

Fumisense An Instrument for the Measurement of Phosphine, Methyl Bromide and Sulfuryl Fluoride during Fumigation

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Abstract: Phosphine, methyl Bromide and sulfuryl fluoride are the common fumigants used by the fumigators for different commodities and under different circumstances. At present, no single instrument is available, which can measure all the three gases using the same instrument in the concentration range of interest to the fumigators.

The present instrument developed by us, uses a thermal conductivity detector for the measurement of methyl bromide (0 – 200 mg/L) and sulfuryl fluoride (0 – 100 mg/L). For the measurement of phosphine (0 – 2000 ppm) it uses an electrochemical sensor. There are two sampling lines, one for methyl bromide or sulfuryl fluoride and the other one for the measurement of phosphine.

The instrument is fully microprocessor based and all the operations are menu driven, which makes the instrument extremely user friendly. The instrument is calibrated for phosphine, methyl bromide and sulfuryl fluoride with a choice to select the gas and the sampling line. Two inbuilt sample draw pumps are used on two sampling lines to draw the sample air to the monitor and put it back to the source. Two thousand measurement data can be stored in the microprocessor of the monitor with gas name, silo number and all other pertinent parameters. The data can later be downloaded on the computer. The instrument is ideally suited for fumigators using all the three fumigants.

The paper also discusses the pros and cons of different measurement techniques used for the detection of phosphine, methyl bromide and sulfuryl fluoride.

Key words: fumigation monitoring, gas detection

Introduction

Methyl bromide (MB) & Phosphine (PH_3) are some of the common fumigants used for fumigating a wide range of agricultural, horticultural and wood products. In recent years the use of Sulfuryl fluoride (SO_2F_2) is also being talked about. The choice of a particular fumigant is dictated by several factors including the type of products, the time available for the fumigation etc.

Fumigation is generally carried out by covering the commodities within a leak proof enclosure and applying the fumigant to generate the desired concentration. As a process control measure it is necessary to monitor the gas concentration at various stages of fumigation.

Fumigant gas concentration used with MB/ SO_2F_2 fumigation ranges from 50 to 100 mg/L and hence the monitoring instrument should have the adequate range of measurement. Thermal conductivity detector based on the differing thermal conductivity of fumigant gas or an interferometric based monitor which uses the diffe-

ring refractive index of the fumigant gas with respect to air are used for the measurement of MB/ SO_2F_2 .

However for the measurement of Phosphine both these techniques fail as they do not have the sensitivity to measure the PH_3 concentration used for PH_3 fumigation which ranges from 0 – 3 mg/L approximately or 0 to 2 000 ppm. Generally the most suitable sensor for this measurement is an electrochemical sensor which is extensively used on PH_3 monitors. At present there is no single instrument which can measure all these three gases using the same instrument.

The instrument described in this paper is developed for use by fumigators who provide fumigation service using all the above mentioned fumigants.

Description

Figure 1 gives the block diagram of the instrument including the sample air path. It uses a TCD (Thermal Conductivity Detector) for the detection of MB/ SO_2F_2 in the range of 0 to 200 mg/L and an electro-chemical sensor for

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the detection of Phosphine in the range of 0 – 2 000 ppm. Two separate sample draw pumps and two separate gas lines, one for PH₃ and the other for MBr/SO₂F₂ are used. The sensor output from the electro-chemical sensor or the Thermal Conductivity Detector are processed by two separate signal conditioning circuits and are digitized by a common ADC. The ADC outputs are processed by a common micro-controller and a common LCD displays the gas concentration after measurements. The instrument is fully micro-processor based and all the operations are guided by a user friendly menu. At a time the instrument can be used for making measurement for one of the three fumigants.

Being a micro-controller based instrument there is provision for logging the measurement data on the micro-controller which can also be downloaded through RS232 port to a PC.

Three thousand such data can be stored in the instrument. The instrument is powered by 14.8 V rechargeable battery with a DC – DC converter to give the desired ± 5 V.

When the instrument is ON, and the gas

line is chosen on the instrument, the corresponding pump starts to draw the fumigant gas for a predetermined time ranging from 1 to 3 minutes, after which the pump stops and the measurement is made. The gas concentration is displayed on the LCD display.

Calibration

The instrument has got several modes of operation such as measurement mode', parameter setting mode', calibration mode' etc. It is possible to navigate from one mode of operation to the other by using four membrane key pads on the monitor.

