Trade of Metal Fabrication	
Module 5:	Pipe Fabrication
Unit 4:	Pipe Developments
	Phase 2

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Document Release History

Date	Version	Comments
12/02/07	First draft	
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Module 5 – Pipe Fabrication

Unit 4 – Pipe Developments

Duration – 5 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Develop patterns using parallel line method
- Draw hidden detail
- Mark cutting lines from developed templates
- Describe the principle and features of a radial arm drilling machine
- List the advantages of hole punching compared to drilling
- Describe the difference between counterboring and countersinking
- Fabricate a mitred flange and pipe joint
- Describe angles and the angular properties of parallel lines

Key Learning Points:

Rk D	Interpretation and drawing of pattern developments on paper using parallel line method. Indexing of points.
M	Calculate dimensions required -pipe circumference. *(Classroom work also).*
Sk D	Make pattern developments, transfer patterns to pipes. Oxy-fuel cut pipe.
Rk Sk	Centre line positioning for alignment.
Sk Rk H	Radial arm drilling machine - safety, work clamping. *(For more information see Module 1 Unit 3).*
Rk	Counterboring - countersinking - applications on pipe flanges.
Sk	Pipe mitre cutting/flange cutting - drilling.
Sk D	Geometry (angles and parallel line).
P	Planning work sequence, communications.

Training Resources:

- Drawing equipment
- Pipe oxy-fuel cutting plant, apprentice toolkit
- Fabrication workshop and equipment
- Safety clothing and equipment
- Handouts, notes and technical manuals
- Pipe sections
- M.S. plate

Key Learning Points Code:

M = Maths D= Drawing RK = Related Knowledge Sc = Science

P = Personal Skills Sk = Skill H = Hazards

Circumference

The circumference is the total distance around the circle (perimeter).

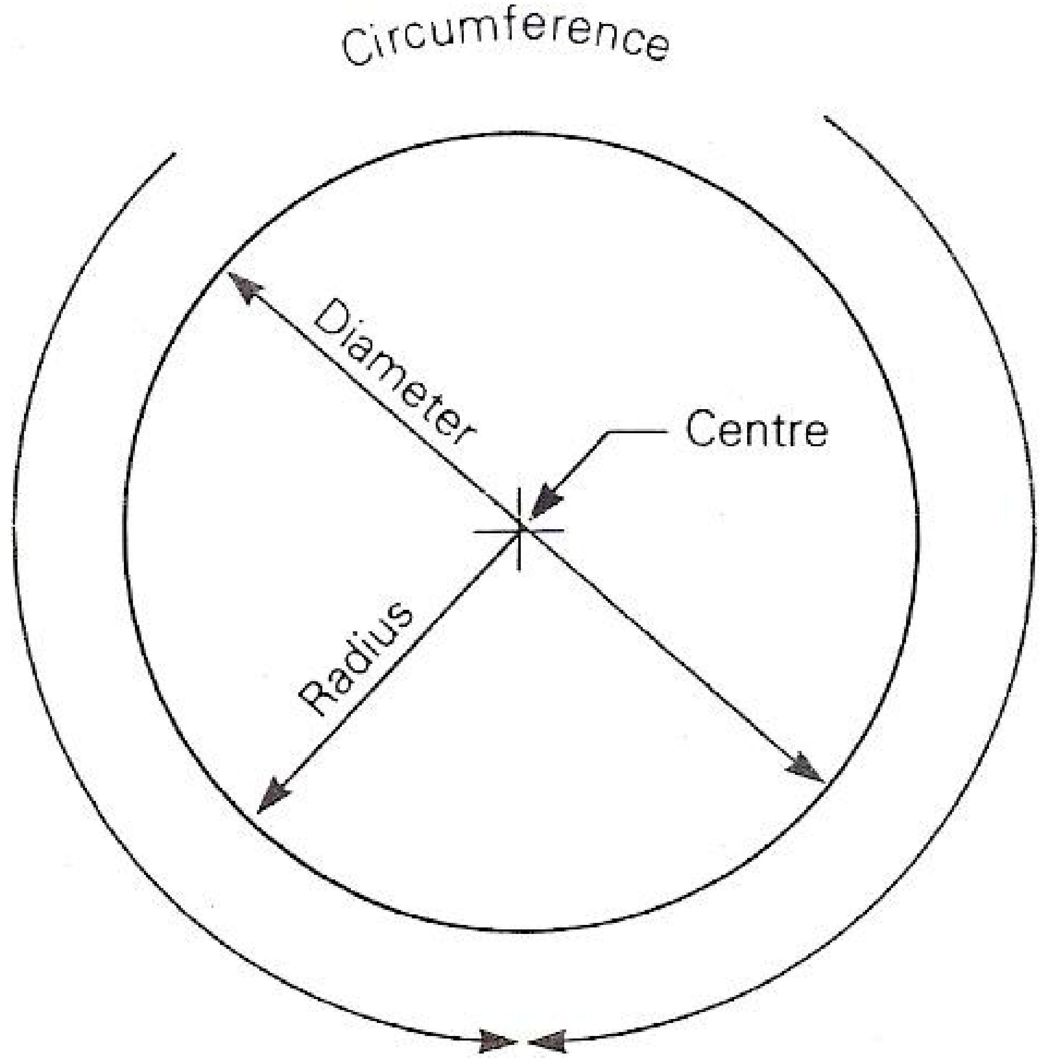
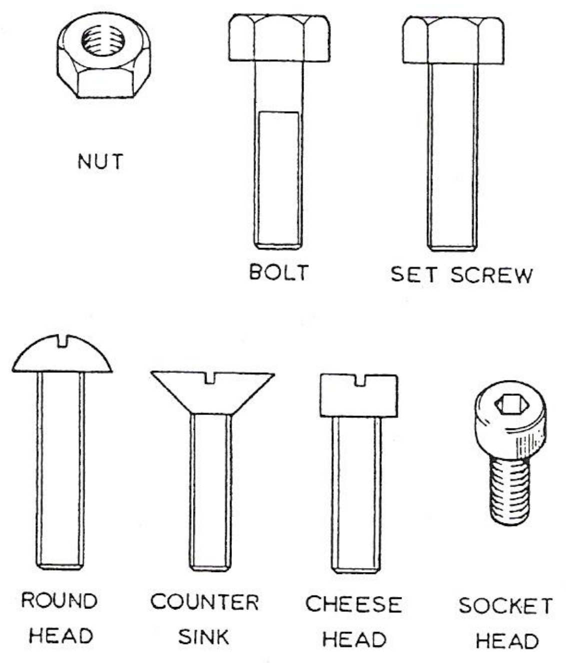
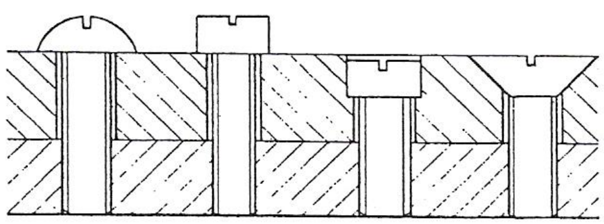


