Ethylene Oxide EC Sensor for Selected VOCs

Introduction

The ethylene oxide (ETO) electrochemical sensor responds to some VOCs in addition to ETO itself, This Technical/Application Note compares the ETO sensor to the 4-Series PID for VOC detection. The 4-Series PID is used in the POLI multi-gas detectors and the ETO sensor can be used as either a UNI single-gas monitor or installed into a POLI. Neither of these low-cost sensors can match the speed and sensitivity of our high-performance NEO PIDs, but they may be suitable when small size or cost are at a premium, or moderate performance is acceptable.

Performance Overview

The summary table below compares the main specifications of the ETO vs PID sensors, the latter with standard 10.6 eV lamp. The ETO sensor costs less initially but requires more frequent replacement and thus may not cost much less in the long run. Its range is not as wide but the detection limit near 0.5 ppm is essentially the same as for the PID. The main advantage of the PID is its much faster response time of about 10 seconds, versus 2 minutes for the ETO sensor. The ETO sensor does have a small positive (but transient) interference due to very high humidity as in heavy breath, but it does not exhibit the quenching effects on VOC response observed with the PID.

ETO vs PID Summary Table

Parameter	ETO EC Sensor	POLI 4-Size PID Sensor (10.6 eV) †
List Price	$248	$775
Range	0-100 ppm, 0-200 ppm	0-2000 ppm
Display Resolution	0.1 ppm	0.1 ppm
Detection Limit	0.5 ppm*	0.5 ppm
Response t_{90}	120 seconds	10 seconds
Warranty	1 year	1 year
Life Expectancy	1 year	2 years
Humidity Effect	No Response Loss @ 45% RH	20% Response Loss @ 45%RH 50% Response Loss @ 100%RH
10-s Breath Test	1.1 ppm	0.1 ppm
Methane Effect	≤10% effect @90%Vol CH_4	No VOC response in pure methane
Oxygen Required	No, if exposure is <5 min	No

† A ppb-range (0.01-200 ppm) 4-size PID is available for the POLI at $920 which has resolution and detection limits 10-fold lower, with other parameters the same.

* Theoretical detection limit; current deadband is 4.5 ppm, which can be adjusted to 0.5 ppm for special applications (contact mPower).

ETO Sensor vs PID Chemical Response

The cross-sensitivity table below compares the response of the ETO sensor and PID to various chemicals. The ETO sensor detects mainly low-molecular-weight compounds like methanol, formaldehyde, formic acid, carbon monoxide, hydrogen cyanide and methyl mercaptan. Other small compounds like ethanol, ethylene oxide and acrylonitrile have better sensitivity on the ETO sensor than on the PID. Conversely, the PID responds better to larger molecules including fuel-type hydrocarbons such as hexane and benzene, solvents like trichloroethylene, acetone and ethyl acetate, and to hundreds of other organic compounds listed in TA Note 2. Thus, the ETO sensor fills a niche subset of VOCs that the PID often has difficulty to measure.

Methanol detection is of particular interest because it is commonly requested by Hazmat teams, and there is no other convenient way to monitor for it. PID requires 11.7 eV lamps, which last only 1-2 months, gas detection tubes don't give continuous monitoring, and flame ionization detectors (FIDs), are costly and cumbersome. The ETO sensor offers a good, low-cost continuous monitoring and can also measure ethanol and isopropanol at equal or better sensitivity than the PID.

Acrylonitrile, used in the manufacture of rubber and plastics, is another compound that the ETO sensor can measure while PID requires the short-lived 11.7 eV lamp. The detection limit of about 5 ppm makes it unsuitable for measurements at the OSHA TWA level of 2 ppm, but useable for warning against Ceiling levels of 10 ppm.

For formaldehyde, we recommend using the EC sensor designed specifically for this gas, because the ETO sensor does not have a low enough detection limit.

