Welding Terminology
TIG – MIG/MAG

BIL

2021

1

Program

Timing	Program
13h00 - 15h00	Welding terminology TIG welding MIG-MAG welding
15h00 - 15h10	Break
15h10 - 17h00	Destructive testing

2

Content

1 Welding Terminology

2 TIG welding

3 MIG/MAG welding

3

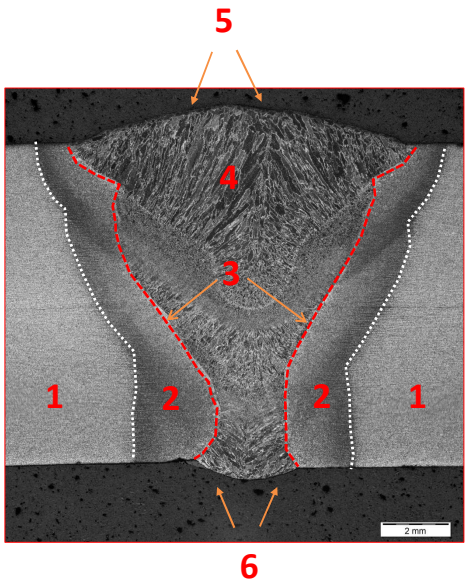
Joining your future.

3

INFOTHEEK

3

Welding Terminology



1 Base material (BM)
2 Heat affected zone(HAZ)
3 Fusion line
4 Weld metal (WM)
5 Cap of the weld
6 Root of the weld

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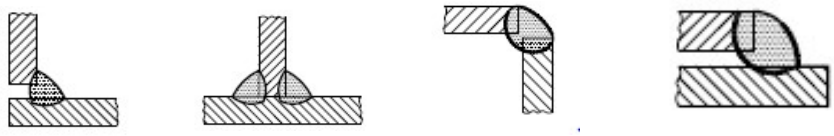
4

4

Welding Terminology: type of welds

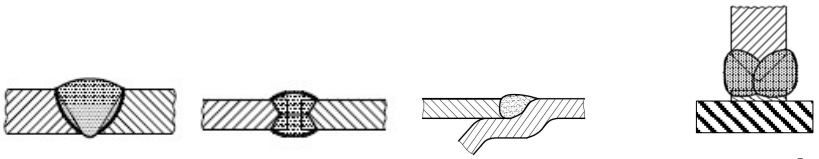
- **FW** = **F**illet **W**eld

Triangular weld in a square preparation for making a T-joint, corner joint or lap joint



- **BW** = **B**utt **W**eld

Weld other than a fillet weld, made in a groove or in a square preparation



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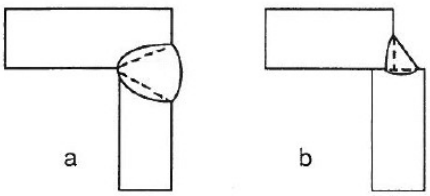
5

5

Welding Terminology: type of joints

- **Joint:** junction of workpieces or the edges of workpieces that are to be joined
- **Corner joint**
  - Parts ± perpendicular
  - Weld on both plate edges
  - Single sided or double sided
  - With or without full penetration



6

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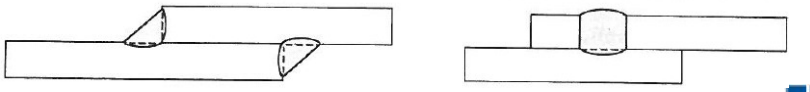
6

6

Welding Terminology: type of joints

- **Butt joint**
  - Plates / tubes ± in the same plane

- **Overlap joint**
  - Advantage : no preparation
  - Disadvantage: additional moment in the connection



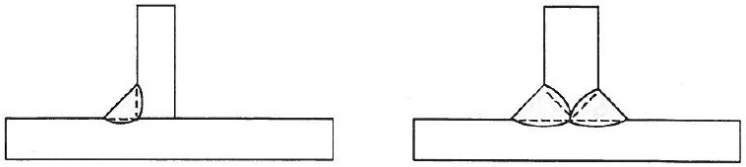
Plug welds

7

7

Welding Terminology: type of joints

- **T-joint**
  - Parts ± perpendicular in T-shape
  - Without weld preparation→ fillet weld
  - With weld preparation→ combination BW+FW



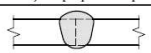
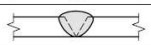
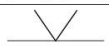
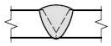
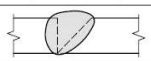
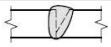
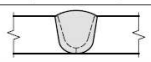
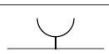
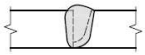
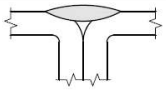
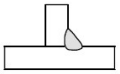
8

8

Elementary welding symbols ISO 2553

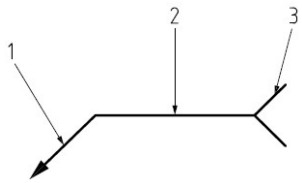
The symbol used to indicate a weld represents more or less the shape of the weld preparation.

This symbol says nothing about the welding process to be used!

No.	Designation	Illustration (dashed lines show joint preparation prior to welding)	Symbol[a]
1	Square butt[b]		
2	Single-V butt[b]		
3	Single-V butt with broad root face[b]		
4	Single-bevel butt[b]		
5	Single-bevel butt with broad root face[b]		
6	Single-U butt[b]		
7	Single-J butt[b]		
8	Flare V		
10	Fillet		

9

Welding Terminology: basic welding symbol ISO 2553



Basic welding symbol:
Used to indicate the location of a weld

1) Arrow line:

- Shall point to and shall be in contact with a solid line of the joint on the drawing
- Shall be drawn at an angle and joined to a reference line and completed with a closed filled arrowhead

2) Reference line:

- parallel to the bottom edge
- Location for elementary symbol

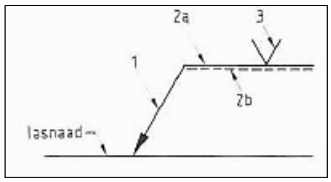
3) Tail:

- Optional, only if there is extra information

10

Welding Terminology: basic welding symbol ISO 2553

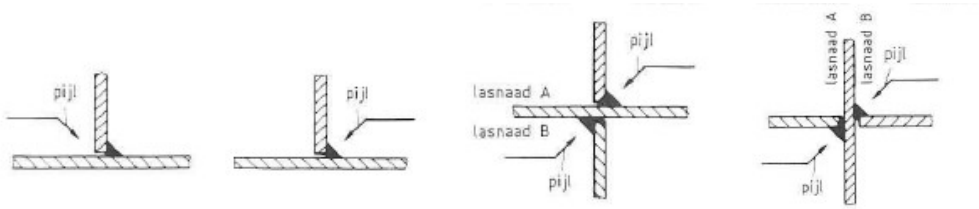
- **Arrow and Reference line system A**:



> **Elementary symbol**:

- on continuous line= weld arrow side

- on dashed line = weld on the other side of the arrow

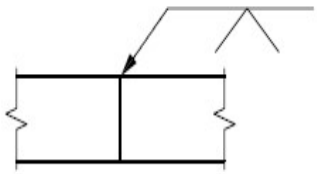


11

11

Welding Terminology: basic welding symbol ISO 2553

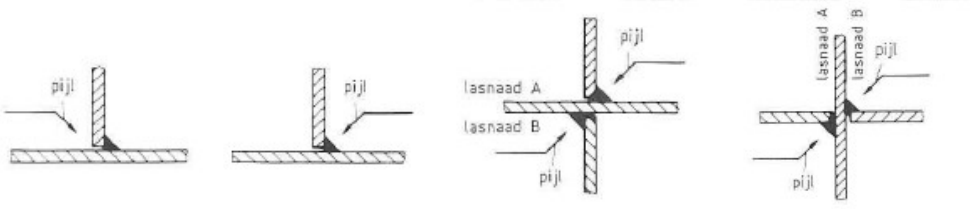
- **Arrow and Reference line system B**:



