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# Controlling feeding pig ventilation according to levels of harmful gas

*A fundamental of animal health is good ventilation in livestock housing. This is why legal maximum limits have been established for certain harmful gases in calf and pig housing regulations. In cooperation with ventilation companies a ventilation controlled by harmful gas levels, with $NH_3$ levels as additional control parameter alongside temperature, was developed and successfully tested in a feeding pig house. Simple $NH_3$ sensors, tested in a laboratory gas mixing station and in practical trials appear still not suitable at the moment for use in a long-term and reliable ventilation system controlled by harmful gas levels.*

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## Keywords

Ammonia, control, ventilation, sensors

Literature details are available from the publishers under LT 01210e or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

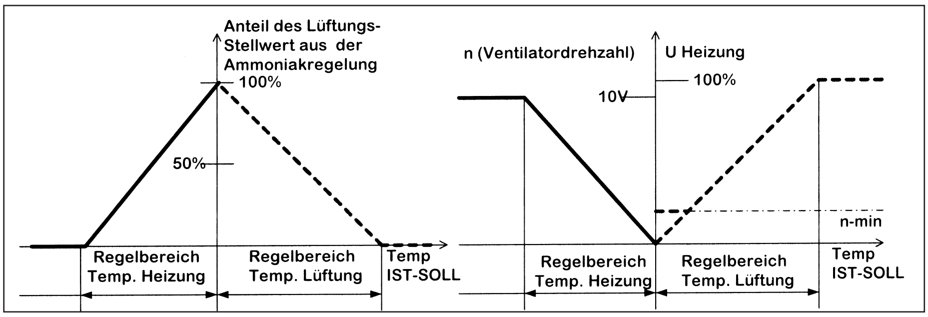


*Fig. 1: Control scheme of ammonia controlled ventilation (Source: Ziehl-Abegg)*

Legal regulations [1, 2] stipulate maximum levels of harmful gas concentrations of carbon dioxide ($CO_2$), hydrogen sulphide ($H_2S$) and ammonia ($NH_3$) which must not be exceeded in livestock production. DIN 18910 [3] gives an orientation on ventilation plant capacities for closed housing. However in the case of ventilation dimensioning according to DIN 18910 it cannot be guaranteed that the stipulated maximum values in [1] and [2] will be met for all gases. Because of this, a ventilation control system with $NH_3$ as additional controlling parameter was developed at the Bavarian State Institute for Agricultural Engineering in cooperation with Ziehl-Abegg and Schönhammer.

### Development of a ventilation system controlled by harmful gas levels

The basic development of a ventilation controlled by harmful gas levels was already described in [4]. Such a system comprises a process regulator which carries out a present-value/desired- value correction between pre-determined values for regulating parameters temperature and $NH_3$ and the actual values as measured by the specific sensors. From this information the settings for ventilators and heating are calculated.

### Sensors

Different simple $NH_3$ sensors were tested within the research project. The sensors presented in the *table 1* overview were tested in the laboratory and in practice, whereby the practice testing was divided into one eight-week phase in continuous use (phase I) and two phases of two (winter, phase IIa) and four (Spring, phase IIb) weeks in intermittent operation. Used as reference measuring equipment in the practical tests was a PAS-IR spectrometer [5] in phase I and a Fourier Transform Infrared spectrometer (FTIR-S) [6] in the phases IIa and IIb. For operation where ventilation is controlled by harmful gas levels, a measurement precision of ma-

*Table 1: Tested ammonia sensors*

| Sensor | Function principle | ~ Costs DM | Method of function |
|---|---|---|---|
| Reference | PAS-IR (photo-acoustic) | 14000 | Infrared light determiner wavelength meets with gas in measurement cell, which heats up through absorption and expands. Pressure changes recorded via measuring microphone. |
| PAS (MGU) | PAS-IR (photo-acoustic) | 10000 | |
| MOS I<br>MOS II | Resistance changes on metal oxide sensor | 500<br>1000 | Measurement gas attaches to semi-conductor surface and thus alters its conductivity. |
| OC I<br>OC II | optical-chemical<br>optical-chemical | 1000<br>1800 | Light beam transfixes substance which reacted with measurement gas and altered optical properties. Changes in light signal are measured. |
| ECS I<br>ECS II | electro-chemical<br>electro-chemical | 3500<br>3000 | Electrical potential changes through the reaction of the gas to be measured with electrolyte or electrode. |

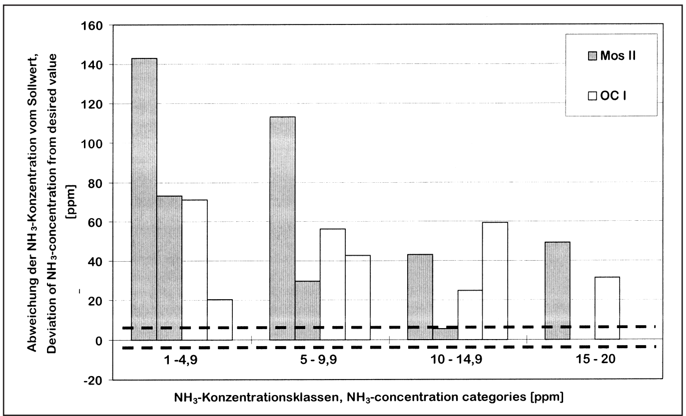


*Fig. 2: Results of sensor testing in continuous operation mode (phase I), sensors showing high deviations from desired value, the dotted line indicates the postulated inaccuracy*

