Lesson 04: Welded joints

The fastenings (i.e. joints) may be classified into the following two groups:

1. Permanent fastenings, and
2. Temporary or detachable fastenings

The permanent fastenings:
are those fastenings which can not be disassembled without destroying the connecting components. The examples of permanent fastenings in order of strength are soldered, brazed, welded and riveted joints.

The temporary or detachable fastenings:
Are those fastenings which can be disassembled without destroying the connecting components. The examples of temporary fastenings are screwed, keys, cotters, pins and splined joints

- A welded joint is a permanent joint which is obtained by the fusion of the edges of the two parts to be joined together,
- with or without the application of pressure and a filler material.
- The heat required for the fusion of the material may be obtained by :
  - burning of gas (in case of gas welding)
  - or by an electric arc (in case of electric arc welding). The latter method is extensively used because of greater speed of welding.

Whenever parts have to be assembled or fabricated, there is usually good cause for considering one of joining processes in preliminary design work:

- welding,
- brazing,
- soldering,
- cementing, and
- gluing

Main advantages

- The welded joints provide maximum efficiency (may be 100%) which is not possible in case of riveted or fasteners joints.
- Alterations and additions can be easily made in the existing structures.
- As the welded structure is smooth in appearance, therefore it looks pleasing.
- A welded joint has a great strength. Often a welded joint has the strength of the parent metal itself.

- Sometimes, the members are of such a shape (i.e. circular steel pipes) that they afford difficulty for riveting. But they can be easily welded.
- It is possible to weld any part of a structure at any point. But riveting requires enough clearance.
- The process of welding takes less time than the riveting

Disadvantages

- Since there is an uneven heating and cooling during fabrication, therefore the members may get distorted or additional stresses may develop.
- It requires a highly skilled labor and supervision.
- The inspection of welding work is more difficult than riveting work.

Welding Processes

The welding processes may be broadly classified into the following two groups:

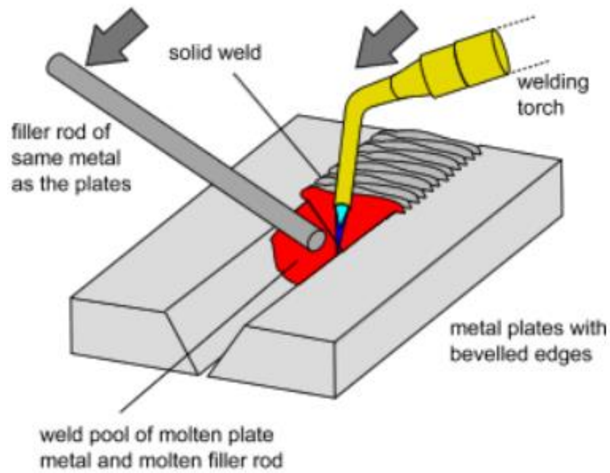
1. Welding processes that use heat alone e.g. fusion welding.
2. Welding processes that use a combination of heat and pressure e.g. forge welding.

Fusion Welding

- In case of fusion welding, the parts to be jointed are held in position while the molten metal is supplied to the joint.
- The molten metal may come from the parts themselves (i.e. parent metal)
- or filler metal which normally have the composition of the parent metal.
- When the molten metal solidifies or fuses, the joint is formed.
- The fusion welding, according to the method of heat generated, may be classified as:
    - Gas welding, and
    - Electric arc welding.

Gas Welding

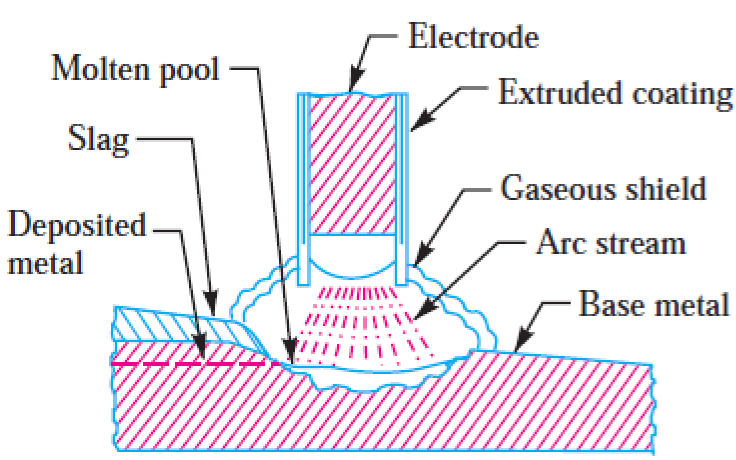
- A gas welding is made by applying the flame of an oxy-acetylene or hydrogen gas from a welding torch upon the surfaces of the prepared joint.
- The intense heat of the flame heats up the local surfaces to fusion point while the operator manipulates a welding rod to supply the metal for the weld.
- it can be used on thinner materials.

