Chilled Water Plants; Basic Principles, Ongoing Commissioning/Operation, and Optimization

Cooling Tower Optimization

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New System Diagraming Resources

Hot off the presses:

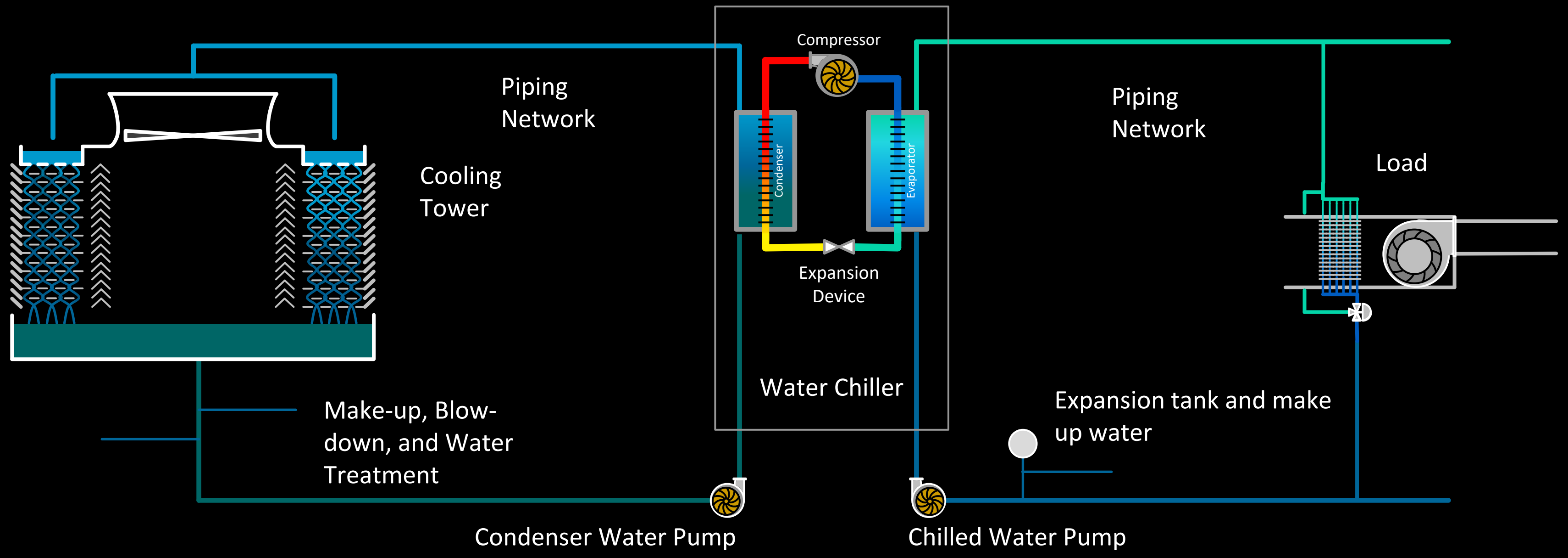
- Introduction to System Diagrams – Part 1
  tinyurl.com/SystemDiagramIntroPart1
  https://www.screencast.com/t/dG8Gf2VrYB8n
- Introduction to System Diagrams – Part 2
  https://www.screencast.com/t/dSpXAM7W9E
  tinyurl.com/SystemDiagramIntroPart2

New System Diagraming Resources

Hot off the presses:

- Hijend Distribution Loop – Part 1
  https://tinyurl.com/HijenDistributionLoopPart1
  https://www.screencast.com/t/bQK628Jqn
- Hijend Distribution Loop – Part 2
  https://tinyurl.com/HijendDistributionLoopPart2
  https://www.screencast.com/t/imBXcBdyc
- Coming soon!
  Hijend Distribution Loop Part 3 and Part 4

