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Kuratorium für Technik und Bauwesen in der Landwirtschaft

Exhaust Air Treatment Systems for Animal Housing Facilities

KTBL publication 464

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in cooperation with the KTBL working group „Status of Process Engineering and Costs of Exhaust Air Treatment in Farm Animal Housing“

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Published with the support of the Federal Ministry of Food, Agriculture and Consumer Protection | Bonn

Copy editor
Dr. Anita Heidenfelder | Uffing

Editor
Ewald Grimm | KTBL

Cover photo
Ewald Grimm | KTBL

Distribution
KTBL | Darmstadt

Printing
Druckerei Lokay | Reinheim

Printed in Germany

ISBN 978-3-939371-60-1

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Preface

For more than 35 years, treatment techniques for exhaust air from animal houses have been discussed as a possible way of solving the immission problems of animal housing facilities. Only in the past years, however, has exhaust air treatment gained in importance in practice. This is the result of stricter immission protection regulations and farm size growth, which causes more serious and consequential environmental impacts, while developable locations are becoming scarcer. In addition to relocation, exhaust air treatment has therefore become an important option which allows the future of developable farms to be secured.

At the same time, process technology has also made progress. In addition to classic biofilters and trickle bed reactors, chemical scrubber and multiple-stage treatment techniques have established themselves. Moreover, the introduction of a voluntary, Germany-wide certification test for exhaust air treatment systems in the form of a DLG SignumTest is an important contribution towards the assurance and improvement of the quality of these systems. Meanwhile, the installations have reached a technical standard which allows for long-term reliable operation and the efficient reduction of odour, ammonia, and dust emissions.

During the entire time, this development was accompanied by controversial discussions about the efficiency and in particular the costs of the techniques as well as the question of whether or not exhaust air treatment was generally state of the art technology.

In order to make this discussion more objective, the current development status and the costs of exhaust air treatment techniques for use in animal housing facilities were summarized for the first time. These explanations and the recommendations derived from them make this publication an indispensable source of information for the operators of animal housing facilities and agricultural advisers before investment decisions are made where the installation of an exhaust air treatment system is being considered. In addition, it also serves as a basis for planners and experts for the objective evaluation of the different techniques with regard to the possibilities and conditions of their application in animal housing

This publication is the coordinated result of the KTBL working group “Status of Process Technology and Costs of Exhaust Air Treatment in Farm Animal Housing”, whose members are primarily confronted with this topic as scientists, advisers, experts and members of the test committee for the certification of exhaust air treatment systems. This working group was also in charge of a project of the same name carried out in cooperation between the Universities of Hohenheim and Bonn, which was promoted as part of the KTBL work programme “Calculation Tables 2003”. In addition, it provided an incentive for the Germany-wide introduction of certification for exhaust air treatment systems, which had been available only in the county of Cloppenburg before.

My cordial thanks are due to all those who worked on this publication. In particular, I would like to thank the manufacturers of exhaust air treatment systems for the provision of system-specific information.

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Content

2.4 Chemical scrubbers

2.4.1 Functional principle

In animal housing, chemical scrubbers mainly improve ammonia separation (cf. table 2.12). As a single process stage, they are not suitable for odour elimination because odour reduction is relatively insignificant. In addition, it is subject to considerable fluctuations. As a result, crude air odour can regularly be perceived in the clean gas.

The main distinctive criterion of chemical scrubbers and trickle bed reactors is that the pH-value of the scrubbing water is reduced to pH < 5 by adding an anorganic acid (generally sulphuric acid). This provides a significant improvement of ammonia separation and higher concentrations of nitrogen in the scrubbing water without leading to the formation of a "biofilm" or biological growth on the contact bed surfaces. Therefore, this technique does not allow any noticeable odorant degradation to be achieved.

2.4.2 Design of a chemical scrubber and important functional elements

The design principle of a chemical scrubber with its main functional elements is shown in Figure 2.7. In general, a fan (1) presses the exhaust air through the chemical scrubber. However, ventilation by suction is also possible. It must be taken into account, however, that acid aerosols have a negative effect on the service life of the fan. The fan should be able to overcome a pressure difference of at least 100 Pa in addition to the flow resistance of the animal house without noticeable capacity loss.

As contact beds (2), mainly plastic packings as well as fibre and pipe bundles are used. However, bulkcontact bed packings are also possible. The specific surface of these materials ranges between 100 and 500 m^2/m^3. Layer thickness varies between 0.15 and 1.6 m.

In the simplest case, feeding pipes with a 90° bend as an end piece are used for liquid distribution. With regard to even liquid distrubtion, however, clog-free nozzles or special liquid dispensers, such as weir riser pan or orifice pan distributors, are significantly better.

In order to avoid aerosol discharge, drip separators (4) are indispensable. In general, however, they cause far greater pressure losses than the entire contact bed packing. As the simplest form of these drip separators, wire-cloth drip separators out of plastic are available. These drip separators allow particles with a diameter of more than 5 µm to be separated almost completely.

