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A Review of Strategies to Prevent and Respond to Barn Fires Affecting the Horse Industry

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Barn fires detrimentally affect equine recreational enthusiasts, horse owners, and practitioners regardless of geographic location or economic conditions. As the number one local emergency expected to affect agricultural facilities, fires kill more horses than any other type of disaster. Strategies and equipment to mitigate their effects are available but underutilized; the effectiveness of detection, alert, suppression, and immediate response systems is further emphasized by appropriate design, management, planning, and emergency drills. Authors' addresses: Technical Large Animal Emergency Rescue, Inc., 2472 Six and Twenty Road, Pendleton, SC 29670 (Gimenez R); Reflected J Livestock Consulting, RR #1, Blackie, Alberta T0L 0J0, Canada (Woods); Maxwell H. Gluck Equine Research Center, University of Kentucky, Lexington, KY 40546 (Dwyer); and Department of Animal Veterinary Science, Clemson University, Clemson, SC 29634 (Gimenez T); e-mail: rebecca_gimenez@us.army.mil.

1. Introduction

Fire can affect horse owners and their animals in several ways. Barn fires are unfortunately too common, and each year, hundreds of valuable horses die or are severely injured in these incidents (Fig. 1). Wildfires consume thousands of acres annually in almost every state in the United States, particularly in wildfire-prone areas of the West and Southeast; plus, they threaten scattered communities with horses and livestock that must be evacuated or sheltered in place. Transportation fires (truck and/or trailer), although rare, do happen and present extreme challenges. This paper will focus on addressing the issues associated with barn fires.

Mitigation can be defined as the positive actions taken by facility owners to permanently eliminate or reduce the long-term risk to life, property, and purpose from a particular hazard (e.g., fires). Together with preventative actions to decrease the severity of an event and immediate suppression techniques, a well-planned facility and/or property strategy can significantly reduce potential losses in both equine life and property. Understanding basic fire behavior, new construction materials, fire-service response, and advances in fire detection and suppression equipment available will contribute to better horse facility design and long-term improvements in management by owners.

Around the world, volunteer fire departments in rural areas are usually going to be the first responders to a fire scene, but the team of responders should include equine practitioners to provide expertise, veterinary medical triage, treatment, and possible

NOTES

Fig. 1. Horse in a wooden structure with halter and lead rope at the ready. Other safety features include electrical components that are protected and in conduit, a reflective stall number, and an easy open latch. Photo courtesy of Tomas Gimenez.

euthanasia. With only an average of 3–5 min to save equine lives, owners and bystanders will try to save the animals themselves. Education, better facility design, and alert and suppression systems are key to decrease the risk of losing animals as well as people who try to help them. Equine and livestock veterinary practice facilities are vulnerable to all of the above fire hazards; therefore, the following information applies not only to client animals but also to practitioner horses, equipment, facilities, and structures.

The objective of this paper is to suggest facility design improvements based on a review of the small amount of literature and statistics available and to educate the reader on relevant aspects of horse barn fire prevention and response. Additionally, information on new advances in building materials and detection equipment for equine facility construction will be presented.

2. Tracking Incidence of Horse Barn Fires

Collecting the actual number of these events is impossible at this time, because there is no nationalized reporting system. A literature search revealed a small pool of information about treatment of burn injuries in horses and animals and an inconsequential amount of fire research or incidence reporting on agricultural barn fires. Thus, much of the knowledge of how horses behave in fires and how fires occur and suggestions for better prevention and response come from a combination of journalistic reporting, firefighters sharing their career knowledge, actual owner accounts, and reports from veterinarians that have responded to these incidents. Fallacies related to fire response in the equine industry have come from the lack of scientific rigor available.

Experts in fire and arson investigations estimate that 80–85% of horse barn fires are caused by accidents, human error (e.g., open flame from smoking cigarettes, welding next to combustible materials, arson), or electrical malfunctions. They speculate that lightning is the next most common cause; however, there are no actual data available. Obtaining statistical data specifically for the number of horse barn fires that occur in the United States would seem to be a straightforward task achieved by obtaining and comparing data already in the National Fire Incident Reporting System (NFIRS). However, livestock structure fires are subclassified by cattle, poultry, swine, or "other livestock" facilities, which may include a "horse" or "hay" barn. Nearly 11,500 fires in the generalized grouping of "agricultural storage facilities," which includes barns, stables, silos, and even grain elevators, are reported each year with estimates that ≤88% of these are barns and stables. These fires cause an average of 100 injuries, 10 fatalities, and $249.7 million in property loss. National estimates are based on NFIRS data (1996–1998) and the National Fire Protection Association's (NFPA) annual survey, *Fire Loss in the United States*.[1] Also, insurance companies do not have a centralized reporting agency for retrieving such data. Obviously, the need for data represents a rich environment for future study.

Union Carbide Chemicals Company's Fire Protection Engineering Division conducted fire tests and studies in the 1970s on racetrack stables for the New York Racing Commission. The California Thoroughbred Breeders Association and Horsemen's Benevolent and Protective Association issued a report on a study of racetrack stable fires. Additionally, the NFPA published "Occupancy Fire Record" (FR 63–2) describing fires in racetrack barns and stables. Although the results are interesting, >90% of investigated fires were located at racetracks. This was because of required insurance reporting before reimbursement payments were made for property damage and media coverage.[a]

Informal collection and compilation of data on horse barn fires by all of the authors has revealed a significant number of these events, especially in the winter, which agrees with more formalized surveys by fire science researchers.[2] However, without having the NFIRS official reports for these specific types of fires, the causation and other details cannot be specifically defined, although they may have been determined later by the ongoing fire personnel investigation. Often, the journalist/reporter does not have access to or receive the details on the fire that are most important to disaster scientists or veterinary epidemiologists.

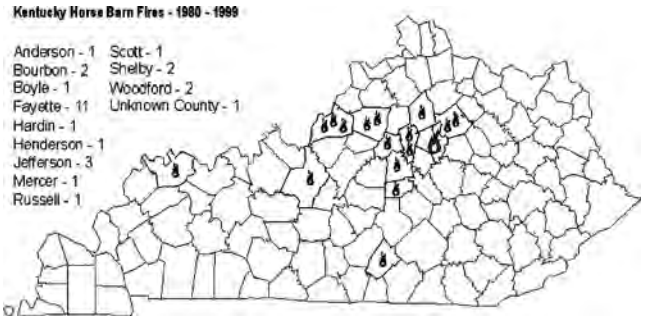

Fig. 2. Geographical locations of twenty-eight (28) barn fires reported in Kentucky over a 20 year period (1980–1999). Incidents of barn fires are indicated on the map and the county of the reported fire is listed. (Used with permission–Dr. Roberta Dwyer).

Breed incidence

Breed	Number died	Number of fires *
American Saddlebred	83	5
Thoroughbred	77	10
breed not reported	51	5
Tennessee Walking Horse	24	1
Standardbred	14	1
Arabians	13	3
Miniature Horse	2	1
Pony	2	1
Hackney Pony	1	1

* some fires involved more than one breed

Fig. 3. Breeds of horses that were reported in the Kentucky study over a 20 year (1980–1999) period. American Saddlebreds and Thoroughbreds overwhelmingly are represented in the barn fires reported, but are also very common breeds in Kentucky. The total number of horses lost in the fires was 267. (Used with permission–Dr. Roberta Dwyer).

3. Data Reported on Horse Barn Fires

There are some studies available. One database included only horse barn fires in Kentucky over a 20-yr period, and it was obtained through the generous efforts of members of the Lexington, Kentucky Fire Department, multiple librarians, newspapers, and lay equine publications. To determine the significance of horse barn fires in Kentucky, attempts were made in 1999 to uncover the incidence and causes of such fires.[3] Twenty-eight horse barn fire news reports were examined, and their geographical locations are shown in Figure 2. Fires caused the deaths of 267 horses at the following locations: 23 privately owned farms, 1 racetrack, 1 racehorse training facility, 1 public riding stable, 1 veterinary clinic barn, and 1 building in which ownership was not mentioned.

