ARE YOUR GAS DETECTORS ACTUALLY WORKING?

MINE ELECTRICAL SAFETY ASSOCIATION

2017 CONFERENCE

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PRESENTATION OVERVIEW

1. Essential attributes of a gas sensor.
2. Common gas sensing technologies applied in mining.
3. Response time:
   - A blocked sensor will be slow, but for some types there is a link to absolute accuracy as well …. blocked sensors can also under report or read incorrectly.
4. Time to alarm or T90 – which one counts?
5. Practical response time testing – it's a mine not a lab …
6. Summary observations.

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ATTRIBUTES OF A GAS SENSOR

... its all about absolute accuracy isn't it?

- Whether it is monitoring for explosive risk or toxicity a gas detector must:
  1. Accurately sense the gas concentration,
  2. Transmit (and sometimes locally display) the concentration, and/or;
  3. Signal a warning or alarm to initiate an action in a timely manner.
- … so there are three fundamental attributes:
  1. Accuracy;
  2. Telemetry; and,
  3. Time response.

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PERFORMANCE REQUIREMENTS

... defined for new gas detectors

- All ***new*** gas detectors used in Australian mining undergo performance testing to validate all three attributes:
  1. Accuracy;
  2. Telemetry; and,
  3. Time response.
- Flammables: AS/NZS 60079.29.1
- Toxics and Oxygen: AS/NZS 4641

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MAINTENNANCE OF GAS DETECTORS

New revision of AS2290.3 includes accuracy, telemetry and response testing

- Until recently Standards and Industry practice for maintenance of gas detectors focussed almost exclusively on absolute accuracy.
  - Regular bump tests and NATA calibration.

- Testing telemetry and time response were largely ignored …AS 2290.3 will now require telemetry and response testing.
  - … so why the change after so many years?

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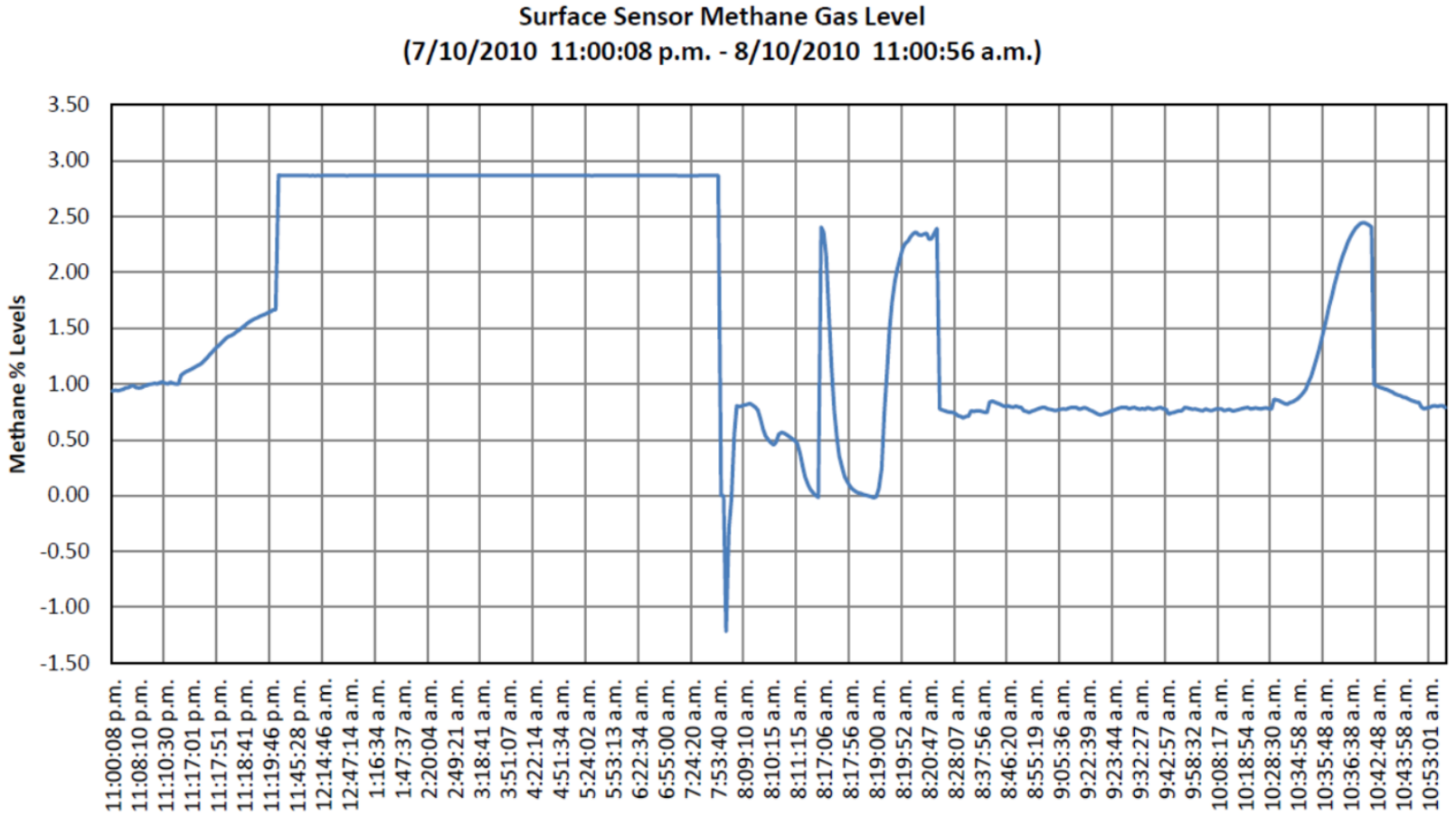
TELEMETRY

