Cooling Tower Selection Considerations

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Learning Objectives

- Cooling Tower Basics
  - Definitions and Principle of Operation
  - Cooling Tower Classifications
  - Terminology and Selection Inputs
  - Codes and Standards

- Cooling Tower Selection Considerations
  - Energy efficiency and water usage
  - Layout
  - Sound

Cooling Tower Basics

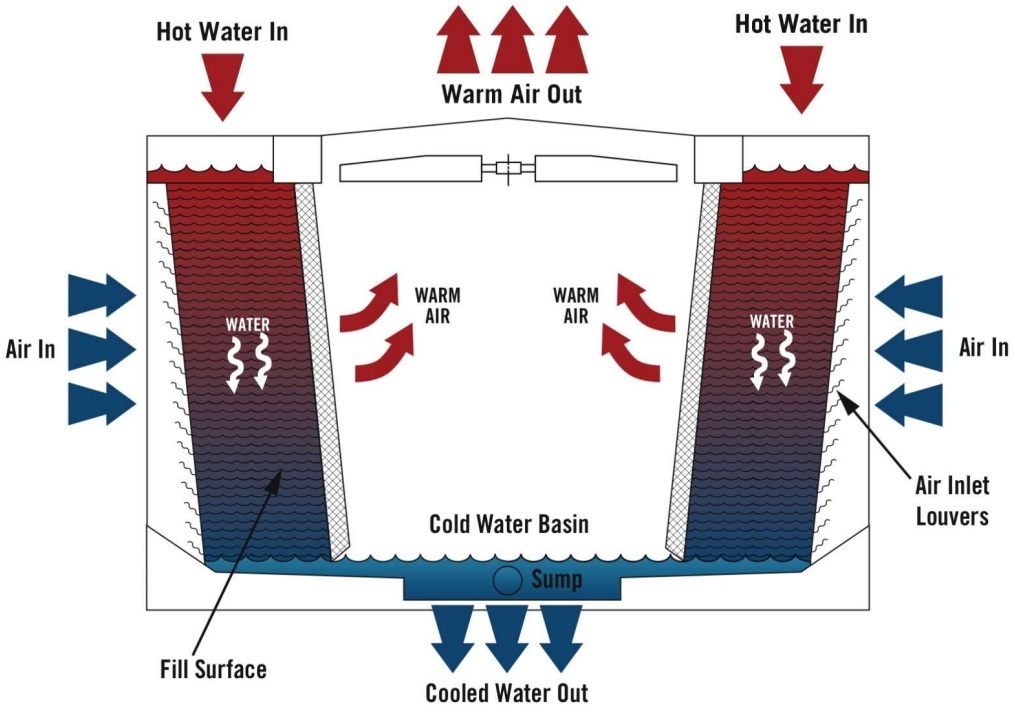
What is a Cooling Tower

An enclosed, steady flow device used to dissipate low grade waste heat from water-cooled refrigeration, air-conditioning and industrial process systems to the atmosphere through the evaporation of water.

How does a Cooling Tower Work?

A cooling tower enhances natural evaporative cooling processes by increasing the contact surface area and time of exposure between the circulating water and ambient air.

Principle of Operation



Thermal Performance Terms

“Range” = Entering Temp – Leaving Temp

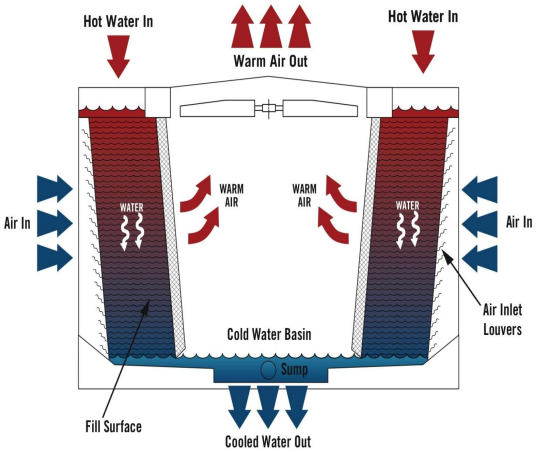
“Approach” = Leaving Temp – Wet Bulb Temp

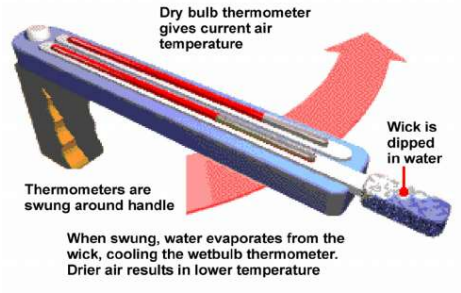
Total Heat of Rejection (BTUH) = Flow x Range x 500

MBH = 1,000 BTUH

Wet Bulb Temp = The temperature read by a thermometer covered in a water-soaked cloth over which air is passed.

