

# SPONTANEOUS COMBUSTION OF HAY

Article prepared by Mark Hazelton, Feedworks

- ➔ NO HUMAN INTERVENTION in starting the fire
- ➔ NO SOURCE OF IGNITION involved

Culprit is microbial activity, which is the presence of moisture heating the hay to auto ignition temperature.

Spontaneous combustion of hay is simply the reaction of large surface areas of hay with oxygen. This reaction becomes spontaneous / explosive if the temperature is above about 76°C. This temperature is initially attained from microbial metabolism and then later increases because the heat from the chemical reaction of hay with oxygen does not dissipate fast enough.

A hay explosion occurs as a result of the following situation.

Hay is stored at a relative humidity about 76% (all relative humidity figures in this article refer to the relative humidity inside the stack, not the relative humidity of the air outside the haystack). This initiates microbial action. This microbial action produces heat, which raises the temperature of the stack to 76°C. If the relative humidity in the middle of the stack is below 95% then the micro-organisms become inactive and the temperature of the stack drops. If the relative humidity in the middle of the stack is above 97% then the resultant heat of vaporisation of the water dissipates the heat rapidly and the temperature of the stack drops. This explains why very wet silage does not explode. However if the narrow window of 95%-97% relative humidity is obtained, then the micro-organisms continue to produce heat, which cannot escape, which raises the temperature. This temperature rise accelerates the chemical oxidation of the hay, releasing more heat. An ever increasing rate of temperature rise is obtained, ie **bang** – one haystack fire. It is indeed an unfortunate fact that the microbial tolerance of temperature and the start of the chemical oxidation of hay overlap at around 76°C when the relative humidity is 95%-97%. A small window of opportunity (see figure 1) but one that nevertheless can occur.

## HAYSTACK IGNITION CONDITIONS

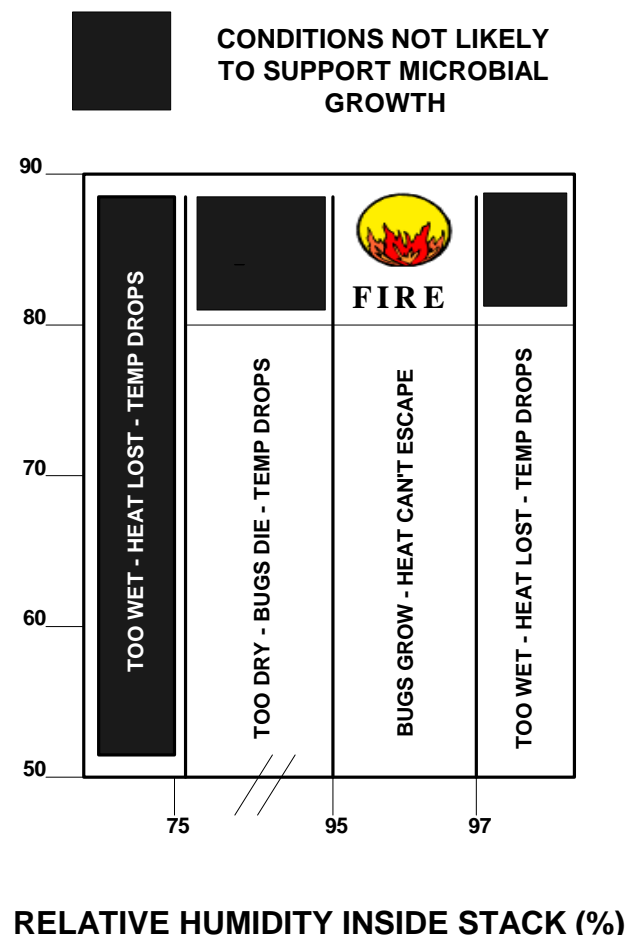
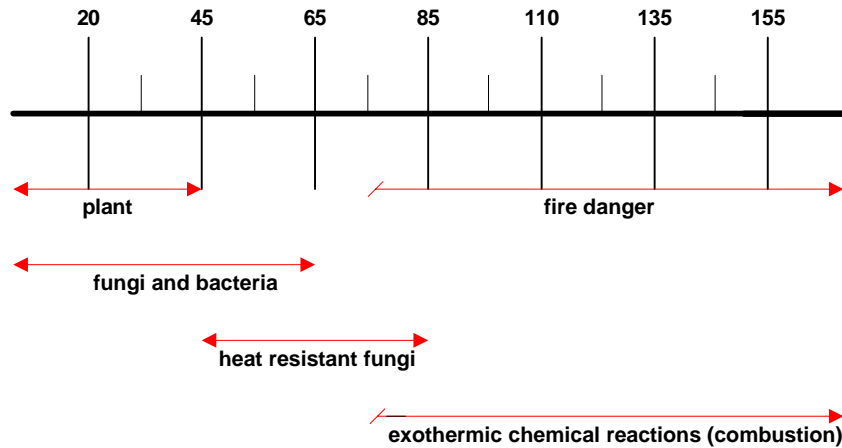


FIGURE 1 - A temperature versus humidity chart which shows conditions that lead to spontaneous combustion.

## *Spontaneous Combustion of Hay Continued*

The extent of temperature rise and duration of heat production in hay depends on moisture content. A relative humidity of 90 to 100 percent, which favours mould development, can develop in 20 percent moisture hay that is stored in sheds. The heat generated by the metabolic activity of the micro-organisms and plant respiration increase the temperature of hay (Figure 2). Heat resistant fungi are active when the temperature is between 45 and 65 degrees C.



### **CAUSATIVE AGENTS IN THE HEATING OF HAY**

A large variety and number of micro-organisms are associated with plant material in the field, but fungi are the microbes primarily responsible for breakdown of complex carbohydrates. Heating above 80 degrees C results in thermal death of microbes; then heat-producing chemical reactions serve to further increase temperatures. A subsequent rapid oxidation of reactive compounds may cause a further temperature rise to an ignition point of 231 to 274 degrees C. If enough oxygen is present, flames will erupt. The time required for heating to combustion may vary from 4 to 10 weeks, depending on storage and climatic conditions and on the moisture content of the forage.

The obvious solution to the problem is to only stack thoroughly dry hay. However, fire prevention procedures for suspect stacks involve temperature monitoring. Thrusting a crowbar into the side of the stack and leaving it for two hours, then to feel the end of the bar on removal is a gauge of temperature. Another technique is to push a 20mm galvanised pipe into the stack and lower a thermometer down the pipe. If the temperature is lower than 60°C then the hay should not cause any concern. If the temperature is between 60°C and 70°C then a ventilation hole should be cut to allow air to circulate. If the temperature is above 70°C then a stack or stored area should be dismantled and fire fighting equipment held in readiness as well as ensuring an adequate water supply.



Examples of heat affected hay



**SPONTANEOUS COMBUSTION**

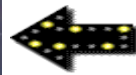
**Note extensive heat damage**



**This bale is close to igniting when exposed to oxygen**



**Fully involved  
round bales of straw**



**Note fire in base of stack**

**Consider the exposures –  
buildings and equipment**

**THEN**



**best to allow to burn  
out. May need to  
open up to allow  
oxygen**

