Operating Characteristics and Handling Manual for the NAP-56A Explosive/Flammable Gas Sensor

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The Nemoto NAP56A is a new, improved-low cost catalytic flammable gas sensor. Closely related to the very popular NAP-55A sensor, the NAP-56A uses exactly the same sensing elements, but the enclosure in which they are mounted employs a nickel plated brass mounting cap and a phenolic resin header, instead of the Nylon 66 material used in the NAP-55A. As a result, the sensor exhibits an increased sensitivity output and an increase in useful temperature range, whilst being very slightly larger in dimensions, compared to the NAP-55A. The widened temperature range of the NAP-56A makes it particularly suitable for applications such as recreational vehicles, caravans and marine applications where a wide temperature range is required. The mechanical construction and technical performance of this sensor makes it also suitable for a wide variety of Industrial and commercial gas detection applications.

Nemoto has a policy of continuous development and improvement of its products. As such the specification for the device outlined in this document may be changed without notice.

NAP-56A-manual, Issue 4, September 2015

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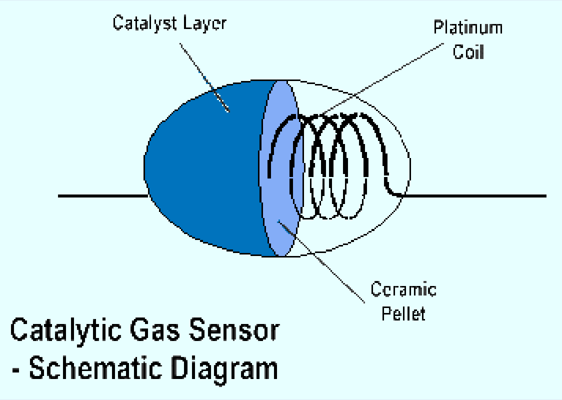
Note that the Performance measurements expressed in this document should be considered as typical characteristics for guidance only, and not as specifications which are guaranteed, apart from those in the sections "General Specifications" and "Dimensions" (Pages 4 and 5). It is the instrument designer's responsibility to ensure that the sensor is suitable for any given application.

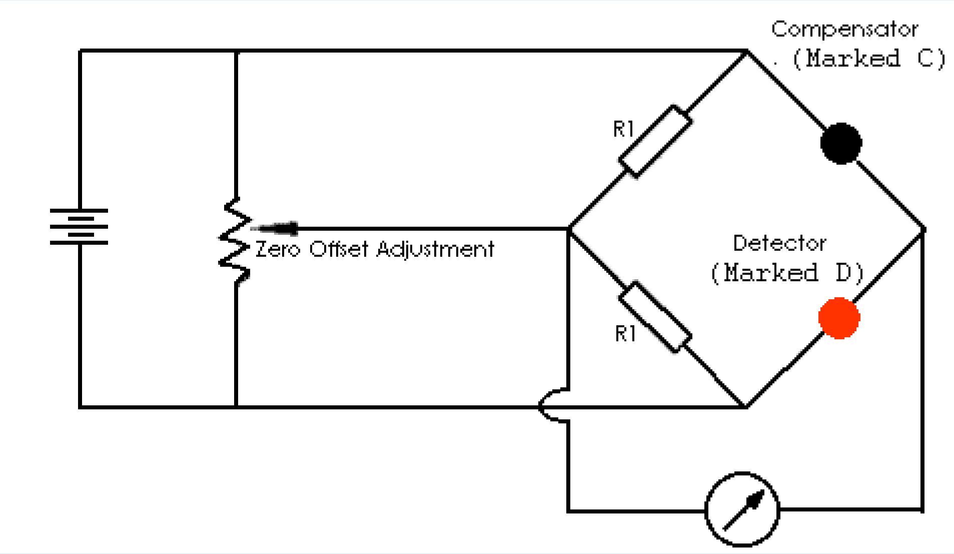
Principles of Operation:

Catalytic combustion has been the most widely used method of detecting flammable gases in Industry since the invention of the catalysed pelletized resistor (or "Pellistor") over 40 years ago.



