Portable Combustion Analyzers

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Agenda

- General Theory
- Understanding Emissions
- Understanding Electrochemical Sensors
- Understanding Sample Conditioning
- Proper Testing Procedures
- Data Collection

General Theory

ecom®

What do portable combustion analyzers do?

Measure exhaust gases that are formed as a result of combustion.

Why use portable combustion analyzers?

Measuring the exhaust gases allows you to tune your equipment for combustion efficiency, decreasing fuel consumption and thus decreasing emissions.

What type of analyzer is right for my application?

Analyzers range from small handheld units for basic tuning to larger multi-gas analyzers for compliance-level emissions testing. Determining which type of analyzer best fits your needs depends on the fuel type and size of your equipment, along with the application (e.g. spot-checking, installation, production line, etc.)

Portable Analyzer Features

- Probe & Sample Line
- Water Removal System
- Internal Pump
- Electrochemical Sensors
- Display Screen

These are the core features of any portable combustion analyzer. However, there are important differences in quality and reliability among analyzer brands.

Portable Analyzer Features (cont)

Optional features include:

- Printer
- Heated sample line (increases NO2 and SO2 accuracy)
- USB, Bluetooth, or WiFi
- Remote display
- Software
- Calibration gases

For data collection, the printer is the easiest way to collect results. To create data reports, you will need software and some way of communicating to a computer.

Portable Analyzer Brands

- ECOM
- Bacharach
- Testo
- Enerac
- E-Instruments
- UEI
- Kane Maye

Understanding Emissions

Emission Formation

- Air consists of:

  78% nitrogen (N_2) and 20.9% oxygen (O_2)

- Fuel consists of:

  molecular chains of hydrogen (H_2) and carbon (C) generically called hydrocarbons

- Fuel + air + ignition = combustion

Emission Formation

- Ideal combustion, i.e. stoichiometric combustion, chemical formula

  $C + H + O_2 + N_2 \rightarrow CO_2 + H_2O + N_2$ (heat)

  $C + 4H + 2O_2 + N_2 \rightarrow CO_2 + 2H_2O + N_2$ (heat) *BALANCED*

- A complete combustion is a process burning all the carbon to CO_2 & all the hydrogen to H_2O

  Fuel + air $\rightarrow$ $CO_2 + H_2O$ + heat (energy)

- Combustion is never perfect!

  Fuel + air $\rightarrow$ $CO_2 + H_2O$ + heat (energy) **+ byproducts**

By-Products of Combustion

As N_2, O_2, CxHy and other components are oxidized (burned), different chemical compounds are formed:

CO, CO_2, NO, NO_2, (NOx), SO_2, O_2, & HC

O2, CO, NO, NO2

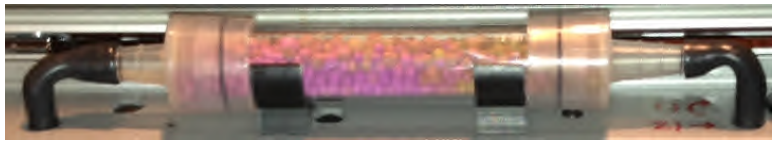
CO2 Formation

- Indirectly proportional to O2 formation
  - As O2 goes up, CO2 goes down

- Analyzer calculates CO2, which is accurate if:
  - The O2 % is correct
  - The correct fuel type is selected in the analyzer

CO Formation

- High CO indicates unburnt fuel
- “Too rich”
- CO is troublesome for some electrochemical analyzers to measure:
    - Accurate measurement of CO requires a potassium permanganate filter to scrub out NO2 & SO2 which may interfere with the reaction at the sensor

