# FIRE INVESTIGATION OF SPONTANEOUS HEATING

**Author: Donald E Berg,** Senior Principal Consultant, Envista Forensics

The investigation of spontaneous heating fires can be challenging and come with a unique set of circumstances due to many factors; evidence is consumed, a site is left with little or no evidentiary material, or collected evidence sent for laboratory analysis does not show the presence of chemical residues.  Additionally, burn patterns from such fires can be difficult to interpret.

**Highlights**

- Self-Heating Spontaneous Combustion
- Autoignition of Fires
- Investigation of Spontaneous Ignition
- Case Study and Myths

The methodology for performing an origin and cause investigation after a spontaneous heating fire does not change, but the efforts to determine the specific area of origin needs to be well established before spontaneous ignition can be confirmed.  This type of investigation requires in-depth analyses of the events leading up to the fire including witness statements, a precise timeline, weather conditions (including the temperature and humidity), and the location of any contributing factors, such as material remains or product residue.

## Spontaneous Combustion Due to Self-Heating

The 2021 edition of the National Fire Protection Association (NFPA), chapter 5, section 5.7.4.1.1.5, describes spontaneous combustion due to self-heating as a special form of smoldering ignition that does not involve an external heating process.  This happens when an exothermic reaction within the material leads to ignition and burning.  According to the NFPA, when a material is able to dissipate the heat generated by internal exothermic reactions, it is considered ignition by self-heating.  If the generated heat cannot be dissipated to the surroundings, the material will rise in temperature and a smolder front can be formed.  Ambient temperature, pile size, and the reaction of kinetics of the exothermic process are key variables in self-heating2.  The NFPA states, "As the ambient temperature rises, the baseline reaction rate increases, and as the pile size increases, the ability to dissipate heat to the surroundings decreases.  Both high ambient temperatures and large pile sizes favor self-heating processes."  To fully understand the process of self-heating, it is necessary to first understand some basic terms related to the development of spontaneous ignition fires.

## What to Look for During Autoignition

The autoignition temperature, or kindling point of a substance, is the lowest temperature at which a substance spontaneously ignites in a normal atmosphere, without an external source of ignition, such as

a flame or spark. It is important for a substance to reach this temperature to supply the activation energy needed for combustion. Spontaneous heating, self-heating, and spontaneous combustion are common terms used to identify an exothermic reaction associated with fires that occurs in organic materials without an external ignition source.

Spontaneous heating is commonly detected by fire investigators from the improper storage and disposal of oily rags, paint brushes, and paint rollers used in the application of stains and varnishes containing organic drying oils, such as linseed, Tung oil, as well as in the preparation of tempura flakes. These oils are commonly found in paint and varnishes, which polymerize and become hard and rigid when exposure to air. The drying oils manufactured in the paint and varnish industry also have additives that can further accelerate the drying process. The rapid oxidation during the drying process can lead to spontaneous combustion but before ignition can actually occur, there must be a series of events in place. These factors include ambient temperature and relative humidity, size, type and amount of saturated material, the way materials are stored, and ventilation.

Ambient temperature (hot or cold) is the most significant contributing factor in autoignition. For example, moving a material from a warm to cold environment can cause moisture and condensation to form. Raising the temperature can lead to rapid oxidation and speed up the oxidation process.

Often seen in fire investigations at commercial laundry facilities, towels and rags saturated with saturated vegetable oils, massage oils, or animal fats are other common sources of spontaneous heating. These towels and rags are typically washed at relatively low temperatures, which does not remove all of the oils, and are then dried at high temperatures and stacked in closed baskets or hampers immediately after being removed from the dryer. The temperature in the center of the stack retains the heat for a longer period of time, leading to an ignition. Many restaurants and spas that routinely use commercial laundries to wash their towels and rags saturated with organic oils and fats have experienced spontaneous ignition fires.

Another commonly observed example of spontaneous heating follows the sanding of wood floors. Contractors use professional floor sanders with dust collection bags and following the sanding process, it has been seen that these workers either forget to or do not empty the collection bag for whatever reason. Dust collection bags can be filled with fine particles of saw dust, old floor finishes, or a coat of stain or varnish that can auto-ignite. When investigating floor sanding fires, fire investigators should be wary of ignition from floor nails. When sanded, nails in the floor can create a spark and have often been attributed to spontaneous ignition in collection bags. The spark creates a hot ember that can become imbedded within the sawdust collection bag. The ember can smolder for hours or even days before igniting the surrounding sawdust. Worn sanding disks can also lead to friction during the sanding process, creating small embers that are then vacuumed up into the collection bag or vacuum cleaner.

## Aroma

There are well documented reports that, prior to a fire, witnesses have reported noting acrid or sweet odors that they could not locate. The components involved with the odors from spontaneous heating are aldehydes, which are an organic acid created during the oxidation process. They can take on a variety of odors including fresh mowed grass, burnt animal fats or oils, and sweet, pungent fruity smells. Witnesses also report having watery eyes from the acrid acids that permeate the area.

