Best Practice, Direct Evaporative Cooling Technology for Combustion Turbine

By Pat Zeller, Munters Corporation

Sponsored by:

Turbine Inlet Cooling Association (TICA)

June 11, 2014; 1 PM (U.S. Central Time)

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Welcome & Introduction

- Webinar Series co-sponsored by

  Turbine Inlet Cooling Association

- Industry (end users, developers, engineers, etc.) looking to optimize and improve power generation and efficiency of the turbine inlets.

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Introductions

Pat Zeller, GTEC National Sales

Munters Corporation

Annette Dwyer, Chair, TICA

Munters Corporation Technical Product Manager

Who is TICA?

The Turbine Inlet Cooling Association (TICA) promotes the development and exchange of knowledge related to gas turbine inlet cooling

The TICA website is one-stop source of TIC technical information, including Installation Database & Performance Calculator

TICA is a non-profit organization.

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TICA Member Benefits

Access to full/detailed version of TIC Installation Database

Access to full/detailed version of the TIC Technology Performance Calculator

GT Users get access to the TIC Forum

Suppliers have access to information space on the TICA Website and access to booths at various electric power trade shows

Become a Member Today!!!

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Turbine Inlet Cooling Technologies

Webinar Schedule

June 11, 2014
- Best Practices for Wetted-Media Evaporative Cooling

August 13, 2014
- Best Practices for Fogging Evaporative Cooling

October 8, 2014
- Best Practices for Chiller Systems

December 12, 2014
- Best Practices for Thermal Energy Storage

February 11, 2015
- Best Practices for Wet Compression

April 8, 2015
- Best Practices for Hybrid Systems

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Webinar Procedures

To avoid background noise, please mute your line

Please submit questions during the presentations by typing them into the “chat” window area of the screen

After the featured presentation is complete, we will answer your submitted questions

You may receive a online survey immediately following the webinar . We would appreciate your participation to:

- Provide feedback on webinar series
- Suggest other topics and speakers

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Presentation Agenda

- Why turbine inlet cooling
- Direct Evaporative Cooling for Combustion Turbines
- How Direct Evaporative Cooling Works
- Where Direct Evaporative Cooling Works
- Examples
- Design Considerations
- Water Management
- Technology Comparison

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Why CT Power Output Capacity Decreases with Increase in Ambient Temperature?

- Power output of a turbine is proportional to the mass flow rate of hot gases from the combustor that enter the turbine
- Mass flow rate of combustor gases is proportional to the flow rate of the compressed air that enters the combustor
- Compressors provide compressed air and are volumetric machines, limited by the volumetric flow rate of inlet air they can pull or suck in
- As ambient temperature increases, the air density decreases. This results in a decrease of the mass air flow rate
- Reduced mass flow rate of inlet air reduces the mass flow rate of the combustor gases and hence reduced power out put of turbine

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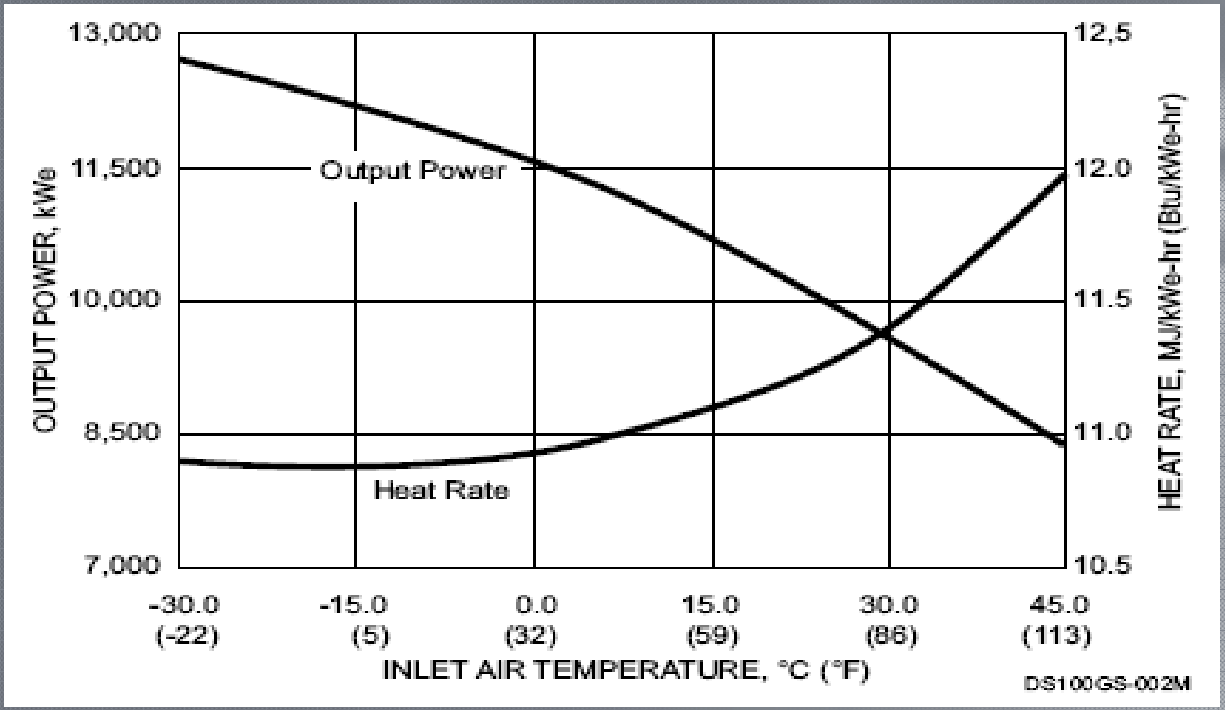
Smaller Capacity Systems More Sensitive to Ambient Temperature

Capacity Loss of over 21% from ~10,750 kW to ~8,500 kW



Efficiency loss of over 8 % from HR of ~ 11,100 to ~12,000 Btu/kWh

Source: Solar Turbines

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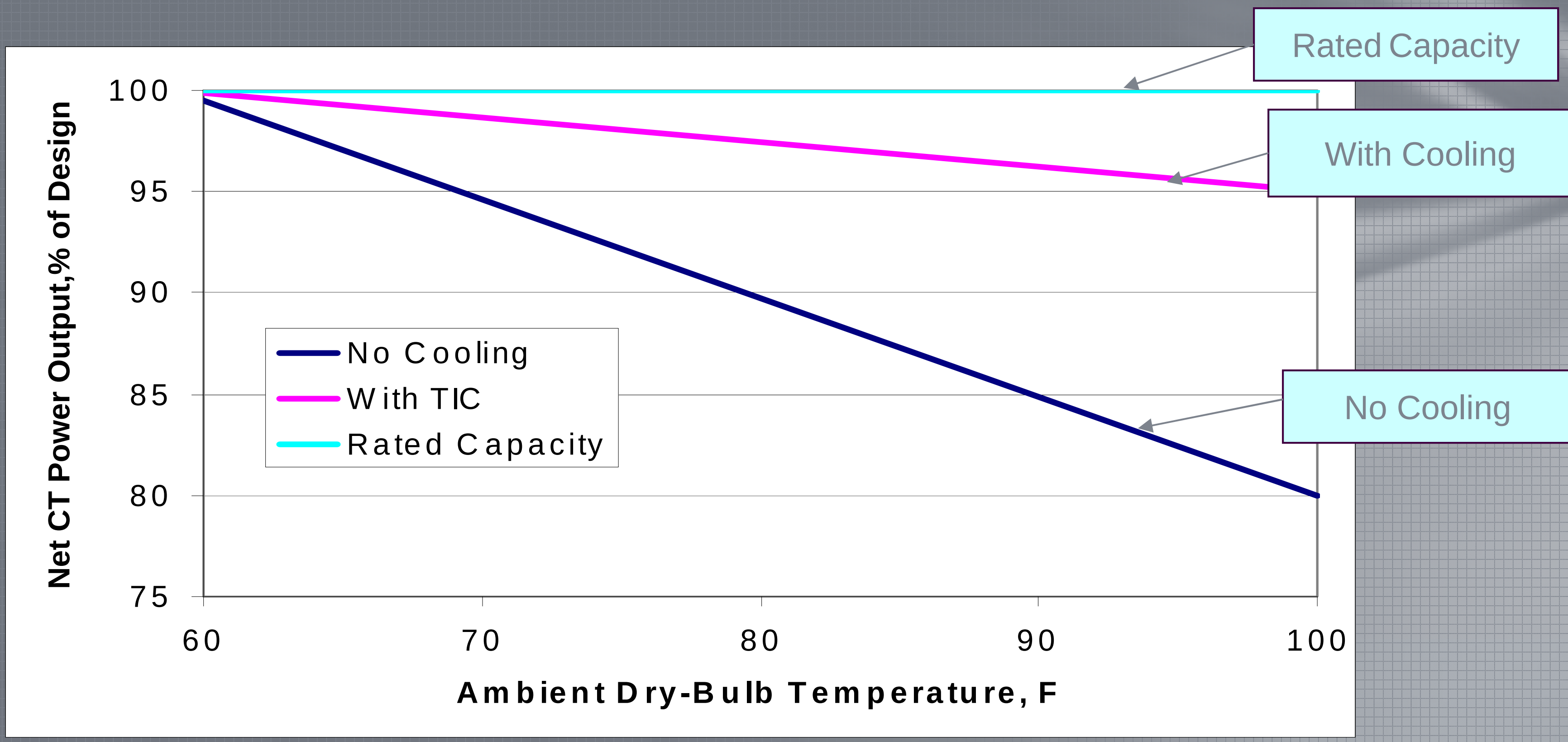
Turbine Inlet Cooling Overcomes the Effects of the CT Flaws During Hot Weather



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Why Use Direct Evaporative Cooling for Turbine Inlets

Direct Evaporative Turbine Inlet Cooling (TIC) provides a cost-effective, energy-efficient, and environmentally beneficial means to enhance power generation capacity and efficiency of combustion/gas turbines during hot weather.

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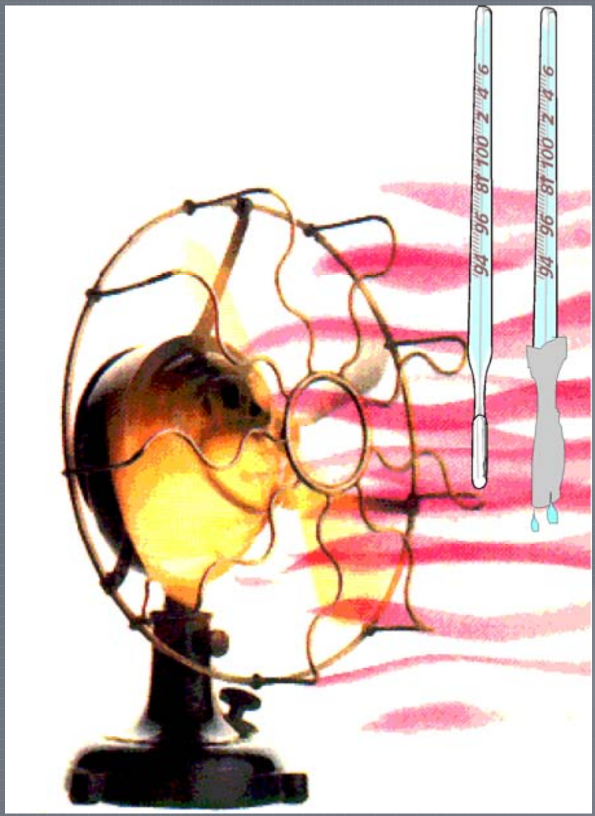
How Direct Evaporative Cooling Works



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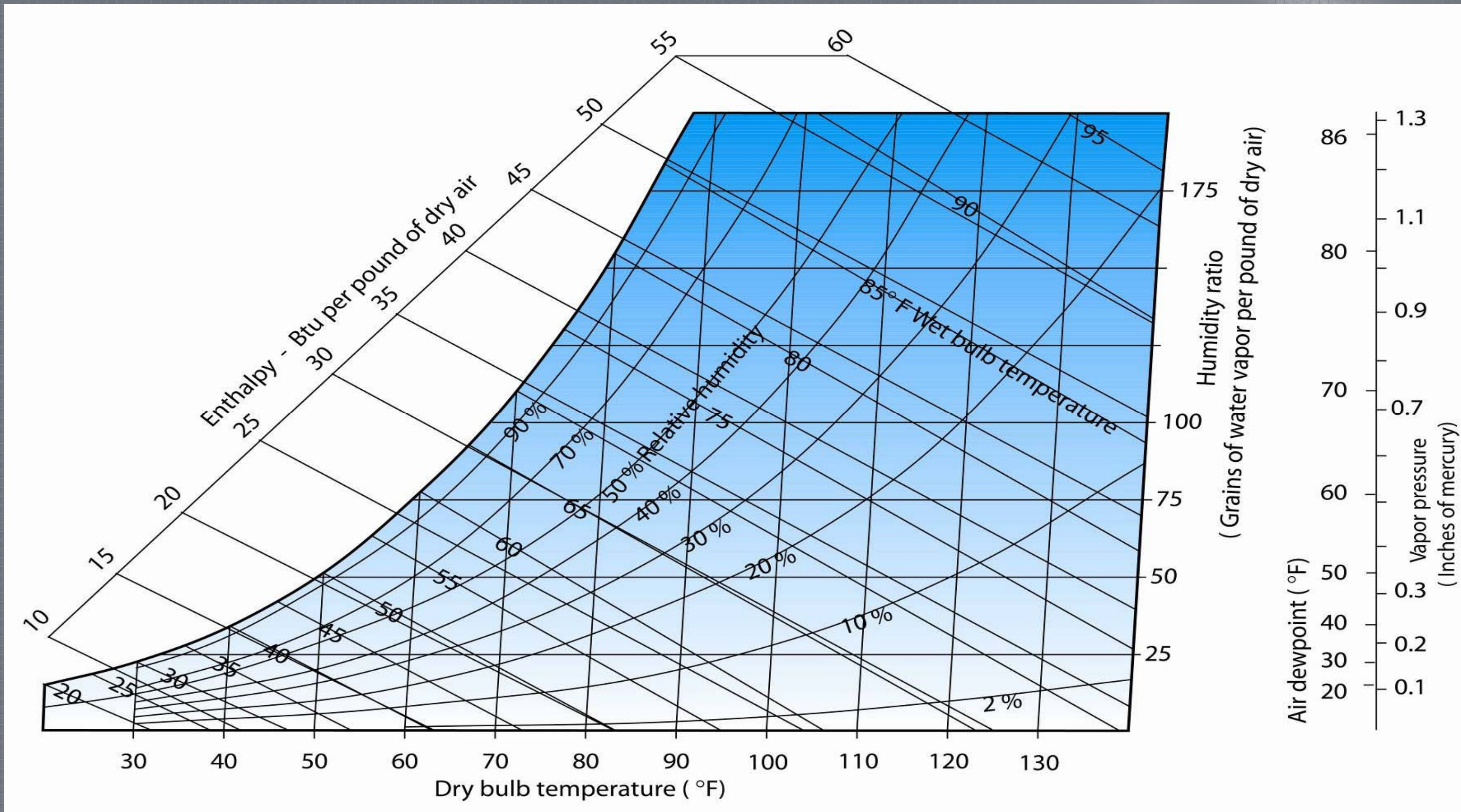
Psychometric Chart



