Contents

Introduction

In this section, you will become familiar with technical drawing conventions and learn to interpret the meaning of mechanical drawings.

The work of the Standards Association of Australia towards standardisation of drawing practice has been of great value in recent years. Not only are we reaching the situation where all drawings produced in Australia are similar, but drawings produced overseas are also more readily interchanged with ours due to the Standards Association's affiliation with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

This section is designed to make you familiar with the Australian standard drawing symbols and give you some practice in drawing and recognising them.

After completing this section, you should be able to:

- describe the drawing standards and conventions used in drawings of mechanical components as specified in AS1100
- explain the meaning of basic abbreviations and symbols used in drawing of mechanical components
- lay out a drawing of mechanical components using engineering drawing convention.
- identify the commonly use drawing representation used in the electrotechnology industry

Types of mechanical drawings

In this section we will examine the basic types of mechanical drawings, and their purpose. Engineering drawings can be classified according to their style (type of projection), or according to the purpose that the drawing serves.

Types of projection

There are two common styles of mechanical drawing – pictorial and orthographic drawings.

Pictorial Drawings

In *pictorial* or three-dimensional drawings, the completed drawing looks like a three dimensional object. The viewpoint is chosen from a skew direction (not parallel to the object's axes) in order to reveal the most information about the object in one view. Styles of pictorial representation include *isometric*, *oblique*, and *perspective* drawings, with isometric projection being the most common.

These types of drawings make it easy to imagine how the object will look, but they distort the dimensions of the object. Figure 1 below shows a pictorial drawing, specifically an isometric projection.

Orthographic drawings

The other style shows different views of the object on one drawing, as seen from different directions. This style of drawing is known as an *orthographic projection*. The viewing directions are at right angles, and may include a top or *plan* view, a front view or *elevation* and an end view.

Figure 2 below shows an orthographic projection of the object in Figure 1.

In Australia, the *third angle* projection has been adopted as the standard method of projection for orthographic drawings. For this projection, you draw the view you see from the side you are looking. That means that the top view is drawn above the front view, a view from the right is drawn on the right side and a view from the left drawn on the left. It is as if the object is placed in a glass box, and the view from each side is traced is drawn on that face. The sides of the box are opened and laid flat to produce the orthographic views. Up to six views may be obtained using this method.

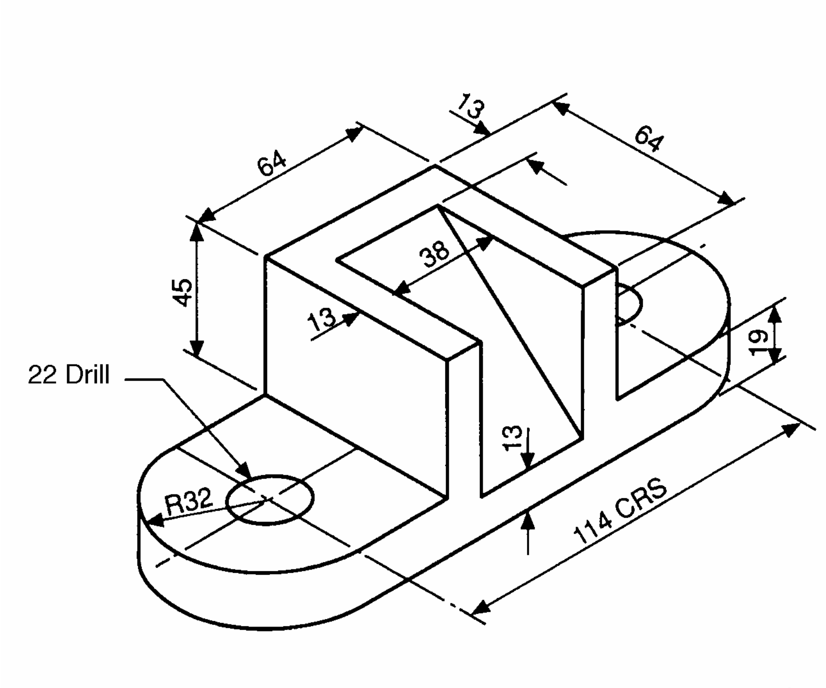

Figure 1: Pictorial drawing

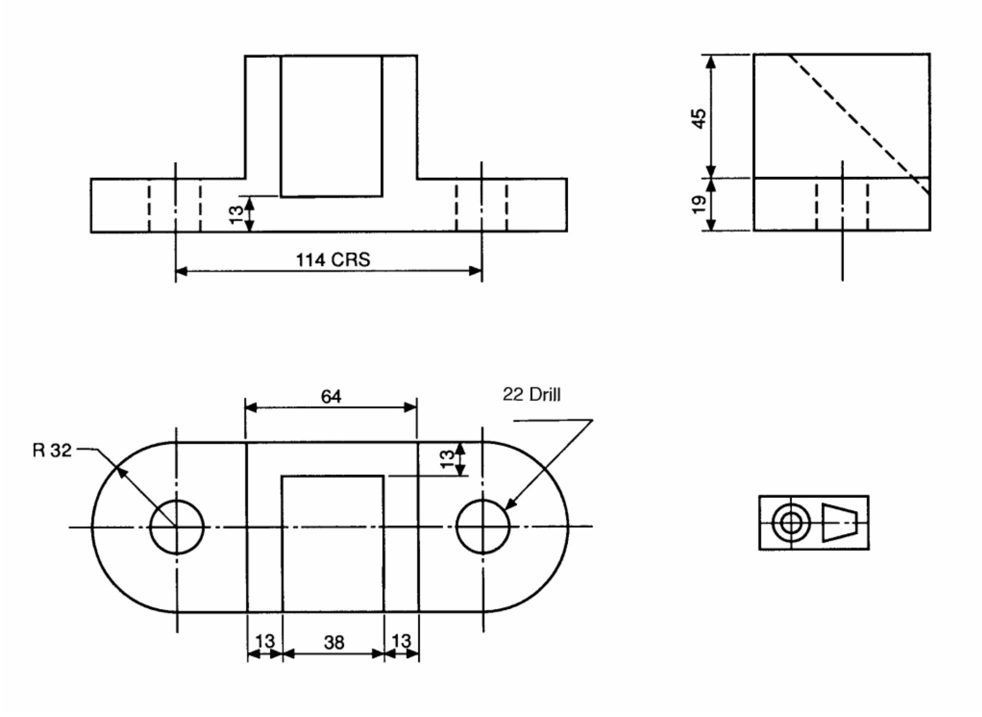

Figure 2: Orthographic (third angle) projection

The third angle symbol

To indicate that the orthogonal drawing has been produced in 3rd angle projection, a symbol is placed either in the title block or in the top left corner of the sheet. This symbol consists of two views of a truncated cone drawn in the same projection as the drawing itself. Figures 3a, 3b and 3c show the derivation of the symbol.

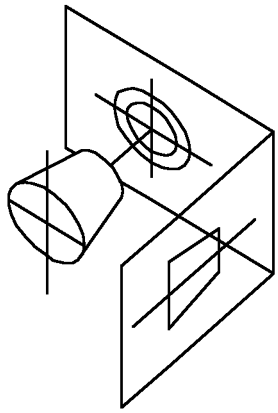

Figure 3a: third angle symbol

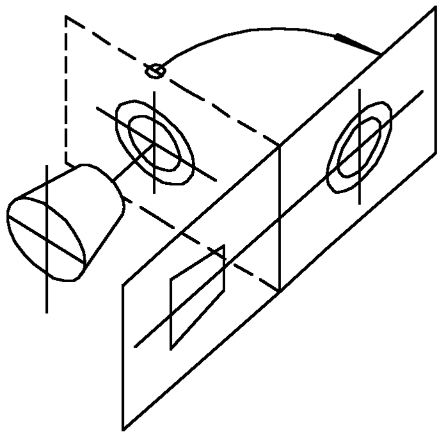

Figure 3b: third angle symbol

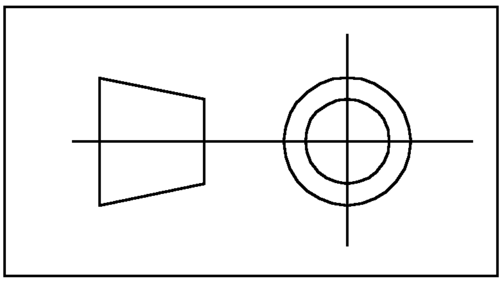

Figure 3c: complete third angle symbol

Detail and Assembly drawings

When something is manufactured, a set of *working drawings* are produced to ensure that all the parts are produced and assembled correctly. Working drawings can be subdivided into *detail drawings* and *assembly drawings*.

