Amiad's Industrial Cooling Solutions

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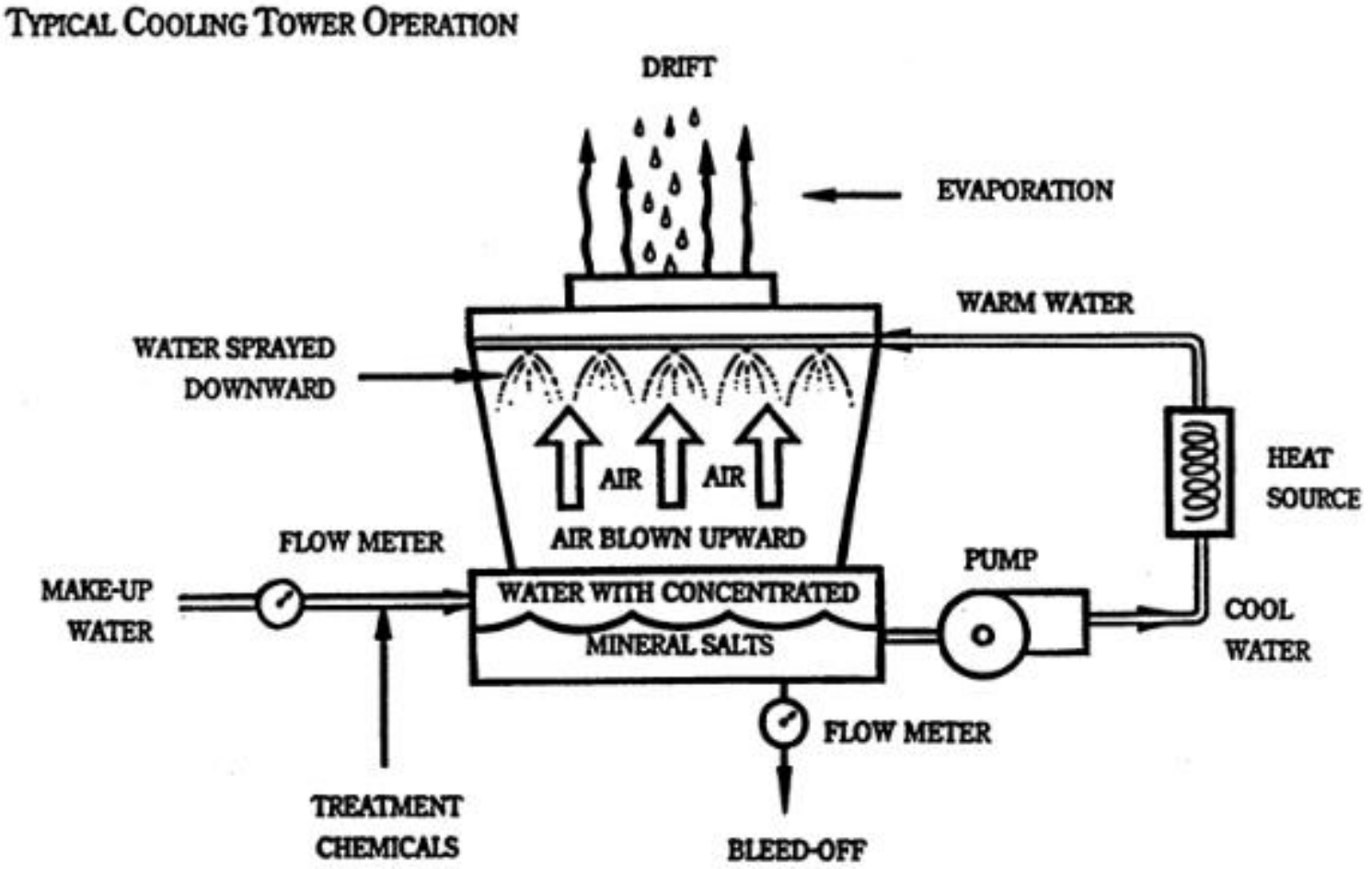
Applications

- Open (adsorption) cooling towers
  - Side stream
  - Full stream
- Closed loop – chillers
- Make-up water
- Heat-exchanger protection
- Nozzle protection
- Sweeper jets (for basin)

What is a cooling tower?



What is a cooling tower?

- A cooling tower is a huge heat pump
- Uses atmospheric evaporation and solar energy
- Each ton of water that evaporates equates to:
  - 539,000 kCal
  - 626.75 kW/hr
  - 2,138,752 BTU
  - 841 HP

The cost of cooling tower evaporation

- It may be assumed that a cooling tower will have 0.8 - 1.2% evaporation out of its circuit volume (depending on climatic conditions)

- Only water evaporates – salts and suspended materials stay behind and accumulate and concentrate in the water
- Blow down of water (based on concentration of contaminants) and introduction of make-up water is used to control concentration of contaminants

What are differences between chillers and cooling towers

- Both chillers and cooling towers are used to remove heat from water

- Cooling towers remove heat from the water that is discharged from a condenser
  - discharged water is recycled back into the plant to be used to cool the system again, or discharged into the water tank

- Chillers absorb heat from a coolant, which is fully contained in a cooling system
  - heat is transferred into the air around the chiller unit

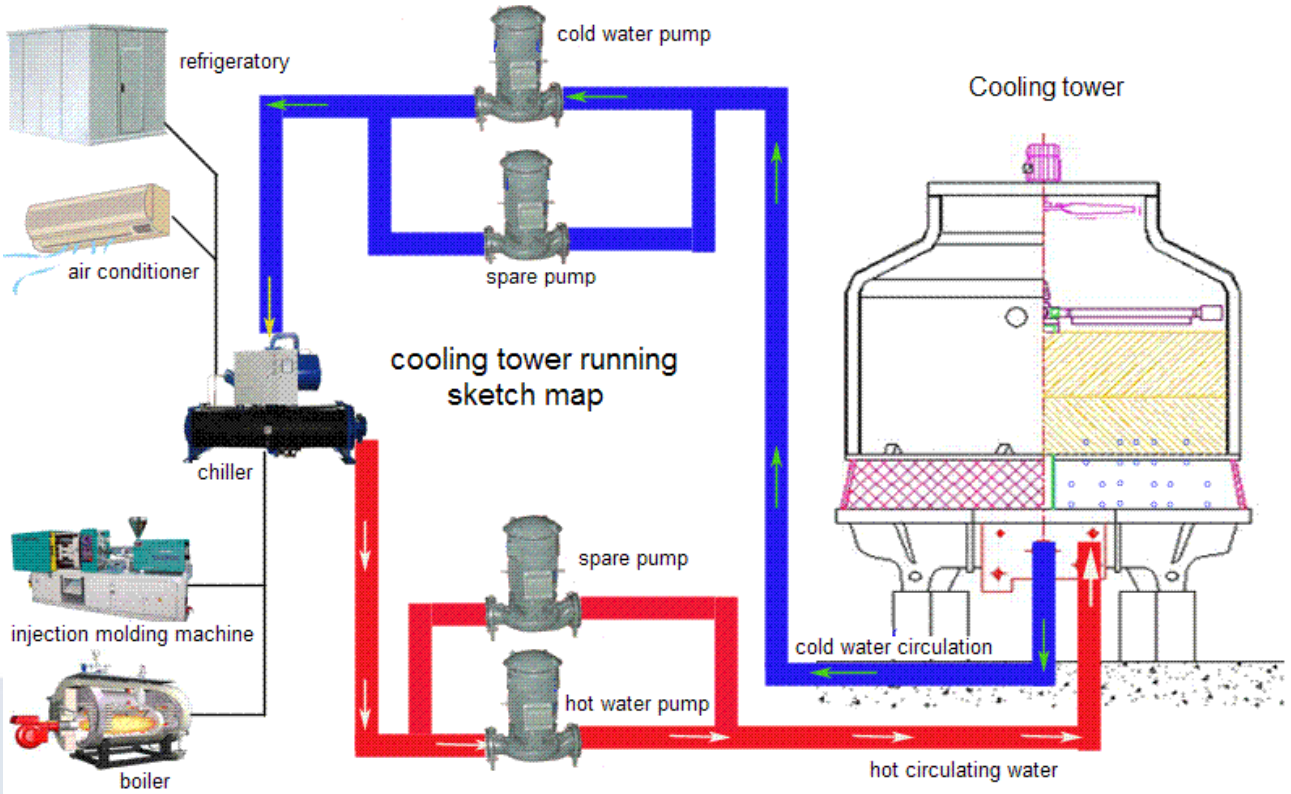
What is a chiller?

