


# Cooling Distribution

APPA Institute for  
Facilities Management  
Ft. Worth, TX  
January 11, 2023



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**Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.**

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## Today's Presentation


**Course Description:**  
This course explores:

This course will explore the various equipment components and methods that comprise the cooling distribution system, as it applies to both a building and campus-wide district cooling. We will discuss what they do, how they work, and the challenges that go with operations of this equipment.

**Learning Objectives:**

1. Become familiar with various chilled water systems and components
2. Understand how various distribution mechanisms and equipment move cooling from production to consumption
3. Understand how the various components of cooling equipment can be integrated into different types of systems
4. Understand how different distribution concepts can improve or degrade system efficiency

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## Purpose of Today's Presentation

- To provide a broad understanding of chilled water distribution systems and components
- Explore in some detail various distribution system configurations
- Provide some useful observations and solutions

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## Agenda

- System Concepts
  - Definitions
  - Basic Formulae
    - $\Delta T$
  - Hydraulic Profile
- System Components
- System Configurations

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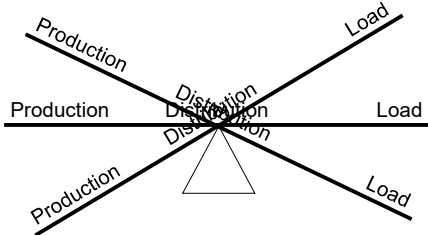
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## WORDS OF WISDOM

It's not how much you've got; it's whether you can use it.



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## Definitions

- System (Static/Fill) Pressure: The non-flowing pressure to which the system must be filled to assure flooding of the highest device.
  - System pressure is usually set so that there is at least 5 psig measured at the highest device in the system.
- Dynamic Pressure:
  - The flowing pressure the system pumps must develop to overcome the friction due to piping, coils, valves, fittings, and other devices in the system at a given flow rate.
  - Head loss, measured in feet of head = 2.31 ft. W.C./psi (.434 psi/ft)
- Design Pressure
  - The dynamic pressure the system pumps must develop at the *maximum* flow in the system.
  - The *differential* pressure between the supply and return piping at the pump, i.e. the **total head**

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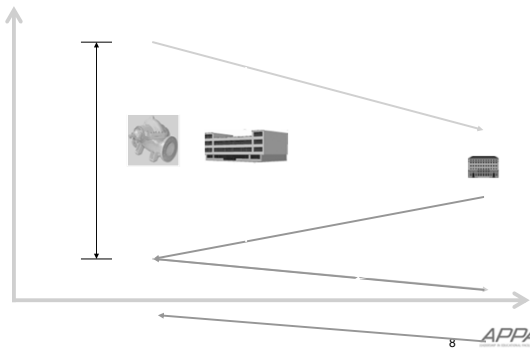
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## System Hydraulic Profile



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## Basic Formulae

The heating and cooling capacity of water when it flows through a coil

$$Q_{\text{tons}} = \frac{GPM \times \Delta T}{24}$$

12,000 BTU / 1011-111

$\Delta T$  = temperature difference between supply and return

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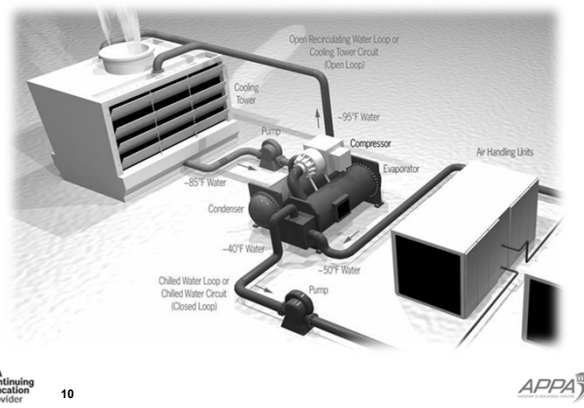
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## Chilled Water System Components



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## Chilled Water System Components and Interactions

- Pumps/ Piping
  - Parallel Pumping
  - Series Pumping
  - Variable Speed Pumping
- Effect of  $\Delta T$  on Pump Energy
- Effect of  $\Delta T$  on Pump Flow
- Effect of  $\Delta T$  on Dynamic Pressure

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## Pumps

- Driving force to move water in piping
- Provide pressure and flow
- Primary type
  - Centrifugal

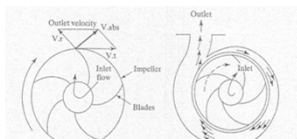
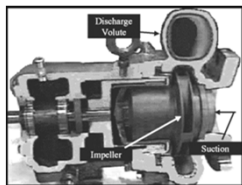


Figure 19.4 Impeller and volute interaction. [Reprinted by permission from ASHRAE Systems and Equipment 1995 (IP & SI), p. 38.2.]



