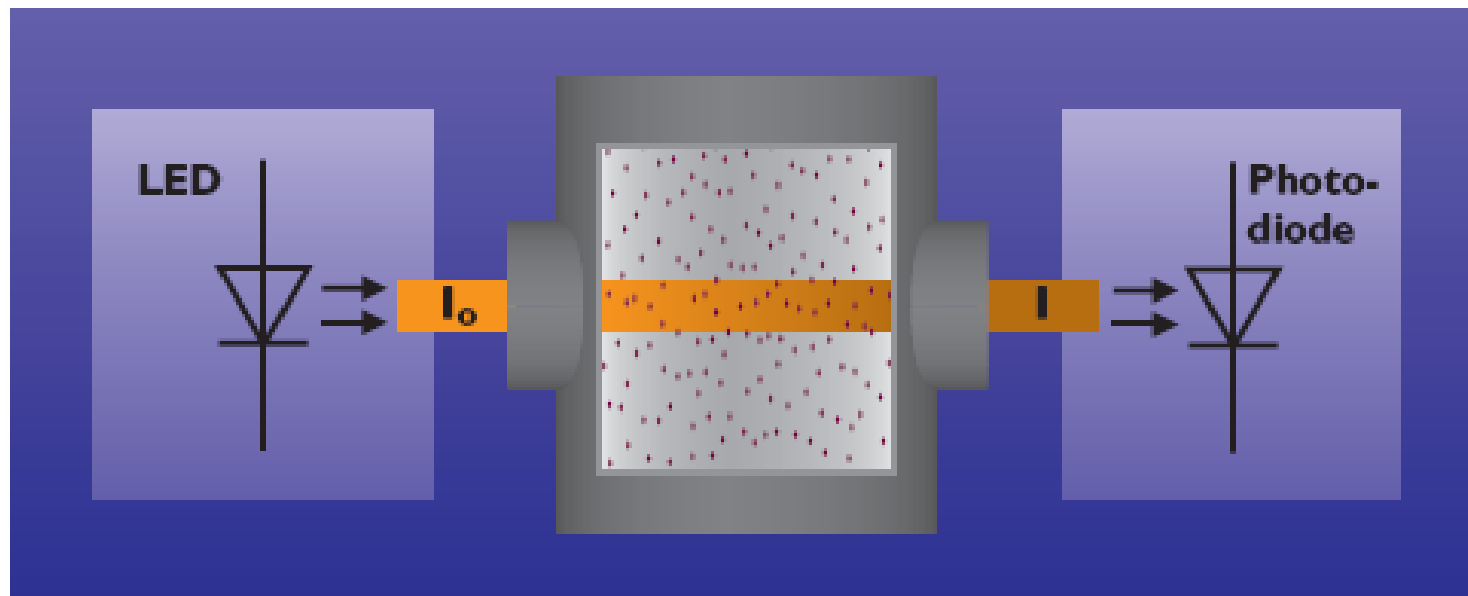


**CEM Specialties Inc.**  
**Process & Emission Monitoring**  
**Specialists**

**OPACITY**

- **What is Transmittance?**

Transmittance is the relationship between the intensity of light received and the intensity of the emitted light from the modulated light source.



- **How is Transmittance Calculated?**

$$\text{Transmittance} = I/I_0 * 100\%$$

- $I_0$  = the reference intensity
- $I$  = the intensity of emitted light after passing through the stack gas and returned by the reflector to the transmissometer.