Chiller functions:

- Cool water or coolant down below ambient temperatures
- Heat water or coolant to high temperature

Types of chillers

- Air-cooled chiller: It uses outdoor air as the medium to remove the heat
- Water-cooled chillers: The heat is transferred to water which is an efficient medium



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Cooling tower vs. chillers

Parameter	Cooling tower	Chiller
Temperature differential	40°F	Depends upon heat exchangers
Cooling energy	By the atmosphere – energy consumption is by pumps and blowers	By gas compressor, gas is usually cooled by 2nd loop
Flow rates	Medium to large (can be very big for full stream)	Small to medium, large flows would demand too much energy
Water loss	Open to evaporation, blow-down and make-up water	Closed loop, leaks and limited evaporation are only losses

Cooling tower vs. chillers

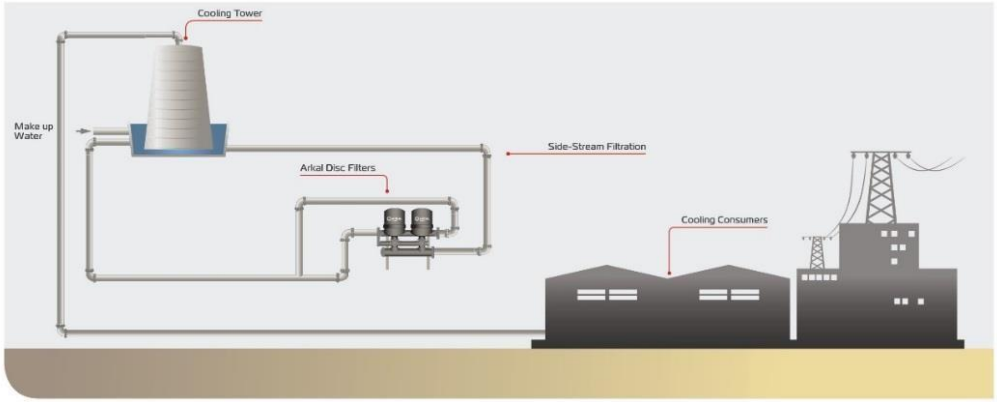
Parameter	Cooling tower	Chiller
Water contaminates	Solids from air exposures, make-up water, piping, bio-growth	Piping, bio-growth
Treatment targets	Scale, corrosion, bio-control, filtration, pH control, blow-down	Corrosion, bio-control, minimal filtration, pH control
Treatment methods	Chemical (anti-scalents, corrosion inhibitors, bio-control, pH control), Physical (filtration of suspended solids)	Chemical (anti-scalents, corrosion inhibitors, bio-control, pH control),
Proximity to process	Removed, in utility location	Very close to process

Cooling tower water treatment

- Cooling towers require large amounts of high quality water
- Inadequate water treatment systems can result in:
  - Equipment fouling/clogging → failures
  - Poor heat transfer
  - Reduced water efficiency (frequent blow down, increased make-up water needs)
  - Increased chemical usage
  - Dangerous health and safety concerns
- All of these issues can be very costly and drastically reduce the overall plant productivity and efficiency

Open tower systems

- Cooling towers act in a similar way to air scrubbers by collecting all particles from the surrounding environment into the cooling water
- Particles such as dust, sand, algae and pollen attach easily to the hot surfaces during the circulation inside cooling system, and cause clogging, fouling and reduction in efficiency of the process
  - Results = shut down of the system for cleaning
- Efficient filtration is very important for maintaining the continuous operation of the cooling system
- Amiad automatic self cleaning filters, either as side stream or full flow filters, will remove particulate to help avoid the above mentioned problems and will also decrease the chemical consumption required for water conditioning



Cooling water contaminant: scale

- Forms on heat transfer surfaces when dissolved solids precipitate out of the cooling tower water
  - Carbonate precipitation
- Problems caused by scale:
  - Reduces heat transfer in condensers and other water cooled heat exchangers
  - Can cause higher pressure requirements to move water through impacted openings
  - Increases power consumption
- Solutions
  - Chemical treatment to prevent precipitation or remove precipitates
  - Filtration – by reducing suspended solids in the water, less chemicals are required for scale treatment

