C S A E S C G R

#6371

CANADIAN SOCIETY OF AGRICULTURAL ENGINEERING
SOCIÉTÉ CANADIENNE DE GÉNIE RURAL

Paper No. 92 - 209

A REVIEW OF EUROPEAN, ONTARIO AND USA STANDARDS AND CODES ON INDOOR AIR QUALITY AND WORKING ENVIRONMENT IN LIVESTOCK BUILDINGS WITH RESPECT TO LIVESTOCK PRODUCTION IN ONTARIO

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For presentation to the
CANADIAN SOCIETY OF AGRICULTURAL ENGINEERING
at the Agricultural Institute of Canada Annual Conference
July 5 - 9, 1992 - Brandon, Manitoba

ABSTRACT:

Numerous recommendations on indoor air quality inside livestock buildings from European countries were reviewed. At the present time, there is no evidence that these standards should be used in Ontario.

The adoption of the present Ontario and USA OHSA codes could be easily accommodated by dairy and swine producers. However, the poultry industry would be challenged to reduce the high ammonia levels currently typical of broiler, laying hen and turkey barns.

RÉSUMÉ

Les diverses normes et recommandations européennes traitant de la qualité de l'air ambiant dans les étables d'élevage ont été revisées. Selon les connaissances actuelles, ces normes ne devraient pas être appliquées en Ontario. Les producteurs laitiers et porcins pourraient aisément se conformer à la loi sur la santé et la sécurité au travail de l'Ontario en ce qui a trait aux rèlements sur les agents biologiques et chimiques dans l'air ambiant. Par contre, les producteurs dans le domaine de la volaille auront la lourde tache de réduire les concentrations élevées d'ammoniaque présentes dans les poulaillers de poules pondeuses, poulets de chair et dindons.

INTRODUCTION

From research carried out in the European Community (EC), the United States and Canada, it would appear that a number of livestock producers, farm workers and family members suffer from varying degrees of bronchitis, occupational asthma, organic dust toxic syndrome or a general irritation of mucosal membranes. This may be due to the poor air quality inside certain livestock buildings. In addition, the work environment inside agricultural buildings is generally negatively perceived by potential farm workers and the public due to the unpleasant odours, and elevated air contaminant and noise levels.

Some countries in the EC have established strict standards relating to air contaminants to enhance the public image of farms' indoor air quality, and to protect farm workers. Presently in Ontario, the Ministry of Labour has the Occupational Health and Safety Act with the associated regulations concerning the control exposure to biological and chemical agents. However, the act does not currently apply to farming operations.

OBJECTIVE

In order to propose some standards for indoor air quality and working environment for Ontario, the objectives of this study are:

1 - to review the recommendations on allowable gas and dust concentrations from eleven European countries, the USA and Ontario;

2 - To study the effect of adopting present Ontario regulations on the exposure to biological or chemical agents, as specified under the Occupational Health and Safety Act for livestock production; and

3 - to recommend an action plan for the protection of farm workers and identify the areas of research needed related to indoor air quality in Ontario.

REVIEW OF EUROPEAN RECOMMENDATIONS AND CODES

Table 1 summarizes the present recommendations and/or codes for maximum alowable gas concentrations for different European countries, as well as presents the standards proposed to the Council of Europe (CIGR, 1984 or newer directives). The maximum levels recommended for carbon dioxide (CO_2) vary from 2000 to 5000 ppm, for ammonia (NH_3) from 10 to 50 ppm, for hydrogen sulphide (H_2S) from 0 to 10 ppm, for carbon monoxide (CO) from 5 to 50 ppm, and for total dust is 10 mg/m^3.

