How to Configure an Equine Facility to Prevent and Better Respond to Barn Fires

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1. Introduction

The tendency of most U.S. states and local fire jurisdictions to consider horse barns and veterinary treatment facilities as "agricultural buildings" has led to lax standards and reliance on traditional design, construction, and management practices that can contribute to the ability of fires to ignite and to spread quickly.

Many aspects of an equine facility can be considered as fire hazards (traditional wooden open interior aisle construction, use of hay and shavings and storage of these multiple potential ignition sources, lack of compartmentalization, etc.). Building a "fireproof" barn is not realistic; however, there are strong measures that can be taken to dramatically reduce the chance of an incident in your facility and that of clients. Prevention can be enhanced with updates to daily management practices, original property and facility design, and attendant emergency planning and practice. This paper will explore how to configure an equine facility to prevent barn fires based on new technologies and understanding of how fire behavior affects facilities for more efficient and effective response.

Few practitioners and horse industry stakeholders are aware that a great percentage of barn fires that occur are fully involved within 5 to 7 minutes of ignition (implying the total loss of the facility and everything within it and that the local—especially a rural—fire department will not have even had time to arrive within this time constraint.) Most facilities reach a dangerous to life level of smoke production at the 3 to 5 minute mark. Realistic reporting of these fires includes very few incidents where the animals are successfully salvaged from a burning building (Figs. 1 and 2) and even fewer where the F2 facility is not completely destroyed. It is unfortunate that equestrians have a common idealistic and romanticized view of barn fires, which includes thinking that the fire department will arrive, put out the fire, and retrieve their horses from the smoke. It is far more common that the entire facility is fully involved and the animals are long since dead from smoke inhalation when the fire department arrives on scene. Even if they arrive in time to attempt rescue, horses presented with firefighters in full gear and breathing apparatus are slow to accept being caught, haltered, and led by what must appear to be an alien being (Fig. 3). Numerous F3 training simulations across the country by one of our authors (Gimenez) has shown that it is very difficult for firefighters under realistically simulated conditions to find horses in dark smoky stalls with firefighting gear and remove them safely. Firefighting gloves, masks, and clothing make it difficult to move, see, hear, and manipulate locks, halters, and even open latches in the dark and smoke.

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Fig. 1. Dogwood stables fire, Aiken, SC, 2013. All animals were successfully removed by a wedding party on the grounds when the fire started. Courtesy of George Hagan.[1]

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Fig. 3. TLAER training event. Live demonstrator horse removed from a stall in training smoke and being walked out be a firefighter using an emergency rope halter (photo courtesy Gimenez). AQ: 11

There are numerous overlooked aspects to investigate when diagraming the layout of a future facility. Understand that most owners design a barn for its aesthetic appearance or efficiency, not necessarily for fire prevention, and rarely are veterinarians, fire prevention contractors, ventilation engineers, or fire marshals consulted by barn designers or builders. Barn fires occur all over the United States at various times of the year—there seems to be very little predictability to time of year, location, or facility type other than what would be expected (cold weather increases fires due to heating systems and hot weather increases fires due to fans and cooling systems.) Worse, the National Fire Incident Reporting System (NFIRS) is not formatted for and makes it difficult to extract data appropriate to learning about these fires. Adding to the problem, many equine facilities were established decades ago and need retrofitting to modern codes while others are newly constructed but may not have ascribed to national recommendations and codes. No matter what the age of the building is, there are some simple improvements that can be made to reduce the incidence of equestrian barn fire and improve safety for response when it does occur. Some of these improvements represent a small financial investment, and others are changes in management and design.

The National Fire Protection Association (NFPA) has updated their standards for animal housing facilities in the 2013 version of NFPA 150[2], which includes horse facilities, although few local jurisdictions have adopted their guidelines. The NFPA recommendations remain the "best practices" reference for how to design, construct, and manage animal facilities for practitioners, clients, and owners. Their suggestions include numerous ways for both new construction and for retrofit of older facilities to reduce hazards to people and animals working and living within. Since many horse facilities are well known to increasingly feature human living spaces and electrical conveniences for both horses and people, we should not consider them just agricultural facilities. Improving standards for construction, especially for electrical service, would greatly decrease the number of electrical source fires. AQ: 3

