What we do

- Program Design and Delivery
- Lending Center
- Engineering Services
- Innovation Exchange
  - Research
  - Education and Outreach
- Public Policy
How Condensing Boilers Outperform Conventional Boilers

• Conventional Boilers
  • All “steam” goes out the vent
  • Safety factor to prevent condensation limits efficiency

• Condensing Boilers
  • A portion of the steam is used for heating
  • No safety factor
Condensing Efficiency “Boost”

- 1 pound captured steam can heat 50 pounds of water
Condensing Boiler Efficiency Improvement

- Conventional Boiler
- Condensing--Minimum
- Condensing--Ideal
- Condensing--Your Building

If condensate drain dry after running

80% 85% 90% 95% 100%

Centers for Energy and Environment
Getting The “Rated” Efficiency Boost Out of Condensing Boilers (>90% Efficiency)
Chart for Showing Moisture in Air Issues

- Curve at top shows when “Air” can’t hold any more moisture (aka dewpoint or saturated)

- Once at the top, cooling more condenses moisture out of air
Applying Condensing Boilers vs Furnaces

![Graph showing efficiency vs entering water/air temperature]

- Efficiency:
  - 100%
  - 95%
  - 90%
  - 85%
  - 80%
  - 75%

- Entering Water/Air Temperature:
  - 60°F
  - 80°F
  - 100°F
  - 120°F
  - 140°F
  - 160°F
  - 180°F
  - 200°F
Applying Condensing Boilers vs Furnaces

Efficiency vs Entering Water/Air Temperature

- 60°F
- 110°F
- 160°F

- 75%
- 80%
- 85%
- 90%
- 95%
- 100%
Applying Condensing Boilers vs Furnaces
3 Rules for “Energy Value” of Condensing Boiler System

1) Low Return Water Temperature!
2) Low Return Water Temperature!
3) Low Return Water Temperature!
Getting Heat from One Fluid to Another

- Heat naturally flows “Downhill” from hot to cold
  - The bigger the temperature difference, the faster the heat flows

- The bigger the area, the faster the heat flows
Getting Heat into a Space in a Building: “Typical” Central System

Gas, Coal or Oil
3,500 – 4,000°F

Avg Boiler Water  170°F

~350 to 400°F

Boiler

Radiator

Air Handler/VAV

Mixed or Cooled Air

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Mixed or Cooled Air
Central System Designed for Condensing Boiler

Gas at 3,500°F

Boiler Water 160°F Average

Radiators

Radiant Floor

Air Handler/VAV

Heated Air

Mixed or Cooled Air

Mix

Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec
System and Load Affects on Condensing Boiler Efficiency “Boost”

• Outdoor reset control
  • Lower return water temperature = condensing boiler efficiency improvement
  • Reduces load from overheating and pipe heat loss

• Lower flow (e.g. pump VSD & 2-way valves)
  • Pump energy savings
  • Low return water temperature = condensing boiler efficiency improvement
Outdoor Reset Lowers Water Temperature

As the heating load goes down, less temperature difference is needed to drive the heat flow.
Reducing Flow in Buildings

- Heat carried by water or air
  - Depends on temperature change (TD or $\Delta T$)
  - Depends on water or air flow rate
System Piping: Driving return water temperature down

- Avoid 3-way/4-way valves on main line
- Reduced flow brings down return temperature
- If mixed boilers – cold water & max load to condensing
Combined Outdoor Reset & VSD

- Traditional 20°F Drop
- 60°F Drop

Boiler Water 150°F Average

Space 75°F
Reducing Flow & Return Temp: 
3-Way Valves
Reducing Flow & Return Temp: 2-Way Valves

- Lower Temperature
- Lower Flow
Getting The “Rated” Efficiency Boost Out of Condensing Boilers (>90% Efficiency)
Service Hot Water: Driving Return Water

- Traditional coil-in tank requires high boiler temperatures
  - Efficiency > traditional water heaters
  - Efficiency sacrificed with condensing equipment
Key Design & Application Considerations: Preventing Problems

• General load & system issues
  • Ability to provide adequate heat w/low return temperatures
  • Ability to reduce flow rate w/out branch balance problems
  • 2-way valves on loads to replace 3-way valves

• Product-specific issues
  • Control coordination
  • Small water passages in old cast iron system
  • Pressure drop compatibility with system
  • Flow rate compatibility (short-cycling)
  • Dual temperature inlets
Key Design & Application Considerations: Preventing Problems (cont.)

- **Venting Considerations**
  - Design and installation details to deal with condensate
  - Sidewall venting can cause moisture problems with large boilers
  - Orphaned water heater
  - Vent cost key factor @bottom of hi-rise
Key for Condensing Boiler Efficiency: Driving Return Water Temperature Down

- ✔ Space heating elements
- ✔ System piping
- ✔ System control—pump
- ✔ System control—temperature
- ✔ Service hot water
Condensing Boiler Sensitivity to Excess Air

- Controlling excess air even more important
  - Excess air reduces concentration of water vapor
  - Dewpoint decreases
Traditional Factor of Burner “Excess Air”

Graph showing the relationship between boiler efficiency and entering water temperature with and without excess air. The graph indicates that increasing excess air by 20% shifts the curve downwards, affecting boiler efficiency.
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Project Overview: Condensing Boiler Optimization

• Market Study & Site Selection
• Monitoring & Analysis of 12 Building
  • 4 Education
  • 4 Multifamily
  • 4 Government/Office
• Industry Survey of CIP Program Options
• Dissemination
Minnesota’s Condensing Boiler Market: Preliminary Findings

• Condensing boilers have become the default choice
• Used in all building types that have space heating boilers
• Manufacturer’s reps acknowledge often suboptimal situations
• Part-load efficiency improvements may be significantly overstated in some cases
Water Temperatures: Outdoor Temperature When 130°F Reached

Preliminary Results
Water Temperatures:
Outdoor Temperature When 130°F Reached

Preliminary Results
Water Temperatures:
Outdoor Temperature When 130°F Reached

Preliminary Results
Excess Air Variations
In Conclusion…

• Condensing boilers can be a great, green investment
• Success depends on different approach by all
  • Minimize return water temperature!
    • Outdoor reset control
    • Reduce flow through building
    • Solve zone specific issues
  • Boiler tuning of air-fuel ratio is even more critical with condensing boilers
  • Control coordination must be well thought out & verified
Resources...

- High Efficiency Boiler Information
  - Air-Conditioning, Heating, and Refrigeration Institute (www.ahrinet.org)
  - EnergyStar.gov
  - California Energy Commission web site
  - Consortium for Energy Efficiency
  - CEE web site
THANK you!

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