Combustion Turbine Inlet Cooling using Direct Evaporative Cooling

By Pat Zeller, Munters Corporation

Sponsored by:

Turbine Inlet Cooling Association (TICA)

August 22, 2012; 1 PM (U.S. Central Time)

http://www.meetingzone.com/presenter/default.aspx?partCEC=4147918

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Introductions

- Trevor Richter
  - Chairman, TICA
  - Stellar Energy Inc.
- Pat Zeller
  - Munters Corporation

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.

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

- August 22, 2012: Wetted-Media Evaporative Cooling
- October 18, 2012: Fogging
- December 19, 2012: Chiller Systems
- February 13, 2013: Thermal Energy Storage
- April 17, 2013: Wet Compression
- June 19, 2013: Hybrid Systems

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All Webinars start at 1 PM (U.S. Central Time)

Agenda:

- Why Cool Turbine Inlets
- How Direct Evaporative Cooling Works
- Anatomy of Direct Evaporative Coolers
- Things to Consider in Evaporative Cooling of CT's
- Water Quality and Usage
- Quick Compare to Other Cooling Technologies
- Why Direct Evaporative Cooling for Combustion Turbines

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Unfortunate Fundamental Characteristics of All Combustion Turbine Power Plants

- During hot weather, just when power demand is at it's peak………….
  1. CT Total Power output decreases up to 35% below rated capacity (Extent of the decrease depends on the CT design)
  2. Efficiency decreases leading to increased fuel consumption (heat rate) and emissions per kWh……..up to 15% more fuel consumed (Extent of the decrease depends on the CT design)

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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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Why CT Efficiency Decreases with Increase in Ambient Temperature?

- Compressor of a CT system consumes almost two-third of the turbine's gross output
- Compressor requirement increases with increase in air temperature
- Increased power required by the compressor reduces the net electric power available from the CT system

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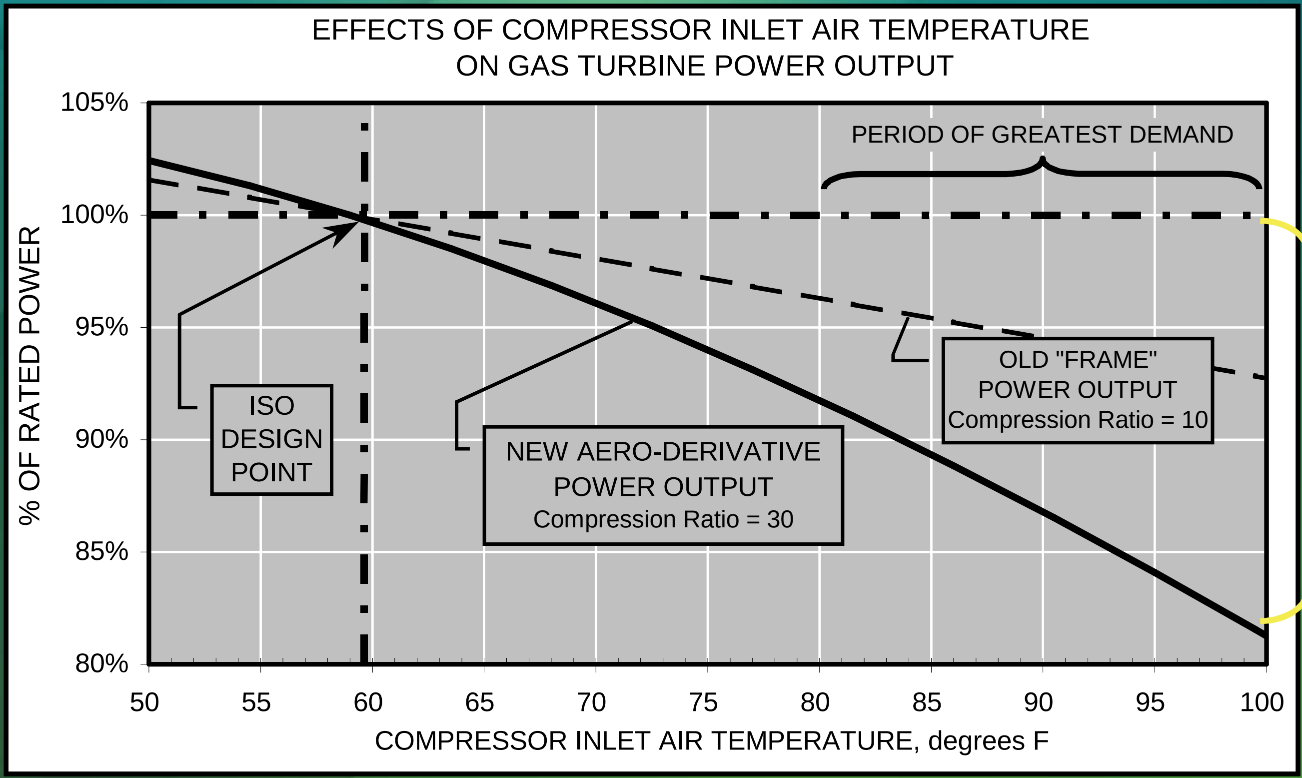
Effect of Hot Weather on CT Generation Capacity Depends on CT Design



Up to 19% capacity loss at peak demand for this CT

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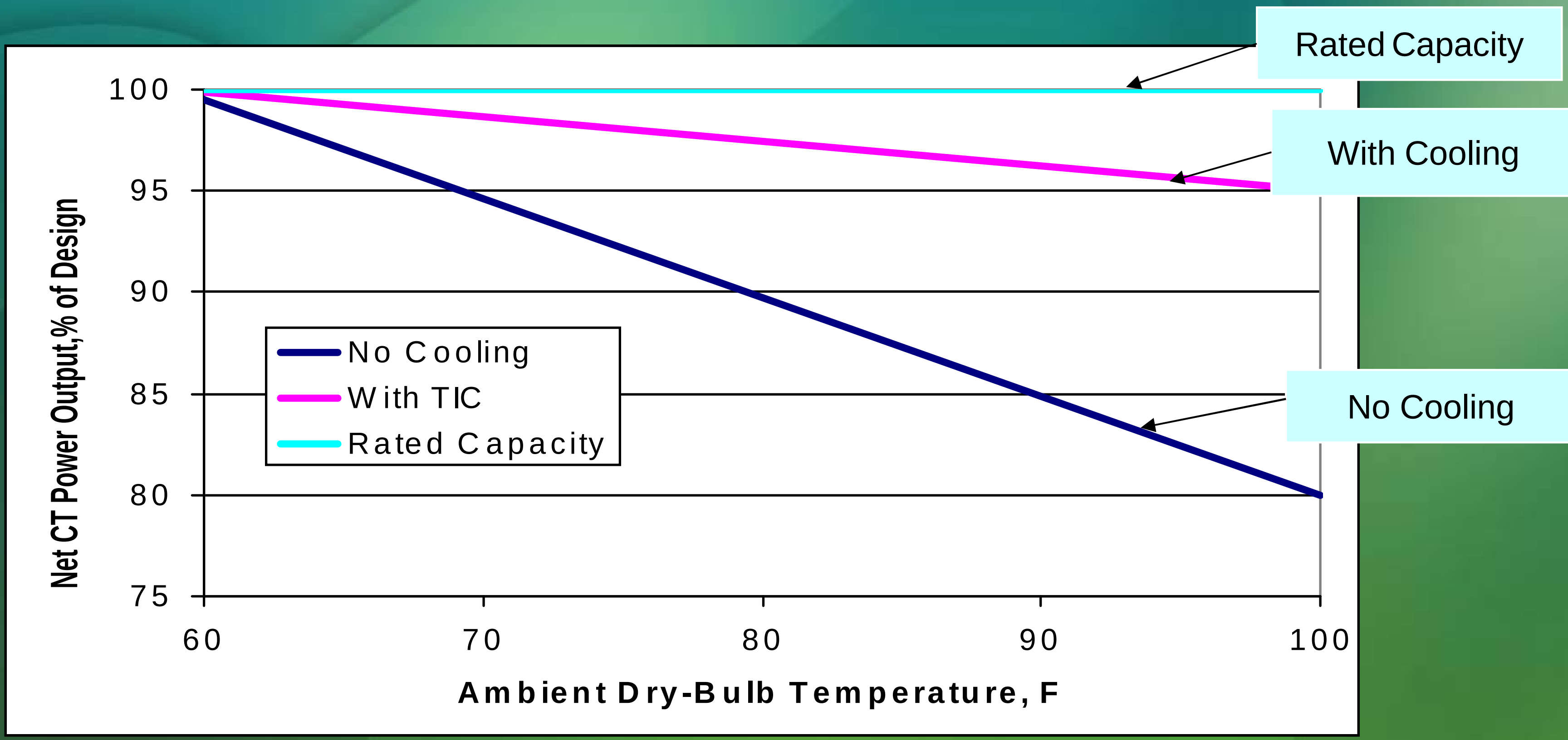
Turbine Inlet Cooling Overcomes the Effects of the CT Flaws During Hot Weather



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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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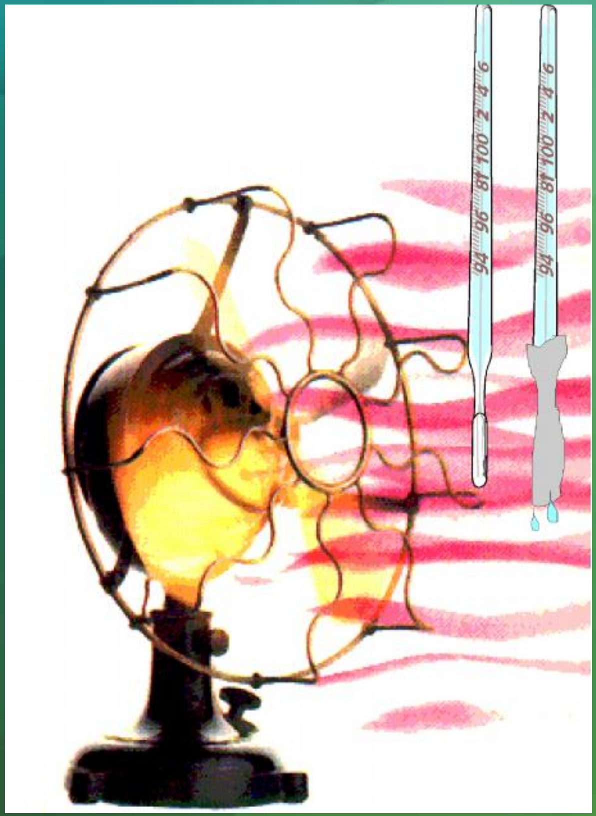
How Direct Evaporative Cooling Works



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How Direct Evaporative Cooling Works

