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Section 1: Steel plate and pipe manufacture

Introduction

In normal circumstances it would be expected that significant plate or pipe defects would be detected and eliminated in the pipe mill or during the pre-commissioning hydrostatic pressure test.

Provided a pipeline operates below the maximum allowable operating pressure (MAOP) no further failures from plate or pipe defects should be expected. However such defects can provide the initiation point for in-service defect growth by degradation mechanisms such as corrosion or fatigue.

The following pages show examples of both plate and pipe defects, organized into the following sections:

- Plate defects
- Seamless pipe defects
- ERW pipe defects
- DSAW pipe defects

Steelmaking developments

Approximate dates for the introduction to general use of new steelmaking techniques are shown in Table 1.

Pipemaking developments

Approximate dates for the introduction to general use of new pipemaking techniques are shown in Table 2.

Year	Steel type	Properties
Pre – 1890s	Wrought iron (pure iron with stringers of silicate/oxide).	Usually riveted/bolted; mechanical properties depend on direction of testing, welding needs care (avoid fillet welds).
1890s – 1970s	Semi-killed steel (deoxidizing additions of manganese but low silicon levels), ingot cast then hot rolled or normalized.	Toughness can be low, intermediate strength (up to X52), satisfactory weldability.
1970s – present	Fully-killed steel (deoxidizing additions of manganese and silicon), continuously cast then normalized.	Good toughness, high strength (up to X65), weldability can be poor due to high carbon equivalent.
mid 1970s –present	Fully-killed, aluminium-treated, low-sulphur steel (deoxidizing additions of manganese and silicon, microalloying additions of niobium and/or vanadium), continuously cast then controlled rolled.	Good toughness, high strength (up to X65), good weldability; good sour performance when calcium treated.
1980s – present	Fully-killed aluminium-treated low-sulphur steel (deoxidizing additions of manganese and silicon, microalloying additions of niobium and/or vanadium), continuously cast then controlled rolled and accelerated cooled.	Good toughness, high strength (X70 plus), good weldability; good sour performance when calcium treated.
1990s – present	Fully-killed aluminium-treated low-sulphur steel (deoxidizing additions of manganese and silicon, alloying additions of chromium, copper, nickel, or molybdenum, with microalloying additions of niobium and titanium), continuously cast then controlled rolled and accelerated cooled.	Good toughness, very high strength (X100 plus with high Mn content), satisfactory weldability; sour performance questionable.

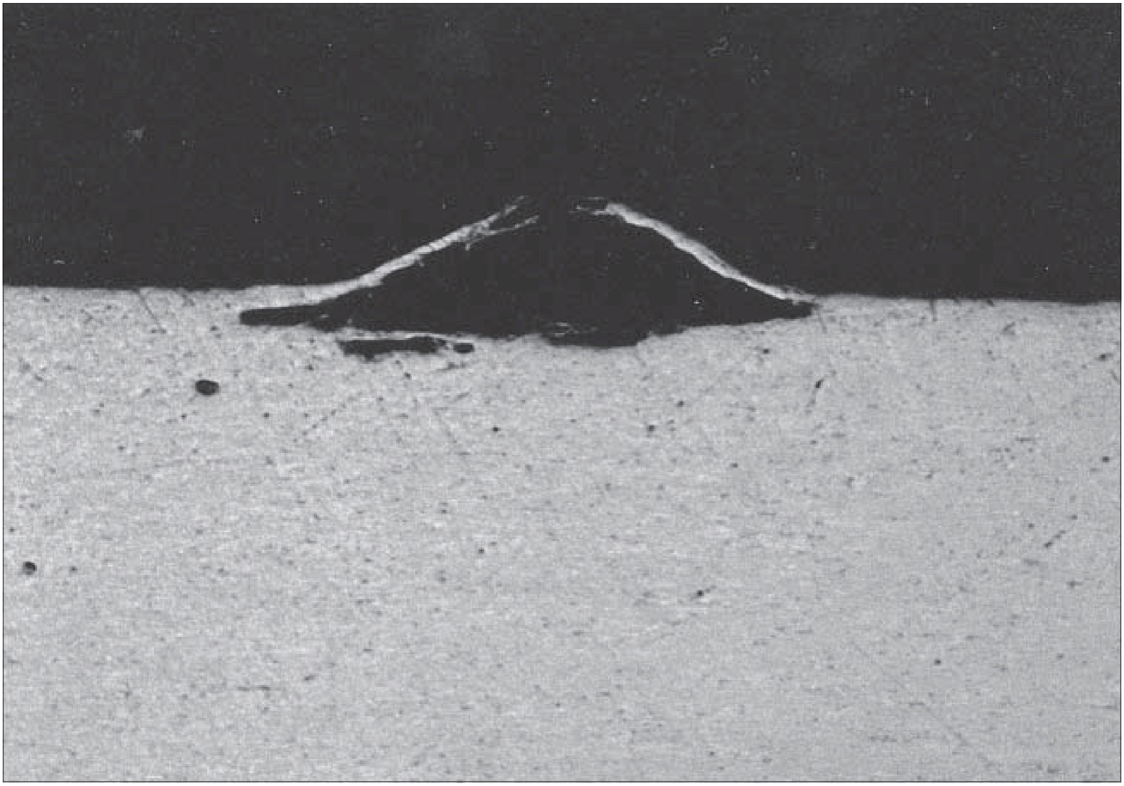
Table 1. Steelmaking developments.

