TALAT Lecture 4203

Weld Imperfections

10 pages, 9 figures

Basic Level

prepared by Ulrich Krüger,
Schweißtechnische Lehr- und Versuchsanstalt Berlin

Objectives:

– to illustrate the type of weld imperfections and their causes and corrections

Prerequisites:

– basic knowledge in metallurgy of aluminium

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4203 Weld Imperfections

Table of Contents

4203.01 External Irregularities

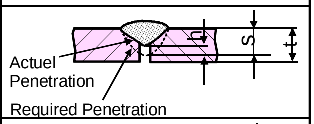
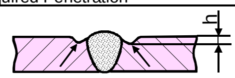
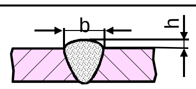
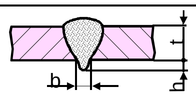
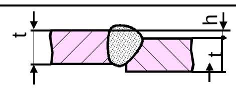
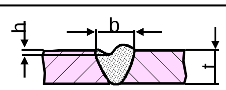
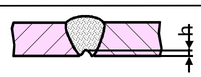
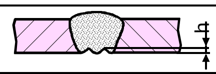
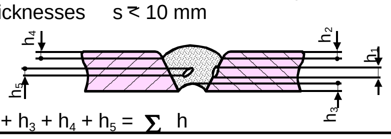
- External irregularities in butt welds
- Limiting values for the irregularity "Misalignment of Edges" (507)

External Irregularities in Butt Welds

This list of external irregularities for butt welds was extracted from the standard DIN-ISO 10 042 (arc-welded joints in aluminium and its alloys).

The different irregularities are indicated (e.g., notches, misalignment of edges and poor joint geometry) together with their illustrations and classification numbers according to ISO 6520. The dimensions indicated with alphabets can be arranged in the evaluation classes B, C and D which lay down the allowable limiting values (**Figure 4203.01.01**).

External Irregularities in Butt Welds

Irregularity Description	Classification No. According to ISO 6520	Remarks
Welding Penetration Insufficient	402	
Undercutting	5011 5012	
Weld Reinforcement Too High (Butt Weld)	502	
Root Reinforcement Too High	504	
Edge Misalignment	507	
Top Bead Depression	511	
Root-Side Suck-Back	515	
Root Notches	5013	
Multiple Irregularities in Cross-Section	Special Conditions can be Necessary for Thicknesses s ≲ 10 mm  $h_1 + h_2 + h_3 + h_4 + h_5 = \sum h$	

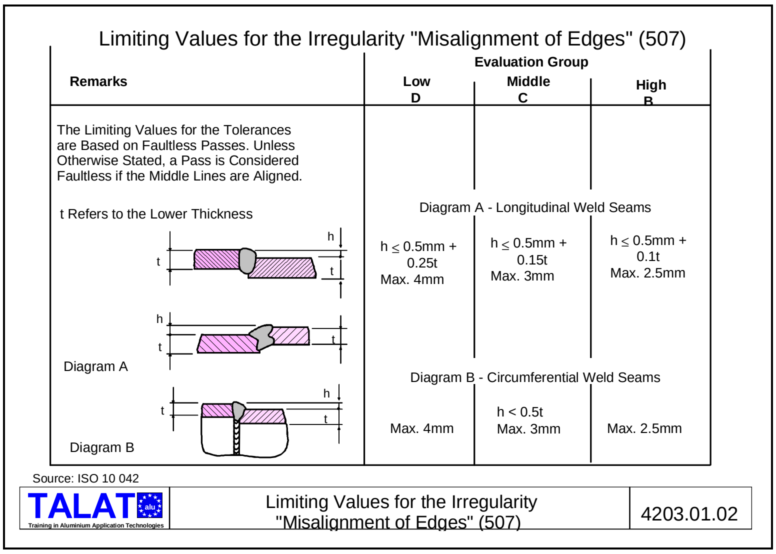
TALAT Training in Aluminium Application Technologies | External Irregularities in Butt Welds | 4203.01.01

Limiting Values for the Irregularity "Misalignment of Edges" (507)

Figure 4203.01.02 gives the limiting values for the irregularity "misalignment of edges" (number 507 according to ISO 6520) according to DIN-ISO 10 042.

Figure A contains the limiting values for the misalignment of height (h) and the material thickness for longitudinal welds. Figure B depicts the corresponding values for circumferential welds.

Depending on the evaluation group, the maximum allowable height misalignment is reduced in the following order: group D > group C > group B.



