Electric Welding 3 – Course: Techniques of Electric Welding. Methodical Guide for Instructors

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Electric Welding 3 – Course: Techniques of Electric Welding. Methodical Guide for Instructors

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0. Introductory remarks

These methodical instructions have been elaborated in order to impart knowledge, capacities and skills in electric welding.

It is the purpose of the methodical instructions to give aid and support to an instructor for practical vocational training in the preparation and realization of his instructional work. What is suggested to the instructor are possible ways to reach the goals of his pedagogical activities.

The methodical instructions are organized in such a way that the trainees are systematically informed of

– fillet welding in the vertical–up position,
– V type welding the vertical–up position,
– V type tacking, 5 tacks,
– welding a profile joint, root pass and two cover passes, and fillet welding in the semioverhead position.

The preparation of the welding specimens (plates), the selection of the electrodes and the respective electrode manipulation as well as the evaluation of the welds are the most important points to be considered.

Learning the above mentioned skills of welding and welding positions carries on the task of Parts I and II of Electric Welding instructions. The order of succession of learning the weld types and welding positions was determined on the basis of experience gained in the training of electric weldors. Thus mastering the weld types and welding positions described in Parts I and II of the Electric Welding instructions is prerequisite to learning the weld types and welding positions explained in the present instructions. Having passed the examination, the trainees are authorized to weld

– fillet welds in the vertical–up position and the semioverhead position,
– V type weld in the vertical–up position,
– V type welds with 5 tacks,
– profile joints with a root pass and two cover passes on plates and profiles with a thickness of 6 – 12 mm.

1. Fillet welding in the vertical–up position

Recapitulate the concepts of a fillet weld and the vertical–up position. Start to discuss this section only if the trainees perfectly master fillet welding in the horizontal position.

Let one of the trainees demonstrate fillet welding in the horizontal position. Tell him also to discuss the most important points to be considered. Evaluate the demonstration together with the trainees. Accord praise for good workmanship. Recapitulate the preparation of the specimen plates for fillet welding in the horizontal position. The same preparations are applicable to fillet welding in the vertical–up position. Therefore, use the methodical instructions for horizontal fillet welding. The same holds for tacking the fillet weld. Discuss the differences between fillet welding in the horizontal and the vertical–up position.

Summarize the differences in a table.

Horizontal fillet welding		Vertical–up fillet welding
4.00 mm 160... 200 A	Welding electrode Amperage	3.25 mm 120... 160 A
adjust amperage to 180... 190 A	root pass welding	adjust amperage to 110 A
at the left–hand end of the T–butt joint	arc starting	at the lower edge of the fillet weld
without weaving, as a string bead carried out with regular stippling	welding the root pass	with triangular electrode manipulation. Initially the fillet weld is still cold and must be preheated using a longer arc.
45°	angle between the electrode and the boom plate	45°
2 cover passes	cover pass welding	1 cover pass
4.00 mm	electrode	3.25 mm
170 A	amperage	110... 120 A
string bead carried out with weaving motion 2/3 of the root covered	welding the 1st cover pass	weave bead arc–type electrode manipulation
tilt the electrode towards the web plate at an angle of 60°, hold the arc very short at the web plate	welding the 2nd cover pass	not applicable

The procedure before welding the root pass is as described in the instructions for horizontal fillet welding.

1.1. Welding the root pass

Demonstrate root welding to the trainees. For that purpose, place the specimen on the welding table with the fillet weld arranged vertically. Point out to the trainees that the specimen must be put on 10 mm thick plate strips. This enables an unobstructed working with the arc at the beginning of the seam.

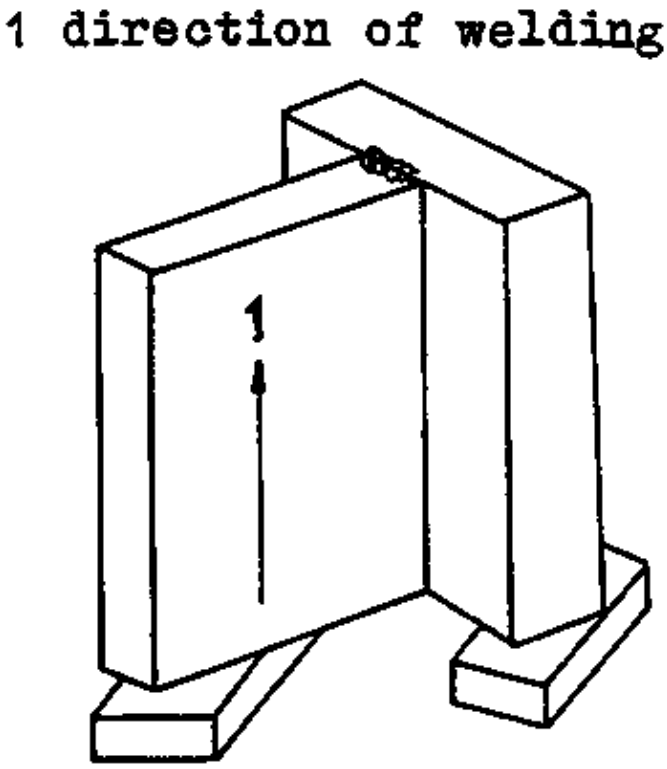


Fig. 1 Specimen arranged for vertical–up fillet welding

Sequence of operation in root welding:

- Adjust the amperage to appr. 110 A
- Start the arc at the lower edge of the fillet weld
- Weld the root pass with, triangular electrode manipulation

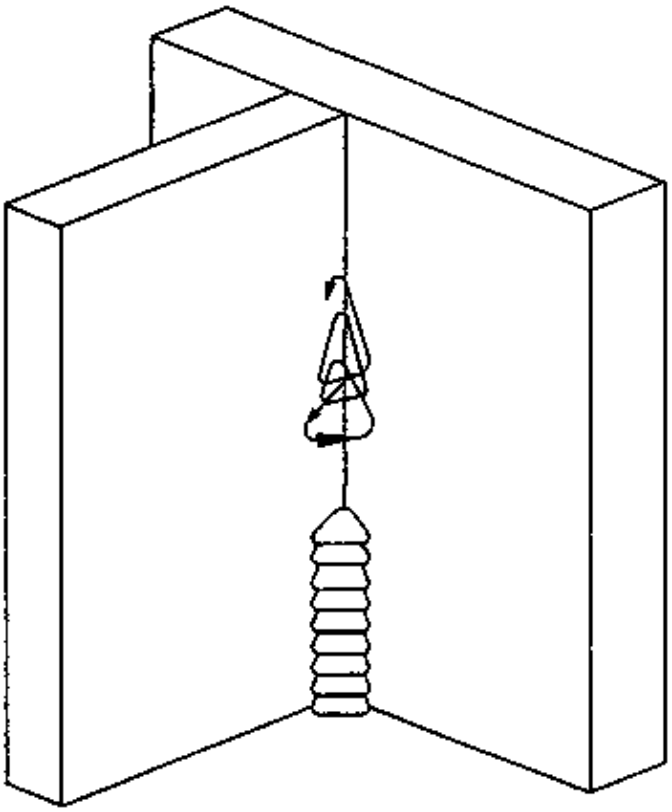


Fig. 2 Electrode manipulation in root welding

Explain to the trainees that at the beginning of root welding the fillet weld is still cold and must be preheated by means of a longer arc.

To obtain a symmetrical, central weld buildup, the position of the electrode must be such that the angle of 45 between the electrode and the boom plate and web plate, respectively, is exactly maintained

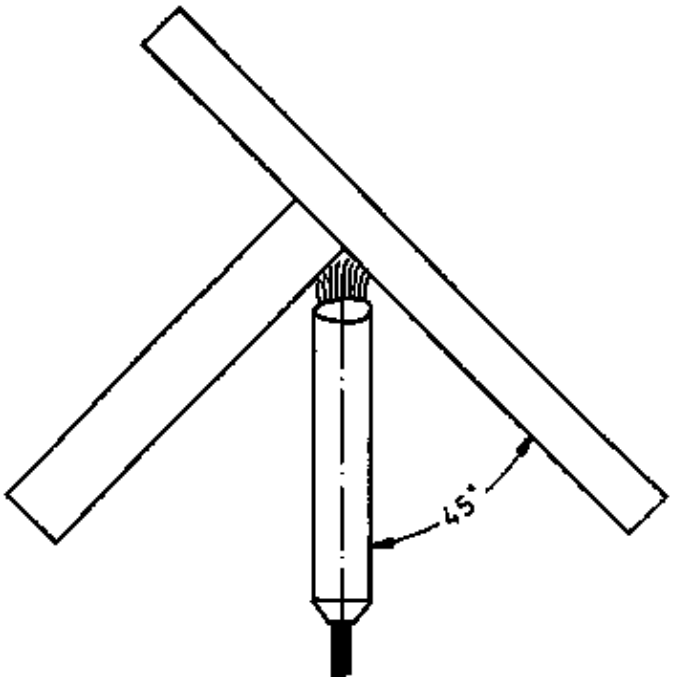


Fig. 3 Electrode position for obtaining a central weld buildup

One again, draw the trainees' attention to the arc blow effect. This effect must be counteracted by tilting the electrode in the direction of welding at the beginning of the seam and in the opposite direction when approaching the end of the seam.

