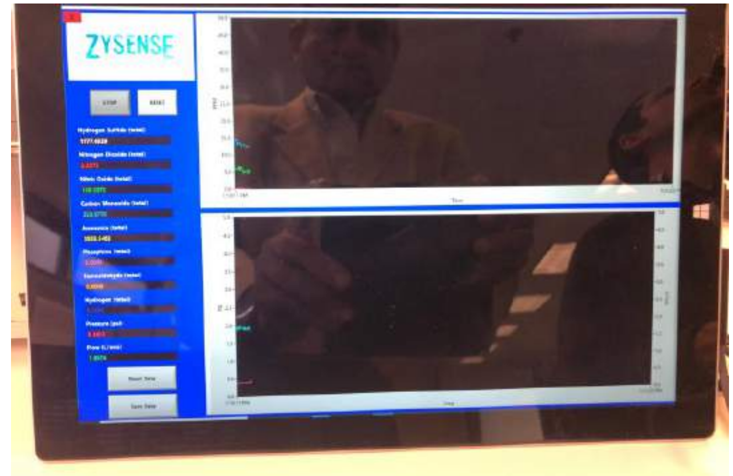
ZYSENSE MGA 800 ANALYZER



ZYSENSE MGA 800 - TABLET SCREEN

ZYSENSE MULTI-GAS ANALYZER MGA -800

REAL TIME MEASUREMENT OF 5 GASES CONCENTRATION, FLOW & PRESSURE

ZYSENSE MULTI-GAS ANALYZER MGA- 800

Zysense Multi-Gas Analyzer was developed at the request of several researchers in the Nitric Oxide research community to measure other two cell signaling molecules of interest, Hydrogen Sulfide, Carbon Monoxide. In addition to the above several other medical, bio pharmaceutical, and doctors in clinical research requested several others gases like Ammonia, Hydrogen, Phosphine, Nitrogen Dioxide, Formaldehyde and others. Since most of the gases interact and interfere with the measurements at low concentrations, it was critical to develop sensors that were accurate and were not influenced by the presence of other gases.

The medical research community also requested a versatile, robust equipment where they could change sensors and measure multiple parameters critical to a specific disease or measure certain exhaled gas markers that provide some “non invasive” insights into the health of the subject.

The unique features of Zysense MGA -800 are as follows:

1. Unique custom developed sensors designed for clinical research applications (Nitric Oxide, Nitrogen Dioxide, Carbon Monoxide, Hydrogen Sulfide, Ammonia, Hydrogen, Oxygen, Phosphne, and Formaldehyde).
2. Sensors are uniquely designed to minimize or eliminate interaction between the various gases that are being measured.
3. All gases can be measured simultaneously using the same instrument
4. Can be used to measure gases in a gas stream or exhaled breath, or from nasal exhalation from a subject.

Applications:

5. Can also be used in neonatal incubator (isolette) to measure exhaled gases.
6. Can be used to measure breath exhaled gases in sleep studies, and stress tests on a treadmill.
7. Can be used to measure the Nitric Oxide, Nitrogen Di Oxide, Oxygen levels while dosing nitric oxide to clinical subjects

Major Research currently underway that utilize Multi-Gas Analyzer Zysense MGA-800

1. Exhaled breath for the measurement of microbiome in lower airway in lungs - looking for anaerobic conditions
2. Exhaled breath gas measurement during Pulmonary Function Tests (Planned Clinical Trial in 2Q 2020)
3. Exhaled breath gas measurement for Cystic Fibrosis in children (Planned trial)

Potential advantages and limitations of exhaled breath analysis:

Advantages	Limitations	Mitigation Steps
Non-invasive and non-intrusive	Confounders such as diet and environment	Managed DOE
Allows for repeated measurements	Lack of standardization	Standardizing methods
Can be inexpensive	Poor reliability of prototypes	Reliable Sensors (MGA 800)
Potential for portability	Storage	Extremely rugged (MGA-800)
Potential for real-time results	Physician acceptance	Multiple Clinical Trials with(MGA 800) by doctors
Personalized medicine (“breath-print”)	None	Future MGA 800 use in clinics

