RECOMMENDATIONS FOR WATER TREATMENT AND CORROSION PREVENTION IN DISTRICT HEATING

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SILHORKO-EUROWATER has supplied a new plant for producing make-up water for the district heating grid in Aalborg, Denmark. The plant is a vital part of Aalborg's maintenance plan, allowing the main make-up production facility to be shut down on a regular basis for maintenance.

Denmark is considered the leading district heating market when it comes to innovation and practical experience with modern district heating. For this reason, recommendations issued by the Danish District Heating Association are typically received with much interest from other countries, in order to learn "Best Practice" based on findings from the close to 400 district heating companies in Denmark.

Water treatment plants can be designed partly based on water analysis for the water used as inlet for the plant, partly based on information on which water quality it needs to deliver at the outlet.

Design parameters include opportunities for water and energy savings, minimum use of chemicals, minimum floor space footprint for the plant, trouble-free installation and operation, fast/safe and reliable commissioning of plants etc. It means we often supply frame mounted installations combining several water treatment technologies into one compact plant complete with PLC's.

Recently, the Danish District Heating Association published its recommendations for correct water treatment for district heating with a view to prevent corrosion of pipes etc. – which could cause water leakages (loss of water and energy), intake of untreated water through the network as well as interruption of supply to the customers of the district heating company. Correct water treatment strongly influences lifecycles and maintenance requirements for key assets such as pipes, fittings, boilers, heat exchangers etc. The recommendations apply to all water-born district heating systems irrespective of operating temperature. In other words, the recommendations are all about good asset management.

Several typical operational problems in district heating systems origin from (lack of) water quality and can be addressed by changing the water quality:

- Oxygen corrosion in expansion vessels, holding tanks, pipe systems, and in radiators.
- Calcium carbonate precipitations on heating surfaces, in boilers and heat exchangers.
- Crevice corrosion at assembly points in armatures, radiators, holding tanks and general surface corrosion.
- Sludge and deposits on meters, adjustment devices, radiators, holding tanks, and in general in places with low flow.
- Stress corrosion of stainless steel due to high chloride content.
- Sulphide attack on plant parts of copper and copper alloys.
- Circulation, flow issues due to air discharge in boilers and heat exchangers.
- Microbial corrosion and biofilm.

Black untreated steel and low-alloy steel are the most common materials in district heating systems. Water treatment and corrosion prevention primarily aim at protecting these materials against corrosion considering that other materials could be present. The main elements of corrosion prevention pertaining to non- and low-alloyed steel are:

- Oxygen-free environment with an oxygen content < 0.02 mg/l.
- Alkaline environment with pH = 9.8 ± 0.2.
- Minimization of salts, formation of deposits, and precipitations.

On clean and untreated steel surfaces, a thin magnetite layer will form at pH-values over approx. 9.5, which passivates the steel surface. The magnetite layer is soluble at lower pH-values and can be liberated by mechanical influence or resulting from thermal and dynamic movement in the pipe system. In case of new plants, it is important to clean the surfaces before commissioning, i.e. iron scales, paint residue, and oil stains are removed by sand blasting and degreasing.

SUCCESS CRITERIA OF WATER TREATMENT

A success criteria of good water treatment in district heating systems is optimum technical and economical operation both in the short and in the long run. Likewise, low chemical consumption is a success criteria, since the environment will be the least stressed by leakage of district heating water and at the same time, the risk of corrosion will be reduced. This means:

- Minimization of corrosion and formation of deposits.
- Optimum plant and operating economy.
- Minimum maintenance costs.
- Minimum internal and external environmental impact.

Front page of Danish District Heating Association latest recommendations for water treatment and corrosion prevention.

The water treatment recommendations from the Danish District Heating Association include a message to minimize (and where possible fully avoid) the consumption of chemicals – especially for removal of oxygen in the water, where new technologies have been developed.

Chemicals clearly add to the salt content in district heating water and thereby cause risks for corrosion. Chemicals also add to the operational costs (OPEX); they are a health and safety issue for storage and handling – and finally, it makes sense that a sustainable heating system is constructed from sustainable components/technologies.

25 years ago, most Danish district heating companies produced make-up water from municipal water by softening to remove hardness, then added chemicals for pH adjustment and oxygen removal. Today, in addition to softening the recommendation calls for removal of salts through membrane technology (RO) or ion exchange technology, in order to produce demineralized water with low conductivity.

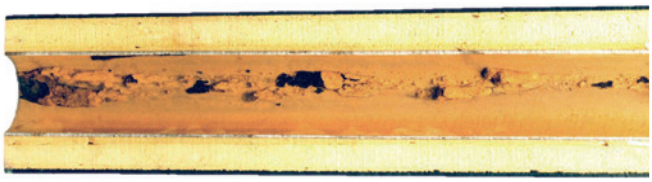
These steps can then be followed by oxygen removal, e.g. by a membrane technique. Use of chemicals for that purpose is viewed as the least attractive alternative. The last step is adjustment of pH by means of sodium hydroxide.

Reasons for using demineralized water include:

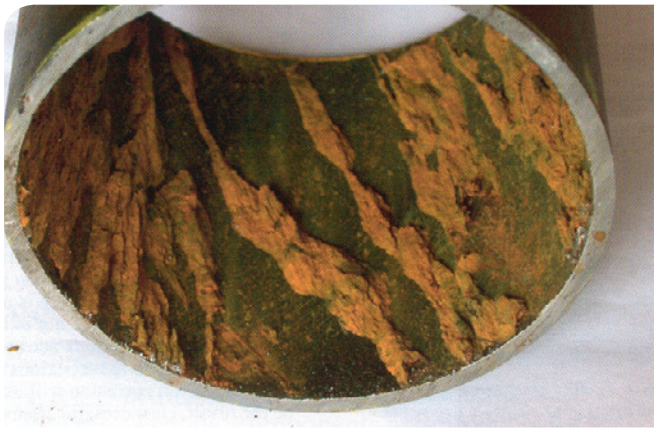
- Salts in district heating water promote local corrosion in which oxygen is consumed. Local corrosion is damaging for the components.
- Salt load in district heating water provides a nutrient supply for bacterial growth and thus promotes microbial corrosion.
- Salt load is crucial for how much NaOH (Sodium hydroxide) to use to raise the pH to 9.8 (> 90% reduction of chemical consumption for pH adjustment when switching from softened to demineralized water).
- Demineralized water makes it easier to detect intrusion of raw water.