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How Direct Evaporative Cooling Works, Dry Bulb

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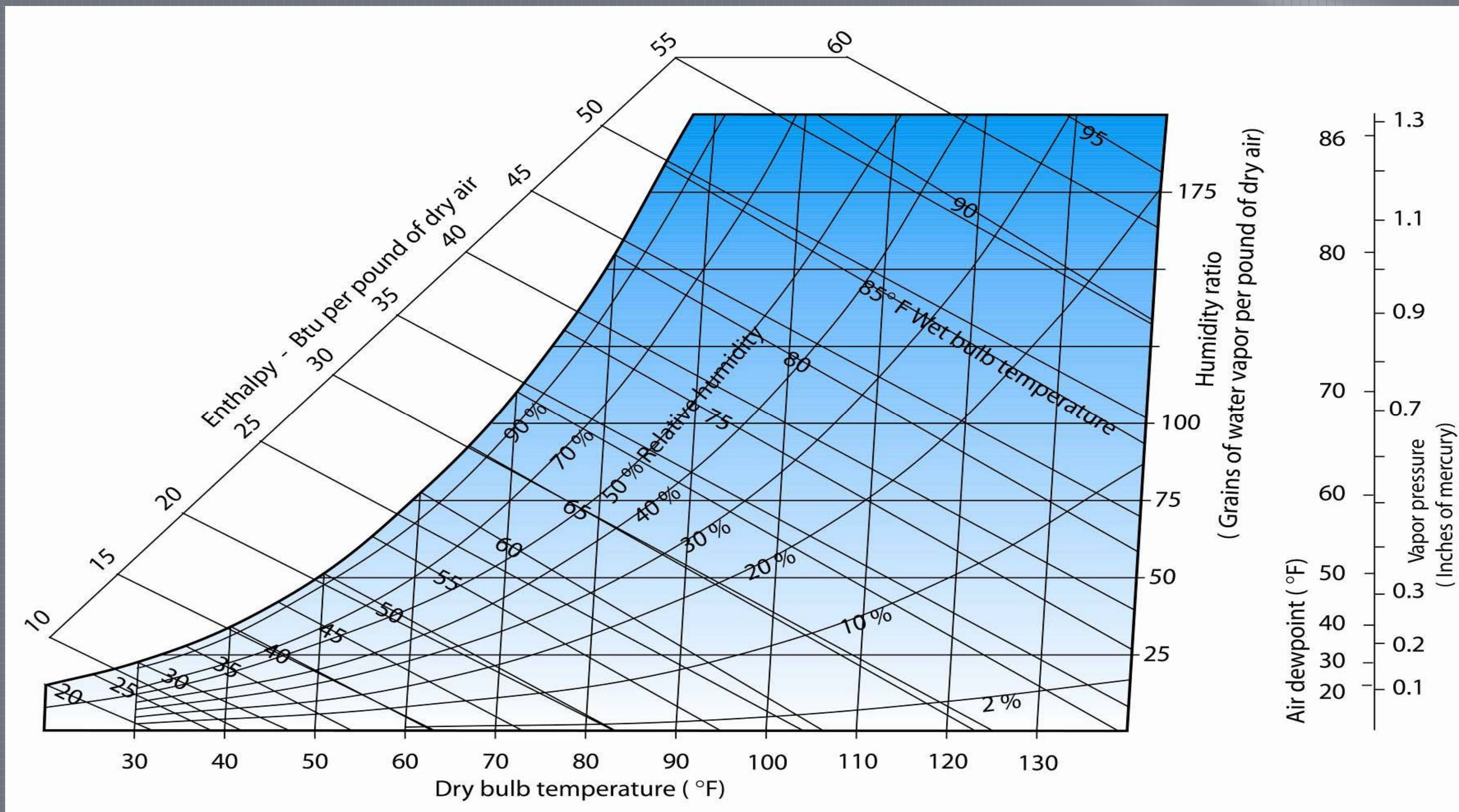
How Direct Evaporative Cooling, Dry Bulb



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How Direct Evaporative Cooling Works, Wet Bulb

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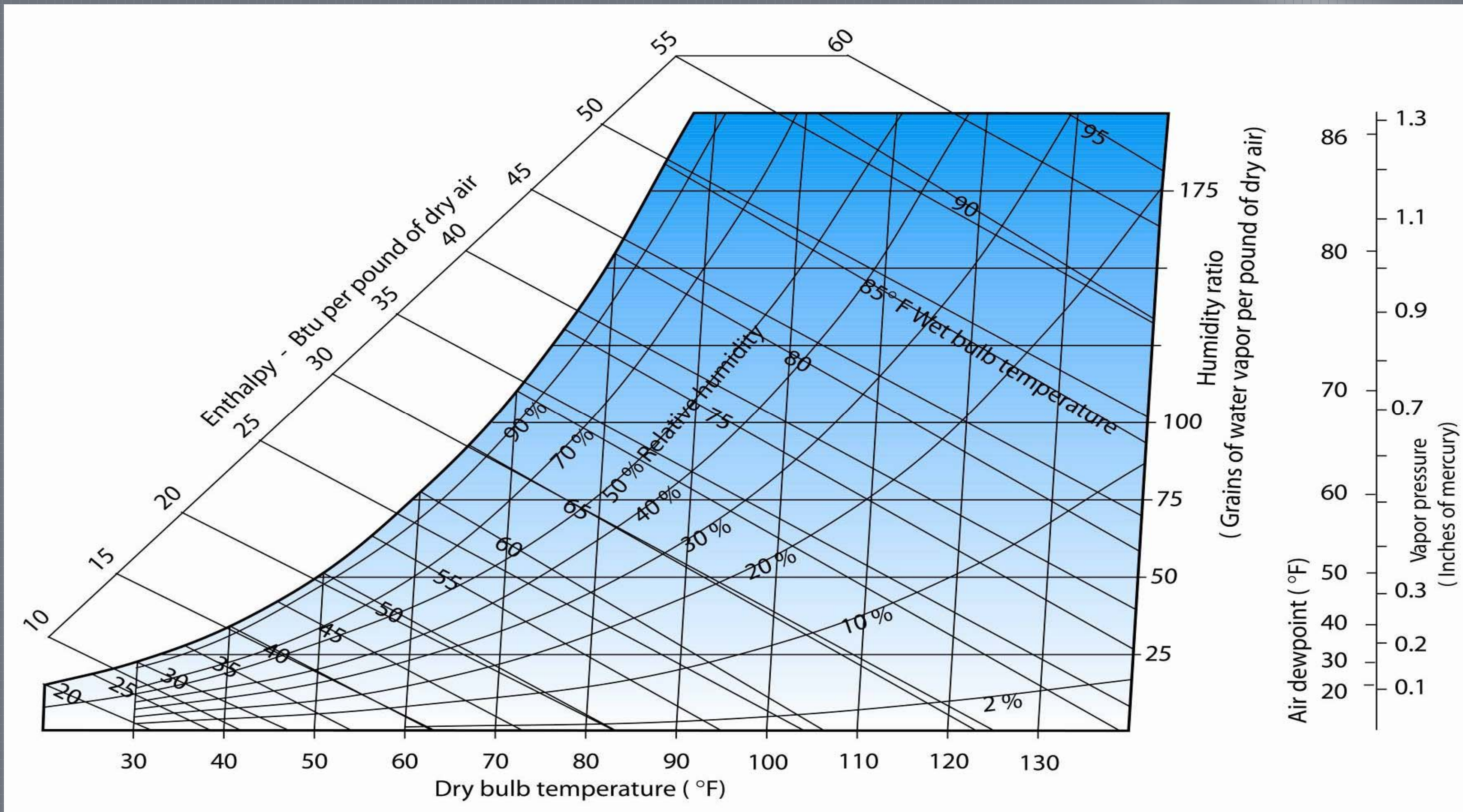
How Direct Evaporative Cooling Works, Wet Bulb



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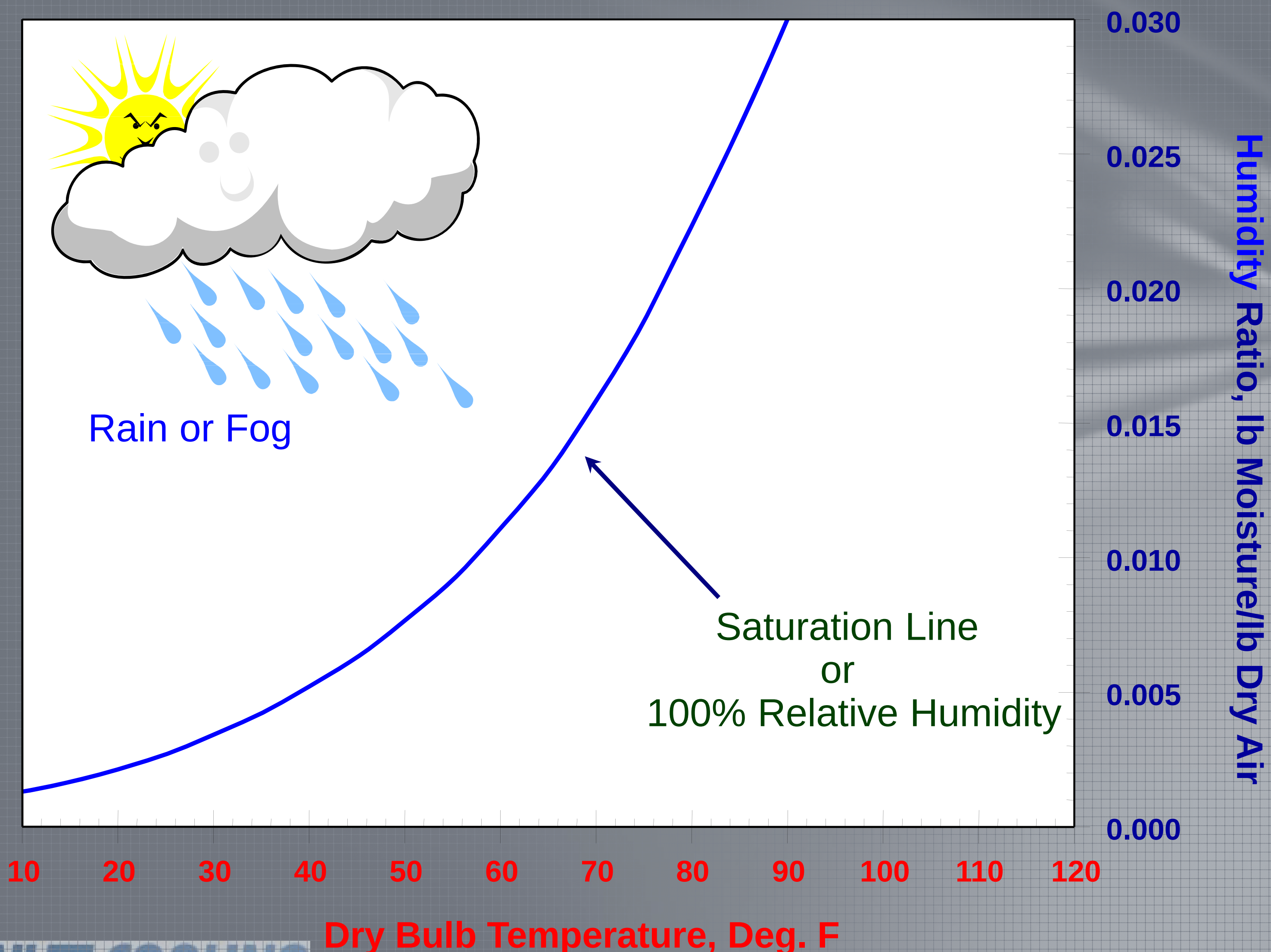
How Direct Evaporative Cooling Works



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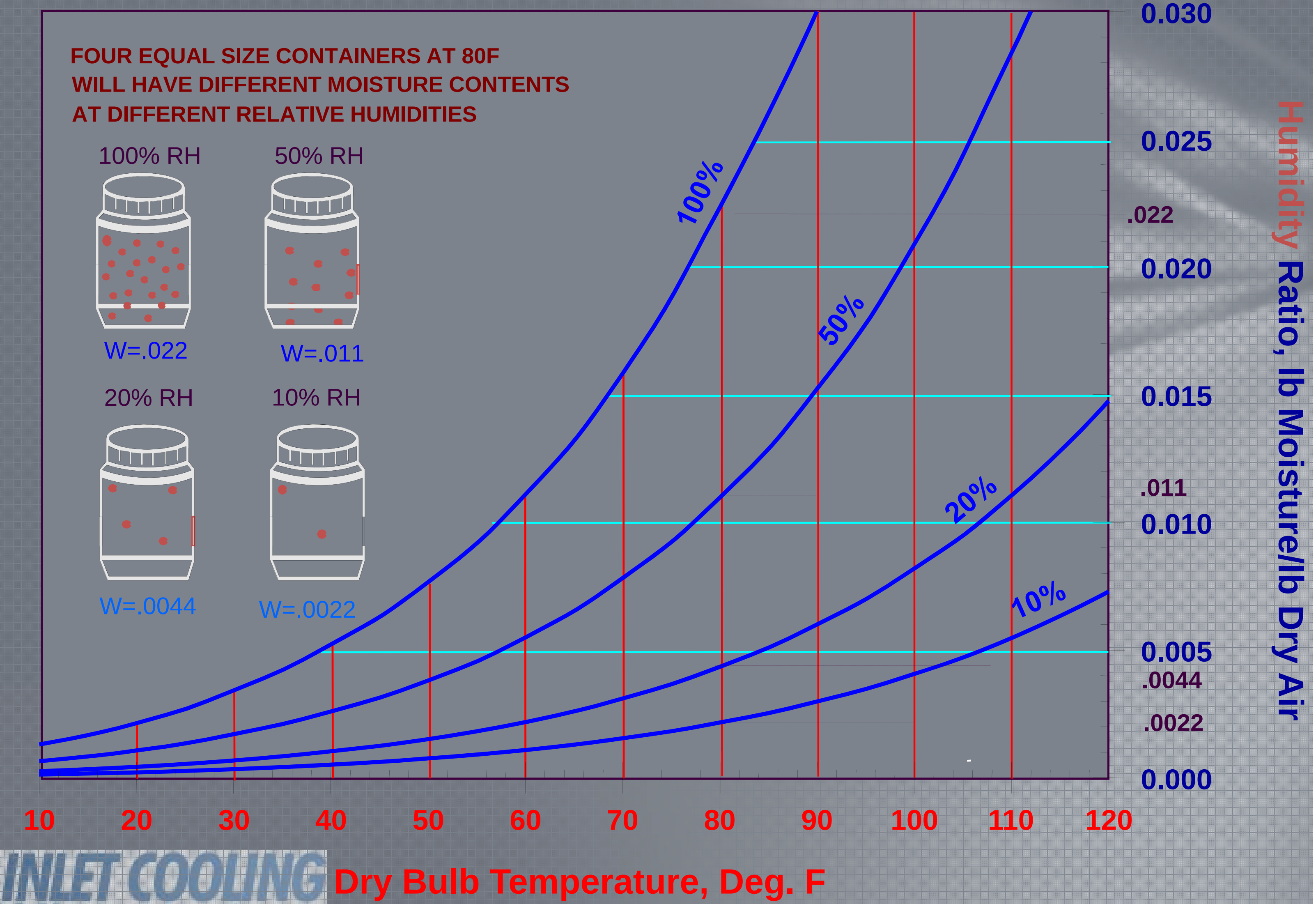
Moisture Content in Air



