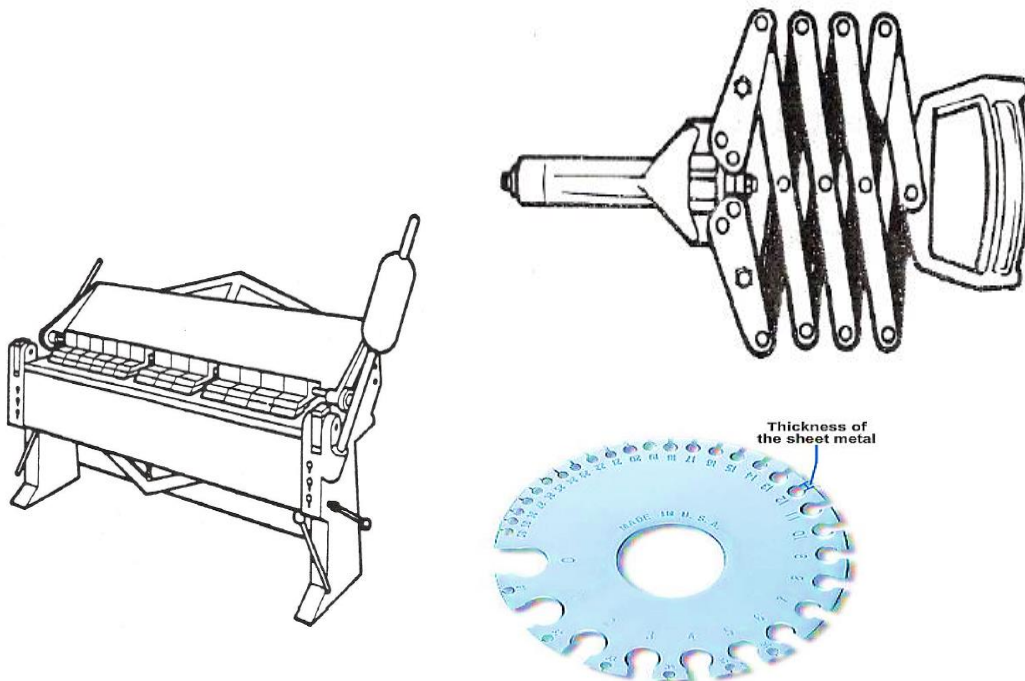


# MACHINING

## LEVEL – I

**Based on March, 2022, Curriculum Version 1**



**Module Title: - Cutting and Joining Sheet Metal**

**Module code: IND MAC1 M04 0322**

**Nominal duration: 80Hour**

**Prepared by: Ministry of Labour and Skill**

August, 2022

Addis Ababa, Ethiopia

Page 1 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
---------------	--	--------------------------	----------------------------

## Table of Content

<b>Table of Contents</b>	<b>Page</b>
<b>Table of Content</b> .....	<b>2</b>
<b>Acknowledgment</b> .....	<b>5</b>
<b>Acronym</b> .....	<b>6</b>
<b>Introduction to the Module</b> .....	<b>7</b>
<b>This module covers the units:</b> .....	<b>7</b>
<b>Learning Objective of the Module</b> .....	<b>7</b>
<b>Module Instruction</b> .....	<b>7</b>
<b>Unit one: Analyze work task</b> .....	<b>9</b>
1.1. Task requirements .....	10
1.1.1. Working drawing .....	10
1.2. Quality assurance.....	11
1.2.1. Definition of quality.....	11
1.2.2. Quality assurance .....	11
1.2.3. Quality of Sheet Metal Working.....	11
1.3. OHS requirements.....	13
1.3.1. OHS in cutting and joining sheet metal .....	13
1.3.2. Safety precautions .....	14
<b>Self-check-1</b> .....	<b>15</b>
<b>Unit Two: Plan and prepare work</b> .....	<b>18</b>
2.1. Tasks sequence .....	19
2.1.1. Planning tasks.....	19
2.1.2. Tasks sequence .....	21
2.2. Tools, equipment and materials.....	22
2.2.1. Sheet metal tools and equipment.....	22
2.2.2. Cutting Tools and equipment .....	27
2.2.3. Bending and forming tools and equipment.....	34

2.2.4.	Type of sheet metal Materials .....	43
2.2.5.	Personal Protective equipment (PPE) used for sheet metal work .....	45
2.3.	Preparing work area. ....	46
2.4.	Sealants, fixing and sheet metal materials .....	46
2.4.1.	Sealant.....	46
2.4.2.	Types of sealants.....	47
2.4.3.	Material compatibility of sealant .....	48
2.4.4.	Fixing materials.....	49
<b>Self-Check -1 .....</b>		<b>53</b>
<b>Unit three: Develop patterns as required .....</b>		<b>55</b>
3.1.	Pattern development methods.....	56
3.1.1.	Types of Developments .....	56
3.2.	Allowances for fabrication and assembly .....	72
<b>Self-check-1 .....</b>		<b>79</b>
<b>Operation sheet-1 .....</b>		<b>80</b>
<b>Unit Four: Cut and join sheet metal.....</b>		<b>81</b>
4.1.	Marking out Sheet metal.....	82
4.2.	Measuring and Cutting Sheet metal to pattern. ....	82
4.2.1	Measurement methods .....	83
4.2.2.	Metric (SI) systems .....	83
4.2.3.	English System .....	84
4.3.	Surface contaminants.....	84
4.3.1.	Cleaning surface of sheet metal.....	84
4.3.2.	Five Important Steps Preparing Metal for Paint .....	85
4.4.	Join Sheet metal.....	86
4.4.1.	Fabrication of Edges, Joints, Seams, and Notches.....	86
4.4.2.	Fabricating Seams joints.....	88
4.4.3.	Rivets .....	91
4.4.4.	Size of rivet .....	92
4.4.5.	How to select rivet size .....	92
4.4.6.	Rivet set.....	93
4.4.7.	Hollow rivets (blind rivet) .....	93
4.4.8.	Hole size and preparation .....	94
4.4.9.	Rivet diameter.....	94
4.4.10.	Edge distance .....	94

4.4.11. Rivet pitch .....	94
4.4.12. Rivet material .....	94
<b>Self-check-1 .....</b>	<b>95</b>
<b>Operation sheet-1 .....</b>	<b>95</b>
<b>Unit Five: Quality assure work and clean up .....</b>	<b>97</b>
5.1. Measure aligns, join and sealed components.....	97
5.1.1. Types of joining.....	97
5.2. Maintain work area, tools and equipment .....	101
5.2.1. Clean safe Workspaces, .....	101
5.2.2. Correct Maintenance of Tools and Equipment .....	101
5.3. Workplace documentation .....	101
5.3.1. Importance of Documentation in the Workplace .....	102
5.3.2. The Manufacturing Formula should include: .....	102
5.3.3. Packaging Instructions.....	102
5.3.4. Testing .....	103
<b>Self-check-1 .....</b>	<b>103</b>
<b>-.....</b>	<b>103</b>
<b>Reference.....</b>	<b>104</b>

## Acknowledgment

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Page 5 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022



## Acronym

Page 6 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022

## Introduction to the Module

In machining filed; the Cut and Join Sheet Metal helps to analyze work task, to plan and prepare work, to develop patterns as required, to cut and join sheet metal, to Quality assure work and clean up for machining filed.

This module is designed to meet the industry requirement under the machining occupational standard, particularly for the unit of competency: Cut and Join Sheet Metal.

### This module covers the units:

- Work task
- Plan and prepare work
- Patterns development as required
- Cut and join sheet metal
- Quality assures

### Learning Objective of the Module

- Analyze work task
- Plan and prepare work
- Develop patterns as required
- Cut and join sheet metal
- Clean up quality assure work

### Module Instruction

For effectively use these modules trainee are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit

Page 7 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
---------------	--	--------------------------	----------------------------

3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” given at the end of each unit and
5. Read the identified reference book for Examples and exercise



## Unit one: Analyze work task

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Task requirements.\
- Quality assurance.
- OHS requirements associated with cutting and joining sheet metal

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Analyze task requirements.
- Identify and adhere quality assurance.
- Adhere OHS requirements associated with cutting and joining sheet metal

## 1.1. Task requirements

**Sheet metal** is one of the fundamental forms used in metalworking and it can be cut and bent into a variety of shapes. Many objects are fabricated from **sheet metal**. The larger the gauge number, the thinner the **metal**. The thickness of sheet metal is not above 3.5mm a metal thickness above 3.5mm is called a plate not sheet metal. Thicknesses can vary significantly; the **extremely thin** thicknesses are considered **foil or leaf**.

- Thickness of sheet metal = 0.4 mm to 3.5 mm
- Thickness of plate stock > 3.5 mm
- Operations usually performed as cold working

A sheet metal worker is a skilled trades man who creates, installs, and repairs sheet metal products. Most commonly these products include elements of heating, cooling, and ventilation systems, although sheet metal workers also fabricate and repair products for drainage and roofing applications etc.

### 1.1.1. Working drawing

Is drawing in isometric projection, orthographic projection or detailed views that show the shape of the object to be produced? Drawing has dimension to which size the object to be made. You have to read the dimension accurately to produce the product as the given standard

Sheet metal workers typically do the following tasks:

- Studying blueprints, drawings and specifications to determine job, material and equipment requirements
- Select types of sheet metal, such as stainless steel, galvanized iron, mild steel, aluminum and copper, and checking sizes, gauges and other dimensions of metal stock against specifications
- Measure and mark dimensions and reference lines on metal sheets by using templates, gauges and other measuring instruments.

Page 10 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
----------------	--	--------------------------	----------------------------

- Drill holes in metal for screws, bolts, and rivets, along guidelines using hand and power shears, guillotines and drills.
- Shaping and forming cut metal stock into products using folding and bending machines, rollers, presses and hammers.
- Fasten and assembling seams or joints by welding, bolting, riveting, soldering, brazing and otherwise into final products.
- Finishing products by polishing, filing, sanding and cleaning assembled products

## **1.2. Quality assurance.**

### **1.2.1. Definition of quality**

Quality is the acceptable standard. Once standard has been selected, a method is chosen for ensuring that the product meet the specification. Check the quality without affecting the product. A good product properly developed may lead to saving of time and money.

### **1.2.2. Quality assurance**

Quality Assurance is defined as all the planned and systematic implemented within the quality system that can be demonstrated to provide confidence that a product or service will full-fill requirements for quality.

The Quality Assurance worker is charged with the responsibility for acquiring and analyzing data using appropriate statistical methods to facilitate process analysis and improvement. The Quality Assurance worker will develop standardized inspection methods for like process groups that will ensure critical characteristics are clarified and captured for statistical analysis.

### **1.2.3. Quality of Sheet Metal Working**

A metal plate of thickness less than 4 mm is considered as sheet. The size of the sheet is specified by its length, width and thickness in mm. In British system, the thickness of sheet is

Page 11 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
----------------	--	--------------------------	----------------------------

specified by a number called Standard Wire Gauge (SWG). The commonly used gauge numbers and the equivalent thickness in mm are given below.

SWG (No.)	16	17	18	19	20	22	24	27	30
Thickness (mm)	1.62	1.42	1.22	1.02	0.91	0.71	0.56	0.42	0.37

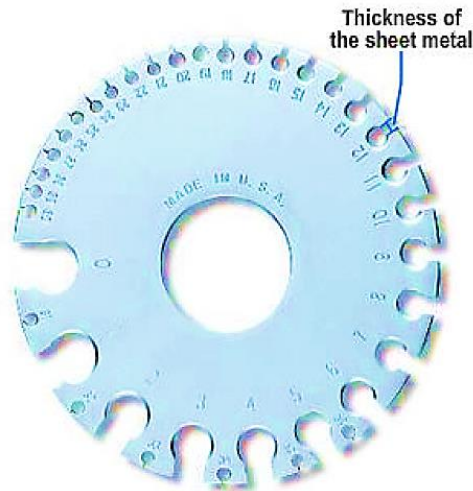
One of the most important decisions when working with sheet metal is deciding what thickness you will need. Sheet metal thickness is measured in gauges, with a higher number indicating a thinner sheet. To measure the thickness, you can use a sheet metal gauge, which will show you thickness in both gauge number. One important note is that ferrous and non-ferrous sheet metals of the same gauge have different thicknesses, so you'll need one gauge for ferrous metals, and one for non-ferrous.

Then the quality requirement for sheet metal work should depend on the thickness, accuracy of measurements, the accuracy of cutting, types of joints and the types of materials of sheet metals.

The thickness of sheet metal is in the USA commonly specified by a traditional, non-linear measure known as its gauge. The larger the gauge number, the thinner the metal.

Commonly used steel sheet metal ranges from 36 gauges to about 0 gauges. Gauge differs between ferrous (iron based) metals and a nonferrous metal such as aluminum or copper; copper thickness, for example are measured in ounces (and represents the thickness of 1 ounce of copper rolled out to an area of 1 square foot). In the rest of the world the sheet metal thickness is given in millimeters. Do not attempt to cut metal heavier than the designed capacity of the shears.

The maximum capacity of the machine is stamped on the manufacturer's specification plate on the front of the shears. Check the gauge of the metal against this size with a sheet metal gauge. This figure below shows the gauge used to measure the thickness of metal sheets. The gauge is a disc-shaped piece of metal, having slots of widths that correspond to the U.S. gauge numbers from 0 to 36 each gauge number is marked on the front and the corresponding decimal equivalent is marked on the back.



**Fig.1.2.** Sheet metal gauge.

### 1.3. OHS requirements

#### 1.3.1. OHS in cutting and joining sheet metal

Occupational Health and Safety require workers to assess, eliminate and control risks associated with plant. The Occupational Health and Safety require employers to assess employee and staff exposure to accident and to take measures to control that accident to minimize any risk to health and safety

Many injuries in the sheet metal fabrication industry a result of carelessness. Severe injuries can occur due to improper handling of tool or machines or other reasons. These injuries can be easily controlled by adopting various safety measures. To get the desired output, and for safe operation, you are required to follow some basic safety norms while using a sheet bending machine. Here are some of the major ones:

##### *A. Proper Use of Tools*

Every student should be skilled the proper use of a sheet metal fabrication tool. This is because improper use of these tools may lead to severe injuries. It should be ensured that the tool or the machine is in good working condition before an employee starts working with it. This can be easily done by launching a daily or regular inspection. Also, trainees must be instructed to avoid

Page 13 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
----------------	--	--------------------------	----------------------------

wearing accessories or clothing that may get caught in the machine. All necessary guards and safety features of the equipment should be used, while working with them.

### ***B. Hold the Sheet Parallel to the Bender***

Placement of the sheet is very important. For a safe operation, you should always hold the sheet at a proper angle. Before you start the bending process, always ensure that the sheet is parallel to the bender. The wrong placement may cause the sheet to hit your body, and cause injury.

### ***C. Mind your Hands***

You should be careful while operating the bender. When you place the sheet on the bender, you should ensure that your hands are away from getting hurt. Lack of attention can lead to severe accidents, or even permanent injuries.

## **1.3.2. Safety precautions**

Sheet metal work causes damage / accident. Sheet metal and plate metal worker should follow safety precautions required in terms of personal safety, work shop safety, and tools and equipment safety

Some of the safety precautions applicable to sheet metal tools and equipment have been mentioned throughout this module. Here are a few additional precautions that should be carefully observed when you are working with sheet metal.

- Sheet metal can cause serious cuts. Handle it with care. Wear steel-reinforced gloves whenever feasible.
- Treat every cut immediately, no matter how minor.
- Remove all burrs from the metal sheet before attempting to work on it further.
- Use a brush to clean the work area. NEVER brush metal with your hands.
- Use tools that are sharp.
- Keep your hands clear squaring shears

- A serious and painful foot injury will result if your foot is under the foot pedal of the squaring shears when a cut is made.
- Do not run your hands over the surface of sheet metal that has just been cut or drilled. Painful cuts can be received from the burrs.
- Get help when large pieces of sheet metal are being cut. Keep your helper well clear of the shears when you are making the cut.
- Keep your hands and fingers clear of the rotating parts on forming machines.
- Place scraps pieces of sheet metal in the scrap box.
- Always remember to keep a clean shop. Good housekeeping is the key to a safe shop.
- Do not use tools that are not in proper working condition: hammer heads loose on the handle, chisels with mushroomed heads, power tools with guards removed, and so forth.
- Wear goggles when in the shop.

### Self-check-1

**Directions:** Answer all the questions listed below.

1. To make a product of desired shape and size has to consider \_\_\_\_\_

Page 15 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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- A. Interpret work as needed
  - B. Make layout on sheet metals
  - C. Read the dimension accurately
2. The extremely thin thicknesses are considered \_\_\_\_\_ or \_\_\_\_\_.  
D. Sheet metal                      B. Foil or leaf                      C. Plates
  3. The quality requirement for sheet metal work should depend on:  
A. The thickness    B. Accuracy of measurements                      C. the accuracy of cutting  
D. Types of joints and the types of materials of sheet                      E. All are answer
  4. \_\_\_\_\_ require workers to assess, eliminate and control risks associated with in work area/plant.  
A. PPE              B.OHS              C. Measuring tools                      D. Using tools and equipment
  5. Which one is the safety norm while using a sheet bending machine and equipment in the work shop?  
A. Mind your Hands                      B. Proper Use of Tools  
C. Wear a Protective Equipment                      D. All

**Directions:** Answer all True or False questions listed below

1. Drawing has dimension that show the shape of the object to be produced.  
A. True                      B. False
2. Larger the gauge number, shows the thinner the sheet metal.  
A. True                      B. False
3. Many injuries in the sheet metal fabrication industry a result of carelessness.  
A. True                      B. False
4. When you are working with sheet metal don't wear goggles when in the shop  
A. True                      B. False



- **Operation sheet-1**
- **Lap Test-1**

Page 17 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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## Unit Two: Plan and prepare work

This unit to provide you the necessary information regarding the following content coverage and topics:

- Tasks sequence.
- Tools, equipment and materials,
- Preparing work area.
- Sealants, fixing and sheet metal materials for compatibility

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Plan and sequence tasks.
- Select and check tools, equipment and materials,
- Prepare work area.
- Check Sealants, fixing and sheet metal materials

## 2.1. Tasks sequence

### 2.1.1. Planning tasks

**Planning** means a set of preparation is to do in order to achieve something or any kind of task/work. Preparation means programs drawings, Materials requirement and their sources, time schedule, cost estimate, scheme and design and method of preparation etc.

- It is a management function of defining goal of an individual / organizations.
- It determines the task/work and resources necessary to achieve set goals.
- It helps to save materials, labor, time, money efforts and process etc. so that any kind of work/task can be performed successfully without having any difficulty with full confidence.

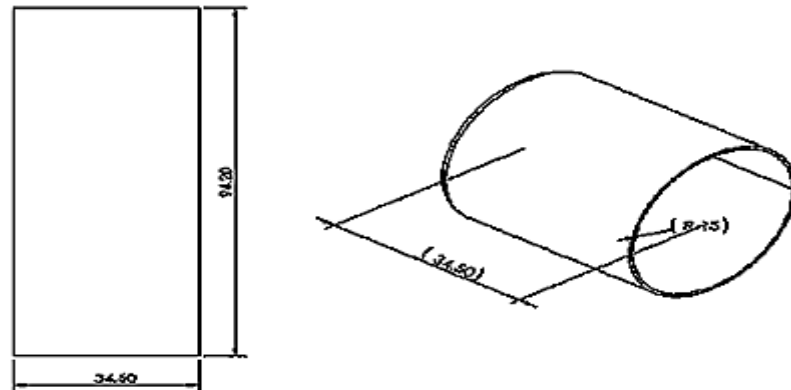
Job planning is important prior to starting any task. The drawing should first be studied and understood. The drawing can initially be used to calculate the material requirement for the component to be manufactured. The work piece is marked out using the dimensions and datums as specified on the drawing.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

One of the first steps in preparing to layout a pattern on metal is to square the bottom left-hand side of the piece of material. A steel square may be used for this purpose, or a sheet maybe squared using the squaring arm on the guillotine. The next step is to ensure that the sheet lies perfectly flat on the bench as a sheet that is not flat will cause measurements to be inaccurate.

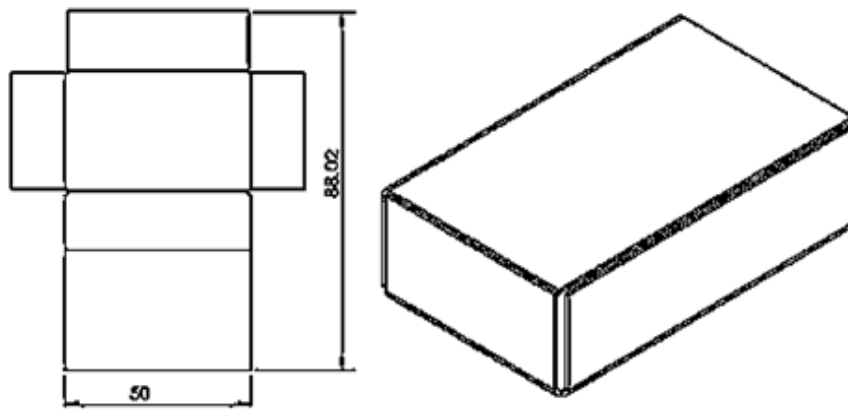
Sheet metal articles are made of flat pieces of metal cut according to outlines that are drawn or traced on the sheets of metal. To obtain the current size and shapes, patterns are used. These patterns may be drawn on paper first, and then transferred to the metal, or they may be laid out directly on the metal.

- Templates or master pattern- patterns that are used repeatedly and are made of metal.

- Stretch-out – the distance across the flat pattern or flat piece of metal before it is formed into shape. The illustration in Figure 1 shows the stretch-outs for square and cylindrical jobs.

