Combustion Turbine Inlet Cooling using Fog Evaporative Cooling

By Don Shepherd – Caldwell Energy Company

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

Call-In Number: 1 877 406 7969
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Introductions

BALTIMORE AIRCOIL COMPANY

- Greg Henderson
  - President, TICA
  - Baltimore Aircoil Company

CALDWELL Since 1887
Water - Energy - Industrial

- Don Shepherd
  - Director, TICA
  - Caldwell Energy Company

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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

- 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 Combustion Turbines (CT)
- How Fog Evaporative Cooling Works
- Components of Fog Evaporative Cooler systems
- Things to Consider before Fog Evaporative Cooling of CT's
- Generations of Fog Evaporative Coolers
- Quick Compare to Other Cooling Technologies
- Why Fog 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

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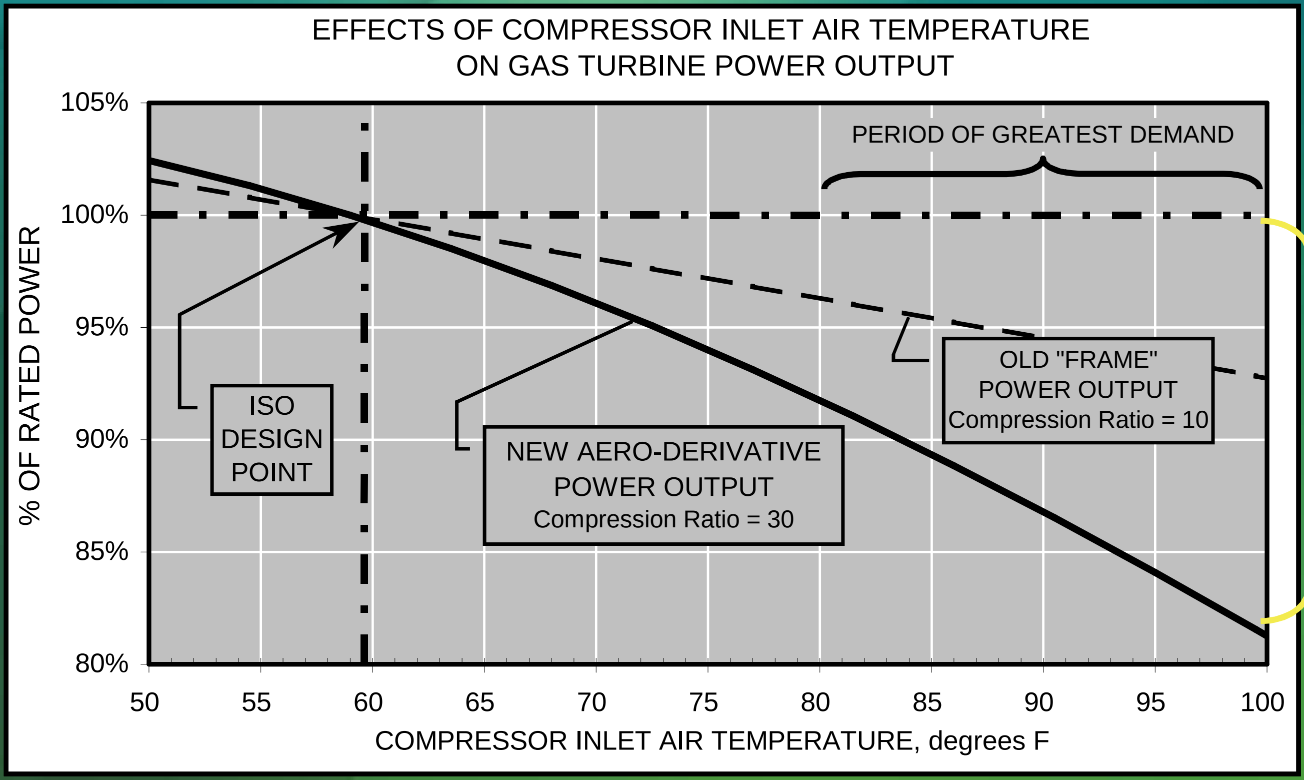
Effect of Hot Weather on CT Generation Capacity Depends on CT Design



