- *Wood chips are as safe, and in some cases a safer fuel than oil, gas or even coal. Like any fuel, however, safety rules apply.*
- *Never store wood chips that are wet (>45% moisture content) for any length of time and*
- *Store all chip for as short a time as possible.*
- *Never store chips that contain needles or leaves.*
- *Use the "first in-first used" rule when combusting wood chips.*
- *Use a face mask with a P3 filter when handling wood chip or stay inside a closed cabin with overpressure and a good filtering system.*
- *If a fire starts in a wood chip pile, remove the sound chips from around the fire, and then tackle the fire. Use minimal amounts of water, otherwise one will destroy the fuel value of the chips.*
- *If a fire burns on the surface of a wood chip pile, the most workable solution in many cases is to contain the fire, cordon-off the area and let it burn out.*
- *Only work in silos that have been sufficiently vented.*
- *Handle wood ash with care; the material is highly alkaline and contains a lot of fine dust.*

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Health and safety aspects of using wood chips as a fuel

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Introduction

Any fuel has a set of safety rules, which if they are followed reduce the risk of accidents. The same is valid for wood fuels: if one follows simple rules, wood is as safe and in some cases a safer fuel than oil, gas or even coal.

How risks occur and what happens when wood fuels are stored should be fully understood by those using wood chips. Safety aspects of wood pellets are covered in Guidelines for designing a wood pellet storage facility (Kofman, 2008).

Wood is an organic matter that is a substrate for microorganisms, mainly bacteria and fungi, as well as insects, and for some large animals including elephants and horses. It predominantly comprises carbohydrates and lignin, with small amounts of nutrients (minerals) in the tissues. Fresh wood also has a high moisture level: Sitka spruce contains up to 60%, hardwoods like beech and oak around 45%, and ash even less when fresh.

Fungi and bacteria

The higher the moisture content in the wood chips, the more bacteria and fungi will grow on the wood. If the wood is dry, with levels similar to those found indoors (around 8-10% moisture), these organisms will not grow; wood under these conditions can remain stable for decades or even centuries. However, as soon as moisture is added to wood, it becomes susceptible to fungal decay.

If wood has less than 25% moisture content, decay is very slow, but with increasing moisture content, the decay accelerates. Table 1 provides indicative storage periods for wood chips at increasing moisture content and is based on trial results and long experience.

Moisture content %	Indicative storage period
0-15	Very long periods of time – several years
16-25	Several years
26-35	Up to a year
36-45	Months
46+	Days to weeks, maximum 1 month

What is happening with wood and microorganisms?

Initially bacteria start to consume the wood, a process which uses oxygen and releases carbon dioxide, water and heat. This tiny amount of energy and the preparation of the surface by the bacteria make it easier for the first set of fungi to colonise the wood chips. They also consume the wood and generate carbon dioxide and water, while they release far more heat than bacteria, which also predisposes chips to colonisation by the more aggressive thermophyllic (heat loving) fungi. While the first set of fungi may take the temperature in the pile up to 45 °C, thermophyllic ones take it up to 70-80 °C. This is still far below the self-ignition temperature of wood, which is around 250 °C.

When the temperature inside the pile reaches 70-80 °C it effectively kills off fungi and bacteria. Before they die, they typically produce enormous amounts of spores, which, under suitable circumstances, germinate and produce the next generation.

Fungal spores are tiny particles that can enter the air ways of people and animals. If one is slightly allergic, one gets similar symptoms to a mild cold. However by repeated exposure, the allergic reaction will increase over time. From a mild cold, it will accelerate into bouts of fever, and if the reaction becomes very bad, one might have to give up working in environments where the spore level is very high, like around badly stored wood chips. This illness is called allergic alveolitis, or in common language farmer's lung[7].

To prevent exposure to spores causing problems, one should wear a filter mask with a P3 dust filter or one should stay in a pressurized cabin, where the air supply is drawn in through a filtering system with the same spore capture capacity.

Where possible, the fuel store of a wood chip boiler should be separated from the rest of the building, so that the spores remain outside the working environment. By drawing the combustion air from the fuel store, a continuous ventilation of the fuel store takes place and large amounts of fungal spores are drawn off the pile and through the fire.

Self-heating

In smaller piles, the heat from the biological process dissipates, but if the pile becomes very big (in excess of 1000 cubic metres), or if there is bad natural air flow in the pile (because of many small particles or fines) or has been compacted by driving across it, then heat does not readily dissipate.

Self-heating of a pile depends, as stated, on the moisture content, but also on the nutrient content of the wood chips. Wood chips of pure wood, without bark or needles, will heat very slowly or not at all, because there are no nutrients for the micro-organisms to develop and multiply. When however wood chip has bark attached (which has a much higher nutrient content than wood itself), or in the worst case scenario also contains leaves or needles, then there will be enough nutrients for the organisms to grow and multiply.

Self-heating is a very fast process: a pile of wood chips with 45% moisture content and enough nutrients can reach a temperature of 60-80 °C in as little as 24 hours. The elevated temperatures can be maintained for weeks and it can take many months before pile returns to the ambient temperature.

During self-heating bacteria and fungi consume the wood and thus dry matter is lost from the pile. In piles of very wet, nutritious wood chips (such as chips of short rotation willow), losses of dry matter of over 3% per month have been measured. In normal forest chips, particularly those with moisture contents in excess of 35-40%, dry matter losses of around 1% per month can be expected.

