The quality requirements for wood chip depends on the size of the installation in which it is to be used:

- *Small boilers (<250 kW) require a high quality wood fuel with a low moisture content (<30%) and a small, even chip with few, if any, oversize or overlong particles. A low level of fungal spores is required.*
- *Medium boilers (250 kW<X<1 MW) are more tolerant of moisture content (30-40%) and can handle a coarser chip than small boilers. Still, the amount of oversize and overlong particles should be limited. A low level of fungal spores is required.*
- *Large boilers (>1 MW) are tolerant of both moisture content (30-55%) and chip quality. The level of fungal spores can be higher because these installations usually take their combustion air from the chip silo which reduces spore concentrations in and around the storage area.*

In all cases chips should be stored away from work areas, to reduce contact with spores and the possibility of allergic reactions.

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Quality wood chip fuel

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Quality wood fuel depends mainly on:

- moisture content,
- particle size distribution,
- tree species,
- bulk density,
- level of dust and fungal spores in the fuel, and
- ash content.

Good quality wood chip fuel is produced by machines with sharp knives, with the ability to vary the size of chip produced to meet end-user specifications. Other machines use hammers or flails to reduce particle size and produce hogfuel, which is unsuitable for use in small installations. Large installations can, however, also have problems in handling and combusting hogfuel. For forest thinnings and other roundwood, chipping is the preferred option.

This note deals with wood chips only, even though there are other wood fuels, such as hogfuel, sawdust, firewood, peelings from fence posts, etc.

Fuel quality is set out in ***IS CEN TS 14961:2005 Solid Biofuels – Fuel Specifications and Classes*** (available from NSAI: www.standards.ie).

Moisture content

Moisture content is expressed as percent water of the total weight, and determines to a large degree where the wood chips can be used and if they can be stored.

Freshly felled trees have a moisture content range of 40-60%. Conifers (softwood) have a fresh moisture content of at least 55%, while hardwoods such as oak and beech have a moisture content of around 50%. The exception is ash, which has a low natural moisture content of around 40%. Willow, on the other hand, has a very high moisture content, between 55 and 60%.

Wood that is to be used as fuel is usually seasoned before use. Leaving felled trees in the forest as whole trees for one summer can reduce the moisture content by between 10 and 15%. An additional benefit is that the needles will drop off

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which reduces corrosion risk in the boiler and retains nutrients in the forest. Moisture contents of around 30% can be achieved for wood stored as roundwood in a covered pile at the roadside or in a yard.

Given time, natural drying can reduce moisture content levels to a minimum of about 20%. If lower moisture content is required, this can be achieved through artificial drying by ventilation with warm air or dry steam.

The required moisture content depends largely on the size of the installation that is going to burn the chips.

For small installations, i.e. for single households or similar buildings up to 250 kW, dry chips are needed with a maximum of 30% moisture content. For slightly larger installations such as heating boilers in hotels and other large buildings - up to 500 kW - chips with a moisture content of up to 40% can be used. Large installations such as power plants of over 1 MW are usually not very demanding on moisture content with a consistent moisture content being more important than the actual level - boilers are usually adjusted to a certain moisture content and have to be readjusted if the moisture content in the fuel changes significantly.

For all installations, a drier fuel will result in better efficiency of the boiler. Before wood can burn, the moisture has to be evaporated. In large installations, the evaporated moisture can be condensed again and the evaporation heat regained by cooling the flue gas. This process is generally too expensive for small installations.

When wood chips are stored, even for a short period, a process of biological degradation starts immediately. Moisture and nutrients are essential ingredients for degradation of wood: the wetter the chips and the more nutrients they contain, the faster the degradation. The by-products of degradation are heat, water and carbon dioxide, and dry matter will be lost. Chips from freshly felled conifers will heat up very rapidly to 70-80°C. Rarely, however, will this lead to spontaneous combustion. For that to happen, very large piles of chips, over 12 m high, and very large volumes are needed.

For storage of chips, the ideal moisture content should be below 30%. In such chip stacks, the biological activity will be minimal. Biological activity will increase with increasing moisture content. Chips of up to 40% moisture content can be stored for a short period - up to a few months - while chips over 40% moisture should be burned straight away.

