

## ***Investigation report.***

Investigation into the cause of leaks in Stainless steel Pipes  
in a large Beer brewery.

Client: Large Beer brewery.



Author: J. van Duijn (Cobra Consultancy)

Report number: 1- 6046

Data: 5-9 June 2026

Page number: 1

Pages: 8.

## Introduction:

A pipeline of a Large Beer Brewery during the reconstruction was found to be leaking after approximately six months of service. In connection with this, a section was removed from the pipeline and radiographic examinations were performed on a weld. These revealed that the weld contained defects, namely gas porosity, lack of penetration, and a minor lack-of-fusion defect.

According to the information provided, the pipeline was made of Stainless steel of type AISI 316L / Werkstoffnr. 1.4404 and treated drink water flowed through it. After welding, the pipeline was pressure tested and flushed with untreated drink water, because the water treatment installation was not yet ready. After the pressure test (where the pipes are not blown dry), a few months later the installation was put into service.

A pipeline section approximately 6 cm wide, containing the weld and identified as Beer Brewery 1, was submitted to Cobra consultancy for investigation. Cobra Consultancy was requested to investigate the section containing the weld in order to determine the nature and cause of the leakage.

## Investigation performed

The pipeline section was examined visually and macroscopically, after which several transverse sections through the weld and through the leak were prepared. These cross sections were prepared for macro- and microscopic examination. The chemical composition of the pipe material and the weld metal (at the outer surface) was determined by optical emission spectrometry.

## Results and discussion

### Visual and macroscopic examination

The pipeline section had a width of 60 to 66 mm, with the circumferential weld located approximately in the middle. See (**fig. 1**). The weld joined two pipe sections, one with an outer diameter of 248 to 256 mm and a wall thickness of 2.0 mm, and the other with an outer diameter of 251 to 257 mm and a wall thickness of 2.5 mm. Parts of the weld were not fully penetrated, as had also been shown by the radiographic examination.

From the 0-point to approximately 8 cm, the 2.0 mm thick pipe section was inserted into the 2.5 mm thick pipe section. This was probably the result of transverse shrinkage during welding.

In the section, at approximately 63 mm (29°) from the indicated 0-point (mark from the radiographic examination), a longitudinal weld was present in the 2 mm thick pipe section. In the 2.5 mm thick section, a longitudinal weld was present at approximately 190 mm (87°) from the indicated 0-point.

The leak was marked and was located at 133° from the 0-point, on the fusion line on the side of the 2.0 mm thick pipe section. The leak followed the contour of the weld and had an approximately triangular top view with a maximum dimension of about 1 mm. See (**fig. 2**).

At the outer surface, the area of the leak had been scratched. As a result, possible corrosion products were not available for examination.



The inner surface of the section showed discoloration in zones on both sides of the weld. The 2.0 mm thick pipe section was dark brown discolored in the area from 290 to 620 mm from the 0-point. The width of this zone was up to 7 mm. see (fig.3). Elsewhere, the zones near to the weld showed slight yellow to blue discoloration up to a width of 12.5 mm, and part of the inner surface was bright.

The outer surface showed light to a dark heat tint.

Part of the section was pickled by Cobra Consultancy in a stagnant solution of 20 vol% concentrated nitric acid (69%) and 2 vol% concentrated hydrofluoric acid (40%) in demineralized water. The heat tint proved to be easily removable. See (fig.4)

### Examination of transverse weld sections

Four sections were taken from the weld and prepared for examination:

1. Through the leak: The leak appears to have originated at the inner side of the pipe. The surface is heavily undercut beneath the hole. The hole runs partly along the fusion line and partly into the weld. It was found to be filled with grey corrosion product. See (fig. 5)
2. At the location of a misalignment (hi-low). See (fig.6).
3. At the location of a misalignment (hi-low). See (fig.6).
4. From a good part (right) of the weld. See (fig.6).

The weld had a typical austenitic cast structure with interdendritic delta ferrite.

### The chemical composition

The chemical composition of the weld (outer surface) and the pipe materials was determined by optical emission spectrometry. Based on these results, both pipe sections and the weld are stainless steel type 316L.

