IOWA STATE UNIVERSITY
University Extension

# LIVESTOCK CONFINEMENT DUSTS AND GASES

**Summary**

In typical modern livestock housing, where animals are densely confined, dusts from the animals, their feed, and their feces, ammonia (NH3) which comes primarily from the animals' urine and feces, and hydrogen sulfide (H2S) from manure pits, especially during agitation and emptying, can rise to harmful levels. Dust and gas levels are highest in winter, although dust levels increase whenever animals are fed, handled, or moved. Hazardous dusts and gases induce the strongest and most frequent human respiratory responses in swine confinement buildings. This unit concentrates on workers in these buildings, although similar respiratory responses could occur among poultry confinement workers or (less commonly and severely) workers in other types of confinement operations.

Confinement dusts and gases can affect any exposed person within a short time, and in extreme cases have caused sudden death or have forced owners, employees, and veterinarians to stay out of confinement buildings or seek other employment. Responses often vary from person to person, may affect any part of the respiratory tract, and may include irritant, toxic, or allergic processes. Potential responses include acute or chronic bronchitis (the most common reaction), increased airways reactivity, asthma, chronic airways obstruction, and a systemic influenza-like reaction, the toxic organic dust syndrome or TODS. When manure pits constructed underneath confinement buildings are agitated for emptying, the level of H2S can rise to lethal levels within seconds; this has caused a number of deaths. Researchers suspect that chronic obstructive pulmonary disease may occur among confinement workers with long-term exposure.

When diagnosing and treating respiratory illness in confinement workers, physicians should make a conscientious attempt to discover links between exposure to dusts and gases in the houses and the illness. This will avoid use of nonspecific treatments that are ineffective in the long run. Instead a patient must be protected by reducing dust and gas levels in the confinement house through engineering and management practices, or by use of respirators. Confinement house workers should be monitored for development of chronic respiratory problems. Manure pits should never be entered without proper respiratory protection, and when pits are being agitated or emptied, workers should stay out of the pits and out of the buildings above them.

## I. CONFINEMENT HOUSING AND ITS HAZARDS

Compared to conventional livestock housing, the typical confinement system is more enclosed and tightly constructed. A much higher density of animals is housed in these buildings, usually for 24 hours a day from birth to shipment to the slaughter house. Because large numbers of animals are confined in small spaces, these buildings must include devices to ventilate and heat the buildings and to dispose of animal wastes. Often, feeding and watering operations are semiautomatic or automatic. (See Fig. 1) Poultry confinement operations first appeared in the United States in the late 1950's. Swine confinement operations came

into use a decade later. Today sheep, beef cattle, dairy cattle, and veal calves also are housed in confinement buildings, although far less commonly than swine and poultry. Quarters for these other animals often are not completely enclosed, or the animals may be kept outside for at least part of the year.

Manure is handled by one of two systems: it either drops through a slatted floor into a pit beneath the house where it remains until the manure slurry is pumped out to be distributed on fields (usually twice a year), or it is removed through any of several mechanisms to a storage pit or lagoon outside the building. Outside storage is typical of most newer systems, but a large number of older buildings with pits directly below the house remain in operation.

What toxic dusts and gases are found in confinement houses?

Dust is generated from animals and their feed, and dust and gases from animal wastes. These dusts and gases accumulate to concentrations that may be hazardous to human and animal health.

Each confinement house contains its own complex mixture of dusts and gases, which is dependent on numerous factors including ventilation of the building, the type of animals, how they are fed, and how their wastes are handled. (See Fig. 2) Dust and gas composition change within a single house over time. The types of confinement operations and corresponding dust and gas exposures are listed in Table 1. This unit concentrates on swine operations, where potentially hazardous dusts and gases and resulting health problems are best studied and are thought to be most extreme. Similar responses would occur most commonly among poultry confinement workers.

