LEISTER
PLASTIC WELDING

Roof Applications

Guidelines

Reliably Welding Plastic Single Ply Membranes

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We know how.

Content

1. Introduction

When working on the roof, you always need to be able to fully rely on your devices. This is our firm belief. And this is why you should certainly have high expectations of a Leister automatic roof welding machine: We guarantee to provide you with maximum device reliability and the best all-round service.

Our welding machines are highly dependable, even when operated under difficult conditions , such as undervoltage. A high level of flexibility is also required when it comes to automatic welders. Our machines are used in numerous roof applications, as well as in situations where space is at a premium. With their sophisticated ergonomics, the easy-to-handle automatic roof welding machines are keeping abreast of the trend, which is moving away from manual welding and in the direction of automatic welding.

We always strive to tailor the machines to meet our customers' needs in the best way possible. Our development department is continually carrying out research into new technologies so that we can offer you the highest-possible quality. This is why you can count on Leister to provide machines that use state-of-the-art technology. The next generation of automatic welders will offer greater process control utilizing the MyLeister app, where key welding parameters are recorded so that possible deviations can be displayed with a report.

Roland Beeler
Head of Business Line
Plastic Fabrication
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Technical Sales
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2. Basic Principles of Welding Single Ply Membranes

In principle, it is easy to install and weld thermoplastic membranes. The formulation of today's single-ply membranes allows for a favorable welding window. These guidelines should help you to join the sheets in a reliable and cost-effective manner. Increased seam integrity is just one of the guarantees with a latest-generation **automatic welder with closed-loop technology**. The parameters are constantly monitored, making ergonomic and safe working possible. Safety and weld quality are significantly higher with an automatic welder, as all welding parameters are constantly checked and regulated:

- Temperature
- Speed
- Pressure
- Air volume

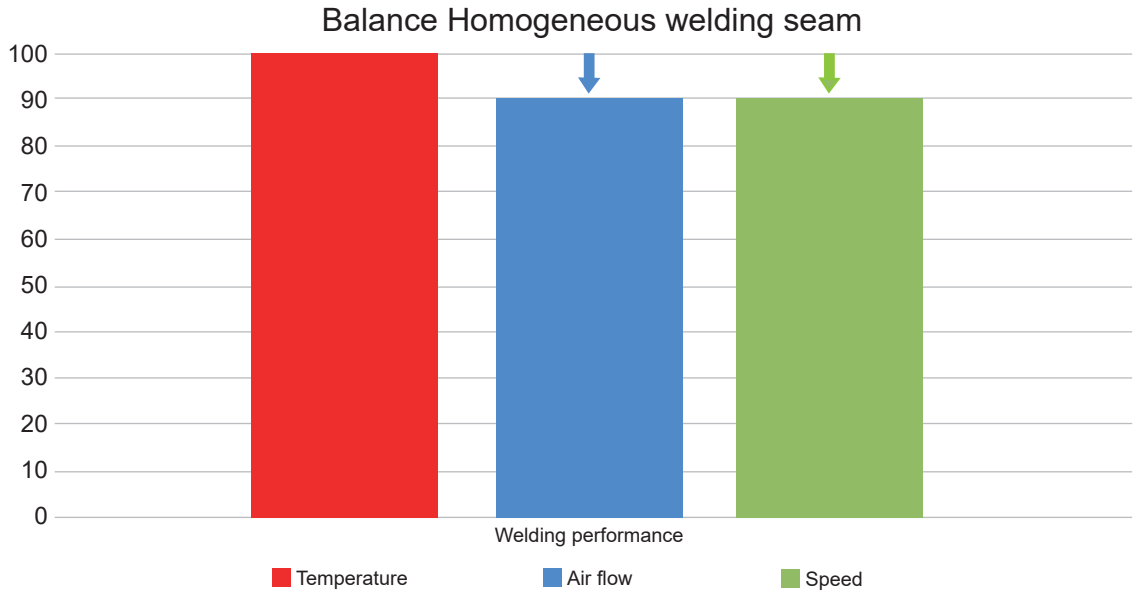
The welding is described with the following parameters in accordance with DVS 2225-4: temperature, speed, pressure. In accordance with DVS 2225-4, do not weld at temperatures below 5°C as otherwise the membrane will be stressed too much. To illustrate the interaction of the parameters, the following must be taken into account:

$$\text{Welding performance} = \frac{\text{Temperature x air volume (undervoltage must be taken into account)}}{\text{Speed}}$$

In other words, the speed must be adjusted as soon as changes are made to a parameter such as temperature / air volume. Otherwise, the welding parameters will no longer be in equilibrium and, under certain circumstances, it will no longer be possible to create a molecularly homogeneous seam. It is not possible to compensate for excessive welding temperatures with the speed as the molecules could already be destroyed.