It is important to recognize how much of a toll these incidents put on the equestrian industry. Some recently reported fires:[3–17]

December 2009—2 people and 43 horses dead at racetrack (Canada)
September 2010—27 horses killed at racetrack (WV)
September 2012—14 horses die (NH)
April 2011—13 horses dead and 3 people injured (TX)

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Fig. 2. Dogwood stables fire, Aiken, SC, 2013. All animals were successfully removed by a wedding party on the grounds when the fire started. Courtesy of George Hagan.[1]

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May 2011—6 Olympic horses dead, 2 people injured (PA)
April 2013—12 polo horses die (FL)
July 2013—21 horses removed successfully, total loss of facility (SC)
October 2013—1 person, 3 horses killed (FL)
December 2013—1 person, 4 horses killed (NY)
February 2014—5 horses and a cow killed, vet clinic damaged (WV)
February 2014—18 horses killed (GA)
February 2014—0 horses killed, $260 000 value loss (MI)
February 2014—17 horses killed (OH)
February 2014—8 horses killed, vet clinic (KY)
February 2014—5 horses killed (LA)
February 2014—0 horses killed, barn total loss (Kansas City, MO)
February 2014—6 horses killed (CA)
March 2014—35 horses died at race stables (MI)
March 2014—2 horses died (MA)

Although there is no official statistics on barn fires, and this list represents only a few recent examples picked from the headlines of newspapers, there are numerous barn fires reported regularly across the country. Media reporting rarely gets the scope of the large dollar losses correct and often fail to follow up on these incidents.

2. Materials and Methods

Analysis of preventative measures into building and retrofitting equine facilities merits further clarification. The common methodologies that have been employed in so-called "modern" barn construction haven't really changed in over 400 years. However, there are numerous new measures available to increase the positive outcomes in both prevention and response to fires in equine facilities.

Layout

The overall layout of facilities is a key component. The primary thing to consider is compartmentalization of storage facilities and potential combustibles by physically separating each "type" of stored item (Fig. 4). As an example: Fire doors may be practical in some facilities and can be as simple as a roll up door that separates the facility in half or thirds. Fire walls are built of heavy duty materials or fire retardants and separate different areas of the barn from each other (second floor living areas from the main barn on the first floor, one section of the barn from the other, etc.). Compartmentalization helps to separate combustibles from the main barn as much as possible and includes hay, farm equipment, appliances, electrical system, manure, and fuels in separate facilities (Fig. 5). Practically, this means a separate shed for hay, bedding, and straw; no "hay lofts"; a separate manure compost or storage area; and a separate shed for tractors and vehicles. Potential negative effects are increased property tax costs.

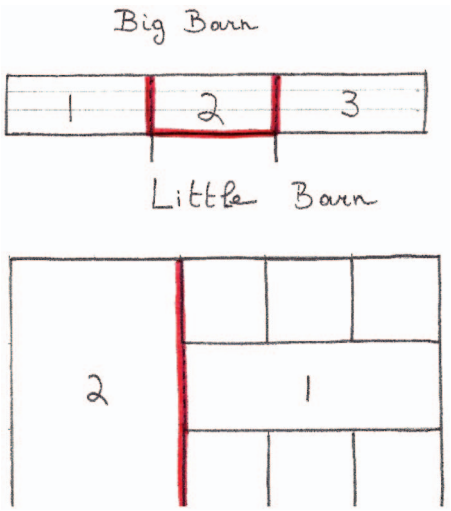

Fig. 4. Fire door and firewall use in barns (red lines) for compartmentalization. These ideas can be utilized in small or large facilities and only allow more time for removal of people and horses once the fire is detected.

Manure, hay, and bedding are three major products related to or produced by an equine facility. All three are not only found in high quantities on a property, but they are highly combustible fuel and even ignition sources. The presence of stall bedding inside the barn cannot and should not be prevented, but storage away from the main barn of excess bedding is ideal, and some forms of bedding (shavings) have lower combustibility or dust ratings than others (hay, straw).

