Cooling Towers

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Training Agenda: Cooling Towers

Introduction

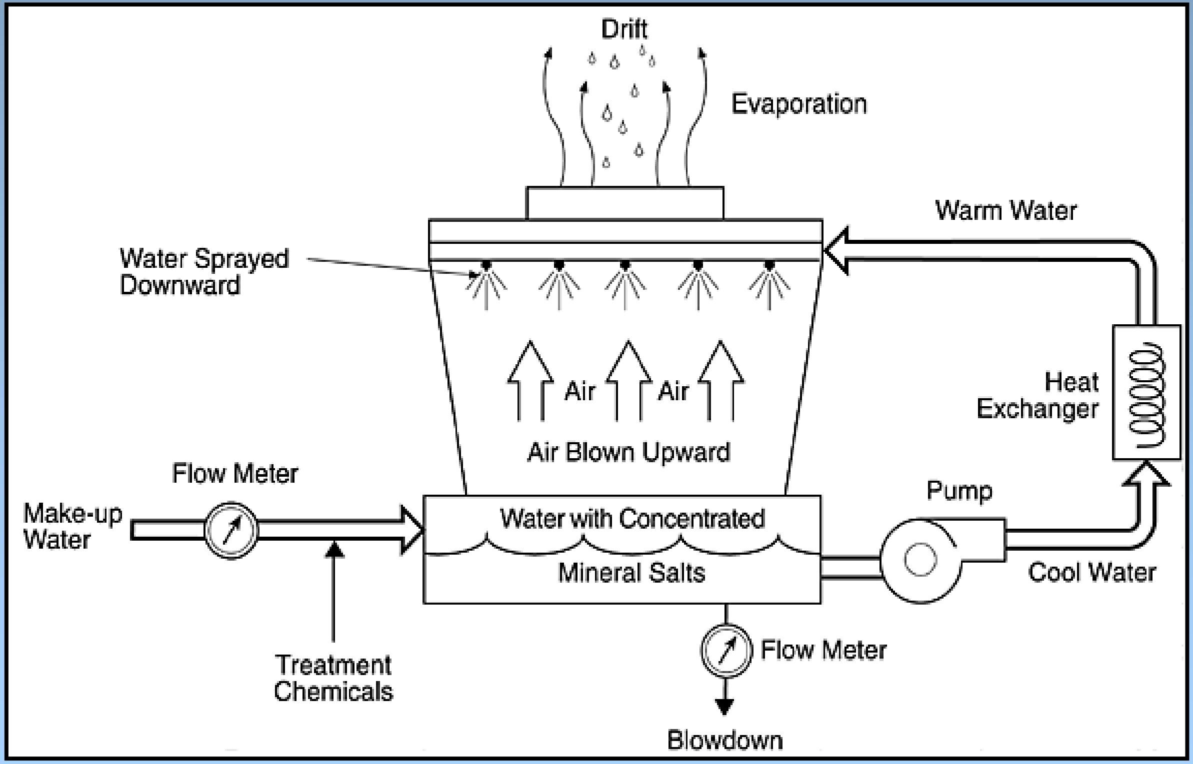
Types of cooling towers

Assessment of cooling towers

Energy efficiency opportunities

Introduction

Main Features of Cooling Towers



(Pacific Northwest National Library, 2001)

Introduction

Components of a cooling tower

- **Frame and casing: support exterior enclosures**
- **Fill: facilitate heat transfer by maximizing water / air contact**
  - **Splash fill**
  - **Film fill**
- **Cold water basin: receives water at bottom of tower**

Introduction

Components of a cooling tower

- **Drift eliminators: capture droplets in air stream**
- **Air inlet: entry point of air**
- **Louvers: equalize air flow into the fill and retain water within tower**
- **Nozzles: spray water to wet the fill**
- **Fans: deliver air flow in the tower**