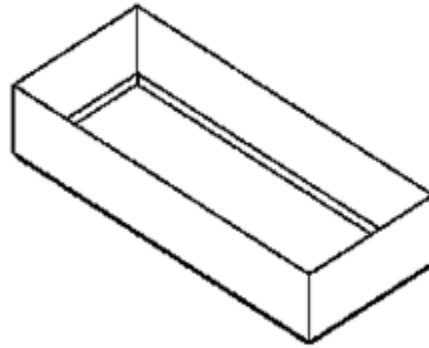


**Fig.2,1** Stretch out for cylinder



**Fig.2,2** Stretch out for box/ cube

Pictorial drawings – show the object as it actually appears after formed into shape. This is illustrated in Figure 3. Such a drawing cannot serve as means of giving accurate information for the fabrication of the project because the true shape and size of the object is not shown



**Fig 2.3,** Pictorial drawing show the type of objects as they appear after forming

### 2.1.2. Tasks sequence

Sheet metal workers first study plans and specifications to determine the kind and quantity of materials they will need. Then measure, cut, bend, shape, and fasten pieces of sheet metal to make ductwork, counter tops and other custom products. In an increasing number of shops, sheet metal workers use computerized metalworking equipment. This enables them to compare different layouts which use the least materials to minimize waste and to select the one that results in the least waste of material.

They cut or form parts with computer-controlled saws, lasers, shears, presses, and plasma cutters. In shops without computerized equipment, and for products that cannot be made on such equipment, sheet metal workers use hand calculators to make the required calculations and use tapes, rulers, and other measuring devices for layout work. They then cut or stamp the parts on machine tools.

Before starting to any operation, you must plan the sequence of your tasks. While you are planning you have to set the sequences of operation to be performed that are listed in the plan. During planning you have to consider factors that affect your working procedure.

- Plans, drawings and specifications are obtained from supervisor for planned work activity.
- Tasks are planned and sequenced in conjunction with others involved in or affected by the work.

Page 21 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
----------------	--	--------------------------	----------------------------

- Sheet metal is marked out according to plans and specifications.
- Work area is prepared to support efficient cutting and joining of sheet metal.
- Selected sheet metal is checked for compliance with plans and specifications
- Surface is prepared and cleaned of grease and other contaminants.
- Laps are measured and shaped for joining using appropriate tools and equipment according to plans and specifications.
- Work area is cleared and materials disposed of, reused or recycled according to legislation, regulations, and codes of practice and job specification.
- Information is accessed and documentation completed according to workplace requirements.
- Make a list of all of the tasks that you need to complete, and break everything down into single activities.

## 2.2. Tools, equipment and materials

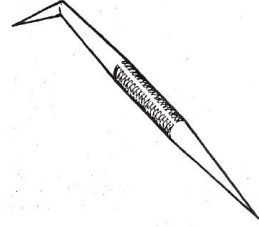
### 2.2.1. Sheet metal tools and equipment

Sheet metal hand tools are used to scribe or measure lines, perform layout operations and shape or cut metals. Some of the hand tools in the following notes actually perform these operations while others, such as stakes and punches, serve as aids in performing them. It is important to keep tools in good shape. Avoid tools going rusty by giving steel tools an occasional oiling. Tools with a sharp point should be stored carefully.

#### *A. Layout tool and measuring Tools*

Layout tools are used for drawing fabrication jobs on metal. Some of the more common layout tools are scribe, flat steel square, combination square, protractor, prick punch, dividers, trammel points, and circumference ruler.

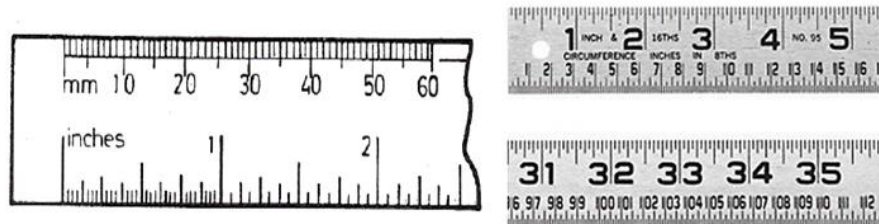
Page 22 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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**Fig. 2.4:** Scribe

### Steel Rule

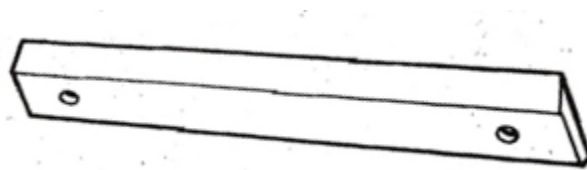
Steel rules are manufactured in a variety of types and lengths; each of which is designed for measuring or laying out different work. Available in lengths from 100mm to 1000mm.



**Fig.2.5:** Steel Rules

### Straight Edge

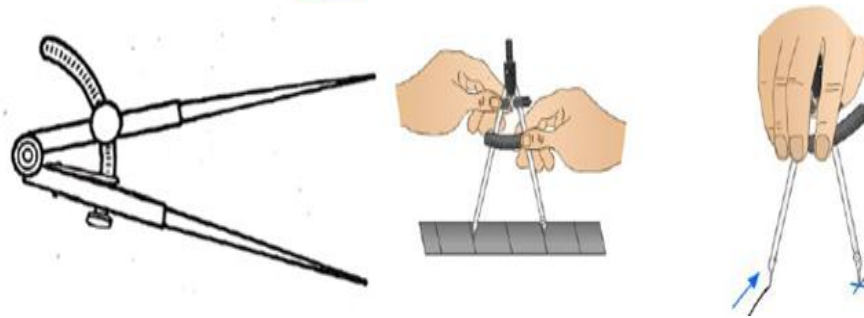
The Straight Edge is used as a guide for a scribe or pencil when marking or drawing a straight line between two points. It is also used in conjunction with square to draw lines at right angles.



**Fig.2.6:** Straight edge

### Dividers

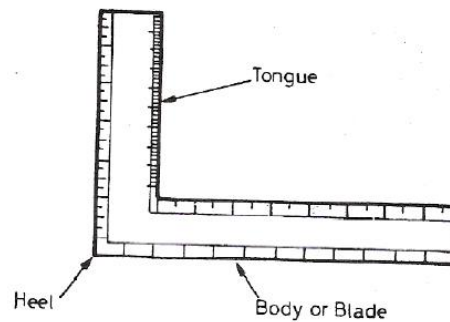
This is made with each straight leg tapered to a needle point. Dividers are manufactured in various sizes and types and are used to space off equal distances, to divide lines into equal parts and to scribe arcs and circles. Spring loaded screw dividers are also available. Supplied in lengths from 150mm to 500mm. Spring dividers are also available in sizes from 75mm to 300mm.



**Fig.2.7:** Divider and method of uses

### Steel Square

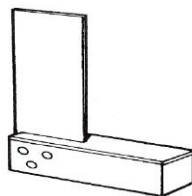
The flat Steel Square is used to layout right angles ( $90^\circ$ ) and can also be used as a scale. It is an invaluable tool for accurate layout work in pattern drafting since all layouts must start from a square corner. The long arm is known as the body or blade, the short arm is known as the heel or tongue. These squares come in various sizes.



**Fig.2.8:** Steel square

### Steel Try Square

It is used for marking and checking right angles ( $90^\circ$ ). These squares come in various sizes from 75mm to 300mm.

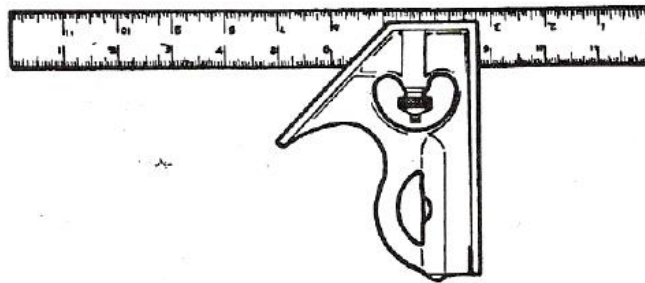


**Fig.2.9:** Steel Try Square



### Combination Square

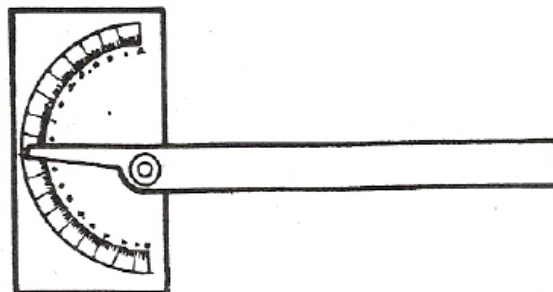
This is one of the most useful and convenient tools for laying out small work. It is used as a square for measuring or laying out  $90^\circ$  or  $45^\circ$  angles. A spirit level is mounted in the stock. It is available in 300mm lengths.



**Fig.2.10:** Combination square

### Protractor

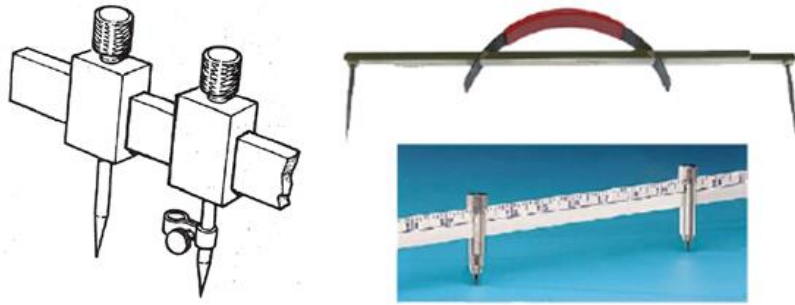
This is a device for measuring and laying out angles from the edge of the work. This protractor consists of a head and a movable blade. The head of the protractor has a semicircular scale graduated from zero to  $180^\circ$ .



**Fig.2.11:** Protractor

### Trammel Points (sometimes called a beam compass)

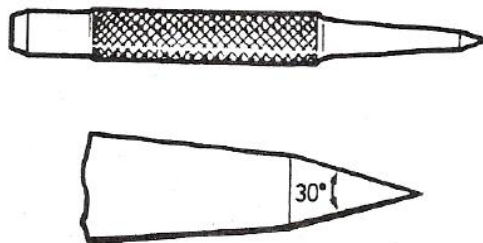
These are used for scribing large arcs and circles. They are manufactured in various types with two straight, removable legs tapered to needle points and attached to separated heads or holders. The heads or holders slide on wood or steel beams and are held in place by thumb screws. Either of the points can be removed and often one point has adjustment for fine settings. A special clamp for a pencil can be attached to one of the points.



**Fig.2.12:** Trammel Points

### **Prick Punches**

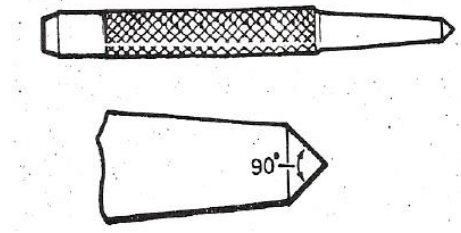
Prick Punches are made of tool steel and having a tapered point ground to approximately  $30^\circ$  included angle. These punches are used for making small dents or indentations and/or establishing points for dividers and trammel points.



**Fig.2.13:** Prick punch

### **Centre Punch**

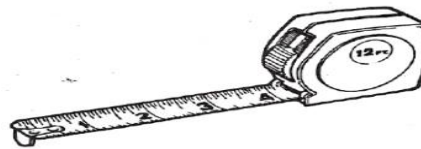
Similar in design to the prick punch except that the tapered point is ground to an angle of  $90^\circ$  included. They are used primarily for marking the location of points and the centers of holes to be drilled. Such punches are manufactured in various sizes and may be purchased in sets. Neither prick punches nor center punches should be used to punch holes. These are both intended for establishing points only.



**Fig. 2.14:** Center Punch

### **Tape Rule**

It is very popular for measuring and laying out large jobs. Available in various lengths,



**Fig.2.15:** Tape Rule

## **2.2.2. Cutting Tools and equipment**

### **Hand Snips**

Various types of hand snips and hand shears are used for cutting and notching sheet metal. All of the snips, shears, and nibblers are either manual or power operated. Hand snips are necessary because the shape, construction, location, and position of the work to be cut frequently prevent the use of machine-cutting tools.

Hand snips are divided into two groups. Those for straight cuts are straight snips, combination snips, bulldog snips, and compound lever shears. Those for circular cuts are circle, hawk's bill, aviation, and Trojan snips. These snips are shown in *Figure bellows*. The following is a brief description of each type of snip.

**Straight snips** have straight jaws for straight-line cutting. To ensure strength, they are not pointed. These snips are available for right- or left-hand use.

**Combination snips** have straight jaws for straight cutting, but the inner faces of the jaws are sloped for cutting curves as well as irregular shapes. These snips are available in the same sizes and capacities as straight snips.

**Bulldog snips** are a combination type. They have short cutting blades with long handles for leverage. The blades are inlaid with special alloy steel for cutting stainless steel.

**Compound lever shears** have levers designed to give additional leverage to ease the cutting of heavy material. The lower blade is bent to allow the shears to be inserted in a hole in the bench or bench plate. This will hold the shear in an upright position and make the cutting easier. The cutting blades are removable and can be replaced.

**Circle snips** have curved blades and are used for making circular cuts, as the name implies. They come in the same sizes and capacities as straight snips and either right- or left-hand types are available.

**Hawk's bill snips** are used to cut a small radius inside and outside a circle. The narrow, curved blades are beveled to allow sharp turns without buckling the sheet metal. These snips are useful for cutting holes in pipe, in furnace hoods, and in close quarters work.

**Aviation snips** have compound levers, enabling them to cut with less effort. These snips have hardened blades that enable them to cut hard material. They are also useful for cutting circles, squares, compound curves, and intricate designs in sheet metal. Aviation snips come in three types: right hand, left hand, and straight. On right-hand snips, the blade is on the left and they cut to the left. Left-hand snips are the opposite. They are usually color-coded in keeping with industry standards-green cuts right, red cuts left, yellow cuts straight. Both snips can be used with the right hand.

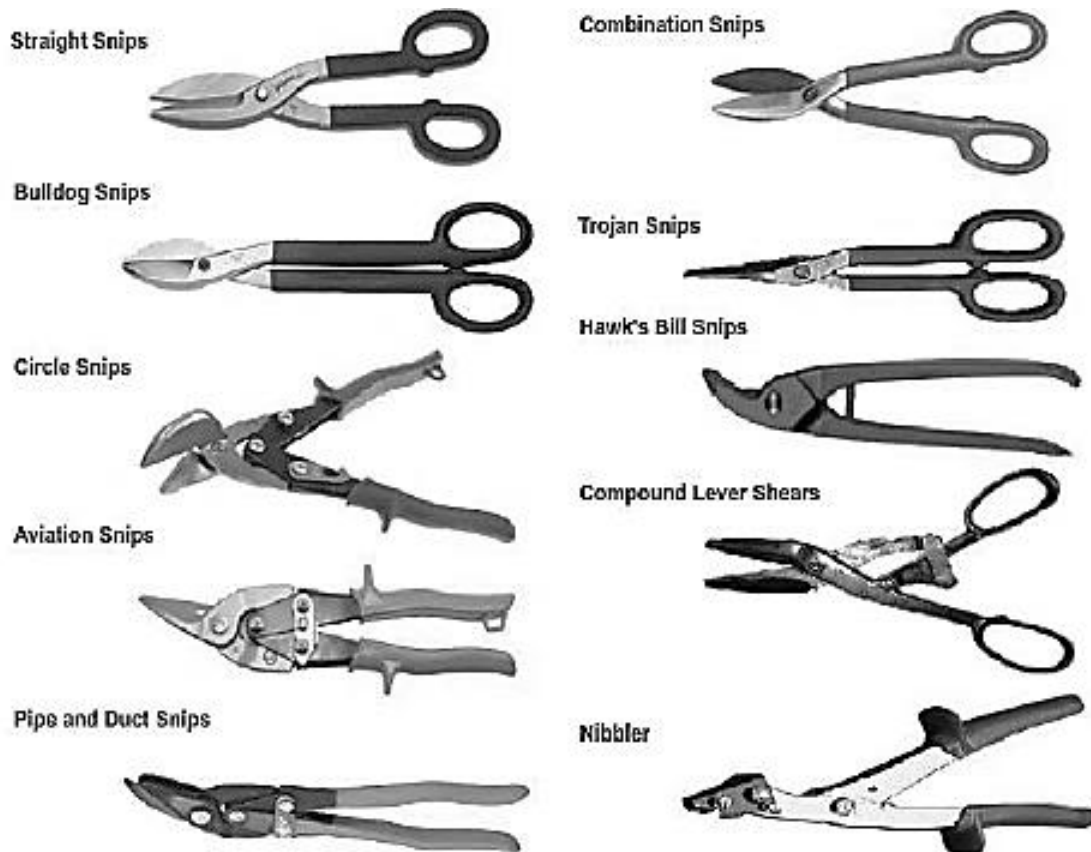
**Trojan snips** are slim-bladed snips that are used for straight or curved cutting. The blades are small enough to allow sharp turning cuts without buckling the metal. These snips can be used to cut outside curves and can also be used in place of circle snips, hawk's bill snips, or aviation snips when cutting inside curves. The blades are forged high-grade steel.

**Pipe & Duct snips** (Double Cut) have a straight cut blade pattern. This style of aviation snip cuts a narrow section equal to the width of the center blade as it cuts. The material on either side of

the cut tends to stay flat, as only the narrow section takes a curl as it is cut. This style can be used in stovepipe and downspout work where distortion on either side of the cut is not desirable.

**Nibbler** is for cutting sheet metal with minimal distortion. One type operates much like a punch and die, with a blade that moves in a linear fashion against a fixed die, removing small bits of metal and leaving a kerf approximately 6 mm wide.

Another type operates similar to tin snips, but shears the sheet along two parallel tracks 3–6 mm apart, rolling up the waste in a tight spiral as it cuts. Nibblers may be manual (hand operated) or powered.

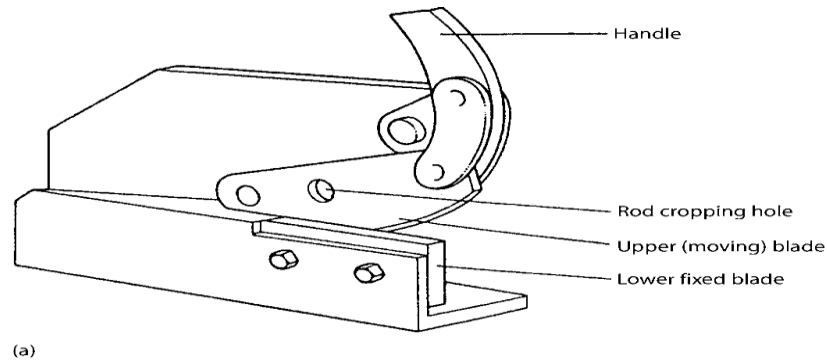


**Fig.2.16:** Types of hand snips

### **Bench shear**

Page 29 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022

Bench shear and hand shears have blades that rotate about a pivot and it is this pivoting action that creates the shear angle. For more information observe this video: <https://www.youtube.com/watch?v=izInJffsnpQ>



**Fig. 2.17:** Bench shear

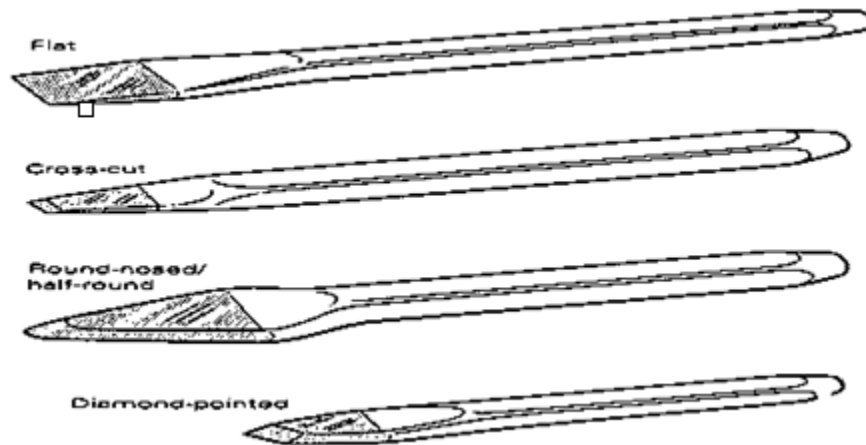
### Chisels

They are generally used in sheet metal work for cutting sheets, rivets, bolts and chipping operations. A good number of cold chisels are used.

The flat chisel and round nose chisel are most widely used in sheet metal work.

The various types of chisels are used for cutting metal.

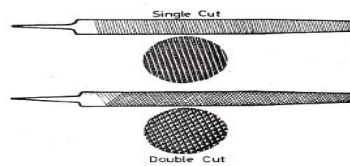
- **Flat cold Chisel.** Sheet metal workers generally use this chisel more than the other types since it is used for cutting sheet metal, rivets, bolts, and in chipping operations.
- **Cape Chisel.** Cape chisels are used for cutting grooves and keyways.
- **Diamond Point Chisel.** These chisels are used for cutting V shaped grooves, for chipping corners, and sometimes for removing bolts whose heads have broken off.
- **Round Nose Chisel.** Round nose chisels are used for roughing out the concave surfaces of corners and also for cutting grooves.



**Fig.2.18:** Types of Chisels

### Files

There are many shapes and sizes of files available with various grades of cut. Files are used to remove burrs from sheets of metal, to straighten uneven edges and for various other operations that require a small amount of metal to be removed. They should always be used with a handle. Common types used by the industrial insulator are: flat, square, round, half-round.