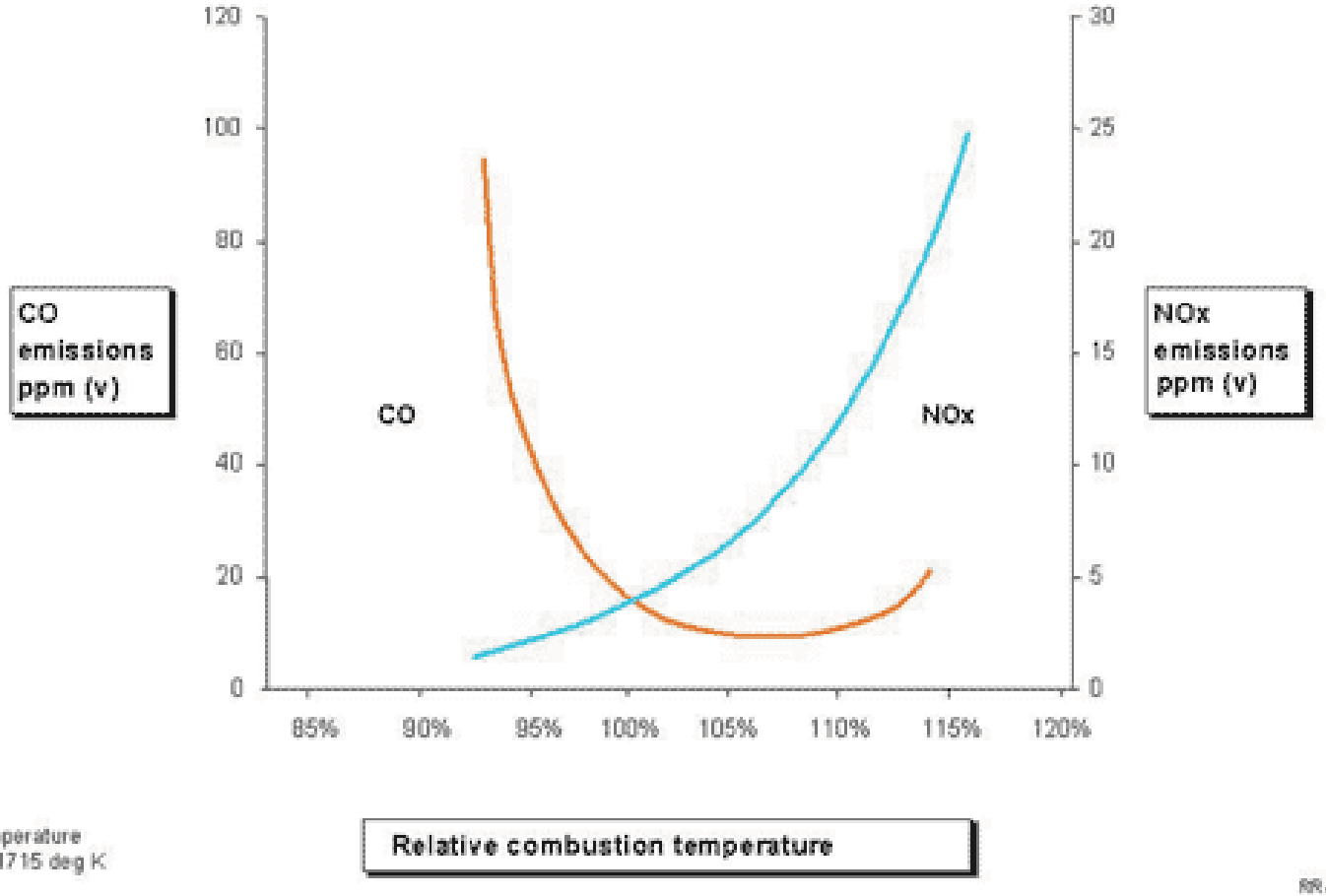


NOx Formation

- NOx = NO + NO2
- Nitrous oxides
- Higher combustion temp = Higher NOx formation
- Usually, as CO goes up, NOx goes down
    - And vice versa
- In the stack, NOx is primarily NO, but in the atmosphere all NO converts to NO2
    - This is why it is collectively termed “NOx”

