Trade of Metal Fabrication	
Module 1:	Basic Fabrication
Unit 10:	Template Making
	Phase 2

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Document Release History

Date	Version	Comments
22/08/06	First draft	
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Module 1 – Basic Fabrication

Unit 10 – Template Making

Duration – 5 Hours

Learning Outcome:

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

- Mark out and cut various light gauge aluminium templates
- Relate the importance and use of templates to the industry

Key Learning Points:

Rk	Opposite handing.
Rk	Use of templates. Types of templates. Materials used in template making.
Rk	Divisions of a circle. Bisecting of angles.
Sk	Setting out, marking, cutting and forming.
Rk	Instruction and information provided on templates.
H	Sharp edges. Safe use of hand tools. *(See "Bibliography" for reference to Hand Tools Safety video).*
Sk	Marking and cutting of templates.
M	Percentages - definition and symbol.
P	Communication.

Training Resources:

Fabrication workshop. Apprentice toolkit. 1mm aluminium sheeting. Tin snips. P.P.E.

Key Learning Points Code:

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

P = Personal Skills Sk = Skill H = Hazards

Opposite Handing

It is sometimes required to have opposite handing sections/brackets etc. suitable for the job at hand.

For example, a fabricated piece may require a left-hand/right-hand handle and although they may look the same the fabricated piece would only suit one side. So it is always important to check and make sure that if you are shaping brackets/handles etc. that they are suitable for both sides (interchangeable) or produced to suit opposite hands.

Circles

A circle is a plane figure which is bounded by a curved line called the circumference, which is always the same distance from a fixed point called the centre of the circle. Alternatively we could define a circle by saying that it is the path traced out by a point which moves in a place in such a way that its distance from a fixed point is always constant. This distance from the centre to the circumference is the radius of the circle.

A diameter is a straight line passing through the centre and bounded by the circumference. Clearly the diameter of a circle is twice the radius.

An arc is the name for the part of the circumference between any two points on it.

A chord is a straight line which joins any two points on the circumference.

A segment of a circle is the area which is bounded by a chord and the arc it cuts off.

A sector of a circle is the area which lies between two radii and the arc between them.

A quadrant is the area bounded by two radii which are at right angles to each other and the arc which lies between them. It is a quarter of a circle.

A semi-circle is the area bounded by a diameter and that portion of the circumference which it subtends. As its name implies it is half the area of the circle.

