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One Schwenk Drive
P.O. Box 279
Shippensburg, PA 17257-0279

Phone: 717-532-7321
Fax: 717-532-7704
www.shipcopumps.com

Re: Softened Water Corrosion

Corrosion Accelerators

Some corrosion will occur whenever a metal is exposed to water and a number of factors will accelerate corrosion. These include:

Low pH. Acid waters clearly accelerate corrosion by providing a plentiful supply of hydrogen ions. Although even absolutely pure water contains some free hydrogen ions, free carbon dioxide in the water can multiply the hydrogen ion concentration many times. When carbon dioxide dissolves in water, it reacts with the water to form carbonic acid, a so-called weak acid, but an effective source of acidity. Even more acidity is sometimes encountered in acid mine waters, or in those contaminated with industrial wastes.

Dissolved oxygen. This gas works to destroy the protective hydrogen film, and to oxidize dissolved iron to an insoluble form. Deposits of rust in a plumbing system can form differential aeration cells and accelerate corrosion.

High mineral concentrations. The electrical conductivity of water increases with its dissolved mineral concentration. Thus highly mineralized waters readily conduct the electrical currents of electrolytic cells, and accelerate this type of corrosion.

Water temperatures. High water temperatures not only accelerate the chemical reactions of corrosion, but also may reverse normally protective systems. For example, zinc galvanizing protects iron or steel at normal temperatures by "plating" a protective deposit over exposed iron at a pit or break in the zinc coating. However, at temperatures above 160° F., the iron will attempt to deposit on the zinc, thus creating a deep pit or hole where the iron is exposed.

Other physical factors, including *high flow velocities, solid particles* in the water, and *deposits on metal surfaces* may cause or accelerate corrosion.

Corrosion in Hard and Soft Water

Many natural waters have strong corrosive activities. In sections of New England, and the far Northwest, much of the underground strata is granite which has very low solubility, does not neutralize natural carbon dioxide concentrations, and has little effect on dissolved oxygen. Thus, ground waters in these areas are corrosive because of the acidity due to carbon dioxide and the dissolved oxygen present.

Sections of the southeastern states, where much of the underground structure is organic matter, have waters, which are low in minerals and oxygen, but high in carbonic acid derived from decaying organic matter. The corrosive nature of these low hardness waters is well established.

At the other end of the range are many waters found in the Southwest, where extremely high hardness and mineral concentrations are common. Although usually alkaline in nature, these waters have high electrical conductivities, and in arid regions, may have high dissolved oxygen concentrations. Thus these highly mineralized waters are known to be extremely corrosive, but for different reasons than the naturally soft, acid waters.

The lowest rates of corrosion are usually found with well waters of moderate mineral concentrations in limestone regions. Such waters have little dissolved oxygen, and the natural carbon dioxide has been largely neutralized by the alkalinity dissolved from the underground minerals. The conductivity is relatively low, so galvanic corrosion is not serious under usual circumstances. This water is found in wells over most of the Midwest.

Surface water supplies frequently follow the trends of water quality of ground waters in a region, but usually have lower mineral concentrations because of the dilution effects of rain and snow. However, surface waters are almost always saturated with dissolved oxygen from the air, and this element often produces serious corrosion.

All water is corrosive to the metals in plumbing systems to at least some degree, and both naturally soft and naturally very hard waters can produce high corrosion rates.

Soft Water

The removal of hardness with an ion exchange water softener does not affect the factors, which cause or accelerate corrosion. Softening does not change the pH or carbon dioxide concentration, the dissolved oxygen concentration, or the total chemical concentration of minerals. A softener may reduce the amounts of solid particles in the water, but obviously cannot change other physical factors such as temperature, flow rates through pipes, or volumes of water used. Thus ion exchange softening neither causes nor controls corrosion.