Detail drawings

Detail drawings give the information and instructions required to manufacture a single part. They usually include all details such as the shape, dimensions, materials, tolerances and surface finish of the part. Most commonly, detail drawings will be an orthographic projection. Figure 4 below shows an example of a detail drawing.

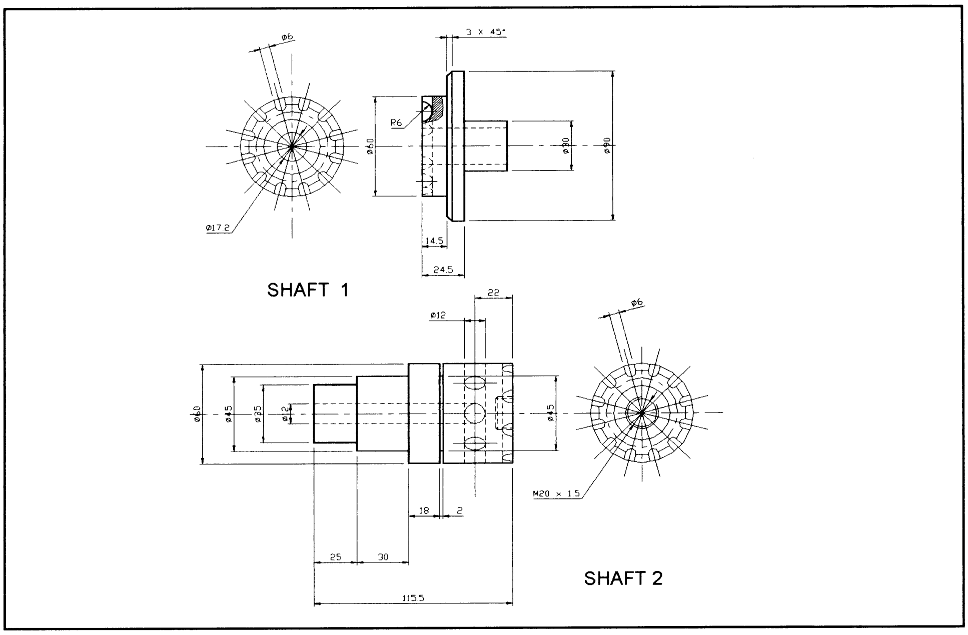

Figure 4: Shaft detail drawing

Assembly drawings

Assembly drawings show how the parts of a product can be fitted together. Many of the details present in the detailed drawing will be excluded from the assembly drawing. Assembly drawings show the relative position of the parts, and the most important dimensions for assembly and use of the product. Assembly drawings are often pictorial, but may also be orthographic.

Figure 5 shows an example of a complete assembly drawing. Here the parts are labelled directly, but often the labels are shown as numbers or letters, to avoid cluttering the diagram. In this case, a key would be provided for the names of each part.

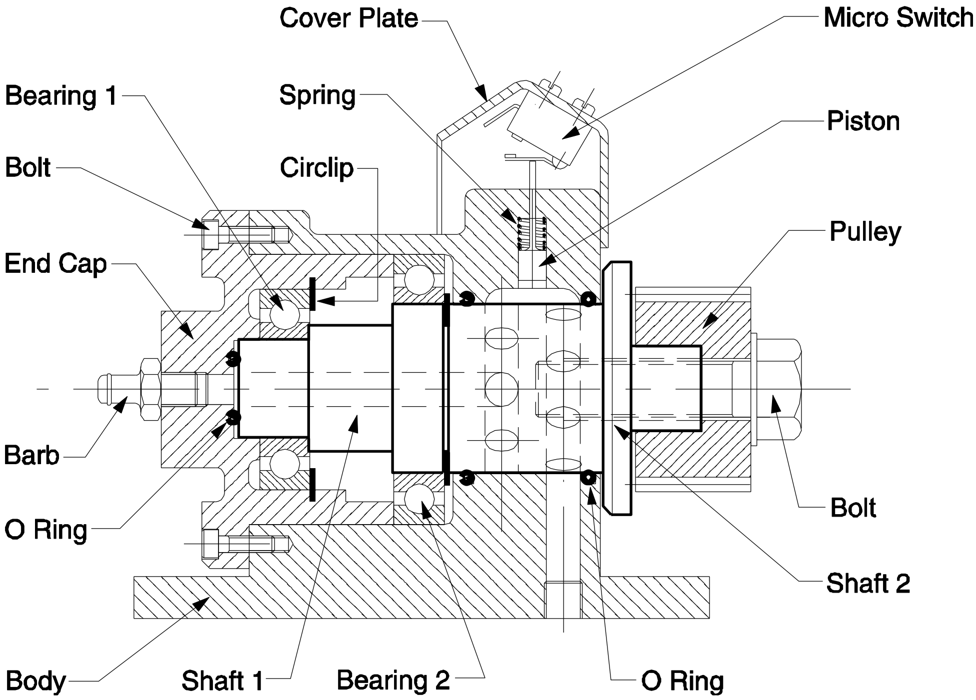

Figure 5: Main assembly

Note that cylindrical objects such as the shafts and proprietary items such as nut and bolts are not sectioned in assembly drawings. Note also that dimensions are not shown unless they relate to the assembly procedure. This diagram is commonly referred to as a General Assembly drawing.

