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Boiler Combustion Analysis

All ECM content was independently developed and reviewed to be vendor, product and service provider-neutral.

Description

Performing a combustion analysis on a boiler can help determine whether it is running at optimum efficiency. Making boiler combustion analysis part of a facility's preventive maintenance/continuous commissioning program will result in a low-cost/no-cost way to save energy.

Project Talking Points

- A boiler's efficiency is largely determined by the combustion process. Combustion requires oxygen, a fuel and an ignition source in certain ratios.
- The boiler can operate at a relatively wide range of ratios, but it will either burn too much fuel (rich) or with too much oxygen (lean), which will result in a decline in efficiency of the boiler system.
- Most boilers are designed to supply between 12 and 15 parts of air for each part of gas (10 is "ideal" for combustion but unsafe to operate).
- Advanced control strategies can actively "trim" the amount of oxygen to optimize combustion.

Benefits

- **Cost benefits:** Optimizing boiler combustion will result in decreased energy use and lower utility costs.

Environmental benefits: Boilers running "rich" (too much fuel) will have increased emissions and decreased efficiency. Fixing this issue will result in fewer greenhouse gases and a lower carbon footprint.

- **Social benefits:** Boilers with improper air to fuel ratios can be dangerous. A regular combustion analysis will prevent any danger to occupants.

Purchasing Considerations

There may be controls upgrades necessary to execute some of the advanced strategies to optimize combustion. Be sure to have your controls contractor perform a payback analysis



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How-To

1. Engage the members of the facilities team including the controls expert, boiler operator and mechanical contractor, if not performing the analysis in-house.
2. If this will be the first combustion analysis performed and you wish to track results, note the date of the changes to see the resulting energy savings.
3. Wait until the boiler is near full load so you can wait long enough, approximately 10 minutes, to get the proper readings before the boiler cycles off.
4. Depending on your boiler type, there are different procedures for completing the combustion analysis. Air Conditioning, Heating and Refrigeration News (ACHR) offers [step-by-step instructions](#).
5. Analyze the results of the combustion analysis to see if any adjustments need to be made to the air-fuel ratio (AFR). Take note of the carbon monoxide (CO) readings, as its presence will need to be addressed immediately.
 - Typical readings:
 - Oxygen: Depends on boiler type
 - Carbon dioxide: Between 8.5% and 10%
 - CO: Must be below 400 parts per million (ppm) “air free” (ideally below 150 ppm) measured as follows:
$$CO_{Air\ Free\ ppm} = \left(\frac{20.9}{20.9 - O_2} \right) \times CO_{Measured\ ppm}$$
 - Excess air: Between 20% and 50%
 - Draft: Slightly negative, approximately -0.05 in water column inches (WC)
6. Ensure boiler and controls are compatible before making any controls changes that could affect operation.

Resources

- Several boiler and tool manufacturers have their own calculators.
- Bergmann, Jim; [Performing a Combustion Analysis](#). ACHR News, March 3, 2008
- Engineering Toolbox: [Combustion Efficiency and Excess Air](#)
- Energy University Course: [Boiler Types and Opportunities for Energy Efficiency](#)



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- Fey, Carol; [Combustion Analysis is Serious Business](#). Contractor Magazine, March 2nd, 2012
- Wohlfarth, Ray; [Should you own a Combustion Analyzer?](#) PM Mag, September 1, 2017
- Wohlfarth, Ray; [Tips for Combustion Analysis of Commercial Boilers](#). PM Mag, February 17, 2016

Regulations, Codes and Standards, Policies

- [American National Standards Institute \(ANSI\)/Air-Conditioning, Heating and Refrigeration Institute \(AHRI\) Standard 1500 – 2015 Standard for Performance Rating of Commercial Space Heating Boilers](#)
- [The American Society of Heating, Refrigerating and Air-Conditioning Engineers \(ASHRAE\) Handbook – HVAC Systems and Equipment, Boilers](#)
- [Department of Energy – Energy Conservation Program for Appliance Standards: Energy Conservation Standards for Residential Furnaces and Commercial Water Heaters](#)

ECM Synergies

- Practice preventive maintenance of major heating, ventilation and air conditioning (HVAC) equipment.
- Establish a baseline for current energy consumption.

ECM Descriptors

Energy

Category List:

- Building and maintenance
- Commissioning
- HVAC
- Operations

ECM Attributes:

- Optimize operations
- Repair or optimize existing systems (fix what you have)

Improvement Type:

- Commission/retro-commission





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- Retrofit/renovations
- New buildings
- Operations and maintenance

Department:

- Engineering/facilities management