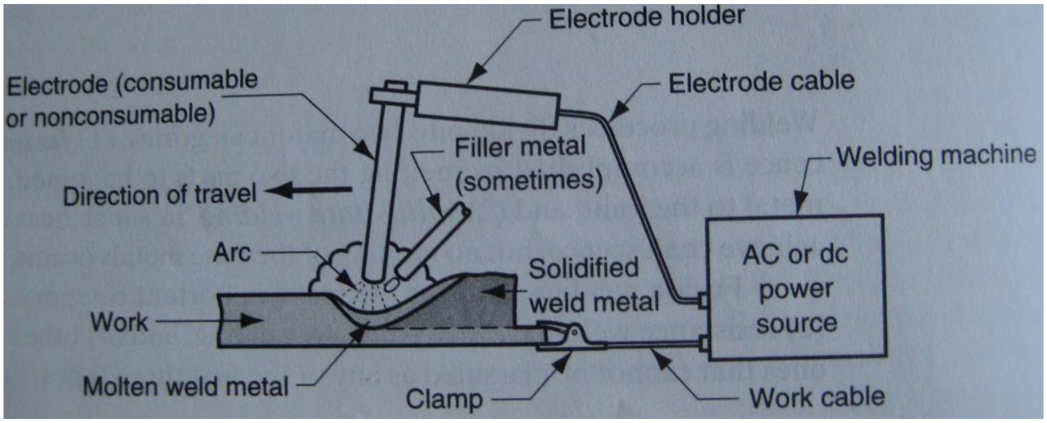


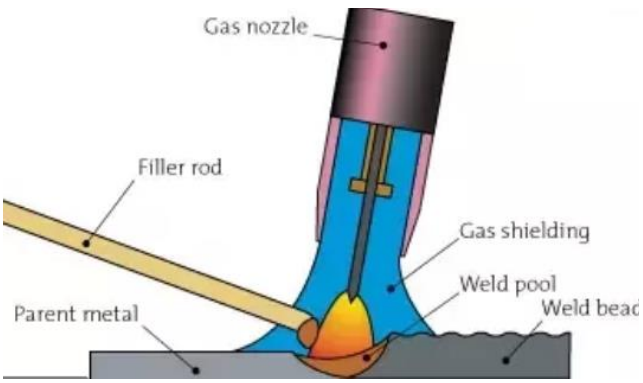
Cross section of a completed weld. The edges of the metal plates and molten filler rod have fused together to form the join.

Electric Arc Welding

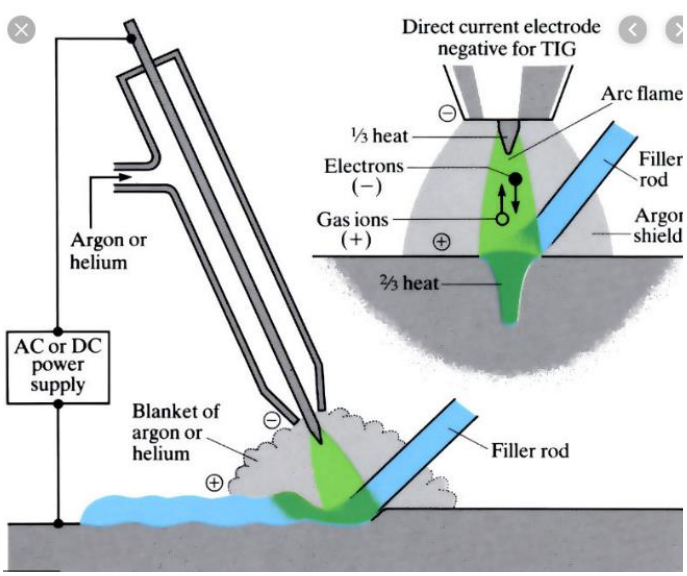
- the work is prepared in the same manner as for gas welding.
- filler metal supplied by metal welding electrode.
- The operator, strikes an arc by touching the work of base metal with the electrode.
- The base metal in the path of the arc stream is melted, forming a pool of molten metal,
- The slag is brushed off after the joint has cooled.
- The arc welding does not require the metal to be preheated and since the temperature of the
- arc is quite high, therefore the fusion of the metal is almost instantaneous.
- There are two kinds of arc welding depending upon the type of electrode.
    - Un-shielded arc welding, and
    - Shielded arc welding.







