



## 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.

### Combustibles (LEL)

**Sensor Type:** Protected catalytic bead  
**Gases detected:** Most combustible gases and vapors  
**Range:** 0 to 100% LEL  
**Resolution:** 1% LEL  
**Response Time (t<sub>90</sub>):** 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

Compound	LEL Relative Sensitivity*	LEL CF
Methane	100	1.0
Propane	62	1.6
Propene	67	1.5
n-Butane	50	2.0
Isobutylene	67	1.5
n-Pentane	45	2.2
n-Hexane	43	2.3
Cyclohexane	40	2.5
Benzene	45	2.2
Toluene	38	2.6
n-Heptane	42	2.4
n-Octane	34	2.9
Turpentine	34	2.9
Leaded gasoline	48	2.1
Methanol	67	1.5
Ethanol	59	1.7
Isopropanol	38	2.6
Acetone	45	2.2
Methyl ethyl ketone	38	2.6
Ethyl Acetate	45	2.2
Carbon monoxide	75	1.2
Hydrogen	91	1.1
Ammonia	125	0.80
Phosphine	385	0.26

\* Response of the RAE Systems LEL sensor to a range of gases at the same LEL, expressed as percent of methane response (=100). These figures are for guidance only and are rounded to the nearest 5%. For the most accurate measurements, the instrument should be calibrated with the gas under investigation. See TN-156 for more details and more compounds.

### Oxygen (O<sub>2</sub>)

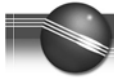
**Sensor Type:** Electrochemical  
**Range:** 0 to 30%  
**Resolution:** 0.1%  
**Response Time (t<sub>90</sub>):** 15 sec.  
**Bias & Equilibration:** No bias; 10 min after installation  
**Temp Range:** 5 °F to 104° F (-15° C to +40° C)  
**Pressure Range:** Atmospheric ± 10%  
**Operating Humidity:** 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% N<sub>2</sub>  
**Note:** Measurements can be made in pure ethylene; recovery to ambient air may require a few hours.

### Ammonia (NH<sub>3</sub>)

**Sensor Type:** Electrochemical  
**Range:** 0 to 50 ppm  
**Max Overload:** 200 ppm  
**Resolution:** 1 ppm  
**Response Time (t<sub>90</sub>):** 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 NH<sub>3</sub>, balance N<sub>2</sub>  
**Calibration flow rate:** 1000 cc/min. for 3 min.

#### Cross-sensitivity data NH<sub>3</sub>

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



## Carbon Dioxide (CO<sub>2</sub>)

**Sensor Type:** Non-dispersive infrared (NDIR)  
**Range:** 0 to 50,000 ppm (0 to 5 vol%)  
**Resolution:** 10 ppm  
**Response Time (t<sub>90</sub>):** 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 to 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:** 1 year from date of shipment  
**Calibration Gas:** 5,000 ppm CO<sub>2</sub>, balance air  
**Calibration flow rate:** 500 cc/min. for 2 min.

## Carbon Monoxide (CO)

**Sensor Type:** Electrochemical  
**Range:** 0 to 500 ppm  
**Max Overload:** 1,500 ppm  
**Resolution:** 1 ppm  
**Response Time (t<sub>90</sub>):** 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 to 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.

### Cross-sensitivity data CO<sub>2</sub>

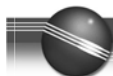
Gas	Conc.	Response
CH <sub>4</sub>	25,000 ppm	<20 ppm
Ethane	10,000 ppm	<20 ppm
Ethylene	13,500 ppm	<20 ppm
Acetylene	12,500 ppm	<20 ppm
Propane	10,000 ppm	<20 ppm
Acetone	10,000 ppm	<20 ppm
Carbon disulfide	10,000 ppm	<20 ppm

