

**Electric Welding 2 – Course: Techniques of Electric Welding.  
Methodical Guide for Instructors**



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# Electric Welding 2 – Course: Techniques of Electric Welding. Methodical Guide for Instructors

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## 0. Preliminary Remarks

The present Methodical Instructions have been developed for instructors in practical vocational training and serve to impart knowledge, abilities and skills in electric welding.

These Instructions will give help and assistance to the instructor in the preparation and realisation of practical vocational training. Ways of solution are suggested to the instructor; they enable the realisation the aim of training specified in the course of his pedagogic activities.

The Methodical Instructions are arranged in such a way that the trainees are in a position to acquire systematically

- fillet welding "h",
- corner-seam welding "h",
- V-seam welding "g".

Subjects of particular importance are the preparation of the plates, the selection of electrodes, and the various ways of moving the electrode as well as the assessment of and the commenting on the various welds involved.

The acquisition of the above weld seams and the welding positions in question is the continuation of the Instructions of electric welding 1. On the basis of the experiences gathered in the training of electric weldors, the sequence in the acquisition of the types of seams and the welding positions required for the production of them have been specified. Consequently, the mastering of welding of individual seams "g" and building-up welding "g" is the basis for the acquisition of the knowledge and skills for welding the seams and the execution of the work involved in the various welding positions specified in these Instructions. When the trainees have passed the examination, then they are entitled to weld

- fillet welds and corner welds in "h"-position and
- V-welds in "g"-position

in 3-mm plates.

## 1. Fillet Welding "h"

At the beginning, repeat the terms of fillet weld "h"-position, T-joint, parallel joint, edge fillet weld and side fillet weld.

- For fillet welds, a distinction is made between the weld thickness "a" (also known as seam thickness) and the weld height "a'".

Draw a blackboard picture of Fig. 1 and explain the terms of seam thickness and seam height.

Also show the various cross-sections possible of fillet welds. Also draw sketches of the latter on the blackboard (see Fig. 2). According to the mass of filler metal used, a distinction is made between

- concave fillet weld, flat fillet weld and convex fillet weld.

Also enter into particular on the path of lines of force in the concave fillet weld and convex fillet weld. For this purpose, take advantage of Fig. 3.

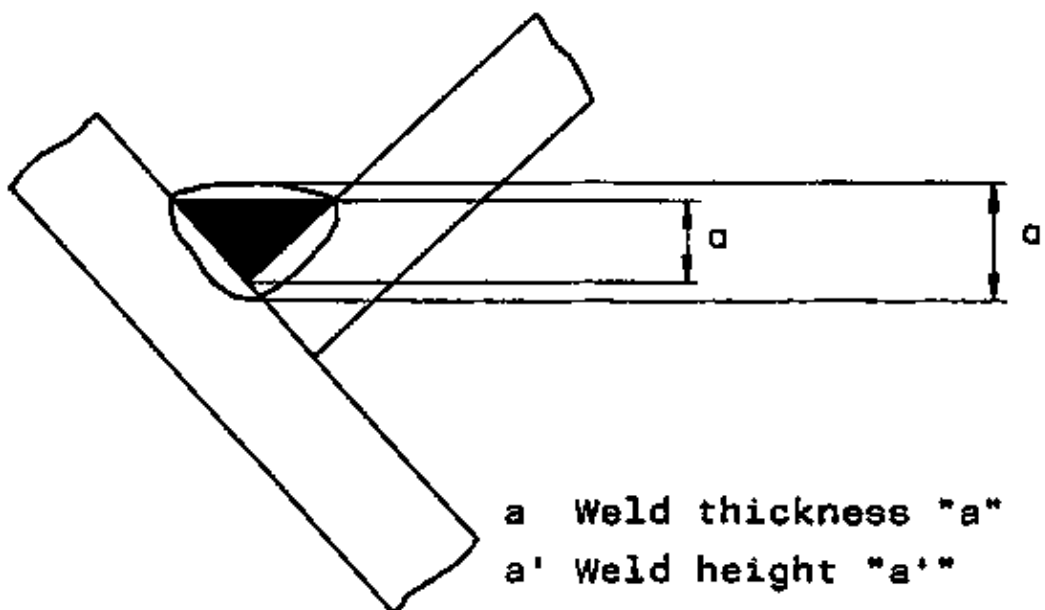
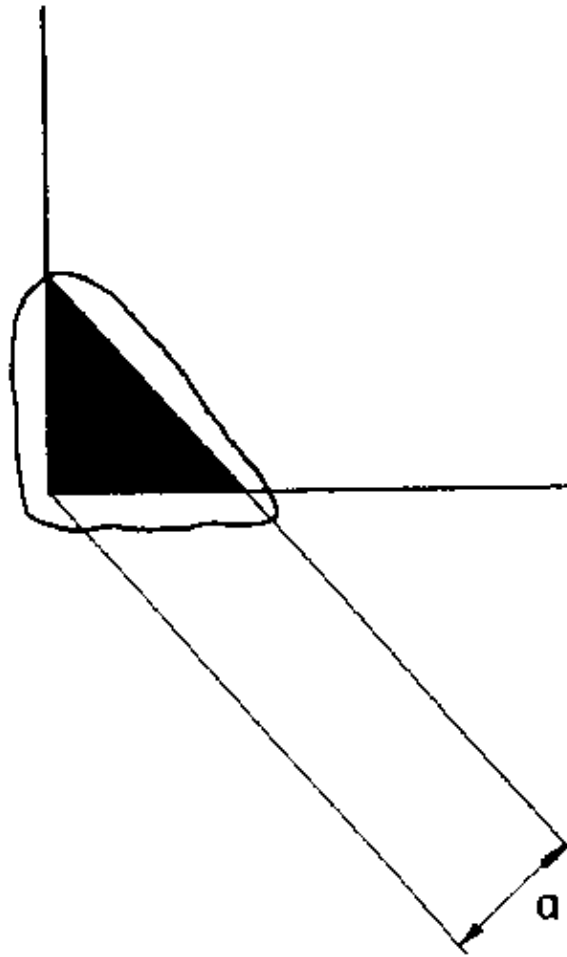
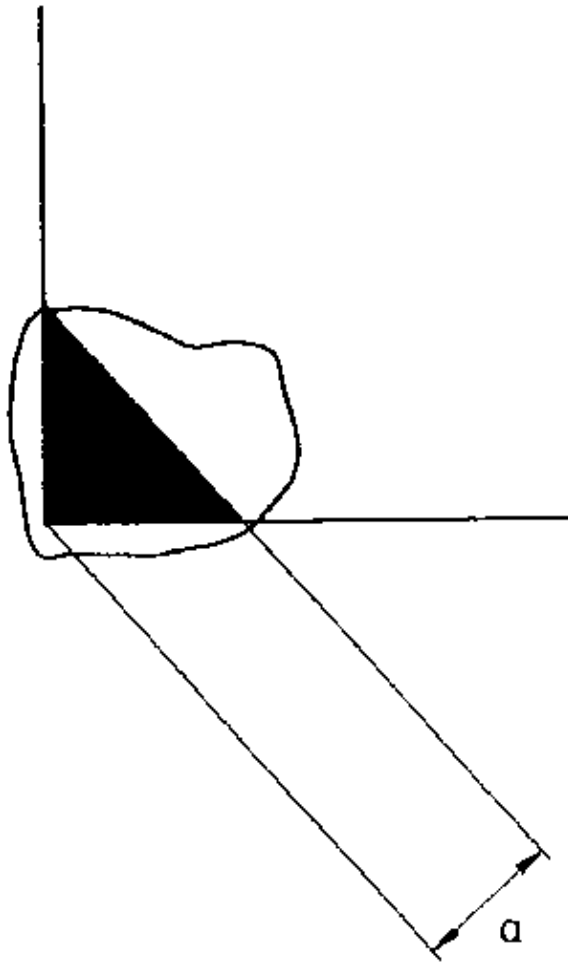


Fig. 1 Dimensions of the fillet weld

Fig. 2 Fillet welds in different forms

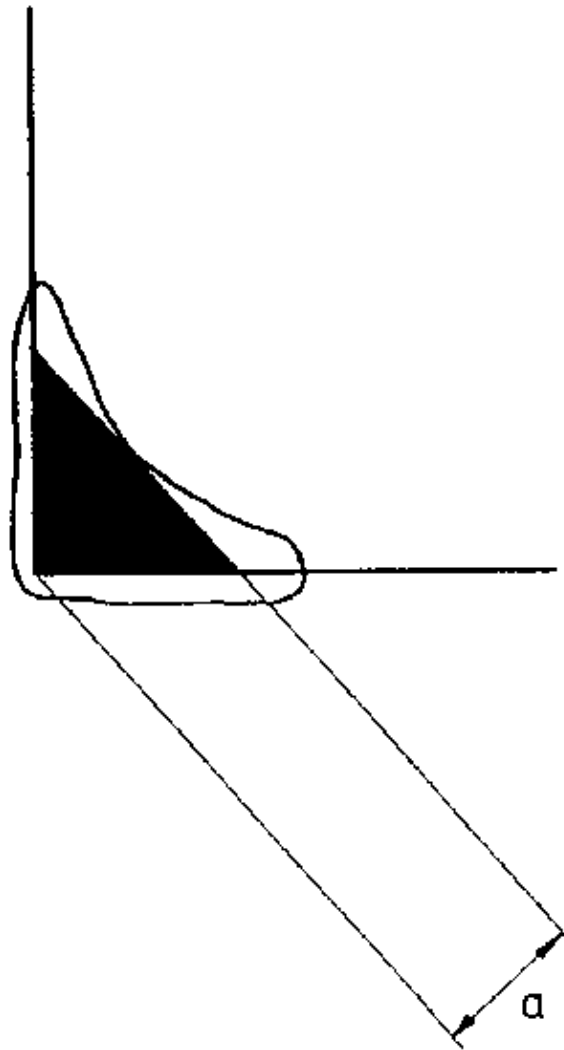


1 Flat weld



2 Concave weld





3 Convex weld

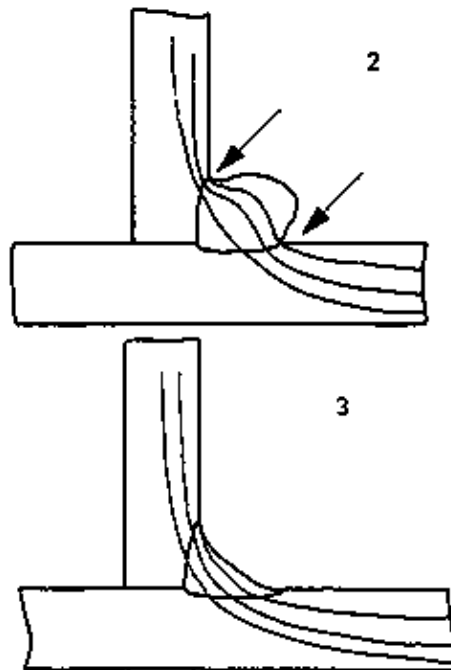


Fig. 3 Path of lines of force in the convex seam (2) and the concave seam (3)

## 1.1. Preparation of the Exercise Plates

Tell the trainees the dimensions of the plates. Enter into particulars on the state of the plates.

