

High Efficiency Condensing Boilers and Other Ways to Increase System Efficiency

Presented By
Brett Stueland
RM Cotton



Outline

- Boiler Efficiency Classifications
- Condensing Boilers
 - Efficiency
 - Turndown
 - Materials
 - Designs/Types
 - Venting
 - Maintenance/Commissioning
- Other Ways to Increase System Efficiency

Boiler Efficiency Classifications

- Standard Efficiency (80-85%)
 - Kewanee, Hurst, Unilux, Cleaver Brooks, Slant Fin, Ray Pak, Superior
 - Mid Efficiency (87-88%)
 - Thermal Solutions, Lochinvar
 - High Efficiency (90+%)
 - Aerco, Viessmann, Lochinvar
- NON - CONDENSING
- CONDENSING
-
- The diagram illustrates the classification of boilers based on their efficiency. It features a list of three efficiency categories on the left, each with a list of associated brands. On the right, two large curly braces group these categories. The top brace, labeled 'NON - CONDENSING', encompasses the 'Standard Efficiency (80-85%)' and 'Mid Efficiency (87-88%)' categories. The bottom brace, labeled 'CONDENSING', encompasses the 'High Efficiency (90+%)' category.

Boiler Comparison

	STD	MID	HIGH / CONDENSING
Efficiency	80-85%	87-88%	90+%
Min RWT	140°F	140°F	≤50°F
Fuels	Gas/Oil	Gas Only	Gas/Oil*
Physical Size	Large	Small	Small
Venting Type	Cat I or III	Cat I, II, III or IV	Cat IV
Venting Size	Med - Large	Med	Small
Longevity	40+ Yrs	10+ Yrs	20+ Yrs

* Does not condense when firing on oil.

Condensing Boilers

Condensing Boilers Considerations

- Condensing?
- Actual Efficiency
- Material Type
- Technology/Type
 - Firetube
 - Watertube
 - Sectional
- Venting
 - Material
 - Size
 - Max Length
 - Boiler Exhaust Location
- Physical Size
- Clearances
- Noise
- Serviceability
 - Access
 - Parts
 - Qty
 - Proprietary
- Operating Parameters
 - Flow Rates (Min/Max)
 - Min Return Water Temp
 - Max ΔT
 - Max Operating Pressure
- Fuels
 - Nat
 - LP
 - LP Air Mix
 - Nat & LP
 - Digester
 - (Nat or LP) & Oil
- Turndown
- Included Features/Controls
- Years in Service

Efficiency

UP TO **99%**
THERMAL EFFICIENCY

- **UP TO 99% EFFICIENCY**
AHRI Certified up to 97% Efficiency

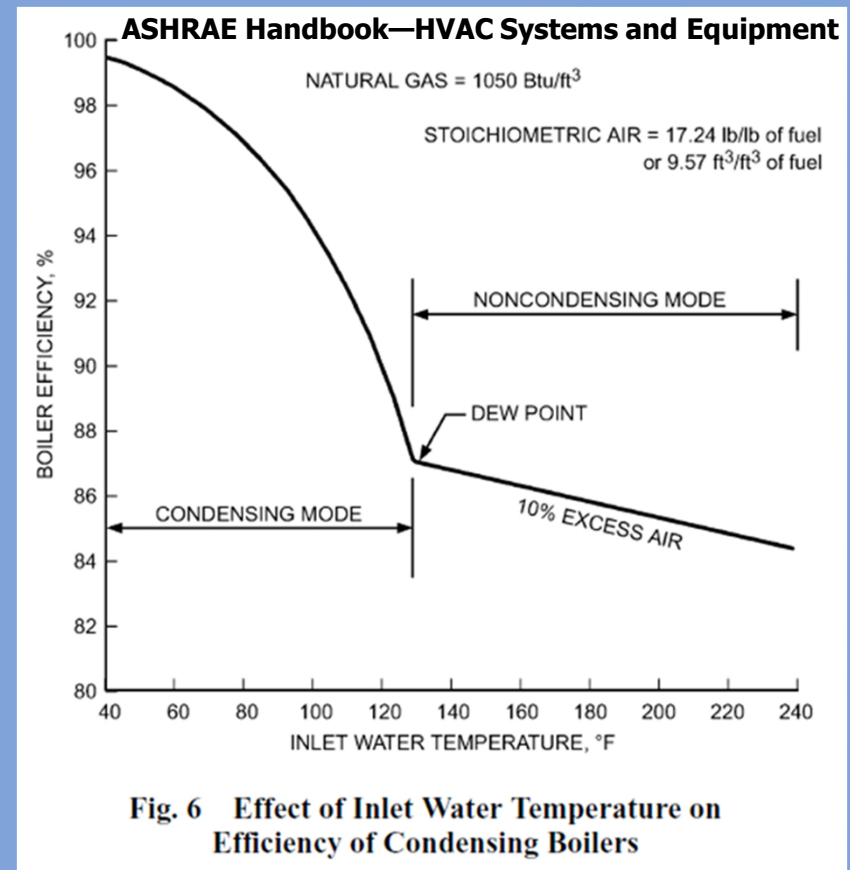
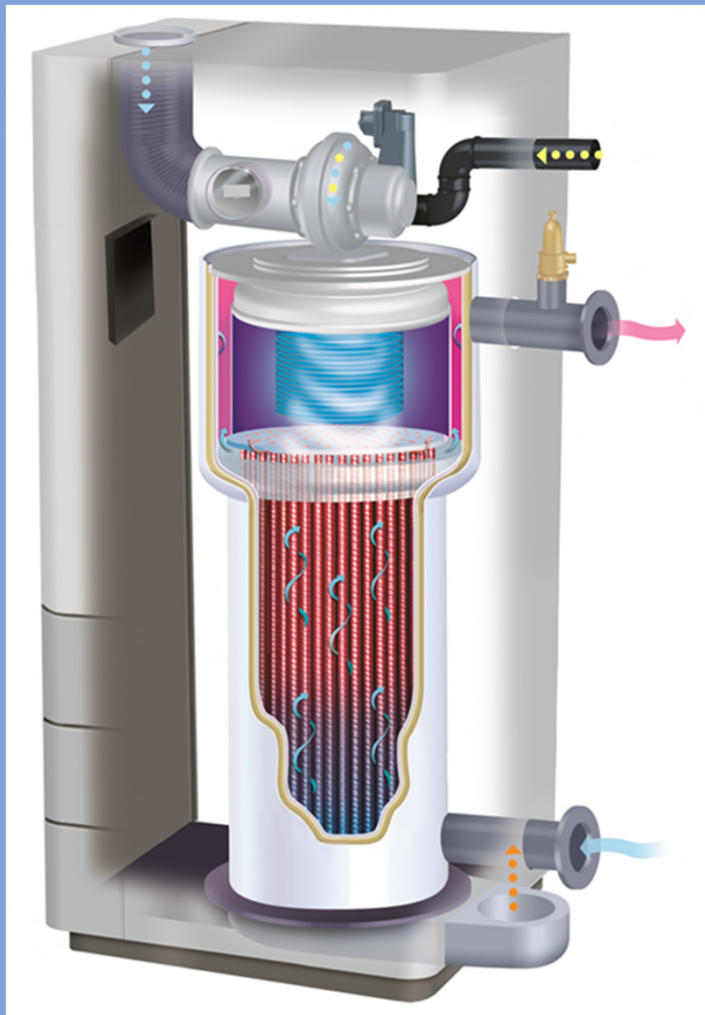
Once installed, boilers operate at up to 99% efficiency, while producing low NOx and CO₂.

