Trade of Sheet Metalwork	
Module 1:	Sheetmetal Fundamentals
Unit 12:	Riveting
	Phase 2

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Document Release History

Date	Version	Comments
11/07/06	First draft	
04/04/14	2.0	SOLAS transfer

Module 1 – Sheetmetal Fundamentals

Unit 12 – Riveting

Duration – 3 Hours

Learning Outcome:

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

- Describe different types of rivets and their applications
- Calculate rivet lengths for rivet types, size
- Assemble components for riveting
- Assemble components using universal & countersink rivets
- Make countersink rivet holes to suit rivets

Key Learning Points:

Rk	Different metals, their properties and benefits.
Rk	Benefits of riveting as against other jointing methods.
Rk	Component preparations.
Rk	Errors made preparing parts for riveting.
Rk	Correct methods used when preparing parts to be riveted.
Sk	Countersinking of rivet holes.
Sk	Closing of plates and forming rivet head.
Sk	Avoiding work marks from rivet dolly/set and snap.
M	Rivet length calculations.
M	Averages, percentages, ratios and proportion.

Training Resources:

- Toolkit
- Bench Vice
- Materials – 0.8mm mild steel, 0.9mm half hard copper, 1.5mm aluminium
- Combined rivet set and snap
- Demonstration and handouts from instructor
- Rivets of various types and lengths
- Dolly

Exercise:

Rivet together the parts described in Figure 1 to the given tolerances.

Key Learning Points Code:

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

P = Personal Skills Sk = Skill H = Hazards

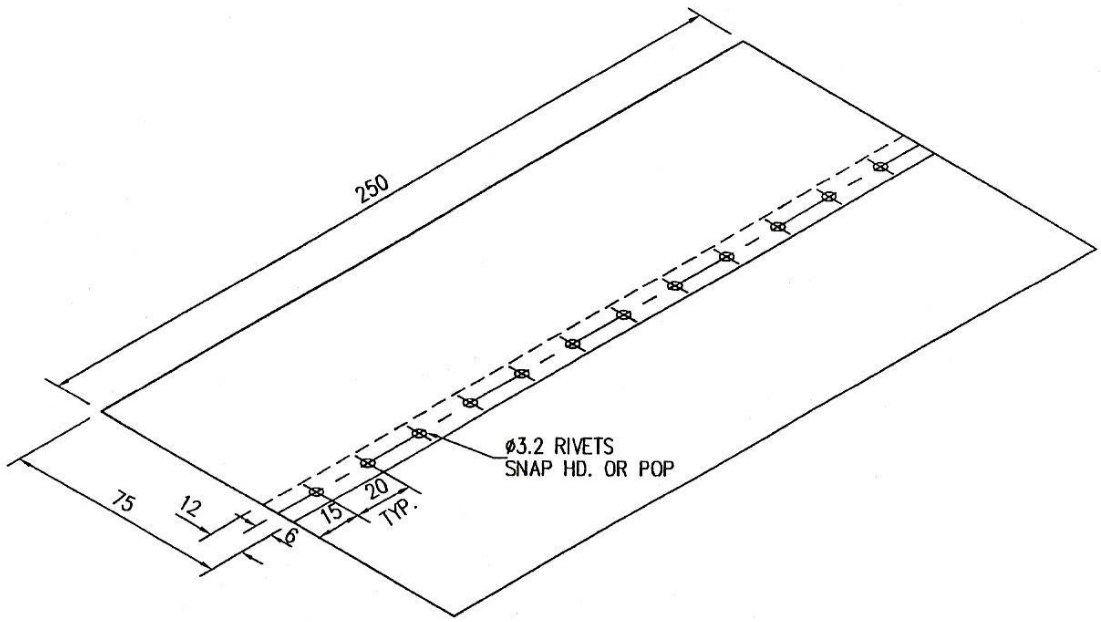


Figure 1 - Drilling/Riveting

Fasteners for Sheet Metal

There are several types of fasteners used to join pieces of sheet metal and to attach sheet metal to other materials. This chapter will cover the commonly used types of fasteners, their characteristics and standard designation and the various types of welding used in sheet metal work.

Rivets

Before modern welding techniques came into common use, riveting was one of the most common methods for joiing sheet metal. Since the advent of the new welding techniques and modern machines that form seams on sheet metal, riveted seams are not so common in modern sheet metal work. However, the sheet metal worker will often use rivets on sheet metal too heavy for machine forming and where welding is not practical.

Rivets may be made from steel, copper, brass, aluminium or other materials. Standards for rivets sizes and shapes have been put forward by several agencies.

