MACHINING

Level - III

Learning Guide 1

Unit of Competence: Perform Advanced Engineering Detail Drafting

Module Title: Performing Advanced Engineering Detail Drafting

LG Code: IND MAC3 01 0217

Instruction Sheet	Learning Guide #1

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determine drawing requirements
- Prepare assembly, lay- out and detail drawing
- Quality assure drawing

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- ❖ drawing are checked and interpreted from work order Drawing, including auxiliary views, sections and assemblies in ISO first and third angle projection are produced by using manual instruments and CAD geometric tolerances and specifications.
- ❖ limits and fits assembly/fabrication is made possible based on applied standards

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below page 3 to 57.
3. Read the information written in the information sheet.
4. Accomplish the Self-check.
5. If you earned a satisfactory evaluation from the "Self-check".
6. Do the "LAP test".

Information Sheet-1	LO1: Determine drawing requirements

1. Determine drawing requirements

1.1. Check requirements and purpose of *drawing* from work order or similar

- Checking drawing requirements and purpose of *drawing* from work (customer) order is very essential for any person who read drawing.
- Among the drawing requirement
  - Necessary drawing equipment to prepare the drawing
  - Necessary dimensions, symbols, and all information that complete the drawing.
  - Any information which used for production of the given project including working (detail) drawing.

Document Control Functions

The typical document control function does the following:

- Assign all part numbers, change numbers, and document revision levels.
- Control master design document after the appropriate point of initial release (master file, either hard copy or electronic).
- Change request monitoring.

- It is important, however, to assure that certain elements are present on drawing formats. It is also very important to emphasize that certain data elements should not be on those formats.

Document Formats and Standards

- Keep as few formats active as possible. A well thought out drafting standard will help in this area. Use the commercially available *Drawing Requirements Manual* (DRM) as a guideline for your own standard, taking care to assure that all the following rules and guidelines have been taken into account as well. In other words, don't just invoke one of these standards, read and modify it according to the parts of this text that you wish to adopt, deleting those parts that are not applicable to your business.

- Some general definition of the parts of design documents, regardless of size; drawings, specs, lists, and other documents, should have a common format. They should all have a *Body*, *Title Block*, and *Revision Block,* as seen in Fig. 1.1.

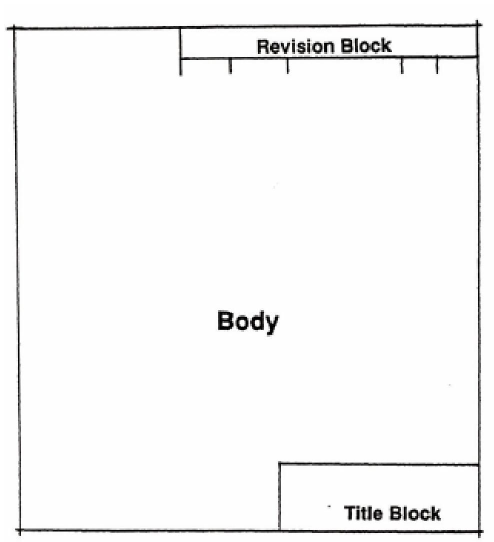


Fig. 1.1.

Drawing Requirements

- When used in the field of the drawing, item numbers shall be enclosed in circular-shaped 1/2-inch-diameter balloons.
- The same find or item number shall be used for any group of reference designations assigned to items of identical characteristics.
- The item or find numbers on any drawing shall be assigned independently of those on any other drawing. Find numbers assigned to subassemblies shown on an assembly drawing shall be distinguished from those assigned to parts by adding a letter suffix to the subassembly find number.

Purpose and Scope

Purpose

- Purpose is to describe the specification process, which defines the desired project result and enumerates the project requirements.

- Engineering departments document their agreements with other organizations in the form of engineering specifications detailing the technical and project requirements of the system to be provided.
- It is important to note that managers and project leaders may introduce additional requirements, such as further reviews or documentation, outside the technical specifications described in manual. The design engineer must fulfill these requirements during the implementation of the engineering project.

1.2. Source required information from workshop manuals, customer specifications, product suppliers, and designers or similar.

Item Specifications

- Specifications are words that describe an item. They are generally in a text format, but may have text, charts, graphs, envelope drawings, or combinations of these and other techniques. They are generally prepared to describe the end product, but may be defining a sublevel of the product.

The definition, therefore, becomes fairly general.

Definition: Specifications define the critical characteristics of an items form (appearance), physical, or functional nature.

- Specification Control Drawings are item specifications. Certain assemblies may be described by a specification, whether made or purchased.
- An assembly that is tested is usually defined by a test specification. There is one level of the product that must have at least one specification that is the end product itself. These take various forms and names. They will be called *product specifications* in this text.
- Whatever they are called, they are so important that they need to be a released document and under change control. When several products are combined into a system, the product specification may be referred to as a System Integration Specification.
- Product specifications requirements vary depending upon whether you are in a make to stock make to order, or make to print environment.

Make-to-Stock Product Specifications

The single most important of all Design Documents is the Product Specification. This document must be agreed upon by key company management. This agreement must occur very early in the product definition phase.

- ❖ All Sources required information should be obtained from workshop manuals, customer specifications, product suppliers, and designers or similar sources.

1.3. Plan Scope of drawing including layout, additional required information and resources

- ➢ Scope; is limit or span or range of the project to be to be produced.
- ➢ Project Standards and Specification which should be regarded as a Recommended Practice, specifies the minimum requirements for handling of a project in the detail design and procurement stages.
- ❖ However, depending on the nature and extent of the contract between the Company and Contractor, some parts/sections may be added, modified or deleted as required.
- ❖ The main activities for implementation of the detailed engineering, procurement services and supply of equipment and materials are covered in this Standard Specification.
- ❖ The Project Standards and Specification does not deal with the construction/production activities and/or efforts which normally should be made after or in parallel with the engineering phase for completion of the project in the site.

Self-Check -1	Written Test

Self check questions

Choose the best answer from the best answer

1. _____________are words that describe an item.
   A. Specifications
   B. Symbols
   C. Scope
   D. All of the above
2. ___________is limit or span or range of the project to be to be produced.
   A. Scope
   B. Symbols
   C. Specifications
   D. All of the above
3. Drawing Requirements
   A. When used in the field of the drawing, item numbers shall be enclosed in circular-shaped 1/2-inch-diameter balloons.
   B. The same find or item number shall be used for any group of reference designations assigned to items of identical characteristics.
   C. The item or find numbers on any drawing shall be assigned independently of those on any other drawing.
   D. All of the above
4. *One of the following is not true about* Specifications
   A. define the critical characteristics of an items form (appearance), physical, or functional nature
   B. define the critical prices of an items form (appearance), physical, or functional nature
   C. define the critical quantities of an items form (appearance), physical, or functional nature
   D. All of the above

Answer for Self check questions

1. A
2. A
3. D
4. A

Information Sheet-2	LO2: Prepare assembly, lay-out and detail drawing

2.1. Determine drawing details, specifications

- ❖ Drawing detail and specification should be determined before start to design any project.
  - ☛ *Working drawing* is a set of drawing used during the work of making a product.
  - ☛ *Working drawing*
    - ➢ *Detail drawing*
    - ➢ *Assembly drawing*

Detail drawing is a *multiview representation* of a single part with *dimensions and notes*.

Assembly drawing is a drawing of various parts of a machine or structure assembled in their relative working positions.

Purpose

Detail drawing conveys the *information* and *instructions* for manufacturing the part.

Assembly drawing conveys

1. Completed shape of the product.
2. Overall dimensions
3. Relative position of each part
4. Functional relationship among various components.

INFORMATION INDETAIL DRAWING

1. General information ⟹ Title block
2. Part's information

   2.1. Shape description

   2.2. Size description } ⟹ *Object's views*

2.3 Specifications ⟹ Notes

GENERAL INFORMATION

- Name of company
- Title of drawing (usually part's name)
- Drawing sheet number
- Name of drafter, checker
- Relevant dates of action (drawn, checked, approved etc.)
- Revision table
- Unit
- Scale
- Method of projection

PART' S INFORMATION

- Shape
  - Orthographic drawing
  - Pictorial drawing
- Size
  - Dimensions and Tolerances
- Specifications
  - Part number, name, number required
  - Type of material used
  - General notes
  - Heat treatment
  - Surface finish
  - General tolerances

RECOMMENDED PRACTICE

Draw one part to one sheet of paper.

If not the case,

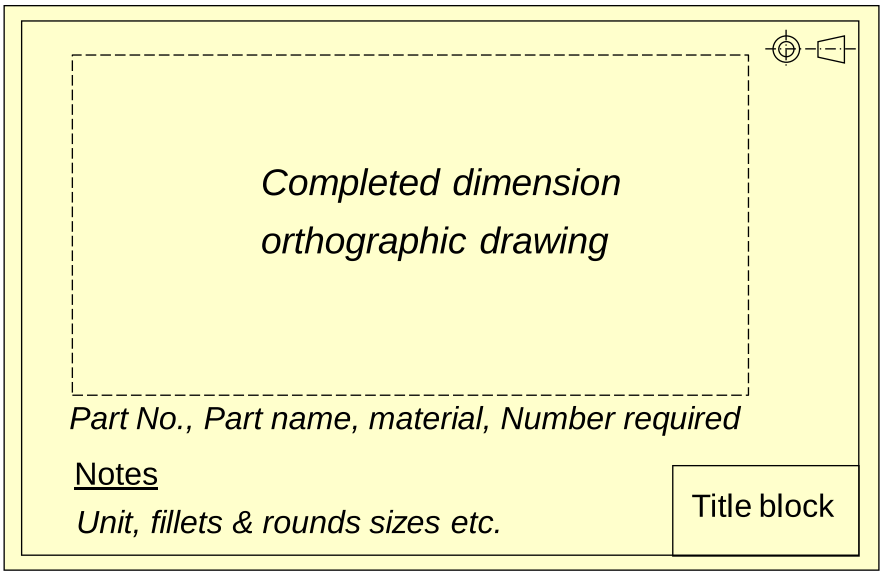
- apply *enough spacing* between parts.

- draw all parts using the *same scale*.

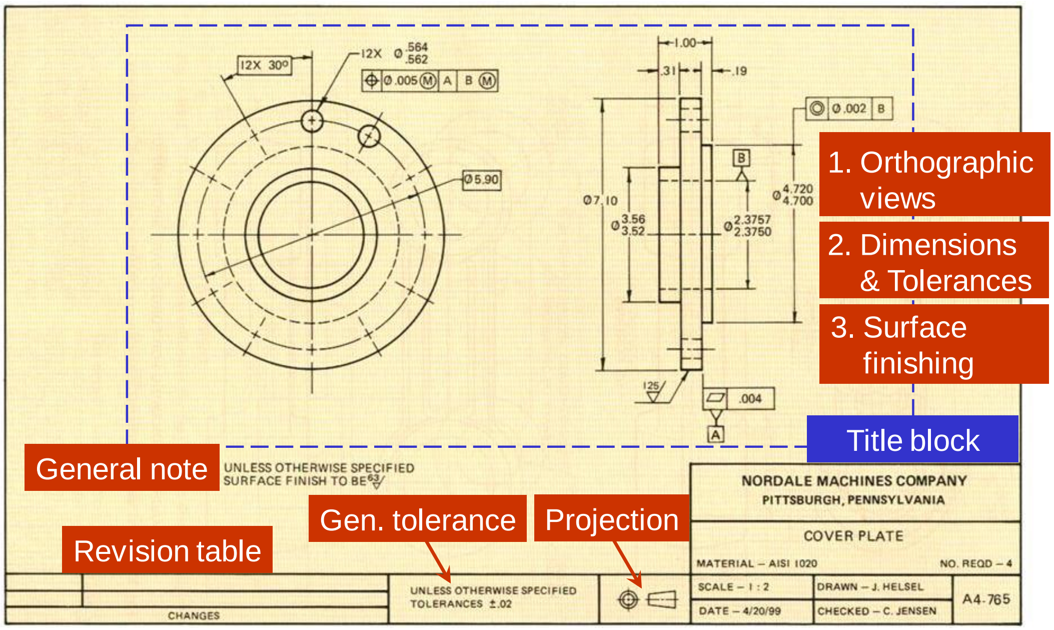
- Otherwise, the scale should be clearly note under each part's drawing.
- Standard parts such as *bolt*, *nut*, *pin*, *and bearing* do not require detail drawings.

PLACING AN INFORMATION

(This course)



EXAMPLE : Interpreting detail drawing



TYPES OF ASSEMBLY DRAWING

1. Exploded assembly drawings

The parts are separately display, but they are aligned according to their assembly positions and sequences.

2. General assembly drawings.

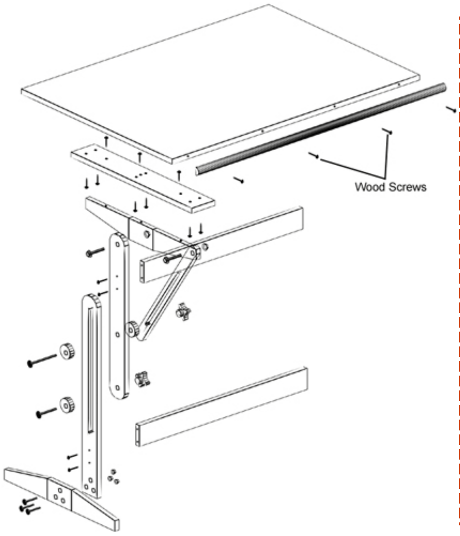
All parts are drawn in their working position.

3. Detail assembly drawings

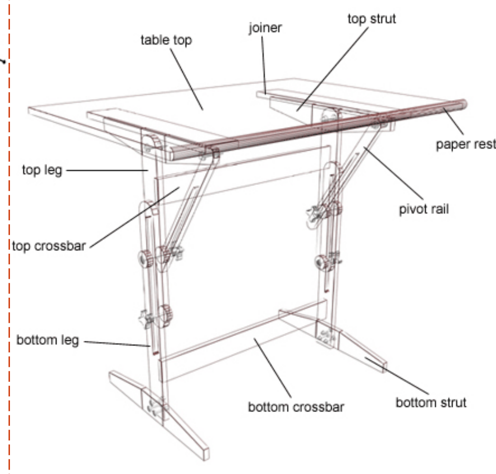
All parts are drawn in their working position with a completed dimensions.