FEATURES

- High Mass and Water Volume
- Low Cost of Ownership
- Low Electrical Consumption
- Rugged, Robust, Reliable
- **Ultra High Efficiencies**
- Simple Installation
- Minimal Maintenance Costs

UP TO **99%**
THERMAL EFFICIENCY

How a Condensing Boiler Works



Boiler Combustion Efficiency

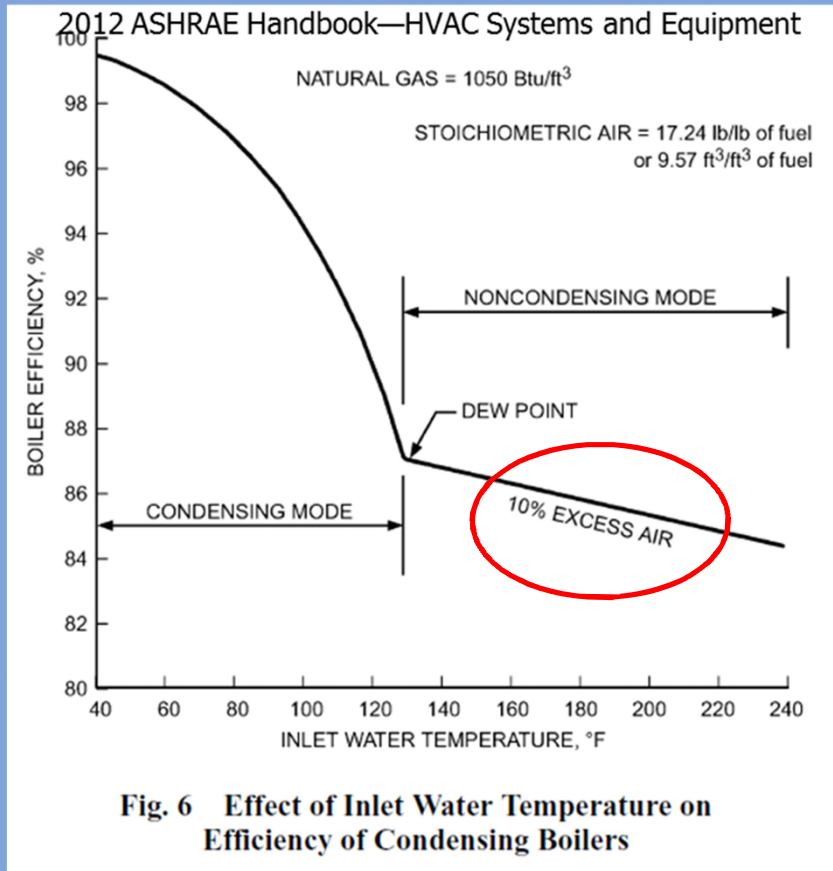


Fig. 6 Effect of Inlet Water Temperature on Efficiency of Condensing Boilers

O ₂	Excess Air	CO ₂	Dew Point
3%	13%	10.5%	134.2°F
4%	19%	10.0%	132°F
5%	25%	9.6%	130°F
6%	33%	8.9%	127°F
7%	42%	8.3%	124.5°F
8%	55%	7.7%	120.7°F
9%	69%	7.1%	117.8°F
10%	84%	6.5%	114.5°F
11%	105%	5.8%	110.9°F
12%	124%	5.2%	106.5°F
13%	149%	4.7%	103.5°F
14%	173%	4.2%	100.3°F
15%	210%	3.8%	97.9°F
16%	235%	3.1%	92.1°F
17%	265%	2.7%	88.3°F
18%	295%	2.0%	82.5°F
19%	325%	1.5%	77°F

Chart B – O₂ & Dew Point

AHRI Boiler Eff

- Tests all Boilers at same conditions
 - 80-180
 - High fire
- Most boilers are listed
- www.ahridirectory.org

AHRI Boiler Eff



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and Refrigeration Institute



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- > Boilers
- > Direct Heating Equipment
- > Furnaces

COMMERCIAL

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- > Automatic Commercial Ice-Cube Machines and Ice Storage Bins
- > Boilers
- > Central Station Air-Handling Units
- > Comm. Refrigerated Display Merchandisers And Storage Cabinets
- > Finned Tube
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- Verify Certificate
- AHRI Announces New Certification Mark; Implementation Schedule
- Find CEE Qualified Air Conditioning and Heat Pump Systems
- Find Standards | Learn more about Certification Programs
- List of Rerated Products following AHRI verification testing
- Listing of Products that have been Challenged through the AHRI Certification Program
- Find NATE-certified HVACR contractors

AHRI Boiler Eff

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Certified Reference Number	<input type="text"/>	Model Number	<input type="text"/>
Model Status	All <input type="button" value="v"/>	Manufacturer	Please Select a Manufacturer <input type="button" value="v"/>
Trade/Brand Name	Please Select a Trade/Brand Name <input type="button" value="v"/>	Fuel Type	Please Select a Fuel Type <input type="button" value="v"/>
Material	Please Select a Material <input type="button" value="v"/>	Input (MBTUH)	Min. <input type="text"/> Max. <input type="text"/>
Gross Output (MBTUH)	Min. <input type="text"/> Max. <input type="text"/>	Net Rating - Steam (MBTUH)	Min. <input type="text"/> Max. <input type="text"/>
Net Rating - Water (MBTUH)	Min. <input type="text"/> Max. <input type="text"/>	Combustion Efficiency	Min. <input type="text"/> Max. <input type="text"/>
Thermal Efficiency	Min. <input type="text"/> Max. <input type="text"/>	Heating Medium	Please Select a Heating Medium <input type="button" value="v"/>
Draft Type	Please Select a Draft Type <input type="button" value="v"/>	Ignition Type	Please Select <input type="button" value="v"/>
Location	<input type="radio"/> Outdoor <input type="radio"/> Indoor <input checked="" type="radio"/> No Preference	Sold In USA?	<input type="radio"/> Yes <input type="radio"/> No <input checked="" type="radio"/> No Preference
Electro-Mechanical Vent Damper(s)	<input type="radio"/> Yes <input type="radio"/> No <input checked="" type="radio"/> No Preference	Condensing?	<input type="radio"/> Yes <input type="radio"/> No <input checked="" type="radio"/> No Preference
Control	Please Select a Control <input type="button" value="v"/>		



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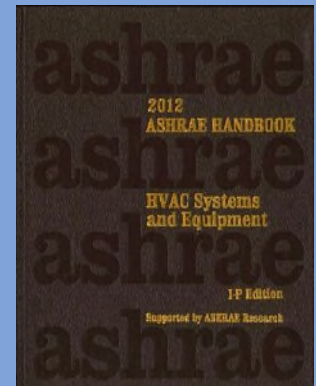
AHRI Boiler Eff

