Wisconsin Healthcare Engineering Association presents

Achieving Energy Savings & Reducing Maintenance Costs in Hot and Chilled Water Systems

Presenter – Matt Pefley

Learning Objectives

Upon completion of this program you will be able to:

1. Examine maintenance costs associated with air and dirty system water.
2. Review traditional methods and equipment to address air & dirt.
3. Discover why hydronic systems cannot perform to their peak design when air and dirt are present.
4. Discuss energy savings and other efficiencies gained throughout the system.

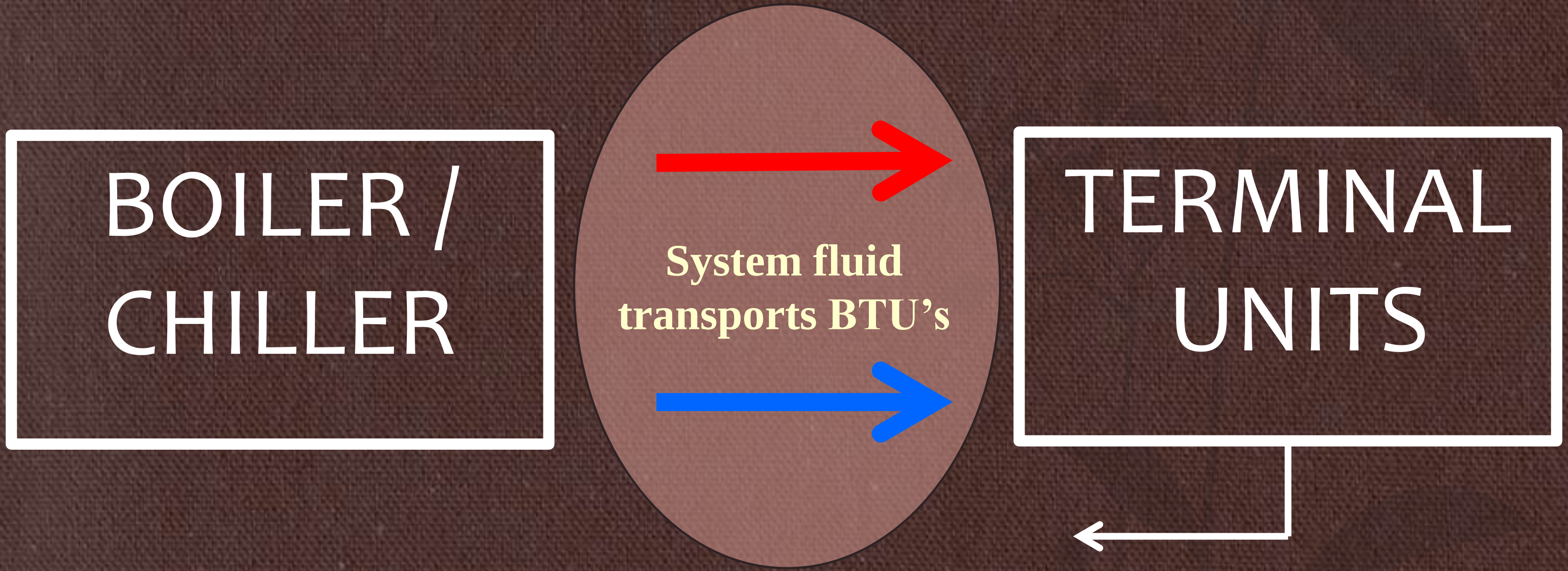
WHY IS THIS STILL INTACT?

(Hull construction is 1" thick steel plates and steel/iron rivets)

WHITE STAR LINE

R.M.S. TITANIC

THERMAL DISTRIBUTION EFFICIENCY



Q. What specific component in the system protects the efficiency of the BTU heat transfer from generation point to termination point?

Air In Hydronic Systems

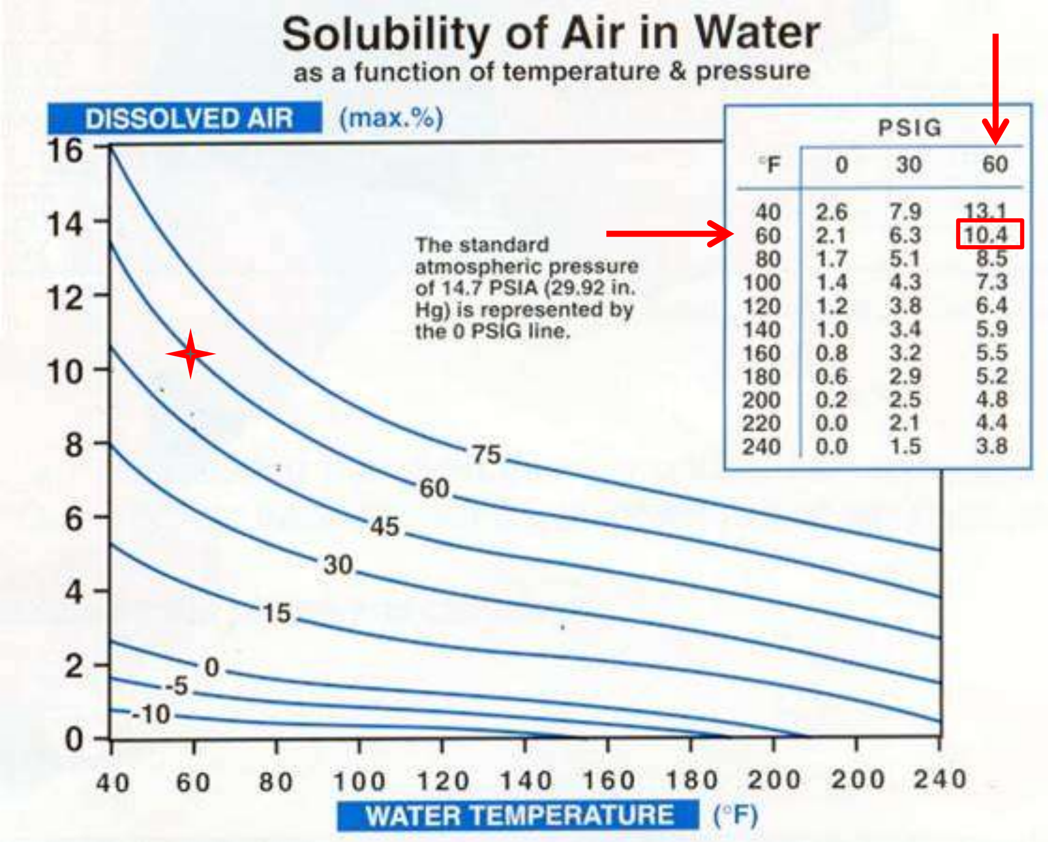
- Sources of Air
  - Initial System Fill and Subsequent Operation
    - Air Never Fully Removed in the First Place!
- Planned & Unplanned Maintenance
- Makeup Water Due to Leaks
- Building Adds to System Loops

Air Types In Hydronic Systems

- "Free" or "Entrapped" Air
  - Large bubbles found in risers, tops of coils, high points in the system
- "Entrained" Air
  - Smaller than free air, and is visible
  - Moves with the water flow
    - Not light enough to separate from the flowing water
- "Dissolved" Air
  - Smallest size in the system
  - Only coalescing type air separators can remove dissolved air
  - Dissolved air responds to high / low pressure & temperature points in the system

Air In Hydronic Systems

- How Much Air is in Water?
  - Henry's Law… Air Wants to be Present at a Specific % at a Given Temperature and Pressure.



°F	PSIG 0	PSIG 30	PSIG 60
40	2.6	7.9	13.1
60	2.1	6.3	10.4
80	1.7	5.1	8.5
100	1.4	4.3	7.3
120	1.2	3.8	6.4
140	1.0	3.4	5.9
160	0.8	3.2	5.5
180	0.6	2.9	5.2
200	0.2	2.5	4.8
220	0.0	2.1	4.4
240	0.0	1.5	3.8

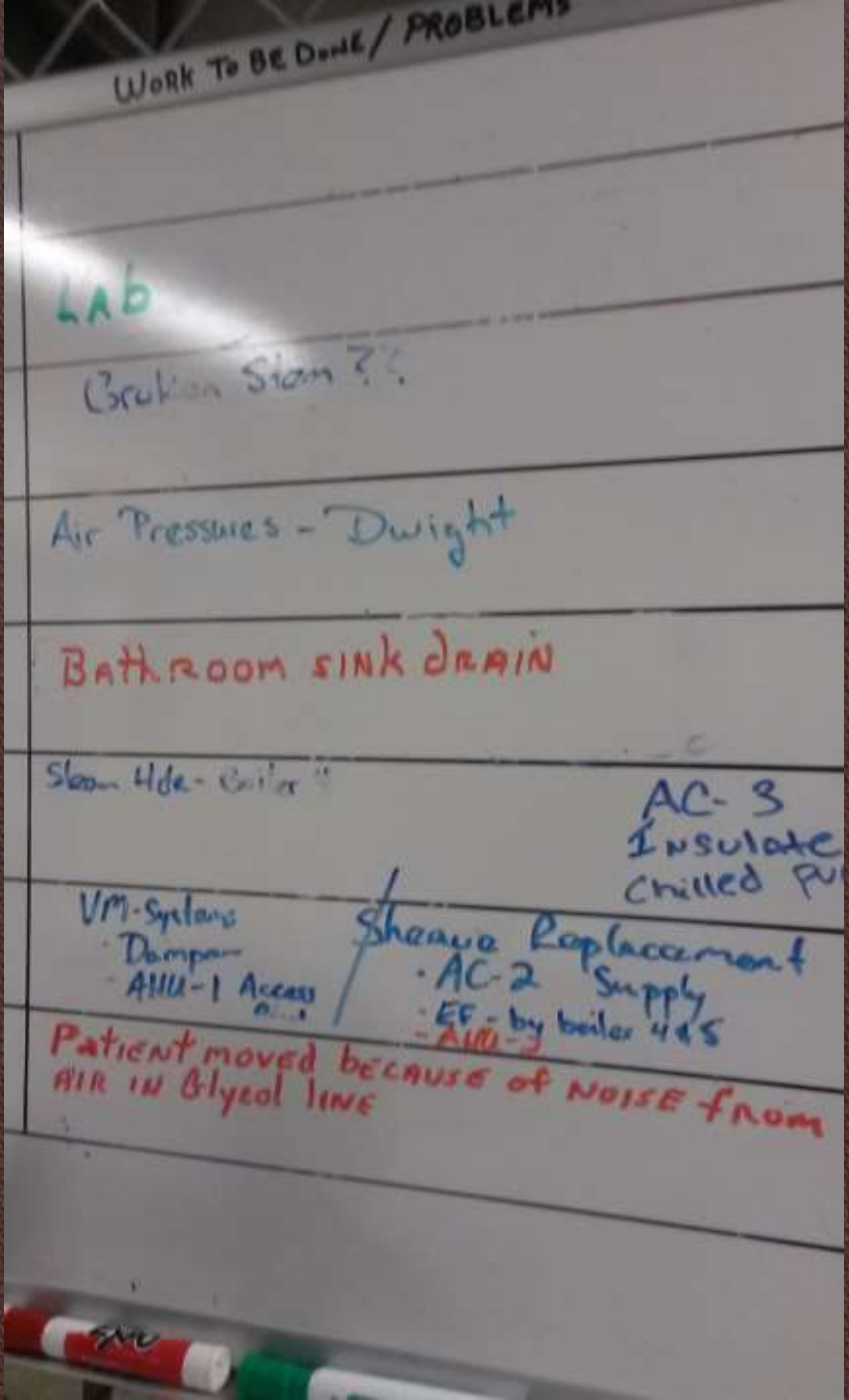
Air Why the Concern?

- Air is Compressible
  - Pumps Try to Squeeze Air & Push Water
    - Cavitation
  - Low Pressure Points Allow Air to Become Free/Entrapped
  - Free Air Leads to Low / No-Flow Points
    - AKA – No Heat Calls
  - Maintenance $$$ Spent Getting the Water to Move

LABOUR PUMP DATA

2 percent entrained air can reduce pump performance by 10 to 12 percent.

4 percent entrained air can reduce pump performance by 44 percent.

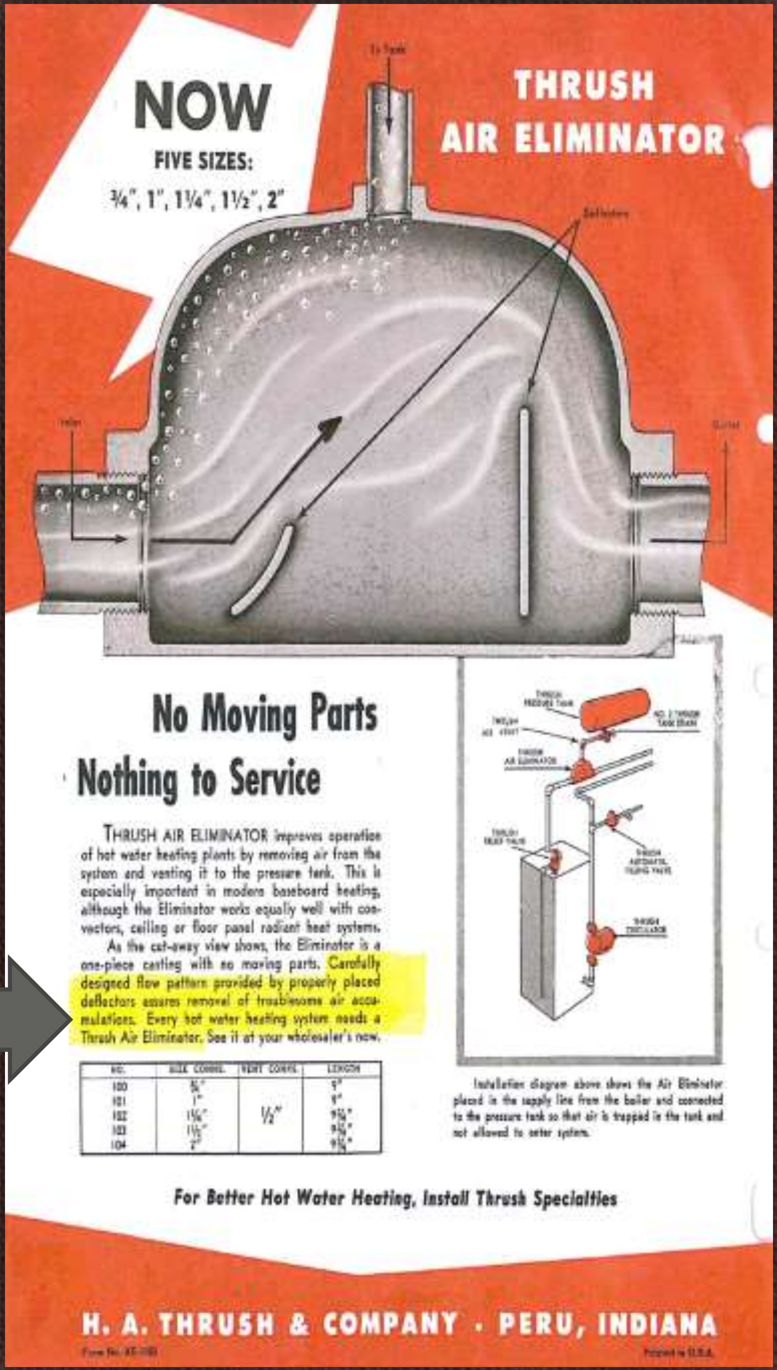

WORK TO BE DONE / PROBLEMS
Lab
Air Pressures - Dwight
Bathroom sink drain
AC-3
Insulate
Chilled
Sheave Replacement
AC-2 Supply
Patient moved because of noise from
AIR IN Glycol line

Why have an air separator?