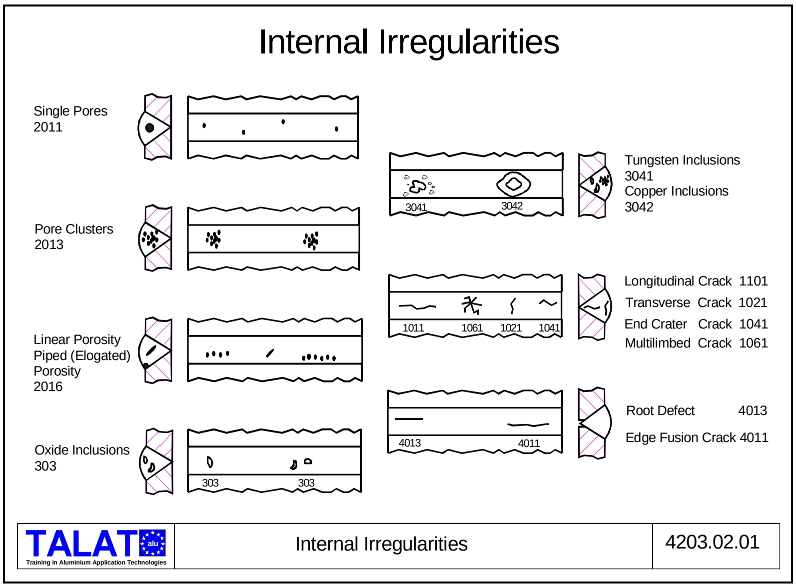
4203.02 Internal Irregularities

- Internal irregularities - survey
- Possibilities of gas absorption during welding
- Hydrogen content and porosity during welding
- Time available for formation of pores in the weld pool
- Effect of hydrogen content on the width of the pore forming zone
- Effect of hydrogen on porosity
- Porosity in TIG welds

Internal Irregularities - Survey

The DVS instructional pamphlet 1611 with the title "Evaluation of radiographs in railway coach construction - fusion-welded joints in aluminium and its alloys" serves as a basis for the evaluation of X-ray radiographs according to the guidelines DIN 54 111, part 1 and DIN 54 109, part 2.

The internal irregularities are illustrated as charts giving the type and distribution of porosity, inclusions, cracks and fusion defects. Thus, the size and amounts of weld discontinuities can be estimated (**Figure 4203.02.01)**.

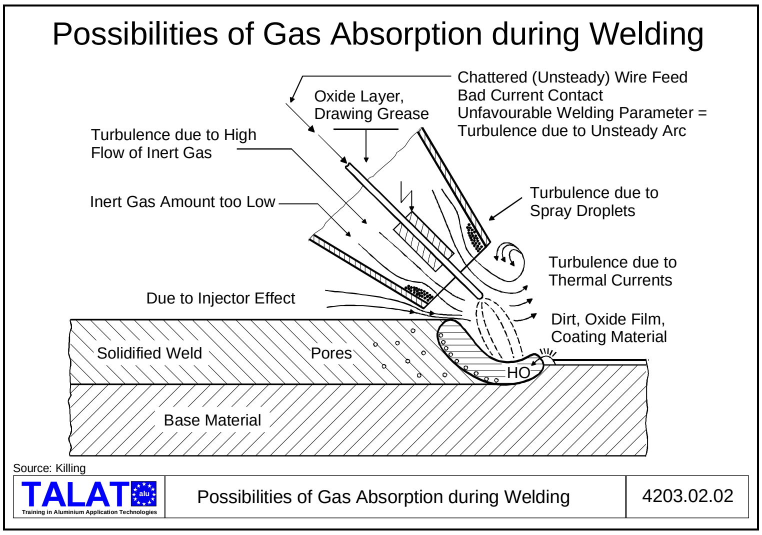


Possibilities of Gas Absorption during Welding

Gases, which cause pores in the weld, can be absorbed in a number of different ways. Once the source of this gas absorption is known, steps can be undertaken to eliminate it. The major cause of gas uptake in the weld pool is the occurrence of turbulences in the shielding gas envelope, caused by too high or too low flow rates. Other causes are:

- unstable arc
- torch held at too high a slanting angle
- draught at the welding work-place
- sprayed droplets in the shielding gas nozzle
- entrance of air in the shielding gas envelope

Finally, impurities on the work-piece surface and on the welding wire can release gases like oxygen and hydrogen which can then be absorbed in the weld pool (**Figure 4203.02.02**).