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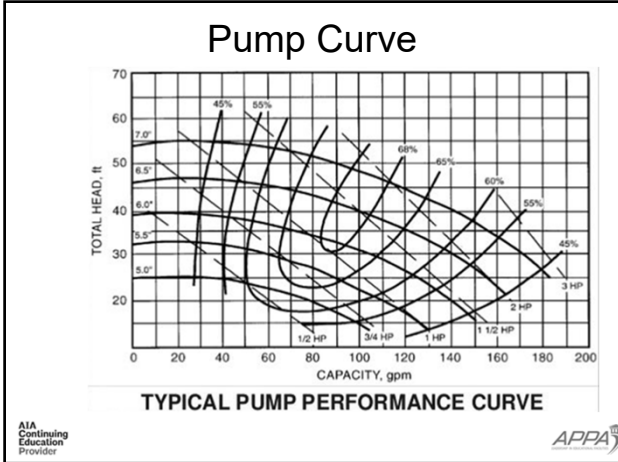
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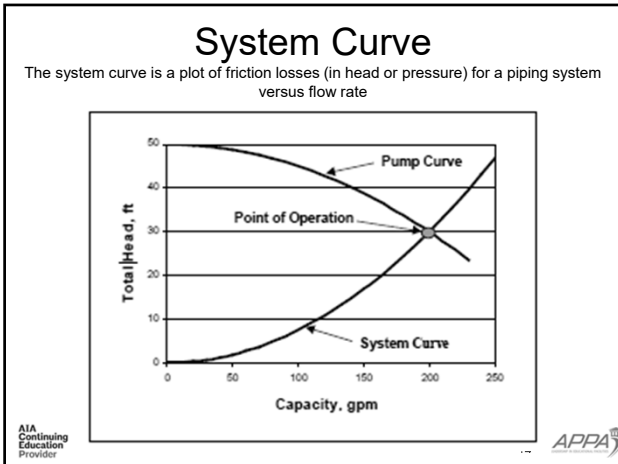
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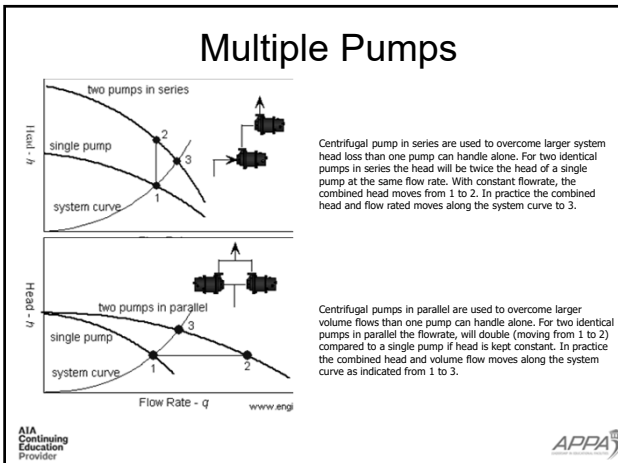
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## Varying Pump Speed

$$Q_{\text{pump}} = \frac{GPM \times \Delta T}{24}$$

### Affinity Laws:

**If speed is decreased by 10%,  
Law 1: Flow is Proportional to Shaft Speed.**

Flow is decreased by 10%

**Law 2: Pressure is Proportional to the Square of Shaft Speed.**

Pressure is decreased by ~18% ( $1 - .90^2$ )

**Law 3: Power is Proportional to the Cube of Shaft Speed.**

Power is decreased by ~27% ( $1 - .90^3$ )

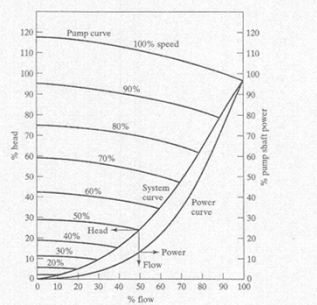


Figure 19.7 Pumping power, head, and flow vs. pump speed. [Reprinted by permission from ASHRAE Fundamentals 1993 (IP & SI), p. 38.7.]