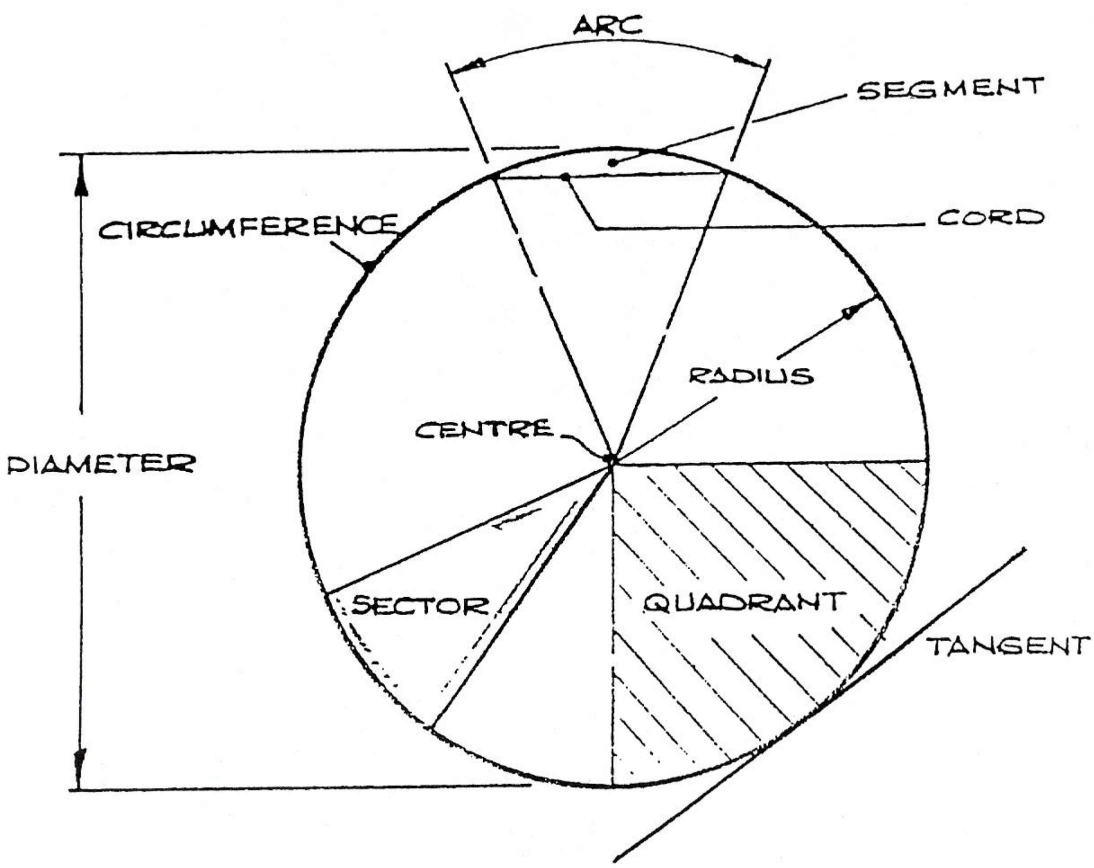

Figure 1 - Circles

To Construct an Angle of 45º

1. Construct a right angle at A of the line AC using the right-angled set square or by the construction given.
2. With centre A, and suitable radius draw arcs to cut the line AB at D and AC at E.
3. With centres D and E and same radius draw arcs to intersect at F.
4. Join FA. Angle FAE is the required angle of 45º.

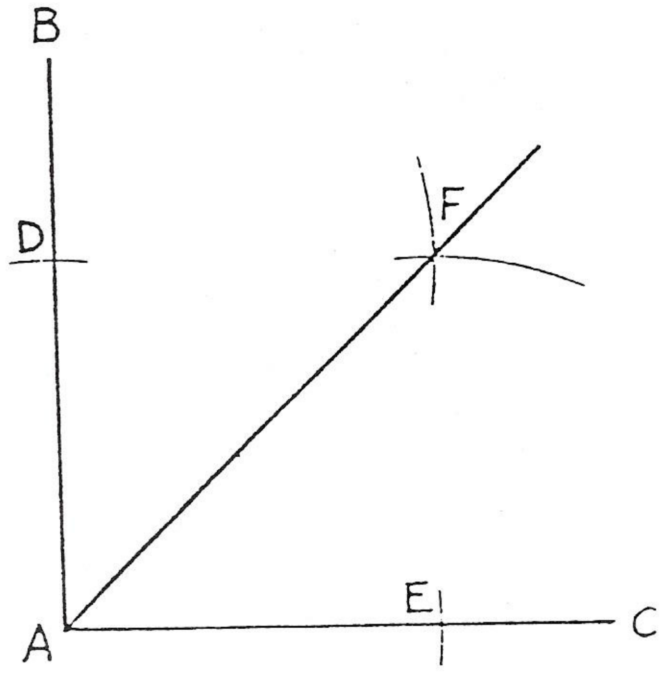

Figure 2 - Angle of 45º

To Construct an Angle of 60º

1. Draw the line AB.
2. Mark point C anywhere on this line.
3. With centre C and any suitable radius draw an arc to cut the given line at D.
4. With centre D and same radius draw an arc to cut the former arc at E.
5. Join CE. The angle ECD is the required angle of 60º.