Tinman’s Rivets

They are small flat headed rivets with relatively short lengths. The size number of tinman’s rivets are determined by the approximate weight per thousand rivets. Each weight of rivet has a definite diameter and length.

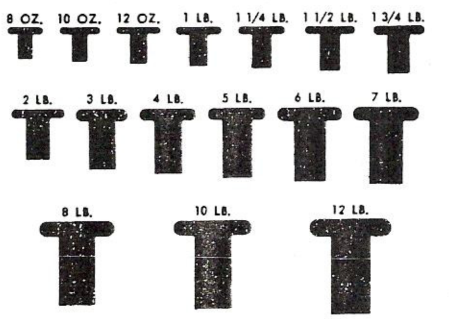


Figure 2 - Tinman's Rivets

Riveting

Riveting may be done by hand or by machine. When the job is performed by hand, as is usually the case in sheet metal work, it is done with a hammer and rivet set.

Types of Rivets

Many types of rivets are used in the sheet metal shop. The most common types are the tinman's rivets, flathead, snap head (also called roundhead) and pop rivets.

The countersunk is used where a flush surface is desired, and the snaphead when exceptional strength is required.

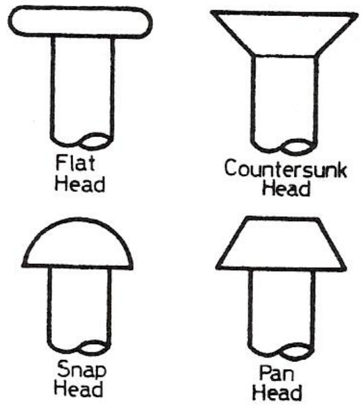


Figure 3 - Types of Rivets

Rivet Sizes

The size of the tinman's rivets are determined by the weight of 1,000 rivets i.e. 1 lb. rivets weigh 1 lb. per thousand, 2 lb. rivets weigh 2 lb. per thousand.

Flathead rivets vary in diameter from 3/32" to 7/16" in steps of 1/32". Other rivets vary in size with 1/8" and 3/16" snaphead rivets being the most popular in the sheet metal shop.

F1athead, snaphead and countersunk rivets may be purchased in various lengths depending upon the thickness of the metal being joined.

There are no definite rules to follow in selecting the size of a rivet. In general the length should be sufficient to protrude through the pieces being joined, from l½ times the diameter of the rivet. This allows ample material for forming the head.

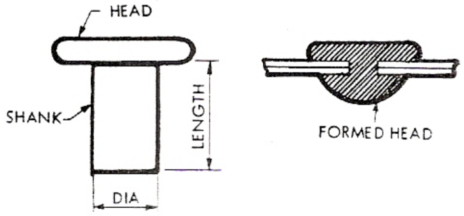


Figure 4 - Rivet Sizes

Forming Rivet Heads

The shallow cup-shaped hole shown by the cross section view of a rivet set is used to form the head on the rivet. The deep hole is used to draw the sheets and rivet together and also to draw the rivet directly through thin sheeting without previously punching a hole. The outlet on the side allows the metal slugs to drop out. The rivet set selected should have a hole, slightly larger than the diameter of the rivet. A good job of riveting can be done with not more than six normal blows of the hammer and after a little practice this number can be cut by half.

A skilled sheet metal worker will perform the operation in sequence by striking a blow on the rivet set, one blow to flatten the rivet down and another blow on the rivet set to form the head.