A Pellistor consists of a very fine coil of platinum wire, embedded within a ceramic pellet. On the surface of the pellet is a layer of a high surface area noble metal, which, when hot, acts as a catalyst to promote exothermic oxidation of flammable gases. In operation, the pellet and so the catalyst layer is heated by passing a current through the underlying coil. In the presence of a flammable gas or vapour, the hot catalyst allows oxidation to occur in a similar chemical reaction to combustion. Just as in combustion, the reaction releases heat, which causes the temperature of the catalyst together with its underlying pellet and coil to rise. This rise in temperature results in a change in the electrical resistance of the coil, and it is this change in electrical resistance which constitutes the signal from the sensor.

Pellistors are always manufactured in pairs, the active catalysed element being supplied with an electrically matched element which contains no catalyst and is treated to ensure no flammable gas will oxidise on its surface. This "compensator" element is used as a reference resistance to which the sensor's signal is compared, to remove the effects of environmental factors other than the presence of a flammable gas.



Pellistor Drive/Measurement Circuit: A simple Wheatstone Bridge to compare the resistance of two hot elements

The advantage of using this technique when detecting flammable gases for safety purposes is that it measures flammability directly.

Nemoto provides matched pair Pellistors conveniently mounted in a variety of enclosures for different applications. Some of these options contain the detector and compensator elements in separate enclosures (the NP range for Industrial applications). In the case of the NAP-56A, both elements are contained within a plastic enclosure for ease of use and low cost.

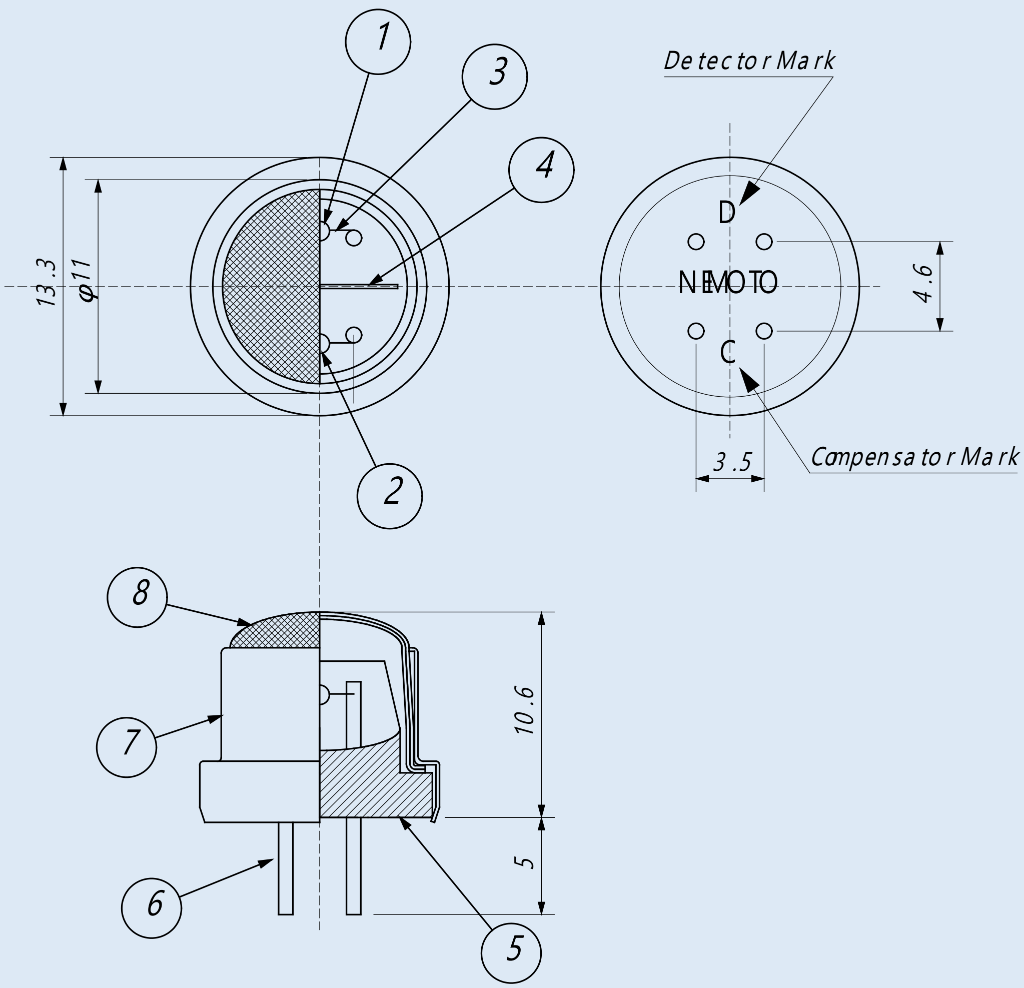
Catalytic pellistor type gas sensors have many advantages compared with semiconductor type gas sensors

- Linear output in proportion to gas concentration
- Greater Stability
- Higher reproducibility
- Gas specific - will only respond to flammable gases
- Unaffected by humidity
- Stable output for long periods
- More resistant to shocks and vibrations.

