Welding Inspector

Welding Imperfections And Materials Inspection Section 3

Welding Imperfections and Materials Inspection

- Definitions
- Cracks
- Cavities
- Solid inclusions
- Lack of fusion and penetration
- Imperfect shape and dimensions
- Miscellaneous imperfections
- Acceptance standards

Welding Imperfections 3.1

Definitions : (See BS EN ISO 6520-1)

- Imperfection: Any deviation from the ideal weld.
- Defect: An unacceptable Imperfection.

Welding Imperfections 3.1

Standards for Welding Imperfections

Classification of Imperfection according to BS EN ISO 6520-1:

This standard classified the geometric imperfection in case of fusion welding, dividing them into six groups:

1 Cracks

2 Cavities

3 Solid inclusions

4 Lack of fusion and penetration

5 Imperfect shape and dimensions

6 Miscellaneous imperfections

Welding Imperfections 3.1

Standards for Welding Imperfections

EN ISO 5817 *(2003)* Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections

This main imperfections given in EN ISO 6520-1 are listed in EN ISO 5817 with acceptance criteria at 3 levels, namely

Level B (highest)

Level C (intermediate)

Level D (general)

This Standard is 'directly applicable to visual testing of welds'
...*(weld surfaces & macro examination)*

Welding imperfections 3.1 classification

Cracks

Cracks 3.1

Definition: An imperfection produced by a local rupture in the solid state, which may arise from the effect of cooling or stresses. Cracks are more significant than other types of imperfection, as their geometry produce a very large stress concentration at the crack tip, making them more likely to cause fracture.

Classified by Shape / Direction

- Longitudinal
- Transverse
- Radiating
- Crater
- Branching

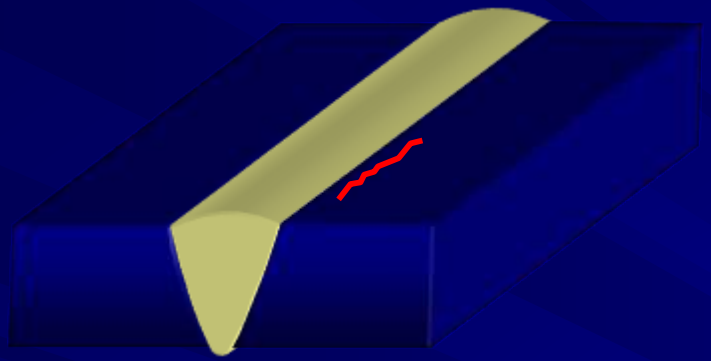
Classified by crack Location

- Weld metal
- HAZ
- Parent metal

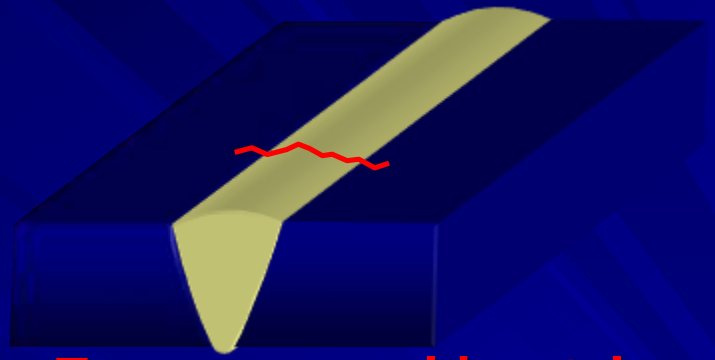
Exception: Crater cracks are found only in weld metal.

Note: Cracks are classed as Planar Defects.

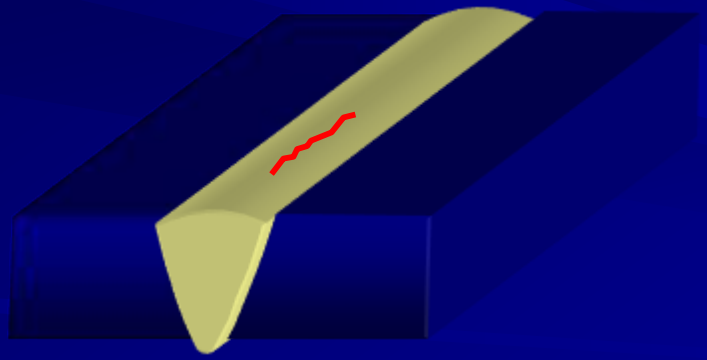
Cracks 3.1



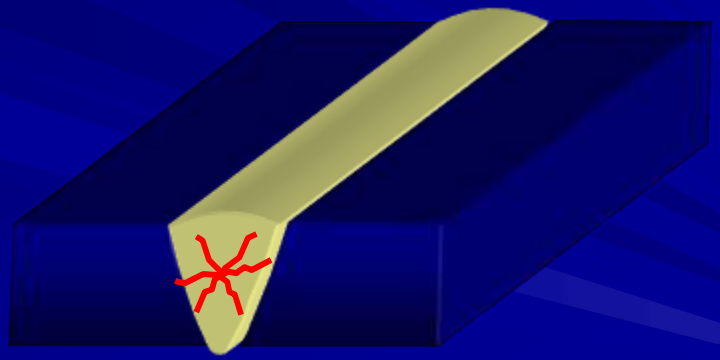
Longitudinal parent metal



Transverse weld metal

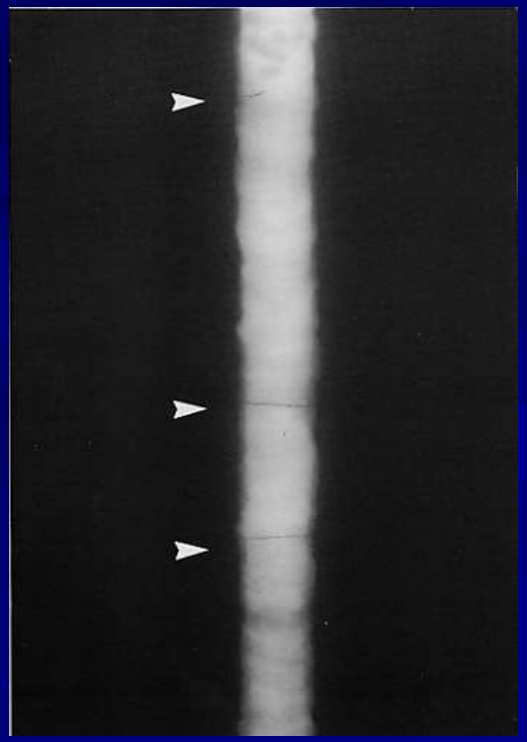


Longitudinal weld metal

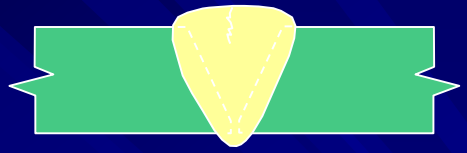


Crater crack weld metal

Cracks 3.1



Transverse crack



Longitudinal crack

Cracks 3.2

Main Crack Types

- Hot (ie solidification liquation Cracks)
- Precipitation induced (ie reheat cracks).
- Cold (ie hydrogen induced cracks).
- Lamellar tearing.

Cracks 3.2

Solidification Cracking

- Occurs during weld solidification process
- Steels with high sulphur impurities content (low ductility at elevated temperature)
- Requires high tensile stress
- Occur longitudinally down centre of weld

Cracks 3.3

Hydrogen Induced Cold Cracking

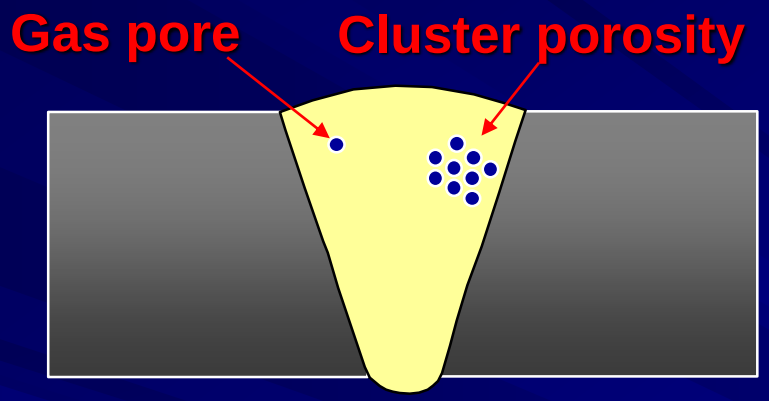
- Requires susceptible hard grain structure, stress, low temperature and hydrogen
- Hydrogen enters weld via welding arc mainly as result of contaminated electrode or preparation
- Hydrogen diffuses out into parent metal on cooling
- Cracking developing most likely in HAZ