Discuss the consequences of ignoring the arc blow effect with the trainees.

Ignoring the arc blow effect results in welding faults such as

– interrupted weld,
– slag inclusions,
– heavy spattering of the weld sides.

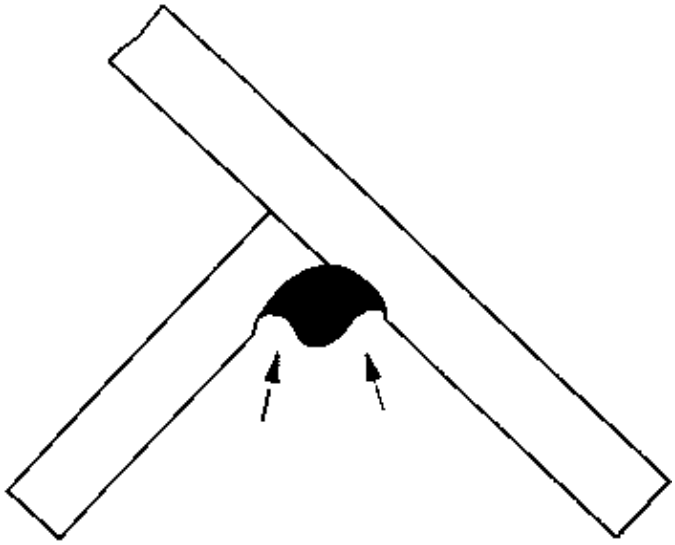


Fig. 4 Excessive reinforcement of the root pass with deep undercutting

Point out to the trainees that the root pass must be welded so as to avoid a reinforcement in the centre of the seam. If this is disregarded, then not only the slag is difficult to remove, but there will also occur slag inclusions at the side walls of the seam when the first inner pass is welded.

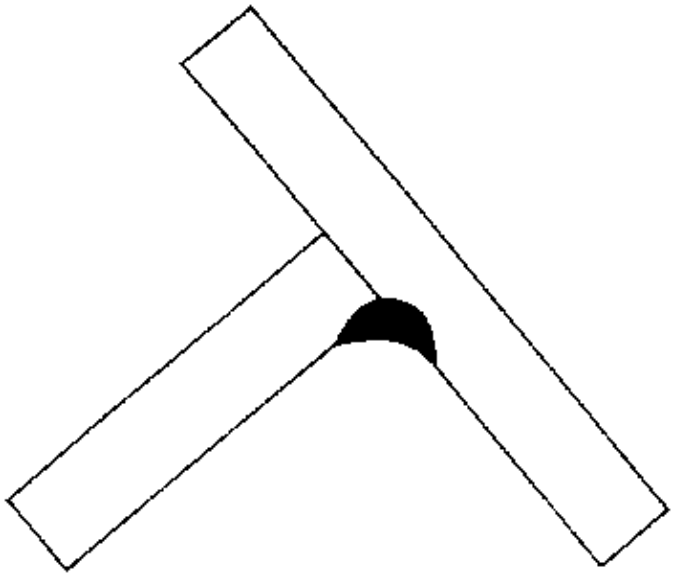


Fig. 5 Central and undercut–free execution of the root pass

Therefore, in the triangular manipulation of the electrode, take care to provide for an adequate dwell time of the electrode at the seam side walls in order to fill the undercuts resulting from the arc.

Take care to carry out triangular manipulation of the electrode in the following rhythm:

left – middle – right, left – middle – right,

where the dwell time of the "left" and on the "right" must be somewhat longer than in the "middle".

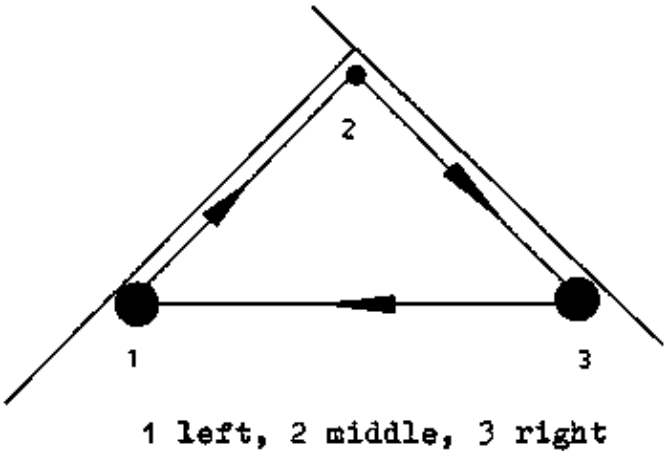


Fig. 6 Sequence of electrode manipulation in root welding

– When welding a seam length of 200 mm, an electrode change will be required.

In this case proceed as follows:

Clean the seam end from slag and spatter. Start the arc with the new electrode at the lower end of the end crater.

A gradual preheating will absolutely be necessary in order to melt the end crater; this is achieved by a slight weaving with a long arc. The actual weld buidup is restarted not earlier than the weld metal threatens to flow off.

Demonstrate and explain the procedure of electrode changing.

A slight overhang of the seam is better than a lack of fusion. If necessary, this overhang can be removed by chipping.

– Take care to provide for a good filling of the end crater of the root pass. This is achieved by shortening the arc.

After the root welding has been finished, the fillet weld is carefully cleaned from slag and spatter.

Check the root passes welded by the trainees for central alignment and for possible welding faults such as pores, slag pockets and undercutting.

1.2. Welding the cover pass

Demonstrate cover pass welding to the trainees.

Explain the following sequence of operations:

– Use electrodes with a diameter of 3.25 mm.

– Adjust the amperage to 110... 120 A.

– The cover pass is welded as a weave bead, i.e. with an arc–like electrode manipulation, the arc being closed in the direction of welding.

Take care that the arc is not drawn too steeply, because this would lead to a lack of fusion of the root. To achieve a sufficient fusion of the side walls of the seam and to avoid undercutting, the following rhythm must be kept in the weaving motion of the electrode:

– left 2–3, right 2–3, left 2–3 etc.

Again and again tell the trainees to follow this rhythm. Check that the trainees count the rhythm.

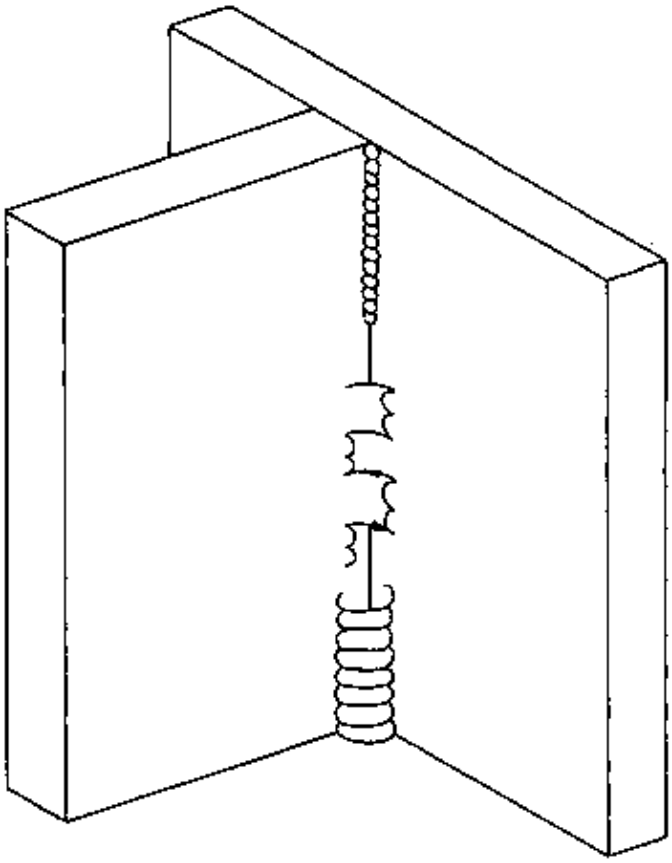


Fig. 7 Electrode manipulation in welding the cover pass

Once again, draw the trainees' attention to the arc blow effect. Demonstrate to the trainees how to manipulate the electrode accordingly; see Fig. 7.

The electrode change is carried out as described for root welding.

Thereafter fill the end crater.

Finally allow the fillet weld to cool down and clean it.