Figure 1 - Circumference

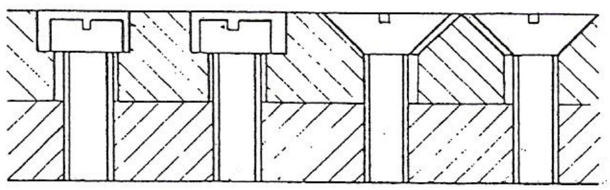
Counterboring/Countersinking

Simple Locking Devices Related to Applications on Pipe Flanges





APPLICATIONS OF SCREW HEADS



CHEESE HEADS COUNTERSINKS

Nuts, bolts and screws are used to build up assemblies when it is known that the assembly may have to be 'broken' down for such reasons as adjustment, or maintenance of machine tools or dismantling pipe/flange services etc.

For assemblies that require the maximum tightening, nuts and bolts are used because the heads are made to fit standard spanners which are designed to give the maximum tightening. Plain washers also assist the tightening of nuts and bolts as they reduce the friction between the face of the nut and the surface of the job thus allowing extra pressure to be exerted through the thread.

Screws are generally known by the shape of the head and each one has a specific use.

The round head is used for light work, where the head can protrude above the surface. Hexagonal heads are used under similar conditions but they afford greater tightening. The countersink screw is used for light work where the head must lay flush or below the surface. Great care must be taken when drilling and tapping for countersink screws as the design of the head allows them to tighten properly only when the holes are in line.

The cheese, head can replace the round if greater tightness is required, as the head is stronger, also it cart replace the countersink if it is known that the holes may be out of line, provided that the counterbores are large enough to accommodate the errors.

The socket type head is preferred where permanent locking and maximum strength is required.

Work Holding & Clamping Force

Work Holding

Strap clamps are widely used when work is clamped to the table of a milling machine or a drilling machine. Strap clamps may be considered as simple levers which are illustrated below.

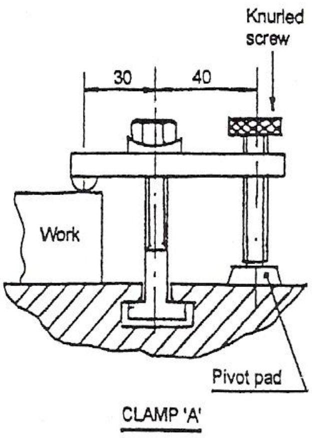


Figure 2 - Strap Clamp 1

Figure 2 above shows a knurled screw which when rotated clockwise, provides the clamping force on the workpiece.

Figure 3 below shows another arrangement of strap clamp which may be used for clamping the work piece to the milling machine table.

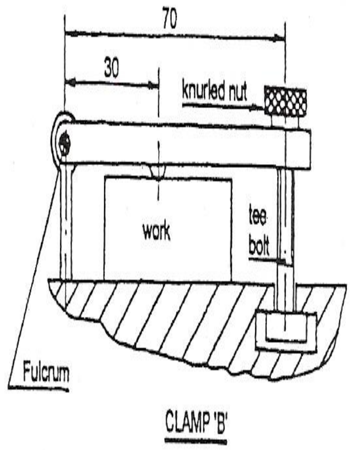


Figure 3 - Strap Clamp 2

The third arrangement of strap clamping which is shown in the Figure 170 is the most widely used method of securing a workpiece to a milling machine table. The clamping force is provided by rotating the hexagonal nut clockwise.

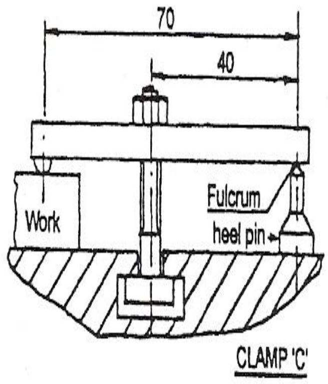


Figure 4 - Strap Clamp 3

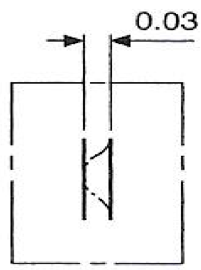
Application of Geometrical Tolerances

In this chapter, examples are given of the application of tolerances to each of the characteristics on engineering drawings by providing a typical specification for the product and the appropriate note which must be added to the drawing. In every example, the tolerance values given are only typical figures: the product designer would normally be responsible for the selection of tolerance values for individual cases.