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Types of Cooling Towers

Natural Draft Cooling Towers

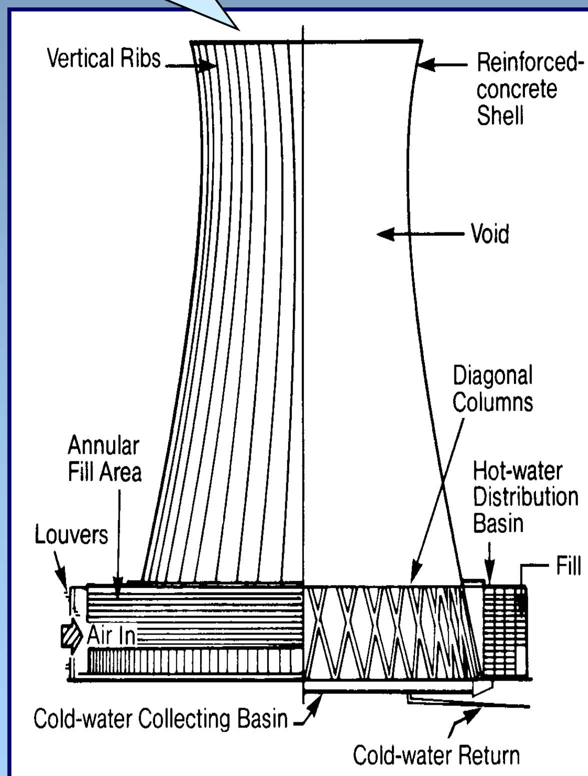
- Hot air moves through tower
- Fresh cool air is drawn into the tower from bottom
- No fan required
- Concrete tower <200 m
- Used for large heat duties

# of Cooling Towers

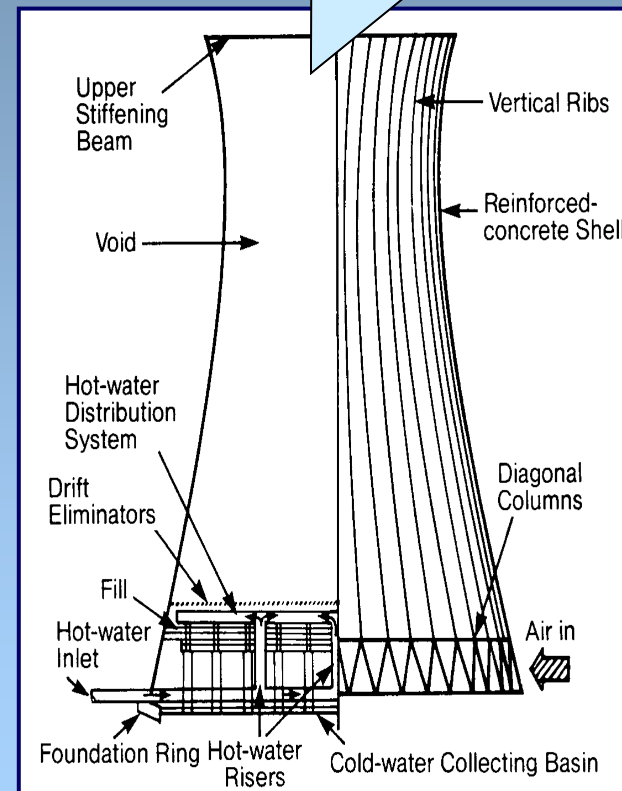
al Draft Cooling To

- Air drawn across falling water
- Fill located outside tower

- Air drawn up through falling water
- Fill located inside tower



Cross flow



Counter flow

(Gulf Coast Chemical Commercial Inc.)