**Dusts and Gases In Various confinement Operations: Implications for Human Health**

| Type of operation | Dusts | NH2 | H2S(following manure agitation) |
|---|---|---|---|
| swine | major concern | moderate concern | major concern |
| poultry | moderate concern | major concern | none (manure is stored as solid) |
| sheep<br>veal calf<br>dairy cattle<br>beef cattle | minimal concern<br>(lower dust concentrations, resulting in fewer and less severe inflammatory reactions) | moderate concern | major concern, if have liquid manure system |

Dust particles contain approximately 25% protein, and range in size from less than 2 microns to 50 microns in diameter. One-third of the particles are within the respirable size range (less than 1011 in diameter). 125 Fecal material particles including proteins from gut epithelium are quite small and constitute the major alveolar burden, while large particles of feed grains form the major airways burden. Also present are animal dander, broken bits of hair, bacteria, bacterial endotoxins, pollen grains, insect parts, and fungal spores. The dust absorbs NH3 and possibly other toxic or irritating gases (e.g. H2S), multiplying the potential hazards of each gas individually. Ammonia, for example, may adsorb to respirable particles and be drawn deep into the lungs where it possibly could cause irritation or increase inflammatory responses to the dust.

Toxic, irritating, and asphyxiating gases are continuously generated in the manure pit, and can rise into a confinement house. Of the 40-plus gas types in anaerobically degenerating manure, H2S, carbon dioxide (CO2), methane (CH4), and carbon monoxide (CO) are present most commonly and in highest concentrations. The majority of NH3 is thought to be released by bacterial action on urine and feces on the confinement house floors. Carbon monoxide and CO2 may be produced by heating systems in winter, as well as by the animals' respiration (CO2 only).

Who is exposed to these dusts and gases, and when?

Dust and gas concentrations in swine confinement buildings can be high enough to affect anyone who enters, but persons with long-term occupational exposures are in greatest danger of developing chronic problems and possibly irreversible lung damage. Confinement house owners and managers, hired hands, and farm family members may work in the houses anywhere from a few hours a week to eight or more hours daily. (See Fig. 3) During this time, workers are preparing feed, feeding animals, cleaning the building, sorting and moving animals from one building to another, and performing routine vaccinations, treatments, or other management and maintenance procedures. The turnover rate of hired swine confinement house workers is quite high, and some owners have had to sell their operations because they could not work in their own units, reportedly because of respiratory problems. Some veterinarians who entered houses sporadically to treat sick animals have reported that the severity of their respiratory reactions forces them to stay out of these buildings, or to use respirators effective in reducing exposure.

Dust and gas loads increase in winter when the houses are tightly closed to conserve heat, and when CO and CO2 are released from poorly vented or improperly functioning heaters. Dust loads also increase when animals are being moved, handled, and fed. Ventilation systems frequently do not reduce dust or gas levels adequately, so that levels remain unhealthful for humans. When ventilation systems fail for several hours, CO2 from animal respiration, heaters, and manure pits can rise to asphyxiating levels. Although some massive animal losses have been attributed to this situation, it is probably not a human health threat.

Hydrogen sulfide from manure pits is most hazardous when the pits are fully or partially beneath the houses. However, if gases from outside pits are permitted to backflow, they too can enter confinement units. Manure pit gases pose an acute hazard when the liquid

manure slurry is agitated, a common operation performed to suspend solids so that pits can be pumped empty. During agitation, H2S can be released rapidly, soaring from usual ambient levels of less than 5 ppm to lethal levels of over 500 ppm within seconds.20 Animals have died and workers have become seriously ill in swine confinement buildings when H2S has risen from agitated pits underneath. Several workers have died when entering a pit during or soon after the emptying process to repair pumping equipment or clean out solids.20 Persons attempting to rescue these workers also have died. Workers may be exposed to high H2S levels when they enter the pit to retrieve animals or tools, or to repair ventilation systems or cracks in the cement.

Swine confinement houses and resulting health problems are concentrated in the Corn Belt of the Midwest, but are also found in western Nebraska, Kansas, Colorado, and in southeastern states including North Carolina and Georgia. Poultry confinement houses and resulting respiratory problems are concentrated in the Northeast, Southeast, Midwest, and Far West. Other types of confinement operations are ,primarily located in the Midwest's Corn Belt.

How commonly does such exposure occur?

In the United States, an estimated 700,000 persons work in confinement operations. This number includes owner-operators, spouses, children, employees, and veterinarians. In a highly agricultural state such as Iowa, over 80,000 persons (or an estimated 53% of the people working with swine) work in swine confinement buildings. Included in this number are spouses and children who may work short periods of time.