Straightness

A straight line is the shortest distance between two points. A straightness tolerance controls:

1. the straightness of a line on a surface,
2. the straightness of a line in a single plane,
3. the straightness of an axis.



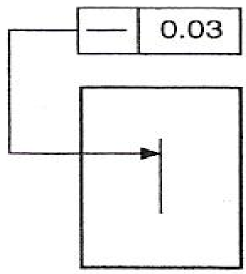
Case 1

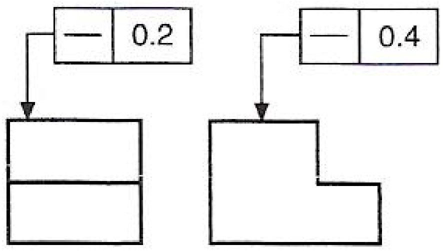
Product requirement

The specified line shown on the surface must lie between two parallel straight lines 0.03 apart.

Drawing instruction

A typical application for this type of tolerance could be a graduation line on an engraved scale.



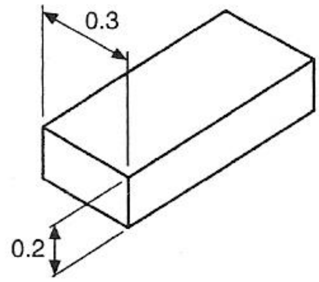


In the application shown above, tolerances are given controlling the straightness of two lines at right angles to one another. In the left-hand view the straightness control is 0.2, and in the right-hand view 0.4. As in the previous example, the position of the graduation marks would be required to be detailed on a plan view.

Case 2

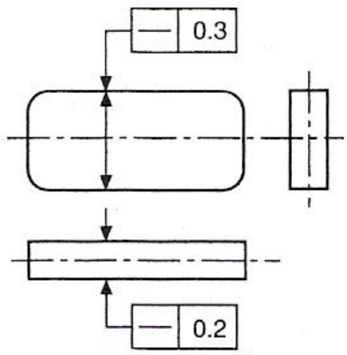
Product requirement

The axis of the whole part must lie in a boxed zone of 0.3 x 0.2 over its length.

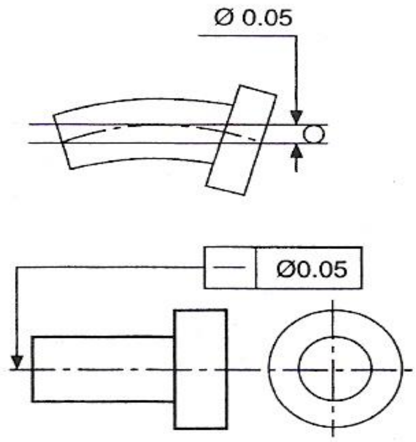


Drawing instruction

As indicated, the straightness of the axis is controlled by the dimensions of the box, and could be applied to a long rectangular key.



Case 3



Product requirement

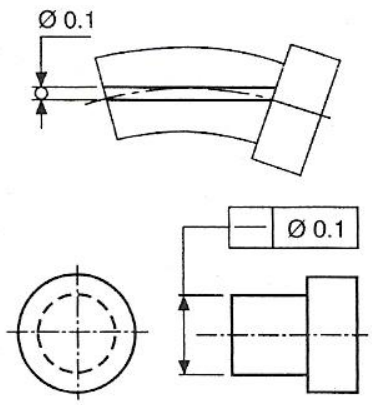
The axis of the whole feature must lie within the cylindrical tolerance zone of 0.05.

Drawing instruction

Case 4

Product requirement

The geometrical tolerance may be required to control only part of the component. In this example the axis of the dimensioned portion of the feature must lie within the cylindrical tolerance zone of 0.1 diameter.



Drawing instruction

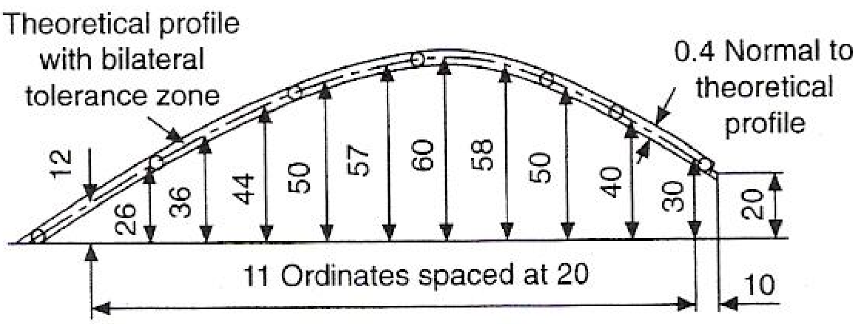
Profile Tolerance of a Line

Profile tolerance of a line is used to control the ideal contour of a feature. The contour is defined by theoretically exact boxed dimensions and must be accompanied by a relative tolerance zone. This tolerance zone, unless otherwise stated, is taken to be equally disposed about the true form, and the tolerance value is equal to the diameter of circles whose centres lie on the true form. If it is required to call for the tolerance zone to be positioned on one side of the true form (i.e. unilaterally), the circumferences of the tolerance-zone circles must touch the theoretical contour of the profile.