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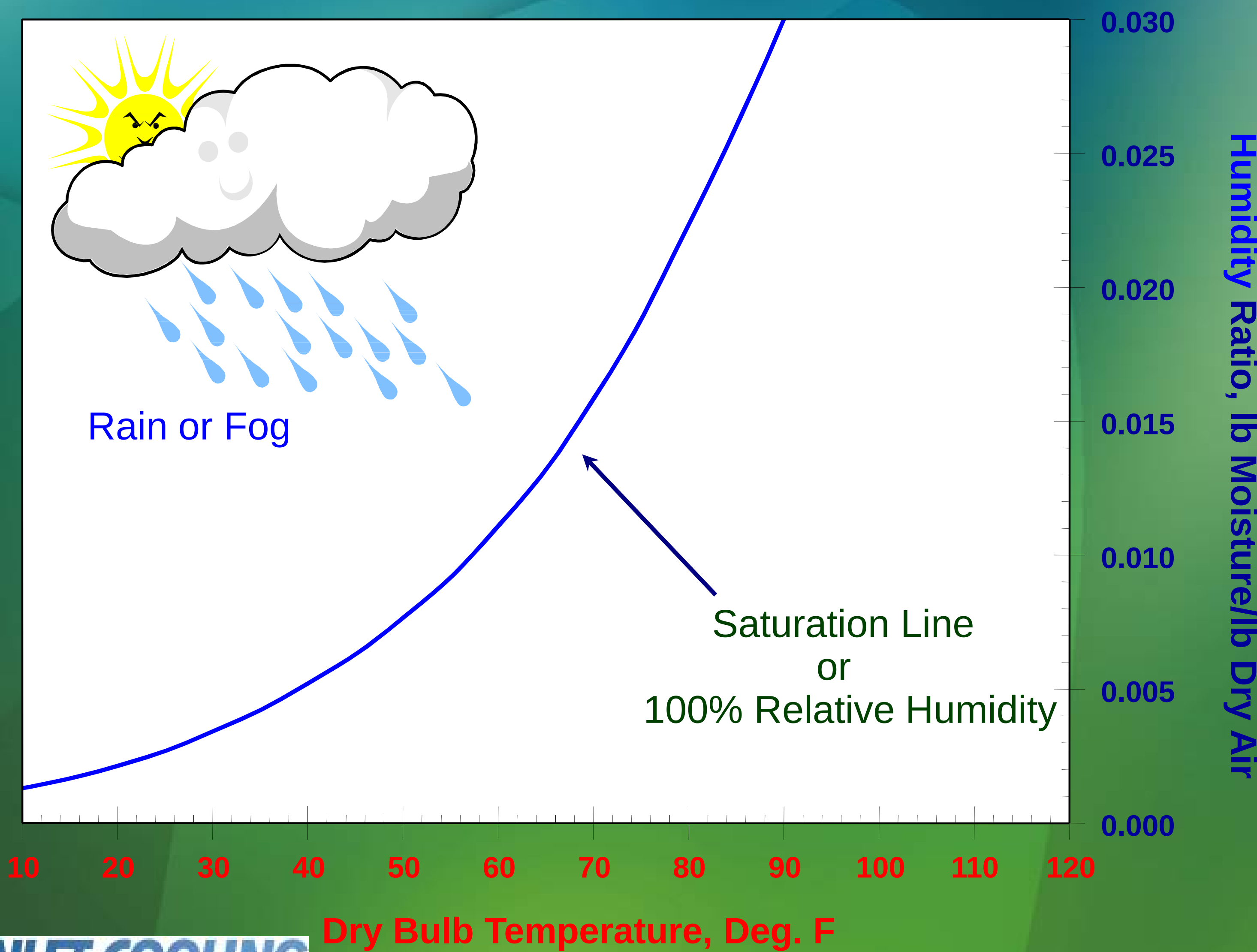
How Direct Evaporative Cooling Works



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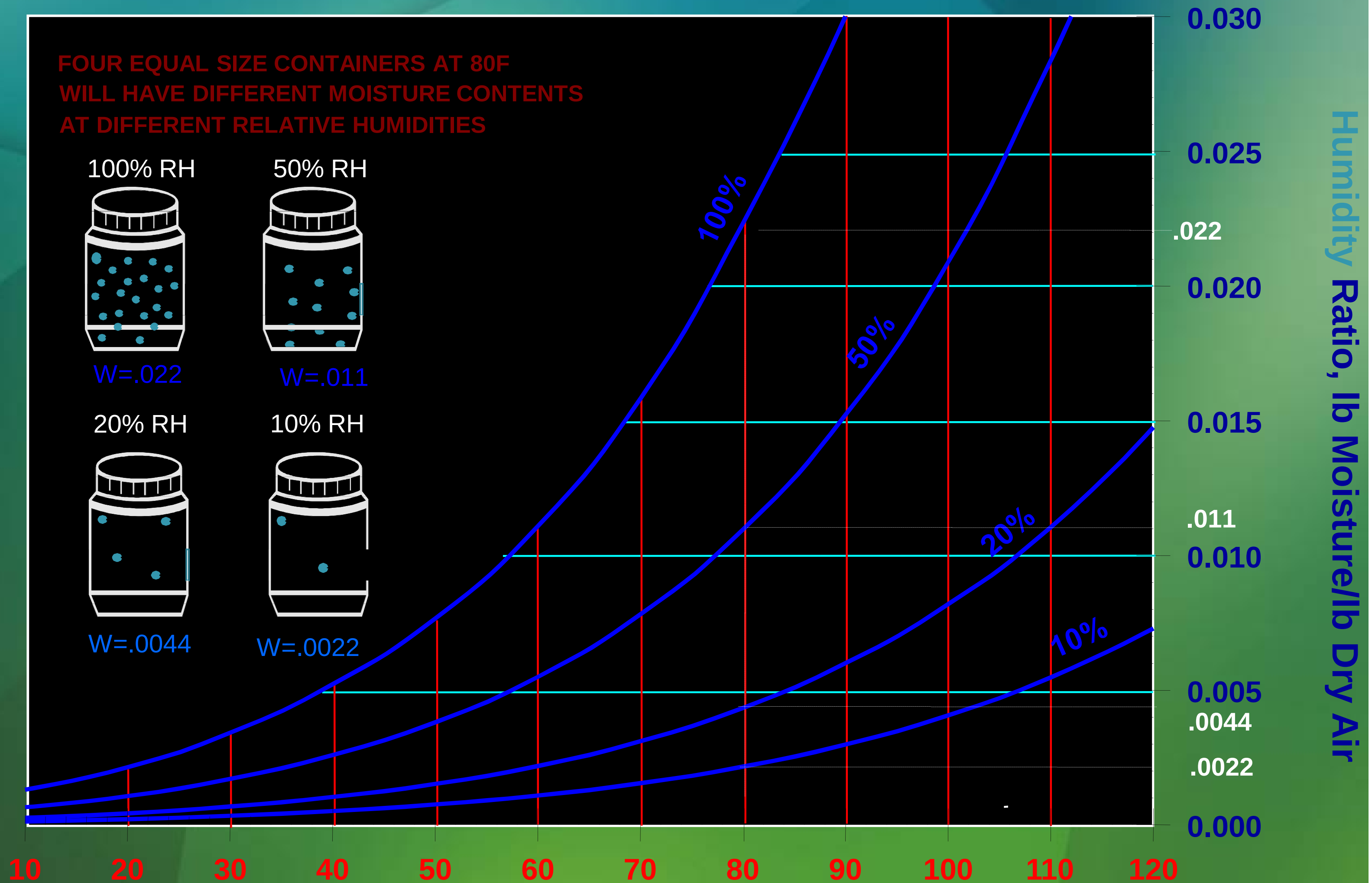
Moisture Content in Air



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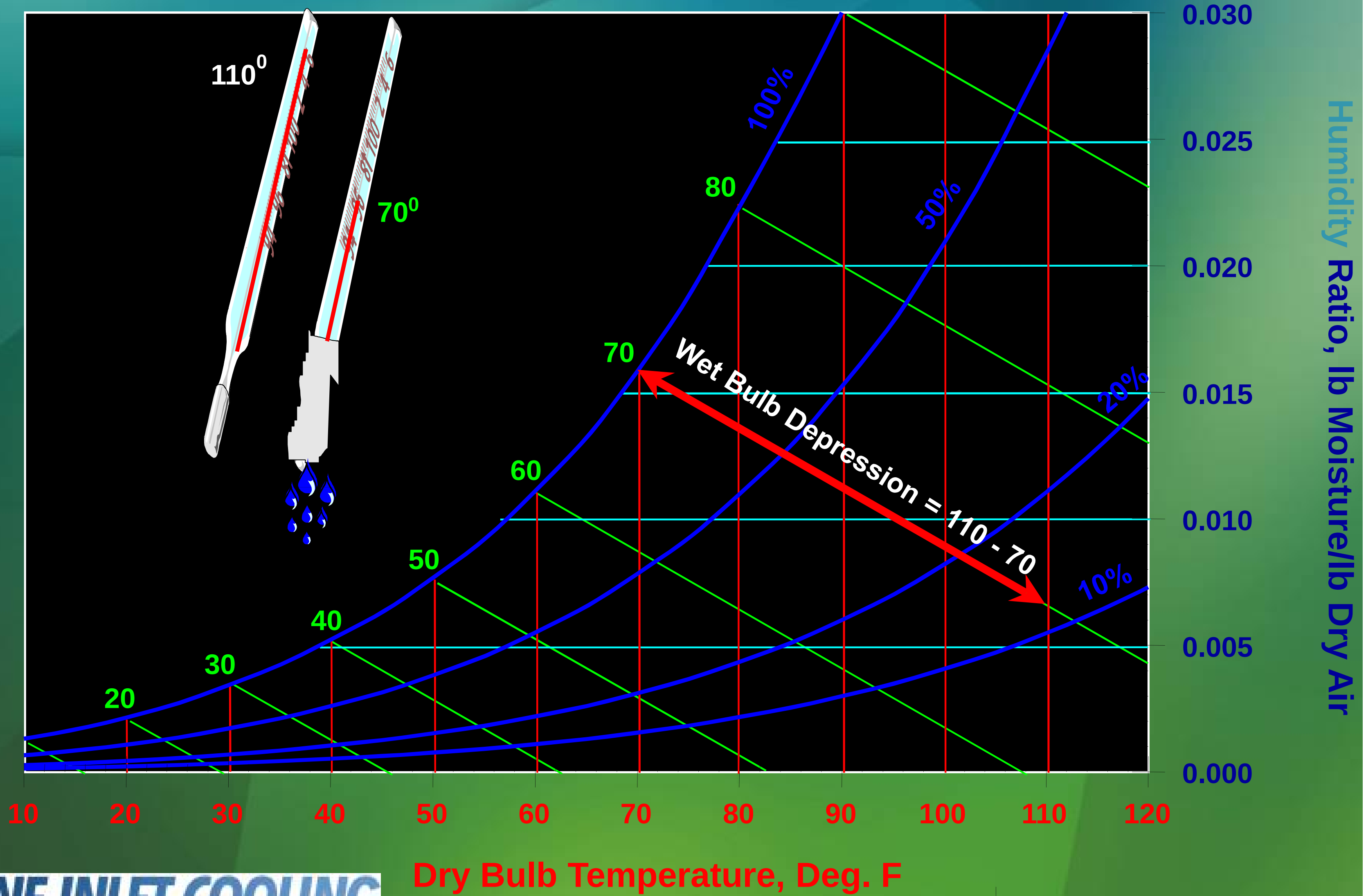
As We Cool Air Close to the Wet Bulb Line