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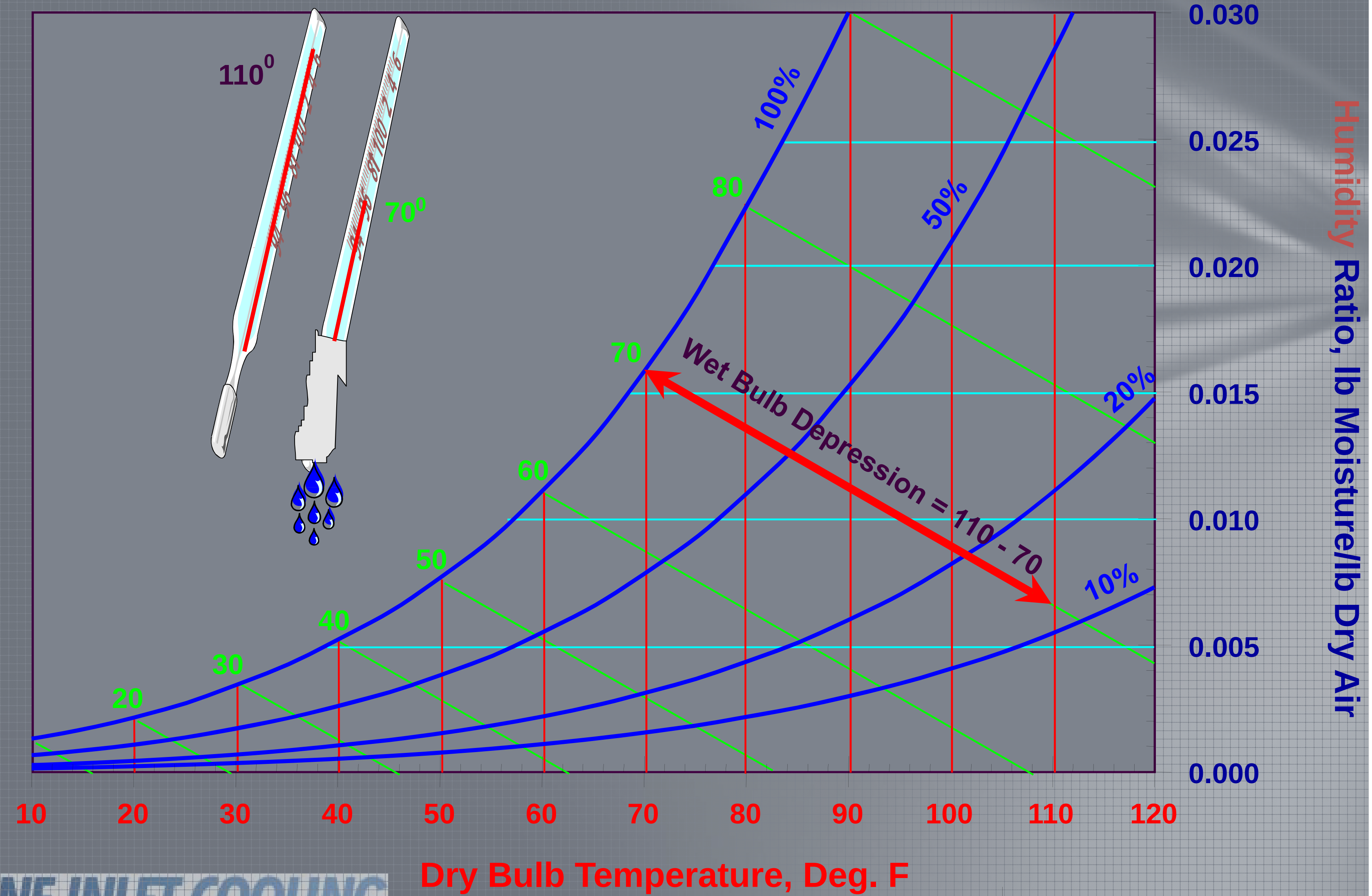
As We Cool Air Close to the Wet Bulb Line



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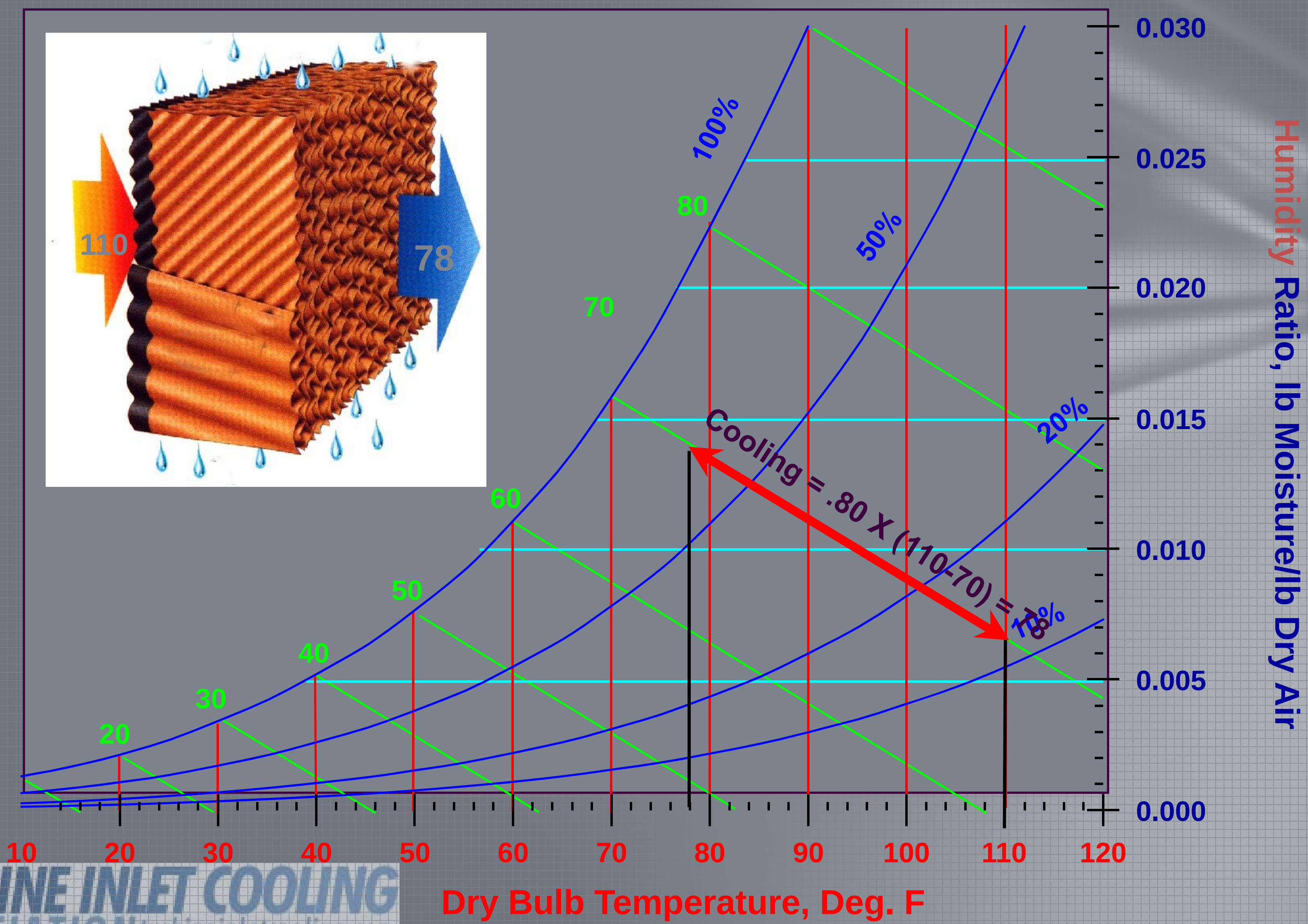
Direct Evaporative Cooling of an Airstream



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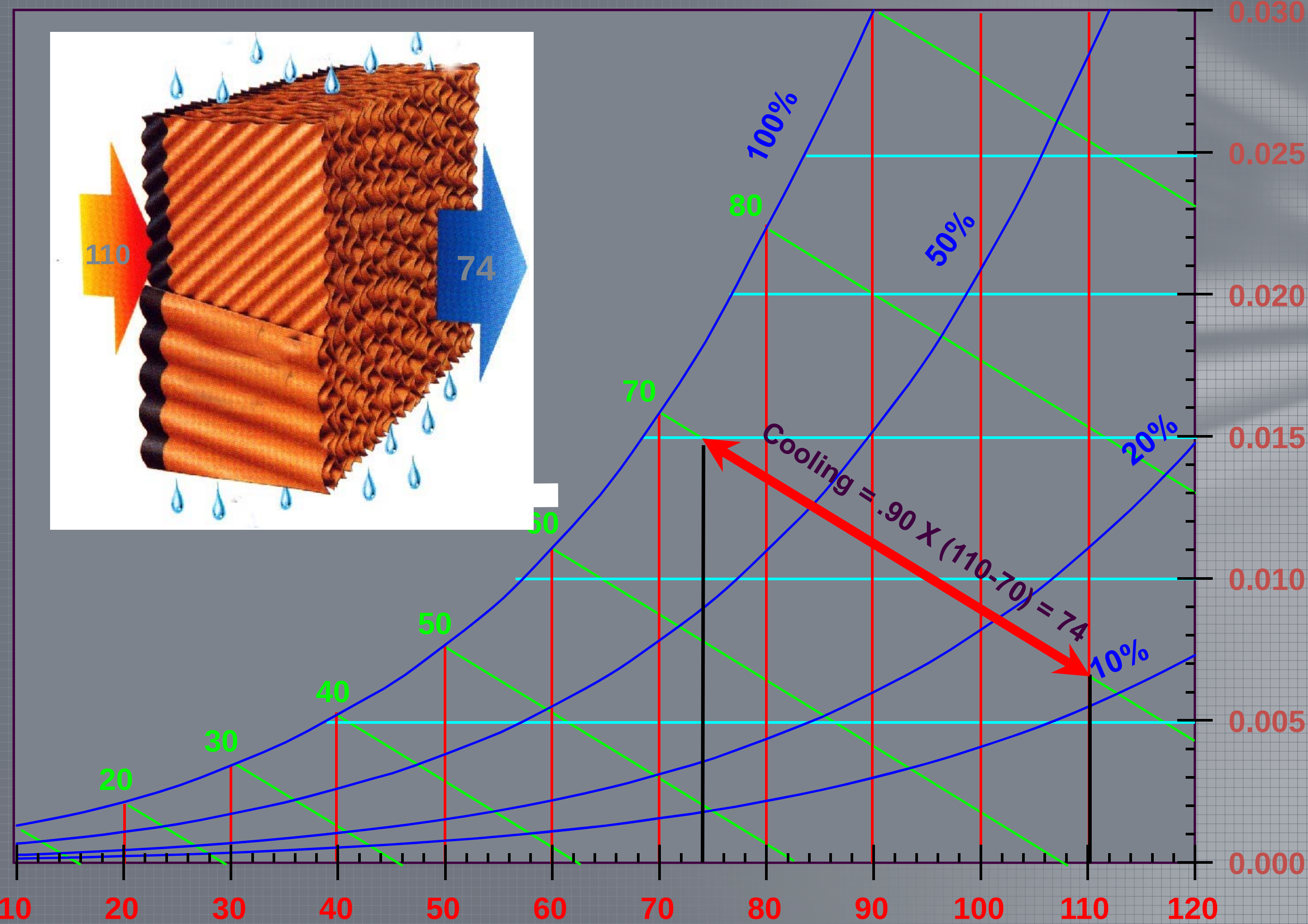
Direct Evaporative Cooling of an Airstream