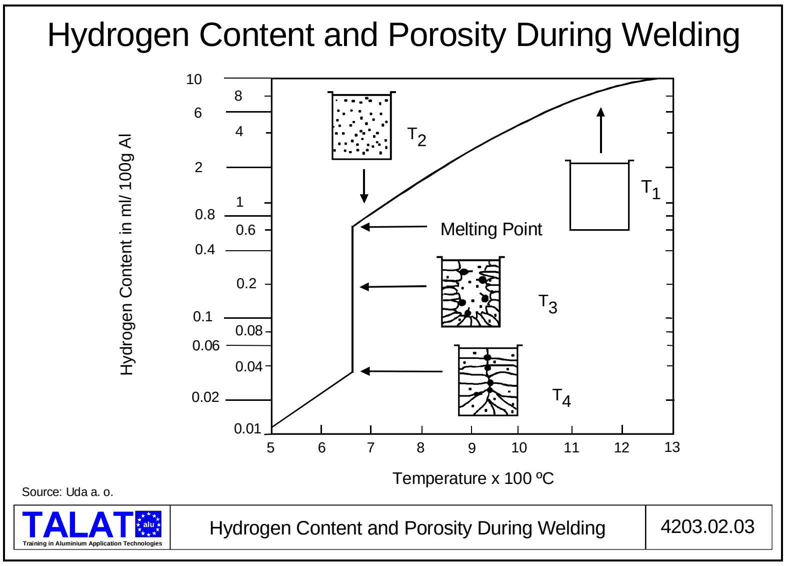


Good degassing of the welding parts and preheating of the work-piece can reduce the gas porosity of welds.

Hydrogen Content and Porosity during Welding

Gas porosity caused by hydrogen is a major problem during welding of aluminium and its alloys.

The cause of porosity during solidification is the fact that the molten weld pool can absorb a large amount of gas, this absorption increasing with the weld pool temperature. During cooling and solidification, the excess gas is released causing pores.



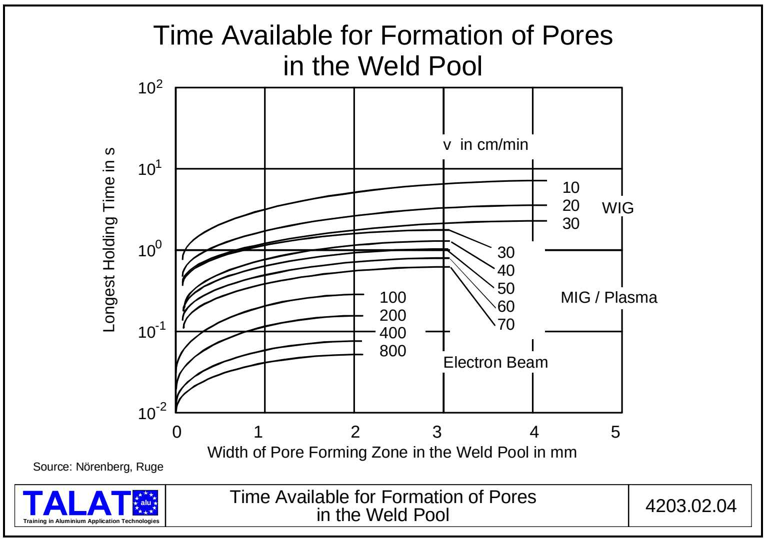
When, during cooling, the melting point is reached, the hydrogen solubility decreases suddenly by the factor of 20. The excess gas released is surrounded by the solidification front which prevents the gas from escaping out of the weld (**Figure 4203.02.03)**.

In the solidified weld, depending on the solidification morphology of the alloy, the hydrogen pores are either distributed uniformly or linked together to form chain-like structures.

Time Available for Formation of Pores in the Weld Pool

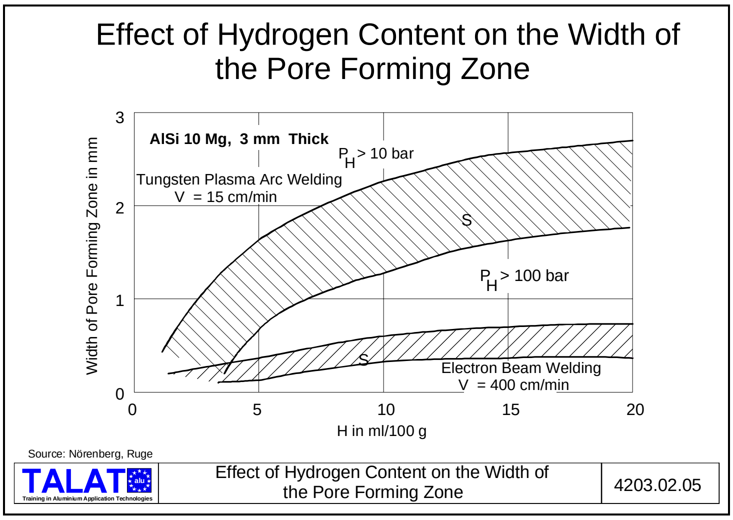
The high gas content of aluminium pressure die castings, causes a very high porosity of the weld joint during welding.

