How to Determine the Ideal Location for a Cooling Tower

Nick McCall, P.E., Woodard & Curran

Keynote Speaker

The recording and slides of this webinar will be made available to attendees via email within 2 days

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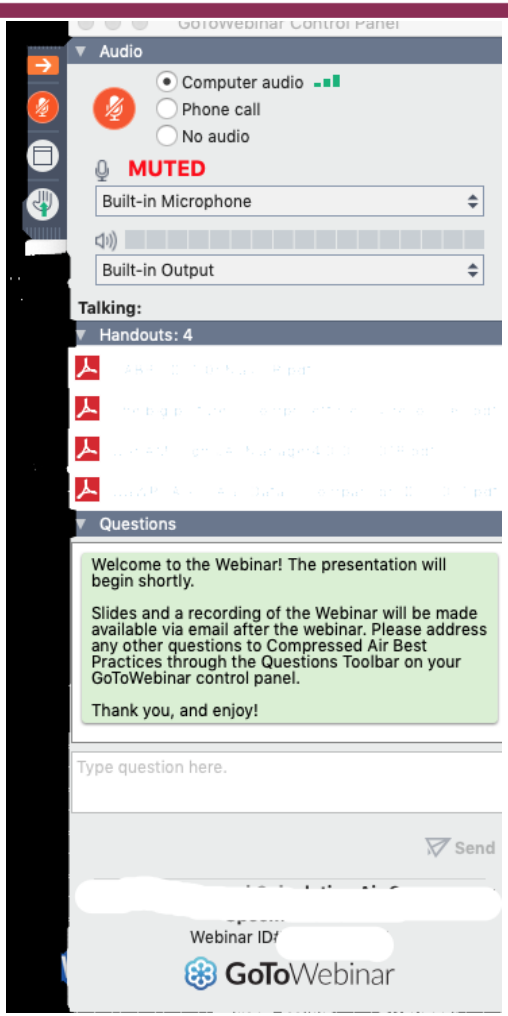
Q&A Format



- Panelists will answer your questions during the Q&A session at the end of the Webinar.
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PROFILE OF THE FIRM


PROCESS & UTILITY ENGINEERING


COOLSPEC
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Comparing and selecting evaporative cooling systems just got a whole lot smarter and easier!
BEST FITS
Rank your customer's priorities by order of importance to uncover optimal products for the application
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Accessorize with upgrade options for efficiency gains, safety measures and maintenance reductions
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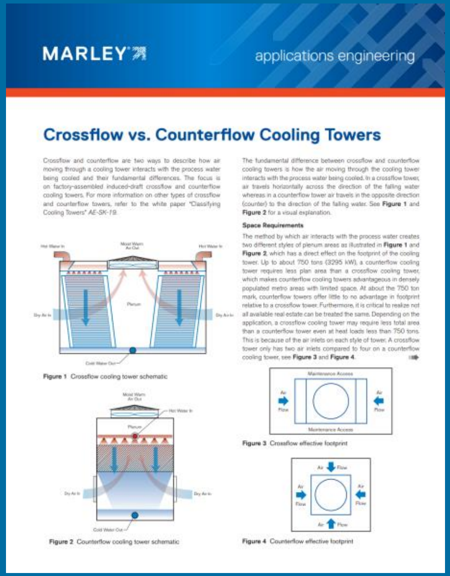
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applications engineering
Crossflow vs. Counterflow Cooling Towers


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How to Determine the Ideal Location for a Cooling Tower

Introduction

Chiller & Cooling Best Practices® Magazine

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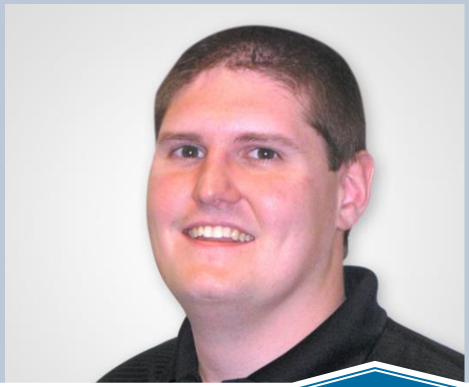
About the Speaker



Nick McCall, P.E.
Woodard & Curran

- Technical Manager, Woodard & Curran
- Utilities engineer since 2008
- Handle utilities installations including chillers, air compressors, dryers, boilers, and cooling towers as well as supporting utilities for manufacturing equipment

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Outline

- Interference
- Recirculation
- Plume behavior and recirculation potential
- Tower siting and orientation

Interference

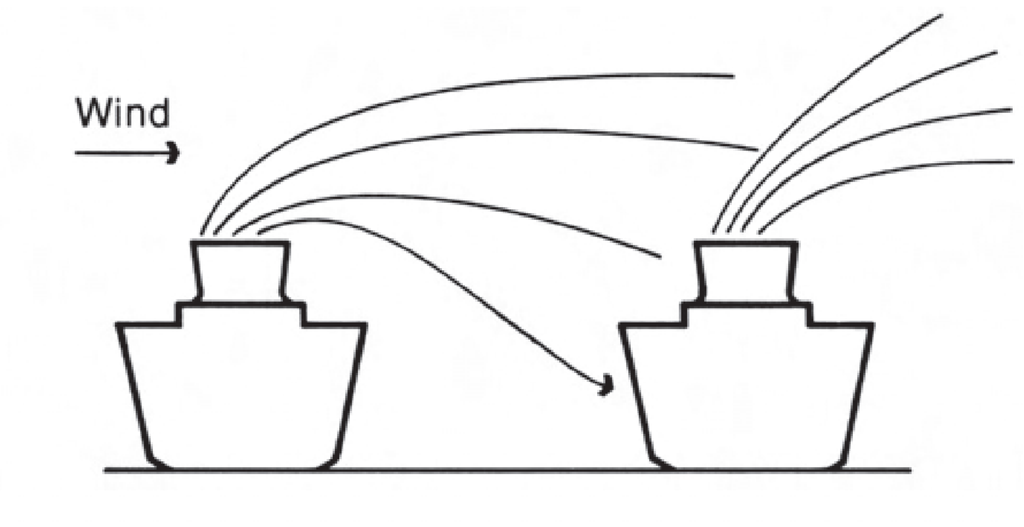

Figure 29 — Interference.

- Local heat sources upwind of the tower can elevate the wet bulb temperature of air entering the tower, detrimentally affecting the tower performance. This could include existing towers or other heat rejecting equipment.
- Proper location and orientation can minimize interference effects. Adjustments to tower layout/designs may be necessary to mitigate interference effects.
- New towers should be located out of the lee of any existing towers and capacity increased if it must be placed within the lee of any existing towers. Site specific conditions will need to be considered.

Interference

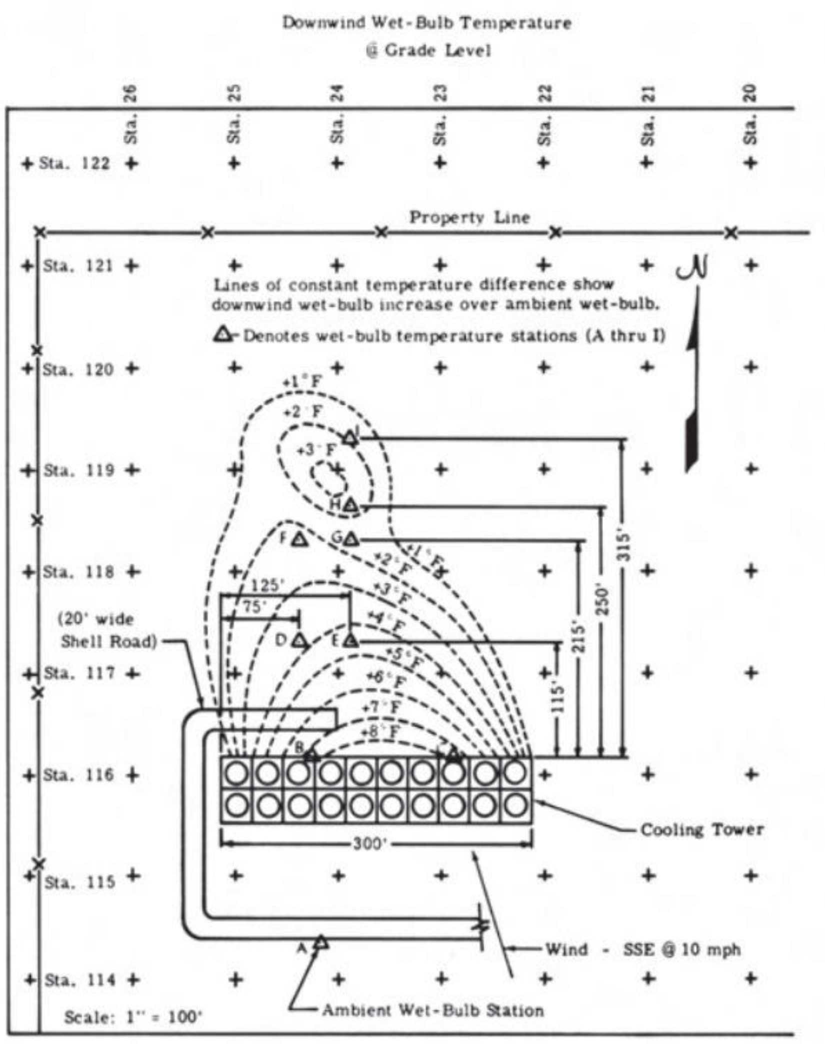

Figure 30 — Downwind wet-bulb contour of large existing cooling tower.

