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RSD BASICS

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Two Acronyms: FEAT and RSD

- Fuel
- Efficiency
- Automobile
- Test

- RSD Remote Sensing Detector

http://www.feat.biochem.du.edu/

http://www.etest.com/
HOW FEAT/RSD WORKS

• RSD COMPARES things.

• It compares the pollutant ratios (CO/CO₂, HC/CO₂, NO/CO₂ etc.) in the vehicle exhaust to the pollutant ratios in a certified cylinder or gas cell.

• RATIOS are what we MEASURE; all other results such as fuel specific emissions (grams/gallon or g/kg) are derived from the measured ratios.

• Reported % and ppm are corrected for excess air not used in combustion (and for water).
RSD works by Absorption Spectroscopy

- Light absorption is how our eyes see smoke from diesel vehicles which absorbs sky light.
- At night, no sky light, we can not see smoke.
- RSD uses specific absorption bands, infrared and ultraviolet for pollutant detection.
- Vehicle parts, dust, spray, snow, all absorb light; special software and hardware is needed to discriminate.
IR
Non Dispersive

![Graph showing IR spectra with peaks labeled CO, CO2, REF, and HC. The x-axis represents wavenumbers and the y-axis represents adsorbance.](image)
New Denver FEAT Measuring Measures

- CO, HC, NO, $NO_2$, $SO_2$, $NH_3$, smoke, speed, acceleration.
- About 5000 vehicles per day.
- Fuel-based mass emissions in gm/kg of fuel.
- Fuel-based emissions are very much less dependent upon driving mode than are emissions per km.
UV Dispersive Spectroscopy

Absorbance (offset) vs Wavelength (nm)

- NO
- SO₂
- NH₃
NO$_2$ Spectrum from FEAT Remote Sensor
IR Plume Signal vs. Time

- Reference
- CO
- CO₂
- HC

Volts vs. Time (ms)
Convert voltage signals to column amounts

• Notice the already low voltage for CO$_2$
• This arises because the vehicle only adds a little CO$_2$ to the CO$_2$ already in the air.
• Ratio all signals to a reference signal to remove interferences.
• Use laboratory calibrations to determine pollutant readings versus time.
Pollutant Readings vs Time

- CO2
- CO
- HC

Time (ms)

Percent in 8cm

HC (ppm) in 8cm
Pollutant Ratio Plots

- CO/CO₂ = 0.41
  - gCO/kg ~ 550
- HC/CO₂ = 0.0067
  - gHC/kg ~ 14
Some Drivers Cheat

1% of the Measurements =
~20% or more of the CO & HC
Denver 1999 CO

\[ y = 0.6785x + 14.003 \]

\[ R^2 = 0.9736 \]
Denver 1999 HC

\[ y = 0.4108x + 0.8305 \]

\[ R^2 = 0.9783 \]
Denver 1999 NO

\[ y = 1.0848x + 1.7888 \]

\[ R^2 = 0.9783 \]
Klausmeier report to Colorado State Auditor 2009: “Many vehicles only operate on surface streets which are not suitable remote sensing sites”.

The second phrase of the above is not correct.
Figure D-10

RSD HC vs. IM240 HC Binned Averages By Model Year
R-Square=0.994
Figure D-9
Colorado Automobile Inspection and Readjustment (AIR) Program
Correlation Between IM240 Test Results and Rapid Screen Results
for 1998 Model-Year Passenger Vehicles
CONCLUSIONS

• Remote sensing is worthless because the results sometimes do not correlate to IM240 failures.
• IM240 is worthless because the results do not correlate to the on-road emissions that the I/M program is supposed to be reducing.
• Both conclusions are WRONG.
• Both tests are just fine, the vehicles are the problem.
Motor Vehicle Emissions Variability

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Lowell Ashbaugh
University of California at Davis, Davis, California
Exhaust HC by FTP
Normal and High Emitters - All Fuels

AQIRP data

Grams/mile

Vehicle Number

Normal Emitters

High Emitters
To use RSD in an I/M Program

• You must be up front about the variability of emissions. The same test can give different numbers on the same car on two different days, especially for broken cars.
• Advanced system hardware and software can validate the measurements used for screening.
• There is a well known, well documented and entirely understandable tendency to cheat on scheduled emission testing.
• Fraud is another well documented issue in I/M tests.
• See independent California BAR report in 2001. 85-95% of on-road gross emitters failed an IMMEDIATE roadside I/M test. Link on web site.
Thank You

• Questions