REMOTE MONITORING FOR CORROSION PREVENTION

By Steve Munn, Hevasure Ltd

Corrosion is the unseen enemy of heating and chilled water systems resulting in premature failure of components, loss of efficiency and huge costs. All too often building owners and maintenance companies rely on ad-hoc water sampling to check for signs of corrosion or, worse still, only react once the system has started to leak. This article explains how monitoring the parameters that can lead to corrosion maintains systems in optimum health, significantly reduces the risk of failure while improving efficiencies. Monitoring should therefore be an integral part of any asset management program.

Corrosion of pipework and components in water based heating and cooling systems nearly always results in costly repairs and unwelcome disruption, especially where district heating schemes, large office blocks, or hospitals are concerned. Not only does corrosion lead to premature failure of components and pipework but the resultant debris causes significant loss of efficiency due to reduced heat transfer and circulation problems. In addition, the lack of real data usually means that root causes of any problems remain unknown (risking repeating the damage) and different parties involved all blame each other. Litigation in such cases is not uncommon with the only winner being the lawyers.

One of the basic problems has been that maintenance / facilities management companies have relied on periodic water sampling to check on the health of the systems. Not only does this only give a partial picture (water composition is only one aspect that needs to be considered), it is a snap-shot view taken at best once per month. The industry has been slow to seize on the opportunity that continuous monitoring presents; namely; measuring and recording of all key parameters that influence corrosion. Developments in sensors, data loggers and communication technology now make it possible to remotely monitor a range of parameters continuously in real time and provide electronic alerts if critical levels are exceeded. Not only can this prevent potentially very expensive and disruptive problems but systems can be maintained at optimum efficiency throughout their lifetimes, saving costs and helping meet sustainability targets.

Figure 1 - Monitoring System

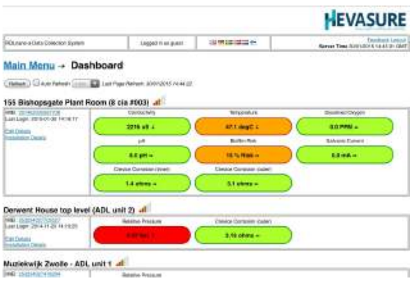

Figure 2 - Dashboard View

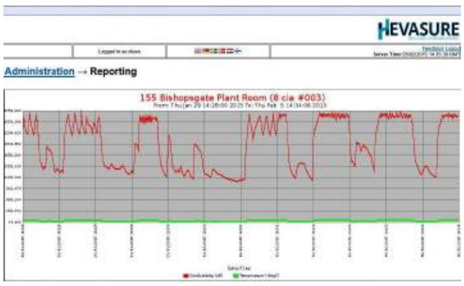

Figure 3 - Graphical View

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Parameters that need to be monitored

The health of a closed heating and chilled water system is dependent on a combination of engineering integrity and water chemistry. In fact, it could be argued that engineering integrity is the most important consideration and that throwing chemicals at a badly maintained system is both ineffective and wasteful. Table 1 below looks at the system parameters that we would need to monitor to ensure system integrity

System Parameter	Importance of monitoring
Dissolved Oxygen	Closed heating / chilled water systems need to be air-tight to prevent the ingress of dissolved oxygen. The cathodic reduction of dissolved oxygen is the main driver for anodic metal dissolution reactions and therefore this should be kept to an absolute minimum. For a typical closed system, dissolved oxygen levels should be below 0.1 mg/L.
Pressure	Positive pressure must be maintained throughout the system at all times to prevent air being drawn-in. If the pressurisation unit and expansion vessels are not set-up and maintained correctly then negative pressures may occur at the highest point in the system (drawing in air through seal and AAV's). Conversely, excessive pressures result in water losses through PRV's.
Make-up water	The intake of fresh make-up water into a system indicates a planned maintenance activity (e.g. flushing operation) or an unplanned event such as a leak. Either way it contributes to increasing dissolved oxygen levels. Monitoring the quantity of water drawn into a system is a good way to record when such events occur.
Temperature	This is a key parameter of any HVAC system and needs to be constantly checked to ensure it is operating at the intended level.
Flow	The correct flow through different parts of the system is vital for efficiency. Changes to flow rates may indicate blockages or wear of control valve seats.

Table 1: Aspects of engineering integrity that require monitoring

As well as ensuring that the system is operating properly from an engineering perspective, it is necessary to check that the characteristics of the water (chemically and biologically) are not going to lead to corrosion problems. Water treatment, although not essential, can act as a second line of defence and significantly reduce corrosion rates for all metals in the system providing correctly selected and dosed. The parameters, which can be monitored, are discussed in table 2 below.