1. EXPLODED ASSEMBLY

Pictorial representation



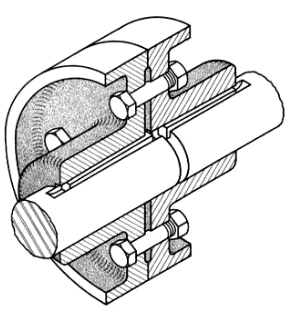
Finished product

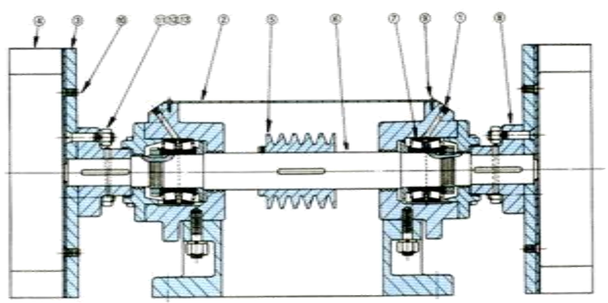


2. GENERAL ASSEMBLY

Pictorial

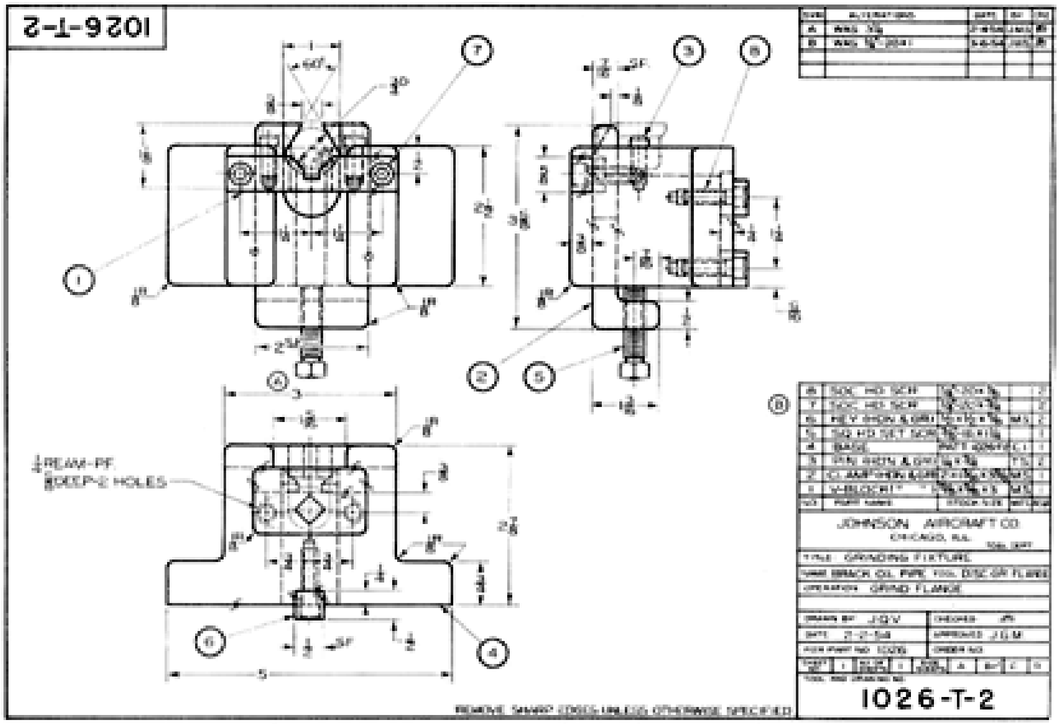
Orthographic



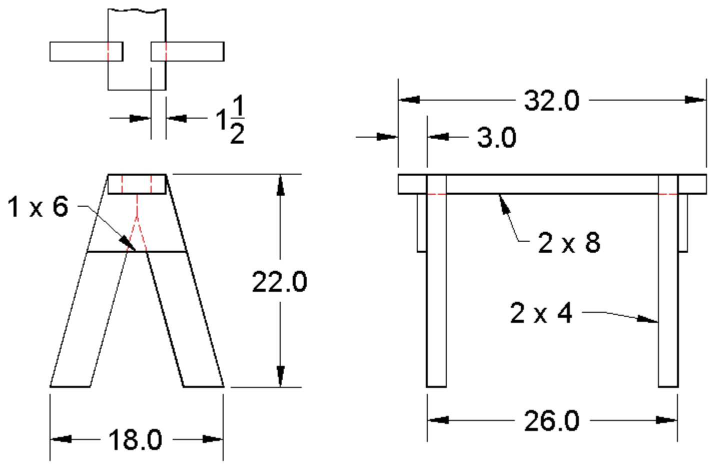


3. DETAILED ASSEMBLY

(working-drawing assembly)



DETAIL AND ASSEMBLY DRAWINGS



DETAIL ASSEMBLY DRAWING OF A SAWHORSE

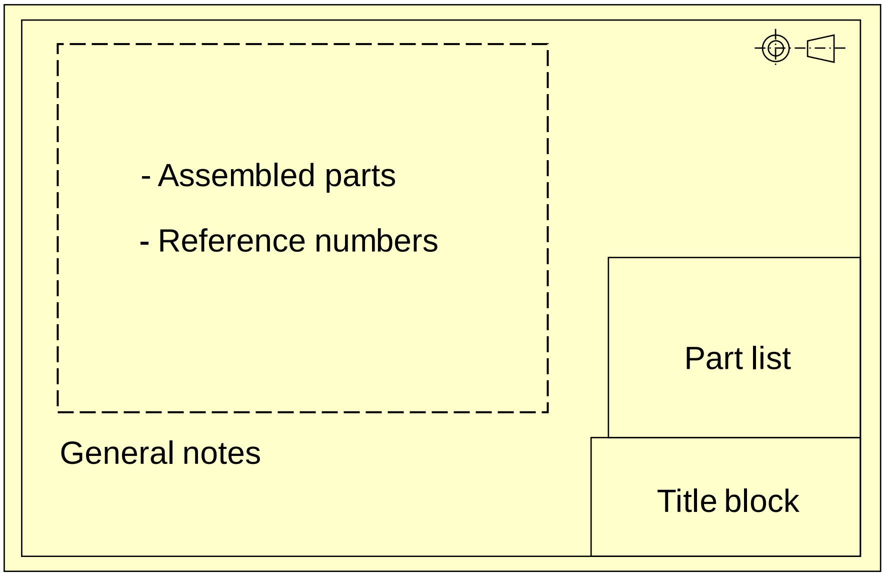
REQUIRED INFORMATION IN GENERAL ASSEMBLY DRAWING

1. Part list (or bill of materials, BOM)
2. Part list (or bill of materials, BOM)
    1. Item number
    2. Descriptive name
    3. Material, MATL.
    4. Quantity required (per a unit of machine), QTY.

3. Leader lines with balloons around part numbers.
4. Machining and assembly operations and critical dimensions related to operation of the machine.

PLACING AN INFORMATION

(This course)

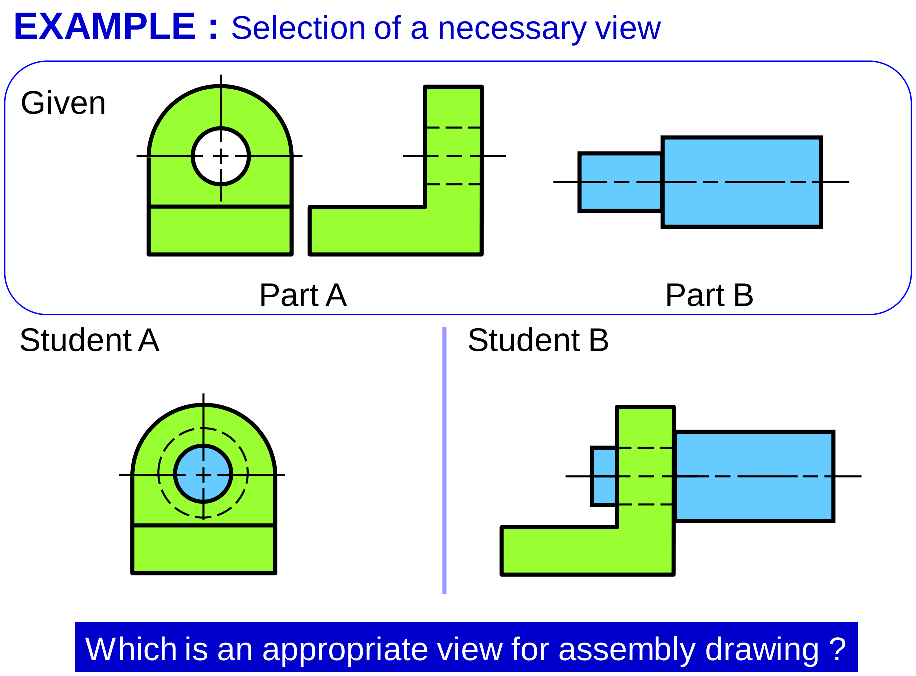


STEPS TO CREATE ASSEMBLY DRAWING

1. *Analyze* geometry and dimensions of all parts in order to understand the *assembly steps* and overall shape of device or machine.
2. Select an appropriate view.
3. *Choose major parts*, i.e. parts that have several parts assembled on.
4. . Draw a view of *major parts* according to a selected viewing direction.
5. Add detail view of the remaining parts at their working positions.
6. Apply *section technique* where relative positions between adjacent parts are needed to clarify.
7. Add *balloons*, *notes* and *dimensions* (if any).
8. Create BOM.

GENERAL PRACTICE

- The *number of views* can be one, two, three or more as needed, but it should be minimum.
- A good *viewing direction* is that represents all (or most) of the parts assembled in their working position.

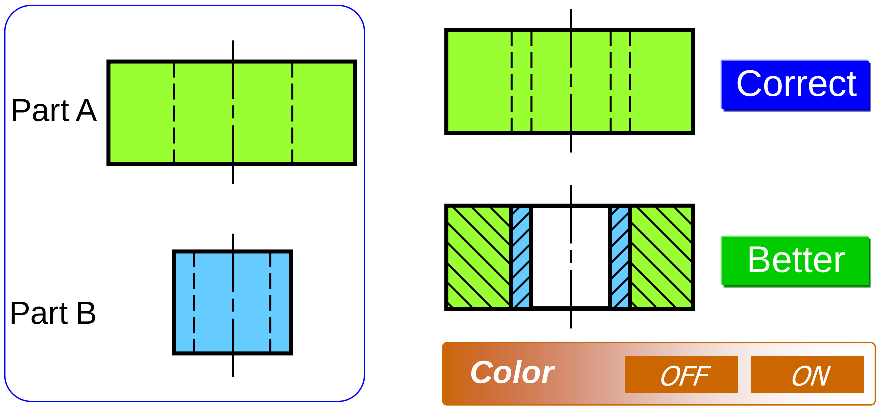


GENERAL PRACTICE

- *Hidden lines* usually omit unless they are absolutely necessary to illustrate some important feature that the reader might otherwise miss.

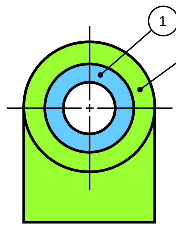
GENERAL PRACTICE

- ***Section technique*** is usually need to clarify mating of the parts.
- Use ***different*** section line styles for adjacent parts.

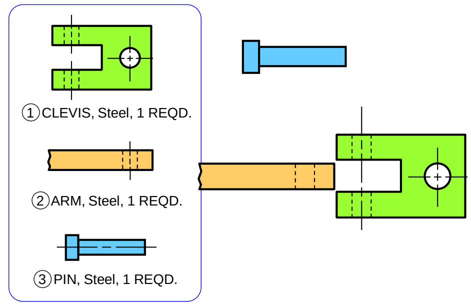


LEADER LINE PRACTICE

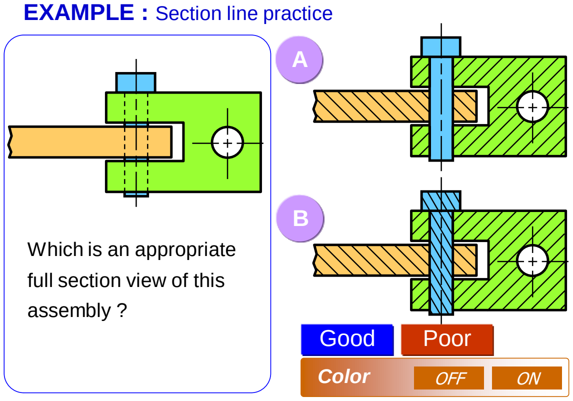
- Drawn from the inside of the part to the balloon and placed a filled circle at the beginning of a line.
- Drawn in the ***oblique*** direction.



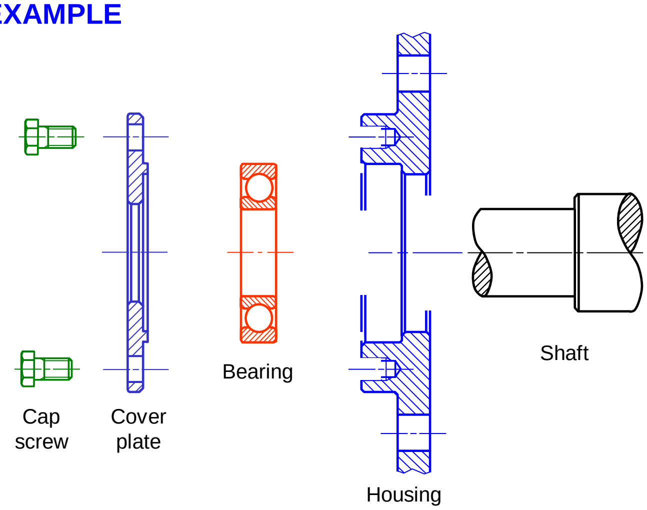
EXAMPLE 1 : Assembly steps



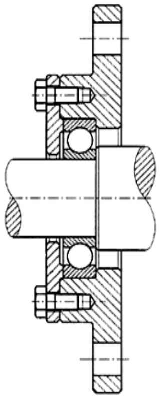
EXAMPLE : Section line practice



EXAMPLE



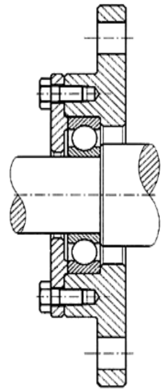
EXAMPLE 1 : *Shaft support on a machine housing*



Assemble steps

1. Install bearing to the shaft.
2. Install the bearing-shaft unit to the housing.
3. Install the cover plate.
4. Tighten the screw.