Not required for a hydronic system to "work"

No standards/rules stating one is required

Dealing With Air



"assures removal of troublesome air accumulations"

"Every hot water heating system needs one."

Dealing With Air

Traditional Solution:

- Float Vents

Traditional Solution:

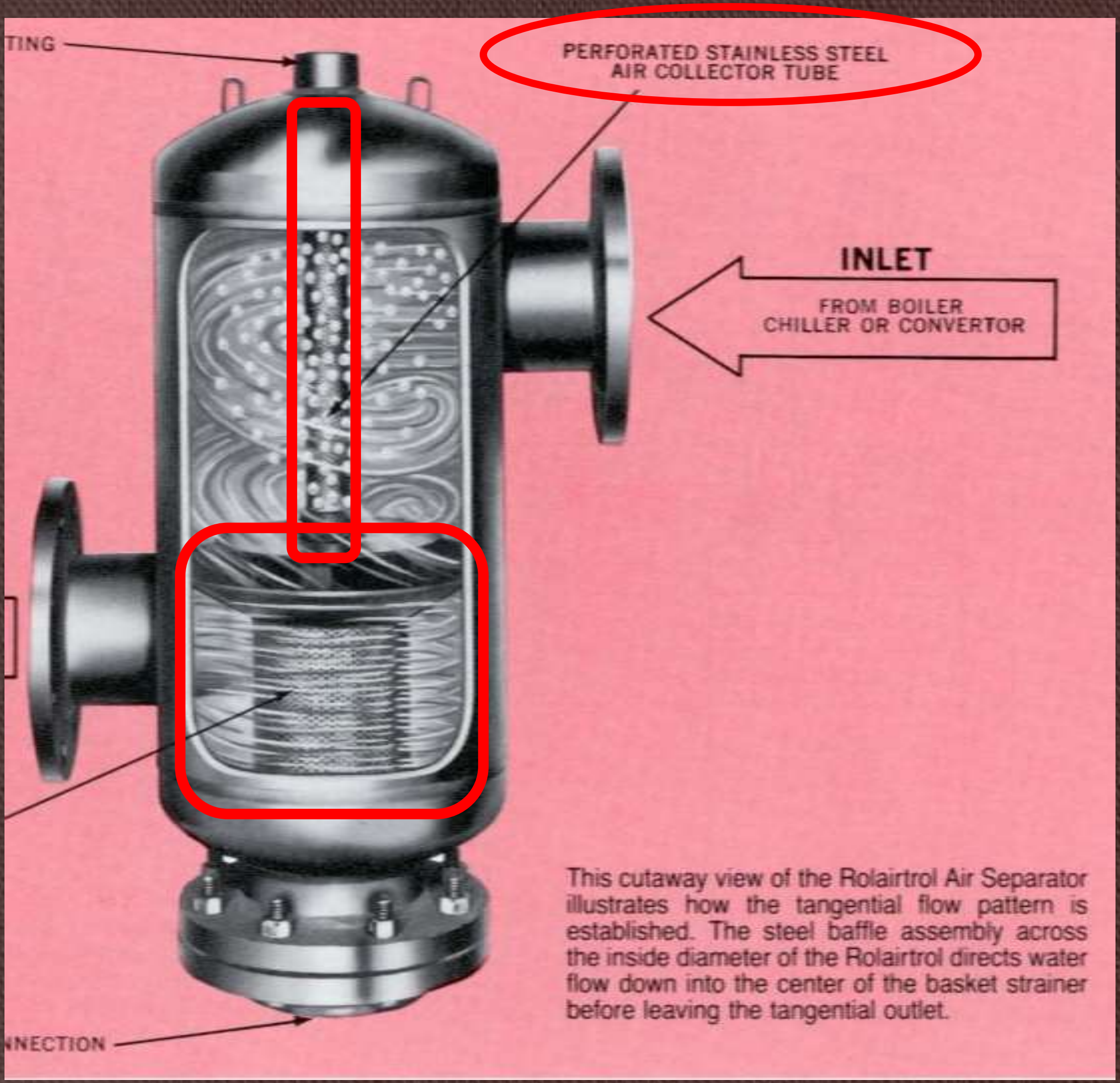
- Air Scoops

Dealing With Air

- Traditional Solution:

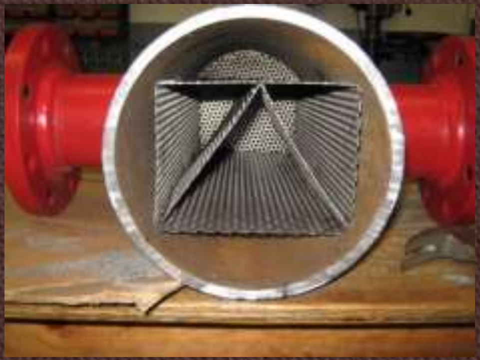
- Tangential Air Separator
  - Removes ~ 40% of Free Air at Design Capacities
  - Proper Sizing = Large Unit

AIR
TRADITIONAL TREATMENT SOLUTIONS

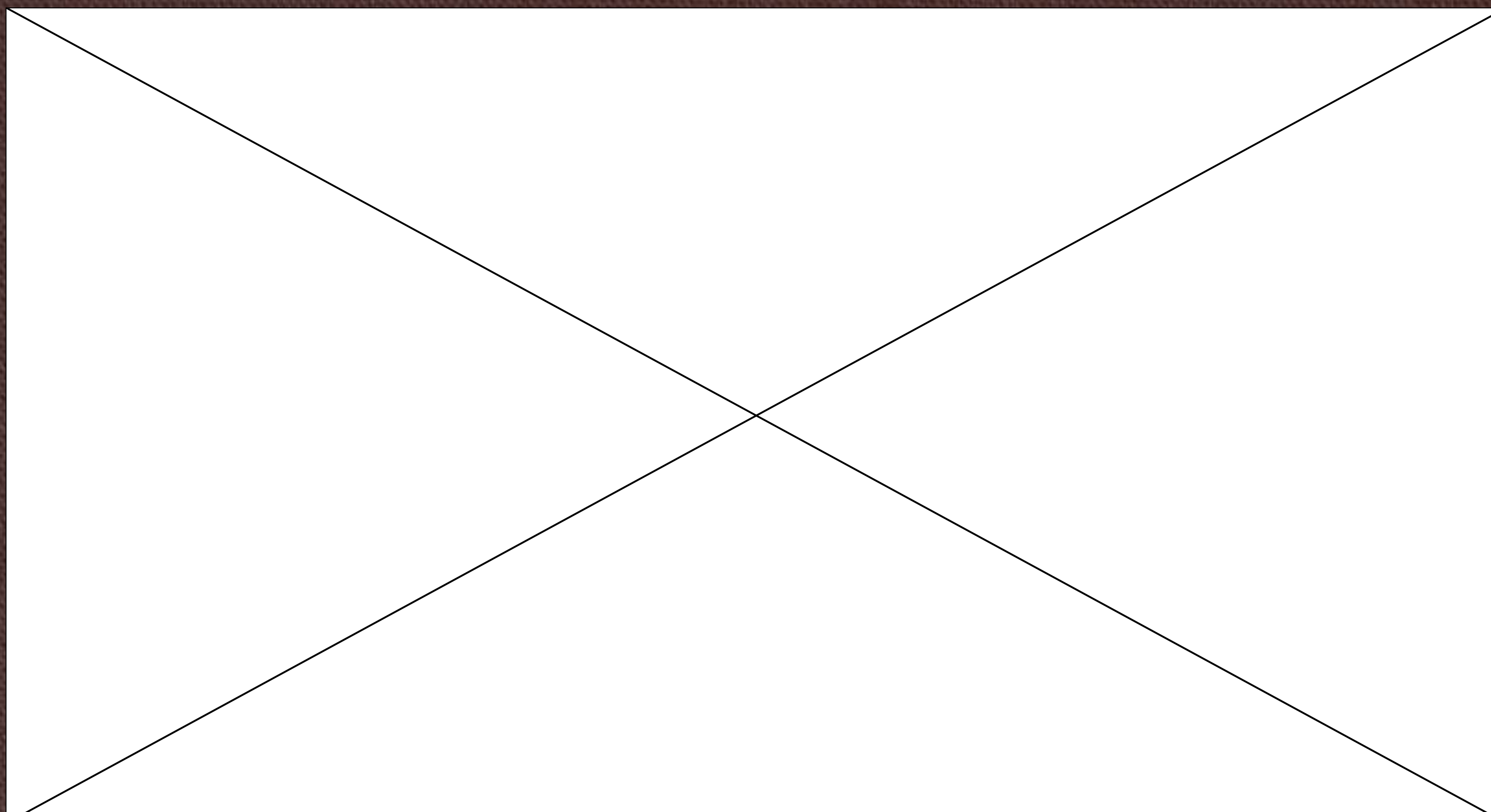


Dealing With Air

- New Solution
  - **Coalescing Media**
    - Free Air Exits Quickly
    - Entrained Air Has Space to Escape
    - Dissolved Air Has Material to Cling to and Coalesce to Form Larger Bubbles and Escape

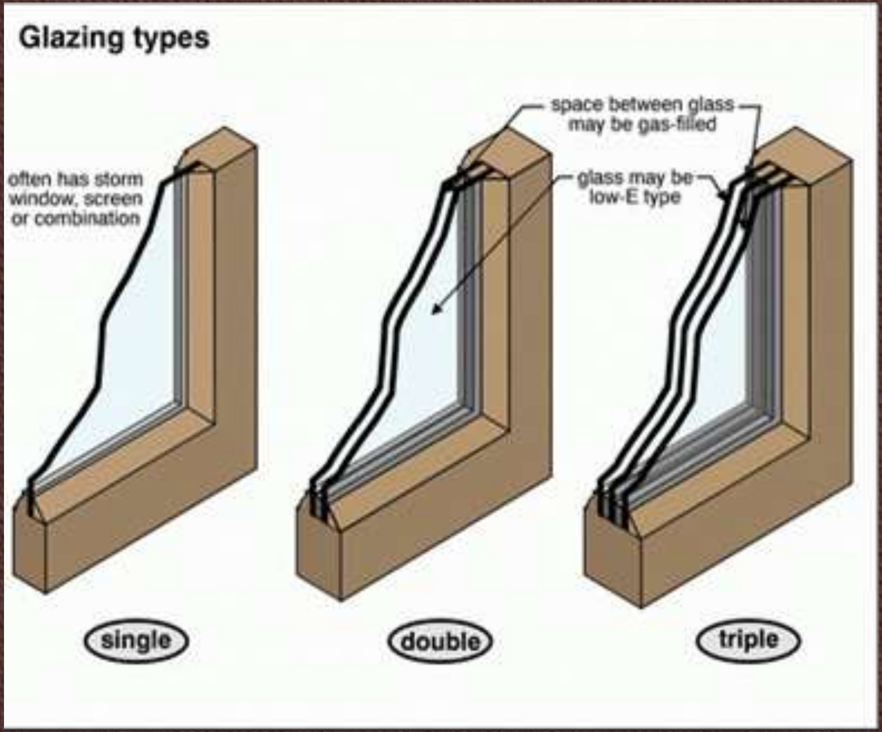


AIR ELIMINATION



Air Why the Concern?

- Air is an Insulator
  - Inhibits Thermal Transfer
    - "Energy in / Energy out"
  - Entrapped Air in Coils Requires the System to *Run Longer* in Order to Satisfy Space Temperature Requirements



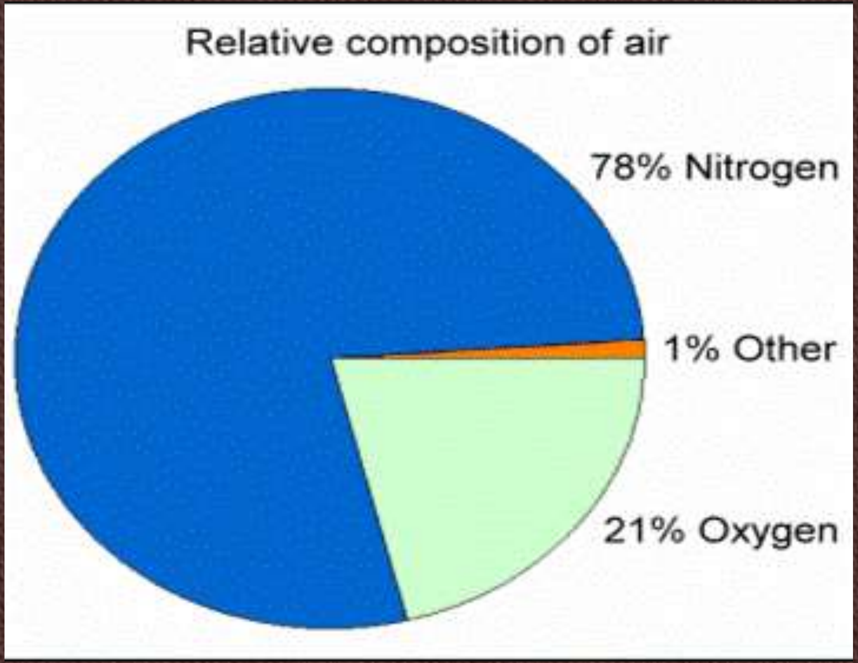
Air Why the Concern?

