How Water and Steam Systems; Basic Principles, Ongoing Commissioning, Operation, and Optimization

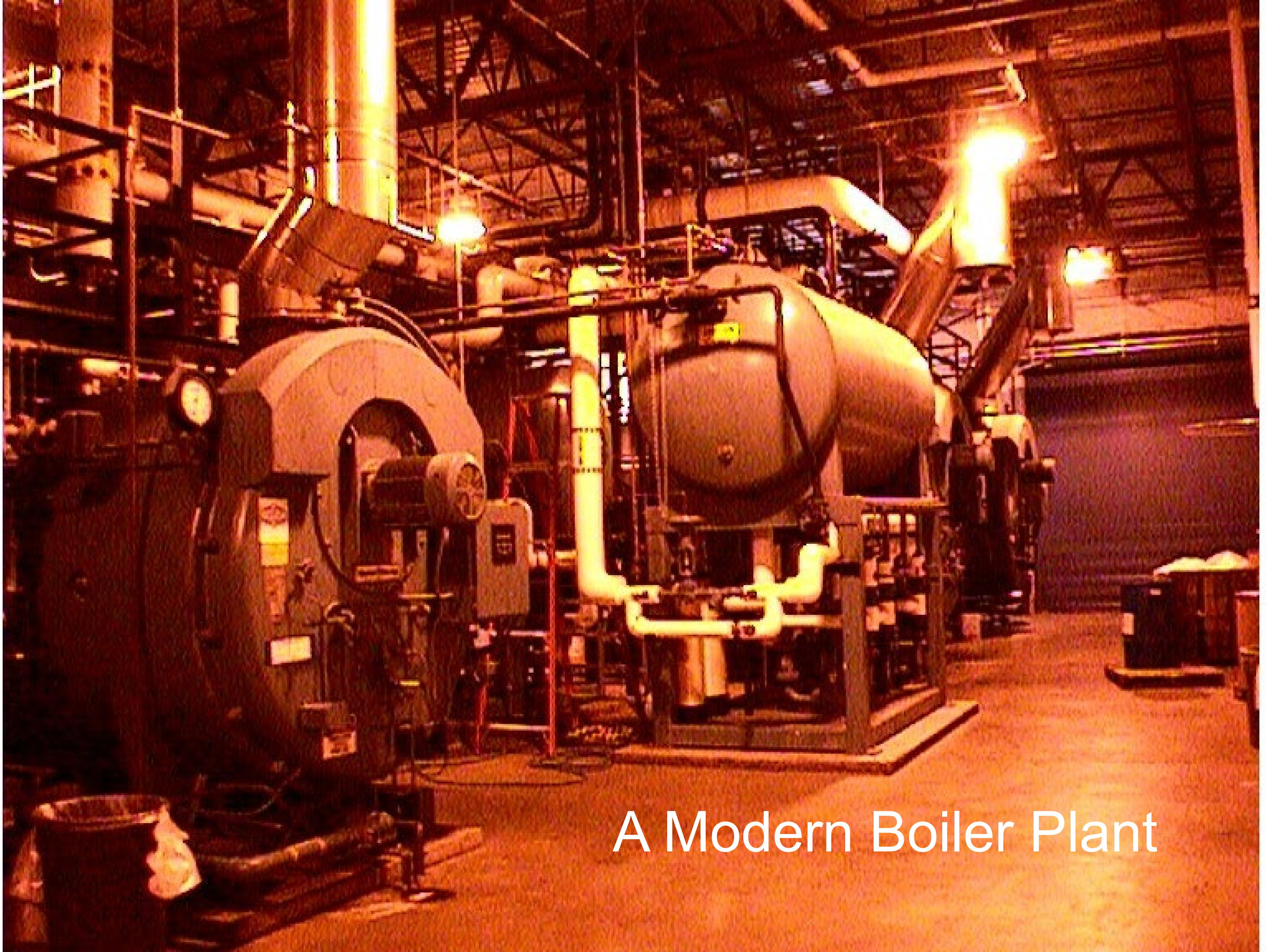
How We Generate Heat in Buildings

Presented By:
David Sellers
Senior Engineer, Facility Dynamics Engineering

Your Basic Boiler Plant

Your Basic Boiler Plant

https://tinyurl.com/SaturatedSystemsP4PotBoils


A Modern Boiler Plant


A Really Big Modern
Boiler Plant

The Steam Drum

The Combustion Air Fan


Combustion Air and
Fuel Control Linkages

Adjustable Cam and Follower for the Modulating Gas Control Valve

Flue Gas Energy Recovery System

The Process Control Graphic

The Heat Recovery Pumps

The Heat Recovery Heat Exchangers

The Flue Gas Condensate Pumps

Steam and Condensate

They go hand in hand

- Condense a pound of steam, gain a pound of condensate
  - Condensate needs to return to the plant
    - Gravity and pipe pitch
    - Pumps

The Combustion Process

Steam and Condensate

They go hand in hand

- Condense a pound of steam, gain a bunch of energy

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O + \text{Heat}$$

Since air is more than just Oxygen, what happens to the other stuff?

Steam and Condensate

They go hand in hand

- Condense a pound of steam, gain a bunch of energy

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O + \text{Heat}$$

What would happen to boiler efficiency if we condensed this water vapor?

Steam and Condensate

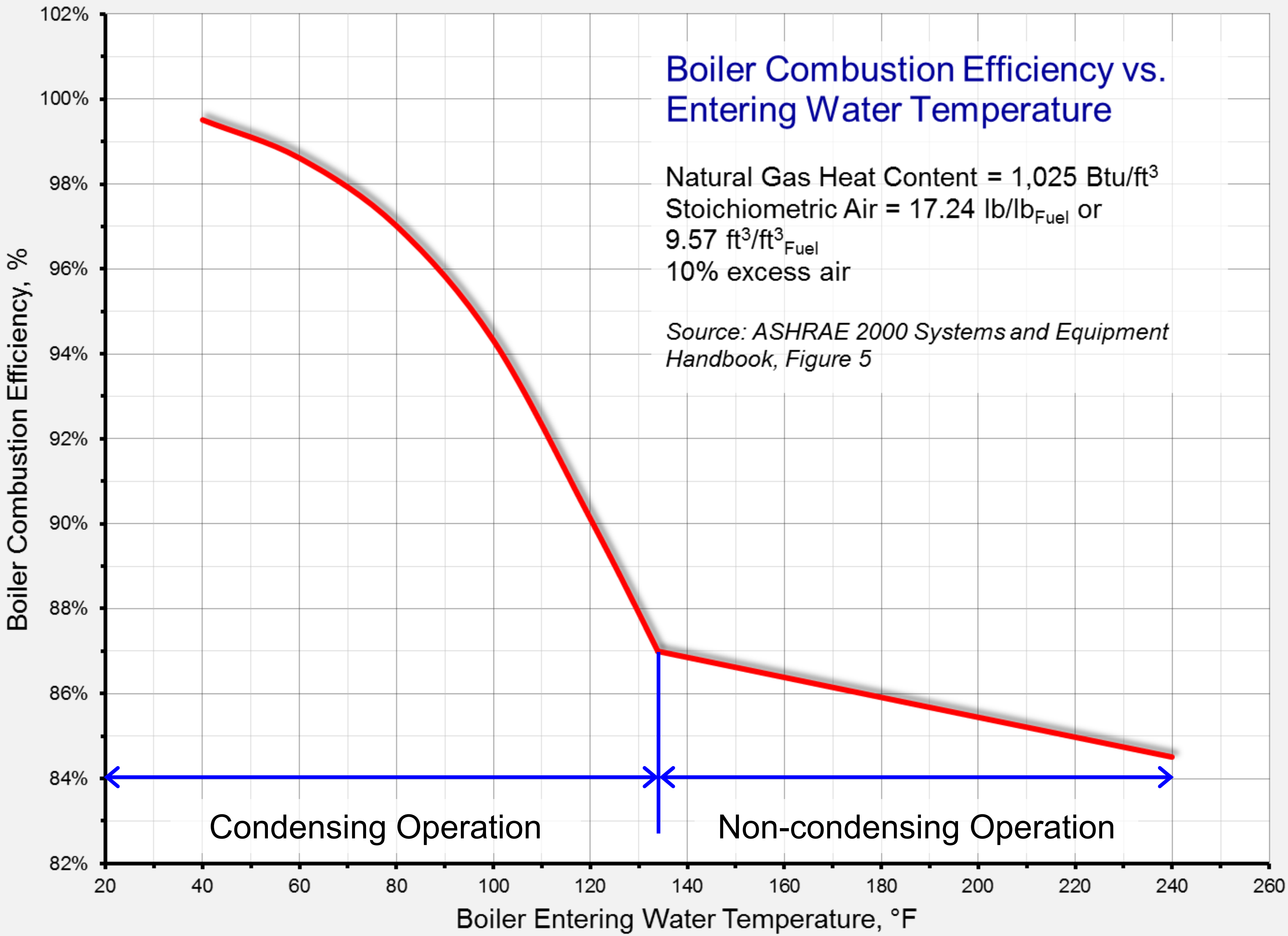
They go hand in hand

– Condense a pound of steam, gain a bunch of energy

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O + \text{Heat}$$

How do we get the water vapor to condense?

Combustion Efficiency

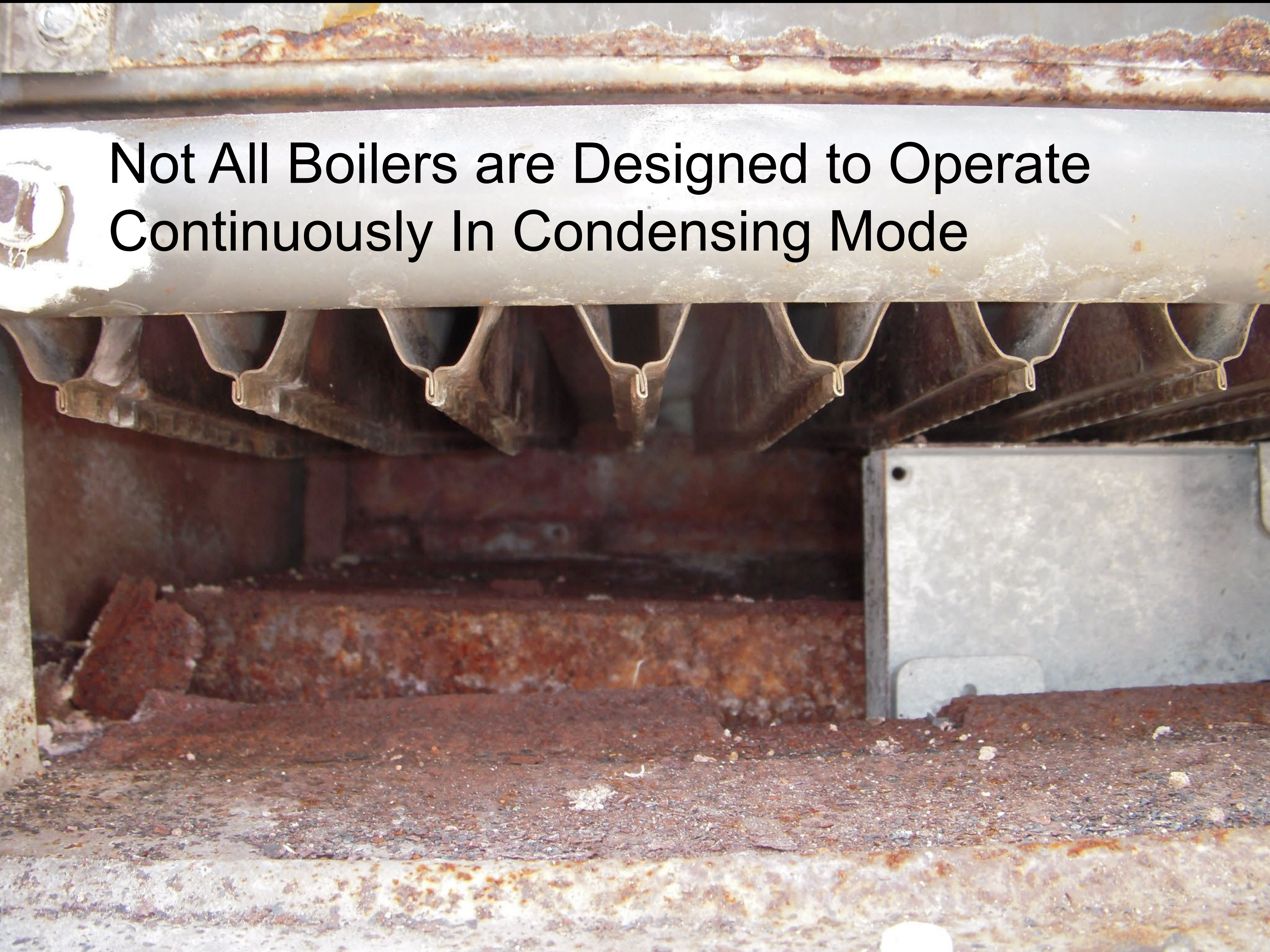


Boiler Combustion Efficiency vs.
Entering Water Temperature
Natural Gas Heat Content = 1,025 Btu/ft^3
Stoichiometric Air = 17.24 lb/lb$_{Fuel}$ or
9.57 ft^3/ft$^3_{Fuel}$
10% excess air
Source: ASHRAE 2000 Systems and Equipment Handbook, Figure 5
Condensing Operation
Non-condensing Operation
Boiler Combustion Efficiency, %
Boiler Entering Water Temperature, °F
102%
100%
98%
96%
94%
92%
90%
88%
86%
84%
82%
20
40
60
80
100
120
140
160
180
200
220
240
260

All Boilers are Condensing Boilers …

… at some point in their operating cycle

Not All Boilers are Designed to Operate Continuously In Condensing Mode

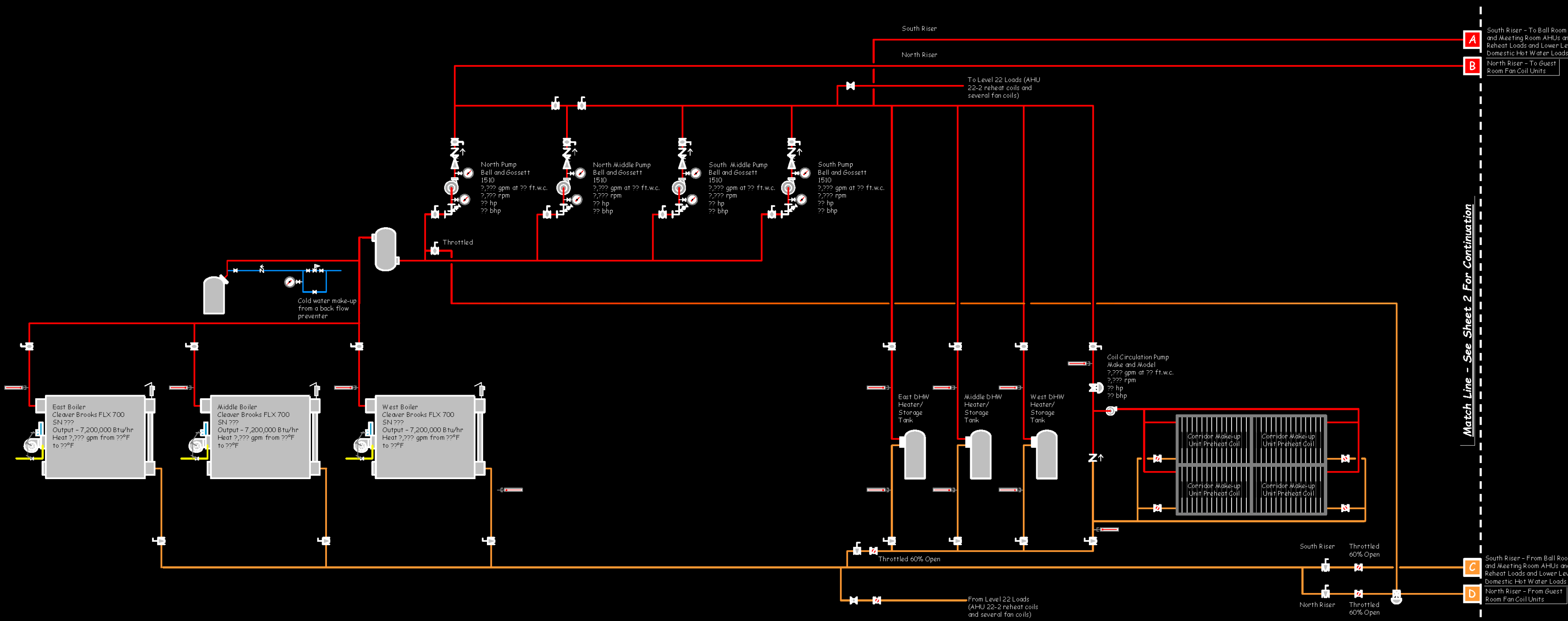


A Boiler Designed to Not Operating in Condensing Mode

Courtesy Christian Weber

An Example

Applying These Concepts



General Note:

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Columbus Hotel
Heating Hot Water System Diagram
2015-11-19
DS

General Building Arrangement

- 22 Floors, 408 Guest Rooms, 485,000 sq.ft.

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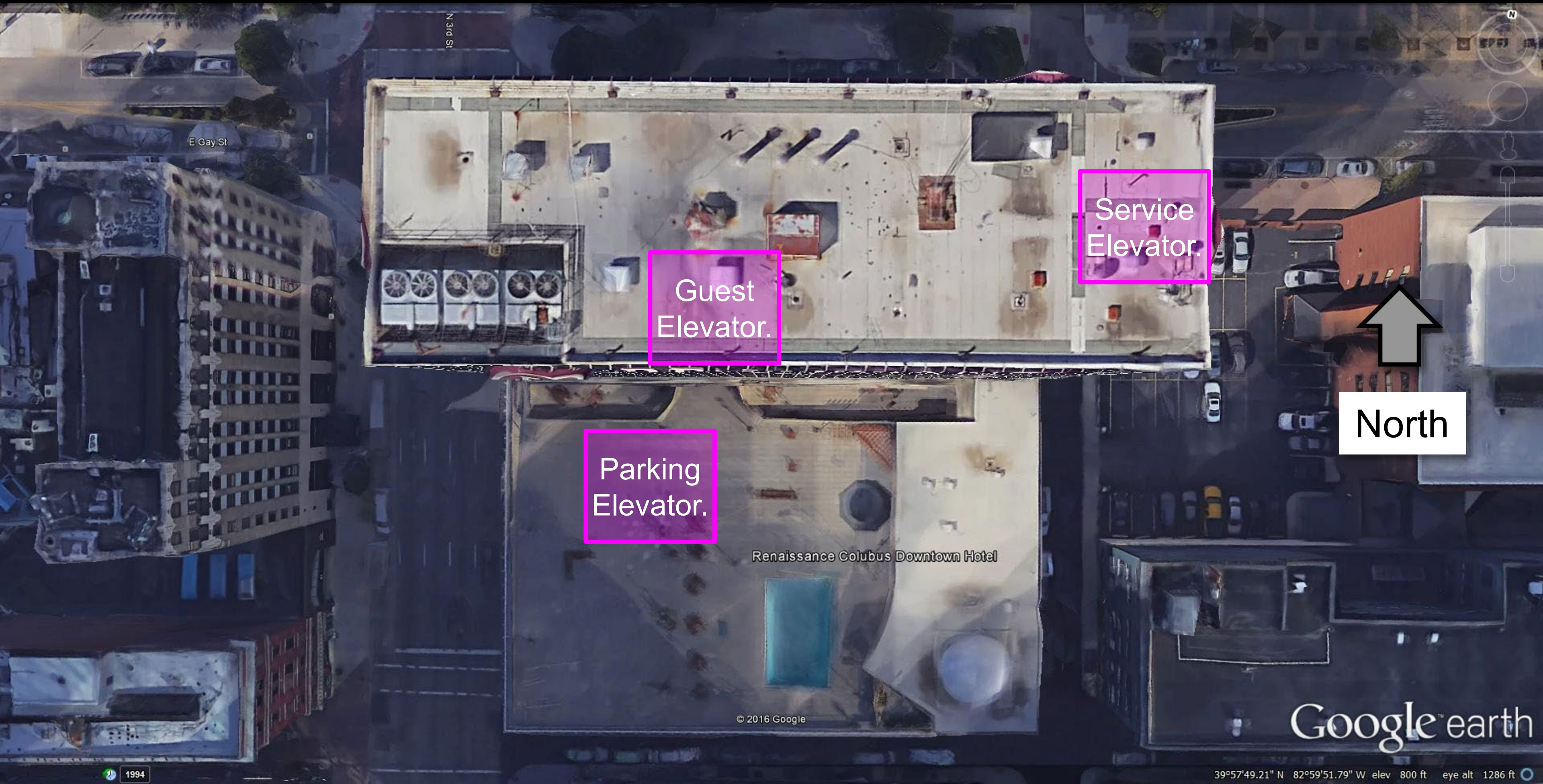


General Building Arrangement

- 22^{nd} Floor – Engineering Office and Major Mechanical Space

General Building Arrangement

- Floor plan Expands at Level 3

General Building Arrangement

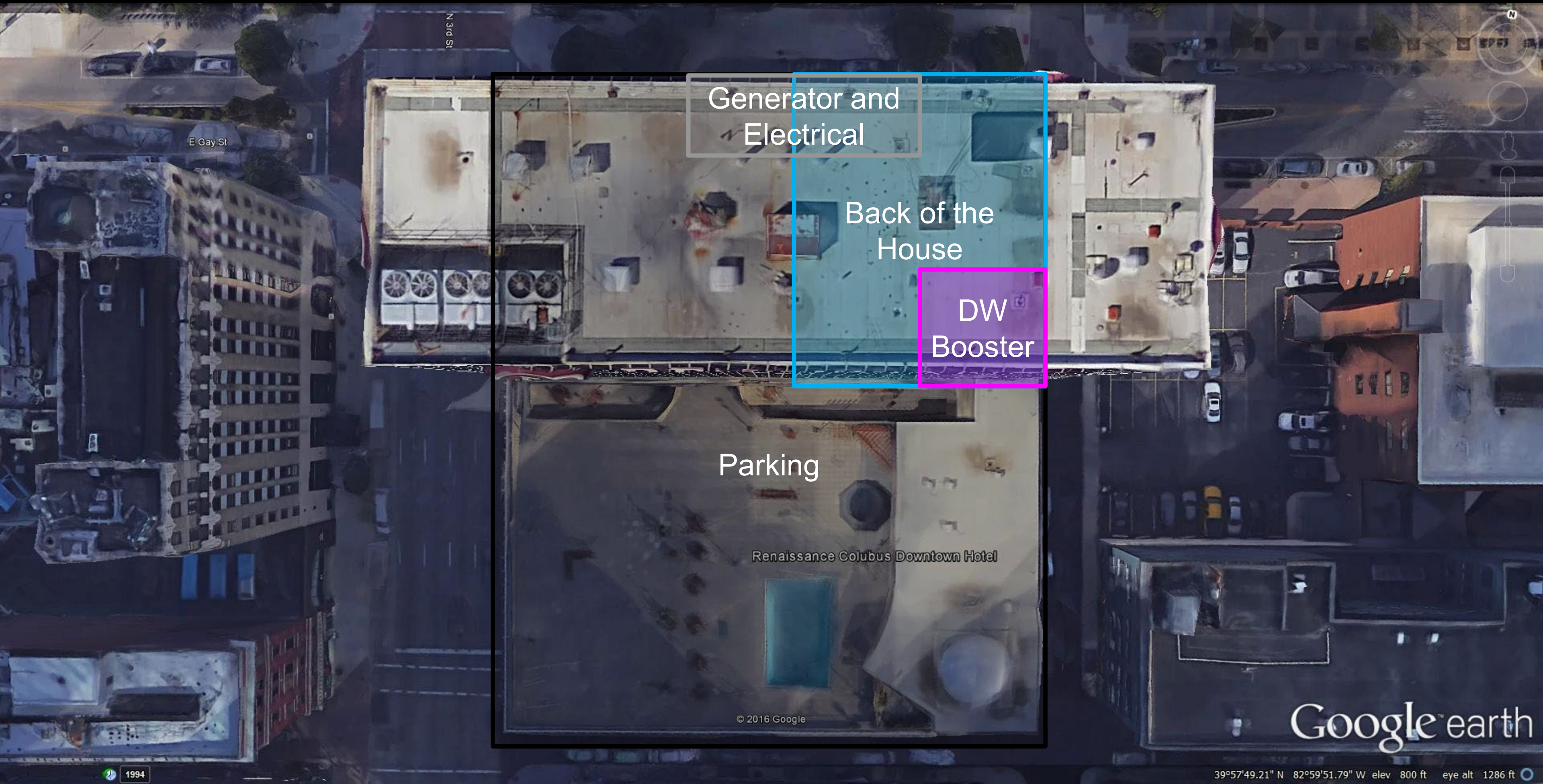
- Note that parallax/perspective/vanishing point makes the top of tower look wider than the bottom