									AHRI Certified Ratings	
Trade/Brand Name	Manufacturer	Model Number	Material	Location	Fuel Type	Heating Medium	Input (MBTUH)	Gross Output (MBTUH)	Combustion Efficiency (%)	Thermal Efficiency (%)
AERCO	AERCO INTERNATIONAL, INC.	BMK 1000	Stainless Steel	Indoor	Natural Gas	Water	1000.0	968	96.8	96.8
AERCO	AERCO INTERNATIONAL, INC.	BMK 1500	Stainless Steel	Indoor	Natural Gas	Water	1500.0	1419	95.1	94.6
AERCO	AERCO INTERNATIONAL, INC.	BMK 2000	Stainless Steel	Indoor	Natural Gas	Water	2000.0	1892	95.1	94.6
AERCO	AERCO INTERNATIONAL, INC.	BMK 2500	Stainless Steel	Indoor	Natural Gas	Water	2500.0	2337	94.0	93.5
AERCO	AERCO INTERNATIONAL, INC.	BMK 3.0 LN	Stainless Steel	Indoor	Natural Gas	Water	3000.0	2856	95.2	93.9
AERCO	AERCO INTERNATIONAL, INC.	BMK 3000	Stainless Steel	Indoor	Natural Gas	Water	3000.0	2805	94.0	93.5
AERCO	AERCO INTERNATIONAL, INC.	BMK 6000	Stainless Steel	Indoor	Natural Gas, Propane Gas	Water	6000.0	5670	95.0	94.5
AERCO	AERCO INTERNATIONAL, INC.	BMK 750	Stainless Steel	Indoor	Natural Gas	Water	750.0	721	96.2	95.6

Turndown

- Excerpts:

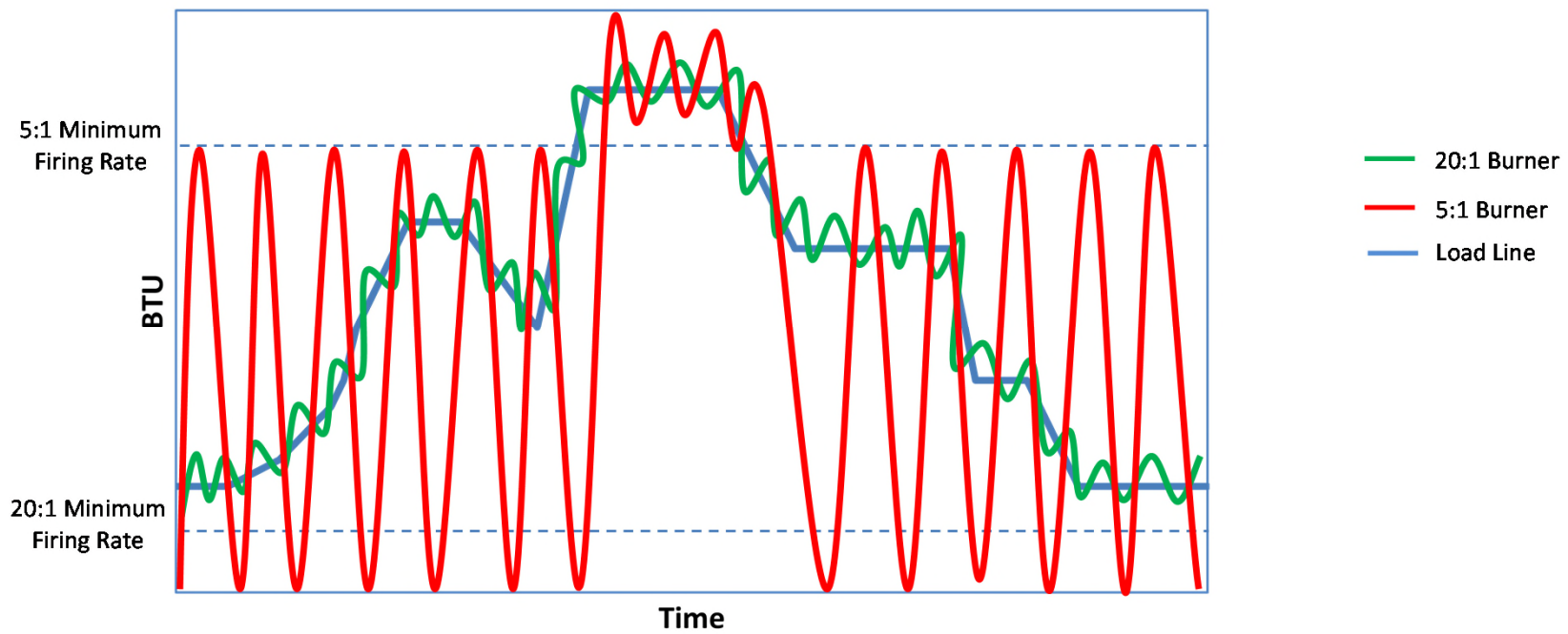
- *"The turndown ratio has a significant effect on system performance; lack of consideration of the source system's part-load capability has been responsible for many systems that either do not function properly or do so at the expense of excess energy consumption."* – 2012 ASHRAE Handbook
- *"A higher turndown ratio reduces burner starts, provides better load control, saves wear and tear on the burner, reduces refractory wear, reduces purge-air requirements, and provides fuel savings"* – US Department of Energy, Upgrade Boilers with Energy-Efficient Burners



Turndown

- Ratio = Max Firing Rate / Min Firing Rate
- Example 1:
 - 2000MBH Boiler
 - Minimum Firing Rate 100MBH
 - TURNDOWN = 20:1 (2000/100)
- Example 2:
 - 2000MBH Boiler
 - Minimum Firing Rate 400MBH
 - TURNDOWN = 5:1 (2000/400)

Turndown

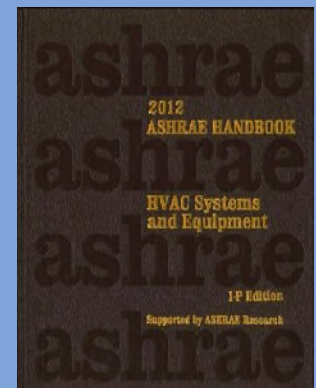


Material

- Stainless Steel (300/400 Series or Duplex)
- Aluminum
- Copper with External SS or Coated Heat Exchanger
- Carbon Steel & Duplex Stainless Steel
- Carbon Steel & Corten
- Cast Iron

Material

- Excerpts taken from 2012 ASHRAE Handbook: HVAC Systems and Equipment
 - *"Condensing boilers are typically made of stainless steel or aluminum because copper, cast iron and carbon steel will corrode because of acidic condensation"*
 - *"For maximum reliability and durability over the extended product life, condensing boilers should be constructed from corrosion resistant materials throughout the fireside combustion chamber and heat exchangers."*