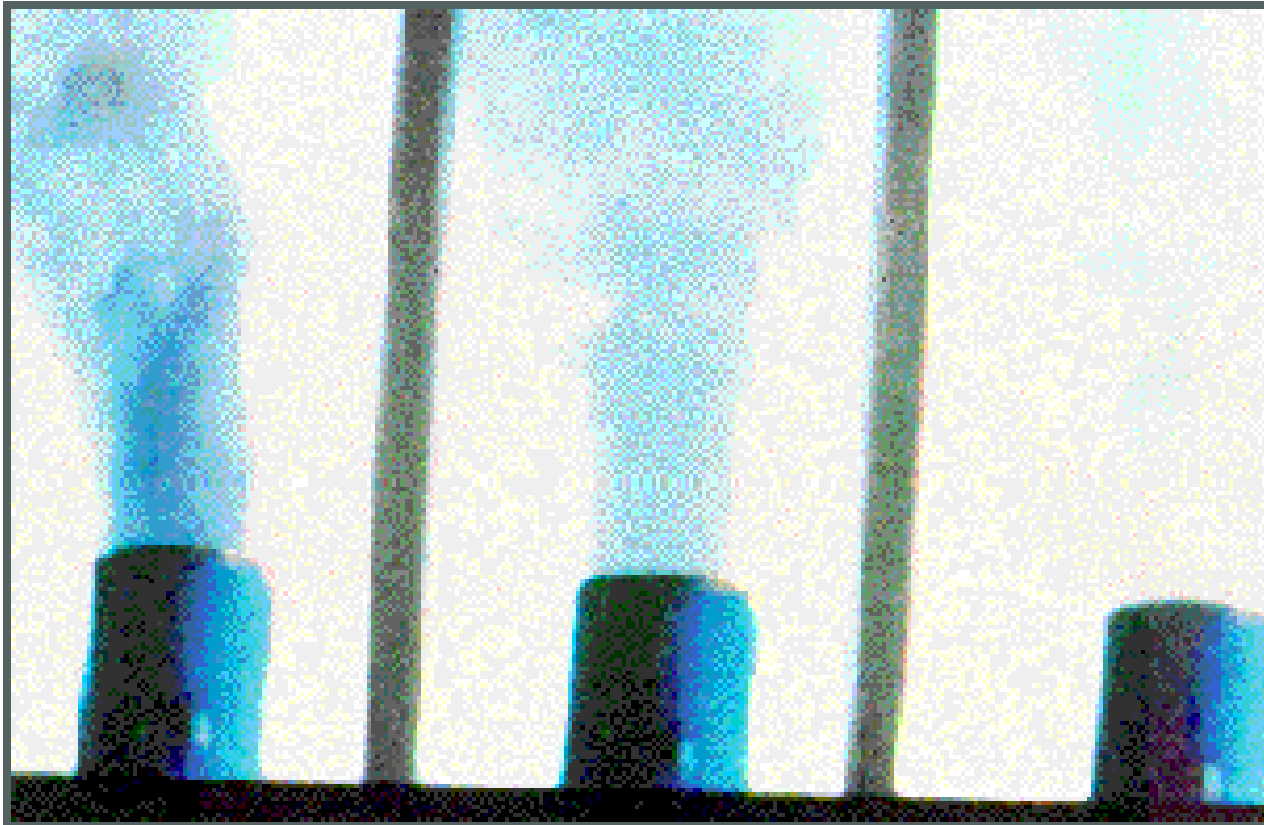
- **What is Opacity?**

The transmission of light through stack gas, containing particulate matter, will be reduced through absorption and scattering of light. The result is opacity, the opaqueness of stack gas exiting the stack and into the atmosphere. Opacity reduces the transmission of light received by the transmissometer from the reflector. If the transmitted light is not able to pass through the stack gas, no light is received by the transmissometer and the opacity is 100%. In turn, if all of the light is received back to the transmissometer, the opacity is 0%.

- **How is Opacity Calculated?**

$$\text{Opacity} = (1 - I/I_0) * 100\%$$

# Decreasing Relative Opacity (left to right)



- **What is Relative Opacity?**

A visible emissions observer determines the stack gas opacity at the stack exit. The relative opacity is a calculation to obtain a consistent reading between the visual observer and the opacity monitor. Since the opacity monitor is located at a different location (upstream of the stack exit) than the visual observed measurement (stack exit), and the monitor is a double pass monitor, opacity data must be corrected for single pass and stack exit values.

## Calculation for Relative Opacity

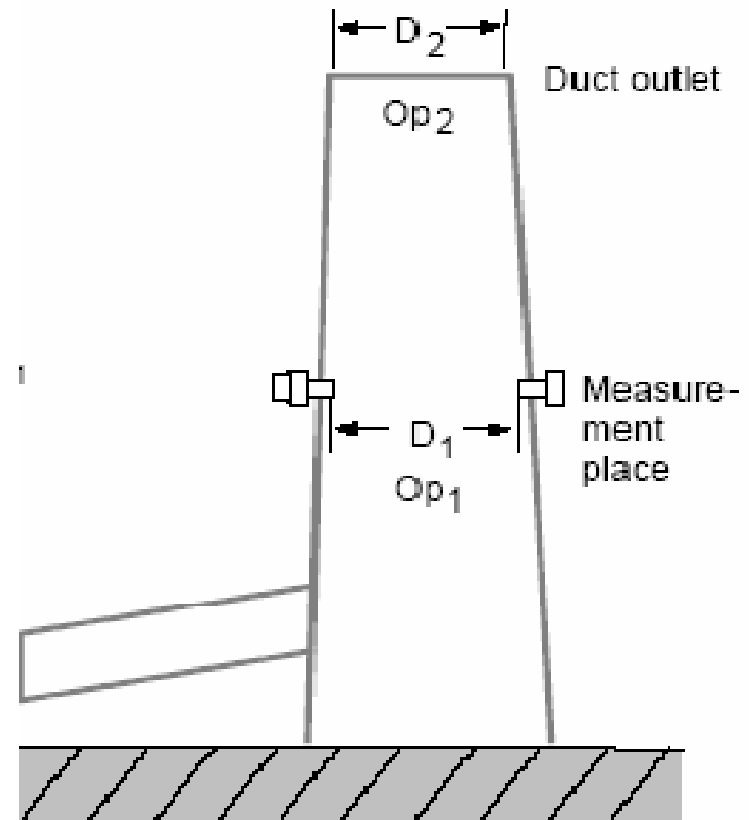
$$\text{Relative Opacity (OR)} = 1 - (1 - Op) \frac{D_2}{D_1}$$

$D_2$  = Outlet stack inside diameter [meters].