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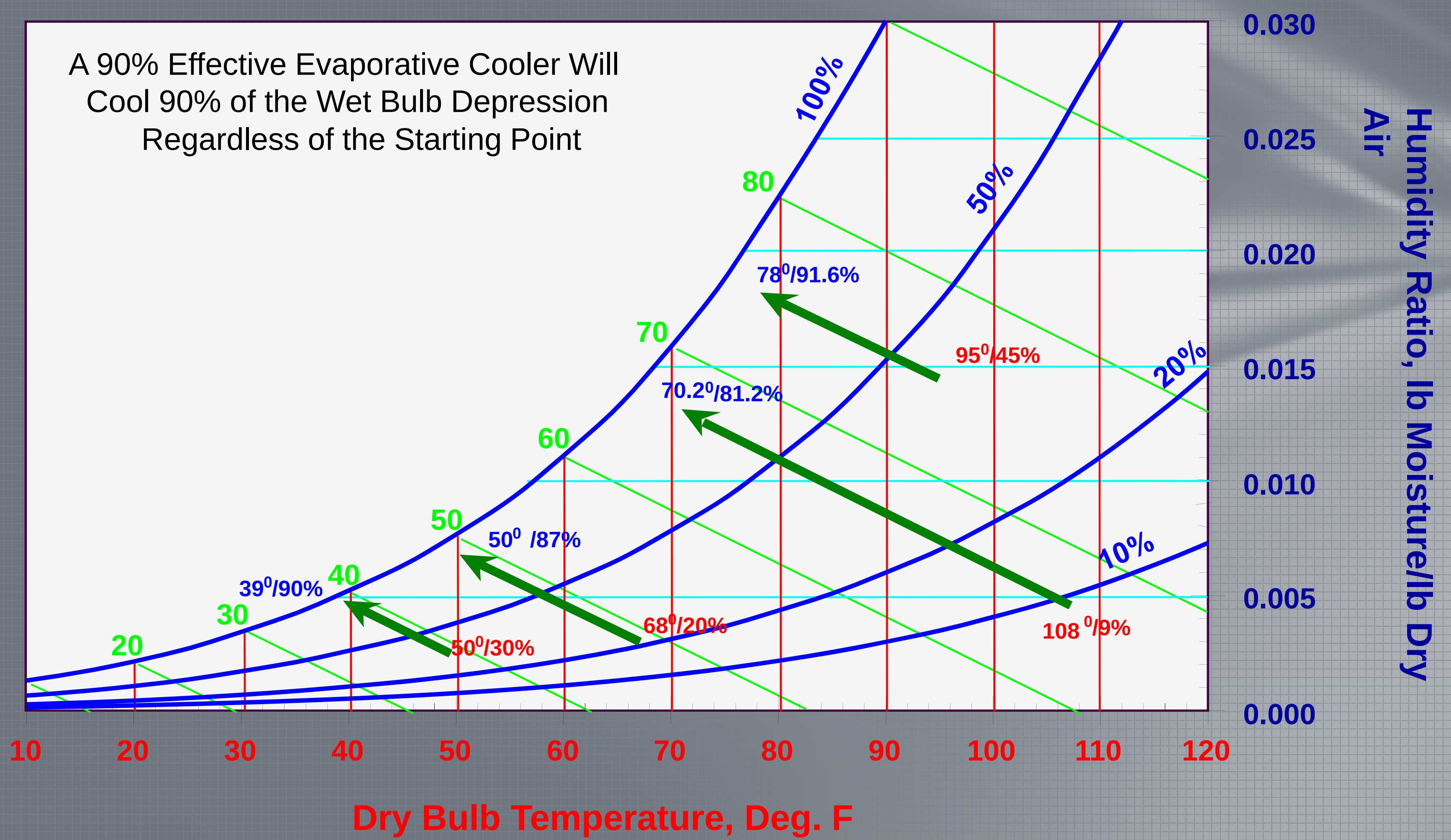
Cooling Efficiency is the Same Regardless of the Starting Point



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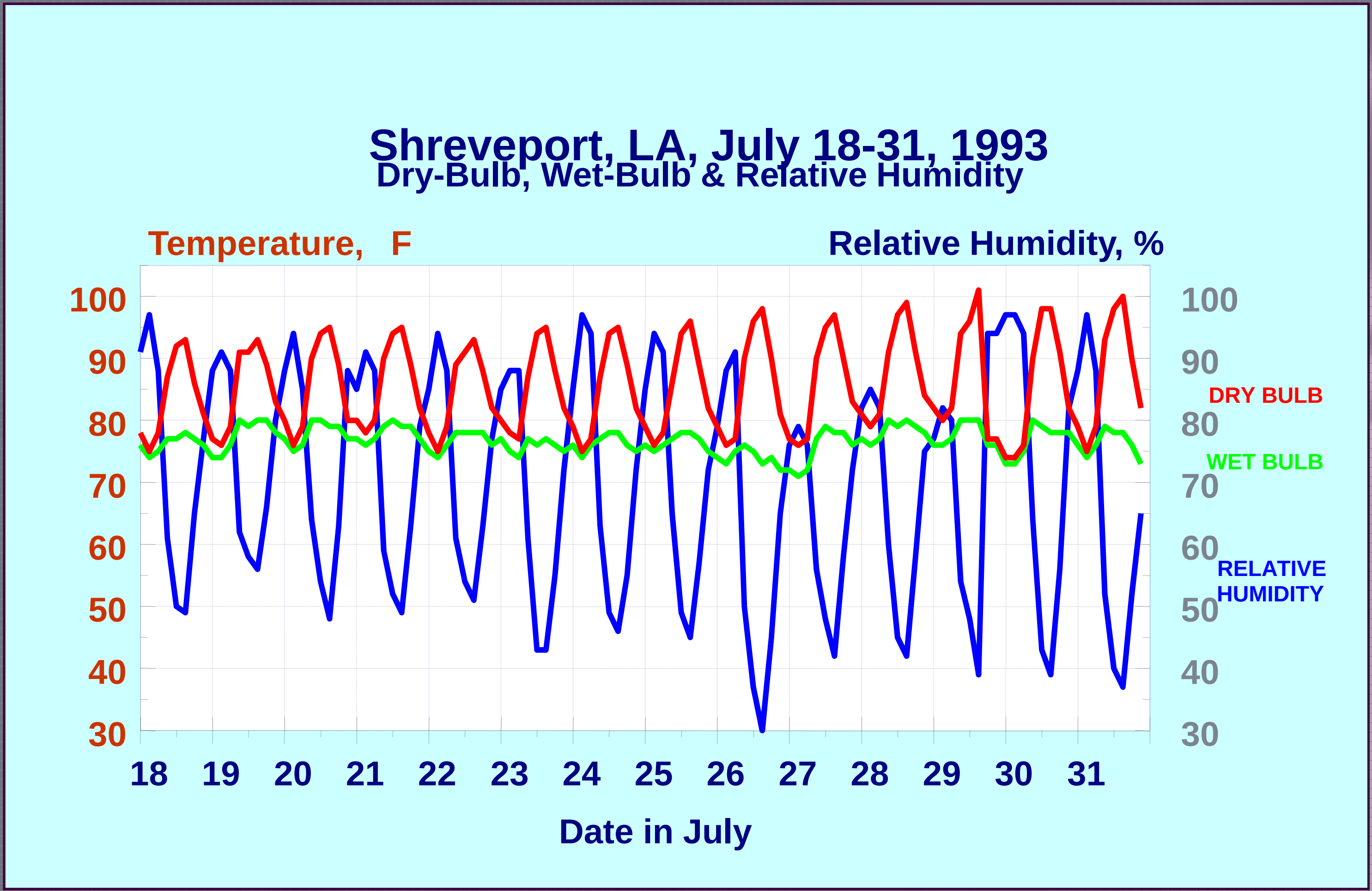
As the Day Temp Heats Up



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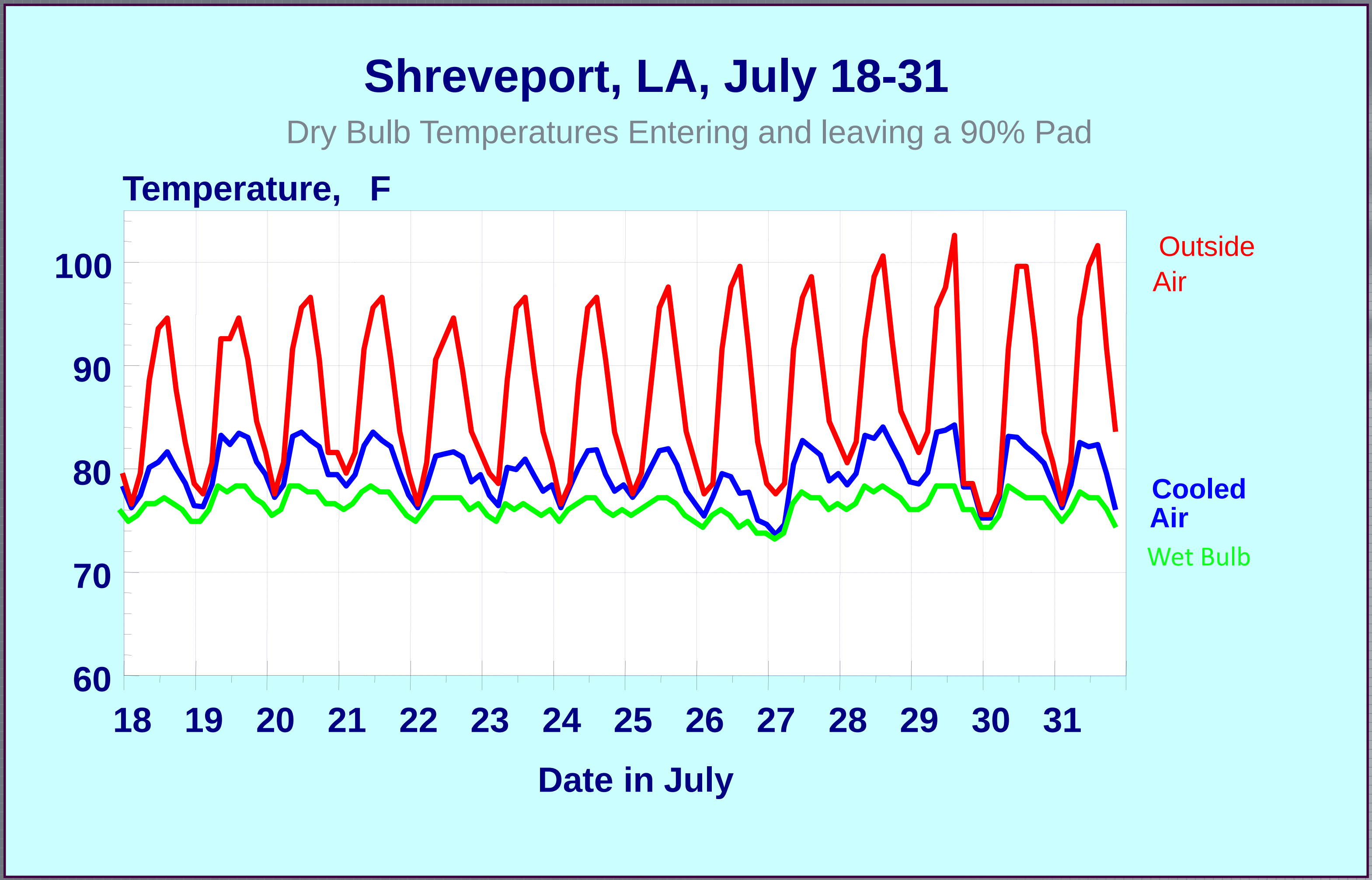
Even in Humid Areas, Direct Evaporative Cooling Works



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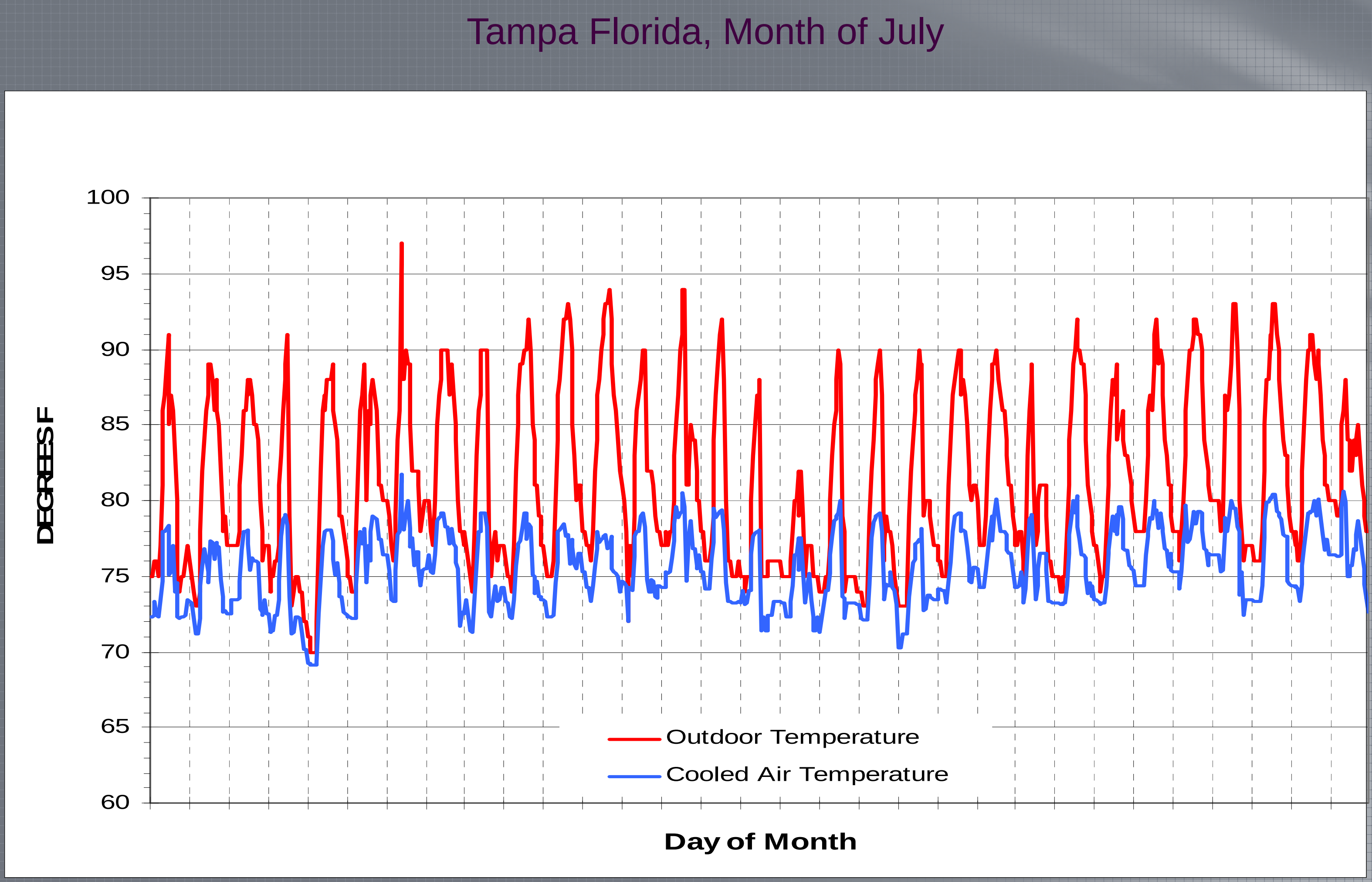
Looking at Tampa Florida



