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## Document Release History

| Date | Version | Comments |
| :--- | :--- | :--- |
| $12 / 02 / 07$ | First draft |  |
| $13 / 12 / 13$ | SOLAS transfer |  |
|  |  |  |
|  |  |  |

## Module 5 - Pipe Fabrication

## Unit 6 - Pipe Development Unequal Diameter 'T' Piece

Duration - 8 Hours

## Learning Outcome:

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

- Fabricate an unequal tee pipe intersection
- Develop patterns for interconnecting pipe and hole of penetration
- Define linear velocity and its relevance to pipe systems
- Identify performed pipe fittings (elbows, bends, tees etc.)
- Calculate the total amount of area covered
- Job planning


## Key Learning Points:

| Rk Sk | Parallel line development of equal tee pipe intersection. <br> (For more information see Module 5 Unit 4). |
| :---: | :---: |
| Rk D Sk | Indexing of points. |
| M | Methods of measurement - calculation of areas and volume. <br> (For more information see Module 5 Unit 1). |
| Sc | Velocity in relation to pipe diameters. |
| Rk | Types of values and functions. <br> (Instructor will demonstrate in class). |
| Sk | Template making for pipe intersections. |
| Sk | Alignment of cut pipe sections/assembly. |
| P Rk Sk | Sequence of operations, work planning. |
| H | Workshop hazards - oxy/fuel cutting, drilling, welding. <br> (For more information see Module 4 Unit 1 and Module 2 Unit 3). |

## Training Resources:

- Drawing equipment
- Apprentice toolkit
- Template material
- Fabrication workshop and equipment
- Safety clothing and equipment
- Handouts, notes and technical manuals
- Sample of pipe fitting and valves

Key Learning Points Code:
$\mathrm{M}=$ Maths $\quad \mathrm{D}=$ Drawing $\quad \mathrm{RK}=$ Related Knowledge $\mathrm{Sc}=$ Science
$\mathrm{P}=$ Personal Skills $\quad \mathrm{Sk}=$ Skill $\quad \mathrm{H}=$ Hazards

## Area of Circle

If we were to divide a circle into a very large number of very thin triangles as shown below and then rearrange them as shown underneath, we would obtain a figure which is very nearly a rectangle of length, half the circumference ( m ) and height equal to the radius (r).


Figure 1 - Area of Circle
Area of Rectangle $=\pi r \times r=\pi r^{2}$

## Example 1

Find the dimension Z, perimeter and area of the figure shown in the sketch below.


Dimension Z
Radius of each end $\mathrm{r}=2.5 \div 2=1.25 \mathrm{~m}$

$$
\mathrm{Z}=7 \mathrm{~m}-2 \mathrm{r}=7-2.5=4.5 \mathrm{~m}
$$

Perimeter

$$
\begin{aligned}
& =2 \mathrm{Z}+\pi \mathrm{D} \\
& =(2 \times 4.5)+(3.14 \times 2.5)=16.85 \mathrm{~m}
\end{aligned}
$$

Area

$$
\begin{aligned}
& =\text { Circle }+ \text { Rectangle }=\pi r^{2}+2.5 \times \text { Z } \\
& =\left(3.14 \times 1.25^{2}\right)+(2.5 \times 4.5)=16.15625=16.16 \mathrm{~m}^{2}
\end{aligned}
$$



Answer:

Dimension

$$
\begin{aligned}
& \mathrm{Z}=100-20=80 \mathrm{~mm} \\
& \mathrm{Y}=80-10=70 \mathrm{~mm}
\end{aligned}
$$

Area $=$ Circle + Rectangle - 2 Circles
$=\pi \times 10^{2}+80 \times 20-2 \times \pi \times 5^{2}$
$=314 \times 1600-157$
$=1757 \mathrm{~mm}^{2}$

## Conversion between Units of Area

There are 1000 mm in 1 metre.
One square metre contains:

$$
1000 \times 1000=1,000,000 \mathrm{~mm}^{2}
$$

$1,000,000$ ( 1 million) is a very large number and is often written as $10^{6}$, the 6 represents the number of zeros after the initial 1 .

## Example 2

1 in . $=25.4 \mathrm{~mm}$. Estimate the number of square $\mathrm{mm}\left(\mathrm{mm}^{2}\right)$ in 1 square inch $\left(1 \mathrm{in}^{2}\right)$ :
1 in x 1 in $=1$ sq. inch.
$25.4 \times 25.4=645.16 \mathrm{~mm}^{2}$
$1 \mathrm{in}^{2}=645.14 \mathrm{~mm}^{2}$
Test Yourself
Determine the number of $\mathrm{mm}^{2}$ in a circle of radius
2 in . 2 in.

Answer:
$2 \mathrm{in}=2 \times 25.4=50.8 \mathrm{~mm}$
Area of circle $=\pi r^{2}$
$=3.14 \times 50.82=8103 \mathrm{~mm}^{2}$

## Volume

The volume of a solid, liquid or gas is a measure of the space it occupies.
The unit of volume is the cubic metre. It is the space occupied by a cube with edges 1 m as shown below.


