Dust Measurement Techniques

Dust emission measurement

Particles emitted from a combustion process include smoke, soot, ash & carried-over process materials (such as cement).

All of these particles are visible. They can be measured by looking at how much they absorb and scatter visible light.

Dust emission limits

Sr. No.	Category	Emission Parameters
1	Thermal power plant	Before 2003 – 100 mg/Nm^3 2003 to 2016 – 50 mg/Nm^3 After Jan 2017 – 30 mg/Nm^3
2	Cement	30 mg/Nm^3
3	Iron & Steel	30 – 50 mg/Nm^3
4	Petroleum oil refinery	Gas fuel 10 – 5 mg/Nm^3 Oil Fuel 100 – 50 mg/Nm^3
5	Sponge iron	Gas fuel 50 mg/Nm^3 Dust Fuel 100 mg/Nm^3
6	Diesel Engine	100 – 75 mg/Nm^3
7	Aluminium	150 – 250 mg/Nm^3
8	Glass	50 mg/Nm^3

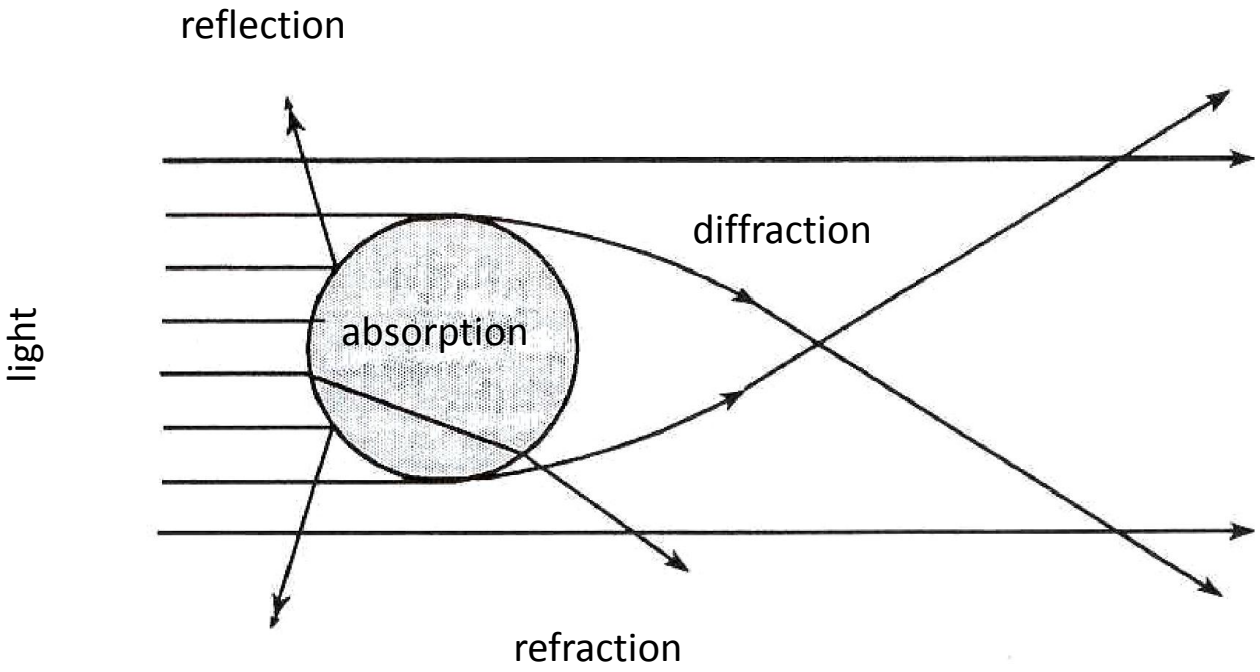
Dust arresting techniques

- ESP
- Bag House
- Wet scrubber
- Mechanical cyclone

Continuous dust monitoring techniques

- Single pass transmissometer (Opacity)
- Double pass transmissometer(Opacity)
- Double beam transmissometer(Opacity)
- Optical scatter
- Probe electrification
- Optical Scintillation
- Extractive particulate monitoring