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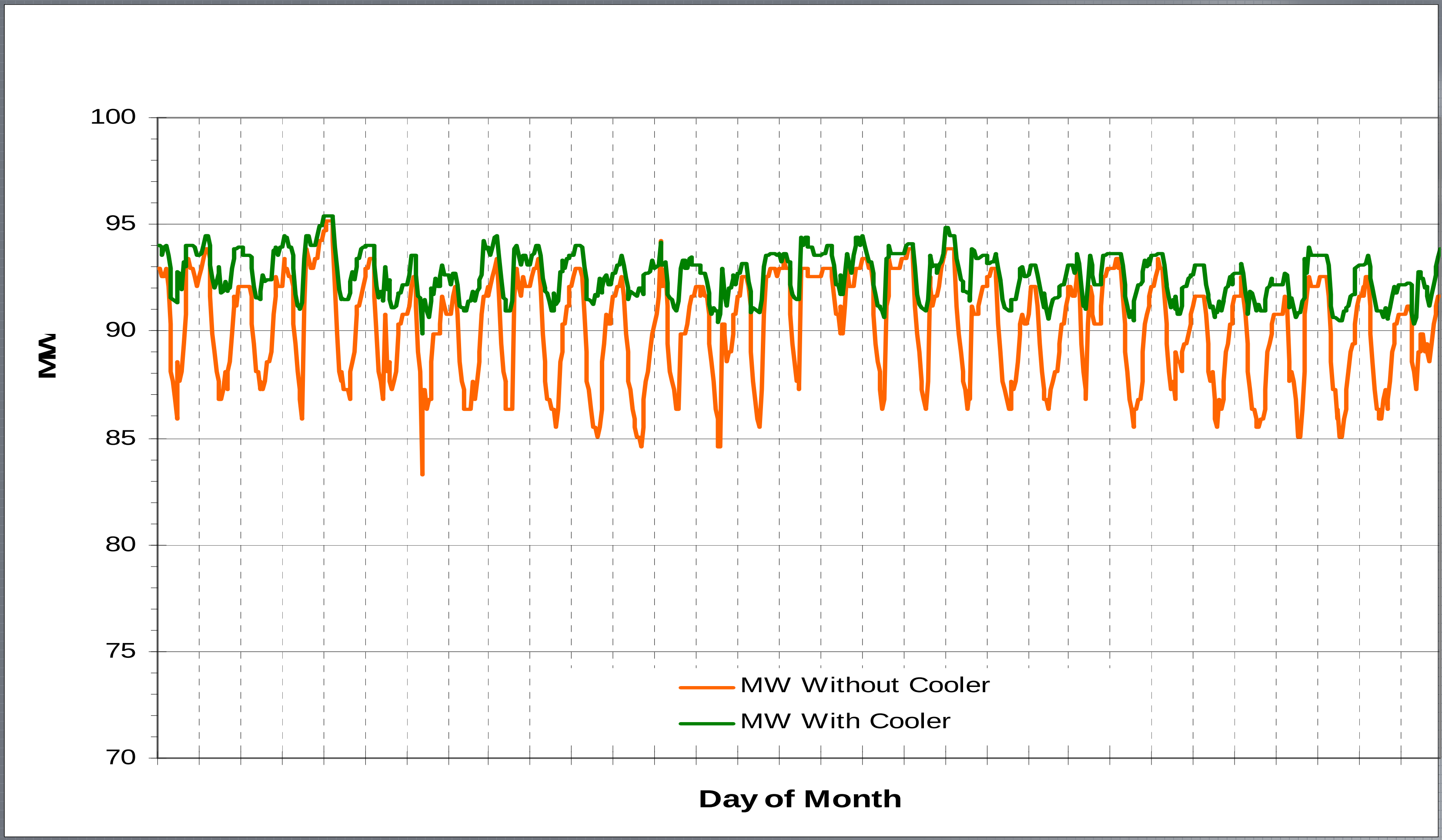
Turbine Performance

Performance of 100 MW CT in Tampa, Month of July with 90% Effective Evaporative Cooler



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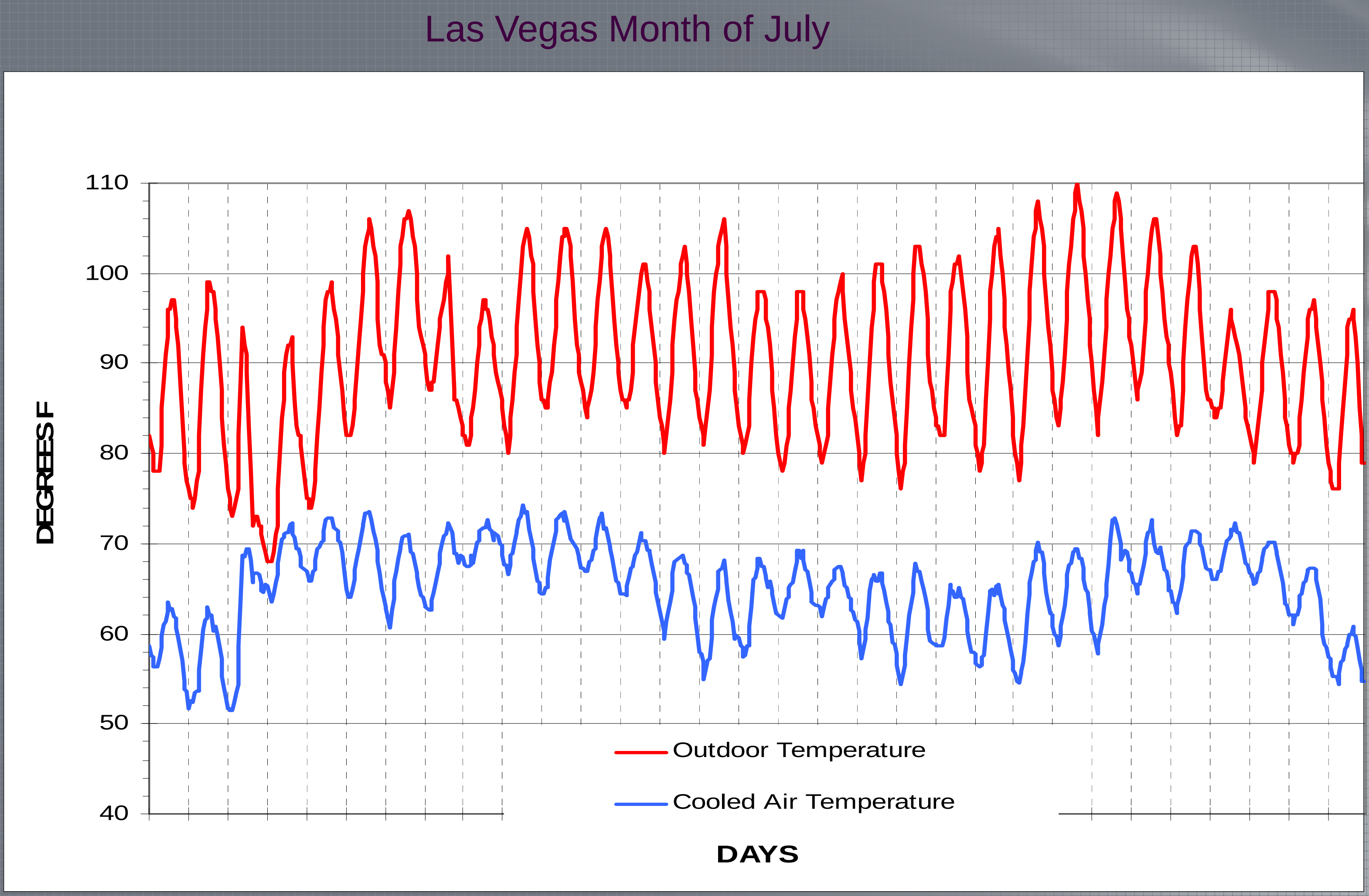
Looking at Las Vegas Nevada



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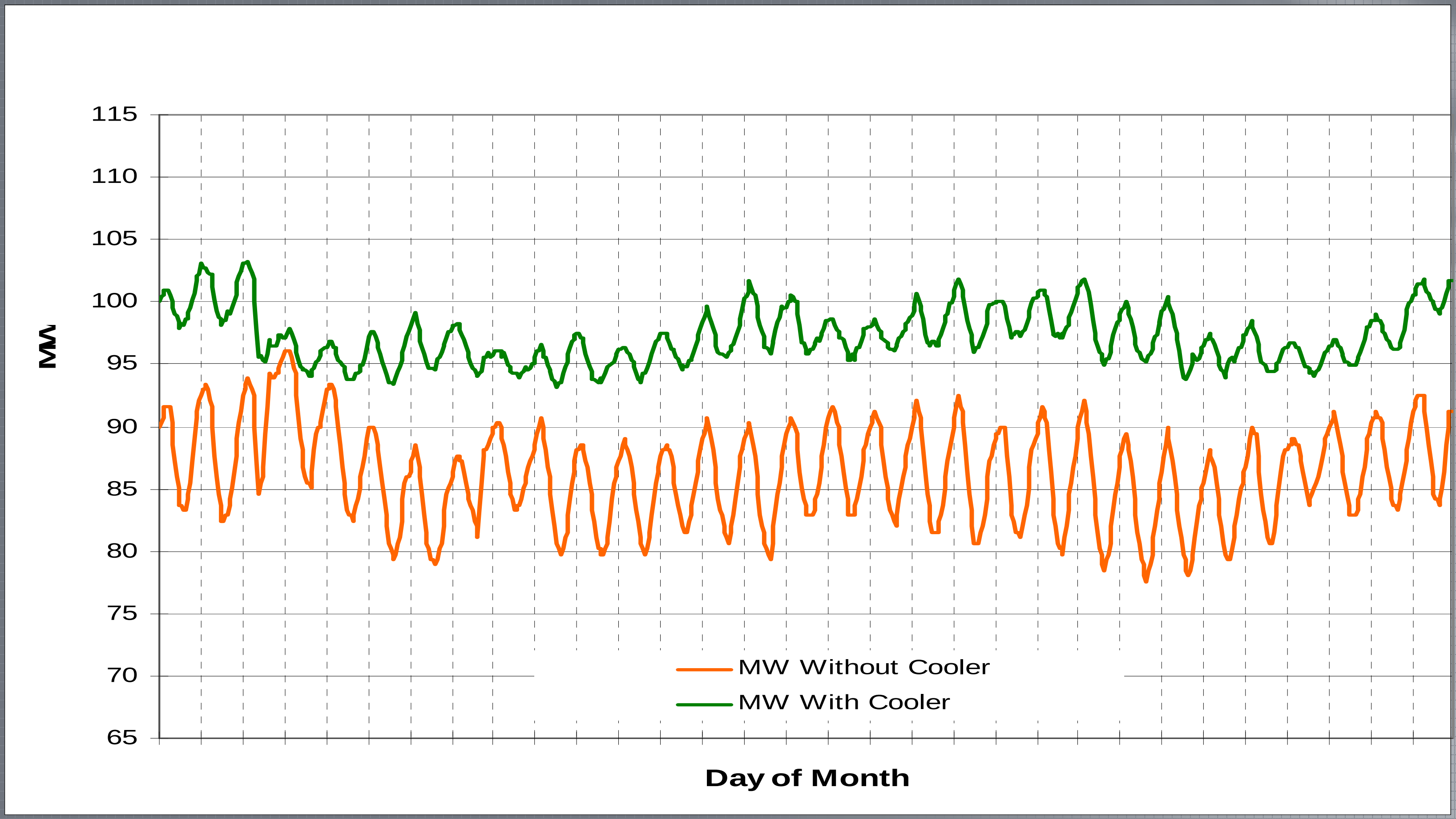
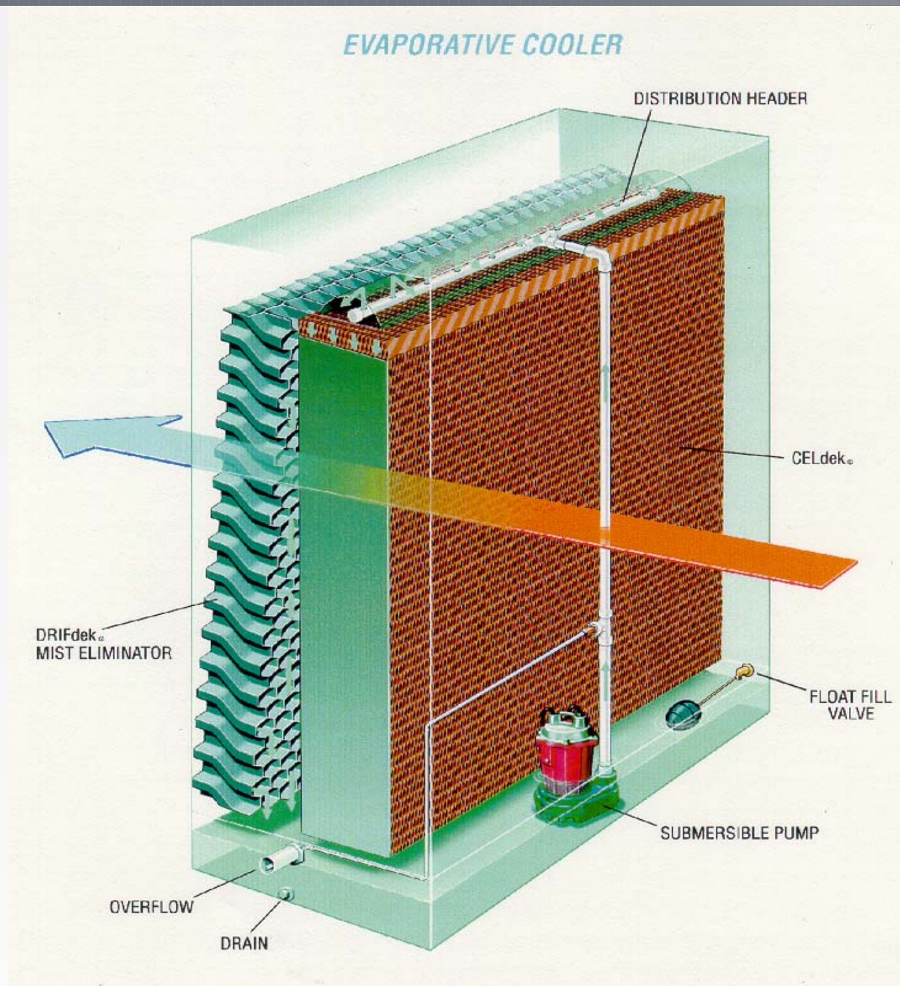