General Specifications:

Operating Specifications:	
Detected Gases	**All Flammable Gases (All specifications are based on the detection of Methane/Natural Gas)**
Standard Concentration Range	**0 – 2.5% Methane in Air (0-50% LEL)**
Recommended Bridge Voltage	**2.5V +/- 0.25V**
Current Consumption (at Recommended Bridge Voltage)	**170mA +/- 10mA**
Bridge zero offset	**0 +/- 35mV**
Output Sensitivity	**15-23 mV for 3000ppm CH_4**
Linearity	**Effectively Linear to 50% LEL**
Response Time (Measured as T90)	**<10 secs**
Accuracy (Measured as Repeatability)	**± 0.5mV for Zero ± 0.5mV for Gas Sensitivity**
Long Term Stability Drift	**Zero: Less than +/- 2mV per year Sensitivity: Less than +/- 2mV per Month**
Expected Lifetime in the field	**Over 5 Years. (In an appropriate Residential or Light commercial application)**
Environmental Specifications:	
Temperature Range	**-30°C to +70°C**
Standard constant Humidity Range	**15 to 90%RH**
Standard Constant Pressure Range	**1atm ± 10%**
Recommended storage Temperature Range	**0 to 20 degree C**
Recommended Maximum Storage Time	**6 months**
Mechanical Data	
Enclosure Material	**Nickel Plated Brass**
Connector Pin Material	**Nickel**
Header (Base) Material	**Phenolic Resin**
Protective Mesh Material	**316 SS**

Dimensions, Structure and Materials of Construction



No	Parts	Materials	Remarks
8	Mesh	SUS316#100	Duoble
7	Strainer	Brass with Ni coating	t=0.2
6	Pin	Ni	φ0.8
5	Base mount	Phenol	—
4	Separator	SUS304	t=0.2
3	Coil	Pt	φ0.03
2	Compensator	—	—
1	Detector	—	—

Performance Measurements

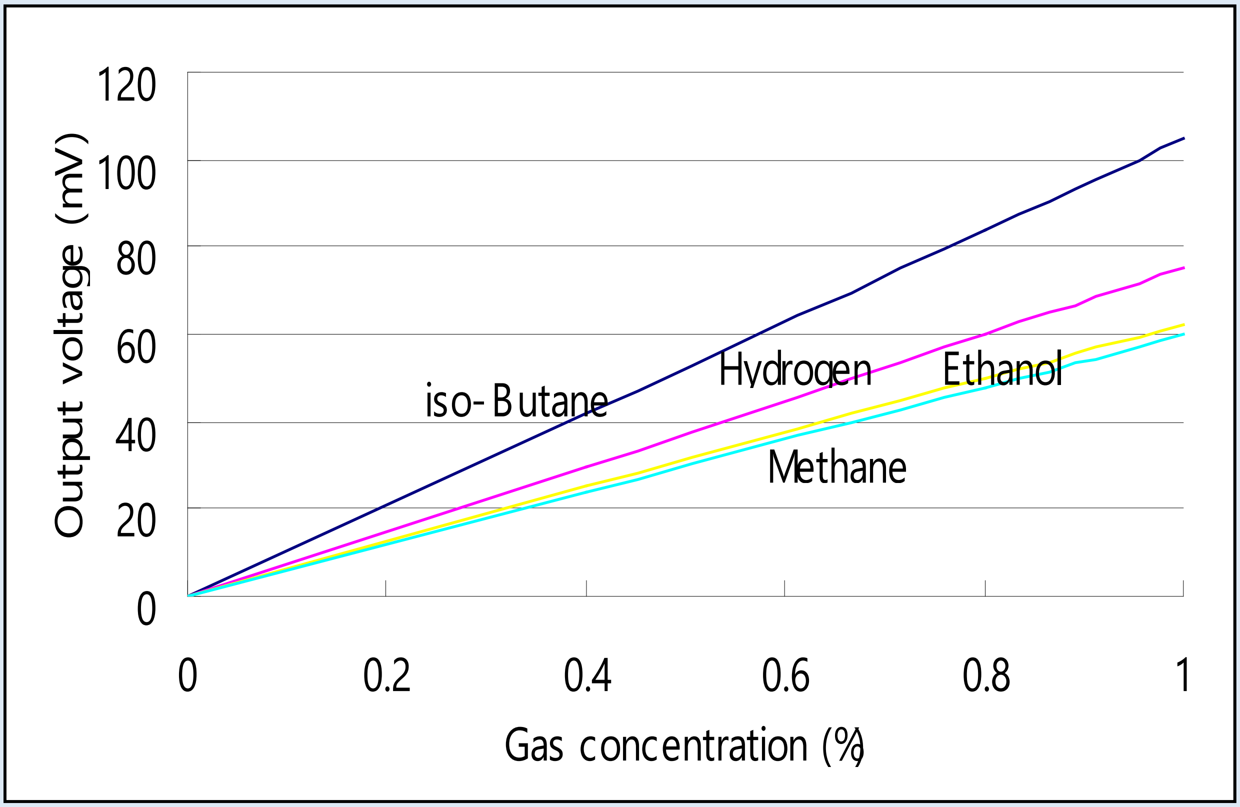
The NAP-56A sensor is derived largely from the very popular NAP-55A sensor, the only difference being in the enclosure, which is slightly larger and made from different materials to result in a device which is tolerant to a wider temperature range. The typical performance of the sensor can hence be largely taken as being very similar to the NAP-55A in most respects.