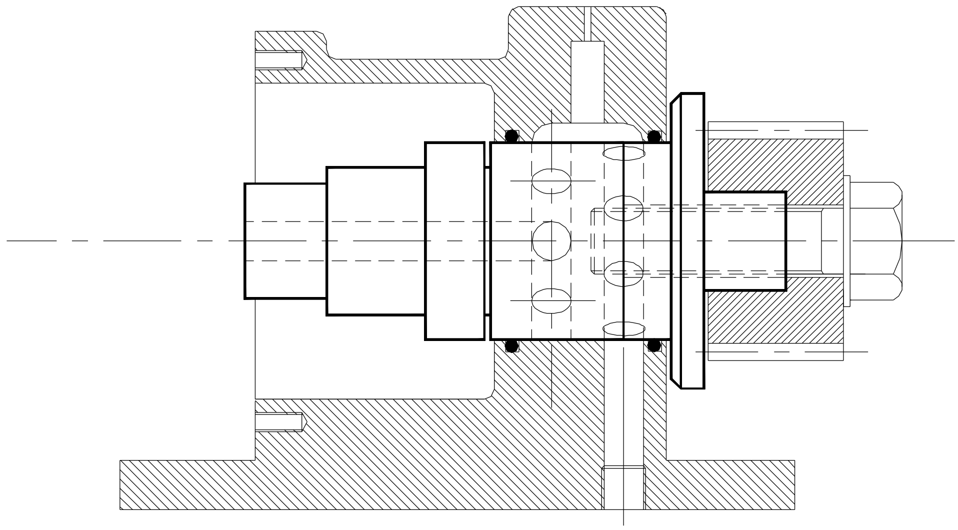

Figure 6: General assembly

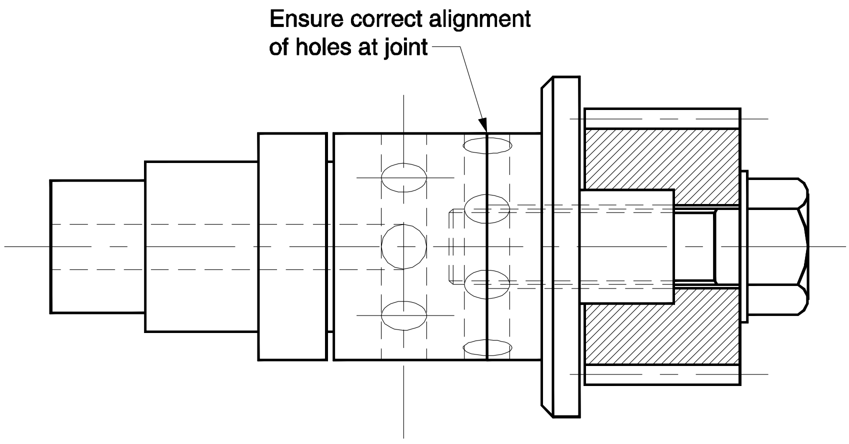

Figure 7: Shaft and end cap assembly

Sub-assemblies

Figures 7, 8, 9 and 10 show examples of *sub-assembly drawings*. A sub-assembly comprises a number of parts that are assembled separately as a unit, before being integrated into the complete assembly.

Sub-assembly drawings provide more detail than the general assembly drawing. Subassemblies may be manufactured and tested in isolation from the remainder of the completed product. Often, critical assembly notes will be provided on the drawing, as shown in figure 7. In this drawing, the matching and alignment of the radial holes at the join is very important for the operation of the machine.

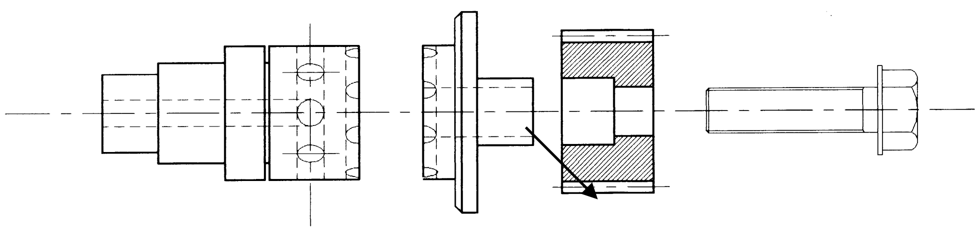

Figure 8: Shaft and Pulley Sub-Assembly

Exploded views

Assembly drawings are often shown as *exploded views,* which show the parts aligned along their assembly axis but separated in space. This makes the shape, number and assembly sequence of the parts very clear. Figure 9 shows an exploded orthogonal projection, and Figure 10 shows an exploded pictorial view.

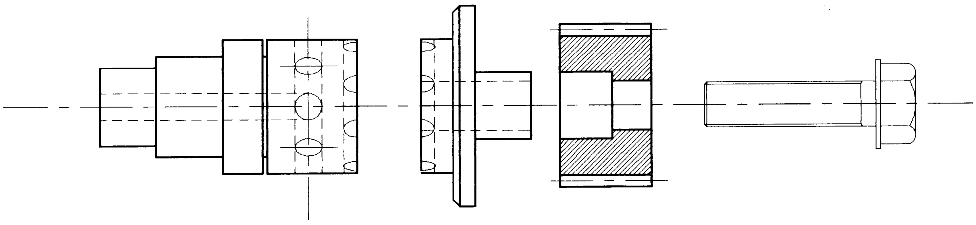

Figure 9: Shaft and pulley sub-assembly – exploded orthographic

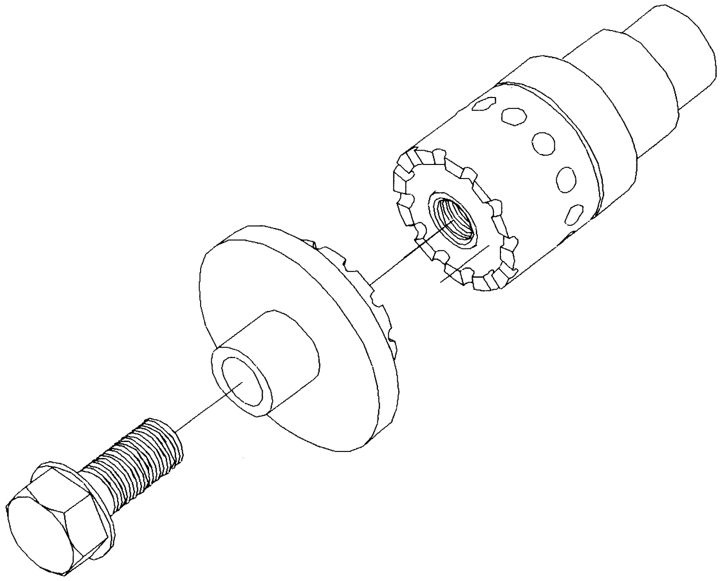

Figure 10: Shaft sub-assembly – exploded pictorial

An exploded assembly drawing is very useful for repair or maintenance drawings and can be read easily by people who are not familiar with orthogonal drawings. They are used in spare parts listings, maintenance diagrams or in explaining assembly procedures.

Activity 1

Referring to Figure 11 below, answer the following questions.

