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Corrosion Monitoring in Cooling Water Systems

Application Note

Efficient removal of heat is an economic consideration in the design and operation of cooling systems. Failure of these systems can have severe consequences, such as plant shutdown and even safety-related incidents.

The function of the cooling system is to remove heat from processes or equipment via a heat exchangers using water as the cooling fluid.

There are two major elements impacting cooling system performance: deposition and corrosion. Excessive deposition of calcium/magnesium carbonates reduces the heat transfer efficiency in heat exchanger tubes, causing local overheating with subsequent corrosion. Lack of a protective layer of calcium carbonate will accelerate corrosion with subsequent buildup of iron oxide layers and severe under-deposit degradation.

Uncontrolled biological growth, stemming from inadequate chlorination or biocide treatment, will generate serious localized corrosion issues irrespective of the pipe metallurgy.

Continuous control of the water quality and its deposition and corrosion properties is a standard practice in the industry. It is used to determine treatment effectiveness and to establish the optimum level of treatment that is most cost-effective.

There are a number of variables requiring certain attention, as they can influence corrosion rate, especially for mild steel and surface deposition of calcium/magnesium carbonates:

1. Water hardness (calcium and total)
2. Temperature (inlet/outlet)
3. pH, conductivity (inlet/outlet)
4. Concentration level.
5. Free chlorine or biocide level (ORP)
6. Bacteria count

Figure 1 SmartCET® CET5500 Corrosion Transmitter.

The purpose of corrosion monitoring is to assess and predict corrosion behavior of the system. Basically, there are two objectives to monitoring:

1. Obtain information on the condition of the operational equipment and,
2. Relate this information to the operating variables (i.e., pH, temperature, water quality, chemical treatment).

Meeting these objectives will provide the following results:

3. Increase life of the plant
4. Improve the quality of the plant's product
5. Predict maintenance needs at the plant
6. Reduce plant's operating cost

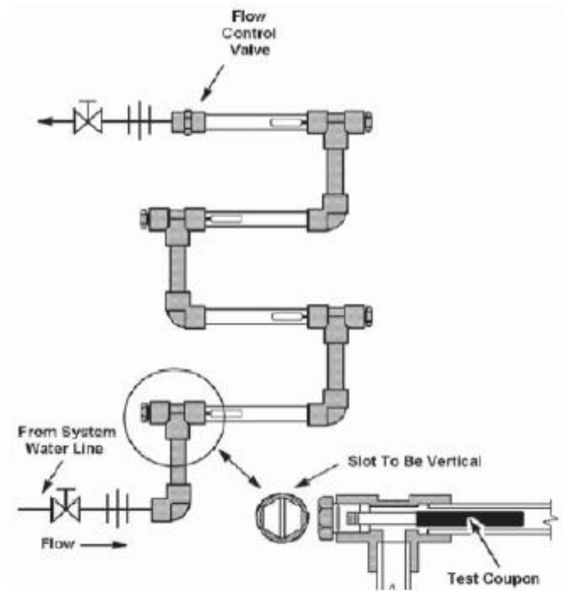

Figure 2 Typical corrosion-rack

Traditional Corrosion Monitoring

So called "corrosion racks" (Figure 2) are the most common method of corrosion monitoring, allowing for simultaneous application of various measurement techniques.

Corrosion coupons remain the most popular technique for corrosion measurement in cooling water systems followed by traditional Linear Polarization Resistance (LPR). Coupons, however useful in providing valuable information about the nature of deposition or corrosion mechanisms, can only present cumulative, off-dated results on corrosion rate.

Similarly, the traditional LPR technique, which may sometimes provide reasonable estimation of corrosion rate, fails in effective determination of the localized corrosion mode. Furthermore, based on fixed Stern-Geary parameter (B=26mV), traditional LPR under certain conditions (e.g.,bio-deposition) may under/overestimate measured corrosion rate – leading to false conclusions in terms of water treatment efficiency.