Tig and Mig welding:



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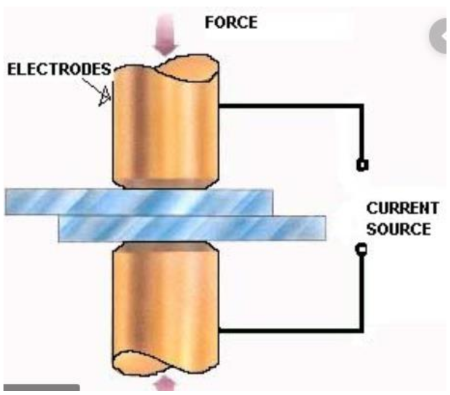
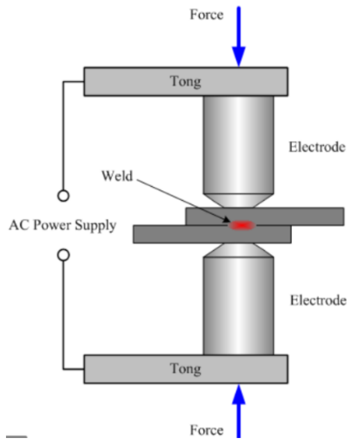
Forge Welding

- In forge welding, the parts to be jointed are first heated to a proper temperature in a furnace or forge and then hammered.
- This method of welding is rarely used now-a-days.
- An electric-resistance welding is an example of forge welding.
- The principle of applying heat and pressure, either sequentially or simultaneously, is widely used in the processes known as spot, seam, projection, upset and flash welding

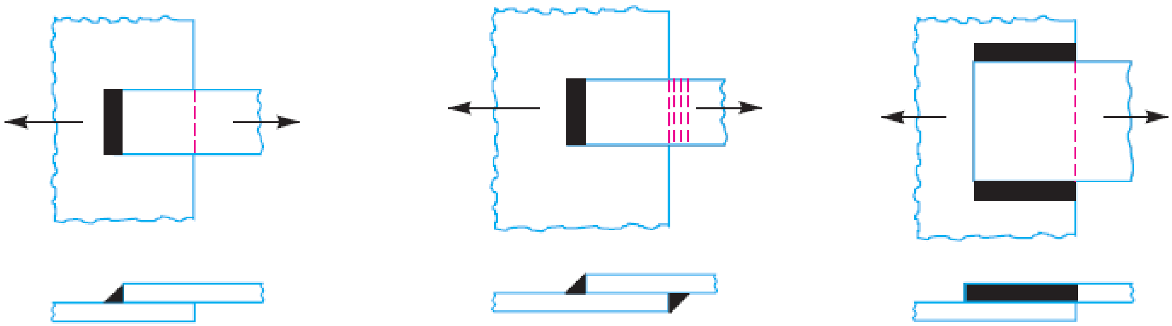




Types of Welded Joints

The lap joint or the fillet joint:

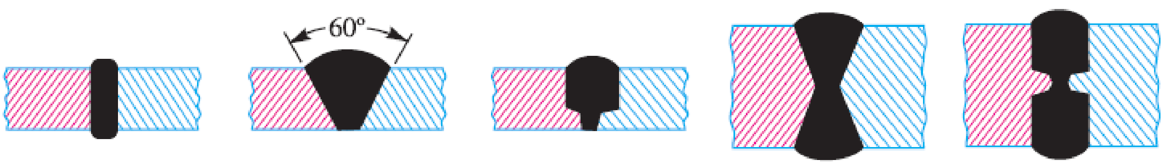
- obtained by overlapping the plates and then welding the edges of the plates.
- The cross-section of the fillet is approximately triangular.
- The fillet joints may be
  - Single transverse fillet,
  - Double transverse fillet,
  - Parallel fillet joints.
- A single transverse fillet joint has the disadvantage that the edge of the plate which is not welded can buckle or warp out of shape.