The largest group of exposed workers with the most frequent and severe health problems is associated with swine confinement houses. Here, the average dust load is six milligrams per cubic meter. Buildings with 10 to 20 milligrams are common, concentrations high enough so that one is unable to see clearly across a 100 foot room. Concentrations of H2S, CO2, and CO may exceed levels recommended as safe in industrial occupational settings. Nearly 70% of swine confinement workers experience one or more symptoms of respiratory illness or irritation. Prevalence of respiratory illness among workers in nonswine confinement operations is lower.

## II. RESPIRATORY EFFECTS OF INHALING CONFINEMENT HOUSE DUSTS AND GASES

Inhalation of confinement house dusts and gases produces a complex set of respiratory responses. An individual's response depends on characteristics of the inhaled components (such as composition, particulate size, and antigenicity) and on the individual's susceptibility, which is tempered by extant respiratory conditions (including allergies and asthma), reactivity of the bronchi, and smoking history. Irritant, toxic, or allergic processes may be involved, alone or in combination. Since dusts include both respirable (~10 microns ) and larger (10--50 microns ) particles, lung tissues, large airways, and small airways may all be affected. For the most part, responses cannot be tied to a specific dust or gas component. Specific mechanisms involved often cannot be defined, and conditions may be described symptomatically.

Acute, delayed, and chronic responses are described in following paragraphs and outlined in Table 3. Descriptions concentrate on health problems of swine confinement workers. Hazardous exposures of other types of confinement operations have been listed in Table 1; respiratory problems vary

accordingly.

Symptoms of swine confinement workers are listed in Table 2. The most common respiratory symptoms (cough, sputum production, chest tightness, shortness of breath, and wheezing) are manifestations of airways disease, composed of bronchitis often associated with increased airways reactivity Evidence suggests that those exposed become increasingly reactive to the confinement environment with increasing exposure (greater than two hours per day and six years work experience). In general, the symptoms increase among smokers and also increase as the number of swine raised increases. Health effects are also greater among those with pre-existing respiratory problems (hay fever, bronchitis) and among those with heart trouble or allergies. Chest tightness, coughing, nasal, and eye symptoms have been experienced in some persons within 30 minutes of entering these houses for the first time, but usually two or more hours of exposure are required. These symptoms usually disappear 24 to 48 hours after leaving the unit, although they can persist for several days or weeks or even months among workers exposed for several years. A small percentage, 12%, of these cases are thought to be specific allergic-mediated illnesses such as asthma (classical type 1 reactions), while the remaining proportion appears to be nonallergic reactions.

Table 2 Symptoms of Swine Confinement Workers

| Symptom | Prevalence |
|---|---|
| Cough | 67% |
| Sputum or phlegm | 56% |
| Scratchy throat | 54% |
| Runny nose | 45% |
| Burning or watering eyes | 39% |
| Headaches | 37% |
| Tightness of chest | 36% |
| Shortness of breath | 30% |
| Wheezing | 27% |
| Muscle aches and pains | 25% |

Manure pit agitation can result in the sudden release of large quantities of H2S causing H2S intoxication (See Fig. 4) At moderately high concentrations (100-400 ppm), H2S produces rhinitis, cough, dyspnea, tracheobronchitis, and possibly pulmonary edema; at higher concentrations, sudden collapse associated with respiratory paralysis and pulmonary edema occurs. A number of deaths of confinement workers have resulted from this exposure.

Delayed responses include a toxic organic dust syndrome (TODS) experienced four to six hours after working for several hours in a confinement house during particularly dusty operations such as handling, moving, or sorting animals. Symptoms include fever, malaise, muscle aches and pains, headache, cough, and tightness of chest. This episodic problem, experienced by about 10% of workers in confinement buildings,1 may be the same toxic syndrome resulting from exposure to decayed plant material (see Unit 2) and grain dusts (see Unit 3). Inhaled endotoxins from aerosolized gram-negative bacteria might cause this syndrome.

