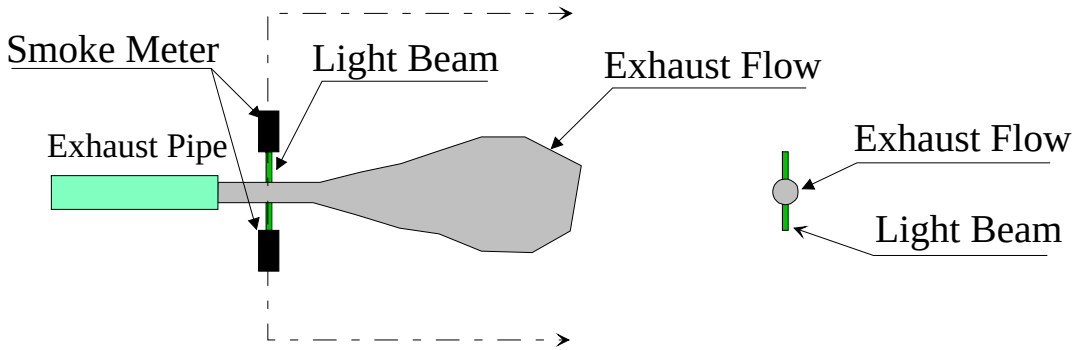
SMOKE MEASUREMENT

Environmental Systems Products
Gary Full

Standard Smoke Meter
(light beam passes through entire smoke column)

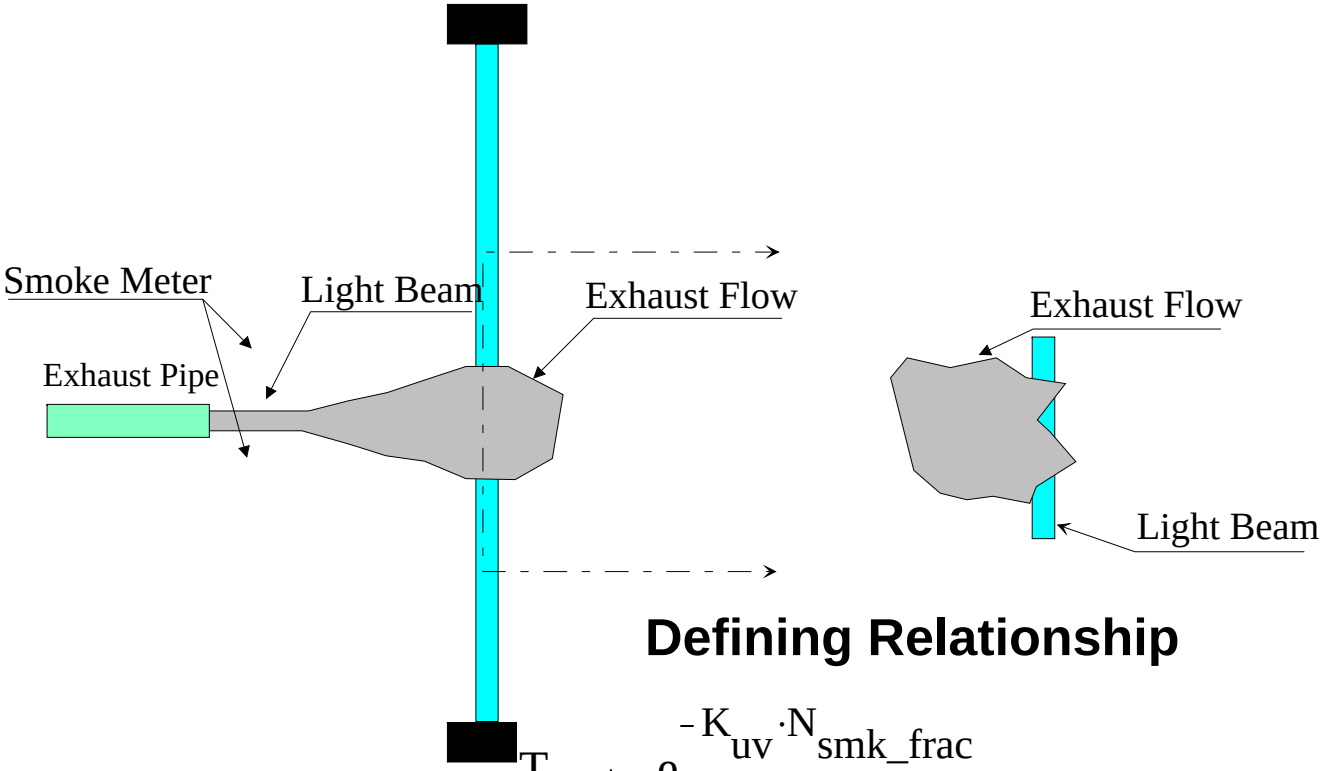


Defining Relationship

$$T_{gl} := e^{-K_{gl} \cdot N_{smk\_total}}$$

T_{gl}	Green light transmittance (1-opacity) measurement.
K_{gl}	Apparent cross-sectional size per particle at green light wavelength.
N_{smk_total}	Total number of smoke particles per unit cross-section.

Remote Sensing Smoke Measurement
(light beam passes through a portion of smoke column)



Defining Relationship

$$T_{uv} := e^{-K_{uv} \cdot N_{smk\_frac}}$$

T_{uv}	UV transmittance (1-opacity) measurement
K_{uv}	Apparent cross-sectional size per particle at UV wavelength.
N_{smk_frac}	The number of smoke particles per unit cross-sectional area; a fraction of total.

Remote Sensing Foundation

- Since the sensing beam does not necessarily pass through the entire exhaust column, “total” exhaust measurements are not possible.
- On the other hand, for a small time period (time prior to significant diffusion or stratification effects), the exhaust can be treated as a uniform mixture at any instant in time. This means the ratio measurement of one exhaust component to another exhaust component is accurate.
- Remote sensing measurements are ratios!

Other Gas Relationships
(simplified approximations)

Defining Relationships

$$T_{CO} := e^{-K_{CO} \cdot N_{CO\_frac}} \qquad N_{CO\_frac} := \frac{-\ln\left(T_{CO}\right)}{K_{CO}}$$

$$T_{CO2} := e^{-K_{CO2} \cdot N_{CO2\_frac}} \qquad N_{CO2\_frac} := \frac{-\ln\left(T_{CO2}\right)}{K_{CO2}}$$

$$T_{HC} := e^{-K_{HC} \cdot N_{HC\_frac}} \qquad N_{HC\_frac} := \frac{-\ln\left(T_{HC}\right)}{K_{HC}}$$

Our Smoke Number

(a value proportional to number of exhaust smoke particles per unit fuel)

$$SF := \frac{-100 \cdot \ln\left(T_{uv}\right)}{N_{CO2\_frac} + N_{CO\_frac} + N_{HC\_frac}}$$

where

N_{CO2_frac} is amount of plume CO2 in %-cm

N_{CO_frac} is amount of plume CO in %-cm

N_{HC_frac} is amount of plume HC in %-cm

SF Summary

- Numerator is result of opacity-based measurement across an unknown portion of the exhaust column. Measurement is made at UV wavelengths (~232nm) which is the ~wavelength for peak mass density of diesel particulate
- Denominator is the sum of measured carbon-based gases across the same unknown portion of the exhaust column. Carbon-based components can only come from the fuel.
- The ratio is an accurate representation of smoke per unit fuel at the instant (0.5-second) that the data is acquired.
- Smoke can be represented as particle density or as mass density per unit fuel through proper engineering units.