Operating Principles

OP16 - MNO-LO Nitric Oxide ppb CiTiceL

CONTENTS

Document Purpose

The purpose of this document is to describe the functionality of the product, and to provide information and advice regarding the appropriate use of the sensors.

This document and the information contained within does not constitute a specification. This document should be used in conjunction with the Product Datasheet.

Operating Principles

Introduction

The toxic Gas CiTiceL development programme began in 1981 with the introduction of the Carbon Monoxide CiTiceL. Since then new CiTiceLs have been developed for various toxic gases, resulting in a range of sensors with an enviable reputation for reliability, stability and robust design.

The MNO-LO is a miniature sensor designed to measure nitric oxide in the range 0-300 ppb NO. Its compact size makes it an ideal choice for portable instrumentation where size is paramount.

Operating Principles

The simplest form of sensor operating on electrochemical principles has two electrodes (Sensing and Counter) separated by a thin layer of electrolyte and connected by a low resistance external circuit. Gas diffusing into the sensor is reacted at the surface of the Sensing electrode, by oxidation or reduction, causing a current to flow between the electrodes through the external circuit. The current is proportional to the concentration of gas and can be measured across a load resistor in the external circuit.

For reaction to take place the Sensing electrode potential must be within a specific range. As the gas concentration increases so does the current flow, causing a change in the potential of the Counter electrode (polarisation). With the electrodes connected together by a simple load resistor, the Sensing electrode potential follows that of the Counter. If the gas concentration continues to rise, the Sensing electrode potential will eventually move outside its permitted range. At this point the sensor will become non-linear, effectively limiting the upper concentration of gas a two electrode sensor can be used to measure.

The limitation imposed by Counter electrode polarisation can be avoided by introducing a third, Reference electrode, and by using an external potentiostatic operating circuit. With this arrangement the Sensing electrode is held at a fixed potential relative to the Reference electrode. No current is drawn from the Reference electrode, so both maintain a constant potential. The Counter electrode is still free to polarise, but this has no effect on the Sensing electrode and so does not limit the sensor in any way. Consequently the range of concentrations a three electrode sensor can be used to measure is much greater.

By controlling the potential of the Sensing electrode, the potentiostatic circuit also allows greater selectivity and improved response to the target gas. The same circuit is used to measure the current flow between the Sensing and Counter electrodes.

The MNO-LO cell has a four electrode design incorporating a highly specific catalyst to enable ppb measurement of NO. The fourth electrode is effectively a copy of the sensing electrode but is not exposed to target gas. This is utilized for baseline compensation.

Nitric Oxide (NO) diffusing into the sensor is reacted at the sensing electrode by oxidation.

$$NO + 2H_2O \rightarrow HNO_3 + 3H^+ + 3e^-$$

The Counter electrode acts to balance out the reaction at the Sensing electrode. As oxidation occurs at the Sensing electrode, oxygen is reduced to form water at the Counter. The standard equation for this electrode can be written as:-

$$\tfrac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$$

IMPORTANT NOTE: For correct operation, CiTiceLs require a small supply of oxygen to the Counter and Reference electrodes. This is usually provided in the sample stream, by air diffusing to the front of the sensor, or by diffusion through the sides of the sensor (a few thousand ppm is normally sufficient). Continuous exposure to an anaerobic sample gas may cause the sensor to malfunction in spite of the oxygen access paths. The sensor must not therefore be completely potted with resin or totally immersed in an anaerobic gas mixture.

Operating Principles

Recommended Circuitry

Figure 1 shows the recommended circuit for use with the MNO-LO sensor.

MNO-LO is designed to work with the Sensing electrode at a more positive potential than the Reference electrode. This is known as 'biased' operation, and the recommended operating circuit is shown on figure 1.

The output from the circuit will always be Positive with respect to common.

The bias voltage must be applied via IC1 so as not to draw any current from the Reference electrode. It must not be applied by connecting a battery directly to the Reference and Sensing electrodes. It is strongly recommended that a bias potential is maintained at all times, even when an instrument is switched off. If it is not maintained, very long start up times may be required when the instrument is switched on. Applying bias to a new MNO-LO sensor will produce a large, rapidly decreasing baseline which is sufficiently stable within 24 hours for measurements to be made. The baseline will continue to stabilise slowly over time until fully settled.

