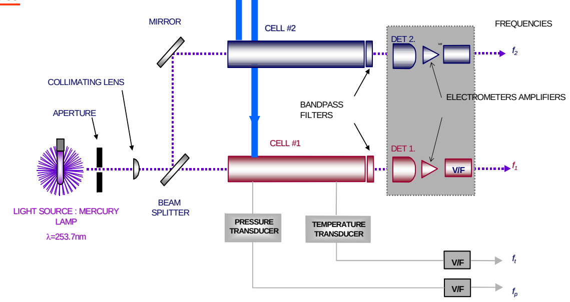
Ozone Standard Reference Photometer

Optical bench schematic

Realisation of the measurement equation :

- P_{mes} and T_{mes} are measured in cell#1
- L is the length of the cells
- D is deduced from the frequencies f_1 and f_2 in two half-cycles



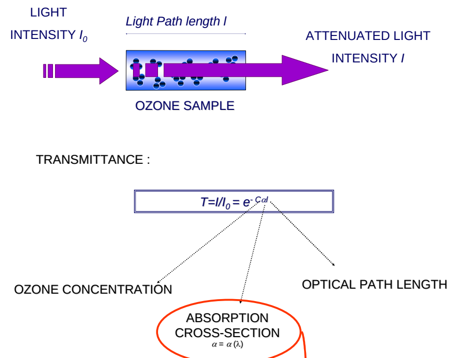
Measurement principle : the Lambert-Beer law

The measurement equation is derived from the Lambert-Beer and ideal gas laws. The number concentration (C) of ozone is calculated from :

$$C = \frac{-1}{2\alpha l}\frac{P_{std}}{P}\frac{T}{T_{std}}\ln(D)$$

where

α is the absorption cross-section of ozone at 253.7nm in standard conditions of temperature and pressure.
L is the optical pathlength of one of the cells,
T_{mes} is the temperature measured in the cells,
T_{std} is the standard temperature (273.15 K),
P_{mes} is the pressure measured in the cells,
P_{std} is the standard pressure (101.325 kPa),
D is the product of transmittances of two cells

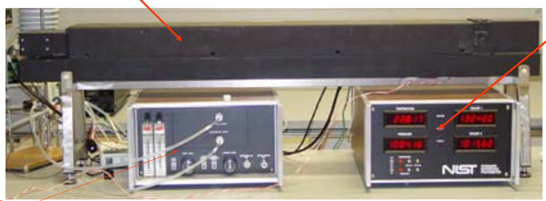


Standard Reference Photometer

The ozone Standard Reference Photometer is used to calibrate ozone analysers in the range 0.2 -1000 nmol/mol of ozone in dry air. It contains an ozone generator to deliver the same ozone concentration to its photometer part (optical bench) and to the instrument to be compared to (or calibrated). A comparison between two photometers consists of producing ozonized air at different mole fractions over the required range, and measuring these with the photometers. The comparability of the two instruments is evaluated with a linear regression fit performed on the two sets of measured ozone mole fractions.

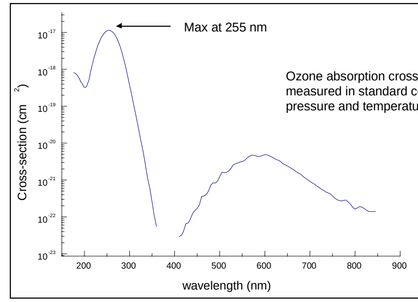
Optical bench

Electronic module



Ozone generator and gas distribution

The absorption cross-section is wavelength dependent

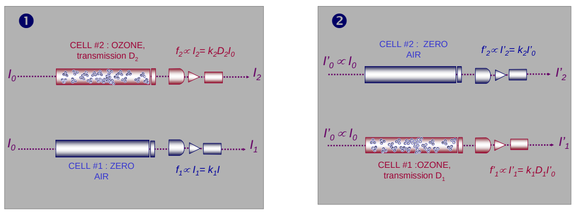


The two cells principle in details

The measurement of one ozone concentration in the SRP is performed in two half-cycles with an inversion of the two cells roles.

First half-cycle : the ozone sample is injected in cell #2

Second half-cycle : the ozone sample is injected in cell #1



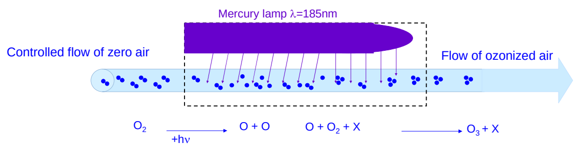
If the ratio D is defined as $D= (f_2/f_1)(f'_1/f'_2) = D_1D_2$

$D = e^{-c\alpha l1} \times e^{-c\alpha l2} = e^{-c\alpha(l1+l2)}$ =Transmittance of a cell of length l_1+l_2

- The light path length is two times one cell length, improving the instrument resolution (0.20 nmol/mol).
- The use of two gas cells overcome the instabilities coming from the light source.

Ozone production

The very reactive nature of ozone precludes its storage in cylinders. As a consequence, ozone has to be produced and measured simultaneously. Each SRP system includes an ozone generator. This generator is based on the photolysis of O_2 molecules contained in pure air using radiation at 185 nm.

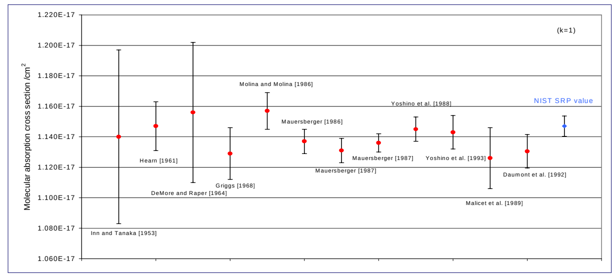


$O_2 \xrightarrow{+h\nu} O + O \qquad O + O_2 + X \rightarrow O_3 + X$

- The lamp intensity is varied to obtain different ozone concentrations
- The generator stability depends on the lamp intensity stability
- Importance of the zero air quality :
  - no element reacting with O_3
  - no interfering element

Ozone absorption cross-section value at 253.7 nm

The ozone absorption cross-section at 253.7 nm has been measured at least 12 times since 1953. The conventional value recommended by the ISO standard 13964[1] is : 1.147 10^{-17} cm^2/molecule with an associated uncertainty of 1.5% at 95% level of confidence.



1 :ISO 13964:1998, Air Quality - Determination of ozone in ambient air - Ultraviolet photometric method