CONDENSING BOILER TECHNOLOGY

Presented by:

Jim Cooke

Mechanical Solutions NW

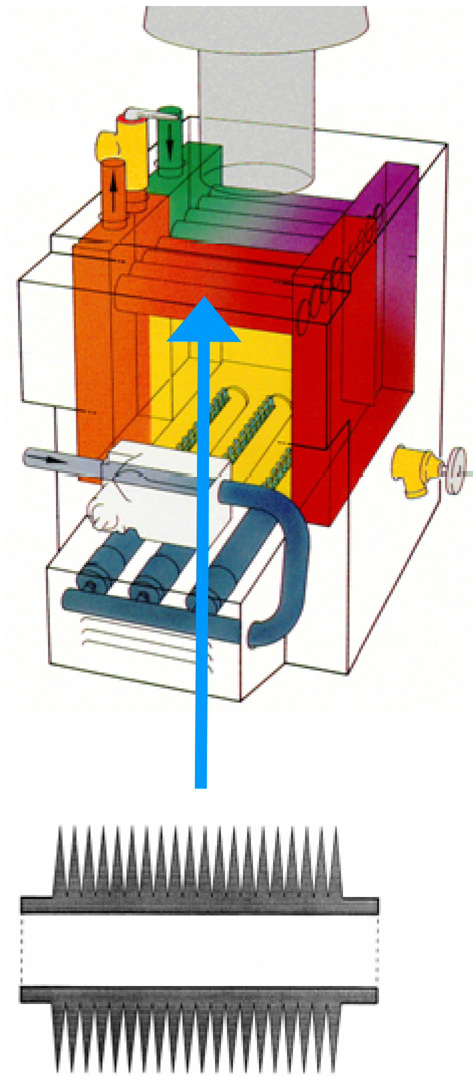
1125 Andover Park W. Bldg. D

Seattle, WA 98188

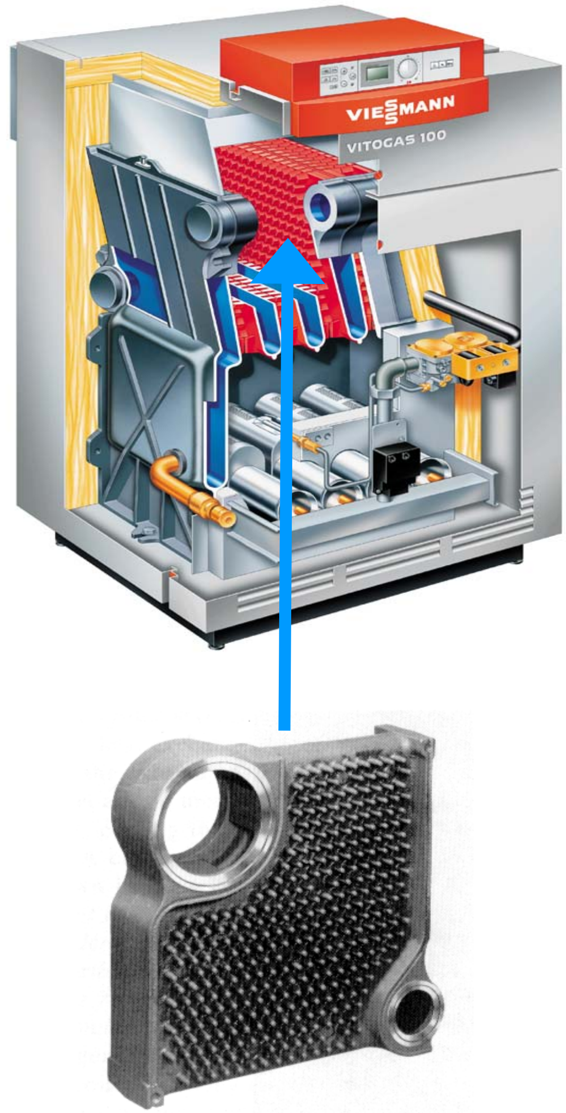
Email: jim@msinw.com

What is condensing boiler technology?

CONVENTIONAL BOILER TECHNOLOGY
Non-condensing construction

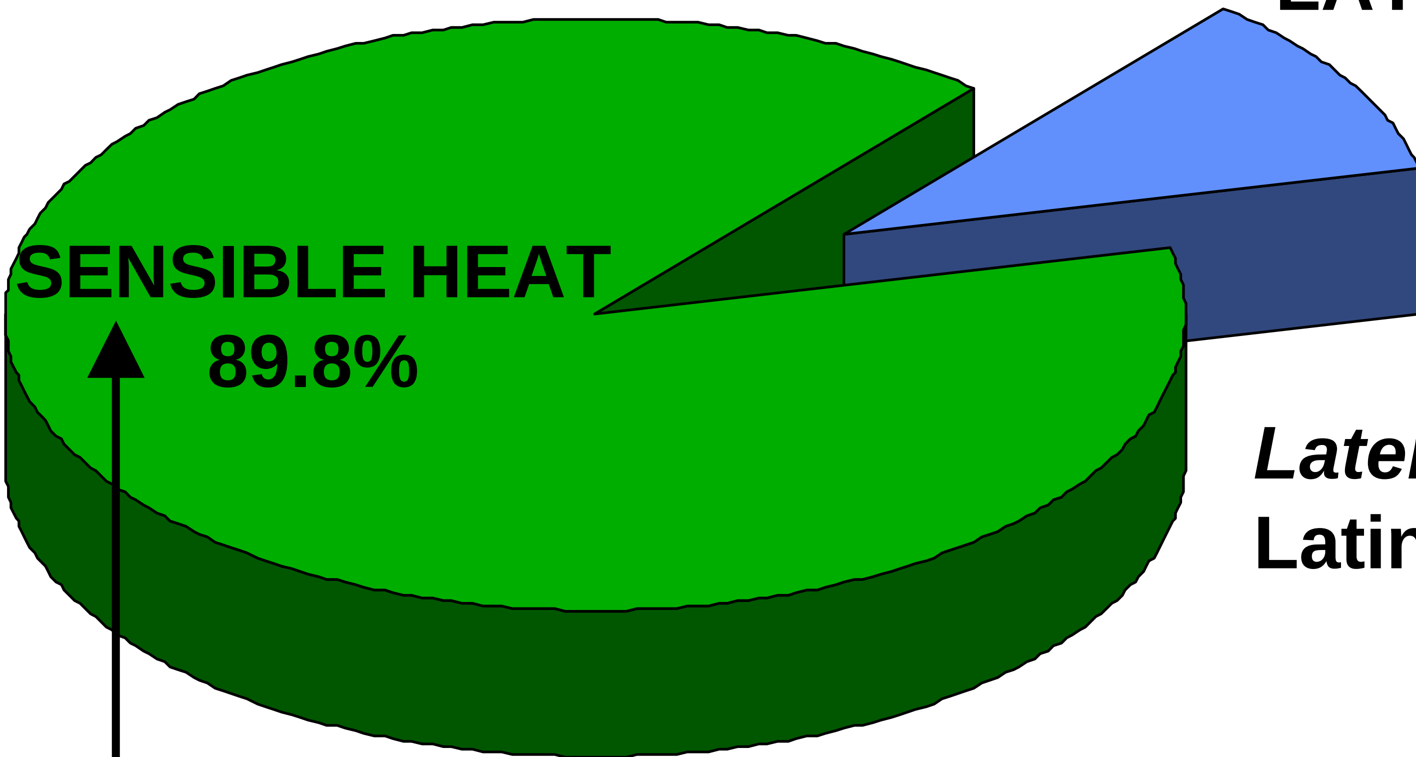


Fin tube boiler



Cast-iron sectional boiler

ENERGY CONTENT OF NATURAL GAS

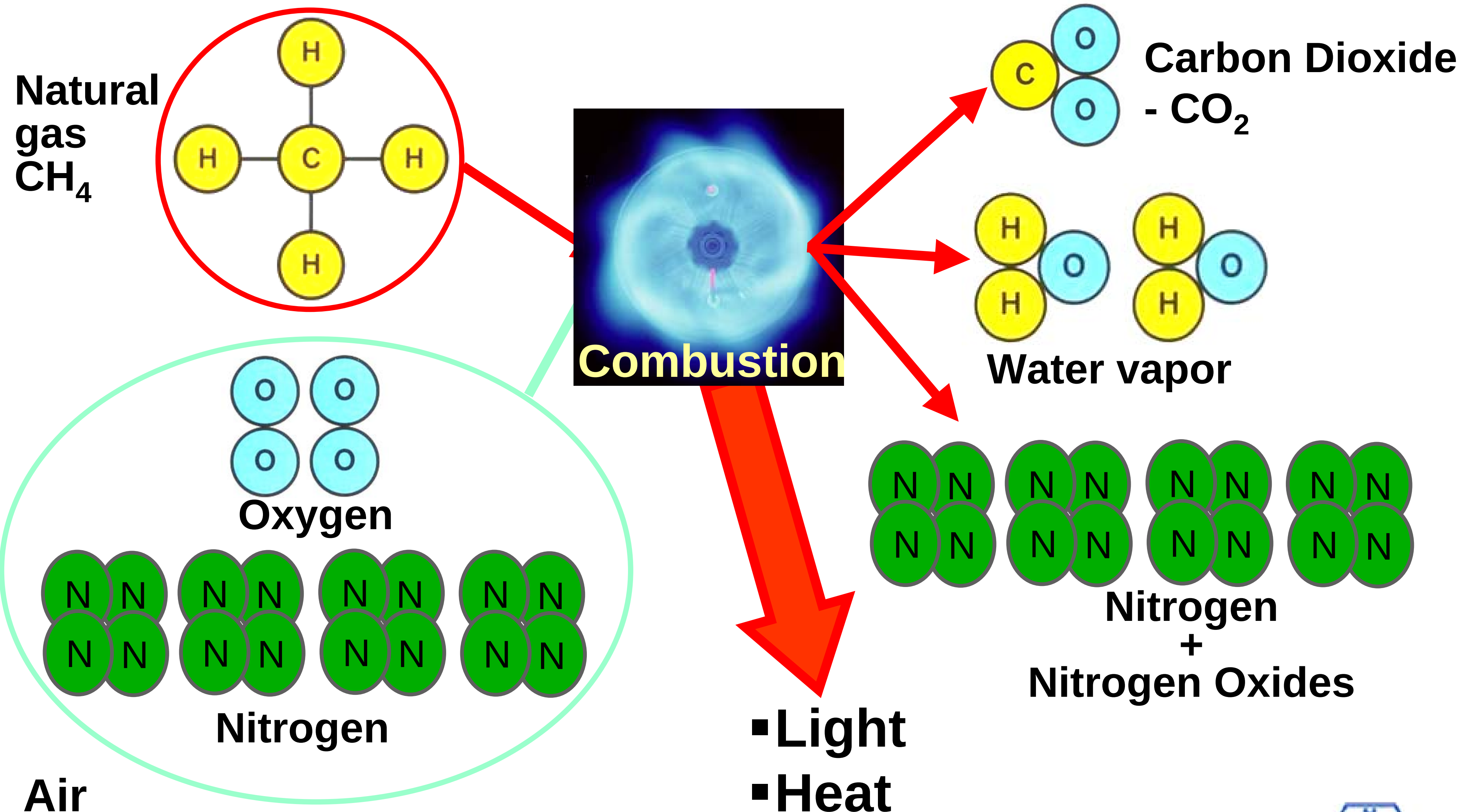


LATENT HEAT
10.2%

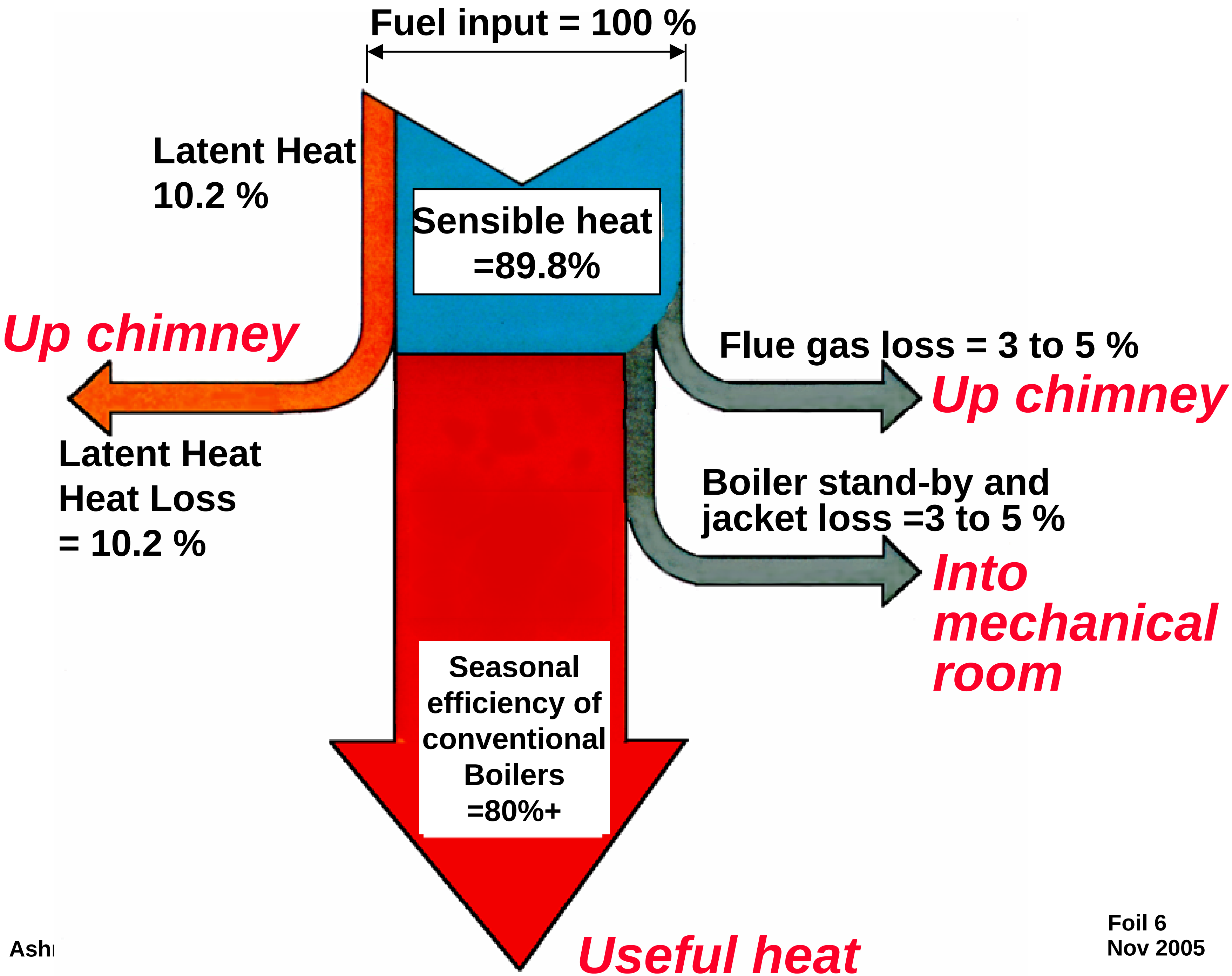
Latent **– Definition:**
Latin for "hidden"

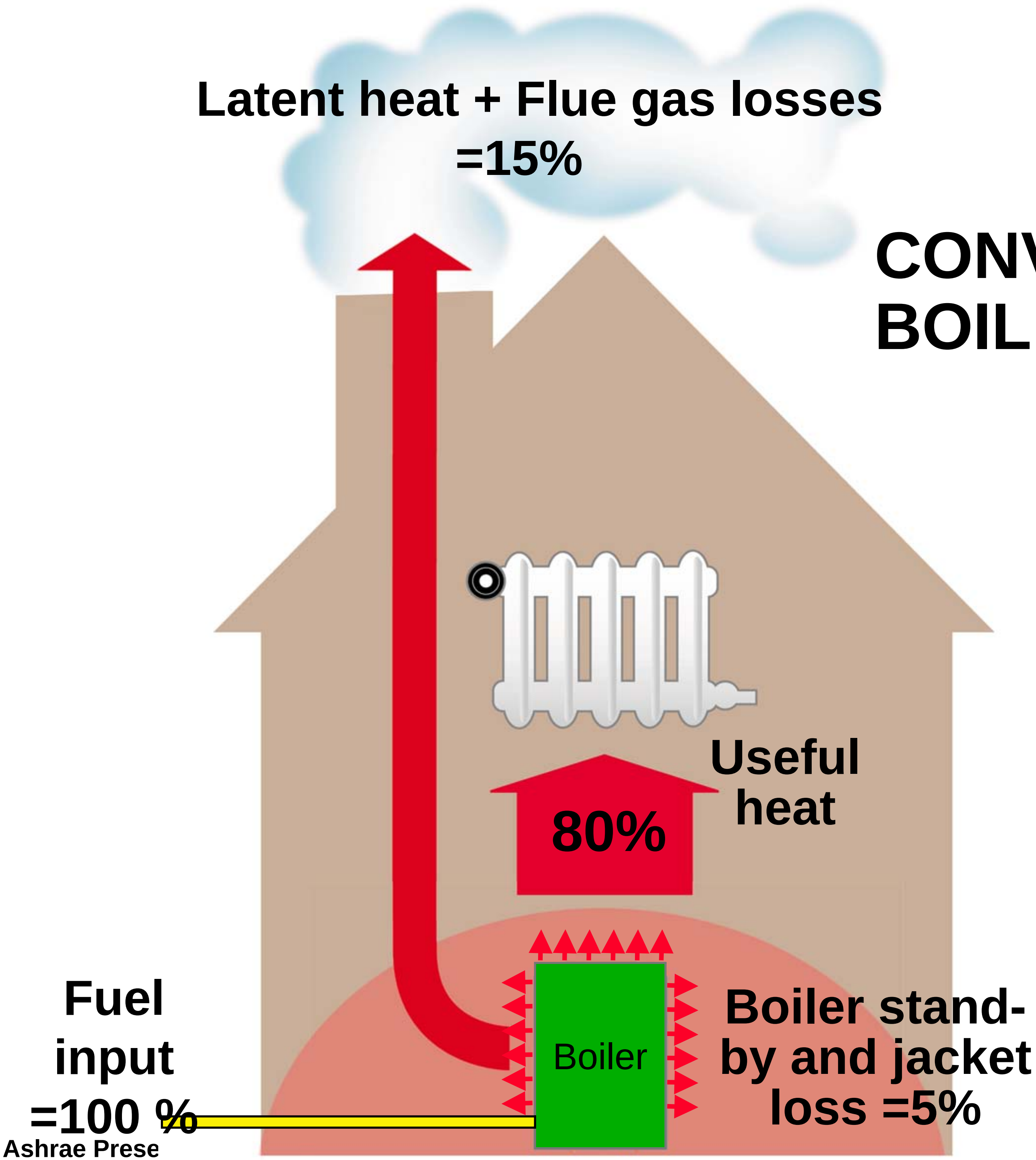
Heat that can be measured or felt by a change in temperature

NATURAL GAS COMBUSTION



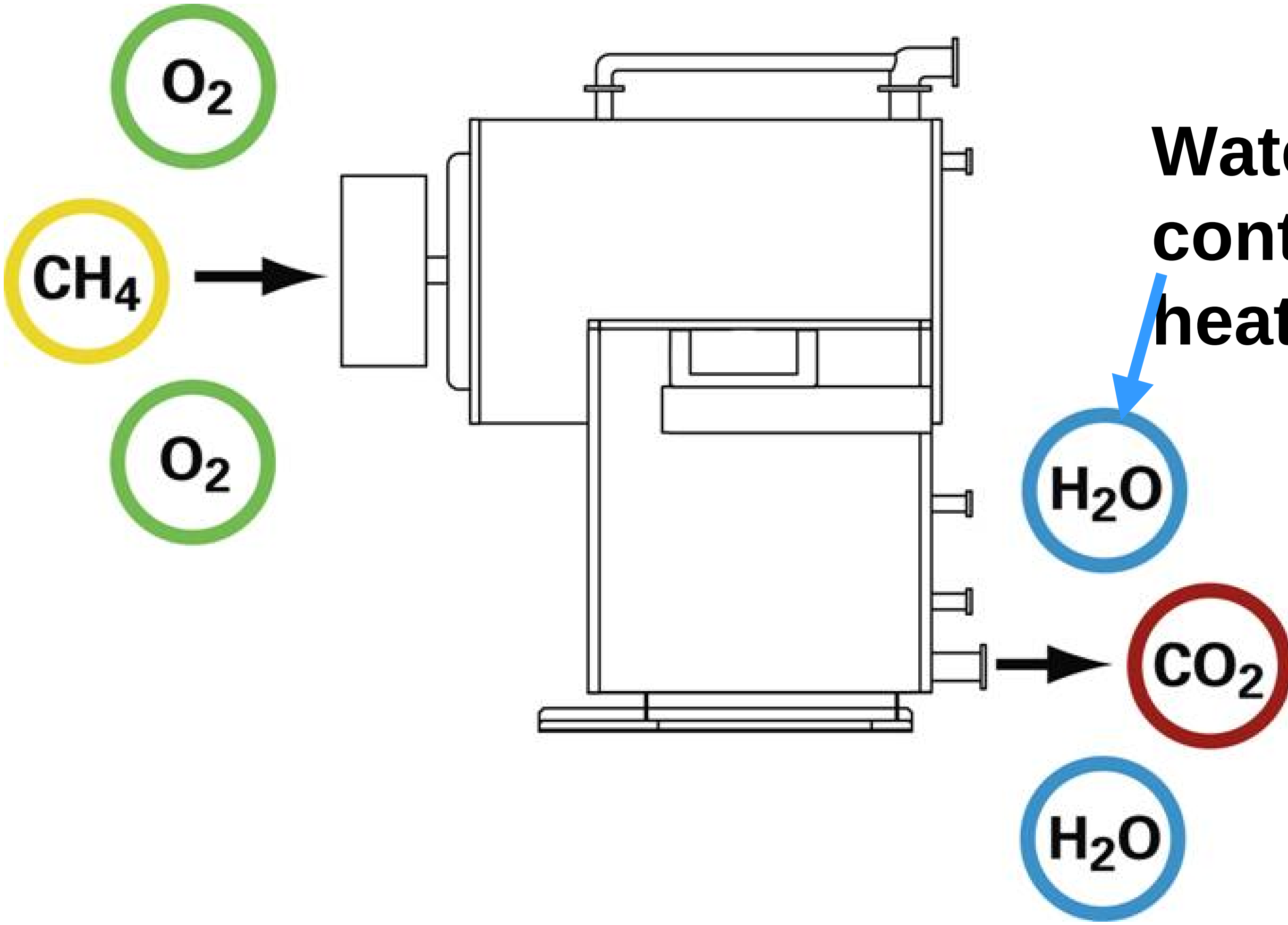
CONVENTIONAL BOILER HEAT FLOW





CONVENTIONAL BOILER HEAT FLOW

HEAT RECOVERY FROM FLUE GASES



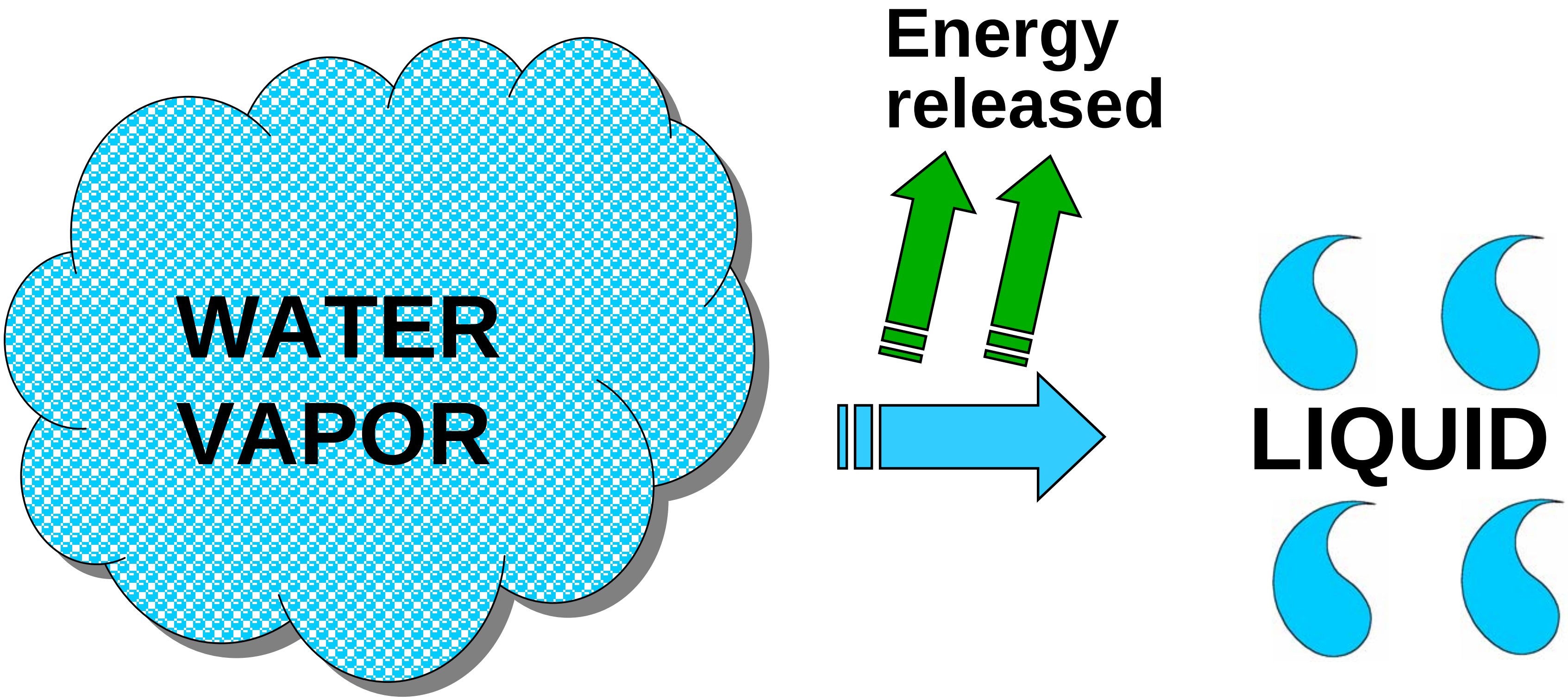
Water vapor (steam) containing latent heat

How do we capture the latent heat?