Recirculation

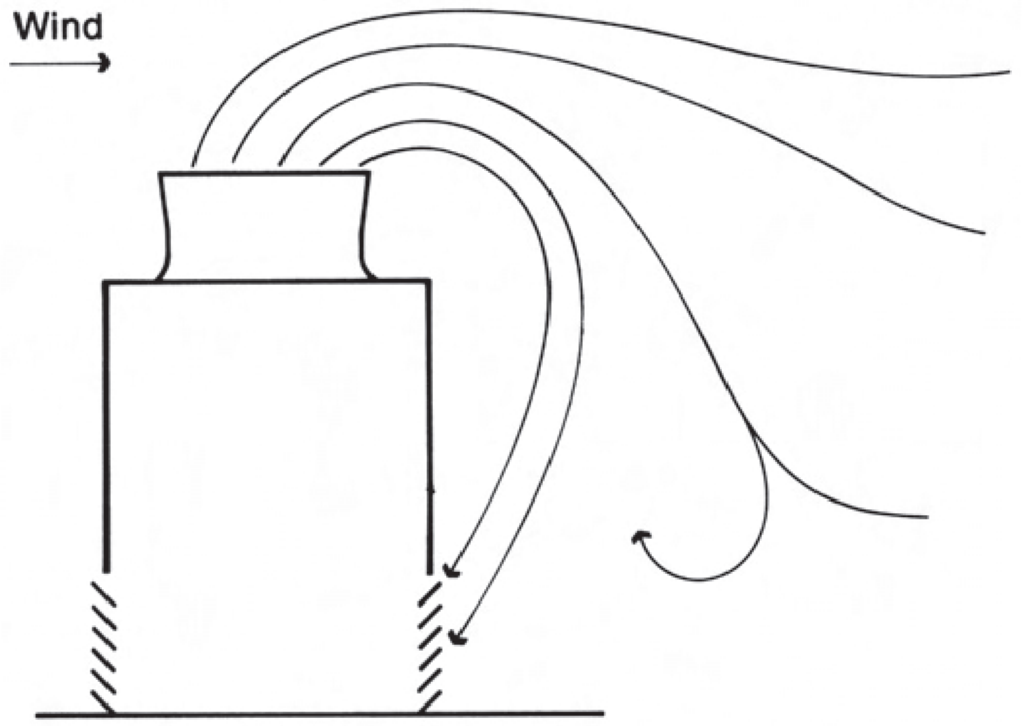

Figure 31 — Recirculation.

- Tower entering wet-bulb temperatures can be affected by some amount of saturated air exiting the tower being drawn back into the tower air intakes (recirculation). Tower manufacturers usually have designed their towers to minimize this effect.
- Recirculation potential is determined by wind force and direction. Recirculation effects tend to increase with wind velocity increases. Towers are typically tested to codes relating to thermal performance at wind velocities of 10 mph or less.

Plume Behavior and Recirculation Potential

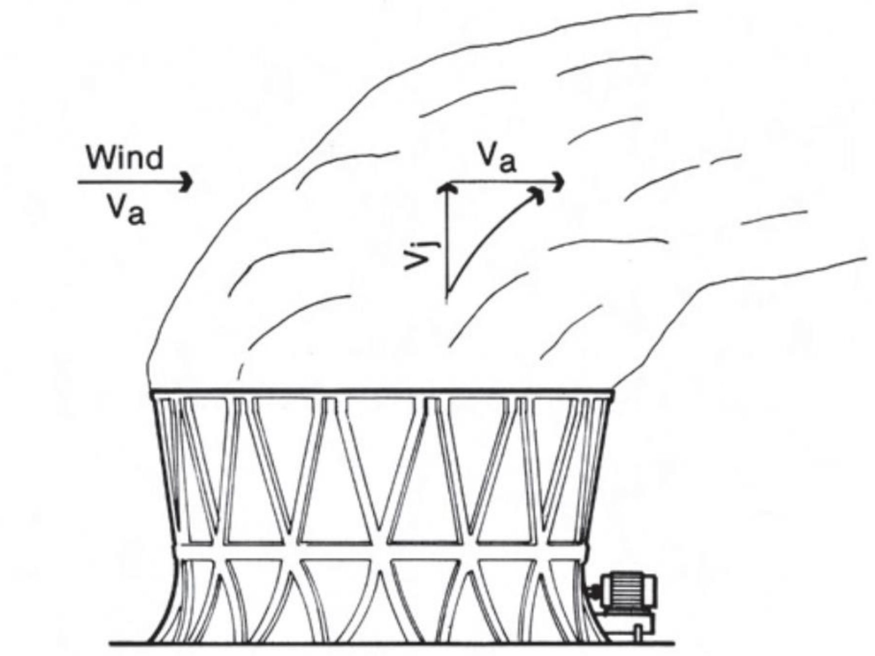

Figure 34 — Effect of wind velocity and discharge velocity on plume behavior.

- Fan imparts kinetic energy to the air and the heat load reduces the density of the effluent exiting the tower. The result is the air is pushed upward out of the tower, and the plume final height is determined by these two factors (independent of prevailing wind).
- Plume travels in direction dependent on speed, direction, and psychrometry of the prevailing wind. Low wind speeds result in almost vertical plume.
- For induced draft towers in calm conditions, the entering and ambient wet bulb temperatures are typically considered to be the same.
- With increasing wind speeds, plume direction becomes more horizontal. The plume to becomes drawn down and into the lee side of the tower.

Plume Behavior and Recirculation Potential

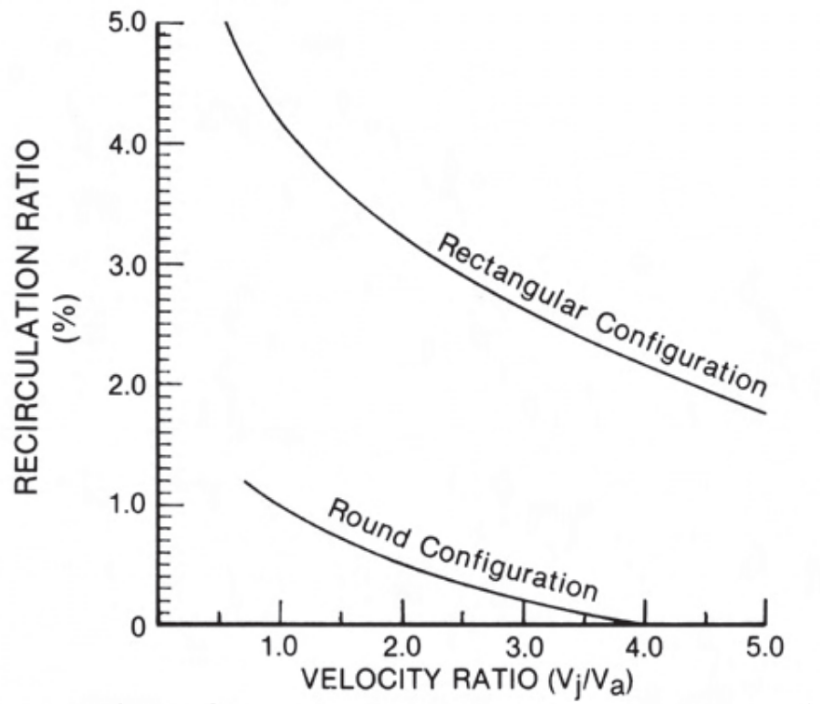

Figure 35 — Comparative recirculation potential of round and rectangular towers.

- Velocity ratio: plume discharge velocity divided by the ambient wind velocity.
- Recirculation ratio: percentage of total effluent air that is reintroduced into the tower by recirculation.
- Lower velocity ratios (higher wind velocities) result in higher recirculation ratios.
- Values in Figure 35 for the Rectangular Configuration represent a moderately sized industrial tower broadside to the prevailing wind. Recirculation ratios for that tower could be minimized if the tower were oriented 90 degrees from it's shown configuration (parallel to prevailing wind).
- Velocity ratio is also a function of the tower discharge air velocity. Velocity ratio will decrease if the tower discharge air velocity is decreased, resulting in a higher recirculation ratio.

Plume Behavior and Recirculation Potential

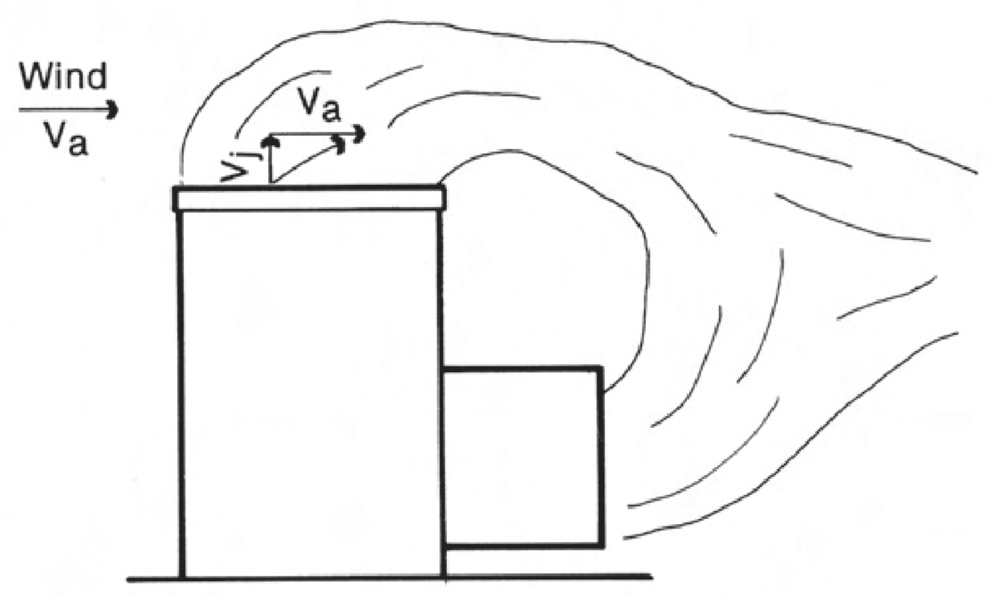

Figure 36 — Recirculation potential in a forced draft cooling tower.