1 What is the name of the drawing?

___

2 On what size sheet is the drawing?

___

3 The what scale is the drawing made?

___

4 What revision has been made to the drawing?

___

5 What is the name of Item 2?

___

6 From what material is Item 2 manufactured?

___

7 On what date was the drawing made?

___

8 On what date was the drawing issued for manufacture?

___

9 In what zone is the dimension R4.5?

___

10 What bend radius is used for the material?

___

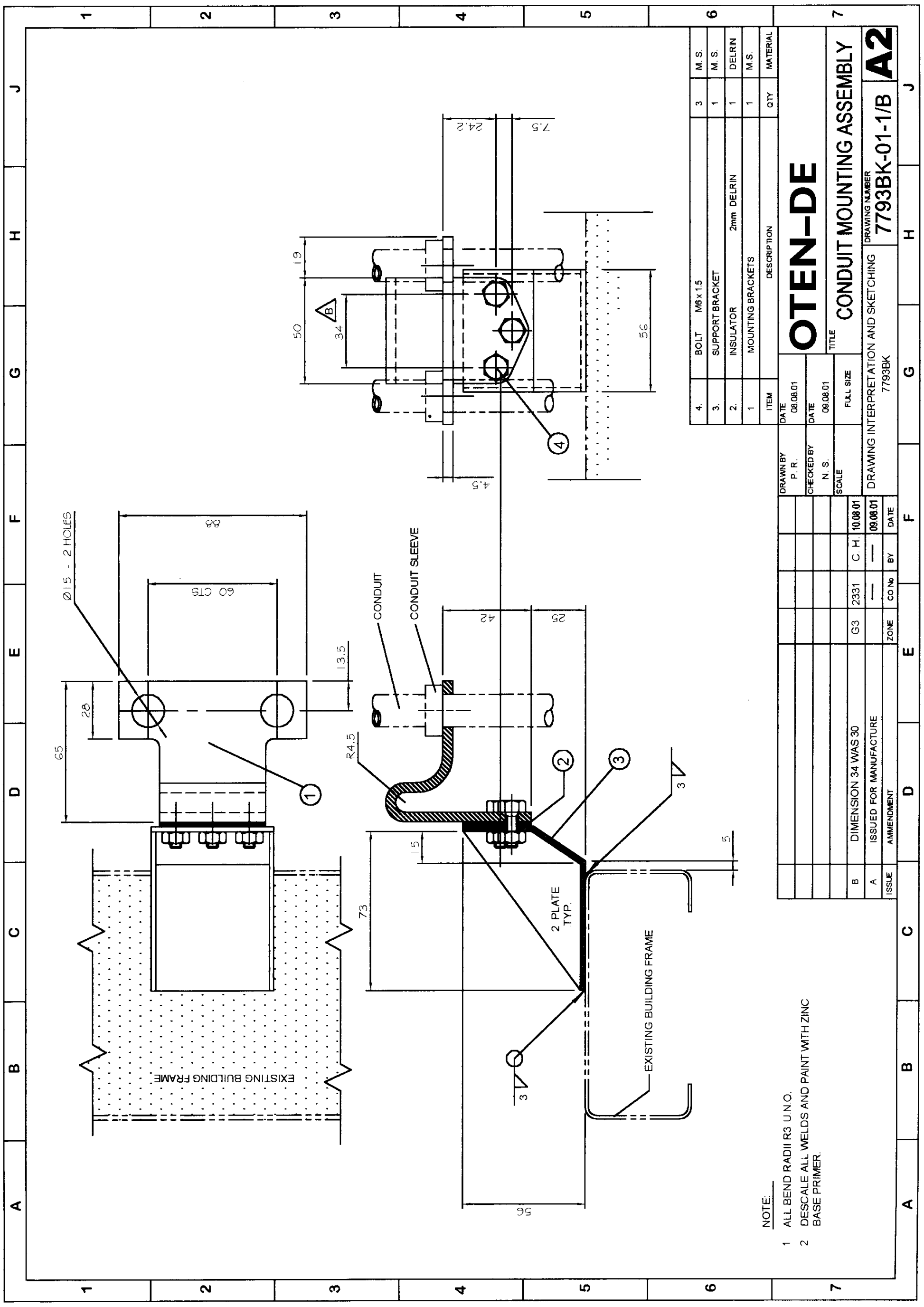

Figure 11: Conduit mounting assembly

Activity 2

Figure 12 below shows another view of the conduit mounting assembly from figure 11. Answer the following questions.

1 What type of drawing is this?

____

2 What is the advantage of a drawing of this type?

____

____

3 What, if any, would be the disadvantage of drawing of this type?

____

____

4 Where would this type of drawing be most likely to be used?

____

____

5 How many parts are required in the assembly?

____

____

6 What is the specification for the bolts?

____

____

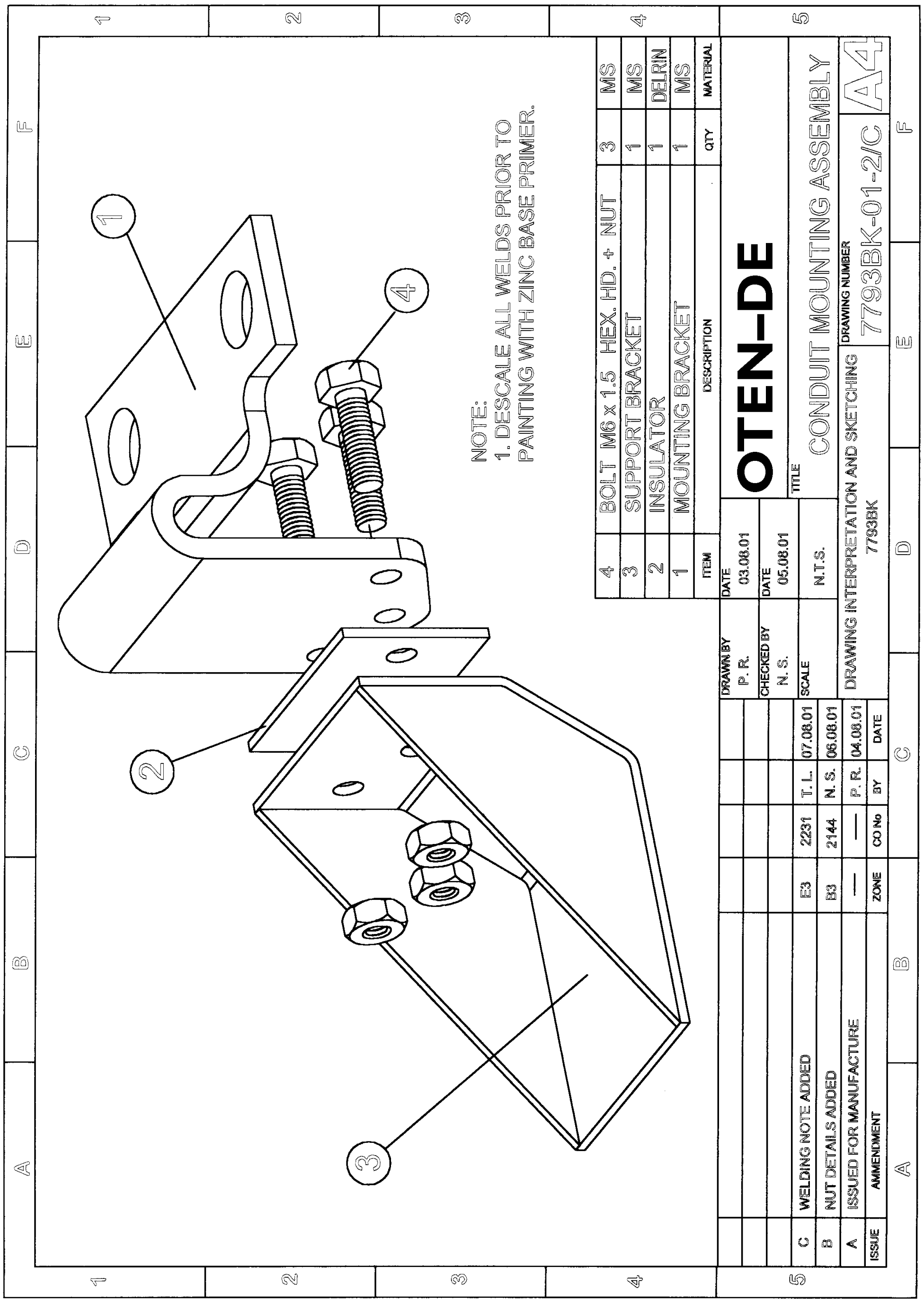

Figure 12: Conduit mounting assembly

Technical drawing presentation

Most technical drawings you encounter will have a standard presentation. They will be presented on paper of standard size, with a standard title block.

Drawing sizes

The standard drawing sizes in use in Australia are A0, A1, A2, A3, and A4. Normally it isn't necessary to know the exact sheet sizes as you purchase drawing sheets to this specification. As long as you can recognise the difference between A3 and A2, for example, you will be all right.

Each size increase represents a doubling of the area. The smallest is A4 which is the size of the paper which this material is printed on. Two A4 sheets joined together down their long sides is the same size as an A3 sheet. An A2 sheet can be made by joining two A3 sheets together and so on.

The choice of which sheet size to use will depend on a number of factors. These are:

- complexity of the drawing;
- number of sheets to be used;
- filing and handling considerations;
- requirements of computer aided design and printing.

The title block

Title blocks are often designed to incorporate company logos and other information. The following information must appear as a minimum.

Drawing title

The drawing needs a name. The name may consist of the overall project name, the particular apparatus, and the type of drawing. For example:

Lithgow College of TAFE Refurbishment

Electrical Engineering Classroom/Workshop

Equipment Location Diagram.

The first line here is the project name, the next line is the particular apparatus (or, in this case, the part of the project shown on the drawing), and the last line describes what type of drawing it is.

Drawing number

Each drawing will have a number for filing purposes. Usually the number will have provision for recording the version number of the drawing. The original may be 1480 A1, for instance, and when later amended it may become 1480A1/A.

Date

The date the drawing was authorised.

Drawn by

The name or initials of the person who drew the drawing.

