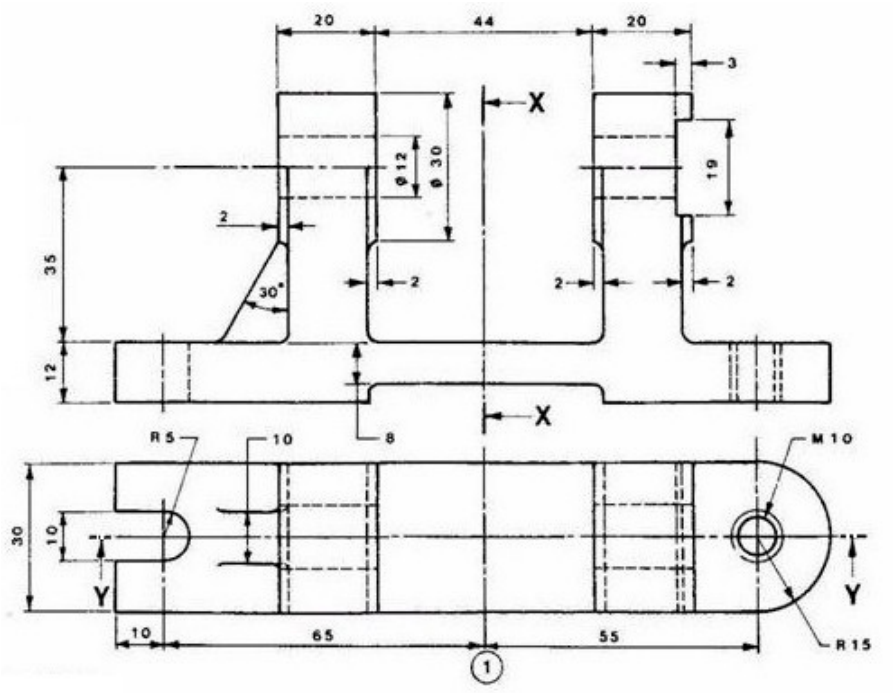
Question No. 36 (Referring to Figure 7.19)

Calculate the maximum and minimum limits for the following fits and add these dimensions on the assembly drawing above.

(a) H7/p6 between shaft (3) and two bushes (4),
(b) H9/e9 between two bushes (4) and belt pulley (2)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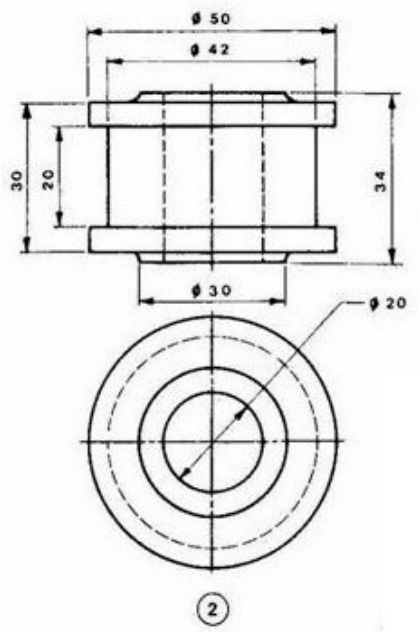
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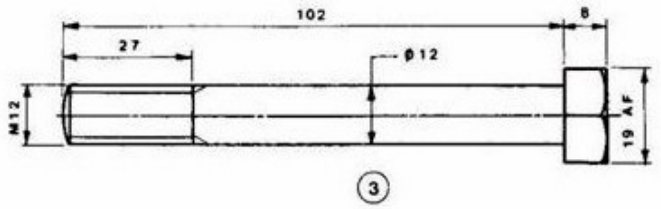
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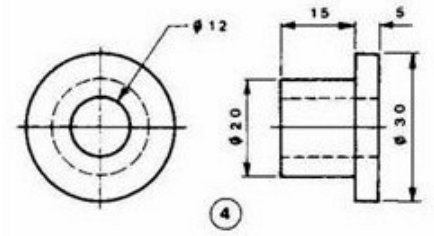
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