Ammonia: Out Of My Barn!

Ammonia buildup can affect a horse's respiratory health and performance, but it is preventable with sound management practices

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Have you ever entered a barn only to be assaulted by the noxious fumes of ammonia? Your eyes water, your nose waters, your throat closes; you might be tempted to sneeze just thinking about it. Imagine then what it must be like for horses confined in an enclosed space with poor ventilation. Where can they go to breathe sweet, fresh air?

The good news is ammonia buildup in a barn is preventable to a large degree with sound management practices.

Ammonia's Impact

Melissa Mazan, DVM, Dipl. ACVIM, associate professor of clinical sciences at Tufts University's Cummings School of Veterinary Medicine, in Massachusetts, has investigated environmental influences on equine respiratory health and performance. She considers ammonia gas to be a severe respiratory tract irritant, noting, "The EPA (Environmental Protection Agency) recommends that people should not be exposed to more than 1.4 ppm (parts per million) on a chronic basis; levels of 24 ppm create severe throat and nose irritation.

"Ammonia at typical levels in the barn mostly affects the horse's upper airways,"

JENNAY HITESMAN

A well-ventilated stable flushes stale air out and allows fresh air to enter. Thus, a stable that can "breathe" has less ammonia, odors, and humidity.

she notes. "However, at higher concentrations, ammonia bypasses the upper airways to cause lower airway inflammation and pulmonary edema, usually occurring at levels higher than 500 ppm. The most severe exposures with pulmonary edema have potentially fatal consequences."

Studies have shown that stalled horses exhibit more signs of upper and lower respiratory inflammation than pastured horses. Ammonia sets up inflammatory conditions in equine airways, increasing mucus, adversely affecting the immune response, and interfering with the action of cilia (microscopic hairs) lining the airways—these cilia serve as a natural defense, preventing dust and debris from entering deeply into the respiratory tract. Ammonia's respiratory impact detracts from a horse's performance and vitality, particularly when the airways also are assaulted by dust, endotoxin (a component of bacteria), and other particulates.

TRAVIS CHURCH

Frequent, at least daily, removal of soiled bedding is key to ammonia control.

Checking for Ammonia

Eileen Fabian Wheeler, MS, PhD, professor of air quality at Pennsylvania State University, has a special interest in optimizing the barn environment. She remarks, "If you can smell ammonia in the stable then it's already above the recommended threshold for good air quality." She reports that ammonia levels in the barn should be maintained below 10 ppm, yet most human recognition of ammonia smell doesn't occur until 20 to 30 ppm, which is higher than desirable for horse health. "Ammonia is lighter than air, but its level is highest near its source—urine and feces deposited in the stalls," says Wheeler. "To properly evaluate ammonia, you'll need to measure it within your horse's breathing zone (the two-foot sphere around the horse's nose from where he draws his breath)."

Mazan describes devices available to check for ammonia: "Many companies make relatively simple devices to measure ammonia. Some get a 'snapshot' of ammonia levels at given times while others provide a readout over a longer period, which gives a more accurate assessment of the horse's exposure levels." (For instruments and instructions for measuring ammonia concentrations, see Wheeler's publication at www.abe.psu.edu/extension/factsheets/g/G110.pdf.)

Clean Air Recommendations

Good ventilation and practical hygienic strategies are required to rid a barn of ammonia. Ventilation is airflow that flushes stale air out of the barn and allows fresh air to enter. "Horse stables should never be closed up, even in winter," says Wheeler. "A proper stable has openings (yes, holes) in the structure that are open year-round." Failure to provide such openings leads to stalls that smell like manure and ammonia and also allows condensation to stain and degrade the structure. High levels of humidity that result from poor ventilation cause a barn to feel chilly/cold, dank, and stuffy. Wheeler stresses that allowing a stable to "breathe" reduces ammonia, odors, and humidity and keeps it fresh and dry even in the coldest weather.

Air exchange should occur four to eight times each hour in horse stables during winter. However, Wheeler notes that air exchanges are virtually impossible to measure, so ventilation recommendations are based on proven general rules: "Use permanent openings that provide at least one square foot of opening per horse housed—this is best as a long slot rather than a square, such as a one-inch wide, permanently open slot along the entire 12-foot length of the stall at the eaves." She points out that by placing this slot inlet high up at the eaves, cold air enters as a thin air stream that mixes quickly with the still, slightly warmer stall air. This allows entry of draft-free, fresh air with stale air circulating outward. "Openings should be at least the aforementioned size—larger openings improve the chance to maintain good air quality year-round. Provide larger, adjustable openings for warmer weather," she says.

Take advantage of thermal buoyancy—warm air rising; moist air is less dense and rises to the high openings. Wheeler explains, "As warmed, humid air rises and is released outside by high openings in the stable, it creates a mild 'siphoning' or stack effect that allows fresh outside air to enter the stable through lower openings. Thermal buoyancy is one of two natural ventilation driving forces; the other is wind, which is much more effective than thermal buoyancy in ventilating a horse stable, particularly if more than one mile per hour."

Wheeler also notes, "Another important point is to supply at least two sets of openings located on different parts of the building; one ventilation opening alone won't be effective at improving air quality throughout the stable. Include eave openings along both long sidewalls or at the eaves (low) and ridge (high) of the roofline."

She mentions the value of replacing ridge vents with cupolas that have openings: "A cupola … offers an outlet for warm, moist, odorous air at the top of the stable roof, and it allows wind to move air into and out of the stable."

Wheeler warns that having a well-ventilated working aisleway, yet poorly ventilated stalls, is not useful to the horses. "Open partitions between stalls greatly assist airflow throughout the stable with added benefits in socialization for the horses and easy management view of all horses," she says. For horses stabled on hot days, Wheeler recommends installing stall doors with mesh or sturdy screening to both the outside and the barn interior. This allows cross-flow breezes to move across horses' bodies.