- **Simplified Chemical Combustion Formula:**

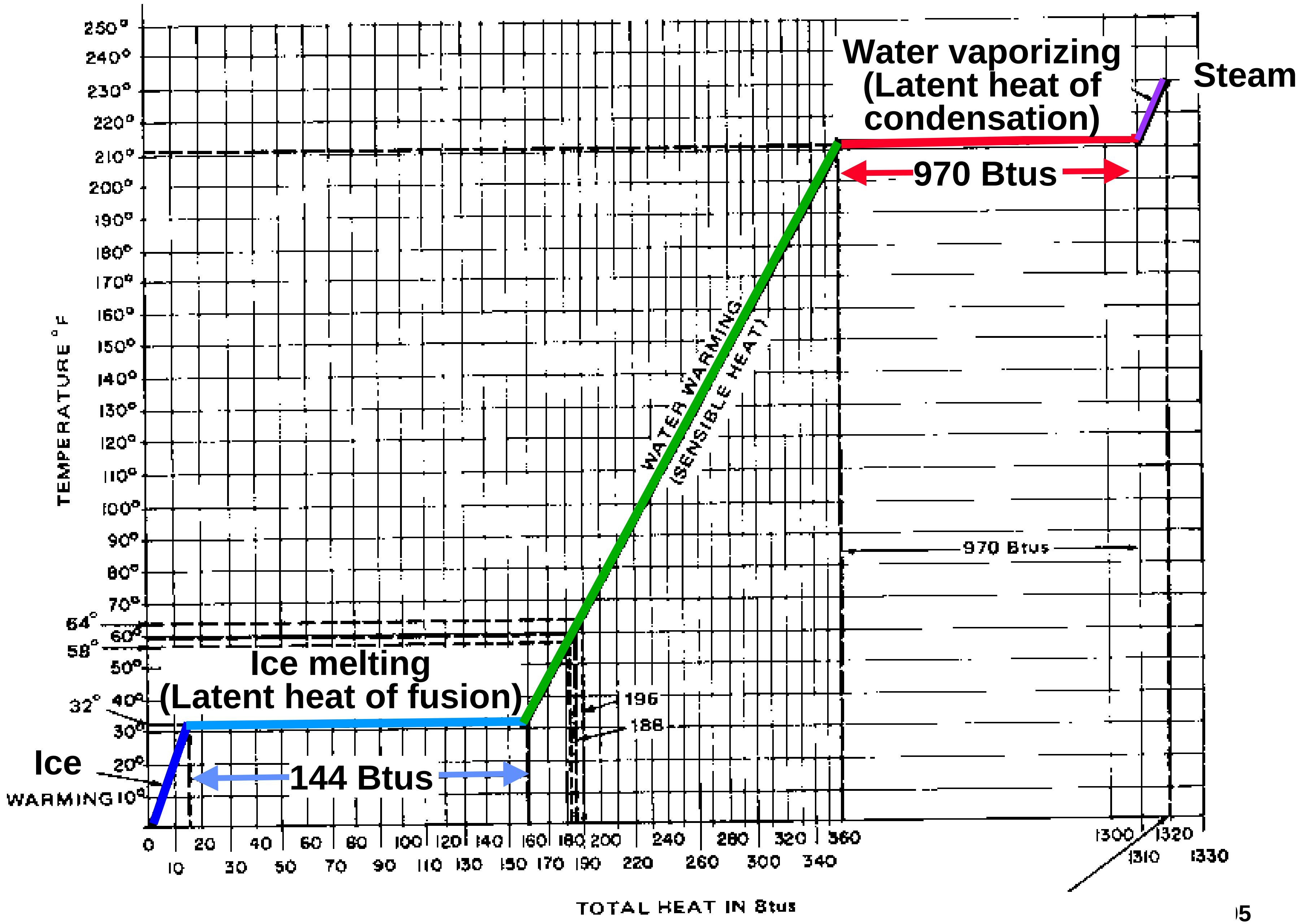
$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

LATENT HEAT RECOVERY

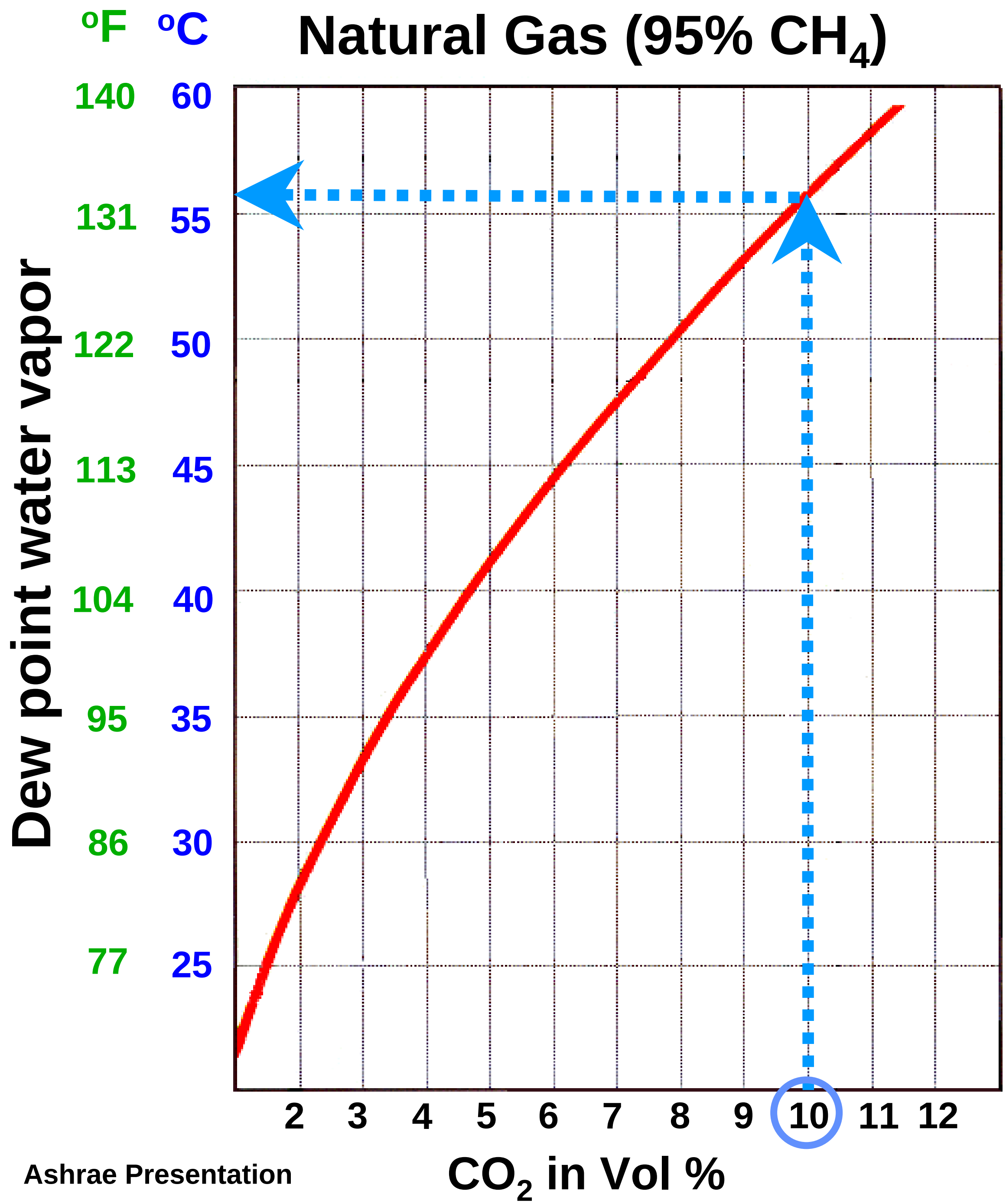


- **Water vapor turns to liquid when it is reduced in temperature.**
- **Energy is released when vapor turns to liquid**

LATENT HEAT RECOVERY
1 pound of water

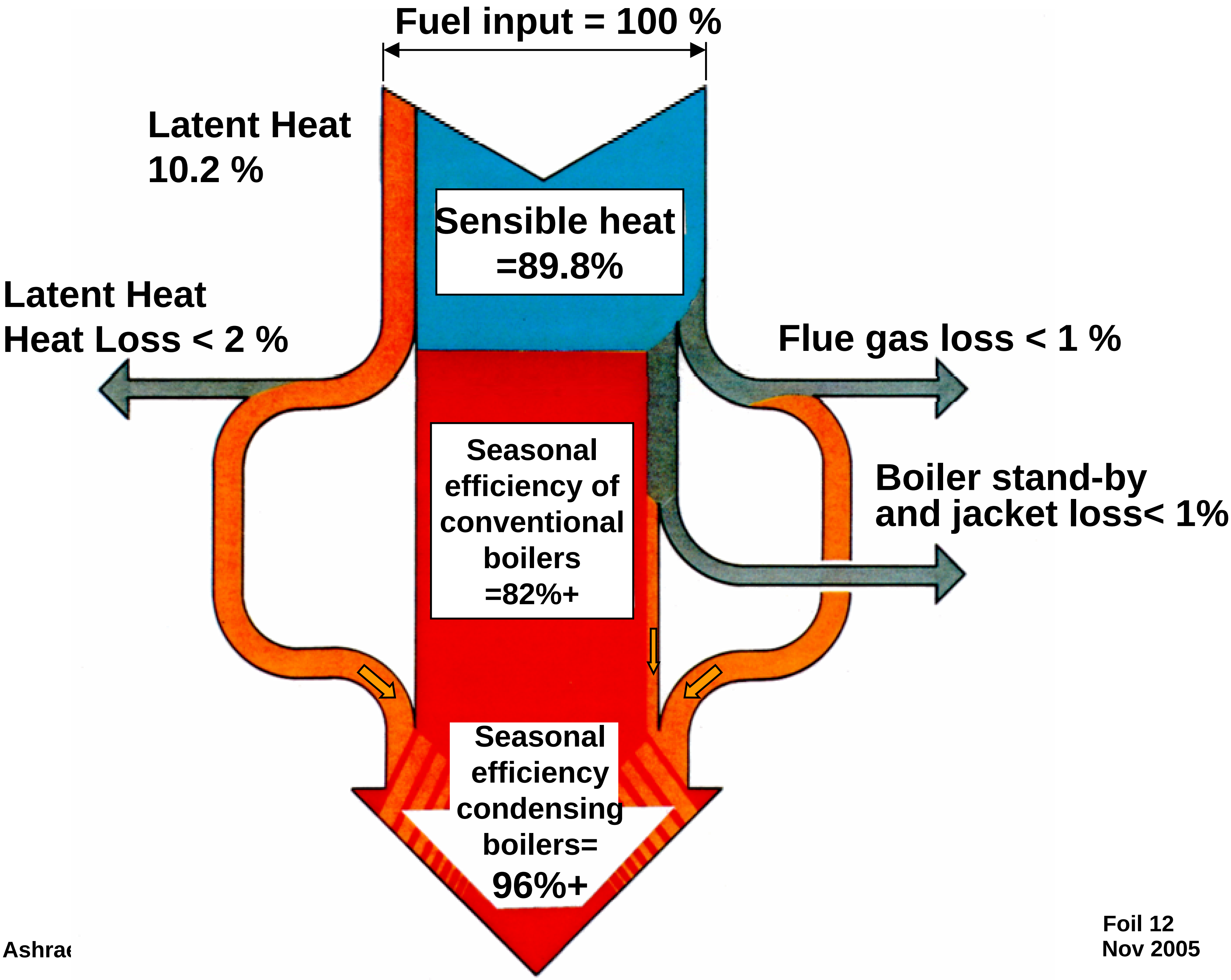


WATER VAPOR DEW POINT

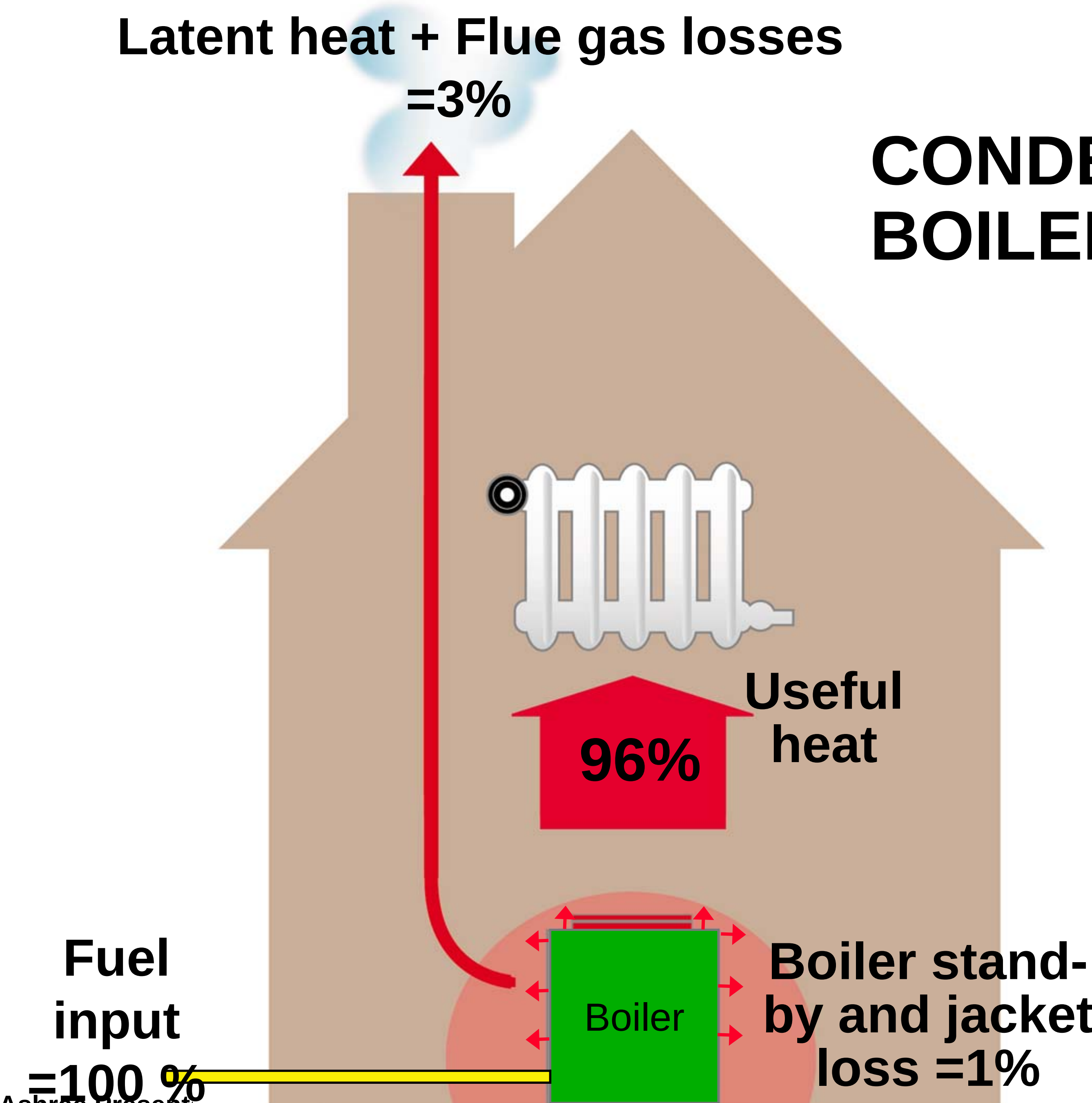


- Water vapor condenses below the dew point temperature
- CO_2 % of flue gas influences dew point temperature

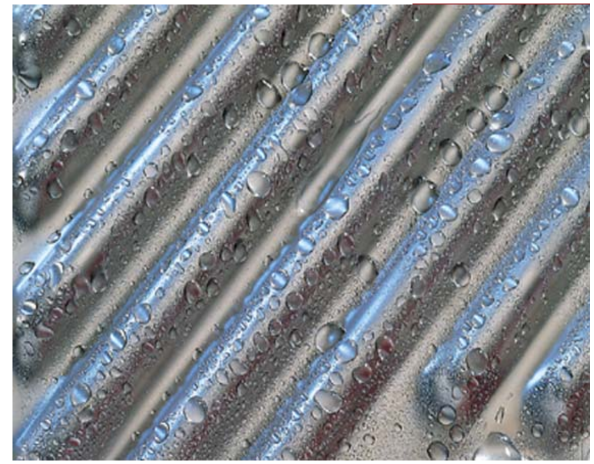
CONDENSING BOILER HEAT FLOW



CONDENSING BOILER HEAT FLOW



EFFICIENCY INCREASES DUE TO FLUE GAS CONDENSATION



Combines the following:

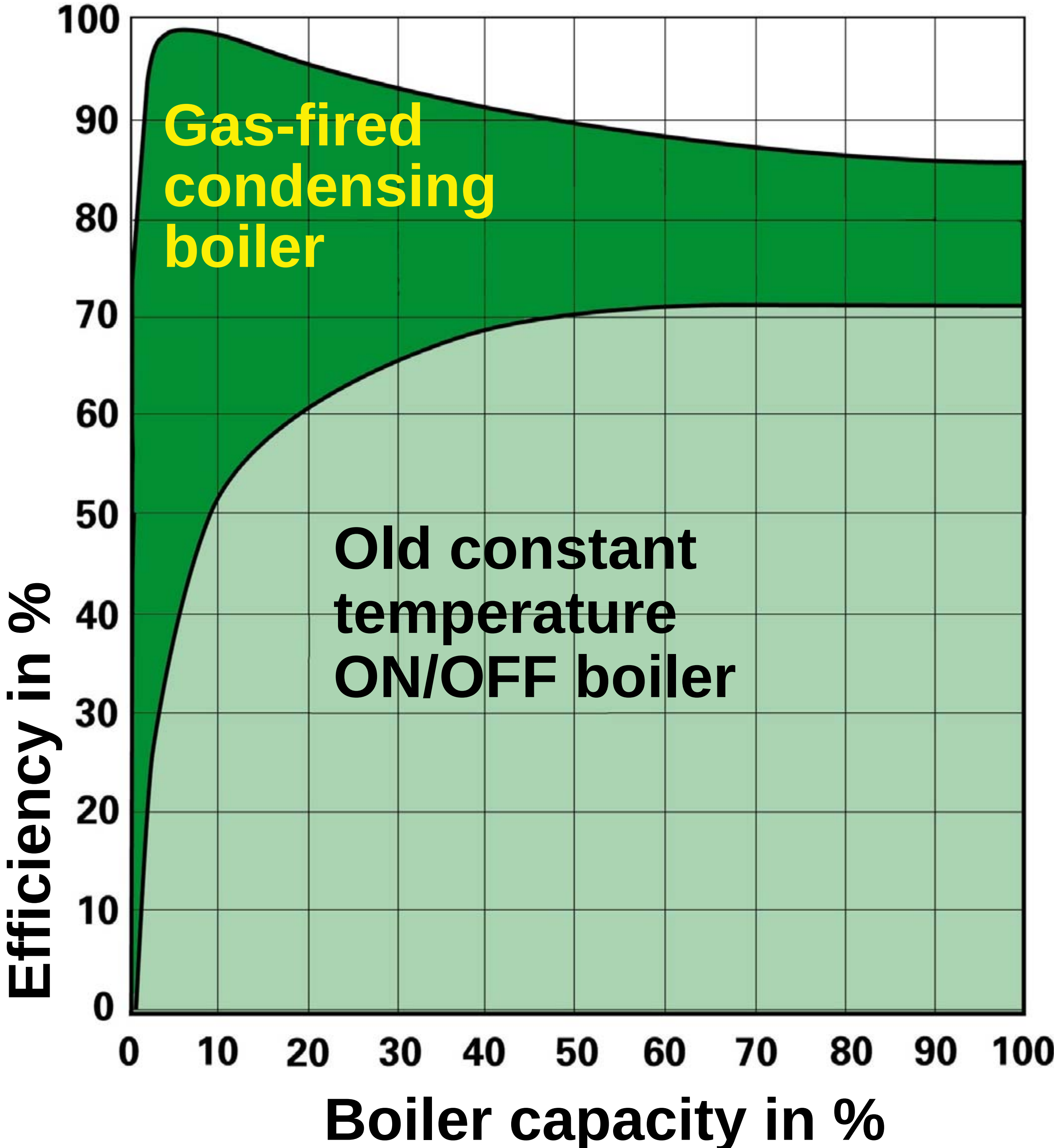
1. **Additional latent heat gain from condensate**

2. **Lower flue gas loss:**
   - **The flue gas temperature is lower because the sensible and latent heat is almost completely transferred to the boiler water**

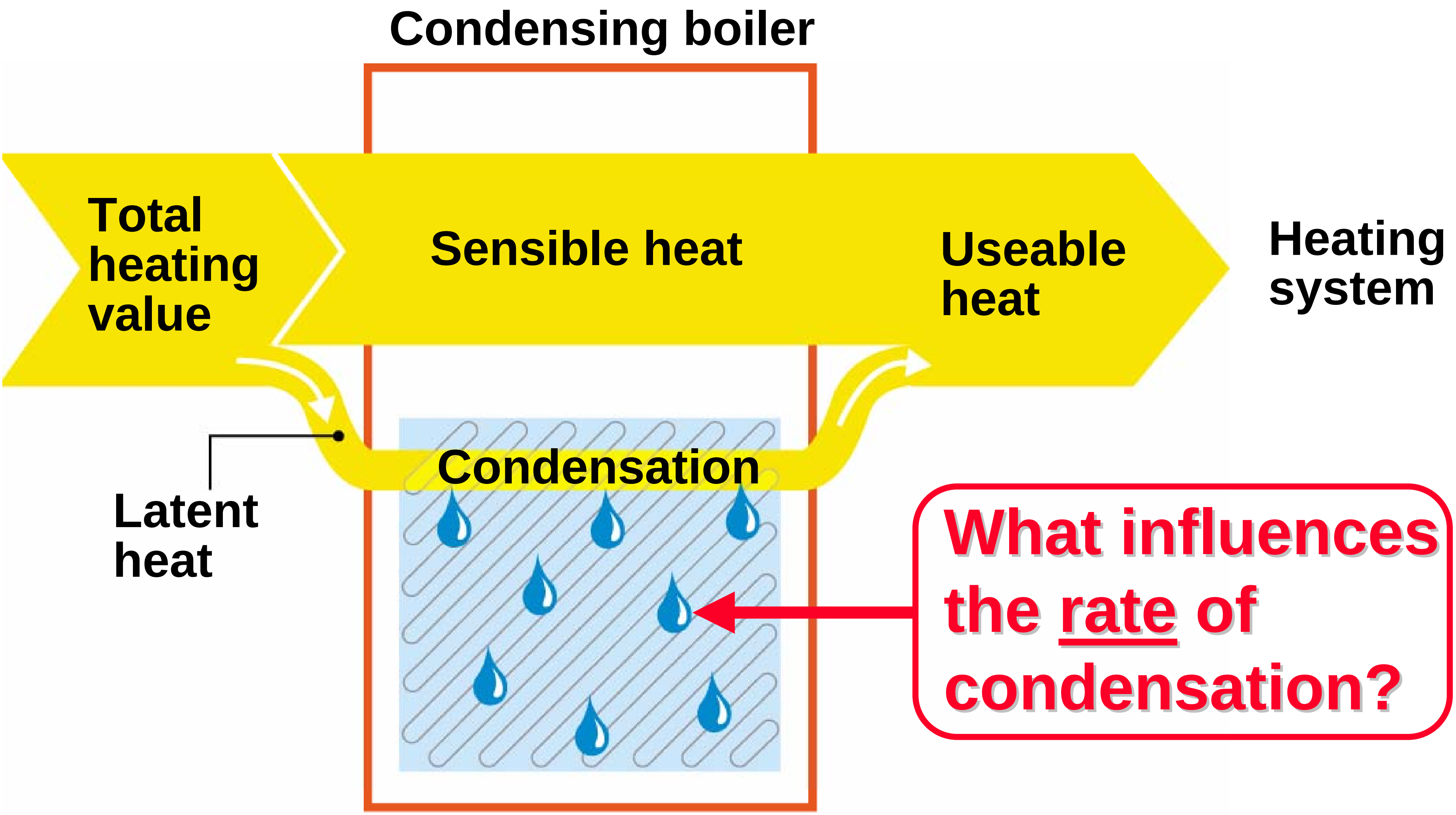
3. **Lower radiant standby losses:**
   - **Due to lower boiler water temperatures**

Why use condensing boiler technology?