General Building Arrangement

- Three Basement Levels with Parking, Laundry, Lockers, and other "Back of the House" Areas (Level 3 Shown)

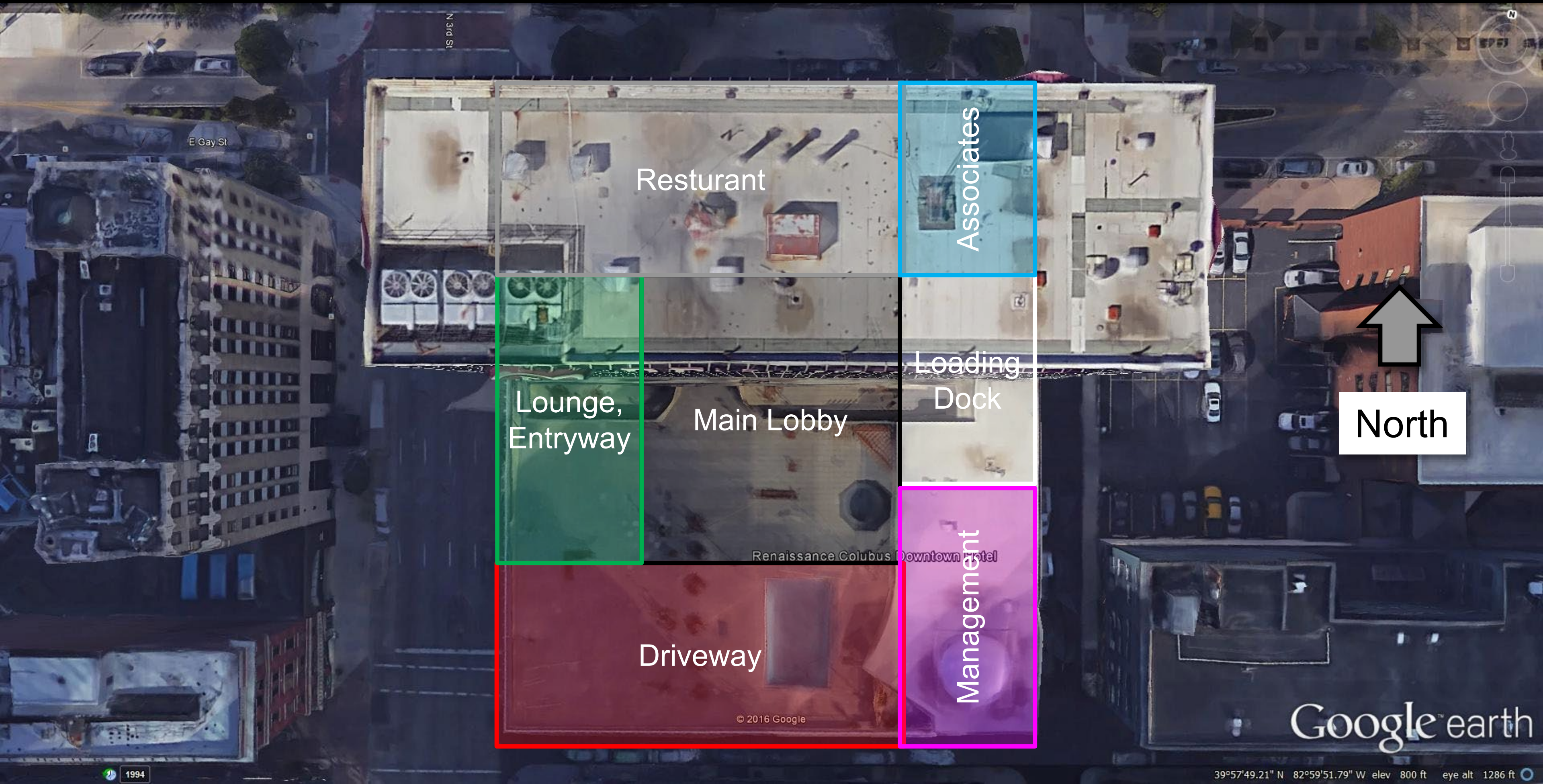
General Building Arrangement

- Three Basement Levels with Parking, Laundry, Lockers, and other “Back of the House” Areas (Level 1 Shown)



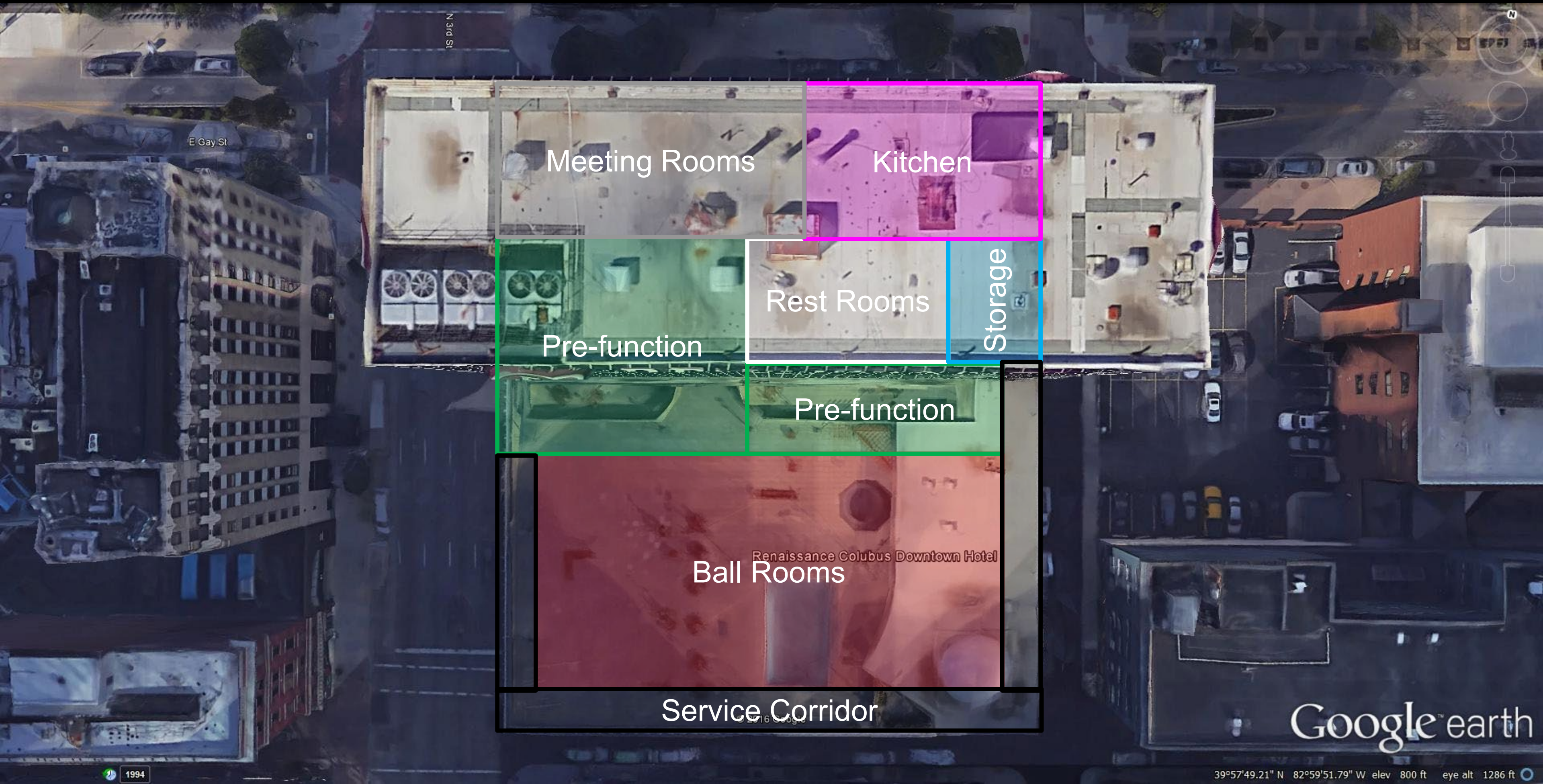
General Building Arrangement

- 1st Floor; Main Lobby, Food and Beverage, Management, Loading Dock



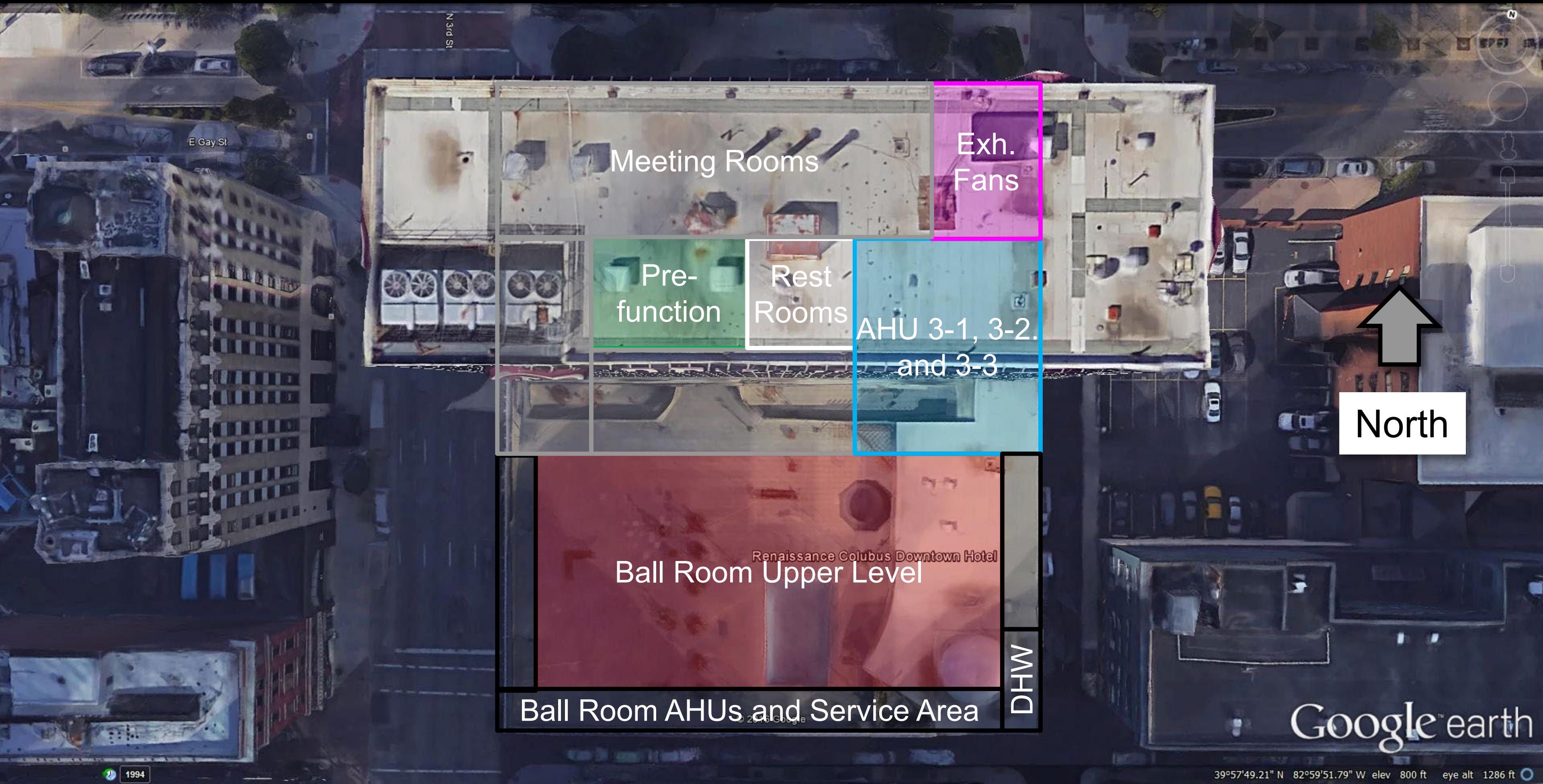
General Building Arrangement

- 2nd Floor; Ballrooms, Pre-function, Meeting Rooms, Kitchen, Storage



General Building Arrangement

- 3rd Floor: Meeting Rooms, Pre-function, Restrooms, Mechanical Space, Ball Room Upper Level, DHW Heaters

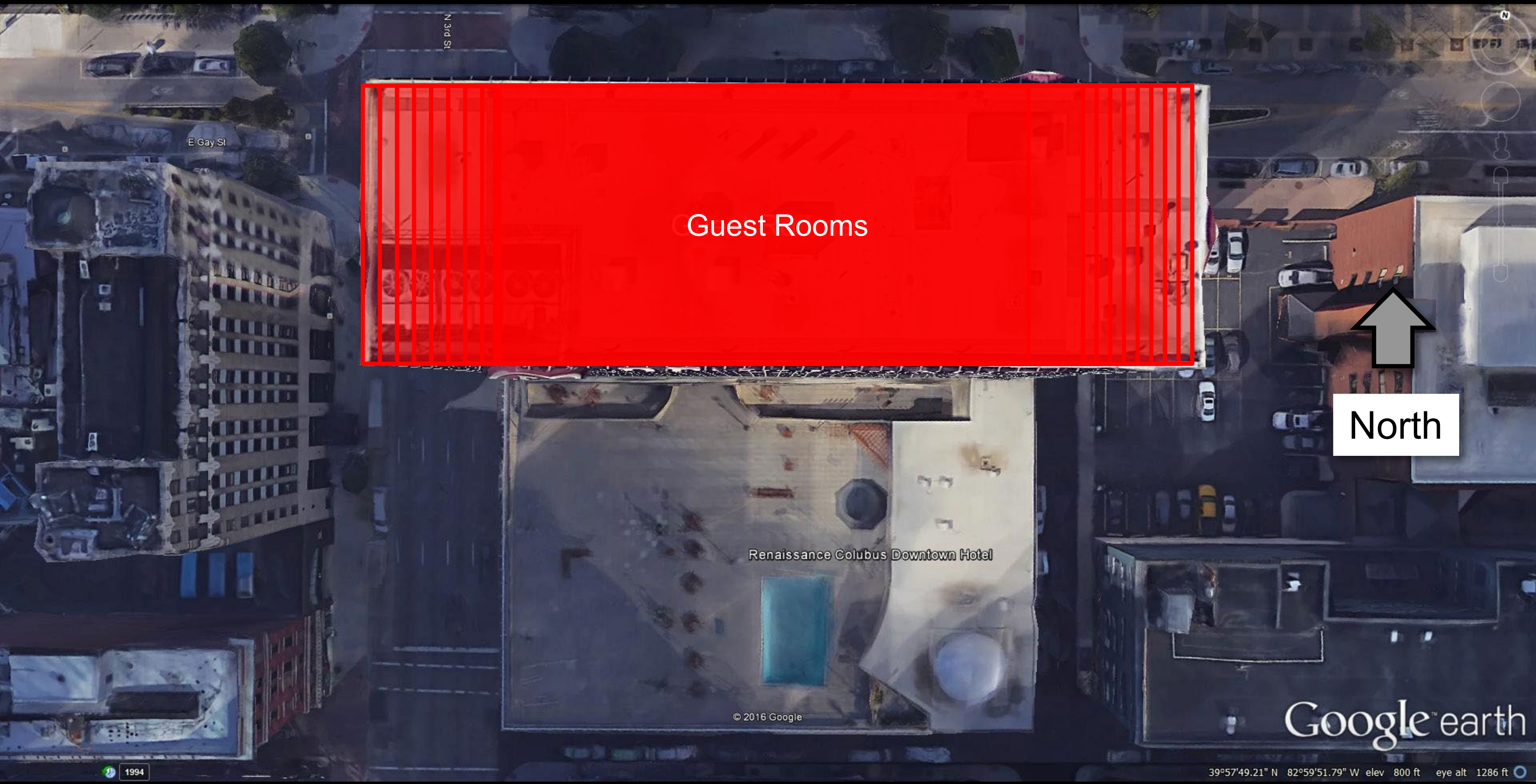


General Building Arrangement

- Guest rooms Start on the 4th Floor

General Building Arrangement

- Guest rooms Start on the 4th Floor



Thinking Through a Condensing Boiler Application

- Existing boiler provide 180°F water running with 550-560°F flue gas temperatures
- Combustion air is entering the burner at 70-80°F
- Annual gas consumption - 2014 basis - 365,139 therms
- Current annual gas cost - 2014 basis - $213,452 per year
- Existing boilers are about to be replaced with condensing boilers
- An EBCx project is about to take place in the facility

1. *What are some of the opportunities?*

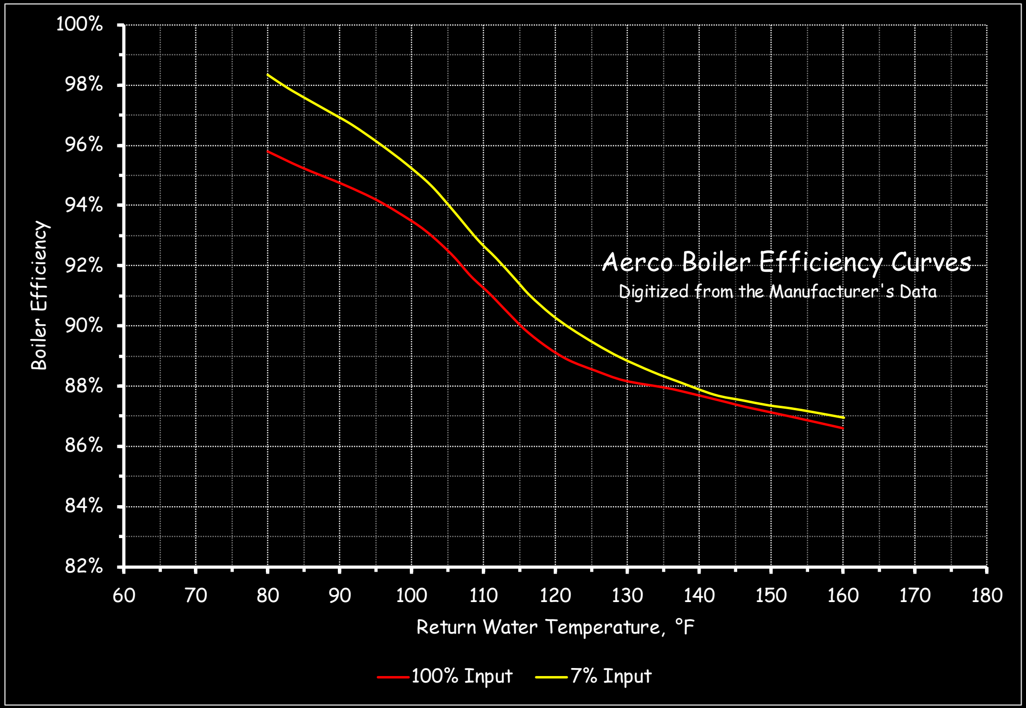
New Boiler Efficiency Curves

New Boiler Efficiency Curves

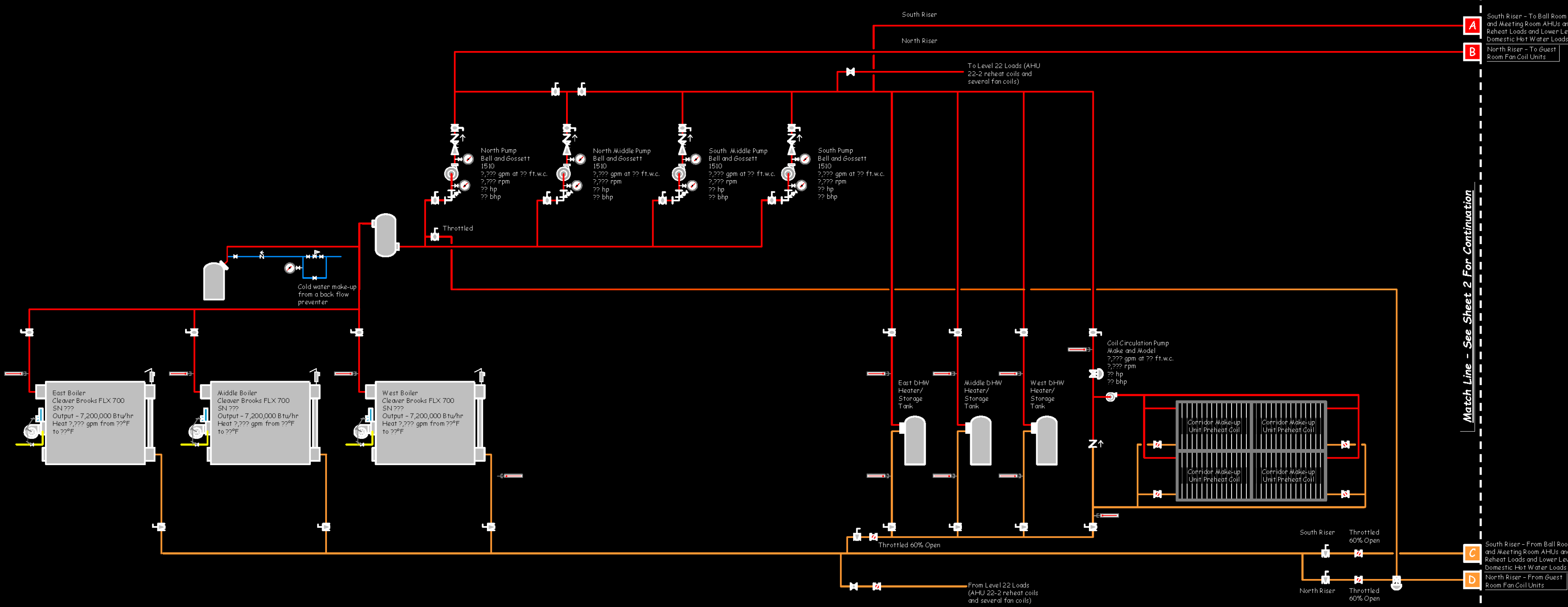
If:

- Current boiler efficiency is in the 75% range
- Current gas cost is in the range of $213,452 per year

Can we project a conservative estimate of the savings to be achieved?



