OpreX™ Analyzer | Application Notes

Cooling Tower

pH and Conductivity Measurement

Introduction

Cooling towers are essential heat-transfer units that play a critical role in maintaining water-cooled systems' efficient and economical operation. They are utilized in various industries, including plastics, dry cleaning, manufacturing, petroleum refining, and electrical generation, to reduce the temperature of the water and repurpose it for repeated use.

In the past, cooling was achieved by using available water from nearby sources. Still, the high cost of equipment and growing environmental regulations by the local and governmental legislations have increased the emphasis on water treatment and reuse through recirculating cooling towers.

The performance of cooling towers is of utmost importance as the mineral content in the cooling water increases, leading to scaling and corrosion, which threaten the efficient operation of the heat exchanger. Water treatment programs are implemented to maximize concentration cycles (When the water contains two times the original mineral content, it is said to contain two cycles of concentration. When it contains three times the original mineral content, it has three cycles of concentration and so on) while minimizing scaling, corrosion, and microbiological growth.

It is crucial to bleed off or blow down a fraction of the recycled water and replace it with fresh water of a lower mineral concentration to prevent scaling. Two types of cooling towers exist: direct cooling towers, which are enclosed structures with internal means to distribute warm water, and indirect cooling towers, which involve no direct contact between air and the fluid being cooled.

Process Information- Cooling Towers

Cooling towers remove heat from water-cooled systems by allowing a small portion of the water being cooled to evaporate into a moving site stream, which provides cooling to the rest of the water stream. The cooled water is then recirculated back into the system. However, keeping the heat transfer surfaces clean is crucial for efficient operation. As the mineral content in the cooling water increases, scaling and corrosion become more likely, which can reduce heat transfer and cause thermal stress. For example, the solubility of calcium carbonate($CaCO_3$) decreases with temperature, leading to calcium carbonate scaling on the heat transfer surfaces. To prevent these, a water treatment program is needed to minimize scaling, corrosion, and microbiological growth.

One way to prevent scaling is to bleed off or blow down some of the recycled water and replace it with fresh water of a lower mineral concentration. There are two types of cooling towers: direct and indirect. Direct cooling towers involve distributing warm water over a labyrinth-like packing, while indirect cooling towers have two separate fluid circuits.

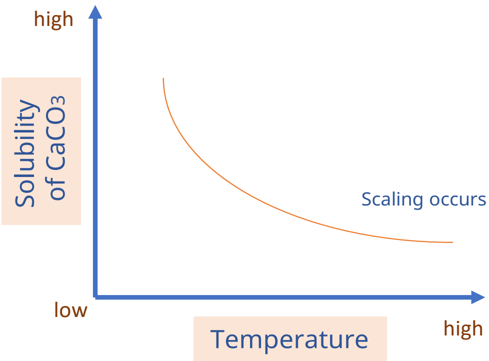


Figure 1. Temperature- Solubility of $CaCO_3$ relation

Impurities in cooling water can cause scaling and corrosion. Scaling impurities, such as calcium bicarbonate, can be removed by adding acid to the circulating water to lower the pH and increase solubility. However, care must be taken not to damage galvanized steel surfaces. Corrosive salts, which include dissolved minerals, salts, and metals, can be controlled using a conductivity analyzer and blowdown valve. Corrosion can be minimized by using a corrosion inhibitor.

Biocides, dispersants, and inhibitors are also added to prevent suspended solids' biological growth and coagulation/flocculation. Chlorine can be used as a biocide, and its activity level can be monitored using an ORP analyzer. Overall, cooling towers play a vital role in cooling water-cooled systems. Proper maintenance and treatment are necessary to prevent scaling, corrosion, and biological growth and to ensure efficient operation.

Note:
1. pH is a measure of the acidity or alkalinity of a solution. Aqueous solutions at 25°C with a pH less than seven are considered acidic, while those with a pH greater than seven are considered basic (alkaline). When a pH level is 7.0, it is defined as 'neutral' at 25°C because at this pH, the concentration of H_3O+ equals the concentration of OH-in pure water.
2. Conductivity is the measure of a solution's ability to carry an electric current. A voltage is applied across two plates which make up the conductivity cell. The current through the cell is dependant on the resistance of the liquid (Ohm's Law). Conductivity is the reciprocal of resistance; Siemens (conductivity) = I/OHM (resistivity).