Forage Storage

In traditionally built barns, hay and grass forage was stored in the "hayloft." We now know that hay should never be stored overhead in a barn, as it only increases the fuel loading within the barn and speeds the spread of fires as well as sometimes contributing to ignition sources. Very few barns have used a fire wall to separate the hay from the rest of the barn, or detection, alarm, and suppression systems (Fig. 6). If it is critically necessary to store hay in the barn, consider storage of the majority in a separate facility and bringing in only a couple of days worth of feedings into the hay loft or storage area. Compartmentalization and proper handling is critical, especially with hay and straw. Green hay is highly combustible, particularly when it has just been baled in high humidity content and put into storage in the summer months. A probe should be used to determine the internal temperature of the bales stored in a location separate from the horse facility for at least 3 months after baling to determine if there is any immediate danger (Fig. 7).

Facility Access

Fire truck and first responder access and safety are topics for immediate consideration. The parking

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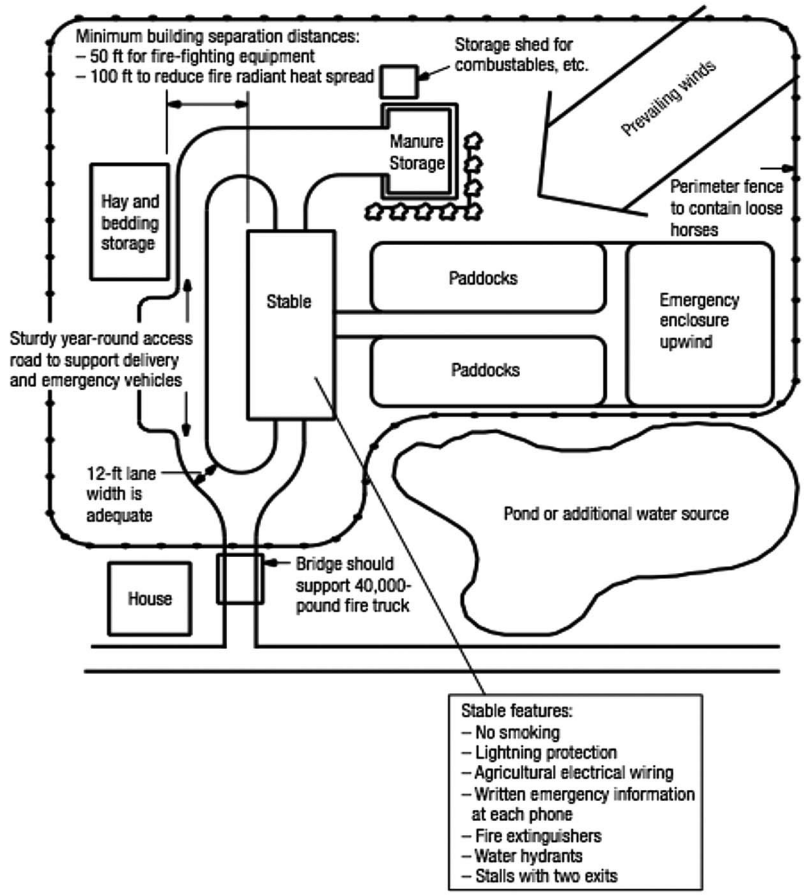

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Fig. 5. Possible barn layout intended to maximize compartmentalization on a small acreage and provide security.[18]

lot needs to be strong enough to hold the fire truck's weight—ideally a gravel or asphalt driveway. Many fire trucks will not advance on grass or sand in fear of getting stuck and, therefore, should have maximal access to sources of water (ponds, fire plugs, pools, etc.). The first responders are there to

Fig. 6. Hayloft with installed detection, alarm, and sprinkler system. Notice that instead of filling the hay storage area completely, only a limited several days of hay is brought in to limit the fuel load (photo courtesy Gimenez).

Table 1. Determining Hay Temperatures with a Probe

You should use a probe and thermometer to accurately determine the temperature inside a stack of hay. Push or drive the probe into the stack and lower the thermometer to the end of the probe on a lightweight wire. If the probe is horizontal, use a heavier wire to push the thermometer into the probe. After about 15 minutes, retrieve the thermometer and read the temperature. Refer to the following temperature interpretations:

Below 130°F	No problem.
130 to 140°F	No problem yet. Temperature may go up or down. Recheck in a few hours.
150°F	Temperature will most likely continue to climb. Move the hay to circulate and cool the air. Monitor temperature often.
175 to 190°F	Fire is imminent or may be present a short distance from the probe. Call the fire department. Continue probing and monitoring the temperature.
200°F or above	Fire is present at or near the probe. Call the fire department. Inject water to cool hot spots before moving hay. Have a charged hose ready to control fire when moving hay.

