Energy Efficiency Best Practices for Cheesemakers

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Efficiency Vermont
January 23, 2020

Thermal energy efficiency topics

- Boiler O&M
- Boiler replacement- Design for Efficiency
- Boiler reset controls (Hydronic)
- Boiler burner retrofit (All systems)
- Pipe insulation
- Steam Pressure reduction
- Steam trap repair and replacement
- Fuel switch- fossil fuel to AWH (Advanced Wood Heating).

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Additional Measures

- Thermal Shell
- Outside Air reduction
- Heat recovery
- System & Building Control Optimization
  - Optimized start-stop
  - Vary flow of air and water based upon need
  - Scheduling

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Hot water & Steam

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Hydronic and Steam

- Hydronic systems = heated, liquid water near 180F or less
- Steam Systems = Steam heated
  - Low Pressure (0 to 15psi)
    - 212 to 250f
  - High Pressure (Over 15psi)
    - Most up to 50psi or 75psi
    - 250 to 320f
  - *Has an extremely important condensate return system*

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Steam systems

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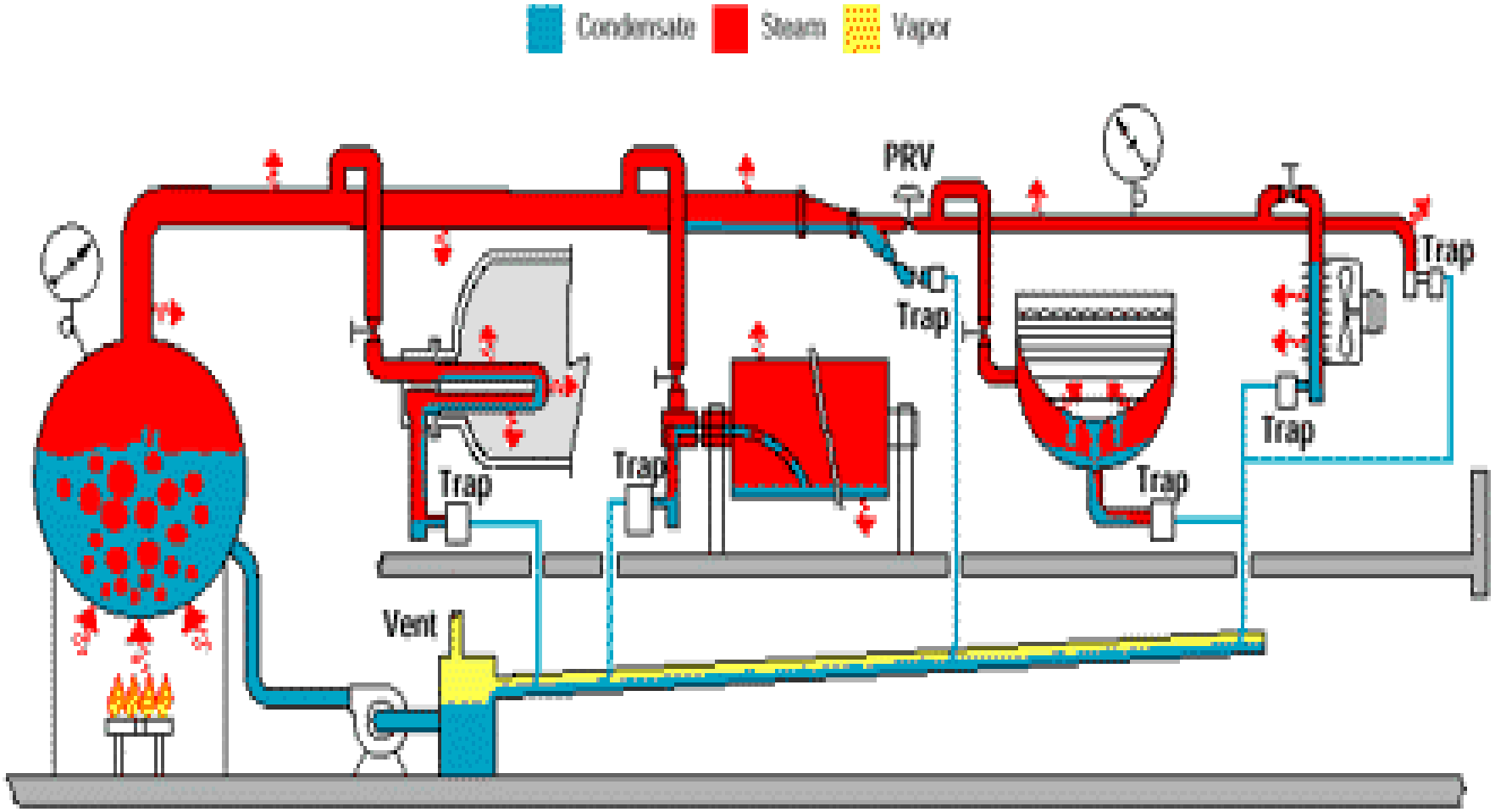
Steam system components



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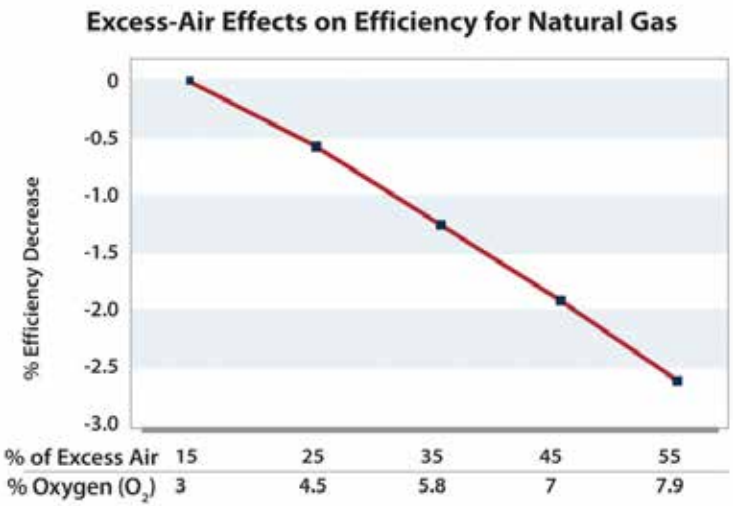
O&M- Tune-up

- Protect your investment and Save operating costs



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Boiler O&M

- Annual tune-up
- Water chemistry
- Steam Trap maintenance
- Insulation inspection and repair

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Steam -Boiler Blowdown Controls

- The water that is added to the boiler to make-up for steam and condensate lost increases the total dissolved solids (TDS) levels in the boiler.
- If the TDS levels exceed a certain level the minerals deposit on the heat transfer surfaces of the boiler and cause failure.
- To prevent TDS build-up steam boilers are regularly blown down to discharge the concentrated water and make up with cleaner diluted water.

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Steam Boiler Blow-down Controls

- If too little blow-down, minerals build up.
- If too much blow-down, energy, water, and water treatment chemicals are lost.
- Want the blow-down to be just right!
- Solution is to install a conductivity meter and controller to monitor TDS and blow-down to maintain acceptable levels
- In larger systems with a lot of blow-down, blow-down heat exchangers are a good idea

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Hydronic, Efficient Condensing Boilers – Design for Correct temps

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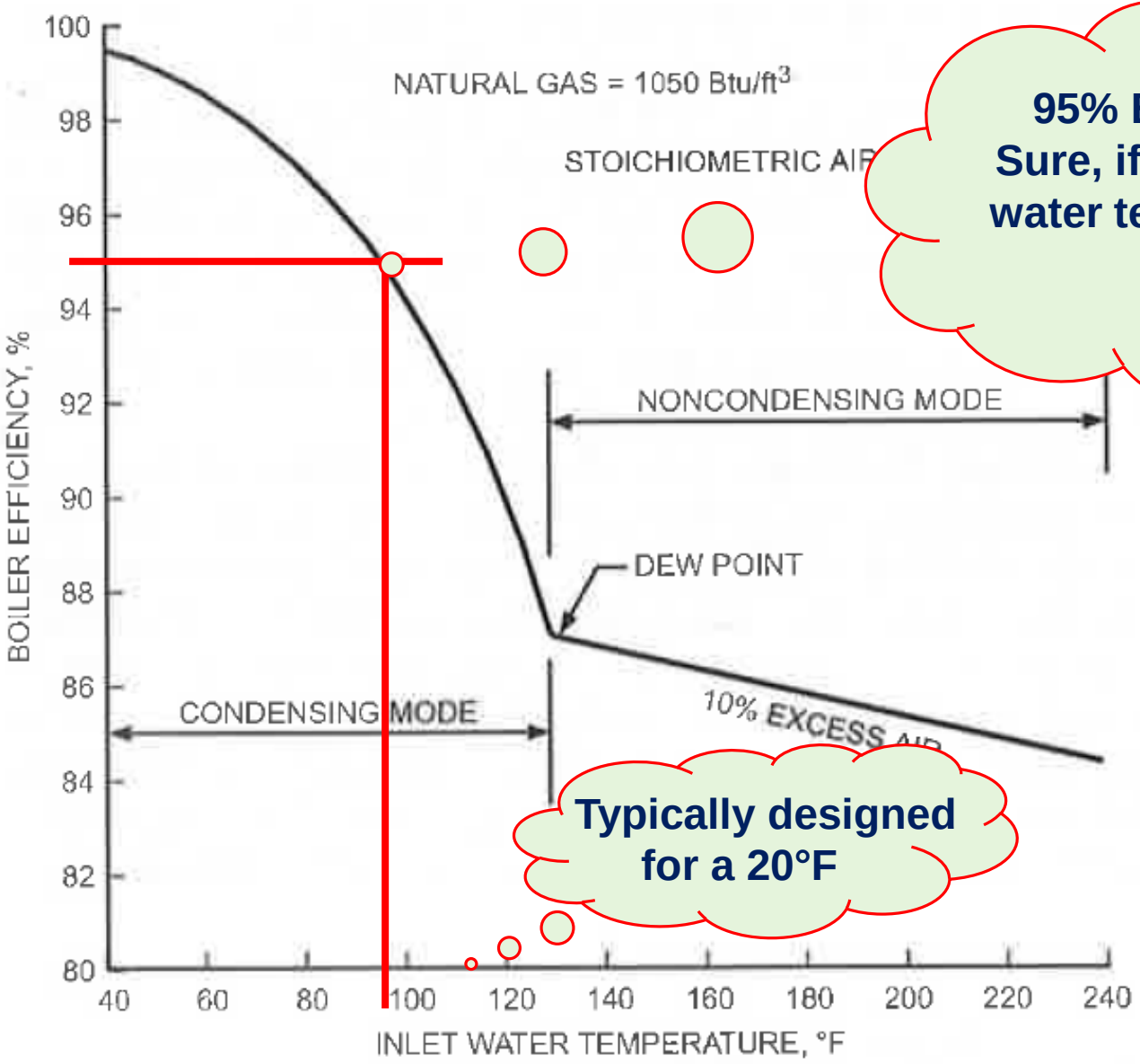