Once in calibration mode, the instrument is first Zeroed' in clean air. Subsequently the target gas of known concentration is applied to the sensor and using the UP/DOWN keys the monitor is made to read the applied gas concentration. It is also possible to use a surrogate gas like CO for PH₃ and CO₂ for MB/SO₂F₂ for calibrating the instrument. The relation between the surrogate gas and the target gas is given in Table 1.

Table 1 – A Thermal conductivity data of fumigant gases

Sr. No.	Name of Gas	Thermal conductivity data mW/m K @ 27;	Ratio of thermal conductivity of CO ₂ :Target gas	Remark
1	CO ₂ (Surrogate Gas)	26.20	-	-
2	Methyl Bromide (Target gas)	16.80	1:0.33	100 mg/L CO ₂ gas and 33 mg/L CH ₃ Br gas gives the same signal
3	Sulphuryl Fluoride (Target gas)	5.04	1:0.647	100 mg/L CO ₂ gas and 64.7 mg/L SO ₂ F ₂ gas gives the same signal

Table 1 – B Sensor output ratio of CO and PH₃ Electrochemical Sensors

Sr. No.	Name of Gas	µA/ppm generated in an electrochemical Sensor	Ratio of electrical signal CO: PH ₃	Remark
1	CO (Surrogate Gas)	0.1	-	-
2	PH ₃ (Target gas)	0.3	3:1	100 ppm CO and 33 ppm PH ₃ generate the same signal

Discussion

This portable instrument weighing 2.8 kg, housed in a rugged box should prove to be ideal for those fumigators who provide fumigation service to different customers and use different fumigants like PH₃, MB and SO₂F₂. Being a three gas monitor, it is very cost effective and it

is designed keeping in mind the fumigator's as well as customer's requirement. It makes measurement and the measured data can be stored in its memory with all the relevant information such as warehouse number, silo number, the sampling location (Top, middle, bottom) in the silo, date, time etc. A GUI (Graphic User Interface) software provided with the instrument can

later sort out all the measurement data from individual silos. From the stored data various, analysis reports can be generated. The reports in-

clude fumigation reports to be given to the customers or silo wise fumigation report for records etc.

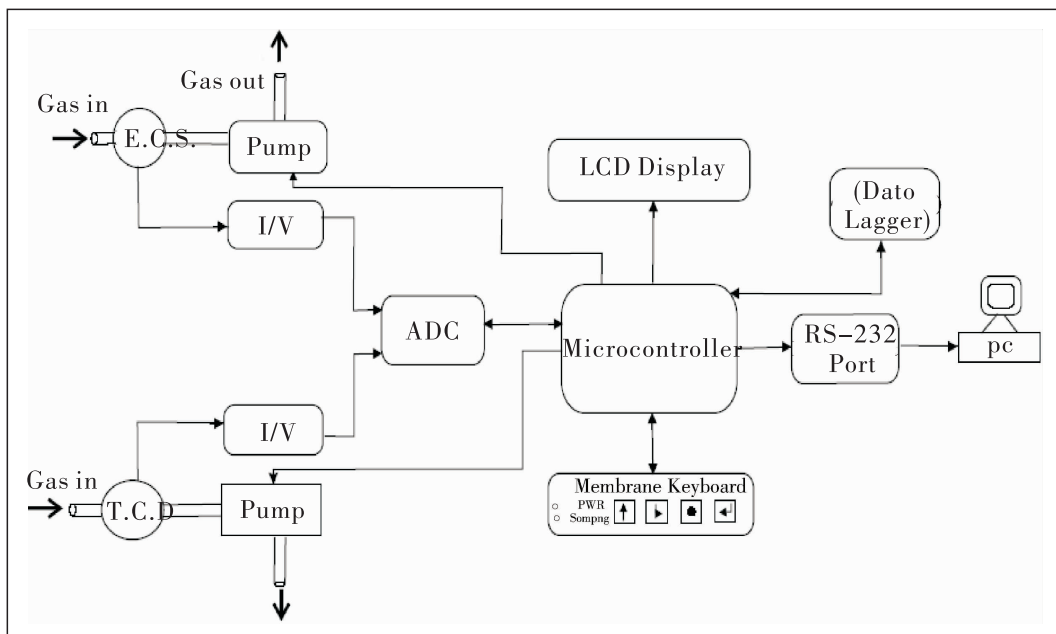


Fig.1 Block Diagram of Fumisense