The Art of Boiler Tuning

Presented by Steve Connor
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Today We Will Cover

The Art of Boiler Tuning

1. What tuning really is.
2. Why is tuning important?
3. Why is tuning considered an art?
4. Pre-Tune-up Procedures
5. Proper Procedures During Tune-up
6. Post Tune-up Procedures
1. What Is Boiler Tuning?

Simple Definition

Boiler tuning is essentially tuning the burner - adjusting the fuel/air ratio to operate the boiler more efficiently while maintaining safety.
1. What Is Boiler Tuning?
   Encompasses All Types of Boilers
2. Why Is Tuning Important?

**Economics**

RULE OF THUMB

The boiler will consume in fuel on average 4 times its initial cost every year.
2. Why Is Tuning Important?

Economics

Issue: Heavy Sooting

Results

- Overheated Tubes
- Energy Losses
- Downtime
2. Why Is Tuning Important?
Economics, Safety & Emission Compliance

Oxidation Requires
- Fuel
- Oxygen
- Ignition source

Result
- Heat
- CO₂
- H₂O
- CO
- NOₓ, SOₓ

- Mixing
- Turbulence
- Temperature
- Contact Time

Fuel: C, H₂, S, Some Fuels
Air: O₂, N₂
Output: Heat, CO₂, H₂O, CO, NO, NO₂, SO₂ (sometimes)
2. Why Is Tuning Important?

Excess Air & Efficiency

RULE OF THUMB

For every 2% increase in O₂, you lose 1% in efficiency

Reference PDF Available:
2. Why Is Tuning Important?

The Variables
- Barometric Pressure
- Relative Humidity
- Ambient Temperature

**RULE OF THUMB**
Tune your boiler in the Spring & Fall to avoid ambient air swings.

Combustion settings will change as weather and ambient conditions vary.
2. Why Is Tuning Important?

EPA Compliance

Periodic Tune-Ups Required

Major Source

Area Source

Reference Material Available:
http://cleaverbrooks.com/epa.aspx
2. Why Is Tuning Important?

EPA Compliance Exclusion

Area Source gas fired boilers are NOT included unless they burn fuel oil and the burning of it exceeds 48 hours annually, and it is not the result of a gas curtailment.

Reference Material Available:
http://cleaverbrooks.com/epa.aspx
BURNER TUNING
3. Burner Tuning Is An Art

Qualifications

1. Knowledge
2. Electro/Mechanical
3. Hands on Experience
3. **Burner Tuning Is An Art**

**Preparedness**

1. Fully Equipped
2. Parts Access
3. Ready Back-up

**Combustion Analyzer**

**Basic Tools**
3. Burner Tuning Is An Art

Equipment Uniqueness

Integral Burner

Gun Burner
3. Burner Tuning Is An Art

Disaster Avoidance

Fuel rich and uncontrolled ignition can cause loss of people and property.

Fireside explosion
3. Burner Tuning Is An Art

Proper Balance of Fuel/Air

Combustion Curve

- Minimize excess air
- Control CO
- Maintain minimum safety margin (15% excess air)

RULE OF THUMB

Stay at 3% O₂ or 15% excess air for efficiency and safety.
4. Proper Pre-Tune-up Procedures

Initial Boiler Room Review

1. Nameplate Inspection
2. Burner Management System/Programmer
3. Fuel/Air Ratio Control
4. Gas Train/Gas Pressure
5. Water Level
6. Stack/Breeching Arrangement
7. Air Ventilation
8. Feedwater Sources
9. Electrical Supply
10. Boiler Room Log
11. Benchmark Expectations
4. Proper Pre-Tune-up Procedures

Nameplate Inspection

- Boiler Model
- Design Pressure
- Maximum Input

Proper burner setup means achieving full input as efficiently and safely as possible.
4. Proper Pre-Tune-up Procedures

Burner Management System/Programmer

- Sequence is automatic
- All safeties in place
- Pre-ignition interlocks powered
- Running interlocks powered

The technician needs to know the BMS’s characteristics - regardless of whether it is electro-mechanical or PLC based.
4. Proper Pre-Tune-up Procedures

Fuel/Air Ratio Control

Parallel Positioning

Single Point Positioning

Actuators

Drive Motor

Cams
4. Proper Pre-Tune-up Procedures

Gas Train/Gas Pressure

CHECK GAS PRESSURE

Is it within the manufacturer’s recommended range?
4. Proper Pre-Tune-up Procedures

Water Level

Hot Water Boiler

Steam Boiler

Expansion Tank

Low Water Cut Off & Gauge Glass
4. Proper Pre-Tune-up Procedures

Stack/Breeching Arrangement

Looking for:

• Leakage/condensation

• Excessive restrictions or bends

Exceeding manufacturer’s recommended draft pressure (+/-) in stack/breeching will cause combustion problems.
4. Proper Pre-Tune-up Procedures

**Combustion Air**

**RULE OF THUMB**

- 1 in²/2000 BTU Input of open area
- 1 in²/4000 BTU Input for fan
4. Proper Pre-Tune-up Procedures

Feedwater Sources

Vented Receiver

Deaerator
4. Proper Pre-Tune-up Procedures

**Feedwater Sources**

**Modulating Feedwater Valve**

Must be working properly; supplying adequate feedwater matched to evaporation rate
4. Proper Pre-Tune-up Procedures

Electrical Cabinet

CHECK FOR LOCK OUT/ TAG OUT
4. Proper Pre-Tune-up Procedures

Cleaver-Brooks Boiler Room Log: Steam

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Boiler #</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Water visible in gauge glass</th>
<th>Combustion check (visual)</th>
<th>Steam pressure</th>
<th>Feedwater pressure</th>
<th>Feedwater temperature</th>
<th>Flue gas temperature</th>
<th>Burner</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Burner</th>
<th>Gas pressure</th>
<th>Gas meter reading</th>
<th>Oil pressure (regulated)</th>
<th>Oil temperature</th>
<th>Oil meter reading</th>
<th>Atomizing air pressure</th>
<th>Ambient air temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Make-up water</th>
<th>Blowdown water column</th>
<th>Blowdown boiler</th>
<th>Chemical analysis</th>
<th>Comments/Observations</th>
</tr>
</thead>
<tbody>
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Gas pressure, flue gas temperature, and ambient air temperature impact the proper tuning of the burner.
What are the customer’s expectations regarding:

- Excess Air
- Carbon Monoxide
- $\text{NO}_x$
5. Proper Procedures During Tune-up

Scenario Assumptions

Assuming:

- Natural Gas
- Load
- Hot Boiler
- Near Operating Pressure
5. Proper Procedures During Tune-ups

Flue Gas Analysis

Insert probe into the stack:

- Stack Temperature
- $O_2$
- CO
5. Proper Procedures During Tune-ups

Pre-Purge

Power the burner switch and place in manual mode

- BMS will go through pre-purge before pilot and main flame ignition

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Burner Switch
Manual/Auto Switch
5. Proper Procedures During Tune-ups

Pilot Adjustments

- **Pilot problem?**
  - Burner switch off
  - Trial for ignition
  - Pilot test switch on
  - Make pilot adjustments

Adjustments are made through the gas pilot regulator and manual cock in the pilot line.

Pilot Test Switch
5. Proper Procedures During Tune-ups

Low Fire Adjustment

- Check Analyzer for $O_2$ & CO readings
- Check Manifold Pressure

RULE OF THUMB

A good excess air at low fire is between 5 – 8% $O_2$. 

Low Fire

Manifold Pressure
5. Proper Procedures During Tune-ups

**Cam Adjustments**

**Single Point Positioning System**
5. Proper Procedures During Tune-ups

Increasing the Firing Rate

Low Fire

Increased Input

Check for signs of sooting or instability.
5. Proper Procedures During Tune-ups

Fuel/Air Ratio Adjustments

RULE OF THUMB

Assure the combustion is set at the maximum efficiency at the rate your boiler fires most of the time, while maintaining 15% excess air, and as close to a linear, but safe curve from low to high fire as possible.
5. Proper Procedures During Tune-ups

High Fire Check

Do you have the full input to the burner as defined by the manufacturer?
5. Proper Procedures During Tune-ups

High Fire Check

Manual/Auto Switch

High Fire

Low Fire

Single Point Positioning: Do you have any hitches or slippage in the linkage?
5. Proper Procedures During Tune-ups

Boiler Pressure & Temperature Relationship

RULE OF THUMB

A stack temperature between 50-100 degrees above the saturation or water temperature = well tuned boiler/burner.
6. Post Tune-up Procedures

Safety Checks

1. Check Low Water Cut-Off (Evap. Test)

2. Check ALWCO

3. Check Additional Safeties:
   a) Scanner
   b) CAPS
   c) HGPS
   d) LGPS
Today’s Take-A-Ways

• Tuning is an art requiring knowledge & experience
• There are many benefits
• Important to review the boiler room before starting
• Need the proper tools and back-up
• The boiler needs to be hot to properly tune it
• Fuel pressures and combustion air are critical
• Proper tuning is a compromise between efficiency & safety
• The correlation between stack temperature & efficiency
• Post tuning safety checks
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