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Types of Cooling Towers

Mechanical Draft Cooling Towers

- Large fans to force air through circulated water
- Water falls over fill surfaces: maximum heat transfer
- Cooling rates depend on many parameters
- Large range of capacities
- Can be grouped, e.g. 8-cell tower

Types of Cooling Towers

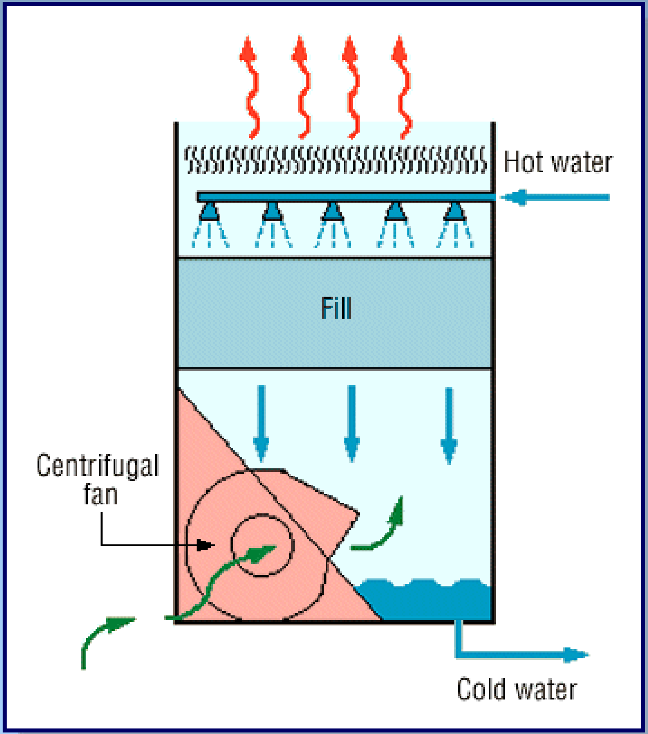
Mechanical Draft Cooling Towers

Three types

- **Forced draft**
- **Induced draft cross flow**
- **Induced draft counter flow**

Types of Cooling Towers

Forced Draft Cooling Towers



(GEO4VA)

- Air blown through tower by centrifugal fan at air inlet
- Advantages: suited for high air resistance & fans are relatively quiet
- Disadvantages: recirculation due to high air-entry and low air-exit velocities