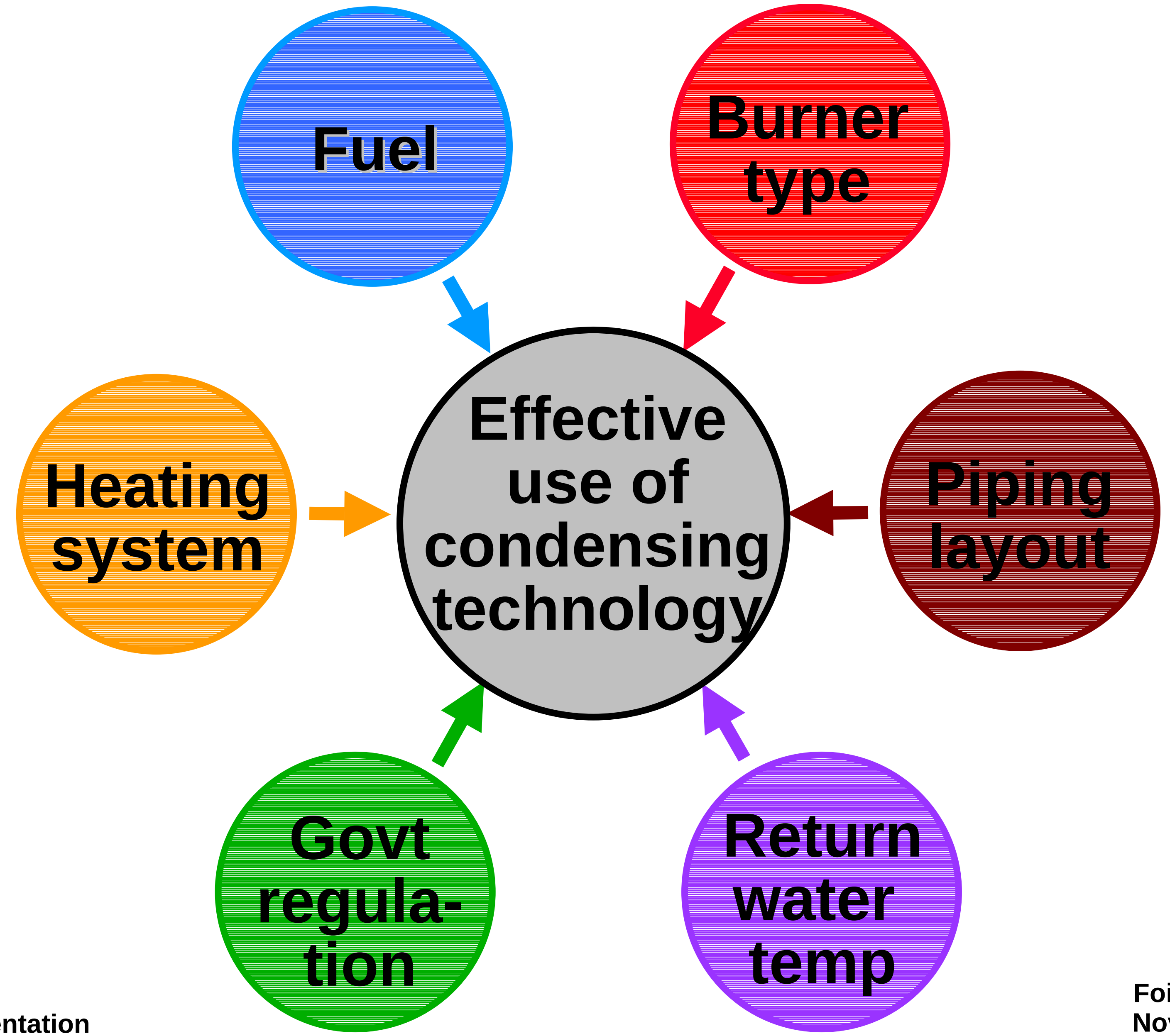
TYPICAL BOILER EFFICIENCIES



MORE USABLE HEAT THROUGH CONDENSATION



FACTORS INFLUENCING EFFECTIVENESS OF CONDENSING TECHNOLOGY



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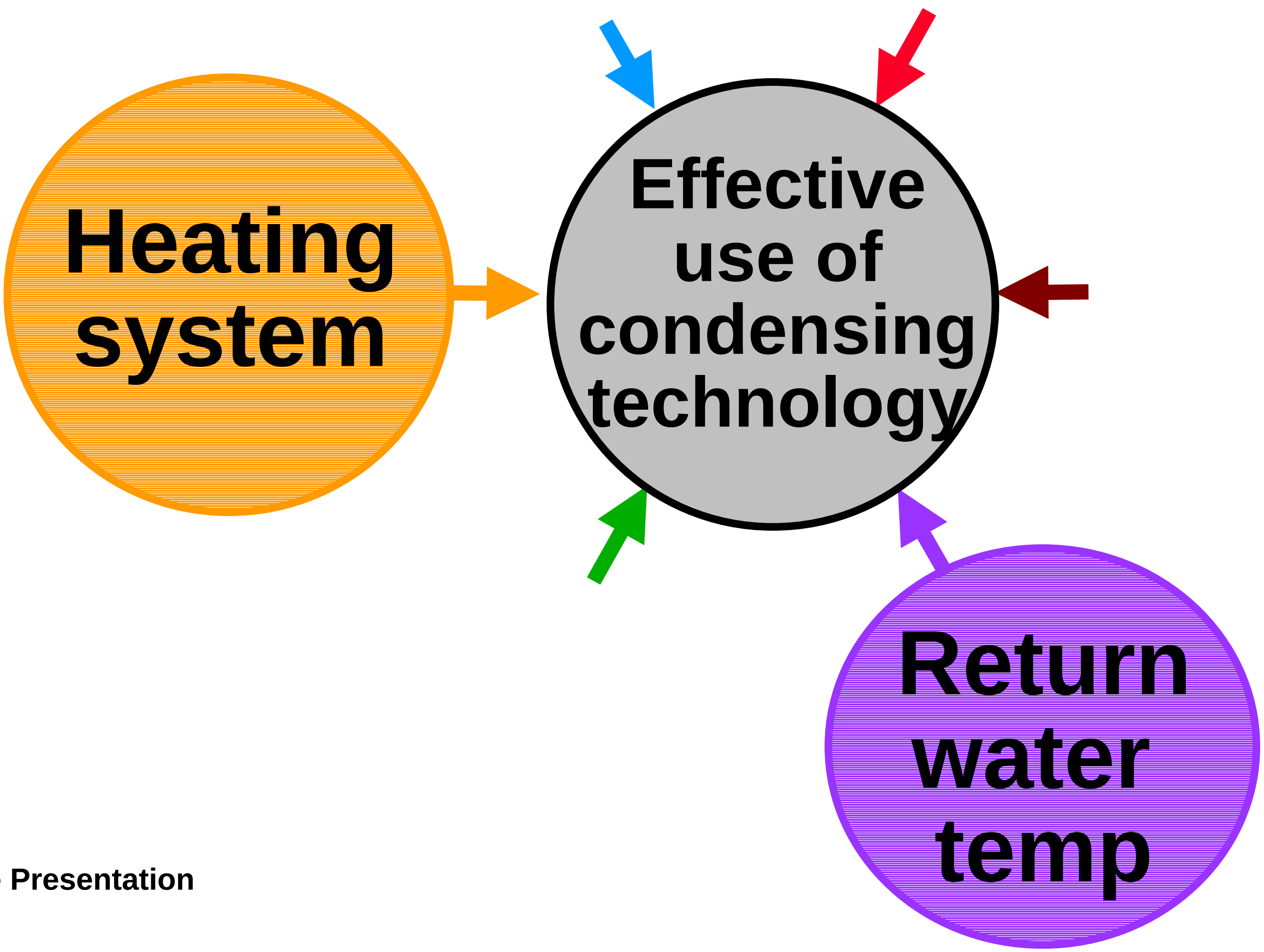
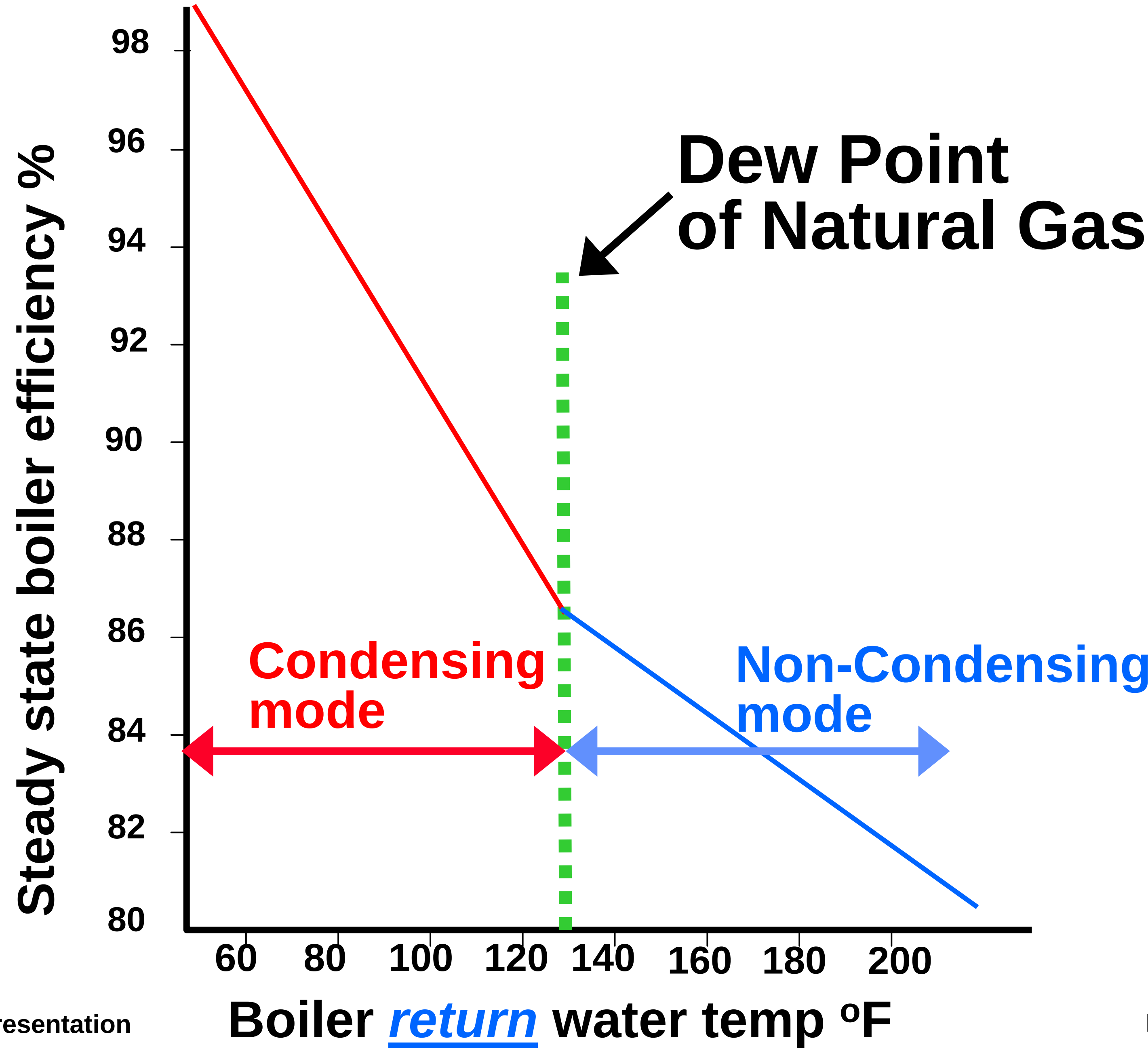
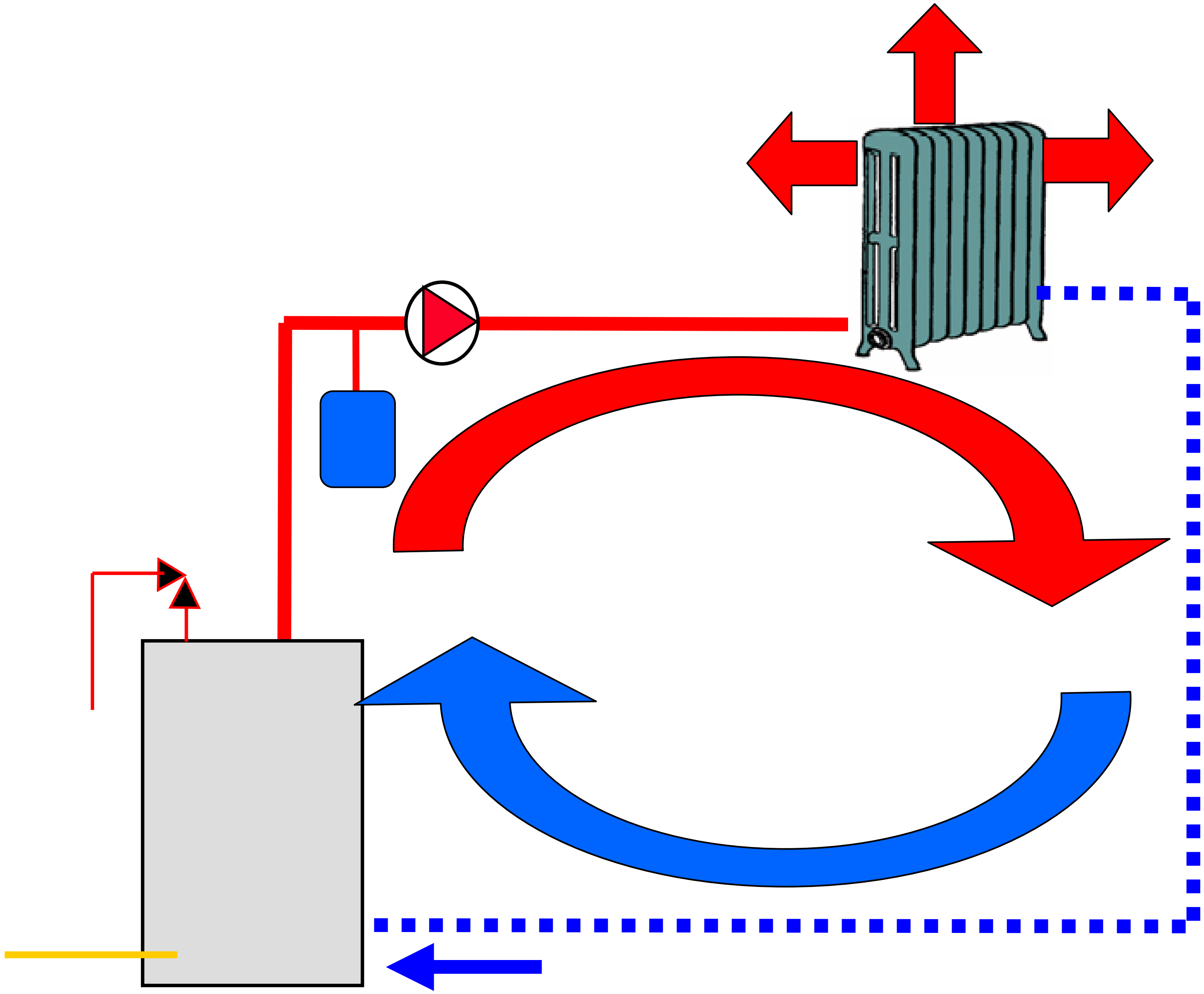


SIMPLIFIED CONDENSING BOILER OPERATION



RETURN WATER TEMPERATURE

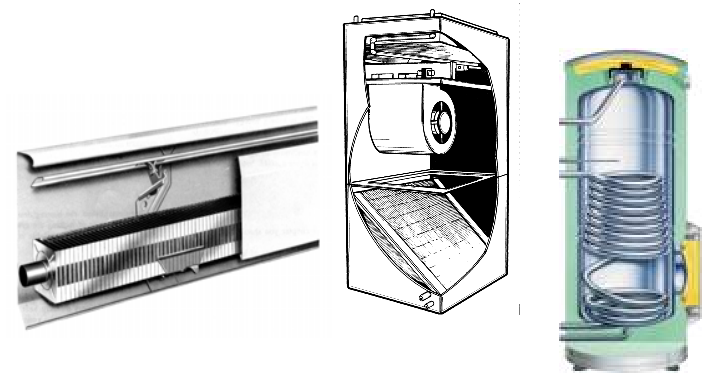


Boiler *return* water temperature determines condensing operation

TYPICAL HYDRONIC WATER TEMPERATURE REQUIREMENTS:

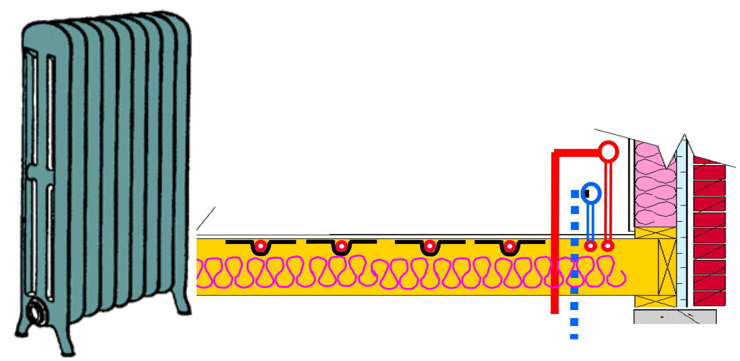
High temperature:

- ➔ Finned tube baseboard 140 - 190 ^{o}F
- ➔ Air heat fancoils 140 - 180 ^{o}F
- ➔ Pool/spa heat exchangers 160 - 180 ^{o}F
- ➔ DHW production 150 - 190 ^{o}F



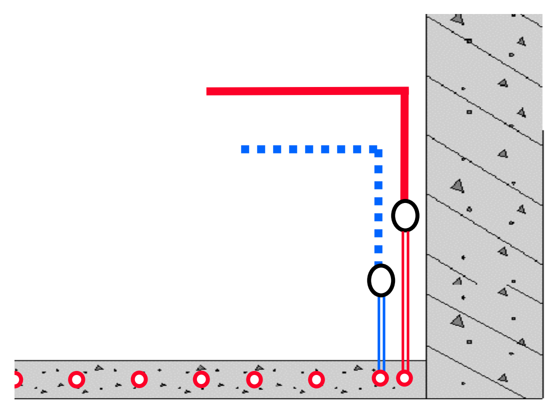
Medium temperature:

- ➔ Cast iron radiators 100 - 140 ^{o}F
- ➔ Low mass radiant floor
  ie: wood joist floors 100 -150 ^{o}F



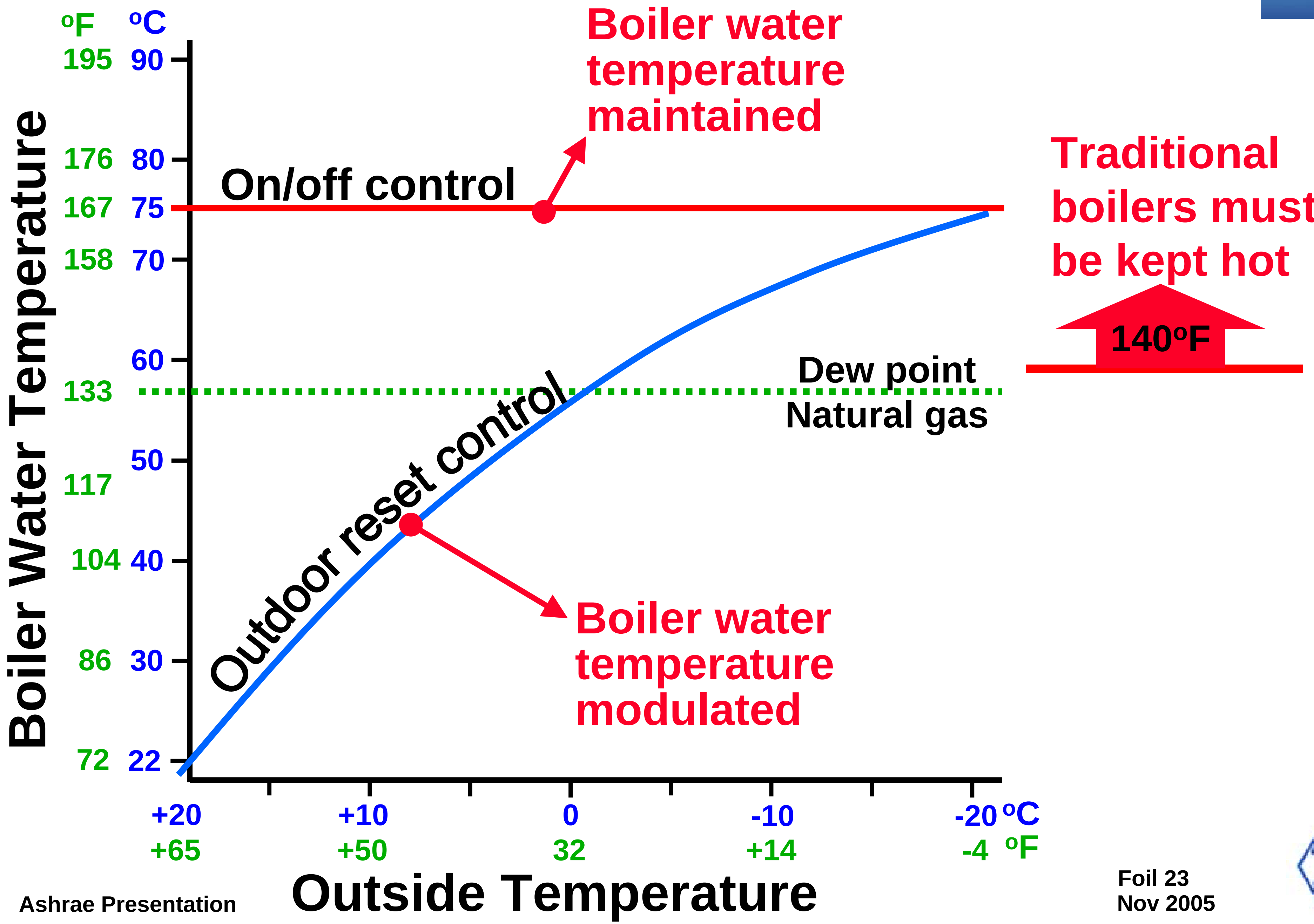
Low temperature:

- ➔ High mass radiant floor
  ie: concrete floors 80 - 120 ^{o}F
- ➔ Snowmelting systems 80 - 120 ^{o}F



Ashrae Presentation

HYDRONIC WATER TEMPERATURES

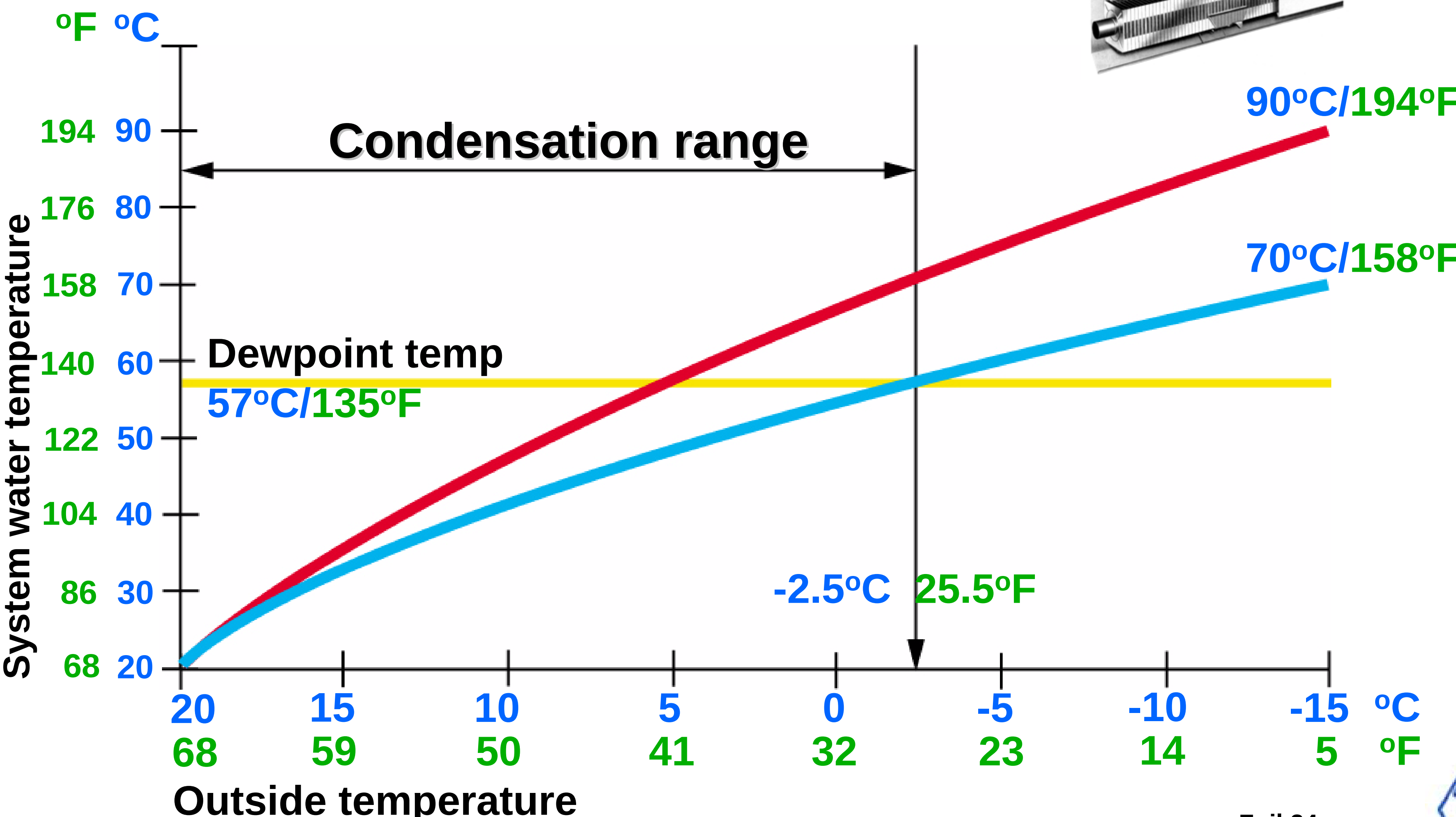


IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

Example 1: Supply/return temperature:

90/70ºC, 194/158ºF

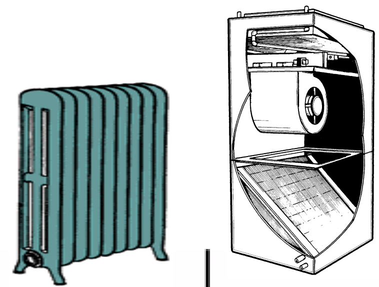
Fin tube



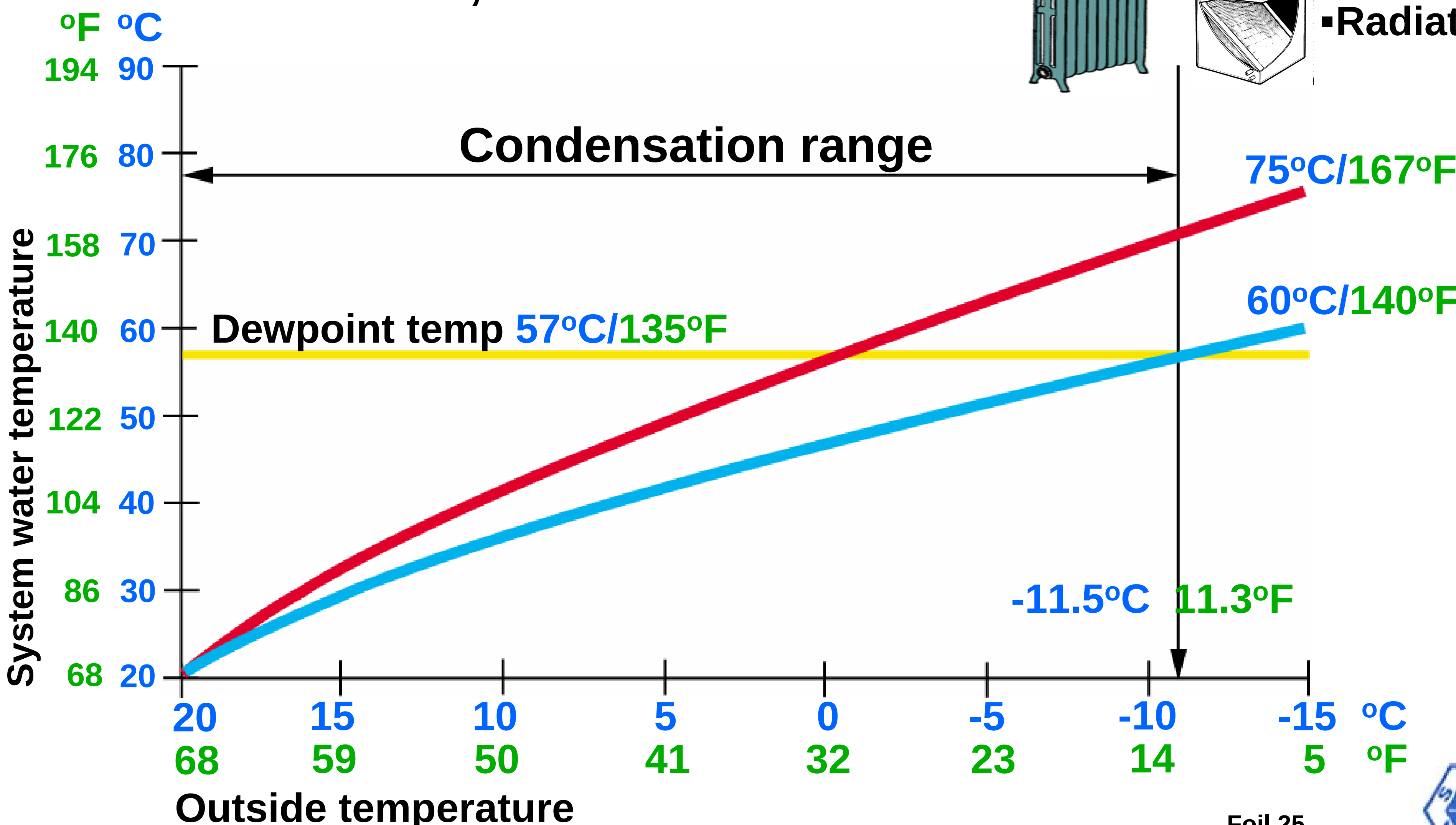
IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

Example 2: Supply/return temperature:

75/60ºC, 167/140ºF



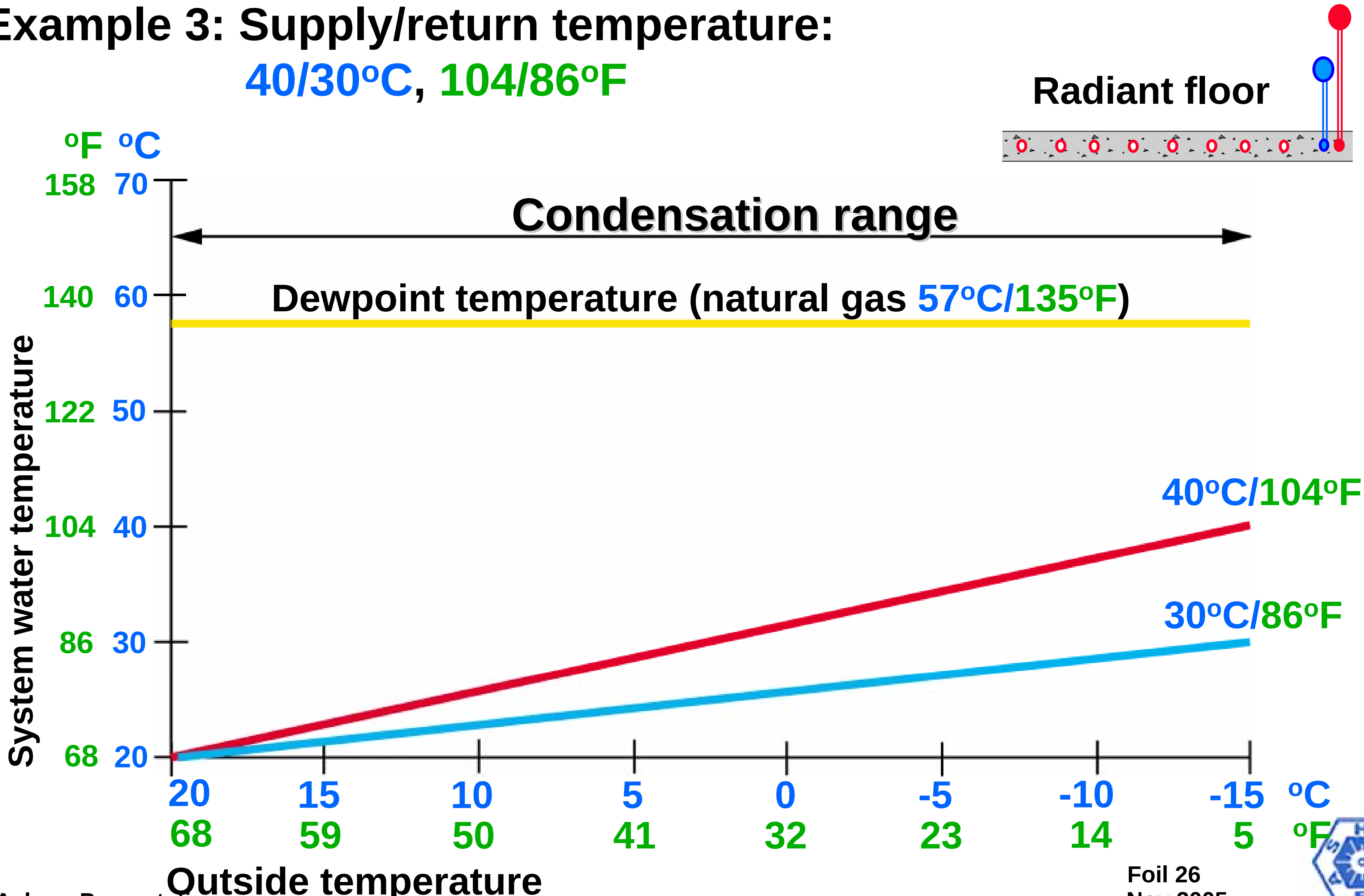
- Hydro-Air
- Radiators



IMPACT OF SYSTEM TEMPERATURES ON CONDENSATION

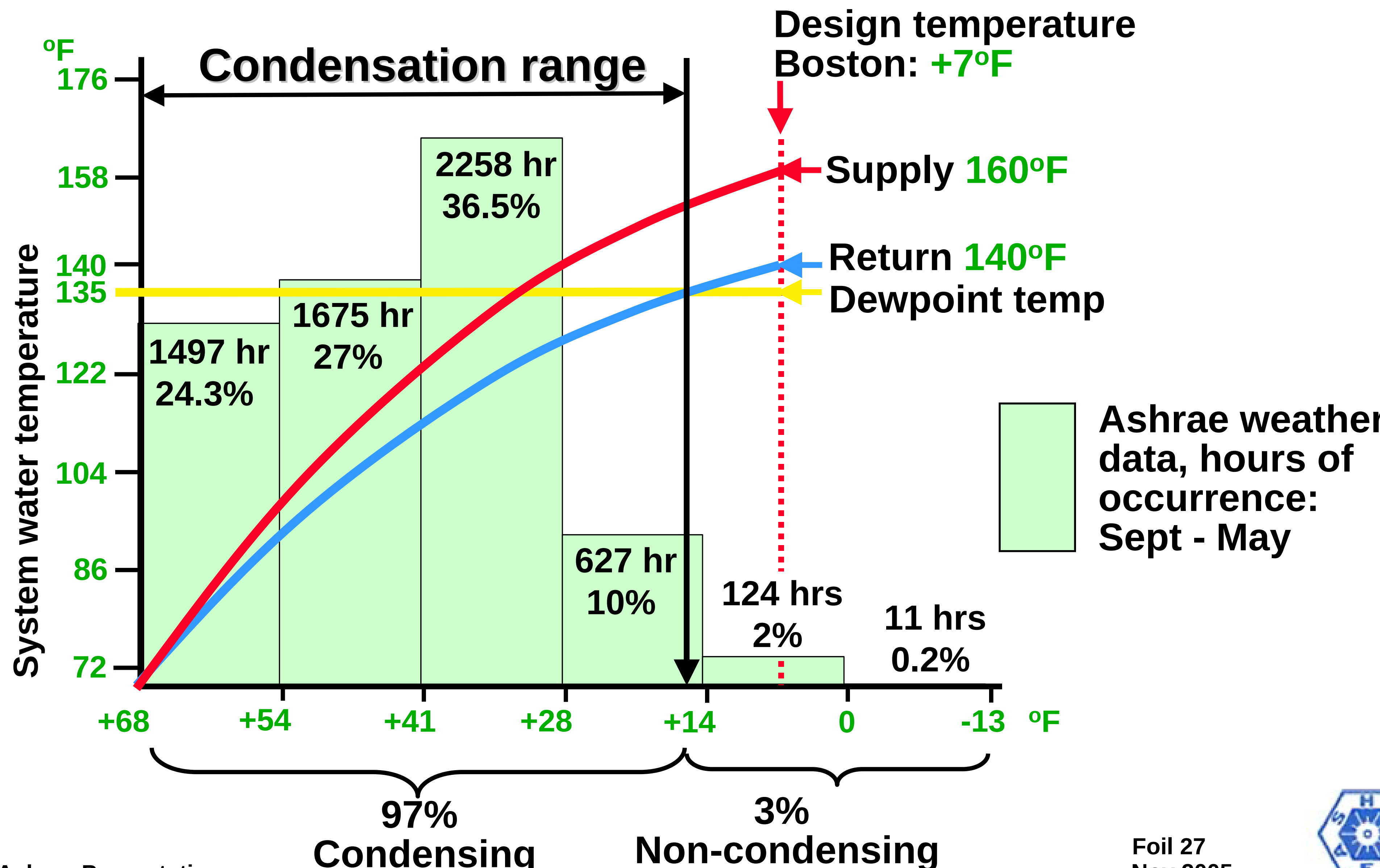
Example 3: Supply/return temperature:

40/30ºC, 104/86ºF



CONDENSING / NON CONDENSING RATIO

ASHRAE weather data for Boston, MA



CONDENSING / NON CONDENSING RATIO

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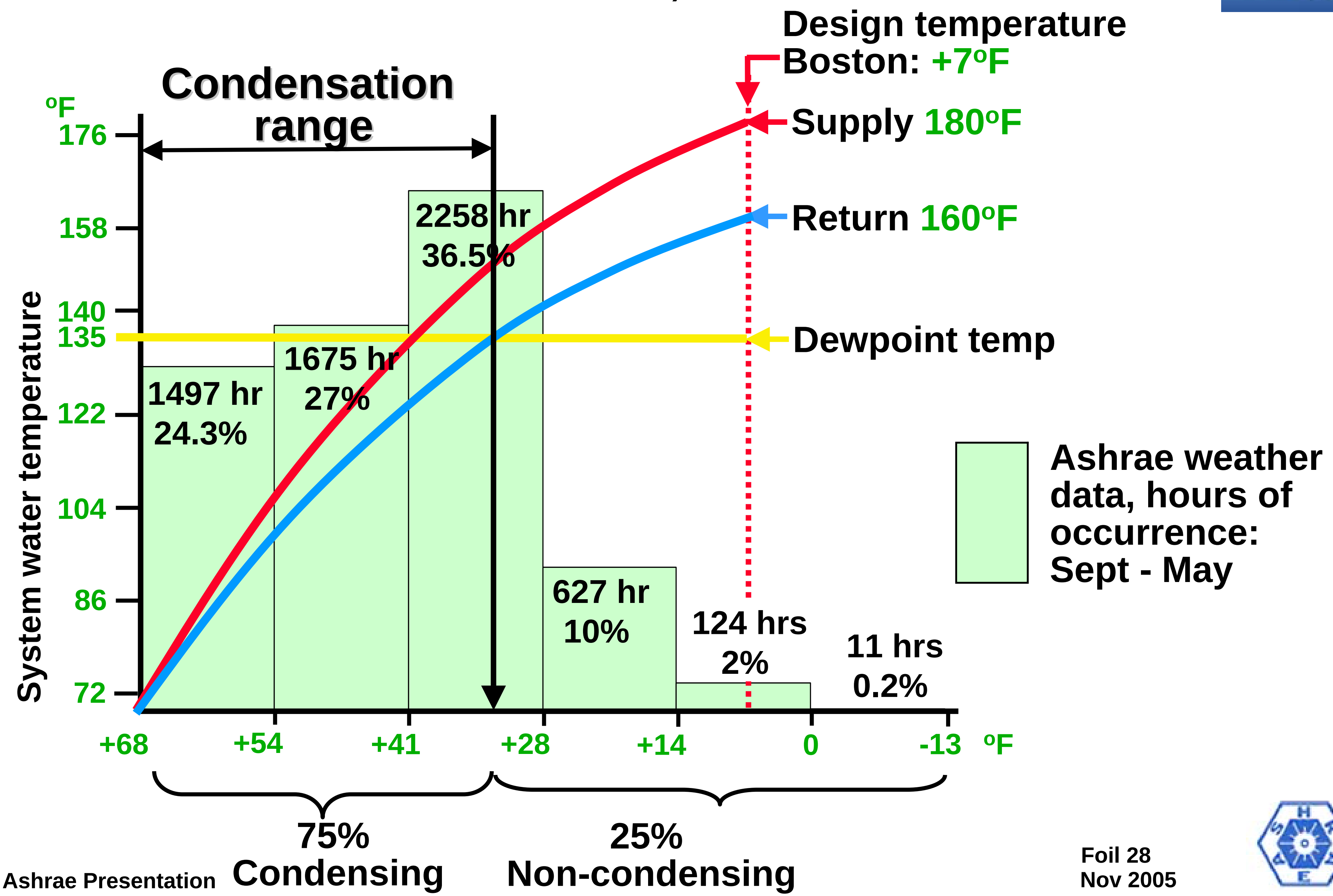
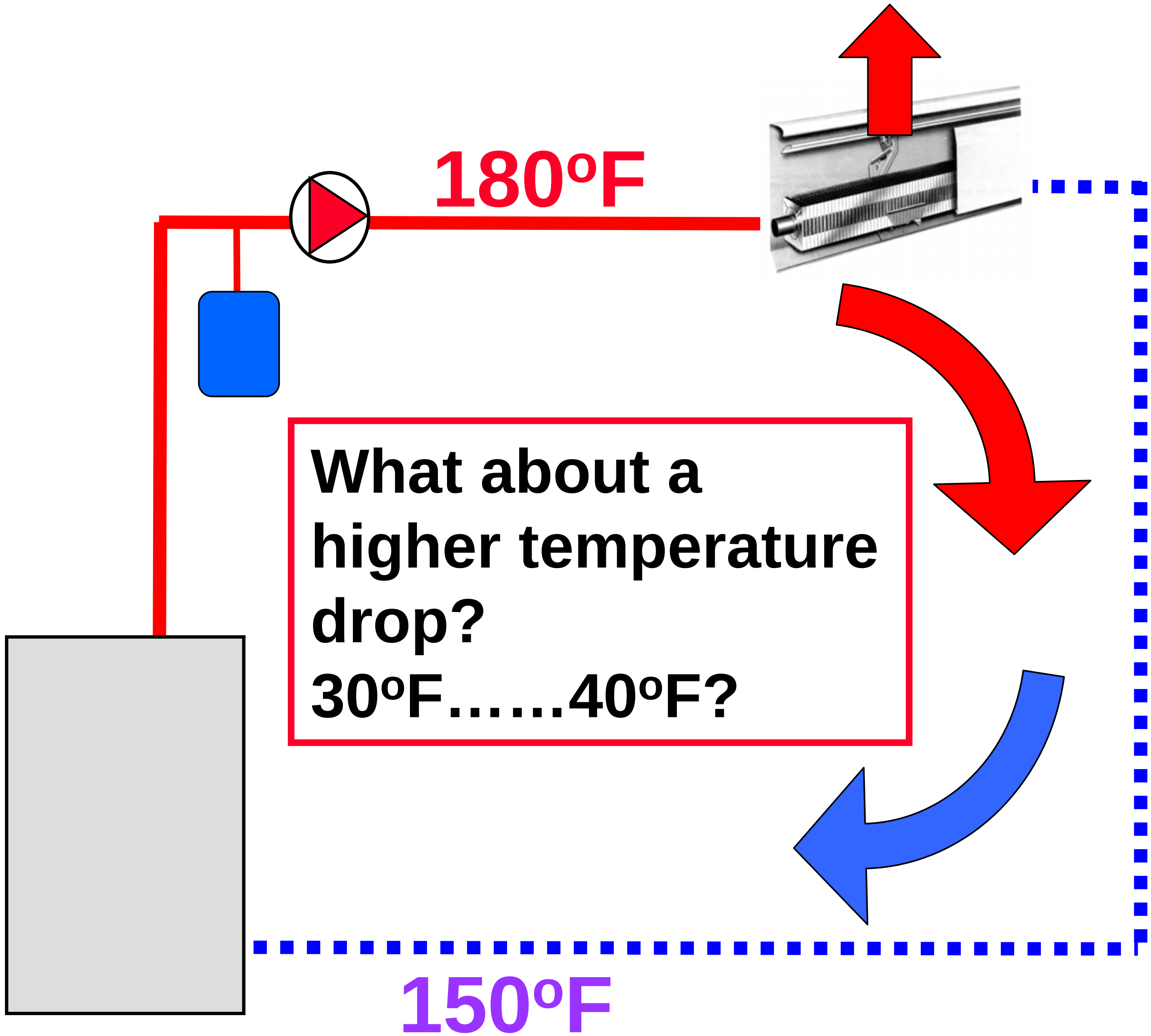
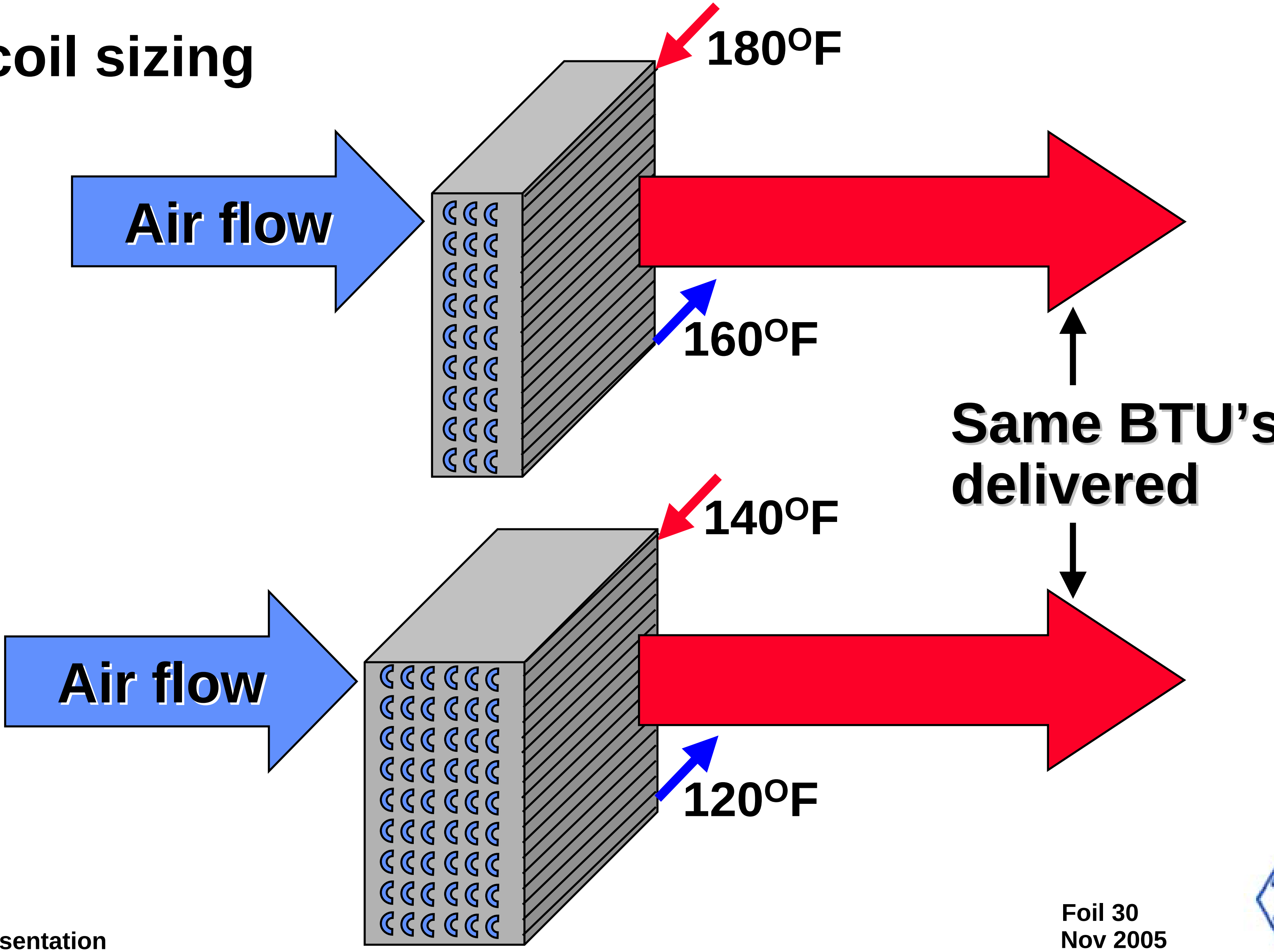