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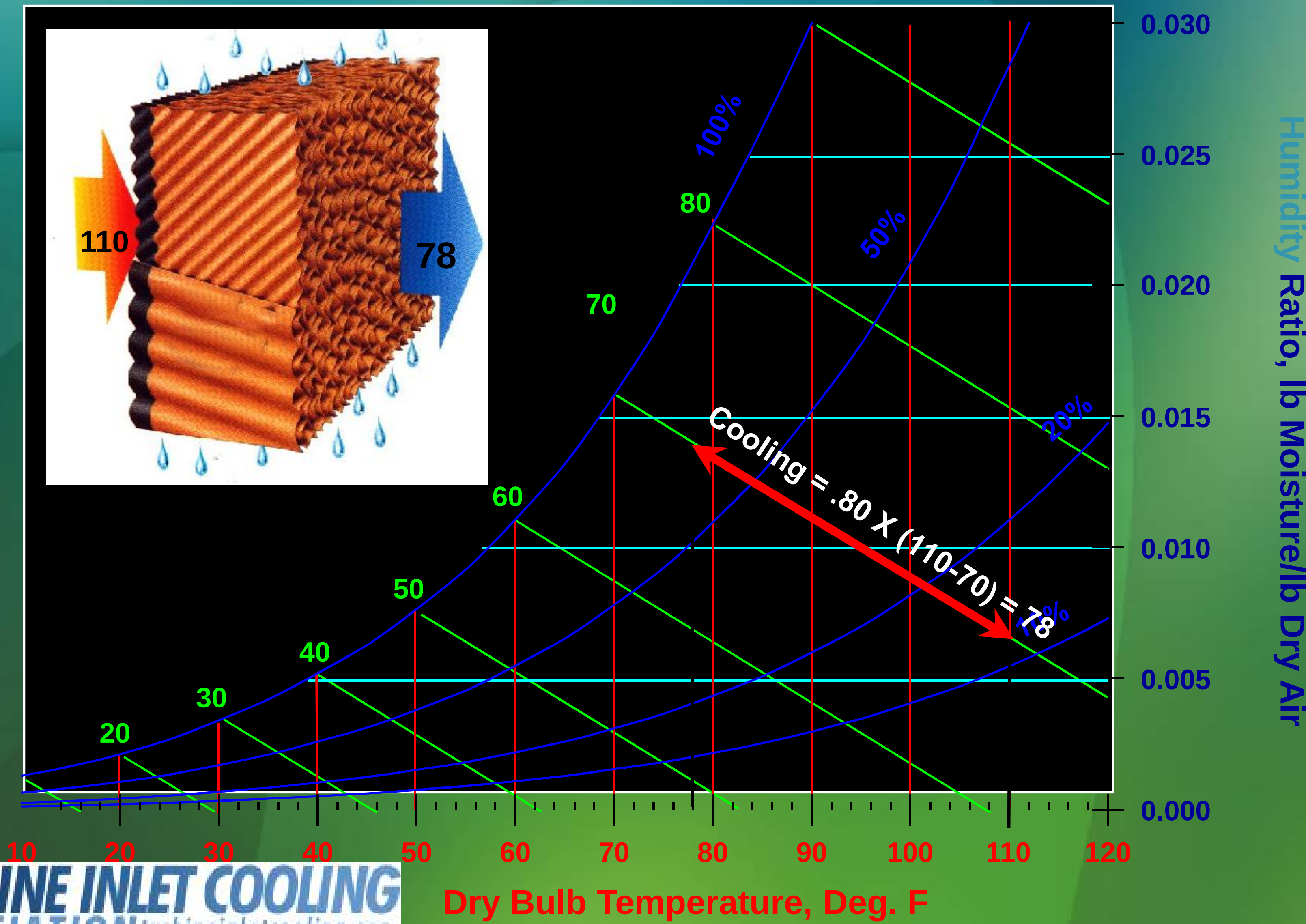
Direct Evaporative Cooling of an Airstream



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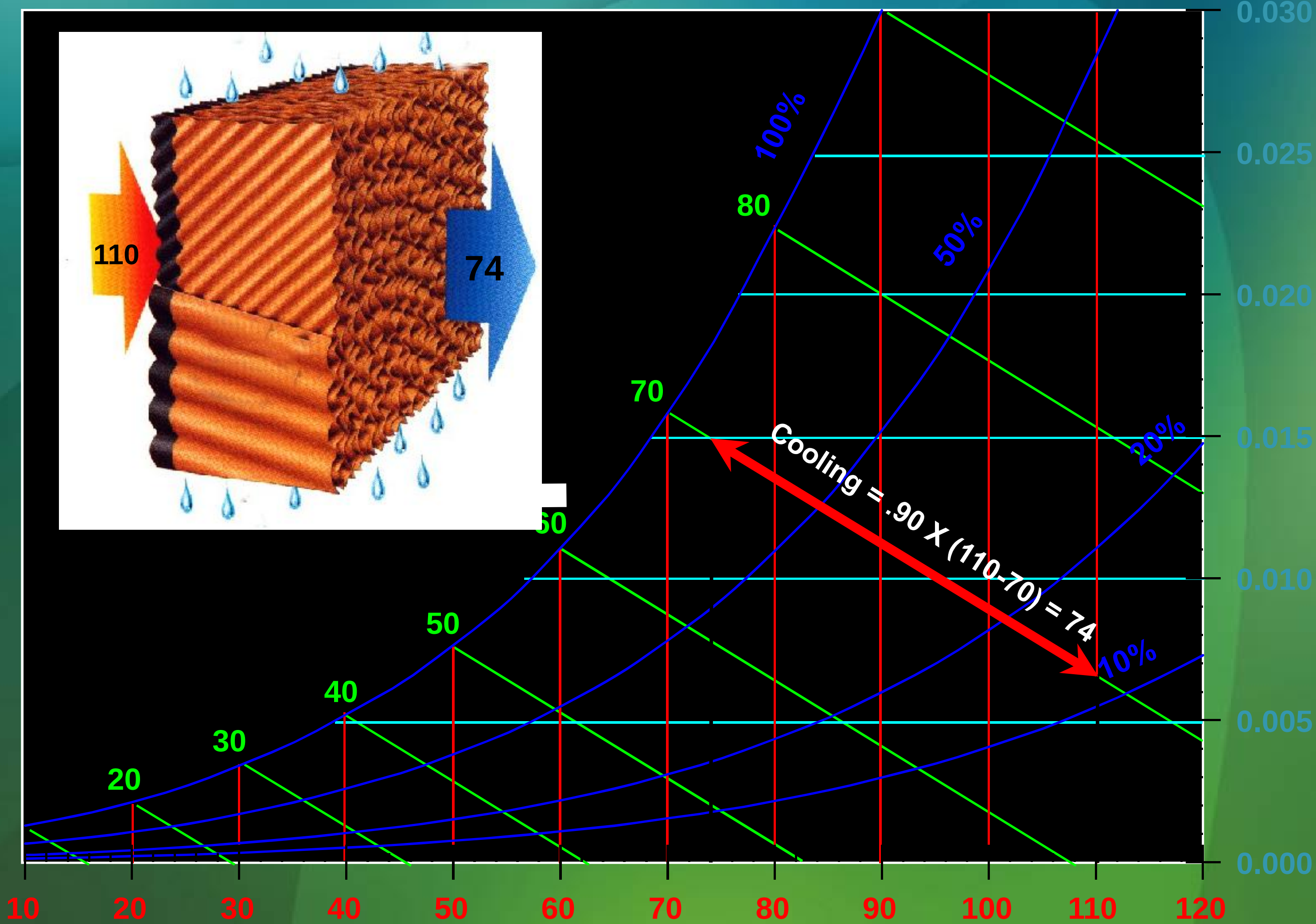
Direct Evaporative Cooling of an Airstream



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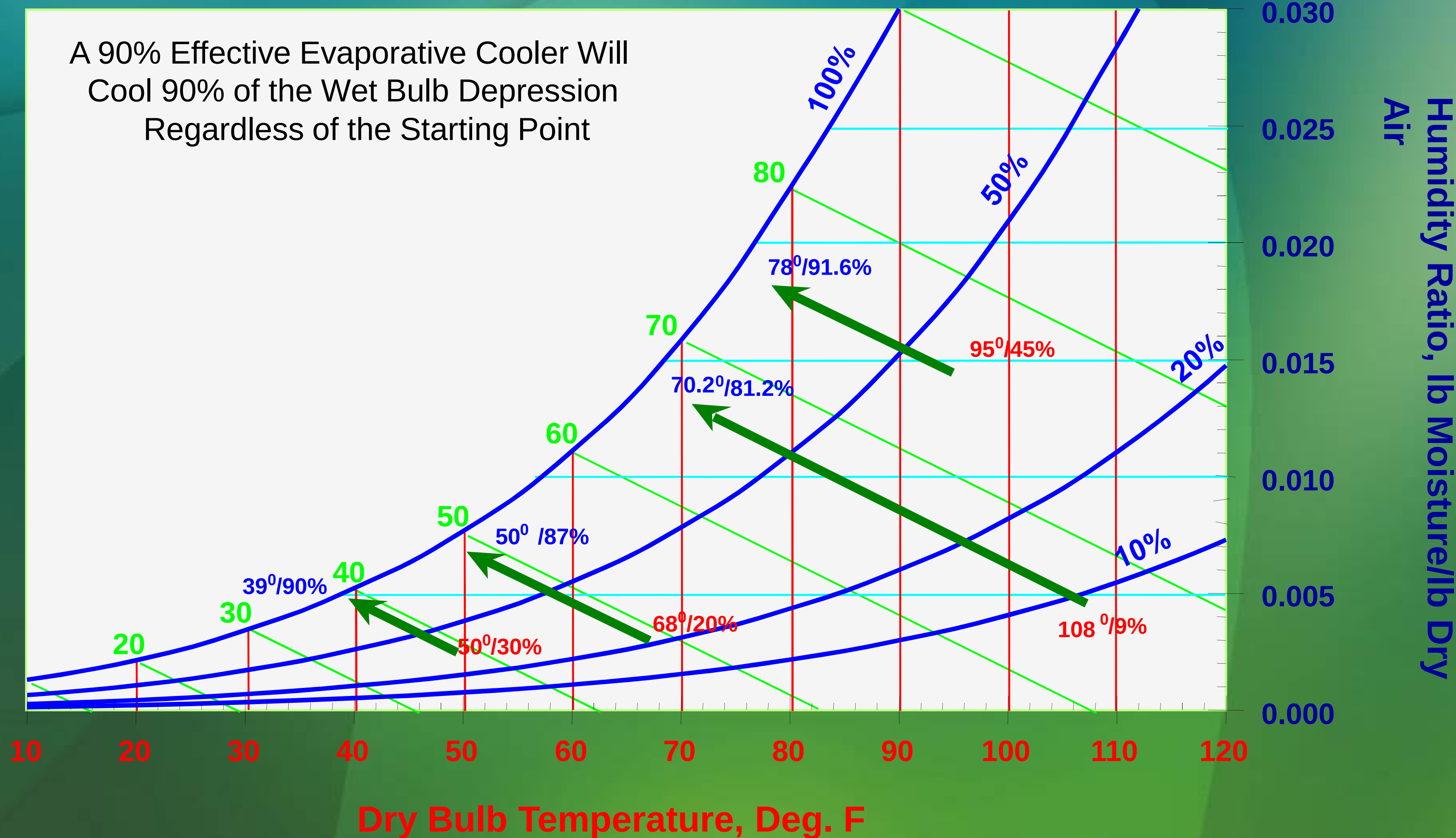
Cooling Efficiency is the Same Regardless of the Starting Point



