THE SAWMILL PROCESS

From raw material to finished product

SWEDISH FORUM
FOR WOOD
TECHNOLOGY

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Foreword

Knowledge and skills are essential for the competitiveness and long-term survival of businesses. Rapid advances in a number of different areas have driven up demand for skills in many sectors — not least the sawmill and wood engineering industries.

Good access to competent employees is vital for companies to grow and develop. And in order to recruit employees, it is necessary for the industry to consciously invest in strengthening its attractiveness.

There is a consensus that we need to constantly evaluate how the market is working and how to organise our operations, which creates new demands for constant access to relevant training and accessible knowledge.

Swedish Forum for Wood Technology (Svenskt Trätekniskt Forum, STTF), has updated a previous publication by the Swedish Forest Industries Federation and, with generous help from several machine supply companies, produced a new edition titled *The Sawmill Process* to better represent today's modern sawmill and planing operations. Parts of the material have also been taken from *Choosing Wood, edition 10:2020* published by Swedish Wood.

Here at Swedish Forum for Wood Technology, we are pleased to present *The Sawmill Process* as a source of active support and development for the industry's workers, whatever their job, but also for higher education institutions that offer wood industry education.

Combined with Swedish Forum for Wood Technology and Swedish Wood's web-based training, *The Sawmill Process* provides a good basic grounding in what happens in each production department at the sawmill, as well as discussing wood as a material and its applications.

The publication can also be ordered via Swedish Forum for Wood Technology's website: **www.sttf.info**.

Umeå, April 2023

Tomas Ivarsson
Swedish Forum for Wood Technology

INTRODUCTION

The Swedish sawmill industry is known for its high-quality raw material, high productivity and technically advanced companies. The future looks bright from several perspectives. Sweden leads the way in health and safety practices, we have an ambitious quality policy and the locally produced timber comes from environmentally certified forestry operations in Swedish forests. Wood is a versatile raw material and one of the few renewable building materials, and in production the companies do their utmost to promote continued sustainability for the future.

Advanced electronics and digitalisation have become an increasingly indispensable addition to the technical repertoire in most sawmill departments, although rapid automation and digitalisation in the industry mean that existing tasks will gradually change or disappear altogether. The professional groups most deeply affected include machine and process operators, who need considerable skills in areas such as technology and IT.

Technological advances have affected the sawmill industry and the labour market over time, creating new jobs, contributing to strong productivity growth, generating economic prosperity and laying the foundation for strong competitiveness. However, it should be stressed that knowledge of wood and its properties is a factor that should never be underestimated, whoever the employee is.

The growing need and demand for technical competencies is a fact. Investments in new technologies and digitalisation, the emergence of new job types and changes in work content are making the availability of highly-skilled employees more important than ever. To meet the future needs of the labour market, basic training material has to be in place to support the learning of employees who have chosen to work in sawmills and the wood engineering industry.

The publication *The Sawmill Process* is aimed at new employees, temporary workers and existing employees in the industry. The purpose of the training material is to give the employee a good insight into what happens in each production process and an overall picture of the business, so that they can settle into their job faster and feel secure in their employment. A further aim is for the book to create added value for both the individual and their company, providing a basis for thoughts or ideas that can lead to lasting improvements.

Holmen Timber, Braviken Sawmill, Norrköping.

SUSTAINABLE DEVELOPMENT – A VITAL ISSUE FOR THE WOOD INDUSTRY

How we manage the forest

Establishing a new forest

When a forest owner wants to establish a new forest, there are a few different approaches they can take. Sometimes nature can be left to do it on its own with the help of a few seed trees left behind. This is called natural regeneration and is most common in pine forests. In lands with very vigorous vegetation, new seedlings need to be planted by humans to give them a chance to survive the fierce competition. This is usually done on land where spruce is dominant. In addition to the planted seedlings, there is always natural self-seeding, especially of various deciduous trees. Some of these deciduous trees will then become part of the mature forest, together with the planted trees.

When is it time to harvest?

A high proportion of Sweden's forests are privately owned, which means that our forest is managed in a variety of ways. This is because forest owners' goals for their forest naturally vary depending on individual interests and objectives, which can range from letting the forest grow so that it produces valuable timber to giving the forest high social or environmental value. Whatever the aim, the Forestry Act prevents the forest owner from carrying out regeneration felling before the forest has reached a certain age. For conifers, the minimum permitted age varies between 45 and 100 years. When it comes to deciduous trees, beech for example may not be felled until it is 80 years old and oak until it is 90 years old.

There are different ways of harvesting, and many methods have been used over the years. For a while it was more common to employ large-scale clear felling, where not much was left after harvesting, before new trees were planted. But in the 1970s, it was realised that this was not good for either the flora or the fauna and so more care began to be taken. 1993 saw the introduction of the Forestry Act, which marked a breakthrough for nature conservation work during harvesting. Today, high stumps or dead wood are left on the ground to create favourable habitats for insects and plants. Groves of trees are also left behind both to protect species and to reduce the sense of bareness.

Biodiversity and our responsibility

Climate change presents us with major challenges and it is essential to protect biodiversity. What are Sweden's forest owners doing and how can biodiversity be measured?

Sweden's *Red List* assesses and summarises the risk of individual species dying out in Sweden, and provides an overview of their status. The list can provide support when deciding on nature conservation priorities and is an important source of knowledge in the drive to achieve set environmental goals.

There is nothing to suggest that the forests have become less species-rich in recent centuries, but there is also no evidence of an increase in diversity. The Swedish bird survey does, however, indicate an increase in birdlife in the forest. We also know that many of the habitats that are crucial for biodiversity have seen an increase, with more ancient forest, large trees, broadleaf trees and deadwood. Since the 1950s, no species has disappeared from Sweden solely as a result of forestry. According to the Swedish Species Information Centre's Red List, harvesting "may have been a contributory factor" in the disappearance of five species in modern times, but there are also many other reasons behind these species losses.

The Forestry Act of 1993 puts environmental and production goals on the same footing. Achieving environmental goals and securing production goals are thus of equal importance. This is a responsibility to which all forest owners contribute.

The Swedish Species Information Centre and the Swedish Taxonomy Initiative at the Swedish University of Agricultural Sciences, SLU, provide much of the nation's official statistics.

Forest owners' responsibility

Responsibility for biodiversity in the forest is shared between the state and the forest owners.

The state preserves forests through nature reserves, habitat protection areas, nature conservation agreements and national parks. Forest owners discharge their responsibility by showing environmental consideration in their silviculture measures and, for example, voluntarily setting aside land for nature conservation.

How much of Sweden's forest land is not managed?

Sweden has 28 million hectares of forest land, but not all of it is used for forestry purposes. Let us explain the different concepts involved:

- **Formally protected forests**
  Sweden has 30 national parks, over 5,200 nature reserves, over 8,400 habitat protection areas and 5,400 nature conservation agreements. Formally protected forest totalled 2.4 million hectares at the end of 2020, according to Statistics Sweden, SCB, which corresponds to 9 percent of Sweden's forest land. Of this, a little over 1.3 million hectares relate to productive forest, representing almost 6 percent of the nation's productive forest land.
- **Voluntary set-asides**
  Forest owners who are certified under one or both of the certification schemes FSC and PEFC refrain from working at least 5 percent of the productive forest land on their property. Often, forest owners who are not certified also choose to keep some areas free from forestry activities. Sweden's voluntary set-asides currently total a little over 1.3 million hectares of productive forest land.
- **Non-productive forest land**
  Non-productive forest land is forest on poor soil where total tree growth falls below one cubic metre per hectare per year. Non-productive forest land covers a total of 3.1 million hectares, or 11 percent of Sweden's forest land, according to the SCB.

2030 Agenda
The wood industry's contribution to the Sustainable Development Goals starts with the seedling in the forest and continues to the finished product, thanks to the unique properties of wood from a climate and resource perspective – but also thanks to an innovative, forward-looking and curious industry that is constantly changing and improving, with its sights firmly set on the climate goals. The 2030 Agenda comprises 17 global goals for sustainable development. The goals balance the three dimensions of sustainable development: the social, the economic and the environmental. The whole wood industry contributes to all three of these dimensions.

How are the calculations done?

If you want to work out the amount of Sweden's productive forest land that is formally protected, the figure is 6 percent. But if you instead calculate how much of the total forest land is exempt from forestry activity, the figure is around 25 percent.

Sweden has a very strict definition of what can be considered protected. Most EU countries claim that they protect at least 20 percent, some even more. However, this protection can often include allowances for agriculture and forestry — which is not the case in Sweden.

Products and use of resources

Our trees will have been growing for 60—120 years by the time they are harvested. We therefore have a particular responsibility to produce the right products from every part of the tree and to make the very best use of the raw material.

Optimised use of each log

When the logs arrive at the sawmill, considerable resources are mobilised to get the most out of each log, both financially and in terms of volume. Each log is unique when it comes to shape, structure and quality. Matching each log to a potential, saleable wood product and achieving a high yield is an extremely complex job.

This process has made great advances in recent years with the help of digital tools. Modern x-ray technology allows the sawmills to see knot structures, heartwood ratios and other properties before the log has come anywhere near a saw. This allows the mills to quickly make reliable assessments of which product will maximise the use of each log. Will it become a wood floor in Sweden, a stud wall in the USA, packaging material in the UK or decking in Norway?

The technique of x-raying logs is constantly advancing, as is the precision of the choices being made. This development is also accompanied by work on improved sawing precision, thinner saw blades and better drying methods — all to increase what we get out of the raw material.

Logs are usually transported by truck. The goal is to make the transport sector fossil-free by 2030, which will require energy-efficient modes of transport, engines and driving methods.

What do we mean by a renewable raw material?

A "renewable resource" is a natural resource that is depleted more slowly than it regenerates. The benefit of forest raw material is that it is both renewable and circular.

Paper fibre can be reused up to 25 times, after which it can be turned into a biofuel and put to use one last time.

The difference between fossil and bio-based products

Oil is an example of a fossil raw material. It is actually made of plants that have been pressed down into the Earth's crust and subjected to high pressure over millennia. Because it takes such an incredibly long time to create oil, it is considered a finite resource. And when we burn it, it changes the natural balance in the carbon ecocycle of the planet, while raw materials from the forest, soil and sea are part of a natural ecocycle based around photosynthesis.

So there is a difference between fossil carbon emissions (which we get from burning oil, for example) and biogenic carbon emissions (which we get from burning firewood, for example). The fossil carbon emissions add to the amount of carbon in the atmosphere. Biogenic carbon emissions are part of a constant cycling of carbon atoms between the atmosphere and the biosphere.

Would we still need to harvest the forest if we consumed less?

Substituting finite, fossil products with renewable, bio-based products is part of the solution to climate change, resulting in more sustainable consumption. It will no doubt be important in the future to reduce our overall consumption of raw materials, particularly those that are not part of a circular system.

Products made from fossil and finite raw materials, which are not circular, should be phased out first, because they add bound carbon atoms to the atmosphere. Then we can begin to reduce our demand for renewable materials. However, this kind of transition takes a long time. Reducing the use of renewable raw materials today would result in higher demand for fossil materials.

It is also worth remembering that many of the products we make from the forest currently fulfil important social functions. Packaging in the food industry protects the food and reduces our food waste. Hygiene products are important for reducing the spread of diseases. Access to period products is important in enabling women the world over to participate equally and actively in society. The list of vital products from the forest that improve our quality of life is a long one. Ending their use would have major negative impacts on daily life.

The overall climate benefit of Swedish forest

As well as providing products that we need in our everyday lives, the forest can also be part of the solution to the climate challenges we face. So what is the best way of using it and what would happen if we just left the forest alone?

The forest makes a positive contribution to the challenges of climate change. As trees grow, they capture and store carbon in a process known as sequestration. The Swedish forest grows by an average of 120 million cubic metres each year, which equates to a carbon sequestration rate of over 140 million tonnes per year. Sweden's territorial emissions (emissions that occur within Sweden's borders) of greenhouse gases amounted to 46.3 million tonnes of carbon dioxide equivalents in 2020.

The effect of the forest is often summed up as "capturing, storing and replacing". Trees capture carbon dioxide as they grow. When they reach old age and the growth rate slows, so does this capacity for carbon sequestration. We harvest forest and use it to build houses and furniture or to make board, paper, textiles, hygiene products and so much else — products that all store carbon dioxide. Using the forest as a raw material, we can also replace products that would otherwise be made from fossil resources, providing what is known as the substitution effect. If wood can be used instead of oil, this keeps more carbon in the ground. It is good to have different areas of the forest at different stages of maturity. Because a tree's capacity to capture carbon deteriorates as it ages, managed forest with trees of different ages delivers greater climate benefit than a really old forest whose trees are all the same age.

Would the climate benefit be greater if we didn't manage the forest?

Active management is the best strategy for ensuring that the forest delivers a climate benefit over the short and long term. By using wood as a material, we can store carbon dioxide even as we create housing, furniture, bioenergy, packaging and textiles. It is important to have trees in the forest capturing carbon dioxide. But at the same time we need wood, a renewable raw material, for a whole host of different uses, enabling us to cut back on our use of fossil resources such as oil and coal. Today, around 90 percent of

Tree trunks contain natural chemicals such as terpenes, phenols and phosphorus, many of which are part of the tree's defence against fungi and insects. However, it is important to transport the timber out of the forest in good time to avoid damaging the surrounding environment or reducing the value of the sawn product.

single-family houses are built in wood and about 20 percent of multi-storey buildings have a timber frame.

Benefits of managed forests

Would it be better to leave the forest intact, so it can be used as a carbon sink? Why do we manage the forest? There are many different answers to that question. If we couldn't use wood, which is a renewable raw material, we would need to use more fossil resources when building houses, making furniture or heating our homes. We would not be able to manufacture toilet paper or packaging from paper pulp.

Forestry also contributes to the Swedish economy. Today, the forest industry employs around 115,000 people, making it a vital economic hub in many Swedish regions, particularly outside the big cities. In fact, the forest industry provides 20 percent or more of the industrial jobs in many counties.

The forest has an economic value for all the 315,000 private forest owners in Sweden, and in 2020 the forest industry accounted for around 9—12 percent of Swedish industry's total employment, exports, sales and value added.

Social benefits are also created thanks to Swedish forestry. Forest roads are currently being built and maintained because they are important for accessing and moving logs. There are around 210,000 km of forest roads in Sweden. These roads allow lots of people to get out into the forest and countryside, as well as facilitating firefighting work in the event of a wildfire.

ENERGY EFFICIENCIES AT THE SAWMILLS

A sawmill has many energy-intensive components. In addition to the machinery itself, there is also ventilation, heating, lighting and control systems. Continuously measuring and mapping energy consumption in the manufacturing process provides excellent opportunities to improve energy efficiency.

With their high energy demand, sawmills can benefit greatly from efficiencies to reduce their costs and carbon footprint. To achieve this, it is important to monitor and control electrical installations and optimise their energy use. Another reason to work on energy issues within a company is the positive effect it has on active environmental work.

The phrase "to measure is to know" is very much applicable to energy efficiency. Measuring electricity consumption in real time allows you to identify the areas with the greatest energy losses and focus on them first. It is also important to measure electricity consumption over time to evaluate the impact of energy efficiency measures.

Staff engagement is crucial for success in this area. All employees should be aware of the importance of energy efficiency and how they can help to reduce energy losses and our carbon footprint. Training staff, presenting real-time measurement data and involving them in energy efficiency efforts can create a culture of energy saving that could yield significant results over the long term.

With ever larger sawmills and increased production volumes, energy use has gradually risen in recent years, while at the same time more and more resources have been devoted to both mapping energy consumption and designing machinery that requires less energy.

In a sawmill, there are great opportunities to save energy with relatively small means. The key is to work systematically and keep energy top of mind when it comes to both existing equipment and future investments.

Some practical examples of measures that can help to reduce energy costs are:

- Recover surplus heat from various production processes.
- Procedures to reduce idling, such as a daily check of all premises at the end of production.
- Install more efficient control equipment.
- Review the efficiency of the drying kilns, which are among the most energy-intensive installations in a sawmill.
- Identify unnecessary heat loss through thermal photography and fixing leaks.
- Save energy in production facilities and offices, for example by changing fluorescent tubes to LED lighting.

Stable production relies on good power quality, with measurements and analysis able to reveal the presence of reactive power, namely the energy that is not translated into useful work and that can create both disruption and unnecessarily high energy costs. Installing capacitors or other compensating equipment can reduce the reactive power and thus increase efficiency.

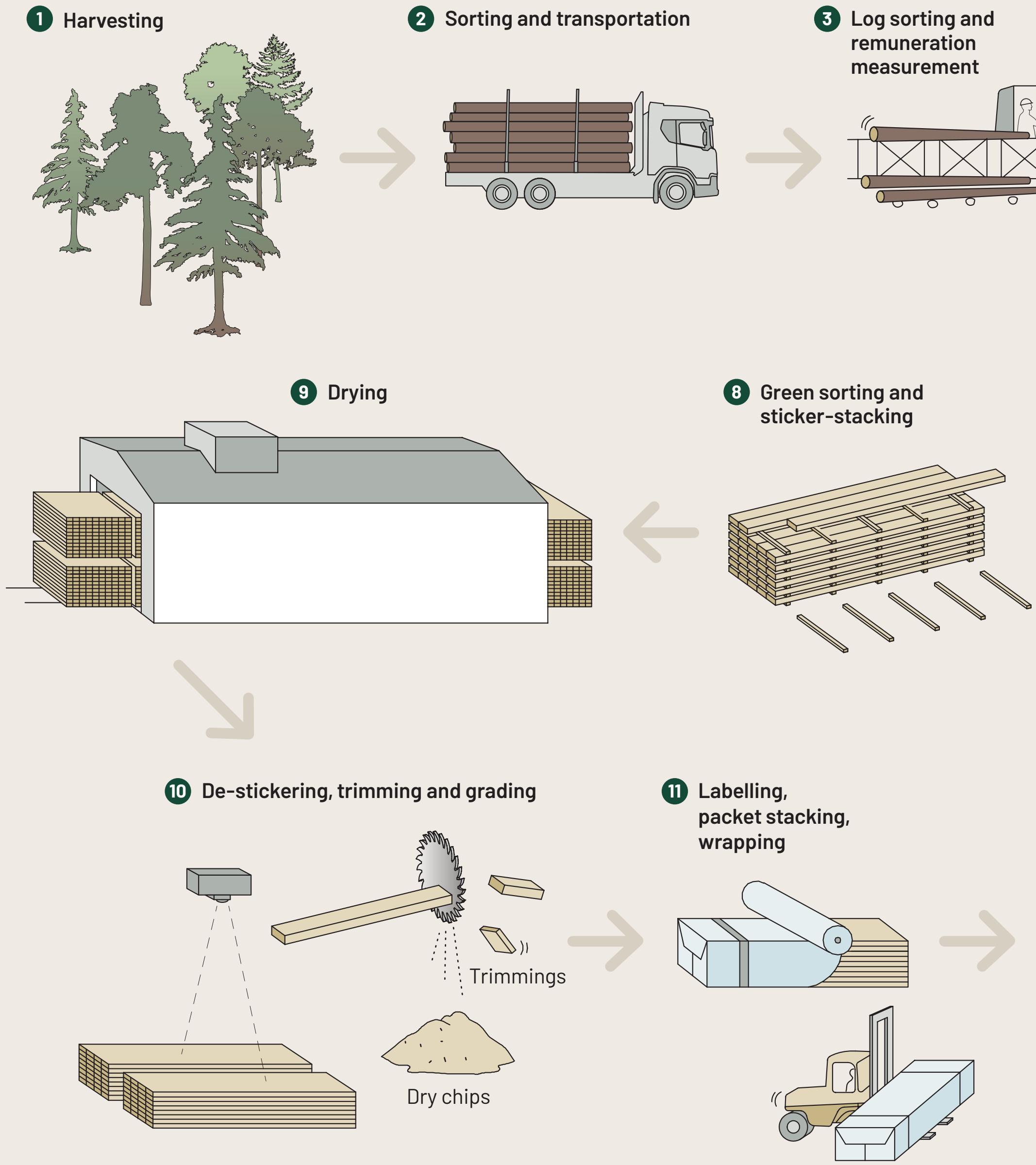
In summary, energy efficiency is an important part of sustainability in the sawmill industry. Measuring electricity consumption, having good power quality, limiting reactive power and achieving balanced energy consumption can reduce energy losses and lower energy costs.

Sectional distributor for hydraulic pressure to the various components of the machine equipment. The distributor is located close to each machine group for easy access and ensures precise control and monitoring of the hydraulic flow directly alongside the saw line.

Industrial heat recovery system. To achieve maximum efficiency, careful calculation is required based on the size of the premises and the extraction requirements.

PRODUCTION FLOW

The figure shows an example of the material flow through a sawmill and the different production processes. In general, the flow looks pretty much the same at most sawmills.



1 Harvesting
There are different types of harvesting: first thinning, second thinning and final harvesting. Under the Forestry Act, felling may not be carried out in just any way – special regulations apply, not least for environmental reasons.

2 Sorting and transportation
Harvested raw material is sorted by tree species into pulpwood and sawlogs and transported to the sawmill or the paper and pulp mill by truck or rail. *See page 14.*

3 Log sorting and remuneration measurement
Logs arriving at the sawmill must be measured impartially and accurately, as grading into different diameter classes and qualities is based on this measurement data. *See page 14.*

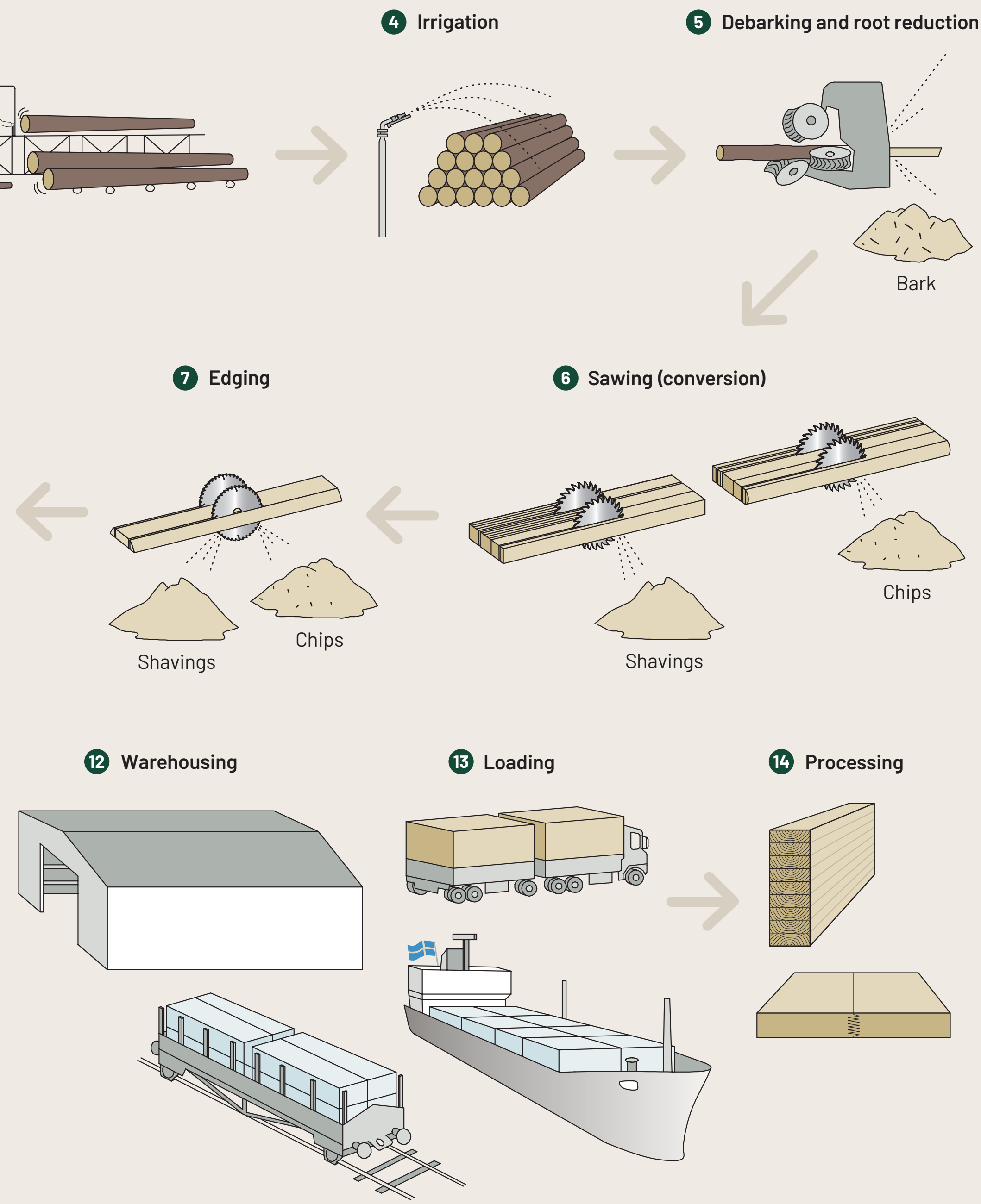
4 Irrigation
During the warm season, the timber is watered to prevent the logs from being damaged by blue stain fungus and insects or by cracking. *See page 17.*

5 Debarking and root reduction
Before sawing, the timber is debarked in a debarking machine equipped with cutting tools that shear off the bark. The root reducer mills away butt flare or large buttress roots. Bark and reducer chips are used as fuel. *See page 19.*

6 Sawing (conversion)
The most common method of sawing/converting a log is cant sawing followed by rip sawing. The wood from the outer parts of the log and the block (or cant) is then sent to the edging section. Alternatively, the logs are broken down using a profiling saw. *See page 23.*

Shavings and chips
The cellulose chips, or green chips, come from the outer parts of the log and are an important raw material for sawmills. *See page 34.*

7 Edging
The wood from the outer parts is called the side yield. This is cut based on a maximum volume or value using an automated edger. *See page 31.*



10 De-stickering, trimming and grading
The dried timber is sorted by dimension, length and grade. The grade of the timber is assessed on the basis of a number of parameters specified in accepted grading rules. *See page 41.*

Trimmings and dry chips
The dry sorting line cuts the timber to the appropriate grade and length. The trimmings are then transported to a chipper and the chips produced are mainly used as fuel.

11 Labelling, packet stacking, wrapping
Each piece of timber is usually stamped on the end with a shipping mark indicating its grade. The timber packet is wrapped with plastic or paper to protect it from rain, sun and dirt. *See page 52.*

12 Warehousing
The packaged timber is stored under cover in unheated warehouses pending delivery. Lower grades are sometimes stored outdoors in covered packets.

13 Loading
See page 54.

14 Processing
Timber can be processed into a number of different products based on its properties such as grade, length and moisture content. Processing may take place at the company's own sawmill or it may be the customer who planes, splits, cuts, glues or finger-joints the timber into a final product. *See page 67.*

8 Green sorting and sticker-stacking
The green sorting line receives the timber from the sawmill and sorts it by size. The lengths of wood are then layered with drying stickers, and stacking stickers can be placed between packets that will be stacked in the dryer. *See page 32.*

9 Drying
The wood is dried in progressive or batch kilns to reduce the moisture content without cracking and so that it can be stored or transported without damage. *See page 36.*

LOG HANDLING

The roundwood, which often comes in on special timber trucks, can be quickly unloaded using a log stacker.

Each individual log entering the green sorting facility has to be measured and sorted into a log class.

Log sorting and remuneration measurement

The first sub-process at a sawmill is the arrival of the raw material at the log sorting facility, usually by timber truck, but sometimes also by rail. The logs are unloaded and placed in a pile ready for measuring and grading.

The main process here is to value the roundwood so that the right amount can be paid to the supplier. Alongside the quality of the wood, the value is also determined by the volume, namely how many cubic metres have been delivered according to the contract. The valuation of the wood, called remuneration measurement, is carried out by staff from Biometria, an independent, member-run company that impartially measures and accounts for forest products in the trade between forestry and industry. Biometria's members are natural and legal persons who sell, buy and handle forest raw material or biofuels, or who are otherwise active in the forest industry or the forest flow.

Units for volume measurement

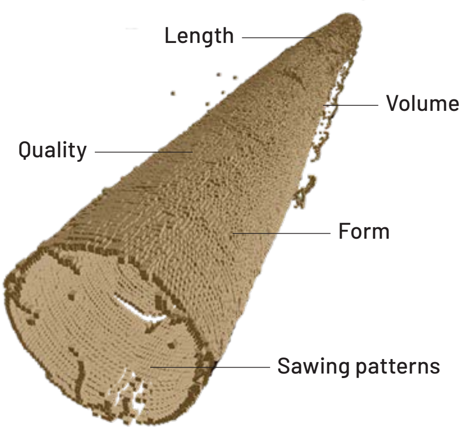
m^3sk Growing stock, solid over bark, meaning the volume of the whole tree above the stump cut, including bark.

m^3 sob Cubic metres solid over bark.

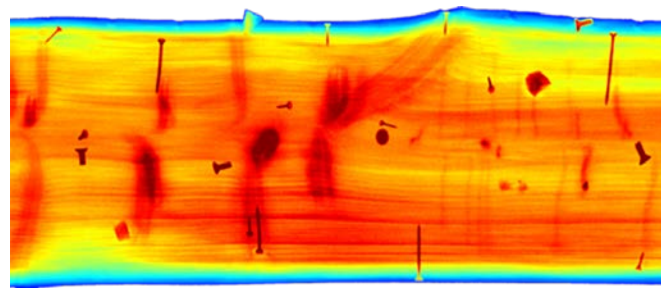
m^3 sub Cubic metres solid under bark.

m^3t ob Cubic metres stacked, over bark.

$m^3$to ub Volume in cubic metres of a cylinder calculated as the top diameter (under bark) times the log's length.



The x-ray frame records all the internal and external characteristics of the log. The recorded information is then used to optimise the sorting for the best value yield.



It is of utmost importance to sort out faulty logs before conversion. Logs containing stones, metal and other foreign objects cause production losses during the conversion process.

Sawlog measurement is generally conducted on a log-by-log basis, with each individual log valued according to its volume and quality. For larger deliveries, random sampling methods are sometimes used, usually by taking a first measurement of a roundwood stack, either manually or using camera technology. There are different ways of measuring sawlogs, see *Units for volume measurement, page 14*.