SYSTEM WATER TEMPERATURE DROP

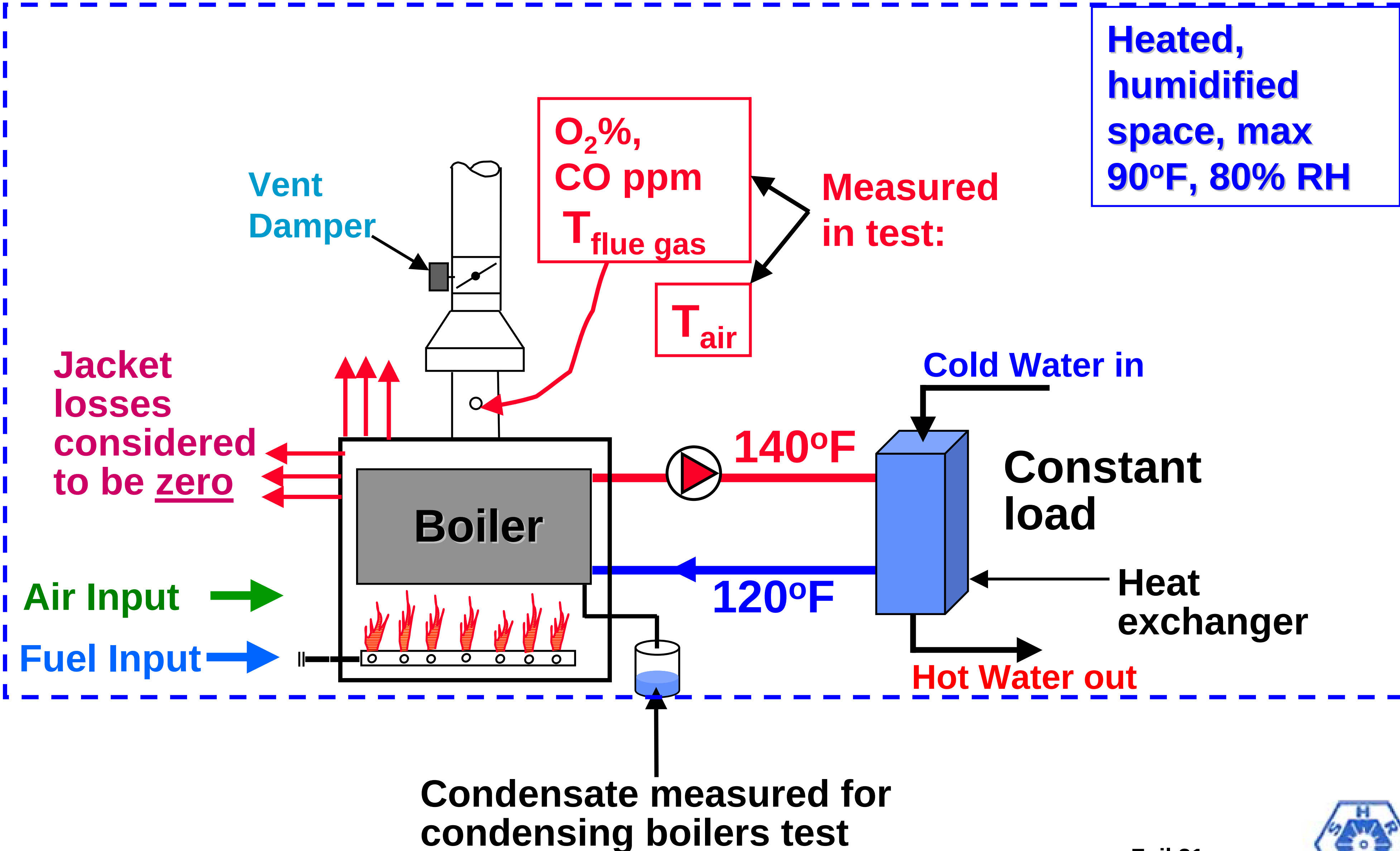


TRUE SYSTEM EFFICIENCY
System Components

Fan coil sizing

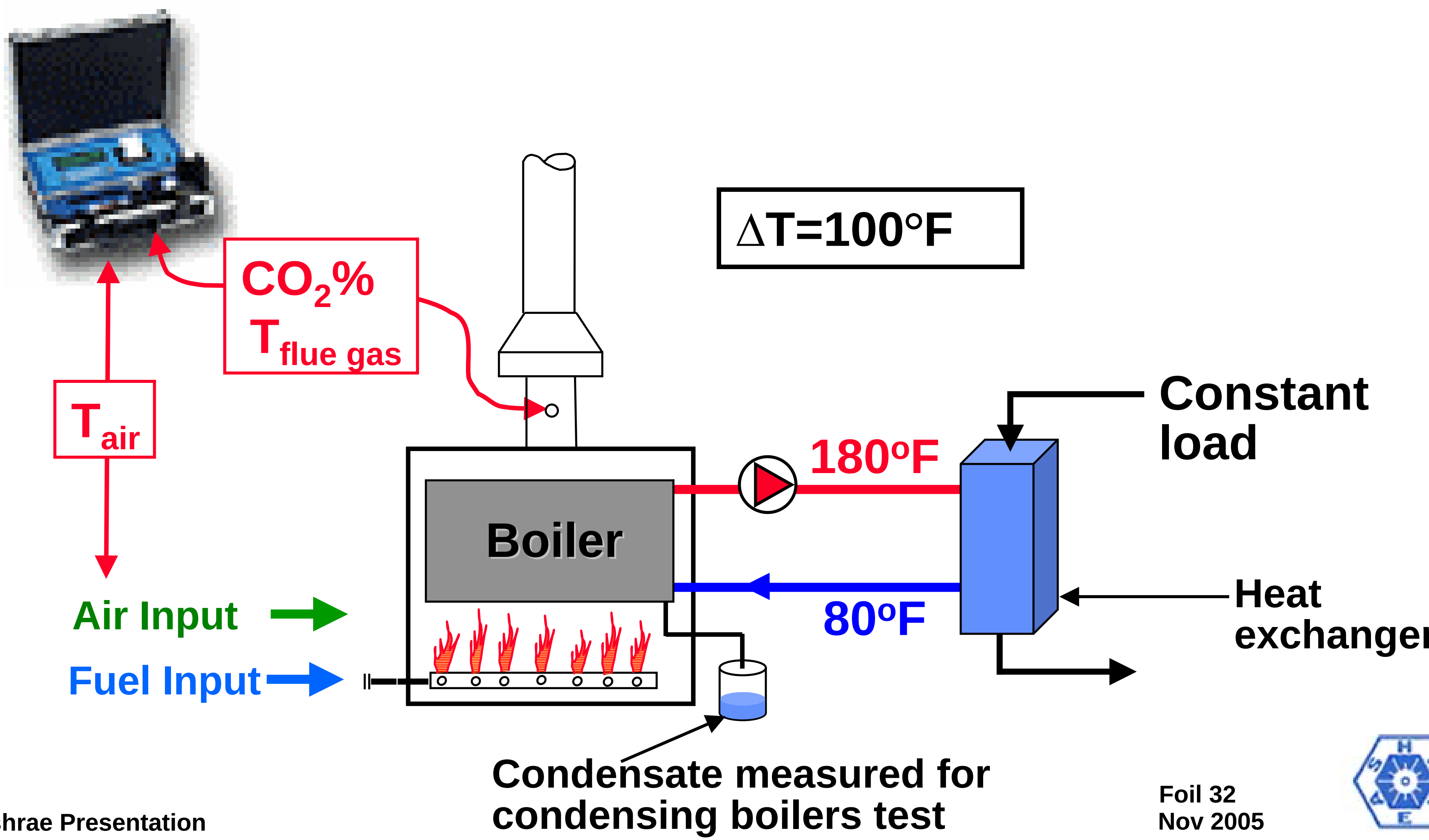


ANNUAL FUEL UTILIZATION EFFICIENCY
For residential boilers < 300 MBH

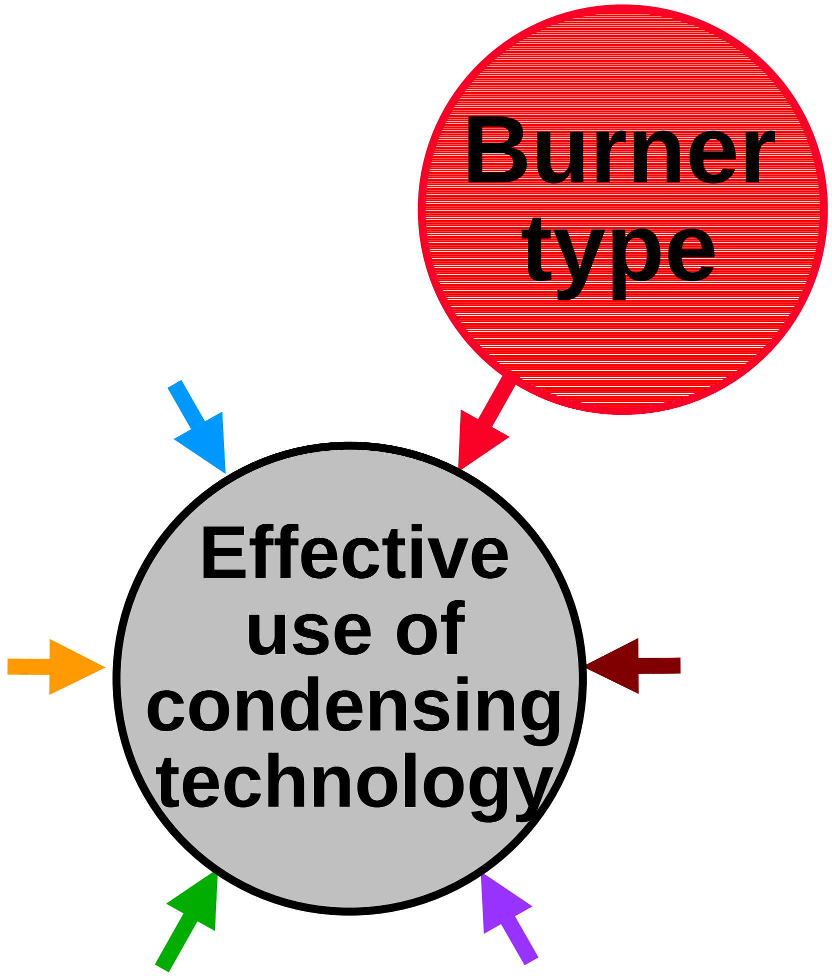


COMBUSTION EFFICIENCY
Testing for non-condensing gas commercial boilers

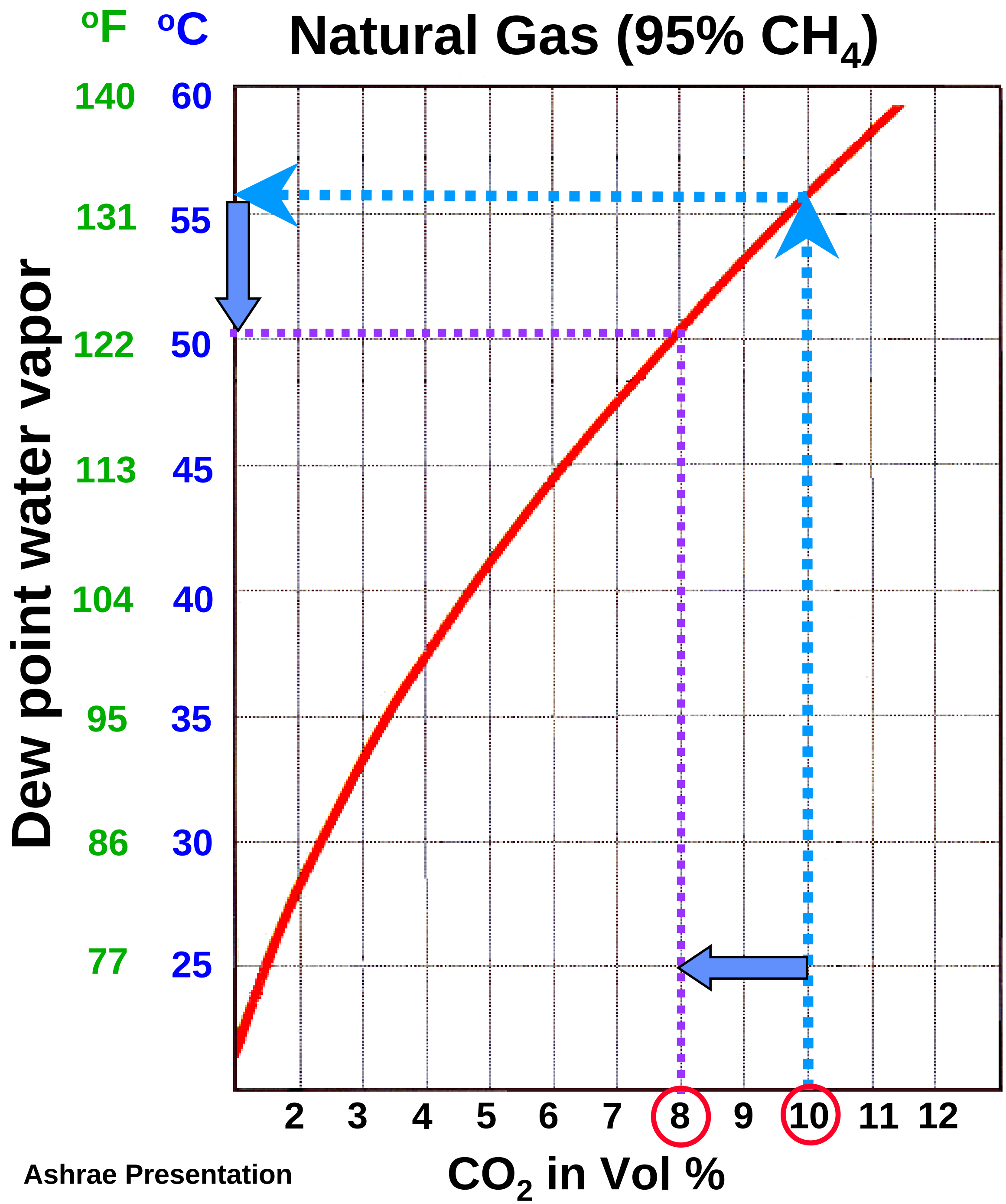
ANSI Z21.13 / CSA 4.9-2000



FACTORS INFLUENCING EFFECTIVENESS OF CONDENSING TECHNOLOGY



WATER VAPOR DEW POINT



CO_2% of flue gas influences dew point temperature

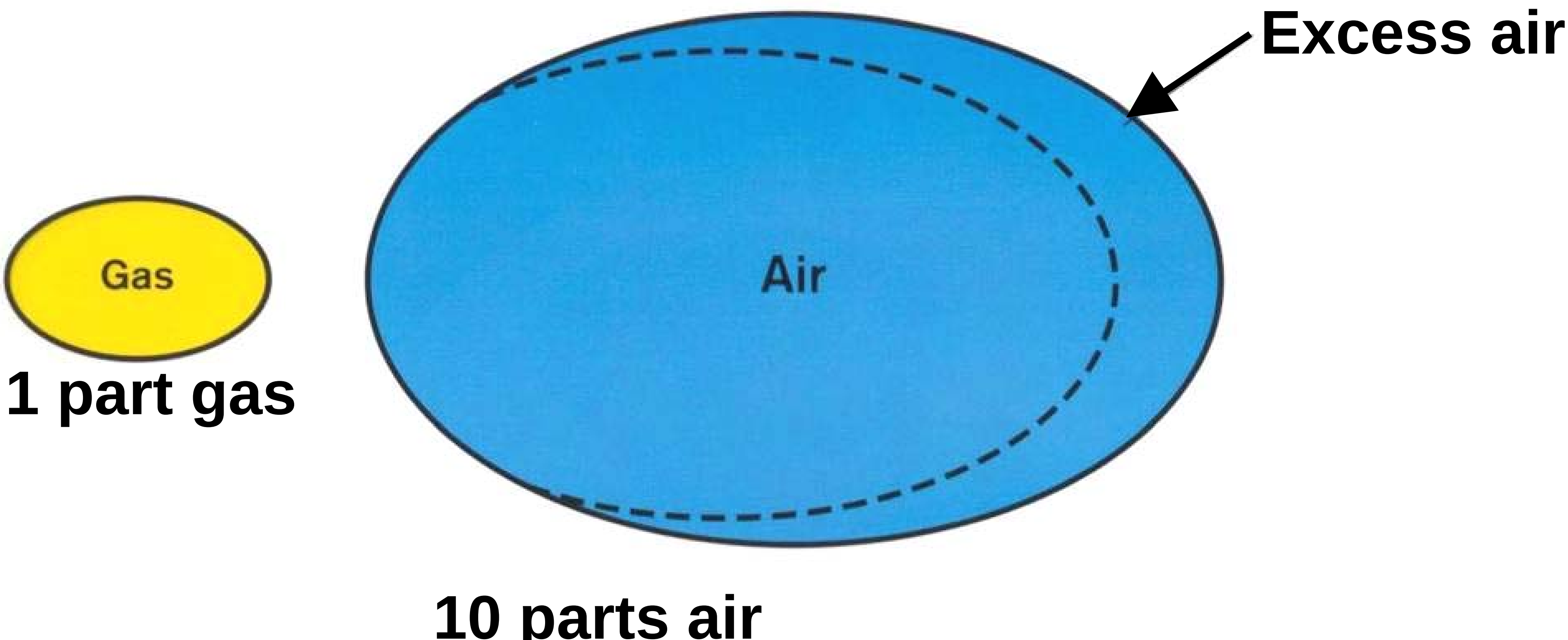
Higher CO_2
=Higher Dew point
=More Condensation

Lower CO_2
=Lower Dew point
=Less Condensation

What influences the CO_2% ?

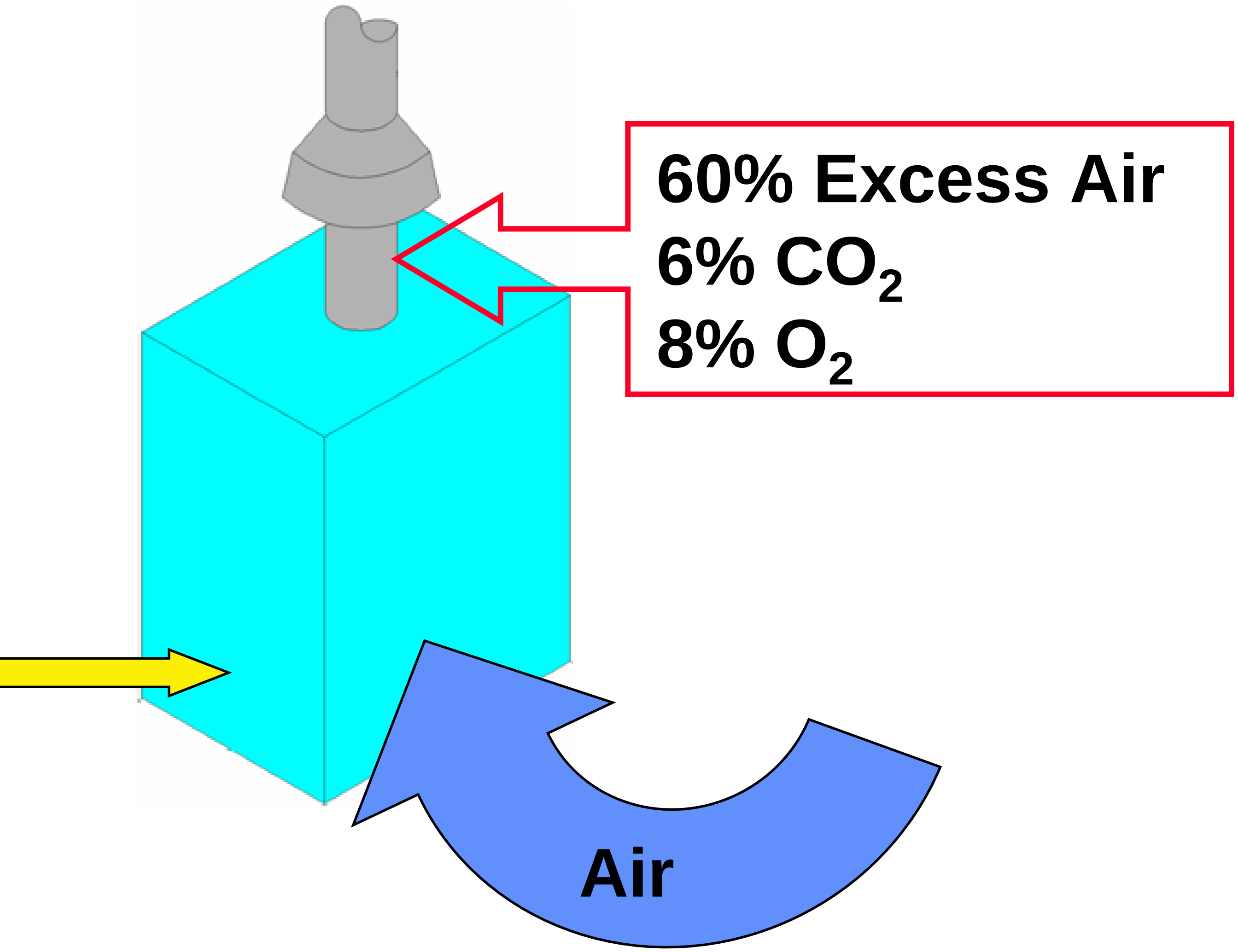
THE BURNER!

