Industrial Finishing - Wood
Facts and Figures

CONTENTS

This brochure, "The industrial surface treatment of wood", has been produced for our partners and users of lacquers and paints. In this issue we share our knowledge and give practical advice on industrial surface treatment of wooden surfaces and try to answer many questions which arise during the surface treatment. We have used our own experience as well as the assistance of many specialists along with extensive special literature to produce this brochure. The aim of the brochure is to easily describe the most common surface treatment materials; the wood materials, the application techniques and the drying methods. The issues of economy, surface resistance and environmental aspects have also been taken into consideration.

AKZO NOBEL

AKZO NOBEL is an international corporation which is active in more than 75 countries with approximately 68 000 employees. The head office of the corporation is located in Arnhem, The Netherlands.

AKZO NOBEL is a renowned manufacturer of chemicals, paints and pharmaceutical products.

AKZO NOBEL was founded towards the end of 1994 by the merging of two corporations - AKZO and NOBEL. Many companies with a long and rich history are part of AKZO NOBEL. The oldest companies are Det Holmbladske Selskab (Sadolin), established in 1777, Sikkens (The Netherlands), and Bemberg (Germany), who started their activities in 1792, and Nordsjö - Nordström & Sjögren AB (Sweden) who started in 1903.

AKZO NOBEL is the leading paint manufacturers world-wide. The corporation manufactures products for both the consumer and industrial markets. The industrial products are marketed by some 20 plants in different countries.

Akzo Nobel is one of the leading manufacturers of surface treatment materials for wood, with new products and new technologies which have a minimal environmental influence. Wood Coatings develop, produce and market paint, lacquer and stain systems used in the industrial wood segment. The corporation's paint products are used for surface treatment of furniture, parquet, windows, doors, boards and other wooden surfaces.

WOOD

Considering our long-term environmental influence, the usage of wood is very important as it is a natural, renewable raw material. Wood also serves as a beautiful decorative material - a wide scale of decorations can be created by mixing details from different kinds of wood, coatings and technologies. Furthermore, wood possesses even more remarkable features which in many ways give it a leading position over alternative materials: excellent heat and sound insulation independent of the temperature, as well as the fact that wood does not accumulate electrostatic charges are a few examples.

One of the features of wood is to exchange moisture with the surrounding air, which helps to keep a balanced humidity in a room with wooden windows. Under stable humidity surroundings the wood helps keep its moisture in balance. The correlation between the relative air humidity and the wood moisture is shown in the enclosed chart. By increasing or decreasing the humidity, the wood starts to swell or shrink accordingly. Moisture causes the wood to swell minimally along the fibres, more sufficiently across them and mostly along its tangential cut. Swelling and shrinking can differ depending on the kind of wood. Cycled or even single swelling or shrinking of the wood surface may cause severe damage to the treated surface resulting mostly in cracking which appear on the surface of the coating. To minimise or to avoid the risk for cracking, wood with the proper moisture content should be used. The wood moisture should be kept stable during the treatment process as well as during storage, transportation and usage. According to the opinion of many specialists, the recommended moisture content in wood to be used for indoor furniture should be 6-8%, and for windows and outer doors 12-15%.

Some properties are in common in every kind of wood: year-rings, resin, knots, pores, etc.:

In the wood cells, which are the building bricks of the tree, the cells of the spring wood have thick walls and a large cavity; the summer wood cells however have thicker walls and smaller, flatter cavities. The summer wood is a harder, denser material than that of the spring wood.

Some kinds of soft woods, the so called fat kinds of wood, are characterized by more or less resin contents whilst the hardwoods often have big cell rooms or pores. Resin, or sapwood, are often present in the outer year-rings which are paler while the heartwood, the inner rings, is normally darker. Different kinds of heartwoods are pine, larch, oak, yew-tree, ash, elm, willow, poplar, mountain ash, walnut etc. Birch is an example of wood without heartwood.

Year-rings are formed by the tree's yearly growth and consist of two bands: a light-coloured band which is directed towards the tree centre and a darker band directed towards the bark. The inner band of the ring is formed at the beginning of the cambium growth and is therefore called "Early wood." The darker outer band grows at the end of the summer and is therefore called "late wood."

Ash, mahogany and coto are examples of hardwood with bigger pores, and these can cause blisters when they are coated – this is a well-known phenomenon.

SOFT WOOD

The natural "yellowing" which occurs under the influence of UV-light contained in solar radiation is typical for soft wood. This process of "yellowing" can be significantly retarded or eliminated by using special UV-resistant lacquers. Certain sorts of soft wood contain large amounts of resin, which might result in the occurrence of grey spots during the treatment of such wood. For this reason, the drying process of the coated soft wood should not be done at higher temperatures as the resin starts to dissolve at +45 ^{0} C.

HARDWOOD

There are two types of surface treatment for hardwood: open- and closed-pored. In the former the coating fills up the pores, and in the latter it only covers the surface.

BOARD MATERIALS

A large number of wood-based board materials are used in the production of furniture and interior decorations. The most predominant materials are chipboards, MDF-boards and hardboards. The different kinds of board have different characteristics regarding density, evenness, moisture resistance etc.

CHIPBOARDS

Chipboards are manufactured by hot pressing of resinous wood chips. Chipboards can have different thicknesses, densities, and usages depending on the refinement. Some examples are: fine layer-boards, chipboards with coated paper, foils or melanin and chipboards with fillers. Chipboards are used for the production of wardrobes, bookshelves, beds and walls. It has lately become possible to achieve a significant reduction of formaldehyde emissions in chipboards by using new adhesives (e.g. E1-approved chipboards).

FIBREBOARDS

Fibreboards are manufactured by hot pressing of wooden fibres. Compared to chipboards, the surface of a fibreboard is much easier to treat. Fibreboards are used for manufacturing different kinds of board components in furniture production. The most popular boards are MDF-boards (medium density boards) and HDF-boards (high density boards).

In the manufacture of high density boards the so-called "wet process" is used whereby the shaping of a board is done at high temperatures and under high pressure. The adhesion between the fibres is achieved mainly by the natural resins contained in wood, yet artificial resins might also be used.

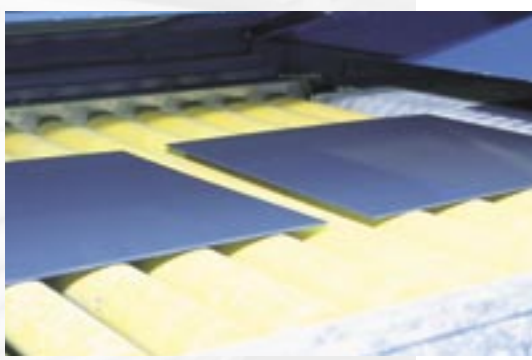
For manufacturing medium density boards the so-called "dry process" is used involving a lower temperature and lower pressure. Adhesion between the fibres is done by synthetic resins. MDF-boards are manufactured in different thicknesses, densities and surface treatments. MDF-boards with special features, such as resistance to moisture, fire, weather conditions or with a higher density are also widely-used.

The usage of MDF-boards has increased and practically replaced massive wood as a raw material when top coating (e.g. turned and profiled objects).

VENEER

Veneer is manufactured from slicing or turning and is normally 0,5 – 0,8 mm thick. When producing veneer, breaches in the material easily occur, and this can later on be seen as cracks in the veneer and the lacquer layer.

Veneer is normally used in the production of furniture and interior decoration details. It is often used in the production of high-quality details; and for this reason the demands on the veneer coating are very high regarding elasticity, adhesion etc; the choice of surface treatment system is also very important.



SANDING

Sanding is an important technical stage of the surface treatment process. The sanding has the following aims:

- to calibrate the objects to the required size;
- to remove scratches, splinters, pencil marks, glue residues and other defects from the surface;
- to remove grain raised from the surface by moisture or coating;
- to assure adhesion between the coating and the surface, or between coats;
- to reduce the consumption of coating material, as improperly sanded wooden surfaces absorb the coating and grain raising more intensively;
- to produce a good end-result with the correct sanding technology and surface treatment material;
- to emphasise the natural beauty of wood and its structure;

SANDING MATERIALS

A sanding belt consists of a basis (paper, fabric or a combination of both) onto which the abrasive grains are stuck using an adhesive. Normally belts used for higher tension have a mixed and firm basis. Belts for sanding profiled surfaces are made from an elastic fabric basis.

Both natural and artificial subjects are used as abrasive materials. Artificial abrasive materials are harder and their usage is more extensive. The choice of grains for different abrasive materials depends on the purpose of a sanding belt. The most commonly used abrasive materials are the oxides of aluminium (corundum), zirconium and silicon carbide. The abrasive materials are divided into ten grades of hardness (Mohs' scale); the hardness of the tenth grade equals diamond hardness. Abrasive grains are primarily diminished and then sorted in fractions by straining. The grain's fraction size is determined by the number of holes in one square inch of a sieve and is defined by rounded numbers (40, 60, 80, 100, 120, 150, 180 etc). The bigger the number - the more

holes per square inch of the sieve, thus the smaller the grains are.

Paper-based materials are sorted in accordance with the paper density as follows: A-paper (60-80 g/m^2), B-paper (95-105 g/m^2), C-paper (114-126 g/m^2), D-paper (146-158 g/m^2), and E-paper (218-242 g/m^2).

Abrasive grains may be spread over the basis in a tight (close coat) or loose (open coat) way. Sandpaper with loosely applied abrasives should be used for sanding the resinous kinds of wood (pines, dens).

There are not only belts, but also other special materials used for sanding, wool or felt made of abrasive fabric, sanding brushes, sanding sponges etc.

SANDING RECOMMENDATIONS

The sanding should be done without any extreme tension of the belt. Too high a tension results in a belt's premature wear and loss of finishing quality of a treated object. An optimal tension of the sanding belt significantly increases the belt's life-time, improves the quality and reduces consumption of the coating material.

The usage of a flexible press during the sanding preserves the sanding belt and improves the sanding quality significantly.

It is necessary to check the direction of a sanding belt when placing it on the roller of a sander. The correct direction is indicated

by an arrow drawn on the reverse side of the sanding belt.

The tension of a sanding belt should be reduced after the end of a sanding process in order to avoid stretching the belt and to prolong the belt's life-time.

The speed of the sanding belt and feeder should be set in accordance with the properties of the treated surface and recommendations of the belt manufacturer.

During operation of a sanding unit, all contact between a sanding belt and metals or other firm materials should be avoided as it may result in a break or destruction of the grains of the sanding paper.

It is necessary to make regular checks of the dust-disposal system and to constantly ensure a clean working environment.

The usage of the proper sanding materials improves the sanding results.

