PROPRIETARY
SCALE AND CORROSION
INHIBITORS

Presented at

Alberta Infrastructure
Property Management

Water Treatment Co-ordinators' Meeting #31
Sam Livingston Fish Hatchery
Calgary, Alberta
April 19th 2000

by

G.F. Yuzwa, P.Eng.

H2O ENGINEERING LTD.
539 Edgemont Bay N.W.
Calgary, Alberta
T3A 2K7

INTRODUCTION

Most of us can relate to the terms “generic” and “proprietary” in the context of prescription drugs. In this context, proprietary drugs are developed, and later copied & marketed as the generic equivalent.

However, in the context of water treatment scale and corrosion inhibitors, one could say that the opposite is true. That is, the successful field performance of generic scale & corrosion inhibitors is used as a building block in the development of proprietary scale & corrosion inhibitors.

Specifically, a generic scale & corrosion inhibitor is a single component chemical (e.g., sodium sulphite, powder or aqueous solution), whereas a proprietary scale & corrosion inhibitor is multi-component mixture of generic chemicals (e.g., Aquaguard 101 — an aqueous solution of sodium sulphite, sodium carbonate & sodium phosphonate, all in patented proportions).

The typical components, advantages, disadvantages, and control limits for the more common types of proprietary scale & corrosion inhibitors for closed, open and steam boiler systems, as well as the safe handling & monitoring requirements of these inhibitors, are presented herein.

CLOSED WATER SYSTEMS

Proprietary Sulphite Based Corrosion Inhibitors

Proprietary sulphite based corrosion inhibitors usually consist of an aqueous solution of either sodium sulphite or sodium bisulphite, a pH buffer, and possibly a dispersing agent. If an azole—corrosion inhibitor for amphoteric metals—is required, it must be added separately. However, an azole must **not** be added if the system is used for direct/indirect heating/cooling of a potable water system.

Corrosion protection is provided by scavenging the residual dissolved oxygen from the system and by controlling the pH level within an acceptable range.

Sulphite based corrosion inhibitors have a low environmental impact, they have a low toxicity, they are easy to test, and they provide excellent corrosion protection & are economical to use when there is very little air ingression into the system.

However, excessive or continuous air ingression into the system will increase the sulphite inhibitor demand (and its cost), thus increasing the TDS concentration & pH level of the system, thus causing corrosion of the iron & amphoteric metals in the system. Also, the presence of sodium sulphite is a contributing factor in the stress cracking of stainless steel expansion bellows, and it is a nutrient for sulphate reducing bacteria.

Typically, a sulphite concentration of 50-100 ppm SO_3 (80-160 ppm Na_2SO_3) is maintained in the system, and the pH & TDS levels are maintained within their respective ranges of 8.5-9.5 & 2500 micromhos/cm maximum.

Proprietary Silica Based Corrosion Inhibitors

Proprietary silica based corrosion inhibitors usually consist of an aqueous solution of sodium silicate. An azole must **not** be added if the system is used for direct/indirect heating/cooling of a potable water system.

Corrosion protection is provided by the hydrolysis of sodium silicate to form negatively charged colloidal particles which migrate to the anodic area of the corrosion cell where they form a protective film with solid corrosion products.

Silica based corrosion inhibitors have a low environmental impact, they have a low toxicity, they are easy to test, they provide good corrosion protection under flowing conditions & TDS concentrations of less than approximately 500 ppm, they are economical to use, and they are a non-nutrient for bacteria.

However, poor corrosion protection is provided by silica based corrosion inhibitors under extended static conditions. Also, if the make-up rate is substantial, it must be softened in order to prevent the formation of hard calcium silicate deposits which have a low thermal conductivity value, and which can seriously damage rubber washers, "O" rings, diaphragms, etc.

Typically, a silica concentration of 25-40 ppm SiO_2 is maintained in the system, and the pH & TDS levels are maintained within their respective ranges of 8.0-9.5 & 500 ppm maximum.

Proprietary Nitrite Based Corrosion Inhibitors

Proprietary nitrite based corrosion inhibitors usually consist of an aqueous solution of sodium nitrite, a pH buffer, possibly a dispersing agent, and an azole. These inhibitors must **not** be added to a system that is used for direct/indirect heating/cooling of a potable water system.

Corrosion protection is provided by a protective "barrier" film that is formed by a chemical reaction between nitrite and iron. Therefore, initially the iron surface must be reasonably clean and free of corrosion products.

Nitrite based corrosion inhibitors are easy to test, and they provide excellent corrosion protection & are economical to use when there is very little air ingression into the system.

However, excessive or continuous air ingression into the system will oxidise the nitrite to the ineffective nitrate form, thus resulting in corrosion of iron material in the system. Also, sodium nitrite is a nutrient for bacteria, it has a high environmental impact, and because of its high concentration in the system, the resulting high TDS concentration causes extra wear on pump & valve seals, and deposits wherever there is a leak in the system.

Typically, a nitrite concentration of 800-1200 ppm $NaNO_2$ is maintained in the system, and the pH & TDS levels are maintained within their respective ranges of 9.0-10.5 & 3500 micromhos/cm maximum.

