Grasp success by the roots

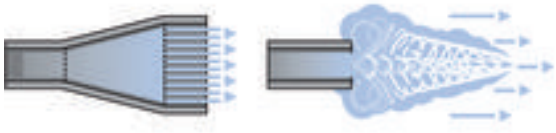
Forming and root protection ensure perfect weld seams and roots

Profit from forming

For more than 40 years, root protection and forming have proven their value in welding technology. They permit an increase in weld seam quality and contribute to a reduction of follow-up costs. The focus here is on reworking, pickling costs, the associated transport costs and the not inconsiderable loss of time. With correct forming, weld seams and roots can be produced which need no reworking.

Forming and root protection

Root protection is the bathing of the weld root and the heat affected zone with shield gases, while simultaneously displacing atmospheric oxygen (DVS Data Sheet 0937). When applied to pipes and tanks, it is known as forming. This technique is used for the welding of gas sensitive materials such as high alloyed CrNi steels, for example, to ensure the corrosion resistance of the materials. Without forming, the weld seam and the heat affected zone are oxidised by the oxygen in the atmosphere. Forming gases are even occasionally used for the welding of unalloyed steels in order to improve the root quality. The correct processing of gas sensitive materials, such as titanium, zirconium, molybdenum or magnesium, for example, is actually impossible without forming.



Laminar and turbulent flow

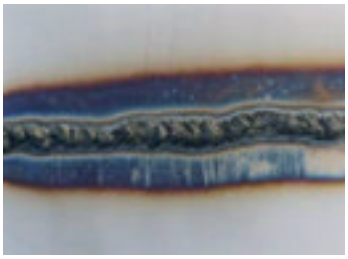
Laminar flow instead of turbulence

In order to ensure the high quality and economy of the work, a few basic rules must be observed. One of the most important concerns the feed of the shield gas to the weld seam region. This should never be uncontrolled. In an optimum shield gas feed, the flow is laminar. If the flow is turbulent, the eddies result in mixing of the forming gas and the atmosphere. A laminar flow is generated with the help of a diffusor, usually comprising pipes, sheets or mouldings of sinter material. The sinter metal distributes the gas feed over a large area, from which the forming gas is emitted in laminar form. Forming techniques are divided, according to the physical properties of the forming gases, into:

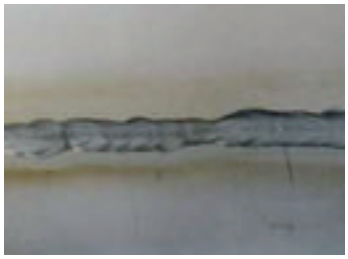
- Forming with gases lighter than air
- Forming with gases heavier than air
- Forming with gases of the same density as air

Forming with gases which are lighter or heavier than air

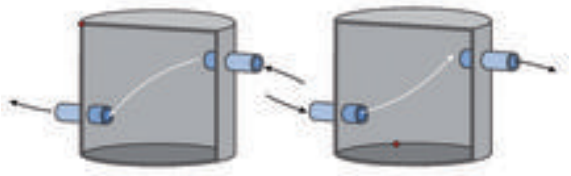
The distinguishing factor is the difference in density between the forming gas and air. When gas mixtures with a density greater than air are used, the vessel is filled from the bottom up and has a vent at the top for escape of the atmospheric air displaced. In the case of gas mixtures with a lower density than air, this mechanism is reversed.



Root without root protection



Root with root protection

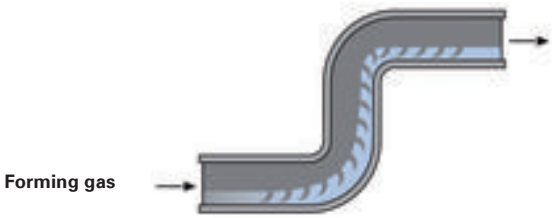


Forming gas (l.) lighter than air and (r.) heavier than air. Red marking: Weld seam zone

The choice of technique can be decided by the forming gases available locally or, in the case of large construction components, for example because of the position of the weld area in the component, they may be deliberately applied.

Forming of pipes

In the forming of pipes, problems may arise due to mixing if the difference in density between the forming gas and air is too great. In order to prevent this mixing, gas mixtures with the same density as air can be used. These are argon/nitrogen/hydrogen mixtures with a variable hydrogen content.



Flow in pipes

The right hose material

Another important component is the shield gas hose itself. Here, the hose material is crucial. Generally available PVC hoses, originally intended for the transport of compressed air, are not suitable for this purpose. The hose material is capable of absorbing moisture from the atmosphere and passing it on to the dry forming gas. Hoses manufactured in accordance with DIN EN 559 and marked accordingly usually meet the requirements and can be obtained from any well-stocked welding accessory dealer. Savings made at this stage may turn out to be very expensive!