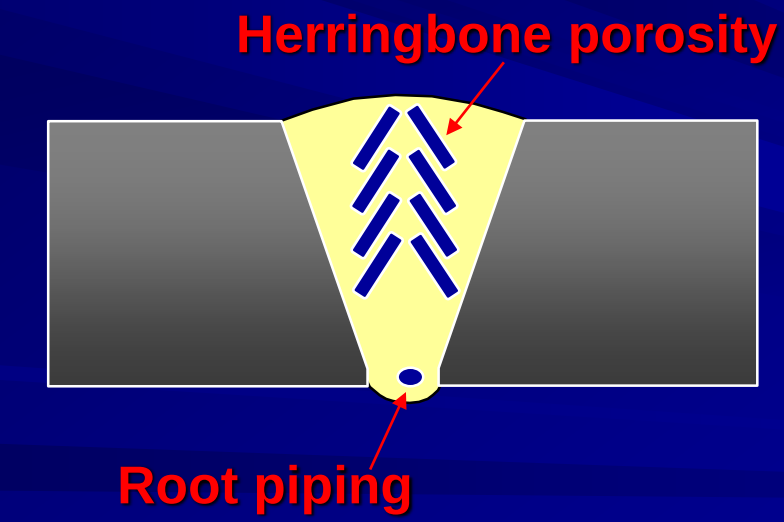
Lamellar Tearing 3.5

- Location: Parent metal
- Steel Type: Any steel type possible
- Susceptible Microstructure: Poor through thickness ductility

- Lamellar tearing has a step like appearance due to the solid inclusions in the parent material (e.g. sulphides and silicates) linking up under the influence of welding stresses
- Low ductile materials in the short transverse direction containing high levels of impurities are very susceptible to lamellar tearing
- It forms when the welding stresses act in the short transverse direction of the material (through thickness direction)

Gas Cavities 3.6



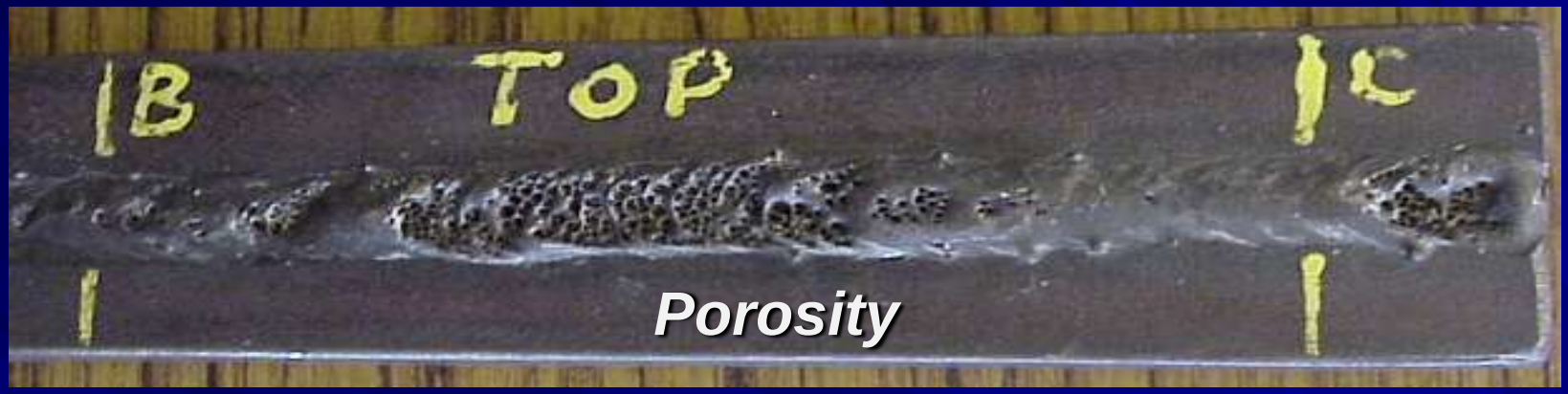


Causes:

- Loss of gas shield
- Damp electrodes
- Contamination
- Arc length too large
- Damaged electrode flux
- Moisture on parent material
- Welding current too low