Example: If the air volume is reduced by 10%, then the speed should also be reduced by 10%. If the original speed was 4 m/min, it must therefore be reduced to 3.6 m/min. With a Leister automatic welder with display function, the parameters are maintained constantly using closed-loop technology (regulated technology). Thanks to the integrated power reserve, the parameters are also guaranteed in the event of undervoltage of up to 20%.

- The time and speed factor is very important! The hot air must have enough time to fuse the material; otherwise, it will not be possible to create a good seam. Generally, a distance of 25 mm is specified for manual hand welding, and 42 mm distance when using an automatic welder.
- The master parameter when welding plastic and bitumen is the temperature, and should not be changed initially should parameter adjustments be required.
- It is important to ensure that enough pressure is available during the welding process.
- The contact pressure must be adapted depending on the material type / thickness and the substrate.



Interaction between the welding parameters without taking pressure into account

- The welding parameters can be determined with a 10-second test with a gap of +/- 5 mm while heat is applied (400–450 degrees). The materials can also be defined using a sample by fusing the materials.
- It is important to ensure that the nozzle does not narrow.

1 right
2 wrong Reason:
- Clogged or bent nozzle
- Insufficient air supply
- Defective heating element

- The seam to be welded must be clean and dry.
- If moisture has penetrated into the seam to be welded, it must be dried or the moist area must be cut out.
- It is important to ensure that any seam between a waterproofing membrane which has become “aged” or "contaminated" in terms of weldability as a result of an installation delay (between surface and parapets / firewalls) and newly dried materials be prepared properly before welding in order to guarantee a homogeneous joint.

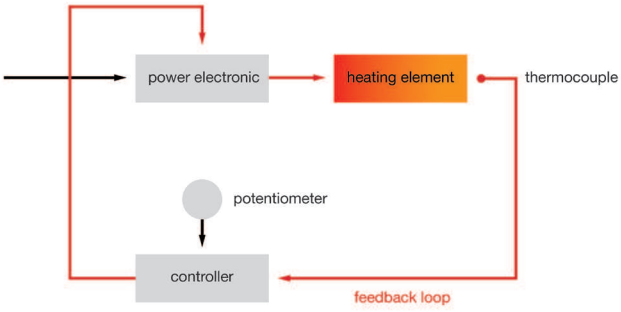
3. Prerequisite for Modern Automatic Welders

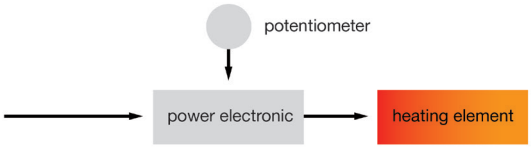
3.1 Closed-loop Technology

We recommend using closed-loop technology, which keeps the parameters constant and offsets voltage fluctuations on the construction site. The differences between the electronic systems and the advantages of regulated technology are listed below:

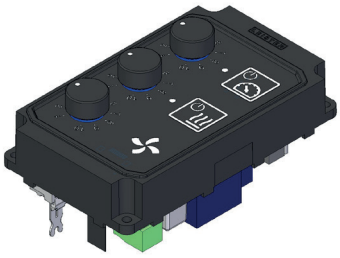
Closed-loop (regulated)
- The welding parameters are constantly monitored
- Voltage fluctuations are offset
- Cable lengths are taken into account

Open-loop (controlled)
- Manual setting is not monitored
- Voltage is not balanced
- Cable lengths cause undervoltage





Display with closed-loop technology



Potentiometer with open-loop technology

In the event of undervoltage of more than 20%, state-of-the-art Leister automatic welders, such as the VARIMAT V2 / UNIROOF AT, stop the welding process to guarantee a reliable seam.

3.2 Operating Automatic Welders

The guide bar must not be held too high as otherwise this will affect the contact pressure.

Modern automatic welders have an adjustable transport axle allowing for close-edge welding, eliminating the need for manual welding:

It's ergonomic, reliable, and safe!