ZYSENSE LLC (www.Zysense.com)
ZYSENSE MULTI-GAS ANALYZER MGA 800 SPECIFICATIONS

SENSOR	NO	NO2	NH3	H2S	CO	PH3	O2	Hydrocarbon Senor	H2
Range Minimum	0-50 PPM	0-10 PPM	0-50 PPM	0-10 PPM	0-50 PPM	0-500 PPB		0-200 PPM V/V	0.02% V/V
Range Maximum	0-500 PPM	0-200 PPM	0-500 PPM	0-200 PPM	0-1000 PPM	0-2000 PPB			10% V/V
Linearity	+/- 3%	+/- 3%	+/- 3%	+/- 3%	+/- 3%	+/- 3%	+/- 3%	+/- 3%	+/- 2%
Response T-90	20 Seconds	40 Seconds	120 Seconds	60 Seconds	T50 = 20 Seconds, T90 = 40 seconds	T50 ≤ 30 Seconds, T90 ≤ 150 seconds		T50 - <30 SEC T-90 -<150 SEC	T50 = 20 Seconds, T90 = 75 seconds
Zero Drift	< 1 PPM/ Month	<0.5 PPM/ Month	<2 PPM/month	<0.5 PPM/ month	<2 PPM/month	<2 PPB/month		< 2% /month	
Span Drift	< 2%/month	<2%/month	<2%/month	<2%/month	<2%/month	<2%/month	<2%/month	<2%/month	<1%/month
Operating Temperature Range	-20 to +40 C	-20 to +40 C	-20 to +40 C	-20 to +40 C	-20 to +40 C	-30 to +50 C	-20 to +40 C	-20 to +40 C	-20 to +40 C
Operating Pressure Range	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG	-5 to +50 PSIG
Operating Humidity Range	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing	15-95% RH Non Condensing
Data Collection Rate	10 data points/ second	10 data points/ second	10 data points/ second	10 data points/ second	10 data points/ second	10 data points/ second	10 data points/ second	10 data points/ second	10 data points/ second
Calibration Frequency	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed	Every 3 months or as needed

SENSOR	NO	NO2	NH3	H2S	CO	PH3	O2	Hydrocarbon Senor	H2
Calibration Gas Standard	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas	Zysense approved Gas
Zero Stability	± 1 PPM at constant temperature ± 3 PPM over ±10° C ambient temperature change	± 0.2 PPM at constant temperature ± 0.5 PPM over ±10° C ambient temperature change	± 1 PPM at constant temperature ± 3 PPM over ±10° C ambient temperature change	± 0.2 PPM at constant temperature ± 0.3PPM over ±10° C ambient temperature change	± 1 PPM at constant temperature ± 3 PPM over ±10° C ambient temperature change	± 10 PPB at constant temperature ± 20 PPB over ±10° C ambient temperature change	Data is being obtained	± 0.2 PPM at constant temperature ± 0.3 PPM over ±10° C ambient temperature change	± 0.02% H2 at constant temperature ± 0.05% H2 over ±10° C ambient temperature change
Operating Life	>18 months under clean conditions	>18 months under clean conditions	>18 months under clean conditions	>18 months under clean conditions	>18 months under clean conditions	>24 months under clean conditions	>18 months under clean conditions	>24 Months under clean conditions	>24 months under clean conditions
Recommended Best Life	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use	Recommended to replace every 12 months for best sensor performance if used regularly and if stored less than 25C in sealed container when not in use
Comments	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below	See sensor specific information given below

HYDROCABON SENSOR

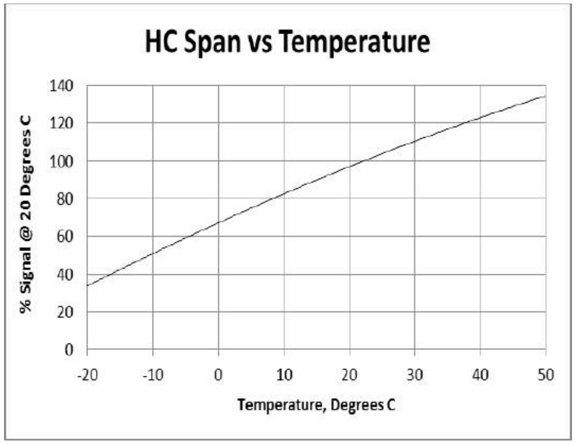
Hydrocarbon vapor sensor is an electrochemical device used for the detection of a variety of hydrocarbon vapors in ambient air. This sensor is used for measurement of ethylene oxide, formaldehyde, alcohols, acetylene, ethylene, and others. The cross-sensitivity table given below lists the hydrocarbons that may be detected with this sensor. It is designed to be used in conjunction with Zysense MGA 800 Multi-Gas Analyzer.
The HC sensor is a 3-electrode electrochemical cell and operates by generating a small electrical current proportional to the partial pressure of hydrocarbon vapor in the surrounding air. The current results from the direct oxidation of the hydrocarbon on the measuring electrode to form carbon dioxide. Oxidation of formaldehyde is shown in the formula below.

$$HCOH + H2O \rightarrow CO2 + 4H+ + 4e-$$

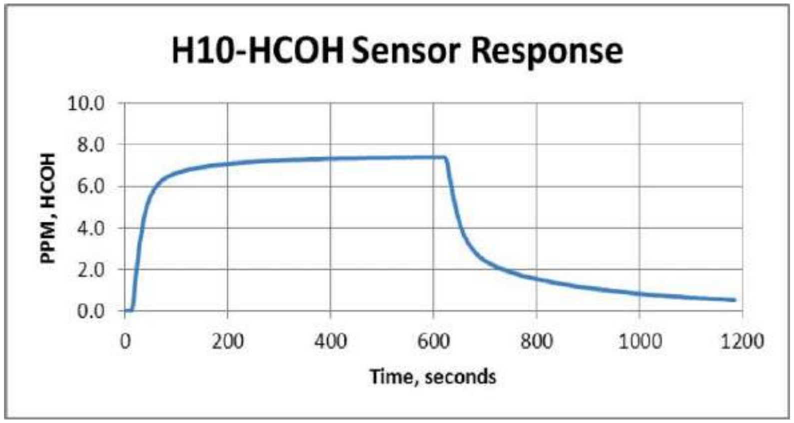
Hydrocarbon Sensor - Cross Sensitivity Data