- Air (Oxygen) Causes Oxidation of the Pipe Walls
  - Dirt / Scale Cause Premature Failure of:
    - Pump Seals
    - Control Valves
    - Metering Equipment
    - Pipe Degradation

- Liquid Sandpaper Moving Through the System

Air In Hydronic Systems

- Chemical Treatment
  - Objective is to interrupt the oxygen corrosion process
  - Various types:
    - Oxygen Scavengers
    - Corrosion Inhibitors
    - Additional additives usually required to prevent Nitrites from degradation by microbial activity.
  - What about Heat Transfer Efficiency?
    - Air is still in the system!



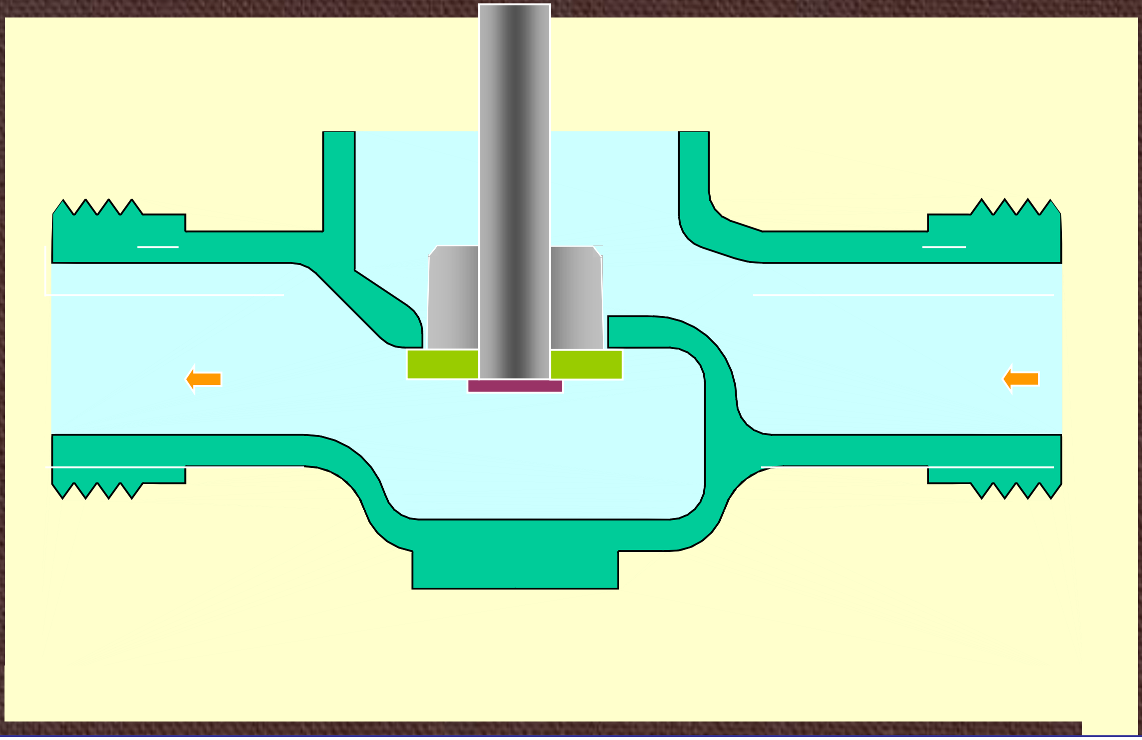
Dirt In Hydronic Systems

- Oxygen Based Corrosion Leads to **Dirt** in the System Fluid

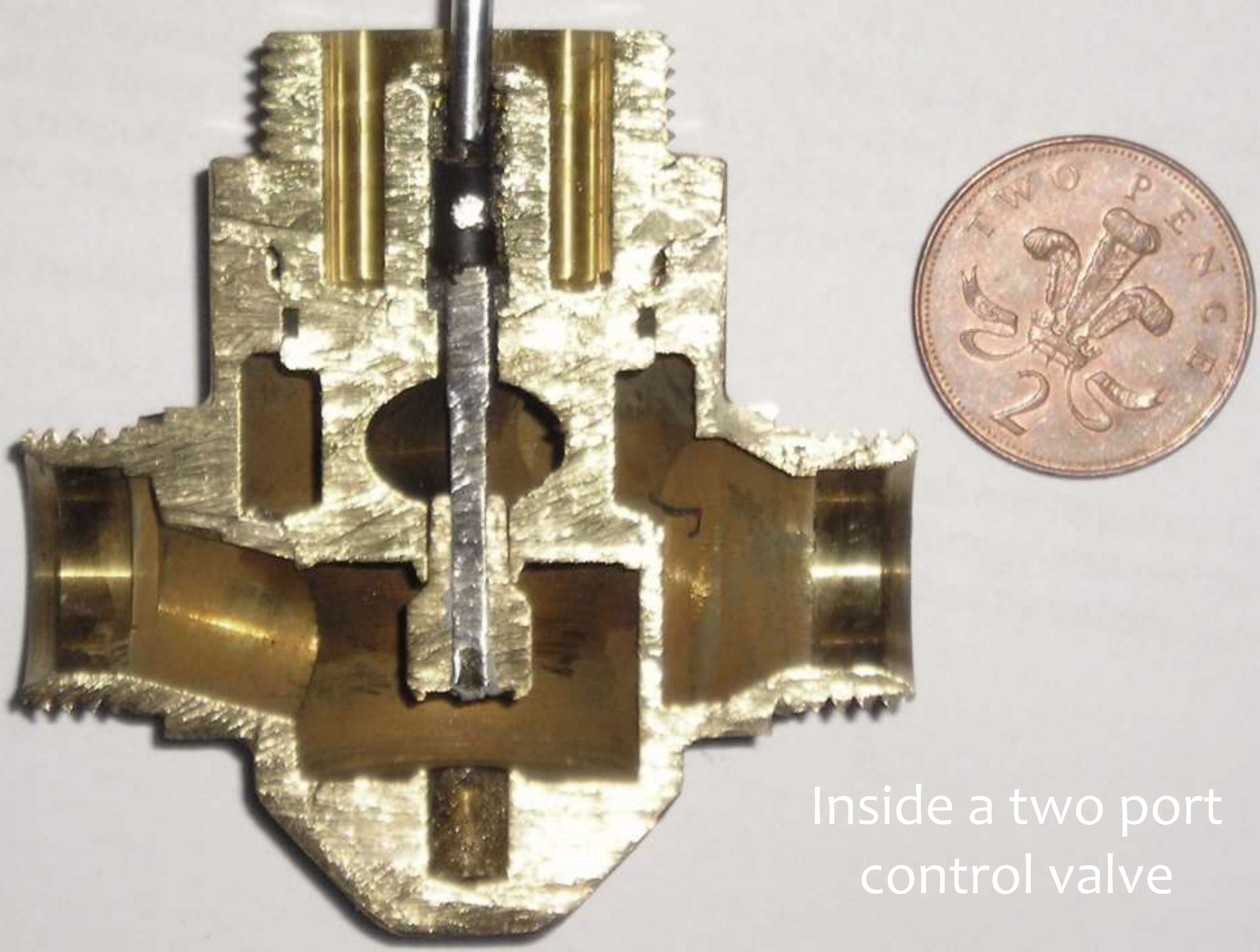
Worn pump seals

Dirt In Hydronic Systems

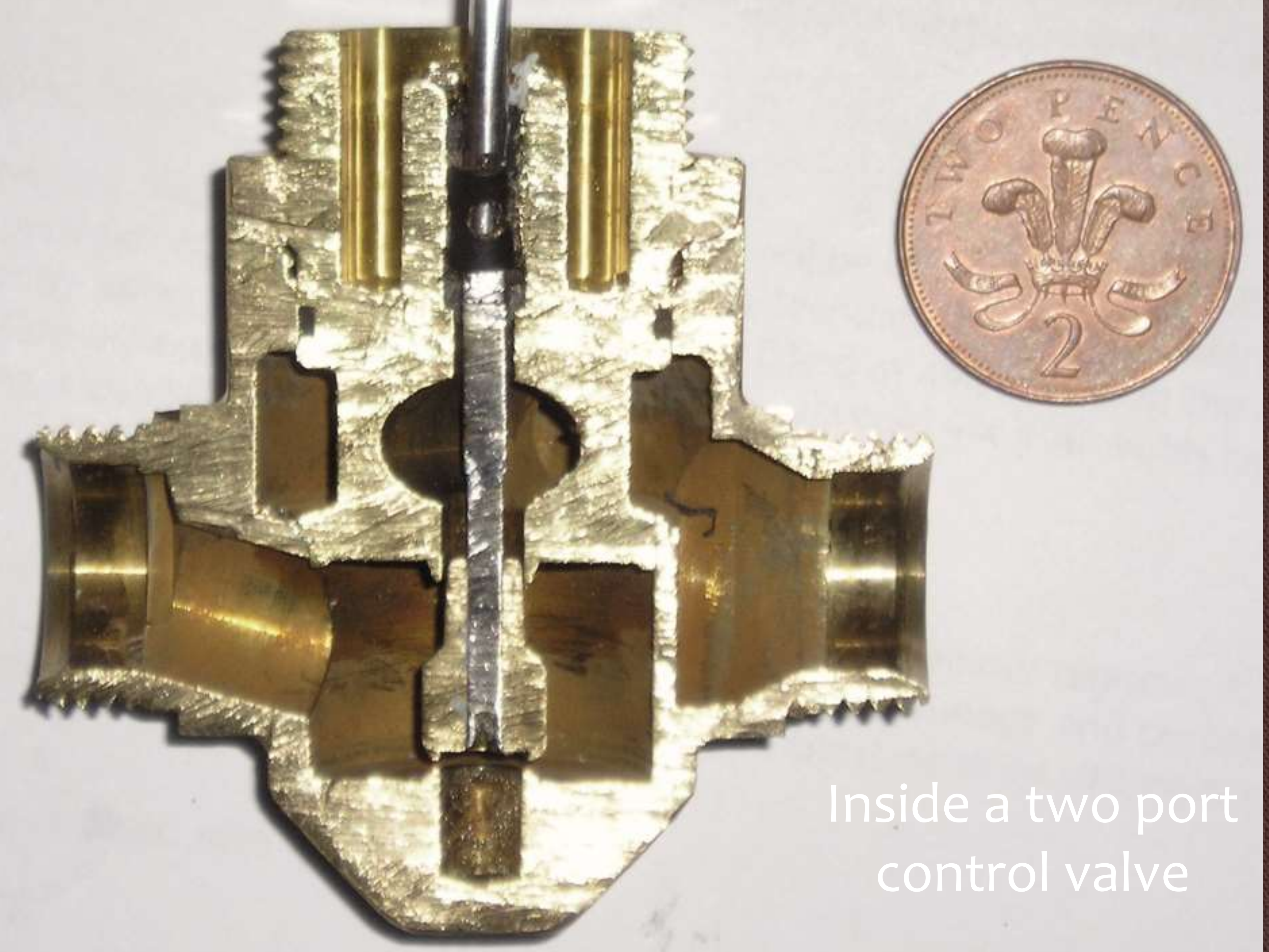
- Control Valve Seats can be Scored



Two port control valves are typically globe pattern valves, similar to double regulating valves but with a different design of plug and seat. These types of valve would be used for on/off or modulating control of flow rate to heating or cooling terminals. *NB modulating control being the gradual closure of the valve in response to internal room temperature.*