95% Efficiency? Sure, if your supply water temp is 115°F!

Typically designed for a 20°F

Fig. 6 Effect of Inlet Water Temperature on Efficiency of Condensing Boilers

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Lower Distribution Temperature

Small Commercial building

<u>BEFORE</u>

250 MBH boiler (86%)
180 supply, 160 return
5000 hours of heating
Average Pipe size 1.25”
` 400 feet of piping

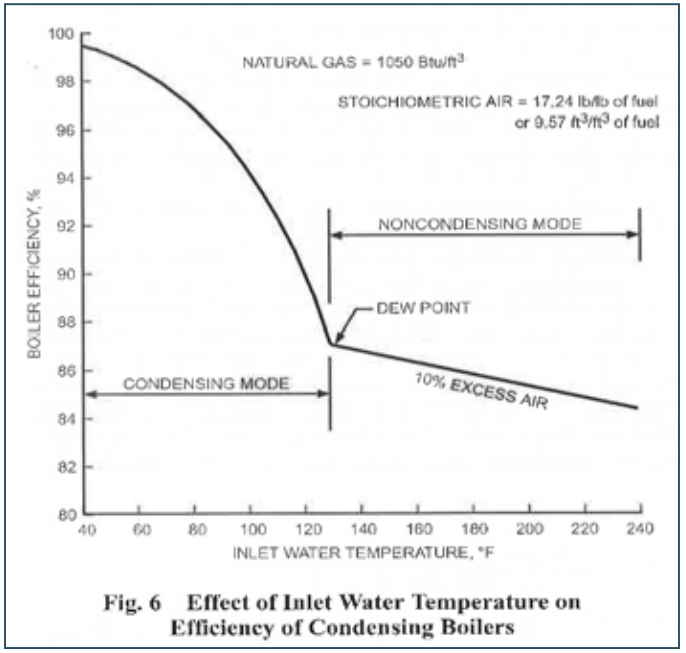

Fig. 6 Effect of Inlet Water Temperature on Efficiency of Condensing Boilers

900 FTE hours of boiler operation the building will require 225 MMBTU (2,850 gal propane)

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Lower Distribution Temperature

Small Commercial building

AFTER

250 MBH boiler (92%)
140 supply, 110 return
5000 hours of heating
Average Pipe size 1.25”
` 400 feet of piping

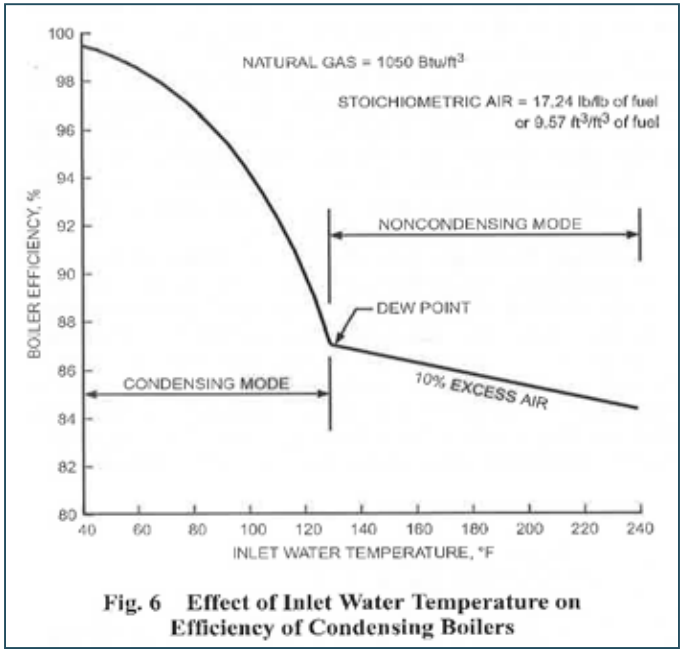

Fig. 6 Effect of Inlet Water Temperature on Efficiency of Condensing Boilers

Boiler LP savings.

2,850 Gallons at 86%

2,670 Gallons at 92%

180 Gallons Saved = 7% Savings

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Lower Distribution Temperature

Small Commercial building

AFTER

Average Pipe size 1.25”

` 400 feet of piping

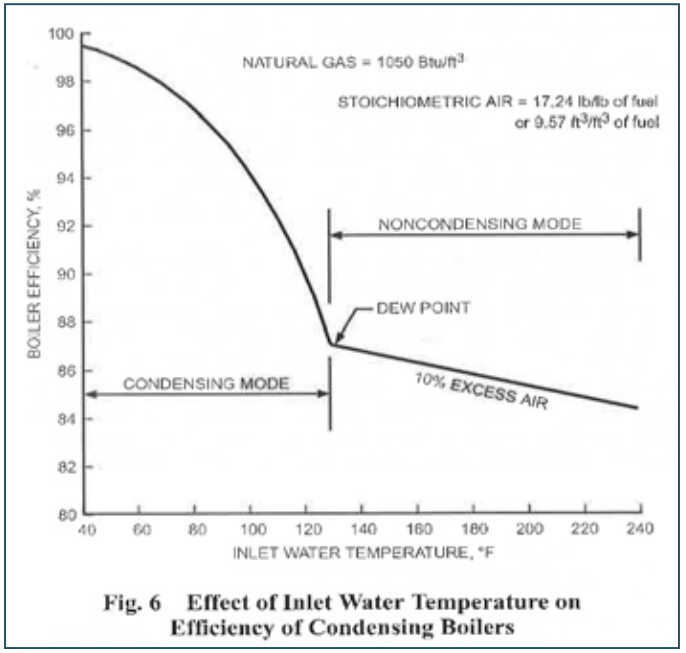

Fig. 6 Effect of Inlet Water Temperature on Efficiency of Condensing Boilers

Reduced Piping Heat Loss

170 Deg Average water T

8.8 MMBTU

125 Deg Average water T

5.0 MMBTU 3.3 MMBTU Saved 40 Gallons of LP

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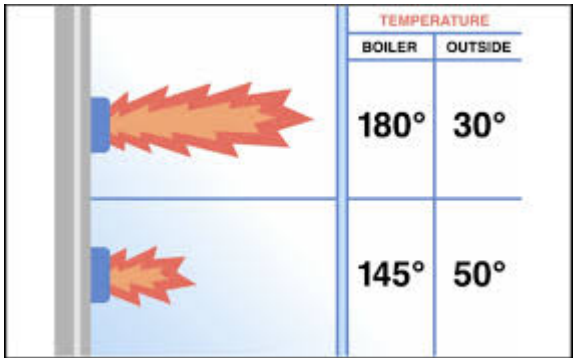
Boiler Reset Control



Changes Firing Rate as outside temperature changes.

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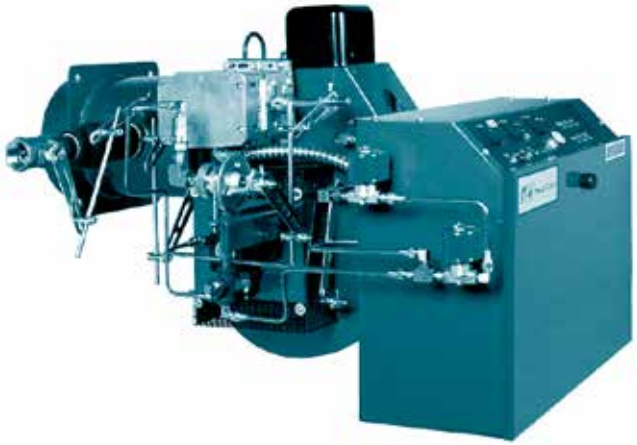
Burners – Can save up to 15%