Year	Technique	Properties
1800s – 1960s	Lap-welded pipe	Poor seam-weld quality and toughness.
1900s – present	Seamless pipe	Gradual improvements in pipe quality due to materials, forging technology, and inspection.
1930s – 1960s (up to 1978 in some mills)	ERW (electric-resistance welding): low-frequency welding current	Prone to lack of fusion and poor seam-weld toughness.
1960s – present (from 1978 in some mills)	ERW: high-frequency welding current	Reduced tendency for lack of fusion.
1980s – present	ERW: improved seam-weld inspection and heat treatment	Improved toughness, fewer defects.
1990 – present	HFI (high-frequency induction) welding: induction heating introduced	Reduced tendency for lack of fusion, especially for heavy-wall pipe.
1900s – present	SAW (submerged-arc welding) longitudinal welded pipe	Gradual improvements in pipe quality due to materials, welding technology, and inspection.
1900s – present	SAW helical-welded pipe	Gradual improvements in pipe quality due to materials, welding technology, and inspection. Increased use for high-pressure applications in last 30 years.

Table 2. Pipe manufacture developments.

Plate

Blisters



Description

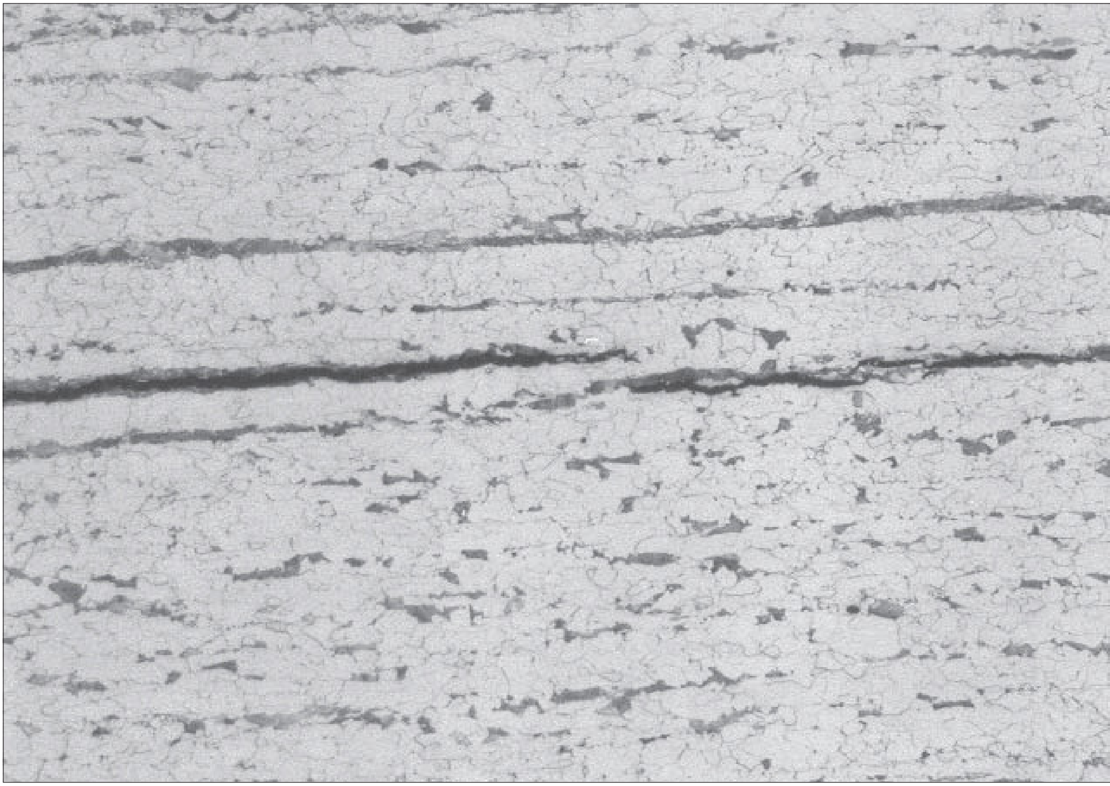
A blister is a void, close to the pipe surface, enclosed by a thin filament of steel caused by entrapment of gas released during the solidification of the steel.