> **Elementary symbol**:

- above reference line = weld on the other side of the arrow

- below reference line = weld arrow side



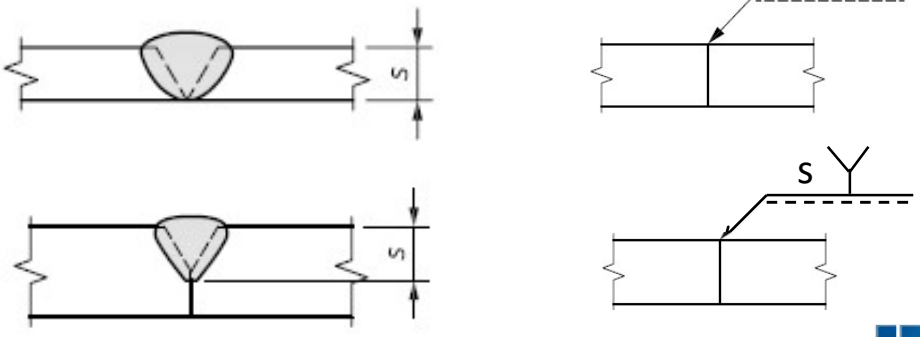
12

12

Welding Terminology: dimension of welds ISO 2553

- **Butt weld:**
  - penetration depth « s »: thickness of the weld metal excluding any reinforcement

No cross-sectional dimension > full penetration!

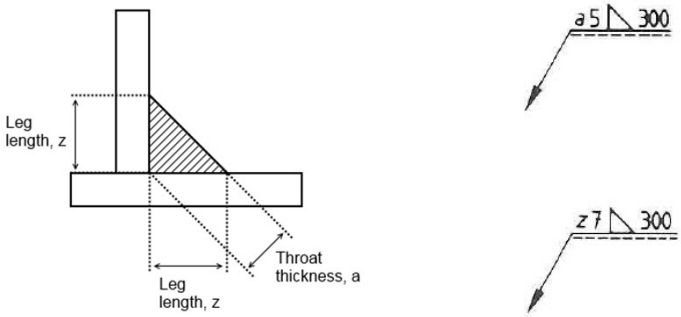


13

13

Welding Terminology: dimension of welds ISO 2553

- **Fillet weld**:
  - throat thickness « a »: height of the largest isosceles triangle that can be inscribed in the section of a fillet weld
  - leg length « Z »: distance of the intersection of the fusion faces and the toe of a fillet weld

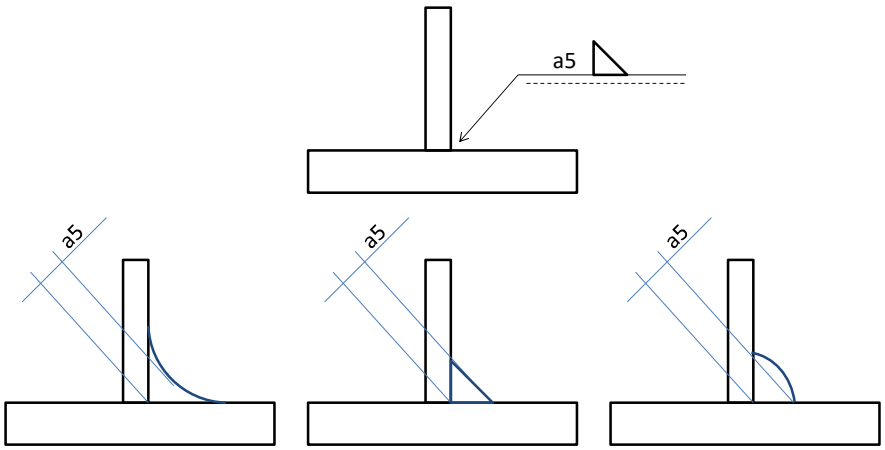


14

14

Welding Terminology: dimension of welds ISO 2553

- **Cross-sectional dimensions:**
  - **Fillet weld:**



15

15

Welding Terminology: Weld preparation

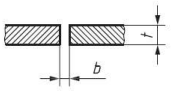
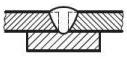
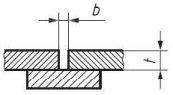
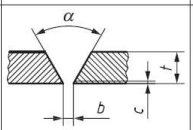
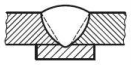
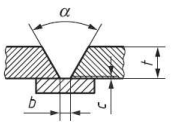
- Which weld preparation to choose?
- ISO 9692-series gives recommendations:
- Part 1: Electrode, MAG, TIG, autogenous welding of steel
- Part 2: Submerged arc welding of steel
- Part 3: MIG en TIG welding of Alu
- Part 4: Clad steels

16

16

Welding Terminology: Weld preparation

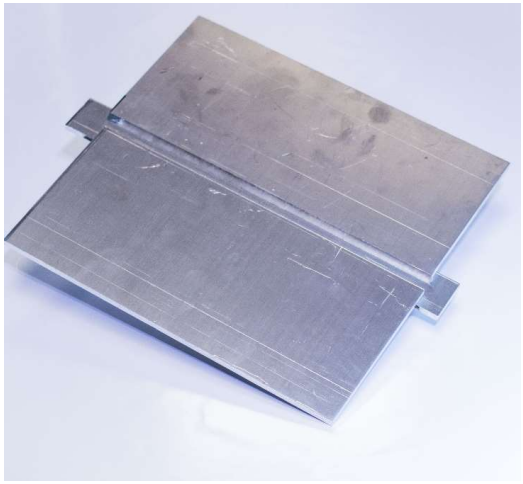
ISO 9692-3: MIG en TIG welding of Alu

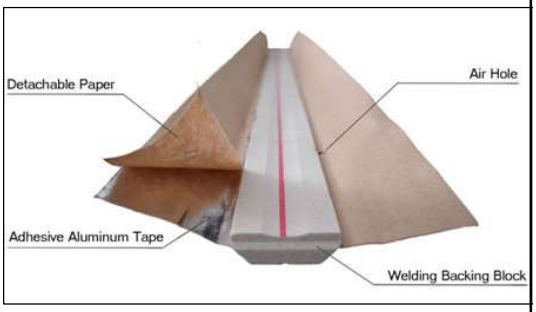
Weld				Joint preparation					
Workpiece thickness t	Designation	Symbol[b]	Illustration	Cross-section	Angle α, β	Gap b	Thick-ness of root face c	Other dimensions	Recommend-ed welding process[c]
$t \le 4$	Square butt weld				—	$b \le 1$	—	—	141
$2 \le t \le 4$	Square butt weld with temporary (MR) or perma-nent (M) backing				—	$b \le 1,5$	—	—	131
$3 \le t \le 5$	Single-V butt weld				$60° \le \alpha \le 90°$	$b \le 2$	$c \le 2$	—	131
	Single-V butt weld with removable/ temporary (MR) or permanent (M) backing				$60° \le \alpha \le 90°$	$b \le 4$	$c \le 2$	—	131

17

Welding Terminology: Weld preparation

Backing:

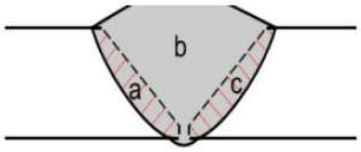




18

Welding Terminology: Dilution

- Dilution: used to evaluate the chemical composition of the weld metal



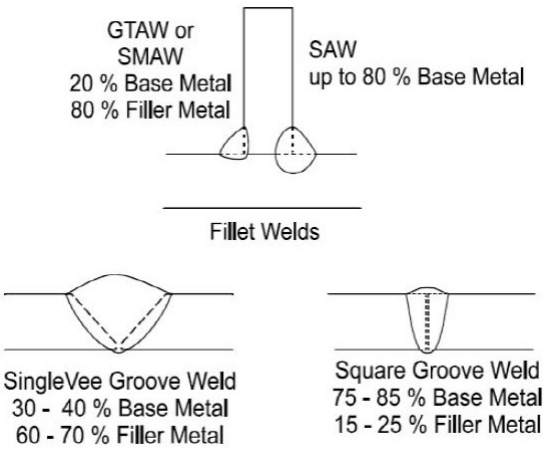
% Base Metal Dilution =

$$\frac{a + c}{a + b + c} \times 100\%$$

19

Welding Terminology: Dilution

- Influancing factors: joint type, welding process, location



- MIG/MAG: root 10-40%; filler 5-20%

20

Content

1 Welding Terminology

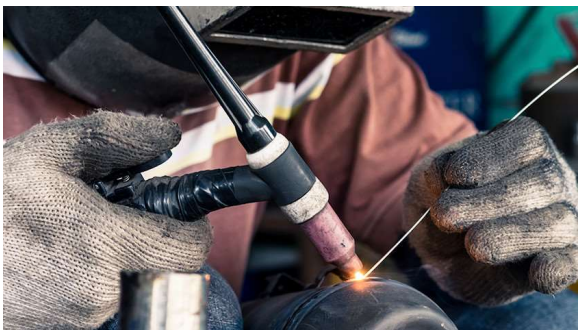
2 TIG welding

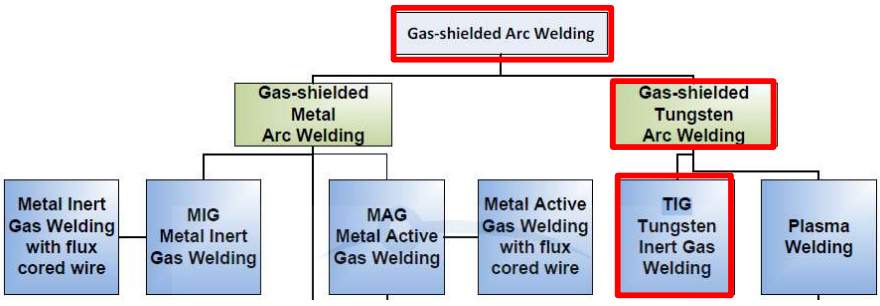
3 MIG/MAG welding

Arc Welding with gas

- Why do we need gas?
  - Protection of weld pool against environmental influences (shielding gas)
    - Air composition: 78% N_2 + 21% O_2 + 1% remaining gas
  - Protection electrode (TIG)
  - Melt pool reactions (MAG)
    - Adding active components: oxidizing or reducing
  - Ionization of the arc (arc energy)
    - Welding arc = electrically conductive gas column
  - Weld seam formation
    - Influence of the surface tension
    - Influencing the weld pool shape

TIG welding





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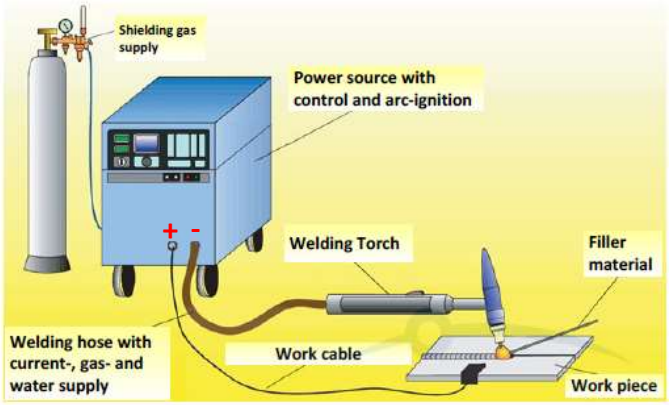
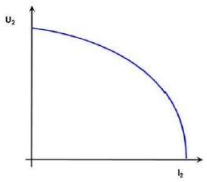
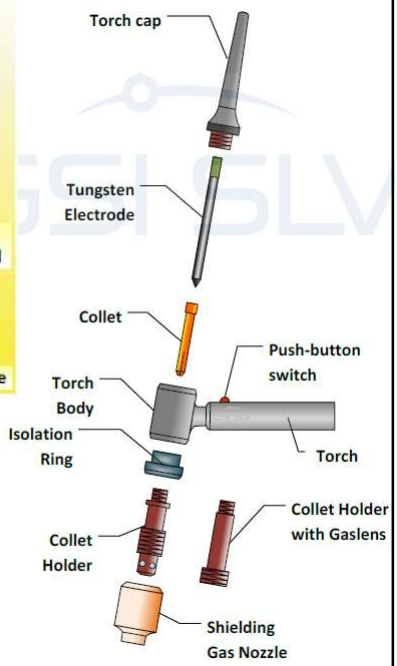
23

23

TIG welding: overview equipment







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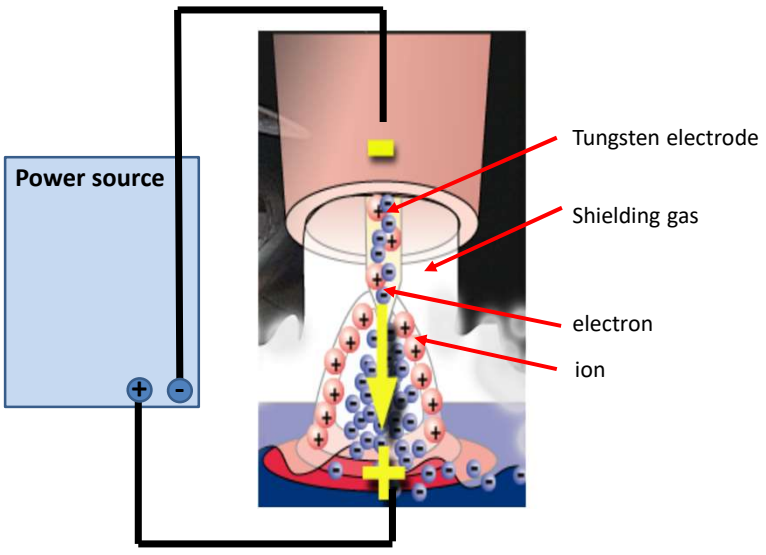
24

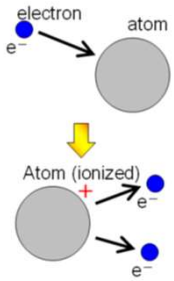
TIG welding:

- Application:
  - Welding of
    - C-steel
    - Stainless steel
    - Aluminium
    - Thickness 0,5mm up to 5mm
    - The root in higher thicknesses
- + :
  - High quality
  - Fewer welding defects
- - :
  - Slow
  - Low deposition rate

25

TIG welding: The arc





26

TIG welding: The arc

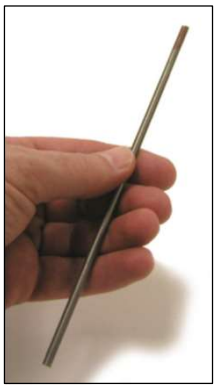
- **Ignition**
  - Lift-arc, scratch arc

  - High frequency (Mhz) and high voltage (kV)

27

TIG welding: The electrode

- **Requirements**
  - High melting temperature
  - Emission of electrons should be easy
  - Ignition of arc should be easy



  - Tungsten: melting point: 3422 °C (3695K)
  - Addition of oxides to improve electron emmission and ignition
    - (Thorium Th) radioactive, so limited use
    - Zirconium Zr
    - Lanthanium La
    - Cerium Ce

28

TIG welding: The electrode

- **Types**

Tungsten Electrode Types

(Green)
Unalloyed, pure tungsten. Good arc stability with AC with either balanced wave or continuous high-frequency stabilization. Preferred for AC welding of aluminum and magnesium. When heated, the pure tungsten electrode forms a balled end.

