Beyond MACT DDDDD: Heater and Boiler Tuning From a Best Management Practices Perspective

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Denver, Colorado
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Regulatory Framework
Industry Applicability of Boiler MACT

<table>
<thead>
<tr>
<th>NAICS Code</th>
<th>Regulated Entity</th>
</tr>
</thead>
<tbody>
<tr>
<td>211</td>
<td>Extractors of crude petroleum and natural gas</td>
</tr>
<tr>
<td>221</td>
<td>Electric, gas, and sanitary services</td>
</tr>
<tr>
<td>316, 326, 339</td>
<td>Manufacturers of rubber and plastic products</td>
</tr>
<tr>
<td>321</td>
<td>Manufacturers of lumber and wood products</td>
</tr>
<tr>
<td>322</td>
<td>Pulp &amp; Paper mills</td>
</tr>
<tr>
<td>324</td>
<td>Petroleum refineries and coal product manufacturing</td>
</tr>
<tr>
<td>325</td>
<td>Chemical manufacturers</td>
</tr>
<tr>
<td>331</td>
<td>Steel works and blast furnaces</td>
</tr>
<tr>
<td>332</td>
<td>Electroplating, anodizing, annealing, metal polishing</td>
</tr>
<tr>
<td>336</td>
<td>Manufacturers of motor vehicle parts and accessories</td>
</tr>
<tr>
<td>611</td>
<td>Educational services and institutions</td>
</tr>
<tr>
<td>622</td>
<td>Health services and institutions</td>
</tr>
</tbody>
</table>
Which Facilities Are Applicable?

- **DDDDDD (5D)** applies to major HAP sources
- **JJJJJJJJ (6J)** applies to minor or area HAP sources
- Authorized under Section 112 of the Clean Air Act (CAA)
- CAA required establishment of National Emission Standards for Hazardous Air Pollutants (NESHAPS)
- **Rule Applicability:**
  
  >25 TPY of all HAP’s or >10 TPY of any single HAP
  
  \[ \text{DDDDDD} = \text{MACT} \]

  <25 TPY of all HAP’s and <10 TPY of any single HAP

  \[ \text{JJJJJJJJ} = \text{GACT} \]
Which Facilities Are Applicable?

• What doesn’t meet the definition of heater/boiler and is otherwise exempt from the Rule?
  – Used for R&D
  – Used in military propulsion systems
  – Used as “control devices” and already complying with another MACT Rule
  – Heaters and boilers otherwise subject to “Utility MACT” in Subpart UUUUUU (Electric Generating Units)
Combustion Fuels Regulated by Boiler MACT

- Solid Fuels
  - Coal
  - Biomass

- Liquid Fuels
  - No. 6, No. 4, No. 2 Fuel Oil (Heavy)
  - Other Distillate Oils (Light)

- Gas Fuels
  - Gas 1 = Natural gas + Refinery gas
  - Other Gases (bio-gas, landfill gas, coal gas etc.)
Tune-Up Requirements

• For all major HAP sources, the MACT 5D rule requires combustion sources to undergo:
  − One-time energy assessments
  − Initial/pre-compliance tune-ups
  − Periodic tune-ups thereafter

• EPA defines a boiler tune-up as:
  “the act of re-establishing the air to fuel mixture for the operating range of the heater or boiler. Oxygen and unburned fuel (carbon monoxide is usually the indicative measurement) are balanced to provide safe and efficient combustion. The primary goal of a combustion tune-up is to improve combustion efficiency.”
Tune-Up Requirements

- Visual inspection of the burner(s), burner assembly, and air registers/louvers
- Visual inspection of the main fuel control valve and header
- Visual inspection the flame pattern
- Prior to tuning, measure the flue gas temperature, O₂, CO, and NOₓ emissions at a high boiler load
- At the same load conditions, adjust the air-to-fuel ratio to optimize total emissions of CO
• The objective of the tune-up work practice standard is to ensure that post-tuning conditions are more efficient than pre-tuning conditions:
  − Reducing CO emissions
  − And in turn:
    • Reduce excess $O_2$ and $NO_x$
    • Improve combustion efficiency
# Tune-Up Requirements