Taking a Closer Look at the System



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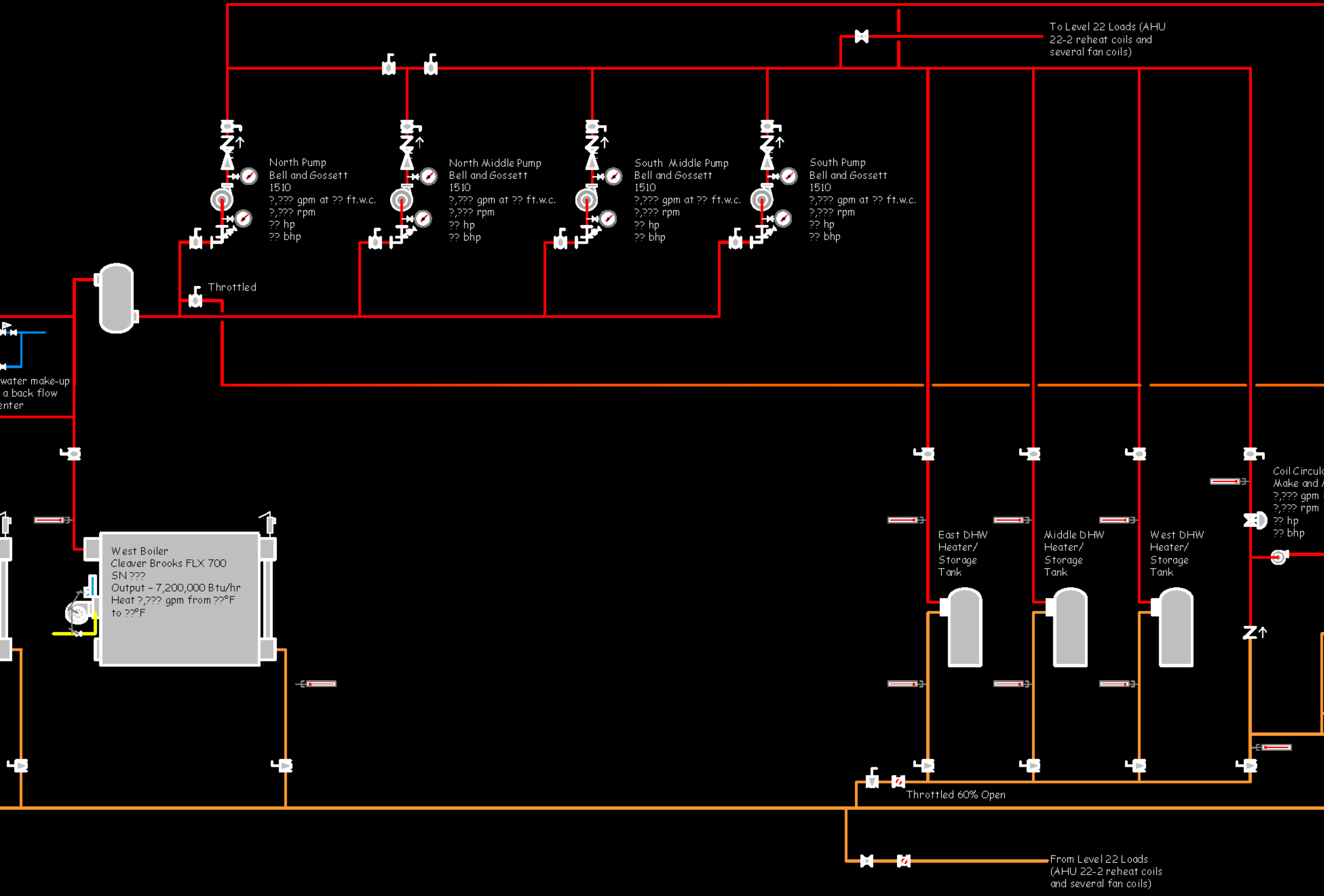

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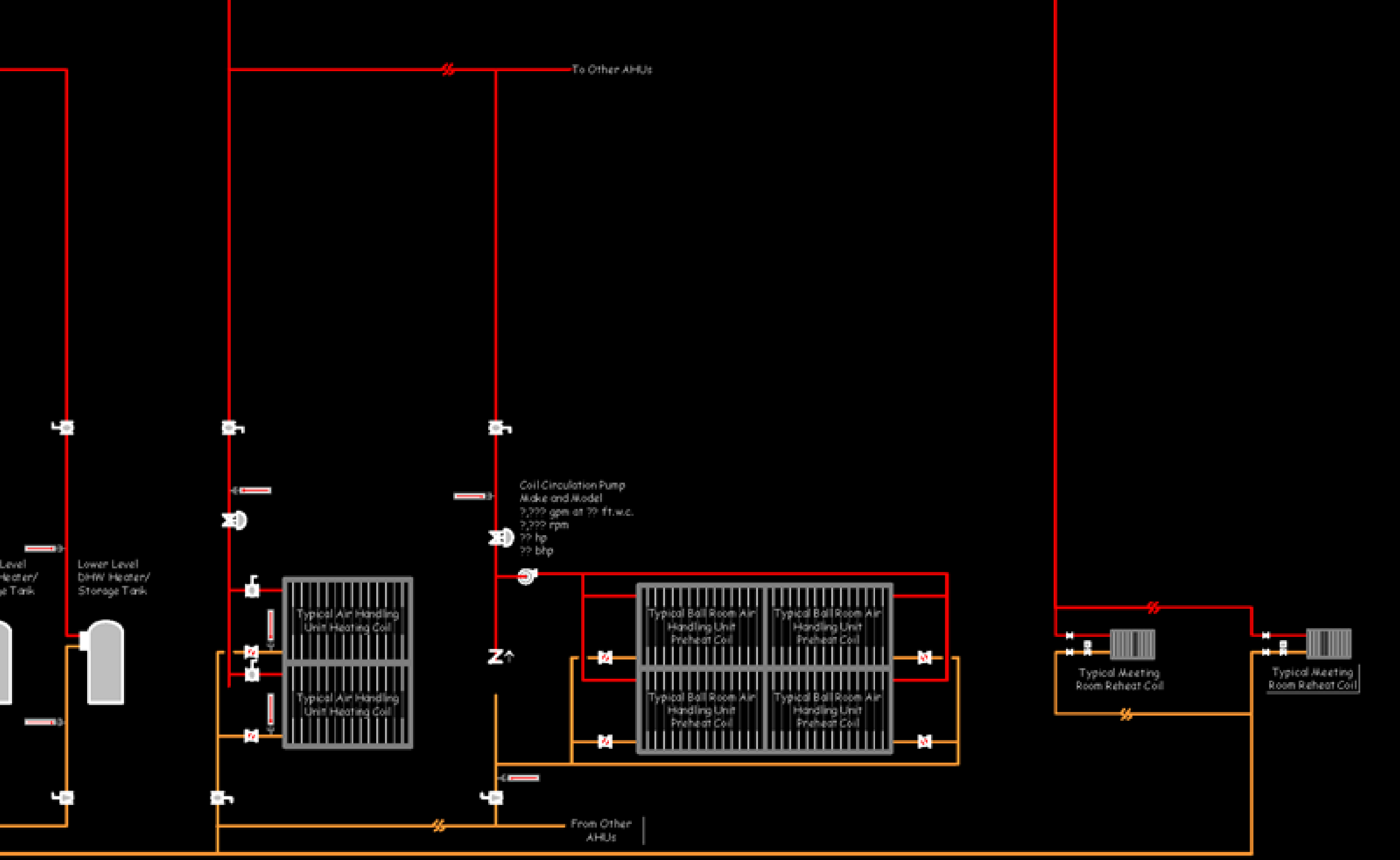

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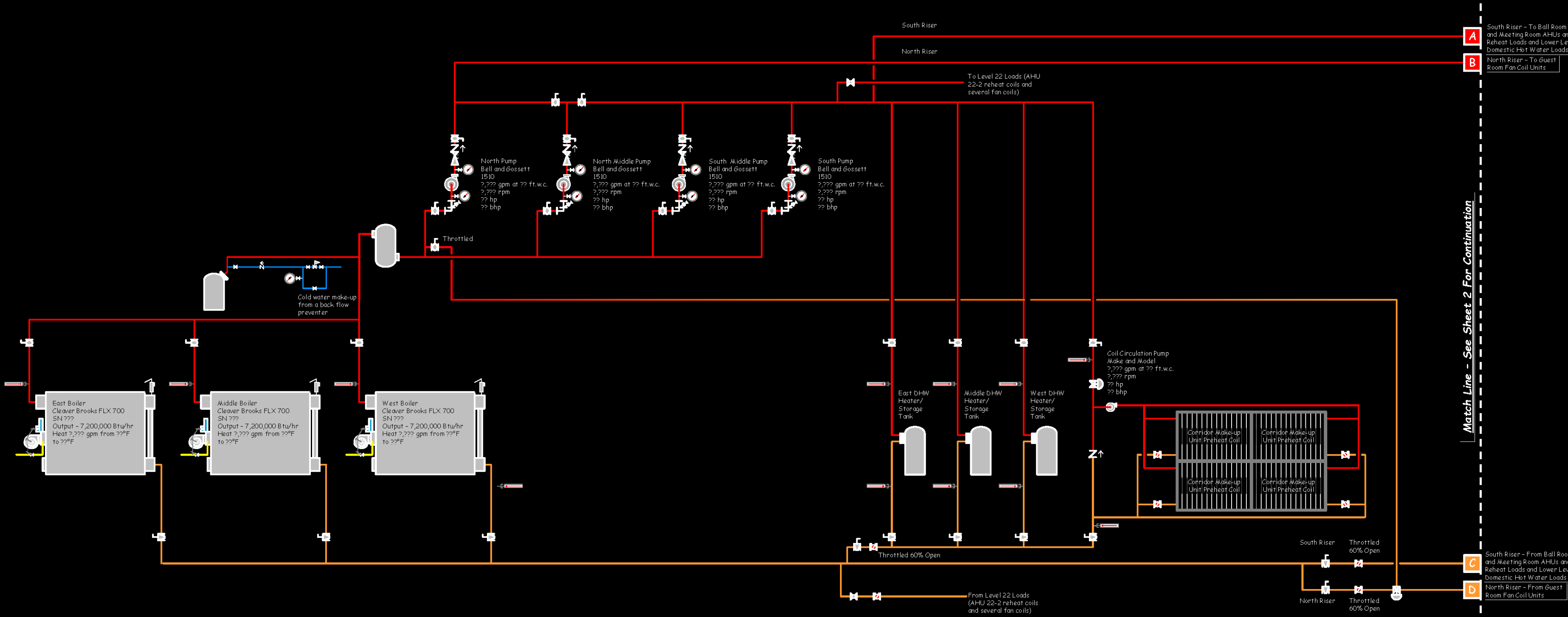
Is There a Constraint on the Temperature We Can Operate the New Boilers At?



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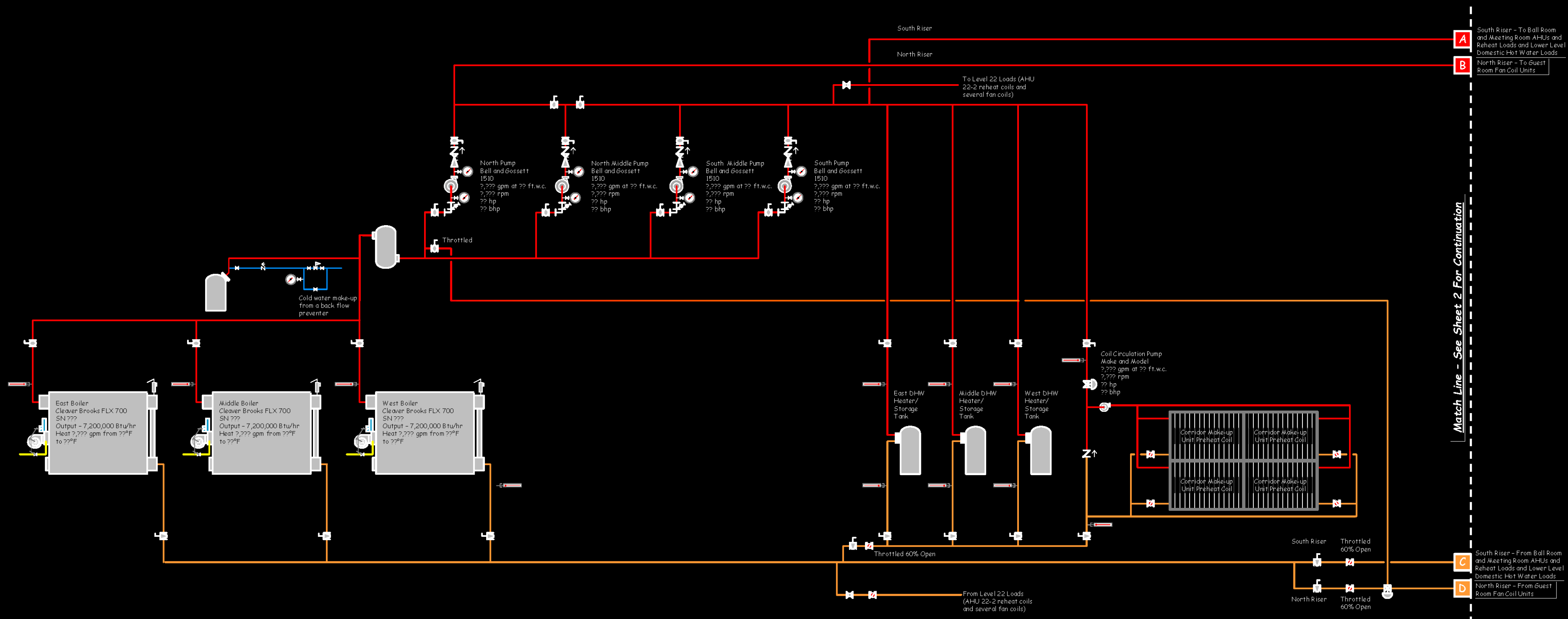
Was the 20% Premium for Condensing Boilers Worth It?



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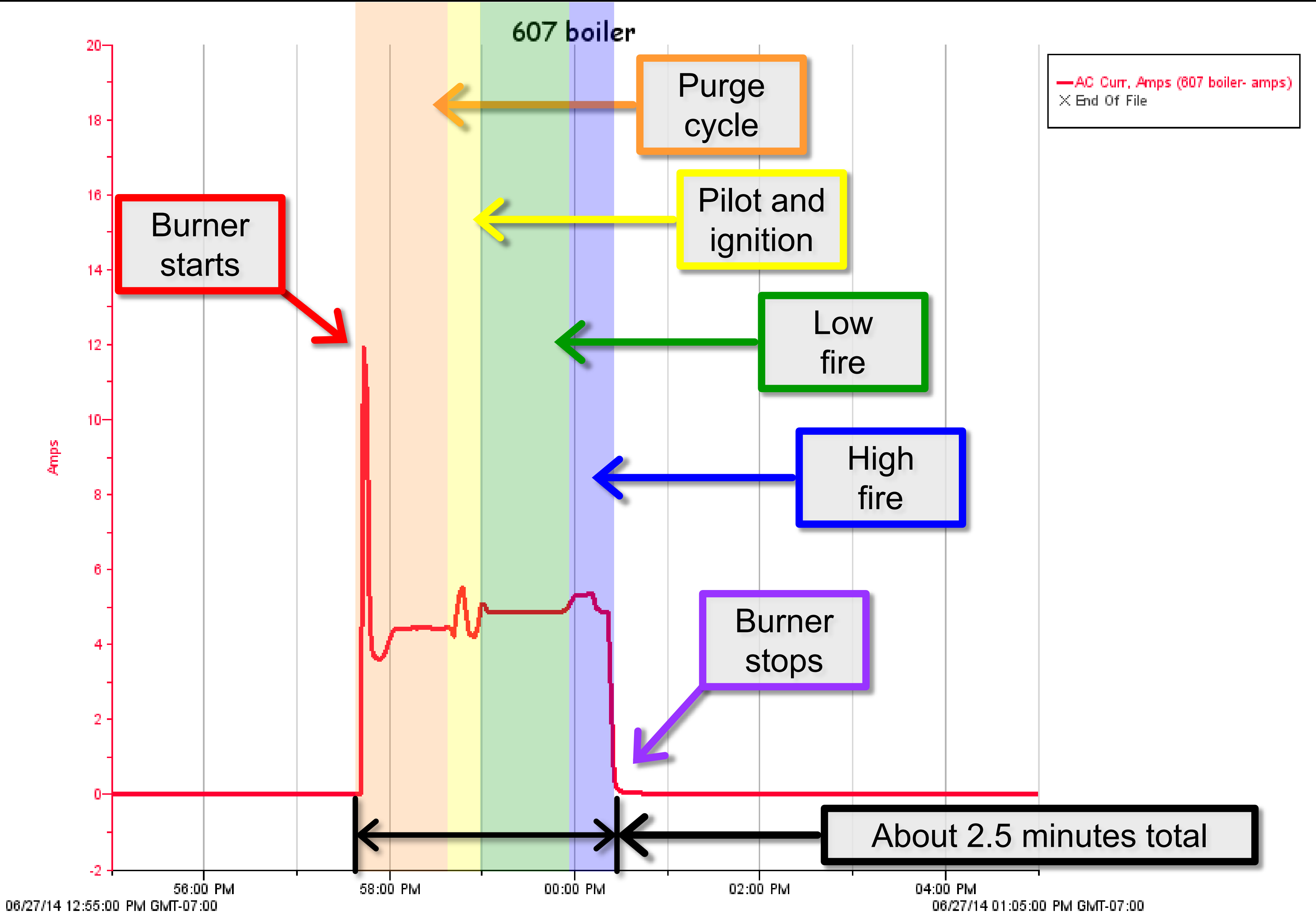
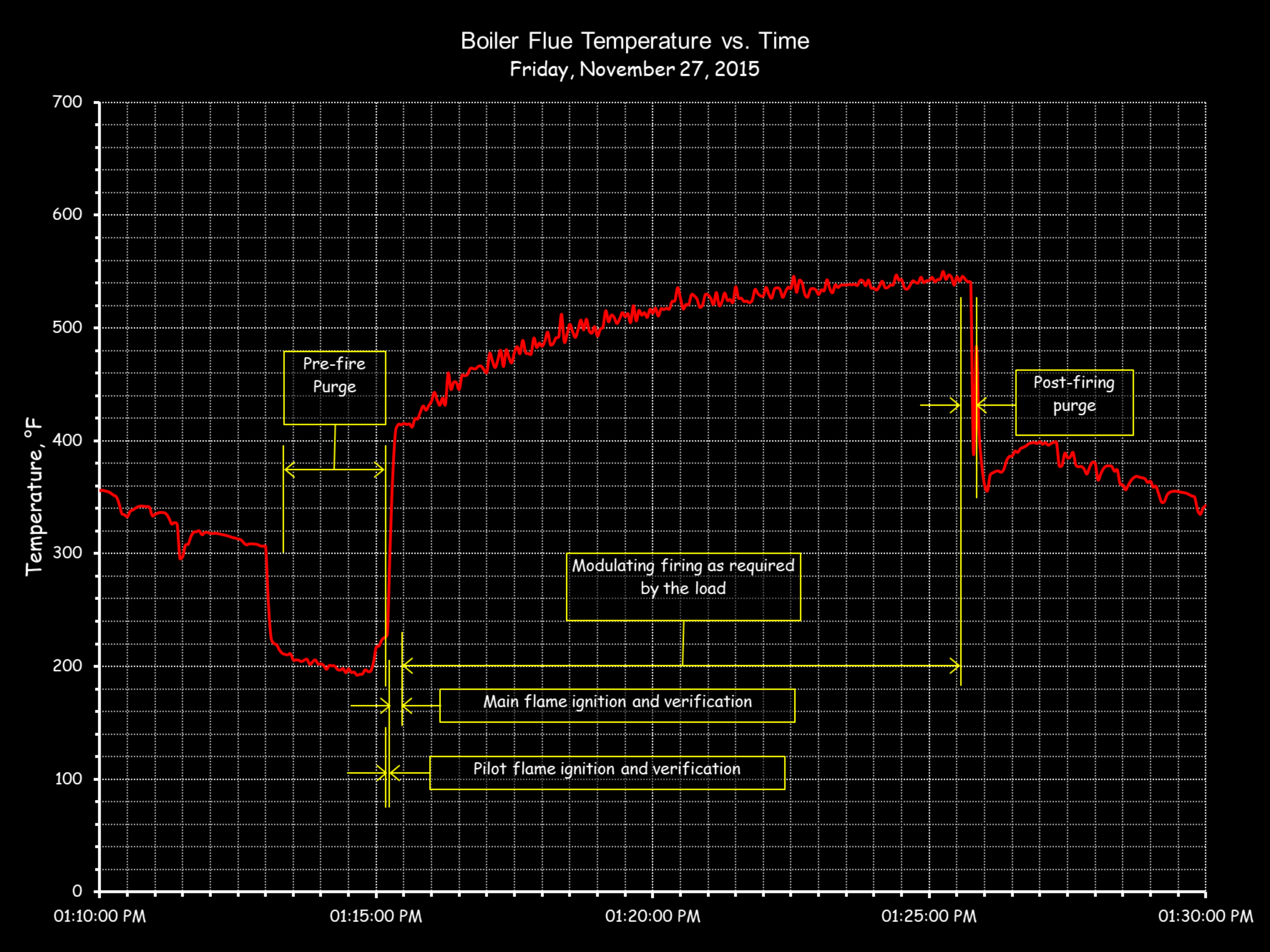
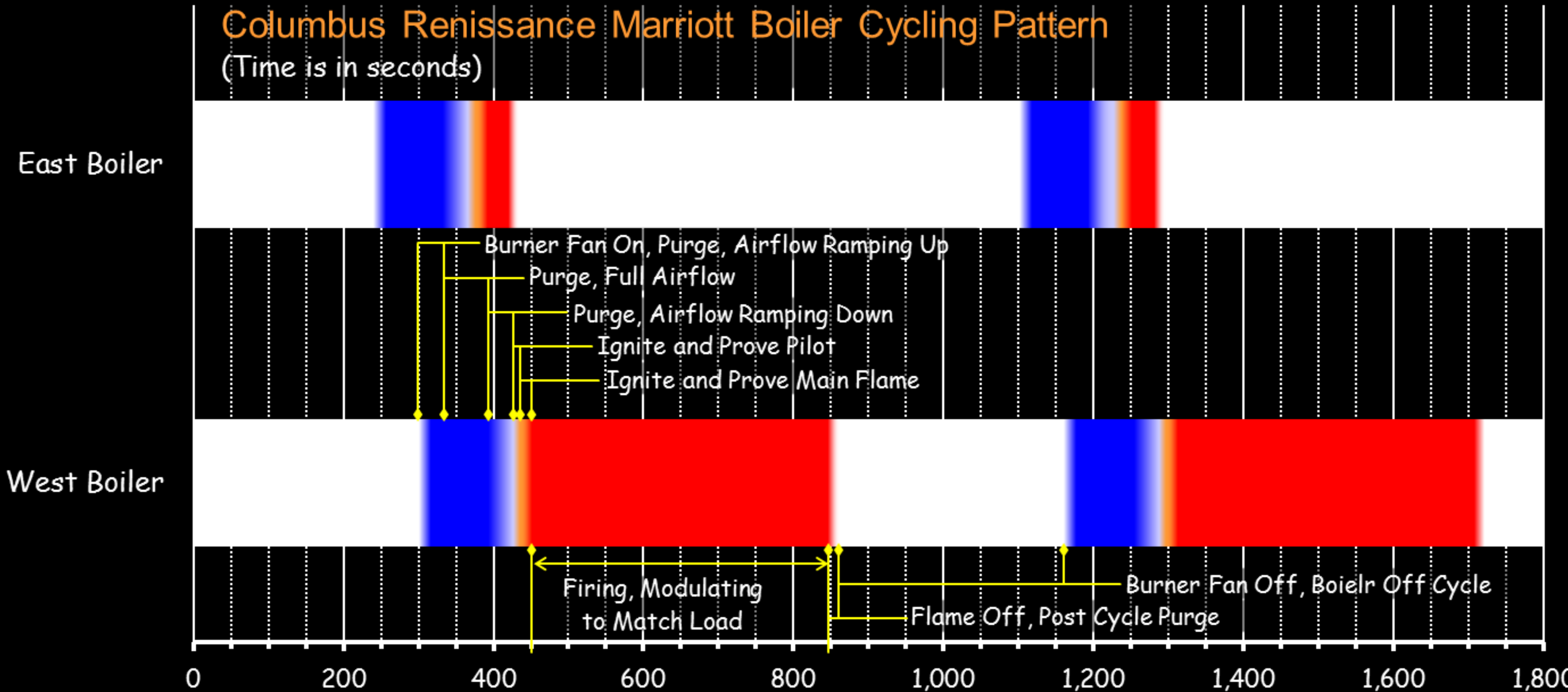
Another Potential Opportunity



607 boiler
Purge cycle
Pilot and ignition
Low fire
High fire
Burner starts
Burner stops
About 2.5 minutes total
AC Curr, Amps (607 boiler- amps)
End Of File
Amps
20
18
16
14
12
10
8
6
4
2
0
-2
56:00 PM
58:00 PM
00:00 PM
02:00 PM
04:00 PM
06/27/14 12:55:00 PM GMT-07:00
06/27/14 01:05:00 PM GMT-07:00


Boiler Flue Temperature vs. Time
Friday, November 27, 2015
Temperature, °F
700
600
500
400
300
200
100
0
01:10:00 PM
01:15:00 PM
01:20:00 PM
01:25:00 PM
01:30:00 PM
Pre-fire Purge
Post-firing purge
Modulating firing as required by the load
Main flame ignition and verification
Pilot flame ignition and verification



Burner Fan On, Purge, Airflow Ramping Up, 30 sec. +/-; This is the of the purgey cycle which blows air through the boiler to remove unburned gas in the combustion chamber due to gas valves leaks, thus prevention an explosion when the pilot is igniated.

Purge, Full Airflow 60 sec.: This is the main portion of the purge cycle with the combustion air fan running at high fire air flow.

Purge, Airflow Ramping Down, 30 sec.+/-: The end of the purge cycle ; sets up the ignition cycle at the low fire airflow rate.

Ignite and Prove Pilot, 10 sec,: The pilot gas valve opens and an ignites the pilot flame. An electronic sensor verifies ignition before allowing the cycle to proceed.

Ignite and Prove Main Flame, 15 sec: The main gas valve is opened and the burner operates on low fire ; main flame is verified.

Firing, Modulating to Match the Load, time varies with load: This is the heart of the firing cycle and the burner modulates between low and high fire as necssary to match the load.

