Corrosion of Galvanized Piping in Domestic Water Systems

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(from the *Conduit*, Vol 13, No 1)

Construction of a high-end condominium building had recently been completed when residents began to complain about rusty water coming out of the faucets, staining sinks and showers, and clogging up dishwashers and other hot water-using appliances. The source of the rust was discovered to be sections of galvanized carbon steel piping located downstream of a conventional water softener and before the hot water boiler. The soft water, particularly when heated, quickly removed the protective zinc coating, leaving the carbon steel underneath vulnerable to attack.

Hotels, high-end residences/condos, stadiums, hospitals, etc. often have specifications that require the builder to use copper pipe for all potable water piping that is two inches in diameter or smaller, but may allow substitution of other suitable materials for larger piping. Large hot water systems in these types of complexes that use circulated hot water have defaulted to using galvanized carbon steel piping for these larger diameter pipe sections. This is due to the lower cost of galvanized pipe compared to copper or other materials. The degradation of the galvanized piping in a soft water system can occur in a short period of time, and problems can arise in as few as two to five years after a new installation (Figure 1). This degradation is a major issue that should be addressed.

Water is softened to minimize calcium carbonate scaling that can occur when hard water is heated. In municipal systems, treatment and additives are often already in use in the potable water to prevent this scaling, but builders often think that completely soft water is better.

Hardness in water consists of calcium and magnesium compounds, which are important for human health and impart taste to the water. However, when hard water is heated, the calcium carbonate precipitates and builds-up debris/scale on the pipe walls. This is the reverse of many compounds, which usually have increased solubility at higher temperatures. Softening the water removes the calcium and magnesium and replaces them with sodium (or sometimes potassium).

Softened water is actually aggressive (corrosive) to carbon steel and galvanized materials. The zinc (galvanized) layer on the steel pipe gains much of its protection from a zinc carbonate layer that forms on the surface. The presence of some hardness (calcium carbonate) in the water is beneficial, as it aids in forming the protective layer. In addition, the combination of a thin layer of calcium carbonate with the zinc carbonate is more resilient to corrosion than zinc carbonate alone in completely softened water. When hardness has been fully removed, the protective layer does not properly form and the zinc layer is susceptible to corrosion. In this situation, the galvanized layer first acts as a sacrificial anode and corrodes preferentially to the steel underneath it. However, once the zinc is completely gone, the steel pipe itself begins to corrode and iron corrosion debris gets into the water.

This process does not take long. Acuren Inspection has seen failures in piping systems that are only a couple of years old.

Another issue with using galvanized piping is that the pipes are often threaded or seam rolled in the field during installation. This destroys the galvanized layer wherever the machining or rolling takes place. Sometimes these areas are covered over with zinc-rich paint or primer after forming, but this does not provide as much protection as the original zinc coating. Therefore, corrosion often occurs first at threaded fittings, seams, or rolled grooves in the galvanized pipe (Figure 2).

While building owners and builders are often aware of a corrosion problem long before the first failure occurs, the corrosion debris leads to brown, rusty water in sinks and bathtubs, and can also plug appliances that results in actual damage. Piping failure is also a possibility, and Acuren has seen multiple leaks in hot, softened water systems that used galvanized piping.

Figure 3 shows a water pipe from a hotel with internal corrosion that led to multiple complaints about rusty water. Severe pitting was noted on the internal surface of the pipe (Figure 4 and Figure 5). In addition, most of the piping samples had no remaining galvanized layer present, particularly after the softener. This system was only six years old, and much of the piping had to be replaced. Figure 6 shows a pipe from hot, softened domestic water service in a stadium. Much of this piping system had internal corrosion, and failures had also occurred. This pipe was only two years old, and thousands of feet of piping were replaced in the facility.

The bottom line is that galvanized piping should not be used for hot, softened water service, regardless of how much cost savings is gained. It is just a matter of when it becomes a corrosion issue, not if it will. Any piping after the softener should be made of copper or some other suitable material that does not experience accelerated corrosion rates in hot softened water, such as PVC or stainless steel.