The Netherlands

The Netherlands has the most ambitious program for low CO_2 and NH_3 levels inside livestock buildings. They are aiming for only 2000 ppm of CO_2 and 10 ppm of NH_3. Also, from discussions with van't Klooster (1992), the Netherlands government may propose to lower the total dust levels to between 2 and 4 mg/m^3. Data from van't Klooster *et al.* (1991) and Klimaat Werkgroep (1991) showed that for swine barns they were able to maintain an average CO_2 level of 2000 ppm, 10 ppm of NH_3 and 2 to 4 mg/m^3 of total dust by using different room air filtering or management techniques. However, it should be remembered that the outside temperature rarely dropped below -5°C during the testing period and the incoming fresh air in the ventilated rooms was always prewarmed to 5°C. Consequently, their ventilation rates were considerably higher than those in Ontario.

The Netherlands may also add a maximum allowable concentration of methane (CH_4). This is in response to explosions that have occurred in livestock barns in recent years (van't Klooster, 1992).

Sweden

Sweden has a fairly cold climate (design temperature of -15 to -24°C, CIGR, 1984). However, they recommend maximum levels of 3000 ppm of CO_2 and 10 ppm of NH_3. This means supplemental heating during the winter for most livestock barns. An exception is a level of 25 ppm for NH_3 for poultry production. Even with this NH_3 level, supplemental heating may be required to maintain necessary ventilation rates.

United Kingdom

General levels of air contaminants have been adopted in the United Kingdom. However, there are some accepted exceptions; for example, for adult cattle levels have been increased to 5000 ppm of CO_2, 25 ppm of NH_3, 10 ppm of H_2S and 50 ppm of CO (United Kingdom, 1990a). There was no explanation available or reasons given for these exceptions in the BSI Standard, 5502 part 40. The general levels appear to be achievable in most livestock and poultry production systems, when considering the UK winter climate.

Council of Europe, European Community

The proposed maximum gas concentrations of the EC (although not their directive as yet) are achievable for most European countries without supplemental heating. Current ventilation practices can control CO_2 levels at or below 3000 ppm. Good manure handling techniques help to restrict the NH_3 concentration to below 20 ppm. A maximum total dust level of 10 mg/m^3 is also easily achievable.

Problems may occur in the Scandinavian countries, southern Germany, Switzerland and other eastern European countries that regularly experience cold winter conditions. The European recommendations on indoor air quality are apparently related to the climate and are feasible in each country. At the present time, there is no solid scientific evidence that these standards should be used as a reference for Ontario.

Ontario and the USA

Table 2 presents the allowable levels of air contaminants that have been adopted under the Ontario Occupational Health and Safety Act, 1980, in the regulations on the control of exposure to biological and chemical agents. Also, some American (USA, 86/87) regulations, which differ from Ontario, are included. At the present time, the OHSA does not apply to farming operations. Consequently, farming operations are exempted from the general industrial establishment standards which cover ventilation requirements, and the regulations regarding air contaminants and dust. This is also the case in the USA (1970). Lately, there have been some discussions on the extension of the OHSA to agriculture. This would imply the adoption of relevant indoor air quality standards.

Carbon Dioxide

For dairy production, a level of 5000 ppm for CO_2 is rarely exceeded given the Canadian climate. Average CO_2 levels ranged between 1727 to 3553 ppm for free stall dairy barns (Clark and McQuitty, 1987) and 2400 to 4040 ppm for tie stall barns (Feddes *et al.*, 1984). Clark and McQuitty (1987) reported that a maximum hourly average level of 5700 ppm was measured only once.

Barber *et al.* (1991) reported that during the winter (outside temperature between -13 and -16°C), the 5000 ppm level for CO_2 was exceeded 24% of the time inside several swine buildings. Since these winter temperatures are common in southwestern Ontario and frequent in eastern and northern Ontario, there is considerable potential for exceeding the 5000 ppm level.

