Facts on finishing
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A commitment to provide products and techniques that are geared to customers’ needs and which promote our customers’ development and endeavours for a better environment is central to the Becker Acroma business concept.

As new finishing techniques become available, it becomes increasingly important to understand the complex interrelationship between products, application methods and curing techniques, and how these form an integral part of the finished wood product.

Our new “Facts on finishing” brochure aims to describe, in a simple and straightforward manner, the most common surface finishing materials, the various substrates, and different application- and curing methods. The brochure also addresses topics such as environmental considerations, cost efficiency and the durability of finishes.

We trust that “Facts on Finishing” will prove useful, wherever a basic knowledge of finishing techniques is required.

Should you require more detailed data on finishing techniques or products, you are always welcome to contact us at Becker Acroma. We have established a special unit — “Becker Acroma Engineering” — to bridge the gap between chemistry and the mechanics of industrial application, which can assist in the development of new paints and lacquers, and which also functions as a “consultant” to our customers.
ADVICE AND INSTRUCTIONS

This section provides guidance on how to achieve an optimum finish. By following this advice, you will use the material correctly and thereby avoid problems during the finishing process. This will optimise capacity and keep production costs to a minimum.

PRETREATMENT

THE SUBSTRATE

The evenness and density of the substrate is critical to a satisfactory finish and low surface treatment costs. It is therefore essential that sanding of the wooden substrate and painted surface is done correctly.

Repairing defects and damage to the substrate during the finishing process is time-consuming and expensive. If defects occur regularly, determine the reason and take appropriate action. Avoid using inferior veneers and be precise when trimming and joining them. Sanding through primers and sealers will permit absorption by the substrate, will raise the fibres and cause “matt patches”.

Components must be dust-free prior to surface treatment, to keep dust to a minimum in the finishing unit. Impurities such as grease, oils, wax and silicones cause creepage, glossy patches, “fisheyes” and craters. Avoid using hand creams containing such substances. Always wash your hands after mealtimes and after contact with greasy objects.

You can read more about substrates in the chapter of the same name.

THE CONTAINER

Waterborne products should be kept in plastic or stainless containers. Containers with UV-curing products should always have a lid, to prevent unnecessary exposure to light.

Acid-curing finishes should be kept in containers made of plastic (polyethylene) or acid-resistant steel, to prevent discolouration of the contents caused by acid acting on the metal of the container. When this happens, the finish acquires a reddish-brown or dark grey hue, which discolours light-toned wood. In no case whatsoever should aluminium be used.

Note that the container is not suitable for mixing. To avoid mistakes, make a habit of keeping unmixed finishing materials in their original containers, and of using other containers for ready-mixed materials.
THE FINISHING MATERIAL

- Check to ensure that the correct material, colour and gloss are used.

- Stir carefully. Pigment and flatting agents stratify during storage, so insufficient stirring can cause differences in colour and gloss. Rolling a tin of lacquer or paint around, or shaking it by hand, is not enough.

- Storage times for paints and lacquers can vary sharply. Conventional solventborne products normally have a storage time of one year. The storage times for waterborne-, PE-based or UV-curing products can be considerably shorter. It is important to keep an eye on storage times. These are stated in the product data sheets. The date the product was manufactured is stated on the container's label, in the form of a batch number.

Follow this simple rule — when it comes to stocks of finishing material: first in, first out!

THE HARDENER

- Check that the correct hardener is added.

- Make sure that the correct quantity is used. Use a graduated litre measure of polyethylene or stainless steel. If too much acid hardener is used, for example, the coating may become brittle and cracked (an effect called “crazing”), the hardener may be “sweated out” and the veneer become discoloured. Too much or too little PU hardener will result in a coating that is too hard or too soft. An incorrect quantity or incorrectly mixed batch of PE hardener can actually be dangerous and destroy the coating.

- Never add amounts of hardener measured with a “dip stick” or by eye. When mixing PE, never mix the hardener with the catalyst.

THE THINNER

In most cases, a certain amount of thinner must be added to the finishing material. Thinners are mixtures of solvents adapted to suit various types of materials and application methods. Check that the correct thinner is used. Ensure that the mixture is stirred thoroughly!

VISCOITY CHECK

Guide values indicating the appropriate viscosity for different application methods are stated in Becker Acroma’s technical data sheets. Always check that the mixture has the correct viscosity.

Viscosity is normally measured using a cup (DIN cup) featuring a 4 mm drain hole. The cup is filled with the mixture, and the time it takes for the cup to empty is then measured. The time taken, in seconds, is used as a measure of viscosity.

Note that the paint/lacquer shall have a temperature of 23°C, to conform with the measurement criterion applied (DIN). If it has been stored cold, it will be thicker and will require more thinner to dilute it. Cold lacquer can result in thin coatings, blistering and other surface defects.

When curtain coating or roller coating, check viscosity when starting, before and after breaks, when refilling with new lacquer and regularly while
coating is in progress. An automatic viscosimeter can be used to ensure consistent viscosity.

Let the mixed lacquer “stand” a while, prior to use. This will permit the release of any air worked in during the agitation process. This is of paramount importance when curtain coating, where trapped air bubbles can lead to curtain break, blistering or foam in the film of lacquer.

**POT LIFE**

The curing process (polymerisation) starts when hardener is added to a two-pack finish. The time it takes for the mixture to gel (set) after adding hardener is called its pot life. Depending on the type of lacquer, the pot life can vary from a few hours to several weeks.

If the amount of ready-mixed acid-curing lacquer cannot all be used on the same working day, the surplus can usually be mixed into the next day’s batch.

In such a case, observe these ratios: one part of the original mixture to two parts of the new. This eliminates differences in gloss, and the lacquer retains its original properties.

In each case, consult your supplier about the best way to store and use your lacquer.

All polymerisation will cease when kept in cold storage.

**QUANTITY APPLIED**

Becker Acroma has prepared a list of recommended application quantities for different types of lacquer. These should be regarded as guidelines only, and quantities may be exceeded or reduced to achieve the desired result.

Maximum values are indicated for some lacquers. These apply mainly to light-coloured sealers and very fast-drying two-pack finishes. If such lacquers are applied too thickly, problems may arise during the subsequent finishing process.

When spraying, it can be difficult to determine the amount of lacquer applied to a given substrate. One way to measure the approximate amount applied is to test-spray a surface, and then lacquer a piece of paper (as described in the test to determine application quantities when curtain coating). Careful checking of viscosity and the quantity of lacquer applied will ensure a uniform result and keep consumption to a minimum.

When curtain coating, the amount applied can easily be checked by coating a paper which can then be weighed on an accurate scale. This check shall be made at the start, after breaks, each time the coater is filled with new lacquer and at least every hour while coating is in progress.