Name of company

This is more than just an advertisement. The drawing number may only be unique within the one company. Another company may possess a drawing with an identical drawing number.

Drawing Scale

Drawings are usually reduced-size versions of the real-life object, but may also be magnified. If we draw something at actual size, the scale is said to be ‘one to one’ (1:1).

If we draw something so that ten millimetres on the drawing represents one metre in actual size we have drawn at a scale of 1:100. The fact that the smaller number comes first tells us that we have reduced our drawing from real life. A scale of 100:1 is a magnification which may be appropriate for a very small component.

If a drawing is not to scale, or if some measurements are unknown at the time of drawing, the words: ‘not to scale’ or ‘do not scale’ can be added to the drawing.

Material list, parts list and legend

These parts of a drawing are almost always in the form of tables. If it is a drawing showing the various parts of an automatic washing machine and how they fit together, the *parts list* would list all the parts shown on the drawing and relevant information about them. This information might be 'Manufacturer'; 'Description of Part'; and 'Part Number'.

If the drawing was of something to be fabricated from raw materials such as sheet steel, the parts list would be called a *material list.*

If the drawing was a layout or site plan, or a circuit diagram, a legend should be included if there are departures from the commonly recognised symbols.

An example may be a refurbishment layout drawing for a set of offices. Walls, light fittings (luminaires), telephone points and many other items may need to be relocated, removed completely, or supplied new. While there is a standard symbol for a telephone point, for instance, it is cumbersome to write an explanatory note next to each point.

Symbols are often changed slightly to indicate the work required. As an example, a new telephone point might use the standard symbol but represent it filled in; an existing one to be removed might be drawn with dashed lines; a new point to be installed as part of the project may have a circle drawn around it; and an existing point which is to stay undisturbed might be shown as the standard symbol without modification. Obviously these specially designed symbols need to be defined on a legend.

Once you have put a legend on a drawing it is a good idea, especially if the drawing is part of an instruction to a contractor, to include all but the most widely understood symbols in a legend on the drawing itself. If a drawing forms part of a set, or if the number of parts of types of symbol is large, a separate drawing may be made for the purpose of a parts list or legend.

Dimensioning drawings

Generally speaking, the dimensions shown in a detailed drawing are the dimensions that will be needed to produce the object. Assembly drawings may contain no dimensions, or only those dimensions critical to the assembly or operation of the item.

Care should also be taken not to 'over-dimension' the object. If a dimension is shown twice on a drawing, confusion arises in the factory or on site as to which dimension to use, especially if a change is made to one of the dimensions.

As with any other part of a drawing, dimensions must be placed on the drawing in accordance with the current drawing standards AS100.

The basic rules of dimensioning are:

- Dimensions for the size of a component's features should be placed on the drawing once only.
- Dimensions should be read from the bottom and right side of the drawing sheet.
- Placing the dimension on the centreline, on the outline or inside the outline of the object should be avoided. Dimensions should be placed away from the object be using extension lines from the points to be dimensioned.
- Dimensions are placed above the dimension line.

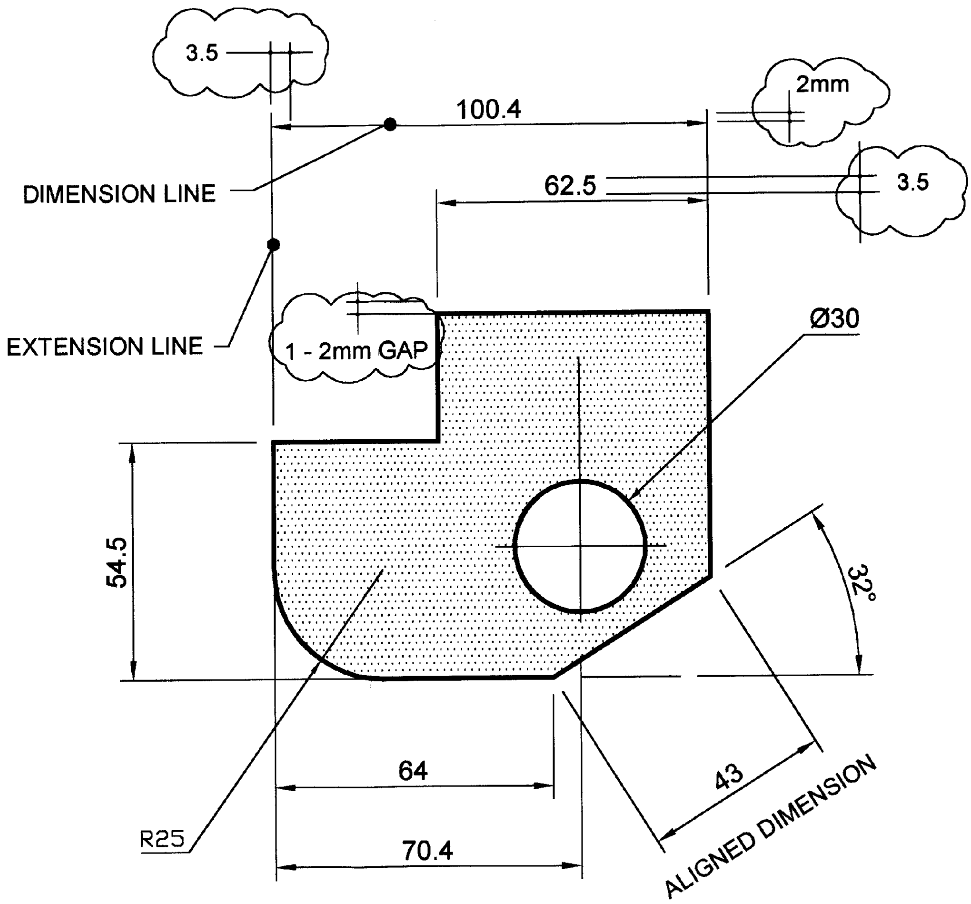

Figure 13: Dimensioning conventions

Activity 3

Questions relating to Figure 14, a drawing of an open eye bolt.