The volume measurement is done by passing the log longitudinally through a measuring frame that records a wealth of data from the outer parts of the log, while assessing the volume of each log. The recorded data covers diameter, length, ovality and any crookedness in the log — all the vital statistics.

The logs are divided and sorted by tree species and into log classes based on the diameter of the top end of each individual log. The number of log classes varies from sawmill to sawmill depending on the number of compartments in the log sorting system or the type of production.

Using x-ray technology, logs can be sorted by internal characteristics at an early stage, ensuring a better yield from the log.

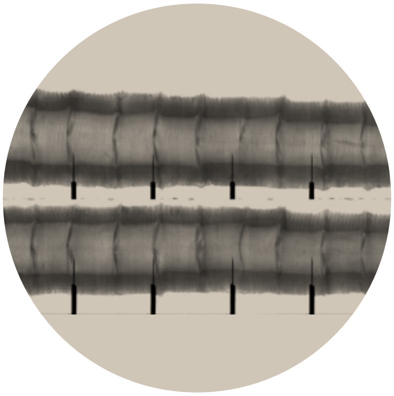
The number of log classes varies from sawmill to sawmill depending on the type of production.

The data from the measuring frame is used to sort the log as required. Above all, it is important that the top diameter should be as similar as possible for all logs in each class, as this makes production more efficient and economical.

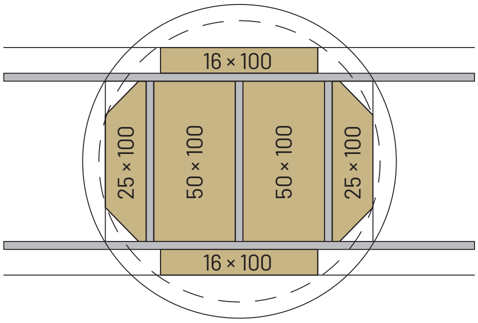
The log sorting also removes defective logs, for example because they contain metal, rot or insect damage or they are too narrow or thick. These logs are placed in a special pile. The sorting process also includes a measurement check of randomly selected control logs and a check of the measuring equipment, along with a competence check and internal calibration measurements. It is essential that all the measuring equipment functions according to the established limit values and that the quality assessment is carried out in an equivalent and correct manner. This system of checks and balances should ensure the detection of any error that may affect the measurement, and provide a basis for improving measurement regulations, methods and techniques.

Today, advanced x-ray technology, known as Computed Tomography, CT, scanning, is available to scan the logs, allowing the wood to also be sorted by its internal characteristics in order to increase the value of the sawn timber.

After sorting, the logs are stored in sorted stacks, with one stack then processed at a time.



X-rays can be used to select raw material with the exact properties required for a particular end product.



EXAMPLE OF SAWING PATTERNS

It is beneficial to sort logs according to the sawing pattern to increase saw yield and minimise by-products. The log is then turned into the optimal position before conversion.

Storage, irrigation and transport

After the wood has been measured, classified and sorted into diameter classes, it is re-stacked ready for conversion. The amount of logs stored in the lumber yard can vary depending on the season and transport availability. However, the inflow of timber can be greater than usual at certain times, such as when the forest roads have dried up after the spring thaw, and the stockpile temporarily grows larger.

The logs are stored outside. Newly felled raw material contains a large amount of water, is sensitive and needs to be protected from drying out during the summer months. Wood stored outside needs to be either sawn immediately or irrigated. If not, the risk of damage increases significantly.

Proper timber irrigation is crucial in avoiding quality-impairing damage and unnecessary environmental impacts, for example:

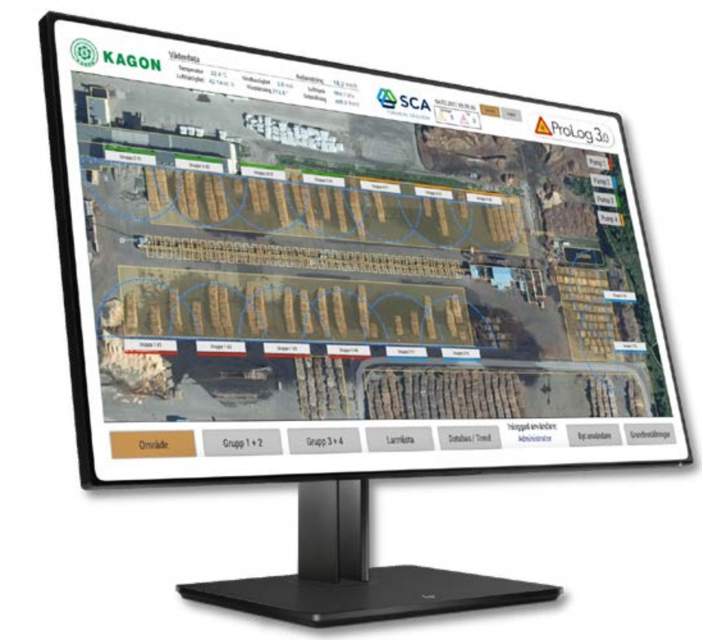
- **Cracks** — dimensional changes due to drying out.
- **Insect infestation** — physical damage by insects and transmission of spores.
- **Blue stain** — fungal attack by insect- or wind-borne spores.
- **Increased permeability** — bacterial attack leading to over-absorption of paint and stain.
- **Leaching of substances** — excess inputs of organic matter can affect watercourses.

Rain gun with long range and jet breaker.

It is important not to under- or over-irrigate the timber, but to base it on the evaporation and needs of the wood, depending on the prevailing conditions such as weather and humidity. It is thus necessary to ensure the correct irrigation capacity and to control the intervals with an intelligent system for optimum protection of the raw material.

Over-irrigation of timber — watering more than the stack needs over time — can cause bacterial damage to the wood. This can result in properties such as increased permeability.

Weather and relative humidity affect evaporation from the stack.



Irrigation is carefully adjusted to protect the wood from drying and prevent loss of value due to damage.

Permeability refers to the water absorption capacity of the timber, which is not visible to the naked eye but only becomes apparent when the timber is stained, for example. The damaged areas attract more stain and create a patchy finish. The damage is usually discovered too late, as the piece of wood is already in place in a piece of furniture, for example. The increased permeability also leads to greater water absorption in outdoor joinery, such as window frames, with an increased risk of rot. Timber that has been wet stored for a long time is not suitable for windows.

The irrigation of timber requires a permit under the Nature Conservation Act. In many cases, the County Administrative Boards' environmental management units have ordered sawmills to reuse and recycle the water, in order to minimise discharges into nearby watercourses. When recycling the water, coarse particles must be filtered out.

The Environmental Protection Agency has no requirements for recycling when irrigating sawlogs. However, there are requirements on how much pollution in the form of phenols, phosphorus, nitrogen, etc. may be released into watercourses. Excessive input of organic material can, for example, lead to reduced oxygen availability in a water system. This in turn can lead to the formation of hydrogen sulphide and the release of iron and manganese into the groundwater.

However, the impact of the leachate on the environment also depends on the ability of the site to degrade the substances leached and the type of water source adjacent to the lumber yard. Other factors to consider include whether it is a flowing watercourse or a drinking water source.

From the lumber yard, the logs are transported by loaders to the log feed before the saw line itself. On this journey, the timber is subjected to a number of stresses. It is important that the lumber yard is free of contaminants such as stones. Stones pressed in by the loader's forks can damage the surface of the logs and the machine tools, which can then affect production and the yield of sawn timber.

Log feed

Log feed, root reduction, debarking and top-root rotation

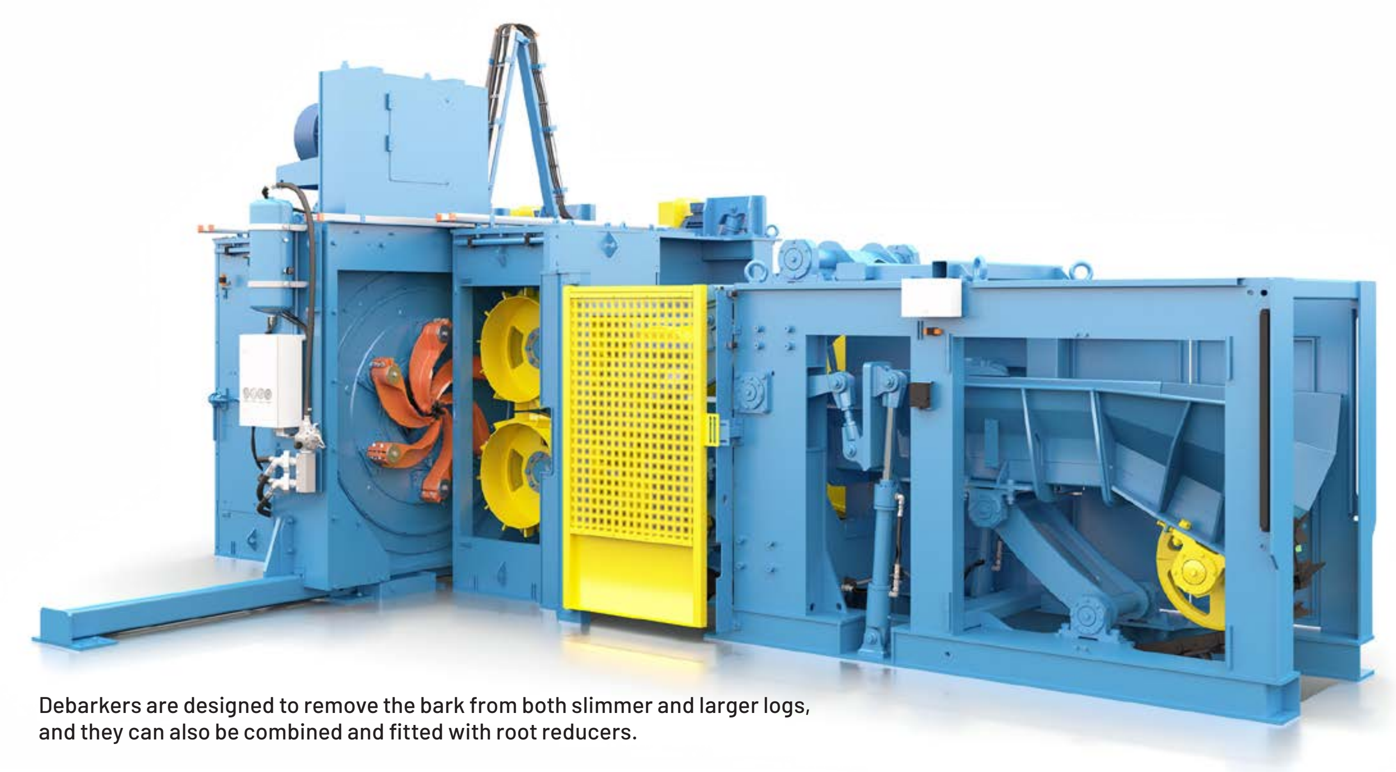
Loaders transport the logs from the lumber yard to the log feed, which sits adjacent to the saw line. A large number of logs can be kept here as buffer stock. The log feed is generally unmanned, but can be monitored and controlled from the operator's station on the saw line. Before conversion, the logs have to be debarked and outgrowths known as buttress roots or butt flares need to be reduced by means of milling. Most sawmills also tend to rotate the logs so that the top enters the saw line first.

Many of the tools at the sawmill are sensitive, so it is important to protect them, for example from nails and other metal objects that might be found in the logs. Ideally, they should be passed through a metal detector before making their way onto the saw line. The metal detector might be located in the log sorting unit or in the log feed.

Large butt flares or buttress roots are removed by either turning or milling them away using a root reducer through which the logs pass either crossways or lengthways.

Root reducer

Debarker



Debarkers are designed to remove the bark from both slimmer and larger logs, and they can also be combined and fitted with root reducers.

The root reduction process makes the logs a more even thickness at the root end, so that they can pass through the debarker and be machined by the saw.

Debarking — removing the bark from the logs — is usually kept until right before the infeed into the sawmill, as retaining the bark for as long as possible protects the wood from drying out and other damage. Bark makes up between 7 percent and 16 percent of a raw log's volume, *see page 14*.

The debarking also takes place lengthways. The logs are fed into a machine with a rotor, where the debarking tools press against the log to shear the bark off the logs. The bark and the chips resulting from the root reduction are used as fuel at the plant or sold to an external heating plant.

The important thing is to make sure no bark is left on the logs, as any remaining bark will contaminate the wood chips that are sold on to the pulp industry, causing the value of the chips to fall sharply.

Most, but not all, sawmills, prefer the logs to enter the saw top end first, with a log turner rotating them either left or right depending on which end enters first. The log turning is normally done automatically by passing the log through a measuring frame that measures top diameter, length and root diameter. These values then automatically control the turning.

Once butt flares and bark have been removed and the log is oriented correctly, it goes into the sawmill.

Log turner.

Storage bays for bark.

PRODUCTION PLANNING

The production planner takes into account different information and conditions in pursuit of the most efficient production possible.

Decisions on what to saw are based on the grades and quantities being sold and the type of wood available. The workflow may differ, but here is an example:

The salesperson has specified a variety of information in the contract with the customer, for example:

- Detailed quality specification
- Wood species
- Dimensions
- Sawing method
- Moisture content
- Planing method
- Application
- Packet stacking
- Banding
- Wrapping.

The production planner plans production based on the salesperson's information, timber stocks and delivery dates. There may be a technical salesperson to coordinate communication between production, sales and the customer.

The salesperson provides the information to the production planner, who plans the production based on this information as well as information on timber stocks and delivery dates.

Production monitoring in sawmills

It is important to continuously monitor how the production process is going and whether the outcome is as expected. There are many examples of how a small deviation in one department can have a negative impact on a later part of the production chain.

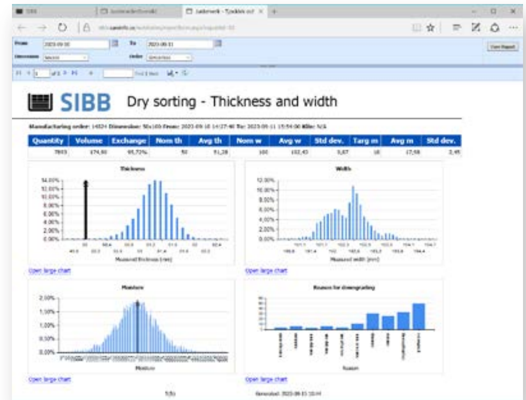
System monitoring may be both manual and automated. Whatever the system, it is important that all incoming and outgoing data is recorded and analysed so that nonconformities can be detected and corrected. The purpose of monitoring procedures is to achieve greater efficiency throughout the sawmill.

Some examples of production monitoring:

- **Timber stocks:** Quantity, diameter, length distribution, quality
- **Conversion:** Saw yield, dimensional accuracy, production rate, availability, causes of downtime
- **Drying:** Drying times, moisture content, energy consumption, use of capacity
- **Dry sorting line:** Quality outcomes, downtime, production rate, reasons for downgrading
- **Logistics:** Current stock, efficiency, routes.

As a rule, production reports are generated from each department and many follow up what are known as OEE values. OEE stands for Overall Equipment Effectiveness. However, it is often difficult to put a value on quality outcomes at sawmills, as many of the quality problems may be related to the raw material.

Effective production monitoring requires tools that link what is happening in each sub-process, as the consequences of problems in a sub-process often manifest later in the production chain. There are several production monitoring systems that store production data. One example is the production database SIBB, SawInfo Blue Box, which collects all production information related to logs, orders, packets, drying, timber pieces, downtime, etc. in a database that can be integrated with and retrieve data from existing systems. With data linked in real time, you can, for example, trace measured moisture content on the dry sorting line back to drying kilns and dried batches.

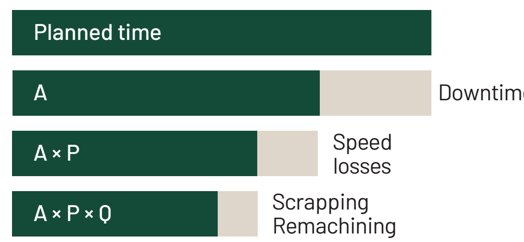


A system that records all data in each sub-process and links them together enables detailed monitoring.

Downtime monitoring – a way to increase availability

Achieving high efficiency is one of the most important issues for sawmills and this factor is closely linked to high utilisation of the capacity available in the plant. There are many terms used in this context, such as availability, utilisation rate, efficiency and plant utilisation. To achieve optimal efficiency and increase productivity in the long term, production needs to be continuously monitored.

Availability is determined by analysing how much of the planned production time the production equipment is actually in operation. It is important to identify and try to eliminate availability losses in the form of unplanned stoppages due to equipment failures and material shortages, and to reduce unplanned stoppages such as retooling time. There is a major risk of ignoring small stops of less than a minute that operators resolve themselves without the help of maintenance, but it is important that even these are noted down. Maximum utilisation of the machine equipment is essential for good profitability, and a focus that must never stop.



OEE VALUES

OEE is a key metric for production efficiency, showing the relation between actual production and what is theoretically possible over the same time period. The factors included are:

A: Availability
The percentage of the planned operating time used for production.

P: Performance
The percentage of products produced compared to the plan.

Q: Quality
The proportion of the output that is of sufficiently high quality.

A × P × Q = Overall Equipment Effectiveness.

Carefully analysing what happens in production provides an important basis for improving productivity.

CONVERSION

Detailed measurement of the log makes it possible to assess which sawing pattern will give the best yield.

Measurement and sawing pattern software

Before sawing, the length and top diameter of the log are measured to determine what is to be sawn from the log. The shape of the log is also assessed, including crookedness and tapering. The purpose of these measurements is:

- to obtain data for production statistics
- to get positioning data so that the sawing equipment is set for the best possible yield from the log.
- if possible, to weed out logs of the wrong diameter.

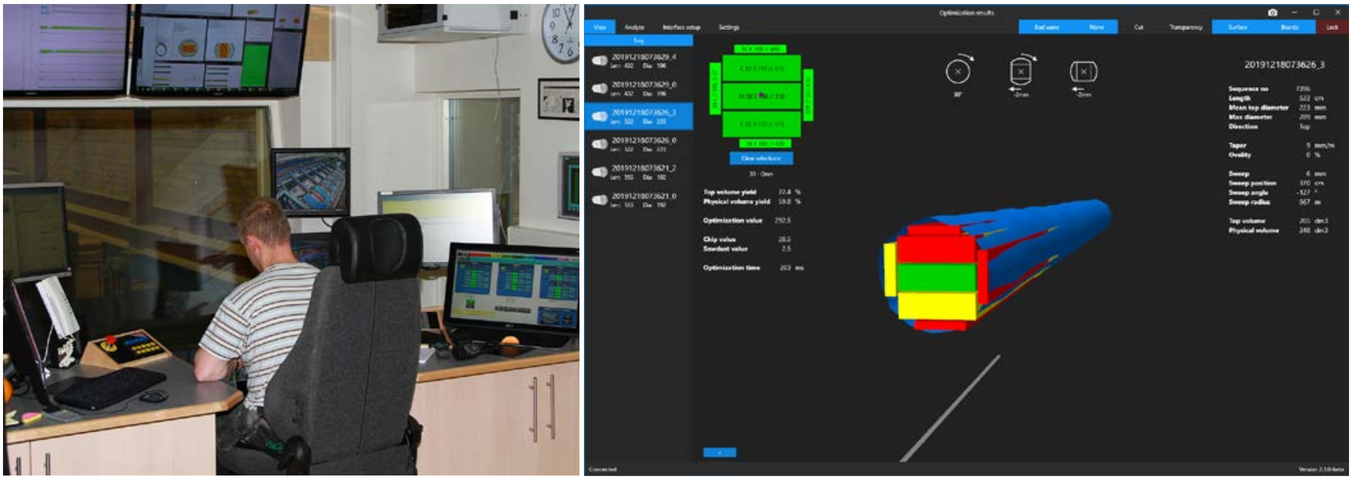
The shape of the log is measured in several directions and once it has passed through the measuring frame, sawing pattern software can choose the conversion — based on given parameters — that gives the best volumetric and value yield. The 3D measurement is done using three or more measuring heads to obtain a complete profile of the log. The measuring frame is placed in the sawmill infeed or on the saw line directly after debarking, which means that the information contained in the software refers to debarked timber. The measured values are compared with a sawing pattern table that has been entered into the computer, which suggests a sawing pattern for the sawing equipment based on the table. The sawmill operator can then judge whether the suggestion made by the computer is correct or, time permitting, choose to adjust the proposed sawing pattern.

Log optimisation is the basis for efficient conversion.

Log x-rays

Industrial Computed Tomography, CT, scanners can x-ray timber at high resolution and calculate in real time how each individual log should be sawn to achieve maximum yield. Using this advanced equipment, the internal quality of the logs can be determined, so that the right log can be allocated to the right product from the initial log sorting stage. This makes it possible to maintain high and consistent quality while reducing waste, and the products that do not meet the customer's requirements can be sorted out at an early stage and transported back to the log sorting facility.

The Computed Tomography equipment (CT Log) is installed in the log sorting area or adjacent to the saw line. The fully automated system positions and manages the log based on what the x-ray scan shows, so that the quality characteristics of the log can be optimally utilised. The equipment enables continuous, qualitative and complete 3D log reconstruction. The internal properties of the raw material



The sawmill operator uses a number of screens to monitor production on the saw line and can study the optimisation software's assessment of each individual log.

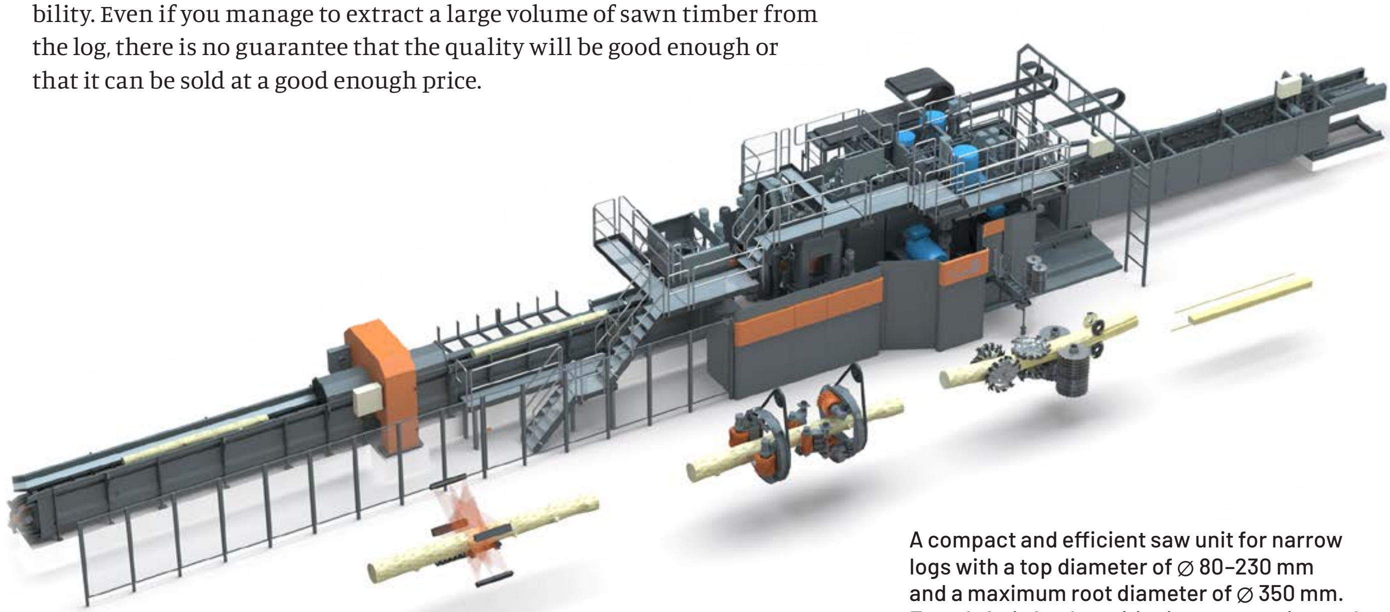
are accurately described in all three dimensions. Using this data, the system evaluates appearance, quality and strength and assesses their impact on the final products. Sawing patterns and positioning of the log during its initial breakdown at the start of the conversion process are continuously optimised to provide the highest possible quality and value.

The log rotator accurately rotates the log before centring it in the optimal position for cant sawing as calculated by the measurement and optimisation system.

Conversion

The conversion process produces both sawn timber and by-products in the form of chips and sawdust.

With the raw material making up a sawmill's single largest cost item, the conversion needs to produce as high a yield of sawn timber from the log as possible. However, the economics of the sawmill are not determined by the saw yield. The value that can be extracted from the log and the production costs of sawing the timber are what determines profitability. Even if you manage to extract a large volume of sawn timber from the log, there is no guarantee that the quality will be good enough or that it can be sold at a good enough price.



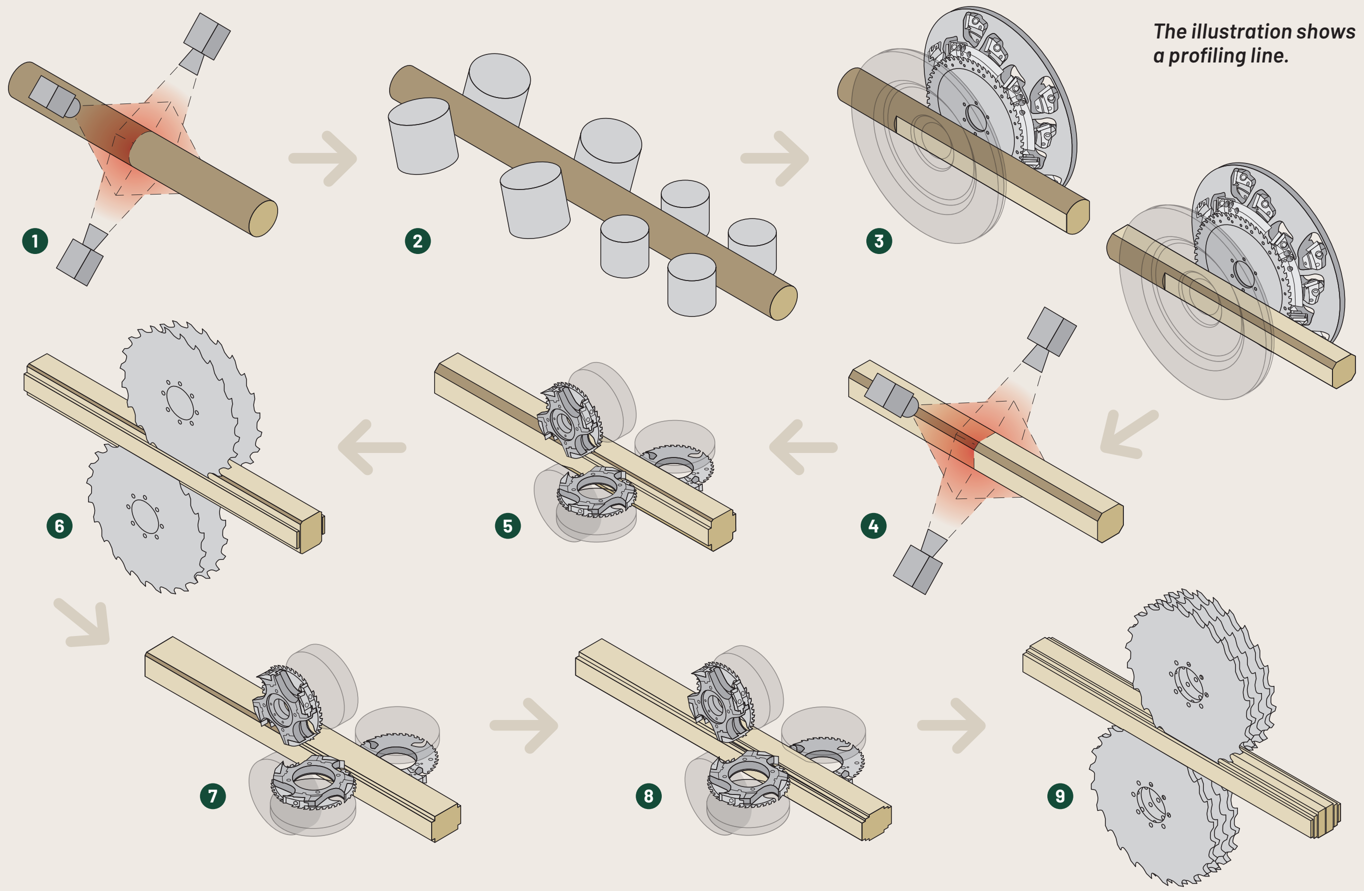
A compact and efficient saw unit for narrow logs with a top diameter of ∅ 80–230 mm and a maximum root diameter of ∅ 350 mm. From left: infeed, positioning, conversion and finished product.

Conversion – processing principle

In the past, a sawmill's breakdown equipment for converting logs consisted of frame, circular or band saws and edgers, usually of the same make. The output, or saw yield, was largely influenced by the professionalism of the operators and the technical level of the equipment.

The actual principle of converting logs has not changed significantly over time, but as the machinery has developed, mechanical systems have gradually been replaced by sophisticated optimisation systems. New saw lines are also often straight, with no sawn timber transported laterally.

Sawmill equipment may vary from one sawmill to another, but increasingly it has a function that monitors all the stages of the conversion process, checking against the optimised plan from the initial log measurement stage throughout production to ensure the highest possible yield.



1 3D measurement
In order to select the best position and the correct turning angle, the geometry of the log is measured with a 3D scanner. Computed Tomography also allows the internal quality of the log to be taken into account. Optimisation focuses on maximum volumetric or value yield.

2 Rotation
For optimal yield, it is important to have precise control over the position of the log before the first conversion stage. Modern camera monitoring systems that check the surface of the log during the rotation significantly improve the process.

3 Reducing in two steps
The first reducer creates two parallel flat surfaces on the log to form a block, known in the industry as a cant. Hooks on the side then turn the cant. The second reducer creates the curve in one or more radii for optimal yield. In active curve sawing, the cut is made along an independently defined line instead of along the natural curve of the log.