In their literature review for poultry production, Perkins and Morrison (1991) did not report CO_2 levels above 5000 ppm. McQuitty *et al.* (1985) reported average CO_2 concentrations between 2340 and 3620 ppm in commercial laying hen barns, with no peak above 5000 ppm. In addition, Leonard *et al.* (1984) observed 1313 to 4001 ppm of CO_2 in commercial broiler barns. In turkey barns, Licsko and Feddes (1988) measured CO_2 levels of 2802 ppm (outside temperature of -18°C) and 3844 ppm (outside temperature of -24°C). Carbon dioxide levels are generally lower during warmer weather due to increased ventilation rates. At no time did the building CO_2 levels exceed 5000 ppm.

In the USA, Donham *et al.* (1989) reported that the air quality in barns was safe for swine producers when the CO_2 level was below 1540 ppm. This low value for CO_2 would be accompanied with low levels of ammonia, dust and other contaminants. However, the use of 1540 ppm of CO_2 in swine barns is not practical for the Canadian climate. Efforts should be devoted to reduce the other toxic contaminants inside swine buildings.

The adoption of a TWAEV (time-weighted average exposure value) of 5000 ppm would not be a major problem for dairy and poultry producers, but some swine producers would have to improve their ventilation system to reduce CO_2 levels. By using the European recommendation of 3000 ppm, the supplemental heating costs would increase severely, due to the higher winter ventilation rates required to achieve these levels.

Ammonia

For dairy production, Clark and McQuitty (1987) reported overall mean values of 7 to 20 ppm of NH_3 for a free stall barn under winter conditions (outside temperature from -1.7 to -10°C). Once, however, a maximum hourly mean concentration of 54 ppm was recorded, which was above the short-term exposure value (STEV) of 35 ppm.

For swine production in Saskatchewan, Barber *et al.* (1991) reported that the 25 ppm level for NH_3 is exceeded during 10% of the time inside all swine barns. In Ontario, Patni and Clarke (1991) reported a large variation in NH_3 levels among swine facilities (1 to 37 ppm). They suspected the ventilation rates and airflow patterns influenced the occurrence of local NH_3 concentration peaks. During winter conditions in a finishing swine barn in Ontario, Morrison (1988) reported average NH_3 concentrations of 24 ppm (minimum of 7, maximum of 50) and 14 ppm (minimum of 5, maximum of 32) when 2 and 5 air changes per hour were used as ventilation rates, respectively. Although some ammonia peaks were above the 35 ppm STEV, adequate ventilation could easily lower the NH_3 level below the TWAEV. Phillips and Thompson (1989) presented data for fan ventilated and naturally ventilated finishing swine barns where average NH_3 concentrations were within a range of 5.7 to 26.7 ppm during the winter. The high NH_3 concentrations were measured in a barn with a high stocking density and may have been an influenced by the type of feed and the manure system used. Consequently, with good manure management and adequate ventilation, it should be possible to restrict the NH_3 concentration to 25 ppm or less inside swine buildings.

Perkins and Morrison (1991) discussed the fact that high ammonia levels in poultry barns is a major problem. For example, with outside temperatures between -7.1 and -4.9°C, McQuitty *et al.* (1985) reported average NH_3 concentrations of 53 and 33 ppm for deep-pit and shallow-gutter laying hen barns, respectively. This is far above the recommended TWAEV. Leonard *et al.* (1984) measured NH_3 levels between 1.8 and 12.1 ppm in broiler barns. Barber and Feddes (1988) indicated that the use of fresh litter for each batch helps to keep the NH_3 levels down. They cited an Alberta study that reported 78 ppm of NH_3 inside a broiler breeder barn when the litter was reused for a second batch. Licsko and Feddes (1988) measured 26 and 32 ppm of NH_3 in a commercial turkey facility when the outside temperature was between -18 and -24°C, respectively. However, lower levels in the range of 10 to 20 ppm were established when the ventilation rates were increased. If a 25 ppm TWAEV is used, the high levels of ammonia common in poultry barns would have to be addressed. However, it has been demonstrated that it is feasible to maintain acceptable levels of NH_3 with proper manure management and adequate ventilation in poultry barns (Perkins and Morrison, 1991).

