Trade of Toolmaking	
Module 1:	Induction & Bench Fitting
Unit 2:	Marking Out, Cutting & Filing
	Phase 2

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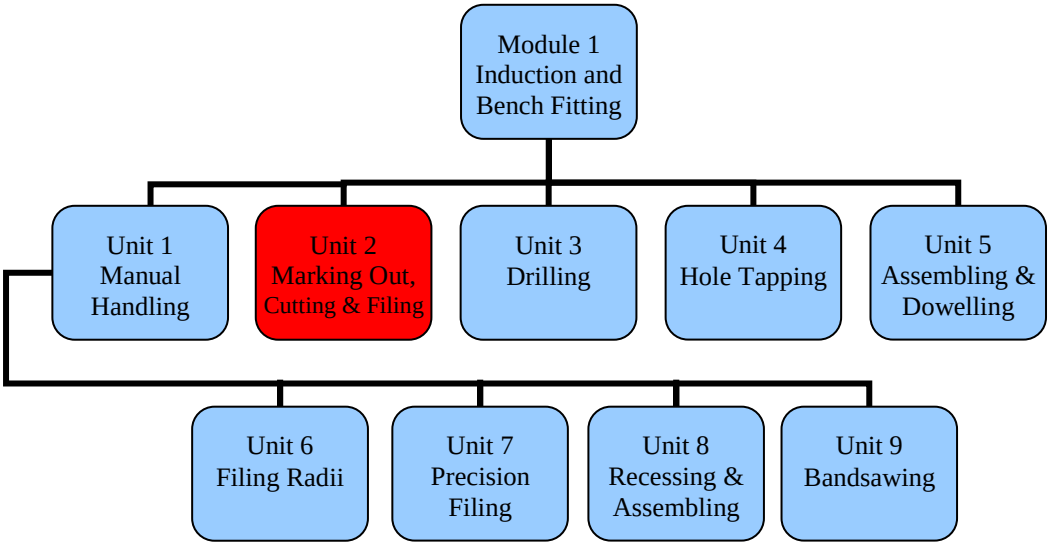
Unit Objective

On completion of this unit you will be able to read technical drawings, mark out, cut and file mild steel plates to the specified dimensions using the appropriate equipment.

Introduction

Module one of this course covers induction and bench fitting. This is the second unit in module one and introduces the techniques associated with marking out, cutting and filing metal plates to the required drawing specifications.

Marking out, cutting and filing are used to shape mild steel plates, although manual and CNC machines are used nowadays for machining multiple parts, where greater precision and speed is required. It is important to be proficient in bench fitting as it forms one of the basic fundamentals of metal shaping and fabrication. In industry, metal plates are generally marked out prior to machining and act as a guide to the operator and files are used to remove burrs and round corners.



By the end of this unit you will be able to:

- Interpret and read first angle and third angle drawings, calculate material requirements and plan workshop activities
- Identify precision measuring and marking out equipment
- Describe and demonstrate the correct use and care for precision measuring and marking out equipment
- Mark-out horizontal and vertical dimensions to ± 0.20mm and ± 0.20º using the appropriate techniques and datum edges from first and third angle drawings
- Cut mild steel plate using a hack-saw to the marked dimensions while allowing material for filing to the finished size
- Describe and explain the safety precautions and procedures to be used when in the workshop environment in the context of marking out, sawing and filing
- File and finish components to size using second cut and smooth files to the required tolerance and geometry shown on the supplied drawings
- Steel production, classification of steels and non-ferrous materials

1.0 Drawing Interpretation, Materials And Workshop Activities

Key Learning Points

Drawing symbols, first angle and third angle, orthographic, free hand sketches on grid paper. Drawing sheet layout, borders and standard title block and information. Preliminary techniques lettering and printing, types of lines used in engineering drawing, line weights, use of BS 8888 drawing standards. Job planning through each stage of manufacture. Motivation: professional approach to task planning.

1.1 First and Third Angle Orthographic Projection

There are two systems of projection, First Angle and Third Angle, which are based on a framework of planes at right angles. In first angle projection, each view shows what would be seen by looking on the far side of an adjacent view. In Third angle projection, each view shows what would be seen by looking on the near side of an adjacent view. The Projection symbol must be added to the drawing to indicate which system has been used.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 4, *Principles of first and third angle orthographic projection.*
ISBN-13: 9780750651202

1.2 Linework And Lettering

Technical drawings are prepared using two line thicknesses, a continuous wide line for component edges and outlines and continuous narrow lines for dimension lines. The letters, numbers and symbols should be clearly written and it is important to remember that the drawing is the main line of communication between the draftsperson and the end user.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 5, *Linework and lettering.*
ISBN-13: 9780750651202

1.3 Drawing Layout

The drawing should have adequate information to allow the workpiece to be manufactured without having to source further information.