Gas pore <1.5mm

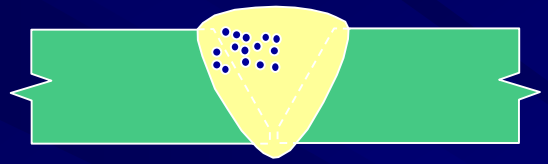
Gas Cavities 3.7

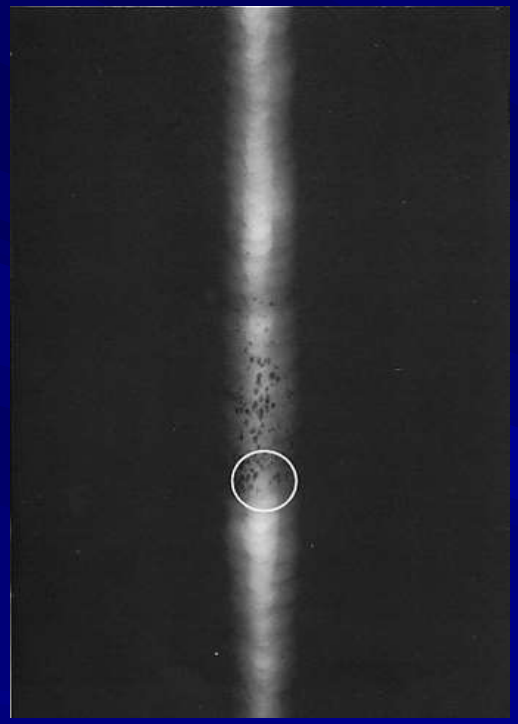


Porosity

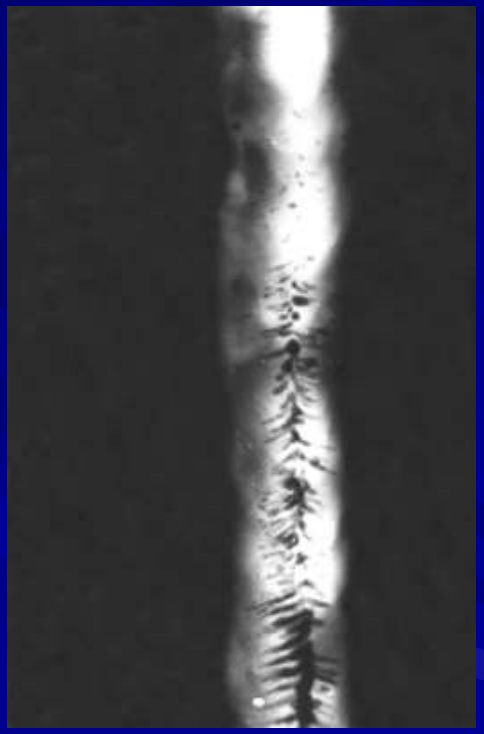
Root piping

Gas Cavities 3.8



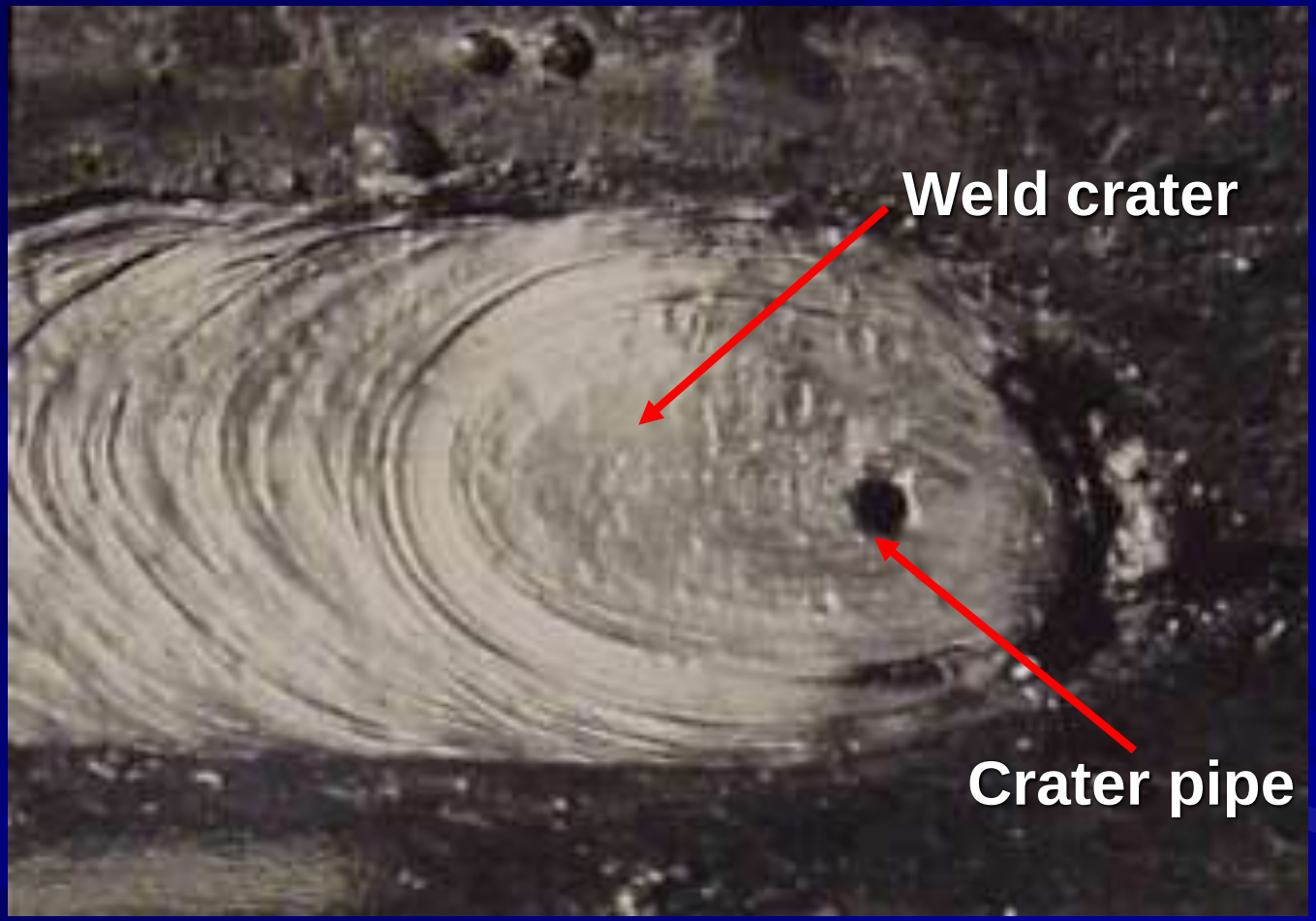


Cluster porosity



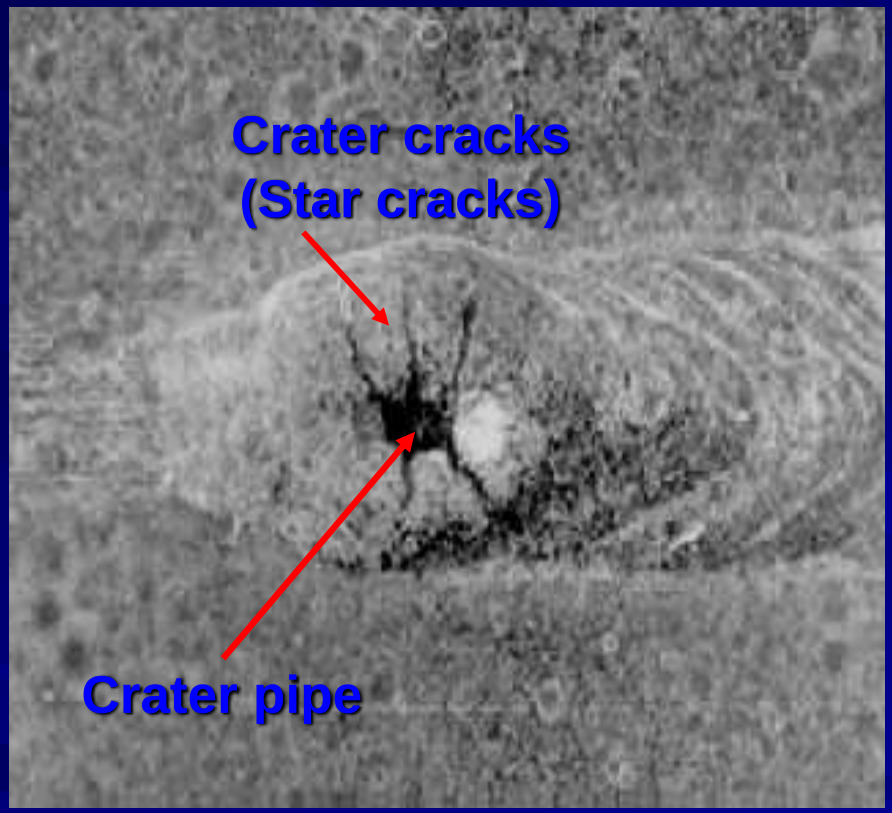
Herringbone porosity

Crater Pipe 3.9



Crater Pipe 3.9

Crater pipe is a shrinkage defect and not a gas defect, it has the appearance of a gas pore in the weld crater

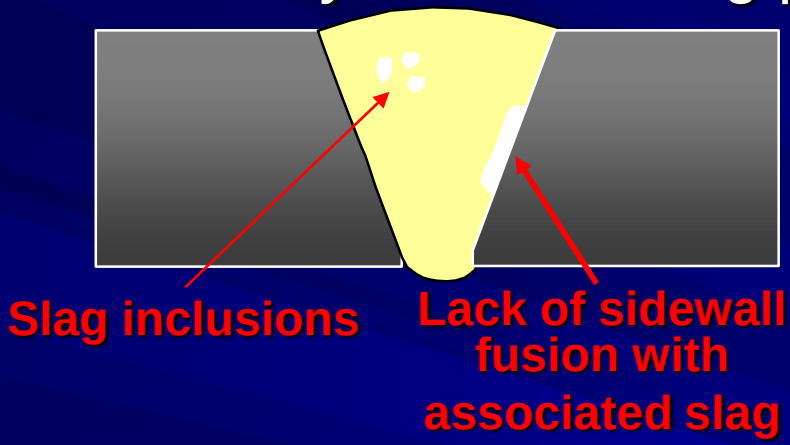


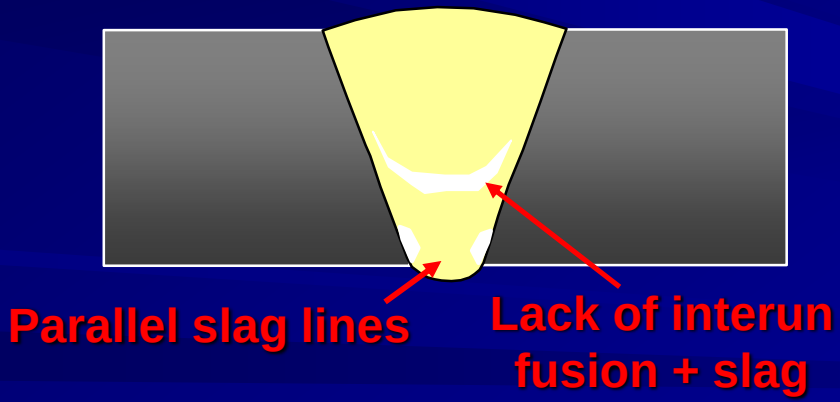
Causes:

- Too fast a cooling rate
- Deoxidization reactions and liquid to solid volume change
- Contamination

Solid Inclusions 3.10

Slag inclusions are defined as a non-metallic inclusion caused by some welding process

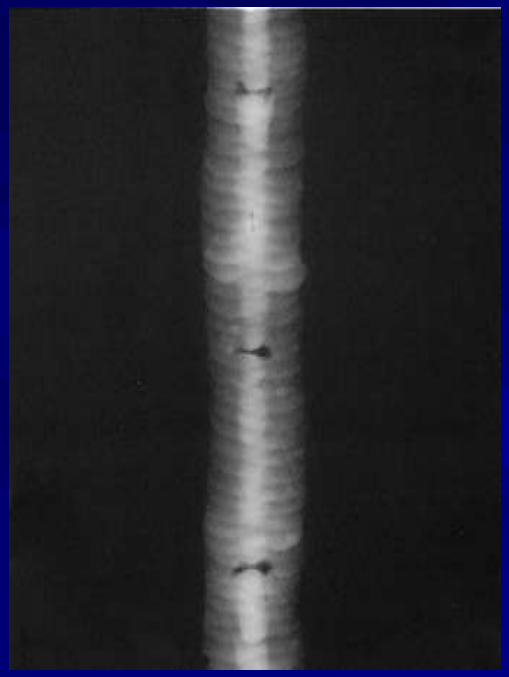




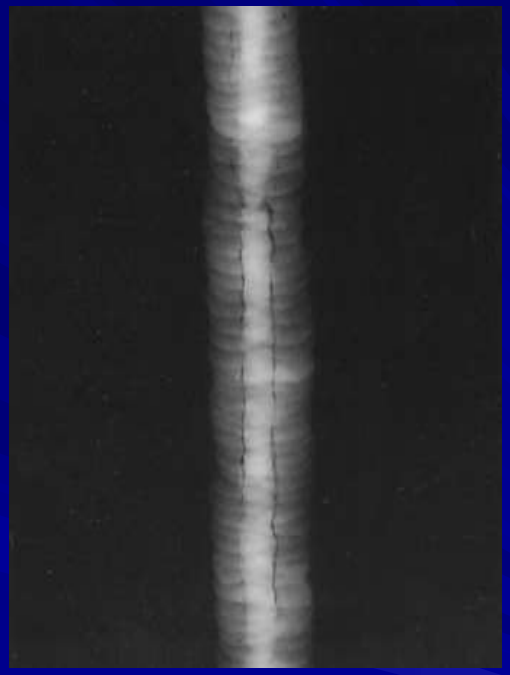
Causes:

- **Slag originates from welding flux**
- **MAG and TIG welding process produce silica inclusions**
- **Slag is trapped by inadequate cleaning**
- **Other inclusions include tungsten and copper inclusions from the TIG and MAG welding process**

Solid Inclusions 3.11



Interpass slag inclusions



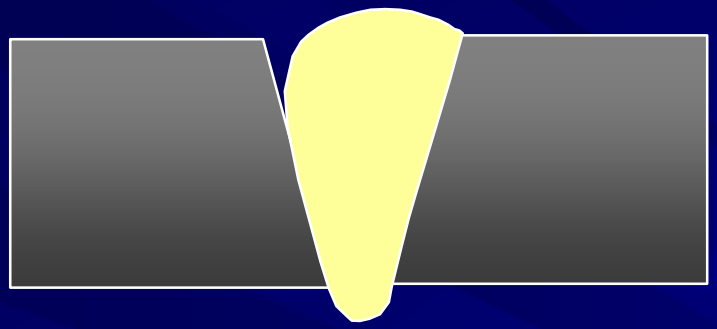
Elongated slag lines

Welding Imperfections 3.13

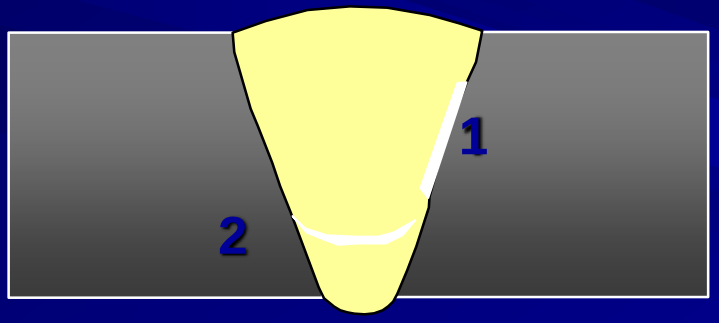
Typical Causes of Lack of Fusion:

- **welding current too low**
- **bevel angle too steep**
- **root face too large (single-sided weld)**
- **root gap too small (single-sided weld)**
- **incorrect electrode angle**
- **linear misalignment**
- **welding speed too high**
- **welding process related – particularly dip-transfer GMAW**
- **flooding the joint with too much weld metal (blocking Out)**

Lack of Fusion 3.13



Incomplete filled groove +
Lack of sidewall fusion

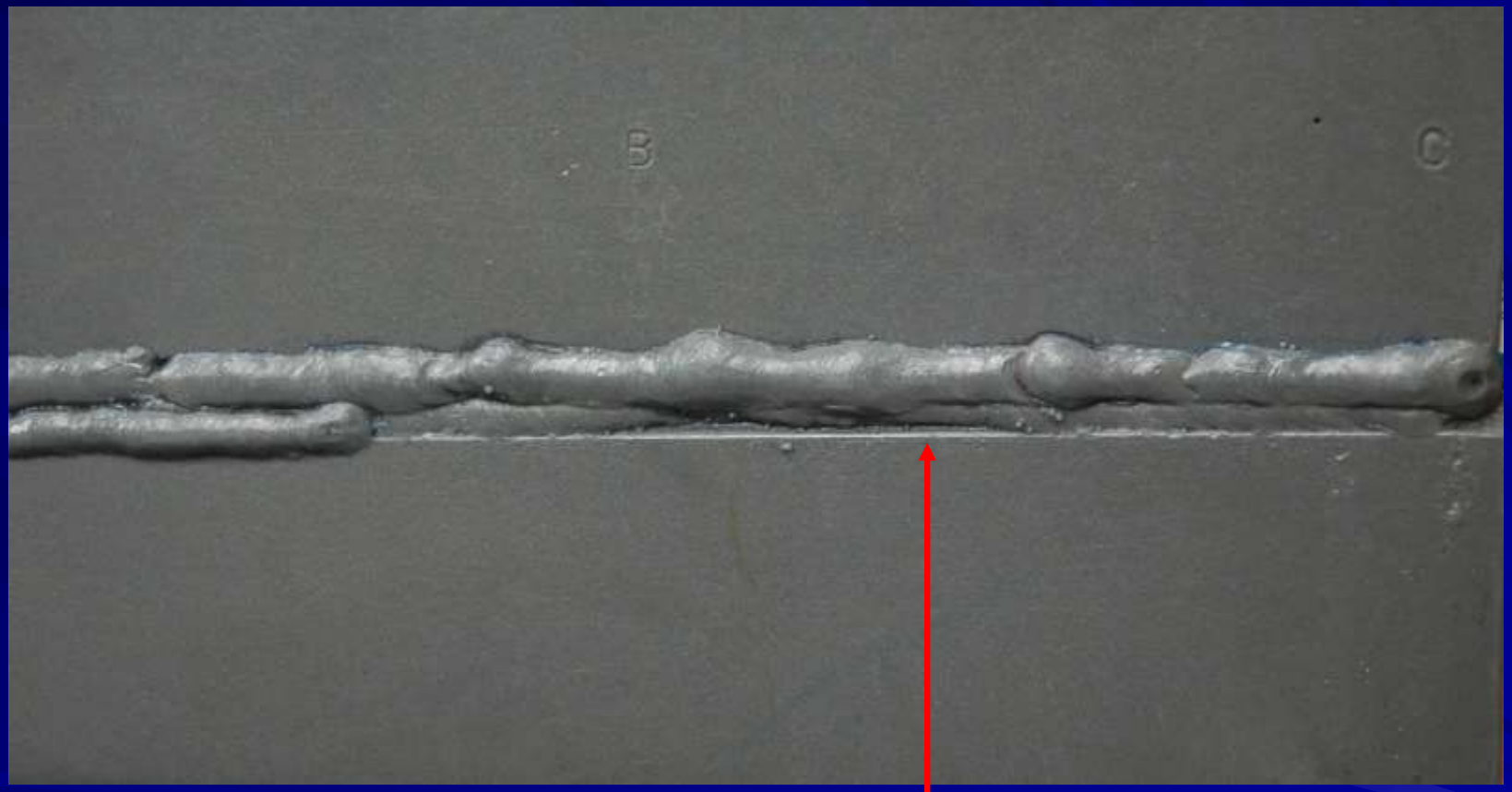


1. Lack of sidewall fusion
2. Lack of inter-run fusion

Causes:

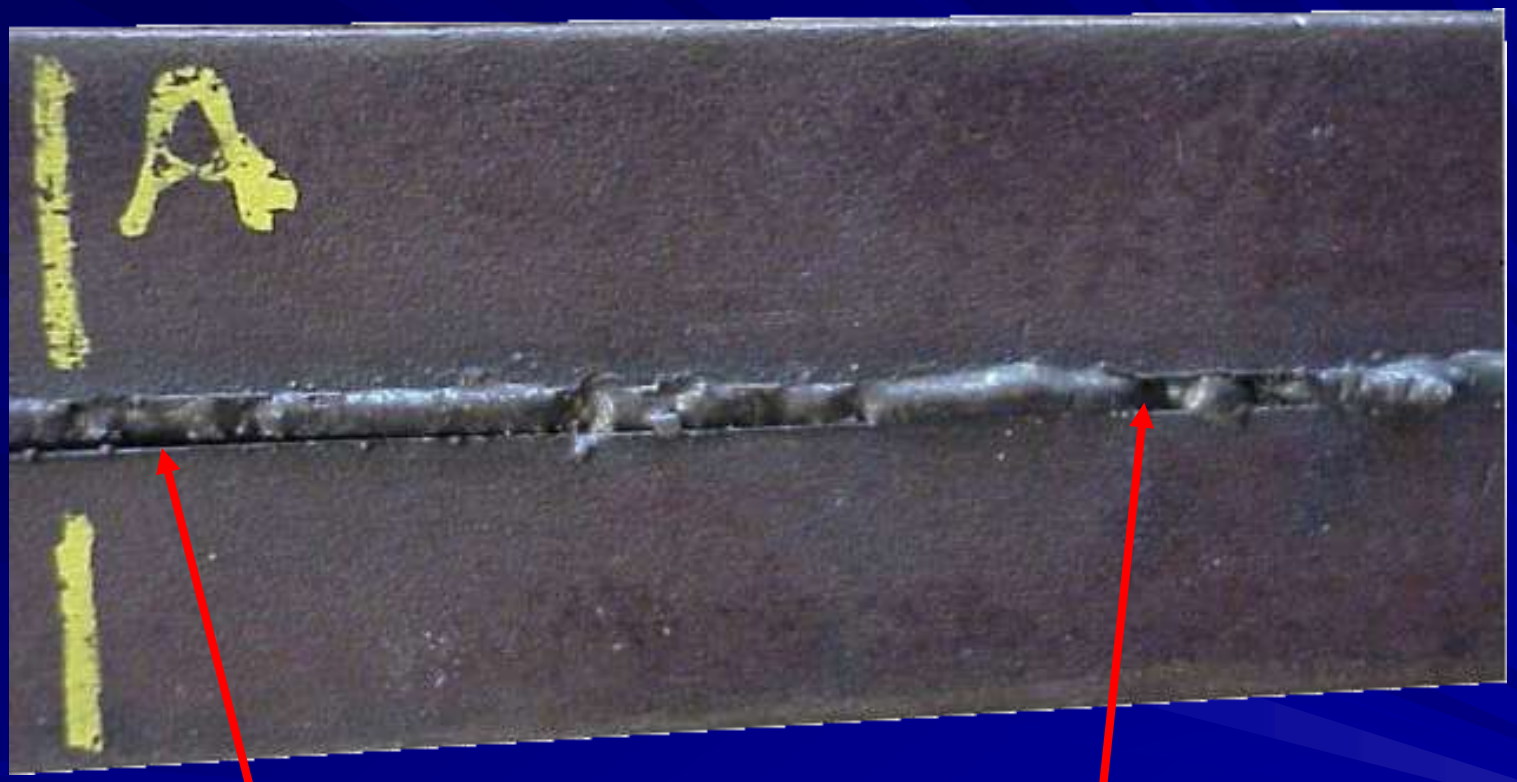
- Poor welder skill
- Incorrect electrode manipulation
- Arc blow
- Incorrect welding current/voltage
- Incorrect travel speed
- Incorrect inter-run cleaning