Element %    Pipe thick 2 mm    Pipe thick 2,5 mm    Weld

C	0,03	0,03	0,03
Si	0,49	0,51	0,60
Mn	1,64	1,66	1,64
P	0,016	0,020	0,017
S	<0,0020	<0,0020	0,0029
Cr	16,94	16,98	17,66
Mo	2,57	2,56	2,51
Ni	10,74	10,75	11,41
Al	0,01	0,01	0,01
Co	0,14	0,12	0,10
Cu	0,44	0,41	0,27
Nb	0,03	0,04	0,04
Ti	0,01	0,01	0,01



## Findings

In summary, the following was established:

- The pipe material and weld are consistent with stainless steel type 316L.
- Attack occurred only at the fusion line.
- There appears to be no relationship between the weld imperfections found during The investigation and the occurrence of the leak or the corrosion damage.
- The leak started from the inner surface and shows a strongly undercut appearance.
- The pipe sections showed heat tint on both sides of the weld.
- These heat tint colors could be easily removed by pickling.

## Possible causes

The following causes appear possible for the observed attack:

1. Under-deposit corrosion.
2. Corrosion caused by precipitation of iron oxides and hydroxides.
3. Chloride attack associated with fouling.
4. Attack by sulphate-reducing bacteria (SRB).
5. Attack by Gallionella bacteria.

Under-deposit pitting corrosion may occur due to the presence of a deposit on the surface. Such a deposit generally forms in areas of low flow. Beneath a deposit, the surface is oxygen-depleted relative to the surroundings, resulting in oxygen concentration cells that cause pitting.

This type of attack is aggravated by the presence of iron hydroxides (rust) on the surface, which contribute to the breakdown of the protective oxide film on stainless steel. Chlorides also play a role in disrupting the protective oxide layer. Sulphate-reducing bacteria attack stainless steel directly and excrete iron sulfide.

Gallionella bacteria can survive up to 70 degrees Celsius. These bacteria occur mainly in iron-containing water and lead to pitting corrosion. They form colonies, especially in locations with (nearly) stagnant water. Iron and iron ions, as commonly present in untreated drink water, play an important role in the metabolism of these bacteria, causing local accelerated dissolution of iron. The result is pitting, generally with a somewhat undercut appearance, similar to the observed pit. MIC is known to occur preferentially at the fusion line of welds. The presence of an incomplete oxide film, such as heat tint, increases susceptibility to MIC.

At the inner surface near the leak, hardly any remaining corrosion products or deposits were found. These were probably removed by scratching. It is not known whether the section was additionally cleaned during removal.



## Conclusion

Based on the investigations, the main cause of the observed attack appears to be microbiologically induced corrosion (MIC), probably caused by Gallionella bacteria, possibly in combination with the effects mentioned under 1, 2, and 3. The pit probably initiated before the installation was put into service, as a result of flushing with untreated drink water. During service, the resulting undercut corrosion pit gradually grew.

To solve the corrosion problem, it is recommended to pickle and passivate the inner surface of the pipe near the welds. Existing corrosion pits will not be re-passivated by such treatment and must be removed by grinding before pickling and passivation.

**The pipe leaked as a result of microbiologically induced corrosion (MIC). The inside of the pipe was not pickled and passivated.**