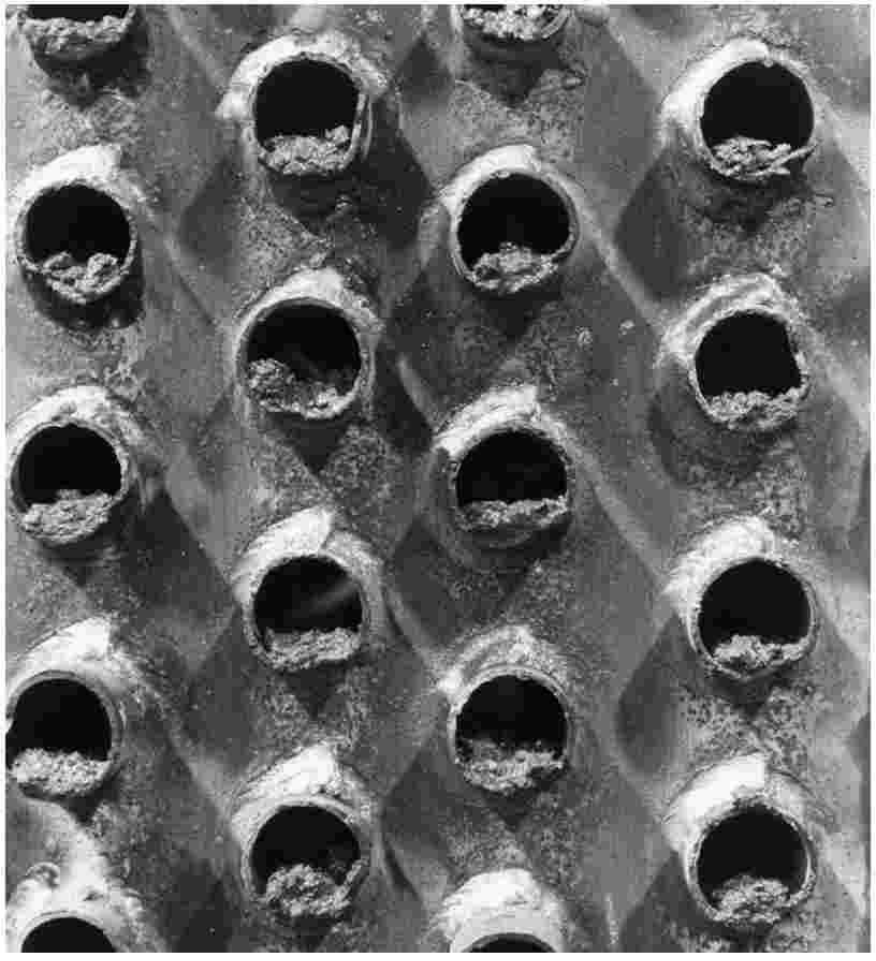
Cooling water contaminant: corrosion

- Electrochemical reactions between the metallic in the system and the water
- Problems caused by corrosion:
  - Reduces heat transfer in condensers and other water cooled heat exchangers
  - Can cause flow restrictions and leaks
  - Damages equipment
- Solutions
  - Chemical treatment to prevent corrosive reactions
  - Filtration – removes metal oxides and flakes that may plug nozzles and damage equipment

Cooling water contaminant: fouling

- Buildup of contaminants on equipment within the cooling tower system (most typical – heat exchangers and tower fill
  - Can include growth of bacteria, algae, fungi or other organisms circulating in the system
- Problems caused by biological fouling:
  - Uncontrolled biological growth and its waste deposits on system equipment
  - Reduces heat transfer in condensers and other water cooled heat exchangers
  - Change in piping diameters resulting in lower flow and higher pressure drops
  - Increased energy requirements (pumping to overcome pressure drops)
  - Clogs valves and solenoids
- Solutions
  - Chemical treatment to prevent corrosive reactions
  - Filtration – reduces biological suspended solids leading to less chemical requirements

Fouling examples



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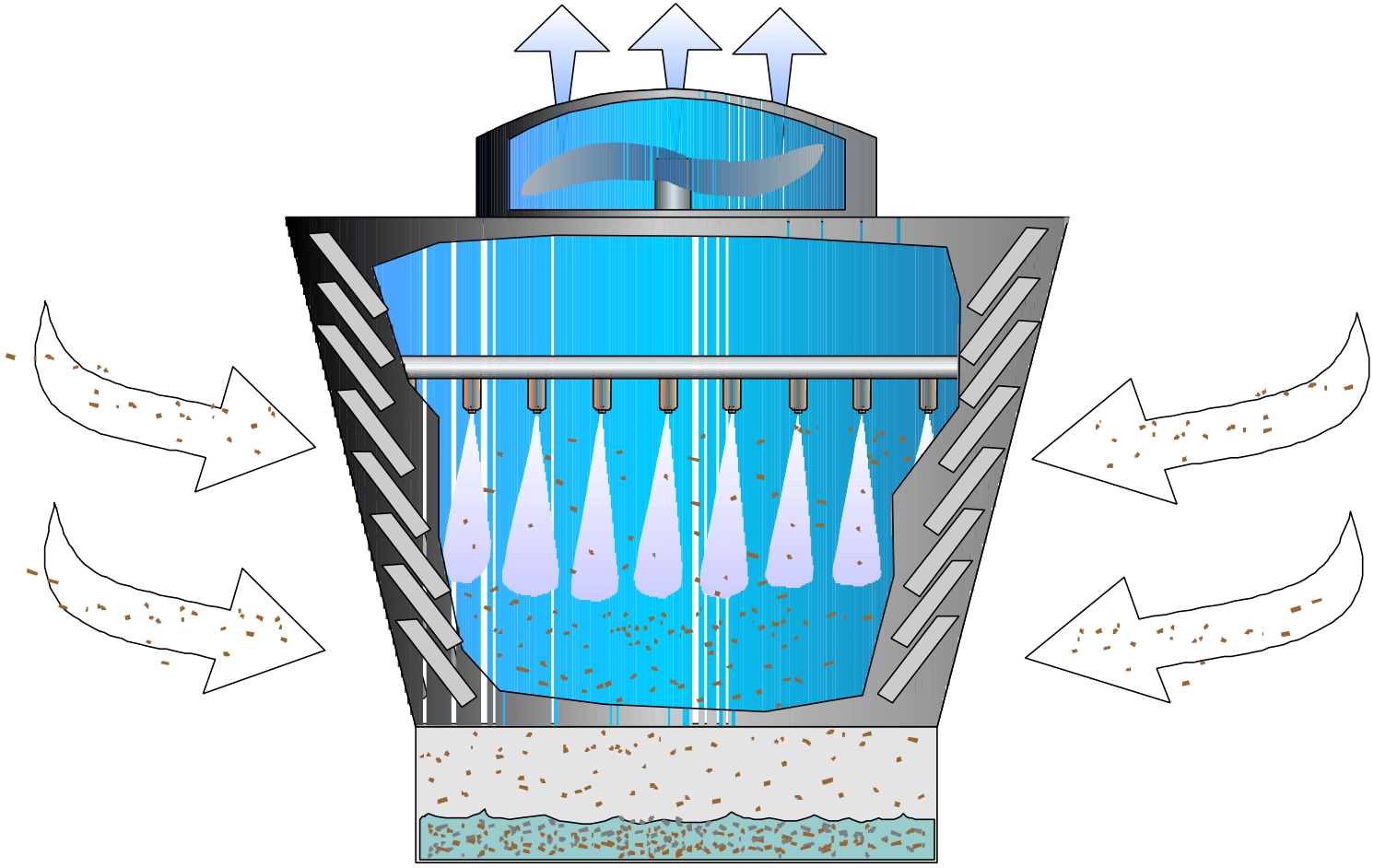
Cooling water contaminant: airborne particulate



Cooling water contaminant: airborne particulate

- Drawn into the tower(s) as part of the cooling process and collects in the tower water
- "a typical 200 ton cooling tower in a season, may assimilate upwards of 600 pounds of particulate matter from airborne dust and make-up water supply" (ASHRAE Handbook, 1996)
- Problems caused by airborne particulate:
  - Settle on equipment surfaces and deposit in the tower basin
  - Reduces heat transfer in condensers and other water cooled heat exchangers
  - Adds surface area for scale build-up and biological growth
  - Can cause flow restrictions
  - Clogs valves and solenoids
- Solutions
  - Filtration – reduces biological suspended solids

Objectives of cooling tower water treatment

- **Prevent scaling of condenser and cooling tower**
  - Removal of scale-forming constituents through external treatment
  - Keeping scale-forming constituents in solution with internal treatment
- **Prevent fouling of condenser and cooling tower**
  - Removal of suspended solids by filtration
  - Use of dispersants/surfactants
  - Use of condenser tube brushes (on-line)
- **Prevent corrosion of metal in contact with cooling water**
  - Corrosion inhibitors
  - Adjusting pH
  - Sacrificial anodes