Effect on dust particles

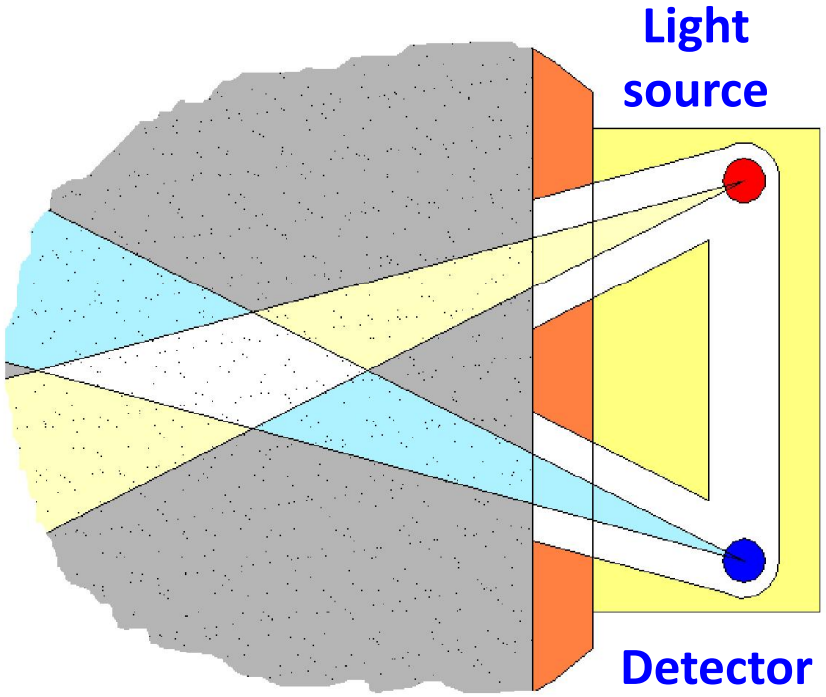


Back, forward or side scatter

Measures light reflected from illuminated particles

Merits

- High sensitivity
- Easy to install
- No moving parts

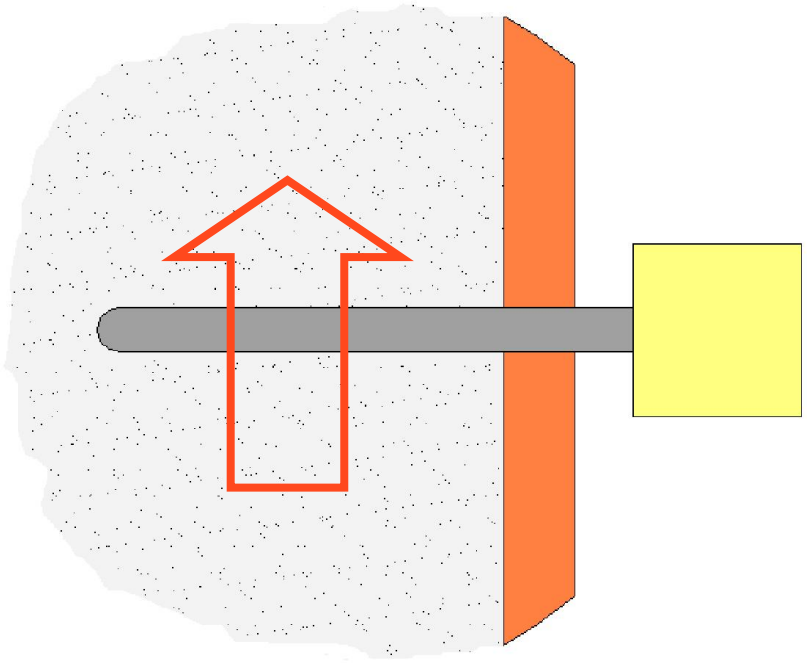


Demerits

- Measures in a very small zone – measured zone not consistently representative
- Unsuitable for large ducts
- In-duct reflections can cause zero errors
- Measurement affected by change in particle size, shape.

Probe Electrification

Measures electrical charge transfer as particles collide with the probe



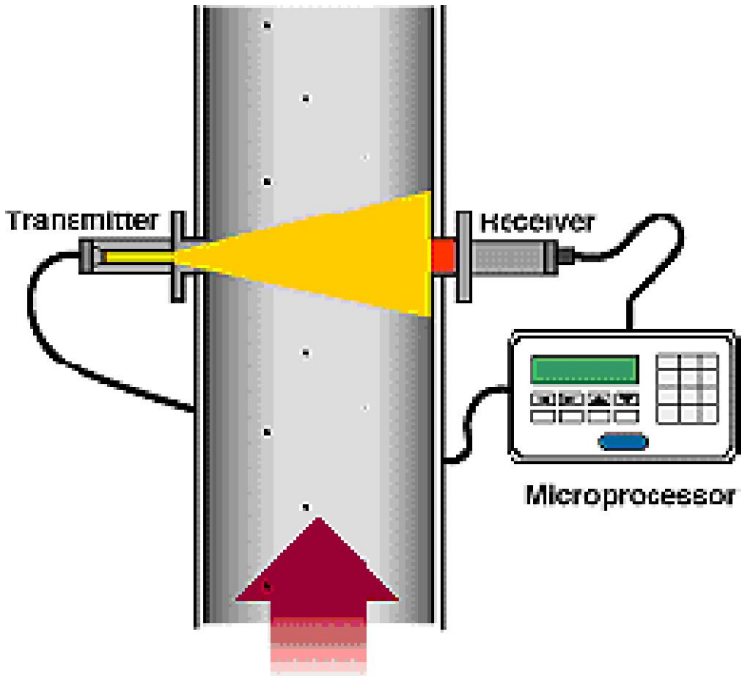
Merits

- Simple low cost probe
- Easy to install
- High sensitivity
- Simple installation