Proprietary Molybdate Based Corrosion Inhibitors

Proprietary molybdate based corrosion inhibitors usually consist of an aqueous solution of sodium molybdate, a pH buffer, possibly a dispersing agent, and an azole. These inhibitors must **not** be added to a system that is used for direct/indirect heating/cooling of a potable water system.

Corrosion protection is provided by a protective “barrier” film that is formed by a chemical reaction between molybdate and iron. Therefore, initially the iron surface must be reasonably clean and free of corrosion products.

Molybdate based corrosion inhibitors are easy to test, and they provide excellent corrosion protection irrespective of the amount of air ingression into the system & are economical to use when the make-up rate is low.

However, if the make-up is excessive or continuous, the hardness that is introduced into the system will precipitate the molybdate, thus resulting in increased inhibitor demand and corrosion of the iron material in the system. Also, because the molybdenum concentration in the total waste water that is discharged to the sanitary sewer system must be less than the maximum limit of 5 mg/l Mo indicated in the Water Treatment Program Environmental Guideline, molybdate based corrosion inhibitors have a high environmental impact.

Typically, a molybdenum concentration of 50-150 ppm Mo is maintained in the system, and the pH & TDS levels are maintained within their respective ranges of 9.0-10.5 & 2500 micromhos/cm maximum.

OPEN WATER SYSTEMS

The composition of proprietary scale & corrosion inhibitors for open condenser water and air washer humidifier systems are far more complex than the inhibitors for closed systems. The active component is usually a phosphonate, but it is complimented with complex polymers, dispersants, alkalinity builders, and possibly an azole. A biocide is added separately for bacteria control.

Scale formation is controlled by maintaining the hardness salts in solution so that they may be removed from the system through the bleed-off, whereas corrosion protection is provided by a protective “barrier” film that is formed by a chemical reaction between the phosphonate and iron. Therefore, initially the metal surfaces must be reasonably clean and free of scale & corrosion products.

These inhibitors are relatively easy to test, and they provide excellent scale & corrosion protection; however, they are expensive to use.

Typically, a phosphonate concentration of 10-20 ppm is maintained in the system, and a TDS level is maintained such that the maximum hardness concentration in the system is approximately 500 ppm $CaCO_3$.

STEAM BOILER SYSTEMS

Proprietary scale & corrosion inhibitors for steam boiler systems are either phosphate based or molybdate based inhibitors. The components of phosphate based inhibitors usually consist of phosphate, caustic, sulphite & possibly a dispersant, whereas molybdate based inhibitors usually consist of sodium molybdate and caustic. Proprietary amine mixtures may be included with either inhibitor type or they may be added separately.

Scale formation is controlled by maintaining the hardness salts in solution and/or by creating a soft non-adherent sludge that may be removed from the system through bleed-off & blow-down. Corrosion protection is provided by the sulphite oxygen scavenger for the phosphate based inhibitors, and by a protective “barrier” film that is formed by a chemical reaction between the molybdate & iron for the molybdate based inhibitors.

The pH, TDS, sulphite, phosphate & alkalinity levels for the phosphate inhibitors are easy to test, as is the molybdenum concentration for the molybdate inhibitors. Both types of inhibitors provide good scale & corrosion protection; however, they are expensive to use.

Typically, a pH level of 10-11, a TDS level of 2500-3500 micromhos/cm, a sulphite level of 30-50 ppm SO_3, an OH alkalinity level of 150-300 ppm $CaCO_3$, a maximum total alkalinity level of 700 ppm $CaCO_3$, and a phosphate level of 20-60 ppm PO_4 are maintained in the boiler water for phosphate inhibitors, and a molybdenum boiler water concentration of 75-125 ppm Mo is maintained for molybdate treated systems. Condensate pH levels are maintained at 8.5-9.5 (8.0-8.5 for systems with combined steam heating & humidification) for both inhibitor types.

SAFE HANDLING OF PROPRIETARY INHIBITORS

All chemicals (including water test reagents) must be handled with safety upper-most in mind. That is:

- Chemical packaging must be labelled as per WHMIS regulations;
- MSDS (Material Safety Data Sheets) for each chemical must be on site, and personnel who are handling the chemical must be familiar with its properties & first aid treatment, and must observe the recommended safety precautions (e.g., protective clothing & eye safety goggles);
- Dry chemicals should not be handled in areas of air turbulence;
- Expired or contaminated chemicals should be discarded in accordance with the Water Treatment Program Environmental Guideline.

MONITORING OF PROPRIETARY INHIBITORS

The monitoring requirements for proprietary scale & corrosion inhibitors are the same as those for the generic inhibitors.

That is, closed systems must be tested at least once per month while in the flooded condition for the concentration of the active material (i.e., sulphite, silica, nitrite, or molybdenum) and the pH & TDS levels, and all test results & corrective actions must be documented on dedicated record sheets.

Similarly, open water systems & steam boiler systems must be tested at least 3 times per week for the appropriate routine tests. In addition to these tests, open water systems must also be tested at least once per month for bacteria. All test results & corrective actions must be documented on dedicated record sheets.

The water test kits are interchangeable (i.e., Guardian test kits may be used to test water that contains BetzDearborn proprietary inhibitors); however, the individual reagents within each test kit are not interchangeable between Suppliers. Also, one should be aware that in some cases, the test result units of one test kit may be different than those of a different test kit (i.e., SO_3 Vs. Na_2SO_3 and Mo Vs. MoO_4).