4 Control measurement
The square cant is checked and compared with the input 3D measurements. If the measurements do not match, re-optimisation is possible in subsequent machines, along with feedback and an alarm, if nonconformities often occur. The created curve on the block is also measured, and then the cant is hooked upwards again.

5 Profiling of side boards
Two or four side boards are profiled. There is the option of diagonal profiling and optimising width, position and thickness.

6 Cant sawing
The profiled side boards are sawn off. After cant sawing, the cant is hooked to the side again for the subsequent curve processing on the ripping line.

7 Profiling of centre boards 1 + 2

8 Profiling of centre boards 3 + 4
The centre boards are profiled. Here too, it is possible to optimise width, position and thickness.

9 Rip sawing
The centre boards are sawn and separated by a board separator. The centre and side boards go on to the green sorting process.

If there is no profiling line, steps 5, 7 and 8 are omitted and the boards are sent to an edging machine for assessment and edging.

Here, a board separator separates sawn side boards from the cant onto an underlying transverse conveyor. The cant then moves on to a cant turner.

Saw line for different sized logs with features such as optimisation, curve sawing, edging, high-speed infeed and quick change of sawing pattern.

Step-cutting and spiral-cutting discs with serrated blades.

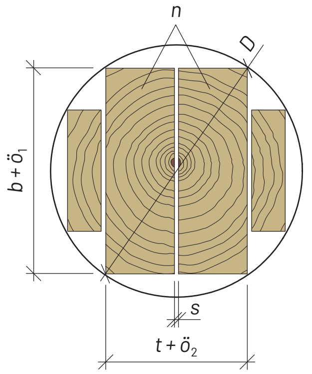
Sawing patterns

Sawing involves cutting the log into planks and boards according to a specific pattern. The aim is to get the best possible economic result from the log. The sawing pattern is drawn up once the sawing method has been chosen.

The pattern is determined by a cutting calculation where in most cases a sharp-edged centre yield is sought. We can see here an example calculation of how small the top diameter may be in order to obtain a certain centre yield. The calculations are made using Pythagoras' theorem:

$$D^2 = B^2 + C^2$$

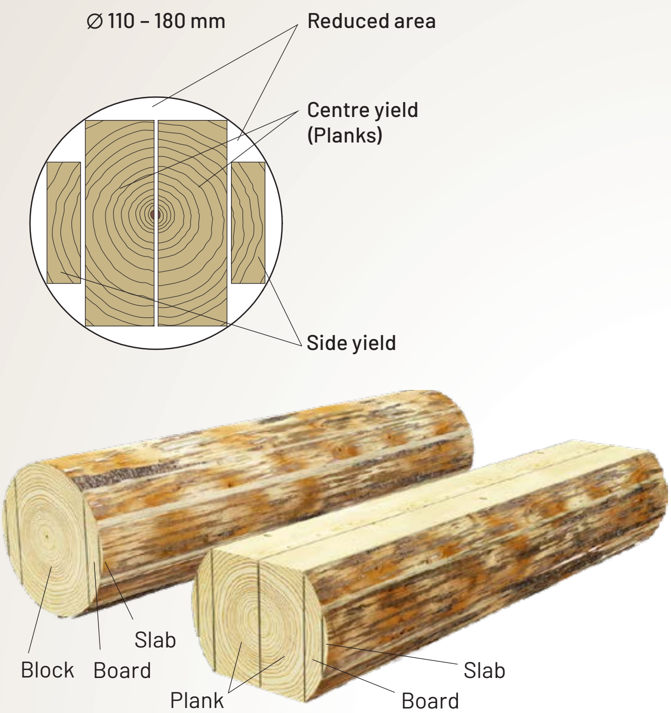
$$\sqrt{\left(b + \ddot{o}_1\right)^2 + \left(n\left(t + \ddot{o}_2\right) + (n-1)\cdot s\right)^2}$$



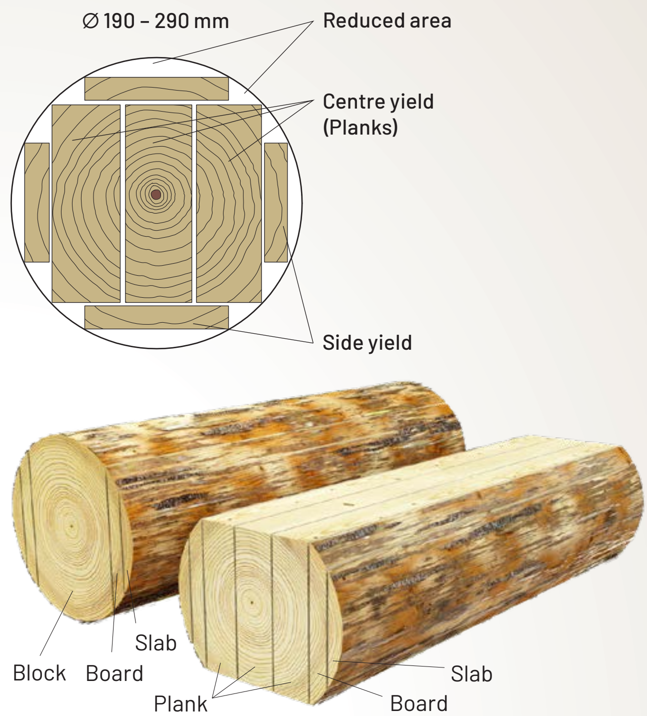
D Top diameter
t Thickness of centre yield
b Width of centre yield
$\ddot{o}_1$ Size of the trimming allowance for width
$\ddot{o}_2$ Size of the trimming allowance for thickness
n Number of centre boards
s Width of the saw cut.

Resawing a profiled cant with opposing blades.

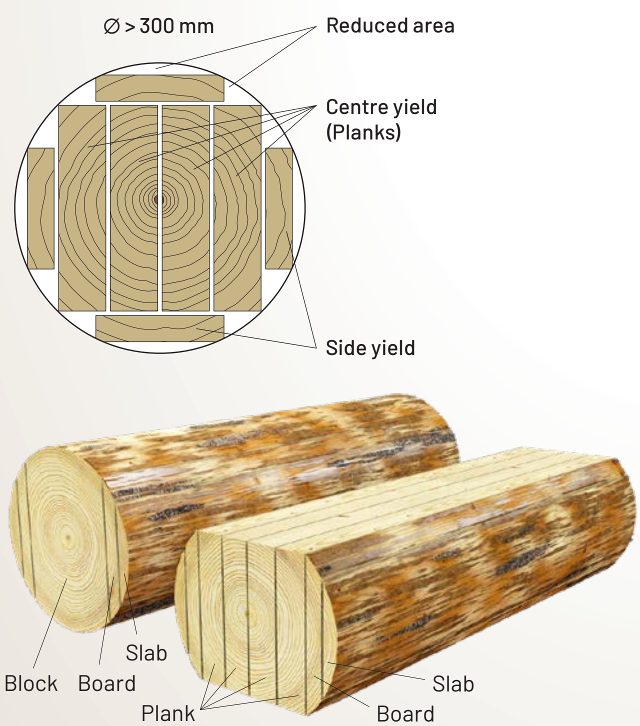
Example of sawing patterns



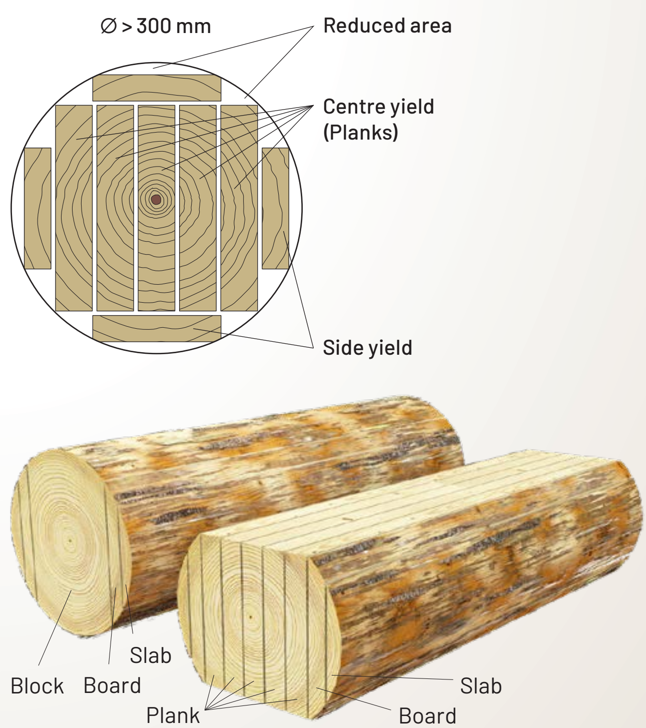
SAWING, 2EX CENTRE CUT
(Nordic sawing practice)



SAWING, 3EX CUT



SAWING, 4EX CENTRE CUT
(Nordic sawing practice)



SAWING, 5EX CUT

The cutting calculation can be done using specific sawing pattern software. If using a computer to make the calculations, there are a number of software programs that can be used for sawing pattern calculations. These can be used to calculate, for example, the yield by volume or value and the cost of sawing using different patterns.

In the simplest programs you only have to enter the top diameter, taper and length of the log. The more advanced programs also take into account other parameters such as log ovality, bow height, diameter spread, infeed accuracy, quality outcomes and pricing. Such information also makes it possible to perform calculations for different sections of the log.

However, it is important to remember that no matter how sophisticated these computer programs are, the knowledge of the user is always paramount. This applies both to the selection of input data and the evaluation of final results.

The sawing pattern is affected by many different factors, a few of which are shown here.

Raw material

- Wood species
- Top diameter
- Length
- Tapering
- Curve
- Quality.

Timber prices

- Price differences for different dimensions and grades
- Distribution by grade.

Machines

- Number of saw cuts
- Width of saw blade
- Bottlenecks, where machines limit production
- Capacity of the machines.

Sawing methods

Different methods can be used to break down the logs. In Sweden, the main method used is the square-sawing method.

Square sawing

Square sawing is by far the most common sawing method in Sweden. This is mainly because it gives a relatively high saw yield and because sawing costs can be kept down through rational production.

In square sawing, a four-sided cant is made from the log. This can be done by sawing off part of the surface or by milling away part of the log in a reducer. The log is then sawn into planks and boards.

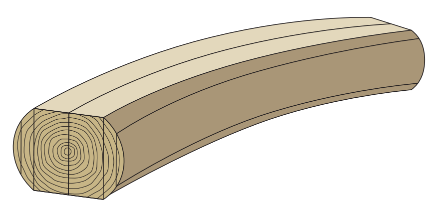
In the first saw, the cuts are made parallel to the longitudinal axis of the log.

In the second saw, the cant is laid flat and the two remaining unsawn sides are cut in the same way.

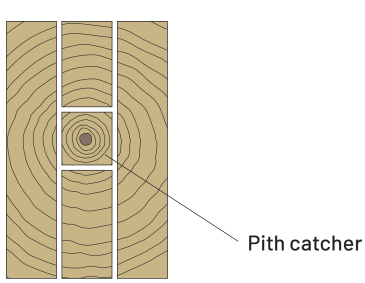
The saw cuts are then made either parallel to the longitudinal axis of the log or parallel to the centreline — depending on whether curved or straight sawing is used. The result is a square cant.

Sawing with a pith catcher

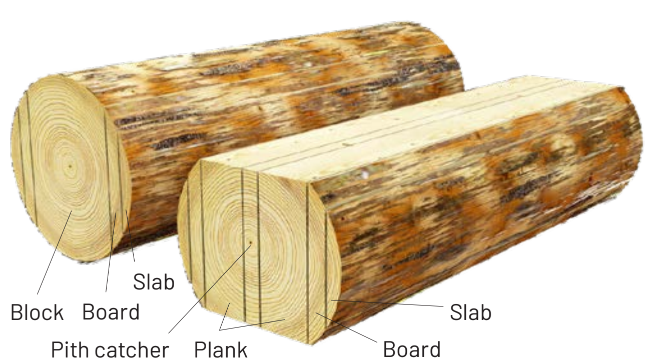
A pith catcher is usually a board that is sawn out from the centre part of the log to contain the pith. A sawing pattern with a pith catcher results in products that are less susceptible to cracking and distortion. Pithless sawing and other specialist sawing should be specified in contracts.



CURVE SAWING
The saw cut follows the natural curve of the log, allowing for an increased yield.



SAWING WITH A PITH CATCHER



SQUARE SAWING WITH A PITH CATCHER

Cant sawing

The cant sawing produces a cant and side boards, while reducers remove the outer parts of the log in the form of chips. The side boards can be profiled to the finished width and length, but they may also go to an edger for trimming. The profiling technique does not require an edger, as the form of the side board is created during the conversion process.

Rip sawing

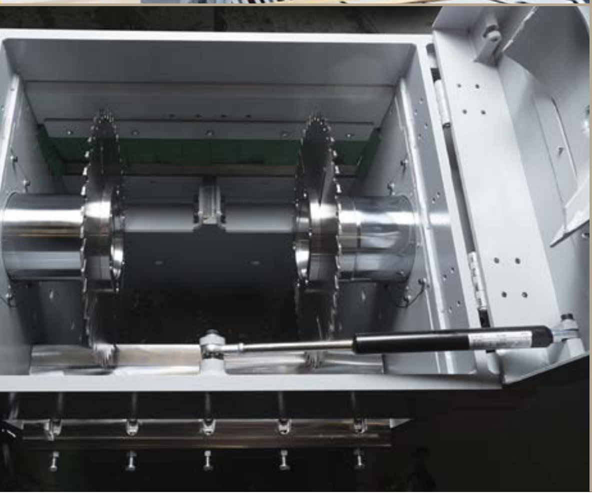
When we split the cant, we get a centre yield and side boards. Normally, the centre yield is conveyed to the green sorting line. In this case too, the side boards can be profiled to the finished width and length or sent to an edger for trimming. The rip saw is equipped with a number of saw blades and the amount of centre yield and side boards varies depending on the size of the log.

Infeed accuracy

In order to achieve optimal volume and value yield from the logs, it is important that the saw line is correctly aligned and that the mechanical and electronic equipment is reliable. The prerequisite for a high yield is that the sides of the logs are as equal as possible after processing, which requires careful turning and positioning of the log in conjunction with the sawing of side boards. The log positioning may be manual, but it is usually done automatically by transporting the log through a measuring frame that records information about the shape and internal quality of the log. After the log has passed through the measuring frame, the measurement data is sent to a Programmable Logic Controller, PLC, which calculates the best possible angular positioning of the log. The log turner receives the data from the PLC and turns the log to the desired position. This position should then be followed throughout the sawing process.

Side board sawing is a first step in the conversion process, where a cant is produced by sawing out two or four boards from both sides of the log.

A double-shaft circular saw can be placed as a rip saw after the cant reducer, or as a stand-alone rip saw.



The edger has two parallel blades that can be quickly positioned at high feed rates.

Conversion produces side boards that are conveyed to the edging unit.

Edging

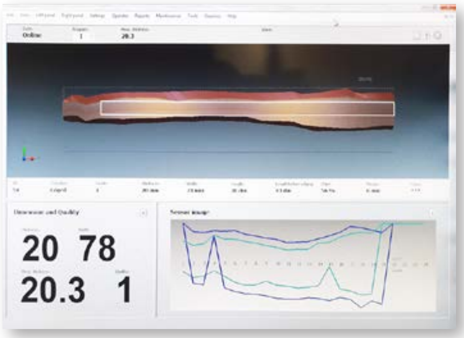
In addition to the cant and rip saw, the saw line is equipped with an automated edger for trimming the edges of the side boards. If the sawmill uses the profiling technique, this machine system is not necessary.

The edging unit normally consists of an elevator, a scanner system, an edger feed system, an edging machine with blades and a trim separator. The edger is a high-capacity machine and is usually unmanned.

The edging process involves passing unedged boards under a scanner system that uses advanced camera technology to read the profile of the boards and optimise the cutting for maximum volume or value yield. A volume-optimising edger calculates the maximum volume yield of the board based on its length and width. The alternatives may be a long and narrow board or a wide and shorter board. After scanning and calculation, the board is aligned and fed into the edger, which cuts the sides according to the programmed data. The board may be either centred or edged on the diagonal, depending on the original board profile.

A value-optimising edger is able to detect the wood characteristics that affect the quality outcome, such as knots. In both cases, the edger takes into account the permitted wane and the price of finished dimensions and chips.

To achieve a high yield, it is important to maintain the machinery well and continuously monitor the output. Dirt and dust affect the optimisation function and the high production speed places considerable wear on the mechanical parts.



The edger optimises the maximum volume or value of the board based on programmed value data.

A misaligned board means economic losses, for example in the form of trimmings due to excess wane.

GREEN SORTING AND STICKER-STACKING

After conversion, all the wood is checked before being sorted into different dimensions.

Green sorting

The conversion of the log has produced planks and boards of various dimensions, as well as chips and shavings. Planks or centre boards are sawn from the central part of the log. Normally, between two and five pieces are sawn from the centre, and they usually have the same dimensions in terms of thickness and width. The side boards sawn from the outer part of the log can now be profiled to the correct length and width, or if this is not possible, they must be sent to the automated edger for assessment. Regardless of the dimensions and whether it comes from the main or side yield, the timber must go through the green/dimension sorting process.

In order to achieve efficient timber handling, we need to deal with one set of dimensions at a time in the process of sticker-stacking and final trimming. This is ensured by sorting the green, undried timber by dimension. When the wood comes to the green sorting unit, each individual piece of timber is sorted into different dimensions based on thickness and width. The operator examines the timber and cuts away, for example, any excess wane or other factors affecting quality.

Most modern sawmills automate this assessment using technology such as cameras that assess both the faces and sides as the timber passes by. In this system, the cameras detect all four sides of the timber and use the measured values to cut away any faults. Some of the pieces may be so crooked or bad that they are unusable, and these are cut into chips.

There are also systems that, instead of cameras, use other types of measuring equipment to detect length, dimensions and wane. Input values set the parameters for how much the piece of wood should be cut.

The equipment that performs the cutting, called a trimmer, has multiple blades that make it possible to cut the pieces of wood to the desired length. In front of the trimmer, a positioner aligns the piece of wood against the fixed saw blades. It is possible to choose not to cut anything at all or to cut in lengths based on 30 cm modules, but also to cut to other lengths with the help of a cutter that can be positioned within a module. Whatever the technique, it is important for economic reasons to avoid over-cutting and creating chips instead of timber.

After the trimmer, the pieces of wood are transported on a sorting conveyor to be sorted by thickness and width into bins with specific dimensions. These compartments may be vertical, where the pieces of wood sit on top of each other, or horizontal, which allows for gentler handling.

Sticker-stacking

The green sorting system has produced bins containing wood of a single dimension. The next step in the process is called sticker-stacking. The pieces of wood are transported to the stacker, alternating between left and right. This ensures that the length of the packet is the same, regardless of the length and dimension of the individual pieces of timber.

At this stage the wood is in its raw or green state — undried and containing a lot of water. For efficient drying, air needs to be able to circulate around all the timber, which is why battens, known as sticks or stickers, are laid lengthways between each layer of timber in the packet using a sticker-stacker. This creates an air gap between the layers of wood. The number of stickers varies from sawmill to sawmill, but there are usually 9–13 stickers in a packet of normal length.

To avoid damage to the timber, it is vital that stickers are placed between each layer of timber, that the sticker rows are even and straight and that the first piece of timber in each layer is laid in the same direction. The timber packets need to be correctly positioned in the infeed and the stickers need to be positioned in such a way that they do not get stuck in the system and misalign during tilting. Broken stickers should be discarded as they risk creating production problems. Increasingly, sorting and removal is done automatically by scanning the shape of the sticker.

The sticker-stacker builds up packets and places the stickers across the pieces of wood in rows directly above each other. This makes the stacks stable and ensures maximum airflow.

Chips are produced during cant and rip sawing and chipping. The chip screen sorts the chips into different fractions. Oversized chips are returned for rechipping and shavings are sorted separately.

The chips are collected in a special chip bin away from the saw line.

CHIPS AND BY-PRODUCTS

Chipping

Breaking down logs on the saw line produces not just planks and boards, but also chips, shavings and sawdust. Chips are created during log reduction (cant and rip sawing) and laths are cut when the boards are edged. Shavings are created during sawing and cutting in the trimmer during green sorting, but also on the final trimming and sorting line. The chips and shavings produced in the sawmill are wet (undried), while the chips and shavings coming from the final trimming and sorting line are dry. The chips from the saw line and the dry sorting line must not be mixed.

Chips and shavings have different uses and must therefore be separated from each other. This takes place in a screening plant. The chips from the reducers, as well as trimmings and laths that have passed through the chipper, are transported to the screening plant. Oversized chips are returned to the chipper.

Wood chips are an important source of income for sawmills, which sell them to the pulp and paper industry to make paper, hygiene products or paperboard.

The laths from the edged board are transported to the chipper to be turned into wood chips.

Chips are priced according to their quality and they need to be pure. Wood chips to be used in paper and pulp production must be free of plastic or other contaminants and it is also important that they are free of bark.

The shavings and sawdust, which also generate income, are either burned in the company's own boiler plant or sold to thermal power plants, the chipboard industry or pellet manufacturers.

Control of chip quality

Cellulose chips or wet chips come mainly from the outer parts of the log and are an important raw material for the pulp and paper industry. As a virgin raw material, cellulose chips are used for a range of wood fibre-based products such as paper, paperboard and hygiene products.

The quality of the chips depends not only on their purity but also on a number of other factors, such as the season and the characteristics of the wood, as well as the sawmill's technical systems, the accuracy and maintenance of the machinery and the screening system.

Chip properties and composition are also influenced by the debarking method, breakdown equipment and conveyor system to the chip bin.

A sawmill generates chips during several different stages of processing:

- Root reduction produces fuel chips.
- Reduction of the log sides in a chipping canter produces wet chips.
- The edging of boards produces wet chips.
- The chipping of slabs, trimmings and laths in a chipper produces wet chips.
- The chipping of dry trimmings produces dry chips.

Broadly speaking, a distinction is made between the wet chips produced during the conversion process and the chips cut off on the final trimming and sorting line, known as dry chips.

Once the chips have been delivered to the pulp and paper industry, their quality is checked by the independent organisation Biometria to determine the fractional distribution of the chips, that is, the size distribution, *see Table 1*. A sample quantity of 8—10 litres is used with bark and rotten chips removed. This sample is screened according to standard SCAN-CM 40:01 from the year 2022.

Refusal to measure

Measurement is refused if the wood chips do not meet the agreed assortment and quality requirements, as well as for wood chips containing snow, ice, garbage, coal, oil, soot, plastic, stone or other foreign objects such as metal.

Bark and contaminants must not be present in wood chips destined for pulp and paper production.

TABLE 1 | FRACTIONS, HOLE OR GAP WIDTH

Frame no.	Fraction	Hole size or spacing	Name
1	1	Sieve plate with 45 mm round holes	Oversize chips
2	2	Bars, 8.0 mm spacing	Overthick chips
3	3A	Sieve plate, 13.0 mm round holes	Accept chips (large)
4	3B	Sieve plate, 7.0 mm round holes	Accept chips (small)
5	4	Sieve plate, 3.0 mm round holes	Pins
6	5	Fines bin	Fines

In a progressive kiln, the timber batches are carried through a long channel at a constant speed.

Batch kiln

TIMBER DRYING

Almost all timber must be dried before it is used. A newly felled tree contains large amounts of moisture:

- below 50 % moisture content in the heartwood
- up to 160 % moisture content in the sapwood.

There are large differences in moisture content between different trees and tree species.

Drying helps to make the wood suitable for different uses. In other words, it is a vital part of wood processing. If the timber is undried, it will shrink when placed in a warmer and drier environment. During storage, there is a high risk of microbial growth such as mould, blue stain and discolouration if the timber is insufficiently dried. In addition, green wood is heavy to handle. The wood must also be dried down for impregnation and surface treatment. Dry wood is both stronger and easier to work with.

Wood adapts to the relative humidity, RH, of the environment. Wood that is stored for a long time in the same environment acquires an equilibrium moisture content, which corresponds to the relative humidity of the air. This ability of the timber is used in both air drying and drying in kilns. If the relative humidity is constant, the wood will eventually neither absorb nor release moisture to the surrounding air. There will be an equilibrium between the moisture of the wood and the air = the equilibrium moisture content of the wood.

The wood should be dried so that the moisture content corresponds to the equilibrium moisture content of the environment in which the wood is to be used as a finished product.

It is important that the wood is properly stickered so that air can circulate around the pieces. The timber packets should also be uniform in length, which can be achieved by levelling up the ends alternately. This ensures an even air speed through the drying packets.

Once dried, the timber is transported by truck to an intermediate warehouse to reach equilibrium before going on to final trimming and sorting.

Basic concept

Drying wood is an important part of the production process and generally speaking, all wood must be dried before use. The wood needs to have the moisture content appropriate to its final use.

Timber drying is energy intensive and can be complicated due to the hygroscopic nature of the material, which means that its shape changes with the moisture content. Therefore, before processing the wood, the correct moisture content must be achieved.

The relationship between the moisture mechanics of wood and the relative humidity of the air must be understood in order to operate and understand wood drying equipment. In the treatment of dried timber, it is important to emphasise the importance of maintaining the correct humidity in the seasoning, manufacturing and storage areas so that the intended moisture content of the timber is maintained. It must be ensured that the dried timber is not exposed to moisture.

The moisture content varies depending on the type of timber and the purpose for which the timber will be used, see examples in *Table 2*.

Measurement methods

The moisture content of a batch of timber before drying can vary greatly, especially if it is freshly sawn timber. Therefore, several samples should be taken in order to obtain a more reliable basis for assessing the whole batch.

TABLE 2 | GUIDE VALUES FOR MOISTURE CONTENT

Type of wood or purpose	Moisture content (%)
Kiln-dried timber	16 – 20
Construction timber	12 – 16
Planing-dry timber	10 – 16
Joinery timber	9 – 15
Furniture-grade timber	6 – 10

During the drying process, the water evaporates roughly:

- 20 times faster with the grain than across the grain.
- 10 times faster with the grain than in a radial direction.

This means that the timber dries more quickly at the ends and cracking occurs. The ends of the timber are thus drier than the rest of the timber. Samples should therefore be taken at a distance of at least 300 mm from the end. If the timber is large, the distance may be slightly less.

The moisture content of the wood can be measured by the so-called oven dry method, using an electrical resistance moisture meter with insulated hammer electrodes or a continuous moisture meter.

Oven dry method

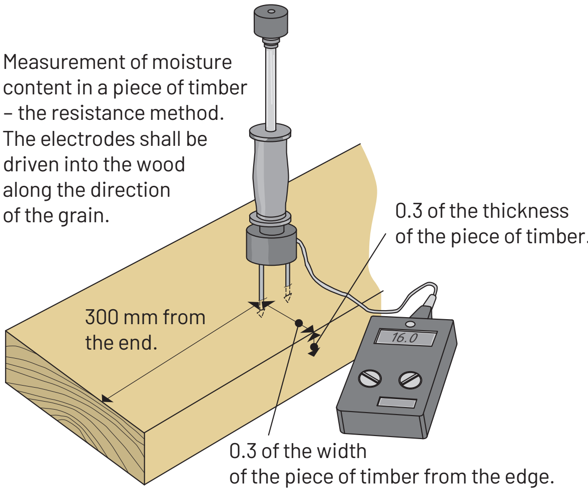
When calculating the moisture content using the oven dry method, the weight of the timber before drying is compared to the dry weight of the timber. Moisture content refers to the amount of water in a piece of timber in relation to its dry weight. The moisture content is usually expressed as a percentage and is calculated as follows:

- Suitable pieces are taken from the timber, free from knots and wane.
- The samples are weighed and the wet weight (*V*) is obtained.
- The samples are dried until all moisture has evaporated.
- The dry samples are weighed and the dry weight (*T*) is obtained.
- The moisture ratio in % — *u* — is calculated using the following formula:

$$u\,(\%) = \frac{V - T}{T} \cdot 100$$

$$u = \frac{\text{(weight before drying - weight after drying)}}{\text{weight after drying}} \times 100 = \text{moisture content in \%}$$

Using a drying cabinet, the moisture content of wood can be calculated with great accuracy by the oven dry method.



MEASUREMENT OF AVERAGE MOISTURE CONTENT

Sampling with an electrical resistance moisture meter

The figure shows an example of an electrical resistance moisture meter with insulated hammer electrodes. The method using this device is based on the resistance principle — the current between the electrodes meets more resistance, the drier the wood is. The hammer is used to drive the electrodes to the desired depth, and the result then appears on the instrument display.

To regulate the effect of the way the meter is used, standard EN 13183-2 sets out how the insulated hammer electrodes should be inserted into the piece of wood. The average moisture content of wood is measured as follows: measure 300 mm from the end. Insert the insulated hammer electrodes into the face of the wood, in the direction of the grain, and along an imaginary line running 0.3 times the width of the wood in from the edge. The measurement depth should be 0.3 times the thickness of the wood.

The electrical moisture meter does not give values as accurate as the oven dry method, which should be used if the requirements are strict.

Continuous moisture content measurement

Continuous moisture content meters are placed on the dry sorting line to take measurements of the moisture content of each piece of timber as it passes through.

Different moisture content values

When dried below 30 %, the so-called fibre saturation point, the wood begins to shrink. It shrinks most — about 8 percent — in the tangential direction in relation to the growth rings (parallel to the rings). It also shrinks about half as much — about 4 percent — in the radial direction (across the growth rings). Shrinkage with the grain (in the longitudinal direction of the wood), is negligible at 0.1—0.35 percent. The volume reduction amounts to 7—21 percent.

In order to compensate for the shrinkage, the timber is sawn with a trimming allowance. On centre wood, the allowance is around 4 percent. On boards, the allowance is around 6—8 percent.

Shrinkage creates such tension in the material during drying that it is difficult to completely avoid cracks, and shape changes can also occur. It is therefore important to carefully control the drying process.

In order to control the kiln, you need to be able to measure and control the climate. This is done using a psychrometer, which basically consists of a dry and a wet thermometer. You enter:

- the desired dry temperature of the drying air
- the psychrometric difference.