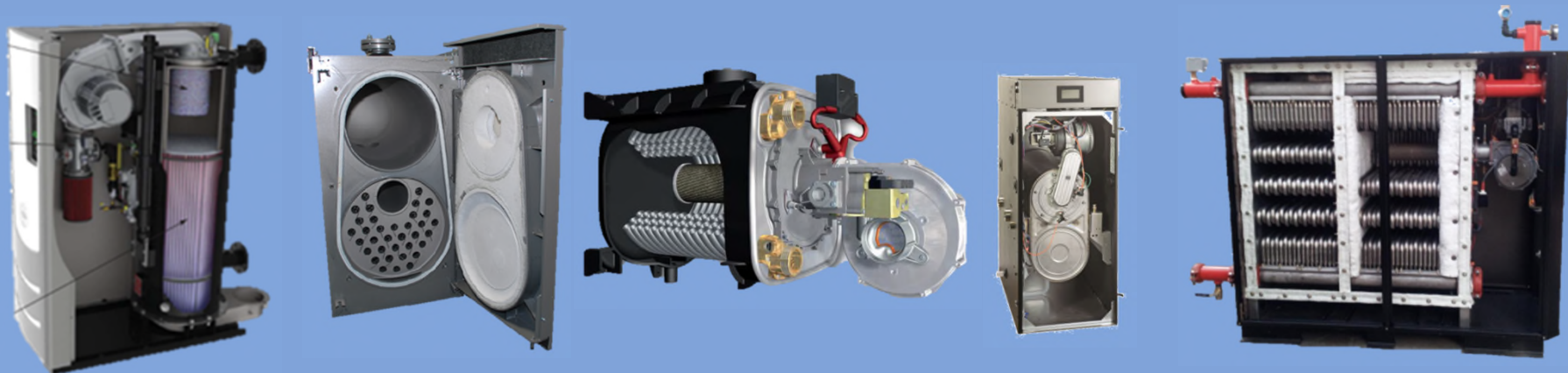
Material

- Stainless Steel (300/400 Series or Duplex)
- Aluminum
- Copper with External SS or Coated Heat Exchanger
- Carbon Steel & Duplex Stainless Steel
- Carbon Steel & Corten
- Cast Iron

Material

■ Stainless Steel

Austenitic 304/316	Ferritic 430, 439	Duplex 2205
Moderately Strong	Moderately Strong	Very Strong
Excellent Ductility, Toughness & Weldability	Moderately Ductile, Limited Toughness & Weldability	Good toughness, Ductility & Weldability
Corrosion Resistant	Corrosion Resistant	Corrosion Resistant
Susceptible to Stress Corrosion Cracking	Virtually Immune to Stress Corrosion Cracking	Resistant to Stress Corrosion Cracking
Expensive	Cost Effective	Cost Effective
High Thermal Expansion	Lower Thermal Expansion	Intermediate Thermal Expansion
Low Thermal Conductivity	Higher Thermal Conductivity	Intermediate Thermal Conductivity