Ref: Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology, chapter 7, *Drawing layouts and simplified methods.*
ISBN-13: 9780750651202

1.4 Job Planning

Job planning is important prior to starting any task. The drawing should first be studied and understood. The drawing can initially be used to calculate the material requirement for the component to be manufactured. The workpiece is marked out using the dimensions and datums as specified on the drawing. A basic level of maths is required such as addition, subtraction, multiplication, division, fractions, decimals and percentages.

2.0 Precision Measuring And Marking-Out Equipment

Key Learning Points

Tool types and applications for marking out and measuring.

2.1 Marking-Out Equipment

The term marking out means the scribing of lines on a metal surface to show the profile or outline of the finished component. The following equipment is used for marking out the workpiece prior to cutting and filing: Scriber, Dividers, Straight Edge, Height Gauge, Protractor, Angle Block, Try Square, Vee-block and Marking-off table. Precision measuring equipment is used such as the; Rule, Vernier Caliper, Micrometer, Try Square and the Protractor.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*.
ISBN-13: 9780750660730

2.2 Measuring Equipment

Precision measuring equipment is used such as the; Surface Plate, Try Square, the Protractor, Dial Gauge, Rule, Micrometer and the Vernier Calipers.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out, chapter* 6, *Measuring equipment*.
ISBN-13: 9780750660730

3.0 Use Of Precision Measuring And Marking Out Equipment

Key Learning Points

Reading the vernier callipers, vernier height gauge, protractor and external micrometer. Care/storage of tools and equipment. Metric system: units of length, linear and angular measurements.

3.1 Reading The Vernier Callipers, Vernier Height Gauge, Protractor And The External Micrometer

There are many types of measuring instruments used in industry, such as the vernier callipers, the micrometer and the protractor. The vernier height is used for marking out. The accuracy of these instruments depends on how they are used and treated.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 6, *Measuring equipment*, p. 95.
ISBN-13: 9780750660730

3.2 Care And Storage Of Tools And Equipment

Care should be taken when using marking out equipment, as many of them have sharp features. Treat measuring equipment as delicate precision instruments, as they can be easily damaged and should be stored in a secure place. Tools should be stored in a locker or in a toolbox and should be returned to the original location after use.

3.3 Metric System: Units of Length, Linear and Angular Measurements.

The basic unit of length is the metre (m). For small units of length the millimetre (mm) is used. There are 1000 millimetres (mm) in a 1 metre (m). The kilometre (km) is used to measure long distances. 1000 metres (m) = 1 kilometre (km).

4.0 Marking-out Using Datum Edges

Key Learning Points

Parallel blocks and marking out equipment.

4.1 Marking Out Equipment

The workpiece is marked with scribing block or a vernier height gauge to the dimensions specified on the drawing. The scribed lines should be marked from the same datum edge as specified on the drawing. The *datum* is described as a reference edge or a point from which measurements are made. For angled lines use the protractor or straight edge and scriber. For scribing radii, punch the centre point and scribe the radius using dividers.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 3, *Marking out*, p. 44.
ISBN-13: 9780750660730

5.0 Cut Mild Steel Plate To Size

Key Learning Points

Hacksaw blade selection and assembly (junior/senior), Hand hack-sawing technique and practice, power hack sawing. Calculation of the material requirement for the components to be manufactured, including necessary excess material.

5.1 Hacksaw Blade Selection and Assembly

Mild steel plates are cut using a hacksaw. The plates are cut close to the scribed lines, allowing additional material for filing to the finished size. For cutting solid metal such as mild steel, a blade with a staggered tooth set should be used, which prevent the blade wedging in the slot. For cutting tube or sheet metal, a waved blade with a fine pitch is used. A junior hacksaw blade is used for cutting small sections and in confined conditions.