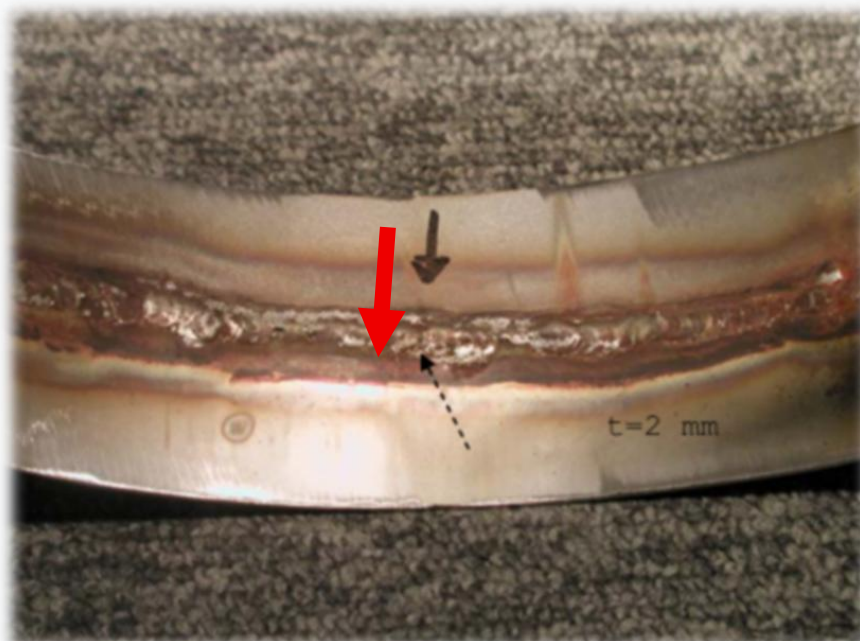


**Fig. 1.** Overview of the section with circular weld received for examination.



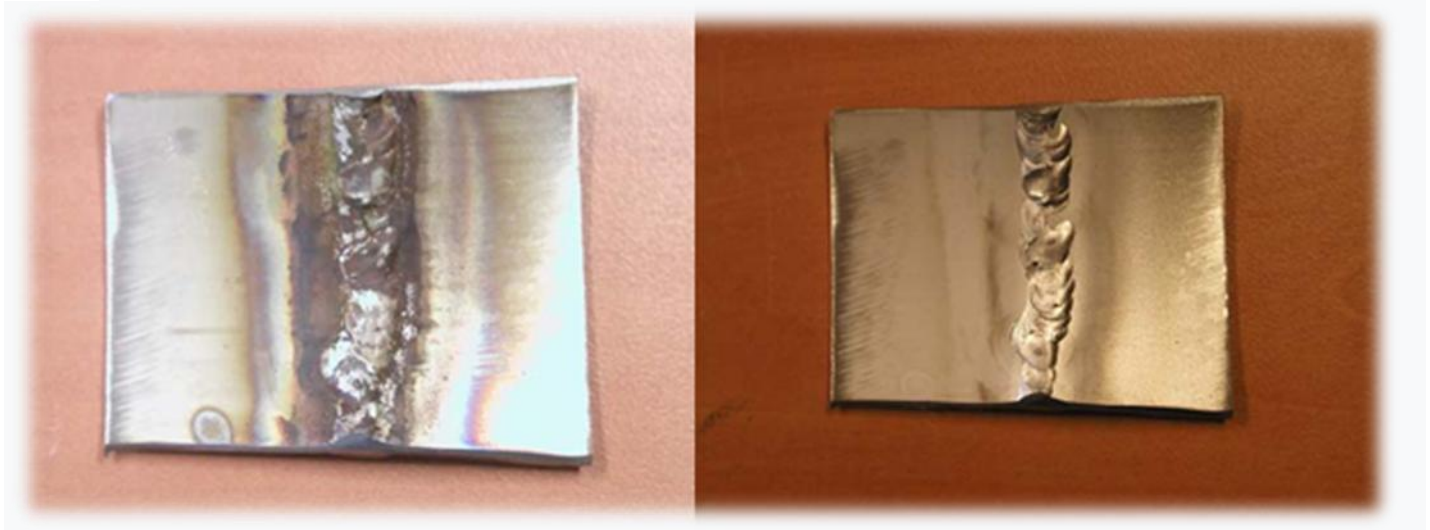


**Fig.2.** Inner surface of the section with the leak at the location of the melt line on the 2 mm side. The leak had a size of approx. 1 mm. Magnification: 25x.



**Fig. 3.** Black dotted line place leakage, red arrow discolored not passive weld.





**Fig. 4.** Left part of discolored before pickling. Right after pickling Cobra Consultancy.

The oxide layer is restored as a result, reducing the risk of corrosion deposits.