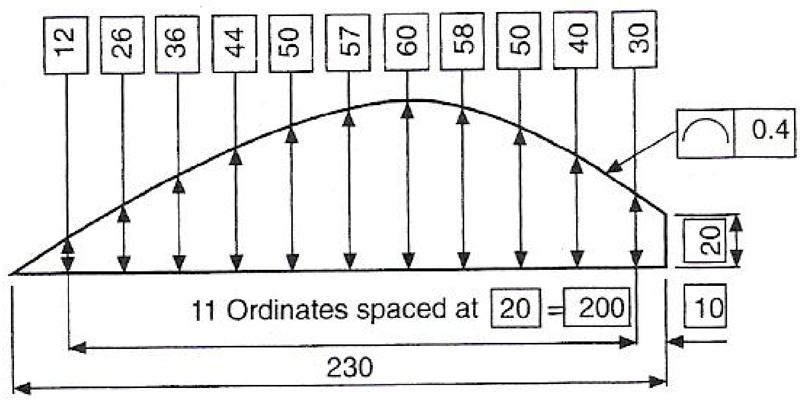
Case 1

Product requirement

The profile is required to be contained within the bilateral tolerance zone.



Drawing instructions

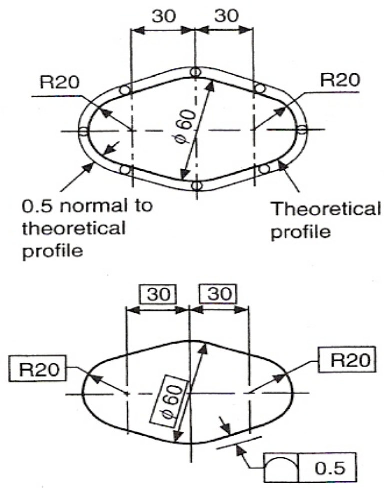


Case 2

Product requirement

The profile is required to be contained within the unilateral tolerance zone.

Drawing instruction

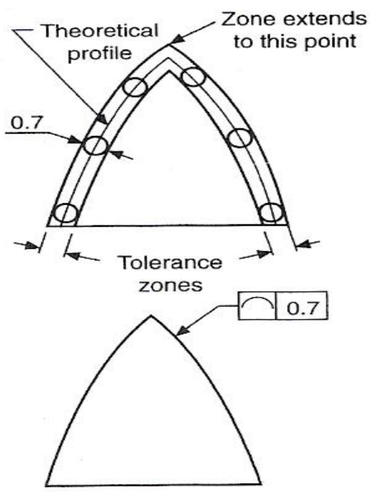


The figure below shows an example where the toleranced profile of a feature has a sharp corner. The inner tolerance zone is considered to end at the intersection of the inner boundary lines, and the outer tolerance zone is considered to extend to the outer boundary-line intersections. Sharp corners such as these could allow considerable rounding; if this is desirable, then the design requirement must be clearly defined on the drawing by specifying a radius or adding a general note such as 'ALL CORNERS 0.5 MAX'. It should be noted that such radii apply regardless of the profile tolerance.

In the example given, the product is required to have a sharp corner.

Product requirement

Drawing instruction



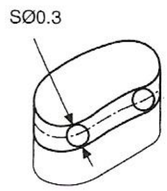
Profile Tolerance of a Surface

Profile tolerance of a surface is used to control the ideal form of a surface, which is defined by theoretically exact boxed dimensions and must be accompanied by a relative tolerance zone. The profile-tolerance zone, unless otherwise stated, is taken to be bilateral and equally disposed about its true-form surface. The tolerance value is equal to the diameter of spheres whose centre lines lie on the true form of the surface. The zone is formed by surfaces which touch the circumferences of the spheres on either side of the ideal form.

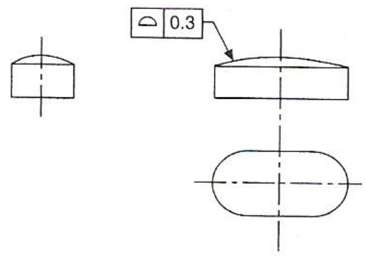
If it is required to call for a unilateral tolerance zone, then the circumferences of the tolerance-zone spheres must touch the theoretical contour of the surface.

Product requirement

The tolerance zone is to be contained by upper and lower surfaces which touch the circumference of spheres 0.3 diameter whose centres lie on the theoretical form of the surface.



Drawing instruction



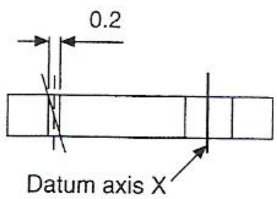
Parallelism

Two parallel lines or surfaces are always separated by a uniform distance. Lines or surfaces may be required to be parallel with datum planes or axes. Tolerance zones may be the space between two parallel lines or surfaces, or the space contained within a cylinder positioned parallel to its datum. The magnitude of the tolerance value is the distance between the parallel lines or surfaces, or the cylinder diameter.

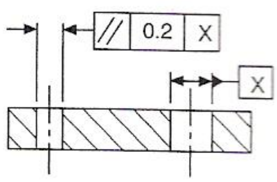
Case 1

Product requirement

The axis of the hole on the left-hand side must be contained between two straight lines 0.2 apart, parallel to the datum axis X and lying in the same vertical plane.



