

Control and Prevention of Hay Fires

K-STATE
Research and Extension

Spontaneous combustion hay fires cost farmers thousands of dollars in lost or damaged feed supplies, buildings, and income every year. Typically, these fires, which are preventable, occur within six weeks after baling. The fires can occur in hay stored inside as well as outside.

What Causes Hay Fires?

Regardless of when or where the fire occurs, the most common cause is excessive moisture. Heating caused by plant cell respiration (the burning of plant sugars to produce energy) in hay bales is normal and generally of little consequence. Heating occurs to some extent in all forage material unless it contains less than 15 percent moisture. However, if bale moisture levels are too high (greater than 20 percent), the heat and moisture create a suitable environment for the growth and multiplication of mesophilic (warm temperature) bacteria that are present on forage crops. Respirating mesophilic bacteria release heat in the bale, creating interior bale temperatures that can reach 130° to 140° F. Within this temperature range, most mesophilic bacteria die and interior bale temperatures start to decline.

Microbial action occurs because freshly cut forage is not dead. Respiration continues in plant cells after cutting, releasing a small amount of heat in the bale. Many producers refer to this elevation in bale temperature as “sweating” or “going through a heat.” In hay that is baled at the proper moisture concentration, plant cell respiration has slowed dramatically and will eventually stop on its own.

The potential for fire occurs when the interior bale temperature does not cool after the first heating cycle. Temperatures rise when the heat created by mesophilic bacteria makes an environment favorable for the growth and multiplication of thermophilic (heat loving) bacteria. The thermophilic organisms multiply and produce heat that can raise the interior bale temperature to 170° F before microbial activity ceases.

This cycle of heating and cooling may occur several times during the weeks after baling as the microbial population increases and decreases. However, the maximum temperature decreases during each subsequent cycle and the interior bale temperature eventually stabilizes near the ambient temperature. Hay that experiences these heat cycles loses much of its quality as a feed source, but is unlikely to catch fire. In some cases, cows may actually prefer the taste of the brown, heat-damaged hay but the nutritional value has decreased considerably.

Reducing the Risk of Hay Fires

Hay moisture concentration is a major factor in the microbial activity that leads to hay fires. Therefore, hay should be cured to the proper moisture concentration before baling. Moisture levels for safe storage of hay vary with size and density of bale and type of hay. In general, hay in small rectangular bales

Forages Series

**John Slocombe, Professor,
Ag Machinery**

**Lyle Lomas, Professor,
Southeast Agricultural
Research Center**

**K-State Research and
Extension**

should be baled at less than 22 percent moisture to keep molding and heating to a minimum. Large rectangular and large round bales retain internal heat much longer than conventional bales. Therefore, hay should be less than 18 percent moisture before baling in large bales. If you are storing or sheltering some of your big bales, this long-term heat retention affects the proper time to move big bales into storage. Hay baled with more than 22 percent moisture should probably not be put into storage for at least 30 days. This is especially true if bales are to be stacked several layers deep. With the threat of barn fires removed by outside hay storage, many operators of large round balers try to bale hay with too much moisture. But excessive heating and molding can cause the loss of as much as one-third of the feeding value of hay baled at 28 percent moisture.

Carefully monitor the weather forecasts before scheduling hay baling operations. Weather conditions during hay curing have the greatest influence on achieving proper moisture concentration. Ideal hay-curing weather is slightly windy with a relative humidity of 50 percent or less. Hay should not be baled in the early morning because its moisture concentration increases overnight when the air tends to be more humid.

Specialized hay equipment can help reduce moisture concentration by increasing crop drying rates, especially during good hay-curing weather. Conditioning equipment crimps or roughens crop stems to break up the waxy outer layer surrounding the stem. Crimping allows plant moisture to evaporate and speeds the drying process. Tedders fluff, spread, or move windrows to improve air movement through the crop. Windrow turning equipment lifts, inverts, and fluffs windrows, allowing the bottom side of the windrow to be exposed to the sun, which speeds drying during good hay-curing weather.

