

Sensor Specifications And Cross-Sensitivities

Note: All performance specifications are subject to change without notice and are based upon conditions at 68°F (20°C), 50% relative humidity and 1 atm (1013 mBar). See

the glossary on the last page for definitions of the specifications.

c/a

Combustibles (LEL)

Sensor Type: Protected catalytic bead
Gases detected: Most combustible gases & vapors
Range: 0-100% LEL
Resolution: 1% LEL
Response Time (t₉₀): 30 sec.
Bias & Equilibration: No bias; 10 min after installation
Drift: <10% LEL/month
Storage Life: 2 years in sealed container
Operating Life: 2 years in air
Warranty: 2 years from date of shipment
Calibration Gas: 50% LEL of Methane, or 2.5% by volume, balance air

Response Data LEL

Please see TN-156 for cross sensitivity data, this document is the primary source for such data with respect to the LEL sensor.

Oxygen (O₂)

Sensor Type: Electrochemical
Range: 0 to 30%
Resolution: 0.1%
Response Time (t₉₀): 15 sec.
Bias & Equilibration: No bias; 10 min after installation
Temp Range: 5° F to 104° F (-15° C to +40° C)
Pressure Range: Atmospheric ± 10%
Operating Humidity: 0 to 99% non condensing
Drift: < 2% signal/month
Storage Life: 6 months in sealed container
Storage Temp: 32° F to 68° F (0° C to 20° C)
Operating Life: 2 years in air
Warranty: 2 years from date of shipment
Calibration Gas: Ambient air (20.9% oxygen)
Zero Gas: 99.9% N₂
Note: Measurements can be made in pure ethylene; recovery to ambient air may require a few hours.

Ammonia (NH₃) P/N: 008-1118-000

Sensor Type: Electrochemical
Range: 0 to 50 ppm *
Max Overload: 200 ppm *
Resolution: 1 ppm
Response Time (t₉₀): 150 sec
Bias & Equilibration: Bias on; 6 hrs. after installation
Temp Range: -31° F to 86° F (-25° C to 30° C)
Pressure Range: Atmospheric ±10%
Operating Humidity: 15 to 90% non-condensing
Drift: < 10% signal loss/month
Storage Life: 6 months in sealed container
Storage Temp: 32° F to 68° F (0° C to 20° C)
Operating Life: 1 year in air
Warranty: 1 year from date of shipment
Calibration Gas: 50 ppm NH₃, balance N₂
Calibration flow rate: 1000 cc/min. for 3 min.

Cross-sensitivity Data NH₃

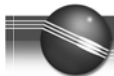
c

Gas	Conc.	Response
Triethylamine	50 ppm	25 ppm
CO	300 ppm	0 ppm
H ₂ S	15 ppm	about 15 ppm
SO ₂	5 ppm	about 3 ppm
NO	35 ppm	about 7 ppm
NO ₂	5 ppm	0 ppm
Cl ₂	1 ppm	about -0.5 ppm
H ₂	100 ppm	0 ppm
HCN	10 ppm	about 0.5 ppm
HCl	5 ppm	0 ppm
Hydrazine		3:1
Ethylene	100 ppm	0 ppm

* Consumable Iodine reagent sensor.

- To be discontinued in 2008 Units affected: VRAE, MultiRAE+, QRAE+, and AreaRAE





Ammonia (NH₃) – P/N: 008-1125-000

Sensor Type: Electrochemical
Range: 0-100 ppm *
Max Overload: 100 ppm *
Resolution: 1 ppm
Response Time (t₉₀): 60 sec
Bias & Equilibration: No Bias; 10 min after installation
Temp Range: -4° F to 104° F (-20° C to 40° C)
Pressure Range: Atmospheric ±10%
Operating Humidity: 15-90% non-condensing
Drift: <2% signal loss/month
Storage Life: 1 year in sealed container
Storage Temp: -20° C to +40° C
Operating Life: 2 year in air
Warranty: 1 year from date of shipment
Calibration Gas: 50 ppm NH₃, balance N₂
Calibration flow rate: 1000 cc/min for 3 min

* Short gas exposure of ~60 seconds.

- Available for VRAE, MultiRAE+, and QRAE+ in 2008.