Objectives of cooling tower water treatment

- **Prevent bio-mass and bio-corrosion**
  - Chemical treatment
  - Condenser tube brushes (on-line)
  - Removal of suspended solids by filtration
- **Prevent deterioration of cooling tower (lumber or metal)**
  - Chemical treatment of the tower
  - Chemical treatment of the water
- **Prevent the proliferation of pathogens (Legionella bacteria)**
  - Removal of suspended solids by filtration (proliferation site)
  - Chemical treatment of the water

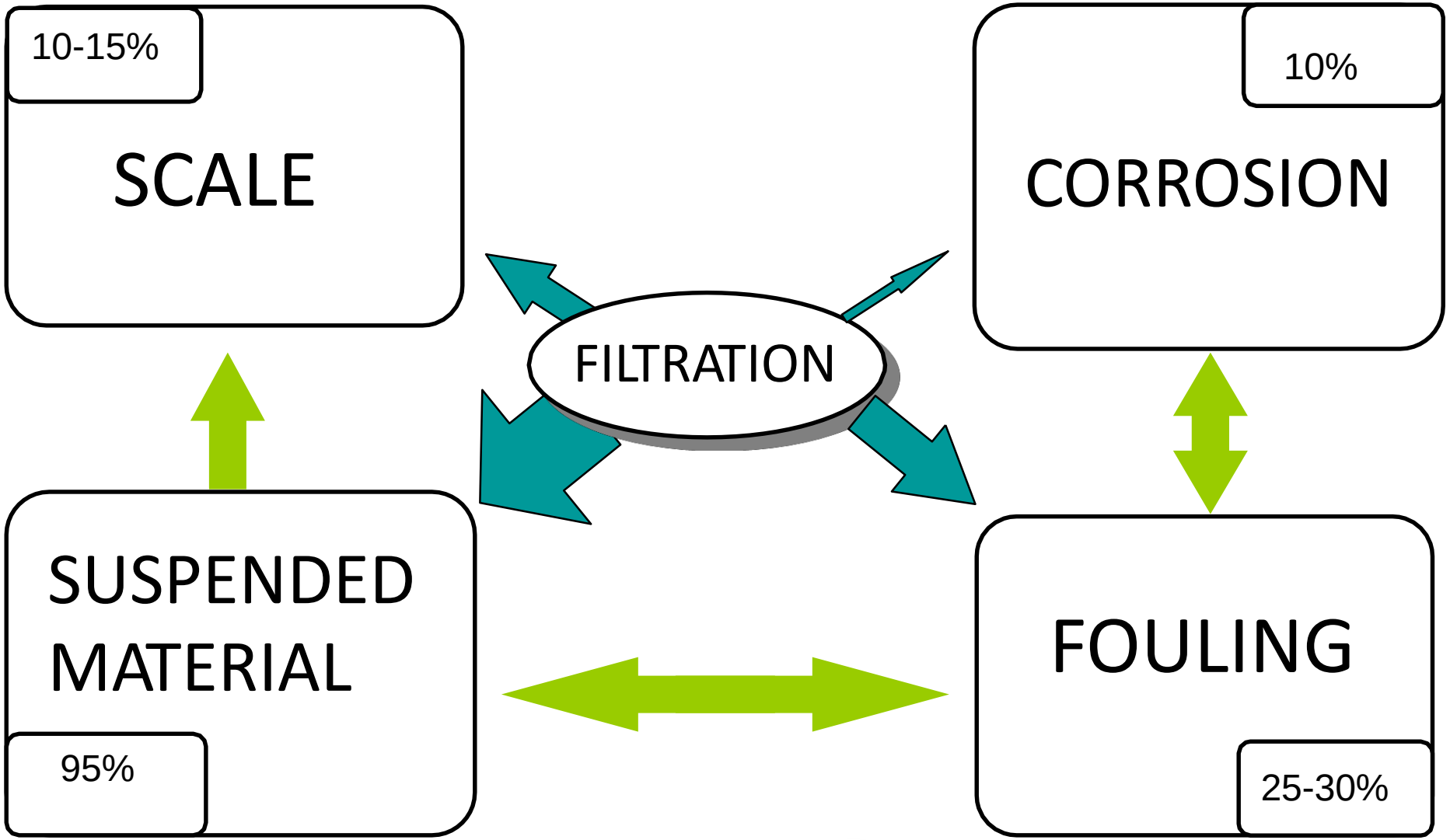
Objectives of cooling water treatment

The goal is not to eliminate chemical treatment, but to work with chemical treatment to build the most efficient and effective treatment system

Improved chemical performance

- Chemicals used to inhibit scaling and corrosion are adsorbed onto particles instead of the equipment surfaces they are designed to protect
  - Suspended solids are detrimental to a water treatment program and will require the use of more chemicals.
- Particles also adsorb biocides allowing increased microbial growth
- If suspended solids settle out in low-flow areas due to poor design, they provide additional bio-growth area