System Parameter	Importance of monitoring
Conductivity	For systems dosed with an inhibitor or glycol, conductivity is directly related to concentration. Measuring this parameter is essential to ensure that minimum thresholds are maintained, otherwise inhibitors are ineffective and glycols offer insufficient freeze protection. Conversely, over-dosing is an environmentally unacceptable and expensive waste.
pH	For systems containing aluminium (e.g. heat exchangers), it is important that the pH of the system water is kept below 8.5 at all times otherwise the surfaces lose their passivity and corrosion occurs.
Biofilm risk	Biofilms forming on pipework can lead to oxygen concentration cells, encourage the growth of sulphate reducing bacteria (SRB) and reduce effectiveness of biocides and inhibitors. Left untreated, SRB can lead to microbial influenced corrosion (MIC).

Table 2: Aspects of the system water that require monitoring

Finally, a monitoring system would not be complete if it did not include some means of measuring corrosion rates. Not only should this include a sensor to measure general corrosion but, if possible, a means of monitoring localised corrosion within crevices and under debris (where corrosion usually starts) should be incorporated. In large systems, measurements of localised corrosion should be made at a number of locations, especially in areas of low flow (see table 3).

System Parameter	Importance of monitoring
Galvanic currents	The galvanic current is the current that flows between different metals within a system (e.g. steel and copper). Maintaining low galvanic currents is indicative of low oxygen levels and/or good inhibition of metallic corrosion.
Crevice corrosion	Crevice corrosion can occur even if general corrosion rates are low. It occurs in localised regions (weld seems or under debris) due to differential aeration effects and is a frequent cause of pitting attack and pin-holing.
Corrosion rates	General corrosion rates of specific metals (usually steel) can be measured by use of LPR devices and probes. Usually, these give a reading of corrosion rates in mpy or mm per year but are not usually set up for measuring remotely.

Table 3: Aspects of corrosion that require monitoring

Benefits of continuous monitoring

Eliminating corrosion in heating and chilled water systems has enormous benefits for everyone concerned. In a new build, the responsibility for the system passes between a number of parties (installer, commissioning company, maintenance company etc.).

y monitoring key parameters, the health of the system can be established throughout the various phases. On hand-over, key data will be available to prove that the system had been properly commissioned and operated up until that point. For existing builds, a monitoring system can be installed to check on the condition of the heating or chilled water system before a maintenance company decides to take over the maintenance contract. This would prevent them from inadvertently taking over the management of a 'night-mare' system and incurring large financial losses.

The benefits of continuous corrosion monitoring are clear and protection of some of the most expensive assets in a building (or district heating system) is in everyone's interest. However, there are undoubted specific benefits to all the stake-holders involved as outlined in table 4.

Stakeholder	Benefit
Building owner	No disruption due to breakdowns – happy tenants Lower running costs (systems more efficient) Lower insurance premiums
Installer	Proves that the system was properly installed and there are no integrity issues (ensures that all contractual obligations are met) Enhances reputation
Commissioning company	Proves that the system was properly commissioned (ensures that all contractual obligations are met) Enhances reputation
Maintenance company	Ensures systems are operating efficiently, free from corrosion damage Inhibitor / glycol use kept to an optimum level (save money by not over-dosing) Proves that the system is being properly maintained (ensures that all contractual obligations are being met - data maintained throughout length of contract Avoids unnecessary call-out of engineers. Enhances reputation

Table 4: Benefits for stake-holders

Continuous Corrosion Monitoring in action

The theory and benefits of monitoring have been discussed in detail above. The good news is that continuous corrosion monitoring systems not only now exist but have been proven in extended field trials. Figure 1 shows such a system developed and tested over several years by Midland Corrosion Services and Hevasure Ltd. This fully integrated system incorporates a web enabled view of the data in real time (dashboard view, figure 2) with a graphical view of trends over any selected time period (figure 3). All data is relayed over a mobile phone network to a central database and web server. Interpretation is made by experts in corrosion and alerts sent out if parameters exceed critical levels. Monthly reports are also provided informing management on the overall health of the system and providing recommendations to keep the system operating in tip-top condition.

With the availability of monitoring equipment, maintenance and protection of valuable assets such as heating and chilled water systems are now possible in line with the asset management standard ISO 55000. By ensuring systems are operating at or near peak efficiencies also helps organisation meet environmental and sustainability targets while keeping energy costs to a minimum.

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