Go to the video

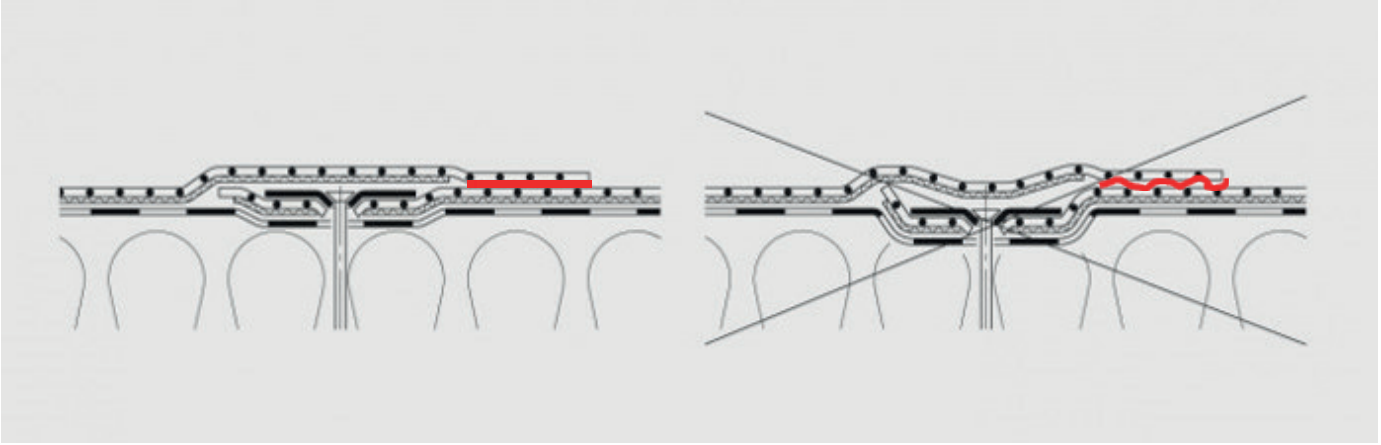
It is now possible to weld close to the edge behind scaffolding poles thanks to the compact design.

Various major applications covered with just one machine – the **UNIROOF AT**:

- Basic overlap welding
- Flashing details as close as 10 cm from parapets
- On top of narrow parapet walls

3.3 Greater Fastening Screw Load

Welding with automatic welder **Manual welding**



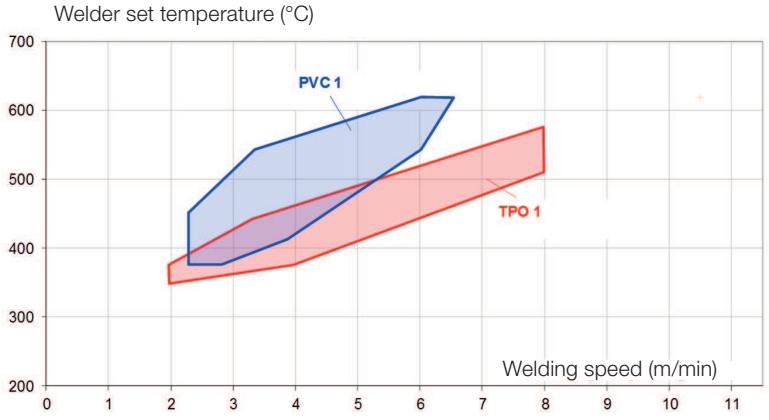
As a result of the constant welding parameters with an automatic welder, the rated load of a fastener is considerably higher than if the seam was created manually.

4. Differences Between the Most Common Single Ply Membranes

Today's commercial roofing manufacturers offer a wide variety of high-quality single-ply membranes. The most commonly used materials are:

- PVC (polyvinyl chloride)
- TPO/FPO (thermoplastic polyolefin / flexible polyolefin)

Please note that single ply membranes have different polymers and formulations, therefore, care must be taken to select the correct welding parameters. The typical welding parameters are shown below:



Typical welding windows for TPO and PVC

The differences between each product's welding parameters can be significant and must be taken into account prior to welding.

4.1 TPO

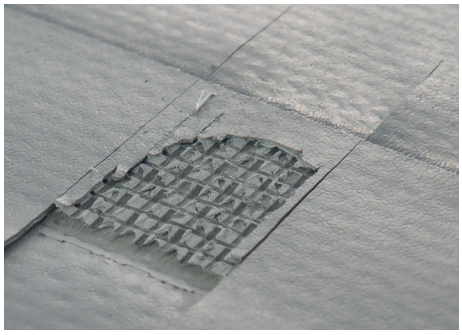
- Ensure that the welding temperatures are not set too high, as excessive temperatures destroy the molecules. This cannot be offset by increasing the speed as the molecules will already have been destroyed by the excessive temperature.
- In the event of high outdoor temperatures, we recommend lowering the welding temperature and not increasing the speed. The parameters can therefore deviate from those specified by the material manufacturer (with closed-loop [regulated] machines, the temperature correction is lower than with unregulated machines).
- When PE and PP are used as the raw materials for the FPO / TPO membranes, these change in length much more than PVC, which can lead to wave formation when heat is applied.
- With the right welding parameters, FPO and TPO sheets have very favorable welding characteristics. For renovations or repairs, you can typically use the standard welding parameters, as the material absorbs less moisture than PVC. TPO sheets often have a longer life expectancy (no plasticizers).

4.2 PVC

- The material can be more tolerant to temperature due to the plasticizers and different formulations.
- If too much smoke develops during the welding process, the muriatic acids will escape. Do not breathe in the fumes!