The amount applied can be checked using a 250 mm x 400 mm sheet of paper (0.1 m²). Weigh the sheet, attach it to a board before coating, and weigh it after coating. Multiply the result by 10, and the answer will be the amount of finish applied in g/m².

This check is made still easier if the scale is first calibrated to zero to calculate net tare (i.e. the scale is adjusted to zero with an uncoated sheet on top).
DRYING – CURING

The drying time for different finishes can vary considerably, depending on fluctuations in temperature, air supply, humidity and the amount applied.

When a finish is dried and cured at room temperature, with no heat or air supply other than that designed for heating and ventilating the premises, drying times for the same finish will always vary. Low nighttime temperatures and/or excessive humidity can severely inhibit the curing process, reducing abrasion resistance and resulting in sticking when stacking newly coated products.

Drying and curing at a higher temperature in combination with effective ventilation will always cut curing time and ensure an optimal finish.

See also the section on “Drying and curing”.

SANDING FINISHES

Curing times for acid-curing finishes have been slashed in recent years, at the same time that the finishes themselves have acquired increased resistance to chemicals and solvents. Consequently, the finish must normally be sanded on the same day/shift, before adding a new coating, to avoid problems with poor adhesion.

This is especially important if the coating has been cured at a higher temperature (curing oven) or if the period between coatings has been fairly extended (such as a weekend).

Read more about this in the section “Sanding”.
THE SUBSTRATE

The correct choice of substrate and its correct treatment is decisive to the final result in all types of surface treatment.

In this section, we highlight some of the factors that are fundamental to achieving a successful result.

If you are unsure whether your wooden substrate is appropriate for surface treatment, or have other questions about the finishing process, feel free to contact us at Becker Acroma.

SOLID WOOD AND VENEERS

The wood substrate, whether we are talking about solid wood or veneer, is a natural product of indigenous or foreign trees. Whatever the country of origin, the structure of these trees has a number of features in common.

An annular ring is formed for every year of the tree’s growth. This annular ring consists of a light-coloured band of spring growth (early wood), followed by a darker band of autumn growth (late wood). Taking a closer look at the wood cells, which are the tree’s building blocks, the cells of early wood feature thin walls and large cavities, while those of late wood have thick walls and smaller, flattened cavities.

Consequently, late wood is a harder and denser material than early wood. This is worth remembering, since it has a significant impact on the end result.

When working the wood, blunt cutting tools can cause “depressions” in the soft early wood. These “depressions” become visible when the surface is stained or lacquered. This problem is further accentuated if waterborne materials are used.

 Certain conifer species, known as “pitchy” woods, feature a high resin content, while the cellular structure of deciduous species often features large cavities or “pores”.

These radically differing properties demand quite different approaches and present quite different problems when sanding and surface treating the wood.

Coarse-pored species of wood such as ash, mahogany and koto form a beautiful substrate for a range of surface treatments, such as rustic staining. However, they can also cause a number of problems: blistering, a common problem that can arise after surface treatment; problems with good wetting properties when using waterborne finishes, problems associated with removing sanding residues from the pores etc.

Veneers demand certain special qualities of the surface treatment material. Veneer is manufactured by slicing or peeling, in thicknesses that normally range from 0.5 to 0.8 mm. Consequently, breaks can easily occur during the manufacturing process, breaks that later become visible as cracks in the veneer and coating.
BOARD MATERIALS

Chipboard (particle board), MDF board (Medium Density Fibreboard) and hardboard are the dominant materials in the production of furniture and fittings.

Chipboard is available in a number of different versions and qualities, geared to a range of different applications.

It is manufactured with a number of different finishes: with a veneer; coated in paper, foil or melamine, or primed and sealed, featuring a surface smoothed with filler.

Each type of board requires its own special treatment. Melamine coated board, which has become an interesting alternative – only one side need be coated – requires special treatment to ensure good adhesion. Choosing the appropriate finishing technique is therefore decisive to cost efficiency, as well as to the end result.

MDF board, which has steadily gained increasing significance and which has in principle replaced solid wood as the material of choice for machined and profiled wood products that are to be finished in a covering lacquer, also requires special pretreatment and finishing. It is important to select the right type of steel and cutting angle when machining, and to fine-sand the wood with sandpaper of the correct grain size. MDF board always requires a finer grade of sandpaper than solid wood. For more details, see the section “Fine-sanding wood”.

Special regulations apply when surface treating MDF board. The Becker Acroma range of products offers the correct material for every stage of the process. Nowadays, specially developed wood finishing systems can be supplied in the form of solvent-based, waterborne or UV-curing systems. To meet every requirement, for every type of MDF board and every production process.

Finishing systems used for hardboard have also developed rapidly in recent years. UV-curing and waterborne systems now dominate this sector. In addition to these two types of finishing system, Becker Acroma also offers solvent-borne systems for hardboard.

Board is normally manufactured with amino-resin glues, which release formaldehyde. To reduce the amount of formaldehyde released, some manufacturers use ammonia as an inhibitor.

If ammonia has been used, there is a risk of discolouration (yellowing) when using alkyd-modified products, such as acid-curing modified NC and PU finishes.

If ammonia is used to reduce formaldehyde release, contact Becker Acroma for advice concerning the correct choice of surface treatment material.

The board manufacturing industry is developing rapidly.

New materials and combinations are being tested all the time. Becker Acroma closely monitors these developments and can offer customers new systems that are geared to the special requirements of such materials.

FINE-SANDING OF WOOD

A classic saying in the wood finishing industry goes something like: “A well sanded surface is half the secret of a perfect finish!”

Correct sanding techniques combined with the right finishing material and technology are decisive to a quality finish.

A quality finishing material can never compensate for poor pretreatment or a poor quality substrate. Quite the reverse: the surface treatment process is more likely to exaggerate any defects in the substrate, rather than masking them.
**POINTS TO KEEP IN MIND**

- All surface treatment shall be conducted as soon as possible after pretreatment. Preferably on the same day. Wait too long, and problems will arise. The wood will swell more, the resins in the wood will rise to the surface and there will be an increase in fibre release. Ideally, finishing shall be handled “on-line”, immediately subsequent to pretreatment.

- Pretreatment shall smooth away differences in the substrate. The more uniform the properties of the material passed from one unit to the next, the more consistent the result. Ensure that film-thickness tolerances are rigorously observed, especially when roller coating! They should be kept to an absolute minimum of not more than +/- 0.2 mm.

- Fine-sanding of wood will eliminate any traces of “cutter marks”.