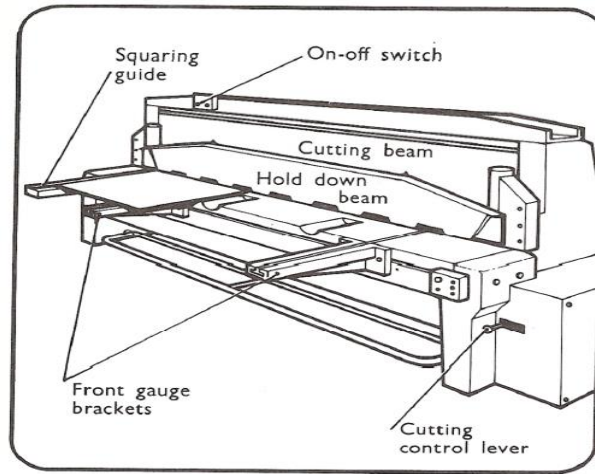


**Fig.2.19:** Single cut and Double cut files

### Guillotine machine

The principle of shearing is similar to punching except that the area being sheared is a relatively small continuous section, starting at one end of the sheet and ending at the other. A hold-down clamping stop holds the sheet rigid while the blade of the guillotine shears through the sheet. For more see: <https://www.youtube.com/watch?v=kF-EULAbKZQ>





**Fig.2.20: Guillotine**

An important factor in the production of a good cut edge is the clearance between the blades as well as the sharpness of the blade edges. Some machines have provision for altering the blade clearance to suit the thickness of sheet being cut out; usually the clearance is set at manufacture and checked periodically. A reasonable guide is 0.1 mm increase in clearance for every 1 mm of sheet thickness. The shearing capacity of the guillotine should be more than the shearing strength of the material being cut.

### **Compound lever shears**

Compound lever shears; view have levers designed that give additional to ease the cutting of heavy material. The lower blade is bent to allow the shears to be inserted in a hole in the bench or bench plate. View has levers designed that give additional leverage to ease the cutting of heavy material. The lower blade is bent to allow the shears to be inserted in a hole in the bench or bench plate.

- portable power shear
- Actuated squaring shears
- Ring and circular shear



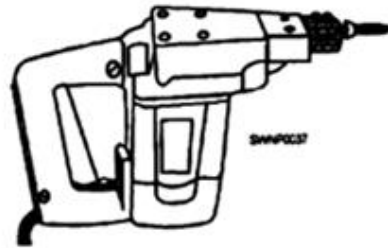


Figure 2-20.—Portable power shears



fig.2.21: Solid punch.

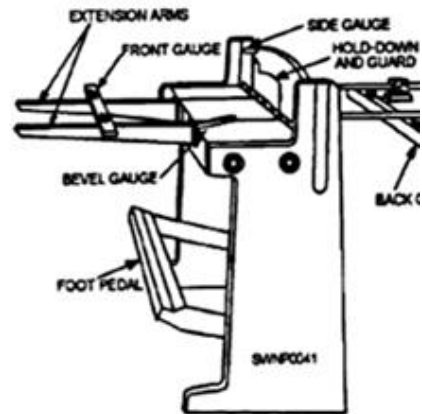


fig.2.22: Foot-actuated squaring shear

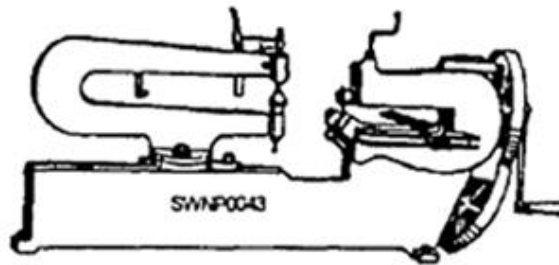


fig.2.23: Ring and circular shears

### Side Cutting Pliers

These pliers have flat jaws grooved to hold the work, and are sharpened to cut light wire.

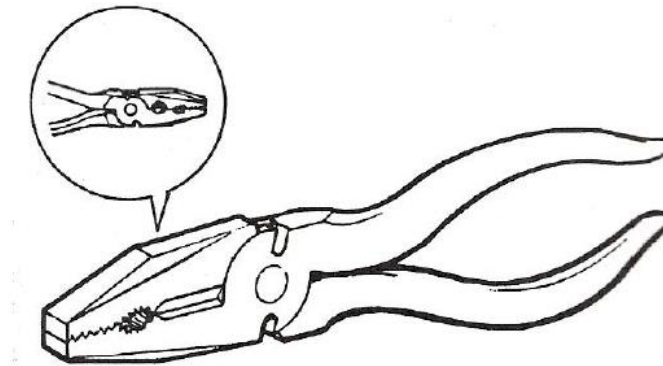


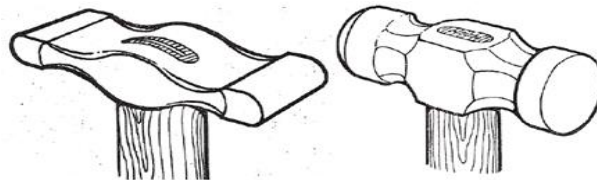
Fig.2.24: Side Cutting Pliers

### 2.2.3. Bending and forming tools and equipment

#### Hammers and Mallets

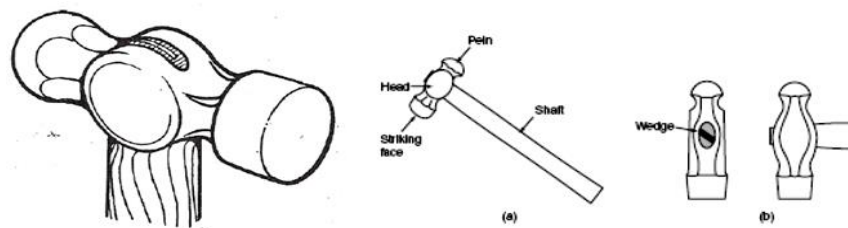
There are various types and sizes of hammer use in metal working.

- **Stretching Hammer:** - This is used for stretching edges and flanges on curved work. It is normally used in conjunction with a stake.
- **Planishing Hammer:** - The principal purpose of the Planishing Hammer is for smoothing and finalizing a surface after it has been roughed out to the required shape.



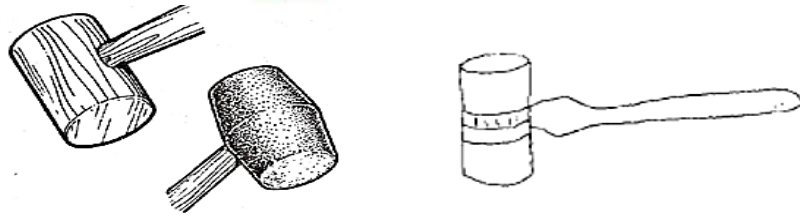
**Fig.2.25:** Stretching Hammer and Planishing Hammer

- **Engineers Ball Pein hammers:** - This is used for striking chisels, punches, rivets etc. The ball peen or machinist's hammer has a round, slightly curved face and round head. It is a general purpose hammer for general engineering use.



**Fig.2.26:** Ball Pain hammers

- **Boxwood and Rubber Mallets:** - It is Plastic-headed hammer of round or rectangular cross section. The striking face is made flat to the work. A mallet is used to give light blows to the Sheet metal in bending and finishing. Mallets are properly used where steel hammers would deface the work. These mallets can be used on mild steel, copper or aluminum to prevent marring the metal.

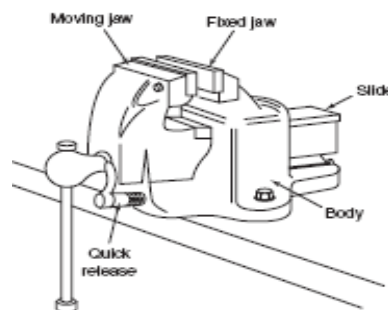


**Fig.2.27:** Boxwood and Rubber/plastic mallet

Sheet metal is given three-dimensional shape and rigidity by bending. Sheet metal can be formed by hand or with various special tools and machines. Several techniques are described in the following sections.

### **Bench vice**

The most commonly used vice is parallel jaw vice. It is often fitted with a quick-release device that frees the screw from the nut so that the vice can be opened and closed quickly when changing between components of different widths in order to save time.



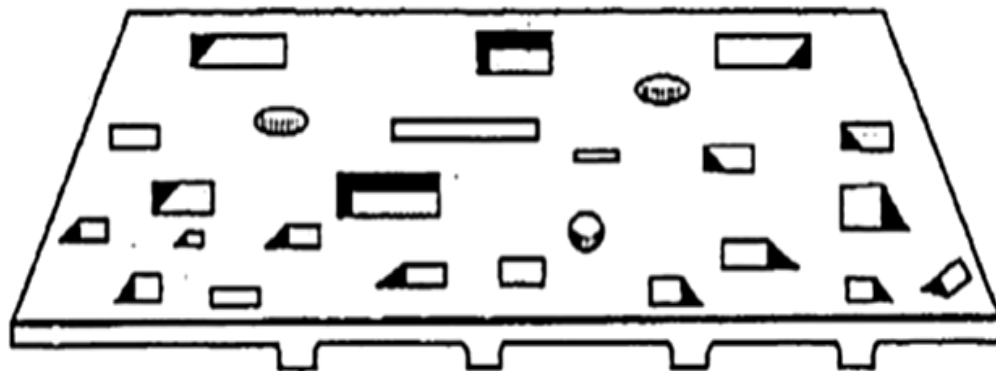
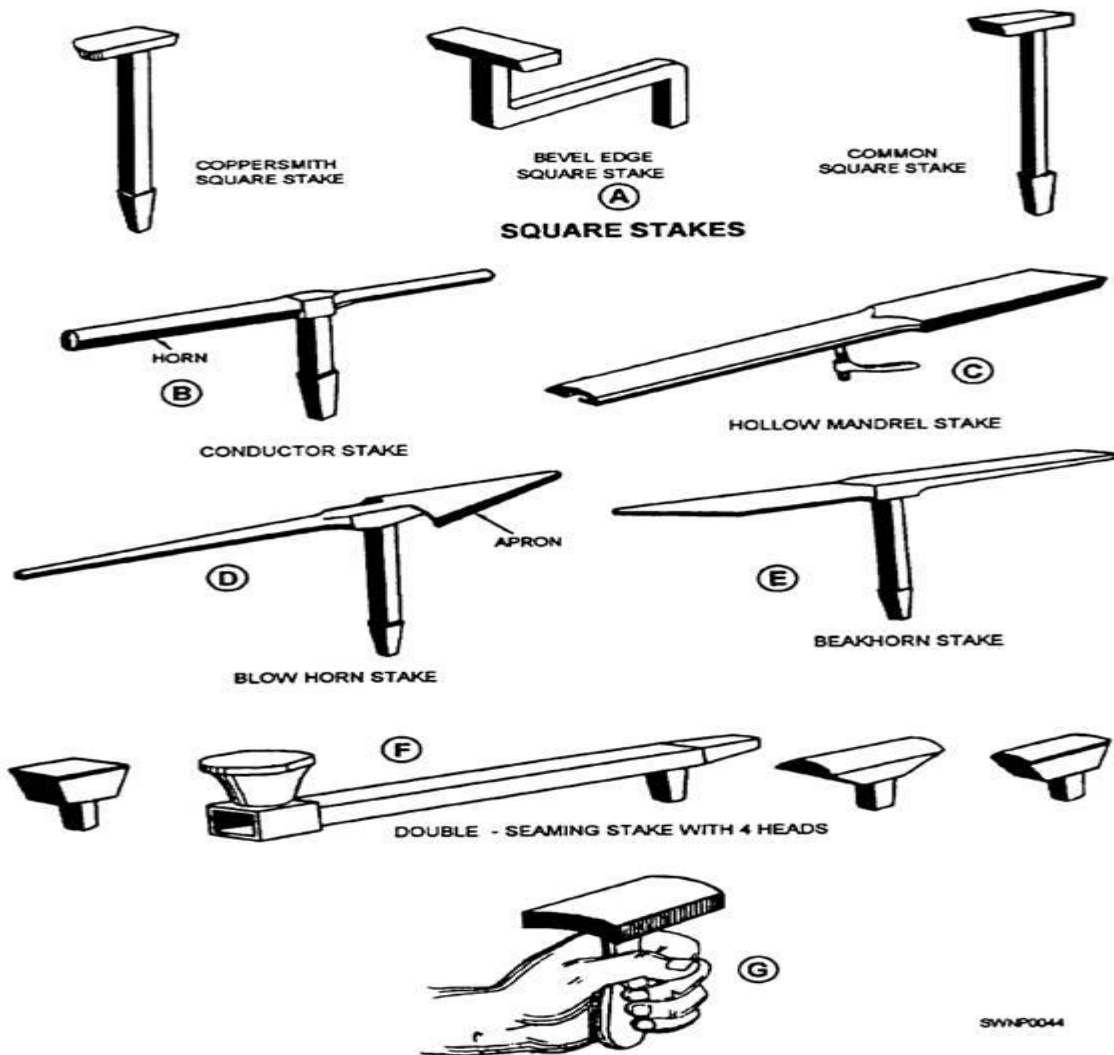
**Fig.2.28:** Bench Vice

### **Bench stakes**

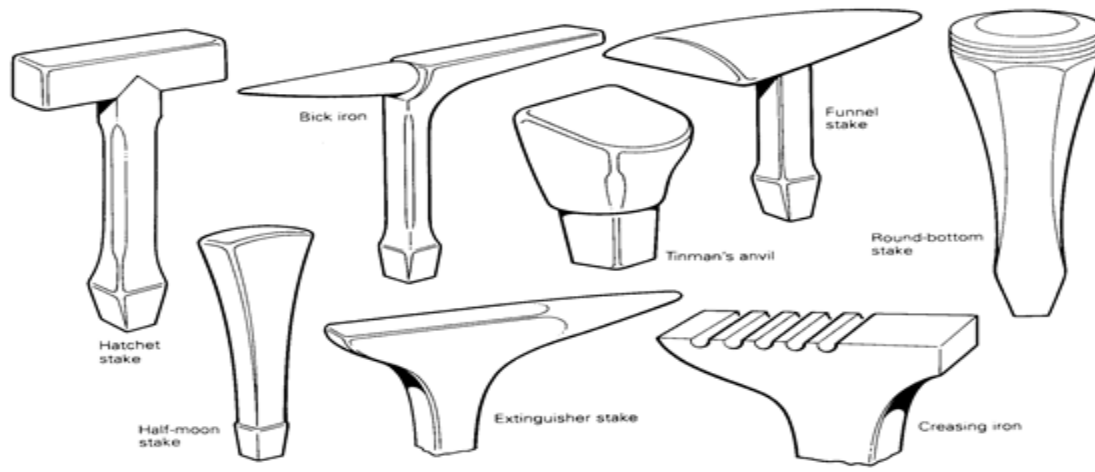
Stakes are the sheet metal workers evils used for bending, seaming or forming, using a hammer or mallet. They actually work as supporting tools as well as forming tools. They also help in bending operation. They are made in different shape and sizes to suit the requirements of the work

- **Mandrel:** - This stake is a single horizontal metal bar. One end has a flat surface and the other end is rounded. The flat length has a slot cut in it which permits the stake to be fastened directly to the bench. This stake is used for forming, seaming or riveting. These stakes are available in various lengths and weights.

- **Hatchet Stake:** -The Hatchet Stake is a sharp, straight stake with a hardened and beveled edge. It is used for making straight sharp bends, folding, bending edges and is used as a support when flanging
- **Tinman's Anvil:** -The Tinman's Anvil has a flat, square shaped head with a short shank and is used for general working operations
- **Pipe Stake:** -The Pipe Stake consists of one or two cylindrical horns having different diameters. This stake is used for forming pipes and cylindrical work pieces. The stake with the two horns is called a Double Ended Pipe Stake.
- **Funnel Stake:** -The Funnel Stake has a thick tapered head and is used in forming, riveting and seaming tapered articles such as funnels.
- **Blowhorn Stake:** -The Blowhorn Stake has a short, tapered horn at one end and a long-tapered horn at the other. It is used in forming, riveting and seaming abrupt and slender tapering objects.
- **Half-Moon Stake:** -The Half-Moon Stake consists of a single vertical shank with a half-rounded head on top. The stake is used for forming or shaping curved flanges.
- **Bick Iron Stake:** -The Bick Iron Stake has a square tapering, flat horn on one side and a round tapered horn on the other side. It serves as a general-purpose anvil for riveting and shaping round and flat surfaces, straight bending and corner seams.
- **Creasing Stake:** -This stake is available in two patterns. One has a double rectangular shaped horn and contains a number of grooved slots for creasing metal and bending wire; the other pattern has a round and tapered horn at one end and a rectangular shaped horn on the other and is used for forming, riveting or seaming small tapering objects.
- **Drip Pan Stakes:** -This is used for finishing off knocked-up joints on small trays and boxes. They are also used for general work in the sheet metal shop.
- **Round Bottom Stakes:** -The Round Bottom Stake consists of a single vertical piece with a flat round head on top. It is used for flanging circular and curved work.
- **Ball Head Stack** This is used in the process of raising and planishing a hollow article.



*Stake Holder.*

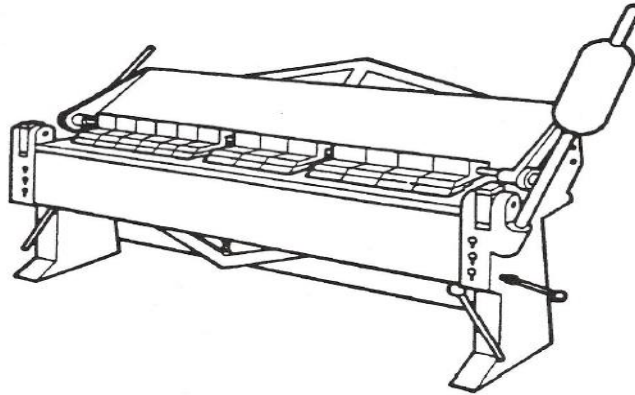


**Fig.2.29: Bench stakes and stake holder**

### **Sheet metal Folding Machine**

This type of machine, while suitable for all types of bending operations, has special provision for folding pans, trays or boxes. No rods, wires or metal beyond the capacity of the machine should be bent on this machine.

- The most important points when using this machine is to set the machine to suit the metal thickness being folded.
- Never bend beyond the capacity of the machine. This strains the machine and will shorten the life-span and quality of the folders.
- Never bend round bar etc. in the machine.
- When removing or inserting the fingers (of machine) take care not to get your own hand or fingers squashed.



**Fig.2.30:** Folding Machine

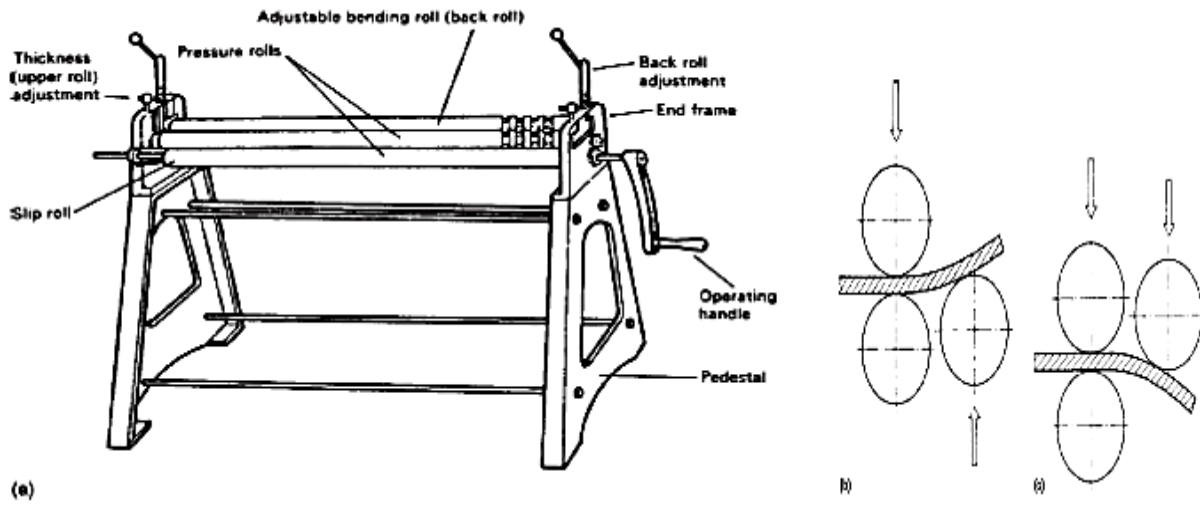
### **Hazards:**

- Beware of swinging counter-balance weights and bottom leaf (bed) of machine.
- Use the proper manual handling techniques when using this machine or moving metal in or out of benders. This machine can put great strain on your back.
- Refer to module 1-unit 2-manual handling.
- Beware of crushing of fingers when using machine and especially when changing the blades.

### **The Bending Rolls**

The two types of bending rolls used in sheet metal are the plain bending and slip bending rolls. These machines are for curving sheet metal. On the slip bending rolls the upper roll can be released and this facilitates the removal of the work piece. This can't be done on plain rolls. There are power and manually operated types available.