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

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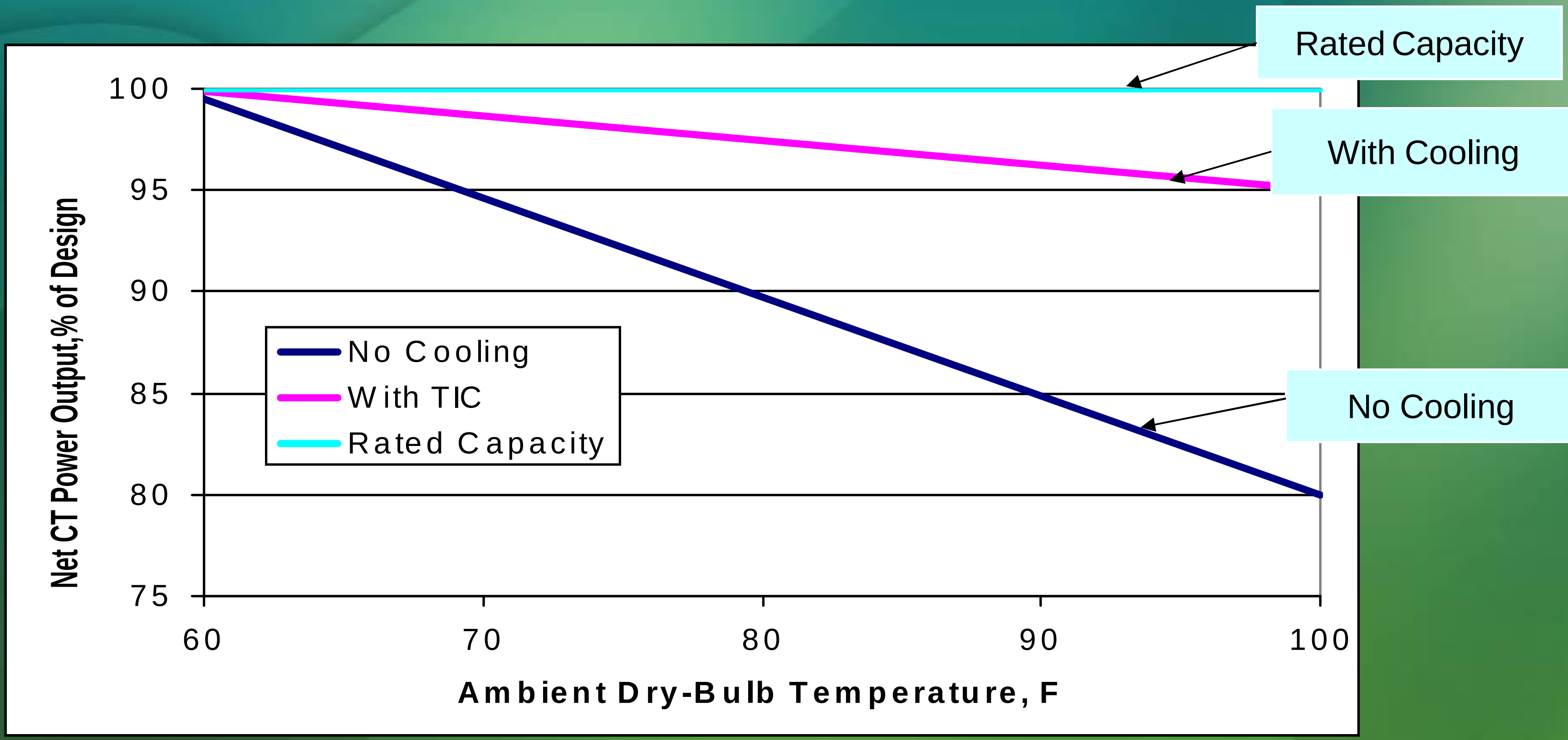
Turbine Inlet Cooling Overcomes the Effects of the CT Flaws During Hot Weather



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Why Use Direct Evaporative Cooling for Turbine Inlets

- Fog Evaporative Turbine Inlet Cooling (TIC) provides a cost-effective and energy-efficient mean to increase a CT's output during hot weather
- Fog Evaporative cooling is an environmentally beneficial means to enhance power generation capacity.