- Forced draft towers are susceptible to lower velocity ratios.
- Normal discharge velocities from an induced draft tower are around 20 mph, while velocities from a forced draft tower are around 5-6 mph.
- This 4:1 difference results in a greater recirculation ratio in a forced draft tower.

Other Factors Affecting Recirculation

Figure 32 — Round mechanical draft tower operating in a significant wind. Compare plume rise to flat trajectory of smoke leaving stack.

- Tower shape: wind flow around obstructions is affected by the shape of the obstruction. Flowing wind leaves a low-pressure zone or “wake” on the downwind side of the obstruction. Wind will typically fill this area by the shortest possible route.
- Tall and narrow objects: wind can flow easily on either side of the obstruction.
- Low and long objects (like towers): wind typically flows over the top of the obstruction and down. This can present a difference in air intake wet bulb temperatures, degrading performance.
- Wind tends to flow with a smaller to negligible “wake” around round cylindrical shapes (Figure 32).

Other Factors Affecting Recirculation

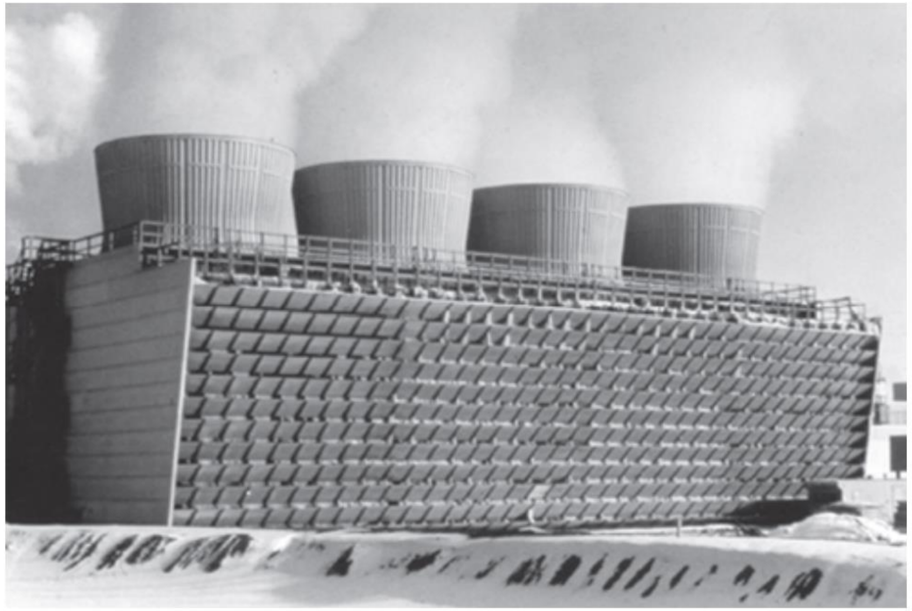

Figure 33 — Longitudinal wind direction concentrates separate stack plumes into one of high buoyancy.

- Orientation with prevailing wind: tower orientation can be altered to minimize wind effects (turning tower 90 degrees to face the narrower side of the tower towards the prevailing wind). This minimizes the tower “wake” and causes the fan effluents to “stack”, forming an exhaust plume that is more concentrated and buoyant.
- Round mechanical draft towers are unaffected by wind direction, and the center clustered fan arrangement produces a plume that is both concentrated and buoyant.

Other Factors Affecting Recirculation

- Fan cylinder height and spacing: discharge heights of tower fan cylinders can be increased, and spacing can be altered to provide more space between them to allow wind to flow more freely around the cylinders. Both of these are usually done together and can greatly reduce the recirculation potential in most situations (at an increase to the tower cost).

Tower Siting and Orientation

- Air Restrictions: towers are often screened from view by barriers/enclosures for aesthetic reasons. These screening devices can restrict air flow around the tower. Shrubs, fences, or walls with louvers should be placed several feet away from the air inlets to allow normal air flow to the tower. Consult tower manufacturer for input on screening barriers and enclosures concerning design and placement.

Tower Siting and Orientation

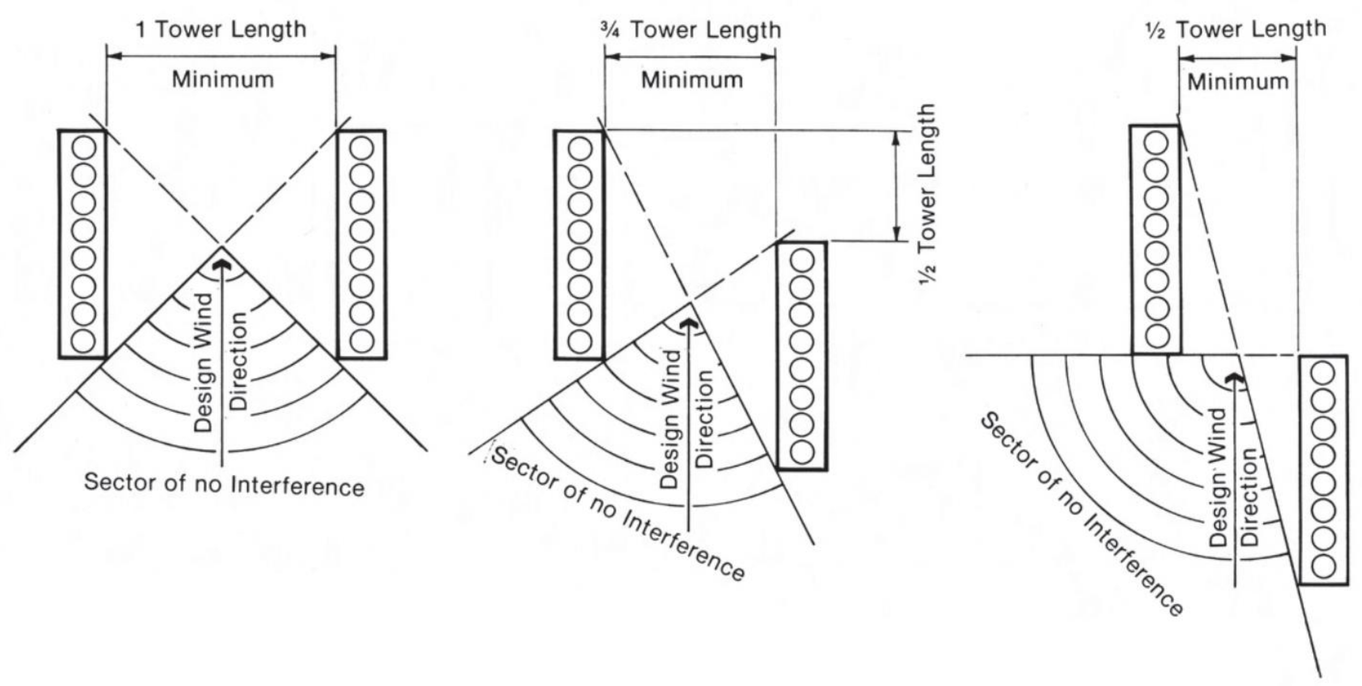

Figure 37 — Proper orientation of towers in a prevailing longitudinal wind. (Requires relatively minimal tower size adjustment to compensate for recirculation and interference effects.)

Tower Siting and Orientation

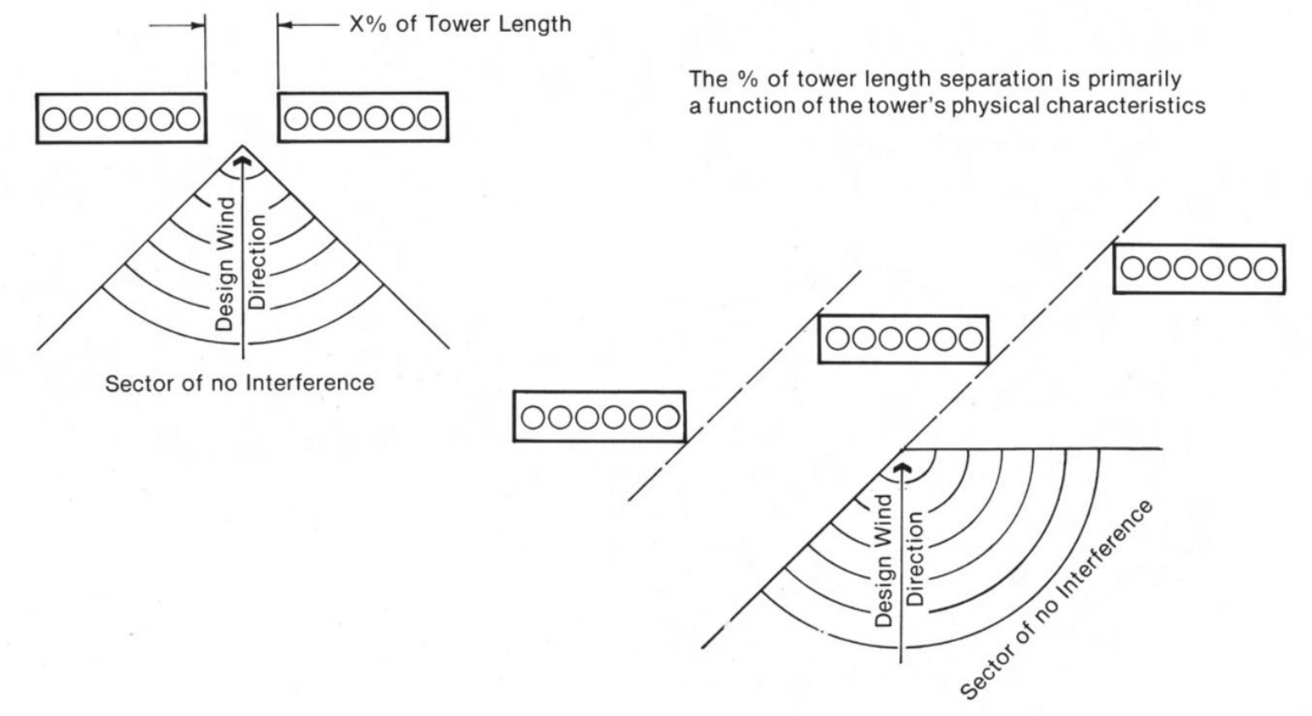

Figure 38 — Proper orientation of towers in a prevailing broadside wind. (Requires significantly greater tower size adjustment to compensate for recirculation and interference effects.)