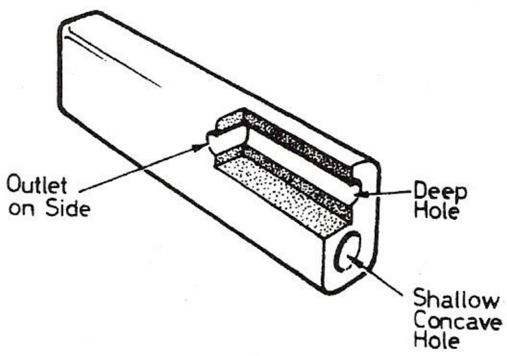


Figure 5 - Cross Section of Rivet Head

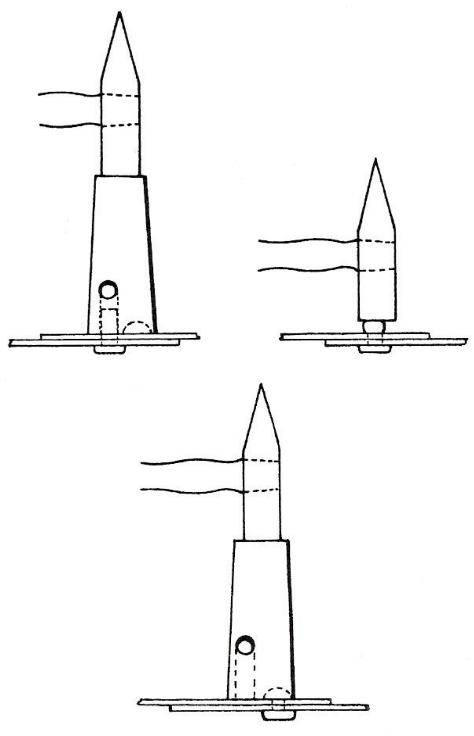


Figure 6 - Forming Rivet Heads

Spacing Rivet Holes

Rivet holes should be spaced according to the job specification. The space from the edge of the metal to the centre of the rivet line should be at least twice the diameter of the rivet, thus preventing the rivet from tearing out. The minimum distance between the rivets should be three times rivet dia. approx. The maximum distance between rivets should never be such that the material is allowed to buckle between them.

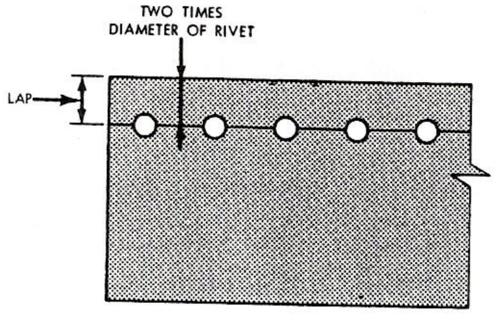


Figure 7 - Spacing Rivet Holes

The method of spacing rivet holes for longitudinal seams in pipes is different from the manner in which the rivet holes are spaced for cross seams.

Although there are various methods of laying out holes for longitudinal seams, the metal strip procedure is generally preferred when the same job is laid out repeatedly.

This method consists of using a narrow strip of metal in which the required number of holes have being evenly spaced and pricked punched. The strip is then laid on the edge of the metal and the location of the holes marked by prick punching through the strip into the metal. One draw back to this method is, as the strip is continually used the holes become enlarged and accurate marking becomes difficult.

Care should be taken to see that the strip is not reversed when switching to the opposite side of the work, since the distances from the end holes are not alike.

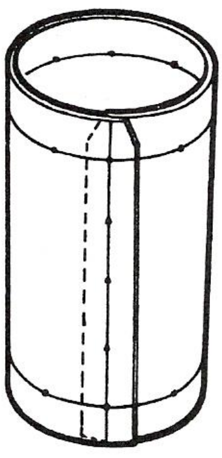


Figure 8 - Longitudinal Seams

Riveting Seams

When making round pipe with riveted seams, the section of the pipe should be formed with the burred edge of the hole on the outside of the pipe. After selecting the correct size rivets and rivet set and hammer, place a rivet in one end hole and place the job on a stake. Rivet as described previously, proceed to rivet other end and centre of cylinder and then rivet alternately right and left of centre.

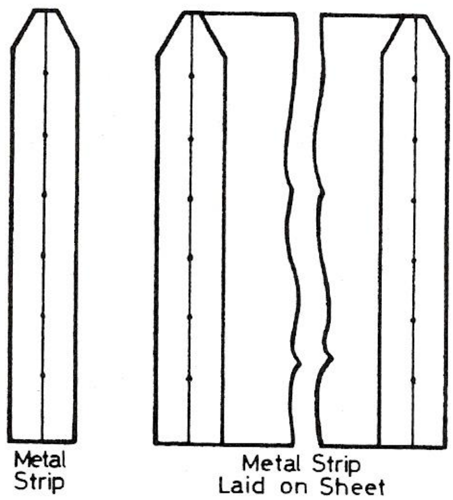


Figure 9 - Riveting Seams

Abbreviations

Term	Abbreviation
Across Flats	A/F
British Standard	BS
Centres	CRS
Centre line	CL or
Chamfered	CHAM
Cheese Head	CH HD
Countersunk	CSK
Countersunk head	CSK HD
Counterbore	C'BORE
Diameter (in a note)	DIA
Diameter (preceding a dimension)	Ø
Drawing	DRG
Figure	FIG
Hexagon	HEX
Hexagon head	HEX HD
Material	MATL
Number	NO
Pitch circle diameter	PCD
Radius (in a note)	RAD
Radius (preceding a dimension)	R
Screwed	SCR
Specification	SPEC
Spherical diameter or radius	SPHERE Ø or R
Spotface	S'FACE
Standard	STD
Undercut	U'CUT

Table 1 - Abbreviations for Written Statements

Single-Strap Butt Joint

To make a riveted butt joint it is necessary to use a separate piece of metal called a 'strap' to join the two component edges.