Chips of freshly felled conifers, with needles, will lose up to 2-3% dry matter per month of storage, while losses in dry wood chip are minimal.

Particle size

The particle size distribution of wood chips depends on the type of chipper, the setting of the knives and the level of maintenance of the machine. To establish the particle size distribution of wood chips, they are sieved through a range of sieve sizes. The amount retained on each screen is divided by the total weight of the sample to give a percentage.

The IS CEN standard classifies chips as P16, P45, P63 and P100; these require that 80% of all particles in a sample can fall through a screen with the indicated gap size. However, tests have shown that the classes do not cover the correct size spectrum and a revision of this part of the standard is being considered. Generally speaking, however, the smaller the boiler the smaller the size of chip.

For the layman, a simpler measure is the nominal size of the chip. If one selects several particles, one can easily see how they have been cut. The width of the cut is the nominal size of the chip, which relates directly to the setting of the knives of the chipper. In Figure 1, a chip with a small nominal size is shown next to one with a large size. Figure 2 illustrates the various measurements and dimensions of chips.

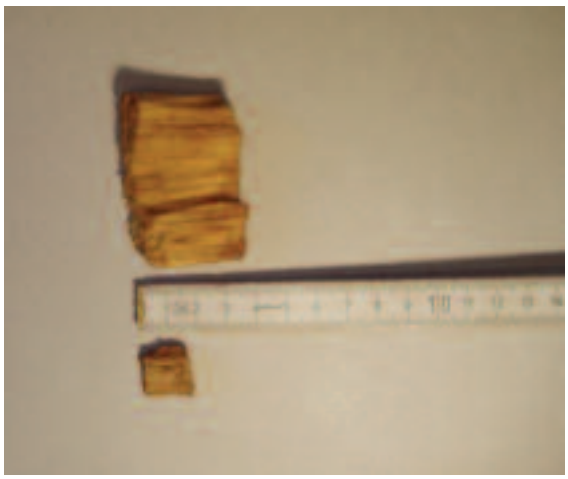

Figure 1: The nominal size of a small and a large chip particle.

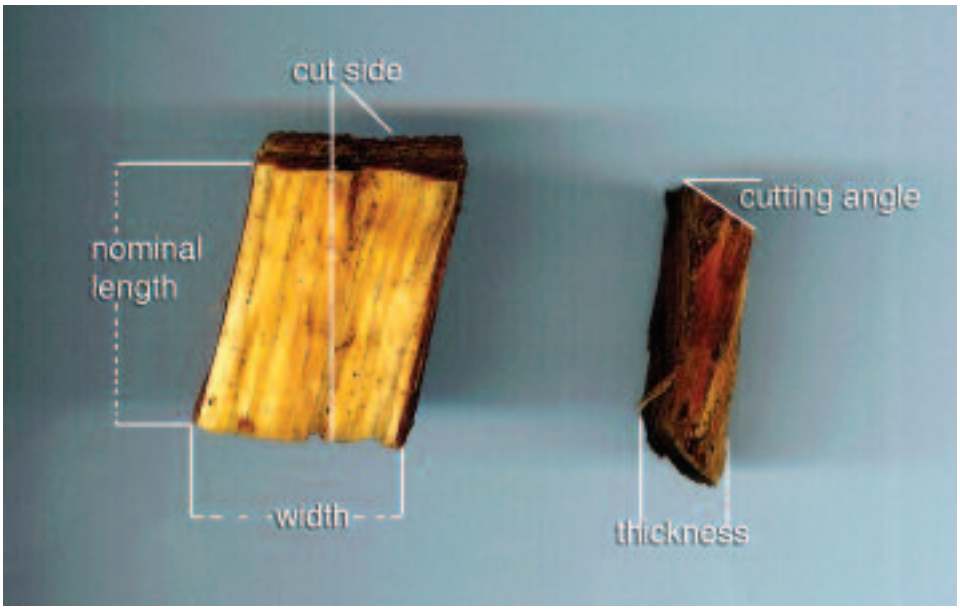

Figure 2: Measurement of wood chips.