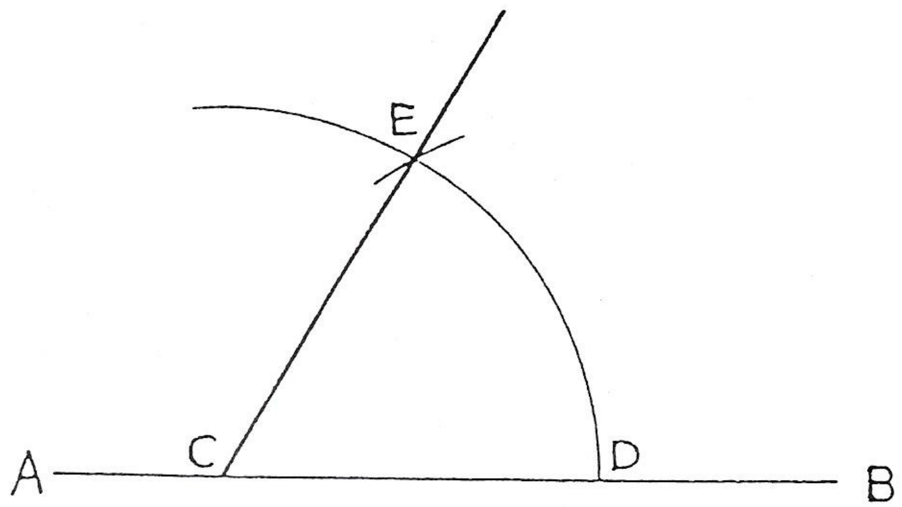

Figure 3 - Angle of 60º

To Bisect a Given Angle

1. Draw the given angle BAC.
2. With centre A and any suitable radius draw an arc to cut AB at D and AC at E.
3. With centre D and any radius draw an arc between AB and AC.
4. With centre E and same radius draw an arc to intersect the other arc at F.
5. Join AF. This is the required bisector.

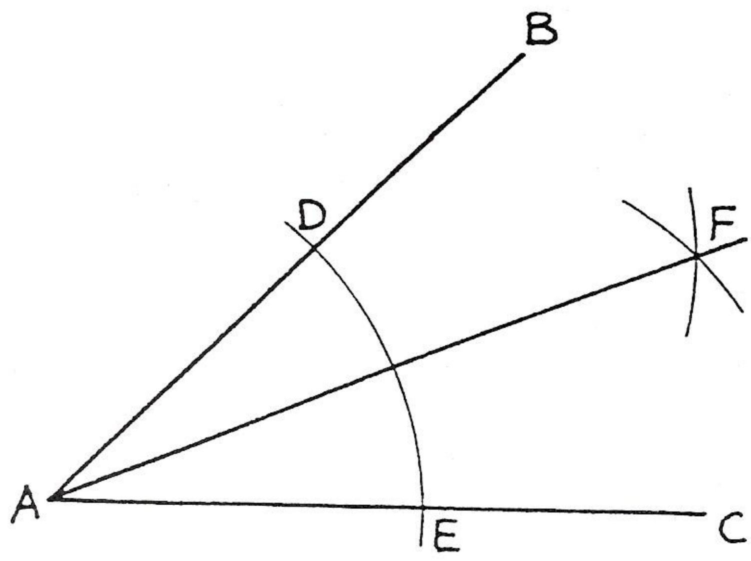

Figure 4 - Bisect a Given Angle

The Need for Templates

There are several reasons for the use of templates or patterns in the sheet metal and plate fabrication industries. For example:

1. To avoid repetitive measuring and marking-off of the dimensions, where a number of identical parts or articles are required. Marking-off large numbers of exactly the same type from a template or pattern is a much quicker method and a great deal more accurate than measuring and marking each part individually.
2. To avoid unnecessary wastage of material. Very often, when marking a full-size layout directly on to a sheet or plate, from information given on a drawing, it is almost impossible to anticipate exactly where to begin in order that the complete layout can be economically accommodated. Consequently, large-size layouts tackled in this manner generally result in an extravagant waste of material.

Template Making (Large Fabrication Shops)

Large fabrication workshops are often provided with an area reserved for template making, known as the 'template shop' or 'loft'.

Such shops are usually situated above the normal shop floor level, but those situated at ground level are fitted with an overhead runway and lifting tackle to handle steel plates for the making of steel templates.

A template shop should be well glazed to ensure good lighting during daylight hours, and provided with adequate artificial lighting for use in the darker hours.

Specialist template makers are employed in the template shop to produce accurate templates for use in the various fabrication shops by the croppers, smiths, benders, platers and welders when cutting, marking for drilling, punching, forming and welding the steel parts. Skilled template makers must possess a sound knowledge of the principles of plane geometry and be able to apply workshop calculations. They must be able to interpret detailed drawings and also have the ability to use carpenter's tools.

Much of the machinery used in a template shop is of the type normally used for woodworking, such as a circular saw, fret-saw, planing machine and woodworker's drilling machine. It also includes a cardboard shearing machine to cut the special template paper.