### Cross-sensitivity data CO

Gas	Conc.	Response w/o Filter#	Response w/ Filter*
H <sub>2</sub> S	24 ppm	0 ppm	
SO <sub>2</sub>	5 ppm	0 ppm	
Cl <sub>2</sub>	10 ppm	0 to 1 ppm	
NO	25 ppm	0 ppm	
NO <sub>2</sub>	5 ppm	0 ppm	
NH <sub>3</sub>	50 ppm	0 ppm	
PH <sub>3</sub>	5 ppm	0 to 1 ppm	
H <sub>2</sub>	100 ppm	40 ppm	40 ppm
Ethylene	100 ppm	16 ppm	
Acetylene	250 ppm	250 ppm	
Ethanol	200 ppm	1 ppm	
Ethylene oxide	125 ppm	≥40 ppm	
Propane	100 ppm	0 ppm	
Isobutylene	100 ppm	0 ppm	0 ppm
Isobutylene	1000 ppm	7 ppm	2 ppm
Hexane	500 ppm	0 ppm	
Toluene	400 ppm	0 ppm	
Nitrogen	100 %	0 to 4 ppm	

# New sensor. Used sensors show increasing response to VOCs.

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



## Chlorine (Cl<sub>2</sub>)

<b>Sensor Type:</b>	Electrochemical
<b>Range:</b>	0 to 50 ppm
<b>Resolution:</b>	0.1 ppm
<b>Response Time (t<sub>90</sub>):</b>	30 sec
<b>Bias &amp; Equilibration:</b>	Bias off; 10 min after installation
<b>Temp Range:</b>	-4° F to 104° F (-20° C to 40° C)
<b>Temperature Effect:</b>	no effect on sensitivity or zero
<b>Pressure Range:</b>	Atmospheric ±10%
<b>Operating Humidity:</b>	5 to 95% non-condensing
<b>Drift:</b>	< 10% signal/six months
<b>Storage Life:</b>	6 months in sealed container
<b>Storage Temp:</b>	32° F to 68° F (0° C to 20° C)
<b>Operating Life:</b>	2 years in air
<b>Warranty:</b>	1 year from date of shipment
<b>Calibration Gas:</b>	10 ppm Cl <sub>2</sub> , balance N <sub>2</sub>
<b>Calibration flow rate:</b>	1,000 cc/min. for 2 min.

### Cross-sensitivity data Cl<sub>2</sub>

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

## Chlorine Dioxide (ClO<sub>2</sub>)

<b>Sensor Type:</b>	Electrochemical
<b>Range:</b>	0 to 1 ppm
<b>Resolution:</b>	0.01 ppm
<b>Response Time (t<sub>90</sub>):</b>	120 sec.
<b>Bias &amp; Equilibration:</b>	Bias off; 10 min. after installation
<b>Temp Range:</b>	-4° F to 104° F (-20° C to 40° C)
<b>Pressure Range:</b>	Atmospheric ±10%
<b>Operating Humidity:</b>	5 to 95% non-condensing; no effect
<b>Drift:</b>	< 5% signal/six months
<b>Effect of Temperature:</b>	<0.02 ppm increase from -4° F to 122° F (-20° C to 50° C)
<b>Storage Life:</b>	6 months in sealed container
<b>Storage Temp:</b>	32° F to 68° F (0° C to 20° C)
<b>Operating Life:</b>	2 years in air
<b>Warranty:</b>	1 year from date of shipment
<b>Calibration Gas:</b>	0.50 ppm ClO <sub>2</sub> from gas generator or equivalent of 1.25 ppm Cl <sub>2</sub>
<b>Calibration flow rate:</b>	1,000 cc/min. for 2.5 min.. Requires on-site ClO <sub>2</sub> gas generator, Cl <sub>2</sub> surrogate gas, or quarterly factory calibration

### Cross-sensitivity data ClO<sub>2</sub>

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

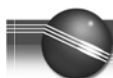
\* Short exposure of <few minutes of <100 ppm, with filters

<sup>#</sup> Onboard filters removed.

#### Notes on ClO<sub>2</sub> sensor calibration and operation:

ClO<sub>2</sub> sensors require a ClO<sub>2</sub> generator for calibration because this gas is too unstable to store in a cylinder. ClO<sub>2</sub> sensors may contain a built-in filter that removes Cl<sub>2</sub> and therefore cannot be calibrated using Cl<sub>2</sub> surrogate gas when the filter is present. ClO<sub>2</sub> sensors without the filter may be calibrated using a Cl<sub>2</sub> surrogate gas. NO<sub>2</sub> is not a reliable surrogate whether filter is present or not. This sensor should not be exposed to H<sub>2</sub>S, which plugs the on-board filter, unless the filter is absent.