**Fig.2.31: Bending Rolls**

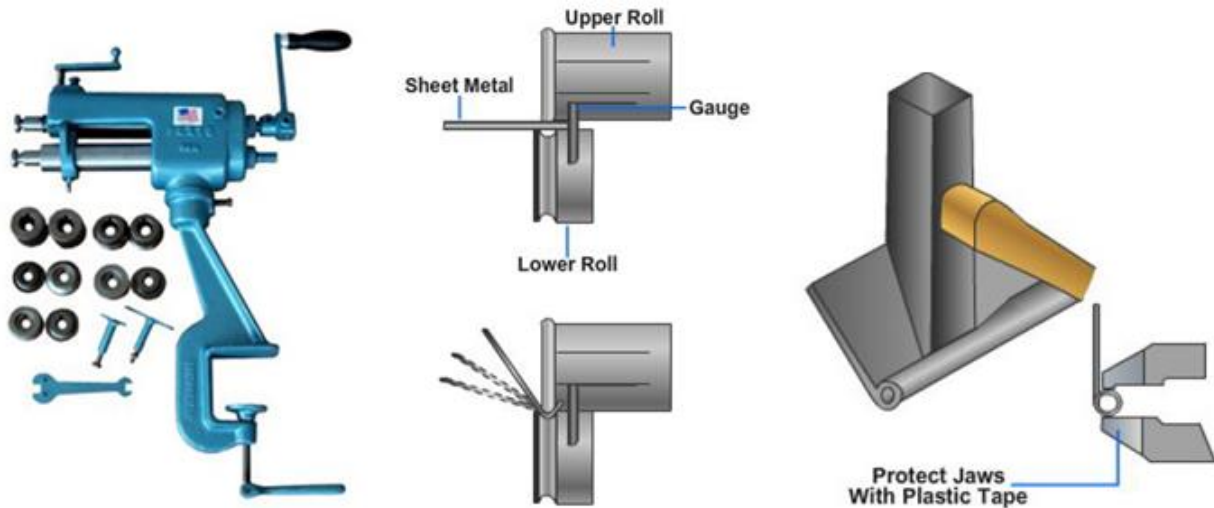
**Hazards:**

- Loose clothing e.g., cuffs may get caught up in machine. Always wear tight fitting overall.
- Exercise caution as fingers may also get caught in the machine.

**Combination Rotary Machine**

Preparing sheet metal for a wired edge, turning a burr, beading, and crimping are probably the most difficult of sheet metal forming operations to perform. Combination rotary machine with a selection of rolls will prove acceptable for most shop uses. The wire edge must be applied to tapered shapes after they are formed. This is accomplished by turning the edge on the rotary machine. Gradually, lower the upper roll until the groove is large enough for the wire. The edge is pressed around the wire with the rotary machine. The wire edge can be finished by hand if a rotary machine is not available. The edge is formed on the bar folder and forced into place around the wire with a setting hammer or pliers.





**Fig.2.32:** Combination Rotary Machine

### Lubricating Machines

It is vitally important to lubricate all machines on a regular basis. A lubricant is used for a number of different reasons:

- To reduce friction.
- To prevent wear.
- To prevent adhesion.
- To aid in distributing the load.
- To cool moving parts.
- To prevent corrosion.

The range of materials used as lubricants has greatly broadened over the years so that in addition to oils and greases many plastics and solids and even gases are now being applied in this role. Because of the wide selection of lubricating materials available, great care is advisable in choosing the right material and the correct method of application. Always refer to the manufacturer's manuals regarding the type of lubricant to use, the correct method of application and the frequency of application.

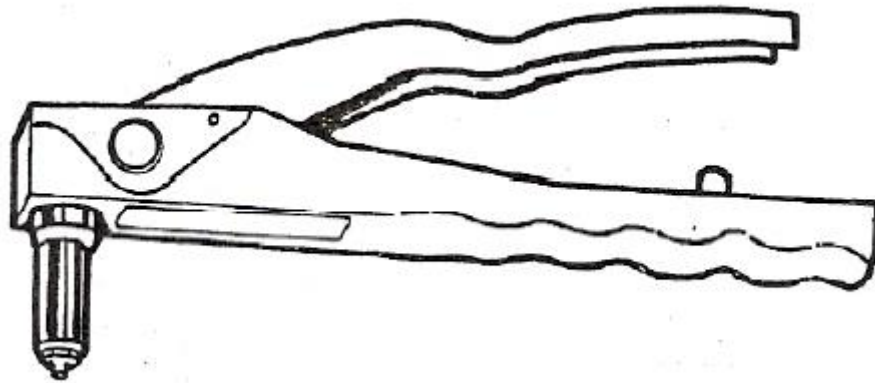
### Pop Riveting Guns

Page 41 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022

“Pop” Riveting Guns are used extensively with “pop” rivets for the assembly of light fabrications and are particularly useful for the assembly of metal cladding where access is restricted to one side of the work only. There are three different types available: hand “pop” gun, lazy tongs and pneumatic (air).

### Hand “Pop” Gun

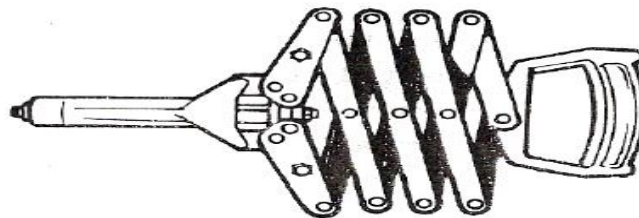
Riveting in confined spaces requires the use of a hand “pop” gun. These are unsuitable for larger dimensions of rivets, due to the reduced amount of leverage available.



**Fig.2.33:** Hand “Pop” Rivet Gun

### Lazy Tongs

Lazy Tongs are used for the larger diameters of rivets, where sufficient working space is available to permit operation of the tool. The construction of the tool permits a moderate pressure on the handle to provide a strong pulling force on the rivet mandrel.



**Fig.2.34:** Lazy Tongs

#### 2.2.4. Type of sheet metal Materials

There are many types of sheet metal. If an alloy can be stretched out into a sheet, that is all it takes to be sheet metal. Sheet metal is categorized by their alloy, thickness, and then further categorized by its hardness, method of manufacturing, tensile strength, and quality. With all these different variables, the types are endless. There are many varieties of sheet metal types, but here are the most common:

##### Steels Sheet

Steel is the most commonly used material in the sheet metal shop. This is because it is relatively cheap and is available in alloys and with special coatings for various uses. The most commonly used types of sheet steels are **mild steel, galvanized and stainless**.

Mild steel comes in two forms: hot-rolled commonly known as black iron, and cold-rolled commonly referred to as mild steel. Black iron is a cheaper variety and tends to be softer than mild steel. Any sheet metal can be obtained in 2000 x 1000 mm sheets and also available in roll form.

##### Galvanized Sheet Metal

It is a sheet steel coated with zinc. In the most common one, the steel is dipped in an acid both for cleaning and then is dipped into the zinc. Galvanized sheets are identified by their even grey color and are mainly used for their ability to resist corrosion.

Zinc is highly resistant to corrosion and, as long as it remains intact on the sheet, galvanized mild steel will have high corrosion resistance.

##### Stainless Steel

Stainless steel is one of the most important materials within industry. As the name indicates, stainless steel has high resistance to foreign or corrosive elements. It is also very easily cleaned. For these reasons, it is widely used in residential kitchens, institutional and restaurant kitchens, for hoods, sinks, splash backs etc. It is also widely used in the dairy industry for milk storage tanks and containers. It is also used for metal cladding where appearance and fire resistance are very important.

Page 43 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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### **Copper**

This is a solid sheet easily recognized by its reddish color. The great advantage of copper is its high resistance to corrosion. Copper sheet is very expensive. The greatest use of copper today is in architectural sheet metal work. It is used extensively for high quality roofing, gutter, downpipes, roof flashings and hoods. Copper sheeting is available in both hot and cold rolled.

### **Aluminum**

The main properties of aluminum are its light weight, corrosion resistance and appearance. Sheet aluminum weighs approximately one-third as much as sheet steel and is just as strong. Pure aluminum is too soft to hold a permanent shape in sheet form so the sheets are manufactured as an alloy.

### **Lead**

In sheet form it has a number of uses, shower pans, flashings, tanks for highly corrosive materials and radiation shields are some of the major applications. The chemical and physical characteristics of lead sheet make it very useful for industry. For example, it is durable and has high resistance to corrosion from most acids and from exposure to air. It is very soft and easy to work. Lead is therefore commonly used on roof flashings on both corrugated and tiled roofs where it can be adapted by hand to contours of the roof.

### **Zinc**

Sheet zinc is highly resistant to corrosion and is used in some instances where galvanized steel cannot provide adequate resistance. Compared to other metals, zinc is rather brittle so care must be taken while bending it. Zinc sheets are usually ordered by specifying decimal parts of an inch for thickness.

### **Tin**

Steel sheets are coated with pure tin and have bright silvery appearance. This is used for nearly all solder work as it is easiest metal to join by soldering. The thicknesses of the tin plates are denoted by special marks not by gauge numbers. It is used for making buckets, pans, cans, etc.

Page 44 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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### 2.2.5. Personal Protective equipment (PPE) used for sheet metal work

It is very important to select the correct PPE. Just as important, the PPE must be working correctly every time you use it, either alone or in combination with other PPE. When several pieces of PPE are used together, they must not interfere with each other. For example, protective goggles must not interfere with the operation of a respirator.

Sheet metal worker fabricate in the sheet metal workshop a number of operations such as cutting, folding/ bending, edging, making seams, forming, crimping, beading and swaging.

So that it must have to safe from hazards. Sheet metal workers are recommended to wear protective clothing, such as gloves, goggles and hard hats, at all times while working in the steel making environment.

Goggles are particularly important, because debris and small metal shards can be emitted from the machinery, and hit the unprotected worker, which can possibly cause blindness. Safety goggles when grinding and drilling. Safety shoes and clothes/ overall at all time; gloves when needed; also ear protection etc.



**Fig.2.12:** Leather Gloves



**Fig.2.35:** Safety Google



**Fig.2.36:** Safety clothes, shoes, hardhat

## 2.3. Preparing work area.

In the work area safety precaution should be observed i.e., safety equipment, protective equipment and others should be observed. Each person should pay attention to own work area. A neat work area reflects a worker's approach to his work and equipment. Good housekeeping begins with planning ahead. Materials should be neatly stacked and any spillages of oil or grease should be cleaned up immediately.

Safe work practices can reduce the numbers of injuries on the job while lowering liability-related costs. Before instituting a safety program, evaluate current procedures and protocols to determine which are effective and which need improvement. It's important to take the time to plan a comprehensive program that thoroughly addresses current and potential safety risks.

The first step in preparing a safe work practices plan involves completing a safety hazard assessment. Visit every department and note dangers such as machinery without safety guards, employees working without eye protection or piles of supplies blocking walkways. Observe the way employees perform their jobs to determine if they follow safety protocols or perform actions that put them at risk of injury. The U.S. Department of Labor suggests asking for employee input during the assessment and encouraging staff to identify safety issues and provide possible solutions.

## 2.4. Sealants, fixing and sheet metal materials

### 2.4.1. Sealant

Page 46 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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is a type of mechanical seal that is widely used in domestic and industrial applications in order to fill up unwanted gaps and openings that may cause the seepage of water, gases or any particulate matter? Mating of two or more parts together results in gaps, which adversely affect the integrity and the performance of the object. Sealants are effectively used to fill up gaps between the surfaces and close off any spaces that may occur. However, sealants are not an alternative to adhesives while some sealants do have adhesive properties.

### 2.4.2. Types of sealants

Currently, there are more than forty types of sealants available in the market, out of these the most common industrially used sealants are as follows:

#### a. Silicone

Silicone sealants are one of the most commonly used sealants. Silicone sealants exist in either neutral cure or acetoxy. The production of silicone sealants involves an extensive polymerization and hydrolysis process of siloxanes and silanes. Both the neutral and acetoxy silicone sealants cure at the room temperature and are compatible with a variety of materials. Acetoxy silicone sealants are cheaper than its counterpart and offers quicker cure time. Neutral cure silicon sealants have a slower cure time and a bit more expensive to produce as compared to acetoxy. Silicone sealants have a life expectancy to around 10-20 years after application.

#### b. Epoxy

Epoxy sealants are usually supplied in two-pack configurations consisting of a resin and a hardener. They are mixed together in pre-set ratio for the epoxy to perform its joint sealing. Epoxy sealants are well known for their high strengths, exceptional cure toughness and the ability to resist the environmental or chemical damage to the sealing. Epoxy sealants are one of the few sealants that also hold great strength to act as an adhesive. Epoxy sealants cure at room temperature whereas; in some case they might be required to be cured thermally.

#### c. Phenolic Sealant

Page 47 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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Phenolic sealants are types of resins that provide effective bonding and have a good endurance rating against high temperature. Phenolic sealant is the only sealant that is available in powder, liquid and film form. The phenolic sealant is usually composed of phenol and formaldehyde chemicals.

#### **d. Acrylic sealant**

Acrylic sealants are processed from acrylic acid (hence acrylic sealant) via catalytic reaction. Acrylic sealants are highly resistant to degradation caused by environment. Acrylic sealants however, are prone to chemical damage. Acrylic sealant is curable via many different ways however, if thermally cured; the curing time is lowered significantly. Acrylic sealants have a high holding power and avoid any infiltration by foreign particles.

#### **e. Polymers**

The group of polymers that makes up this category of sealant includes polyesters, polyamide, polysulfide and vinyl. The polymers form a permanent flexible seal at the joint and use the moisture in the air to cure. Polymer sealants are ideal to be applied on joints that encounter repetitive movements or are subjected to a varying temperature. One of the drawbacks to polymer sealant is that it requires the most curing time as compared to the rest of the sealants. Therefore, polymer sealants once applied to a joint are kept untouched for a long duration of time.

### **2.4.3. Material compatibility of sealant**

To decide which sealant to use of all the available sealants, it must be made sure before application that whether the joining material is compatible or not. Having a sealant being applied on an incompatible material may result in the degradation of the material and failure to seal off the joint.

- **Porous surfaces:** porous surfaces have the best compatibility with sealants having a high viscosity or gel like texture. Silicone, polymers and epoxies are the best-suited sealants for porous materials.
- **Concrete:** Concrete is the constructing material that is used for construction of buildings, walls and other structures. Polymer sealants are usually used to seal concrete joints.



- **Metal:** Metal joints are usually sealed together using silicone and polymer based sealants. Silicone is highly compatible with iron, aluminum, steel and iron compounds.
- **Ceramics:** Ceramics are the oxides and nitrides that are non-metal and have a high melting and boiling point. Ceramics can be sealed off using epoxy, silicone and acrylic sealants.
- **Textiles:** Textiles are most compatible with silicone-based sealants.
- **Plastics:** Plastics are the organic, process or synthetic materials obtained from
- **polymer.** Silicone and polymer acts as the most suitable sealants

#### 2.4.4. Fixing materials

Fasteners join two thin materials together and must be purpose-designed for the application. These are generally either self –drilling stitcher screws with bonded sealing washers and integral laps, blind sealed rivet. Uses of fixing material on the building like, doors, windows, wall sheet metal part and roofs to prevent water, dust and air linking. Different types of fixing materials are explained below:

- **Rivets**

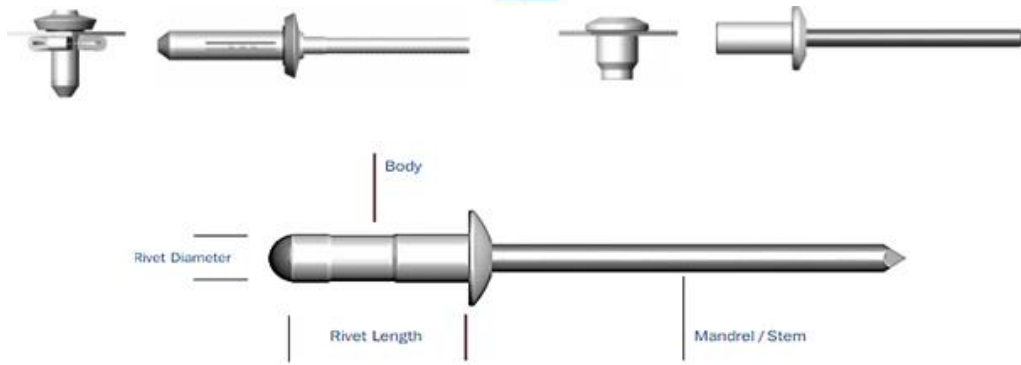
Rivets are used to make permanent joints in metal, to join metal to soft materials and for joining soft materials to each other.

##### **Solid rivets**

**Snap or round head rivets** are used for general purposes where a flush finish is not important and countersinking would weaken the job.

**Countersunk head rivets** are used for general purposes where a flush surface is needed. They are the most commonly used type.

**Flat head rivets** are used for joining thin plates which cannot be countersunk.

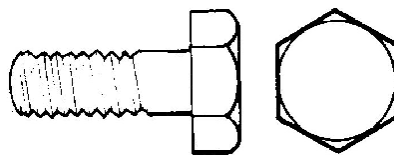


**Fig.2.37.:** Rivets

- **Nuts, bolts and machine screws**

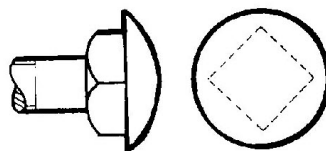
All these fixings are usually made of steel or brass and can be coated either to rustproof the steel or to improve their appearance.

**Bolts** usually have either a square or a hexagonal head. They are ordered by the diameter of the thread and the length to the underside of the head. Bolts may be threaded for all or part of their length.



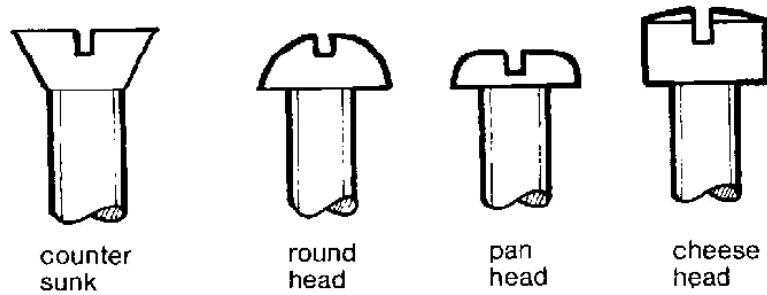
**Fig.2.38.:** Bolts

**Coach bolts** are used to join wood to wood or wood to other materials. They have a domed head with a square collar underneath which is pressed into the wood to prevent the bolt turning. They are usually used for strong structural woodwork.



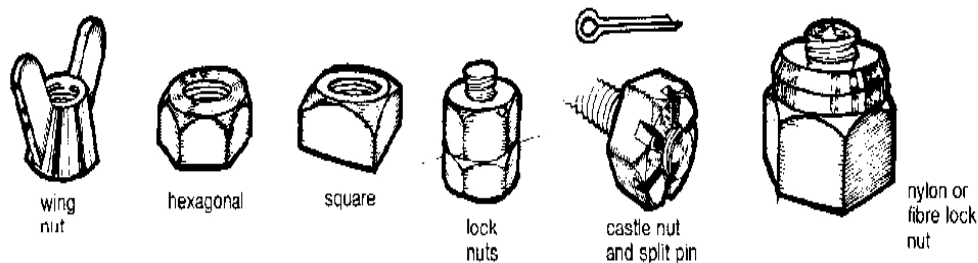
**Fig.2.39.:** Coach bolts

**Machine screws** are available in a wide range of thread diameters, lengths and head shapes.



**Fig.2.40:** Machine screws

**Nuts** are either Plain Square, plain hexagonal, wing nuts for easy removal, or special locking nuts to prevent vibration loosening them.



**Fig. 2.41.:** different types of nuts

**Washers** are used to protect the surface when the nut is tightened, to spread the load or to prevent vibration loosening the joint.



**Fig.2.42:** Washers

**Self-tapping screws** are used to join thin sheets of metal and plastics and as chipboard screws where ordinary woodscrews would cause the chipboard to crumble. They are made of hardened steel so that they can cut their own thread as they are screwed in. Common sizes are 6 mm to 50 mm with Phillips, Posidrive and straight slots. Drill a tapping size hole equal to the core diameter of the screw.



## Screw Joint / Fasteners



**Fig,2.43 Self-tapping screws**

## Self-Check -1

**Directions:** Answer all the questions listed below. Choose the best answer.

1. \_\_\_\_\_ is important prior to starting any task.  
A. Job panning                      B. patterns      C. A&B
2. To make sheet metal work or project the first things you do is  
A. Read and understanding of drawing      B. Prepare Sequence of operation
3. Which one of the following sheet metal marking / layout tools?  
A. chisel                      B. snip                      C. Scriber
4. From the given choose which one is cutting tool and equipment.  
A. Aviation snip      B. Chisel      C. Arm leaver shear      D. guillotine      E. All
5. One of the following is forming tool and equipment.  
A. Hand Grover      B. Different profiles of stakes      C. Crimping and beading      E. All

**Directions: - Answer true or false for the following questions**

1. Safety precaution in the work area should not be observed  
A True      B. False
2. Good housekeeping is one of handling method in work area  
A, True                      B. False
- 3. Self-tapping screws** are used to join thin sheets of metal and plastics  
A, True                      B. False
- 4.** It is not very important to select the correct PPE  
A, True                      B. False
- 5.** The flat Steel Square is used to layout right angles (90°) and can also be used as a scale  
A , True                      B. False

## Operation Sheet 1

- **Operation title:** - Methods of preparing workplace for cutting and joining sheet metal
- **Purpose:** - To applying work place preparation
- **Instruction:** - Follow the stapes & prepare work place properly
- **Tools & equipment's**
  1. Cleaning materials
  2. Cutting tools
  3. Joining tools & materials
- **Procedure of work:** -

Step 1- Do not block exits

Step 2- Change burned-out light fixtures in work areas, walkways, and exits

Step 3- Keep floors and work areas clean, dry, and grease-free

Step 4- Keep steps and ladders in serviceable condition

Step 5- Keep emergency equipment clean and unobstructed

Step 6- Ensure that all signs and caution labels are in good condition and visible

- **Quality Criteria- Safe work place**
- **Precautions:** - use & apply safety pre questions

## LAP Test

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Time started: \_\_\_\_\_ Time finished: \_\_\_\_\_

**Instructions:** Given necessary templates, tools and materials you are required to perform the following tasks within 2:00-2:30 hours.