Linkage Controlled Burner

Digitally Controlled Burner

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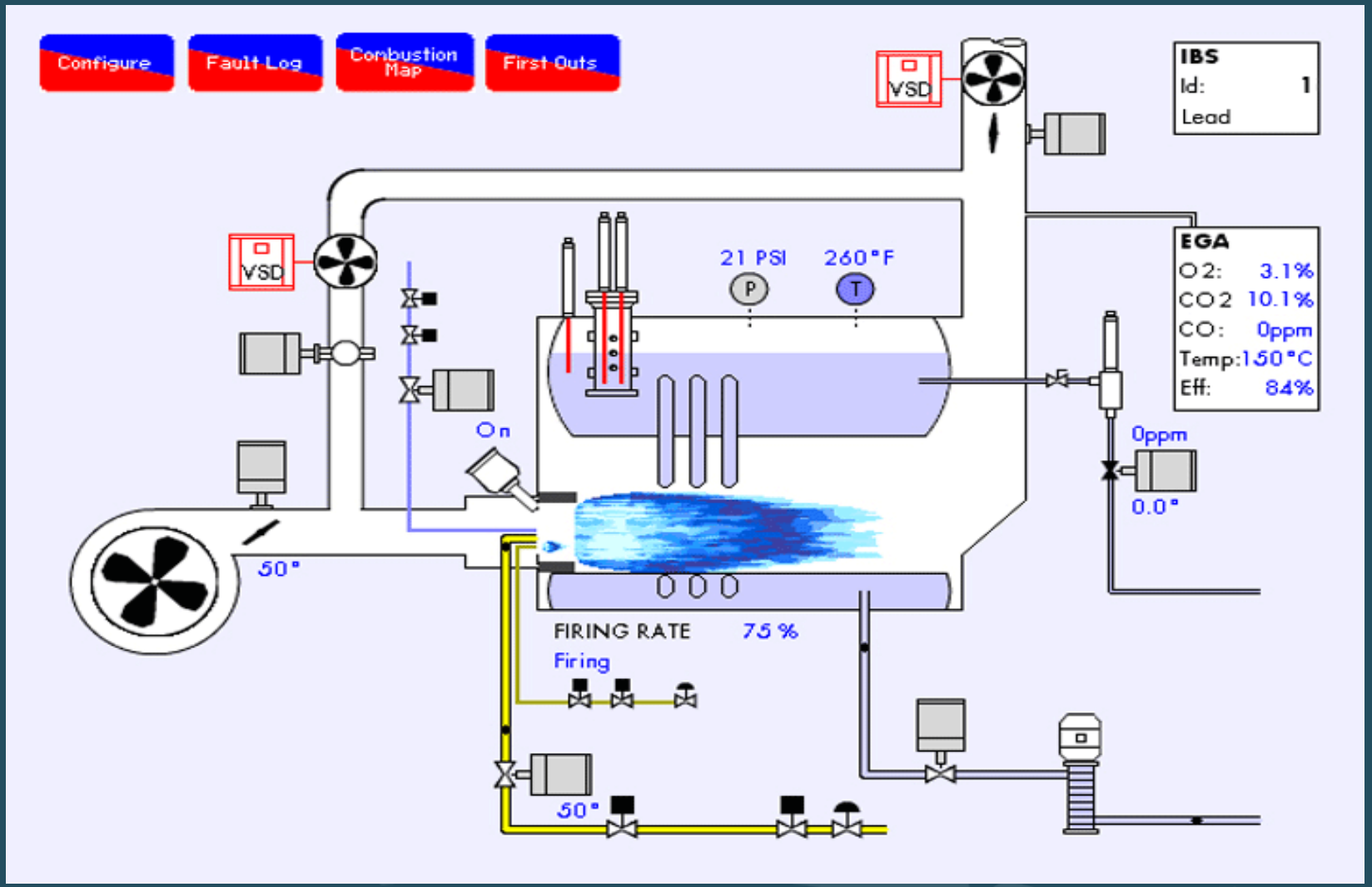
Combustion Controls



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Pressure Reduction – 1% or higher

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Steam Properties at different Pressures

Distribution Measures

- Pipe Insulation
- Low temperature distribution
- Steam Traps
  - Repair, replace, insulate

These are all low cost, low resource, quick payback measures.

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Pipe Insulation

- Vermont Energy Code C403.2.10 Hot water and steam pipes need to be insulated.
- Is it ever ok not to insulate hot water piping?

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Pipe Insulation

- Vermont Energy Code C403.2.10 Hot water and steam pipes need to be insulated.
- Is it ever ok not to insulate hot water piping?
  - The code says NO.
  - But…at times…

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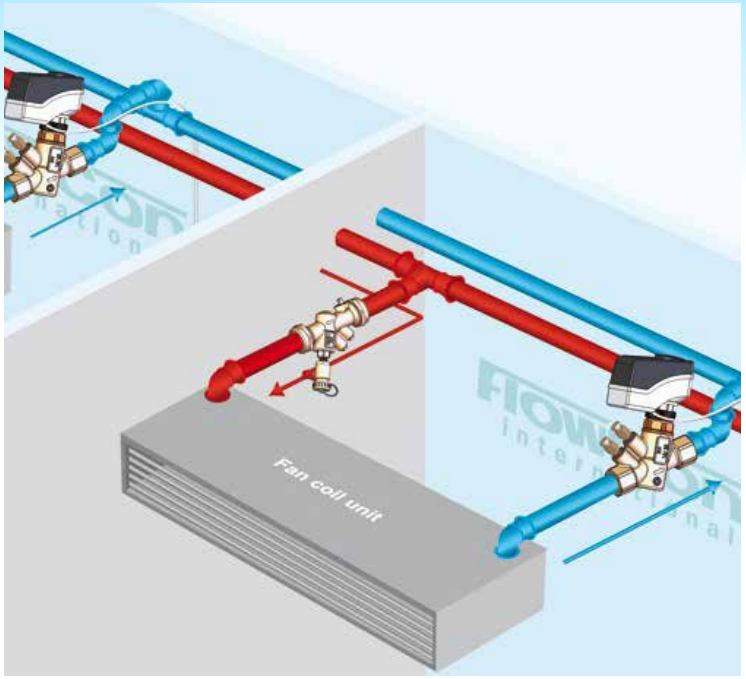
Example ¾” Pipe

Small Commercial building

Hot water heating

- LP Boiler 86%
- 180 Deg Supply
- 160 Deg Return
- 5000 hour run time.



12” of ¾” uninsulated copper pipe rejects **41** btu/h

With 1.5” insulation **4** btu/h

That’s **185,000** btus per year

2.4 gallons of propane

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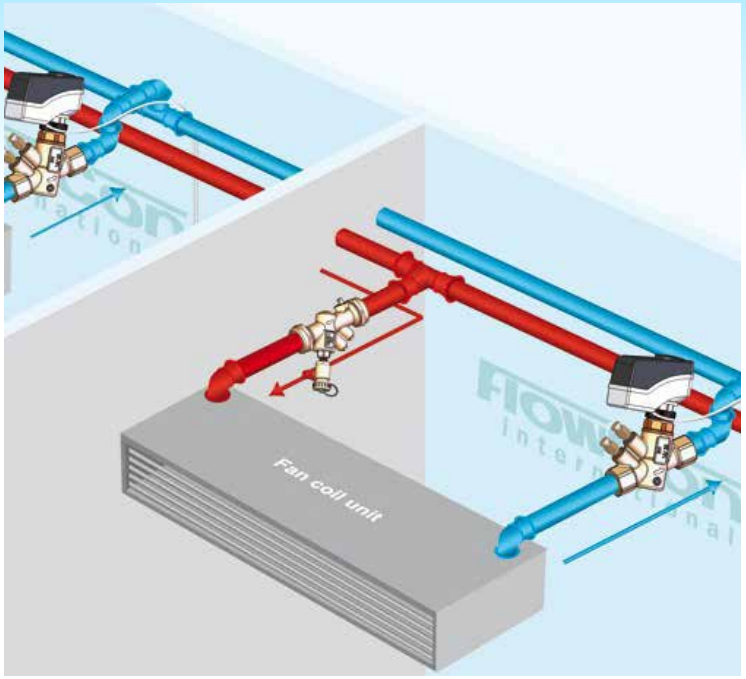
Example 1” Pipe

Small Commercial building

Hot water heating

- LP Boiler 86%
- 180 Deg Supply
- 160 Deg Return
- 5000 hour run time.



12” of 1” uninsulated copper pipe rejects **52.5** btu/h

With 1.5” insulation **4.5** btu/h

That’s **240,000** btus per year

3 gallons of propane

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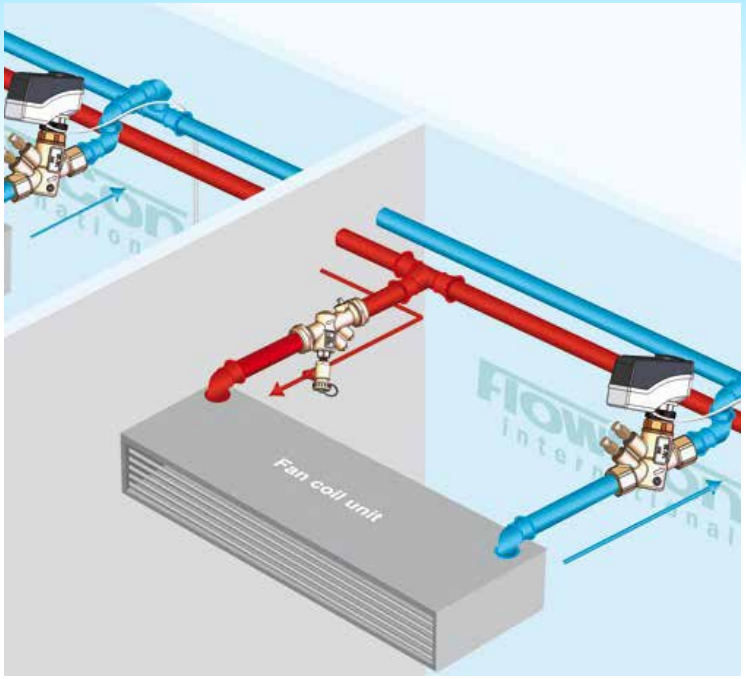
Example 2” Pipe

Small Commercial building

Hot water heating

- LP Boiler 86%
- 180 Deg Supply
- 160 Deg Return
- 5000 hour run time.