1 What is the drawing number?

____

2 What are the revisions?

____

3 What is the size of the thread required?

____

4 What is the diameter of the open eye bolt?

____

5 How is the washer held onto the open eyebolt?

____

6 What is the size of the hole in the washer?

____

7 How many welds are required in the assembly?

____

8 What is the scale of the drawing?

____

9 How deep is the thread tapped into the open-eye nut?

____

10 What processes are applied to the components after bending and welding?

____

11 What is the purpose of the ± 5 shown after some of the dimensions?

____

12 What is the overall length of the eyebolt?

____

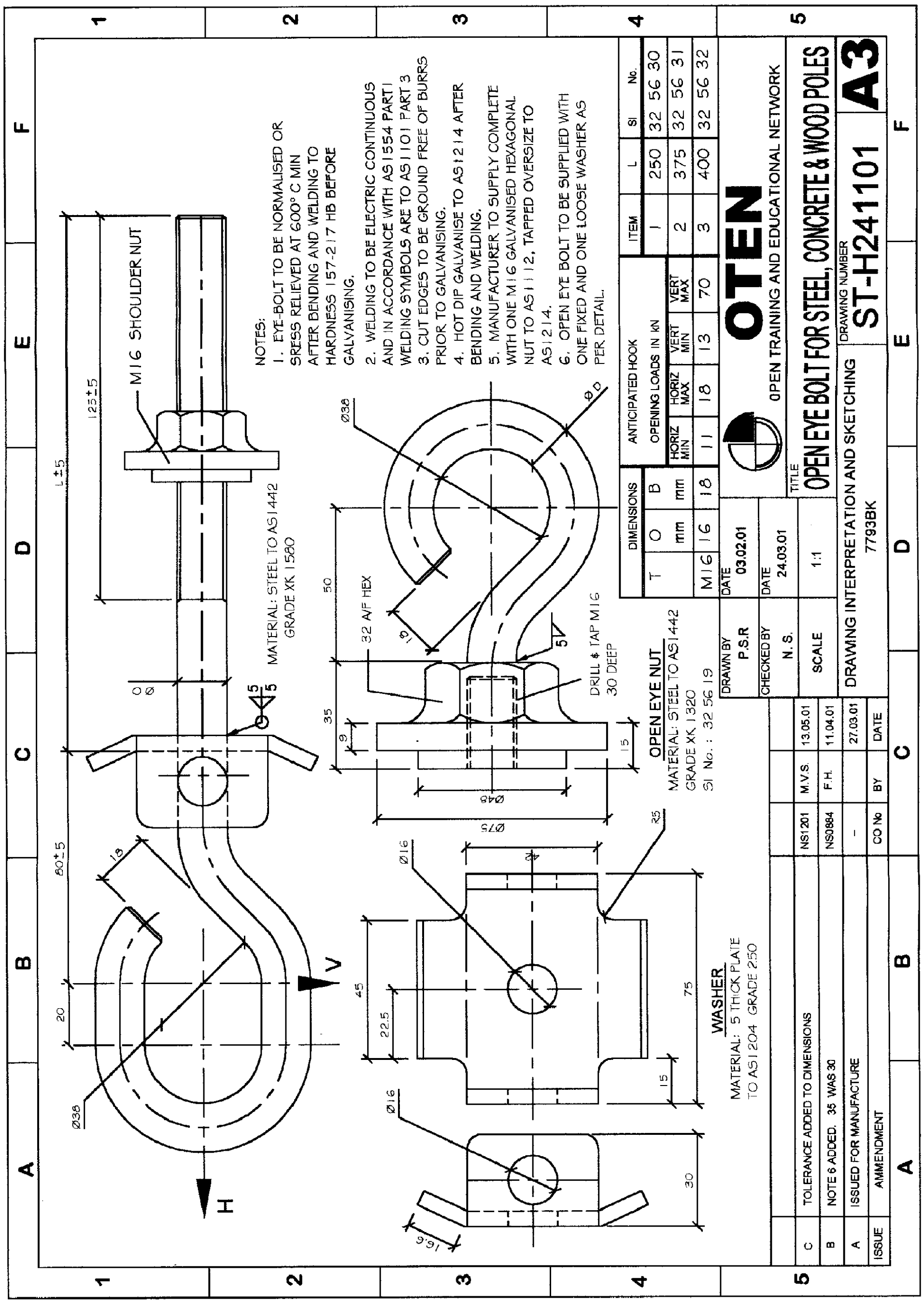

Figure 14: Open eye bolt drawing.

Sectioning, holes and threads

Sectioning

Sometimes it doesn't matter how well you draw in third angle projection, there is something that you just can't show in enough detail. An example is the adaptor fitting shown in Figure 15.

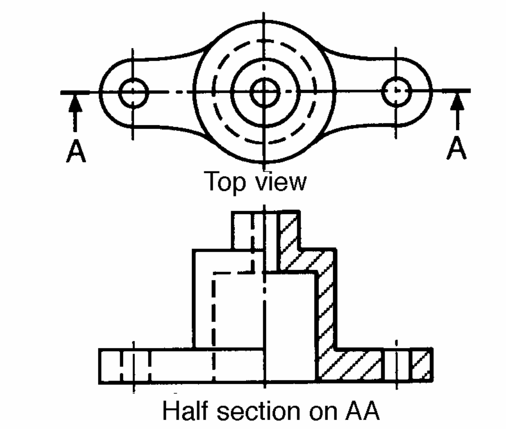

Figure 15: Sectioning

Although the internal drillings can be shown by broken lines on one of the normal views, too many broken lines can be difficult to follow. A clearer drawing results when the view is 'cut open' to show the internal details.

Normally a sectional view is included as an extra view on the drawing unless, as in the case of our example, a *half sectional* view can be included which will serve both the needs of a sectional view and that of an additional third angle view.

Note on Figure 15 the *sectioning plane* is shown on another view by the arrows A and A. The direction of the arrows indicates the direction that the section is being viewed from. Sometimes a shape is so complex that several sectional views are shown. They may be labelled A–A, B–B, C–C, and so on.

If necessary an isometric drawing can be sectioned. Figure 16 shows the adaptor in isometric representation with a 90 degree section taken from it.

Notice that arrows labelled A–A or similar are not used to indicate sectioning in the isometric drawing, but lines showing where the removed piece came from are used instead.

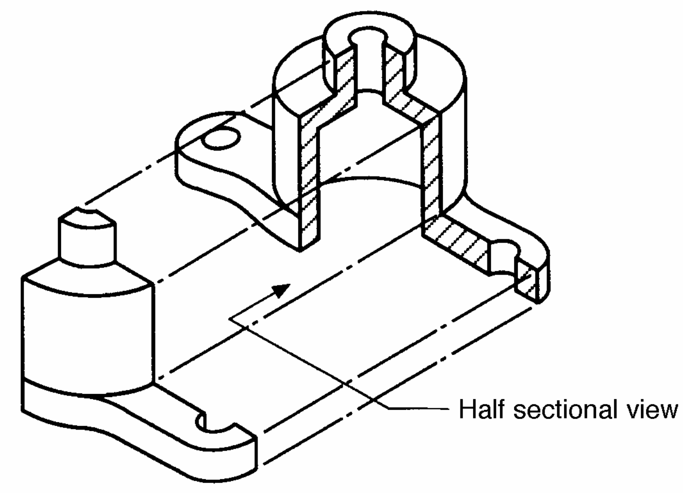

Figure 16: Isometric half sectional view

In both orthogonal and isometric drawings the actual surface of the cut is indicated by a series of slanting lines, known as *hatching*.

Holes

You may have noticed in Figure 15 that holes are represented from the top and bottom (in third angle) by circles. From the side the holes are shown as broken lines (broken lines indicate that something is there but can’t be seen from where the view is being drawn). A faint chain line indicates the centre line of the hole.

When sectioned the section may expose some hidden parts, as it does in our illustration. Therefore in the sectioned portion, the hole is shown as full lines with no hatching between them.

Note that if there are hidden parts behind a section plane, they would not be shown on the section because broken lines would be hard to see amongst the hatching. It is good practice to choose a hatching plane which shows the maximum detail.

Threads

Drawing a screw thread promises to be a difficult task, however, technical drawings are designed to convey information as simply as possible. This means that there is a simplified way of representing threads without having to draw them all in.

Threads are simply drawn as concentric cylinders or holes with the larger diameter equal to the diameter across the tops of the threads, and the smaller diameter equal to the diameter across the bottom of the threads.

Looking down on the top or bottom of the thread it is shown in a similar way, but the larger diameter circle is not completed and is drawn with a thinner line than the hole.

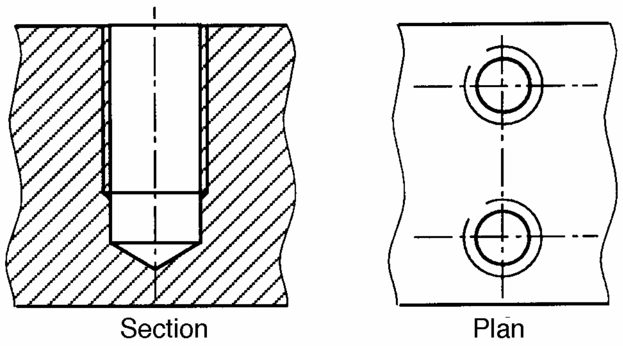

Figure 17: Drawing convention for threads

Threads in holes would not normally be shown on an isometric drawing. Threads on bolts would normally be shown the way they really look, as a set of helical cuttings. Remember an isometric is a picture drawing intended for non-technical people or as an extra aid for technical people.