- One chord plate and one web plate of the dimensions 80 x 200, 10 to 12 mm thick, are used.
- They must be plane and have a clean surface.

Check the preparation of the exercise plates!

Again point out to the rule:

Successful welding calls for the preparation of clean and exact welding areas!

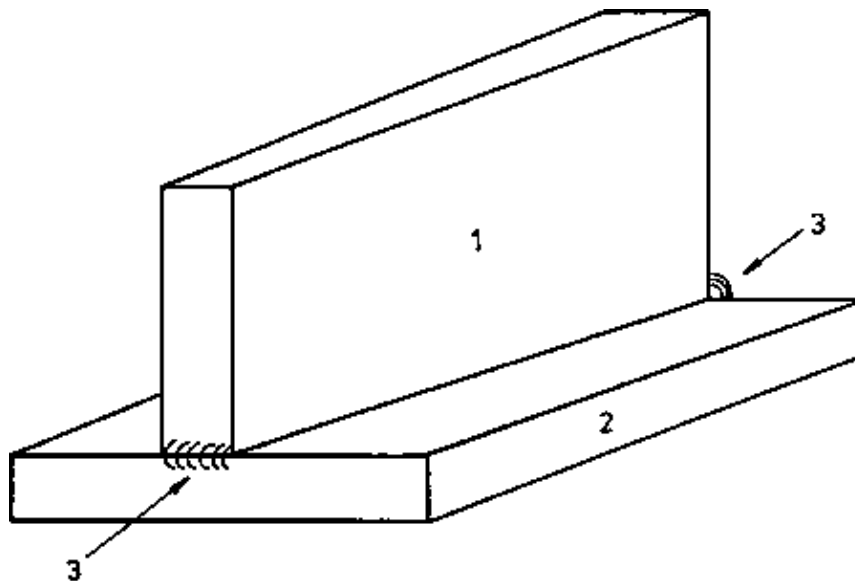
## 1.2. Tacking the Fillet Weld

Demonstrate the assembling and tacking the parts forming the fillet weld. Again explain the steps involved:

- Place the web plate (1) on the chord plate (2) in the centre of the latter and fix the web plate by means of a C-clamp.
- Check that the two plates are fitted one upon another without forming a gap by holding the fixed T-joint against the light.

When there is a gap between web plate and chord plate, slag will penetrate into it when the root is welded so that welding defects will be caused.

- If necessary, the plates must be adjusted by pressure or grinding.



1 Web plate, 2 Chord plate, 3 Ends of the T-joint

Fig. 4 Fillet weld tacked

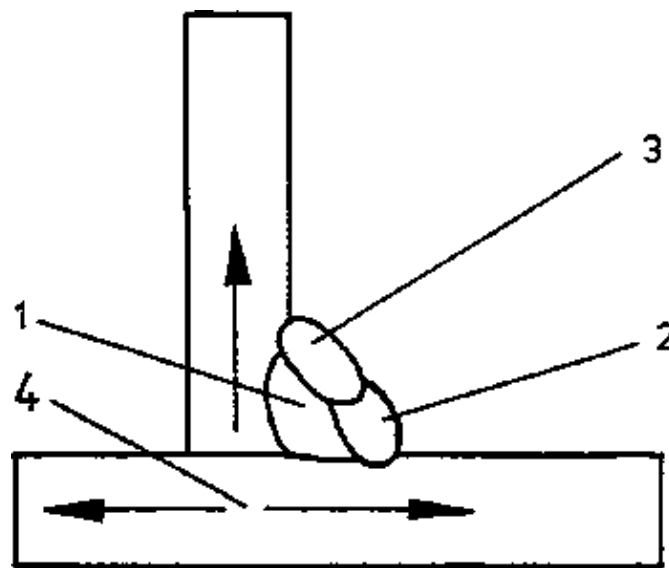
Now, demonstrate the tack welding.

- The ends (3) of the T-joint are tacked each by means of a string bead.
- The length of the tack weld should be equal to the thickness of the web plate.
- The C-clamp can be removed.
- The tack welds must be cleaned, i.e. slag and spatters must be removed by means of deslagging hammer and wire brush.

Check that the trainees properly tack the fillets.

### 1.3. Welding the Fillet

Give explanations to the trainees to the effect that, with plates having a thickness between 10 and 12 mm, a seam height "a" of 5 to 6 mm is required. Therefore, the welding of one root pass (1) and two cover passes (2) and (3) is necessary.



fillet seam "h"

1 Root pass  
2/3 Cover passes  
4 Heat dissipation

Fig. 5 Weld buildup of the fillet seam "h"

Before you demonstrate the welding of the root, point out to the trainees that, in fillet welds, the heat is dissipated to three directions (4).

#### 1.3.1. Welding the Root Pass

Show the trainees how to weld the root pass.

Place the fillet on the welding table parallel to the viewing direction of them. Again indicate the steps involved in welding.

- Setting the current to 180 to 190 A.
- Igniting the arc at the left-hand end of the T-joint.
- Welding the root pass without oscillating motion in the form of a string bead while uniformly touching and retouching the work with the electrode.

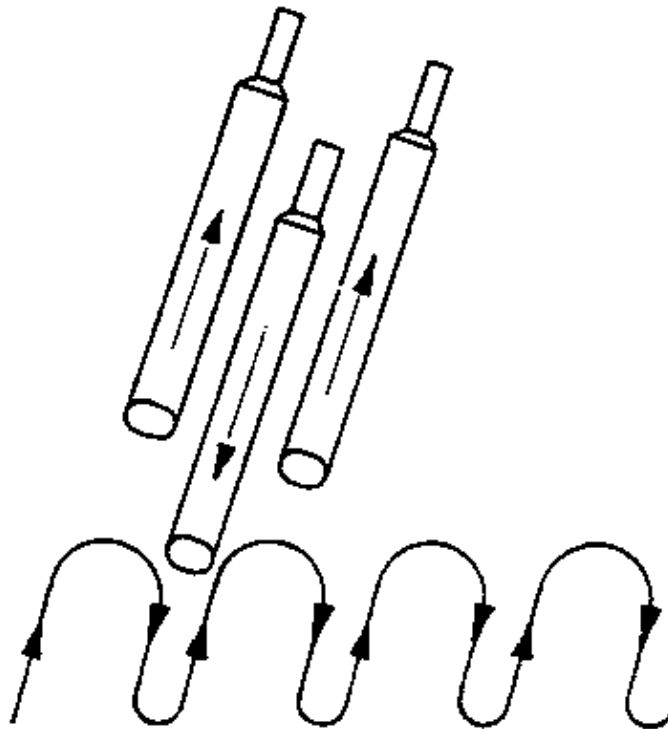


Fig. 6 Touching and retouching motions of the electrode for welding the root pass

The trainees should commit to their memory the following rule:

To ensure an isosceles weld buildup located in the centre, the electrode must be kept in such a manner that it forms an angle of exactly 45° with the chord plate and with the web plate.

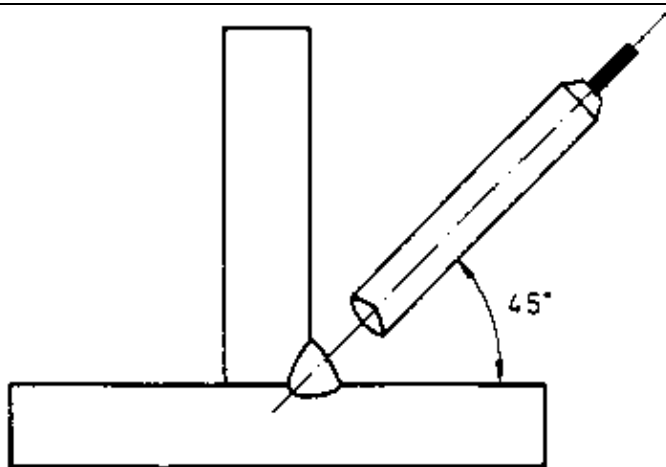


Fig. 7 Electrode position for fillet, horizontal, root pass

Inform the trainees of the consequences when the blow effect is not counteracted.

When the blow effect is not observed, such welding defects will be the cause as

- interrupted seam,
- slag inclusions,
- many spatters on the seam sides

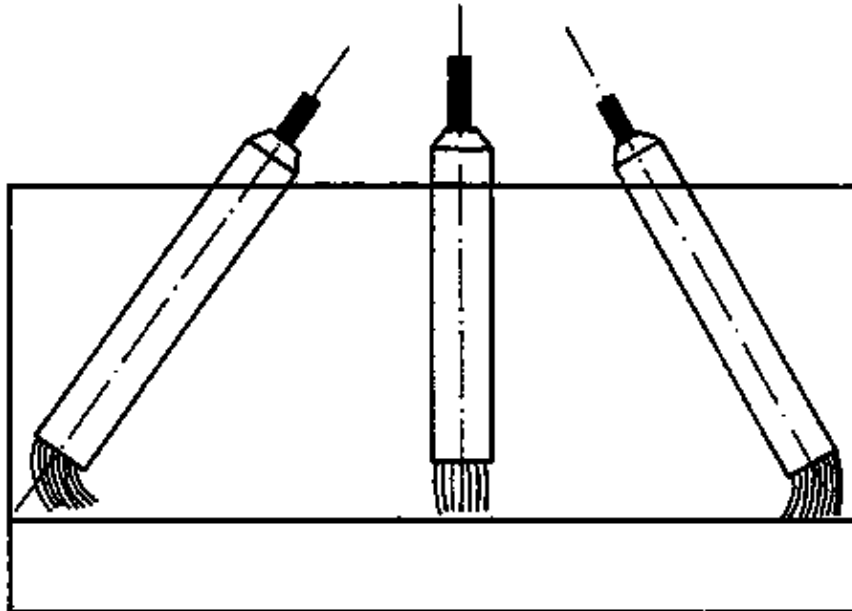


Fig. 8 Inclination of the electrode against the blow effect

- The end crater of the root pass must be filled properly.

When having finished the root welding, the fillet weld is carefully cleaned from slag and weld spatters.

Point out to the trainees that remains of slag and slag pockets cannot be removed by overwelding. Therefore, pay particular attention to the careful cleaning of the weld seams.

Check the root welded for proper central position of the root pass and welding defects such as pores, slag pockets and undercuts.

### 1.3.2. Welding the First Cover Pass

Demonstrate the first cover pass to the trainees.

Steps:

- Setting the current to 170 A.
- The first cover pass is deposited in the form of a string bead, performing slightly oscillating motions, so that it cover 2/3 of the root.
- The electrode must be kept so that it forms an angle  $70^\circ$  with the chord plate.