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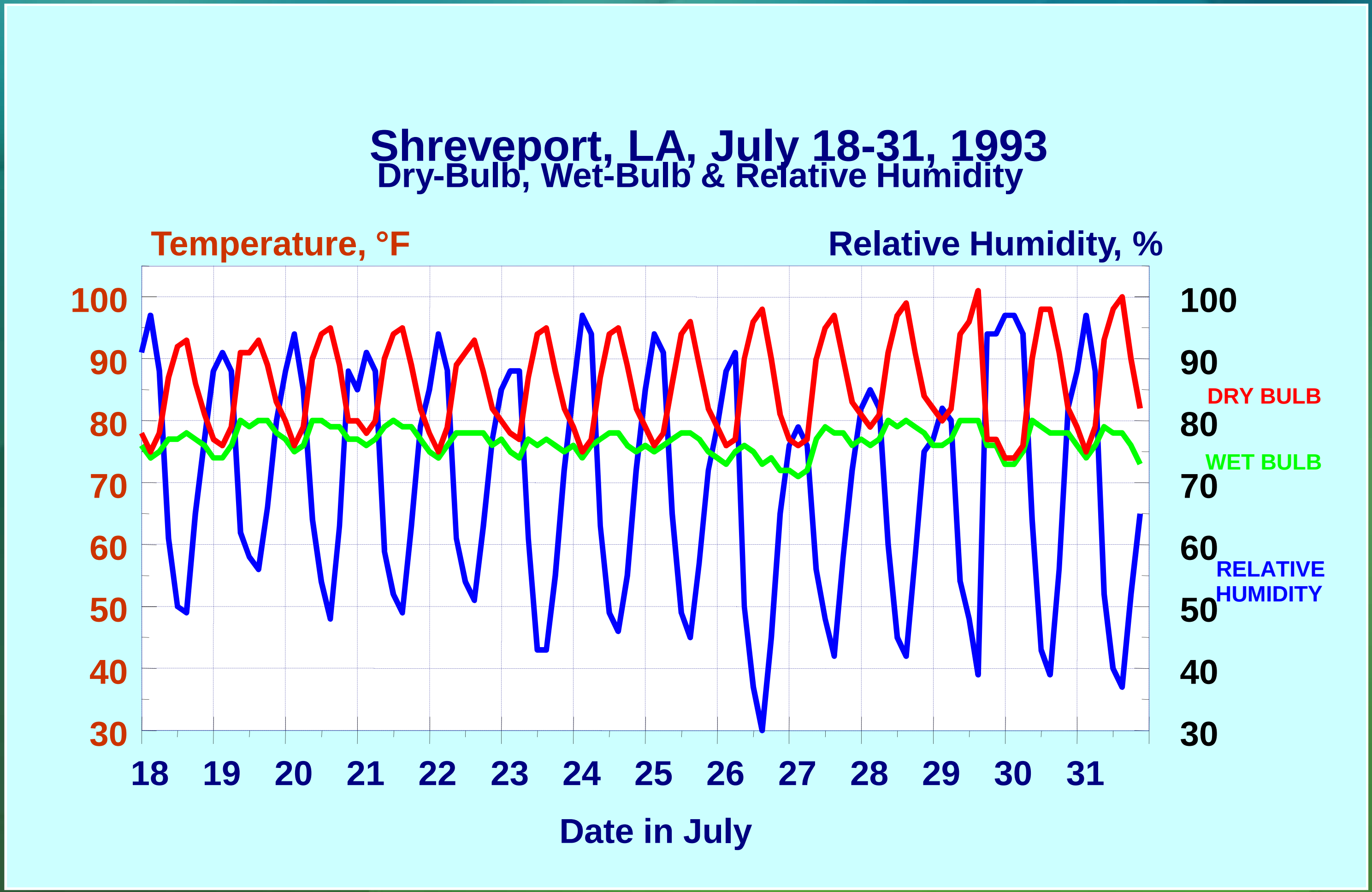
As the Day Temp Heats Up



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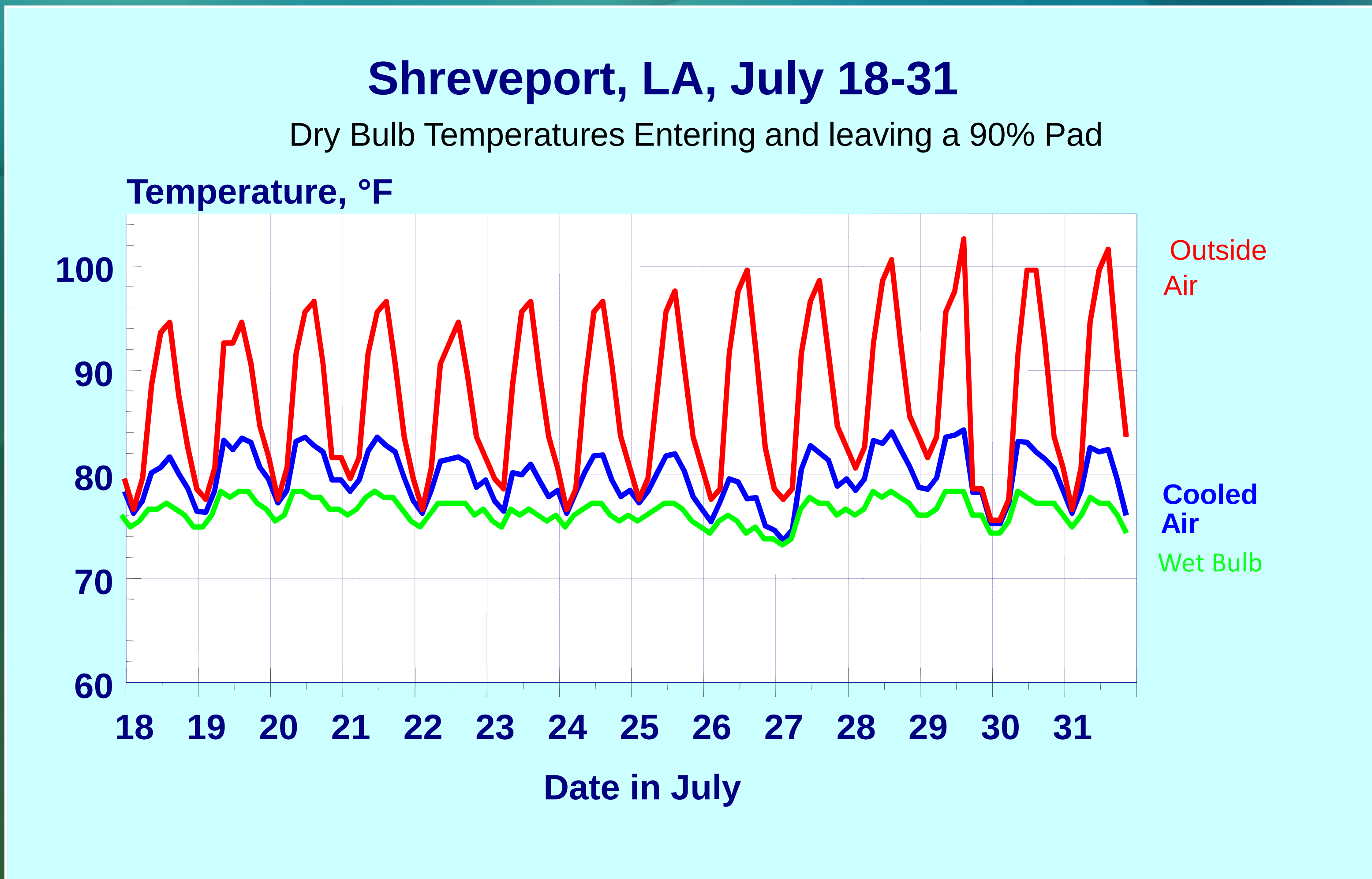
Even in Humid Areas, Direct Evaporative Cooling Works



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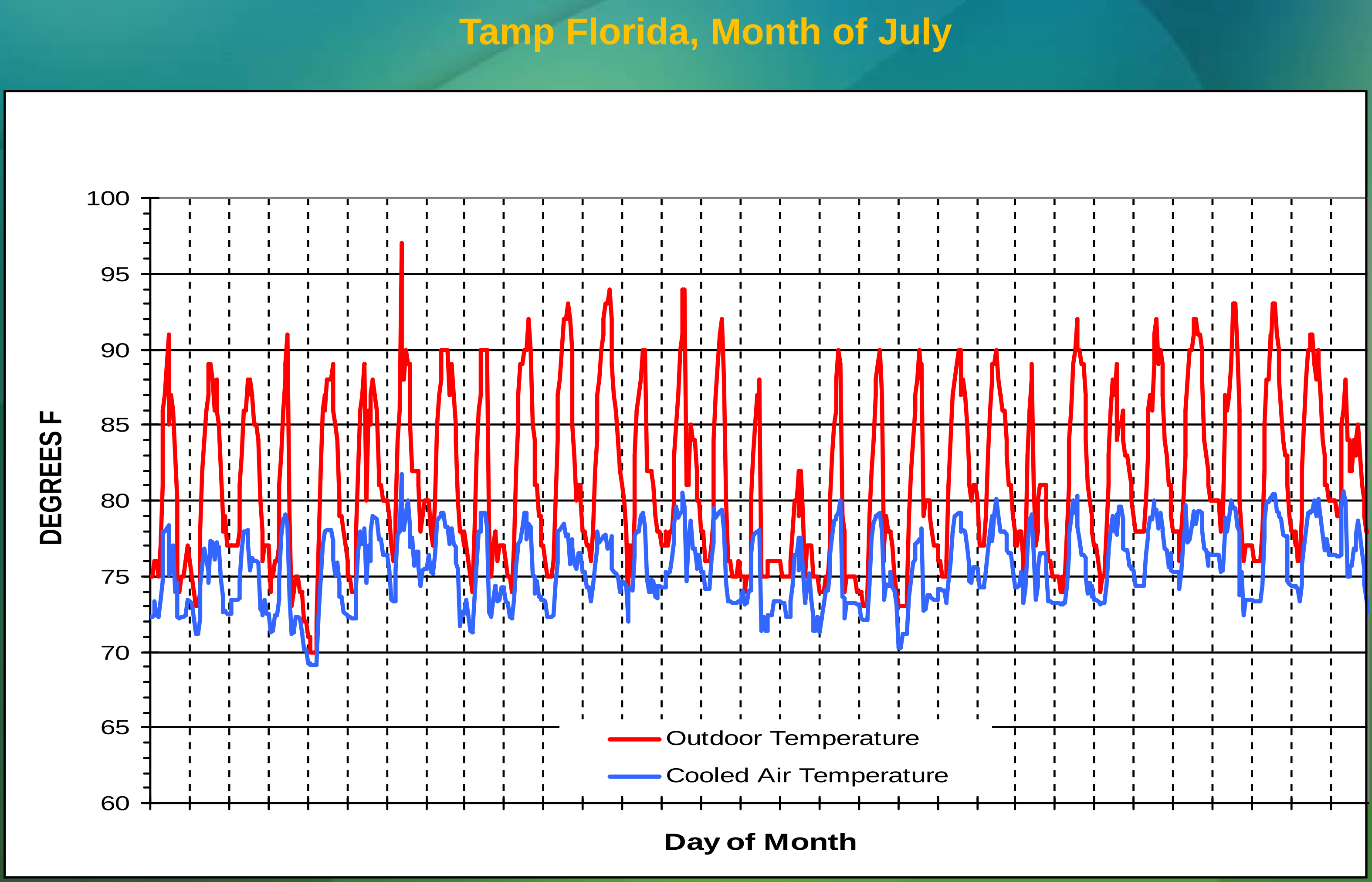
Looking at Tampa Florida