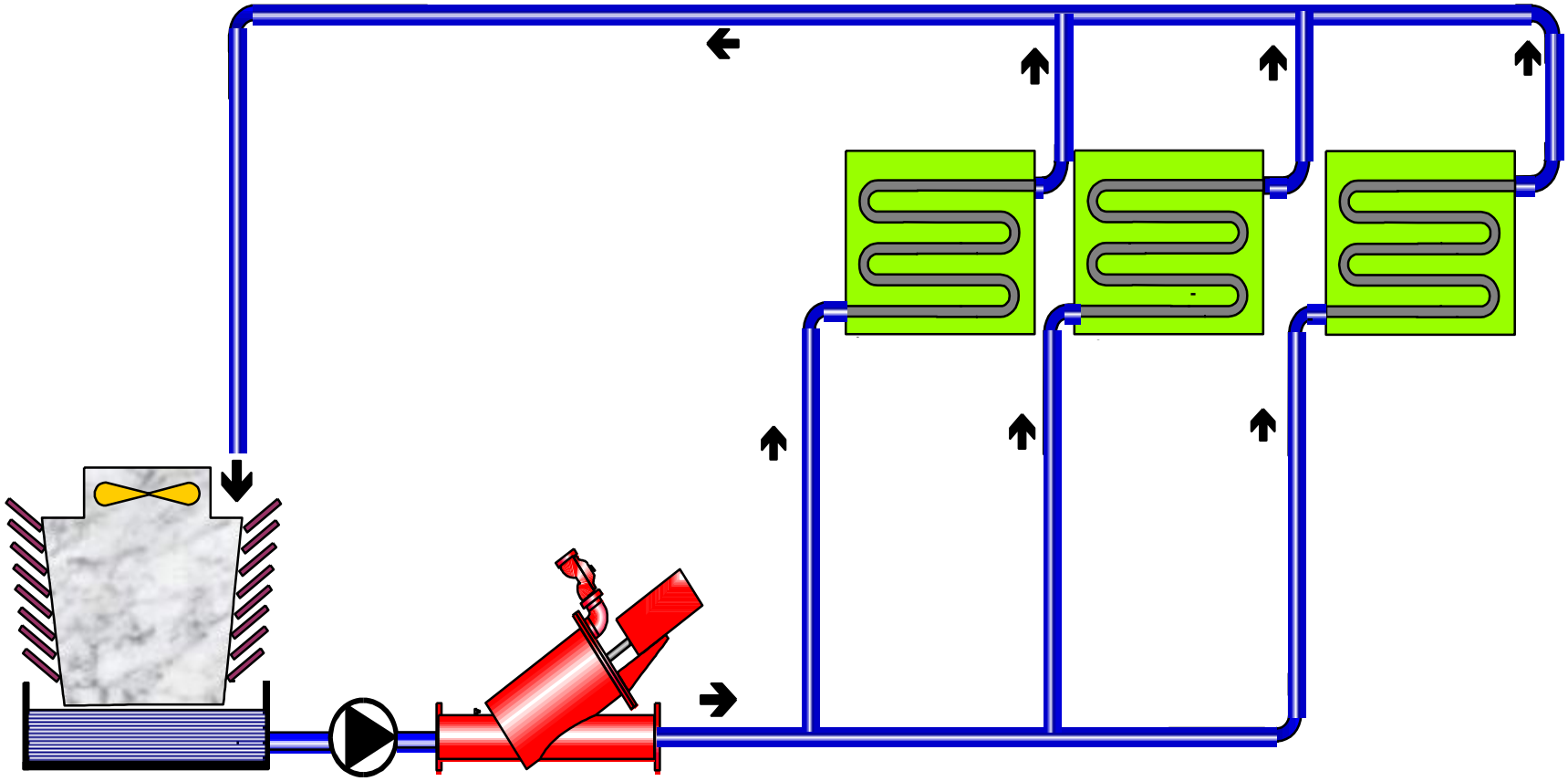
Effect of filtration on contaminants



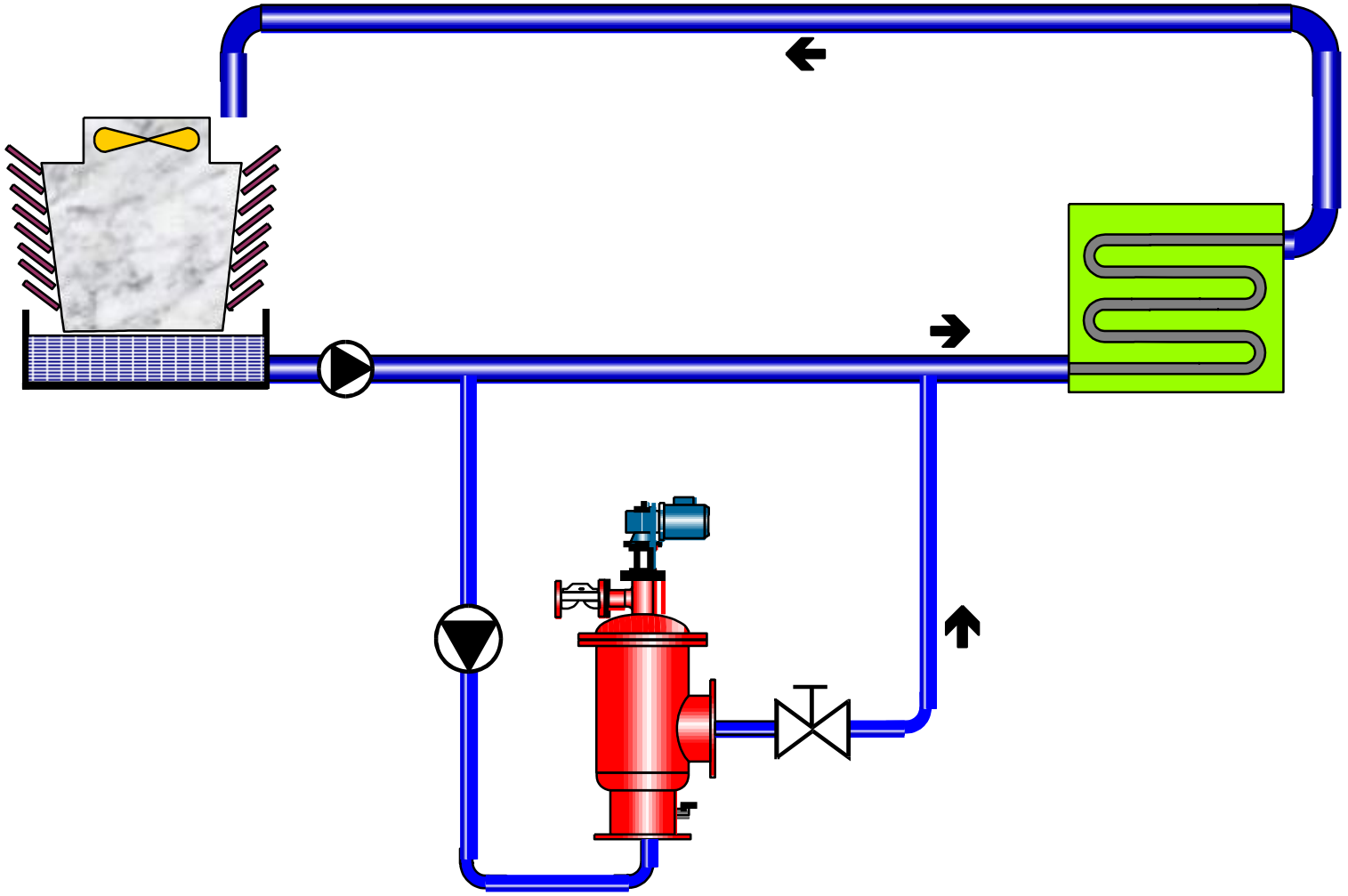
Side stream vs. full stream filtration

	Full stream	Side stream
Operation concept	The full flow of the circulated stream is filtered	Only a certain portion of the flow is filtered, 5-15%
Filtration grade range	40-100 micron	40-75 micron
TSS that can be achieved with filtration	10-20 PPM	40 PPM for typical percentages, lower TSSs with higher side stream
Wastewater of filter vs. blow down	Similar to blow down rate	Only 5-10% of typical blow down
Bypass	Required – to prevent shut down during maintenance	Not required
Costs	Higher	Much lower, even with finer filtration
Time to reach steady state	Hours	A few days
Costs	High	More cost effective to treat side stream