Demerits

- Unsuitable for large ducts
- Not suitable after ESP
- Measurement affects by Particle size & velocity

Optical scintillation



Merits

- Easy to install
- Measures across the stack

Demerits

- Measures liquid drops as dust
- Lens cleaning is an issue
- Measurement affected by change in particle size, shape.

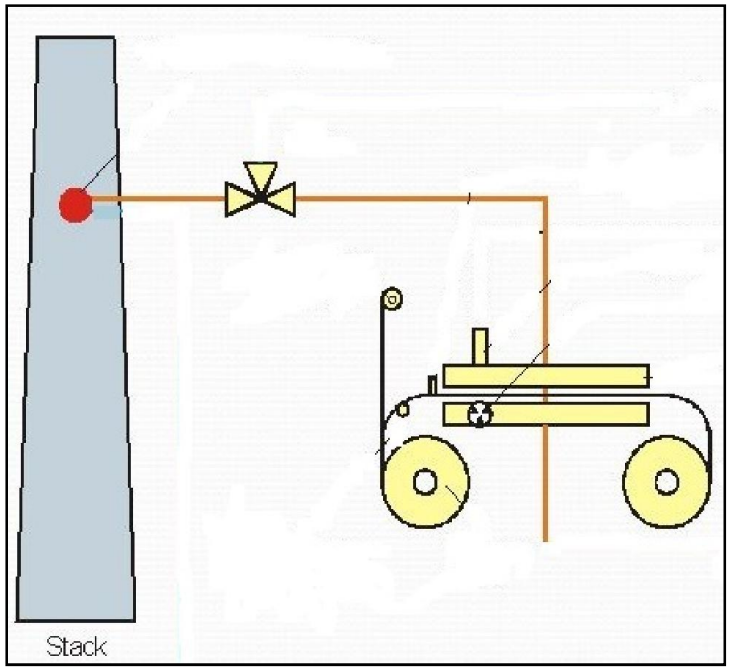
Extractive Particle Monitoring

Merits

- Direct Measurement
- Work in wet gas application
- Suitable for all the application

Demerits

- Difficult to install
- Not cost effective
- Dust transportation is difficult
- Use hazardous source

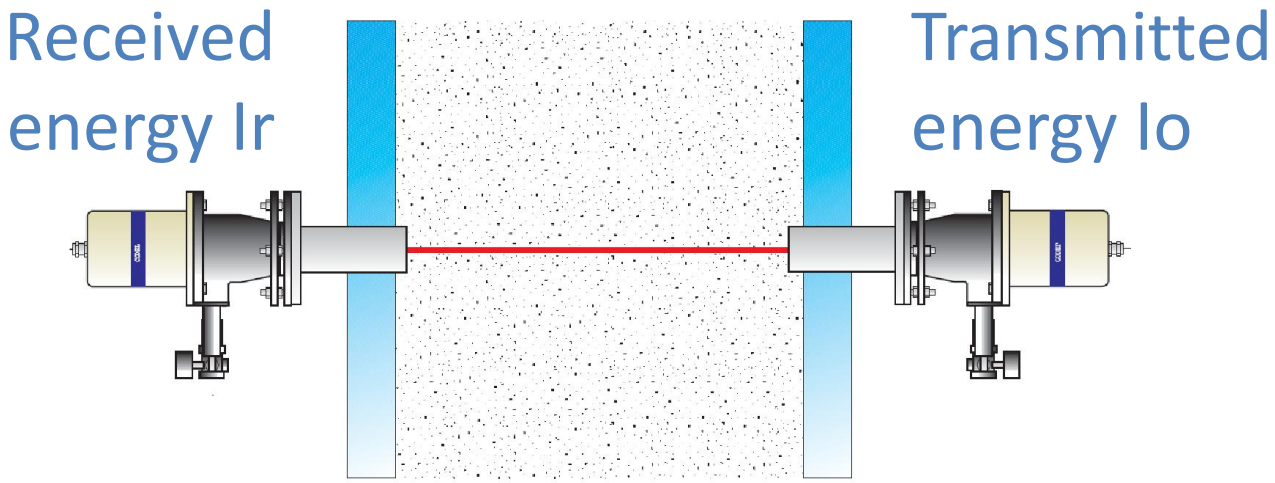


Dust Measurement

To measure dust emission, first we need to measure Opacity of the dust in the flue gas This is the simplest continuous measurement. It is the opposite of transmittance expressed as a percentage.