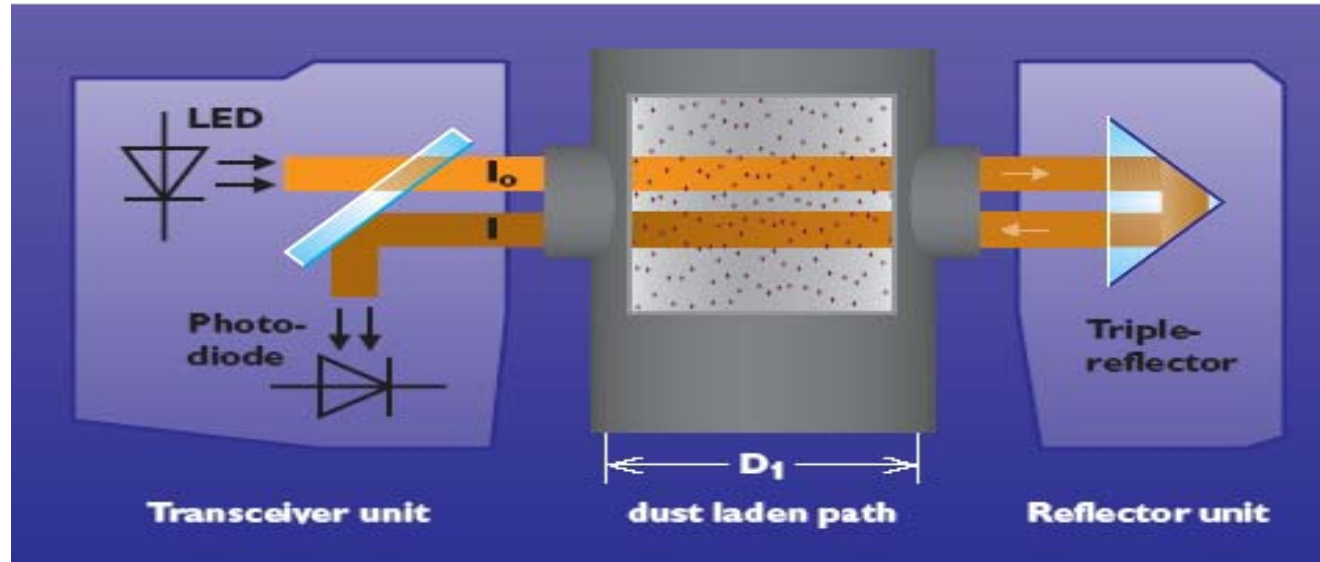
$D_1$  = opacity location inside stack diameter [meters].

$OP_1$  = opacity at the monitor location [%]

$OP_2$  = Relative Opacity [%]



# Dual Pass Opacity Monitor



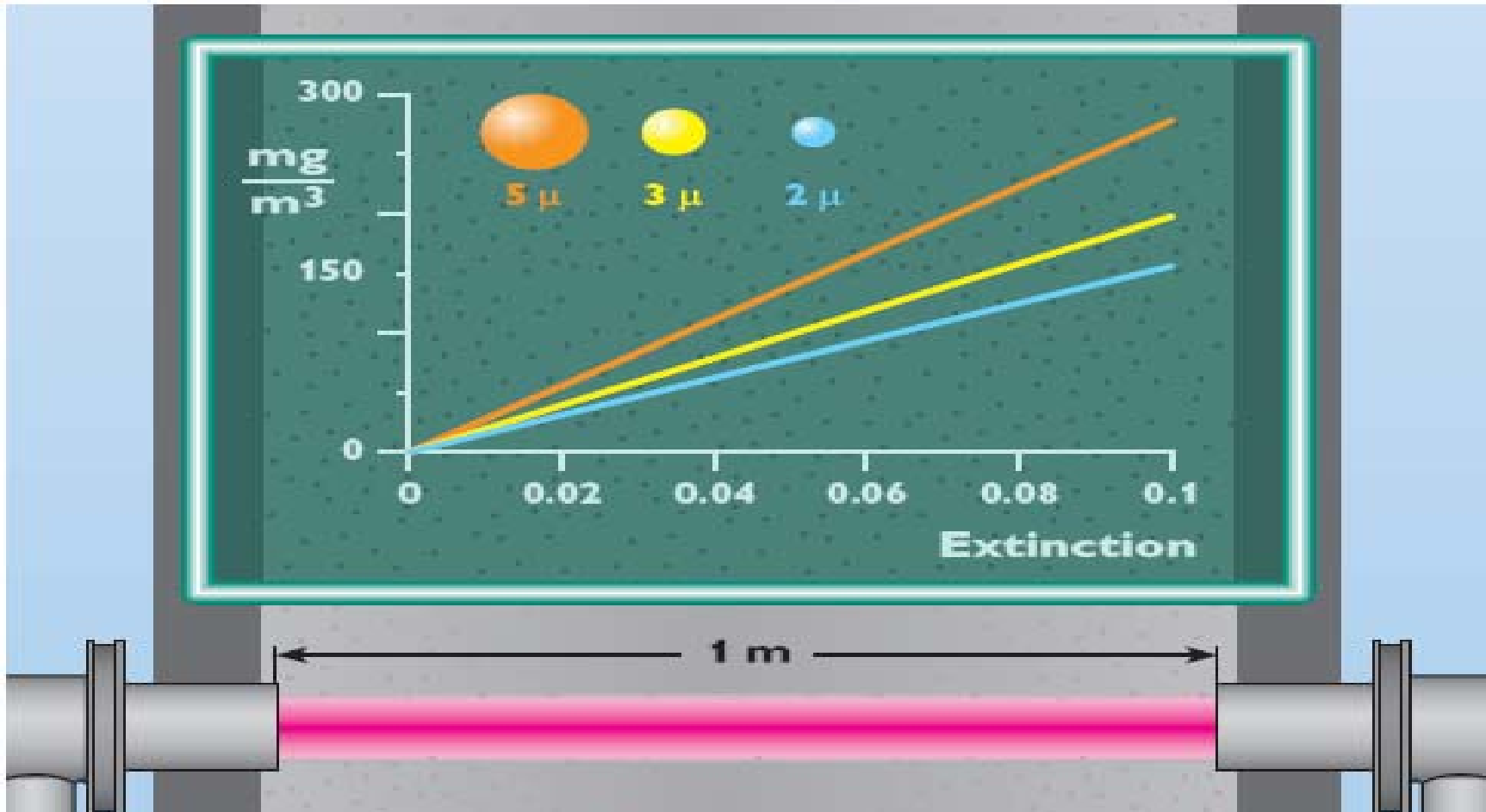
- The Transmission is the ratio of the attenuated light “I” to the unattenuated light “ $I_0$ ”