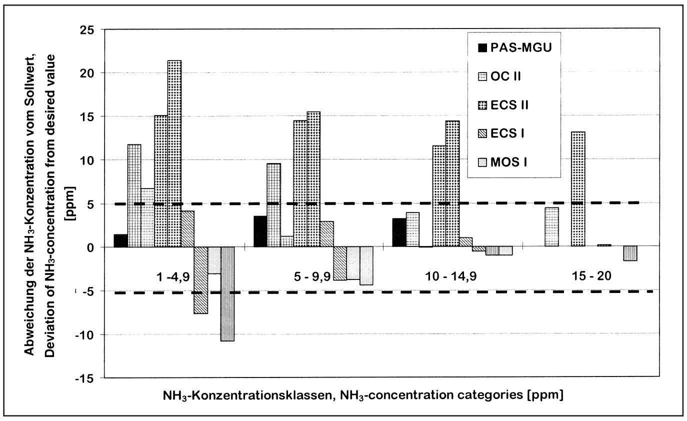


*Fig. 3: Results of sensor testing in continuous operation mode (phase I), sensors showing minor deviations from desired value; the dotted line indicates postulated inaccuracy; PAS-MGU was not operating in the first week of testing*

ximum 5 ppm with $NH_3$ concentrations up to 30 ppm is to be encouraged, with higher concentrations the measurement precision should not exceed around 20% of the reported value. Criteria for the $NH_3$ sensors were low investment costs, long-term reliability (keeping maintenance/servicing costs down and giving optimum working security).

## Regulating process

In that $NH_3$ was integrated as the second regulating parameter next to temperature in the control process, the regulating system used up until that time had to be adjusted. Presented in the left of *figure 1* is how the $NH_3$ concentration is evaluated for calculation of ventilation setting values under differing ventilation and heating performance levels within the control area. Presented in the right of the illustration is how the adjustment parameters heat voltage and fan speed are increased up to their maximum values at the end of the control range. This control showed itself in the main to be capable of functioning.

## Trial development

The laboratory testing of the sensors and measuring equipment took place within a gas production and mixing unit. Here, single gases and gas mixes could be produced in variable concentrations. Additionally, there existed the possibility of adding moisture in defined concentrations via capillary system.

## Laboratory

*Selectivity (cross sensitivity) and measurement precision*
The cross-sensitivity on water was small with all sensors because the calibration function that was used resulted from the calibration with moist test gas. The measurement precision [8] of the sensors OC I, OC II and MOS II was unsatisfactory.

## Practice

*Continuous working (phase I)*
During the trial period the concentrations in the house were relatively low at 1 to 20 ppm. In order to be able to evaluated the sensors, the gas concentrations were divided into four classes each of 5 ppm, the value of each class determined and the absolute deviation from the reference value of the PAS-IR reference measurement equipment calculated. These observations were carried out in the first and the last recording week in order to thus record the effects taking place through the permanent increasing with $NH_3$. These include sensor ageing and "oversupply". Demonstrated in *figure 2* (sensors with larger deviations from the reference value) and *figure 3* (sensors with smaller deviations from the reference value) are the results of the sensor testing in continuous work (phase I). The first column represents the results of the first week, the second of the last week in which there were no concentrations over 15 ppm. MOS II and OC I show very high deviations from the desired values (*fig. 3*). With EC II relatively high deviations of more than 10 ppm could be observed which, however, remained constant in all concentration classes and with that could be regarded as having a tolerable zero point postponement. The demands on the sensors were to a great extent met, especially with PAS-MGU but also with ECS I and MOS I. However, ECS I changed its deviation from positive (first week) to negative (last week). This could be attributed to the sensor oversupply which is a known aspect of electro-chemical sensors. With increasing length of measurement time OC II indicated smaller concentrations. The test with the sensors intermittently used confirmed in the main the continuous use results. A comprehensive presentation of results can be found in LANDTECHNIK-NET.com

*Summary of sensor testing*
According to currently available information, none of the simple sensors tested proved suitable for continuous application in ventilation controlled by levels of harmful gas. In the laboratory tests, OC I , OC II, which was exchanged later on, and MOS II did not fulfil the selection criteria. In practical operation MOS II and OC I also failed to fulfil the required measurement precision. The electro-chemical sensors ECS I and ECS II deviated, either by low or high concentrations, widely from the desired value or indicated inconsistent deviations from the desired value over longer period of time so that the user would have had to depend on unreliable values. Especially with high $NH_3$ concentrations, MOS I indicated large deviations from the desired value. At least during the test phases, the tested PAS-MGU showed itself as having less working reliability in that it had to be often repaired. Otherwise, it could be seen as an alternative to the simple sensors. On the whole, the regulating indicated that it was capable of functioning. However, it was apparent that also the $NH_3$ regulated ventilation should be driven with minimum air flow in order to avoid variations in house temperature through cold air intake at high $NH_3$ concentrations.

## Conclusions

Ventilation controlled by the levels of harmful gases was able to be achieved technologically. Cost-effective sensor technology for this task requires still to be optimised. A classification of the system under economical and environmental-technological aspects, and according to animal welfare criteria, is taking place as part of continuing work.

## Literature


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