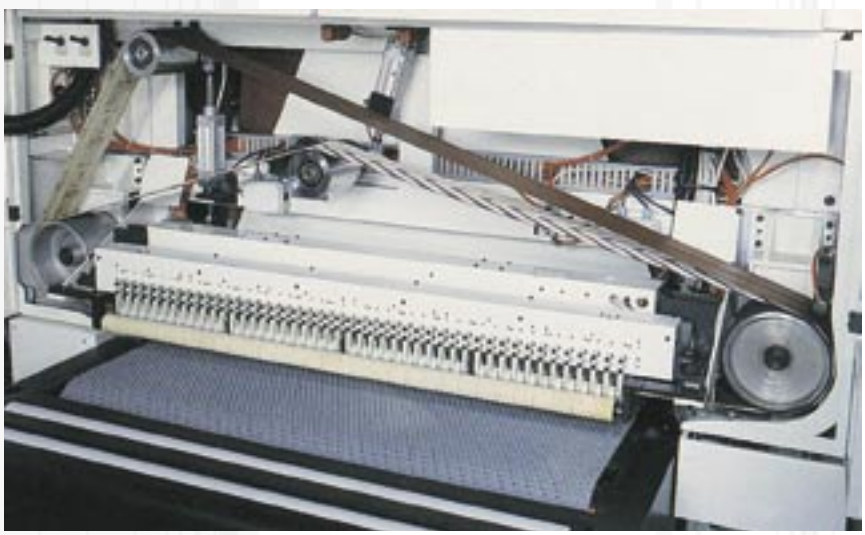
It is not recommended to go into a finer sanding by changing the size of the grains too much during some sequential sanding cycles. For such cases the usage of materials with the following range can be recommended: 60-100-150-220 or 40-80-120-180-240.

The quality of the surface will be much better on a finely sanded wood object if it is sanded with grains of size 180 instead of 120, which gives a heavy grain raising that binds the primer on top of the surface. Grains of size 180 give less grain raising, thus the primer will penetrate the wood surface better and doesn't have to be sanded away. For this reason, the final wood sanding should be done with a sanding paper with fine grains. If the sanding furthermore takes place immediately before the priming, the adhesion will be much better.

SANDING EQUIPMENT

The most popular sanding machines used for sanding along the fibres are the wide-belt sanders (with a roller or a so-called pad contact). For sanding across the fibres use narrow-belt sanders, vibration belt sanders, circle sanders for example. Sanders with special structures are used for sanding edges and profiles. It is often possible to combine different ways of sanding in order to achieve better results.

1. Wide-belt sander with a roller contact.
2. Wide-belt sander with a pad contact.



Narrow-belt sander for sanding across the fibres.

The main purpose of the surface treatment is to protect the surface of a product and to give it a good appearance. Different materials are used for finishing: fillers, stains, wood-protective products, prime and finishing lacquers, primer and top coating, furniture oils and waxes.

Fillers are used to fill up cracks and small cavities in the wooden surface.

Stains are usually applied under transparent coats (lacquers, furniture oils and waxes). A stain's purpose is to give the surface the required colour, to emphasise the natural beauty of the wood and its structure.

Wood-protective products are used for treatment of surfaces which need protection against biological influences (micro organisms, mould, insects etc.) - such as garden furniture, window frames and other exterior wooden surfaces.

Lacquers and paints are the coating materials mostly used. The main difference between lacquers and paints is the pigment content. Lacquers contain an insignificant quantity of pigments or no pigments at all, (transparent), whilst paints have a high quantity of pigments and they do therefore provide a opaque coating.

In order to obtain a good appearance of the treated wood object, a lacquer/paint system is used. The system consists of:

a) For clear coat systems:

- the Sealer; characterized by e.g. easy sanding properties and a good transparency,
- the Top Lacquer - characterized by e.g. hard, resistant surface properties in the intended gloss;

a) For pigmented systems:

- the Primer; -characterized by e.g. good filling and sanding properties,

- the Topcoat; - characterised by e.g. hard, resistant surface properties in the intended colour and gloss.

The usage of furniture oils and waxes serves where necessary to preserve the natural appearance of the wood.

When choosing a surface treatment system it is necessary to consider the coherence or suitability of the different layers to the treated surface as well as the correspondence of the chosen treatment system to the properties of application, transportation and usage of the finished product.

Coating materials consist of binders, fillers, pigments, flatting agents, solvents and additives.

The main properties of surface treatment materials depend upon the binder type. Materials with binders based on amino resins, polyurethane, acrylate, polyester or nitrocellulose are mainly used for the treatment of wooden surfaces. A combination of different types of binders is often used for manufacturing a coating with special properties.

NC-PRODUCTS (NITROCELLULOSE)

NC-products are based on nitrocellulose binders with a large molecular mass usually modified by alkyd binders. The drying of NC-products occurs through evaporation of the solvent. The advantages of NC-products are: short drying time, uncomplicated application and absence of formaldehyde in its contents. The major disadvantages are: low resistance to chemical and mechanical impacts and a low build coating.

Apart from the ordinary NC-products modified by alkyds, there are products modified by acrylate as well as water-borne NC-products.

ACID-CURING PRODUCTS

Amino resins (urea or melamine) and alkyd resins, which are often modified with nitrocellulose, are used as binders for acid-cured materials. Acid-cured materials can have one or two components. An acid hardener should be added to the two-component base before application. Acid-curing products harden as a result of a polycondensation process which starts when a catalyst (acid hardener) is added. The process of hardening can be dramatically accelerated by increasing the drying temperature and intensifying the air-exchange. Rapid drying, good hiding power and durability against chemical and mechanical impacts are typical properties of acid-curing materials.

WATER-BORNE PRODUCTS

Water (both in total and to a large extent) is used instead of an organic solvent in water-borne materials. Such binders as emulsion, colloidal dispersion or totally water-soluble binders may be used for water-borne products. Considering emulsions, this is a dispersion of a binder, with a large molecular mass, in water. The main reason for the ever growing usage of water-borne materials is that the emission of organic solvents is avoided or dramatically reduced during the coating process. Apart from that, the water-borne materials have good light and fire resistance.

There are a lot of different water-borne products/technologies with different properties depending on the field of application and demand profile. The water-borne products can be alkyd-, polyurethane-, acrylate-, or polyesterbased – as one- or two-component products. The water-borne UV-tehcnology is now also used on the market.

The disadvantages of these materials are: storage and transportation can only take place at temperatures above 0, as well as the possible swelling of the wood.

POLYURETHANE PRODUCTS

Polyurethane products dry as a result of chemical reactions between the isocyanate and hydroxyl polymer groups. Most PU-products are two-component products based on organic solvents, yet there are also one-component and water-borne PU-products. Many polyurethane products are modified by acrylate and nitrocellulose. The pot life of two-component polyurethane products is short after adding the hardener, usually 2-6 hours. Compared to the acid-curing products, polyurethanes dry more slowly. PU-products are known for good resistance to chemical and mechanical impacts and have excellent moisture resistance.

Polyurethane coatings developed for exterior use have good mechanical resistance. Thanks to their flexibility they possess good resistance against wood swelling and shrinking which might occur under the influence of weather conditions.

UV-CURING PRODUCTS

UV-curing products are cured by exposure to ultraviolet radiation. Acrylate combined with a photo initiator is often used as a binder. Under UV-radiation the photo initiator starts a rapid process of curing. Apart from the ordinary UV-curing materials which are applied by rolls, there are airless-sprayed UV-lacquers and water-borne UV-products. UV-curing products are acrylate binders or polyester binders, both with a 100% dry-solid content.

The radiation is obtained with UV-curing lamps, of which there are two kinds:

a/ The "Hg-lamp" – cures transparent and clear UV-lacquers;

b/ The "Ga-lamp" – cures pigmented UV-Paints.

Please note: In most cases a combination of "Hg-lamps" and "Ga-lamps" are used for curing primers and topcoats.

In case of water-borne UV-curing products, the UV curing is used at the end of the coating process. The treated object first passes through conventional and/or IRM-drying (medium infra red radiation), which is done in order to evaporate the water, before the final curing can take place.

STAINS

The stain is used to give the wood a different colour, but with a transparency which reveals the structure of the wood. Stains are made up of transparent pigments,

binders, water or solvents. The type of pigment used is important in order to achieve the right colour and light resistance of the stain. Lately many water-soluble stains have replaced the solvent-borne qualities.

ADDITIVES

Additives are used to achieve special additional properties of the coating products. Additives are binders, fungicides, defoamers, catalysts, plasticizers, emulgators, anti-skinning agents etc.

SOLVENTS

Solvents are used to control the binder's consistency and are also important for the drying process of the coating. Depending on the type of coating, organic solvents, water or water combined with a small quantity of an organic solvent are used as solvents. The following properties have to

be considered while choosing a solvent: rate of evaporation, electrical conductivity, flash point and dissolving capability.

Evaporation is the ability of a liquid solvent to evaporate. Hereby the solvents can be theoretically divided into three groups: rapid, medium and slow. Slow solvents prolong the drying time of a coating improving its flow so that the surface becomes smoother and glossier. The usage of rapid solvents allows the drying time to be reduced. Yet some condensed moisture can remain under the applied coat of lacquer which may result in the appearance of white spots. Apart from the above mentioned aspects, the application method and weather conditions determine the choice of the correct solvent.

Conductivity depends on solvent polarity: polar solvents are good electrical conductors and the opposite. A correct mixture of solvent components must be chosen in order to attain the required conductivity for the process of electrostatic application.

Flash point is the temperature at which vapours of the solvent when mixed with oxygen can be ignited by a spark or open fire.

Most of the paint- and lacquers for industrial use contain several types of organic solvents. The choice of solvent and its mixture depends upon the requirements of the final product. The most common organic solvents for coatings are: alcohols, acetates, ketones, aromatic mixtures etc.

Alcohols are widely-used polar and photochemical non-active solvents. Alcohols cannot be used in two-component polyurethane products because the OH-alcohol group causes an active reaction with the NCO-group of the polyurethane.

Acetates are widely-used for both acid-cured, nitrocellulose and polyurethane products. Depending on the evaporation speed, acetates can be divided into rapid ones (Methyl Acetate) and medium ones (Butyl Acetate). Acetates are not photo/chemically reactive.

Ketones offer a very strong solvency which is important for reducing the coating viscosity, and they are good electrical conductors. The most popular keton is acetone, which has a very high speed of evaporation and a low flash point, making it extremely flammable.

Aromatic solvents are present in acid-curing, polyurethane and NC products. All aromatic solvents are photo/chemically reactive.
The most widely-used aromatic solvents in coatings are toluene and xylene.

SPRAYING ROOMS

Spraying rooms should be used to improve the spraying results. The rooms also serve to ensure a cleaner working environment by removing solvent vapours and spraying particles from the coating. Depending on the type of applied filter, there are spraying rooms with dry, wet and mixed filters. Constant airflow coupled with good ventilation is of great importance.

