# BOILER SELECTION

## Basic Terminology
## Definition
## Classifications
## Boiler Types

# BASIC TERMINOLOGY

British Thermal Unit (BTU)

## WHAT IS A BTU?

**A BTU is the amount heat energy needed to raise 1 lbs. of water 1° F**

# BASIC TERMINOLOGY

**Pounds Per Square Inch (PSI)**

**WHAT IS PSI?**

**A measurement of pressure.**

**Boiler pressure is measured in PSI.**

# BASIC TERMINOLOGY

**Input (MBH or CFH)**

**WHAT IS BOILER INPUT?**

**It is the gross amount of heat energy (btu's) being used by the boiler measured in MBH, CFH or GPH.**

**1 MBH = 1,000 btu./hr.**
**Natural Gas = 1,000 Btu / cu. ft.**
**LP Gas = 2,570 Btu / cu. ft.**
**#2 Fuel Oil = 140,000 Btu/gallon**

# BASIC TERMINOLOGY

**Boiler Horsepower (BHP)**

**WHAT IS BOILER HORSEPOWER?**

**Boiler Horsepower (BHP) is a measure of a boiler's capacity.**

**1 BHP = 33,472 btu./hr.**
**1 BHP = 34.5 #/hr. of steam (from & @ 212° F)**
**1 BHP = 9.8 KW**
**1 BHP = 139.5 sq. ft. E.D.R (Steam)**

# Definition

**WHAT IS A BOILER?**

**Boiler = energy converter / heat exchanger.**

**Converting energy from one form (Fuel – NG, LP, oil, electricity, bio-mass, etc.) to another form (steam or hot water).**

**OAC 4101:4-1-01 Definitions – "boiler" means a closed vessel in which water is heated, steam is generated, steam is superheated or any combination thereof, under pressure or vacuum for use externally to itself by the direct application of heat from the combustion of fuels or from electricity or nuclear energy.**

# Classifications

**BOILER CLASSIFICATIONS**

**Low Pressure:**
**Steam: Up to 15 PSIG & 250° F Design.**
**Hot Water: Up to 160 PSIG & 250° F Design.**
**ASME Code Section IV (Heating Boilers).**

**High Pressure:**
**Anything greater than the design conditions listed above.**
**ASME Code Section I (Power Boilers)**

# Boiler Types

**Steel Boilers**

- **Firetube Design – combustion gases on the inside of the tubes with water surrounding the outside of the tubes.**
- **Water tube Design – water is inside the tubes and combustion gases pass around the outside of the tubes.**

**Cast Iron Sectional**

**Electric**

**Condensing – hot water only, available in both firetube and water tube configurations**

# Boiler Types

## Firetube Boilers

### Scotch Marine

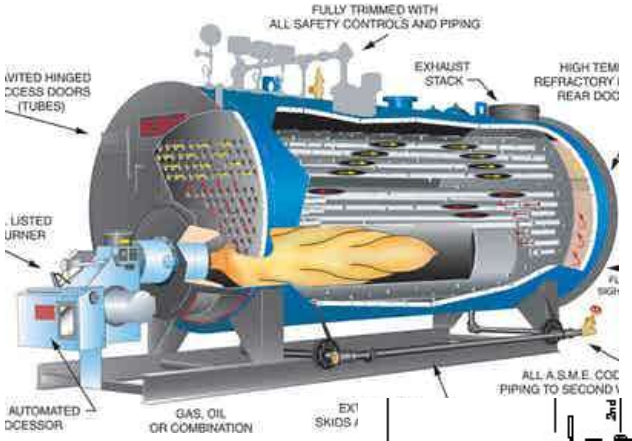
- 335 – 73,645 MBH (10 – 2200 BHP) or 345 PPH – 75,900 PPH
- Steam DP# - 15, 150, 200, 250, 300, 350, & 400 PSIG
- Water DP# - 30 to 100 PSIG at 250° F
- Wetback – Dryback construction
- Multi-pass designs.

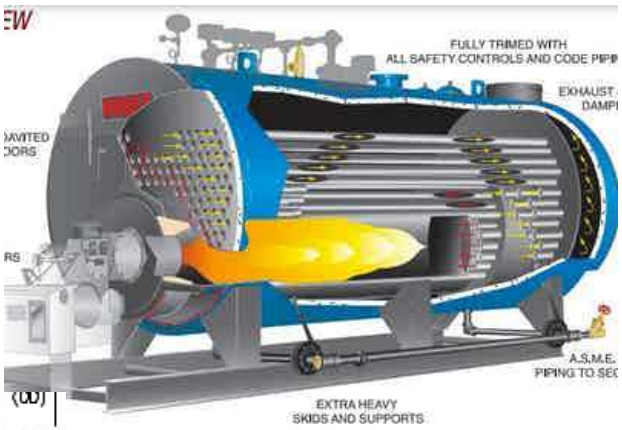
### Firebox

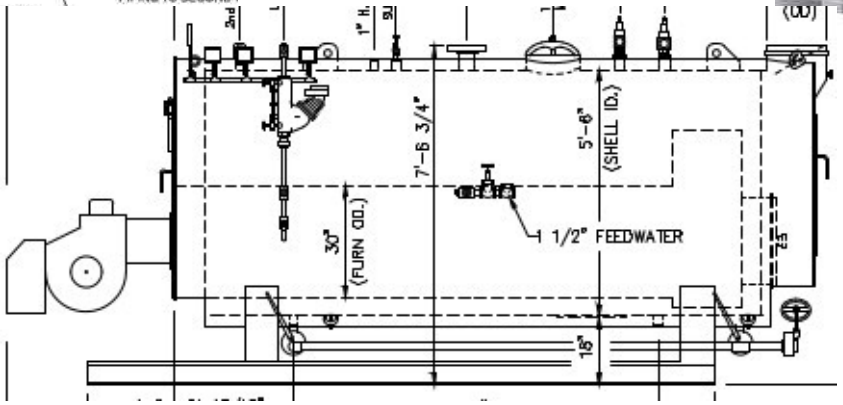
- 248 – 27,215 MBH (7.4 – 813 BHP) or 255 PPH – 28,000 PPH
- Steam DP# - 15 PSIG
- Water DP# - 30, 60, & 100 PSIG at 250° F
- Wetback 3 – pass construction.