Lack of Fusion 3.13



Lack of sidewall fusion + incomplete filled groove

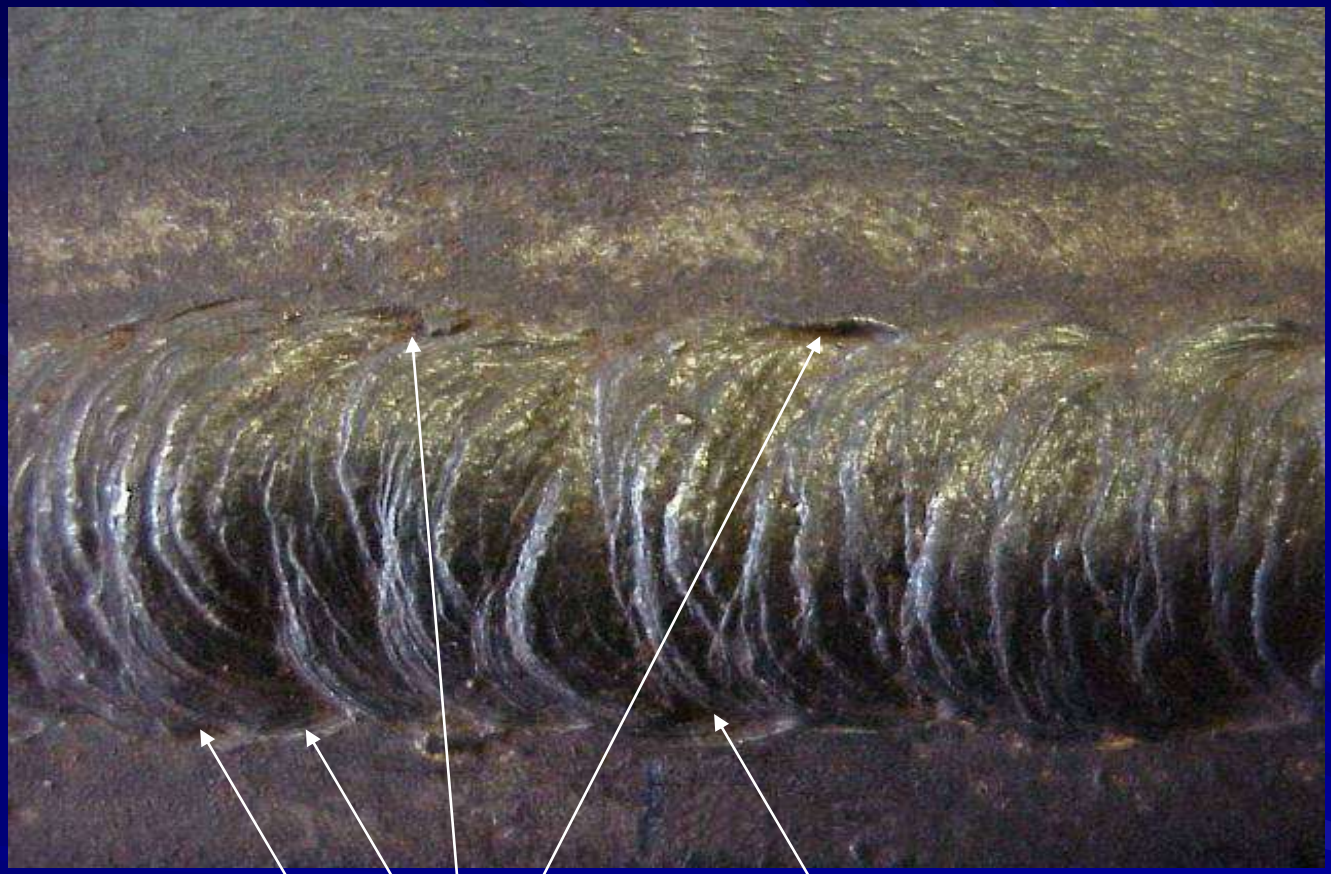
Weld Root Imperfections 3.15



Lack of Root Fusion

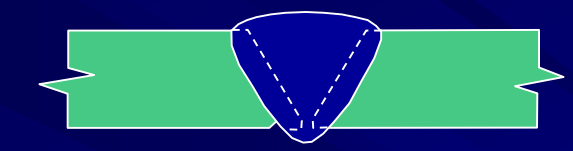
Lack of Root Penetration

Cap Undercut 3.18

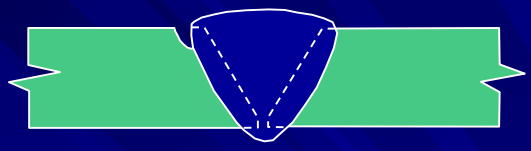


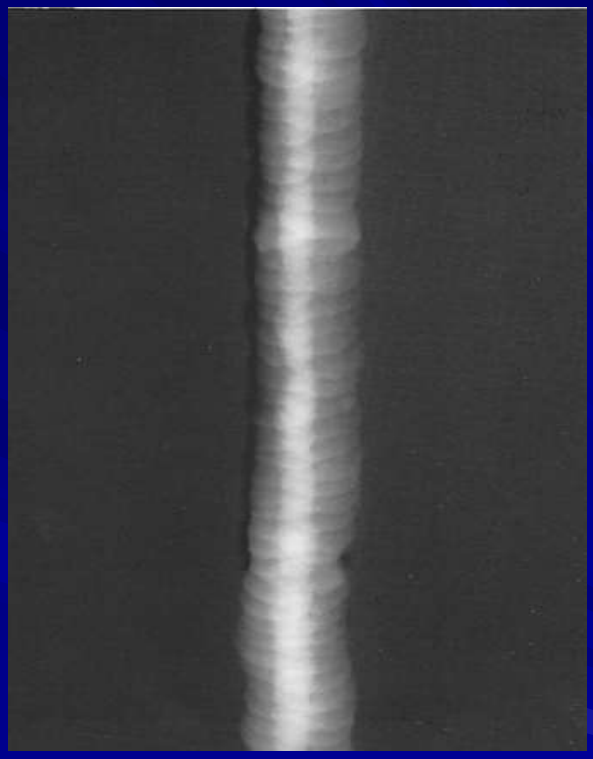
Intermittent Cap Undercut

Undercut 3.18



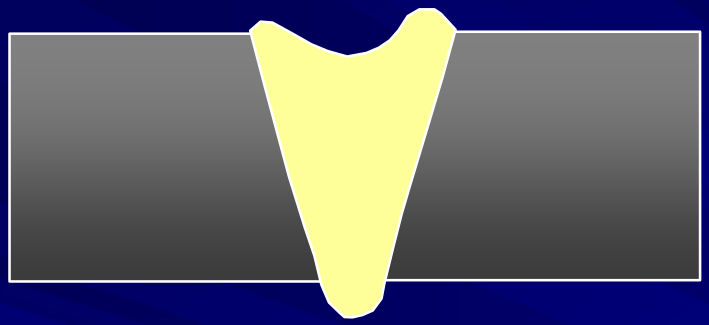
Root undercut



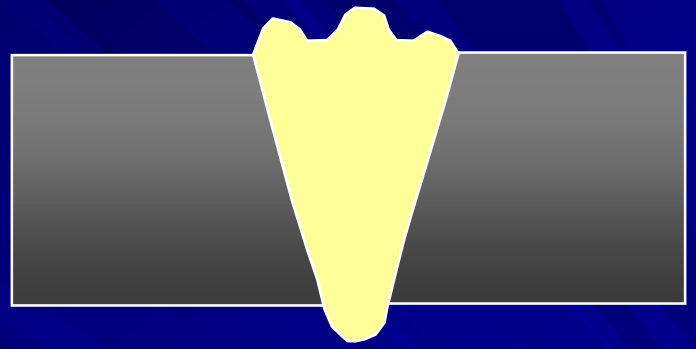


Cap undercut

Surface and Profile 3.19

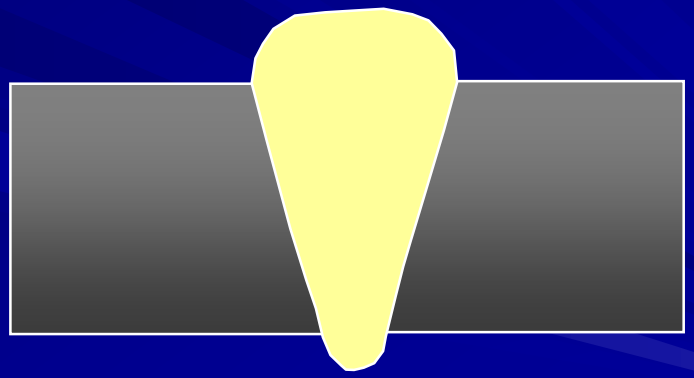


Incomplete filled groove



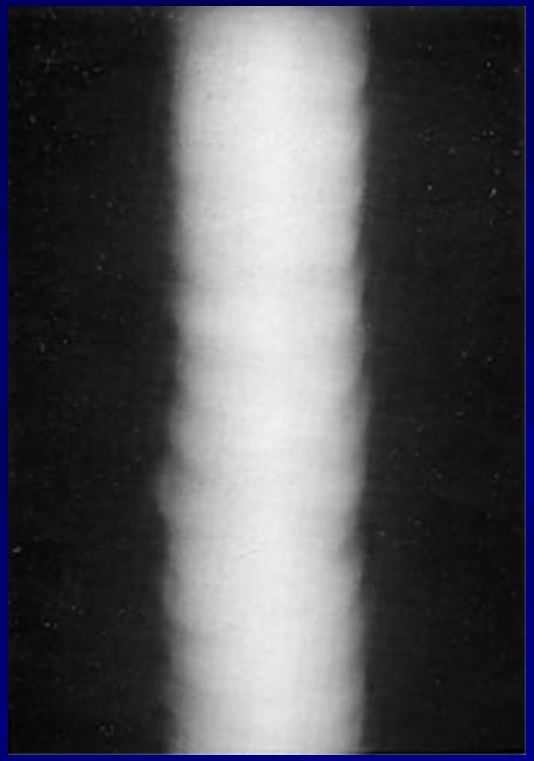
Poor cap profile

Poor cap profiles and excessive cap reinforcements may lead to stress concentration points at the weld toes and will also contribute to overall poor toe blend