The psychrometric difference is the difference between the wet and dry temperatures. Both the psychrometric difference and the dry temperature are important, as is the air speed, which affects the drying rate. This must be at least 2 m/s once it has passed through the stacked timber.

A modern wood kiln has fans to circulate the air, while the heat for drying is provided by steam or hot water. Today's kilns are controlled by computers, which regulate the heat and humidity of the drying air. If the humidity in the kiln is too high, moist air is released through an exhaust damper, while an equal amount of fresh air is simultaneously drawn in through a supply damper.

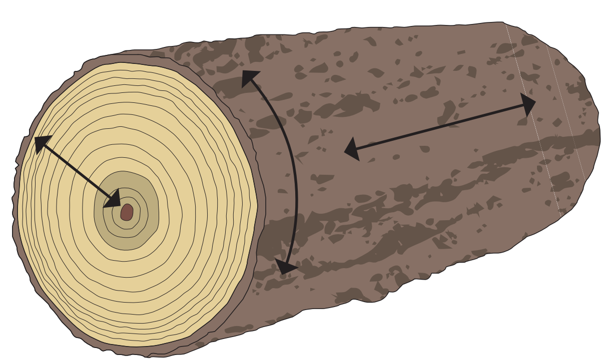
Different wood species and dimensions require different drying programmes, as large dimensions must be dried much more slowly than small dimensions, for example.

The drying time to bring pine down to 18 % moisture content is roughly:

- 2.5—3 days for wood that is 25 mm thick
- 4—5 days for wood that is 50 mm thick
- 7—10 days for wood that is 75 mm thick.

The drying time is about 10—15 percent shorter for spruce.

Radial shrinkage about **4 percent** | Tangential shrinkage about **8 percent** | Longitudinal shrinkage **0.1–0.35 percent**



LOG SHRINKAGE IN DIFFERENT DIRECTIONS

In a progressive/continuous kiln, the wood is dried as it moves through a number of zones with separate climates. The timber is placed lengthwise on trolleys and fed from a buffer conveyor at the infeed end of the kiln.

Pressure frames ensure minimal deformation of the top layer of timber.

Timber drying is the largest single energy consumer in a sawmill. When drying to "shipping dry", 16—20 % moisture content, an average of 200—250 litres of water evaporates per m^3 of wood.

The temperature in Swedish wood kilns is high — between 50 and 80 °C — so access to the kiln is highly restricted.

Wood kilns

A wood kiln is basically a room where the timber has been placed for drying. The climate, temperature and humidity can be adjusted according to the kind of timber and the drying required.

The climate in the kiln can be changed via:
- Condensation. The air is dried out (dehumidified) using a condensing unit. The same air is used throughout.
- Air exchange. Moist, heated air is exchanged for dry, warm air. The moisture from the wood is absorbed by the air, and when this air has become too humid, it is discharged through a duct. Dry, warm air then enters through another duct.

Air exchange kilns

Air exchange kilns are the most common choice and they are suitable for all dimensions. The heat may come from hot water and steam, but also electricity. In modern kilns, the heat and humidity are controlled by computers.

There are several types of air exchange kilns, including:
- batch kilns, also known as compartment kilns
- progressive kilns, also known as continuous kilns.

Batch kiln

With a batch kiln, all the wood to be dried is loaded into the kiln at the same time. The wood is thus dried under equal conditions. Temperature and humidity in the kiln are changed according to a suitable programme.

Batch kilns are suitable for drying:
- large dimensions
- wood that needs to have a low moisture content.

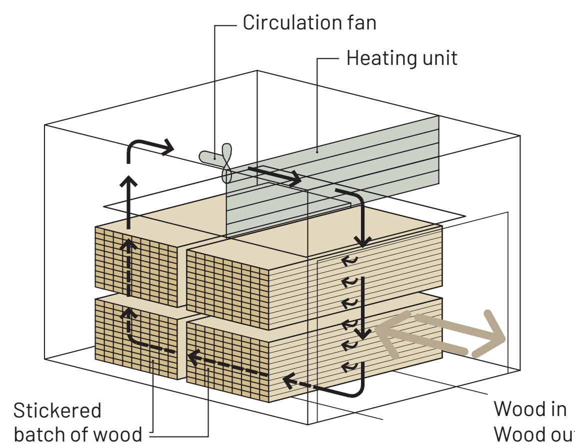
Progressive kiln

The timber packets are placed in one end of the kiln and are then transported through a long channel where the climate is humid at the beginning and dry at the end. The speed through the dryer is constant. The air circulates through the wood packets from the "dry" to the "wet" end.

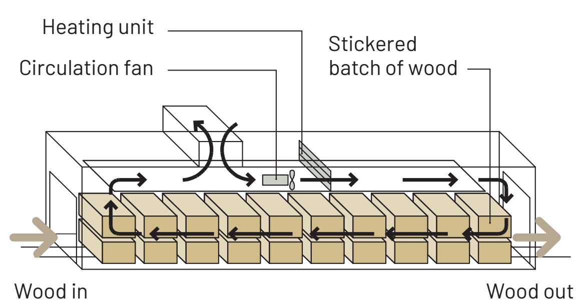
Progressive kilns are suitable for drying:
- large volumes of timber with uniform dimensions
- when the final moisture content of the timber doesn't need to be particularly low.

There are different methods of moving the wood packets through the kiln. The kiln is operated by one or more kiln operators, who also operate the boiler plant.

With the help of computers and a number of sensors, the operator can monitor progress in the kiln.



BATCH KILN



PROGRESSIVE KILN

QUALITY GRADING OF WOOD PRODUCTS

De-stickering

Once the timber is fully dried and conditioned, it has to be quality assessed and sorted. The stickered timber packets that have been dried to the correct moisture content are stored in timber warehouses or under cover to protect them from sunlight, rain and dirt that could affect the quality. The timber in each packet has the same dimensions, but the packet contains different grades and lengths. The next step is to create a timber packet of the same dimensions, grade and length.

A forklift collects the timber from the intermediate storage and takes it to the infeed section of the dry sorting line. The dried, stickered packet is placed on an inclinable lifting table called a tilt hoist, where the packet is automatically de-stickered by angling the tilt so the timber pieces fall onto a conveyor before the sorting table.

The de-stickering process is designed to handle one layer of timber at a time, and is repeated by raising the lifting table between layers. The drying stickers slide down between the chain guides to an underlying belt conveyor and are collected in a sticker receiver next to the plant.

The stickers are then piled up for later transport back to the green sorting line.

Trimming and sorting

In this case, trimming means cutting down the length of the timber. Some cutting also takes place in the green sorting process, but the final trimming takes place here on the dry sorting line. At the same time, the timber is quality assessed and graded so that it can be sorted into different grades.

The dry sorting line consists of:

- intake
- sorting
- bins
- packet stacking
- wrapping.

A forklift places the timber packet on a conveyor in the infeed section, where it is tilted and each layer is conveyed to the sorting section in a longitudinal direction. In some sawmills, the moisture content of each individual piece of timber is measured at the same time. A report on the moisture content of each timber batch is worth obtaining at an early stage, in order to avoid potential complaints.

After de-stickering, the wood is transported to the sorting section for quality assessment.

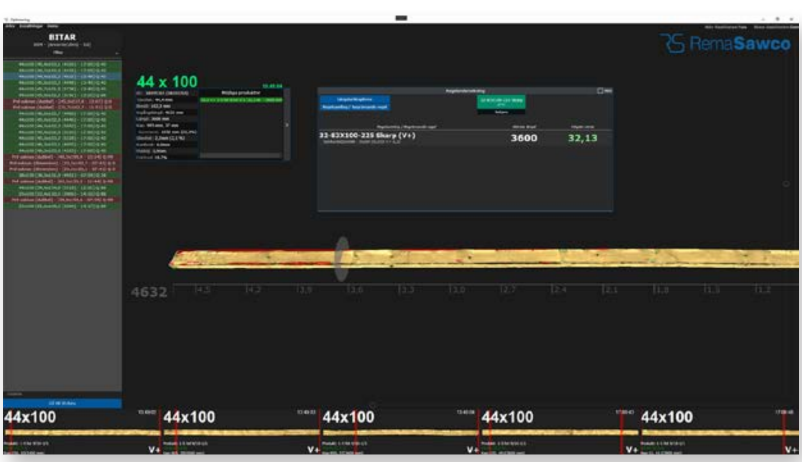
The boards pass through a scanner and are measured on all four sides to assess dimensions and quality.

In addition, it is possible to remove pieces of timber that have too high a moisture content.

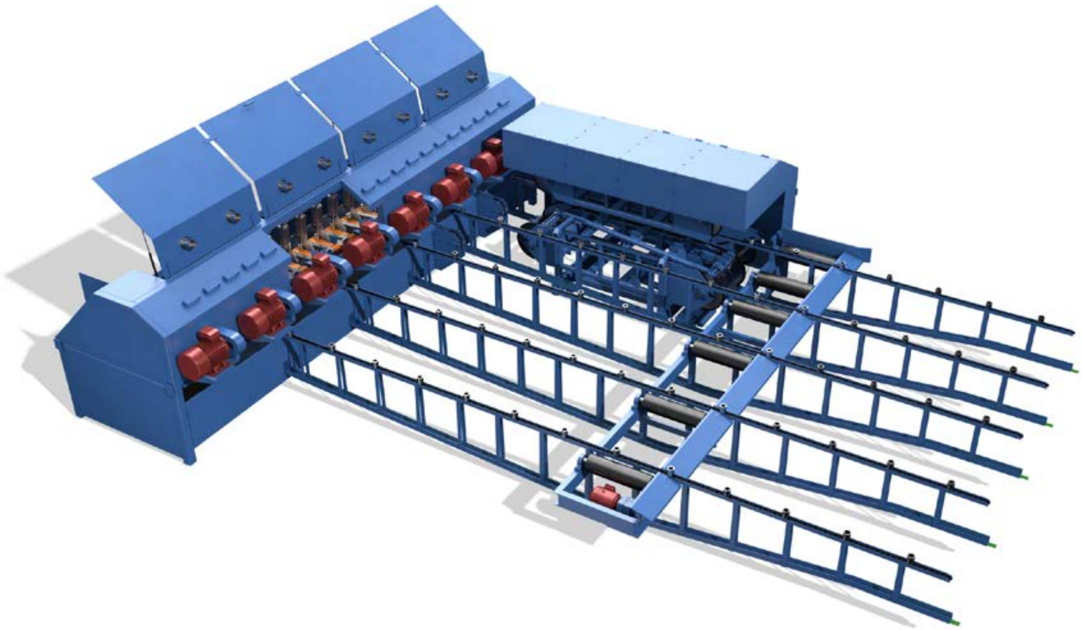
Each individual piece of timber must be quality assessed and cut to the correct length based on the rules programmed into the machine. The cutting to length takes place at both the top and root end of the timber piece.

In order to meet customer requirements regarding the quality and characteristics of the timber, the sawmill carries out a grading process and often also a cut optimisation of planks and boards. This grading has traditionally been done by hand by operators, but most sawmills now use various types of camera systems. The systems are used to determine the characteristics of the timber, ranging from knot type and size to mechanical strength. This data is then used as the basis for setting the rules, with different end products having different limits. The systems can optimise where to cut the piece to obtain the highest possible value, given the rules and product set-ups that are active.

This type of grading is often called automatic grading or camera grading because the pieces are automatically given a grade by the system. Automatic grading systems usually have several different types of sensors depending on the type of grading to be carried out. There are types of grading that simply measure the external shape — dimensions, wane and deformation. This kind of grading usually occurs at the green sorting stage. However, there are also a number of more advanced systems that combine lasers, the dispersion of the laser in the wood fibres and RGB images at different levels to measure properties such as knot size, cracks, deformations, blue stain, rot, resin pockets and other rare defects. This type of more advanced measurement is used on dry sorting lines and planing lines, but is also increasingly common in green sorting.



Board optimisation involves assessing the highest value a board can have, given its characteristics and possible cuts.



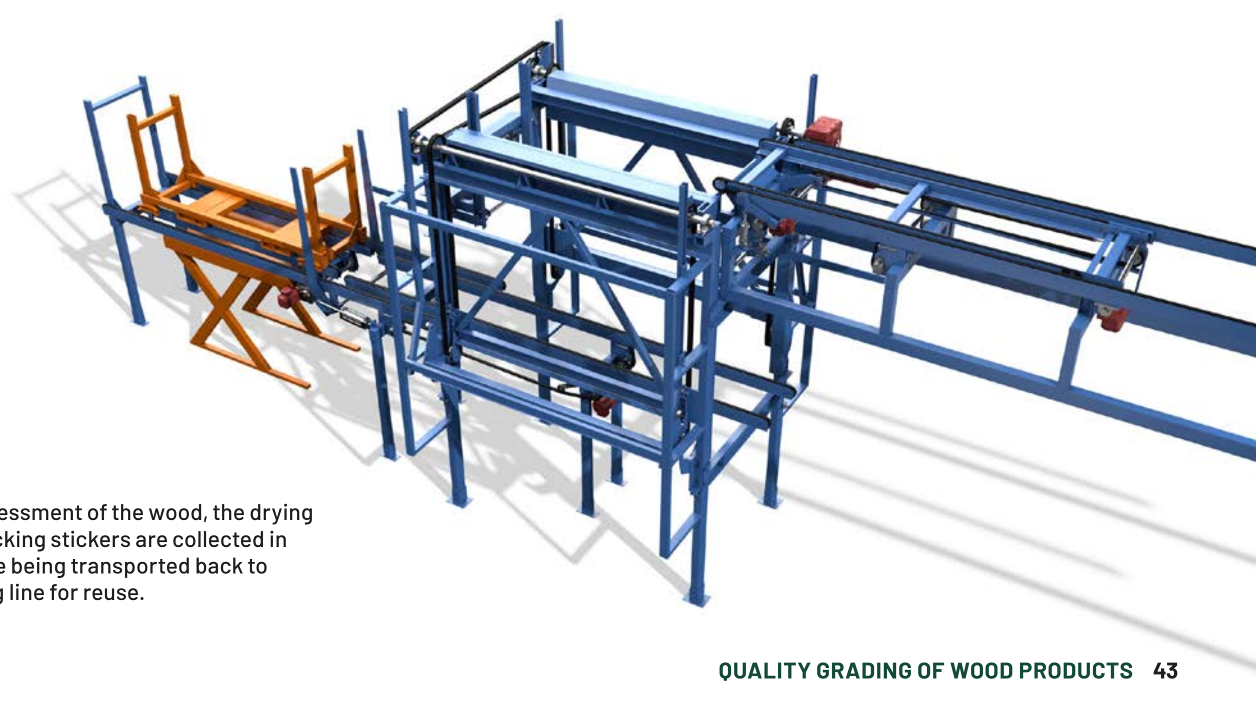
A trimmer consists of a number of blades for modular cutting of timber pieces. The timber pieces are transported through the trimmer on a chain conveyor with carriers and on to the bins.

After quality assessment and optimisation, the timber pieces are cut to the right length by a system comprising a positioner, a trimmer and an adjustable blade for millimetre-precision cutting in the last module. The optimisation equipment sends a signal to the trimmer about how much to cut each piece of wood. The wood pieces are then transported through the trimmer on a chain conveyor with a carrier.

A trimmer consists of a number of cutting blades, one for each module. The trimmer cuts the piece of timber at the far end, bringing the blade down just outside the final cut. A piece less than 300 mm remains to be cut. After the trimmer, the ends are levelled out and the final cut down to the last millimetre is made in the subsequent positioning and cutting unit. A piece of timber may be scrapped by a number of blades chopping the timber into short lengths for transportation to the chipper.

With a fully equipped cutting system, the piece of wood can be cut exactly according to how the camera system has value-optimised the piece. Nowadays there is no talk of root cuts and top cuts, because the automatic system decides exactly where to cut the piece. The minimal clean cut must be made at each end of the timber to produce a clean, even surface on which to place a stamp. A piece of timber must also be cut cleanly to avoid end cracks. If a cut for length and/or quality has to be made, it is of course not necessary to make a special clean cut at the top end, but one must be made at the root end.

On most pieces of timber, the clean cut at the root end — that is, the root cut — only needs to be minimal in order to obtain a smooth and clean surface, while the other two types of cuts usually have to be made at the top end. It is important to make the root cut truly minimal to avoid losses in yield.



After quality assessment of the wood, the drying stickers and stacking stickers are collected in a receiver, before being transported back to the green sorting line for reuse.

In the sink bins, the timber is sorted into vertical bins, the bottom of which is gradually lowered. Once a bin is full and needs emptying, the bundle of timber is lowered onto an underlying chain conveyor for further transport to the stacker.

In the tray sorter, the timber is sorted into horizontal layers. When a tray is full, the timber is emptied by means of an emptying flap that is moved between the different levels. The timber is then transported to the stacker.

Quality defects such as wane and knots may have to be cut away for the timber to qualify for the different quality grades according to the grading rules used at the sawmill. It is often a matter of cutting away certain individual defects in order to increase the quality, and thus the value, of the piece of timber.

Cutting the timber down to remove quality defects is mostly done at the top end but can also occur as part of the root cut. However, timber defects are rarely cut in the middle of a piece of timber to create two smaller, cleaner pieces. Technology is now available whereby timber can be split in the trimmer and then optimised, with each piece cut separately for maximum value. Length cutting is done to produce timber of set lengths, as specified by the buyers.

Traditionally, timber is delivered in 300 mm modules and the Swedish standard for sawn timber follows this custom. The minimum length is 1800 mm (6 modules), and the maximum length is 6000 mm (20 modules). In the case of special orders, the length can be precision cut to the millimetre as specified in the purchase contract.

After quality assessment and grading, the timber is then sorted into separate bins for different dimensions, grades, lengths and other properties.

In principle, the bin section consists of:

- An overhead sorting conveyor, which transports the wood pieces and drops them into different bins.
- A number of bins for different grades and lengths.
- An underlying conveyor, which transports the timber from the bins to the section for packet stacking and wrapping.

The bins may be sink bins or horizontal bins, known as tray sorters. Horizontal bins are the gentlest on the timber, but sink bins can be equipped with a gentle emptying function.

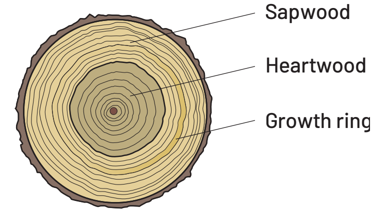
Quality assessment

Whether the quality assessment is done manually or by machine, the starting point for the final trimming and sorting is the same, namely to sort according to the sawmill's established grading rules for different quality grades or the customers' specific wishes.

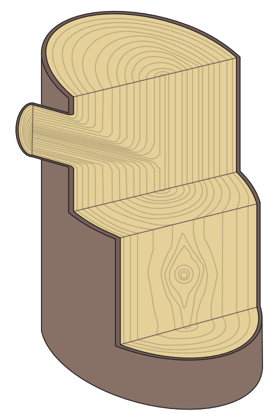
All timber has different characteristics due to the fact that the trees have grown under different conditions, and the quality can vary considerably. Sorting into different quality grades is based on the presence of different characteristics, such as knot shape, type of knots, biological factors that have affected the quality and production-related characteristics. The timber is sorted into different quality grades in order to be used for different purposes based on appearance, external shape and/or strength. The regulatory framework for the grading of sawn timber, called *Commercial Grading of Timber*, has been drawn up collaboratively by the sawmill associations in Sweden, Norway and Finland.

The specified quality grades in *Commercial Grading of Timber* reflect the grades that forestry produces on a sustainable basis and that sawmills can then continuously supply to the market. This grading framework, which is now applied in the Nordic region, demonstrates the sawmills' ability to adapt and deliver wood products that meet the end customer's demand and needs. *Commercial Grading of Timber* is the backbone of sorting.

The system applies to domestic production and sales on export markets and divides the sawn timber into quality grades according to the characteristics of the timber. Grades in Sweden are sold in accordance with standard EN 1611-1.



SAPWOOD AND HEARTWOOD
Cross-section through a pine stem.

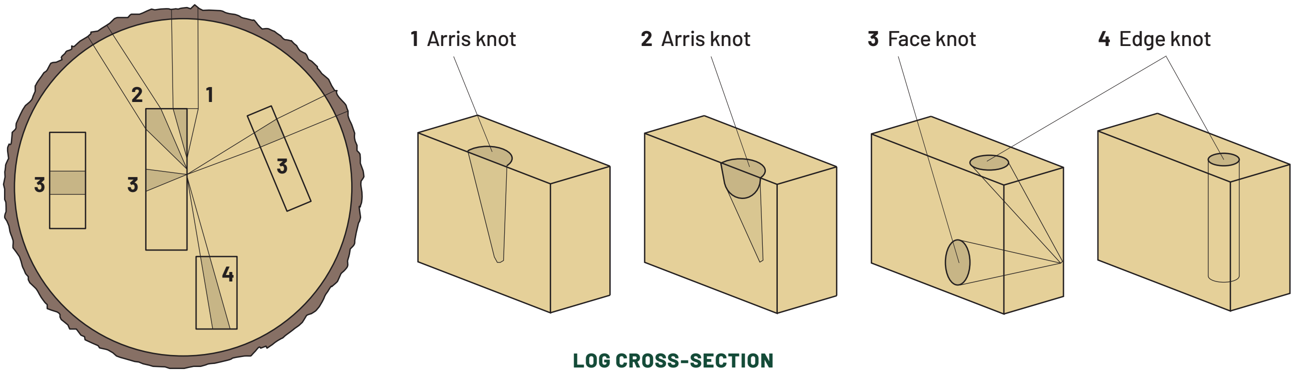


LOG SECTION

Standard EN 1611-1

According to standard EN 1611-1 Sawn timber — Appearance grading of softwoods, the grading may be performed on the faces and the edges or only on the faces. In these cases, the grades are called G4 and G2 respectively. The grading designations are followed by a number from 0—4 stating the quality of the wood, with 0 as the highest quality. A grade can thus have the designation G4-2, which means a 4-sided visual sorting of typical construction timber, corresponding to GRADE V, Fifths, in the *Commercial Grading of Timber* system.

The commercial grading indicates the maximum permitted values for the wood properties in each grade. It is rare that several wood properties with the maximum permitted values are present at the same time in a piece of wood. Therefore, a batch with a normal distribution of the wood properties will come in below the maximum permitted values.



LOG CROSS-SECTION
Position of timbers and knots in log cross-section.

New demands from end customers and the environment can be met if the industry has a good knowledge of the properties and functions of wood. With process automation and data processing in the sawmill industry requiring precisely defined grading criteria, we have taken the challenges of the measurement technology into account as far as possible. *Commercial Grading of Timber* is also used as a teaching aid when personnel in the wood industry are trained in commercial grading and become Certified Timber Graders.

Commercial Grading of Timber divides the sawn timber into quality grades depending on the characteristics of the timber for the main grades:

- GRADE US I — GRADE US IV
- GRADE V
- GRADE VI
- GRADE VII

The classification of the wood products in each grade is to be considered as a guideline and is not binding. The sawmills can, by agreement with the customer, put together individual customer and product-specific grades with their own grade designations, as specified in the contract or agreement. This is done with a grade mixture based on the timber properties of the main grade.

TABLE 3 | CONVERSION TABLE
Approximate relations between the different EN-1611-1 quality grades – Grades from the *Commercial Grading of Timber*.

Grading rules	Quality grades						
Commercial Grading of Timber	US				Fifths	Sixths	
	I	II	III	IV	V [2]	VI	VII
EN 1611-1							
4-sided grading	–	–	G4-0	G4-1	G4-2 [2]	G4-3	G4-4
2-sided grading [1]	–	–	G2-0	G2-1	G2-2	G2-3	G2-4

[1] 2-sided grading, G2, is seldom used in Sweden.
[2] The most common building timber.

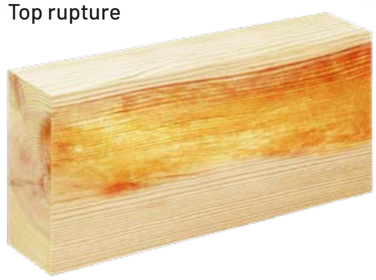
Examples of features

Knots

Top rupture

Wane

Insect attack

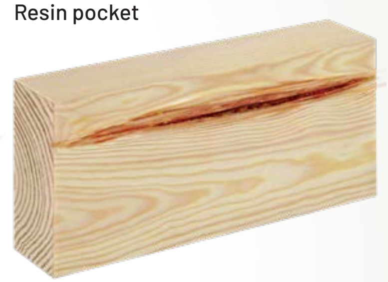


Resin wood

Resin pocket

Bark pocket

Reaction wood



Scar

Deep blue stain

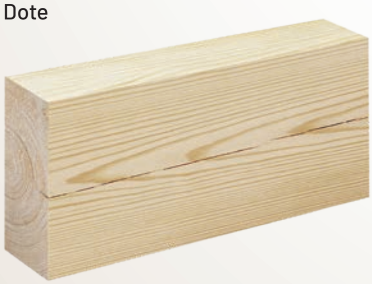
Surface blue stain

Curly grain

Dote

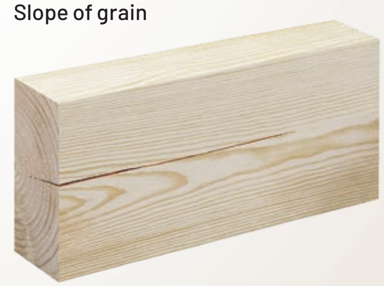
Soft rot

Slope of grain



Check

Ring shake



End shake

Images of quality grades

The timber is displayed in the dimensions: 25 × 100, 50 × 150 and 75 × 200 mm.

GRADE US I – Pine

GRADE US I – Spruce

GRADE US II – Pine

GRADE US II – Spruce

GRADE US III – Pine

GRADE US III – Spruce

GRADE IV – Pine

GRADE IV – Spruce

GRADE V – Pine

GRADE V – Spruce

GRADE VI – Pine

GRADE VI – Spruce

STRENGTH GRADING

The grading into different strength classes can be carried out mechanically by so-called tapping, whereby a spring-loaded hammer mechanism is activated by the transverse transport of the timber and strikes the end of the timber. Microphones capture the vibrations caused by the hammer impact, allowing the dynamic modulus of elasticity to be determined by measuring the resonance frequency. The length and density are also measured at the same time.

Strength grading of construction timber for load-bearing structures usually takes place mechanically or visually. The old visual grading rules (T-virkesreglerna) have been replaced by joint Nordic grading regulations. In Sweden they are issued as Swedish standard SS 230120, while the joint Nordic designation is INSTA 142. The rules apply to pine, spruce, silver spruce, larch, Sitka spruce and Douglas fir. The wood continues to be called T-virke and the classes are T0, T1, T2 and T3.

To judge the impact of the knots on strength, the grading regulations specify measurement rules stating how the size of the knots must be measured and how they are to be assessed.

- Size in relation to dimensions of wood
- Positioning on edge and face
- Positioning along the length of the wood.

It is also necessary to conduct a visual assessment of other factors that affect the strength or usability of the wood, such as cross grain, growth ring width, checks, top rupture, compression wood, fungal attack, deformation, wavy grain, handling damage and dimension deviations. Wood graded in line with SS 230120 is labelled with a grading class of T0, T1, T2 or T3, and a strength class of C14, C18, C24 or C30. The C classes follow standard EN 338 Structural timber — Strength classes. The labelling also includes the number of the standard and the company's mark.

Grading T-virke wood requires special training. Mechanical grading follows the standard EN 14081-1, which also gives detailed labelling rules. During mechanical grading, these strength classes can be produced: C14, C18, C24, C30 and C35.

Mechanical strength grading identifies a physical property that is associated with strength, such as the static or dynamic modulus of elasticity. Some machines combine judgements on multiple properties, such as density, modulus of elasticity or inner structure, using x-rays. The most common mechanical principle in use today involves determining the modulus of elasticity by measuring the resonance frequency from a tap on the end of the wood. Visual supplementary grading is also required for parameters that machines cannot assess, such as cross grain, top rupture, compression wood, fungal attack, checks, deformation, wavy grain, handling damage and dimension deviations.

Visually and mechanically graded construction timber must be CE marked and have a performance declaration in line with EN 14081-1. Pressure treated wood can also be ordered as strength graded construction timber and this must then also be CE marked. Typical base values for calculating the load-bearing capacity and stiffness of construction timber in strength classes C14—C50 are stated in the standard EN 338.

Strength graded construction timber for prefabricated roof trusses.

Description of construction timber in strength classes C14–C35

Strength class C14

Strength class C14 is used for wall studs in load-bearing internal and external walls with deformation requirements that are not too stringent. C14 is a strength class where factors that affect the strength and deformation of the construction timber are permitted to a large extent. Construction timber in strength class C14 is stocked by most builders' merchants, but often only in small sizes, although treated timber is also stocked in larger dimensions.

Strength class C18

Strength class C18 can be used for load-bearing structures that do not require high strength, or where it is possible to use large dimensions or short lengths. The strength class can also be used for wall studs in load-bearing structures if the requirements concerning deformation are not high. C18 is a strength class where factors that affect the strength of the construction timber are permitted to a moderate extent. Construction timber in strength class C18 is rarely kept in stock.

Strength class C24

Strength class C24 is used in load-bearing structures that require high strength, such as roof trusses and floor systems. C24 is a strength class where factors that affect the strength and deformation of the construction timber are permitted to a low extent. Construction timber in strength class C24 is stocked by most builders' merchants.

Strength class C30

Strength class C30 is suitable for load-bearing structures that require high strength but cannot make use of large dimensions. C30 is a strength class where factors that affect the strength and deformation of the construction timber are permitted to a low extent. Construction timber in strength class C30 is rarely kept in stock.