Cooling tower ton = BTUH/15,000 (for a 10 degree range this = 3 GPM/Ton)





Design Wet Bulb for Des Moines

Design conditions for DES MOINES, IA, USA

Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
1a	*1b*	*1c*	*1d*	*1e*	*1f*	*1g*	*1h*	*1i*
DES MOINES	**725460**	**41.52N**	**93.65W**	**965**	**14.191**	**-6.00**	**NAC**	**7201**

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6%			99%			0.4%		1%			
			DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
2	*3a*	*3b*	*4a*	*4b*	*4c*	*4d*	*4e*	*4f*	*5a*	*5b*	*5c*	*5d*	*6a*	*6b*
1	**-7.8**	**-2.9**	**-18.3**	**2.1**	**-6.1**	**-13.0**	**2.8**	**-2.0**	**31.0**	**14.1**	**28.1**	**14.3**	**10.5**	**310**

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	*8*	*9a*	*9b*	*9c*	*9d*	*9e*	*9f*	*10a*	*10b*	*10c*	*10d*	*10e*	*10f*	*11a*	*11b*
7	**18.3**	**93.5**	**76.0**	**90.3**	**74.8**	**87.4**	**73.3**	**78.2**	**89.1**	**76.9**	**87.4**	**75.3**	**84.9**	**12.3**	**190**

Cooling Tower Types

Modular vs Field Erected

Modular

Field Erected

Cooling Tower Fan Types

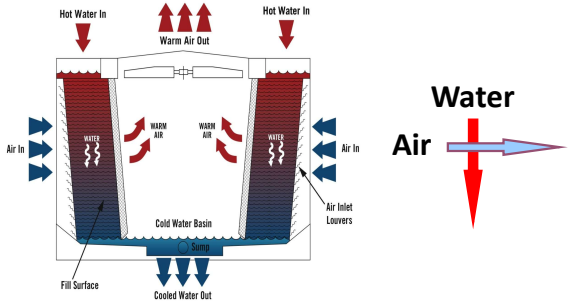
Centrifugal Fans

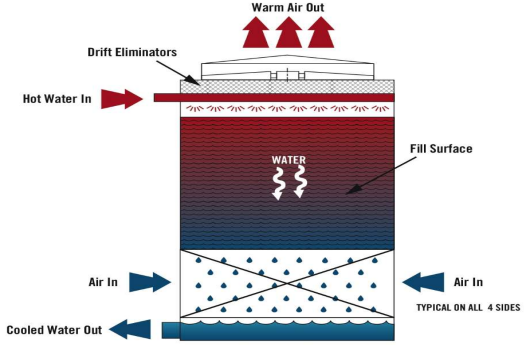
- High volume/static pressures
- High energy consumption
- Quiet operation
- Indoor applications

