A review of European and North American water treatment practices (1996 N8)

Summary
This report outlines the European approach to water treatment and corrosion prevention in hot water district heating systems, specifically the approach advocated by Nordvärme, the district heating association of Nordic countries in Europe. The intent of this report is to make information and operating experiences on the Nordvärme approach available to North American system operators as well as to describe common North American water treatment methods.

An interest in the European approach to water treatment has grown recently because of developments in advanced fluids for district heating and cooling systems. New additives are sometimes incompatible with chemicals traditionally added in North America to prevent corrosion in hot and cold water systems. In particular, some corrosion inhibitors have been shown to be incompatible with the use of friction reducing additives.

Friction or drag reducing additives reduce the frictional losses from water in turbulent flow by suppressing the formation of turbulent eddies. This results in lower pumping energy requirements and costs. Interest in these additives has grown over the last few years and the additives have been successfully demonstrated in several systems, including a transmission system in Herning, Denmark in which pumping energy requirements were reduced by 70% and overall operating costs were reduced by 40%.

In North America, corrosion of steel district heating pipes has traditionally been prevented by adding corrosion inhibitors which protect the pipe by forming a protective passivating film on the internal surfaces.

Most corrosion inhibitors are inorganic oxidizing substances which passivate the metal surface by forming an impervious film which interferes with the anodic or cathodic corrosion reactions. These inhibitors work with metals that exhibit active-passive transitions such as iron, nickel, chromium and alloys containing these metals.

As well, chemicals are sometimes added which react with and remove dissolved oxygen. This limits corrosion by limiting the oxygen reducing cathodic reaction. Restricting either the cathodic or anodic reactions will limit the overall corrosion rate since these processes are dependent on one another. The electrochemical mechanisms of corrosion are explained in more detail in the first paper in this report, "Corrosion and Water Treatment in Nordic District Heating Systems, Experience and Practice".

The overall treatment strategy also includes filtering and demineralizing (or softening) system water and raising the pH. The second paper in this report describes chemical additives which are currently used to prevent corrosion in North American closed cold and hot water distribution systems and explains some of the advantages and disadvantages of each.

Common chemical additives for corrosion prevention in North America

Passivators:
- chromate
- borate nitrite
- silicate
- molybdate

Oxygen scavengers:
- hydrazine morpholine
- sulphite caustic soda/soda ash

The strategy recommended by Nordvärme is simply to maintain high quality water in the system through continual filtering, deaeration and demineralization (or softening) and to maintain the pH between 9.5-10 by adding

sodium hydroxide. The procedure requires careful monitoring of the chemistry of the system water. The corrosion rate must also be monitored through the use of corrosion coupons or piping samples inserted in the flow. Demineralization is preferable to softening because it reduces the total ionic concentration.

Summary of Nordvärme water treatment method

- filter
- demineralize or soften
- deaerate
- raise pH to 9.5-10 by adding sodium hydroxide (NaOH)
- monitor corrosion rate and concentrations

The first paper in this report is an English translation of the Nordvärme water treatment manual for district heating system operators. This manual was prepared by expert representatives from five member countries of the Nordvärme working group on water treatment. In it, Nordvärme gives recommended ceiling concentrations for chemicals in the system water.

Summary of guideline values of dissolved species in district heating water

pH at 25 °C	9.5-10.0
Oxygen concentration	< 0.02 mg O_2/kg
Ammonia concentration	< 10 mg NH_3/kg
Total iron concentration	< 0.1 mg Fe/kg
Total copper concentration	< 0.02 mg Cu/kg

The Nordvärme approach has been successfully applied in the two district heating systems in Prince Edward Island, Canada. In these systems raw water entering the network is filtered, softened and deaerated. Water in the system is continually filtered. The pH is maintained between 9 and 9.5 by adding sodium hydroxide.

In the St. Paul, Minnesota district heating system in the United States, water is pretreated by filtering and softening and a corrosion inhibitor is added to the system. The cost of this treatment is $0.12 per gallon of makeup water compared with $0.05 per gallon of makeup water in the P.E.I. systems. The cost of water treatment in the P.E.I. systems however, is dependent on the cost of laboratory analyses. In the St. Paul system, testing is included as a service with the purchase of the corrosion inhibitor.

The experiences in the P.E.I and St. Paul systems are outlined in the paper beginning on p. 44 of this report. This paper was presented at the annual conference of the International District Energy Association in Indianapolis in June 1995, and again at the IDEA's distribution workshop in St. Paul in November 1995.

Feedback from the audience at the IDEA conferences indicated that many North American operators were more comfortable contracting out water treatment activities. Even if there are savings to be made, operators prefer a complete treatment "service", where providing the chemicals and monitoring the system are both the responsibility of the chemical company. Water treatment activities sometimes require both time and a level of expertise that plant staff do not have.

Conversations with plant staff have indicated that in busy seasons, water treatment monitoring is sometimes the first activity put on hold although it is vital to the long-term health of the system. The assumption is sometimes made that if a given method has worked well in the past, it will continue to work. Stopping monitoring, however, can lead to unexpected problems.
A number of conditions in the system can change such as the chemistry of the makeup water, and the operation of the deaeration and deionization equipment and chemical feed equipment.

Comparison of Nordvärme approach and the use of corrosion inhibitors

Nordvärme approach (Carried out by plant staff)

Advantages

- avoids the need to add corrosion inhibitors
- if corrosion rate increases, corrosion inhibitors
- can be added later
- can be cheaper

Disadvantages

- requires careful monitoring

Corrosion inhibitors (chemical supply and monitoring by chemical company)

Advantages

- will protect pipe surfaces regardless of rate of oxygen infiltration
- addition and monitoring are the responsibility of the chemical company

Disadvantages

- once corrosion inhibitors are being used in a system it is difficult to stop
- in the future, use of some common corrosion inhibitors may be restricted because of environmental impact and regulations

Conclusions

The low corrosion rates seen in the PEI systems indicate that the European approach for water treatment in hot water systems as described in reference 1 can be effective in North American situations. In this treatment strategy the risk of corrosion is minimized by removing oxygen from the feed water through chemical or thermal deaeration, by raising the pH to at least 9 and by decreasing the hardness by softening. Good water quality monitoring and leak detection systems are important elements of this type of water treatment program.

Operators of new hot water systems might want to consider simple pH control as an alternative to the more common North American approaches. The treatment strategy is suitable when there is a slow rate of makeup and when leakage into or from the system is small. This strategy might be especially suitable for systems considering the use of friction reducing additives, since some corrosion inhibitors have been shown to lower their drag reducing capabilities.

For the cases examined, the simpler approach to water treatment is less expensive. The cost of maintaining corrosion inhibitors in the St. Paul system exceeded the cost of the simpler approach in the Charlottetown system. Other considerations which should be taken into account include the amount of makeup required in the system, availability of steam for deaeration, and the availability of staff to operate the equipment and monitor the water quality.

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