- *Wood pellets are a safe fuel, like all fuel types safety rules apply.*
- *For small scale installations, wood pellets are a very safe fuel, just as long as the silo is well ventilated (Kofman, 2007).*
- *In large storage facilities and during transportation in ships, oxygen can become depleted and carbon monoxide generated from wood pellets. Silos or ships holds and ship stairwells must always be thoroughly ventilated for a long time before a person enters.*
- *Dust explosions can occur when large scale industrial volumes of wood pellets are handled. All storage areas must be rigorously cleaned on a regular basis to prevent dust build up. It is strongly advised to install a dust filtration system in the storage area.*
- *Water should be used sparingly in fighting fires in wood pellets. The best approach is to remove as much of the sound pellets as fast as possible and then extinguish the rest.*
- *Fires in high rise silos are particularly difficult to tackle and every care should be taken to remove excessive fines and keep the pellets cool and dry before and during storage. In the event of fire it can only be fought by pumping liquid nitrogen into the silo, but piping and coupling points for pumps have to be installed before wood pellets are stored.*
- *Ash from wood pellets should be handled with care as it is a highly alkaline substance.*

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Health and safety in the handling, storage and use wood pellets

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Introduction

Wood pellets have become a normal fuel for heating of households and small businesses, but also for use in energy plants in the UK and further afield. Like all fuels wood pellet use has a series of rules that should be followed to increase safety and to safeguard health.

It is very important to state that wood pellets are a safe fuel for small users, problems like self-heating and dust explosions are extremely rare to nonexistent. These are issues for very large volume users. Generally speaking wood pellets are at least as safe as fossil fuels such as oil, gas, coal or peat.

How risks occur and what happens when wood pellets are stored should be fully understood by those using them. Safety aspects of wood chips are covered in *Health and safety aspects of using wood chips as a fuel* (Kofman, 2016).

Self-heating

Unlike wood chips, the self-heating of wood pellets is a chemical process and not a biological one. During the production process wood pellets have been subjected to temperatures above 120 °C and as such are sterile when they enter the silo.

Self-heating in small storage silos in households and small businesses rarely if ever occur, unless water enters the silo. In this case self-heating may occur, and then due to biological processes as well. So, as long as wood pellets are kept dry, self-heating should not arise in small silos.

In large silos problems sometimes can occur, especially when there is insufficient ventilation both inside and outside the pile. Care should be taken that pellets that are stored in large silos are at a temperature of below 50 °C when they enter the silo, that the amount of fines in the consignment is as low as possible (preferably less than 1 %), and that the building is well ventilated, while guarding against condensation.

Self-heating in wood pellets is usually attributed to fatty acids in the wood being chemically oxidised. This process consumes some oxygen and releases a little bit of heat and of course carbon dioxide and some moisture. If the pile is well ventilated, the heat will dissipate to the surroundings and the carbon dioxide and moisture will vent out of the silo or containment area.

If the pile is not sufficiently ventilated, either because there are too many fines blocking the venting process or because of overpressure from large amounts of pellets , then heat can start to build up. Even though the pellets are relatively dry (around 8%) when they enter the storage facility, they can dry even further because of the heat. When the moisture cannot escape from the pile due to restricted ventilation, it will condense again inside the pile. When water vapour condenses, it releases the energy that has been used to evaporate it, so the temperature where the condensation takes place also rises. This process continues on an ever-increasing scale and adds to the self-heating of the pile.

In extreme cases, self-heating can lead to self-ignition, which occurs when the temperature exceeds 250 °C.

High-rise silos, especially ones designed for storing grain, are susceptible to self-heating, because there is often no ventilation, and there is the added risk of reduced ventilation at the bottom of pile due to the weight of pellets bearing down.

Self-ignition

If the temperature from the self-heating reaches 250 °C spontaneous ignition can occur. Often, a metal object can act as a catalyst to set the fire going.

Since the moisture content in the pile is very low, the fire can escalate rather fast. Also, unlike wood chips, pellets can have a surface fire with visible flames.

To prevent self-ignition one should check the temperature of the pellets when they enter the silo: it should be well below 50 °C. Where there are a lot of fines and the pellets are being stored for any length of time it is good practice to sieve out the fines. The storage building should be well ventilated. A close watch should be kept for any early sign or indication of fire. If at all possible the "first in-first out" rule should be followed and the storage period should be kept as short as possible.

Dust

Often wood pellets are made of saw dust as a raw material and as such already contain a lot of fines. Anyway all base materials pass a hammer mill to ensure that all particles are less than 3 mm in size. This hammer-milling process will increase the amount of very small particles as well. Many particles will be way less than 3 mm. During handling and transportation, pellets will start to wear down, some will break and others fall apart if they come in contact with water. All these processes can create a large amount of fines in the pellets and when they subsequently are handled again, the fines tend to swirl into the air.

