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Horse Barn Ventilation Systems

How HVLS Fans Maintain Uniform Air Temperatures

Table of Contents

Introduction	pg. 3
Why Horse Barn Ventilation is Necessary	pg. 4
Challenges of Natural Ventilation Systems	
How HVLS Fans Supplement Natural Ventilation Systems	
How HVLS Fans Work – The Laws of Physics	pg. 7
HVLS Fan Advancements – Reducing the Number of Blades	
Measuring Fan Performance – Or, What is “CFM”?	
Benefits of Using HVLS Fans in a Horse Barn	pg. 10
How to Choose the Right HLVS Fan for your Horse Barn’	
About MacroAir Technologies	pg. 12

Introduction

Indoor air quality is important whether you work in a warehouse or a barn. Indoor air, when it isn't continuously mixed with fresh air, becomes stuffy and smelly. (Think about how the air smells on a plane if you don't have the little fan above your head running during your flight.)

This is especially true in a barn where you're subject to smells from urine, hay, horses, and other substances. In addition, pathogens and molds float in the air, causing allergy sufferers much grief. High summer temperatures can also lower indoor air quality by increasing humidity and discomfort.

Poor indoor air quality in the barn not only affects people, it also affects horses. According to Amy DeGeer Oberdorf, in her article, "Barn Ventilation Affects Horse Health" for MyHorse.com, "Poor barn ventilation is among the leading causes of decreased performance, illness, and possibly death in today's horse population. It's also a commonly unaddressed issue for most horse owners." In the same article, Dr. Brad Cumper of Saginaw Valley Equine Clinic in Freeland, Michigan unequivocally states, "Poor barn ventilation can ultimately kill your horse."

Many barn and stable owners and managers use natural ventilation systems to maintain good air quality. These systems include orientating the stable or barn to take advantage of natural airflow, opening barn doors and windows to allow the free flow of fresh air, and incorporating a roof ridge and eaves into the building design to draw in fresh air. Barn owners and managers also use high-speed box fans to keep horses cool during summer months and to help circulate fresh air.

The problem with natural ventilation systems is that they present numerous challenges – namely, it's difficult to maintain uniform temperatures. And, while box fans can help with improving air quality and lowering temperatures, they consume vast amounts of energy, they're expensive to run, and you need lots of them to cool down a barn. They also kick up a lot of dust – further adding to horses' discomfort.

In this white paper, you'll learn how HVLS (high volume, low speed) fan technology supplements natural ventilation systems while reducing or eliminating the problems commonly associated with these systems.

“With natural ventilation systems, it's difficult to maintain uniform air temperatures due to humidity and other factors.”

Why Horse Barn Ventilation is Necessary

Barn ventilation systems serve numerous purposes. According to the Fact Sheet developed by the Ontario, Canada Ministry of Agriculture, Food and Rural Affairs, these purposes include replacing “warm, moist, dusty and smelly air in the barn with the appropriate amount of fresh air . . . and ensuring good air distribution throughout the barn” in order to avoid dead air pockets.

Barn ventilation systems also help lower humidity and reduce the amount of contaminants in the air due to urine and manure, grasses, feeds and bedding, and the horses themselves. “Barn air humidity is important,” the Fact Sheet authors state. “Very dry air (low relative humidity) dries out a horse’s nasal mucosa and can be a source of dust and pathogen infiltration into the horse’s respiratory system.

Very moist air (high relative humidity) combined with low air temperatures can reduce the insulation properties of the horse’s hair coat. Gases, such as ammonia (NH₃) and hydrogen sulphide (H₂S), form acids that burn respiratory tissues.”

Very moist air (high humidity) also causes moisture build-up and this moisture poses a challenge as it drips down onto the surfaces of the building materials in the horse barn, and on the horses themselves. Condensation also builds up on concrete floors, making them slippery for both horses and people.

Barn ventilation systems also play a key role in helping to lower temperatures during the summer months. Horses, like people, need to feel cool and comfortable. Experts recommend that barn temperatures range between 45° F and 65° F (7.2° C and 18° C respectively). An effective ventilation system helps maintain a uniform temperature.