Which gas for which application?

The gas mixtures in question are based on argon or nitrogen. To reduce the residual oxygen, hydrogen is added to the gases. In addition to their density relative to air, other criteria may also be applied for selection of suitable gases:

1. The material to be formed – gas sensitivity?
2. The forming task – upper or lower component area?
3. The shape of the component – sheet, tank or pipe?

Incompatibilities may occur between materials and gases. The constituents of the forming gases, for example, may damage the material through the formation of nitrides or oxides or through hydrogen cracks. Particular attention must be paid to this when selecting the forming gases. The table gives an overview of recommended forming gases. The shape of the component may also have an influence on the choice of gas. In the case of pipes and tanks with complicated geometries, forming with gases lighter or heavier than air is often accompanied by the common problem of irregular forming results. Here, a gas mixture with the same density as air can be used for even filling of the tank or pipe. Customer-specific argon, nitrogen and hydrogen mixtures with varying hydrogen content permit quick and reliable forming.

Root protection	Materials
Argon/ hydrogen mixtures	Austenitic Cr-Ni steels, Ni and Ni-based materials
Nitrogen/hydrogen mixtures	Steels, with the exception of high-strength, fine-grained construction steels, austenitic Cr-Ni steels
Argon	Austenitic Cr-Ni steels, austenitic-ferritic steels (duplex), gas sensitive materials (titanium, zirconium, molybdenum), hydrogen sensitive materials (high-strength, fine-grained construction steels, copper and copper alloys, aluminium and aluminium alloys and other NF metals), ferritic Cr steels
Nitrogen	Austenitic Cr-Ni steels, austenitic-ferritic steels (duplex)

Choice of metal and forming gases

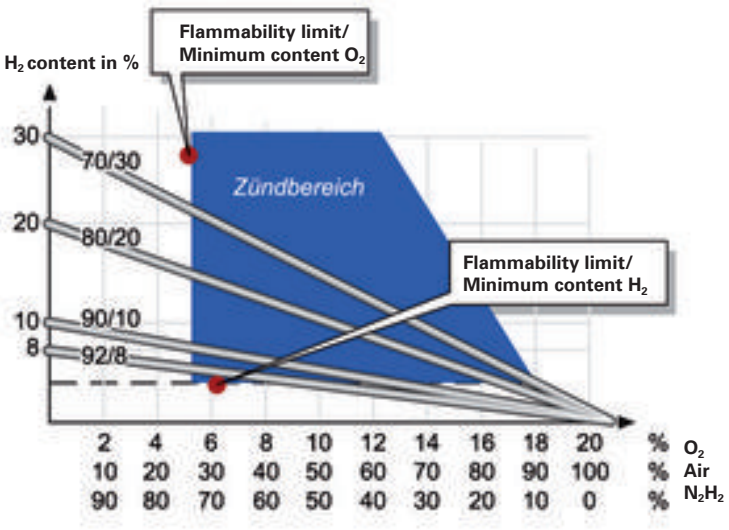
Flammable range

The final consideration is extremely important: "How much hydrogen do I need for my forming process?" According to their hydrogen content, forming gases may be combustible in the atmosphere. These must be flared off as they leave the component being formed.
The ignition limit is 4% H_2 and the gases must be flared off at 10% H_2 (DVS Data Sheet 0937). A distinction is made between spontaneously and non-spontaneously igniting forming gases. In the case of non-spontaneously igniting mixtures, the use of a pilot flame is necessary. A risk in the use of flammable forming gases is that of deflagration. This exists if a flammable mixture of forming gas and air is still present at the start of the welding work.

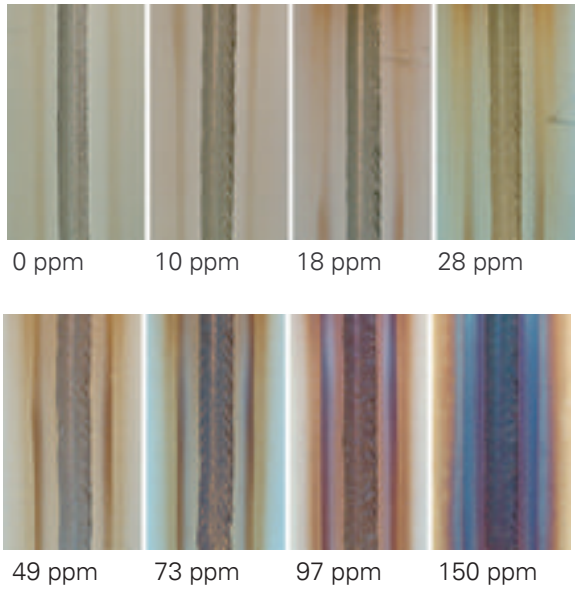
The forming gas/air mixture in the tank varies its composition continuously during the forming, passing through a flammable range.