Materials Used for Templates

Table 1 gives details of the materials used for templates together with some of their applications.

In the making of templates considerable use is made of timber: it is easy to drill and cut to shape, relatively light in weight, and fabrication instructions can be pencilled on it.

Suitable wooden battens of various convenient widths and usually 10 mm or 12 mm thickness are cut to represent the steel members outlined on the template floor. These battens are then laid on the appropriate lines on the floor together with the paper or hardboard patterns representing gusset plates and cleat angle connections. All are temporarily nailed to the floor in their exact positions to represent the particular steel structure.

The centres of holes required for making the connections to be bolted or riveted are marked on the assembled templates, which are then removed from the floor to be drilled and have the necessary fabrication instructions marked on them. After being drilled, and the information for the guidance of the fabricators having been marked on them, the whole assembly is replaced in the correct position on the template floor and checked for accuracy. They are then carefully stored until required on the workshop floor.

Material	Applications
Template paper	Outlines for small bent shapes, such as brackets, small pipe bends and bevelled cleats, may be set out on template paper. Used for developing patterns for sheet metal work.
Hardboard	Templates for gusset plates to be produced in small quantities.
Timber	Used in considerable quantities for steel-work templates. Easy to drill and cut to shape. Whitewood timber strips (battens) up to 153mm wide and 12.7mm thickness are used to represent steel members. Plywood used for making templates for use with oxy-fuel gas profiling machines.
Sheet metal	Used for making patterns for repetition sheet metal components. Templates for checking purposes. Steel, 3.2mm thick is used for profiling templates on oxy-fuel gas profiling machines fitted with a magnetic spindle head.
Steel plate	Light steel plate fitted with drilling bushes is used as templates for batch drilling of large gusset plates.

Table 1 - Materials for Templates

Information Given on Templates

On wooden or hardboard templates the necessary information is best marked with an indelible pencil. Coloured pencils are also used for marking information. On sheet metal templates, for example, which are to be used for the marking of various diameter holes, it is common practice to mark rings, triangles or squares around the holes required to be of the same diameter with a distinguishing colour. On steel templates, whitewash or white paint is often used for marking the information.

Typical information 'written-up' on templates may be as follows:

1. Job or contract number,
2. Size and thickness of the plate,
3. Steel section and length,
4. Quantity required,
5. Bending or folding instructions,
6. 'This side up', 'left hand' or 'right hand',
7. Drilling requirements,
8. Cutting instructions,
9. Assembly reference mark.

The Use of Templates

Many detailed parts of a structure are so simple that they do not require to be set out on the template floor; instead they are marked out direct from drawings at the bench in the fabrication shop. However, templates are made for these simple details where a number of identical parts are required.

Templates for Setting out Sheet-Metal Fabrications

Tinplate or light-gauge sheet steel and template-making paper are the materials most commonly used when making templates or PATTERNS for sheet-metal fabrications. For economy reasons, many patterns are developed half-full-size or to scale from the drawing and then the information contained on them is transferred to full-size dimensions when the craftsman marks it off on the job 'in the flat'. Very often, on precision sheet-metal details, the job is marked off from a scale drawing which provides co-ordinates with precise dimensions marked on them. With many sheet-metal developments it is only necessary to use part patterns which are lined up with DATUM LINES.

'Patterns' are used to mark out sheet metal prior to cutting and forming operations.

For example, a smoke-cowl is made out of 1.2 mm-thick mild steel. The edges of the open ends are wired with 3.2 mm-diameter wire. The connection flanges are 12 mm for spot welding, and the side seams are 6 mm grooved. The completed assembly is hot dipped galvanised.

Basically, this component is a combination of 'Tee'-pieces between cylinders of equal diameter, and only requires a part template which may be made from template paper or light-gauge sheet metal. This is then used to mark-out the contours of the intersection joint lines for the parts ‘A’, ‘B’ and ‘C’ whose developed sizes are marked-out in the flat with the appropriate DATUM LINES.