The chief performance difference between the two sensors is that the signal output of the NAP-56A is slightly higher than for the NAP-55A, and so the performance details given here are those which is related to this difference.

Response characteristics, resistance to catalyst poisons, wind / flow rate effects and lifetime considerations can be considered to be similar to those given in the operating manual for the NAP-55A.

Gas sensitivity

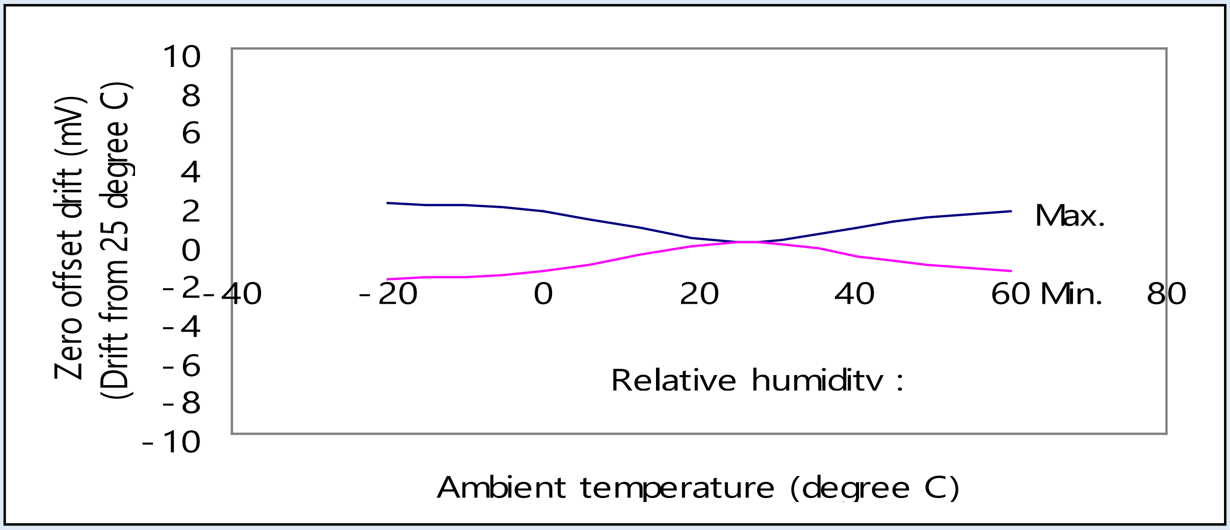
The graph below shows the typical sensitivity characteristics for methane, hydrogen, Isobutane and Ethanol