- The air in a wood-finishing plant, especially during winter, can be very dry. Consequently, the wood raw material can dry out rapidly, leading to warping. Warped material poses severe handling problems in a well-controlled process, and can often cause through-sanding, uneven coating etc. This is best avoided by checking and regulating humidity in the finishing unit.

- Correct pretreatment will eliminate all mechanical defects in the substrate — soiling, depressions etc.

- Correct fine-sanding will ensure uniform and attractive staining. Sanding that is too coarse will cause excess stain penetration, producing a dark finish. Sanding that is too fine will inhibit stain penetration, producing a light finish. It will also cause the stain to “swim” over the surface, creating a blotchy, uneven effect.

- Careful inspection of the substrate prior to coating always pays. Normally speaking, the finishing process actually emphasizes any defects in the substrate. Something worth thinking about!

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**GRAIN SIZE**

There are many grain sizes to choose from when sanding: the normal range for wide-belt sanders is 24 to 800. The lower the number the coarser the grain, and vice versa.

Coarse grains remove more than fine grains and have a longer service life. The coarser the grain selected, the cheaper the sanding process per component. Conversely, coarsely sanded substrates require more lacquer and more sanding of the sealer. The finish will be much better on a fine sanded component if 180 grain sandpaper is used instead of 120 grain. 120-grain will produce significant fibre release, binding the primer above the
true surface. Sanding with 180-grain paper will reduce fibre release, improving primer penetration of the wood substrate, avoiding the need to sand away surplus primer.

It therefore pays dividends to select a fine-grain sandpaper for the final fine sanding process.

If this sanding is conducted immediately prior to applying primer, good adhesion is assured. A sanding belt featuring just one grade finer grain can reduce paint consumption by as much as 20%.

A two-grade increase in grain size is a reasonable step between each sander or sanding process. This usually ensures good load distribution between sanding belts, contributing to a satisfactory service life. Practical tests, including a follow-up of the sanding result, must be conducted to determine the optimum combination.

The examples above of commonly used grain series can provide a useful guide when selecting the most appropriate grain sizes.

### Type of Sanding Unit

Several methods can be used for fine-sanding wood: a transverse sanding belt and sanding pad, a wide belt sander and sanding pad, a roller sander or various combinations of all three.

Determining the best method for each occasion depends on a number of variables, such as the material/substrate, the required result, the choice of surface treatment material etc.

When using waterborne finishing systems, for example, pre-sanding treatment must often differ from that required when applying UV-curing systems or solvent-based finishing systems.

If in doubt, contact Becker Acroma.

**Remember: A well sanded surface is halfway to the perfect finish!**
Wood finishing materials consist primarily of binder, solvent and a range of additives. Coloured paints additionally contain pigment and filler.

**Binders**

Binders may be “dissolved” or dispersed, featuring a range of properties – such as wetting, film formation and penetration – that can be altered and controlled. Binders provide the coating with properties such as good adhesion, flexibility, durability, body and numerous other beneficial characteristics.

Typical binders include nitrocellulose, alkyd resins, amino resins, acrylates and polyester resins.

**Solvents**

The type and quantity of solvent used in the binder determines the consistency, ease of application and wetting properties of the selected finish and, to some extent, film drying time too.

In this respect, waterborne finishes function and react quite differently from solvent-based systems. Wetting properties, surface tension characteristics, film formation etc. are controlled in different ways and react quite differently to various surfactants.

What may be quite “correct” when using solvent-based systems may be quite “wrong” when using a waterborne system.

When delivered from the stockist, the lacquer will contain a specific mixture of solvents, formulated to optimize its properties. When applying the lacquer, further solvent – thinner – is normally added. The amount added can be adjusted to enhance the end result, e.g. improve flow, adhesion and rate of evaporation, combat blistering etc.

**Additives**

These are used for controlling certain finish properties, such as gloss, consistency, wetting, flow, blister prevention and sandability.

**Pigments**

Pigments are used to give finishes hiding power and a specific colour. The Becker Acroma range of paints uses non-toxic pigments only. Pigment is also used in glazes to obtain the right colour. Both soluble and dispersed pigments are used for stains.

**Different Types of Finish**

Depending on what binders they contain, lacquers, paints and fillers pass through different phases during the curing and drying process, and may therefore be classified as follows:

**Waterborne Products**

These mainly comprise thermoplastic systems, mostly acrylate dispersions. In recent years, systems featuring a cross-linking process have also been developed. These can be one-pack or two-pack systems. Waterborne systems, both clear lacquers and pigmented products, have noted dramatic
development in the past few years, with significantly improved quality.
Practically speaking, a waterborne alternative is now available for every
application area. Nevertheless, it is worth noting that we are here talking
about a complete change in technology. It is not simply a question of repla-
cing a solvent-based lacquer with a waterborne equivalent. A changeover
demands a thorough review of the customer's existing production technology,
which must then be modified for waterborne products. Legislation concerning
reduced solvent emissions are forcing increasing numbers to use waterborne
systems or invest in various forms of emission-control and cleaning systems.
Becker Acroma has developed complete waterborne systems to meet
the wood finishing industry's every need.

**AIR-DRYING PRODUCTS**
This refers to finishes which dry through evaporation of the solvent.
These include cellulose-based lacquers, where drying time can be sharply
reduced by heating and good ventilation.

**REACTION-CURING PRODUCTS**
With this group of products, the curing process is triggered by a chemical
reaction. In many cases, these reaction-curing finishes are two- or multi-
pack products.

**ACID-CURING SYSTEMS**
The products in this group are based mainly on alkyd and amino (urea or
melamine) resins, often combined with nitrocellulose.

The hardener (acid component) is a catalyst which starts and maintains
the binder's curing process until the chemical reaction is complete. The sol-
vent evaporates prior to and during the chemical reaction, and forms no
part of the final film of lacquer, paint or filler. Curing of acid-curing products
can be dramatically accelerated by applying heat.

In most respects, acid-curing products offer the optimal combination of
required properties: they combine a competitive price per square metre with
high durability, rapid throughput and uncomplicated production processes;
they can be combined with "mild" solvents and have a relatively high dry-
solids content.

A disadvantage is the limited release of formaldehyde in connection with
the curing process. Becker Acroma has developed a new generation of pro-
ducts in compliance with the "E0 directive".

**UNSATURATED POLYESTER SYSTEMS**
A cobalt catalyst and peroxide hardener are added to these products, to ini-
tiate and maintain the curing reaction.

In this case, solvent must also be added. This may be styrene – which
also functions as a reactive element of the paint system and which is inclu-
ded in the final coating – or conventional solvent which, however, must first
evaporate.

Polyester resins offer several benefits, including more body (high dry-
solids content) combined with high reactivity. The disadvantages are limited
pot-life and the fact that both hardener and catalyst require careful storage
and handling.