(*a*) Single transverse. (*b*) Double transverse. (*c*) Parallel fillet.

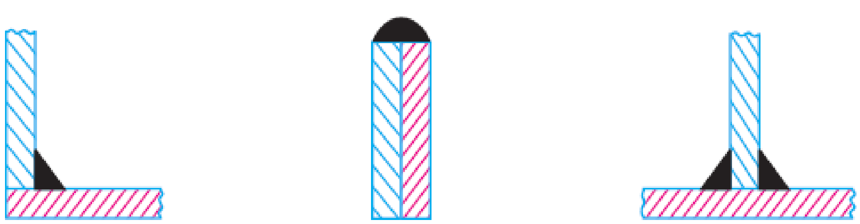
Butt Joint

- The butt joint is obtained by placing the plates edge to edge
- In butt welds the plate edges do not require bevelling if the thickness of plate is less than 5 mm. On the other hand, if the plate thicker than 5 mm, the edges should be bevelled to V or U-groove on both sides.



(*a*) Square butt joint. (*b*) Single *V*-butt joint. (*c*) Single *U*-butt joint. (*d*) Double *V*-butt joint. (*e*) Double *U*-butt joint.

The other type of welded joints are corner joint, edge joint and T-joint

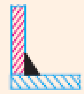
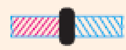
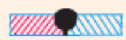
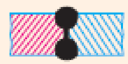
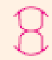
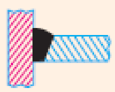
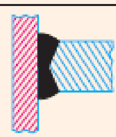
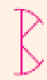


(*a*) Corner joint. (*b*) Edge joint. (*c*) *T*-joint.

The main considerations involved in the selection of weld type are:
1. The shape of the welded component required,
2. The thickness of the plates to be welded, and
3. The direction of the forces applied.

Basic Weld Symbols:

The basic weld symbols according to IS : 813 – 1961 (Reaffirmed 1991) are shown in the following table.

S. No.	Form of weld	Sectional representation	Symbol
1.	Fillet		
2.	Square butt		
3.	Single-*V* butt		
4.	Double-*V* butt		
5.	Single-*U* butt		
6.	Double-*U* butt		
7.	Single bevel butt		
8.	Double bevel butt		

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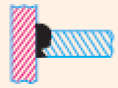
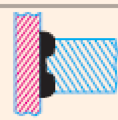
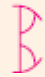
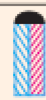
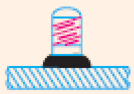
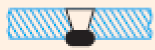
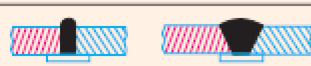
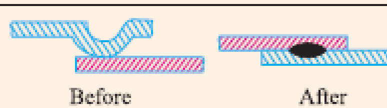
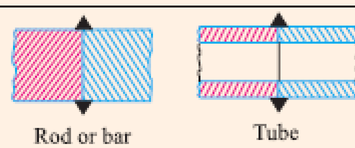
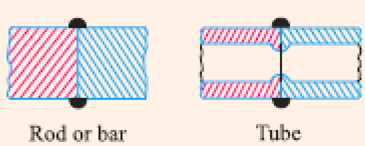
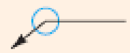
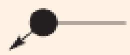
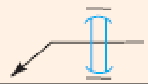
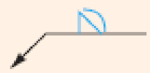
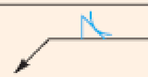
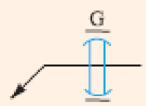
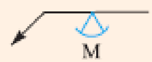
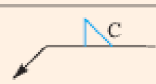
S. No.	*Form of weld*	*Sectional representation*	*Symbol*
9.	Single-*J* butt		
10.	Double-*J* butt		
11.	Bead (edge or seal)		⌓
12.	Stud		⊥
13.	Sealing run		○
14.	Spot		
15.	Seam		
16.	Mashed seam		
17.	Plug		
18.	Backing strip		=
19.	Stitch		
20.	Projection		△
21.	Flash		
22.	Butt resistance or pressure (upset)		|

Supplementary Weld Symbols

In addition to the above symbols, some supplementary symbols, according to IS:813 – 1961 (Reaffirmed 1991), are also used as shown in the following table.

