

# Horse Facility Temperature And Humidity During Winter Conditions

E. F. Wheeler, J. L. Zajackowski, and R. E. Graves<sup>1</sup>

## ABSTRACT

During late winter three stables and two indoor riding arenas were monitored for temperature and humidity profiles. Study objective was to collect background information on current practices and conditions in horse stabling during cold weather conditions. Wireless datalogger/sensors were mounted on stall walls and protected by wire cages from horse damage. Horse stables are often under-ventilated due to the common use of residential (rather than agricultural) construction practices and a misdirected objective of providing tight construction for trapping animal heat. The study compares three stables with more typical agricultural construction. One was a well-designed naturally ventilated stable and two were renovated bank barns. The two old converted dairy barns relied on hundreds of meters of cracks for air infiltration between barn boards for cold weather air exchange. The well-designed stable retained barn-board crack ventilation which was supplemented with substantial eave and ridge vents. All three stables performed adequately, according to common natural ventilation guidelines, with the eave-ridge vent system providing the most uniform and desirable environment. The indoor riding arena environments were similar to outdoor temperatures but were more humid, presumably due to the large quantities of water added to the riding surface to decrease dust. This high humidity condition needs to be recognized in construction material selection and practices.

**KEYWORDS:** Ventilation, Indoor Riding Arena, Stall, Stables, Sensors, Bank Barn

## INTRODUCTION

### *Horse stable environment control lacks quantification*

Horse stabling has a dearth of environmental characterization. Although recommendations for proper horse stable ventilation exist (Wathes, 1989; MWPS, 1971) few stables are built to these specifications. According to Briggs (1998), ventilation might be one of the most over-looked requirements of horse housing partly because horses have different environmental requirements as they are maintained for longevity and athletic performance. This was echoed by Clarke (1987) and Golden et al. (2000). Most horse stables employ natural, rather than mechanical, ventilation due to the relatively low density of mature animals within the building. By agricultural engineering definition, stables are “cold” housing with no supplemental heat and no or limited insulation. In the past couple decades, the trend has been to tighten up construction to a more “residential” standard rather than staying with livestock housing ventilation recommendations. This trend is influenced by the reliance on residential and commercial builders and architects who often have limited education in livestock building construction. Hence, most horse barns are under-ventilated in an attempt to maintain comfortable conditions for handlers and an honest, but misdirected, attempt to provide comfort for the horse (Sainsbury and Rossdale, 1987).

Much is written on the importance of good air quality (such as Rossdale, 1988; Clarke, 1987) and its impact on equine respiratory health and athletic ability yet very few studies have documented air quality conditions within stables. Much is known about ventilation and its impact, through air quality, on livestock performance. A comprehensive evaluation of

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<sup>1</sup> E. F. Wheeler, Assistant Professor, J. L. Zajackowski, Senior Research Technologist, and R. E. Graves, Professor, Department of Agricultural and Biological Engineering, Agricultural Engineering Building, The Pennsylvania State University, University Park, PA 16802.

temperature and other ventilation parameters in horse stables would be useful in establishing modern horse stable ventilation recommendations. Wheeler et al. (1999) have demonstrated the feasibility of using small, low-cost temperature and humidity sensing and recording devices in livestock housing. The objective of the study reported here was to collect background information on current environment control practices and conditions in horse stabling during cold weather conditions.

## METHODS

### *Commercial facilities monitored*

Two central Pennsylvania horse facilities were evaluated during Winter 2000 to determine temperature and humidity levels in relation to suitability of their environments. Box-stall stables and indoor riding arenas were monitored. Figures 1 and 2 show plan view layouts of each facility, both of which were commercial horse boarding stables under professional management. The farms were about three-kilometers apart with virtually the same weather at both sites. The collected data represent background information on current conditions in a horse stabling configuration common in the northeastern United States: the converted dairy bank barn. The horses were housed in box stalls fit into the lower level where cows were previously kept while bedding and hay (and equipment, etc.) were stored in the upper story of the facility. With the barn banked into sloped ground, at least one sidewall and parts of two other walls are below grade. This offered challenge to fresh air entry that must come in through the above ground portions of the structure. Bank barns, such as these particular ones built in the 1930s, were constructed specifically for housing about twice as many dairy cow animal units (45 dairy cows at 1.5 animal units [AU] each is 60 AU) versus the horses (28 horses at 1 AU each) they now contain. So current animal density is much lower.