1.3. Evaluation of the finished fillet weld

Evaluate the finished fillet weld together with the trainees.

Informe the trainees of the evaluation criteria.

Evaluate the weld appearance, the accuracy to size and the fracture appearance.

<u>Weld appearance</u>

- Symmetry of the weld buildup
- Uniformity of bead ripples
- Arc strikes
- End crater
- Undercutting
- Spatter

<u>Accuracy to size</u>

Determine the three measuring points by means of a weld gage.

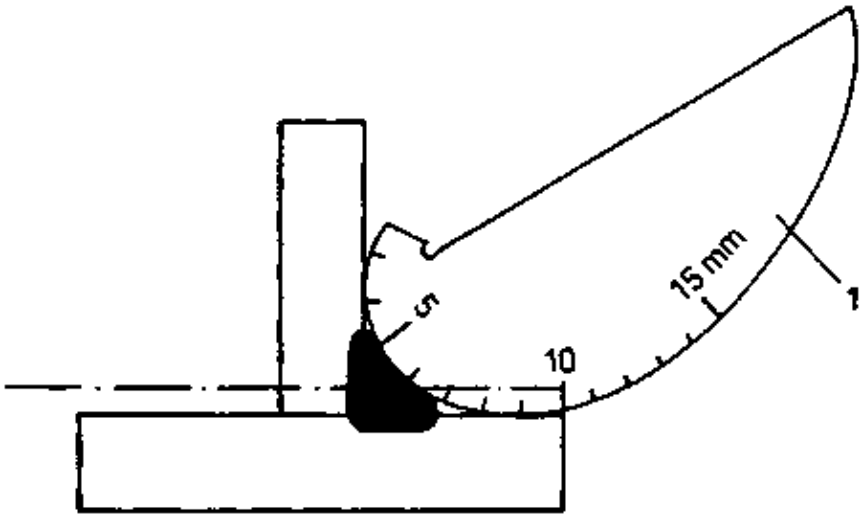


Fig. 8 Weld gage (1) for measuring the fillet weld height

For vertical–up fillet welds, the permissible tolerance of the weld height is + 2.0 – –0,5 mm

Fracture appearance

To evaluate the fracture appearance, break the fillet weld specimen in a suitable fixture.

The criteria for evaluating the fracture appearance are as follows:

- Melting of the web plate edge
- Slag inclusions
- Porosity
- Lack of fusion

Thereafter evaluate the results of work. Take concrete examples to discuss weld faults and their causes.

Evaluation of the Section "Vertical–up fillet welding"

After finishing the training section of fillet welding, the trainees should have acquired the following knowledge, capabilities and skills:

- Obeying the labour safety regulations including order and cleanliness at the working place
- Preparation of the welding specimen
- Mattering vertical–up fillet welding
- Recognition of typical welding faults in fillet welds
- Evaluation of their own work.

Examples of questions on the Section "Vertical–up fillet welding"

1. Describe the weld buildup of a vertical–up fillet weld.

2. What are the typical welding faults which occur in vertical–up fillet welding?

   How can these faults be avoided?

3. Explain the marking of the welding electrodes used.

4. What are the dangers the weldor is faced with in his work?

   How can he protect himself from such dangers?

2. V type welding in the vertical–up position

Mattering vertical–up fillet welding is an important precondition for V type welding in the vertical–up position.

Explain the differences between V type welding in the gravity and the vertical–up position.

Summarize these differences in the form of a table.

V type weld		V type weld
Gravity position		vertical–up position
core diameter of 3.25 mm	electrode	all passes with a core diameter of 3.25 mm
Inner and cover passes are welded with a core diameter of 4.00 mm,		
type "Garant" E 43 4B 110 20 (H)		type "Titan" E 43 4 RR (B) 22 red colour marking
–0, + 1.5 mm	weld reinforcement	–0, +2.5 mm

2.1. Welding the root pass

Demonstrate root welding to the trainees.

Give the following instructions:

– For the electrode with a core diameter of 3.25 mm, adjust the amperage to appr. 90 – 100 A.

– The lower plate– edge should be adequately preheated using a long arc. As soon as the tack begins to melt, continue welding with a short arc.

– The electrode is guided along an open arc in the direction of welding.

Count in the rhythm "right 2–3, left 2–3" while moving the electrode a little upwards each time.

Take care that the trainees count during the welding operation. Counting is very helpfuhl in learning the correct electrode manipulation.

– When moving the electrode upwards, take care to obtain a good fusion of the seam edges.

– The weld metal is deposited with a short arc in the centre of the groove while counting 2–3,

– To achieve a perfect fusion at the root, the weld metal must be pushed into the prepared groove with a slight pressure.

– When changing the electrode, then after ignition again weave the electrode with a somewhat longer arc at the surface of the weld, and as soon as the metal begins to melt, push the weld metal through the groove with a short arc. The electrode is guided perpendicularly to the specimen.

All the following operations are the same as described for welding the root pass in the gravity position.

Therefore continue the welding process as described in the instructions of gravity V type welding.

Check the root pass for possible welding faults such as insufficient fusion, excessive root sagging, arc strike

faults, porosity, slag inclusions, lack of fusion and undercutting.

Unevennesses should be removed using hammer and chisel.

2.2. Welding the inner passes

Demonstrate the inner pas welding to the trainees.

– Use electrodes with a core wire diameter of 3.25 mm. adjust the amperage to 100... 115 A. This high amperage is required to melt the root reinforcement and to flush out minor slag residues at the side walls of the seam.

– The electrode is guided along an arc–like path which is closed in the direction of welding. In this case there should also be a somewhat longer dwell time of the electrode at the side walls of the seam with a stippling arc.

– Point out again that the electrode manipulation should be markedly rhythmic.

– Again count "left 2–3, right 2–3" etc. At 2 – 3, let the electrode dwell at the side wall of the seam with a stippling arc in order to flush out possible minor slag residues. This will also produce a flat shape of the inner pass. Inner passes with a high reinforcement can only be smoothed out very unsatisfactorily.

– In all inner passes, guide the electrode as shown in the figure below.

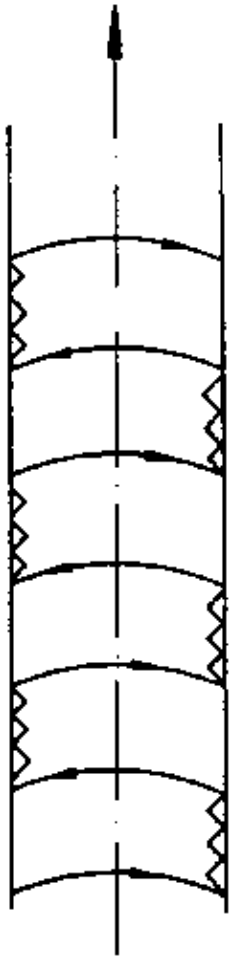


Fig. 9 Electrode manipulation for welding the inner passes and the cover pass

– Mind the arc blow effect in this case, too. It is counteracted in the same way as in welding the root pass.

According to the basical representation of the electrode manipulation, give to the trainees the following instructions for welding the inner passes.

Take care that the amplitude of the weaving motion is not too broad. The outer edge of the electrode coating must not move beyond the existing bead width.

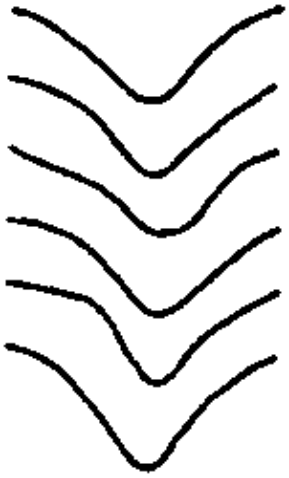
– If the weaving amplitude is broader, then too large a molten bath results and the weld metal flows down in the centre, which leads to a high reinforcement of the inner pass.

– The electrode is to melt to a length of 40 mm.

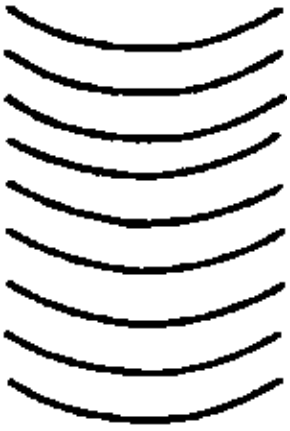
– After the first inner pass has been welded and cleaned from slag and spatter, the next inner pass can be welded.

– All the inner passes are welded in the same way as the first one, only the amperage can be reduced by 20... 30 A. The electrode manipulation can be maintained without any change.

Fig. 10 Poor and good bead ripple pattern of the cover pass



1 – poor ripple pattern



2 – good ripple pattern

Take care that the plate does not become too hot during welding, because this would lead to a poor appearance of the weld bead; the ripple pattern would no longer be straight but with downward–hanging tips in the middle of the seam.