Siting Configuration and Effect on Site Piping

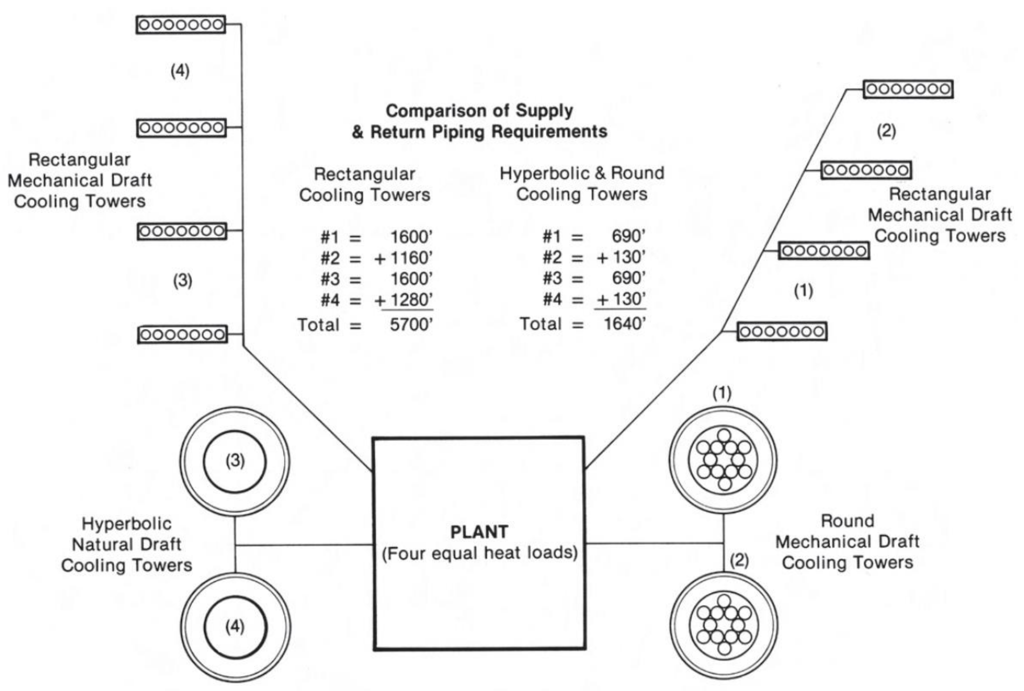

Figure 39 — Comparison of piping and ground use for both rectilinear towers and round towers. (Both types selected for equal performance.)

- Effect on site piping: Proper siting/orientation of towers generally takes precedence over concerns regarding complexity/quantity of site piping to towers. For smaller installations, tower location typically has minimal impact on total site piping costs. For larger installations (multiple towers), there may be on the order of hundreds of feet of large diameter piping required to site the towers in the proper location, and piping costs can represent a large portion of the overall project budget. Due to the variation in water distribution systems for towers, the amount of required site piping can be kept to a minimum for rectangular tower layouts. However, more effective reductions in site piping requirements can be made using round mechanical draft/hyperbolic towers due to tolerance for much closer spacing.

Summary

- Recirculation and interference both affect the long term capability/performance of cooling towers; determining proper site placement cannot be overstated.
- Tower performance is dependent on the amount and quality of air entering the tower. Any external influences on the wet-bulb temperature of the air or restrictions to its flow can negatively affect tower thermal performance.
- Attention must be paid to the distance between the heat load and the tower, effects around piping and wiring distance, noise/vibration issues, drift/fogging in areas sensitive to moisture or vision obstructions, and working access to all sides of the tower for repair and maintenance.
- Orienting the tower such that the louvered intake faces are parallel to the prevailing winds is the proper placement to minimize recirculation effects.
- Towers should not be situated such that any one tower is located within another tower's/heat source's (air cooled chiller, boiler stack, etc.) downwind interference zone or lee. If this is not possible, the tower should have it's design wet bulb adjusted accordingly.
- Round towers do not suffer greatly from recirculation, but they are not immune to interference effects and they can also act as interference sources as well.
- There are no hard and fast rules to cover all possible tower installation scenarios. Location/orientation of the tower can affect the entering wet bulb temperature by anywhere from 0.5 deg F to 5 deg F, and it would be wise to consult the cooling tower manufacturer for guidance in these areas, especially on sites with critical processes and substantial heat loads.

Thank you for watching!

Nick McCall, PE
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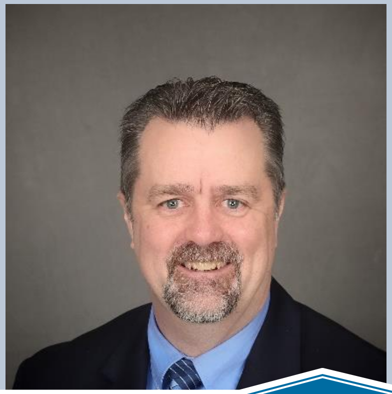
About the Speaker



Mark Pfeifer, P.E.
SPX Cooling Tech, LLC

- Sr. Manager, Technical Services, SPX Cooling Tech, LLC
- 30+ years of cooling tower experience
- Secretary of ASHRAE's Technical Committee for Cooling Towers and Evaporative Condensers (TC8.6)

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Locating Cooling Towers – A Manufacturer's Perspective

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October 20, 2022

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Agenda

- Why Evaporative Cooling
- Selection & Design
  - Tower Type Effects
  - Sound Mitigation Effects
- Making it Fit - How Manufacturers can Help
  - Product Selection Tool
  - Piping Layout Options

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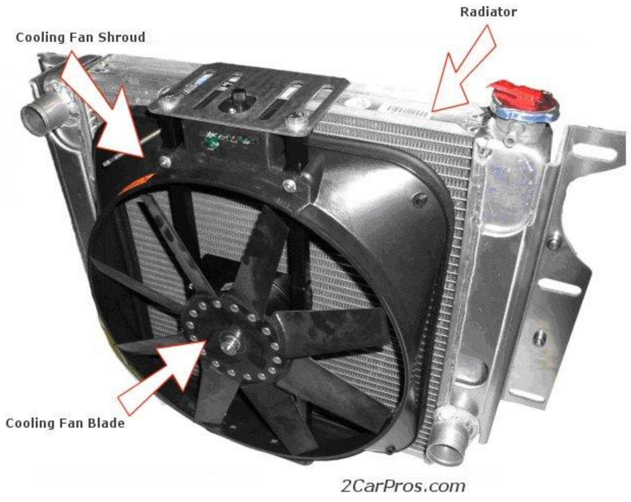
The “Cooling” in Cooling Towers

Sensible (aka dry cooling)

- **<u>Sensible Cooling</u> of 1 lb of water 1ºF rejects <u>1 btu</u>.**
- Dry Bulb temperature is the driving force
- Hard to cool 95º water with 95º air
- Example: Car radiator



Latent (aka evaporative cooling)

- **<u>Evaporating</u> that same 1 lb of water rejects <u>1,000 btu!</u>**
- Example: Perspiration evaporating

The “Cooling” in Cooling Towers

Evaporative cooling

- Can cool water approaching the wet bulb temperature
  - providing colder water to process
  - **Providing additional system efficiency**

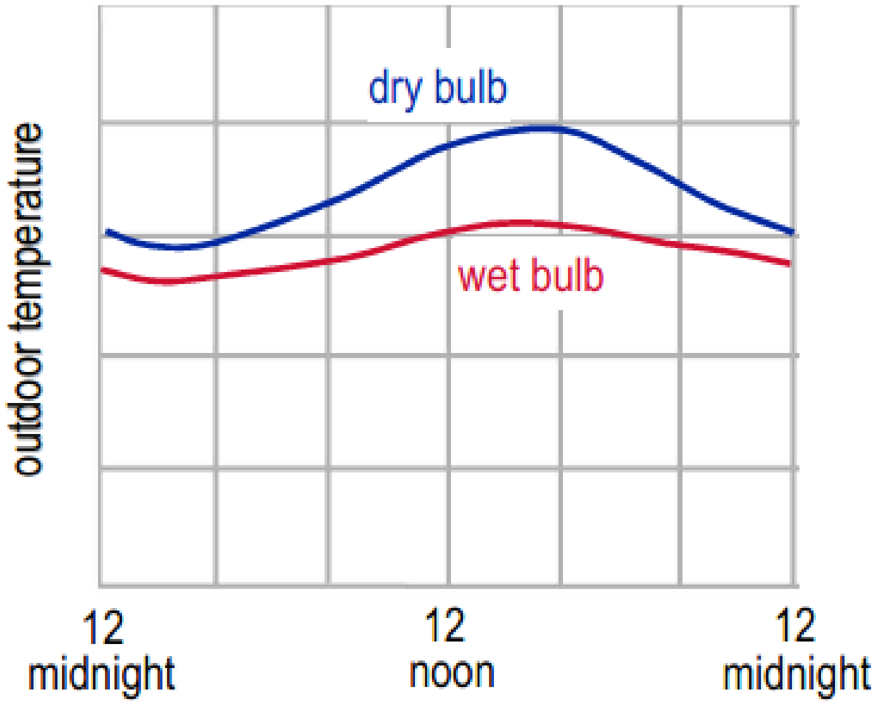


Image courtesy Trane Technologies

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Tower Space Requirements

NC - Crossflow

Tonnage	Crossflow
100 – 750	80 – 315 sf
>750	270 – 315 sf
Multi Cell (ex 6000)	1350 sf