EXAMPLE 1 : *Shaft support on a machine housing*

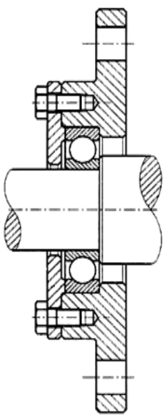


Functions of main parts

1. Bearing :
Support the rotating shaft.

2. Cover :
- Control an axial movement.
- Prevent the bearing unit from rotation.

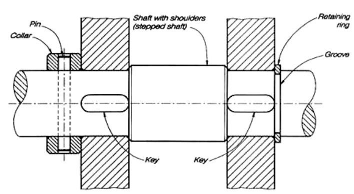
EXAMPLE 1 : *Shaft support on a machine housing*



Design concept

Avoid direct contact between rotating shaft and housing as well as cover plate by using a bearing and clearance holes.

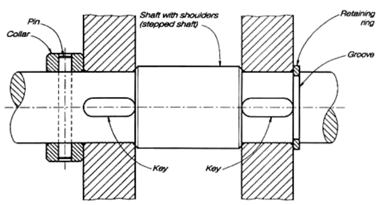
EXAMPLE 3 : Fixing parts on a shaft.



Assemble steps

1. Place the keys on the key seats.
2. Insert the parts to the shaft until their surfaces lean against the shoulder.
3. Insert collar and then pin or retaining ring into the groove.

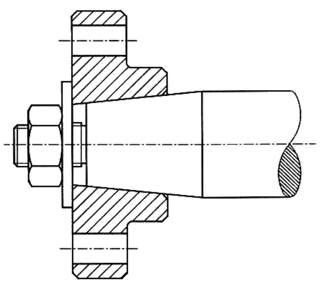
EXAMPLE : Fixing parts on a shaft.



Design concept

Retaining ring can resist lower axial force than collar & pin unit.

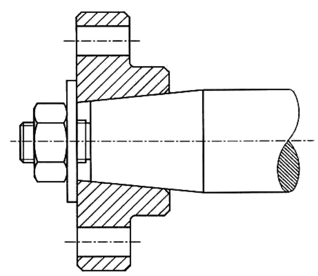
EXAMPLE : P*arts with tapered holes on tapered shaft.*



Assemble steps

1. Insert the part on the tapered end of the shaft.
2. Insert the washer (non-standard).
3. Tightening the nut.

EXAMPLE : P*arts with tapered holes on tapered shaft.*

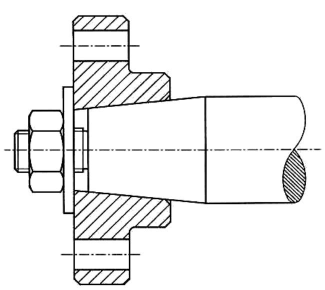


Function

1. Washer :

- Improve the distribution the tightening force on the part.

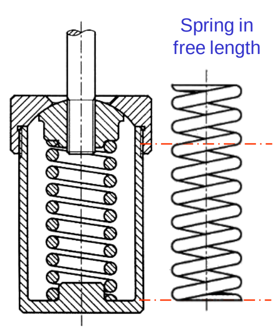
EXAMPLE : P*arts with tapered holes on tapered shaft.*



Design concept

Length of the tapered portion and depth of the tapered hole require a calculation.

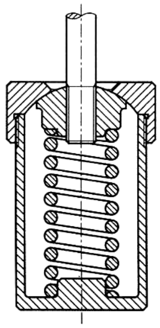
EXAMPLE : *Parts having preloaded spring*



Assemble steps

1. Insert the spring into the casing.
2. Tighten the rod to the spring loader.
3. Close the cap and tighten.

EXAMPLE : *Parts having preloaded spring*

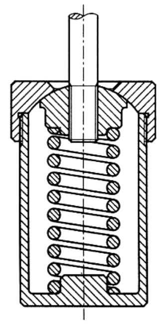


Function

1. Spring plunger :

- Transmit a force from rod to spring.
- Keep the spring in a position.

EXAMPLE : *Parts having preloaded spring*



Design concept

Spring plunger has a spherical surface contacts to the cap; therefore, the rod can align itself to original position.

POINTS TO CONSIDER

1. Surface finishing
2. Tolerance
   - Size
   - Geometry

SURFACE FINISHING

Surface finishing means the quality of a surface. It relates to the level of roughness of a surface.

Purpose

1. To control the accuracy in positioning and tightness between mating parts.

2. To reduce the friction, especially for the part moves relative to other parts.

TOLERANCE

Tolerance is the total amount dimension may vary.

It is defined as the difference between the upper and lower limits.

Purpose

1. To control an *interchangeability* of parts.

2. To ensures the mating part will have a desired fit

2.2. Insert dimensions and geometric tolerances

- Tolerances: Engineers realize that absolute accuracy is impossible, so they figure how much variation is permissible. This allowance is known as tolerance.
- Tolerances is stated on a drawing as (plus or minus) a certain amount, either by a
    - Fraction or
    - Decimal.
- Limits are the maximum and/or minimum values prescribed for a specific dimension, while tolerance represents the total amount by which a specific dimension may vary.

- Tolerances may be shown on drawings by several different methods; figure 2-1 shows three examples.

    - The unilateral method (view A), is used when variation from the design size is permissible in one direction only.
    - In the bilateral method (view B), the dimension figure shows the plus or minus variation that is acceptable. In the limit dimensioning method (view C), the maximum and minimum measurements are both stated.

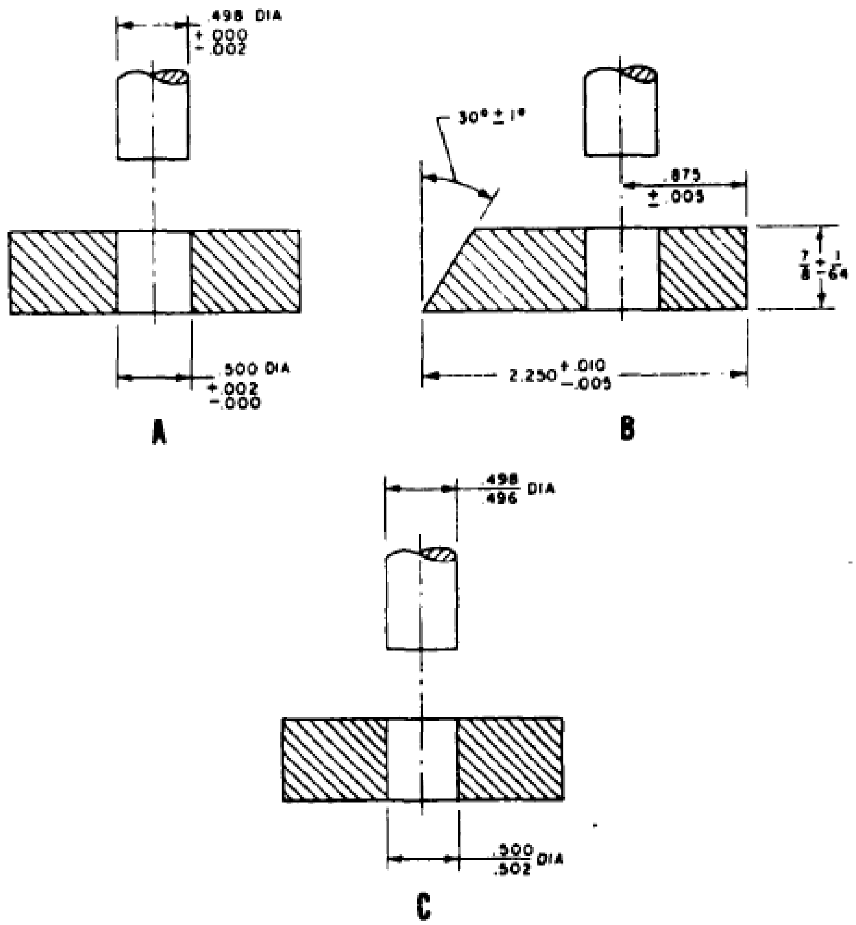
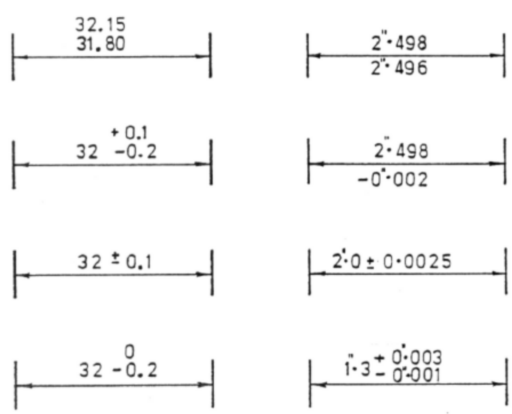


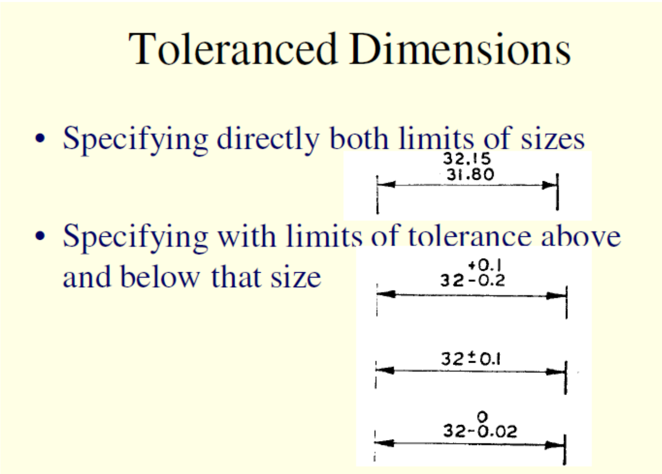
Fig. 2-1 -**Methods of indicating tolerance.**

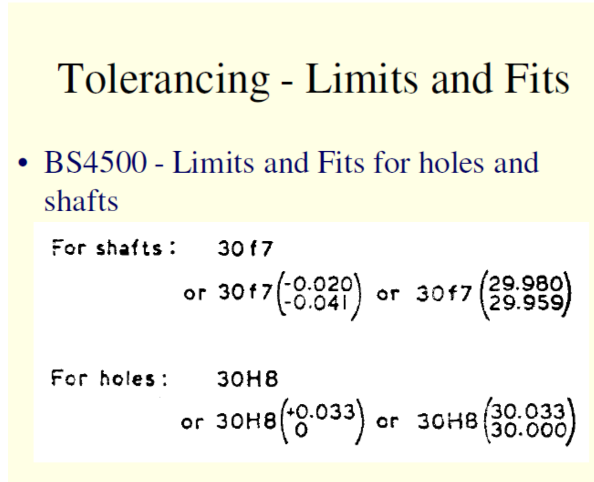
If a dimension is specified, in millimeters, as 10 ± 0.02, the part will be acceptable if the dimension is manufactured to an actual size between 9.98 and 10.02 mm. Below are some examples of ways of defining such limits for a linear dimension.

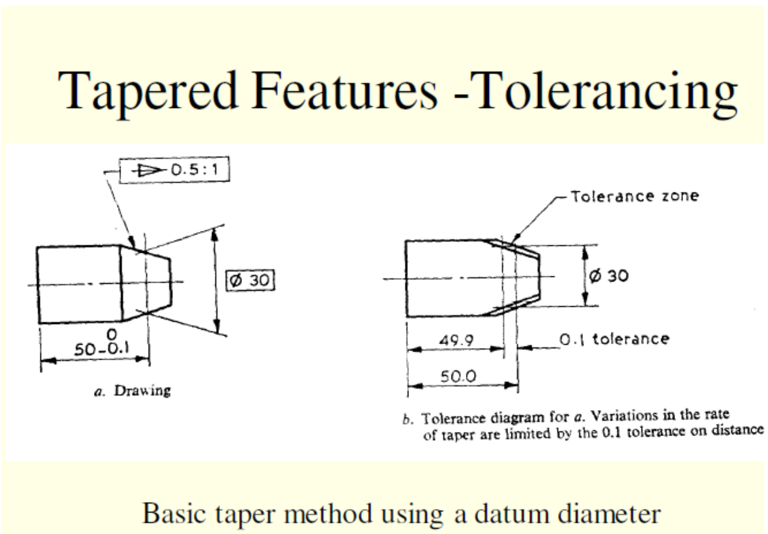
Maximum and minimum **limits** of size:

Nominal size with **limits** of tolerance:









The surfaces being tolerance have geometrical characteristics such as roundness, or perpendicularity to another surface. Figure 2-2 shows typical geometrical characteristic symbols. A datum is a surface, line, or point from which a geometric position is to be determined or from which a distance is to be measured. Any letter of the alphabet except I, O, and Q may be used as a datum identifying symbol.

2.3. Include appropriate symbols for limits and fits, surface texture…

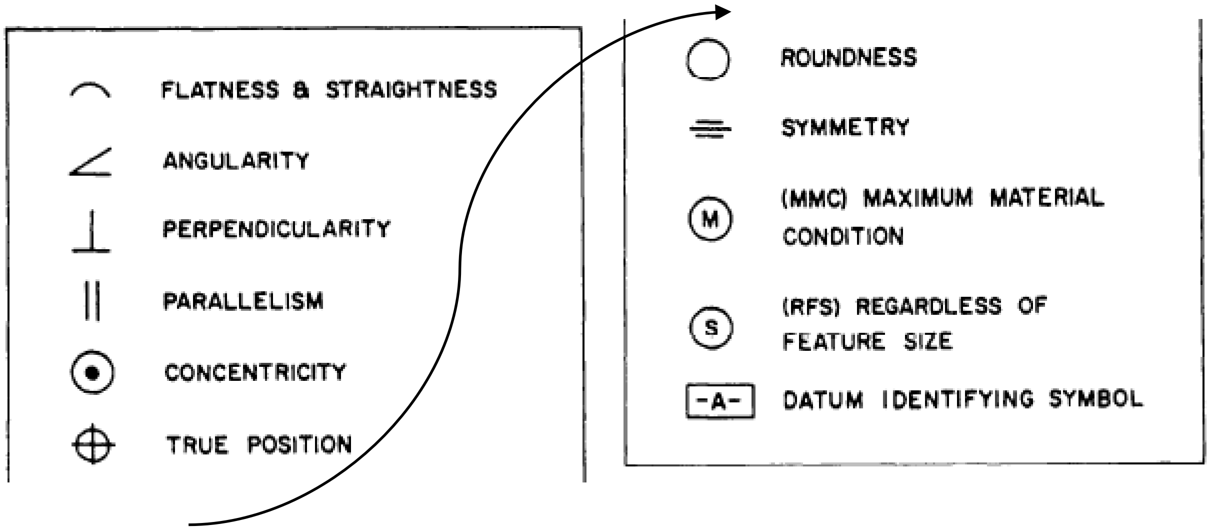


Fig. 2-2 Geometric characteristic symbols.