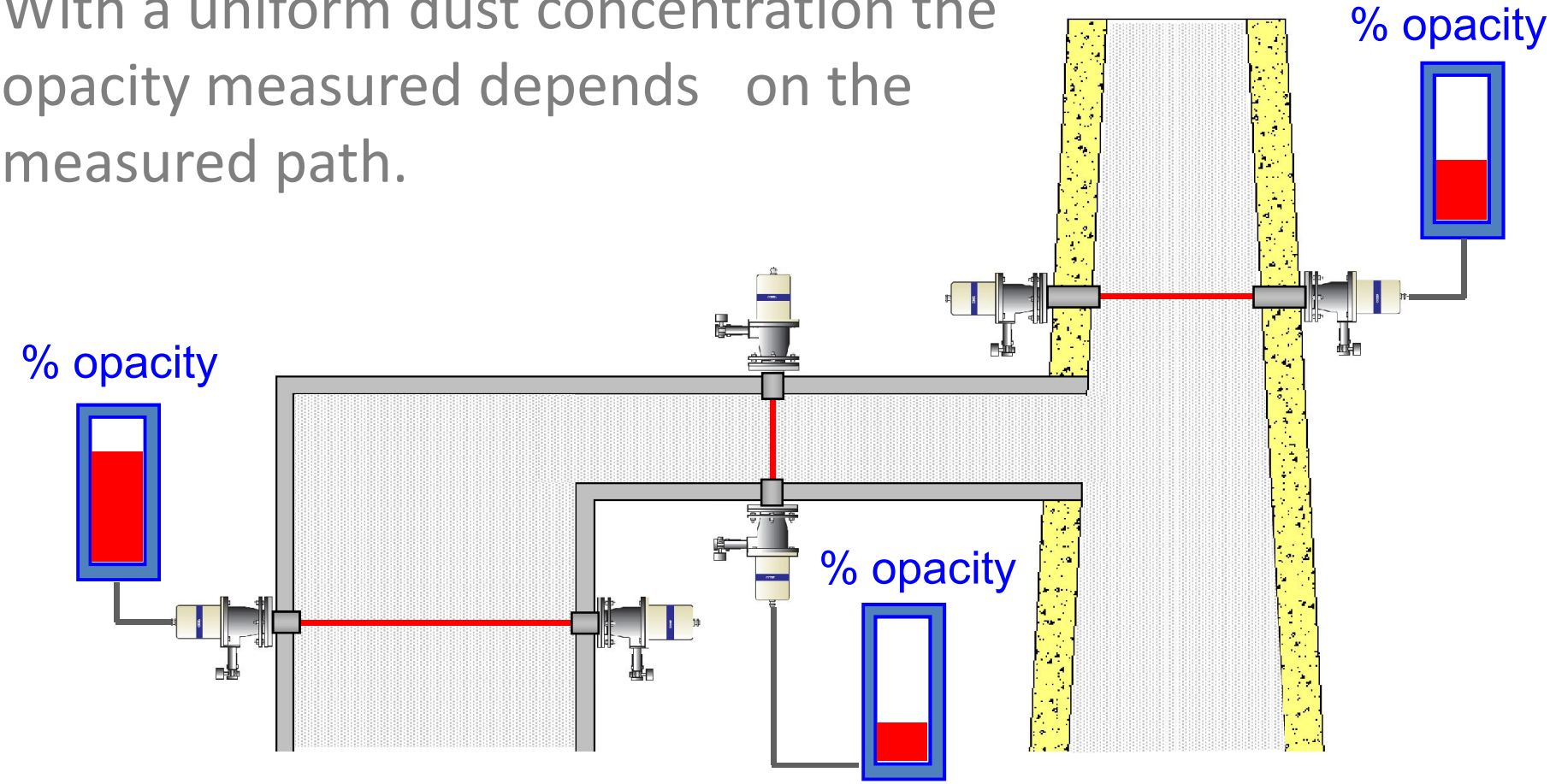
Transmittance T = Ir/Io

%opacity = (1-T)x100



Opacity

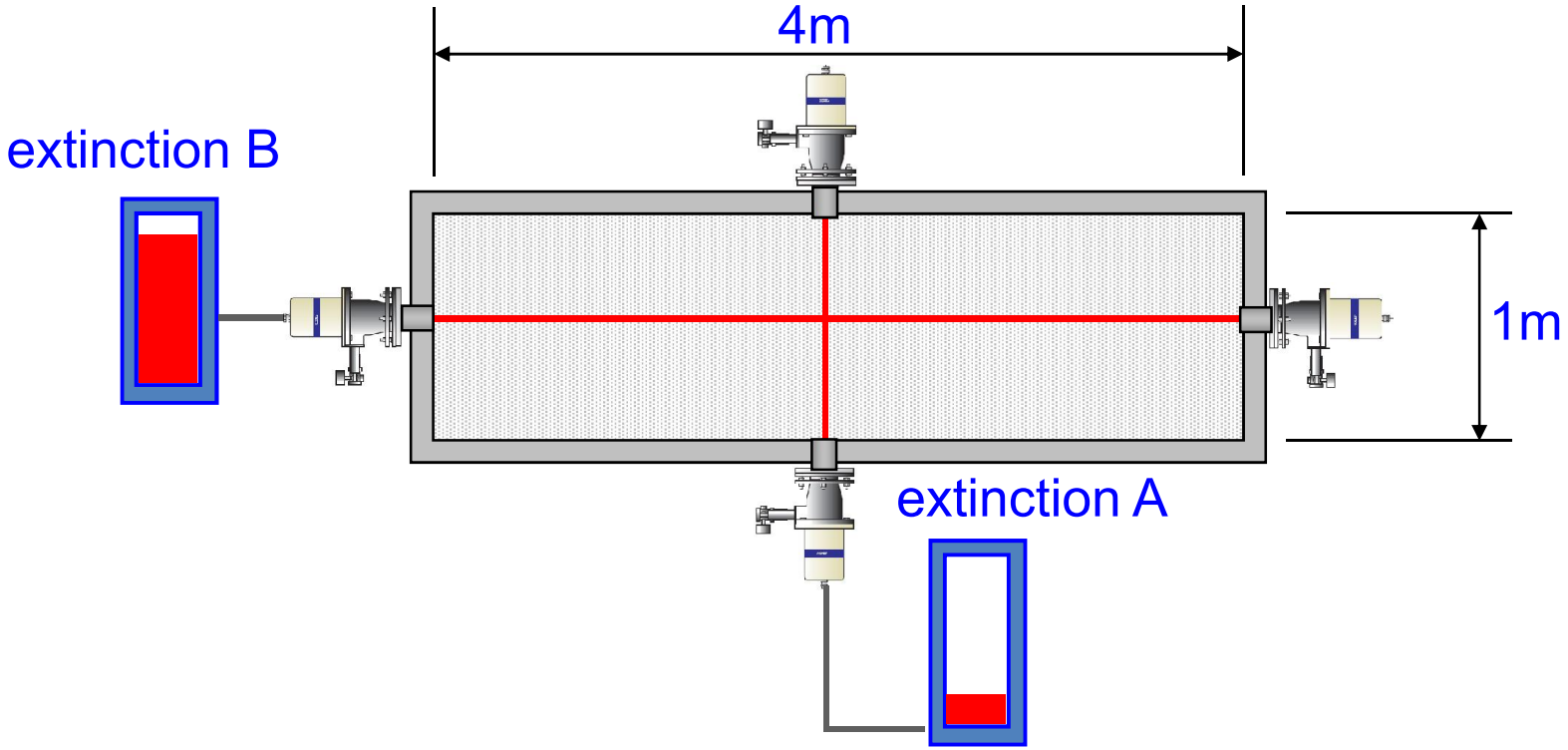
With a uniform dust concentration the