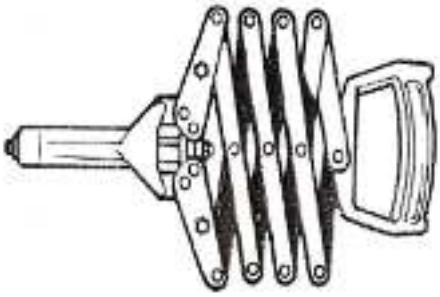
Mechanics

Level – I

Based on March, 2022, Curriculum Version 1



Module Title: Cutting and Joining Sheet Metal

Module code: IND MCS1 M06 0322

Nominal Duration: 50 Hours

Prepared By: Ministry of Labor and Skill

August, 2022

Addis Ababa, Ethiopia

Table of Contents

Acknowledge

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

PPE-Personal Protective Equipment

TTLM-Teaching Training Learning Materials

LAP-Learning, Activity Performance

Introduction to the module

In Mechanics 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 cleanup for Mechanics Filed.

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

This module covers the units:

- Plan and preparing work
- Cutting and joining sheet metal
- Quality assure

Learning Objective of the Module:

- Understand Plan and prepare work
- Perform Cut and join sheet metal
- Perform Clean up **q**uality assure work

Module Instruction

For effectively use this module 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
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit One: Plan and Preparing Work

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

- Tasks sequencimg.
- Tools, equipment and materials,
- Preparing work area.
- Sealants, fixing and sheet metal materials

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:

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

1.1. Tasks Sequence

1.1.1. Tasks Planning

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 datum 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.

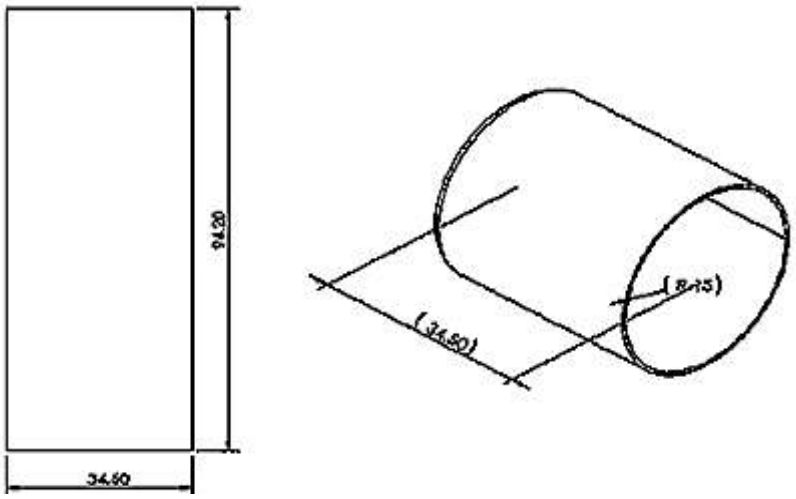


Figure 1.1 Sterching out for cylider

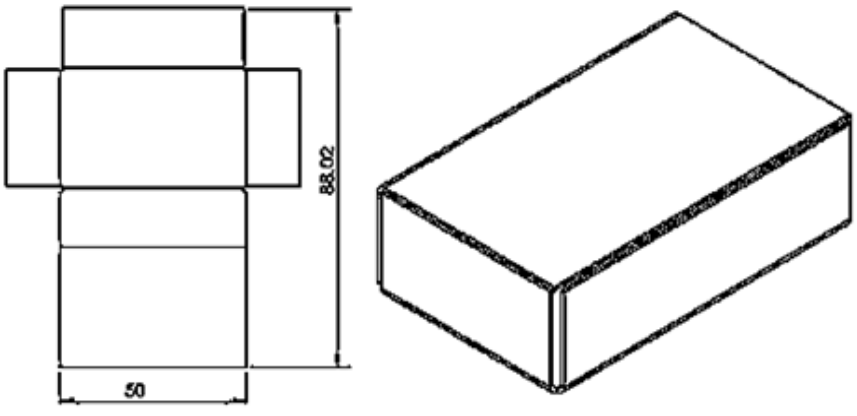


Figure 1.2. Scrchig out for box/ cube

Pictorial drawings: show the object as it actually appears after formed into shaped. This is illustrated in figure 1.3. 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:

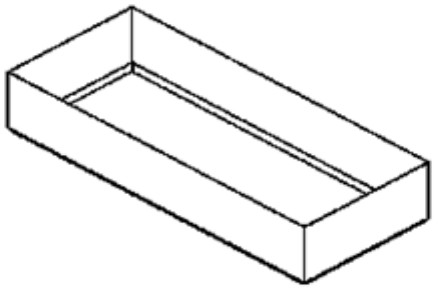


Figure 1.3. Pictorial drawing show the type of objects as they aper after formig

1.1.2. Plan Sequencing

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 plane. 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.
- 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.

1.2. Tools, equipment and materials

1.2.1. 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.

1. Lay Outing and Measuring Tools

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

Figure 1.4. Scriber

A. 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.

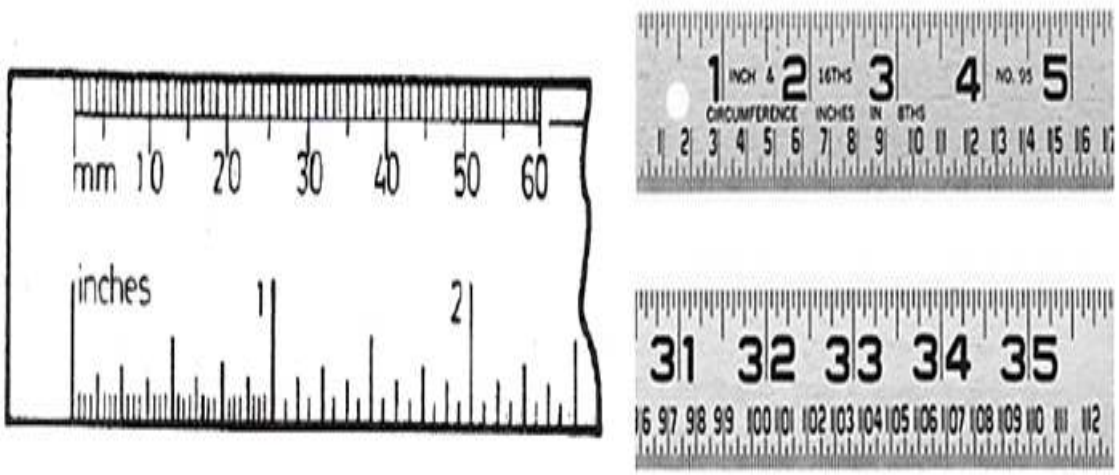


Figure 1.5. Steel Rules

B. Straight Edge

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

Figure 1.6. Straight edge

C. 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.

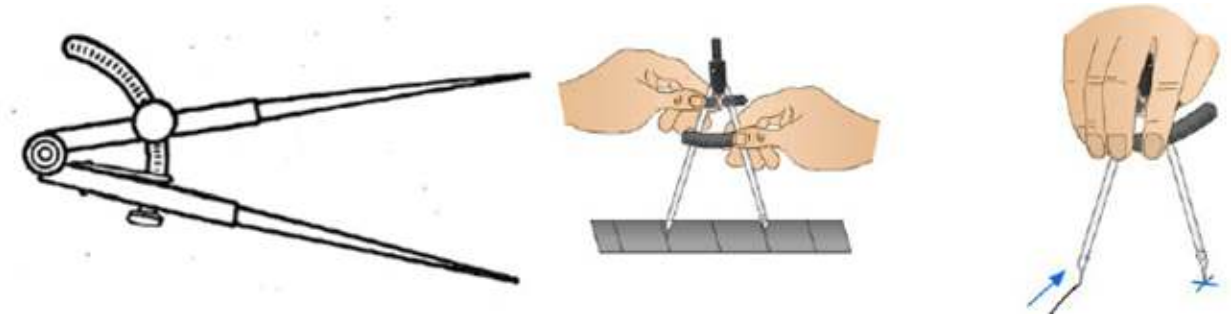


Figure 1.7. Divider and method of uses

D. Steel Square

The flat Steel Square is used to layout right angles (90°) and can also be used as a scale. It is an invaluable tool for accurate layout work in pattern draftingsince 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.

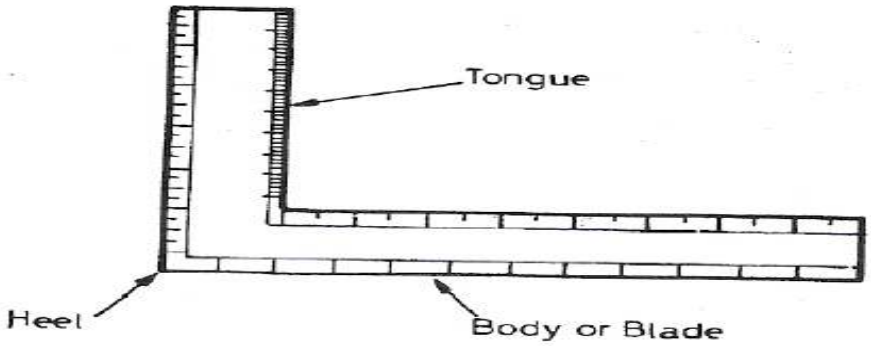


Figure 1.8. Steel square

E. Steel Try Square

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

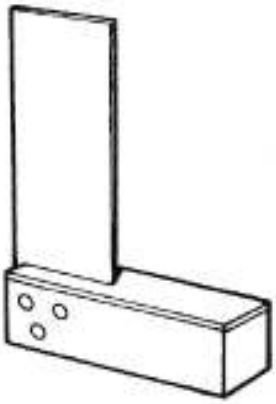


Figure 1.9. Steel Try Square

F. 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° or 45° angles. A spirit level is mounted in the stock. It is available in 300mm lengths.

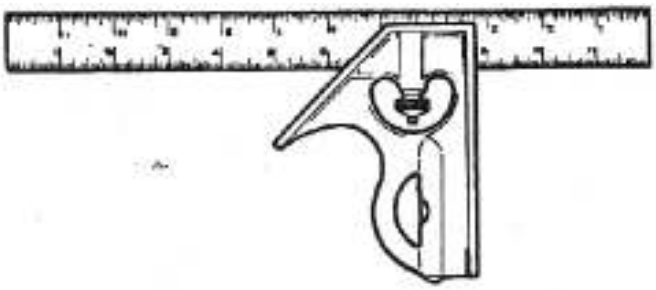


Figure 1.10. Combination square

G. 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°.

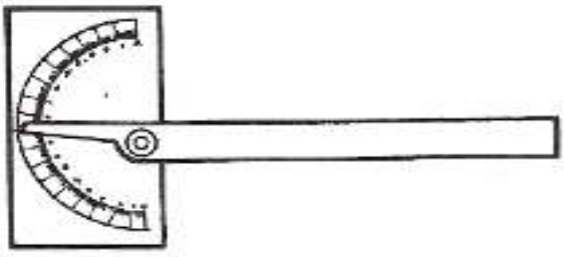


Figure 1.11. Protractor

H. Trammel Points (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.

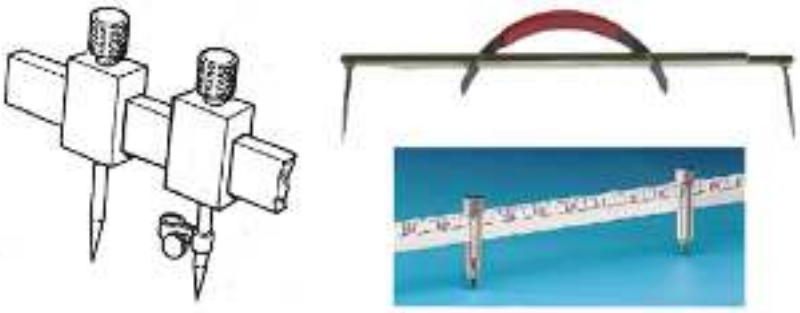


Figure 1.12. Trammel Points

I. Prick Punches

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

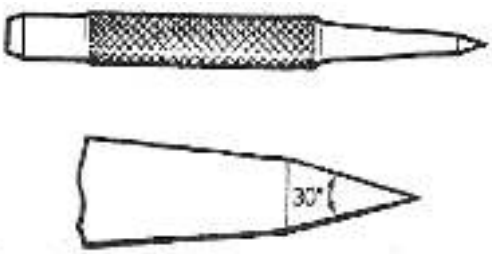


Figure 1.13. Prick punch

J. Centre Punch

Similar in design to the prick punch except that the tapered point is ground to an angle of 90° 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.