Carbon Dioxide (CO₂)

Sensor Type: Non-dispersive infrared (NDIR)
Range: 0-50,000 ppm (0-5 vol%)
Resolution: 10 ppm
Response Time (t₉₀): 60 sec
Bias & Equilibration: No Bias; 10 min after installation
Temp Range: -4° F to 122° F (-20° C to 50° C)
Pressure Range: Atmospheric ±20%
Operating Humidity: 5-95% non-condensing
Drift: <5% signal/month
Storage Life: 2 years in sealed container
Storage Temp: -40° F to 122° F (-40° C to 50° C)
Operating Life: 2 years in air
Warranty: 2 years from date of shipment
Calibration Gas: 5000 ppm CO₂, balance air
Calibration flow rate: 500 cc/min for 2 min.

Cross-sensitivity Data CO₂

Gas	Conc.	Response
CH ₄	25,000 ppm	<20 ppm
Ethane	10,000 ppm	<20 ppm
Ethylene	13,500 ppm	<20 ppm
Acetylene	12,500 ppm	<20 ppm
Propane	10,000 ppm	<20 ppm
Acetone	10,000 ppm	<20 ppm
Carbon disulfide	10,000 ppm	<20 ppm

Carbon Monoxide (CO)

Sensor Type: Electrochemical
Range: 0-500 ppm
Max Overload: 1500 ppm
Resolution: 1 ppm
Response Time (t₉₀): 35 sec
Bias & Equilibration: Bias off; 10 min after installation
Temp Range: -4° F to 113° F (-20° C to 45° C)
Pressure Range: Atmospheric ±10%
Operating Humidity: 15-90% non-condensing
Drift: <2% signal/month
Storage Life: 6 months in sealed container
Storage Temp: 32° F to 68° F (0° C to 20° C)
Operating Life: 2 years in air
Warranty: 2 years from date of shipment
Calibration Gas: 50 ppm CO, balance air
Calibration flow rate: 150 cc/min

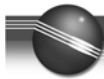
New sensor. Used sensors show increasing response to VOCs. See Technical Note 121 for more information.

* Disk-shaped activated carbon fiber filters (p/n 008-3006-005) placed on top of the CO sensor help reduce response to VOCs

Cross-sensitivity Data CO

Gas	Conc.	Response w/o Filter#	Response w/ Filter*
H ₂ S	10 ppm	0 ppm	
SO ₂	5 ppm	0 ppm	
Cl ₂	10 ppm	0-1 ppm	
HCl	10 ppm	0 ppm	
NO	35 ppm	1 ppm	1 ppm
NO ₂	5 ppm	0 ppm	0 ppm
NH ₃	100 ppm	0 ppm	0 ppm
H ₂	100 ppm	40 ppm	40 ppm
Ethylene	100 ppm	24 ppm	20 ppm
Acetylene	250 ppm	250 ppm	
Ethanol	200 ppm	0 ppm	0 ppm
Ethylene oxide	125 ppm	≥40 ppm	
Propane	100 ppm	0 ppm	0 ppm
Butane	100 ppm	1 ppm	1 ppm
Isobutylene	100 ppm	9 ppm	4 ppm
Isobutylene	1000 ppm	30 ppm	22 ppm
Hexane	500 ppm	0 ppm	0 ppm
MEK	100 ppm	0 ppm	0 ppm
TCE	100 ppm	25 ppm	15 ppm
Nitrogen	100 %	0-4 ppm	





Carbon Monoxide (CO) High Range

Sensor Type: Electrochemical
Range: 0-2000 ppm
Resolution: 10 ppm
Response Time (t₉₀): 35 sec
Bias & Equilibration: Bias off; 10 min after installation
Temp Range: -4 °F to 122°F (-20°C to 50°C)
Pressure Range: Atmospheric ±10%
Operating Humidity: 15-90% non-condensing
Drift: <2% signal/month
Storage Life: 6 months in sealed container
Storage Temp: 32° F to 68° F (0° C to 20° C)
Operating Life: 2 years in air
Warranty: 2 years from date of shipment
Calibration Gas: 200 ppm CO, balance air
Calibration flow rate: 500 cc/min

New sensor. Used sensors show increasing response to VOCs.
 See Technical Note 121 for more information.