Pot-life can be considerably extended by using mixing pumps that feature
multi-component dosing, or curtain coaters with two wet-on-wet heads.

In such cases, the catalyst is mixed into the lacquer from the first head,
while the hardener is mixed from the second.

Thanks to the excellent quality of the final finish and their high dry-solids content, these lacquers have regained their popularity in recent years. The curing process can be dramatically accelerated by the addition of heat.

**POLYURETHANE SYSTEMS**

Polyurethane products are two-pack systems, in which hydroxyl groups (the binder) react with isocyanate resin (the hardener).

With pure polyurethane products, applying heat will not appreciably accelerate the curing process. With blocked polyurethane products, however, heat will accelerate the curing process.

These types of product have attracted renewed interest on the Scandinavian market, in connection with requirements concerning formaldehyde-free processes. They now offer a promising alternative to acid-curing lacquers, thanks to rapid development in recent years, combined with a sharp reduction in the previously high level of free isocyanate.

Becker Acroma has developed a patented process which ensures extremely low levels of free isocyanate, far below the officially prescribed levels.

**UV-CURING SYSTEMS**

UV-lacquers refer to products that are cured by exposure to UV radiation. They may be based on unsaturated polyesters, although the most common are acrylate-modified polyesters, polyurethanes or epoxy binders. Also called prepolymers. Polyester is often diluted with styrene, vinyl ethers or an organic solvent. Acrylate prepolymer is often diluted with a low viscosity binder. These are not volatile like an organic solvent, but form a film with the prepolymer by means of cross-linking.

A photo-initiator must be present to catalyse the cross-linking process. Its purpose is to transform UV radiation and initiate the curing process by means of a chain reaction. This curing process is very rapid. UV-curing products with a dry-solids content of 100% are best suited to roller coating. Waterborne UV-curing systems can be one- or two-pack systems, for clear or pigmented lacquers. One-pack pigmented UV-curing lacquers require UV lamps, known as “Ga-lamps”, featuring a staggered wavelength area (400-420 nm). Otherwise, normal UV lamps (200-400 nm), known as “Hg-lamps”, may be used. The advantage of such systems, apart from the fact that they can be curtain-coated or sprayed, is that once all moisture has been removed and UV-curing has been completed, they produce a non-thermoplastic finish that is fully comparable with the high durability commonly associated with conventional UV-curing systems.

**STAINS**

Stains are used to give wood another colour without masking the structure of the wood substrate. They consist of colour and very finely dispersed transparent pigment, water, solvent and binder.

Earlier, staining mainly involved solvent-based stains. In recent years, however, waterborne stains have been developed and now dominate the market.

Two factors in particular have contributed to this increase in the use of waterborne stains. With waterborne stains, the structure of the substrate appears more consistent, and there are obvious environmental gains.

During the staining process, the more porous portions of the wood absorb more stain, creating a reversed stain image. Nowadays, stains are
even available which can neutralize this effect, and actually produce a “positive” stain image.

Stain can be applied using highly rational finishing line techniques, either by spraying, roller staining or flow-coating. Stains can also be applied manually by dipping, or by application with brush or sponge. Certain differences can be noted with different qualities of stain. For instance, a roller stain is much stronger than a spray stain. And try to keep in mind that, when staining, fine sanding of the substrate is crucial to the end result. The colour can vary considerably depending on the size of grain and type of sandpaper.

For this reason, conduct stain tests before starting production, to check and determine the colour and appearance of the stained product.

**Surface Treatment with Oils**

Oil and wax treatments are well-known traditional surface treatment methods which have started to gain new relevance. Such processes are simple to perform, but also require regular care.

This type of surface treatment originally required the skills of individual craftsmen, but techniques are now being developed for simplified industrial production.

Oil has a strongly penetrative effect on wood, which varies according to the structure of the substrate. Once again, the way the wood is prepared has a dramatic effect on the amount of oil the wood absorbs. A solid but unevenly grown piece of wood will demonstrate very different absorption characteristics, which may give the oiled surface a blotchy appearance. Normally, the surface must be dried and perhaps sanded again before the next film of oil can be applied.

Oil can be lightly tinted, to function both as a stain and as surface protection. Here, it is more important than ever to ensure a smoothly sanded surface with consistent absorption characteristics. Add no more than 2-3% of tinting paste, to avoid the risk of smearing.

Solvent-free oils are ideally suited to the industrial finishing of pine and other wood flooring.

**Wax Treatment**

Waxes are normally classified as “cold waxes” and “hot waxes”.

Cold waxes are usually waterborne, but are not always completely free from solvents. They are colourless but can be tinted, to provide an attractive stain-like appearance. An opaque finish can be achieved by multi-layer waxing, as well as special effect (metallic, etc.) and plain finishes.

The alternative is hot wax treatment, which requires a special type of application equipment. These waxes generally provide better protection than cold waxing. Hot wax can be tinted too, but involves a much more complex process, as a result of which the entire hot wax container acquires the same tint, making it very difficult to clean. Even after hot waxing, the product will still require regular care.
APPLICATION METHODS

CONVENTIONAL ("LOW PRESSURE") SPRAYING
This is the most flexible and adaptable method. The finishing material is transported and dispersed with compressed air.

The finishing material is fed forward to the paint nozzle. The flow is controlled by a needle valve, operated via the spray-gun trigger. When the trigger is depressed, the compressed air valve is opened first. The needle is then drawn back, and the finishing material can pass through the paint nozzle. The paint meets the jets of air beyond the nozzle and is atomized in the form of tiny droplets. Spray breadth and spray pattern (spray cone) are regulated by the amount of air supplied to the air nozzle.

The finishing material is fed to the nozzle by suction or pressure generated by a pump or pressure vessel. The correct spray nozzle must be selected, according to the method used. The amount of finishing material can be roughly regulated by adjusting the pressure in the lacquer container and the size of the hole in the spray nozzle. Fine adjustment is achieved by changing the length of stroke of the paint needle.

The disadvantages of conventional spraying are the relatively slow production rate, fairly high paint consumption and high environmental load.

HVLP
In recent years, conventional spraying has been modified to reduce overspray. The spray gun and nozzle have been modified to atomise the paint using a large volume of air at low pressure, the High Volume, Low Pressure (HVLP) method.

AIRLESS SPRAYING
This method offers certain advantages compared with conventional spraying, but is not as flexible when it comes to regulating spray-field width. Atomization of the lacquer is less satisfactory and in some cases inadequate. It is a rapid method with a minimum of overspray.