Double-Strap Butt Joint

When two cover plates are riveted on either side of a butt joint, the joint is known as a 'double-strap butt joint'.

When single or double straps are used for riveted butt joints the rivets may be arranged as follows:

Single riveted: One row of rivets on each side of the butt;

Double, triple or quadruple riveted: In which case the chain or zig-zag formation may be employed.

Riveted Joints

Riveting is a method of making permanent joints. The process consists of drilling or punching the plates to be riveled, inserting the rivet, and then closing it by an applied compression force so that it completely fills the hole and forms a rigid joint.

A variety of riveted joints is used in construction and fabrication work:

1. single riveted lap joint;
2. double riveted lap joint;
3. single-strap butt joint;
4. double-strap butt joint.

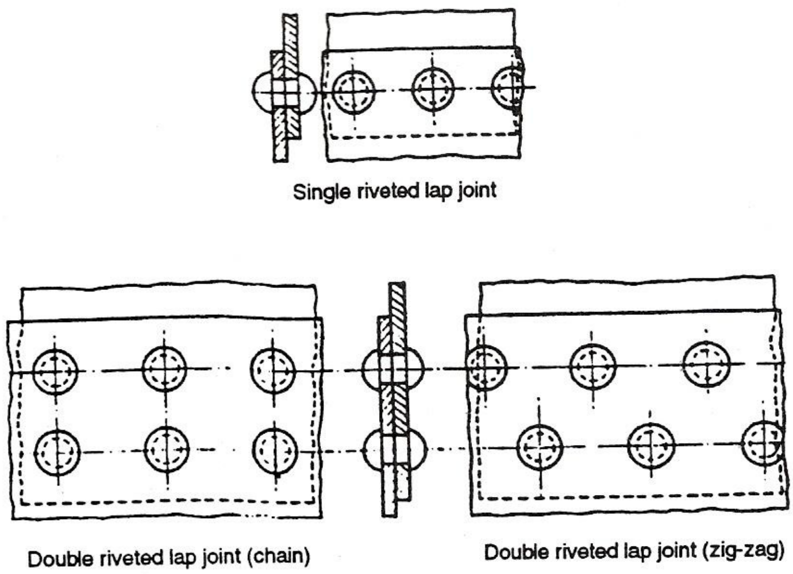


Figure 10 - Types of Riveted Joints

Single Riveted Lap Joint

This is the simplest of all riveted joints and is widely used for joining both thick and thin plates. The plates to be joined are overlapped by a short distance. Then a single row of rivets, conveniently spaced along the middle of the lap, completes the joint.

Double Riveted Lap Joint

A lap joint with two rows of rivets is known as a double riveted lap joint. Sufficient overlap must be provided to take a double row of rivets. This type of joint may have the two rows of rivets arranged in a square formation. This is known as chain riveting. If the rivets are arranged diagonally to form triangles, this is called zig-zag riveting.

Types of Rivet and Rivet-Head

The standard types of rivet heads are shown in Figure 11 and Figure 12. Also shown is the way in which thin material is joined to thick material with countersunk rivets.

Tinners and flat-head rivets are used in most general sheet metal fabrications, where the metal is very thin and little strength is required. The countersunk head is used when a flush surface is required, and the roundhead or snaphead is most widely used where the joint must be as strong as possible. Mushroom head or 'knobbled' rivets, as they are called in the steel construction industry, are used where it is important that the rivet head does not stick up above the surface too much. They are used on outer fuselage skins of aircraft in order to decrease 'drag'. In the case of steel chutes and bunkers they are used to reduce obstruction on the inside surfaces.

Pan head rivets are very strong and are widely used for girders and heavy constructional engineering.

'Tinners' are similar to flat-head rivets. They are made of soft iron and are usually coated with tin to prevent corrosion and to make them easier to soft solder.

Always use the correct rivet for a particular metal to be riveted. When riveting aluminium, for example, use aluminium rivets; and when riveting copper use copper rivets.