* Disk-shaped activated carbon fiber filters (p/n 008-3006-005) placed on top of the CO sensor help reduce response to VOCs

Cross-sensitivity Data CO High Range

r/c

Gas	Conc.	Response w/o Filter#	
H ₂ S	15 ppm	0 ppm	
SO ₂	5 ppm	0 ppm	
Cl ₂	10 ppm	0-1 ppm	
NO	35 ppm	-10-0 ppm	
NO ₂	5 ppm	0 ppm	
H ₂	100 ppm	<50 ppm	
Ethylene	100 ppm	<30 ppm	
Ethanol	200 ppm	0 ppm	

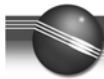
Chlorine (Cl₂)

Sensor Type: Electrochemical
Range: 0 to 50 ppm
Resolution: 0.1 ppm
Response Time (t₉₀): 30 sec
Bias & Equilibration: Bias off; 10 min after installation
Temp Range: -4° F to 104° F (-20° C to 40° C)
Temperature Effect: no effect on sensitivity or zero
Pressure Range: Atmospheric ±10%
Operating Humidity: 5 to 95% non-condensing
Drift: < 10% signal/six months
Storage Life: 6 months in sealed container
Storage Temp: 32° F to 68° F (0° C to 20° C)
Operating Life: 2 years in air
Warranty: 1 year from date of shipment
Calibration Gas: 10 ppm Cl₂, balance N₂
Calibration flow rate: 1,000 cc/min. for 2 min.

Cross-sensitivity Data Cl₂

s

Gas	Conc.	Response
NH ₃	65 ppm	0
CO	300 ppm	0
CO ₂	10%	0
H ₂ S	10 ppm	-0.3 ppm
SO ₂	5 ppm	-1.2 ppm
NO	35 ppm	<3 ppm
NO ₂	5 ppm	0.1 ppm
N ₂	100%	0
H ₂	1000 ppm	0
HCN	10 ppm	0
HCl	20 ppm	0
Br ₂	1 ppm	1 ppm
ClO ₂	0.32 ppm	0.3 ppm
Ethanol	6.6%	0
Hydrocarbons	% Range	0



Chlorine Dioxide (ClO₂)

Sensor Type: Electrochemical
Range: 0 to 1 ppm
Resolution: 0.01 ppm
Response Time (t₉₀): 120 sec.
Bias & Equilibration: Bias off; 10 min. after installation
Temp Range: -4° F to 104° F (-20° C to 40° C)
Pressure Range: Atmospheric ±10%
Operating Humidity: 5 to 95% non-condensing; no effect
Drift: < 5% signal/six months
Effect of Temperature: <0.02 ppm increase from -4° F to 122° F (-20° C to 50° C)
Storage Life: 6 months in sealed container
Storage Temp: 32° F to 68° F (0° C to 20° C)
Operating Life: 2 years in air
Warranty: 1 year from date of shipment
Calibration Gas: 0.50 ppm ClO₂ from gas generator or equivalent of 1.25 ppm Cl₂
Calibration flow rate: 1,000 cc/min. for 2.5 min..
 Requires on-site ClO₂ gas generator, Cl₂ surrogate gas, or quarterly factory calibration

Cross-sensitivity Data ClO₂

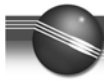
Gas	Conc.	Response
Cl ₂	1 ppm	0 ppm*
Cl ₂	1 ppm	0.4 ppm [#]
ClF ₃	1 ppm	1 (theor.) ppm
O ₃	0.1 ppm	0.03 ppm
H ₂ S	10 ppm	0 ppm*
H ₂ S	25 ppm	-1.1 ppm [#]
SO ₂	5 ppm	0 ppm [#]
CO	1000 ppm	0 ppm [#]
CO	50 ppm	0 ppm [#]
CO ₂	5000 ppm	0 ppm
HCl	5 ppm	0 ppm
HF	3 ppm	0 ppm
H ₂	10,000 ppm	0 ppm
NH ₃	50 ppm	0 ppm [#]
PH ₃	300 ppm	0.3 ppm
AsH ₃	1 ppm	0.8 ppm
HCN	10 ppm	0 ppm
H ₂ Se	0.1 ppm	0 ppm
NO	25 ppm	0.9 ppm [#]
NO ₂	5 ppm	1.5 to 2.3 ppm [#]
Chloropicrin	100 ppm	0 ppm [#]
Hydrocarbons	% range	0 %
Alcohols	1000 ppm	0 ppm

* Short exposure of <few minutes of <100 ppm, with filters
[#] Onboard filters removed.