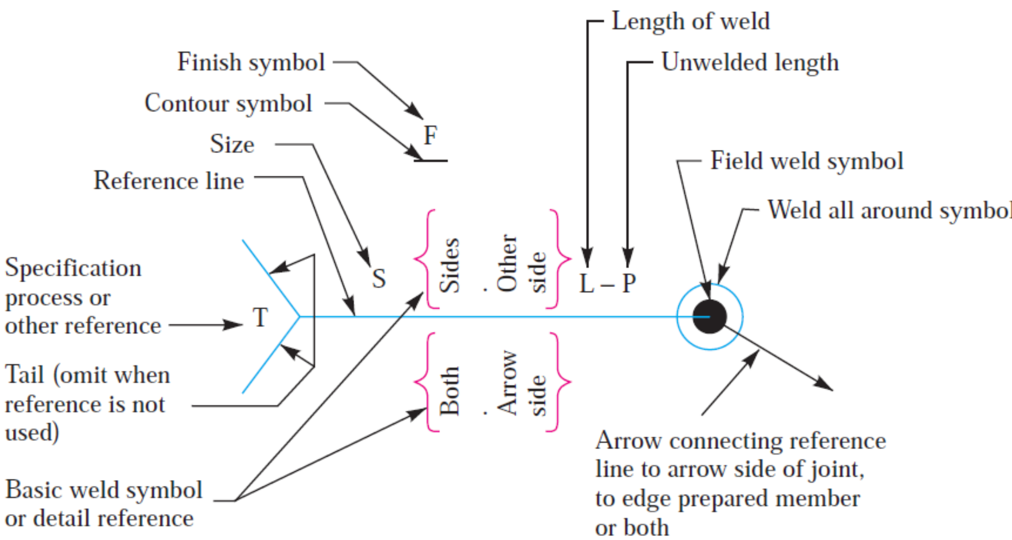
S. No.	*Particulars*	*Drawing representation*	*Symbol*
1.	Weld all round		○
2.	Field weld		●
3.	Flush contour		—
4.	Convex contour		⌒
5.	Concave contour		◡
6.	Grinding finish		G
7.	Machining finish		M
8.	Chipping finish		C

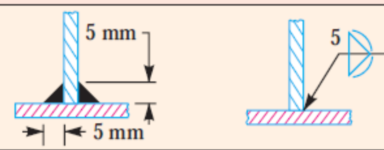
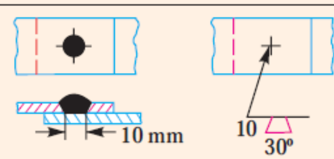
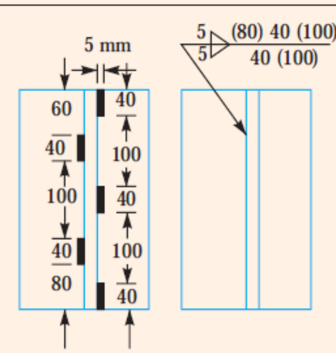
Elements of a Welding Symbol

A welding symbol consists of the following eight elements:

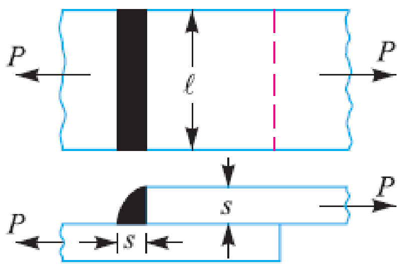
1. Reference line,
2. Arrow,
3. Basic weld symbols,
4. Dimensions and other data,
5. Supplementary symbols,
6. Finish symbols,
7. Tail, and
8. Specification, process

Standard Location of Elements of a Welding Symbol:

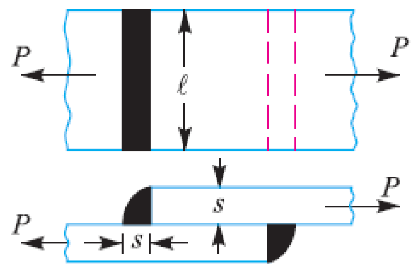


S. No.	*Desired weld*	*Representation on drawing*
1.	Fillet-weld each side of Tee- convex contour	
2.	Single V-butt weld -machining finish	
3.	Double V- butt weld	
4.	Plug weld - 30° Groove-angle-flush contour	
5.	Staggered intermittent fillet welds	