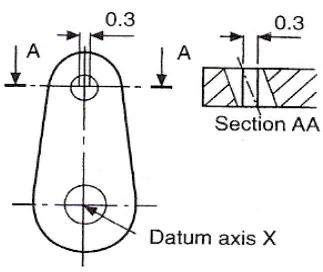
Drawing instruction



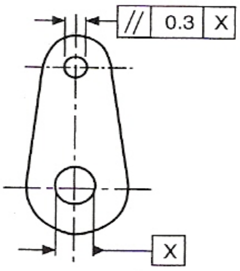
Case 2

Product requirement

The axis of the upper hole must be contained between two straight lines 0.3 apart which are parallel to and symmetrically disposed about the datum axis X and lie in the same horizontal plane.



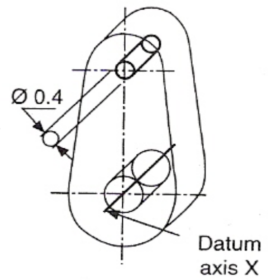
Drawing instruction



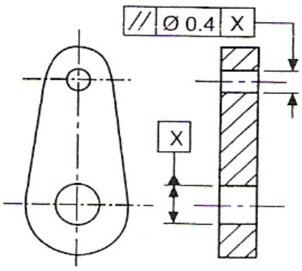
Case 3

Product requirement

The upper hole axis must be contained in a cylindrical zone 0.4 diameter, with its axis parallel to the datum axis X.



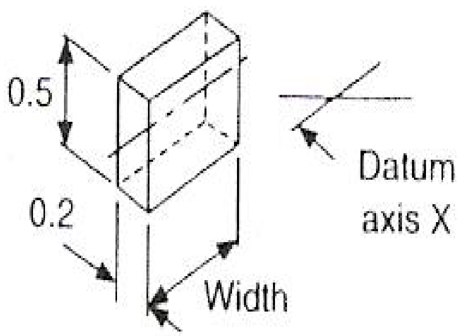
Drawing instruction



Case 4

Product requirement

The axis of the hole on the left-hand side must be contained in a tolerance box 0.5 x 0.2 x width, as shown, with its sides parallel to the datum axis X and in the same horizontal plane.



Interpretation of Drawing Patterns

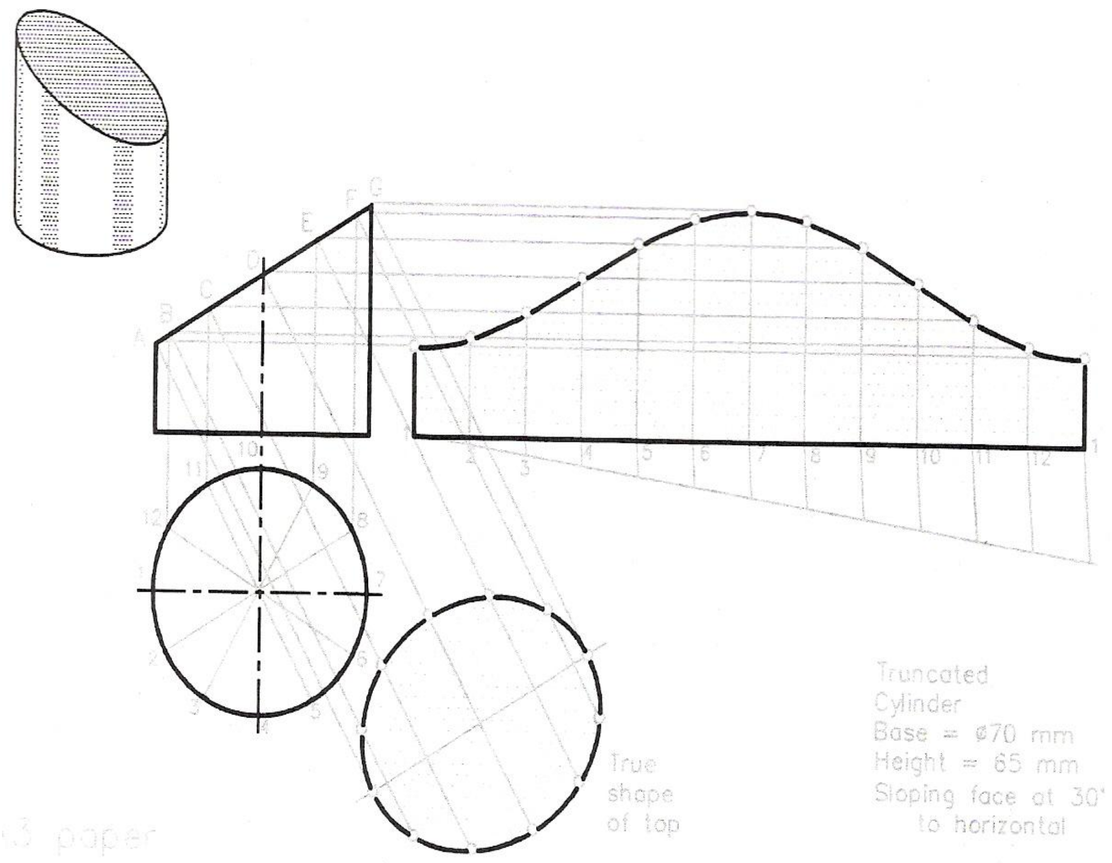


Figure 5 - Development of Surfaces of Truncated Cylinder

Drawings 1 & 2

1. Draw a Front view and a Plan of the cone to the given sizes.
2. Divide the base circle into 12 equal parts with the aid of a 30, 60 set square.
3. Project from each of the 12 points on the circumference of the Plan onto the base line of the Front view.
4. From each of the points on the base of the Front view draw lines to the apex of the cone A.
5. With a compass centred at A and of radius A1 draw an arc.
6. Set a compass to the chord length of one of the divisions in the Plan circumference - such as from 1 to 2.
7. Step off the length 12 times along the arc centre A.
8. Draw a line from the 12th division (marked 1) to the apex A to complete the development.