Inside a two port control valve



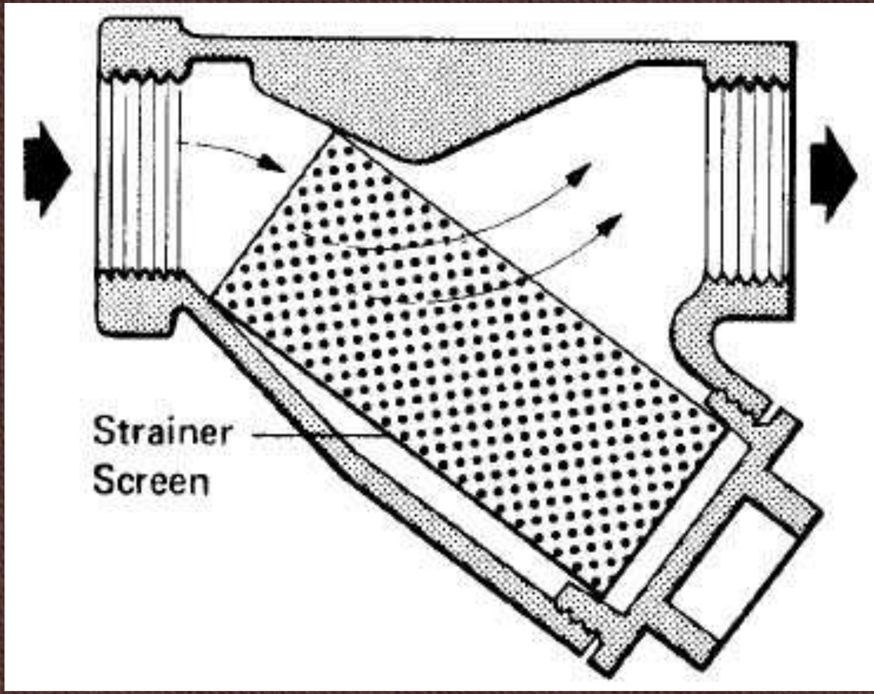
Inside a two port control valve

Dirt In Hydronic Systems

- Sludge

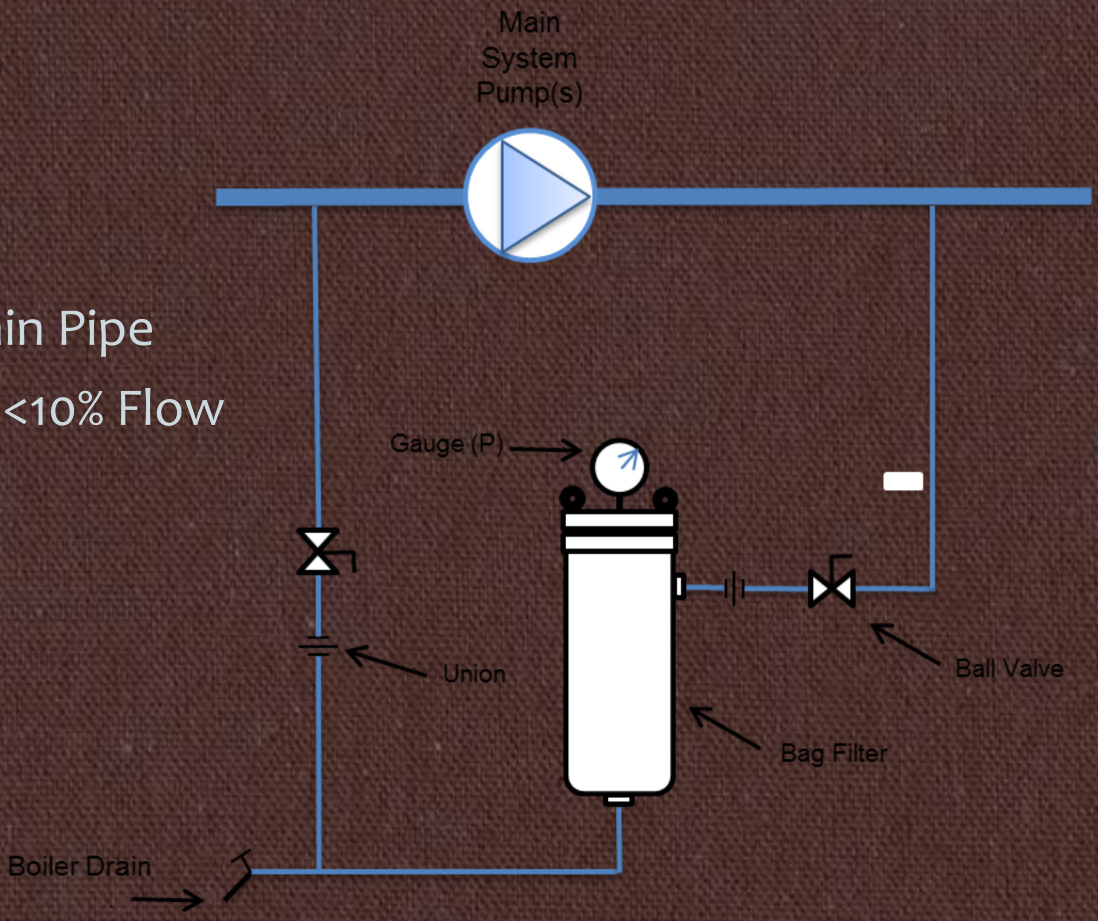
Dealing With Dirt

- Traditional Methods
  - Full Flow
    - **Strainers**
      - Used In-Line
      - Various Screen Mesh Sizes Available
      - As They Collect Debris, Pressure Drop Increases
        - How Often Are They Serviced??



Dealing With Dirt

- Traditional Methods
  - Side Stream Filtration
    - **Bag Filters**
    - Typically Smaller Than Main Pipe
    - As Side Stream, They See <10% Flow

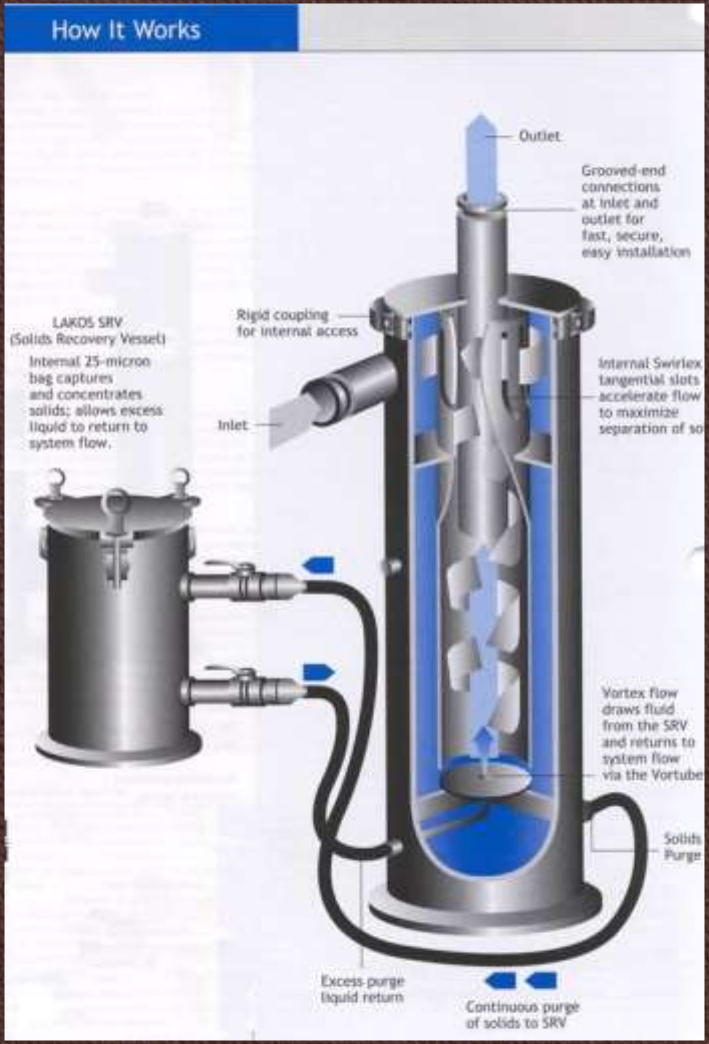


Dealing With Dirt

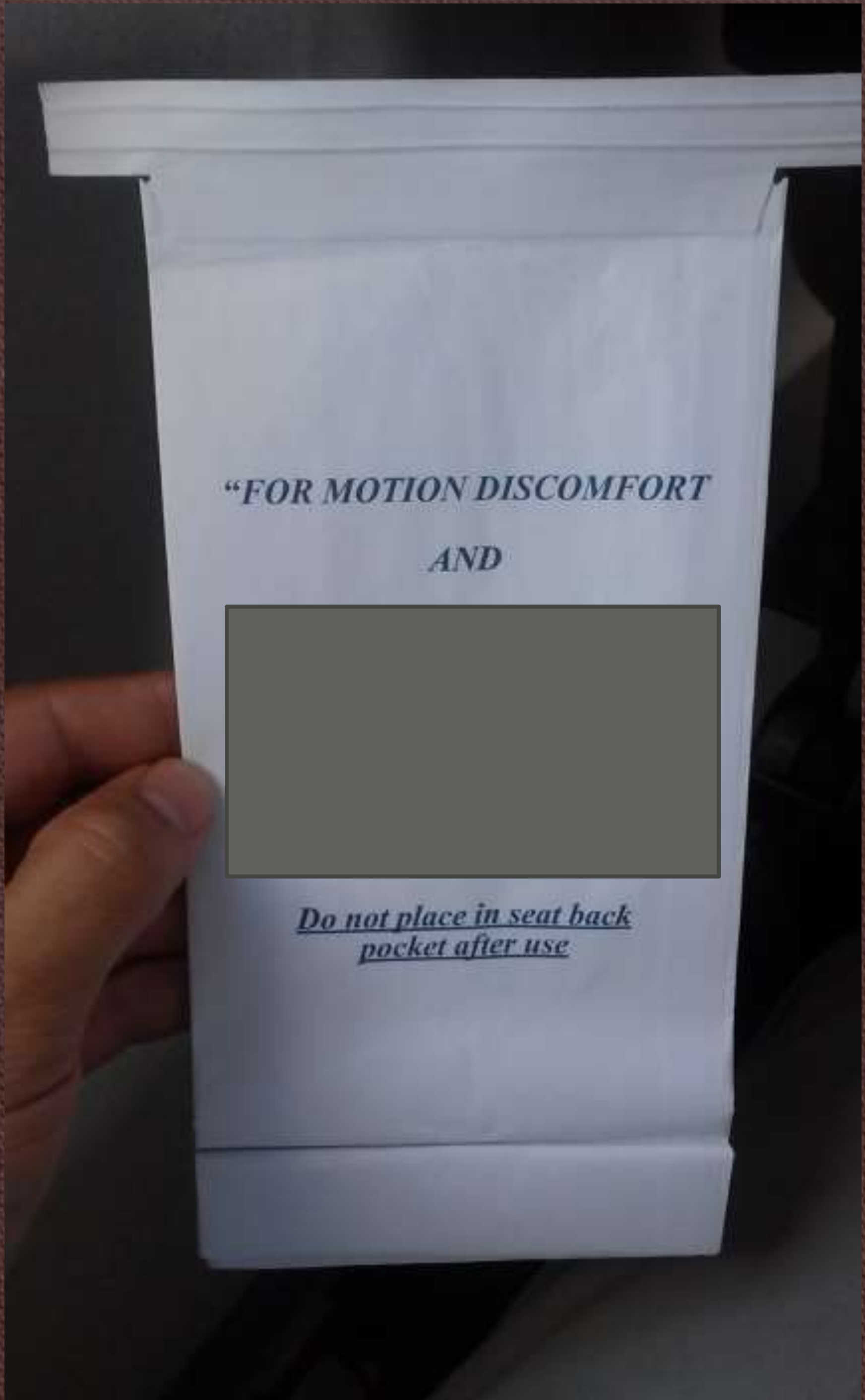
- Traditional Methods
  - Side Stream Filtration
    - **Sand Filters**
    - Typically Smaller Than Main Pipe
    - Back Washing Required
    - Can Achieve Small Size Separation
      - Necessary?
    - Pump Needed - High Pressure Drop

Dealing With Dirt

- Traditional Methods
  - Side Stream Separation
    - **Cyclonic Separators**
    - High Pressure Drops
    - Effective to ~ 70-micron

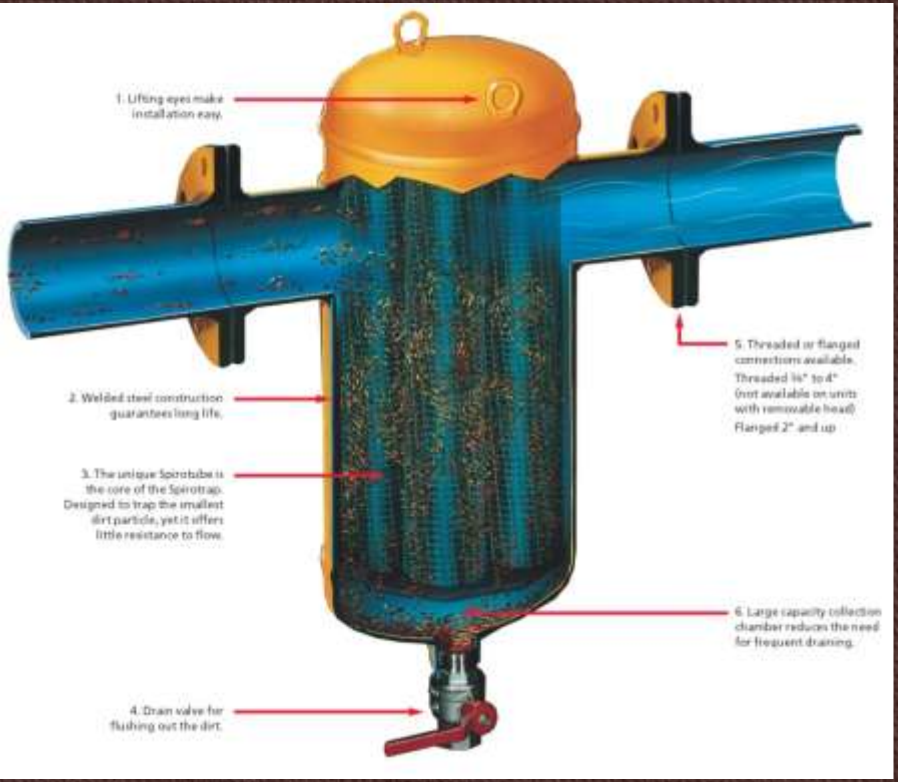


- Used to contain a “mess”
- Does nothing to improve health
- Is this any different than sidestream Filtration?