Datum

• Datum surfaces and datum features are used as references to control other features on a part.

• Datum features can be actual features on the part, such as a point, line, plane, cylinder, or other geometric form assumed to be exact.

☛ A feature control symbol is made of geometric symbols and tolerances. Figure 2-3 shows how a feature control symbol may include datum references.

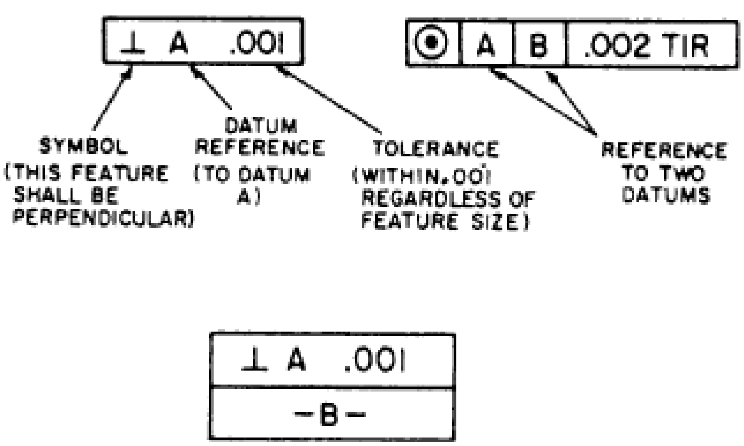
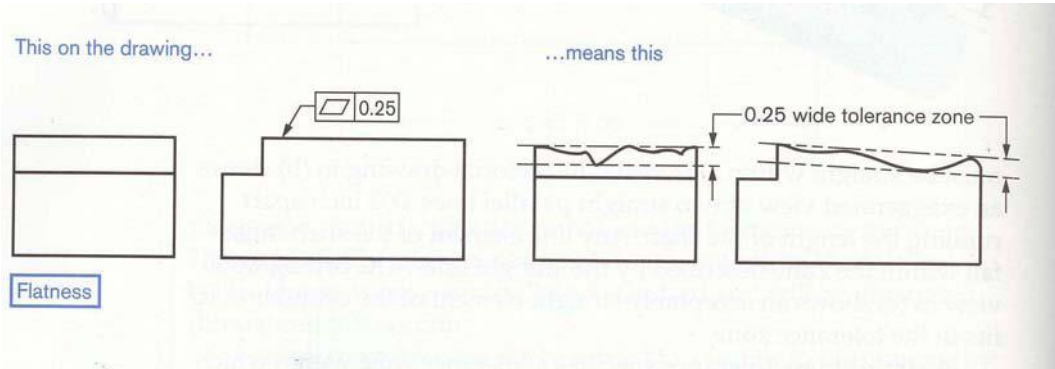


Fig. 2-3 Feature control frame indicating a datum reference.

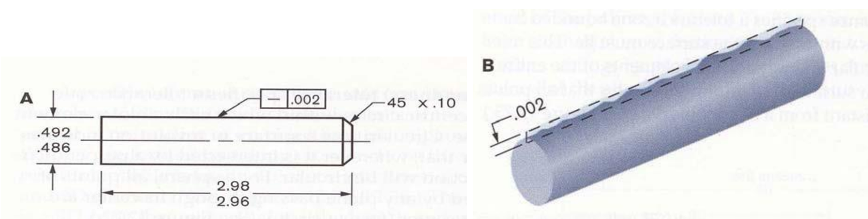
Flatness

• A flatness tolerance specifies a tolerance zone defined by two parallel lines within which the surface must lie



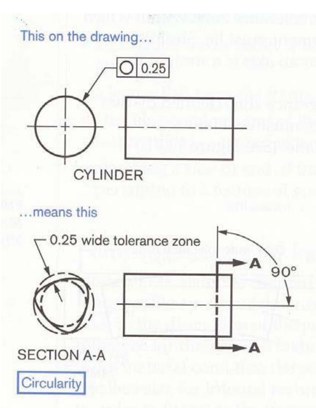
Straightness

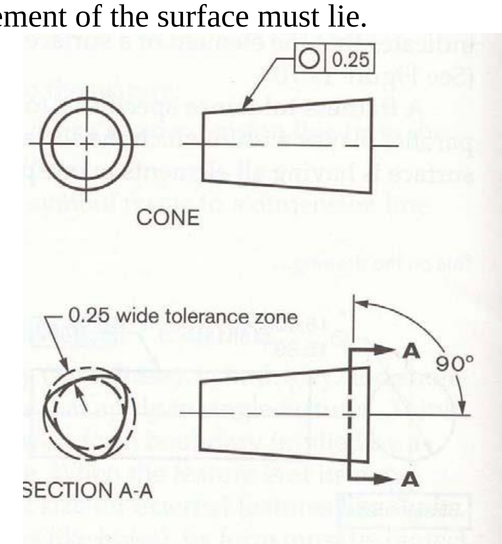
• Specifies a tolerance zone within which an axis or all points of the indicated element must lie.
• Straightness indicates that the element of a surface or an axis is a straight line.



Circularity

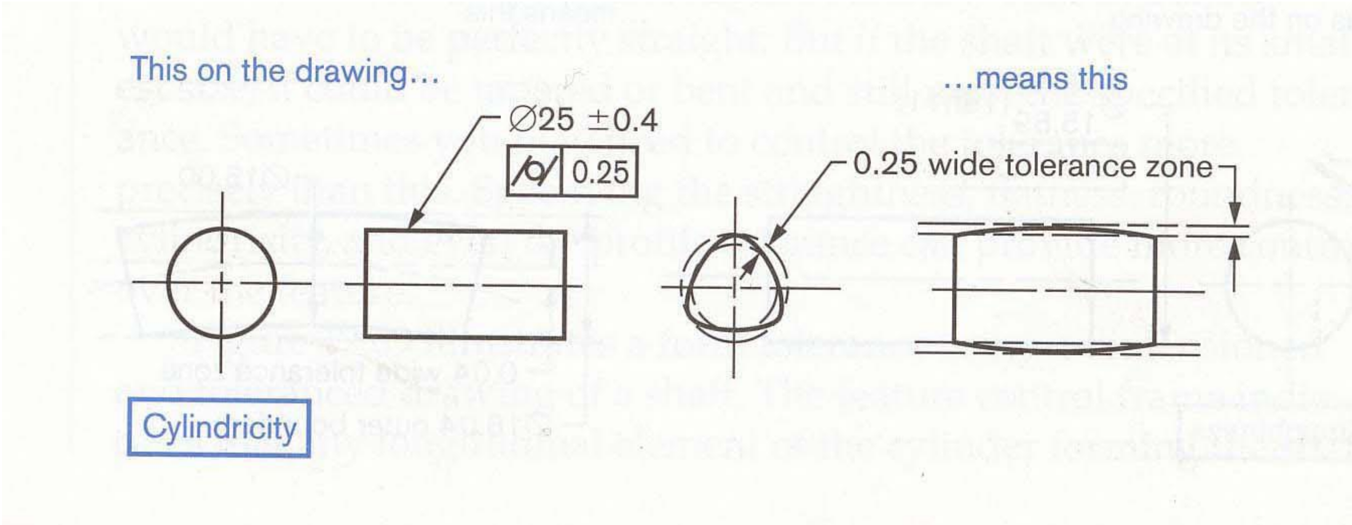
- A circularity (roundness) tolerance specifies a tolerance zone bounded by two concentric circles within which each circular element of the surface must lie.





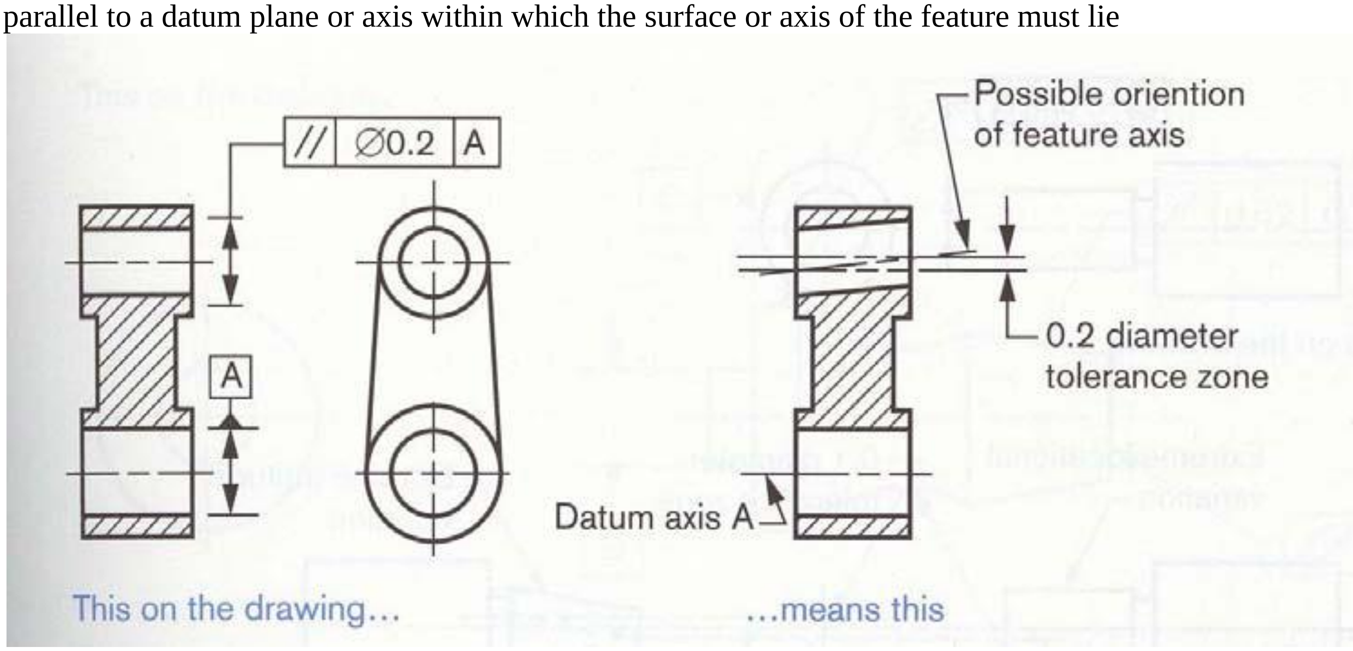
Cylindricity

- A cylindricity tolerance specifies a tolerance zone bounded by concentric cylinders within which the surface must lie.

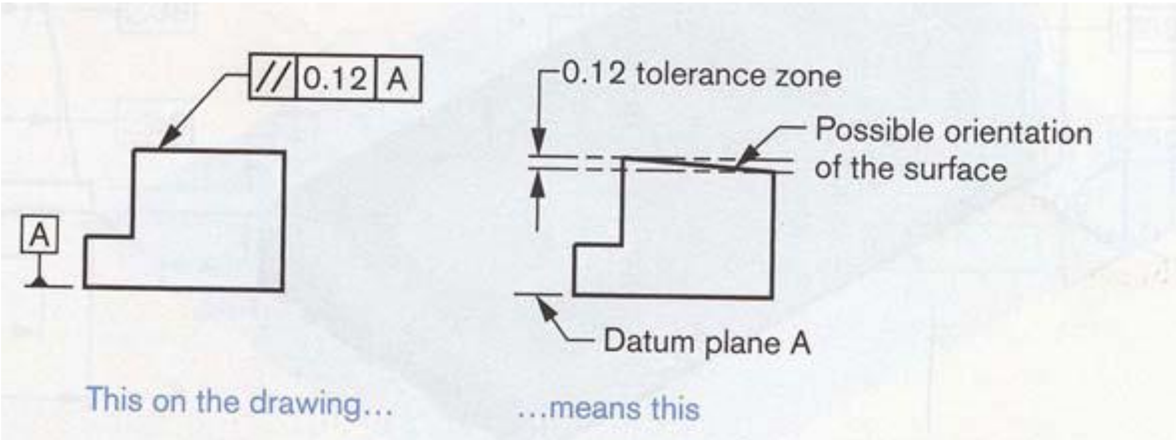


Parallelism

- A *parallelism tolerance* specifies a tolerance zone defined by two parallel planes or by two lines parallel to a datum plane or axis within which the surface or axis of the feature must lie



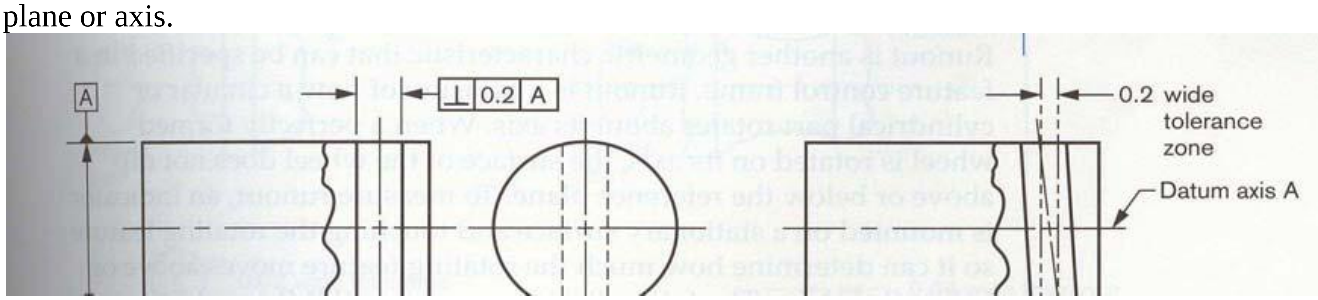
Parallelism for an axis



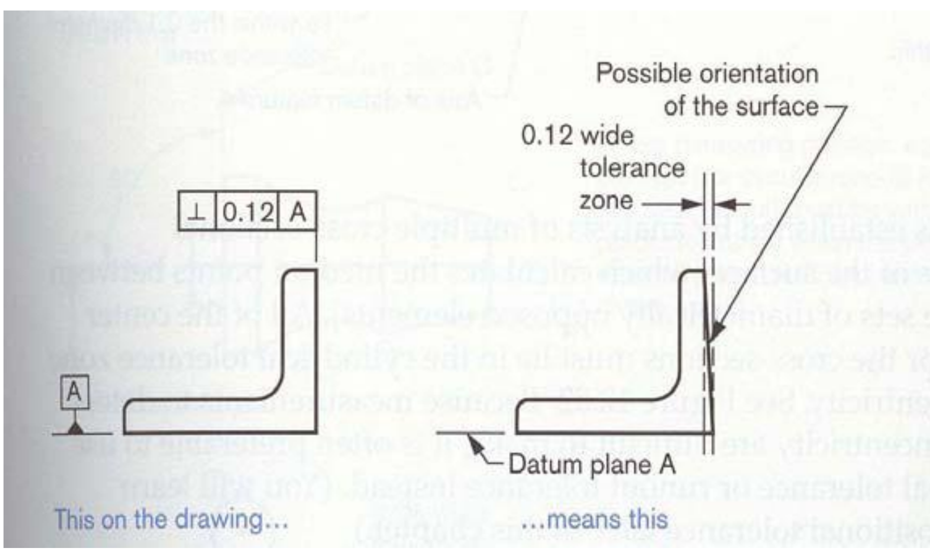
Parallelism for a plane

Perpendicularity

- A *perpendicularity tolerance* indicates that a surface, median plane or axis is at 90 degrees to a datum plane or axis.