Chronic health effects are manifest as chronic bronchitis with or without airways obstruction, experienced by 58% of all swine confinement workers. This is the most commonly defined chronic health problem

of this occupational group, and is suffered by three times as many swine confinement workers as farmers who work in conventional swine housing units or in agricultural operations other than swine or poultry production. Symptoms include chronic cough, with excess production of phlegm and sometimes chronic wheezing. Smokers experience a greater prevalence and severity of chronic bronchitis than do nonsmokers. Most workers removed from the confinement house environment become asymptomatic (in the absence of smoking) within a few months, but bronchitic symptoms in some workers can persist for two years or more.

Chronic or irreversible airways obstruction other than chronic bronchitis has not been identified, but long-term lung damage may be occurring. Confinement workers' lung functions do not differ significantly from those of workers in conventional swine buildings when baseline PFT's (FEV and FVC) are measured in the morning, before work begins.1721 However, these pulmonary function values of most confinement house workers do decrease significantly through the workday. In addition, the severity of chronic bronchitic symptoms increases in workers with a longer history of confinement house work. This suggests that chronic obstructive pulmonary disease may occur among these workers in future years. Evidence of permanent lung damage has not yet been found, possibly because swine confinement houses are a relatively new innovation or because there have been no systematic clinical studies to assess confinement workers. In 1981, the average swine producer with confinement structures had used these structures for only six years.

Because of the high concentrations of animals and associated microorganisms, infectious diseases transmissible to humans are especially hazardous when contracted by confined animals. Some of these infectious diseases are described in Unit 7.

Diagnosis

Use of diagnostic aids is of secondary importance to a detailed clinical and occupational history. Remember that a patient's response to confinement dusts and gases is variable, and that one or more conditions may be occurring simultaneously. Question a patient in detail about chief complaints, including questions on how long symptoms have been present and the time relationship of symptoms to work exposure. Take an in-depth personal and family medical history, including questions on allergies, asthma, and hobbies or personal habits (such as smoking) that might complicate the issue. Ask how many hours per day or week the patient works in confinement buildings, how long the patient has held this job, and what conditions prevail within the confinement building.

Physicians may fail to relate a patient's symptoms to exposure to a confinement house atmosphere. In addition, misdiagnosis and subsequent treatment of confinement-related respiratory conditions as allergic responses are not uncommon; such treatment may provide symptomatic relief through bronchodilation, but is nonspecific and probably ineffective in the long run.

Table 3 Occupational Respiratory Conditions Associated with Swine Livestock Confinement--Diagnosis, Treatment, and Control

**BRONCHITIS**

Symptoms/History:

- Cough, with sputum production, possibly tightness of chest.
- Very frequently seen among swine confinement workers; somewhat

less often in poultry workers.

- Smoking associated with increased frequency and more severe symptoms.
- Symptoms continuing for 2 or more years classified as
- chronic bronchitis.

**Work Exposure:**

Usually occurs in those who work in swine confinement for 2 or more hours per day. More frequent and severe for those who have worked 6 or more years in confinement. Generally occurs in buildings with poor environment: dusty (appears hazy and dust accumulates on accumulates on horizontal surfaces) poor ventilation, often older building (built before 1975). Nursery buildings and those with manure pits under slatted floors may be biggest offenders. Usually worst during cold weather.

**Diagnostic Aids:**

- Symptoms and history usually sufficient for diagnosis.
- PFT may show decreased flow rates.
- Skin tests or other immunological tests not indicated.
- Treatment/Control:
- Protection from environment most important action.
- Medications usually not indicated.
- Antihistamines, decongestants, antibiotics may provide
- temporary relief of symptoms but should not be used long-term.
- Improved ventilation crucial.
- Employ management procedures to limit dust generation(i.e. frequent cleaning).
- Install dust and gas control technology.
- Establish a respirator program.
- Abstain from smoking.

**Prognosis:**

- Most improve if environmental exposure is controlled
- through engineering, management, or use of respirator.
- Cessation of smoking also crucial.
- Temporary removal from the environment or use of a respirator may help until other measures can be taken.
- Long-term or permanent damage has not been reported to date.
- Usually not necessary to quit working.