Pike River example



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TELEMETRY

Pike River example

23. Further, Energy New Zealand concluded the sensor was installed in such a way that 5% methane (the upper limit of the sensor) would have reported as 2.96%.[38] This problem was not detected at the mine. Mr White said he was not aware of it,[39] and he agreed it raised serious issues about the reliability and accuracy of the sensor.[40] The sensor did go through a calibration exercise on 4 November 2010,[41] but this was carried out with a concentration of 2.5% methane, 'which was within the functional operating range of the system.'[42] Accordingly, the issue was not uncovered during the calibration process.

- Telemetry on the detector had never been tested, the total burden installed on the 4..20mA loop was too high and the sensor could not report more than 2.96% CH_4 … bump tests were done at 2.5% CH_4 .

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RESPONSE TIME

Pike River example …

- Did you know a blocked sensor will still respond to cal gas and can be calibrated?
- … the Pike sensor still worked but significantly under reported when tested … ?

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RESPONSE TIME & ACCURACY ??

... Response time is not independent of accuracy for some sensor types

- The interaction between time response and absolute accuracy for some sensor types in widespread use is poorly understood.
- Even though a blocked sensor will calibrate correctly:
  - It can under report concentration in still air.
  - Read incorrectly in moving air.
  - Fail to identify transient gas concentrations.

- … we will come back to this …

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COMMON SENSOR TYPES

… In widespread use in Australia

- Catalytic
  - Catalytic oxidation (low temperature combustion) of target gas to produce heat, subsequently measured as a changing resistance in a sensing element or wire.
- Electrochemical
  - Chemical oxidation or reduction to produce a flow of electrons, subsequently measured as a current.
- Infra-red
  - Spectroscopic identification of target gas (absorption of light).

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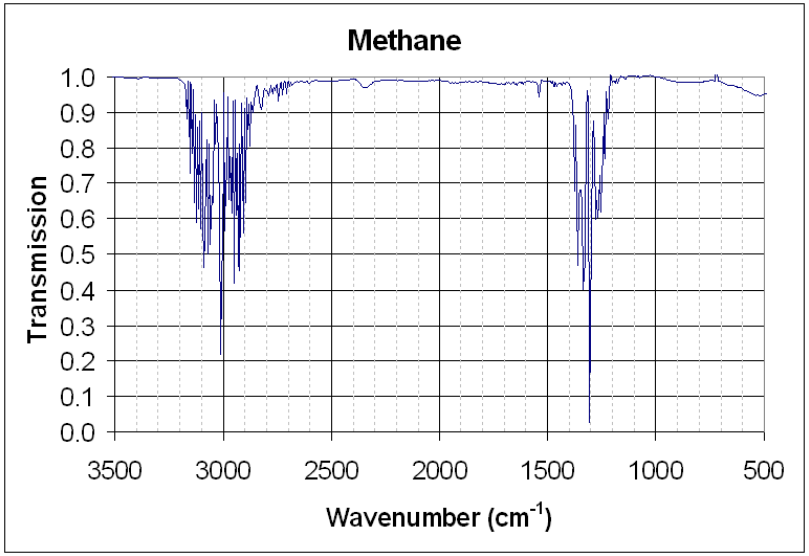
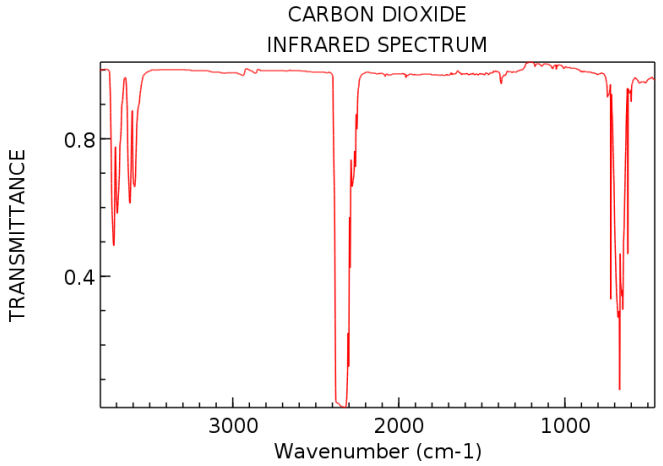
INFRA-RED SENSORS

... Spectroscopy

- Many compounds have unique radiation absorption bands that can be used to identify them:
  - Methane absorbs light at 3.3µm & 7.7µm
  - Carbon Monoxide 4.2-4.5µm
- IR sensors literally measure the number of molecules shading the sensor from the radiation source.





NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

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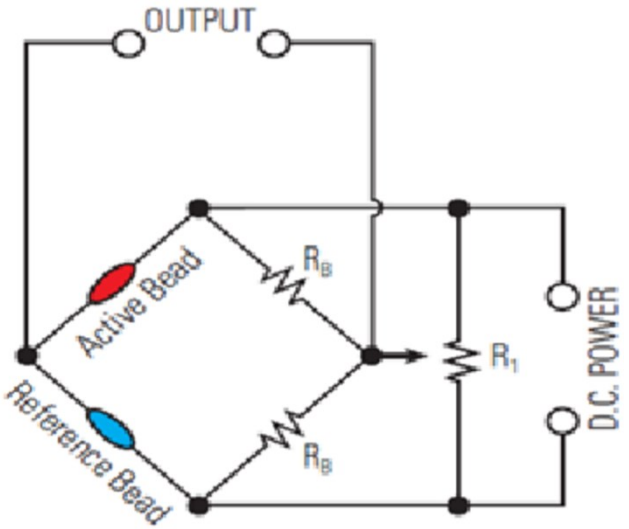
CATALYTIC SENSORS

... produce heat detected by a change in resistance

- Platinum wire coated in a catalyst oxidises the target gas to produce heat.
- The wire resistance changes with temperature from oxidation.
- Heat produced (and so temperature) is directly related to the rate of oxidation and so the concentration of target gas.



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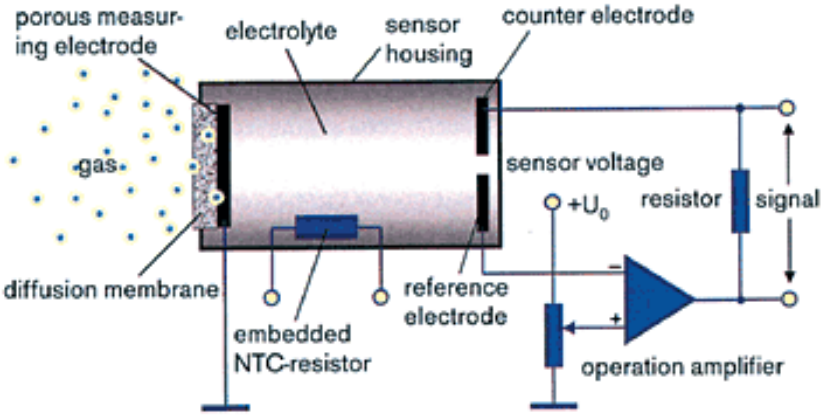
ELECTROCHEMICAL SENSORS

... chemical oxidation or reduction

- Chemical oxidation or reduction results in a flow of electrons.
- The flow is collected via electrodes and constitutes a current which is then measured.
- The current is directly related to the concentration of target gas.



Electochemical sensor measuring principle

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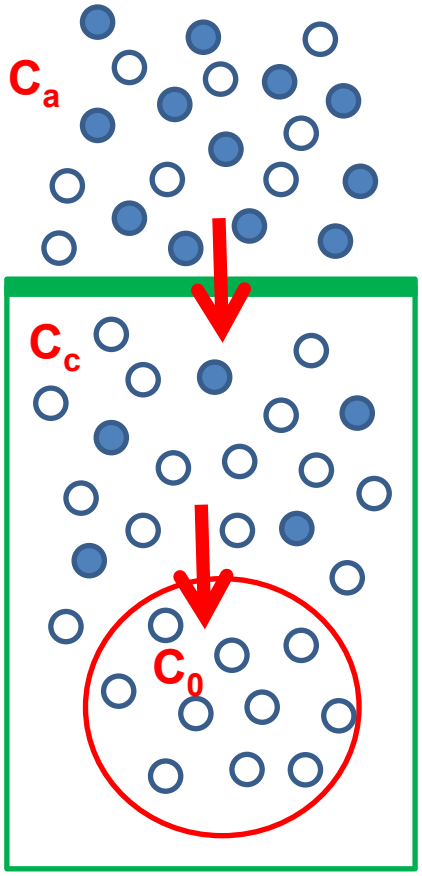
DIFFUSION SENSORS

- The ambient atmosphere containing the target gas diffuses through a porous membrane.
- Catalytic and electrochemical cells consume the target gas as a fuel.
- A constant concentration of gas results in a constant flow of fuel through the porous membrane where it is consumed by the sensor at a constant rate.