This contact bed packing is sprinkled with water from the scrubbing water tank (6) using a circulation pump with dry running protection (5). The circulation pump also allows the necessary elutriation of the concentrated ammonium solution (10) to be realized, which must be stored in a separate container and used for agricultural purposes according to the Fertilizing Decree. As compared with the scrubbing water quantities in trickle bed reactors, the quantities needed here are considerably smaller. Under optimal conditions, only ca. 40 litres per fattening place and per year are produced in litterless fattening pig housing. Immediately before slurry spreading, the ammonium solution can be mixed with the slurry in the outdoor container.

Inspection openings (7) are required for the treatment of the contact bed packings and the drip separator. It should be possible to remove and clean these functional elements quickly and simply.

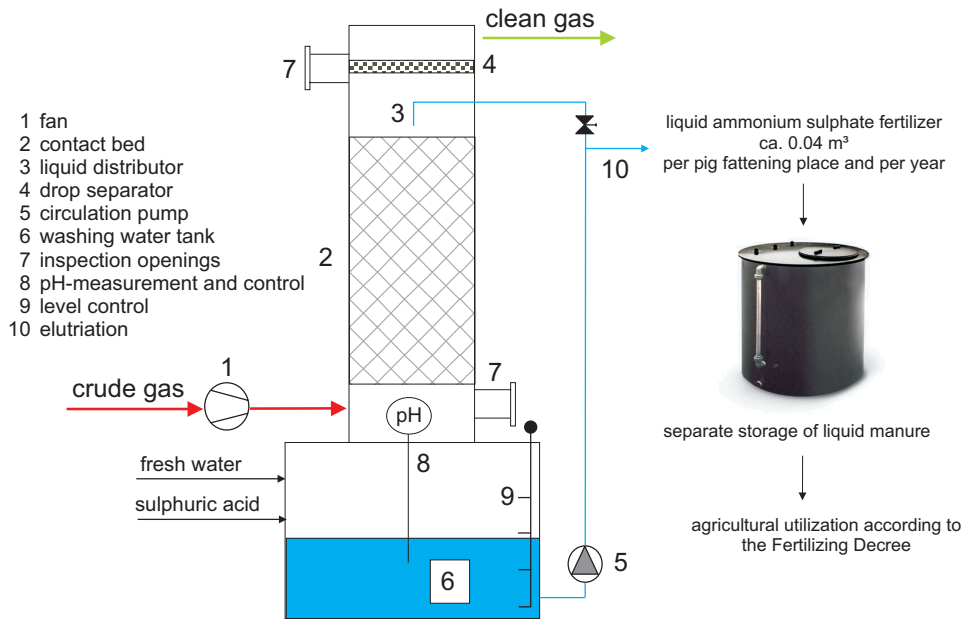

Figure 2.7: Design of a chemical scrubber with its main functional elements

With the aid of an acid metering system with pH-value measurement and control (8), the pH-value of the scrubbing water must be kept at values below pH 5 in the return line from the contact filter packing. For pH-value control, mainly sulphuric acid 96 % is used because it is highly concentrated, readily available, and relatively cheap and because it releases virtually no acid fumes. Moreover, many soils need additional sulphur fertilizing, which can be provided by utilizing the wastewater (ammonium sulphate solution). However, other anorganic acids, such as hydrochloric acid 25 %, can be used as well.

Filling height control requires a fresh water supply system with level control (9).

2.4.3 Specifications for the design of chemical scrubbers

Important specifications for the dimensioning of chemical scrubbers are listed in Table 2.5.

Table 2.5: Specifications for the dimensioning of chemical scrubbers for the treatment of exhaust air from litterless animal housing facilities

Parameter	Unit	Specifications
Filter surface load	$m^3/(m^2\ h)$	1 900–5 200
Filter volume load	$m^3/(m^3\ h)$	1 200–10 000
Dwell time	s	0.4–3
Thickness of the contact bed packing	m	0.15–1.6
Specific contact bed surface	m^2/m^3	100–500
Pressure loss	Pa	up to 100
Sprinkling density	$m^3/(m^2\ h)$	1.7–2.2[1)]
pH-value of the scrubbing water	–	1.5–5
Fresh water requirements	l/1 000 m^3 exhaust air	5–7[2)]
Sulphuric acid requirements (96 %)	kg/kg NH_3-input	3
Elutriation rate	m^3/kg NH_3-input	≥0.011

[1)] Under the conditions of large ammonia loads, it may be necessary to increase sprinkling density, which must be chosen such that a pH-value < 5 is maintained in the return line from the contact bed packing in any case.
[2)] Water requirements for the compensation of evaporation losses.

Due to very different process techniques, the dimensioning parameters for chemical scrubbers vary significantly. In many cases, the limiting factor for design is not ammonia separation itself, but rather the dust load, which can lead to clogging of the contact bed and in particular the drip separator. If the air contains little dust, filter volume loads can be increased to up to 10,000 $m^3/(m^3\ h)$ without the efficiency of ammonia separation sinking if an acid scrubbing solution is used. However, increased pressure loss must be expected.