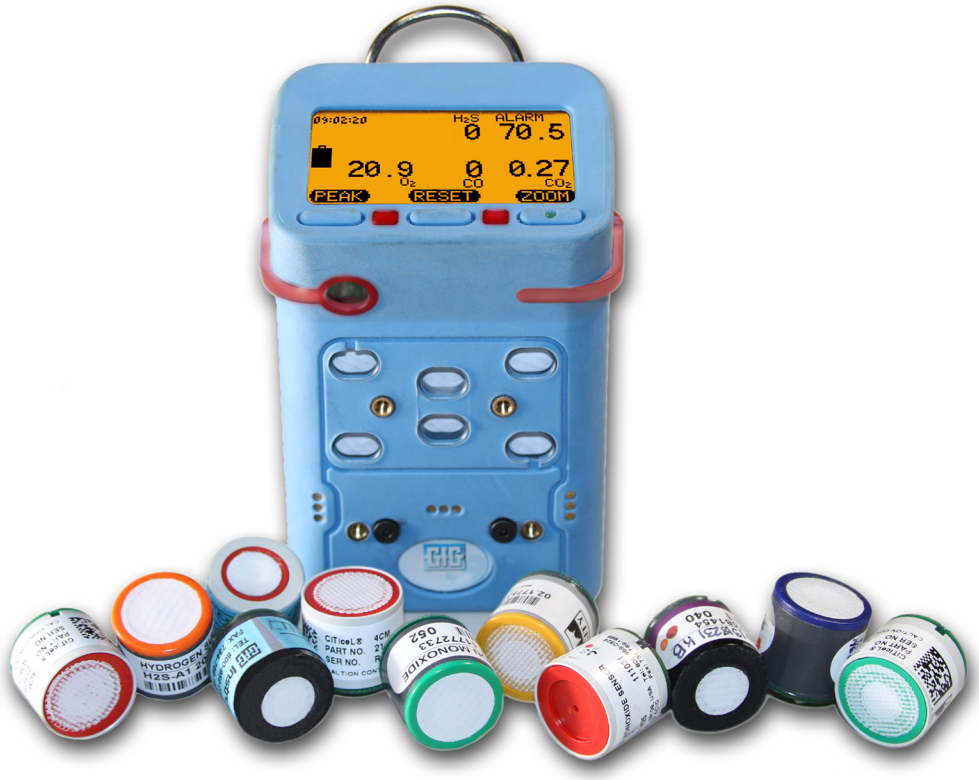
TN 2015:
Electrochemical (EC) sensors: gases measured, ranges and resolution



Substance-specific electrochemical (EC) sensors are available for an increasing number of toxic gases and vapors. Besides the primary gas the sensor is designed to measure, it may be possible to calibrate and use the same sensor to measure other gases with similar chemistries.

Electrochemical (EC) sensors are one of the most common types of sensors used in portable gas detectors. Multi-sensor confined space monitors generally contain an oxygen sensor, a flammable/combustible sensor and one to three additional electrochemical sensors for specific toxic gases. Single-sensor instruments equipped with EC toxic sensors are also extremely popular for use in situations where a single toxic hazard is present.

Electrochemical sensors are available for monitoring for an increasing number of contaminants including hydrogen sulfide (H_2S), carbon monoxide (CO), sulfur dioxide (SO_2), chlorine (Cl_2), chlorine dioxide (ClO_2), ammonia (NH_3), phosphine (PH_3), cyanide (HCN), hydrogen (H_2), ethylene oxide (C_2H_4O), nitrogen dioxide (NO_2), nitric oxide (NO), ozone (O_3), hydrogen fluoride (HF), hydrogen chloride (HCl), phosgene ($COCl_2$), and others.

EC sensors are usually designed to minimize the effects of interfering contaminants, making the readings as specific as possible for the gas being measured. However, most substance-specific sensors still show some cross sensitivity to at least a few other gases. Alternatively, "broad-range" EC sensors are deliberately designed to provide a measurable response to a wide array of contaminants. Most electrochemical sensors fall somewhere between the two extremes in terms of specificity.

The following tables provide a partial list of the gases and vapors detectable by means of EC sensors in GfG products.

Table 1 lists the types of available EC sensors by the gas they are designed to measure, as well as the standard range and resolution for each sensor.

Table 2 shows other substances which are also detectable by using sensors listed in Table 1.

Always consult the manufacturer before using an EC sensor to measure a different gas from the one it is primarily designed to measure!