Two main considerations for creating a natural ventilation system is to ensure the length of your barn or stable is perpendicular to the prevailing wind and that all obstructions around the barn that prevent fresh air movement be removed. Architects also incorporate roof ridges and eaves into the building design as these help encourage natural airflow into and up and out of the barn.

Challenges of Natural Ventilation Systems

Ensuring your barn or stable has a natural ventilation system is ideal for your horses. However, these systems come with their own inherent challenges.

Maintaining uniform temperatures is difficult

With a natural ventilation system, you must constantly monitor humidity and temperature. In the summer, it can be difficult to cool down the interior of a barn if a breeze isn't blowing. If you live in areas of high humidity, opening doors and windows is simply not an option. In the winter, it may be too cold to open barn doors and windows, yet keeping them closed causes heat build up.

In an America's Quarter Horse article, "Improperly Heated Barns May Cause Horse Health Problems," author Donald Stotts states, "Closed barns have increased humidity. This humidity, combined with warm temperatures, can cause enough nitrogen smell or bacteria growth to irritate the horse's respiratory system. These frequently result in chronic, minor respiratory problems that interfere with animal performance."

Building must be oriented correctly

To take advantage of prevailing natural conditions, a barn must be oriented correctly. However, this is not always possible, given individual terrain considerations. In addition, the area around the barn must be free of obstructions to allow for the free flow of air; again, this could be problematic if your barn backs up to a hillside or is fronted by trees.

Build up of condensation

On high humidity days, water vapor is released into a building. Water vapor moves independently of air and always flows to the coldest point, such as concrete floors, which cool down at night. Once the concrete slab reaches dew point as temperatures increase, condensation is formed on the floor, which poses real safety hazards to people, horses and machinery. Condensation on roof beams also drips to the floor and on horses and surfaces, causes discomfort and materials damage.

How HVLS Fans Supplement Natural Ventilation Systems

To solve these problems, and to help lower interior temperatures in the summer, barn owners and managers use high-speed box fans. The problem with these fans, however, is that to effectively cool a barn, you need quite a few of them, which drives up costs as box fans consume vast amounts of energy. They also kick up dust, which irritates horses' respiratory systems.

A relatively new technology, HVLS (high volume, low speed) fans work in tandem with natural barn ventilation systems. They also reduce or eliminate many of the challenges associated with these systems while offering significant energy efficiencies and significantly lowering costs.

Proven technology in the dairy industry

Dairy cattle stop eating when they suffer from heat stress. When they don't eat, milk production slows or comes to a halt, a bottom-line breaking challenge for dairy farmers in an already highly competitive business.

Previous to 1995, dairy farmers used small high-speed fans to help keep cattle cool. These fans helped but posed their own challenges: they didn't cover a wide enough area, were considerably inefficient, consumed excessive and costly energy, and required ongoing maintenance. They also had a short mechanical life.

Taking advantage of the laws of physics, Walter Boyd, a lifelong inventor, designed a ceiling fan that moved a large volume of air gently down to the ground and outward 360 degrees. This ceiling fan was very different from what existed: instead of being 36 inches diameter, the fan Boyd designed was eight feet in diameter with 10 aluminum blades. And, instead of turning quickly, the fan blades moved very slowly.

This new, large fan did something smaller fans couldn't do: it moved a large, slow moving air mass throughout the barn, continuously mixing incoming fresh air with stale air and minimizing the amount of ventilation required to achieve good air quality. Most importantly, the new fan design cooled the cows without causing them stress due to excessive noise or kick-up of dust and thus increased milk production.

The new HVLS fan proved to be incredibly energy efficient as one HVLS fan consumed about the same amount of electricity as one high-speed fan while moving over 12 times the amount of air. In fact, Boyd discovered that one HVLS fan could replace up to 50 high-speed box fans while covering up to 20,000 square feet of barn space!

“Boyd discovered that one HVLS fan could replace up to 50 high-speed box fans while covering up to 20,000 square feet of barn space.”

How HVLS Fans Work - The Laws of Physics

For some people, the slow movement of an HVLS fan is deceptive — how can such a slow moving fan cool down animals in a hot barn? You don't need a physics degree to know that a breeze moving across your skin on a hot day feels good, especially in humid environments.

The cool moving air breaks up the moisture-saturated boundary layer surrounding the body and accelerates evaporation to produce a cooling effect. People have been using fans to cool themselves long before the advent of the electric motor; it was logical then, that fans would be one of the first things to be mechanized.