Central Plants Typically Have Open and Closed Systems Associated with Them

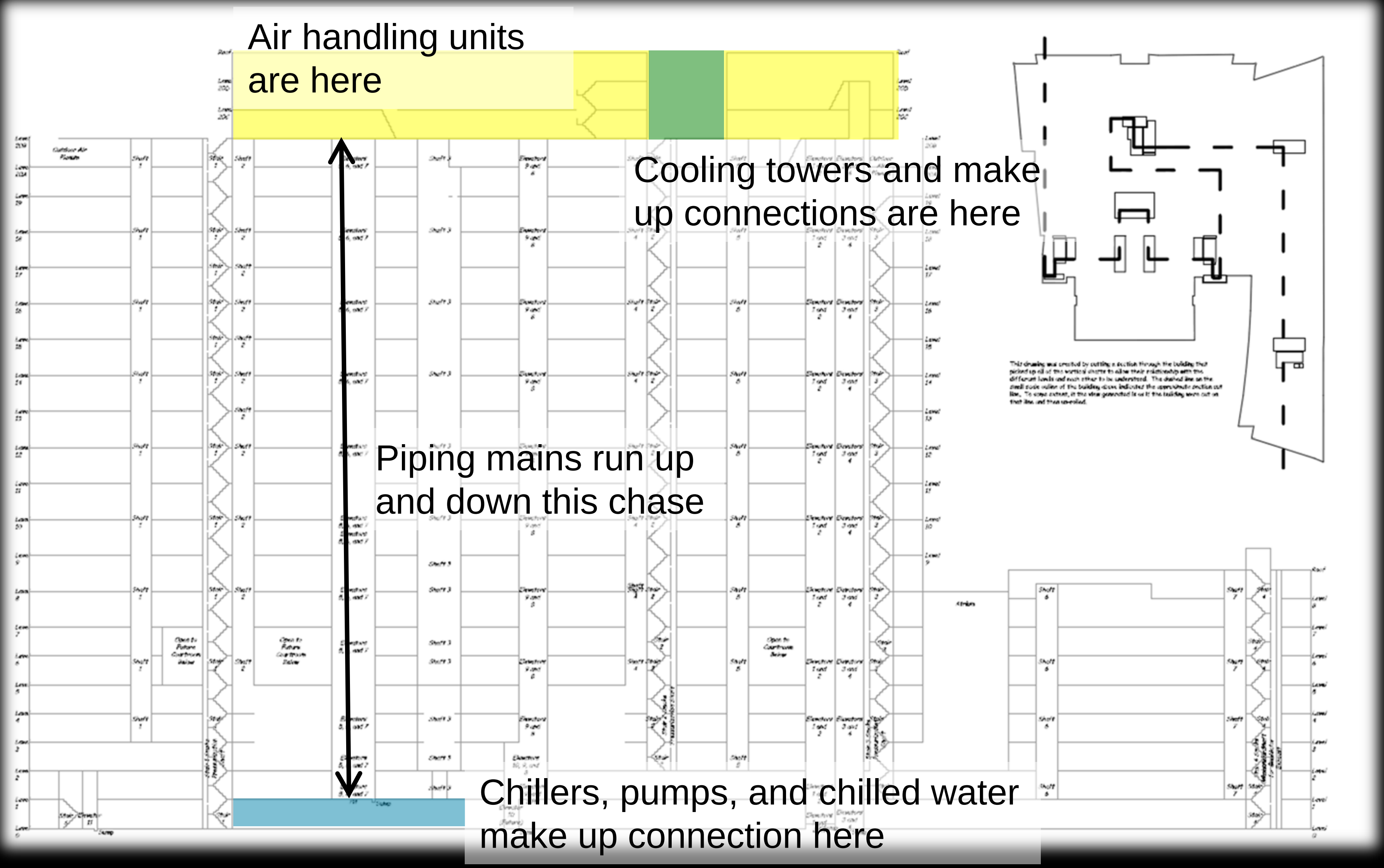


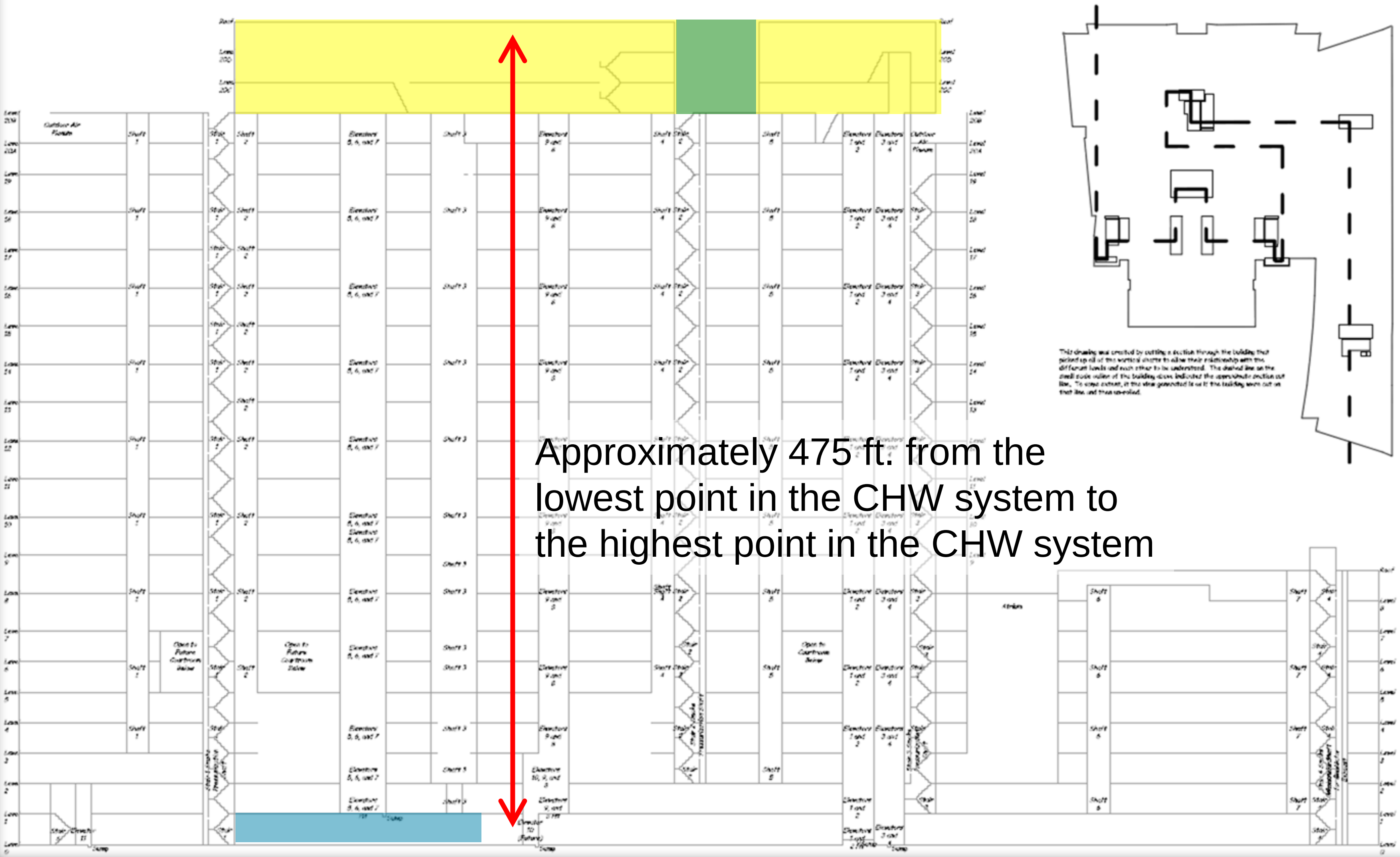
Typically an open system

More than one interface with the atmosphere or a compressible gas

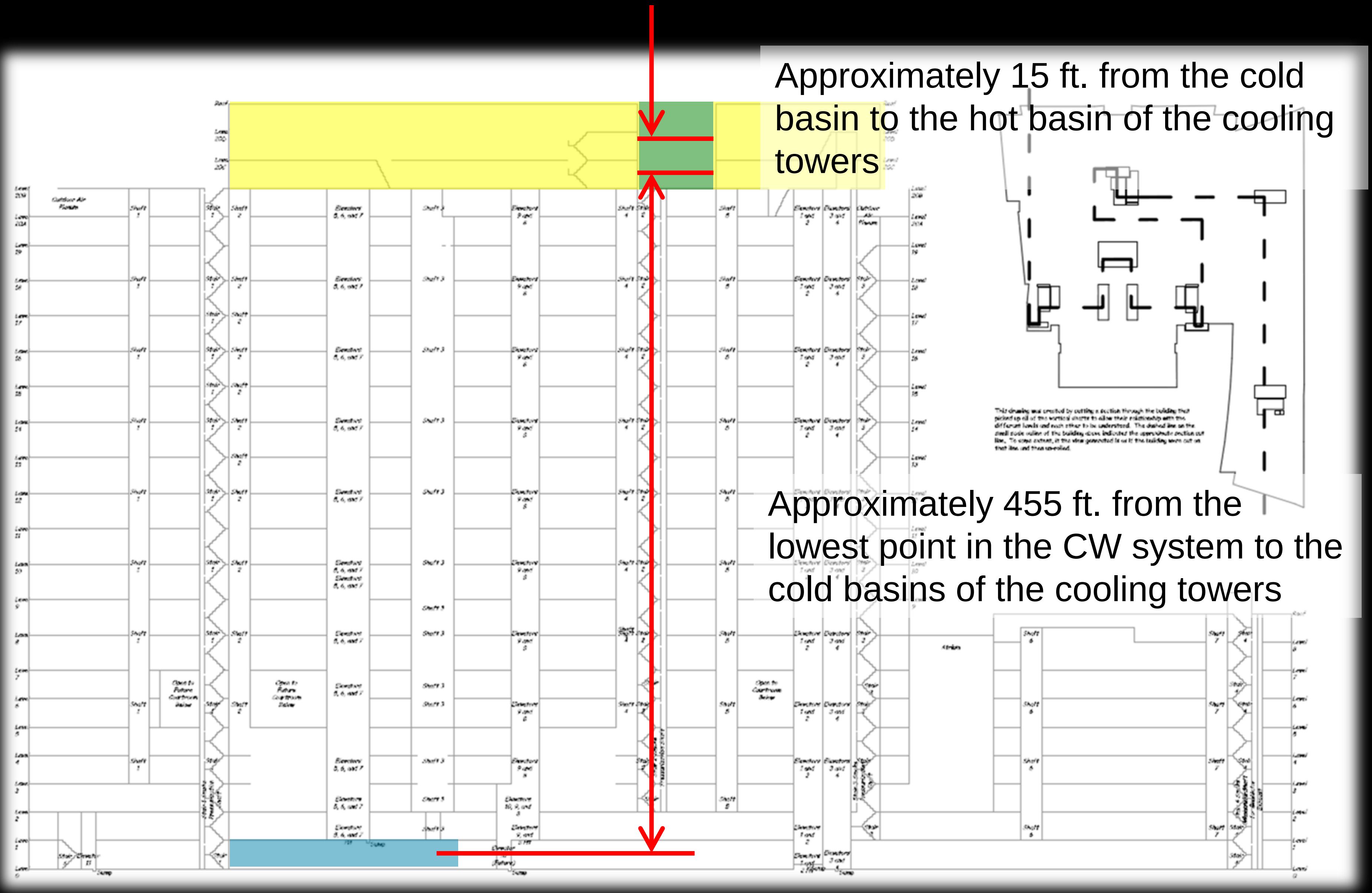
Typically a closed system

Only one interface with atmosphere or a compressible gas


Air handling units are here
Cooling towers and make up connections are here
Piping mains run up and down this chase
Chillers, pumps, and chilled water make up connection here