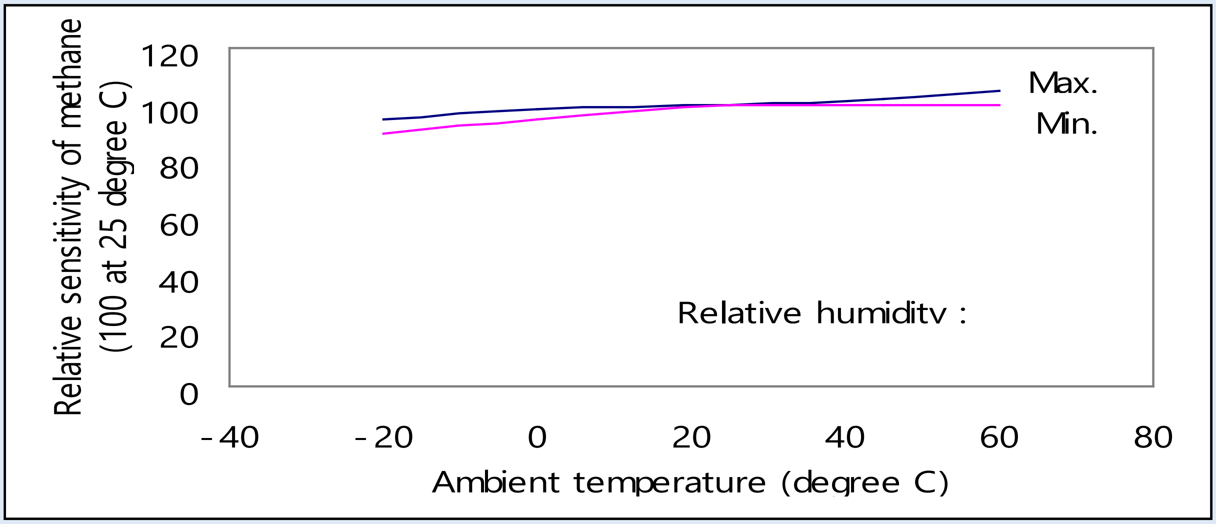
For other flammable gases, Nemoto can advise on the anticipated sensitivity of the sensor alone, but since the relative sensitivities to various gases is also dependent on the mounting arrangement within an instrument, it is always recommended that the instrument maker determines the response of the sensor to the target gas by experiment using the final product design wherever possible.