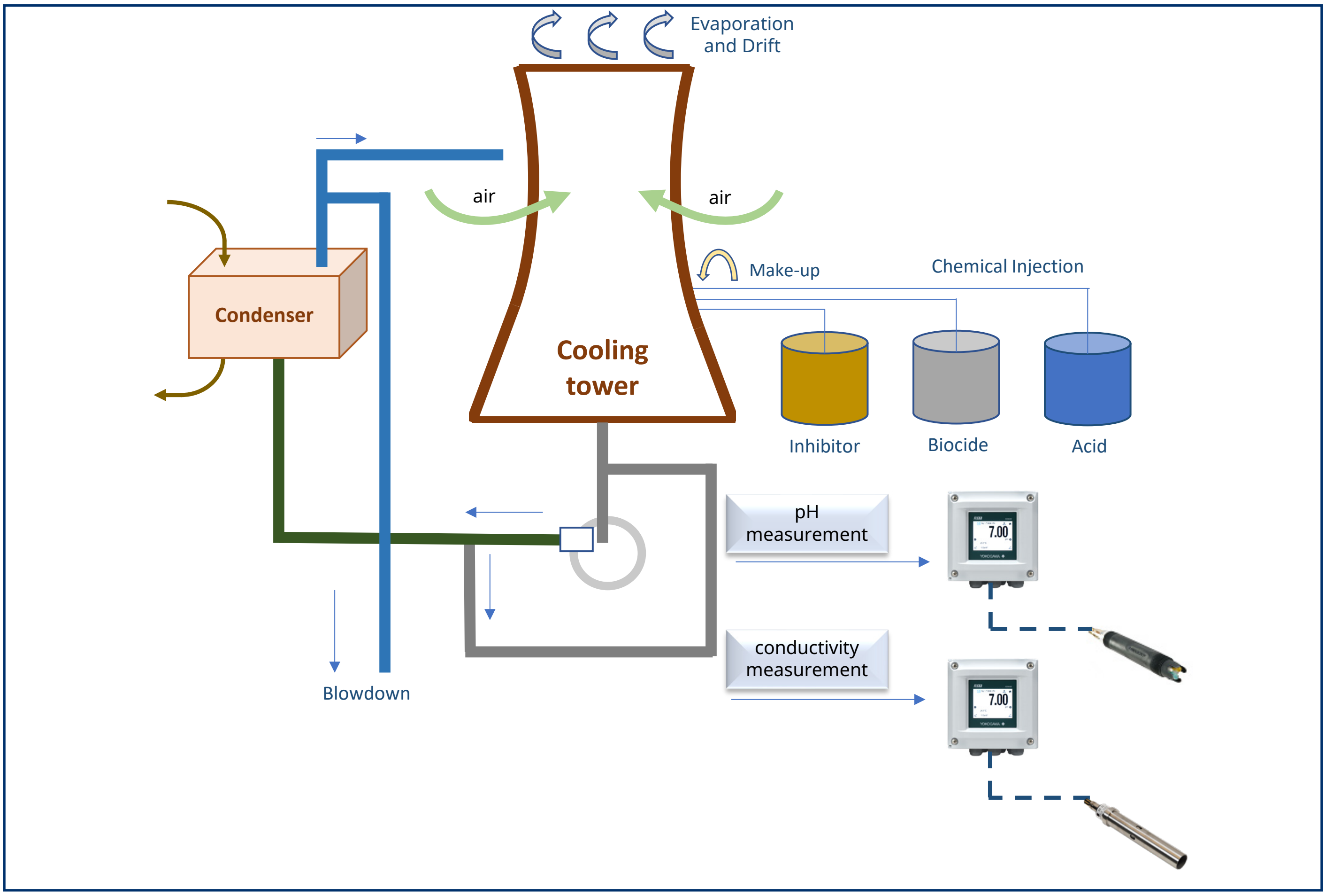


Figure 2. Cooling Tower Process

Summary

Most large air conditioning systems, and many industrial processes, require the use of water to cool some other fluid in a heat exchanger. The heat in the water is dissipated by cascading it down the inside of a cooling tower and blowing air through it. A good deal of the water will thereby be lost due to evaporation, but almost all of the dissolved solids will be left behind.

Over a period of time the level of dissolved solids will steadily increase until a number of undesirable things begin to happen, including corrosion and scaling. To maintain the efficiency of the heat exchanger and to protect the expensive equipment, it is necessary to "dump" some of the contaminated water and replace it with fresh blowdown. Conductivity is the measurement of choice for this blowdown application, while a pH measurement is used to measure and control the alkalinity level of the water in order to prevent corrosion.

Most towers can be adequately controlled using just conductivity and pH instrumentation. The "logic" circuit shown in figure 2 disables the chemical feeds during the blowdown of the tower. This saves costly chemicals by not allowing them to be fed down the drain with the solids being removed during the blowdown. More complex cooling tower systems include the addition of biocides, inhibitors ,and dispersants to protect the equipment further.