Gas	Symbol	Response to 1 PPM
Ethylene Oxide	C_2H_4O	1.0
Formaldehyde	HCOH	1.0
Methanol	CH_3OH	1.2
Ethanol	C_2H_5OH	0.7
Isopropyl Alcohol	C_3H_7OH	0.25
Acetylene	C_2H_2	1.2
Ethylene	C_2H_4	1.0
Vinyl Chloride	C_2H_3Cl	0.6
Propylene Oxide	C_3H_6O	0.7
Propylene	C_3H_6	0.6
Methyl Methacrylate	$C_5H_8O_2$	0.25
Acetaldehyde	CH_3CHO	0.25
Styrene	C_8H_8	0.25
Carbon Monoxide	CO	0.5
Nitrogen Dioxide	NO_2	0.1
Sulfur Dioxide	SO_2	0.4
Methyl Mercaptan	CH_3SH	1.0
Hydrogen	H_2	0.05
Nitric Oxide	NO	0.8

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for an HC sensor exposed to Formaldehyde. Response to other hydrocarbons may be somewhat different. Note that response times can become significantly slower at temperatures below -20°C.



CARBON MONOXIDE SENSOR

CO sensors exhibit response to certain other gases. When applying this sensor to specific applications, it is good practice to verify whether or not any of these potential interferences are present and might present interference issues.
Note that cross-sensitivity data is approximate. In some cases, response to other gases may not be stable or may be transient.

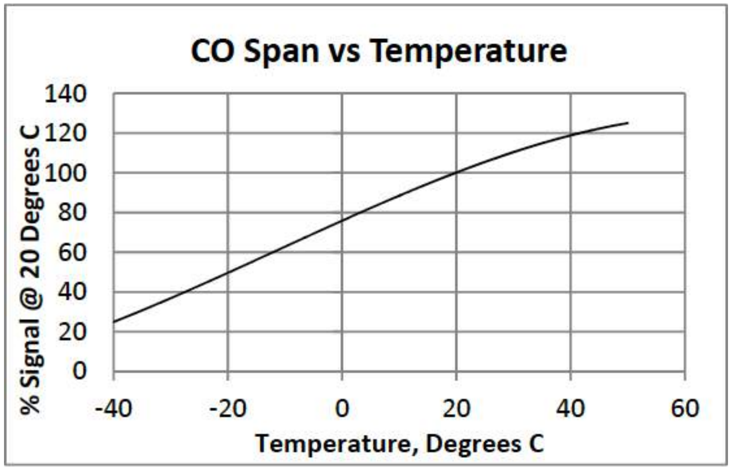
Carbon Monoxide sensor is an electrochemical device used for the detection of CO gas leaks in ambient air. It is designed to be used in conjunction with ZYSENSE MGA 800. Carbon Monoxide sensors operate by generating a small electrical current proportional to the partial pressure of CO gas in the surrounding air. The current is the result of the electrochemical oxidation of CO on a catalytic electrode as shown below. Carbon monoxide sensors are 3-electrode sensors and **require oxygen levels above 5% to operate** properly. They **may not be used** in **oxygen free** applications.

$$CO + H_2O \longrightarrow CO_2 + 2H^+ + 2e^-$$

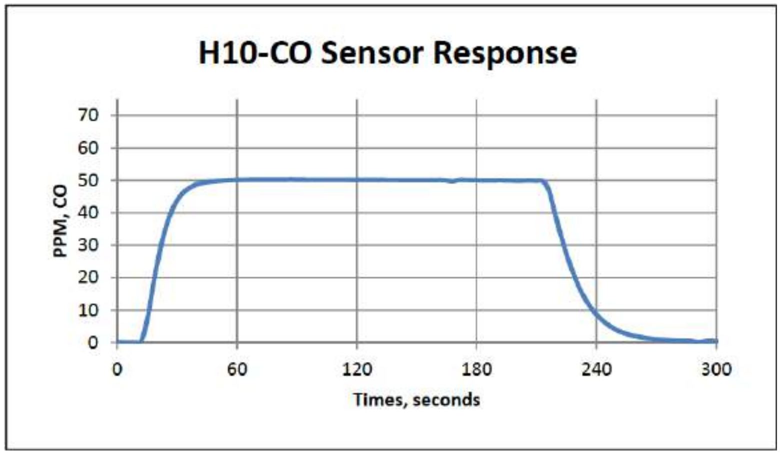
Carbon Monoxide sensor cross sensitivity data

Gas	Symbol	Response to 1 PPM
Hydrogen	H_2	0.1
Ethylene	C_2H_4	0.1
Hydrogen Cyanide	HCN	0.1
Acetylene	C_2H_2	0.1
Nitric Oxide	NO	0.1
Carbon Dioxide	CO_2	None
Acid Gases	HX	None
Hydrogen Sulfide	H_2S	None
Nitrogen Dioxide	NO_2	None
Sulfur Dioxide	SO_2	None
Phosgene	$COCl_2$	None
Chlorine (Oxidants)	Cl_2	None

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for a carbon monoxide sensor. Note that this response time can become significantly slower at temperatures below -20°C.