In finding the volume of a figure we need to know how many cubic units are contained in that figure. A rectangular solid is a familiar and simple figure to start with.

## Example 1

Calculate the volume in cubic metres of a room 3 m high x 3 m wide x 4 m long as shown below.


From the sketch one may observe that the volume is $36 \mathrm{~m}^{3}$. In general, the volume of a rectangular solid is the product of its length, width and height.

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## Volume and Surface Area - Prisms

A Prism is a solid object which has exactly the same cross-section throughout its length. Thus a triangular prism, shown below, is a solid object with a triangular cross-section throughout its length.


## Example 2

Determine the cross-sectional area and the volume of the prism shown above.

Cross-Sectional Area

$$
=\text { Area of Triangle }=\frac{3 \times 4}{2} \quad=6 \mathrm{~m}^{2}
$$

Volume

$$
=6 \times 7=42 \mathrm{~m}^{3}
$$

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## Surface Area of Cylinder

A cylinder is a prism with a circular base. The figure below shows a sketch of a cylinder of diameter 0.4 m and a height of 1.2 m . The surface area around the side of the cylinder is known as the curved surface area. If a sheet of paper was cut until it fit exactly around the curved surface of the cylinder, it would be found that the paper would be rectangular in shape as shown.


$$
\begin{aligned}
& \text { Curved surface area }=\pi \mathrm{dh} \\
& =3.14 \times 0.4 \times 1.2=1.5 \mathrm{~m}^{2}
\end{aligned}
$$

## Volume of Cylinder

The volume of a cylinder may be found by multiplying the cross-sectional area of the cylinder by its length.

## Example

Find the volume of the cylinder shown in the figure above.
Cross-Sectional Area

$$
=\pi \mathrm{r}^{2}=3.14 \times 0.2 \times 0.2=0.1256 \mathrm{~m}^{2}
$$

Volume
$=$ Cross-Sectional Area $\times$ Length $=0.1256 \times 1.2=0.15 \mathrm{~m}^{3}$
Volume of Cylinder
$=\pi \mathrm{r}^{2} \mathrm{~h}$ where: $\mathrm{r}=$ radius of cylinder, $\mathrm{h}=$ height of cylinder

## Conversion between Units of Volume

There are 1000 mm in 1 metre.
One square metre contains...

$$
\begin{aligned}
& 1,000 \times 1,000 \mathrm{~mm} \\
& =1,000,000 \mathrm{~mm}^{2}
\end{aligned}
$$

One cubic metre contains...

$$
\begin{aligned}
& 1,000 \times 1,000 \times 1,000 \mathrm{~mm} \\
& =1,000,000,000 \mathrm{~mm}^{3}
\end{aligned}
$$

One billion is a very large number which is often written as $10^{9}$, the 9 represents the number of zero's after the initial 1.


Figure 39

Answer:
Cross-Sectional Area

$$
\begin{aligned}
& =\pi \mathrm{R}^{2}-\pi \mathrm{r}^{2} \\
& =3.14 \times 60 \times 60-3.14 \times 50 \times 50 \\
& =3454 \mathrm{~mm}^{2}
\end{aligned}
$$

Volume

$$
\begin{aligned}
& =\text { Cross-Sectional Area } \times \text { Length } \\
& =3454 \times 1000 \\
& =3,454,000 \mathrm{~mm}^{3}
\end{aligned}
$$

Volume in $\mathrm{m}^{3}$

$$
\begin{aligned}
& =3,454,000 / 10^{9} \\
& =0.003,454 \mathrm{~m}^{3}
\end{aligned}
$$

## The Design Process

## What is Design?

Design is the process of developing solutions to practical problems. As we all have to solve problems in our daily lives, we are all designers to an extent. If you decide to rearrange the layout of your bedroom, you are making a number of design decisions in the process. You may move the bed to an area of the room that gets the morning sunlight or move your study desk to an area of the room that gets the sun in the evening. This is designing because you are using your knowledge of the direction of the sun at various times during the day to assist you in deciding the position of furniture in your bedroom (Figure 2).


Figure 2-A Design Problem

While this example may be typical of the type of design problem you encounter in your daily life, professional designers are presented with new and challenging problems on a daily basis (Figure 3). Such designers normally adhere to a standard procedure called the Design Process; to solve design problems.


Figure 3 - Professional Designers at Work

## Stages in the Design Process

The stages in the design process vary depending on the type of problem you are solving. However, the design process normally includes all of the following steps:

- The Design Brief is a statement which outlines what you must achieve and the restrictions you are working under. For example, you may be asked to design a logo for a shop that must be opened next week. In this situation, the timescale is your obvious restriction.
- Analysis and Research. You must get a clear understanding of what is required. Why has the problem arisen? Are there any related issues?
- Alternative Solutions. This stage involves sketching your various solutions. All ideas are recorded. Once you have considered a range of ideas you must then carefully consider the merits of each solution decide if it solves the problem. It sometimes helps if you list the advantages and disadvantages associated with each solution.
- Final Solution. In deciding on a final solution, it is important that you consider any design restrictions. For example, there is no point deciding on a solution that will cost $€ 500$ if your budget is $€ 20$. Equally, there is no point deciding on a solution that takes six months to produce if the final product is required in five days. Designers constantly make compromises between their ideal solution and what is realistically attainable.