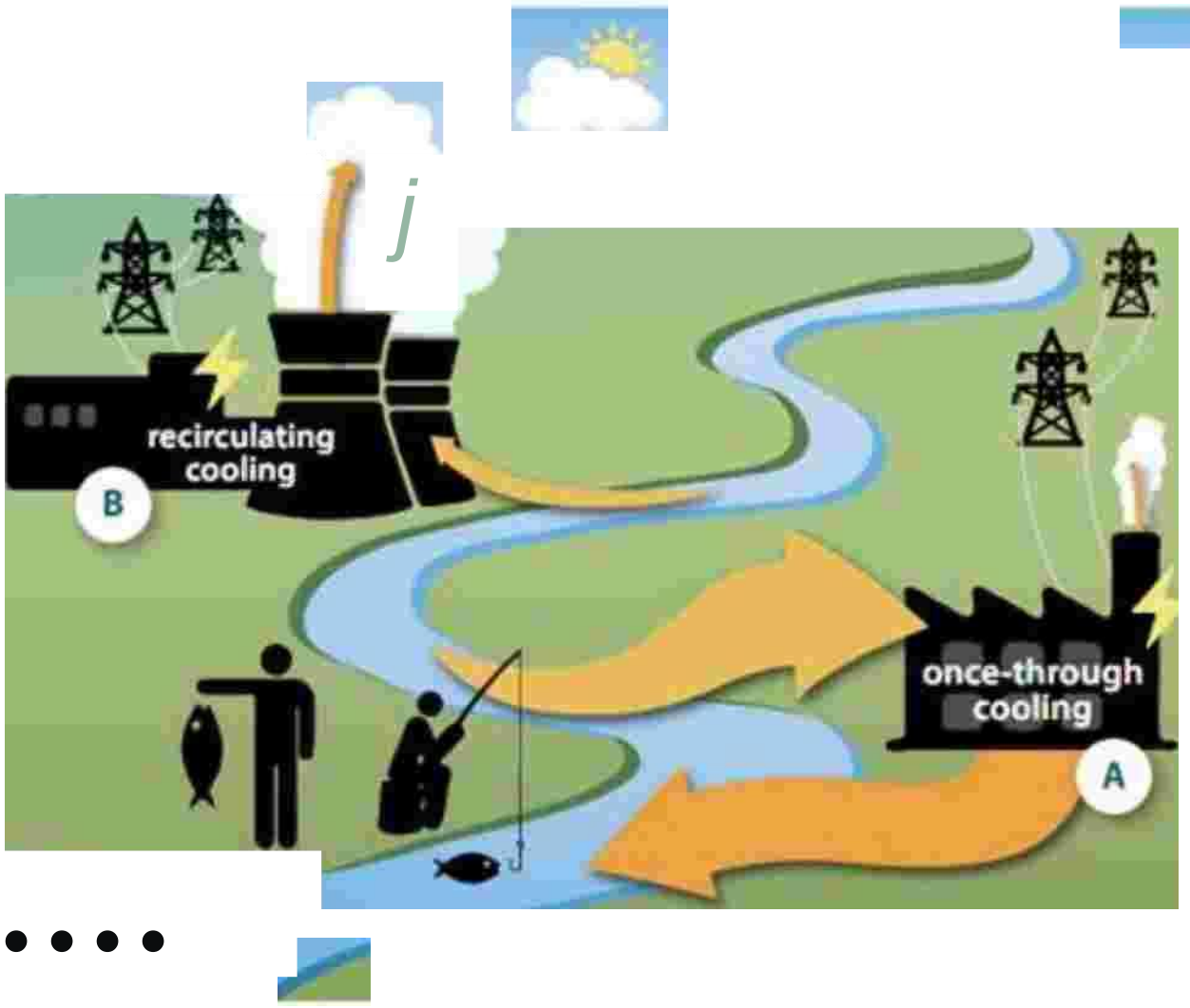
Full stream filter system



Side stream filtration – example 2



Cooling tower water treatment applications



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Recirculation cooling systems

- Typically lower flow rates (hundreds to thousands of GPM)
- Common problems
  - Corrosion
  - Microbiological contamination/fouling
  - Inorganic fouling
- The results
  - High energy consumption and high maintenance costs
  - Increased use of chemicals
- Centrifugal filers frequently seen in this service
  - These are useless in this capacity!
  - The majority of the solids you need to remove are small and light

Amiad technologies for recirculation cooling

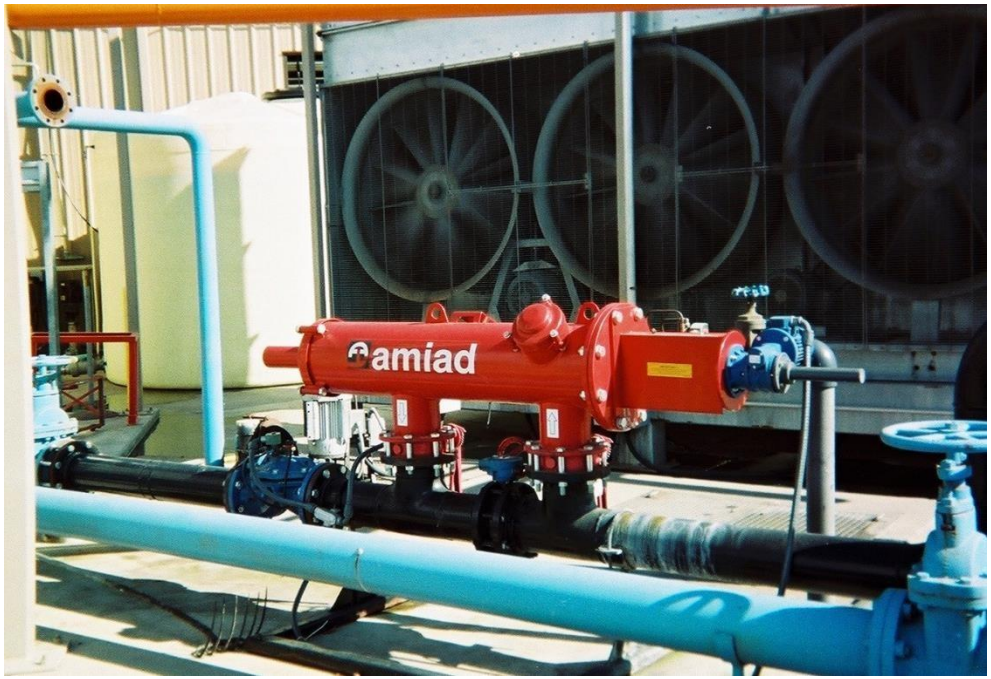
- What can Amiad offer?
  - Full flow or side stream filter systems

- Typically 10-80 micron filtration
  - Sometimes coarser for open cooling towers

- Suitable technologies
  - Suction scanner screen type filters – SAF, EBS, OMEGA
  - SpinKlin disc filter
    - Best option for biological removal, organics removal
  - Media filters

Cooling tower – side stream application

- Hilmar Cheese, Hilmar, CA
- 6” SAF-4500, 100 micron
- 700 GPM @ 60 PSI
- Re-circulating cooling loop – side stream
- Installed: June 2000



Cooling tower – side stream application

- Columbia Pacific Bo-Refinery
- Application: installation of new filtration system on cooling water system, side stream to benefit system performance and to reduce chemical consumption
- 4000 GPM
- 3 x EBS 10,000 with space for expansion to 7 units in the future (with reduction to 25 micron), 50 micron now
- Installed in 2011
- Amiad competed with media filtration, Amiad selected based on price, minimal footprint, performance and reputation in this application. Key benefit elimination of biogrowth in the filtration system, whereas media filters tend to contribute biogrowth back into the system

Cooling tower – side stream application

- Samsung
- Korea
- Application: Process and cooling water treatment, side stream
- 792 GPM
- 4”x5x8” 55 micron

Cooling tower – open tower, side stream application

- El Paso Electric
- Application: side stream cooling system, feed from cooling tower sump, removing light particles blown into open tower by frequent wind storms (pollen, seeds, grass, dusts)
- 700 GPM
- SAF-6000, 25 micron

Cooling tower make-up water

- Can be a portion of the intake water flow
  - May require it own filtration system (finer than intake filtration)
- Typically lower flow rates (hundreds to thousands of GPM)
- Same concerns as once through cooling systems

Make-up water sources

- The water sources for cooling systems can come from several sources
  - City water
  - Wells
  - River
  - Surface water
  - Wastewater (reuse after treatment, industrial and municipal)

- **Amiad's solutions effectively remove the suspended particles from the water source to protect sensitive system components**