NITRIC OXIDE Sensor

Nitric Oxide sensor is an electrochemical device used for the detection of NO gas leaks in ambient air. It is designed to be used in conjunction with Zysense Multi-Gas Analyzer MGA - 800.

Nitric Oxide sensors operate by generating a small electrical current proportional to the partial pressure of NO gas in the surrounding air. The current is the result of the electrochemical oxidation of NO on a catalytic electrode as shown below. Nitric Oxide sensors are 3-electrode sensors and **require oxygen levels above 5% to operate properly**. They **may not be used in oxygen free applications**.

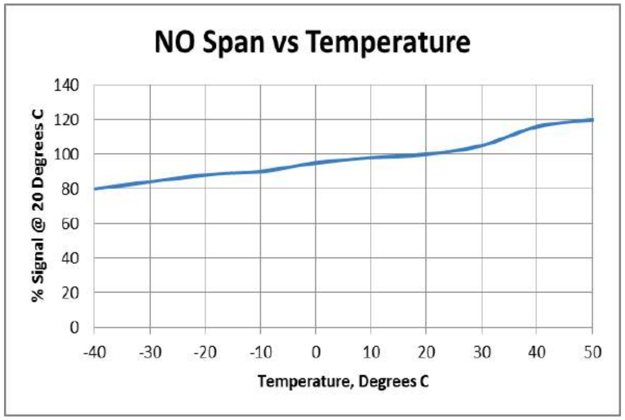
NO + 2H2O —> NO3- + 3e- + 4H+

NO sensors exhibit response to certain other gases. When applying this sensor to specific applications, it is good practice to verify whether or not any of these potential interferences are present and might present interference issues. Note that cross-sensitivity data is approximate. In some cases, response to other gases may not be stable or may be transient.

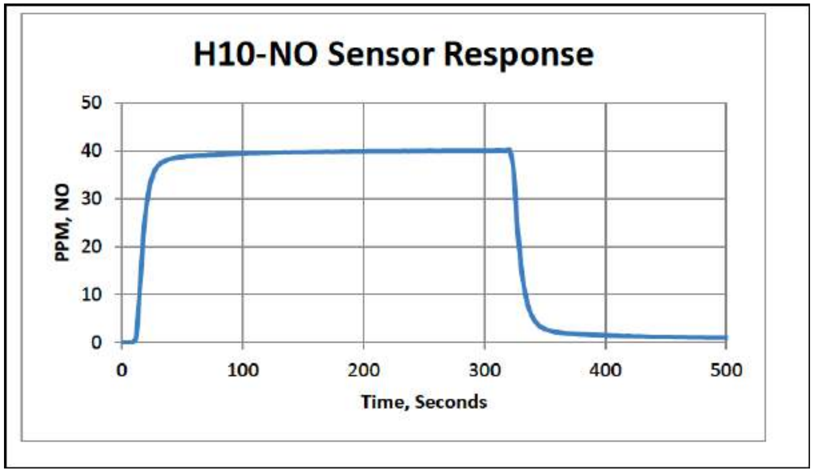
Nitric Oxide Sensor - Cross Sensitivity data:

Gas	Symbol	Response to 1 PPM
Hydrogen	H_2	None
Ethylene	C_2H_4	None
Hydrogen Cyanide	HCN	None
Acetylene	C_2H_2	0.01
Phosphine	PH_3	None
Carbon Dioxide	CO_2	None
Acid Gases	HX	None
Hydrogen Sulfide	H_2S	None
Nitrogen Dioxide	NO_2	None
Sulfur Dioxide	SO_2	None
Phosgene	$COCl_2$	None
Chlorine (Oxidants)	Cl_2	None

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for a nitric oxide sensor. Note that this response time can become significantly slower at temperatures below -20°C.



NITROGEN DIOXIDE (NO2) SENSOR

Nitrogen Dioxide sensor is an electrochemical device used for the detection of NO_2 gas leaks in ambient air. It is designed to be used in conjunction with Zysense Multi-Gas Analyzer MGA -800. .