Drawings 3 & 4

1. Draw the Front view and Plan to the given sizes.

2. Divide the circle in the Plan, draw an arc from A and step off divisions along the arc as in Drawing 2.

3. Join each of the points numbered 1 to 12 to 1 on the arc to A.

4. Project from the 12 points in the Plan onto the base in the Front view. Join each point to the apex A.

5. Where these lines meet the slope line of the cone in the Front view project lines horizontally.

6. Taking the point C as an example - it is on lines 3 and 11. From C project horizontally on to the slope line of the cone.

7. With a compass set to the length from A to where the horizontal from C meets the slope line, draw an arc centred at A to meet lines 3 and 11 from the arc of the development.

8. Find the other points from the horizontals in the same way.

9. Draw a fair curve through the points to complete the development.

10. The development of the sloping face of the cone is found by contrasting its true shape. If a development of the base is required, it will be a circle of base diameter.

Lines of Intersection and Developments – 1

Two examples are shown here of the lines where two equally shaped solids meet at an angle of 90 degrees. The two examples are a joint of two square pipes and another of two hexagonal pipes. In both cases, the line of intersection (as it is called) is a straight line at 45 degrees to each of the solids. No matter what the shape (the 'sectional' shape) of the solids, if they are both equal, the line of intersection will be at 45 degrees if the solids meet at 90 degrees. If two solids of equal shape section meet at angles other than 90 degrees, the line of intersection, forms an angle of half the angle at which the parts meet.

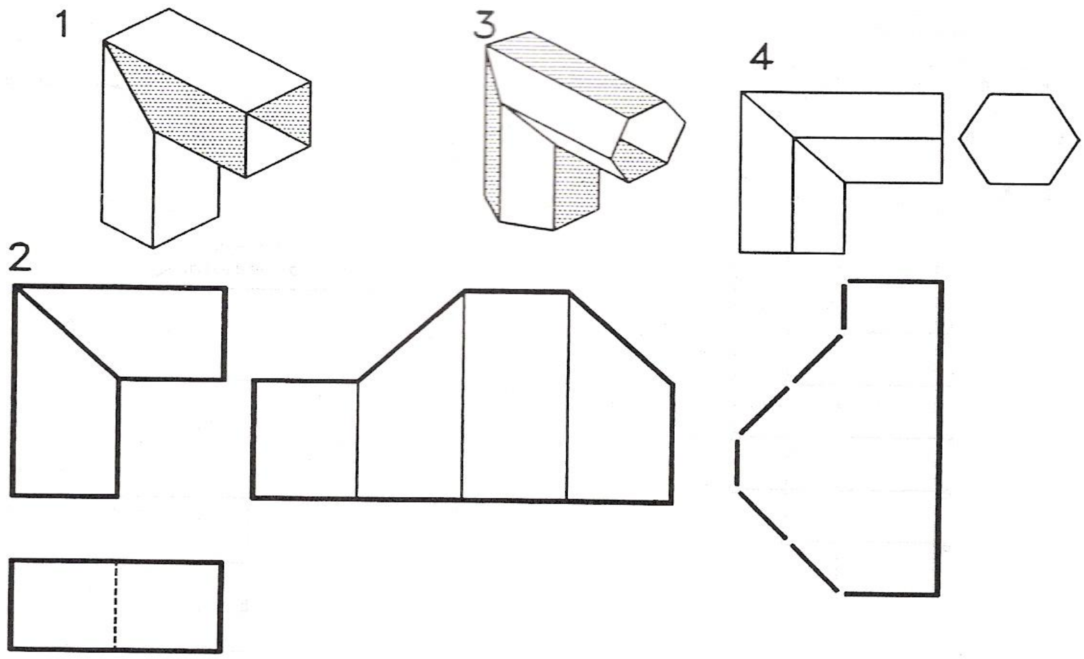


Figure 6 - Lines of Intersection and Developments – 1

Drawings 1 & 2

1. Draw the Front view and Plan of the intersecting pipes to the dimensions given in Figure 6.
2. Draw a base line for the development of one of the pipes and mark 4 equal divisions of 35 mm (the pipe edge length) along the line. Draw verticals at these points.
3. Project from the Front view as shown to obtain the true shape of each of the sides.

Drawings 3 & 4

1. Draw a Front view and the End view of the hexagonal section of the pipe as shown. Work to the given dimensions.
2. Project a line from the base and step off six 20 mm divisions along this line - six hexagon edge lengths.
3. Project from the Front view downwards on to each line in turn.
4. Draw lines between the points so obtained to complete the development.

Lines of Intersection and Developments – 2

Note: In each example only one part of the two making up the intersecting joints has been developed. This is because the second development in each case would be the same as the first.

Two further examples of pipes of equal section meeting at 90 degrees are shown here. In the first, the two pipes are equal size cylinders. In the second the two pipes are equal size hexagonal pipes. In the second example the hexagons of the pipes have been turned through 60 degrees.