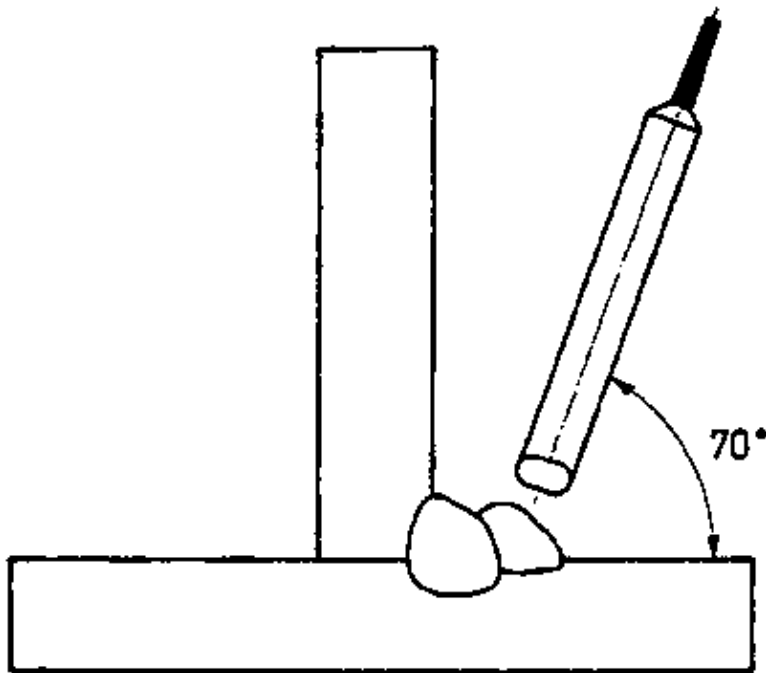


Fig. 9 Electrode position for fillet weld, horizontal, second pass

- The blow effect must be taken into account.
- The end crater must be filled properly.
- After welding, the weld must be checked for welding defects.

### 1.3.3. Welding the Second Cover Pass

Explain in an instructive talk why the second cover pass, that is the third pass of the fillet, must be welded with particular care. Instruct the trainees that the electrode must be kept at an angle of 60° formed with the web plate.

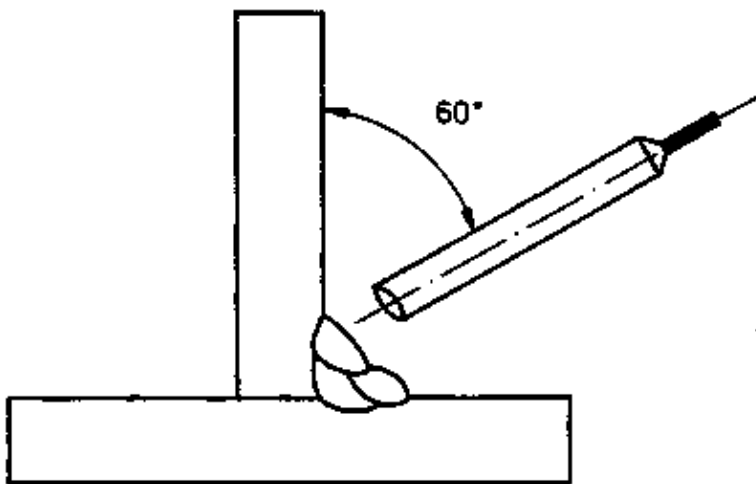
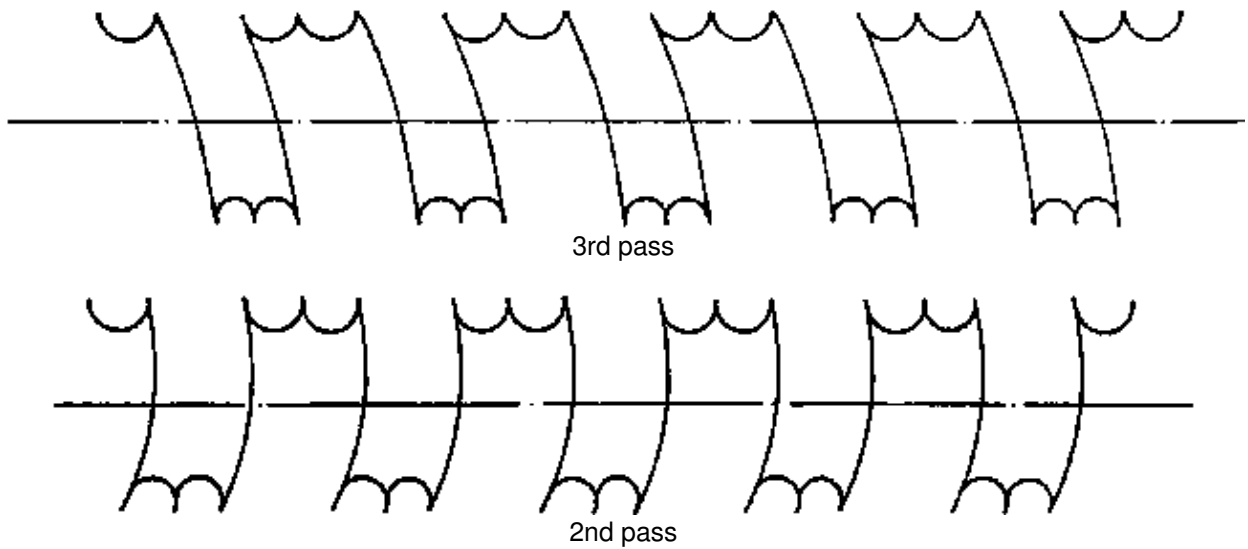


Fig. 10 Electrode position for fillet, horizontal, third pass

The trainees must pay particular attention to the fact that the line of the oscillating motion must be displaced, that is to say, the lower leg is drawn forth slightly while the upper leg of the seam is retained.

Fig. 11 Electrode motion in welding the second and third passes



- The arc must be kept very short at the web plate. The displacement mentioned above is necessary in order that the weld metal cannot run off from the upper edge but will get a hold by the drawing forth.

#### 1.4. Assessment of the Welded Fillet – Welding Defects and Their Causes

Discuss the welded fillet together with the trainees in order to arrive at an opinion. Tell them the assessment criteria. The following items should be assessed by you

- the appearance of the weld,
- the accuracy to size,
- the appearance of the fracture.
- Appearance of the weld
  - Symmetry of the weld buildup
  - Uniformity of bead ripple
  - Points of arc strike
  - End craters
  - Undercuts
  - Weld spatter
- Accuracy to size

By means of a weld gauge, three points of measurement have to be determined. Demonstrate the testing for accuracy to size. Ask a trainee to show the procedure once more.

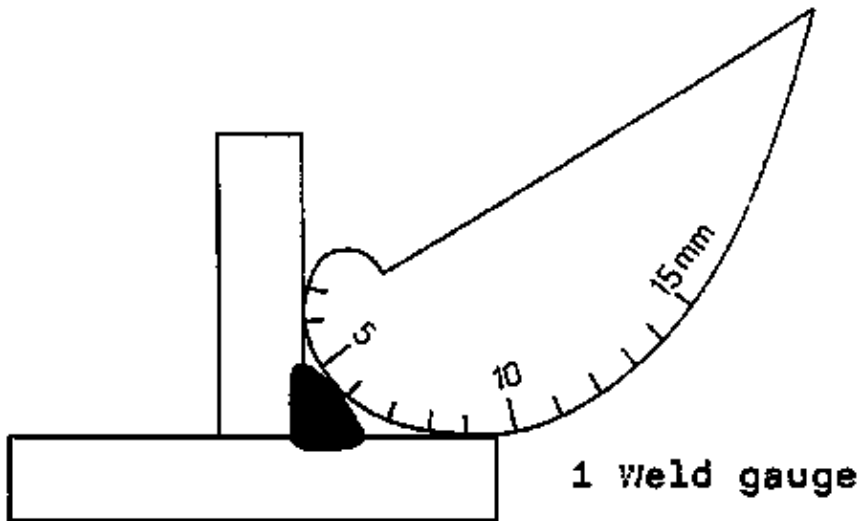
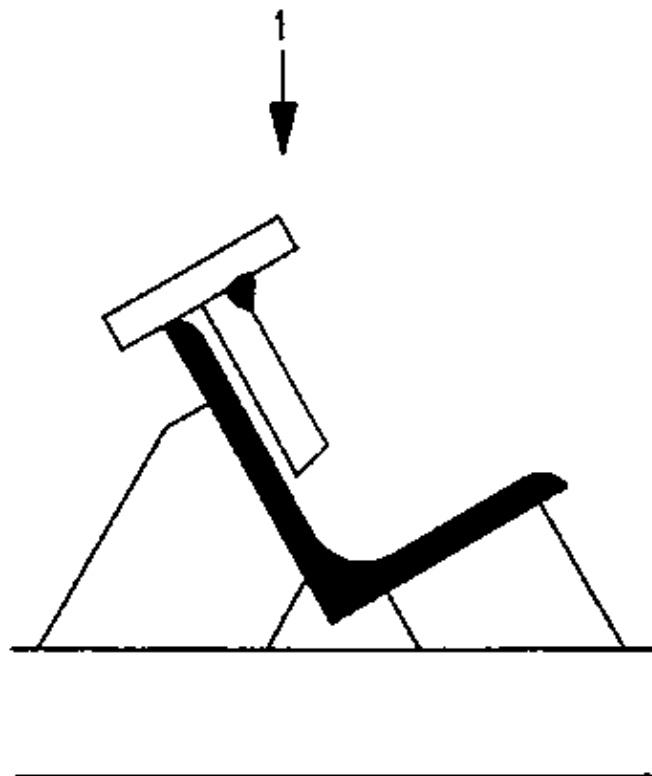


Fig. 12 Use of the weld gauge for the measurement of the height of fillets

Weld gauge (1) for the measurement of the fillet height. For fillet welds in "h" – position. a deviation of the weld height of + 1.0 and –0.5 is permissible.

– Appearance of the fracture

To be in a position to assess the appearance of the fracture, the fillet weld must be broken in a special device. For the purpose, the use of the following device is recommendable. Point out to the relevant labour protection regulations.



**1 Action of force**

Fig. 13 Device for breaking the fillet weld

Criteria for the assessment of the appearance of fracture are:

- Fusing of the edge of the web plate
- Slag inclusions
- Pores
- Lack of fusion



Point out to welding defects. Discuss them together with the trainees. Compare properly welded workpieces with those showing welding defects.

### Evaluation of the Section "Fillet Welding "h" "

With the conclusion of the exercise section "Fillet Welding "h" ", the trainees should have acquired the following knowledge, abilities and skills:

- observance of the relevant labour safety regulations and order and tidiness at the working place,
- preparation of the welding sample
- mastering the fillet welding in h–position,
- Identification of typical welding defects in fillet welds.
- Comments on their own work.

### Examples of questions regarding the Section Fillet Welding "h"

1. Describe the buildup of a fillet to be welded in horizontal position!
2. Which design of a fillet is the most economical one?
3. How do you achieve sufficient root penetration in fillet welds?
4. How is the heat dissipation in fillet welding?