Nitrogen Dioxide sensors operate by generating a small electrical current proportional to the partial pressure of NO_2 gas in the surrounding air. The current is the result of the electrochemical reduction of NO_2 on a catalytic electrode as shown below. Nitrogen Dioxide are 3-electrode sensors and require **oxygen levels above 5% to operate properly**. They **may not be used in oxygen free applications.**

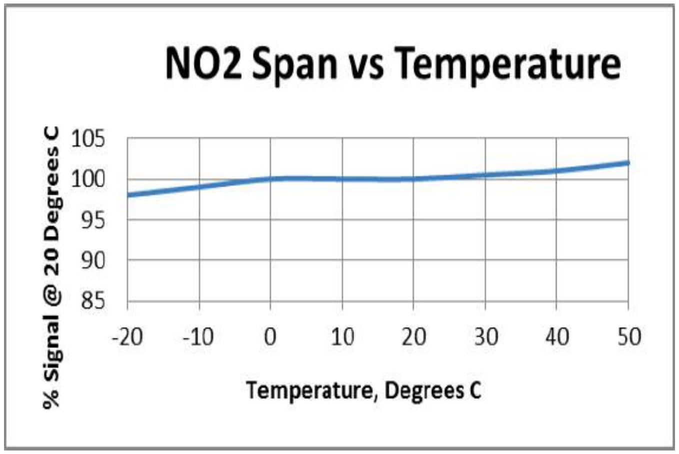
$$NO2 + 2e- + 2H+ \longrightarrow NO + H2O$$

H10-26 NO_2 sensors exhibit response to certain other gases. When applying this sensor to specific applications, it is good practice to verify whether or not any of these potential interferences are present and might present interference issues. Note that cross-sensitivity data is approximate. In some cases, response to other gases may not be stable or may be transient.

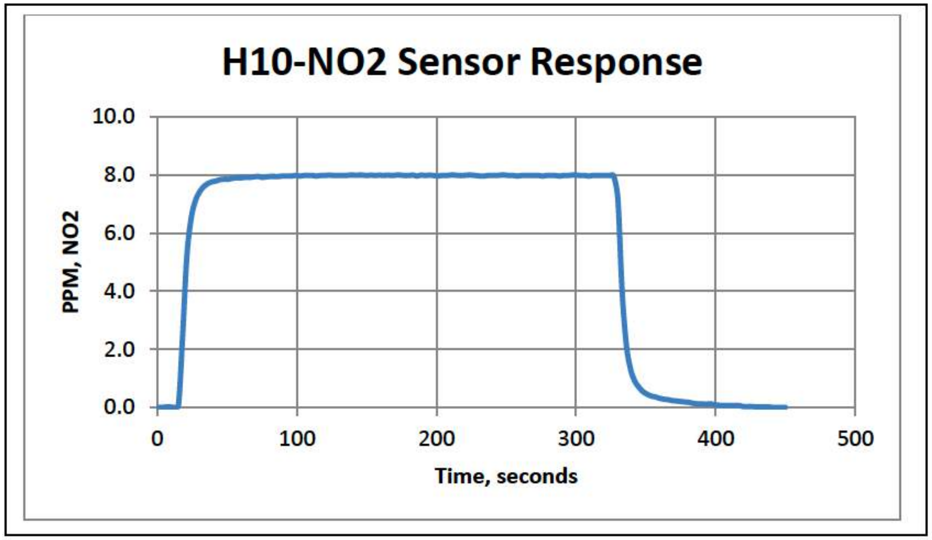
Nitrogen Dioxide Sensor - Cross Sensitivity data

Gas	Symbol	Response to 1 PPM
Hydrogen	H_2	-0.1
Ethylene	C_2H_4	-0.01
Hydrogen Cyanide	HCN	-0.02
Acetylene	C_2H_2	-0.02
Phosphine	PH_3	-3.5
Carbon Dioxide	CO_2	None
Hydrogen Chloride	HCl	-0.05
Hydrogen Sulfide	H_2S	-5.0
Nitric Oxide	NO	None
Sulfur Dioxide	SO_2	-0.8
Phosgene	$COCl_2$	None
Chlorine	Cl_2	1.0

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for a nitrogen dioxide sensor. Note that this response time can become significantly slower at temperatures below -20°C.



HYDROGEN SENSOR

Hydrogen gas sensor is an electrochemical device used for the measurement of H_2 in ambient air. It is designed to be used in conjunction with Zysense Multi-Gas Analyzer MGA -800. .

H_2 sensors operate by generating a small electrical current proportional to the volumetric concentration of hydrogen gas in the surrounding air. The current is the result of the oxidation of hydrogen on the surface of a catalytic electrode, with a resulting signal that is linear with respect to hydrogen concentration. Hydrogen sensors are 3-electrode sensors and require the presence of at least 5% oxygen to operate properly. They are not suitable for use in oxygen free environments.