12” of 2” uninsulated copper pipe rejects **98** btu/h

With 2” insulation **5** btu/h

That’s **465,000** btus per year

5.9 gallons of propane

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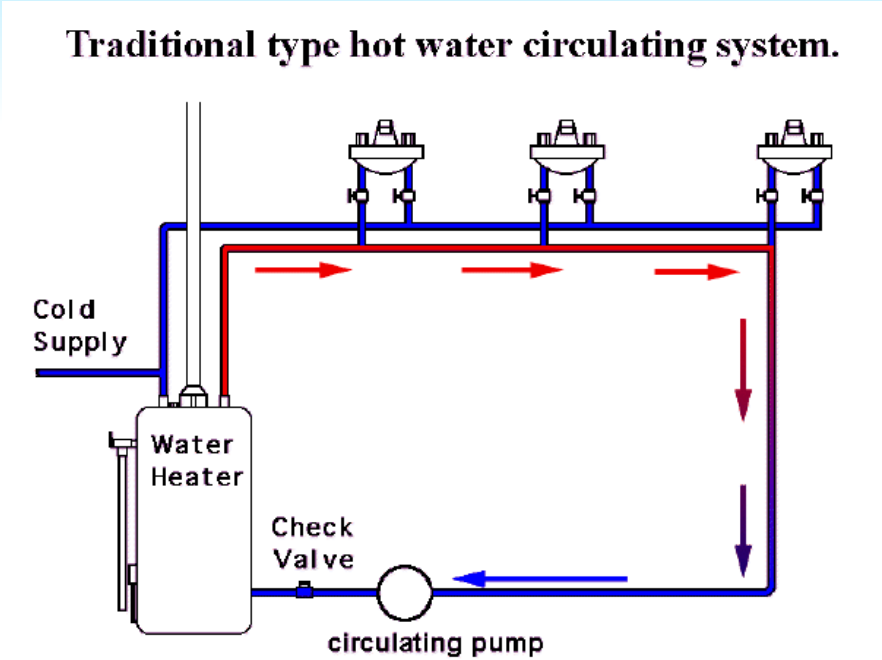
Example DHW

Domestic Hot water

WH 86% (LP)

120 Deg Supply

8000 hour per year.



12” of 1” uninsulated copper pipe rejects **27.5** btu/h

12” of 2” pipe with 1.5” insulation **2.5** btu/h

That’s **165,600** btus per year

2.5 gallons of propane

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Insulation Blankets

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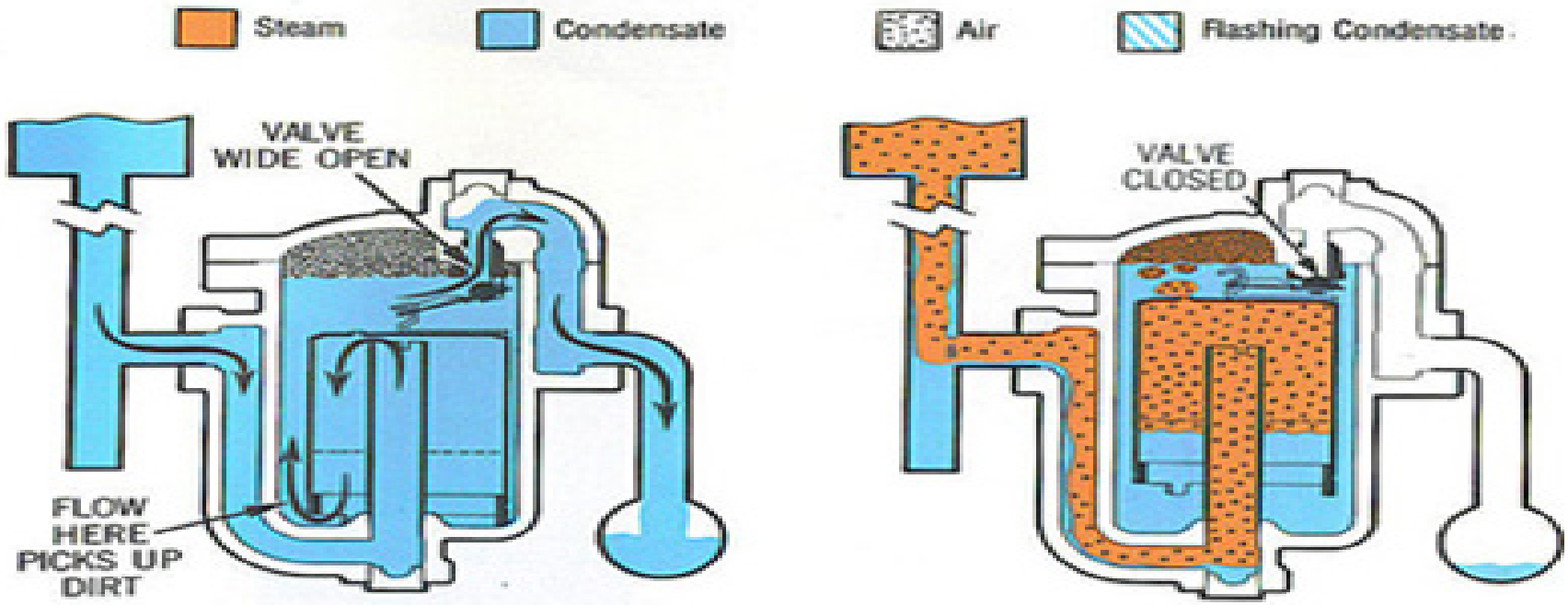
CONFINED SPACE
DO NOT ENTER

Steam Trap Inverted Bucket



1. Steam trap is installed in drain line between steam heated unit and condensate return header. At this point, bucket is down and valve is wide open. As initial flood of condensate enters the trap and flows under bottom edge of bucket, it fills trap body and completely submerges bucket. Condensate then discharges through wide open valve to return header.

2. Steam also enters trap under bottom edge of bucket, where it rises and collects at top, imparting buoyancy. Bucket then rises and lifts valve toward its seat until valve is snapped tightly shut. Air and carbon dioxide continually pass through bucket vent and collect at top of trap. Any steam passing through vent is condensed by radiation from trap.

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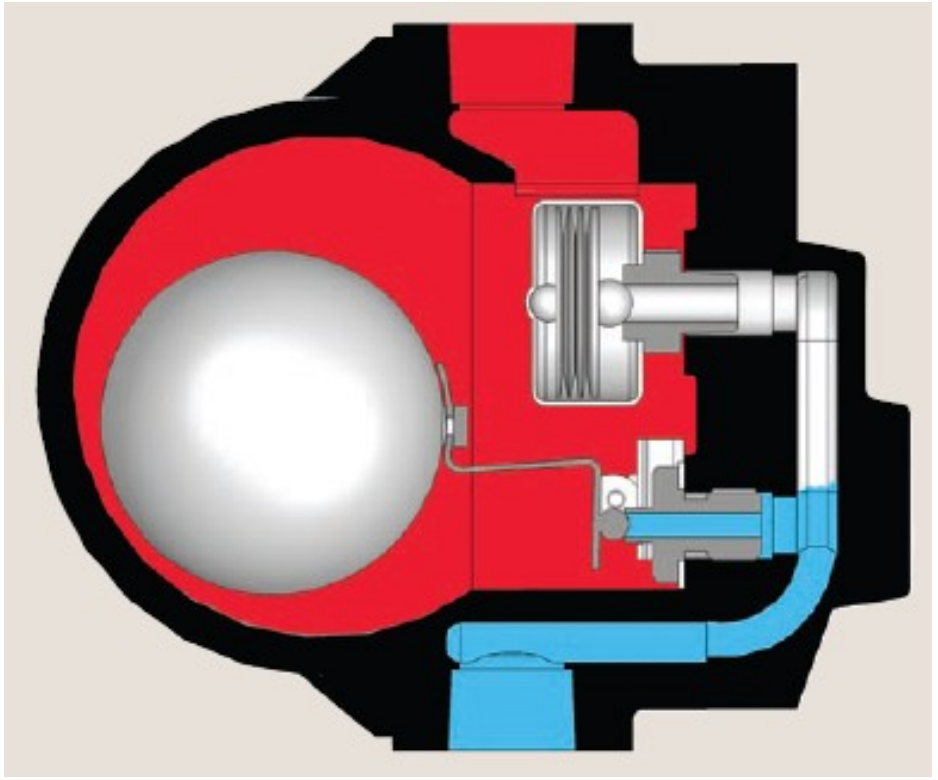
Steam Trap Float & Thermostat