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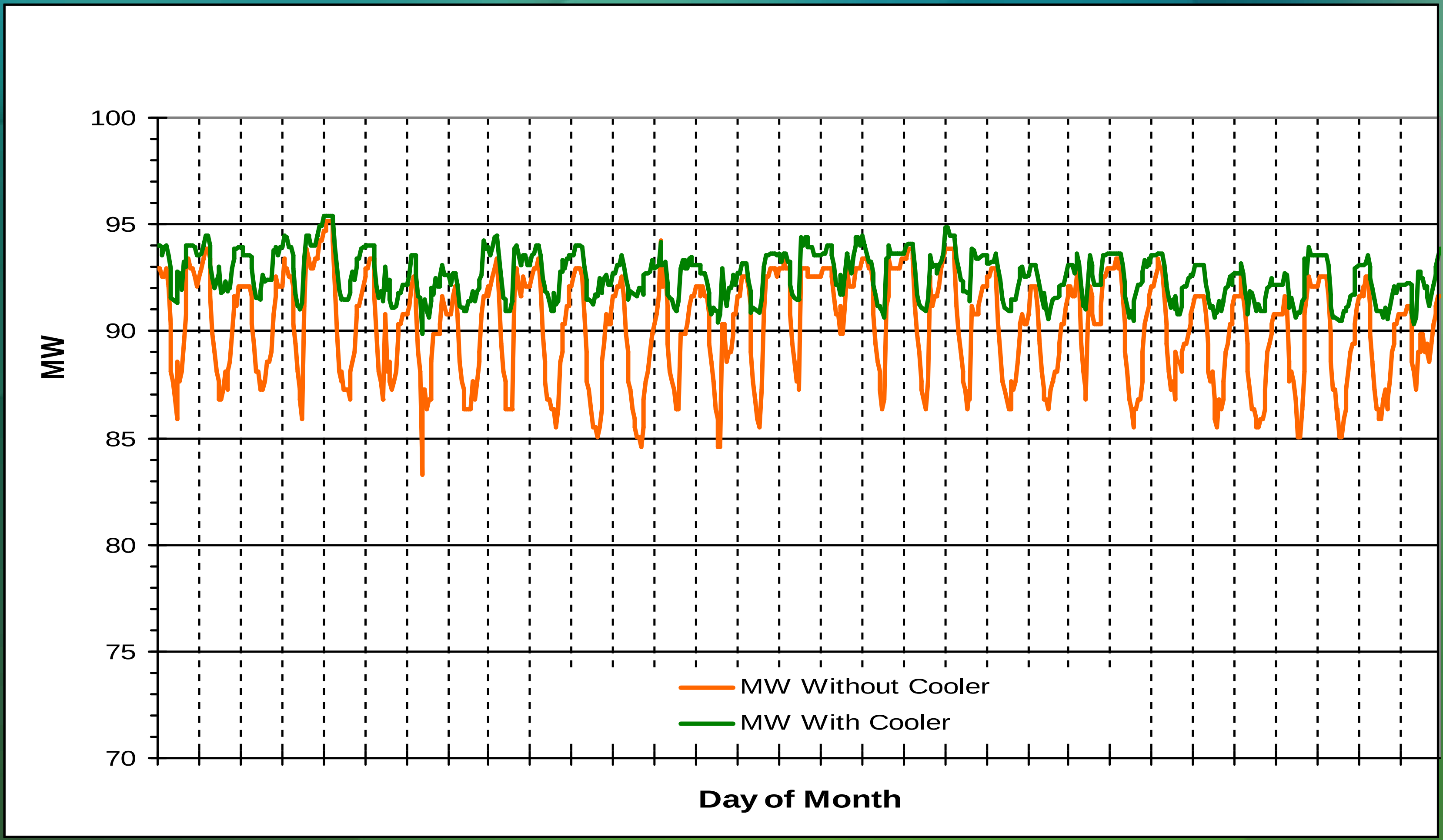
Turbine Performance

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



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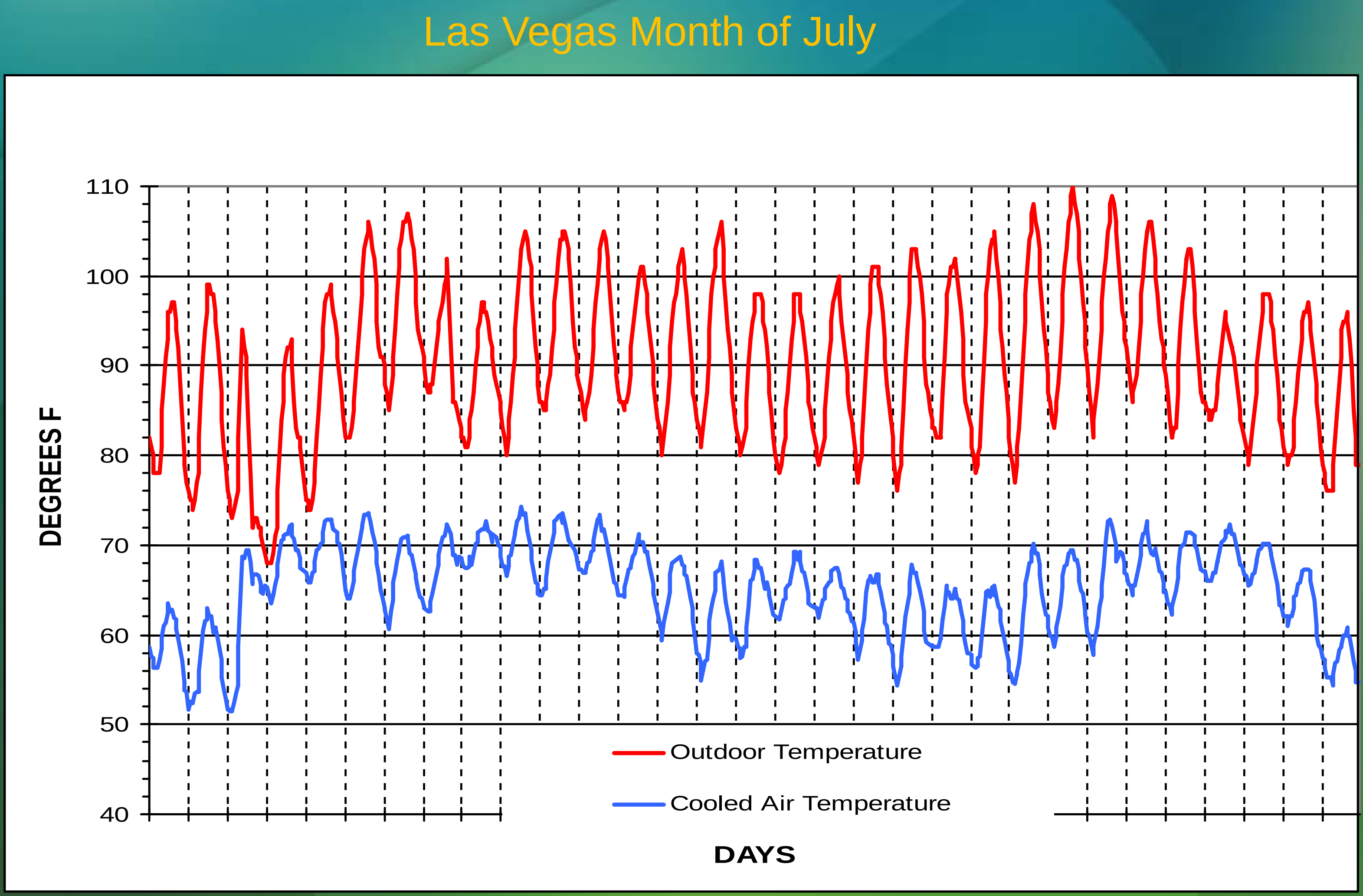
Looking at Las Vegas Nevada



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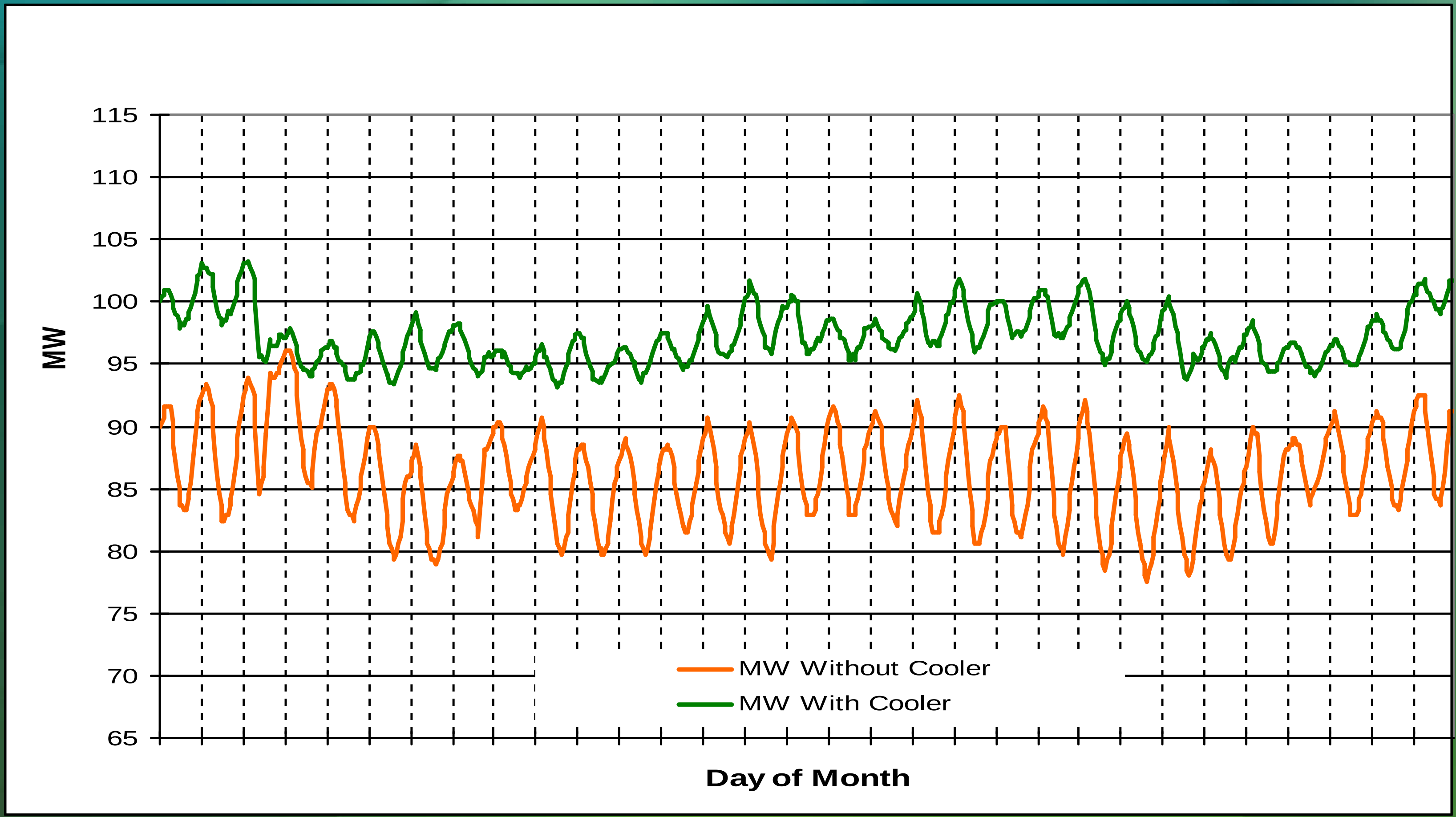