Direct Evaporative Cooler Anatomy



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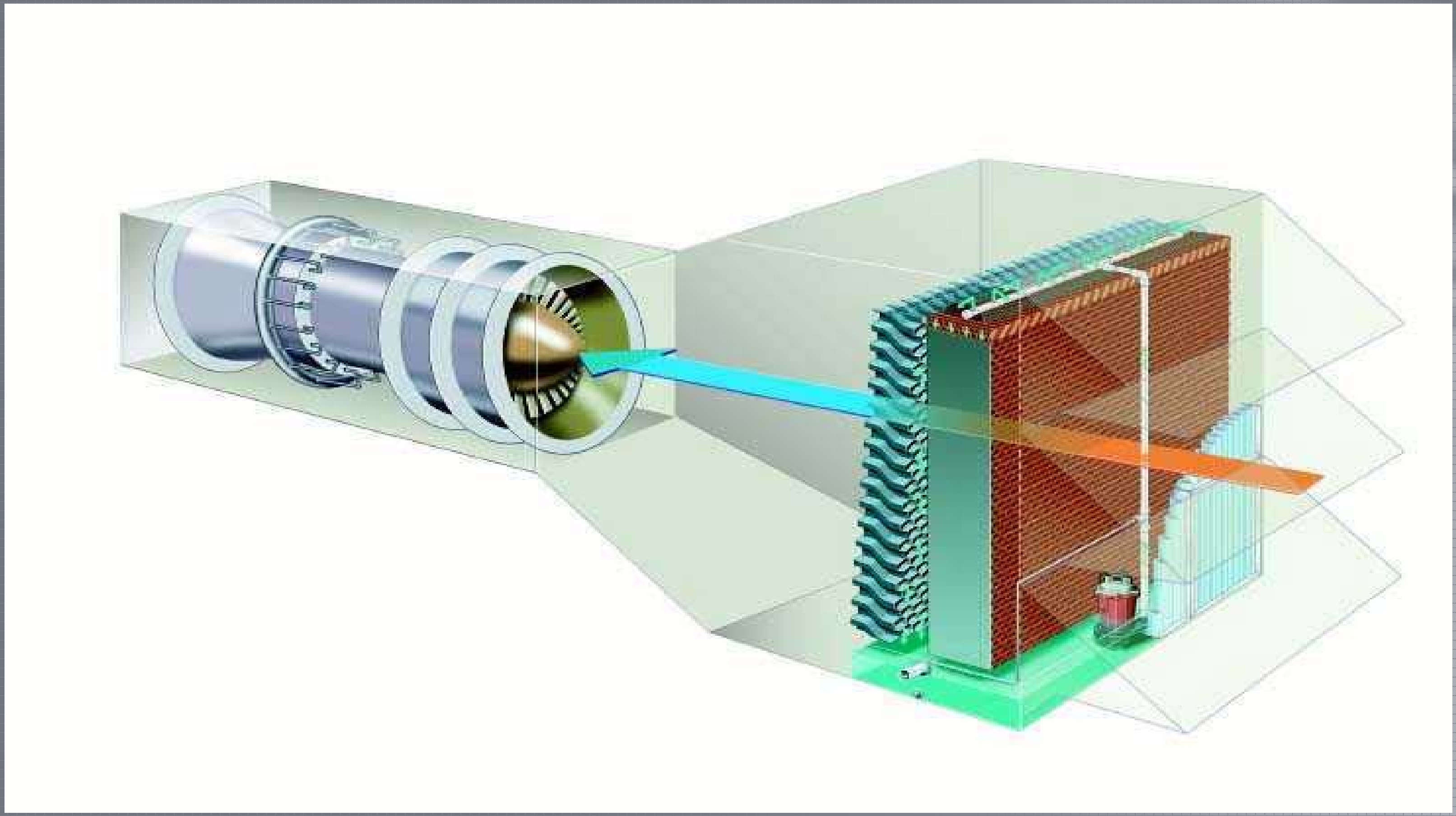
Construction & Examples



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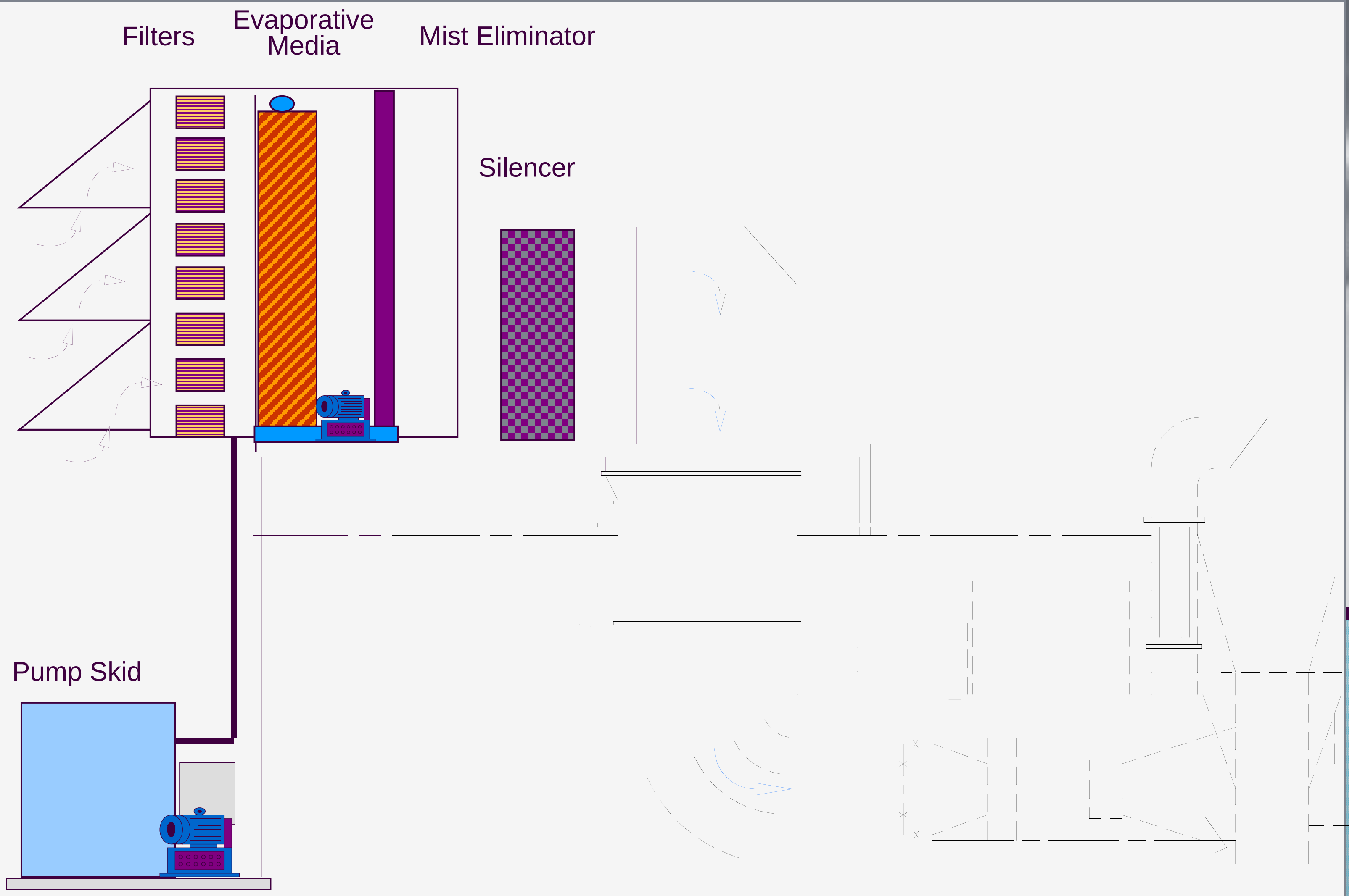
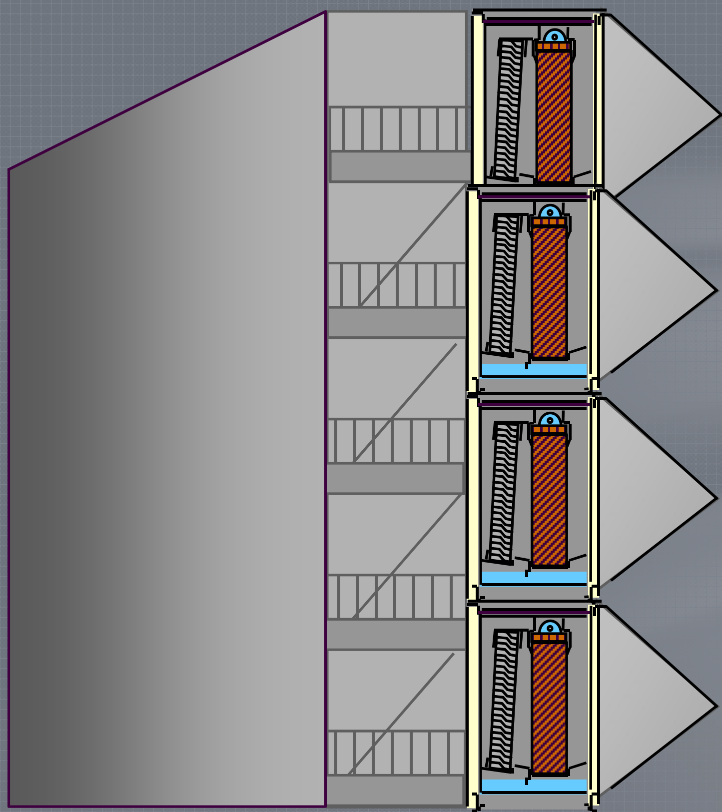
Location of the Evaporative Cooler



Examples



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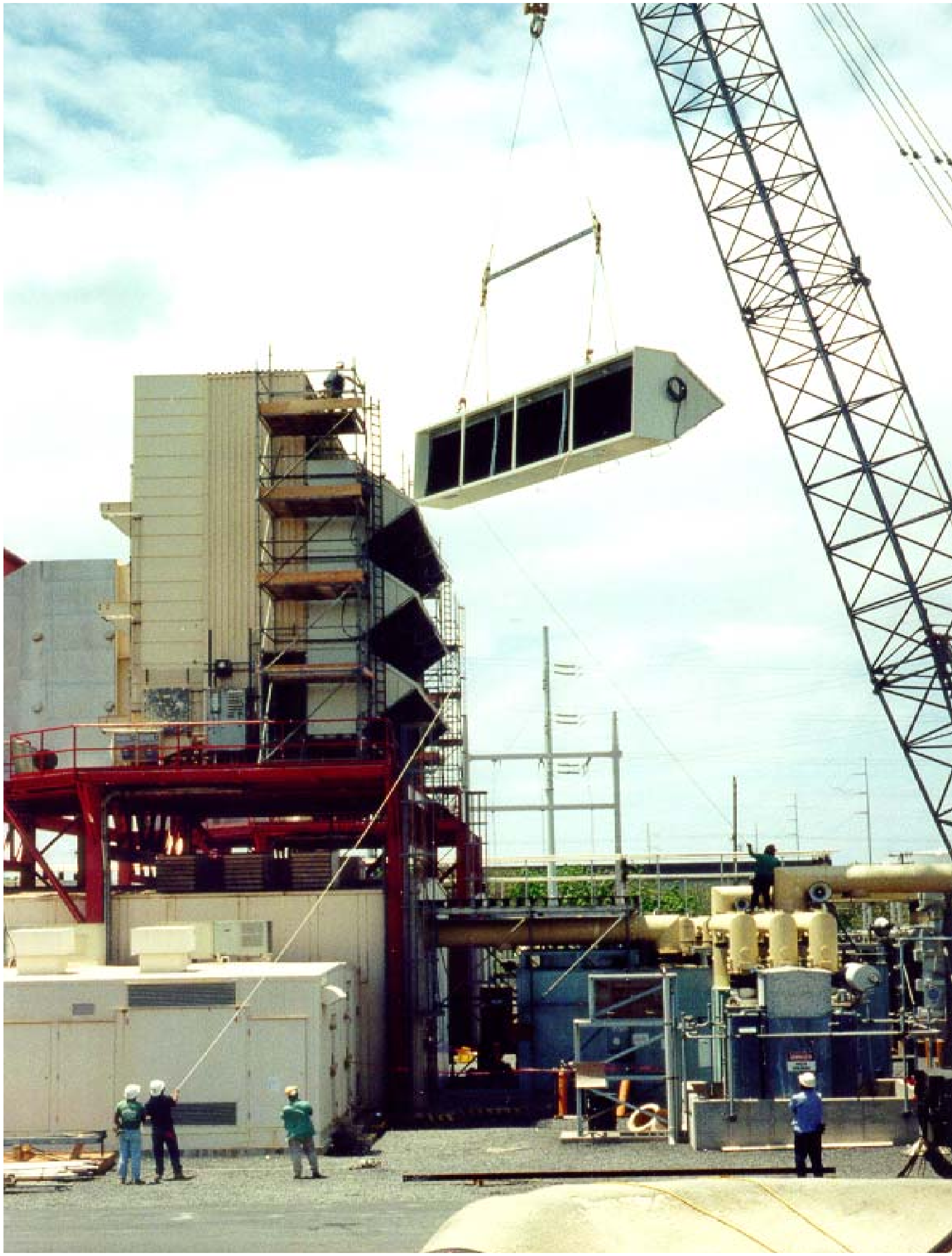


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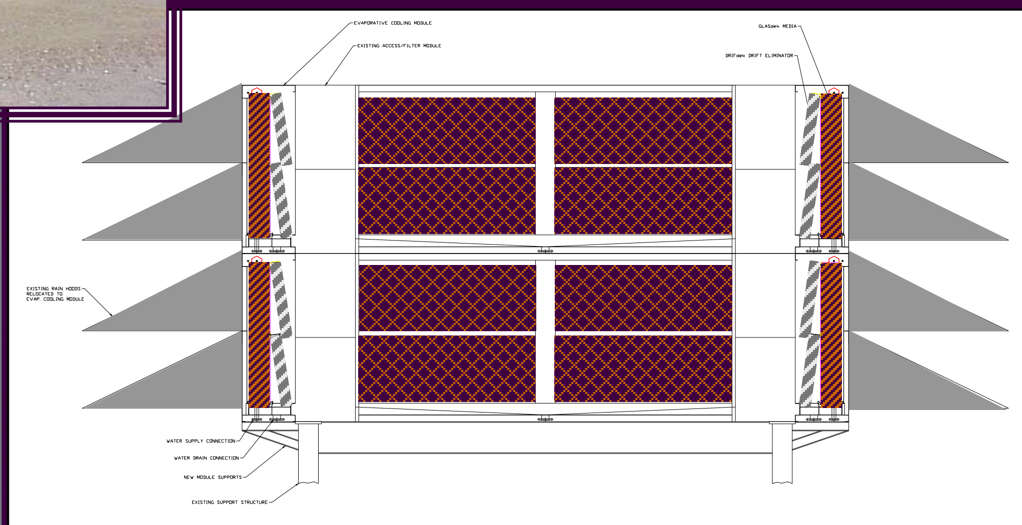
ANTHONY