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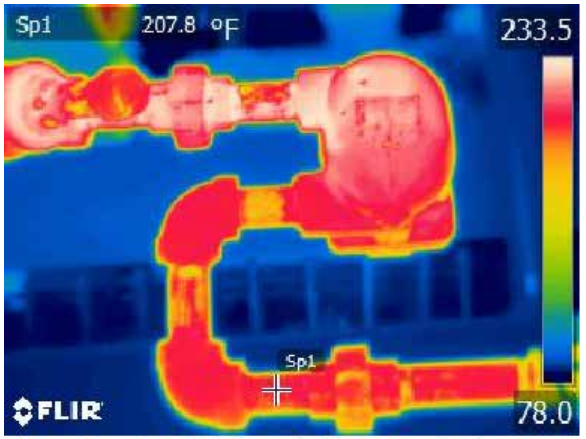
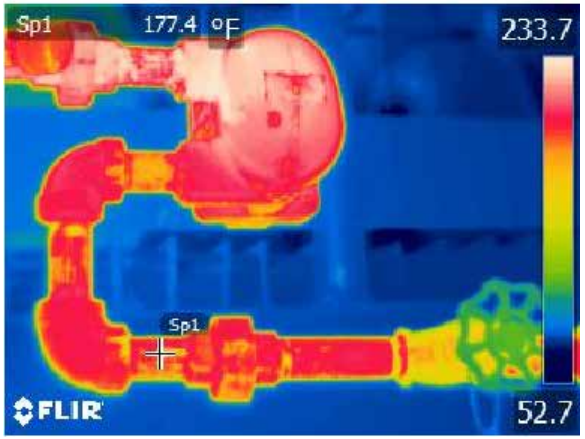
Steam Traps

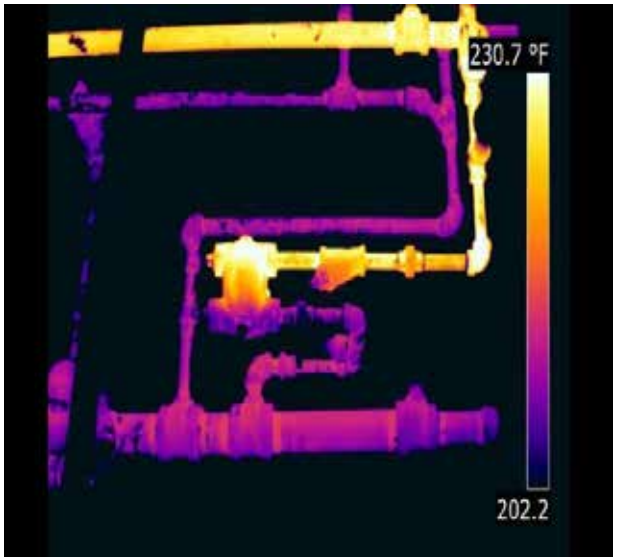
- Thermal Losses
  - Piping around steam trap.
  - Steam, lbs of water



Above: Steam trap failed open (note condensate return temperature is 207.8F)

Below: Replacement steam trap operating properly (note condensate return temperature now 177.4F)





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Steam Traps
What To do, Who Can Help?

- Insulate the piping before and after the Trap
  - 3.5 MMBTU per Trap (Save $35.- year)
- Perform a Steam trap audit

- Fix the leaks/ Fix the traps
  - 5 lbs/ hr leak correction = 38.5MMBTU (Save $380.-)
  - 120 Gallons of water saved if leaking trap
  - 4920 Gallons of water saved if steam leak.
- Steam Trap Correction = Easy Savings

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Advanced Wood Heat

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Fuel Types

Green Woodchips

- 35-50% Moisture
- 4,750 BTU/ LB
- $ 65 Ton (delivered)
- $ 6.80 / MMBTU
- 1.5 Million – 10 Million

Dry Woodchips

- 25% Moisture
- 6,250 BTU/ LB
- $ 125/ Ton (delivered)
- $ 10.00 / MMBTU
- 100 MBH – 2 Million

Wood Pellets

- 6-8% Moisture
- 7,750 BTU/ LB (input)
- $ 245 / Ton (delivered)
- $15.81 / MMBUT
- 100 MBH – 2 Million

(Cost per ton ($)) / ((BTU/LB x 2000) / 1000000) = $/ MMBTU

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Summary Rules of Thumb

- Average heating cost of a commercial building is about $1.00/sf
- Installing a modulating burner can save 15% of the heating cost.
- Installing a condensing boiler w/ modulating burner can save 30%.
- Hot water reset can save between 5-7% annually.
- Demand control ventilation can save 50% of the heat & electric cost of the system controlled.
- Heat recovery systems average about 65% effectiveness.
- Steam trap repair/replace can save between 5% - 50% of steam cost
- Pipe Insulation on heating systems typically results in a 2-4 year simple payback.
- Kitchen Hoods are typically the largest heating and electrical load in a commercial kitchen. Hood controllers can save up to 50% of the electric and fossil fuel cost annually.

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Questions

Questions

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JANUARY 23, 2020

Refrigeration Energy Efficiency

Outline

- Refrigeration System Overview
- How to identify opportunities
- Efficiency Vermont support
  - Evaporator fans
  - Evaporator fan controls
  - High Efficiency Condensing Units (HECU)
  - Refrigerant Management
  - Natural Refrigerants

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What is refrigeration?

A process of moving HEAT from one location to another by use of refrigerant in a closed repetitive cycle

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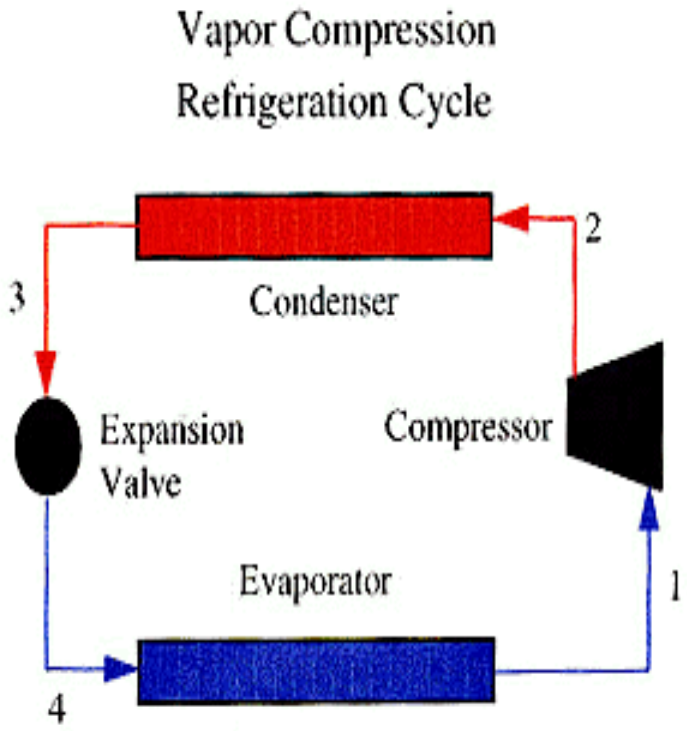
The Refrigeration Cycle

1. **Compressor** compresses refrigerant gas (increasing temperature and pressure)
2. **Condenser** provides surface area for heated refrigerant to transfer heat
3. **Expansion** valve allows refrigerant to expand (reducing temperature and pressure)
4. **Evaporator** allows refrigerant to absorb heat



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Condensing Units

- Packaged system
- Compressors & Condenser HX
- The “OUTSIDE” component of most refrigeration systems

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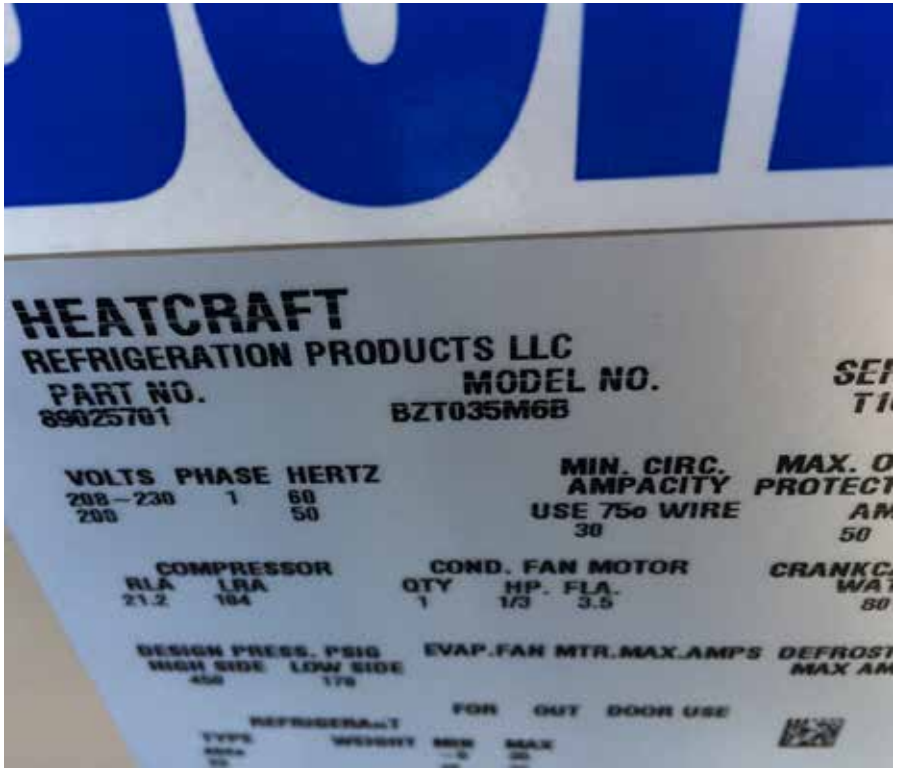
Condensing Units



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High Efficiency Condensing Units

- Condensing units packaged with
  - High Efficiency Scroll/discus compressors
  - Floating head pressure controls
  - ECM Condenser Fans
  - Components to Flood evaporator

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Compressor: Scroll

- Quieter than other compressors
- Often more efficient: higher mass flow rate
- 80% less moving parts than a reciprocating compressor
- Digital scroll allows variable speed