## **2. Corner Welding "h"**

Repeat the terms and their definitions of corner weld and "h"–position by purposive questioning. Then tell the aim of this exercise Section. Pay particular attention to this Section because corner welding is the most important preliminary exercise for the V–joint welding.

Great store should be set by the mastering of the root welding.

### **2.1. Preparing the Exercise Plates**

Tell the trainees the dimensions of the exercise plates and how their state must be.

- One chord plate and one web plate 80 × 200 mm in size and 6 to 12 mm thick are used.
- They must be plane and their surface must be clean.

Instruct the trainees that the plates must be prepared by flame cutting or by cutting by means of shears. Show a plate of an irregular and unclean surface and demonstrate how it is straightened and cleaned.

- The cutting edges of the plates must be free from scale, scores and other irregularities. Sometimes grinding is required.

Control the preparation of the exercise plates.

### **2.2. Tacking the Corner Joint**

Demonstrate the assembling and tacking of the plates. Tell the trainees the steps involved.

- Plate (1) and plate (2) have to be arranged between two angle–steel profiles in such a way that the plates form an angle of 90°.

One or two electrode remains having a diameter of 3.25 mm must be placed between the edges of the plates where they contact each other.

- Exactly align the plates

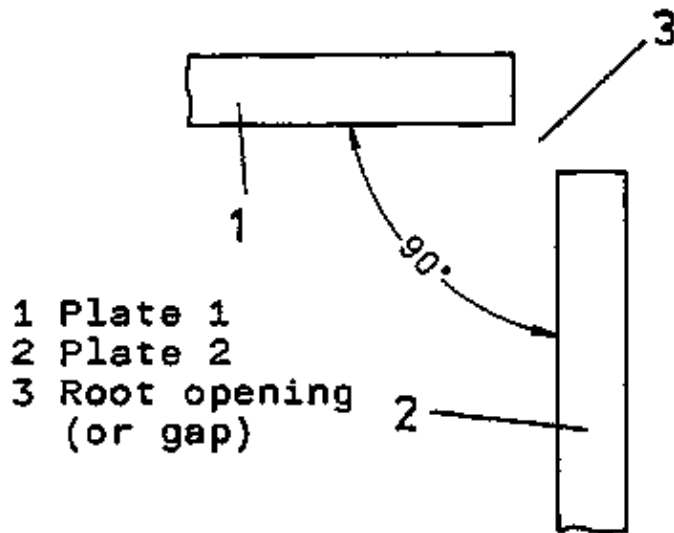


Fig. 14 Arrangement of the plates for tacking

- Tacking the plates on the back of an external seam end.
- Correcting the position of the plates relative to each other.
- Tacking the second seam end.

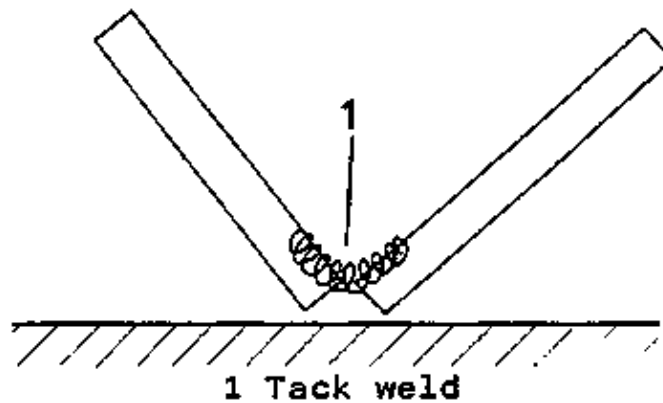


Fig. 15 Position of the tack weld immediately at the plate edge

The trainees should commit to their memory the following rule:

A successful root welding is dependent on the exactly observed root gap (3.25 mm).

### 2.3. Welding the Corner Seam

Familiarise the trainees with the weld buildup of a corner seam or corner weld.

- For a plate having a thickness of 10 mm, one root pass, five filler passes and four cover passes are executed. Depending on the individual electrode guidance, deviations from this number of passes are allowed.

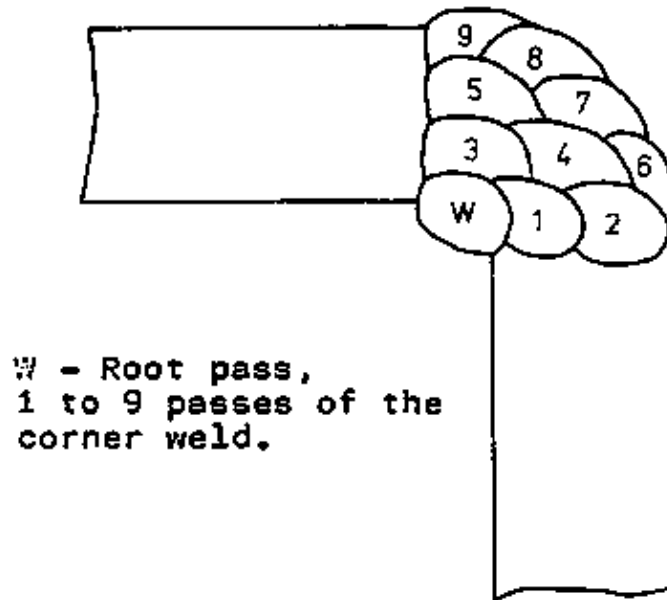


Fig. 16 Buildup of passes of a corner weld

### 2.3.1. Welding the Root Pass

Demonstrate the welding of the root to the trainees.

For this purpose, mount the fillet sample in a position stand in such a way that the horizontal welding position is ensured.

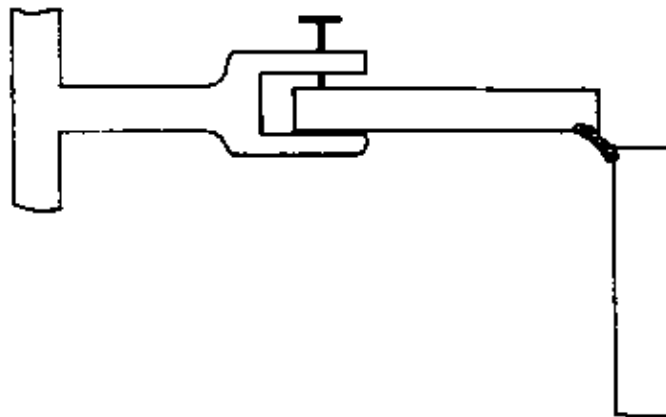


Fig. 17 Corner seam fastened in horizontal position in a position stand

Point out to the trainees that the welded root pass must be uniformly welded through. In this connection, enter into particulars on the special electrode movement.



Fig. 18 a) Moving the electrode for the root welding

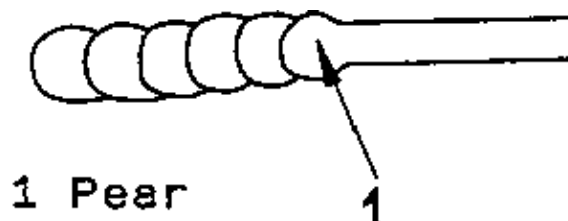


Fig. 18 b) Formation of the root with the pear

– The electrode is moved in an arc which is open in welding direction. The web edged must be fused adequately in order that lack of fusion at the seam sides are avoided.

This is achieved reliably when a "pear" is formed.

Quote the following rule for the trainees:

Long arc – much heat – ample penetration  
Short arc – little heat – poor penetration

In your demonstration and explanations, you should set great store by the heat conduction by the arc. The trainees must master the arc heat conduction.

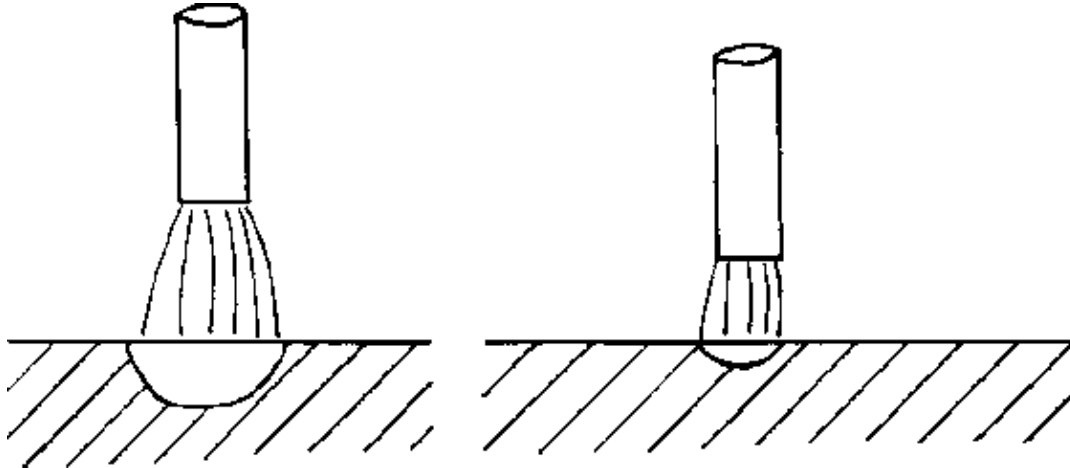


Fig. 19 Heating the plate by differently long arcs

Explain to the trainees how the heat input to the seam sides and the penetration effect obtained in this way can be controlled by the welding speed. Quote the following rule for the trainees:

Small molten pool (pear closes) – Low welding speed –  
Moving the electrode in a small arc or curve with a long electric arc large molten pool (pear becomes too large, weld metal runs through) –  
High welding speed – Moving the electrode in a large curve with short electric arc

Point out to the trainees that a uniform root formation is achieved by continuously changing the length of the arc and the welding speed in accordance with the requirements.

Weld the entire length of the root from the left to the right.

Draw the trainee's attention to the fact that the root gap becomes smaller and smaller with progressing welding operation towards the seam end.

This phenomenon is due to the expansion and shrinkage of the exercise plate.

Explain to the trainees that heated material zones considerably expand.

For this purpose, allow the trainees to measure a workpiece before and after heating.

– To ensure a uniform root fusion, a constant root gap is required. This is achieved in the following way: at first 30 mm of the root are welded from the right to the left and then the remaining root is welded from the left: to the right.

Pay attention to the correct execution of the further steps of the work.

– When the two root sections meet, one must allow the electrode to dwell for a moment with a short arc without moving it.

- It may be necessary to change the electrode several times because the length of extension of one electrode will not suffice for the length of the root.

Demonstrate the electrode change. The trainees should make a mental note of the following steps:

1. When the electrode comes to an end, enlarge the arc length in order to obtain a large pear.
2. With the new electrode, start about 10 mm in front of the pear on the root and move the electrode into the pear, and allow the arc to burn long enough inside the pear. Then continue to move the electrode in the manner required for the root welding.

Due to this measure, defective place in the root pass are avoided and a uniform root formation is ensured.

Show how the root pass is properly cleaned. Flaws due to starting points in the seam side area must be removed by means of a chisel. Summarise the most important items of the welding of roots.

### 2.3.2. Welding the Filler Passes

Demonstrate the welding of the filler passes.