Dealing With Dirt

- New Solution
  - Full Flow Separation
    - **Straight Through Separators**
    - Low Pressure Drops
    - Debris is Captured Out of the Flow Path
      - No Added Resistance to System Flow
    - Some Are Capable of Separating Down to 5-micron Particles
    - Simple, Blow Down Avoids Large Quantities of System Fluid Loss
    - Maintenance & Operating Expenses are Kept to a Minimum



DIRT SEPARATION

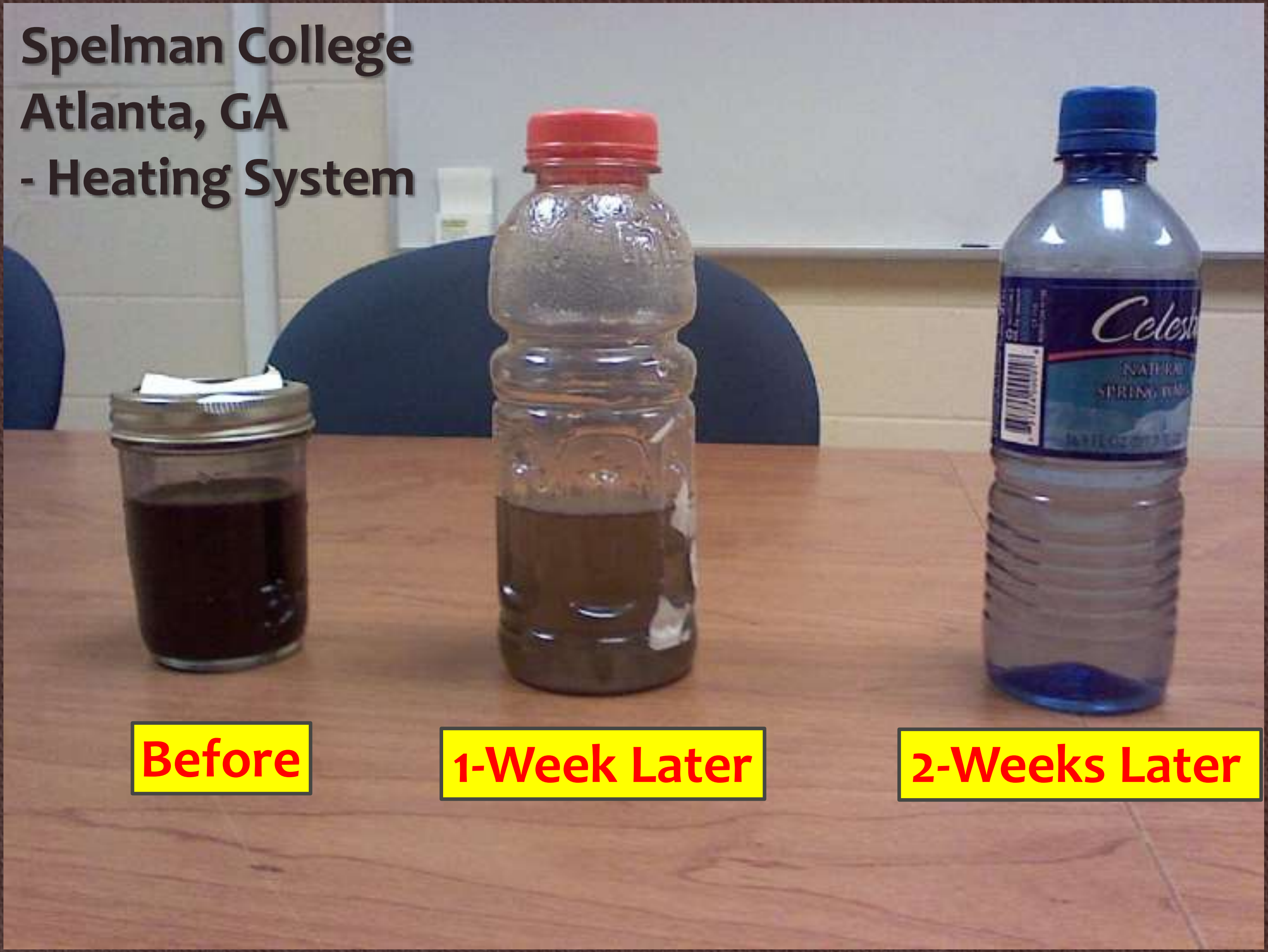
Maintenance requirements?

- Ball Valve needs to be opened periodically. Frequency depends on water clarity/quality.
- Typically done in a short period of time - weeks or within a couple months depending on system size
- No media replacement (filters/cartridges/sand)
- Blowdowns can be automated by timer/BAS


Automated Blowdown


CHW BLOWDOWN VLV
AF24-SR US
BELIMO
CW

Dirt In Hydronic Systems



Oscar G. Johnson V.A. Medical Center
Iron Mountain, Michigan

- 6th floor heating system before 9/18/14 and after 10/29/14 results

Oscar G. Johnson V.A. Medical Center
Iron Mountain, Michigan

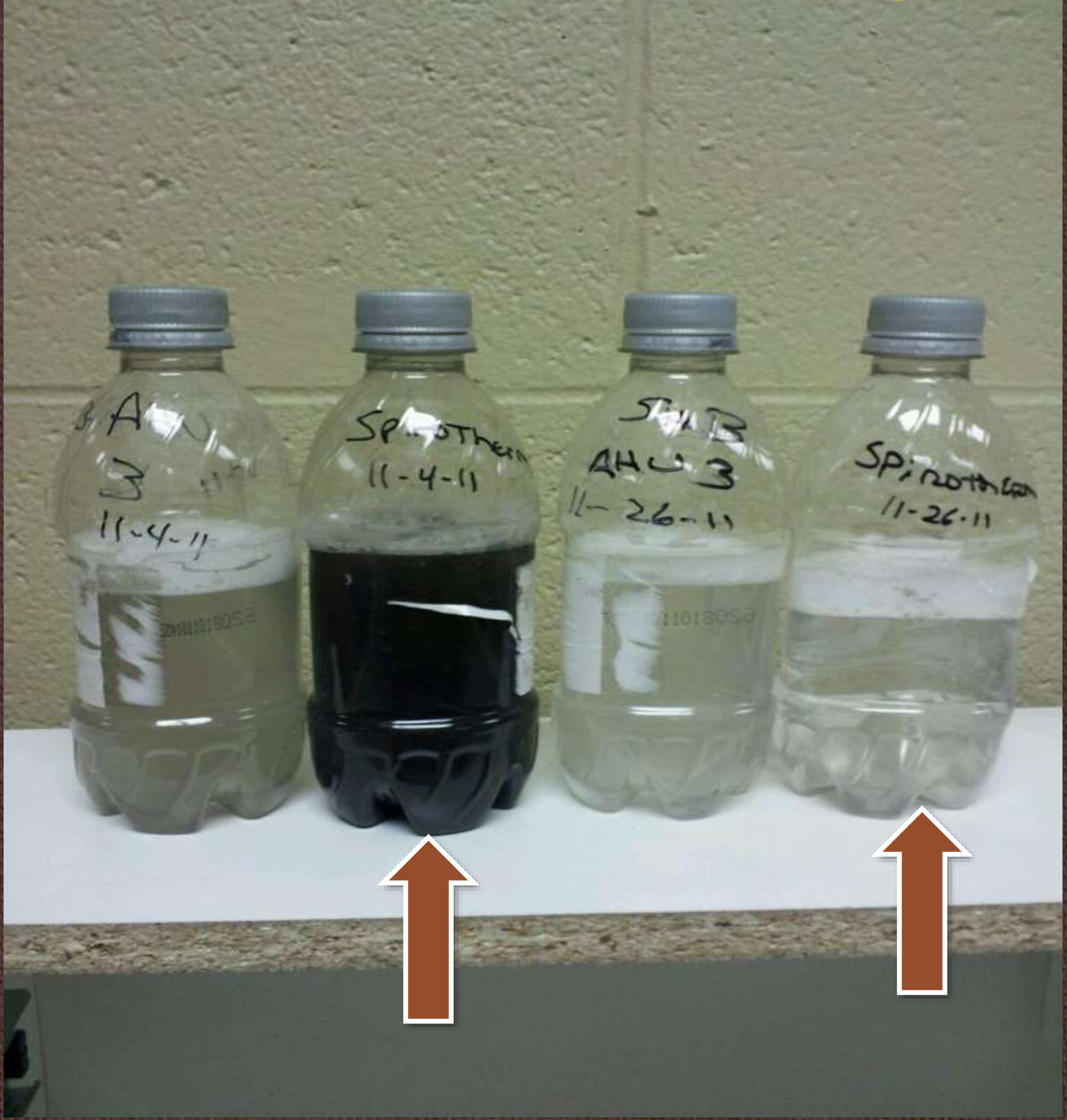
- System Fluid showing settled particulate after 5 days of non-operation


6/17
6/22/15
11:00 SWRS
6/22
1:30
10:15 SW
6-24

DIRT SEPARATION PERFORMANCE

Before **After**

St. Joe Hospital Chilled Water - Michigan

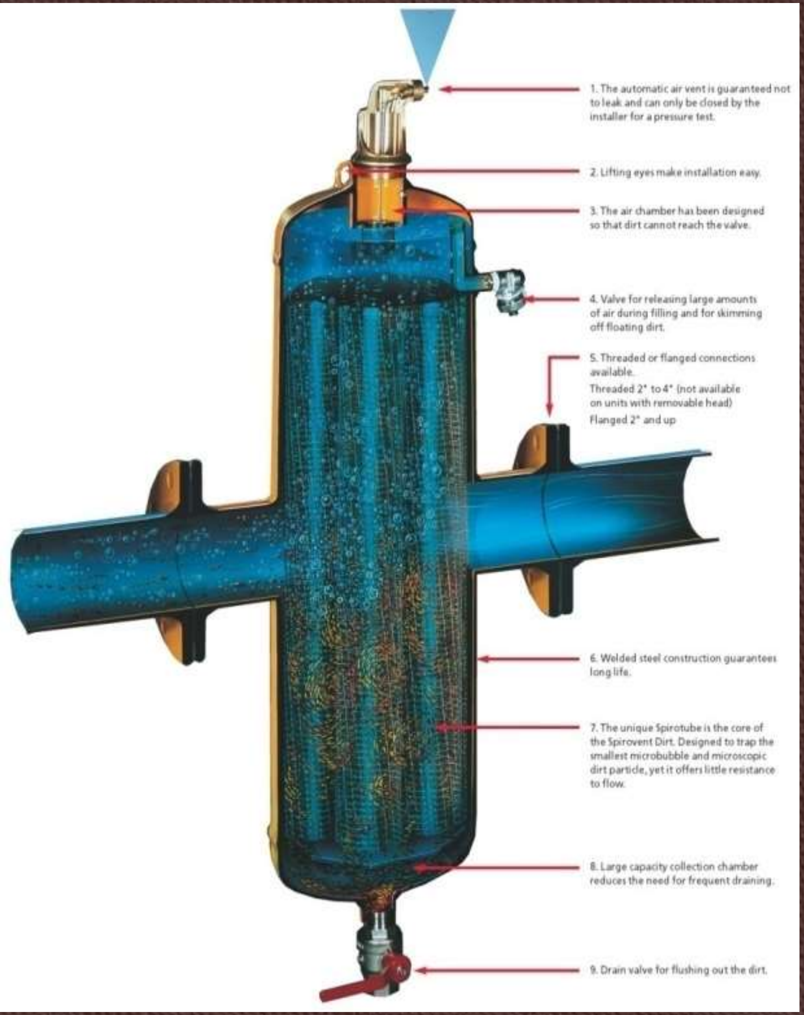


University of Wisconsin Milwaukee

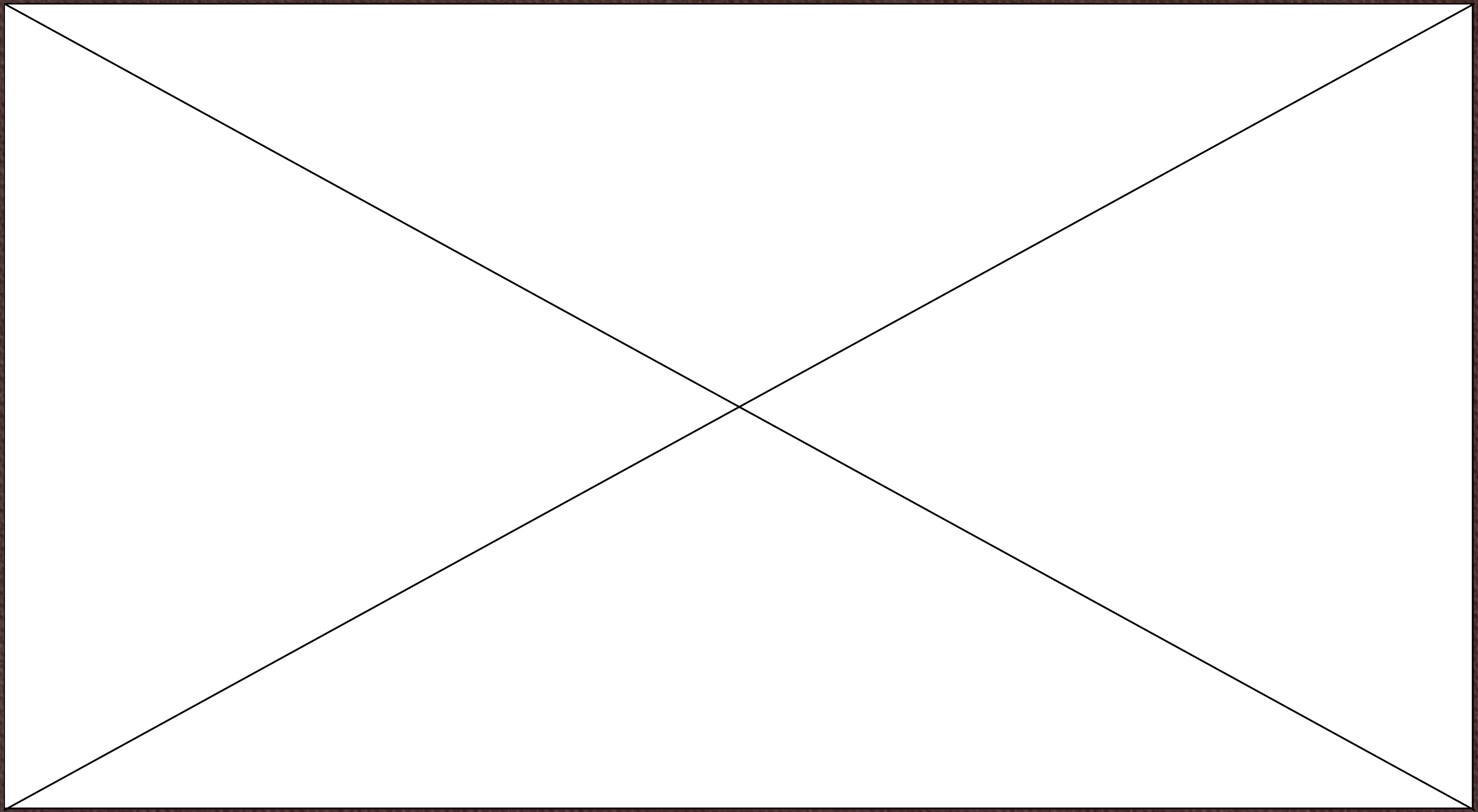
Dealing With Air & Dirt

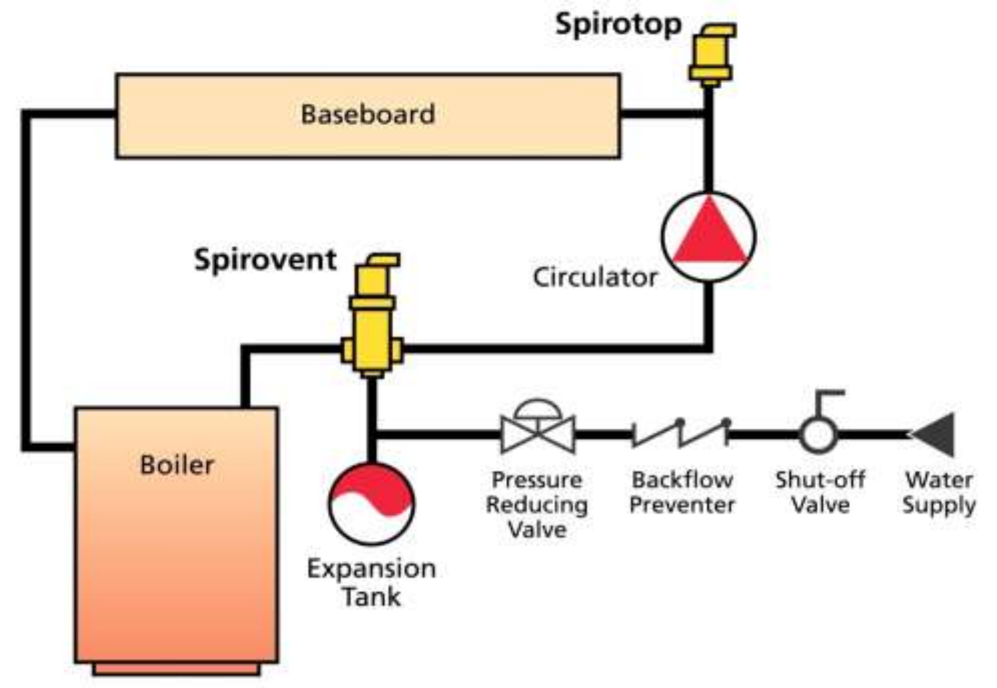
- Combination Air & Dirt Unit Addresses both issues with one vessel