The diffusion-dependent formation of pores increases with the time a volume element is held at the pore forming zone. Consequently, this holding time duration increases with increasing width of this zone. The electron beam welding process with its markedly low energy input compared to the other arc welding processes, therefore has a narrow pore formation zone, thereby decreasing the tendency for porosity in welds. Holding times of < 0.1 s do not seem to be critical for pore formation. This can also be influenced by changing the welding rate (**Figure 4203.02.04**).



Effect of Hydrogen Content on the Width of the Pore Forming Zone

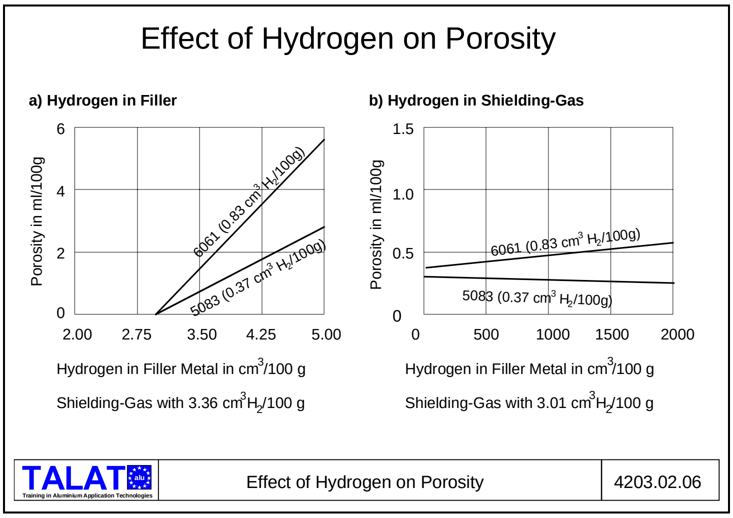
The desired narrow pore formation zone occurs during the plasma arc welding of pressure die castings for very low hydrogen contents.



In contrast, the electron beam welding has a very narrow pore formation zone and therefore produces a low weld porosity (**Figure 4203.02.05**). In this case, higher contents of gases in the base material can be tolerated. The influence of welding rate is evident here also. Low welding rates lead to broad pore formation zones and high holding times so that weld porosity increases.

Effect of Hydrogen on Porosity

The hydrogen available at the weld pool is introduced either as impurities in the shielding gases used (Ar, He, Ar-He mixture) or from the filler metal. Reactions in the arc region can be excluded. The weld porosity increases rapidly with increasing content of hydrogen in the filler metal. Consequently, special care must be taken to assure that the proper quality of wire with a clean surface is employed. The hydrogen content of the inert gases plays only a minor role (**Figure 4203.02.06**).



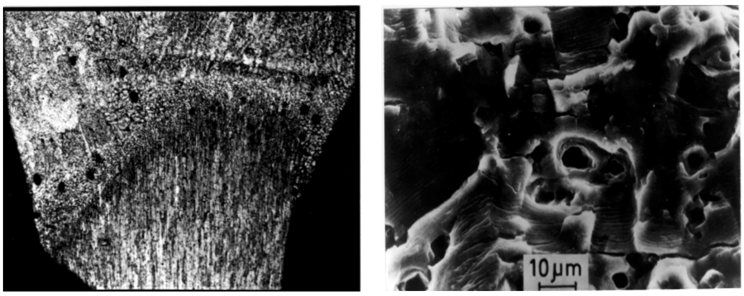
Porosity in TIG Welds

Figure 4203.02.07 shows the macrograph of a welded specimen of alloy AlZn4,5Mg1 with a defined amount of intentionally introduced hydrogen porosity which is concentrated close to the fusion boundary.

The scanning electron microscope (SEM) photograph shows how the pores are arranged in the fatigue crack surface (to be recognised by the occurrence of numerous fine lines) of a fatigue test specimen. These are round with a diameter of ca. 5 to 10 µm and are distributed uniformly in the observed region.

Porosity in TIG Welds

AlZn4,5Mg1 F 35; 2.0 mm Thick
Filler Metal: S-AlMg4,5Mn



Macrostructure in the Region of the Melting Line

SEM Photograph of Fatigue Failure Surfaces with Pores

Source: SLV Berlin

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4203.03 Literature/ References

Killing, R.: Handbuch der Schweißverfahren, Teil 1: Lichtbogenschweißverfahren, Fachbuchreihe Schweißtechnik Bd. 76, Deutscher Verlag für Schweißtechnik, 1991, Düsseldorf

Martukanitz, R.P. et al.: Sources of porosity in gas metal arc welding of aluminium. Aluminium 58 (1982), H.5 p. 276/279

Nörenberg, K. and Ruge, J.: Wasserstoffporosität beim Schmelzschweißen von Aluminiumwerkstoffen.
Pt. 1: Aluminium 68 (1992), Nr. 4, p 322/325
Pt. 2: Aluminium 68 (1992), Nr. 5, p 406/409

4203.04 List of Figures