[Source: Ogburn, 1995]

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Fig. 7. Chart to assist with determining the fire danger in increasing stored hay temperatures. Freshly stored hay should be checked regularly until it is cured.[19]

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Fig. 8. Trailers parked away from the main barn to allow easy access around the gravel drive that goes all the way around the facility (photo courtesy Gimenez).

Fig. 9. Pole barn open barn design with fire retardant wood, excellent ventilation, electrical service to public facility code, appropriate egress, and preventative fire measures installed (photo courtesy Dr. Tomas Gimenez).

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help prevent spread of the fire, but will not risk their own safety to save animals or to stop the barn fire; if there is not sufficient room between structures they will not be able to maneuver close to the burning structure. Ensure that gates and fences at the entrance of the property have openings wide enough for the emergency trucks to enter through. "No Parking" signs and enforcement should be at every major entry to the barn to allow full access in case of an emergency. There is not time to get keys and move cars or horse trailers that are in the way when AQ: 4 firefighters arrive on the scene of a barn fire (Fig. 8).

The arriving firefighters will first conduct a 360° hazard analysis and risk assessment. This includes looking for electrical sources to turn off, possible propane or gasoline hazards, while assessing the smoke/fire development and determining whether to make an inside attack to the facility (rare) or providing outside fire/smoke suppression and further exposure protection. Practically, this means that in most cases they will stay outside the facility and attempt to knock down the fire from a safer position instead of entering the building due to the well known dangers of agricultural fires (speed of spread, large fuel load, and lack of egress).

Building Materials

Many building construction and daily management materials used in an equine facility construction can fall in one of numerous product specific rating systems for materials, which give an idea of how fast they may allow smoke development, flame spread, and an overall fire rating. These ratings give the builder an idea of how the material will behave in a fire compared to some traditional materials such as concrete. When building a barn, consideration should be given to masonry, heavy timber, and fire-retardant woods since it takes longer for flames to spread across their surfaces; however, these are often more expensive. When substituting modern wood construction materials, consider the use of flame retardant soaked or sprayed wood to accomplish the same rating (Fig. 9). F9

Unfortunately, most common varnishes used in barns can accelerate the spread of fires because most of them are not fire retardant, although the fire retardant versions do exist. Existing facilities can be sprayed with these solutions as well. Talk with your builder and see what materials they offer that can withstand horses, weather, extensive use, and slow the spread of smoke and flame if a fire were to arise.

Electrical Service

Electrical failures along with human errors are the cause for an estimated 80% to 85% of barn fires.[20] Modern barns commonly have as many electrical appliances in them as a residential structure and sometimes even living quarters co-located. If building new construction, you should establish the best electrical blue print for the barn (Fig. 10) to F10 provide sufficient service and minimize the need for extension cords. An electrician should understand what types of electrical appliances (bucket water heaters, clippers, heaters, infra-red heaters, hot water heater, microwave, washer/dryer, vacuum, etc.) that you might use in the "barn" to determine the kind of service panel you need and where the best location for it is. Ideally the electrical panel should be kept closed, easily accessible, and out of the way of dust, cobwebs, and humidity (Fig. 11). F11

If retrofitting a barn, an electrical review by a certified contractor is the best way to ensure safety of the electrical system and prevent potential fires. Walk through the barn together to look for issues (visible wires, lightning suppression systems (if

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Fig. 10. ~~Left:~~ Example of a clean and safe electrical panel (courtesy of Catherine Morauw).

present), solar electrical systems (if present), lack of conduit on wiring, incorrect or missing connections, lack of "outdoor" panels or plugs, sufficient panel service for the size and needs of the facility, etc.) that need to be addressed. While retrofits tend to be more expensive, it is a wise investment that may be reflected by contacting your insurance company and receiving a lower premium or higher coverage of the facility, and obviously is much cheaper than loss of the facility, contents, and live animals. Extra apparatus plugged into the electrical system need to be considered and either minimized (turned off when not in use) or ensure that they are rated for outdoor/agricultural use (infra-red radiators, heaters, air conditioners, microwaves, and fans). Small appliances have a great risk of becoming ignition sources to a barn fire when they are overloaded on a circuit, chewed electrical cords, or have a lot of dust get into their motors (Fig. 12). F12