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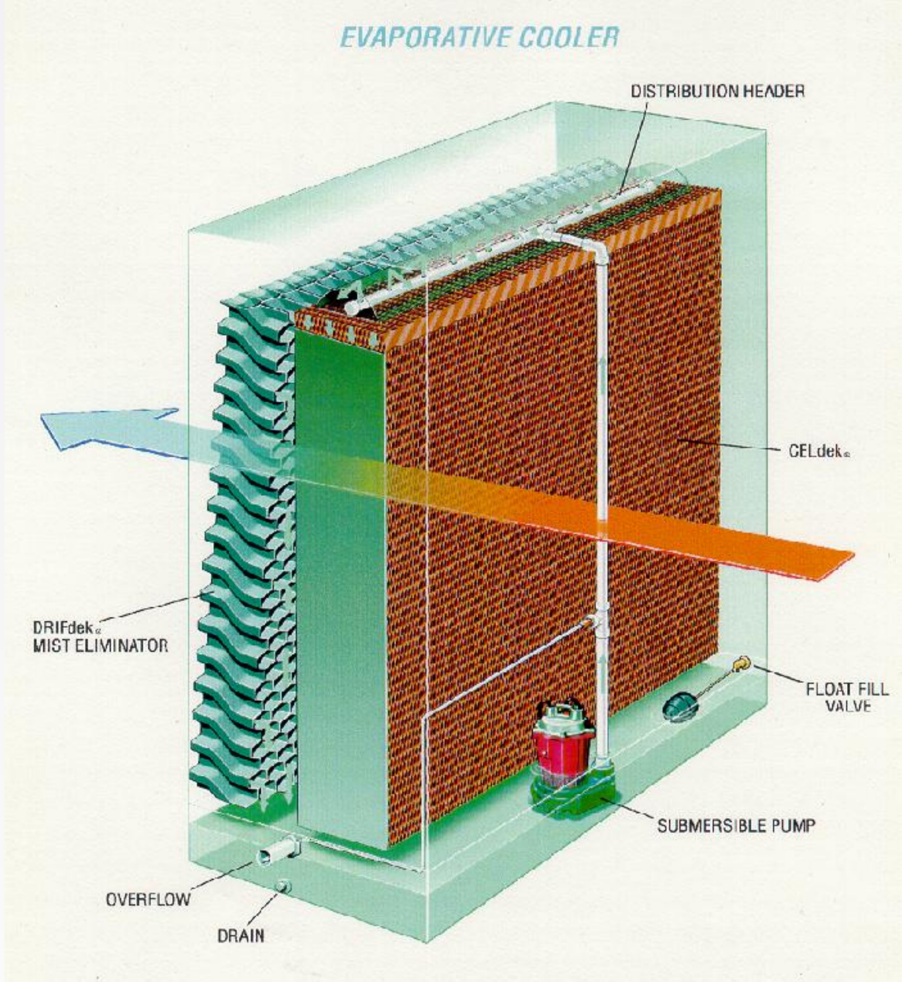
Direct Evaporative Cooler Anatomy



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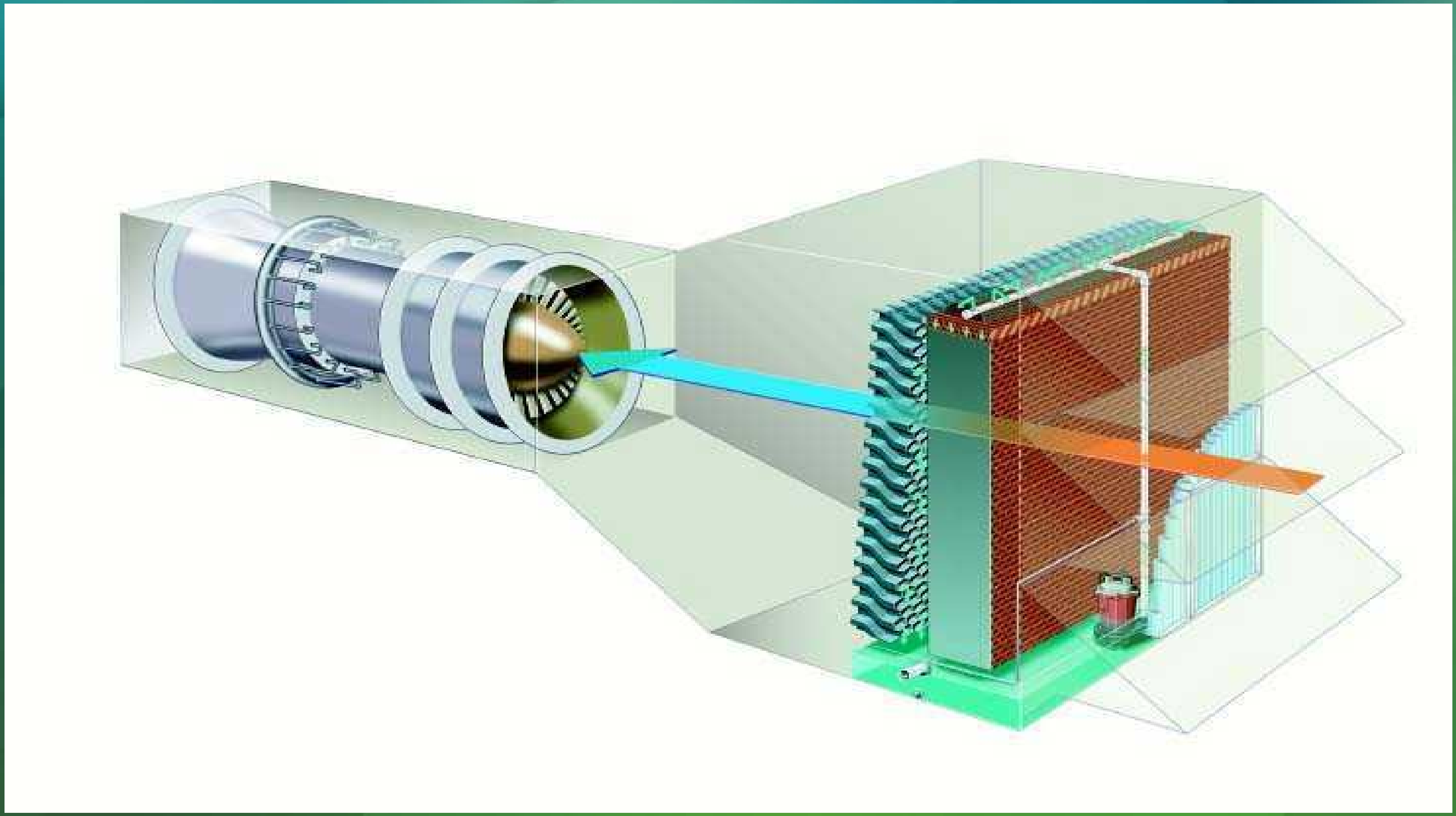
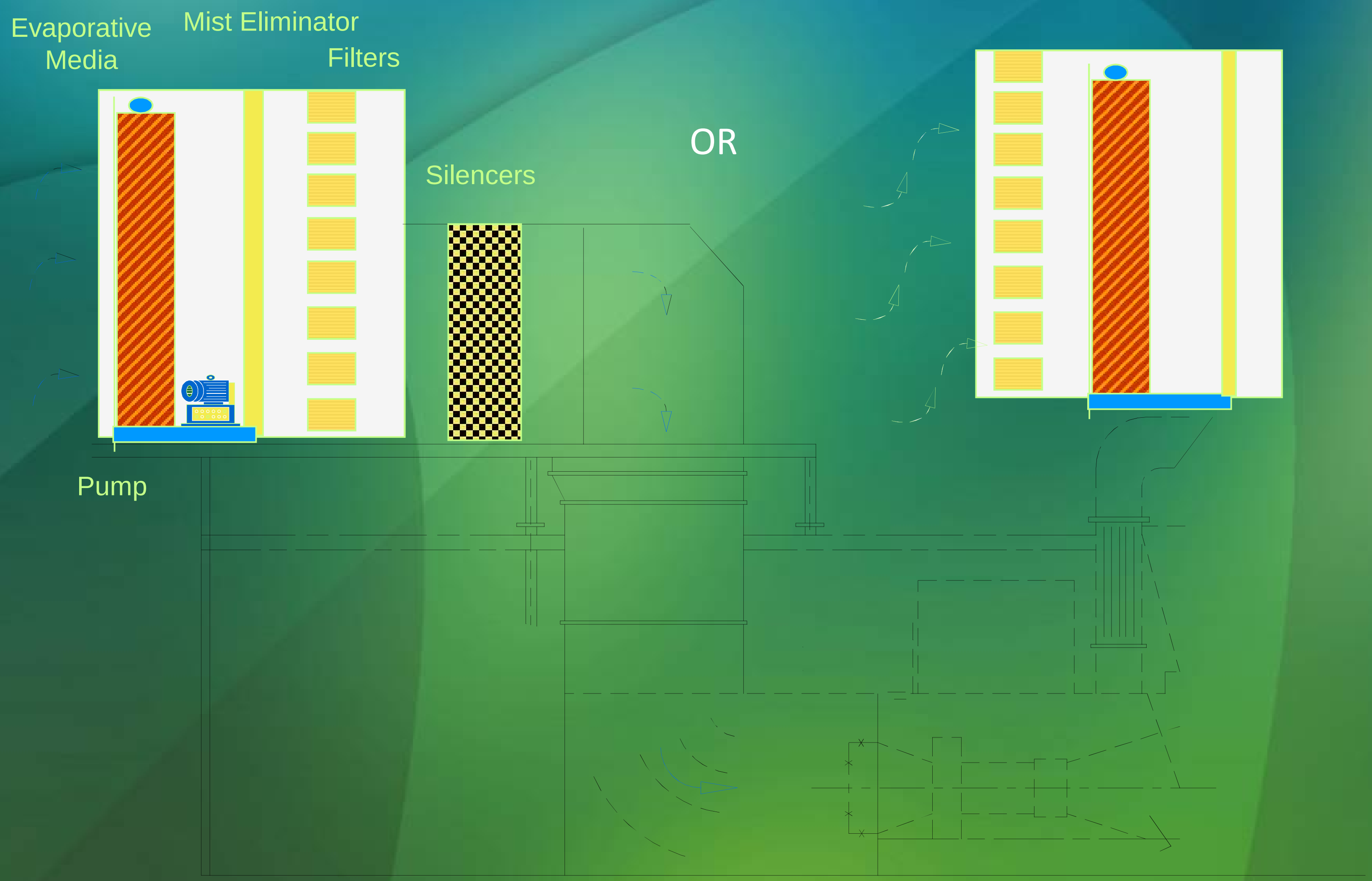
Construction & Examples