Excessive cap height

Surface and Profile 3.19



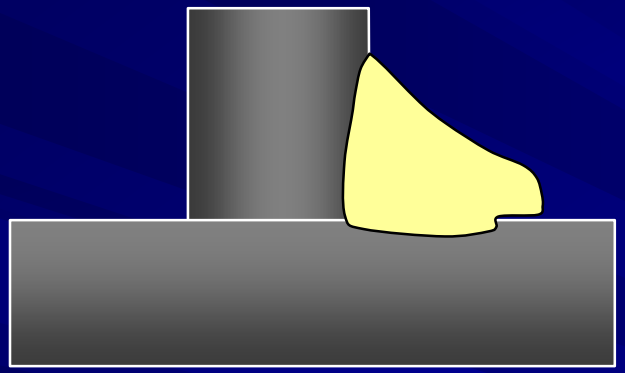
Excess cap reinforcement

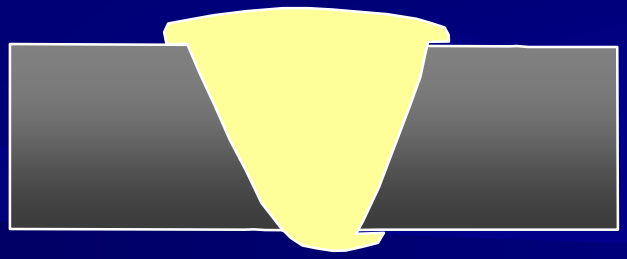
Incomplete filled groove

Weld Root Imperfections 3.20

Overlap 3.21

An imperfection at the toe or root of a weld caused by metal flowing on to the surface of the parent metal without fusing to it

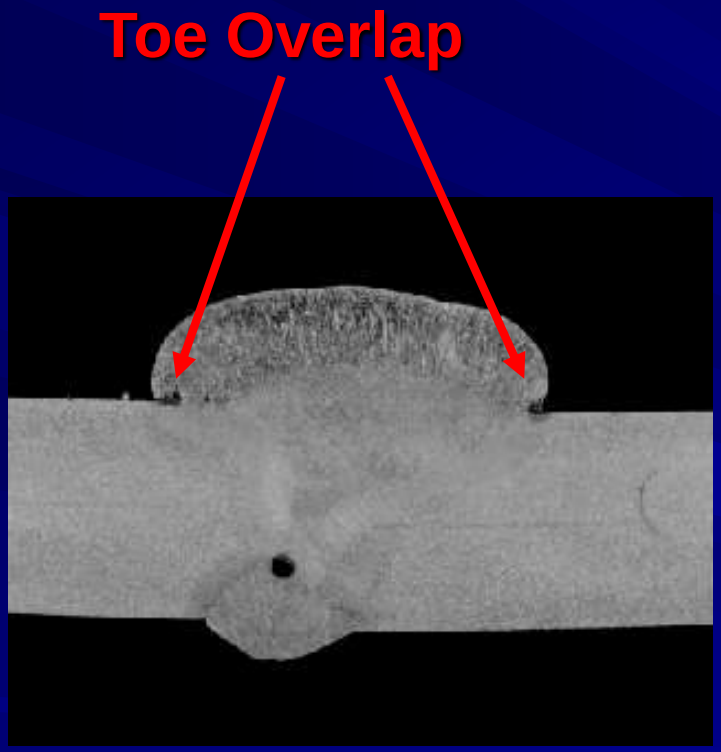




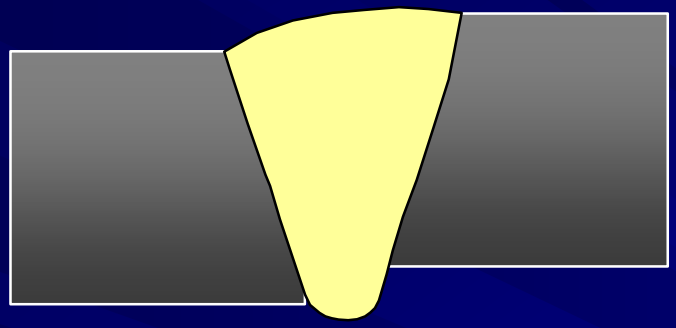
Causes:

- **Contamination**
- **Slow travel speed**
- **Incorrect welding technique**
- **Current too low**

Overlap 3.21

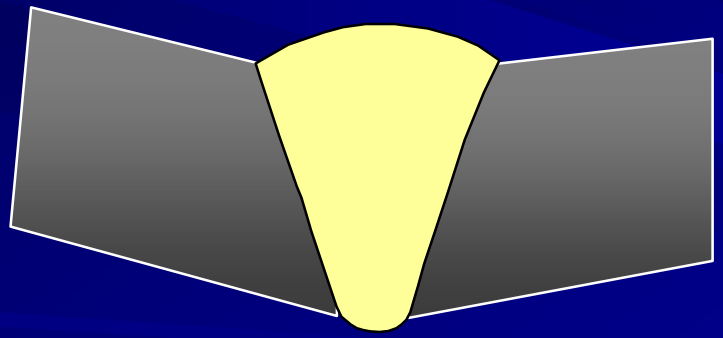


Set-Up Irregularities 3.22



Plate/pipe Linear Misalignment (Hi-Lo)