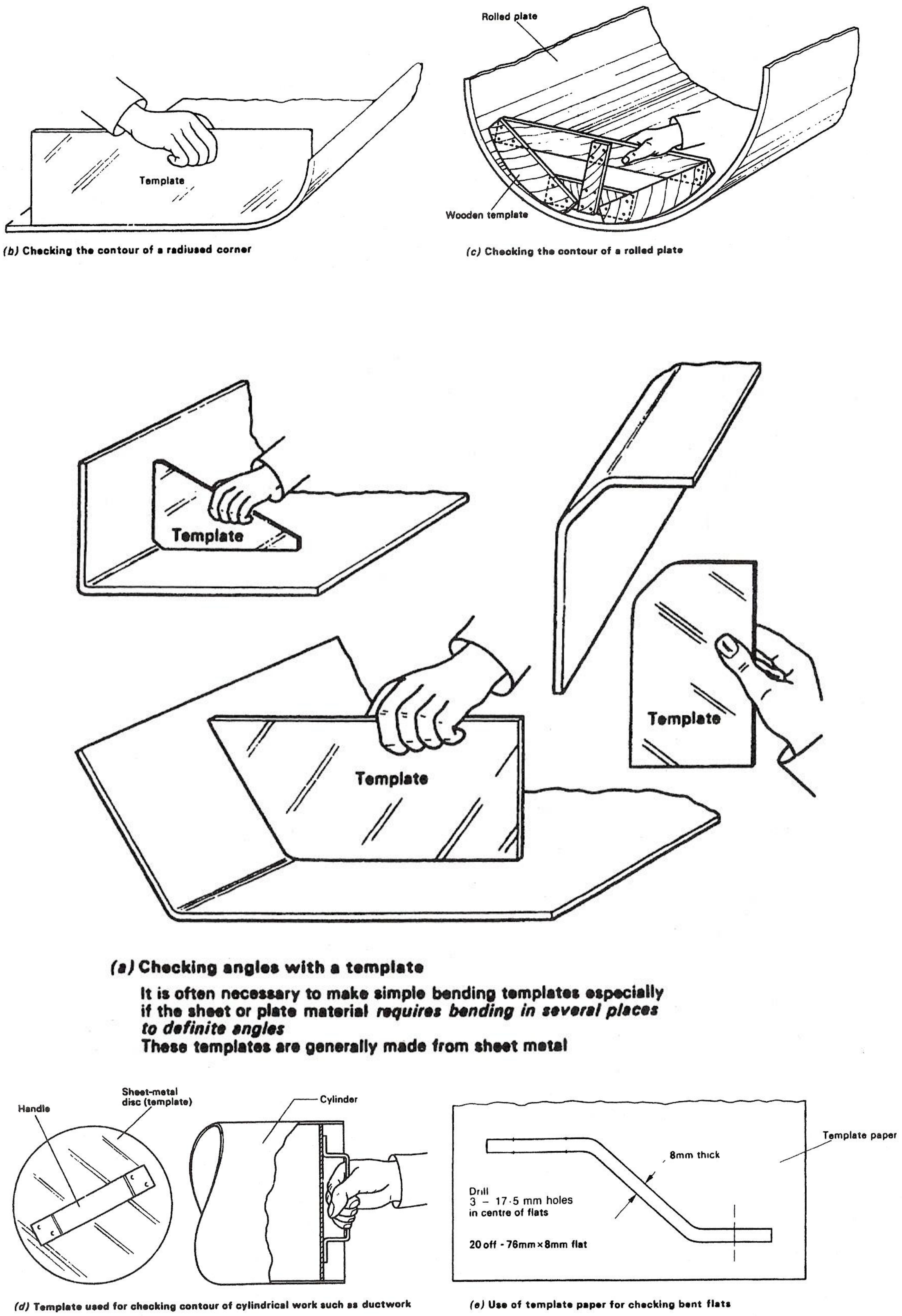

Figure 5 - The Use of Templates as a Means of Checking

Procedure for Using the Template

1. On the developed part, datum lines are marked to represent quarter circumference lines, and the depth of the mitre. IN THIS EXAM THE CONTOUR OF THE MITRE LINE IS IDENTICAL FOR EACH QUARTER BECAUSE THE INTERSECTION IS BETWEEN EQUAL DIAMETERS.
2. Place the mitre line template in alignment with the datum lines and mark the contour for the mitre for each quarter in turn, reversing the template where necessary. An alternative method of marking the flange allowance is to move the template up the width of the flange and mark the contour, using a scriber.