Hydrogen Sulphide

In Alberta dairy free stall barns, Clark and McQuitty (1987) always measured concentrations of H_2S below 145 ppb. However, they recognized that dangerous concentrations could be reached during the agitation of under-slat manure storages. Patni and Clarke (1991) measured H_2S concentrations of 130 ppm during the agitation of manure pits in swine facilities, which is far above the recommended STEV of 15 ppm. Consequently, proper manure handling procedures should be enforced. During normal operation, there was only a trace of H_2S inside the buildings tested.

Hydrogen sulphide levels were below 10 ppb in broiler (Leonard *et al.*, 1984), laying hen (McQuitty *et al.*, 1985) and turkey (Licsko and Feddes, 1988) barns.

Carbon Monoxide

DeBoer and Morrison (1988) reported that CO levels above 50 ppm have been measured in American swine facilities. Since CO is produced from the incomplete combustion (propane, natural gas), care should be taken in the proper adjustment and venting of these burners. However, only trace amounts of CO should be measured inside agricultural buildings when the internal combustion burners are used properly, consequently the TWAEV of 35 ppm should be easily met.

Nitrogen Dioxide

Normally, there is no NO_2 inside livestock facilities. However, a high level could be present in silos, especially after filling (CPS M-7410, 1988). A TWAEV of 3 ppm inside livestock buildings should be easy to accommodate.

Dust

The OHSA regulations on biological and chemical agents give levels of 4 mg/m^3 for grain dust and 10 mg/m^3 for total dust. For respirable dust, the USA has a TWAEV limit of 5 mg/m^3; there is no similar regulation in Ontario.

Clark and McQuitty (1987) measured dust concentrations less than the TWAEV for total dust or grain dust, in dairy free stall barns during the winter. However, Robertson (1989) reported levels between 4.8 and 16 mg/m^3 during straw bedding operations in different cattle barns. May *et al.* (1989) reported total dust levels of 104 mg/m^3 near the tower silo chute and 19.4 mg/m^3 in the centre of the feed room. The measured respirable dust level near the tower silo chute was 22.1 mg/m^3. In this case, the tower silo showed signs of poor haylage preservation and high levels of high temperature bacteria. The farm workers showed signs of respiratory problems when exposed to these dust levels. In other cases with better preserved haylage and corn silage, they measured total dust levels from 0.8 to 20.8 mg/m^3 and respirable dust levels from 0.2 to 20.0 mg/m^3 near the silo chute. Also, farm workers exposed to the low dust levels showed some signs of organic dust toxic syndrome six hours after exposure. The extensive study of Emanuel *et al.* (1989) on dairy farmers in Wisconsin, USA, also revealed that a high number are affected by respiratory problems, especially associated with the feeding of hay, silage and grains.

Generally, dairy farmers are exposed to very high respirable dust levels for short periods of time, such as during the feeding of hay, silages or grains, as well as during bedding. In these cases, the OHSA total dust level of 10 mg/m^3 is often exceeded.

For swine production, Barber *et al.* (1991) reported that the total dust level of 10 mg/m^3 was exceeded in only 5% of farms studied. These high levels were recorded in finishing swine barns and feed preparation centres. However, the 5 mg/m^3 level of dust was exceeded in 26% of farms studied.

DeBoer and Morrison (1988) reported work performed by the University Hospital of Toronto on swine farmers in Ontario. As many as 27% of the people tested with personal dust samplers had samples exceeding 10 mg/m^3 total dust. Also, 53% of the samples were above the 4 mg/m^3 level recommended for grain dust. The highest levels of dust occurred during feeding and feed grinding. Holness and Nethercott (1989) reported that the occurrence of respiratory problems of swine farmers was significantly higher than for other farm operations. In this study, done in swine barns, the average total dust level was 3.22 mg/m^3 and the average respirable dust level was 0.41 mg/m^3.