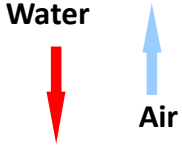
Axial Flow Fans

- High volume/low static pressure
- Low energy consumption

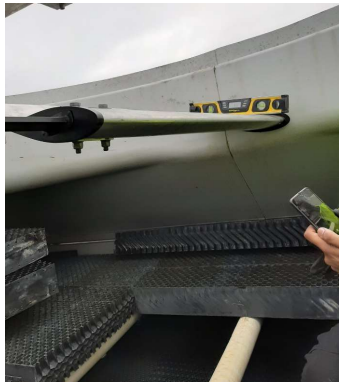
Crossflow Versus Counterflow

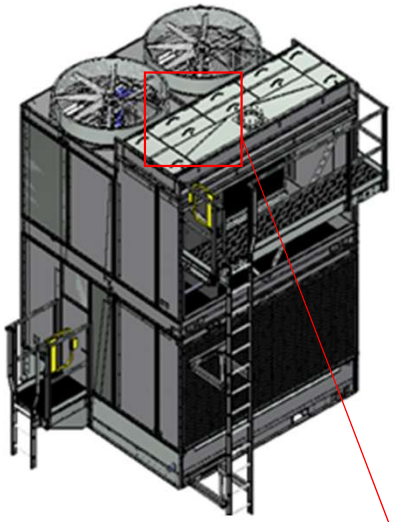


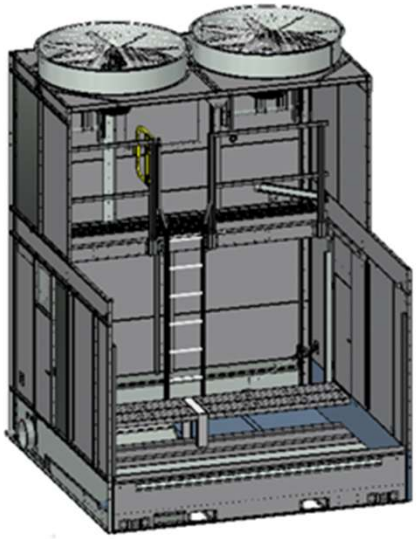


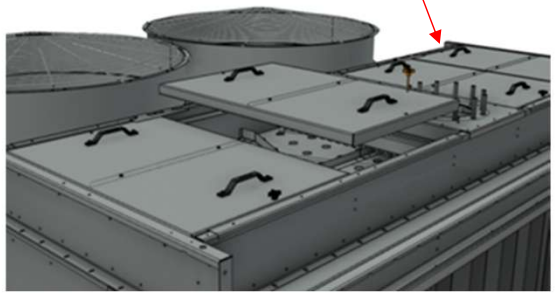


Crossflow Versus Counterflow Maintainability



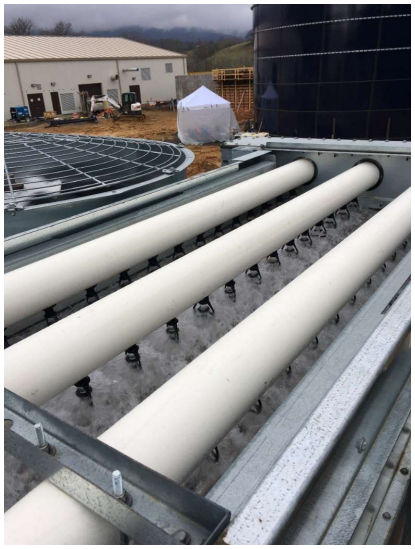






Maintenance Check List

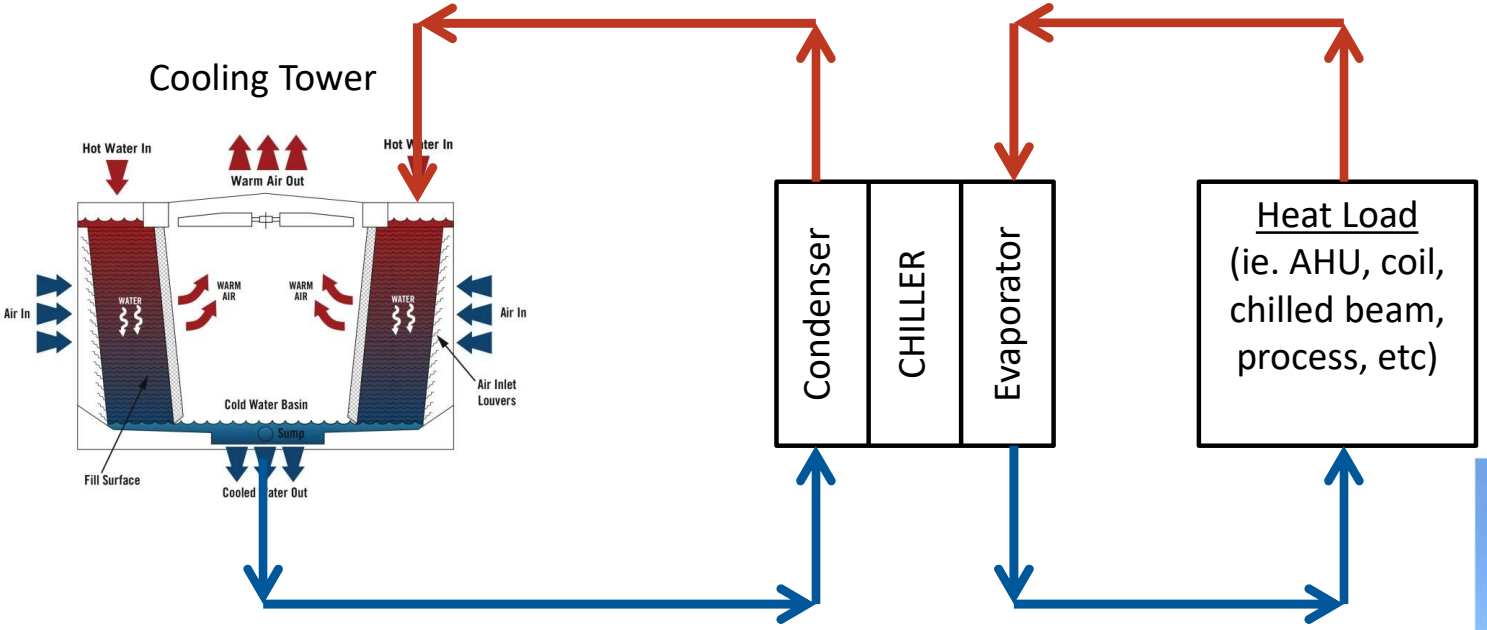
- Check fan pitch quarterly
- Lubricate fan shaft bearings quarterly
- Check spray nozzles quarterly
- Inspect cold water basins quarterly



✓ Recommended **Maintenance** Service[1]

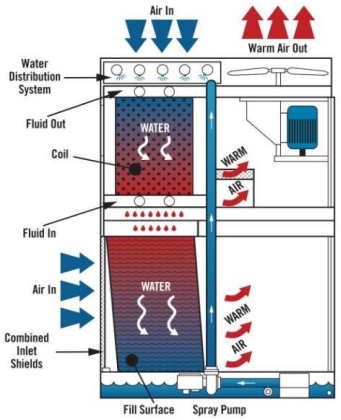
Inspect and clean as necessary:	Start-Up	Monthly	Quarterly	Annually	Shutdown
Inspect general condition of the unit[2] and check unit for unusual noise or vibration	✓	✓			
Inspect cold and hot water basins	✓		✓		
Flush water distribution system/Inspect spray nozzles	✓		✓		
Drain basin and piping	✓				✓
Inspect air intake louvers/Combined inlet shields	✓	✓			
Check and adjust water level in cold water basin	✓	✓			
Check operation of make-up valve	✓	✓			
Check and adjust bleed rate	✓	✓			
Check optional EASY CONNECT® Piping Arrangement	✓				✓
Inspect unit finish				✓	
Mechanical equipment system:	**Start-Up**	**Monthly**	**Quarterly**	**Annually**	**Shutdown**
Check belt condition		✓			
Adjust belt tension[3]	✓		✓		
Lubricate fan shaft bearings[4]	✓		✓		✓
Lubricate motor base adjusting screw	✓		✓		✓
Check and lubricate optional gear drive or ENDURADRIVE® Fan System	See "Fan Drive System" on **page 13** for detailed instructions and schedule.				
Check drive alignment				✓	
Check motor voltage and current	✓		✓		
Clean fan motor exterior	✓		✓		
Check fan motor for proper rotation	✓				
Check general condition of the fan	✓		✓		
Verify fan blade drain holes are not obstructed (hollow blade fans)			✓		
Check fan for uniform pitch			✓		
Check fan for rotation without obstruction	✓		✓		
Verify the fan guard is properly installed	✓			✓	
Verify the operation and function of electric immersion heater and controls, if so equipped			✓		
Check and recoat steel shafts with RUST VETO®	✓		✓		✓
Check optional vibration cutout switch	✓			✓	

