Cooling Distribution

APPA Institute for
Facilities Management
Indianapolis, IND
September 11, 2023

AIA Continuing Education Provider

1

Credit(s) earned on completion of this course will be reported to American Institute of Architects (AIA) Continuing Education Session (CES) for AIA members.

Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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

AIA Continuing Education Provider

2

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**

AIA Continuing Education Provider

3

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

4

4

Agenda

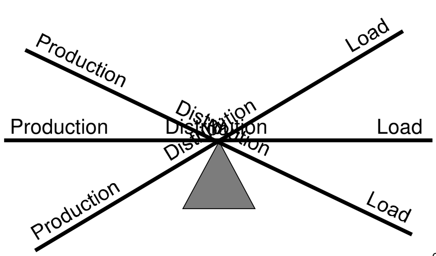
- System Concepts
  - Definitions
  - Basic Formulae
    - ΔT
  - Hydraulic Profile
- System Components
- System Configurations

5

5

WORDS OF WISDOM

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



6

6

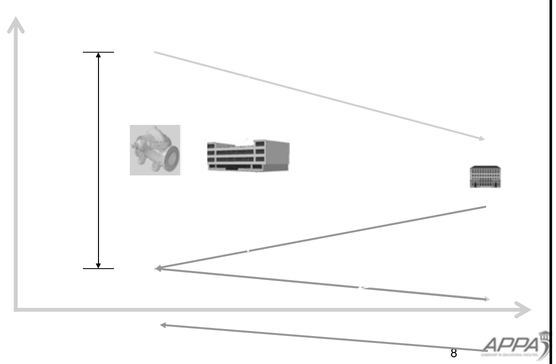
Definitions

- 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**

AIA Continuing Education Provider 7 APPA

7

System Hydraulic Profile



AIA Continuing Education Provider 8 APPA

8

Basic Formulae

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

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

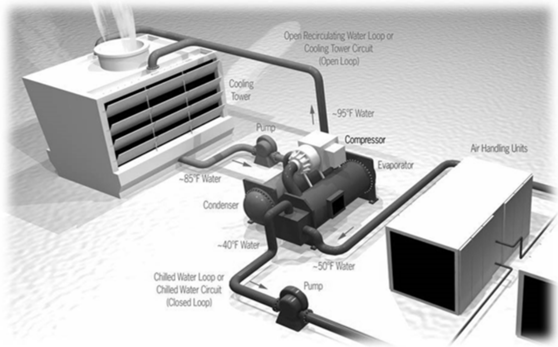
12,000 BTU/Ton-hr

ΔT = temperature difference between supply and return

AIA Continuing Education Provider 9 APPA

9

Chilled Water System Components



10

Chilled Water System Components and Interactions

- Pumps/ Piping
  - Parallel Pumping
  - Series Pumping
  - Variable Speed Pumping
- Effect of ΔT on Pump Energy
- Effect of ΔT on Pump Flow
- Effect of ΔT on Dynamic Pressure

11

Pumps

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

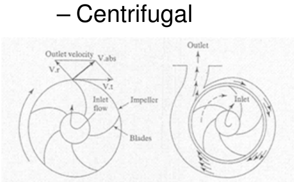
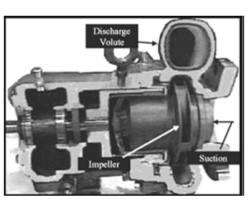
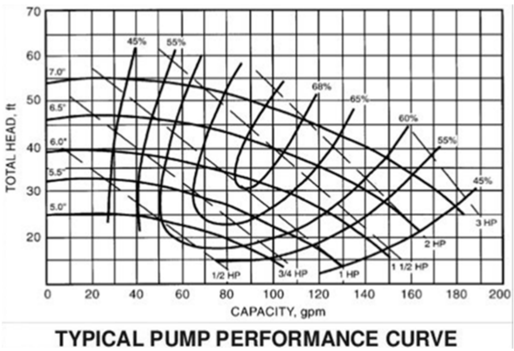


Figure 19.4 Impeller and volute interaction. [Reprinted by permission from *ASHRAE Systems and Equipment 1996* (IP & SI), p. 38.2.]



12

Pump Curve

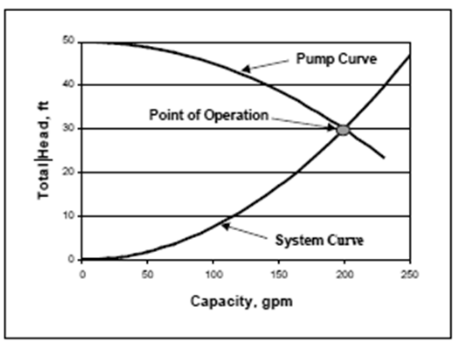


AIA Continuing Education Provider

13

System Curve

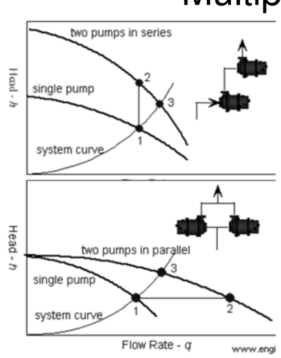
The system curve is a plot of friction losses (in head or pressure) for a piping system versus flow rate



AIA Continuing Education Provider

14

Multiple Pumps



Centrifugal pump in series are used to overcome larger system head loss than one pump can handle alone. For two identical pumps in series the head will be twice the head of a single pump at the same flow rate. With constant flowrate, the combined head moves from 1 to 2. In practice the combined head and flow rated moves along the system curve to 3.