Flame Off; Post Cycle Purge, 14 sec. +/-: The fuel cycles off because at low fire, the burner capacity exceeds the current load; the burner fan remains in operation to purge any unburned gas from the combustion chamber.

Burner Fan Off, Boiler Off Cycle, time varies with load: The boiler stands by until the load drops the entering water temperature below set point. Then, the cycle repeats.

Potential Savings via Optimizing Boiler Staging to Minimize Short Cycling and Purge Requirements

Maximum Short Cycle Rate (Note 1)	Lead Boiler Continuous Firing Temperature, °F (Note 2)	% Excess Air, (Note 3)	Boiler Efficiency, % (Note 3)	Annual Purge Cost (Note 4)			Potential Savings (Note 5)	
				Therms		% of Total		Dollars
7	52	9.5%	78.9%	2,929	$1,712	0.80%	1,414	$827
7	52	9.5%	72.6%	3,181	$1,859	0.87%	1,536	$898
14	52	9.5%	78.9%	3,801	$2,222	1.04%	1,850	$1,082
14	52	9.5%	72.6%	4,127	$2,413	1.13%	2,009	$1,175
7	52	81.6%	78.9%	4,857	$2,840	1.33%	2,346	$1,371
7	52	81.6%	72.6%	5,275	$3,083	1.44%	2,547	$1,489
14	52	81.6%	78.9%	6,303	$3,685	1.73%	3,069	$1,794
14	52	81.6%	72.6%	6,845	$4,001	1.87%	3,332	$1,948

Notes

1. This is how many times the boilers cycle during warm weather. The higher number is based on assuming both the East and West boiler cycle at the same rate as the East boiler does currently. The low rate is an arbitrary reduction to 50% of this.
2. This is the temperature below which, with the current load profile, it is assumed the lead boiler will fire continuously. It is based on a curve fit extrapolated from the logger data, which included days at this temperature.
3. This is based on a combustion efficiency assessment that was done using the DOE Steam Boiler Tip Sheet #4 and the observed flue gas temperature.
4. Percent of total refers to the percentage of the total boiler gas use that is represented by the purge losses.
5. This is based on adjusting the staging of the boilers to eliminate short cycling of the lag boiler under conditions when the lead boiler should be able to carry the load by itself (temperatures above the Lead Boiler Continuous Firing Temperature).

A detailed explanation can be found here:

https://tinyurl.com/PurgeLosses

Steam vs. Hot Water

Hot Water Boilers

and

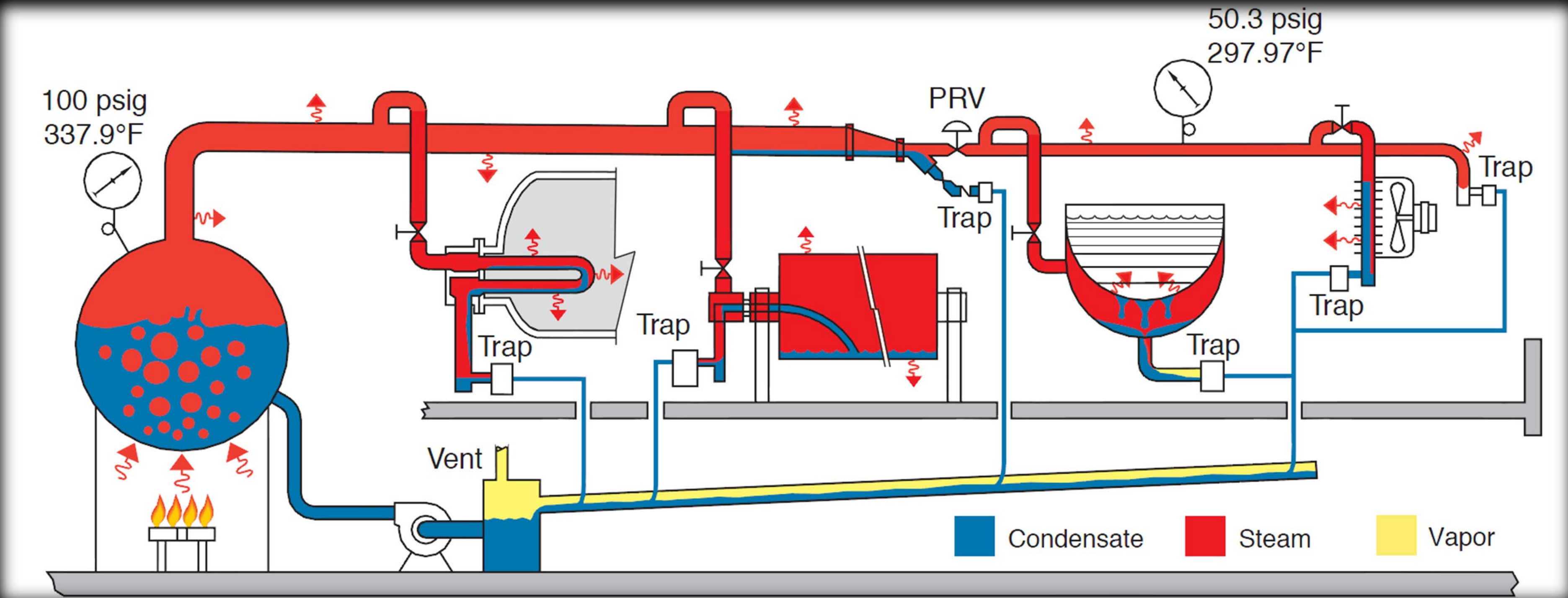
Steam Boilers

- Similar in form
- Similar safeties
- Different controlled variable
  - Hot water fired for a temperature set point
  - Steam fired for a pressure set point

- Different operating limitations

Steam Systems

http://www.armstronginternational.com/files/products/traps/pdf/P-101.pdf



Screen shot of Figure CG-6 from P-101

Hot Water Systems are Basically Pumping Systems

- Pumps; Design, Performance, and Commissioning Issues
- Chilled and Condenser Water Systems: Design, Performance, and Commissioning Issues
- EDR Design Briefs
  - *Centrifugal Pump Application and Optimization*
  - *Pump System Troubleshooting*

www.EnergyDesignResources.com

Why Use Steam Instead of Hot Water?

Transferring 10,000,000 Btu/hr with Hot Water

Given:

- The load
- A design supply temperature of 180°F
- A design temperature drop of 20°F

Determine

- Required flow rate
- Line size
- Insulation thickness

The Waterside Load Equation

$$Q_{Btu/Hr} = 500 \times Flow_{gpm} \times \left(t_{Entering,^\circ F} - t_{Leaving,^\circ F}\right)$$

Where:

$Q_{Btu/Hr} =$ Load in Btu/hr

$500 =$ Units conversion constant, good for water between 30 and 200°F

$Flow_{gpm} =$ Flow through the heat exchanger in gallons per minute

$t_{Entering,^\circ F} =$ Temperature entering the heat exchanger in °F

$t_{Leaving,^\circ F} =$ Temperature leaaving the heat exchanger in °F

Why Use Steam Instead of Hot Water?

Transferring 10,000,000 Btu/hr with Hot Water

Q = 500 x gpm x Δt

- Q = 10,000,000 Btu/hr
- Supply = 180°F
- Return = 160°F
- Δt = 20°F
- gpm = 1,000
- Line size = 8”
- Number of lines = 2
- Insulation = 1-1/2”

Why Use Steam Instead of Hot Water?

Transferring 10,000,000 Btu/hr with Steam

Q = Pounds per hour x $\Delta\eta$

- Q = 10,000,000 Btu/hr
- $\Delta\eta$ = 1,000 Btu/lb
- Pounds per hour = 10,000
- Supply line size = 6”
- Temperature = 240°F
- Insulation = 2-1/2”
- gpm returned = 20
- Return line size = 1-1/2”
- Temperature = 200°F
- Insulation = 2”

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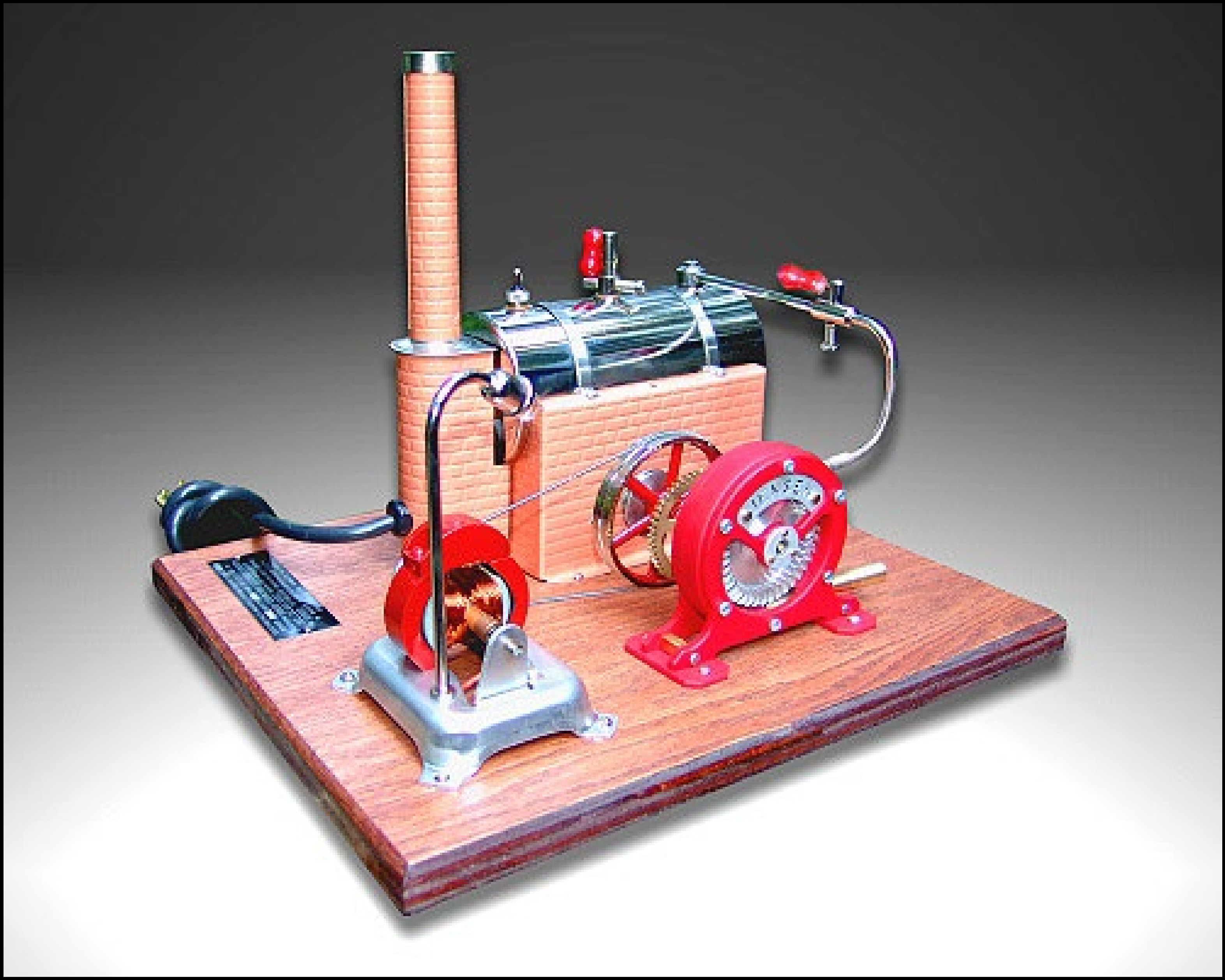
- Insulation = 2-1/2”
- gpm returned = 20
- Return line size = 1-1/2”
- Temperature = 200°F
- Insulation = 2”

Why Use Steam Instead of Hot Water?

- Processes require steam
  - Humidification
  - Cooking
  - Production
  - Power Generation

http://jensensteamengines.com



High Temperatures

An Issue Common to Both Steam and Hot Water

- Missing insulation = Common Low Hanging Fruit

Energy Savings From Installing Removable Insulated Valve Covers (Btu/hr)

Temperature, °F	Valve Size, inches					
	3	4	6	8	10	12
200	800	1,090	1,560	2,200	2,900	3,300
300	1,710	2,300	3,300	4,800	6,200	7,200
400	2900	3,800	5,800	8,300	10,800	12,500
500	4,500	6,200	9,000	13,000	16,900	19,700
600	6700	9,100	13,300	19,200	25,200	29,300

Based on DOE Steam Tip Sheet #17

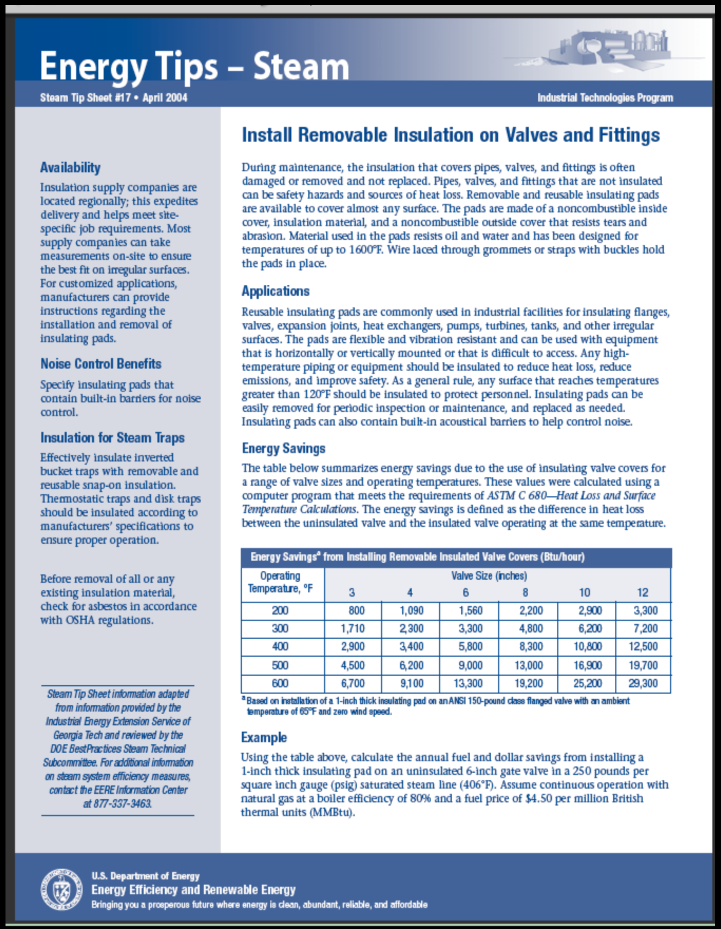
High Temperatures

An Issue Common to Both Steam and Hot Water

Leverage Existing Resources

- US DOE Industrial Technologies Program
  - Best Practices Web Page
  - Steam Energy System Link
  - www1.eere.energy.gov

https://tinyurl.com/InsulationTools



Energy Tips – Steam

Steam Tip Sheet #17 • April 2004

Industrial Technologies Program

Install Removable Insulation on Valves and Fittings

During maintenance, the insulation that covers pipes, valves, and fittings is often damaged or removed and not replaced. Pipes, valves, and fittings that are not insulated can be safety hazards and sources of heat loss. Removable and reusable insulating pads are available to cover almost any surface. The pads are made of a noncombustible inside cover, insulation material, and a noncombustible outside cover that resists tears and abrasion. Material used in the pads resists oil and water and has been designed for temperatures of up to 1600°F. Wire laced through grommets or straps with buckles hold the pads in place.

Applications

Reusable insulating pads are commonly used in industrial facilities for insulating flanges, valves, expansion joints, heat exchangers, pumps, turbines, tanks, and other irregular surfaces. The pads are flexible and vibration resistant and can be used with equipment that is horizontally or vertically mounted or that is difficult to access. Any high-temperature piping or equipment should be insulated to reduce heat loss, reduce emissions, and improve safety. As a general rule, any surface that reaches temperatures greater than 120°F should be insulated to protect personnel. Insulating pads can be easily removed for periodic inspection or maintenance, and replaced as needed. Insulating pads can also contain built-in acoustical barriers to help control noise.

Energy Savings

The table below summarizes energy savings due to the use of insulating valve covers for a range of valve sizes and operating temperatures. These values were calculated using a computer program that meets the requirements of *ASTM C 680—Heat Loss and Surface Temperature Calculations*. The energy savings is defined as the difference in heat loss between the uninsulated valve and the insulated valve operating at the same temperature.

Energy Savings[a] from Installing Removable Insulated Valve Covers (Btu/hour)

Operating Temperature, °F	Valve Size (inches)					
	3	4	6	8	10	12
200	800	1,090	1,560	2,200	2,900	3,300
300	1,710	2,300	3,300	4,800	6,200	7,200
400	2,900	3,400	5,800	8,300	10,800	12,500
500	4,500	6,200	9,000	13,000	16,900	19,700
600	6,700	9,100	13,300	19,200	25,200	29,300

[a] Based on installation of a 1-inch thick insulating pad on an ANSI 150-pound class flanged valve with an ambient temperature of 65°F and zero wind speed.

Example

Using the table above, calculate the annual fuel and dollar savings from installing a 1-inch thick insulating pad on an uninsulated 6-inch gate valve in a 250 pounds per square inch gauge (psig) saturated steam line (406°F). Assume continuous operation with natural gas at a boiler efficiency of 80% and a fuel price of $4.50 per million British thermal units (MMBtu).

Availability

Insulation supply companies are located regionally; this expedites delivery and helps meet site-specific job requirements. Most supply companies can take measurements on-site to ensure the best fit on irregular surfaces. For customized applications, manufacturers can provide instructions regarding the installation and removal of insulating pads.

Noise Control Benefits

Specify insulating pads that contain built-in barriers for noise control.

Insulation for Steam Traps

Effectively insulate inverted bucket traps with removable and reusable snap-on insulation. Thermostatic traps and disk traps should be insulated according to manufacturers' specifications to ensure proper operation.

Before removal of all or any existing insulation material, check for asbestos in accordance with OSHA regulations.

Steam Tip Sheet information adapted from information provided by the Industrial Energy Extension Service of Georgia Tech and reviewed by the DOE BestPractices Steam Technical Subcommittee. For additional information on steam system efficiency measures, contact the EERE Information Center at 877-337-3463.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
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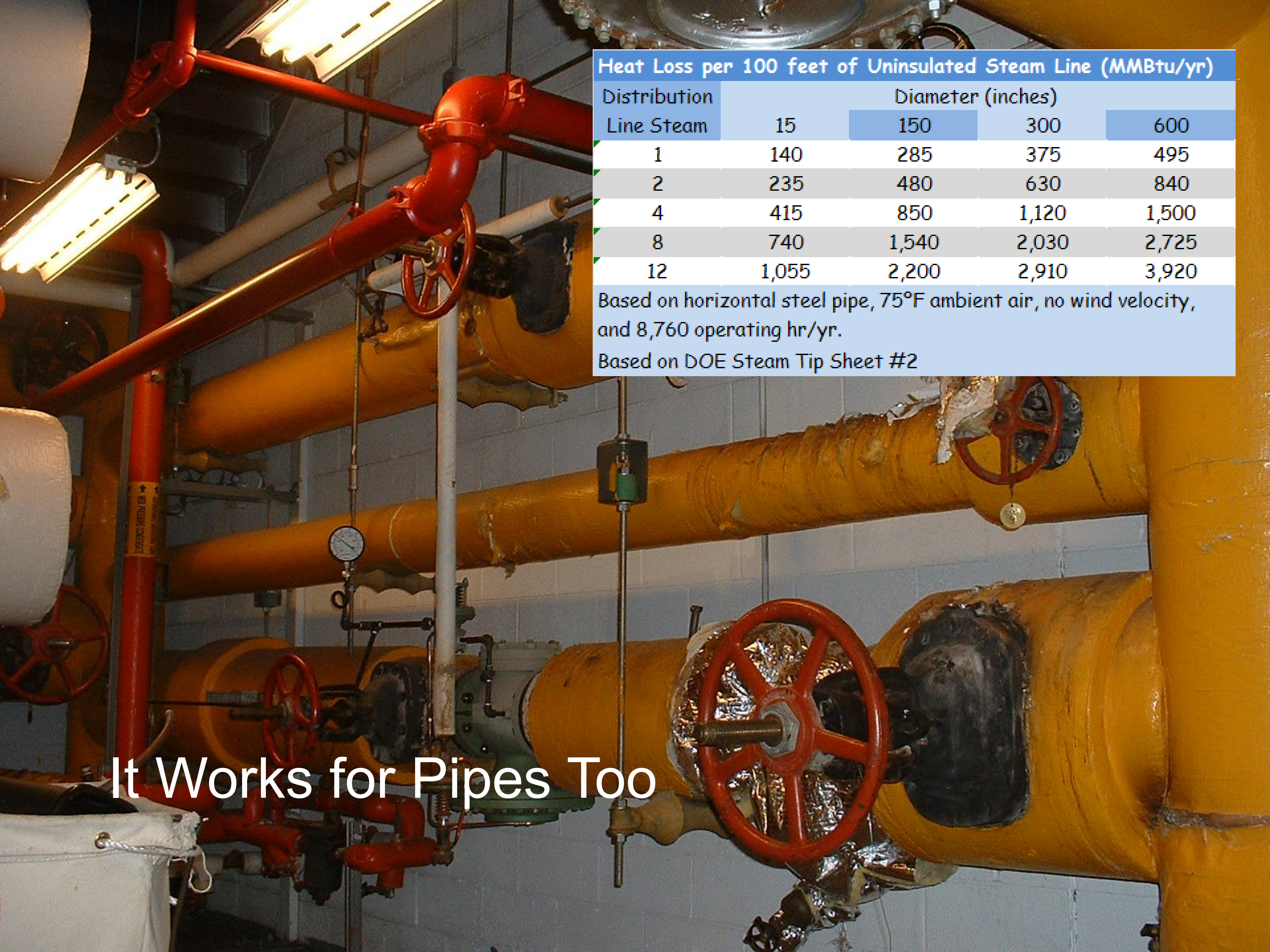
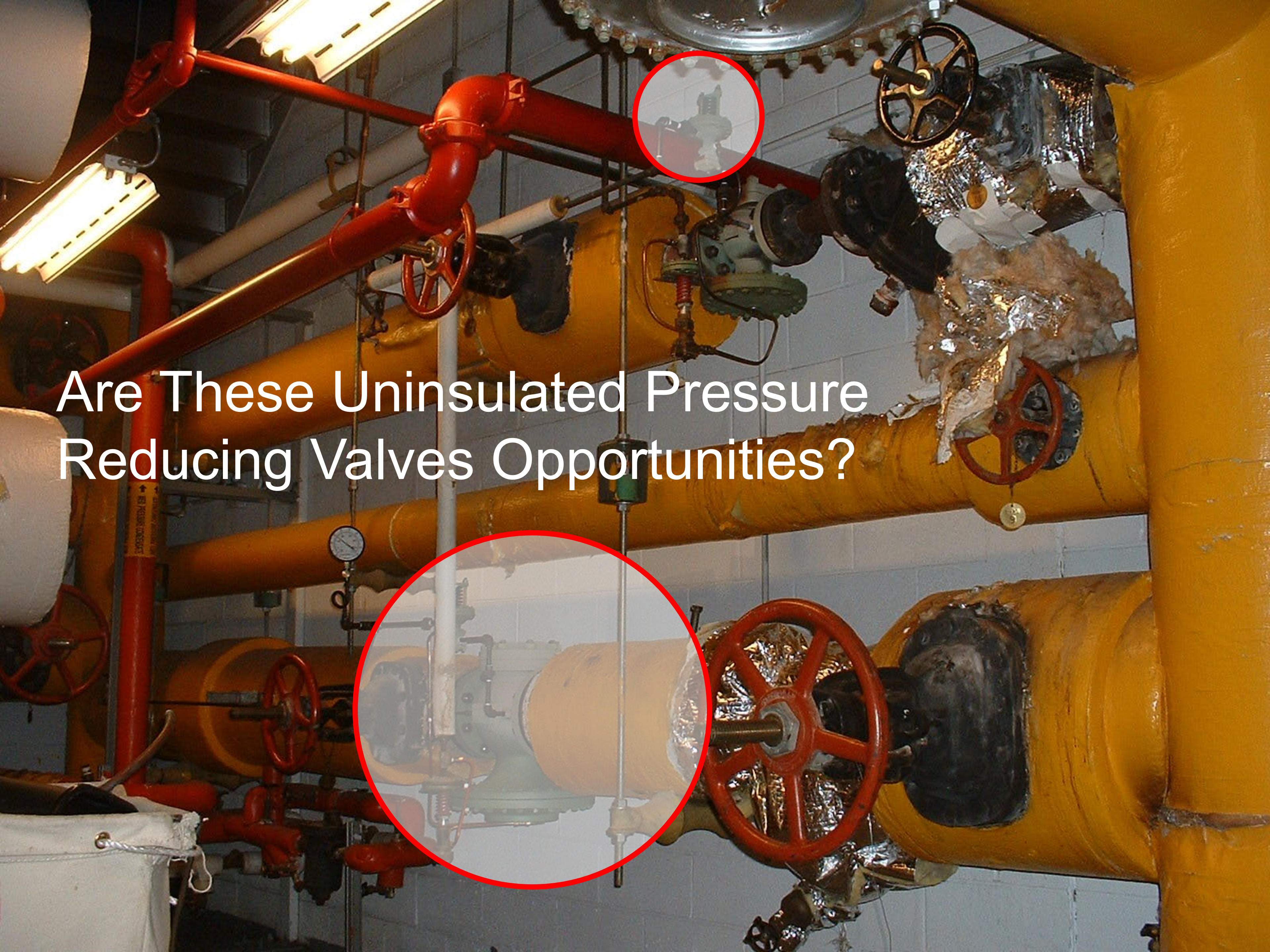
It Works for Pipes Too



Heat Loss per 100 feet of Uninsulated Steam Line (MMBtu/yr)				
Distribution	Diameter (inches)			
Line Steam	15	150	300	600
1	140	285	375	495
2	235	480	630	840
4	415	850	1,120	1,500
8	740	1,540	2,030	2,725
12	1,055	2,200	2,910	3,920

Based on horizontal steel pipe, 75°F ambient air, no wind velocity, and 8,760 operating hr/yr.