EWTh-1 (Yellow), EWTh-2 (Red)

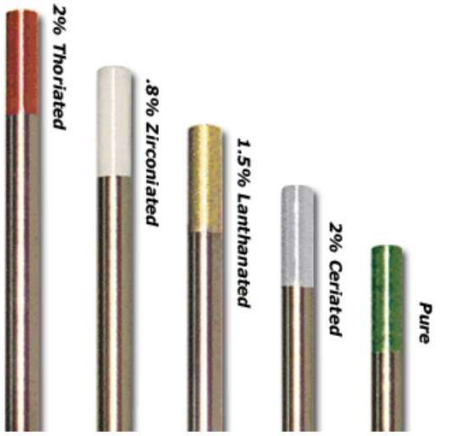
Designed for DC applications. Thoria content is dispersed evenly throughout entire length. Maintains a sharpened point well, which is desirable for welding steels. Good arc

EWCe-2 (Orange)
Alloyed with about 2 percent ceria, the most abundant of the rare elements. These are all-purpose electrodes that operate with AC or DC of either polarity. Provide long life and high current-carrying capacity. Unlike thoria, ceria is not a radioactive material.

EWLa-1 (Black)
Has 1 percent lanthanum oxide, often referred to as lanthana, another of the rare-earth elements. The operatin g characteristics and advantages are similar to the EWCe-2 electrode.

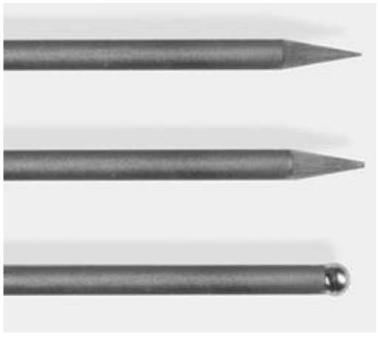
EWZr-1 (Brown)
Designed for AC welding when the highest-quality work is necessary. Contains less than 1 percent zirconium oxide, which produces a stable arc. Current-carrying capacity equal to or greater than equal-sized thorium electrode. Not recommended for DC welding.

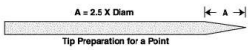
EWG (Gray)
Contains unspecified additions of rare-earth oxides or combinations of oxides, which must be identified by the manufacturer. Electrode capabilities also should be identified by the manufacturer.

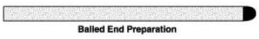


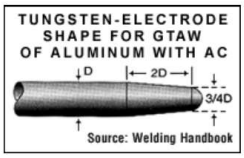
29

TIG welding: The electrode



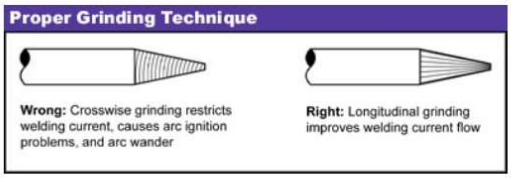






30

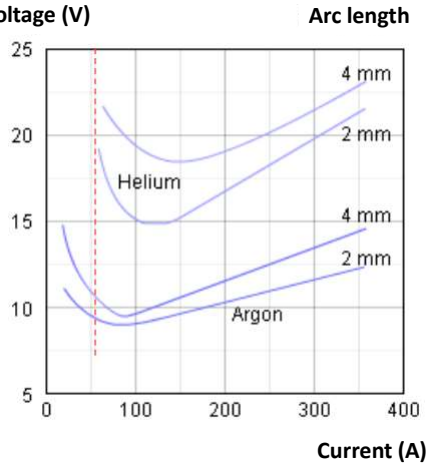
TIG welding: The electrode



31

TIG welding: The gas

- **Ar or He**

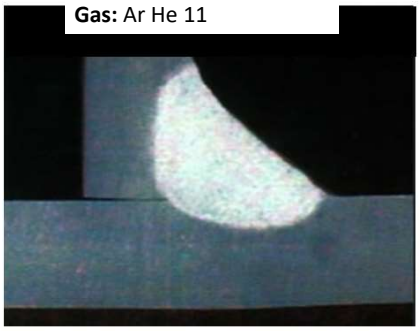


32

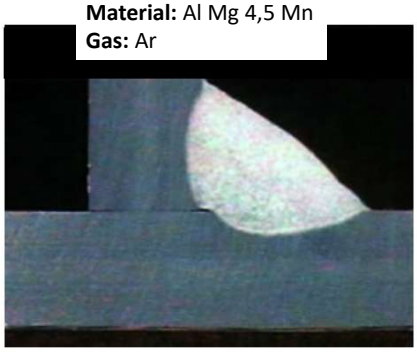
TIG welding: The gas

- **Penetration**

Material: Al Mg 4,5 Mn
Gas: Ar He 11



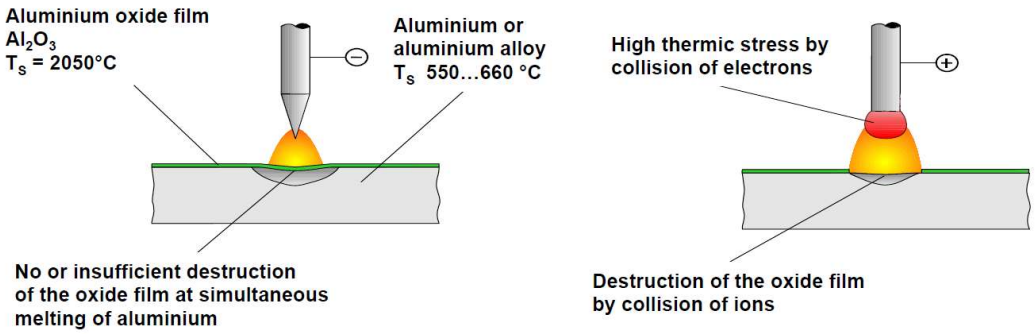
Material: Al Mg 4,5 Mn
Gas: Ar



33

TIG welding: Welding alu

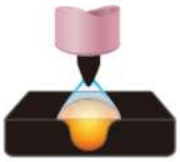
- **Problem of welding Aluminium**



34

TIG welding: Welding alu

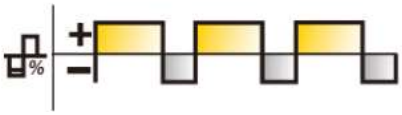
Wider bead, good penetration ideal for buildup work

