Monitoring gases from pig buildings: testing and calibration of an ammonia sensor (Phase 1)

Harper Adams University
Project Report 100

SUMMARY

- European Union rules, protecting habitats and health, are making pig farmers adopt low emissions housing systems. Current atmospheric ammonia-measuring devices are prohibitively expensive which limits the validation of housing types. A lower cost alternative is sought.
- The aim of this first phase of a 3-phase study was to calibrate and assess the capacity of an ammonia sensor, LGD F200, (based on the tunable diode laser principle) to monitor ammonia concentrations at typical levels for pig buildings.
- Many practical tests were undertaken to assess the reliability and stability of the sensor. Overall, the sensor proved suitable for monitoring ammonia levels within the expected range. The recommended flow rate is 3 litres per minute (LPM). The temperature around the sensor should be stabilised and the start-up time before measurements are taken should be at least 1.5 hours.

AMMONIA LEVELS REGULATIONS

The level of ammonia emissions within and from pig buildings to the atmosphere is an important environmental issue. Ammonia can be produced as a gas from slurries and manures and causes soil acidity and damage to plants. Reductions in ammonia emissions from farm livestock buildings, by 2020, have been proposed by the European Union under the revised National Emission Ceilings Directive (NECD). For the UK, the proposed reductions are expected to be in the region of 10%.

However, currently there is no suitable affordable technology to measure and monitor the levels of ammonia in livestock buildings at a practical level. A standard sensing system, known as the Innova PhotoAcoustic, can be used for research purposes but would be costly for farm-scale use.

The AHDB Division-BPEX recognised the need for a cost-effective monitoring system with low maintenance for measuring and monitoring ammonia concentrations in pig buildings. This needs to be integrated into a sensing system for the building which would include other functions such as the measurement of CO_2, exhaust air, temperature and humidity.

AIM OF THIS PHASE OF THE STUDY

The aim of this first phase of a 3-phase study, at Harper Adams University and commissioned by the AHDB Division-BPEX, was to calibrate, and assess the capacity of, a particular sensor, the LGD F200, to monitor ammonia emissions at typical concentrations found in pig buildings. Other phases are described in reports noted in 'Further Information'.

PRACTICAL TESTING

Tests were undertaken to check the reliability and stability of the LGD F200 which incorporates the technology of TDLS (see box). The tests included:

- the effect of temperature and humidity;
- reading stabilisation after a cold start;
- linearity and relative accuracy;
- precision;
- response time;
- calibration and zero drift.

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Tunable Diode Laser Spectrometry (TDLS)

Tunable diode laser spectrometry works on the principle that all gases have a characteristic absorption band in the infrared wavelength region so gases can be identified and measured.

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TEST RESULTS

The tests were all undertaken at Harper Adams University. Figure 1, below, shows the relative accuracy and repeatability from the testing of the sensor (twice) with different known ammonia concentrations. The agreement of the sensor with standard dilutions is very evident for most of the values tested. (The higher ammonia concentrations showed the greatest deviation from the standard dilution.)

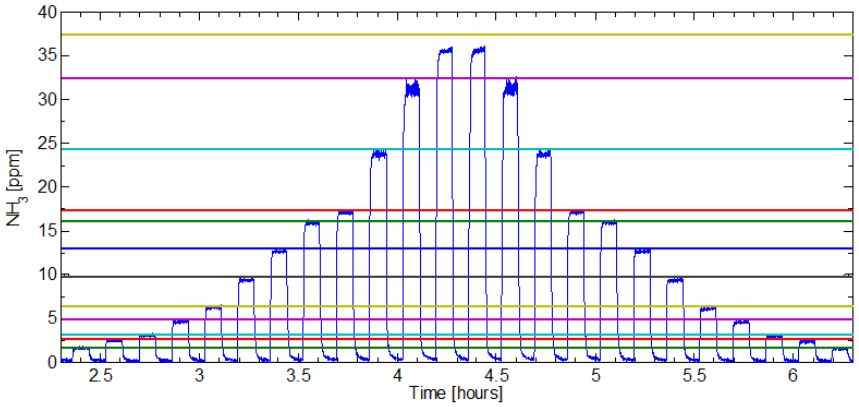


Fig 1. Accuracy of the sensor when exposed to different ammonia (NH_3) concentrations

OVERALL ADVANTAGES

The advantages of the LGD F200 sensor for ammonia measurement include the following.

- The high sensitivities are comparable to those obtained by the standard Innova PhotoAcoustic.
- There is a reduced possibility of interference from other gases.
- The cell volume is very small thus reducing the amount of sample and calibration gas needed, and the instrument is compact and lightweight (approximately 3 kg).
- No consumables are needed, keeping operational costs low.
- The functional temperature range is from -30^{O}C to 65^{o}C.
- This sensor is considerably cheaper than the standard Innova PhotoAcoustic.

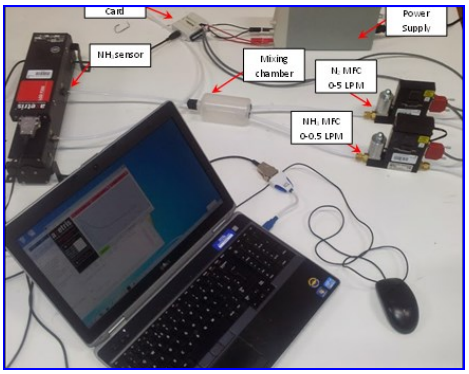
LIMITATIONS

Limitations of the LGD F200 sensor include the following.

- The system is based on a multi-pass measurement cell which may present a problem with the maintaining of optical alignment.
- Absorbance is measured indirectly.
- Only ammonia and water vapour concentration can be measured in the sample simultaneously.

CONCLUSION AND RECOMMENDATIONS

Overall the LGD F200 proved suitable for measuring ammonia levels within the range that is expected in the field. The largest deviations from the dilution standards were seen when flow rates through the sensor were less than that those used by the vendor during calibration. Therefore, the recommended flow rate is 3 litres per minute (LPM). Additionally, it is advised that the temperature around the sensor is kept stabilised and the start-up time should be at least 1.5 hours (see box).



Effects of Temperature

The results demonstrated that a temperature increase of around 1°C per second added low frequency noise to the reading which took about 40 minutes to stabilise.

When the sensor was rapidly heated from cold it also took time (1.5 hours) for the reading to stabilise.

Further Information

Norton, T. and Clare, D. 2014. *Monitoring gases from pig buildings: development of a multi-channel monitor (Phase 2)*. HAU Project Report 102. Available from: http://ofi.openfields.org.uk/1.14070029

Norton, T. and Clare, D. 2014. *Monitoring gases from pig buildings: field evaluation of a multi-channel monitor (Phase 3)*. HAU Project Report 104. Available from: http://ofi.openfields.org.uk/1.14070030

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