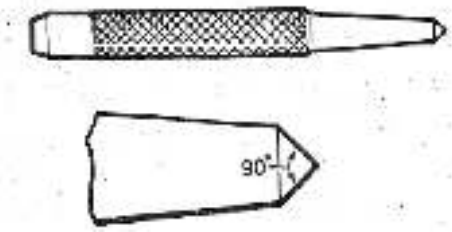


Figure 1.14. Center Punch

K. Tape Rule

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

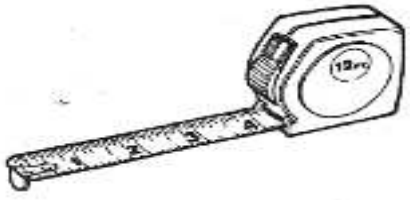


Figure 1.15. Tape Rule

2. Cutting Tools and equipment

A. 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.

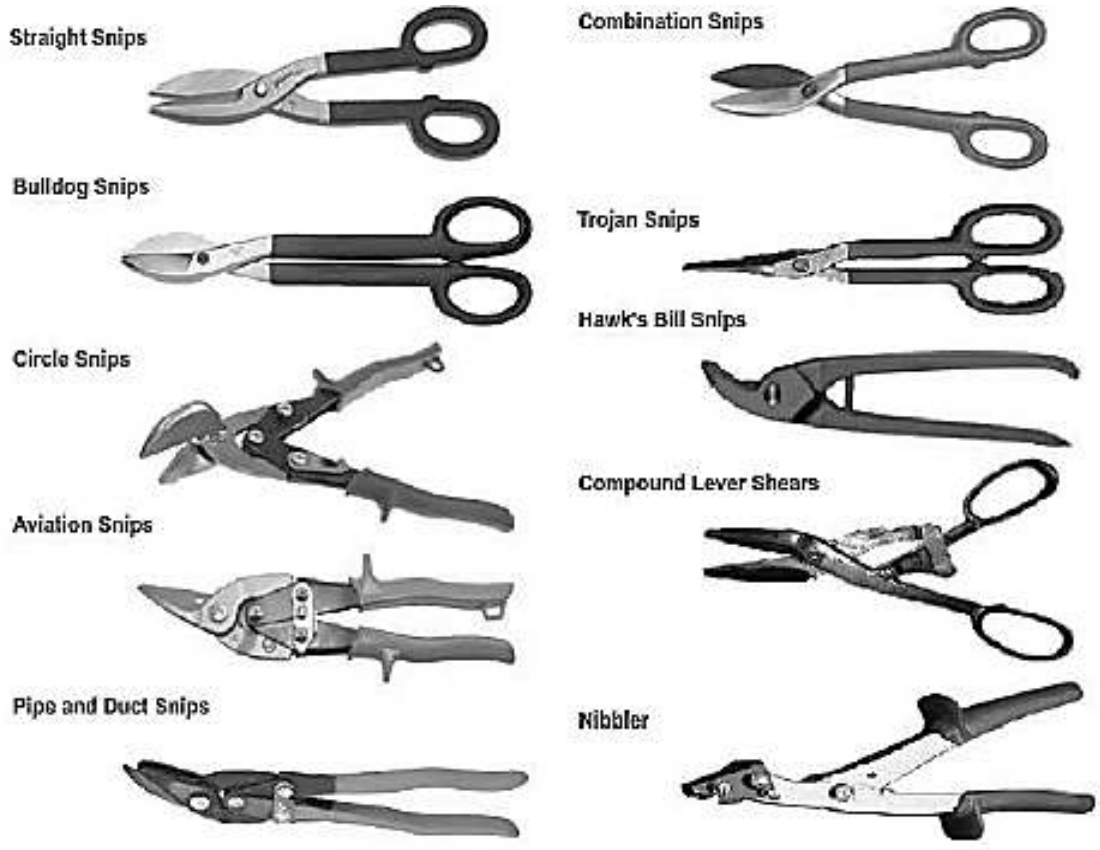


Figure 1.16. Types of hand snips

B. Bench shear

Bench shear sand hand shears have blades the rotate about a pivot and it is this pivoting action that creates the shear angle.

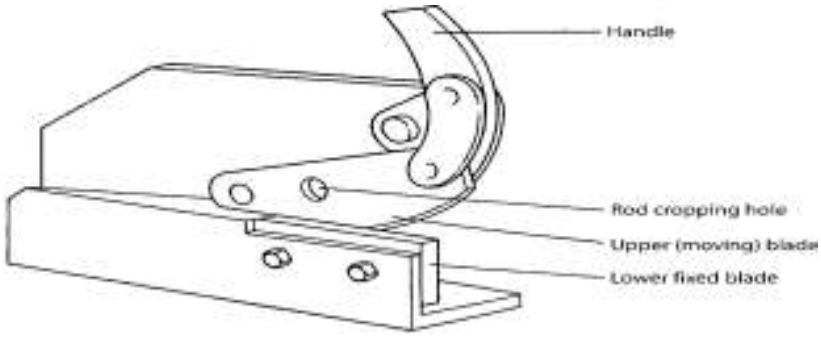


Figure 1.17. Bench shear

C. Chisels

Theyare 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 usethis 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 arid also for cutting grooves.

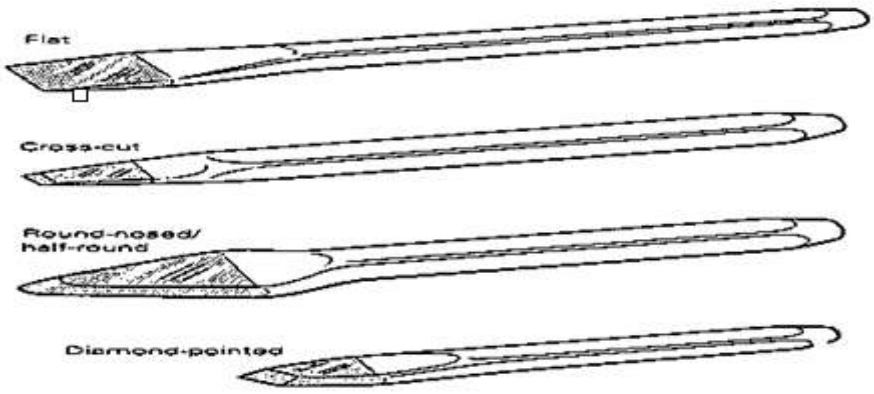


Figure1.18 Types of Chisels

D. 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.

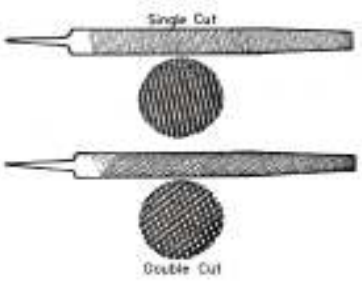


Figure 1.19. Single cut and Double cut files

E. 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

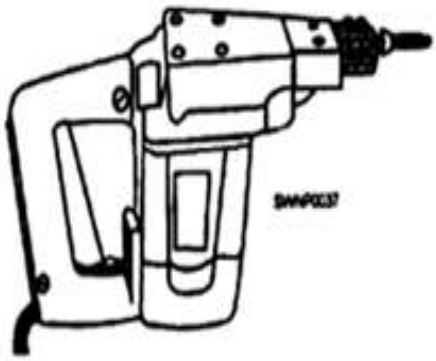


Figure 1.20. Portable power shear

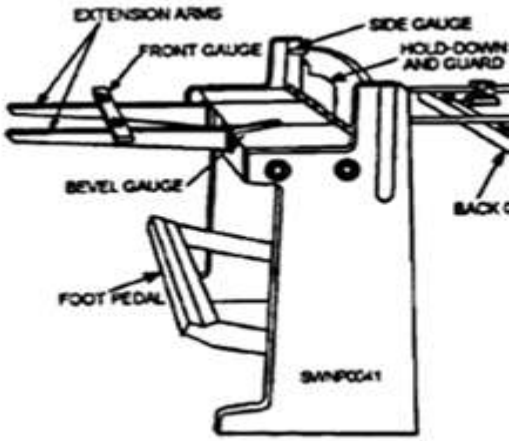


Figure 1.21. Actuated squaring shears

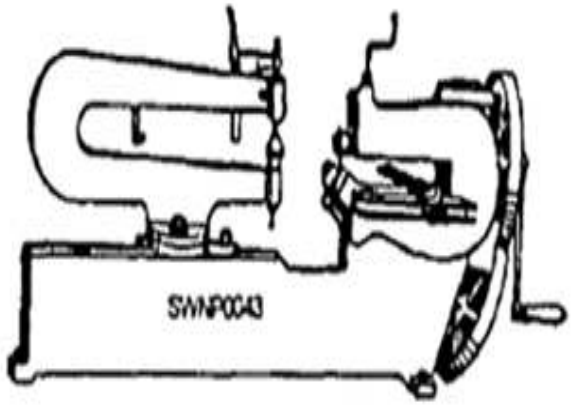


Figure 1.22.Ring and circular shear

F. Side Cutting Pliers

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

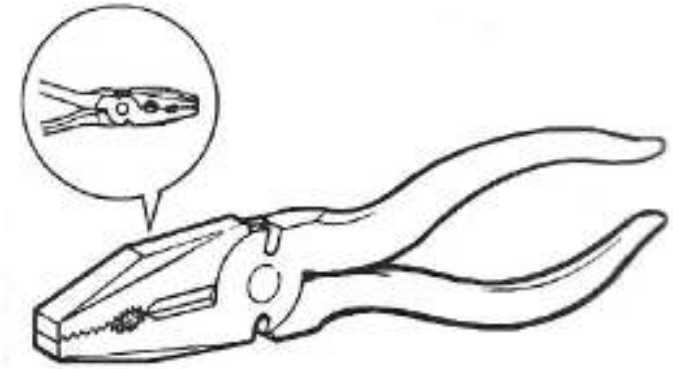


Figure 1.23.Side Cutting Pliers

3. Bending and forming tools and equipment

A. 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.
- **Plashing Hammer:** The principal purpose of the Plashing Hammer is for smoothing and finalizing a surface after it has been roughed out to the required shape.

Figure 1.24.Stretching Hammer and Plashing Hammer

- **Engineers Ball Pain 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.

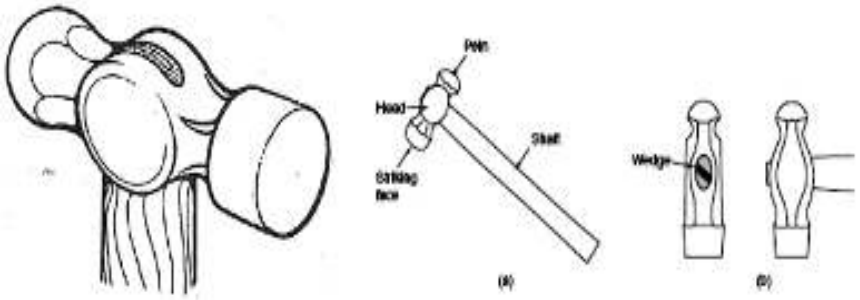


Figure 1.25.Ball Pain hammers

- **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.

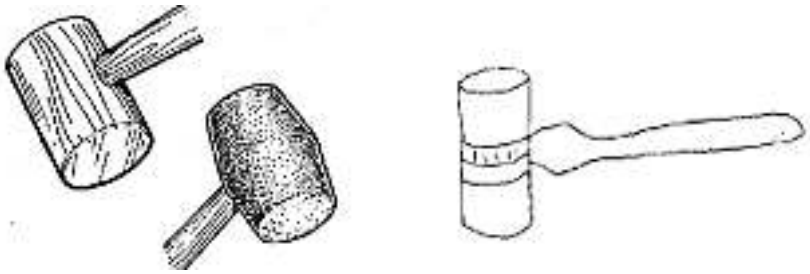


Figure 1.26.Boxwood and Rubber/plastic mallet

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.

B. 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.

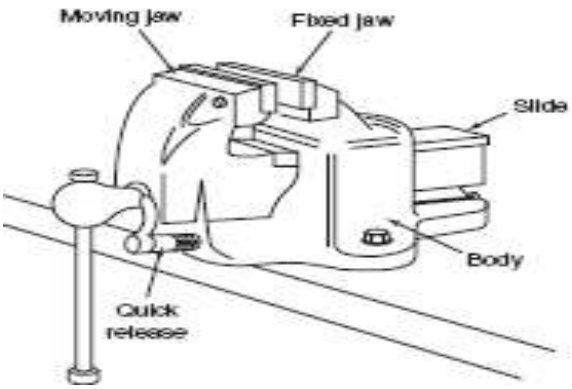


Figure 1.27. Bench Vice

C. 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
- Tin man's Anvil: The Tin man'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.
- Blow horn Stake: The Blow horn 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 plashing a hollow article.