Residual oxygen

When gassing a tank or a pipe with forming gas, in spite of observing a precise working procedure, mixing with the atmosphere to a greater or lesser degree is inevitable. During welding, the resulting residual oxygen content leads to oxidation of the surface, manifesting itself as annealing colours. As the forming process progresses, the residual oxygen content in the tank is reduced. Depending on the material, a sufficiently low residual oxygen content must be set before the welding work commences. As a rule, this is approx. 20-50 ppm. An indication of the residual oxygen content can be obtained with a suitable measuring instrument. In the case of series components with low manufacturing costs, the optimum purge time can also be determined empirically by trial and error.



The graph shows the flammable ranges of different N_2/H_2 gas mixtures.



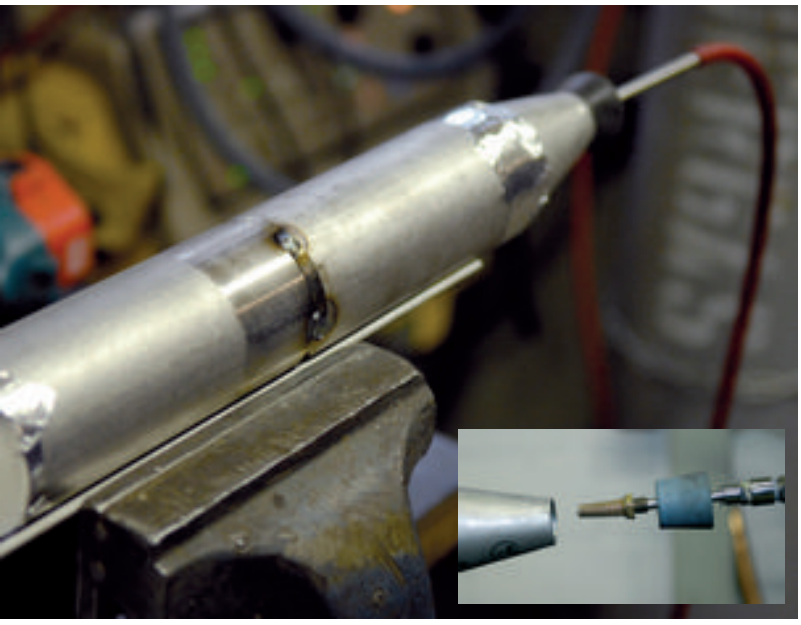
Influence of the residual oxygen content on the forming result

Determining prepurging times

When the correct procedure is followed, the prepurging times for the different components are dependent only on the required residual oxygen content. That means, the more sensitive the material, the longer the prepurging time. In the case of sheet metal and irregular tanks, the residual oxygen content can be measured or the purging time can be determined empirically. For the forming of pipes, there is a graphic aid (DVS Data Sheet 0937) for determination of an adequate purging time.Dependent on the pipe diameter, the purging time per metre of pipe can be determined.

Aids for root protection and forming

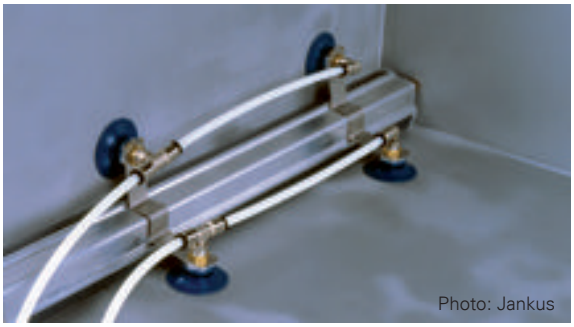
For root protection or forming, the affected zone should, if possible, be spatially demarcated. Numerous aids for this purpose are available from dealers.