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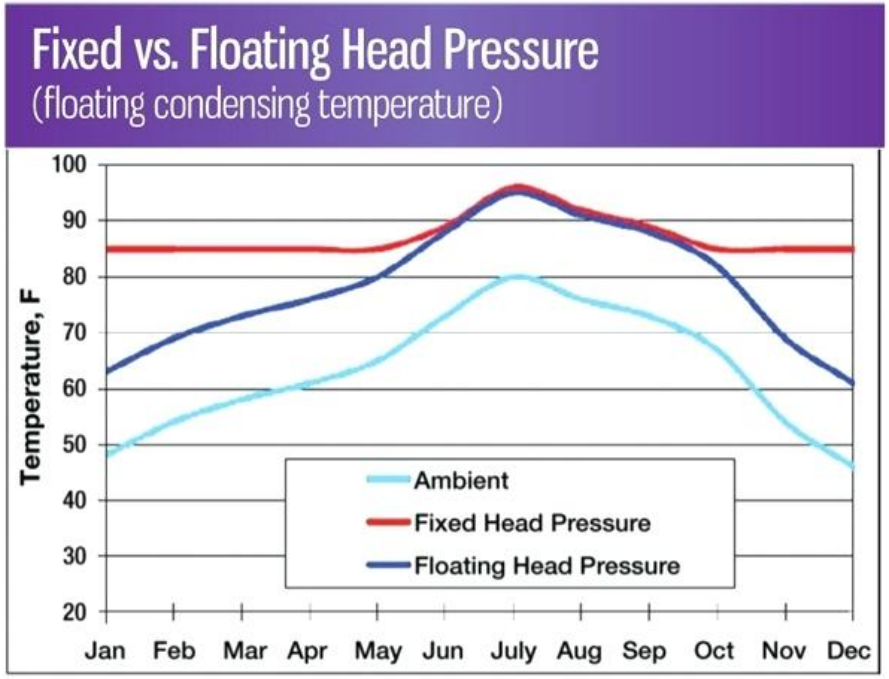
What are floating head pressure controls?

- Cycling or varying the speed of condenser fans
- Traditional systems - 90F min. condenser temperature set point
- FHP systems – 70F or lower
- Compressor becomes 1.5% more efficient per degree



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Business Case

High efficiency condensing units / replacement of failed unit				
	Condensing Unit (HP)	Annual $ Savings	Vermont Incentive ($)	Payback (years)
Cooler	1	622	600	Instant
	2	676	1200	Instant
	3	839	1800	Instant
	4	1002	1600	Instant
	5	1008	2000	Instant
Freezer	2	619	1200	Instant
	3	702	1800	Instant
	4	832	1600	Instant
	5	961	2000	Instant

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Who sells HECUs

- Heatcraft (Bohn, Larkin, Chandler) makes the Orbus system
- Trenton, Keeprite make the Limitrol, Smart Speed, TQZ system
- Copeland & Mueller make qualifying units
- 3-4 week lead time, Trenton is better than Heatcraft, at least on east coast.

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Evaporators

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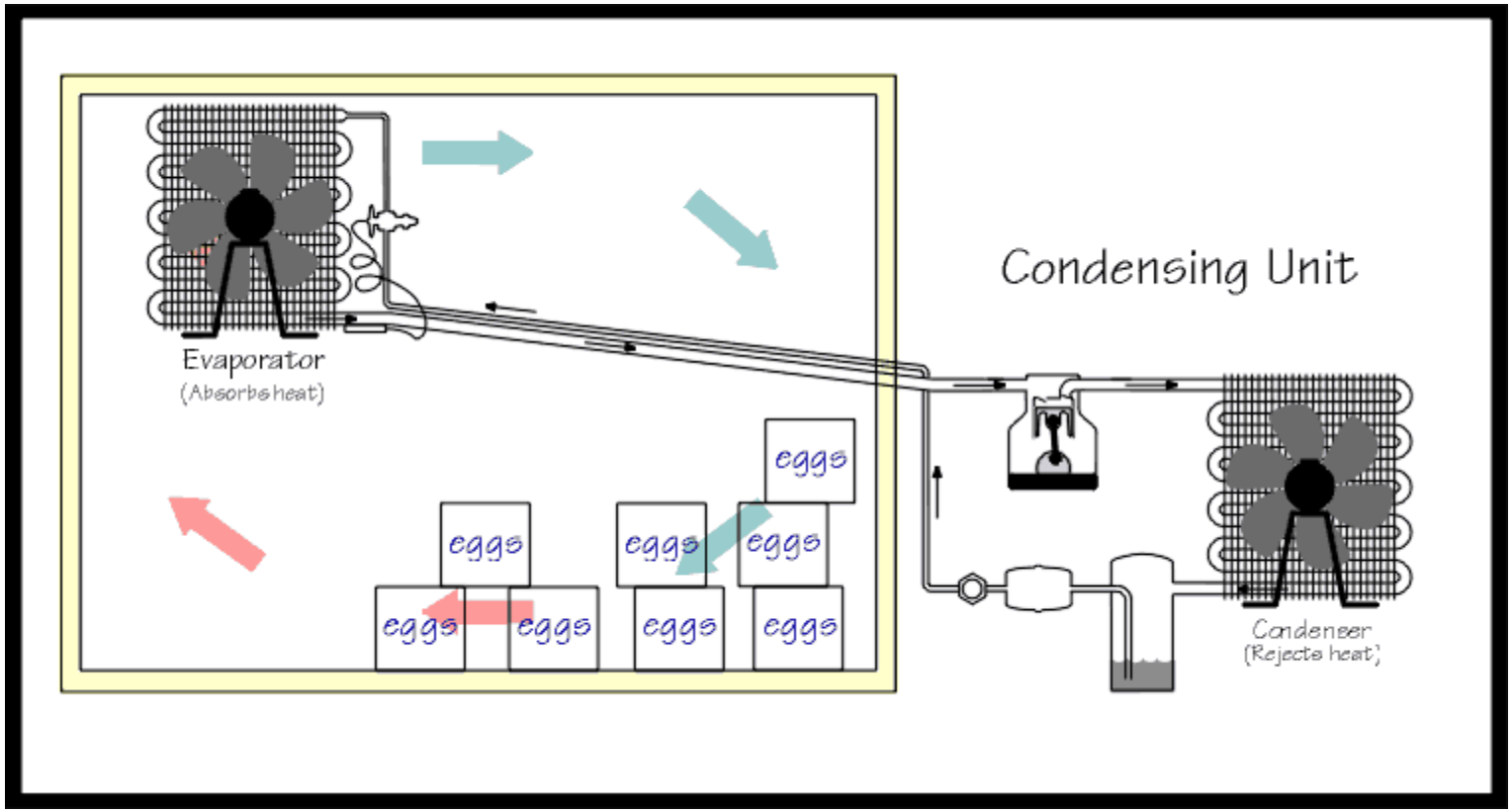
Evaporator function



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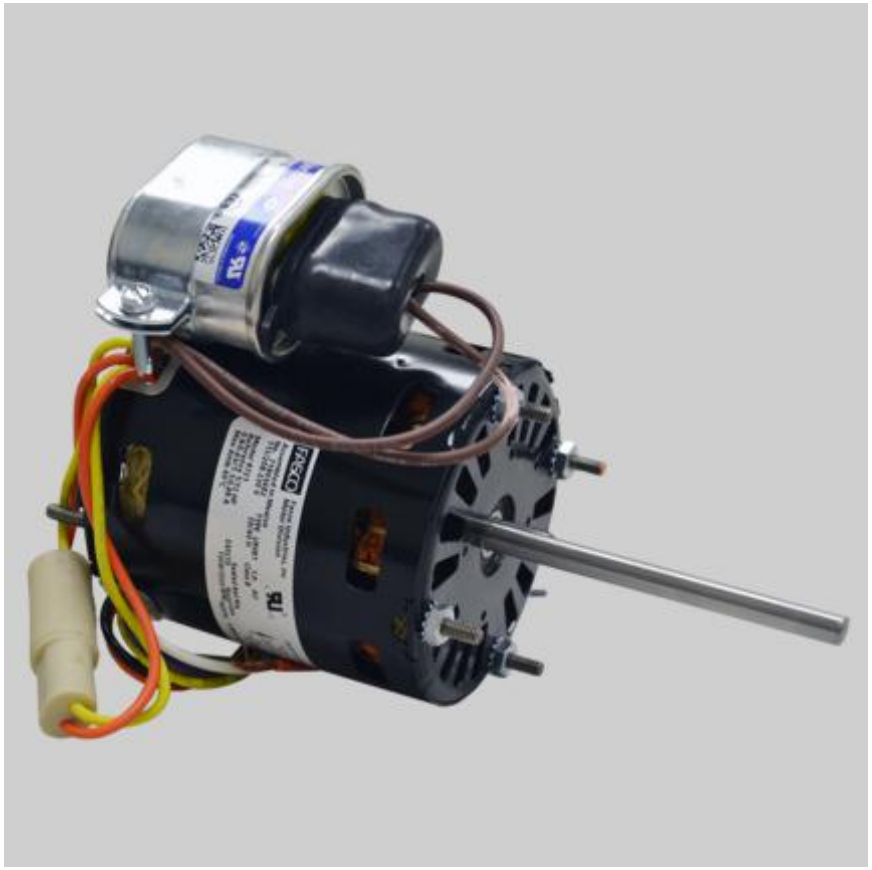
Evaporator Fan Opportunities