Activity 4

1 Why would you want to draw a sectional view of an object?

2 Which of the third angle views should be replaced by the sectional view?

3 What is the name given to the slanting lines used to show a sectional plane?

4 How are holes shown?

5 How are the ways threads are shown different on orthogonal and isometric drawings? Why is this so?

Structural steelwork

Steel sections

Figure 18 below shows the shapes and designations of common steel sections used in fabricating steel structures.

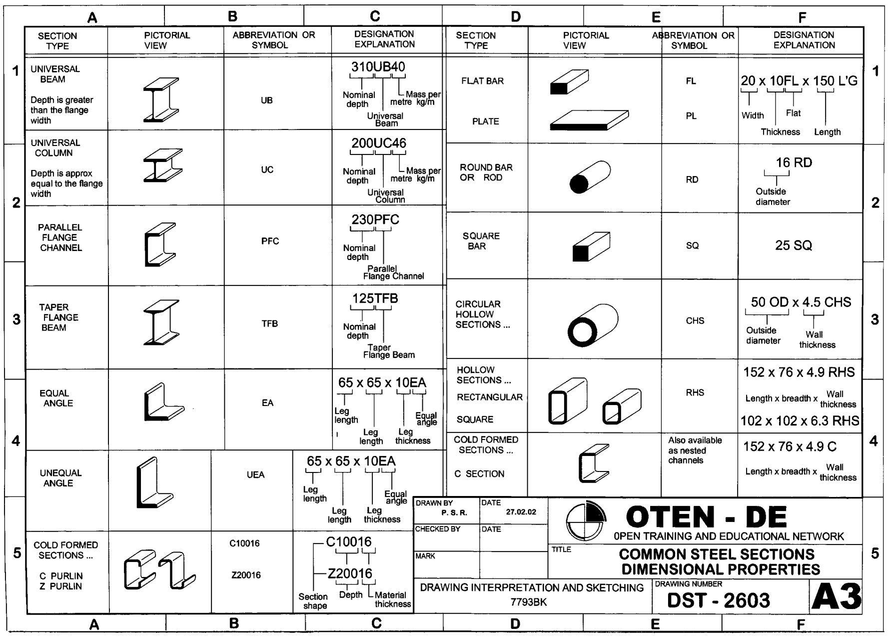

Figure 18: Common steel sections.

Example

The designation '100 × 100 × 10EA' represents rolled steel with an L-shaped ('angle') section, with each leg of the L having a dimension of 100 mm, and the thickness of steel being 10 mm.

Weld terminology

The most common types of welds are the fillet and butt welds as shown in Figure 19 below. Most other welds are derivations of these welds with the differences mainly being in the shape of the weld preparation. These modifications are made to the basic weld form to provide additional filler material to the joint and hence greater strength and penetration into the parent metal. The selection of the type of joint is usually the decision of the designer or engineer who takes into consideration the loads and conditions to which the fabrication may be subjected.

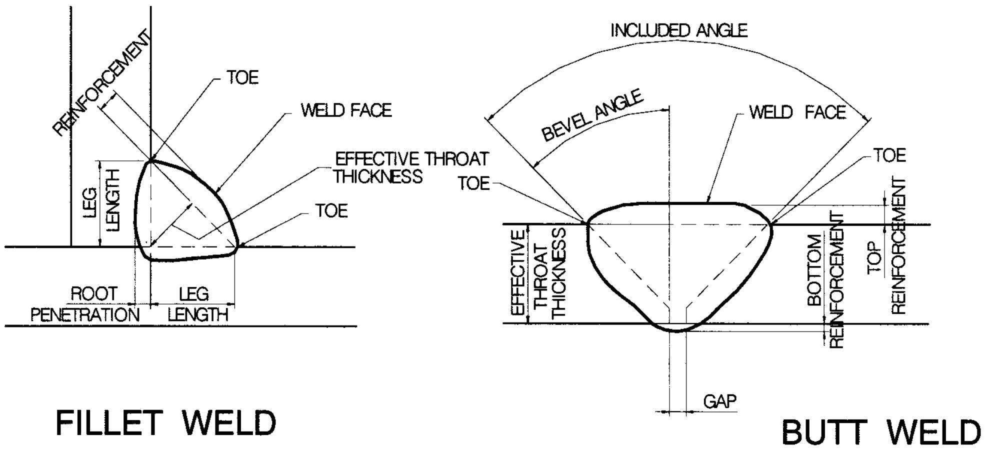

Figure 19: Weld terminology

Weld symbols

Figure 20 shows a drawing of a speed control mounting bracket assembly. To create this assembly, six components are cut to size and welded together by means of various types of welds which are indicated on the drawing by the standard weld symbols. The legend on this drawing shows a sample of some of the weld symbols, their appearance and description, and the name given to the type of weld. At the bottom of the legend there is a diagram which illustrates the recommended configuration of the weld symbols.

More detailed explanations of weld symbols can be found at the web sites below.

http://www.unified-eng.com/scitech/weld/weld.html

http://www.welding.com/weld_symbols_welding_symbols.shtml

The weld symbol consists of the following components:

Detail	**Explanation**
Reference Line	The horizontal line
Arrow	This line points to the joint. It also indicates the side of the connection on which the joint preparation is to be made.
Weld shape	This is a standard symbol which indicates the way the metal is prepared for the weld
W	The length of the weld if it is not continuous
M	This is the space between the lengths of welds for and intermittent weld.
S	This is the throat size of the weld.
P	The tail at the end of the reference line can contain information for weld procedure or processes.

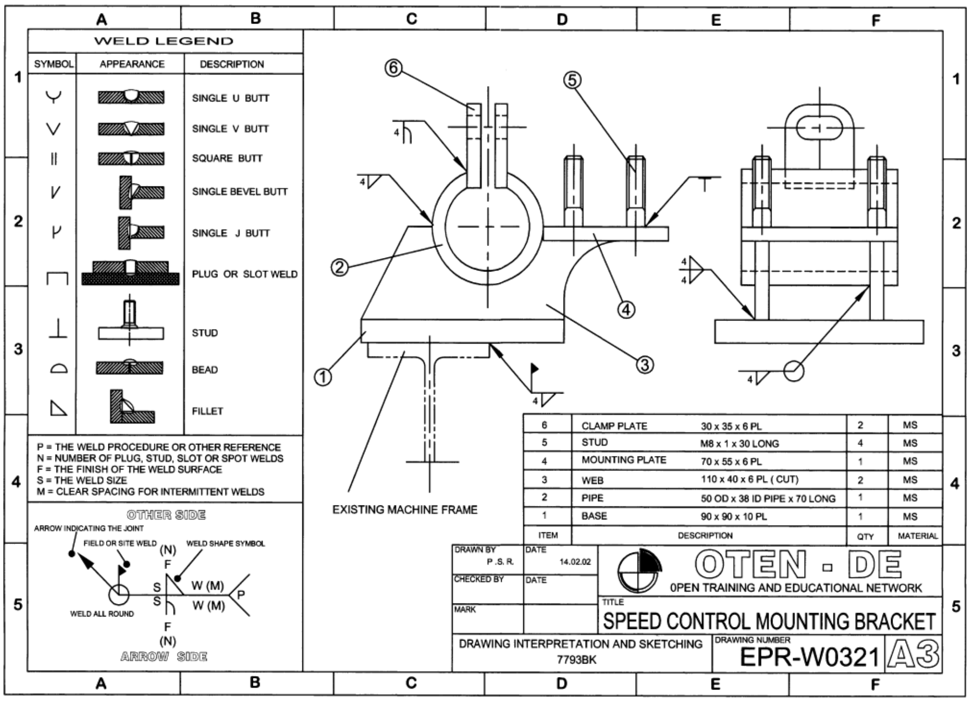

Figure 20: Speed control mounting bracket.