Types of Cooling Towers

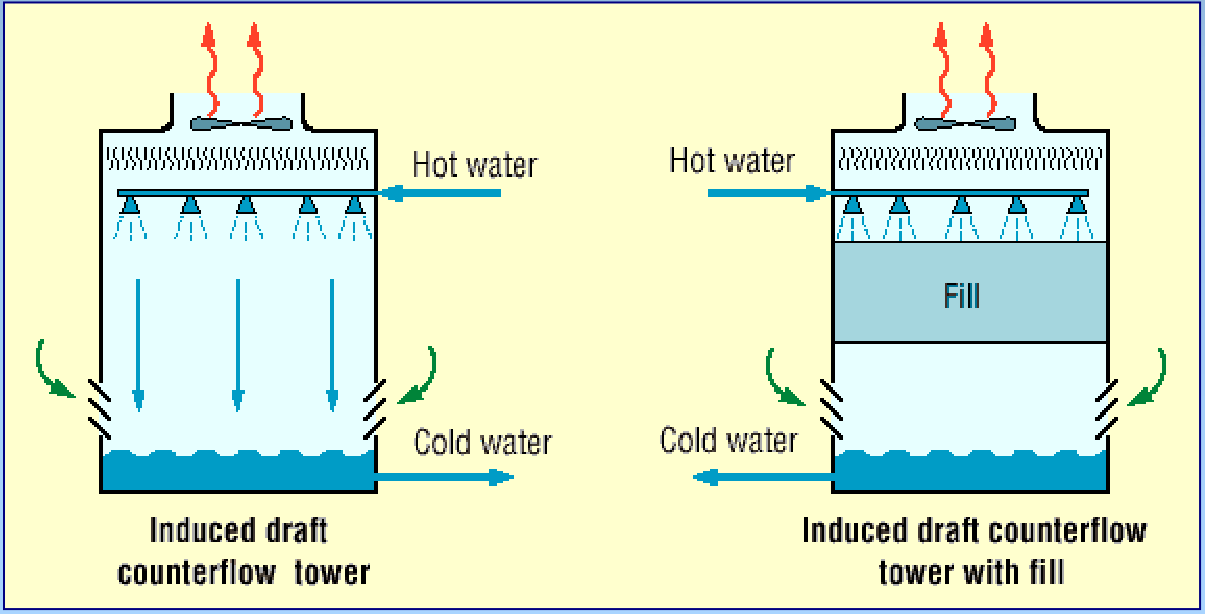
Induced Draft Cooling Towers

- Two types
  - Cross flow
  - Counter flow
- Advantage: less recirculation than forced draft towers
- Disadvantage: fans and motor drive mechanism require weather-proofinh

Types of Cooling Towers

Induced Draft Counter Flow CT

- Hot water enters at the top
- Air enters at bottom and exits at top
- Uses forced and induced draft fans



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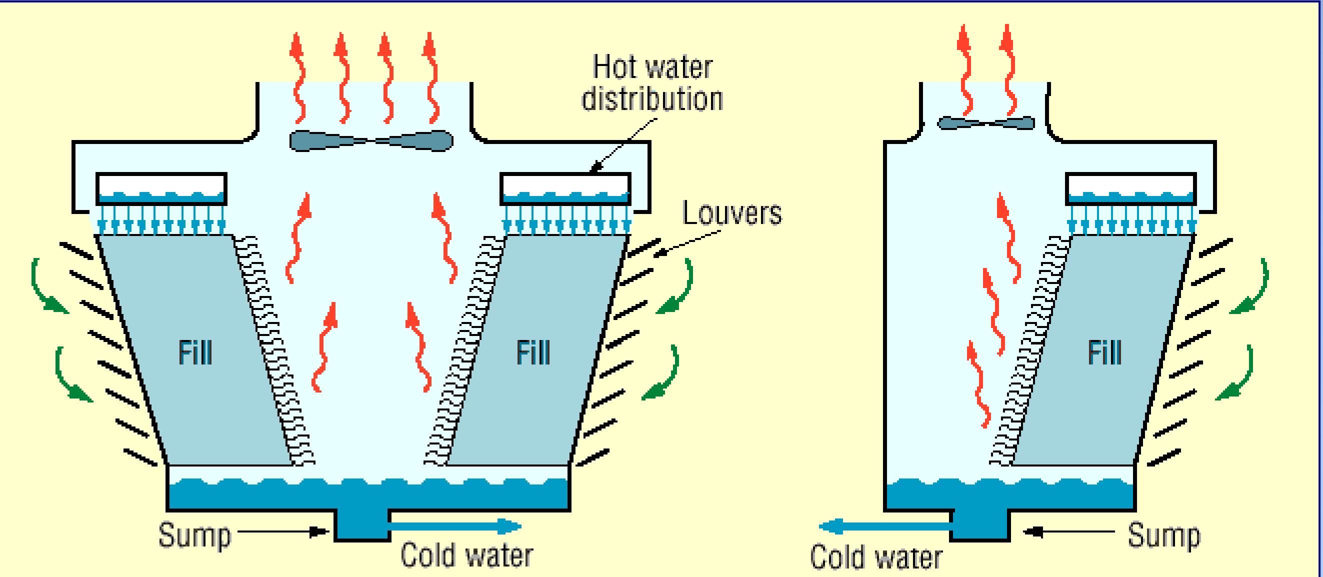
Types of Cooling Towers

Induced Draft Cross Flow CT

- Water enters top and passes over fill
- Air enters on one side or opposite sides
- Induced draft fan draws air across fill



Induced draft, double-flow crossflow tower

Induced draft, single-flow crossflow tower

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Assessment of Cooling Towers

Measured Parameters

- Wet bulb temperature of air
- Dry bulb temperature of air
- Cooling tower inlet water temperature
- Cooling tower outlet water temperature
- Exhaust air temperature
- Electrical readings of pump and fan motors
- Water flow rate
- Air flow rate