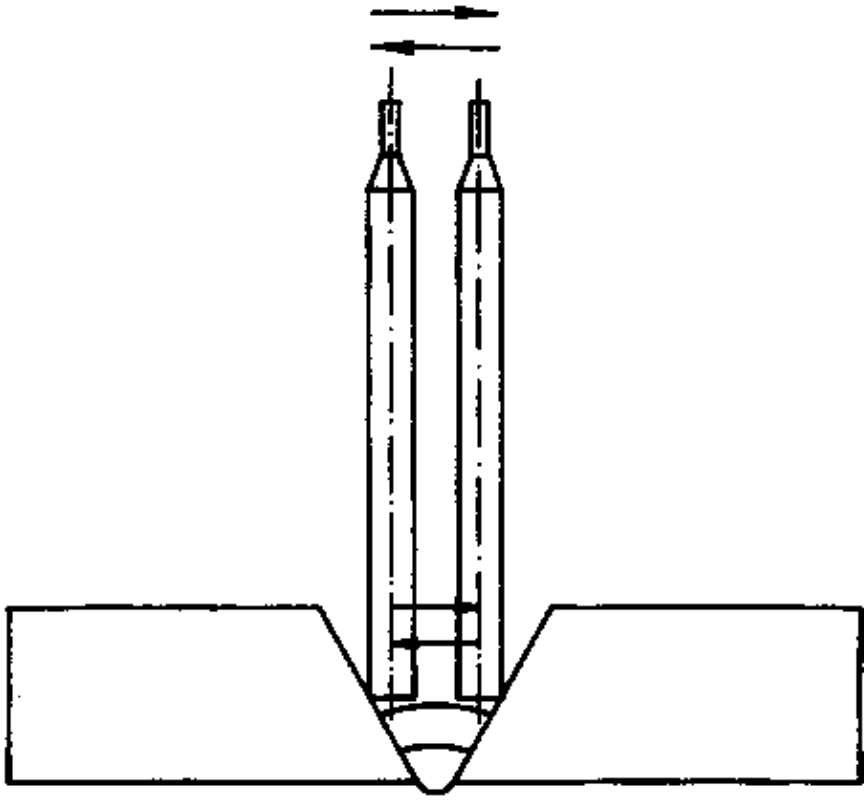


Fig. 11 Electrode position for avoiding undercuts at the side walls of the seam

– To avoid overheating of the weld, it is necessary to have a short interruption after each pass in order to provide for the cooling required.

– After finishing all the inner passes, the upper edge of the last inner pass should be 1... 1.5 mm below the plate surface.

The remaining edge allows an orientation in welding the cover pass.

– The end craters of all inner passes should be filled very carefully. This is achieved by shortening the arc.

After finishing the inner pass welding, clean the weld carefully from slag residues and spatter. Check the uniformity of the last inner pass. Unevennesses should be smoothed out by chipping. A successful welding of the cover pass depends critically on the appearance of the last inner pass.

2.3. Welding the cover pass

Demonstrate cover pass welding to the trainees. Give the following explanations:

– Use electrodes with a core wire diameter of 3.25 mm.

– Adjust the amperage to appr. 110 A.

– Weld the cover pass most slowly and carefully in order to obtain a good weld penetration on the left and right sides of the seam side wall, with a good weld–base metal interface and without undercutting.

– The weaving motion and the manipulation of the electrode correspond to those used in welding the inner passes.

– The welding speed is regulated by slower or faster counting.

– Again a stippling motion is applied, but the dwell time at the seam side walls should be longer than with the preceding passes.

– Take care to draw the arc most quickly over the centre of the seam in order to avoid an excessive buildup of weld metal.

– When welding the cover pass, do not weld beyond the plate edge on the right and left sides of the seam.

– When the arc is re–started, this should be done in the middle of the end crater. The end crater is filled by slow weaving. Subsequently the welding operation is continued in the usual thythm.

Evaluation of the Section "Vertical–up V type welding"

Having finished the training section on V type welding, the trainees should have acquired the following knowledge, capabilities and skills:

– Obeying the labour safety regulations including order and cleanliness at the working place
– Preparation of the welding specimen
– Mattering V type welding in the vertical–up position
– Recognition of typical faults in V type welds
– Evaluation of their own work

Examples of questions on the Section "Vertical–up V type welding"

1. Describe the buildup of a V type weld in the vertical–up position.
2. Explain the marking and the properties in use of the welding electrode employed.
3. What are your possibilities of obtaining a uniform root formation by electrode manipulation?
A. How do you counteract the arc blow effect in vertical–up welding?

3. V type welding with 5 tacks

In a discussion, explain the objective of this training section. Recapitulate the points of importance to be considered in tacking a V type weld.

Subsequently discuss the particularities of welding 4 tacks in the gravity position and 2 tacks in the vertical–up position.

– Each tack must have a length of 30 mm. The quality must correspond to that of a high–quality root weld.

– When welding very long butt welds, several tacks will be required. In cases where this is necessary for constructional reason, the tacks must then be included in the whole root.

This exercise has been included in the scope of training and examination in order to teach placing proper tacks in the middle of a butt joint. Draw the trainees' special attention to this fact.

Root welding in the gravity and the vertical–up position has already been dealt with in the sections on gravity V type welding and vertical–up V type welding. These skills should be taken as a basis. Let the trainees tack a V type weld in the gravity and the vertical–up position.

The following explanations will only give the instructions required for welding the tacks.

3.1. Preparation of the specimen plates

Inform the trainees of the dimensions and the condition required for the specimen plates.

– Four 100 x 100 mm plates 10... 12 mm thick will be used.
– The bevel angle of the plates is 30 °.
– The plates must be flat and have a clean surface.

3.2. Tacking the V type welds

Demonstrate the assembling and tacking of the V type welds. Again point out the angular shrinkage and, in a discussion, recapitulate the measures to be taken to counteract angular shrinkage.

Then go on as described in the methodical instructions on gravity V type welding.

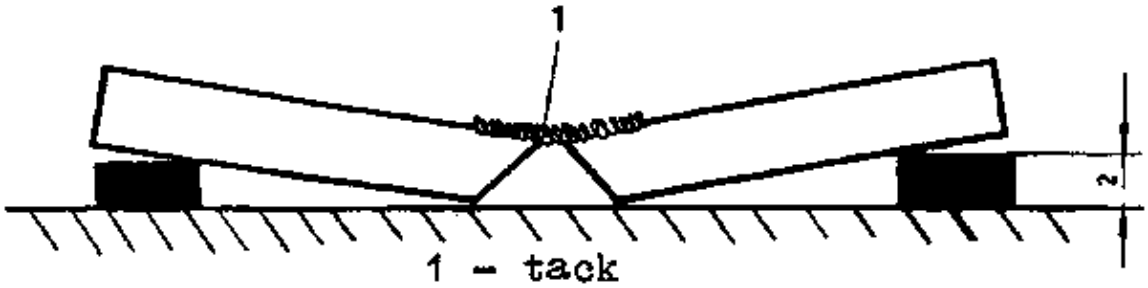


Fig. 12 Tacking the V type weld in a roof–like configuration

Assemble the plates so that a root opening of 3 ... 3.5 mm is left between the side walls of the seam. In a repetition, make clar which value of the root opening is required. Check how the rule for determining this value has been learnt.

Thereafter discuss the further operations:

– Fix the plates by means of two short tacks. Take care that the welded tacks are strong and clean. If the tacks crack during root welding, the welding operation cannot be continued. After finishing the tack welding operation, the tacks must be carefully cleaned from slag residues and spatter.

Check the proper tacking of the V type weld by the trainees.

3.3. Welding the tacks in the gravity position

Weld three tacks with a length of 30 mm each in the gravity position.

The arrangement of the tacks can be observed from the figure below.