Strength class C35

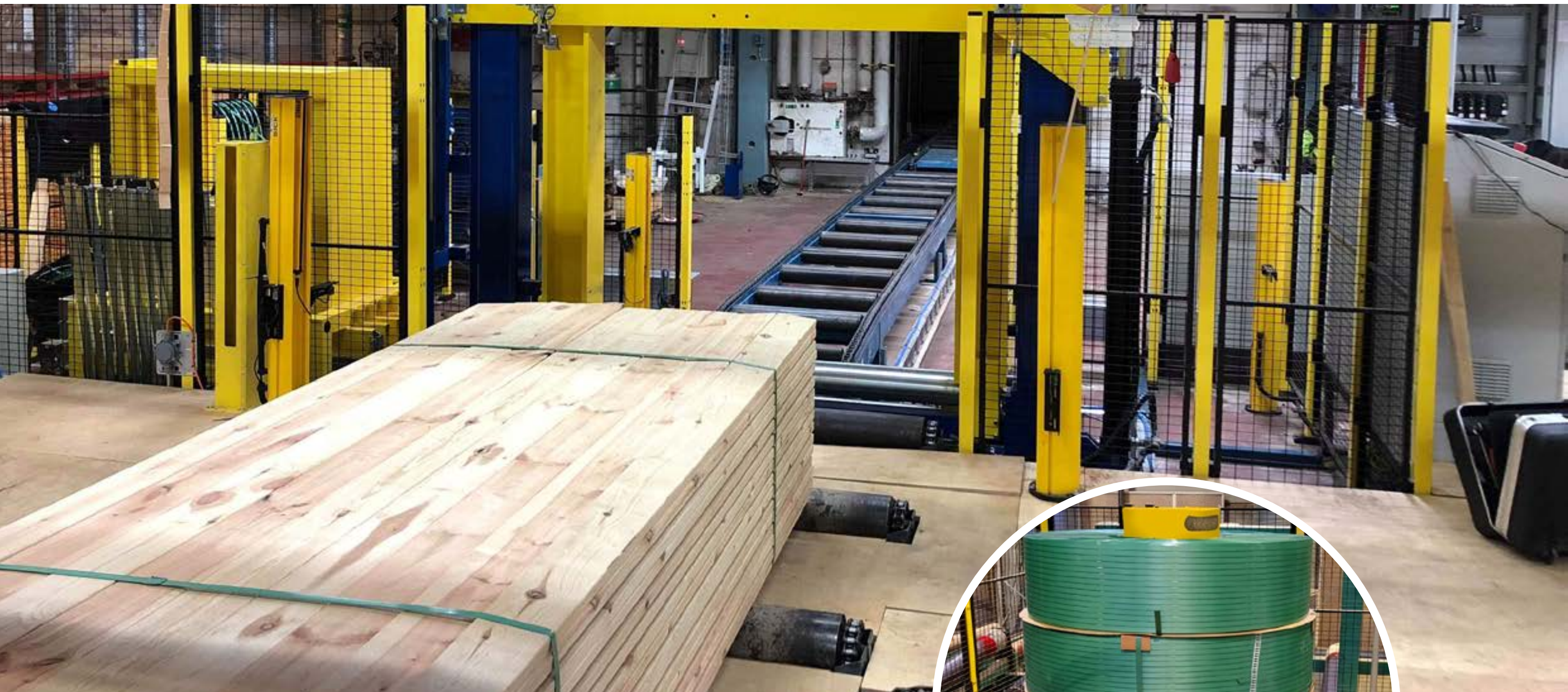
Strength class C35 is suitable for load-bearing structures that require extra high strength but cannot make use of large dimensions. C35 is a strength class where factors that affect the strength and deformation of the construction timber are permitted to a low extent. Strength class C35 can only be mechanically graded. Construction timber in strength class C35 is rarely kept in stock.

TABLE 4 | DIFFERENT STRENGTH CLASSES AND APPEARANCE GRADES HAVE DIFFERENT DEFORMATION REQUIREMENTS

Feature	Strength class C14	Strength class C18	Strength class C24	Appearance grade G4-2	Appearance grade G4-3
Bow (*w*)	20 mm/2 m	20 mm/2 m	10 mm/2 m	10 mm/2 m*	20 mm/2 m*
Spring (*x*)	12 mm/2 m	12 mm/2 m	8 mm/2 m	4 mm/2 m	10 mm/2 m
Twist (*y*)	2 mm per 25 mm width	2 mm per 25 mm width	1 mm per 25 mm width	2 mm per 25 mm width	2,5 mm per 25 mm width

* For wood thicknesses ≥ 45 mm.

PACKET STACKING AND WRAPPING



Stacking and wrapping of timber packets.

The trimmed and sorted timber is collected in a bin containing the same size, grade and, as a rule, length. These timber packets then need to be wrapped to protect the wood from the elements, while also offering the opportunity to promote the company's brand.

To make a packet, the timber is emptied out of the bin and transported to the stacker, where the timber is stacked up layer by layer. Sawn timber is mainly delivered in 1 m high packets, and planed goods mainly in 50 cm high packets. Some products, such as battens, are delivered in quarter packets that are 25 cm high. The width of all the packets is around 1 m.

Polyester (PET) strapping, which has good stretching capacity, is used to secure timber packets. The straps are often made from recycled materials. The reels are available in different sizes to reduce the number of stops to replace the strapping.

Automated machine for polyester (PET) strapping, together with a press that compresses the packets during strapping.

Automated wrapping machine. The result when the packet comes out of the wrapping machine is a strong, waterproof packet that can also be printed with the company logo.

Once between five and ten layers have been laid out, binding sticks are laid across the length of the packet, in order to provide stability and prevent it from falling apart.

After the packet has been assembled, it is transported to the next section where it is strapped and wrapped. To keep the packet together in transit, it is strapped in several places depending on the length of the timber and the mode of transport.

The type of packet and wrapping is chosen based on the customer's needs and wishes. A packet may, for example, be furnished with a full cover, half cover or top cover, either automatically or manually.

Fully automated polyester strapping machine with electric top and side press.

Shipping mark and packet specification

As part of the packaging process, the wood is marked on the end with a shipping mark, which for many years has served as the sawmill industry's trademark. The marking is done using an inkjet printer. Each sawmill has individual shipping marks that indicate the quality grades of the wood products.

Once the wrapping is complete, you also need to show what the packet contains in the form of a packet specification. This document provides information such as dimensions, grade, length, number of pieces of timber and number of cubic metres. The specification also contains a barcode that registers the storage location and is read during dispatch.

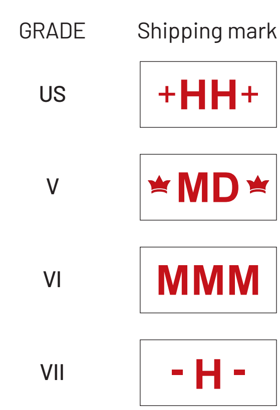
It is vital that the timber is marked clearly and that the content of the packet specification is easily identifiable.

Wood products are packaged in different ways depending on their use and handling.

Single-length packets, designated LP, are cut into standard modules of 10 cm, for example a length of 4.2 m throughout the packet.

Assorted packets contain mixed lengths. The wood may be cut in single centimetre increments, such as 1.80, 1.81, 1.82 m and so on, up to 5.4 m, or in 30 cm increments, such as 1.8, 2.1, 2.4 m and so on, up to 5.4 m.

Once the packets have been wrapped, the timber is stored. The very last thing the sawmill does is also the first thing the customer sees, so the wrapping is incredibly important to create a good first impression.



EXAMPLES OF SHIPPING MARKS


The company's shipping mark is automatically stamped on the end of the timber using a marking device that is permanently installed on the production line.

EXAMPLE OF PACKET SPECIFICATION

INTERNAL TRANSPORT

Sawmills use various types and sizes of forklift trucks, depending on their purpose, along with loaders that operate mostly out in the lumber yard and in the sawmill infeed. The forklifts are mainly used in the green sorting, timber drying, dry sorting and dispatch operations, including transportation of:

- stickered timber packets from the green sorting line/ sticker-stacker to the drying kilns or intermediate storage
- stickered timber packets from kiln to dry sorting line
- graded and wrapped timber packets to intermediate storage
- timber packets for dispatch.

Loaders are used for a variety of purposes in sawmills, but the main tasks are usually:

- unloading logs from timber trucks
- log handling in intermediate storage
- responsibility for ensuring that the sawmill has logs to saw and that the measuring station has logs to measure
- loading by-products such as wood chips, shavings, bark and other potential fuel raw materials.

In the flow from log handling to delivery of sawn goods, the timber is exposed to a high risk of handling damage. Damaged timber in turn reduces the yield in terms of

Accurate loading is essential. Timber packets should be properly wrapped and secured so that they are not damaged in transit.

volume and value, and increases the risk of production stoppages. Crushing damage and breakages can occur during handling, which could mean side boards having to be chipped or logs getting stuck in the production line.

It is common for timber packets to be moved several times, not only when they are stickered but also when they are ready for delivery. During these movements, transport damage can occur, such as edge damage or tearing of the wrap.

The volumes handled on a daily basis, both in the lumber yard and in the timber yard, and careless handling can cause major losses. The loader and forklift drivers therefore have an important task and must drive carefully.

Safety first

The area where forklifts and loaders operate is risky, largely because the size of the machines limits visibility. Pedestrian traffic should be well separated from truck traffic and there should be sufficient signage and warning markings in place.

It is important that the operator of a forklift or loader has the necessary knowledge and skills for the tasks they are assigned to perform. This also applies to contract workers, who should be given clear instructions for the specific workplace. General rules are that pedestrians must wear high-visibility vests, make eye-contact with the forklift driver and exercise caution when passing the truck's work area.

By law, forklift or loader operators must have documented theoretical and practical knowledge, but it is not necessary to have a formal forklift licence. The most common way to acquire these skills is to attend a forklift driver training course. Several organisations, both independent and those linked to truck manufacturers or particular industries, offer training courses. It is the employer's responsibility to ensure that staff have sufficient knowledge to operate a forklift at work. Authorisation must be given in writing.

More information on safety issues is available in the Swedish Work Environment Authority's regulation on the use of forklifts and its general advice on application of regulation AFS 2006.5 (year 2022), or via Prevent's website **www.prevent.se.**

Prevent shares knowledge that helps companies to create a good work environment through information and training, as well as developing products that help with health and safety work. Prevent is a non-profit organisation owned by the Confederation of Swedish Enterprise, the Swedish Trade Union Confederation, LO, and the Council for Negotiation and Co-operation, PTK, and as such its work is developed jointly by trade unions and employers.

Electric trucks in sawmills

Forklifts have run on diesel for many years, but they are switching to fossil-free alternatives. Electric forklifts have been around for a long time in the smaller weight categories, but are now also appearing among heavier trucks in the sawmill industry. Electric forklifts help to improve environmental efficiency, while also generating lower noise and vibrations, which is good for the work environment.

SAFETY

It is essential to have a clear induction programme for new employees that includes information on the risks of ill-health and accidents and how to work safely in the company. The induction may include working practices, information on how equipment works and the risks involved in the work and how to avoid them. The information should be adapted to the needs and abilities of the employee, as should the working conditions.

Prevent's free online training course Säkra Sågverk at **www.sakrasagverk.se** provides a basic grounding in health and safety in the work environment and risks in sawmills.

Everyone's responsibility to participate

The goal is that no employee should be injured at work. Working together on health and safety creates a positive safety culture where everyone takes the risk of accidents seriously and works to reduce them. No one, regardless of their task or position, should compromise on safety or behave in a way that causes injury. The management's actions, prioritisation of and responsibility for the work environment are crucial factors for safety at the sawmill. To this end, sawmills must have a functioning systematic work environment management system.

Examples of personal protective equipment designed for professional use.

The production workers are usually the first to spot shortcomings in the workplace and have good knowledge of what needs to be done. Identified risks should be reported and documented. To avoid accidents, the safety features and personal protective equipment available at the sawmill must be used, even for simple tasks.

Major improvements have been made to health and safety at sawmills, not least enclosing machinery and automating the production process to reduce the risk of accidents. This does not mean that we can rest on our laurels — there are always ways to improve health and safety and reduce the risk of accidents.

Personal protective equipment

Personal protective equipment protects against injury and risks that threaten safety or health. The equipment must be tailored to each individual and be CE marked to guarantee that it meets certain basic requirements. It is the responsibility of employees to use the personal protective equipment that is needed for their work. To be able to use the right equipment in the right way, it is therefore important to know the conditions associated with the work and the work environment. Workers must be trained in how and when to use the protective equipment.

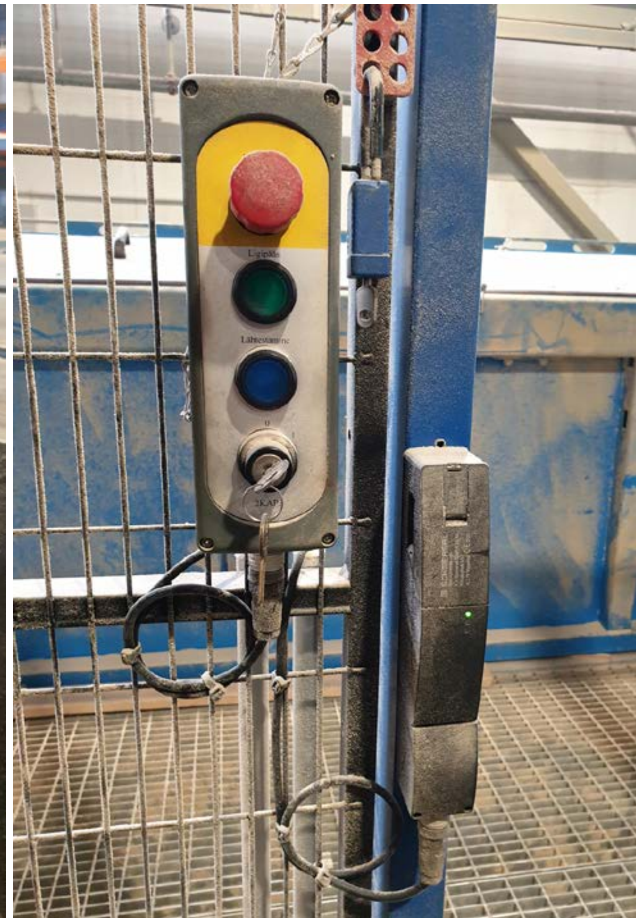
Personal protective equipment must also be maintained in good working order. It needs to be kept clean and should always be tested by the person who will be using it. Don't forget that this is personal equipment.

Follow procedures and instructions

Clear instructions are needed to achieve a good work environment, and as a worker you should familiarise yourself with and follow them. Here are a few examples:

- A **procedure** lists a set of activities to be carried out, in what order and who is responsible for it.
- An **instruction** is more detailed and describes how, when and why one or more activities should be carried out. Clear instructions show how certain tasks should be carried out, but they can also cover topics such as fire safety or first aid.
- Particularly hazardous work must have **written instructions**. This may include repair and service work, where the instructions ensure that machinery cannot be started unintentionally while work is in progress.

A light barrier or light curtain acts as an invisible fence around a hazardous area to prevent injury. If the light curtain is broken, the machine stops.



An electrically operated gate is equipped with a key, plus start/stop and emergency stop buttons. If the gate is opened during production, the machinery stops and an acknowledgement is required to restart.

Clean and tidy

Remember that keeping things clean, tidy and organised is one of the best and cheapest foundations for a safer working environment. For example, when everyone knows where tools live, production becomes more efficient and less time is wasted — and the risk of workplace accidents is reduced.

Clear communication and helping each other keep things clean and tidy at the sawmill are active contributors to a good safety culture.

Nonconformity reporting

Everyone working at the sawmill can help to identify risks in the workplace, including matters that lie outside the physical work environment, such as workload and job satisfaction. Involving employees in health and safety work often leads to a greater sense of responsibility for the work environment. Together, you can then find more solutions to problems and measures to mitigate risks.

The employer is responsible for ensuring that a system is in place to report accidents and near-misses, as this is a key way of identifying risks in the workplace. The aim is to obtain all possible information that can be used to prevent accidents. The better everyone in a workplace is at reporting nonconformities, the more accidents can be prevented.

SYSTEMATIC WORK ENVIRONMENT MANAGEMENT
Systematic work environment management is an ongoing process consisting of various activities that lay the groundwork to conduct and implement health and safety work in the best possible way.

Tool maintenance on an automatic band saw blade roller stretcher.

CUTTING OPERATIONS

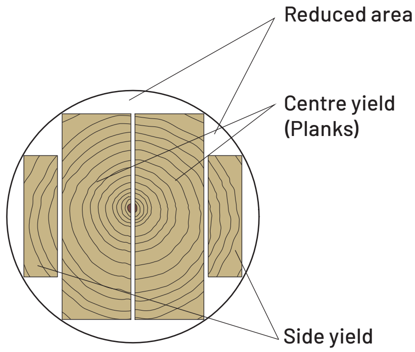
General

Most sections of a sawmill use various forms of cutting tools.

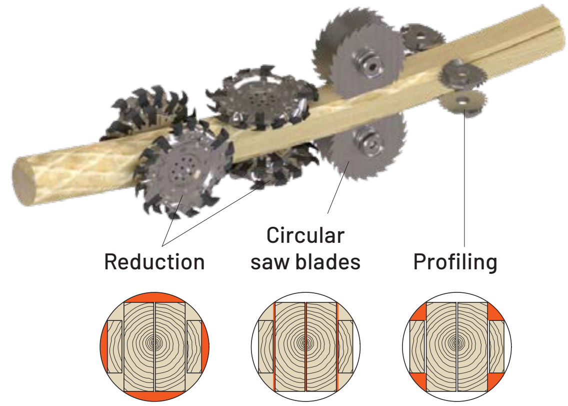
Log feed
The log feed section has debarking and in many cases root reduction machines with their associated tools.

Saw line
The saw line contains most of the cutting tools. The first process is reduction, which means that the round conical shape of the log is converted into a square cant. About 35 percent of the log's volume becomes chips. Reducing involves two cutting functions: milling flat surfaces and creating chips.

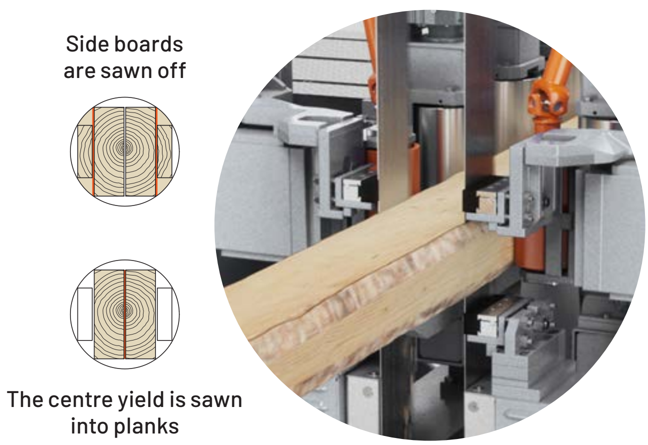
Pneumatically controlled debarking tools with carbide plates.



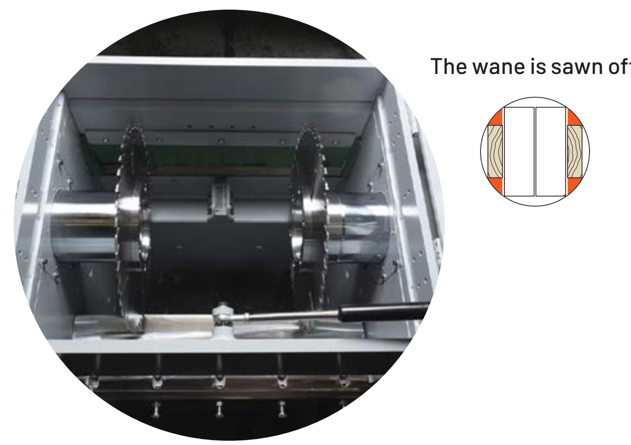
After reduction, the cant can be broken down in different ways.



Reducing, breaking down and profiling in the same machine.



BAND SAWING
Band sawing of side boards with wane.



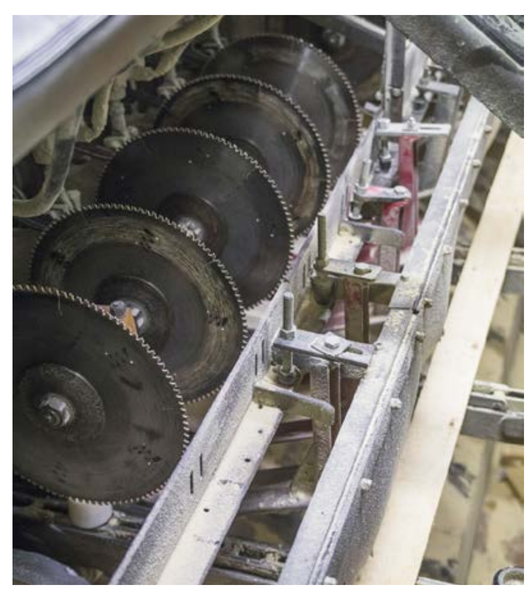
EDGING
Two blades saw off the wane of the side boards.

After reduction, there are many different ways to break down the square cant. A common approach is profiling and cutting with circular saw blades. Profiling involves milling off the wane of the side board while the side board is still on the cant. Circular saw blades then remove the side boards from the cant and cut the centre yield into planks. The saw cut (kerf) is usually 3—5 mm wide.

Another common variant is breakdown with band saw blades and subsequent edging with circular saw blades. Here the functions of reduction, band sawing and edging may be spread across different machines. The band saws are often set up in three sawing groups, with the first two taking side boards from the reduced cant with the wane remaining, after which the side board is transported to the edging plant where circular blades cut away the wane. The third sawing group cuts the centre yield into planks. A band saw blade produces a kerf of less than 3 mm.

Green sorting and dry sorting

In the green sorting section, the cutting activity takes place in a trimmer, using circular saw blades, before drying. A trimmer with circular saw blades also machines the timber that comes out of the kilns, on the dry sorting line. In both instances, trimmer blades cut the timber across the grain.



A trimmer has a number of blades for cutting lengths of wood. Each piece is transported through the trimmer on a chain conveyor and cut to the desired length.

For high-quality cellulose chips, the chipper's cutting tools must be sharp and other machine parts that affect output must be well maintained.

Lower section
The lower section of the saw unit collects all the by-products, which are of much less value than the sawn goods. The cutting process that takes place here is chipping, the aim of which is actually the same as in the reducer, namely to create chips of the right quality.

Sawmill tool department
Most sawmills have a department that looks after all the cutting tools and ensures that all the various machines always have functional cutting tools. Some sawmills carry out their own maintenance of certain tools.

In summary, all the cutting tools in a sawmill are selected according to their function in the different machines. What is common to all cutting tools is that they have a cutting edge that does the actual work. It is important that the cutting edge is not damaged or too worn, and that the tool is correctly mounted in the machine. These are basic conditions for the cutting tool to perform as intended.

Tool performance

When selecting a cutting tool for all the functions in the sawmill, the principle is to maximise the process efficiency of the entire sawmill, *see Production planning, page 21*. A cutting tool will always generate:

- A machined wood surface — surface finish, waviness, dimensions and dimensional variation
- Shavings, chips or bark — the fragments that do not have a machined surface
- Wear — cutting edge and tool body.

Measuring Overall Equipment Effectiveness – OEE

Availability
You want to replace any cutting tools that do not perform well enough under planned conditions. Measuring the time you spend on unplanned stoppages to change a cutting tool that is underperforming or has broken down gives you an idea of how much of the total unplanned stoppage time is related to the performance of the tools. This is usually referred to as downtime or availability loss where the cause is the cutting tools.

Performance
You want to run the sawmill's machines as fast as possible while maintaining acceptable quality and without having any unplanned production stoppages. The choice of cutting tools often has a decisive impact on how well the sawmill can utilise the speed of its machines. There are a number of tooling parameters that affect this, such as the number of cutting edges, the size of the gullet area and the geometry and dimensions of the cutting edge.

The performance of the cutting tools and their contribution over time to the sawmill's Overall Equipment Effectiveness — that is, availability, performance and quality — is determined jointly by tool maintenance and machine maintenance. Tools cannot perform better than the weakest link.

The saw unit has many moving parts that wear out and can affect efficiency. You should begin by checking the cutting edge that does the actual work and then examine what it is attached to, such as a saw blade for breaking down timber, which in turn is attached to the saw unit. The sawing machine also has a feeder that has to hold the log properly during sawing, and that can affect the performance of the tool. Finally, the timber itself and any foreign matter such as stones and gravel stuck to the log also have an impact.

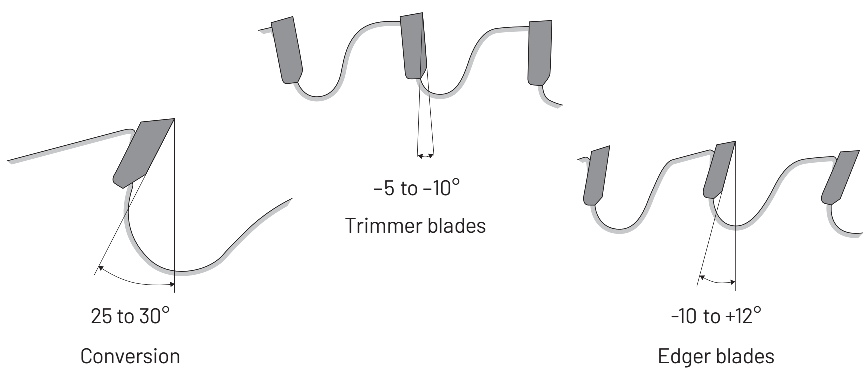
Quality
The most important and expensive part of the sawmill is the timber. The main aim is to achieve the right surface quality and dimensions of the sawn wood products, planks and side boards. You also want to minimise the saw cut in the conversion, which produces low-value sawdust. When chipping and reducing, the aim is to achieve high quality chips. By measuring surface quality, dimensions and dimensional variation, yield (amount of chips from the conversion), and chip quality, you can determine when the cutting tools are underperforming and need to be replaced.

Technical parameters affecting performance

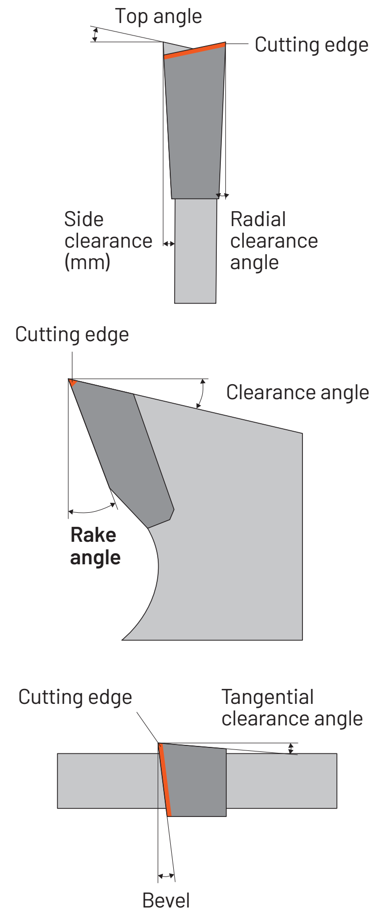
The technical parameters that affect the performance of a tool can essentially be divided into six categories: cutting geometry, cutting data, timber, tool engagement, tool material and tool body. Some of the most common parameters that affect performance are discussed below.

Cutting geometry

The first parameters that should be selected are the angles of the cutting edge geometry. The most important angle to select is the rake angle, because this affects the magnitude and direction of the cutting force and thus the stability and performance of the cutting tool. It is the geometry parameter that differs most between applications. Examples of common rake angles are: conversion, trimmer blades and edger blades.



EXAMPLES OF COMMONLY USED RAKE ANGLES



ANGLE DESIGNATIONS
Examples of angles that are sharpened.

Cutting data

Cutting data can be simply described as the movements that can be set in a sawing machine. The key parameter is the chip thickness that each cutting edge produces, with common chip thicknesses shown in *Table 5*.

In order to control this parameter, you need to know, among other things, how fast the cutter moves (cutting speed, usually 65—110 m/s for conversion), and how fast the log is fed through the saw machine (feed rate, m/min).

Calculation of chip thickness, band saw blade:

$$\frac{\text{Feed rate (m/min)} \times \text{Tooth interval (mm)}}{60 \times \text{Belt speed (m/s)}} = \text{Chip thickness (mm)}$$

Example: $\frac{80 \times 45}{60 \times 58} = 1.03$

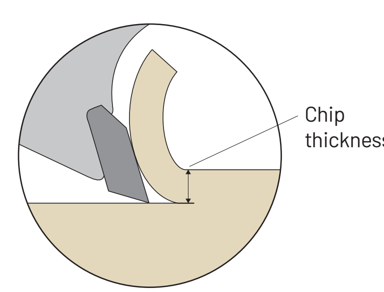
Calculation of maximum chip thickness, saw blades:

$$\frac{\text{Feed rate (m/min)} \times 1000}{\text{Speed (rpm)} \times \text{Number of teeth on the blade}} = \text{Chip thickness (mm)}$$

Example: $\frac{135 \times 1000}{3000 \times 30} = 1.5$

TABLE 5 | COMMON CHIP THICKNESSES

Material	Chip thickness (mm)
Solid wood, cutting	0.10–0.35
Resawing dry	0.30–0.50
Resawing green	0.40–1.00
Resawing green, circular saw blades	0.70–1.50
Resawing green, band saw blade	0.80–1.30

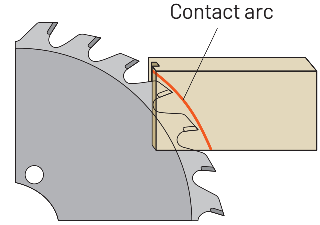


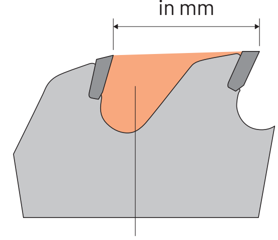
CHIP THICKNESS

Timber – the impact of the material

The cutting edge is affected by the material it encounters when cutting a chip. The extent of this impact may depend on factors such as:

- Wood species (spruce or pine)
- Sapwood (side boards) or heartwood (planks)
- Moisture content (green or dry)
- Temperature of green wood (above or below zero)
- Quantity of knots (quality grades)
- Fibre direction (conversion — cutting in trimmer — planing)
- Foreign objects (stones, nails, screws, bullets, etc.).





GULLET AREA
Area used to assess the chip load, that is, how much chip can fit in the gullet.