Figure 6 shows a square to round transformer. Figure 6(a) shows an ISOMETRIC VIEW of the sheet-metal transforming piece to be used for connecting a circular duct to a square duct of equal cross-sectional area.

In this example, the diameter of the circular duct is 860 mm, the length of one side of the square duct is 762 mm, and the distance between the two ducts is 458 mm. The transformer is to be made from galvanised steel 1.2 mm thick.

Figure 6(b) represents a scale development pattern on which are marked the full-size ordinate dimensions. Such drawings are supplied by the drawing office for use by the craftsman for marking-out purposes. Any necessary allowances for seams and joints must be added to the layout (two off required).

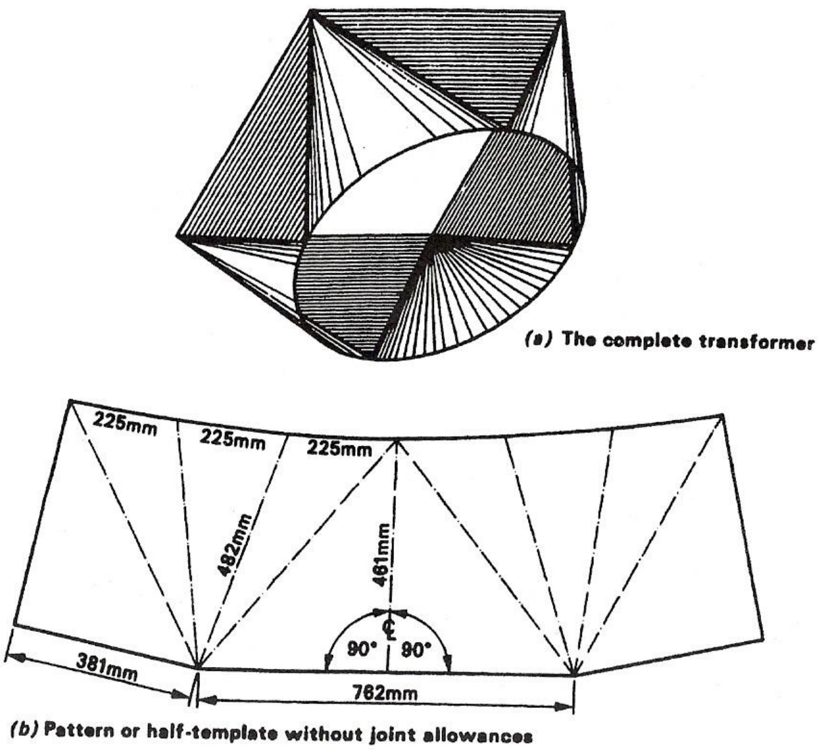

Figure 6 - Square to Round Transformer

Templates for Hopper Plates

Large steel hoppers are usually of riveted or welded construction made up off our tapered steel plates. The templates for these hopper plates may be made from wooden battens, sheet metal or template paper. The template is laid on the plate and the outline marked with French chalk and 'witness marks' are centre-punched at suitable positions.

Rivet holes (where applicable) are marked through the template with a nipple punch. When paper templates are used, the holes are not provided in the template, as is the case with wooden and metal templates. The centres of the hole positions are marked on a paper template and may be transferred on to the plate by centre-punching through the template.