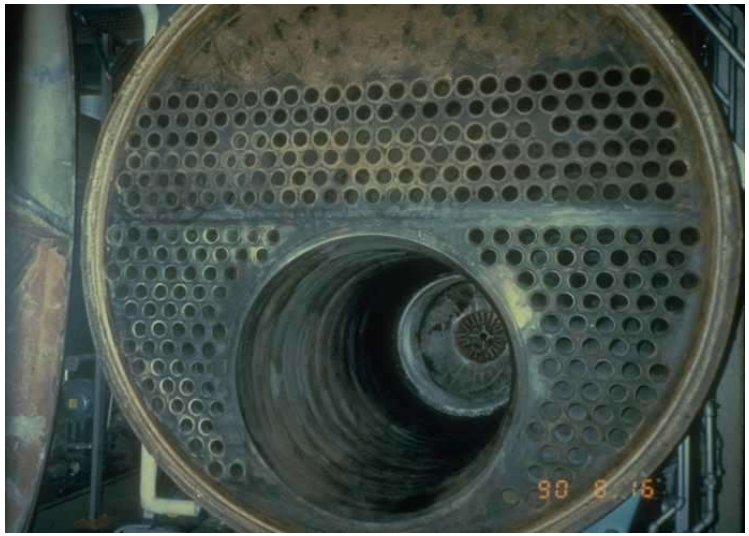
# Boiler Types

## Firetube Scotch Marine Hot Water & Steam Boilers

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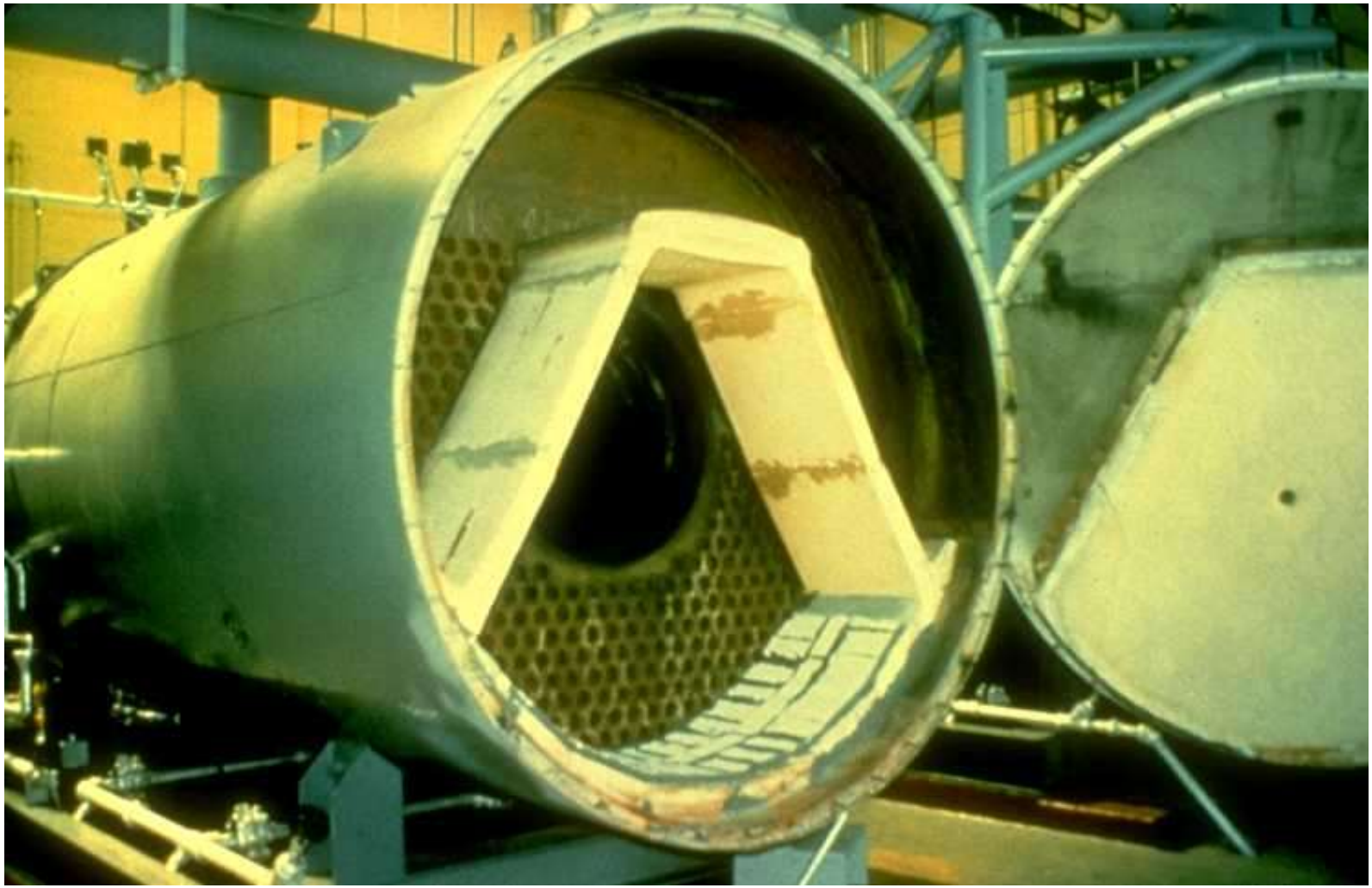


# Firetube Advantages

- **High Quality Steam**
- **Longevity**
- **Large storage volumes**
- **Multiple fuel options**
- **Replaceable Tubes (inexpensive)**
- **Decent efficiency especially when packaged with flue gas economizer**

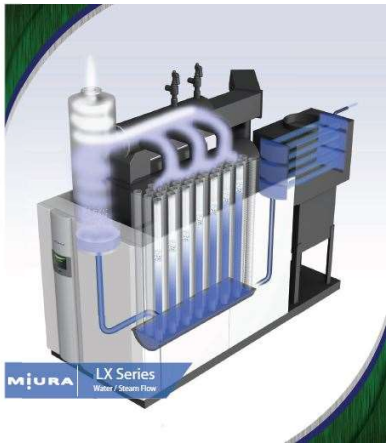
# Firetube Disadvantages

- Operating weight
- Footprint
- Space required for tube removal and cleaning
- Thermal shock potential
- Refractory maintenance cost (dryback designs)
- Inability to respond quickly to load changes
- Long time to steaming
- Water treatment required

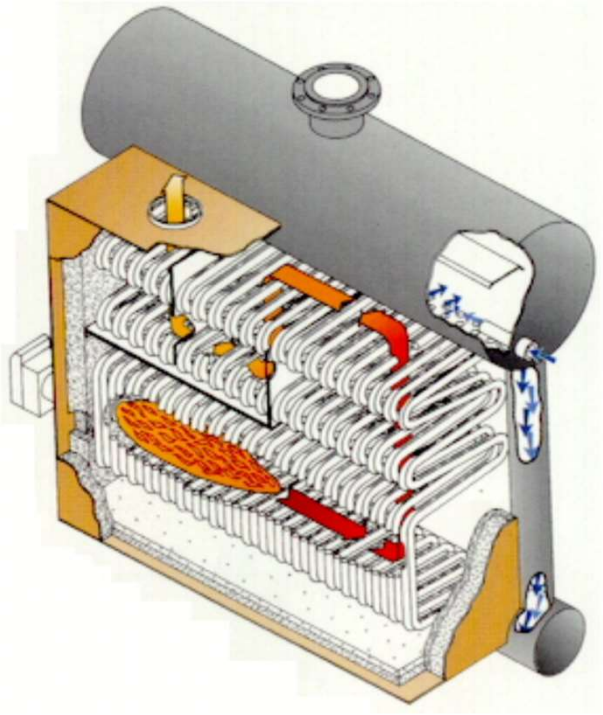
# Water Tube (Steel)
# Hot Water & Steam Boilers

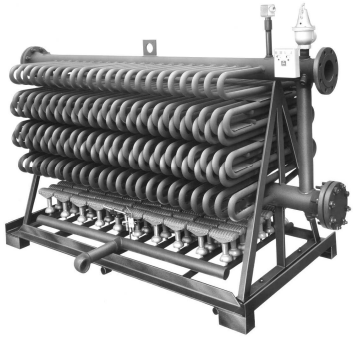
Commercial (Flextube)

Industrial (IWT)

