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AIR QUALITY INSIDE LIVESTOCK BARNS

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INTRODUCTION

In modern livestock barns, proper indoor air quality is imperative to maintain the health and productivity of farm workers and animals. Some problems related to the health of farm workers have been noticed, especially since the 1970's, coinciding with the rapid changes from small traditional farms to large intensive livestock operations.

The purposes of this Factsheet are to identify the contaminants present in the air inside livestock barns and to discuss the effects of adopting the present industrial indoor air quality standards from the Occupational Health and Safety Act by Ontario farmers.

AIR QUALITY REQUIREMENTS FOR FARM ANIMALS

Good indoor air quality depends on barn management, feeding and manure handling systems, the ventilation system, as well as on the overall cleanliness of the operation, and type of livestock. It is assumed that to maintain good growing and production levels, the animals need good air quality. The primary role of any ventilation and heating system is to provide an adequate supply of fresh air inside the barn, to control the temperature and to obtain acceptable levels of moisture, gas, dust and odors. However, during the cold season, the ventilation system alone is very often insufficient to maintain ideal indoor air quality conditions.

Let us try to understand the problem. Dairy, swine and poultry operations all include the following: (1) feeding, (2) metabolism, (3) production of by-products, and/or (4) weight gain. For example, a dairy cow eats, and transforms the feed to give milk and produces meat; this cow also breathes, defecates and urinates, releasing moisture and gases. Large quantities of dust are also produced during feeding or bedding.

When dairy cows are pastured, or pigs and chickens are raised outside, the contaminated air is dissipated into the atmosphere. However, in a barn, the air quality has to be controlled by the housing system and management, as well as the ventilation system.

AIR QUALITY FOR LIVESTOCK PRODUCERS

In modern livestock operations, many producers work in the barn between 4 and 8 hours per day. Past research on barn ventilation has been oriented towards animal productivity and comfort without adequate emphasis on the health of the workers themselves. It is likely that gas and dust levels inside most barns are harmful for most producers and their employees, especially during the winter.

NOXIOUS GASES

Among all the gases present in the ambient barn air, the most dangerous ones to worker health are hydrogen sulphide (H_2S), carbon dioxide (CO_2), ammonia (NH_3) and methane (CH_4). For example, Table 1 presents the allowable levels of air contaminants that have been adopted under the Ontario Occupational Health and Safety Act, 1980, in regulations relating to control of exposure to biological and chemical agents. 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.

Carbon dioxide and water are the primary by-products of respiration. Every living animal produces carbon dioxide. A potential health hazard can occur if too much carbon dioxide is present in the barn. Normally, there is no problem with dairy operations. However, a Saskatchewan study of several swine buildings revealed that during the winter (outside temperature between -13° and -16°C), the maximum exposure level of 5000 ppm for carbon dioxide was exceeded in 24% of the barns studied. Also, similar high levels of carbon dioxide are often found during winter in broiler barns. Since these winter temperatures are common in many farming areas across Canada, there is considerable potential for exceeding the 5000 ppm level.

Ammonia is produced by the decomposition of the nitrogenous compounds (e.g., non-degraded proteins) in manure. Its characteristic strong odor makes it easily detectable as soon as levels reach 5 to 10 ppm. High levels of ammonia, between 20 and 50 ppm, irritate the eyes, nose and throat.

In dairy operations, ammonia levels are not really a problem except inside unbedded dairy calf and veal barns where levels of ammonia above 25 ppm are commonly encountered. In swine operations, numerous Canadian studies reported ammonia levels above 25 ppm. However, it is in poultry operations where the highest levels of ammonia are

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Table 1. Time-weighted average exposure values (TWAEV), short-term exposure values (STEV) and ceiling exposure values (CEV) not to be exceeded for biological and chemical agents (Occupational Health and Safety Act, Ontario, 1986). Some USA values are also included.

Agent	TWAEV	STEV	CEV	Agricultural operations with concentrations often exceeding TWAEV
Carbon Dioxide (ppm)	5000	30,000		Swine, poultry
Ammonia (ppm)	25	35		Poultry, swine and dairy calves
Hydrogen Sulphide (ppm)	10	15		During manure agitation for swine, dairy and poultry
Carbon Monoxide (ppm) USA (86/87)	35 50	400 400		Poultry and swine facilities when unvented fuel fired heaters are maladjusted
Nitrogen Dioxide (ppm)	3	5		Inside silos after filling
Grain Dust, (mg/m³)	4		20	Livestock feed rooms and grain centres
Total Dust, (mg/m³)	10		50	Most barns after animal feeding
Respirable Dust, (mg/m³) for USA, 86/87	5		25	

Calculation of Exposure Values (OHSA, Ontario, 1986)

1. The time-weighted average exposure value (TWAEV) is the average of the air-borne concentrations of a biological or chemical agent determined from air samples of the air-borne 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 air-borne concentration of a biological or chemical agent to which a worker is exposed in any 15 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 air-borne concentration of a biological or chemical agent to which a worker is exposed at any time.