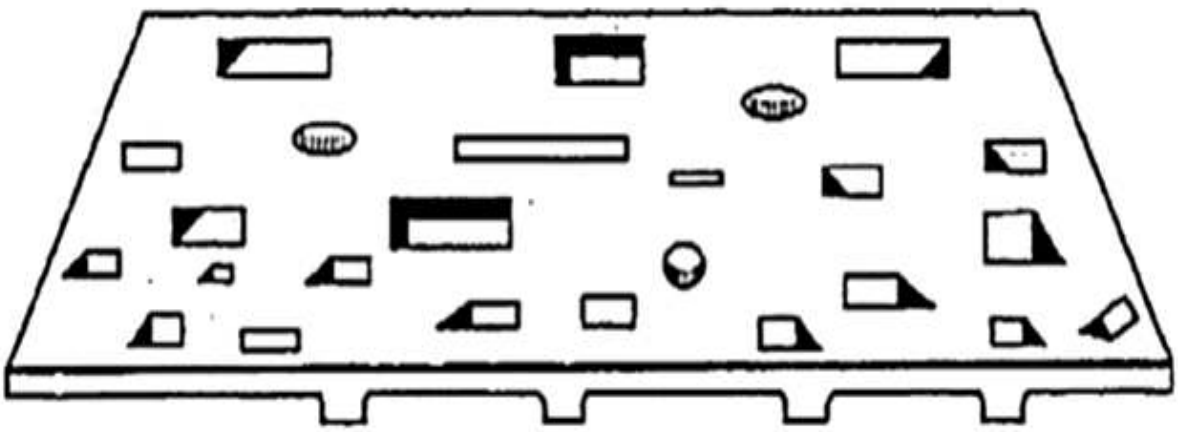


Figure 1.28. Stake holder

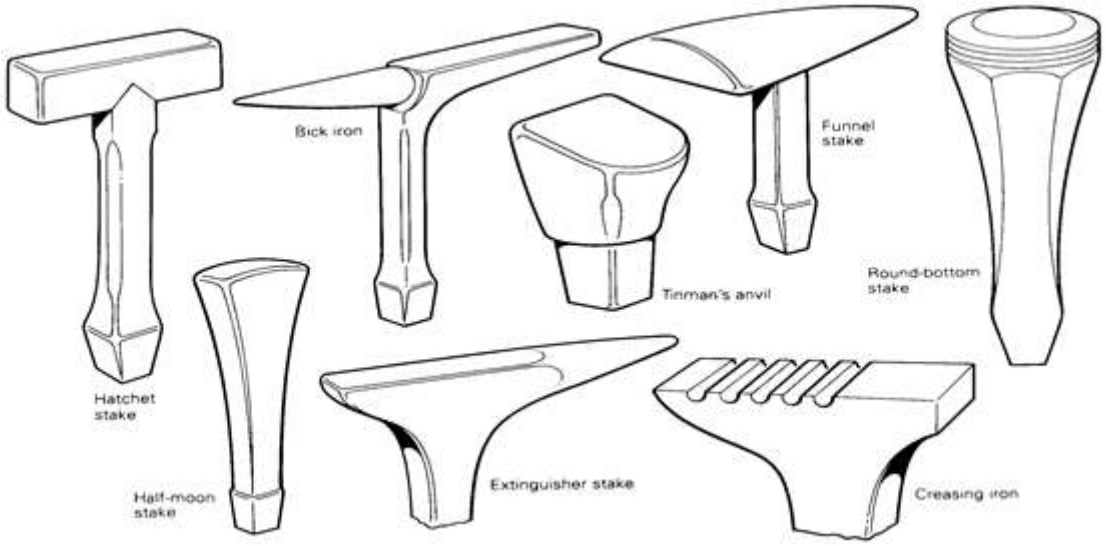


Figure 1.29. Bench stakes

D. 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.

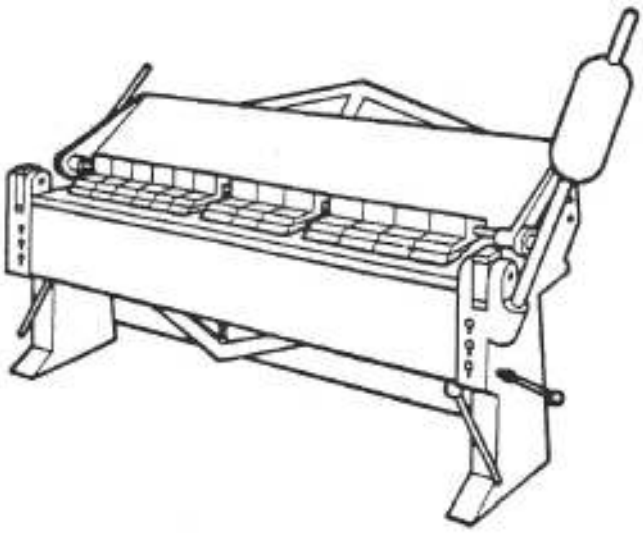


Figure 1.30.Folding Machine

E. 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.

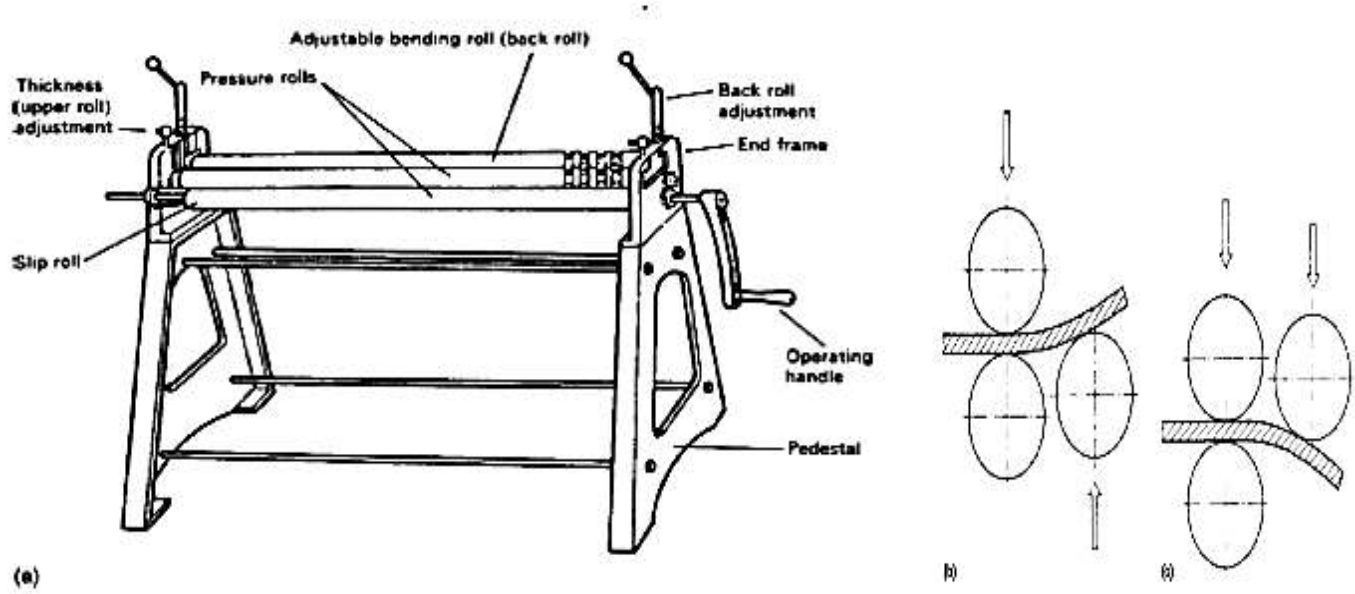


Figure 1.31. Bending Rolls

F. 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.

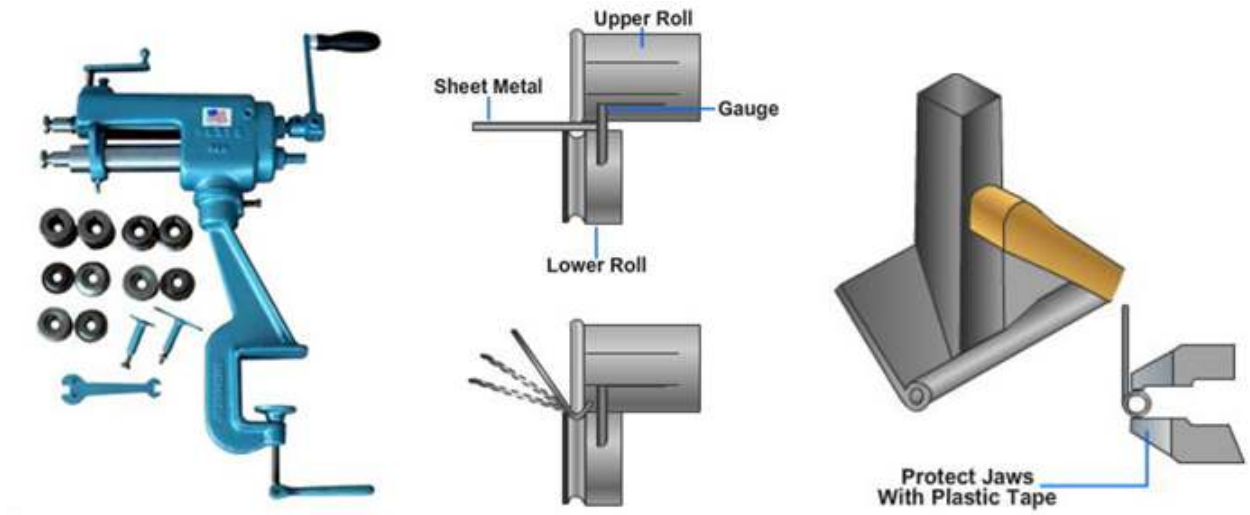


Figure 1.32. Combination Rotary Machine

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.

G. Pop Riveting Guns

"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).

H. 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.

Figure 1.33.Hand “Pop” Rivet Gun

I. 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.

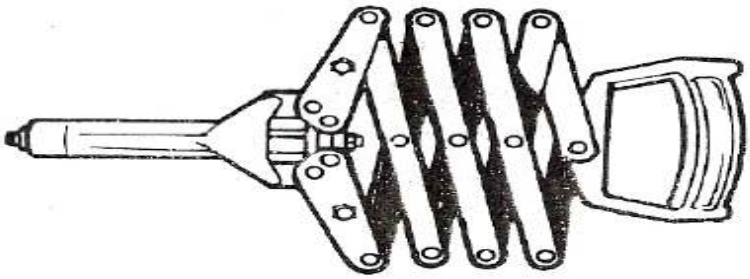


Figure 1.34.Lazy Tongs

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:

A. 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.

B. 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.

C. 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.

D. 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.

E. 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.

F. 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.

G. 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.

H. 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.

1.2.2. Personal Protective equipment (PPE)

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.

Figure 1.35. Leather Gloves

Figure 1.36. Safety Google

Figure 1.37. Safety, shoes,

1.3. 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 panning 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.

1.4. Sealants, fixing and sheet metal materials

1.4.1. Sealant

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.

1.4.2. 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. Phenol Sealant

Phenol sealants are types of resins that provide effective bonding and have a good endurance rating against high temperature. Phenol sealant is the only sealant that is available in powder, liquid and film form. The phenol 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.

1.4.3. Material compatibility

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
- **polyme**r. Silicone and polymer acts as the most suitable sealants.

1.4.4. Fixing materials

Fasteners join two thin materials together and must be purpose-designed for the application. These are generally either self –drilling stitchery 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 bellow:

- **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.

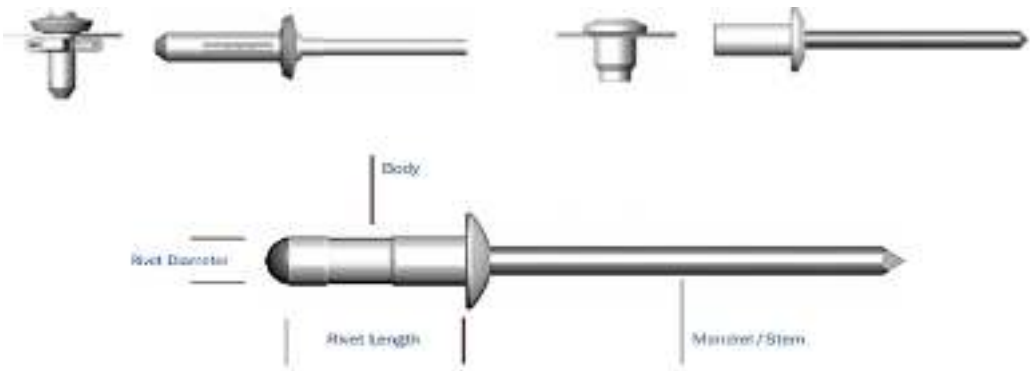


Figure 1.38. Rivets

- **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.

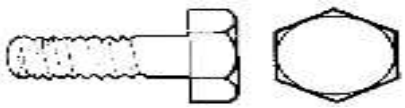


Figure 1.39. Bolts

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.

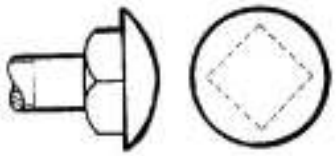


Figure 1.40. Coach bolts

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

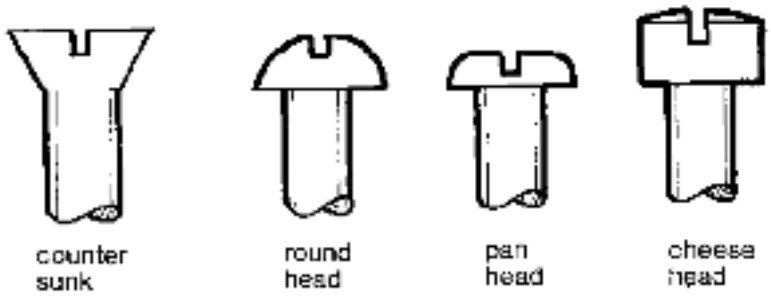


Figure 1.41. Machine screws

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

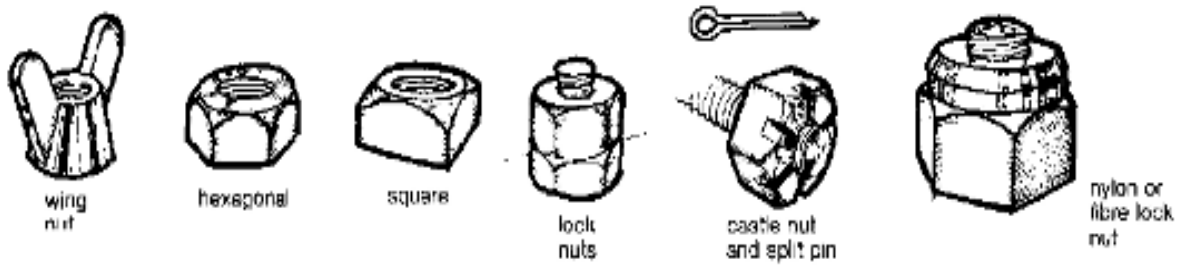


Figure 1.42. Different types of nuts

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

Figure 1.43. Washers

Self-check-1

Part I: Multiple Choice

Instruction: Choose the Correct 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 groove B. Different profiles of stakes C. Crimping and beading E. All

Part-II: Matching

column A column B

1. parallel jaw vice	A. Coach bolts
2. used to join wood to wood	B. Bench vice
3. used to make permanent joints	C. Rivet
	D. Job panning

Part-III: True or Force

1. The main properties of aluminum are its light weight, corrosion resistance?
2. Tape Rule It is very popular for measuring and laying out large jobs, available in various lengths?
3. Safety it is essential in the work shop?