Based on DOE Steam Tip Sheet #2


Are These Uninsulated Pressure
Reducing Valves Opportunities?

Steam Traps

Similar Techniques can be Applied to Steam Traps

In

Out

Similar Techniques can be Applied to Steam Traps

In

Out

Condensate and Traps

An Issue Particular to Steam Systems

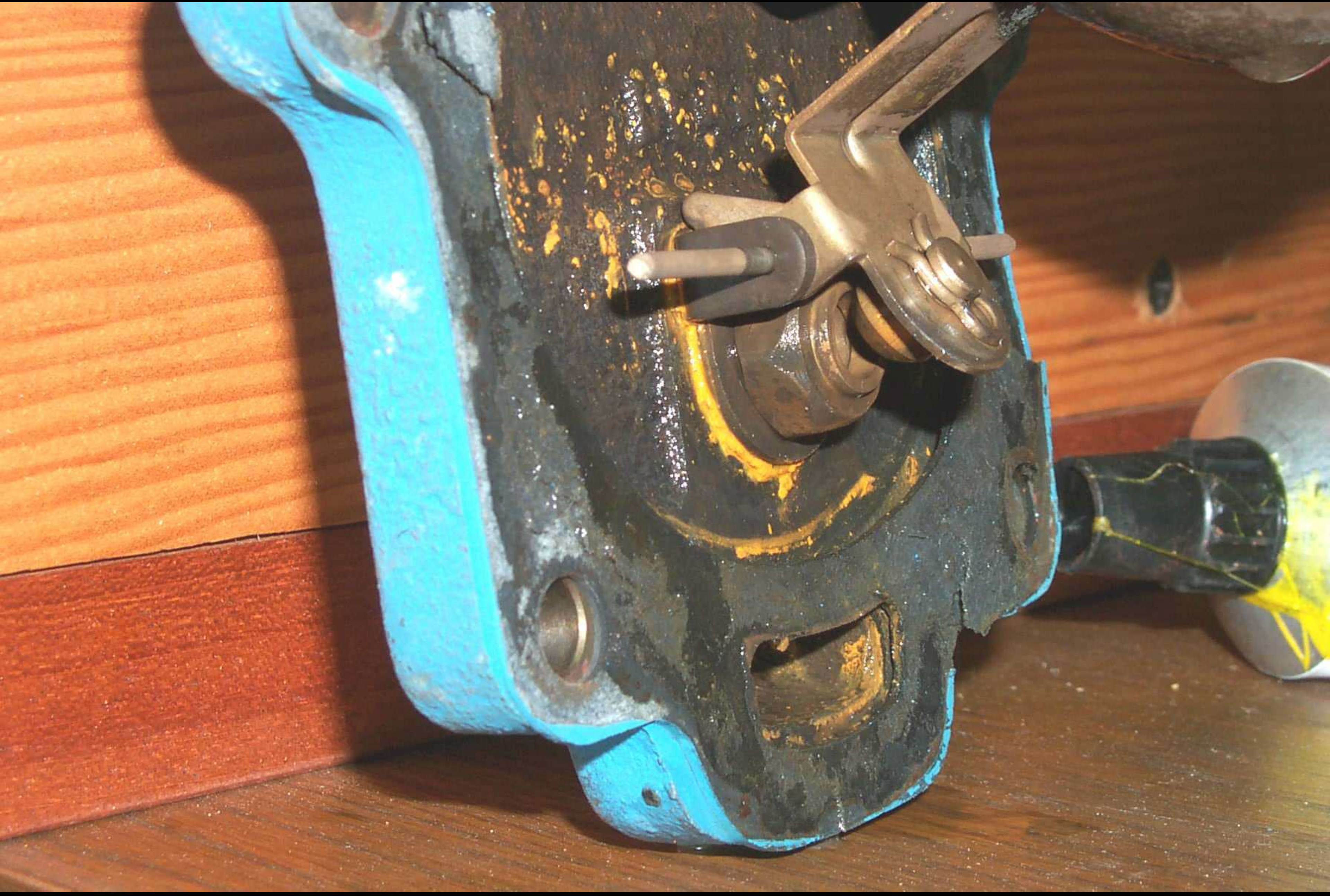
A Inverted Bucket Trap

A Bucket Trap

A Bucket Trap

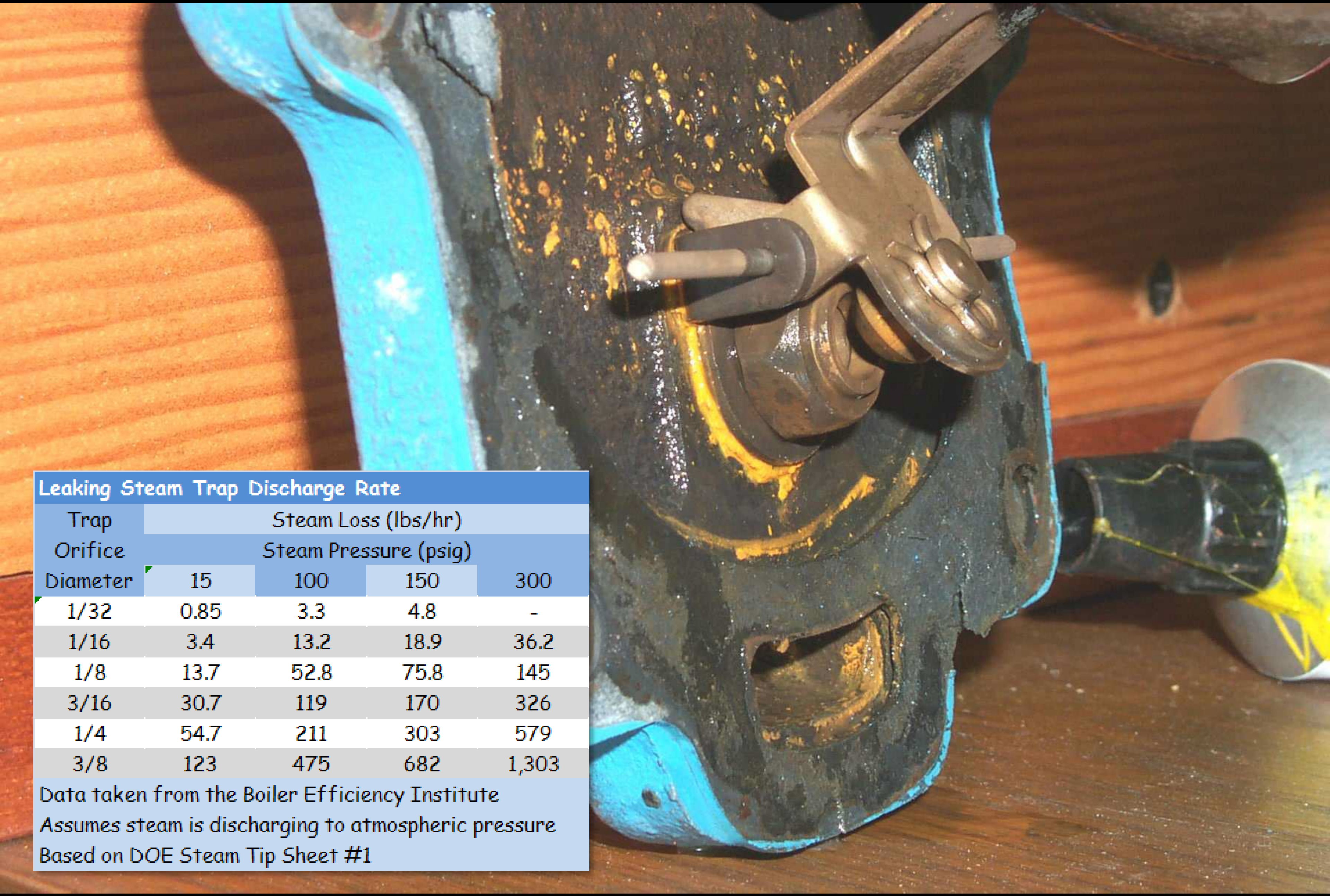
- Operating Principle
  - Condensate enters the trap by gravity at the bottom
  - Vapor trapped in the inverted bucket causes it to float on the liquid
  - As the vapor cools and condenses, the bucket sinks
  - The sinking bucket opens the discharge valve
  - Steam pressure forces the condensate out
  - New vapor entering the trap causes the bucket to float again, closing the trap
- Two position operation (open or closed)
- Capable of “lifting” condensate

A Bucket Trap



- Operating Principle
  - Condensate enters the trap by gravity at the bottom
  - The float “floats” on the liquid, modulating the flow of condensate out to the return system to match the load
  - Air rises to the top and is cooler than the steam
  - A thermostatic bellows vents the air
- Modulating capability is a good match for modulating loads
- Gravity must push condensate through the trap
  - Loads typically operating below atmospheric pressure
  - Trap requires the load to be elevated above it to move condensate through it

A Float and Thermostatic Trap (F&T Trap)



Leaking Steam Trap Discharge Rate

Trap Orifice Diameter	Steam Loss (lbs/hr) Steam Pressure (psig) 15	100	150	300
1/32	0.85	3.3	4.8	-
1/16	3.4	13.2	18.9	36.2
1/8	13.7	52.8	75.8	145
3/16	30.7	119	170	326
1/4	54.7	211	303	579
3/8	123	475	682	1,303

Data taken from the Boiler Efficiency Institute
Assumes steam is discharging to atmospheric pressure
Based on DOE Steam Tip Sheet #1

A Condensate Issue Unique to Planets with Gravity


4/27/2001 11:55am

Returning Condensate


LPRP-1
WARNING
EXPLOSIBLE
CONSOLITROL
CP-1
Vacuum Condensate Return Pump

- Operating Principle
  - Condensate returns by gravity to an isolated chamber
  - Pumps run continuously circulating water through a venture which pulls a vacuum on the chamber and thus, the condensate return system
  - A float switch in the chamber triggers a discharge cycle when the chamber fills up and the condensate is pumped out to the boiler feed water system
  - Minor leaks in the return system tend to eradicate the ability of the pumps to pull a vacuum
- RCx Opportunity
  - Give up on the vacuum approach
  - Allow the pumps to cycle on the float switch

Vacuum Condensate Return Pump

- Reasons for vacuum
  - Remove air from the steam system
    - Air is not a good heat transfer media
    - Air displaces steam which is the intended heat transfer media
    - Air can cause corrosion
  - Older systems
    - Lower steam system saturation pressure and thus lower operating temperature as a temperature control strategy
- Not Intended to Lift Condensate

Vacuum Condensate Return Pump

Steam Powered Condensate Pump

- Operating Principle
  - Condensate returns to the tank by gravity
  - When the tank fills up, level switches open a steam valve that pressurizes the tank, forcing the steam out the discharge pipe
  - A check valve prevents back-flow into the condensate return system
  - Could be powered by compressed air also
- Required no electricity to run

But the boiler or compressor making the steam or air still use energy

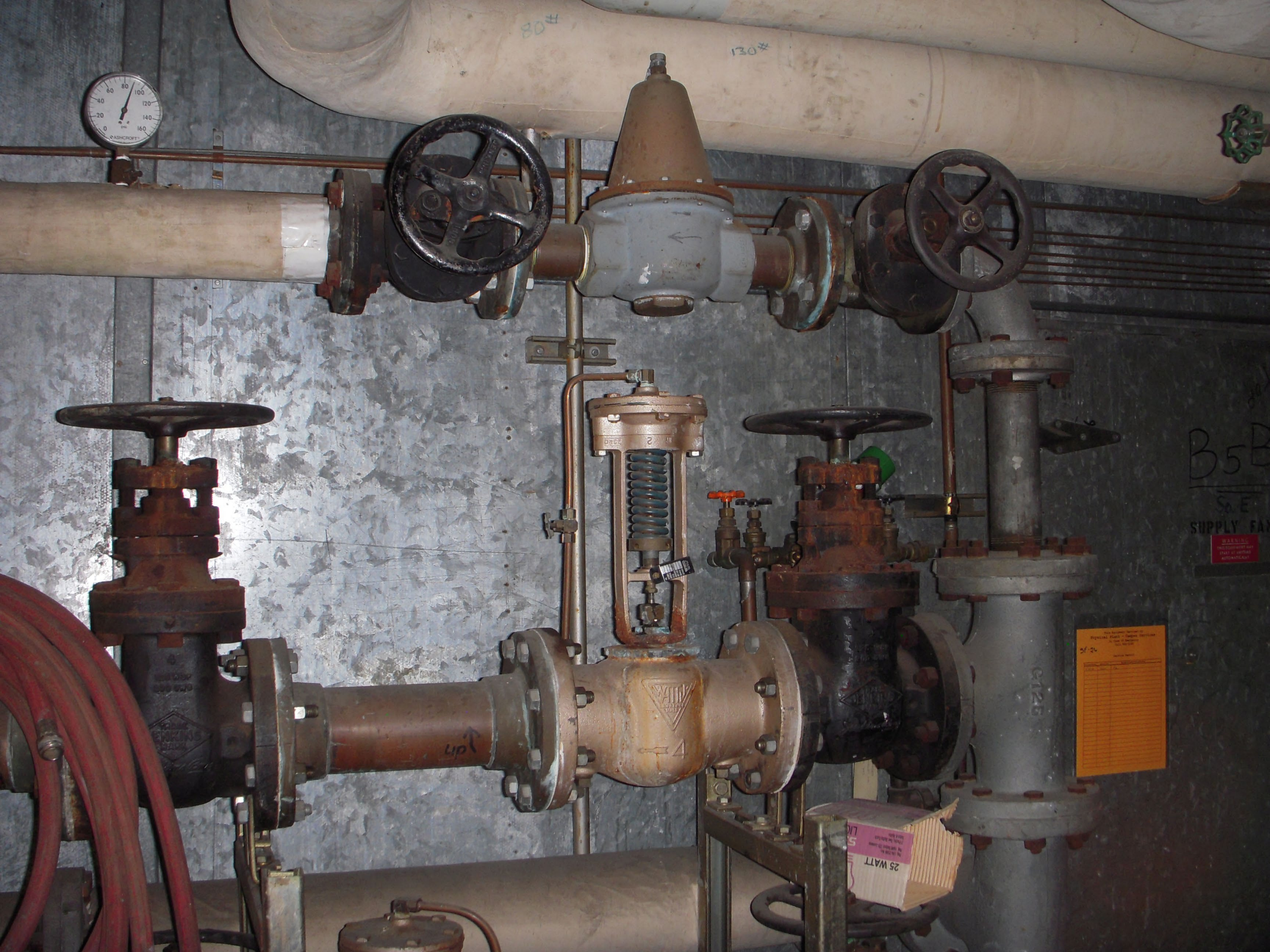
Steam Powered Condensate Pump

Steam Powered Condensate Pump

The Video: Watch the Sight Glass and Listen

Pressure Reducing Valves

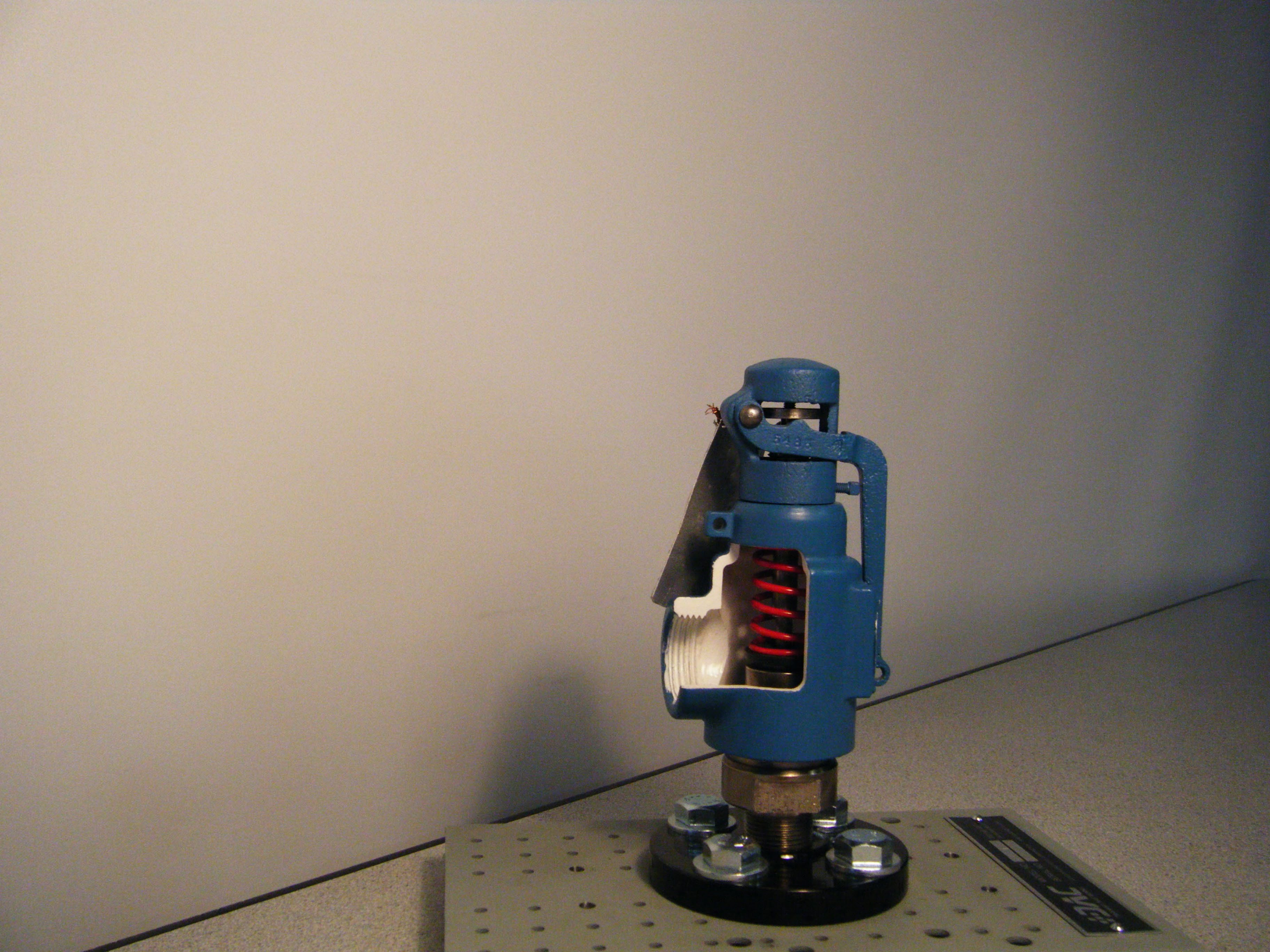
- Found on both hot water and steam systems
- Different application considerations

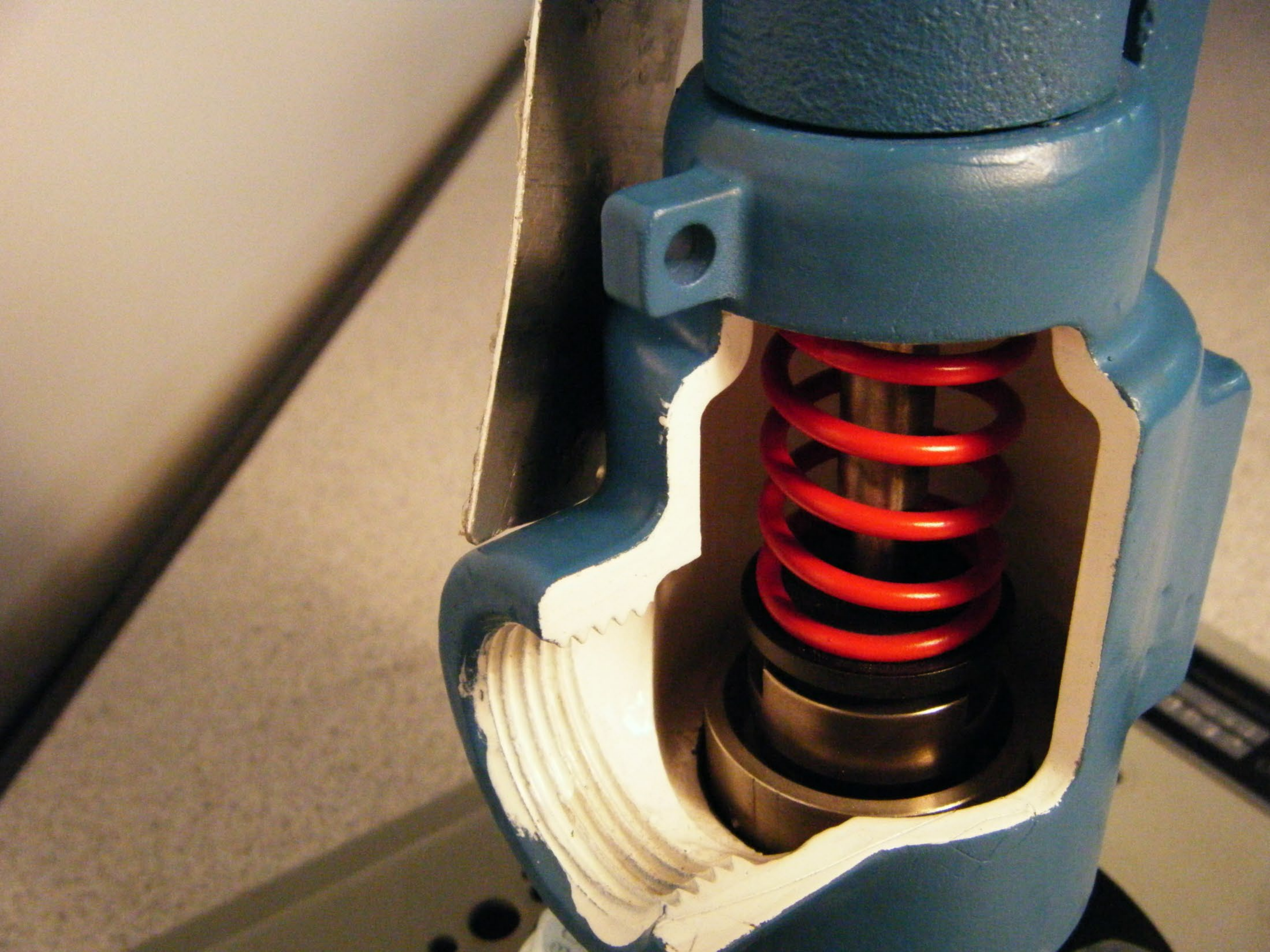

80#
130#
up
SUPPLY FAN
25 WATT

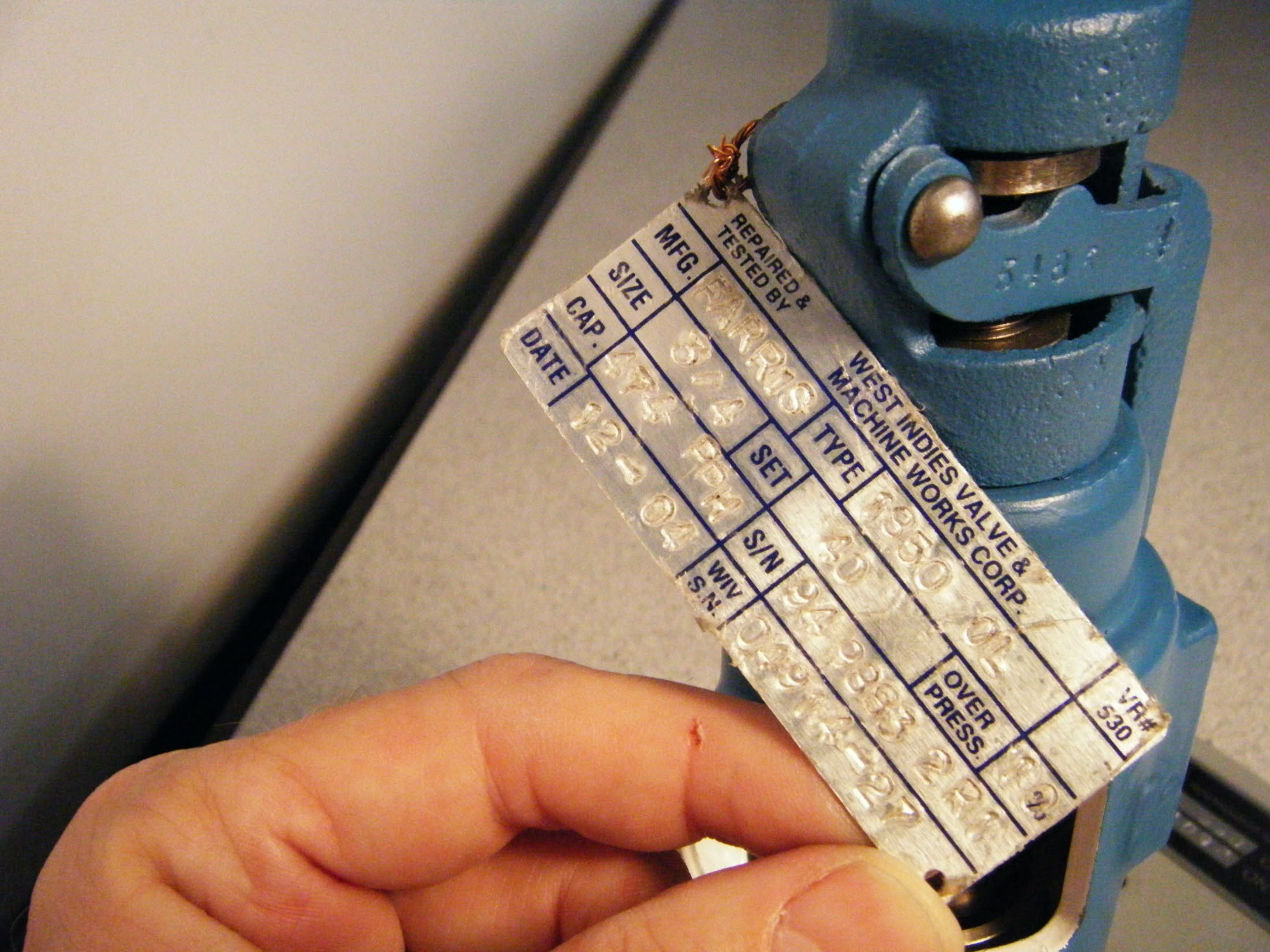
Pressure Relief and Pressure Reducing Valves