- The filler passes are executed as string beads without oscillating motions.

Ask the trainees to adjust the current to 140 to 170 A. Explain to the trainees that this increased current intensity is necessary in order to obtain a sufficiently deep penetration and to flush the slag out of the molten pool.

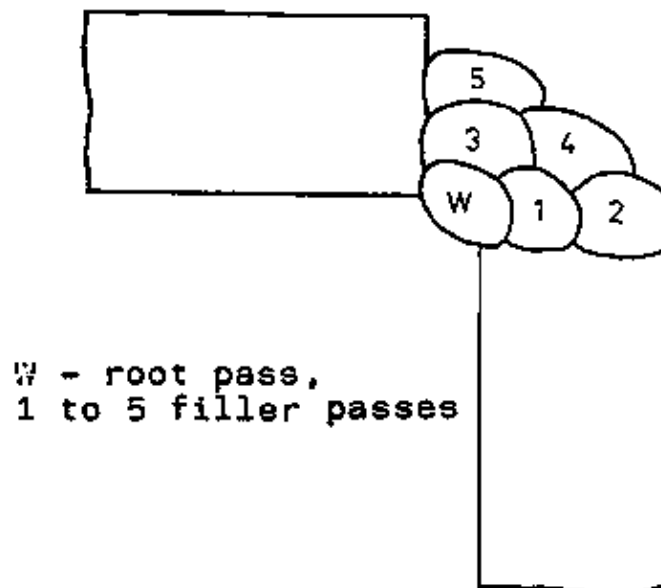


Fig. 20 Buildup of the filler passes

In welding the filler passes, the blow effect of the arc is considerable. Intense spatter and unclean appearance of the seam are the consequences.

During the exercising, pay attention to the fact that the trainees oppose this effect by an adequate inclination of the electrode.

Quote the following rule to the trainees:

At the beginning of the seam, the electrode must be inclined in the welding direction.

In the centre of the seam, the electrode must be kept steeper.

In the range of the last third of the seam, the electrode must be inclined opposite to the welding direction.

Now start demonstrating the welding of the filler passes.

- Filler passes 1 and 2 are welded on the face of the vertical plate.

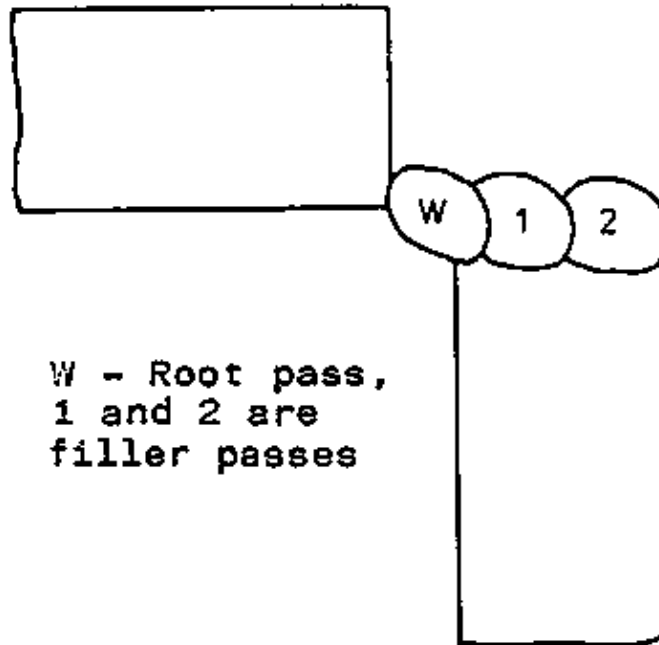


Fig. 21 Arrangement of the filler passes 1 and 2

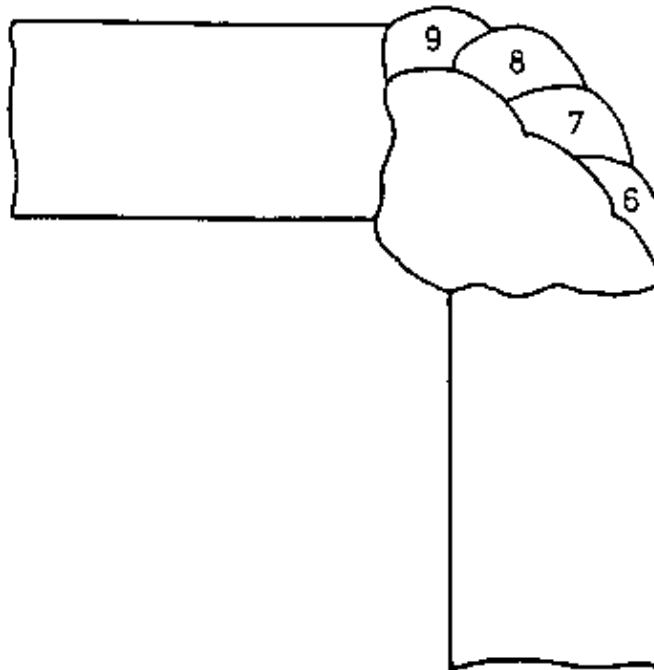
- Point out to the trainees that the filler pass number 2 properly covers the plate edge of the vertical plate, and
- that, in the event of a change of electrodes, the end crater is properly fused by means of a long arc.

After every filler pass, slag and spatters must be properly removed from the seam.

### 2.3.3. Welding the Cover Passes

Demonstrate the welding of the cover passes. Explain the following to the trainees:

- The cover passes are executed as string beads without oscillating motion.
- The current is adjusted to anything between 120 and 140 A.
- The blow effect is counteracted by the same working technique as in welding the filler passes.



### **6/7/8/9 Cover passes**

Fig. 22 Arrangement of the cover passes

In general, four cover passes will suffice.

Point out to the trainees the items to be observed in welding the cover passes:

- The first string bead on the upright plate must properly cover the edge of the seam. Undercuts must not form.
- The next string bead must cover 1/3 of the first string bead. The formation of undercuts is avoided when keeping the arc short.
- After any string bead, the seam must be carefully cleaned, especially slag and spatters must be removed. The last string bead should be executed particularly carefully because it must cover properly the edge of the plate in horizontal position. Undercuts must not be formed in this bead, too.

When having finished the cover pass welding, the corner weld is cooled in cold water and cleaned by means of a wire brush.

#### **2.4. Assessment of the Welded Corner**

Give comments on the welded corner seam together with the trainees. Tell them the assessment criteria. The following items should be assessed by you.

##### Appearance of the seam

- Symmetry of the weld buildup
- Uniformity of the cover pass buildup
- Uniformity of the root sag (maximum 3 mm)
- Points of arc strike
- End craters
- Undercuts
- Weld spatters

##### Appearance of the fracture

In order to assess the appearance of the fracture, the corner seam must be broken.

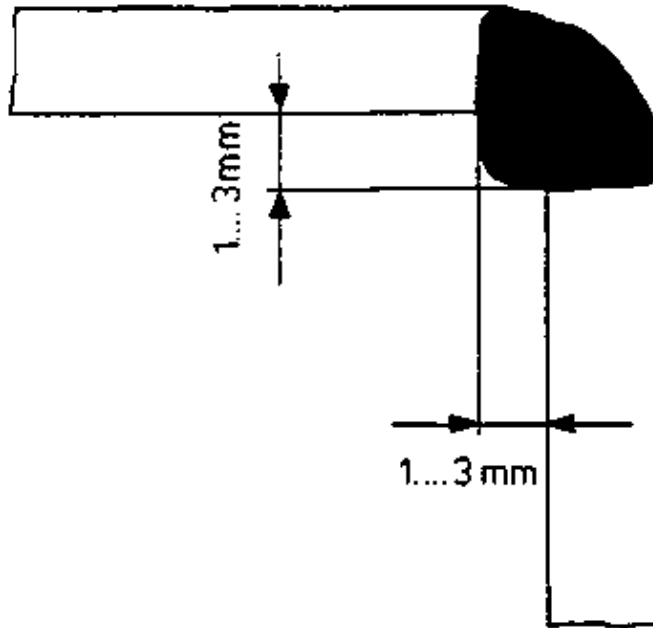


Fig. 23 Welded Corner with a root height of 1 to 3 mm

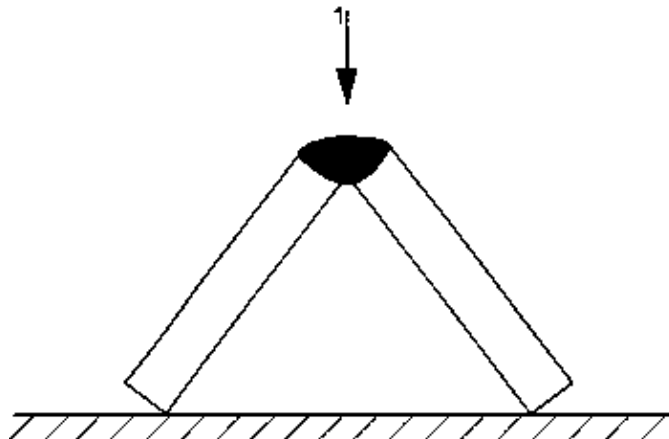


Fig. 24 Position of the corner seam for breaking 1 Force

Criteria for the assessment of the appearance of the fracture are:

- Fusion of the edges of the plate within the range of the cover passes
- Covering the plate edges within the range of the root pass
- Slag inclusions
- Pores
- Lack of fusion

#### Weld defects and their causes

Discuss weld defects, if any, and their causes. Proceed in the same way as in the previous Sections.

Then, allow the trainees to exercise the welding of corners according to your demonstration. Once more, summarise the most important items. Analyse and discuss the results of the exercise together with the trainees.

#### Evaluation of the Section on Corner Welding "h"

With the conclusion of the exercise Section Fillet Welding, the trainees should have acquired the following knowledge, abilities and skills:



- observance of the relevant labour safety regulations and order and tidiness at the working place
- preparation of the welding sample
- mastering the corner welding in "h"-position
- identification of typical welding defects in corner welds
- comments on their own work

Examples of questions regarding the corner welding "h"

1. Describe the buildup of a corner seam in horizontal position!
2. How do you achieve a thorough and uniform fusion at the root pass?
3. Which are the hazards to which a weldor is exposed by the arc? How to face them?
4. How do you counteract the blow effect?

### 3. V-seam Welding "g"

Only start with this Section, when all trainees are in a position to weld a fillet.

Here, also repeat and define the terms V-weld and "g"-position. Then familiarise the trainees with the aim of this Section. In a lecture, impart the necessary knowledge of the welding of a V-groove, i.e. the production of a V-weld. Prepare a blackboard picture of the following illustrations. Subsequently, give the leaflet or instructional pamphlet to the trainees. Explain the terms associated with a V-weld. Ask the trainees to enter the terms into the sketches of the pamphlet.

Check the terms entered into the pamphlet by the trainees. As one trainee to do this at the blackboard. The other trainees compare with their records. Immediately correct errors occurring.