Unfortunately, certain methods of calculating the probable corrosive potential of natural waters have been misapplied to softened waters, with misleading results. The Langelier Index, and some of its modifications, may be used to indicate whether or not a particular water will precipitate calcium carbonate scale at a given temperature. This information certainly is useful to those responsible for operating many systems.

Further, when applied to natural waters, these methods of calculation may indicate that when such an excess of carbon dioxide over alkalinity exists in the water, the precipitation of calcium carbonate would be impossible. Such excesses of carbon dioxide clearly make waters strongly corrosive, as demonstrated by the low pH waters found in New England and the Northwest.

These methods, however, should not be applied to waters softened by ion exchange, since there is no real chemical similarity with the naturally soft acid waters. The removal of calcium by a softener obviously prevents scale formation. Yet, as indicated above, it does not change either the carbon dioxide content of the water, or the natural alkalinity, which tends to neutralize the carbon dioxide. Thus softening will not make a water more acid, or affect the other corrosion accelerating factors.

Some persons argue that the precipitation of calcium carbonate scale will protect the metals from corrosion. While some scales are capable of such protection, other scales are porous or soft, and thus non-protective. Further, it is rare that scale formation is uniform, for the heaviest scale usually forms at points of heat transfer and at low points in a system. In a water heater, for example, most scale forms at the bottom where heat is applied, while the top of the heater tank may show little or no scale. Thus even in hard, scale forming waters, thousands of water heaters fail every year due to corrosion. Examinations of these heaters usually show that corrosion has occurred under or through the scale, or in locations where protective scale has not formed. Thus it is clear that corrosion protection is not assured simply because a water will precipitate calcium carbonate, as indicated by various calculation or test methods. Further, none of these methods take into account the effects of dissolved oxygen, water flow velocities, the presence or absence of solid particles, the volume of water through the system, or other environmental factors which affect the rate of corrosion.

Corrosion Control Procedures

When corrosion does occur in a water supply, several corrective treatments are useful in reducing the corrosion rate. Clearly the best method is to prevent water to metal contact, and a number of coating and plating procedures are used for this purpose. Yet these methods are not always possible or economically feasible, and a number of chemical treatments have been developed to condition the water to reduce the corrosion rates to reasonable levels.

In industrial systems or where the water will not be used for human consumption, oxygen scavengers are frequently used to reduce this corrosive gas in the water. High concentrations of "passivating" chemicals are common in recirculating systems because of their inhibiting effects. Yet neither of these approaches are applied to water used in households because of the possible toxic effects of the chemicals, and because some make the water unsuitable for general household use, producing heavy stains or discolorations.

Thus, corrosion control methods for municipal and household water systems are currently limited to two approaches, neutralization of acidity with alkaline materials, and the feeding of small amounts of chemicals which tend to line the water system with protective films.

Calcite (calcium carbonate) and magnesia (magnesium oxide) filters have long been used to neutralize household acid waters. As water flows through beds of these materials, the acidity dissolves enough of the filter media to produce an essentially neutral water. Other installations use chemical solution feeders to introduce solutions of soda ash (sodium carbonate) or caustic soda (sodium hydroxide) to the water in proportion to the acidity, producing a neutral or slightly alkaline water. Some municipal systems use lime (calcium hydroxide) to increase alkalinity and pH. Several types of polyphosphates and silicates may be fed into water systems for corrosion control. In some cases slowly soluble forms are fed with "pot" type feeders, while in others, solutions are fed with chemical solution pumps. Both the silicates and polyphosphates tend to form thin films on the interior surfaces of the plumbing, thus reducing the water to metal contact. Feeds should be essentially continuous, however, to form and maintain the protective films.

ACKNOWLEDGEMENTS

Shipco® is not expert on dionized water or chemicals. This article paraphrases information taken from an article published by The Water Quality Association titled "Corrosion". Its purpose is to provide some basic understanding. For more detailed information and trouble shooting of a specific problem, consult a professional who works with water softeners.

Sincerely,

Shipco® Marketing and Sales Department

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