Pressure Relief Valves

- Found on both hot water and steam systems
- Different application considerations

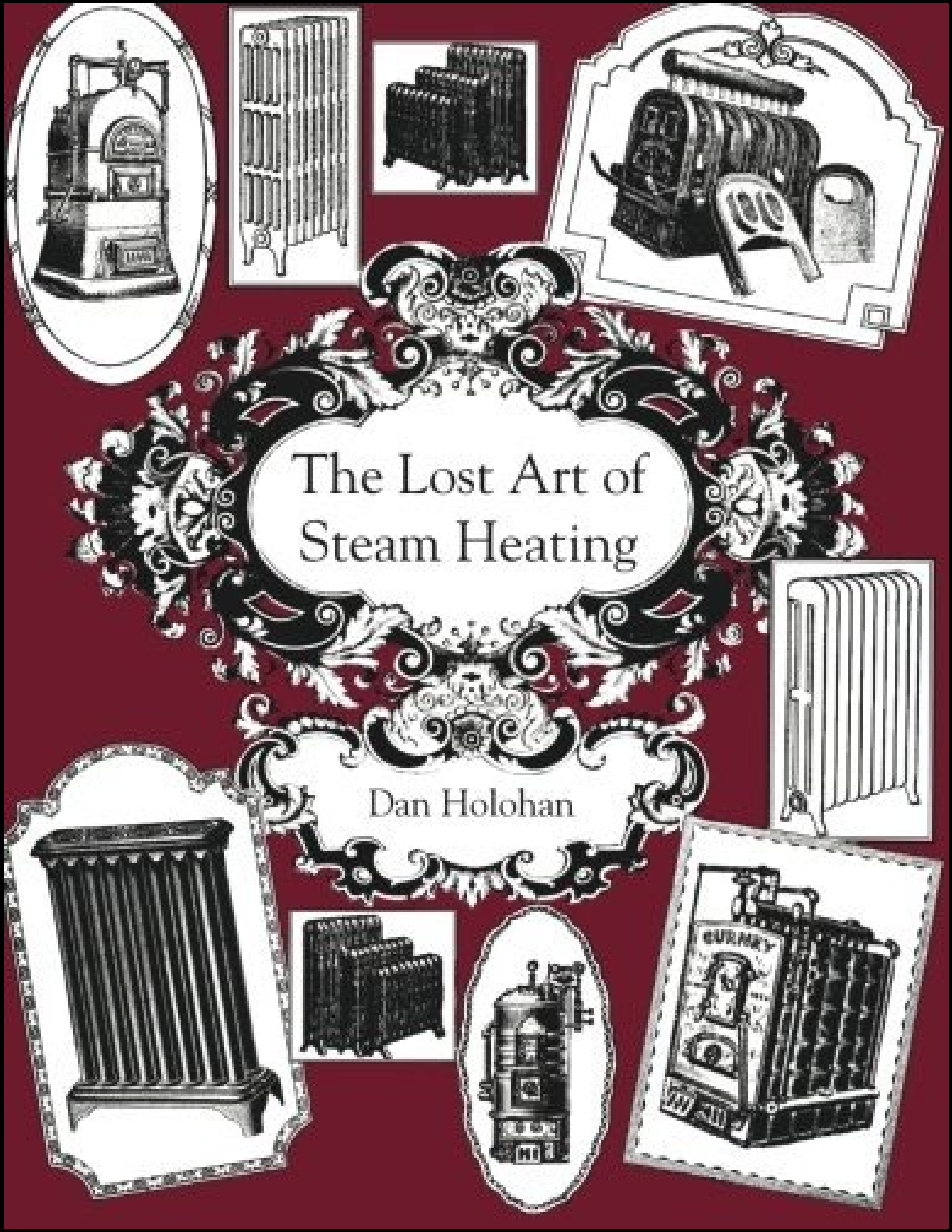






REPAIRED & TESTED BY
WEST INDIES VALVE & MACHINE WORKS CORP.
MFG.
FARRIS
SIZE
3/4
CAP.
474 PPH
DATE
12-1-04
TYPE
1350
SET
40
S/N
WIV S.N.
OVER PRESS.
VR# 530

One Pipe Steam Systems

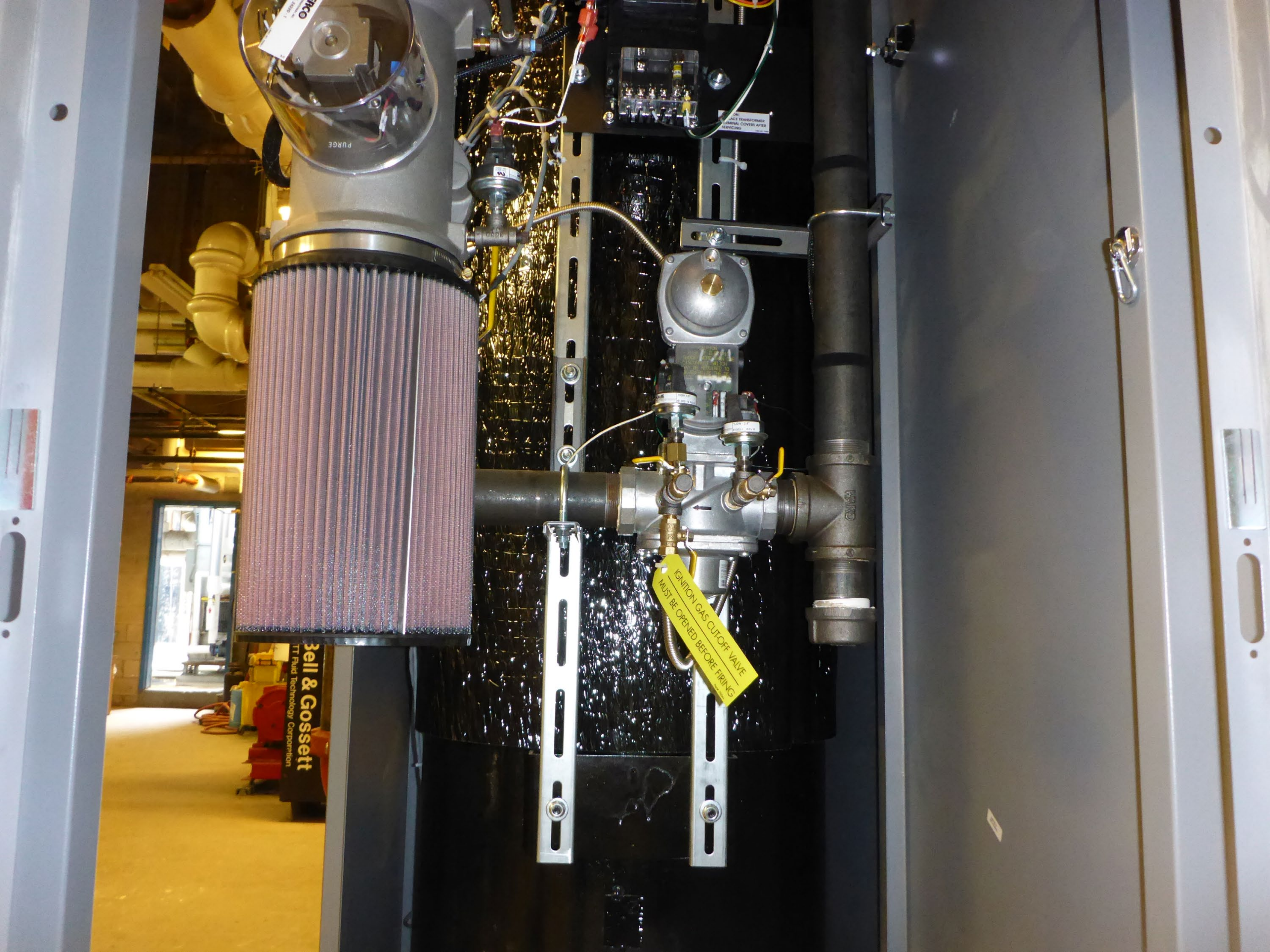


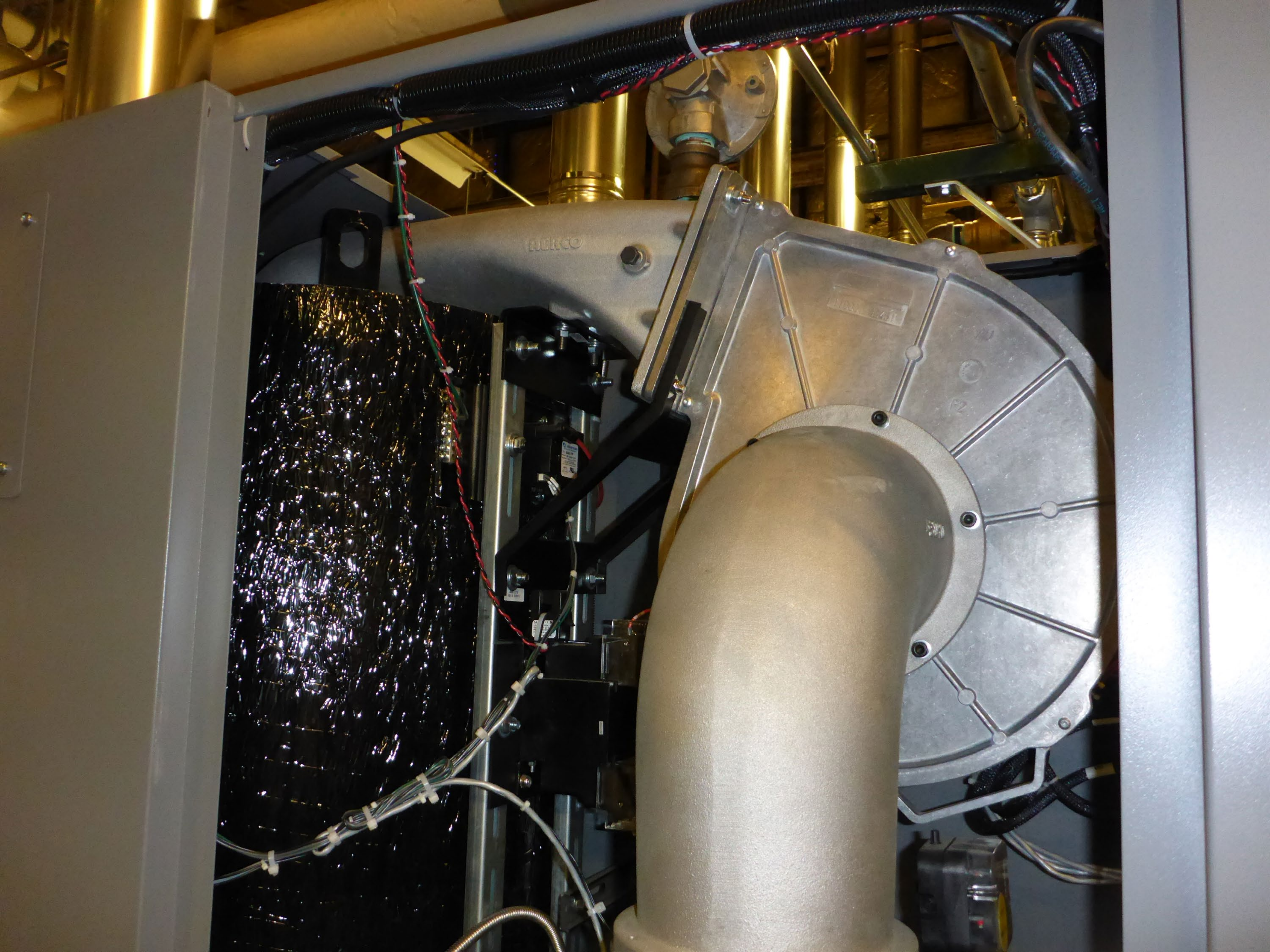
Taking a Look at Equipment

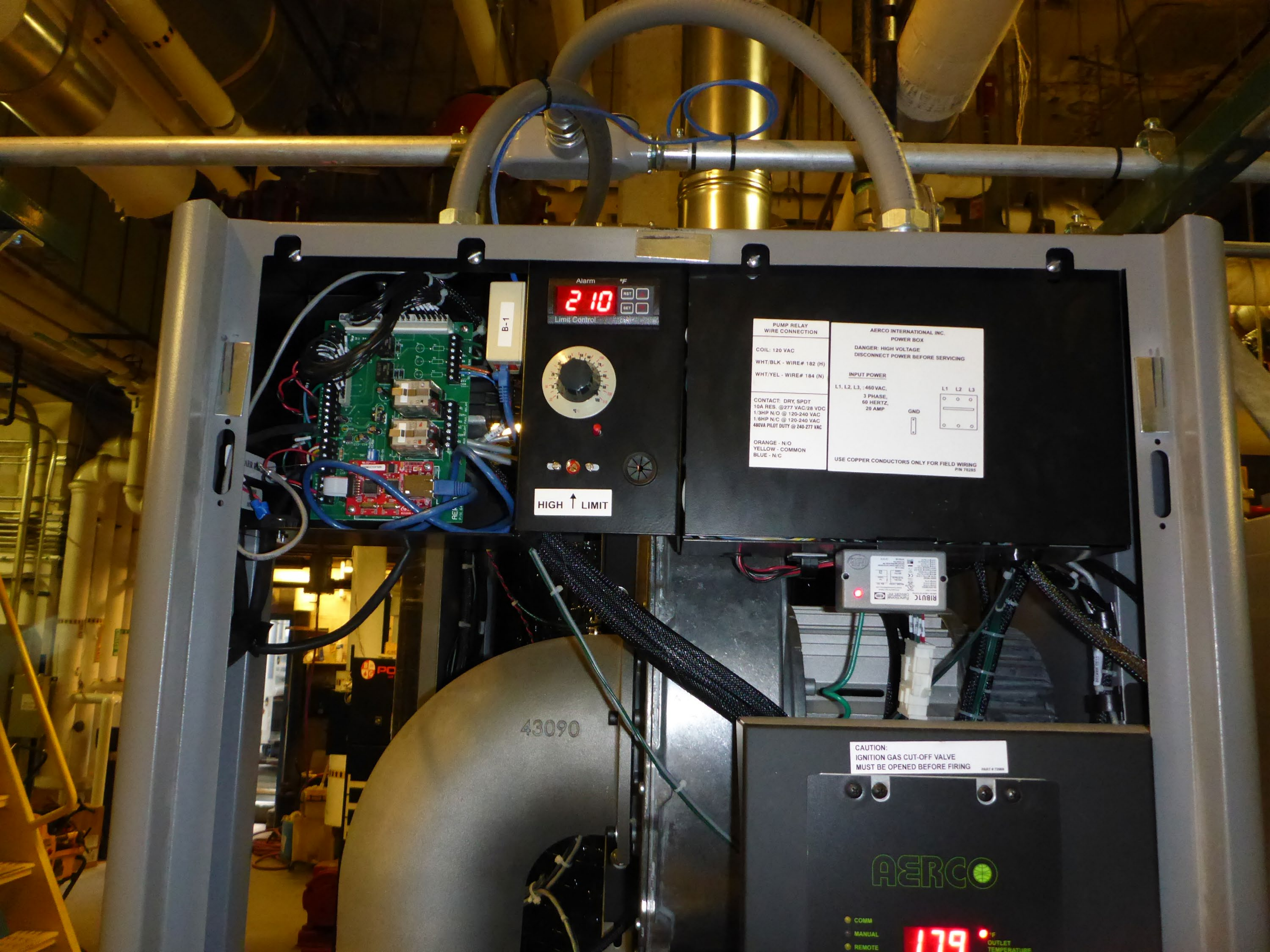
Inside A Fire Tube Boiler

Inside a Water Tube Boiler

Inside a Condensing Boiler


PURGE
IGNITION GAS CUT-OFF VALVE
MUST BE OPENED BEFORE FIRING
Bell & Gossett
ITT Fluid Technology Corporation




B-1
Alarm
°F
210
RST
SET
Limit Control
HIGH LIMIT
PUMP RELAY
WIRE CONNECTION
COIL: 120 VAC
WHT/BLK - WIRE# 182 (H)
WHT/YEL - WIRE# 184 (N)
CONTACT: DRY, SPDT
10A RES. @277 VAC/28 VDC
1/3HP N/O @ 120-240 VAC
1/6HP N/C @ 120-240 VAC
480VA PILOT DUTY @ 240-277 VAC
ORANGE - N/O
YELLOW - COMMON
BLUE - N/C
AERCO INTERNATIONAL INC.
POWER BOX
DANGER: HIGH VOLTAGE
DISCONNECT POWER BEFORE SERVICING
INPUT POWER
L1, L2, L3, : 460 VAC,
3 PHASE,
60 HERTZ,
20 AMP
GND
L1 L2 L3
USE COPPER CONDUCTORS ONLY FOR FIELD WIRING
P/N 70285
43090
CAUTION:
IGNITION GAS CUT-OFF VALVE
MUST BE OPENED BEFORE FIRING
AERCO
COMM
MANUAL
REMOTE
179
°F
OUTLET

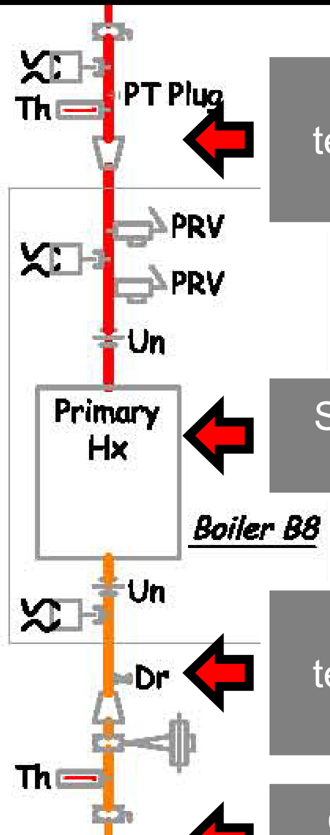

Serial Number
G-16-0591

Inside a Condensing Boiler that was *not really* "or equal"


CONDENSATE


CAUTION
-RISK OF ELECTRIC
SHOCK- MORE THAN ONE
DISCONNECT SWITCH
MAY BE REQUIRED TO
DE-ENERGIZE THE DE-

The Difference Between Boilers



Leaving water temperature range – 85 - 180°F

Single condensing heat exchanger

Entering water temperature range – 80 - 160°F

Constant volume pumping circuit

Leaving water temperature restricted to130°F minimum

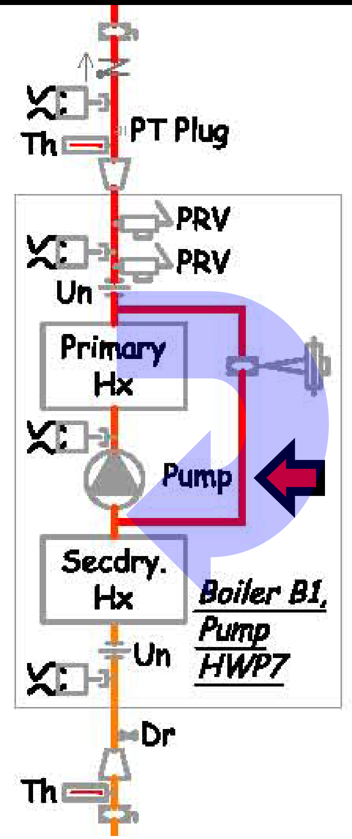
Noncondensing heat exchanger restricted to130°F EWT

Pump and control valve control EWT and make boiler loop variable flow

Condensing heat exchanger

Entering water temperature range – 85 - 160°F

Constant volume pumping circuit



A Typical Neutralization Basin

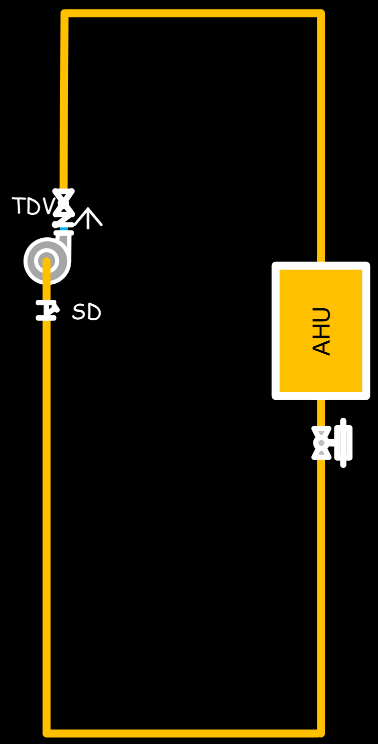
A Typical Neutralization Basin

An Electric Boiler

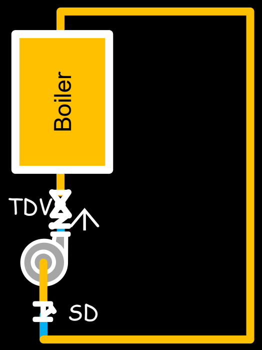
Maintaining Circulation;