Both bank barns underwent renovation in order to be suitable for horse stabling. Stall sizes were variable (2.9 to 3.5 m per side [9.5 to 11.5 feet]) within both facilities due to the need to fit stall walls within the structural support available in the barn. Both bank barns had ceilings over the entire stall area. The 28-stall bank barn underwent major renovation as the floor level was dug out about two-thirds-meter (two-feet) and structural support modified to provide the recommended 2.4-meter (8-foot) minimum ceiling height for horses in the lower animal story (with the sloped barn floor, ceiling height varied from 2.3 to 2.9 meter (7.7 to 9.7 feet) to the beams supporting the ceiling). A metal-sided 18 m by 48m (60-ft by 160-ft) indoor riding arena was attached to this wooden-sided bank barn through a short building addition which linked stable and riding areas into one interior environment. The 16-stall bank barn underwent less extensive renovation and the 21 m by 46 m (64-ft by 152-ft) indoor riding arena was a separate facility.

### *Aspects of natural ventilation*

Ventilation of the bank barns is through natural ventilation with cold weather air exchange dependent upon infiltration air leakage through structural cracks; both planned and unplanned. Any exhaust ventilation fans from the original dairy design were removed during renovation. Cracks between wood plank siding boards provided hundreds of meters of narrow spaces for air entry throughout most of the stable area. On portions of these barns which are below grade or adjacent to other structures, there are no board cracks to provide infiltration air exchange so conditions would likely be stale in those areas as there is no additional means of providing internal air circulation (i.e. no circulation fans or ducts). Windows are not present in these two bank barns but large aisle doors were used for warm weather air entry. Both bank barns had solid stall partitions on three sides but the front partition had an open mesh on the top half.

The facility designated as the “naturally-ventilated” 8-stall stable provided ventilation design which matches current natural ventilation recommendations for livestock housing. Although the

bank barns under study were also naturally ventilated, they both benefit from “unplanned” natural ventilation of board cracks versus the deliberate attempt to provide recommended natural ventilation design seen in the 8-stall facility. This 8-stall stable was built in the early 1990s and had substantial eave and ridge vent openings (continuous 36- and 15-cm (14- and 6-inch) openings covered with 1-inch wire mesh, respectively) that were permanently open and endwall aisle doors for warm weather air exchange. There was 18 cm (7-inches) of wire mesh covered opening along the gable roofline overhang. The builder maintained the board crack openings in the siding for additional diffuse air entry. This stable was also built into a bank and attached at one sidewall to the 16-stall bank barn. It was an open, airy interior with no ceiling and bars on the upper half of the stall dividers and stall fronts. Interestingly, the farm manager charged more board for horses stabled in the naturally ventilated addition due to the better environment than in the bank barn.

#### *Indoor riding arena monitoring*

The indoor riding arena data collected during this project were considered important due to the lack of any available study on the subject of temperature and humidity conditions within these structures. Builders have been challenged with the dusty and cold environment within arenas. Ventilation was provided to the arena attached to the 28-stall barn by 10 cm (4-inch) continuous eave vent openings covered with wire mesh on the 15 cm (6-inch) overhang and a residential-type ridge vent. The separate riding arena at the other boarding facility had 1.8-meter (6-foot) tall curtains along the entire length of both sidewalls (similar to curtains used on dairy freestall facilities) which may be open, partially open, or closed. The lower 2.4-meter (8-feet) of the arena sidewall was solid material with the curtain opening positioned on the upper 2.4-meter (8-feet) of the sidewall. Eave vents of 20 cm (8-inch) width with no wire mesh on the 40 cm (16-inch) overhang were located along both sidewalls for ventilation should the curtain be closed. Ridge opening was provided with three functioning cupolas. The manager left the curtains open year round.