MD - Counterflow

Tonnage	Counterflow
100 – 750	50 – 220 sf
>750	290 – 430 sf
Multi Cell (ex 6000)	1650 sf

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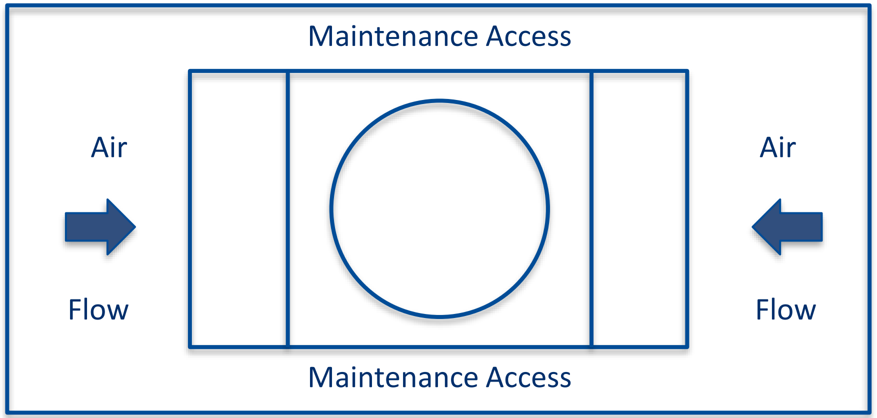
Crossflow Tower is Rectangular & Horizontal; Counterflow Tower is More Square & Vertical

Total Tower Space Requirements

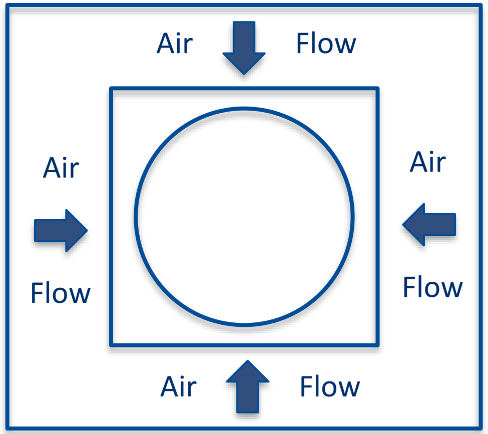
NC - Crossflow



Tonnage	Crossflow
100 – 750	250 – 850 sf
>750	850 sf
Multi Cell (ex 6000)	2800 sf

+ Air inlet space only required at the ends
– Space required on side to access the door

MD - Counterflow



Tonnage	Counterflow
100 – 750	200 – 990 sf
>750	990 – 1500 sf
Multi Cell (ex 6000)	4600 sf

– Air inlet space required on all 4 sides

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Crossflow Requires Less Total Space

Tower Height

NC - Crossflow

Tonnage	Crossflow Ht.
100 – 750	10' – 12'
>750	18' – 22'
Multi Cell (ex 6000)	10' – 22'

- Add ~3' for Guardrail

MD - Counterflow

Tonnage	Counterflow Ht.
100 – 750	10' – 17'
>750	16' – 19'
Multi Cell (ex 6000)	10' – 19'

- Some manufacturers up to 22'

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Advantage Depends on Job Requirements

Agenda

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Sound: Primary Sources

Air Outlet

- Mechanical equipment noise
  - Fan, motor, speed reducer
  - Low to mid-frequency

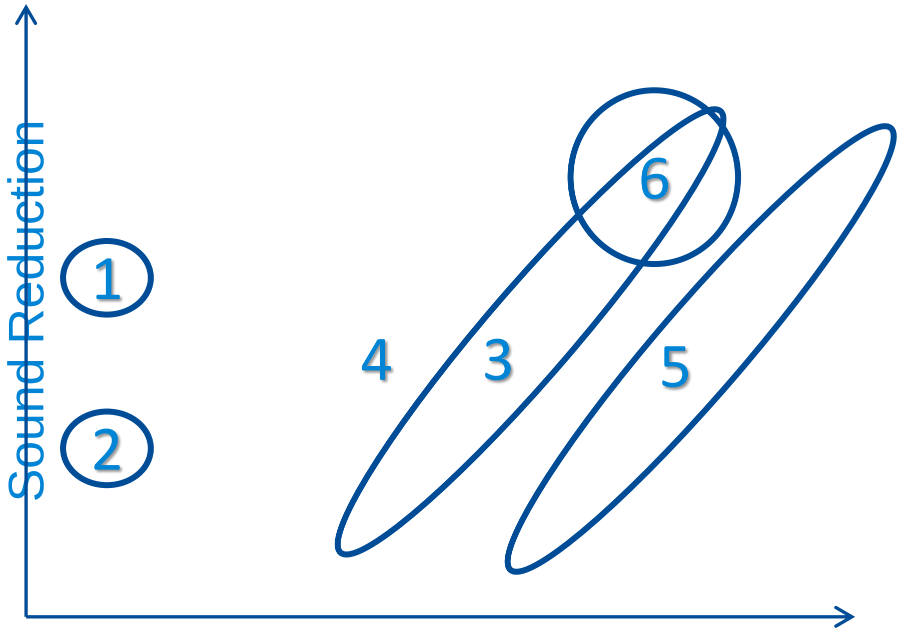
Air Inlet

- Mechanical equipment noise in far field
- Falling water noise in near field
  - High frequency splashing (lower in crossflow)
  - Attenuates with distance

Orient Cased Face Toward Critical Sound Measurement Locations

Sound Mitigation Techniques

1. Orient the cased face toward receiver (crossflow tower)
2. Locate the tower farther from receiver
3. Oversize the tower and run at reduced fan speed
4. Low Noise Fan Options
5. Attenuation Options
6. Place a barrier between the tower and receiver



Move the tower before changing the tower

Agenda

Why Evaporative Cooling

Selection & Design

Tower Type Effects

Sound Mitigation Effects

Making it Fit - How Manufacturers can Help

Product Selection Tool

Piping Layout Options

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COOLSPEC PRODUCT SELECTOR

SPX

- Sizing and Selection tool for cooling towers, fluid coolers and evaporative condensers
- Guided selection / recommendations based on System, Application, and User Priorities
- Compare functionality
- Filter functionality to limit key criteria
- Minimum enclosure clearances provided

Select Product Type

Confirm selection of product type below

Confirm Priorities

We've suggested the following recommendations based on patterns from similar users

Drag and drop the items below to sort by importance

Very Important	Important	Somewhat Important	Not Important
First Cost	Operating Cost	Installation Ease	Indoor-Ducted Installation
Energy Efficiency	Corrosion Resistance	Redundancy	
Footprint		Cold Weather Operation	
Height			
Weight			
Sound			
Maintenance Ease			

Minimum Enclosure Clearance

Clearance required on air inlet sides of tower without altering performance. Assumes no air from below tower.

Solid Wall	7 ft
50 % Open Wall	5 ft

Register at https://coolspec.com/

Single flow Crossflow – Marley AV

125 – 772 tons/cell

- Induced draft single flow cooling tower
- Crossflow features in less space than a double flow NC
- Great for less than 750 ton
- Used on rooftops with limited space
- Great cold weather operation
- Low perimeter sound
- Low pump head
- Superior variable flow capabilities

Great alternative to counter-flow in small capacity applications

Forced Draft Counterflow – Marley MCW

25 – 600 tons/cell

CTI CERTIFIED

- Forced draft counter-flow design
- Typically HVAC replacement market applications
- Low sound levels above the tower
- High sound levels around perimeter
- High static pressure fans good for indoor ducted applications
- Typically double the fan power of induced draft cooling towers

Niche market applications – indoor ducted fan outlets

Plume Abated Crossflow – Marley NCWD

546 – 921 tons/cell

CTI CERTIFIED

FM APPROVED

- Induced draft double flow cooling tower
- Parallel path plume abatement
- Coil section in upper module uses inlet water to warm the discharge air
- Applications for airports, urban environments, roadway safety, visual pollution concerns, environmentally conscious building

COOLSPEC PRODUCT SELECTOR

- Sizing and Selection tool for cooling towers, fluid coolers and evaporative condensers
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MARLEY

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Piping Layout – Why Discuss?