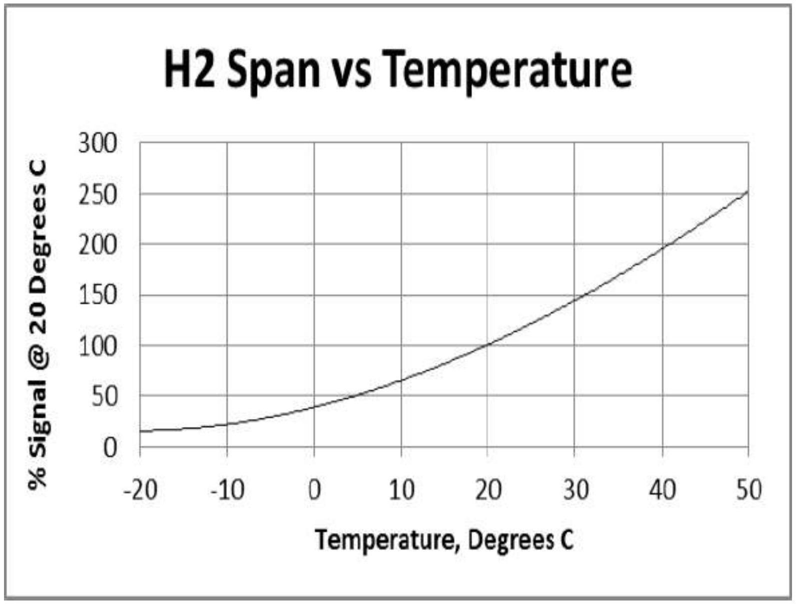
$$H_2 \longrightarrow 2H^+ + 2e^-$$

Hydrogen sensors respond to very few other gases. When applying this sensor to specific applications, it is good practice to verify whether or not any potential interferences are present and might present interference issues. Note that cross-sensitivity data is approximate and based on exposures under 100 PPM. In some cases, response to other gases may not be stable or may be transient.

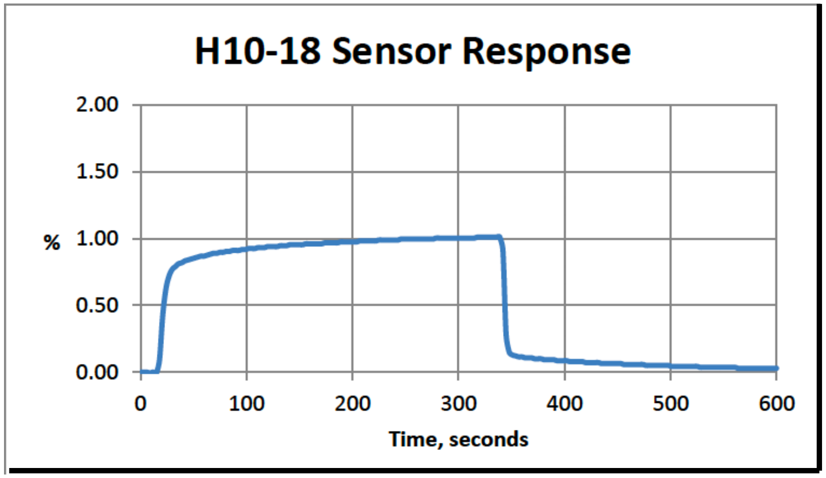
Hydrogen Sensor Cross Sensitivity Data

Gas	Symbol	Response to 1 PPM
Carbon Monoxide	CO	0.1
Acetylene	C_2H_2	0.1
Ethylene	C_2H_4	0.1
Ethanol (alcohol)	C_2H_6O	None
Nitrogen Dioxide	NO_2	None
Sulfur Dioxide	SO_2	None
Hydrogen Sulfide	H_2S	None
Methyl Mercaptan	CH_3SH	None
Chlorine	Cl_2	None
Hydrogen Cyanide	HCN	None
Hydrogen Peroxide	H_2O_2	None
Ammonia	NH_3	None
Hydrogen Chloride	HCl	None
Carbon Dioxide	CO_2	None
Nitric Oxide	NO	None
Hydrogen Fluoride	HF	None

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span of changing temperature



Shown below is a typical response time graph for an H_2 sensor. Note that this response time can become significantly slower at temperatures below -25°C.



PHOSPHONE SENSOR - PH3

Zysense Phosphine sensor is an electrochemical device used for the measurement of very low levels of phosphine gas in ambient air. It is primarily used for parts-per-billion level leak detection. The sensor is actually a “hydride” sensor and is used for other hydride gases such as arsine, diborane, and hydrogen selenide. The cross-sensitivity table on page 2 lists the relative response of this sensor to other hydride gases. Zysense Phosphine sensor is designed to be used in conjunction with Zysense Multi-Gas Analyzer MGA-800.

The sensor is a 3-electrode electrochemical cell and operates by generating a small electrical current proportional to the partial pressure of hydide gas in the surrounding air. The current results from the direct oxidation of phosphine gas on the measuring electrode as shown below.

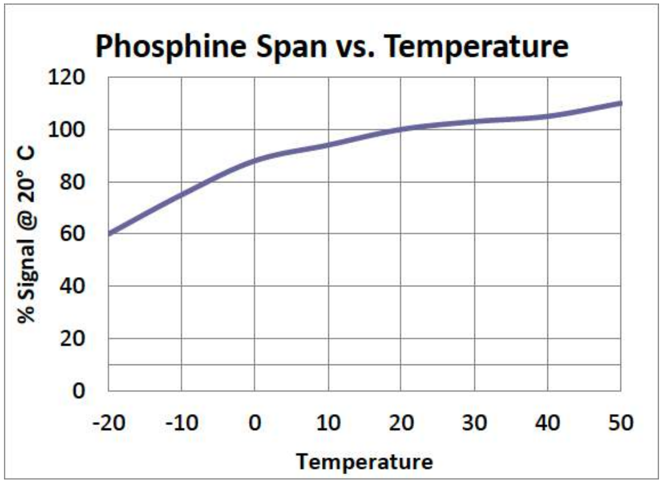
$$PH3 + 4H2O \rightarrow H3PO4 + 8H+ + 8e-$$

H10-32 PPB Phosphine sensors exhibit response to few other gases and vapors. When applying this sensor to specific applications, the user should verify whether vapors other than the target vapor are present. Note that cross-sensitivity data is approximate. In some cases, response to other gases may not be stable or may be transient.