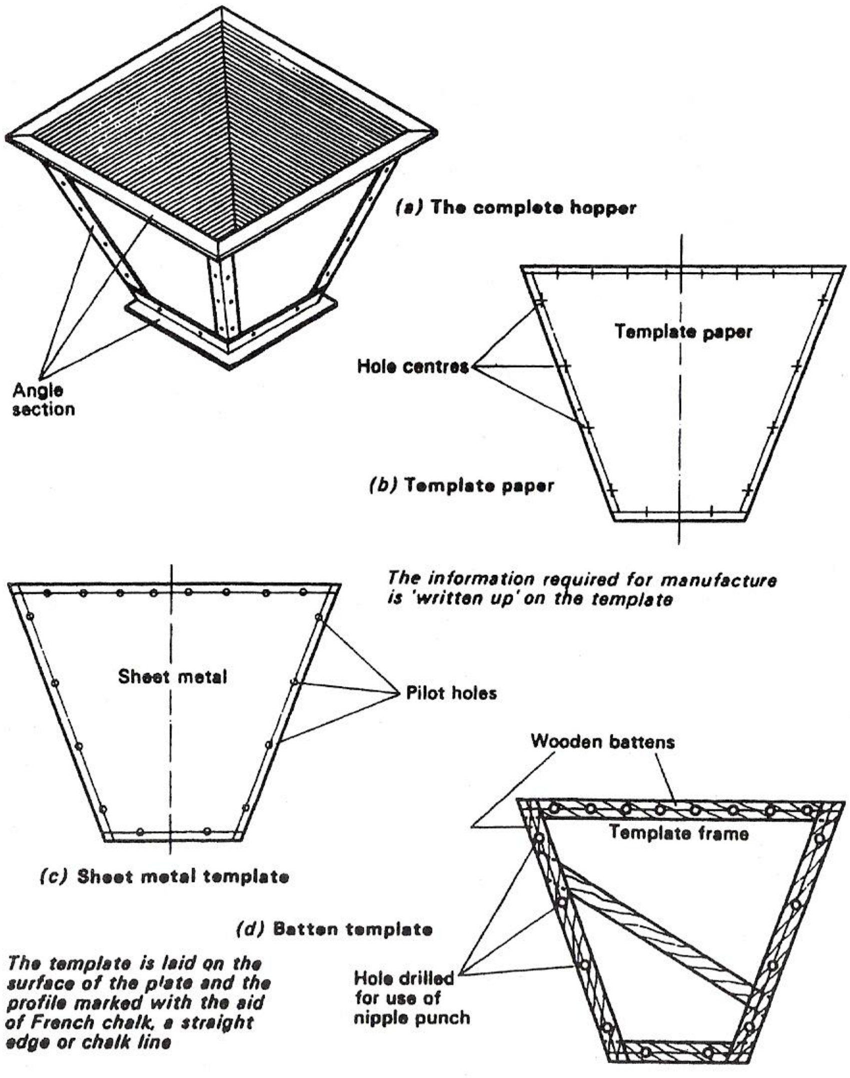

Figure 7 - The Use of Templates for Hopper Plates

Although many such hoppers are of welded construction, the example shown in Figure 7 is of riveted construction, using angle sections.

This simple type of hopper is made up off our identical steel plates for which only one template is required. The choice of template material is as follows:

When only one or two off are required, template paper may be used, as shown in Figure 7(b). The profile of one side is developed and marked out on the paper, together with the exact positions for the centres of the holes. The template is then sheared to size on the guillotine.

Light-gauge sheet metal is ideal material for the template where a quantity of identical hoppers are required (see Figure 7(c)).

Small pilot holes are either punched or drilled in the template in the correct positions. The hole positions are then transferred to the hopper plate with the aid of a centre punch.

The batten template shown in Figure 7(d) is relatively light in weight and is used for quantities. It is constructed from suitable wooden battens, in the form of a frame to represent the developed profile of the required hopper plates. All the outside edges of the template are planed straight. The hole positions are drilled to suit the diameter of the nipple punch.

Sharp Edges

When steel has been cut, formed or shaped, it can have rough edges, burrs etc.

When handling steel, especially sheet steel it is important to wear gloves. If steel has been cut in the guillotine/cropper it can sometimes leave very sharp razor-like edges, particularly so if the blades are worn on either the machine and/or the metal thickness has not been set correctly on the machine prior to cutting.

Drill holes also can leave burrs that can be quite sharp.

The above can be made safe using a grinding/sanding disc to make the edges smooth.

Percentages

This is an important section with many practical applications and should be studied carefully.

The words *per cent* mean *per hundred*, and the symbol % is used to denote 'per cent'.

Thus: 10 per cent, or 10%, means $\frac{10}{100}(\frac{1}{10}$ or 0.1)

5 per cent, or 5%, means $\frac{5}{100}(\frac{1}{20}$ or 0.05)

25 per cent, or 25%, means $\frac{25}{100}(\frac{1}{4}$ or 0.25)

Note any fraction may be converted to a percentage by multiplying it by 100.