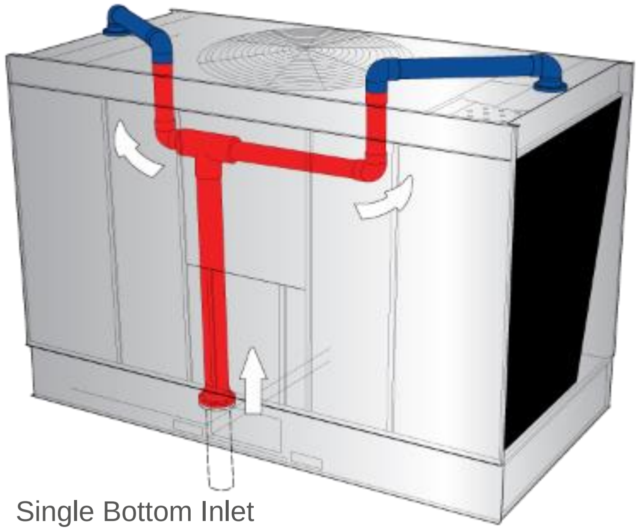
SPX Photo

Inlet Configurations: Dual Top Inlet

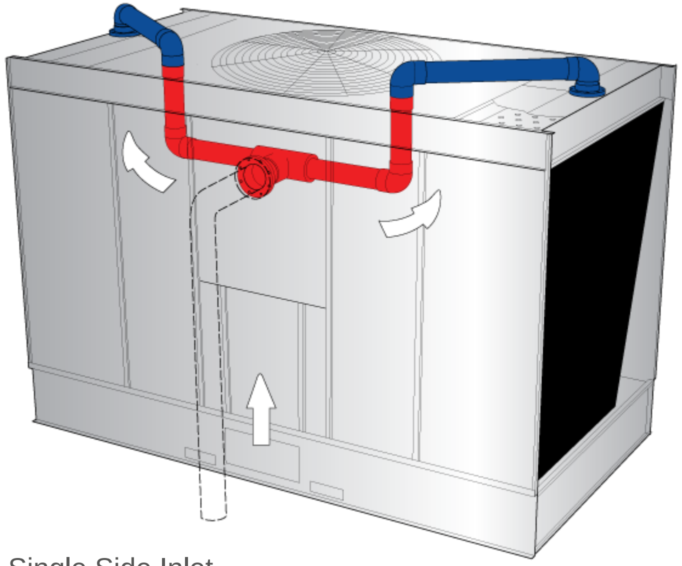
- Typically provides lowest pump head option (vs single inlet)
- Optional Horizontal Control (HC) Valves provide economical hydraulic control

HC valve

Inlet Configurations: Single Inlet



Single Bottom Inlet



Single Side Inlet

Installed at SPX factory

Ships Separately for Field Install

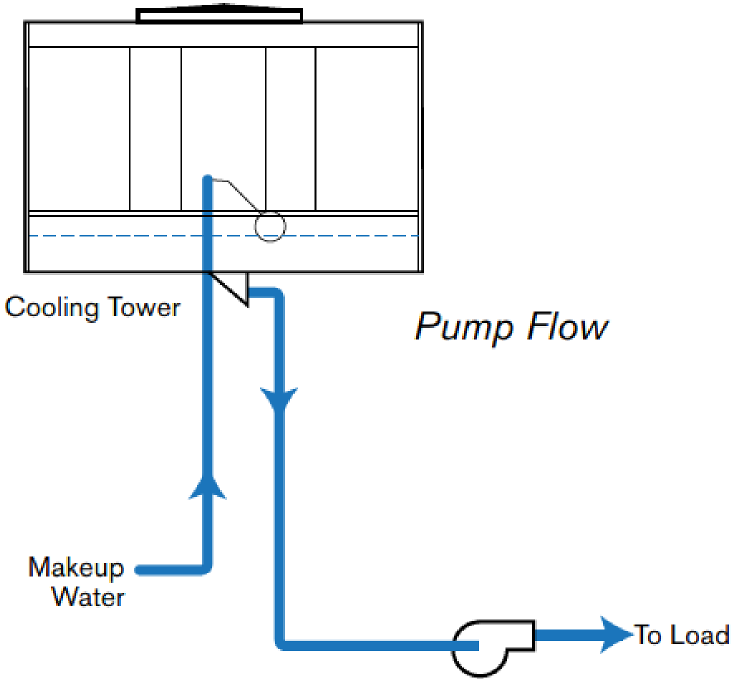
Designed & installed by others

- Reduces piping design and installation costs
- Eliminates the need for additional piping and supports
- Auto balance feature (orifice plates) balances flow between hot water basins

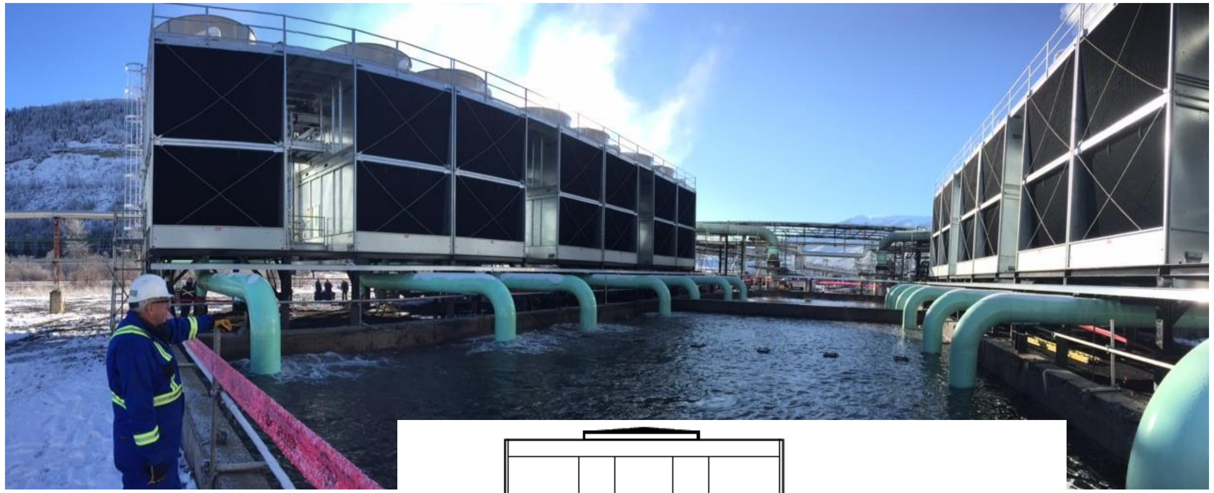
Convenient Piping Solutions

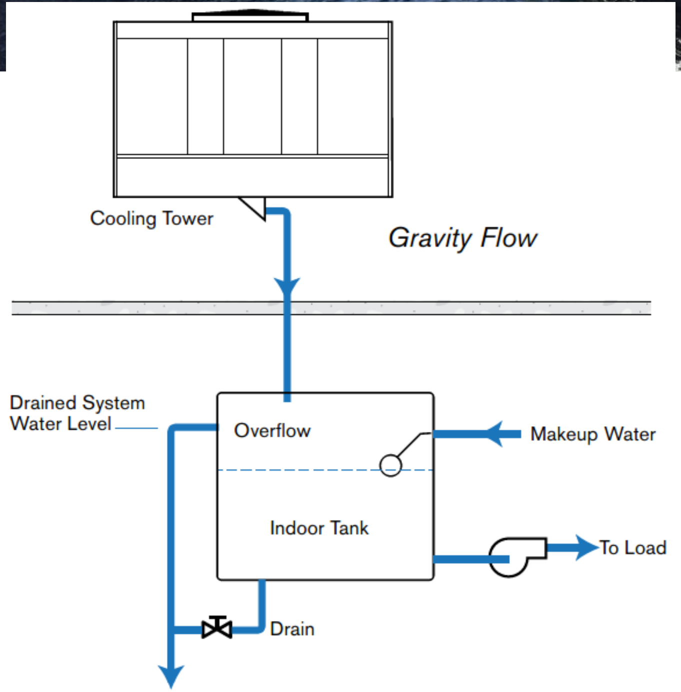
Outlet Flow Types: Pump Flow

- Pump suction piped directly to the tower basin
  - Pump draws water directly from the basin
- Water remains in basin upon shutdown
- Freezing climates require basin heaters if basin not drained
- Predominant design