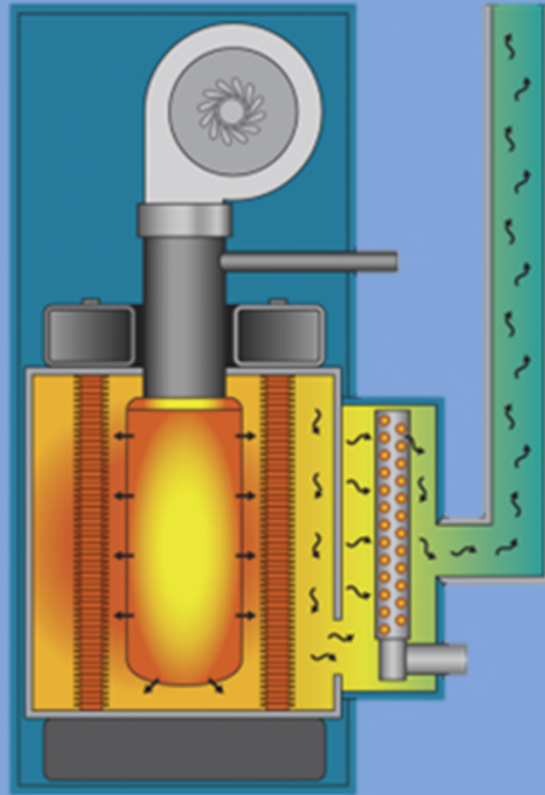
Material

- Aluminum
 - Must Use Proper Glycol
 - Must maintain PH Level



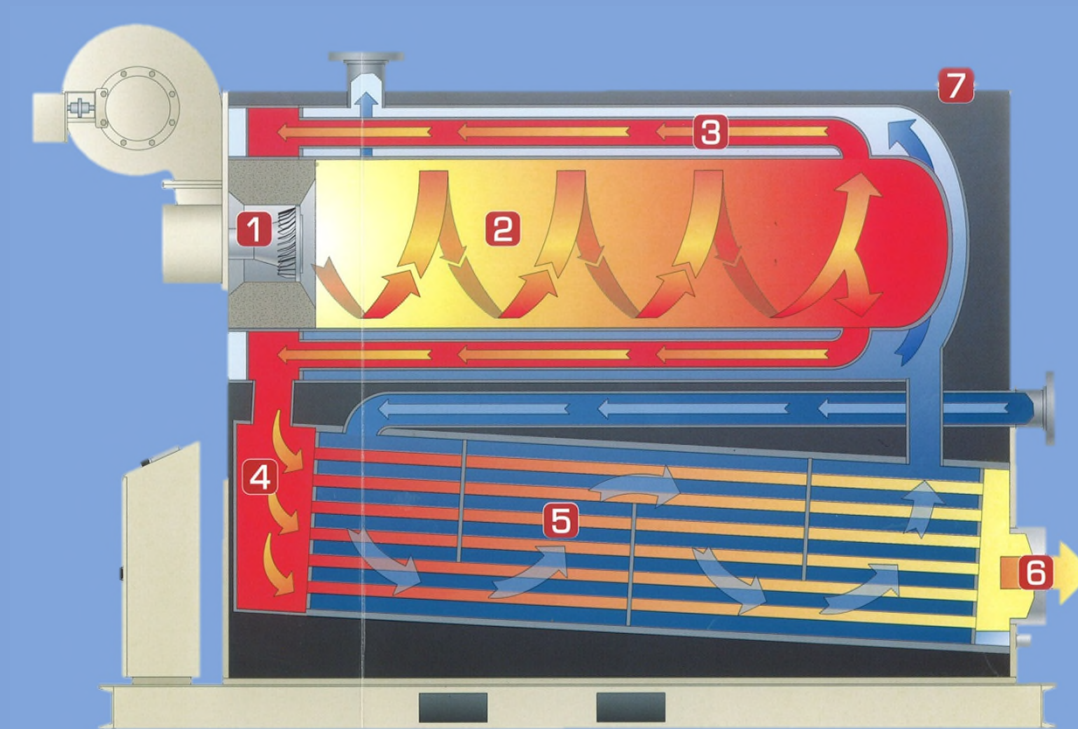
Material

- Copper with External SS Heat Exchanger



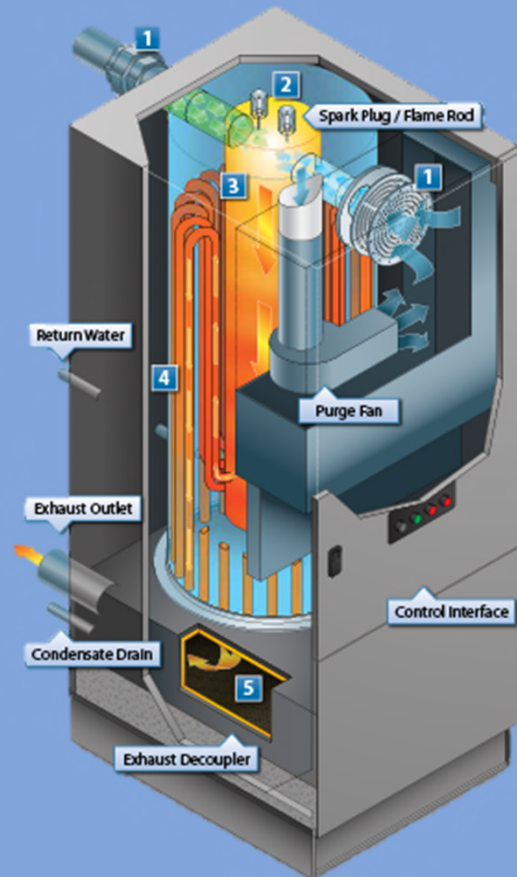
Material

- Carbon Steel with Duplex



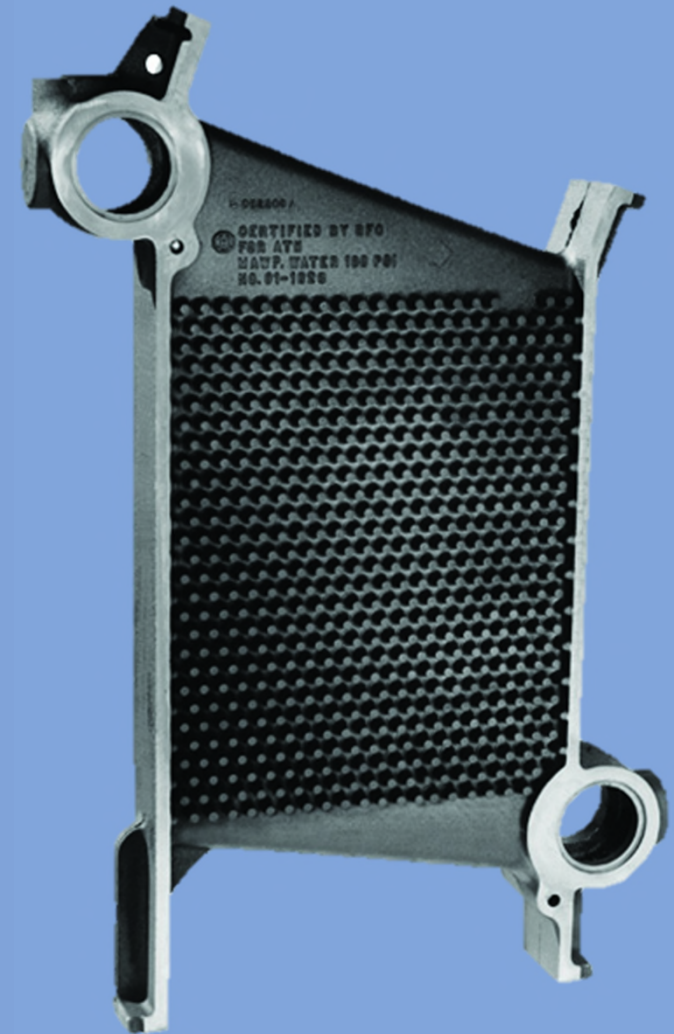
Material

- Carbon Steel with CorTen



Material

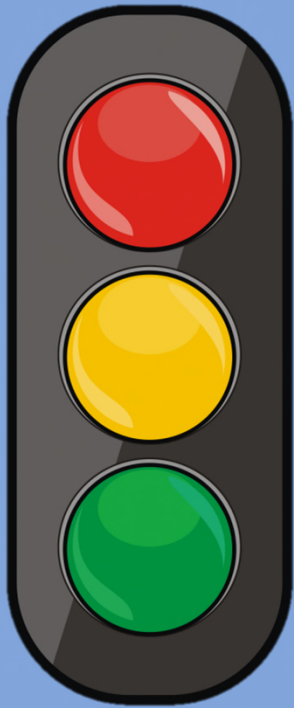
- Cast Iron



Condensing Boiler Types

- Firetube
- Watertube
- Sectionals

Condensing Boiler Types



NOT SO GOOD

MEDIOCRE

GREAT

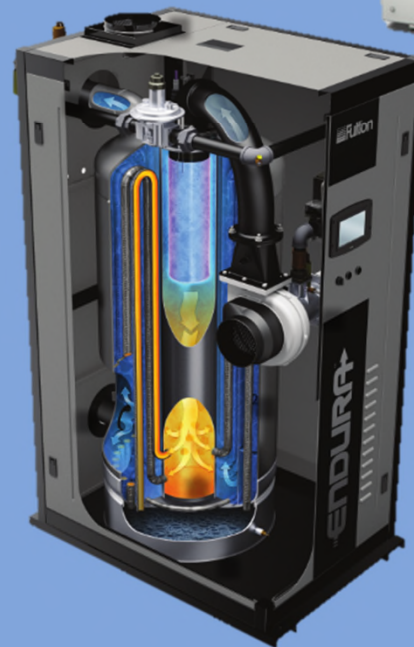
Condensing Boiler Types

Technology Comparison

	Firetube	Watertube	Flexible Watertube	Sectionals
Water Volume	Medium to High	Low	Medium	Low to Medium
Flow Requirements	Less Stringent	Very Stringent	Less Stringent	Varies
Piping Requirements	Any	Primary/Secondary Only	Any	Varies
Fuels Available	Natural, Propane, Oil, Methane or Combination	Natural or Propane	Natural or Propane	Natural or Propane
Fireside Cleanability	Easy	Moderate	Moderate	Hard
Waterside Scale Issues	Low	High	Moderate	Moderate
Easy Field Repairable HE	NO	NO	YES	Moderate