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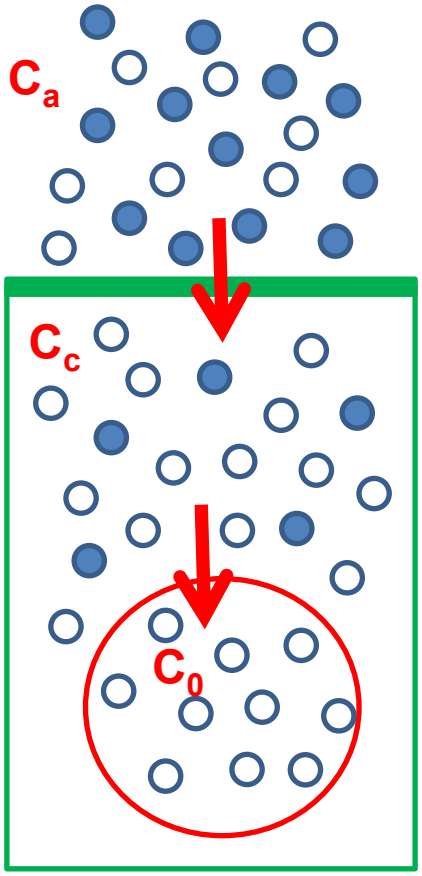
BLOCKED MEMBRANE?

... the sensor response time is just slower – right?

- If the porosity of the membrane reduces (becomes blocked), the flow rate of fuel through the membrane also reduces.
- The sensor records the reduced fuel flow rate as a reduced concentration.
- A sensor that is blocked will not only respond slower, but also under report the actual gas concentration.



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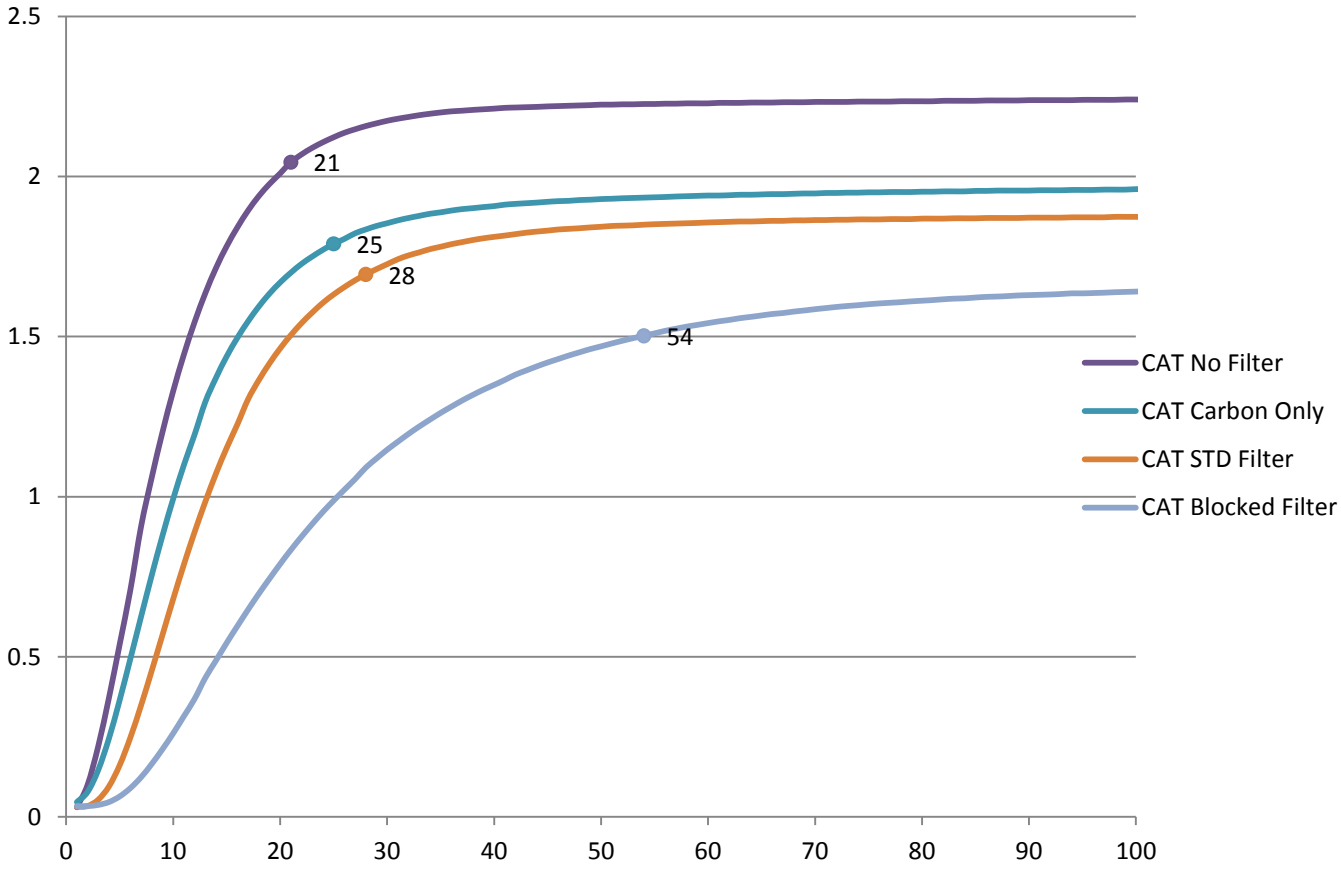
BLOCKED SENSOR RESPONSE