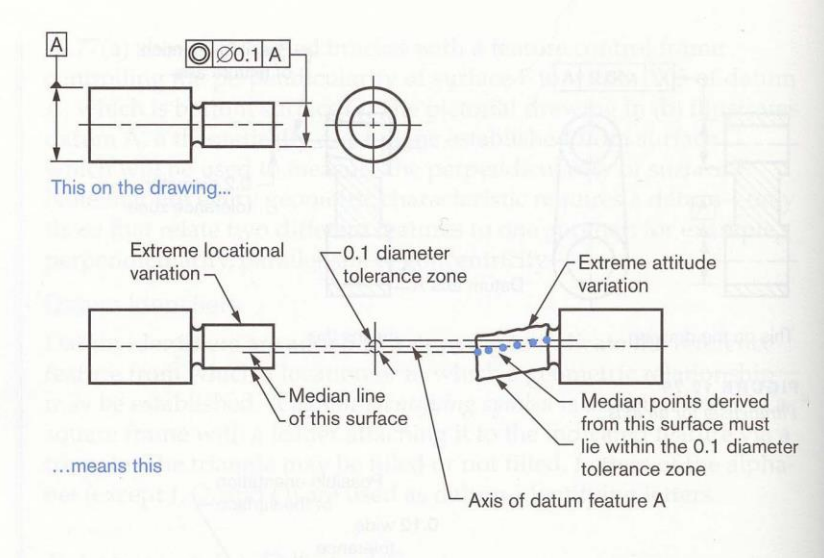
Perpendicularity for an axis



Perpendicularity for a plane

Concentricity

- A *concentricity tolerance* indicates that a cylinder, cone, hex, square or surface of revolution shares a common axis with a datum feature. It controls the location for the axis of the indicated feature within a cylindrical tolerance zone whose axis coincides with the datum axis.



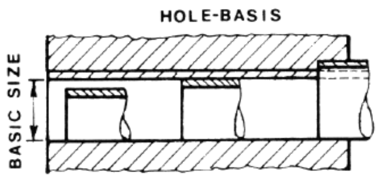
- Other Form Tolerances are
  - Profile tolerance
  - Positional tolerance
  - Angularity

2.3.1.Limits and fits for shafts and holes

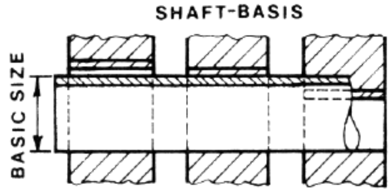
Basic size and shaft/hole tolerance systems

The basic size or nominal size is the size of shaft or hole that the designer specifies before applying the limits to it. There are two systems used for specifying shaft/hole tolerances:

Basic hole system: Starts with the basic hole size and adjusts shaft size to fit.



Basic shaft system: Starts with the basic shaft size and adjusts hole size to fit.



Because holes are usually made with standard tools such as drills and reamers, etc, the basic hole system tends to be preferred and will therefore be used here.

Fit

The fit represents the tightness or looseness resulting from the application of tolerances to mating parts, e.g. shafts and holes.

Fits are generally classified as one of the following:

- Clearance fit: Assemble/disassemble by hand.
  - Creates running & sliding assemblies, ranging from loose low cost, to free-running high temperature change applications and accurate minimal play locations.
- Transition fit: Assembly usually requires press tooling or mechanical assistance of some kind. Creates close accuracy with little or no interference.
- Interference fit: Parts need to be forced or shrunk fitted together.
  - Creates permanent assemblies that retain and locate themselves.

2.3.2. ISO limits and fits

- Fits have been standardized and can be taken directly from those tabulated in the BS 4500 standard, 'ISO limits and fits.'

Holes:	**H11**	**H9**	**H8**	**H7**					
Shafts:	**c11**	**d10**	**e9**	**f7**	**g6**	**k6**	**n6**	**p6**	**s6**

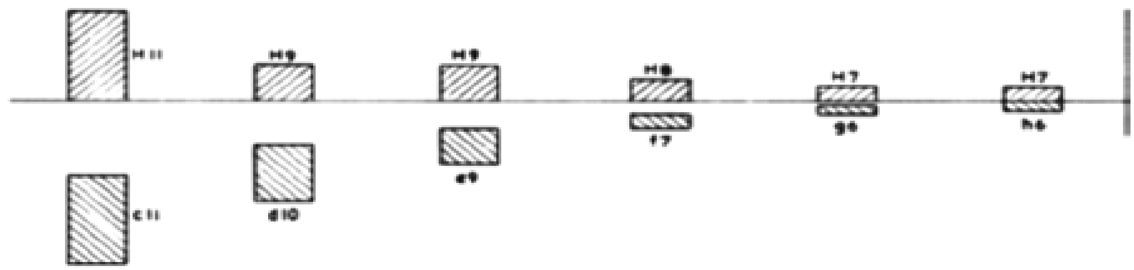
Remember:

- Capital letters always refer to holes, lower case always refer to shafts.
- The greater the number the greater or wider the tolerances.
- The selection of a pair of these tolerances will give you the fit.

Clearance Fits

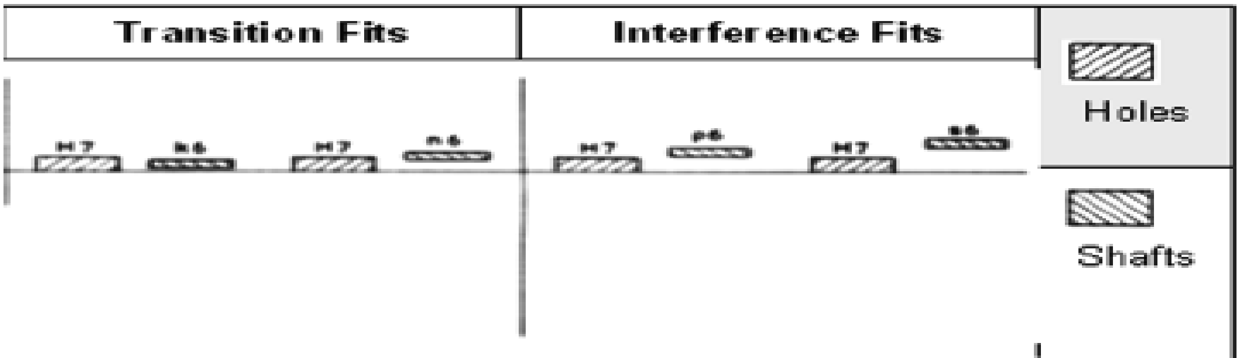
Holes

Shafts



Nominal Sizes		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance	
Over	To	H11	c11	H9	d10	H9	e9	H8	f7	H7	g6	H7	h6
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm
-	3	60 0	-60 -120	25 0	-20 -60	25 0	-14 -39	14 0	-6 -16	10 0	-2 -8	10 0	-6 0
3	6	75 0	-70 -145	30 0	-30 -78	30 0	-20 -50	18 0	-10 -22	12 0	-4 -12	12 0	-8 0
6	10	90 0	-80 -170	36 0	-40 -98	36 0	-25 -61	22 0	-13 -28	15 0	-5 -14	15 0	-9 0
10	18	110 0	-95 -205	43 0	-50 -120	43 0	-32 -75	27 0	-16 -34	18 0	-6 -17	18 0	-11 0
18	30	130 0	-110 -240	52 0	-65 -149	52 0	-40 -92	33 0	-20 -41	21 0	-7 -20	21 0	-13 0
30	40	160 0	-120 -280	62	-80	62	-50	39	-25	25	-9	25	-16
40	50	160 0	-130 -290	0	-180	0	-112	0	-50	0	-25	0	0
50	65	190 0	-140 -330	74	-100	74	-60	46	-30	30	-10	30	-19
65	80	190 0	-150 -340	0	-220	0	-134	0	-60	0	-29	0	0
80	100	220 0	-170 -390	87	-120	87	-72	54	-36	35	-12	35	-22
100	120	220 0	-180 -400	0	-260	0	-159	0	-71	0	-34	0	0
120	140	250 0	-200 -450	100	-145	100	-84	63	-43	40	-14	40	-25
140	160	250 0	-210 -460										
160	180	250 0	-230 -480	0	-305	0	-185	0	-83	0	-39	0	0
180	200	290 0	-240 -530	115	-170	115	-100	72	-50	46	-15	46	-29
200	225	290 0	-260 -550										
225	250	290 0	-280 -570	0	-355	0	-215	0	-96	0	-44	0	0
250	280	320 0	-300 -620	130	-190	130	-110	81	-56	52	-17	52	-32
280	315	320 0	-330 -650	0	-400	0	-240	0	-108	0	-49	0	0
315	355	360 0	-360 -720	140	-210	140	-125	89	-62	57	-18	57	-36
355	400	360 0	-400 -760	0	-440	0	-265	0	-119	0	-54	0	0
400	450	400 0	-440 -840	155	-230	155	-135	97	-68	63	-20	63	-40
450	500	400 0	-480 -880	0	-480	0	-290	0	-131	0	-60	0	0
		Slack Fit		Loose Fit		Easy Fit		Normal Fit		Close Fit		Slide Fit	

Transition Fits				Interference Fits					



Tolerance		Tolerance		Tolerance		Tolerance			
H7	k6	H7	r6	H7	p6	H7	s6	Over	To
0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	mm	mm
10 0	6 0	10 0	10 4	10 0	12 6	10 0	20 14	-	3
12 0	9 1	12 0	16 8	12 0	20 12	12 0	27 19	3	6
15 0	10 1	15 0	19 10	15 0	24 15	15 0	32 23	6	10
18 0	12 1	18 0	23 12	18 0	29 18	18 0	39 28	10	18
21 0	15 2	21 0	28 15	21 0	35 22	21 0	48 35	18	30
25	18	25	33	25	42	25	59	30	40
0	2	0	17	0	26	0	7	40	50
30	21	30	39	30	51	30 0	72 53	50	65
0	2	0	20	0	32	30 0	78 59	65	80
35	25	35	45	35	59	35 0	93 91	80	100
0	3	0	23	0	37	35 0	101 79	100	120
40	28	40	52	40	68	40 0	117 92	120	140
						40 0	125 100	140	160
0	3	0	27	0	43	40 0	133 108	160	180
46	33	46	60	46	79	46 0	151 122	180	200
						46 0	159 130	200	225
0	4	0	31	0	50	46 0	169 140	225	250
52	36	52	66	52	88	52 0	190 158	250	280
0	4	0	34	0	56	52 0	202 170	280	315
57	40	57	73	57	98	57 0	226 190	315	355
0	4	0	37	0	62	57 0	244 208	355	400
63	45	63	80	63	108	63 0	272 232	400	450
0	5	0	40	0	68	63 0	292 252	450	500
Push Fit		Drive Fit		Press Fit		Force Fit			

2.4. Undertake Engineering calculations, dimensions limits and fits, surface texture, datum references and geometric tolerances

ISO limits and fits, determining working limits.

Consider an example of a shaft and a housing used in a linkage:

Type of fit:	'Normal' clearance fit.
Basic or Nominal size:	∅40mm

We will determine the actual working limits, the range of allowable sizes, for the shaft and the hole in the housing.

Look along the bottom of the ISO Fits Data Sheet 4500A and locate 'Normal Fit'. We will use this pair of columns to extract our tolerances.

The tolerances indicated are:	1st column	**H8**	for the hole	(upper case **H**)
	2nd column	**f7**	for the shaft	(lower case **f**)

The actual tolerances depend upon the basic, or nominal, diameter as well as the class of fit. So, locate 40mm in the left hand **Nominal Sizes** column. Either the **30 - 40** or **40 - 50** range is acceptable in this case. Read across and note the tolerance values for the hole and the shaft, as shown below.

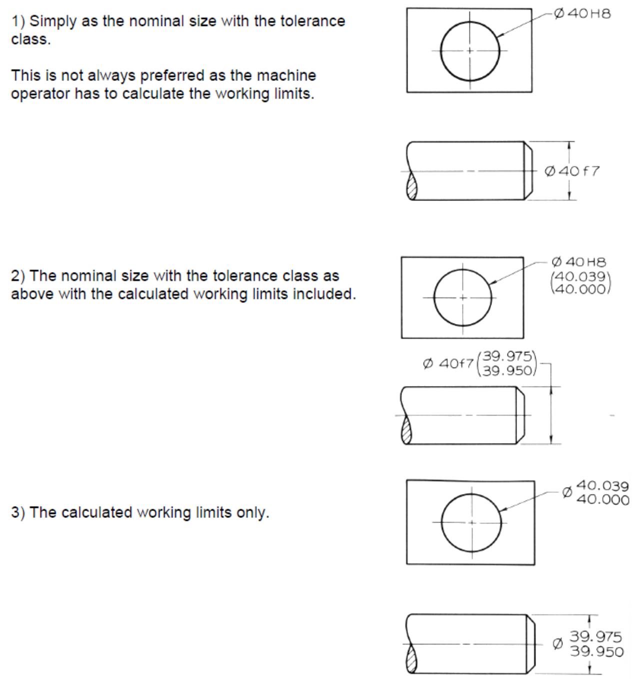
For the hole diameter we have a tolerance of: **+0.039mm** **-0.000mm**

For the shaft diameter we have a tolerance of: **-0.025mm** **-0.050mm**

These tolerance values are simply added to the nominal size to obtain the actual allowable sizes.

