

Moisture Effects on Facility Life: Sources and Corrections

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■ Introduction

Moisture, when unmanaged, can be the source of a variety of problems affecting the life of both the interior and exterior of swine facilities. It can cause rot, corrosion, mould (indoor air quality health issues), staining, shrinkage and/or swelling, and insect infestations. Other problems from poorly managed moisture levels (relative humidity) inside the barn can arise, including elevated pathogen levels affecting animal and human health (**Figure 1**). Other gases, such as hydrogen sulfide and ammonia, combine with moisture inside barns and accelerate deterioration rates.

This paper provides background information on moisture balance, sources of moisture, moisture problems, and how to control moisture as a primary destructive force of swine facilities.

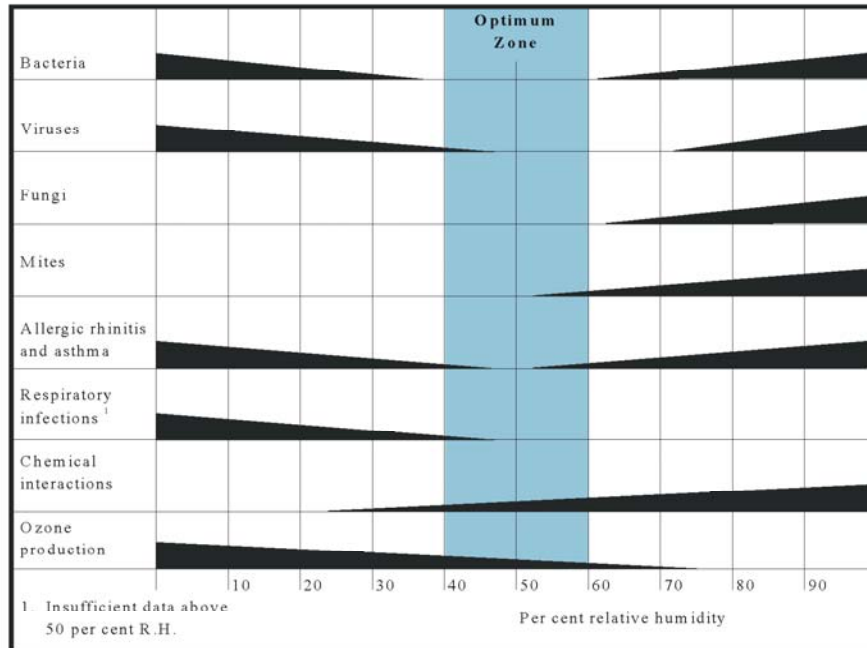
Moisture Balance

Moisture balance is based on wetting and drying. Water is present or available in several phases, liquid, solid, vapour and adsorbed. Sources and mechanisms of wetting include (Lstiburek, 2004; Straube, 2003):

- Rain, groundwater, manure, urine, other water sources inside the barn such as feed water spillage, pressure washers; absorption (wicking) and penetration in liquid form.
- Interior & exterior air: vapour is transported by air leakage (convection) and diffusion.
- Built-in moisture: This is moisture stored as a liquid, solid or vapour in masonry/concrete, in green lumber, and as rain/snow accumulated during construction. As the name implies, this is not transported into the structure after completion.

- Soil Moisture: transported by diffusion, absorption and liquid penetration as either a liquid or a vapour.

Figure 1. Effects of Relative Humidity



E.M. Sterling. Criteria for Human Exposure to Humidity in Occupied Buildings, 1985 ASHRAE

Sources of drying include (Straube, 2003):