The effect of the raised temperature in the pile is that the centre dries out as the moisture in the wood evaporates. However the moisture - together with moisture released as the wood is consumed by bacteria and fungi - condenses at the colder surface of the pile, creating a very wet outer layer.

Self-ignition

Self-ignition of a pile of wood chips is caused by a chemical reaction that takes over after the biological processes. Chemical oxidation produces even more heat, moisture and carbon dioxide, and eventually the temperature in the pile can reach the ignition temperature of wood which is around 250 °C. It should be pointed out that self-ignition of wood chip piles only occurs in exceptional cases and mostly then in very large chip piles, and then only when a well-established set of pre-conditions come together. These risks can be readily assessed and dealt with, as outlined in what follows.

Piles of wood chip that do self-ignite are typically very large (in excess of 1000 cubic metres loose volume) and contain at least some concentrations of wet chips. Often the piles have been compacted by driving across them. In almost all cases, a metal object is associated with the initiation of the fire. The metal acts as a catalyst; metal pieces can be anything from parts that fall off machinery to chipper knives that were accidentally incorporated in the pile, or other contaminants.

[1] *Working with mouldy hay releases spores which can cause the illness called farmer's lung.*

To prevent self-ignition, wood chips that are stored for more than 2-3 weeks should have moisture contents less than 35%, should not contain tree needles or leaves, should not be compacted and should be free of metal objects. The pile should be kept as small as possible with a regular shape. When a pile has an irregular shape, rain water may concentrate in "valleys" and increase the moisture content there, and lead to self-ignition processes beginning and accelerating.

In large or very large silos self-ignition is usually prevented because the turn-over in these buildings tends to be very fast, as long as the "first in, first used" rule applies when combusting wood chip.

Wood dust

Wood dust is generated during the chipping process and subsequent handling. It can cause severe irritation of the lungs. When handling wood chips, one should either wear a filter mask with a P3 filter, or stay in a pressurized cabin of the delivery or handling vehicle, which should have sufficient filter capacity on the air supply system so that the dust particles do not enter the cabin.

Dust explosions

In small installations like domestic boilers and in small businesses, the danger of a dust explosion is negligible. In larger installations where a lot of fuel is handled, cleaning of the building should have a high priority as wood dust and fungal spores can settle in many nooks and crannies. An expert once said: "if you can write your name in the dust on a surface, then a dust explosion is imminent".

Controlling fire in a wood chip pile

If by accident a pile of chips catches fire, usually the fire smoulders inside the pile and is only detectable as a blue haze emanating from the pile and a distinct smell of burning wood. Fire on the surface of the pile is even rarer and if it occurs, it is usually only on piles of very dry chips for example from recycled wood.

Extinguishing a fire in a wood chip pile is not done by pumping water on the pile in the hope that the water eventually will seep down into the fire. This approach will result in absolutely good wood chips being made unsuitable for burning.

The correct approach to controlling fire in a wood chip pile is to remove as much of the sound chip away from the area which is burning and spread it on an adjacent surface, so that it can cool down. Once the fire itself is located then water can be pumped onto it to put it out. All the while one removes chips that are no longer burning. By using minimal amounts of water, wood chips are maintained in good condition. Even charred chips are still useable as a fuel, even though they will of course have lost some of their heating value.

In rare cases where the wood chips pile consists of very dry chips, for example those sourced from recycled wood, fire can rage on the surface of the pile. The cause of the fire in these cases is usually not self-heating but due to sparks from equipment or other external causes. These fires are very hard to extinguish and usually one tries to contain the fire, but not extinguish it. It may take several days or even more than a week for such a pile to burn out. During this period the pile fire should be well cordoned-off and constantly monitored for any new flare-ups.

Oxygen depletion in silos

Wood is a living material, and after it has been chipped it is still respiring and using up small amounts of oxygen. Bacteria and fungi that grow on the wood also consume oxygen. This means that after a while a silo (be it above or below ground) that has not been properly ventilated will suffer from oxygen depletion.

In principle one should not enter a silo if that structure has not been properly ventilated. Even when the silo has been ventilated, one should never work alone. One person should be working in the silo, while the other keeps watch from outside. This second person can come to the rescue or sound the alarm.

Oxygen depletion has also been noted in ships holds and staircases between holds, when wood chips are being transported. Research has shown that even in ships that carry roundwood, oxygen levels can become depleted.

So before ships are unloaded, the holds and staircases must be properly ventilated or if there is work below deck during a shipment, fresh air must be provided in another way.

Safe handling of wood ash

Ash results from the burning or gasification of wood and consists of silica, minerals that the trees have taken, and in some cases soil and other contaminants. Ash is a very alkaline substance with a pH of around 12. It is corrosive and should only be handled when wearing protective gloves.

The fine dust and high pH generated by ash necessitates that in large installation in particular a filter mask should be worn to prevent inhalation.

A lot of the minerals in the ash are water soluble and therefore the ash should be stored under roof so that rain will not wash out these minerals and pollute the ground water.

References

Kofman, P. 2008. *Guidelines for designing a wood pellet storage facility,* COFORD, Department of Agriculture Food and the Marine, Dublin. Available at: http://www.coford.ie/media/coford/content/publications/projectreports/coford-connects/pp12_pelletstoragefacility.pdf. [Accessed 06 January 16].