$$\text{Transmission "T"} = I/I_0 \times 100\%$$

With Autocollimation Principle I is attenuated twice, as light passes the measurement path between transceiver unit and reflector twice



# Opacity vs Particulate



# Basic Opacity Monitor Layout

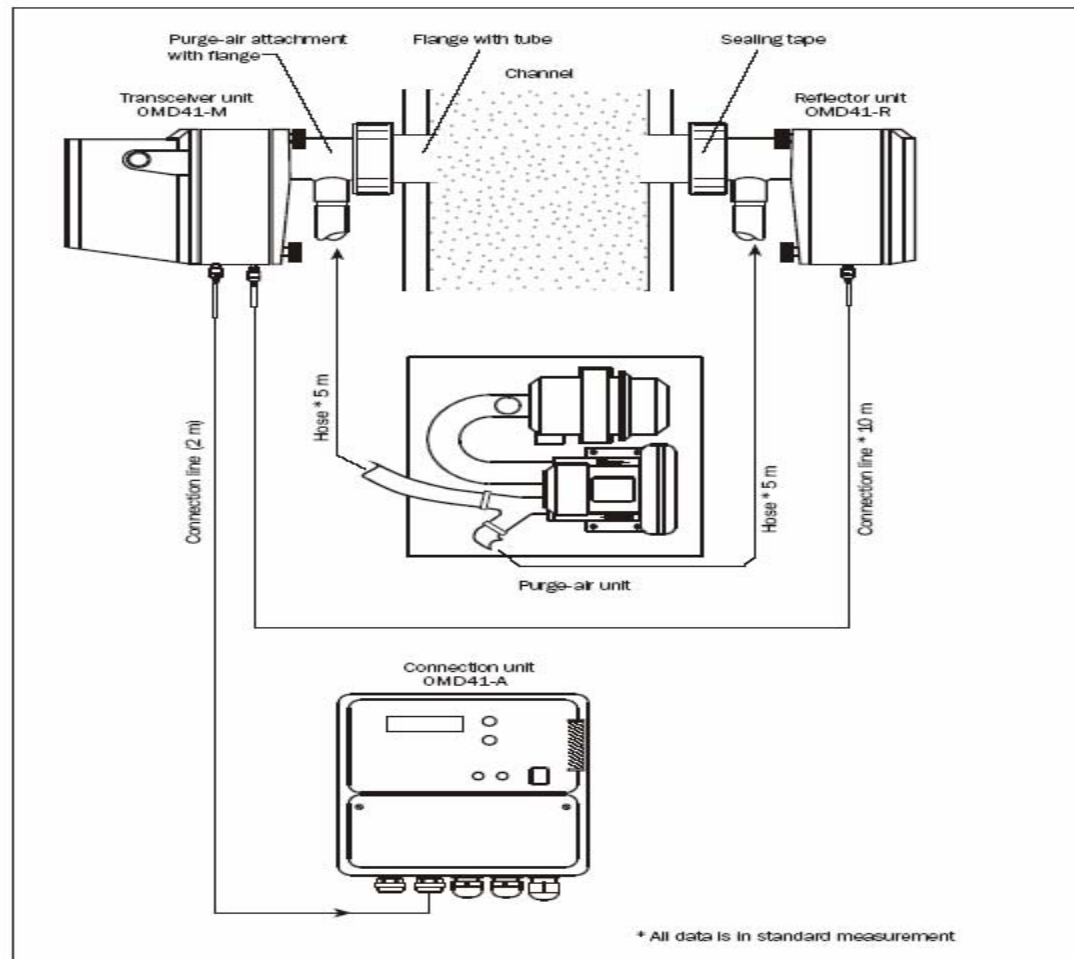


Fig. 2 – 1 Summary of Device

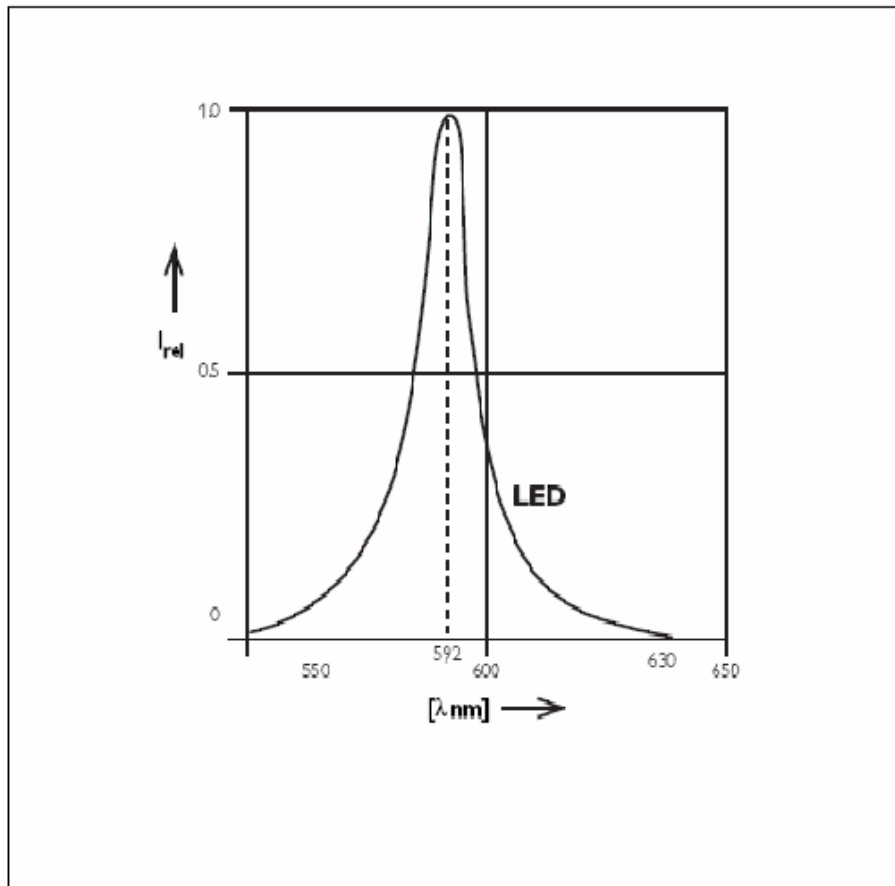
# PS-1 Guidelines

EPA PS1 Guidelines (ASTM 6216-98)