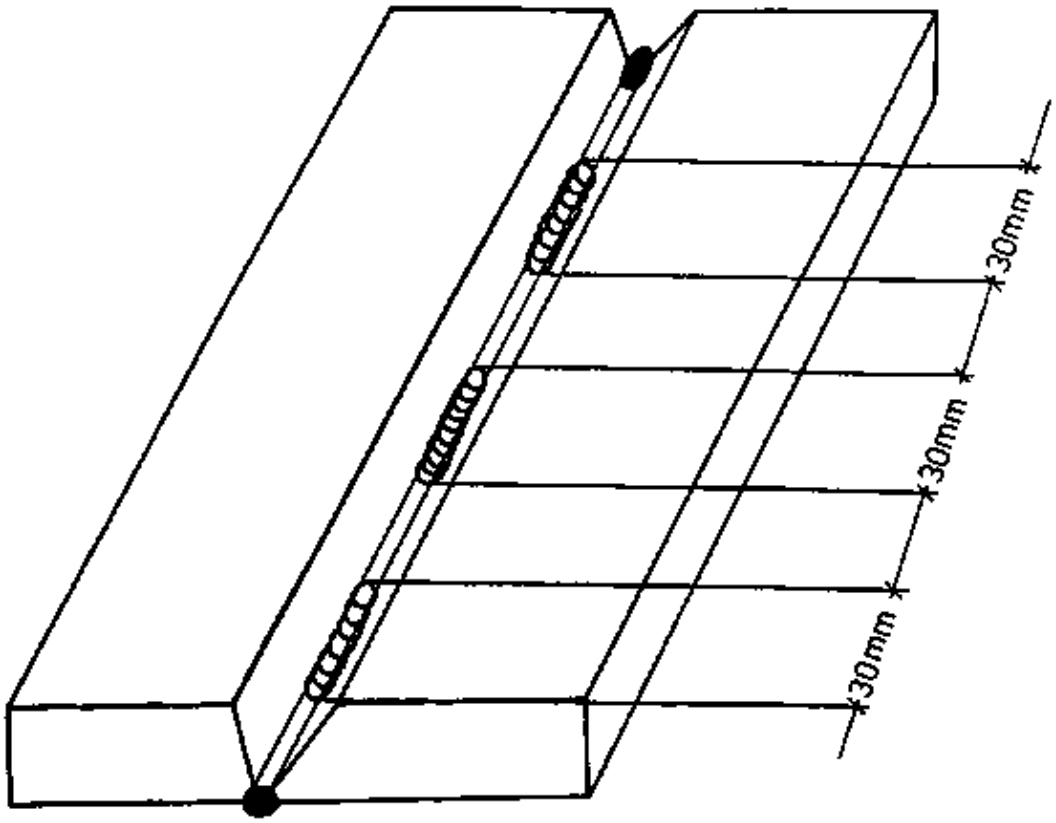


Fig. 13 Tacks in the gravity position

Use an electrode of type "Titan" E 43 4 BE (B) 22 with red colour marking.

Demonstrate the tack welding to the trainees.

Inform the trainees of the following points of importance:

– Adjust the amperage to appr. 110 A.

– The first tack is welded at a distance of 20 mm from the beginning of the seam at the left–hand side.

– The second tack is started at a distance of 50 mm from the right–hand end of the seam.

– The third tack is placed in the middle of the remaining weld groove.

– This welding sequence will avoid a high degree of shrinkage of the V type weld, which would cause the necessary root opening to disappear.

– After ignition, the electrode, with a somewhat longer arc (arc length of appr. 5–6 mm), is moved over a distance of about 10 mm in the direction of the beginning of the seam. At this point let the electrode dwell for a moment, until the beginning of the seam is sufficiently heated up. Then, using an arc length of 3–4 mm, perform a stippling motion without moving the electrode forwards, until the weld metal threatens to sag. At this very moment move the electrode forwards along an arc–like path being open in the direction of welding, as it is done in root welding. After welding a tack 30 mm long, the end crater must be filled. This filling is achieved by pushing the electrode very close to the weld metal in order to obtain a short arc. Then do not move the electrode but hold it in a fixed position until the end crater is filled. Now the electrode must not be drawn in the direction of welding or upwards, but it is moved back to the finished tack weld with a short arc, which is extinguished there. This avoids cracks and pores in the end crater.

– After welding all three tacks, clean the weld carefully from slag and spatter.

3.4. Welding the tacks in the vertical–up position

Weld two tacks with a length of 30 mm each in the vertical–up position.

The arrangement of the tacks can be observed from the figure below.

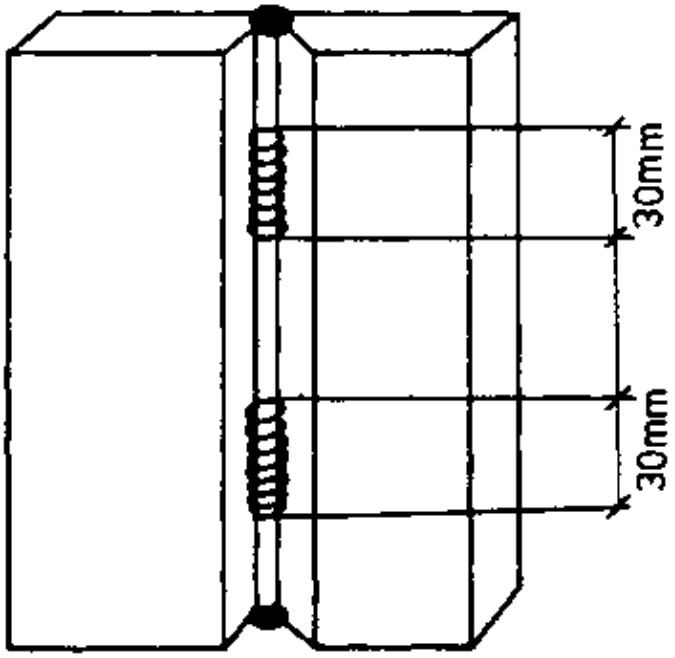


Fig. 14 Tacks in the vertical–up position

– The first tack in the vertical–up position is again started at a distance of 20 mm from the beginning of –the seam; the second tack likewise ends at a distance of 20 mm from the end of the seam.

– Otherwise than in the gravity position, in the vertical–up position the arc is started directly at the beginning of the tack weld. As soon as the arc has been started, the electrode is weaved from left to right and back along a straight line, with an arc length of appr. 5 mm, until the weld is sufficiently heated up. As soon as the weld metal threatens to flow off the arc length is reduced (to appr. 3 mm), and then the electrode is weaved over the specified tacking distance in the same way as in vertical–up root welding.

At the end of the seam, the end crater must again be filled. As described above, this is achieved by holding a short arc in a fixed position until the end crater is filled. At this very moment the electrode is drawn back to the finished weld with a short arc, and the the arc is extinguished.

– After finishing the tack welding, clean the specimen carefully from slag and spatter.

3.5. Evaluation of the finished tacks

Evaluate the finished tacks together with the trainees. Inform them of the criteria of evaluation.

Evaluate

– the weld appearance of the tack,
– the uniformity of bead ripples,
– the end craters,
– undercutting and
– weld spatter.

Discuss the welding faults and their causes very thoroughly.

Evaluation of the Section "V type welding with 5 tacks"

Having finished the training section on tack welding, the trainees should have acquired the following knowledge, capabilities and skills:

– Obeying the labour safety regulations including order and cleanliness at the working place
– Preparation of the welding specimen
– Mastering gravity and vertical–up tack welding
– Recognition of typical welding faults in V type welds
– Evaluation of their own work.

Examples of questions on the Section "V type welding with 5 tacks"

1. Describe assembling and tacking of the V type welds.
2. Th what extent does a non–uniform root opening affect the quality of root welding?
3. Explain the sequence of tack welding in the gravity position.
4. What are the dangers arising for a weldor from wet working gloves?

4. Welding a profile joint with a root pass and two cover passes

The hitherto acquired skills in electric welding are prerequisite to the discussion of the following section. To begin with, clarify and recapitulate, respectively, the concepts of a profile joint, the root, cover passes and the horizontal position.

Let one of the trainees explain and illustrate the concepts of root and cover passes by means of a blackboard sketch before the other trainees.

4.1. Preparation of the welding specimen

Informe the trainees of the dimensions of the welding specimen. Explain the condition the welding specimen must exhibit.

– Use an NT 10... NP 16 channel profile, i.e. a standard profile, with a length of 100 mm to 160 mm and a height of 50 mm.

– Further a base plate 10 to 16 mm thick is required, which is 50 mm longer and wider than the channel profile.

The channel profile must fit properly and closely to the base plate. Therefore it is recommended to cut it to size using a steel sawing machine.

The base plate can be prepared in the usual way by flame cutting. Take care that the base plate is perfectly flat.

If necessary, the plate must be straightened by hammer blows or with a hydraulic press.

The plate surface should be cleaned from rust, scale or paint residues, oil and grease with a wire brush.

The channel profile cut off, with a height of 50 mm, should also be carefully cleaned from cutting burr and rust coatings.

Point out to the trainees that a proper preparation of the component to be welded will avoid many welding faults. In many cases porosity is simply due to contaminated plate surfaces.

Check the preparation of the welding specimen.

Make sure that the dimensions of the welding specimen as specified by you are adhered to.

4.2. Tacking the specimen

Demonstrate assembling and tacking of the specimen. For that purpose, place the channel profile centrally on the base plate and fix the two parts with a screw clamp. Check that there is no gap between the channel profile and the base plate.

Both parts must fit closely to each other.