At some point however, engineers became so focused on using speed to increase fan displacement – the cubic feet of air per minute (CFM) moved through a fan – that some important physics-based issues were overlooked.

While having a cool breeze brush over our hot skin feels good, high velocity air movement is both unpleasant and disruptive. And, air speed beyond four or five miles per hour usually offers little, if any, additional cooling benefit as very slow moving air actually cools best in very hot, high humidity conditions.

Small high-speed fans create a pressure differential that's essential for many applications, but where slow movement of free air is the objective, pressure differential is not important. Therefore, displacement, the amount of air that actually moves through the fan, is of no real significance. It's the down-stream effects that are important.

Large fans versus small fans

The reason why a large, slow moving fan actually cools better and more efficiently than a small high-speed fan is a little complex but also very interesting. A turbulent, high velocity air jet dissipates very quickly. A large column of air, however, "travels" farther than a small one. The friction between moving air and stationary air occurs at the periphery of the moving column.

The perimeter of a column varies directly with column diameter. And while the cross-sectional area varies with the square of the diameter, the large column has proportionately fewer peripheries, and therefore less "drag." The air column from a three-foot diameter fan, therefore, has more than six times as much "friction interface" per cubic foot as does the air column from a 20-foot fan.

When the down column of air from an HVLS fan reaches the floor, the air turns in the horizontal direction away from the column in all directions. The air flowing outward is called the “horizontal floor jet.” Since the height of the floor jet is determined by the diameter of the column of air, a larger diameter fan naturally produces a larger air column and thus a higher floor jet.

Smaller high-speed fans of equivalent displacement are incapable of producing the same effect.

The power to drive a fan increases roughly with the cube of the average air speed through the fan. A commercial fan delivering air at 20 miles per hour (mph) requires about 64 times as much power as a similar sized fan delivering air at five mph!

Airspeed, combined with fan “effectiveness,” means that when the objective is to cool people or animals, very large, low-speed commercial fans are enormously more efficient and effective than small high-speed fans.

A later design enhancement added a “down wash” to the airfoil blades in the same manner a spoiler keeps the rear wheels of a car on the road. This new addition increased airflow CFM (cubic foot per minute) by almost 30% with only a minimal increase in power consumption.

HVLS Fan Technology Advancements – Reducing the Number of Blades

Extrusion is the name for the process used to manufacture objects of a fixed cross-sectional profile, including airfoil blades, plastic pipe, tubing and sheets of film, terra cotta bricks, and even food products.

Basically, the material, such as plastic or metal, is heated and pushed through a die to form a specific shape. To create an HVLS fan blade, for example, an extrusion company heats up aluminum ingots, pushes the ingots through a die to create the foil, and then cuts the foil at the desired length. The larger the shape to be extruded, the more tonnage and capacity required by the extruder.

As extrusion capacities increased, HVLS fan engineers began experimenting with larger airfoil shapes – something they couldn’t do when the first HVLS fans were created. Creating a larger airfoil wasn’t simply the answer to improving efficiency. The airfoil must work efficiently through a range of speeds, and engineers had to take into account that as the HVLS fan rotates, the end of the blade moves faster than it does at its fixed point at the fan hub. In addition, engineers had to consider airflow patterns and what happens when air hits the floor.

Due to the laws of physics, a larger airfoil shape meant that fewer fan blades were required to achieve optimal performance; fewer blades also reduced torque (the tendency of a force to rotate an object about an axis, fulcrum, or pivot). Fan longevity is related to torque:

$$\text{Horsepower} = \frac{\text{Torque} * \text{Revolutions Per Minute (RPM)}}{5252}$$

As RPM goes up, torque goes down for the same horsepower. HVLS fan engineers discovered that a fan with fewer blades rotated slightly faster, which lowered torque. Since torque is a constant stress on a fan's motor, bearings and gear, less torque meant longer fan life.

Fewer blades also meant that HVLS fan manufacturers could reduce the manufacturing carbon footprint. The electrolysis process used to produce aluminum requires large quantities of electrical power. When the cost of producing one ton of primary aluminum is broken down, almost one third is devoted to electrical power.