In Québec, Lavoie *et al.* (1989) and Cormier *et al.* (1990) performed indepth studies of the aerial contaminants inside swine barns. They reported high levels of total dust and also very high levels of active bacteria and molds. They stated that in general, the air in swine confinement buildings is always contaminated with bacteria, yeast and molds, up to 1200 times higher than the "normal air standard".

In Ontario, Morrison's (1988) study reported that higher ventilation rates do not reduce significantly dust levels during the winter. However, Gao and Feddes (1991) in a laboratory study where the production rate of dust was kept constant reported a reduction of the respirable dust levels with an increase in the ventilation rate. The difference in the above studies might be explained by differences in dust production rates related to differences in relative humidities, increased air speeds at the air inlet, and increased air mixing induced by supplemental heaters. Numerous researchers are presently working on dust reduction techniques for swine barns.

If adopted, the 10 mg/m^3 total dust level would be exceeded by some swine producers. However, when appropriate feeding and other dust reduction techniques are used, it is possible to restrict the dust content of the air to below this level.

For broiler production, Leonard *et al.* (1984) measured levels varying from 0.01 to 0.07 mg/m^3 of respirable dust in broiler barns. The highest levels were recorded at the end of the production cycle. As discussed by these authors, the main potential hazard is that most of the dust is respirable.

For commercial laying hens, McQuitty *et al.* (1985) measured averages between 0.08 and 0.13 mg/m^3 of respirable dust accompanied with 0.09 to 0.13 mg/m^3 of total dust. Licsko and Feddes (1988) measured dust levels in turkey barns. Average total dust levels were between 0.16 and 0.80 mg/m^3.

Therefore, the adoption of the 10 mg/m^3 dust level would not present any problem for poultry producers. However, Perkins and Morrison (1991) reported serious respiratory problems among a large group of poultry producers. They discussed the combined action of dust and ammonia on the respiratory system.

RECOMMENDATIONS CONCERNING THE ADOPTION OF THE OHSA REGULATIONS ON BIOLOGICAL AND CHEMICAL AGENTS

If the existing OHSA regulations concerning the control of exposure to biological or chemical agents were adopted, dairy farmers would be able to meet the prescribed CO_2, NH_3, H_2S and CO levels. However, farm workers could be exposed to dust levels above 10 mg/m^3 during time periods of feeding and bedding.

A quarter of the swine farmers would have to increase their winter ventilation rates to reduce the CO_2 levels below 5000 ppm and 10% would have to reduce their NH_3 levels. This might mean increasing the building's insulation or adding supplemental heat. A cost would then be associated with this measure. Only 5% of producers would have to undertake additional work to reduce the dust levels inside their facilities.

The majority of poultry producers, especially in the turkey, laying hen and broiler operations, would be the most affected by the adoption of the 25 ppm for NH_3 levels. However, due to the high frequency of respiratory problems encountered by farm workers in the poultry business, the adoption of the current OHSA standard might encourage the industry to develop new ventilation and environmental control equipment, including new dust control equipment, to reduce the existing acute NH_3 problem.

ACTION PLAN FOR THE INDOOR AIR QUALITY AND WORKING ENVIRONMENT INSIDE LIVESTOCK BUILDINGS ISSUES

The work environment inside agricultural buildings suffers from being generally negatively perceived by farm workers and the public due to the unpleasant odours, and elevated air contaminant and noise levels. The excessive levels of chronic respiratory problems observed in farm workers should encourage researchers to:

1 - establish Threshold Limit Values (TLV) for combined indoor air pollutants commonly encountered in agricultural buildings in relation to short-term and/or long-term exposure of farm workers, and animal health and safety.

2 - prepare Codes of Practices and/or Standards for indoor air quality and working environments inside farm buildings.

3 - reduce the dust, toxic gas, odour and noise levels inside livestock housing. Methods to cut the production of air contaminants at their sources or reduce their levels in the indoor working environment should be evaluated.