**Task 1:** Select PPE, Tools and Equipment used for sheet metal work

**Task 2:** prepare workplace for cutting and joining sheet metal

Page 54 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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### Unit three: Develop patterns as required

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Pattern development methods
- Allowances for fabrication and assembly

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

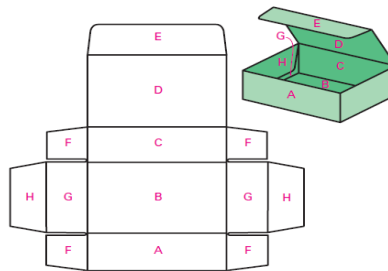
- Apply parallel line, radial line and triangulation development methods
- Determine and transfer allowances for fabrication and assembly

### 3.1. Pattern development methods

Making patterns or pattern developments is an important part of industrial drafting. Many different industries use them. Familiar items such as pipes, ducts for hot- or cold air systems, parts of buildings, aircraft, automobiles, storage tanks, cabinets, boxes and cartons, frozen food packages, and countless other items are designed using pattern developments. To make such items, a drafter must first draw them as a pattern or pattern development.

A pattern development, also called a stretch out or simply a development, is a full-size layout of an object made on a single flat plane. A development that is not full size is not a pattern; it is simply a drawing or representation of the pattern. Therefore, outlines for very large objects drawn at a reduced scale are not pattern developments.

The pattern is the original part of the pattern development from which flat patterns can then be cut from flat sheets of material that are folded, rolled, or otherwise formed into the required shape (see Figure 3.1). Materials used include paper; wood; fiberboard; fabrics; various cardboards, plastics, and films; metals such as steel, tin copper, brass, and aluminum; and so on.



**Figure -3.1** Pattern for a one-piece package with fold-down tabs

#### 3.1.1. Types of Developments

The type of development needed for an individual object depends on the object's shape. The three basic types are parallel-line development, radial-line development, and triangulation.

- **The parallel line**

Page 56 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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method of pattern development is based on a system of lines drawn parallel to one another on the surface of a sheet metal article and is used to develop items such as elbows, segmental bends, Tee-pieces or valve boxes for example. In general, it is used to develop square, rectangular and cylindrical shapes (prisms). An example of parallel development can be seen below.

**Example: Step 1** Draw the required views which are the top view and side view. These two views provide the five pieces of information required to layout the pattern.

### **Pattern development of rectangular prism**

While learning about this pattern development, you will once again follow the six basic steps you learnt in both the previous

**Step 2** Not only is there a need to identify each of the four corners in this example, but also the change of shape (C3 and F6) located mid-way along the long side of the rectangular prism which can only be seen in the side view. The seam or join is positioned at the corner A–1.

**Step 3** Calculate the perimeter of this rectangle prism.  $\text{Perimeter} = (\text{length} + \text{width}) \times 2$

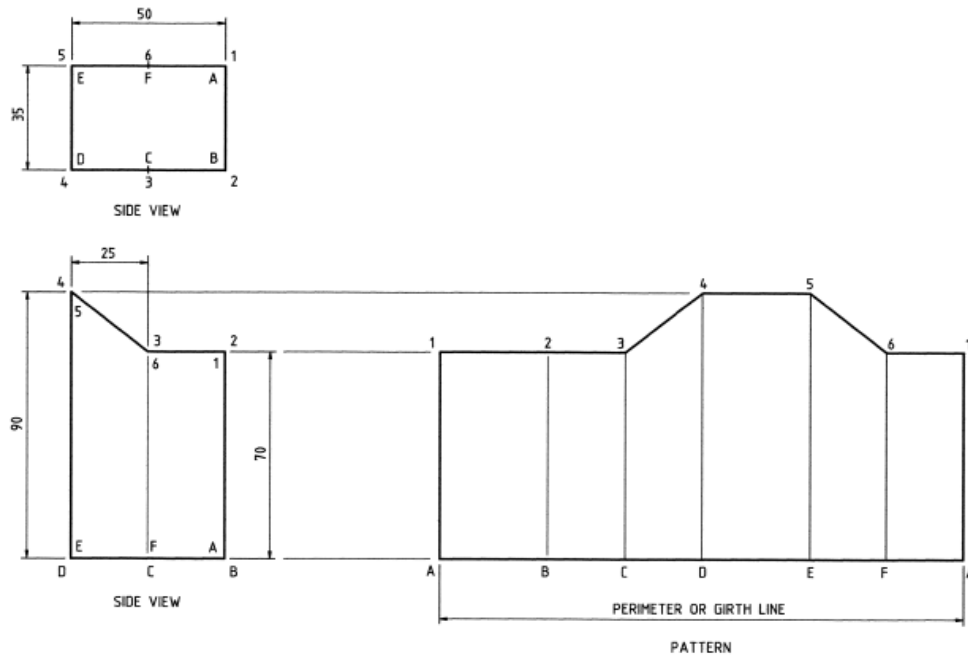
**Step 4** Commence the pattern by drawing its girth line which as you can see has been drawn to the right and on the same horizontal plane as the base line of the side view.

**Step 5** Mark off the six top view measurements, AB, BC, CD, DE, EF and FA along the girth line of the development, as illustrated.

**Step 6** Construct the seven parallel lines from and perpendicular to the girth line. Each of these seven lines being A1, B2, C3, D4, E5, F6, and A1 a second time. To easily obtain the correct heights for these lines, project two horizontal construction lines from the side view; one from position 1–6 and the other from 4–5.

Note: Each of the seven vertical and parallel lines can be transferred from the side view to the pattern with a compass.

To finalize the pattern simply join each of the points 1–2, 2–3, 3–4, 4–5, 5–6 and 6–1 with an outline. Also outline the other three sides – A1, A1 and the girth line.



**Figure 3.2.** Parallel Line Development

### Radial-Line Development

The edges on cones and pyramids are not parallel. Therefore, the stretch out line is not a continuous straight line. Also, instead of being parallel to each other, measuring lines radiate from a single point.

This type of development is called radial-line development

Imagine the curved surface of a cone as being made up of an infinite number of triangles, each running the height of the cone. To understand the development of the pattern, imagine rolling out each of these triangles, one after another, on a plane (flat surface). The resulting pattern would look like a sector of a circle. Its radius would be equal to an element of the cone, that is, a line from the cone's tip to the rim of its base. Its arc would be the length of the rim of the cone's base.

### Terminology

The terminology used in radial line development can be listed under the following four headings:

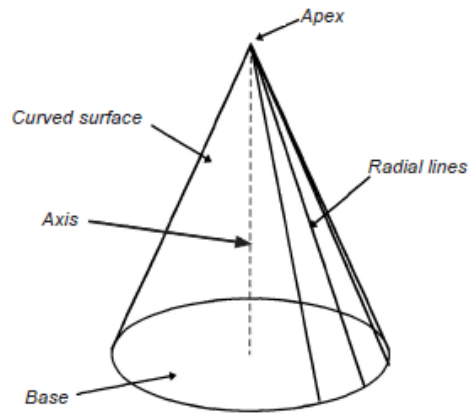
Page 58 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022

➤ **Shapes:** -Cone, pattern, right cone

➤ **Points:** -Apex

➤ **Lines**

- axis
- centerline
- radial lines
- base circle
- arc



**Fig,3.3.** Right cone

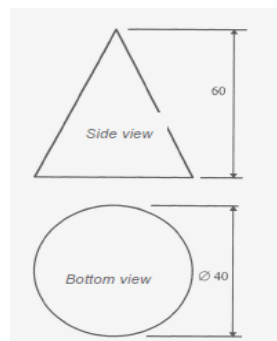
➤ **Surface:** - curved surface

### Pattern development

The following logical sequence of events is presented, to assist you to learn to develop patterns for right cones using the radial line pattern development technique

**Step 1** Draw the required views; for example – the side view and the top or bottom view.

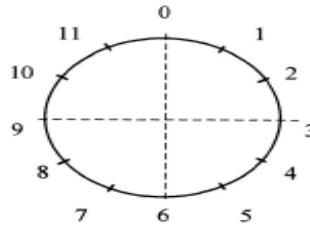
With these two views drawn the radial line pattern development for a right cone can be commenced.



**Fig,3.4.** side view

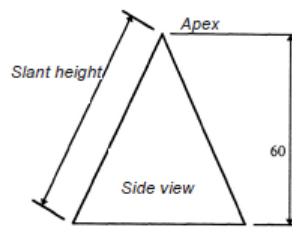
**Step 2** Divide the circumference of the top/bottom view into 12 equal divisions.

Page 59 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022



**Fig 3.5.**top/bottom view

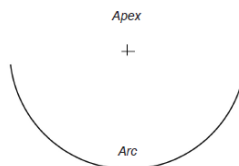
**Step 3** Set your compass to the slant height of the side view; apex to base.



**Fig 3.6.** side view; apex

**Step 4** Commence the pattern by scribing an arc, which has a radius equal to the slant height of the side view.

Slant height = pattern radius



**Fig.3.7.** scribing an arc

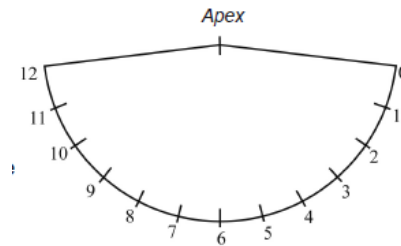
**Step 5** Set your compass to 1/12th of the cone's base circumference.

The dimension can either be copied from one of the bottom view divisions or it can be calculated.

$$\begin{aligned}
 1/12^{\text{th}} \text{ of circumference} &= \pi \times \text{diameter} \\
 &= \pi (3.142 \times 40) \div 12 \\
 &= 126 \text{ mm} \div 12 \\
 &= 10.5 \text{ mm}
 \end{aligned}$$

**Step 6** The pattern is completed by stepping off  $\frac{1}{12}$ th of the base diameter of the cone (10.5 mm) twelve times along the arc of the pattern, to reproduce the cone's base circumference.

Outline the three sides of the pattern apex to 0, apex to 12 and the arc 0 to 12. Slant height



**Fig.3.8.** base diameter of the cone

#### Example: **Pattern development of right cone**

While learning about this pattern development, you will once again follow the six basic steps you learnt earlier in the introduction to radial line development.

**Step 1** Draw the required views, which once again you will note are the top or bottom view and side view. These two views provide the two pieces of information required to layout the pattern for this right cone.

- The vertical height, which is 95 mm.
- The slant height which is used as the radius to commence the pattern layout.
- The diameter of the base of the cone, which is 90 mm.

**Step 2** Divide the circumference of the bottom view into 12 divisions, as illustrated in the drawing 2B. The lines drawn from each of these points on the circumference to the apex, represent those drawn from the cone's base to the apex in the side view.

**Step 3** Set your compass to the slant height of the side view; apex to base.

**Step 4** With your compass set at this measurement, scribe an arc to commence the pattern layout.

**Step 5** Set your compass to  $\frac{1}{12}$ th of the cone's base circumference, eg 0 to 1 of the bottom view.

Page 61 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1
			August, 2022

A more accurate method of obtaining 1/12th of the circumference of the cone's base is to calculate it.

$$1/12\text{th of circumference} \times \text{diameter} = \pi \ 3.142 \times 90 \div 12 \ 282.75 \div 12 \ 23.56 \text{ mm}$$

$$1/12\text{th of circumference} = \pi \times \text{diameter}$$

$$= 3.142 \times 90 \div 12$$

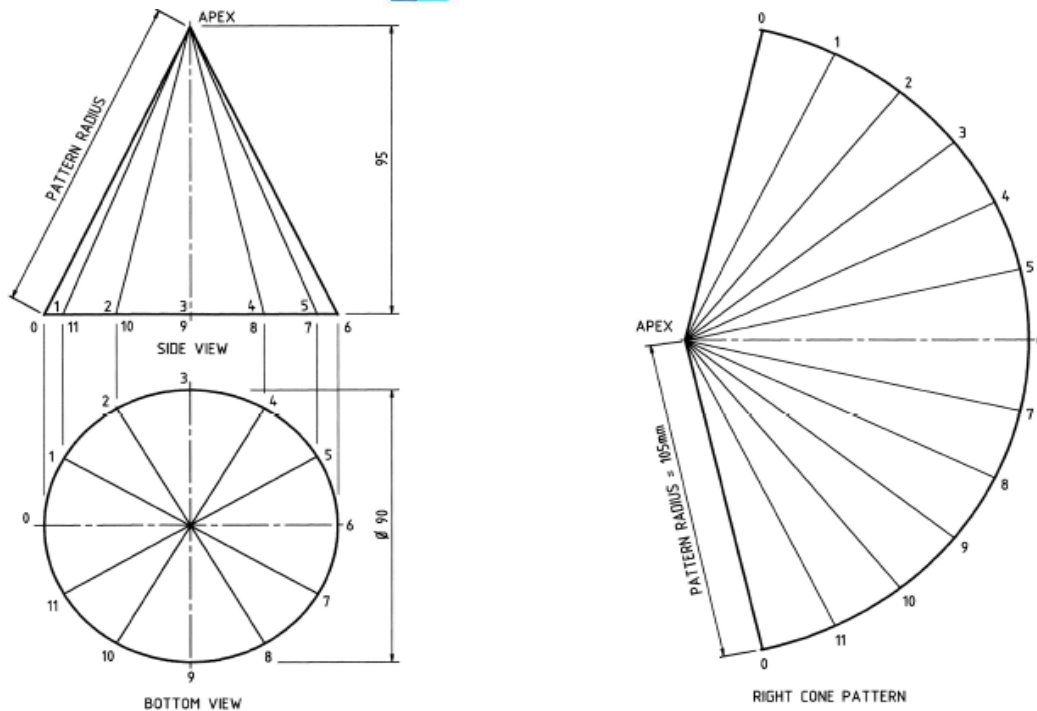
$$= 282.75 \div 12$$

$$= 23.56 \text{ mm}$$

**Step 6** With your compass set at this measurement, step it off 12 times along the arc of the pattern layout, so as to transfer the cone's base circumference to the pattern layout.

Finalize the pattern by outlining the two seam lines 0 to apex and apex to 0, and outline the portion of the arc required.

Note, each of the points 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 on the arc of the pattern can be joined to the apex with a light construction line if you wish. These lines will assist you when rolling the cone into shape, but are of no other practical use to the pattern.



**Figure 3.9.** Development of right cone

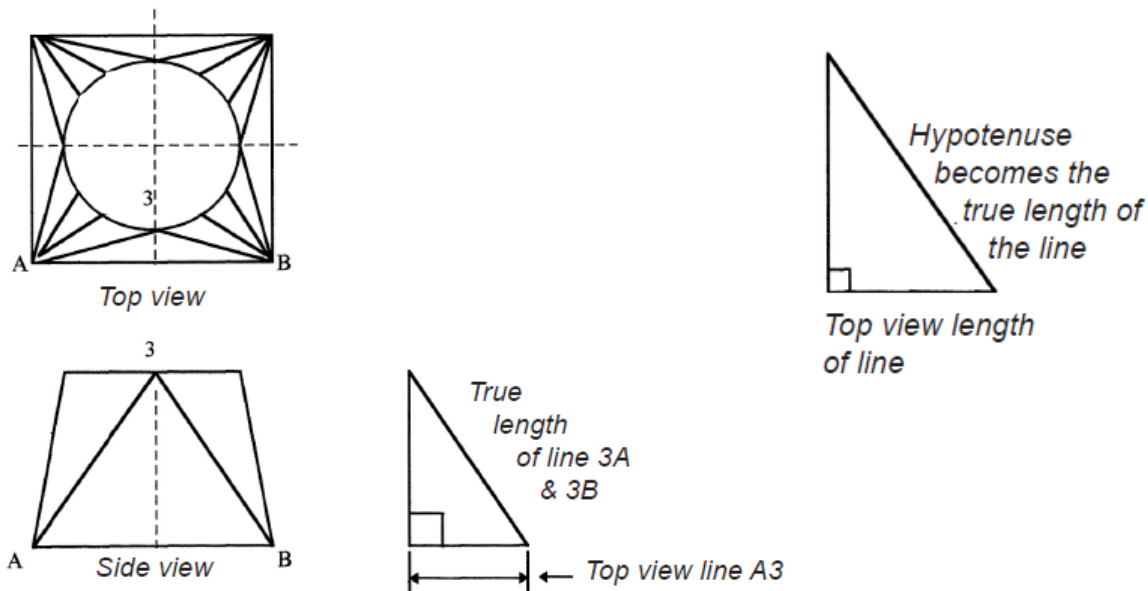
### Triangulation

Triangulation is the name given to a pattern development method to develop the shapes, or more correctly the surfaces of shapes, which do not consist of either parallel or radial line elements. However, it must be made clear that all surface shapes can be developed using this triangulation method.

In this method the surface of the object to be developed is divided into a number of triangles, with each triangle (as a true shape and size) being placed next to each other to produce the pattern for the given object.

**The golden rule of triangulation states:**

The true length of a line is obtained by placing the top view (or bottom view) length of a line at right angles to its vertical height.



**Fig 3.10.** True length

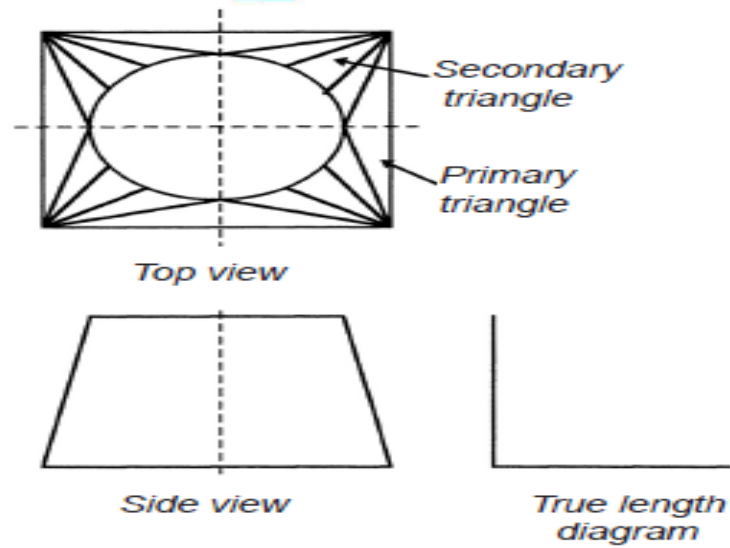
In the above example the top view line A3 has been placed at right angles to its vertical height, so as to obtain its true length which can be used in the pattern development of this square to round

**Terminology:** The terminology used in triangulation can be listed under the following headings.

### Shapes

- top view
- side view
- true length diagram
- transition
- square to round
- rectangle to round
- primary triangle
- secondary triangle
- pattern.





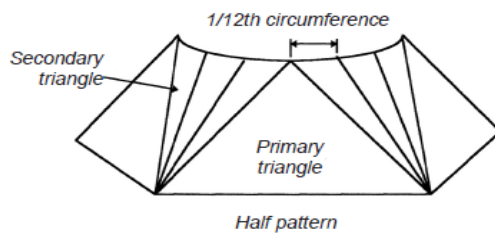
**Fig 3.11.** triangulation

### Line

- centerline
- triangular (generator) lines
- top view line
- side view vertical height line
- circumference
- half circumference
- 1/12th circumference

### Surface

- flat surface
- curved surface.



**Fig.3.12** curved surface

A half pattern is often produced in preference to a whole pattern, because two halves are easier to shape and form when compared to a whole pattern. The two halves are joined by an appropriate method to produce the final component.

### **Triangulation pattern development steps**

The following sequence of events is presented as a logical approach to pattern development while using the triangulation development method. Such a sequence of events will not only ensure an accurate pattern, but also an effective and efficient use of all resources, including time.

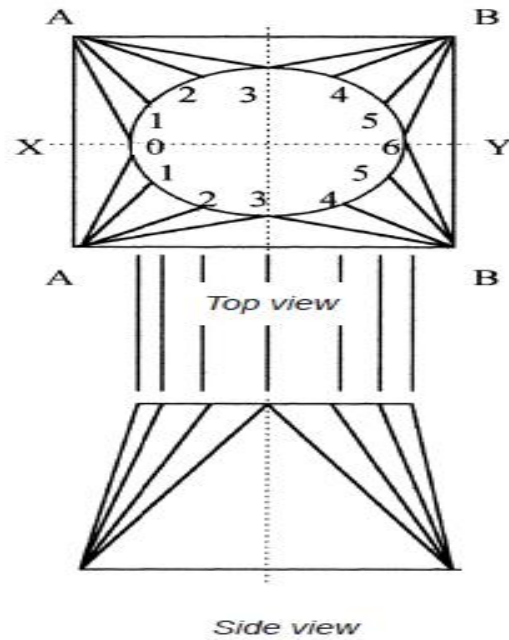
**Step 1** Draw the required views; for example – top and side view. Pattern development by triangulation cannot be commenced until these two views are drawn. Fig 1 illustrates the two views required for the development of a concentric square to round transition.

These two views provide all of the information required to develop the pattern for this square to round transition.

For example, all of the following dimensions are true length and can therefore be transferred directly to the pattern development:

- the sides of the square are all true length
- the dimensions AX and BY are also true length
- each of the 1/12th divisions of the circle's circumference is a true length.

