THERMAL DISTRIBUTION

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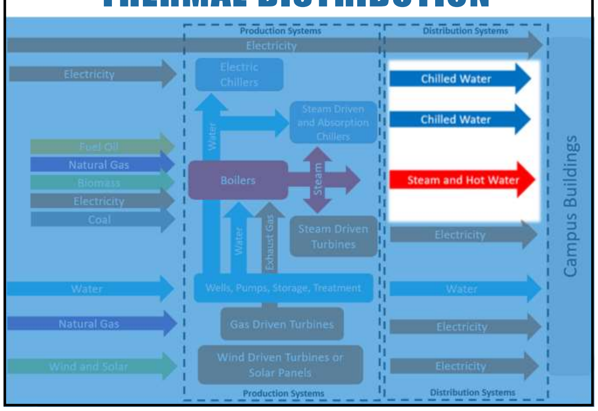
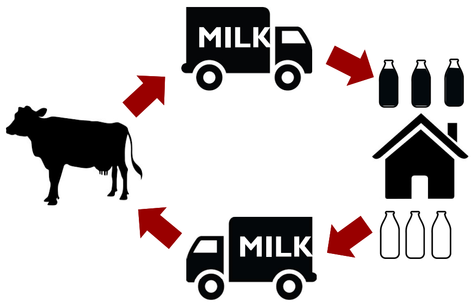
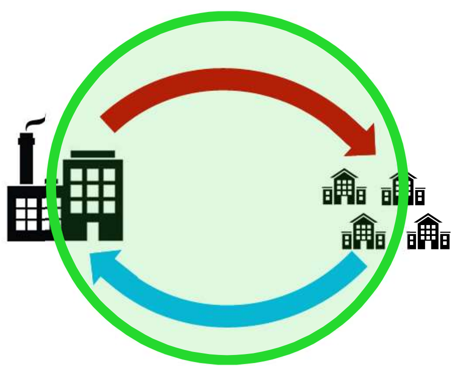
THERMAL DISTRIBUTION



HEATING/COOLING A CAMPUS

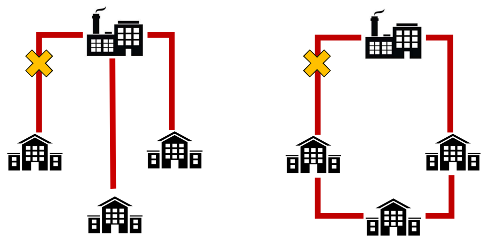




OVERVIEW

- Radial or Looped
- How Pipe Fails
- Steam or Hot Water
- Pipe Materials
- Direct Buried or Tunnel
- Costs
- Design Considerations

RADIAL OR LOOPED



Radial

Looped

HOW PIPE FAILS

- Corrosion
- Expansion
- Water Hammer
- Excavation

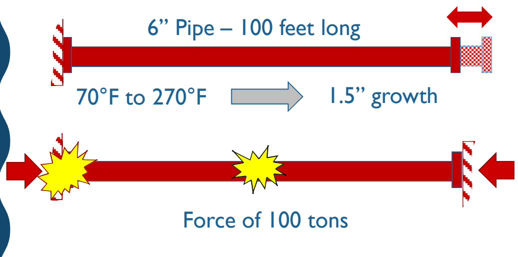
CORROSION

External and Internal

Water + Iron + Oxygen = Rust

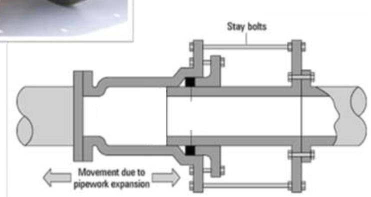
Solution:
No Water,
No Iron, or
No Oxygen