Sinter metal shield gas finger for the forming of pipes

Root protection for sheet metal welding

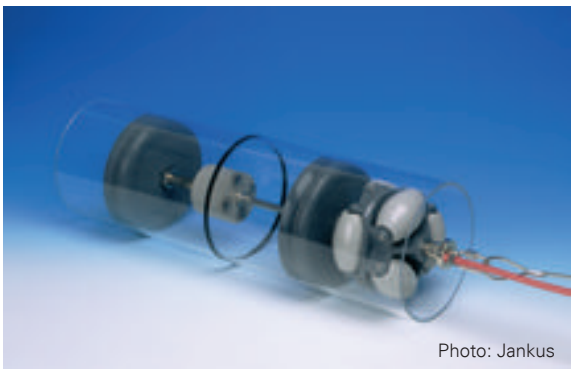
In the case of sheet metal welding, the root zone is often accessible, so that a forming device can be attached. This applies both for butt joints and for T and corner joints. The device must completely cover the root and the heat affected zone. In principle, a distinction must be made between butt and T joints. On completion of the welding work, the component temperature must be measured and the cover only removed after it has cooled sufficiently.



Shield gas angle profile for corner seams

Forming of pipes and tanks

Compared with root protection for sheet metal welding, the forming of pipes and tanks is more complicated. The roots of the joints are often difficult to get at. Adequate covering of the root zone with forming gas can usually only be achieved by using special forming devices or, in extreme cases, by completely filling the pipe.



Shield gas cylinder for the forming of pipes

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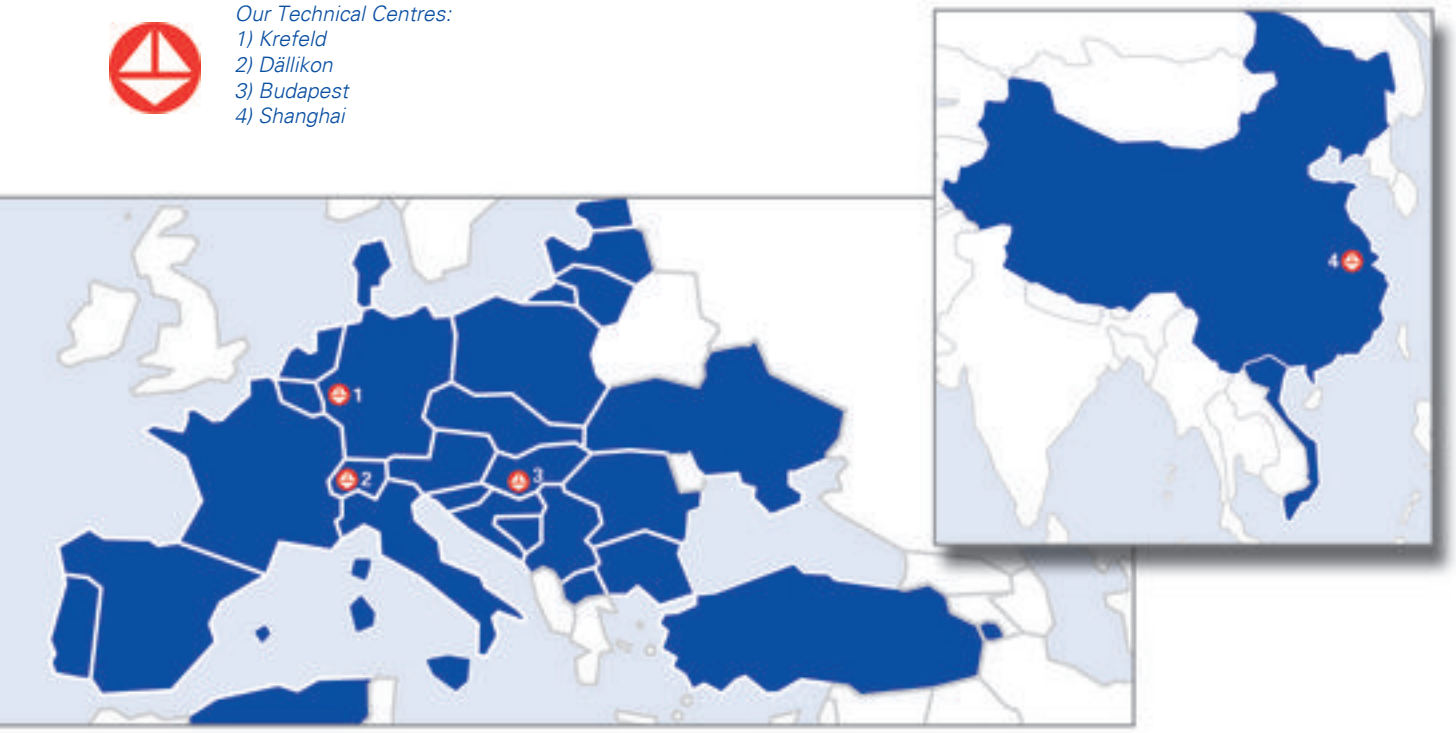

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