Significance

A blister is not structurally significant but may be an initiation site for pitting corrosion if the void is contaminated, for example by salt from a marine atmosphere.

Blisters may cause holidays in thin-film coatings unless they are removed by grinding before the final grit blast.

Centreline segregations



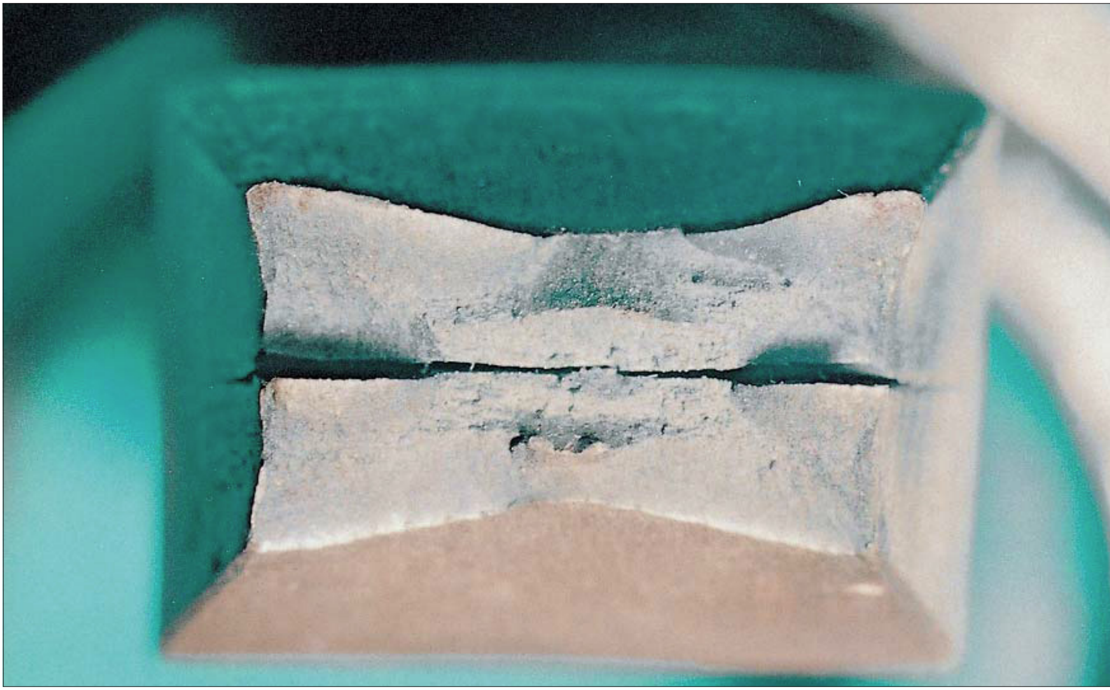
Description

During solidification of an ingot or continuously cast slab, non-metallic inclusions such as carbides, sulphides, and silicates may become concentrated at the centre of the ingot in the last liquid to solidify. When the ingot or continuously cast slab is rolled into plate, these appear as segregated bands at the mid-wall position.

Significance

Centreline segregations are generally not structurally significant for pressure retention but they may provide an initiation point for cracking in sour service, and may contribute to weld defects. Modern steels are much cleaner than older steels, and consequently the degree of centreline segregation is less.

Centreline splits



Description

Aligned inclusions or segregations create a line of weakness in the steel plate, typically along the centreline, which leads to cracking in test pieces, such as this tensile test specimen.

Significance

These features are a symptom of the test and, since any cracking in the segregated band runs parallel to the pipe wall and hence parallel with the principal hoop stress in the pipe, they are not usually structurally significant.