**MCOC: Manufacturers Certificate of Conformance**

# Spectral Response

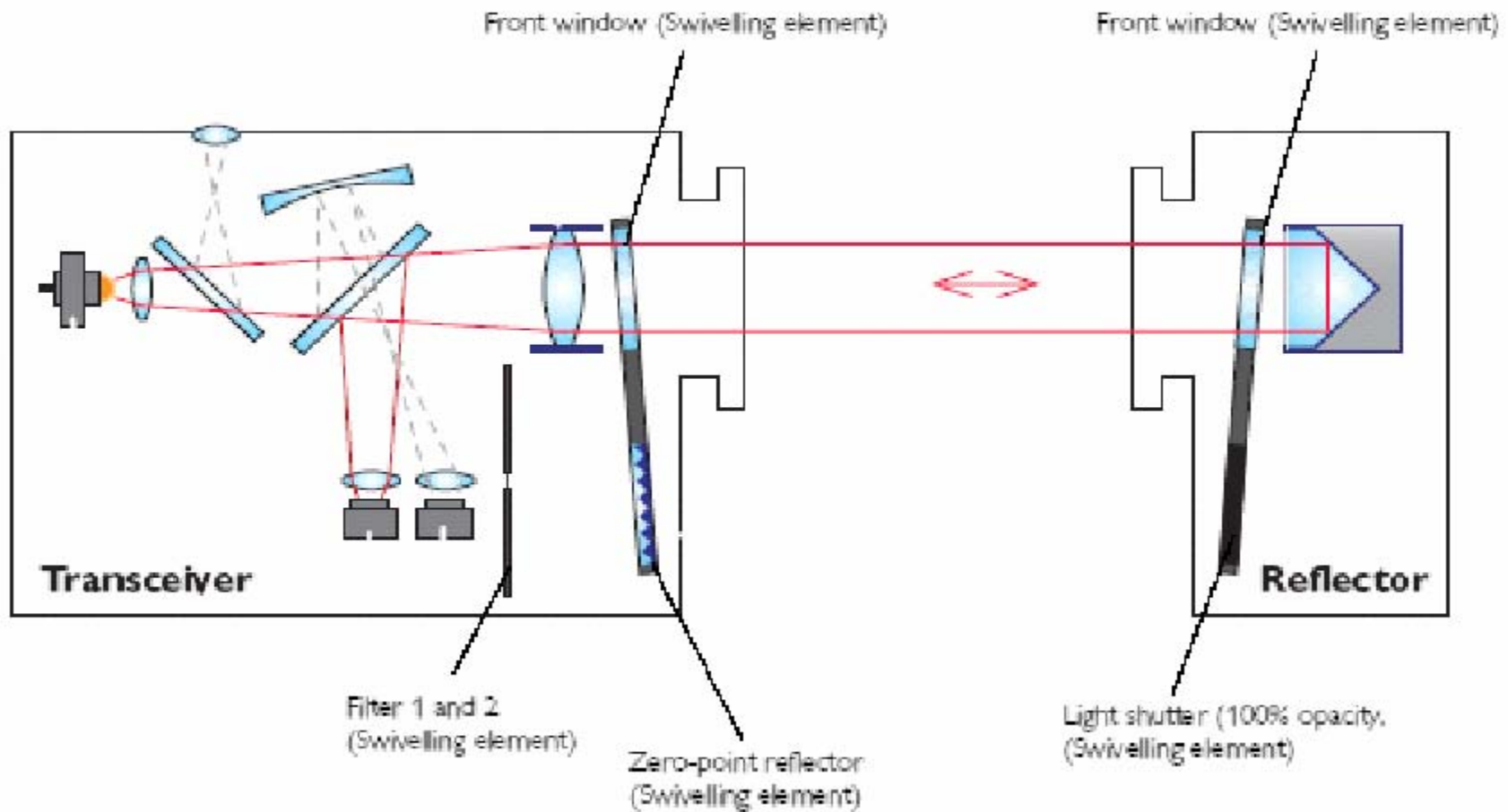
## EPA PS1 Guidelines (ASTM 6216-98)



- Visible LED Light Source (~ 400 to 700 nm)