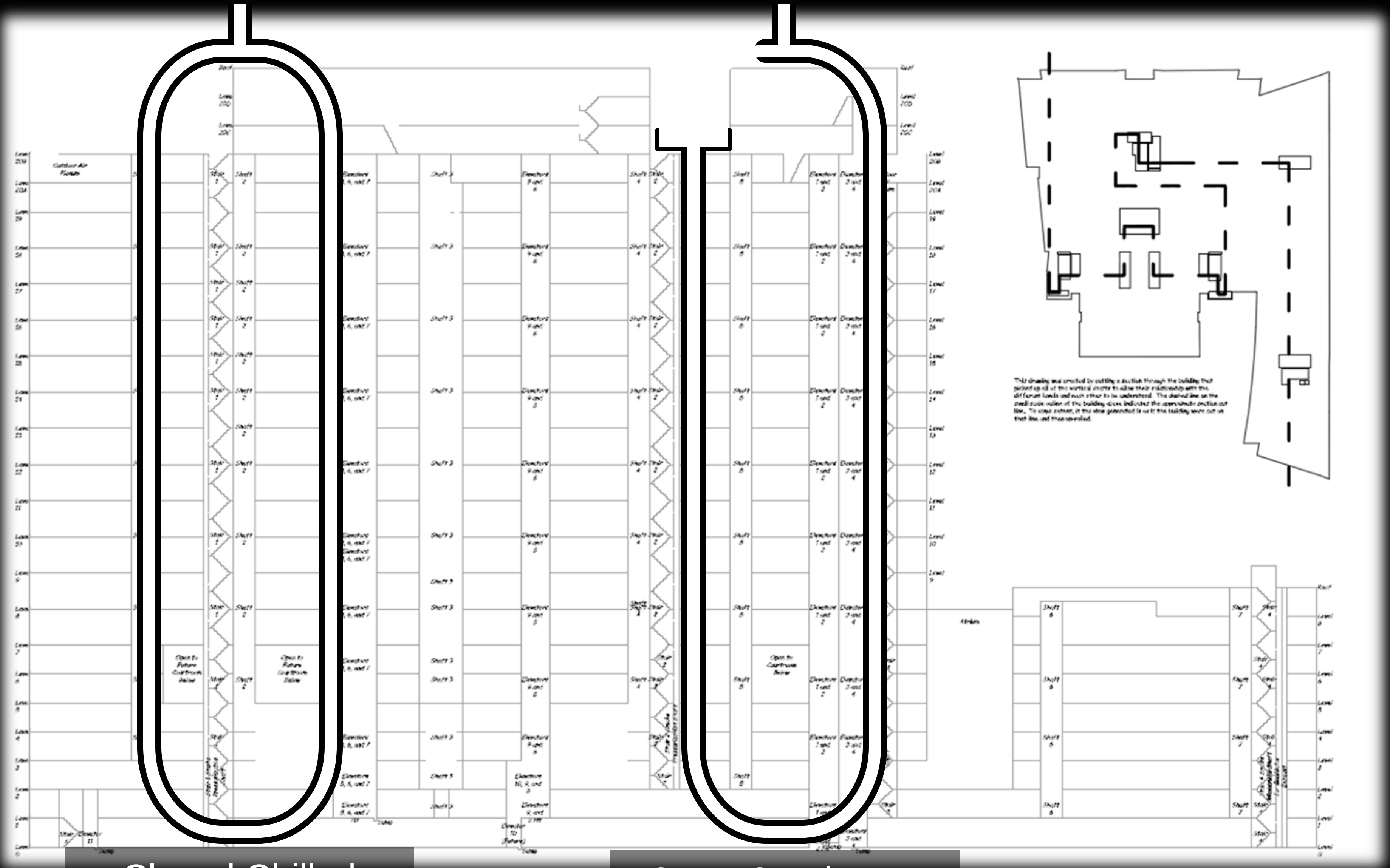


Approximately 475 ft. from the lowest point in the CHW system to the highest point in the CHW system



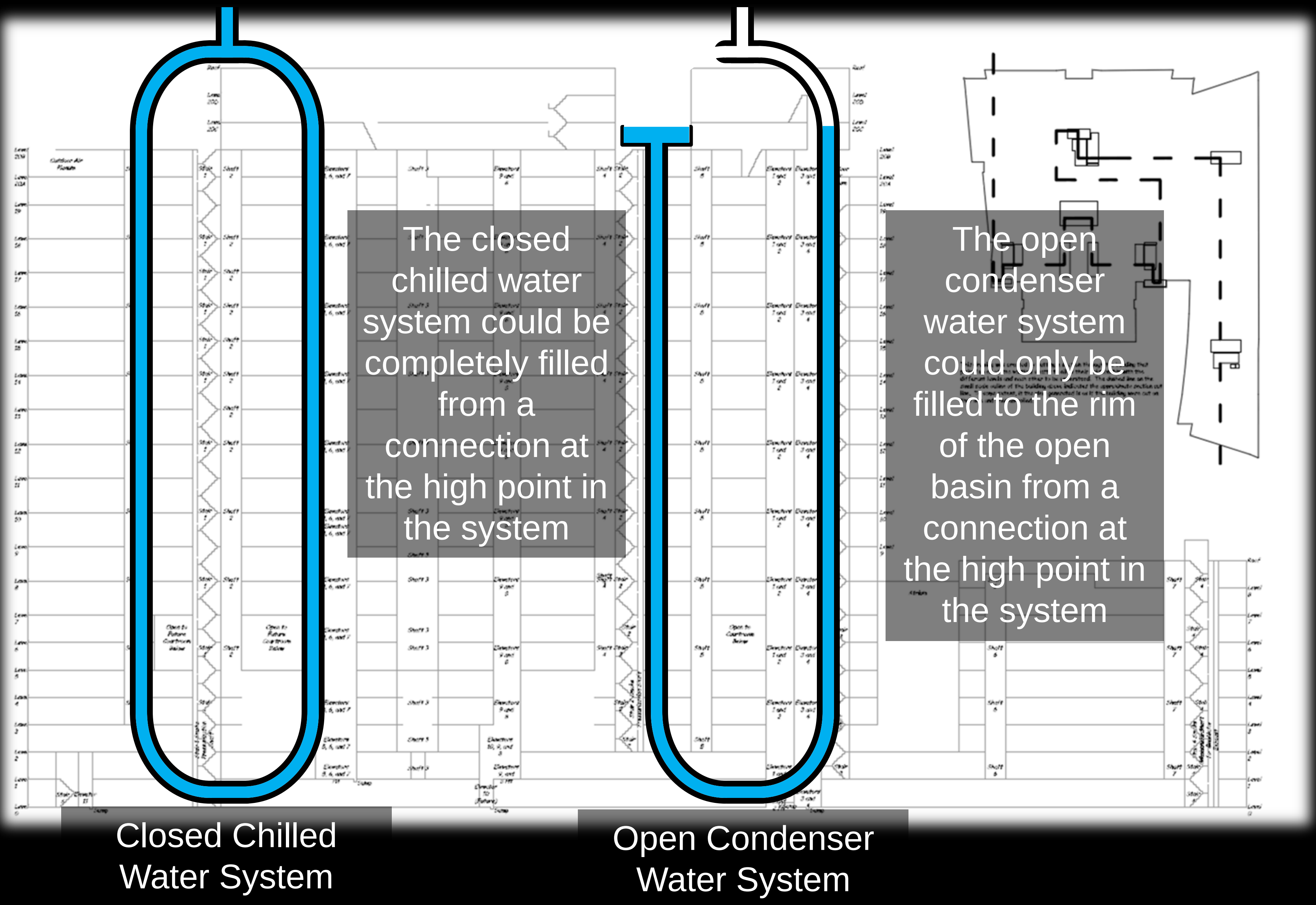
Approximately 15 ft. from the cold basin to the hot basin of the cooling towers