To ensure a good coating quality, the incoming air must be pre-filtered to eliminate dust particles and must be warmed up in the cold season.

In the rooms where a dry filter is installed, the remainders of the finishes are removed by a glass-fibre filter or by a paper filter. The effectiveness of removing finishes from the spraying room by such a filter is 70-90% with a ventilated air flow speed of approximately 0,5 m/sec. Spraying rooms with dry filters are mostly used in small production areas.

In spraying rooms with hydro filters, the coating residues are eliminated by using water.

Coagulants are combined with water to sink the residues or to bring them up to the water surface.

The coagulants are chosen depending on the applied coating. In the production process coagulants have to be added according to the consumed amount of coatings to enrich the solvent. Both the room and the water containers have to be thoroughly cleaned afterwards.

CONVENTIONAL AIR SPRAYING

Conventional air spraying is the most flexible and adaptable method whereby the coating is sprayed through a gun nozzle using compressed air at 3-6 bars' pressure. The coating material is fed forward to the nozzle from the upper lacquer container under gravitational force, or is sucked from the bottom container under high pressure or low pressure. Alternative feeding methods use a membrane pump or pressure vessel. The amount of coating can be regulated by the supply of compressed air. The advantages of this method are: uniform coating, possibility to use different coating materials, good quality, uncomplicated regulation of the spray width and material consumption. The disadvantages of this method are: low production rate, fairly high solvent consumption (as it is necessary to use coatings with relatively low viscosity) and significant waste of material during spraying.

LOW PRESSURE SPRAYING

Low pressure spraying is a modification of conventional air spraying which uses compressed air leaving the spraying gun under a pressure not higher than 0,7 bars. The coating is fed forward to the nozzle in case the upper lacquer container is used under gravitational force, or through the tube of a membrane pump or pressure vessel. The spray width is adjusted by compressed air.

The advantages of this method are: uniform coating at lower pressure, possibility to use different coating materials, good quality, uncomplicated regulation of the nozzle and material consumption and good coating economy compared to conventional air spraying. The disadvantages of this method are: lower production rate and fairly higher solvent consumption.

HIGH PRESSURE SPRAYING

Spraying under high pressure is done by a high pressure pump which carries the pressure over to the coating. Spraying takes place through the nozzle under a pressure of 90-360 bars. The spray width can be adjusted by replacement of the nozzle of the sprayer. The advantages of this method are: high production rate, possibility to

use coating materials with higher viscosity, reduced waste of spraying material and a possibility to a thicker spray coat than in the case of low pressure spraying. The disadvantages of the method are: adjustment of the spray width which can be achieved only by replacement of the nozzle and a fairly low coating quality compared to the previous method.

MIXED SPRAYING (AIR MIX)

Air mix is a combination of high pressure and low pressure spraying. The coating material is fed to the nozzle under a pressure which is lower than average (in the range 20-120 bars). The compressed air pressure added for adjustment of the spray width is not higher than 1,5 bars. Spraying with this type is a compromise which combines the advantages of high pressure and low pressure spraying. This is the most widely-used method for high-quality coatings of wooden surfaces.

ELECTROSTATIC FIELD SPRAYING

Spraying in electrostatic fields is based on the movement of atomised particles along the power lines of an electromagnetic field which is created between a negatively charged spray gun and a grounded object. The stronger the electromagnetic field between the spray gun and treated object is, the stronger the effect of electrostatic spraying will be. The field power depends on the distance between the spray gun and the treated object, as well as on the potential difference (voltage). Usually the voltage between the earthed object and a spray gun is about 80 kV. The distance depends on the equipment and might range between 0,3-0,5 m. Apart from the low pressure and mixed sprayer the so-called bell system is used for electrostatic spraying. The working principle of an electrostatic bell system is that the coating, which is led to the high-speed rotary bell, is atomised by centrifugal force at the bell's edge into small particles that are forced onto the treated objects by an electromagnetic field. Considering that wooden surfaces have poor conductivity, its moisture ratio should be 10-12% with a relative humidity of the ambient air of not less than 60 - 70% in order to reach the required electrostatic effect. The major hazards of electrostatic spraying are: risk of explosion and risk of electric shock for the user. In order to avoid the explosion risk, both the treated objects and the spraying equipment must to be properly earthed in order to eliminate the electric discharge through ignition. Furthermore the flash point of coating has to be fairly high. The advantages of electrostatic spraying are: extremely small waste of coating material, a high production rate and a uniform coating. The disadvantages are: a rather complicated treatment of inner corners and high installation costs.

HOT SPRAYING

For hot spraying it is important that the viscosity of the coating is low enough. A solvent is usually added to the coating to decrease the viscosity. Another possibility to decrease the viscosity is to increase the temperature of coating material (see the enclosed chart). By using hot spraying, a temperature increase of up to 40-80 ^{0} C takes place inside a special heating unit. Hot spraying allows the solvent consumption to be reduced, which results in a reduction of the drying time, avoiding surplus material, increase of production rate and improvement of the coating quality.

TWO-COMPONENTS SPRAYING

This method is mainly used when spraying two-component coatings with a short pot-life. In this application process the base and the hardener are combined in a special pump immediately before spraying. The advantages of this method are: precise and uniform dosage of the applied mixture and a possibility to reduce the costs as the required quantity of applied mixture is prepared immediately before spraying.

Spraying by robotic spray units is used for the treatment of more complicated objects, whereby it is necessary to reproduce the human hand movement. The robotic spray unit consists of a microprocessor and a spraying application. The spraying application is managed by a microprocessor according to the software provided with it.

AUTOMATIC SPRAYING

Automatic spraying is used above all to achieve a high production rate. Spraying units based on different technological principles are used for automatic spraying.

Stationary sprayers are used for the treatment of narrow frame edges and flat objects. Objects are fed by a conveyor belt. Photo sensors switch on the sprayers at the moment the object is fed to the spraying area.

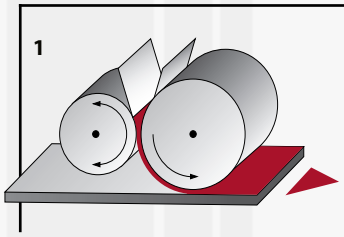
Sprayers with horizontal or vertical transversal movements and rotary sprayers are used for the treatment of bigger objects. Contrary to the curtain coaters and the roller units, an automatic spraying unit is capable of treating profiled objects and edges.

ROLLER COATING

Roller coating machines are used for treatment of objects with a flat surface. Stains, primers, lacquers and topcoats can be applied with a roller coating machine. Roller coating machines consist of application and dispenser rollers with doctor-blade rolls and a conveyor belt for the treated objects. The application roller is covered in a special rubber material. The hardness of the rubber on this roller is indicated by the numbers based on the Shore method. In accordance with the applied coating, a rubber roller with the appropriate rubber hardness should be chosen: coatings with an organic solvent base = +/- 30 Shore, primers and topcoats- +/- 50 Shore. The dispenser roller, used to regulate the dosage of the applied material, is made of metal. The applied quantity can be adjusted by using a) a distance adjustment between the dispenser and the application roller; b) adjustment of the pressure upon the treated object; and c) adjustment of the direction and the rotation speed of the dispenser roller.

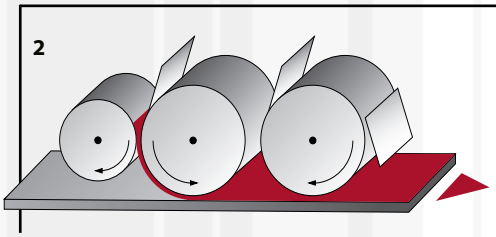
Different modifications of roller coating machines are used for treating wooden surfaces. Some of them are described below:

1



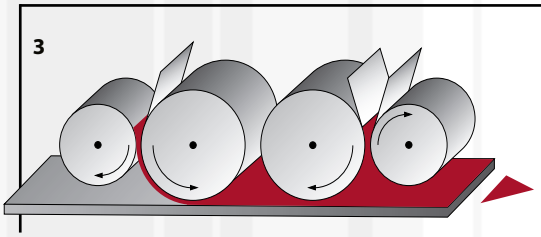
Roller coating machine with reversible dispenser roller (standard and reversed mode). It is suitable for the application of stains, primers, lacquers and topcoats. By rotating the dispenser roller against the rotating direction of the application roller (reversed mode) a more uniform coating can be produced.

2



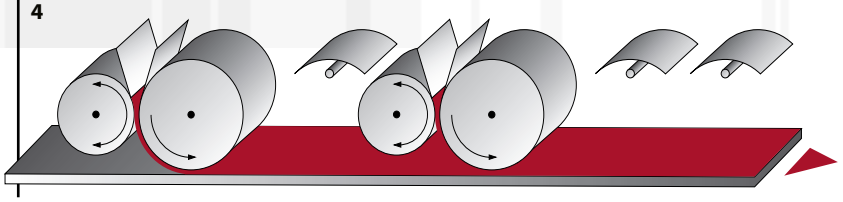
Machine for application of paints with a dispenser, and adjacent rollers rotating in standard mode.

3

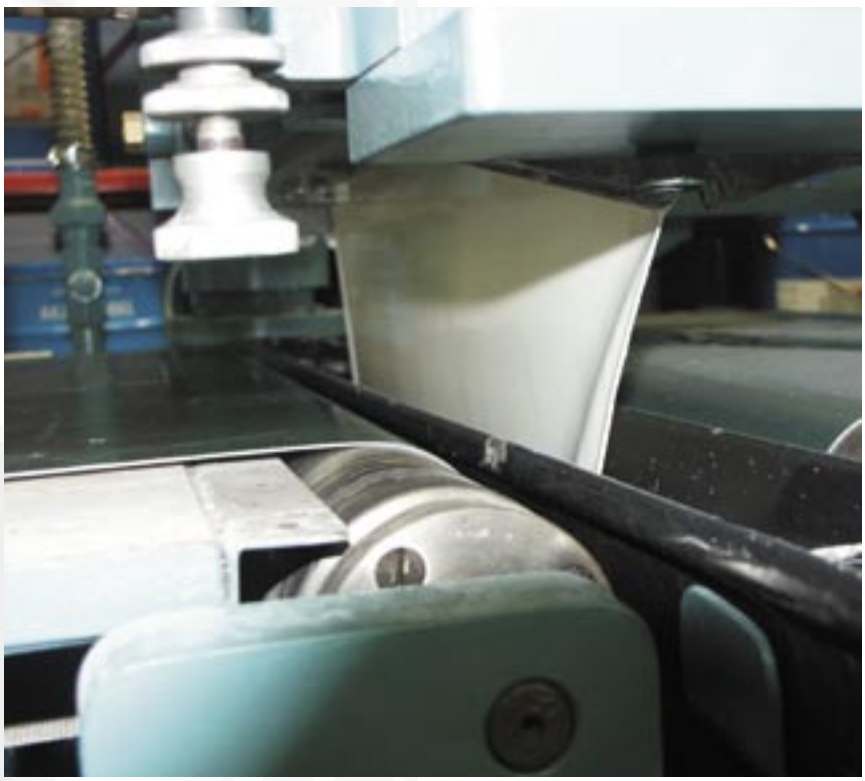


Machine with two application rollers. The second application roller rotates in the opposite direction to the direction of the objects on the conveyor belt. It allows the consumption of material to be regulated and a more uniform coating to be produced. It is mostly used for application of priming UV-lacquers.