- 1 Included angle,  
angle of vee,
- 2 Bevel angle,
- 3 Groove face
- 4 Groove length
- 5 Workpiece  
thickness
- 6 Root gap

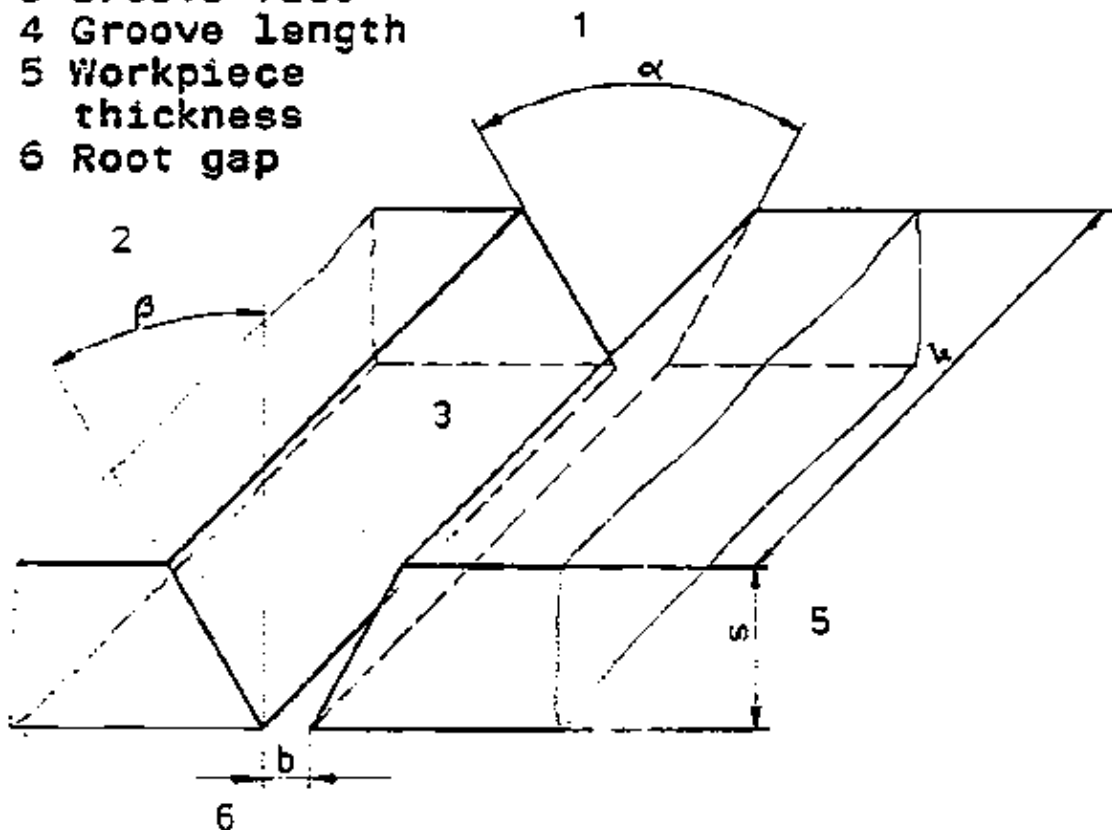
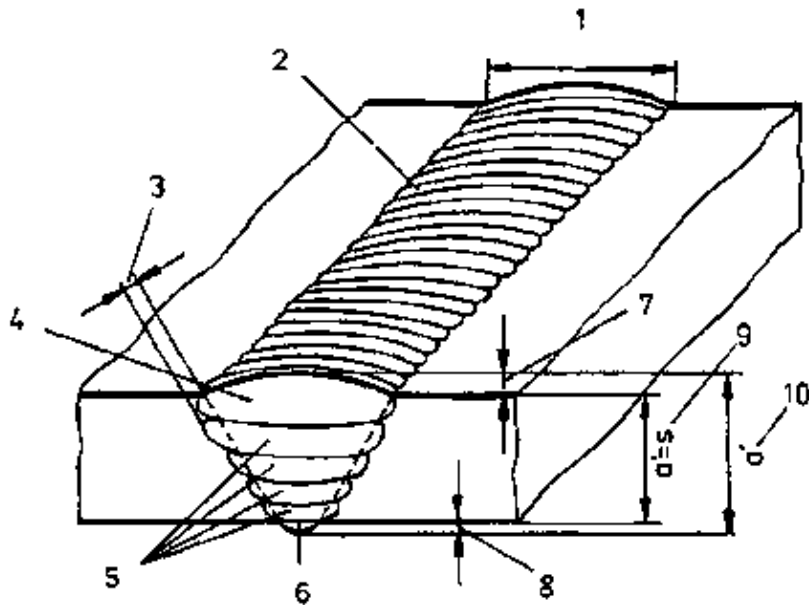


Fig. 25 Groove preparation for a V-weld, terms



- 1 Weld width 2 Bead ripples 3 Side wall fusion**  
**4 Cover pass 7 Weld reinforcement 8 Root reinforcement**  
**9 Weld thickness 10 Weld height**

Fig. 26 Terms of the V-weld

### 3.1. Preparation of the Exercise Plates

Tell the trainees the dimensions of the exercise plates and how their condition must be.

- Two plates having the size of 100 x 200 mm and a thickness of anything between 10 and 12 mm are to be used.
- The bevel angle of the plates is 30°.
- The plates must be plane and have a clean surface.

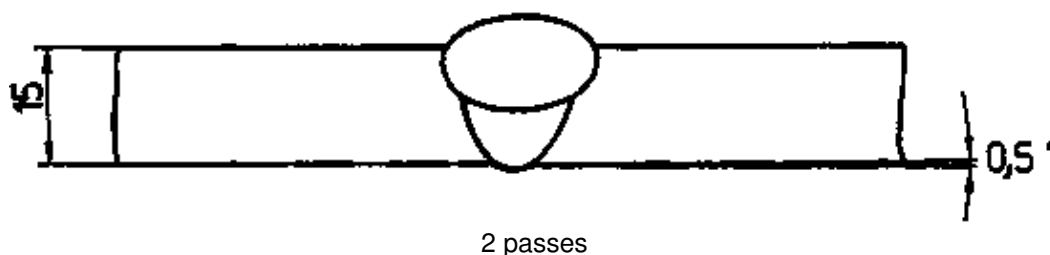
Check the preparation of the exercise plates by the trainees. Take into consideration the information given in the previous instructions.

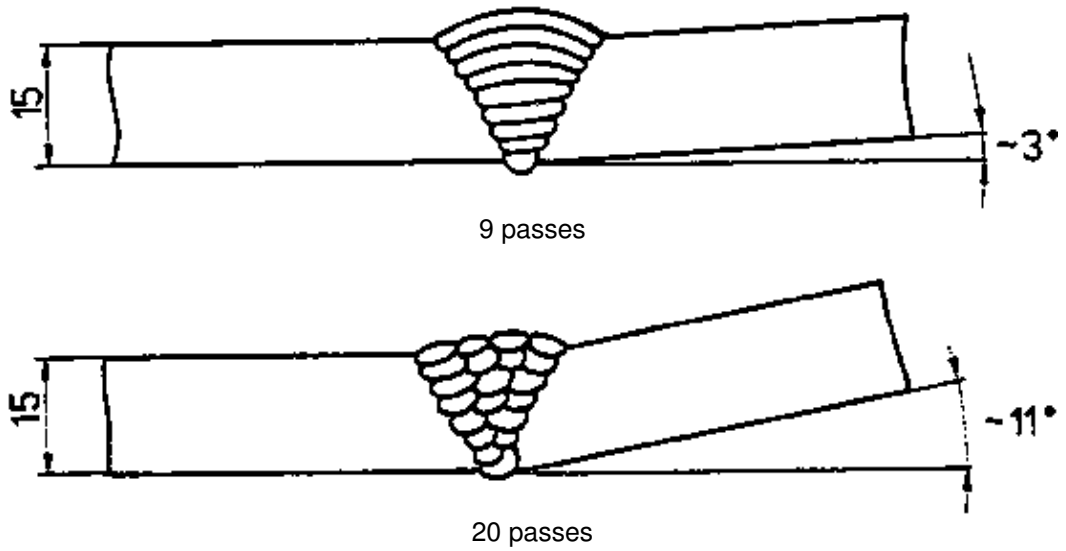
### 3.2. Tacking the V – groove

Demonstrate the assembling and tacking of the plates forming the V-groove. Point out to the trainees that during welding and after this process a shrinkage occurs in the longitudinal direction of the weld and across the weld in all types of welds. The transverse shrinkage of the weld contracts the two plates and, in V-welds, effects an angular shrinkage towards the cover pass which draws the two external edges upwards.

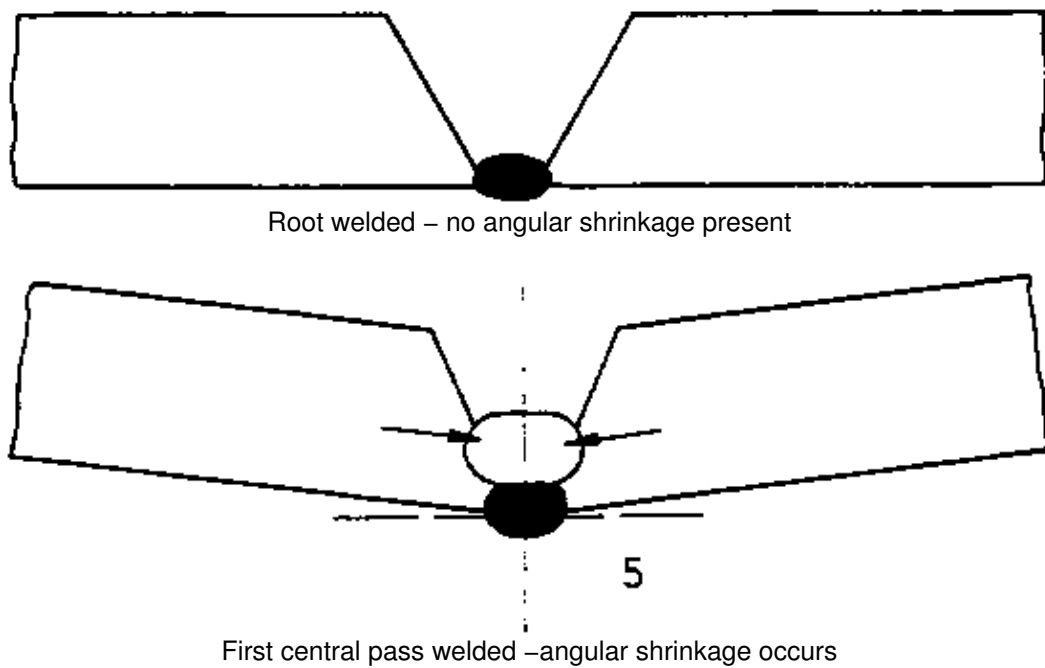
Fig. 27 Angular shrinkage in V-welds

a.) Dependence of the angular shrinkage on the number of passes





b.) Originating of the angular shrinkage by a hinge effect produced by the root pass



Any welded V-weld should remain straight after welding, however. For this purpose, before tacking the two plates are arranged in the form of a roof, that is to say, small strips of sheet metal having a thickness of anything between 2 and 2.5 mm are placed under the left-hand and right-hand ends.

