

COOLING TECHNOLOGY INSTITUTE

Deposit Monitoring



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This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Approved by the CTI Executive Board.



This document has been reviewed and approved as part of CTI's Five Year Review Cycle. This document is again subject to review in 2027.

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CTI-Guideline
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WTG-130B Deposit Monitoring

Scope

The purpose of this document is to identify the available deposit monitoring techniques and procedures for cooling water systems, along with their advantages and limitations.

Two other CTI documents exist to address problems that lead to deposits. One document addresses corrosion monitoring (WTG 130 A) and the other addresses microbiological monitoring (WTG 130 C). This document is focused on deposits in general and does not cover the specifics of corrosion monitoring nor microbiological monitoring.

This document will discuss some of the methods associated with practical monitoring of deposition in cooling systems.

Introduction

The purpose of this document is to provide a review of deposit monitoring techniques used in cooling water systems. This review will provide methods that can be used by owners, operators, and water treaters of cooling water systems. After an introduction describing deposits, the sources of deposits and where they can be expected to exist, a description of both qualitative and quantitative deposit monitoring will be provided.

Water-cooled equipment is inherently prone to deposition from mineral scales, particulates, corrosion products, and biological organisms. In open recirculating systems, dissolved minerals and particulate matter can enter the system with the makeup water. For instance, if cold lime softening is used for pretreatment, loss of lime feed can dramatically change the water characteristics; pH, hardness, etc. Recycle waters can present a challenge from a chemical variability standpoint.

Additionally, particulate matter, aerosols and gases, such as CO₂ and NH₃ are scrubbed from the air in the evaporative section of the cooling tower. Iron oxide corrosion products (chip scale and tubercles) increase the deposition potential by reducing flow (water velocity). Bits of cooling tower wood resulting from chemical attack I (delignification) or microbial activity or pieces of plastic fill or fiberglass adds to debris fouling and can impede water flow. Biological growth adds to the fouling potential by reducing flow and by providing an excellent substrate for the adherence of particulate matter carried by the recirculating water. These types of deposits can result in reduced heat transfer, equipment corrosion, premature equipment failure, and increased operating costs.

Monitoring deposition is an essential part of any cooling system evaluation program. The gathering and interpretation of the various data can be used to determine the effectiveness of the deposition control program. There are numerous methods that can be used to measure the effectiveness of a treatment program in cooling systems.

Monitoring can and should include simple inspections of any exposed and observable components, such as cooling tower supports and any opened equipment or piping that may be viewed during routine or non-routine unit shut-downs. Inspection monitoring mostly provides qualitative data, and generally does not yield quantitative data, which is typically more effective for trending analyses.

Mineral deposition is typically affected by pH, temperature, velocity, and concentration of scaling species in the cooling water, among other factors. Methods employed to monitor deposition should take these factors into account. The most accurate monitoring will be accomplished by the devices that most closely simulate actual heat exchanger performance and geometry.

Deposition Characteristics

Most often there is one compound that is the primary source or cause of the deposit. However, the presence of the deposit or the act of deposition may cause more than one compound or type of deposit to be present (co-precipitation). Using laboratory analyses, one can determine the most likely composition of the deposit and then use that information to establish the causes of the deposition and potentially eliminate them. Cooling water deposits are broadly classified into either mineral scales or foulants. Mineral scales are generally crystalline structures that result from the formation and precipitation of dissolved salts, such as calcium carbonate, calcium sulfate, calcium phosphate, silicates, and silica scale; silica can also be amorphous. Foulants are amorphous deposits formed when suspended materials settle out or otherwise adhere to surfaces. The most common foulants are mud, sand and silt, sludges, metal oxides (corrosion products), process contaminants, and microbial material (bacteria, fungi, and algae).