Operation Sheet:1

Operation title: Methods of preparing workplace for cutting and joining sheet metal

P**urpose**: to applying work place preparation

Instruction: Follow the stapes & prepare work place properly

Procedure of work: Use properly cleaning material & joining materials

1- Don't block exits

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

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

4- Keep steps and ladders in serviceable condition

5- Keep emergency equipment clean and unobstructed

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

Quality Criteria- Safe work place

Precautions: - use& apply safety rules.

LAP Test

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks.

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

Task 2: Prepare workplace for cutting and joining sheet metal

Unit Two: 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 contaminantion.

- 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:

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

2.1. 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 I 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.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.

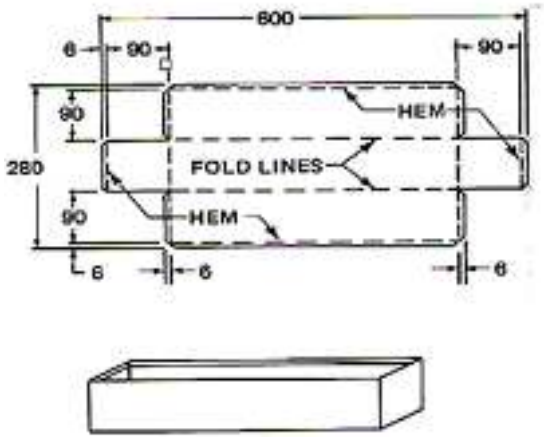


Figure 2.1.Marking or laying out box

2.2. Measuring and Cutting Sheet metal

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.

2.2.1. 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.

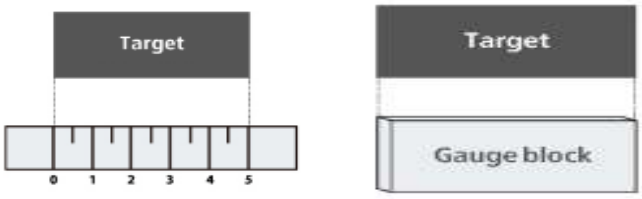


Figure 2.2.Measurement methods

2.2.2. Metric and English Systems

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).

Table 2.1.Metric (SI) systems

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

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.

Table 2.2. English system

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

2.3. Surface contaminants

2.3.1. 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.

2.3.2. Important Steps for Preparing Metal

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-Oleo 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 base 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.

2.4. Join Sheet metal

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.

2.4.1. 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 sire, and by the strength of the edge needed.

The **single hem edge** is shown in *Figure2.3below*, 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.

Figure 2.3.Single hem edge Figure 2.4.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 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 1/2 and your answer will be 10mm, which you will allow when laying out sheet metal for making the wire edge.

Figure 2.5.Development of a wire edge on a cylinder

2.4.2. 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 groove. When making a grooved seam on a cylinder, you fit the piece over a stake and lock it with the hand groove. The hand groove should be approximately 1/16 inch wider than the seam. Lock the seam by making prick punch indentions about ½ inches in from each end of the seam.

Figure 2.6.Development of a grooved seam joint

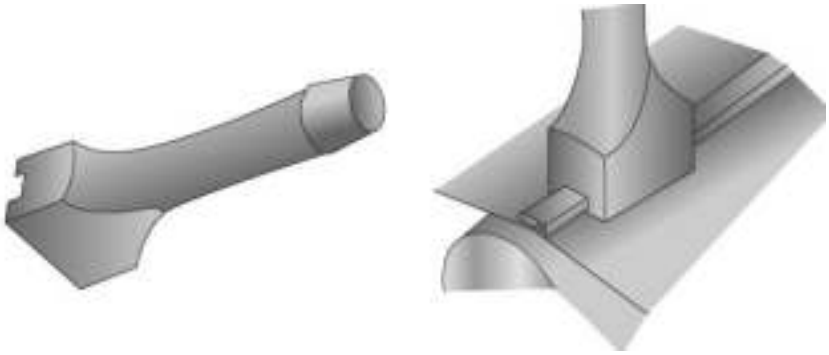


Figure 2.7.Hand groove and locking a grooved seam.

The **cap strip seam** (figure 2.8, A) is often used to assemble air-conditioning and heating ducts. A variation of the joint, the locked corner seam (*Figure 2.8. B*), is widely accepted for the assembly of rectangular shapes.

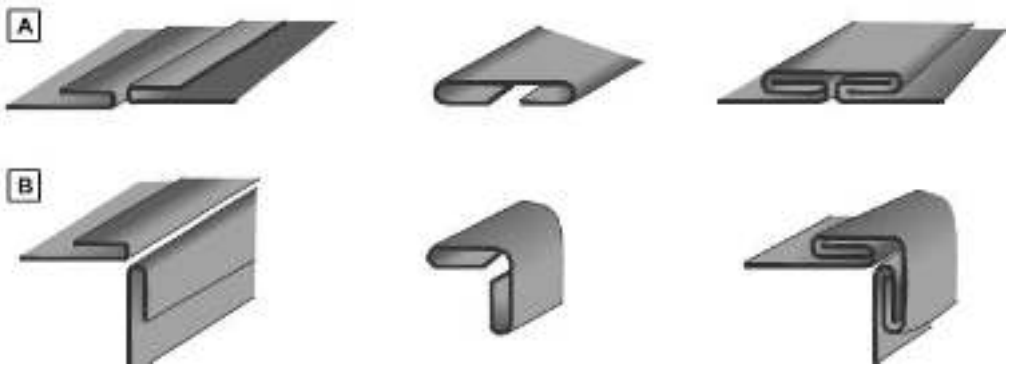


Figure 2.8.(A) cap strip seam, (B) locked corner seam

2.4.3. Fabricating Seams

Many kinds of seams are used to join sheet metal sections. Several of the commonly used seams are shown in *Figure bellow*. 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.

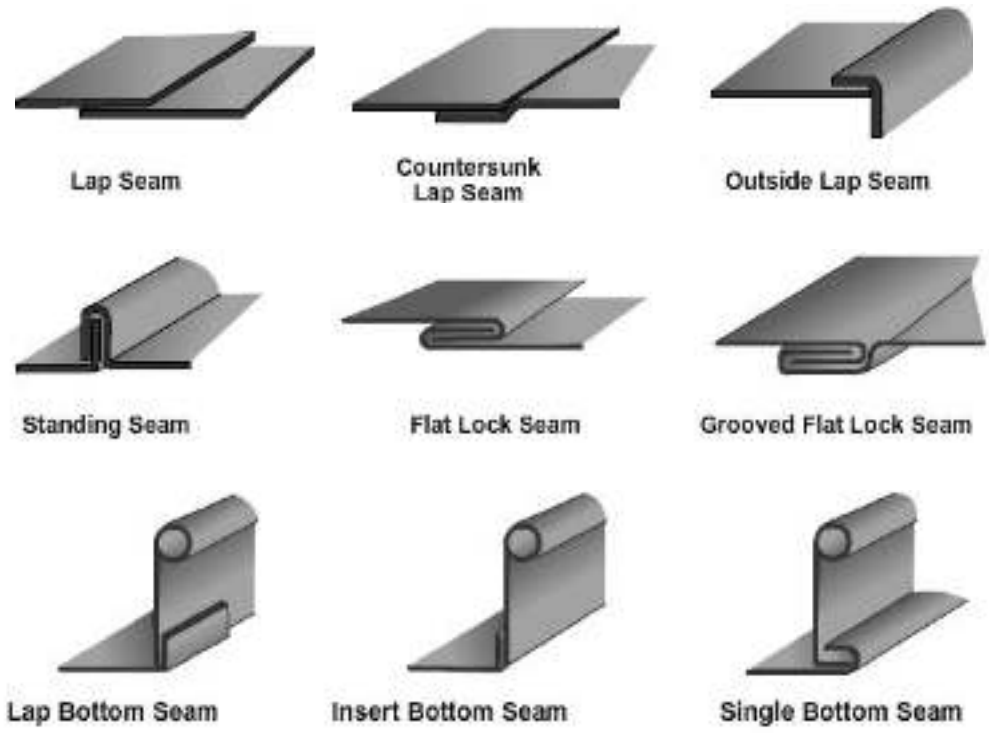


Figure 2.9.Common sheet-metal seams

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.

Figure 2.10.Types of Lap seam

The **Pittsburgh lockseam** is a comer 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 comers 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.

Figure 2.11.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.

Figure 2.12.Dovetail lock seam

Notching is the last step to be considered when you are getting ready to lay out 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 comer when a single hem is to meet at a 90-degree angle.

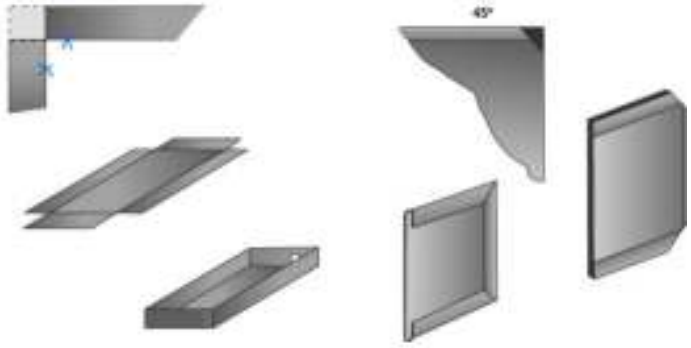


Figure 2.13. Notches

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.

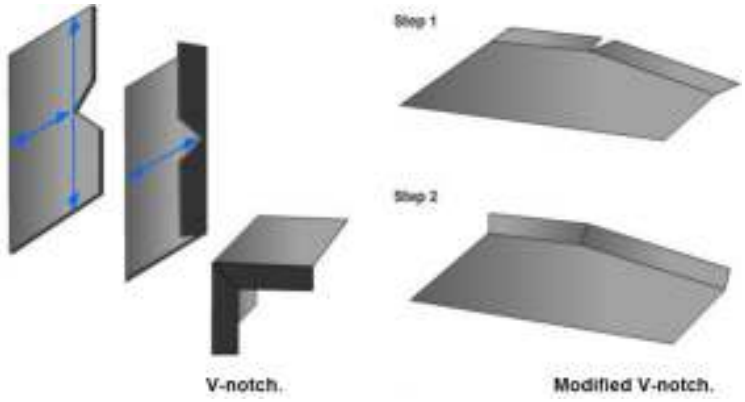


Figure 2.14.Types of notching

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.

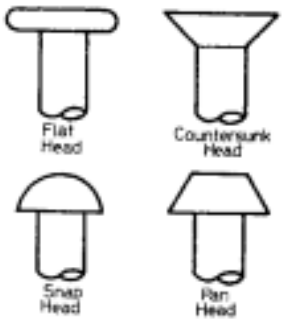


Figure 2.15.Types of rivets

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 3to 10mm in diameter in 0.75mm steps and from 6 to 76mm in length

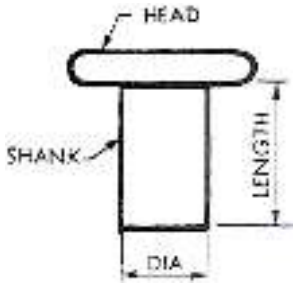


Figure 2.16.Sizes of rivets

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 90 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.

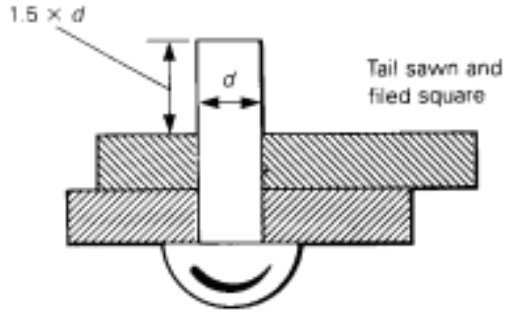


Figure 2.17 Rivet size

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.

Figure 2.18.Rivet set

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 ot 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

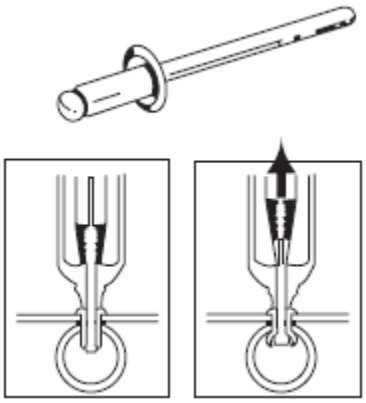


Figure 2.19. Operating principle of hollow rivet

Work piece materials

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

Hole size and preparation

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

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.

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.

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.

Rivet material

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

2.5. Pattern development

Layout or development generally refers to the method of developing the lines which form the pattern. The common methods of layout or development are:-

Parallel Line Development

Radial Line Development

Triangulation

2.5.1. Parallel Line Development

It uses a series of parallel lines to develop square, rectangular and cylindrical shapes. The patterns of these shapes are shown when they are unfolded or rolled out flat. They are often referred to as "**stretch outs**".