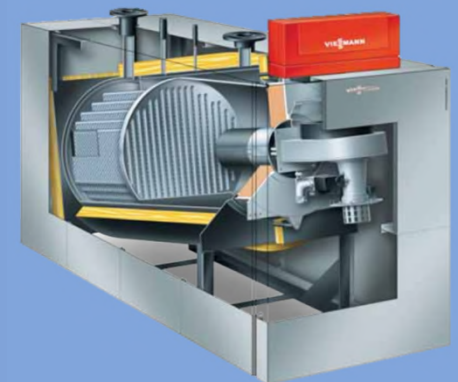
Condensing Boiler Designs

- Firetube - Vertical



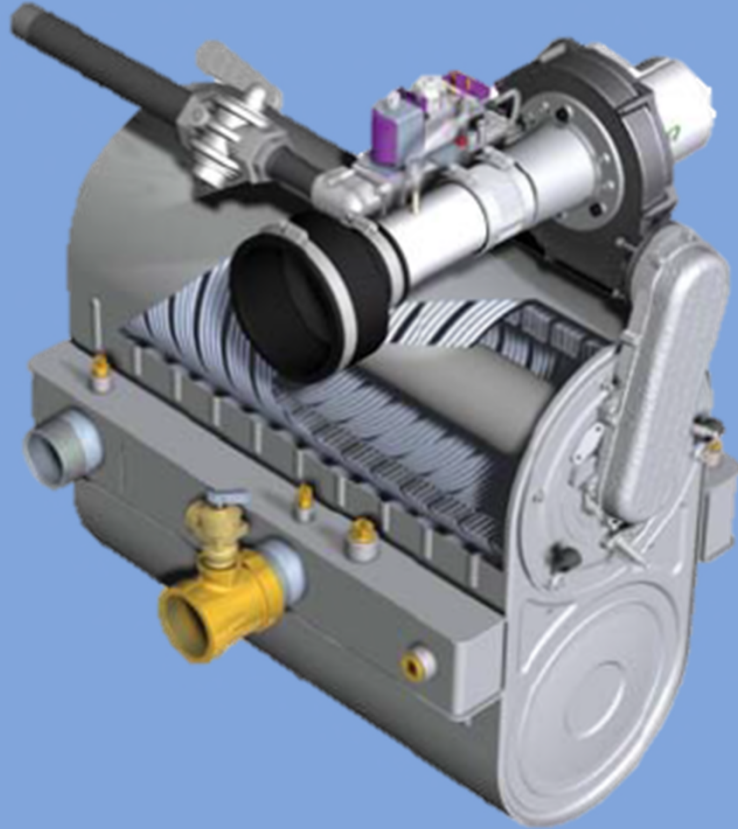
Condensing Boiler Designs

- Firetube - Horizontal



Condensing Boiler Designs

- Watertube – Stainless Steel



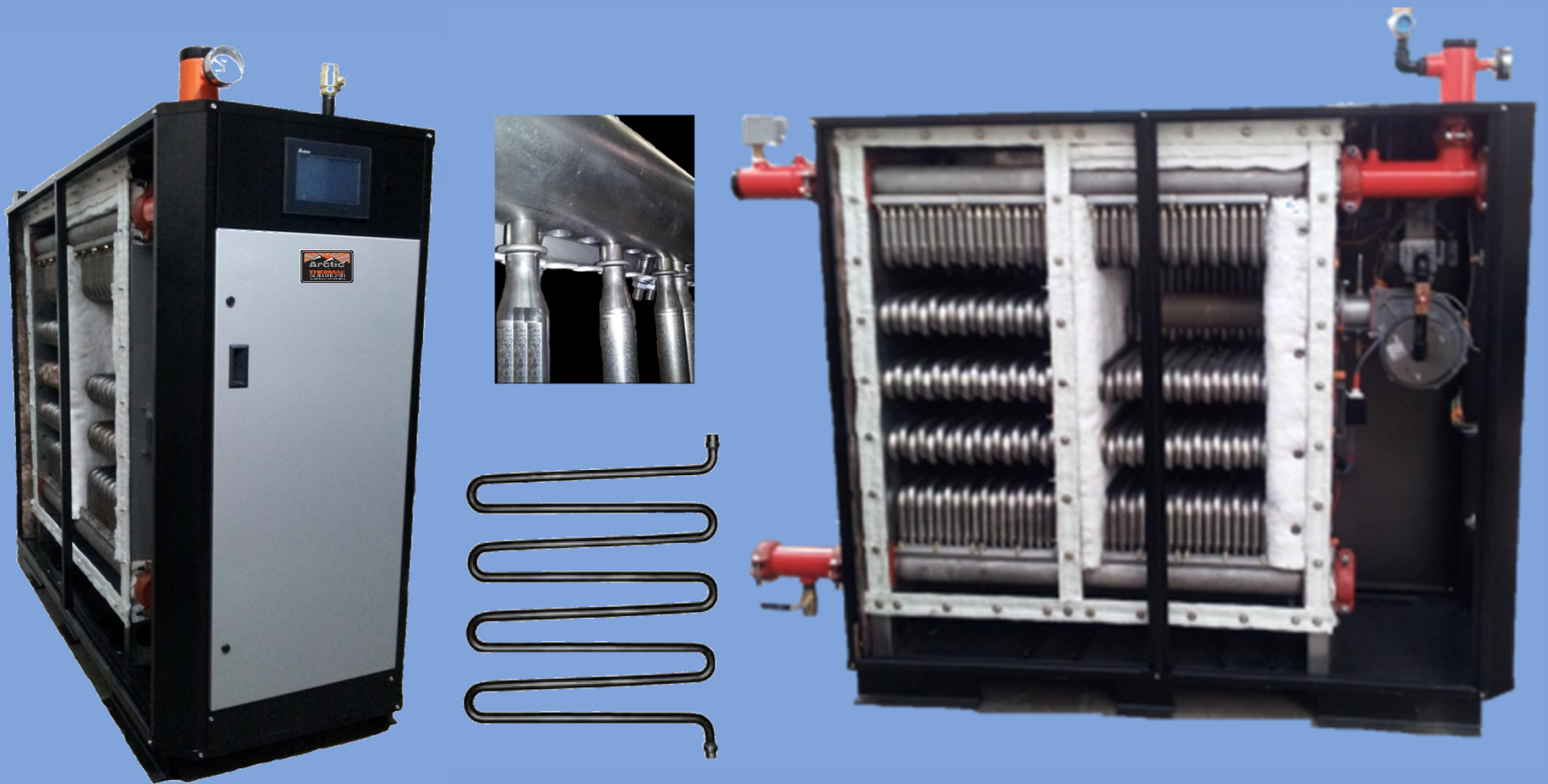
Condensing Boiler Designs