Amiad technologies for make-up water

- What can Amiad offer?
  - Full flow filter

- Typically 200 to 50 micron filtration

- Suitable technologies
  - Suction scanner screen type filters – SAF, EBS, OMEGA
  - SpinKlin disc filter
    - Best option for biological removal, organics removal

Cooling tower – make-up water application

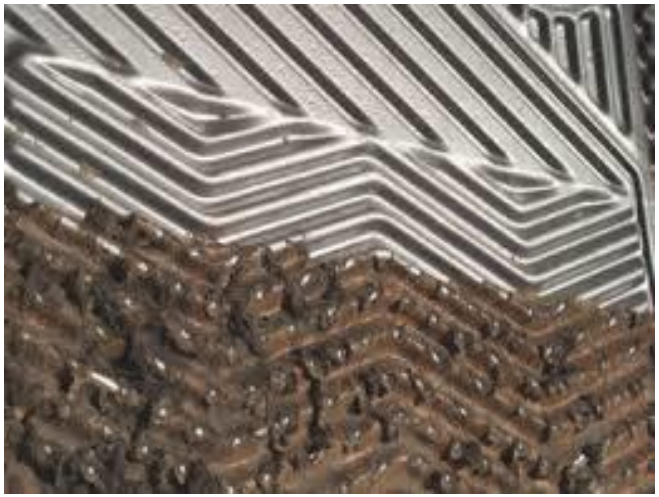
- Kemper County Coal Power Plant
- Application: cooling tower make-up water from lakes
- 6600 GPM
- 11 modules of 4”x5x10”, 55 micron

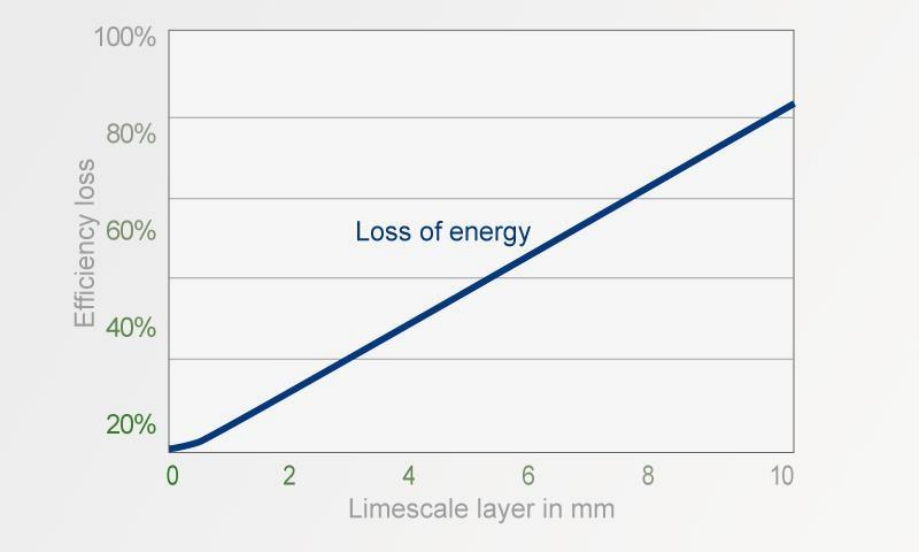
Cooling tower – make-up water application

- Alabama Power – Plant Barry
- Application: Cooling tower make-up water system, part of carbon emission capture system, cooling tower initially installed with media filters which were undersized and not able to provide the needed level of water filtration and flow capacity
- 500 GPM
- Solution: 4”x6x10”, 20 micron
- Installed June 2012

Heat exchanger protection

- Main problem: decrease in efficiency due to the accumulation of particles on surface (FOULING)
- Even a minor layer of scale causes a dramatic decrease in the transfer of heat which can result in the unforeseen shut down of the system
- Pre-filtration to the heat exchanger
  - removes suspended solids and particles to prevent accumulation on or within the unit
  - provides uninterrupted working conditions for heat exchangers (reduced maintenance)





Amiad technologies for heat exchanger protection

- What can Amiad offer?
  - Full stream pre-filtration to heat exchanger

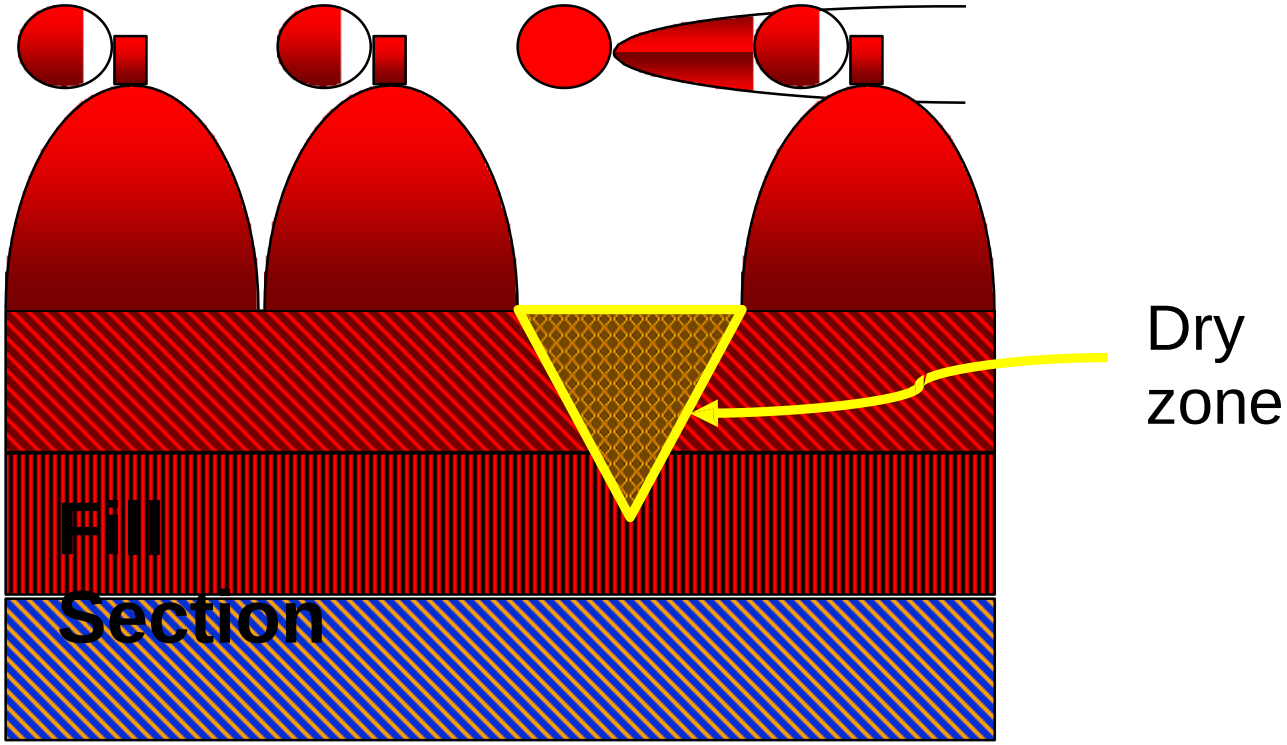
- Typically 40-100 micron filtration (depends upon heat exchanger design/orifice sizes)