EXPANSION



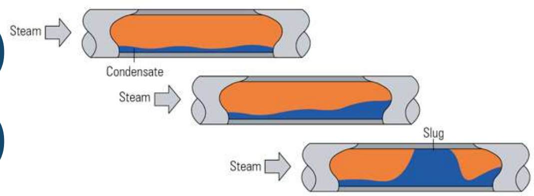
Solution:
Add Flexibility

EXPANSION



EXPANSION

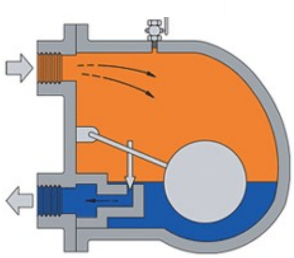
STEAM INDUCED WATER HAMMER



Solution:
Remove condensate from steam line

STEAM INDUCED WATER HAMMER

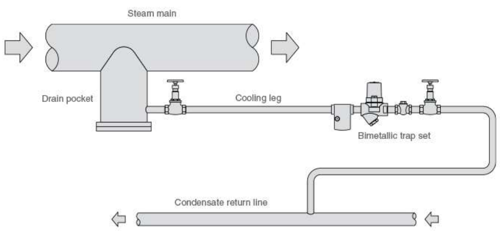
STEAM INDUCED WATER HAMMER



Traps

Float
Inverted Bucket
Thermostatic
Thermodynamic
Nozzle

STEAM TRAPS



STEAM INDUCED WATER HAMMER

EXCAVATION

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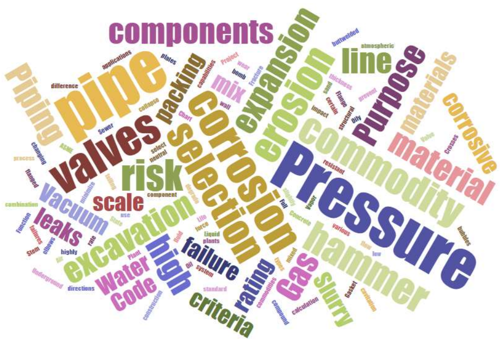
Know what's below.
Call before you dig.

PIPE



DIRECT BURIED PIPE

STEEL

High Temp. = Steel

- Corrosion
+ Expansion
+ Water Hammer
- Excavation

$500 - $1,000/ft

DIRECT BURIED PIPE - STEEL

DIRECT BURIED PIPE

PLASTIC

Low Temperature:
Plastic is an option

+ Corrosion
+ Expansion
+ Water Hammer
- Excavation?

$400 - $700/ft

TUNNELS

+ Corrosion
+ Expansion
+ Water Hammer
+ Excavation

$4,000 - $7,000/ft

SHALLOW TRENCH

+ Corrosion
+ Expansion
+ Water Hammer
+ Excavation

$2,000 - $3,000/ft

COMPARISON

Direct-Buried
+ Simple and fast
+ Lowest cost

- Less reliable
- More disruption

Tunnel
+ High reliability
+ No disruption

- Very expensive
- Low flexibility

Shallow Trench
+ Good reliability
+ Low disruption

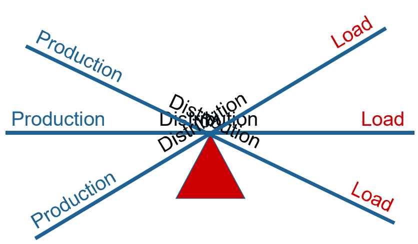
- Expensive
- Low flexibility

DISTRIBUTION DESIGN

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

WORDS OF WISDOM

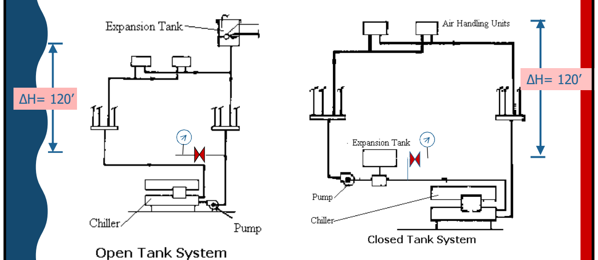
It's not how much you've got; it's whether you can use it.



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**

Fill Pressure, Makeup, and Expansion



System Pressure = .434 psi/ft X 120' + 5 = 57 psig

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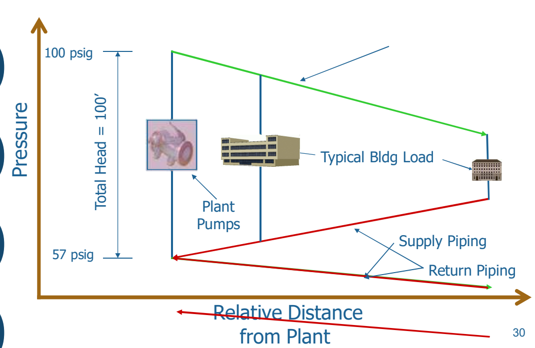
SYSTEM HYDRAULIC PROFILE



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BASIC FORMULAE

$$Q_{BTUH} \approx GPM \times \Delta T$$

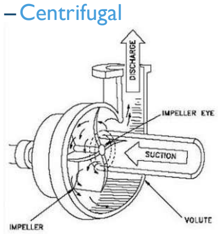
ΔT = temperature difference between supply and return