... not just response time, apparent concentration changes too!



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RECALIBRATION

... we correct the reading error as a result of the bump test

- The error is corrected so the sensor accurately displays the test gas concentration, but:
  - Does it correctly display a different test gas concentration? and,
  - Now it responds more slowly and will fail to identify transient gas concentrations.
- We cannot detect these deficiencies with a conventional bump test looking at final accuracy of displayed value at one concentration only.

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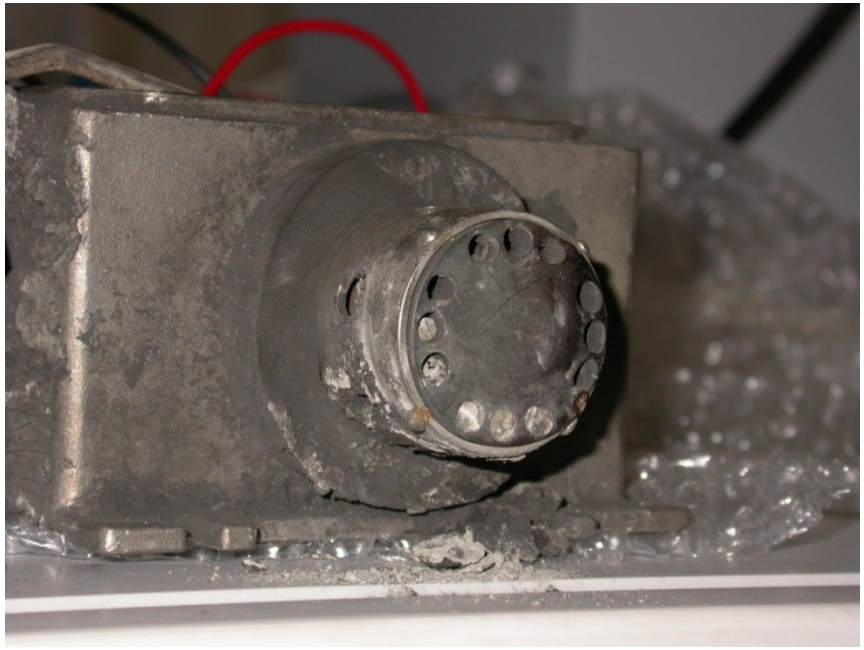
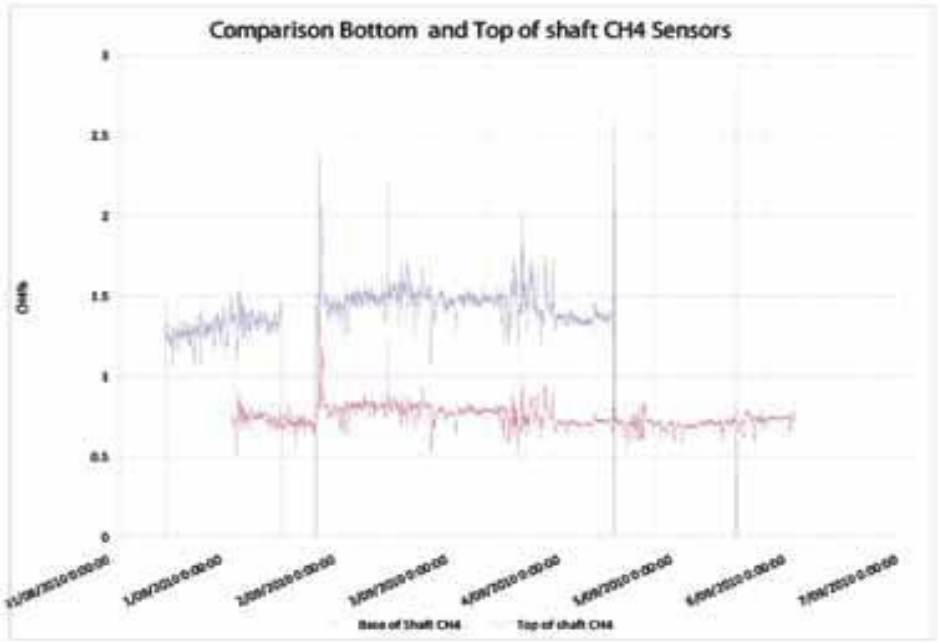
PIKE RIVER SHAFT GAS SENSORS

… Same body of air, different concentrations?