Reasons to remove oxygen from the water:

- Oxygen is necessary for corrosion to proceed.
- In district heating systems, no chemicals react more quickly with oxygen than the steel.
- Remove the oxygen before adding make-up water to the district heating network. In most cases, this is the necessary and sufficient means to control corrosion, i.e. there is no reason to add oxygen binding agents also.
- The Danish District Heating Association does not, in general, recommend chemical oxygen binding agents, as they contribute to the salt load and promotes bacterial growth in district heating water.



Oxygen corrosion due to high oxygen content and low pH-value in district heating make-up water.



Corrosion at the bottom of district heating pipe caused by particles, sludge and oxygen in the water.

Factors causing corrosion - issues that can be experienced through inadequate water treatment in district heating:

- Aggressive ion content, especially presence of chloride. High salt content promotes damages by local corrosion, low salt content leads to widespread general corrosion that is far less damaging.
- Oxygen content above a few micrograms per litre.
- Incorrect pH-value of the water. pH above 9 maintains the protective oxide layer on steel surfaces.
- Biological activity: Demineralized water adjusted to pH 9.8 with sodium hydroxide and low content of organic substances presents the least attractive conditions for growth and thus stresses the bacteria maximally.

Furthermore, correct water treatment helps minimize formation of deposits.

Biofilm in district heating systems can cause much technical and environmental damage:

- Microbial corrosion.
- Reduced heat transfer.
- Increased pump costs.
- Increased chemical consumption.

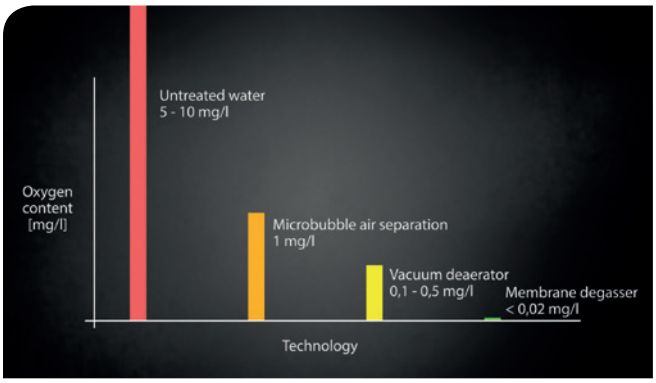


Illustration showing comparisons on different technologies to remove oxygen from district heating water.

In March 2017, the co-writer of Danish District Heating Associations water treatment recommendations, Karsten Thomsen, specialist in water chemistry from COWI A/S – issued an article in the association's magazine dealing with the comments received since the recommendations were released late 2015. The recommendations have been very positively received by the district heating companies in Denmark.

Gothenburg Energy's membrane degasser installation.

The general picture, however, is that chemicals historically have been added to try to help a problem of more fundamental character with inadequate water chemistry. The water treatment recommended by the Danish District Heating Association takes the basic conditions of corrosion into account and avoids the problem without the use of chemicals. This may be seen as a professional way to handle the real issue before it becomes a problem.

Historically, use of demineralized water and removal of oxygen without chemicals were often not economically feasible – now this has changed due to new technologies available on the market. On top of that, chemicals are expensive so investments in new technology to remove oxygen without chemicals represents a short return of investment.

Therefore, the recommendations from the Danish District Heating Association can be implemented as the modern, correct way to secure optimum water chemistry, and in the long run reduce maintenance costs of the district heating system. The German water treatment standard for district heating, AGFW FW510 to a large extend shares conclusions with the Danish recommendations. The Danish guidelines are, however, more comprehensive and detailed i.e. concerning recommended pH-range as well as oxygen levels in the water.

The recommendations for water treatment in district heating do not apply to water and steam circuits in combined heat and power plants, nor to water treatment for steam installations. In such cases, we refer to separate recommendations for relevant technologies, e.g. "The International Association for the Properties of Water and Steam", SIAPWS.

IN CONCLUSION:

Why is water treatment important?

Optimum treated make-up water and circulating water are demineralized and deoxidized, free of mechanical impurities, and suitably alkalized with as few chemicals as possible. If these facts are disregarded, you run the risk of corrosions and precipitations in installations. The most common risks to district heating systems are:

- Corrosion.
- Leakage- loss of water and energy.
- Bacteria growth.
- Shortened plant life.
- Shortened pipe networks life.
- All risks are due to contents of oxygen, salt and mechanical impurities.

COSTS, SECURITY AND ENVIRONMENTAL PROTECTION

If the make-up water is not treated, it may result in leakage and shortened plant life. The water treatment thus has a direct impact on the operational cost of a district heating plant and its pipe network. The recommended water treatment and water quality focus on corrosion prevention by minimal use of chemicals.

Most of the make-up water that is lost every year leaks into the nature as a direct cause of neglected water treatment. A well-maintained plant through proper water chemistry is therefore also a safety issue in the daily operation as well as an economical and environmental gain.

The new water treatment recommendations from the Danish District Heating Association can be downloaded from www.eurowater.com (English) and www.eurowater.de (German).

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