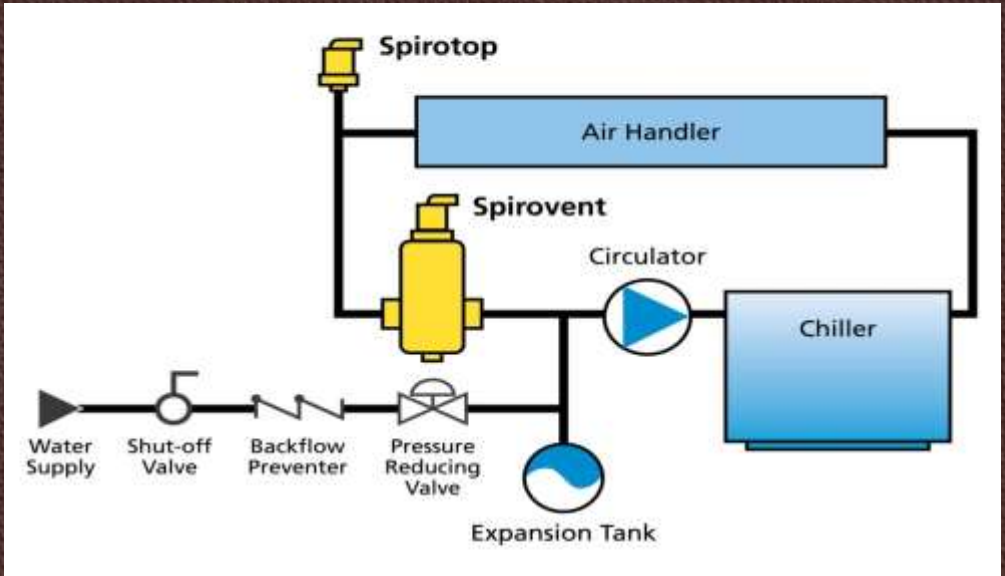
- Should be mounted at the point of lowest solubility = Highest temperature & lowest pressure

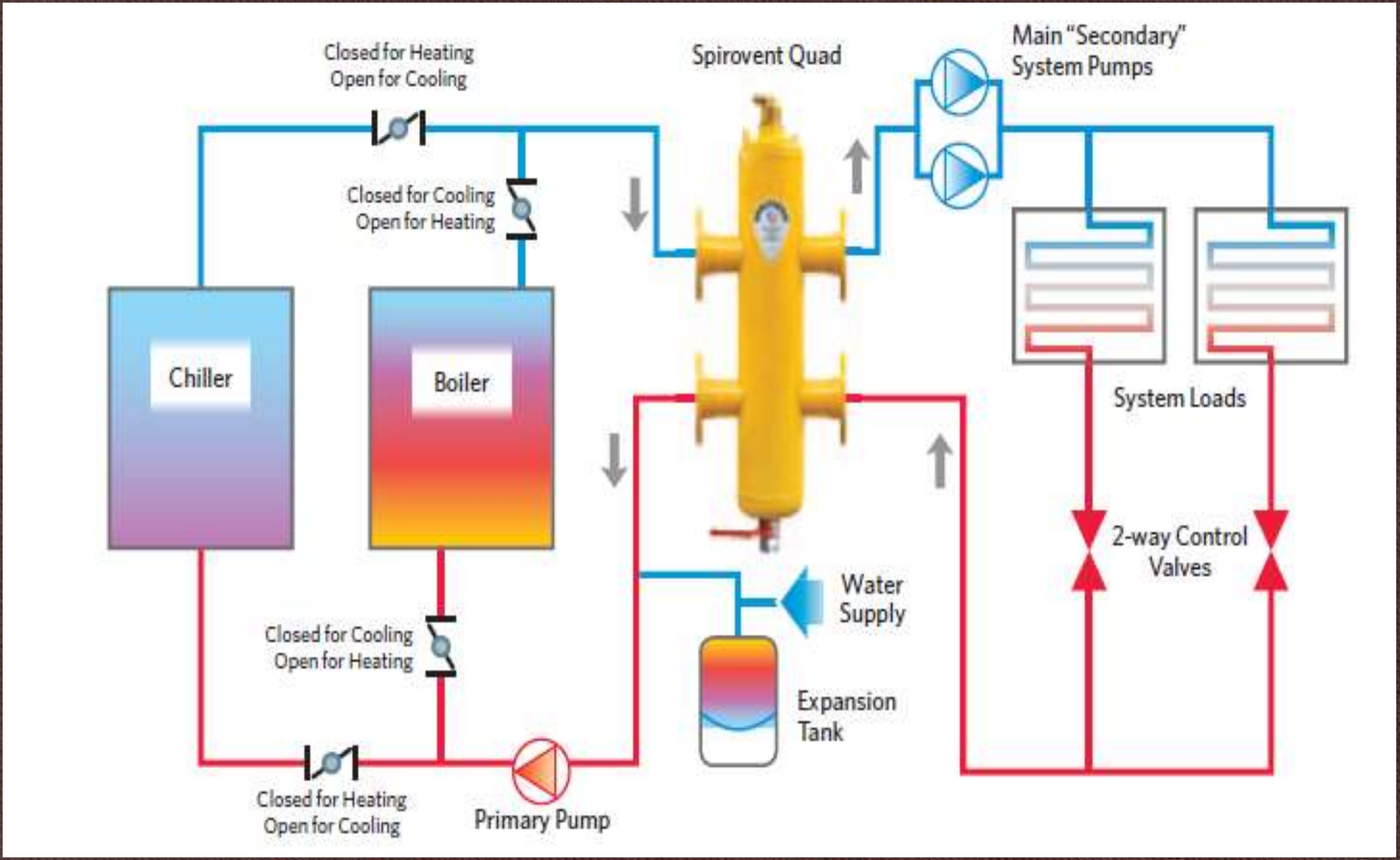


AIR / DIRT COMBINATION

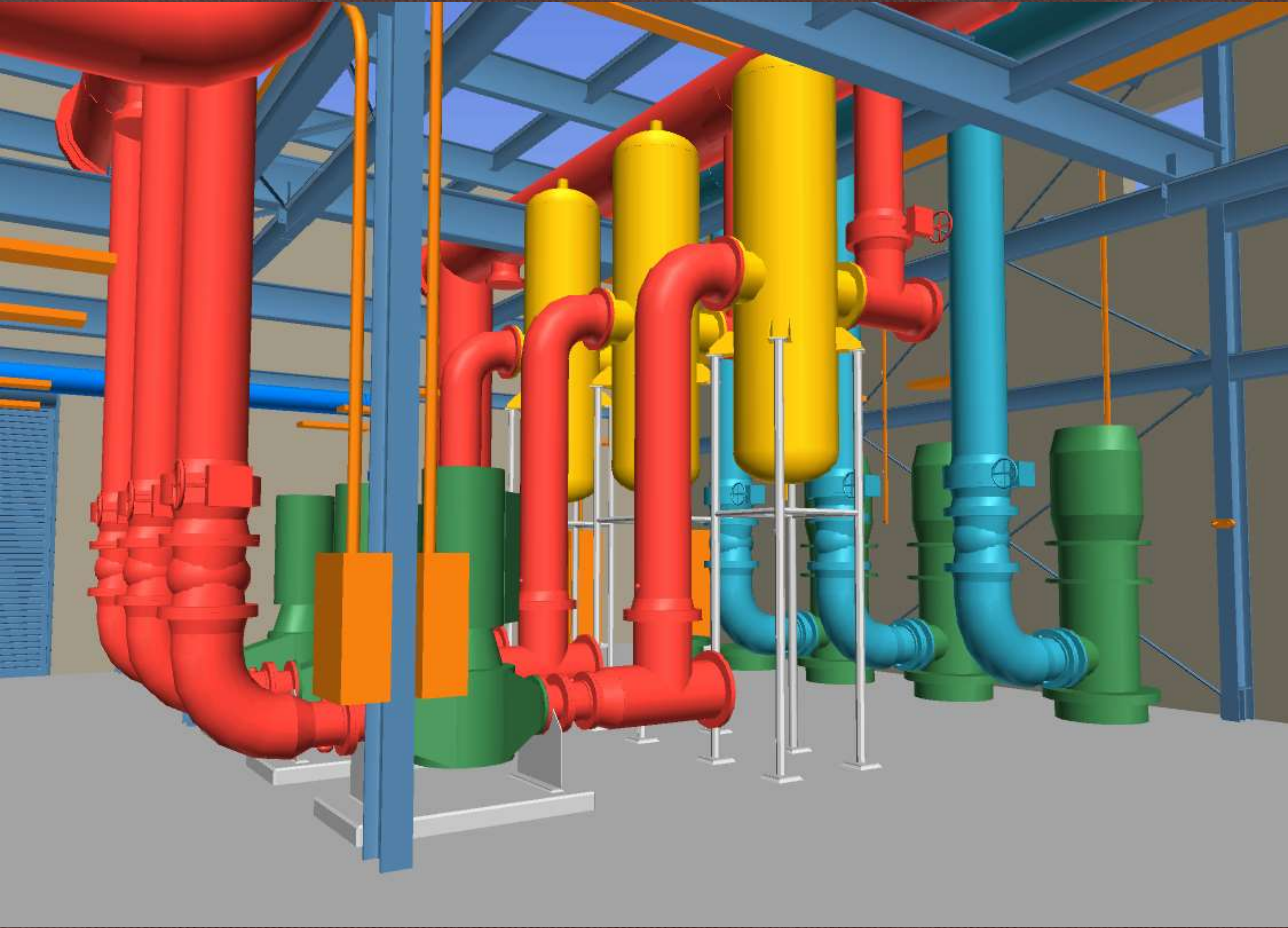



Spirotop
Baseboard
Spirovent
Circulator
Boiler
Pressure Reducing Valve
Backflow Preventer
Shut-off Valve
Water Supply
Expansion Tank


Spirotop
Air Handler
Spirovent
Circulator
Chiller
Water Supply
Shut-off Valve
Backflow Preventer
Pressure Reducing Valve
Expansion Tank


Closed for Heating
Open for Cooling
Spirovent Quad
Main "Secondary"
System Pumps
Closed for Cooling
Open for Heating
Chiller
Boiler
System Loads
2-way Control
Valves
Water
Supply
Closed for Cooling
Open for Heating
Expansion
Tank
Closed for Heating
Open for Cooling
Primary Pump

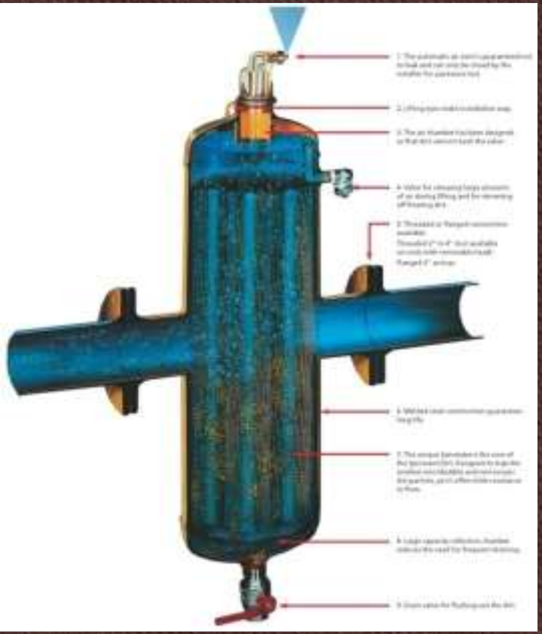
- Meriter Hospital – Madison, WI
- A little tight?!?
- If not enough space, then what?