# Investigation of Spontaneous Ignition

## Timeline

The timeline is a critical factor in the investigation of spontaneous ignition.  Research shows that most spontaneous ignition fires occur within four to six hours of the onset of the chemical process, with ambient temperature being the critical factor in the time involved for the fire to occur.  Autoignition of drying oils can occur within one hour or take as long as 14 to 16 hours to ignite.  Early indications of spontaneous ignition are the acrid odor and white smoke created by the evaporation of moisture from surrounding material, which can occur well before a flame ignites.

## Interviews

During investigations of spontaneous heating fires, interviewing the first arriving fire crews is just as critical as interviewing witnesses to the fire, as well as those who were present prior to the fire.  This is because early indicators of spontaneous ignition are often reported as vague odors and light smoke that can't be specifically located or identified.

## Reignition

Fire suppression efforts often extinguish the fire only to have it reignite.  This is due to the reacting material usually buried deep within the mass, reigniting upon exposure to the air.  Even when large piles of wood mulch are extinguished and excavators or shovels are used to spread out the material, a fire still has the ability to reignite.  The same can be said for haystacks and stored animal feeds.  When the material gets wet or has a high moisture content, an aerobic reaction can occur as microorganisms (i.e. mold, fungi, and bacteria) create heat due to respiration.  These types of fires usually take extended periods of time to occur, even weeks or months after the vegetation has been cut and stacked.  Prior to a fire, Maillard reaction, a chemical reaction between amino acids and reducing sugars, can occur.  This causes dark spots, which can be observed on the exterior of the pile as the heat from the interior of the mass progresses towards the exterior creating the telltale dark brown spots.

## Self-Heat Materials

Among others, coal, charcoal, and charcoal dust have been known to self-heat for centuries.  Autoignition of coal requires exposure to oxygen and is accelerated by being exposed to moisture.

# Case Study: Self-Heating Sushi

There have been several unexplained fires occurring in sushi restaurants.  Eventually, the fires were caught on a video surveillance camera, which showed that the fires were attributed to the self-heating of tempura flakes, properly called tenkasu, agedama, or crunch.[1]  Tempura flakes are prepared by making a batter and deep-frying the batter in a vegetable oil or soybean oil.  During the preparation process, the crunch is placed in a colander to drain the excess oil.  During the drying process a shell is formed over the outer layer of the crunch,



1 Tempura is a popular Japanese dish in which food (most commonly seafood, vegetables, or sushi) is lightly battered and deep fried to create a light, crispy coating. Any time you see the term "tempura fried" on the menu at your favorite Japanese steakhouse, this simply refers to food that was dipped in this batter and fried." https://www.allrecipes.com/article/what-is-tempura/

causing the crunch to be insulated and allowing the internal temperature to continue to raise to the point of combustion.

# Myths

## 1. Spontaneous Human Combustion (SHC)

For centuries, there have been numerous reported cases of spontaneous human combustion (SHC), a myth that a body can self-ignite. Although there have been some unusual circumstances involving this phenomenon of spontaneous human combustion, there is no known research or testing that has confirmed that it can occur. This is most likely the result of the wick effect from an exterior ignition source. The wick effect is when a body starts to burn, but the fat turns liquid, seeps into the clothing, and turns the body into a gruesome kind of human candle. According to the Scientific American Blog Network, it burns things in the immediate vicinity, but because it's a slow burn, nothing else is affected.[2] The myth states that the external ignition source is believed to have ignited the deceased's clothing that spread up towards the torso, where the most fat is located within the human body. The slow burning of fat, viscera, and tissue often does not affect surrounding combustibles leading to the erroneous assumption that because there were no external heat sources the fire must be internal.

## 2. Charcoal Can Combust

Although coal is known to spontaneously heat, charcoal in the form of briquets is considered an inferior form of coal that even when wet will not self-heat. Briquets are composed of coal dust or manufactured wood by-products compressed with additives to make them light and burn more consistently. When wet, briquets simply disintegrate into small particles and will simply not auto ignite.

# Conclusion

The temperature, humidity, timeline, and products used prior to a fire, and their disposal or storage, are critical factors in determining if the fire started from self-heating. Though, the most important part of the investigation of spontaneous heating fires is the in-depth analysis of events and witness statement leading up to the fire.

Often spontaneous heating fires are unfounded and labeled as undetermined, as the investigator either can't locate or find the specific source of the fire. When dealing with the investigation of spontaneous heating, fire investigators must be meticulous in combining all the known factors and empirical data to make a reasonable determination that a fire was the result of self-heating. The elimination of all other possibilities and the careful review of witness observations and early supplied data is necessary to confirm that the fire was the result of self-heating.

 

2 Burn, Baby, Burn: Understanding the Wick Effect - Scientific American Blog Network