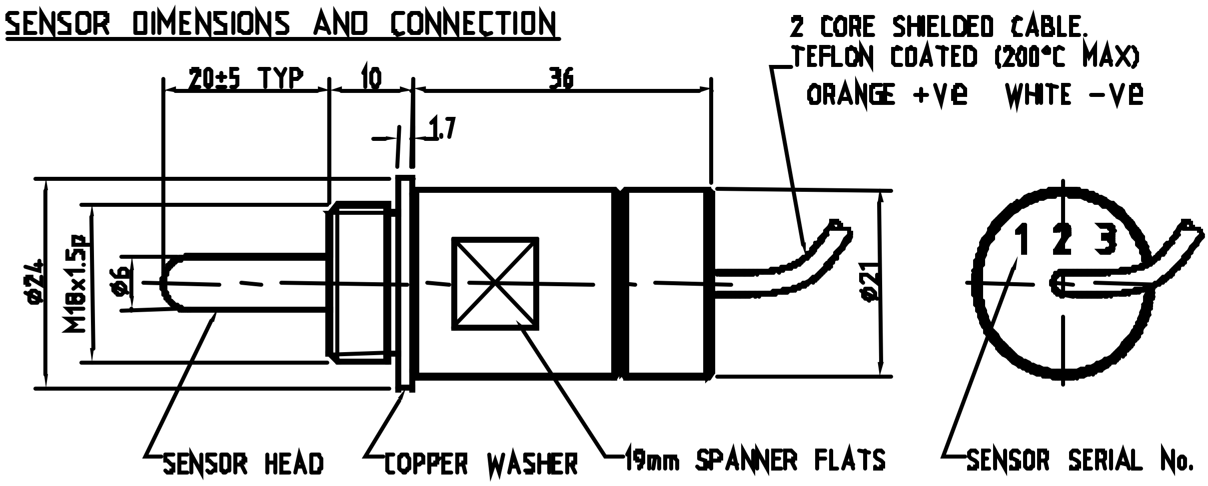
ionotec

INNOVATION WITH ELECTROCERAMICS

NOx GAS SENSOR #105/0058

The sensor is a potentiometric Nernst-type cell designed for continuous operation at temperatures in the range 150-500°C. The floating output voltage within the range 2.0-3.5 V provides a gas concentration-sensitive signal that can be delivered to a signal processing unit incorporating temperature compensation for conversion to 0-20 mA if required.



Note

The information provided in this document is provided for Ionotec customers' information and evaluation purposes only. The sensor has been extensively tested and calibrated in the laboratory and, to a lesser extent, in field trials on a stationary engine and boiler exhaust test beds. The information presented herein is accurate to the best of Ionotec's knowledge but Ionotec does not guarantee that a customer in any given application will obtain the same response, mainly because variations in environmental factors such as fuel composition, which are beyond Ionotec's control, may have a large influence on sensor response.

Specification

Sensor principle	Potentiometric Nernst type
Operating temperature range of sensing head	150 – 500°C
NOx concentration range	1 ppm – 10,000 ppm
Sensor output range	2.0 – 3.5 V DC
Functional relationship	voltage ~ log (concentration)
Voltage sensitivity per decade of concentration (e.g. 10 to 100 ppm NO_2)	+200 mV at 200°C +120 mV at 400°C
Characteristic response time	10 seconds at 200°C 2 seconds at 400°C
Temperature sensitivity of sensor output	- 2 mV per °C
Cross sensitivity to O_2, CO_2, H_2O	< +10 mV per decade
Cross sensitivity to CO, CH_4	< -10 mV per decade

Principle of the NOx Sensor

Ionotec's gas sensor has been developed for routine monitoring of emissions of NOx in applications such as gas/diesel exhaust and boiler exhaust. The sensor is a Nernst-type potentiometric device based on a solid electrolyte membrane that will detect ppm (parts per million) changes in NO_2 concentration in hot gases.

Since exhaust gas has a temperature typically in the range 400-600°C and the form of NOx present is mostly NO rather than NO_2, either a gas sampling circuit with cooling system or an oxidation catalyst chamber upstream of the sensor will probably be required for accurate monitoring of NOx content. The sensor has a reasonably high sensitivity to NO_2 and in typical conditions a change in NO_2 level of 2% will yield a voltage change of 1 mV. However the sensor does not itself exhibit a stable response to pure NO in a low-oxygen environment.

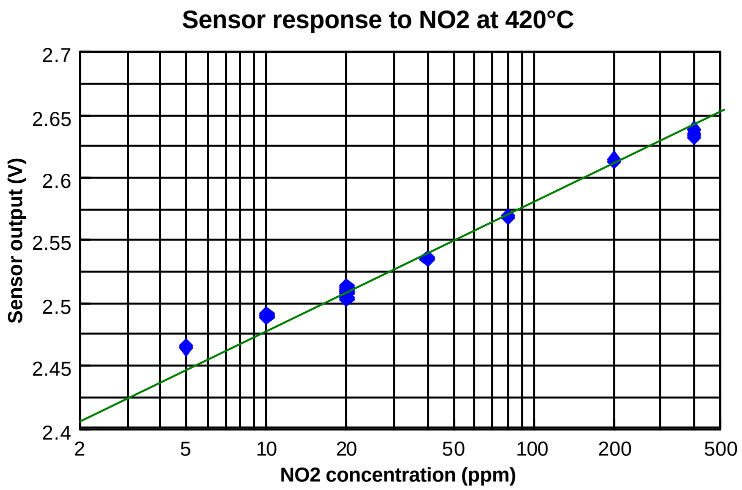
The sensor output is a DC voltage across the ion-conductive ceramic electrolyte generated by the difference in thermodynamic activity of the mobile species between the sensor?s sealed reference electrode and its working electrode which is exposed to the exhaust gas. For a sodium-based reference the redox reaction at the working electrode is thought to be:

$$Na^+ + NO_2 + \frac{1}{2} O_2 + e^- = NaNO_3$$

Theoretically the potential difference between working and reference electrodes due to difference in activity of sodium across the solid electrolyte is related to gas partial pressures p given by