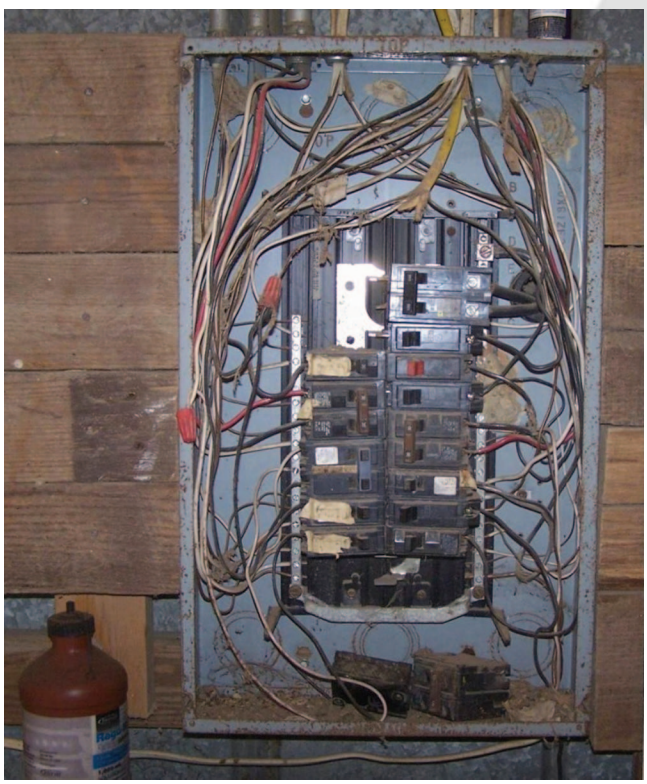

Fig. 11. ~~Bottom:~~ Example of an unsafe electrical panel (courtesy of Justin Mcleod).

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Fig. 12. Horse with electrical box fan. Small appliances can be increased fire hazards and can become an ignition source. Purchasing an agricultural rated fan is recommended (photo courtesy Gimenez).

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Another commonly overlooked aspect of animal buildings is thunderstorm security with lightning rods (Fig. 13). A well-grounded lightning system F13 can reduce the occurrence of fires (and injury to animals and people in the barn) from a lightning strike by diverting the energy to ground. Lightning systems are easy to install in both current barns and new construction. It is critical to have the system installed by a professional and maintained, or else the system may do more harm than good.[19]

When building any kind of facility, local fire codes should always be consulted, and if they do not align with national fire prevention guidelines, consider the recommendations of NFPA Standard 150—Animal Facilities.[2] Even if it is considered an "agricultural structure," there are usually minimal codes that need to be followed but consulting a fire marshal for information on improved standards will increase future success in preventing fires. Safety

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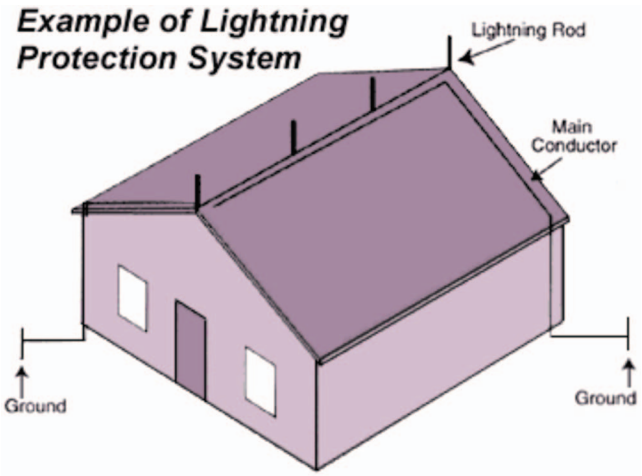

Fig. 13. Lightning rods installed on a barn.[21]

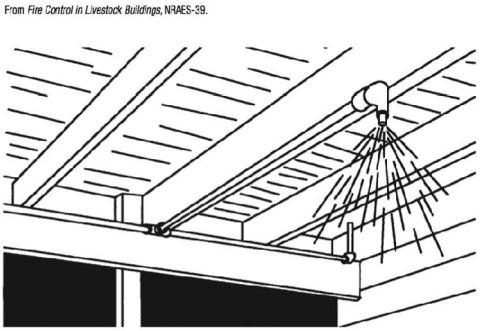

Fig. 14. Example of a Sprinkler suppression system.[18]

standards as set forth in local jurisdictions are created to ensure the safety of humans and animals but in most communities are a minimum protection level; for more valuable and insured animals, a higher safety standard should always be sought.

