Avoid Hay Fires – Manage Moisture

by Krishona Martinson, University of Minnesota

Hay fires that damage or destroy hay and buildings cost farmers millions of dollars in building and feed replacement costs, lost revenue, and increased insurance rates. Since 2000, there have been over 900 livestock and poultry barn fires in Minnesota, resulting in over $26 million in damages (Minnesota Fire Incident Reporting System - MFIRS). Although not specifically tracked by MFIRS, some of these fires have been caused by spontaneous combustion of hay that was baled too wet.

Proper moisture at baling is the key to preventing hay fires. Proper management of the curing process and hay storage system is vital in reducing the risk of hay fires as well.

MOISTURE IS THE KEY

Moisture content of the hay at baling is the single biggest fire risk. Hay baled at 15% moisture has minimal risk of fire. As moisture content increases, the risk of DM losses and fire also increase (Table 1).

Table 1. *Effect of moisture on forage quality and fire risk.*

Moisture Ranges (%)	Estimated Storage Dry Matter Losses (%)	Comments
<10	<5	Too dry. Hay may be brittle and dusty.
10 - 15	<5	Recommended moisture range for baling and storage. Minimal risk of fire.
16 - 20	<5	May mold unless propionic acid is used (propionic acid is safe for livestock), slight risk of fire hazard.
21 - 25	8	Will likely mold unless propionic acid is used, moderate risk of fire hazard.
>25	>11	Severe heat damage is likely, high risk of fire hazard.

BALE TEMPERATURE AND THE CURING PROCESS

Due to natural fungi and bacteria respiration, most hay will heat when baled, but the maximum temperature will depend on the moisture content at time of baling. Many refer to this as sweating or curing. Baling at the proper moisture (Table 1) causes respiration to slow and eventually cease, usually within 2-6 weeks, resulting in minimal DM losses and minimal heat produced. However, if moisture levels are greater than 15% at the time of baling, and propionic acid is not used or the bales are not wrapped in plastic, the heat and moisture will provide a more suitable environment for the growth and multiplication of fungi and mesophilic (warmth loving) bacteria that are naturally present in hay. The respiration of these naturally occurring bacteria releases additional heat which may significantly increase the temperature and risk of fire.

Baled hay becomes a potential fire hazard when the interior bale temperature does not decrease. This occurs when the respiratory heat created by the mesophilic bacteria provides a favorable environment for thermophilic (heat loving) bacteria. Respiration from thermophilic bacteria can raise interior bale temperatures to above 170°F. Table 2 lists the effects of internal bale temperature and the potential for fires.

Temperatures above 170°F can lead to a chemical reaction commonly referred to as spontaneous combustion, a unique reaction that requires the correct combination of hay mass, heat (produced by respiration), moisture, and oxygen. Usually, hay will smolder (it runs out of oxygen) and turn black, leading to burned out areas and a total loss of nutritional value.

In addition to maximum temperature, rate of temperature rise should also be monitored and considered when addressing a fire risk. If the internal bale temperature is gradually rising, there is usually minimal risk of fire; if a rapid rise in temperature occurs over a brief time period, the risk of fire is high (Henning and Wheaton, 1993)

Table 2. *Effects of internal bale temperature and fire potential.*

Temperature Ranges (° F)	Comments
<130°	130° will feel warm to the touch, but not hot. Temperature <130° have minimal fire risks and are a result of the natural curing process.
130° - 140°	Temperatures may continue to rise or may fall. Continue checking temperatures frequently.
150°	Temperatures will most likely continue to rise. Move hay away from buildings, restack to provide air circulation, and continue to monitor temperature frequently.
175° - 190°	Fire is imminent or may be present inside the bale. Call the fire department.
>190°	Use extreme caution and call the fire department. Bales may combust when moved.

MINIMIZING THE RISK OF HAY FIRES

Most hay fires occur within 2-6 weeks after baling, but may occur in hay several years old if the hay is rewetted or mixed with newly baled hay. Remember the following tips when buying hay:

- If buying hay out of the field, the moisture content must be known.
- Storage of hay prior to purchase reduces the risk of a hay fire for the buyer.