- Peak = 592 nm
- <10% Below 400 nm
- <10% Above 700 nm

# Pass through the measuring path twice (dual pass)

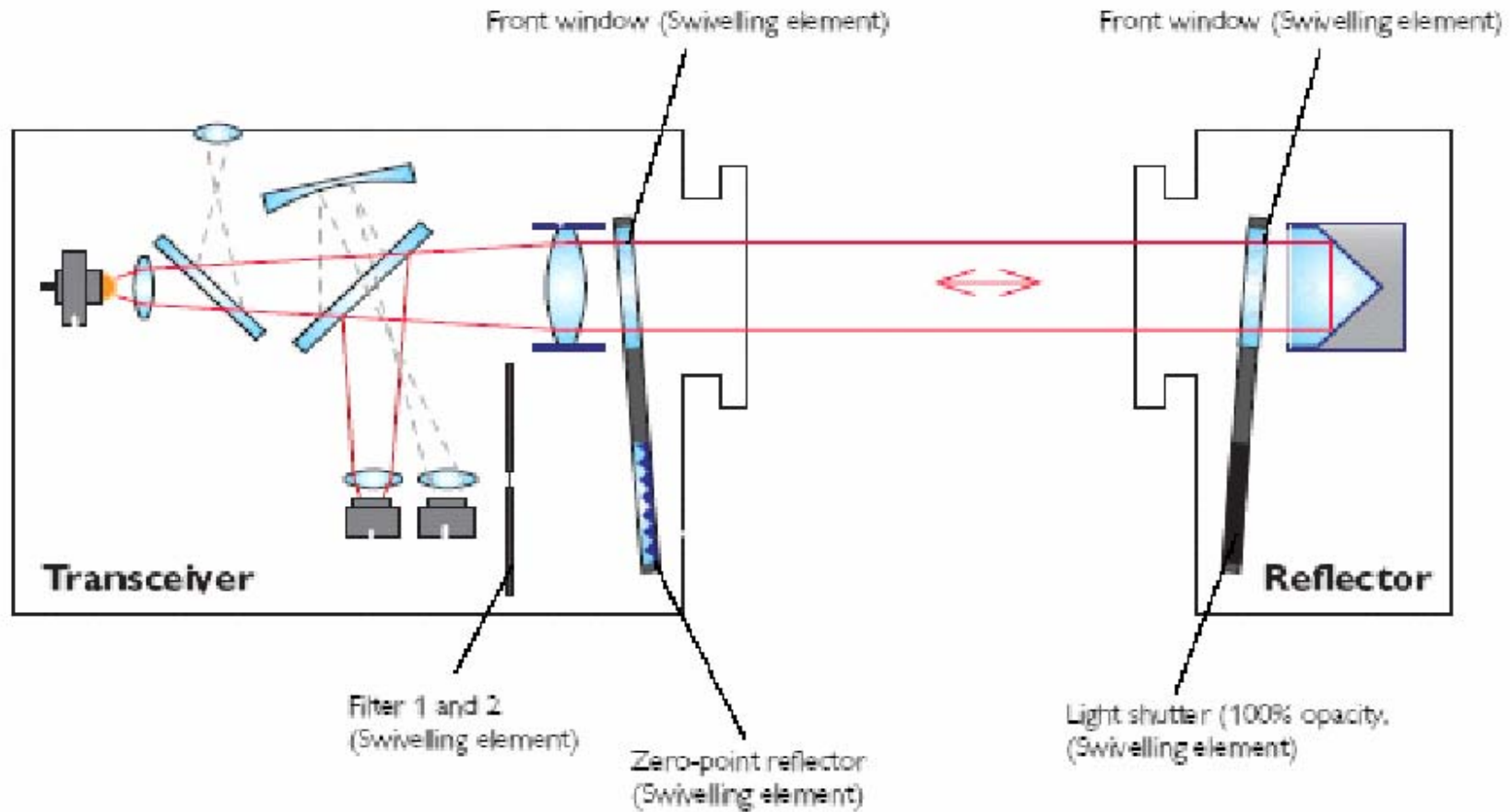
EPA PS1 Guidelines (ASTM 6216-98)