Notes on ClO₂ sensor calibration and operation:

ClO₂ sensors require a ClO₂ generator for calibration because this gas is too unstable to store in a cylinder. ClO₂ sensors may contain a built-in filter that removes Cl₂ and therefore cannot be calibrated using Cl₂ surrogate gas when the filter is present. ClO₂ sensors without the filter may be calibrated using a Cl₂ surrogate gas. NO₂ is not a reliable surrogate whether filter is present or not. This sensor should not be exposed to H₂S, which plugs the on-board filter, unless the filter is absent.

Caution: ClO₂ sensors without the on-board filter have a negative cross-sensitivity to H₂S and other reducing gases, and may underestimate the ClO₂ concentration if H₂S is present.



Hydrogen Chloride (HCl)

Sensor Type:	Electrochemical
Range:	0-15 ppm
Max Overload:	20 ppm
Resolution:	0.1 ppm (0.3 ppm threshold)
Response Time (t₉₀):	180 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 104° F (-20° C to +40° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal loss/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	1 year in air
Warranty:	1 year from date of shipment
Calibration Gas:	10 ppm HCl, balance N ₂
Calibration flow rate:	500 cc/min for 4 minutes
Regulator:	Corrosion resistant

Cross-sensitivity Data HCl

Gas	Conc.	Response
Acetic acid	100 ppm	Yes
SO ₂	20 ppm	16 ppm
Cl ₂	1 ppm	0.7 ppm
CO	100 ppm	0 ppm
CO ₂	5000 ppm	0 ppm
H ₂	3000 ppm	<1 ppm
Alcohols	1000 ppm	0 ppm
Hydrocarbons	% range	0 ppm
HF	6 ppm	10 ppm
HNO ₃	1997 ppm	10.0 ppm

*Short exposure of a few minutes

Hydrogen Cyanide (HCN)

Sensor Type:	Electrochemical
Range:	0-50ppm
Max Overload:	100 ppm
Resolution:	1 ppm
Response Time (t₉₀):	200 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 122° F (-20° C to +50° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal loss/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	2 years in air
Warranty:	1 year from date of shipment
Calibration Gas:	10 ppm HCN, balance N ₂
Calibration flow rate:	1000 cc/min

Cross-sensitivity Data HCN

Gas	Conc.	Response
CO	300 ppm	about 0.5 ppm
H ₂ S	15 ppm	see note below
SO ₂	5 ppm	~8 ppm
NO	35 ppm	about 3.5 ppm
NO ₂	5 ppm	about -10 ppm
H ₂	200 ppm	0 ppm
Ethylene	100 ppm	about 1 ppm

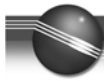
Due to a very high cross-sensitivity to H₂S, this sensor is unsuitable for use in atmospheres that contain H₂S.

Hydrogen Fluoride (HF)

Sensor Type:	Electrochemical
Range:	0-10 ppm
Max Overload:	20 ppm
Resolution:	0.1 ppm
Response Time (t₉₀):	20 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 104° F (-20° C to 40° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	1 year in air
Warranty:	1 year from date of shipment
Calibration Gas:	10 ppm HCl, balance N ₂ (set span value to 6 ppm)
Calibration flow rate:	500 cc/min for 4 min
Regulator:	Corrosion resistant

Cross-sensitivity Data HF

Gas	Conc.	Response
Acetic acid	100 ppm	yes
SO ₂	20 ppm	16 ppm
Cl ₂	1 ppm	0.7 ppm
CO	100 ppm	0 ppm
CO ₂	5000 ppm	0 ppm
H ₂	3000 ppm	<1 ppm
Alcohols	1000 ppm	0 ppm
Hydrocarbons	% range	0 ppm
HCl	10 ppm	6 ppm



Hydrogen Sulfide (H₂S)

Sensor Type:	Electrochemical
Range:	0-100 ppm
Max Overload:	500 ppm
Resolution:	1 ppm
Response Time (t₉₀):	30 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 113° F (-20° C to 45° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° (0° to 20° C)
Operating Life:	2 years in air
Warranty:	2 years from date of shipment
Calibration Gas:	10 ppm H ₂ S, balance N ₂