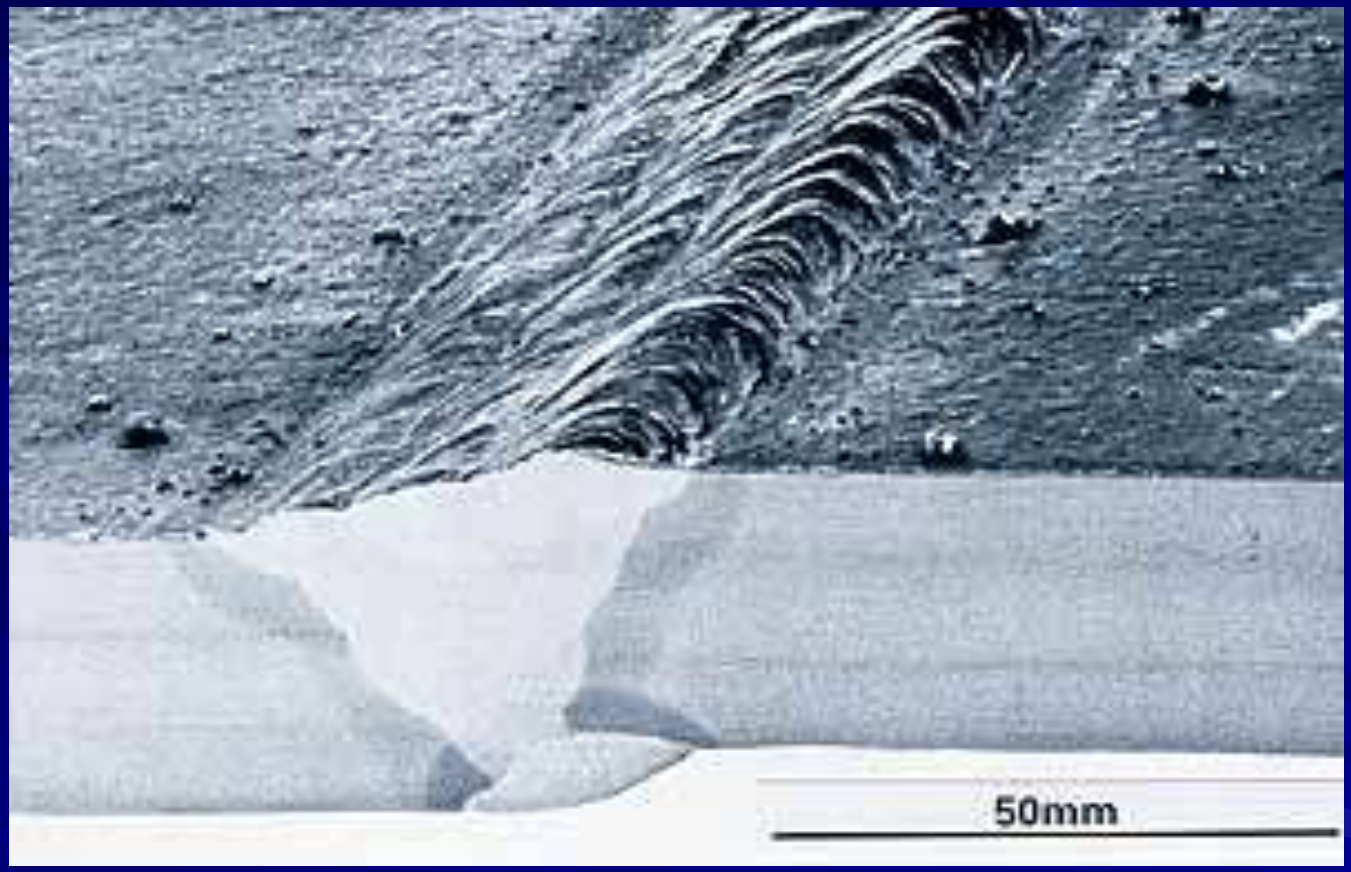
Linear misalignment is measured from the lowest plate to the highest point.



Angular Misalignment

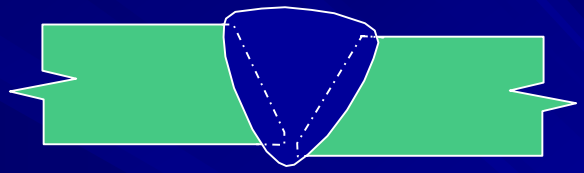
Angular misalignment is measured in degrees

Set-Up Irregularities 3.22



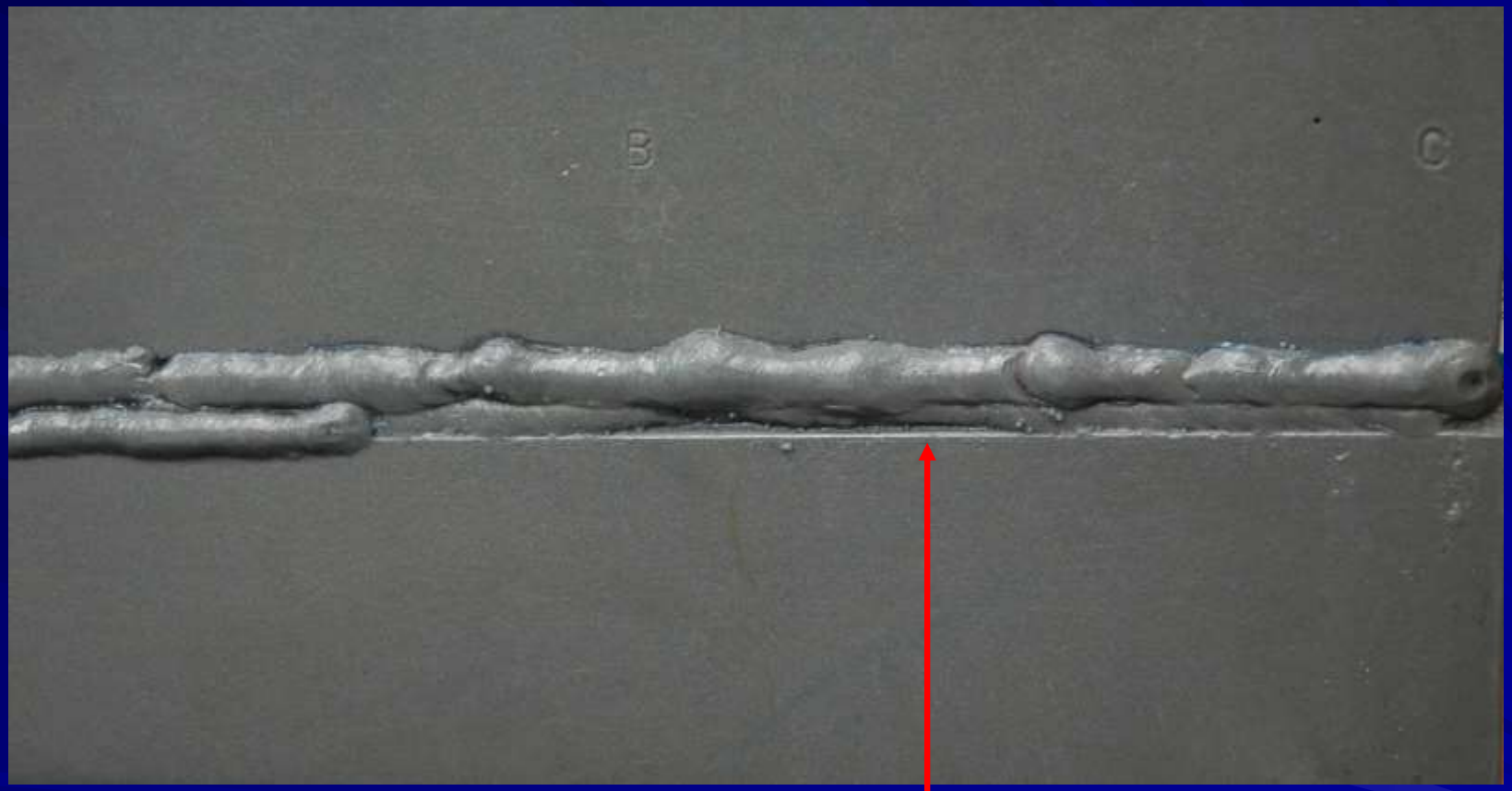
Linear Misalignment

Set-Up Irregularities 3.22



Linear Misalignment

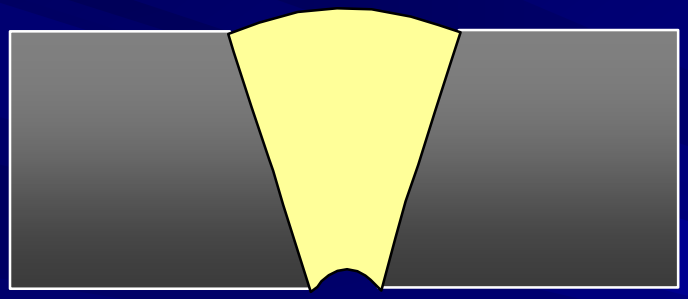
Incomplete Groove 3.23



Lack of sidewall fusion + incomplete filled groove

Weld Root Imperfections 3.24

A shallow concave groove like shape, which may occur in the root of a butt weld

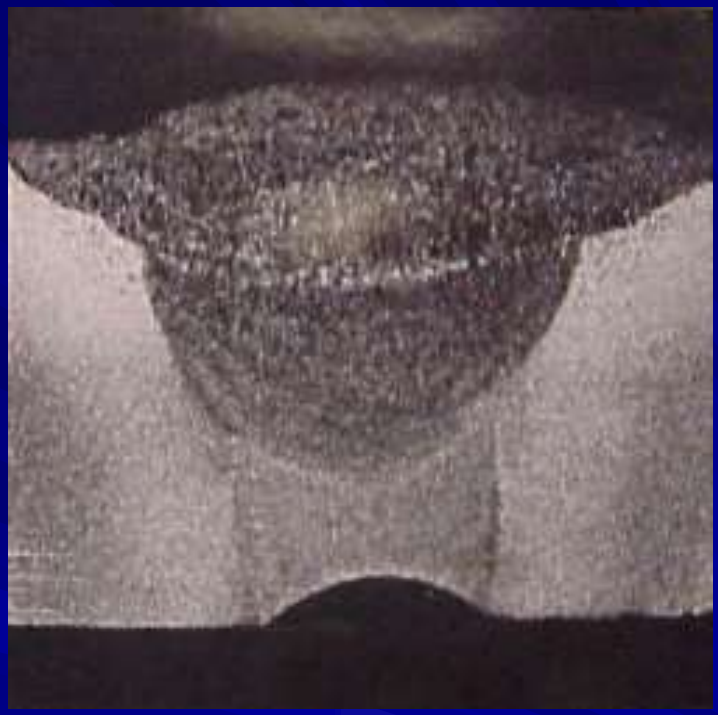


Concave Root

Causes:

- Excessive back purge pressure during TIG welding
- Excessive root bead grinding before the application of the second pass
- welding current too high for 2nd pass overheated welding
- root gap too large - excessive ‘weaving’

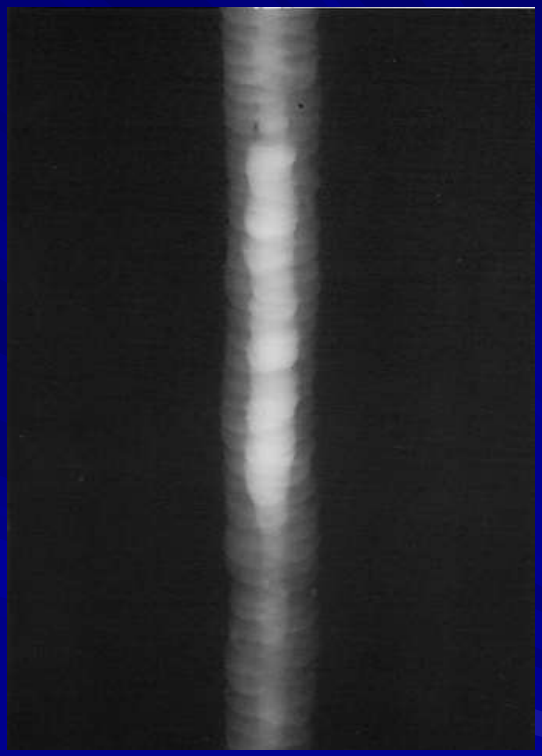
Weld Root Imperfections 3.24



Concave Root

Weld Root Imperfections 3.24

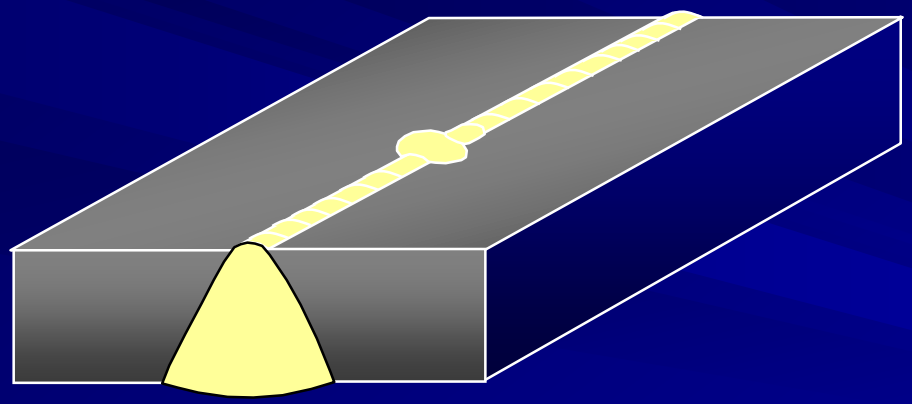
Concave root



Excess root penetration

Weld Root Imperfections 3.25

A localized collapse of the weld pool due to excessive penetration resulting in a hole in the root run

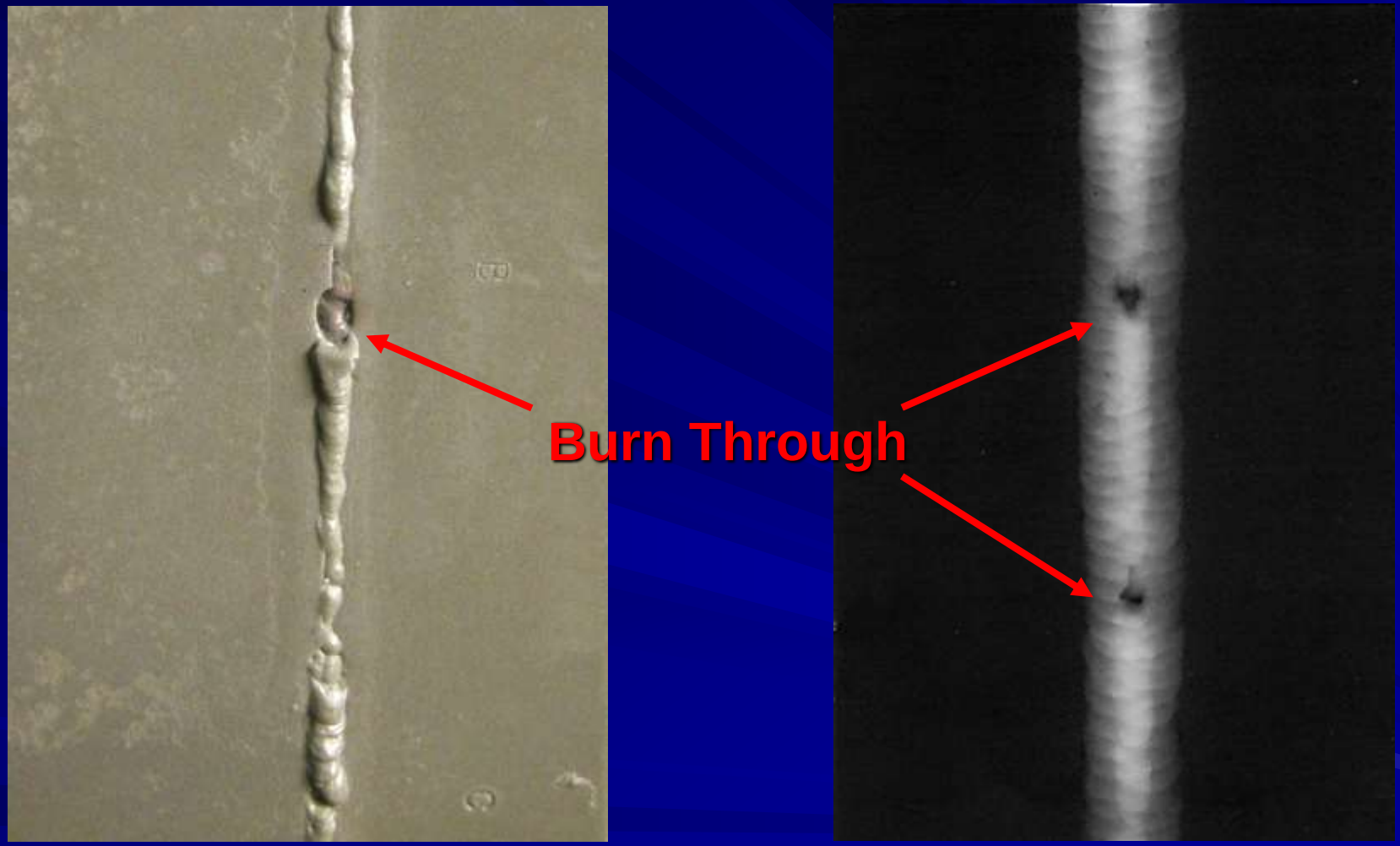


Burn through

Causes:

- High Amps/volts
- Small Root face
- Large Root Gap
- Slow Travel Speed

Weld Root Imperfections 3.25



Oxidized Root (Root Coking)

Causes:

- Loss or insufficient back purging gas (TIG)
- Most commonly occurs when welding stainless steels
- Purging gases include argon, helium and occasionally nitrogen

Miscellaneous Imperfections 3.26

Stray Arc (Arc strike)

Causes:

- Poor access to the work
- Missing insulation on electrode holder or torch
- Poor return lead clamping
- Adjusting wire feed (MAG welding) without isolating welding current

Miscellaneous Imperfections 3.27

Spatter

Causes:

- Excessive current
- Damp electrodes
- Contamination
- Incorrect wire feed speed when welding with the MAG welding process
- Long arc length
- Wrong selection of shielding gas (100% CO_2)

Mechanical Damage 3.28

Mechanical damage can be defined as any surface material

damage cause during the manufacturing process.

- **Grinding**
- **Hammering**
- **Chiselling**
- **Chipping**
- **Breaking off welded attachments**

  (torn surfaces)
- **Using needle guns to compress**

  weld capping runs

Mechanical Damage 3.28