The number of horse deaths in the Kentucky survey (per fire) ranged from 1 to 38 horses. In five fires, no horses were killed because of successful evacuation or the fact that the horses were at pasture at the time of the fire. The breeds involved are listed in Figure 3. One fire caused the death of one person. Fires occurred in the evening/night (6:00 pm-6:00 am) on 14 occasions and during daytime hours in 7 cases. Six reports did not state the time.[3]

In an analysis of nine major horse barn fires reported by the Associated Press media from October 2005 to November 2007, the following statistics speak to the futility of late response: Epona Farm, Illinois (33 died, 1 rescued); Norwich, Vermont (0 died, 14 rescued); Fair Hill, Maryland (24 died, 4 rescued); Little Full Cry Farm, Virginia (10 died, 0 rescued); Eureka Downs, Kansas (43 died, 1 rescued); Lutts, Tennessee (9 died, 7 rescued); Miami County, Ohio (10 died, 2 rescued); Halifax, Kentucky (24 died, 0 rescued); Marcy, New York (25 died, 10 rescued); and Kingsley, New Brunswick, Canada (0 died, 16 rescued). The Kingsley and Norwich fires stand out as both having personnel on scene when the fire started in the barn, and thus, the horses were able to be removed in time. Every facility in these incidents was a complete loss. The Norwich facility was under construction at the time of the fire.

An Associated Press search for barn fires reported in the United States between January 1, 2006 and October 31, 2007 revealed a total of 87 barn fires with horses reported to be in them at the time of the fire. This represents a total loss of 461 total animals.[4] This study also collected information on all agricultural barn fires in the United States reported in the press that contained animals at the time of the fire. Horses (304 lost during this time period) were only a small part of the "870,984 confined animals that died in preventable fires in 2007" as tracked in the press database maintained by Laurie Loveman.[4] Other animals included pigs, goats, zoo animals, cattle, and small animals. Loveman[4] reported that "of the 203 (total barn) fires, only 4 were arson or suspicious; the remaining 199 fires were probably all preventable, since the fires in which the causes were determined were all preventable."[4] This further highlights the education, response, and prevention challenges inherent in issues of barn fires.

4. Prospective Economic Losses

The economic losses of barn fires can be devastating, killing numerous horses (estimated actual and sentimental values) and destroying structures (Fig. 4). A fire that is not suppressed in the first minutes rarely fails to involve the entire structure; total losses will include tack, vehicles, equipment, animals, and structures. Most structures are a total loss. In 14 reports that mentioned the estimated value of the horses and/or property lost, the losses were estimated at $5.6 million (total).[3]

Fig. 4. A fully involved barn fire. Photo courtesy of Becky Kalagher.

In August 2002, the Woodbine Race Track in Toronto, Canada barn fire damaged buildings (estimated at >$1.5 million) and killed horses (estimated at >$5 million). In each of the Eureka Downs, Kansas (February 2006) and Fair Hill, Maryland (November 2005) fires, initial estimates for property damage and value of the horses lost ranged from $1 to $1.9 million. An estimated $124.6 million in direct damage to property (loss of farm equipment, livestock, and buildings) occurred in the United States between 1999 and 2000. These estimates were based on 5800 barn structure fires; other livestock buildings are included in this report. Thirty-four people were injured, and one person died in these fires.[2]

Even small barn fires will require deployment of large firefighting resources. For example, in the early hours of a February 2006 morning, a mare and her hours-old foal in Colorado were lost in a four-stall barn fire. By the time a passerby saw the fire, called 911, and alerted the owners, the barn was fully engulfed. Firefighters from two departments responded with a total of seven trucks and thirteen personnel, and they were on scene for 2 h and 37 min to extinguish the fire, overhaul, and salvage the building. The damage was listed by the departments as extreme, and the fire was quickly traced to a heat lamp used for the newborn foal. An equine practitioner was contacted and responded to the scene in time to treat another horse affected by smoke.

The Federal Emergency Management Agency (FEMA) has been encouraged to establish a data code to specify horse barns for future data analysis. Development of a reliable, ongoing database as part of the NFIRS system and an easy tracking system for incidences of horse barn fires would make it possible to provide more accurate information for equine disaster epidemiologists, facility insurance industries, and firefighters.

5. Check for People First

In the case of fire, the first thing to be determined is if there is any chance that people might be in that smoldering barn. A barn manager may live in an apartment above the stalls, someone may be on foal watch in the lounge, or a child might be playing or sleeping in the hay loft. Additionally, a well-meaning person may have gone into the inside aisle of the barn to try to evacuate the animals.

The October 27, 2007 barn fire in Merrillville, Indiana trapped and killed a worker in an apartment above the stable, killed 22 horses, and destroyed the barn; only three horses were saved in the fatal fire. State fire officials said that the fire may have been caused by an electrical problem inside the apartment, and the facility was not insured. An inspection of the facility several years earlier noted that at least one electrical box in the stable was unsafe. The cause of a fire in Berwick, United Kingdom in November 2005 was ruled accidental but at the cost of two teenage boys that were playing in the barn. Other fires in October 1999 and October 2007 each involved a person who went into a fully involved barn to rescue the horses; their bodies were found by firefighters after the barn collapsed.

In some states, insurance is not available for a barn with human living quarters above the horses, because carriers know the significantly high risk inherent in these facilities. Dormitories, tack rooms, and other facilities used for sleeping purposes should be of at least 0.75-h fire resistant protected construction and comply with all applicable provisions of NFPA Standard No. 101-1973 (Life

Safety Code). NFIRS data have shown that the extent of flame damage that residential structures sustain is worse in rural areas than in non-rural areas, which is likely caused by two factors. Emergency response times are longer in rural areas because of longer travel distances. Additionally, fires may burn longer before being noticed in rural areas because of lower population densities.

People without respiratory protection and proper fire protective clothing and training should never enter smoking or burning barn structures, especially down the center aisle; however, they may be able to assist horses accessed from the outside wall. All personnel commonly around barns should be familiar with the evacuation plan and the location of barn fire response equipment such as emergency phones, hoses, and fire extinguishers.

6. Basics of Fire Behavior

A fire requires three things to burn: an ignition source (spark or intense heat), a fuel source (combustible material), and oxygen. Based on the availability of oxygen, the arrangement of the combustibles, and the type of fuel, the fuel source begins to smolder, sometimes for hours. Although smolder is the stage at which a fire is easily brought under control, paradoxically, the smoldering fire is the most difficult to detect and to extinguish (e.g., hay and manure fires). In addition, some commercial detection and notification systems may not sense the fire at this low level of heat and smoke.

Causes of barn fires in one study were electrical fires (4), suspected or confirmed arsons (3), lightning strikes (2), light-fixture malfunction (1), electrical heater malfunction (1), overheated electrical cord attached to a fan (1), hay ignited by heat lamp (1), lawn tractor, which was stored in the barn, malfunction (1), cigarette dropped by farm worker (1), and sparks from a welder (1). In 12 fires, the cause was not disclosed.[3]

Tests in a 12 × 12-ft stall, using two bales of fresh straw, showed that it took 1 min for these fast, clean-burning fires to create air temperatures of 190°C 15 ft above the floor. A similar test, using slow-burning straw, did not develop noticeable quantities of smoke, and the temperature 15 ft above the floor reached only 66°C during the first 1.5 min. As the fire continued to burn, dense smoke developed, and at 3.5 s, the temperature reached 121°C.[3]

Straw bedding reaches a burning temperature of 148°C in 1–5 min, during which time it will burn an area 10 ft in diameter and develop as much heat and burn at the same rate as gasoline. Living things usually cannot survive more than short exposure to 66°C heat, and the searing heat can quickly destroy delicate tissues of the lungs. For this reason, humans and animals must be rescued out of a burning stall within 30 s, for no injury, to 1 min, injury incurred. After 1 min, the lungs are seared, and the human or animal begins to suffocate. By 3 min, the human or animal is dead.[5]

An animal should be able to survive a fire <1 ft in diameter and/or temperatures at the 15-ft level of <66°C (150°F). When a fire starts, the animal in that stall seldom has >30 s to be rescued before suffering fatal internal burns of smoke and heat inhalation. Horses in adjoining stalls have up to 5 min to be rescued, depending on stall construction, ventilation, and separation.[5]

When flames appear, more heat is being produced, and the fire begins to rapidly grow. At this point, it may be too late to save any living things in the barn. Flames move quickly unless design features of the facility slow its progress or treatments of the wood do not support propagation of the flames. After flame eruption, it may take only minutes for temperatures to exceed 982°C (1800°F) at the level of the ceiling[5] and 3–5 min to approach the flash point at which all combustibles within that space of superheated air will ignite. In livestock barns, this is usually the "loft" area above the ceiling of the first floor and below the roof. Unfortunately, this is a common space for storage of bedding, hay, and other combustibles, ensuring loss of the building contents and the animals caught within it. It is common for a fire department to return to the scene of the initial fire hours or days later to extinguish smoldering pockets, especially in hay or bedding that are not penetrated by water extinguishment.