NATURAL GAS COMBUSTION



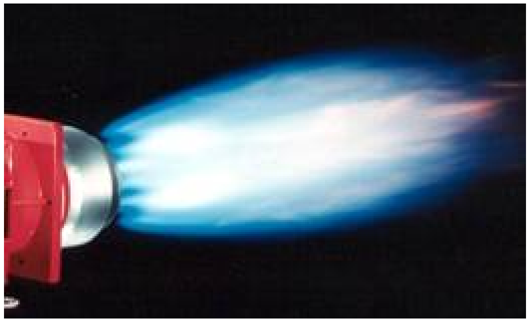
NATURAL GAS COMBUSTION

Atmospheric Burner technology

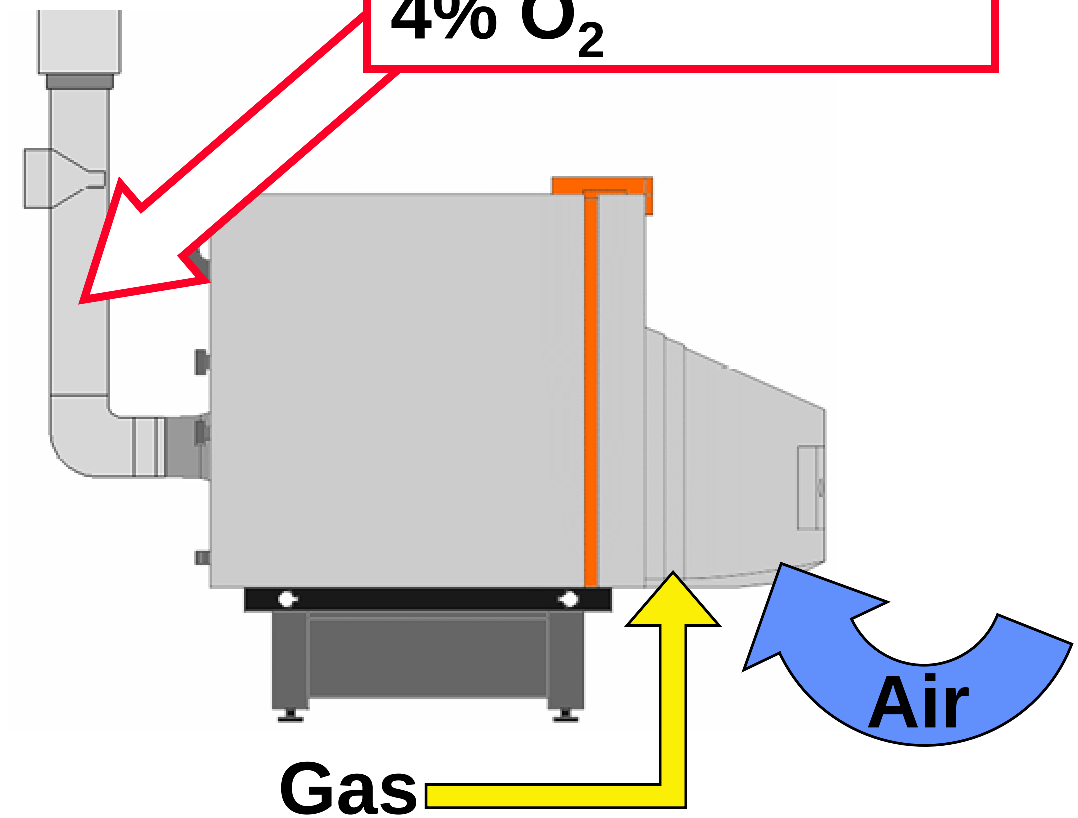


NATURAL GAS COMBUSTION

Power-fired burner technology



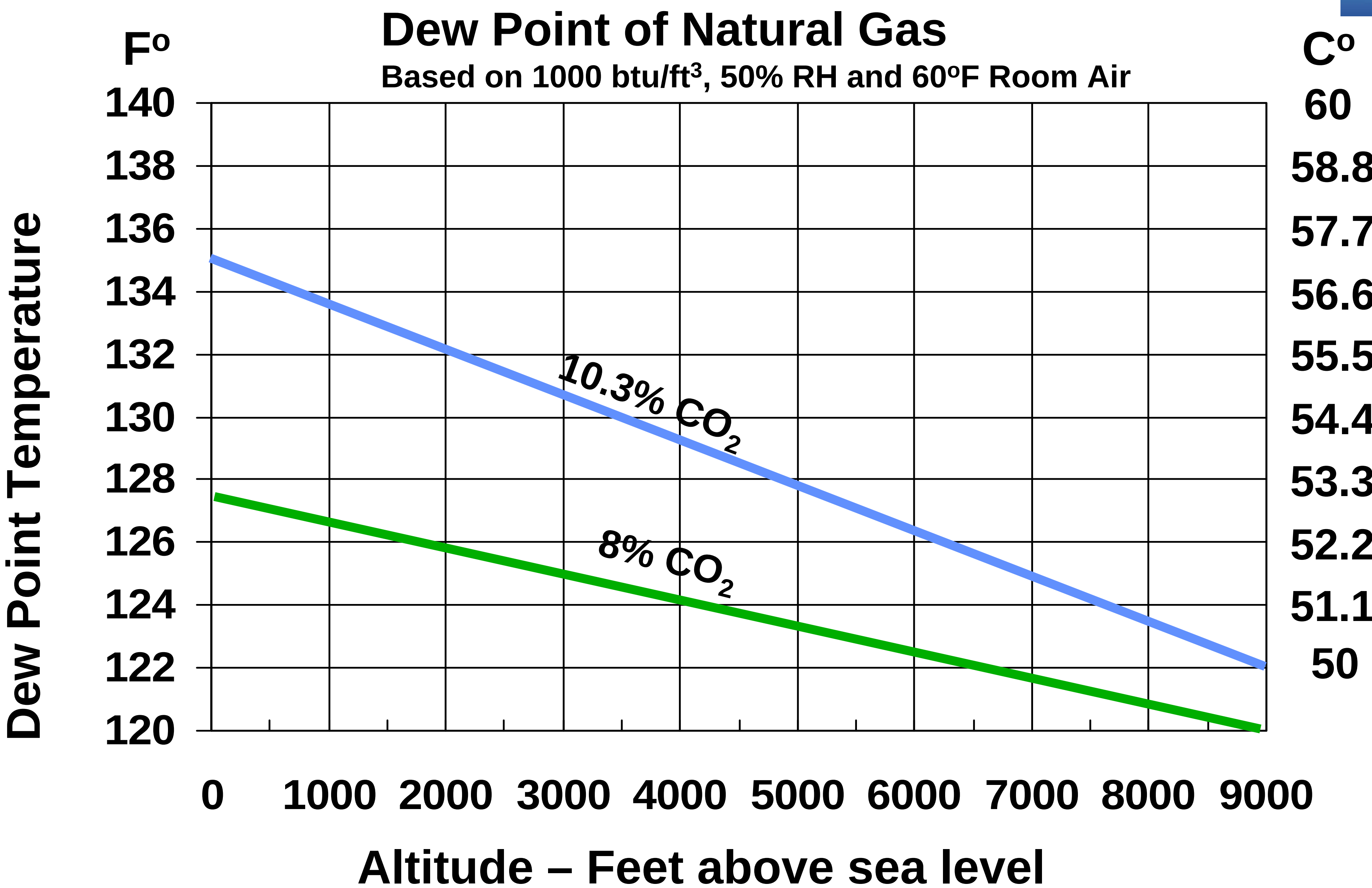
25% Excess Air
9.5% CO_2
4% O_2



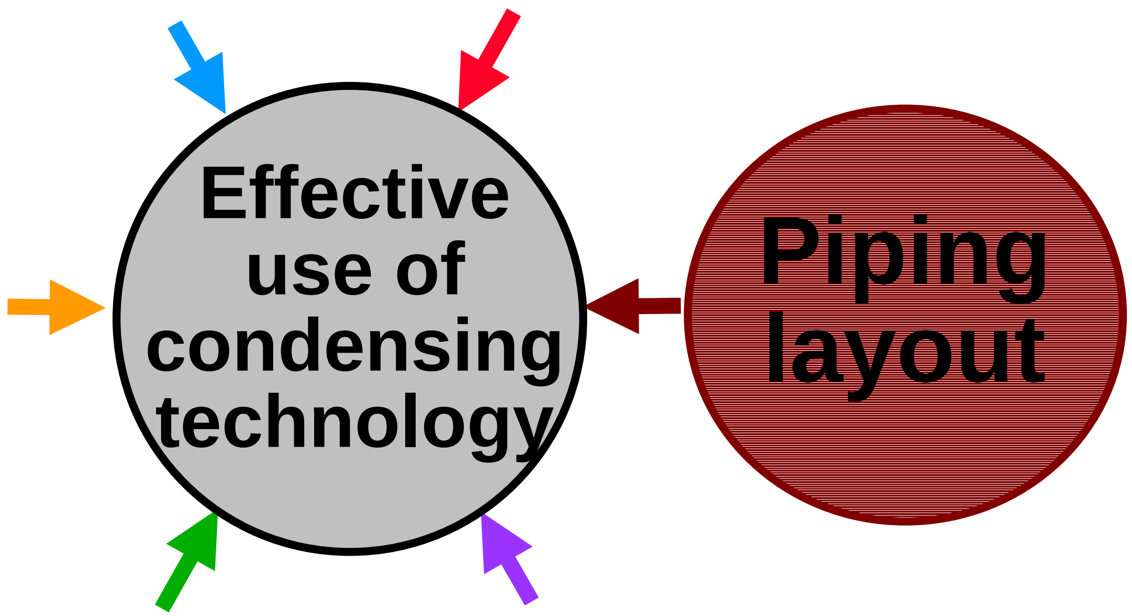
BURNER REQUIREMENTS FOR CONDENSING BOILERS

- Combustion with minimal excess air
  - CO_2: 9.5 to 10%
  - Excess air: 20 – 25%
- Fully modulating input
- Precise calibration thru entire firing range
- Low NO_x and CO emissions

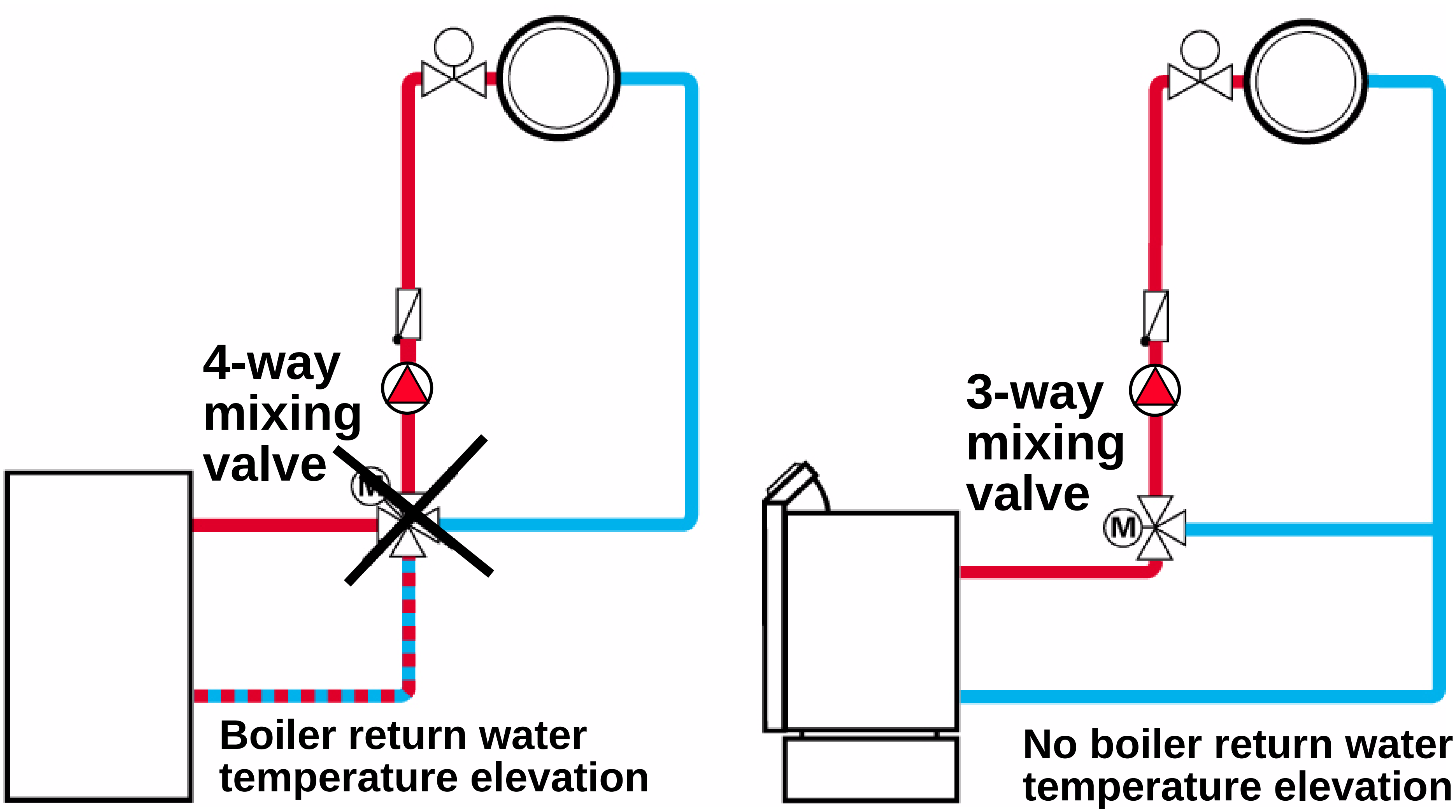
DEW POINT AND ALTITUDE



FACTORS INFLUENCING EFFECTIVENESS OF CONDENSING TECHNOLOGY



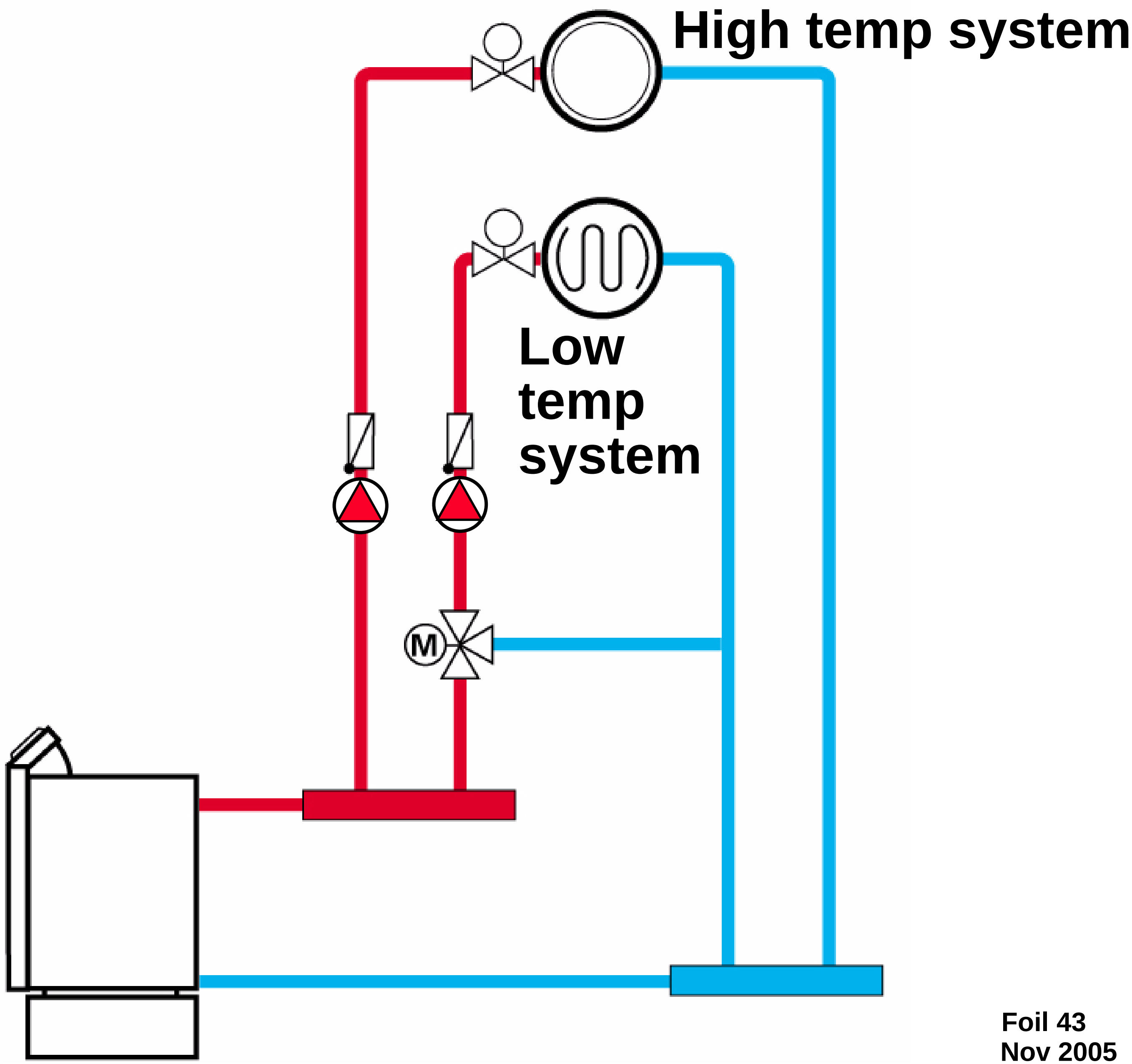
USE OF MIXING VALVES WITH CONDENSING BOILERS