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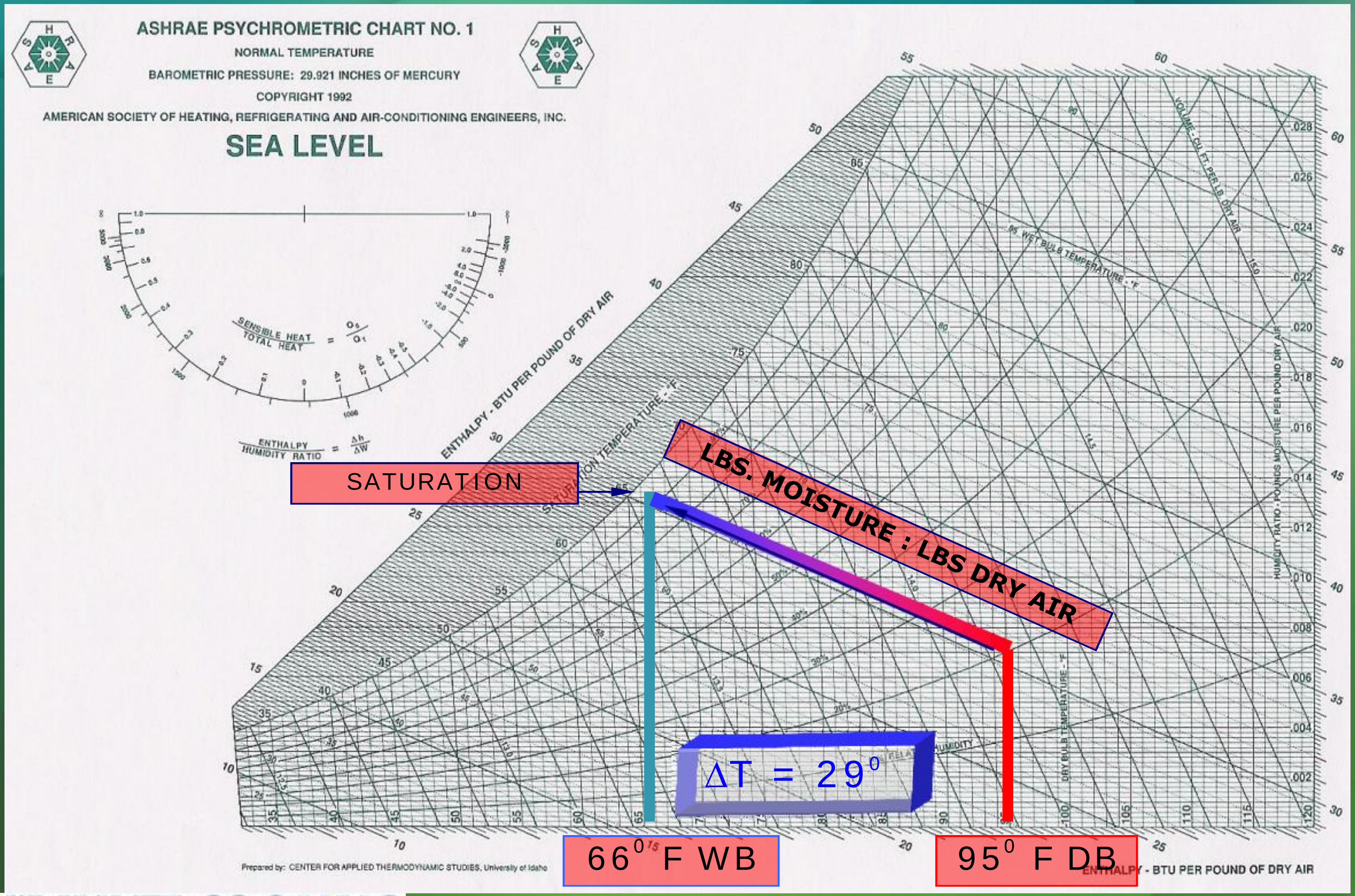
PSYCHROMETRIC ANALYSIS