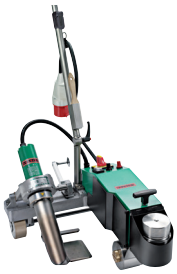
4.3 Welding Window Service

Leister offers a service to create a welding window for material manufacturer partners. The ideal parameters are determined using standardized procedures and brand new material.


As a general rule, all welding must be carried out using clean and dry material. Welding dirty material is prohibited. It must be cleaned first.

5. Recommended Welding Parameters for Welding Machines

Machine selection overview Roof automatic welders		 VARIMAT S VARIMAT V2		
Recommended initial welding parameter depending on membrane type (tested at 20°C room temperature):	**UNIROOF AT** PVC: 2.0 m/min, 520°C, air volume 100 % TPO: 2.5 m/min, 450°C, 100 % **UNIROOF ST** PVC: 1.8 m/min, 520°C, 100 % TPO: 2.0 m/min, 450°C, 100 %	**VARIMAT V2** PVC: 4.0 m/min, 550°C, air volume 85 % TPO: 5.0 m/min, 500°C, air volume 100 % **VARIMAT S:** PVC: Temperature level 8.5–9 (550°C) TPO: No trailing roller, so can only be used to a limited degree	**TRIAC Drive ST** PVC: Level 1.5 (1 m/min, 400°C, air volume 100 %) TPO: Level 2.5 (1.5 m/min, 380°C, air volume 100 %)	**BITUMAT B2** Nozzle up to 100 mm Modified bitumen: 5.0 m/min, 650°C, air volume 100 %

Machine selection overview Hot-air hand tools				
Initial welding parameters for manual welding	**TRIAC ST** PVC: from 360°C TPO: from 295°C	**TRIAC AT** PVC: from 360°C TPO: from 295°C	**ELECTRON ST** Modified bitumen: From 550°C	**HOT JET S** PVC: from 360°C TPO: from 295°C With 20 mm nozzle

Welding modified bitumen with hot air, thus eliminating open flame.

6. How to Create Simple and Reliable Plastic Seams

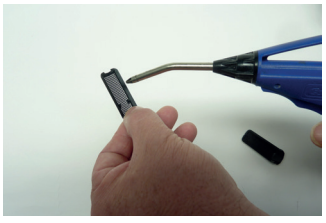
6.1 Before Welding

Everything is easier with the right accessories. Accessories are part of a reliable and cost-effective welding process.

Check that the machines are working and check for voltage.

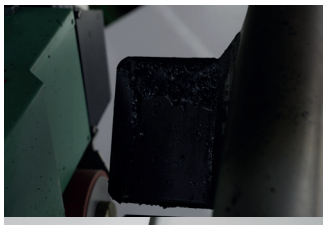
Clean the filters and heating elements periodically for the best performance:

- The heating elements do not get clogged and the correct temperatures are therefore ensured
- High air volume thanks to clean filters



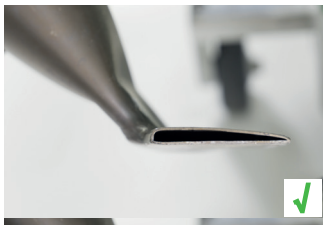
Check the nozzle:

Clean if there are slag deposits on the nozzle.



Check that the nozzle is the correct shape for maximum performance:

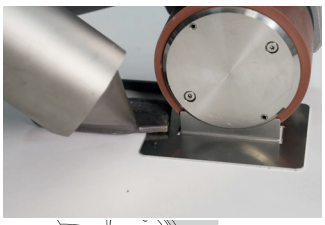
Damaged nozzles cause leaks or incorrect welding.

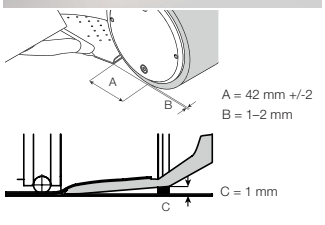



Check the nozzle is set correctly on the automatic welder:

→ More info in the machine operation manual.

The nozzle can be set correctly with the setting gage.

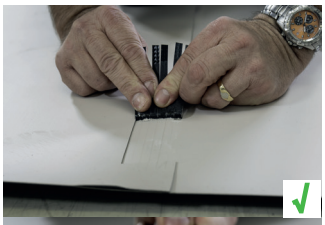
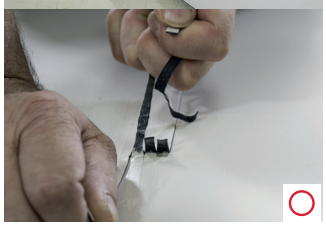
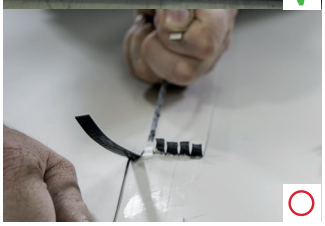





Perform a test weld manually and with the welding machine.