Tool engagement

Tool engagement can simply be described as how the cutting edge starts cutting, how long the cutting edge cuts a chip and how the cutting edge stops cutting. The key parameter is the length that the cutting edge cuts a chip, known as the contact arc. A minimum of two and a maximum of four teeth should be engaged when sawing solid wood.

This is what determines the tooth interval and thus how many cutting edges the tool has. A parameter that often affects performance is the chip load — whether the volume of chips cut during the length of the engagement is sufficiently accommodated in the gullet between the saw teeth. This is calculated as:

$$\frac{\text{Contact arc (mm)} \times \text{chip thickness (mm)}}{\text{Gullet area (mm}^2\text{)}} = \text{Chip load (\%)}$$

Tool material

The material of the cutting edge affects how quickly the cutting edge wears or breaks when the tool is used or handled in and out of the machine. Common tool materials are carbide, stellite and hardened steel. In some cases, the tool body's material is used as the tool material.

Tool body

The tool body is the part on which the cutting edges are located, together with the tool's fixing point. The body has an impact on the performance of the tool, especially in the case of circular and band saw blades. These tools require the body to be level and, in most cases, under tension. Band saw blades are always made from cold-rolled sheet metal that is machined with rollers to create internal tension, while the body of circular saw blades is normally based on hot-rolled sheet metal that is ground flat and cold-rolled to create internal tension. A hammer and anvil can be used to remove bumps or local irregularities.

There are many different types of circular saw blade with different functions. They have to be appropriate for the respective operations, such as sawing, edging and trimming. Circular saw blades can also be used in planing or joinery production.

Maintenance of cutting tools

The cutting tools used in sawmills are used many times over, with periodic maintenance. A new tool is expected to perform well for a certain planned time. For example, a band saw blade for ripping timber is usually expected to work for two shifts (approx. 16 hours), or four shifts (approx. 32 hours).

After use, you want to maintain the tool and use it again for as long as it continues to perform and contribute to the overall efficiency of the sawmill. Many tools are used 15—20 times before they are worn out.

Examples of common actions to maintain a cutting tool:
- Cleaning and monitoring the performance of the tools.
- Sorting tools of similar size and with similar maintenance actions.
- Repairing cracks in the tool body and damaged teeth.
- Levelling and tensioning the tool body.
- Replacing cutting edges on the body (swaging, soldering, welding).
- Regrinding the cutting edge.
- Quality inspections.

Cleaning and monitoring the performance of the tools

Their use often leaves tools covered in dust, sap and other resinous coatings. A tool must be cleaned before maintenance can begin, as it can be difficult to see what maintenance needs to be done if the coatings are not removed. The dirt will also affect and contaminate the machines used to flatten and align a band saw blade, for example. The dirt will also be transferred to the grinding discs when regrinding the cutting edge, greatly impeding their efficacy. Dust and dirt on clamping surfaces can cause eccentricity and skewing on blades set up in grinding machines, which reduces accuracy.

During cleaning, decisions can be made about the maintenance that needs to be done or whether the tool is beyond repair. Many sawmills also note down maintenance measures and follow up on how the tool has performed in order to promote improvements. Some maintenance measures are carried out at the sawmill and others by a supplier who carries out tool maintenance.

Levelling and tensioning the tool body

Levelling involves hammering or cold rolling the surfaces flat on a circular or band saw blade. It is best to hammer against a metal anvil or sometimes a wooden block. Levelling bumps and ridges by hand requires great skill, and is quite time-consuming.

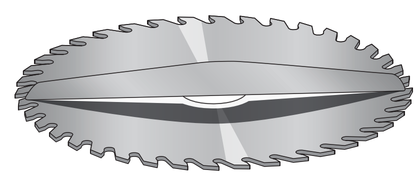
There are also automatic levelling machines that detect irregularities and then level them out with integral electromagnetic hammers or rollers.

Tensioning of both band saw and circular saw blades can be done using rollers. There are automatic stretcher rolls for band saw blades, which save a lot of time and provide optimal tensioning, because the machine measures the light gap that occurs when, for example, the centre section of the band saw blade is stretched. However, the light gap is not a completely ideal measure of stretching.

A ruler can be used to manually check that a circular or band saw blade is flat and has the correct tension. Make sure that light enters only from the front. If a blade is tensioned correctly, a light gap is visible across the entire diameter.

A saw blade with damaged teeth will leave the sawn timber with incorrect dimensions and a defective sawn surface.

A broken chopping knife can cause poor chip quality.



MANUAL CHECK OF THE SAW BLADE
A ruler is used for a quality check of flatness and tensioning.

Replacing cutting edges on the body

Sometimes you need to replace damaged cutting edges with new ones, for example on circular and band saw blades. This may be when the cutting edge has been resharpened many times and has become too small to work, or when some cutting edges are badly damaged but the body of the tool is not worn out.

Circular saw blades usually have carbide in the cutting edge and are soldered to the blade body. Band saw blades tend to use stellite for the cutting edge, which is usually welded to the band saw blade body. Some sawmills also use swaged teeth on band saw blades. A swaged tooth is one where the body material is plastically deformed and then a cutting edge is ground out.

Regrinding the cutting edge

When the frame is clean, flat and has the correct tension and there is enough tool material to form a cutting edge, the geometry of the cutting edge is ground on all the tool's cutting edges. There are many different types of machines for grinding the tools, essentially one for each type of operation, but many machines can be used for several forms of grinding.

It is important not to grind with excessive pressure or to take off too much. The development of heat can easily tarnish the cutting edge, as well as affecting the material of the cutting edge and reducing its ability to resist degradation and wear.

The heat of the grinding process can be partially removed with coolant. Wet grinding is a common method where oil or an oil emulsion is used as a cooling medium. When grinding tools that have been in production, each cutting edge must be carefully inspected for damage so that grinding begins on the most damaged cutting edge.

Sharpening saw blades is an important part of saw production. A grinding machine must be kept in good condition to ensure the right dimensions of the timber and a good sawn surface. It will also make saw blades last longer with more efficient sawing.

MAINTENANCE WORK

Sawmills have developed into a process industry with highly diversified and complex machine systems — a development that has increased the need for skilled workers, but has also placed greater demands on the way the work is organised. Effective cooperation between operations and maintenance is a prerequisite for achieving high availability on the production line.

Sound maintenance work requires a good knowledge and understanding of the functioning of machine systems. Increased productivity requirements mean advanced equipment with higher capacity and demands for greater plant availability. In this context, maintenance deficiencies can lead to high costs and production stoppages.

Poor maintenance often only manifests when problems arise, which is why it is important to manage maintenance effectively. Well-designed maintenance also relies on other factors being in good order, such as health and safety, the environment and finances, not to mention sustainability.

Poor maintenance can also lead to risks of personal injury due to high noise levels, stress, chemical hazards and poor ergonomics, and it is therefore important to comply with existing laws, regulations and health and safety rules. Unforeseen disruptions and stoppages in industrial production are costly and must be prevented as far as possible — they must not be seen as an inevitable part of life.

Remedial, preventive and improvement maintenance are terms that can be defined in many different ways, but they are generally used as follows:

Remedial maintenance, RM, means conducting repairs usually, but not necessarily always, on an urgent basis. The fault is present and has been detected. This includes all maintenance carried out with the aim of correcting a fault that has occurred without warning.

Preventive maintenance, PM, includes all programmed maintenance, carried out according to a specific plan, with the aim of either preventing the occurrence of failures or detecting failures before they occur.

Improvement maintenance. This refers to modifications carried out to improve equipment, for example in the form of new investment. However, the level of investment can be fluid.

The maintenance mechanic works throughout the sawmill on both preventive and emergency interventions. This job requires great flexibility and knowledge in several areas such as welding, some electricals, hydraulics, pneumatics and mechanics.

Examples of activities and working practices

The Maintenance Department is responsible for general technical matters and the maintenance of machinery and buildings. It also carries out some production engineering work, in terms of getting machines to function mechanically and technically with new installations.

The department is also involved in the purchase and installation of new machines so that they fit into the company and produce output as planned.

Other duties include ongoing maintenance and repair work. Preventive maintenance is a priority in order to avoid faults in the machines and unnecessary production stoppages.

Production staff check the machinery and are responsible for changing the cutting tools.

Preventive maintenance should mainly be carried out by production staff. This includes daily maintenance and checks, paying attention to nonconformities and monitoring the condition of the machine during startup, shutdown and operation. If there are signs of potential minor faults, the production staff can take action directly without the need to call in the maintenance department. In the event of more serious faults that require permits and specialist expertise, authorised staff must be called in.

Preventive maintenance also includes the correction of faults detected during the equipment inspections, in a bid to head off mechanical failure. Faulty parts are replaced before anything serious happens to the machine. The intention is to never reach the stage when a fault occurs and causes a production stoppage.

Equipment inspections are best carried out when the machines are stationary for whatever reason. These general inspections involve going into the machine and checking for any tendencies towards faults of any kind. In other words, production staff check the general condition of the equipment, such as bearing vibrations. If necessary, they purchase the parts that need to be replaced. However, if an accident does occur and causes a serious stoppage, emergency solutions are often required. The machine is repaired as well as possible, so that it can quickly re-enter production, with a more thorough repair carried out during a longer shutdown, such as a holiday break.

Production is built around large and technically complex machines, and a stoppage or breakdown can be very costly. It is therefore vital to maintain a certain level of preparedness in order to minimise downtime, including keeping a stock of spare parts so that, as far as possible, there is no need to wait for deliveries from machine manufacturers. Staff can also make some spare parts themselves when the need arises.

As the technology in sawmills has become increasingly complex, especially on the electronics side, where troubleshooting can be time-consuming, computer-based tools have been developed. These indicate the fault in question and the most suitable measurement or control points, thus leading to the shortest troubleshooting path. Information in the form of downtime statistics can also be entered into the system, providing useful data for preventive maintenance work.

Machines for high-speed planing of construction timber.

FURTHER PROCESSING BY SAWMILLS

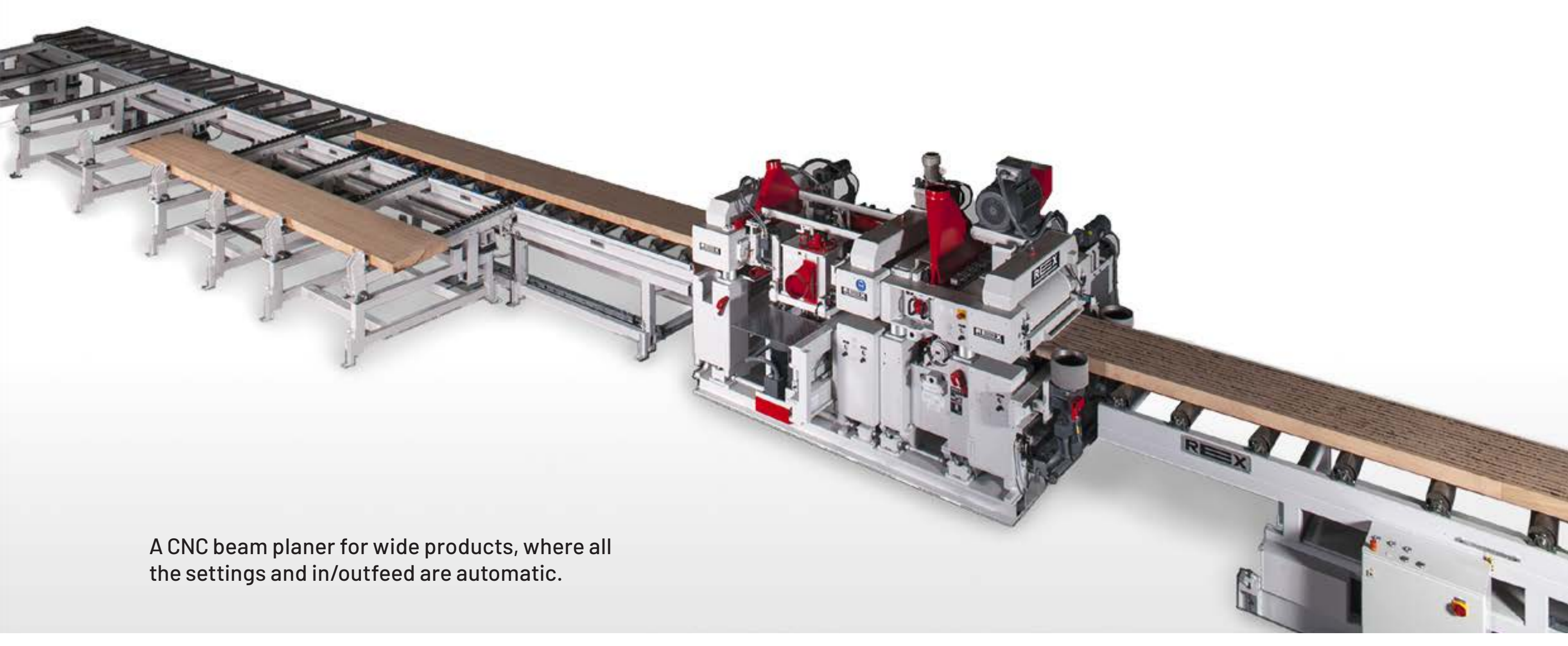
Planing and resawing

Wood used as a material for manufacturing different products must first undergo various processing, and it is not uncommon for these production processes to take place in conjunction with each other. Generally speaking, wood products made by sawmills will undergo some form of processing, either on site by the manufacturer, if they have that kind of equipment, or at a customer's facility.

A large volume of the sawn timber will be passed through a planing machine. The finished planed timber can have all kinds of possible profiles depending on the application and what the customer has ordered. There are, however, standardised dimensions, which can be viewed in Swedish Wood's Product Catalogue, **www.traprodukter.se**.

Planing may also be used to create other types of specialist products that do not follow a specific standard, such as interior and exterior cladding or mouldings with unusual profiles.


Tilt with extra hoist is used in trimmers and planers. The extra hoist means that no production is lost during package changes.

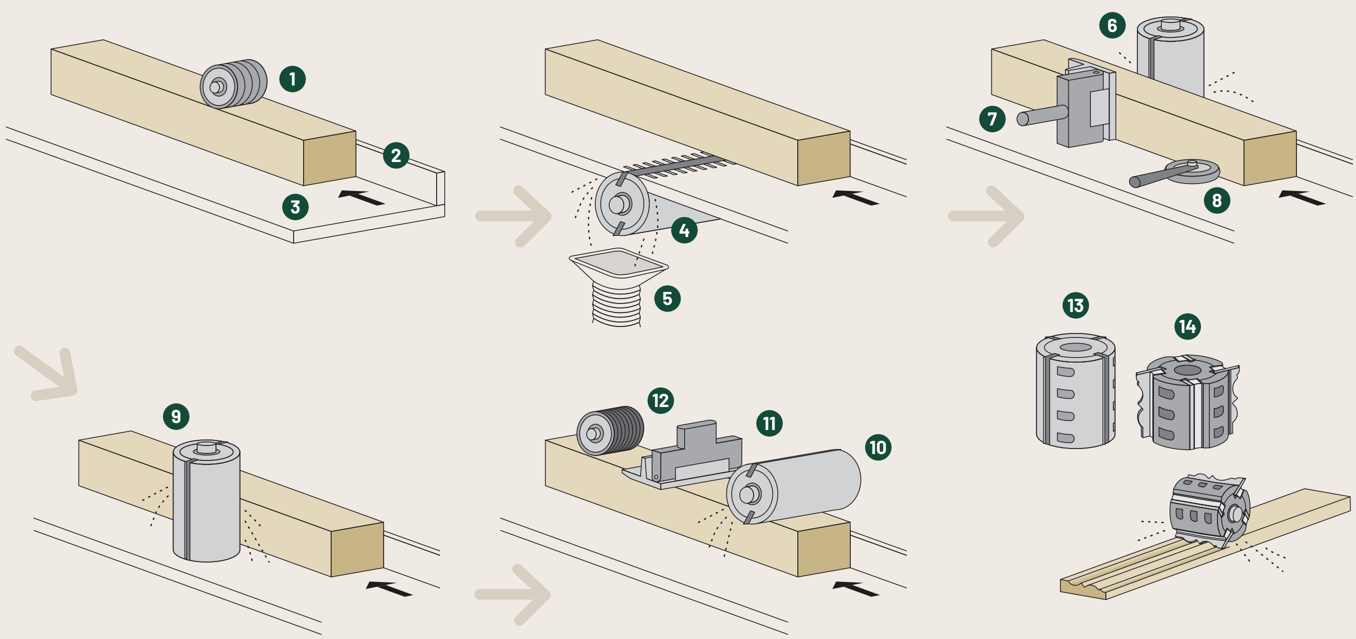


A CNC beam planer for wide products, where all the settings and in/outfeed are automatic.

Planing – processing principle

A planer moulder planes the wood material on four sides simultaneously. It usually has 4 to 9 spindles — rotating shafts on which finish planers and profile cutters are attached. First the bottom face is planed, then the sides individually and finally the top face. Profiles can also be milled.

The machine is used by planing mills, joinery workshops, timber merchants, house manufacturers and builders' merchants, mainly to produce interior and exterior cladding, but also windows, doors, mouldings and construction timber such as beams and joists.



1 Infeed roller
The feed wheels drive the wood material through the machine at an even speed.

2 Fence
The adjustable fence controls how much wood is planed away by the first side cutter.

3 Infeed table
The infeed table can be raised and lowered to adjust the amount of wood to be planed off by the first, bottom cutter. The table is lubricated to reduce friction against the wood.

4 Bottom cutter
The wood to be planed is fed to the first cutter, which planes the underside.

5 Chip extraction
Each spindle has an associated chip extractor. The chips are collected and can then be packed into bales, for example.

6 Right side cutter
The planer first works one side, usually with a finish planer, but a profile cutter can also be used.

7 Side pressure plate
This tool holds the material against the first cutter.

8 Pressure roller
The pressure roller holds the material against the opposite side.

9 Left side cutter
The planer then machines the other side, usually with a finish planer, but a profile cutter can also be used.

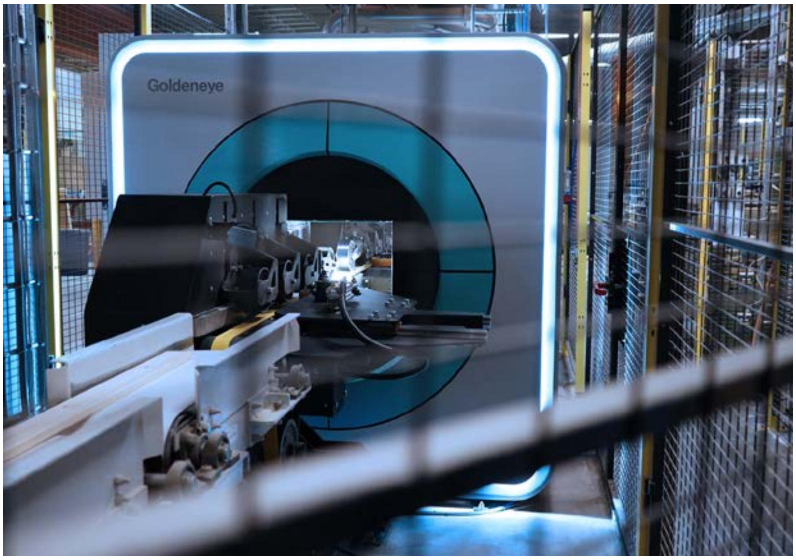
10 Top cutter
Once the top face has been planed, the entire workpiece has an even thickness and width, along with smooth surfaces.

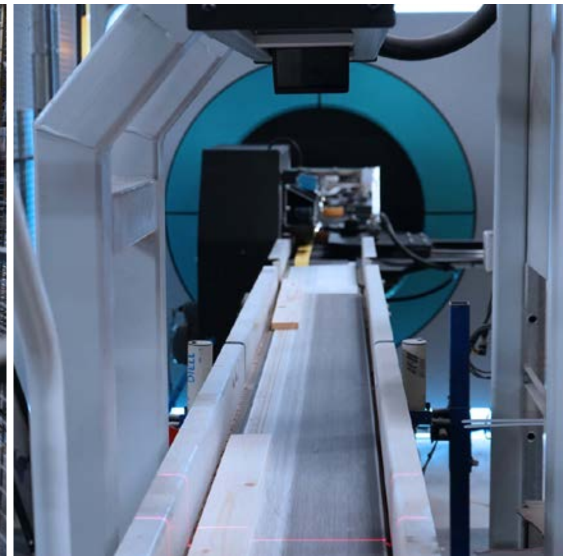
11 Pressure shoe
The pressure shoe holds the wood down so that it does not kick. There is a pressure shoe behind each overhead tool.

12 Outfeed roller
An upper rubber-clad feed roller pulls out the machined material.

13 Finish planer
A finish planer is a metal cylinder with a number of blades that give the timber a flat surface.

14 Profile cutter
A profile cutter is used to mill profiles into the timber. The tool can have either fixed profiling knives or loose, interchangeable knives.





Timber quality can be scanned automatically using x-rays, cameras and sensors. The camera technology determines the characteristics of the timber and is able to locate different types of knots, cracks, discolouration and so on, to determine the true value of each individual board or plank.

A key factor in achieving a good production result is that the raw material entering the planer is of the right dimensions and, above all, that it is free of dirt and other contaminants. A small grain of gravel on the raw material entering the planer could damage the cutter, and that will be visible in the finished planed timber. Damage to the timber means that production has to stop to change the cutting tool and a loss of production is always costly. It is important to take the best possible care of the equipment and all the cutters, as the dimensional accuracy of the final product depends on it. Grinding cutting tools is a matter of hundredths of a millimetre, so precision is a crucial factor.

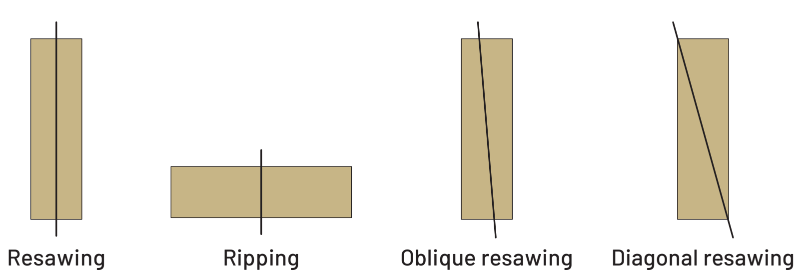
A modern planing mill can produce a large number of running metres per minute. It is imperative that all employees working in the plant are vigilant and prevent possible faults by following established procedures, such as checking the dimensions and quality of the incoming raw material, but above all of the pieces of wood that have been planed.

Resawing

The cutting of planks into boards is known as resawing, and it is mostly reserved for kiln-dried timber. Resawing usually involves cutting the same dimension in large batches.

Resawing terms

- **Resawing**. Sawing through the sides of the timber = vertical resawing.
- **Ripping**. Sawing through the flat faces of the timber = horizontal resawing.
- **Oblique resawing**. Sawing slightly off perpendicular through the parallel sides of the timber.
- **Diagonal resawing**. The saw cut runs diagonally through the cross-section of the timber, producing a triangular profile.
- **Fine sawn surface**. The surface obtained after resawing dry timber.



EXAMPLES OF RESAWING METHODS

Planing

In medium and large planing mills it is common to have two planing lines — one large machine for longer production runs and one machine for specialist products in small runs. Large plants may have a third machine dedicated to the production of trimmed timber.

Production might proceed in the following order:
- Sorting of planks by quality or length
- Resawing of planks into boards
- Sorting of boards
- Planing
- Grading
- Bundling
- Packaging.

When measuring the moisture content of all the pieces in a batch with a target moisture content of 16 %, the average value for the moisture content of the whole batch (average moisture content) is allowed to fall between 13.5 % and 18 % to be approved. As regards the individual pieces in a batch, the moisture content of 93.5 % of these must fall between 11.2 % and 20.8 %.

Different planing tools

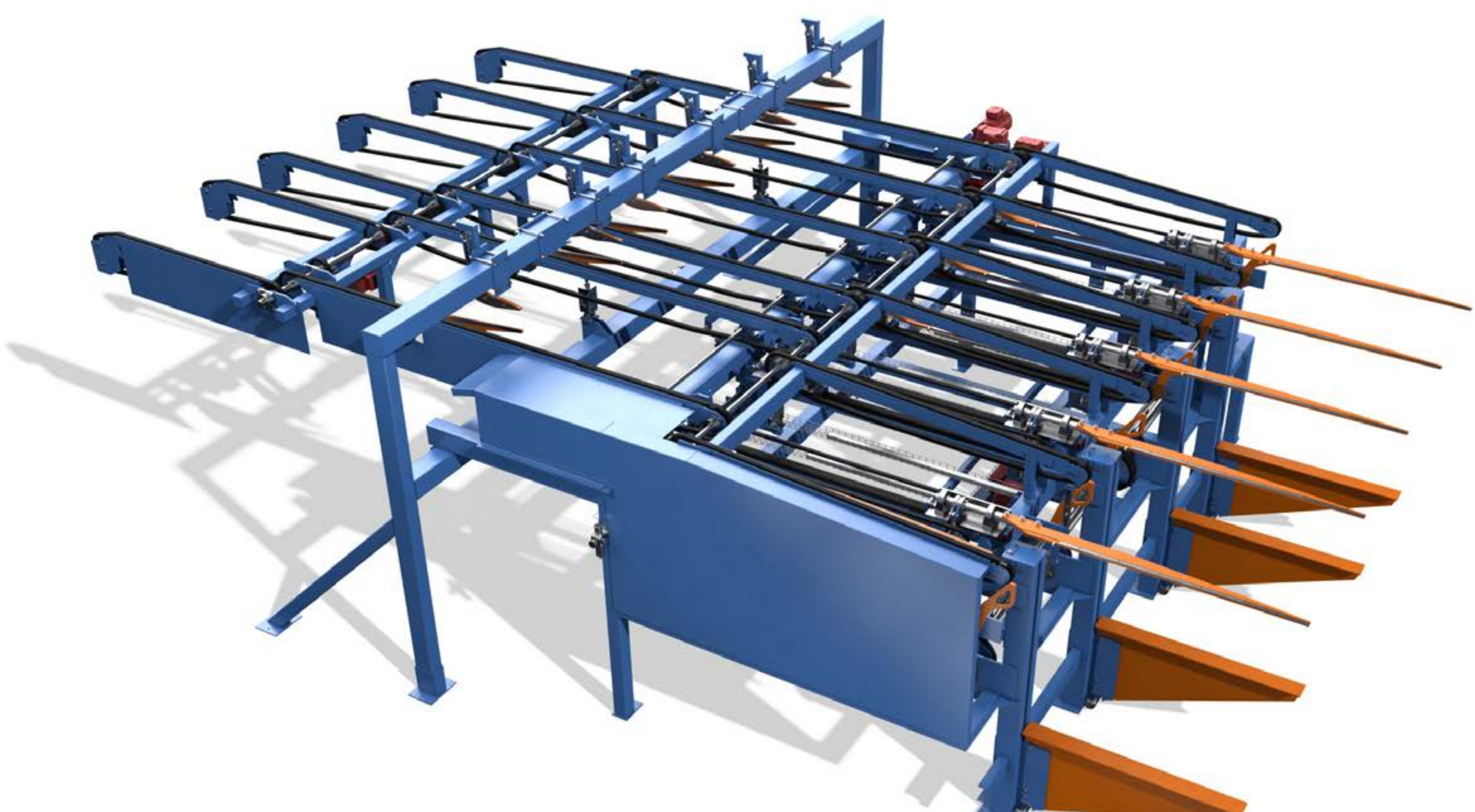
Jointer

Once the timber has been dried and graded, some boards may be deformed, for example warped, crooked, bowed or cupped.

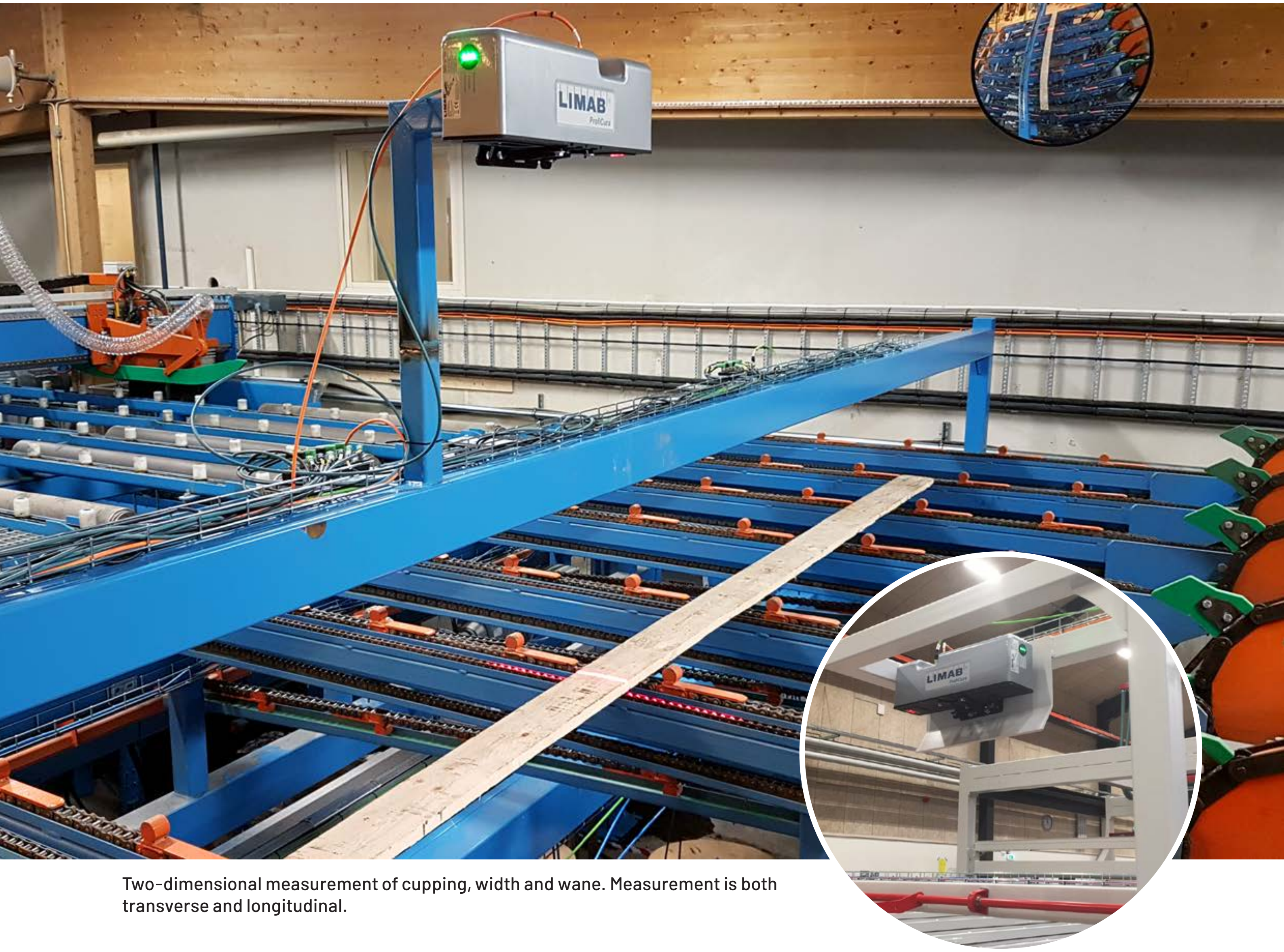
A jointer flattens out the timber, eliminating any irregularities. One or two adjacent sides are planed so that they are absolutely flat. Any cupping and warping is planed away. If there are major irregularities, the timber may need to pass through the cutter several times.