Activity 5

Study the drawing of the speed control mounting bracket (Figure 20). Write descriptions of each weld by referring to the weld symbols on the detail drawing and the legend

Weld this...	**...to this**	**using procedure...**
Stud	Mounting Plate	
Base	Web	
Assembly	Machine Frame	
Clamp plate	Pipe	
Pipe	Web	

Activity 6

Figure 21 shows a drawing of a portal frame arrangement. The steel sections used are to be indicated by standard designations on the drawing, but there are missing letters. Complete each designation in the box provided by referring to data sheet DST-2603 (Figure 18).

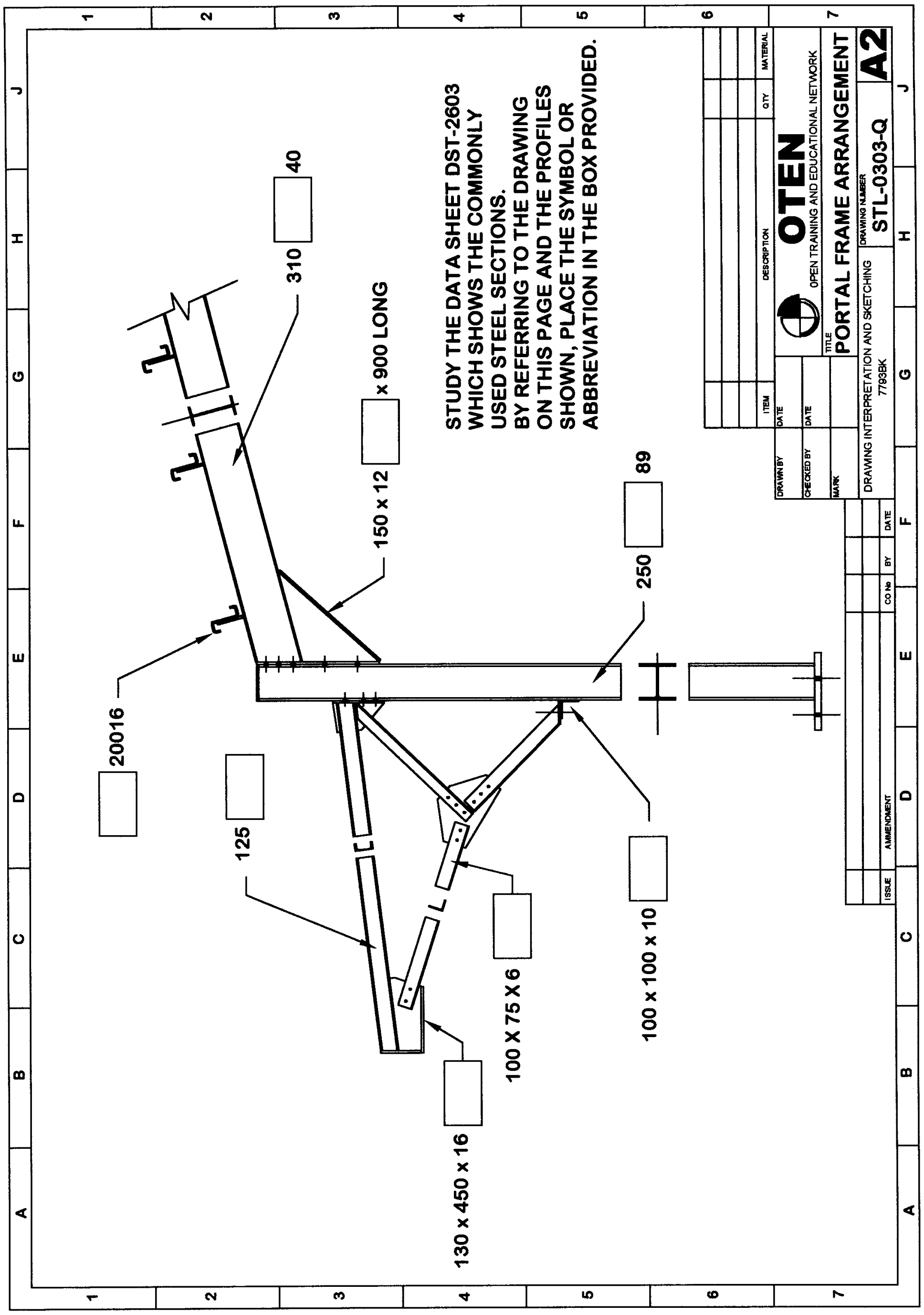

Figure 21: Portal frame arrangement.

Summary

This section has introduced the common conventions and symbols in engineering drawings.

- Classified according to style, drawings can be orthographic (orthogonal) or pictorial.
- Orthographic drawings project an image of the object onto the faces of a cube surrounding the object. Third angle projection is used almost exclusively for orthographic projections in Australia.
- Pictorial drawings show a three-dimensional impression of the object, and include isometric, oblique and perspective drawings. Isometric projections are the most common type of pictorial drawing for manufactured objects.
- Classified according to use, engineering drawings can be detail or assembly drawings.
- Detail drawings show all the details for the manufacture of a part, including dimensions, surface finishes, materials, tolerances and fabrication (eg welding) details. Detail drawings are usually third angle projections.
- Assembly drawings show only enough detail for the assembly of the completed item, or part of it (a sub-assembly). Assembly drawings often cater for a non-technical audience, and so a pictorial style is often used.
- Exploded views are often used in assembly drawings to clearly show the individual parts and their assembly sequence.

Answers

Activity 1

1 Conduit mounting assembly

2 A2

3 Full size

4 Dimension 34 was 30

5 Insulator

6 Delrin

7 08-08-01

8 09-08-01

9 D3

10 R3 unless noted otherwise

Activity 2

1 An exploded, pictorial assembly drawing

2 Assembly drawings are easy to read,

3 Pictorial views take more time to produce or modify than orthogonal

4 spare parts listing, on site assembly

5 3 bolts, 3 nuts, insulator, mounting bracket & support bracket (9 parts)

6 m6 × 1.5 hexagon head

Activity 3

1 ST-H241101

2 Note 6 added, 35 was 30 Tolerance added to dimensions

3 M16

4 16mm diameter

5 Welded all around with 5mm fillet weld on both sides of the plate

6 16 mm

7 Two welds are required, one for the washer to eye bolt and one for the nut

8 The scale is full size (1:1)

9 30 mm

10 Normalised or stress relieved at 600ºC min
to hardness of 157–217 HB

11 ±5 mm tolerance.

12 375 + 80 + 20 + R19 + 16 = 510 mm

Activity 4

1 A sectional view would be required if details were fully or partly hidden on the other third angle views.

2 None of them. The sectional view should be a separate view in its own right. An exception is if a half sectional view of a symmetrical object can be utilised. In this way the one view can serve two purposes.

3 Hatching.

4 In third-angle they are shown by broken lines with a centre line when viewed from the side, and by full circles when viewed from the top. In isometric the broken lines are omitted.

5 Threads are shown in a shorthand way on orthogonal drawings but need to be fully drawn in an isometric. This is because an isometric is a picture drawing and the viewer may not be aware of the technical shorthand.

Activity 5

Weld this to ……	this	Weld procedure
Stud	Mounting Plate	Stud 4 mm
Base	Web	Fillet 4 mm both sides
Assembly	Machine Frame	Fillet 4 mm Site Weld
Clamp plate	Pipe	Single J Butt 4 mm.
Pipe	Web	Fillet 4 mm

Activity 6

The designations are (clockwise from top):

- Purlins: Z purlin: Z20016
- Roof beam: Universal beam 310UB40
- Web stiffener: plate 150 x 12FL x 900 LONG
- Column: Universal column: 250UC89
- Truss attachment beam: equal angle 100 x 100 x 10EA
- Truss member: Unequal angle 100 x 75 x 6UEA
- Eave: unequal angle 130 x 450 x 16UEA
- Truss top member: parallel flange channel: 125PFC