The optimum bias voltage is given in the product datasheet. The recommended level has been shown to offer the greatest balance of features for operational use. A positive bias voltage indicates the Sensing electrode will be more positive than the Reference electrode.

Caution: The Reference and Sensing electrodes are not meant to have the same potential, so are dispatched from City Technology without the usual shorting link. As shorting can cause permanent damage, MNO-LO must be stored with the electrodes unshorted.

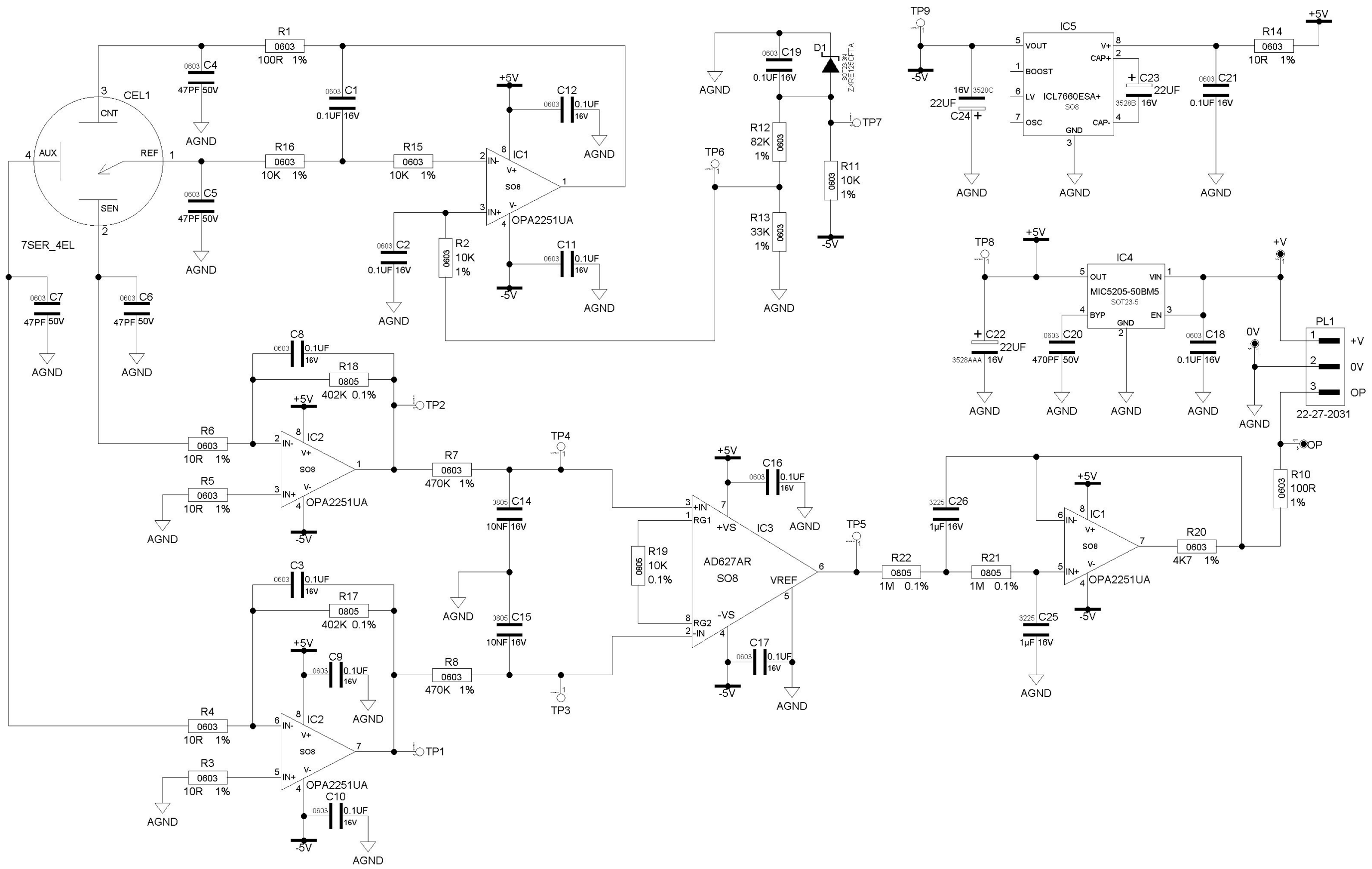

Figure 1 – Recommended Circuitry for the MNO-LO

Operating Principles

Startup and Stabilisation Time

MNO-LO is designed to work with the Sensing electrode at a more positive potential than the Reference electrode. This is known as biased operation. To maintain the MNO-LO in a 'ready to work' condition, it is supplied attached to a bias board which maintains the potentials at the correct levels.

Applying bias potential to a new sensor will produce a large, rapidly decreasing baseline which is sufficiently stable after 24 hours for measurements to be made. The baseline will continue to stabilise slowly during the following three weeks, after which time it should be fully settled.

It is strongly recommended that bias voltages be maintained at all times, even when an instrument is switched off. If the bias potential is not maintained, very long start up times will result when the instrument is switched on.

Calibration Guidelines

For maximum accuracy, the MNO-LO should be calibrated using a gas mixture in the range where most measurements are to be made. Where this is not possible, a mixture towards the top of the CiTiceL range should be chosen. Calibration gases exceeding the range of the CiTiceL must not be used as this may not provide an accurate calibration. Calibration at less than 50 ppm will result in possible complications due to the zero offset (unless the zero offset is measured independently).

As calibration normally involves exposing the sensing face of the CiTiceL to gas for a relatively short period, a calibration gas need not contain oxygen - sufficient is supplied from ambient air, for a limited time, through the side access paths. As all performance data is specified based on a 15 second exposure, calibration should also be performed using an exposure time of 15 seconds.