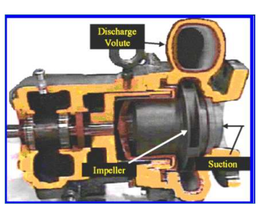
SYSTEM COMPONENTS

- 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

PUMPS

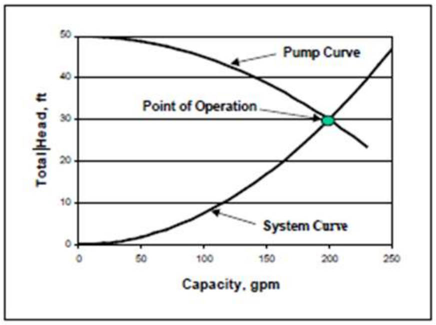
- Driving force to move water in piping
- Provide pressure and flow
- Primary type
  - Centrifugal



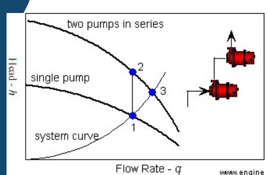


SYSTEM CURVE

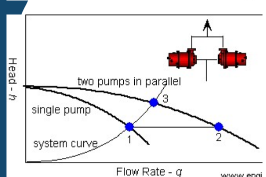
The system curve is a plot of friction losses (in head or pressure) for a piping system versus flow rate



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 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.

VARYING PUMP SPEED

$Q_{BTUH} \approx \text{GPM} \times \Delta T$

Affinity Laws:

If speed is decreased by 10%,

Law 1: Flow is Proportional to Shaft Speed.

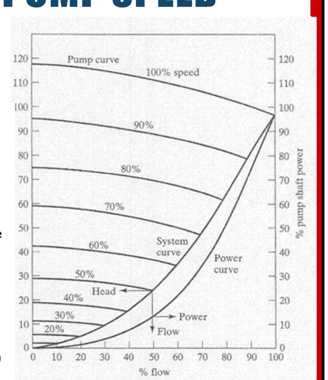
Flow is decreased by 10%

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

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

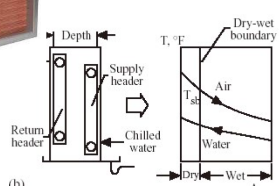
Law 3: Power is Proportional to the Cube of Shaft Speed.

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

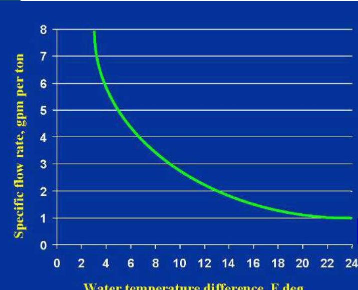


PIPING SYSTEM

CHILLED WATER COILS



SPECIFIC FLOW VS. ΔT



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

System Pump HP ~ Q^3

DYNAMIC PRESSURE VS ΔT

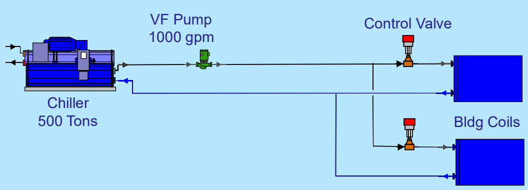
$$Q_{BTUH} \approx \text{GPM} \times \Delta\text{T}$$

- 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

Variable Primary Only (One unit on)



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

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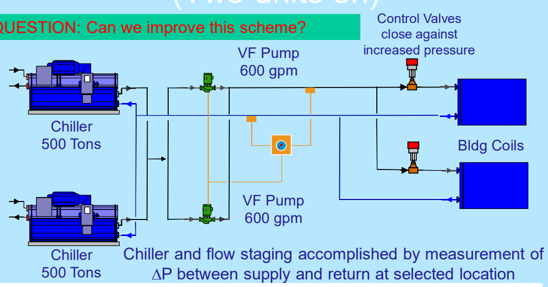
Variable Primary Only (Two units on)

QUESTION: Can we improve this scheme?



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

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PIPE CAPACITY

100,000 GSF
1,000 feet

What size pipe?

125 psig system
4" pipe - $400,000 (100,000 GSF)

10" pipe - $500,000 (1,200,000 GSF)

+25% Cost = +1200% capacity

CHILLED WATER DELTA-T

2,000 ton load
1,000 feet of pipe

Cost of poor ΔT?

10°F ΔT – 4,800 GPM requires 16" pipe = $800,000

16°F ΔT – 3,000 GPM requires 12" pipe = $650,000

Bigger heat exchanger will save $150,000 initially
$5,000 every year due to less pumping power

QUESTIONS?

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