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Table 1: Available EC sensors, standard ranges and resolution

Gas	Formula	Sensor model	Resolution	Range(s)	G450	G460	Micro	Fixed	Notes
Ammonia	NH_3	NH3 3E 5000 SE	1.0 ppm 5.0 ppm 10.0 ppm	0 - 200 ppm 0 - 500 ppm 0 - 1,000 ppm		X	X	X	
Arsine	AsH_3	AsH3 3E 1 F LT	0.03 ppm	0 - 1.0 ppm				X	
Carbon monoxide	CO	4CM	0.1 ppm 1.0 ppm 1.0 ppm	0 - 300 ppm 0 - 500 ppm 0 - 1,000 ppm	X	X	X	X	
Carbon monoxide (CO-H)	CO	2CF	1.0 ppm 1.0 ppm 1.0 ppm	0 - 500 ppm 0 - 1,000 ppm 0 - 2,000 ppm	X	X	X	X	CO sensor with low H_2 cross sensitivity
CO / H_2S	CO H_2S	4COSH	CO: 1.0 ppm H2S: 0.2 ppm	0 to 500 ppm 0 to 100 ppm		X			Dual channel CO / H_2S
Chlorine	Cl_2	Cl2 3E 50	0.1 ppm	0 - 10.0 ppm		X	X	X	
Chlorine dioxide	ClO_2	ClO2 3E 10	0.1 ppm	0 - 2.0 ppm		X	X	X	
Diborane	B_2H_6	B2H6 3E 1 LT	0.03 ppm	0 - 1.0 ppm			X		
Ethylene oxide (EtO)	C_2H_4O	ETO-A1	0.1 ppm	0 - 20 ppm		X	X	X	
Hydrogen	H_2	4HYT	1.0 ppm	0 - 2,000 ppm		X	X	X	
Hydrogen	H_2	H2 3E 4%	0.01 % vol.	0 - 4.0% vol.		X	X	X	
Hydrogen bromide	HBr	HCl/HBr 3E 30	0.1 ppm	0 - 30 ppm		X	X	X	
Hydrogen chloride	HCl	HCl/HBr 3E 30	0.1 ppm	0 - 30 ppm		X	X	X	
Hydrogen cyanide	HCN	HCN 3E 30 F	0.2 ppm	0 - 50 ppm		X	X	X	
Hydrogen fluoride	HF	HF 3E 10 SE	0.1 ppm	0 - 10.0 ppm		X	X	X	
Hydrogen sulfide	H_2S	4HS-LM	0.1 ppm 0.2 ppm	0 - 100 ppm 0 - 500 ppm	X	X	X	X	
Methyl mercaptan	CH_3SH	TBM 2E	0.3 ppm	0 - 25 ppm		X	X	X	
Nitric oxide	NO	4NT	1.0 ppm	0 - 100 ppm		X	X	X	
Nitrogen dioxide	NO_2	NO2 A1	0.02 ppm 0.04 ppm	0 - 30 ppm 0 - 50 ppm		X	X	X	
Oxygen	O_2	O2-A3	0.1% vol.	0 - 25.0% vol.	X	X	X	X	3-year life
Oxygen	O_2	4OX-V	0.1% vol.	0 - 25.0% vol.	X	X	X	X	2-year life, vented design
Ozone	O_3	O3 3E 1	0.02 ppm	0 - 1.0 ppm		X	X	X	
Phosgene	$COCl_2$	COCl2 3E 1	0.02 ppm	0 - 2.0 ppm		X	X	X	6-month life
Phosphine	PH_3	4PH - Fast	0.1 ppm 0.01 ppm	0 - 10.0 ppm		X	X	X	
Silane	SiH_4	SiH4 3E 50 LT	1.0 ppm	0 - 40 ppm		X	X	X	
Sulfur dioxide	SO_2	4S	0.04 ppm 0.1 ppm	0 - 10.0 ppm 0 - 50 ppm		X	X	X	
Tetrahydrothiophene (THT)	C_4H_8S	THT 3E	1.5 mg/m^3 (0.3 ppm)	0 - 100 mg/m^3 (0 - 50 ppm)		X	X	X	

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Electrochemical sensors are designed with specific usage requirements in mind. The same manufacturer may offer multiple models of sensor for the detection of the same gas, but that are optimized for different sets of interferents and operating conditions. Thus, cross sensitivities may vary widely between different models and brands of sensors. For instance, a Cl_2 sensor that is deliberately designed for use in atmosphere that contains significant background levels of H_2S may be equipped with filters or electrodes which limit the effects of H_2S on the sensor's readings. Chlorine sensors designed for use in atmosphere that does not contain hydrogen sulfide may have a very different relative response.

Note: Some compounds (e.g. BF_3, BCl_3, BBr_3) can be detected indirectly by using their property to react with the moisture present in the ambient air, thus forming compounds for which a specific sensor is available (e.g. HF, HCl, HBr). Other gases can be detected by using cross-sensitivities of some of the sensors.

Very importantly, use of an electrochemical toxic sensor is not always the best approach. Many volatile organic chemical (VOC) vapors are best detected by a photoionization detector (PID) sensor, while combustible gases and vapors are usually measured by means of catalytic combustion (CC) or non-dispersive infrared (NDIR) sensors. Consult the instrument manufacturer for advice on which type of sensor will provide the best performance for your application.