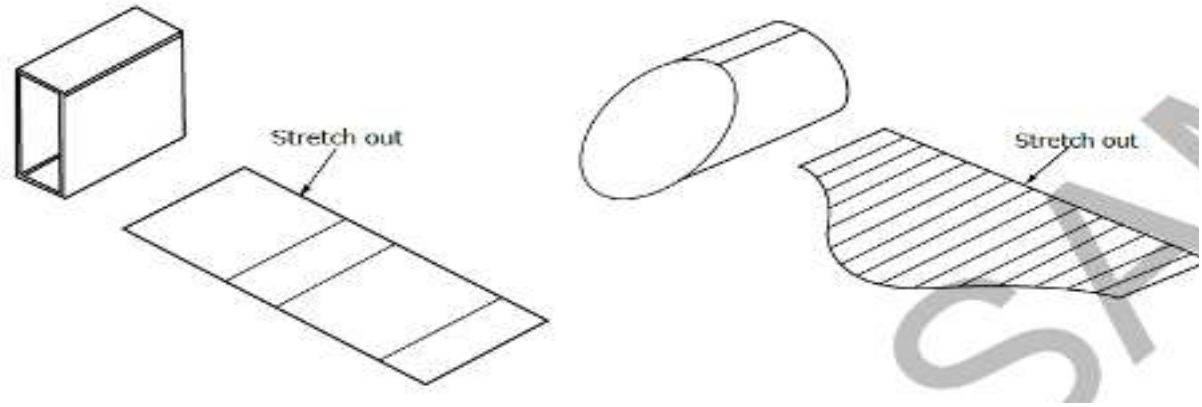


Figure 2.20. Parallel line development

Parallel line development is based upon the fact that a line that is parallel to another line is an equal distance horn that line at all points. Objects that have opposite lines parallel to each other or that have the same cross-sectional shape throughout their length are developed by this method To gain a clear understanding of the parallel line method, we will develop, step by step, a layout of a truncated cylinder (fig. 2-21). Such apiece can be used. This piece of sheet metal is developed in the following procedure:

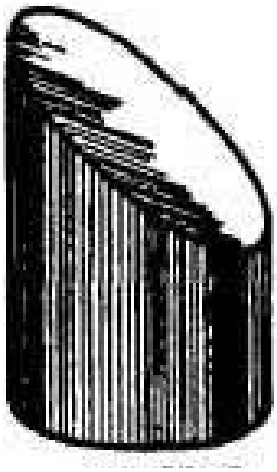


Figure 1.21.truncated cylinder

1. First, draw a front and bottom view by orthographic projection (figure 1.22, view A).
2. Divide half the circumference of the circle (figure 1.22, view A) into a number of equal parts. The parts should be small enough so that when straight lines are drawn on the development or layout between division points, they will approximate the length of the arc. Project lines from these points to the front view, as shown in figure 1.22, view B. These resulting parallel lines of the front view are called elements.
3. Lay off the baseline, called the stretch-out line, of the development to the right of the front view, as shown in figure 1.22, view C.

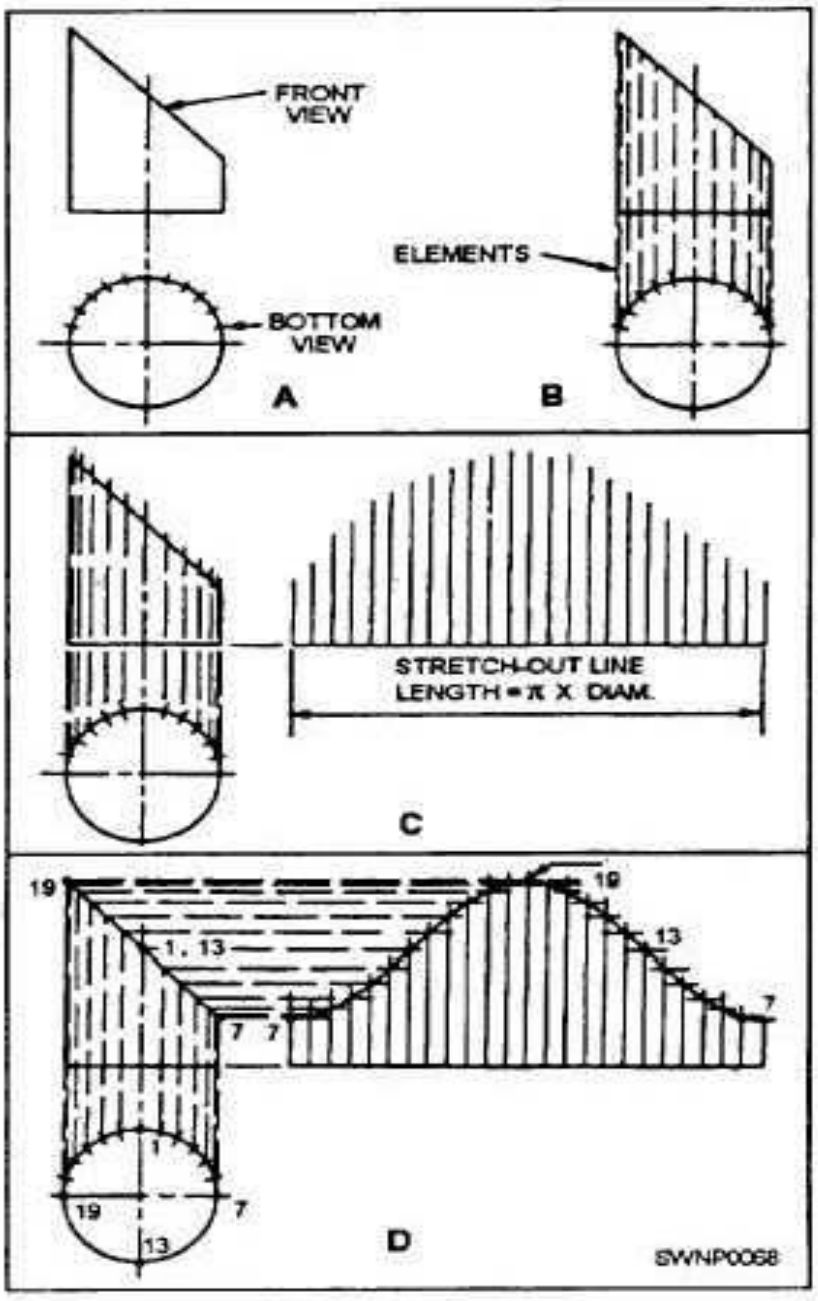


Figure 1.22. Stretching out line

4. Divide the stretch-outline into twice the number of equal parts equal to each division of the circumference on the half circle of the orthographic view (figure 1.22,, view C).

5. Erect perpendicular lines at each point, as shown in figure 1.22, view C.

6. Using a T-square edge, project the lengths of the elements on the front view to the development (figure 1.22, View D).

7. Using a curve (French or other type), join the resulting points of intersection in a smooth curve. When the development is finished, add necessary allowances for warns and joints, then cut out your patterns.

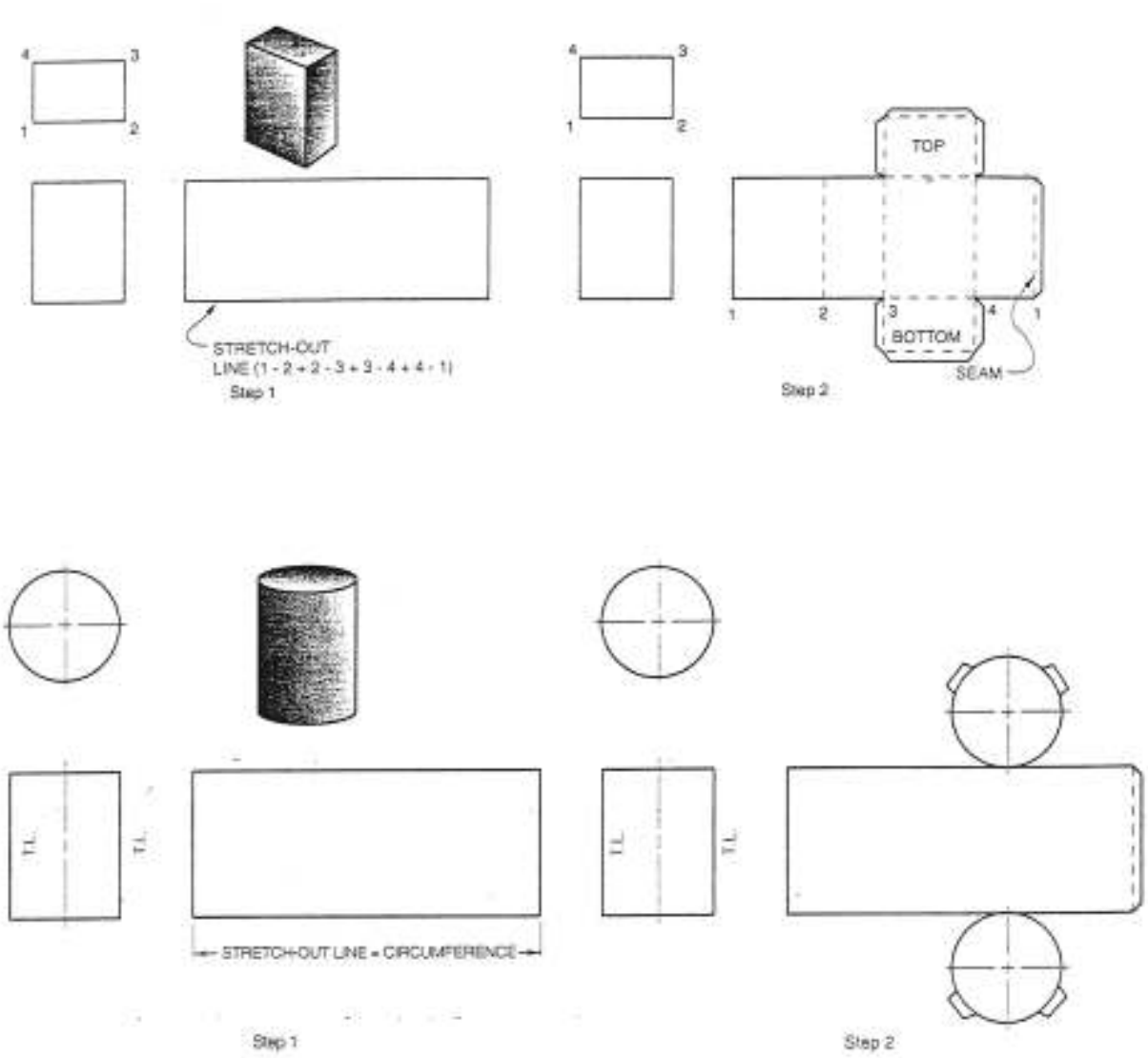


Figure 1.23. Development of a rectangular box

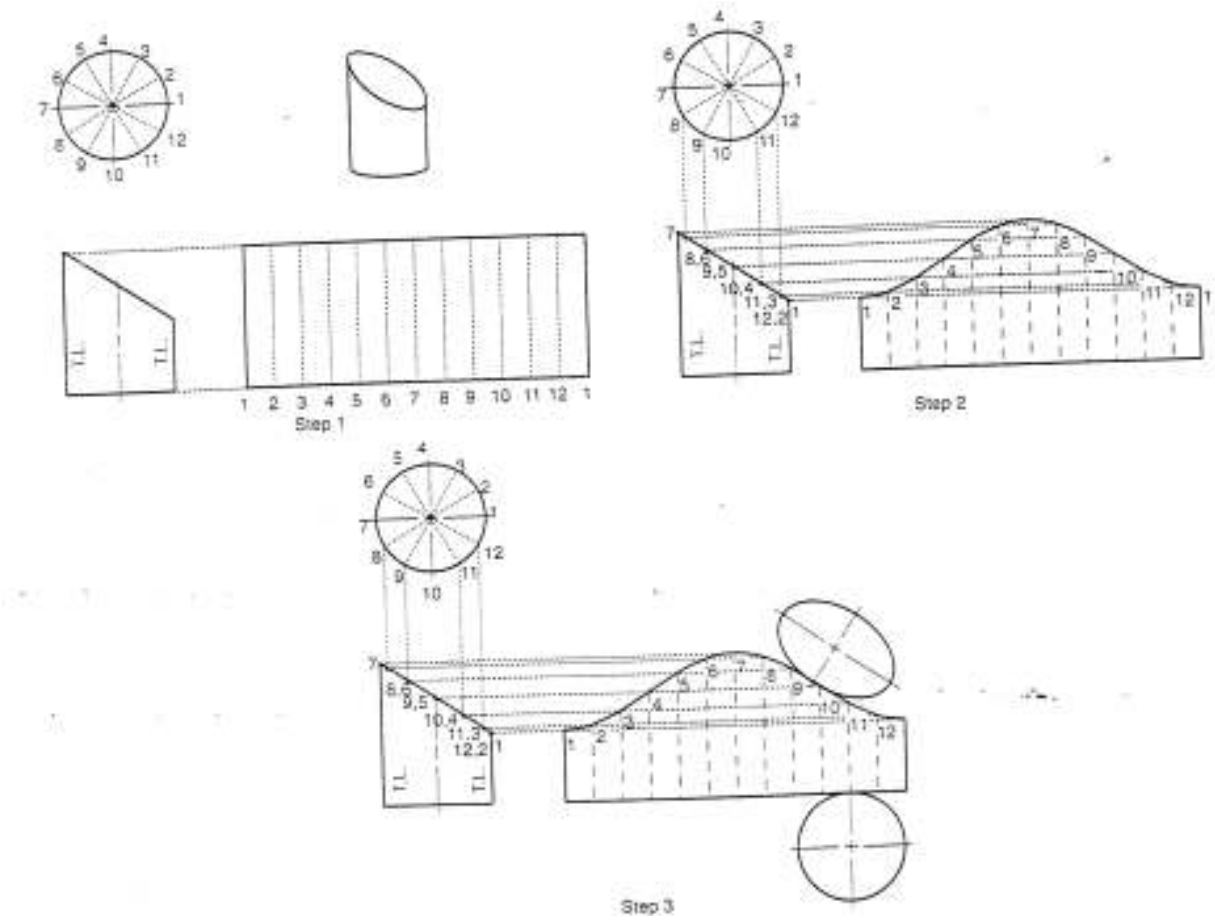


Figure 1.24. Development of a truncated cylinder

2.5.2. Radial line development

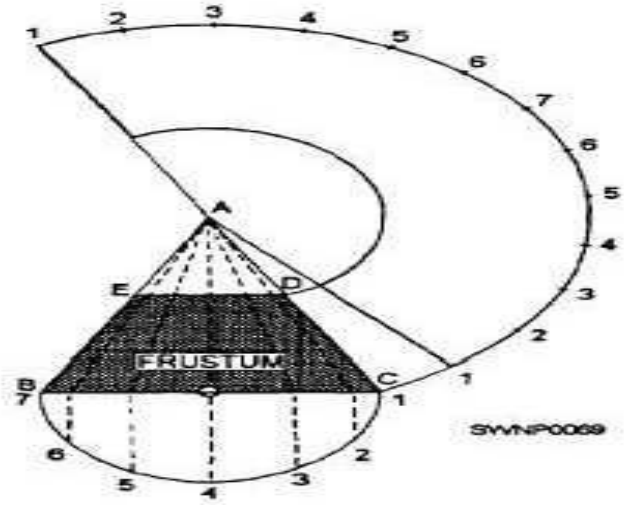
It uses radial lines to develop patterns of pyramids and conical shapes. Generator lines radiate from the apex of the pyramid or cone. These lines are used to develop the pattern or stretch-out.