Hay preservatives can cut the risk of hay fires by reducing the growth of bacteria in moist hay. Propionic acid is a liquid that is applied to hay during baling and is the most effective preservative available. However, a tank and a spray application system must be added to the baler to hold and dispense the preservative. Furthermore, spray nozzles must be spaced to distribute the chemical over all the forage as it enters the baling chamber.

The amount of propionic acid needed depends on the hay moisture concentration. Small bales with a moisture concentration between 20 and 25 percent should be treated with about 0.5 percent propionic acid on an as-baled basis. The application rate should be increased to 1 percent for hay with a moisture concentration between 25 and 30 percent. Propionic acid and other hay preservatives may not work for hay with a moisture concentration greater than 30 percent. The main disadvantages of using propionic acid are its corrosiveness and the cost of application equipment. The estimated cost of adding spraying equipment to a baler is \$1,000 to \$1,500.

Hay that is baled at the proper moisture concentration can become a potential fire hazard if it becomes wet during storage. Hay barns should be weather tight with adequate drainage so water will not enter the barn and damage hay during storms. Hay that is stored uncovered outside should be formed into the

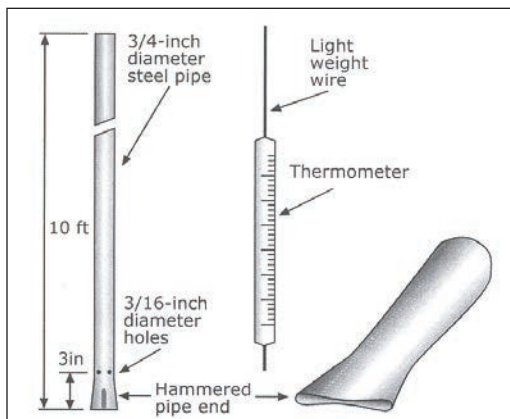


Figure 1. Homemade hay temperature probe with thermometer.

tightest packages possible to resist penetration by rain. Do not place unprotected bales or stacks tightly against each other. Instead, arrange uncovered bales so air can freely circulate around them to promote drying. Protect bales from ground moisture and runoff by placing them on a bed of gravel, old tires,

poles, or pallets. Plastic or other waterproof covers will protect bales by shedding precipitation.

Monitoring Temperatures During Storage

The temperature of hay that has been baled at a high moisture concentration should be checked twice a day for six weeks after baling. Use a probe and thermometer to accurately determine the temperature inside a stack of hay. A simple temperature probe can be made in the farm shop from a 10-foot piece of 3/4-inch diameter iron pipe. Drill eight 3/16-inch diameter holes about three inches from one end then hammer that end of the pipe together to form a sharp edge (Figure 1). Commercial temperature probes are available, but are often too short to monitor the maximum interior temperature zone within a hay stack.

Check hay temperature in the center of the stacked hay bales. The easiest way to do this is from the top of the stack. Do not walk directly on the stacked hay because pockets may have already burned out under the hay surface. Place boards, plywood, or a ladder on the hay to walk on (Figure 2). This will spread the weight of the person monitoring the temperature over a larger area and prevent falling into burned out cavities. Work in teams of at least two people and attach a lifeline to the person checking hay temperature just in case the surface collapses. The second person, standing safely away from the hay, should hold the other end of the lifeline (usually a heavy rope) to pull out the person monitoring the temperature in the event of a collapse.

Drive the probe from the top of the hay stack to the inner most bales (Figure 3). Lower a thermometer to the end of the probe with a piece of light wire. After 10 to 15 minutes, retrieve the thermometer and read the temperature. If the temperature has reached 150° F, it is likely to continue to increase and bales should be moved to create more air circulation and cooling (Table 1). Continue monitoring the temperature every two or three hours.

