Moly Does the Job

This article is the fourth in a series of case histories where the application of moly has helped companies to solve technical problems which have occurred. Nicole Kinsman of Technical Marketing Resources, consultants to IMOA, is the author and she will continue to write similar articles for future issues of this Newsletter.

Readers with similar experiences, where moly has assisted in solving problems, are invited to contact the Secretariat.

Summary

A large, international, food manufacturing company encountered through-wall leaks in a Type 304 stainless steel hot water line after only two years of service. The leaks were caused by a combination of Microbiologically Influenced Corrosion (MIC) and manganese pitting corrosion. An upgrade to the more corrosion resistant 6% molybdenum stainless steel permanently solved the problem. Three years after the initial piping replacement, the plant completed replacement of the entire hot water line with 6% molybdenum high performance stainless steels.

The Process

Well water, which is used as a food ingredient is pre-chlorinated and passed through a green sand/carbon filter and pumped into a reservoir. From there it is chlorinated again and brought into the plant. A Type 316 heat exchanger heats the water to 150°F (65°C). The water is carried into the food processing area by an overhead "hot water line". The insulated line is about 2,000 feet (610 m) long and was originally built in Type 304 stainless steel. It has a main header of Type 304, 4-inch (100 mm) diameter schedule 10 pipe (0.12 inch / 3.2 mm wall thickness). At the far end of the insulated water line, the water temperature decreases to 80° – 120°F (25° – 50°C). Leaking of smaller diameter pipe began in less than two years. Within five years, leaking was evident along the entire line.

The Corrosion

The chloride content of the hot water is 50 to 100 ppm. The chlorination target is 0.2 to 0.3 ppm and never exceeds 0.5 ppm free chlorine. These are moderate concentrations which normally are considered to be below the critical level which might cause pitting in Type 304. However, pitting occurred in numerous places, predominantly in the mid-length section of the line in the lower third of the piping cross section.

The pitting was thought to be related to the high manganese content of the water. If manganese-metabolizing bacteria are

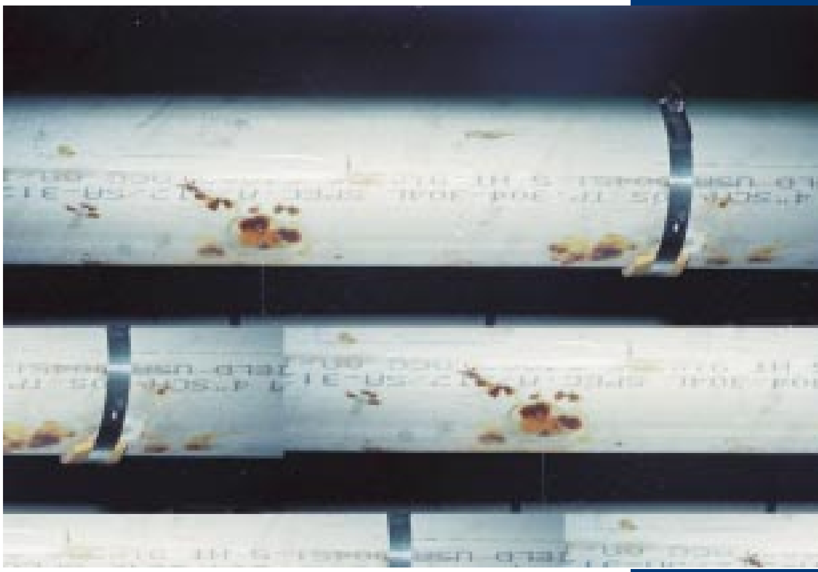

Fig 1: Numerous pits are found on the lower third of the pipe. A patch, covering a leak, is seen in the picture.

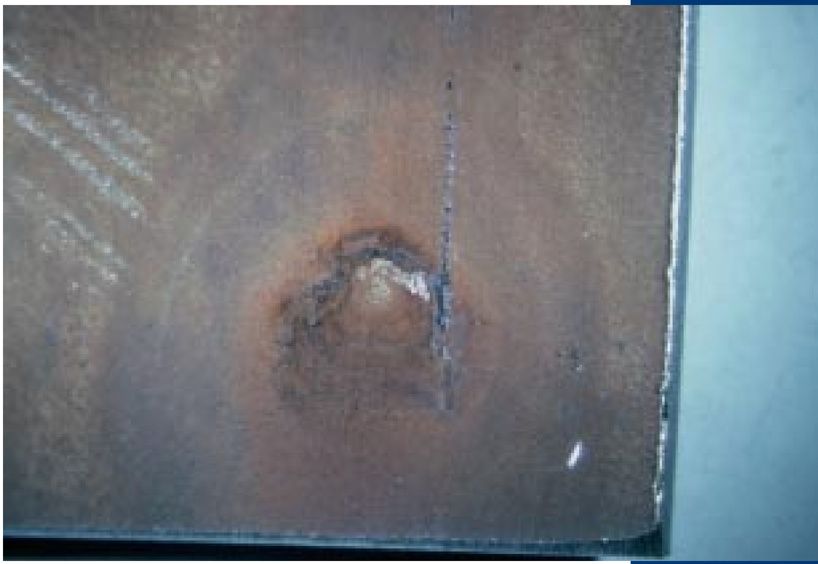

Fig 2: Close-up of the pitting corrosion.

present, manganese can be transformed into the permanganate ion. In association with the chloride ion, permanganate can initiate pitting in Type 304 stainless steel. This form of corrosion is relatively rare, but if it occurs, propagation may be rapid. Further evidence for this mechanism, in addition to the presence of metal-oxidizing microbes in the water, was the location of the pitting in portions of the line where intermediate temperatures prevailed. It did not occur initially with the high temperatures in the heat exchanger or the relatively cool ones at the end of the water line. Bacterial activity is greatest at somewhat elevated temperatures.

In most practical situations, it is difficult to prove conclusively that MIC is the cause of pitting. This case was further complicated by the possibility that the rapid pitting corrosion was caused by the interaction of chlorine and manganese to form permanganate.

The Solution

It could not be determined whether the pitting was caused by MIC (due to the manganese-metabolizing bacteria) or by manganese pitting (due to the interaction with chlorine). However, both mechanisms can be prevented through a change in water chemistry, which is usually not practical, or through a significant upgrade in the corrosion performance of the piping material. In this case, the company decided to replace the Type 304 with the 6% molybdenum stainless steels, UNS S31254 and UNS N08367. Upgrading only to Type 316 stainless steel (2% Mo) is normally not sufficient to prevent MIC or manganese pitting.

The Cost Savings

The plant began their piping replacement in small stages within a maintenance budget which did not require detailed cost saving analysis. However, the final upgrades were two capital projects for which detailed justification was required. Management determined that benefits including food product integrity, maintenance cost savings, and safety issues, easily justified the remaining pipe replacement. The problem-solving experience with the 6% Mo high performance stainless steels was communicated to the many other plants operated by this international company.

"Once again – Moly does the Job."

Table 1: Typical chemical compositions of the stainless steel grades in this article. Note: The company used two different 6% molybdenum stainless steels in their hot water line, 254 SMO and AL-6XN.

	UNS No.	Molybdenum	Chromium	Nickel	Nitrogen	Other
Type 304	S30400	-	18	9	-	
Type 316	S31600	2	17	11	-	
254 SMO®	S31254	6	20	18	0.2	0.75 Cu
AL–6XN®	N08367	6	20	24	0.2	

The 6% molybdenum stainless steel names are protected trademarks of the following companies:

254 SMO Avesta Polarit AL-6XN Allegheny Ludlum