#### *Sensor technology for field experiments*

Temperature (T) and relative humidity (RH) were measured with Hobo Pro [Onset Computer Corporation, Pacasset, MA] units. These were battery powered, wireless sensors with integral datalogger for recording conditions. A five-minute data collection interval was used with data downloaded weekly from the sensor unit to a laptop computer. An outdoor sensor was necessary to monitor the temperature and humidity against which the indoor environment could be compared. It was mounted near each stable in an OnSet radiation shield. Sensors monitored the facility environments from 16 to 28 February, 2000. Data from four days are presented here for discussion.

Location of sensors in the horse-occupied zone was considered important. Although well-protected, sensors had to be accessible for data downloading and exposed to conditions which represented the nearby environment. Of prime interest in horse stalls was protecting sensors without exposing the horse to sharp objects. Rounded, strong sensor protection was desirable. Wall mounted sensors at horse hip height were protected by strong wire bird suet feeders. Feeders were carefully selected for rounded design with no protruding wire and strong, thick wire construction (16 gage minimum). Surprisingly, horses left unprotected sensors alone when sensors were mounted under feed buckets or out-of-sight on posts. Since horses are turned out (from these stables) most of the day and brought in for nightly feed and rest, they presumably had better things to do than rip apart the sensors. In the indoor riding arenas, two sensors were wall-mounted on posts without protection at about 1.8-meter (6-feet) off the floor. The most important sensor placement was in the arena middle and this was accomplished by mounting it with wire, then taped, on a post of a jump standard. A total of three sensors were located in each indoor riding arena.

## RESULTS AND DISCUSSION

Criteria of proper natural ventilation were evaluated to determine how well the facilities were designed and performing. Factors such as temperature uniformity within 2.8°C (5°F) around the structure can indicate uniform air distribution within the interior while maintenance of interior temperature within 2.8 to 5.5 °C (5 to 10°F) of outdoor temperature is considered desirable for cold housing air exchange. Horse stables are considered cold housing since no supplemental heat is supplied to mature animals that are tolerant of cold conditions.

### *Horse stables*

Both facilities turned out horses for exercise for most of the daylight hours. The 28-stall facility rotated groups of horses at turnout so that about 2/3rds of the stalls were occupied during the day. The 16- and 8-stall facility turned out all horses all day (with an individual exception for a horse undergoing treatment). One of the challenges of interpreting horse stable environment data was the uneven animal density over time in the facility. The 8- and 28-stall stables were full of horses while the 16-stall stable had only 11 horses. The occupied stalls were those near the entry doors to the barn while there were no horses in the four stalls along the back of the bank barn at the underground stone wall. Analysis focused on nighttime when horses were stabled.

All three stables were adequate in natural ventilation function but ranged from very well-ventilated to being just outside the criteria. The naturally ventilated 8-stall stable addition met the ventilation criteria most closely (Figure 3). The temperatures around the stable interior were typically within 2.8 °C (5°F) of outdoor temperature and within 2.8 to 4.4 °C (5 to 8°F) even on the coldest night presented here. The 16-stall bank barn was similar in being within 2.8 to 3.8 °C (5 to 7°F) of outdoor temperature; within 5.0 to 6.7 °C (9 to 12°F) on the coldest night (Figure 4). The biggest spread of temperature was seen in the 28-stall facility where the difference between indoor and outdoor temperatures was normally 5.5 to 7.2 °C (10 to 13°F) with a 7.2 to 8.3 °C (13 to 15°F) difference on the coldest night (Figure 5). (The C-Quad west wall sensor data was removed from analysis since it experienced afternoon solar load. Stalls with more than one sensor in B- and D-Quads are presented as averages of both sensors.) Uniformity of temperature around the stable interior was also very good among all three stables. Again, the more uniform temperatures were found in the 8-stall naturally-ventilated addition: 0.6 to 1.7 °C (1 to 3°F) temperature spread across the barn during the entire study period. The bank barns were more variable with 1.7 to 2.2 °C (3 to 4°F) temperature variation within for the 16-stall bank barn (2.2 to 2.8 °C [4 to 5°F] including the West stall) and 2.2 to 3.3 °C (4 to 6°F) for the 28-stall bank barn.