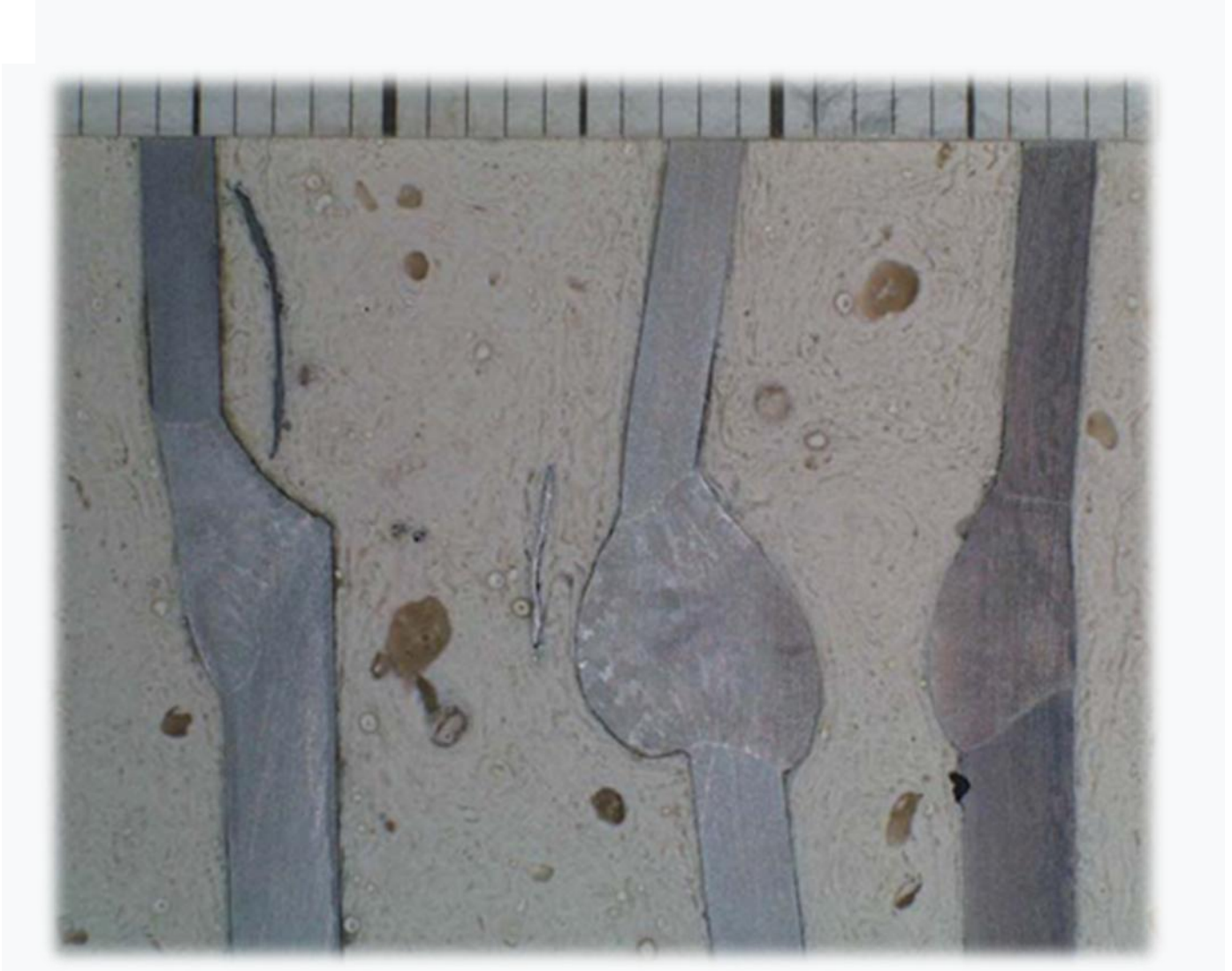


**Fig.5.** Cross-section next to the leak. The leak was undercut and filled with corrosion product.

Deformation had occurred on the outer surface (right) due to scratches made to locate the leak.

Magnification 50x.





**Fig. 6.** Prepared cross-sections at the point of alignment (left, center) and a good (right) part of the weld.

Etching agent: 10% oxalic acid.

## Final conclusion and recommendations

In previous reports I have paid a lot of attention to stagnant water in Stainless steel fire extinguishing pipes of hotels, heat exchangers (special during the covid time in swimming pools), wine estates (see report microbiology wine tanks in the Loire) and Beer breweries. The problem of stagnant water is underestimated, which can cause enormous damage due to production downtime in various companies as a result of the leaks! It is therefore recommended to blow the pipes dry during new construction after pressure testing and during a longer downtime period. It is also recommended to always form with forming gas during welding and to pickle and passivate er welding so that the oxide layer of the stainless steel recovers. This reduces the chance of MIC or Microbiological corrosion.