4



Roller coating machine with two application rollers. Between the application of the first and the second coating, the material has not dried but turned into gel. It is done mainly to improve the adhesion.



CURTAIN COATING

The principle of the curtain coater is based upon application of coating by a curtain. The main parts of a curtain coater are: a conveyor belt and coating heads. The material waste is minimised by application of a curtain coater because the over sprayed material is recovered and reused.

Depending on their construction, the curtain coaters may have one or several coating heads. For example, reciprocators with several heads are used for coating with polyester mixtures with a short pot-life. Thereby one of the applied coatings contains hardener, and another - accelerator. If different materials are to be used in one line, such reciprocators with several coating heads are handy and productive. There are gravitational and pressure coating heads. Inside the gravitational coating heads the coating passes through the finish blades and forms a coating curtain under the influence of gravity. Overpressure is used to move the coating material through the finishing blades inside the pressure coating heads. Coating heads can be stationary and removable. The advantage of removable coating heads is that they can be cleaned easily. If the treated objects are placed at an angle on the conveyor belt, then apart from the surface, the edges can also be treated. Curtain coating allows a high production rate to be reached - the speed of the conveyor belt might be as high as 150 m/min. The material consumption can furthermore be regulated within a wide range (60-450 g/m^2). Different coatings can be applied by a curtain coater, such as nitrocellulose, water-borne, poly-urethane, acid-cured and others.

FLOW COATING

Coating can be applied upon treated objects with the aid of flow. The flows are led upon the objects horizontally or vertically through a stationary pipe system, which moves in single steps under the object. Surplus coating from the objects is led back through recovery channels and is reused later. It is important to create proper conditions inside the room for the flow coating (low air movement, correct moisture ratio etc) in order to enhance a uniform coating on the object surface and remove surplus stains. It is also important that the objects are placed on the conveyor belt in a way that allows a good coating flow and minimizes drop forming in sharp corners. A good flow and hiding power are important properties for materials applied by flow coating. Such materials do not produce any foam while rotating in a system. Furniture and window manufacturers use flow coating mainly for the application of stain, wood impregnators and primers. The main advantages of flow coating are uniform coating of the surface, small material consumption, low personnel costs and an effective usage of the production site.

TUMBLING

Finishing in a tumbling unit is mainly used for the treatment of small objects. Treated objects are placed inside a cylinder into which an appropriate amount of coating is sprayed. Then a rotating tumbler is switched on. After the application of the coating, the details are dried by the air blown into the cylinder.

CONVENTIONAL DRYING

Conventional drying is the same as drying at room temperature. This method is widely-used since most industrial coatings start to dry rapidly even at a room temperature. The drying time depends on the temperature, the moisture and the air exchange.

CHAMBER DRYING

Chamber drying differs from conventional drying by a higher temperature and a more intensive air exchange. The temperature increase accelerates the solvent evaporation and the chemical reaction, resulting in a reduction of the drying time and an improvement of the applied lacquer or topcoat. A temperature increase of $+10^{0}C$ can cut down the drying time by 50%. The drying process is extremely intense at a temperature of $+50\ ^{0}$ C.

PHYSICAL DRYING

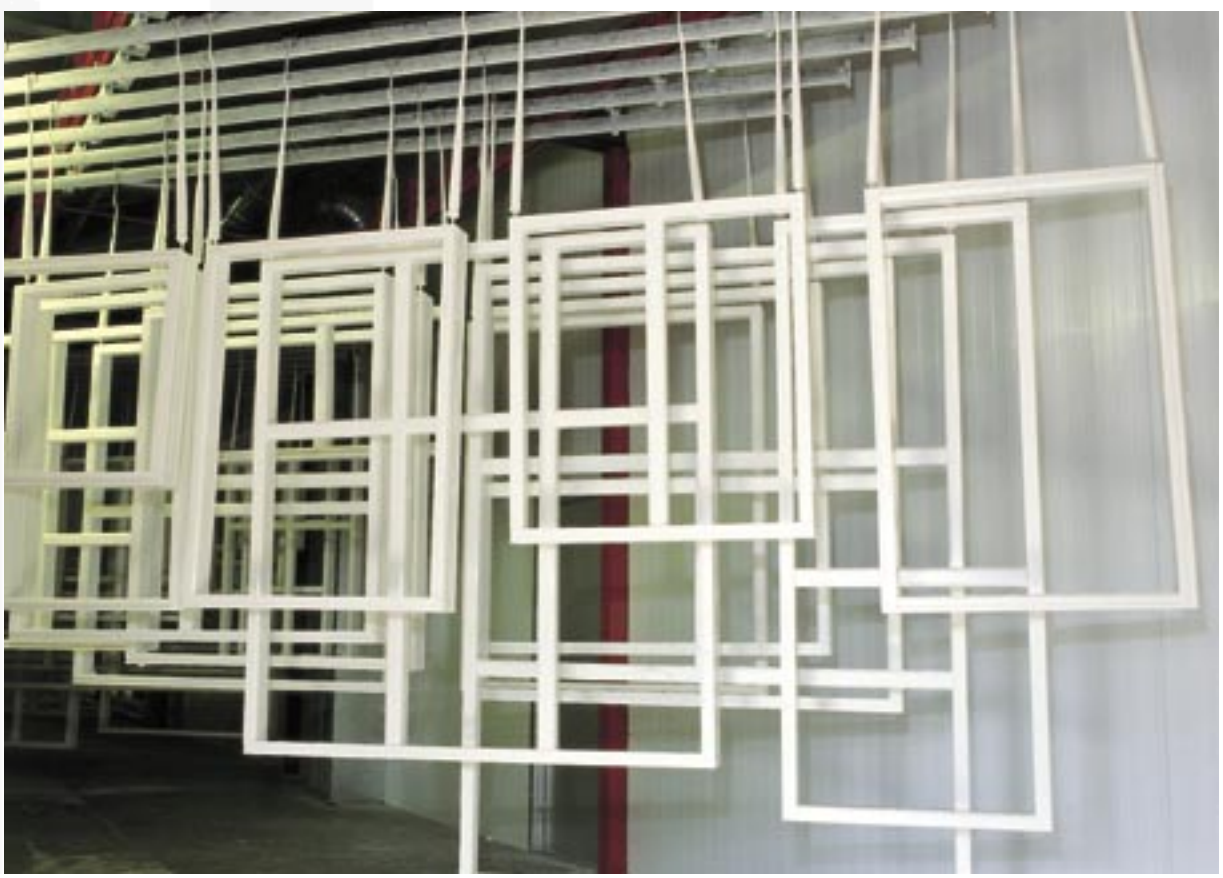
Some products, such as nitrocellulose ones, dry as a result of the solvent evaporating. After drying, these materials can be resolved again. The time for the physical drying is significantly reduced by a temperature increase.

OXIDATION DRYING

The drying and curing of synthetic alkyd resins is caused by the evaporation of solvents and a reaction between the binder and the oxygen of the air. The drying time of this technique is not influenced very much by any temperature increase.

CHEMICAL CURING

Accelerated curing of an acid-curing material starts as soon as the acid hardener has been added. Curing of polyurethanes starts after adding the isocyanate-contained hardener. It is possible to accelerate the solvent evaporation somewhat, and the chemical reaction between the binder and the hardener, by a temperature increase.



DRYING METHODS

Major methods of drying are convection, radiation and pre-heating. These drying methods are often combined.

During pre-heated drying, a pre-heated object transfers part of its temperature to the coating material. This accelerates the solvent evaporation, and the drying of the coating starts from the object's surface.

During convectional drying, the object's surface with the applied coating is dried by circulated air. The drying of the coating starts from the outer surface.

During radiation drying, the coating is dried and cured under the exposure of radiation. For this drying, UV-radiation (ultraviolet radiation), IR-radiation (infrared radiation) and EB-radiation (electron beam or beta radiation) is used.

DRYING UNITS

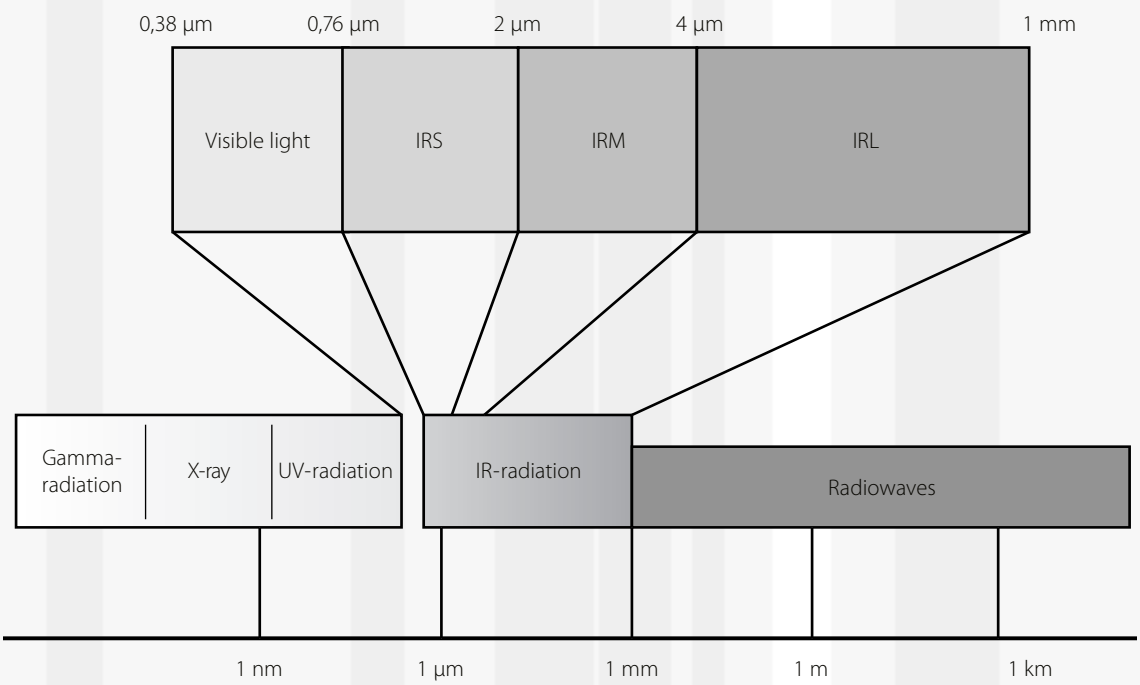
Drying units can be different depending on their construction. For an effective usage of the available production space, tunnel or multistage dryers are often used instead of convectional drying. In case of radiation drying the objects are moved along the conveyor belt at the same angle.