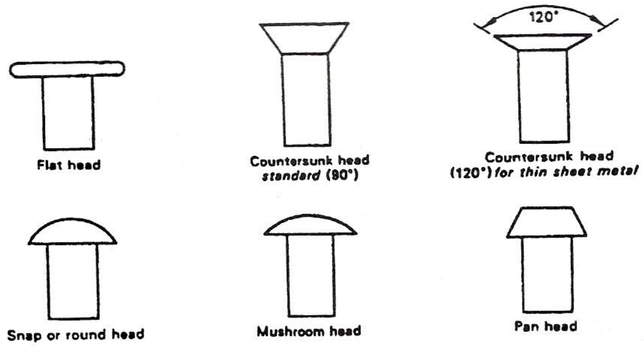


Figure 11 - Standard Types of Rivet Heads

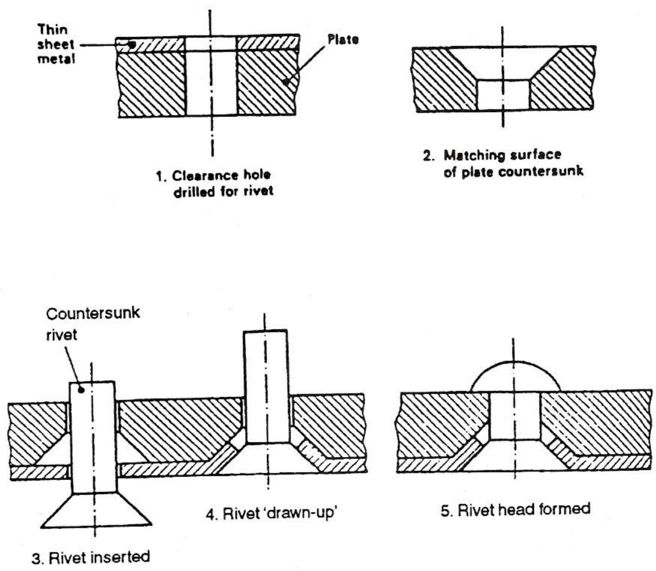


Figure 12 - Countersunk Riveting of Thin Material to Thick Material

Defects in Riveted Joint

When making joints with rivets, the following points should be followed to prevent many common defects:

1. use the correct allowance for edge clearance and pitch when marking out;
2. all drilled or punched holes should be made to the correct clearance size to suit the rivet diameter, or as specified on the drawing;
3. remove any 'burrs' from around the edges of all holes before finally assembling the parts to be joined;
4. ensure that holes are correctly aligned and matched before inserting the rivet;
5. use the proper type of rivet as specified on the drawing;
6. use rivets of the correct length;
7. when inserting rivets, do not attempt to force or drive them into the hole;
8. always use the correct tools for the job.

Some of the common forms of defects associated with riveted connections are shown in Table 2.

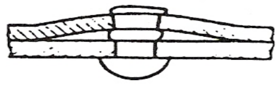
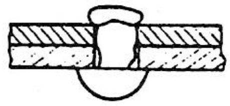
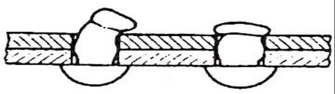
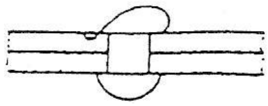
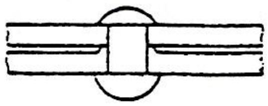
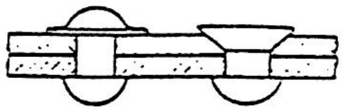
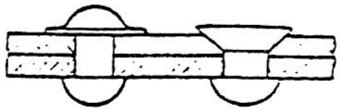
Cause of Riveting Defect	Resultant Effect
Sheets not closed together – rivet not drawn up sufficiently.	Weak joint. Rivet shank swells between the plates.  Not enough shank protruding to form correctly shaped head.
Rivet holes not matched.	Weak misshapen head.  Rivet deformed and does not completely fill the hole.
Insufficient hole clearance.	Rivet not completely 'drawn through'. Not enough shank protruding to form head.  Original head of rivet 'stands proud', the formed head is weak and misshapen.
Hole too large for rivet.	Hole not filled.  Rivet tends to bend and deform. Head weak and poorly shaped.
Rivet set or dolly not struck square.	Badly shaped head off-centre.  Sheet damaged by riveting tool.
Drilling burrs not removed.	Not enough shank protruding to form the correct size head.  Plates or sheets not closed together. Unequal heads.
Rivet too short.	Not enough shank protruding to produce correct shaped head.  Plate surface damaged. Countersinking not completely filled.
Rivet too long.	Too much shank protruding to form required head.  'Flash' formed around head (Jockey cap). Countersinking over-filled.

Table 2 - Common Defects in Riveting

The Strength of Riveted Joints

A riveted joint is only as strong as its weakest part, and it must be borne in mind that it may fail in one of four ways:

i. shearing of the rivet;
ii. crushing of the metal;
iii. splitting of the metal;
iv. rupture or tearing of the plate.

These four undesirable effects are shown in Figure 13 to Figure 16.

Note: For design purposes the rivet should only be loaded in shear and its tensile strength in assuming to be zero.