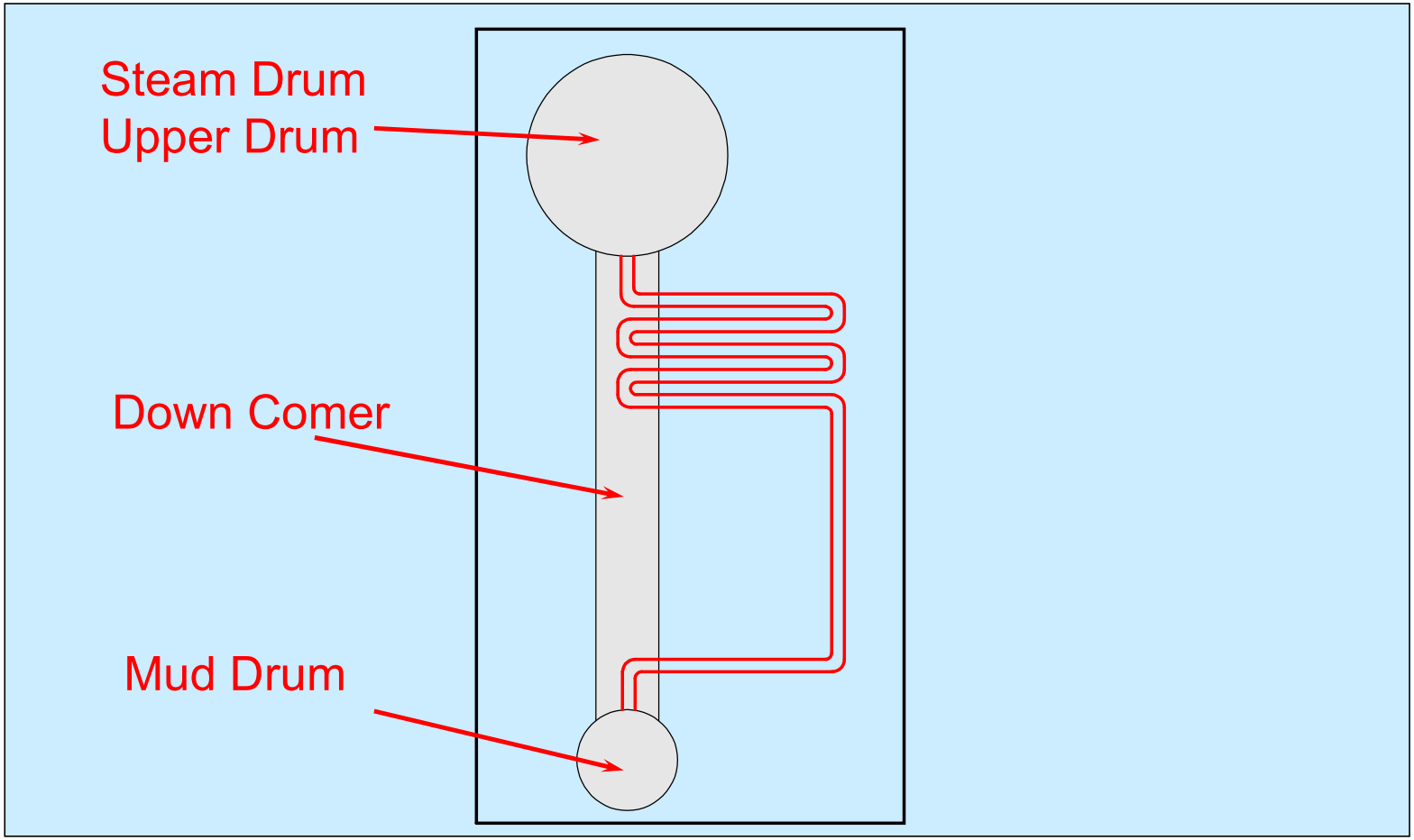


# Flex Tube (Bent Tube)
# Hot Water & Steam Boilers



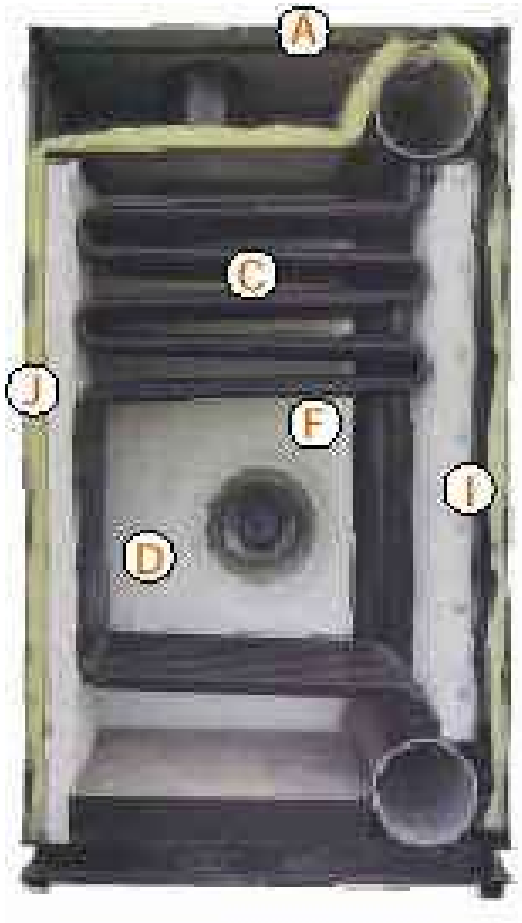


# Water Tube Boiler



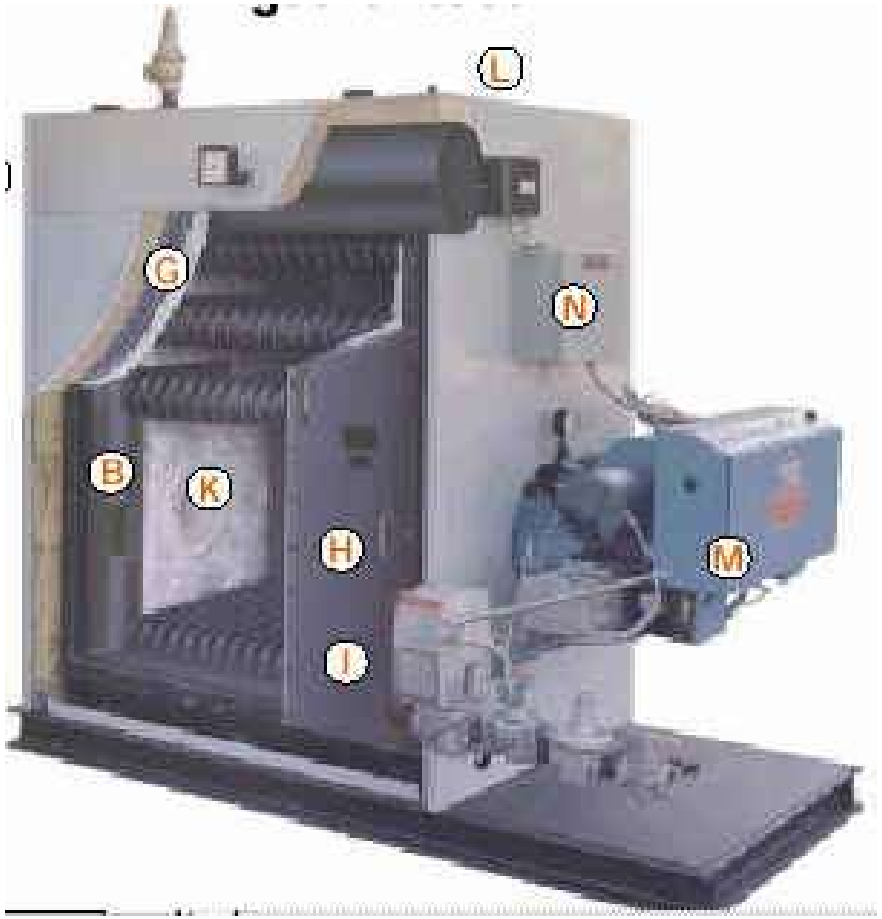
# Steel Watertube Boilers

Bent Watertube



# Steel Watertube Boilers

## Bent Watertube



# Steel Watertube Boilers Commercial

**Commercial:**

**Gross outputs from 70,000 to 21,000,000 BTUH.**
**Design pressure/temperature:**
**Steam: 15 PSIG or 150 PSIG is standard.**
**Water: Up to 160 PSIG at 250$^{o}$ F is standard.**

# Watertube Advantages

- Initial cost - Operating weight - Longevity - Large furnaces
- Factory packaged or field erected
- Gas, and oil firing
- Footprint
- Bent (flex) tube resistive to thermal shock
- Tube replacement is mechanical – no welding (some designs)
- Low water volume
- Reacts quickly to load swings

# Watertube Disadvantages

- Poor steam quality
- Limited capacity and pressures
- Water side pressure drop on some types
- If refractory is used, high maintenance cost
- Commercial construction