Examples



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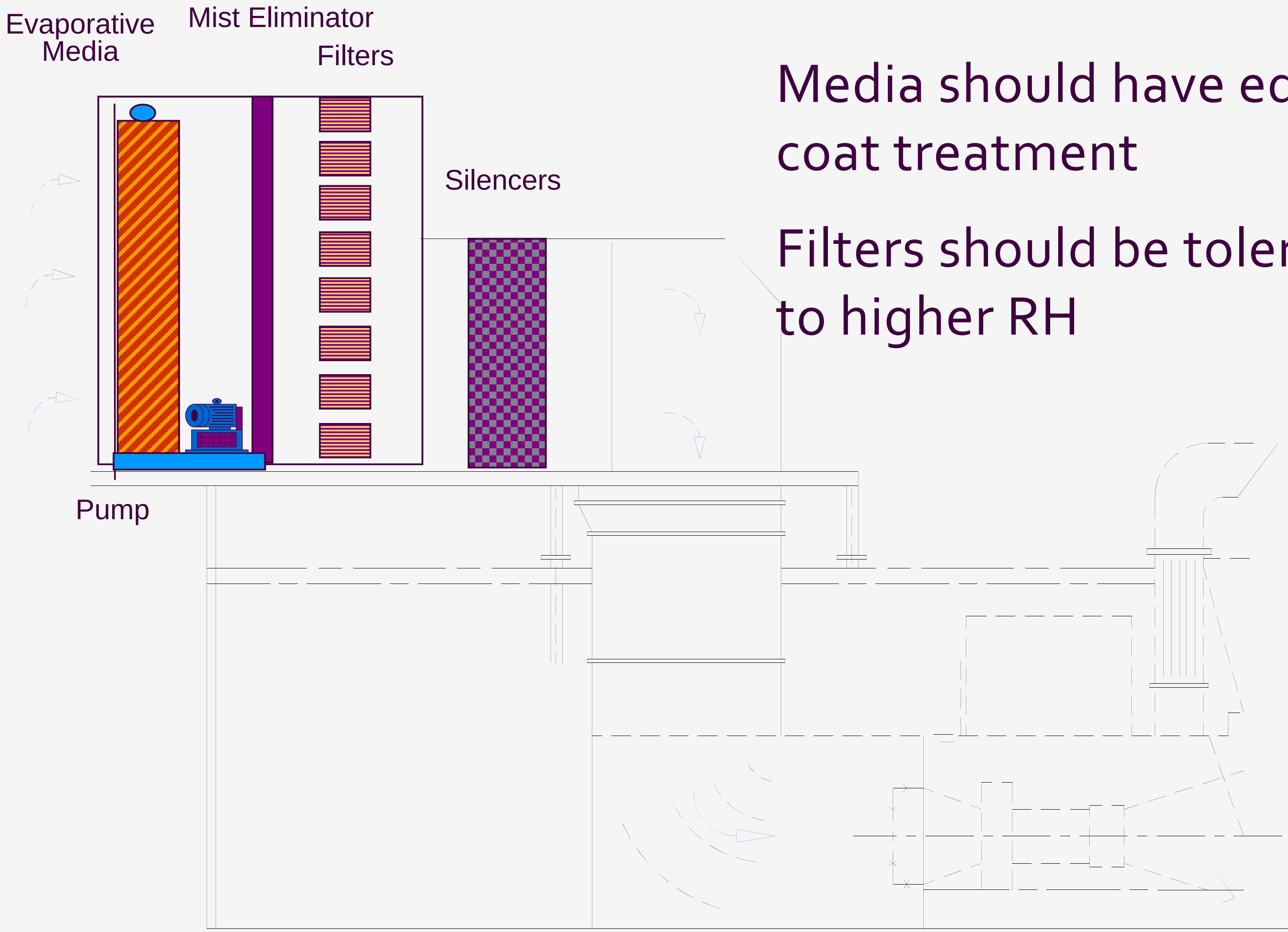
Media Upstream of Filters



Media should have edge coat treatment

Filters should be tolerant to higher RH

Examples

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GHH BORSIG


Simple, but Require Engineering, Experience & Robust Design

Design & Construction Considerations

- Face velocity
- Materials of construction
- Material gauge
- Media type
- Water source
- Valve function and locations
- Drains and overflows
- Air bypass
- Sump water management

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Simple, but Require Engineering, Experience & Robust Design

Design

- Design around 500 ft/min (most efficient), dwell time
  - If exceed 650'/min, explore moisture elimination
  - In some applications, may determine air tunnel size

Specification

- Full stainless construction is the best
- Fully welded basins, no bolted panels
- Appropriate steel gauges
- Media TURBOdek or CELdek with edge coating
- Proper water flow

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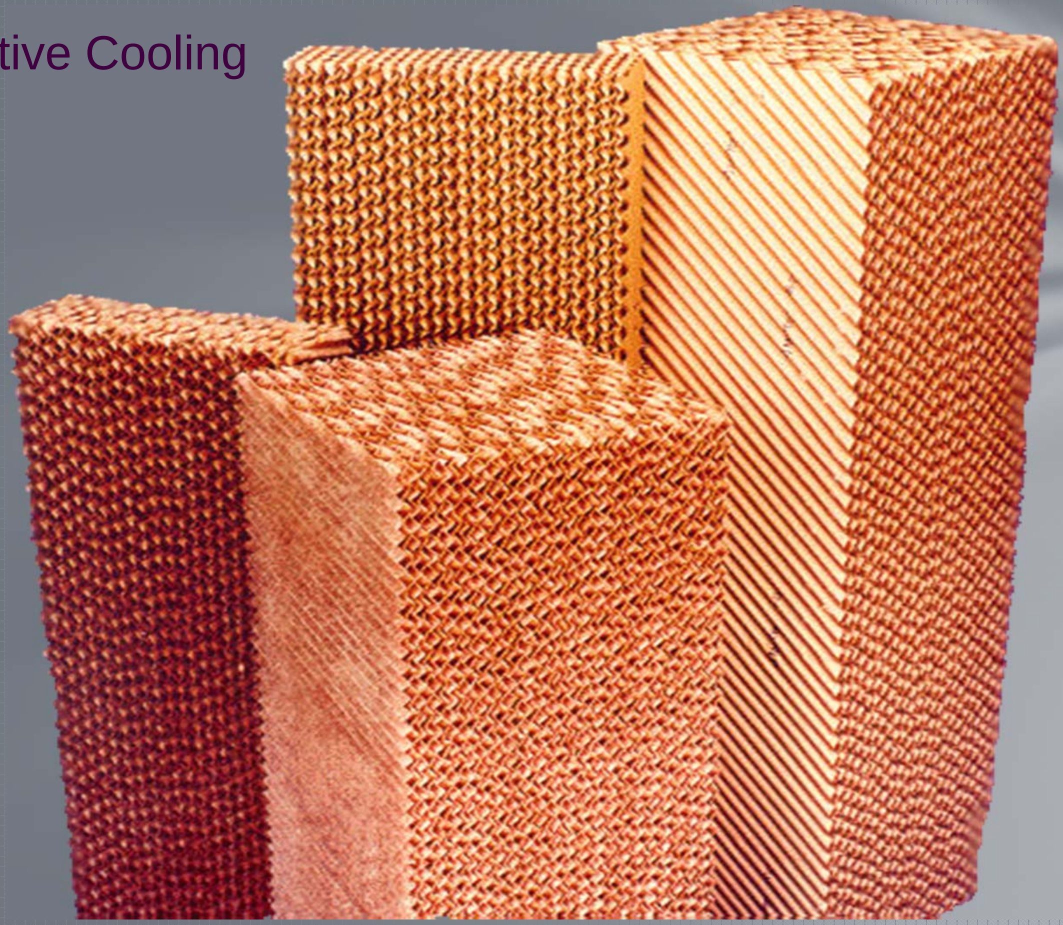
Simple, But Require Engineering, Experience & Robust Design

Media is the heart of Evaporative Cooling



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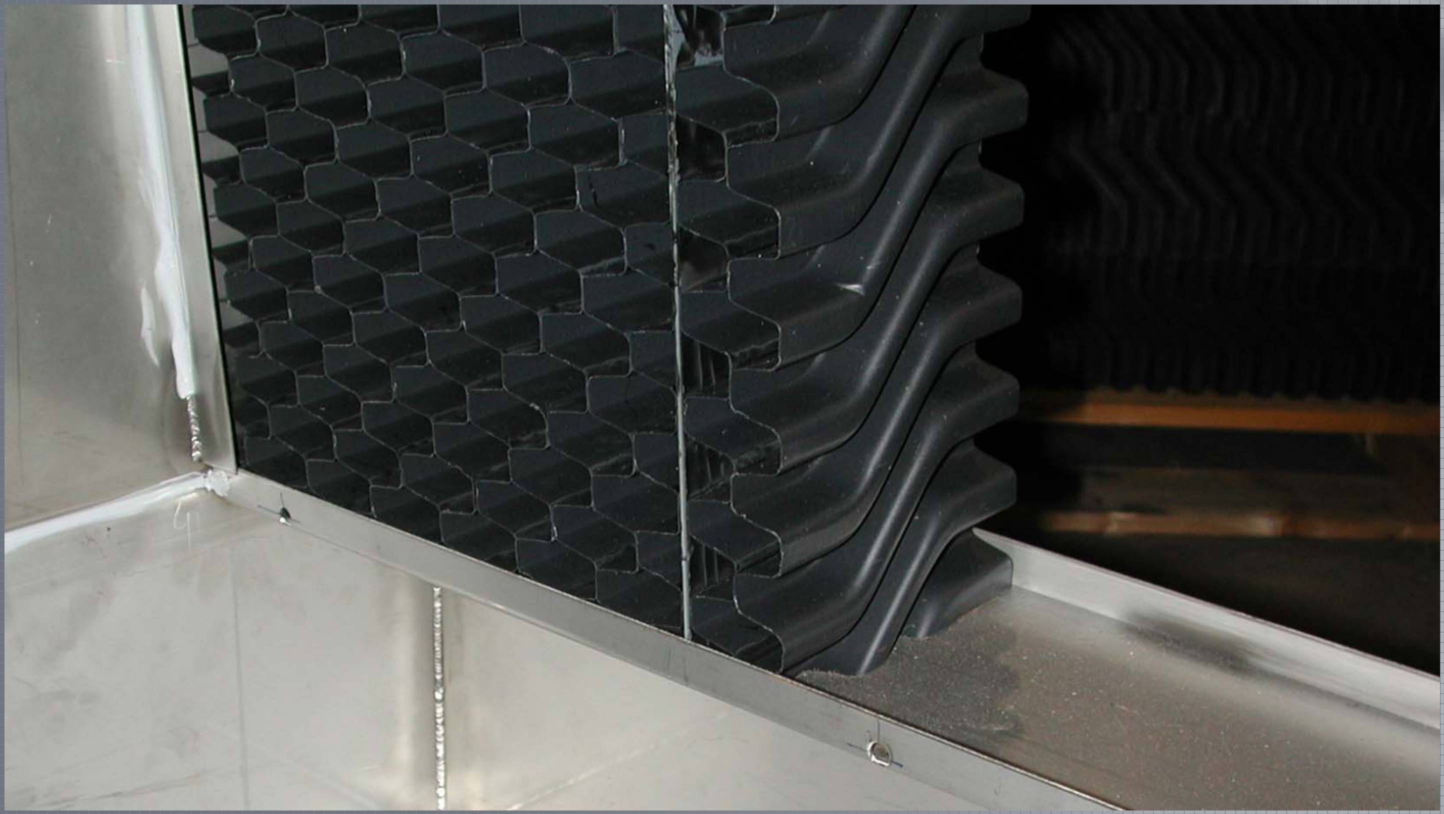
Drift Elimination

- 99.9% down to 50 microns



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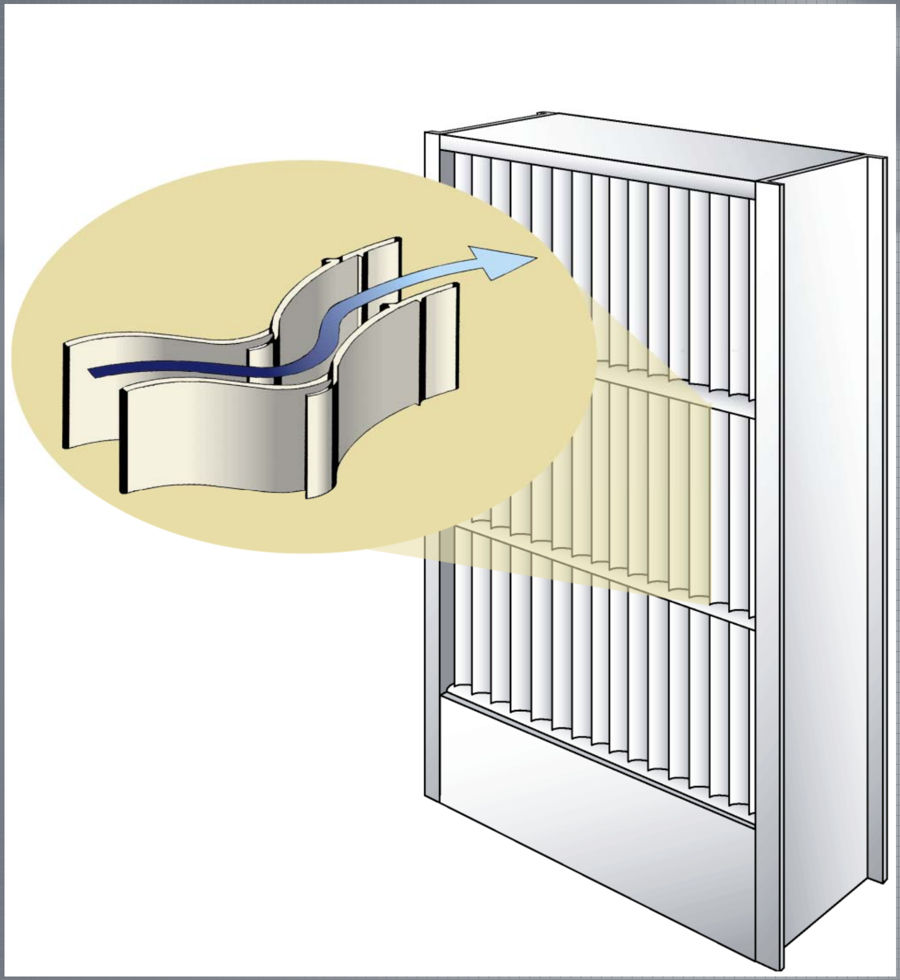
Drift Elimination

