OZONE ANALYZER BMT 961 TPC
with Temperature and Pressure Compensation

The OZONE ANALYZER BMT 961 TPC measures not only the density of the ozone in the cuvette (in **g/m³**, mass per volume), but additionally temperature and pressure of the sample gas. From these three quantities the instrument computes the density of the ozone **as if the sample gas would be at Normal Temperature and Pressure** (NTP: $0^{\circ}C$ and $1\,atm = 1.013\,mbar$, see IOA 002/87 F). The displayed quantity is **g/Nm³** (grams of ozone per Normal cubic meter of sample gas).

The temperature is measured in the cuvette block since the temperature of the gas in the cuvette is nearly that of the cuvette block.

The pressure of the sample gas is measured just before it enters the cuvette. The pressure transducer is measuring **absolute** pressure of the sample gas. It is housed in a stainless steel capsule with a welded stainless steel membrane. Stability of the transducer is high. Nevertheless it should be checked from time to time.

The electric pressure signal is provided at terminal **10** of the 18 pole terminal block of the POWER SUPPLY BMT 961 P. Common is provided at terminals **16** and **18** of the terminal block. Voltage at terminal **10** is nominally zero at zero absolute pressure (vacuum), and it is nominally +10 V at the instrument's nominal pressure **Pmax** (2.1 or 3.5 bar abs, as indicated on the label at the rear panel of the OZONE ANALYZER BMT 961 TPC).

Zero offset of the pressure transducer can be adjusted with a trimming potentiometer which is located at the rear panel. To check, or to adjust, the pressure signal the cuvette of the analyzer should be vented to the atmosphere. Atmospheric pressure **Pa** should be known from a good barometer. Voltage at terminal 10 now should be **10 Pa/P max** [V]. If not, adjustment has to be made with the trimming potentiometer mentioned above.

When the cuvette is vented to the atmosphere and the push button "TEST 50 % (FROM ZERO)" is pressed, temperature compensation is cancelled, and the reading of the analyzer is 50 % of range, if the ambient pressure would be 1 atm = 1.013 bar abs. If the ambient pressure is e.g. 1.030 bar abs the displayed value would be 49.2 % (50 x 1.013/1.030 = 49.2). This is another way to roughly check the pressure transducer.

At terminal 17 of the terminal block the temperature compensated (but not pressure compensated) signal is provided. When the push button "TEST 50 %" is pressed, temperature compensation is cancelled, too. Voltage at terminal 17 has to be +5.00 V now, independently of the cuvette pressure, as long as the ozone concentration is zero.

The TPC voltage signal 0 - 10 V (concentration signal compensated for temperature and pressure, as well) is connected to terminal 11 (common is at terminals 16 and 18). The TPC current signal 4 - 20 mA is connected to terminal 9 (common - or return - is at terminal 8).

Attention! Terminal 11 has to be connected with terminal 15 to make the instrument display the TPC concentration.

Measurement range vs. pressure

The nominal range in g/Nm^3 can be utilized only at a pressure equal or below the Normal pressure of 1 atm. This is due to the fact that the UV photometer "sees" only the amount of ozone contained in the cuvette, no matter at which pressure the sample gas would be. Actually the range limit of the photometer is reached when the concentration equals the nominal range in g/m^3. At e.g. 2 atm the limit is only 50 % of the nominal range in g/Nm^3. With an overrange reserve of 10 % the measurement limit of the instrument is given by the diagram.
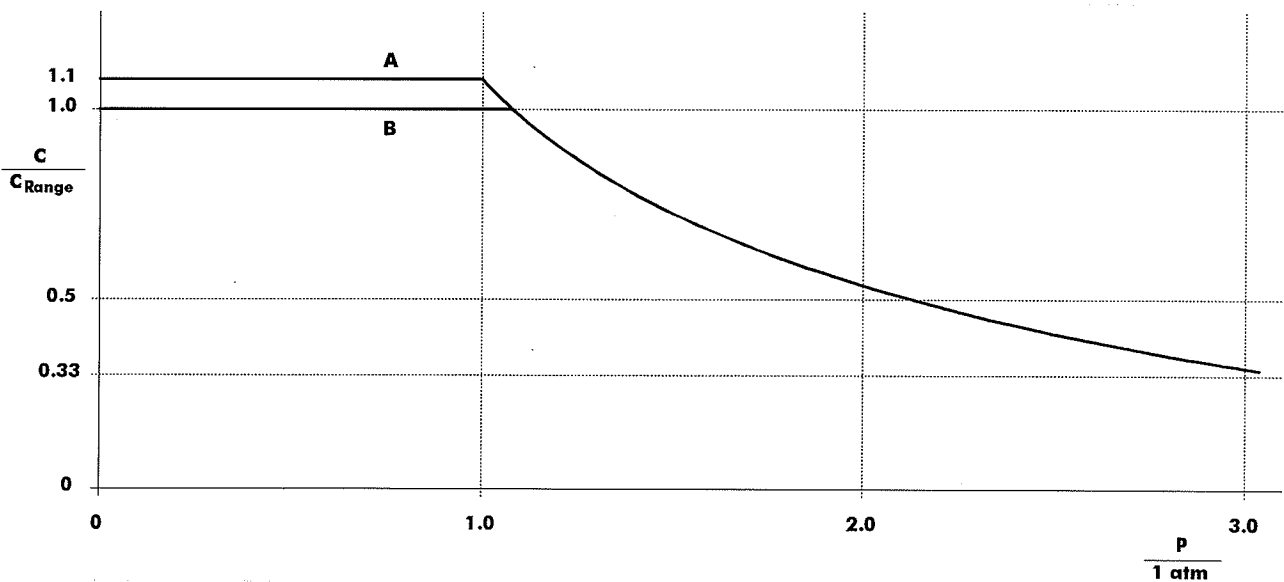
A: all ranges, except 20 and 200 g/Nm^3
B: ranges 20 and 200 g/Nm^3 (display 19.9 or 199.9, resp.)