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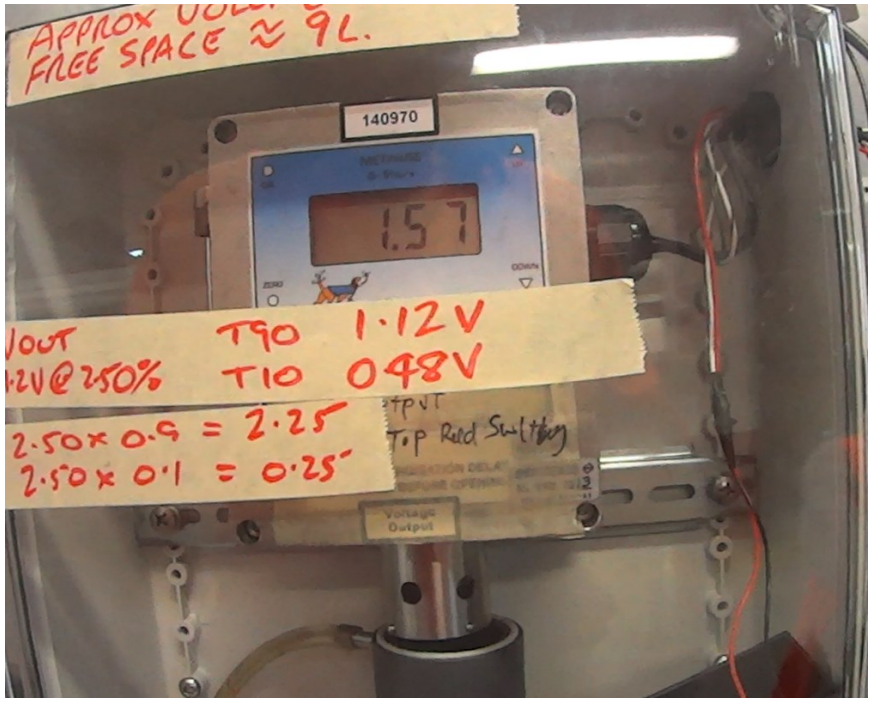
WHAT ABOUT MOVING AIR?

… How does that change the reading?

- Manufacturers carefully select membrane porosity so moving air does not produce an excessive error in reading.
- What happens if the membrane becomes partially blocked … a video to help you decide …



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A NEW PATENT?

... the methane producing fan.

- Moving air outside is at a lower pressure than the still air inside the sensing chamber.
- The increased partial pressure across the membrane, increases the flow of fuel to the sensor, so the apparent concentration seen by the sensor increases.
- Maybe a good thing? The error is towards safety … or is it?
- If we calibrate in moving air, we may under-report concentration in slower or still air.

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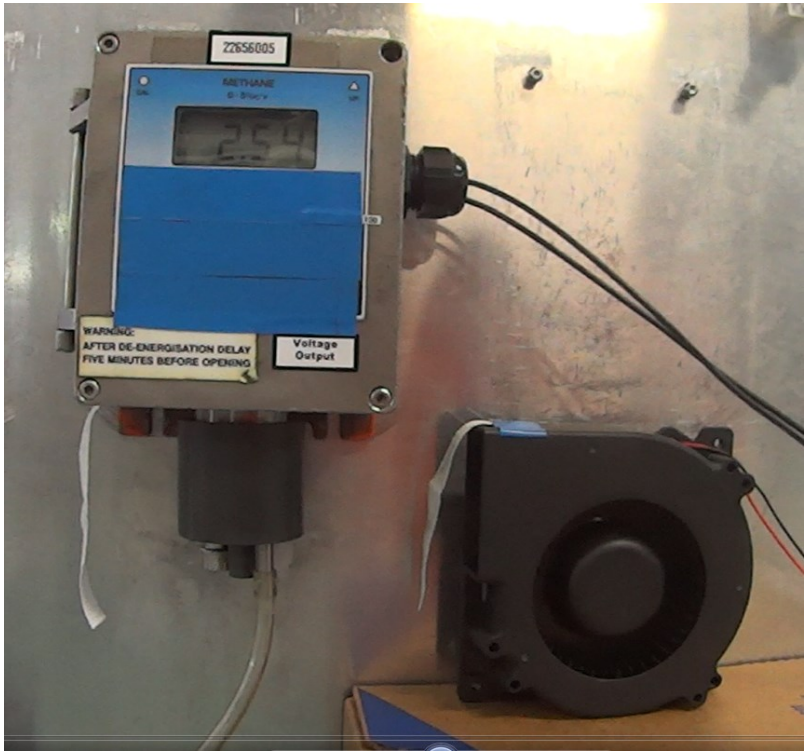
RETURN OF THE METHANE PRODUCING FAN

- We all calibrate our sensors in moving ventilation air inside the mine.
- What if we don't quite apply the cal cup properly, or we don't get a perfect seal?