Presence and absence of horses in the stable can be seen in the graphs. The barns were warmer than outdoor temperatures during night hours when all the horses were stabled. During the day, the stable was often cooler than outdoor conditions as the stable thermal mass held steady against Spring warming temperatures.

Relative humidities of two stables are plotted in Figure 6. Due to warmer interior temperatures, the RH was lower at night in the stables but matched outside conditions during the day. An indication of good air exchange may be observed when indoor RH profile matches outdoor RH profile. Magnitude may be different due to temperature differences but profile and trends would be similar.

### *Indoor riding arenas*

Despite the label of “indoor” riding area, conditions within these facilities were almost the same as outdoor conditions and in some ways, even harsher. Indoor arenas have a reputation of being dusty and the data collected during this project found them to be surprisingly humid. Relative humidity in the indoor riding arenas was always higher than outdoor conditions (Figure 7) even though the temperatures inside and outside were within 0.6 to 1.1 °C (1 to 2°F). Moisture from

the large quantities of water used to dampen dust in the arena footing materials was thought to be the main contributor to the high indoor RH. Wetting of the arena footing materials is part of proper arena management so has to be included in design specifications for indoor arena environment and the materials used in arena construction. Outdoor grade construction materials are recommended.

## CONCLUSIONS

Temperature and humidity monitoring within three stables and two indoor riding arenas have provided background information for evaluating horse facility environment. The results from the indoor arenas were the most surprising as high levels of humidity were encountered in these well-managed facilities. Natural ventilation openings on stables can allow interior conditions to be similar to outdoor. Another useful study would compare more modern American horse stable construction where the center aisle is flanked by stalls on both sides. Modern horse stable construction is tending toward residential tightness in regards to air exchange and this should make a noticeable difference in air temperature and humidity conditions in the stable.

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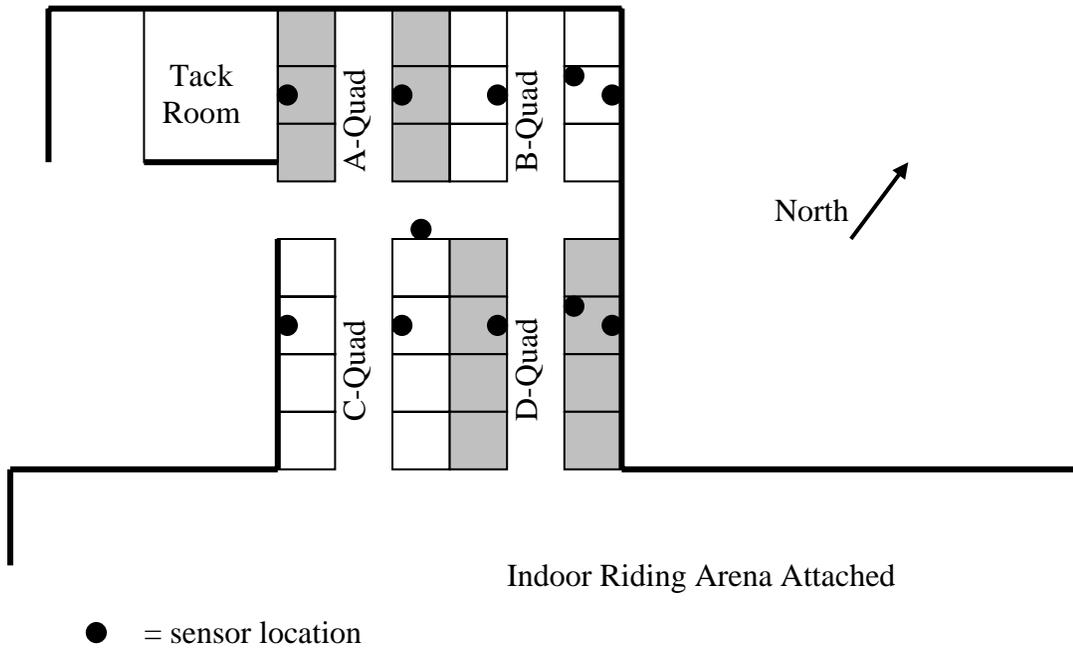


Figure 1. Plan view of 28-stall bank barn stable with attached indoor riding ring. North wall of stable is below grade.