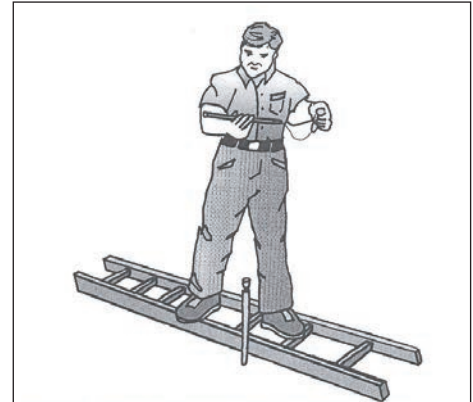


Figure 2. Proper procedure for monitoring hay temperatures.

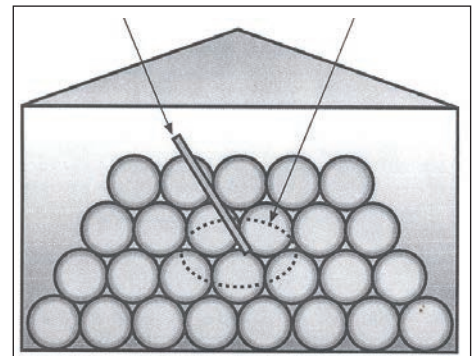


Figure 3. Proper location for inserting temperature probe.

Table 1. Temperature interpretations for hay stacks

Temperature (°F)	Interpretation
<130	Continue monitoring temperature twice a day.
130 – 140	Temperature may go up or down. Recheck in a few hours.
150	Temperature will most likely continue to climb. Move the hay to provide air circulation and cooling. Monitor temperature every two hours.
≥175	Fire is imminent or present. Call the fire department immediately.

Fire is imminent if interior bale temperatures exceed 175° F and fire is present at temperatures greater than 200° F. Other symptoms of hot hay or an internal hay fire include a slight caramel or strong burning odor, visible vapor or smoke, a strong musty smell, and/or hay that feels hot to the touch. If any of these symptoms occur, **call the fire department immediately**. Do not move hay if signs of fire are present. Moving hay exposes the overheated or smoldering hay to oxygen and may stoke the fire.

Hay Fires

In the event of a hay fire, surveying the fire scene is the most important step to ensure everyone's safety. Scan the area surrounding the hay fire. If flammable products (e.g. gasoline, fertilizers, and pesticides) are located nearby, **evacuate the area immediately** and wait for firefighters to arrive. Do not attempt to remove the flammable products.

If there are no flammable products in the area and time permits, there are steps you can take before the fire department arrives.

- For hay stored outside, create a firebreak around the stacked hay by disking a 15-foot wide perimeter around the stack. If water and a high-pressure hose are available, water the hay and the surrounding vegetation to keep the fire from spreading.
- For hay stored inside a building, if the area is safe and time permits, evacuate all livestock from the building. Relocate animals to an area that is a safe distance from the structure. Turn off the building's electricity to prevent an electrical fire. Monitor wind direction carefully. If water and a high-pressure hose are available, water the roof of adjacent structures that are downwind of the fire.

Damaged Hay

Hay that has been damaged by heat, smoke, or water should be removed to a safe location. Use damaged hay as mulch for erosion control on slopes or in gullies. If you are uncertain whether heat-damaged hay is suitable for feeding, have a sample tested.

Publication modified and illustrations used with permission from *Hay Fire Prevention and Control*, Virginia Cooperative Extension Service, publication 442-105, 2003, Gay, Susan W., Grisso, Robert "Bobby", Smith, Ray, and Swisher, Jerry M., Jr.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned.

Publications from Kansas State University are available at: www.bookstore.ksre.ksu.edu

Contents of this publication may be freely reproduced for educational purposes. All other rights reserved. In each case, credit John Slocombe and Lyle Lomas, *Control and Prevention of Hay Fires*, Kansas State University, December 2008.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF2853

December 2008

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, John D. Floros, Director.