4 - develop indoor air quality control strategies for maintaining a safe working environment; e.g. a purge by the ventilation system or a partial sprinkling before the workers enter the building.

5 - test respiratory protection devices intended for the workers, and/or alarm systems for high levels of air contaminants.

With the existing knowledge on gas and dust reduction methods, it would be beneficial to initiate educational and incentive programs on management techniques to improve indoor air quality and working environment, and on the selection of protective devices, such as face masks, for farm workers and farm families.

SUMMARY AND CONCLUSION

Recommendations on indoor air quality vary among the different European countries. Apparently, each country's recommendations are related to their climate and technical ability to reach these levels. At the present time, there is no scientific evidence that Ontario should use these standards.

The direct application of the current regulations under the Ontario Occupational Health and Safety Act respecting the control of exposure to biological or chemical agents would mean upgrading some dairy and swine facilities. However, the poultry industry would have a serious challenge to economically reduce the high ammonia levels encountered in broiler, laying hen and turkey barns.

With existing knowledge, an educational and incentive program on management techniques to insure good indoor air quality, and on the selection of farm workers' protective devices would be beneficial.

RÉSUMÉ ET CONCLUSION

Les recommandations européennes sur la qualité de l'air ambiant dans les bâtiments d'élevage varient beaucoup selon leur pays d'origine. Il apparaît clairement que chaque pays a adopté des niveaux de gaz et de poussière techniquement réalisable selon leur climat bien spécifique. Selon l'état des connaissances actuelles, il n'y a aucune évidence scientifique qui indique que l'Ontario doit ou devrait utiliser les normes européennes.

L'adoption des normes de qualité de l'air ambiant selon les règlements sur les substances biologiques et chimiques prescrites dans la loi sur la santé et sécurité au travail aurait les effets suivants. Certains productions laitiers et porcins devront améliorer leur système de ventilation et/ou réduire les émissions de certains gaz et de la poussière dans leur étables. Par contre, un effort majeur devra être fait par les producteurs dans le domaine de la volaillle pour réduire de façon économique les taux élevés d'ammoniaque rencontrés dans les poulaillers de poules pondeuses, poulets de chair et dindons.

Avec les connaissances actuelles, il serait bénéfique de planifier un programme éducatif et incitatif sur les techniques pour améliorer la qualité de l'air ambiant dans les bâtiments d'élevage ainsi que sur la sélection d'un équipement de protection pour les travailleurs agricoles.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge K. Boyd, P.Eng., Education and Research Fund, Ontario Ministry of Agriculture and Food, AgriCentre, Guelph, Ontario; C. Weil, P.Eng., Head of the Agricultural Engineering Department and M. Paulhus, P.Ag., Principal, Alfred

College of Agriculture and Food Technology, Alfred Ontario; G. Garland, P.Eng., Head of the Engineering Resources Unit, J. Johnston, P.Eng., Manager, and V. Spencer, Director of the Resources Management Branch, Guelph, Ontario for their support and funding.

Special thanks are addressed to the numerous Agricultural Engineering Colleges which were contacted during Choinière and Kains' European Study Trip, 1992.

Thanks are also addressed to W.D. Morrison, University of Guelph; J.J.R. Feddes, University of Alberta; and E.M. Barber, University of Saskatchewan, for reviewing this paper.

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Definitions on the Calculation of Exposure Values (Ontario, 1986)

1. The time-weighted average exposure value (TWAEV) is the average of the airborne concentrations of a biological or chemical agent determined from air samples of the airborne concentrations to which a worker is exposed in a work day or a work week.

2. The short-term exposure value (STEV) is the maximum airborne concentration of a biological or chemical agent to which a worker is exposed in any fifteen minute period determined from a single sample or a time-weighted average of sequential samples taken during such period.

3. The ceiling exposure value (CEV) is the maximum airborne concentration of a biological or chemical agent to which a worker is exposed at any time.