- Watertube – Stainless Steel



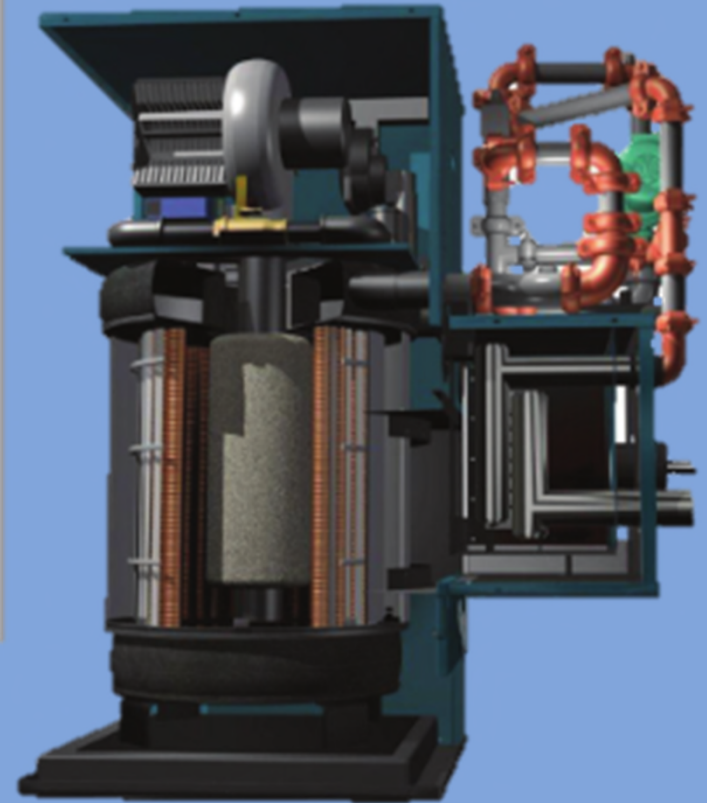
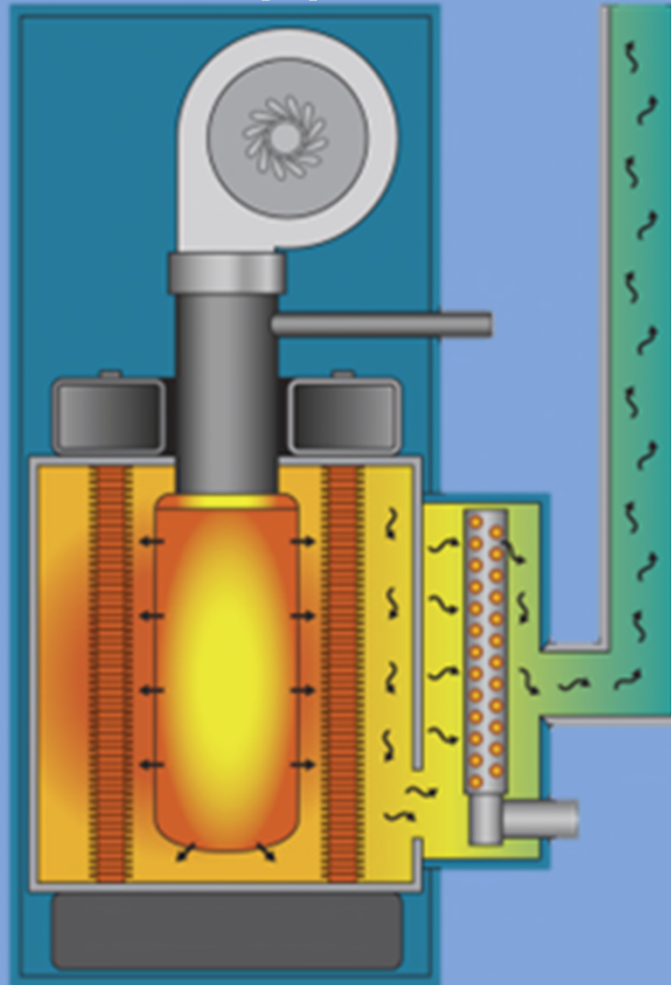
Condensing Boiler Designs

- Watertube (Flexible) – Stainless Steel



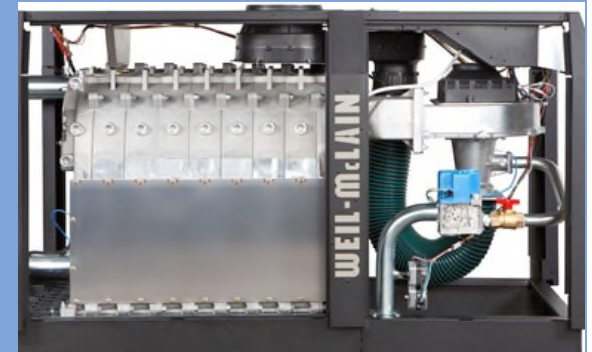
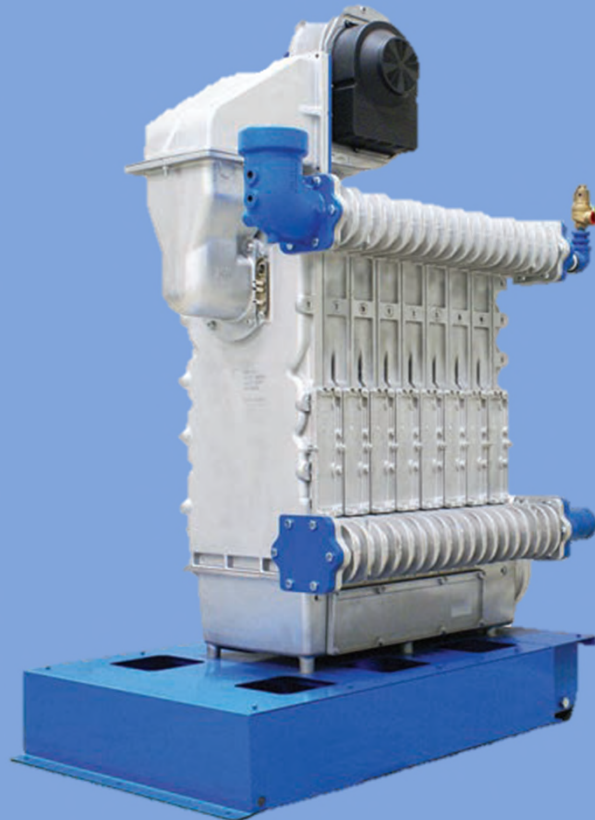
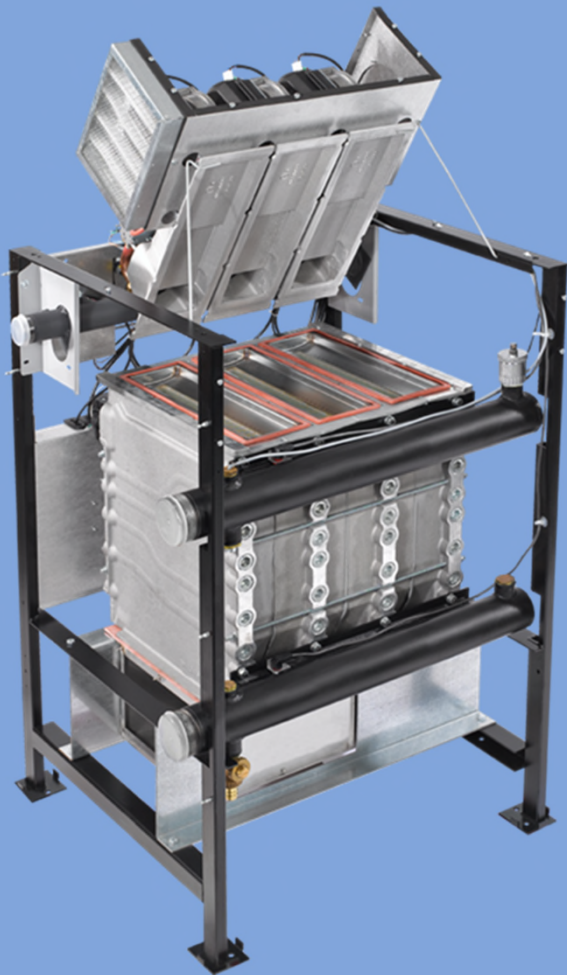
Condensing Boiler Designs