With airless spraying, the finishing material is fed forward to the spray-gun nozzle under high pressure (as much as 200 bar). It is atomized as it passes through the spray-gun nozzle. Pressure is generated by a piston pump. Spray width and paint/lacquer quantity are adjusted by replacing the spray-gun nozzle. Better atomization can be obtained by using a "pre-nozzle", which makes the spray cone less elliptical (to achieve a less diffuse spray pattern).

Airless spraying is now widely used when applying waterborne finishes with automated spray coating systems.
AIRMIX SPRAYING

Airmix, Air-Plus, Airassist etc. are combinations of the methods described above. Nowadays, this is one of the most commonly used spraying methods in the wood finishing industry, thanks to fine atomization and minimum overspray.

The combination comprises:

- A high-pressure pump featuring an adjustable pressure of 15-45 bar (far less than for airless spraying).
  The pump sucks the finishing material from an open container, e.g. the transport container.

- A spray gun with a high-pressure nozzle and an air-nozzle for atomization and spray-width adjustment, which can shape the mist of lacquer to a spray field. The air pressure used to atomize the lacquer is usually very low – no more than 0.5-2 bar – with air consumption of approximately 40 litres a minute.
  The finishing material is fed from pump to spray gun via a thin hose.
  The pump has a pressure relief valve to adjust the amount of compressed air fed to the spray-gun nozzle.

HOT SPRAYING

If it is to be atomized and sprayed, the finishing material must have a low viscosity – a viscosity that will ensure a good finish. To achieve the appropriate viscosity, finishes are normally diluted with a solvent, but the correct viscosity can also be achieved by heating them. In several countries, strict environmental regulations enforce the use of “high solids” products to reduce solvent emissions. In such cases, hot spraying can offer a viable way of combining good flow characteristics with minimal use of solvents. This technique produces a more full-bodied finish and, in some cases, may even preclude the need for a further coating.

One-pack lacquers are especially suited to this type of application. Certain waterborne products can also be hot sprayed. This is highly important, since the classic problem of raised and swelling fibres can be minimized, thanks to the reduction in the water content of the paint/lacquer, a consequence of increased high-solids content.

Another method is to heat the air used to atomize the lacquer, instead of the lacquer itself. This produces improved flow characteristics with less solvent and lower atomization pressure.

ELECTROSTATIC SPRAYING

Equipment for electrostatic spraying of wood is increasingly commonplace. As the result of ongoing development, the method now offers a viable alternative or complement to conventional spraying. Large-scale electrostatic finishing units now exist for chairs, beds, window frames etc.

Electrostatic spraying exploits the electromagnetic field that arises between two bodies that possess different electrical charges.

This field can be demonstrated by field lines (see illustration), where “A” represents the negatively-
charged spray gun, and "B" the positively charged item that is to be sprayed. Paint/lacquer particles are charged in the spray gun and therefore strive to follow the electromagnetic field lines to the item that is to be painted. The electromagnetic field creates a "wrap-around" effect. Consequently, even the sections hidden from the spray gun get coated. The stronger the electromagnetic field, the stronger the electrostatic effect. When the charged particles come in contact with the item, which is earthed, they release their negative charge, which is immediately earthed via the conveyor system. However, the electrostatic effect will be negated if, for example, the conveyor hooks are coated with paint at the point of contact. A special range of products has been developed for electrostatic spraying. Such products must possess the appropriate electrical resistance to receive the electrical charge. They should also have a flashpoint above +21°C. The Becker Acroma range of electrostatic finishes meet all these criteria.

Thanks to developments in electrostatic equipment in recent years, this method of application can now also be used for waterborne paints and lacquers.

Units for the electrostatic application of waterborne products must be fully insulated. All paint hoses must lie on an insulated substrate, and at a good distance from earthed items.

THE RELATIVE HUMIDITY OF AMBIENT AIR
To ensure a satisfactory electrostatic effect, the ambient air should have not less than 50% relative humidity (RH).

During winter, it is especially important to add water vapour to the air in the finishing unit, via sprinklers, for example, since relative humidity can fall to 10-20% on cold days. Aim for a minimum relative humidity of 50-60%, to minimise paint loss and promote an optimum finish. It is also a good idea to humidify the air in the joinery phase of the production process, where electrostatic methods are used, to reduce the risk of wood products becoming too dry.

MEASURES TO IMPROVE ELECTROSTATIC SPRAYING
Wood's poor characteristics as a conductor of electricity present a problem when striving to create an adequate electromagnetic field for electrostatic spraying. Electrical conductivity and thereby the "wrap-around effect" can be enhanced by:

**Increasing the moisture ratio of the wood**
Different species of wood normally demonstrate different levels of conductivity. Oak and beech are better conductors of electricity than birch, due to differences in their composition.
Because of variations in the moisture ratio of the wood, it should be stored at a constant, high relative humidity. Teak, which has a low moisture content after drying, is especially difficult to paint electrostatically. However, the prospects are dramatically improved if the wood's moisture ratio can be raised to 8-10%.

**Increasing the wood's surface conductivity**
Surface conductivity can be improved by applying a special primer.
Insulated equipment
Water in particular, but acid-curing lacquers too, can be difficult to charge because of low electrical resistance. This problem can be eliminated by using an insulated electrostatic system. These systems have gained wide acceptance in recent years.

Reduced air speed in the spray booth
Air speed inside the spray booth should not exceed 0.3 m/s.

ALTERNATIVE ELECTROSTATIC SYSTEMS
- The disc or clock principle is applied in systems that equipment suppliers refer to as “pure” electrostatic systems. In such systems, a disc or clock rotates at high speed, thereby atomizing the lacquer. The resultant mist of lacquer is electrically charged by a high-voltage generator, the high voltage further atomizing the particles of lacquer. The disc or clock can be mounted vertically or horizontally, e.g. on a vertical automated unit. This type of equipment is used for automated coating of goods that are transported past one or more painting units on an overhead conveyor.
- Manual electrostatic spray guns, just like conventional spraying equipment, rely on air or high-pressure to atomize the lacquer. The particles of lacquer are then charged as they exit the nozzle. Special air nozzles, which create a spiral spray pattern, are available for certain electrostatic spray guns. This spiral effect reduces lacquer-particle velocity.

SPRAY BOOTHS
When spray painting, premises must be effectively ventilated to remove solvent emissions and other chemical substances associated with the finishing material. Spray rooms, spray booths or spray cupboards are used for manual spray painting. Although such facilities are equipped with some form of separation system for solid particles, solvent emissions have until now generally been released direct to the open air. However, efficient techniques now exist for cleaning this type of emission. Spray booths are designed according to the dry or wet separation principle. The latter is most efficient and should be used for continuous spray painting.