opacity measured depends on the measured path.



Extinction

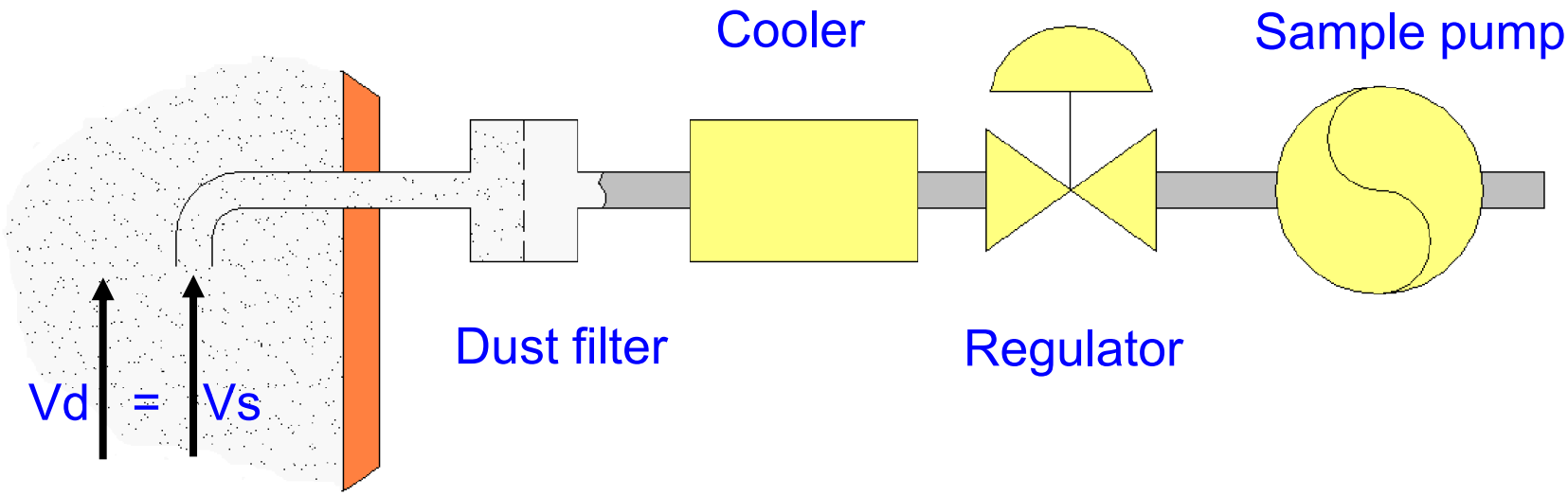
Extinction is proportional to the number of particles in the measured path.

