Monitor of Isobutane Content in the RPC Gas Mixture

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Motivation

The RPC gas mixing ratio is set by 4 MKS mass-flow controllers.

Although these products are quite reliable, they drift slowly with time.

It is not practical to calibrate these controllers frequently (sending gas samples either IHEP or Princeton for analysis using a gas chromatograph).

We need to make sure the Isobutane content is below the lower explosive limit (LEL) – about 6%.

A precision of \pm 0.2% on the nominal 4% Isobutane fraction should be good enough.

Options:

- A monitor RPC

- A catalytic bead sensor (as used in the hazardous gas sensors in the Isobutane cabinet).

- An Infrared sensor.





RPC Dark current as a Monitor of Isobutane fraction?



Dark current is observed via the Bertan HV power supply current-monitoring port.





Gas chromatography of the OPERA RPCgas mixture



opera 2008-10-22 11_19_45130.DATA - TCD



Peak results :

Name	Time	Quartity	Helgit	Area	Area 🐕
	[M b]	X Area	[IV]	[IV.Mb]	[4]
UNKNOWN	4.32	64.41	5602.3	875.8	64.415
UNKNOWN	4.95	0.82	103.5	112	0.821
UNKNOWN	10.58	5.19	263.4	70.5	5.188
UNKNOWN	11.43	29.58	1221.1	402.1	29,577
		100.00	7190.3	1359.6	100.000
	Name UNKNOWN UNKNOWN UNKNOWN	Name Time [Mil] UNKNOWN 4.32 UNKNOWN 4.96 UNKNOWN 10.58 UNKNOWN 11.43 UNKNOWN 14.34	Name Time Quantity [Min] [% Area] UNKNOWN 4.32 64.41 UNKNOWN 4.95 0.82 UNKNOWN 10.58 5.19 UNKNOWN 11.43 29.58 UNKNOWN 10.00 100.00	Name Time Quantity Height [Mh] [% Area] [W] UNKNOWN 4.32 64.41 5502.3 UNKNOWN 4.95 0.82 103.5 UNKNOWN 10.58 5.19 263.4 UNKNOWN 11.43 29.58 1221.1 UNKNOWN 11.43 29.58 1221.3	Name Time Quantity Height Area [Mh] [% Area] [W] [W.Mh] UNKNOWN 4.32 64.41 5602.3 875.8 UNKNOWN 4.95 0.82 103.5 11.2 UNKNOWN 10.58 5.19 263.4 70.5 UNKNOWN 11.43 29.58 1221.1 402.1 UNKNOWN 11.43 29.58 1221.3 402.1

Data collected at Princeton

With a Varian Model





GC Test Results



We tested three different gas mixes, with Ar flow rates @65, 74 and 85 sccm, other three flow rates unchanged):

Ar/R134A/Isob/SF6:

72.63/22.35/4.47/0.56;

75.13/20.3/4.06/0.51;

77.63/18.26/3.65/0.46.

The gas chromatograph tracked to the mixing ratio change very well.





Dark Current Variation



Dark Current Variation (cont'd)

Expanded time scale during the period of Ar fraction changes:





Strong correlation between dark current and Argon fraction.



Effect of Change in the Isobutane Fraction

In a second set of tests, we varied the Isobutane flow rate: 3.0, 4.0 and 5.0 sccm, whiling keeping the other three gas-flow rates constant.

The GC tracks this well:





Does RPC Dark Current Change When Isobutane Changes bt \pm 1%?

The effect of a 1% change in Isobutane fraction on RPC dark current is hard to distinguish from "noise".



Catalytic Bead HAD sensor

We have obtained a catalytic bead HAD sensor (\$500) from RKI for use with the Isobutane gas cabinet.



Features

- Explosion proof housing
- Patented water repellent sensor coating
- Available for LEL, H2S, CO, O2, and ppm HC
- IR sensors available for LEL & CO2
- Long life sensors (2 + years typical)
- Competitively priced
- UL or CSA classified (most versions) Applications
- Petrochemical Plants
- Refineries
- Gas Plants
- · Offshore Drilling Platforms
- Water & wastewater treatment plants
- Pulp & paper mills
- · Gas, telephone, & electric utilities
- Parking garages
- Manufacturing facilities
- Steel
- Automotive
- Chemical storage buildings

We have calibrated this sensor with 50% of LEL Isobutane calibration gas, and it appears to be working well.