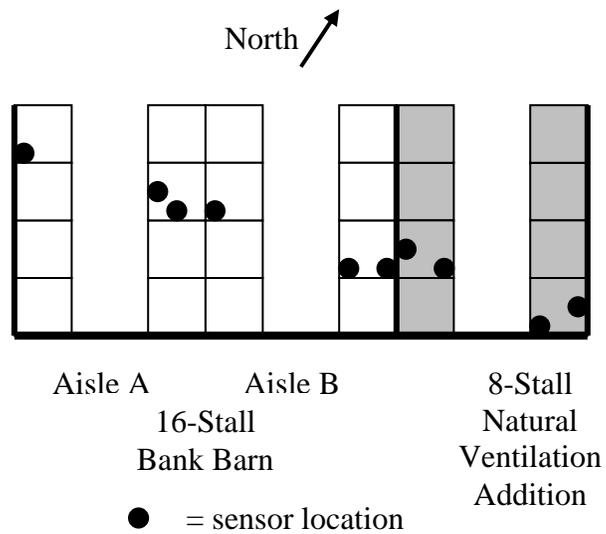


Figure 2. Plan view of 16-stall bank barn stable with naturally ventilated 8-stall addition. Indoor riding arena was a separate building about 100-meters northwest of the stable. The south stable wall is below grade.

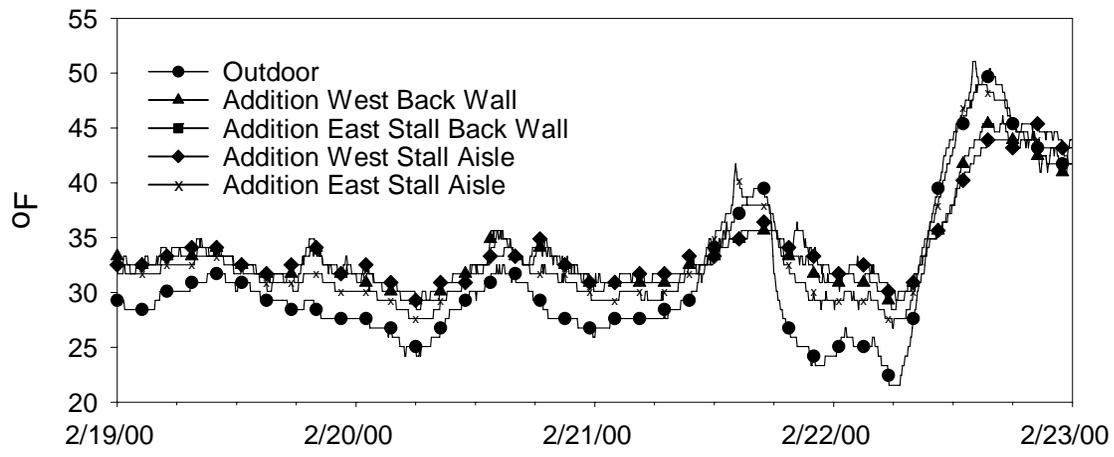


Figure 3. Temperatures in 8-stall naturally-ventilated stable addition.