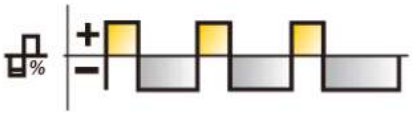


Narrower bead, good penetration ideal for buildup work

Wider bead and cleaning action

Narrower bead, with no visible cleaning





35

TIG welding: Welding alu

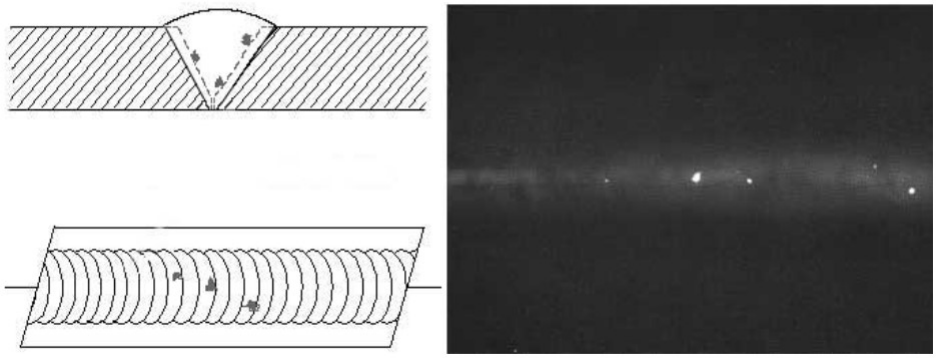
Workpiece thickness mm	Shape of groove weld	Tungsten electrode diameter mm	Welding current *) A	Filler rod diameter mm	Argon consumption L/min.	Amount of Layers
1	II	1.6	50 ... 60	2	4 ... 5	1
2	II	2.4	60 ... 90	2	5 ... 6	1
3	II	2.4	90 ... 150	3	5 ... 6	1
4	II	3.2	150 ... 180	3	6 ... 8	1
6	V	3.2	180 ... 240	4	8 ... 10	2
8	V	4.0	200 ... 280	4	8 ... 10	2
10	V	4.8	260 ... 350	5	10 ... 12	2 ... 3
12	V	6.4	320 ... 400	5	12 ... 14	3

*) Values for butt welds; in the case of fillet welds these should be increased by 10 to 20%.