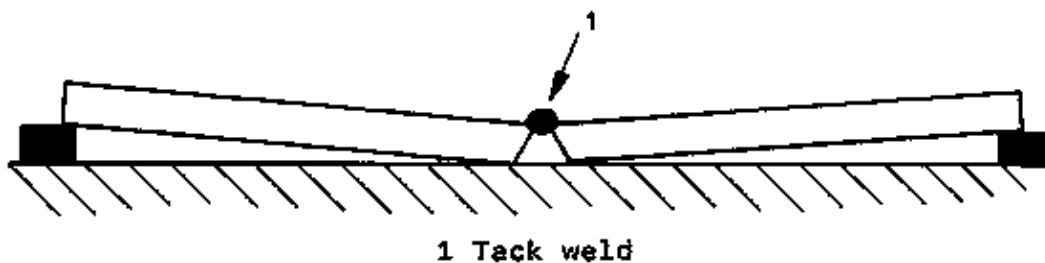


Fig. 28 Roof-shaped tacking of the plates for the V-weld

– The plates must be arranged in such a way that a root gap of 3 to 3.5 mm is present between the faces.

Quote the following rule to the trainees:

For V-welds, the root gap should be equal to the core wire diameter.

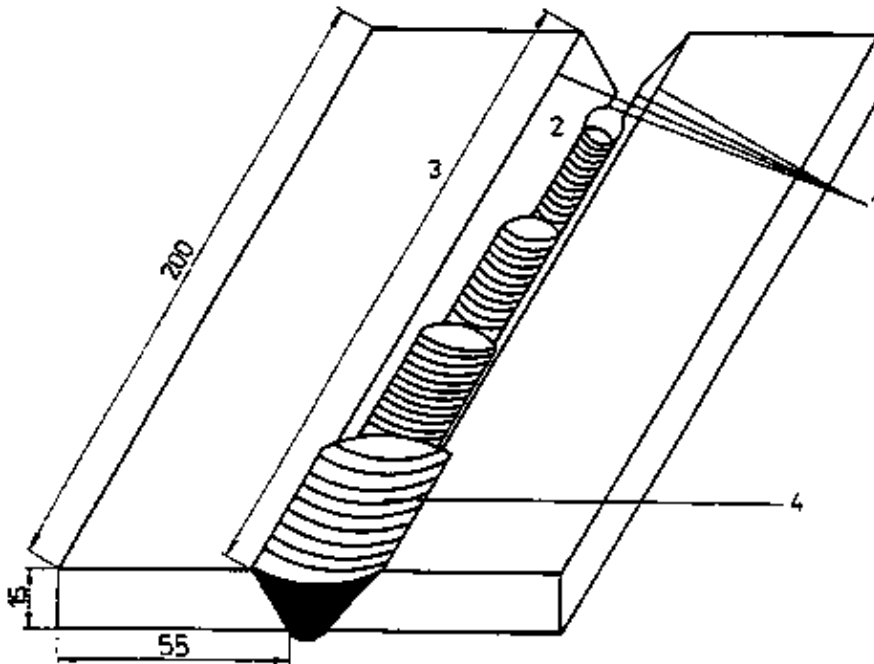
The tack welds have to be applied directly to the plate edges. The tack welds must be strong and clean. When the tack welds break during the root welding, the welding of the root cannot be continued.

When the tack welds have been finished, slag remains and spatters must be carefully removed from these tack welds.

Carefully watch the proper tacking of the V-groove performed by the trainees.

### 3.3. Welding the V-weld

With a plate having a thickness of anything between 10 and 12 mm, multi-pass welding is carried out, namely, the root pass by means of electrodes having a diameter of 3.25 mm, two to three inner passes with 4-mm electrodes and one cover pass with 4-mm electrodes. The weld reinforcement should be  $-0 +1.5$  mm.



1 Longitudinal edges of the groove 2 Groove face  
3 Length of the seam 4 Surface of seam and bead ripples

Fig. 29 Buildup of passes in the V-weld

– As electrode, the "Garant" E 43 4B 110 20 (H) has to be used. This electrode with a basic coating must be welded at the direct-current positive pole.

– Take care that only dried electrodes are used. Otherwise intense pore formation may be inevitable. With this electrode, a particularly short arc must be maintained. It is suitable for all welding positions with the exception of the vertically down position.

#### 3.3.1. Welding the Root Pass

Show the trainees how to weld the root.

The trainees should make a mental note of the following sequence of operations:

– Placing the plates on two strips of sheet metal having a thickness of about 10 mm. This ensures that the formation of the root pass will not be disturbed.

- Arrangement of the V-groove parallel to the direction of viewing on the welding table. Care should be taken that the exercise piece is properly located on the welding table.
- The current is set to 130 A roughly with respect to the core wire diameter of 3.25 mm used.
- It should be noted that the electrode to be used must have a base coating and, consequently, must be connected to the positive pole of the current source.
- The electrode is moved in a U-shaped curve which is open towards the welding direction.



Fig. 30 Welding the root with the electrode moving in a U-shaped curve

- The electrode must be allowed to dwell for a sufficiently long time at the root edges in order to fuse them properly.
- The curve open in welding direction must result in a pear-shaped opening, the so-called "pear". Owing to this electrode motion it is ensured that the root fusion complies with the requirements.
- During welding, the arc length must be varied in order to adapt it to the different situations.

It should be borne in mind:

long arc – high thermal effect  
short arc – low thermal effect

- If it can be apprehended that there will be a lack of root fusion, the arc must be longer accordingly. By heating the groove faces, the weld metal will run more readily into the root gap.
- When the "pear" becomes too large, the electrode must be kept so that the arc becomes shorter in order to avoid an excessive reinforcement of the seam sides.
- By taking advantage of the welding speed, a uniform formation of the root can be achieved,
- In this connection, it should be noted:

Root welding should not be performed at a uniform welding speed. By varying the welding speed, an influence can be exerted on the heat input.

High welding speed –  
Low heat input!  
Slow welding speed –  
High heat input!

- By varying the arc length and the welding speed, a uniform heat input and thus a uniform root formation are achieved.
- The shaping of the correct size of the "pear" is also of great importance the appearance and evenness of the root.

As a rule of thumb for the pear size, the following holds: it should not fall below the core wire diameter of the electrode used.

The pear size is ideal when the 3,25 mm electrode inclusive of its coat can be inserted into it.

- Further it should be borne in mind that the electrode is allowed to dwell long enough at the seam sides. This is achieved by a rhythmic electrode motion.

As rhythm in welding, a "counting" in the oscillating motion is to be used

- to the left, two, three –
- to the right, two, three –

while the dwell time of the electrode on the seam side is defined by "two, three".

Point out to the trainees that there are grave consequences when this instruction is not observed.

- Undercuts will occur in the seam sides where slag will accumulate. Since this slag can hardly be removed it is usually overwelded and, in this operation, insufficiently fused. Welding defects in the form of slag inclusions are the consequence.

Have the oscillating motion carried out as a dry exercise, that is to say, the oscillating motion is practised without actually welding. For this purpose, the welding converter must be switched off.

Point out to the fact that

- by varying the speed in oscillating, the heat input can also be varied considerably.
- The trainees should make a mental note of the following rule:

- |   |
|---|
| <ul style="list-style-type: none"><li>– rapid oscillating – small amount of heat</li><li>– slow oscillating – high amount of heat</li></ul> |
|---|

- Explain that the quality of a root pass is influenced by three quantities to the trainees

- variation of the welding speed (oscillating motion)
- variation of the arc length
- variation of the rhythmic electrode motion.

The welding of root passes presents difficulties to many trainees because the three quantities can be coordinated only after a long period of exercising.

Therefore, pay particular attention to the exercising of root welding. Encourage the trainees who find it difficult to acquire root welding.

Give the following information to the trainees:

- As a result of root welding, considerable shrinkage of the workpiece occurs. This transverse shrinkage may be so remarkable that, under certain circumstances, the root gap can no longer be retained by the tack weld and is lost. Without the specified root gap, proper root welding, is impossible, however.

- One should proceed as follows:

30 mm of the root pass are first welded from one end and then the remaining length of the root is welded from the other end.

By turning the plate it is ensured that the same welding direction is maintained.

- When welding the root pass, the already known blow effect will again occur.

The blow effect is counteracted by inclining the electrode from the beginning of the weld in welding direction and, towards the end of the weld, opposite to the welding direction.

- The extension length, i.e. the length of the root which can be welded with one electrode, is not sufficient for the length of the seam. Therefore, starting points are necessary.

- When the electrode is molten down sufficiently, the arc is guided in such a way that a large pear is formed. The arc is ignited about 1.5 cm in front of the pear on the root pass and, with a long arc, a thin bead is drawn to the pear. Now, allow the arc to burn in the pear. After the pear has been fused sufficiently, one can continue to weld the root pass.

With this method, defects due to the starting or arc striking are avoided. After root welding, slag and weld spatters are carefully removed from the V-weld.

Check the root weld for welding defects such as insufficient through-welding, excessive root sag, starting defects, pores, slag inclusions, lack of fusion and undercuts. Uneven starting points can be smoothed by means of hammer and chisel.

### 3.3.2. Welding the Inner Passes

Show the trainees how the inner passes have to be welded. The trainees again should make a mental note of the sequence of operations.

- Electrodes with a core wire diameter of 4 mm are to be used.
- Adjust the current to an intensity of 190 to 200 A. Due to the high current intensity, in the groove faces a good penetration is obtained for the root pass and the bead lies flat without notches in the groove.
- Observe the following procedure for welding the inner passes.

When electrodes with a thick coating are used, the electrode is oscillated in a semi-circle which is closed in the welding direction.

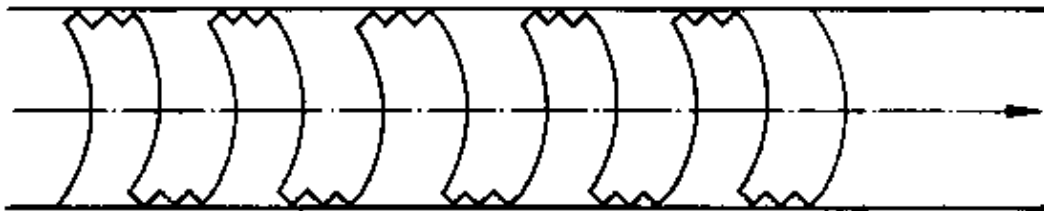


Fig. 31 Motions of the electrode for electrodes with thick coating for welding inner passes and cover passes

This procedure ensures that during the motion of the electrode, also known as electrode manipulation, slag is not included. The teeth in the above illustration shall show the dwell of the electrode at the seam sides. The oscillating motions of the electrode must be effected in a pronounced rhythmic manner. The trainee should count during oscillating in the following manner:

- to the left – two – three,
- to the right – two – three,
- to the left – two – three,
- to the right – two – three, etc.