However, this type of catalytic bead sensor requires some oxygen in the gas, so it can't be used to measure the fraction of Isobutane in the RPC gas stream.



The active bead is coated with a catalyst that, when in contact with a combustible hydrocarbon or solvent, causes the gas or vapor to "burn" or oxidize at concentrations below the Lower Explosive Limit (LEL). This oxidization process raises the temperature of the active bead and increases the resistance of the internal wire coil.



An alternative (somewhat more expensive) version of the HAD sensor, an IR (infrared) sensor, has no such restriction, so it could be a candidate for our application.

We asked Enmet the following question: Is an IR sensor suitable for instream measurement of Isobutane fraction with to +/- 0.2% precision on top of 4% nominal Isobutane?

Their answer is YES.





Working Principle of the IR sensor



The principle: Use infrared light absorption as a means to detect the presence of combustible hydrocarbon gases.

Components: an IR radiation source + two pyroelectric detectors: "active" and "reference" detectors.

The active detector is covered with a filter specific to the portion of the IR spectrum absorbed by a particular hydrocarbon.

The reference detector has a filter specific to the non-absorbed part of the IR spectrum.

Hydrocarbon gases absorb a fraction of the IR radiation and the active detector signal decreases. The reference detector signal remains unchanged.

The ratio of the active and reference detector signals is used to compute the gas concentration.





Cost Estimate of an IR Isobutane Monitor

ITEM.	QTY.	DESCRIPTION	UNIT PRICE	TOTAL
1	1	ENMET Model IR-6000 NDIR hydrocarbon detector sensor/transmitter. (0-10% Vol Isobutane)	\$1,995.00	\$1,995.00
2	1	Flow Housing for Item #1 (Set for $\frac{1}{2}$ lpm at atmospheric pressure.)	\$495.00	\$495.00
3	1	#04640-001 CP-10 Controller, 110 VAC. See attached technical information.	\$895.00	\$895.00
			TOTAL	\$3,385.00

IR-6000

Infrared Hydrocarbon Sensor/Transmitter 0-100% LEL

FEATURES

- Infrared sensing technology
- Low maintenance
- Immune to poisoning
- Designed for harsh environments
- Explosionproof
- Fast response time
- Self-compensating optical bench
- No moving parts



DESCRIPTION / OPERATION

The IR-6000 hydrocarbon detector is a single source dual wavelength instrument. The sensing and reference elements are self-compensating for optical integrity and other signal inhibitors. The 4-20 mA analog output can be connected to one of the several MX-Series Controllers available from ENMET. These controllers furnish 24 Vdc power for sensor/transmitters and provide a digital display of gas concentration, audio/visual alarm and relays.

СР-10

SINGLE-CHANNEL, WALL-MOUNT CONTROLLER Accepts 4-20 mA Input from Remote Sensor/Transmitter

The CP-10 is an economical, yet versatile singlechannel controller with the features needed for monitoring a remote 4-20 mA gas sensor/transmitter or similar device. The instrument provides 24 VDC loop power, audio/visual alarms, alarm relays and other features. The CP-10 is easy to install, designed for wall mounting and completely programmable from the front panel membrane switches.



SPECIFICATIONS Display: 8 0

8 Character, alphanumeric, high contrast dot matrix LCD with backlight





There are two options for using IR sensor as Isobutane monitor:

1) Make a portable device with previous mentioned components from Enmet; carry this device to each Hall routinely, such as once a month, to check the fraction of Isobutane in the mix;

2) Install such device for all three EH, then the fraction of Isobutane can be continuely monitored on-line.

Option 1) costs ~ \$3400;

Option 2) costs ~ \$9000 (we can integrate the controller into our gas system control crate to save some money).





• An IR HAD sensor can be used to monitor Isobutane fraction up to +/- 0.2% precision on top of 4% of nominal concentration;

• The dark current variation of a test RPC due to Isobutane fraction change is not sensitive enough to be used as Isobutane monitor.