For small boilers (<250 kW) a nominal size of 8-15 mm is required. The amount of oversize particles should be restricted, which means avoiding lumpy chips or overlong particles (longer than 10 cm). Oversize or overlong particles can clog the auger feeding the boiler. In the worst case scenario the safety pin on the auger might shear.

For medium boilers (250 kW<X<1 MW) a nominal size of 8 to 25 mm can be used. The demands on the amount of oversize and overlong chips are not as stringent as for the small boilers. The augers feeding this type of boiler are much larger and more robust than for the small boilers. Too many overlong particles will, however, increase the tendency of the fuel to bridge over openings, which might cause the boiler to stop because of a lack of fuel.

For large boilers (>1 MW) a large nominal size of 25 to 35 mm is usually required. There are hardly any restrictions on oversize or overlong particles, because this type of boiler is usually fed by a crane into a hopper and from the hopper by hydraulic ram into the boiler. Even though the requirements are low, too many overlong particles might get the fuel to bridge over the infeed hopper and thus cause the boiler to stop because of a lack of fuel.

Chipping machines

There are two main types of machine: disc or drum chippers. Usually disc chippers deliver a more homogenous chip. The knives of the machine as well as the anvil should be well maintained. If a knife becomes blunt, the amount of fines increases, as well as the amount of overlong particles and the general shape of the chips becomes less well defined.

Tree species

Tree species has an influence on the quality of fuel. Many hardwoods such as oak, beech, ash and sycamore have stiff branches which will give overlong particles in the fuel. Small birch trees have pliable branches, which will give many thin overlong particles.

The bulk density of hardwood chip is much higher than softwood. This means that a smaller volume of hardwood chip needs to be fed into the boiler to get the same amount of energy as for softwood. However, on a unit dry weight basis, the amount of energy is almost equal for all trees. Ash chip has a much lower moisture content than chip from other hardwood species, especially when comparing freshly harvested material.

Bulk density

The wet bulk density (the same thing as bulk density received) of chip is expressed as the weight per unit volume of chip, usually in kg per m^3 loose volume. Typically for

softwood, such as Sitka spruce, the weight of a cubic metre of chip with 45% moisture is in the order of 270-300 kg. For the same volume of beech, the weight is in the order of 320-370 kg.

The dry bulk density is the weight of bone dry chip in one cubic metre. For softwoods the dry bulk density is in the order of 150-165 kg dry matter per cubic metre loose volume of chips. For beech this would be 180-205 kg.

Dust and fungal spores

Wood chips will always contain dust and if they have been stored they will also contain fungal and bacterial spores. The dust is generated during the chipping process and little can be done to prevent this.

Bacteria and fungal spores are omnipresent and, given a good growth medium such as moist wood chip, they will flourish. They will convert wood to moisture, heat and carbon dioxide. The temperature in wet wood chip will rise rapidly from the initial 10-20°C to up to 90°C. At such high temperatures the pile will sterilise itself and the fungi and bacteria will die off, but not before they have generated a large amount of spores.

Fungal spores can be the cause of severe allergy. For every exposure to spores, the allergy will increase. At first the reaction is rather mild with a small irritation of the respiratory tract, later it can cause fever. If the exposure is prolonged, and the person is susceptible, then they should do other work where contact with wood chip is avoided.

For these reasons, it is recommended that indoor storage of chip be located as far as possible from areas frequented by people. The storage space should also be well ventilated. For larger installations, it is recommended that the air for the burning process be drawn from the chip silo, which will create a negative pressure in the storage area and reduce the volume of spores in the surrounding air.

Ash content

The ash content of pure wood without bark is quite small, perhaps as low as 0.5%. If wood with bark is burned, the percentage increases to about 1%. If wood chip with bark and needles is burned, the ash percentage might be slightly higher. If the wood has been contaminated with soil, sand or grit, then the ash content can easily reach 5-10%. For this reason alone wood chip should be as clean of soil as practicable.

Garden and horticultural waste, which often includes stumps etc., frequently has an ash content of over 5 or even 10%.

For information and a free on-line advisory service on the wood energy supply chain, the quality of wood fuels and internal handling visit www.woodenergy.ie.