OZONE CONCENTRATION MEASUREMENT IN A
PROCESS GAS BY U.V. ABSORPTION

OBJECT

The present standard method concerns the determination of ozone in air, oxygen or other process gases in the range of 1 to 300 g/m^3.

BACKGROUND

The strong absorption of ozone between 200 and 300 nm (Hartley band) can be used for the determination of ozone concentration in the gas phase. The method is based on the Lambert-Beer absorption law in the form

$$I = I_o \, 10^{-Acd} \qquad (1)$$

where I and I_o are the measured U.V. intensities passing the absorption cell with and without ozone present. c is the ozone concentration in mol per litre, d the internal width of the absorption cell (cm), and A the molar extinction coefficient in 1 mol^{-1} cm^{-1}.

The value of A is accurately known for the wavelength of the mercury resonance line at 253.7 nm which is close to the absorption maximum of ozone. Most spectro-photometers are capable of measuring the absorbance or optical density (OD).

$$OD = \log \frac{I_o}{I} = Acd \qquad (2)$$

from which the ozone concentration c can be derived

$$c = \frac{OD}{Ad} \qquad (3)$$

To obtain the normal concentration C_N at standard conditions (STP) the temperature T and pressure P in the absorption cell are required

$$C_N = \frac{OD}{Ad} \, \frac{P_N}{P} \, \frac{T}{T_N} \qquad (4)$$

The standard conditions (STP) are T_N = 273.15 K, P_N = 1.013 x 10^5 Pa (corresponding to 0°C and 760 Torr or 1013 mb). Equation (4) gives the ozone concentration mole per litre (at STP). To obtain the concentration in g/m^3 the value has to be multiplied by the factor 48 000.

The molar absorption cross-section (base 10) of ozone at the wavelength $\lambda = 253.7$ nm is

$$s_{M, 10} = 300 \ m^2 mol^{-1}$$

within an uncertainty of less than 1% resulting in a molar extinction coefficient (base 10)

$$A = 3000 \ l \ cm^{-1} \ mol^{-1} \ (STP) \pm 30$$

PROCEDURE

Only ozone resistant materials should be used (such as glass, quartz, PTFE). The gas is passed through a flow-through absorption cell with quartz windows. The absorbance can be measured either with a double-beam spectrophotometer with a wavelength setting of 253.7 nm and a slit width corresponding to about 1 nm resolution or with a double-beam absorption set-up using a low-pressure mercury lamp and a suitable interference filter. Single path instruments with an incorporated internal standard can be used as an alternative.

The accuracy of the apparatus should be checked with calibrated quartz filters having an optical density of 0.5 - 1 at 253.7 nm (10 - 30% transmission), or with the iodometric method (001/87 of IOA Standardisation Committee Europe). This is particularly the case for industrial monitors.

To avoid ozone destruction a minimum gas flow of 1 litre per minute should flow through the absorption cell.

For precision measurements the width of the absorption cell should be chosen with respect to the ozone concentration to give an absorbance between 0.5 $\leq OD \leq 1.0$. $\frac{I_0}{I} = 3,2 \div 10$

If single-beam instrumentation is used the settings of 0% and 100% transmission have to be checked regularly (every 30 - 60 minutes). Particular care must be taken to avoid leakages in the gas transfer.

ACCURACY

The U.V. absorption technique can be used in the concentration range of up to 300 g/m³. With good instrumentation an absolute accuracy of about $\pm$ 2% can be attained. There is no interference from other species that may possibly be found in the output of ozone generators (nitrogen oxides, H_2O_2, HNO_3).

* * *

Brussels, 1987

IOA Standardisation Committee
c/o CIBE
764, Chaussée de Waterloo
B - 1180 Brussels