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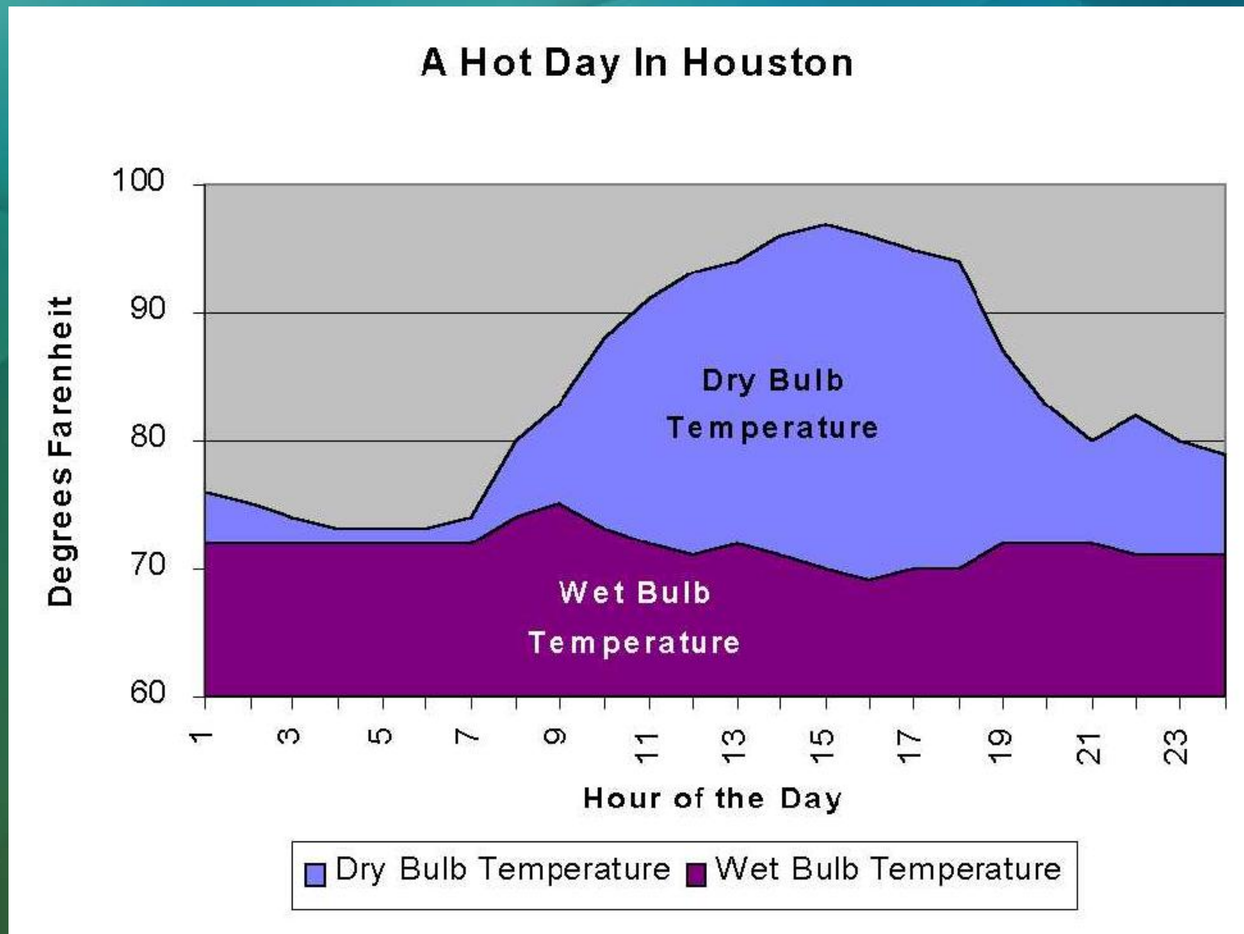
TEMPERATURE CHARACTERISTICS