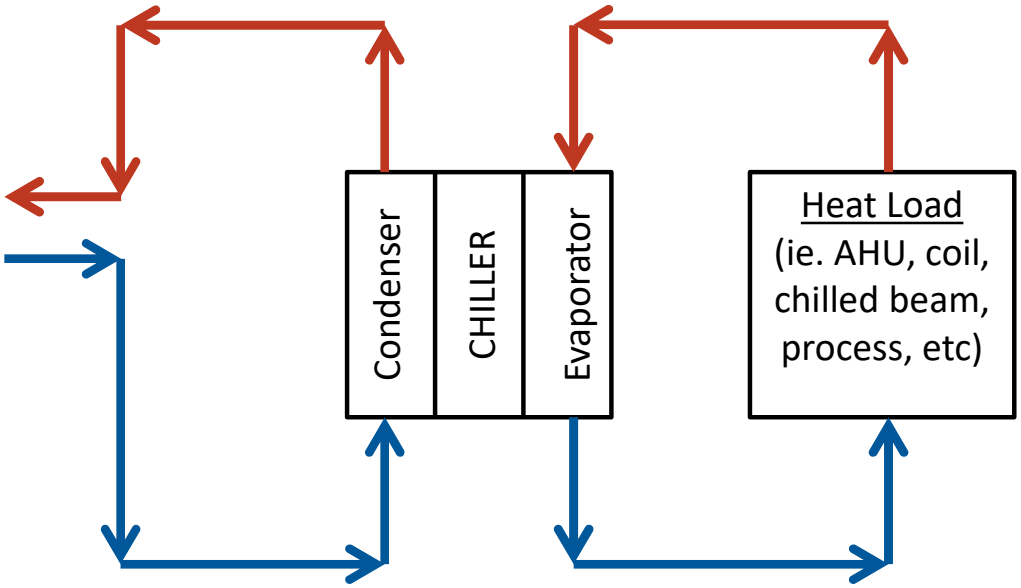
Open Cooling Towers

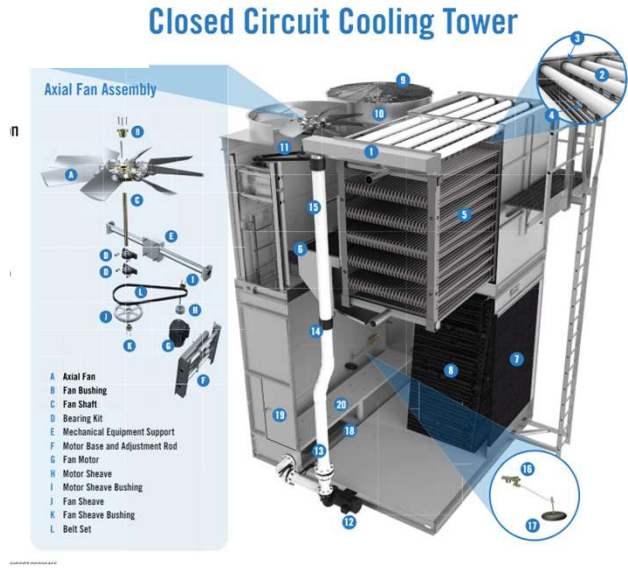


Closed Circuit Cooling Tower

Closed Circuit
Cooling Tower







Benefits of Closed Circuit Systems

- Reduced Maintenance Cost
  - ➢Equipment fouling is minimized
  - ➢Less shutdowns for cleaning
  - ➢Location flexibility a CCCT can be located at grade or below the load.
  - ➢Can cool fluids other than water (e.g. glycol).

CCCT Primary Applications

HVAC applications

- Water source heat pumps
- Water cooled VRF
- Modular Chillers
- Tower location flexibility

Process cooling applications

- Air compressors
- Welding machines
- Waste water cooling
- Machine cooling

CCCT used whenever cleanliness of the cooling loop is critical

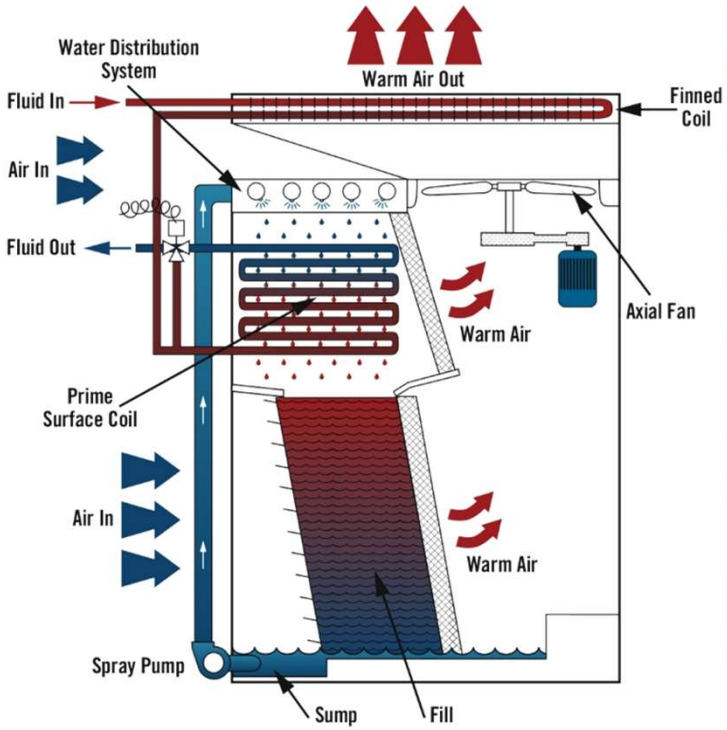
Hybrid Fluid Coolers

Hybrid = Capable of wet cooling and dry cooling simultaneously

Can operate 100% dry below a “dry switch point”

Can operate wet with the dry coil trimming the load above the “dry switch point”