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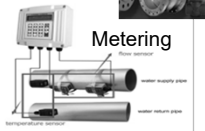
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## Piping System



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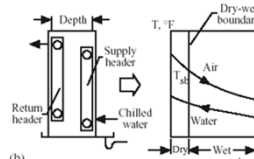
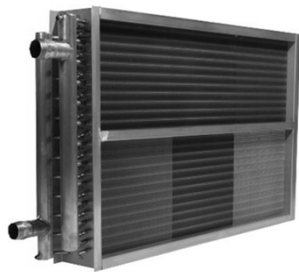
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## Chilled Water Coils



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## Chilled Water System $\Delta T$

- Effect of  $\Delta T$  on Pump Energy
- Effect of  $\Delta T$  on Pump Flow
- Effect of  $\Delta T$  on Dynamic Pressure

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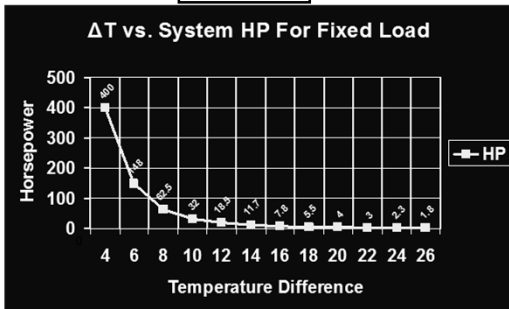
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## Delta T vs. Req'd System HP

$$Q_{\text{tons}} = \frac{\text{GPM} \times \Delta T}{24}$$



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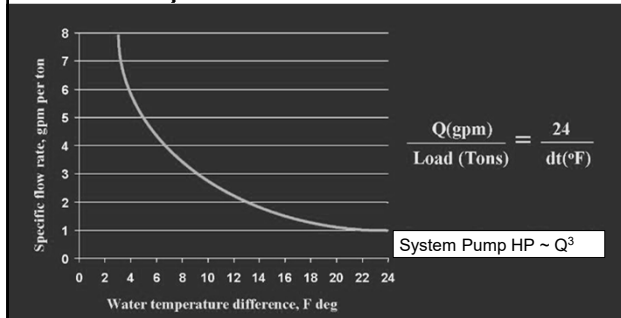
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## Specific Flow vs. $\Delta T$



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## Dynamic Pressure vs $\Delta T$

$$Q_{\text{zone}} = \frac{\text{GPM} \times \Delta T}{24}$$

- Increasing supply-to-return differential temperature requires less flow for same heat transferred
  - Less flow in a given pipe system results in lower velocity
  - Lower velocity equals lower friction and lower pressure loss
  - Lower pressure and flow equals lower energy
- Three Rules for Chilled Water System Optimization

Reduce Flow  
Reduce Flow  
Reduce Flow

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## Chilled Water Distribution System Configurations

- Constant/Variable Flow Combinations
  - Primary
  - Primary/Secondary
  - Primary/Secondary/Tertiary
- Variable Direct Primary

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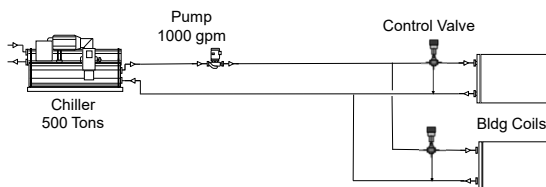
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## Constant Primary Only (One unit on)