Approximately 455 ft. from the lowest point in the CW system to the cold basins of the cooling towers



Closed Chilled Water System

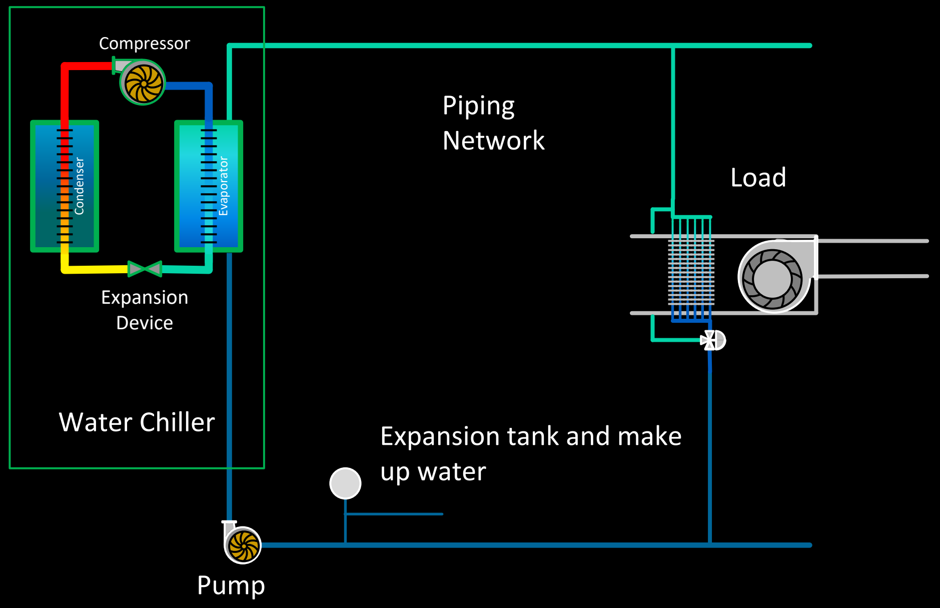
Open Condenser Water System



The closed chilled water system could be completely filled from a connection at the high point in the system
The open condenser water system could only be filled to the rim of the open basin from a connection at the high point in the system
Closed Chilled Water System
Open Condenser Water System

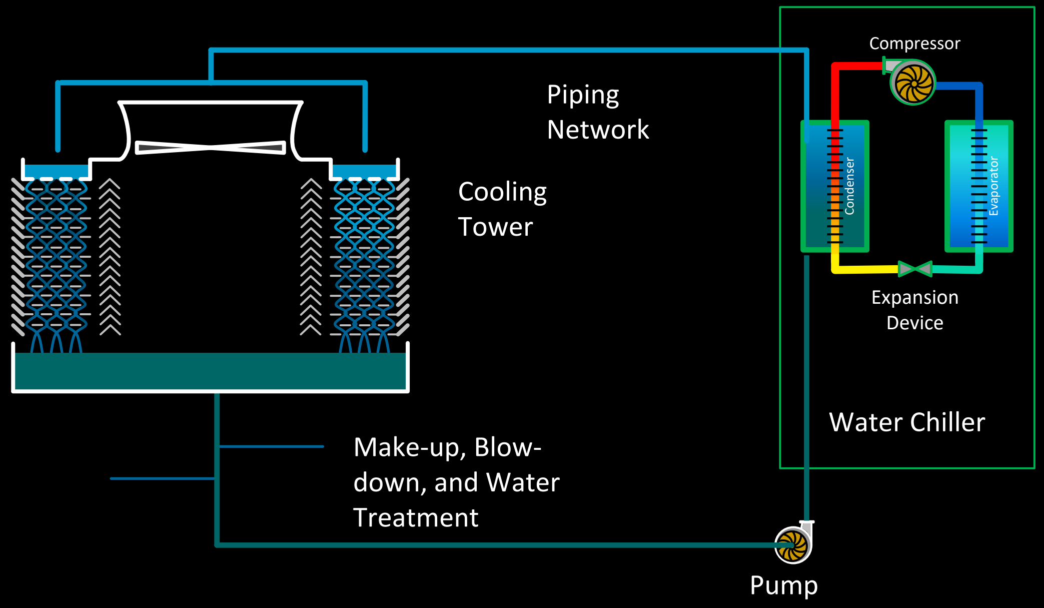
Closed Systems

- Interface is at the expansion tank
  - Open or diaphragm type
    - Different sizing issues
    - Different piping issues
- Pressure tends to hold constant at the expansion tank
- Expansion tank typically at the distribution pump suction connection
- Air separation may or may not be at the expansion tank
- Fill pressure needs to be sufficient to vent air at high points



- Make up typically connected at the expansion tank
  - Very little required once filled
  - Limited water treatment
  - Monitor volume and pressure

Open Systems



- Water treatment requirements more significant
- Chilled and hot water systems can be open systems

- Interfaces are at the cooling tower return and supply points
  - Cold water typically connected to a sump or cold basin
  - Hot water distributed by spray nozzles or orifices in a “hot basin”
- Pump head must lift the water between the basins
- Make-up requirements more significant
  - Evaporation
  - Blow-down