Gas Turbines

Influence of temperature on CO and NOx emissions



NOTES
1) 100% Temperature is approx 1715 deg K

RR-CO-3.PPT

Understanding Electrochemical Sensors

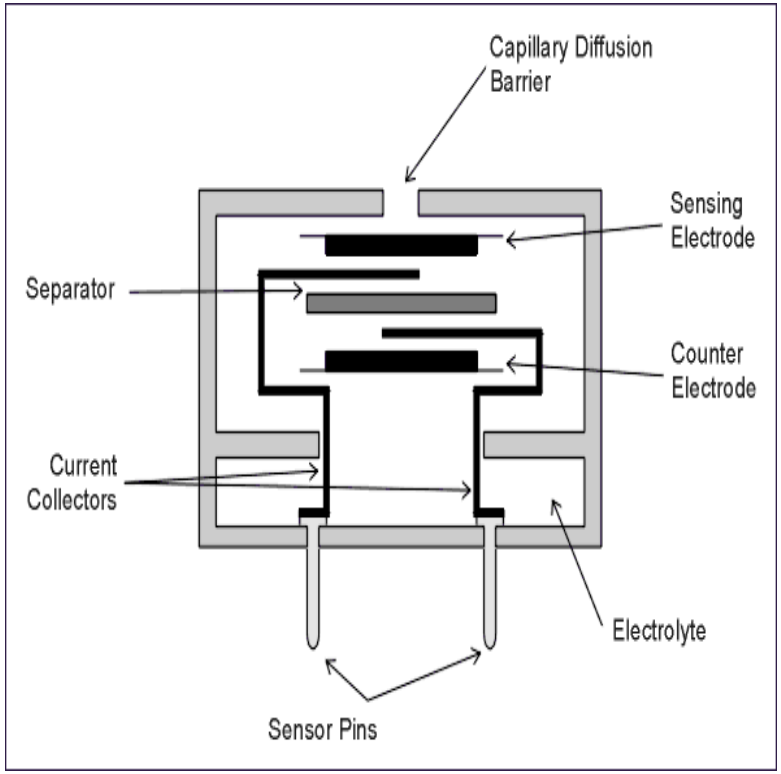
Electrochemical Sensor Technology

A small capillary allows gas to diffuse into the sensor at controlled rate

A chemical reaction occurs:
oxidation or reduction

The chemical reaction generates a current.

This current is directly proportional to the concentration of the gas.



Calibration

- How often do I need to calibrate?
  - *This depends on 2 main factors: the ppm levels of your gas samples and the frequency of testing. It is highly recommended to have your own calibration gas to perform periodic “bump checks” between annual factory calibrations.*

- What concentration of calibration gas should I get?
  - *You will want to get a calibration gas that is at the high range of the gases you expect to see.*

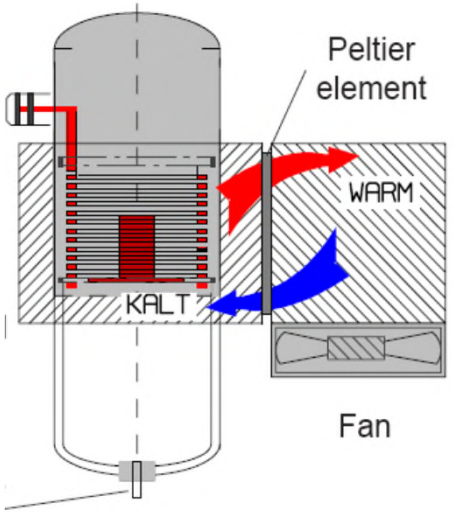
- How does calibration work?
  - *Calibration of electrochemical sensors are plotted along a linear curve. This means you need a good zero point and a good calibration point to get an accurate calibration curve across the entire range of the sensor.*

Understanding Sample Conditioning

Sample Conditioning

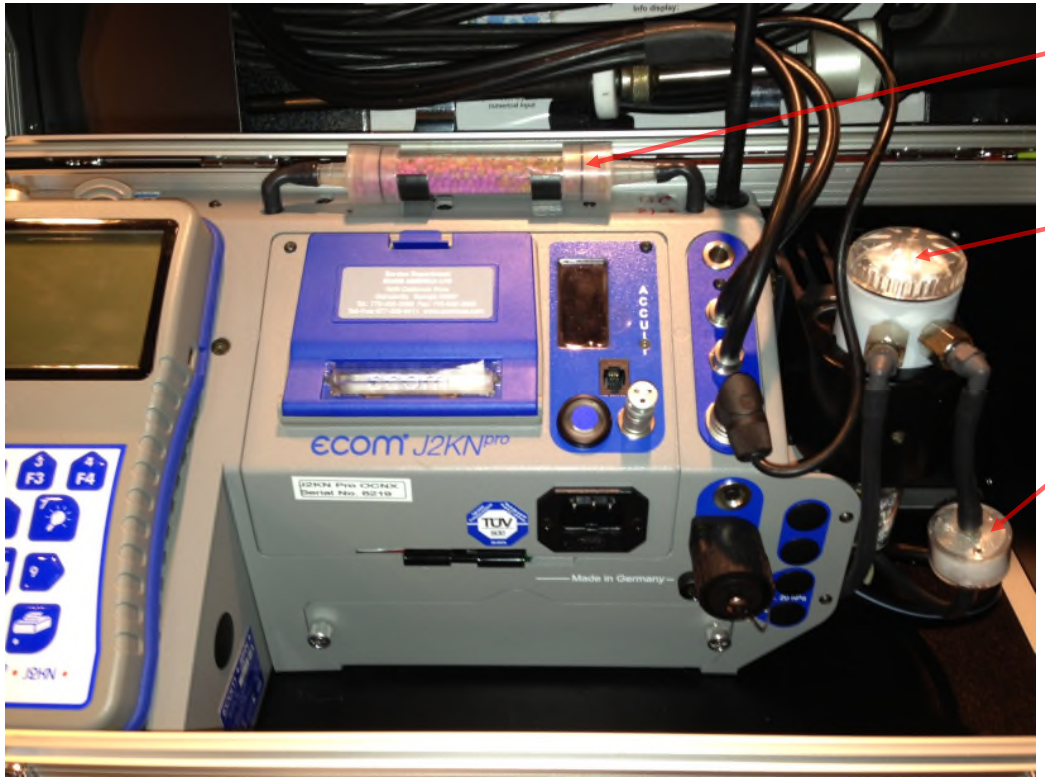
- Sample conditioning = transforming a hot, wet, dirty gas into a cool, dry, clean gas without compromising accuracy
- Sample conditioning system is comprised of:
  - Pump
  - Filters
  - Water removal
- Higher speed pumps increase accuracy by decreasing the chance that water will form in the sample line
  - If water forms in the sample line, water-soluble gases (NO2 + SO2) will drop out by binding to water
- Using a heated sample line is the most accurate way to measure NOx and SO2