36

TIG welding: Imperfections

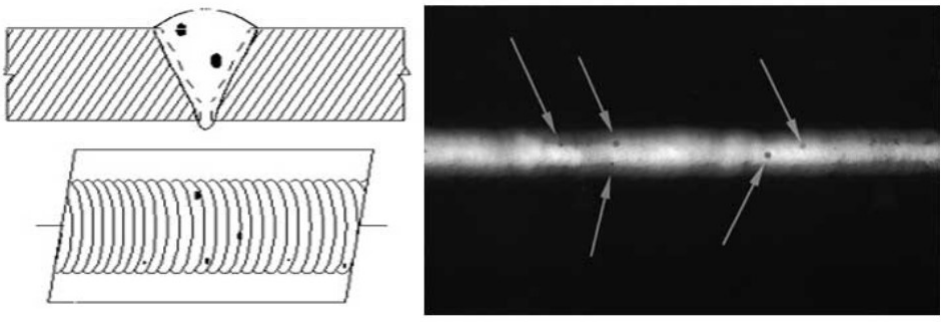
- Tungsten inclusions



37

TIG welding: Imperfections

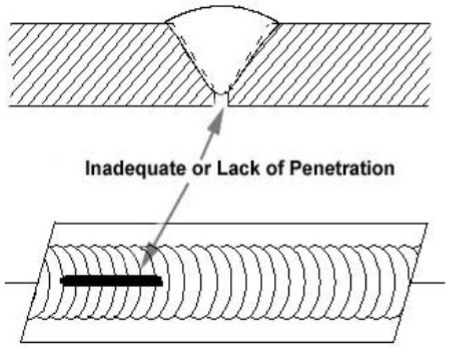
- Porosity

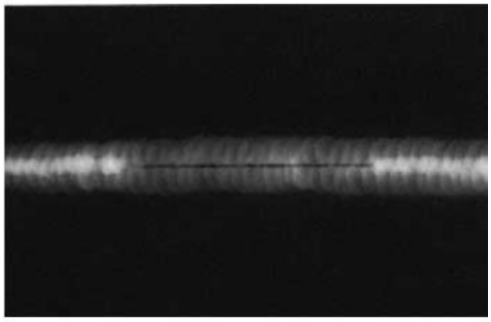


38

TIG welding: Imperfections

- Lack of penetration

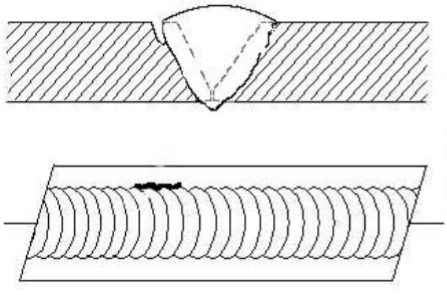


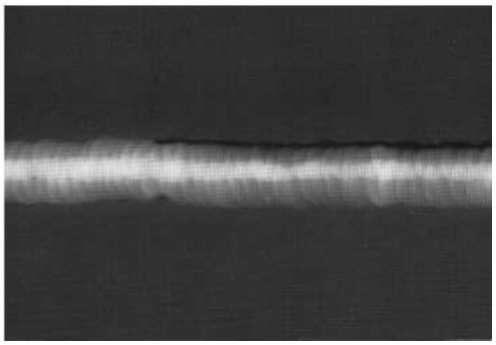


39

TIG welding: Imperfections

- Undercut

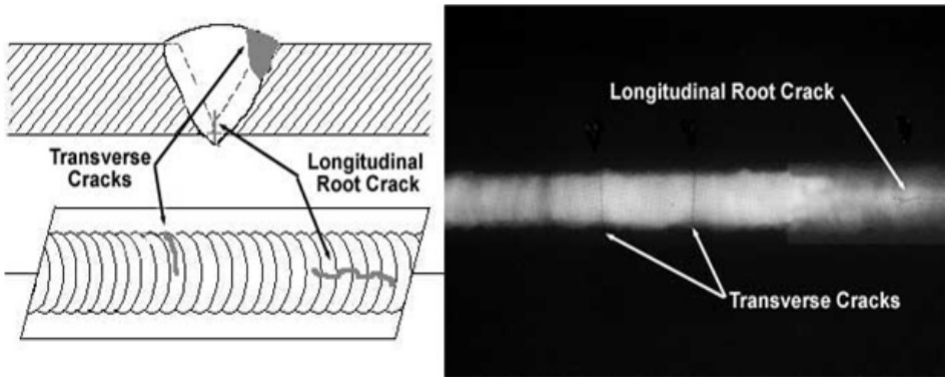




40

TIG welding: Imperfections

- Cracks



41

Content

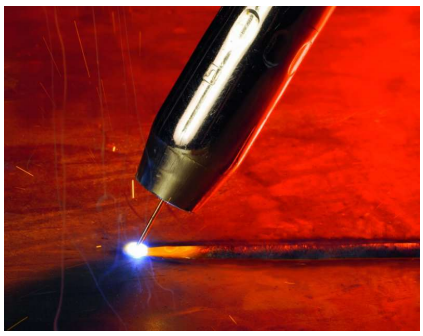
1 Welding Terminology

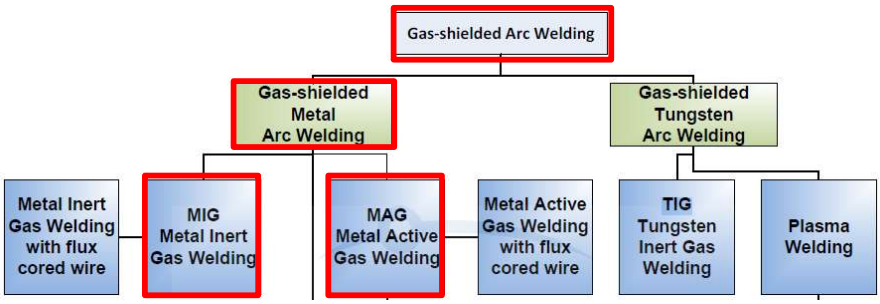
2 TIG welding

3 MIG/MAG welding

42

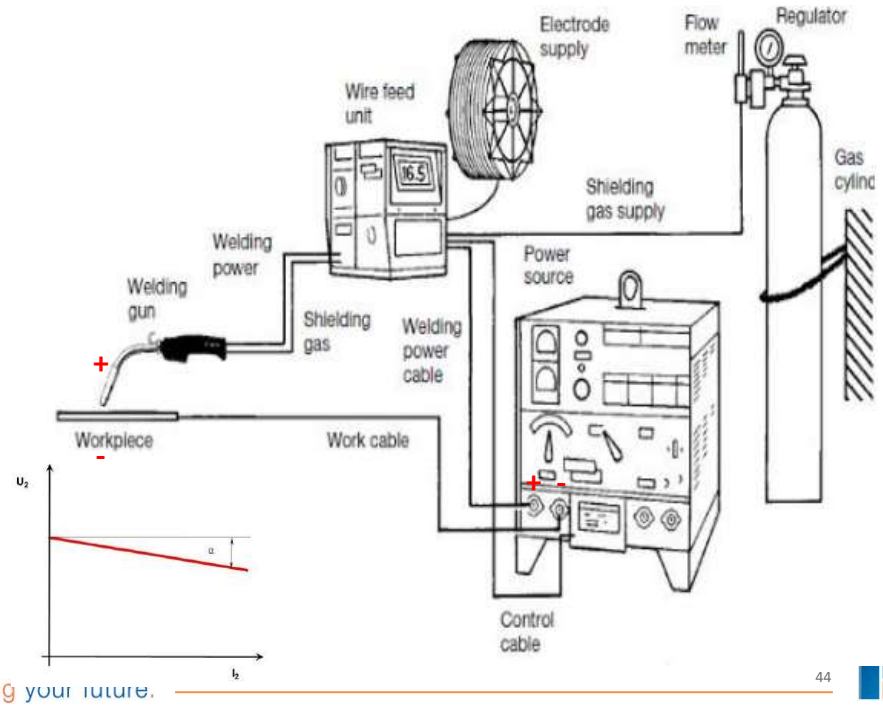
MIG – MAG welding





43

MIG – MAG welding: overview equipment



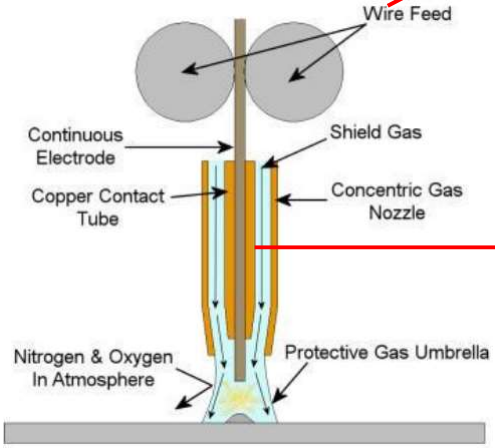
44

MIG – MAG welding:

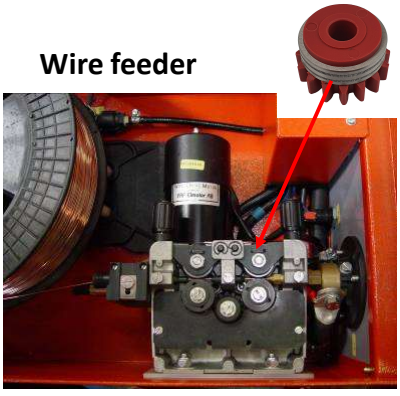
- Application:
  - Welding of
    - C-steel
    - Stainless steel
    - Aluminium
    - Thickness ≥1mm
- + (compared to TIG) :
  - Higher deposition rate (1 to 6 kg/h)
  - Easier to automate
- - (compared to TIG):
  - Higher risk of weld defects
  - More complex equipment
  - More critical welding parameters