When flattening two sides that are perpendicular to each other, start with the face.

Then tackle the side. To ensure that the side is perpendicular to the face, it is very important to turn the levelled face towards the fence. Do not press on the workpiece, as this could flatten out the timber temporarily as it moves through the jointer, leaving the same crookedness in place after machining.



After the timber has been planed, it is stacked into packets. A stacker is capable of forming all kinds of packets, such as full, half and quarter packets. Binding sticks are placed in the packet between predetermined layers and loaded manually into a cassette on the walkway next to the machine.



Two-dimensional measurement of cupping, width and wane. Measurement is both transverse and longitudinal.

Thicknesser

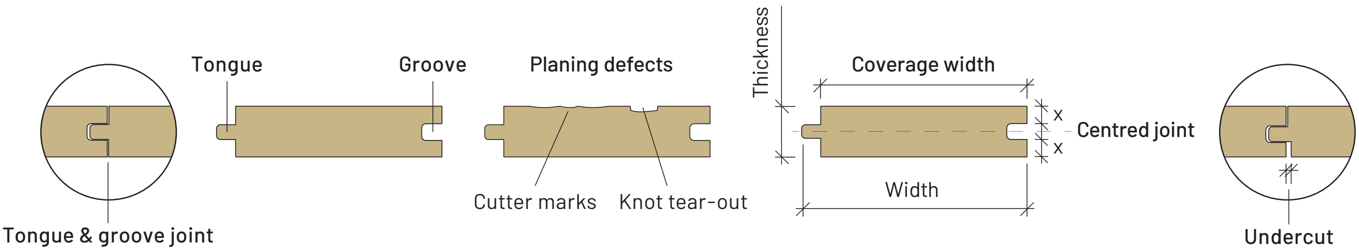
The timber must of course have specific dimensions in line, for example, with the Swedish standard. The timber is therefore planed to certain dimensions using a thicknesser, producing wood with a quadratic or rectangular cross-section. Dimensionally planed timber can be used for structures, such as the frames of houses. Since it is not visible, there are no major surface finish requirements, so the wood can simply be roughly planed.

A profile cutter is used to plane cladding and mouldings, but also for custom products.

Profile planer

The wood can be given a special cross-section/profile by machining the wood with a cutter, milling cutter or circular saw blade. The surface may be roughly planed or finely planed, depending on what the timber will be used for.

The timber is planed to profiles set out in Swedish or industry standards, as represented in Swedish Wood's Product Catalogue, **www.traprodukter.se**, or into custom profiles.



PLANED WOOD TERMS

Planed wood terms

Tongue & groove
Timber with a tongue on one edge and a groove on the other for joining.

Tongue
The tongue protrudes from the edge of a tongue & groove board, and fits into the groove of another tongue & groove board.

Groove
This is the track cut into one edge of a tongue & groove board. The groove accepts the tongue to form the joint.

Planing defects
Planed wood may have technical planing defects such as knot tear-out, pronounced cutter marks or dimensional errors.

Coverage width
The width of the front face of the timber without the tongue.

Centred joint
The tongue and groove are centred (located in the middle of the board edge).

Undercut
The visible face, the so-called good side without the tongue, is slightly wider than the back or underside to provide a tight joint. Under the Swedish standard, the tongue and groove are placed lower than the centre, away from the good side.

On the green sorting, trimming and planing lines, boards are measured according to customer rules and requirements. Here, a high-resolution 3D laser system is scanning along and across the board to detect geometric defects and then adjust, optimise or classify them.

Bundling and strapping of small timber packets is common in the production of smaller dimensions, such as cladding, mouldings and battens.

Dimensionally planed construction timber of standard dimension 45 × 170, well protected in the timber warehouse.

Examples of different types of planed wood

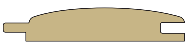
Roughly planed timber

The surface is levelled out with a cutter. There may be visible cutter marks.

Planed timber (flat planed, smooth planed, planed square edge)

All sides are planed.

Profile planed timber



Planed wood that has a special cross-section.

Moulding

Planed or profiled timber with a small cross-section.

Tongue & groove

A tongue sticks out on one edge. On the other edge there is a groove.

Sheathing

Tongue & groove boards with one face grooved, the other planed or grooved and the sides planed. A development of regular tongue & groove.

Planed tongue & groove

Planed timber with tongue and groove.

Single-sided tongue & groove

Tongue & groove that is chamfered on one face alongside the tongue.

Double-sided tongue & groove

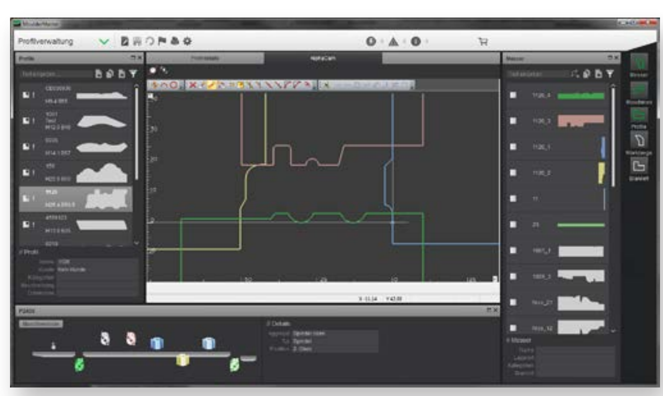
Tongue & groove that is chamfered on one face alongside both the tongue and groove.

Beaded tongue & groove

Planed tongue & groove that has a bead running along one face next to the tongue.

Cutter block

Optical measuring instrument that measures the radius of the tool both axially and radially.



CAD system for the production of profiles.

Planing standards and custom profiles

Planed timber may be:

- Manufactured to a Swedish standard
- Manufactured according to the industry-wide standard set out in Swedish Wood's Product Catalogue, **www.traprodukter.se**.
- Custom-made.

Manufactured according to Swedish standard or industry-wide standard set out in Swedish Wood's Product Catalogue, www.traprodukter.se

Many countries use standard measurements for different types of timber, partly to facilitate the construction of houses and so on. In Sweden, SIS is the body that draws up and publishes standards in various areas.

In order to describe wood products in a clear and user-friendly way, the industry organisation Swedish Wood has created a basic range of products that can be found in its Product Catalogue, **www.traprodukter.se**. This was developed by the Swedish wood engineering industry in partnership with its customers over the period 2010—2022. All wood products are accompanied by a property declaration and a dimensioned drawing of the product.

This states, for example:

- The varieties to which the standard and the industry-wide standard apply. This may include, for example, different types of mouldings and tongue & groove timber.
- General and specific requirements for timber quality. For example, the timber must be free from rot, the surface must be smooth, and so on.
- Standard dimensions of various planed products.

Custom-made

Some manufacturers have specialised in various custom profiles.

Raw material measurements

A sawn product that is to be planed naturally has different dimensions than the final planed product. But there is a certain relationship between the sawn and the planed timber. The aim is to get as many boards as possible and reduce waste.

It is important to take into account any cupping, which increases with the width of the timber. To reduce waste, double-bladed saws are used. With a three-knife saw, the middle piece is a fixed size. The outer pieces may be a little larger to allow for the removal of the cupping.

Let's look at an example:

Suppose we want to produce planed cladding with dimensions of 15 × 120 mm. We start with a raw material measuring 75 × 125 mm.

Original thickness	75.0 mm
4 boards @ 15 mm	60.0 mm
Residual	**15.0 mm**
3 saw cuts @ 1.7 mm	5.1 mm
Residual	**9.9 mm**
Planing allowance 1 mm × 4 boards	4.0 mm
Residual for warping or cupping	**5.9 mm**

To make better use of the wood, we can try again:

Original thickness	75.0 mm
3 boards @ 15 mm	45.0 mm
Remainder	**30.0 mm**
1 board @ 18 mm	18.0 mm
Remainder	**12.0 mm**
3 cuts @ 1.7 mm	5.1 mm
Residual	**6.9 mm**
Planing allowance 1 mm × 4 boards	4.0 mm
Residual for warping or cupping	**2.9 mm**

In *Table 6* we can see the relationship between:

- the dimensions of the raw material
- the dimensions of the planed product
- the size of the saw cut
- the thickness with respect to planing.

Table 6 is based on sawing with one blade.

Let's look at some rows in *Table 6*. We want to produce three boards with dimensions of 22 × 220 mm. The raw material has dimensions of 75 × 225 mm.

Original thickness	75.0 mm

If we take into account that the boards will be planed, we see that:

2 boards should be 23.0 mm	46.0 mm
1 board should be 22.5 mm	22.5 mm
Residual	**6.5 mm**
2 cuts @ 2.2 mm	4.4 mm
Remainder = trimming allowance	**2.1 mm**

When measuring resawn timber, a calliper or other equivalent instrument is used. Width and thickness should be measured in three places, 150 mm from each end and in the middle. Measure a little below the edge. Measurements are given in mm to one decimal place.

Dimensions for original sawn timber

For original sawn timber, see *Table 7*.

Sorting of planed timber

The instructions in *Commercial Grading of Timber* also apply to planed wood products. In the case of planed timber, some additions may be made because the wood has been further processed after sawing.

Timber can be assessed on the basis of one of the following four conditions:

- Moisture content
- Form
- Material quality
- Manufacturing factors.

Dimensions for planed timber

For planed timber, see *Table 8*.

TABLE 6 | RELATIONSHIP BETWEEN DIMENSIONS, YIELD AND SAW CUTS. All dimensions are in mm.

Dimensions of raw material	Dimensions of planed product	Blade thickness	Tooth set	Size of saw cut	Thickness taking into account planing, 1 board	Thickness taking into account planing, 2 or 3 boards
38 × 150	2 st 15 × 145	1.0	0.7	1.7		16.5
44 × 150	2 st 9 × 148	1.0	0.7	1.7		20.2
50 × 100	3 st 9 × 95	1.0	1.0	0.6	0.6	1.6
	1 st 12 × 95	1.6	10.0	10.3		
50 × 100	2 st 15 × 195	1.0	1.0	0.6	0.6	1.6
	1 st 12 × 195	1.6	16.0	16.3		
63 × 125	2 st 15 × 120	1.0	1.0	0.6	0.6	1.6
	1 st 21 × 120	1.6	16.0	16.3		
63 × 125	2 st 12 × 120	1.0	1.0	0.6	0.6	1.6
	1 st 15 × 120	1.6	13.0	13.3		
63 × 150	2 st 19 × 148					
	1 st 15 × 145	1.2	0.8	2.0		41.5
63 × 150	2 st 18 × 145	1.0	1.0	0.7	0.7	1.7
	1 st 15 × 145	1.7	19.2	19.5		
63 × 150	3 st 18 × 145	1.0	0.7	1.7	19.2	19.5
63 × 150	2 st 19 × 148	1.0	1.0	0.7	0.7	1.7
	1 st 18 × 145	1.7	19.8	20.0		
75 × 150	3 st 15 × 145	1.0	1.0	0.7	0.7	1.7
	1 st 18 × 145	1.7	16.2	16.5		
75 × 150	4 st 15 × 145	1.0	0.7	1.7	15.2	16.5
75 × 175	4 st 15 × 170	1.2	0.8	2.0	16.3	16.7
75 × 200	3 st 21 × 195	1.2	0.8	2.0	22.3	22.7
75 × 225	3 st 21 × 220	1.4	0.8	2.2	22.5	23.0

TABLE 7 | CROSS-SECTIONAL DIMENSIONS FOR SAWN TIMBER. All dimensions are in mm.

Thickness	Width: 25	38	50	75	100	125	150	175	200	225	250
16				Board	Board	Board	Board				
19	Batten	Batten	Batten	Board	Board	Board	Board				
22		Batten	Batten	Board	Board	Board	Board	Board	Board		
25	Batten	Batten	Batten	Board	Board	Board	Board	Board	Board		
32				Board	Board	Board	Board	Board	Board		
38		Batten	Batten	Stud	Stud	Stud	Plank	Plank	Plank	Plank	Plank
44				Stud	Stud	Stud	Plank	Plank	Plank	Plank	Plank
47				Stud	Stud	Stud	Plank	Plank	Plank	Plank	Plank
50			Stud	Stud	Stud	Stud	Plank	Plank	Plank	Plank	Plank
63				Beam and spar	Beam and spar	Beam and spar	Plank	Plank	Plank	Plank	Plank
75				Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar
100					Beam and spar		Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar

- = Batten
- = Board
- = Stud
- = Plank
- = Beam and spar

In practice, the boundaries between the designations are not clear and absolute. They vary between different builders' merchants and locally across Sweden. Spars are wood with no or max 25 mm difference between thickness and width. These are not to be confused with other load-bearing elements such as rafters, which follow the angle of a sloping roof.

TABLE 8 | CROSS-SECTIONAL DIMENSIONS FOR PLANED TIMBER. All dimensions are in mm.

Thickness	Width: 22	33/34	45	70	95	120	145	170	195	220	245
12/13				Board	Board	Board	Board				
15/16	Batten	Batten	Batten	Board	Board	Board	Board				
19				Board	Board	Board	Board	Board			
22	Batten	Batten	Batten	Board	Board	Board	Board	Board	Board	Board	
28			Batten	Board	Board	Board	Board	Board			
33/34		Batten	Batten	Stud	Stud	Stud	Plank	Plank	Plank		
45			Stud	Stud	Stud	Stud	Plank	Plank	Plank	Plank	Plank
70				Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar	Beam and spar	
95					Beam and spar						

- = Batten
- = Board
- = Stud
- = Plank
- = Beam and spar

In practice, the boundaries between the designations are not clear and absolute. They vary between different builders' merchants and locally across Sweden. Spars are wood with no or max 25 mm difference between thickness and width. These are not to be confused with other load-bearing elements such as rafters, which follow the angle of a sloping roof.

Pressure treated timber must be impregnated in accordance with the regulations of the Nordic Wood Preservation Council, NTR. Wood preservation class NTR AB means that the timber is intended for use above ground, for example for fencing, railings or decking.

Impregnation

The properties of wood and wood products can be altered in various ways, for example by treatment against fungal and insect attack. Treating the wood chemically can inhibit or completely neutralise wood-destroying organisms. Different chemicals give different degrees of protection, and the amount of the agent also influences the effect. The agents can be applied manually by brushing or dipping, or industrially through pressure treatment.

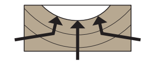
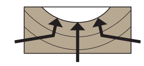
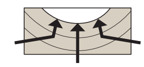
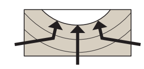
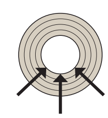
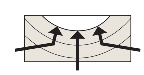
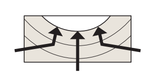
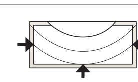
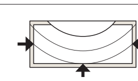
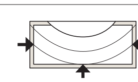
Pressure treatment is used primarily on pine. With its open cells, the sapwood has the capacity to absorb the impregnation agent, while only superficial penetration is achieved in the heartwood. The difference between heartwood and sapwood is clearly visible on the end of a piece of wood. The heartwood is reddish and the sapwood is light. Pine heartwood is to some extent self-impregnated as it contains large amounts of sap and resins.

Pressure treating the timber takes about two hours, regardless of its size. The pressure inside the impregnation tube is about 12—13 bar. The timber is automatically removed when ready and the packets are placed in an inclined position, since quite a lot of the impregnation fluid needs to evaporate. The time required for evaporation and runoff is around five or six hours. All the liquid runoff is recovered for reuse. Once the treatment process is complete, the finished timber is transported to an intermediate storage facility for onward delivery to the end customer. It is not uncommon for this type of timber to go to a builders' merchant.

A classification system developed by the Nordic Wood Preservation Council, NTR, applies to timber sold in the Nordic countries. Pressure treated timber that is quality controlled and NTR labelled is third-party certified. This certification relates to the quality of the finished product and how much preservative the wood has absorbed, but the label also takes into account other key environmental issues.

The NTR marking is followed by various combinations of letters indicating the wood preservation class. The most common wood preservation classes for decks and similar structures are NTR A for load-bearing parts and NTR AB for decking. *Table 9* shows the different wood preservation classes along with areas of use, labelling and penetration depth.

TABLE 9 | TREATED WOOD – PRESERVATION CLASSES, APPLICATIONS, LABELLING AND PENETRATION

Wood preservation class	Area of use	Labelling		Penetration depth
NTR M NTR M mod	**Pine wood * in seawater (salinity 0.5–3 %)** • Jetties • Poles • Other wooden structures in saltwater	NTR | M	Labelling on end wood: blue.	
		NTR | M MOD	Labelling on end wood: blue. Poles are individually tagged.	
NTR A NTR A mod	**Pine wood * in contact with ground or freshwater, plus structures above ground where personal safety requires that they are not weakened or that can be difficult to inspect or replace** • Posts • Fence posts • Bridges • Garden woodwork • External stairs • Balconies • Decking directly on the ground • Freshwater structures (jetties, etc) • Sole plates • Timber frame under decking • Playground and fitness equipment	NTR | A	Labelling on end wood: white.	
		NTR | A MOD	Labelling on end wood: white.	
NTR A pole	**Pine wood * for utility poles**	NTR | A POLE	Labelling: Individually tagged.	
NTR AB NTR AB mod	**Pine wood * above ground** • Fencing • Trellises and pergolas • Exterior cladding • Bargeboards and fascia boards • Roof battens • Decking above ground	NTR | AB	Labelling on end wood: yellow.	
		NTR | AB MOD	Labelling on end wood: yellow.	 Heat treatment also covers heartwood in certain cases.
NTR B NTR B mod	**Pine wood * above ground, finished exterior joinery** • Windows and external doors	NTR | B	Labelling on end wood: red.	
		NTR | B MOD	Labelling on end wood: red.	
NTR Spruce	**Spruce wood for exterior cladding** • Exterior cladding • Bargeboards and fascia boards • Counter battens and battens • Nailing battens	NTR | GRAN	Labelling on end wood: orange.	

* Other wood species may also be appropriate.

Finger-jointing

Finger-jointed timber is used for large spans where the normal timber length is not sufficient. The process also allows for maximum use of the timber. Since the customer buys timber in specific dimensions according to their needs, it is possible to cut shorter lengths and minimise waste, while simplifying and streamlining the work.

Finger-joining timber involves milling the ends of the timber into small finger-like wedges and joining them together. Before milling, defects such as rot, large knots or other undesirable features that may interfere with strength need to be cut away. The fingers of the timbers are glued and pressed together, after which each piece of wood can be cut to the desired length. In some cases, the piece of wood is also planed in the same operation.

Finger-jointing the timber provides greater opportunities to make maximum use of the wood raw material. Timber of a given dimension is glued on a continuous line before being cut into predetermined lengths. The timber is then cut into specified dimensions. This process eliminates the waste that would otherwise occur during dimensional sawing from the log.

There are several reasons to finger-joint timber:

- Pieces of wood of equal length can be produced without waste.
- It allows production of timber that is longer than normal logs — that is, longer than 5.4—6 metres.
- Longitudinal wood waste can be reduced when making a custom product.

A distinction is made between the jointing of construction timber and the jointing of timber that will not be used for structural purposes. The jointing of structural timber must follow specific rules. Production is checked both internally and externally by approved third-party bodies such as RISE Research Institutes of Sweden. When joining ordinary timber that is not to be used in load-bearing structures, no inspection by the approved third-party is required. Ordinary timber may be finger-jointed to make use of offcuts, for example.

Component timber

For those who use timber in their production, uniformity of all dimensions, including length, is beneficial for efficiency. Such timber, where each piece can be treated as a finished component for a particular use, is called component timber. The production of such timber requires a jointing technique that allows the timber to be cut without reference to the location of the joints, which means that the jointed area must not be weaker than the whole timber. However, it must also not be so stiff that the timber around the joint could break.

Furthermore, the joint should not be too pronounced, otherwise it will stand out after any surface treatment. The glued joint should react as similarly as possible to the solid wood during surface treatment, and not repel paint or react chemically.

Two different types of finger-joints are used. One is a long joint, for timber where the strength of the joint is of crucial importance. This applies, for example, to strength graded timber for roof trusses and other load-bearing structural components. The second type of joint is shorter and does not provide the same strength. On the other hand, it is virtually invisible and therefore suitable for exposed joinery with no question of very high loads, such as façade timber.

Industrial manufacturers are the main users of component timber, particularly manufacturers of prefabricated houses, furniture and interior joinery who work on a modular basis. Applications include:

- window frames
- frame wood for both windows and doors
- construction timber for roof trusses or joists.

Finger-joints are used when lengths of over 5400 mm are required.

A wooden component that has been industrially drilled and grooved ready for fixings.

Glulam

Glulam is an engineered wood product designed primarily for load-bearing structures. In relation to its weight, glulam is one of the strongest construction materials available. Sometimes it is used in exposed supporting structures and as a defining feature of a space. Glulam load-bearing frames are common in halls and public buildings, and have become increasingly used in high-rise apartment blocks. Bridges are another key area of use, while the use of glulam in low-rise buildings is also on the up.

Manufacture and control
Glulam structural elements are manufactured industrially under controlled conditions. The principle of production is that finger-jointed laminates of wood are stacked up in layers and glued together into large structural elements. Swedish glulam is produced in line with the requirements set out in standard EN 14080 and must be CE marked. Manufacturing glulam requires considerable precision not least regarding the milling of the finger-joints, glue preparation and application, pressure and timing. In-house controls take place on a rolling basis to ensure that glulam products maintain consistent, high quality, and this involves taking regular samples from the production line to check for strength and other performance factors. Glulam manufacturers are third-party certified by accredited certification bodies.

Properties
Glulam is primarily a construction material, making strength, stiffness and durability generally the most important characteristics. The high strength and stiffness of glulam enables large unsupported spans to be achieved. With construction timber, the strength of an individual plank is determined by the weakest cross-section — usually at a large knot or area of cross grain. The wood lamellas are also strength graded.

Although glulam is a flammable material, its large and homogenous cross-section makes it relatively stable during the initial stages of a fire. The way the heat develops during a fire is often crucial in determining whether the fire will spread or burn out. The charred layer that forms on the surface of the glulam in a fire protects the inner parts and helps the glulam to retain its load-bearing capacity as the fire progresses.

Product range
Glulam products are produced as straight or curved elements. The most common cross-section shape is rectangular, but other cross-sections can be manufactured on request. Straight elements with a rectangular cross-section are standardised in terms of dimensions and appearance grade. Glulam is also available in pressure treated versions.

Spruce glulam posts and beams.

Five-layer CLT panel.

Cross laminated timber, CLT

Cross laminated timber (also known as CLT, crosslam and X-lam), is an industrially manufactured product that takes the form of sheets, slabs, posts and beams, made of strength graded boards or planks glued together in alternating perpendicular layers. It is widely used for the structural components of carcasses for high-rise buildings, schools, nurseries, industrial buildings, low-rise housing, bridges and specialist constructions.

The key feature of CLT elements is the ability to manufacture large dimensions with high load-bearing capacity and stiffness. CLT elements allow for a high degree of prefabrication and their low self-weight provides many benefits in terms of transport, foundations and assembly.

Edge-glued panels.

The combination of advanced manufacturing techniques and good performance makes CLT one of the most important frame materials, with many unique properties:

- High flexibility.
- High strength in relation to its own weight.
- Small manufacturing tolerances and good dimensional stability.
- Good load-bearing capacity in fire.
- Good heat insulation capacity.
- Low self-weight, which means lower transport and assembly costs, as well as simpler and cheaper foundations.
- Good capacity to tolerate chemically aggressive environments.
- Flexible production that even allows the manufacture of curved surfaces.

Large scale fire tests have shown that the effective charring rate of CLT may increase due to glue line integrity failure of lamellae if the adhesive and CLT lay-up used are sensitive to high temperature. The suggested new Eurocodes take this into consideration by introducing different charring rates for the design of CLT, depending on its resistance against glue line integrity failure. Additionally, a test procedure and a performance criterion are introduced to determine whether the CLT glue line has sufficient heat resistance.

Edge-glued panels

These are glued panels of wood that are used to make furniture, doors and fittings. The production process uses standard sawn timber.

A typical pattern for this process is as follows. The timber is first cut, before being machined in a multi-head planer and sawn into lamellas with a multi-blade circular saw. The glue edges are planed and the faces are rip sawn. Once the glue has hardened, both the front and back of the boards are roughly sanded. Finally, the edges of the board are sawn to shape.

Outdoor surface treatment

The absolute best result for outdoor painted wood is achieved through a combination of the right timber, the right surface moisture content and the right surface treatment. It is therefore important to pay attention to all the steps in the process: sawing, handling, finishing and storage, but also installation.

Wood performs well outdoors without any surface treatment if it is not in contact with the ground or exposed to moisture traps. Various paint systems and other means are used when the preference is for better moisture protection, or a certain look or colour. These systems work in different ways depending on their composition, so it is important to choose the right system to achieve the desired effect and appearance.

What we call paint is a combination of binders, pigments and additives. The binder is what forms the actual paint film, pigments provide the desired colour and various additives, such as fillers, curing agents and biocides, give the paint its properties. These components are dissolved in a solvent so that the paint can be applied. The most common diluent is water, and the paint is then referred to as water-based. Paints that use white spirit, for example, are called solvent-based.

The paint is named after the binder on which it is based, with acrylate, alkyd and linseed oil as the most common. Mixtures of these also occur, under the term hybrid paint. Acrylate and alkyd paints are often water-based and are applied and handled in a similar way.

Linseed oil paints are solvent-based and have certain properties specific to them. Among other things, they dry slowly, which means that they should be applied in thin layers to avoid linseed oil blisters. They also turn matt faster than acrylate/alkyd paints and chalk in a particular way.

In Sweden, it is common to paint outdoor surfaces with distemper. However, it does not have a film-forming effect that protects against moisture, which places high demands on the structural wood protection. Combinations of distemper and linseed oil paint are used to obtain a surface treatment with more moisture protection. In this case, the paint is seen as a linseed oil paint with distemper pigments.

Paint systems

Modern paints are applied in a specially developed system. You start with a priming oil that penetrates deeply and reduces moisture absorption. It is not always necessary to cover the whole surface with penetrating primer, but it is important on joints, end-grain wood, nailing points and other parts exposed to a high moisture load. After the primer comes an undercoat whose job, among other things, is to help the topcoat to adhere to the substrate. The topcoat then provides the finish that creates the final look of the façade.

Considerations for outdoor surface treatment

When painting, it is important that the substrate is completely clean — partly to ensure that the surface treatment adheres properly, but also because the surface can become discoloured by microbial growth that shows through the paint. The surface of the wood changes more and more as time passes after sawing, which can make adhesion difficult. The recommendation is therefore to paint on relatively freshly sawn timber that has a surface moisture content of no more than 18 %. It is also vital that the wood has the right moisture content for the paint to adhere properly. When painting, it is important not to paint on wood that is exposed to strong sunlight, as this also makes adhesion difficult and causes the paint to dry quickly and unevenly. Also make sure to follow the paint manufacturer's recommendations regarding undercoating, thickness and drying time.

Brushing is the most common method of applying paint outdoors, although some paint systems, such as distemper, are also suitable for spray painting on larger buildings.

Factory-painted and quality-assured external cladding

Exterior cladding is available from builders' merchants in factory-painted form. Certified Painted Panel, CMP, is a Swedish system for quality assurance of the process that also sets requirements concerning the wood raw material, covering factors such as tree species, moisture content, wood properties, presence of knots and deformations.

Paints and paint systems are manufactured by several different suppliers, but must comply with accepted standards and CMP regulations and be approved by CMP. Factory-painting of the façade boards is controlled, as well as packaging and storage, and the whole process is documented. Once the CMP cladding is installed on the façade, a final coating is required within 12 months. It is essential to adhere to this timeframe so that the façade does not become dirty or suffer from microbial growth.

The cladding boards should also have a surface moisture content of 16 % or less, which must be checked before final painting. Only recommended paints should be used. It is important to use the same colour system from the primer all the way to the topcoat to ensure the best possible adhesion and results. It is also recommended that when the boards are cut, a wood treatment is applied during final coating at the construction site. CMP is available in different surface treatment classes, where CMP-G is a primer-only exterior cladding board that requires two additional coats of paint and CMP-G/M is primed and undercoated and requires one additional coat of paint.

Vertical exterior cladding, primed and undercoated

Horizontal exterior cladding, primed and undercoated

CMP-G
Exterior cladding boards that are industrially primed and require a further two coats of paint.

CMP-G/M
Exterior cladding boards that are industrially primed and undercoated and require one final coat of paint.

SURFACE TREATMENT CLASSES FOR EXTERIOR CLADDING BOARDS UNDER THE CMP SYSTEM

GLOSSARY

Appearance grading of softwoods EN 1611-1 Grading according to appearance grades G4-0, G4-1, G4-2, G4-3 and G4-4 and G2-0, G2-1, G2-2, G2-3 and G4-4. Sweden mainly uses 4-sided grading, G4. 2-sided grading, G2, is seldom used in Sweden. *See page 46*.