Genie

Dealing With Air & Dirt

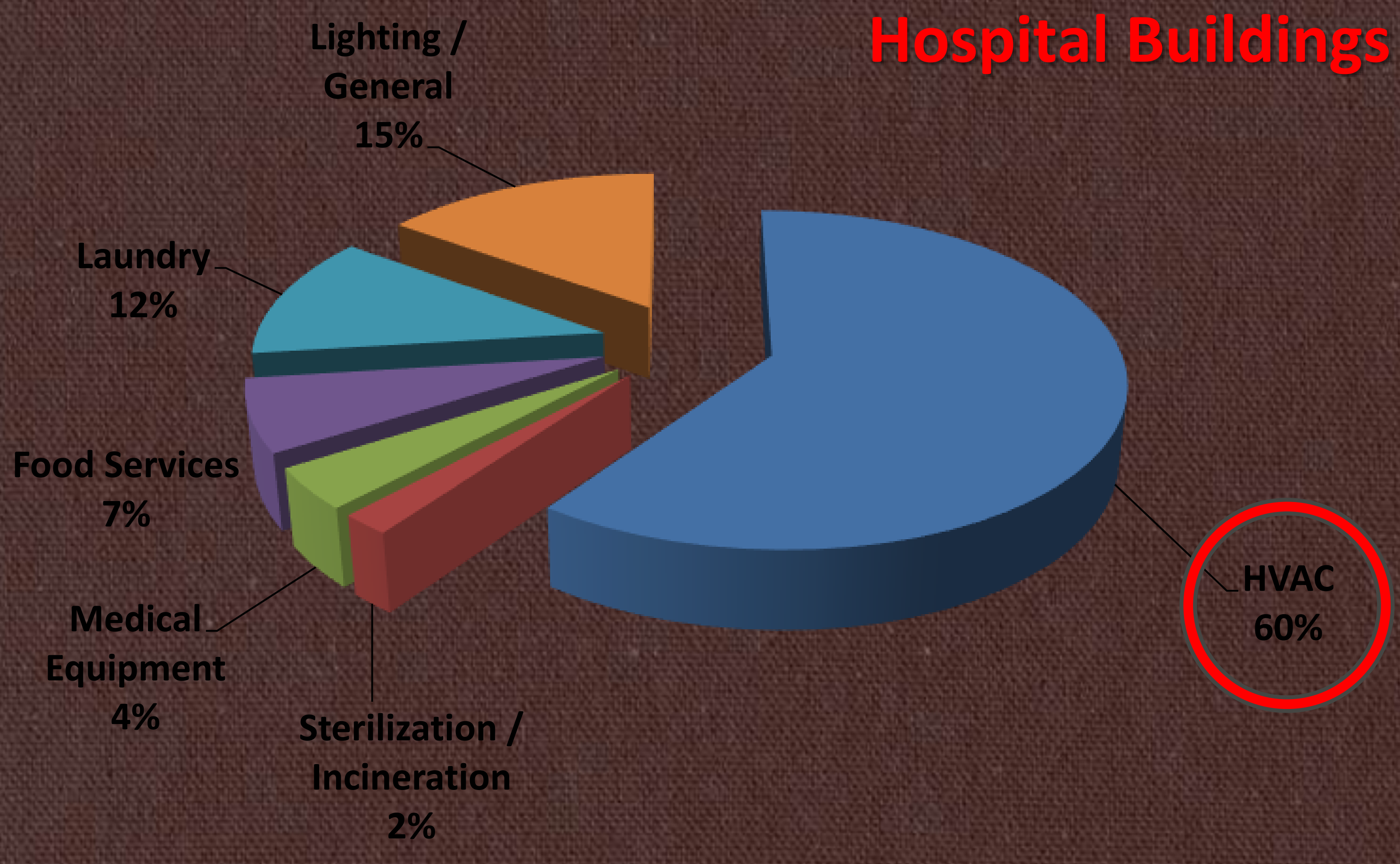
- What We've Learned So Far…
  - Air Insulates
    - Prevents Maximum Thermal Energy Transfer
  - Air is Compressible
    - System Flows are Compromised
  - Air is 21% Oxygen
    - Oxidation in Piping Leads to Dirt and Debris
  - Dirt is "Liquid Sandpaper"
    - Shortens Life Expectancy of System Components
  - Dirt Collects at Various System Points
    - Reduces System Flow and Heat Transferability



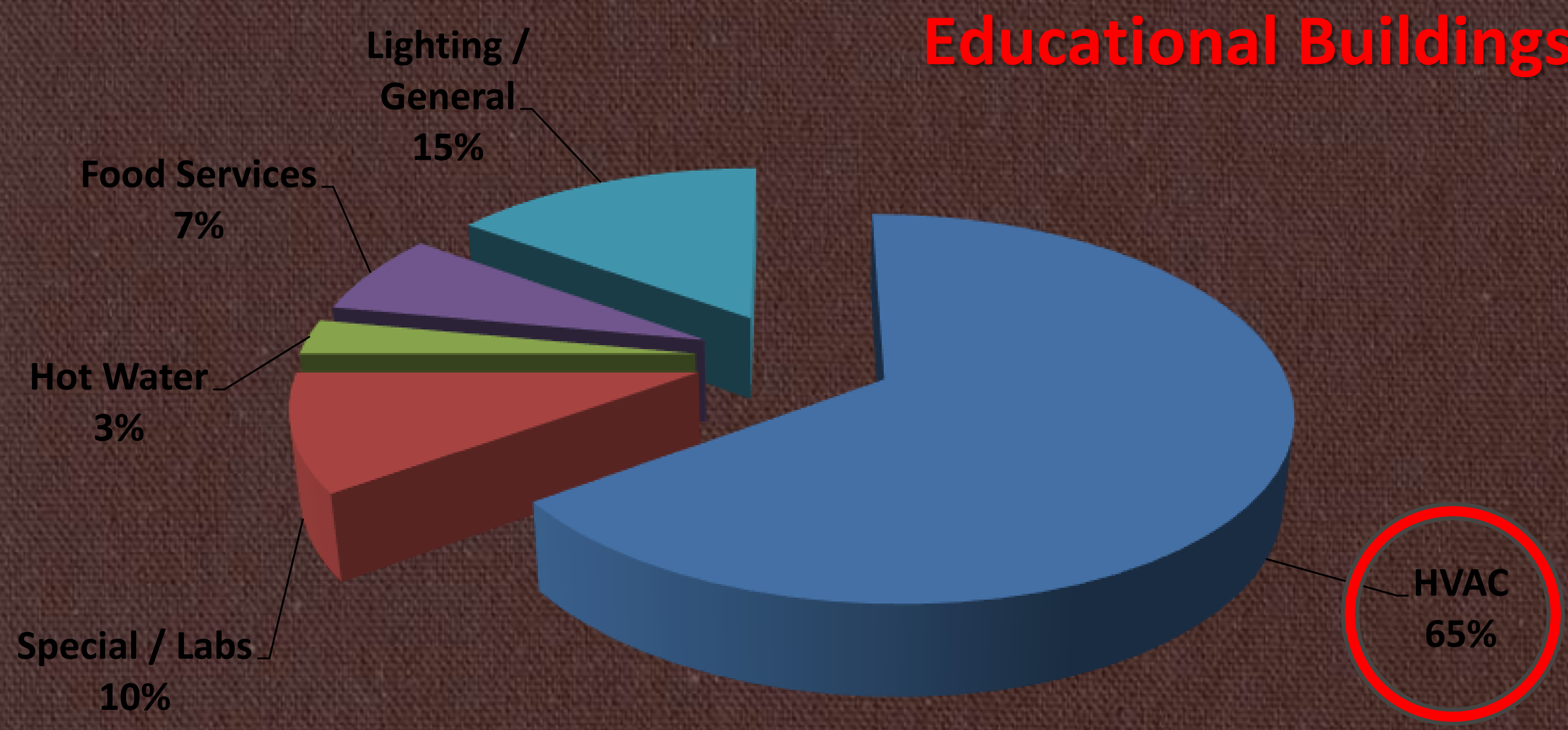
Demonstration Time!!!

- Not Hollywood quality
- Like a concert… not the same experience as being there and seeing close up!

Energy Consumption



Energy Consumption



CHILLER PERFORMANCE IMPROVEMENT

Youngstown State University

Case Study

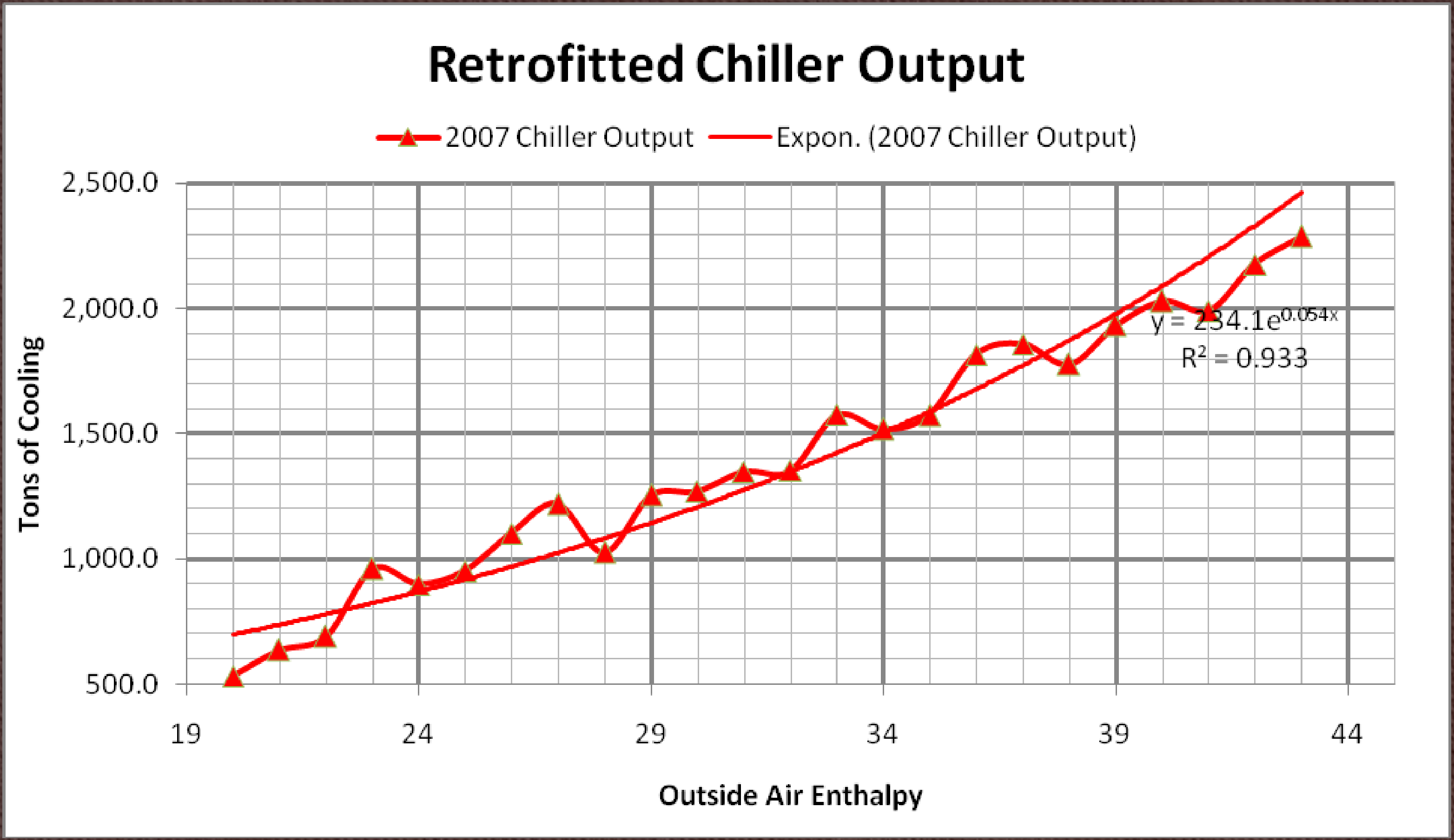
SCOPE

- (3) 1200 Ton York Chillers
- (3) 250 HP Chilled Water Pumps
  - Max Design Flow = 8,640 GPM
- Variable Frequency Drives
  - Set at 6,500 GPM
  - System Presently Requires Constant Flow
    - (Future Plans For Variable Flow)
- Chiller Output Variable

EXISTING AIR SEPARATOR

- Conventional Centrifugal Type
- Installed on Return to Pump Header
- 16" Line Size
  - Rated for 8,000 Max Flow
  - Max Flow = 40% Efficiency
- Part of Plant Retrofit Early '07

EXISTING DATA



NEW AIR / DIRT SEPARATOR

- Coalescing Type
  - Customized to Meet Height Constraints
- 20" Line Size (Required to Handle Max Design Flow)
  - Rated for 9,400 Max Flow
  - At Max Flow
    - 100% Free Air Eliminated
    - 100% Entrained Air Eliminated
    - Up to 99.6% Dissolved Air Eliminated
  - Installed June '08

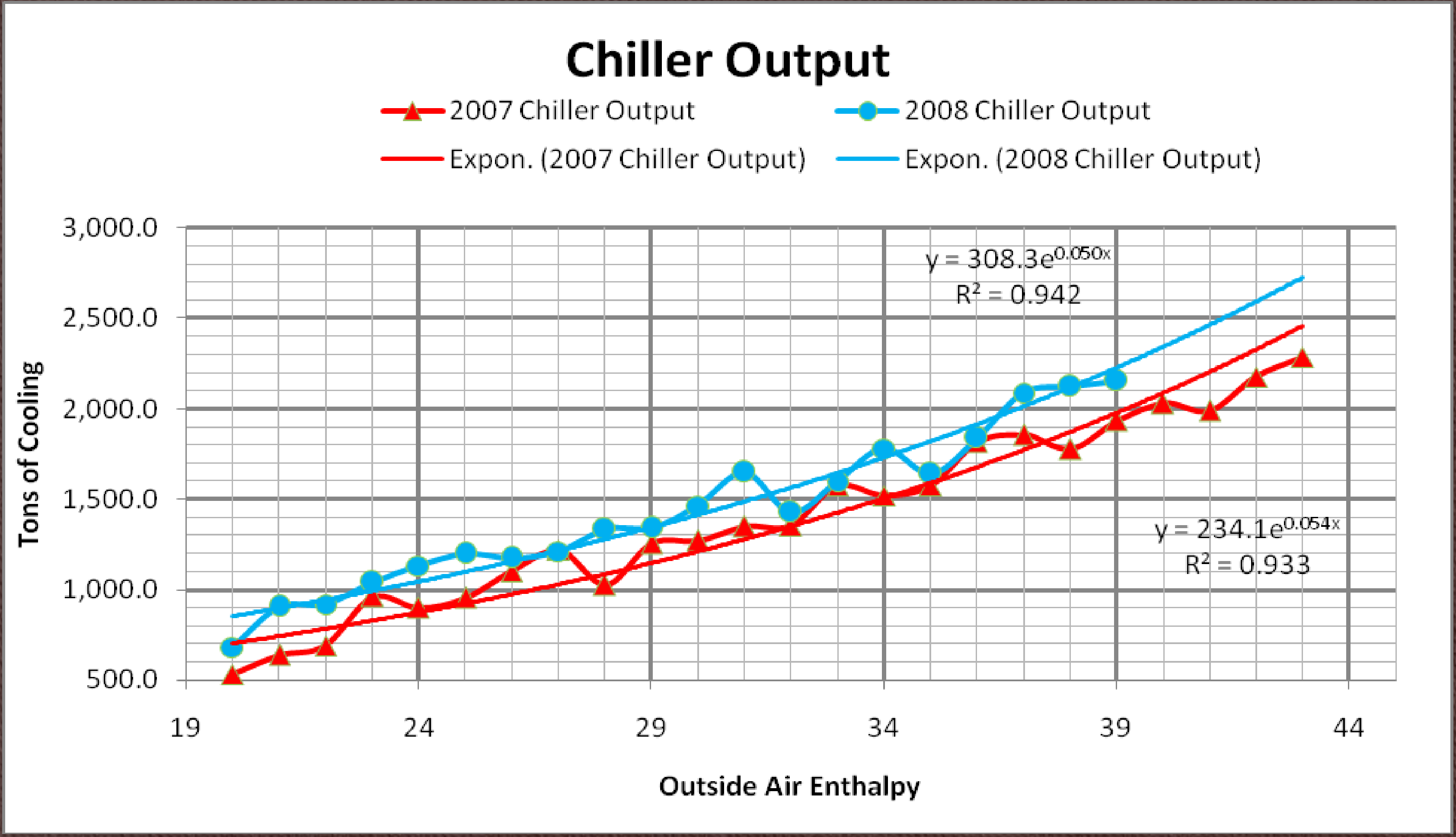
ADDITIONAL FEATURE

- Dirt Separator Function
  - 80% of All Dirt and Sediment 30 Microns and Larger Removed Within 100 Passes
- Cost Effective Adder Eliminating Need for Sidestream Filters