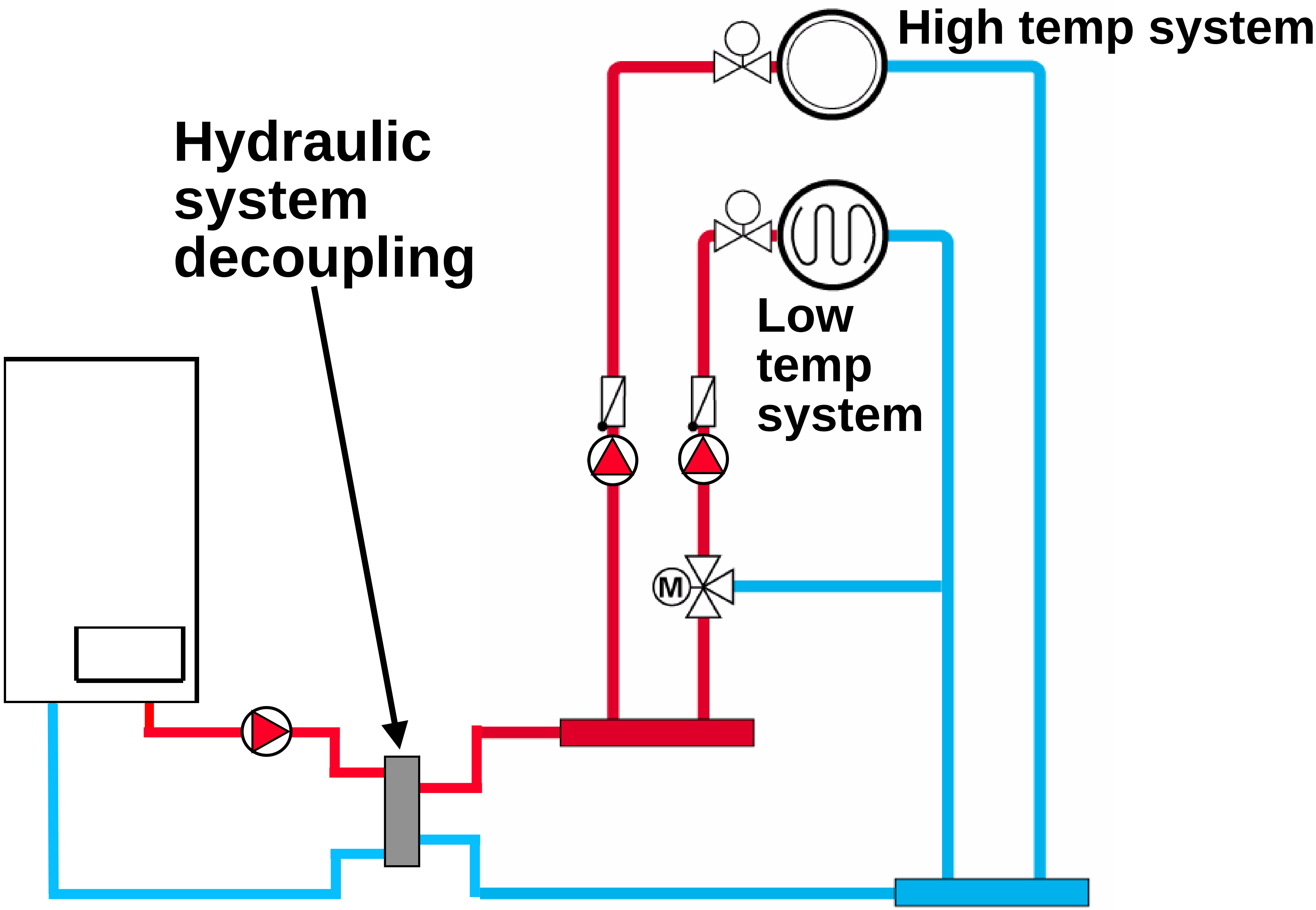
INCORRECT

CORRECT

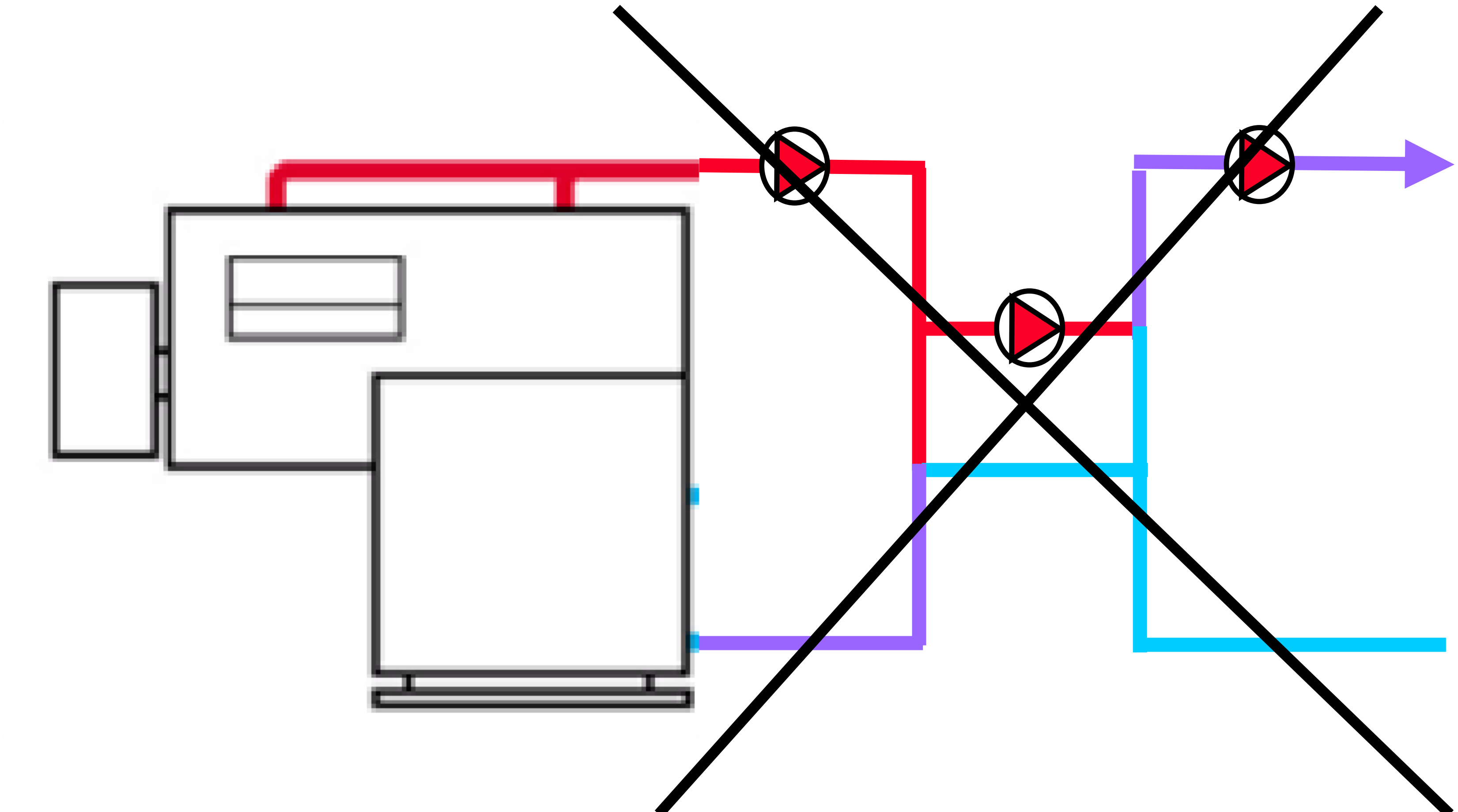
CONDENSING BOILERS IN TWO TEMPERATURE SYSTEMS



CONDENSING BOILERS IN HIGH FLOW SYSTEMS

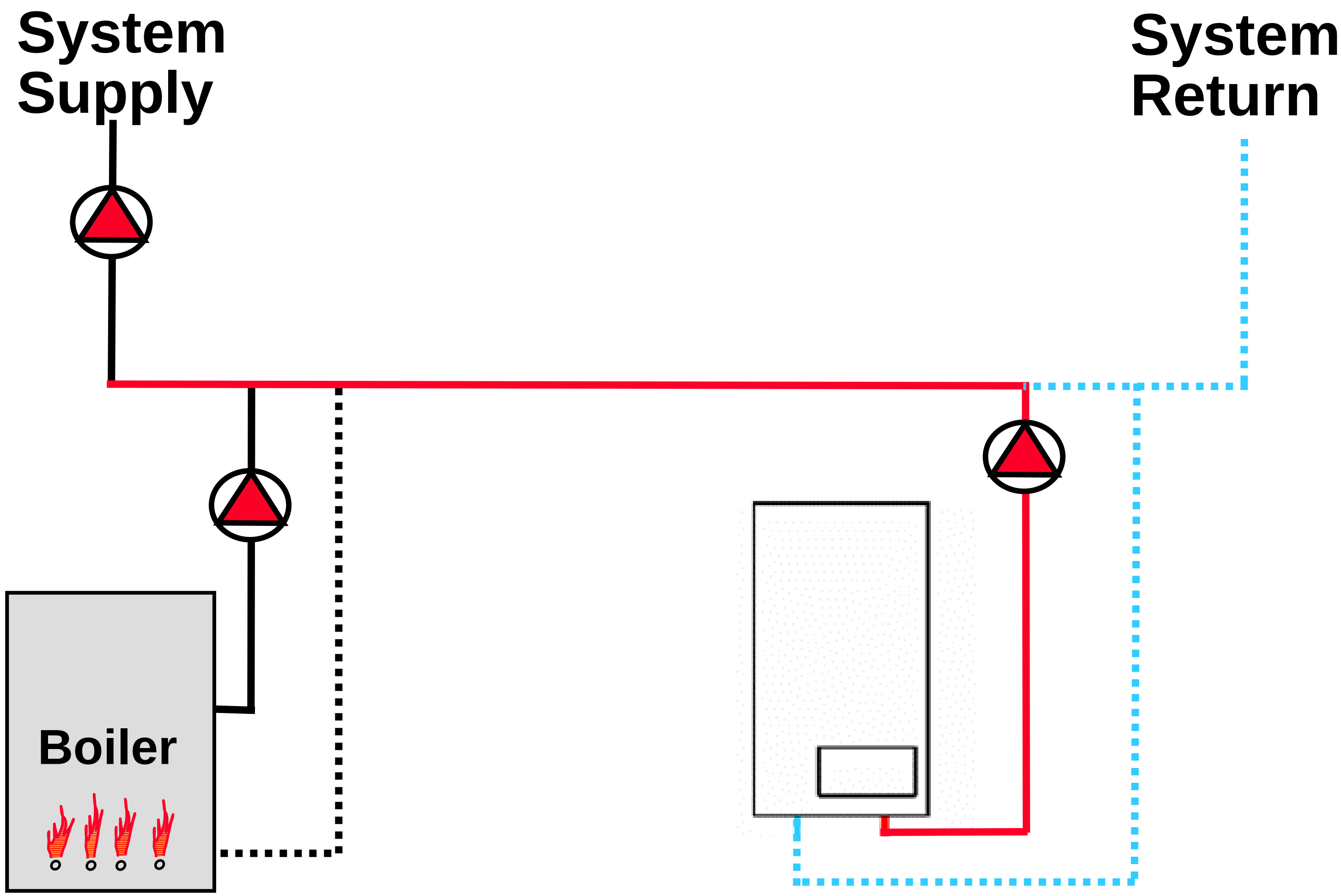


INJECTION PUMPING WITH CONDENSING BOILERS



INCORRECT

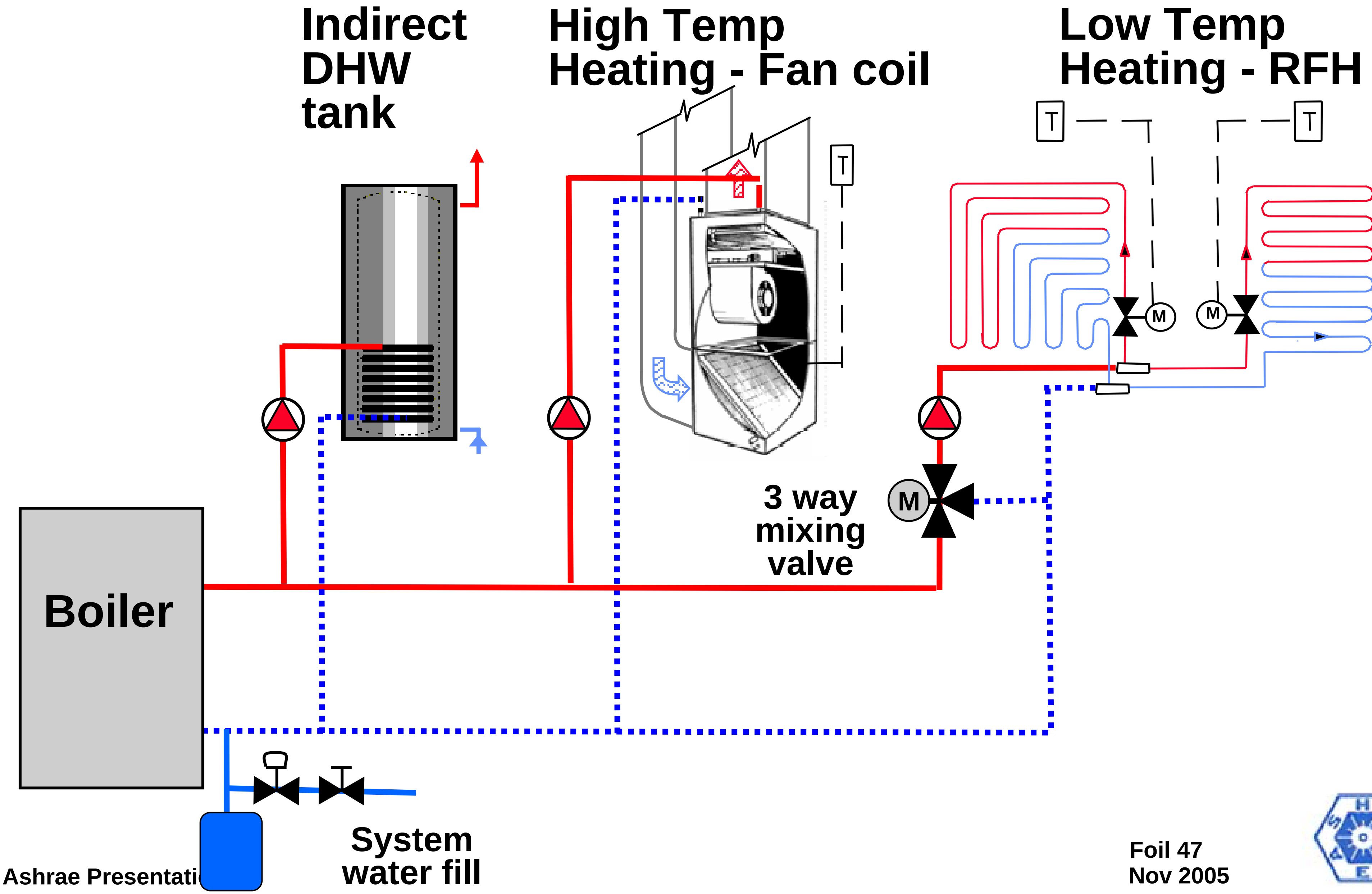
COMBINATION OF BOILERS



Non-Condensing boiler
LAG BOILER

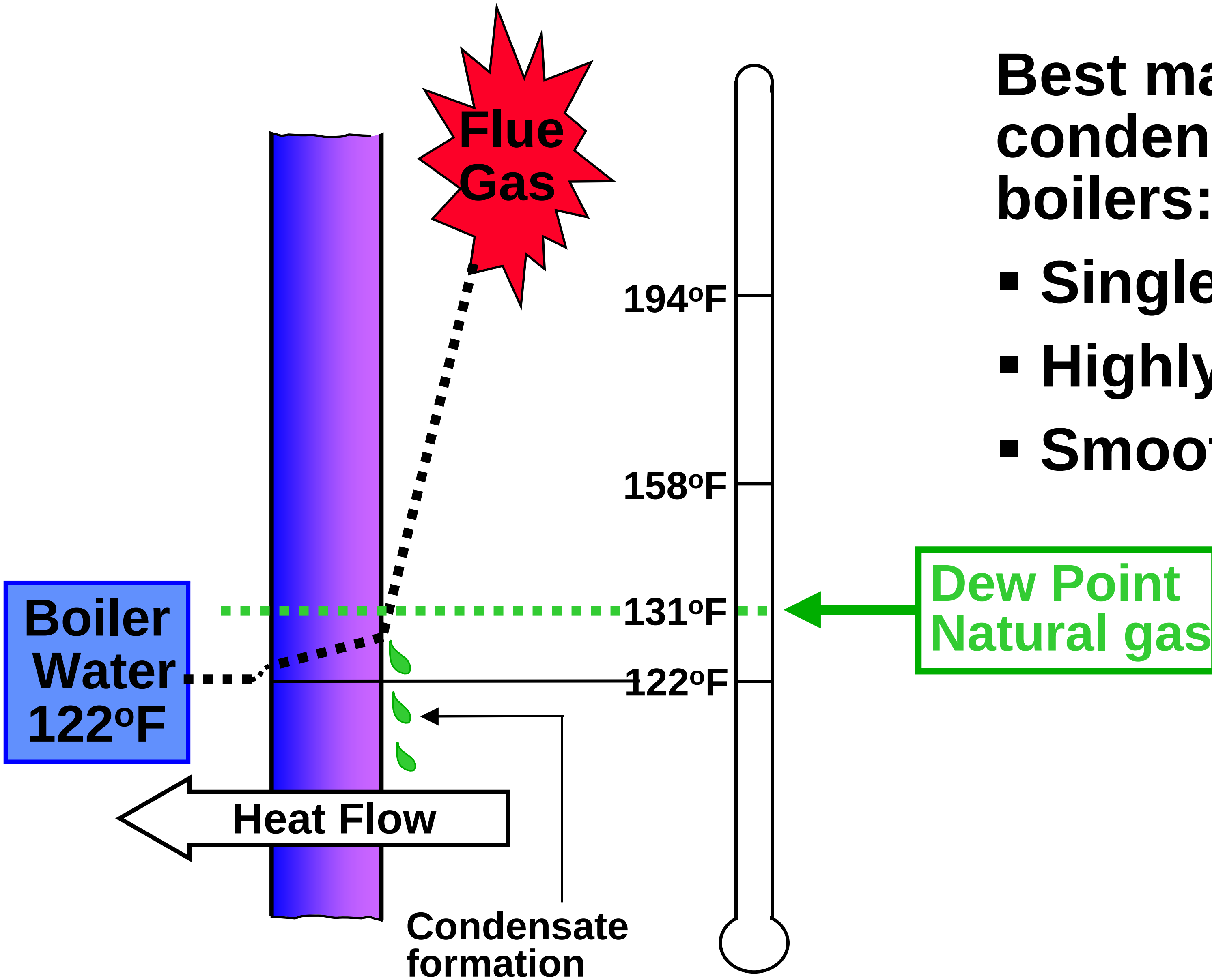
Condensing boiler
LEAD BOILER

MULTIPLE FUNCTION, MULTIPLE TEMPERATURE SYSTEM



Construction requirements of condensing boiler technology

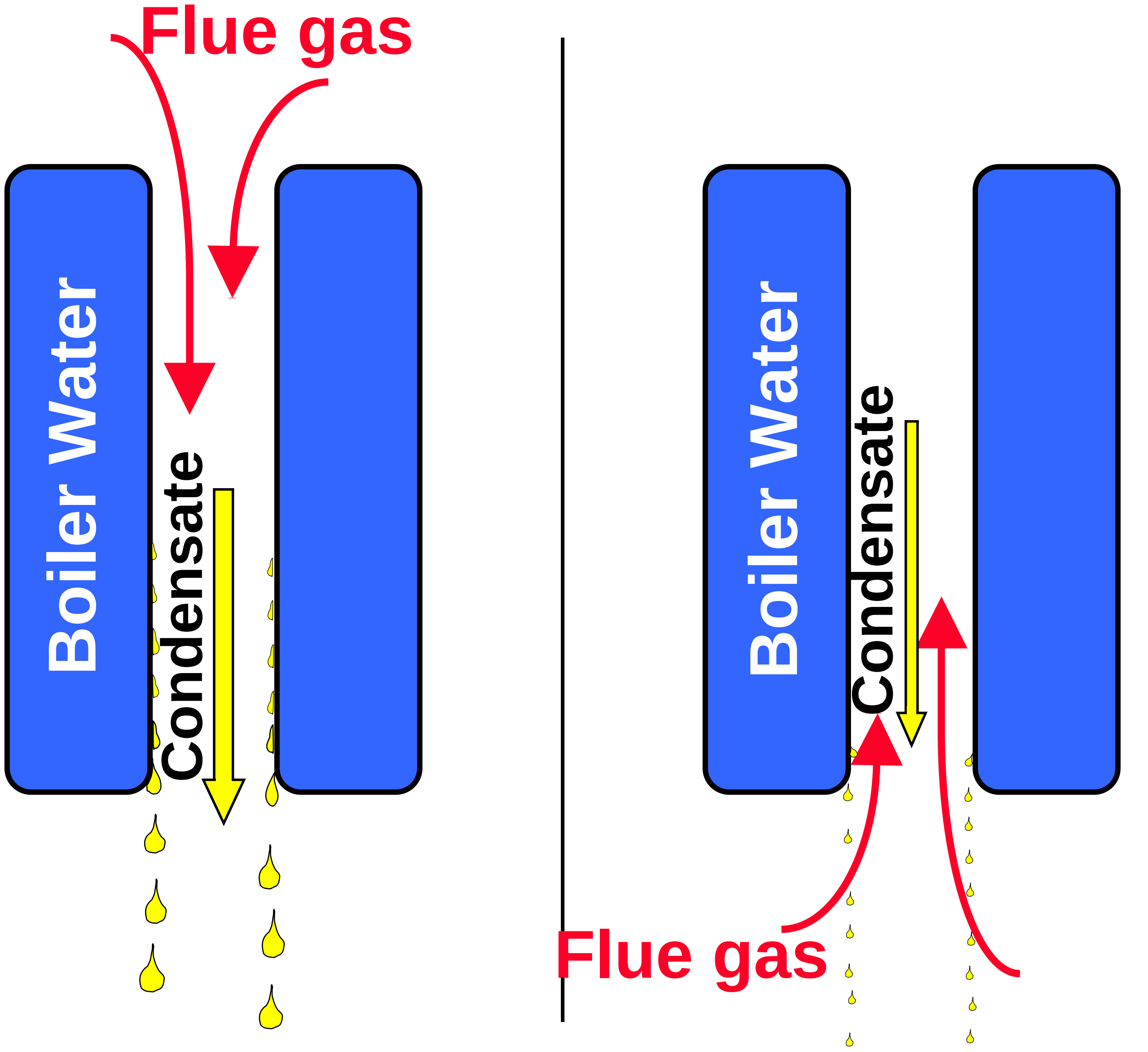
PHYSICAL REQUIREMENTS OF THE HEAT EXCHANGER SURFACES



Best material for condensing boilers:

- Single wall
- Highly conductive
- Smooth surface

PHYSICAL REQUIREMENTS OF THE FLUE GAS AND CONDENSATE PASSAGE WAYS



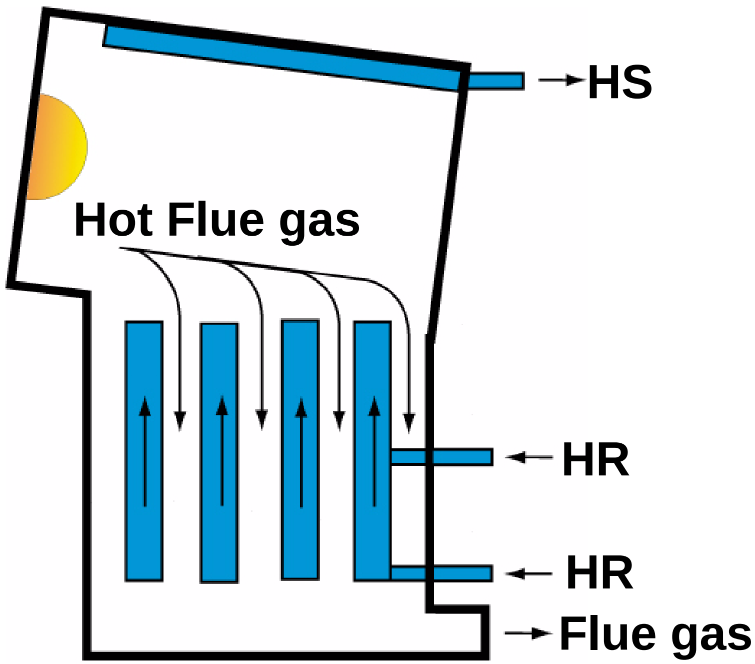
CORRECT

INCORRECT

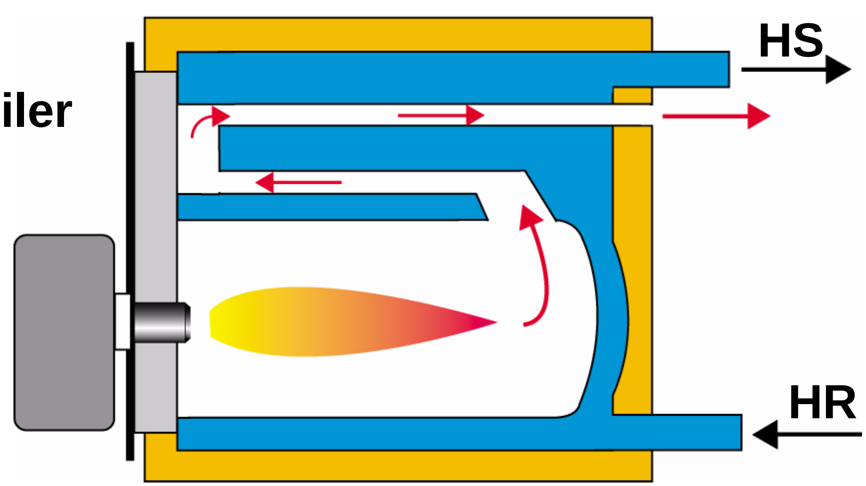
Flue gas and condensate must flow in the same direction (parallel flow)

CONDENSING BOILER CONSTRUCTION

Condensing boiler



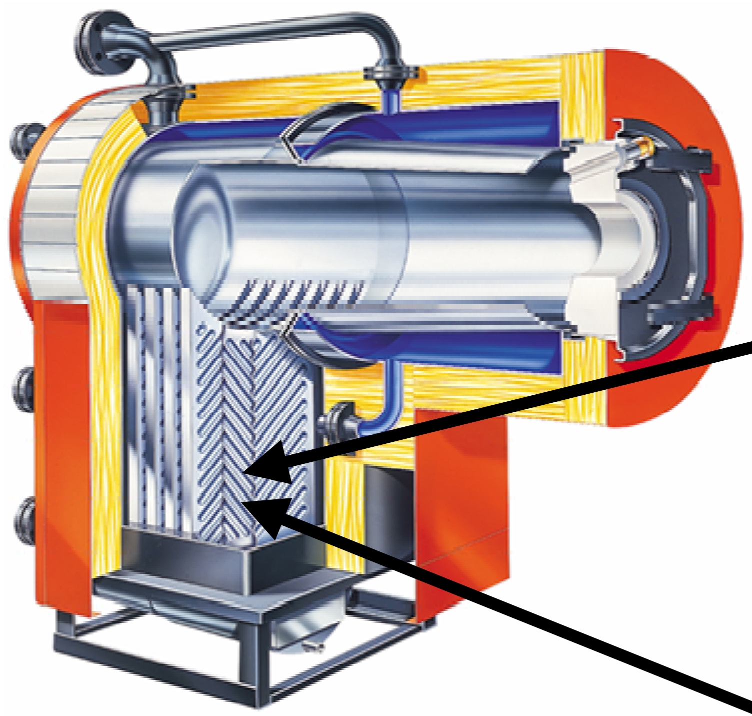
Normal heating boiler



Condensing boiler requirements:

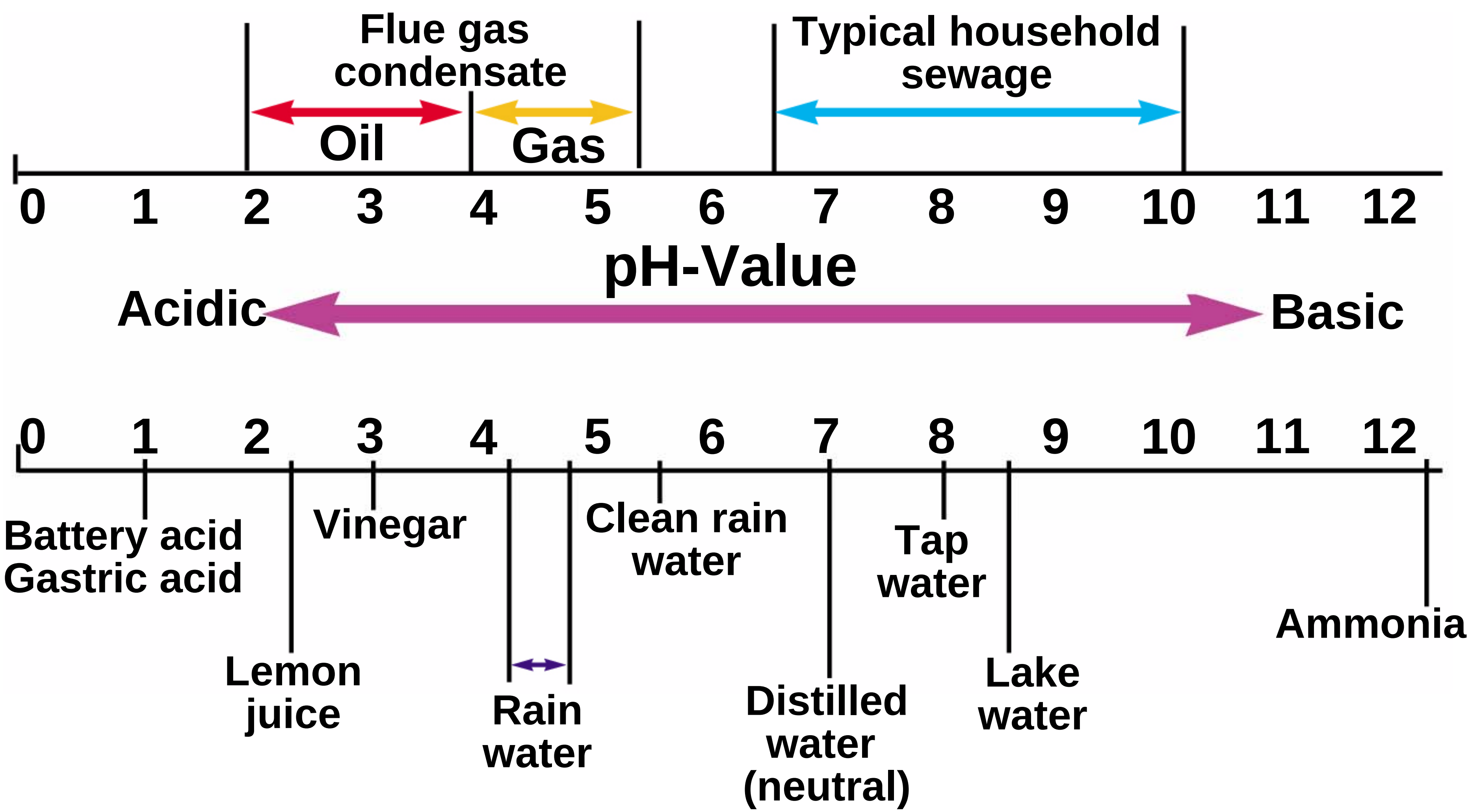
- Counterflow principle for flue gas and boiler water – optimal heat transfer
- Parallel flow direction for flue gas and condensate – uniform flow with self-cleaning effect of heat transfer surfaces

HEAT EXCHANGER CONSTRUCTION



Why is material construction of the boiler heat exchanger so important?