- The radial line method of pattern development is used to develop patterns of objects that have a tapering form with lines converging at a common center. The radial line method is similar in some respects to the parallel line method.
- Evenly spaced reference lines are necessary in both of these methods. But, in parallel line development, the reference lines are parallel like a picket fence. In radial line development, the reference lines radiate from the APEX of a cone like the spokes of a wheel.
- The reference lines in parallel line development project horizontally. In radial line development, the reference lines are transferred from the front view to the development with the dividers. Developing a pattern for the frustum of a right

cone is a typical practice project that will help you get the feel of the radial line method.

- You are familiar with the shape of a cone. A right cone is one that, if set big-side-down on a flat surface, would stand straight up. In other words, a centerline drawn from the point, or vertex, to the base line would form right angles with that line. The frustum of a cone is that part that remains after the point, or top, has been removed. The procedure for developing a frustum of a right cone is given below.

1. Draw a cone ABC with line ED cutting the cone in such a way that line ED is parallel to the base line BC. EDCB is called a frustum.
2. With center O and radius OB, draw the half-plan beneath the base line BC. Divide the half-plan into an equal number of parts and number them as shown.
3. With vertex A as a center and with dividers, set a distance equal to AC and draw an arc for the stretch-out of the bottom of the cone.
4. Set the dividers equal to the distance of the step-offs on the half-plan and step off twice as many spaces on the arcs as on the half-plan; number the step-offs 1 to 7 to 1, as shown in the illustration (Figure 1.25).
5. Draw lines connecting A with point 1 at each end of the stretch-out. This arc, from 1 to 7 to 1, is equal in length to the circumference of the bottom of the cone.
6. Now, using A for a center set your dividers along line AC to the length of AD. Scribe an arc through both of the lines drawn from A to 1. The area enclosed between the large and small arcs and the number 1 line is the pattern for the frustum of a cone. Add allowance for seaming and edging and your stretch-out is complete.


FRUSTUM
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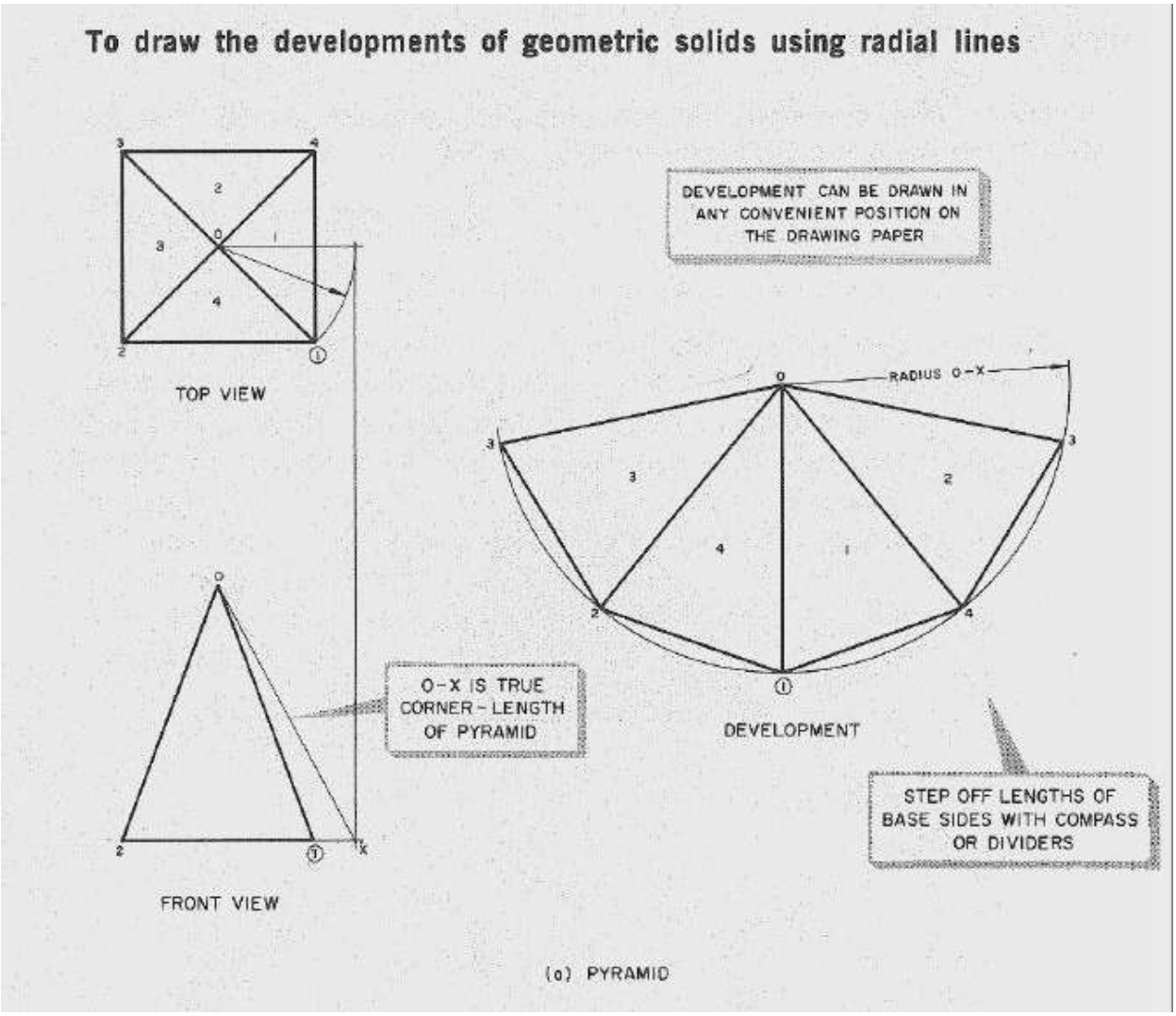

To draw the developments of geometric solids using radial lines
DEVELOPMENT CAN BE DRAWN IN ANY CONVENIENT POSITION ON THE DRAWING PAPER
TOP VIEW
RADIUS O-X
O-X IS TRUE CORNER - LENGTH OF PYRAMID
DEVELOPMENT
STEP OFF LENGTHS OF BASE SIDES WITH COMPASS OR DIVIDERS
FRONT VIEW
(a) PYRAMID

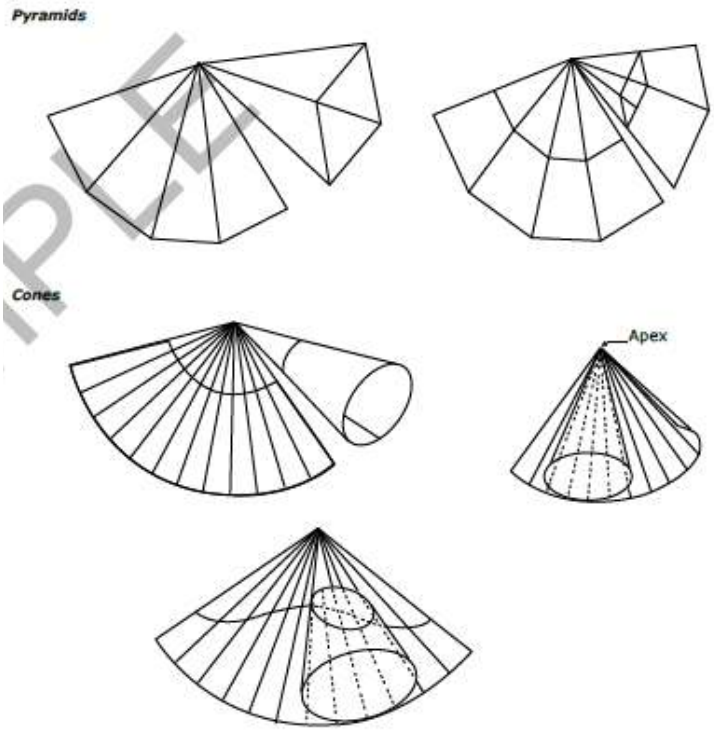


Figure 1.25.Radial line development of pyramid and frustum of a cone

2.5.3. Triangulation development

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.

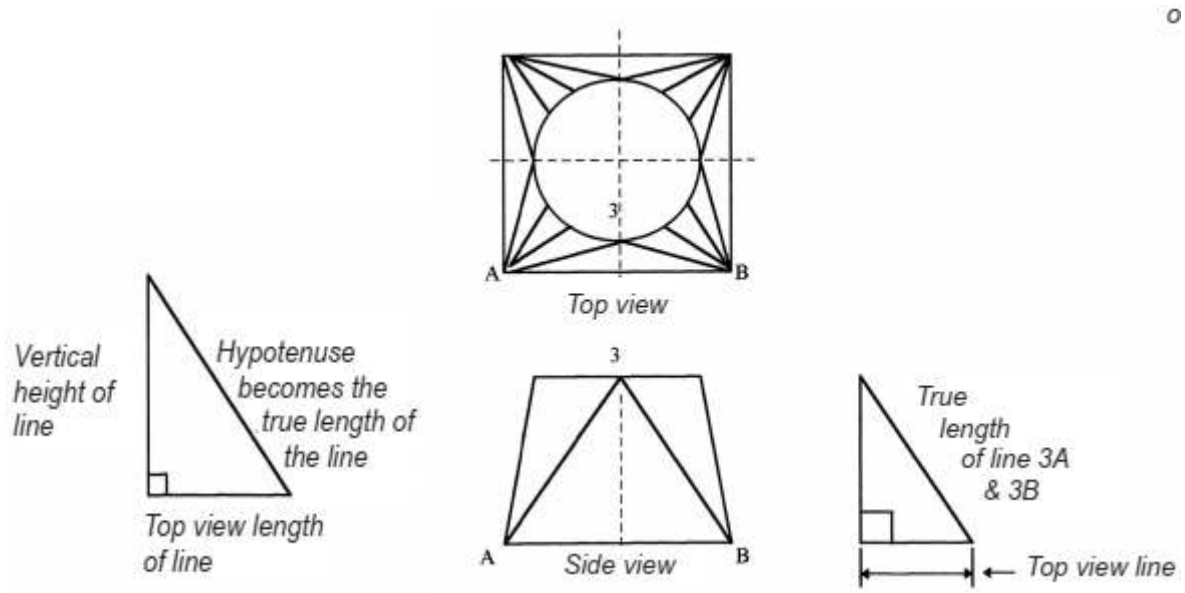


Figure 1.26.True length diagram

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

Lines

- Centerline

- Triangular (generator) lines
- Top view line
- Side view vertical height line
- Circumference
- Half circumference
- 1/12th circumference.

Surface

- Flat surface
- curved surface.

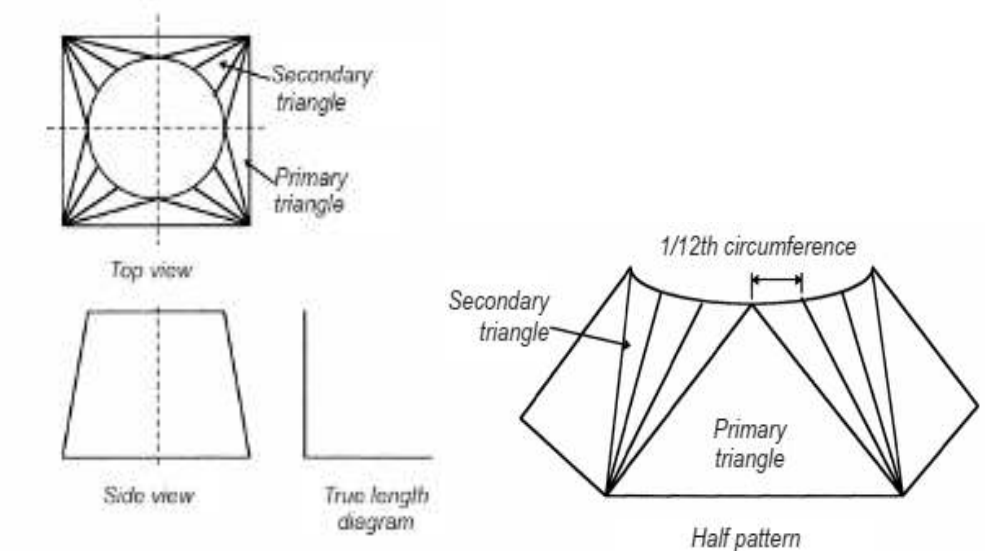


Figure 1.27. Triangulation development procedures

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.