Modern, Real Time Corrosion Monitoring

The SmartCET® technology employs a combination of Electrochemical Noise (ECN), Low Frequency Impedance (LFI) and Harmonic Distortion Analysis (HDA) to provide output of a general corrosion rate, but also an evaluation of potential for localized corrosion (known as the Pitting Factor). This multi-technique monitoring system has been used for over 15 years to evaluate the mode of corrosion failure in cooling water and process water systems, and then subsequently employed in the same systems to help identify a suitable formulation and dosage level of corrosion inhibitor to control the localized corrosion.

Availability for Wireless communication and option for standalone data-logging data acquisition makes SmartCET a universal corrosion monitoring tool for cooling water systems.

Technology Description

The SmartCET® technology combines three individual electrochemical measurement techniques to provide, at every 30s, the most accurate general corrosion rate, together with indications of:

a. localized (e.g., pitting) corrosion, and,

b. the tendency toward scaling (both non-conductive scales and the conductive iron sulfide that may result from microbiological activity).

The SmartCET transmitter can be connected to a variety of probes, each designed with an optimal electrode configuration to enable accurate corrosion measurement in small or large diameter equipment, high or low electrical conductivity, and in processes with a broad range of physical and chemical attributes.

The transmitter is a loop-powered device that uses 4-20mA with HART communications. While the 4-20mA signal is mostly used for general corrosion purposes, the digital HART protocol can be employed to provide three additional variables: Pitting Factor, B Value and Corrosion Mechanism Indicator (CMI). The data can be output directly to a variety of end-user devices, including distributed control systems (DCS – Figure 3), SCADA, paperless data recorders, etc. The availability for wireless communication and an option for standalone data-logging and acquisition makes SmartCET a universal corrosion monitoring tool for cooling water systems.

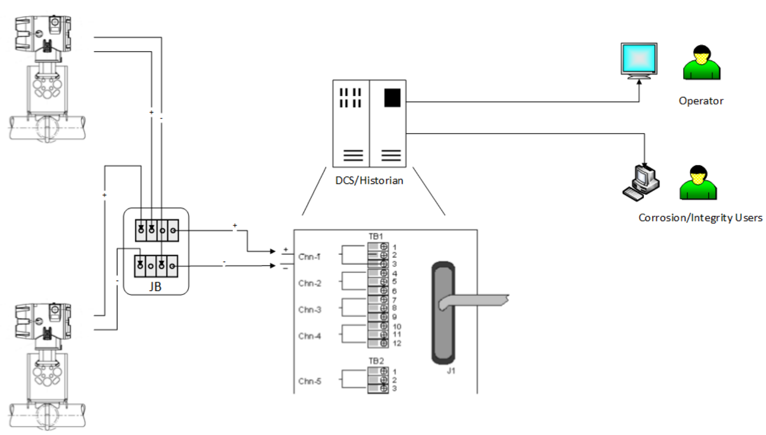

Figure 3 Schematic connection of SmartCET with DCS-HART enabled system

Monitoring locations:

The common engineering practice recognizes at least three typical locations for corrosion monitoring locations. Those are: (1) makeup water after treatment; (2) cold water feed to the process units and (3) water return line to cooling towers – see Figure 3). In several cases, there is a forth (4) location(s), near or at the critical heat exchangers, where corrosion fluctuations are likely occurring due to process conditions, is added.

1. Corrosion monitoring after treatment section, allows users to monitor the corrosivity of make-up water and link it directly to the effectiveness of inhibitor/bio-treatment/anti-scaling treatment. It will not reflect the overall system corrosivity,but may provide early alarm on unexpected failures of treatment system.

2. Low corrosivity in the feed cooling water is an essential element for maintaining the exchanger's performance and keeping the entire piping system protected against corrosion. Typical levels of corrosion in this point should not exceed 1-2mpy (0.025-0.05mm/y).

It is important to mention that due to inertia of the cooling system, changes in water corrosivity will be delayed. Therefore, it is necessary to observe trends of other corrosion variables (B, PF, CMI) to note abnormal excursions, which may be very early indications of changes in water corrosivity.