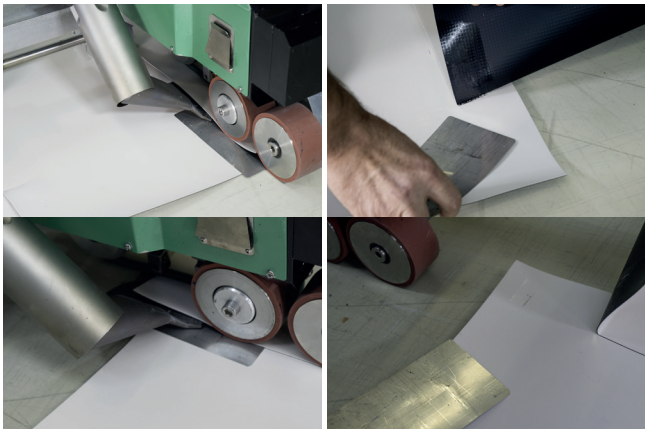
Caution: Always factor in the material manufacturer's specifications and installation instructions. Set the welding parameters each day, taking changes in the weather into account. Test welds must be carried out in the morning and after midday.

The weld is correct if a straight, clean tear can be achieved when you peel lengthwise.

Consider inserting a sheet metal starting plate at the start and end of a machine-welded seam.

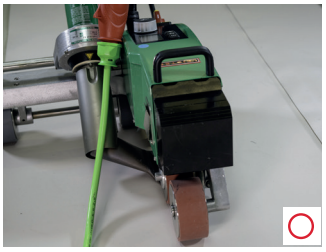
This increases the quality of the transitions between manual and machine-welded seams.



6.2 During the Welding Process

The electrical connection and cable routing on the roof must be planned carefully in order to avoid interference..

Cable laid correctly

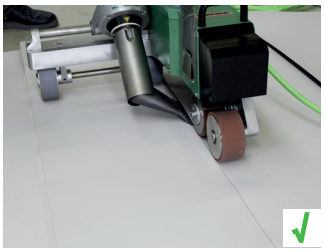


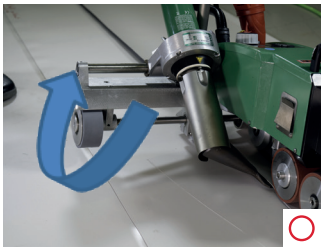
Cable above nozzle

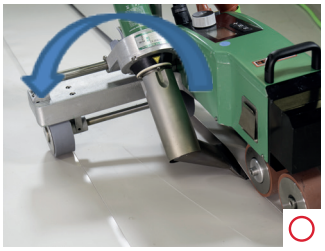
Cable in welding process

Guiding machines:

Do not tilt the welding machine sideways during the welding process, otherwise the contact pressure will no longer be consistent across the welded seam.

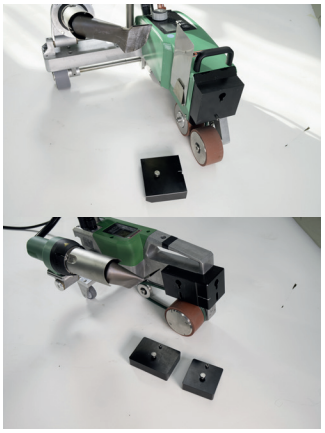


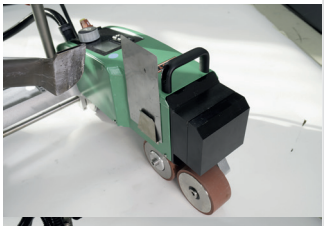


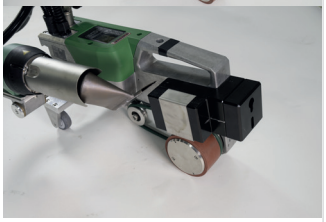


Adjust the contact pressure to the membrane thickness and supplement with additional weights:

- Membranes with a thickness of 2 mm or greater should be supplemented with additional weights.
- TPO sheets require more contact pressure than PVC sheets. The contact pressure must also be adjusted to the sheet thickness. Soft and hard substrates (e.g., thermal insulation) can also affect the contact pressure. Softer substrates require more contact pressure.







Using 400 V automatic welders is advantageous.

→ With 400 V, voltage fluctuations are better offset and more power is available.

At 2.5 mm^2, the cable lengths should not be much more than 50 m to ensure that no undervoltage can occur.