Note that this is a clearance fit. As long as the hole and shaft are manufactured within the specified tolerances the hole will **always** be either slightly oversize or spot on the nominal size and the shaft will **always** be slightly undersize. This ensures that there will **always** be a free clearance fit.

These tolerances may be expressed on a drawing in several ways:



2.5. Show correct convention of parts

Fillets and Rounds

- Fillets are concave metal corner (inside) surfaces. In a cast, a fillet normally increases the strength of a metal corner because a rounded corner cools more evenly than a sharp corner, thereby reducing the possibility of a break.
- Rounds or radii are edges or outside corners that have been rounded to prevent chipping and to avoid sharp chipping and to avoid sharp cutting edges. Figure 2-4 shows fillets and rounds.

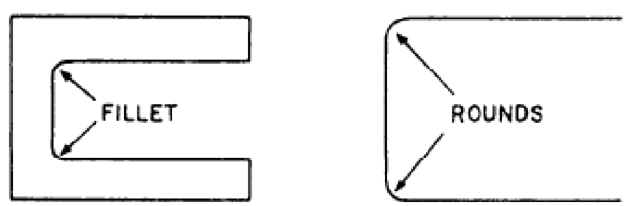


Fig. 2-4 Fillets and rounds

Slots and Slides

Slots and slides are used to mate two specially shaped pieces of material and securely hold them together, yet allow them to move or slide. Figure 2-5 shows two types:

- the tee slot, and t
- the dovetail slot.

For examples, a tee slot arrangement is used on a milling machine table, and a dovetail is used on the cross slide assembly of an engine lathe.

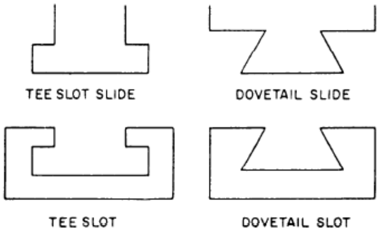


Fig 2-5 Slots and slides.

Keys, Key seats, and Keyways

A key is a small wedge or rectangular piece of metal inserted in a slot or groove between a shaft and a hub to prevent slippage. Figure 2-6 shows three types of keys.

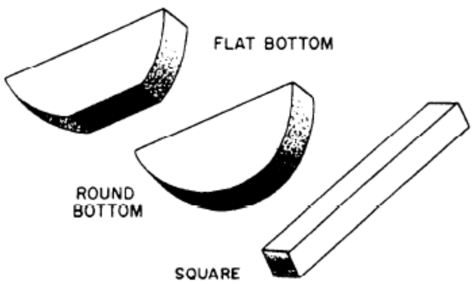


Fig. 2-6 three types of keys

Figure 2-7 shows a key seat and keyway .View shows a key seat, which is a slot or groove on the outside of a part into which the key fits. View B shows a keyway, which is a slot or groove within a cylinder, tube, or pipe. A key fitted into a key seat will slide into the keyway and prevent movement of the parts.

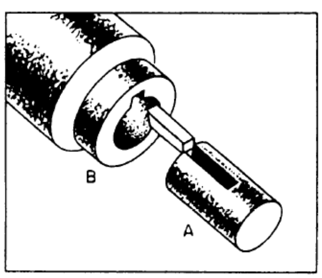


Fig. 2-7 A key seat and keyway.

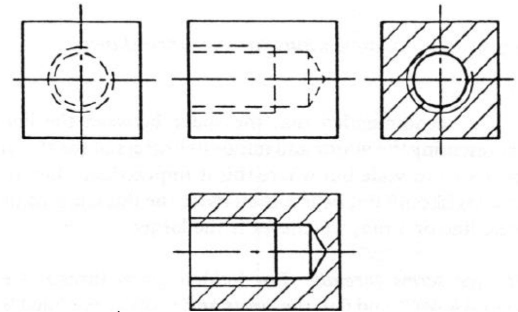
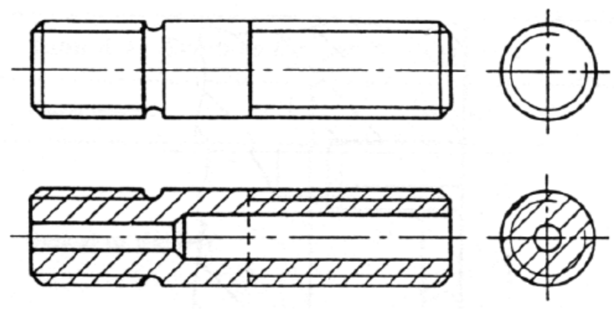
Female thread, blind: Usually drilled and tapped.	
Male thread: Usually cut with a die, turned or rolled. Note use of undercut or groove and appearance of thread in sectioned view.	

Fig. 2-12 Thread representations in drawing

2.6. Produce drawing in third angle projection

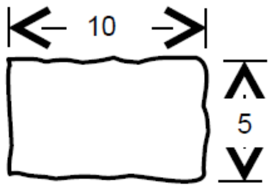
Preparing Engineering Drawings

Usually engineering drawings (of real life objects) are prepared in three stages;

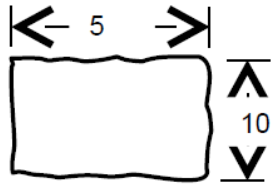
- sketches,
- hand drafts and
- Detail drawings. This sequence is not very binding but most workers find it very useful to work in that order.

Sketches

- Sketching is almost always the first step in the preparation of Engineering Drawings (ED). The work piece (object) is carefully studied and all the necessary dimensions are measured. The views that are necessary to completely describe the object are very roughly drawn (free hand). All dimensions are indicated on the sketch as deemed necessary.



YES



NO

Working Drawings

- working drawings are EDs presenting single items (object/machine component/work piece etc).
- They are meant to enable the person in a workshop to produce (by machining/casting/forging/fabricating etc) the desired item. Such details as dimensional tolerances, surface finish, special treatments, material to be used for the component etc are specified.
- The number of views to be presented depends on the complexity of the item. In many situations, sectional views are included to show hidden details that could not conveniently and explicitly appear in any external view. The scale used for the detail drawing should allow a clear understanding of the drawing (i.e. use enlargements and/or reductions as you find it appropriate).
- Sometimes just a small portion of the drawing is enlarged to show all the details. Such partial enlargements are normally included in the same drawing. When the item is drawn much enlarged, it is recommended to add a picture (drawing) to true size for more information.

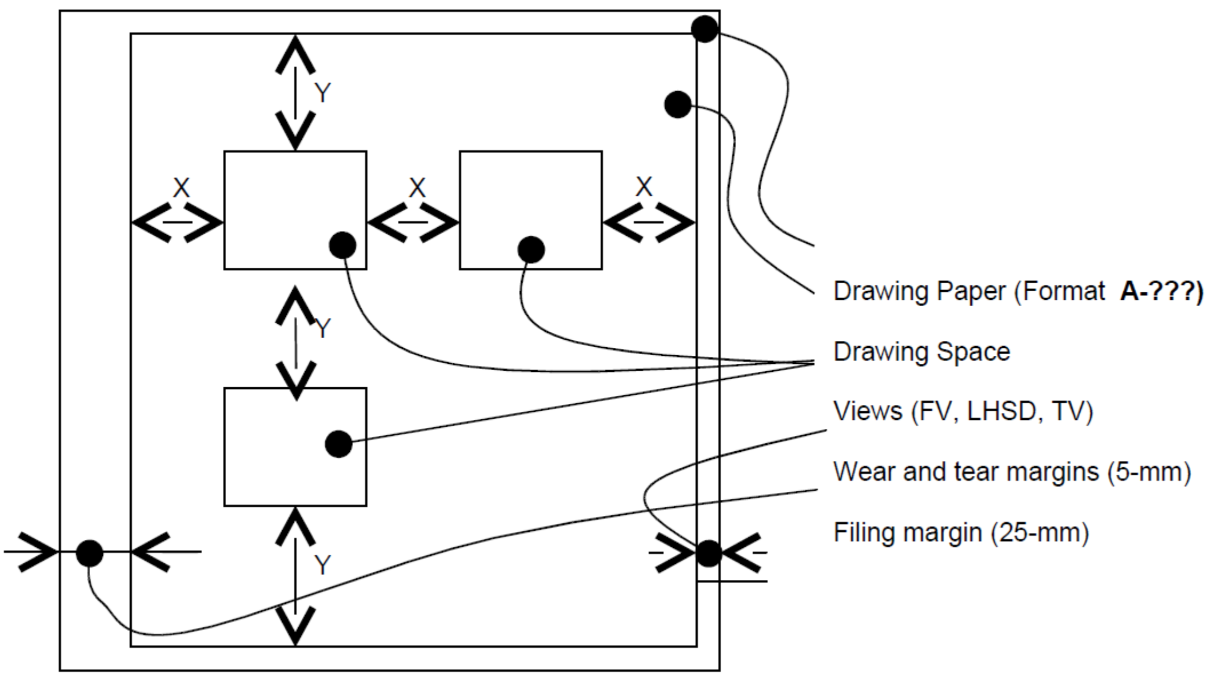
Some Basic Instruments and Equipment

Detail Drawings are prepared with the aid of special instruments and/or equipment. It would have been extremely difficult for most people to prepare EDs according to the required standards/specifications without the aid of such instruments. The following are the basic drafting tools worth understanding:

- T-Square
- Set Square
- Drafting Machine
- Rule Scale
- Wooden Pencil

- Mechanical Drawing Pencils
- Erasing Shield
- Auto CAD and Catia
- General Guidelines
- Spacing of Views

Spacing of views on the drawing paper is extremely important. The general appearance of the drawing is significantly affected if the different views are poorly spaced. Spacing of views requires us to place the views on the drawing paper such that the spaces between the views and between the views and the limits of the drawing space are roughly equal (horizontally and vertically).



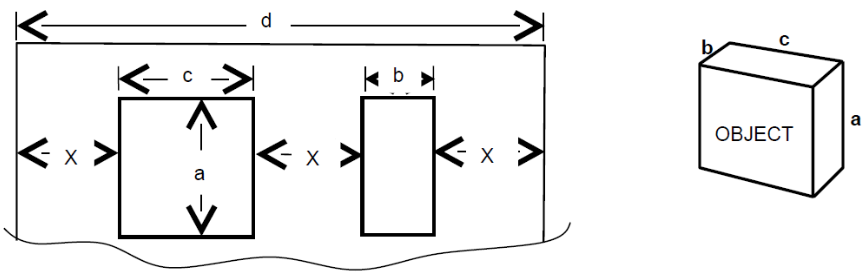
Steps

1. Decide on the views to be drawn (i.e. FV, LHSV and TV)
2. Determine the extreme dimensions of the different views to be drawn

3. Determine the required space, based on the scale to be used, both along the horizontal and vertical directions

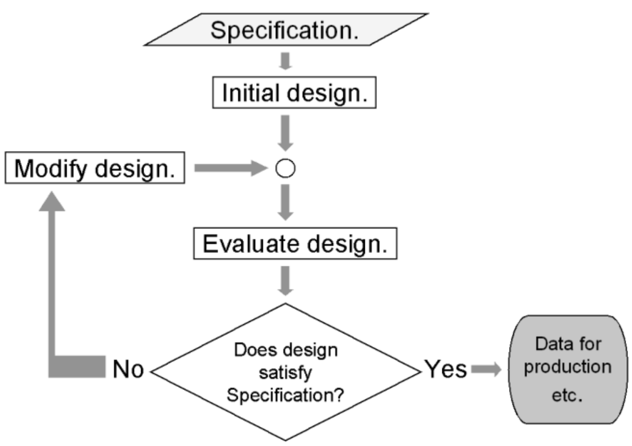
4. Divide the “free space” into three equal portions, both horizontally and vertically. This will give you X and Y

EXAMPLE: *Horizontal Spacing.*
Object Size (a-mm X b-mm X c-mm)
Drawing Space (horizontal = d-mm)



Horizontal Free Space = (Horizontal Drawing Space) – (Occupied Space) = d – (c + b)

X = (Horizontal Free Space)/(Number of Spaces) = {d – (c + b)}/3



It repeats until a satisfactory solution has evolved, as indicated in the flow diagram above.

The design model

- ❖ The concept of the designer working with a model of a design is fundamental to the design process.

- ❖ The design model is a representation of the design. This model could be anything from a few ideas in the designers head, through to rough sketches and notes, calculations, sets of detailed formal engineering drawings; computer generated 3D representations, physical prototypes, etc.
- ❖ The design model would be used by the designer to record and develop ideas and to provide a basis to evaluate the design.
- ❖ Larger design projects are undertaken by more than one engineer. Design models are used to communicate and demonstrate ideas between all those concerned with the product design, development, manufacture and use.
- ❖ A designer needs to have the skills to generate and work with this model in order to communicate ideas and develop a design.
    - To determine any drawing details, specifications we have to prepare Orthographic projection.

The word orthographic means to draw at right angles and is derived from the Greek words

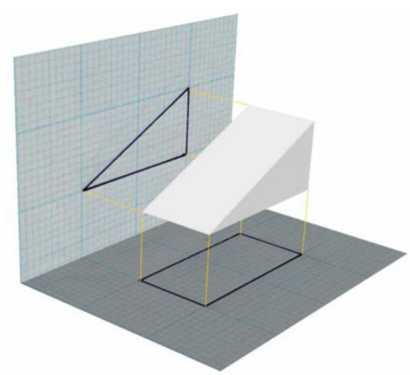


Figure 2.1a, two right angle planes of projection.

ORTHOS - straight, rectangular, upright

GRAPHOS - written, drawn

- ➢ Orthographic projection is the graphical method used in modern engineering drawing.
- ➢ In order to interpret and communicate with engineering drawings a designer must have a sound understanding of it's use and a clear vision of how the various projections are created.