CHOICE OF SPRAY BOOTH
It is important to select the correct size and type. Air consumption is considerable, and the energy expended on heating this air to room temperature incurs substantial costs.

Energy recovery from exhaust air from spray booths is difficult and costly, for a variety of reasons. The best way to reduce energy consumption is to install a spray booth dimensioned for current needs, and to stop the fan when painting is not in progress.
SUCTION HOOD — EVAPORATION ZONE

Newly painted products release a range of solvent and chemical emissions, which can pollute the air breathed by workers in the paint unit. Such newly painted products are normally placed in drying trolleys. Before they are placed in the drying room or curing oven, the paint film is highly sensitive to dust and draughts. A suction hood prevents emissions from newly painted products escaping into the ambient air. The ventilation air in the hood also helps accelerate solvent evaporation.

AIR EXTRACTION FOR APPLICATION EQUIPMENT

All solvent emissions are heavier than air. The air extraction system should therefore be located near the base of application equipment, where air flows are not normally directed.

CLEANING OF/HEAT RECOVERY FROM EXHAUST AIR

In recent years, demands for the reduction or elimination of solvent emissions, combined with increasing energy costs, have resulted in the development of a range of new cleaning and heat recovery solutions for solvent-saturated exhaust air.

These are fully viable solutions, even though the initial investment cost may be high, and offer the only acceptable approach if UV-curing or waterborne paint systems cannot be used for some reason.

There are a number of different "catalytic" incinerator systems on the market, with a normal working temperature of approx. 350°C-450°C, or ceramic incinerators with working temperatures of 700°C or higher. Both types must be fed with a fairly consistent stream of solvent-saturated air to sustain the combustion process. During production stops, the incinerators must be kept up to temperature from an external power source, adding to operating costs. Such incinerators are therefore best suited to large-scale industrial production, with several shifts.

Becker Acroma, which also offers products suitable for biological cleaning, has long been a pioneer in introducing the most environment-compatible solvent-based products on the market. The majority of these products are based on ethanol and esters.

Biological cleaning of solvents can produce extremely good results, and the method is less dependent on a continuous production process. In a biological cleaning process, the solvents should be free of aromatic and aliphatic hydrocarbons if optimum results are to be achieved. Becker Acroma's specialists can contribute advice when biological cleaning is to be installed, and assist in selecting the best products for the best performance. Selecting the wrong product can have a severe impact on the micro environment, causing major disruptions in production.

Many companies choose to continue to use solvent-based coatings, and can now satisfy the related environmental requirements. Becker Acroma cooperates with leading companies that build these facilities.

AUTOMATIC SPRAYING

There are numerous types of equipment for automatic spray painting. The choice of automatic spraying unit is determined mainly by the shape and size of the items to be sprayed and, in some cases, by the type of finish selected.

AUTOMATIC STRIP SPRAY

Used for high-capacity spray coating of mouldings, fillets, wood edgings etc. The goods are transported at relatively high speed under permanently mounted spray guns.
These days, modern automatic strip sprays can be connected to high-efficiency UV-curing ovens, enabling the use of UV technology. These automatic sprays are sealed units, so no spray mist can escape. It is extremely important that these units are connected to high-efficiency cleaning filters, since UV-lacquer spray mist must not be released into the open air. Both clear lacquer and pigmented paint systems are available for this application technology, producing a full-bodied coating with the fastest and best curing.

AUTOMATIC RECIPROCATORS (TRANSVERSAL SPRAY UNITS)
In these units, the automatic spray guns pass over a horizontal conveyor. In some cases, the automatic spray guns are installed on an oval spray-gun carrier, a large wheel, a cross or a suspension device.

Automatic transversal spray units have gained wide acceptance within the wood finishing industry since, unlike curtain coating machines, they can also paint all the edges and sides of products not exceeding 100 mm in height.

An automatic transversal spray unit may comprise 2, 4, 6, 8 or more spray guns. The number of spray guns depends on the width of the unit, the speed of the conveyor and on whether the unit will need to apply different paints and stains. Considerable care must be taken when selecting spray equipment. These days, most automatic spray units are equipped with airmix spray guns. Depending on the type of finish selected and nature of the product to be coated, however, airless and conventional spray guns may also be used.

To ensure optimal paint economy, the automatic spray unit should be equipped with electro-optical sensors that detect the location of the goods to be coated. The spray pattern of the guns is determined as they are switched on/switched off as the front, rear and sides of each object on the conveyor passes the sensors.

Later models of automatic transversal spray units normally feature a solid conveyor belt, which enables overspray to be scraped off for reuse. These machines are more cost efficient to operate. They are also preferable from the environmental viewpoint. This type of spraying unit, with a paint recovery system, works best with waterborne finishes, although can also be used successfully with solvent-based lacquers where a slow-evaporating solvent can be used. The conveyor belt must still be wet when the paint is to be scraped off.

Modern automatic spray units can operate at fairly high conveyor speeds: 8 metres a minute is not unusual. Consequently, these machines have a very high throughput.

Becker Acroma has developed special solvents and cleaning systems to further improve the cost efficiency of both its waterborne and solvent-based finishing systems. The additional benefits of a solid conveyor belt include the elimination of paint loss at the rear of the machine and a still better finish on the edges of coated items.

AUTOMATIC RECIPROCATORS (VERTICAL SPRAY UNITS)
These are used for painting goods transported by a suspension conveyor. The unit features a vertical reciprocating movement. The spray unit control system is similar
to that used by transversal spray units, e.g. a frame of photoelectric cells.

The vertical automatic reciprocator is suitable for operating with electrostatic equipment. The technology to recover overspray from these vertical spray units is already available. The technique involves spraying objects transported by a solid conveyor belt, from which overspray can be recovered and reused. This method is most suitable for waterborne products. This can sharply reduce spray loss when coating small components, which can otherwise be extremely high. If the vertical reciprocator unit also comprises electrostatic spraying, spray loss will be reduced to an absolute minimum.

ROTARY SPINDLE MACHINES
Small, circular products such as knobs and handles, which are mass produced, can be painted in an automatic rotary spindle machine.

This unit consists of a large disc on which a number of rotating spindles are mounted. The objects to be painted are attached to the spindles and the disc (table) rotates, step by step, past the automatic spray guns. The spray guns are mounted in the centre of the table and face outwards, the spray mist being captured by an evacuator with paint traps. Painting is carried out on the side opposite that on which the products are either mounted on or removed from the spindles. This type of machine also functions well with electrostatic equipment.

CHAIN-ON-EDGE MACHINES
These units have rotating spindles too. Painting is normally carried out with fixed automatic spray guns. The spindles are mounted in the holes for the bolts in a long “swivel-joint” chain, placed on edge.