Cross-sensitivity Data H₂S

Gas	Conc.	Response
CO	300 ppm	≤1.5 ppm
SO ₂	5 ppm	about 1 ppm
NO	35 ppm	<0.7 ppm
NO ₂	5 ppm	about -1 ppm
H ₂	3000 ppm	0 ppm
HCN	10 ppm	0 ppm
HCl	10 ppm	0 ppm
NH ₃	50 ppm	0 ppm
PH ₃	5 ppm	about 4 ppm
CS ₂	100 ppm	0 ppm
Methyl sulfide	100 ppm	9 ppm
Ethyl sulfide	100 ppm	10 ppm*
Methyl mercaptan	5 ppm	about 2 ppm
Ethylene	100 ppm	≤ 0.2 ppm
Isobutylene	100 ppm	0 ppm
Toluene	1000 ppm	0 ppm*
Turpentine	3000 ppm	about 70 ppm*

Note: High levels of polar organic compounds including alcohols, ketones, and amines give a negative response.

*Estimated from similar sensors.

Nitric Oxide (NO)

Sensor Type:	Electrochemical
Range:	0-250 ppm
Max Overload:	1000 ppm
Resolution:	1 ppm
Response Time (t₉₀):	20 sec
Bias & Equilibration:	Bias on; 6 hr after installation
Temp Range:	-4° F to 113° F (-20° C to 45° C)
Pressure Range:	Atmospheric ± 10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	2 years in air
Warranty:	1 year from date of shipment
Calibration Gas:	25 ppm NO, balance N ₂
Calibration flow rate:	250 cc/min

Cross-sensitivity Data NO

Gas	Conc.	Response
CO	300 ppm	0 ppm
SO ₂	5 ppm	0 ppm
H ₂ S	25 ppm	2 - 9 ppm
ClO ₂	1 ppm	-0.2 ppm
NH ₃	50 ppm	0 ppm
NO ₂	5 ppm	about 0.5 ppm
HCl	10 ppm	about 0.5 ppm
HNO ₃	1997 ppm	13.2 ppm

Nitrogen Dioxide (NO₂)

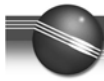
Sensor Type:	Electrochemical
Range:	0-20 ppm
Max Overload:	150 ppm
Resolution:	0.1 ppm
Response Time (t₉₀):	25 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 113° F (-20° C to 45° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	2 years in air
Warranty:	1 year from date of shipment
Calibration Gas:	5 ppm NO ₂ , balance air
Calibration flow rate:	400 cc/min

Cross-sensitivity Data NO₂

Gas	Conc.	Response
NO	25 ppm	2.2 ppm
NH ₃	50 ppm	-0.2 ppm*
CO	50 ppm	-0.2 ppm*
CO	300 ppm	15 ppm
H ₂ S	25 ppm	-2.2 ppm
SO ₂	5 ppm	0 ppm
HCl	10 ppm	0 ppm
Cl ₂	1 ppm	-1 ppm
ClO ₂	1 ppm	-2 ppm
HNO ₃	1997 ppm	12.1 ppm

* Causes a transient drop upon exposure to this compound.





Phosphine (PH₃)

Sensor Type:	Electrochemical
Range:	0-5 ppm
Max Overload:	20 ppm
Resolution:	0.1 ppm
Response Time (t₉₀):	< 60 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 113° F (-20° C to 45° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 10% signal loss/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	1 year in air
Warranty:	1 year from date of shipment
Calibration Gas:	5 ppm PH ₃ , balance N ₂
Calibration flow rate:	1000 cc/min

Cross-sensitivity Data PH₃

Gas	Conc.	Response
Arsine	150 ppb	0 ppb
Arsine	2000 ppb	1200 ppb*
Silane	1000 ppb	900 ppb
Diborane	300 ppb	105 ppb
Germane	600 ppb	510 ppb
NH ₃	100 ppm	0 ppm
NO	100 ppm	0 ppm
SO ₂	5 ppm	1 ppm
CO	1000 ppm	1 ppm
CO ₂	50000 ppm	0 ppm
H ₂	1000 ppm	30 ppm
H ₂ S	25 ppm	5 ppm
HCN	10 ppm	0.6 ppm
HCl	10 ppm	0.2 ppm
Methane	50000 ppm	0 ppm
Ethylene	100 ppm	1.8 ppm
Isobutylene	250 ppm	0 ppm
Hexane, n-	1500 ppm	0 ppm
Benzene	100 ppm	0 ppm
Toluene	100 ppm	0 ppm
Ethylene oxide	10 ppm	0 ppm
CF ₂ Cl ₂	100 ppm	0 ppm
Chloroform	Headspace	0 ppm
Trichloroethylene	Headspace	<0.3 ppm

* Response after 9 minutes exposure. CF = 1.7 average, tested in range 500 to 3000 ppb AsH₃.