- There are two predominant orthographic projections used today.
  - First angle projection
  - Third angle projection

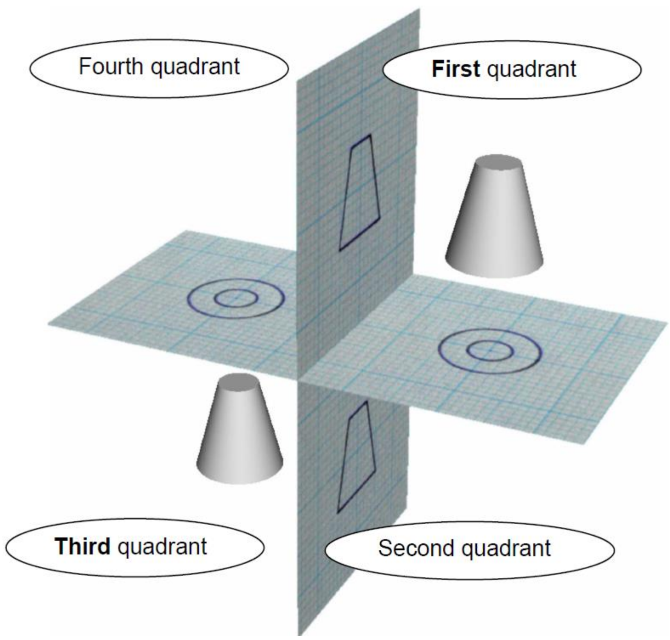
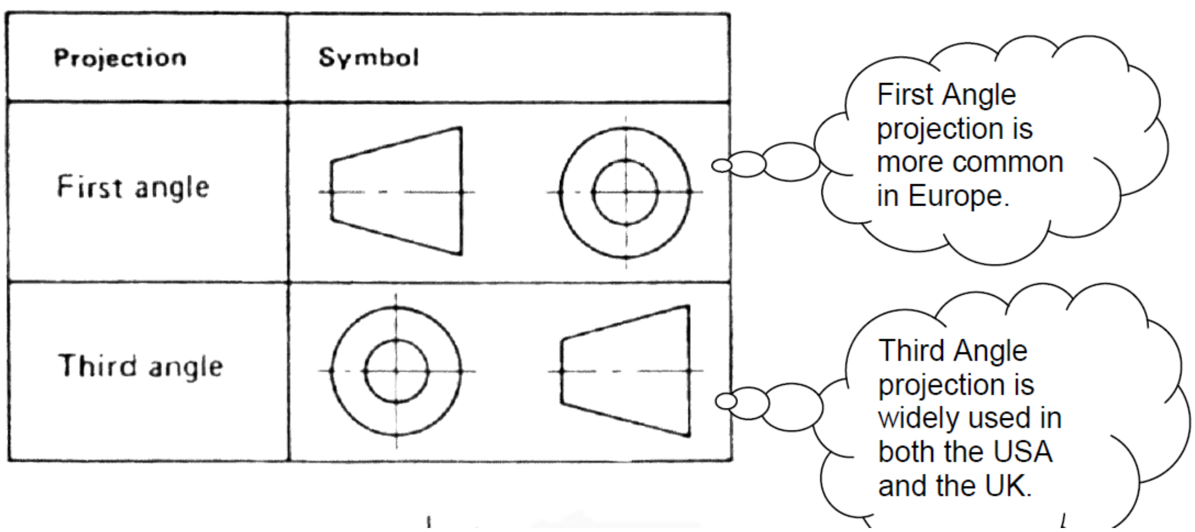
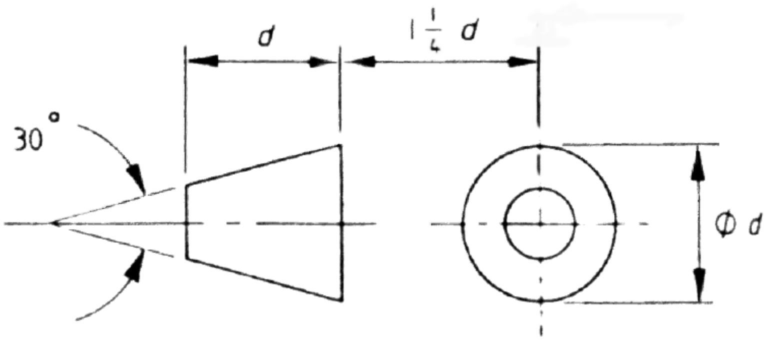


Figure 2.1b.Quadrant representation

Orthographic projection symbols





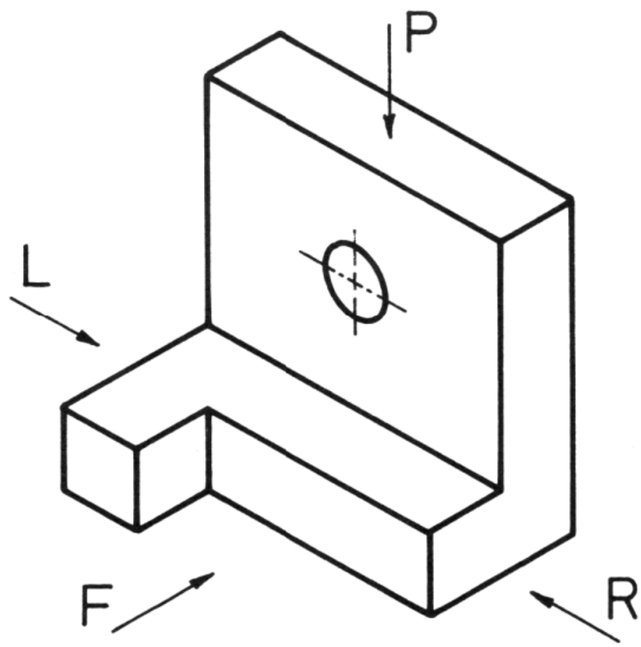
2.7. Produce all drawings in an acceptable standard/ISO

The component:

Your drawing will, for this example consist of four views:

- Front F
- Left L
- Right R
- Plan (Top) P

📖 Usual practice is to orient the component in a position that it is most likely to be found in.



First angle projection

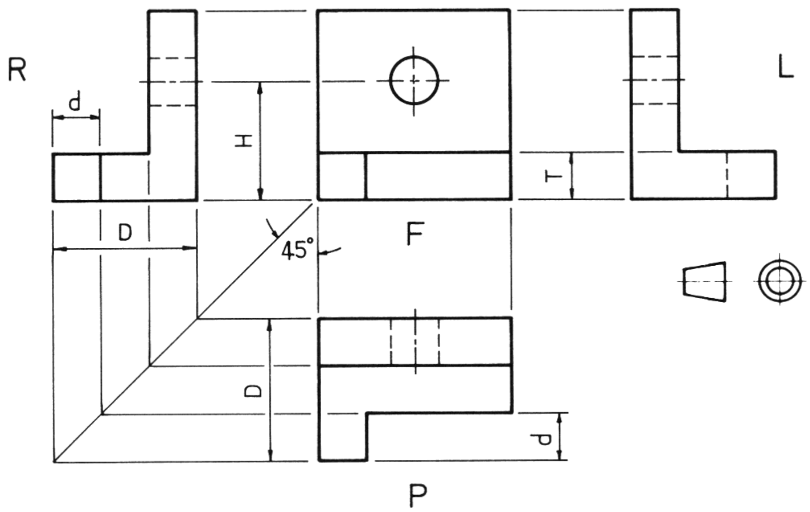
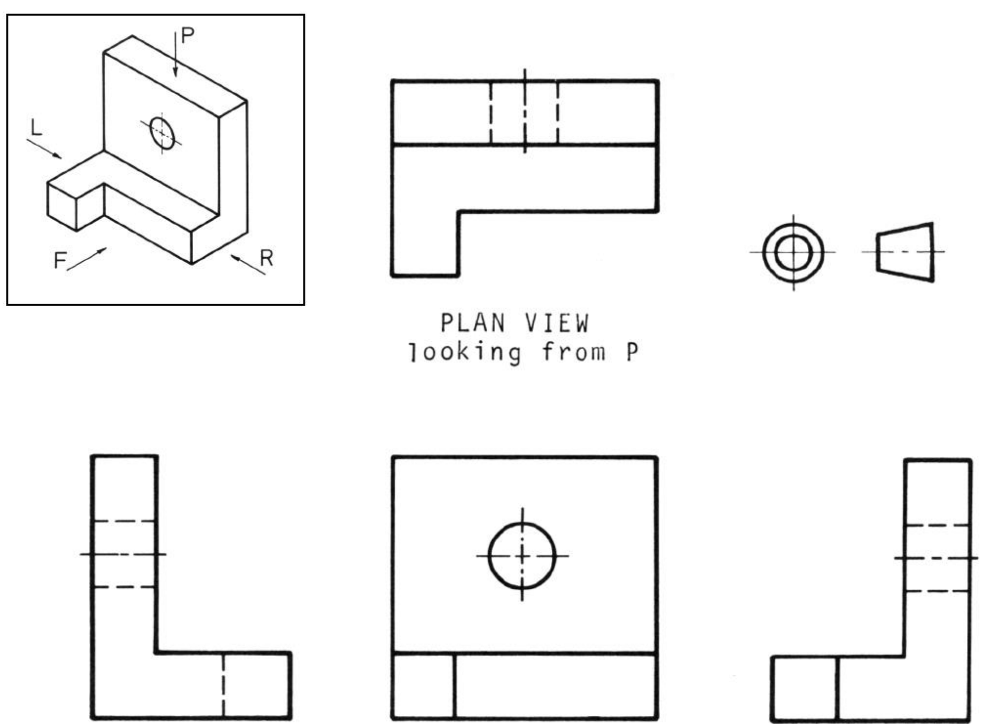


Figure 1.2d. A completed First angle projection drawing

Third angle projection

The construction method used is the same. The difference between first and third angle projection when creating and reading really lies with the positions of the views. For the same component, an orthographic projection drawing with the same front, side and plan views would look like Figure 2. below.



2.8. Select components, material and/or assemblies from data sheets

2.9. Insert dimensions and *geometric tolerances* of various components

Dimensioning

- To enable productions of machine parts/components, all the relevant dimensions have to appear on the drawing. The practice is that any dimension is shown only once in that view in which it appears more explicitly. For this reason, it is not surprising that most of the important dimensions appear in the front view.
- Repetitions are discouraged unless clarity necessitates this. To keep the drawing clean, it is advised to put all the dimensions outside the drawing, except where and when this is unavoidable.
- There are three types of dimensions;
    - Functional Dimensions (FD),
    - Non-Functional Dimensions (NFD) and
    - Auxiliary Dimensions (AD)

Functional Dimensions (FDs)

These are dimensions, which directly dictate the functioning of the component. That is a FD is a dimension defined on the basis of the function of the product and the method of locating it in any assembly of which it may form part of, e.g. the diameter of a shaft, the length of a bolt, etc.

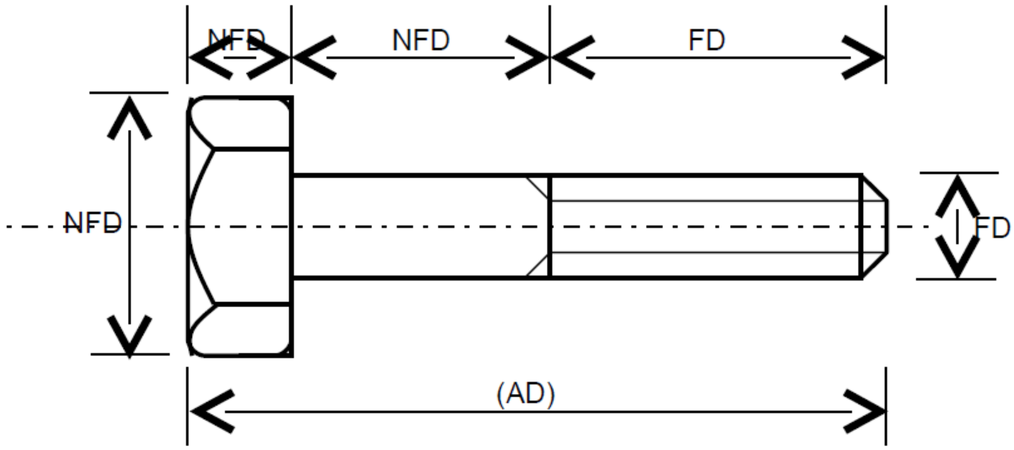
Non-Functional Dimensions (NFDs)

- These are dimensions, which do not directly affect the functioning of the component but have to be specified to enable production of that component, e.g. the size of a bolt head.

Auxiliary Dimensions (ADs)

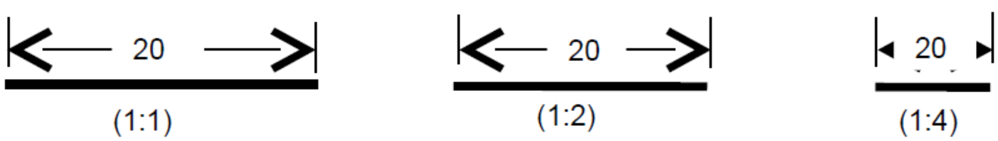
These are dimensions which should not necessarily appear on the drawing but are sometimes included to avoid calculations or when they would provide additional/useful information. ADs are usually written in brackets.