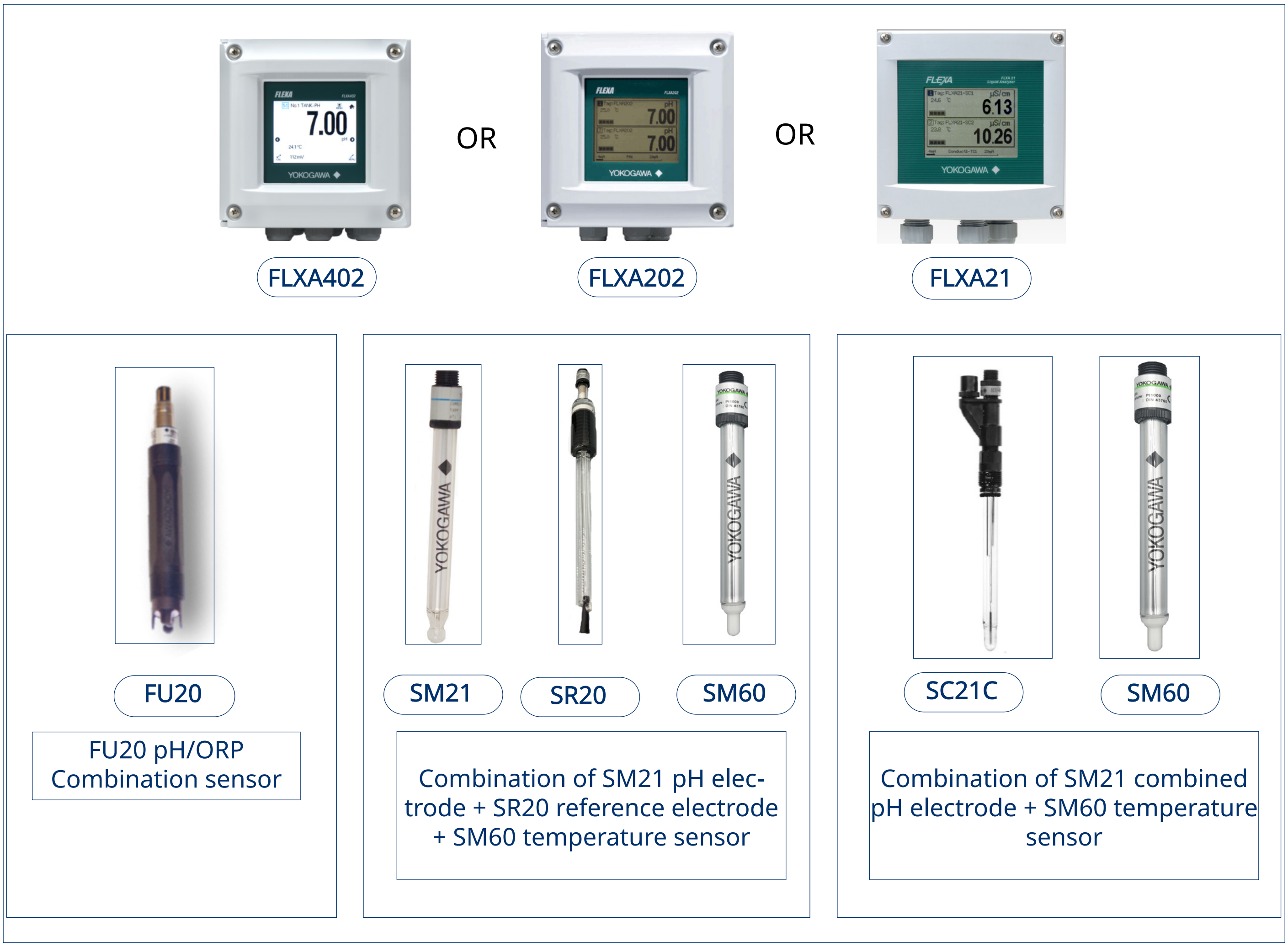
Product Recommendation

pH Measurement System

Transmitter
4-wire pH/ORP measurement system FLXA402
2-wire conductivity measurement system FLXA202/FLXA21

Sensor
Option 1: FU20 pH/ORP Combination Electrode (fittings available for Flow-Thru, Insertion, or Immersion installations
Option 2: F*20 Insertion or Flow-thru assembly series with individual measure, reference and temperature electrodes for pH/ORP (i.e. SM21-AG4, SR20-AP24 and SM60-T1; SC21C-AGC55 and SM60-T1)

2-wire/ 4-wire pH Measurement Systems		
Transmitters		
FLXA202/ FLXA21	2-wire Analyzer	General purpose, Intrinsic safety
FLXA402	4-wire Analyzer	General purpose
Sensors		
FU20	pH/ORP Combination sensor	fixed cable or WU10
SM21-AG4, SR20-AP24 and SM60-T1	Industrial Electrodes for pH/ORP	with WU20 cable
SC21C-AGC55 and SM60-T1	Industrial Electrodes for pH/ORP	with WU20 cable



Conductivity Measurement System

Transmitter
4-wire conductivity measurement system FLXA402
2-wire conductivity measurement system FLXA202/FLXA21

Sensor
Option 1: SC42 Conductivity Sensor (fittings available for Flow-Thru, Insertion, or Immersion installations)
Option 2: SC4A Conductivity Sensor (fittings available for Insertion, Sanitary, or Retractable installations)

2-wire/ 4-wire Conductivity Measurement Systems		
Transmitters		
FLXA202/ FLXA21	2-wire Analyzer	General purpose, Intrinsic safety
FLXA402	4-wire Analyzer	General purpose
Sensors		
SC42	Conductivity Sensor	WU10 or WU40
SC4A	Conductivity Sensor	fixed or WU10

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