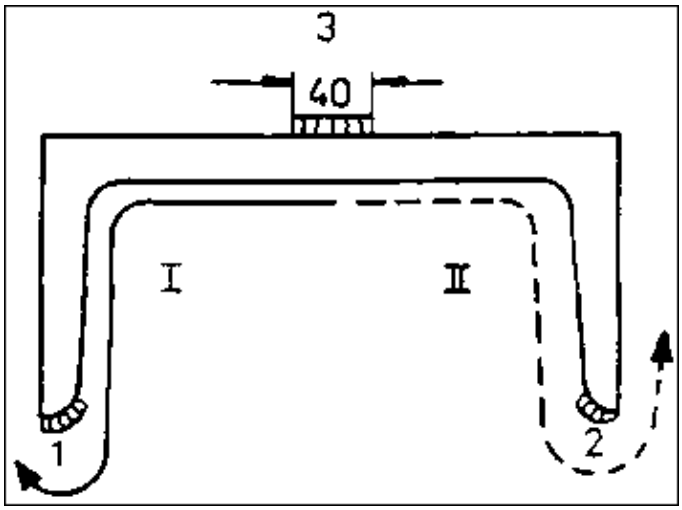


Fig. 15 Channel profile tacked on the base plate; the figure indicates the welding sequence

Now place the tacks No. 1, 2 and 3. Clean the tack spots from slag and the welding specimen from possible spatter. Check the proper tacking of the welding specimen by the trainees.

4.3. Welding the profile joint

The channel profile is joined to the base plate with a fillet weld. One root pass and two cover passes are welded. Draw the trainees' attention to the fact that for fillet welds higher amperages are necessary than for butt welds of comparable plate thicknesses. In welding the profile joint, the arc blow effect will show most evidently; here this effect can only be counteracted by a suitable electrode manipulation.

4.4. Welding the root pass

Demonstrate root welding to the trainees.

Place the tacked specimen so that you face the open side of the channel profile. For the electrode of type "Titan" E 43

4 RR (B) 22, with a diameter of 4 mm, adjust the amperage to 180 A.

Now begin with the demonstration of root welding.

– The root pass is first welded on one half of the inner side of the profile. In this operation the electrode is tilted by an angle of 45 °, being melted off with slightly stippling motions.

Thus welding is started from the middle of the inner side to the right or to the left.

– When welding to the left, the arc will heavily blow to the left if the electrode is arranged perpendicularly to the web plane. Therefore the electrode is tilted to the left, i.e. in the direction of welding, by such an angle that the arc is perpendicular to the molten bath.

Demonstrate these sequences of motions to the trainees. When the trainees practise welding profile joints, you should also take special care that they counteract the arc blow effect properly.

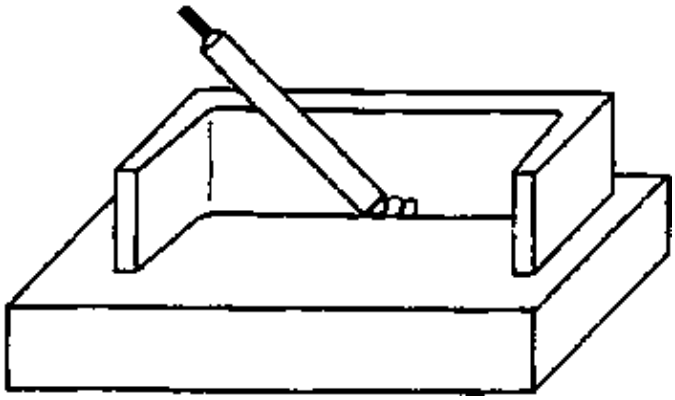


Fig. 16 Electrode position at the beginning of the weld

– After the corner has been welded, the arc blow effect turns the arc towards the seam, so that the electrode must again be given an opposite tilt.

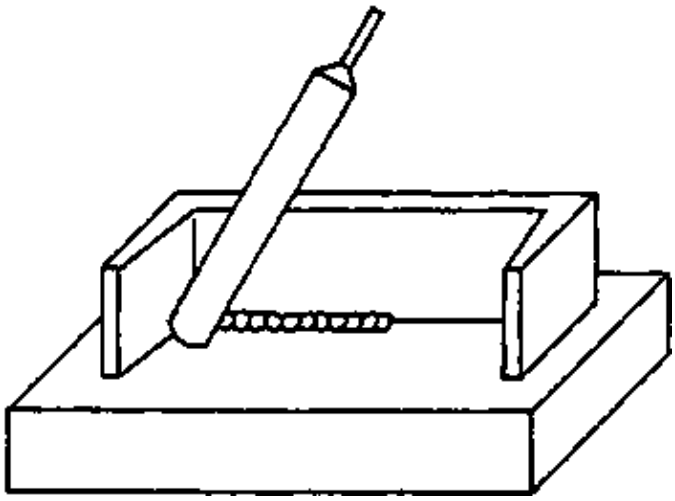


Fig. 17 Electrode position after passing the corner

Now the occurring arc blow effect may also be so strong that the necessary tilt angle cannot be realized, because the web of the channel profile obstructs tilting. In this case the electrode must be slightly bent, but without damaging the electrode coating.

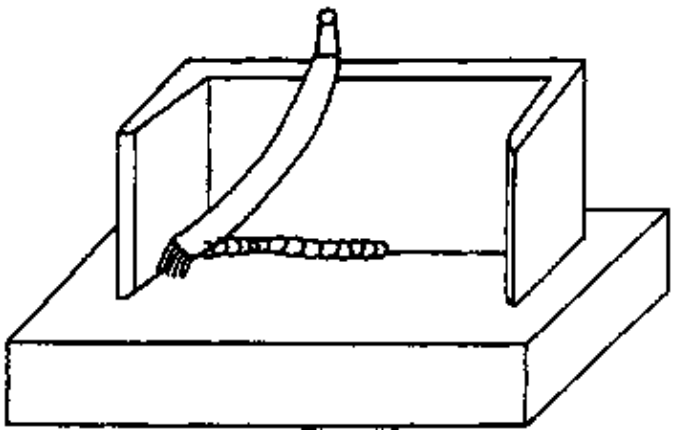


Fig. 18 Electrode bent to counteract an excessive arc blow effect

– The root pass is welded up to the flange edge, i.e. the tack is overwelded. An analogous procedure is adhered to in welding the other half of the profile.

After welding the root pass on the inner side, weld the root pass on the outside of the profile.

Here the arc blow effect is no longer so strong, so that the bead can be laid without an interruption. The direction of welding – to the left or to the right – is arbitrary.

After root welding has been finished, clean the specimen carefully from slag residues and spatter.

Check the root weld for the central arrangement of the root pass and for possible welding faults such as porosity, slag pockets and undercutting.

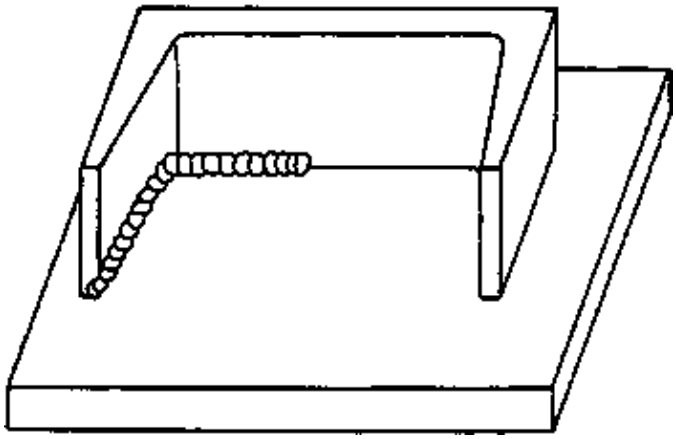


Fig. 19 Finished first half of the root pass

4.5. Welding the first cover pass

Demonstrate welding the first cover pass to the trainees. Place the specimen so that you face the open side of the channel profile.

For the electrode of type "Titan" E 43 4 BE (B) 22, with a diameter of 4 mm, adjust the amperage to appr. 180 – 190 A. Now begin with the demonstration of welding the first cover pass.

Point out to the trainees that the first cover pass must cover two thirds of the root pass.

Use the same technique as in welding a fillet weld.

The welding sequence is the same as in root welding. Take care that the arc strike is displaced from that of the root pass by about 2 cm.

After the first cover pass has been finished, clean the specimen carefully from slag residues and spatter. Check the first cover pass for uniformity, possible porosity, slag pockets, undercutting and faulty arc strikes. Discuss the causes and the prevention of welding faults with the trainees.