The amount of electrical power needed to produce an HVLS fan with fewer blades was less than what was needed to produce a 10-blade fan – hence, six-blade HVLS fans have now become a major fixture in the market.

Measuring Fan Performance – Or, What is “CFM”?

Fan speed performance is measured using CFM (cubic feet per minute) or the measurement of volume over time: the higher a fan's CFM number, the higher the volume or capacity of the fan.

To measure the performance of an HVLS fan, engineers generally use the method approved by the Air Movement and Control Association (AMCA) and measure “thrust,” which is the force the fan produces as a result of the air being pushed through it.

The higher the thrust value, the higher the volume of air and fan performance or CFM – as seen in the table below:

Fan Size	6-Blade HVLS Fan
8 FT	53,623 CFM ¹
10 FT	83,025 CFM ²
12 FT	97,695 CFM ²

¹ AMCA Certified CFM

² Derived from Certified Thrust Data for Comparison

Benefits of Using HVLS Fans in a Horse Barn

HVLS fans impart a number of benefits to barn owners and managers including lower energy costs. In addition to supplementing natural ventilation systems, HVLS fans also reduce or eliminate the challenges inherent in these systems.

Improved ventilation and indoor air quality

Although a building, including a barn, may have an air exhaust system in place, these systems often fail to thoroughly mix all of the air inside the barn. This type of system gets short circuited as doors or windows are opened and closed. Air pressure created in the suction of the exhaust looks to the path of least resistance and circumvents the intake devices. HVLS fans eliminate this problem as they continuously mix incoming fresh air, vastly improving indoor air quality.

Eliminate condensation buildup

Because HVLS fans constantly mix air from roof to floor, a constant state of thermal equilibrium exists inside the building – and hence, condensation doesn't form on the roof beams or floor, eliminating condensation dripping on horses and building surfaces as well as helping to ensure the floor stays dry and safe.

Provide heat destratification

Simple physics states that “warm air rises.” In the winter months, **this effect can cost an additional 25% or more** since more heat is required to maintain floor level temperatures. Why so much? The rate of heat loss or transmission through the roof accounts for roughly 70% of the transmission losses inherent in all structures. The objective, then, is to even out the temperature gradient from floor to ceiling in order to reduce heat loss.

The unique feature of HVLS fans is that they can be run in reverse, which pushes the warm air at the top of the structure down to the floor – effectively and efficiently evening out temperature throughout the building. The result is that one HVLS fan applied to 20,000 square feet of indoor space can easily **return 30% of heating energy dollars**.

How to Choose the Right HVLS Fan for Your Horse Barn

Natural ventilation systems are ideal for horses, as like people, they need a continuous supply of fresh air. In summer, horses need ventilation of at least 300 CFM and approximately 25 CFM in the winter.

To maintain continuous air exchange, add one HVLS fan per 20,000 square feet of space. Which size HVLS fan should you choose? This depends on the size of your barn and its height. The bigger the HVLS fan, the more air it can move over a larger space.

Due to their efficiency, one HVLS fan can produce significantly more CFM per kilowatt than a typical box fan. A box fan produces 20 CFM per watt as compared to an HVLS fan, which produces 260 CFM per watt, a considerable performance difference and one your horses will appreciate.

“A commercial fan delivering air at 20 miles per hour (mph) requires about 64 times as much power as a similar sized fan delivering air at five mph!”

About MacroAir Technologies, Inc.

Since developing the first HVLS 10-blade prototype in 1995, MacroAir Technologies has continually refined the design of the most durable and cost-effective commercial ceiling fan on the market. Design advancements include:

- Eliminating unnecessary blade material
- Reducing overall fan weight and torque
- Increasing airflow efficiency and service life
- Lowering carbon footprint

Our energy-efficient, long-lasting HVLS fans can be found in barns, warehouses, manufacturing plants, air hangers, and retail establishments across the U.S. and around the world. All MacroAir energy efficient fans come backed by exceptional customer service you won't find anywhere else plus the industry's best installation and warranty service. And, MacroAir's 8-, 10- and 12-foot Six-Blade HVLS fans are the only HVLS fans on the market to be ACMA certified for thrust values.

To learn more about how our agricultural, industrial and commercial fans can make a difference to your environment and your bottom line – give us a call at **866-668-3247**.

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