

Hay Fire Prevention and Control

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Fires that damage or destroy hay and barns cost farmers thousands of dollars in building and feed replacement costs and in lost revenues. Many of these fires are caused by the spontaneous combustion of hay that usually occurs within six weeks after baling. This publication discusses the cause and prevention of hay fires and provides guidelines to follow when a hay fire is detected.

What Causes Hay Fires?

Freshly cut forage is not dead; respiration (the burning of plant sugars to produce energy) continues in plant cells and a small amount of heat is released 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 cease.

The heat generated by plant cell respiration in hay bales is normal and generally of little consequence. However, if bale moisture levels are too high (greater than 20 percent), the heat and moisture will provide a suitable environment for the growth and multiplication of mesophilic (warm temperature) bacteria that are present on forage crops. The respiration of mesophilic bacteria releases additional heat in the bale and interior bale temperatures can reach 130° to 140°F. At this temperature range, most mesophilic bacteria die and interior bale temperatures start to decline.

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. The interior bale temperature will eventually stabilize near the ambient temperature. Hay that has sustained these heat cycles has lost much of its quality as a feeding source, but is unlikely to catch fire.

Baled hay becomes a potential fire hazard when the interior bale temperature does not cool after the first heating cycle. This occurs when the respiratory heat created by the mesophilic bacteria provides an environment favorable for the growth and multiplication of thermophilic (heat loving) bacteria. The thermophilic organisms multiply and the heat produced by their respiration can raise the interior bale temperature to 170°F before microbial activity ceases.

The thermophilic bacteria and their respiration heat convert the hay to a form similar to a carbon sponge with microscopic pores. This damaged material combines readily with oxygen at high temperatures and can self ignite in the presence of oxygen.

Reducing the Risk of Hay Fires

Hay moisture concentration has a major effect on the microbial activity that can lead to hay fires. Therefore, hay should be cured to the proper moisture concentration prior to baling. Virginia Cooperative Extension recommends baling at a moisture concentration of 20 percent or less for small rectangular bales. Large rectangular or round bales should be baled at 18 percent moisture or less. See *Determining Forage Moisture Concentration*, Virginia Cooperative Extension (VCE) publication 442-106, for more information on hay moisture concentration.

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 is humid. Carefully monitor the weather forecasts before scheduling hay-making operations.

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Using specialized hay equipment can help reduce hay moisture concentration by increasing crop drying rates, especially during good hay-curing weather. Conditioning equipment crimps or abrades crop stems to break up the waxy cuticle layer surrounding the stem. This process allows plant moisture to evaporate and speeds up the crop drying rate. Tedders fluff, spread, or move windrows to improve air movement through the crop. Windrow turning equipment lifts, inverts, and fluffs windrows. As a result, the bottom side of the windrow is then exposed to the sun, which speeds up drying during good hay-curing weather. See *Management Tips for Round Bale Hay Harvesting, Moving, and Storage*, VCE publication 442-454, for more information on hay preparation.

Hay preservatives can reduce the risk of hay fires because they inhibit or reduce 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 handle the preservative. Furthermore, spray nozzles must be spaced so that the chemical is distributed over all the forage as it enters the baling chamber.

The amount of propionic acid that must be applied depends upon the hay moisture concentration. Small bales with a moisture concentration between 20 percent 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 percent and 30 percent. Propionic acid and other hay preservatives may not work for hay with a moisture concentration greater than 30 percent. The two main disadvantages of using propionic acid are its corrosiveness and the cost of the equipment necessary to apply the preservative. 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 and have adequate drainage so water will not enter the barn and damage hay during storms. Hay that is temporarily stored outside should be covered with plastic or some other waterproof material to prevent rain penetration. Uncovered bales should be arranged so that air can circulate freely between bales to promote drying. Protect bales from ground moisture by placing them on a bed of gravel, old tires, poles, or pallets.

Monitoring Hay 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. The easiest way to do this is from the top of the stack. Do not walk directly on the stacked hay; pockets may have already burned out under the hay surface. Place boards, plywood, or a ladder on the hay and walk on those instead (Figure 2). This will spread the weight of the person monitoring the temperature over a larger area and help keep him from falling into burned out cavities. Be sure to use a lifeline in case the hay surface collapses into a fire pocket. A second person, standing safely away from the hay, should hold the other end of the rope to pull the person monitoring the temperature out in case the hay surface collapses into a fire pocket.

Drive the probe from the top of the hay stack into 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, the temperature is likely to increase and hay bales should be moved to allow increased air circulation and cooling (Table 1). Continue monitoring the temperature every two or three hours.

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. Continue probing and monitoring the temperature.