CONVECTIONAL DRYERS

The following stages are required when using convectional dryers: an area for pre-heating, a flash-off area, a drying area and a cooling area.

In the pre-heated area the objects are heated before the coating application. Object pre-heating is used to accelerate the solvent evaporation from the applied coating, as well as to remove the air from the wood pores.

A flash-off is necessary to achieve a good surface treatment quality. In this area most of the solvent evaporates from the coating, which is now uniform along the object's

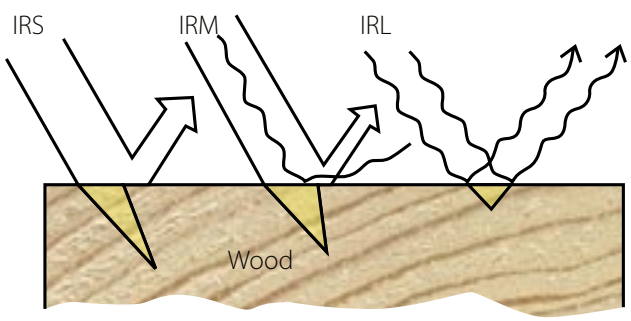


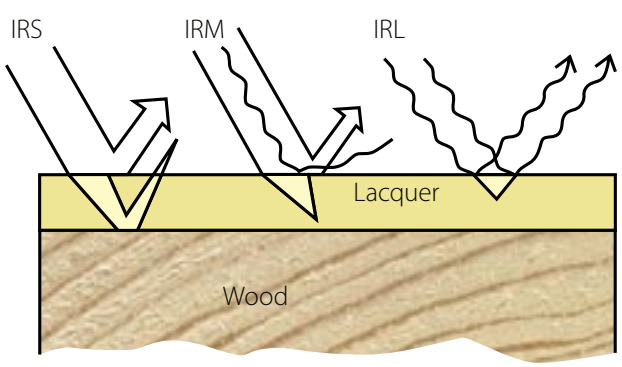
surface and the remaining bubbles are eliminated. It is essential to assure a proper air exchange in the flash-off area. A too intensive air exchange can cause disturbances in the remaining bubbles on the surface.

Inside the drying area the temperature is much higher than in the flash-off area. Here the coating drying takes place and the surface gets its basic curing rate. Inside the cooling area the objects are cooled before being removed from the chamber. The cooling of objects is very important as most coatings are thermoplastic, which means that they soften at high temperatures. The air exchange inside the cooling area has to be very intensive.

IR-DRYERS (INFRA RED)

The heating power of infra red radiation is used in IR-dryers. Electromagnetic radiation with a wave length of 0,76 µm - 1 mm is called infra red. Depending on the wave length of the infra red radiation, the following types of IR-dryers can be used: IRS-dryers (infra red short-wave radiation), IRM-dryers (infra red middle-wave radiation) and IRL-dryers (infra red long-wave radiation). IR-dryers are often combined with convectional dryers.





The usage of IR-dryers shortens the coating drying time. The object cooling becomes easier as IR-dryers only heat up the coating. These dryers are more economical than convectional dryers regarding the power consumption. IR-dryers are also small enough to more effectively use the available production space. It is also possible to pre-heat objects inside IR-dryers.

Care has to be taken while drying resinous kinds of wood inside IR-dryers, as object overheating may result in an excessive resin release.

UV-DRYERS

Inside UV-dryers the coating is cured under ultraviolet radiation. Lacquers and paints contain an acrylate or polyester based binder = the oligomer, and a sufficient amount of reactive diluents = the monomer, which is used to get the right application viscosity to the UV-curing lacquer/paint. Under the influence of the UV-light a co-polymerisation starts between the oligomer and the monomer. Curing occurs very rapidly (10-15 sec for polyesters and 5-8 sec for acrylate).

Two types of radiation sources are used in UV-dryers: "Ga-lamps" and "Hg-lamps."Ga-lamps" have a wave length >420 nm and a lifetime of approximately 2000 hours. They are used for curing pigmented primers and coatings and in most cases in combination with "Hg-lamps". "Hg-lamps" radiate waves of 200-380 nm and have a lifetime of approximately 3000 hours. These lamps are used for curing of transparent and clear UV-lacquers.

Please note: The UV-lamps need to be checked regularly, using UV-control instruments. (Checking the UV-energy, the UV-peaks and the peak temperature).

The pre-heating process with object cooling afterwards is not required for UV-dryers. As curing occurs very fast the length of the finishing line is much shorter. The energy consumption of UV-dryers is significantly less than that of convectional dryers.

Care should be taken while using stains with over coating with UV-clear coats as the pigment might be solved in the coating and thus slow down the process of curing or even stop it. Similar problems may occur when treating the different kinds of wood with special resin content.

ELECTRON RADIATION CURING (EB-curing - dryers with beta-radiation)

The usage of beta-dryers isn't very common as this technology requires large investments. An extremely rapid curing process which lasts less than a second is initiated when beta-radiation passes through the coating. Curing is prevented by the oxygen of the air so an inert gas (usually nitrogen) is used to remove the oxygen from the drying area. The usage of beta-radiation allows a high production rate and good quality.

Compared to convectional dryers, the energy costs are 20-50 times less.

Wood is generally a soft and porous material that easily attracts dirt and moisture. Coating is used to improve the resistance of the wooden surface against mechanical and chemical impacts, to assure biological protection (when used outdoors) and to make the wood surface attractive.

Gloss

Gloss is one of the aesthetic properties of a coating. In accordance with measurements achieved by the application of the Gardner method (60°), the finished surface is classified as follows:

Matte	Gloss less than 10
Half-matte	Gloss 10-35
Half-gloss	Gloss 35-60
Gloss	Gloss 60-80
High-gloss	Gloss more than 80

Opaque and transparent coatings

Opaque as well as transparent coating systems can be applied to a wooden surface. A uniform colour is provided by a opaque system, which consists of a primer and a top coat. The natural beauty of the wood and its structure are emphasised by a transparent system, which consists of a primer and a top lacquer. Pigments give wood a specific colour, they imitate high-grade wood kinds, increase the resistance of the light-sensitive wooden surface against UV-radiation, they hide biological damage to the surface and achieve other special effects.

Pores

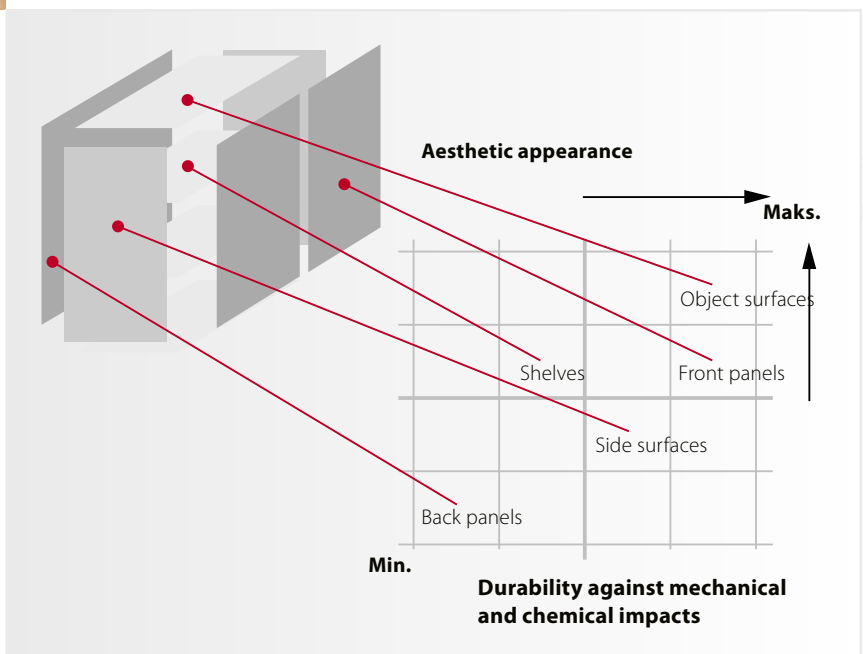
Depending on the coating, which either completely fills up the pores or only covers their inner walls, the coating giving filled or open pores can be applied onto the wooden surface.

Durability

The durability of the surface determines the ability of the finished surface to resist scratches, impacts, wear and tear, thermal changes and controls the swelling or shrinking of the wood. The chemical durability determines the resistance of the finished surface against liquids such as coffee, water etc. Different kinds of tests are done to determine the durability of the wood surfaces against chemical and mechanical impacts. Some of the most common methods are:

EN 12720 - Evaluation of surface durability against cold liquids (water, coffee, alcohol)

EN 12721 - Evaluation of surface durability against damp heat



EN 12722 - Evaluation of surface durability against dry heat

SS 839117 - Evaluation of surface durability against scratching

ISO 4211-4 - Evaluation of surface durability against impact

EN 438-1:2 - Evaluation of surface durability against abrasion

SS 839120 - Evaluation of durability of front edges against water

Depending on the final purpose of the finished objects, certain demands on the finished surface are raised regarding appearance, chemical and mechanical resistance.

The importance of base and coating technology

The durability and appearance of the finished surface of an object depends not only on the coating, but also on the choice of basis and coating technology which are extremely important factors.

The base has to be prepared thoroughly. Cavities and scratches have to be filled up. Apart from sanding before the coating application, it is necessary to repeat the sanding procedure after each applied layer of coating. The following points should be considered when choosing a basis:

- Every kind of wood is sensitive to scratches and impacts.
- It is very difficult to provide beech wood with a substantial resistance to grease since the large pores allow grease to penetrate under the coating easily.
- Wood with large pores has to be treated with a primer with good wetting properties since liquids can later penetrate the wood under the coating.
- Dirt and dust are more conspicuous on dark and glossy surfaces.

Less resistance on the finished wooden surface compared to earlier tests might have the following reasons:

- Application temperature too low, insufficient ventilation or increased air humidity in the working area.
- Insufficient coating thickness.
- Stacking and packing too soon causing objects not completely dry to stick to each other. Also solvents not completely vaporised affect the adhesion between the basis and the coating.
- The coating material was not properly stirred before application.
- Improper dosage of hardener.
- The use of old coating and hardener.
- Microscopic air bubbles in the coating caused by a low application temperature, too high a viscosity and an incorrect choice of thinner.
- Unsuitable basis and coating.

In this chapter a number of important recommendations regarding the application are given. Following these recommendations will lead to a good end result, to less problems and work stops, to optimise the productivity and to decrease the production costs.

It is important to read the guidelines for the applied materials as well as the safety instructions.