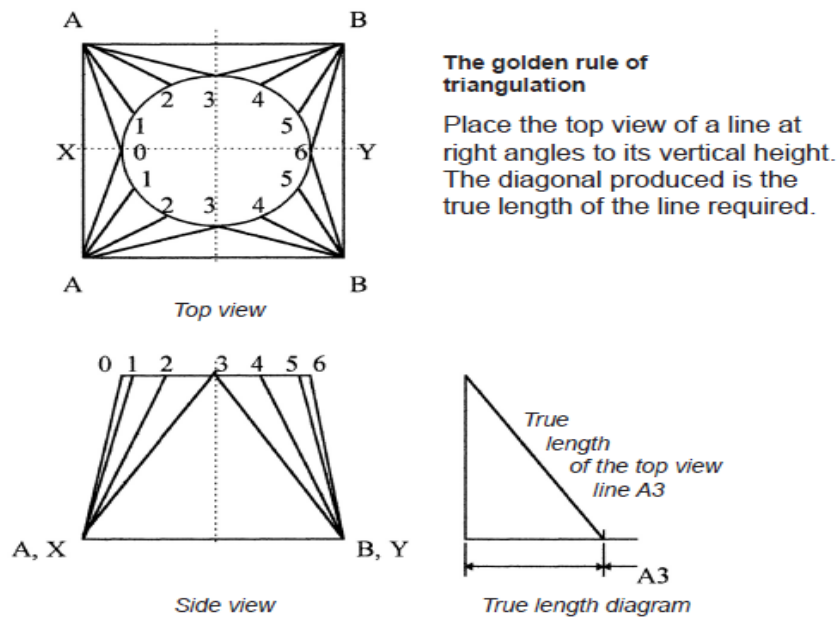
The only lines which are not true length are the triangulation lines which connect the square to the circle. A0, A1, A2 and so on. True length of these triangulation lines will have to be obtained.



**Fig 3.13** Two views

**Step 2** Construct the true length diagram.

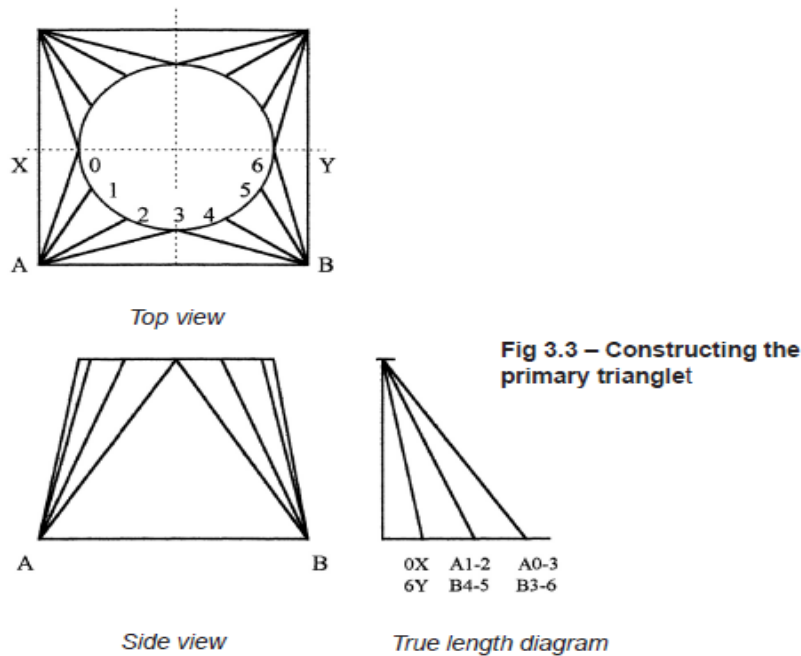
Note: With transition pieces such as this square to round, only one true length diagram is required. The height of this true length diagram is equal to the vertical height of the side view; as can be seen in Fig 2. You will also note that the true length diagram consists of a right angle.



**Fig 3.14** True length diagram

In Fig 2, the true length diagram (a right angle) can be seen constructed to the right of the side view. The vertical arm of this true length diagram being equal in height to the side view, while top view triangulation dimensions, such as A3 are transferred and located on its horizontal arm, as illustrated. The diagonal line created is the true length of the top view line A3, which can now be transferred from the true height to the pattern as per Fig 3.

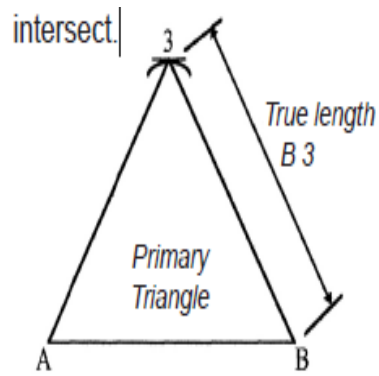
**Step 3** Commence the pattern development by constructing the primary triangle AB3. Note, in this example only a half pattern will be developed



**Fig 3.15** Primary triangle

The primary triangle AB3 is commenced by drawing a horizontal line, equal in length to the top view line AB.

- Whereas to locate the position of 3 in the pattern the true length line A3 (which is also B3) is transferred from the true length diagram to the pattern with a compass.
- Centre the compass on A, swing an arc above the line AB. This procedure is then repeated from point B of the pattern, producing the true location of point 3. That is where the two arcs intersect.



**Fig 3.16** pattern development

**Step 4** Plot the location of the next two points in the pattern, which are points 2 and 4.

- The locating of these next two points will create the next two triangles. These triangles being A–3–2 and B–3–4, both of which are secondary triangles.
- To do this, the true length of the top view lines A2 and B4 need to be obtained from the true height diagram and transferred to the pattern, when centering at both A and B arcs are scribed either side of point 3.

Whereas the two measurements 3–2 and 3–4 are simply 1/12th of the circle's circumference. These are both stepped off from point 3. To the left to intersect the arc scribed from A to create the point 2 and similarly to the right from 3 to locate the point 4.

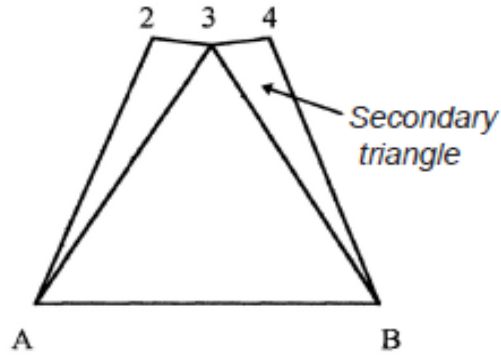
### Calculation

$$1/12\text{th of circumference} = (3.142 \times \text{diameter})/12$$

$$= (3.142 \times 80)/12$$

$$= 188/12$$

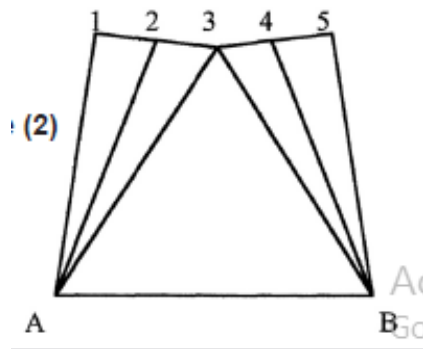
$$= 15.7\text{mm}$$



**Fig 3.17 – Secondary triangle (1)**

**Step 5** Plot the next two points 1 and 5, to create the next two secondary triangles in the pattern.

- To do this, the true length of the top view lines A1 and B5 need to be obtained from the true height diagram and transferred to the pattern, in the same way as A2 and B4 were.
- Whereas the two measurements 3–2 and 3–4, which are 15.7 mm in (1/12th of the circle's circumference), are stepped off, one from point 2 to locate point 1 and the other from point 4 to locate point 5.

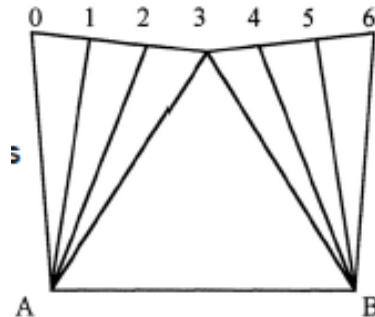


**Fig 3.18 – Secondary triangle (2)**

**Step 6** Locate the next two points 0 and 6, so as to add the next two primary triangles.

- Begin by transferring the top view length A0 (B6) to the horizontal arm of the height diagram, so that its true length can be obtained.
- Next, transfer the true length of A0 (B6) to the pattern. Centre the compass at A and scribe an arc to the left of point 1. Repeat this procedure from B.

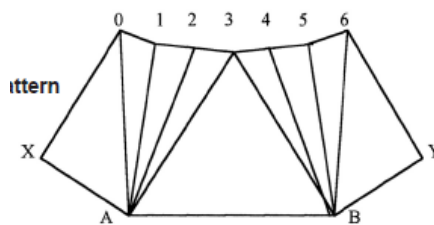
- Now with the compass set to 15.7 mm, scribe an arc from point 1 to intersect the arc scribed from A, to locate the point 0 to the left of point 1. Repeat this procedure from 5, to locate point 6.



**Fig 3.19** – Adding primary triangles

**Step 7** Complete the half pattern by locating the two points X and Y which can be found in the top view.

- Transfer the top view true length line AX directly to the pattern. Centre the compass at A and scribe arc AX to the left of A. Repeat this procedure from B to produce arc BY to the right of B.
- Now, transfer the top view line 0X to the true length diagram, to obtain its true length.
- Next, transfer the true length of 0X to the pattern. Centre the compass on 0 and scribe arc 0X to intersect the arc scribed from A, to locate the point X. Repeat this procedure from point 6 to locate the point Y.



**Fig 3.20** – Finalizing the pattern

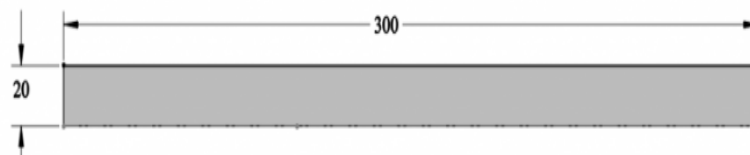
- Finalize the pattern by outlining and draw light construction lines for each of the surface triangulation lines from A and B to points 0, 1, 2, 3, 4, 5 and 6 respectively.

### 3.2. Allowances for fabrication and assembly

Understanding the Bend Allowance and consequently the Bend Deduction of a part is a crucial first step to understanding how sheet metal parts are fabricated. When the sheet metal is put through the process of bending the metal around the bend is deformed and stretched. As this happens you gain a small amount of total length in your part. Likewise, when you are trying to develop a flat pattern, you will have to make a deduction from your desired part size to get the correct flat size. The Bend Allowance is defined as the material you will add to the actual leg lengths of the part in order to develop a flat pattern. The leg lengths are the part of the flange which is outside of the bend radius.

These tests include bending some samples and then do some measurements and calculations.

Consider a sheet with a 20 mm thickness and a length of 300 mm as shown in Figure 1. We are going to review three bending scenarios with three different bending angles; 60, 90 and 120, and we will calculate K-Factor, Bend Allowance and Bend Deduction for them. The bending tool has a radius of 30 mm which means that our Inside Bend Radius (R) is 30 mm. Let's start with 90 degrees bend which is the simplest scenario.

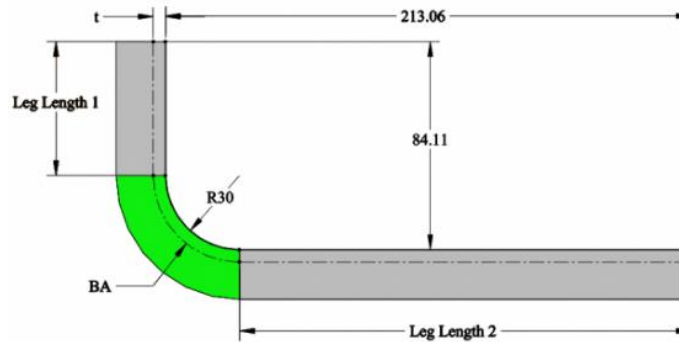


**Figure 3.21:** flat sheet

#### 90 Degrees Bend Angle

Figure 2 illustrates the sheet that is bent with the bend angle of 90 degrees. We will start by calculating the Bend Allowance. From there we can calculate the K-Factor and the Bend Deduction. After bending the sheet we need to do some measurements as shown in Figure 2.





**Figure 3.22: 90-degree bend**

We can calculate the Leg Length 1 and 2 as follows:

$$\text{Leg Length 1} = 84.11 - R = 84.11 - 30 = 54.11$$

$$\text{Leg Length 2} = 213.06 - R = 213.06 - 30 = 183.06$$

At the neutral axis we have:

$$\text{Initial Length} = \text{Leg Length 1} + BA + \text{Leg Length 2}$$

In this formula the initial length is 300 mm. By replacing Initial Length, Leg Length 1 and 2 in the above equation we can calculate the Bend Allowance as follows:

$$300 = 54.11 + BA + 183.06$$

$$BA = 62.83$$

We know that BA is the length of the arc on the neutral axis. The length of the arc for this scenario can be calculated as:

$$BA = \frac{2 * \pi * R'}{4}$$

Where R' is the radius of the arc on the neutral axis. By inserting the Bend Allowance value in the above equation, we reach to:

$$R' = \frac{2 * BA}{\pi} = \frac{2 * 62.83}{\pi} = 40$$

Now if we subtract R from R' we can find the distance of the neutral axis (t) from the inner face:

Page 73 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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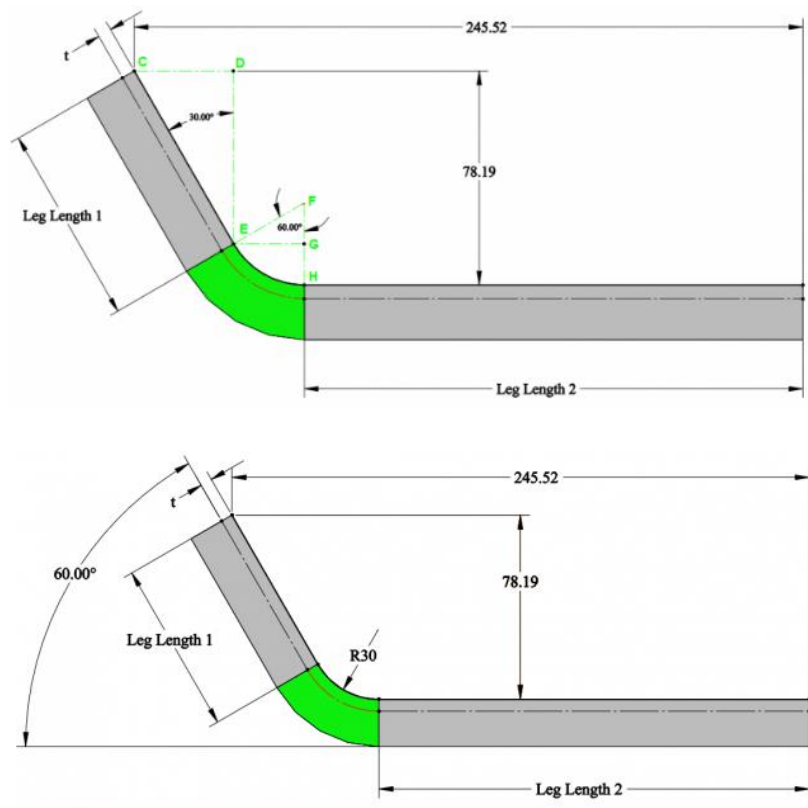
$$t = R' - R = 40 - 30 = 10 \text{ mm}$$

From the K-Factor equation we have:

$$K = \frac{t}{T} = \frac{10}{20} = 0.5$$

### Bending Angles Less Than 90 degrees

For our second scenario we are going to discuss the calculations for bending angles less than 90 degrees. As an example, we are going to use 60 degrees as our bending angle. Again, we have to do some measurements as shown in Figure 3. Then we have to calculate Leg Length 1 and Leg Length 2.



**Figure 3.23** 60 degrees bend

Let's start by calculating Leg Length 1. From figure 3 we know that

$$\cos 60 = \frac{FG}{R} \rightarrow FG = R * \cos 60$$

Where R is the Inside bend radius which is equal to 30 mm in this example. We can calculate Leg Length 1 through a few simple equations as follow:

$$GH = FH - FG \rightarrow GF = R - FG \rightarrow GH = R - R * \cos 60 \rightarrow GH = 30(1 - \cos 60) \rightarrow GH = 15$$

$$78.19 = DE + GH \rightarrow DE = 78.19 - 15 = 63.19$$

$$\cos 30 = \frac{DE}{\text{Leg Length 1}}$$

$$\text{Leg Length 1} = \frac{63.19}{\cos 30} = 72.97$$

Now let's calculate Leg Length 2:

$$\sin 60 = \frac{EG}{R} \Rightarrow EG = R * \sin 60 \rightarrow EG = 25.98$$

$$\sin 30 = \frac{CD}{\text{Leg Length 1}} \rightarrow CD = 72.97 * \sin 30 \rightarrow CD = 36.48$$

$$\text{Leg Length 2} = 245.52 - CD - EG = 183.06$$

Now that we have both Leg Length 1 and 2 we can use the following equation again to calculate the Bend Allowance:

$$\text{Initial Length} = \text{Leg Length 1} + BA + \text{Leg Length 2}$$

$$BA = 300 - 72.97 - 183.06 = 43.97$$

To calculate R' which is the radius of the arc on the neutral axis we can use the following equation:

$$BA = \frac{2\pi R' A}{360} \rightarrow R' = \frac{360 * BA}{2\pi A}$$

A is the bending angle in the above equation so

$$R' = \frac{360 * 43.97}{2\pi * 60} = 42$$

To calculate the neutral axis distance from the inner face (t) we can subtract inside bend radius from R':

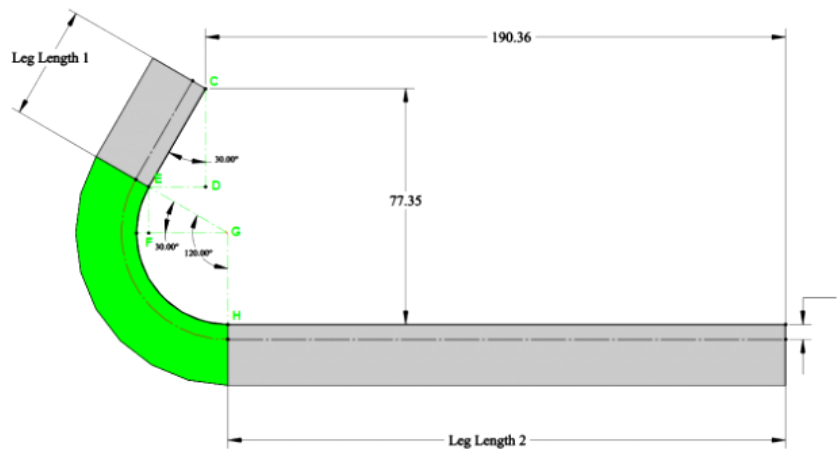
$$t = R' - R = 42 - 30 = 12$$

And by having t and the sheet thickness (T) we can calculate the K-Factor as follow:

$$K = \frac{t}{T} = \frac{12}{20} = 0.6$$

### Bending Angles Greater Than 90 degrees

Like previous scenarios let's start by calculating Leg Length 1.