At the same time, the electrode should be moved so as to slightly touching the work or, in other words, during counting, the electro-should be slightly lifted and lowered.

- The success of any weld depends on the exact manipulation of the electrode,
- Pay attention to the fact that the oscillating motions are not too wide; in other words, the external edge of the coating should not move beyond the width of the preceding bead.

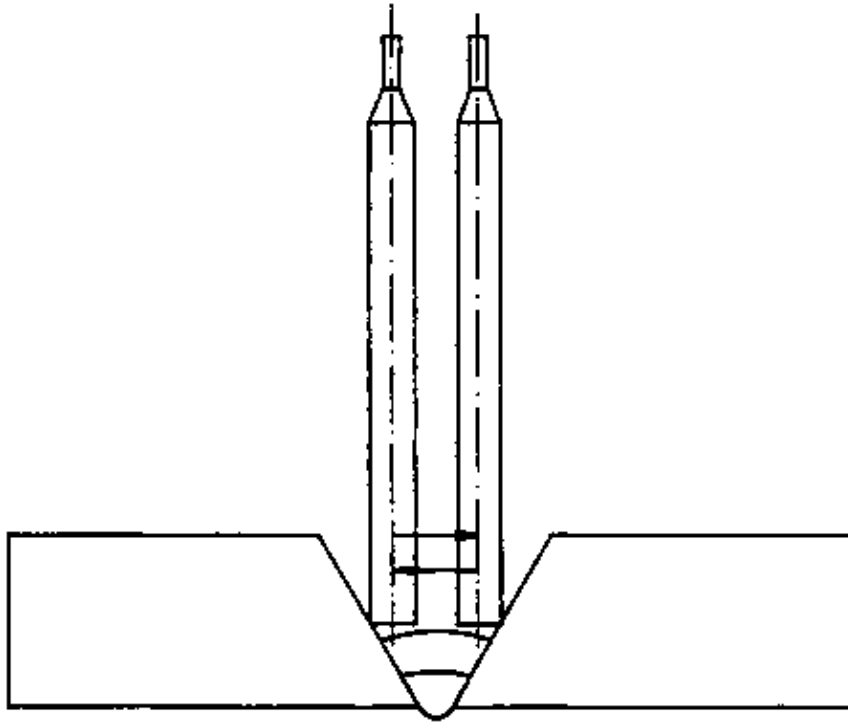


Fig. 32 Electrode position to avoid undercuts at the sides of the seam

- When exceeding this width is oscillating the electrode, the molten pool will become too large and slag runs to the centre.

As a consequence, slag inclusions occur and, in spite of the high current, fusion penetration will remain poor. In this case, too, have the electrodes manipulated by the trainees as a "dry exercise". Point out to the trainees the following items:

- Due to the high currents, the last third of the electrode begins to glow out.

If this glowing piece of electrode is welded, not only an irregular weld surface will be produced but also a large number of pores formed and a poor penetration obtained. The electrode must be replaced in time.

- The electrode stubs should not be thrown away because they can be used for tacking and minor welding operations.
- The electrode stub should not be longer than 40 mm.
- The electrode stubs are collected in tins or sheet-metal boxes. Electrode stubs are valuable secondary raw materials for steel production.

#### Note for labour safety

– Pay attention to the fact the electrode stubs are not thrown on the floor. They constitute a danger of accident because people may slip when stepping on it.

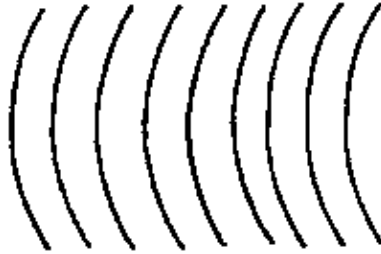
- After welding the first inner pass and removing slag and spatters from it, the next inner pass can be welded.
- All inner passes are welded in the same way as the first one, but the current may be reduced by 20 to 40 A. Electrode manipulation may be carried out invariably.
- During welding, the plate should not become too hot otherwise the weld bead will become poor in appearance. The bead ripples will no longer be round but taper in the direction of the finished pass.

Fig. 33 V-weld, good and poor appearances of the bead ripples of the cover pass





1 poor appearance of the bead ripples



2 good appearance of the bead ripples

- To avoid overheating of the weld, it is necessary to observe a break after any individual pass in order to allow the work to cool down.
- When all inner passes have been welded, then the last one must be so located that 1 to 1.5 mm are free up to the plate surface. The margin left in this way is a guidance for welding the cover pass.
- The end craters of all inner passes must be filled very carefully. This is achieved by shortening the electric arc.

When having finished all inner passes, slag and spatters must be removed from the seam carefully.

Check the uniformity of the last inner pass. Irregularities must be removed by chiselling. The successful outcome of the cover pass is largely depending on the appearance of the last inner pass.

### 3.3.3. Welding the Cover Pass

Show the trainees how to weld a cover pass. Give the necessary instructions.

- Electrodes with a core wire diameter of 4 mm are to be used.
- The current intensity is 170 A.
- The cover pass must be welded with every care and particularly slowly in order that to the left and right of the groove edge a good penetration with a good transition is obtained without undercuts.
- Electrode manipulation and oscillating motions are the same as those required for the welding of the inner passes.
- The welding speed can be reduced by counting at a lower rate.
- Again the electrode is moved up and down but it is allowed to dwell for a longer time at the seam sides as for the preceding passes.
- When welding at a higher rate, the cover pass will become convex and show undercuts. This allows to draw the conclusion that the filler metals requires a certain time in order to penetrate into the parent metal.
- When welding the cover pass, do not weld beyond the plate edge to the right and left.

- When starting with a new electrode, ignite it in the centre of the end crater, fill the latter by slow oscillating motions and then continue welding in the usual rhythm.
- The end crater of the seam must be filled carefully; this is achieved by shortening the arc,
- When having completed the weld, clean the weld and check it for welding defects.

### 3.4. Assessment of the Welded V-weld

Give comments on the welded V-seam together with the trainees. Tell them the assessment criteria.

Give assessments on the appearance of the weld, the accuracy to size and the appearance of the fracture.

#### Appearance of the weld

- Uniformity of the bead ripples
- Appearance of the root
- Points of start and arc strike
- End craters
- Undercuts
- Weld spatters

#### Accuracy to size

- Three measuring points must be determined by means of the weld gauge.

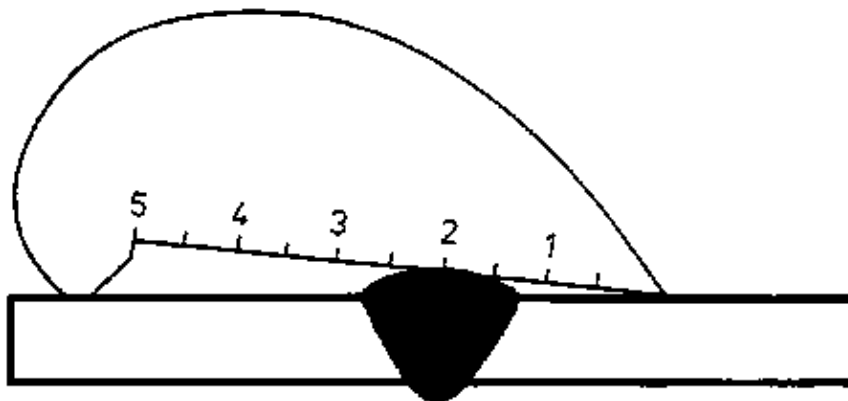


Fig. 34 Measuring the weld reinforcement

Weld gauge (1) for measuring the weld reinforcement. For V-welds in "g"-position, a weld height of + 1.5 mm is permissible.

#### Appearance of the fracture

For assessing the appearance of the fracture, the V-weld must be notched and broken.

- The V-weld is notched by planing.

Take care that the notch tapers to the bottom and has a depth of at least 4 to 5 mm.

- By means of the device shown in the following illustration, the sample is broken in a hydraulic press.

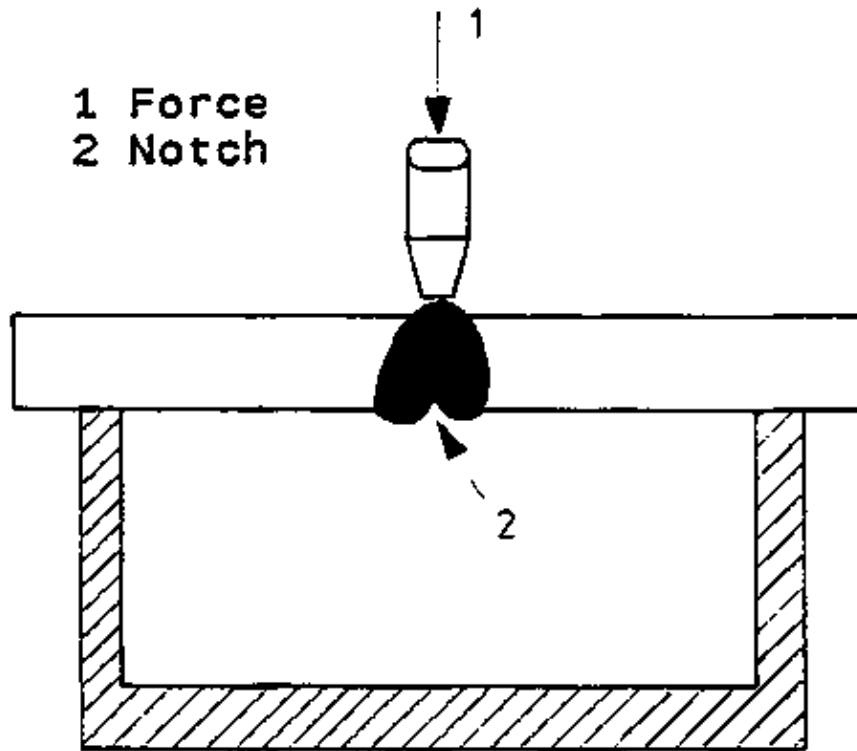


Fig. 35 Breaking the notched V-weld

Criteria for the assessment of the appearance of the fracture are:

- Fusion of the edges of the root
- Slag inclusions
- Pores
- Lack of fusion

Show properly welded and defective welds to the trainees. Give workpieces with defective welds to the trainees. The trainees are then asked to assess the weld, to identify the defects and to tell the causes.

#### Evaluation of the Section V-seam Welding "g"

With the conclusion of the exercise Section V-welding, the trainees should have acquired the following knowledge, abilities and skills:

- observance of the relevant labour safety regulations and order and tidiness at the working place
- preparation of the welding samples
- mastering V-welding in "g"-position
- identification of typical welding defects in V-welds
- comments on their own work

#### Examples of questions regarding the Section V-seam Welding "g"

1. Describe the buildup of a V-weld in "g" position!
2. Explain the marking or designation of the welding electrode used!
3. Describe the groove preparation for a V-weld!
4. What are the faults of the weldor that cause pores in the weld?