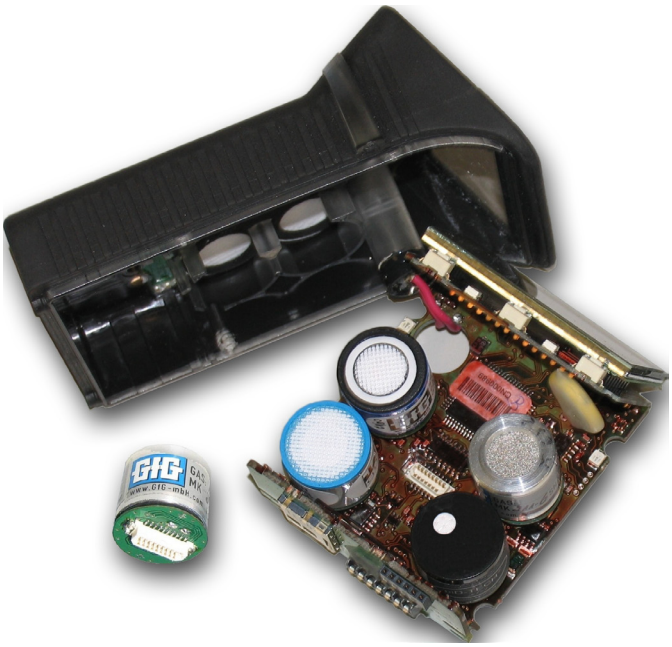

Table 2: Additional toxic gases detectable with EC sensors from Table 1

Gas	Formula	Sensor (ppm)
Acetaldehyde	CH_3CHO	CO
Arsenic trichloride	$AsCl_3$	HCl
Arsenic Trifluoride	AsF_3	HF
Arsenic pentafluoride	AsF_5	HF
Boron trichloride	BCl_3	HCl
Boron tribromine	BBr_3	HCl
Boron trifluoride	BF_3	HF
Bromine	Br_2	Cl_2
Butanethiol	C_4H_9SH	TBM
Carbonyl fluoride	COF_2	HF
Chlorine dioxide	ClO_2	ClO2 or O3
Chlorine trifluoride	ClF_3	ClO2 or HF
Dichlorosilane	SiH_4Cl_2	HCl
Diethylether	$C_4H_{10}O$	EtO
Disilane	Si_2H_6	SiH_4
Disulfur decafluoride	S_2F_{10}	HF
Disulfur dichloride	S_2Cl_2	HCl
Formic Acid	HCOOH	CO
Germane	GeH_4	PH_3
Germanium chloride	$GeCl_4$	HCl
Hydrogen bromide	HBr	HCl
Iodine	I_2	Cl_2 or O_3
Isopropanol	$(CH_3)_2$ CHOH	CO w/o filter
Methanol	CH_3OH	CO w/o filter
Phosphorous trichloride	PCl_3	HCl
Phosphorous pentachloride	PCl_5	HCl
Phosphoryl chloride	$POCl_3$	HCl
Silicon tetrachloride	$SiCl_4$	HCl
Stibine	SbH_3	AsH3
Thiophene	C_4H_4S	THT
Tin tetrabromide	$SnBr_4$	HBr
Tin tetrachloride	$SnCl_4$	HCl
Tin tetrafluoride	SnF_4	HF
Titanium tetrachloride	$TiCl_4$	HCl
Trichlorosilane	$SiHCl_3$	HCl
Trichlortriazine	$C_3Cl_3N_3$	HCl
Trifluorotriazine	$C_3F_3N_3$	HF

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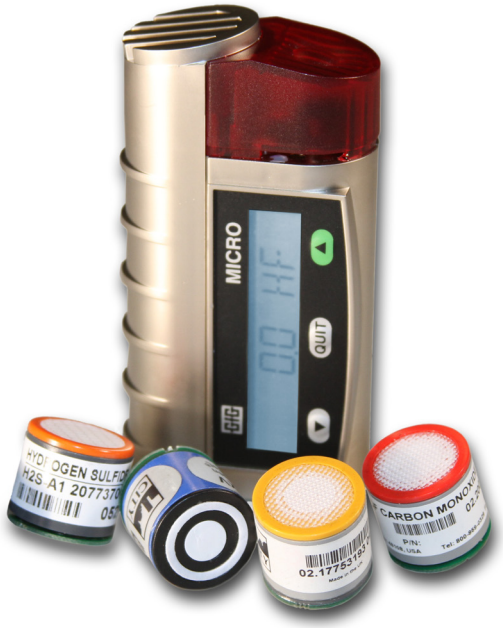

Table 3: EC sensors for LEL range explosive gases		
Gas	Formula	Sensor (ppm)
Ethanol (LEL range)	C_2H5OH	H_2
Hydrogen (LEL range)	H_2	H_2

Changing the type or types of toxic sensors installed in a GfG instrument is generally very easy. However, it's important to let new sensors stabilize for at least 45 minutes after installation, and ALL newly installed sensors MUST be calibrated before use.