## INCREASED AIRWAYS REACTIVITY

**Symptoms/History:**

- Chest tightness, mild dyspnea, some restriction and obstruction during breathing.
- Often accompanied by bronchitis.
- Very common in exposed workers.
- History similar to bronchitis, but often with a nonproductive cough.
- Work Exposure: Identical to bronchitis (above).
- Diagnostic Aids: PFT following a workshift shows flow decreased flow
- rates, primarily FEV, and FEV25-75.
- Respiratory challenge with methacholine or histamine show decreased PFT flow rates.

**Treatment/Control:**

- Identical to bronchitis (above).
- Prognosis: Identical to bronchitis (above).

## OCCUPATIONAL ASTHMA

Symptoms/History:

- Wheezing within minutes (immediate asthma) or for up to 24 hours (delayed asthma) following exposure.
- Only seen in small percentage of workers (less than 10%).
- Work Exposure: Among atopics or those who already have asthma from
- another source, often occurs with first exposure.
- With other workers, a period of sensitization is required, which may vary from a few months to several years.
- Extent of exposure not as important (environment may be relatively clean, and a person may spend very small amount of time in building).
- Diagnostic Aids: Same as asthma from any other source: obstructive air
- flow patterns following exposure; skin test often positive to one or more of feed grains, hog dander, hog hair, various molds, dusts; associated with atopic status and increased airways reactivity. Reversible with bronchodilators.

Treatment/Control:

- Medication and treatment same as any asthmatic.
- Attempts to control exposures by environmental control and respirators may or may not be helpful.
- Desensitization usually not applicable because of multiple antigens and irritant gases.

Prognosis:

- Same as for any asthmatic.
- Depending on degree of sensitivity, may be almost impossible to protect these people from their environment.
- This may be one condition for which patient must quit working in confinement house.
- Increased airway reactivity and asthma may continue past employment.

## TOXIC ORGANIC DUST SYNDROME (TODS)

Symptoms/History:

- Fever, muscle aches, chest tightness, cough, malaise.
- Symptoms develop 4-6 hours following exposure.
- Self-limited symptoms usually resolve 24-72 hours.
- Recurrent episodes common.
- Seen in 10-15% of the swine farming population.
- Often observed in clusters where 2-3 workers have similar exposure.
- Work Exposure: Usually condition associated with work in a totally
- enclosed building.
- Usually follows a particularly heavy exposure (e.g. 4-6 hours of very dusty work such as handling or sorting hogs).
- Diagnostic Aids: Elevated white blood cell count, usually neutrophilia.
- PFT will show decreased FEV, and diminished flow rates.
- PO2 may be decreased.
- Bronchoalveolar lavage usually shows PMN response.
- May show serum precipitins to various molds or dust extracts, but these are not diagnostic.
- X-ray may show scattered patchy infiltrates.
- Lung biopsy may show inflammatory polymorphonuclear cell infiltrates.

Treatment/Control:

- Symptomatic treatment in acute stages may include oxygen,
- IV fluids to correct acid-base imbalance and dehydration.
- Aspirin may be used to control fever.
- Most cases do not seek medical

attention; often confused with influenza.

- Prognosis: Usual recovery period 3-4 days, but patient may feel tired and have shortness of breath for several weeks.
- Subsequent attacks may occur in future following heavy exposure.

## H2S INTOXICATION

**Symptoms/History:**

- Sudden and immediate onset of nausea, dizziness, possibly sudden collapse, respiratory distress, apnea.
- May lead to sudden death or patient may recover if removed from environment, often with dyspnea, hemoptysis, and pulmonary edema, following intensive treatment.

**Work Exposure:**

- Almost always occurs with agitation of a liquid manure pit while emptying it.
- Respiratory effects will occur within seconds of encountering high concentration of H2S.

**Diagnostic Aids:**

- If patient survives: - x-ray often shows pulmonary edema. possibly presence of sulfhemoglobin and sulfide in blood.
- If deceased: - autopsy shows pulmonary edema, froth in trachea, possibly greenish tinge to viscera. – blood contains sulfide and sulfhemoglobin.
- Treatment/Control: Avoidance.
- Remove exposed person from environment (without exposing others) and resuscitate. May have to ventilate.
- Seek medical care, watch for and control pulmonary edema.
- Prognosis: If patient survives initial exposure, will probably
- recover usually with minimal loss of lung function.
- Recovery period may be from days to 2-3 years, depending on severity of exposure.