4. The airborne concentrations of the agent are expressed as parts of the agent per million parts of air by volume (ppm) or as milligrams of the agent per cubic metre of air (mg/m^3).

5. In determining exposure to airborne concentrations of a biological or chemical agent, no regard shall be had or taken to the wearing or use by a worker of respiratory equipment.

6. The daily and weekly time-weighted exposure values shall be calculated as follows:

   (a) $C_1T_1 + C_2T_2 + ... + C_nT_n$ = cumulative daily or weekly exposure, where C_i is the concentration found in an air sample and T_i is the total time in hours to which the worker is taken to be exposed to concentration C_i in a work day or a work week for i taking on the values of 1, 2, ..., n.

   (b) The time-weighted average exposure shall be calculated by dividing the cumulative daily exposure by 8 and the weekly exposure by 40 respectively.

Calculation of Exposure Values Where a STEV or a CEV is Not Indicated

Where a STEV or a CEV is not set out for a biological or chemical agent, a worker shall not be exposed to a concentration of the biological or chemical agent that exceeds,

(a) three times the TWAEV set out in the Schedule for the agent for any period of 30 minutes, and

(b) five times the TWAEV set out in the Schedule for the agent for any period of time.

Table 1. Recommendations for maximum gas concentrations from different E.C. countries.

	Maximum allowable gas concentration in an animal house[1]				
Country	Carbon Dioxide [ppm]	Ammonia [ppm]	Hydrogen Sulphide [ppm]	Carbon Monoxide [ppm]	Dust [mg/m³]
Austria	3500	50	10	10	10
Belgium[2]	3000	20	5	5	10
Denmark	3500	15	0	--	--
Germany	3500	30	--	--	--
Hungary	2000	--	--	--	--
Italy	5000	50	10	--	--
Netherlands[3]	2000	10	0	--	10
Norway	3000	25	10	--	--
Sweden[4], General	3000	10	0.5	--	10
Poultry	3000	25	0.5	--	10
Switzerland	3500	10	5	--	--
United Kingdom, General	3000	20	5	--	10
Adult Cattle[5] (≥200 kg)	5000	25	10	50	10
Calves (<200 kg)	3000	20	5	10	10
Swine[6]	3000	20	5	10	10
Council of Europe	3000	20	5	5	10

[1]Ref.: Commission Internationale du Génie Rural (CIGR) (1984).
[2]Ref.: Belgium (1990).
[3]Ref.: Werkgroep Klimaatsnormen Varkenstallen (1989) and Klimaat Werkgroep (1991).
[4]Ref.: Sweden (1989).
[5]Ref.: United Kingdom (1990a).
[6]Ref.: United Kingdom (1990b).

Notes on the CIGR recommendation:

1 - Maximum allowable gas concentration could be defined as a concentration which shall only be exceeded in exceptional cases (for CO_2, CO, H_2S and dust).

2 - The proposed ammonia concentration is measured as a mean in the animals' dwelling zone.

Table 2. Time-weighted average exposure values (TWAEV), short-term exposure values (STEV) and ceiling exposure values (CEV) for biological and chemical agents (Ontario, 1986). Some USA values are also included.

Agent	TWAEV	STEV	CEV	Agricultural operations with concentrations often ≥ TWAEV.
Carbon Dioxide (CO_2), ppm	5000	30 000		Swine
Ammonia (NH_3), ppm	25	35		Poultry, swine and dairy calves
Hydrogen Sulphide (H_2S), ppm	10	15		During manure agitation for swine, dairy and poultry
Carbon Monoxide (CO), ppm USA (86/87)	35 50	400 400		Poultry and swine facilities using fuel fired heaters
Nitrogen Dioxide (NO_2), ppm	3	5		Inside silos after filling
Grain Dust, mg/m^3	4		20	Livestock feed rooms and grain centres
Total Dust, mg/m^3	10		50	Most barns after animal feeding
Respirable Dust, mg/m^3 for USA, 86/87	5		25	