Selecting the Correct Size of Rivet

To obtain the full strength of a riveted joint, a rivet of the correct diameter and length must be used. For example, if a rivet of a larger diameter were inserted in a thin sheet, the pressure required to drive the rivet would cause bulging of the thin metal around the rivet head.

The diameters of rivets for metal plate work may be determined by use of the following formula:

$D = 1.25\sqrt{T}$ (Urwin's formula);

where D represents the required diameter of the rivet in inches, and T represents the plate thickness in inches.

Example: Determine the diameter of rivet required for a plate thickness of 0·25 inches (¼ inch).

Solution: D $= 1.25\sqrt{T}$

$= 1.25\sqrt{0.25}$

$= 1{\cdot}25 \; x \; 0.5$

Required diameter $= 0{\cdot}625$ inches for $\frac{5}{8}$ inch.

Note: When the thickness of the plate is given in millimetres.

1. Convert millimetres to inches (1 mm = 0·0394 inches).
2. Apply the formula.
3. Convert inches to millimetres (1 inch = 25·4 mm).

Example: Determine the diameter of rivet required for a plate thickness of 12·7 mm.

Solution: T $= 12{\cdot}7 \; x \; 0{\cdot}0394$

$= 0{\cdot}5$ inches (1)

D $= 1.25\sqrt{T}$ (2)

$= 1.25\sqrt{0.5}$

$= 1.25 \ x \ 0.707$

$= 0{\cdot}844$ inches or $\frac{7}{8}$ inches

$= 0{\cdot}844 \ x \ 25{\cdot}4$

Required diameter $= 22{\cdot}5$ mm

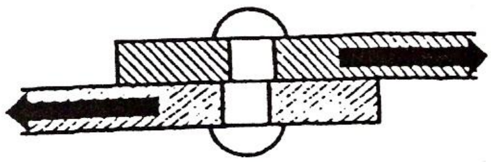


Figure 13 - Shearing of Rivet

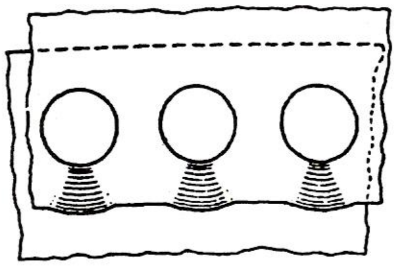


Figure 14 - Crushing of the Metal

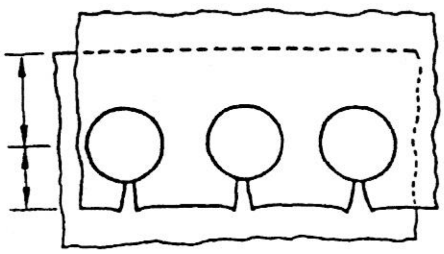


Figure 15 - Splitting of the Metal

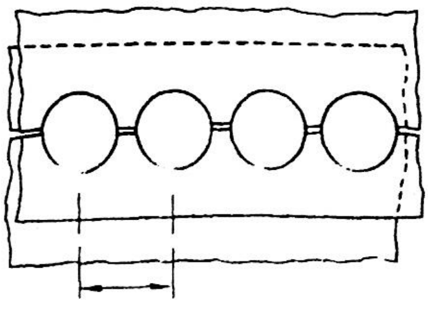


Figure 16 - Tearing of the Plate

Common Causes of Failure in Riveted Joints

Cause: Diameter of rivet too small compared with thickness of plate. The diameter of the rivet must be greater than the thickness of the plate in which it is to be inserted.

Prevention: Select the correct diameter rivet for the thickness of the plate.

Cause: Diameter of rivet too large compared with thickness of plate. The rivets when driven tend to bulge and crush the metal in front of them.

Prevention: Select the correct diameter rivet for the thickness of the metal plate.

Cause: Rivet holes punched or drilled too near edge of plate. Metal is likely to fail by splitting in front of the rivets.

Prevention: Drill or punch the rivet holes at the correct edge distance and use the correct lap allowance for the diameter of rivet selected.

Cause: Plates weakened by rivet holes being too close together. Plates tend to rupture along the centre line of the rivets

Prevention: Punch or drill rivet holes at the correct spacing or 'patch'. In addition remove all burrs from the holes before final assembly.

Diameter of Rivet used in Assembly

mm	Metal Thickness S.W.X.	Diameter of rivet (mm)
0.80 U	22	1.587
1.00 U	20	2.381
1.25 U	18	3.175
1.60 U	16	3.969
2.50 U	14	4.763
2.80 U	12	4.763 or 6.350
3.55 U	10	6.350 or 7.938
4.76		9.525
6.35		11.113 or 12.700
7.94		12.700 or 15.875
9.53		15.875 or 19.050
Code letter U denotes I.S.O. metric preferred series.		