4. The air-borne 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 air-borne 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 Ti 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.

recorded. For example, average levels of 25 to 32 ppm were measured in commercial turkey barns, 33 to 53 ppm in laying hen barns, and 2 to 12 ppm inside broiler barns with fresh litter, but 70 to 80 ppm in a broiler barns where litter from a previous flock was not removed.

Research work on feed additives, manure handling and proper management are currently being undertaken to solve or at least attenuate the ammonia problem. However, it has been demonstrated that it is feasible to maintain acceptable levels of ammonia with proper manure management and adequate ventilation and heating in all livestock and poultry barns.

Methane levels encountered in livestock operations are not normally a health hazard, however cases of barn explosions due to this gas have been reported.

Hydrogen sulphide is the most dangerous gas produced by the manure. Its odor is easy to detect even at very low levels. At high concentration levels, hydrogen sulphide overcomes the sense of smell, so workers do not smell this gas after a short period of exposure. Consequently, the pulmonary system of the victim is paralyzed and rapid death occurs. Normally, there is very little hydrogen sulphide inside livestock barns, however in-barn manure agitation can release large amounts of H_2S which can be very dangerous. There are a number of horror stories of dairy and swine farmers who were killed or seriously injured by manure gas. High concentrations up to 130 ppm were measured by a team of Ontario researchers during the agitation of manure pits in swine facilities. Consequently, it is recommended that you agitate manure pits when there are no animals or humans inside the barn. Ask for Canada Plan Service Leaflet M-8710, entitled "Manure Gas" for recommended procedures for in-barn manure handling.

DUST IN LIVESTOCK BARNS

Dust is composed of fine aerosol particles in suspension. Dust can be characterized according to three important factors:

1. the source and type of particles
2. size of particles
3. the number or concentration of particles

SOURCES AND TYPES OF DUST

Dust found inside livestock barns is composed of numerous components of various shapes and sizes, both organic and inorganic. In animal housing, 70 to 90% of the dust is organic. This means that it is biologically active and will react with the defense system of the respiratory system. Included in the organic barn dust are feed components, dried faecal material, hair and skin cells, feather particles, pollen, insect parts, molds, fungi, viruses and bacteria. Endotoxins are produced by bacteria. These endotoxins are generally strong allergens causing immediate or delayed reactions in the respiratory system. The inorganic dust is composed of numerous aerosols originating from such building sources as concrete, mineral or fibreglass insulation, or material, such as soil particles, drawn into the barn by the fresh air supply.

Table 2 summarizes the different sources of dust encountered in livestock barns.

SIZE OF PARTICLES

When moldy hay or straw is shaken, large dust particles fall rapidly to the ground; the dangerous fine particles remain in suspension. These are called respirable dust since they can be inhaled deeply into a worker's lungs. Their size is smaller than 5 micrometres (or microns, where 1 micron = 0.001 mm). You can not see these particles with the naked eye.

The dust problem inside livestock barns results from the fact that 80 to 90% of the dust inside swine and poultry barns are smaller than 5 microns and can be taken deeply into the lungs. On most livestock farms, the operator is exposed to a large quantity of very small particles.

NUMBER OF PARTICLES

In the atmosphere, there are always dust particles in suspension from soil, pollen and seeds. The Occupational Health and Safety Act regulations on biological and chemical agents (Table 1) prescribes a maximum TWAEV of 4 mg/m^3 (equivalent to 400,000 particles/litre) for grain dust and 10 mg/m^3 (1,000,000 particles/litre) for total dust.

Table 2. Examples of dusts which may present health problems.

Source Material	Problem Particles	Cause
Grain	molds, actinomycetes	storage problem
Hay	molds, actinomycetes	poor conservation
Straw	molds, actinomycetes	combining/poor conservation
Silage	molds	poor conservation
Animal debris	faeces, urine, hair, skin, feathers, fungi, bacteria	animal activity, barn cleanliness, ventilation, etc.
Feeds	numerous particles	feed distribution/poor ventilation

In a dairy barn, there can be about 10,000,000 dust particles per litre present when moldy hay or grains are fed or straw is spread. Even with good hay and straw, levels of 1,000,000 to 2,000,000 dust particles per litre of air are commonly measured. In these cases, an TWAEV of 10 mg/m^3 total dust is often exceeded. So, when you find it difficult to see the other end of the barn because of the dust, this is bad news for your lungs.

In the swine industry, the highest levels of dust occur during feeding and feed grinding. Pig activity has a very large effect on dust levels. An Ontario study showed that 27% of operators were exposed to levels exceeding the 10 mg/m^3 limit during the normal working day.

For broiler, roaster, turkey and laying hen operations, the average number of dust particles is generally below 100,000 particles/litre (1 mg/m^3). However, peaks of dust are always measured during feeding time when all the birds are very active. The main health problems with poultry workers occurred while moving or handling older birds; these symptoms could be attributed to exposure to the combined effects of dust, ammonia and endotoxins.

CONCLUSION

It is strongly recommended that you wear a respiratory protection system such as an adequate face mask or the more efficient positive pressure respirator, especially during feeding and animal handling times. See Canada Plan Service Leaflet M-9707, entitled "Protecting Workers in Livestock Buildings from Dust and Gases" for further information on respirators and masks.

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