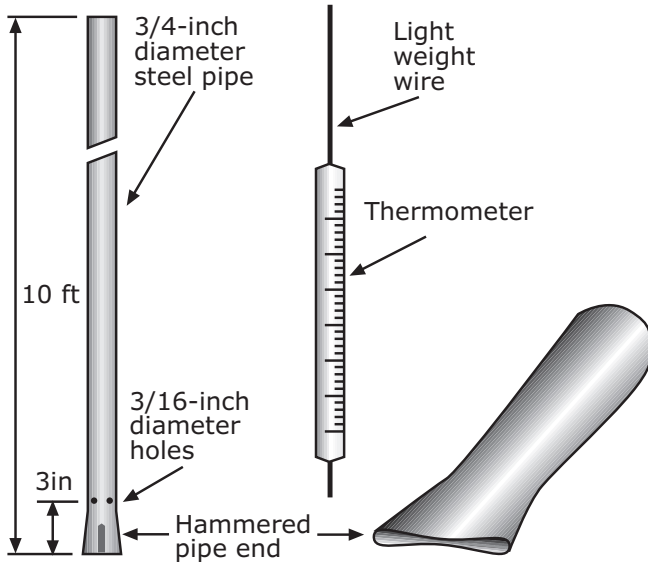


Figure 1. Homemade hay temperature probe with thermometer.

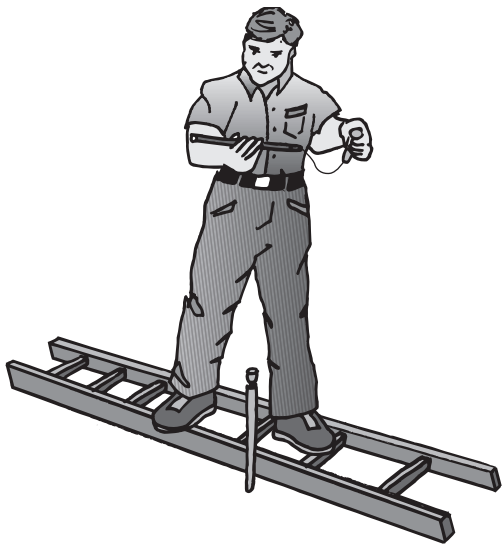


Figure 2. Proper procedure for monitoring hay temperatures.

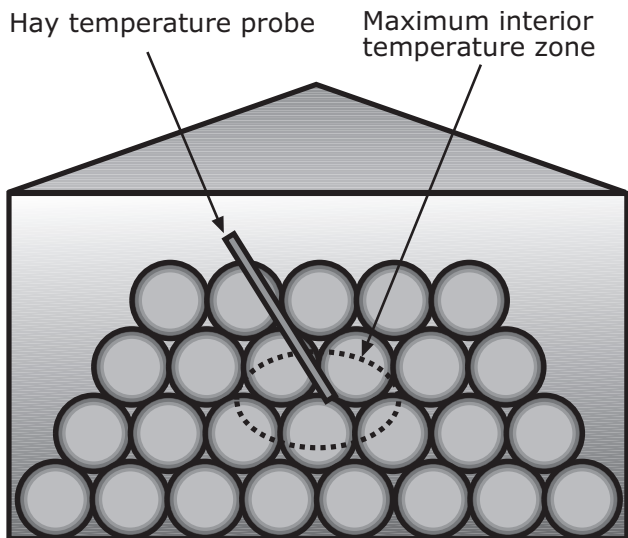


Figure 3. Proper location for inserting temperature probe.

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**. Let firefighters take control of the situation once they arrive. Do not move hay if signs of fire are present. Moving hay exposes the overheated or smoldering hay to oxygen and may cause the fire to burn uncontrollably.

Controlling Hay Fires

In the event of a hay fire, surveying the fire scene is the most important step to ensure everyone's safety. Review the area surrounding the hay fire. If flammable products (e.g. gasoline, fertilizers, and pesticides) are located nearby, **leave the area immediately**. If there are no flammable products in the area and time permits, there are several steps you can take before the fire department arrives.

Hay Stored Outside

Use a disk to create a firebreak around the stacked hay. The firebreak should be approximately 15 feet wide. If water and a high-pressure hose are available, water the hay and the surrounding vegetation to keep the fire from spreading.

Hay Stored Inside a Building

If the area is safe and time permits, evacuate any livestock from the building. Put the animals in a pasture 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 and in gullies. If you are uncertain whether heat has damaged hay too much for feeding, have a sample tested.

Summary

Hay fires that usually occur within six weeks after baling are largely preventable. The risk of hay fire is significantly reduced by curing hay to less than 20 percent moisture concentration prior to baling. Hay temperature should be carefully monitored during the six weeks after baling. If the interior temperature of the hay stack is greater than 175°F, fire is imminent or present and the fire department should be called immediately. Hay temperature should stabilize six weeks after baling and monitoring can be discontinued.

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Additional Information

Forage moisture concentration

“Forage Moisture Determination,” NRAES-59 (\$6.00)

Determining Forage Moisture Concentration, VCE publication 442-106, <http://pubs.ext.vt.edu/442-106/>

Hay Fires

“Extinguishing Fires in Silos and Hay Mows,” NRAES-18 (\$7.00)

“Fire Control in Livestock Buildings,” NRAES-39 (\$5.00)

Hay Preservation

“Silage and Hay Preservation,” NRAES-5 (\$9.00)

Round Hay Bales

Management Tips for Round Bale Hay Harvesting, Moving, and Storage, VCE publication 442-454, <http://pubs.ext.vt.edu/442-454/>

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To order NRAES publications, contact your local Virginia Cooperative Extension office.

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