Toxins released by the process of burning do severe damage to the lungs of any living organism. All 24 horses in the 2005 Fair Hill, Maryland fire were considered to have died of smoke inhalation by the deputy state fire marshal, and personnel on scene reported that there were no sounds from the animals when they arrived at the fire, even though the barn was not yet fully involved.[6] Carbon monoxide and carbon dioxide are common byproducts of fires; when inhaled, they block the absorption of oxygen at the level of the hemoglobin in the blood, which causes asphyxiation through anoxia. Flames do not necessarily need to be visible for this to occur.[5] Additionally, animals removed from burning buildings have been reported to appear medically stable for days but then crash with severe pneumonia. Some animals rescued from barn fires will need to be aggressively treated or euthanized based on the extent of their internal or external injuries; this is where crucial involvement of the attending veterinarian occurs.

7. Fire Codes, Enforcement, and NFPA 150

National Fire Code (NFC)[7] documents define assembly occupancies as those "used for a gathering of 50 or more persons for deliberation, worship, entertainment, eating, drinking, amusement, awaiting transportation, or similar uses" or "as a special amusement building, regardless of occupant load."[7] They define business occupancies as those "used for account and record-keeping or the transaction of business other than mercantile."[7] After a facility meets the requirements for mixed occupancy, it must also meet the most restrictive fire and life safety requirements for those

occupancies; however, this distinction can lead to an enforcement dilemma.[7]

After a series of disastrous racetrack fires, the NFPA established a committee in 1976 to make recommendations to the industry for occupancy requirements, construction, and fire protection. In 1979, the first edition of NFPA-150 Standards on Fire Safety in Racetrack Stables was published and accepted as an American National Standard. With only minor changes in successive versions,[8,9] the NFPA-150 Technical Committee asked the Standards Council in 2004 to authorize the expansion of NFPA-150 Racetrack Stables to include life and fire safety requirements for both humans and animals in all types of animal-housing facilities.[8] The request was based on the NFC classification of buildings that house animals as "storage occupancies," a designation that places barns in the same category as warehouses. In July 2004, the expansion was approved, and it became the Technical Committee on Animal Housing Facilities to reflect the new focus.[7] The Technical Committee does not include a veterinarian or horse-industry representatives, yet the revamped edition of NFPA-150 was published in 2007.

Three of the NFPA's major documents, NFPA-1 Uniform Fire Code, NFPA-101 Life Safety Code, and NFPA-5000 Building Construction and Safety Code, classify any type of animal-housing facility as a "storage occupancy," defined as an "occupancy used primarily for the storage or sheltering of goods, merchandise, products, vehicles, or animals," and it is typically characterized by the presence of few people, usually only owners and employees. If members of the public enter the building, the building can no longer be considered simply "storage occupancy." Depending on the number of people, it may qualify as a "mixed occupancy" between storage and assembly or storage and business.

A single-family home with a 15,000-ft^2 barn of 30 stalls, operating as a private horse-breeding facility, is an example. The only people allowed inside the barn are the barn's owner and employees if it is to be classified as "storage occupancy." The same home and barn operated as a board-and-care facility for horses, where owners come to ride their horses and trainers, veterinarians, and farriers also use the barn, is now a "mixed business and storage occupancy" to those interpreting the definition. This is where the dilemma is highlighted: horses as "storage objects" certainly require human care, especially during an emergency, whereas boxes sitting in a warehouse would not.[7]

Currently, these decisions are left to the local authority-having jurisdiction (AHJ), which results in inconsistent treatment of such facilities across jurisdictions. To provide better guidance to AHJs, the expansion of NFPA-150 addressed all types and developed provisions specific to animal-housing facilities. The technical committee divides NFPA-150 into three major sections: (1) administrative requirements, (2) general requirements (occupancy classification, construction, fire protection, and means of egress requirements for all buildings housing animals), and (3) specific requirements for different types of facilities, taking into account whether the public has access to the building, in both new construction and existing structures. Existing structures will be required to provide a minimum acceptable standard of life and fire safety for humans and animals. The comment closing date on the new revision was February 29, 2008.[8]

8. Arson

Arson is a not a common cause of modern barn fires, but it occurs often enough that it is something for the arson investigator to consider when insured horses were in the barn or insured structures are involved. Arson, or situations that are highly suspected of arson but can not be proven, represent ~15% of barn fires.[3] People who commit arson usually are primarily motivated by profit or anger, and a very low percentage of fires are started by pyromaniacs (people with a compulsion to start fires). Arson of the random type is more common than actual insurance fraud. In the Eureka Downs racetrack stable fire in February 2006, arson dogs were brought in as part of the department's routine investigation, especially because 43 horses died and many were insured; the actual cause of the fire was undetermined, the site was cleared, and the investigators closed the investigation.

The most publicized and prosecuted recent barn fire arson case was in 2001. A firework was maliciously thrown onto the roof of a barn, which resulted in the deaths of 19 horses at a public hunt boarding facility in Michigan. The firework started the fire so fast that only five horses were saved by the night watchman on scene at the time of the mortar firework attack. After a jury trial, defendant Stephen Fennell was convicted of 19 counts of willfully and maliciously torturing or killing animals by Michigan Compiled Laws (MCL) 750.50b(2). The trial court sentenced him to 3 yr of probation, and the first year was to be served in the county jail.[10]

In 2005, there was an unusual case in North Carolina where four teenage girls allegedly trespassed onto a family farm while the owners were off on vacation. They sprayed hairspray in a horse's tail and set it on fire to watch the mare run in fear (Fig. 5). In this case, the mare was outside in a paddock, but if this had been in a barn or if the horse had access to the inner hallway, it could have caused a much worse incident to occur. The mare survived after tail amputation and nursing care.[b]

When a horse barn (or any other structure) burns, the fire commander on scene makes a determination of whether or not a cause is readily apparent; if not, further investigation is needed. If an in-depth study of the incident is required, the investigative unit is called to the scene. The actual cause of the

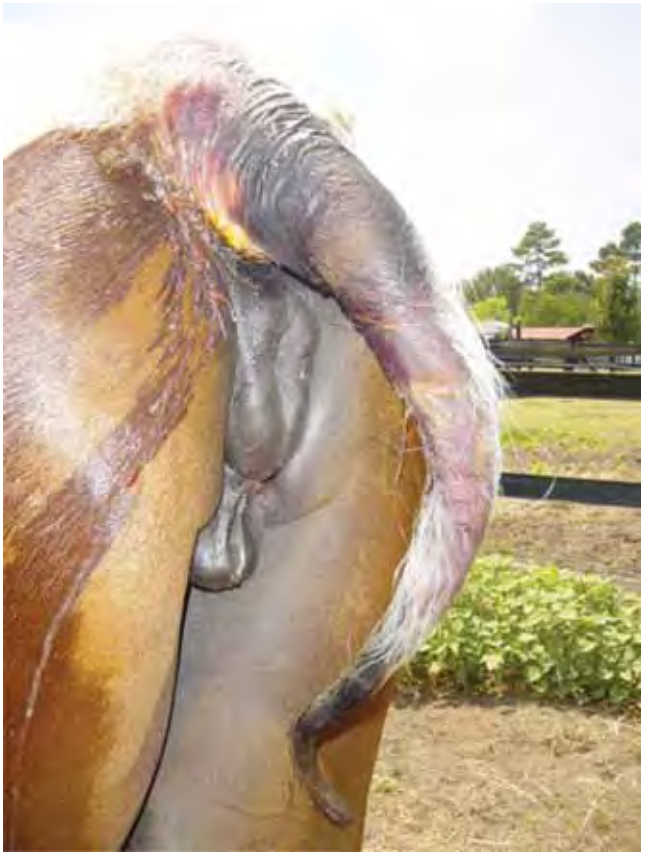

Fig. 5. Tail hairs traumatically burned off of a mare's tail (~4 h after incident). Photo courtesy of Vonda Hamilton.