Optimizes energy/water balance



Adiabatic Fluid Coolers

Benefits

Energy efficiency

Low maintenance

Low water usage

No water treatment

Combines the Benefits of Air Cooled and Evaporative

Common Codes and Standards

Industry Codes and Standards

- ASHRAE 90.1
- CTI Certified Performance
- IBC (Wind and Seismic)
- FM Global (Standard 4930)

ASHRAE 90.1 2022

Energy Standard for Buildings Except Low-Rise Residential Buildings

95°/85°/75° for Open Towers

≥ 40.2 gpm/hp for open axial towers
≥ 20.0 gpm/hp for open centrifugal fan**

102°/90°/75° for closed towers (pump hp included in HP #)
≥ 16.1 gpm/hp for axial
≥ 7.0 gpm/hp for centrifugal

**Above 1100 gpm flows @ 95/85/75 centrifugal fans must meet axial efficiencies unless they are ducted or require sound attenuation.

CTI Ratings

Wet bulb: 60-90°F

Maximum process fluid temp. 125°F

Minimum Range: 4°F

- (EWT-LWT)

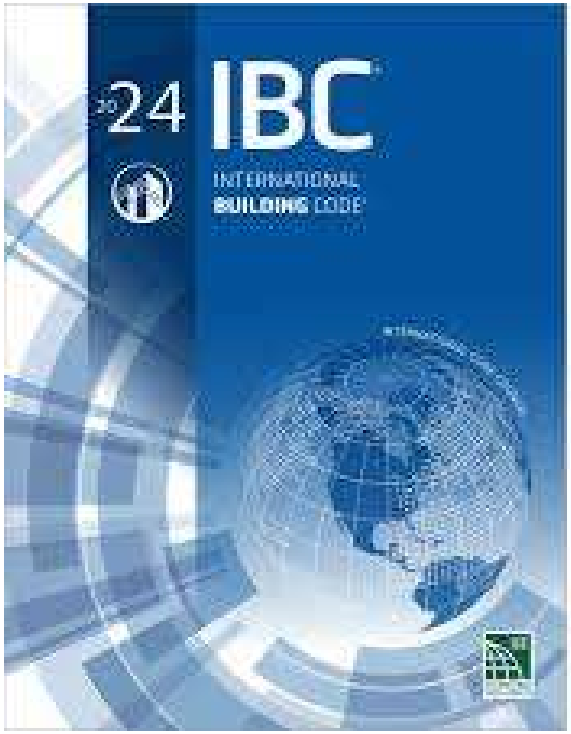
Minimum Approach: 5°F

- (LWT-WB)

Accessories may affect a product's certification

CTI Ratings for each tower line can be found on the CTI web site (CTI.org)

IBC and ASCE-7



Specify the appropriate version of the code

Shake Table Testing

Testing

- Full-size towers tested at independent test laboratories
- Testing conducted on tri-axial shake tables in accordance with AC 156 with input motions satisfying IBC
- Functional tests conducted before and after shaking for Ip = 1.5
- IP 1.5 typical of mission critical facilities e.g. hospitals

Important for manufacturers to know if IP 1.5 is required

FM Global

Global insurance company

- Standard 4930 written for single and multi-cell installations
- Influences the number of cells, materials of construction, and cell spacing
- Have equipment approval guides
- Only relevant for FM Global customers (no benefit to non customers).

This is only applicable for FM Global Customers

FM Approval for Cooling Towers

FM approved cooling towers must meet the requirements and acceptance criteria of the *Approval Standard for Cooling Towers, Class Number 4930*

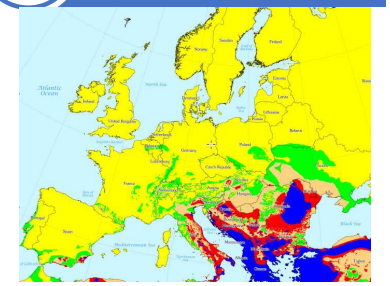
Scope of *Standard* includes fire, wind and seismic hazards

Latest Standard

1 Fire

2 Wind

3 Seismic



Fire

Combustibility:

- A tower must contain damage from a fire to the cell of origin and not spread to adjacent cells or impose a fire hazard to adjacent structures.

Post Fire Operating Capacity

- If one cell is consumed by fire, the remaining cell(s) must be able to provide extra capacity as needed.
- Effective April 2017 - 75% reserve capacity is no longer required for FM approved applications.