An Important Hot Water Boiler Design Consideration

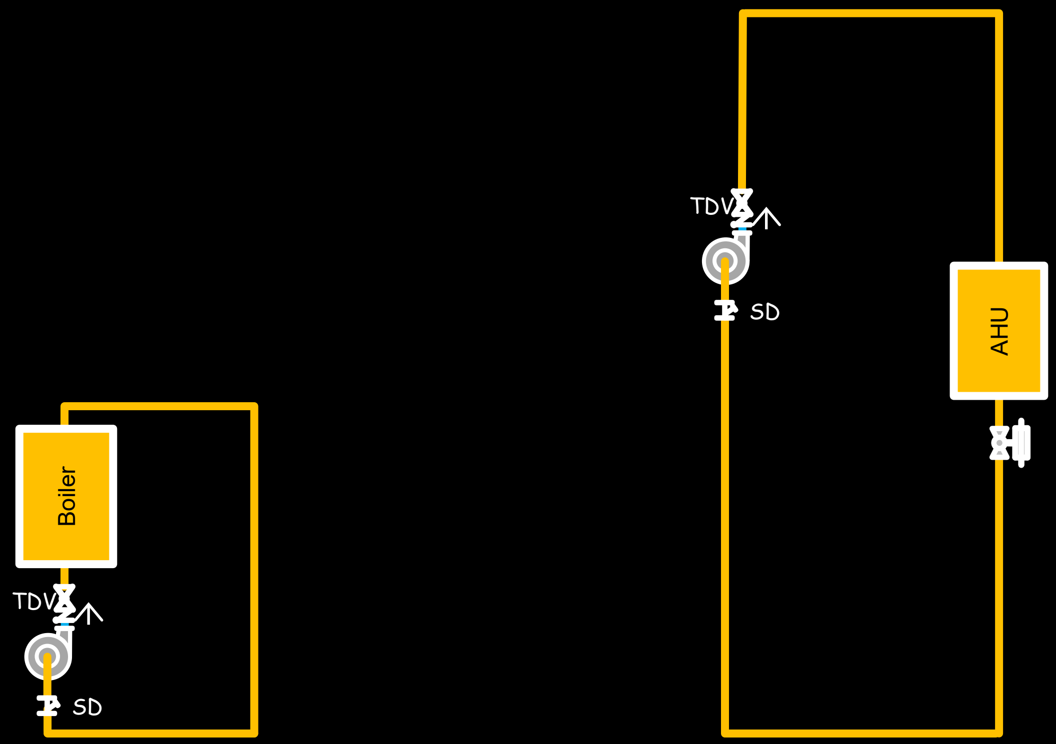
Variable Flow/Variable Volume Systems



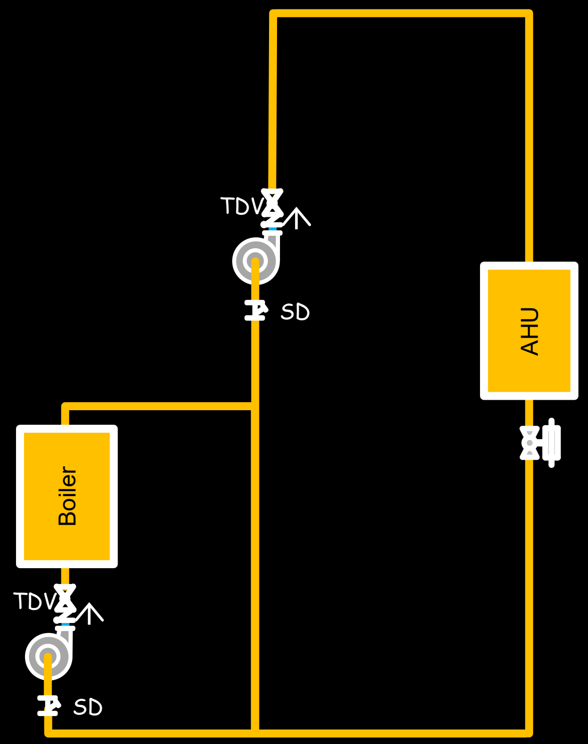
Boiler Loop – A Constant Flow Requirement



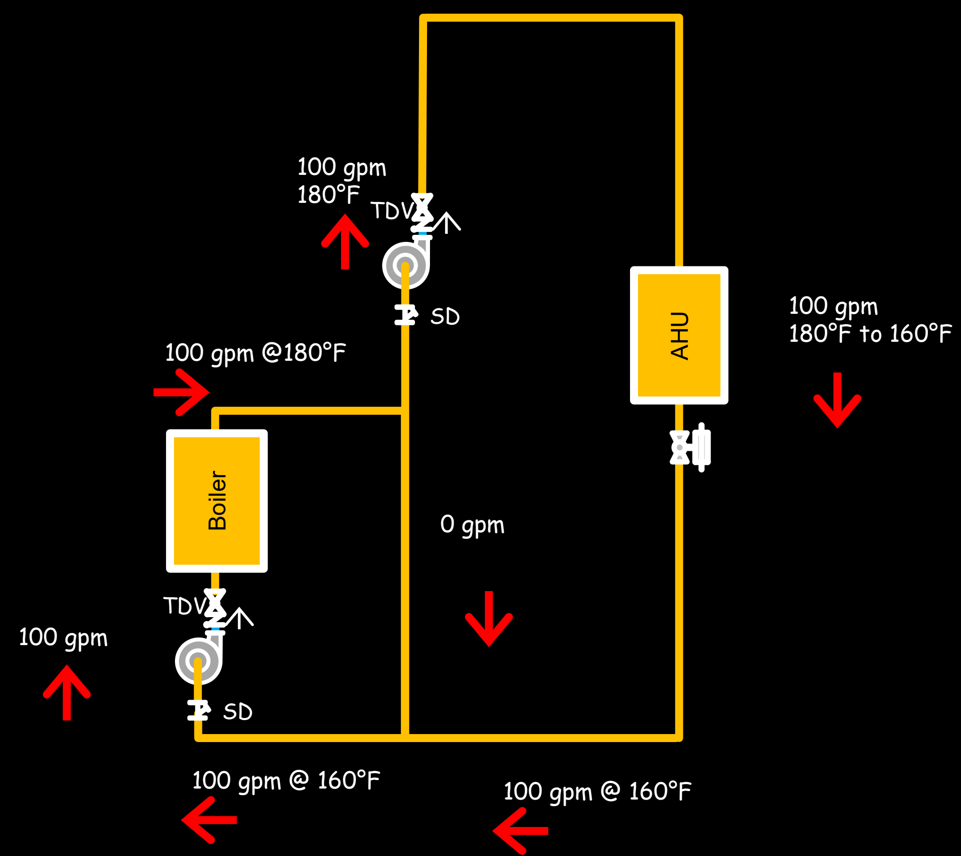
Merging Two Concepts



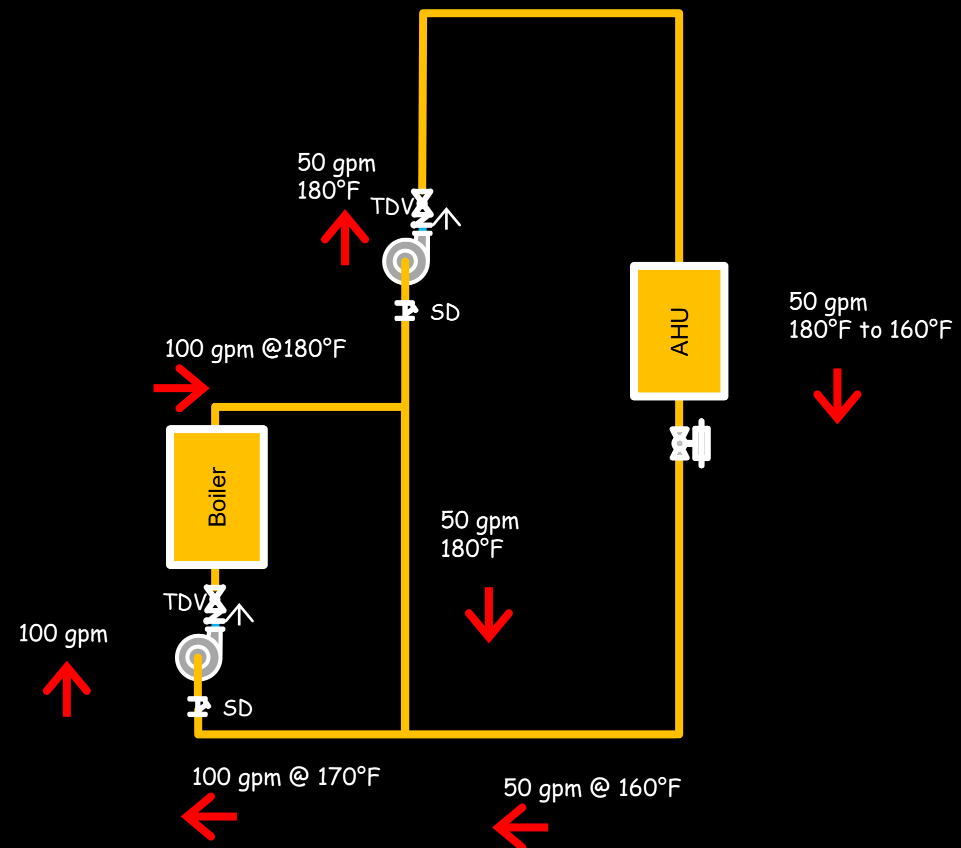
Variable Flow Primary/Secondary



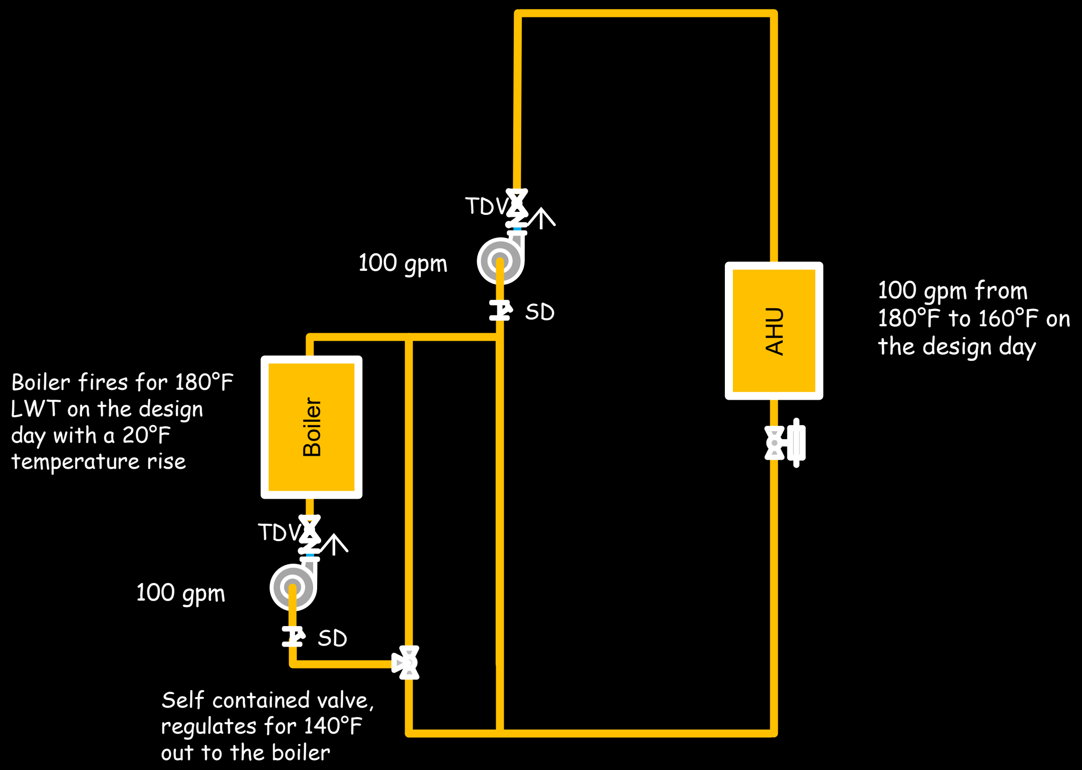
Variable Flow Primary/Secondary – Full Load



Variable Flow Primary/Secondary – 50% Load



Variable Flow Primary/Secondary with Protection for the Non-condensing Boiler




NPS 4
FPE
A4010
CL 30
AFK

Model 4010

Three-Way Thermostatic Valve

4010 4” Flange
4010M 4” Flange with Manual Override

FPE Thermostatic Valves utilize the principle of expanding wax, which in the semi-liquid state undergoes large expansion rates within a relatively narrow temperature range. The self-contained element activates a stainless steel sleeve, which directs flow. All FPE Thermostatic Valves are factory set at predetermined temperatures: no further adjustments are necessary. A wide range of temperatures are available for water and oil temperature control applications.

When used in a diverting application, on start-up the total fluid flow is routed back to the main system. As fluid temperature rises to the control range, some fluid is diverted to the cooling system. As fluid temperature continues to increase, more flow is diverted. When the thermostat is in a fully stroked condition, all fluid flow is directed to the cooling system. FPE Thermostatic Valves may also be used in a mixing application.

In a mixing application, hot fluid enters the “B” port and colder fluid enters the “C” port. The flows mix and the thermostat adjusts to reach the desired temperature, exiting the “A” port.

Standard FPE thermostatic valve housings are made from aluminum and grey iron castings, however, ductile iron, bronze, steel and stainless steel housings are available.

Available Connections: 125 # FF Flange, 150 # RF Flange, 300 # RF and FF Flange, and Navy Flanges

Optional features: Manual Override, High Over Temp element, Plated element

Features

- Self-Contained
- Non-Adjustable
- Tamper-Proof
- Compact
- Wide Range of Temperatures
- Heavy Duty
- Replaceable Element
- Rugged Construction
- Operate in Any Position

FLUID POWER ENERGY, INC.
W229 N591 Foster Court • Waukesha, WI 53186
262•548•6220 Fax 262•548•6239
www.fpevalves.com

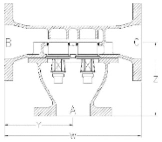
ISO 9001-2000

MADE IN U. S. A.

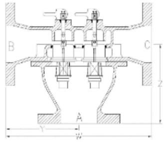
Model 4010

MODEL NUMBER	BODY MATERIAL (*)	NOMINAL PIPE SIZE	PRINCIPAL DIMENSIONS (UNITS in. & (mm))				MAX WIDTH IN THE OTHER PLANE	FLANGE DRILLING			NO. OF ELEMENTS	APPROX. SHIPPING WEIGHT	NOTES OR NUMBERED ENDNOTES
			"X"	"Y"	"W"	"Z"		NO. OF HOLES	DIA. OF HOLES	BOLT CIRCLE			
*4010	A, B, D	4" 125# FF FLANGE	N/A	7 15/16 (201.61)	15 7/8 (403.23)	8 9/16 (217.49)	11 (279.40)	8	3/4 (19.05)	7 1/2 (190.50)	4	A=95#, B=116# D=90#	
	S, SS	4" 150# RF FLANGE	N/A	7 15/16 (201.61)	15 7/8 (403.23)	8 9/16 (217.49)	11 (279.40)	8	3/4 (19.05)	7 1/2 (190.50)	4	S & SS=104#	
*4010M	A, B, D	4" 125# FF FLANGE	N/A	7 15/16 (201.61)	15 7/8 (403.23)	8 9/16 (217.49)	11 (279.40)	8	3/4 (19.05)	7 1/2 (190.50)	4	A=97#, B=118# D=92#	Manual Override
	S, SS	4" 150# RF FLANGE	N/A	7 15/16 (201.61)	15 7/8 (403.23)	8 9/16 (217.49)	11 (279.40)	8	3/4 (19.05)	7 1/2 (190.50)	4	S & SS=106#	Manual Override
*4010X	S, SS	4" 300# RF FLANGE	N/A	7 15/16 (201.61)	15 7/8 (403.23)	8 9/16 (217.49)	11 (279.40)	8	7/8 (22.23)	7 7/8 (200.03)	4	S & SS=126#	
*4010XM	S, SS	4" 300# RF FLANGE	N/A	7 15/16 (201.61)	15 7/8 (403.23)	8 9/16 (217.49)	11 (279.40)	8	7/8 (22.23)	7 7/8 (200.03)	4	S & SS=127#	Manual Override

* (Replace * with body material type; A=Cast Iron, B=Bronze, D=Ductile, S=Steel, SS=Stainless Steel)



*4010, *4010X



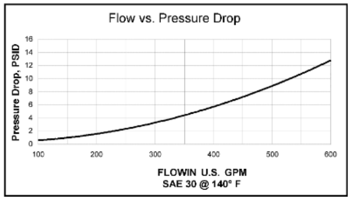
*4010M, *4010XM

PRESSURE RATINGS	
MATERIAL	PSI
A	150
B	125
D	200
S, SS	275
SX, SSX	350

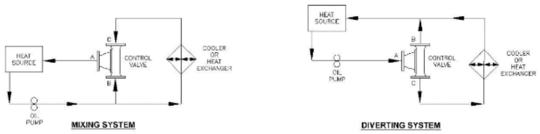
PART #	DESCRIPTION
*4010	VALVE BODY (*See table for material)
*4020	VALVE COVER (*See table for material)
2071	LIP SEAL
4080-C	GASKET
2050-Temp	THERMOSTAT (Temp to follow dash)
1604	HEX BOLT
1605	LOCK WASHER
1590	NAMEPLATE

FPE Model 4000 Replacement Kit (*Includes the following:*)

4080-C	GASKET
(4) 2071	LIP SEAL
(4) 2050-Temp	THERMOSTAT (Temp to follow dash)



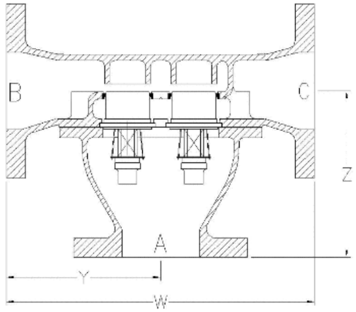
APPLICATION CHARTS



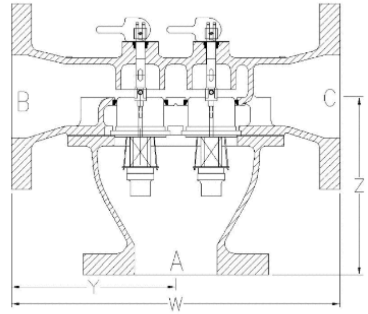
FLUID POWER ENERGY, INC.
W229 N591 Foster Court • Waukesha, WI 53186
262•548•6220 Fax 262•548•6239
www.fpevalves.com

To Order

Specify Model Number, nominal temperature desired, and housing material. For Model coding information, visit our website or consult your factory representative.



*4010, *4010X



*4010M, *4010XM

PRESSURE RATINGS	
MATERIAL	PSI
A	150
B	125
D	200
S, SS	275
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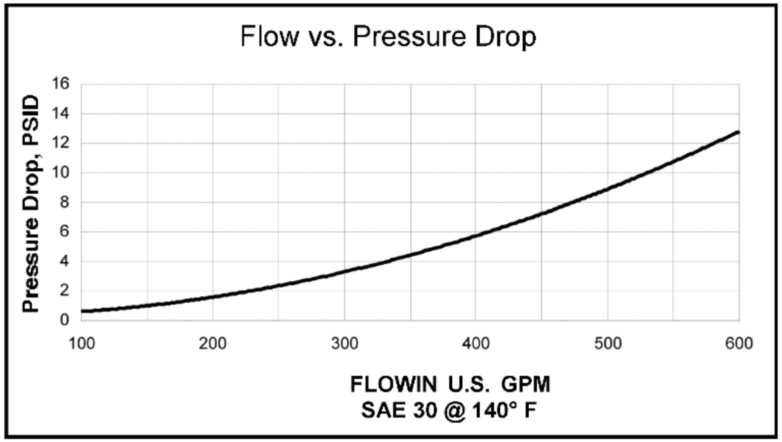
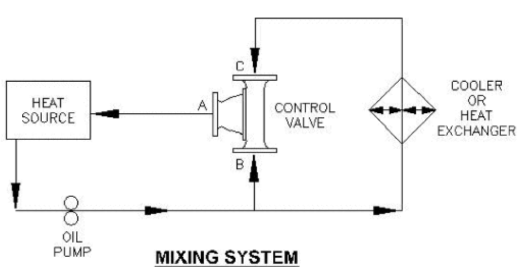
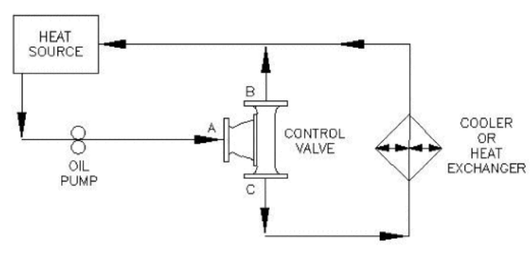
FPE Model 4000 Replacement Kit (*Includes the following:*)	
4080-C	GASKET
(4) 2071	LIP SEAL
(4) 2050-Temp	THERMOSTAT (Temp to follow dash)