5.2 Hand Hack-Sawing Techniques

The hacksaw is controlled with both hands. The saw should be kept straight and upright and should not be allowed to twist or move sideways. Proper technique will come with practice and experience and guidance from your instructor.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 2.2, *The hacksaw*, p. 33.
ISBN-13: 9780750660730

5.3 Calculation Of Material Requirements, Including Excess Material

Mild steel plates are cut with a hacksaw to the marked-out dimensions, while allowing additional material for filing to the finished size. The drawing is used to calculate the material requirement for the component to be manufactured. Excess material is added because the material is roughly cut from standard bar stock using a band-saw. The excess material is removed afterwards with a hacksaw and a range of files. A basic level of maths is required such as addition, subtraction, multiplication, division, fractions, decimals and percentages.

6.0 Safety Precautions and Procedures

Key Learning Points

Hazard avoidance: general workshop safety, tool holding/usage/ housekeeping. Safe and environmentally sound disposal of waste materials and tooling.

6.1 Hazard Avoidance: General Workshop Safety

It is important to keep the work area and the workshop clean and tidy. All tool and equipment must be returned to their respective toolbox or storage area when not in use. When using power tools always wear safety glasses, do not wear loose clothing and tie back long hair. Ensure that the floor is kept free of debris, oil and coolant spills. Clean up spills immediately.

- Care and use of hand tools:
- Select the correct size tool for the job.
- Do not use worn or damaged tools.
- Maintain tools in good condition.
- A cutting tool needs to be sharp to be safe.
- Store and carry tools safely

When the component has been cut on the band-saw, all burrs and sharp edges need to be removed with a file prior to marking-out. For sawing and filing the work should be held securely in a vice, adopting a comfortable balanced stance, maintaining a suitable grip.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 1, *Safe practices.*
ISBN-13: 9780750660730

6.2 Safe Disposal Of Waste Materials And Tools

All waste materials, such as metal cut-offs and scraped parts, should be placed in special metal scrap bins, which can be sent for recycling.

All other waste such as oily paper, cloths, filings etc., should be removed from the workbench or floor using a brush and pan. This waste can be placed in the general disposal bins.

7.0 File Components To Required Drawing Specifications

Key Learning Points

Filing: squareness, maintaining tolerances, breaking corners, draw filing, high spot removal techniques and technique for filing chamfers of workpieces. Location and identification of special tools, equipment and consumables. Concept and applications of tolerance.

7.1 Filing

When the component has been cut roughly to size using a hack-saw, the file is used to finish the component to the specified drawing dimensions. A range of files can be used, which are available in various shapes are Flat, Hand, Warding, Square, Three Square and Half Round, depending on the shape of the component and the precision and finish required. Most files are double cut and are made in grades of cut, Bastard, Second Cut and Smooth.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, chapter 2, *Hand processes*, p. 30.
ISBN-13: 9780750660730

7.2 Location Of Tools, Equipment And Consumables

Files, hacksaws and other tools should be stored in a locker or in a toolbox and should be returned to the original location after use. Consumables such as emery paper and hacksaw blades should be stored safely. Files and hacksaws need to be cleaned after use. Embedded debris can be removed with a wire brush.

7.3 Concept And Application Of Tolerance

Every dimension on the drawing will have a tolerance band to work within. The *tolerance* is therefore the difference between the lower and upper limits of size of any particular feature.

8.0 Steel Production, Classification Of Steels And Non-Ferrous Materials

Key Learning Points

Production of steel, classification of steels. Ferrous and non-ferrous material, types of steels.

8.1 Production Of Steels

There are two main stages in the production of steel. In the first stage Pig Iron is produced in a blast furnace. This type of iron is weak and brittle due to the high carbon content and is of little use in industry. The Pig Iron therefore needs to be processed further to reduce carbon in the steel. The main processes used are: (i) the Bessemer process, (ii) the basic oxygen process and (iii) the open hearth process. Mild Steel, Medium and High Carbon Steels can be produced from these processes.

8.2 Ferrous And Non-Ferrous Materials

The materials mainly used in Toolroom are metals and these are divided into two groups, which are called ferrous and non-ferrous. The ferrous metals are iron and steel and the other metals are referred to as non-ferrous, which include materials such as aluminium and brass.

Ref: Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology, Chapter 13, *Materials* p. 211.
ISBN-13: 9780750660730

Summary

Technical drawing interpretation, materials and workshop activities: Technical drawing is a method of communicating and exchanging design ideas in industry. Drawing sheets consist of a border, title block, views of the component, dimensions, symbols and notes. Multi-view orthographic projection is used in engineering drawing. There are two systems of projection, First Angle and Third Angle, which are based on a framework of planes at right angles. In first angle projection, each view shows what would be seen by looking on the far side of an adjacent view. In Third angle projection, each view shows what would be seen by looking on the near side of an adjacent view. Grid paper is used for drawing free hand sketches of a component.