Important Facts

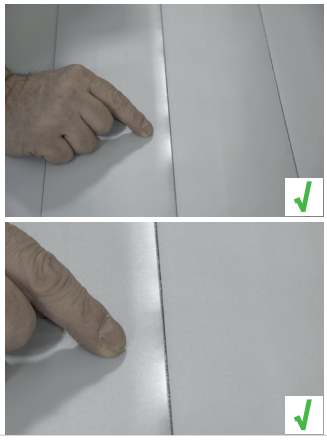
- The cable should be copper, with as large a cross-section as possible
- The cable should be as short as possible
- The following rules of thumb apply:
  Automatic welding machines: maximum 50 m with 2.5 mm^2 cable, e.g., VARIMAT V2 4.6 kW 230 V / over 50 m 4.0 mm^2 Manual welding: maximum 50 m with 1.5 mm^2 cable, e.g., TRIAC AT/ST 1.6 kW 230 V
- Plug for 20 A and a secure connection
- A generator should provide at least10 kW
- A stable electrical environment is required
- The fuse should have 20 A for 230 V and 16 A for 400 V

Copper cable	Varimat V2 230 V / 4600 W			Varimat V2 400 V / 5700 W		
	1.0 mm^2	1.5 mm^2	2.5 mm^2	1.0 mm^2	1.5 mm^2	2.5 mm^2
50 m	200 V (-13%)	209 V (-9%)	217 V (-6%)	377 V (-6%)	384 V (-4%)	390 V (-2.5%)
100 m	177 V (-23%)	192 V (-17%)	205 V (-11%)	256 V (-11%)	370 V (-8%)	381 V (-5%)
150 m	159 V (-31%)	177 V (-23%)	194 V (-16%)	338 V (-16%)	356 V (-11%)	372 V (-7%)
200 m	144 V (-37%)	164 V (-28%)	184 V (-20%)	321 V (-20%)	344 V (-14%)	363 V (-9%)
250 m	132 V (-43%)	154 V (-33%)	176 V (-24%)	306 V (-23%)	332 V (-17%)	355 V (-11%)
300 m	121 V (-47%)	144 V (-37%)	168 V (-27%)	292 (-27%)	321 V (-20%)	347 V (-13%)
350 m	112 V (-51%)	136 V (-41%)	160 V (-30%)	280 (-30%)	311 V (-22%)	340 V (-15%)
400 m	105 V (-54%)	128 V (-44%)	154 V (-33%)	268 (-33%)	301 V (-25%)	332 V (-17%)
450 m	98 V (-57%)	121 V (-47%)	148 V (-36%)	258 (-36%)	292 V (-27%)	326 V (-19%)
500 m	92 V (-60%)	115 V (-50%)	142 V (-38%)	248 (-38%)	284 V (-29%)	319 V (-20%)
550 m	87 V (-62%)	110 V (-52%)	137 V (-41%)	239 (-40%)	276 V (-31%)	312 V (-22%)

Voltage drop due to cable length

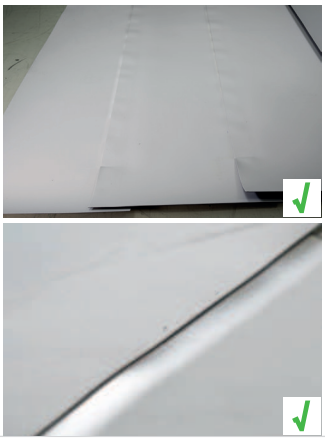
When welding PVC, here are good seam indicators:

Even sheen, welding track clearly visible, slight bleed



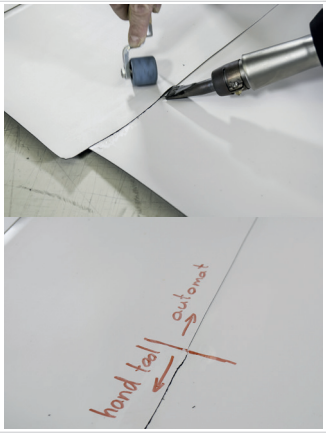
When welding TPO, here are good seam indicators:

Even sheen, small track visible, no bleed out

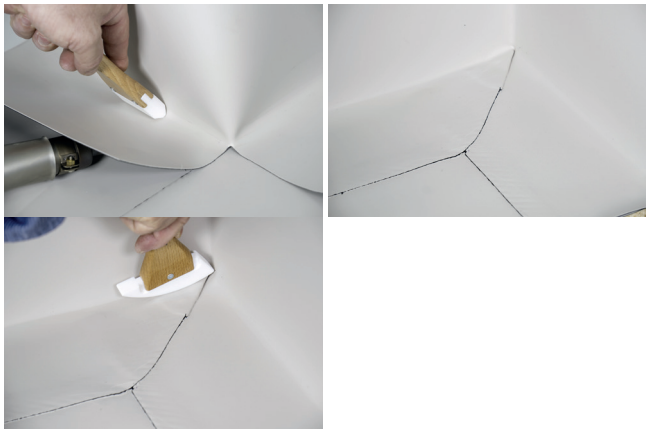


6.3 Implementing Details

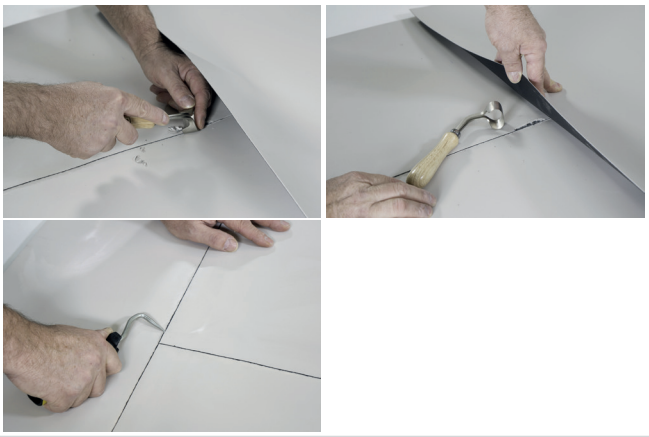
The transition between machine weld start/stops and manual welds must be carefully performed to eliminate any seam voids.



When performing flashing details, the material manufacturers' installation instructions must be observed.

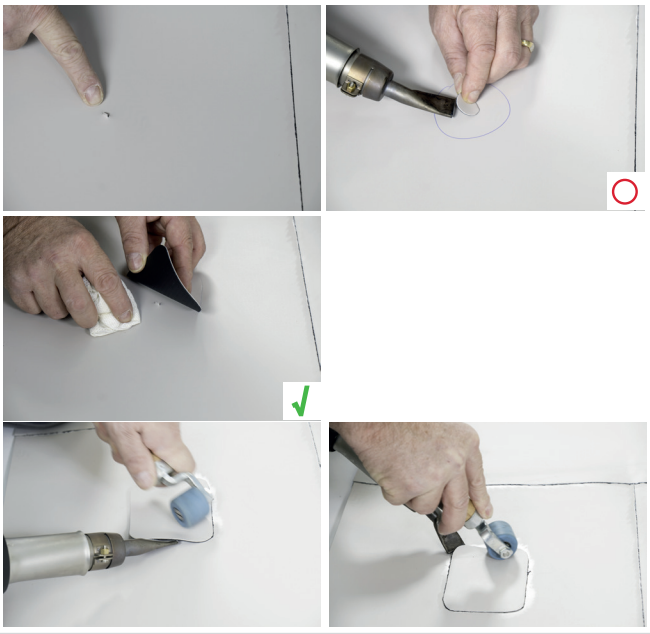


The T-joint must be handled in such a way that the entire width of the weld is tightly welded. The material manufacturers' installation instructions must be observed.



With single-ply membranes, damage and leaks can be repaired easily.

- Do not make the patch too small, minimum 8–10 cm.
- Be certain that welding surfaces are clean and dry.



6.4 After Welding

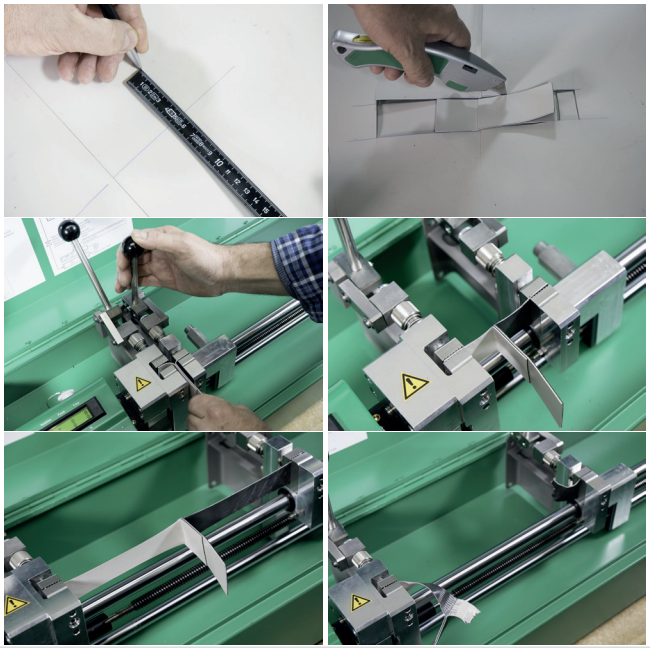
Keep the machines clean. Clean the gliding surfaces periodically, lubricate them, and carry out any maintenance required.

- WD-40 is a cleaning agent and only has gliding properties in the short term.