Detection, Alarm, and Suppression

Obviously, the best key to fire protection is prevention of ignition, but fires are inevitable and a detection system is of great consequence to a fast response. The first sign of a fire is often smoke which may smolder/burn for hours or even days without an open flame. Smoke detectors of several types (flame detectors, thermal rate of rise detectors, ionization detectors, etc. depending on barn design and expense) will need to be installed by a contractor in multiple open and closed areas of the barn. Having the detectors in direct communication with a local fire station or security system when they alarm dramatically reduces emergency response time to the location. Along with ~~a~~ smoke and carbon monoxide detectors, consider a local security alarm installed to notify any local individuals of the intimate danger, which increases the chances of getting the horses out of the barn.

Suppression is vital to saving the horses trapped in a burning facility (Fig. 14). "Sprinklers in a barn at Plainridge Racecourse, a harness racetrack near Boston, saved some 35 horses when a fire broke out May 9. … The racetrack, located in Plainville, about 35 miles southwest of the Boston area, had a sprinkler system installed in the barns in 1999."[3] The question is not whether or not a sprinkler system needs to be installed, but what type of system is best. Insurance premiums are substantially reduced for facilities outfitted with a sprinkler system, but few equine builders or designers emphasize their use, which arises from few equestrians insisting on their use. Part of the challenge is initial expense for these systems can be up to 20% of the building costs, although components have been getting more reliable and cheaper over the last 20 years as contractors have installed more systems.

In residential and public buildings, numerous studies have shown that in facilities with automatic sprinkler systems, the ability of the fire department to respond and save people as well as the facility is substantially improved. Sprinkler systems can have an operational reliability, meaning the system worked as intended. It has been reported that a high of 93%[22] operational reliability can be reached. Performance reliability can also be measured—how adequate the system will perform once it is employed. This number is much lower indicating that sprinklers will control a fire but are not used to extinguish it, establishing again that detection and alarm at the local fire department are crucial to avoid loss of the facility and contents.

A major determining factor for sprinkler system choice is the climate and geographical location of the facility. Sub-zero temperatures will not allow for a "wet" system to be installed or pipes will freeze and burst in the winter months, rendering them useless. The most convenient is a dry sprinkler system where the pipes are filled with compressed air or nitrogen, which in turn holds a valve shut to hold the water out. The sprinkler head will open when there is a temperature variation, leading to the opening of the value and the rush of water flow into the pipes and system. Limitations include that a substantial water source and pump need to be available to provide enough pressure and water for the system (D Farr, oral communication, May 24, 2013). However, these challenges can be overcome with appropriate mitigation. Sprinklers are the single BEST method of suppression of a fire in any type of facility, providing enough time for the first responders to arrive and attempt rescue of trapped horses as well as preventing spread of the fire to prevent facility damage and insured dollar losses. Their lack of use in the horse industry can be attributed to lack of understanding and knowledge by the horse owning community.

Another suppression method that is common but also misunderstood is fire extinguishers. There are three major classes of fire extinguishers: A, B, and

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Orig. Op.	OPERATOR:	Session	PROOF:	PE's:	AA's:	4/Color Figure(s)	ARTNO:
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Fig. 15. Classes of fire extinguishers.[23]

C. Multiple designator extinguishers, Class ABC, are available and are most useful in barns due to their broader target range (Fig. 15). Located at every point of entry in the barn should be a fire extinguisher of a minimal 10 pound size, and these should be checked and maintained (turned upside down) on a monthly basis. Staff and patrons of the facility should all feel comfortable in handling and using a fire extinguisher; this is an easy training event to provide in concert with your local fire department.