fire may be determined in hours or with complex suspected arson cases, days to weeks, and State Fire Marshal investigators may get involved. If the property is insured, the insurance company's investigator contacts the fire department and inspects the scene within 48 h of the fire. After the fire investigation is completed, the fire department files a report with the NFIRS statistical record maintained by FEMA.[8]

9. Construction Considerations

Use Fire-Retardant Materials

Although it is impossible to make a livestock building "fireproof," owners of such facilities will constantly have to manage the risk of fires by using safety practices, prevention strategies, and management. Barn design should attempt to increase the amount of time (minutes) that it takes a fire to reach flash point by modifying building materials, contents, and compartmentalization with fire-resistant barriers, high ceiling heights, or large room volumes.[5] As previously stated, emergency response times are sometimes longer in rural areas because of longer travel distances and volunteer status of departments. Additionally, fires may burn longer before being noticed in rural areas because of lower population densities. Firefighters will seldom choose an offensive approach for agricultural facilities over defense of nearby structures.

A true non-combustible building material would be a material of which no part will ignite and burn when subjected to fire. Builders and owners should look for building materials that are essentially non-combustible. Masonry, heavy timber, and fire-retardant treated wood should be considered for all livestock building construction.

The flame-spread rating of the material used in construction should be considered. This rating estimates how long it would take for flames to traverse the surface of the material compared with the standard concrete block (0 rating) and dry red oak (100 rating). Fire-retardant lumber decreases flame spread by 75% to a rating of 25 and is effective for many years. At the same time, it develops a "carbon char" on the exposed surface that will not continue to burn, which maintains the structural integrity of the wood even longer than unprotected steel during a fire.[5]

A low smoke development rating means that the material produces less smoke as it burns, resulting in better visibility, less noxious gases, and fewer sparks that decrease fire progression. Fire ratings indicate how long a material may block the progression of a fire—the better the rating, the slower (in minutes) the fire will progress. Interestingly, this is the most complicated rating system. Metal siding would have a low (good) flame spread rating. However, because it is a good heat conductor, it has a poor fire rating; this is because combustibles touching it when heated can ignite.[5]

Have a Fire-Protection Strategy

Fire prevention involves separating all ignition sources from fuel sources and minimizing the fuel sources that are present. Storing hay and bedding in a separate building, keeping the barn clean (including free of cobwebs), and enforcing a strict "no smoking" policy are examples of these ideas. Table 1 has an exhaustive list.

Early warning systems should permit notification of the fire service, occupant notification and escape, and timely removal of animals from the facility. Fire detection must lead to fire department notification (alarm, call to dispatch, bells) for an appropriate emergency response to occur, and preferably, it should set off automatic fire-suppression systems (extinguishers, sprinkler systems). Reliable fire detection systems should notify the owners, 911 emergency operators, and/or the nearest firefighting organization with an automatic alarm; many systems also feature an outside noisemaker that can be heard by nearby neighbors (Fig. 6). Most readily available smoke detectors (photoelectric or ionization types) for household use do not perform well in the humid and high particulate environment of barns; instead, carbon monoxide, flame, or "rate of

Table 1.

BARN FIRE PREVENTION:

Invite the local fire department to visit facility and point out problems with fire prevention.
WRITE down and then PRACTICE an evacuation plan at least monthly, with all boarders and personnel that visit or work at the facility.
Ensure there is plenty of ventilation under, over and around hay storage, and that it is properly dried and cured.
Manure piles that are not properly turned for composting can also catch on fire, composting should be done away from the barn.
Build the barn out of the most non-combustible materials affordable (metal siding, concrete block walls, fire retardant treated lumber and fire-resistant insulation.)
Keep barns clean and free of dust, cobwebs, trash, oily tack or hoof cleaning rags, soiled paper towels and other easily ignited fire hazards.
Hay, bedding, gasoline, oil products, scrap wood, tractors and vehicles should be stored in a separate building location.
Consider alternate bedding choices to straw that will slow the development of flames.
Any place you can put up a solid, non-flammable wall to compartmentalize the building will delay a fire.
Install a grounded lightning rod system to protect the barn during electrical storms.
Periodically have a certified electrician check and update the electrical system.
Make sure large fire trucks can get to the barn down the driveway.
Smoke Alarms, Flame Detectors, Heat "rate of rise" Detectors, Sprinkler Systems and Carbon Monoxide alarms must be considered as a system.
Use flame-retardant building materials and outfit tack rooms, lounges and apartments in the barn to the life-safety code level.
Provide 2 exits - build stall doors that lead to the outside as well as the inside of the barn, small paddocks built outside each stall are even better.
Electrical wires should be in conduit and to the fire codes used for commercial buildings.
Turn off all appliances when no-one is in the building (coffee makers, water heaters, vacuums, heaters, fans, radios etc.) or make sure they are safely wired to turn off or pop a fuse if overheated. Hire a professional electrician to evaluate old wiring.
Fire extinguishers should be at both ends of the barn and in the middle, they should be inspected regularly for charging and people should learn to use them properly.
Leave a leather halter on horses in stalls and a leadrope on the outside door of each stall.
If there is a pond or lake or hydrant to draft water from nearby, clear a path to it for fire department vehicles.
There should be a phone in or near the barn to call the fire department.
Stall the most valuable, oldest, weakest and most likely to panic (youngsters?) horses so they can be removed first from the barn.
Have adequate holding pens or an area where horses can be properly confined when removed from the barn.
Train horses to deal with noise, bright flashing lights, during simulated evacuations, etc.
Cell phone, flashlights, extra batteries, and portable generators are all good resources.
The more exits available to the barn and the stalls, the better the chances of getting the people and the animals out.
"No Smoking" signs and a designated smoking area outside should be set up with sand buckets for cigarette butts.
Obstacles should be removed from the barn aisles for quick exit in case of an emergency, for both animals and people.
Aerosol spray cans left in the sun can build up heat and pressure. This can cause a fire if they explode, this can occur with flammable liquids (alcohol, etc) in tight spaces like tack boxes.

PLAN OF ACTION:
CALL THE FIRE DEPARTMENT BEFORE YOU DO ANYTHING ELSE!

Have someone use the ABC rated fire extinguisher at the base of the fire.
People and horses can die from the roof collapsing on them and smoke inhalation, do not allow anyone to go into a burning building especially down the interior aisle.
Try to keep calm – panicked, screaming humans will terrify horses.
Have someone catch, halter and lead each horse individually from the outside door of the stalls and lead them to a safe paddock, roundpen or pasture away from the fire.
Horses should never be let out of a stall loose – in their frightened state they may run back into the barn to their deaths, or run out into the road to be run over by a responding vehicle.
Do not attempt to recover anything (tack, books, pictures, valuables, etc) from the barn – they are not worth your life.
After all horses are removed from the barn, EVERY HORSE should be hosed down, burning cinders unseen in their coat have been known to smolder for hours on rescued horses that were later euthanized from the burn injury.
Obvious burn injuries should be treated by a veterinarian. The less obvious and insidious injury may be smoke inhalation damage to the lungs, causing a fulminate pneumonia days later. Every horse should be evaluated by a veterinarian.