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RESPONSE TIME IS IMPORTANT

… more than previously appreciated!

- A sensor that is compromised in terms of time response:
  - Will still calibrate correctly and to sufficient accuracy when bump tested.
  - Can under report the actual ambient gas concentration in still air.
  - Can read incorrectly in the presence of moving air.
  - Will increase operating risk, unable to respond to transient gas bursts.
- So how do you practically measure time response in an operating environment?

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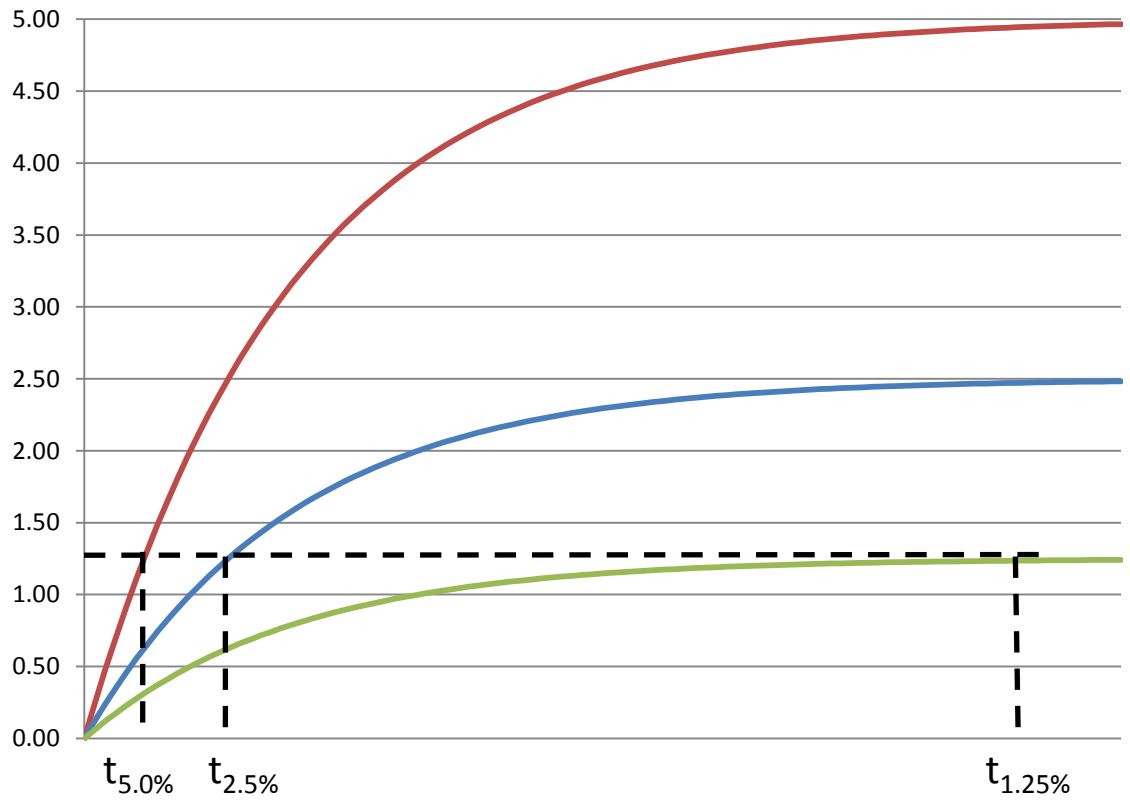
TIME TO ALARM

... is all that counts isn't it?