F15

Egress

Having multiple access/egress for humans and horses is an important factor to the success of evacuating animals and people (especially handicapped riding students at PATH facilities, etc.) A simple change to design of facilities allows initial on scene personnel to get horses out of burning barns more readily and safely. There should be minimum 8-foot-wide and 8-foot-tall openings every 50 feet at a minimum along the outside wall of a facility preferably leading to a fire run-out lane so that animals can be released and chased out of the barn to a safe location.

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Don't believe it? Try it. Time yourself. Run from your vehicle or location outside the facility to the inside, find a halter, catch a horse in a stall, lead it out to a paddock, close the gate, run back in to get the next horse, etc. Did it take you less than the 3–5 minutes that it would require for an ignited barn to reach deadly conditions where you could no longer enter the barn facility? At that point, in most rural areas, the fire department would just be pulling out from the station (Figs. 16 and 17).

F17

As prey animals, in emergency situations stalled horses tend to stay in their stall even if the door is opened since it is normally an area of security for them, and their buddy horses are there with them. Furthermore, when a barn is full of smoke and firefighters geared up with their breathing apparatus on and approach a horse in a stall, most will not willingly approach a firefighter at the door of the stall, and entering the stall of a scared horse is not recommended either.

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Fig. 16. ~~Left:~~ Attempting horse rescue by fire fighters in a training demonstration. In a real barn fire, there is not enough time to catch, halter, and lead out all the horses in the 3 to 5 minutes to full involvement of the barn (photo courtesy Tori McLeod).[20]

Ideally each stall will have an egress to both the inside aisle and outside paddock or run out lane. This allows easy and fast approach and egress for each individual horse with lesser risk of entrapping a human in a burning structure (Fig. 18). Advancing down the interior aisle of a burning barn can never be recommended, as it is known to be extremely dangerous for falling fuels and failure of the overhead roof structure due to the common use in modern barns of lightweight wood construction. In some facilities, there may not be an attached

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Fig. 17. ~~Bottom:~~ Well-meaning owner attempting to rescue horses in a TLAER barn fire simulation. Note horse is reluctant to leave the barn even when being led out (photo courtesy Gimenez).

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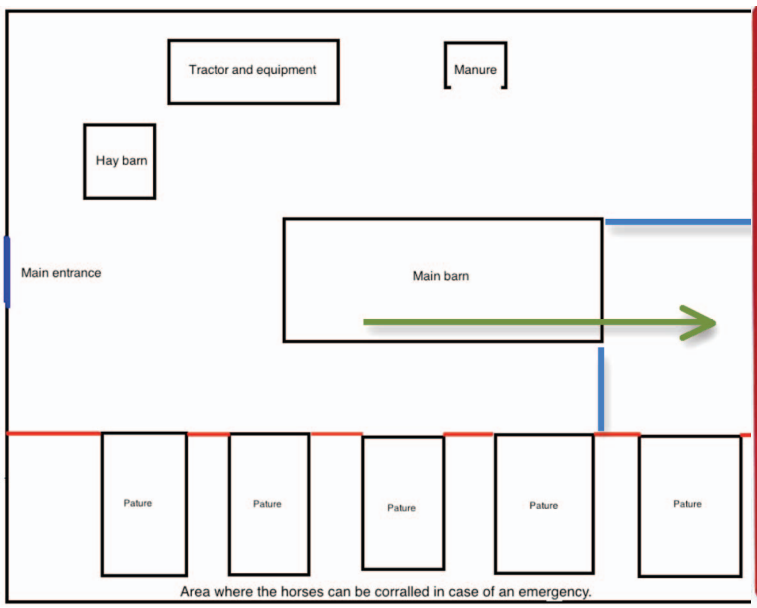

Fig. 18. Illustration of a fire lane in a barn. All the red accesses can be easily opened or closed in a case of an emergency and be used as a corral for the horses. Blue lines indicate permanent fences that can be used to direct released horses out away from the barn toward the corrals/pastures. Green line is direction of driving animals away from the barn as they are released from their stalls.

Fig. 19. Siren operated sensor.

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paddock to every stall. Here a dedicated fire lane (where a few gates can be opened or closed) to provide safe egress as a group to corral the horses and drive them to an open paddock or pasture away from the barn. The ultimate goal is to save the horse from the burning building; however, if they are allowed to get loose and run down the road this will lead to tragic accidents with vehicles responding to the location. A holding area needs to be prepared in case of a fire, and this will allow a head count of both people and animals in a safe location.