45

MIG – MAG welding



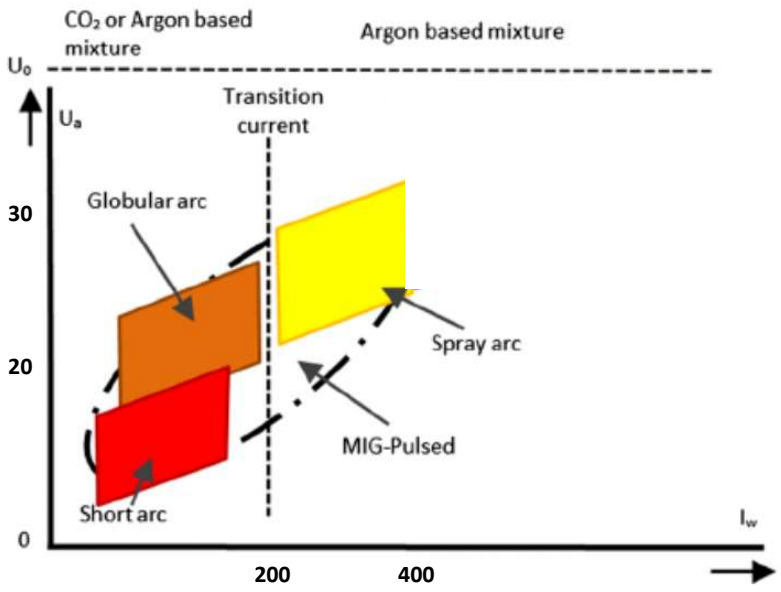
Wire feeder



Contact tips

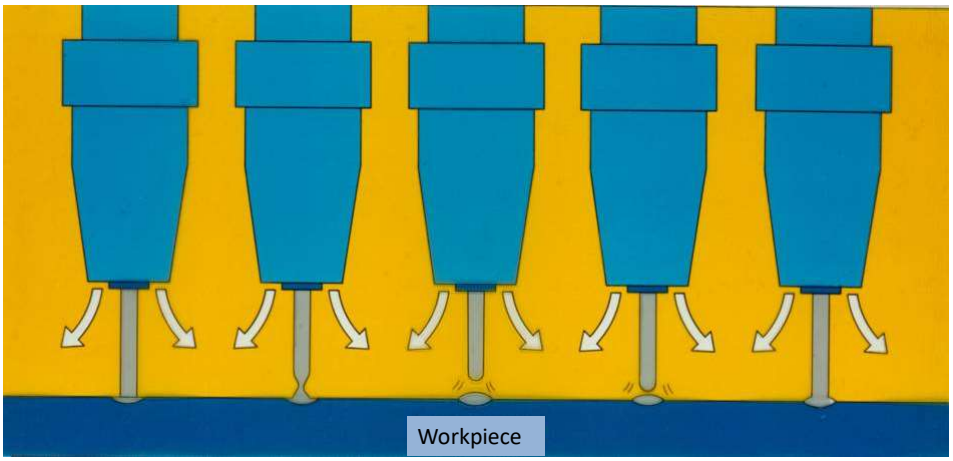
46

MIG – MAG welding: Arc transfer modes



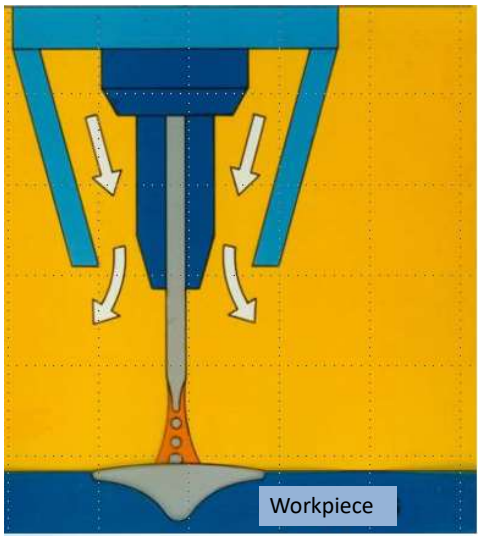
47

MIG – MAG welding: Arc transfer mode: short circuit



48

MIG – MAG welding: Arc transfer mode: spray

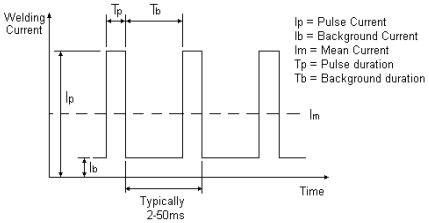


49

MIG – MAG welding: Arc transfer mode:

	Advantage	Disadvantage
Short-circuit transfer	- Welding in position - HI ↘ - Thin material (root)	- Limited deposition rate - Rough weld appearance - Spatter
Spray transfer	- High deposition rate - less spatter - Smooth weld appearance	- Not in position - Hard to control - No thin plate

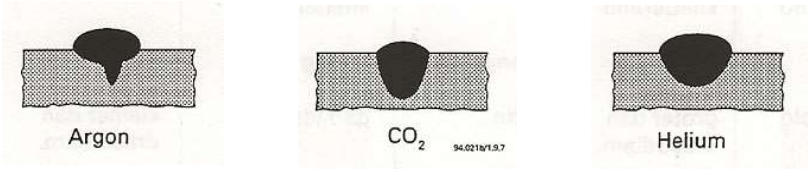
Pulse welding > combines advantages of spray and short-arc



50

MIG – MAG welding: gas

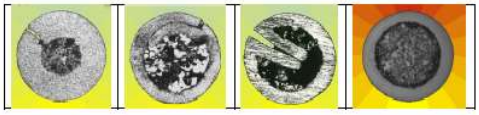
- MIG: Ar, He or mixtures
  - Ar/He 30-75%,… (Alu)
- MAG: mixtures (with an active component)
  - Ar/CO2 mixtures → eg. Ar/CO2 5-20%,… (carbon steel)
  - Ar/O2 mixtures → eg. Ar/O2 1-5%,…
  - Ar/ 2-3%CO2/1%H2 (stainless steel)



51

MIG – MAG welding: wire

- Solid wire:
  - Diameter 0,8 to 2,4 mm
  - Composition depends of the material to be welded
    - unalloyed steel: addition of Mn and Si
  - Thin copper layer on outside of the wire
  - in metal or plastic coils (about 15 kg)
  - in barrels of 250-1000kg
  - Classification according to standards

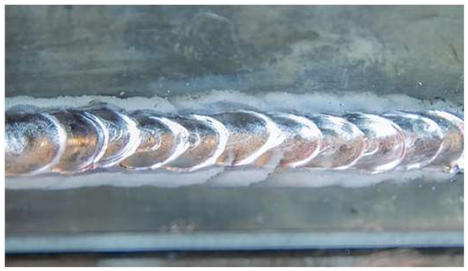


- Cored wire: (more expensive)
  - Diameter 1 to 2,4 mm
  - Metal cored > no slag is formed
  - Flux cored > slag is formed on the weld
    - Alloy elements and arc stabilizers

52

MIG – welding: welding Alu

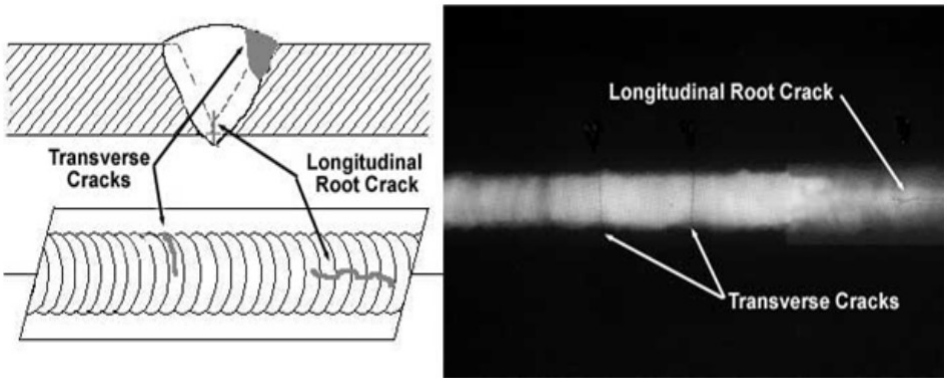
- MIG welding:
  - Ar/He mixture (no CO2)
  - He increase penetration and/or welding speed
  - Pure gas with low H
  - High Q wire with low H in oxide layer
  - Pulsed welding (No short-circuit transfer)
  - DC + (good cleaning)