WILDFIRE PREVENTION:

If possible, buildings should be at least 15m or more from one another to reduce the chance of a fire in one building spreading to another.
Clean roof surfaces, trim shrubbery and clean gutters regularly.
A "fuel break" should be a weedless, brushless cleared area for a minimum 17m perimeter area around all facilities, and preferably a 33m defensible space.
Identify two retreat and evacuation routes from the property.
Clear a 33m firebreak around the barn.
Add lightning rods to the barn by a professional installer.
Place charged fire extinguishers at each entrance, in the feed and tack rooms, approximately every 18m down the barn hall.
Place halters and lead lines in a location that is quickly available in the dark and for strangers. Keep lead lines attached to halters.

continued

Table 1. (continued)

BARN FIRE PREVENTION:
Make sure latches and fastenings on stall doors and barn entrances are in quick and working condition.
Consider marking stalls clearly with glow in the dark or reflective lettering which can be seen in limited lighting.
Install frost proof water hydrant at the entrance to each barn. Make sure that the hose, stored at the hydrant, is long enough to reach the far end of the barn.
Fuel tanks should be located at least 12m away from buildings. Make sure the tanks are properly grounded and that there are fire extinguishers near the tanks.
A list of all emergency telephone numbers; police, fire, hospital (vet and human) EMT, poison control should be available at various locations on the farm.
Wildfire fighting tools to have on hand at your facility should include:
A ladder long enough to reach the barn roof in case of a roof fire
A minimum of 100 feet of pre-connected hose with a spray nozzle
A shovel for clearing vegetation and throwing dirt
A rake for clearing vegetation
Fire extinguisher suitable for use on grass fires
Water buckets
A battery powered radio for monitoring news reports and emergency evacuation broadcasts
Keep these items together in an easily accessible place. Don't let the tools be used for any purpose other than fire fighting. Mark them with red paint if necessary. Make sure everyone who lives, works or boards at your barn knows where the cache is located.
PLAN OF EVACUATION:
Having a plan of action ahead of time - practicing it is the only chance you'll have to be somewhat rational and clear-headed during the panic of a fire.
Keep a halter and lead rope on every stall door to speed up evacuation efforts.
Post directions to your barn next to the telephone, so that if it's safe to call the fire department from the barn, the person who's doing the calling will be able to read them.
Have your fueled up, hitched, cleaned out truck and trailer pointed down the driveway during fire season.
Once you have a plan, call the fire department on the non-emergency line and invite them out to review your plan and procedures.
Many fire departments, especially rural ones, are open to learning how to halter, lead, and handle horses.

rise" temperature change detectors should be used in animal facilities.

Construction of facilities should be designed to limit fire spread, maintain building structural integrity as long as possible, and maintain fire escape routes for a specific period of time. Common methodologies to reduce the chance of failure of a system to detect and alarm would include (1) an inspection, testing, and maintenance program for the system, (2) active monitoring, (3) design redundancy, and (4) use of the simplest system that can provide appropriate coverage.[11]

Fig. 6. Fire alarm siren and visual strobe light in conduit in a barn. Photo courtesy of Tomas Gimenez.

Have an Evacuation Plan

Risk-reduction efforts include a written fire-safety plan and annotating changes on the to-do list. Insurers or the local fire department will walk through facilities and barns with owners to identify hazards and give suggestions for reducing fire risk. Large public riding and show facilities are inspected at least twice yearly; regular inspections are a good idea regardless of the size of the operation or local enforcement. Make a written fire evacuation plan and routinely practice that plan. It is recommended that owners practice one time per quarter. Public facilities and boarding barns should practice a fire drill and review the evacuation plan one time a month to ensure that new boarders, employees, and students are well prepared.

Facilities should have an alternate place to put horses instead of just leading them out of the barn and saying, "Now what am I going to do with the horse?" Locate a paddock, pasture, neighbor's farm, or other structure (round pen, horse trailer) in which to put the horses. Practice that evacuation plan to find the weaknesses within it. Another benefit of this planning cycle is that it will force facility

Fig. 7. Horses in this barn have egress through doors to the inside aisleway as well as to the outside. Dutch doors or paddocks off of each stall are highly recommended to allow responders access to animals even after smoke and fire are present. Photo courtesy of Dr. Tomas Gimenez.

owners to get the local fire department to come out and get involved; after all, they are the professionals that can point out individual problems to consider with prevention.

Improve Facility Design and Fire Prevention Management

Any structure can burn, and few barns have after-hours security or appropriate detection and alarm systems, which can lead to late response. In one reported case, no one realized that the barn was burned until the fire was out the next day. Most stables are long and narrow containing from 4 to 60 stalls, and many have Dutch door arrangements with the lower half of the stall door closed, leaving the top half open for ventilation. Few have rear stall doors in the outside wall leading from stalls to the open or to a paddock of various sizes as in Figure 7. Doors are better than windows in stalls, on both the inside and outside walls, to provide two possible exits or egress points.

In stable construction, people tend to think about convenience and comfort for their horses and humans; their barns have been turned into an extension of the house with air conditioning, heating, and electrical appliances like fans, TVs, coffee makers, and hair dryers. Fire prevention, protection, and suppression considerations might not be foremost in the agricultural building designer's mind but should be insisted on. For barns already built, owners should consider retrofitting to improve detection and fire suppression methods to allow fires to be slowed or extinguished. Installation of frost-free water hydrants with long hoses, alternative water sources for the department to draft from (pond, cistern, or pool), hydrants, or stand pipes should be marked and unobstructed.

Fire walls, which are defined as completely sealed and as providing 1 h of fire protection, are required for human living spaces along with smoke detectors, heat detectors, and carbon monoxide detectors, depending on the jurisdiction and common sense. Fire curtains that break up the open space in the roof trusses into compartments and thus, slow the transfer of superheated air and smoke through the loft space are highly recommended, and they will prevent the truss area from becoming a tunnel for the travel of the heat and flame.[5] A related idea is to build multiple smaller buildings (as often seen at stalls for racetracks and large show facilities) instead of one large connected one, because this is the ultimate in compartmentalization of the facilities.

Particulates in the air (dust, fines) will set off most common household smoke detectors regularly so they may not be appropriate for most barns, but they can and should be used in any living areas, tack rooms, and other enclosed spaces. Ventilation is important for the health of stalled animals on a daily basis, and it also increases their odds of survivability in a fire. The NFPA recommends roof vents as an effective method for ventilation of fire-removing noxious gases, superheated air, and unburned gases. Common options include continuous open-slot ridge venting, louvered or heat-activated

vent monitors, or vents designed to melt, collapse, or spring open at pre-set temperatures (usually 100°C).

Barns should be designed so that there is a doorway leading directly outside within 30 m of travel distance of all portions of the building. It must be possible to exit from any point in the building in at least two directions; dead ends >9 m are not permitted by national code. Travel distance may be increased to 46 m when the barn is of masonry or masonry-veneer construction and is protected by an automatic sprinkler system.[9]

10. Learn From Actual Incident Analyses

Scenario 1

A barn in Texas has 80 horses. At 3:15 in the morning, someone driving by sees smoke and calls the fire department. No one is in the barn. However, this facility's owner had worked previously with their local fire department so they were familiar with the directions to the facility, the basic layout of the barn, and the location of the paddocks. This barn used wood shavings in stalls, had an evacuation plan, and working fire extinguishers were available. (Lead shanks and halters were kept by each horse's stall.)

The Incident Commander on scene reported that "keeping those horses from returning to the barn was really difficult." Because horses are prey animals, running back into a burning barn when frightened is their reaction to fear and confusion. Their 10 × 10-ft stall becomes, over the many hours and years that many animals spend in it, their safe haven. Some owners keep horses in stalls 12–24 h a day; those horses get fed in those stalls, and their buddy is right next door. The stall becomes the place where they are left to themselves, and they get used to it despite natural instincts to be in the wide open spaces. People are running around trying to catch and halter the horses, secreting fear sweat, and screaming "Fire!" The fire department is responding with their lights and sirens. The horses are panicked, and they respond by going back to their safety place. They will consistently try to run back into their stalls, and therefore, it is necessary to have a safe and sturdy place to put them (round pen, paddocks, etc.) that will not be affected by heat and cinders.