# Industrial Water Tube Boilers



# Steel Watertube Boilers
# Industrial

**Gross outputs:**

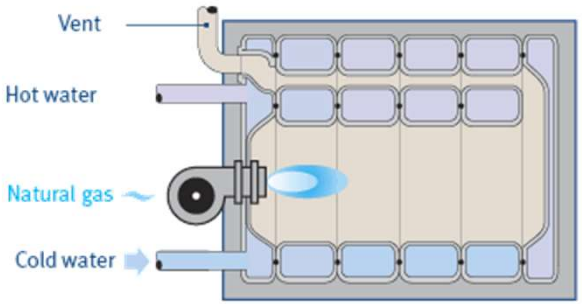
- **10,000 to 500,000 PPH packaged (modular) boilers**

**Design pressure/temperature:**

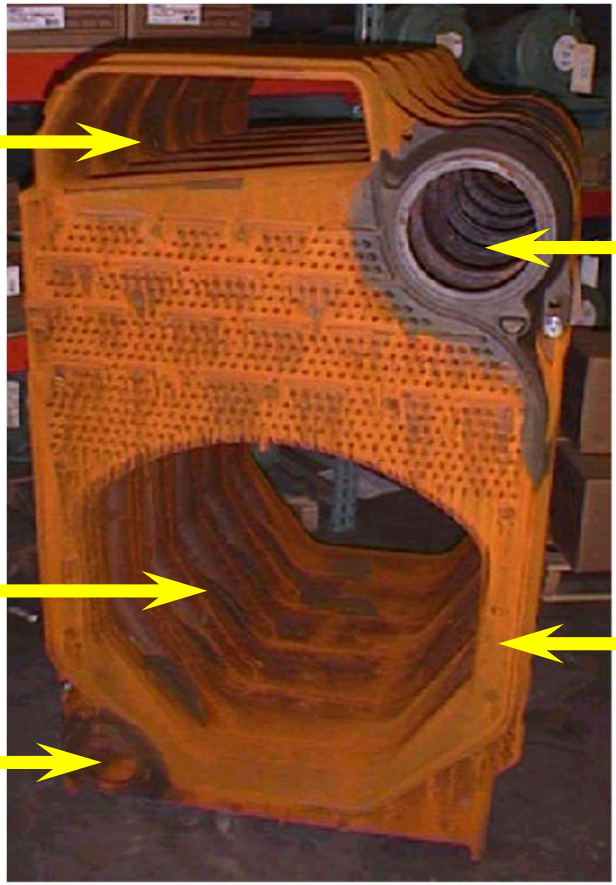
- **Steam: up to 2000 PSIG, Superheated 1000° F.**
- **Water/thermal fluid**
- **Waste Heat (HRSG)**
- **High Temperature Hot Water**

**“A” “O” & “D” Types**

# CAST-IRON Sectional
# Hot Water & L.P. Steam Boilers



# Cast Iron Section



Section Draw Rod

Furnace Side Smoke Seal

Sections can be added or deleted as size requirements change.

# Cast Iron Boilers

**Gross outputs from 50,000 to 5,000,000 BTUH.**

Design pressure/temperature: Steam: 15 PSIG/250$^{o}$ F
Water: 80 PSIG/250$^{o}$ F

## Advantages:

**Rugged durable construction – Longevity**

**Adequate storage volume - No refractories in most designs**

**Factory packaged or field assembled**

**Good efficiencies**

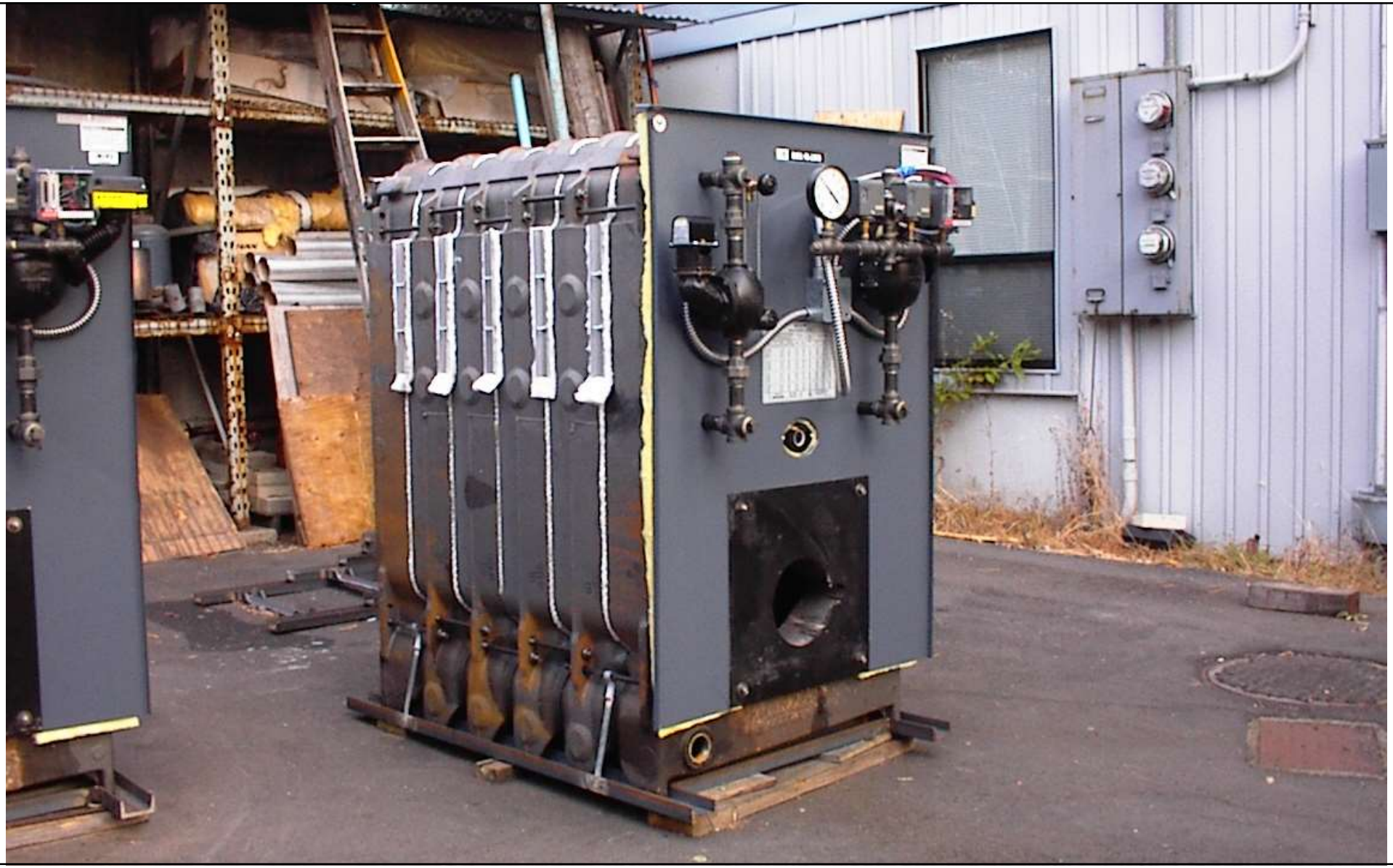
**Low maintenance cost**

**Typically short lead-time**

**Handles Oxygen corrosion well**

# Cast Iron Disadvantages

Operating weight.
Low design/operating pressures only.
(ASME section IV only)
Closed loop applications only.
(not recommended for process applications)
Susceptible to scale



# Electric Boilers
# Hot Water & Steam


# Electric Resistance Boilers

Voltages:

- 208-240 V
- 460/480 V
- 600 V

Steam or
Hot Water

Capacities:

15 – 3,600 KW

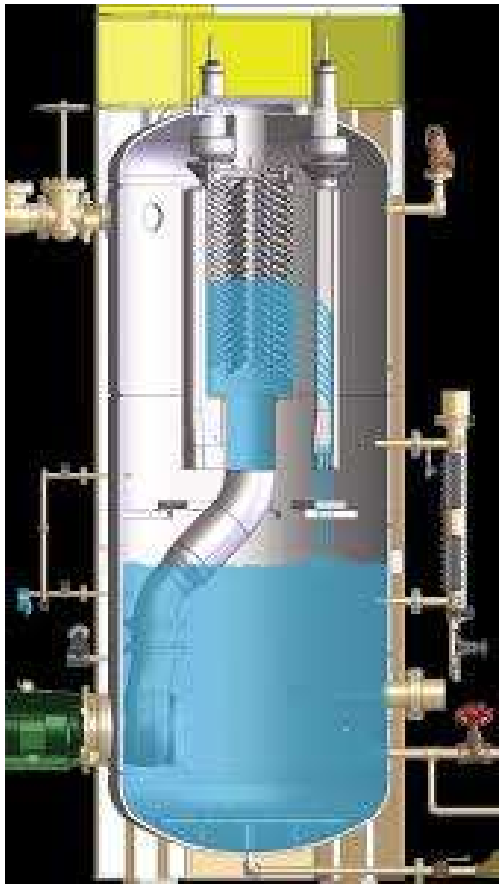
99% Efficiency

51 – 12,283 MBH

# High Voltage (Jet) Electrode Steam & Hot Water Boilers

Voltages:

- 4160 Volts
- 6.9 KV
- 13.8 KV



Capacities:

800 – 50,000 KW

# Electric Boilers

## Advantages:

Responds well to load swings

High steam quality

Very little to no damage in low water conditions (jet design)

Thermal shock is not an issue

Footprint

No Flue – no exhaust emissions

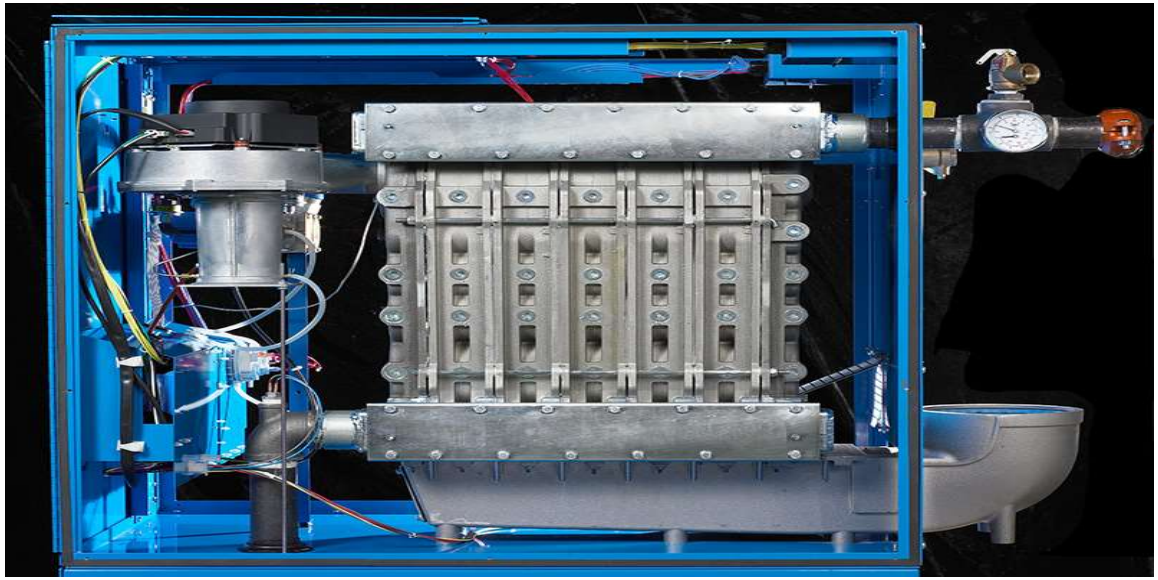
High steam pressure designs (900 PSIG)

## Disadvantages:

High cost of electricity

Amp service of the building

# COPPER WATER TUBE BOILER



# CAST ALUMINUM
# FULL CONDENSING

# Condensing Firetube Boiler


TM

# What Level is Considered High Efficiency

**Base Efficiency: 80 - 83%**

**Mid Efficiency: 84 - 85%**

**High Efficiency: 86% and up (condensing)**

**Condensing - operate at low water temperatures in order to achieve 90%+ efficiency.**

# OHIO SPECIAL LAW

Applies only to steam boilers (low & high pressure)

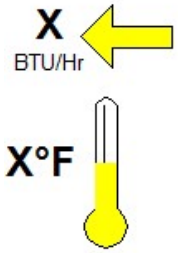
First introduced in 1900, enacted into law in 1904

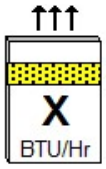
OAC 4101:4-10-01 Licensure and Attendance Requirements of Operators - states no person shall operate a LP steam boiler or a power steam boiler that has more than 360 sq. ft. of heating surface or a steam engine at more that 30 horsepower unless the person holds the required license or is working under the direct supervision of a person holding the required license.

# What is the Boiler Trying to do?

- Tries to match Boiler Input with BTU  Heat Loss.

- Input BTUs into a system at the same rate they are being lost.



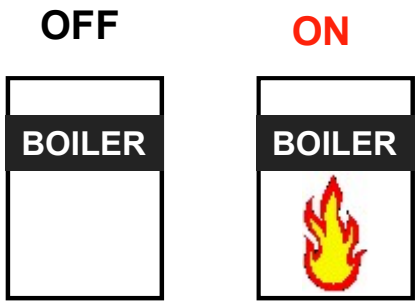

BOILER

# Condensing Boiler Sizing

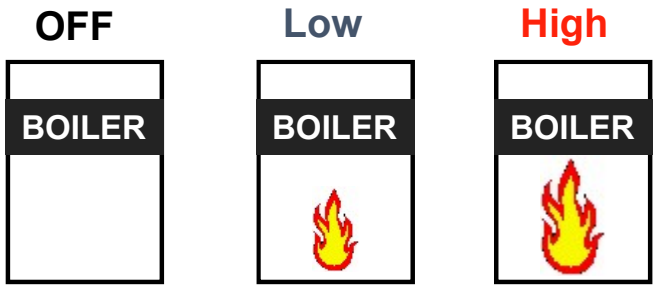
| BOILER RATINGS | SC-650 SCD-650 | SC-750 SCD-750 | SC-850 SCD-850 | SC-1000 SCD-1000 | SC-1500 | SC-2000 | SC-3000 | SC-4000 |
|---|---|---|---|---|---|---|---|---|
| EFFICIENCY | 94% | 94% | 94% | 92% | 96% | 96% | 96% | 96% |
| MAX BTU/HR INPUT | 650,000 | 750,000 | 850,000 | 1,000,000 | 1,500,000 | 2,000,000 | 3,000,000 | 3,000,000 |
| MAX KW INPUT | 191 | 220 | 249 | 293 | 439 | 586 | 879 | 1,172 |
| MAX BTU/HR OUTPUT | 611,650 | 705,750 | 799,850 | 923,000 | 1,440,000 | 1,920,000 | 2,880,000 | 3,840,000 |
| MAX KW OUTPUT | 179 | 207 | 234 | 271 | 422 | 562 | 844 | 1125 |
| MIN FLOW @ IGNITION | 25 | 25 | 30 | 30 | 48 | 48 | 72 | 96 |
| MIN FLOW @ IGNITION (LITRES/SEC) | 1.58 | 1.58 | 1.9 | 1.9 | 3.03 | 3.03 | 4.54 | 6.06 |
| MIN BTU/HR INPUT | 125,000 | 125,000 | 141,000 | 143,000 | 300,000 | 400,000 | 600,000 | 800,000 |
| MIN KW INPUT | 37 | 37 | 41 | 42 | 88 | 117 | 176 | 234 |
| MIN BTU/HR OUTPUT | 122,300 | 117,600 | 133,300 | 131,850 | 288,000 | 384,000 | 576,000 | 768,000 |
| MIN KW OUTPUT | 36 | 34.5 | 40 | 39 | 85 | 113 | 169 | 225 |
| INDOOR/OUTDOOR | Indoor | Indoor | Indoor | Indoor | Indoor | Indoor | Indoor | Indoor |
| TURNDOWN | 5:1 | 6:1 | 6:1 | 7:1 | 5:1 | 5:1 | 5:1 | 5:1 |
| **FUEL**<br>NG=NATURAL GAS, LP=PROPANE, DF=DUALFUEL | NG<br>LP<br>DF | NG<br>LP<br>DF | NG<br>LP<br>DF | NG<br>LP<br>DF | NG<br>LP<br>DF | NG<br>LP<br>DF | NG<br>LP<br>DF | NG<br>LP<br>DF |
| **DIMENSIONS** | **SC-650 SCD-650** | **SC-750 SCD-750** | **SC-850 SCD-850** | **SC-1000 SCD-1000** | **SC-1500** | **SC-2000** | **SC-3000** | **SC-4000** |
| DEPTH (IN / MM) | 54 / 1372 | 54 / 1372 | 54 / 1372 | 54 / 1372 | 65 / 1651 | 66 /1674 | 66 / 1674 | 66 / 1674 |
| WIDTH (IN / MM) | 25 / 641 | 25 / 641 | 25 / 641 | 25 / 641 | 31 / 787 | 32 / 808 | 32 / 808 | 32 / 808 |
| HEIGHT (IN / MM) | 51 / 1295 | 51 / 1295 | 51 / 1295 | 51 / 1295 | 68 / 1727 | 65 / 1652 | 65 / 1652 | 65 / 1652 |

