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

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Regulatory Framework

Industry Applicability of Boiler MACT

NAICS Code	Regulated Entity
211	Extractors of crude petroleum and natural gas
221	Electric, gas, and sanitary services
316, 326, 339	Manufacturers of rubber and plastic products
321	Manufacturers of lumber and wood products
322	Pulp & Paper mills
324	Petroleum refineries and coal product manufacturing
325	Chemical manufacturers
331	Steel works and blast furnaces
332	Electroplating, anodizing, annealing, metal polishing
336	Manufacturers of motor vehicle parts and accessories
611	Educational services and institutions
622	Health services and institutions

Which Facilities Are Applicable?

- **DDDDD (5D) applies to major HAP sources**
- **JJJJJJ (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

    DDDDD = MACT

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

    JJJJJJ = GACT

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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 UUUUU (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, O_2, CO, and NO_x emissions at a high boiler load
- At the same load conditions, adjust the air-to-fuel ratio to optimize total emissions of CO

Tune-Up Requirements

- **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?**

Criteria	Frequency	Subsequent Tune-Up Required after Previous Tune-Up
≥ 10 MMBtu/hr	Annually	13 Months
< 10 MMBtu/hr **<u>and</u>** **> 5 MMBtu/hr**	Biennially	25 Months
≤ 5 MMBtu/hr **<u>or</u>** **Utilizes an oxygen trim system** **<u>or</u>** **Designated in Title V Permit as "limited-use"**	5 Years	61 Months

Boiler Tune-Ups

Not Good

Good

Tuning Equipment

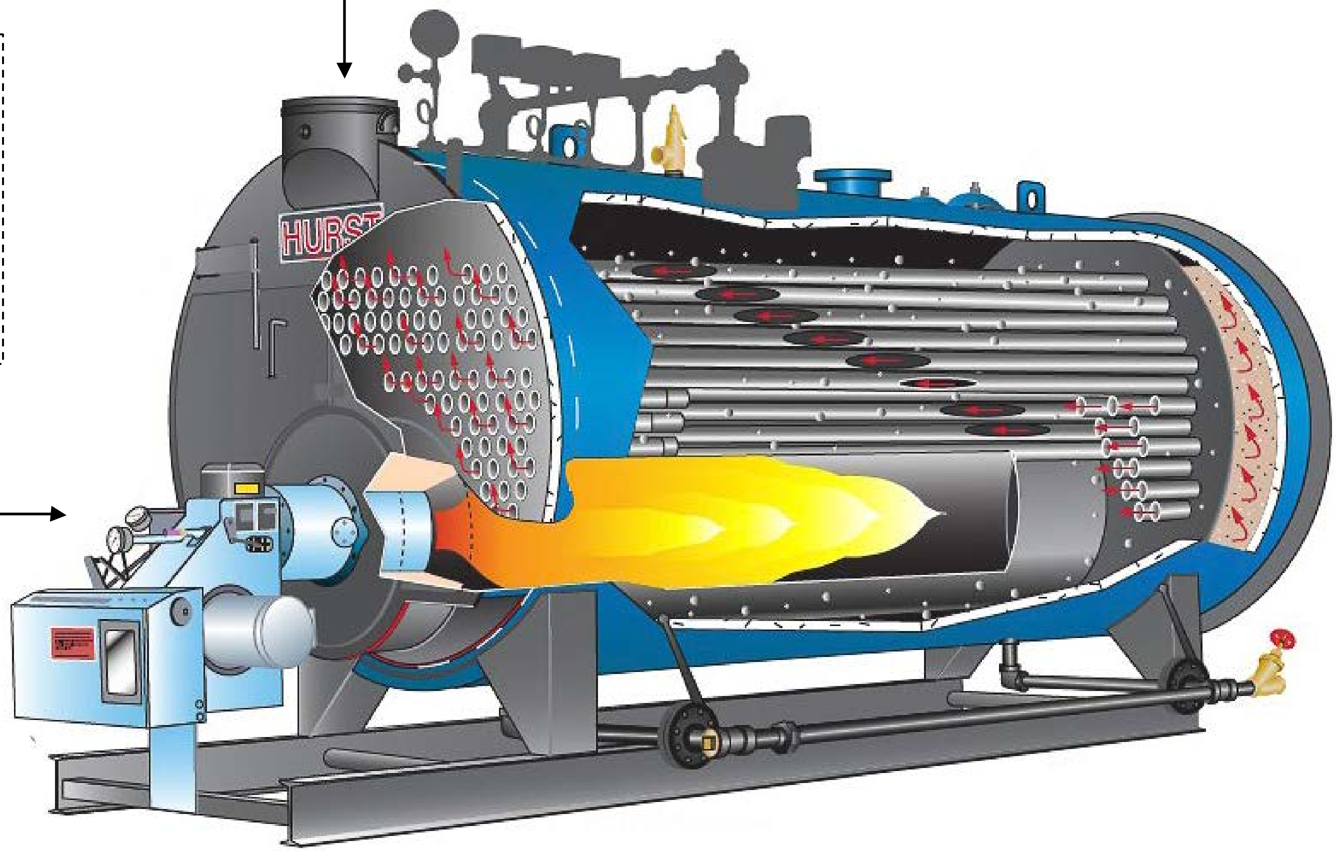
Tool you can use if conducting the tune-ups yourself:

Testo 350
Portable Emission Analyzer

Tuning Equipment

Testing here

- Temperature
- Draft/pressure
- O_2
- CO
- NO_x
- C_xH_y



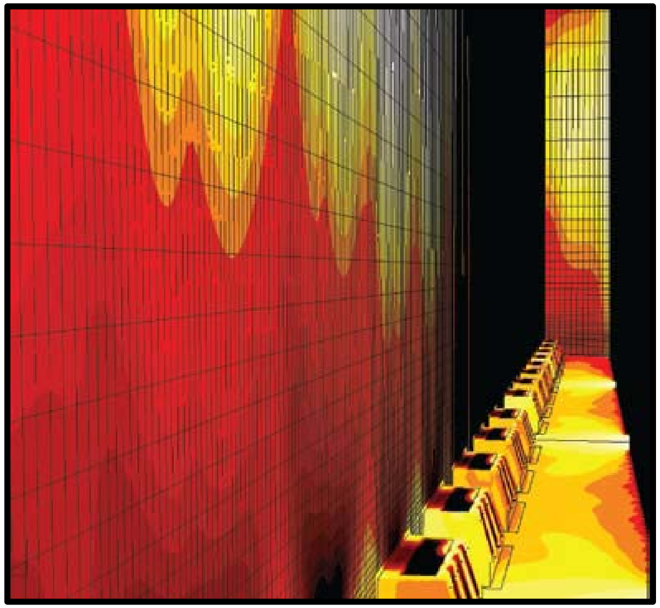
Adjusting here

Adjustments to air-to-fuel ratio

Boiler Tune-Ups

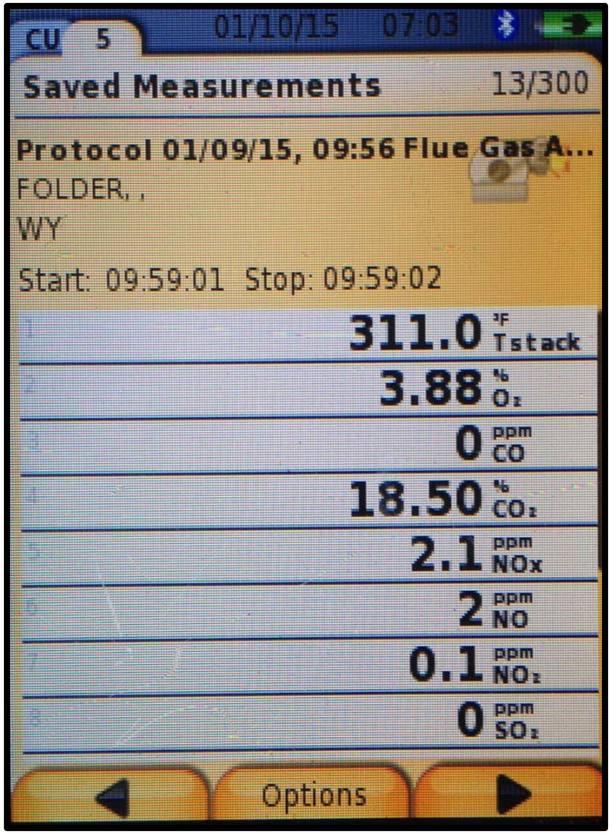
So, if we get it right, it should like this:

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

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Tuning as a Best Management Practice

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

$$\text{Actual Savings after Tuning}\left(\frac{\$}{yr}\right) = \frac{(Final\ Efficiency\ (\%) - Basline\ Efficiency(\%))}{100\ (\%)} \times Price\ of\ Natural\ Gas\left(\frac{\$}{MMBtu}\right) \times Fired\ Capacity\ of\ Source\left(\frac{MMBtu}{hr}\right) \times 24\left(\frac{hr}{day}\right) \times 365\left(\frac{days}{yr}\right)$$

Tuning as a Best Management Practice

Rated Firing Capacity of Source (MMBtu/hr)	Number of Units Tuned	Cost Savings from Actual Tuning per Unit ($/Unit-Yr)
< 10	39	$3,436
10 ≤ x < 25	76	$5,083
25 ≤ x < 40	69	$10,353
40 ≤ x < 80	130	$9,947
80 ≤ x < 100	47	$10,935
100 ≤ x < 150	52	$9,740
150 ≤ x < 200	27	$41,734
> 200	87	$21,552

Tuning as a Best Management Practice

- **True optimization can be overshadowed by the goal of the compliance demonstration**
- **Full optimization to 3-5% O_2 can generate additional savings**
- **Based on the observed relationship between O_2 and efficiency, linear extrapolation can estimate potential efficiency**