- Suitable technologies
  - Suction scanner screen type filters – SAF, EBS, OMEGA
  - SpinKlin disc filter

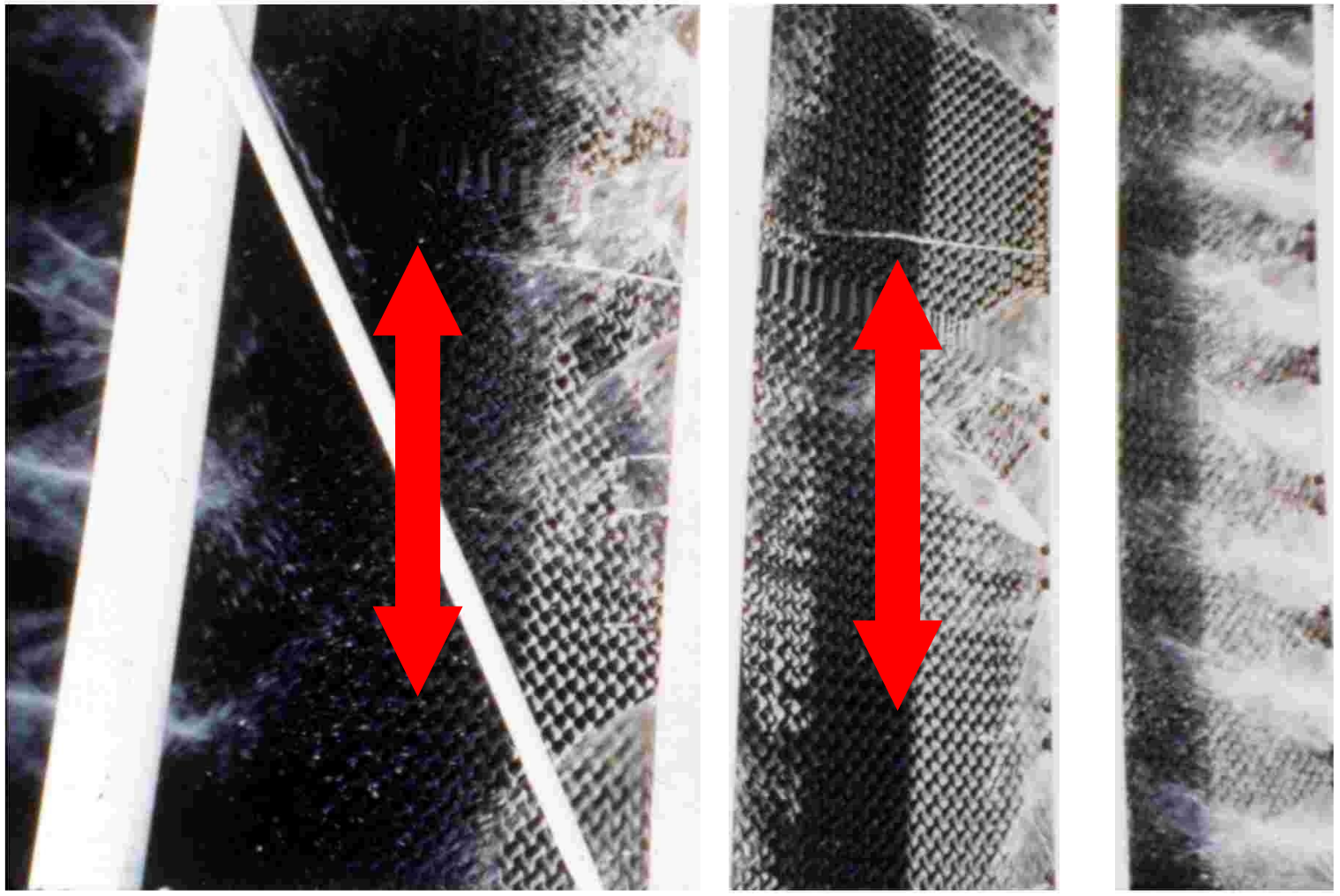
Nozzle protection systems

- Why is nozzle protection required?
  - Plugged nozzles result in:
    - Poor coverage
    - Dry spots
    - Poor heat transfer
    - Increased mineral deposits
    - Increased energy usage

Blocked nozzle



Poor spray coverage from blocked nozzles



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Amiad technologies for nozzle protection

- What can Amiad offer?
  - Solids remove to prevent plugging of nozzles

- Typically 50-200 micron filtration (dependent upon the size of the nozzle)

- Suitable technologies
  - Suction scanner screen type filters – SAF, EBS, OMEGA
  - SpinKlin disc filter
    - Best option for biological removal, organics removal

Nozzle protection application

- Diamond Plastics
- Plaquermine, LA
- 10” SAF-6000, 200 micron
- Process water from PVC manufacturing, protection of spray nozzles and chillers from PVC residue from extruding machines
- Installed in 2000

Heat exchanger protection

- Simplot Food Division, Aberdeen, WA
- Pre-filtration to heat exchanger for digester
- 450-500 GPM
- System: 8” ABF 6,000, 3,500 micron
- Installed: 2008

ROI of filtration systems

- Energy savings
  - The smallest amount of fouling on the tube of a heat exchanger (thickness of a sheet of paper) can decrease flow rates and increase pumping costs
    - In condensers, a fouling of .0001 inch can increase operating costs by **10%**!*
- Maintenance
  - Draining to clean a Tower can take anywhere from 3 – 4 hours to several days
  - Disposal costs of dirt & chemicals are factors to consider
  - The entire product line may have to be shut down to clean the system
- Water treatment chemicals
  - Biocide treatment is the highest cost of a conventional cooling tower treatment program
  - Filtering out the airborne food chain for biological growth can achieve up to 20% chemical savings
  - Filtering out the contamination decreases chemical treatment costs because there is less debris to treat**
  - There is an increase in chemical effectiveness as suspended solids are not negatively impacting the system

*Carrier Corp., "System Design Manual", part 5 Water Conditioning, pg 5-8, Syracuse, NY, 1963

**Exton, R.E. and others, Microelectronics, *Ultrapure Water 15, 10, pgs 38-43, December 1998*

ROI of filtration systems

- Extended equipment life
  - Dirt and corrosion reduce the life expectancy of water cooled equipment
    - Especially true for pumps, mechanical seals, valves seats, air-compressor, water jackets, spot welder tips, condenser tubes, chiller components and heat exchangers
- Environmental
  - The cleaner the water (and the less chemical used in it) the more it can be re-used
  - Clean and filtered water can help the cooling towers conserve two of our most important resources: energy and water
- Health and safety
  - Filtration is also an important method for controlling Legionnaires Disease
    - Infectious bacteria live on types of suspended solids and removal of these solids can help minimize dangerous bacterial colony numbers developing in the cooling system

The Amiad Advantages – all technologies

- Low water and energy usage
- High flow rate capacities in a single vessel
- Robust design and performance Large
- open area in a small footprint Screen/disc
- design guarantees removal at micron rating quoted
- Amiad spring loaded nozzle design allows effective self-cleaning action at low micron ratings

Special industry considerations

- Every plant has multiple applications where Amiad can provide a solution
  - Ask questions and find out where they are having issues
  - Consider the applications we have brought up here as potential avenues for additional sales
- If required we can offer special construction
  - ASME (for metallic filters)
  - 316L stainless steel

Thank you!