LINEARITY OF THE MOCON® COULOX® SENSOR

R&D study data confirms the high accuracy of the COULOX sensor used in MOCON oxygen permeation analyzers.

Background

For many years, AMETEK MOCON has used its proprietary COULOX sensor to measure oxygen transmission rate (OTR) per ASTM D3985, on the legacy and the Next Generation OX-TRAN® permeation analyzers. The sensor is considered absolute, as every molecule counted provides a linear response within its entire measurement range. Therefore, it requires no calibration.

Basic Theory

According to Fick's Law, for an isotropic material, the rate of transfer of a diffusing substance through a unit area of a section is proportional to the concentration gradient measured normal to the cross section, i.e. :

$$F = - D \, dc/dx$$

In other words, the permeation rate of a "Fickian" material is linearly affected by the concentration of the permeant passing through it or the driving force. When determining the linearity of a permeation instrument at different driving force levels, some parameters need to be kept constant, including the test temperature, the test area, test gas and the system purge zero.

It is very important to verify the permeant's concentration rather than use the value on the tank tag. Leaks and tank certification errors can significantly affect test results when using driving forces below 21% oxygen. Dry gas is also important because PET's OTR is sensitive to low RH changes (0-25% RH).

OTR STUDY DISPLAYS THE LINEAR BEHAVIOR OF COULOX SENSOR

TECHNICAL NOTE

Methodology and Setup

The OTR linearity study was carried out on a MOCON OX-TRAN 2/20 ML. A masked 1 cm^2 PET film was used because of its well-known behavior and characteristics. The test conditions were maintained as follows throughout the study:

Test Temperature Range	23°C ± 0.5°C
Test gas flow rates	10 cc/min
Carrier gas (N2) flow rate	10 cc/min
Test sample	NIST traceable PET film (5 mil, with a test area of 1 cm^2)
Ambient pressure	Auto - measured and compensated to 760 mmHg for all data points obtained

Above parameters were applied for both test cells A and B on the OTR analyzer for duplicate runs simultaneously.

The only variable in this study was the oxygen concentration, which was 100%, 21.9%, 9.83% and 0.541%, respectively. These values were verified by a MOCON Head Space Analyzer, which was directly connected to the outlet of the oxygen test gas stream for continuous online measurements. The OTR results were presented in the table below and in Fig 1.

O_2 Concentration	Oxygen Transmission Rate cc/(m^2 • day)	
%	Sample A	Sample B
100	0.5126	0.5272
21.9	0.1044	0.1127
9.83	0.0466	0.0512
0.541	0.0024	0.0026

The graph in Figure 1 indicates a good linear fit for both samples A and B. The coefficient of determination (r^2) is 0.99979 and 0.99993 for samples A and B, respectively. This linear fit is particularly good considering the OX-TRAN 2/20 ML's repeatability specifications of ± 0.005 cm/(m^2 • day) or 1% of reading.

Conclusion

The presented results display the linear behavior of the COULOX sensor. This results in high accuracy throughout the test range specifically toward the low end of the sensitivity limit.

The following MOCON Next Generation oxygen permeation analyzers (Fig. 2) use this COULOX sensor (Fig. 3).

- OX-TRAN 2/22 OTR Analyzer
- OX-TRAN 2/28 OTR Analyzer
- OX-TRAN 2/40 and 2/48 OTR Analyzer for Packages

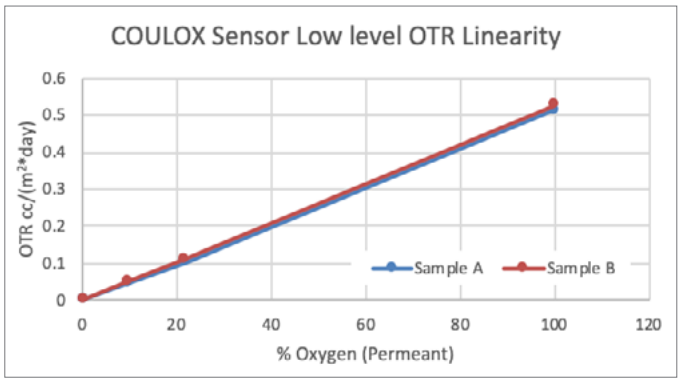

Fig 1. COULOX Sensor Linearity Study (OTR vs %Oxygen)

Fig 2. MOCON OX-TRAN Analyzers using this COULOX Sensor

Fig 3. MOCON COULOX sensor

mocon® / AMETEK®

© 2025 AMETEK MOCON. All rights reserved. Subject to modification without notice.
TN-PPS-5019-Linearity of COULOX Sensor-0225-1.2

AMETEK MOCON
7500 Mendelssohn Ave. N
Minneapolis, MN 55428 USA
info.mocon@ametek.com
www.ametekmocon.com