Table 3 lists the primary respiratory conditions associated with confinement dusts and gases, including symptoms and signs, associated work exposure, and specific diagnostic aids. This table was developed from experience with swine confinement operations. Conditions provoked within other types of confinement buildings may differ.

Treatment Medically, little can be prescribed excluding treatment of some of the acute illnesses (asthma, pulmonary edema from H2S intoxication). These treatments, specific control measures, and the prognosis for these illnesses are listed in Table 3.

Respiratory conditions must be controlled through protecting the patient from the environment, either by reducing dust and gas levels or by isolating the patient from these substances. A patient may need to get in touch with a consulting veterinarian or agricultural engineer who has knowledge of environmental control. The local veterinarian or the Cooperative Extension Service agricultural engineer should be able to recommend an appropriate expert.

Physicians need to address the patient's anxiety as well as the patient's medical problems. Confinement workers often are told to quit working in confinement structures if they are having respiratory problems. Usually this recommendation is unnecessary. It may produce extreme mental stress, and should only be given once the cause and prognosis of illness have been determined and other avenues of controlling harmful exposures have been fully explored. In many instances, the farmer has no reasonable occupational choice other than to continue working in the confinement building. Also, quitting farming is leaving a

life-style as well as a job.

Farmers are becoming increasingly aware of confinement-associated respiratory conditions. A physician can explain potential long-term respiratory conditions but also instill confidence regarding maintenance of the farmer's health status, and assist in protecting the farmer from health problems of the work environment. Monitoring the patient's respiratory status may be reassuring to many patients. An initial exam should include a thorough occupational history, spirometry, and a chest x-ray if patients are symptomatic. These can be repeated if clinically indicated at later annual check-ups.

**III. PREVENTION**

Health hazards associated with confinement houses must be addressed through improvements in the environment and protection of the individual. Techniques for reducing or eliminating the sources of dusts and gases include delivering feed by extension spouts into covered feeders, rather than letting feed fall freely several feet from automatic delivery systems into open feeders (See Fig. 5), frequently and systematically washing buildings with power sprayers to keep them as clean as possible, using wire mesh floors which are more self-cleaning, and assuring that heating units are clean, vented, and functioning properly. Control techniques can be assessed by measuring dust and gas concentrations (see Unit 8).

Because it is impossible to eliminate the formation of dusts and gases, techniques for removing contaminants from the air of confinement houses are critically important. Ventilation will reduce gases, but not necessarily dusts, to healthful levels. Ventilation systems must be properly designed and maintained, and ventilation rates adjusted to include consideration of air quality. These rates often are kept low in winter because of concerns for conserving heat, causing dust and gas concentrations to rise. A number of engineering techniques (e.g. use of heat exchangers which allow increased ventilation while capturing some waste heat) have been tried with varying degrees of success.

Anyone working in a swine or poultry confinement house would be wise to wear a dust mask. Persons exposed to houses with high dust or gas concentrations, or persons with respiratory conditions, may need to use a more sophisticated respirator such as a half-mask cartridge respirator or air helmet. (See Unit 9)

Preventing exposure to high concentrations of $H_2S$ from manure pits requires stringent controls. General safety measures include constructing manure pits outside of the confinement building, constructing openings so that lids or other objects cannot fall into the pit requiring a worker to enter the pit for retrieval, and erecting safety guards and warning signs. Whenever a pit that is under a confinement house is being agitated, people should stay out of the building, ventilation of the house should be maximized, and animals should be removed or observed from outside the building.

Even when not being agitated, manure pits can seldom be entered safely. If entrance is imperative, only a self-contained breathing apparatus, worn by an individual trained in its use, will provide adequate protection. All operators should understand that high concentrations of $H_2S$ cannot be smelled and that $H_2S$ above 1000 ppm produces unconsciousness in only one to three breaths.

A variety of H2S gas alarms give an accurate indication of hazard (See Unit 8).

The National Dairy Database (1992)

**\NDB\OCCSAFE\TEXT2\OF200700.TXT**

TITLE;LIVESTOCK CONFINEMENT DUSTS AND GASES %f COLLECTION;FARM AND OPERATOR SAFETY
ORIGIN;Iowa
DATE_INCLUDED;June 1992