Sulfur Dioxide (SO₂)

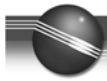
Sensor Type:	Electrochemical
Range:	0-20 ppm
Max Overload:	150 ppm
Resolution:	0.1 ppm
Response Time (t₉₀):	15 sec
Bias & Equilibration:	Bias off; 10 min after installation
Temp Range:	-4° F to 113° F (-20° C to 45° C)
Pressure Range:	Atmospheric ±10%
Operating Humidity:	15-90% non-condensing
Drift:	< 2% signal/month
Storage Life:	6 months in sealed container
Storage Temp:	32° F to 68° F (0° C to 20° C)
Operating Life:	2 years in air
Warranty:	1 year from date of shipment
Calibration Gas:	5 ppm SO ₂ , balance N ₂
Calibration flow rate:	400 cc/min

Cross-sensitivity Data SO₂

Gas	Conc.	Response
CO	50 ppm	0.3 ppm
CO	300 ppm	<3 ppm
CO ₂	1.5%	0 ppm
CS ₂	20 ppm	0.3 ppm
CS ₂	2000 ppm	14 ppm
H ₂ S	15 ppm	0 ppm
H ₂ S	250 ppm	0.3 ppm
H ₂ SO ₄	saturated	0 ppm
NH ₃	100 ppm	0 ppm
NO	25 ppm	≤ -2 ppm*
NO ₂	5 ppm	about -5 ppm
HCl	10 ppm	0 ppm
ClO ₂	0.5 ppm	≤ -2 ppm*
HF	70 ppm	0 ppm
Acetylene	10 ppm	1 ppm
Acetylene	100 ppm	10 ppm
Toluene	100 ppm	0 ppm
Isobutylene	100 ppm	0.4 ppm
1,3-Butadiene	5 ppm	4.3 ppm [#]
Styrene	200 ppm	>40 ppm [#]

* More negative than -2 ppm

[#] Cannot be removed by activated carbon because of SO₂ loss



Sensor Accuracies

Sensor accuracies depend on many factors including temperature, pressure, proper calibration, age of the sensor, and the presence of interferences. The values listed below apply to standard calibration gases within one day of calibration under the same environmental conditions. The accuracy limitation is always the greater of the two choices. For example, for the CO sensor, below 20 ppm the error is 2 ppm and above 20 ppm the error is 10% of the reading (e.g., 5 ppm @ 50 ppm).

Sensor	Estimated Accuracy
LEL	±3% LEL or 10% of Reading
TC	±5 Vol % or 15% of Reading
O ₂	±0.4 Vol % or 2% of Reading
CO ₂	±100 ppm or 10% of Reading <10,000 ppm ± 15% of Reading >10,000 ppm
CO	±2 ppm or 10% of Reading
CO HR	±5 ppm or 10% of Reading
HF	±0.5 ppm or 15% of Reading
H ₂ S	±2 ppm or 10% of Reading
SO ₂	±0.3 ppm or 10% of Reading
NO	±2 ppm or 10% of Reading
NO ₂	±0.3 ppm or 10% of Reading
HCN	±2 ppm or 10% of Reading
HCl	±0.5 ppm or 15% of Reading
Cl ₂	±0.5 ppm or 10% of Reading
ClO ₂	±0.1 ppm or 10% of Reading
NH ₃	±3 ppm or 10% of Reading
PH ₃	±0.3 ppm or 10% of Reading

Sensor Cross-Sensitivities

Electrochemical sensors, like many other sensors, are known to have cross-sensitivity to gases other than its target gas. Depending on the nature of the reaction in the sensor, the gas can either decrease the signal (negative cross-sensitivity) or increase the signal (positive cross-sensitivity). The cross

sensitivity data listed here are based on at most a few batches of electrochemical sensors. The actual values may vary between batches because the cross sensitivity is not typically controlled during the manufacturing process.