# Burner Types

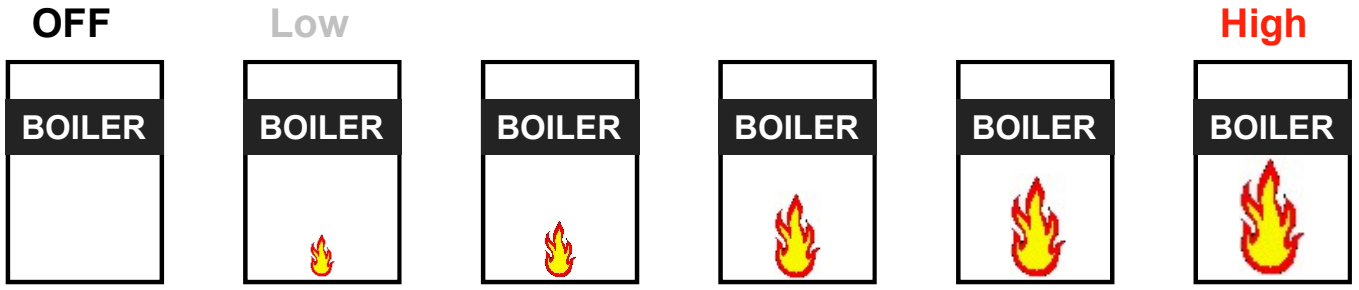
- On/Off Burners
  - Flame is OFF
  - Flame is ON




- Lo/Hi Fire Burners
  - Flame is Off
  - Flame is Low
  - Flame is High




- Full Modulation Burners allow the flame to be adjusted anywhere from low to high fire.



# Turndown Ratios

With Modulating Boilers, 1% may = 20% of the Boilers Capacity

Example: Peak Output Rate = 100,000 BTUh

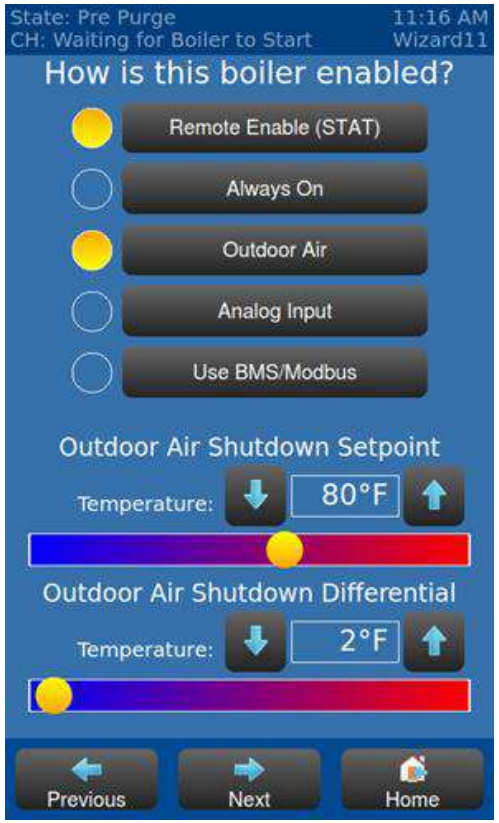
Stable Low-Fire Rate = 20,000 Btuh

Turndown Ratio = 5-to-1

## Multiple Boilers

- Who is lead?
- When do I change lead?
- When do I bring on next Boiler on?
- What happens if control fails?

# How is the boiler enabled?

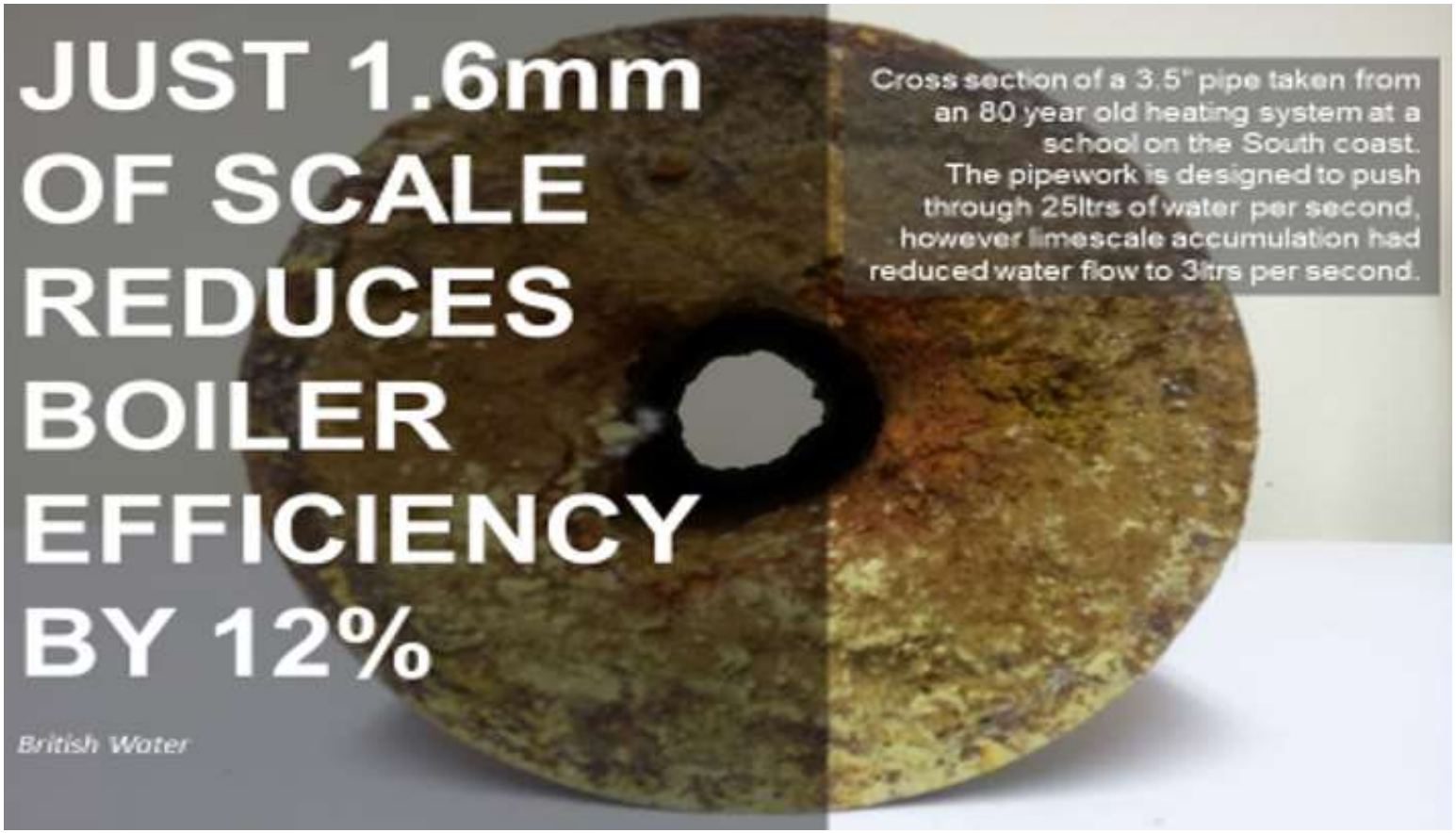



The next question in the wizard set-up is “How is the boiler enabled?” The first decision is to determine if a remote enable signal will be used to allow a remote enable/disable of the system control. Press <REMOTE ENABLE> if it will be used in combination one of the four enable methods

# Venting, venting, venting…

- 97% of all installations are incorrectly vented!?!?
- Condensing boilers have VERY specific draft ranges
- Vent Stacks MUST be ENGINEERED for the application!