Table 3 - Rivet Sizes

The length of 'shank' required to form the 'head' of the rivet (i.e. the length standing proud of the sheet surface when the rivet is inserted in the hole and held up tight) depends upon the form of the head and the 'clearance' between the rivet and the rivet hole. For ROUNDHEAD or SNAPHEAD forms the length of shank required is 1½ to 1¾ times the diameter of the rivet, the Total Length of shank required is this length plus the total thickness of the plates through which it is inserted.

The total length of shank required is equal to the total thickness of the metal to be joined plus the allowance for making the head, i.e. $L = T + T + 1 \cdot 5D$

D = Diameter of rivet

T = Thickness of metal

L = Length of shank

Example: What length of 4 mm diameter rivet is required to form a snaphead and join two pieces of 1·6 mm sheet metal together?

Solution: $L = T + T + 1 \cdot 5D$

$= 1 \cdot 6 + 1 \cdot 6 + 1 \cdot 5 \, x \, 4$ mm

Rivet length $= 3 \cdot 2 + 6$ mm $= 9 \cdot 2$ mm

For the Countersunk Head form, the length of shank required is equal to the diameter of the rivet.

The total length of shank required is equal to the total thickness of the metal to be joined plus the allowance for making the head, i.e. $L = T + T + D$.

Example: What length of 9·5 mm diameter rivet is required to form a countersunk head and join two pieces of 4·76 mm plate?

Solution: $L = T + T + D$

$= 4 \cdot 76 + 4 \cdot 76 + 9 \cdot 5$ mm

$= 19 \cdot 02$ mm

Rivet length $= 19$ mm

Hole clearance is very important and should be kept to the absolute minimum. Table 4 shows the recommended hole clearances for various diameters of rivet.

Rivet Diameter (mm)	Hole Diameter (mm)
1.59	1.63
2.38	2.43
3.18	3.25
3.97	4.03
4.76	4.85
5.56	5.61
6.35	5.52
7.94	8.02
9.53	9.80
11.11	11.40
12.70	13.10

Table 4 - Recommended Hole Clearances for Various Diameters of Rivet

Rivet Spacing

Rivet holes should be spaced according to the specification of the job. The space or distance from the edge of the metal to the centre of any rivet should be at least twice the diameter of the rivet to prevent the rivets from tearing out.

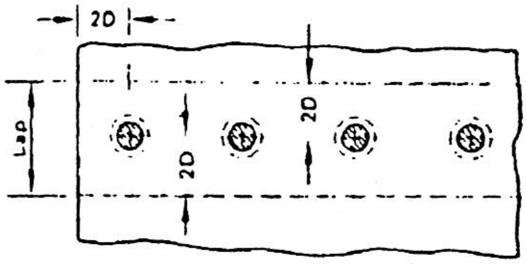
A useful rule is to make the edge distance equal to 1½ diameters plus 9·5 mm. The maximum distance from the edge is governed by the necessity of preventing the sheets from 'gaping' and should be limited to 10 times the thickness of the sheet metal or plate.

The minimum distance between rivets (known as the 'pitch') should be sufficient to allow the rivets to be driven without interference or about three times the rivet diameter.

The maximum distance between rivets should never be such that the material is allowed to buckle between the rivets and in practice should never exceed 24 times the thickness of the sheet.

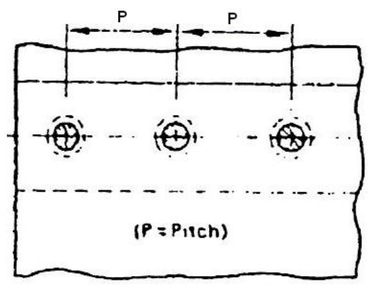
Edge distance = Twice the diameter of rivet

Minimum lap = Four times diameter of rivet



Gaping

The maximum edge distance is governed by the necessity of preventing the sheets from gaping and should be limited to 10 times the thickness of the sheet or plate.

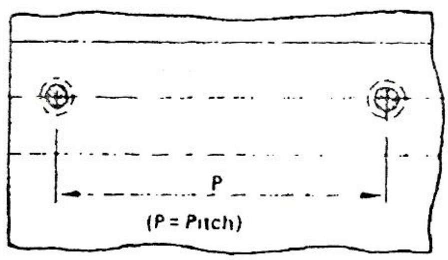


P = 3D (minimum)

D = Diameter of rivet

Bucking

Caused by too great a pitch.