The space between the spindles is determined by the pitch of the chain (i.e. the spacing between the bolts), and can be as little as approx. 100 mm. This unit can also be used to paint large circular products, if they are placed intermittently on every third or fourth spindle.

TUMBLING EQUIPMENT
The use of tumbling for paint application is applied mainly to small products such as knobs, handles, balls etc.

The items are placed in a cylinder (“the tumbler”), which is suspended on a shaft at an angle of approximately 45°. The tumbler is started and a predetermined amount of paint or lacquer is sprayed or poured onto the rotating, tumbling contents. The finish must be fed into the tumbler carefully and at regular intervals, to ensure that the items are coated on every side. Curing is also carried out at intervals, while the tumbler continues to rotate.

PAINTING ROBOTS
Automated painting sometimes requires that spray guns perform more complex movements than are feasible in an automatic painting unit.
To replace a human worker effectively, the movements and “learning capacity” of a machine must correspond as closely as possible to those of a human operator. A machine equipped with a “memory”, that can be programmed and is designed to carry out a physical task, is called a robot. Robots offer an attractive alternative with respect to heavy or monotonous jobs. However, they have certain limitations where the job involves painting large numbers of items of varying shapes and sizes.

Compared with the metal-coating industry, the wood-finishing industry has a fairly limited level of robotisation. This is partly because of the large volume of plane goods, which are best suited to processing in planar production lines. The pace of development in industrial robotics is rapid, however, so that simple robots with “smart” functions will become increasingly common. We can assume that this type of robot will become common for finishing edges, milled grooves and so on. Robots are ideal for operating in environments where human operators would be at risk from spray mist or strong UV radiation.

A robot need not be static. It can be mounted on a trolley, and follow a process as it moves along an assembly line.

**CURTAIN COATING**

Next to spray painting, curtain coating is the most commonly used application technique in the wood finishing industry. It is a very fast method of application. Normal conveyor speed is between 45 and 70 metres a minute, although speeds in excess of 100 metres a minute are feasible. The method is suitable for sheets and strips (fillets, lists) that are flat or slightly contoured in one direction.

If the products are placed at an angle on the conveyor belt (passing through the curtain like a plough), two straight edges can be coated simultaneously.

Despite its considerable coating capacity, a curtain coater can be just as suitable for coating relatively small numbers of products. The high production capacity of a well cared-for machine more than compensates for the time spent on startup and cleaning.

The amount of finish applied, which can vary from 70 to 300 g/m², can be regulated by a combination of the following factors:

- the viscosity of the finish. Thin finish runs through the jaws faster than a viscous finish. Normally 20-50 seconds. (DIN 4)
- the setting of the slot opening in the curtain head.
- the speed of the conveyor belt (20-150 metres a minute)
- The amount of finish pumped to the curtain head (determined by the pressure in the curtain head, controlled by adjusting pump speed or by throttling the flow from the pump).

In a line finishing process, it is essential to be able to swap curtain units rapidly to avoid production downtime when changing finishes, or in the event of a breakdown. There should therefore be two or more curtain units for these machines.

A number of new variants of curtain coating machines have been developed in recent years. One such variant is a curtain coater with a completely open head, in
which the finish runs over an edge and then onto the products that are to be coated. This machine is recommended when applying finish that is sensitive to blistering. Another way to avoid blistering is to use a special cogwheel pump, which ensures more uniform flow, and avoids the risk of air being “whipped in” during pumping.

To further improve the result, use a cartridge filter instead of a plane filter: the paint will be more efficiently de-aerated, as it is forced through the cartridge filter’s considerably larger filter area. Another curtain coating variant combines the properties of both roller and curtain coating machines. The roller curtain coating machine can apply less paint than a conventional curtain coater. It is specially suited for applying UV lacquers to rounded or contoured items.

**ROLLER COATING**

Roller coating is a rapid, simple and cost-efficient way of coating flat products. New systems for transferring finish from the rollers to the object to be coated have yielded excellent results. It has proved possible to increase the amount of finish applied, and the method can now even be used to achieve a premium quality topcoat. New rubber grades ensure that the rollers can withstand powerful solvents. They can also be manufactured with enough resilience to tolerate limited irregularities in the items to be coated.

**ROLLER STAINING**

A roller staining machine can stain large quantities of flat wood products rapidly and efficiently. This application technique offers several advantages — uniform staining, ease of integration into a finishing line, limited stain consumption and extremely high capacity.

The products are transported on rollers or a conveyor belt and are pressed against the application roller, which is clad in a layer of porous rubber (“moose” rubber). The circulation pumping system feeds stain to the roller. The amount is regulated partly by means of a dispenser roller, which presses against the rubber roller, and partly by contact pressure between the application roller and the wood product. The porosity of the rubber plays a decisive role and is graded accordingly: BY-1, BY-2 and BY-3. BY-3 is the most porous and therefore delivers the most stain. BY-2 is the most commonly used roller rubber.

The hardness of stain rollers is indicated by a Shore number (based on the Shore hardness test). The normal rating is approximately 20 Shore.

Roller stains must be matched for type of application roller, required stain effect and colour intensity.

Since rubber can be sensitive to certain solvents, especially aromatic hydrocarbons, it is important that stain solutions, thinner and cleaning liquids are approved for use with the specific rubber roller.

Becker Acroma’s roller stains and thinners are specially formulated to avoid damaging the roller rubber. The solvents contained in roller stains are volatile. Consequently, the colours darken unless new solvent is added during the process. This colour change often goes unnoticed. It is therefore a good idea to check the colour following breaks and downtime and, if necessary, dilute the stain.
SINGLE-ROLLER MACHINE WITH SYNCHRONIZED APPLICATION ROLLER
The illustration shows a single-roller coating machine, equipped with a synchronized application roller.

The lacquer is pumped out between the dispenser and application rollers. The amount of finish applied varies from 10 to 40 g/m². Single-roller coating always results in corrugated trace patterns. The hardness of the roller rubber is indicated by a Shore number. This type of roller is normally covered in rubber rated at 50 Shore.

“RELATIVE PROCESS” ROLLER APPLICATION
In this case, the dispenser roller (steel roller) is a counter-rotating roller. The application roller can have a slightly lower peripheral speed than the conveyor belt. The higher speed of the items on the conveyor means that the application roller lags behind somewhat, with a consequent “glazing” effect.

When applying lacquer by “relative process”, the amount applied can be increased with much less risk of corrugated trace patterns. With the “relative process”, the amount of lacquer applied can be very precisely regulated by adjusting the speed of the dispenser roller. High speed means low lacquer consumption.

The applied amount can vary from 2 to 30 g/m².