Precision measuring and marking out equipment: The term marking-out means the scribing of lines on a metal surface to show the profile or outline of the finished component. Precision marking equipment is used such as, the Scriber, Dividers, Straight Edge, Height Gauge, Protractor, Angle Block, Try Square, Vee-block and Marking-off table. Precision measuring equipment is used such as the; Rule, Vernier Caliper, Micrometer, Try Square and the Protractor.

Use of precision measuring and marking out equipment: Care should be taken when using marking out equipment as many have sharp features. Treat measuring equipment as delicate precision instruments, as they can be easily damaged and should be stored in a secure place.

Marking-out mild steel plates: The metal surface is usually coated in order to show up the scribed lines. The most common coating used is Engineer's Blue. The plates are marked out with the vernier height gauge to the dimensions specified on the drawing. For angled lines use the protractor or straight edge and a scriber. For scribing radii punch the centre point and scribe the radius using dividers.

Cut mild steel plate to size: Mild steel plates are cut using a hack-saw to the marked-out dimensions, while allowing material for filing to the finished size. A junior hack-saw blade is used for cutting small sections and in confined conditions. The drawing is used to calculate the material requirement for the component to be manufactured. Excess material is added because the material is roughly cut from standard bar stock using a band-saw.

Safety precautions and procedures: When the component has been cut on the band-saw, all burrs and sharp edges need to be removed with a file prior to marking-out. For sawing and filing the work should be held securely in a vice, adopting a comfortable balanced stance, maintaining a suitable grip.

File components to required drawing specifications: When the component has been cut roughly to size using a hack-saw, the file is used to finish the component to the specified drawing dimensions. A range of files can be used, which are available in various shapes are Flat, Hand, Warding, Square, Three Square and Half Round, depending on the shape of the component and the precision and finish required. Most files are double cut and are made in grades of cut, Bastard, Second Cut and Smooth.

Suggested Exercises

1. Using a rule, a vernier callipers and an external micrometer, measure a workpiece and write down the measurements. Comment on the accuracy of the different measurements.
2. Explain the meaning of Parallax Error using a sample workpiece and a rule.
3. Sketch an External Micrometer and label the main parts.
4. Using a Vernier Protractor and set up the following angle: 52° 35’.
5. On a sample metal plate use a *Centre Punch* and a *Dividers* to scribe 10mm, 20mm, 30mm and 40mm circles.
6. On a sample metal plate use a Rule and an Odd-Leg Calipers to scribe lines 5mm, 10mm, 15mm and 20mm parallel to the one side of the plate.

Questions

1. Explain the difference between first and third angle projection.
2. What does the term ‘marking out’ mean?
3. List six items that can be used when marking out a mild steel plate, prior to cutting and filling.
4. List four instruments used to measure a workpiece.
5. When cutting solid metal such as mild steel, what type of saw blade is used and why is it used.

Answers

1. First Angle and Third Angle are based on a framework of planes at right angles. In first angle projection, each view shows what would be seen by looking on the far side of an adjacent view. In Third angle projection, each view shows what would be seen by looking on the near side of an adjacent view.
2. The term marking out means the scribing of lines on a metal surface to show the profile or outline of the finished component.
3. The following equipment is used for marking out the workpiece prior to cutting and filing: (i) Scriber, (ii) Dividers, (iii) Straight Edge, (iv) Height Gauge, (v) Protractor, (vi) Angle Block, (vii) Try Square, (viii) Vee-block and (ix)Marking-off table.
4. The following instruments can be used to measure a workpiece; (i) Rule, (ii) Vernier Caliper, (iv) Micrometer, (v) Try Square and the (vi) Protractor.
5. For cutting solid metal such as mild steel, a blade with a staggered tooth set should be used, which prevent the blade wedging in the slot.

Recommended Additional Resources

Reference Books

Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology.

ISBN-13: 9780750660730

Simmons, Colin H & Maguire, Dennis E 2004, *Manual of engineering drawing*, 2nd edn, Elsevier Science & Technology.

ISBN-13: 9780750651202

Bird, John 2005, *Basic engineering mathematics*, 4th edn, Elsevier Science & Technology.

ISBN-13: 9780750665759