In this fire, 9 of 80 horses died (11%; 8 horses and 1 pony). The responders were able to get the rest out, and veterinary assistance arrived promptly.

Scenario 2

In Athens, Georgia, a barn with 37 horses had a fire start at 2:00 in the afternoon; six people were present in the barn.

Somebody was smoking while another was handling flammables in the wash rack, which subsequently ignited the non-fire retardant insulation. The fire crawled up into the roof insulation and then, flashed over within 4–6 min. All six people ran out of the barn and opened every single stall door as they left.

How many horses left their stalls? None. People did not put halters on any of the horses and take them out. They did not have an evacuation plan. The fire extinguishers in the barn were outdated; two did not work at all. A true "no smoking" policy should be implemented in every barn but having signs that warn people not to smoke may not be sufficient. Obviously, there was not an enforced smoking policy, because someone was smoking in the barn next to someone using flammables in the wash rack. The facility had not practiced any evacuation or emergency reaction plans.

This barn had a common design used in the South—a very long, large open hall down the middle of the barn and all the stall doors face the interior hallway. The metal roof covered the entire wood structure (stalls, doors, roof joists, spacers, and poles). Along the outside wall from 1.2 to 2 m up, there was hog wire along the length of the barn for ventilation.

Animals in barns are standing in combustible bedding, eating combustible forage, and living next to combustible walls; they are only able to lift their head 2–3 m above floor level. (An animal does not voluntarily breathe smoke; they go to a window or area to find the cleanest air.) Recent experimentation with practical demonstrations/firefighter trainings included simulating smoke and then practicing evacuation of horses in a fire-drill situation. Researchers found that in these scenarios, every horse went right to the window to get air; if air was not available at the window, they lowered their head to find it at ground level.[b] The window or door is where the bodies of animals burned or dying of smoke inhalation can be expected to be found.

Every dead horse in the Athens, Georgia fire was found right up against the outside wire wall as in Figure 8. This horse shows that the fire burned so hot that it essentially cremated much of the body; only the large abdominal organs were not consumed in the conflagration. Firefighters have reported that if one touched the burned bones in the picture, they would simply crumble into powder. A trailer with hay and a truck, parked >80 ft from the barn, caught on fire, and the tires on the truck actually melted off.[c] In this barn fire, 35 of the original 37 horses died, representing 94% mortality and total loss of contents and facility.

11. Review the Anatomy of a Horse Barn

Even concrete buildings can burn. The wooden rafters/trusses supporting the roof are combustible as is the bedding on the floor of the stalls, forage, rubber mats, and wooden doors on the stalls. Concrete actually contributes to insulation of the heat after it starts, because it contains the heat within the walls. Steel rafters are subject to the heating effect of the hot air trapped under a roof, and they will weaken and fail.

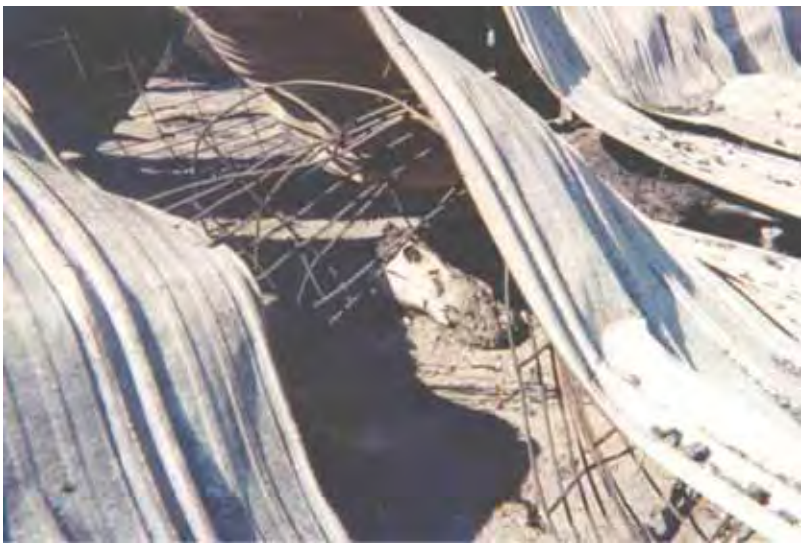

Fig. 8. The body of one horse in the Georgia fire is lying next to where the outside wall used to stand. Note hogwire and metal roofing. This facility was a total loss. Photo courtesy of Melinda Dennis.

The most common horse barn layout has the stall doors opening to the interior hallway as in Figure 9. This design is solely for human convenience, so that the employees or owner can move down through that barn efficiently to feed, water, and muck stalls. All of this work can then be completed without exposure to weather and precipitation (Fig. 10). Numerous do-it-yourself barn-building books and references promulgate this to be an efficient barn design, whereas others make note of the necessity of stall accessibility to the outside.[12] Modern barns, even privately used facilities, are commonly built on a grand scale, ranging from 25 to 100 m from one end of the barn to the other; however, they are sometimes built without escape routes for personnel or animals along the sides.

Most fires start within 1 m of the ground (flicked cigarette butt in stall bedding or insulation or a sparking electrical fire at the outlet in the wall), and flames climb quickly into the roof spaces through insulation or combustibles. The intense heat and sparks are trapped under the cap-like (usually metal) roof, and as the heat increases, the combustibles begin to burn. After the roof joists or rafters

Fig. 9. The interior hallway of a well-constructed horse barn with post and beam. Note the safety features: all electrical in conduit, fire extinguishers, multiple exits, emergency lighting, ventilation, and easily opened latches. Photo courtesy of Tomas Gimenez.

Fig. 10. The interior hallway of another well-constructed barn showing metal-rafter construction, hoses, doors to both the interior and exterior wall, and wide aisleways. Photo courtesy of Tomas Gimenez.

start to burn or weaken and eventually fail, the entire roof will collapse into the interior hallway, and this represents the greatest hazard to responders trying to remove animals. Ventilation, suppression, and compartmentalization are key to slowing the heat release and propagation of fires in enclosed barns; this allows time for the fire department to respond and people and animals to be removed safely.

12. Look for Lightweight Wood-Truss Construction

The tendency for the above scenario is further complicated by modern building methods called "lightweight wood construction" as opposed to post-and-beam heavy timber construction. In an attempt to have roomy and more open facilities, wider clearspan and open arenas, and 5–7 m barn aisles, this kind of engineered construction using gusset plates or joint connectors has been adopted around the United States. Instead of using many nails, the gusset plates hold together the rafter roof joists. It turns out that they are so strong that less wood and nails are required to hold up the roof of the barn. This makes the construction costs cheaper, and more clearspan or cantilever can be made available as in this 80-ft clearspan with gusset plates in Figure 11.

The builder informs the joist company of the size of the rafter and the span, an engineer or computer program determines the number of joint connectors and orientation of the lumber needed to make the joist, and then, the lumber and plates are put into a press that drives them into the wood. Amazingly, those plates are engineered to be so effective that a 120-ft clearspan arena is possible. Builders are able to do things with spans that they could never do before, but they forgot about safety in fire.

Metal absorbs and conducts heat much faster than wood. The heat rising in the burning barn causes the metal to conduct (it has a poor fire rating) heat faster than the wood (which has a better fire rating) in which it is pressed. The hot metal singes the combustible wood, which eventually will fall out. If the wood is not fully cured, water remains inside the wood cells and turns into steam, literally blowing the gusset plates out of their position in the wood. When that happens, the whole truss fails, forcing the surrounding trusses to bear more of the loading weight of the roof. Eventually, those trusses will fail also, collapsing into the interior hall.

13. Getting Animals Out of the Barn Safely

If the barn is burning and people arrive, should they attempt rescue? The answer is maybe, if the animals can be accessed from the outside wall. However, never allow someone into a burning building or down an inside aisleway. The guilt associated with this decision can be devastating to any animal lover, but human life must be the priority. No one should try to be the hero, running down the interior hall to save all the horses. Cooperate with firefighters and law-enforcement officers. Human safety and the

Fig. 11. Joist connectors or gusset plates. Photo courtesy of Tomas Gimenez.

safety of other civilians and emergency personnel is their paramount concern, and if they are spending time worrying about humans, they will not be able to assist the animals.