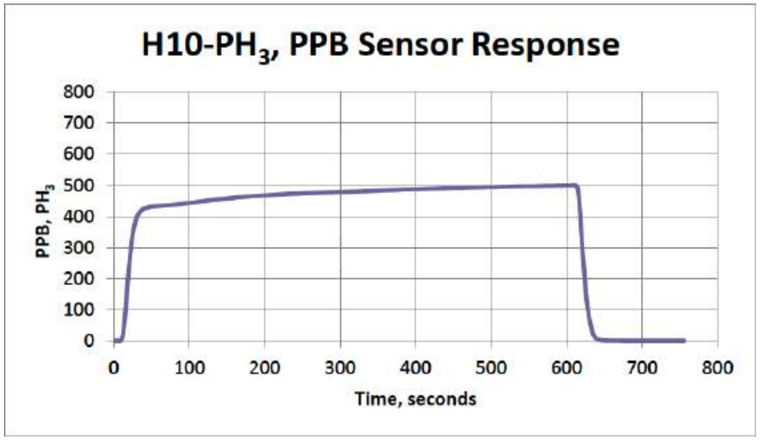
Phosphine Sensor Cross Sensitivity Data

Gas	Symbol	Response to 1 PPM
Phosphine	PH_3	1.0
Arsine	AsH_3	1.0
Diborane	B_2H_6	1.5
Hydrogen Selenide	H_2Se	0.7
Germane	GeH_4	0.5
Silane	SiH_4	0.005
Hydrogen Cyanide	HCN	0.05
Acetylene	C_2H_2	0.0001
Chlorine (Halogens)	Cl_2	-0.01
Nitrogen Dioxide	NO_2	-0.001
Sulfur Dioxide	SO_2	None
Ethylene	C_2H_4	None
Carbon Monoxide	CO	None
Nitric Oxide	NO	None
Alcohol	C_2H_6O	None
Hydrogen	H_2	None

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for a Phosphine. Response to other hydride gases may be somewhat different. Note that response times can become significantly slower at temperatures below -20°C.



HYDROGEN SULFIDE SENSOR (H2S)

Model H10-24 Hydrogen Sulfide sensor is an electrochemical device used for the detection of H_2S gas leaks in ambient air. It is designed to be used in conjunction with Zysense MGA 800 Multi-Gas Analyzer. . Hydrogen Sulfide sensors contain internal electronics and memory that control sensor bias and store calibration data, calibration history, and limited data log. H_2S sensors operate by generating a small electrical current proportional to the partial pressure of H_2S gas in the surrounding air. The current is the result of the direct oxidation of sulfide to sulfate as shown in the equation below. H_2S sensors are 3-electrode sensors and require oxygen to function. They may not be used in applications where O_2 levels are below 5%.

H2S + 4H2O —> H2SO4 + 8H+ + 8e-

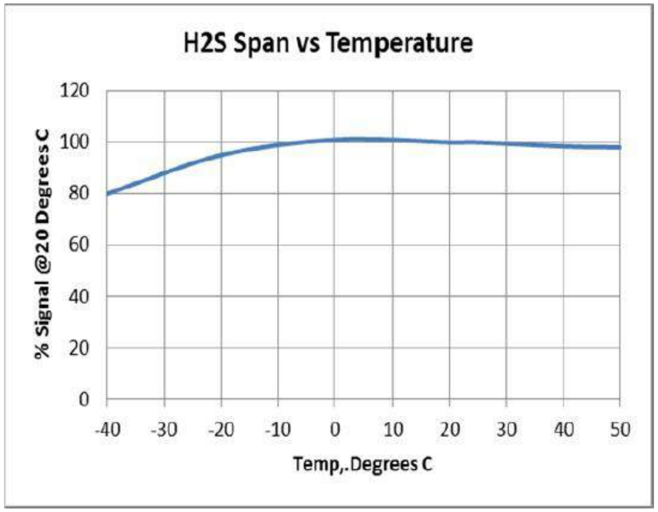
Hydrogen Sulfide sensors exhibit response to certain other gases. When applying this sensor to specific applications, it is good practice to verify whether or not any of these potential interferences are present and might present interference issues.

Note that cross-sensitivity data is approximate. In some cases, response to other gases may not be stable or may be transient.