EXAMPLE

Convert ⅛ to a percentage.

$$\text{Percentage} = \frac{1}{8}\times\frac{100}{1} = \frac{25}{2} = 12½\%\ \textit{Ans}$$

Many fractions may be converted to percentages (and vice versa) mentally.

To increase a quantity by, say, 15%, that is $\frac{15}{100}$, multiply the quantity by $\frac{115}{100}$.

That is $\frac{100}{100}$ for the original quantity plus $\frac{15}{100}$ for the increase, $\frac{100}{100}+\frac{15}{100}=\frac{115}{100}$.

EXAMPLE

Increase 5450 by 10%

$$\frac{5450}{1}\times\frac{110}{100}$$

$= 5995$ *Ans*

Basic Applications

Discounts and List Prices

The prices of building materials and components are often subject to *trade discount*; this means that you may be given the privilege of paying a certain percentage less than the advertised price for the goods. Follow the example carefully.

EXAMPLE

Here is a quotation from a builders' merchant.

(1) 5000 bricks @ €13.25 per 1000 less trade discount of 10%.

(2) $5m^3$ sand @ €2.25 per m^3 less trade discount of 5%.

The net cost (gross cost less discount) of each item is calculated as follows,

(1) Bricks

5000 @ €13.25 per 1000 = €13.25 x 5	= €66·25
Discount (10% = $\frac{1}{10}$)	<u>= €6.625</u>
Net cost	= €59.625

This should be written €59.62½.

(2) Sand

5 m^3 @ €2.25 = €2.25 x 5	= €11.25
Discount (5% = $\frac{1}{20}$)	<u>= €0.5625</u>
Net cost	= €10.6875

This, to the nearest penny, is €10.69.

Bonuses

You may be fortunate enough to receive in your pay packet a bonus of, say, 5%. This means that your pay will be increased by $\frac{5}{100}$ or $\frac{1}{20}$.

Simple Interest

It may be necessary for a builder to borrow money for a period. In these cases a *percentage interest* may be charged. The original amount of money is called the *Principal*, and the *Interest* is usually charged at a certain percentage per annum, called the *rate* of interest. The *amount* outstanding is equal to the principal plus the interest at any given time:

EXAMPLE

Find the amount and the interest on €150 at 5% per annum for a period of 3 years.

To find the Interest, multiply:

Principal x Rate of Interest x No. of years.

$= \frac{150}{1} \times \frac{5}{100} \times \frac{3}{1}$

= €22.50 *Ans*

Amount = €150 + €22.50 = €172.50 *Ans*

Summing Up

Note the following facts which will help you to simplify certain problems.

A *bonus* of 5% means 5p in the € because there are 100p to €1.

A *discount* of 15% on a purchase means a reduction in cost of 15p in the €.

To allow 10% for *wastage* means to add on $\frac{1}{10}$ of the quantity apparently required.

A *profit* of 20% means that you have made a profit of $\frac{1}{5}$ on the cost of the job, because 20% = $\frac{20}{100} = \frac{1}{5}$ of the cost.

An *increase in bulk* of 25% means that the material will increase in volume by $\frac{1}{4}$, because 25% = $\frac{25}{100} = \frac{1}{4}$ increase in volume.

Self Assessment

Questions on Background Notes – Module 1.Unit 10

1. Briefly explain the Forging Process.

2. Briefly explain the Casting Process.

Answers to Questions 1-2. Module 1.Unit 10

1.

The Forging Process:

The Forging Process breaks up and refines the crystal Structure of the metal. The finer the crystals become, the tougher and stronger the metal becomes. The temperature at which the metal is forged is important.

(See Notes: Module 1. Unit 9. P32 – 33.)

2.

The Casting Process:

The Casting Process is an alternative to forging and fabricating Metal.

Metal is extracted from ore then run into molds. Heat limits can restrict the choice of metals that can be cast in a small workshop. Metal can be melted repeatedly. Old castings can be melted to make new things. Casting is done in a mold; sometimes the whole process is described as Molding.

Metal	Degree Fahrenheit	Degrees Celsius
Lead	621	327
Zinc	787	419
Antimony	1166	630
Aluminium	1214	660
Brass	1650	900
Iron	2768	1520

(See Notes: Module 1. Unit 9. P37 – 39.)

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Powered Hand Tools Safety — *Vocam*
Circle Organisation Ltd.
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