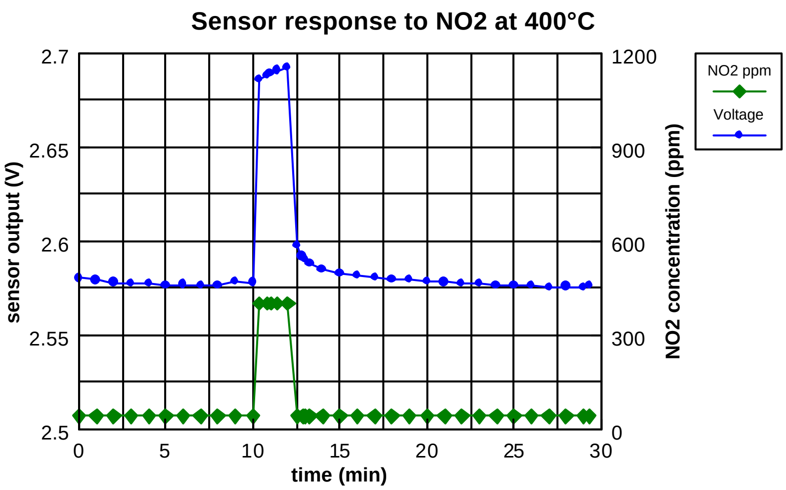
$$E = RT/F \ln p(NO_2) + RT/2F \ln p(O_2) + \text{constant}$$

where T is the operating temperature in 4°K, R is the gas constant and F the Faraday constant. A change in partial pressure $p(NO_2)$ thus causes a logarithmic change in E. The sensor responds reproducibly to variations in NO_2 concentration in the range 1 ppm - 10,000 ppm.



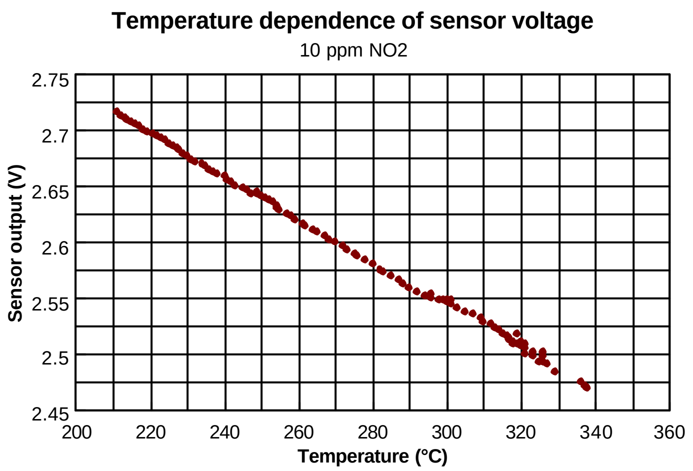
Response time

The response time of the sensor to a change in NOx concentration is somewhat dependent on gas flow velocity and conditions, and laboratory measurements tend to indicate gas system purging effects rather than intrinsic sensor characteristics. Because the impedance of the sensor is low (typically a few ohms) the response of the sensor itself is essentially instantaneous. Observed response and recovery times are faster at higher temperatures.



Temperature dependence of output

The sensor head is capable of operating over a wide range of temperatures and has been demonstrated over the range 150°C to 500°C. The output voltage of the sensor for a given concentration of NO_2 is temperature-dependent (approximately 2 mV change for a temperature difference of 1°C). Temperature measurement of the gas is therefore required at the sensor location at least to an accuracy of ±1°C.



Cross-sensitivity to gas species other than NOx

According to Nernst theory for a sealed reference electrode there should be a high sensitivity to oxygen pressure $p(O_2)$. In practice sensitivity to oxygen partial pressure depends on the presence or absence of NO_2. In the presence of even ppm levels of NO_2 sensitivity to oxygen is suppressed particularly at low oxygen content. Cross-sensitivity to oxygen is not therefore likely to interfere seriously in exhaust gas NOx sensing, except possibly in switching between the extreme conditions of stoichiometric and lean-burn.

With the possible exception of SOx, the NOx sensor is relatively insensitive to most other gas species likely to be encountered at significant levels in an exhaust gas, in particular water vapour, CO, CO_2 and unburnt hydrocarbons. As in the case of oxygen cross-sensitivity to most interfering gas species is to some extent suppressed in the presence of NO_2. The sensor is known to respond to chlorine and fluorine, which may be relevant to biogas fuel applications. In addition there is likely to be a similar sensitivity to SOx that may be relevant to applications involving high-sulphur fuels.

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