- Watertube – Copperfin Tube



Condensing Boiler Designs

- Cast Aluminum Sectional



Condensing Boiler Designs

- Cast Iron Sectional



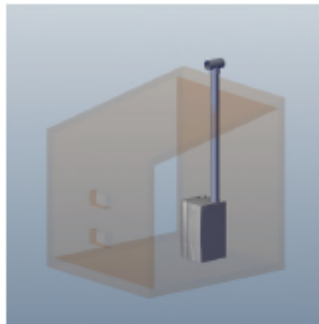
Venting for Condensing Boilers

- Multiple Configurations

Vent Configurations



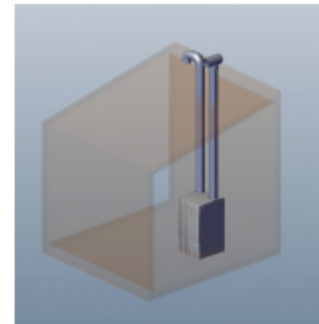
Single sidewall vent room air



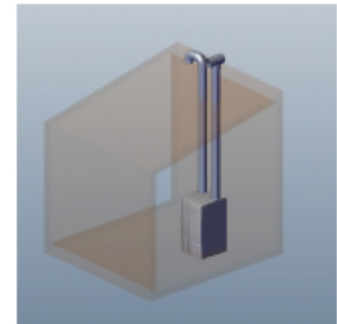
Single makeup air



Single sidewall



Single vertical vent



Single Vertical-Concentric Vent



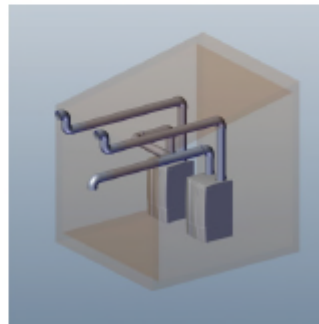
Sidewall Concentric Vent



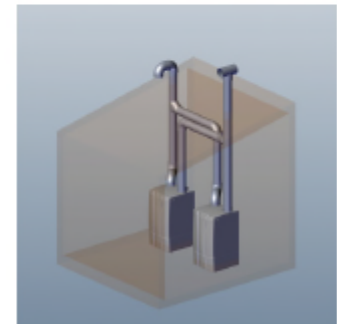
Multi sidewall vent room air



Multi makeup air



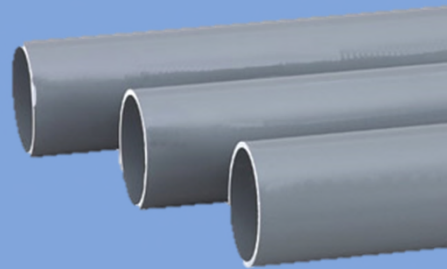
Multi sidewall



Multi vertical vent

Venting

- Venting
 - AL29-4C
 - Polypropylene
 - CPVC
 - PVC



Maintenance / Commissioning

■ Tune Ups / Maintenance

Section	Item	6 Mos.	12 Mos.	24 Mos.	Labor Time
7.2	Igniter-Injector Kit (58023)	*Inspect	Inspect	Replace	15 mins.
7.3	Flame Detector Kit (24356-1)	*Inspect	Inspect	Replace	15 mins.
7.4	Lean O ₂ Sensor (61026)	*Inspect	Inspect		15 mins.
7.5	Combustion Calibration	*Check	Check		1 hr.
7.6	Testing of Safety Devices		See ASME CSD-1 Chart		45 mins.
7.7	Burner			Inspect	2 hrs.
7.8	Condensate Drain Trap	*Inspect	Inspect, Clean & Replace Gaskets	Inspect, Clean & Replace Gaskets	30 mins.
7.9	Air Filter (59139)		Clean	Replace	15 mins.

* Only performed after initial 6 month period after initial startup.

Maintenance / Commissioning

- Commissioning
 - Verify Proper Operation/Sequencing
 - Verify Flow
 - Use Warm Weather Setback



Controls

- Sequencing Boilers
 - Building Management System / Controls Contractor
 - Separate Boiler Sequencing Panel
 - Onboard Integrated Sequencing Controller

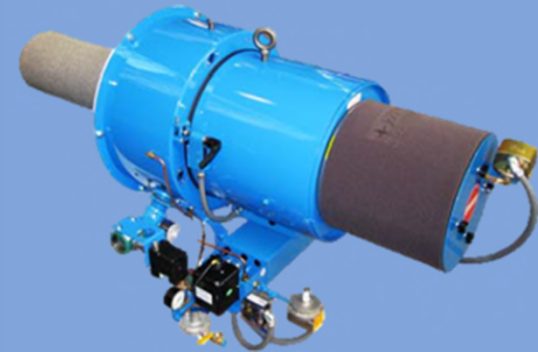


Other Ways to Increase System Efficiency

- Upgrade Burner
 - New Modulating
 - Add Linkageless Controls
 - Higher Burner/Boiler Turndown
- Install Coalescing Air Separator
- Install Stack Economizer
- Use Variable Flow Pumps
- New Boilers
 - Base Load
 - Modular
 - New Plant (Std, Mid or High Eff)

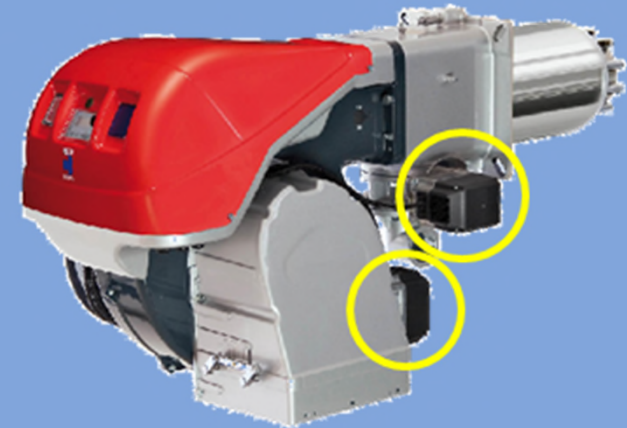
New Burner

- Higher Efficiency
- Modulation in lieu of On/Off or Low/High
- Higher Turndown
- Add Backup Fuel
- Reduce Capacity



Linkageless Controls

- Greater Accuracy
- Greater Efficiency
- 3-15% Fuel Savings
- Higher Turndown
- Less Service Time
- Less Down Time
- Independent Fuel Curves
- O₂ Trim Capable



Coalescing Air Separator

- Superior Air Removal
- Increases Efficiency
 - Increases Heat Transfer
 - Reduces Corrosion
 - Maintains Available Pump Head
- Reduces Maintenance Costs
 - Low Heat Calls
 - Air Bleeding
 - Equipment Corrosion Damage
 - Pump Cavitation Damage



Stack Economizers

- Recovers Wasted Stack Heat
- Steam Boilers – Preheat Boiler Feed Water
- Hot Water Boilers – Preheat Return Water
- Preheat Domestic Water



Variable Speed Pumps

- Reduces Energy Consumption



Base Loading

- Multiple Boiler System
- One smaller boiler handles majority of load
- Winter / High Demand - Use std fire tube / water tube boilers
- Summer / Low Demand - Use high efficiency condensing boilers
- Extend life of large boiler



Modular Systems

- Multiple Burner Turndown
 - 1 = 20:1
 - 2 = 40:1
 - 3 = 60:1
 - 4 = 80:1
 - 5 = 100:1



THANK YOU

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