**Figure 3.24:** 120 degrees bend

Based on Figure 4 we have:

$$\sin 30 = \frac{EF}{EG} = \frac{EF}{R} \rightarrow EF = R \sin 30 = 15$$

$$77.35 = CD + EF + GH \rightarrow CD = 77.35 - EF - R \rightarrow CD = 77.35 - 15 - 30 = 32.35$$

$$\cos 30 = \frac{CD}{Leg\ Length\ 1}$$

$$Leg\ Length\ 1 = \frac{32.35}{\cos 30} = 37.35$$

Next, we calculate Leg Length 2:

$$\sin 30 = \frac{ED}{\text{Leg Length 1}} \rightarrow ED = 37.35 \sin 30 = 18.68$$

$$\cos 30 = \frac{FG}{EG} = \frac{FG}{R} \rightarrow FG = R \cos 30 = 25.98$$

$$\text{Leg Length 2} = 190.36 + ED - FG = 190.36 + 18.68 - 25.98 = 183.06$$

Now we can calculate the Bending Allowance:

$$\text{Initial Length} = \text{Leg Length 1} + BA + \text{Leg Length 2}$$

$$BA = 300 - 37.35 - 183.06 = 79.59$$

By having BA we can now calculate K-Factor:

$$BA = \frac{2\pi R' A}{360} \rightarrow R' = \frac{360 * BA}{2\pi A} = \frac{360 * 79.59}{2\pi * 120} = 38$$

$$t = R' - R = 38 - 30 = 8$$

$$K = \frac{t}{T} = \frac{8}{20} = 0.4$$

### Bend Deduction Calculation

As explained in my first post the Bend Deduction can be calculated using the following equation:

$$BD = 2 * OSSB - BA$$

Where OSSB is the outside setback. OSSB is defined as illustrated in figure 3.25 for different bending angles and can be calculated using the equation below:

$$\tan \frac{A}{2} = \frac{OSSB}{R + T} \rightarrow OSSB = (R + T) \tan \frac{A}{2}$$

Where A is the bending angle, T is the sheet thickness and R is the bending radius

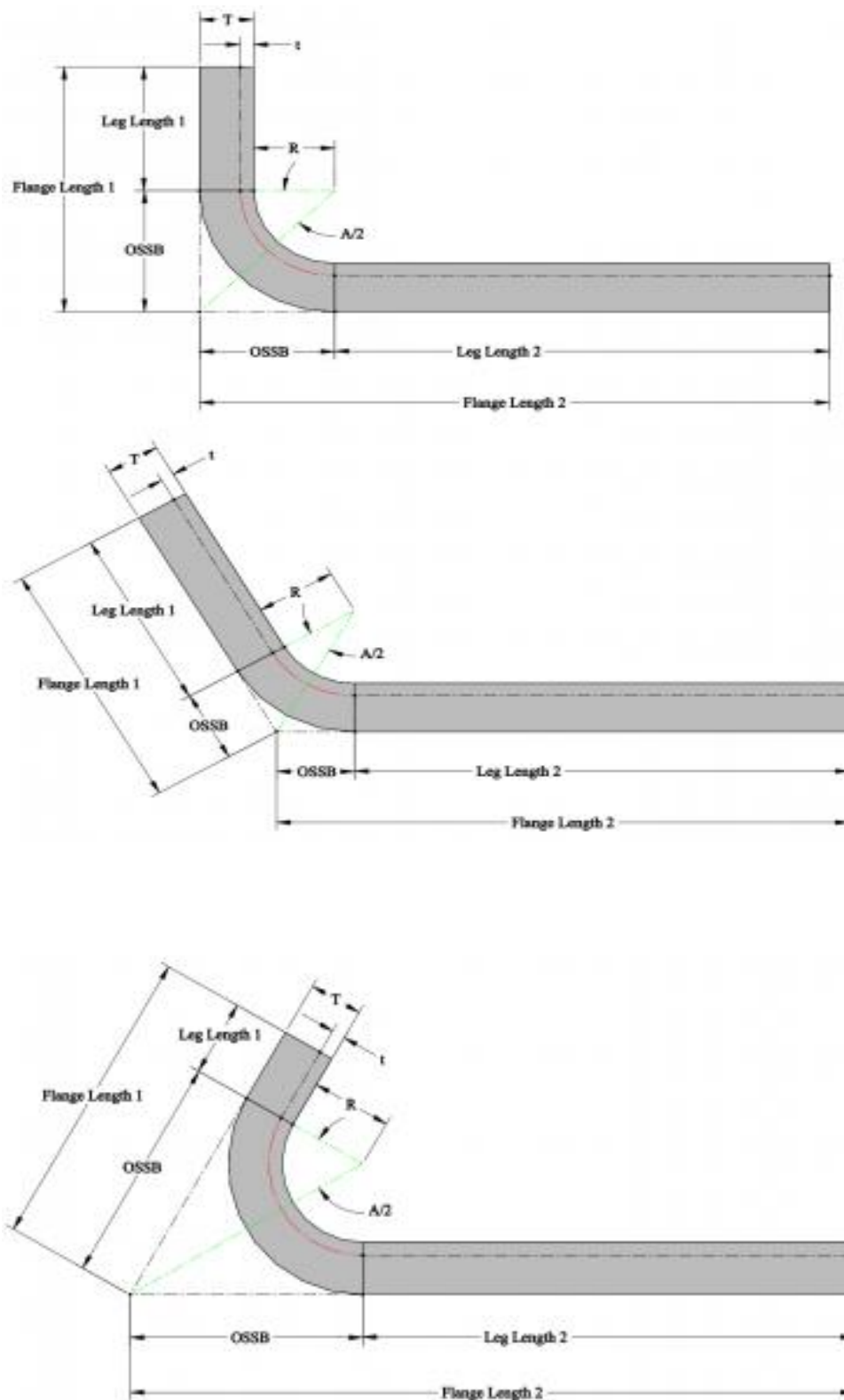


Fig 3.25. Bend Deduction Calculation

## Self-check-1

**Directions:** Answer all the following questions

- The process of transferring measurements from a project drawing to the material from which the project is to be made.  
A. Marking out   B. Drawing   C. Sketching   D. Pattern
- A kind of pattern which is used in making cone-shaped objects such as funnels, buckets or tapered lamp shades.  
A. Triangulation   B. Parallel line   C. Radial line   D. Square
- The resulting flat pattern made directly on the metal.  
A. Drawing   B. Sketching   C. Triangulation   D. Lay-out

**Directions:** Answer all the questions listed below.

- \_\_\_\_\_ is a full-size layout of an object made on a single flat plane. Should provide overall satisfaction to all concerned.
- The three methods used to pattern development are \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_. (3 points)
- \_\_\_\_\_ is also called a stretch out or simply a development, is a full-size layout of an object made on a single flat plane
- \_\_\_\_\_ is the original part of the pattern development from which flat patterns can then be cut from flat sheets of material that are folded, rolled, or otherwise formed into the required shape
- \_\_\_\_\_ is defined as the material you will add to the actual leg lengths of the part in order to develop a flat pattern.

## Operation sheet-1

**Operation title:** - Right cone

**Purpose:** - To applying radial pattern development methods

**Instruction:** - Follow the six basic steps & draw **rectangular prism** you learnt in both the previous

### B. Tools & equipment's

1. Paper

2. Set square

3. T square

3. Protractor, Compass, Divider

### C. Procedure of work: -

**Step 1** Draw the required views

**Step 2** Divide the circumference of the bottom view into 12 divisions

**Step 3** Set your compass to the slant height of the side view; apex to base

**Step 4** With your compass set at this measurement, scribe an arc to commence the pattern layout

**Step 5** Set your compass to 1/12th of the cone's base circumference

**Step 6** With your compass set at this measurement

**Quality Criteria-** required to the instruction & dimension,

**Precautions:** - use & apply safety perquisitions

## Lap Test-1

Task 1. Write the formula of bend deduction

A. Bend allowance for

B. Bending Angles less Than 90 degrees

C. Bending Angles Greater Than 90 degrees

D. Bending Angles equal to 90 degrees

Page 80 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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## Unit Four: Cut and join sheet metal

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Marking out Sheet metal.
- Measuring and Cutting Sheet metal to pattern.
- Surface contaminants.
- Join Sheet metal

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Mark Sheet metal.
- Measure and Cut Sheet metal to pattern.
- Prepare and clean Surface from contaminants.
- Join Sheet metal by avoiding damage to all surrounding surfaces

## 4.1. Marking out Sheet metal

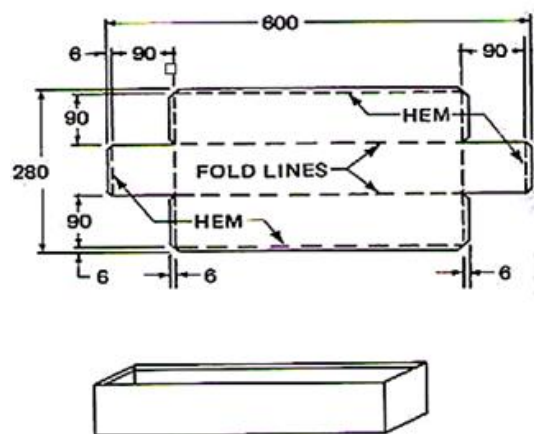
Marking out is the process of transferring measurements from a project drawing to the material or work piece. The resulting flat pattern made directly on the metal drawing on sheet metal is called the layout. It shows the shape and size of the object, the location of all holes or openings, and the areas to be machined or otherwise removed. A layout is similar to a working drawing laid out on a metal work piece. Accuracy is very important, if you make an error, your job can be ruined before you ever start it.

See video: <https://youtu.be/IObgZ5gYWIE>

To make a good lay-out, you must be able to

- Read and understand drawings and prints,
- Use lay-out tools correctly, and
- Transfer measurements accurately from a drawing to the material itself.

The following (fig.2.2.), shows you the pattern what look likes. it shows full information/ data about box , shown also by pictorial drawing.



**Fig 4.1.** Marking or laying out box

## 4.2. Measuring and Cutting Sheet metal to pattern.

**Measurement** is the process of associating numbers with physical quantities and phenomena. Measurement is fundamental to the sciences; to engineering, construction, and other technical fields; and to almost all everyday activities. “Measurement” is the act of determining a target's size, length, weight, capacity, or other aspect.

### 4.2.1 Measurement methods

**Direct measurement** is measurement done by bringing the target into contact with the measurement system to read the length, height, or other aspect directly. Although direct measurement allows measurement results to be known as they are, errors may occur depending on the skill of the person doing the measurement.

**Indirect measurement** is done, for example, by using a dial gauge to measure the height difference between a measurement target and a gauge block and using that height to indirectly determine the target's height. Because this type of measurement is based on a reference, indirect measurement is also referred to as “comparative measurement.”

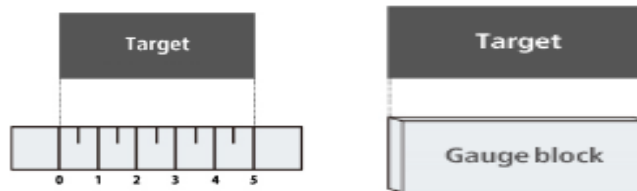


Fig.4.2: Measurement methods

### Metric and English Systems

#### 4.2.2. Metric (SI) systems

The metric system is an internationally agreed decimal system of measurement created in France in 1799. The International System of Units (SI), the official system of measurement in almost every country in the world, is based upon the metric system. In the metric system, each basic type of measurement (length, weight, capacity) has one basic unit of measure (meter, gram, and liter).

10 millimeters (mm) =	1 centimeter (cm)	
10 centimeters =	1 decimeter (dm)	= 100 millimeters
10 decimeters =	1 meter (m)	= 1,000 millimeters
10 meters =	1 dekameter (dam)	
10 dekameters =	1 hectometer (hm)	= 100 meters
10 hectometers =	1 kilometer (km)	= 1,000 meters

### 4.2.3. English System

While the metric system was lawfully accepted for use in the United States in 1866, the US has not adopted the metric system as its "official" system of measurement. The US English System of measurement grew out of the manner in which people secured measurements using body parts and familiar objects. For example, shorter ground distances were measured with the human foot and longer distances were measured by paces, with one mile being 1,000 paces. Capacities were measured with household items such as cups, pails (formerly called gallons) and baskets.

Obviously, this system allowed for discrepancies between measurements obtained by different individuals. A standard was eventually set to ensure that all measurements represented the same amount for everyone.

Length:	Weight:	Capacity:
1 foot (ft) = 12 inches (in)	1 pound (lb) = 16 ounces (oz)	1 tablespoon (tbsp) = 3 teaspoons (tsp)
1 yard (yd) = 3 feet	1 ton = 2000 pounds	1 cup (c) = 16 tablespoons
1 mile (mi) = 5280 feet		1 cup = 8 fluid ounces (oz)
1 mile = 1760 yards		1 pint (pt) = 2 cups
		1 quart (qt) = 2 pints
		1 gallon (gal) = 4 quarts

For more follow: <https://mathbitsnotebook.com/Algebra1/Units/UNMetricEnglish.html>

## 4.3. Surface contaminants.

### 4.3.1. Cleaning surface of sheet metal

Identifying the sheet metal required for work. Before starting to perform your work, you should have to clean the surface of work pieces from sheet metal (foreign materials) like, grease, dust, rust, oil and others. Commonly there are two ways of cleaning surface of sheet metals. They are by mechanically and chemical. Mechanically by using abrasive paper, sand blasting, wire brush, and rage/ stracho, etc. and chemical by using solvents.

Adequate surface preparation is a vital prerequisite for ensuring the quality and durability of metal coatings. Without proper preparation, even the most advanced metal coating technologies will fail. To turn your first metal paint job into a successful experience, we invite you to check the next five steps to preparing metal for paint.

### 4.3.2. Five Important Steps Preparing Metal for Paint

#### 1. Clean the surface.

To properly prepare new metal surfaces, use mineral spirits to remove grease and apply a rust-inhibitive primer before painting. For painted surfaces that are in sound condition, remove dust with a clean, dry cloth, de-gloss the surface with light sanding, and wipe with mineral spirits to ensure good adhesion. To remove persistent dirt, wash surfaces with a mild detergent solution or with a commercial product recommended for cleaning painted surfaces.

#### 2. Remove loose and peeling paint.

If the old paint is in poor condition, you can remove it by hand wire brushing, sanding, or scraping. Since these methods are labor intensive and usually fail to deliver the results expected, many professionals opt for power tool cleaning, which can help remove paint quickly and easily. However, one drawback of using power tools is that they can polish metal surfaces, potentially causing paint-adhesion problems.

#### 3. Remove rust.

When preparing metal for paint, checking for rust is important to make sure that the paint will adhere properly to the surface. To restore lightly rusted metal surfaces to their original state, use a brush to clean off loose rust, sand the area, and apply a high-quality rust-inhibitive primer (e.g. Rust-Oleum Rust Reformer). Also known as rust converters, rust-inhibitive primers can be used to cover rusted spots and turn them into non-rusting, paintable surfaces.

#### 4. Repair small holes and dents.

To repair holes and dents, sand the area until you reach bare metal and wipe with a degreaser mixed with mineral spirits. For small holes and dents, inject an appropriate epoxy-based composite directly into the hole and/or dent. For larger holes, apply epoxy filler to the edge of the hole, cut a piece of fiberglass mesh approximately one inch larger than the hole, and press it into the filler. Then, cover the mesh with epoxy, working your way from the edge toward the center of the hole.

#### 5. Prime the surface

Priming is a very important step in preparing metal for paint, especially if the surface will be exposed to moisture. To select the right primer, the type of metal to be coated along with the desired appearance, performance requirements, and environmental conditions should be

considered. To begin with, water-based (latex) primers shouldn't be used on metal surfaces, as moisture can seep through and cause paint to fail within weeks or months.

Professionals recommend two types of metal primers: the rust converters mentioned above and galvanized metal primers. While a rust converter is ideal for preventing rust from recurring and making a rusted surface easier to paint, a galvanized primer is appropriate for metals (e.g. aluminum) that prevent paint from adhering to the surface. You can also find iron oxide and zinc chromate primers, which can be used on most metal surfaces, including interior and exterior iron and steel.

Priming immediately after cleaning the surface is imperative to prevent dust or dirt from accumulating and flash rust (rust that occurs within hours) from forming.

#### 4.4. Join Sheet metal

##### 4.4.1. Fabrication of Edges, Joints, Seams, and Notches

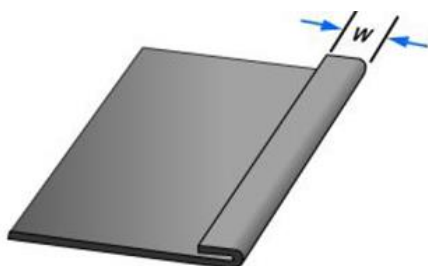
There are numerous types of edges, joints, seams, and notches used to join sheet metal work. We will discuss those that are most often used.

- **Fabricating Edges or Hem**

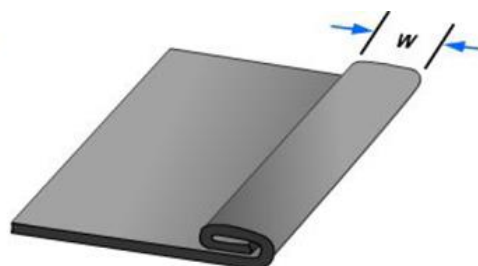
Edges are formed to enhance the appearance of the work, to strengthen the piece, and to eliminate the cutting hazard of the raw edge. The kind of edge that you use on any job will be determined by the purpose, by the size, and by the strength of the edge needed.

The **single hem edge** is shown in *Figure below*. This edge can be made in any width. In general, the heavier the metal, the wider the hem is made. The allowance for the hem is equal to its width (W).

The **double hem edge** is used when added strength is needed and when a smooth edge is required inside as well as outside. The allowance for the double-hem edge is twice the width of the hem.



**Fig. 4.1:** Single hem edge



**Fig.4.2:** Double hem edge.

A **wire edge** is often specified in the plans. Objects such as funnels, water troughs, and garbage pails are fabricated with wire edges to strengthen and stiffen the jobs and to eliminate sharp edges. The allowance for a wire edge is  $2 \frac{1}{2}$  times the diameter of the wire used. As an example, you are using wire that has a diameter of 4mm. multiply 4 by  $2 \frac{1}{2}$  and your answer will be 10mm, which you will allow when laying out sheet metal for making the wire edge.



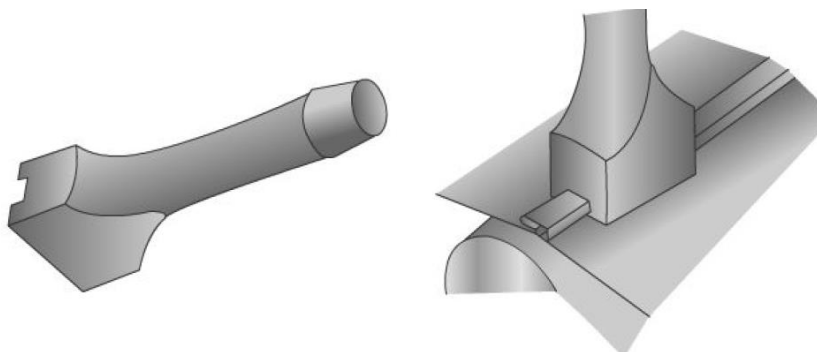
**Fig.4.3:** Development of a wire edge on a cylinder

- **Fabrication of Joints**

The **grooved seamed joint** is one of the most widely used methods for joining light- and medium-gauge sheet metal. It consists of two folded edges that are locked together with a hand Grover. When making a grooved seam on a cylinder, you fit the piece over a stake and lock it with the hand Grover. The hand Grover should be approximately  $\frac{1}{16}$  inch wider than the seam. Lock the seam by making prick punch indentions about  $\frac{1}{2}$  inches in from each end of the seam.

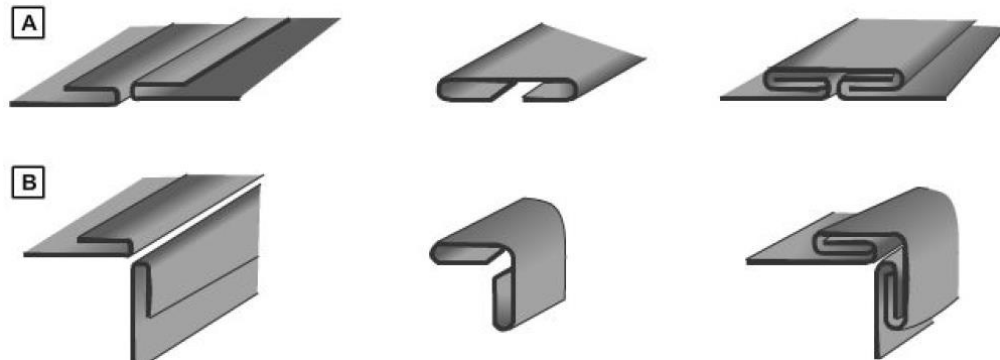


**Fig .4.4:** Development of a grooved seam joint



**Fig.4.5:** Hand groover and locking a grooved seam.

The **cap strip seam** (fig A) is often used to assemble air-conditioning and heating ducts. A variation of the joint, the locked corner seam (*Figure B*), is widely accepted for the assembly of rectangular shapes.

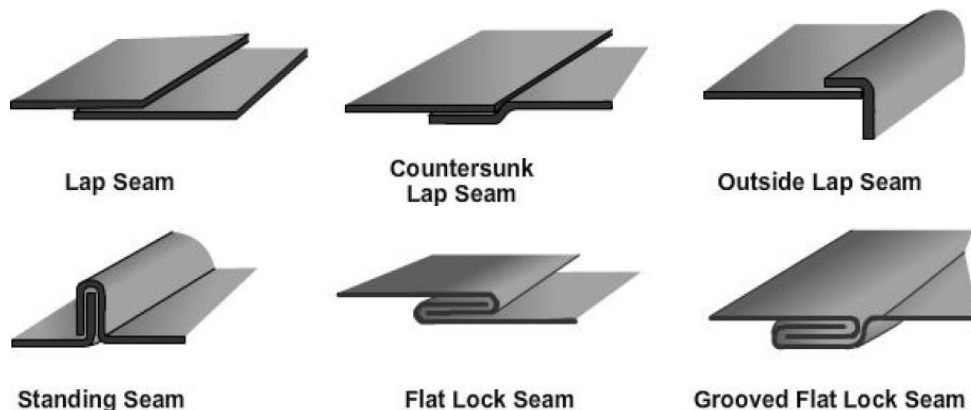


**Fig.4.6:** (A) cap strip seam, (B) locked corner seam

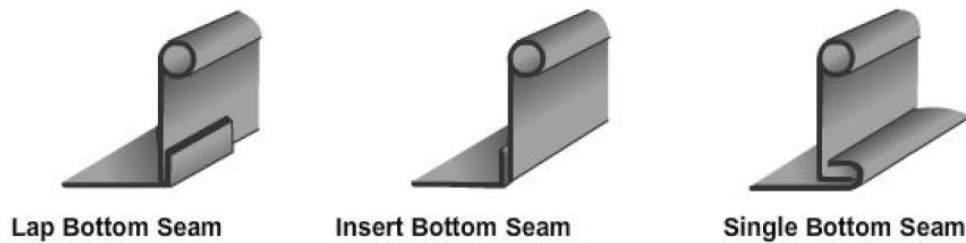
#### 4.4.2. Fabricating Seams joints

Many kinds of seams are used to join sheet metal sections. Several of the commonly used seams are shown in *Figure below*. When developing the pattern, ensure you add adequate material to the basic dimensions to make the seams. The folds can be made by hand; however, they are made much more easily on a bar folder or brake. The joints can be finished by soldering and/or riveting.

When developing sheet metal patterns, ensure you add sufficient material to the base dimensions to make the seams. Several types of seams used to join sheet metal sections are discussed in this section.







**Fig.4.7:** Common sheet-metal seams

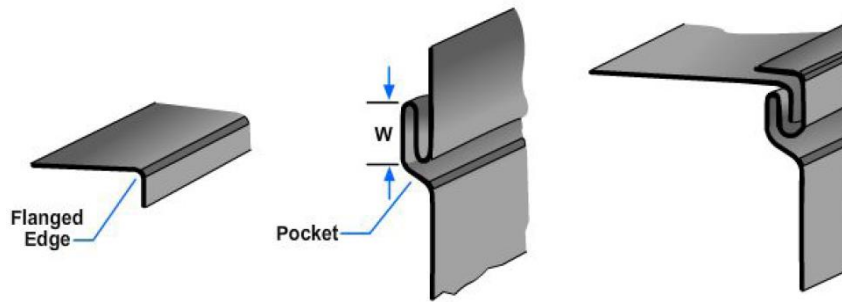
There are three types of lap seams: the *plain lap seam*, the *offset lap seam*, and the *corner lap seam*. Lap seams can be joined by drilling and riveting, by soldering, or by both riveting and soldering. To figure the allowance for a lap seam, you must first know the diameter of the rivet that you plan to use. The center of the rivet must be set in from the edge a distance of 2 1/2 times its diameter; therefore, the allowance must be five times the diameter of the rivet that you are using.