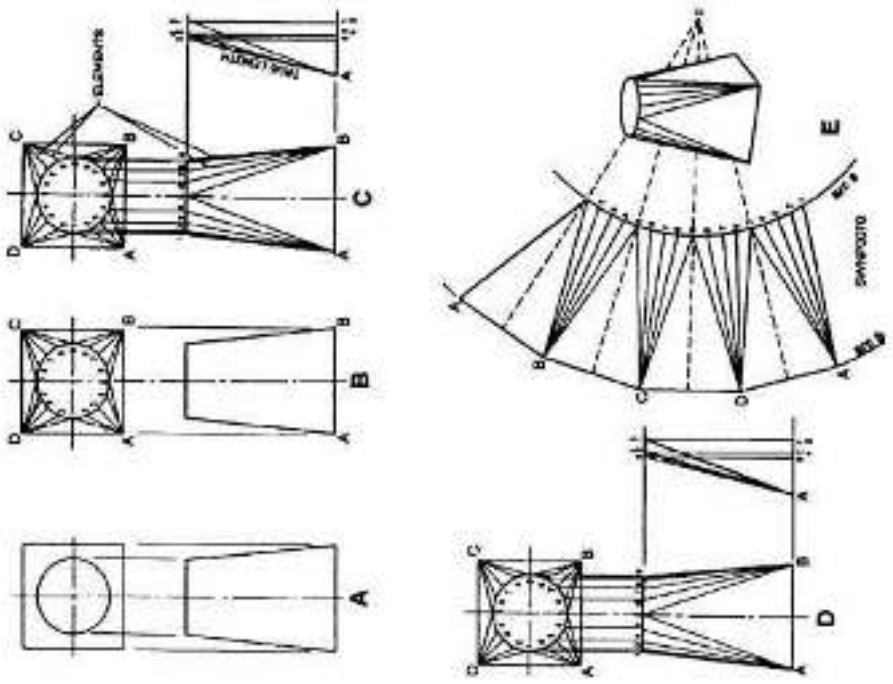
2.5.4. Triangulation method procedures

- Uses a series of adjoining triangles to develop patterns of irregular shaped transition pieces
- Triangulation is slower and more difficult than parallel line or radial line development, but it is more practical for many types of figures. Additionally, it is the only method by which the developments of warped surfaces may be estimated.

- In development by triangulation, the piece is divided into a series of triangles as in radial Line development. However, there is no one single apex for the triangles. The problem becomes one of finding the true lengths of the varying oblique lines. This is usually done by drawing a true length diagram. An example of layout using triangulation is the development of a transition piece. The steps in the triangulation of a warped transition piece joining a large, square duct and a small, round duct are shown in figurebelow. The steps are as follows:

1. Draw the top and front orthographic views (view a, figure 1.28.).

2. Divide the circle in the top view into a number of equal spaces and connect the division points with AD (taken from the top part of view D, figure 1.28).from point A. This completes one fourth of the development. Since the piece is symmetrical, the remainder of the development may be constructed using the lengths from the first part. It is difficult to keep the entire development perfectly symmetrical when it is built up from small triangles. Therefore, you may check the overall symmetry by constructing perpendicular bisectors of AB, BC, CD, and DA (view E, figure 1.28) and converging at point O. From point O, swing arcs a and b. Arc a should pass through the numbered points, and arc b should pass through the lettered points



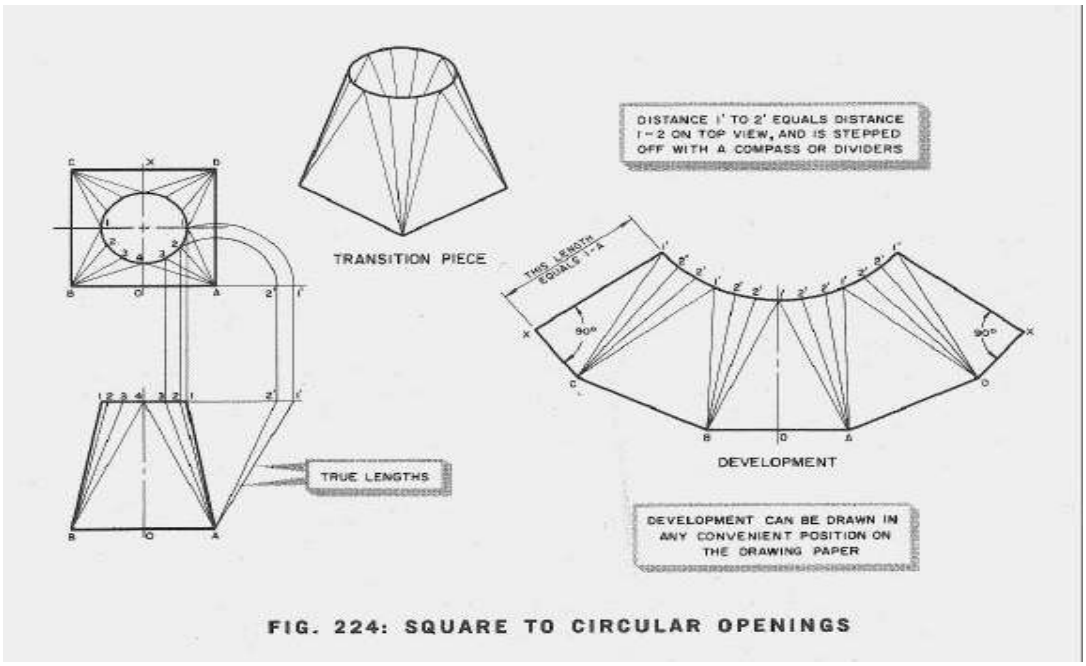


FIG. 224: SQUARE TO CIRCULAR OPENINGS

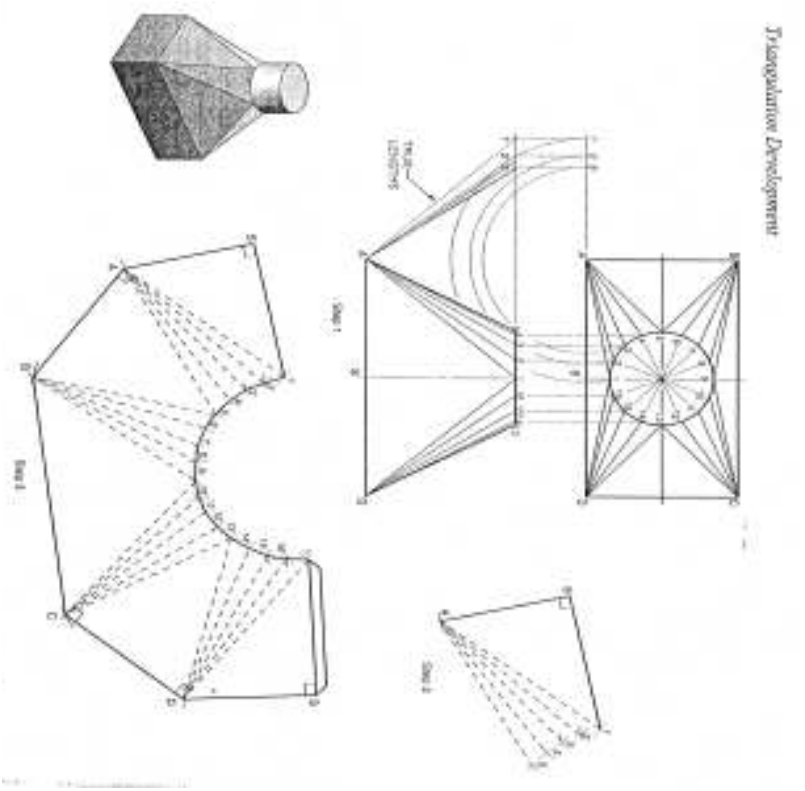


Figure 1.28.Triangulation of a warped transition piece joining a large, square duct and a small, round duct

Self-check 2

Part-I Multiple Choice

Instruction: 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

Part-II Matching

A B

1. Process of associating numbers with physical quantities A/Hand snips

2.Used to cut sheet metals B/Measurement

3.Plain seam, offset seam, and corner seam C/ square notch

D/ three types of lap seams

Part: III.Say True if the statement is correct or false if the statement is incorrect

1. Radial line development, it uses radial lines to develop patterns of pyramids and conical shapes?

2. Parallel Line Development, it uses a series of parallel lines to develop square, rectangular andcylindrical shapes?

3. The size of a rivet is measured by the diameter and length of the body?

Operation sheet: 1

Operation title: Techniques of Laying out and cutting

Purpose: to applyingLaying out Techniques

Instruction: Use proper tools & equipment's within Techniques

Procedure: Techniques of Laying out and cutting on a given sheet metal procedures are:

1- Observed safety precautions, use appropriate PPEs

2- Clean the surface of sheet metal by cleaning materials

3- Copy the given drawing on the drawing papers.

4- Collect the necessary tools and sheet metal.

5- Draw the layout on the work material by using measuring tools and laying out tools.

6- Cut the Sheet along the marked out line by using cutting tools or equipment.

7- Check the edges of sheet for straightness and perpendicularity with the help of try square.

8- Mark the necessary lines to practice straight line cutting.

9- Cut the sheet along the marked lines using straight snips and straighten the sheet by the mallet.

10- Check the dimensions and finish the model.

Quality Criteria: Accuracy of dimension

Precautions: Use proper tools & equipment's, with safety precautions.

Operation sheet-2

Operation title:Developing Book rake store

Purpose: Exercising sheet metal cutting& bending methods

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

Procedure: -

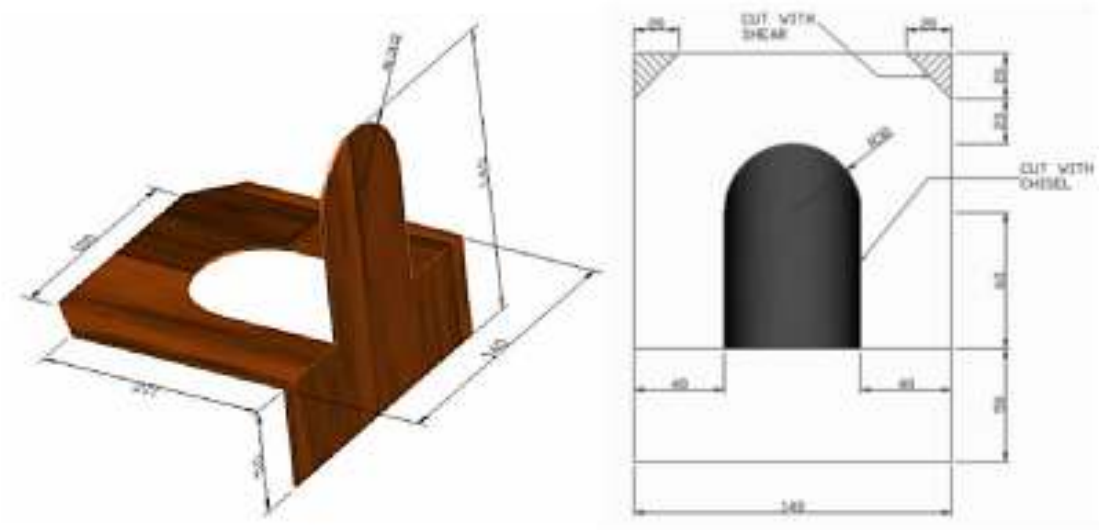
1 Clean the given sheet with cotton waste.

2 Draw the orthographic view as shown in above figure and check with steel rule the size of the given sheet.

1. Mark the measurement and make the development surface sketch diagram.
2. The layout of the cylindrical shape pipe is marked on the given sheet
3. Set 5mm and10mm extra allowance for joining at the ends.
4. Trace the development on given G.P.sheet (galvanized plain sheet 28 gauge) and mark all bending lines
5. Cut the sheet along the line according to the development shape
6. Bend the seam line using bending dies or to the required shape using stakes and mallet.
7. Fold extra allowances in clockwise and anticlockwise directions by keeping hacksaw blade thickness and pressed
8. Remove hacksaw blade, and bend main body using rectangular stake and lock end joint and lock
9. Now the edges are slightly bent to one is one side and the other is opposite side, using stakes and mallet.
10. Join both the ends with in a cylindrical shape.
11. Finish all rectangular faces and longer edges using rectangular faced stakes

Quality Criteria: Accuracy of dimension

Precautions: Use proper tools & equipment’s, with safety precautions.



Operation sheet-3

Operation title: - tray and dustpan

Purpose: - to applying work place preparation

Instruction: - follow the stapes & prepare work place properly

Procedure: -

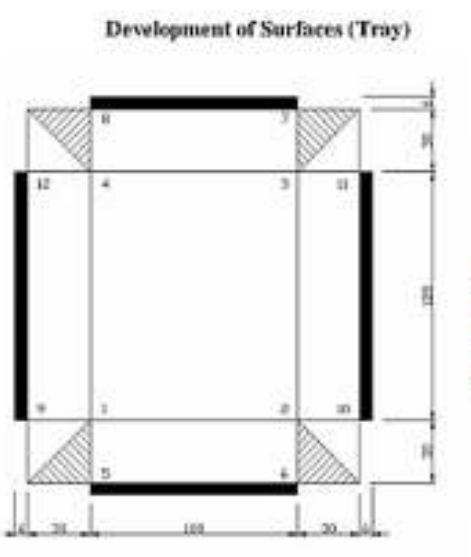
Sequence of operation to prepare tray and dustpan in sheet metal are**:**

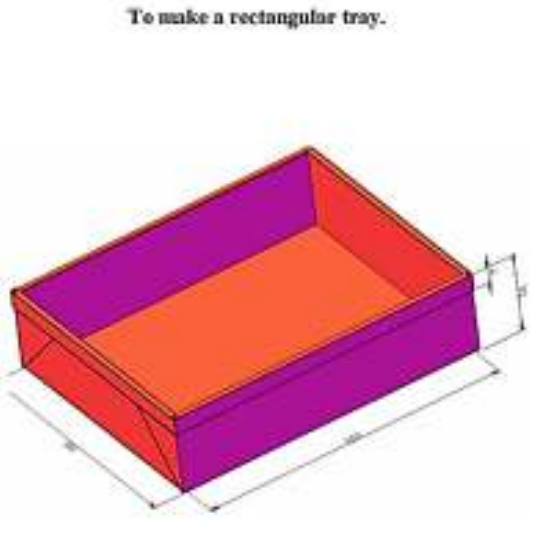
1. Draw 2D/3D sketch as per scale.
2. Draw the development considering all lines must be “TRUE LENGTH”.
3. Construct the base of the Tray/Dust pan.
4. Construct the two sides of the Tray /Dust pan.
5. Construct the two ends of the Tray or Dust pan.
6. Set 5mm extra allowance on side face for joining the corners by seaming.
7. Notch the point to prevent bulging in seaming.
8. Cut the development shape on lines by using scissor.
9. Place and fix the development on given G.P sheet by using Sticker.
10. Punch two thin points on each bending line.