Scale is formed by the precipitation of a soluble species from the bulk cooling water due to supersaturation at a surface or in the bulk water. Calcium carbonate is by far the most common carbonate scale. Magnesium carbonate is rarely seen and will only form when pH is

extremely high and magnesium is the predominant form of hardness present. Calcium phosphate occurs when orthophosphate and calcium precipitate. Calcium can also precipitate with phosphonates particularly at high temperatures and/or inadequate polymer dosing. Other phosphate scales generally involve zinc, iron, or magnesium. Elevated pH increases the precipitation tendency of all phosphate scales.

For temperatures typical in cooling systems and heat transfer surfaces, calcium sulfate follows normal solubility and is pH-independent.

Some salts exhibit retrograde solubility (inversely soluble with respect to temperature) and include calcium carbonate, calcium phosphate, magnesium silicate and calcium magnesium silicate.

The type of silicate scale observed depends upon the pH of the system. Magnesium silicate and calcium magnesium silicate scale are typically observed at higher pH and/or higher temperature.

In contrast to silicate scales, silica scale exhibits normal solubility and can be observed in lower temperature areas, e.g. cooling tower fill.

Other types of scale that can be observed include calcium fluoride and manganese dioxide.

The potential for scaling can be predicted using saturation modeling. Such tools model multi-component simultaneous equilibria interactions of dozens of mineral salts. Saturation modeling can establish when deposition is anticipated to occur and what chemistries, dosages, and operating conditions are required to operate successfully via the mitigation of scaling/deposition. Deposit formation resulting from insoluble particulates in the cooling water is typically referred to as fouling. Fouling can result from particulate matter carried in from the makeup water, scrubbed from air, precipitated within the cooling water, or generated by corrosion. In addition, biofouling is the growth or deposition of biological organisms on a surface (biofilm). Biofouling includes bacterial slime formations actively growing on surfaces and biological masses (e.g., algae and slime) transported by the cooling water.

Qualitative Deposit Monitoring – Non-Heat Transfer

Visual Observations

One fundamental measure of system health is the appearance of the cooling water and the cleanliness of the tower. Visual observations should be conducted on a routine basis. Plant personnel should observe the appearance of the cooling tower basin water, cooling

tower support structures, tower fill, and, for crossflow towers, the distribution pans.

Typical indications of a clean system include clear basin water and negligible sediment. Algae on fill sections of a cooling tower or on the distribution deck for cross flow cooling towers should not be present in a well maintained system. On counterflow towers, the water pattern in the rain zone should be observed. Starved or “dry” sections may be an indication of plugged fill, laterals, or spray nozzles. Conversely, sections manifesting high flow are indicative of broken spray nozzles or leakage from laterals or headers.

Coupons

Visual inspection of corrosion coupons, typically positioned in a side-stream bypass coupon rack, can be a valuable tool to monitor for deposition. Any amount and type of deposition present on the coupons should be noted. A sample should be collected if possible for the purpose of constituent determination.

It is beneficial to insert a stainless steel coupon in the first (upstream) position specifically to monitor for biological fouling. At a minimum, there should be weekly visual inspections. Stainless steel mesh coupons can be used for monitoring biofilm formation (sessile bacteria). Plastic coupons with a roughened surface have also been employed.

However, to quantitatively assess bacterial growth, the test coupon should be either swabbed with cotton or sonicated (vibrated) with a known quantity of sterile water and analyzed with existing techniques for aerobic and anaerobic bacteria. Surface swabbing is a versatile technique resulting in a measurement of biofilm in cfu/cm² (or RLU/cm² with the ATP approach) of swabbed area. One can also use a filter to “collect” microbial debris.

Cooling Tower Basin Sludge

It is beneficial to monitor the sludge depth in the cooling tower basins on a routine basis. Depending on the specifics of the basin design, the sludge layer can get to a point where it sloughs off or becomes entrained in the circulating cooling water leading to fouling problems. Septic sludge is indicated by the presence of anaerobic bacteria (such as sulfate reducing bacteria) in samples and should not be present in well maintained systems. Sludge samples can be obtained with a sampling device for subsequent quantitative analyses.