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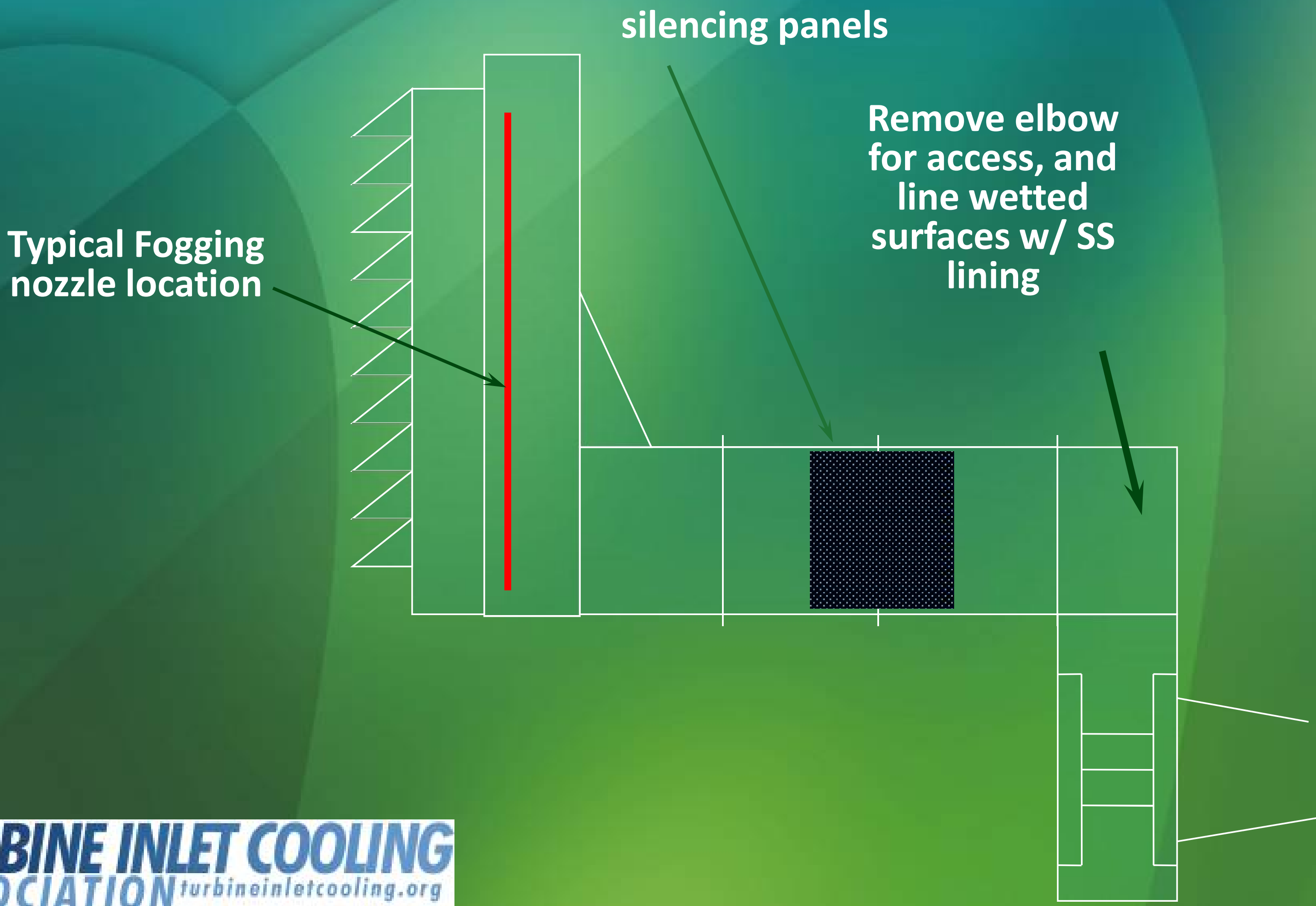
Wet Compression Nozzle Location



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Inlet Fogging Systems

Inlet configurations can promote droplet growth

Large droplets have resulted in excessive blade erosion – greatly exceeding wet compression experience