Wind

Zone HM

Hurricane + Missile

Hurricane-prone regions and subject to missile impact from windborne debris

Zone H

Hurricane

Hurricane-prone regions but not subject to missile impact from windborne debris

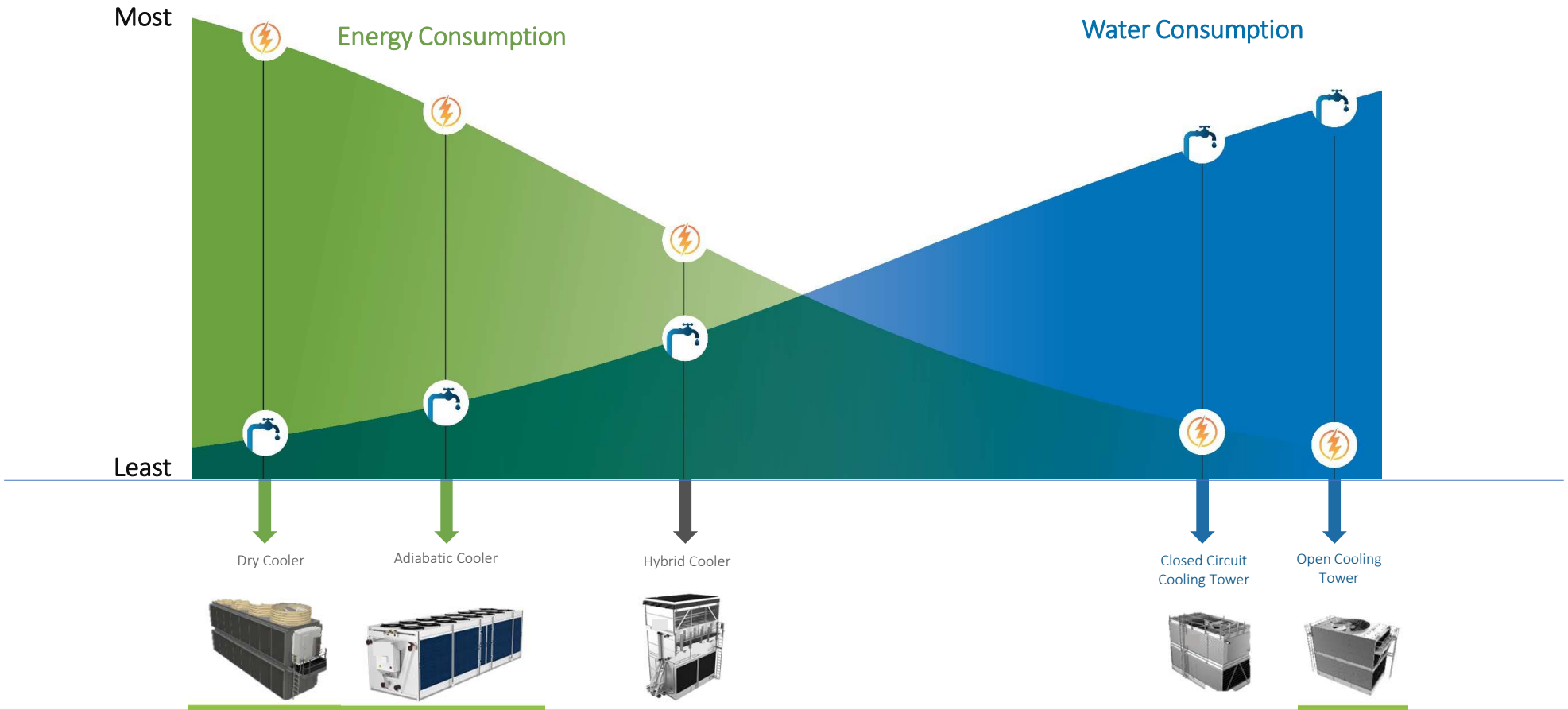
Zone NH

Non Hurricane

No hurricanes or missile impact from windborne debris

Energy efficiency and water usage

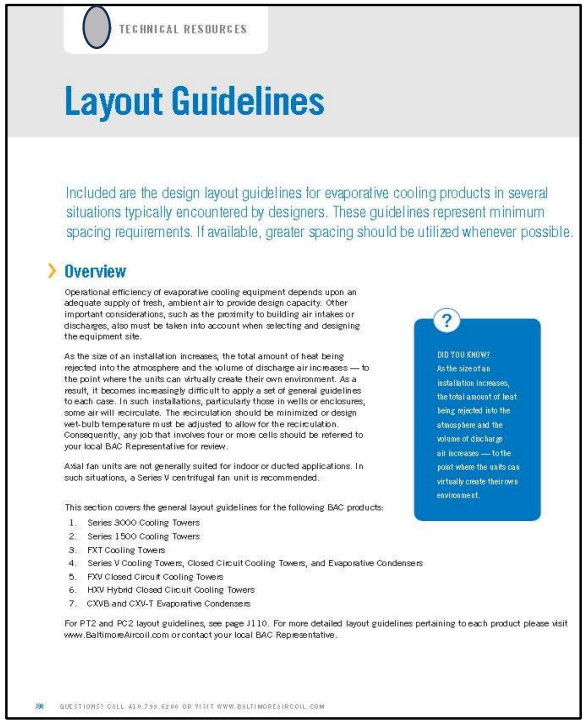
Fluid Cooling - Equipment Options



Layout

Fresh Air Intake: Recommendations

- Provide adequate intake space to insure proper intake velocities
  - Air envelope velocity< 400 fpm
  - Well downward air velocity < 400 fpm
- Discharge air at or above surrounding walls or enclosures
- Place unit 3’ away from louvers
- Size air intake louvers for < 600 fpm and 50% FA
- Consider prevailing summer winds
- Elevating towers on steel provides more intake area
- Consider undercutting walls as an alternative to full louvers
- Uptime: Need to shutdown middle cells



TECHNICAL RESOURCES

Layout Guidelines

Included are the design layout guidelines for evaporative cooling products in several situations typically encountered by designers. These guidelines represent minimum spacing requirements. If available, greater spacing should be utilized whenever possible.

Overview

Operational efficiency of evaporative cooling equipment depends upon an adequate supply of fresh, ambient air to provide design capacity. Other important considerations, such as the proximity to building air intakes or discharges, also must be taken into account when selecting and designing the equipment site.

As the size of an installation increases, the total amount of heat being rejected into the atmosphere and the volume of discharge air increases — to the point where the units can virtually create their own environment. As a result, it becomes increasingly difficult to apply a set of general guidelines to each case. In such installations, particularly those in walls or enclosures, some air will recirculate. The recirculation should be minimized or design wet-bulb temperature must be adjusted to allow for the recirculation. Consequently, any job that involves four or more cells should be referred to your local BAC Representative for review.

Axial fan units are not generally suited for indoor or ducted applications. In such situations, a Series V centrifugal fan unit is recommended.