Assessment of Cooling Towers

Electrical Equipment/ Cooling Towers

Performance Parameters

1. Range
2. Approach
3. Effectiveness
4. Cooling capacity
5. Evaporation loss
6. Cycles of concentration
7. Blow down losses
8. Liquid / Gas ratio

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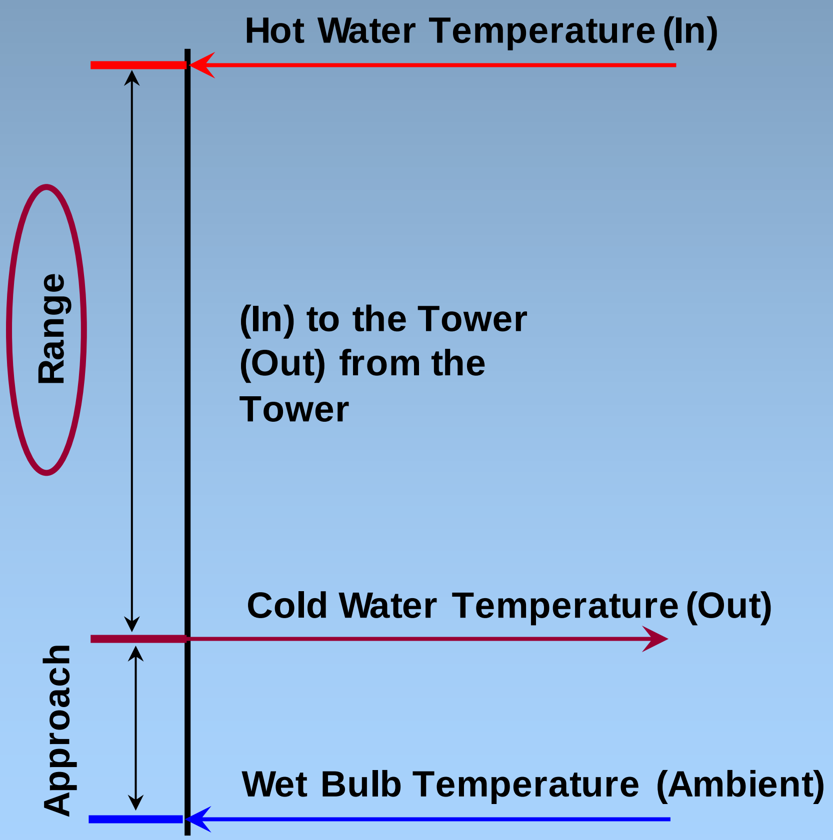
Assessment of Cooling Towers

1. Range

Difference between cooling water inlet and outlet temperature:

Range (°C) = CW inlet temp – CW outlet temp

High range = good performance



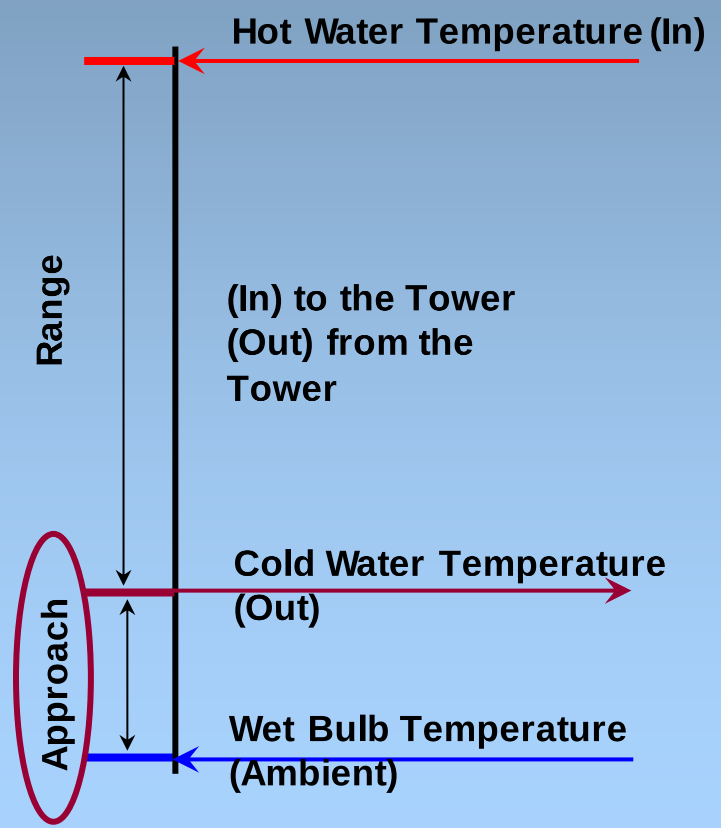
Assessment of Cooling Towers

2. Approach

Difference between cooling tower outlet cold water temperature and ambient wet bulb temperature:

Approach (°C) =
CW outlet temp – Wet bulb temp

Low approach = good performance



Assessment of Cooling Towers

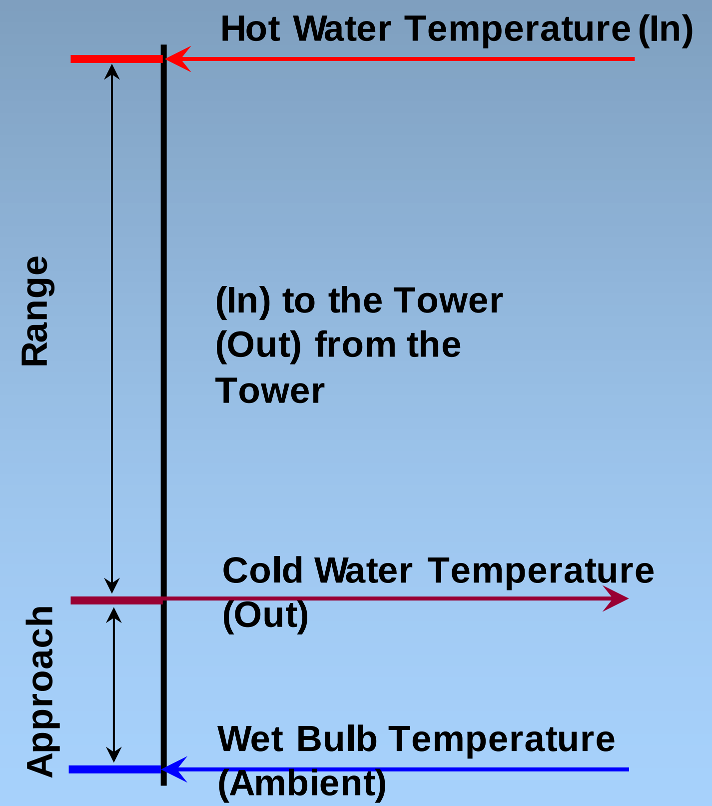
3. Effectiveness

Effectiveness in %

= Range / (Range + Approach)

= 100 x (CW temp – CW out temp) / (CW in temp – Wet bulb temp)