ANTICIPATED BENEFITS

- Coalescing type air/dirt separator
  - High Efficiency Air and Dirt Separation
  - Improved System Performance
    - Increased Output
    - Δ T At Chiller
    - Discharge Air Temperature (DAT)
  - Energy Savings
  - Short Anticipated Payback

NEW DATA



Chiller Output
2007 Chiller Output
2008 Chiller Output
Expon. (2007 Chiller Output)
Expon. (2008 Chiller Output)
y = 308.3e^0.050x
R² = 0.942
y = 234.1e^0.054x
R² = 0.933
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
Tons of Cooling
19
24
29
34
39
44
Outside Air Enthalpy

RESULTS

- Chiller Plant Output
  - From 2300 Tons to 2700 Tons (15.9%)
- Δ T At Chiller
  - Increased From 8.5° F to 10° F
  - 10° F Peak Performance per York
- DAT At Furthest Point On Campus
  - Improved From 65°F to 58.5°F

ENERGY SAVINGS

- If Variable Flow & Constant Output
  - Old Separator
    - 6500 GPM / 2300 Tons = 2.83 GPM / Ton
  - New Separator
    - 6500 GPM / 2700 Tons = 2.41 GPM / Ton
  - 2300 Tons x 2.41 GPM = 5543 (85.3%)
  - Head Reduced to 72.7%
  - Pump Power Reduced to 62.1%
  - 37.9% kWh Savings

HOW?

- The Pump Affinity Laws
  - Flow Could Be Reduced to 85.3%
  - Head Changes By The Square
    - Less Flow = Less Resistance
    - $.853^2 = .727$
  - Energy Changes By The Cube
    - Less Flow / Less Resistance = Less HP
    - .727 x .853 = .621
  - Savings = 37.9%

SAVINGS ESTIMATE

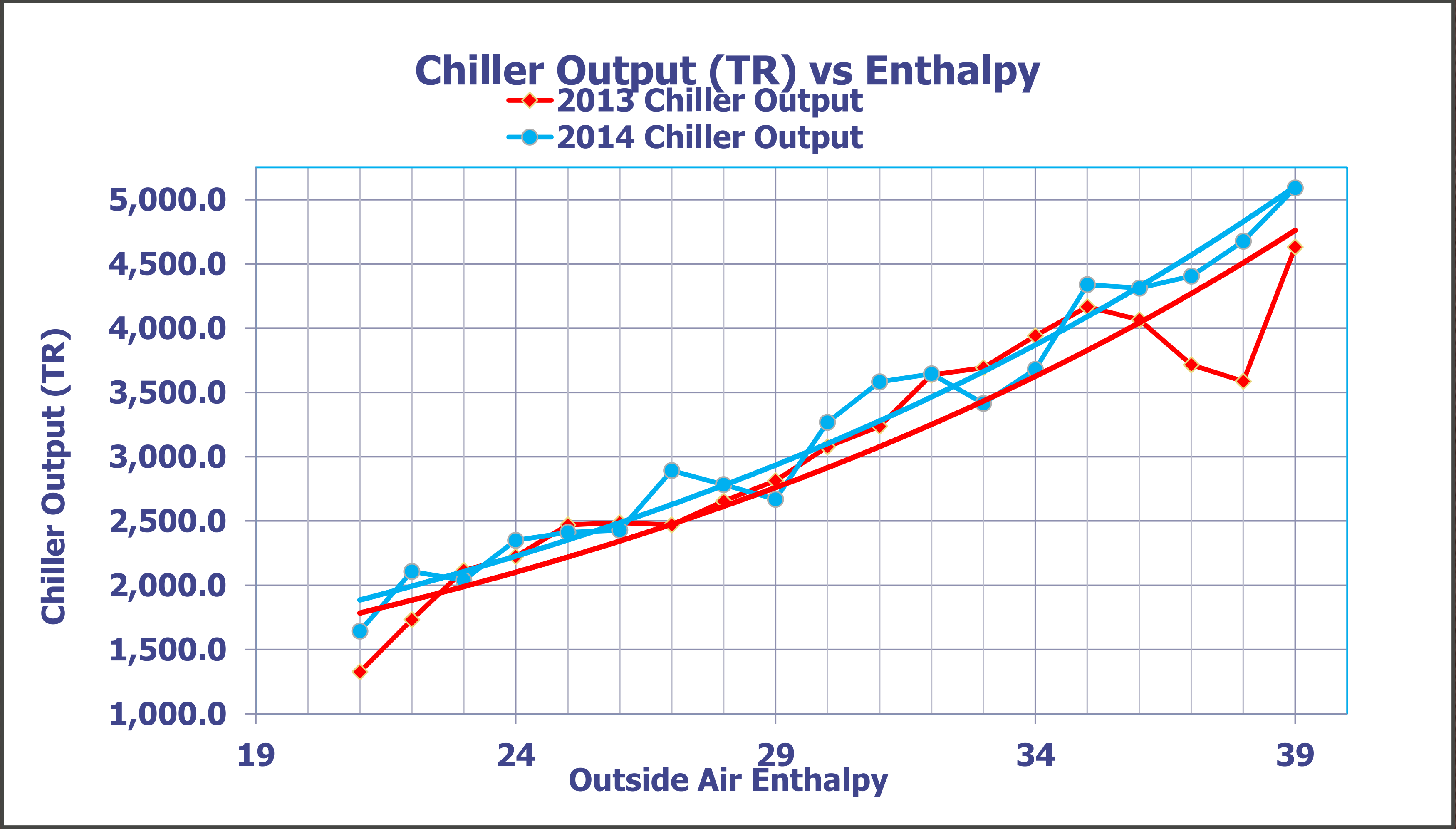
- (3) 250 HP Pumps
  - Set at 6500 GPM (75.2% of Design)
    - Calculates to 106 HP per pump
  - 1774 Average Operating Hours per Pump
    - 3 Pumps @ 106 = 318 HP x .7457 kW / HP = 237.13 kW
    - 237.13 kW x 1774 = 420,669 kWh
  - $0.075 kWh = $31,550. Operating Cost
    - @ 62.1% (previous slide) = $19,593.
  - Annual Savings = $11,957.

PAYBACK ESTIMATE

- Separator Cost = $35,300.
- Installation Cost = $35,000.*
  - *Weekend / Overnight Premium & Pre-Fab
- Total = $70,300.
- Payback
  - $11,957. / 12 = $996. / monthly savings
  - $70,300. / $996. = < 6 Years

EASE OF RETROFIT

U. of Akron – Preliminary Results



SF | SANTA FE COLLEGE

Gainesville, FL

- **Campus Chilled water system**
- **Project goal:**
  - Add Coalescing Air Separator in existing central plant to:
    - Remove air pockets from the system piping
    - Eliminate air noise in AHU's
    - Improve heat transfer efficiencies
- **Results:**
  - No more reported air problems
  - System running very quiet; gauges not "jumping"
  - Formerly 2-3 pumps typically required; now typically 1-2 pumps (except at peak load intervals)
  - Reduced Differential Pressure switch setting from 24# to 14#
    - Variable speed pumping has 23.1 less feet of head to overcome!

WAUKESHA MEMORIAL HOSPITAL
Waukesha, WI

- Significant dirt problems in existing ChW system
- 480 Man hours spent on dirt/air related issues
- Coalescing Air-Dirt separator added
- **RESULTS**:
  - Chemicals added during season down 85%
  - No further clogging of induction coils
  - Recurring Maintenance time down significantly
  - Energy Impact as Measured on Peak load days:
    - Before: VFD’s ran on average at 90% during peak load days
    - After: VFD’s ran at 70% during peak load days
      - 22% decrease
    - Apply pump affinity laws ($.78^3$) = .474

    Impact would be approx. 52.6% less kWh cost

North Memorial Health Care – MN

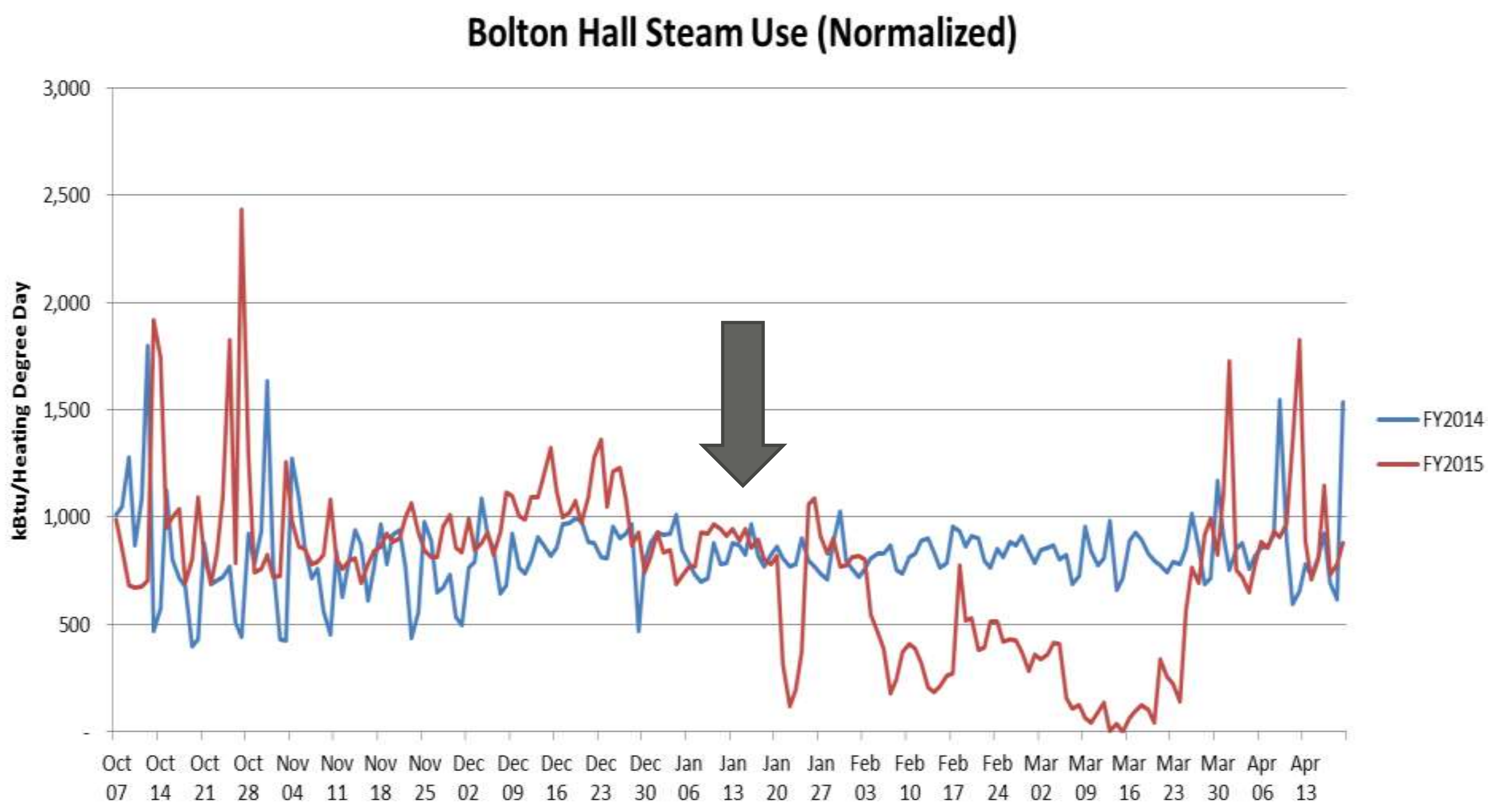
- Problems with the Chilled water system:

- Many ½” three-way & two-way control valves plugged up at induction units.
- Side stream filters and magnets were added to clean up the chilled water and protect induction units.
- Chiller Start up typically required 1 -2 days to purge air

- Coalescing air/dirt separator installed in 2002. Observations:

- Less time spent cleaning strainers and filters.
- Problems with control valves stopped
- Chiller Start up - 1 hour spent purging air.

University of Wisconsin Milwaukee



3 options

- NO Air Separator + -
- Standard (Centrifugal/Tangential) Air Separator + -
- Coalescing High Efficiency + -

In conclusion

- Address the root cause and not the symptom !

- Trickle down effect resulting in
  - Less maintenance time/cost
  - Systems running at peak efficiency
  - Energy saved with better heat transfer

Questions

*** Live Demonstration can be shown at your location ***

www.spirotherm.com