Water Treatment

Side Stream Filtration

Cooling Tower Make-up Piping and Meter

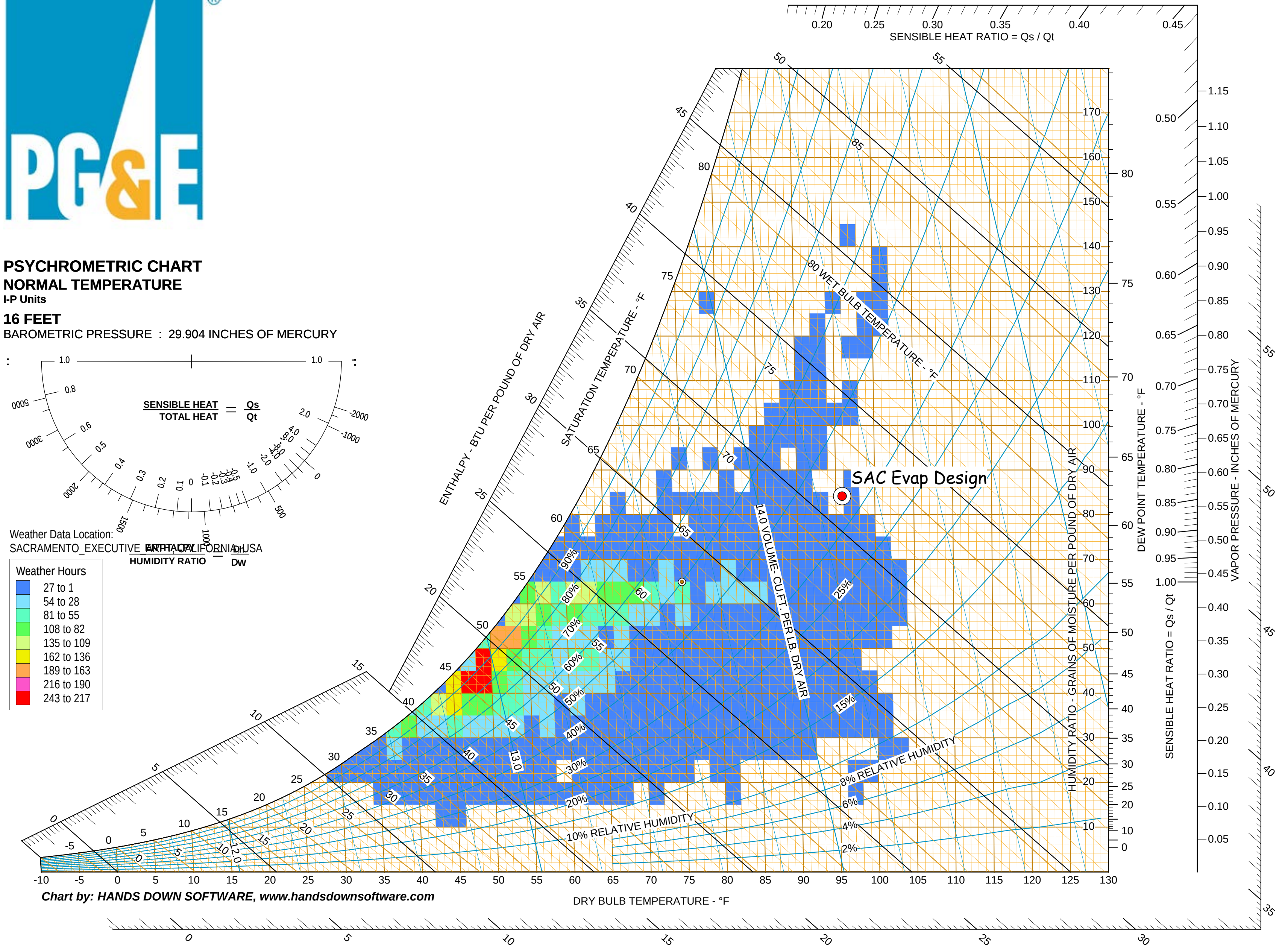
Cooling Tower Blow-down Piping and Meter