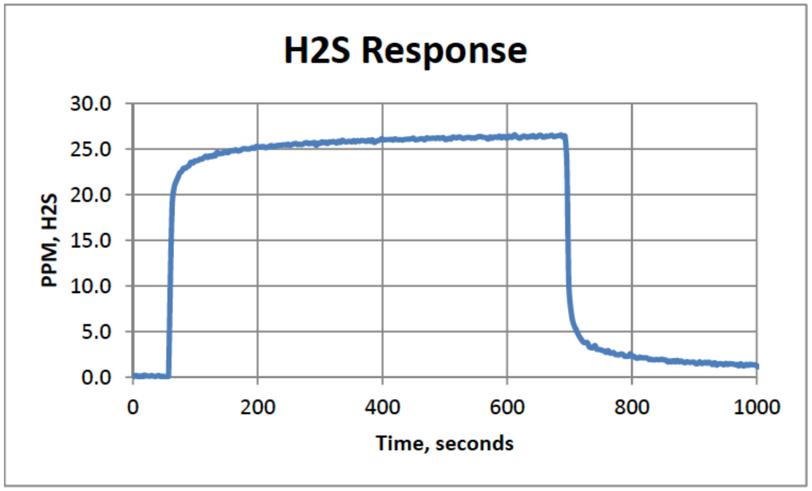
Hydrogen Sulfide Sensor Cross Sensitivity Data

Gas	Symbol	Response to 1 PPM
Ammonia	NH_3	-0.005
Hydrogen Chloride	HCl	-0.005
Carbon Monoxide	CO	0.01
Carbon Dioxide	CO_2	None
Nitric Oxide	NO	0.40
Ozone	O_3	-0.05
Chlorine	Cl_2	-0.05
Hydrogen	H_2	0.0003
Nitrogen Dioxide	NO_2	0.01
Sulfur Dioxide	SO_2	0.08
Methyl Mercaptan	CH_3SH	0.3
Hydrides	PH_3	0.1
Ethanol (alcohol)	C_2H_6O	0.015

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for an H_2S sensor. Note that this response time can become significantly slower at temperatures below -20°C.



Ammonia Sensor (NH3)

Ammonia sensor is an electrochemical device used for the detection of NH_3 gas leaks in ambient air.It is designed to be used in conjunction with Zysense multiage analyzer MGA -800.

Ammonia sensors operate by generating a small electrical current proportional to the partial pressure of NH_3 gas in the surrounding gas. The current is the result of the electrochemical oxidation of NH_3 on a catalytic electrode as shown below. Ammonia sensors are 3-electrode sensors and require oxygen levels above 5% to operate properly. They may not be used in oxygen free applications.

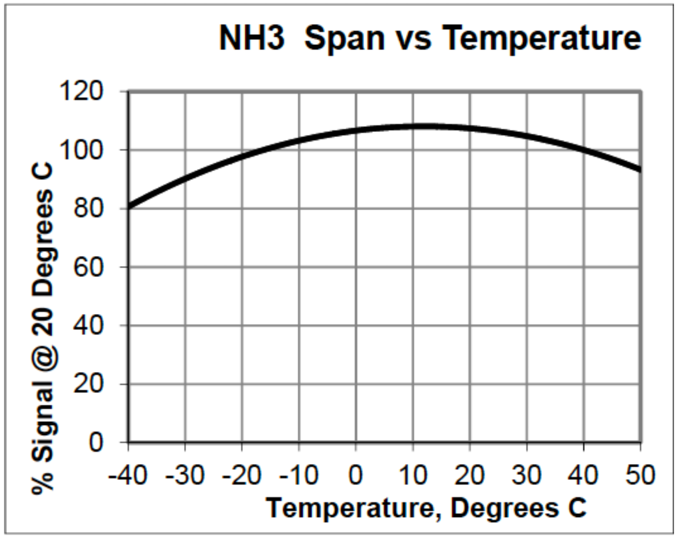
$$2NH_3 \longrightarrow N_2 + 6H^+ + 6e^-$$

Ammonia sensors exhibit response to certain other gases. When applying this sensor to specific applications, it is good practice to verify whether or not any of these potential interferences are present and might present interference issues. Note that cross-sensitivity data is approximate. In some cases, response to other gases may not be stable or may be transient.

Ammonia Sensor Cross Sensitivity Data:

Gas	Symbol	Response to 1 PPM
Dimethylamine	$(CH_3)_2NH$	0.71
Hydrogen Chloride	HCl	-0.5
Carbon Monoxide	CO	0.01
Carbon Dioxide	CO_2	None
Nitric Oxide	NO	0.08
Hydrogen	H_2	0.002
Hydrogen Sulfide	H_2S	1.0
Nitrogen Dioxide	NO_2	-0.08
Sulfur Dioxide	SO_2	-0.1
Methyl Mercaptan	CH_3SH	0.3
Chlorine	Cl_2	-0.5
Hydrogen Cyanide	HCN	0.1
Ethanol (alcohol)	C_2H_6O	0.015

Electrochemical sensors exhibit a response that is temperature dependent to a limited extent. Although the effect of temperature is not large, it is useful to be aware of the effect. Shown below is a graph showing the effect on span (uA/PPM) of changing temperature.



Shown below is a typical response time graph for an ammonia sensor. Note that this response time can become significantly slower at temperatures below -20°C.