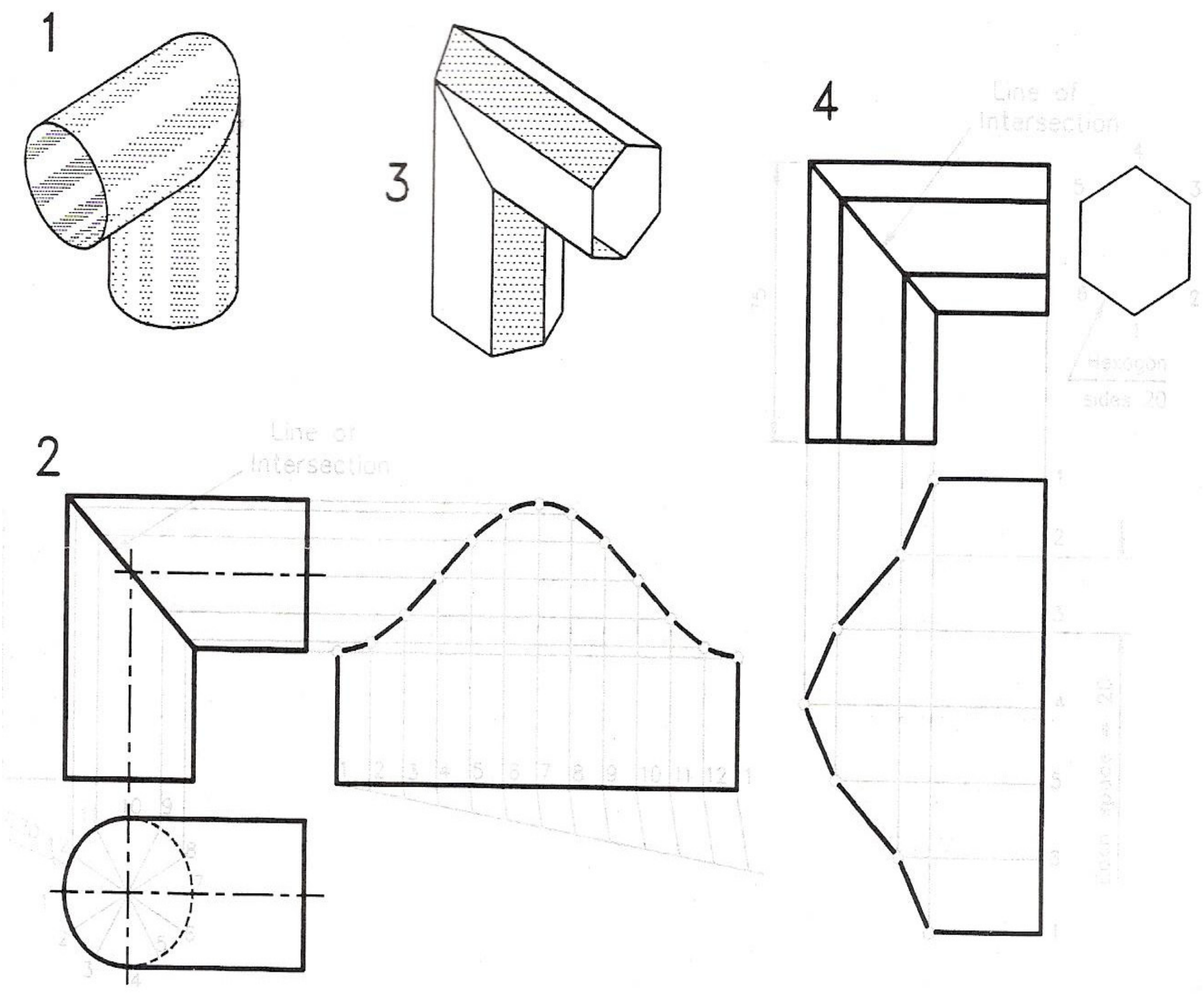


Figure 7 - Lines of Intersection and Developments – 2

Drawings 1 & 2

1. Draw the Front view and Plan of the joining cylinders to the given sizes.

2. Divide the circle of the pipe in the Plan into 12 equal parts.

3. From the Front view project the base line of the vertical cylinder and mark off along it the length of the cylinder circumference to obtain the base for the development of one of the pipes.

4. Divide this base line into 12 equal parts and draw verticals at each division point - points 1 to 12 to 1.

5. Project from the 12 points in the Plan circle up to the intersection line of the pipes.

6. Project from each of the points so obtained onto their respective vertical lines in the development.

7. Draw a fair curve through the points so obtained to complete the development.

Drawings 3 & 4

1. Draw the Front view and the outline of the hexagon of the pipe in its position in relation to the Front view.

2. Following the methods given with Example 2 in Drawings 3 and 4, complete the development as shown.

3. Draw a base line for the development – six equal 20 mm spaces.

4. Project from the Front view onto the horizontals from the 20 mm points.

5. Join the points so obtained in the development with straight lines.

Note: Once again when dealing with a cylinder, the circumference has been divided into 12 equal parts.

Developments of Intersecting Pipes

In the previous examples of intersections, the pipes have joined at right angles. In this example one 60 mm diameter cylindrical pipe is meeting another at an angle forming 60 degrees between the two cylinders. Because the developments of the two parts of the join are not the same, both have been constructed.

1. Draw a Front view and a Plan of the intersecting pipes (Figure 8). In the Plan, the upper circle of the sloping pipe is seen as an ellipse.
2. Draw the development of the vertical cone before the hole for the intersecting pipe is constructed - its base is 3.14 x 60 mm long.
3. Divide half of the Plan circle into 6 equal parts and project from the divisions onto the lines of intersection in the Front view.