3. Corrosion monitoring in hot water return is an ultimate indication of proper corrosion/deposition control in a given cooling system. Usually, the corrosion rate is expected to be slightly higher than in the feed line, but still should not exceed 3-4mpy (0.075-0.1mm/y). Low corrosion on the returning water stream proves the high quality of applied water treatment. Observation of other than the CMI parameter may provide information about deposition in last raw of heat exchangers where concentration of anti-scaling agents may not be sufficient – causing an elevated tendency for deposit formation. This will not immediately impact the corrosion rate (at the end calcium carbonate has some protective properties), but definitely will affect heat exchange efficiency.

4. Critical heat exchangers (with very large temperature gradient between hot and cold medium) should be equipped with separate corrosion monitoring tools. Specific locations will vary from case to case – on the shell side or hot water outlet. Unfortunately, tube-side corrosion measurement is not possible due to limited access to exchanger's tubes and their small ID.

Application areas

SmartCET technology can be used in a variety of water systems, not limited specifically to cooling water areas. Because of combination of low frequency impedance and harmonic analysis, it is capable of measuring corrosion in fluids with conductance of about 2-3 μS/cm without IR-compensation. That makes the technology suitable for real-time corrosion monitoring in steam condensates or pure water streams. Table 1 shows some popular application areas of SmartCET.

Table 1 SmartCET applications in water streams.

Process fluid	SmartCET® applicability
Cooling water systems	YES
Low pressure condensates	YES
Water treatment plant / waste water	YES
Boiler feed water	YES
White water (Pulp&Paper)	YES
Drinking water	YES
District heating systems	YES
Injection water / produced water (Oil&Gas)	YES

Honeywell's field-proven corrosion monitoring technology - SmartCET - offers measurable improvements and benefits for cooling water systems applications:

- Real-time (30s) and accurate corrosion rate measurement
- Localized corrosion potential indication (Pitting Factor)
- Real-B determination – always accurate corrosion rate
- Insight view of surface processes – CMI parameter
- Tight control of inhibitor usage (corrosion inhibitors, anti-deposition agent and biocide)
- Low-cost maintenance
- Capability for rapid testing of corrosion resistance for various materials (e.g., electrodes replacements)
- Allows catching process upsets for faster remediation and minimization of their impacts on asset integrity
- Three options for corrosion data handling:
    - Direct connection to DCS/SCADA via 4-20mA/HART
    - Wireless communication via ISA 100 protocol
    - Standalone, low-cost Data Logger system

Honeywell Predict® Corrosion Suite

Honeywell Predict Corrosion Suite provides next generation corrosion management solution or oil and gas and refining industries seeking to move from reacting to corrosion damage to a more proactive and effective approach, Honeywell Predict® Corrosion Suite provides the next generation of corrosion management solutions. Unlike conventional corrosion management methods, we employ unique prediction models that encapsulate deep expertise and extensive process data to correlate corrosion rates to specific process units, damage mechanisms, and operating conditions. Using Honeywell's tools, global major companies have achieved significant operational and business benefits.

The Honeywell Predict Corrosion Suite is a unique solution for today's industrial facilities, driving a paradigm shift in tackling difficult corrosion problems, and enabling efficient and safe operations. These software tools help users move away from a reactive response to corrosion based on qualitative, manual inspections, to a proactive, reliability-centric predictive approach based on quantitative information from soft sensors, sound process deviation management, and "what-if" scenario analysis tools.

Why Honeywell?

Your operation can benefit from partnering with a proven leader in corrosion asset integrity and preventive/predictive corrosion management. Honeywell has extensive intellectual property in the corrosion field, including unique corrosion prediction and material selection models, and patented corrosion monitoring technology. Our deep expertise includes an in-house team of experts with decades of experience in developing corrosion solutions. Honeywell's IP-based models are licensed and used by many global oil & gas majors, and our company has a recognized track record of world-class execution of projects.

Honeywell has also established a unique corrosion knowledge community through our Center of Excellence (COE). We assist customers with expert local and remote support. Our state-of-the-art corrosion and materials research and engineering laboratory provides a host of standard and tailored services. Utilized in Joint Industry Programs and customized testing, this facility can simulate any service environment.

For More Information

Learn more about Honeywell's Corrosion Solutions, visit www.honeywellprocess.com/Corrosion or contact your Honeywell Account Manager, Distributor or System Integrator.

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