EXAMPLE: *A bolt*

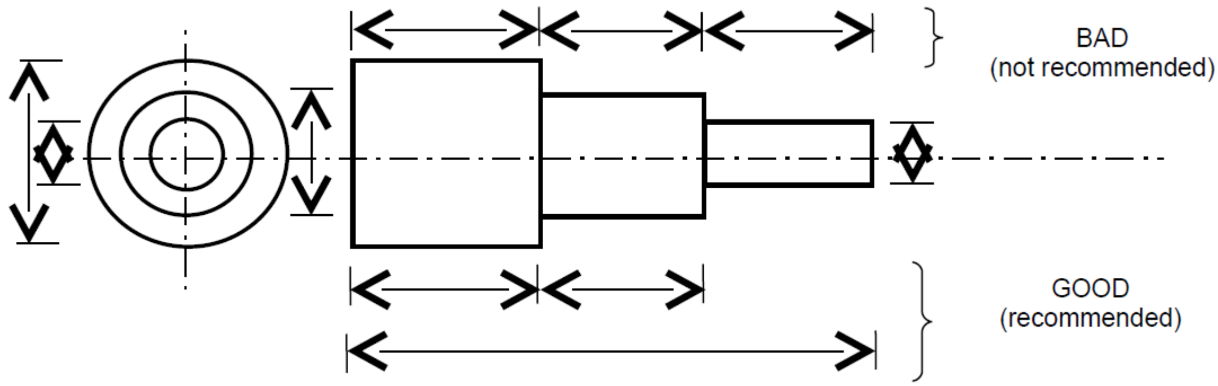


General Hints on Dimensioning

- NOTE that all "rules" on dimensioning are just guidelines. Use common sense depending on circumstances (i.e. there are no strict rules/regulations on dimensioning)
- In metric system, all linear dimensions are considered to be in millimeters
- Show full size dimensions regardless of the scale used in the drawing



- Dimension in a manner that makes it unnecessary to calculate any required size information
- For any feature, place the dimensions where the feature appears most explicitly
- Dimension any feature only once (i.e. no repetitions are allowed)
- Dimension obviously identical features only once


BAD
(not recommended)
GOOD
(recommended)

Self-check	

Self-check questions

Choose the best answer from the best answer

1. One of the following is true about Functional Dimensions (FDs)
   A. These are dimensions, which directly dictate the functioning of the component.
   B. FD is a dimension defined on the basis of the function of the product
   C. The method of locating it in any assembly of which it may form part of, e.g. the diameter of a shaft, the length of a bolt, etc.
   D. All of the above
2. Non-Functional Dimensions (NFDs)
   A. These are dimensions, which do not directly affect the functioning of the component
   B. The size of a bolt head is example of NFDs
   C. It is very basic for the component
   D. A & B   E. All of the above
3. One of the following is true about Auxiliary Dimensions (ADs)
   A. It is very basic for the component
   B. These are dimensions which should not necessarily appear on the drawing but are sometimes included to avoid calculations
   C. They would provide additional/useful information and ADs are usually written in brackets.
   D. A & B   E. B & C
4. One of the following is not types of dimensions
   A. Functional Dimensions (FD)
   B. Non-Functional Dimensions (NFD)
   C. Auxiliary Dimensions (AD)
   D. None
5. First angle projection is more common in
   A. America (USA)
   B. Unit Kingdom

C. Europe

D. All of the above

6. ________________________is the graphical method used in modern engineering drawing.

A. Orthographic projection

B. Geometric development

C. Sketching

D. All of the above

7. A_____________ is a small wedge or rectangular piece of metal inserted in a slot or groove between a shaft and a hub to prevent slippage.

A. Key C. Rivet

B. Shaft D. None

8. For H8 and f7 or H11 and c11, H, f or c represents

A. Shaft and hole respectively

B. Hole and Shaft respectively

C. Shaft only

D. All of the above

9. ________________is the size of shaft or hole that the designer specifies before applying the limits to it.

A. The basic size

B. Nominal size

C. Hole and Shaft

D. All of the above E. A & B

10. Tolerance is stated

A. as positive or negative number

B. As fraction

C. As Decimal

D. All of the above

11. Parts which are not sectioned in a drawing

A. Bolt and nut

B. Bearing

C. Pin
D. Gear
E. A & C

12. Assembly drawing conveys
    A. Complete shape of the product
    B. Overall dimension
    C. Relative position of each part
    D. All of the above

13. _______ is a set of drawing used during the work of making a product.
    A. Working drawing
    B. Assembly drawing
    C. Scope
    D. All of the above
14. One of the following **is not** drawing requirement
    A. Necessary drawing equipment to prepare the drawing
    B. Necessary dimension, symbols, and all information
    C. Information which used for the production
    D. All of the above
    E. None of the above
15. What is the purpose of tolerance
    A. To control interchangeability of parts
    B. To ensure the mating parts will have desired fit
    C. To control the production
    D. A & B
    E. B & C

Answer for Self check questions

1. D
2. D
3. E
4. D
5. D
6. A
7. A
8. B
9. E
10. D
11. E
12. D
13. A
14. E
15. D

Information Sheet-3	**LO3:** Quality assure drawing

3. Check drawing

3.1. Check drawings to ensure compliance (fulfillment) with specifications

Perform engineering measurements

- Straightforward measurement using devices which incorporate visual indications representing units of measurement. Manufacturing symbols, i.e. Surface finish, limit and fit, etc.

Apply quality procedures

- Applying established quality procedures to an employee's own work within a manufacturing, engineering or related environment.

Apply quality systems

- Working within a quality improvement system, either individually or in a team situation.

Plan to undertake a routine task

- A person planning their own work where tasks involve one or more steps or functions and are carried out routinely on a regular basis. It includes the concepts of following routine instructions, specifications and requirements.

Plan a complete activity

- Planning activities which, whilst even as following established procedures, may require a response and modification of procedures or choice of different procedures to deal with unforeseen (unexpected) developments.

3.2. Check drawings to ensure that assembly/fabrication is possible

- The drawing should be easy for assembly and manufacturing (fabrication) process in the workshop for manufacturer.

Note:

- Before deciding to archive using aperture cards, the availability of retrieval equipment and the quality of reproduction should be considered. The quality of drawings, lists, and documents shall meet the legibility and contrast requirements.

3.3. Issue, file and store drawings according to workplace system and procedures

- Checked drawings should be issued (distributed) to the responsible body with a great care.

File management system

- Files management is the process of determining how files will be
  - arranged,
  - categorized,
  - accessed, and
  - Stored, whether in paper or electronic format.
- Having good filing practices ensures that the right file can be retrieved quickly at the right time for the lowest possible cost.
- Users of the system should be part of the planning process and trained on policies and procedures when the system is implemented.
- Create a policy and procedure manual to distribute to staff members for easy reference.

Paper Filing Practices

- The most common methods of arranging documents are
  - Alphabetical
  - , numerical, or alphanumeric.
- The file arrangement should be based on how the information will be retrieved.

Alphabetical Filing

- **There are two types of alphabetical filing.**
  - **Topical** filing arranges files in straight alphabetical order, such as subject correspondence arranged from A to Z, based on the name of the subject.
  - **Classified** filing arranges related documents under a major subheading, such as customer complaint correspondence filed under the general heading of customer relations.

Advantages of alphabetical filing include:

- avoiding the use of an index
- effective filing if adhered to
- ease of browsing through files

Disadvantages of alphabetical filing are:

- the increased risk of misfiling versus numeric systems
- retrieval problems arising over name changes
- may be inefficient and cumbersome in large systems
- ease with which unauthorized persons can find records

Numerical Filing

- **Numerical filing**
  - by file number,
  - by Social Security number,
  - by date, or
  - By patient or case number is common.

Advantages of numerical filing include:

- quicker comprehension of numerical sequences over alphabetical
- ability to add new files without disturbing existing arrangement
- easy identification of misfiled or out-of-sequence numbers

Disadvantages of numerical filing are:

- necessity of an index since it is an indirect arrangement
- possibility of numbers being transposed when files are created

Alphanumeric Filing

- An alphanumeric arrangement uses a combination of numeric digits and alphabets to create a flexible filing system.
- An index is required to use the system effectively.
    - Subjects may be substituted by using alphabetical or numerical codes, such as

      ADM-001 (Administrative files, Director's Correspondence) and
      ADM-002 (Administrative files, Assistant Director's correspondence).

Advantages of alphanumerical filing include:

- eliminating the need for long titles through use of codes
- increased file security because users must understand the coding system

Disadvantages of alphanumerical filing include:

- the necessity of consulting an index in order to access the files
- the need to train users on the index

Indexes

- An index is a listing used to determine file location.
- Alphanumeric systems require and numeric could require an index, but alphabetical does not.
- Most indexes have a heading and the subheading listed alphabetically. The heading is the main class or title of records and the subheading lists records that are derived or related to the main heading.

Disposal

- A key part of filing-system maintenance involves controlling the growth of the system.
- Records should be reviewed regularly to purge and dispose of records that have expired based on Records Retention & Disposition Schedules.
- Documents containing confidential, personally identifying, or private information should be confidentially destroyed.
- A Certificate of Records Destruction must be submitted to the Archival and Records Management Services Division after records have been destroyed.

Audits

- Regardless of the type used, filing systems should be audited periodically and updated as necessary to accommodate any changes in the records or needs of the users.

- Another aspect of the audit is determining if Records Retention & Disposition Schedules are being applied

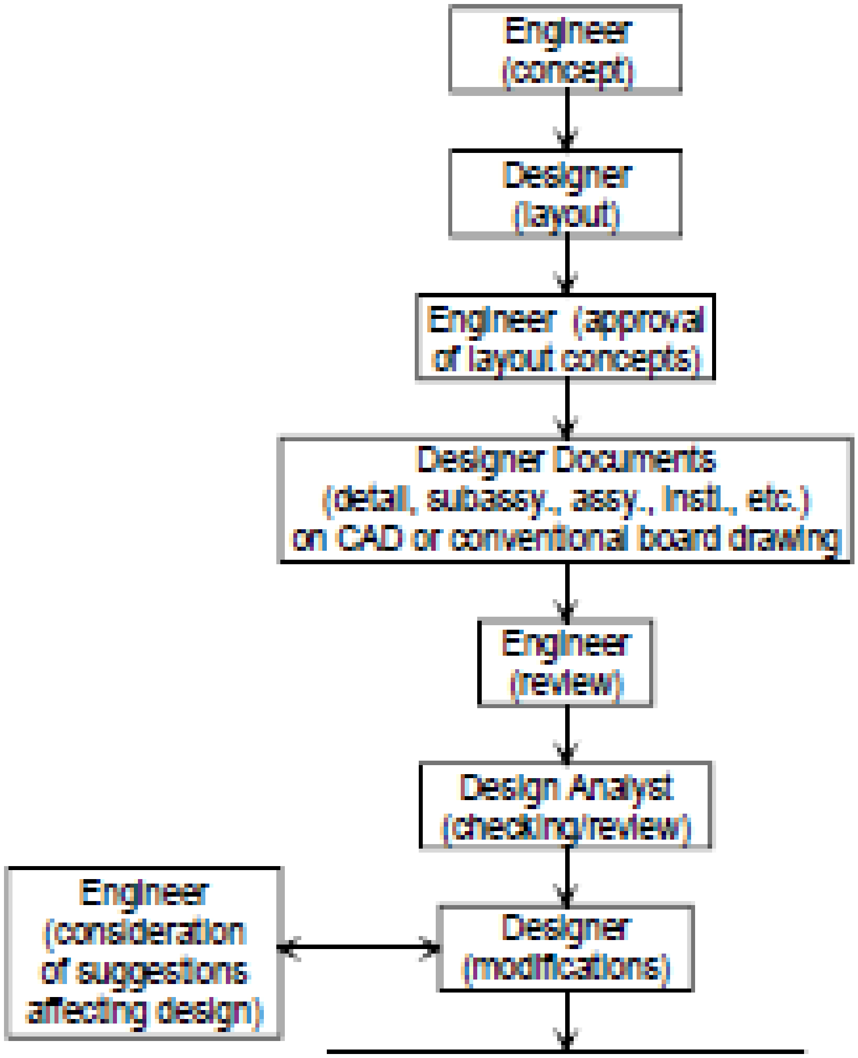
Review retention schedules and compare with destruction certificates to see if records are being promptly destroyed when eligible.

Store and catalogue Approved drawings

Archiving

Drawings, Engineering Orders (EOs), Certification Logs, Associated Lists, and Engineering Parts Lists (EPLs) shall be archived after signoff. Following are some sample archiving methods:

- Filing of all paper originals.
- Scanning of the paper originals to a standard digital raster image format and then using a digital storage system to archive the resulting database of raster images.
- Microfilming and storing on aperture cards when requested by a GSFC division that still has equipment to retrieve the information.


Engineer
(concept)
Designer
(layout)
Engineer (approval
of layout concepts)
Designer Documents
(detail, subassy., assy., Instl., etc.)
on CAD or conventional board drawing
Engineer
(review)
Design Analyst
(checking/review)
Engineer
(consideration
of suggestions
affecting design)
Designer
(modifications)

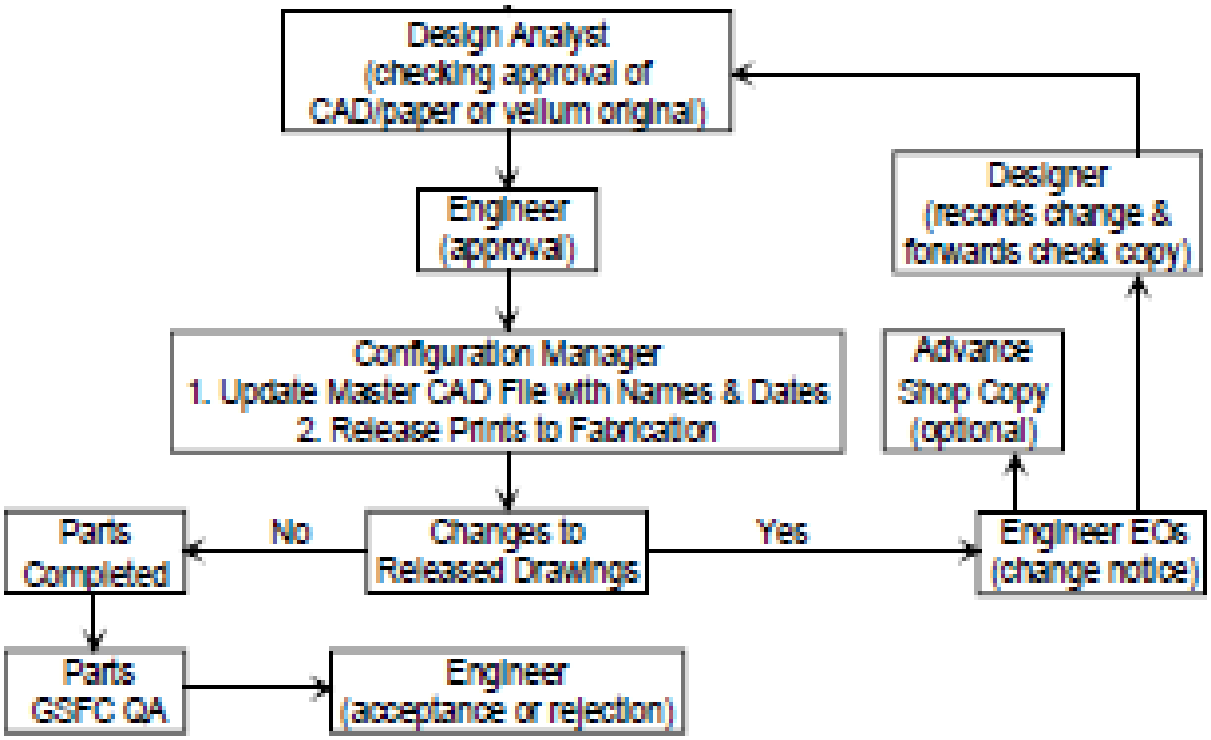


Fig 1 Typical Drawing Flow for Flight Projects