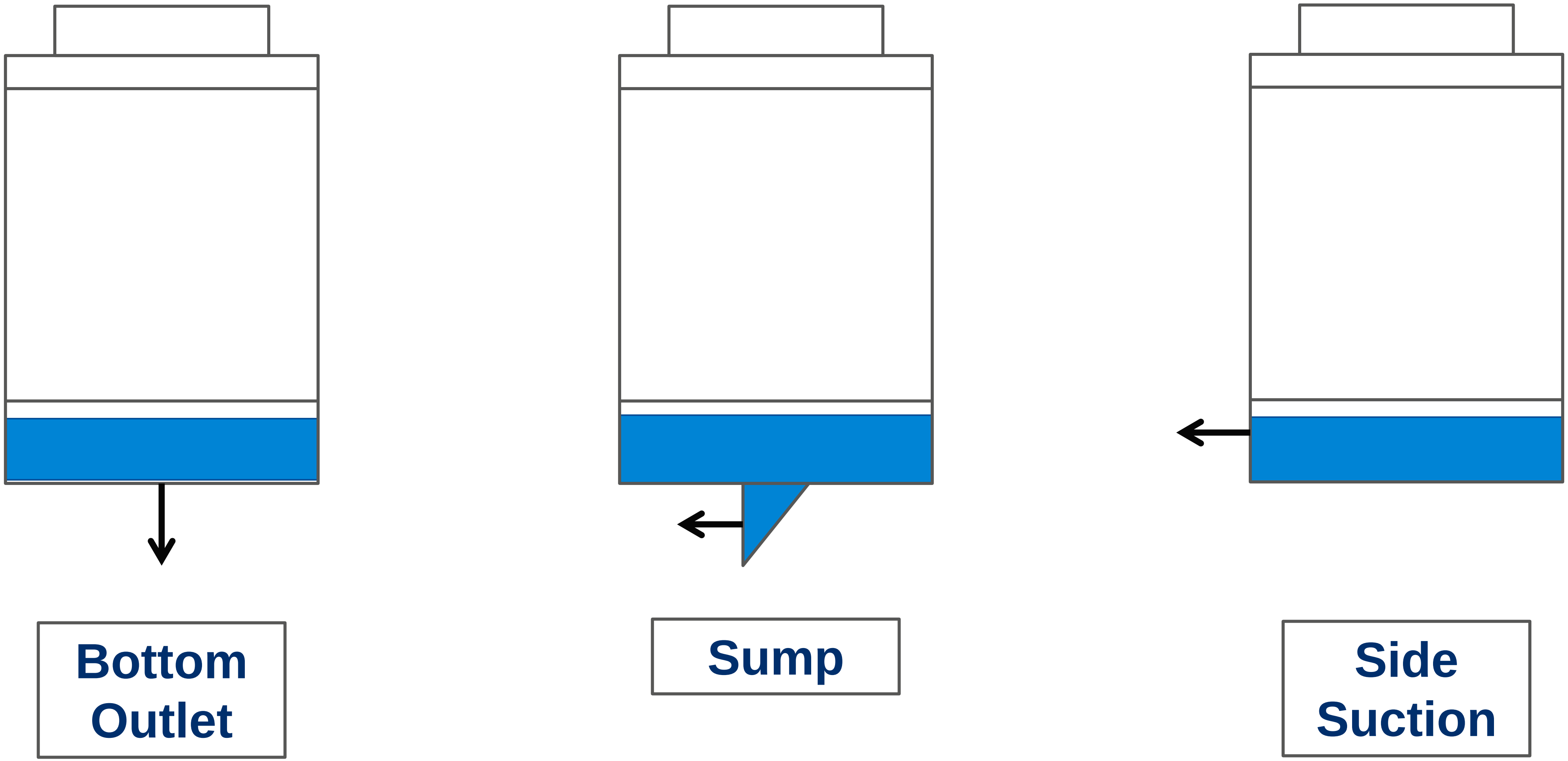
Outlet Flow Types: Gravity Flow



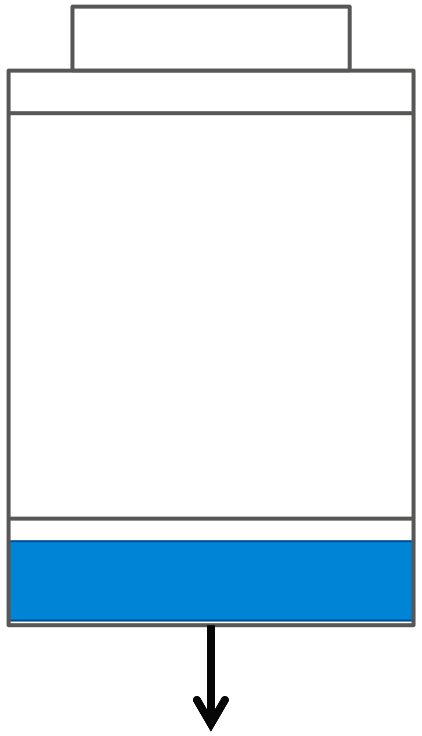


- Basin drains by gravity to a separate basin or remote sump below the tower
  - Pump draws water from separate basin
- No water remains in cold water basin
- Fail-safe
- Trades energy for real estate
- Simplifies water treatment on fluid cooler applications
- **Must** be properly sized
- Less common

Outlet Configurations



Outlet Configurations – Bottom Outlet



Used on pump or gravity flow

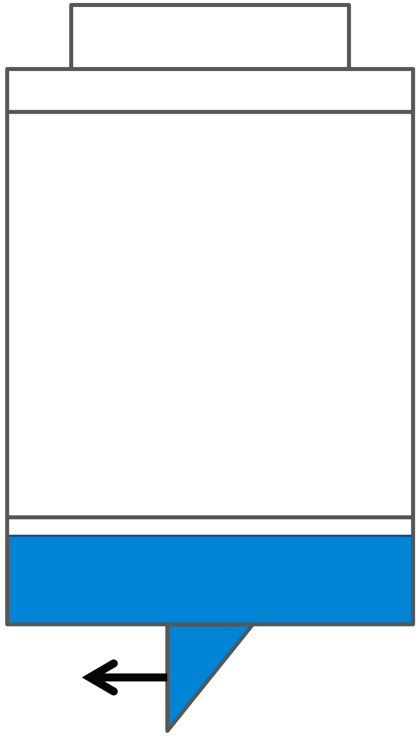
Advantages

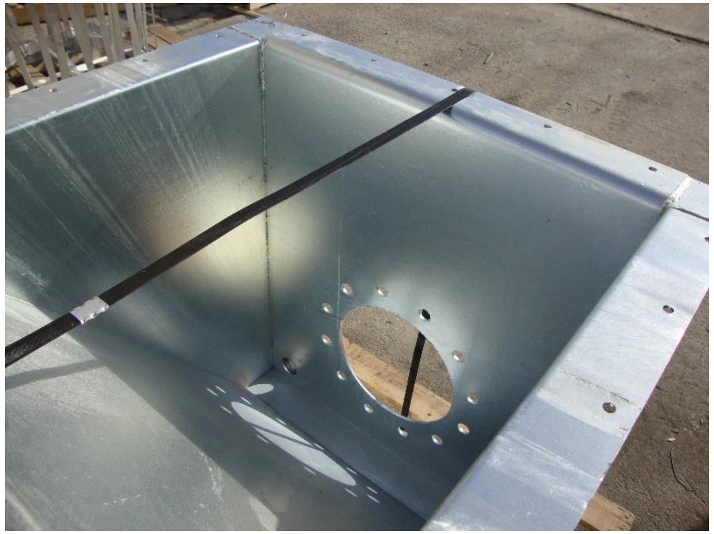
- Simple
- Lowest tower cost
- Handles highest flow rates

Disadvantage

- Requires larger outlet diameter
  - Typically higher piping cost

Outlet Configurations – Sump





Used on pump or gravity flow

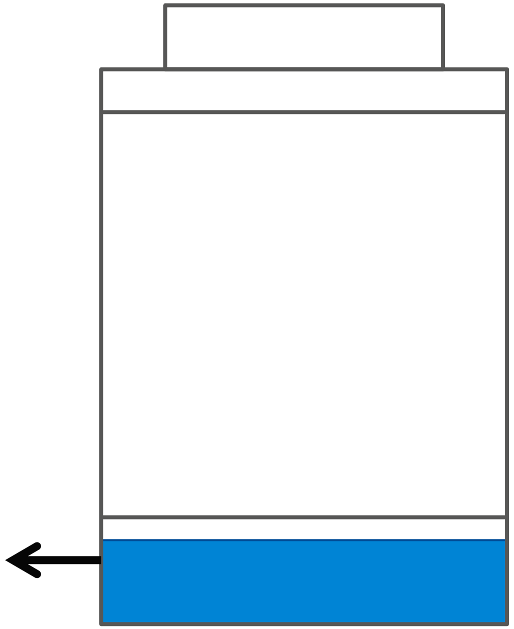
Advantages

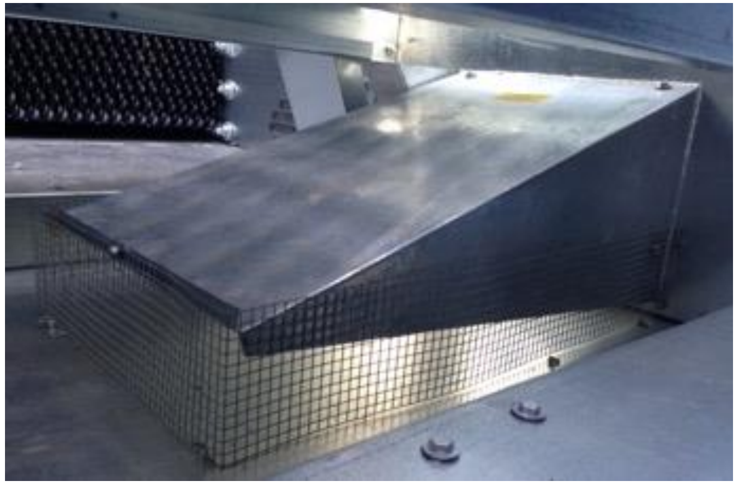
- Reduces chance of cavitation
- High flow capability
- Replaces 90° elbow