For safety concerns, a negative cross-sensitivity may present more risk than a positive one, as it will diminish the response to the target gas and so prevent an alarm. When calibrating a multi-gas sensor that has two sensors whose gas have significant cross-sensitivity, be sure to allow adequate time between calibrations to allow the sensors to clear.

When calibrating sensors with cross-sensitivities, calibrate the most cross-sensitive first, followed by the least cross-sensitive, wait for both sensors to recover to zero, and then expose both to gas again with most cross sensitive first and least cross sensitive second. For example, 50 ppm of NH₃ produces 0 ppm response on a Cl₂ sensor and 1 ppm of Cl₂ produces about -0.5 ppm of response on a NH₃ sensor. So calibrate the NH₃ sensor first with 50 ppm of NH₃. This should have no affect on the Cl₂ sensor. Then calibrate the Cl₂ sensor on 10 ppm Cl₂. This will send the NH₃ sensor negative for some period of time. After calibrating the Cl₂ sensor, return the meter to clean air and wait until the most cross-sensitive sensor (NH₃) fully recovers and/or stabilizes (if it stabilizes to a number other than zero then re-zero the meter). After both sensors return to zero apply calibration gas in the same order (NH₃ first then Cl₂) and note the sensor response. If both sensors are within 10% of the value on the gas cylinder then the calibration of the cross-sensitive sensors was successful.

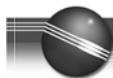
Use extreme caution with mixtures of gases!

The following table and data are based on % cross-sensitivity of a multi-sensor gas monitor to a single gas (for the sensor calibration time, at 0% relative humidity). Mixtures of the gases were not tested and results with mixed gases are unpredictable.

Cross-sensitivity table for selecting sensors for RAE Monitors:	
*	Slight sensitivity (<10% reading of the specified gas)
**	Moderate sensitivity (10 - 50% reading of the specified gas)
***	High sensitivity (>50% reading of the specified gas)
nd	No data
blank	No cross-sensitivity

		S E N S O R S											
		CO	HF	H ₂ S	SO ₂	HCN	Cl ₂	PH ₃	NH ₃	NO	NO ₂	ClO ₂	HCl
G A S	CO		*								*		
	HF				***		***						***
	H ₂ S	*	**			***	*	**	***	**	**	\$	**
	SO ₂	*	***	**		***		**	***	*	*	*	***
	HCN	nd	nd	*	**			*	*	nd	nd	nd	***
	Cl ₂		***	*	*	***		nd	***	*	***	**	***
	PH ₃	*	nd	**	**	***	nd		***	nd	nd	nd	
	NH ₃		**				*				*		**
	NO	*	*	*	*	*		nd	**		*	*	*
	NO ₂		***	**	***	***	**	nd	*	**		**	**
	ClO ₂	nd	nd	nd	***	nd	***	nd	nd	**	***		nd
	HCl		***		***		***						

\$ H₂S can be used with the ClO₂ sensor only if the on-board filter is removed



Extended Calibration Times

Some RAE Systems instruments incorporating electrochemical or NDIR sensors have a fixed calibration time (typically 60 seconds). This time accommodates most sensors, but a few have longer response times. In these cases, it is necessary to apply the calibration gas before starting the 60 to second automatic calibration step. The table below summarizes the recommended pre-exposure times.

Sensor	t ₉₀ (sec)	Total Calibration Time (sec)	Pre-exposure Time (sec)
HCN	200	230	170
PH ₃	60	120	60
NH ₃	60	180	120
HCl	90	180	120
HF	90	180	120
Cl ₂	30	120	90
ClO ₂	120	150	90
CO ₂	60	120	45 (std cal. time is 75 s)

Some RAE instruments do not recognize the presence of calibration gas when a flow is started before the "Apply Gas Now..." prompt, giving a warning, "No gas..." In this case, simply push the [Y/+] key to initiate the calibration.

Glossary

Range: The normal operating concentration of a sensor where the best linearity is found. Exceeding the normal operating range may result in erroneous readings and long recovery times, but should not permanently damage the sensor as long as the Max Overload is not exceeded.

Max Overload: The maximum exposure concentration. Exceeding this value will likely give erroneous readings and cause permanent damage to the sensor. This can be viewed as the sensor IDLH. Ammonia sensors often fail because they have been exposed to over 200 to 300 ppm (see Application Note AP-201).