Arris knot Knot that can be seen on both the face and edge. *See page 45*.

Automated edging The board is optically measured by the automated edger and a computer calculates the optimal volume or value yield. Data on the selected dimensions and length is sent to the edger. *See page 31*.

Band saw A cant saw or rip saw that breaks up the log using band saw blades. *See page 59*.

Bark shredder Machine that grinds up bark and bark residues. *See page 19*.

Bark Debarking ensures that the log is free of bark. Delivery of sawn wood products with bark is not permitted and timber cut into chips must be free of bark. Bark makes up between 7 and 16 percent of the log. *See page 20*.

Bark-encased scar Bark that is partly or wholly enclosed in the wood. Bark-encased scars can occur when the tree is damaged and wood grows over the wound. *See page 47*.

Batch kiln A drying system where all the wood is dried simultaneously in one chamber. Also known as a compartment kiln. *See page 40*.

Biometria Independent organisation that assesses the quality of raw materials. *See page 14*.

Board separator Equipment that separates boards after cant and rip sawing. *See pages 26 and 31*.

Boards Side yield with a thickness of less than 32 mm. *See page 28*.

Bowing The flat faces are curved lengthways. *See page 51*.

Buttress root Flaring at the root end of the log. *See page 19*.

Cant saw The first machine in the sawing process. Cant sawing involves cutting or reducing two sides of the log. *See page 30*.

Centred joint A planed board with the tongue and groove centred. *See page 72*.

Chip screen Machine that sorts the chips into different fractions. *See page 34*.

Chipper Machine that produces green or dry chips from wood residues. *See page 34*.

Chips The largest amount of chips, known as wet chips, are usually produced on the saw line. Dry chips come from dry wood. The quality of the chips is important and they must not contain contaminants. About 30—35 percent of the log is turned into chips. *See pages 34 and 35*.

Circular saw A cant saw or rip saw that breaks up the log using circular saw blades. *See page 30*.

CMP Certifierad Målad Panel = certified painted cladding. *See page 83*.

Component timber Timber that has uniform dimensions and the same lengths. Used, for example, in window frames, frame components and as construction timber for roof trusses or joists. *See page 80*.

Compression/reaction wood "Irregular wood" that usually occurs in crooked or leaning trees and in branches. *See page 47*.

Construction timber Grading based on strength classes C14, C18, C24, C30 and C35. *See page 51*. Moisture content 12—16 %. *See page 37*.

Coverage width The width of the visible face of the timber, excluding the tongue. *See page 72*.

Cross laminated timber, CLT Timber that is glued together with every other layer rotated 90 degrees. Also known as crosslam and X-lam. *See page 81*.

Curly grain Fibres that grow in dense irregular curves. *See page 47*.

Curve sawing Curve sawing means that the saw cuts follow the curved shape of the cant (sweep or bow height). *See page 29*.

Cutter Tool fitted with cutting blades/knives. *See page 74*.

Debarking machine Machine that removes bark from the log. *See page 20*.

De-stickering Stickers are removed from the dried timber packets before the dry sorting line (quality assessment). *See page 43*.

Dispatch The department responsible for loading the graded and packaged timber onto trucks, wagons or ships. *See page 54*.

Dry sorting line Line where the quality of the dry timber is assessed. The timber is divided into different lengths and quality grades. *See pages 41—44*.

Drying cracks Cracks that appear after drying and may be straight or oblique depending on the direction of the fibre. *See page 47*.

Edge knot Knot (oval or round) that occurs on the side of the timber. *See page 45*.

Edge-glued panel Sheets made from timbers glued edge to edge. *See page 82*.

Edger A machine that uses two parallel saw cuts to remove the wane on the board and produce sharp edges. *See page 31*.

End shake A crack at the end of the piece of timber. *See page 47*.

Face knots Round or oval knots occurring on the face of the timber. *See page 45*.

Finger-jointing Pieces of wood are milled at the ends and joined together. *See page 80*.

Furniture dry Moisture content 6—10 %. *See page 37*.

Glulam A glued product designed primarily for load-bearing structures. *See page 81*.

GRADE U/S Quality grade U/S (unsorted) contains the subtypes U/S 1 — U/S IV. Valued as the highest quality of the main grades. *See page 46*.

GRADE V Timber grade, also referred to as Fifths. *See page 46*.

GRADE VI Timber grade, also referred to as Sixths. *See page 46*.

GRADE VII Timber grade. *See page 46*.

Green sorting Section where the sawn timber is sorted by thickness and width. Length and quality sorting may also occur. *See page 32*.

Groove The track set into one edge of planed tongue & groove. *See page 72*.

Growth ring In trees growing in temperate regions, the pattern is created by the lighter wood formed in spring and early summer and the darker wood formed in late summer and autumn (spring wood and autumn wood). *See page 45*.

Handling damage Damage that can occur to the timber during handling, such as fall and pressure damage, or damage from feed rollers, cutting tools or forklift transportation. *See page 55*.

Heartwood Heartwood is the inner, darker part of a tree trunk consisting of cells whose ability to transport water has been inhibited in various ways. The core is resinous and reasonably rot-resistant. *See page 45*.

Horizontal bin Timber in the green or dry sorting unit is transported to the packet stacker in a horizontal direction. *See pages 32 and 44*.

Infeed accuracy A prerequisite for achieving an optimum volume and value yield during conversion. *See page 30*.

Insect damage Bore holes or pinholes in wood caused by insects or insect larvae. *See page 47*.

Irrigation on land Storage of raw material on land under a water spray. *See pages 17 and 18*.

Irrigation Protects against cracking and insect infestation. *See pages 17 and 18*.

Joinery wood Moisture content 9—15 %. *See page 37*.

Lath Wood that has been sawn off when edging the side boards. *See page 34*.

Length cut Cut to give a piece of timber the correct modular length. *See page 44*.

Log blue stain Deep blue stain present in the log before it is sawn. *See page 47*.

Log class Selected diameter range (top diameter) based on the dimensions to be sawn. *See page 14*.

Log pile Stored timber in different diameter ranges. *See page 16*.

Log rotator A device that centres the log in the optimum position for cant sawing. *See page 24*.

Log turner Machine that automatically turns the to put the top diameter first. *See page 20*.

Log sorting Facility where each individual log is measured and graded into a log class. *See page 14*.

m^3 s Cubic metres of solid volume. The total volume of the log including the taper. *See page 14*.

m^3 sk Growing stock, solid over bark. *See page 14*.

m^3 sub The total volume of wood, solid under bark. *See page 14*.

m^3 t Cubic metres stacked. *See page 14*.

m^3 to Top cylinder volume. The total volume of the log excluding the taper. *See page 14*.

Main yield Sawn timber taken from the centre portion of the log. *See page 28*.

Measuring frame Equipment that measures the diameter, length and internal quality of logs. *See pages 15 and 23*.

Module Length of the timber piece in 30 cm intervals (1.8 m — 6.0 m). *See page 44*.

Moisture content meter Measuring instrument to check the moisture content of the timber. *See page 38*.

Moisture content The amount of water in a piece of timber in relation to its dry weight, expressed as a percentage. *See page 37*.

Nonconformity reporting A system designed to prevent accidents in the workplace. *See page 57*.

OEE values Key figures for measuring production efficiency. *See pages 22 and 60*.

Oven dry method Method of calculating the moisture content of wood. *See page 37*.

Packet specification Specification that is attached to the timber packet describing, among other things, grade, dimensions, length, moisture content, m^3, number of pieces. *See page 53*.

Packet stacking Section where the green sorted timber is stacked in packets with stickers in between. *See pages 52 and 53*.

Pith catcher Piece of timber sawn out of the centre of the log or cant. *See page 29*.

Pith-free timber Timber that has been sawn at least 25 mm from the pith and is therefore free of pith. *See page 29*.

Planing defect Defect caused by incorrect planing. *See page 72*.

Planing dry Moisture content 10—16 %. *See page 37*.

Plank Main yield of at least 32 mm thickness. *See page 28*.

PLC Programmable Logic Controller. *See page 30*.

Pressure frame Equipment that ensures minimal deformation of the top layer of timber. *See page 39*.

Pressure treatment Chemical treatment under pressure to combat, for example, fungal and insect attack. *See pages 78 and 79*.

Product-specific sorting Sorting according to specific uses. *See page 46*.

Profiling saw The profile of the board is milled before it is sawn from the log. *See pages 24 and 27*.

Progressive kiln A drying kiln where the wood batches are transported through a long chamber with various drying steps. *See page 40*.

Psychrometer The difference between wet and dry temperature. *See page 38*.

Quality offcut Offcut for e.g. quality defects or other defects in the timber. *See page 44*.

Reaction wood or compression wood Wood with abnormal properties that usually occurs in crooked or leaning trees and branches. *See page 45*.

Reducer Machine that mills the sides of the log and cant into chips. This type of machine can be combined with both a cant saw and a rip saw. *See page 26*.

Remuneration measurement Basis for payment to the sawmill's raw material suppliers. *See page 14*.

Resin pocket A resin-filled opening between two growth rings in a piece of wood. The opening heals over but is usually revealed after sawing. *See page 47*.

Resin wood Pine with abnormally high pitch content. *See page 47*.

Rip saw The second machine in the sawing process. Rip sawing involves splitting the edge-sawn cant into centre yield and side boards. *See page 30*.

Root cut Cut at the root end of the timber. *See page 43*.

Root reducer Turning machine that removes root flare on the log. *See page 19*.

Rot Wood that has been attacked by rot fungi. A distinction is made between firm and loose rot. Loose rot has lost its firmness. *See page 47*.

Sapwood The outer, lighter part of a tree trunk. The sapwood is responsible for transporting water and minerals from root to leaf. *See page 45*.

Saw cut/kerf Total width of the saw tooth. *See page 27*.

Sawdust Sawdust is divided into wet sawdust and dry sawdust. The wet sawdust comes from the machines on the saw line. The dry sawdust comes from sections that process dry wood. Just over 5 percent of the log becomes sawdust. *See page 34*.

Sawing pattern Description of the dimensions to be sawn for optimum yield. *See pages 27—29*.

Sawing pattern software Software that calculates a proposal for dimensions to be cut. *See page 23*.

Scanner Optical equipment that automatically assesses the quality and length of timber based on programmed values. *See pages 23 and 31*.

Scar An opening after damage to the growing tree that has been enclosed in the trunk during healing. *See page 45*.

Shake Cracks running along the growth rings. *See page 47*.

Shipping dry Moisture ratio 16—20 %. *See page 37.*

Shipping mark Company trademark and description of quality grade. *See page 53.*

Side yield Sawn timber taken from the outer part of the log outside the centre yield. *See page 28.*

Sink tray Timber tray in log sorting or the dry sorting line. The timber is collected and the timber bin is lowered successively according to the amount. *See page 44.*

Slope of grain The deviation of the fibre direction in relation to the longitudinal direction of the piece of wood. *See page 47.*

Spring The edges are curved in the longitudinal direction, *see page 51.*

Square sawing (Nordic practice) The most common sawing method. The sawing pattern, according to Nordic practice, involves splitting the log or block with a centrecut — square-cutting. The log is sawn with two parallel cuts. Then the cant is turned and further sawn into centre yield and side boards. *See page 28.*

Square sawing with pith catcher The cant is split with a saw cut on either side of the pith so that the pith is enclosed in the centre piece. *See page 29.*

Sticker receiver Machine that collects the stickers after removal from the timber packets. *See page 43.*

Sticker Wood of 35 × 40 mm, for example, which is placed between the layers of timber in the packet to improve the drying result and minimise deformation. *See pages 33 and 43.*

Sticker-stacker A machine that automatically places stickers between the layers of wood. *See page 32.*

Systematic work environment management A process for conducting and implementing effective health and safety work. *See page 57.*

Target moisture content Requested moisture content in a batch of wood, expressed as a percentage. *See pages 37 and 38.*

Tongue & groove Planed timber with a tongue on one edge and a groove on the other. *See page 72.*

Tongue The protruding bead on one edge of planed tongue & groove. *See page 72.*

Top cut Cutting off the top end of the timber. *See page 43.*

Top rupture Fibre disturbance that occurs when a top shoot breaks off and a side shoot takes over this role. *See page 47.*

Trimmer Cutting equipment that uses different saw blades to cut pieces of wood to the correct length. *See pages 43 and 59.*

Trimming allowance Compensation for the shrinkage of the timber. *See page 27.*

Undercut The visible side of the planed piece of timber is slightly wider than the underside to provide a tight joint. *See page 72.*

Wane The part of the timber's surface that has not been touched by the saw cut. *See page 47.*

Warping Bend or twist in a piece of wood. *See page 51.*

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Contributing companies

www.almab.se

ALMAB Storvik AB offers the sawmill and timber engineering industry process-optimised handling equipment that provides maximum value for the customer. We do this through leading knowledge, equipment and aftermarket services.

ALMAB supplies green sorting lines, dry sorting lines, combi plants, planing lines, processing lines for cutting, resawing and finger-jointing etc., standalone machines, spare parts and servicing.

ALMAB can take total responsibility for site planning and layouts, solution optimisation, manufacturing, installation, commissioning, servicing and spare parts.

www.arivislanda.com

AriVislanda AB is a global supplier of flexible, fully automated and cost-effective sawmill equipment that optimises the process from log to sawn product.

AriVislanda offers everything from single machines for upgrading an existing saw line, to a complete turnkey saw line.

With over 100 years of experience in sawmills, we have become a reliable, customer-focused supplier that also offers spare parts and servicing and is able to provide support worldwide.

www.bruks-siwertell.com

Bruks offers the market's broadest product range of machinery for processing and handling of by-products such as chips, saw dust and bark. With a complete product range that includes chippers, shredders, screens and different types of conveyors such as vibrating and Tubulator conveyors, we put together custom solutions for varying needs, always with a focus on high capacity and availability, coupled with low maintenance.

Bruks also has an extensive after-sales and service operation, with our service technicians offering inspections and preventive maintenance as well as help with urgent problems.

www.cgv.se

C. Gunnarssons Verkstads AB has been a machine supplier to the sawmill industry for more than 70 years, with Europe as its main market. We develop and produce equipment for wood handling using modern technology and genuine know-how, to meet the highest standards in the market. Our ability to develop modern machines is largely due to our excellent relationship with our customers.

Our ambition is for our designs to feature a high level of innovation while not being unnecessarily complicated, as this often leads to poor availability and high maintenance costs.

www.datapolarna.se

DataPolarna has worked since 1998 to supply systems that support and develop logistics, planning, monitoring, control and analysis to our customers in wood processing.

With the SawInfo, GPS Timber, TimberTime and MoistPal product suite, we have just about everything a modern sawmill or other wood processing facility needs. The products are constantly being developed to meet modern requirements and challenges, with the goal of being a driving force and leader through continuous improvement.

Through its products, DataPolarna aims to be the industry's first choice when choosing a data system.

FINNOS
Make the Leap.

www.finnos.se

Finnos is a developing and growing company founded in 2016. Headquartered in Finland, the privately owned company has also had a subsidiary in Sweden since 2020. We currently have around 120 employees and a global network of agents. Within the company, we have over 30 years of experience in value-optimising quality sorting with x-ray, laser and camera technology.

Finnos designs, manufactures and installs value-optimising quality systems from lumber yard to end product. We are a customer-driven and active partner that always strives to be at the forefront of technology and development, in partnership with our customers. In addition to high-tech measurement systems, we are also known for our excellent service and successful technical support with high availability. Finno's work aims to generate commitment, motivation and development. Our positive spirit is reflected in our customers.

FROMM PACKAGING SYSTEMS

www.fromm.se

Fromm Sverige AB is the benchmark for safely packaged goods. Fromm has a number of complete solutions in strapping, stretch film and protective packaging that are ideally suited to the wood industry. The solutions range from simple manual handling to large, fully automated industrial solutions for more demanding needs.

Our goal is to offer high quality tools and materials that meet our customers' needs. With our own production of machines and consumables, we can quickly help our customers to develop the right solution for the right application. Fromm's vision, rooted in always meeting our customers' ever-increasing demands in a changing environment, has created an agile and customer-focused organisation with a strong focus on people.

HewSaw

www.hewsaw.com

HewSaw is a privately owned and world-leading Finnish sawmill manufacturer. HewSaw is a global company and has machines on all forested continents. Our factory is located in Mäntyharju in southern Savonia, where all development takes place. Our saw units are known for their high quality, accuracy and profitability for customers, with about 80 percent of the manufactured machines exported from Finland.

The HewSaw R200 model was the first of its kind – a compact saw with a high feed rate, and its features have been carried over to all subsequent sawing machines. HewSaw SL250 is the umbrella name for the saw lines that cut normal saw logs. The emphasis is on user-friendliness and technological development when it comes to supplying machines that take sawing to another level and are easy to operate and maintain with the proprietary maintenance system HewSaw MP.

HEDLUNDS
Ingenjörsfirma
GÖSTA HEDLUND AB

www.ingfahedlund.se

Hedlunds develops, designs and manufactures solutions primarily for the sawmill industry. We provide sawmills worldwide with first class log and by-product handling equipment. Thanks to innovation, high-tech solutions, finest manufacturing quality and customer support, we are successful both in our home market as well as on remote markets. Our head office and manufacturing plant is located in Alfta in central Sweden – one of Sweden's most important forest districts with the world's probably finest pine resource, which has shaped our business for generations.

Our customers are primarily located in Scandinavia, but we have made many deliveries all over the world. We have our own research and development centre in Solna and manufacturing facility in Alfta, to serve our customers in the best way possible.

Kagon has been delivering timber irrigation systems, cutting tools and other supplies to the wood industry since 1972. Today, the timber irrigation segment is by far the largest product group, closely followed by cutting tools such as knives and band saw blades. Drawing on our long and broad experience, we can help you with optimisation solutions from the lumber yard all the way to stacking/wrapping.

For timber irrigation, we design, dimension and deliver customised, complete systems to the sawmill, pulp and forest industry. With our unique tool concept, we can provide a solution with carefully selected tools adapted to your particular plant. We offer everything from total solutions that include a grinding service and replacement of broken tools, to new sales of individual tools. Kagon is also an agent in Sweden for Stenner and their band saws.

www.kagon.se

LIMAB specialises in laser-based measurement of dimensions and defects for industrial processes. We develop sensors and complete measurement systems for specific applications, with a focus on process control and quality assurance. For the sawmill industry, we offer solutions for trimmer and edger optimisation, sorting, length measurement and more.

LIMAB AB was founded in 1979 and is headquartered in Gothenburg, Sweden. We also have subsidiaries in the USA, Germany and the UK. In other parts of the world we work with distributors and other partners. Product development, production, sales/marketing, administration and service/support are based at head office.

www.limab.se

L.O.A.B. is an agency with many years' experience in marketing machines and machine systems from leading Central European manufacturers. L.O.A.B. offers individually tailored, innovative solutions to meet today's high demand for optimised yield, capacity and availability of large and small sawmills.

We provide everything from timber handling, measuring and x-raying of logs and sawn timber to saw infeeds, profiling and circular saw lines, band saws, edgers, and equipment for board and plank handling on the log sorting and dry sorting lines. We also offer high-performance solutions for optimised cutting lines, material handling, sorting, finger-jointing lines, profile gluing and quality planers for boards, planks and glulam, as well as batch crosscut saws.

www.loab.se

LSAB offers tool solutions for the wood industry and associated grinding services, covering everything from sawmills and planing mills to the furniture industry. We have specialist knowledge in all areas to help you find the best solution with the best financial result. With the help of digital tools, we can map the current situation and create conditions for sharing the information in a simple way. Everything with a focus on optimal yield, minimizing downtime, optimal running times.

LSAB Group is active today in a total of seven countries and export to around 40 more markets and our products are found on every continent except Antarctica. LSAB is certified according to ISO9001 and ISO14001.

cutting excellence

www.lsab.se

MiCROTEC

www.microtec.eu

MiCROTEC is the global technology and market leader in intelligent wood characteristics recognition for optimizing the use in the wood processing industry and has been setting the standards in this market since 1980. With over 6000 installations in 50 countries, MiCROTEC brings excellent service and world-leading scanning solutions to the complete wood processing industry.

The MiCROTEC group employ over 400 people, with offices in Sweden, Finland, Italy, Germany and the US. From the office in Linköping, Sweden, we have a local focus on sales, development, after market and project leading to our sawmill and secondary processing customers on the Scandinavian market.

MILLTECH

www.milltech.se

Milltech AB has been developing smart and integrated control systems for sawmills all over the world for over 20 years. 3D measurement, 3D optimisation and control systems are just some of our products – smart automation to automate the sawmill's entire production.

Our products include contactor switchgear, log sorting, log feeds, saw guides and board sorting, both green and dry, or a combination of these.

Milltech is certified according to ISO 9001 and 14001.

RemaSawco

www.remasawco.se

RemaSawco is one of Northern Europe's leading suppliers of automation, measurement and optimisation systems for the sawmill industry. As a high-tech company founded in 1954, we have dedicated almost 70 years to developing and producing technical solutions that always strive to improve our customers' profitability and quality.

RemaSawco has over 1,000 customers worldwide and is part of the publicly traded Image Systems Group, a world leader in non-contact measurement technology. As a partner in our new service and availability programme, you are guaranteed the best possible usability of your sensors and decision support systems. We offer intelligent solutions in all stages of the sawing process from log feed to board sorting. RemaSawco delivers the sustainable and future-proof digital sawmill.

RENHOLMEN

www.renholmen.se

Renholmen AB was founded in 1952 and is an industry-leading supplier of wood handling equipment for green sorting, dry sorting and planing mills with high-quality and efficient products such as triple stackers, tray sorters and fully electric cutting systems.

The company has a comprehensive range of products with, in many cases, patented design solutions. Renholmen delivers high-quality, efficient products for projects large and small, mainly to sawmills in the Nordic region, but also to other parts of the world. The company has seen strong growth in recent years, substantially increasing its employee numbers and sales, and greatly boosting profitability in the process, due in part to a steep rise in exports.

SIGNODE

www.signode.se

With over $2B+ in revenue, 80+ manufacturing facilities across 6 continents and over 7,000 employees worldwide, **Signode** is a leading manufacturer of a broad spectrum of transit packaging consumables, tools, software, and equipment that optimize end-of-line packaging operations and protect products in transit.

Signode brings this extensive product portfolio of packaging products to help customers pack, bundle, unitize, protect and secure goods during warehousing and transit. Our company is a pioneer in the industrial packaging sector with a long history of customer-focused innovations in materials, processes and automation technology that have revolutionized the sector.

SVETRUCK®

www.svetruck.com

Svetruck AB has been delivering forklifts, container handlers and logstackers across most of the world since 1977, with our concept of genuinely reliable, quality machines equipped with the very best modern technology. Today we are one of the leading manufacturers of forklifts. Our passion for developing and manufacturing quality machines has remained alive since the founders of Svetruck built the first machine in the 1960s. We always focus on quality at every stage of our development and manufacturing.

The heart of Svetruck can be found in Ljungby, where our development department, manufacturing and headquarters are located, all under the same roof. We also have subsidiaries in Germany, Belgium and the USA, along with dealers and agents in almost every part of the world.

Sågspecialisten

www.sagspecialisten.se

Sågspecialisten AB specialises in wood processing machinery. Founded in 1994, the Swedish company is based in Haga industrial park, Jönköping.

Sågspecialisten sells, installs and services machines for which we are agents in Sweden. The companies we represent are mainly from Germany and Austria.

Our machine range includes: trimmers, finger-jointers, cutters, circular saws, wide belt sanders, CNC milling machines, standard machines, planers, window machines, chip extractors, chippers and hand-operated machines.

USNR

www.usnr.com

USNR is a global provider of complete production lines – from debarking to sorting. Our wide range of technologies allows us to customise solutions based on available raw material and desired end products.

Our conversion philosophy focuses on timber yield and thus also on the customer's long-term profitability. To make best use of the raw material, we develop our own control and optimisation systems with their associated user-friendly software. Among our many successful brands are the Cambio debarkers and the Catech edgers. Experience from thousands of installations worldwide has given us a unique knowledge base that benefits our customers every day.

VK

www.valonkone.com

Valon Kone (VK) is a Nordic company with global operations. VK is specialising in the development and production of VK debarkers and all the technology needed to provide the customer with cleanly debarked logs for further processing.

Specialisation in rotor debarking technology and continuous investment in research and development underpin Valon Kone's extensive product range.

Behind the success of the VK brand lies a dedicated and skilled workforce. With over 70 years of experience, Valon Kone's story continues as a technical leader and provider of reliable and innovative solutions for wood processing operations worldwide.

valutec® Good for Wood

www.valutec.ca

Valutec Group AB, based in Skellefteå, Sweden is the world's leading supplier of lumber drying kilns and a promoter of the transition to a more sustainable society. For almost 100 years, we have combined Scandinavian expertise in lumber drying with insights into the challenges faced by our customers. All to push the boundaries of what is possible, both in terms of value-added drying kilns and intelligent control systems.

Valutec makes increasing the use of wood possible, which is the fundamental reason for our existence. It enables us to make our customers more profitable, thus earning our place in the chain.

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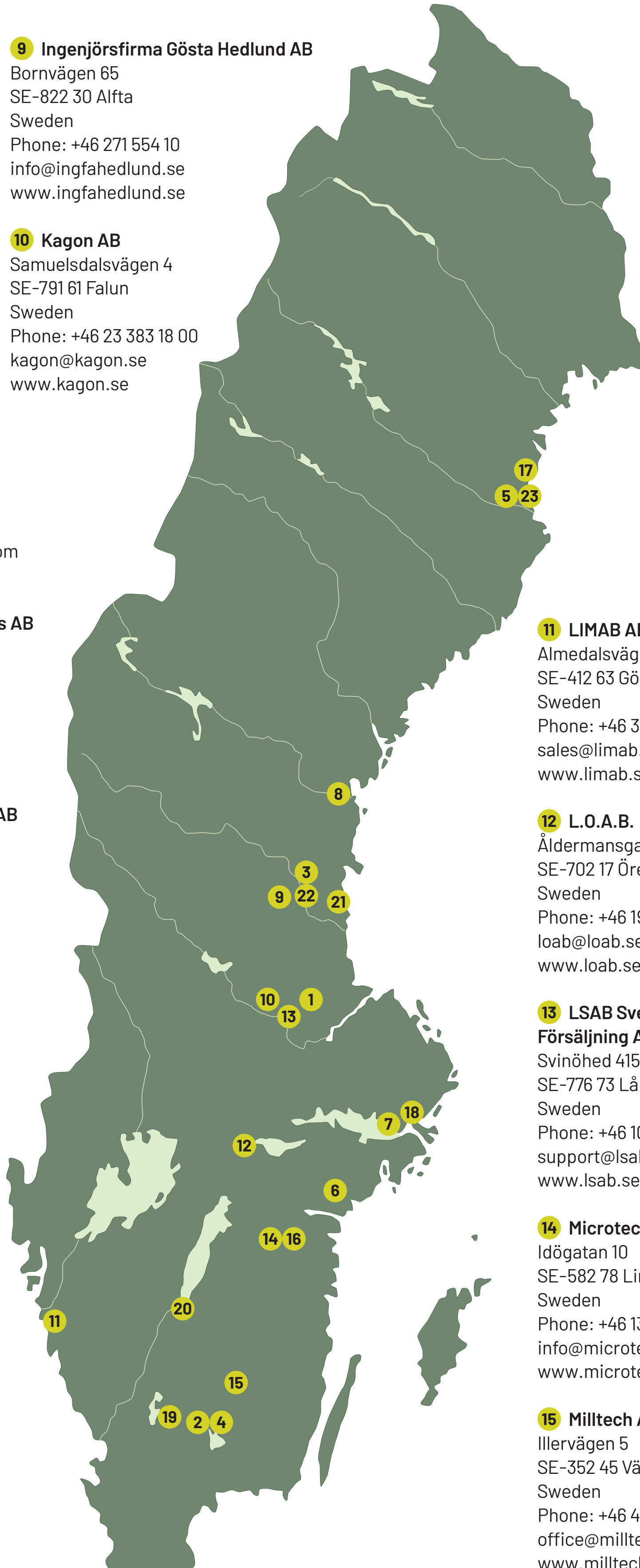

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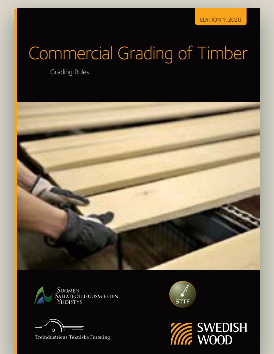

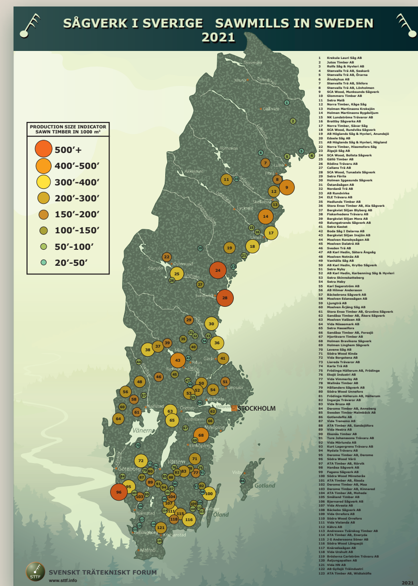

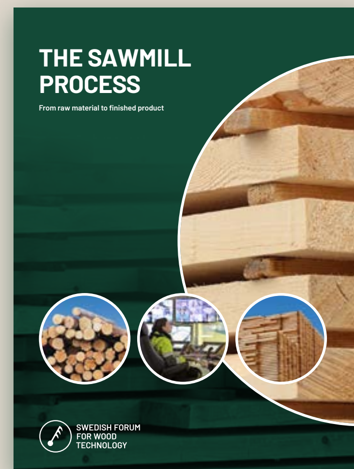

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SWEDISH FORUM FOR WOOD TECHNOLOGY

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The aim of Swedish Forum for Wood Technology is to create an attractive network of people who are active in or interested in the wood engineering industry and wood processing. Our task is to promote technical, commercial and knowledge advances in the wood engineering industry.

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