Load equals 1 chiller = 1000 gpm @ 12°F  $\Delta T$  = 500 Tons

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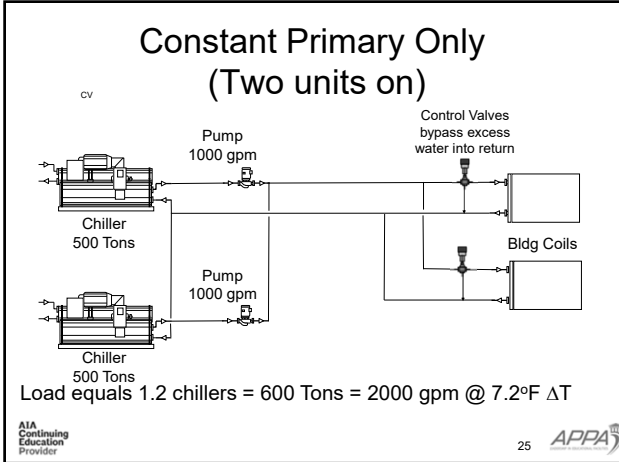
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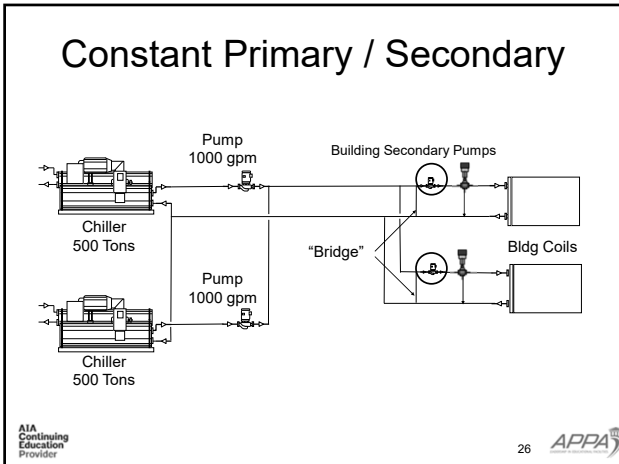
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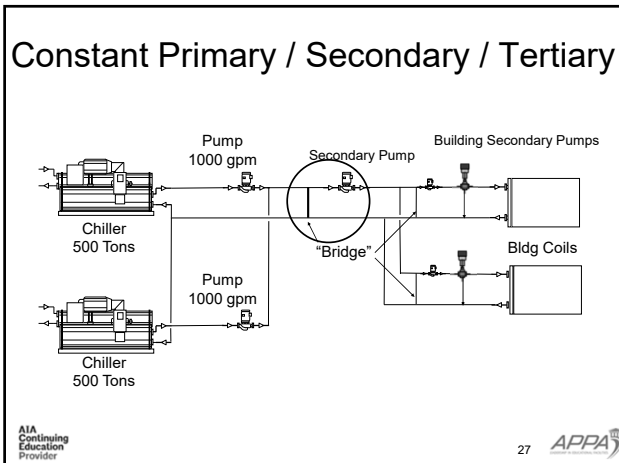
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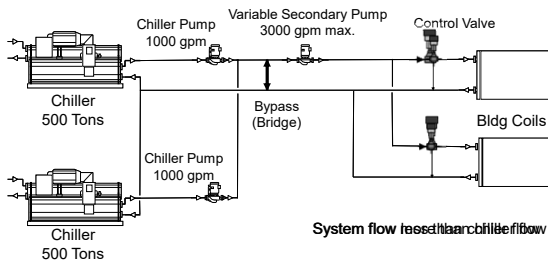
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## Constant Primary / Variable Secondary (primary and secondary pumps in central plant )



Chiller staging indicated by flow direction in the bridge

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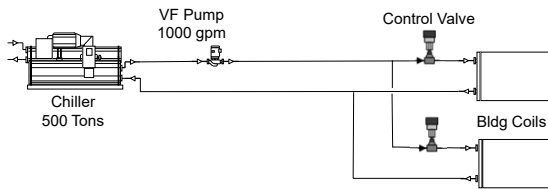
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## Variable Primary Only (One unit on)



Load equals 1 chiller = 1000 gpm @ 12°F ΔT = 500 Tons

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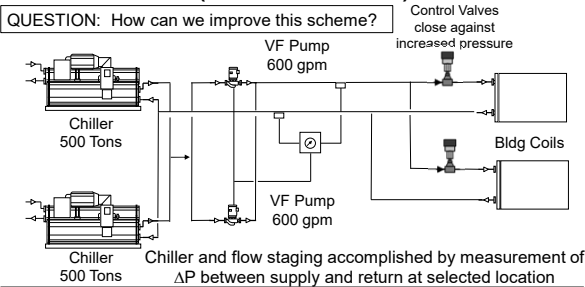
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## Variable Primary Only (Two units on)



Load equals 1.2 chillers = 600 Tons = 1200 gpm @ 12°F ΔT

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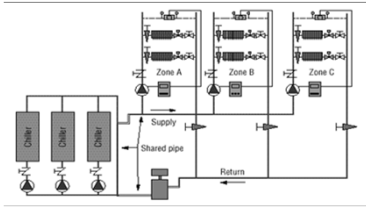
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# Questions & Answers

Thank You!



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