Resolution: The least significant digit on the display or the minimum amount of chemical that the sensor can "see," (also known as: "Increment of measurement").

Response Time (t₉₀): The time for a sensor to reach 90% of its final stable reading. Typically an exposure of twice the t₉₀ time is required to get a stable reading.

Bias & Equilibration: Some electrochemical sensors (NO, NH₃) require a bias voltage to detect the gas, while most do not. Unbiased sensors are shipped with a shorting pin across the electrodes to avoid an accidental bias. The pin should be removed before installation. Biased sensors require an equilibration time (also known as: warm-up time) of about 6 hours after installation for the baseline to become stable enough to calibrate the sensor. Unbiased sensors require only about 10 minutes to stabilize. Once installed, any sensor bias stays on, even when the meter is off. Therefore, even biased sensors are ready for immediate use when the instrument is turned on again, and the equilibration time is needed only when first installed or if the battery becomes completely drained. The SensorRAE can be used to maintain bias on NO and NH₃ sensors, and thus avoid

long equilibration times when swapping these sensors into a multi-gas instrument.

Temp Range: The normal operating temperature of the sensor. Sensors embody physico-chemical processes, which slow down when cooled and speed up when heated. Storing and using detectors outside in the winter may provide low readings if not recalibrated at the temperature of use. Storing detectors in hot cars in the summer may provide high readings and even dry out the sensors. Allowing a meter to return to normal operating temperature typically restores readings.

Pressure Range: The normal operating pressure of the sensor, typically atmospheric (14.7 psia) ±10%. Some sensors have a transient response to sudden pressure changes, which may cause them to go into alarm for a short time.

Operating Humidity: Normal operating humidity. Typically 15 to 90% relative humidity, "non-condensing." Condensing humidity blocks the diffusion pathway, lowering the reading, and consistently high humidity can dilute the electrolyte and cause the cell to burst. Running or storing for extended periods in <10% RH gas can dry out the electrolyte and make the sensor inoperable.

Drift: The amount the sensor output may change over long time periods, expressed in %.

Storage Life: The recommended maximum time a sensor should be stored in its original packaging before being installed in an instrument.

Storage Temp: The recommended temperature to store sensors prior to use.

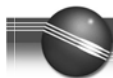
Operating Life: The expected useable life of the sensor after it is installed, as long as the "Storage Life" was not exceeded before installation.

Warranty: The time from shipment up to which RAE Systems will replace a sensor free of charge, or at reduced charge, in case of failure. The warranty period is generally equal to or less than the Operating Life. Thus, a sensor with a storage life of 6 months, operating life of 2 years and warranty of 2 years, stored for one-half year before installation, is expected to be useable for up to 2½ years from the date of shipment, even though the warranty expires 1½ years after it is installed.

The expiration date of the warranty period is programmed into the sensor and is displayed during start-up of most RAE single gas and multi-gas meters. Sensors can be used beyond the expiration date provided that the sensor is properly zeroed and calibrated and the resolution is acceptable for the purpose of the measurements. The resolution can be tested by simply observing the zero fluctuations, or more accurately by measuring the response in the instrument's Diagnostic Mode according to Technical Note TN-123. The expiration date is provided on the instrument only as a reminder to the user that the warranty period for that sensor is complete and that it may become necessary to replace the sensor in the near future.

However, the sensor can operate properly beyond the expiration date as long as it responds to the gas of interest and is tested as noted above.





Calibration Gas: Recommended calibration gas concentration. A lower concentration might not give a stable calibration, while higher concentrations might use up the sensor prematurely. However, if the sensor is operated outside the typical range, it is recommended to use a calibration gas as close as possible to the actual concentrations and gas type being measured. For example, an NO sensor used to measure in the 200 to 500 ppm range is preferably calibrated with 500 ppm NO, instead of 25 ppm. A CO sensor used to measure 100 to

1000 ppm hydrogen should be calibrated with 1000 ppm hydrogen gas.

Calibration Flow Rate: Recommended calibration gas flow rate.

Cross-Sensitivity: Every sensor has some cross-sensitivity. It responds to other gases that are not filtered out and can react on the electrode. It is very important to be aware of potentially cross-sensitive compounds when interpreting data.