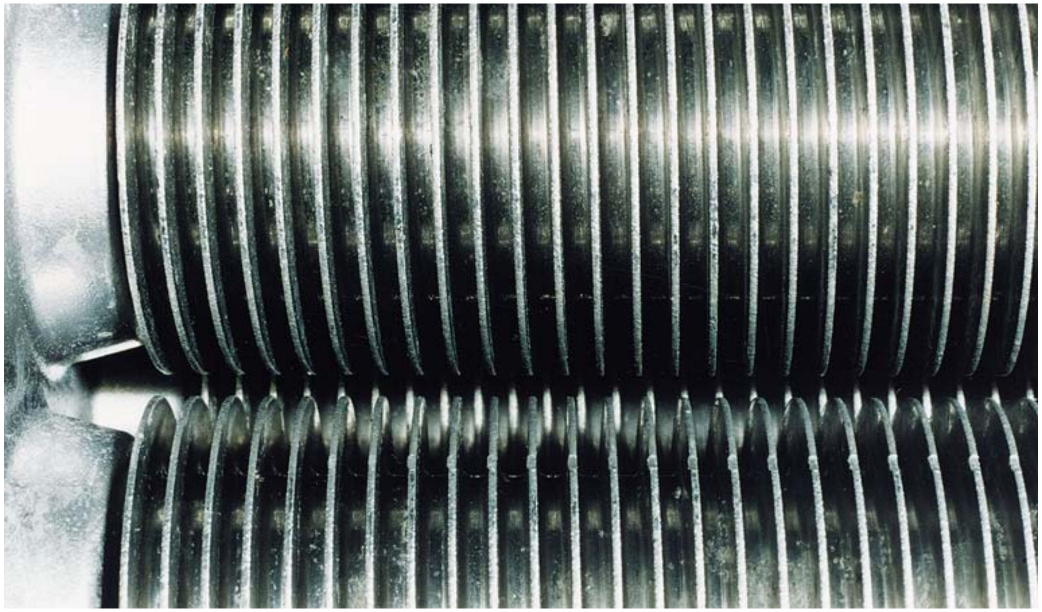
pH VALUES OF VARIOUS FLUIDS



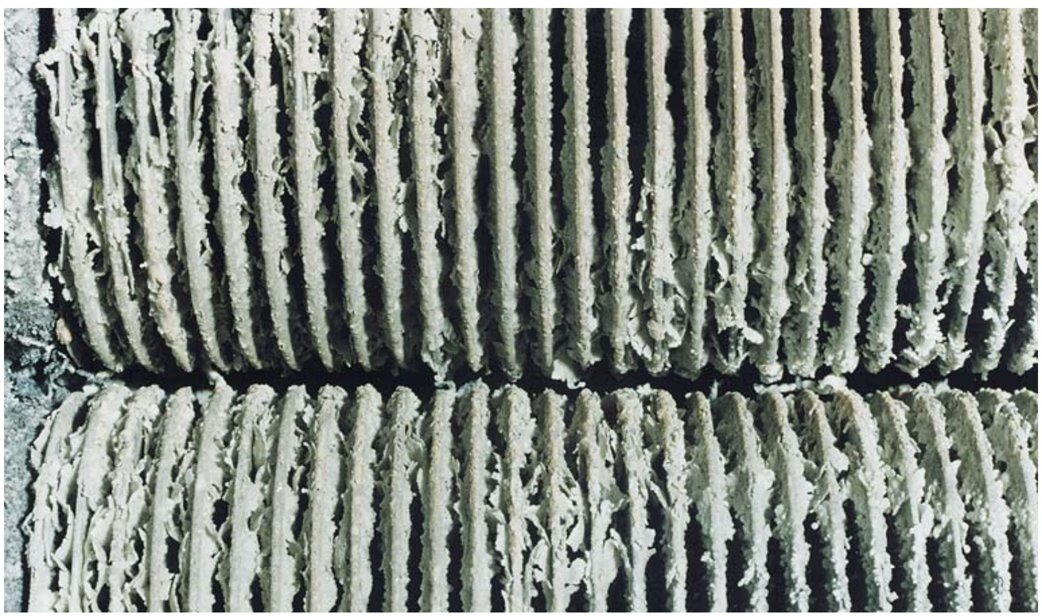
MATERIAL REQUIREMENTS FOR CONDENSING BOILERS

- Highly corrosion resistant
- High strength with thin wall thickness
- Formable
- Long term reliability

FINNED TUBE HEAT EXCHANGERS



New aluminum fin heat exchanger surface



Same heat exchanger surface after short term use

CONDENSATE DISPOSAL

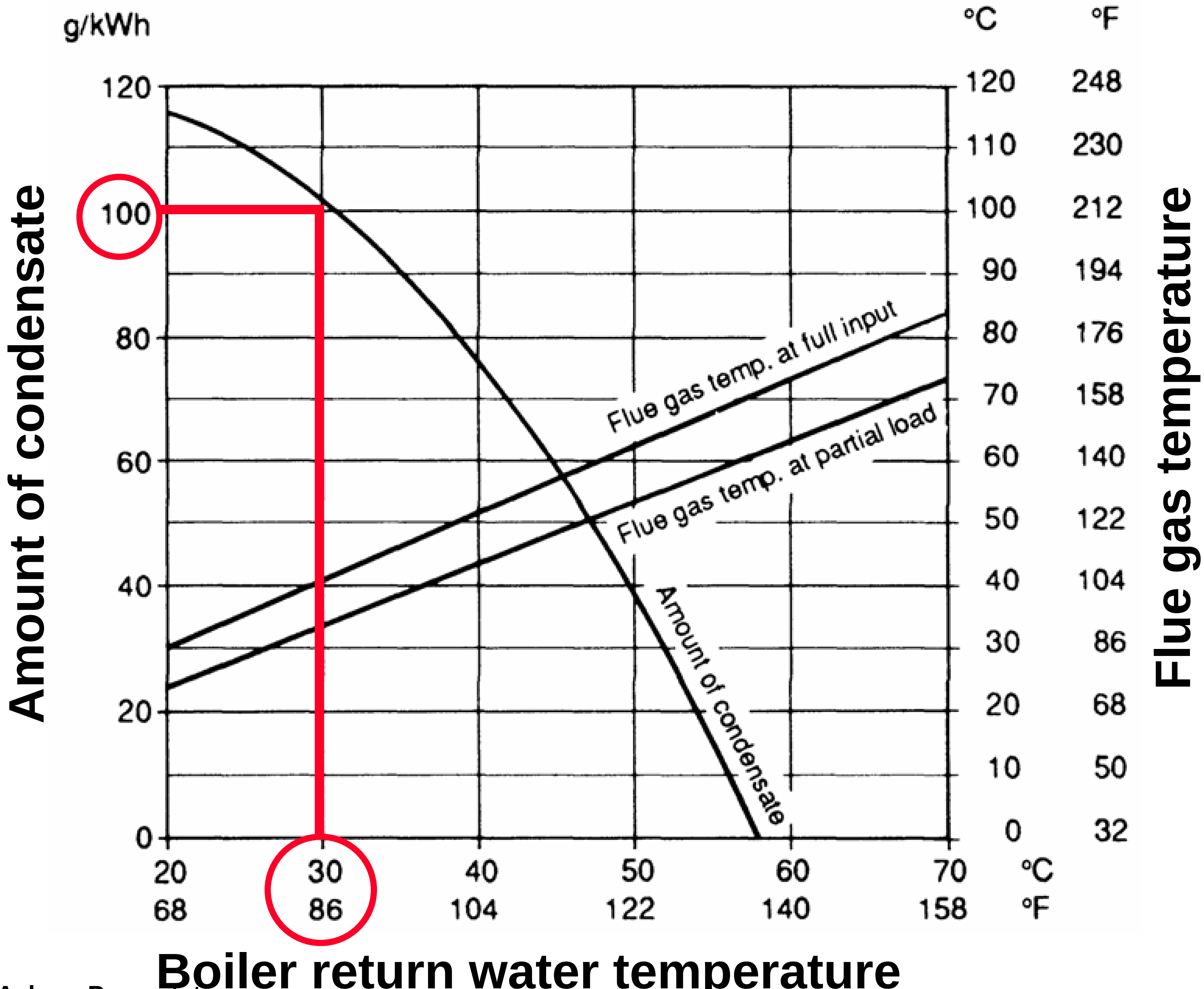
How much condensate will be produced?

What do we do with it?

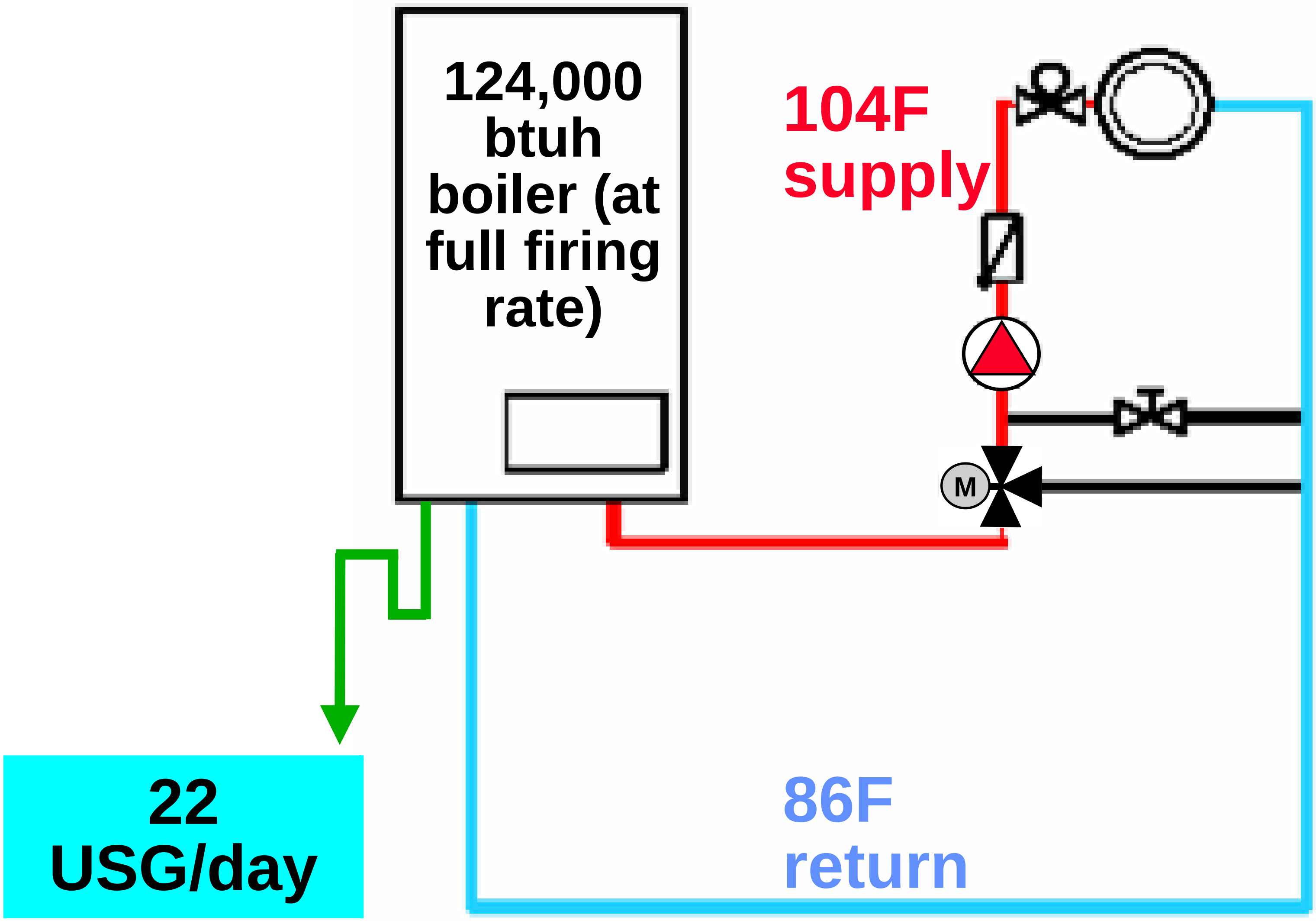
Comparison of condensate components

Components Tested	Drinking Water Limits	Wine	Vertomat 05 - 89 DIN-DVGW Test
	mg/ltr.	mg/ltr.	mg/ltr.
Lead	0.04	0.1 - 0.3	< 0.01
Cadmium	0.005	0.001	< 0.005
Chrome	0.05	0.06 - 0.03	< 0.01
Copper	3.0*	0.5	< 0.01
Nickel	0.05	0.05 - 0.03	< 0.01
Mercury	0.001	0.00005	< 0.0001
Vanadium	-	0.26 - 0.06	not determined
Zinc	5.0*	3.5 - 0.5	< 0.05
Tin	-	0.7 - 0.01	< 0.05
Sulphate	240	5 - 10	4.6
pH Value	6.5 - 9.5	3 - 4 (at 1.9 - 07 g/ltr. tartaric acid)	3.5 - 5 Without neutralization

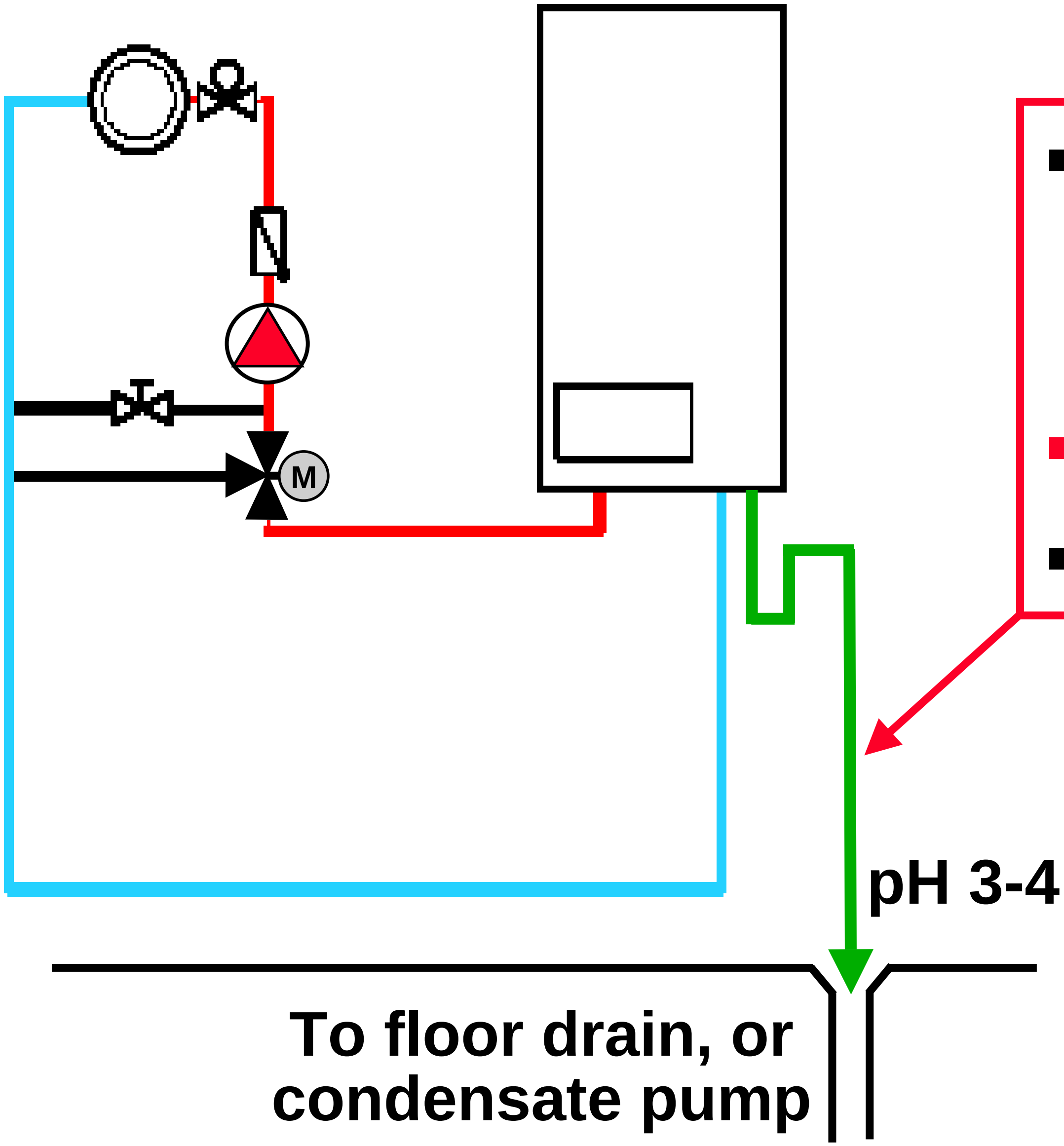
CONDENSATE FLOW RATE



CONDENSATE FLOW RATE

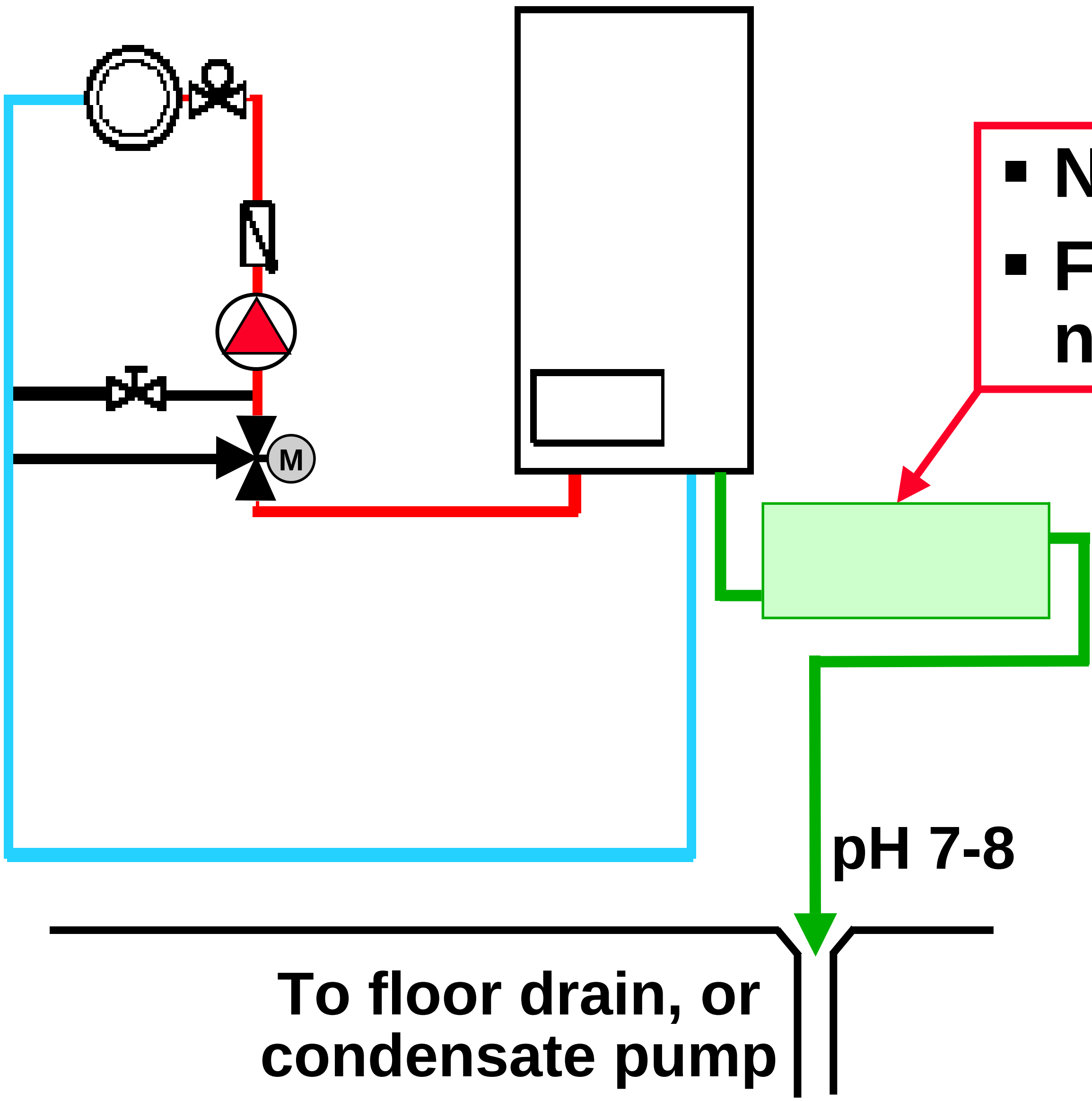


CONDENSATE DISPOSAL



- Plastic pipe (CPVC, ABS, PEX) sloped towards drain
- NO Copper!
- P trap required

CONDENSATE NEUTRALIZATION



- Neutralization unit
- Filled with granular neutralizing material

CONSTRUCTIVE AND PHYSICAL REQUIREMENTS FOR CONDENSING BOILERS

- Combustion with minimal excess air (high CO_2)
- Fully modulating burner
- Low heat exchanger surface temperatures
- Parallel flow of flue gas and condensate
- Counter-flow of flue gas and heating water
- Highly corrosion resistant material

SYSTEM DESIGN REQUIREMENTS FOR CONDENSING BOILERS

- **Low temperature heat release surfaces**
- **Modulate water temperatures with outdoor reset controls**
- **Higher system water temperature drops**
- **Piping layouts to reduce boiler return water temperatures**

CONDENSING BOILER TECHNOLOGY

THANK-YOU

Jim Cooke

Mechanical Solutions NW

1125 Andover Park W. Bldg. D

Seattle, WA 98188

E-mail: jim@msinw.com