**Fig.4.8:**Types of Lap seam

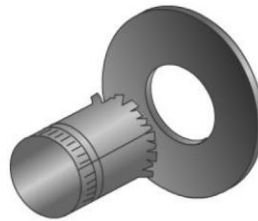
The **Pittsburgh lock seam** is a corner lock seam. Figure below shows a cross section of the two pieces of metal to be joined and a cross section of the finished seam. This seam is used as a lengthwise seam at corners of square and rectangular pipes and elbows as well as fittings and ducts.

This seam can be made in a brake but it has proved to be so universal in use that special forming machines have been designed and is available. It appears to be quite complicated, but like lap and grooved seams, it consists of only two pieces. The two parts are the flanged, or single, edge and the pocket that forms the lock. The pocket is formed when the flanged edge is inserted into the pocket, and the extended edge is turned over the inserted edge to complete the lock.



**Fig.4.9:** Pittsburgh lock seam.

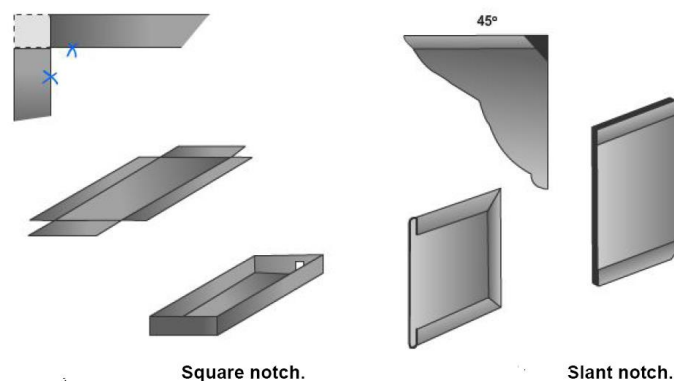
The **dovetail seam** is used mainly to join a round pipe/fitting to a flat sheet or duct. This seam can be made watertight by soldering. *Figure bellows* shows the pattern for forming a dovetail seam and an example of its use.



**Fig.4.10:** Dovetail lock seam.

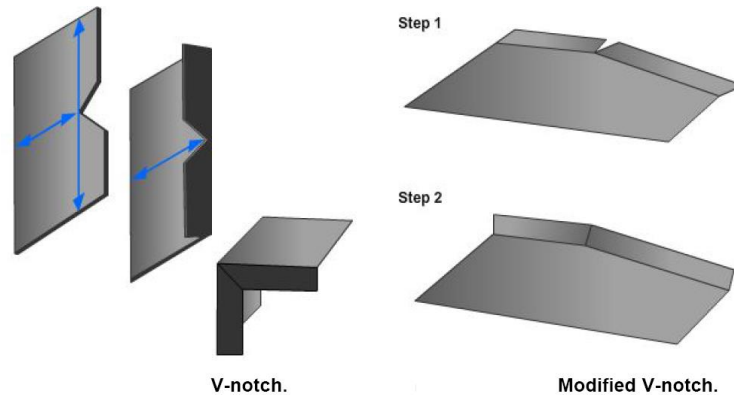
**Notching** is the last step to be considered when you are getting ready to layout a job. Before you can mark a notch, you will have to lay out the pattern and add the seams, the laps, or the stiffening edges. If the patterns are not properly notched, you will have trouble when you start forming, assembling, and finishing the job.

A **square notch** is likely the first you will make. It is the kind you make in your layout of a box or drip pan and is used to eliminate surplus material. This type of notch will result in butt comers. **Slant notches** are cut at a 45-degree angle across the corner when a single hem is to meet at a 90-degree angle.



**Fig 4.11A square notch**

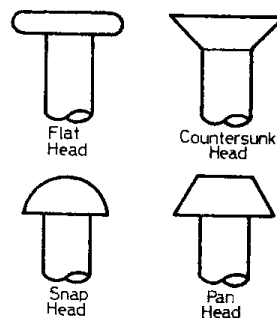
A **V notch** is used for seaming ends of boxes. You will also use a full V-notch when you have to construct a bracket with a toed-in flange or for similar construction. When you are making an inside flange on an angle of less than 90 degrees, you will have to use a modification of the full V-notch to get flush joints. The angle of the notch will depend upon the bend angle.



**Fig. 4.12: V notching**

#### 4.4.3. Rivets

Rivets are metal pins that look like bolts without threads. It may be solid or hollow. It is made of soft malleable metals which will not crack while the head is being formed. Rivets are commonly made of Aluminum, Brass, Copper, magnesium and Mild steel. The most kinds of rivet heads are round, counter sunk and flat.



**Fig.4.13: Types of rivets**

#### 4.4.4. Size of rivet

The size of a rivet is measured by the diameter and length of the body. The head is not included in the length except on those designed to be countersunk. Rivets are available in size ranging from 3 to 10mm in diameter in 0.75mm steps and from 6 to 76mm in length

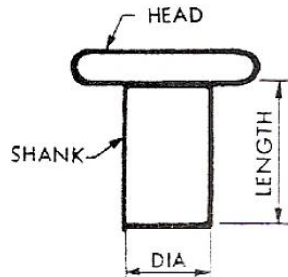


Fig. 4.14: Sizes of rivets

#### 4.4.5. How to select rivet size

Choose rivets that are 0.08mm to 0.4mm smaller in diameter than the holes in the pieces which you are going to rivet. Each rivet must be long enough to go through the pieces, with enough metal for forming a head, which is about 1.5 times the diameter of the rivet. The rivet selected generally should be made of the same material as the metal being riveted.

Example

1. If the diameter of the rivet is 3mm, the extended length will be:-

1.5x diameter of rivet

1.5x 3= 4.5mm, the extended length will be 4.5mm

2. Find the length of a rivet, to rivet together a 0.4mm sheet metal and 0.3mm sheet metal thick and 3.6mm diameter rivet.

**Solution**

Sheet metal1 = 0.4 mm and sheet metal2 = 0.3 mm

$1\frac{1}{2} \times 3.6 \text{ mm} = 5.40 \text{ mm}$ , then  $5.40 \text{ mm} + 0.70 \text{ mm} = 6.10 \text{ mm}$  length of rivet

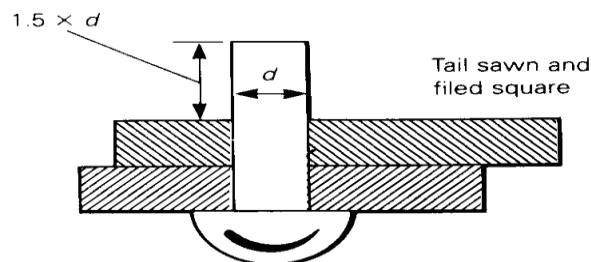


Fig 4.15 set the rivet

#### 4.4.6. Rivet set

A rivet set is made of a hardened steel tool 96 to 144mm long. The large end has a deep hole and a shallow cup- shaped hole. The deep hole fits over the rivet and is used to draw the sheets and the rivet together. The cup-shaped hole is used to form the head on the rivet.

A rivet set can be used to force rivets directly through thin metal without previously punching a hole. An outlet is at the end of the drawing hole to allow the burrs to drop out. Rivet sets are made in a variety of sizes, with the numbers **00, 0, 1, 2... up to 8**. The number 8 is the smallest size and the number 00 is the largest.



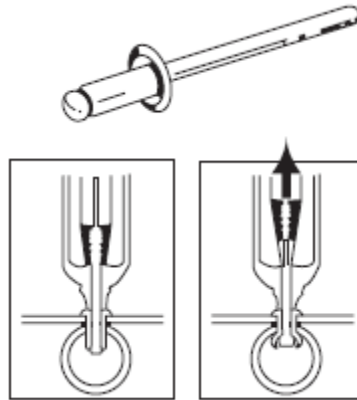
**Fig 4.16** Rivet set

#### 4.4.7. Hollow rivets (blind rivet)

It is a technique which enables a mechanical fastening to be made when access is limited to only one side of the parts to be assembled. You can use also it where access is available to both sides of an assembly. The blind rivet is a two-part mechanical fastener

- Headed tubular body mounted on a mandrel
- Mandrel which is set in the setting tool

Operation of the setting tool pulls the mandrel head in to the rivet body causing it to expand on the blind side of the assembly. When the blind side head is fully formed, continued operation of the setting tool causes the mandrel to break



**Fig. 4.17:** operating principle of hollow rivet

- **Work piece materials**

When materials of different thickness or strengths are being joined, the stronger material – if possible – should be on the blind side.

#### **4.4.8. Hole size and preparation**

Achieving a good joint depends on good hole preparation, preferably punched and, if necessary, de-burred to the sizes recommended.

#### **4.4.9. Rivet diameter**

As a guide for load-bearing joints, the rivet diameter should be at least equal to the thickness of the thickest sheet and not more than three times the thickness of the sheet immediately under the rivet head.

#### **4.4.10.Edge distance**

Rivet holes should be drilled or punched at least two diameters away from an edge but no more than 24 diameters from that edge.

#### **4.4.11.Rivet pitch**

As a guide to the distance between the rivets in load-carrying joint situations, this distance should never exceed three rivet diameters. In butt construction it is advisable to include a reinforcing cover strip, fastening it to the underlying sheet by staggered rivets.

#### **4.4.12.Rivet material**

Choosing rivets of the correct material normally depends on the strength needed in the riveted joint.

## Self-check-1

**Directions:** Answer all the questions listed below.

1. The process of cutting sheet metal
  - A. Shearing      B. Welding      C. Tearing      D. Riveting
2. A kind of sheet metal cutting that makes hole on the metal
  - A. Tearing      B. Drilling      C. Holing      D. Punching
3. A tool which used to cut sheet metals
  - A. Vise grip      B. Diagonal cutting plier
  - C. Hand snip      D. Drill bit
4. After marking out and measuring what is the next to be done?
  - A. Cutting      B. Forming      C. Bending      D. Joining
5. In shearing machine used for straight line cutting
  - A. The lower blade is fixed      B. The upper blade is movable
  - C. The upper blade is inclined to the lower blade      D. All
6. A punching operation that forms rectangular holes in the sheet is:
  - A. Slitting      B. Drawing      C. Slotting      D. Lancing
7. Of the following one is not types of notches
  - A. **square notch**      B. **Slant notches**      C. **V notch**      D. None

## Operation sheet-1

Operation title: - Book rake store using mild steel sheet

Purpose: -Exercising sheet metal cutting& bending methods

Instruction: - Use proper tools & equipment's & make book rake with the given dimension

Procedure: -

2. select materials
3. measure & lay out
4. cut with proper cutting tools
5. Bend as a rule
6. Use finishing materials

#### Tools and requirement

- Scriber
- Steel rule
- Set square
- Protractor
- Compass
- Divider
- Center punch
- Snips
- Bench sheer

**Quality Criteria:** Accuracy of dimension

**Precautions:** Use proper tools & equipment's, apply safe working habits

#### Lap Test-1

1. Explain how take book rake **step by step**



## Unit Five: Quality assure work and clean up

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Measure aligns, joins and sealed components.
- Maintain work area, tools and equipment.
- Workplace documentation.

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Measure aligns, join and seal components.
- Clean, check, maintain and store work area, tools and equipment
- Complete workplace documentation.

### 5.1. Measure aligns, join and sealed components

#### 5.1.1. Types of joining

Page 97 of 106	Ministry of Labor and Skills Author/Copyright	Cut and Join Sheet Metal	Version -1 August, 2022
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There are many ways of joining metal permanently. The method used will depend on the function of the product, the strength needed and the quality of the product.

There are several ways of joining metal permanently.

- riveting
- soldering and brazing
- welding

The latter two of these techniques rely upon heat. With soldering and brazing, the two metals are joined by melting a second metal between them. With welding, the two metals are melted and fused together.

## Rivets

- ✓ Metal pins that look like bolts with no threads.
- ✓ Used to hold pieces together permanently.
- ✓ Used when fastening metals together that are not easily welded, or where welding is not practical.
- ✓ Rivets may be made of steel, copper, brass, aluminum or other materials. Standards for rivet *sizes* and shapes have been put forth by several agencies. The most commonly used standard in the United States is the *American Standard Small Solid Rivets*.

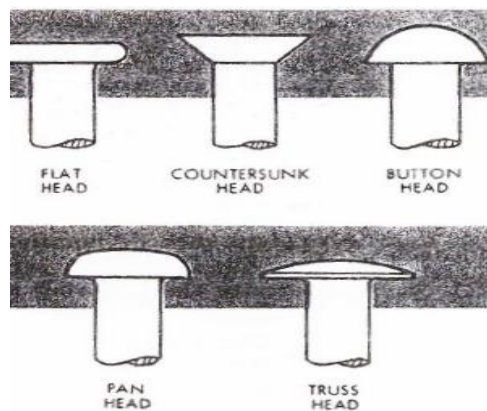


Fig. 6-2. Standard rivets.

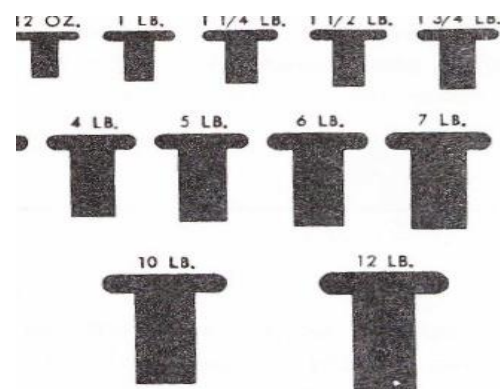


Fig. 6-1. Tinnery rivets.

Fig 5.1. Size of rivets

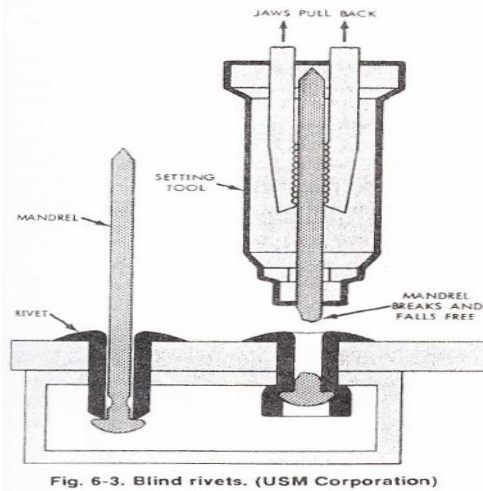


Fig 5.2. Blind rivet hand

## Spot Welding

- ✓ Form of resistance welding done with a spot welder.
- ✓ High current at a low voltage passes through a spot on two pieces of metal (usually sheet metal) for a short period of time.
- ✓ Resistance to the flow of current through the metal at the spot causes heat, which melts the metal and makes a spot weld.
- ✓ Most frequently used to weld metal joints but sometimes used to weld sheet metal to small diameter rods or small flat bars.

## Soldering

- ✓ Process of fastening two metals together with *solder*, a nonferrous metal that has a lower melting point than the parts being joined.
- ✓ Parts being joined are heated until the solder, when brought into contact with them, melts and flows between the surfaces. When the solder solidifies, it adheres (sticks) tightly and
- ✓ forms a strong bond between the two surfaces.

## Soft Soldering

- ✓ Occurs at temperatures *below* 800 degrees Fahrenheit.
- ✓ For general work, a solder called *rosin core 60-40* (60% tin, 40% lead) is often used.

- ✓ Solder often comes in a coil of wire 1/16" in diameter but can come in other pre-cut shapes, sizes, and forms.
- ✓ Heat for soft soldering is applied using *soldering gun* or a *soldering copper*.

### Hard Soldering

- ✓ If solder melts *above* 800 degrees Fahrenheit, it is called *hard soldering*.
- ✓ Used where a strong joint is needed or where the parts will be used in greater heat than the melting point of soft solder.
- ✓ The most widely used hard solders are *silver alloy solders* that come in ribbons, sheets, wire, or pre-cut pieces of various shape and sizes.
- ✓ Often used in jewelry and art metalwork for joining copper, silver, and gold.
- ✓ Heat for hard soldering is applied directly with the flame of a *torch*.

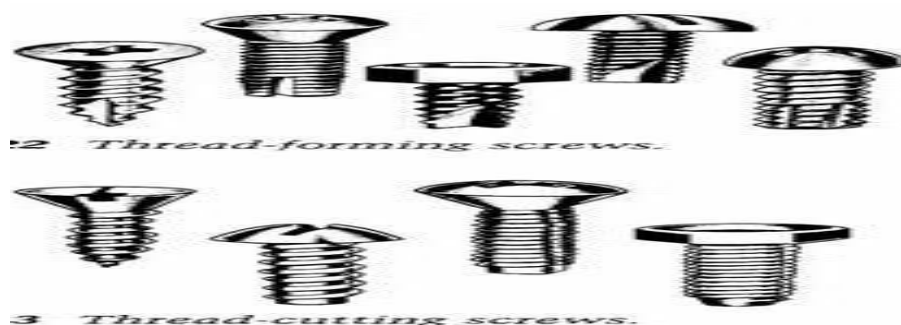
### Brazing

- ✓ Hard soldering processing where the filler material flows into the joints using capillary action (the natural tendency of a liquid to be drawn in between two close fitting surfaces).
- ✓ Filler material used is *brazing rods* (60% copper, 40% zinc).

### Sheet Metal Screws

Short thick screws that are self-threading (cut or form their own threads as driven into soft metals). Used in the economical assembly of sheet metal. Threaded all the way down the shank.

Come in a variety of head types depending on application.



**Fig 5.3. Sheet Metal Screws**

## 5.2. Maintain work area, tools and equipment

Tools and equipment may be as simple as hammers or as complex as computers. Whatever they are, however, workers must use them safely and employers must reduce any **risk in the workplace** that tools and equipment pose.

### 5.2.1. Clean safe Workspaces,

You need to keep the workplace clean and safe for all and ensure that people are protected from falling from heights or being exposed to hazardous substances.

A tidy workplace is a much safer environment when tools and other equipment are being used. Most workplace accidents relate to trips, slips, and falls.

#### Check

You should check that all roads, walkways, floors and stairs are safe to use and not blocked by large pieces of equipment or piled up stock.

### 5.2.2. Correct Maintenance of Tools and Equipment

A key part of a good health and safety strategy is to maintain tools and equipment regularly.

This helps to identify safety problems before they become a serious hazard. Only qualified people should carry out the maintenance. They should also keep records of their inspections which should form part of the company's broader health and safety inspection schedule.

It's very important to make sure that all equipment is inspected regularly. In most cases, a daily pre check should be carried out. You can emphasize the importance to your workers through regular toolbox talks.

## 5.3. Workplace documentation

Documentation includes any kind of record-keeping about an office environment or its employees. There are many types of documentation and formats for those types, but in its most basic form, documentation is simply taking records about things that happen in an office.

There's formal and informal documentation for HR employees to note small occurrences or big events as they see fit. Keeping accurate records of things that happen in an office, like employee actions, disciplinary actions, or performance evaluations, can help create a bigger picture and document an employee's time at a company.

These can be helpful if an employee needs to be evaluated for a promotion or they're considered for termination, plus a whole range of other situations.

Documentation can be kept physically or digitally; you just need to make sure everything is well-organized. It's possible to keep accurate physical records with files on employees and events in the workplace, as long as they're protected and secure.

Storing documentation digitally is how most companies are choosing to keep their HR records, and there's plenty of tools out there to help you get that set up.

### **5.3.1. Importance of Documentation in the Workplace**

A lawyer will say, "If it's not in writing, it didn't happen." Documentation gives substance to a workplace's activities not only for legal matters, audits or disputes, but also for rules and regulations. It keeps an office running systematically and ethically. It would be difficult for employees in a training program to remember everything if it was only presented orally. During an emergency, staff might not remember the proper procedure to exit the building without documentation

### **5.3.2. The Manufacturing Formula should include:**

- The name of the product, with a product reference code relating to its specification;
- A description of the fabrication form, strength of the product and batch size;
- A list of all starting materials to be used, with the amount of each, described; mention should be made of any substance that may disappear in the course of processing;
- A statement of the expected final yield with the acceptable limits, and of relevant intermediate yields, where applicable

### **5.3.3. Packaging Instructions**

Approved Packaging Instructions for each product, pack size and type should exist. It should include, Name of the product; including the batch number of bulk and finished product and a

complete list of all the packaging materials required, including quantities, sizes and types, with the code or reference number relating to the specifications of each packaging material.

#### 5.3.4. Testing

There should be written procedures for testing materials and products at different stages of manufacture, describing the methods and equipment to be used. The tests performed should be recorded.

### Self-check-1

**Directions:** Answer all the questions listed below.

1.It is the process of defining, visualizing and documenting fabrication requirements for sheet metal prior to the manufacturing process.

A. Fabrication      B. Design   C. Installation   D. None

2.Which one is used to give directions for performing certain operations?

A. Manufacturing formulae   B Manufacturing testing      C. procedures

4. Documentation includes –

A.any kind of record      B. an office environment      C. about employees      D. all

5. For each product, pack size and type should exist. It should include, name of the product; including

A. The batch number of bulk and finished product and

B. complete list of all the packaging materials required, including quantities, sizes and types,

C.The code or reference number relating to the specifications of each packaging material.

D. all

-

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8. [www.esnips.com](http://www.esnips.com)



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