High effectiveness = good performance



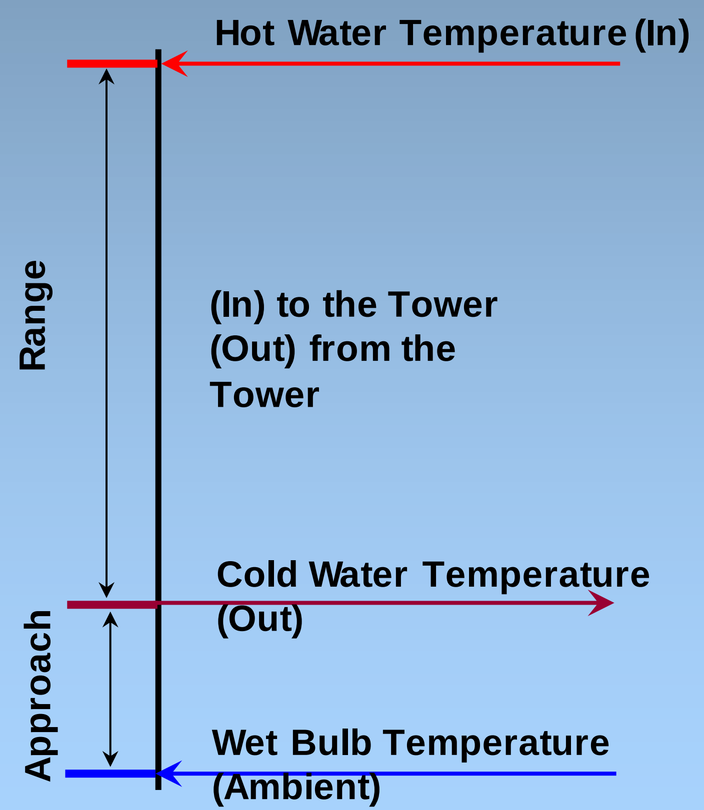
Assessment of Cooling Towers

4. Cooling Capacity

Heat rejected in kCal/hr or tons of refrigeration (TR)

= mass flow rate of water X specific heat X temperature difference

High cooling capacity = good performance

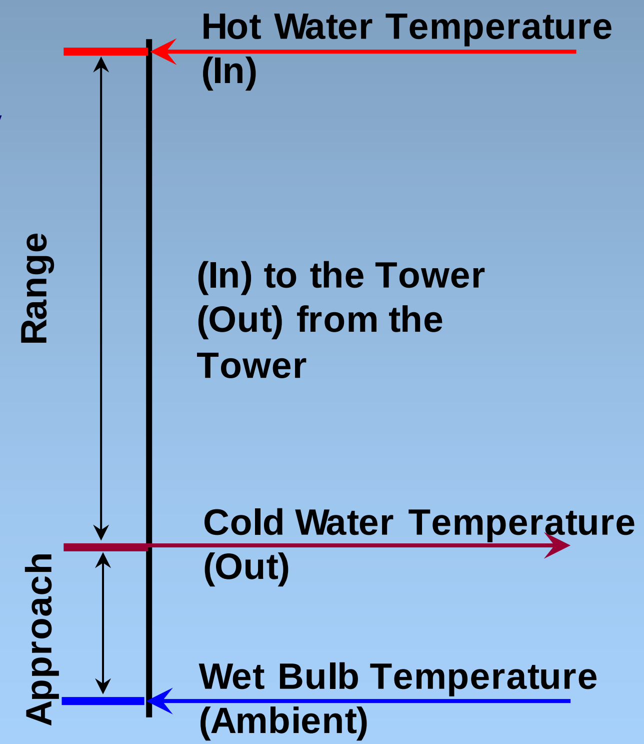


5. Evaporation Loss

Water quantity (m3/hr) evaporated for cooling duty

= theoretically, 1.8 m3 for every 10,000,000 kCal heat rejected

= 0.00085 x 1.8 x circulation rate (m3/hr) x (T1-T2)



T1-T2 = Temp. difference between inlet and outlet water

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Assessment of Cooling Towers

6. Cycles of concentration (C.O.C.)

Ratio of dissolved solids in circulating water to the dissolved solids in make up water

7. Cycles of concentration (C.O.C.)

Depend on cycles of concentration and the evaporation losses

Blow Down =
Evaporation Loss / (C.O.C. – 1)

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8. Liquid Gas (L/G) Ratio

Ratio between water and air mass flow rates

Heat removed from the water must be equal to the heat absorbed by the surrounding air

$$L(T1 - T2) = G(h2 - h1)$$

$$L/G = (h2 - h1) / (T1 - T2)$$

T1 = hot water temp (oC)