**Caution:** ClO<sub>2</sub> sensors without the on-board filter have a negative cross-sensitivity to H<sub>2</sub>S and other reducing gases, and may underestimate the ClO<sub>2</sub> concentration if H<sub>2</sub>S is present.



## Hydrogen Cyanide (HCN)

**Sensor Type:** Electrochemical  
**Range:** 0 to 50ppm  
**Max Overload:** 100 ppm  
**Resolution:** 1 ppm  
**Response Time (t<sub>90</sub>):** 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 to 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<sub>2</sub>  
**Calibration flow rate:** 1,000 cc/min.

### Cross-sensitivity data HCN

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

Due to a very high cross-sensitivity to H<sub>2</sub>S, this sensor is unsuitable for use in atmospheres that contain H<sub>2</sub>S.

## Hydrogen Sulfide (H<sub>2</sub>S)

**Sensor Type:** Electrochemical  
**Range:** 0 to 100 ppm  
**Max Overload:** 500 ppm  
**Resolution:** 1 ppm  
**Response Time (t<sub>90</sub>):** 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 to 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:** 10 ppm H<sub>2</sub>S, balance N<sub>2</sub>  
**Calibration flow rate:** 400 cc/min.

### Cross-sensitivity Data H<sub>2</sub>S

Gas	Conc.	Response
CO	300 ppm	<1.5 ppm
SO <sub>2</sub>	5 ppm	about 1 ppm
NO	35 ppm	<0.7 ppm
NO <sub>2</sub>	5 ppm	about -1 ppm
H <sub>2</sub>	100 ppm	0 ppm
HCN	10 ppm	0 ppm
NH <sub>3</sub>	50 ppm	0 ppm
PH <sub>3</sub>	5 ppm	about 4 ppm
CS <sub>2</sub>	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	10000 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.

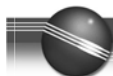
## Nitric Oxide (NO)

**Sensor Type:** Electrochemical  
**Range:** 0 to 250 ppm  
**Max Overload:** 1000 ppm  
**Resolution:** 1 ppm  
**Response Time (t<sub>90</sub>):** 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 to 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<sub>2</sub>  
**Calibration flow rate:** 250 cc/min.

### Cross-sensitivity data NO

Gas	Conc.	Response
CO	300 ppm	0 ppm
SO <sub>2</sub>	5 ppm	0 ppm
H <sub>2</sub> S	25 ppm	2 - 9 ppm
ClO <sub>2</sub>	1 ppm	-0.2 ppm
NH <sub>3</sub>	50 ppm	0 ppm
NO <sub>2</sub>	5 ppm	about 0.5 ppm





## Nitrogen Dioxide (NO<sub>2</sub>)

**Sensor Type:** Electrochemical  
**Range:** 0 to 20 ppm  
**Max Overload:** 150 ppm  
**Resolution:** 0.1 ppm  
**Response Time (t<sub>90</sub>):** 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<sub>2</sub>, balance air  
**Calibration flow rate:** 400 cc/min.

### Cross-sensitivity data NO<sub>2</sub>

Gas	Conc.	Response
NO	25 ppm	2.2 ppm
NH <sub>3</sub>	50 ppm	-0.2 ppm*
CO	50 ppm	-0.2 ppm*
CO	300 ppm	15 ppm
H <sub>2</sub> S	25 ppm	-2.2 ppm
SO <sub>2</sub>	5 ppm	0 ppm
Cl <sub>2</sub>	1 ppm	-1 ppm
ClO <sub>2</sub>	1 ppm	-2 ppm

\* Causes a transient drop upon exposure to this compound.

## Phosphine (PH<sub>3</sub>)

**Sensor Type:** Electrochemical  
**Range:** 0 to 5 ppm  
**Max Overload:** 20 ppm  
**Resolution:** 0.1 ppm  
**Response Time (t<sub>90</sub>):** < 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 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:** 5 ppm PH<sub>3</sub>, balance N<sub>2</sub>  
**Calibration flow rate:** 1,000 cc/min.