DID YOU KNOW?
As the size of an installation increases, the total amount of heat being rejected into the atmosphere and the volume of discharge air increases — to the point where the units can virtually create their own environment.

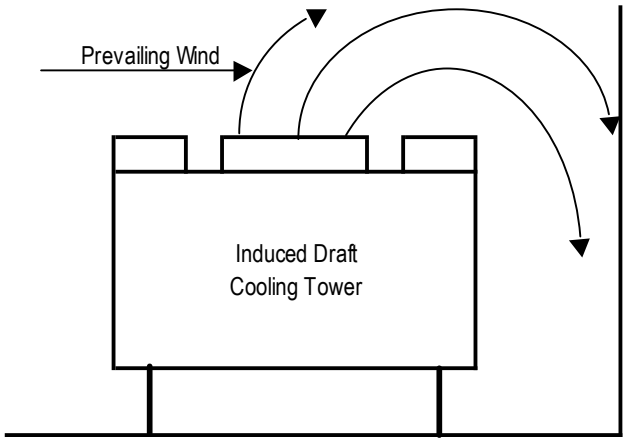
This section covers the general layout guidelines for the following BAC products:

1. Series 3000 Cooling Towers
2. Series 1500 Cooling Towers
3. FXT Cooling Towers
4. Series V Cooling Towers, Closed Circuit Cooling Towers, and Evaporative Condensers
5. FXV Closed Circuit Cooling Towers
6. HXV Hybrid Closed Circuit Cooling Towers
7. CXVB and CXV-T Evaporative Condensers

For PT2 and PC2 layout guidelines, see page J110. For more detailed layout guidelines pertaining to each product please visit www.BaltimoreAircoil.com or contact your local BAC Representative.

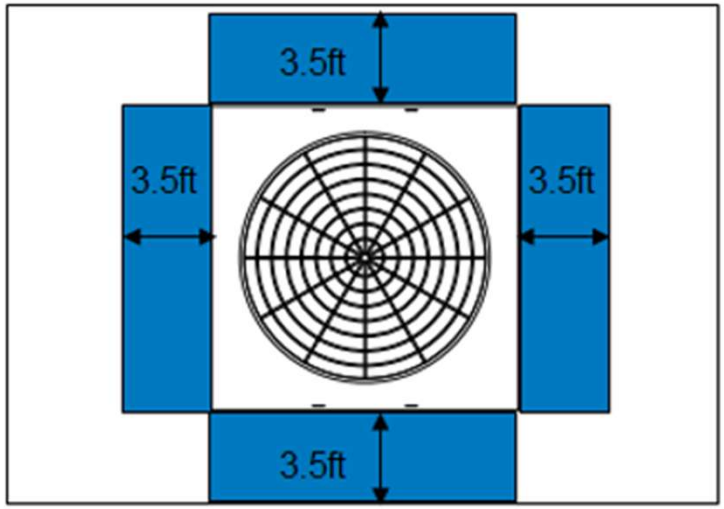
QUESTIONS? CALL 410.799.6200 OR VISIT WWW.BALTIMOREAIRCOIL.COM

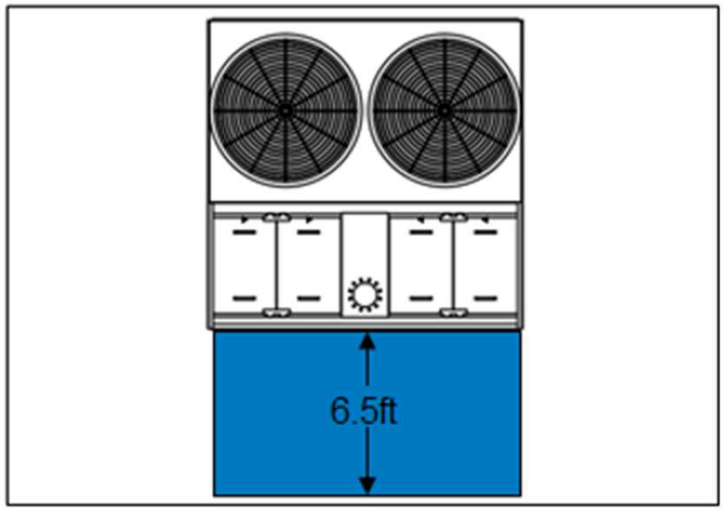
Recirculation Example



Ensure fan discharge is at or above the height of adjacent walls

Layout Comparison 20HP Max, 20’x28’ Well





Abide by the manufacturer’s air intake requirements

Multicell Layout Best Practices

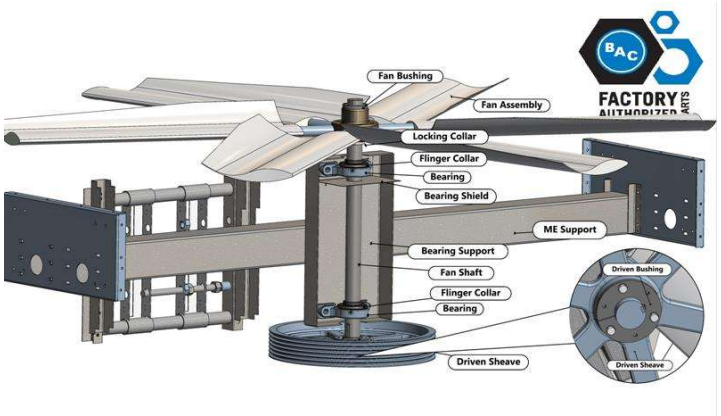
Breaks in the lines of cells allow for greater uptime