Figure 4 - Model of a Proposed Community Centre

- Modelling of Solution. Sometimes it is worthwhile making a model of your solution. A model is a scaled representation of the solution (Figure 4). Models are very effective at communicating design solutions to non-technical people. I suggest you make models of your solution wherever possible. Models help you get a greater understanding of your solution.
- Working Drawings are detailed drawings of each component of the final product.
- Manufacture. The product is made to the specifications of the working drawings.
- Evaluation. Once produced your solution is evaluated against the initial design brief. In a commercial situation the client performs agreed tests on the product before they pay for it.

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You can see from the Figure 5 that although the design process is linear there is interaction between all of its stages.


Figure 5 - Stages in the Design Process

## Presentation Graphics

An important part of any design process is the graphical representation of ideas. Initially this takes the form of freehand sketching. Draw plenty of sketches to communicate your ideas. These ideas must be presented in a logical manner and the important ideas highlighted. It is of course important that your presentation is visually appealing and easy to follow (Figure 6).


Figure 6 - The Presentation of Design Information

## Brainstorming

Sometimes it is difficult to come up with new ideas. Even professional designers have this problem. Realising that teams of people come up with far better ideas than anyone individual, designers commonly pool the resources of many people in a brainstorming session.
In a brainstorming session, a group of between five and ten people meet to discuss a specific problem (Figure 7). One member of the group is appointed to take notes and everybody gives spontaneous ideas which may solve the problem. Each idea is noted without comment. Long involved discussions are avoided. No idea, no matter how ridiculous, is turned down. At a later stage each idea is analysed, and its merits are noted. These sessions are a great source of ideas and they normally last 20-30 minutes. Brainstorming can also be used to solve various design problems in a class situation.


Figure 7 - Brainstorming Session

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## Design Considerations

When designing a product you must ensure that as well as being functionally effective that it is also visually appealing and easy to use. In deciding on a final solution two important items are normally taken into consideration, mainly:

- Proportion
- Ergonomics


## Proportion

Proportion is the relationship between length, width and height of an object. Objects in certain proportions are more visually appealing to the eye than others. Consider the objects shown in Figure 8 and Figure 9. Which do you consider to be more appealing? Both pictures have approximately the same area. However, Figure 9 is more visually appealing as the sides are in good proportion.


Figure 8


Figure 9

## Ergonomics

Ergonomics is the science which deals with the relationship between product suitability and human size. Ergonomics is not only concerned with the size of an object but also with its shape, form, etc. Take for example the driver of a car; the seat must be comfortable for the driver, regardless of the driver's size or age. The driver must also have access to all the car controls without over-stretching. However, the manufacturer doesn't know in advance the age or gender of the driver.

Some basic questions a designer asks are:

- Where will the product be used?
- Who will use the product?
- How will the product be used?
- Will the user be using any other products at the same time?


Figure 10 - Ergonomic Design Consideration

## Developing Cylinders

If a wrapping is placed around a cylinder the shape of the wrapping is rectangular (Figure $11)$. This wrapping is the development of the cylinder. The length of the rectangle is equal to the length of the circumference of the cylinder while the height of the rectangle is equal to the height of the cylinder (Figure 12).


Figure 11


Figure 12

## Problem 1

Draw the elevation and plan of a cylinder, diameter 40 mm , height 72 mm . Construct the development of all surfaces of the cylinder.

## Solution:

1. Draw the elevation and plan of the cylinder.
2. Divide the plan into $30^{\circ}$ divisions using the $30^{\circ} / 60^{\circ}$ set square.
3. Project the development at $90^{\circ}$ to the axis of the cylinder. Establish the length of the development by transferring the length of one of the divisions on the circumference of the circle in plan (d is illustrated) and marking it off 12 times to get the length of the rectangle in development.
4. The base and top of the cylinder are both circles of diameter 40 mm in development.


Figure 13

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## Problem 2

The elevation and plan of portion of a coal bucket is shown in Figure 14. Draw the development of the curved surface of the bucket.

## Solution:

1. Draw the given elevation and plan. Divide the plan into $30^{\circ}$ divisions from the centre.
2. Project the development at $90^{\circ}$ to the axis of the cylinder. The development is started along generator I as it is the shortest generator.
3. Establish the length of the circumference and complete the development as illustrated in Figure 15.
4. As this is a bucket the sloping surface is open and the development of the bottom surface is a circle.


Figure 14


Figure 15

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## Self Assessment

Questions on Background Notes - Module 5.Unit 6

## No Suggested Questions and Answers.

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