### Cross-sensitivity data PH<sub>3</sub>

Gas	Conc.	Response
Arsine	150 ppb	0 ppb
Silane	1000 ppb	900 ppb
Diborane	300 ppb	105 ppb
Germane	600 ppb	510 ppb
NH <sub>3</sub>	100 ppm	0 ppm
NO	100 ppm	0 ppm
SO <sub>2</sub>	5 ppm	1 ppm
CO	1000 ppm	1 ppm
CO <sub>2</sub>	50000 ppm	0 ppm
H <sub>2</sub>	1000 ppm	30 ppm
H <sub>2</sub> S	25 ppm	5 ppm
HCN	10 ppm	0.6 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 <sub>2</sub> Cl <sub>2</sub>	100 ppm	0 ppm
Chloroform	Headspace	0 ppm
Trichloroethylene	Headspace	<0.3 ppm

## Sulfur Dioxide (SO<sub>2</sub>)

**Sensor Type:** Electrochemical  
**Range:** 0 to 20 ppm  
**Max Overload:** 150 ppm  
**Resolution:** 0.1 ppm  
**Response Time (t<sub>90</sub>):** 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<sub>2</sub>, balance N<sub>2</sub>  
**Calibration flow rate:** 400 cc/min.

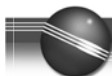
### Cross-sensitivity data SO<sub>2</sub>

Gas	Conc.	Response
CO	50 ppm	0.3 ppm
CO	300 ppm	<3 ppm
CO <sub>2</sub>	1.5%	0 ppm
H <sub>2</sub> S	15 ppm	0 ppm
H <sub>2</sub> S	250 ppm	0.3 ppm
NH <sub>3</sub>	100 ppm	0 ppm
NO	25 ppm	≤ -2 ppm*
NO <sub>2</sub>	5 ppm	about -5 ppm
ClO <sub>2</sub>	0.5 ppm	≤ -2 ppm*
HF	70 ppm	0 ppm
Toluene	100 ppm	0 ppm
Isobutylene	100 ppm	0.4 ppm
1,3-Butadiene	5 ppm	4.3 ppm <sup>#</sup>
Styrene	200 ppm	>40 ppm <sup>#</sup>

\* More negative than -2 ppm

<sup>#</sup> Cannot be removed by activated carbon because of SO<sub>2</sub> 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 <sub>2</sub>	±0.4 Vol % or 2% of Reading
CO <sub>2</sub>	±100 ppm or 10% of Reading <10,000 ppm ± 15% of Reading >10,000 ppm
CO	±2 ppm or 10% of Reading
H <sub>2</sub> S	±2 ppm or 10% of Reading
SO <sub>2</sub>	±0.3 ppm or 10% of Reading
NO	±2 ppm or 10% of Reading
NO <sub>2</sub>	±0.3 ppm or 10% of Reading
HCN	±2 ppm or 10% of Reading
Cl <sub>2</sub>	±0.5 ppm or 10% of Reading
ClO <sub>2</sub>	±0.1 ppm or 10% of Reading
NH <sub>3</sub>	±3 ppm or 10% of Reading
PH <sub>3</sub>	±0.3 ppm or 10% of Reading

## Sensor Cross-Sensitivities:

An electrochemical sensors, like many other sensors, is 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.

**Important:** For safety concerns, a negative cross-sensitivity may present more risk than a positive one, as it diminishes the response to the target gas and so prevent an alarm. When calibrating a multi-gas sensor that has two sensors whose gases 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, then expose both to gas again with most cross-sensitive first and least cross sensitive second. For example, 65 ppm of NH<sub>3</sub> produces 0 ppm response on a Cl<sub>2</sub> sensor and 1 ppm of Cl<sub>2</sub> produces about -0.5 ppm of response on a NH<sub>3</sub> sensor. So calibrate the NH<sub>3</sub> sensor first with 50 ppm of NH<sub>3</sub>. This should have no effect on the Cl<sub>2</sub> sensor. Then calibrate the Cl<sub>2</sub> sensor on 10 ppm Cl<sub>2</sub>. This sends the NH<sub>3</sub> sensor negative for some period of time. After calibrating the Cl<sub>2</sub> sensor, return the meter to clean air and wait until the most cross-sensitive sensor (NH<sub>3</sub>) 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 (NH<sub>3</sub> first, and then Cl<sub>2</sub>) and note the sensor response. If both sensors are within 10% of the value on the gas cylinder, and then the calibration of the cross-sensitive sensors was successful.