Centrifugal pumps in parallel are used to overcome larger volume flows than one pump can handle alone. For two identical pumps in parallel the flowrate, will double (moving from 1 to 2) compared to a single pump if head is kept constant. In practice the combined head and volume flow moves along the system curve as indicated from 1 to 3.

AIA Continuing Education Provider

15

Varying Pump Speed

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

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)

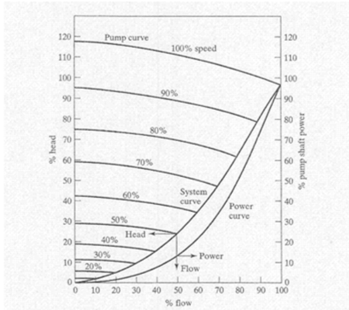
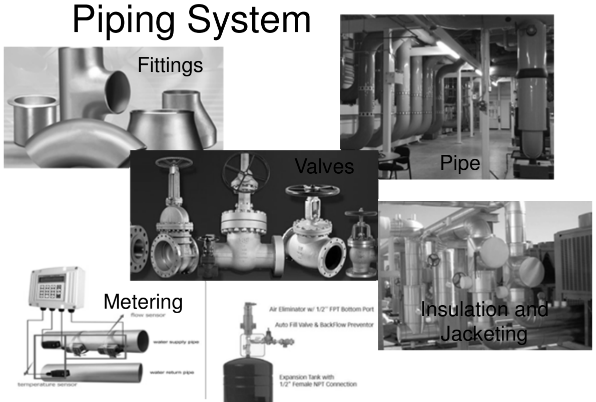


Figure 19.7 Pumping power, head, and flow vs. pump speed. [Reprinted by permission from *ASHRAE Fundamentals 1993* (IP & SI), p. 38.7.]

AIA Continuing Education Provider 16 APPA

16

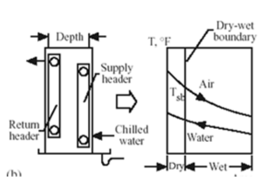
Piping System



AIA Continuing Education Provider 17 APPA

17

Chilled Water Coils



AIA Continuing Education Provider APPA

18

Chilled Water System ΔT

- Effect of ΔT on Pump Energy
- Effect of ΔT on Pump Flow
- Effect of ΔT on Dynamic Pressure

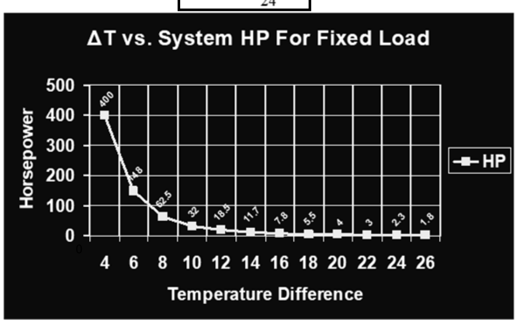
AIA Continuing Education Provider

19 APPA

19

Delta T vs. Req'd System HP

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

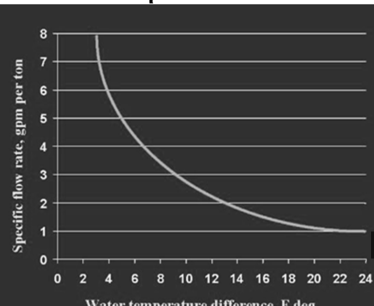


AIA Continuing Education Provider

20 APPA

20

Specific Flow vs. ΔT



$$\frac{Q(\text{gpm})}{\text{Load (Tons)}} = \frac{24}{dt(^{\circ}F)}$$

System Pump HP ~ Q^3

AIA Continuing Education Provider

21 APPA

21

Dynamic Pressure vs ΔT

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

- 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

AIA Continuing Education Provider

22 APPA

22

Chilled Water Distribution System Configurations

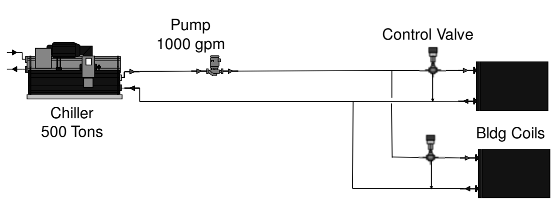
- Constant/Variable Flow Combinations
  - Primary
  - Primary/Secondary
  - Primary/Secondary/Tertiary
- Variable Direct Primary