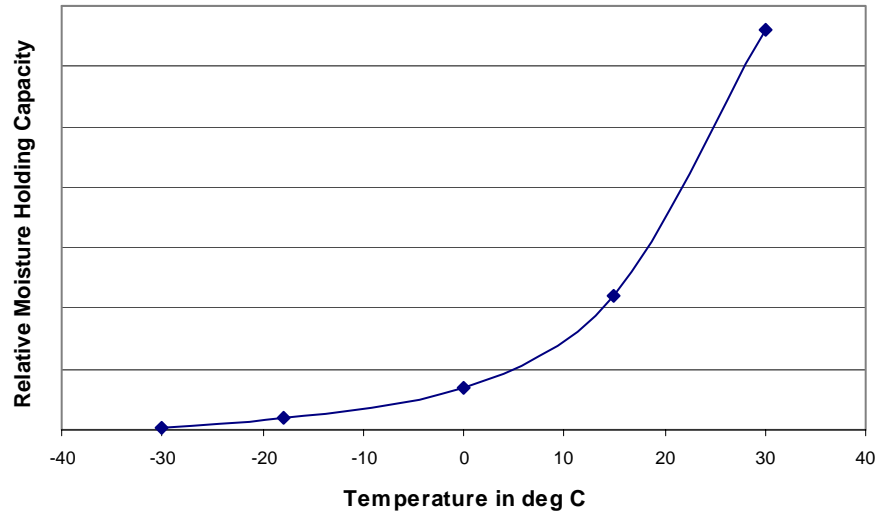
- Drainage: surface water diversion and eavestroughs keep water away from the exterior of the building and thus prevent materials from becoming saturated.
- Evaporation – diffusion: from interior and exterior surfaces.
- Air leakage or convection: to the interior or exterior of the building as a vapour through cracks, holes, and during ventilation.
- Heating.

Water Vapour in Air

Water vapour is present in all air. The amount of water vapour depends on the air's capacity to hold it and is affected by temperature. Condensation occurs when the maximum holding capacity is exceeded. Cool air has a lower

moisture holding capacity than warm air. **Figure 2** shows the rate at which air moisture holding capacity changes with increasing temperature.

Figure 2. Relative Moisture Holding Capacity/Mass of Air

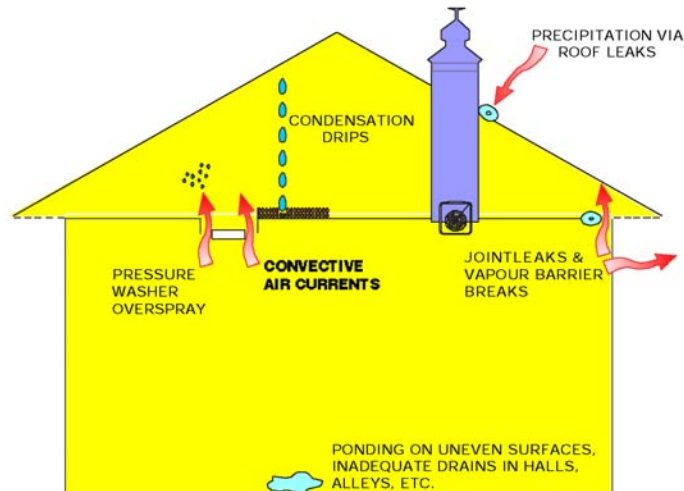


Water vapour moves by diffusion and convection. Diffusion involves the movement from more to less vapour. It is a slow process, which can be slowed further by many materials, including concrete, or can be virtually stopped by plastics (poly), steel and glass. Air leakage or convection involves the movement of water vapour from an area of high pressure to low pressure. Air generally leaks through cracks and fine openings in the walls and ceilings. This movement is usually from the inside to the outside.

■ Sources of Moisture

Moisture is produced in swine production facilities from the livestock, equipment and the structure itself, as shown in **Figure 3**.

Figure 3: Moisture Sources into Barn, Attic and Walls



Livestock

- Manure and urine: remove as quickly as possible to prevent adding liquid and air vapour sources.
- Animal Respiration: manage the moisture content in the air to optimize environment for the animals and minimize potential for moisture build-up. The optimal moisture content to achieve these targets is in the 50-70% range.

Equipment

- Waterers: spills and leaks
- Water pipes and faucets/taps: leaks
- Heaters: natural gas, propane, and fuel oil heaters produce water vapour as a by-product of combustion
- High pressure washers: often drive water into attic and other undesirable places

Structure

- Exterior water “ponding” and subsurface drainage: water lying around the outside of the barn. High water table, freeze – thaw damage, frost heave.