6.5 Evaluating the Seam

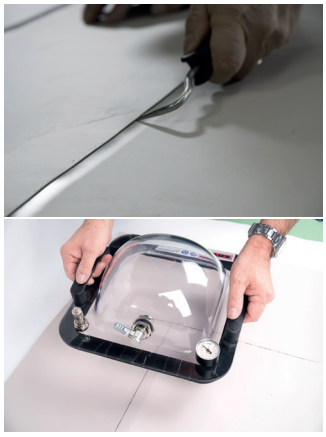
EXAMO weld seam strength tests

- Mark and cut 50 mm strips
- **Tensile tests** according to EN 12317-2 – weld seam strength: tear outside the weld
- **Peel tests** according to UEAtc recommendation for reliable weld seam strength Ø ≥ 150 N / 50 mm, min. ≥ 80 N / 50 mm



Check / acceptance report

- All weld seams must be checked mechanically with a weld seam probe
- T-joints can be checked with a vacuum bell jar
- Once the work is complete, we recommend an acceptance report




Inspektionsvertrag

Zwischen Auftraggeber

und Auftragnehmer

wird für folgendes Gebäude

nachfolgender Inspektionsvertrag geschlossen:

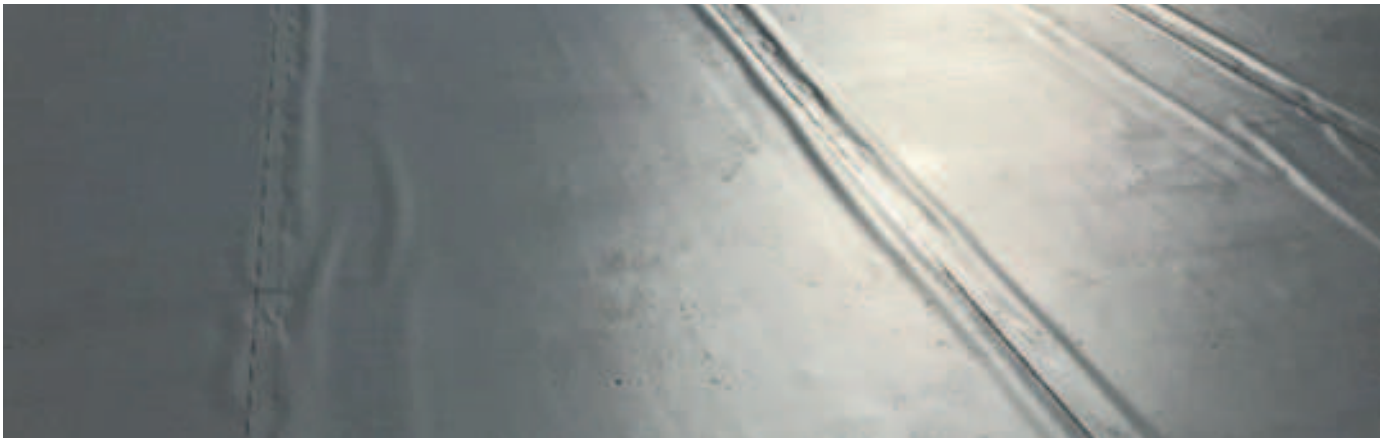
1. Allgemeines

2. Durchzuführende Arbeiten

a) Jährliche Begehung der Dachflächen.
b) Ausarbeitung eines schriftlichen Zustandsberichtes.
c) Erarbeitung von Vorschlägen für Pflege- und Instandsetzungsmaßnahmen.
d) Kostenübersicht.
e) Lückenlose Registrierung und Dokumentation der Dachbegehungen.
f) Sonstiges:

6.6 Common Faults

In the event of high outdoor temperatures, e.g., in the summer, the welding temperatures must be reduced. The material to be welded will then need a lower temperature. If this is ignored, wrinkles may develop and, in the worst-case scenario, the molecules may be destroyed, which could lead to a leaky seam.



Typical weld with wave formation and wrinkles at excessive welding temperatures

From these images, it is evident that:

a) The selected welding temperature was too high (even with high outdoor temperatures)
   → The gloss is much too high and the impression of the air dam belt is apparent
b) The material was not stretched
c) The membrane was fastened before the welding process
d) Welding over the fasteners is not permitted

Typical wave and wrinkle formation at excessive welding temperatures. The welding temperature must be reduced to prevent wave formation!

Wave formation must be avoided when laying the sheets as this can lead to leaks.	 1  2  3
Do not weld too hot: • Oil will escape and too many bubbles will develop	 
An excessive number of patches must be avoided!	

Membranes can be damaged by dirt or incorrect cleaning agents in such a way that welding is no longer possible under certain circumstances.

As a result of different high outdoor temperatures, wave formation cannot be avoided in some circumstances.

7. Greater Control with the MyLeister App

- Automatic data report of the welding parameters with the LQS roofing app

MyLeister app

- Access recommended welding parameters, as specified by the material manufacturer
- Greater control for the foreman and surveyor / assessor, allowing for improved quality control inspections

8. IQDF

If you need more information, there are also guidelines on quality assurance for flat roofs with plastic geomembranes

www.iqdf.de

Elephant park at Zürich zoo, reliably sealed with a thermoplastic membrane.