11. Mark the boundary lines and bending lines with scriber and again mark with marking pen for visible.
12. Shear the boundary line with hand snip or shearing machine.
13. Flatten the sheet by using the mallet on flatter.
14. Always bend seaming line first then the remaining lines to get the desired shape.
15. Perform the forming operation with using suitable stake.
16. Solder the joints.
17. Finish the surface finishing and complete the Tray or Dustpan.

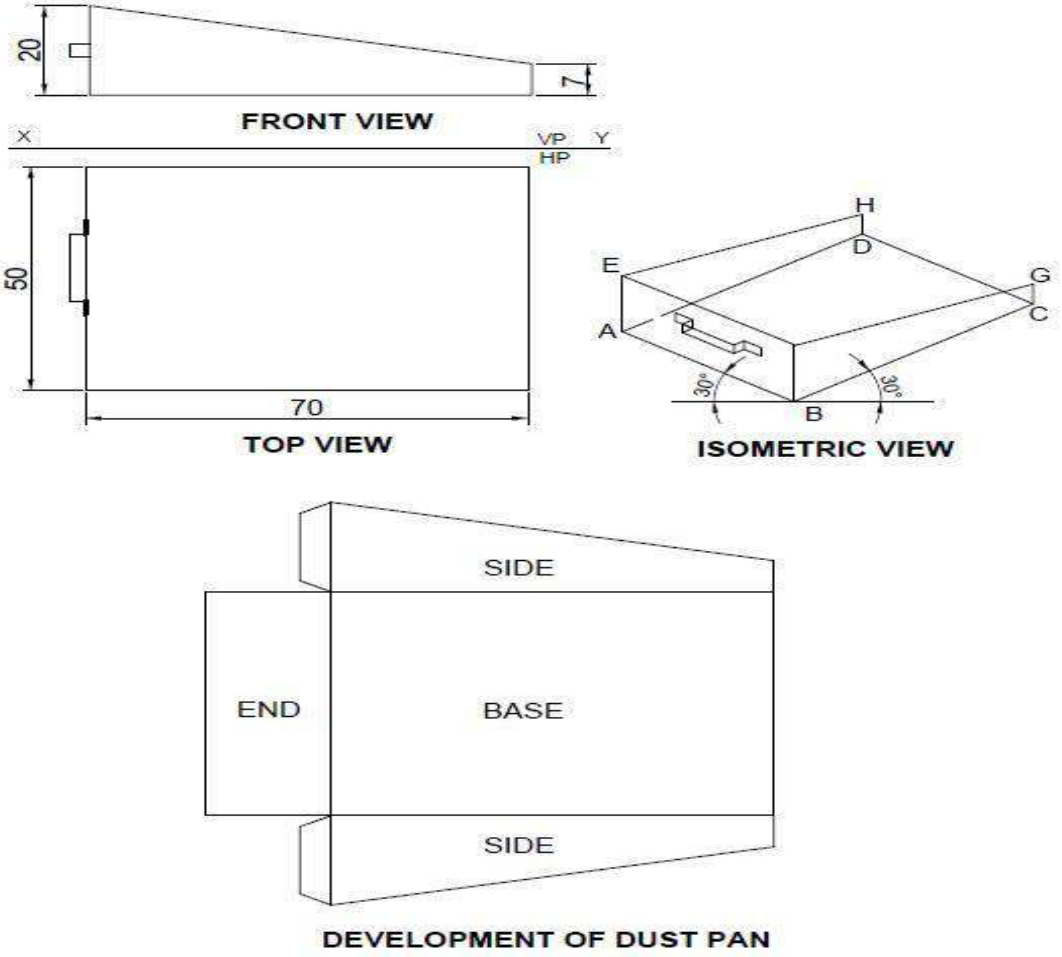
Quality Criteria: Accuracy of dimension

Precautions: Use proper tools & equipment's, with safety precautions.





DUST PAN



Lap Test: 2

Task 1: Perform Laying out, cutting and joining operations on sheet metal

Task 2: Perform book rakemaking

Task 3: Make square funnelusing the given G.I. Sheet or mild steel sheet

Unit Three: Quality Assures

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.

3.1. Measuring joints and sealed components

3.1.1. Types of joining

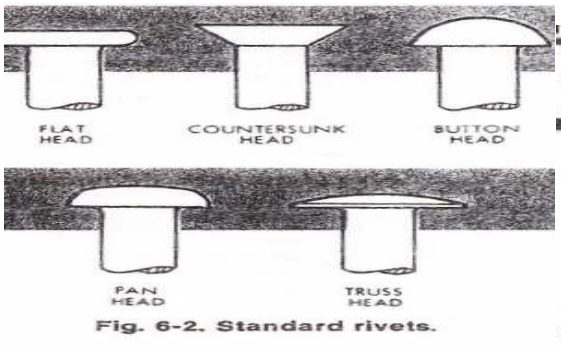
There are many ways of joining metal permanently. The method used will depend on the function of the product, the strength needed and the quality of the product.There are several ways of joining metal permanently.

- 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 SolidRivets.



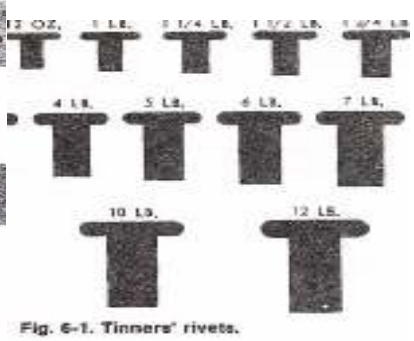


Figure 3.1. Standard rivets

Figure 3.2. Thinner rivets

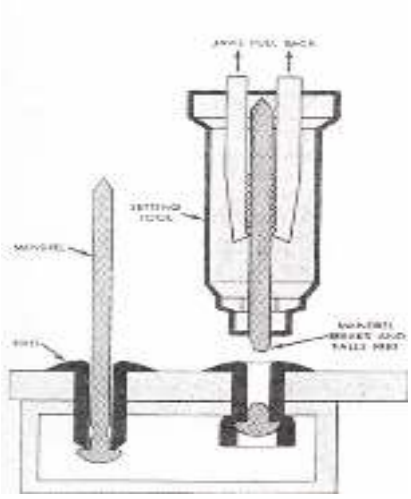


Figure 3.3. Blind rivet

Figure 3.4. 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).

3.1.2. 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.

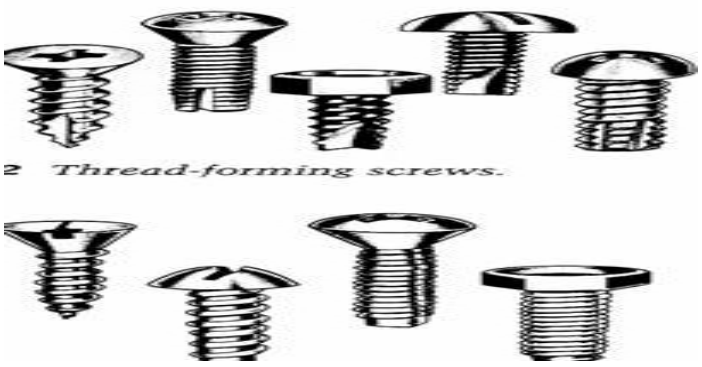


Figure 3.5. Thread cutting screws

3.2. Maintaining working 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**.**

A. 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.

B. 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.

C. 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.

D. **Cleaning, checking, maintaining and storing work area, tools**

Identify work areas to be cleaned and maintained, work equipment to be cleaned and maintained, Identify and locate instructions in relation to cleaning and maintenance, Assess area to be cleaned. Select appropriate cleaning equipment. material and chemicals. Select the protective clothing and equipment to be used. Dispose of waste, Return area to operational condition, Clean, check and store cleaning equipment and chemicals.

3.2.1. Cleaning your work area

Cleaning your work area makes it a safe and pleasant environment for your customers to shop. The cleaning of your work area must be carried out on a regular basis. The quick and easy jobs can be carried out during the day, while other larger tasks such as vacuuming might be done before the shop opens, or at the end of the day's trading. In some larger retail stores, professional cleaners may be used for the larger tasks, but it is still your responsibility to keep your own work area clean and tidy.

In this activity you will learn about cleaning procedures and how to dispose of waste correctly. You will also learn how to handle spills or other potential hazards efficiently to protect customers and your workmates from potential injury.

Poor housekeeping can be a cause of incidents, such as:

A. tripping over loose objects on floors, stairs and platforms

B. being hit by falling objects

C. slipping on greasy, wet or dirty surfaces

D. striking against projecting, poorly stacked items or misplaced material

E. cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

Effective housekeeping results in:

F. reduced handling to ease the flow of materials

G. fewer tripping and slipping incidents in clutter-free and spill-free work areas

H. decreased fire hazards

I. lower worker exposures to hazardous products (e.g. dusts, vapours)

J. better control of tools and materials, including inventory and supplies

K. more efficient equipment cleanup and maintenance

L. better hygienic conditions leading to improved health

M. more effective use of space

N. reduced property damage by improving preventive maintenance

O. less janitorial work

P. improved morale

Q. improved productivity (tools and materials will be easy to find)

3.2.2. Checking and cleaning tools and equipment

Keeping tools properly storing, cleaning, and maintaining will save time and money. In order to keep tools in good working condition during storage, there are some basic preparatory steps that should be taken. It is important to follow the cleaning and storage instructions, especially for larger power tools such as power saws or plate compactor.

Tool housekeeping is very important, whether in the tool room, on the rack, in the yard, or on the bench. Tools require suitable fixtures with marked locations to provide an orderly arrangement. Returning tools promptly after use reduces the chance of it being misplaced or

lost. Workers should regularly inspect, clean and repair all tools and take any damaged or worn tools out of service.

3.2.3. Maintaining of tools and equipment

The maintenance of tools and equipment may be the most important element of good housekeeping. Maintenance involves keeping tools, equipment and machinery in safe, efficient working order and in good repair. It includes maintaining sanitary facilities and regularly painting and cleaning walls. Broken windows, damaged doors, defective plumbing and broken floor surfaces can make a workplace look neglected; these conditions can cause incidents and affect work practices. So it is important to replace or fix broken or damaged items as quickly as possible. A good maintenance program provides for the inspection, maintenance, upkeep and repair of tools, equipment, machines and processes. Maintenance of equipment's: Maintenance of sheet metals machines

- Changing worn blade
- Changing deformed gasket
- Operating frequently
- Changing oil monthly
- Greasing rotating or vibratory parts
- Regular Lubrication
- replacement of worn parts

Maintenance of Grinder

- lubricating with cleaned oil
- Replacing of worn parts of grinding machine.
- Cleaning dusts and other materials
- Changing worn blade

3.2.4. Storing tools and equipment

Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual material handling is required. The location of the stockpiles should not interfere with work but they should still be readily

available when required. Stored materials should allow at least one meter (or about three feet) of clear space under sprinkler heads.

Stacking cartons and drums on a firm foundation and cross tying them where necessary, reduces the chance of their movement. Stored materials should not obstruct aisles, stairs, exits, fire equipment, emergency eyewash fountains, emergency showers, or first aid stations. All storage areas should be clearly marked.

Flammable, combustible, toxic and other hazardous materials should be stored in approved containers in designated areas that are appropriate for the different hazards that they pose. Storage of materials should meet all requirements specified in the fire codes and the regulations of environmental and occupational health and safety agencies in your jurisdiction.

How to Prepare and Store Tools

1. To keep tools tidy, it should be cleaned after use and wiped down with a rag or towel to be sure that they are free of dirt, grease and debris.
2. After cleaning, damage or defects should be checked. If the tool cannot be repaired, it should be thrown to away.
3. Any soil and dirt should be scraped away from the metal surfaces with an approved solution. Before placing in storage it should be dried with a towel or rag.
4. The metal parts of the tools should be coated with a lubricant protector spray.
5. Tools is does not directly stored on the ground both small hand and power tools should be Placed on shelving.
6. Short-handled tools should be stored in a plastic bin or box. All surfaces of Power tools should be cleaned and completely dry before storage and Spraying lubricants

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.

3.3. 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.

3.3.1. Importance of Documentation

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

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

3.3.2. 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.

3.3.3. 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: 3

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 D. all

Part-II Say True or False

1. Documentation includes any kind of record-keeping about an office environment?
2. Cleaning your work area makes it a safe and pleasant environment for you?
3. Effective housekeeping results areimproved morale?

Part three: Match

AB

1. Form of resistance weldingA. Effective housekeeping results
2. decreased fire hazards B. Spot welding
3. kind of record-keeping about an office C.Manufacturing testing
   D.Documentation includes