Firefighters are trained to look at the color and density of smoke to determine the burning conditions. Thick, black smoke tends to be produced by lower temperature fires, but they still never enter a burning structure without appropriate clothing, boots, and lung protection. There are professionals offering training to horse facilities and emergency responders in evacuation and response.[d,e]

Try to remain calm and alert; think clearly, and act decisively. Notify the fire department (correct address and directions to the barn can be typed on cards, inserted in a plastic holder, and tacked to the wall by the phone, making it easier and faster to give correct directions to the fire-department dispatcher). Many times, the person giving directions to the dispatcher will be understandably upset and nervous, which delays dispatch.

Start to remove as many horses as possible from the immediate danger area. Do not try to rescue horses trapped in burning stalls. Sadly enough, most of these horses will die from smoke inhalation, even if freed. Rescue only those horses that can be reached safely and prioritize to get the ones that can be easily saved. Pay attention to conditions and fire behavior. Watch for sudden changes in wind direction or speed, a dramatic change in air temperature or humidity, and changes in the amount of smoke and ash or burning embers dropping. When that changes, it is time to get away from the barn.

Firefighters have recommended that no matter what the animal looks like when it comes out of the barn, remove any "horse clothing" and hose it down from the tip of the nose to the tip of the tail. They further note that synthetic halters or other items commonly melt onto the horse; a handler should hose these items on the horse, but a veterinarian should remove them. Owners should consult a veterinarian immediately for aftercare because of airway complications from smoke and toxic fumes.

In one Kentucky fire, only one horse of the original twelve survived, and severe injuries required >$30,000 in treatment (Fig. 12). The other two horses brought out alive that day had cinders that had fallen on their hair coats. Unfortunately, no one realized how severely burned those horses were until later. The cinders burned under the hair surface and slowly spread, and the horses had to be euthanized soon after the fire.

Fig. 12. The horse, Phoenix, that survived this fire had severe burns over most of the dorsal surface of the body and face. Photo courtesy of Dr. Nathan Slovis.

Fig. 13. Typical wooden horse barn. Photo courtesy of Tomas Gimenez.

14. Worst Case Scenario

You and your staff arrive at a barn that has smoke pouring from the back entrance, and flames are starting to flicker on the outside walls similar to those in Figure 13. The building has only windows in the outside wall. You can hear horses kicking and screaming inside. Is there any possible way to save the entrapped horses?

Firefighters recommend removing the outside wall below the window, possibly with a chainsaw or axe. (Do you own these tools and know how to use them?) First, the horse must be haltered to prevent it running loose around the barn to the interior burning hallway and back into its stall. Think about how to contain or drive the horse out of the barn down a chute/funnel to a paddock or pasture. At the 2005 Fair Hill fire in Maryland, four of the horses that were saved (24 were lost) were brought out of outside-facing stable doors by responders and vet technicians that came to the scene.

A facility with stall doors to the inside hallway and stall doors to the outside should be the industry standard.[f] If firefighters had access to the horses from the outside, they would be able to make better decisions about getting those animals out in a safe manner for both the rescuers and animals. An even better option would be to put paddocks outside each door. That way, the responder can open the door, let the horse out, shut the door, and put a halter on the horse; this way, the horse is already confined and away from the building.

Provide Accessibility for Responders

Ensure that a 20-ton fire engine can access the facility and property, including all driveways. Fire trucks are large and hard to turn in small areas, and they require hard ground to support them all year long. Many facilities have a reflective sign with the address at the road to prevent responders from missing the address, especially in the dark.

Scenario 3

A four-stall barn catches on fire. The owners see smoke from their house and call 911 in the first moments of ignition. The fire department responds within 3 min. Unfortunately, they cannot get their fire truck into the fancy gate or down the winding driveway to the barn. None of the horses are saved.

Swimming pools, fire hydrants, stand pipes, and ponds should be unobstructed so that the fire department can use them as water sources. If using a pond or pool to draft from, there should be stable, hard ground for truck access and <7 m vertical distance between the surface of the pond and the fire truck.

No one should be allowed to park in fire lanes and building access areas at any time, because the minute or two that it takes to find keys, start a vehicle, and move it are precious. Minimize the use of vehicles inside the facility and have designated parking well away from the facility to minimize the chances of the gasoline in the vehicles catching on fire.

The first thing the fire department will do is turn off any electrical power. Make sure there are flashlights or alternate power to provide lighting outside the facility. There should be a map or drawing of the entire property filed with the local fire department and a copy posted outside the facility. All water, gas, and power sources, animal confinement areas, and alternate water sources should be clearly marked on the map so that responders may more quickly determine their options.

15. Update the Electrical Service

Faulty electrical wiring and connections are one of the leading causes of agricultural barn fires, according to data reported by the NFPA. Because it is impossible to render any facility fireproof, management must enforce a program of prevention and train employees in mitigation techniques.[13,14] Hire

Fig. 14. Poorly designed and managed electrical service in a 12-stall horse barn. Photo courtesy of Tomas Gimenez.

a qualified electrician and check for the following items.

Electrical service boxes should be in a dry, dust-free location and mounted on fire-resistant materials. The light fixtures should be free of dust, cobwebs, chaff, or combustible materials (Fig. 14). Clean the dust out of electrical appliances such as fans and heaters. Lightning-protection systems (lightning rods) should be installed by a professional and correctly grounded to allow harmless dissemination of the energy in a lightning bolt to the ground through a heavy-duty conducting cable. Keep heaters or heat lamps clear of combustibles, away from high traffic areas, and out of reach of livestock and children. Any type of heater should only be used with supervision at all times and unplugged otherwise.

Check the wiring for all appliances and light fixtures in the barn (including electric heaters for water buckets, tank heaters, etc.). Lighting fixtures should be Underwriters Laboratories (UL) listed.[15] One person reported that their 300-gal plastic tank had the tank heater pushed against it and caught fire, burning down to the level of the water.[f] Horses can theoretically get electrocuted by these products, because water and electricity do not mix. The better tank heaters fit through the drain at the bottom, making it harder to access. However, in very cold climates, the floating heaters are necessary to keep ice from forming.

Minimize the use of extension cords; instead, install enough electrical outlets for all of the appliances (clippers, heaters, microwaves) that will be loaded onto the circuit. If an extension cord must be used, use a heavy duty cord. Disconnect coffee pots, radios, heaters, fans, portable heaters, and other electrical appliances when not in use. Do not run electric cords over nails as hangers. Cage all electric light fixtures, especially those above horses, to prevent damage or shorts, and make sure that horses do not have access to anything electrical.

Install a main shutoff switch near the entrance/exit so that anyone responding to a fire can turn off the power to the barn. Modify your electrical system to allow power to the buildings to be turned off without cutting off power to the water pumps and sprinkler systems (if installed). It is also not a bad idea to have another power source supplying power to external lights, which are placed well away from the barn but will allow for a place to "gather."

Electrical wires should be in conduit so mice cannot chew through the protective insulation over the wire and spark an electrical fire. Metal or PVC conduits should be used for every inch of the wiring from one box to the next. Use of plastic-covered wires is asking for trouble. If wiring is already installed, check it periodically for worn and hot spots. Make sure the electrical service to the barn is heavy duty and that fuses are correct for the electrical load they are asked to carry.

16. Install Sprinkler Systems

The best thing to invest in for equipment to prevent a total loss and the single best proven method of fire suppression after detection is to install a sprinkler system. Sprinkler systems and fire-suppression methods have been proven to extinguish or slow down fires in barns that have them. Water-pres-

sure availability is the crucial factor to the functioning of this system, and it may require a separate tank and pump to maintain sufficient pressure for the system to work. Obviously, this increases the costs associated with the system, but compared with the value of the facility and animals, it is a minimal cost. Sprinkler heads are individually activated by heat and deliver ~25 gal/min onto the source.