Strength of Transverse Fillet Welded Joints:

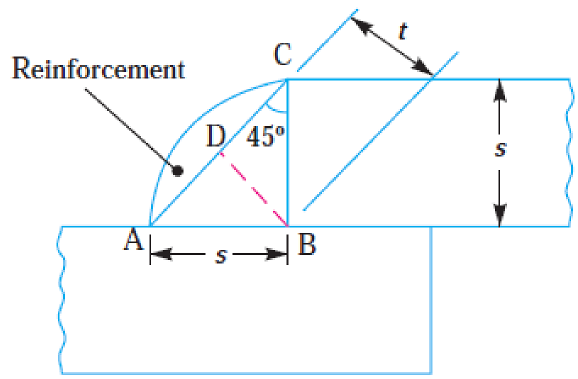


(*a*) Single transverse fillet weld.



(*b*) Double transverse fillet weld.

Assume that the section of fillet is a right-angled triangle ABC with hypotenuse AC making equal angles with other two sides AB and BC.
The length of each side is known as leg or size of the weld and the perpendicular distance of the hypotenuse from the intersection of legs (i.e. BD) is known as throat thickness.
The minimum area of the weld is obtained at the throat BD,



Let
t = Throat thickness (BD),
s = Leg or size of weld, = Thickness of plate,
l = Length of weld,

the throat thickness:

$t = s \times \sin 45° = 0.707\ s$
∴ Minimum area of the weld or throat area,
A = Throat thickness × Length of weld = $t \times l = 0.707\ s \times l$

If σ_t is the allowable tensile stress for the weld metal, then the tensile strength of the joint for single fillet weld,

P = Throat area × Allowable tensile stress = $0.707\ s \times l \times \sigma_t$

and tensile strength of the joint for double fillet weld,

$P = 2 \times 0.707\ s \times l \times \sigma_t = 1.414\ s \times l \times \sigma_t$

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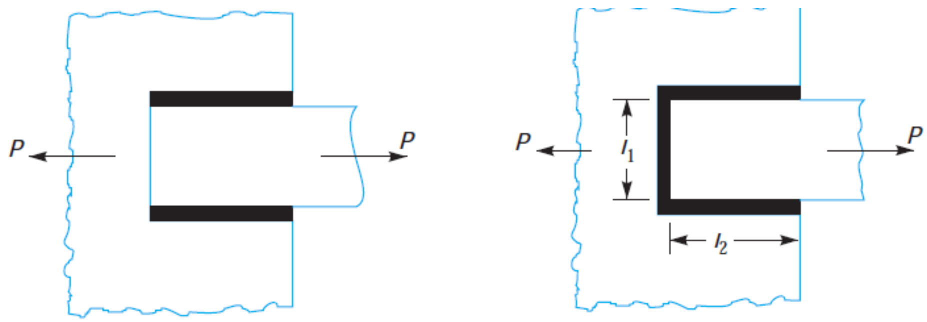
Strength of Parallel Fillet Welded Joints:

The parallel fillet welded joints are designed for shear strength.



(a) Double parallel fillet weld.

(b) Combination of transverse and parallel fillet weld.

If τ is the allowable shear stress for the weld metal, then the shear strength of the joint for single parallel fillet weld,

P = Throat area × Allowable shear stress = $0.707\ s \times l \times \tau$

and shear strength of the joint for double parallel fillet weld,

$P = 2 \times 0.707 \times s \times l \times \tau = 1.414\ s \times l \times \tau$

where l_1 is normally the width of the plate.

Example

A plate 100 mm wide and 10 mm thick is to be welded to another plate by means of double parallel fillets. The plates are subjected to a static load of 80 kN. Find the length of weld if the permissible shear stress in the weld does not exceed 55 MPa.

Solution

$80 \times 10^3 = 1.414 \times s \times l \times \tau = 1.414 \times 10 \times l \times 55 = 778\ l$

$\therefore l = 80 \times 10^3 / 778 = 103$ mm

Adding 12.5 mm for starting and stopping of weld run, we have

$l = 103 + 12.5 = 115.5$ mm