Evaporative Section Location



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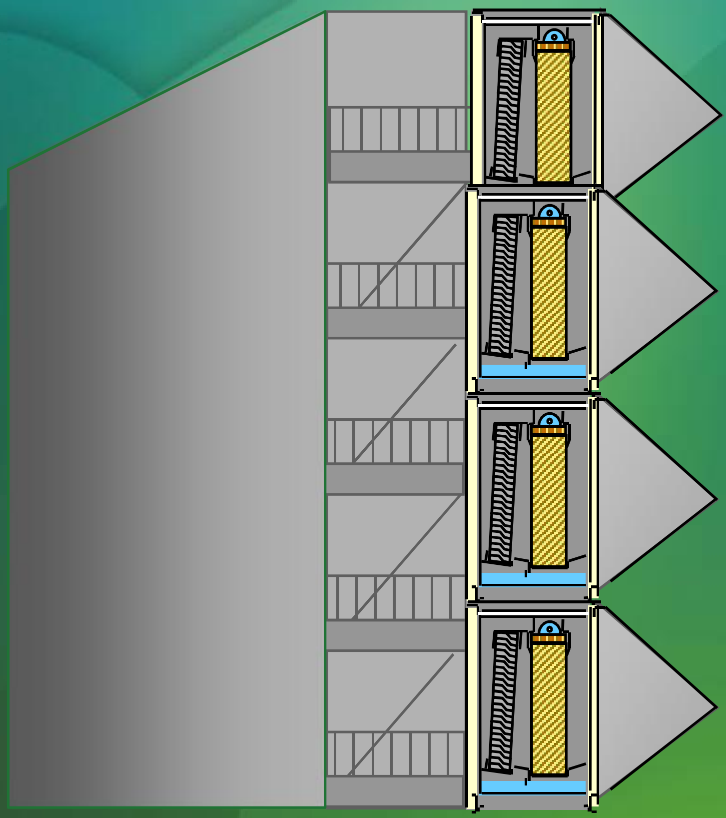
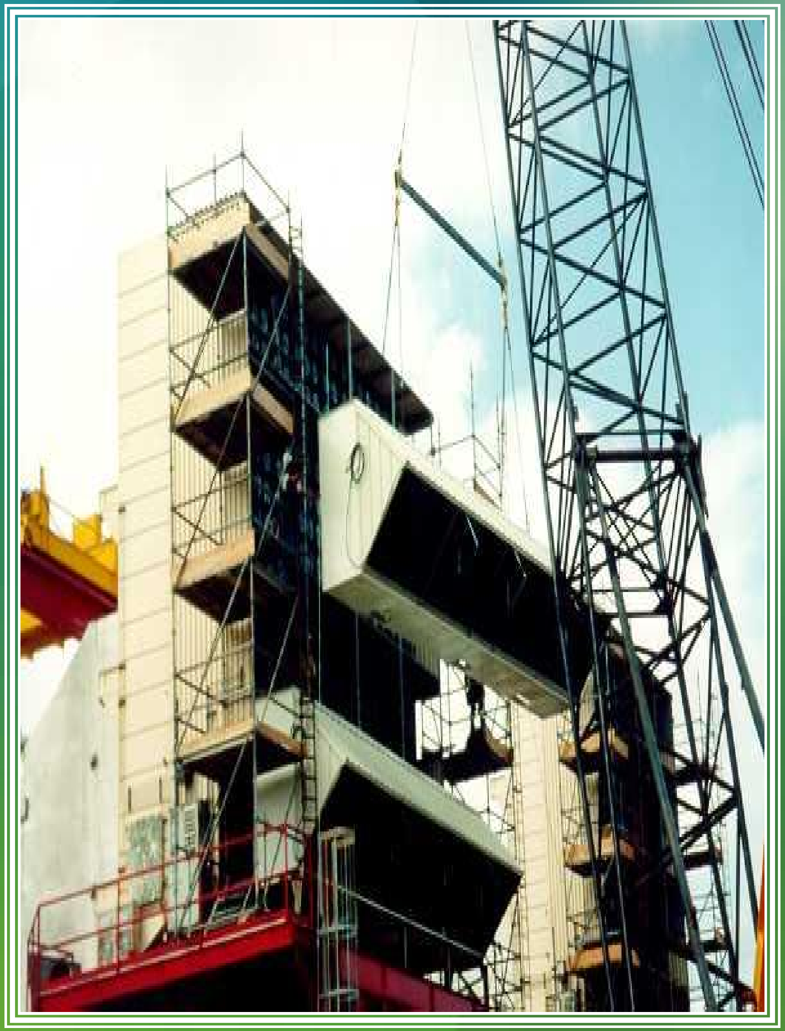
Construction & Examples





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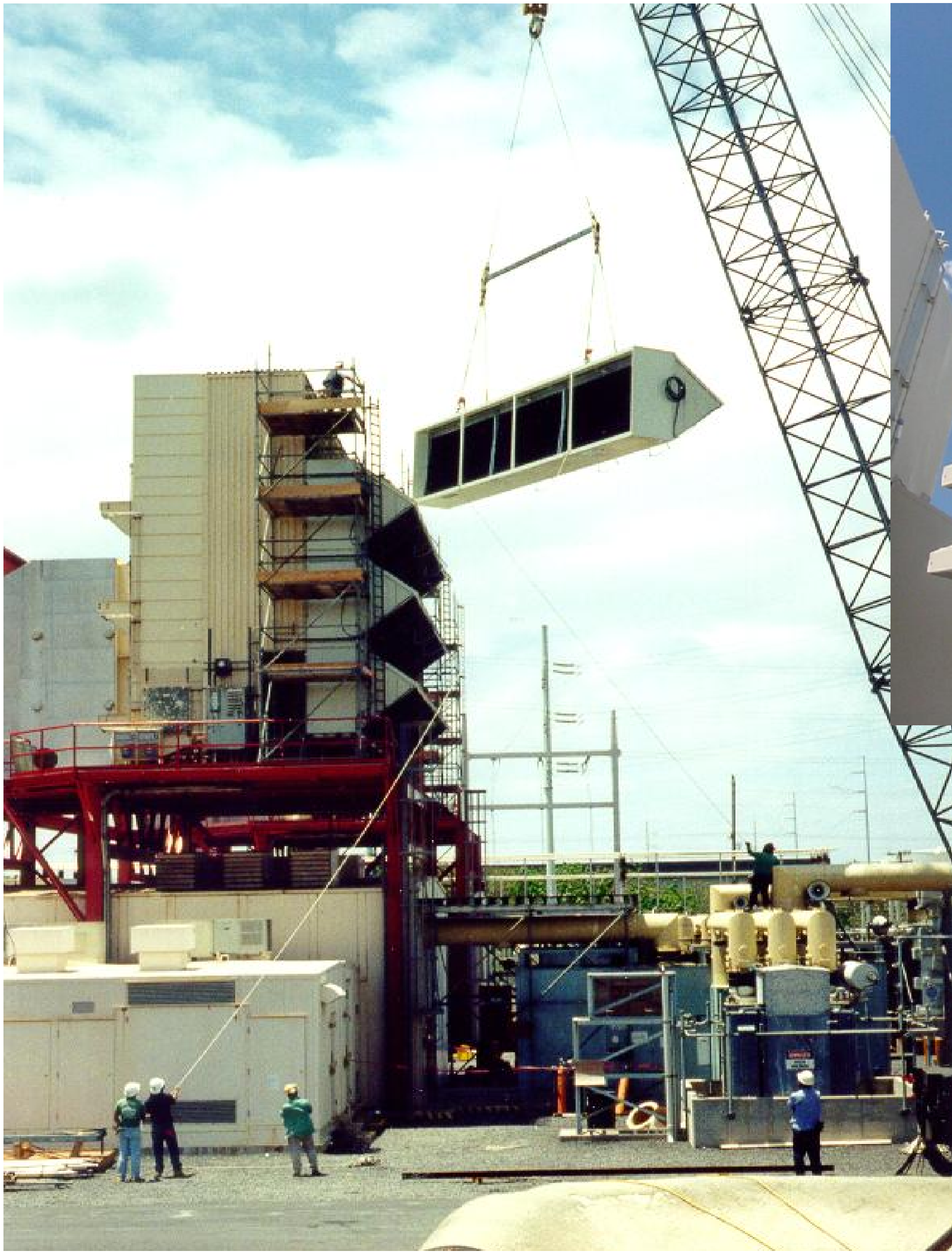

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Installations

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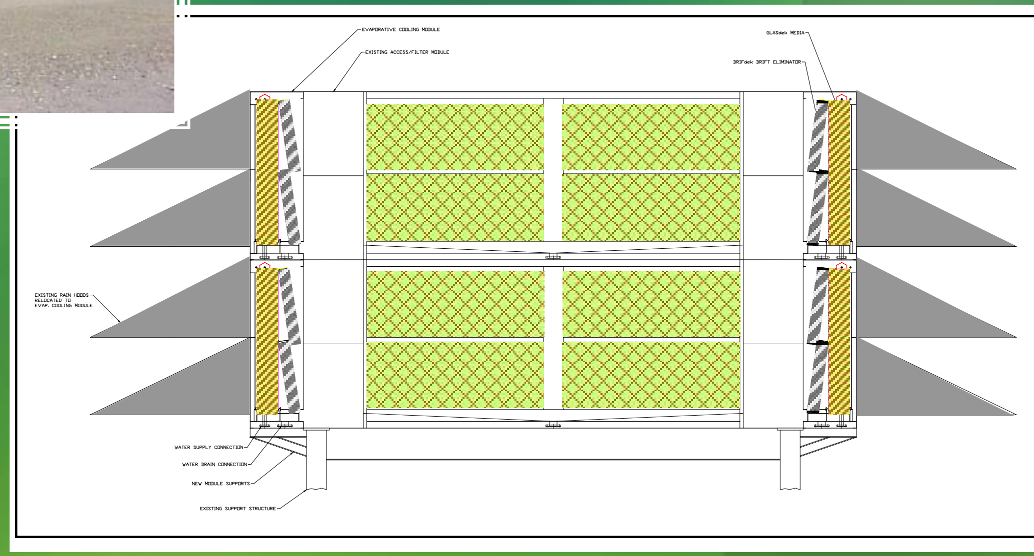
Installations



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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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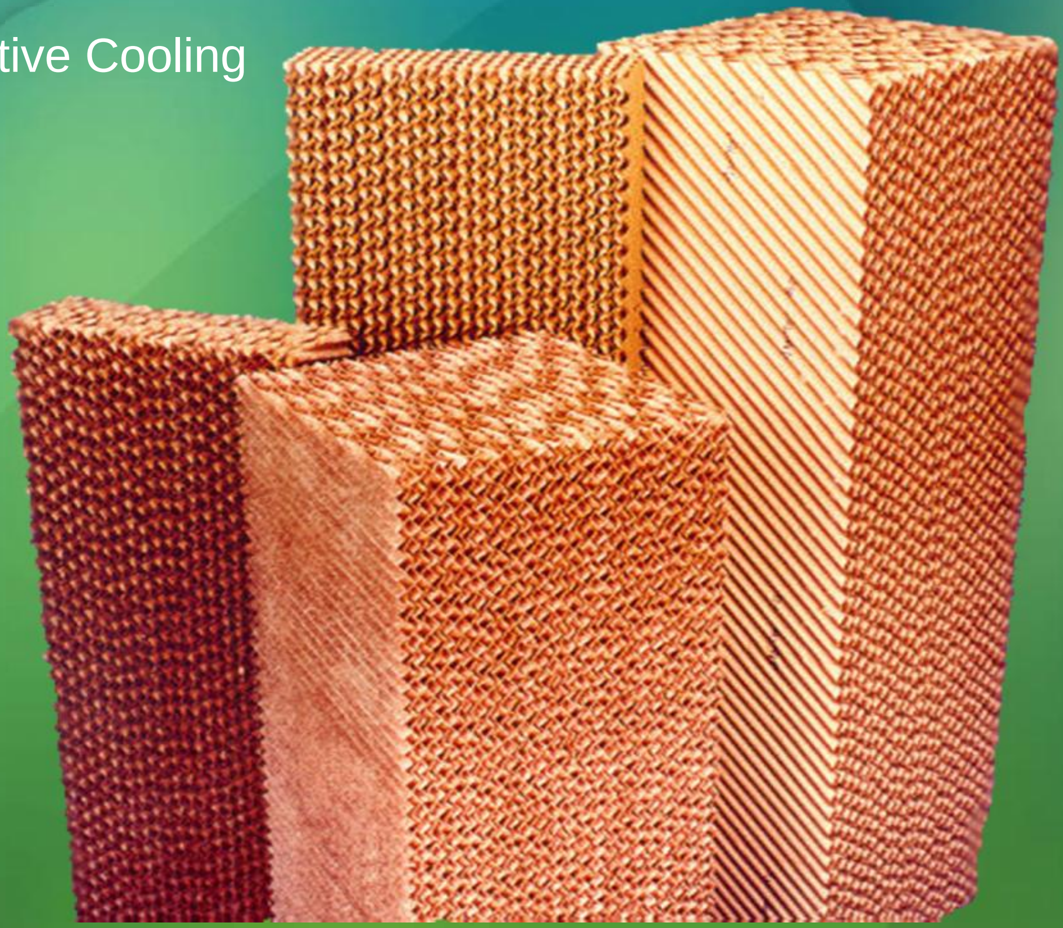
Simple, But Require Engineering, Experience & Robust Design