It is necessary to track down stock movements. Use the FIFO-method (first in first out); which means that the material leaves the stock in the order that they came in.

The finishing system (base, coating, sanding etc) has to be pre-tested regarding their properties for coating, storage, transportation and usage. If any property has been amended it is advisable to retest the whole system.

Check the coating equipment daily. The coating area must be kept clean and orderly in order to assure work safety, fire safety and the coating quality.

Make sure before starting the application that the paint material has the required colour and gloss.

The basis has to be sanded before the coating application. The sanding has to match the technological demands since it has a serious impact on the coating quality and consumption.

The treated objects must be dust-free before they enter the application area. This will reduce the dust level inside the application area greatly.

Make sure that the basis suits the required coating type. It is possible that the basis properties (veneer, chipboard, fibreboard etc) do not suit the chosen coating system.

Repairing defects and damages to the surface during the coating process is time-consuming and expensive. A special area for repair work should be determined.

The surface must be clean. Oil, wax and silicone can cause non-uniform drying, spots and craters.

In order to simplify the handling, the coating material should be mixed in their original containers. Two-component coatings (especially acid-cured coatings) should be stored after mixing in stainless steel or plastic containers since the hardener might otherwise react on the metal of the container and discolour the coating pink.

Add the precise quantity of hardener as per the instructions. Use graded litre measures when mixing the coating material. Using an approximate dosage of the hardener or dosage by using a stick does not provide the necessary precision. Too much hardener makes the coating brittle, and too little hardener may result in a slower drying time.

Use only the thinner indicated in the instructions. The choice of the thinner depends both on the coating and the application.

The coating has to be stirred thoroughly before application as pigment and other additives may form layers during storage. Insufficient stirring can cause differences in gloss and colour. After stirring, the coating needs some time for the elimination of air bubbles.

The viscosity of the coating should be chosen in accordance with the application method, so it is very important to check and adjust the viscosity. This should be done at a temperature of +20°C since the required amount of thinner depends on the temperature. When applying the coating by a curtain coater or a roller coating unit, the viscosity should be checked at the beginning of the work, after each break, after re-supply and once every hour during the treatment process.

Special notice should be taken regarding the pot life of the coating because the curing process is initiated immediately after adding the hardener. This may take - depending on the type of coating – from a couple of hours to several days. Coating residues with a long pot life can usually be used the following day. In this case it is recommended to combine the new and the old mixed coating material with a mixing ratio of 2:1. It is advisable that the residues which will be used the following day are stored in a cool place. Use clean containers to store the residues of the coating. Seal the containers and mark them with date, product code, and name.

The thickness of the applied coating depends on the quality of the wooden surface and on the requirements on the appearance - with open or closed pores. The material consumption shown in the instructions may vary in reality. Too thick a coating may result in cracking, too thin may affect the appearance and the durability against chemical and mechanical impacts.

The coating is usually applied to the surface in several layers which makes the adhesion between them extremely important. Intermediate sanding is one of the most significant conditions for good adhesion. This is especially important for acid-cured, waterborne, UV-cured and polyurethane materials where the top layer doesn't absorb the previous layer as with nitrocellulose materials. To improve the adhesion of applied UV-materials it is possible to partially cure the bottom layer to the gel substance and to finalize the curing process after each layer. Both the intermediate sanding and the application of the next layer should be done after the final curing of the previous layer. The quality of the sanding belt and the sanding speed should be checked during the process of sanding. Too low a sanding speed does not give the required sanding quality, whilst a speed which is too high may result in polishing and basis overheating. Solvents and coating conditions are also very important for the adhesion. If the thinner used is too fast and the air humidity too low the thinner evaporates too quickly whereby no substantial adhesion with the previous layer is achieved. Thinners suitable for all properties are recommended in the technical data sheet, or by a technician. Unknown thinners and thinners not recommended by the coating supplier should be avoided.

The viscosity of the coating and the surface temperature has to be checked at the start of the coating application. The characteristics can be negatively affected if the surface of the coating has a temperature which is too low (recommended temperature is +20°C).

At the end of the coating process, but prior to stacking, the objects have to be cooled down to a maximum of +35°C.9..

POOR HIDING POWER

Possible cause	Solution
A. Applied coating is lighter or darker than the base colour.	**A.** Use primer and sealer of the same colour.
B. Too much thinner has been added.	**B.** Add some concentrated (not diluted) mixed coating material.
C. The applied thinner is too slow or the temperature of the treated surface is too high resulting in a thin coating.	**C.** Use more rapid thinner and check the temperature of the treated surface.
D. The coating is too thin.	**D.** Apply more coating to the surface.
E. The spray width is wrong.	**E.** Adjust the spray width.
F. The mixed coating has not been stirred enough, the pigment is been left on the bottom.	**F.** Stir the mixed coating thoroughly until the pigment has been evenly mixed.

ORANGE PEEL

Possible cause	Solution
A. An incorrect thinner has been used or the quantity is insufficient.	**A.** Add the required quantity of thinner, if necessary use slower thinner.
B. Temperature changes between the coating and the treated surface.	**B.** Check and adjust if necessary the temperature of the coating and the treated surface.
C. Incorrect spraying pressure or distance from the surface.	**C.** Adjust the spray gun and follow the working instructions.
D. Excessive air circulation in the spraying and drying areas.	**D.** Check and adjust air circulation in the spraying and drying areas.
E. The relative air humidity is too low.	**E.** Increase the air humidity in the room.

SPLITTING DURING CURTAIN COATING

Possible cause	Solution
A. The curtain coating is too high.	**A.** Reduce the height of the curtain.
B. Bubbles and foam formation in the curtain coater.	**B.** Remove bubbles and foam using a filter. Ensure there is no pump leakage and that the pump does not suck air.
C. Excessive air supply near the curtain.	**C.** Cover the curtain.
D. Temperature of the coating is too low.	**D.** Store the material in a warm place before application.

UNEVEN SURFACE - CELL FORMATION

Possible cause	Solution
A. Too much thinner.	**A.** Add fresh, undiluted mixture to the mixed finish.
B. The coating is too thick.	**B.** Apply a thinner coating.

BUBBLE FORMATION

Possible cause	Solution
A. Skumbildning i sprutenheten.	**A.** Remove bubbles using a filter and ensure there is no air leakage in the spraying unit.
B. Temperature or air velocity is too high in the drying area. Time for flash-off is too short, excessive temperature increase in the drying area.	**B.** Reduce the temperature and the air velocity in the drying area. Prolong the drying time by reducing the speed of the conveyor belt.
C. Incorrect thinner has been applied resulting in a surface coat sealed for bubbles.	**C.** Use slower thinner.
D. Too low a moisture ratio of the wood.	**D.** Increase the moisture ratio of the wood.
E. Dirty spots on the treated surface.	**E.** Treated surface has to be thoroughly cleaned.
F. Incorrect spraying - spraying distance too close, viscosity too high or the temperature of the coating too low.	**F.** Use correct methods of spraying, adjust the pressure in the spray unit, add thinner to the coating and increase the temperature.

POOR DRYING

Possible cause	Solution
A. Incomplete drying because the temperature is too low or the conveyor belt's speed is too high. **B.** Temperature of pre-heating is too low.	**A.,B.** Check the drying temperature and time. Try different drying temperatures. Check the temperature of the treated surface after pre-heating, drying and cooling as too low a temperature results in extended drying. Check the air exchange and air circulation. A slow air exchange affects the thermo exchange and the thinner evaporation. Check the ventilation and filters.
C. An incorrect quantity of hardener has been applied.	**C.** Ensure the hardener quantity is correct.

GREY PATCHES

Possible cause	Solution
A. The primer has failed to fill the pores.	**A.** Use a primer with better wetting properties.
B. Pores contain dust from sanding.	**B.** Remove dust using compressed air..

CRATERS

Possible cause	Solution
A. Oil, silicone or moisture in the coating.	**A.** Check possible sources of contamination (packers, clean hands, compressed air, containers, etc). Skin creams containing silicone must not be used.
B. Porous surface.	**B.** Use a sanding process for the damaged surface and use a filling primer.
C. Incorrect viscosity of the coating.	**C.** Check the viscosity of the coating.
D. Incorrect thinner.	**D.** Use slower thinner.

RUNNING EDGES

Possible cause	Solution
A. The transport speed is too high when operating the curtain.	**A.** Reduce the speed of the conveyor belt.
B. Incorrect thinner.	**B.** Use faster thinner or less thinner.

UNEVEN TONE AND GLOSS

Possible cause	Solution
A. Uneven application of the coating by the spray unit.	**A.** Check the spray unit and use proper working methods.
B. Unstable transport speed or un-parallel jaws of the curtain.	**B.** Adjust slot gap of the curtain, sharpen the jaws if necessary and check the speed of the conveyor belt.
C. Too much old mixed coating has been added to the fresh one.	**C.** Check the viscosity of the coating and use fresh mixture.
D. Treated surface is defective or absorbs coating unevenly.	**D.** Eliminate the defects and use filling a primer.

LIFELESS STAINED SURFACE

Possible cause	Solution
A. High pigment content in stain solution.	**A.** Use stain solution with less pigments.
B. Stain solution has not penetrated the pores.	**B.** Treat the wet coat with a roller brush.
C. Wood absorbs more stain solution on the edges.	**C.** Treat the edges with a transparent stain solution before application of the stain solution.
D. Stain is solved by the applied coating.	**D.** Use stain which is not solved by the applied coating.

LIFTING

Possible cause	Solution
A. Applied coating is too thick.	**A.** Apply thinner a coat.
B. Top coat is applied before complete drying of the previous layer.	**B.** Let the coating dry completely before applying a new one.

MATTE PATCHES

Possible cause	Solution
A. Bubbles burst too late in the coating.	**A.** Eliminate bubble formation in the finishing unit. Use slower thinner if necessary.

MATTE SPOTS

Possible cause	Solution
A. Topcoat has been absorbed by the prime.	**A.** Use suitable coating materials.
B. Top coat has been applied before complete drying of the primer or the previous coat.	**B.** Let the coating dry completely before applying a new one.

DISCOLORATION

Possible cause	Solution
A. Too much hardener in the mixed finish.	**A.** Check the hardener dosage in the mixed finish.
B. Pink discoloration of coating after contact with rust.	**B.** Keep acid-cured finishes in stainless steel or plastic containers.
C. During treatment of resinous pine wood by acid-cured finishes, too long a break between sanding and application may result in red discoloration of wood.	**C.** Use sanding on the treated objects directly before the coating application. Do not expose sanded objects to open light and store them in a warm place.
D. Water-borne material is not suitable for oak, beech etc.	**D.** Use proper water-borne coating adjusted to the applicable kind of wood.