City Technology recommends a minimum gas flow rate of 300 ml/min NO. Gas access should be diffusion controlled, since forced flow will distort performance due to the open capillaries.

Air cylinders (and other dilutents) may contain ppb levels of NO, and so baseline / purge gas should be filtered to remove all trace levels of the gas.

IMPORTANT NOTE: The MNO-LO is very sensitive to humidity. The humidity levels of the baseline gas and sample gas must be taken into account during calibration and measurements.

Taking Measurements

Measurements should be taken using a 15 second sample time. At City Technology, all measurements were taken at 20°C and 50% ambient RH, 20% sampling RH at ambient pressure with a sampling time of 15 seconds.

Selectivity and Cross Sensitivity

The MNO-LO has been designed to be highly specific to NO, and the effect from other cross-interfering gases has been minimised. This has largely been achieved by the development of a specific electrode catalyst and by the inclusion of an in-board filter to remove acid gases that would otherwise react on the Sensing electrode

Sensor Mounting

The MNO-LO can be mounted in any orientation with no effect on performance. Sensor pins must not be soldered to, as excessive heat will damage the sensor.

Operating Principles

Handling and Storage

• The MNO-LO is relatively insensitive to mishandling and following the simple guidelines given below should ensure correct operation.

• MNO-LO may be stored for up to six months during which time it should be kept sealed in the container in which it was supplied in clean air at 10 - 30°C.

• MNO-LO should be stored within 25% - 75%RH, ideally towards the middle of this range. Storage outside of this range may compromise sensor performance.

• MNO-LO should not be stored in areas containing solvent vapours. All electrochemical sensors are unsuitable for use in applications where organic solvent vapours are present as exposure may inhibit performance.

• MNO-LO must not be subjected to any pressure when handling or clamping.

• At the end of its life, please dispose of the MNO-LO properly as it contains a small amount of hazardous chemicals. MSDS's can be provided for all City Technology products, detailing their hazardous content. The hazardous waste disposal regulations depend on geographic location and local regulations should be checked before discarding the sensors.