P = 24T (maximum)

T = Thickness of metal

Pop Riveting

Pop rivets, unlike solid rivets, are tubular and are much lighter in weight. They are manufactured from either aluminium alloy for lightness or nickel for additional strength and corrosion resistance. They were originally designed for one-sided riveting, by which rivets can be set in places otherwise inaccessible. One operator is needed, the rivets being set or clinched with the aid of special hand-held 'lazy tongs' or pliers. Although their main application has been in aircraft construction and motor vehicle body building, where it is necessary to join thin material to thicker supporting members and lightness is important, they are often used in place of solid rivets for general riveting. They are available in diameters 2·4 mm, 3·2 mm, 4 mm and 4·8 m for joining thicknesses up to 12·7 mm.

A skilled operator may achieve speeds of 20 rivets per minute.

Percentages & Averages

Average: An average or mean value of a number of quantities is given by adding the quantities together and dividing by the number of quantities added.

An average is often called the "mean value" or an "arithmetic mean".

Example: Find the average (mean) of 27·3, 17·8, 21·4, 19·7, 25·1.

$$= \frac{27.3 + 17.8 + 21.4 + 19.7 + 25.1}{5}$$

$$= \frac{111.3}{5}$$

= 22· 26 = average (or "arithmetic mean")

Percentage: To write one number as a percentage of another number:

(a) write the numbers as a fraction

(b) multiply by 100

Example: Write 36 as a fraction of 300.

$$= \frac{36}{100} \times 100$$

$$= \frac{36}{100} \times \frac{100}{1} = \frac{36}{3} = 12\%$$

To find a certain percentage of a number:

(a) find 1% (divide the number by 100)

(b) multiply your answer by the required percentage.

Example: Find 45% of 260.

1% of 260 $= \frac{260}{100} 2.6 = 1\%$

45% of 260 = 2.6 *x* 45 = 117

So: 45% of 260 = 117

Interconversion with Fractions & Decimals

a) To convert a fraction to a percentage (%), simply multiply by 100 and simplify:
Example: $= \frac{2}{5} = \frac{2}{5} \times 100 = 40\%$

b) To change a decimal to a percentage, multiply by 100 by moving the decimal point 2 places to the right:
Example: 0.75 = 75%
0.125 = 12.5% (or 12½%)

Ratios & Proportion

Ratio: A ratio is a comparison of two quantities. The ratio between two quantities is the quotient obtained by dividing the first quantity by the second. For example, the ratio between 3 and 12 is ¼, and the ratio between 12 and 3 is 4. Ratio is generally indicated by the sign (:), thus 12:3 indicates the ratio of 12 to 3.

A **Reciprocal** or **Inverse** ratio is the opposite of the original ratio. Thus, the inverse ratio of 5:7 is 7:5.

In a **Compound** ratio, each term is the product of the corresponding terms in two or more simple ratios. Thus, when:

$$8:2 = 4;\ 9:3 = 3;\ 10:5 = 2$$

then the compound ratio is:

$$8 \times 9 \times 10 : 2 \times 3 \times 5 = 5 \times 3 \times 2$$

$$720 : 30 = 24$$

Note: all ratios can be expressed as fractions for use in calculations.

Example: $12:3 = {}^{12}\!/_{3} = 4$

Proportion: Proportion is the equality of ratios. Thus:

$$6:8^3 = 10:5, \text{ or } 6:3 :: 10:5$$

The first and last terms in a proportion are called the extremes; the second and third, the means. The product of the extremes is equal to the product of the means. Thus:

$$25:2 = 100:8 \text{ and } 25 \times 8 = 2 \times 100$$

If an increase in one quantity produces a proportional increase in another, the quantities are directly proportional. If an increase in one quantity produces a proportional decrease in another, the quantities are **Inversely** proportional.

Example: Thirty four feet of bar stock is required for the blanks for 100 clamping bolts. How many feet of stock would be required for 912 bolts?

Let x = total length of stock required for 912 bolts.

$$34 : 100 = x : 912$$

(feet : bolts = feet : bolts)

$$x = \frac{34 \times 912}{100} = 310 \text{ feet approximately}$$

Self Assessment

Questions on Background Notes – Module 1.Unit 12

1. How would you calculate the area of a quarter circle?

2. How would you calculate the circumference of a quadrant / a quarter of a circle?

Answers to Questions 1-2. Module 1.Unit 12

1.

To find the area of a circle use the following formula:

$$\pi \ R^2 \div 4$$

2.

To find the Circumference of a quadrant:

$$\frac{2\pi R}{4} \quad \text{or} \quad \frac{\pi D}{4}$$

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