- **How often do you have to repeat tune-ups?**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Frequency</th>
<th>Subsequent Tune-Up Required after Previous Tune-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 10 MMBtu/hr</td>
<td>Annually</td>
<td>13 Months</td>
</tr>
<tr>
<td>&lt; 10 MMBtu/hr and &gt; 5 MMBtu/hr</td>
<td>Biennially</td>
<td>25 Months</td>
</tr>
<tr>
<td>≤ 5 MMBtu/hr or Utilizes an oxygen trim system or Designated in Title V Permit as “limited-use”</td>
<td>5 Years</td>
<td>61 Months</td>
</tr>
</tbody>
</table>
Boiler Tune-Ups
Not Good

Good
Tuning Equipment

Tool you can use if conducting the tune-ups yourself:

Testo 350
Portable Emission Analyzer
Adjustments to air-to-fuel ratio

- Temperature
- Draft/pressure
- \(O_2\)
- CO
- NO\(_x\)
- \(C_xH_y\)

Testing here

Adjusting here

Tuning Equipment
Boiler Tune-Ups

So, if we get it right, it should like this:

Well-tuned burners

We can even “model” a unit’s performance and heat transfer characteristics to improve efficiency
Tune-Up Data

- Data during “typical operating conditions”
- Corroborated with CEMS or other monitoring data
Tuning as a Best Management Practice

- MACT DDDDD focuses on improving combustion efficiency
- Flue gas data indicates significant fuel savings from a tune-up

Actual Savings after Tuning \( \left( \frac{\text{\$}}{\text{yr}} \right) \)

\[
= \frac{(\text{Final Efficiency} \, \%) - (\text{Baseline Efficiency} \, \%)}{100 \, (\%)} \\
\times \text{Price of Natural Gas} \left( \frac{\text{\$}}{\text{MMBtu}} \right) \times \text{Fired Capacity of Source} \left( \frac{\text{MMBtu}}{\text{hr}} \right) \\
\times 24 \left( \frac{\text{hr}}{\text{day}} \right) \times 365 \left( \frac{\text{days}}{\text{yr}} \right)
\]
# Tuning as a Best Management Practice

<table>
<thead>
<tr>
<th>Rated Firing Capacity of Source (MMBtu/hr)</th>
<th>Number of Units Tuned</th>
<th>Cost Savings from Actual Tuning per Unit ($/Unit-Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10</td>
<td>39</td>
<td>$3,436</td>
</tr>
<tr>
<td>10 ≤ x &lt; 25</td>
<td>76</td>
<td>$5,083</td>
</tr>
<tr>
<td>25 ≤ x &lt; 40</td>
<td>69</td>
<td>$10,353</td>
</tr>
<tr>
<td>40 ≤ x &lt; 80</td>
<td>130</td>
<td>$9,947</td>
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<tr>
<td>80 ≤ x &lt; 100</td>
<td>47</td>
<td>$10,935</td>
</tr>
<tr>
<td>100 ≤ x &lt; 150</td>
<td>52</td>
<td>$9,740</td>
</tr>
<tr>
<td>150 ≤ x &lt; 200</td>
<td>27</td>
<td>$41,734</td>
</tr>
<tr>
<td>&gt; 200</td>
<td>87</td>
<td>$21,552</td>
</tr>
</tbody>
</table>
Tuning as a Best Management Practice

• True optimization can be overshadowed by the goal of the compliance demonstration

• Full optimization to 3-5% O₂ can generate additional savings

• Based on the observed relationship between O₂ and efficiency, linear extrapolation can estimate potential efficiency