COATING RUNS

Possible cause	Solution
A. Coating viscosity too low.	**A.** Check the coating viscosity.
B. Distance between the spray unit and the object is too small or the spray gun is incorrectly angled towards the treated surface.	**B.** Adjust the spray unit and use correct working methods.
C. Nozzle of the spray gun is defective and the spray pattern is uneven.	**C.** Check the spray width and spray gun nozzle.

WRINKLING

Possible cause	Solution
A. Applied coat is too thick.	**A.** Use less coating.
B. Thinner evaporates too slowly while drying.	**B.** Use another thinner.
C. Top coat is applied before the drying of the primer is complete.	**C.** Let the primer dry completely before coating application.

CONTAMINATION OF FINISHED SURFACE

Possible cause	Solution
A. Dust on the surface of fresh lacquer or paint.	**A.** Check the air exchange and air circulation in the working area.
B. Dry residues from the hose dissolved in the new mixed coating.	**B.** Clean the coating unit thoroughly with a thinner. Replace the hose if necessary.

SILICONE PROBLEMS

Possible cause	Solution
A. Lubricants, compressed air and hand creams have contaminated the coating.	**A.** Keep the working space clean. Regarding skin creams, see “Craters” above.

PEELING

Possible cause	Solution
A. Poor intermediary sanding.	**A.** Check sanding unit and sanding belt.
B. Too long between the sanding and application of the coating.	**B.** Sand directly before application of coating.
C. Too much hardener.	**C.** Check the quantity of hardener added to the mixed finish.
D. Too much old mixture is added to the fresh one.	**D.** Use fresh mixture.

UNEVEN STREAKY SURFACE

Possible cause	Solution
A. Incorrect spray gun settings, defects and impurities in the spray nozzle.	**A.** Check and adjust the spray gun settings. Check and clean the spray gun nozzle.
B. Conveyor belt and spray guns are not synchronised.	**B.** Synchronise the spray gun's movements with the speed of conveyor belt.

SWEATING

Possible cause	Solution
A. Paraffin or wax on the treated surface.	**A.** Use primer and wood materials which do not contain paraffin or wax.
B. Too much hardener in the mixed coating.	**B.** Check the quantity of hardener added to the mixed coating.

CRACKING

Possible cause	Solution
A. Applied coating is too thick.	**A**. Apply thinner coating.
B. Moisture ratio too high.	**B.** Reduce the moisture ratio.
C. Incorrect quantity of hardener.	**C.** Check the mixing ratio.
D. Insufficient drying, bad storage conditions and excessive drops in temperature.	**D.** Check the drying and storage conditions.
E. Unsuitable surface and coating.	**E.** Check suitability of surface and coating.
F. Pot life of mixed finish has expired.	**F.** Use freshly mixed coating.
G. MDF boards are treated by the bland blades.	**G.** Replace the blades. Use primer if necessary.

INSUFFICIENT FLOW

Possible cause	Solution
A. Incorrect solvent or not enough thinner.	**A.** Apply correct quantity of thinner. Use slower thinner if necessary.
B. Coating is too thin.	**B.** Apply more than one layer of coating to the surface.
C. Poorly prepared surface.	**C.** Sand more intensively and fill the basis.

FINISHED COLOUR DIFFERS FROM THE SAMPLE

Possible cause	Solution
A. The colour of the stain solution applied to the wooden surface depends on many factors, such as basis structure and the form of sanding; quantity of applied paint and its application; top coat applied over stain; exposure of surface with paint to the light; chemical reactions between the paint and substances contained in wood.	**A**. Correspondence between the colour of the finished surface and the colour of samples has to be evaluated.

Many costs must be considered when making a calculation of expenses for the coating industry. Personnel, material and equipment costs are significant parts. Energy, environmental protection and other production costs must be added. The choice of coating material has an impact on the above mentioned expenses, and therefore the price per litre of material is not such an important factor, whilst making a general calculation of the expenses is much more important. Some examples of coatings, technologies and different kinds of expenses are given below.

The production cycle has a serious influence on the personnel expenses. The time of the production cycle is directly linked with the drying time, the number of applied coats and sanding operations etc. To reduce the production time for example, some coatings with a shorter drying time or wet-on-wet application might be used.

Energy costs are significant for the drying process. In order to reduce the costs some coating materials with shorter drying times at a low temperature may be used.

The amounts of waste can be minimised by the usage of technologies which allow coating to be applied only onto the surface (like roller coating units) or which allow the residues (curtain coating and flow coating) to be reused. The usage of electrostatic spraying can also reduce waste.

Coatings with good sanding properties do not need much sanding material, and thus makes savings possible.

The pot life of a coating is limited after adding the hardener. Coatings with a longer pot life might be used the following day or even during a longer period. It helps to avoid additional costs for the material residues and destruction costs. Coatings with a short pot life should be applied by two component spray units.

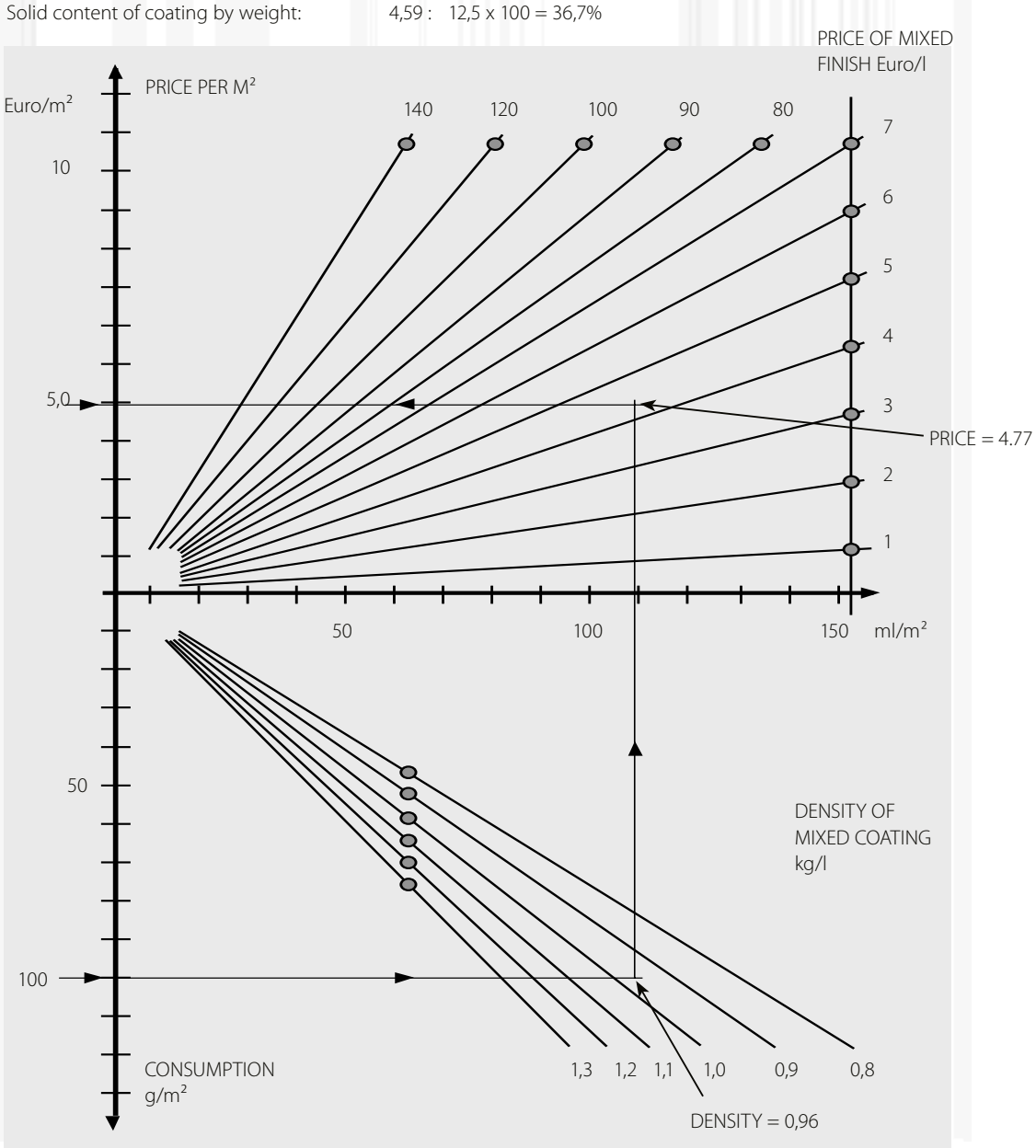
As the price of one litre of coating does not provide a realistic expense figure, it is better to consider a coating cost per square meter. It is therefore important to know the mix ratio of the coating, the price per litre, the viscosity and the material consumption.

An example:

	Price per litre (Euro)	Solid content	Density (kg/l)	Mix ratio, by volume
Coating	5	45%	0,98	100
Hardener	8	20%	0,90	10
Thinner	2	-	0,90	20

	Volume (l)	Weight (kg)	Solid content (kg)	Price (Euro)
Coating	10,0	9,80	4,41	50
Hardener	1,0	0,90	0,18	8
Thinner	2,0	1,8	-	4
Mixed finish	13,0	12,5	4,59	62

Price of 1 litre of mixed coating: 62 : 13 = 4.77 Euro/l
Price of 1 kg of mixed coating: 62 : 12.5 = 4.96 Euro/kg
Price of 1 m^2 with 100 g/m^2 consumption: 4.96 : 10 = 0.50 $Euro/m^2$
Mixed coating density: 12.5 : 13.0 = 0.96 kg/l
Solid content of coating by weight: 4,59 : 12,5 x 100 = 36,7%



The majority of industrially applied coatings contain materials which may be harmful to the human health if not handled properly. In order to provide the necessary information, special labels with the following information are attached to the packaging:

- Product name
- Name, address and phone number of the manufacturer or supplier
- Symbol with indication of danger
- Risk phrases
- Safety phrases
- Dangerous substances
- Packaging volume

Risk for human health and the environment of a chemical preparation is indicated by symbols with indication of danger, R-phrases and S-phrases.