Fogging systems must be carefully integrated with the inlet air system

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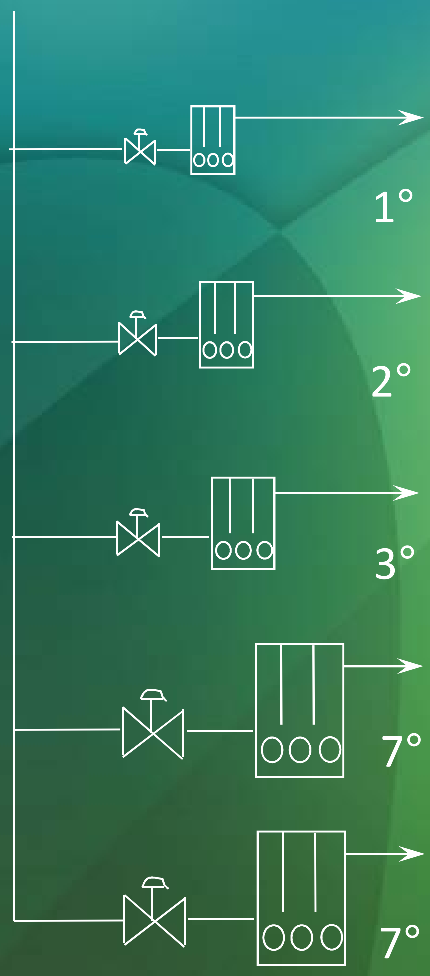
First Generation Fogging Systems



- Pumps dedicated to specific cooling zones –
  - Excessive cycling
  - Loss of cooling increment during pump maintenance
- Pumps operated near design conditions
  - Seal life reduced
- Standard component packaging
  - Excessive vibration
- Impact-pin nozzles
  - Droplet size control & maintenance

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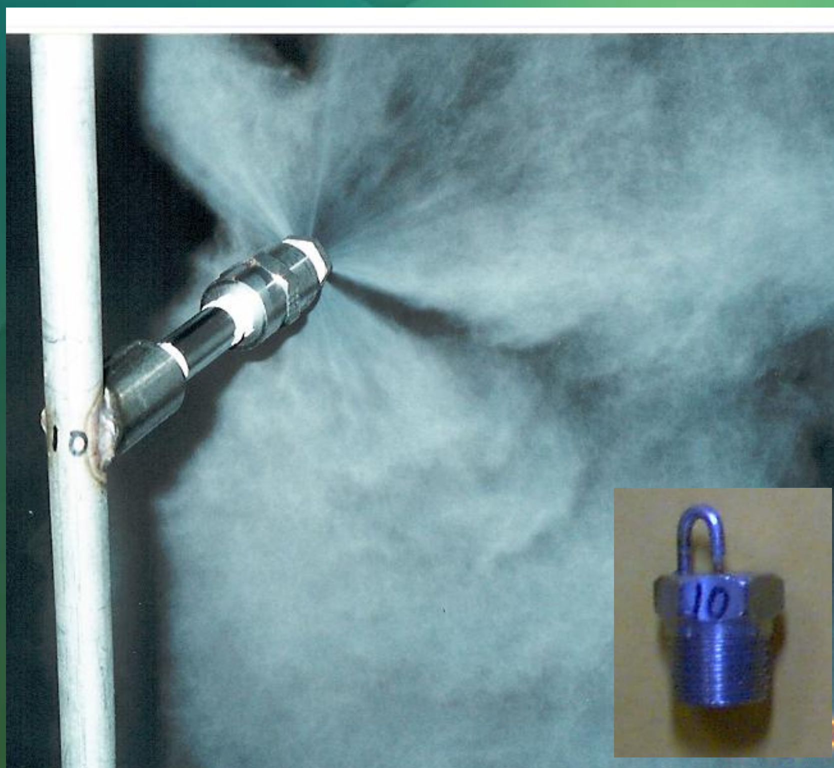
Nozzle Development

Impact Pin Type Nozzle



Pin-less Nozzle for new and service replacement

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Independent PDPA Testing

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4 Zones of Fogging In Operation