APPLICATION CHARTS



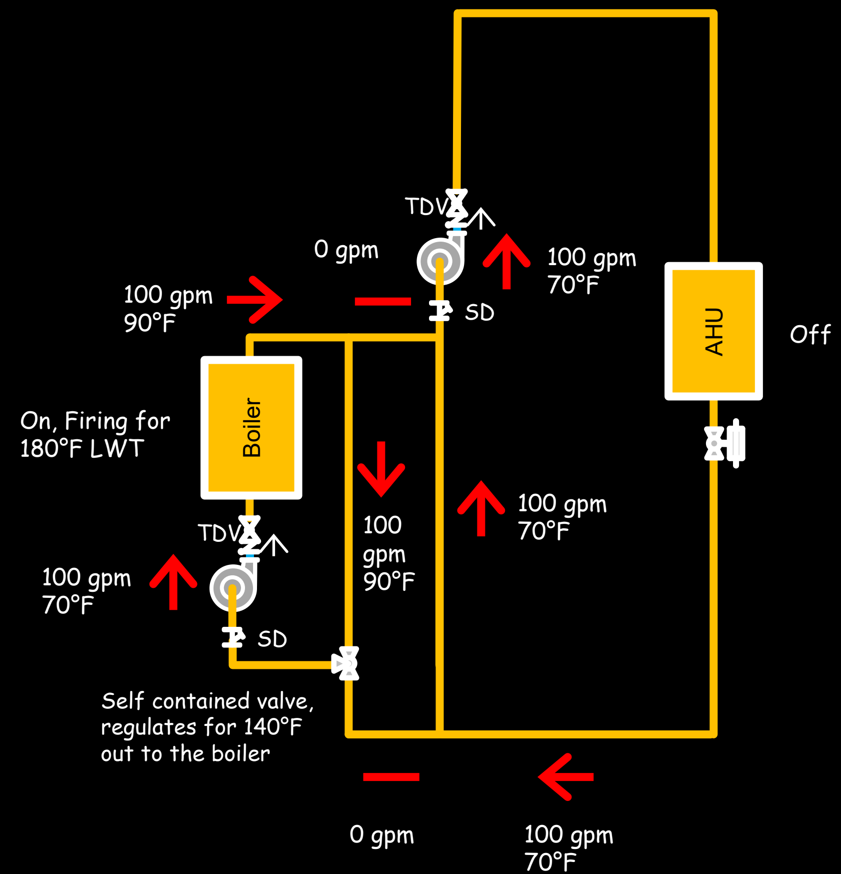
MIXING SYSTEM



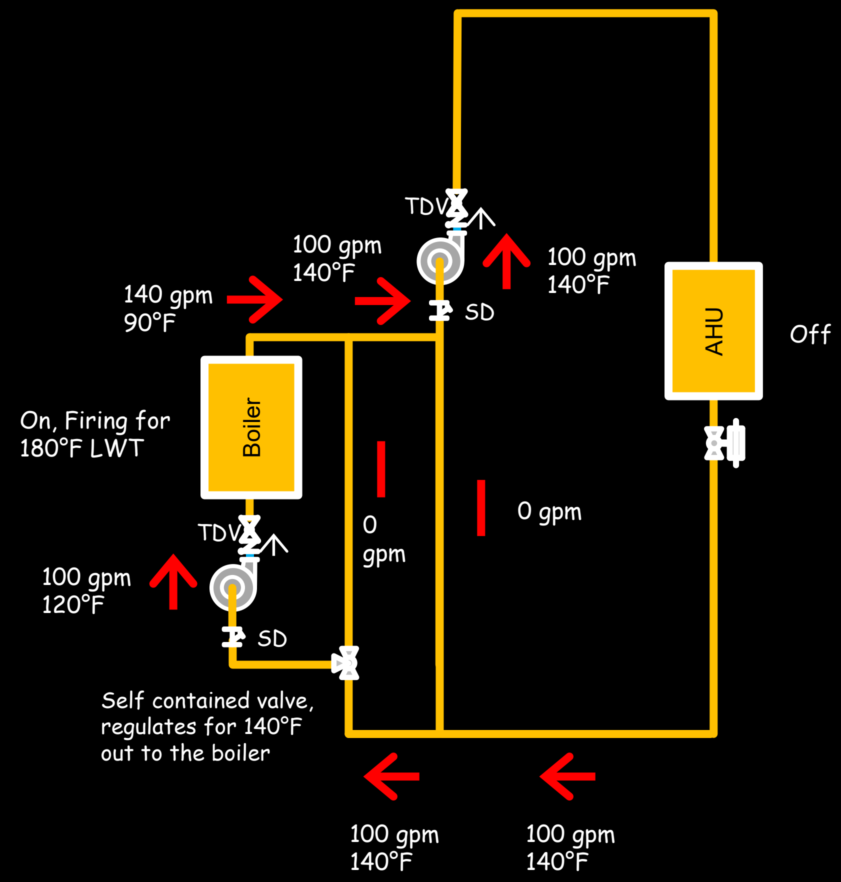
DIVERTING SYSTEM

To Order

Design Day, Cold Start

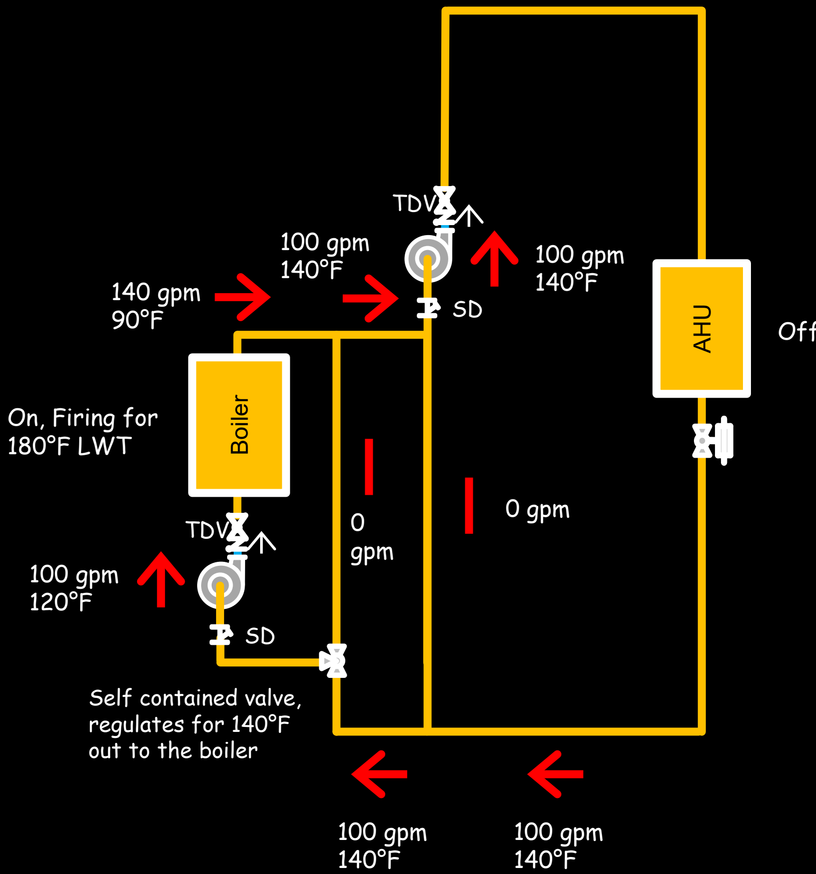


Design Day, Cold Start, Boiler LWT Reaches 140°F

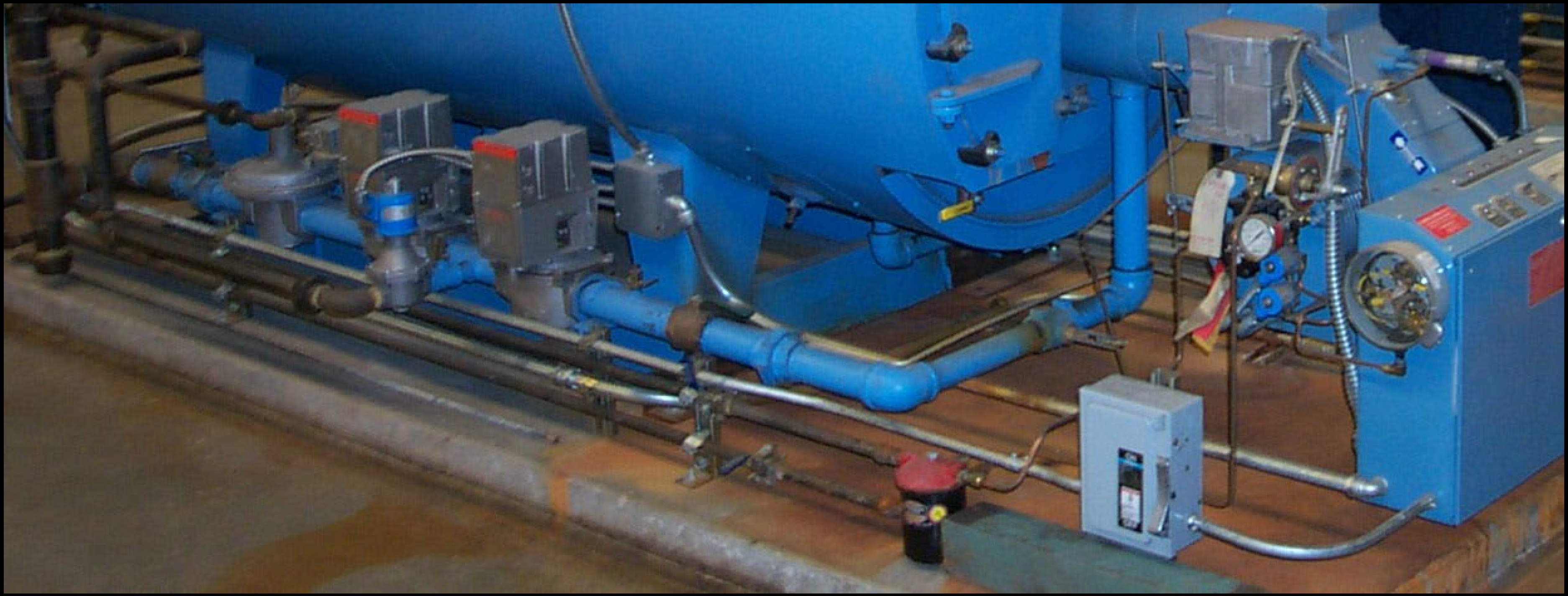


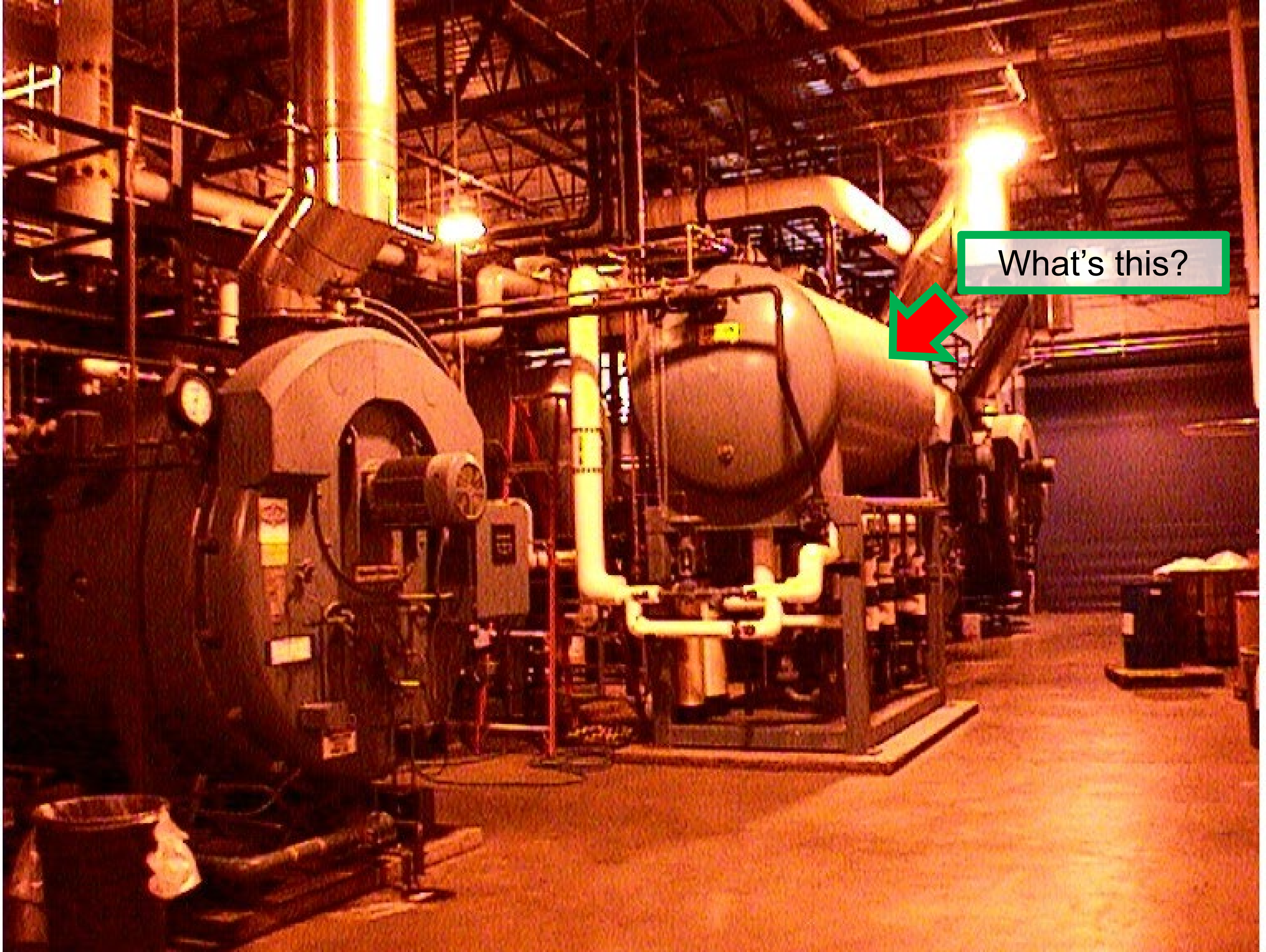
More Information on Variable Flow Systems

https://tinyurl.com/VariabeFlow

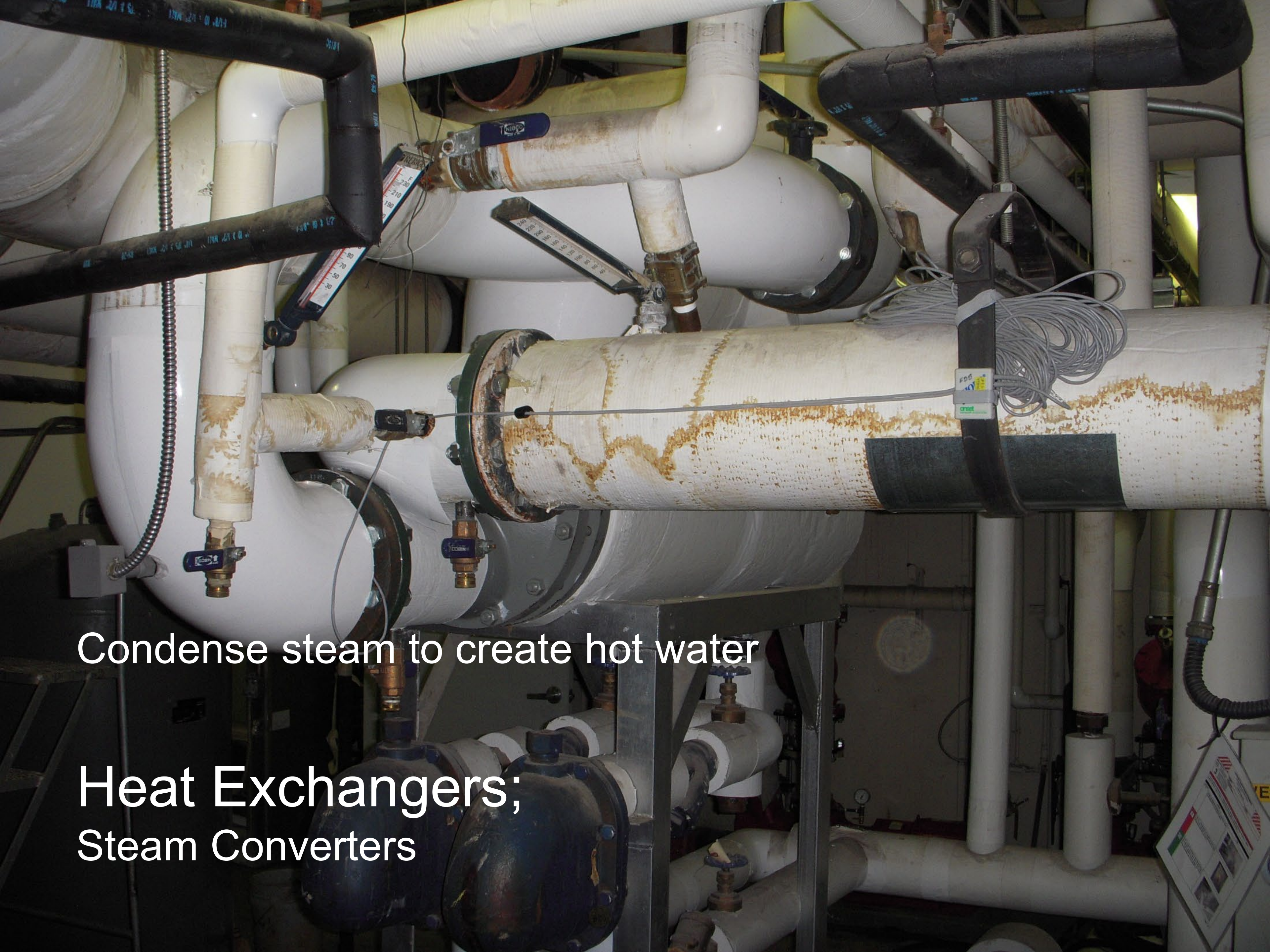


Controlling the Fuel; Critical for All Applications

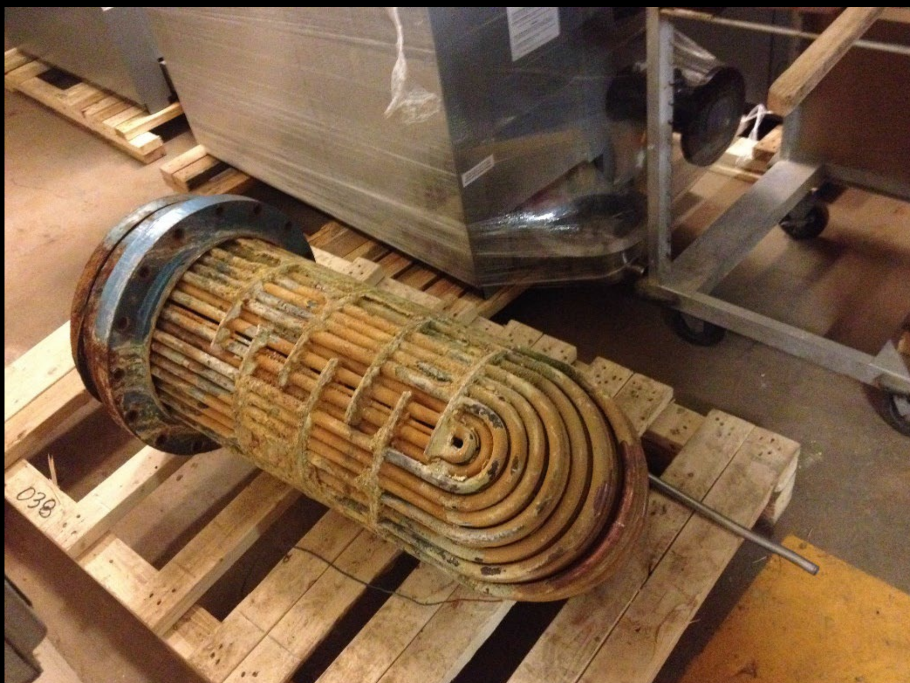


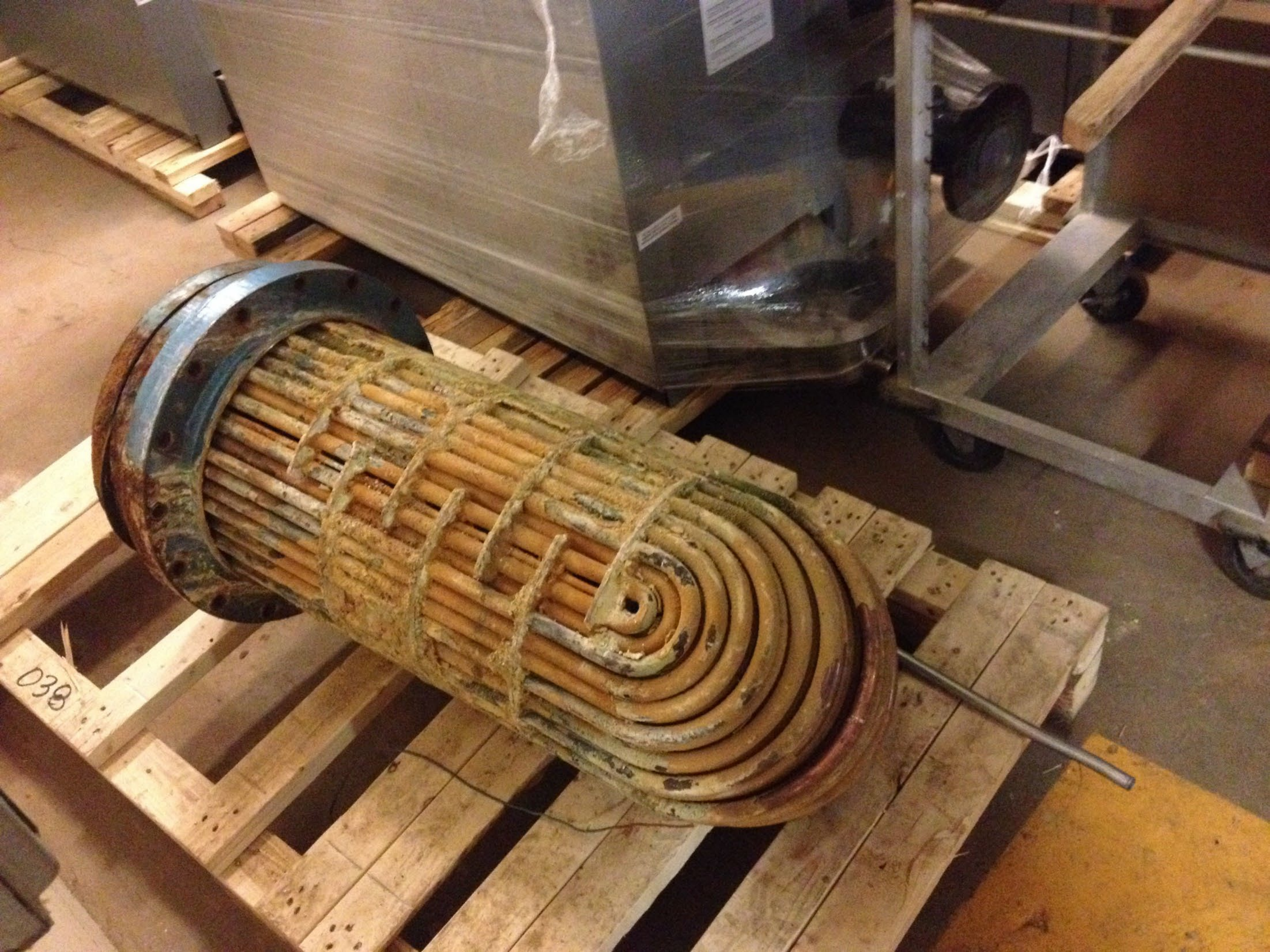

What’s this?

Why Deaerators and Water Treatment Matter


Condense steam to create hot water
Heat Exchangers;
Steam Converters

A Heat Exchanger Tube Bundle



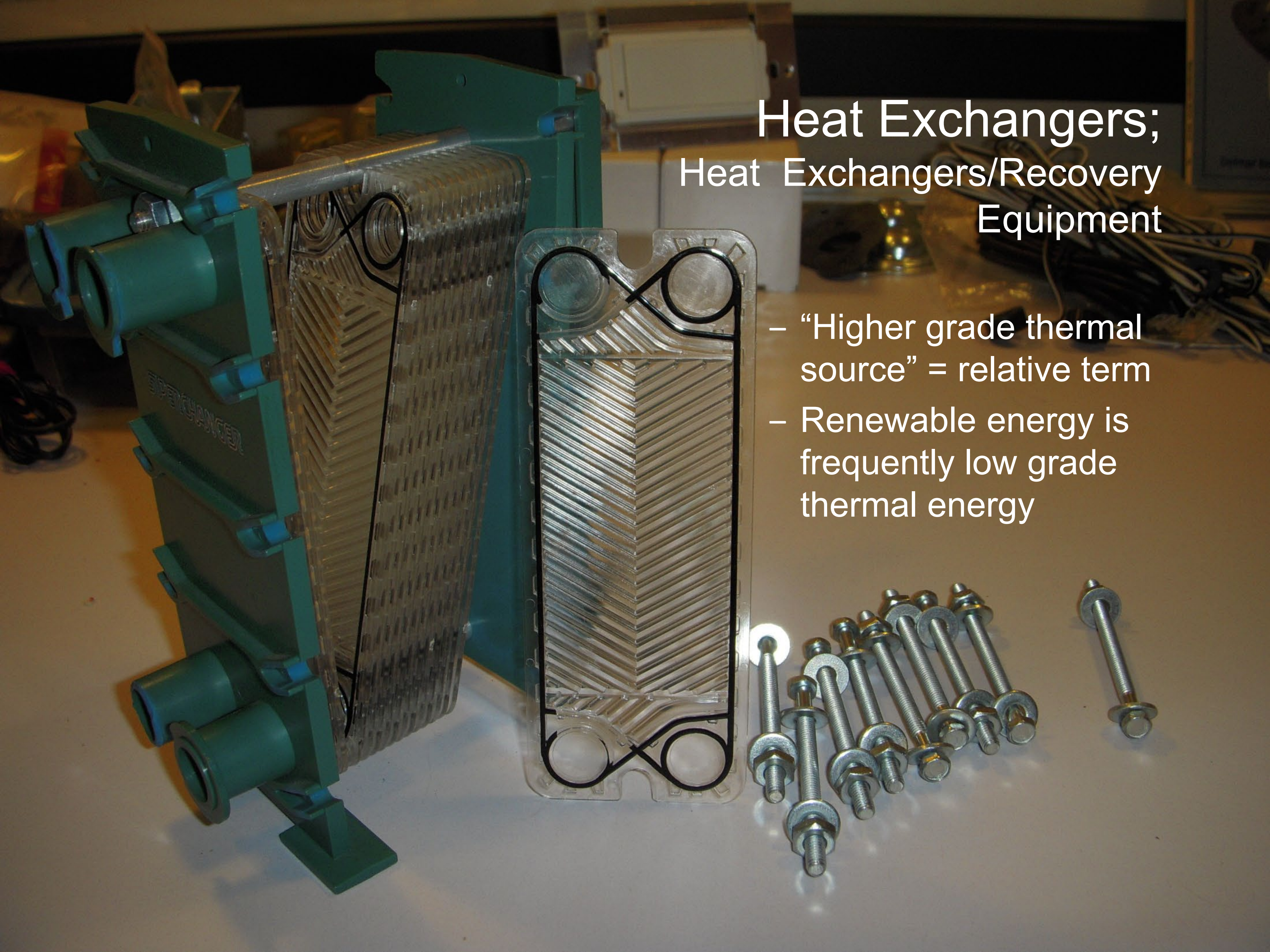

038

Heat Exchangers;
Cogeneration Equipment

- Steam or hot water recovered from power generation equipment
- Heat balance is critical to over-all plant efficiency

Heat Exchangers;

Heat Exchangers/Recovery Equipment



- “Higher grade thermal source” = relative term
- Renewable energy is frequently low grade thermal energy

Questions?

Together, Building
a Better California

Break Time

We will return at 10:25 AM Pacific Time

Together, Building
a Better California