53

MIG – MAG welding: Imperfections

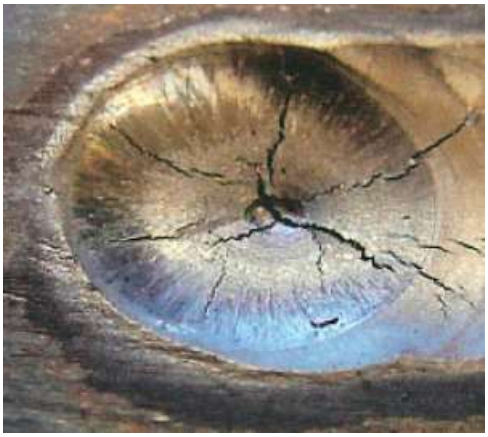
- Cracks



54

MIG – MAG welding: Imperfections

- Crater crack



55

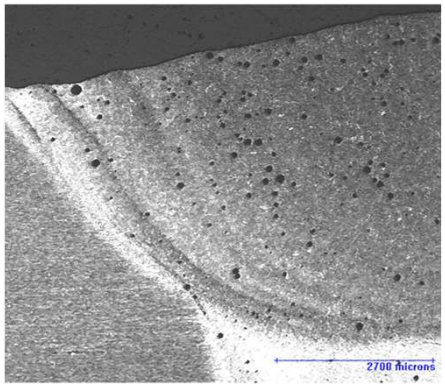
MIG – MAG welding: Imperfections

- Surface porosity

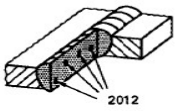
56

MIG – MAG welding: Imperfections

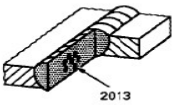
- Porosity internal



Uniformly distributed

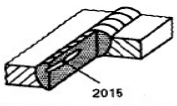


clustered



Linear prorsity

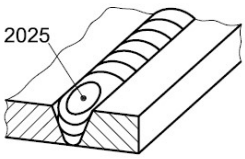
Elongated cavity

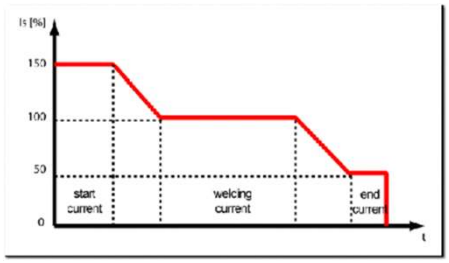


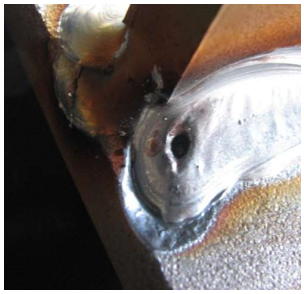
57

MIG – MAG welding: Imperfections

- End crater pipe



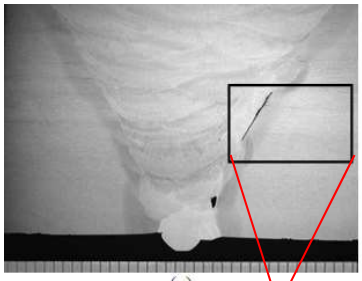




58

MIG – MAG welding: Imperfections

- Lack of fusion



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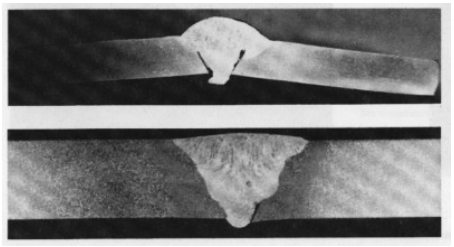
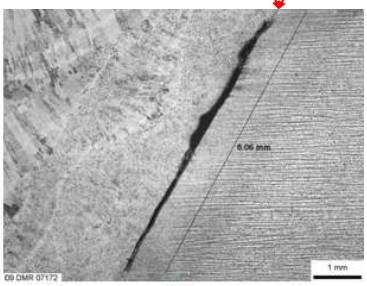


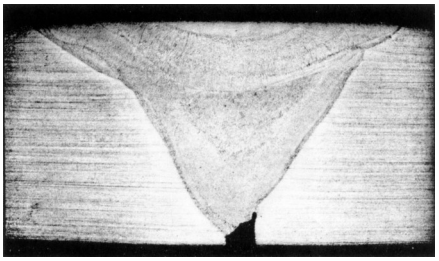


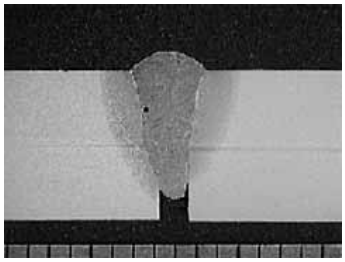
(b)

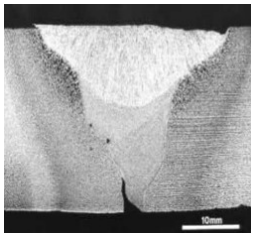
59

MIG – MAG welding: Imperfections

- Lack of penetration



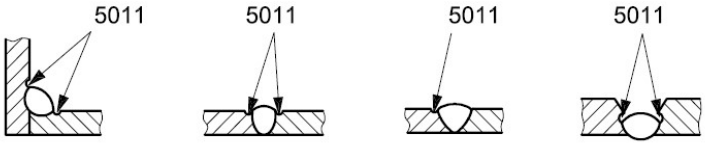


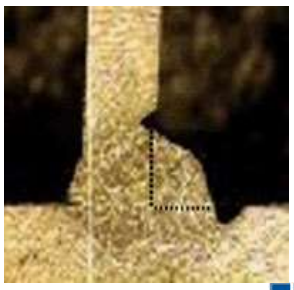


60

MIG – MAG welding: Imperfections

- undercut

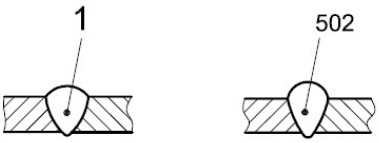


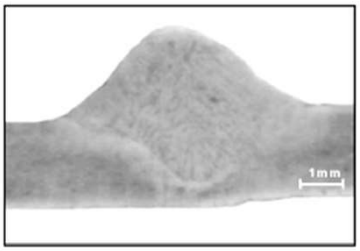


61

MIG – MAG welding: Imperfections

- Excess weld metal

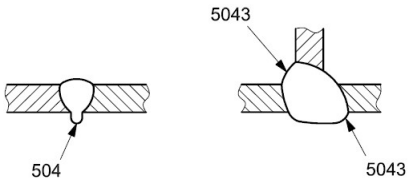


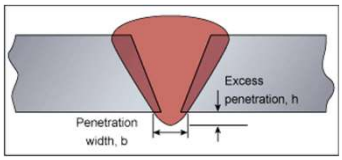


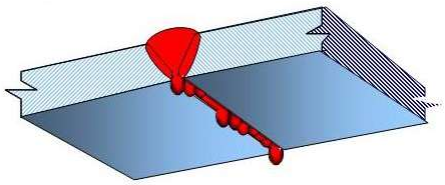
62

MIG – MAG welding: Imperfections

- Excessive penetration



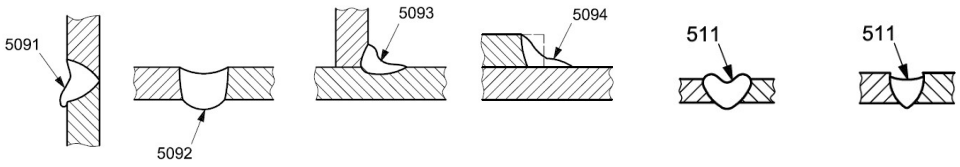




63

MIG – MAG welding: Imperfections

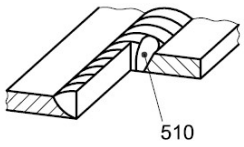
- Sagging / incompletely filled groove



64

MIG – MAG welding: Imperfections

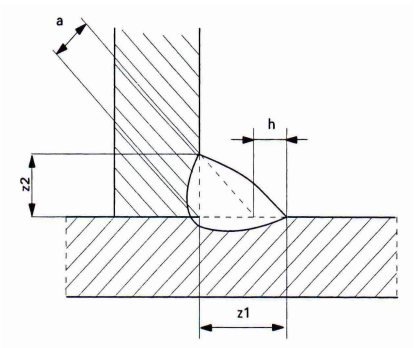
- Burn through



65

MIG – MAG welding: Imperfections

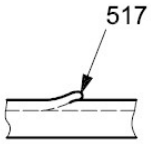
- Excessive asymmetry of fillet weld

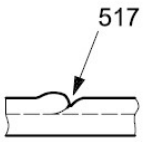


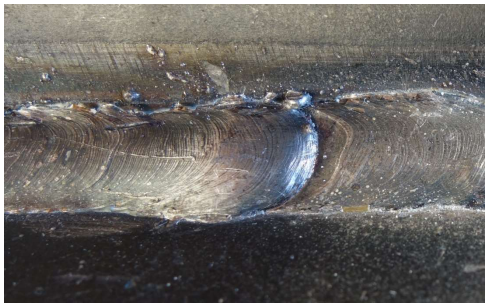
66

MIG – MAG welding: Imperfections

- Bad restart



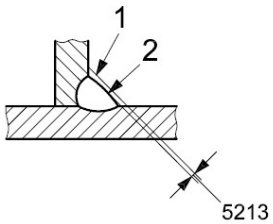




67

MIG – MAG welding: Imperfections

- Insufficient throat thickness



1 design throat thickness
gorge théorique
Sollnahtdicke
2 actual throat thickness
gorge réelle
tatsächliche Nahtdicke

68

MIG – MAG welding: Imperfections

- Spatter / (wire)

69

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70