- Highest Efficiency, 99.9% to 25 microns
- Wide Velocity Range
- Low Pressure Drop
- Need Less room in Air Travel Direction



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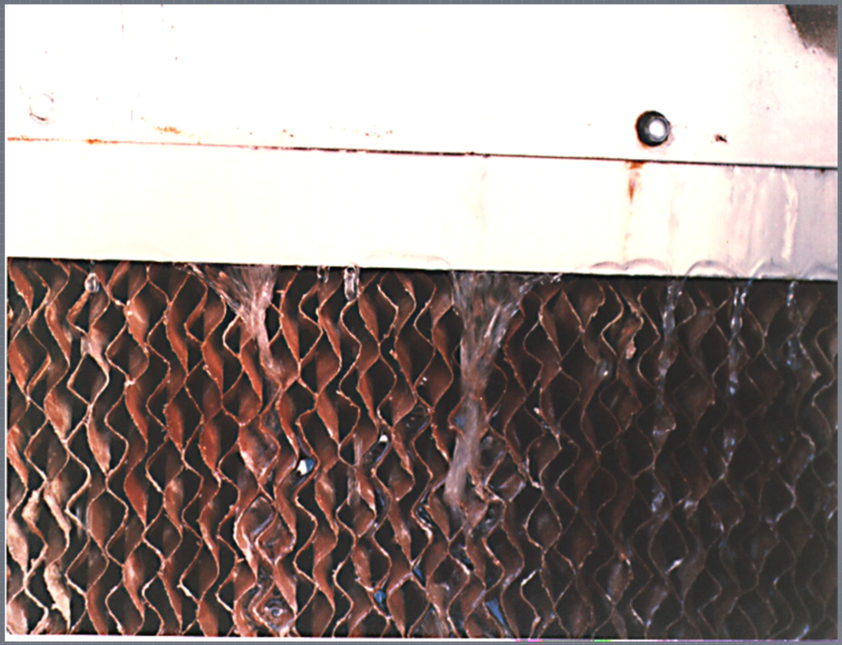
Simple, But Require Engineering, Experience & Robust Design



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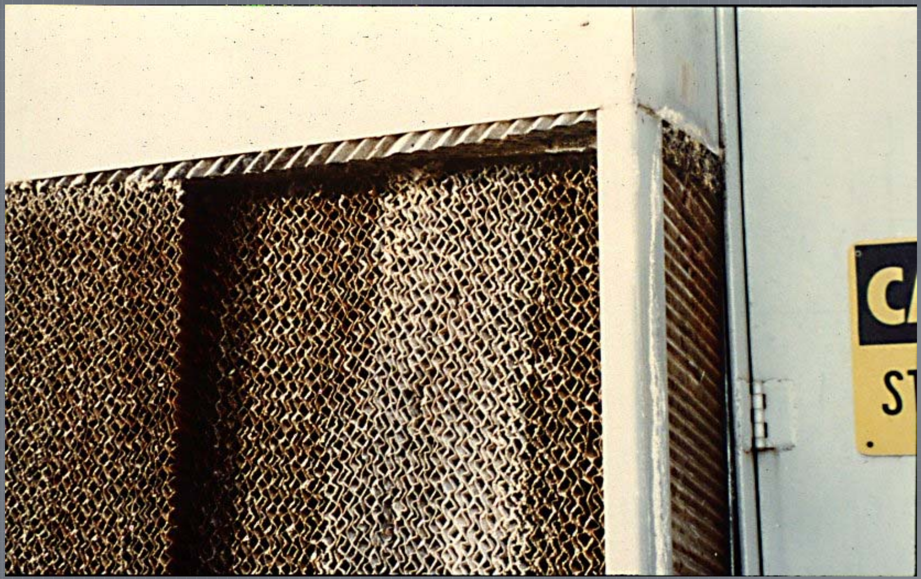
Simple, but Require Engineering, Experience & Robust Design

Areas "starved" for water will be the first to clog or soften.



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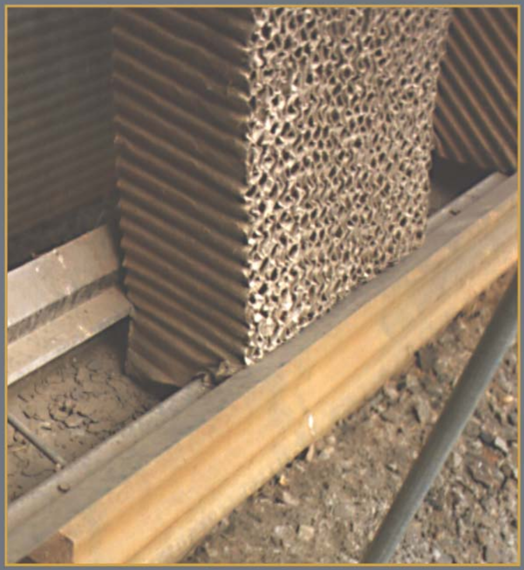
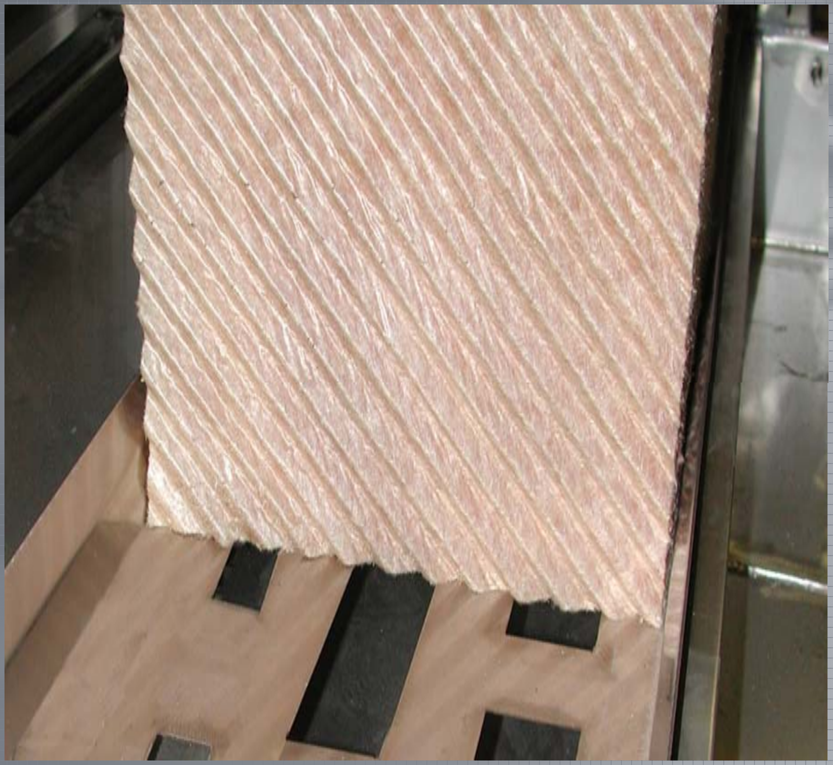
Simple, but Require Engineering, Experience & Robust Design





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Air follows the path of least resistance, think teenagers

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Simple but Requires Engineering, Experience & Robust Design

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Water Quality & Management

Continuous bleed / and or flush and dump used for scale control

- Scale inhibitors not recommended
- Bleed is major method of control
- Biocides not recommended, no oxidizing biocides allowed
- Corrosion inhibitors not recommended
- ALL SS and plastic construction
- Straight RO water is not recommended but a blend is okay

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Water Quality and Management

- Chemicals dry out on the media each time the water is turned off, causing the chemicals to loose their effectiveness
- Some chemicals are corrosive and will harm pads and turbine components.
- Some chemicals contribute to microbial growth.
- Many chemicals cause environmental problems.
- Those who use chemicals often feel they can neglect other maintenance requirements

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Water Quality & Management

Reverse Osmosis	High Cost High Maintenance cost Minimal Bleed off
Demineralization	High Cost Requires handling chemicals Minimal Bleed off
Zeolite Softening	Changes Calcium Carbonate to Sodium Carbonate Does not remove Silica Requires bleed-off
Acid Addition	Typically use concentrated sulphuric acid Makes Calcium and Magnesium less soluble Requires continuous injection of acid Dangerous to handle/ can add too much acid Requires bleed-off
Crystal Modifiers	Requires continuous injection of chemical Leaves a soft sludge residue that can blow downstream
Sequesterants	Require addition of sodium hexametaphosphate Encourages algae growth

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Water Quality & Management

LIMITS FOR MAKE-UP WATER ANALYSIS

The following water quality is established for evaporative cooler water make-up. This water can then be cycled up 2 to 6 cycles to obtain the following stability indices.

Langelier Index = 0.5 ± 0.25

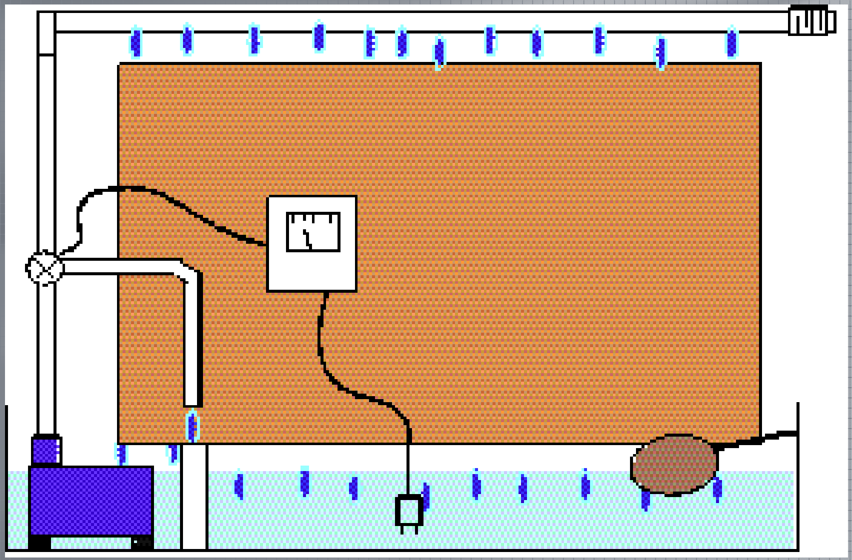
Ryznar Index = 6.0 ± 0.5

Puckorius Index = 6.5 ± 0.5

CONSTITUENT	ALLOWABLE*
Calcium Hardness (as CaCO3)	50 - 150 PPM
Total Alkalinity (as CaCO3)	50 - 150 PPM
Chlorides (as Cl)	<50 PPM
Silica (as SiO2)	<25 PPM
Iron (as Fe)	<0.2 PPM
Oil and Grease	<2.0 PPM
Conductivity	<750 μmhos
Suspended Solids	<5 PPM
pH	6.0 to 8.5

* Need to be evaluated as a system, not in isolation

Water Quality & Management



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Remote Sump Watermanagement

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Remote Sump Water Management

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Water Quality & Management

- We want you system to operate as designed and for your Media Engine to last as long as possible!!!
- PLEASE use Munters experience and chemists to analyze your sites water more often than not……..we make it easy!

Water is the life of our system and we recommend a full water analysis. Project can submit a written water report via the local water municipality or through a water sample. Please submit:

Report to Dan Schumacher
dan.schumacher@munters.com

Water Sample to Southern Analytical Laboratories, Inc

Attn: Travis Wright (for Munters Corp)

110 Bayview Boulevard,

Oldsmar, FL 34677

tel: 813-855-1844

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Low Maintenance

Spray system

- Check water distribution, qtr
- Remove top media & clean spray holes, annual

Conductivity Controller & Bleed

- Clean probes from scale, annual
- Test bleed valve (adjusting conductivity setting), annual

Sump Water Level

- Look for proper water level and/or signs of over filing, annual

Pump Permissive

- Verify pump permissive and overflow switch operate properly, annual

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Water Usage

80 MW Turbine with 500,000 cfm, Arid Climate

	Softened Water	Moderate Water	Hard Water
Evaporation, GPM	180	180	180
Bleed, GPM	20	80	180
TOTAL	200	260	360

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How Direct Evaporative Cooling Compares

Utilities Example for 100 MW CT in Tampa, FL

	Media	Fog	Mechanical Chilling
Deg of Cooling	12.6 F	13.3 F	44 F
Water Evaporated	13 GPM	13.6 GPM	136 GPM (at Cooling Tower)
Blow Down	4 GPM	6.5 GPM (at RO plant)	4.5 GPM at Cooling Tower
Parasitic Power Loss	10 kW	27 kW	3181 kW
Insertion loss	0.3"wg	0.05"wg	1.0"wg

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How Direct Evaporative Cooling Compares

Utilities Example for 100 MW CT in Las Vegas

	Media	Fog	Mechanical Chilling
Deg of Cooling	37 F	39 F	57 F
Water Evaporated	35 GPM	37 GPM	76 GPM (at Cooling Tower)
Blow Down	12 GPM	18 GPM (at RO plant)	4 GPM
Parasitic Power Loss	10 kW	75 kW	2250 kW
Insertion loss	0.3”wg	0.05”wg	1.0”wg

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Low Maintenance

- Design
  - Design around 500 ft/min (most efficient), dwell time
    - If exceed 650’/min, explore moisture elimination
    - In some applications, may determine air tunnel size
- Specification
  - Full stainless construction is the best
  - Fully welded basins, no bolted panels
  - Appropriate steel gauges
  - Media TURBOdek or CELdek with edge coating
  - Proper water flow

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Why Use Direct Evaporative Cooling for Turbine Inlets

One of the most cost effective solutions

- Lowest first install cost
- Low operating costs
- Low maintenance cost

Simple

- To understand
- To design
- To install
- To maintain

1000’s of successful installations Worldwide

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Thank You

And Don’t Forget to Join

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