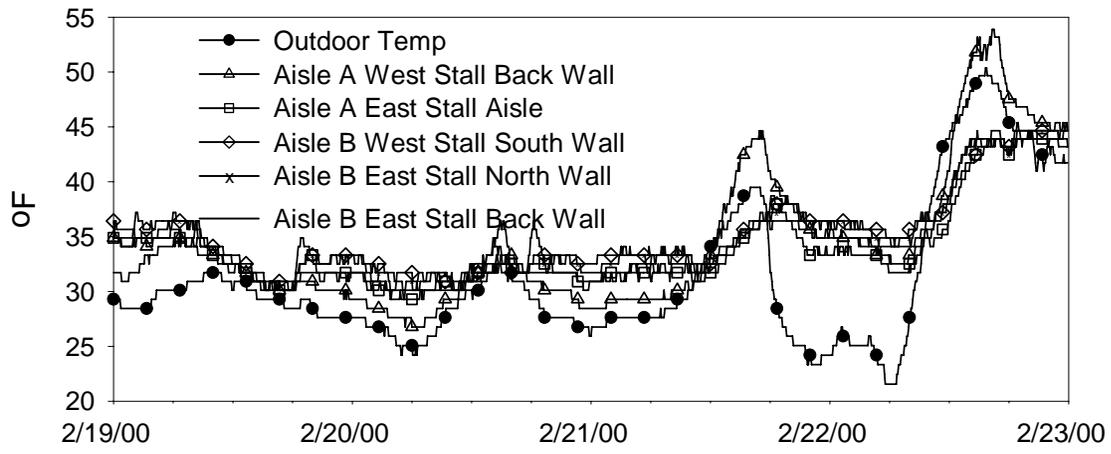


Figure 4. Temperatures in 16-stall bank barn stable.

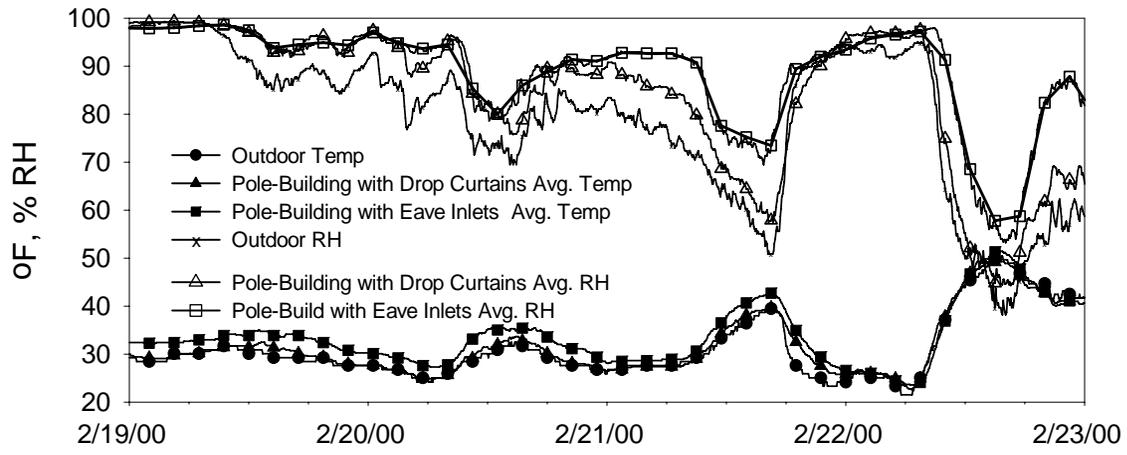


Figure 5. Temperatures in 28-stall bank barn stable.

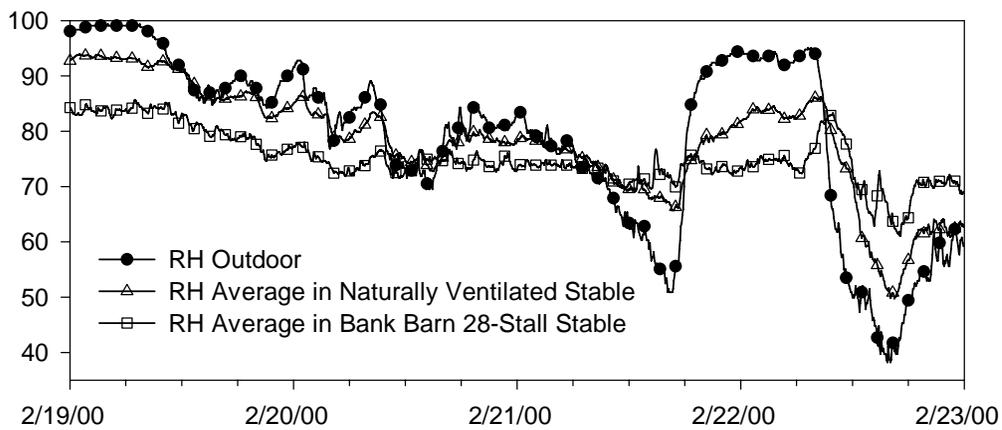


Figure 6. Horse stable relative humidities. Averages of all sensor humidities.

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