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Failure Analysis Case Study

Failure Analysis of a Hot Water Heating System Pipe due to Pitting

Keywords: Pipe, Pitting Corrosion, Material

Material: Steel

Introduction

A thirty—four inch length of one inch NPS pipe with a pinhole near one end was submitted for analysis to determine the cause of the pinhole. The pipe was removed from the wall of a high rise building that was built fifteen years ago but only occupied for the last five and one half years. The pipe is from a hot water heating system and was tagged "2—B, 1/16/89". Visual examination, chemical and metallographic analyses was performed on the submitted boiler sections to look for root cause of the failure.

Visual Examination

Figure 1 is a photograph showing the pipe section as it appeared when it was received. Note the pinhole in the pipe at the three inch marker on the ruler. This pin hole is show again in closer view in Figure 2. Some corrosion is present on the outside surface of the pipe in the area surrounding the pin hole; this corrosion, however, is superficial and was not the cause of perforation. The perforated end of pipe section was longitudinally cut for a length of approximately eight inches in order to expose the inside surface. Figure 3 shows the inside surface thus exposed. The pin hole can be seen can be seen at the three inch marker on the ruler. It is obvious that the perforation was the result of severe pitting corrosion. This corrosion is present over the entire inside surface of the pipe and is covered with thick generalized tuberculation corrosion product. Many other pits are present in the tube wall, some of which are near to the point of complete perforation of the wall.

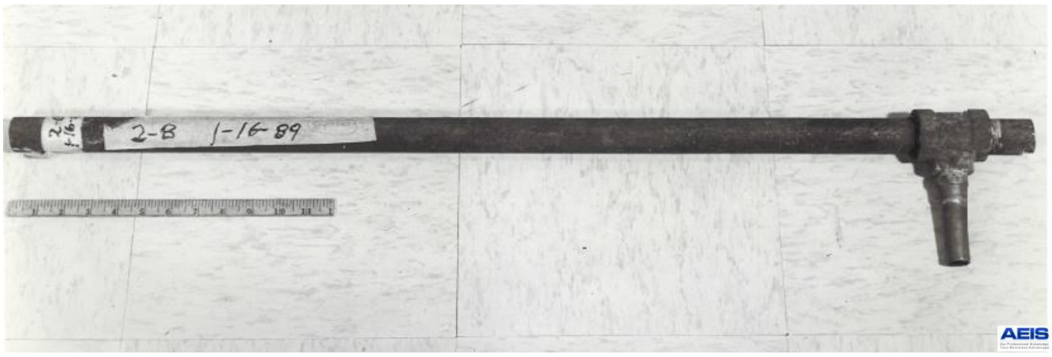

Fig 1 Pipe with pinhole at the end as received condition

Fig 2 Close look of the pinhole

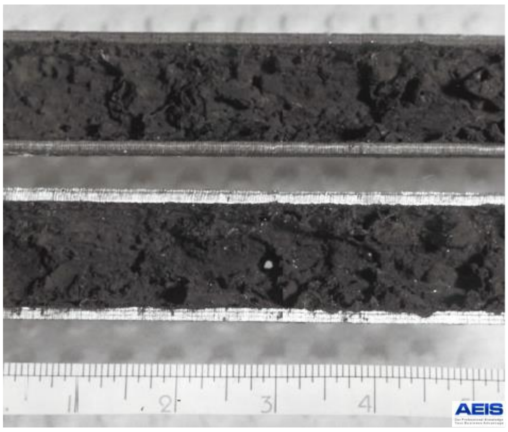

Fig 3 Inside surface of the pipe

Chemical Analysis

The corrosion product found in the pipe was analyzed with the following results obtained:

Anlaysis, %	Result
Moisture Content	0.5
Ignistion Loss	4.8
Sulphates	<0.01
Chlorides	0.1
Molybdenum Trioxide	<0.01
Silica	0.47
Alumina	0.07
Nickel Oxide	0.01
Zinc Oxide	0.02
Copper Oxide	0.6
Iron Oxide	90.3

The product was in essence rust, which was expected. The rust was highly magnetic and, therefore, active corrosion was taking place at the time or removal of the pipe from the system.

Microscopic Examination

A sample containing a pit was mounted and prepared for metallographic examination which revealed that the pitting corrosion was transgranular and was in no way related to microstructure. Figure 4 is a photomicrograph (100X) showing a portion of a deep pit in cross-section. The general microstructure is typical for steel pipe in that it consists of a matrix of ferrite with zones of pearlite. Note that the corrosion is generalized.

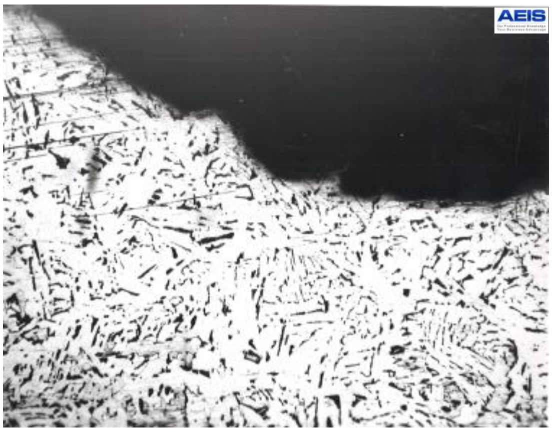

Fig4 Microstructure of pipe X100

Discussion & Conclusion

The degree of corrosion found in the pipe section is not unexpected. Steel pipe, or for that matter even galvanized steel pipe, will not stand up in a hot water system that is not treated with the appropriate corrosion inhibitors. Such pipe can be used in cold water system which conveys temporarily hard water, in as much as the calcium carbonate acts as such inhibitor. However, in hot water systems the calcium carbonate precipitated out at the heater thus leaving the water soft and highly corrosive to steel or the galvanized layer. In such systems copper or brass pipe is normally used. There is no doubt further leaks will develop in the system. The presence of tubercles will serve to assist in the deepening the existing underlying pits. This is the autocatalytic nature of the pitting process. Furthermore, the pitting has progressed to such an extent that cleaning the system and then attempting to stem further corrosion by inhibition is not likely to be effective. It is therefore recommended that the system be replaced with copper pipe.