AIA Continuing Education Provider

23 APPA

23

Constant Primary Only (One unit on)



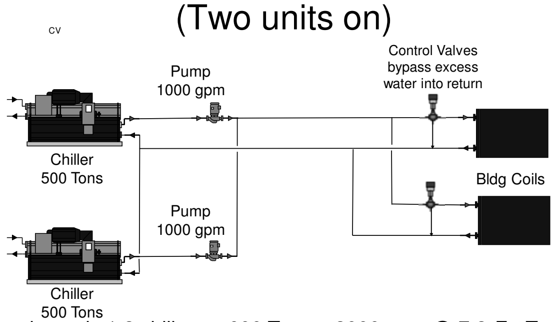
Load equals 1 chiller = 1000 gpm @ 12ºF ΔT = 500 Tons

AIA Continuing Education Provider

24 APPA

24

Constant Primary Only (Two units on)

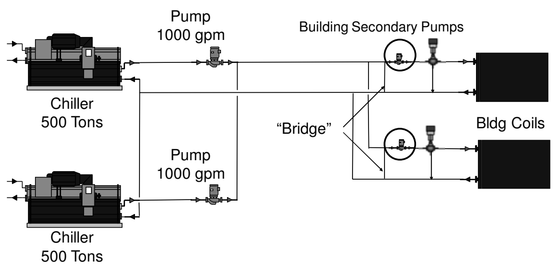


Load equals 1.2 chillers = 600 Tons = 2000 gpm @ 7.2ºF ΔT

AIA Continuing Education Provider 25 APPA

25

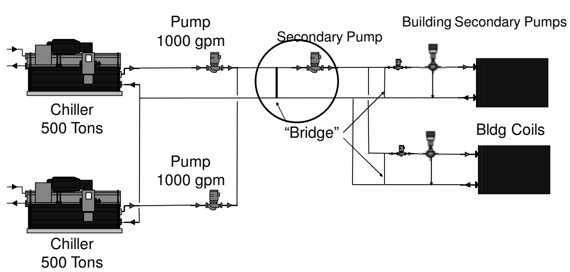
Constant Primary / Secondary



AIA Continuing Education Provider 26 APPA

26

Constant Primary / Secondary / Tertiary

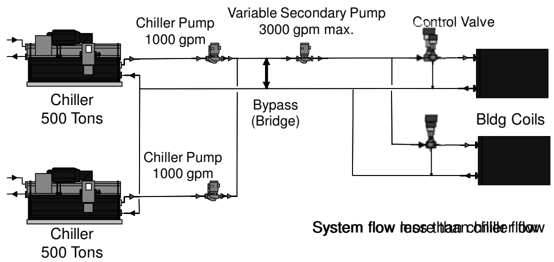


AIA Continuing Education Provider 27 APPA

27

Constant Primary / Variable Secondary

(primary and secondary pumps in central plant)



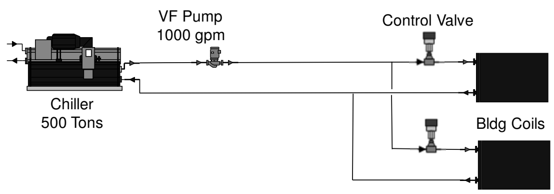
Chiller staging indicated by flow direction in the bridge

AIA Continuing Education Provider

28 APPA

28

Variable Primary Only (One unit on)



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

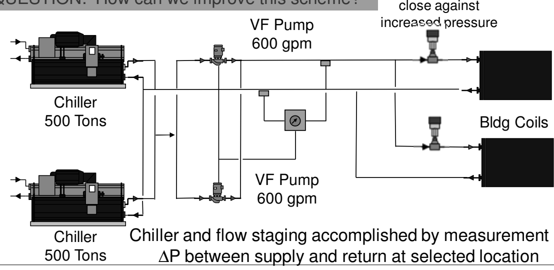
AIA Continuing Education Provider

29 APPA

29

Variable Primary Only (Two units on)

QUESTION: How can we improve this scheme?



Chiller and flow staging accomplished by measurement of ΔP between supply and return at selected location

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

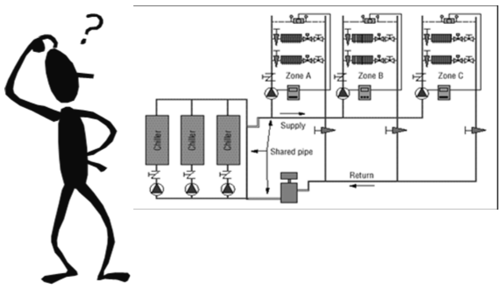
AIA Continuing Education Provider

30 APPA

30

Questions & Answers

Thank You!



31

31

THIS CONCLUDES THE AMERICAN INSTITUTE OF ARCHITECTS CONTINUING EDUCATION SYSTEMS COURSE

32