Fog Droplets Light and Uniform

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Designed for Reliability

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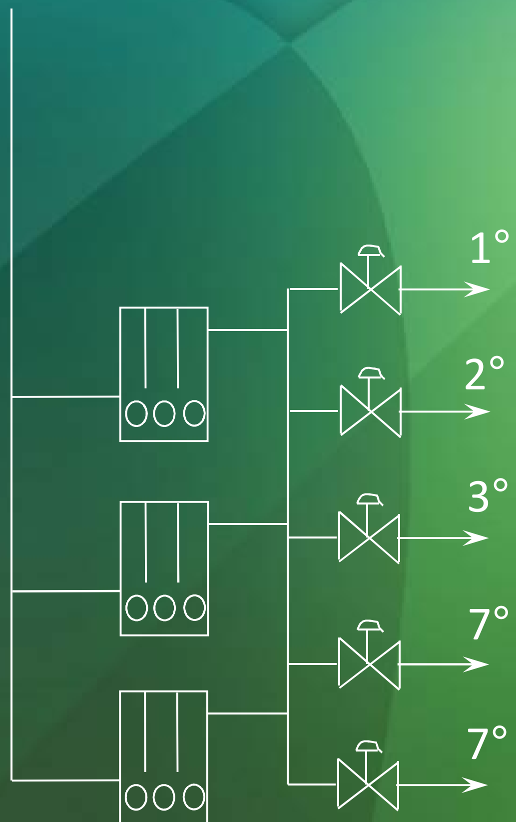
Second Generation Fogging
Focus on System Reliability



- Common discharge manifold
  - Pump schedule based on hours / starts
  - Pump maintenance reduces max flow capability not zone control
  - Enables redundant pump to be used
- Pump design margin (speed & pressure)
  - Extends seal life
- Components custom packaged
- Pin-less nozzles
  - Smaller droplets
  - Less installation / maintenance risk
- O-ring nozzle seal
  - Reduces replacement time and clogging
- In-line filters – reduces nozzle clogging

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Common Manifold Design

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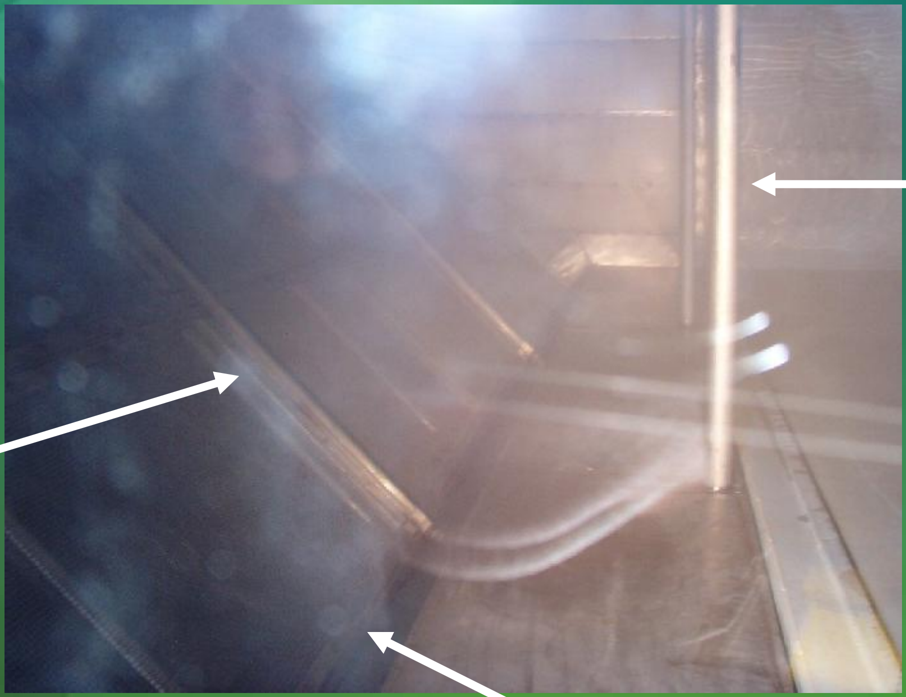
Water Agglomeration

Water coalesces on structural steel - shedding large drops into inlet air stream



Water coalescing on vertical structural steel ran to the duct floor.