If ‘A’ is 0.3 extinction, ‘B’ will be 4x0.3=1.2 extinction



Iso-kinetic sampling

Extinction is proportional to particulate density. The ratio is established by sampling a known volume of gas on each individual installation and collecting the particles in that sample.



Dust density in mg/m3

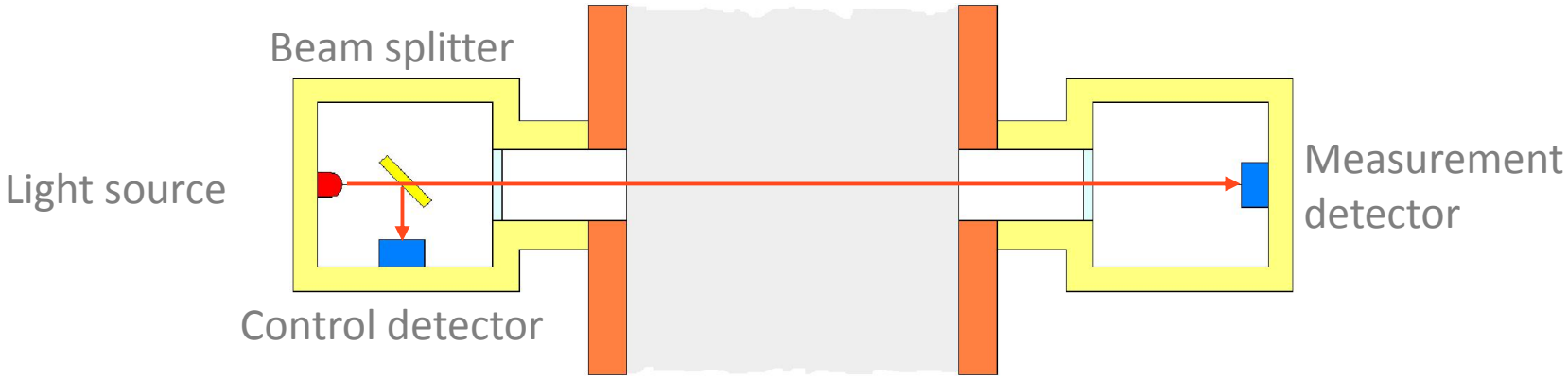
During iso-kinetic dust sampling, it is possible to produce a Dust Factor for each individual installation.

$$\text{dust factor} = \frac{\text{sampled mg/m3}}{\text{average extinction}}$$

During normal operation:

mg/m3 = dust factor x measured extinction

Single Pass Transmissometer



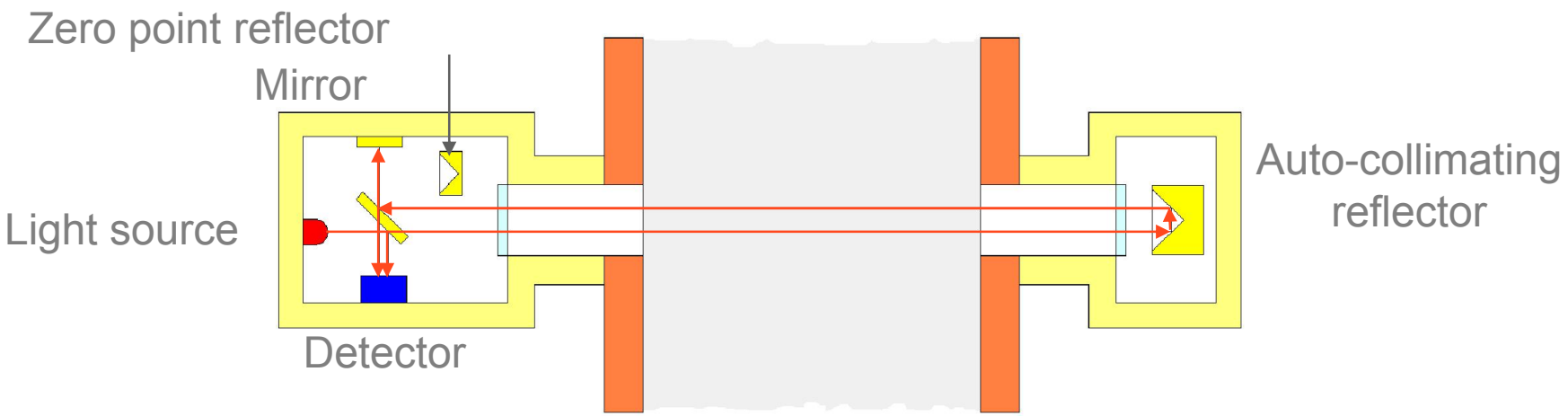
Merits

- Simple low cost technique
- High efficiency air purges to keep windows clean

Demerits

- Cannot differentiate between gas-borne particles and window contamination
- Cannot detect misalignment errors