Cross-Sensitivity Table

	ETO EC Sensor		**POLI PID†**	
Compound	**ETO Sensor CF***	**Det. Limit (ppm) ‡**	**PID Isobutylene CF* (10.6 eV)**	**Det. Limit (ppm) †**
CO (Carbon Monoxide)	2.3	1.2	NR**	NR
HCN (Hydrogen Cyanide)	2.8	1.4	NR	NR
Formaldehyde	*0.4*	0.2	NR	NR
Formic Acid	*1.4*	0.7	NR	NR
Acrylonitrile	9.7	5.0	NR	NR
Methanol	0.9	0.5	NR	NR
Ethanol	1.5	0.8	10	5
Isopropanol	4.0	2.0	6	3
Ethylene Oxide	1.0	0.5	13	6.5
Epichlorohydrin	2.7	1.3	8.6	4.3
Methyl Mercaptan	1.4	0.7	0.54	0.3
NO (Nitric Oxide)	1.6	0.8	6	3
NO_2 (Nitrogen Dioxide)	6.1	3.1	16	8
Ethylene	1.1	0.6	3.6	1.8
1,3-Butadiene	0.8	0.4	0.74	0.4
Isobutylene	1.7	0.9	1.0	0.5
Vinyl Chloride	1.4	0.7	2.0	1.0
Trichloroethylene	NR**	NR	0.61	0.6
Acetone	NR	NR	1.1	0.6
Ethyl Acetate	NR (CF~50)	NR	4.3	2.2
Benzene	NR	NR	0.5	0.3
n-Hexane	NR (CF~100)	NR	3.8	1.9
Methane	NR	NR	NR	NR
Methylene Chloride	NR	NR	NR	NR
Acetonitrile	NR (CF~80)	NR	NR	NR

* CF = Correction Factor = (response of ETO)/(response of compound).
PID CF = (response of isobutylene)/(response of compound) (For PID, see TA Note 2).

** NR = No Response † The 0.01-200 ppm PID has 10-fold lower detection limits.

‡ Theoretical Detection Limit; deadband is 4.5 ppm. Contact mPower if smaller deadband is needed.

Measurements in Methane and at High Humidity

The ETO sensor has a slight positive interference at high humidity but humidity does not quench the VOC response as it does on the PID. A unique feature is the ETO sensor's ability to measure VOCs in a pure methane matrix gas, which completely quenches the VOC response on a PID. Thus it could be used to measure odorants like methyl mercaptan added to natural gas, although there are mercaptan and THT sensors which are more selective for this purpose. As with most EC sensors, oxygen is required in the electrochemical process, but measurements can be done in inert gas such as natural gas or nitrogen if the measurements are kept short (<5 min) and the sensor is kept in air between measurements.

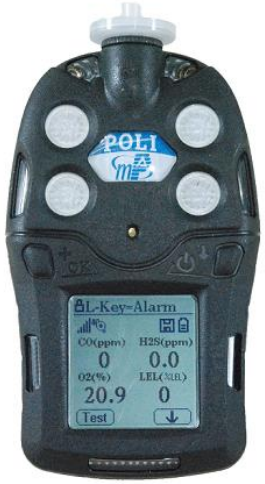
Summary

Beside its main function of monitoring for ethylene oxide, the ETO sensor provides a low-cost option for continuous measurement of small oxygenated carbon compounds like methanol and ethanol that are difficult for a PID. There is little or no effect of humidity or methane gas, which can affect PIDs. When used in a UNI with >2 years battery life, it is particularly useful for detecting alcohols by Hazmat teams, who may need to store sensors for long periods before a need arises. The main drawback of the ETO sensor is its fairly long response time of about 2 minutes. The detection limit of a few ppm is not low enough for highly toxic compounds like acrylonitrile, but quite suitable for less toxic compounds like alcohols.

ETO Sensor Suitability for VOCs

Advantages	Disadvantages
• Low cost	
• Low maintenance	
• >2 Years lithium battery life for UNI single-gas monitor	
• Continuous measurements	• Slow response (t_{90} ≥2 min)
• Detection Limit low ppm	• Upper range limited to 200 ppm
• Selective for small compounds like methanol and ETO	• Cross-sensitive to CO
• Measures alcohols and acrylonitrile	• Deadband of 4.5 ppm
• No humidity quenching	• Slight response at very high RH
• No effect of methane	

UNI Single-gas ETO Monitor



POLI Multi-gas Monitor with ETO sensor and/or PID