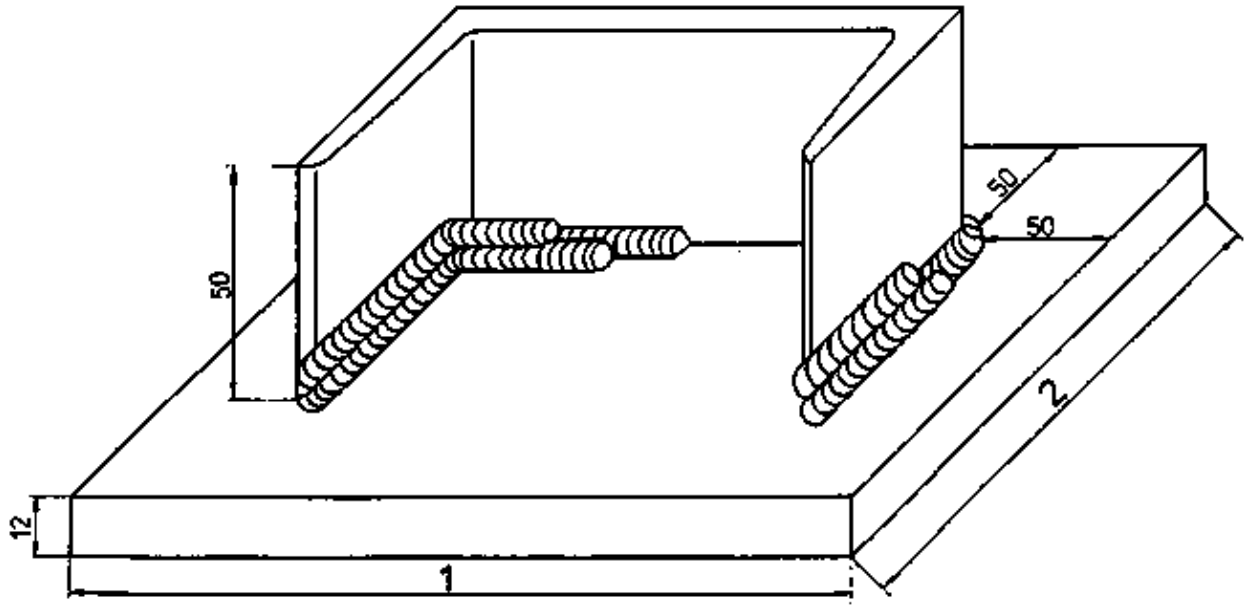
4.6. Welding the second cover pass

Demonstrate welding the second cover pass to the trainees. Place the welding specimen so that you face the open side of the channel profile.

For the electrode of type "Titan" E 43 4 RR (B) 22, with a diameter of 4 mm, adjust the amperage to appr. 180 – 190 A. Now start welding the second cover pass.

Take care that this pass covers one third of the first cover pass as well as the remaining, still visible part of the root pass. Use the same welding sequence as in root welding. Take care that the arc strike is displaced from that of the first cover pass by about 2 cm.

After finishing the second cover pass, clean the specimen most thoroughly from slag residues and spatter.



1 – Longitudinal face of the base plate
2 – Transverse face of the base plate

Fig. 20 Buildup of the individual passes

4.7. Evaluation of the welded profile joint

Evaluate the finished fillet weld together with the trainees. In form them of the criteria of evaluation.

Evaluate the weld appearance and the accuracy to size.

– Weld appearance

- Symmetry of the weld buildup
- Uniformity of the bead ripples
- Arc strikes
- End craters
- Undercutting
- Weld spatter

– Accuracy to size

- Determine the three measuring points by means of a weld gage.

For fillet welds in the horizontal position, a variation of +1.0 mm from your specified weld height is permissible. Just as in the other cases, you should also prepare faulty and properly welded specimens for illustration.

Discuss the causes of the welding faults.

Evaluation of the Section "Welding a profile joint with a root pass and two cover passes"

Having finished the training section on welding a profile joint, the trainees should have acquired the following knowledge, capabilities and skills:

– Obeying the labour safety regulations including order and cleanliness at the working place
– Preparation of the welding specimen
– Welding profile joints
– Recognition of typical welding faults
– Evaluation of their own work.

Examples of questions on the Section "Welding a profile joint with a root pass and two cover passes"

1. What are the measures you take to counteract the arc blow effect in welding a profile joint?

2. What are the dangers a weldor is faced with by weld spatter?

How do you protect yourself from spatter?

3. Explain the welding sequence in welding a profile joint.

4. What is the effect of the welding amperage on the weld appearance?

5. Fillet welding in the semioverhead position

Recapitulate the concepts of a fillet weld and of the semioverhead position.

The procedure up to welding the root pass is the same as in fillet welding in the horizontal position. Therefore, up to the section "Welding the root pass", proceed as described in the instructions on horizontal fillet welding.

5.1. Welding the root pass

Demonstrate root welding to the trainees.

For that purpose, clamp the fillet weld specimen in a positioning fixture with the boom up and the web plate down.

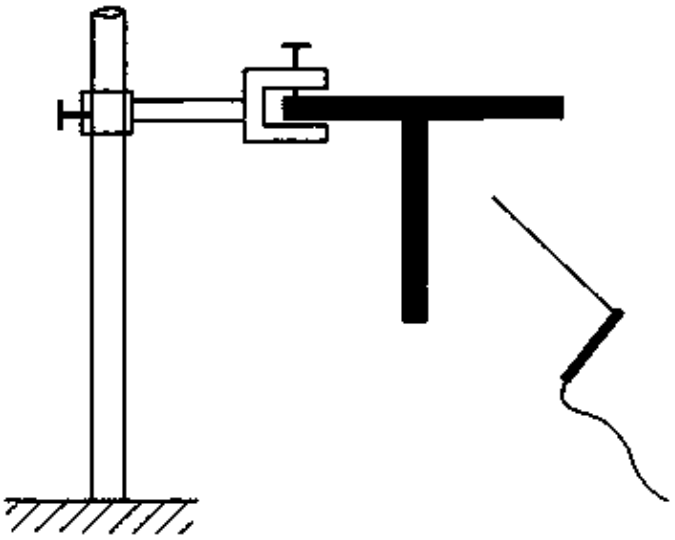


Fig. 21 Fillet weld specimen clamped in a positioning fixture in the semioverhead position

Sequence of operations in fillet welding:

– Adjust the amperage to appr. 140 A.

– Start the arc at the left outer edge of the fillet weld.

– Weld the root pass as a string bead.

– In doing so, consider that at the beginning of the root welding the fillet weld specimen is still cold and must first be preheated with a longer arc.

After one or two centimeters of the root pass, the arc can be shortened to its normal length.

– Generally, use as short an arc as possible in semioverhead welding.

– To obtain a symmetrical, central weld buildup, the electrode position must be such that an angle of 70 ° between the electrode and the boom plate is exactly maintained.

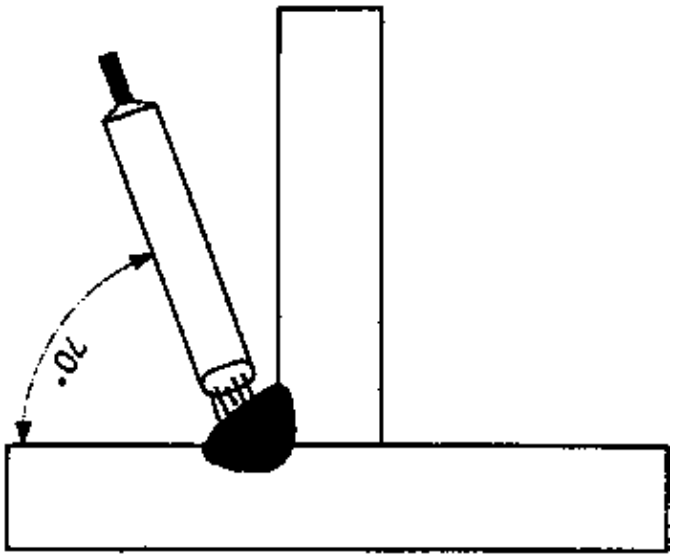


Fig. 22 Electrode position in welding the root pass

– In depositing the string bead, take care to perform a slightly stippling motion in the direction opposite to the drawing direction of the electrode. This "stippling motion" ist intended to yield a better base metal penetration.

– Pay attention to the arc blow effect.

– Counteract the arc blow effect by tilting the electrode in the direction of welding at the beginning of the seam in a direction opposite to that of welding when approaching the end of the seam.