# Conduct Zero and Span Calibration every 24 Hr

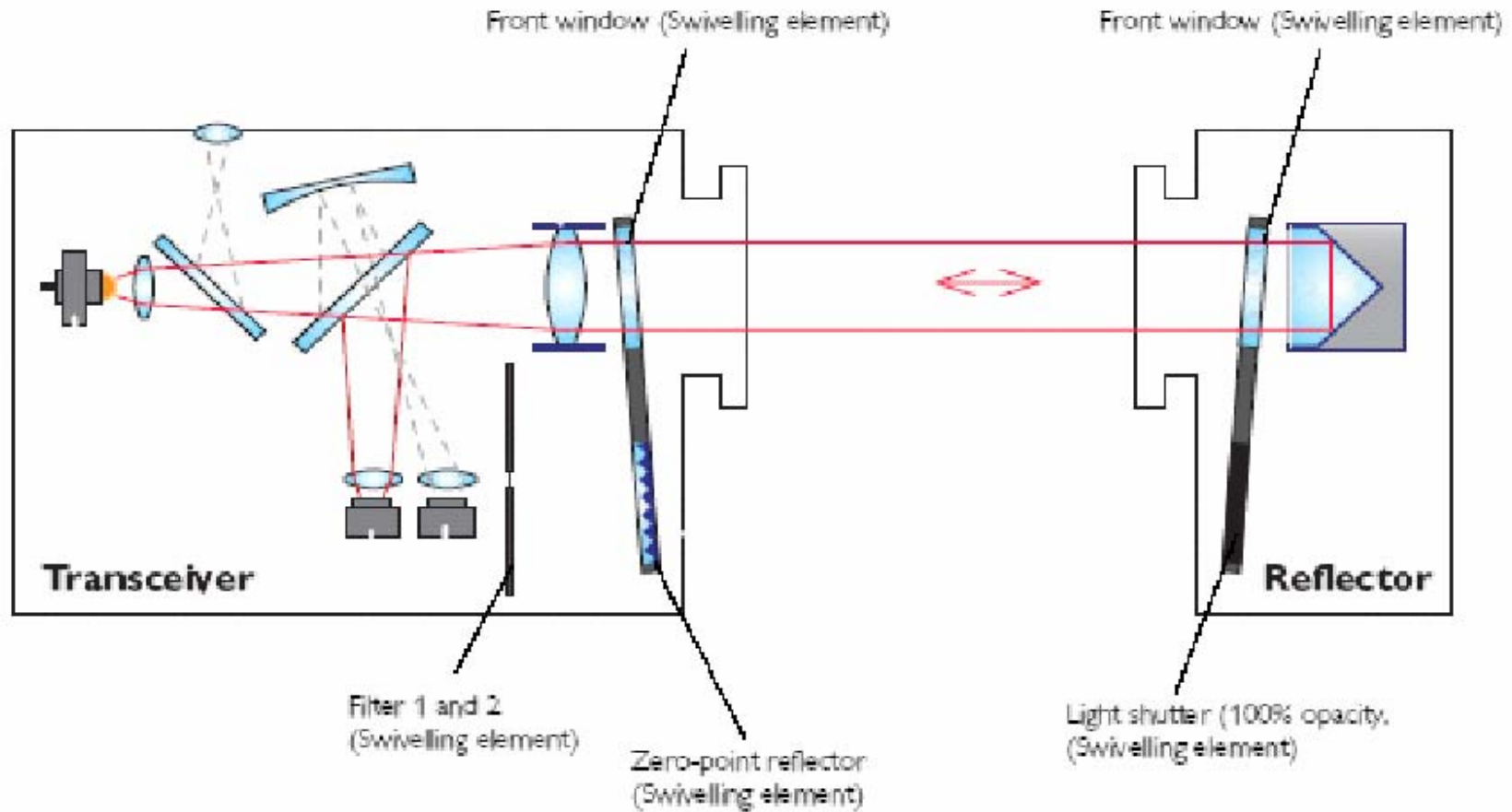
<2% ZERO Drift (24-hr)