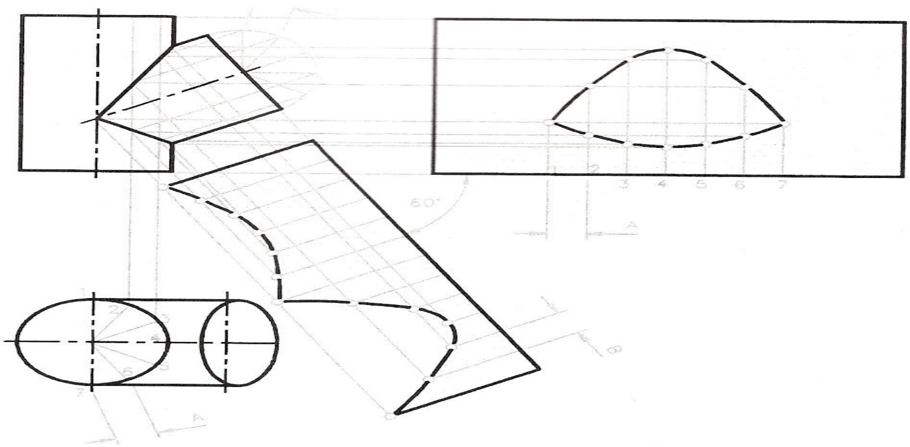


Figure 8 - Developments of Intersecting Pipes

4. The hole for the intersecting pipe is cut in only one side of the vertical cylinder. Thus only 6 of the 12 divisions - 3 each side of a vertical line through the middle of the pipe are required. The spacings between these divisions are taken from A in the Plan.
5. Project horizontally from the points on the lines of intersection in the Front view onto their respective verticals in the development.
6. Draw a fair curve through the points so obtained to complete the hole in the development.
7. Working in a similar manner construct the development of the sloping pipe.
8. Start by drawing a semi-circle on the end of the pipe in the Front view.
9. Mark off the length B from the semi-circle in the Front view 12 times along a line projected at 60 degrees from the end or the sloping pipe.
10. Project lines from the 6 divisions of the semicircle on to the lines of intersection.
11. Where these lines meet the lines of intersection project at 60 degrees on to the 12 spaced lines in the development.
12. Draw a fair curve through the points so obtained to complete the required development.

Self Assessment

Questions on Background Notes – Module 5.Unit 4

1. In relation to locking devices; nuts, bolts etc. Sketch:

- **a.** Countersink Bolt.
- **b.** Cheese Head Screw.
- **c.** Socket Head Bolt.

2. In relation to holding / clamping the work component, what are Strap Clamps?

3. Where would Countersink Bolts / Screws be used.

Answers to Questions 1-3. Module 5. Unit 4

1.

Locking Devices:

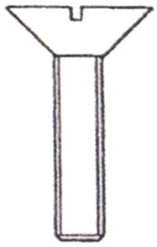


Figure 1: Countersink Bolt.

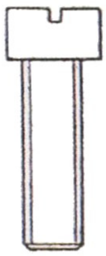


Figure 2: Cheese Head Bolt.

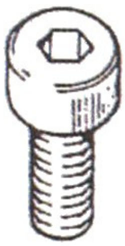


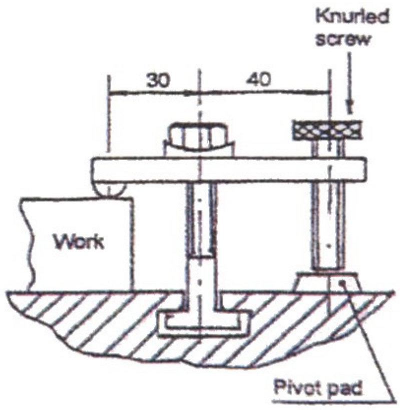
Figure 3: Socket Head.

2.

Strap Clamps:

Strap clamps are widely used when work is clamped to the table of a milling machine or a drilling machine. Strap clamps may be considered as simple levers.

Figure 4: Shows a knurled screw which when rotated clockwise provides the clamping force on the work piece.



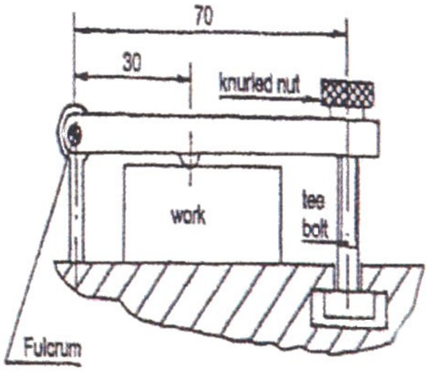
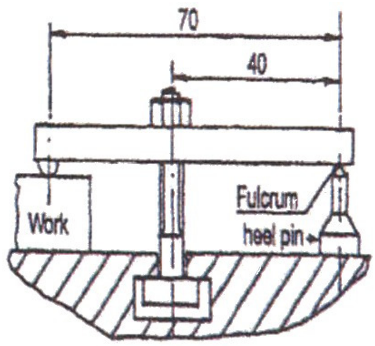


Figure 5:
Arrangement of strap clamp which may be used for clamping the workpiece to the milling machine table.

Figure 6: Most widely used method of securing a work piece to a milling machine table. The clamping force is provided by rotating the hexagonal nut clockwise.



3.

Countersink Screw:

The countersink screw is used for work where the head must lay flush or below the surface. Great care must be taken when drilling and tapping for countersink screws as the design of the head allows them to tighten properly only when the holes are in line.

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