# What Does Scale Affect?



## Patterson-Kelley Addresses Water Quality

### WATER QUALITY STANDARDS FOR PEAK EFFICIENCY

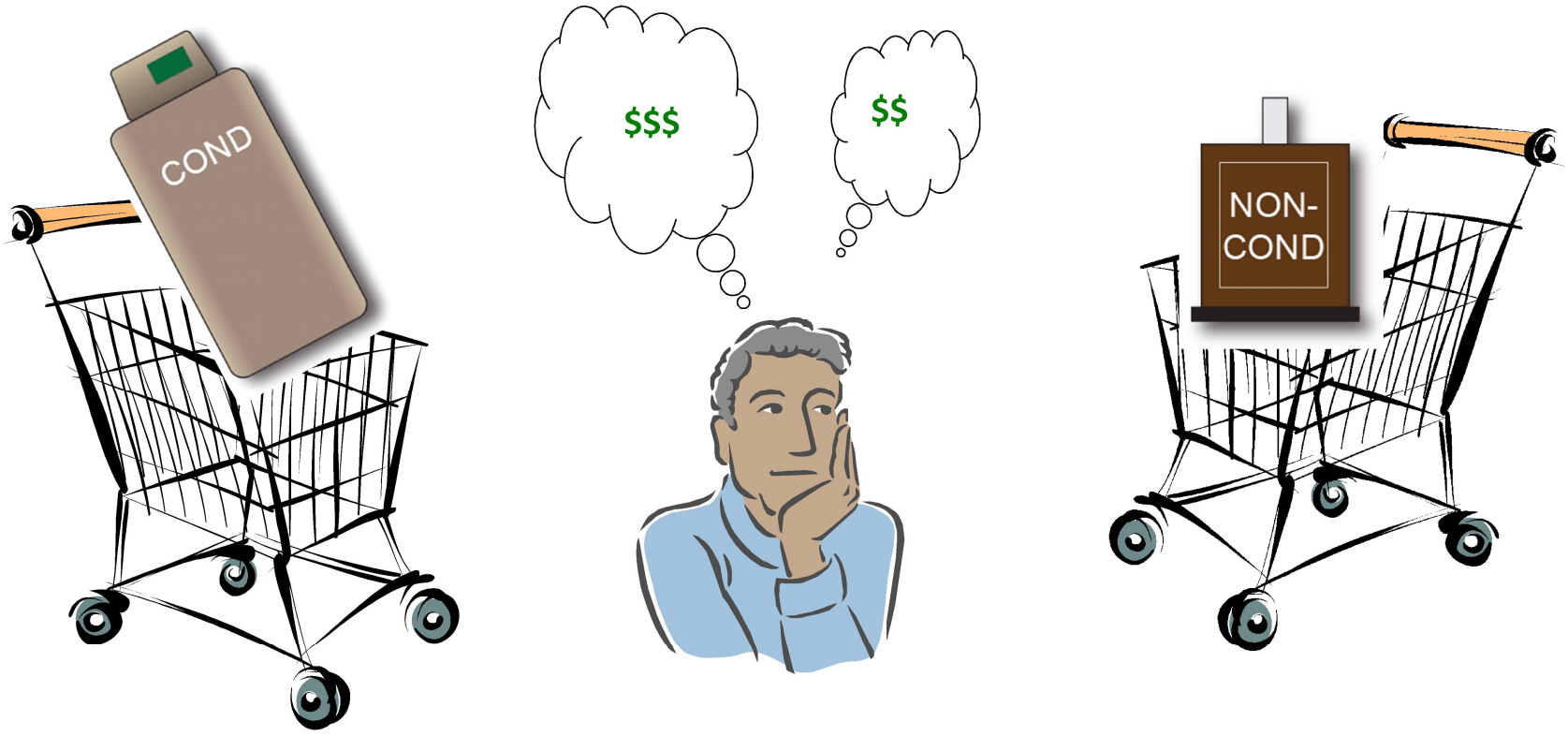
| | |
|---|---|
| pH | 6.5 to 8.5 (6.5-9*) |
| Alkalinity | <300 ppm |
| Copper | <1 ppm |
| Iron | <20 ppm |
| Aluminum | <1 ppm |
| TSS | <10 ppm |
| Chlorides | <100 ppm |
| Hardness | <200 ppm |
| Conductivity | <3000 uS/cm |
| Filtration Rate | 10 microns |