- **Specific to each heater and boiler**

$$\text{Total Potential Savings via Full Optimization}\left(\frac{\$}{yr}\right) = \frac{\left(Potential\ Efficiency\ (\%) - Basline\ Efficiency(\%)\right)}{100\ (\%)} \times Price\ of\ Natural\ Gas\left(\frac{\$}{MMBtu}\right) \times Fired\ Capacity\ of\ Source\left(\frac{MMBtu}{hr}\right) \times 24\left(\frac{hr}{day}\right) \times 365\left(\frac{days}{yr}\right)$$

Tuning as a Best Management Practice

Rated Firing Capacity of Source (MMBtu/hr)	Number of Units Tuned	Cost Savings from Actual Tuning per Unit ($/Unit-Yr)	Total Potential Savings per Unit ($/Unit-Yr)
< 10	39	$3,436	$13,631
10 ≤ x < 25	76	$5,083	$31,004
25 ≤ x < 40	69	$10,353	$28,433
40 ≤ x < 80	130	$9,947	$38,996
80 ≤ x < 100	47	$10,935	$50,287
100 ≤ x < 150	52	$9,740	$19,685
150 ≤ x < 200	27	$41,734	$77,172
> 200	87	$21,552	$68,400

Case Studies

Case Study #1

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

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

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Case Study #2

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

Unit ID	Rated Firing Capacity (MMBtu/hr)	Actual Savings ($/year)	Simple Payback Period (Months)
B-01	227	$131,242	0.3
B-02	227	$54,684	0.8
PH-01	40	$11,563	3.7
Facility-Wide	--	$197,489	0.7

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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