Water puddles in trough created by duct floor and trash screen structural steel

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Fogging System Integration

- Filter house, inlet duct, silencer and compressor manifold treatment (lining, coating, drains)
- New unit inlet duct configuration optimization
- Droplet size control and spacing
- Control logic and integration with Combustion Turbine Control System
- Water quality specification

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Third Generation Fogging Evaporation Enhancements

- Enhanced water distribution at design condition
- Enhanced water distribution at off design conditions
- Reduced droplet size
- Water droplet management (patent pending)
- Single VFD Pump Design

VFD Fogger Skid

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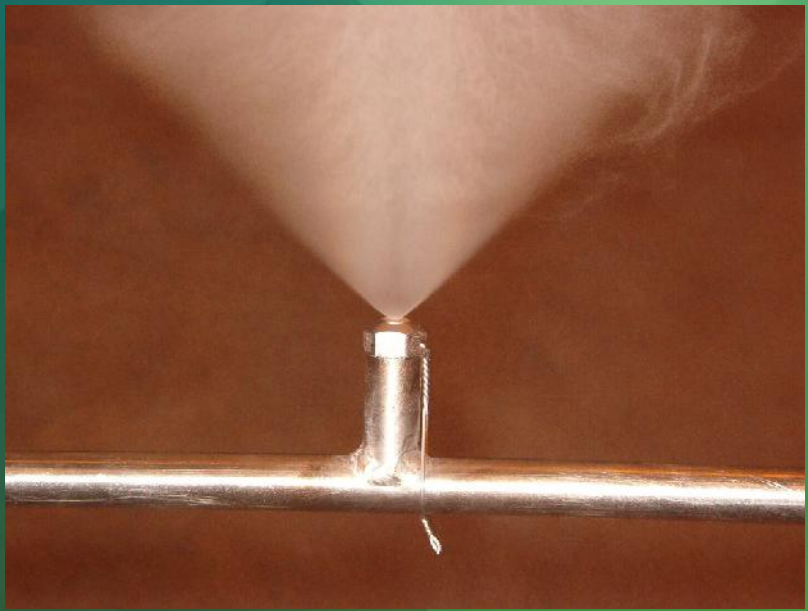
Third Generation Fogging Evaporation Enhancements



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Advantages With Nessie High Pressure Water Pumps PAH/PAHT 50-100/90

Axial piston pump:

- Based upon well know principle from oil hydraulics.
- Swash plate type with fixed displacement.
- Various displacements in same frame.

  - High efficiency
  - Compact design
  - 50 - 100 cc/rev
  - 68 – 145 litre/min output flow
  - 160 Bar Continuous pressure
  - AISI 316 Stainless Steel Housing

Strength/Weakness Nessie Pumps/Plunger pumps

Nessie Pumps

- **High shaft speed (1800 rpm)**
  -Direct connection to el-motor/combustion engine.
- **Very low pressure-ripples (< 2 %)**
  -Reduced risk for water hammer.
- **Storing:**
  -Drain for water and flush with glycol to prevent frost damage and pitting corrosion.
- **Filtration:**
  -10µ abs is recommended (8000 hours service interval).
  -Reduced filtration reduces the service interval.
- **Few components:**
  -Reduced risk for failures.
  -Easy to service (if needed)
  -11 dynamic parts/2 bearings
  -0 dynamic sealing/only static sealing

Plunger Pumps (CAT, Speck)

- **Low shaft speed (<1200 rpm)**
  -Need to be belt/gearbox driven.
  -Need 6 poll motor for direct connection.
- **High pressure-ripples (Approx. 15 %)**
  -Need pulsation damper.
- **Storing:**
  -Drain water and flush with glycol to prevent frost damage and pitting corrosion.
- **Filtration:**
  -50µ is recommended.
  -Reduced filtration reduces service interval.
- **Many components:**
  -Larger risk for failure.
  -More complex to service.
  -13 dynamic parts/8 bearings
  -6 to 18 dynamic seals

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How Fog Evaporative Cooling Compares

100 MW CT in Houston

	Fog	Media	Mechanical Chilling
Deg of Cooling	22 F	20 F	50 F
Water Evaporated	28 GPM	25 GPM	95GPM (at Cooling Tower)
Blow Down	5 GPM	10 GPM	42 GPM
Parasitic Power Loss	45 kW	10 kW	4250 kW
Insertion loss	0.05”wg	0.3”wg	1.0”wg

Why Use Fog 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 maintain
- 1000's of successful installations Worldwide

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Low Maintenance

- Drain and protect from freezing – seasonally
- Clean filters once a year
- Change nozzles 4 to 5 yrs
- Replace or service pumps – 3 to 5 yrs
- Calibrate Instruments once a year

Thank You

And Don't Forget to Join

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