Fans

Fan-driven ventilation includes fresh air inlets, fan(s), and controls that allow more precise air exchange rates so heated air is not wasted through uncontrolled natural ventilation in winter. Wheeler suggests owners provide mechanical fan ventilation for when heat is supplied. She notes, "Very poor interior air quality results from using horse body heat to warm a barn. Insulation does nothing to directly improve airflow—in our homes it only reduces heat loss through the structure's surfaces, whereas in a stable, heat is mostly lost through the ventilation system, yet ventilation is needed to maintain good air quality."

She also stresses, "In a heated barn, condensation is reduced by having the interior wall temperature closer to stable air temperature so that moist air doesn't condense on cold walls. Air temperature in a well-ventilated, unheated stable with good air quality will remain within 5-10° F of outdoors."

The best way to reduce condensation is to ventilate moist air out of the stable. On the coldest nights of the year, condensation is likely unavoidable on cold barn surfaces such as windows or skylights that have little insulation value. According to Wheeler, this should not be a problem as long as sufficient ventilation is later provided to dry out the air and structure.

Wheeler describes efficient movement of air created by an agricultural ventilation circulation fan: "Air moves about 10 fan diameters downstream of its placement (i.e., a 24-inch diameter fan moves air about 20 feet). Such an agricultural fan is built with motor and components sealed to survive for years in dusty and humid environments such as found in horse stables. Circulation fans that flow air through a mist of water are useful in summer—as water evaporates, air temperature drops for a cooling effect similar to air conditioning."

Bedding and Flooring

Besides fresh air, the other ingredient for ammonia control is management. Bedding is useful to soak up urine and contain feces. One study revealed that wheat straw reduced ammonia (but not necessarily dust) in the air more than bedding with wood shavings or straw pellets. Kenaf fiber (made from the kenaf plant, related to cotton) is another bedding type that shows promise in its fluid absorption capacity.

Wheeler remarks, "One remedy is to bed stalls well with extra bedding placed where the horse soils most often. A slight slope to the stall floor spreads urine puddles to surrounding dry bedding for absorption. Frequent, at least daily, removal of soiled bedding is key to ammonia control."

She adds, "Porous flooring (packed dirt, clay, or stone dust) retains urine moisture (and associated odor/fumes) that reaches it. However, impervious flooring (concrete) suffers from being too hard for horses stalled all day." The use of tightly interlocking or seamless stall mats keeps urine from seeping beneath the mats where it wouldn't be accessible to absorbents or cleaning.

Ammonia-Absorbing Compounds

An enlightening study (University of

ARND BRONKHORST

Good ventilation and precise air exchange can be achieved using a combination of fans and ample barn openings to both the outside and barn interior.

Kentucky, 2000) indicated that despite daily stall cleaning, high ammonia levels persisted near the floor in stalls not treated with ammonia-absorbing compounds. Mazan comments, "It's a little worrisome when we see a study like this showing that despite bedding with straw and daily stall cleaning, ammonia at floor level rises from 2.5 to 228 ppm. The situation is worse for foals that spend more time lying down."

Urine contains urea (a product of protein metabolism) that is "broken down" (hydrolyzed) to ammonia and carbon dioxide through the action of the enzyme urease, a protein found in bacteria associated with feces and stall flooring materials that have been fouled with feces. Wheeler reports there are two points where this process can be disrupted effectively: "The first is by feeding a reduced-protein diet (that meets the requirements of the horse) but results in less urea content in the urine and, hence, less ammonia." (Feed supplements, like *Yucca schidigera*, have been used in ruminants to limit ammonia production and could have promise for use in horses, she notes.)

Wheeler continues, "The second is to stop urea hydrolysis by denying access to the enzyme urease; however, urease is ubiquitous in horse stalls. Some stall products contain urease inhibitors. Hydrated lime theoretically could reduce ammonia by creating a hostile, basic (high pH) environment that lessens survival of urease-containing bacteria."

A third option is to prevent ammonia from becoming airborne once it is formed. Many commercial products are available to use for this tactical approach. Wheeler reports, "Zeolites (minerals that absorb water and gases) have a high capacity for adsorption of ammonia molecules; clinoptilolite is a typical zeolite used for animal bedding. Another bedding product is diatomaceous earth that quickly absorbs water, thus lowering the potential for urease-containing bacteria to form ammonia."

Take-Home Message

Many strategies used to eliminate ammonia also diminish the airway insult created by dust, with an added benefit of eliminating fly attractants. These include:

- Clean stalls once or twice daily to remove all urine-soaked bedding, and strip stalls at least weekly.
- Remove horses from stalls while cleaning to minimize exposure to ammonia gases that are stirred up with raking and pitching of bedding.
- Provide good drainage in stalls and aisleways to facilitate exit of urine, and regularly clean under mats when possible.
- Use highly absorbent bedding materials.
- Mix an ammonia-neutralizing product with clean bedding.
- Provide excellent barn ventilation and avoid closing up a barn when possible.
- Use slotted inlets at eaves that are open year-round to allow refreshment of air.
- At every opportunity, house horses outside or turn them out regularly to offer a clean air environment.

ABOUT THE AUTHOR

Nancy S. Loving, DVM, *owns Loving Equine Clinic in Boulder, Colo., and has a special interest in managing the care of sport horses. She has authored the books* All Horse Systems Go, First Aid for Horse and Rider, Go the Distance *(a resource for endurance horse owners), and* Conformation and Performance, *as well as many veterinary articles for both horse owner and professional audiences.*