Figure 1. **Examples of corrosion in galvanized piping in hot, softened water service.**

Figure 2. **Corrosion along a rolled joint at the end of a galvanized pipe section.**

Figure 3. **This galvanized pipe was examined after six years in service. This sample was from the cold, softened water line prior to the heat exchanger, but after the circulating hot water return. Pitting was significant.**

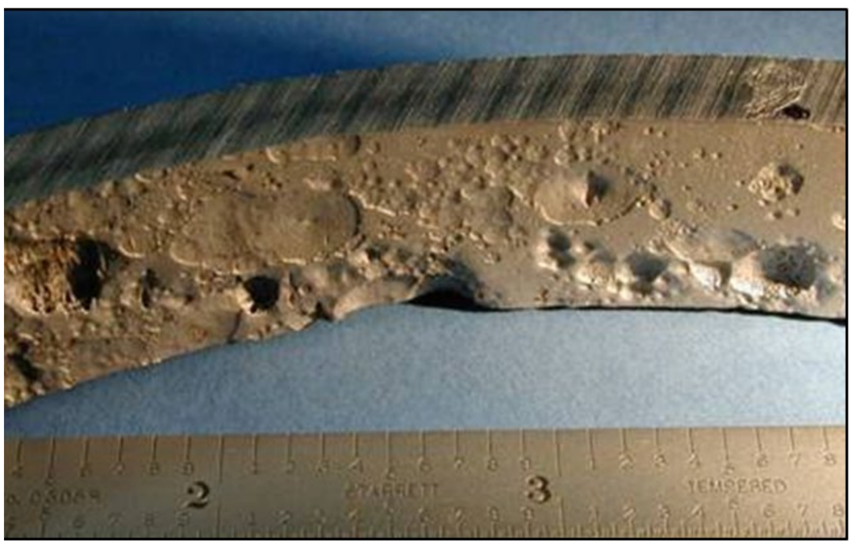

Figure 4. **Multiple pits were noted on the internal surface of the galvanized pipe after cleaning.**

Figure 5. **Cross-section of galvanized pipe shows the severe nature of the internal pitting.**

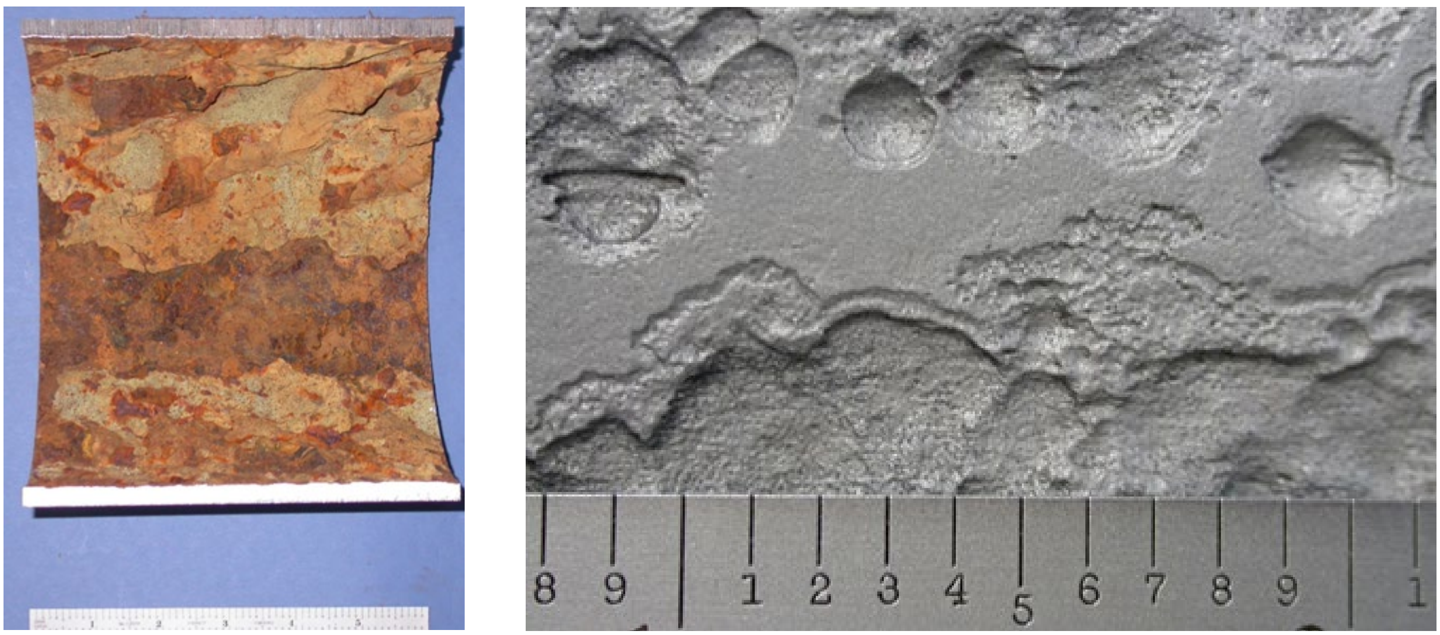

Figure 6. **Internal surfaces of galvanized pipe from a hot, softened water line that was examined after two years in service. Pitting was significant on both sides of the pipe, but worse on the bottom of the pipe (shown here before and after cleaning).**