Media is the heart of Evaporative Cooling



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Simple, But Require Engineering, Experience & Robust Design

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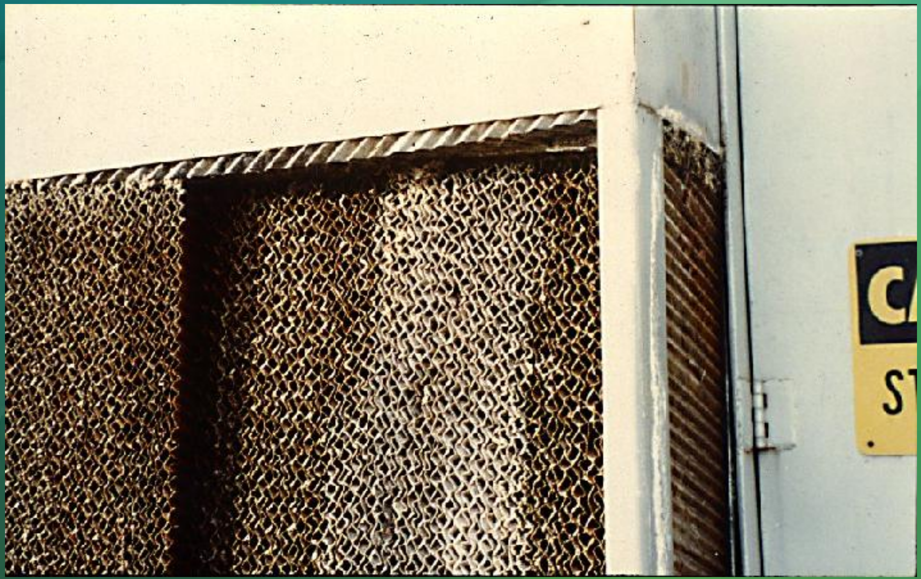
Simple, but Require Engineering, Experience & Robust Design

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



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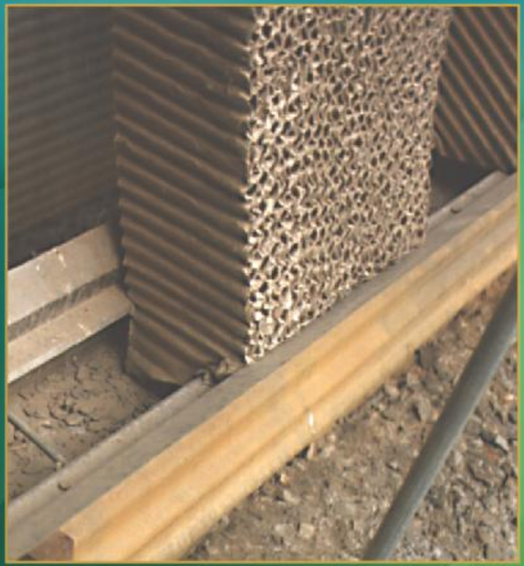

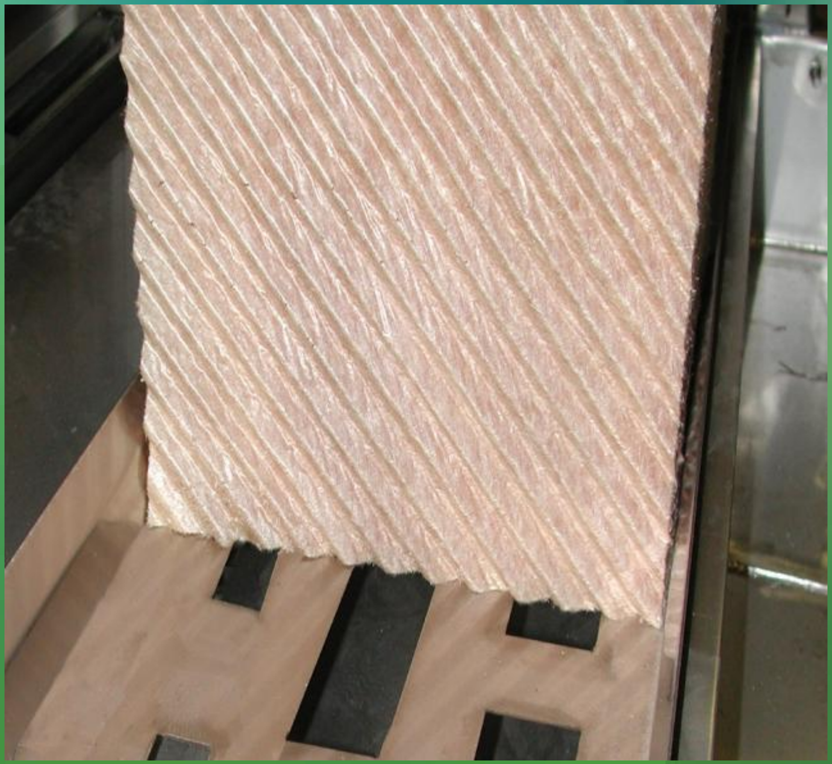

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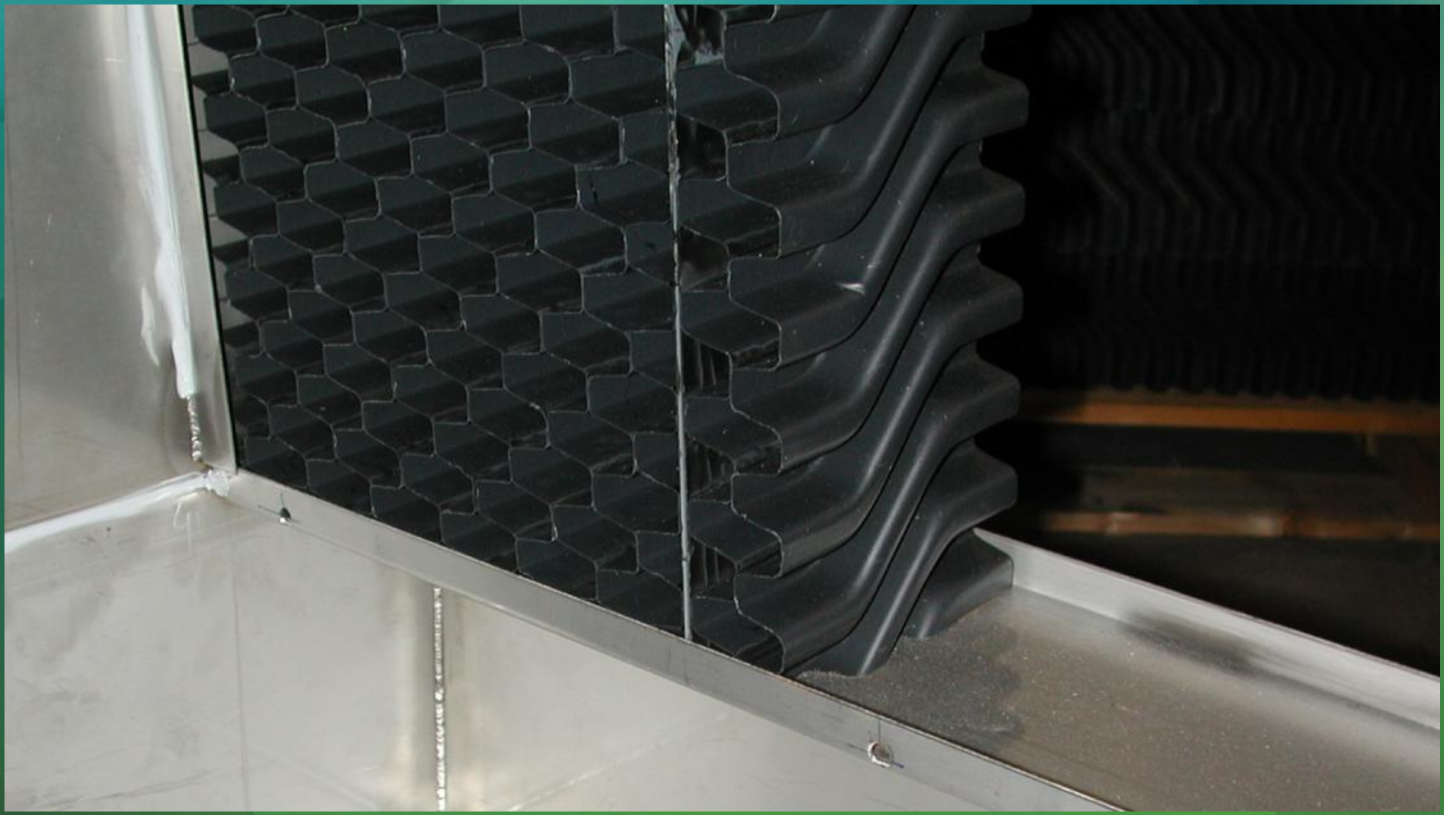
Simple, but Require Engineering, Experience & Robust Design



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Water Quality and 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

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

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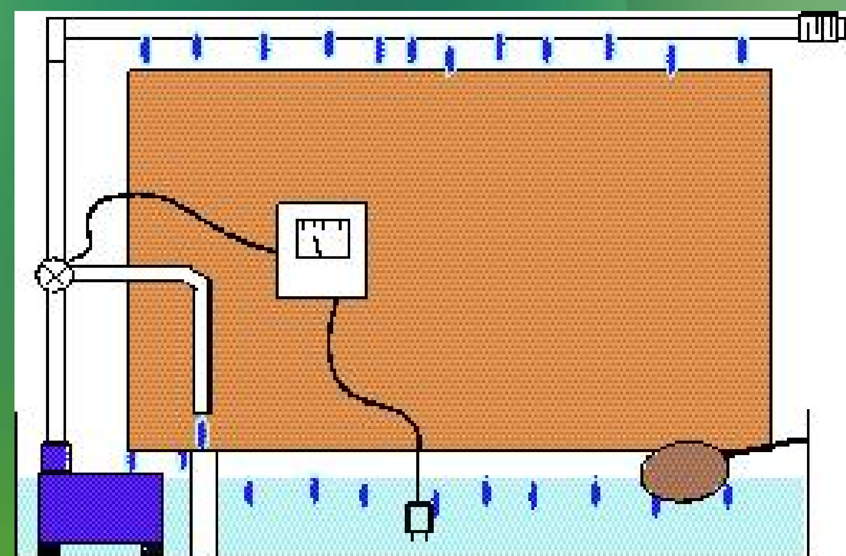
Water Quality & Management



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Remote Sump Water Management

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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

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

- Flush and dump water distribution headers - quarterly
- Clean strainer - quarterly
- Drain and protect from freezing - seasonally
- Change media - 2 to 5 yrs
- Replace or service pumps - 1 to 5 yrs

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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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