- Interior liquid ponding: results from inadequately sloped solid flooring and improperly sized, located and managed drains to storage.
- Ice damming: ridges of ice and icicles form when melt water from further up the roof melts and refreezes on the lower, colder edge of the roof. Damage can be caused to the sheathing, roof structure, ceiling and walls below (Straube, 2002).
- Thermal bridging: in corners, at joists
- Air leaks: around doors, windows, exhaust ventilation fans, air inlets
- Manure storage under floor
- Exhaust air into soffits: moisture laden exhaust air can be drawn directly into the attic space through the soffits if they are located on the same side of the barn as the exhaust fans.
- Room air pressure: if too high, moist air might be drawn in from undesirable locations; if too low, moist air might be drawn to other areas where it might cause damage, for example, the attic space.

■ **Moisture Problems in Swine Facilities: corrosion, mould and decay**

- Corrosion of steel is an electrochemical process, which occurs when the relative humidity is above 80%
- Mould is undesirable in most buildings because it causes decay of materials, staining, offensive odours, and can negatively affect the health of livestock and workers. As mould grows, it penetrates beyond the surface of a material into its open pore structure. This makes mould removal difficult for porous materials and enhances the environment for other undesirable micro-organisms
- Decay of wood is highly dependent on the species of fungi, material and exposure. Fungi that cause decay tend not to cause health related problems. The decay of structural members can become a structural safety problem (Straube, 2004). The factors contributing to decay include:
 - Surface humidity > 95%
 - Moisture content > 30 %
 - Temperatures between 5 and 50°C

■ **Moisture Control**

Enclosures must be designed for rain and air leakage control, as well as to allow drying of incidental moisture. Ventilation, particularly during cold weather, is an essential control requirement. Negative pressure ventilation systems

perform the best, by drawing cold air into the facility via any structural leaks. In contrast, neutral or positive pressure barns allow warm moist air to penetrate the structure and create moisture problems. Vigilance is also required during construction to avoid excess wetting, premature closing in, and insufficient drying. Finally, operation and maintenance must be conducted in such a manner as to avoid moisture problems.

In most cases where moisture is controlled, mould growth will not be a problem. Good moisture control strategies are described in the OAA Rain Penetration Control Guide, CMHC Best Practise Guides, and other moisture control handbooks (Straube, 2004, p. 1).“

Livestock

- Manure and urine: ensure that manure and urine are not allowed to collect for any length of time on the floor in service hallways and room alleys.

Equipment

- Leaks: repair any leaky waterers, pipes and valves.
- Heaters: choose heating systems that vent to the outside in order to remove the moisture laden exhaust gas.
- High-pressure washers: train operators on the proper use of the equipment to prevent over-spray into attic and wall spaces.
- Electrical boxes (outlets, controls switches, etc.): conduit/wiring should enter boxes by openings in the side or bottom only to prevent moisture entry through top openings.

Structure

- Exterior surface grading and eavestroughs: drain surface water away from the exterior of the building to minimize splash and maximize foundation dryness. Install flashings.
- Interior liquid ponding: ensure that solid floors are sloped properly and that drains leading to storage are properly sized, located and managed.
- Ice damming: attic venting provides a cold roof deck, which prevents the thaw – freeze problem.
- Adequate insulation in the structure; including preheat ducts that have cooler air in them, or around them.
- Thermal bridging: Thermal bridges occur at studs and posts within the wall construction. Techniques can be used such as spacers behind studs to allow insulation to fill in (warm side only). On interior walls, there can easily

be an 11°C temperature difference between the room air and the surface temperature of the wall in front of the stud.

- Caulking: around doors, wall and ceiling joints (beware of trim covering poor workmanship) windows, exhaust ventilation fans, air inlets to seal air leaks.
- Manure storage under floor: ensure minimal locations for manure to collect on support posts, walls, and beams, etc.
- Exhaust air (moisture laden): ensure ventilation air does not short-circuit into soffits and thus the attic airspace
- Attic venting: ensure adequate soffit venting and roof peak venting
- Room air pressure: typical target negative pressure should be about 0.05 inches water column and 0.08 inches water column in the summer. Neutral and positive pressure create an opportunity for increased moisture load problems in the structure.
- A vapour barrier retards the migration of water vapour. An air barrier retards the migration of air. All facilities require a combined air/water vapour barrier, properly installed and ship-lapped at all joints, sealed with silicone.

■ References

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