Temperature Dependence

Typical Zero Offset Drift with Temperature

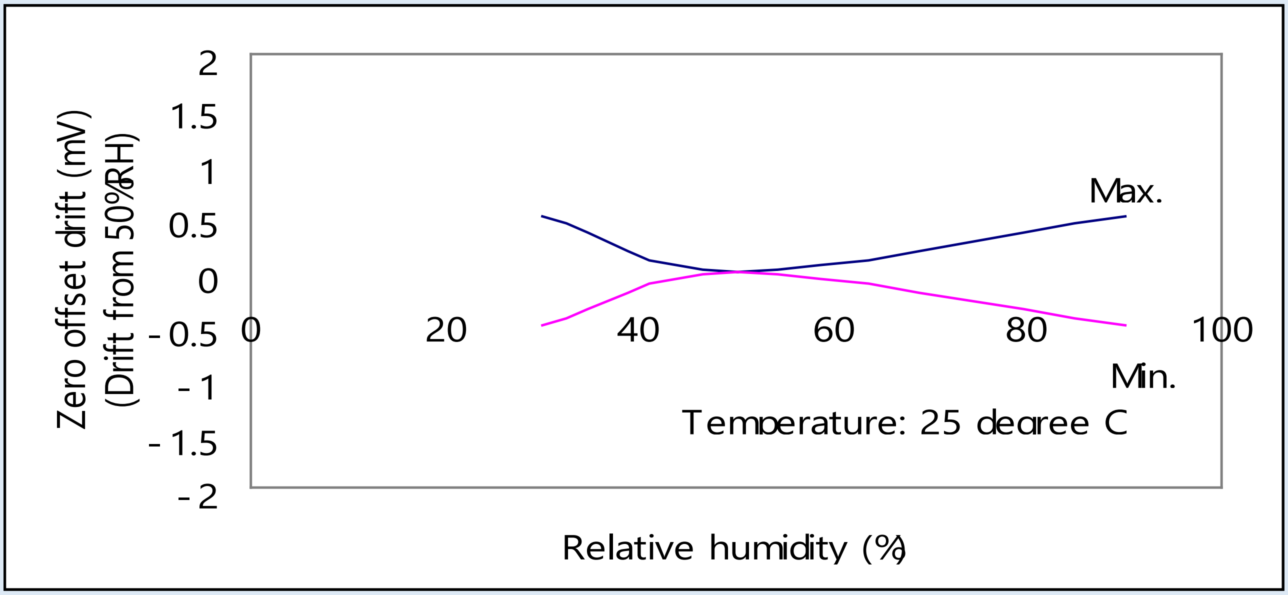


Typical Gas Sensitivity Drift with Temperature

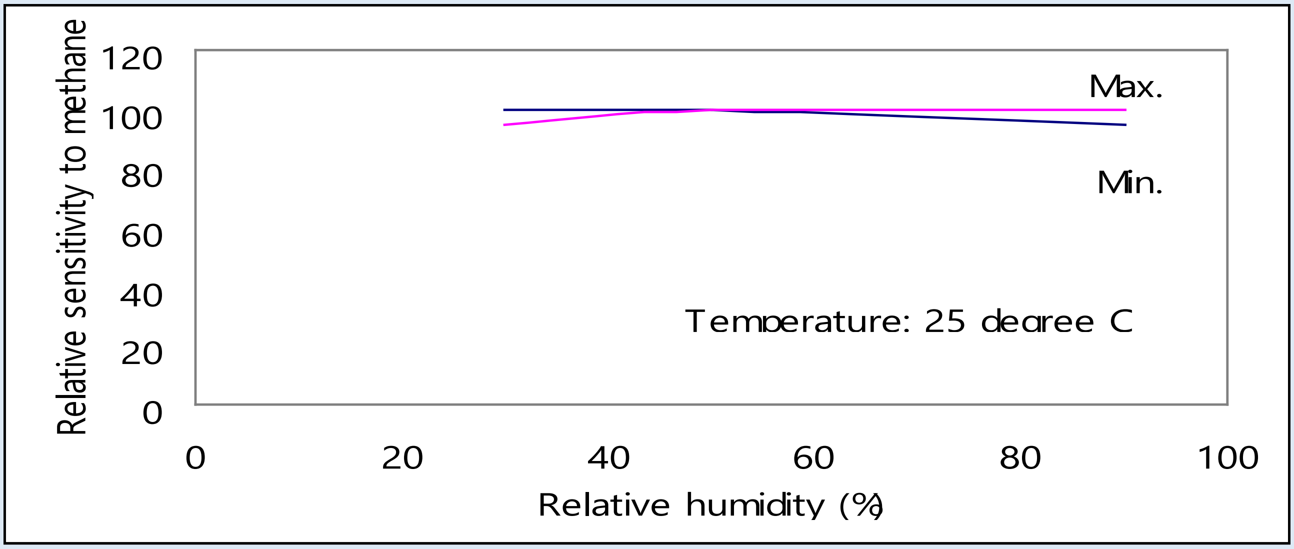


Humidity Dependence

Typical Zero Offset Drift with Humidity

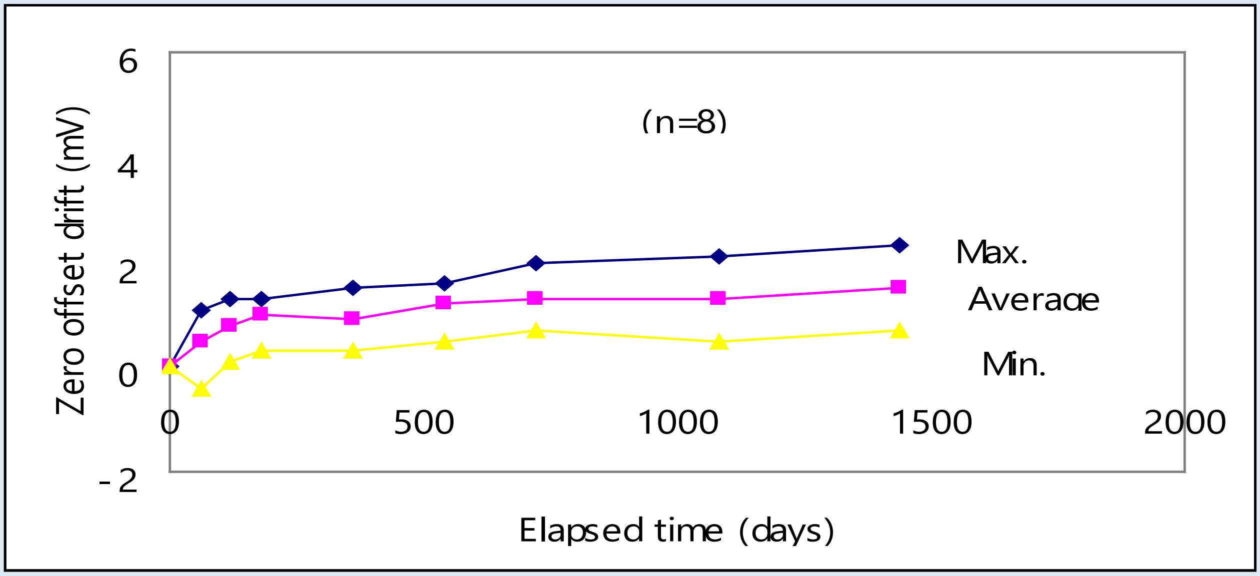


Typical Gas Sensitivity Drift with Humidity

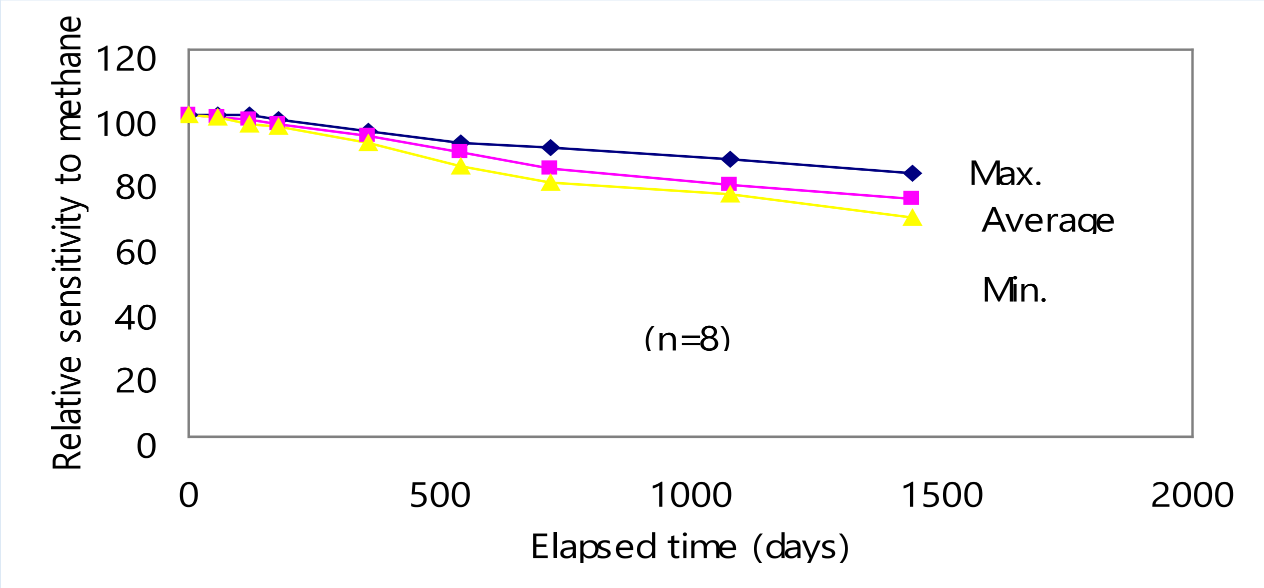


Long Term Stability

Typical Long Term Zero offset Drift



Typical Long Term Gas sensitivity Drift



Relative Responses to various gases

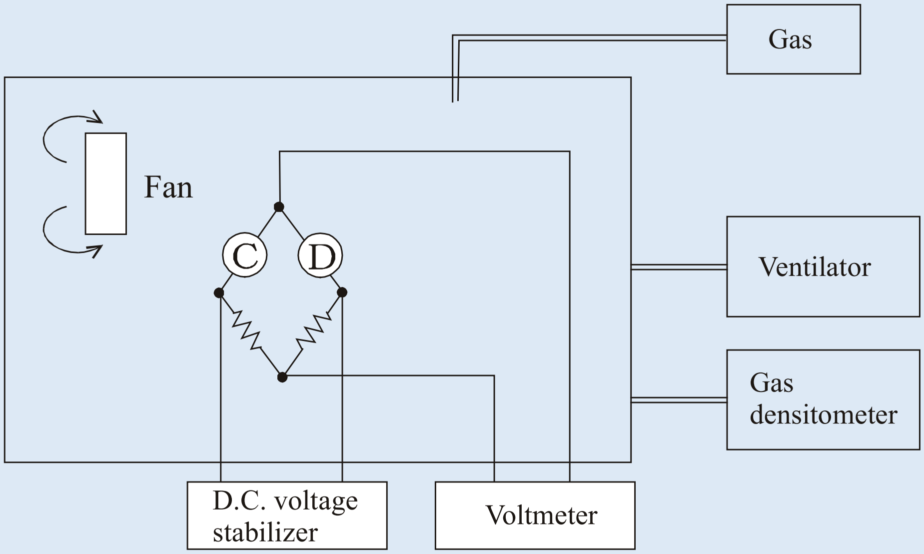
Below is a table of the NAP-56A responses to various flammable gases. The table assumes the sensor is measuring on the 0-100% LEL scale, and also assumes that the response to methane = 100%

Gas	LEL Concentration (%)	Relative sensitivity
Methane	5.00	**100**
Propane	2.20	70
n-Butane	1.80	70
n-Pentane	1.40	65
n-Hexane	1.20	60
n-Heptane	1.05	55
n-Octane	0.95	50
Methanol	6.70	105
Ethanol	3.30	75
Iso-Propanol	2.20	75
Carbon monoxide	12.5	110
Acetone	2.60	60
Methylethylketone	1.90	40
Toluene	1.20	65
Ethyl acetate	2.20	50
Hydrogen	4.00	110
Ammonia	15.0	130
Unleaded petrol	1.20	60
Ethylene	2.70	90