Pump Suction Screens

Most cooling water circulating pumps have some form of screen or strainer in front of the pump. The purpose

of this screen is to prevent large debris from impacting the pump mechanism (usually an impeller) which could cause damage. This debris could also accumulate in a heat exchanger which could block or reduce the water flow. In general, when a heat exchanger experiences reduced water flow its efficiency is greatly reduced, and it can become coated with deposits of one type or another, leading to cleaning expenses at the least, and possible corrosion damage.

To monitor the pump suction screens, one can use visual or instrumental methods. Simple visual inspection will show if they are becoming loaded with debris. A good guideline is to look at the height of the water upstream and downstream of the screen. Using the height difference one would know when to clean the screens. One would want to clean the screen when the height difference of the water exceeds manufacturers' recommendations.

Another common approach is to utilize a differential pressure gauge or two pressure gauges, and clean the screen when a target differential pressure is reached.

Deposit Evaluation by Fill Weight Gain

Deposits in a cooling tower's film fill affect the thermal performance, and, if severe, will compromise the tower's structural integrity. A key element of fill selection is matching the fill design to the circulating water quality. Monitoring the fill conditions can be accomplished using one of the following methods:

Load Cell

On field erected towers, a load cell can be used to monitor weight gain in cooling tower fill. Typical placement is between a bottom support beam and the fill. The fill packs above the load cell are interlaced and an exact reference to fill volume cannot be established. However, measuring the weight gain from a dry pack to wetted conditions will establish a water hold-up weight. Comparing this weight to the fill manufacturers' water hold-up for that fill design based on the tower's circulation water loading (gpm/ft^2 or lpm/m^2) will allow for a relative fill volume. Any additional weight gain would be typically attributed to scale, mineral deposits, sediment, biological matter and/or process contamination, etc. Fill fouling is typically not uniform. Since the load cells only give a general understanding of fouling conditions, other monitoring methods should be considered. Logging of the weight gain and taking preventive action if required is recommended.

In Situ Fill Inspection Area

In this method, one can select an easily accessible area that has representative water loading and locate a

minimum of three fill test samples. Test samples might typically measure 12" (30cm) W x 24" (60cm) H x 24" (60cm) L. Inspection sections are typically installed in the middle layers of a counterflow fill pack. For a 6' (1.8m) fill height, the middle 24" (60cm) layer should be the location of the test samples. By removing the top layer around the test samples for periodic inspections, one can remove these test packs and weigh them. When weighing the test fill packs, set a standard time for drying, such as two minutes after being wetted. For further inspection, these packs are cut to inspect the internal channels for fouling. This also allows sampling for further quantitative deposit analysis. Monthly inspection and logging of results is recommended. For fill that comes in "logs" a comparison of weight gain for the top, middle, and bottom sections of fill may also be useful.

Gamma Scan for Fill Density Measurements

This service involves the periodic use of a radioactive gamma source and receiver positioned across fill sections. This technique is typically utilized when a severe problem is suspected, but it can also be used for surveillance purposes. It is especially useful for sections of fill that cannot be accessed. Fill density can then be compared to clean fill density, thus allowing for proactive system cleaning to prevent catastrophic loss of the fill and supports.

Test Cooling Tower

The largest heat exchanger in the typical open recirculating cooling water system is the cooling tower. Fouling and scaling of the cooling tower fill will affect the heat rejection capacity, particularly for cooling towers utilizing film fill.

For very large installations, an inspection cooling tower is an option for cooling tower fill deposit monitoring. It is required to have the same water loading and relative air velocity, using a slip stream of makeup water. This method is designed to have easy access to the fill packs. The test tower should have the same fill depth as the process tower and a minimum of 4' (1.2m) x 4' (1.2m) plan area. This system will provide similar results as the *in situ* testing, but it also allows for inspections of conditions at any time. Log any fill weight gain weekly.

The drop in the cooling tower's thermal performance due to fouling can justify fill cleaning or replacement if necessary. Monitoring the fill condition can provide additional tools to measure and adjust the water treatment program.