• Specific to each heater and boiler

  Total Potential Savings via Full Optimization \( \left( \frac{\$}{yr} \right) \)

  \[
  = \left( \frac{\text{Potential Efficiency} \, \%}{100 \, \%} \right) \times \left( \frac{\$}{\text{MMBtu}} \right) \times \left( \frac{\text{Fired Capacity of Source} \, \text{MMBtu}}{\text{hr}} \right) \times 24 \left( \frac{\text{hr}}{\text{day}} \right) \times 365 \left( \frac{\text{days}}{\text{yr}} \right)
  \]
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<td>$10,353</td>
<td>$28,433</td>
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<td>40 ≤ x &lt; 80</td>
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<tr>
<td>&gt; 200</td>
<td>87</td>
<td>$21,552</td>
<td>$68,400</td>
</tr>
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</table>
Case Studies
Case Study #1

- Facility utilizes seven natural gas-fired heaters
- Annual tuning is required per MACT DDDDD

<table>
<thead>
<tr>
<th>Unit ID</th>
<th>Rated Firing Capacity (MMBtu/hr)</th>
<th>Actual Savings ($/year)</th>
<th>Simple Payback Period (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH-01</td>
<td>10</td>
<td>$3,132</td>
<td>10.0</td>
</tr>
<tr>
<td>PH-02</td>
<td>11</td>
<td>$15,634</td>
<td>2.0</td>
</tr>
<tr>
<td>PH-03</td>
<td>11</td>
<td>$4,505</td>
<td>7.0</td>
</tr>
<tr>
<td>PH-04</td>
<td>14</td>
<td>$11,467</td>
<td>2.7</td>
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<tr>
<td>PH-05</td>
<td>62</td>
<td>$23,897</td>
<td>1.3</td>
</tr>
<tr>
<td>PH-06</td>
<td>94</td>
<td>$58,876</td>
<td>0.5</td>
</tr>
<tr>
<td>PH-07</td>
<td>94</td>
<td>$52,083</td>
<td>0.6</td>
</tr>
<tr>
<td>Facility-Wide</td>
<td>--</td>
<td>$169,594</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Case Study #2

- Facility utilizes two natural gas-fired boilers and one process heater
- Annual tuning is required per MACT DDDDD

<table>
<thead>
<tr>
<th>Unit ID</th>
<th>Rated Firing Capacity (MMBtu/hr)</th>
<th>Actual Savings ($/year)</th>
<th>Simple Payback Period (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-01</td>
<td>227</td>
<td>$131,242</td>
<td>0.3</td>
</tr>
<tr>
<td>B-02</td>
<td>227</td>
<td>$54,684</td>
<td>0.8</td>
</tr>
<tr>
<td>PH-01</td>
<td>40</td>
<td>$11,563</td>
<td>3.7</td>
</tr>
<tr>
<td>Facility-Wide</td>
<td>--</td>
<td>$197,489</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Limitations
Natural Gas

• Study focused on savings relative to natural gas use
• $2.75/MMBtu used in these calculations
• Savings vary as price fluctuates
• Similar efficiency improvements are possible where units burn RFG
• Value of RFG per MMBtu is lower, so total savings are less in these units
Efficiency

- Limited data available to correlate efficiency and excess oxygen
- Linear extrapolation is a crude estimation
- Actual potential savings estimates are less accurate for larger O2 adjustments
- Adjustments to airflow also affect temperature which impacts efficiency
- Growing body of data and detailed efficiency studies will improve these estimates
Firing Rate

- MACT 5D only requires tuning at high-fire or typical operating load
- Units with highly variable fuel rates may not operate at optimally throughout their cycle
- Establish optimized airflow at multiple loads
- Full savings requires continual adjustment
Key Takeaways

- Simple payback on a 5D tune-up can be realized in a matter of months
- Going beyond the minimum compliance requirements can realize two to six fold savings in just a few hours of extra labor
- Greatest savings potential for larger natural gas units
- Growing body of data and detailed efficiency studies will improve savings estimates
Thank You!

Questions and Comments?

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