Disadvantages

- Higher tower cost
- 1 additional joint to potentially leak

Outlet Configurations – Side Suction





Used on pump flow only

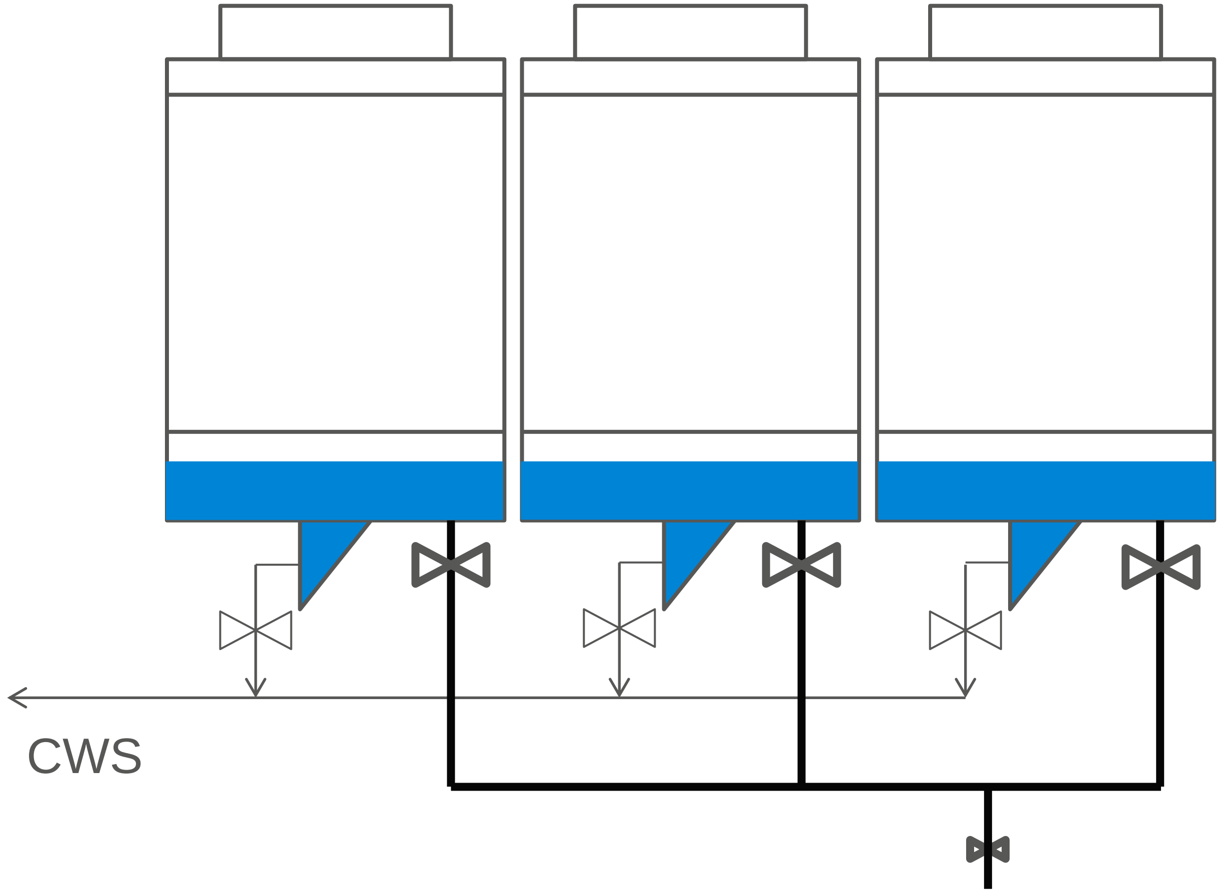
Advantages

- Can be used on slab
- High flow capability
- Does not compete with sweeper system

Disadvantage

- Can only be used on:
  - pump flow
  - 2 cells or fewer
- 1 additional joint to potentially leak
- Basin must be flooded for initial startup

Equalizers – Bottom Equalizers



Used to promote equal operating water levels between cells

Advantages

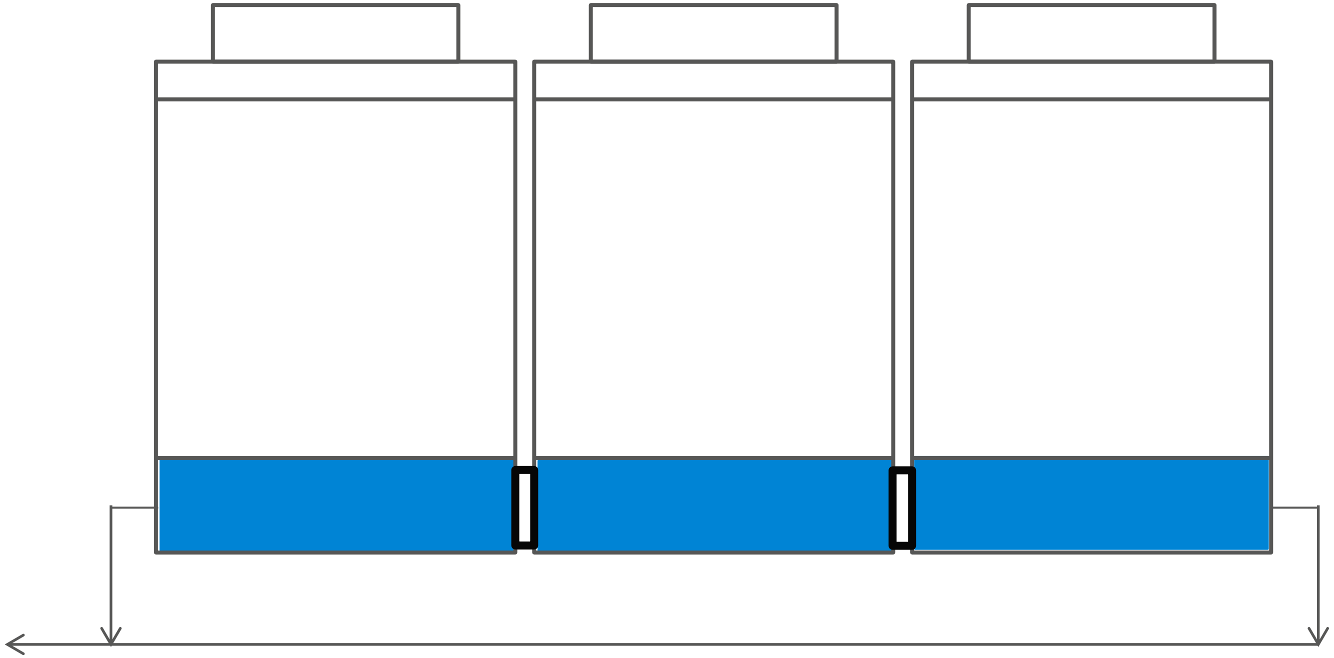
- Pipe runs full of water
- Most forgiving design – provides operational flexibility during wider range of flow rates

Disadvantage

- Requires space under the tower
- Potential dead leg

Recommended Design

Equalizers – Flumes



Used to promote equal operating water levels between cells

Advantages

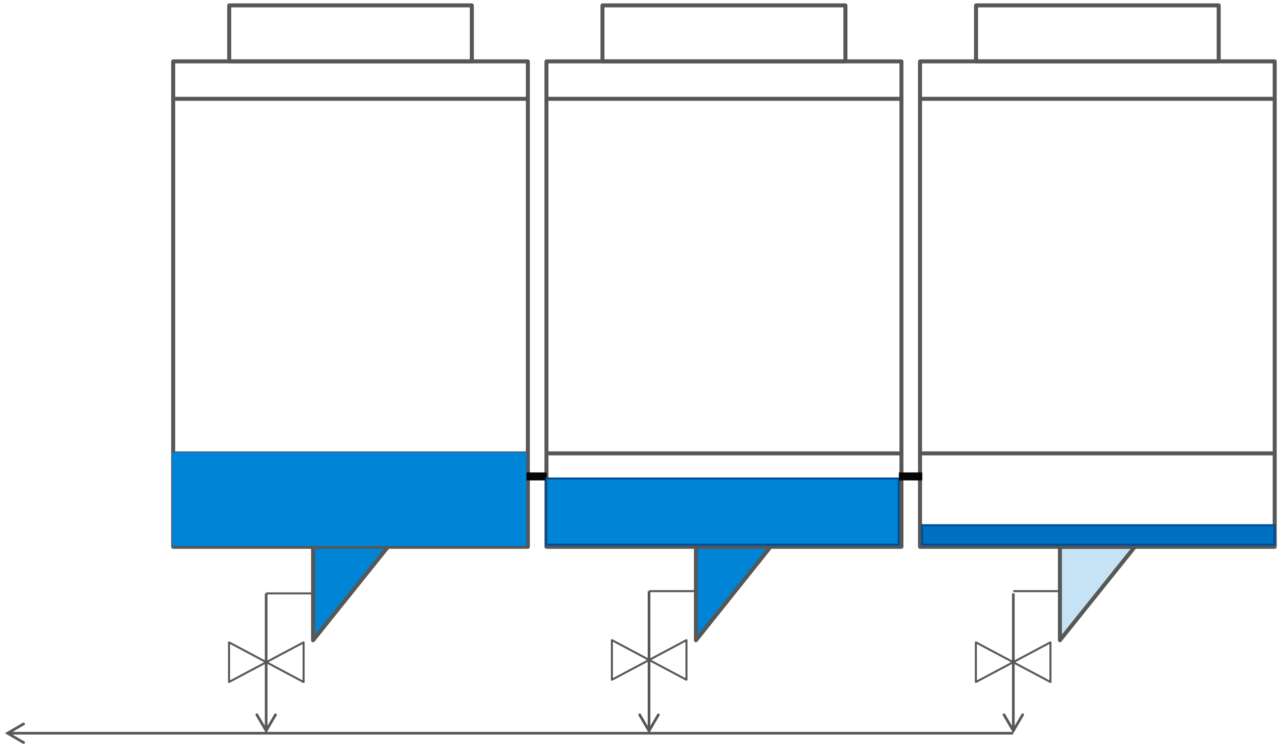
- Can set tower on slab
- Less piping
- Handles highest imbalance between cells
- Avoids potential dead legs

Disadvantage

- Cell isolation with weir plate tedious
- Increased leak potential

Bottom Equalizers recommended over Flumes

Equalizers – Non-conforming



Examples

- Smaller equalizer diameters
- Side equalizers

Advantages

- Often used on proven applications
- Re-uses existing pipe

Disadvantages

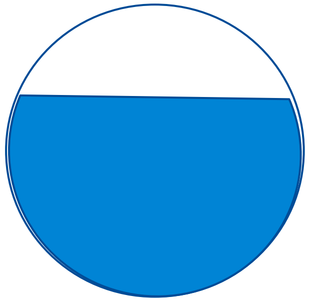
- Reduces operational flexibility
- Increases risk of overflow and pump cavitation

Not Recommended

Equalizers – Non-conforming

Which flows more water?

Flume



Side Equalizer

Side equalizers have limited capability

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