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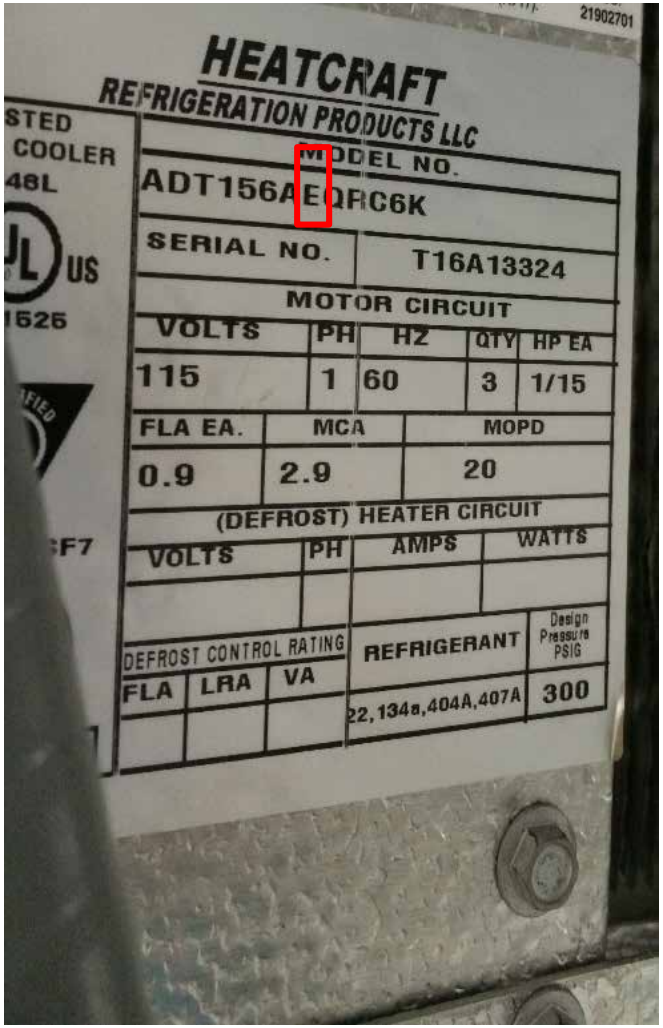
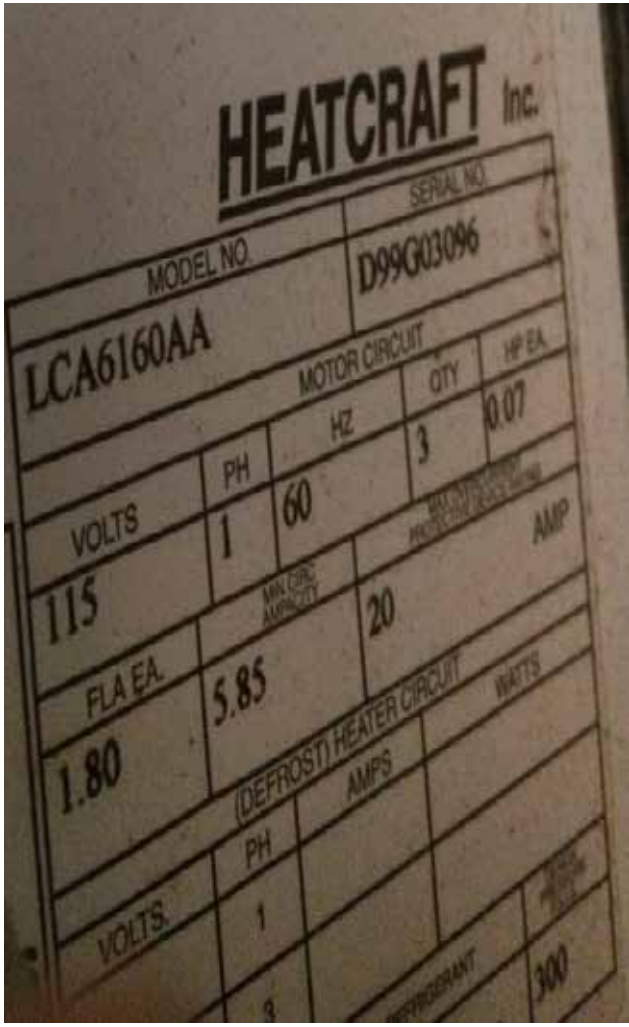
Opportunity Identification

- E in model means ECM motor is installed





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Savings!

- Evaporator Fan motors save $80-$230/year in energy costs
- Payback < 1 year after Efficiency Vermont incentive

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Efficiency Vermont Support

- Work with your Contractor to find motor
- Provide cost and savings estimates
- Provide incentives $60-100/motor

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Evaporator Fan Controls

Three basic options:

- Speed control
- Simple on/off control
- On/off control w/circulation fan

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Available Equipment

- Trenton SmartSpeed Evaporator (2-stage) high/low speed ECM fan motors
- Heatcraft QRC Evaporator (on/off fan cycling)
- ECM motor retrofits (dual RPM motors)
- Custom fan cycling controllers

SMARTSPEED™
FAN MOTOR TECHNOLOGY

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Efficiency Vermont Support

- Work with contractor to determine the best fan control strategy
- Calculate economics- typically around 1.5 year
- Provide incentives $30 / fan motor controlled

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Savings!

(4) ECM fan motors x 57 watts/motor

- On/off with call for cooling $197/year
- QRC fan cycling $131/year
- 2-speed ECM fan motor $155/year
- Smart speed controller $155/year

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Another Option: High Efficiency Evaporators (HEEVAPS)

- Electronic Expansion Valves
- ECM fans
- Fan motor controls
- Smart defrost

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Tier 2 Savings and Incentives

- Incremental cost $500/fan
- Savings is $230/fan
- Incentives are $250/fan
- 2 Tiers

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Who sells HEEVAP's

- Heatcraft (Bohn, Larkin, Chandler) makes the IntelliGen
- Trenton, Keeprite make the ESP+ system

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iNtelliGeN customizable functions

- Superheat control, setpoint is 8 F , can go down to 4F.
- Defrost settings, Timed, Smart, Demand
- Evap fan operation, Standard is default, we want two speed or variable
- Refreeze cycle- this is awesome, after draindown period fans stay off until suction temp is reached

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HEEVAP Tier 1

- Trenton SmartSpeed Evaporator (2-stage) high/low speed ECM fan motors
- Heatcraft QRC Evaporator (on/off fan cycling)
- 2 speed ECM motor retrofits (dual RPM motors)

SMARTSPEED™
FAN MOTOR TECHNOLOGY

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Compressor heat recovery

- Pre-heats domestic hot water
- Pulls excess waste heat from refrigerant
- Also called Desuperheater

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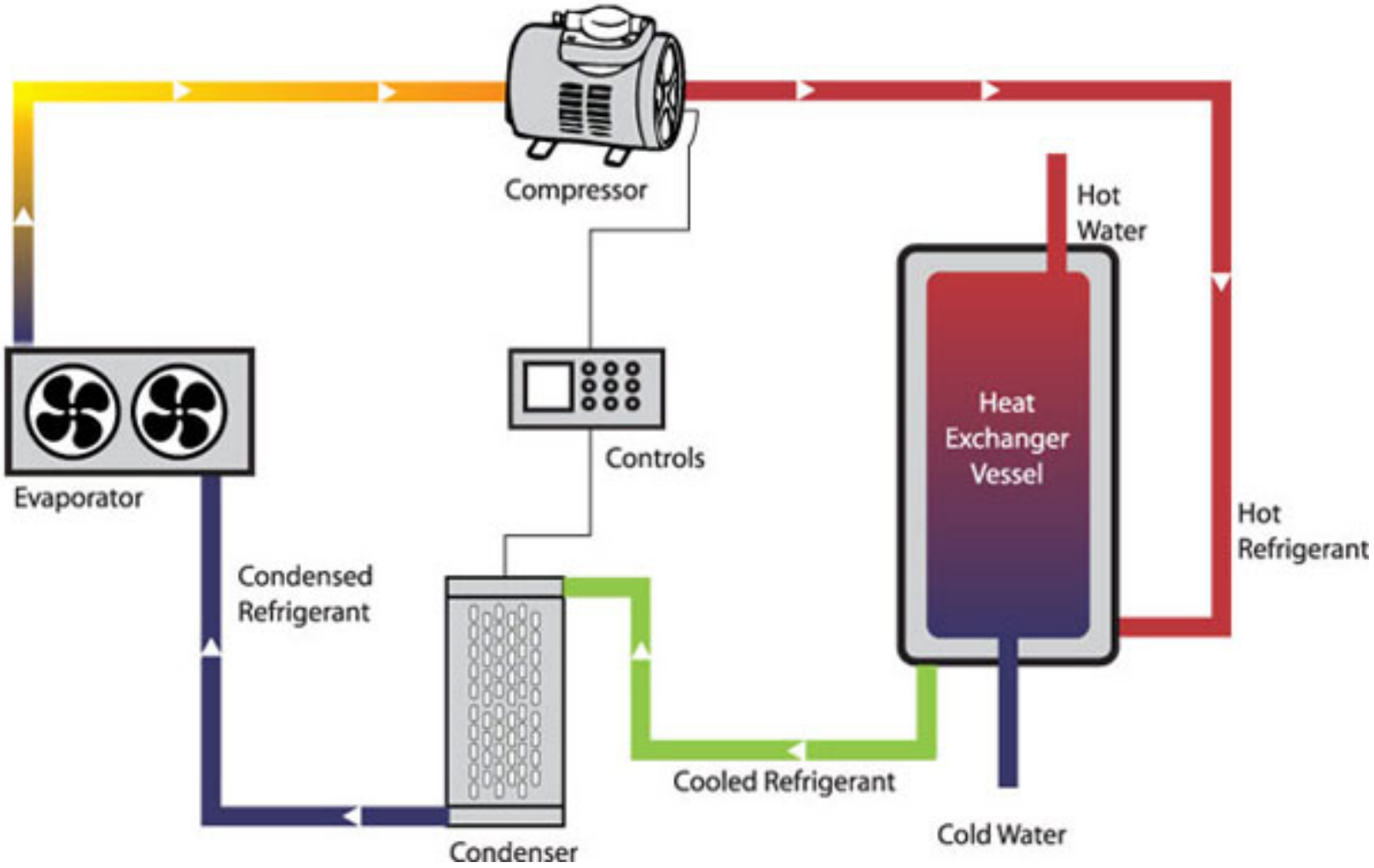
Compressor heat recovery