<2% SPAN Drift (24-hr)



# Correct contaminated windows every 24Hr

<4% Dirty window correction



# Opacity Audit: Conducted Quarterly

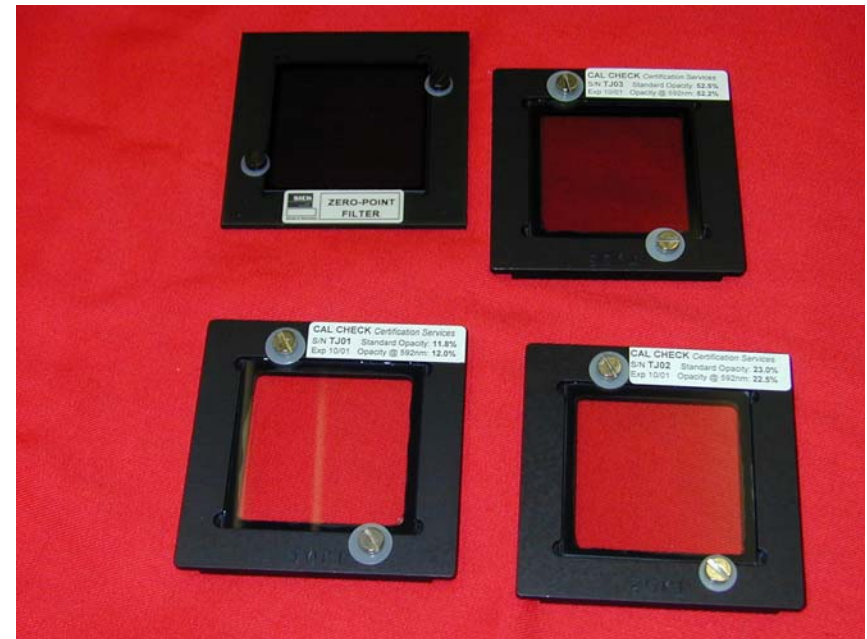
EPA PS1 Guidelines (ASTM 6216-98)

- Open the transmissometer by loosening the knurl nuts. Open the door and mount the zero jig to on to the transmissometer.
- Depending on the version of audit jig, a zero filter will be used during the zero adjust and audit. Using the small head screw and the evaluation unit display screen, adjust the screw until a close to zero reading is achieved. This reading should be on the positive side of zero. A less than zero reading could allow for erratic readings from the opacity monitor.





- Once a “positive zero” is achieved, the audit can begin. Place the 3 filters in the slot of the zero jig, one at a time. Allow the opacity monitor to respond to each filter and record the result.
- Each filter must be analyzed five times. A calibration error of 3% is allowed for each audit filter. The data can be recorded into a excel spreadsheet for easier recordkeeping, data analysis and data storage.



# Zero Adjust on an Emission Free Path

## EPA PS1 Guidelines (ASTM 6216-98)

- Mount the transmissometer and reflector to the mounting stands using the required hardware. The washers are beveled to allow adjustment of the alignment. The washers should be placed on to bolts before the unit is mounted on to flange using the alignment washers and nuts.
- Simulate the path length of the opacity monitor. The distance between the transmissometer and reflector should be the fail safe shutter to fail safe shutter distance.
- All optical surfaces; contamination windows, reflector surface and lens should be cleared of any dust, finger prints, etc. This should be performed with an optical cloth to prevent any lint from appearing on the optical surfaces. For surfaces with aerosol laden contamination, use a small amount of IPA and distilled water.
- Power up the Opacity monitor. The LED should appear brighter, and will be easier for alignment. Using the alignment tool, adjust the alignment at the reflector end until the light appears in the middle of the circle. This is achieved by adjusting the nuts on the flange. Once the middle bolt is slightly tighten, the top bolt can be used to adjust the unit vertically and the bottom nut horizontally. This step will ensure the reflector is aligned properly. The next step is to adjust the transmissometer alignment. This done by adjusting the mounting nuts until the LED is in the middle of the bulls-eye.
- The transmissometer must be focused
- Set opacity monitor to the correct path length into the installation site function. This distance is the fail safe to fail safe distance minus the flanges and fail safe shutters.
- Place the monitor in measuring mode. This will automatically initiate a cycle check. The cycle check will adjust the LED intensity if the contamination window was previously dirty. The opacity is now ready for a clear path calibration. Once the emission free path is confirmed, click on the "Adjustment data" icon and initiate a clear path by choosing "adjust". The zero adjustment calibration has now begun. The measuring path of the opacity monitor must be clear of any debris, dust, etc, during the zero path calibration. During the calibration a Z/M % will appear on the screen. The Z/M is the relationship a between the reference and measured intensities. This relationship must be between 90 and 160 %, required by PS1 regulation New Source Performance Standards. If it is not, the iris and or reflector must be change to reflect these criteria.