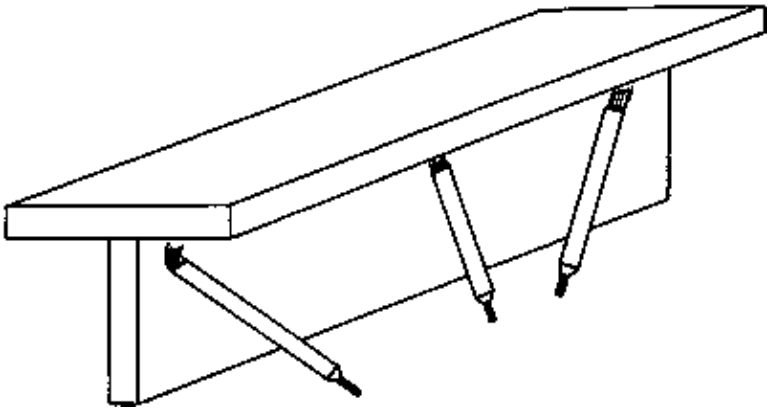


Fig. 23 Electrode manipulation for minimizing the influence of the arc blow effect

Discuss the consequences of disregarding the arc blow effect with the trainees.

This may lead to welding faults such as

– an interrupted seam,
– slag inclusions,
– heavy spattering at the side walls of the seam, etc.

For the seam length of 200 mm, an electrode change will be required.

Tell the trainees to proceed as follows:

Clean the seam end from slag and spatter. Start the arc with the new electrode in the lower part of the end crater. A gradual preheating is absolutely required in order to melt the end crater, which is achieved by a slight weaving motion with a long arc. Start the actual depositing of weld metal not earlier than at the moment when

the weld metal threatens to flow off. A slight overhang of the weld is better than a lack of fusion. If necessary, remove the weld overhang by chipping.

– Take care that the end crater of the root pass is properly filled. This is achieved by shortening the arc.

After the root pass has been finished, the fillet weld is carefully cleaned from slag and spatter.

Slag residues and slag pockets cannot be removed by overwelding.

Check the root weld for the central position of the root pass and for possible welding faults such as porosity, slag pockets and undercutting.

5.2. Welding the first cover pass

Demonstrate welding the first cover pass to the trainees. For that purpose, use an electrode 3.25 mm in diameter. Adjust the amperage to appr. 130 A.

Weld the first cover pass as a string bead with a slight weaving motion.

The first cover pass should only cover one half of the root pass. The tilt angle of the electrode should be 80° from the boom plate.

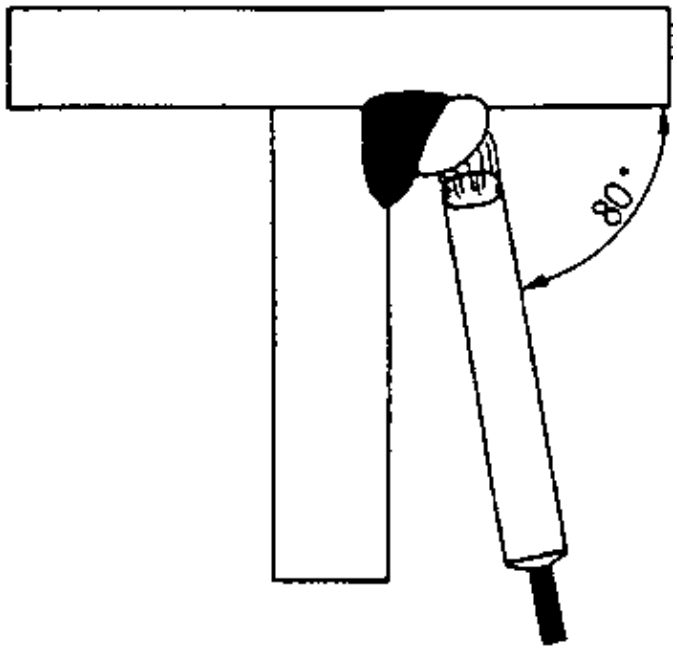


Fig. 24 Electrode position in welding the first cover pass

Cool the fillet weld and clean it from slag residues and spatter.

5.3. Welding the second cover pass

Demonstrate welding the second cover pass to the trainees. Use an electrode diameter of 3.25 mm.

Adjust the amperage to appr. 130 A.

The second cover pass must cover one third of the first cover pass as well as the remaining, visible part of the root pass.

The tilt angle of the electrode should be 75 ° from the boom plate.

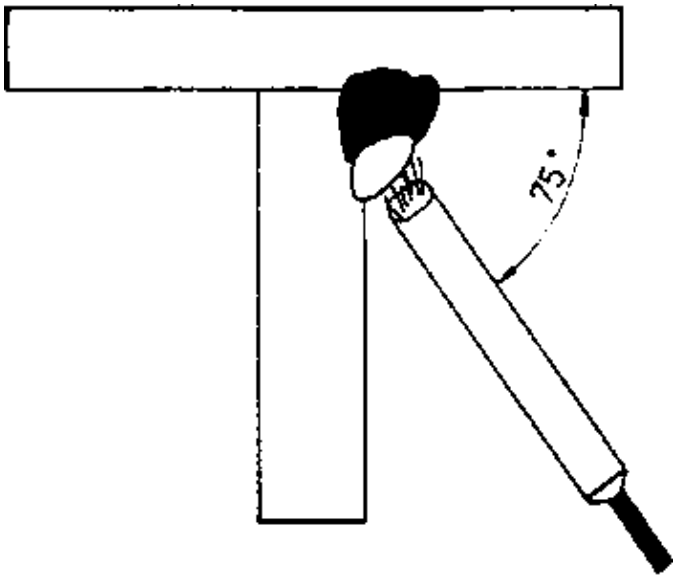


Fig. 25 Electrode position in welding the second cover pass

– When changing the electrode, proceed as described in the root welding instructions.
– Fill the end crater.
– Cool the fillet weld and clean it from slag residues and spatter.

5.4. Evaluation of the finished fillet weld

Evaluate the finished fillet weld together with the trainees. Inform the trainees of the criteria of evaluation. Evaluate the weld appearance, the accuracy to size and the fracture appearance by the following criteria:

– Weld appearance

  • Symmetry of the weld buildup
  • Uniformity of the bead ripples
  • Arc strikes
  • End craters
  • Undercutting
  • Weld spatter

– Accuracy to size

  • Determine the three measuring points by means of a weld gage. Let one of the trainees check the accuracy to size. Make corrections if necessary.

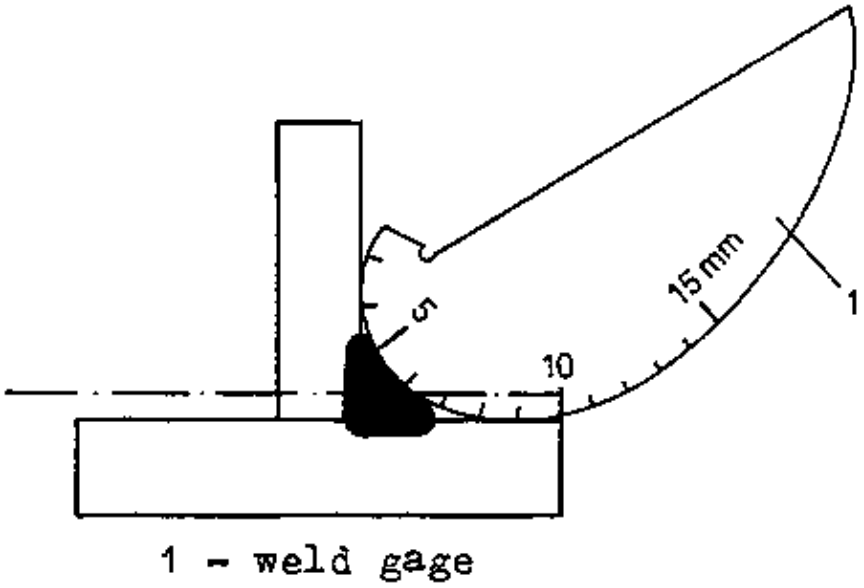


Fig. 26 Weld gage for measuring the fillet weld height

For fillet welds in the semioverhead position, a variation of + 2.0; – 0.5 mm in the weld height is permissible.

– Fracture appearance

To evaluate the fracture appearance, break the fillet weld specimen in a suitable device.

Evaluate the fracture appearance by the following criteria:

- Melting of the web plate edge
- Slag inclusions
- Porosity and lack of fusion

Evaluation of the Section

Having finished the training section on fillet welding, the trainees should have acquired the following knowledge, capabilities and skills:

- Obeying the labour safety regulations including order and safety at the working place
- Preparation of the welding sample
- Matering fillet welding in the semioverhead position
- Recognition of typical welding faults in fillet welds
- Evaluation of their own work

Examples of questions on the Section "Fillet welding in the semioverhead position"

1. Describe the buildup of a fillet weld in the semioverhead position.
2. What are the typical welding faults in semioverhead fillet welding?
How can you avoid such faults?
3. Explain the properties of the welding electrodes employed.
4. Explain the necessity of most careful labour safety measures.