Wood dust from wood pellets can be very fine, take a long time to settle, and may form a haze. The dust content of the haze can be sufficient in certain instances to generate the conditions leading to a dust explosion. An expert once said: "if you can write your name in the dust on a surface, then a dust explosion is imminent".

Dust explosions are well known from coal burning power plants, where strict cleaning regimes are routinely in place to keep dust levels low. Compared to coal dust, wood dust is smaller and the moisture content is lower, so the risk is greater. In coal-fired power plants, cleaning usually involves washing the dust down. In the case of wood dust this is not enough and hosing down must be followed by vacuum cleaning to keep dust within safe levels.

Especially at large users of wood pellets, the cleaning operation should not be underestimated. Wood dust will not only settle on horizontal or inclined surfaces, but will also adhere to perpendicular surfaces like walls.

Dust explosions

There are two kinds of dust explosions:

Primary dust explosion: where the explosion is a stand-alone event and is caused by a spark igniting the suspended dust in the air. The explosion may be followed by a fire.

Secondary dust explosion: where there is an on-going fire and due to structural failings the accumulated dust layers on surfaces in the building fall down and may cause a secondary dust explosion.

As stated, dust explosions can be prevented by rigorous cleaning of the premises. Forced ventilation, through a filtration system to remove dust is a further risk reduction option.

Off-gassing, oxygen depletion and carbon-monoxide generation

Due to the oxidation of fatty acids, wood pellets consume some oxygen and when the oxygen levels become low, the end product of the oxidation will no longer be carbon dioxide, but carbon monoxide (CO), a highly poisonous gas. It is colourless and odourless, and so it is very hard to detect by human senses.

If wood pellets are stored in an enclosed structure, like a silo or a ship's hold, the risk of CO poisoning is greater because the oxygen level has been depleted by the oxidation of the pellets. Because there is a shortage of oxygen, one will breathe faster again and if no remedial action is taken very rapid unconsciousness and death will result.

So before one enters any enclosed structure, where wood pellets have been stored for any length of time, that structure should be thoroughly ventilated and only then be entered when essential. Other inspections should be carried out through glass inspection hatches or such.

In ships not only holds should be ventilated, but also stair wells between the holds. Carbon monoxide will accumulate at the bottom of stairwells and slowly build up from there. Forced ventilation is needed to clear the air. CO monitors should be installed to give an early warning of any build up of Carbon monoxide.

In households, all wood pellet storage areas should be well ventilated, see the COFORD Connects Note *Guidelines for designing a wood pellet storage facility (Kofman, 2008)* on the storage of wood pellets.

Fighting fire in wood pellet piles

Fires in wood pellets are difficult to handle, but one thing is for certain: spraying water on the surface of the pile in the hope that the water will seep down into the fire is not an option under any circumstances. Wood pellets swell up and fall apart within minutes of contact with water. They will form a dense cake, which water cannot penetrate through.

In any fire with wood pellets it is important to remove as many pellets from around the fire as soon as possible and if the pellets are in a silo, to empty that silo as fast as possible to an area where the pellets can be spread out and where the burning pellets can be extinguished. In this way it may also be possible to save a large amount of pellets.

If a fire starts in pellets stored in a high rise silo, it can be very difficult to extinguish or contain. Thus far the only successful attempt has been to pump liquid nitrogen into the silo. Liquid nitrogen is of course extremely cold and it cools the pellets as it evaporates and it also replaces the oxygen so that the fire is suffocated. Pumping nitrogen into silo containing wood pellets is not an easy thing to do, if the silo is not prepared for this. It is good practice to install a piping system close to the bottom of the silo with couplings so that one can inject the nitrogen before loading the silo. Before injection the liquid nitrogen is first pumped into an expansion unit to allow some expansion into the gaseous form.

If a fire has been detected in a high rise silo, seal off as many entries of air into the silo as possible. Where possible pump the nitrogen gas in at the top of the silo also, to avoid the build up of an explosive mixture of carbon monoxide and hydrogen gas. At the same time the flue gasses need to be allowed to escape. Always try to empty the silo as fast as possible, which should also save a lot of the pellets. Once smouldering or even burning pellets come out of the silo, one can extinguish them with a sprinkler system above the conveyor belt.

A report from the Swedish Civil Emergencies Service MSB on Silo Fires provides a lot of useful information and guidance on how to prevent silo fires and how to fight them if one should occur (Persson, 2013).

Safe handling of wood pellet ash

Even though wood pellets have very low ash content (usually less than 0.7%), ash is not a benign substance. It is very fine and has a very high pH of around 12, and is thus very alkaline and should not be handled with bare hands.

The ash of wood pellets should not be used as a fertilizer for food crops, but should be disposed of with household and other waste. However ash from a very large plant can be used as a forest fertilizer instead of storing it in a specialised landfill

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