* Stainless

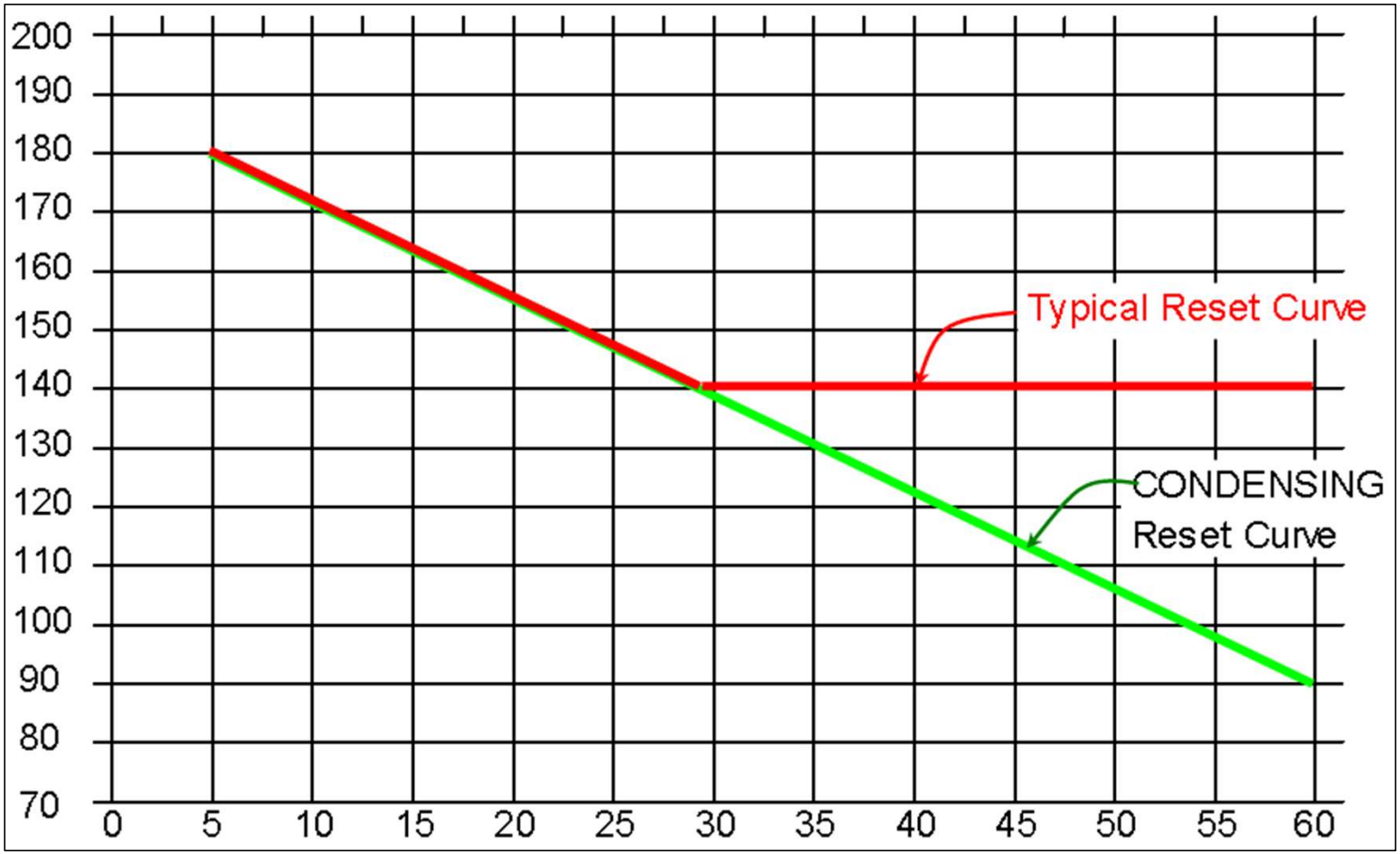
HARSCO INDUSTRIAL Patterson-Kelley

Maintain peak efficiency and reliability by testing water quality is the smart move toward reducing your total energy costs

# How does this application $ave Money?



# Hybrid Boiler System Strategy



# Hybrid Boiler System Strategy

| Avg T | BIN | to | Range | TOT | J | F | M | A | M | J | J | A | S | O | N | D | % TOT | % CUM | % LOAD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63 | 62 | | 64 | 335 | | | | 23 | 45 | 46 | 40 | 45 | 102 | 23 | 11 | | 5.22 | 5.22 | 2.78 |
| 61 | 60 | | 62 | 308 | | | | 20 | 45 | 45 | 48 | 40 | 59 | 40 | 10 | 1 | 4.80 | 10.02 | 5.56 |
| 59 | 58 | | 60 | 200 | | | | 17 | 39 | 33 | 13 | 42 | 36 | 16 | 3 | 1 | 3.12 | 13.14 | 8.33 |
| 57 | 56 | | 58 | 273 | 4 | | 4 | 29 | 71 | 36 | 22 | 21 | 32 | 45 | 8 | 1 | 4.26 | 17.40 | 11.11 |
| 55 | 54 | | 56 | 351 | 8 | 4 | 6 | 38 | 68 | 32 | 10 | 17 | 46 | 89 | 31 | 2 | 5.47 | 22.87 | 13.89 |
| 53 | 52 | | 54 | 285 | 5 | 3 | 28 | 46 | 42 | 16 | 6 | 2 | 38 | 51 | 47 | 1 | 4.44 | 27.32 | 16.67 |
| 51 | 50 | | 52 | 232 | 2 | 3 | 16 | 35 | 38 | 11 | 1 | | 32 | 64 | 27 | 3 | 3.62 | 30.93 | 19.44 |
| 49 | 48 | | 50 | 238 | 1 | 7 | 18 | 52 | 22 | 5 | | | 33 | 42 | 47 | 11 | 3.71 | 34.64 | 22.22 |
| 47 | 46 | | 48 | 258 | | 4 | 27 | 45 | 23 | 1 | | | 28 | 58 | 51 | 21 | 4.02 | 38.67 | 25.00 |
| 45 | 44 | | 46 | 227 | 2 | 2 | 30 | 55 | 22 | | | | 8 | 53 | 39 | 16 | 3.54 | 42.20 | 27.78 |
| 43 | 42 | | 44 | 287 | 4 | 5 | 69 | 76 | 24 | | | | 12 | 48 | 30 | 19 | 4.47 | 46.68 | 30.56 |
| 41 | 40 | | 42 | 180 | 3 | 8 | 56 | 42 | 10 | | | | 5 | 26 | 15 | 15 | 2.81 | 49.49 | 33.33 |
| 39 | 38 | | 40 | 273 | 8 | 20 | 50 | 50 | 32 | | | | 4 | 40 | 41 | 28 | 4.26 | 53.74 | 36.11 |
| 37 | 36 | | 38 | 337 | 24 | 23 | 80 | 46 | 20 | | | | 4 | 41 | 60 | 39 | 5.25 | 59.00 | 38.89 |
| 35 | 34 | | 36 | 257 | 24 | 31 | 39 | 28 | 11 | | | | | 18 | 59 | 47 | 4.01 | 63.00 | 41.67 |
| 33 | 32 | | 34 | 313 | 46 | 50 | 53 | 8 | 4 | | | | | 10 | 69 | 73 | 4.88 | 67.88 | 44.44 |
| 31 | 30 | | 32 | 360 | 50 | 62 | 71 | 9 | | | | | | 9 | 68 | 91 | 5.61 | 73.50 | 47.22 |
| 29 | 28 | | 30 | 298 | 44 | 79 | 45 | 12 | | | | | | 4 | 49 | 65 | 4.65 | 78.14 | 50.00 |
| 27 | 26 | | 28 | 187 | 45 | 32 | 34 | 6 | | | | | | | 22 | 48 | 2.92 | 81.06 | 52.78 |
| 25 | 24 | | 26 | 207 | 85 | 28 | 28 | | | | | | | | 13 | 53 | 3.23 | 84.28 | 55.56 |
| 23 | 22 | | 24 | 142 | 62 | 24 | 32 | | | | | | | | 1 | 23 | 2.21 | 86.50 | 58.33 |
| 21 | 20 | | 22 | 180 | 45 | 45 | 30 | | | | | | | | 7 | 53 | 2.81 | 89.30 | 61.11 |
| 19 | 18 | | 20 | 155 | 37 | 47 | 17 | | | | | | | | 1 | 53 | 2.42 | 91.72 | 63.89 |
| 17 | 16 | | 18 | 105 | 38 | 33 | 7 | | | | | | | | | 27 | 1.64 | 93.36 | 66.67 |
| 15 | 14 | | 16 | 113 | 38 | 47 | 3 | | | | | | | | | 25 | 1.76 | 95.12 | 69.44 |
| 13 | 12 | | 14 | 85 | 46 | 22 | 1 | | | | | | | | | | | | |
| 11 | 10 | | 12 | 54 | 18 | 31 | | | | | | | | | | | | | |
| 9 | 8 | | 10 | 52 | 21 | 26 | | | | | | | | | | | | | |
| 7 | 6 | | 8 | 38 | 22 | 14 | | | | | | | | | | | | | |
| 5 | 4 | | 6 | 21 | 17 | 4 | | | | | | | | | | | | | |
| 3 | 2 | | 4 | 16 | 12 | 4 | | | | | | | | | | | | | |
| 1 | 0 | | 2 | 17 | 14 | 3 | | | | | | | | | | | | | |
| -1 | -2 | | 0 | 13 | 9 | 4 | | | | | | | | | | | 0.27 | 99.53 | 88.89 |
| -3 | -4 | | -2 | 13 | 6 | 7 | | | | | | | | | | | 0.20 | 99.73 | 91.67 |
| -5 | -6 | | -4 | 4 | 4 | | | | | | | | | | | | 0.20 | 99.94 | 94.44 |
| -7 | -8 | | -6 | | | | | | | | | | | | | | 0.06 | 100.00 | 97.22 |
| | | | | | | | | | | | | | | | | | 0.00 | 100.00 | 100.00 |

**78.14% of Heating Season Can Use Condensing Temperatures in Wilkes-Barre**

**Wilkes-Barre, PA**

## Communications Options

- BACnet
- Modbus
- LonWorks
- Internet

# Sensor Monitoring & History

- Water Meter (Make up Water)
- Sump Pump
- System Temperatures and Pressures

# MACH® & SONIC® Condensing Boilers

# Thank You!

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