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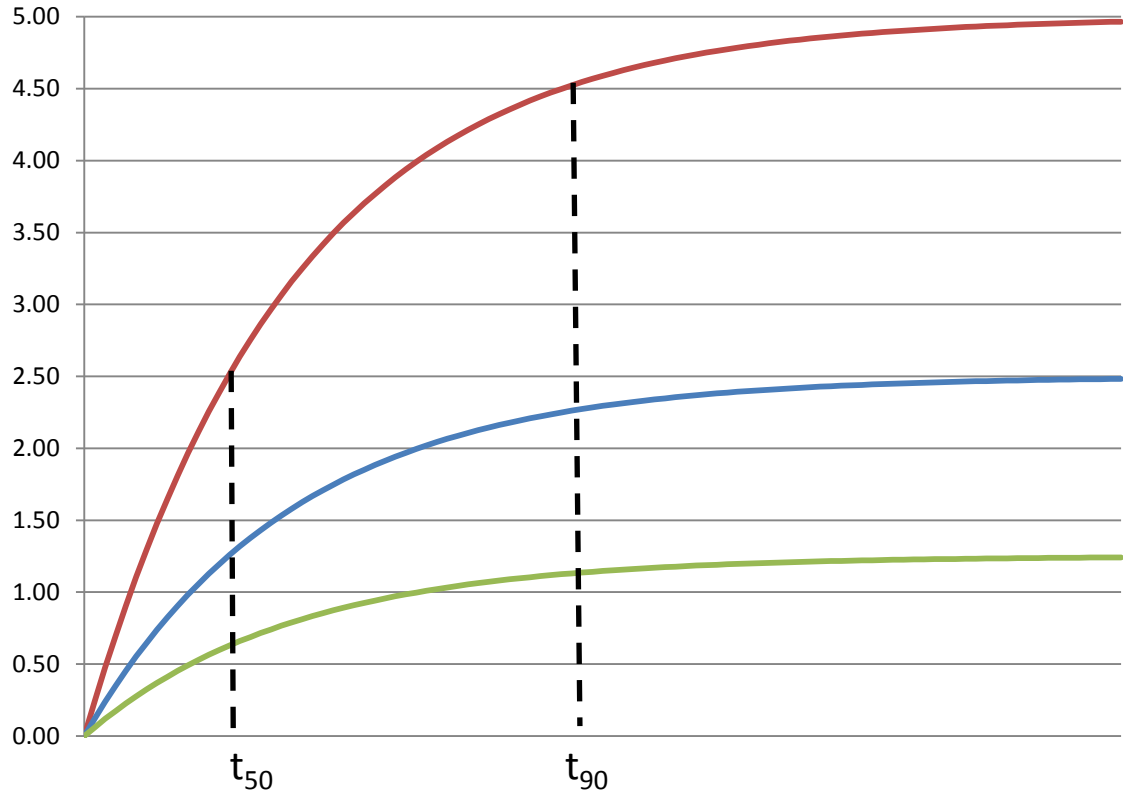
TIME RESPONSE

… is independent of concentration



- Concentration of the cal gas used does not matter, time response is always the same …

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DETECTING A BLOCKED MEMBRANE

... a practical way to measure T90

Filter identification

Filter 1 T90

Filter 2 T90

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SUMMARY OBSERVATIONS

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- Recent changes to AS2290.3 are more significant than generally appreciated.
- Maintenance of gas detectors requires testing to ensure key parameters are ‘as new’, namely:
  - Accuracy;
  - Telemetry; and,
  - Time response.
- These requirements are not new:
  - Both QLD and NSW Inspectorates have released safety bulletins in regard to response times of gas detectors

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SUMMARY OBSERVATIONS

Queensland Government
Natural Resources and Mines

SAFETY BULLETIN

NO. 18

Issued 17/07/2000 by Mines Inspectorate, Safety and Health
Queensland Minerals and Energy Centre, 61 Mary Street Brisbane
GPO Box 194 Brisbane Queensland 4001 Australia Ph. +61 (07) 32371041 Fx. +61 (07) 3237 1242

Vision: 'Our Industries Free of Safety and Health Incidents'

Methane Gas Monitor Response Times

All gas detecting instruments have an inbuilt delay, or response time, between being introduced to a gas and recording the gas concentration. Response time is usually referred to as the *t*(90) time.

The standard *AS/NZS 61779 "Electrical apparatus for the detection and measurement of flammable gas"* defines the response time as being the time from when a gas sensing element in clean air is suddenly exposed to a prepared mixture of gas in air having a concentration corresponding to 100% of full scale gas concentration. The *t*(90) time is the time taken for the instrument to record 90% of full scale gas concentration. To meet the requirements of *AS/NZS 61779* an instrument must have a *t*(90) time of less than 30 seconds.

NSW GOVERNMENT | Industry & Investment

SAFETY ALERT

Portable Gas Monitors

Understanding Response Times

INCIDENT

There have been two incidents at NSW underground mines where mining officials have been exposed to potentially dangerous environments due to the delay in response times of hand-held gas monitors.

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SUMMARY OBSERVATIONS

- A sensor that is compromised in terms of time response:
  - Will still calibrate correctly and to sufficient accuracy when bump tested.
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  - Will increase operating risk, unable to respond to transient gas bursts.

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SUMMARY OBSERVATIONS

- Ampcontrol frequently receives gas detectors from operating mines in an unsatisfactory condition:
  - Despite the detectors being routinely maintained; and,
  - Within NATA calibration windows.

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RESPONSE TIME TESTING?

- If your mine does not do response time or telemetry testing in addition to a bump test …

How do you know your gas detectors are actually working?

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QUESTIONS?