Chemicals are classified as per the following hazards:

1. Physical and chemical properties
1. Health hazards
3. Environmental hazards

1

E

Explosive

O

Oxidizing

F

Highly flammable

F+

Extremely flammable

2

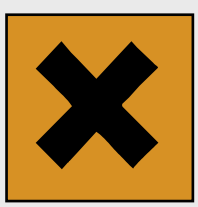
T

Toxic

T+

Very toxic

Xn



Harmful

Xi

Irritant

3	C	N
		
	Corrosive	Dangerous for the environment

More information on a chemical preparation can be found in the Safety Data Sheet issued by the manufacturer. It consists of 16 sections:

- Identification of the substance/ preparation and company
- Composition/information on ingredients
- Hazard identification
- First aid measures
- Fire-fighting measures
- Accidental release measures
- Handling and storage
- Exposure control/personal protection
- Physical and chemical properties
- Stability and reactivity
- Toxicological information
- Ecological information
- Disposal considerations
- Transport information
- Regulatory information
- Other information

The AKZO NOBEL Corporation has developed a color mixing system for industrial coatings, TINTEX COLOR SYSTEM

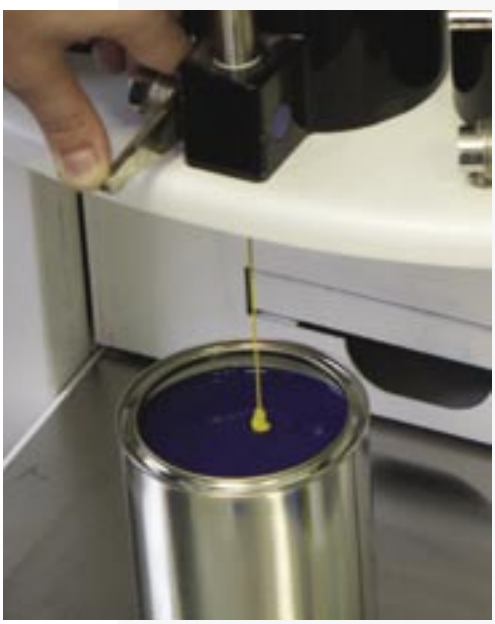
The Tintex Color System enables very quick supply of the desired color, also in small quantities. The reproduceability of the system is very high.

The Tintex Color System is an environmentally friendly system. The product is tinted directly into the final delivery can. Exactly the desired quantity can be tinted and thus avoiding waste.

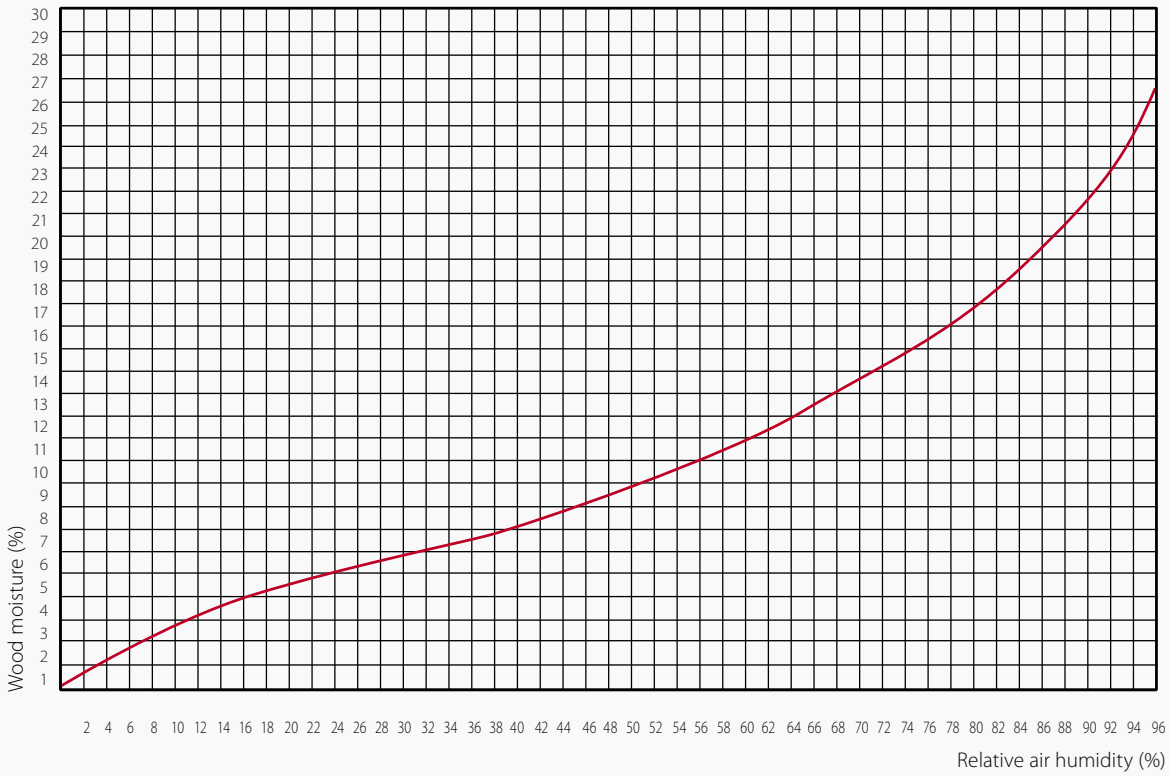
Different colorants are used to tint paints and stains. A base paint is required for opaque coatings while a stain base is used for stains. Colorants are dosed by a tinting dispenser whereafter the product is mixed in a shaker. Water- and solvent-based pastes are available. There are transparent and white base paints. There are also different bases for stains, both solvent- and waterbased.

Tintex Color System covers a broad range of products; nitrocellulose, polyurethane, acid-cured etc. Most water- and solventborne coatings and stains may be tinted in the Tintex Color System.

There is a large bank with colors formulations from the main color charts. NCS-2, Ral 840-HR and Ral 841-GL, Tikkurila Monicolor, Berkley, British Standard 381C, British Standard 4800, Coloriamo il legno, Flügger, Jotun, Jotun Multicolor, Munsell, and PMS, are a few examples. We also match exact shades according to color samples from our customers.



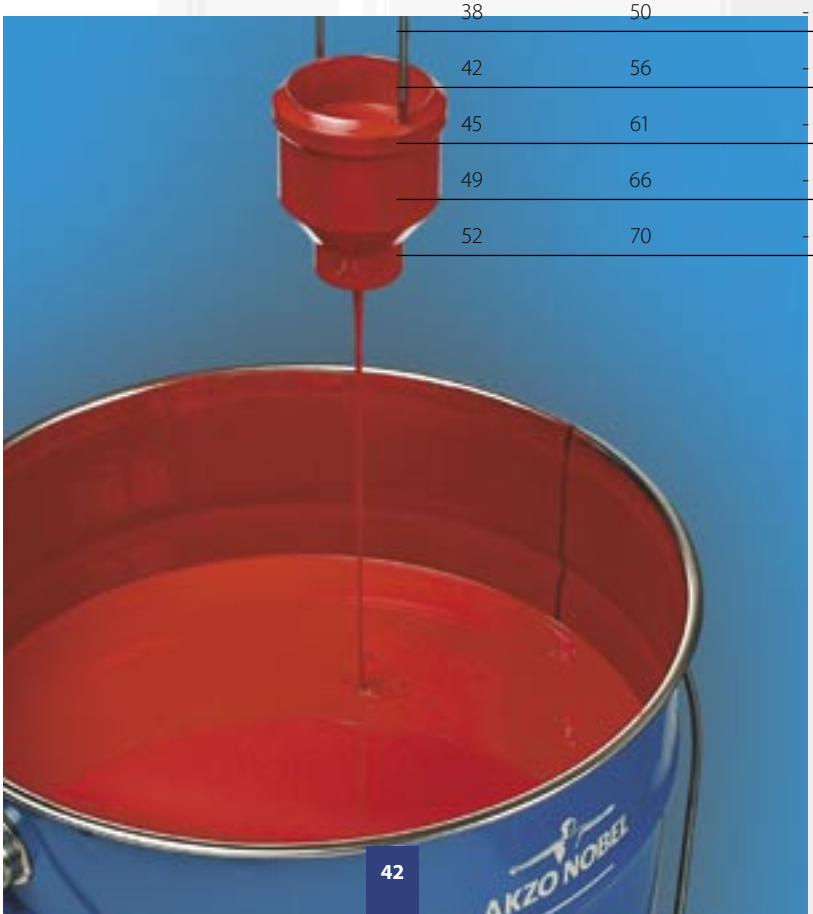
Correlation between relative air humidity and wood moisture at +21 ^{0} C



Viscosity

The coating viscosity is adjusted in accordance with the application technology. The viscosity is measured in centipoises or by the time needed for a certain quantity of coating to pass through the calibrated hole of a viscometer. The below table shows the relation between different systems of viscometers and centipoises.

DIN 4	AFNOR 4 (CA4)	ISO 4	Ford 4 (CF4)	Centipoises
11	12	-	10	20
12	14	17	12	25
14	16	23	14	30
16	20	34	18	40
20	25	51	22	50
23	29	60	25	60
25	32	68	28	70
26	34	74	30	80
28	37	82	33	90
30	40	93	35	100
34	45	-	40	120
38	50	-	44	140
42	56	-	50	160
45	61	-	54	180
49	66	-	58	200
52	70	-	62	220



The correlation between viscosity and coating temperature.

Temperature alteration has a direct impact upon the coating viscosity.
Coating viscosity is lower at the higher temperature.
This table is based on data of organic solvent-based coatings.

	Temperature (°C)																			
V	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
i	27	26	24	23	22	21	21	20	19	18	18	17	17	16	15	15	14	14	14	14
s	33	31	29	27	26	25	23	22	21	20	19	18	18	17	16	16	15	15	14	14
c	39	36	34	32	30	28	26	24	23	22	21	20	19	18	17	17	16	15	15	14
o	46	42	39	36	34	31	29	27	26	24	23	22	21	19	18	17	17	16	15	15
s	54	49	45	41	38	35	32	30	28	26	24	23	21	20	19	18	17	17	16	15
i	58	51	47	43	40	36	33	31	29	27	25	23	21	20	20	19	18	17	16	16
t	61	55	50	46	42	38	35	32	30	28	26	24	22	21	20	19	18	17	16	16
y	69	63	56	52	46	42	39	35	32	30	28	25	24	23	21	20	19	18	17	16
	77	69	62	55	50	46	41	38	35	32	29	27	25	24	22	21	19	18	17	16
S	84	74	67	61	54	50	44	40	36	34	30	28	26	25	23	22	20	18	17	16
I	95	84	75	66	60	54	48	44	40	36	33	30	28	26	24	22	20	19	18	17
S	104	92	81	73	65	58	52	46	42	38	35	31	29	27	24	23	21	20	19	18
	112	100	88	76	69	62	54	49	44	40	36	32	30	27	25	23	21	20	19	18
c	122	108	90	85	75	66	59	53	47	42	38	35	31	28	26	24	22	21	19	18
u	132	120	102	90	80	70	63	55	50	44	40	36	33	30	27	25	23	22	20	18
p	142	124	108	95	84	74	65	58	52	46	41	37	34	31	27	25	23	22	20	18
	152	132	119	101	90	80	69	61	54	48	43	38	35	31	28	26	24	23	21	18
	164	140	123	106	94	83	73	64	56	50	45	40	36	32	29	27	24	23	21	19

Example:

If, according to SIS cup, the coating viscosity is 22 sec at +20 °C, then:

*viscosity is 28 sec at +12 °C

*viscosity is 17 sec at +32 °C