In some climates, a "dry" versus a "wet" or precharged system must be used to prevent the water from freezing in the pipes. Automated sprinkler systems of the wet or the dry type, depending on water pressure and geography (cold), should be installed and maintained. Moreover, it gives people and responders time to rescue the animals.[15] The initial cost can be high. However, many insurance companies will cut premiums by as much as 50%, and this is a depreciable expense. Over the long haul, the owner will save money, especially if the animals within the facility are considered valuable. Savings can be in the thousands of dollars. A sprinkler system can be an asset, but make sure that the water pressure in the barn can handle the needs of the system. According to the NFPA, ~93% of fires where a sprinkler system existed have been controlled or extinguished.

Wet-pipe systems (constantly charged with water) are cheapest and require less maintenance. In most areas of the United Stated, dry-pipe systems must be employed where the climate drops below freezing. Pressurized air or compressed nitrogen fill the lines until the sprinkler head is activated by fusible links. Then, the air is released, which primes the water into the pipes and douses the fire similarly to the wet system. It is a more complicated and thus, more expensive system than the wet-pipe systems.

Future applications of a current technology used in Europe and maritime applications include the water-mist systems where water is highly pressurized to produce finer water droplets with up to 25% less water. Currently, insurance companies do not rate premiums based on this rather expensive system, but in the future, it is hoped that technology advancements will be cost effective for livestock facilities.

17. Use Early Warning Devices

A rule of thumb used in the firefighting profession is that fires involving combustible materials (wood, straw, hay, shavings, etc.) will double in size every 1 min. Therefore, in 10 min, a small fire will increase in size 4086 times, and this emphasizes the need for both fire prevention and prompt action when faced with actual incidents.

Owners should work with a professional alarm company to install an alarm system that is thermally (heat) activated throughout the open part of the facility. These warning devices are highly reliable and activated by heat at a pre-determined level. One disadvantage is that they have to be in close proximity to the heat source to dependably activate. This may mean that the fire is in later stages of progression before it sets off this type of alarm, lessening the time to respond. Fixed-temperature line thermal detectors are recommended for barns to increase the floor area coverage at a minimal cost.[5]

Flame detectors are an expensive option, but the most reliable of all warning devices. Simulating the human eye, they look only for the electromagnetic radiation signature emitted by flames, thus minimizing false alarms. Rate-of-rise heat detectors are less expensive and highly reliable options for horse barns.

The familiar smoke alarm mimics the human sense of smell and gives earlier warnings. Unfortunately, it is necessary to keep them free of dust to avoid false alarm, which is unrealistic to impossible in the high-activity, animal dander-filled, dusty, and humid environment of a livestock barn. Both photoelectric and ionization types of smoke detectors are excellent and provide very early detection when used in low-dust parts of the barn such as tack rooms or other enclosed facilities (office, lounge, living spaces). Smoke detectors of either type should be installed and maintained there. These are common starting places for fires because of the electrical appliances commonly used.

The fire department can provide referrals to installation professionals familiar with livestock facilities. All the early warning devices do no good if they are not hooked into the 911 system, a professional monitoring service, family, neighbors, or straight to the local fire department. When properly used to alert humans, they provide essential time to allow for fire-suppression efforts and the removal of animals from the barn safely.

A mechanism for automatically releasing horses by the electric fire-alarm impulse is described as early as July 9, 1889 (U.S. Pat. No. 406,629).[16] This mechanism does not, however, employ state-of-the-art detection and controlling systems. Therefore, an updated patent invention as a method for saving lives of animals in a fire situation in a stable is U.S. Pat. No. 5,652,563 (patented on July 29, 1997): "doors in all stalls should be opened immediately . . . a safety system should be installed in the stable, including smart detectors installed in the stable for detecting at least one abnormal condition in the stable; an irritant means installed in each stall for spooking horses out of their stalls; and a controlling unit continually monitoring the detectors."[16] This is accomplished with electro-magnetic locks, solenoids, actuators, and gravity doors built into the design of the barn.[16] Similar ideas are beginning to make their ways into designs for horse facilities and should be encouraged, especially in public and large private facilities.

Fig. 15. Practical demonstration of blindfolding and leading from simulated smoke in a barn. Photo courtesy of Jeff Galloway.

18. To Blindfold or Not to Blindfold?

For horses that refuse to be lead out of a stall, a blindfold is a last resort, because horses may or may not tolerate it. Inexperienced personnel should not attempt to lead animals that require a blindfold if there is a better option such as a light crop or paddle (Fig. 15). Clients and veterinary staff should practice leading and handling skills of horses in simulated scary situations so that they will be better prepared to handle horses in real scenarios.

If used, a blindfold should be fastened so that it will fall off if the person leading the animal loses control of the animal. If a panicked horse gets loose with the blindfold still on, it will run in a straight line in fear until it hits a solid object or falls. Obviously, this puts people and the horse in danger.

Fig. 16. Public horse barn built with fire safety in mind: open ventilation, frost-free hydrants, and 33 m of defensible space around the structure. Photo courtesy of Tomas Gimenez.

Fig. 17. Veterinary triage team of veterinary medical assistance team (VMAT) and special medical assessment team-veterinary (SMART-V) members evaluating horses at a mock evacuation facility. Photo courtesy of Rebecca Gimenez.

If someone lets horses out of a burning barn like it is shown in the movies and they do not run back into the barn, they will run down the road and hit the fire truck or other traffic that is responding to the incident, which multiplies the tragedy of the scenario.[f] Smoke does not frighten horses; it is the sight and sound of panicking humans and crackling flames that panics them. After the horse is out of danger, it can be turned loose in a corral, pasture, or arena that is far enough from the flames to be safe. Do not tie horses unless absolutely no other option exists. If a horse must be tied, the loose end of the lead rope should be tied above the level of its head at the highest it can raise it, and there should only be enough slack to allow it to put its head down level with the withers.

Fig. 18. When removing animals from a barn fire, ensure that the handler has good control of the animal which will be exposed to many new sounds, smells and sights. Here a horse is led to a waiting equine ambulance while firefighters respond to the incident. Photo Courtesy Dr. Tomas Gimenez.

19. Wildfires Affect Barns

When choosing to live in an area subject to wildfires that might contribute to a barn fire, owners must have a better evacuation plan than to walk their horses (two at a time) down the street. Although not the focus of this paper, there are new disaster resources and courses available for owners.[17] Barns should be designed with wildfire in mind (Fig. 16). Providing sufficient defensible space around the barn structure allows fire crews to protect it from falling cinders and direct flames in a shelter-in-place scenario where there is not time to evacuate the animals to a safer place. Table 1 provides a good list of prevention strategies for facilities and properties threatened by wildfire.

Some states have finally taken large-animal issues and evacuation more seriously after years of trying to educate livestock owners to evacuate and plan for their own animals. California started setting up veterinary triage points and sheltering facilities in coordination with County Animal Response Teams (CARTs) and humane organizations during wildfire disasters in 2003, and it has consistently used them every year (Fig. 17).

Only use fire-safe gear; avoid synthetic (nylon or plastic) halters or lead ropes, because these may melt and cause serious burns to animals and handlers. Nylon sheets, fly masks, or other synthetic tack or equipment are bad choices during a fire evacuation. In fact, very few items of horse clothing are fire retardant. Firefighters that respond will protect themselves by wearing protective self-contained breathing apparatus (SCBA) gear, but anything living in the barn is going to be breathing toxic fumes.

20. Conclusion

Veterinary professionals are looked to as experts in preventive horse health care, and they should understand current basic barn fire safety and recommendations for improvements around facilities. Barn fires detrimentally affect equine recreational enthusiasts, horse owners, and practitioners, regardless of geographic location or economic conditions. They are the number one local emergency expected to affect horse owners. Strategies and equipment to mitigate their effects are available and constantly being improved, but they are underutilized within the industry. The effectiveness of detection, alert, and immediate response suppression systems is further emphasized by appropriate equine facility disaster planning and emergency drills. Fire prevention concerns could be addressed as part of the annual visit to client farms as part of prevention and mitigation efforts described in this paper.

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