Buying hay out of the field is common and has minimal fire risk if the hay has been baled at 15% moisture or less. The moisture content prior to baling can be determined by an in-field moisture tester (Midwest Plan Service, 1993). The moisture content of baled hay can be determined by a forage quality analysis, but should be taken soon after baling. Table 3 compares the risks and benefits of purchasing hay from the field and after short- and long-term storage.

Table 3. *Risks/benefits of purchasing hay from the field and after short-and long-term storage.*

Purchased	Risks	Benefits
Out of the Field	1. Risk of spontaneous combustion*. 2. Nutritional value and moisture of hay may be unknown. 3. Buyer assumes risk of hay fire.	1. Hay may be less costly 2. Buying hay out of the field may be a necessity.
After Short-Term Storage (< 6 weeks)	1. Risk of spontaneous combustion.* 2. Hay may be more costly. 3. Hay may be needed prior to the end of the storage period.	1. Time to evaluate nutritional value and moisture of hay. 2. Storage facility assumes the risk of hay fire.
After Long-Term Storage (> 6 weeks)	1. Hay may be more costly. 2. Hay may be needed prior to the end of the storage period.	1. Minimal risk of spontaneous combustion*. 2. Time to evaluate nutritional value and moisture of hay. 3. Storage facility assumes the risk of hay fire.

**The risk of spontaneous combustion exists when hay is baled too wet (Table 1) or if the hay is rewetted or mixed with newly baled hay.*

ADDITIONAL SAFEGUARDS

- **Hay Stacking and Storage.** Hay should be stacked to encourage air circulation (Martinson and Peterson, 2007). Do not pack bales tightly into a small space with limited air flow. Stacking bales on pallets encourages air circulation beneath the bales and can help prevent the bales from wicking-up condensation from the ground. Hay that is baled at the proper moisture (Table 1) can become a potential fire hazard if it becomes wet during storage. The storage area should be protected from rain, including open windows. Mixing piles of newly baled and previously cured hay can increase risk of fire and leads to a decrease in quality.
- **Estimating Moisture and Using Propionic Acid.** Hay producers can estimate the moisture of cut hay prior to baling, with a hand-held forage moisture tester. However, testers vary in accuracy and consistency, and several samples need to be taken for a representative average. Propionic acid can prevent molding when applied at baling to hay between 17-25% moisture depending on bale size (Undersander, 2001).
- **Store Hay Away from Animals.** If possible, store hay in a separate area or building from where animals are housed. This does not reduce the risk of a hay fire, but will limit animal loss if a fire occurs.

QUALITY AND DRY MATTER LOSSES

Fire is not the only potential threat of wet hay. Hay that is baled when it is too wet can have significant dry matter loss (Table 1). Most of the dry matter and quality losses are due to molds and bacteria. Heating can also lead to browning or caramelization, thus reducing energy and protein availability within the hay.

In general, dry matter and quality losses are less at lower moistures and temperatures. A brownish color, caramel smell, dust, and mold are all signs of significant dry matter and quality loss, and may render hay unsuitable for livestock feed.

Moldy hay is especially dangerous to horses. Ingestion and exposure to mold spores can cause colic, heaves, and other respiratory health issues. Moldy hay is also a health risk for farmers. Farmer's lung is an allergic reaction associated with inhalation of dust containing spores and dried fungi. Farmer's lung can be disabling for people, and repeated exposure can cause scarring and fibrosis.

Henning, J.C, and Wheaton, H.N. 1993. Making and Storing Quality Hay. University of Missouri Extension. G4575.

Martinson, K., and Peterson, P. 2007. Buying and Storing Horse Hay. University of Minnesota Extension Service. Fact Sheet M08463.

Midwest Plan Service. 1993. Forage Moisture Determination. NRAES-59.

Undersander, D. 2001. Hay Desiccants and Preservatives. Agronomy Advice FC 12.4.1. www.uwex.edu/ces/forage.

Ogburn, C. 1995. Guarding Against Hay Fires. Alabama Cooperative Extension System. Publication ANR-964.