Inside the Tower

Inside the Tower

Inside the Tower

Cooling Tower Design Point vs. Performance Window – Sacramento, CA



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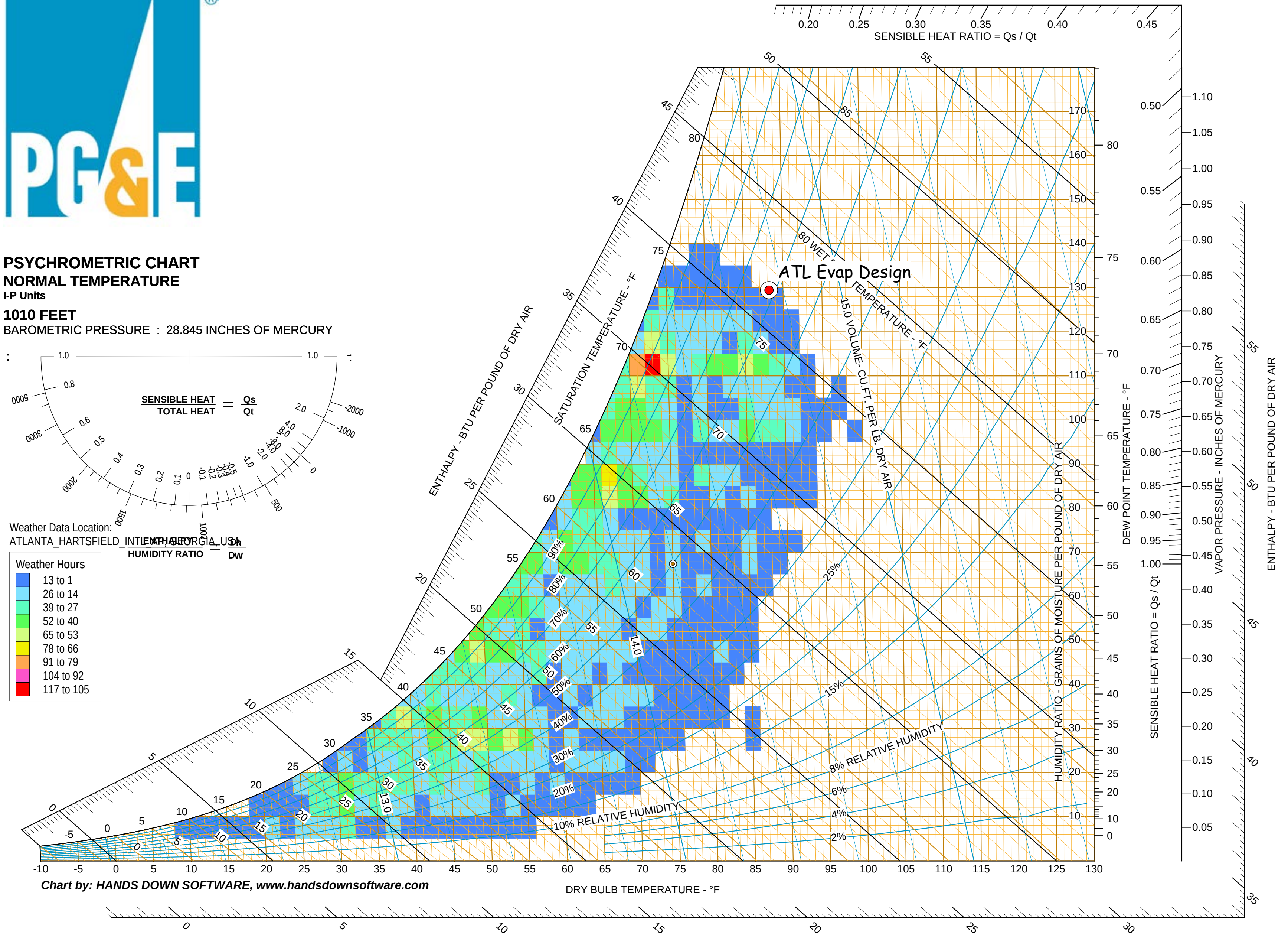
Cooling Tower Design Point vs. Performance Window – Atlanta, GA



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Volumetric Flow Meter

Volumetric Flow Meter

Costs

Item	Min	Max	
Leakage rate -	1	2	oz per second
Conversion factor -	0.0078	0.0078	Gallons per ounce
Leakage rate -	0.0078125	0.015625	Gallons per second
Leakage rate -	0.4687	0.9375	Gallons per minute
Leakage rate -	28	56	Gallons per hour
Leakage rate -	20,531	41,062	Gallons per month
Leakage rate -	246,375	492,750	Gallons per year
Water cost -	$0.0028	$0.0028	$/gallon
Sewer charges -	$0.0048	$0.0048	$/gallon
Water and sewer costs -	$0.0076	$0.0076	$/gallon
Monthly cost -	$156	$312	
Annual cost -	$1,870	$3,740	

1-1/2 Float Valve -	$67	

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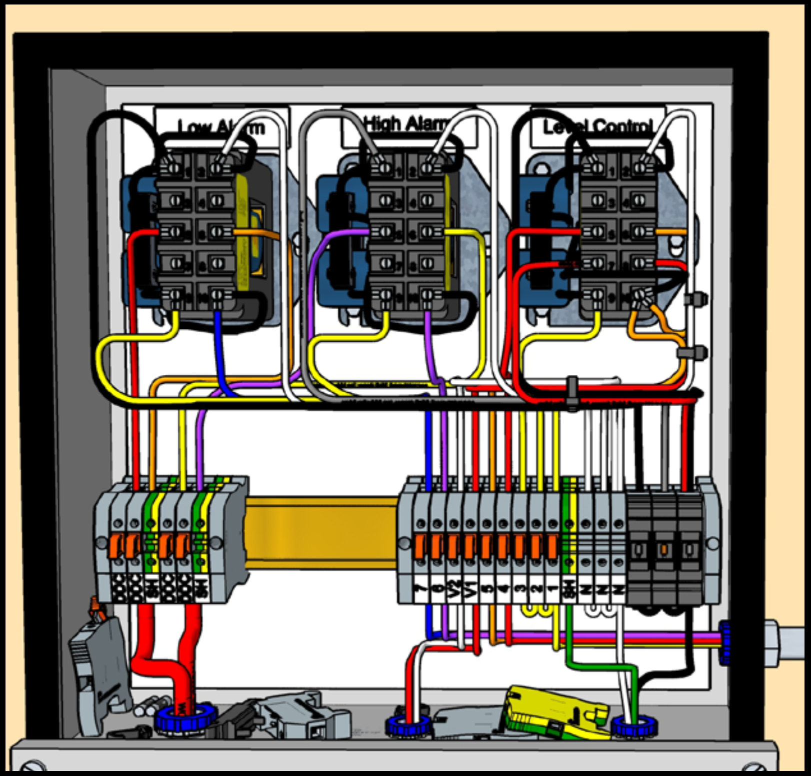
Monthly cost -	$156	$312	
Annual cost -	$1,870	$3,740	
Simple Payback - Materials -	0.87	0.44	years
Simple Payback - Materials plus Installation -	3.05	1.53	years

Level Relay -	$400	
Electrode Holder -	$320	
Electrodes -	$310	
Ball valve with actuator -	$350	
Misc. Materials -	$250	
Materials Total -	$1,630	
Installation -	$4,075	
Total -	$5,705	
1-1/2 Float Valve -	$67	