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Compressor heat recovery

- Can link multiple systems together
  - Multiple tanks
  - Multiple condensers or racks
- Water can be made between 140-160F
- Med- or low-temp systems
- Year round savings, but lower in winter if using floating head pressure controls

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Compressor heat recovery

- Cost is around $5,000 per tank, 119 gallons
- Savings $600 per year, 100 gallons/day

Condensing Unit

Rack (large systems)

Info Needed

- **Gallons of hot water used per day!**
- Water heater model number
  - Fuel type
  - Storage capacity (gallons)
  - Efficiency
- Hot water temperature setpoint
- Compressor capacities
- Condenser model number

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Reach Ins

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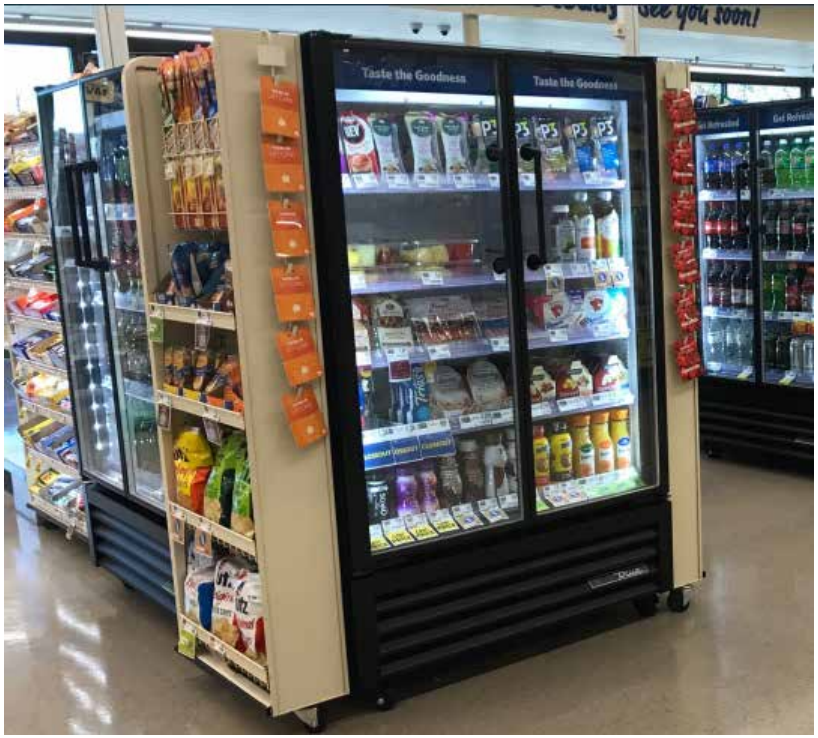
Self-contained Propane Cases

Benefits

- New or existing stores
- Significant Energy Savings
  - 30-50%
- Placement Flexibility
- Remodels/Expansions
- Capital Costs – worth replacing an old, but functional, unit?



Self-contained Propane Cases

Self-contained Propane Cases

TRUE
GLASS DOOR
FREEZER

MODEL	GDM-72F (404A)	GDM-72F-HC (R290)	
kWh/d (HFC | R290)	29.39	20.29	-30.9 %
DOE 2017	21.11	21.11	-3.88%
Refrigerant Charge	42 oz	2 x 5.0 oz (10 oz)	-76.2%
YEARLY SAVINGS		$293.46	

Best Building Practices

- Mechanical Systems
- Evaporators should be equipped with electronically commutated (ECM) or Q-Sync motors
- Evaporator fans should be equipped with some type of speed control, where fans stage or modulate speed based on cooler temperature and/or compressor status (This can be retrofitted in or built into a new evaporator. Keeprite, Trenton, and Heatcraft are a couple manufacturers where you can buy fan speed controls in new evaporators)
- Condensing systems shall be equipped with floating head pressure controls (Heatcraft has the Orbus speed controller. Keeprite & Trenton have the Limitrol system)
- Systems compressors shall meet Efficiency Vermont's performance criteria, typically we want to see high performance Scrolls or Discus compressors.
- Thermal Envelope
- Slab: Freezers shall have no less than R-28 below the slab, and I would recommend approximately R-15 below the slab for coolers
- Ceilings and Walls: Freezers shall have no less than R-32; cooler shall have no less than R-25
- Doorways shall be equipped with some method of minimizing infiltration while doors are open

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Why Refrigerant Management?

DRAWDOWN

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Rank	Solution	Sector	TOTAL ATMOSPHERIC CO2-EQ REDUCTION (GT)	NET COST (BILLIONS US $)	SAVINGS (BILLIONS US $)
1	Refrigerant Management	Materials	89.74	N/A	$-902.77
2	Wind Turbines (Onshore)	Electricity Generation	84.60	$1,225.37	$7,425.00
3	Reduced Food Waste	Food	70.53	N/A	N/A
4	Plant-Rich Diet	Food	66.11	N/A	N/A
5	Tropical Forests	Land Use	61.23	N/A	N/A
6	Educating Girls	Women and Girls	51.48	N/A	N/A
7	Family Planning	Women and Girls	51.48	N/A	N/A
8	Solar Farms	Electricity Generation	36.90	$-80.60	$5,023.84
9	Silvopasture	Food	31.19	$41.59	$699.37
10	Rooftop Solar	Electricity Generation	24.60	$453.14	$3,457.63

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Why Refrigerant Management?

Global warming potential (**GWP**) is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide

Greenhouse Gas (GHG)	Atmospheric Lifetime (yrs)	Global Warming Potental (GWP)	Primary Current Sources
Carbon dioxide (CO_2)	50-200	1	Fossil fuel use, land use, cement
Methane (CH_4)	12±3	21	Fossil fuel use, agriculture
Nitrous oxide (N_2O)	120	310	Mostly agriculture, ~1/3 are anthropogenic
Hydrofluorocarbons (HFCs)	1.5 to 209	150 to 11,700	Alternative to ozone depleting substances
Perfluorocarbons (PFCs)	2,600 to 50,000	6,500 to 9,200	Primary aluminum production; semiconductor manufacturing
Sulfur Hexafluoride (SF_6)	3,200	23,900	Used in electric power transmission, magnesium and semiconductor industries

High GWP gases

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Leak Repair

- New EVT program - leak repair program
  - Geared towards smaller systems
  - 80% cost-share of **proactive** leak audit & repair
  - 6 participating contractors
- Benefits
  - Reduced refrigerant cost
  - Equipment reliability
  - Energy savings
  - Environment

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Natural Refrigerants

- Naturally occurring substances with low environmental impact
  - Ammonia, CO2, propane
- CO2 Condensing Units
  - Currently unavailable in U.S. market
  - Pledged $$$ to cost-share 10 installs in 2020
  - High-efficiency system, great for cheesemaking
- Hydrocarbon cases
- CO2 Heat Pump Water Heater

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CO2 Heat Pump Water Heater

- Sanden SanCO2
- Seasonal COP's greater than 3
- Water temperatures up to 170 degrees
- $600 Efficiency Vermont Rebate
- Best for high-use applications

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Lighting

- LEDs are great…when the economics make sense
- Easy calculation you can do:

Old watts – new watts x hours per year x $/kwh = annual savings

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100% LED

- Efficiency Vermont is promoting customers who are moving 100% to LED

TURN IT OFF	Lighting and Equipment doesn't always need to be running. Air compressors, glue pots and lights are examples
TUNE IT UP	Check building occupancy scheduling. HVAC heating and cooling off hours can be a hidden but considerable cost. Maintain Boiler Keep all air intake filters clean (HVAC, compressor, etc), reduce frost on cooler evaporators
FIX THE LEAKS	Good candidates include: Compressed air, Steam Systems, Refrigeration Leaks, Loading Dock doors, HVAC ductwork, cooler envelope, whole building envelope
MEET THE LOAD EFFICIENTLY	Are exhaust air and/or makeup air units controlled or is it 100% even when load isn't? Change setpoints on equipment to match loads. For air and fluid movement are you utilizing VFD's effectively?
QUESTION ASSUMPTIONS	Just because you've "always done it that way" doesn't mean it's the most efficient way. Do you require 50psi steam or can you lower the pressure?
DO IT RIGHT THE FIRST TIME	Optimize use of energy and water. Can any heat be recovered from the process, can water be re-used? A short-term quick fix may be very expensive in the end.
MAKE IT A HABIT	Use SOP's to record the changes. Review your energy performance regularly, so that gallons of fuel, kW and kWh are as familiar as production metrics such lbs of product produced

Prioritize

All energy projects can be placed in one of the four quadrants listed below.

Quick Wins – Quick and easy opportunities that should be implemented in the short term (~1 to 4 months).

Gems – Medium to High energy saving opportunities that the team should prioritize over all others, and complete as soon as possible.

Strategic – Opportunities that require additional effort and/or investment and should be considered for future implementation.

Don't Do (For Now!) – Not worth pursuing at this time given the high effort required and low energy savings.

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