Drive Types and Materials

Drive Types

Belt Drive

- Lowest first cost
- Easy to stock and replace
- Excellent for winter operation



Gear Drive

- More typical at higher HP
- Accessories often required

Direct Drive

- Premium first cost
- Eliminates majority of maintenance

Water Quality

Property of Water	Recommended Levels for Various Materials of Construction			
	Galvanized Steel	Thermosetting Hybrid Polymer	Type 304 Stainless Steel	TriArmor® Corrosion Protection System or Type 316 Stainless Steel
pH	6.5 to 9.0[1]	6.5 to 9.2[1]	6.5 to 9.2 [1]	6.5 to 9.5[1]
Total Suspended Solids	25 ppm	25 ppm	25 ppm	25 ppm
Total Dissolved Solids (TDS)	1,500 ppm	2,050 ppm	2,050 ppm	2,500 ppm
Conductivity	2,400 (microohms/cm)	3,300 (microohms/cm)	3,300 (microohms/cm)	4,000 (microohms/cm)
Alkalinity as $CaCO_3$	500 ppm[2]	600 ppm[2]	600 ppm[2]	600 ppm[2]
Calcium Hardness as $CaCO_3$	50 to 600 ppm[2]	50 to 750 ppm[2]	50 to 750 ppm[2]	50 to 750 ppm[2]
Chlorides (CL)	250 ppm	300 ppm	300 ppm	750 ppm
Sulfates	250 ppm	350 ppm	350 ppm	750 ppm
Silica	150 ppm	150 ppm	150 ppm	150 ppm

Table 1. Quality Guidelines for Treated Circulating Water

MOC choice has significant impact on the lifespan of the equipment

Passivation

- Performed at startup by the water treatment company
- 4-8 weeks in duration, ideally no heat load
- If missed or done improperly white rust forms

Galvanized steel in the wetted area requires passivation

Sound

Sound Ratings

- Per CTI ATC-128 revision 2019
- Specify sound ratings in dB from each face (5 and 50ft typical)
- Be mindful of cell count.

Project Name:
Selection Name:
Project State/Province:
Project Country/Region: United States
Date: September 07, 2023

Model Information
Product Line: Series 1500
Model: XES15E-1212-10JN
Number of Units: 1
Fan Type: Standard Fan
Fan Motor: (2) 7.50 = 15.00 HP/Unit
Total Standard Fan Power: Full Speed, 15.00 BHP/Unit

Intake Option: None
Internal Option: None
Discharge Option: None

Octave band and A-weighted sound pressure levels (Lp) are expressed in decibels (dB) reference 0.0002 microbar. Sound power levels (Lw) are expressed in decibels (dB) reference one picowatt. Octave band 1 has a center frequency of 63 Hertz.

Top
Sound Pressure (dB)

Octave Band	Distance 5 ft.	Distance 50 ft.
1	76	64
2	81	68
3	80	67
4	81	67
5	76	63
6	71	58
7	66	52
8	59	45
A-wgtd	**81**	**68**

Back
Sound Pressure (dB)

Octave Band	Distance 5 ft.	Distance 50 ft.
1	67	64
2	74	65
3	69	62
4	67	62
5	60	56
6	48	48
7	41	40
8	36	34
A-wgtd	**67**	**62**

End
Sound Pressure (dB)

Octave Band	Distance 5 ft.	Distance 50 ft.
1	69	63
2	74	64
3	69	61
4	67	61
5	59	55
6	51	47
7	44	40
8	36	33
A-wgtd	**67**	**61**

End
Sound Pressure (dB)

Octave Band	Distance 5 ft.	Distance 50 ft.
1	69	63
2	74	64
3	69	61
4	67	61
5	59	55
6	51	47
7	44	40
8	36	33
A-wgtd	**67**	**61**

Air Inlet
Sound Pressure (dB)

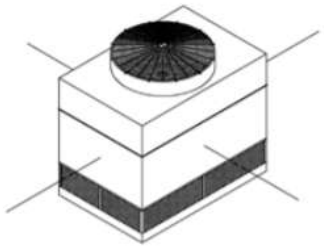
Octave Band	Distance 5 ft.	Distance 50 ft.
1	75	66
2	82	70
3	81	65
4	80	68
5	73	61
6	66	55
7	58	48
8	52	37
A-wgtd	**80**	**67**

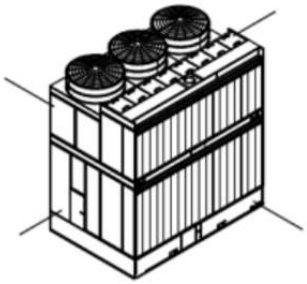
Total Sound Power (dB)

Octave Band	Center Frequency (Hertz)	Lw
1	63	97
2	125	100
3	250	99
4	500	99
5	1000	95
6	2000	90
7	4000	84
8	8000	77
A-wgtd		**100**

Sound Levels at 5ft, 500 Ton Example

	Counterflow		Crossflow	
Standard Fan	85dB	85dB	85dB	85dB
Lowest Sound Fan Option	75dB	75dB	75dB	75dB
Lowest Sound Fan & Water Silencers	81dB	81dB	71dB	70dB
	78dB	76dB	62dB	62dB
	72dB	71dB	60dB	59dB
Lowest Sound Fan & Attenuation	81dB	81dB	70dB	83dB
	76dB	77dB	62dB	74dB
	71dB	72dB	59dB	67dB





Account for sound directionality when specifying equipment

Conclusions

Many factors impact cooling tower selection!

- Capacity
- Open vs Closed
- Footprint and height
- Indoors vs Outdoors
- Energy efficiency vs water usage
- Ease of maintenance
- Material selection
- Code Compliance
- Layout
- Sound

Questions