Resources

Commissioning on Campus

http://www.av8rdas.com/magazine-articles.html#CoolingTowerPipe

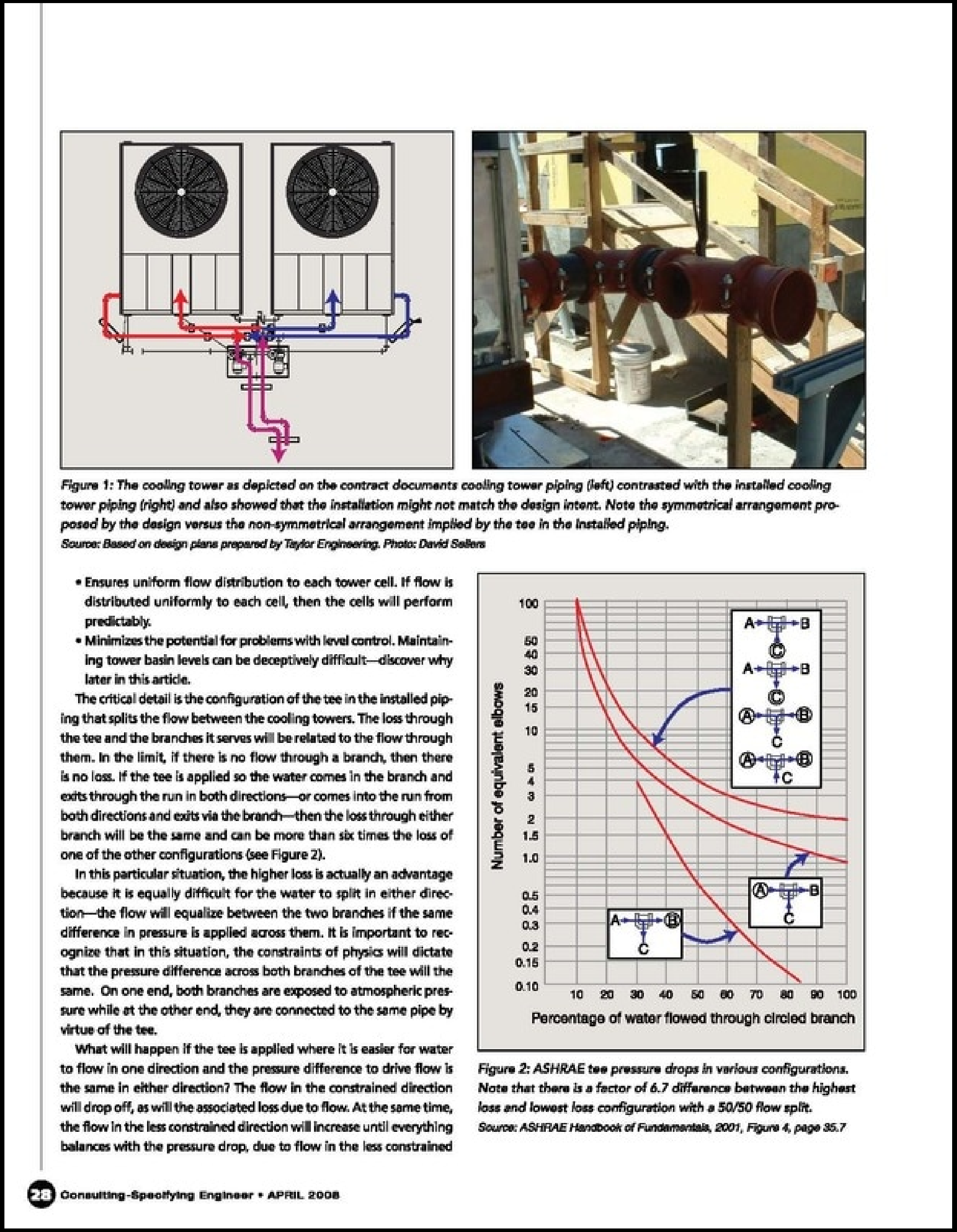


Figure 1: The cooling tower as depicted on the contract documents cooling tower piping (left) contrasted with the installed cooling tower piping (right) and also showed that the installation might not match the design intent. Note the symmetrical arrangement proposed by the design versus the non-symmetrical arrangement implied by the tee in the installed piping.

Source: Based on design plans prepared by Taylor Engineering. Photo: David Sellers

- Ensures uniform flow distribution to each tower cell. If flow is distributed uniformly to each cell, then the cells will perform predictably.
- Minimizes the potential for problems with level control. Maintaining tower basin levels can be deceptively difficult—discover why later in this article.

The critical detail is the configuration of the tee in the installed piping that splits the flow between the cooling towers. The loss through the tee and the branches it serves will be related to the flow through them. In the limit, if there is no flow through a branch, then there is no loss. If the tee is applied so the water comes in the branch and exits through the run in both directions—or comes into the run from both directions and exits via the branch—then the loss through either branch will be the same and can be more than six times the loss of one of the other configurations (see Figure 2).

In this particular situation, the higher loss is actually an advantage because it is equally difficult for the water to split in either direction—the flow will equalize between the two branches if the same difference in pressure is applied across them. It is important to recognize that in this situation, the constraints of physics will dictate that the pressure difference across both branches of the tee will the same. On one end, both branches are exposed to atmospheric pressure while at the other end, they are connected to the same pipe by virtue of the tee.

What will happen if the tee is applied where it is easier for water to flow in one direction and the pressure difference to drive flow is the same in either direction? The flow in the constrained direction will drop off, as will the associated loss due to flow. At the same time, the flow in the less constrained direction will increase until everything balances with the pressure drop, due to flow in the less constrained

Figure 2: ASHRAE tee pressure drops in various configurations. Note that there is a factor of 6.7 difference between the highest loss and lowest loss configuration with a 50/50 flow split.

Source: ASHRAE Handbook of Fundamentals, 2001, Figure 4, page 35.7

This Can Get Really Complicated