Double Pass Transmissometer



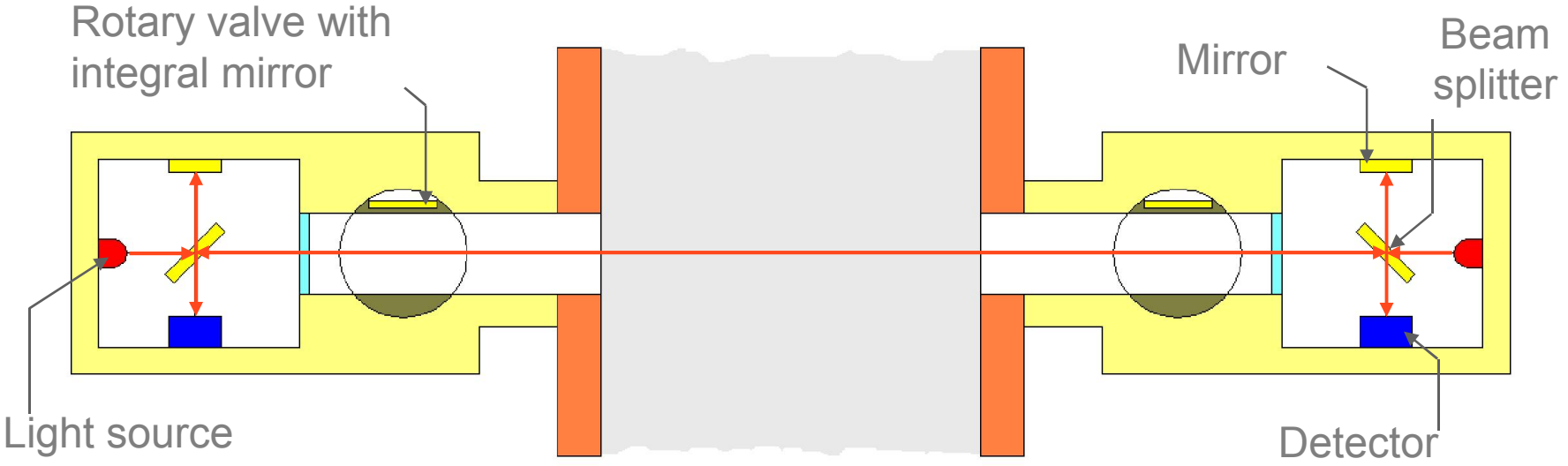
Merits

- Air purges to keep windows clean
- Zero check reflector in transceiver unit

Demerits

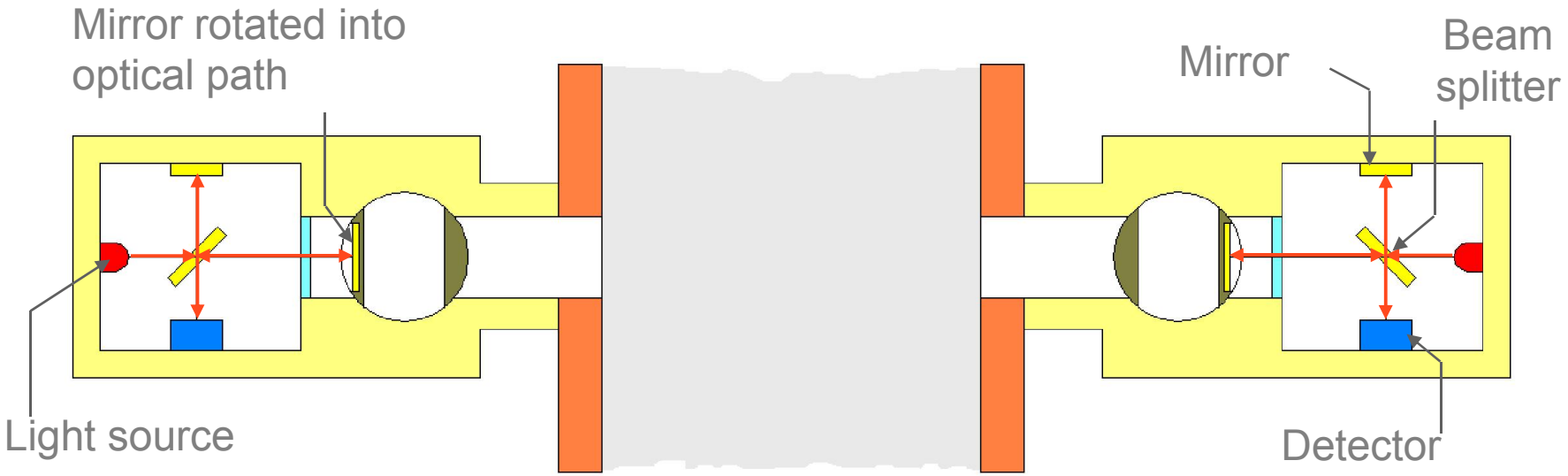
- Window contamination check on transceiver only
- Non-linear due to back scatter from the particles
- Cannot detect misalignment errors

Double Beam Transmissometer - Measuring



- High efficiency air purges keep windows clean
- Alternate, bi-directional measurement provides automatic misalignment check
- Linear – not influenced by back scatter effects

Double Beam Transmissometer Contamination check



- Protected mirrors check individual contamination on both transceivers
- Rotary valves protect transceivers during purge air or power failure

Data Normalisation

International legislation demands that any dilution at the point of measurement must be corrected. The measurement can be diluted by:

- Changes in temperature
- Changes in absolute pressure
- Excess air
- Water vapour

It is necessary to measure these complementary parameters and apply the appropriate correction. This is known as Normalisation.
Normalised values are in mg/Nm^3

Technology selection Matrix

Selection Criteria	Tribo	Opacity	Light Scattering	Extractive
Duct < 1 m	✓	✕	✓	✓
Duct 1 – 4 m	✓	✓	✓	✓
Duct > 4 m	✕	✓	✕	✓
Flue gas temperature > 500°C	✕	✓	✓	✓
Flue gas temperature below dew point	✕	✕	✕	✓
Larger Particles > 20 µm	✓	✓	✕	✓
Dust concentration from 30 to 100 mg/Nm³	✓	✓	✓	✓

Mounting Location

- Safety, Clear approach should be taken into consideration while selecting the location.

- To ensure laminar flow the Particulate Matter monitoring systems shall be installed at a distance atleast at 8 times the stack diameter downstream and 2 times stack diameter upstream from any flow disturbance.

- Ideally, particulate matter monitoring instrument installation required to fulfil the desired criteria. In extreme cases, the location at a distance atleast at 2 times the stack diameter downstream and 1/2 times stack diameter upstream from any flow disturbance.

- Mounting location 500 mm below the manual sampling.

Discussion

Points need to check

- Mounting location
- Approach to the instrument
- Type of instrument & its suitability per selection chart
- Instrument power connection
- Current output
- Dust factor in case of opacity
- Tribo probe insertion length
- Latest instrument verification report with reference gravimetric method.

Maintenance Check

- Operation of instrument
- Instrument power
- Purging air status
- Optical clearance between transmitter & receiver
- Display – fault status
- In case of Tribo – check probe coating

Maintenance Check

- Span
  - Span range shall be 2.5 times of the emission rate

- Diagnostic
  - Communication error
  - Transmittance
  - Misalignment Check
  - Dust factor

- Current output status

- Modbus output status

Maintenance Check - Calibration

- True zero calibration done in plant shut down condition only.
- The Particulate Matter continuous monitoring system shall be calibrated at different operational loads against Isokinetic sampling.
- Initially result from dust monitor shall be cross checked fortnightly, after proven system performance, it can be changed.
- System need to recalibrate after change in fuel, source, detector

Gravimetric sampling – Check Points

- Sampling kit – calibration date
- Leak test for (sampling probe, sampling hose, sampling kit manifolds used)
- Whether sampling is done at each transverse point or not
- Molecular weight corrected with moisture percentage

Thank You …….. GO Green