### Use extreme caution with mixtures of gases!

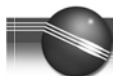
The following table and data are based on % cross-sensitivity of a multi-sensor gas monitor to a single gas (for the sensor calibration time, at 0% relative humidity). Mixtures of the gases were not tested, and results with mixed gases are unpredictable.

**Cross-sensitivity table for selecting sensors for RAE Systems 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)
NR	Not recommended due to possible damage to sensor
nd	No data
blank	No cross-sensitivity

		S E N S O R S									
		CO	H <sub>2</sub> S	SO <sub>2</sub>	HCN	Cl <sub>2</sub>	PH <sub>3</sub>	NH <sub>3</sub>	NO	NO <sub>2</sub>	ClO <sub>2</sub>
G A S	CO									*	
	H <sub>2</sub> S	*			***	*	**	***	**	**	NR <sup>§</sup>
	SO <sub>2</sub>	*	**		***		**	***	*	*	*
	HCN	nd	**	**			*	*	nd	nd	nd
	Cl <sub>2</sub>		*	*	***		nd		*	***	**
	PH <sub>3</sub>	*	**	**	***	nd		***	nd	nd	nd
	NH <sub>3</sub>					*				*	
	NO	*	*	*	*		nd	**		*	*
	NO <sub>2</sub>		**	***	***	**	nd	*	**		**
	ClO <sub>2</sub>	nd	nd	***	nd	***	nd	nd	**	***	

<sup>§</sup>H<sub>2</sub>S can be used with the ClO<sub>2</sub> sensor only if the on-board filter is removed.



		SENSOR									
		CO	H <sub>2</sub> S	SO <sub>2</sub>	HCN	Cl <sub>2</sub>	PH <sub>3</sub>	NH <sub>3</sub>	NO	NO <sub>2</sub>	ClO <sub>2</sub>
G A S	CO	100 %	0.5	≤ 1	1	0	0	0	0	-1 ~ -10 #	0
	H <sub>2</sub> S	0	100 %	1	160 ~ 300	-3	20	360	<60 *	-8 ~ -20 #	> -5 <sup>α</sup>
	SO <sub>2</sub>	0 ~ 5	20	100 %	490	0	20	75	≤10	-3 ~ -15	-1
	HCN	nd	5 ~ -20	35	100 %	0	9	5 ~ 7	nd	nd	nd
	Cl <sub>2</sub>	0	-5 ~ 10	-10 ~ 10	-70	100 %	nd	-50~-100	8	-100 ~ 25	35~45 <sup>α</sup>
	PH <sub>3</sub>	0 ~ 5	60	20	1600	nd	100 %	325	nd	nd	nd
	NH <sub>3</sub>	0	-1	1	-1	0	0	100 %	0	≤-2 #	0
	NO	< 10	<10	> -5	-10 ~ 0	< 1	nd	20	100 %	≤10	4
	NO <sub>2</sub>	0	-20 ~ -35	> -30	-300	0 ~ 45	nd	-4	10 ~ 30	100 %	30 ~ 50
	ClO <sub>2</sub>	nd	nd	> -240	nd	100	nd	nd	-15 ~ -20	240	100 %

\* Response in percent of applied gas concentration, after calibration to target gas. These numbers are rough guidelines only and subject to change at any time. # Transient response that decays to <10% positive or negative effect after >1 minute. <sup>α</sup>With filters removed. This sensor plugs easily on exposure to H<sub>2</sub>S with filters in place.

### 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 <sub>90</sub> (sec)	Total Calibration Time (sec)	Pre-exposure Time (sec)
HCN	200	230	170
PH <sub>3</sub>	60	120	60
NH <sub>3</sub>	150	150	90
Cl <sub>2</sub>	30	120	90
ClO <sub>2</sub>	120	150	90
CO <sub>2</sub>	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 (t<sub>90</sub>):** The time for a sensor to reach 90% of its final stable reading. Typically an exposure of twice the t<sub>90</sub> time is required to get a stable reading.

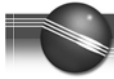
**Bias & Equilibration:** Some electrochemical sensors (NO, NH<sub>3</sub>) require a bias voltage to detect the gas, while most do not. Unbiased sensors are shipped with a shorting pin across the electrodes to avoid an accidental bias. The pin should be removed before installation. Biased sensors require 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 NH<sub>3</sub> 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.