For other flammable gases, Nemoto can advise on the anticipated sensitivity of the sensor alone, but since the relative sensitivities to various gases is also dependent on the mounting arrangement within an instrument, it is always recommended that the instrument maker determines the response of the sensor to the target gas by experiment using the final product design wherever possible.

Notes on sensor testing

All Nemoto specifications are based on testing within a gas filled chamber. Testing the sensor using a flow-through system will yield similar, but not identical, results. The Nemoto test set up is illustrated below:



The test chamber is constructed of glass, or another material known not to absorb gases.

In Nemoto's test regime, test gases are introduced into the chamber by injection, following careful calculation of the amount of gas required to generate the required concentration within the chamber. This may also be accomplished by purging the chamber using gas from a test gas cylinder, provided the flow rate used is not high enough to cause turbulence in the chamber.

The gas inside the chamber is gently agitated by a slow moving fan, to ensure that concentration gradients do not develop during testing, either by stratification layers forming in the chamber, or by the consumption of the gas by the sensors themselves.

Other methods, including the use of flow-through hoods and pumped sampling assemblies, may of course be used by instrument manufacturers, but it should be recognised that the method used to expose the sensor to test gas will have a small effect on the accuracy and repeatability of the results obtained, and the correlation of these results with Nemoto's own routine QA test results. If a flow-through method is to be employed, care should be taken to ensure that:

1) Materials used in the construction, tubing, flanges, joints etc, should be chosen to not absorb the gases to be used, and are free from catalyst poisoning lubricants or mould release agents such as silicones, which could damage the sensor.

2) Flow rates should be carefully calculated so that turbulent flow does not occur in the sensor cavity, and the sensor itself is not subjected to undue back pressure. Flow rates of between 100 ml/min and 400 ml/min is usually appropriate, but it will depend on the design of the assembly.

3) Ideally the sensor should sample the gas flowing above it by diffusion only. Gas should not enter the sensor housing by mass-transport caused by pressure fluctuations. This can be accomplished by the use of a porous ptfe membrane inserted between the flow of gas and the sensor, which will dampen any pressure fluctuations at the sensor. This is especially important if an electric pump is used.

4) The outlet/exhaust of the flow through assembly should allow a non-tortuous exit from the assembly, to avoid back pressure in the sensor cavity.