Water Removal



Condensate filter < Ambient dispersive cooler < Peltier thermoelectric cooler

Filtration



NOx/SOx filter
(potassium permanganate)

Particulate filter

In-line smoke filter

CO Purge Pump

- The CO sensor is the most susceptible to over-saturation. Exposing the CO sensor to a very high concentration of CO can “kill” the sensor.
- A CO purge pump introduces fresh air into the CO sensor when CO concentrations exceed pre-set limits of the sensor (usually 4000ppm).
- This protects the CO sensor from over-range damage.
- The analyzer will monitor the CO level and turn the purge pump off when levels drop below the maximum range of the sensors.
- Since the CO gas path is independent of the other sensors, you will be able to see all the other readings and tune the combustion accordingly.

Proper Testing Procedures

Taking a Snapshot

1. Start the analyzer in fresh air.

2. Insert probe into gas stream and wait 2 minutes (wait up to 5 minutes if you have a lower speed pump).

3. Observe the readings on the display.

4. Remove sample line and allow analyzer to purge with fresh air until O2 readings are above 20.0% and other readings are below 15 ppm before powering off.

Testing Over Time

1. Start the analyzer in fresh air.
2. Allow the analyzer to run for 10-20 minutes to reach a stable temperature.
3. Turn off analyzer and re-power. This resets the temperature compensation to the current internal temperature.
4. Insert probe into gas stream and wait 2 minutes (wait up to 5 minutes if you have a lower speed pump).
5. Observe the readings on the display.
6. Remove sample line and allow analyzer to purge with fresh air until O2 readings are above 20.0% and other readings are below 15 ppm before powering off.

ASTM D6522 Test Protocol

- Find the correct sampling port
  - Sample within a straight portion of the stack, avoiding any bends in the stream which may affect the ‘core exhaust stream’
  - Position the tip of the probe in the center of the stack

Pre-test calibration

- Calibrate the CO, NO, & NO2 sensors prior to the test

Emission test

- 3 test runs at 20 minutes each
- -Ramp-up
  -Measure
  -Purge
  (Repeat 2x)

Post-test check

- Apply calibration gas to the CO, NO, & NO2 sensors after the test
- Can’t drift more than 5% for CO, NO, & NO2 and 0.5% for O2

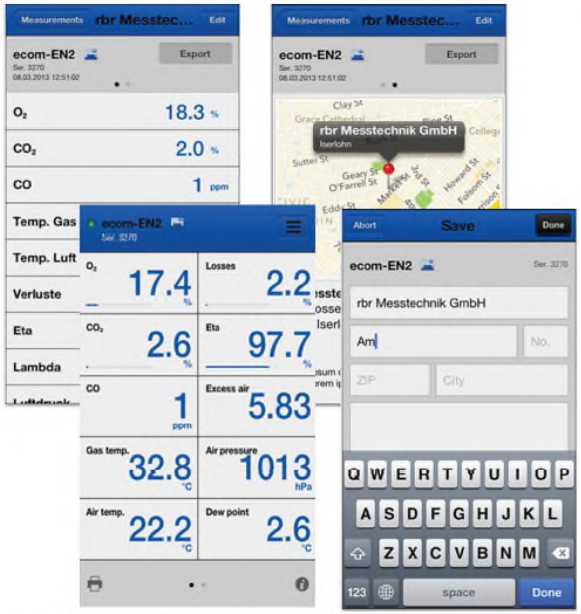
- Reporting requirements
  - Sensor temperature (internal temperature)
  - Pump flow rate
  - O2, CO, NO, NO2 (NOx) readings

Data Collection

Data Collection Options

1. Printer
2. On board data logging
3. SD memory card
   -Log data on board, then transfer to computer later
4. USB connection
   -Hard wire connection to computer
5. Bluetooth connection
   -Wireless connection to computer
6. WiFi connection
   -Wireless connection to computer & smart phone
7. Analogue outputs

WiFi and Smart Phone Apps



Search for "ECOM remote display" in Apple Store or in Android Google Play Store.

Available on the App Store

ANDROID APP ON Google play

iPhone and Android Supported

Thank you

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