T2 = cold water temp (oC)

Enthalpy of air water vapor mixture at inlet wet bulb temp (h1) and outlet wet bulb temp (h2)

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Cooling Towers

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Energy Efficiency Opportunities

1. Selecting a cooling tower
2. Fills
3. Pumps and water distribution
4. Fans and motors

Energy Efficiency Opportunities

1. Selecting a cooling tower

Capacity

- Heat dissipation (kCal/hour)
- Circulated flow rate (m3/hr)
- Other factors

Energy Efficiency Opportunities

1. Selecting a cooling tower

Range

- Range determined by process, <u>not</u> by system

Approach

- Closer to the wet bulb temperature
- = Bigger size cooling tower
- = More expensive

Energy Efficiency Opportunities

Electrical Equipment/
Cooling Towers

1. Selecting a cooling tower

Heat Load

- Determined by process
- Required cooling is controlled by the desired operating temperature
- High heat load = large size and cost of cooling tower

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Energy Efficiency Opportunities

1. Selecting a cooling tower

Wet bulb temperature – considerations:

- Water is cooled to temp higher than wet bulb temp
- Conditions at tower site
- Not to exceed 5% of design wet bulb temp
- Is wet bulb temp specified as ambient (preferred) or inlet
- Can tower deal with increased wet bulb temp
- Cold water to exchange heat

Energy Efficiency Opportunities

1. Selecting a cooling tower

Relationship range, flow and heat load

- Range increases with increased
  - Amount circulated water (flow)
  - Heat load
- Causes of range increase
  - Inlet water temperature increases
  - Exit water temperature decreases
- Consequence = larger tower

Energy Efficiency Opportunities

1. Selecting a cooling tower

Relationship Approach and Wet bulb temperature

- If approach stays the same (e.g. 4.45 oC)
- Higher wet bulb temperature (26.67 oC)

  = more heat picked up (15.5 kCal/kg air)

  = smaller tower needed
- Lower wet bulb temperature (21.11 oC)

  = less heat picked up (12.1 kCal/kg air)

  = larger tower needed

Energy Efficiency Opportunities

2. Fill media

- **Hot water distributed over fill media and cools down through evaporation**
- **Fill media impacts electricity use**
  - **Efficiently designed fill media reduces pumping costs**
  - **Fill media influences heat exchange: surface area, duration of contact, turbulence**

Energy Efficiency Opportunities

2. Fill media

Comparing 3 fill media: film fill more efficient

	Splash Fill	*Film Fill*	*Low Clog Film Fill*
Possible L/G Ratio	1.1 – 1.5	1.5 – 2.0	1.4 – 1.8
Effective Heat Exchange Area	30 – 45 m^2/m^3	150 m^2/m^3	85 - 100 m^2/m^3
Fill Height Required	5 – 10 m	1.2 – 1.5 m	1.5 – 1.8 m
Pumping Head Requirement	9 – 12 m	5 – 8 m	6 – 9 m
Quantity of Air Required	High	Much Low	Low

(BEE India, 2004; Ramarao; and Shivaraman)

Energy Efficiency Opportunities

3. Pumps and water distribution

- Pumps: see pumps session
- Optimize cooling water treatment
  - Increase cycles of concentration (COC) by cooling water treatment helps reduce make up water
  - Indirect electricity savings
- Install drift eliminators
  - Reduce drift loss from 0.02% to only 0.003 – 0.001%

Electrical Equipment/ Cooling Towers

Energy Efficiency Opportunities

4. Cooling Tower Fans

- Fans must overcome system resistance, pressure loss: impacts electricity use
- Fan efficiency depends on blade profile
  - Replace metallic fans with FBR blades (20-30% savings)
  - Use blades with aerodynamic profile (85-92% fan efficiency)

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Cooling Towers

THANK YOU

FOR YOU ATTENTION

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Disclaimer and References

Electrical Equipment/ Cooling Towers

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