Ingress to the property is crucial. First responders need easy access to the facility, preferably on gravel or paved roads that go around the barn. In case of an emergency the horses will need to be evacuated to paddocks or even alternative facilities requiring transport vehicles. Note: A gated property needs a plan established on how the rescue crew can enter. If it is a lock and key, then the fire station and police station should have a copy of that key, or use of a sound operated gate system can be implemented (Fig. 19). Any electrical gates should be supplemented by a solar system or with a battery backup. First responders will take appropriate action and demolish the gate in case of an emergency, but this is unnecessary with correct planning. F19

Cleanliness

The best fire retardant building materials, presence of a sprinkler system, and use of compartmentalization will not be maximally effective if the facility is not kept clean. Cobwebs and dust are substantial fuel sources for a fire, and are also easily combustible.[18] Cleanliness and maintenance of the electrical, immediate response, and detection systems are especially important (Figure 20). F20

Emergency Plan

Lastly, an emergency plan should be written, implemented, and practiced. The facility's boarders, staff, local first responders, and any visitor should be aware of the rescue strategies in case of an emergency. Emergency contact information sheets should be posted throughout the facility, along with first response equipment (fire extinguishers and hoses). Extra halters and lead ropes can be stored in a different building. Take advantage of the previously described compartmentalization and fire run-out plan for getting animals away from the burning building (Figs. 21 and 22). F22

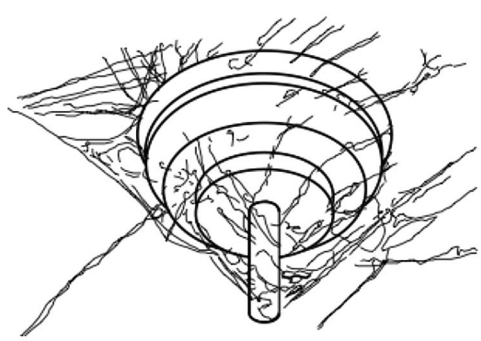

Fig. 20. Keep all detectors free of cobwebs and dust and maintained regularly. From Fire Control in Livestock Building, NRAES-39.[18]

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Fig. 21. This new barn construction shows gates and pastures set up as a fire lane away from the barn in case of a fire. The original barn burned to the ground in 2008, but all of the horses were removed unharmed (photo courtesy of Windchase Farm).

3. Results

There are multitudes of simple to complex actions that can be taken in the quest to prevent a barn fire and improve the local response time and effectiveness of planning and prevention. As veterinarians and equestrians it is important to educate others and share our knowledge based on prior real losses and real response scenarios. Veterinarians will have the opportunity to walk into more different types of equine facilities (great, good, and bad) then most horse owners will in their lifetime. Using the information in this article and having better awareness of the problems will allow practitioners to make a difference within the industry by changing attitudes about fire losses.

The techniques and methods as discussed are intended to reduce the occurrence of barn fires and the associated losses of life (both equine and human) and facilities (invested dollars) that are related to them. For the best outcome, all components of prevention need to be implemented; however, even simple modifications to management and design can measurably reduce the incidence of fires and improve response by bystanders and emergency responders.

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Fig. 22. Windchase Barn Fire, 2008, approximately 24 minutes after lightning struck the barn. There is nothing left to salvage when a structure is fully involved. In this case personnel were on scene and saved all of the horses out of the barn (photo courtesy of Windchase Farm).[24]

4. Conclusion

Barn fires are tragic events that cannot be completely eradicated but can be greatly reduced in occurrence. The number one priority should always be human safety and health, including for the veterinarian, bystanders, and first responders to the scene. Traditional building designs and management practices need to change to increase the success of detection, suppression, and response by both local fire departments and immediate responders. Many of the choices and aspects of building or retrofitting equine facilities affect the incidence of fires, and few traditional strategies are based on current research or technologies. Losses are not just limited to horses, but there are dramatic economic impacts on the loss of equestrian related facilities (including veterinary facilities) as well. Education of horse owning clients and the general public are vital to increased success of improved prevention and response methods being applied to our equestrian clinics and facilities.

Acknowledgments

Conflict of Interest

The Authors declare no conflict of interest. AQ: 7

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