The speeds of conveyor belt, dispenser roller and application roller must be individually adjustable.

In the “relative process”, the doctor-blade must be pressed against the dispenser roller (steel roller).

Nowadays, most doctor-blades are made of plastic, leading to fewer problems when used over long periods. Steel doctor-blades eventually become razor-sharp, at which point sections of the edges can break away, causing lines. These lines are then visible in the lacquered finish.

ROLLER COATING WITH REVERSIBLE ROLLERS
The method involves a twin-roller technique. The rotation of the first application roller is synchronized with the direction of the conveyor belt, while the second rotates in the opposite direction. This technique produces a very smooth finish, but demands considerable machine skills and constant attention.

Reversible rollers permit the application of as much as 80 g/m² of lacquer, without risk of corrugated trace patterns. A very smooth substrate and constant monitoring of the machine are essential, if the benefits of this technique are to be derived in full.

ROLLER COATING BY APPLYING FILLER WITH A GLAZING ROLLER
This roller coating machine is built along the same lines as the single-roller
machine with synchronized application roller described above. It is also equipped
with an adjacent steel glazing roller, as well as a counter-pressure roller fitted
beneath the conveyor.

The filling process involves applying filler generously, with the help of the syn-
chronized rubber-clad roller. The workpiece is then processed by the counter-rota-
ting steel glazing roller, which removes any surplus and presses the filler into every
joint and surface defect.

Thanks to the way modern UV-fillers are formulated, they seldom present a pro-
blem when drilling holes or dressing edges. This coating technique ensures very thoroughly filled and very smooth surfaces. This reduces raw material loss from excess sanding, which would otherwise be required to achieve a satisfactory substrate for a primer and sealer.

Filling has also proved economical, in that it provides a smooth and defect-free primer base at low cost.

Heavy filler coating machines are best suited for processing chipboard and similar materials, while light filler coating machines are recommended for MDF board and veneers.

New pumpable fillers are now also available, which can be pumped with a diaphragm-pump, and which are adapted for the application of primer and filler. The technique offers significant benefits in the production of veneers, ensuring efficient filling of joints between veneer panels.

UV fillers have made great advances in the panel-furniture industry, with respect both to clear-lacquer and pigmented production. Filling now offers a competitive alternative to paper-coated and melamine-coated panels.

OPTI-ROLLER COATING

Opti-roller coating (as named by Bürkle) is a technique used in particular for applying UV-curing finishing lacquers.

The surface of the application roller is threaded with small grooves which rupture surface tension in the finishing lacquer, to produce a completely smooth film. The Opti-roller technique for applying clear lacquers and pigmented systems on a UV-curing base produces results that are fully comparable with curtain-coated and spray-coated finishes.

The Opti-roller method is an excellent way of applying large quantities of lacquer and achieving a smooth finish. With smooth rollers, it is difficult to apply more than 8-10 g/m² if a smooth finish is required. With larger quantities, the surface will become corrugated or stippled, due to surface tension.

The Opti-roller has a very fine thread scored in the surface. It is the crown of this thread that ruptures the surface tension, ensuring that the lacquer lies much flatter – more smoothly – against the substrate.

At present, engineers are attempting to develop rollers that combine high resilience and high durability, which can be pressed hard against the substrate and thereby create a vacuum which presses out the lacquer into a smooth film.

This technique also reduces the number of machines required in a coating line, which means that they can be built shorter.
The technique has been developed for pigmented UV lacquers, and produces finishes that offer the same high resistance and with properties that compare favourably with spray-coated or curtain-coated finishes.

It can be used equally successfully with clear lacquers, primers and sealers. The development engineers have also come up with Opti-rollers clad in very resilient rubber, rated at 20-25 Shore. These are highly tolerant of uneven board products, and have also proved more durable.

**Vacuum Coating**

Vacuum coating is an extremely rapid technique for applying paint and lacquer. The entire workpiece is drenched in paint or lacquer, after which it is subjected to a partial vacuum until enough paint/lacquer has been sucked from the substrate to leave the desired film thickness. One disadvantage is the difference in the amount of finish applied to the front and rear of the individual workpiece. However, the method is well suited to tasks such as coating strip, fillets or mouldings by the metre. Specially developed waterborne products are available for vacuum coating. Oil-based and UV-curing products are also suitable for vacuum application.

**Dip Coating**

Dip coating is an effective technique that is suitable for many different products.

There are two basic approaches. The first is geared to achieving as thick a film as possible. The products are dipped very slowly in a dipping bath containing high-viscosity lacquer. The method is common in the general implements industry (spade handles, baseball bats etc.).

The second approach involves dipping in thin solutions. This is suitable for staining, priming and even for applying sealer/topcoat to, for example, machined components.

Because of the considerable risks associated with exposure to solvent emissions, waterborne products only are recommended for manual dipping. The dipping bath should always be of plastic or stainless steel.

Contact Becker Acroma for advice on choosing the most appropriate dipping lacquer.

**Flow Coating**

“Flow coating” is gaining increasing acceptance. This is partly due to an increase in the popularity of stained wood products, especially pine, partly to the development of environmentally safe waterborne stains.

All sides of the workpieces are stained in a single pass through the machine. The machine consists of a tunnel, through which the workpieces are transported by a net conveyor with raised facings. The workpieces can also be transported by a knife roller conveyor, which passes through a spray zone where stain is applied via a diaphragm pump from nozzles located above and below the conveyor. Surplus stain on the surface, in cavities and accumulated in the milled contours of products is removed by an air jet on emerging from the tunnel.

This process, which may involve one or more stages, is activated from above and below. Surplus stain from the spray zone and air jet zone is led back to the stain vat for recovery and filtering, to be pumped back later and reused.

The method is not suitable for use with solvent-based stains because of solvent-evaporation during atomization and circulation pumping.
DRYING AND CURING

Drying lacquers at room temperature normally takes a long time. This allows solvent emissions to spread, and results in unnecessarily high environmental impact. This method also demands more storage space.

The best way to accelerate drying and at the same time reduce the occupational hazards posed by solvent emissions is to ensure that the process is “sealed” as far as possible. It has also been demonstrated that curing at increased temperatures enhances the properties of the finish.

THERMALLY ACCELERATED DRYING AND CURING

The application of heat can sharply reduce curing times for several types of lacquer. Curing time for an acid-curing lacquer, for example, is halved in proportion to every ten-degree increase in temperature. Really brief curing times are attainable at surface temperatures in excess if 50°C. Accelerated drying can cut curing times for a whole range of different lacquers, from waterborne systems to polyester systems and NC-modified PU-systems.

HEAT TRANSFER

The heat applied to the film of lacquer to accelerate curing may be transferred in several ways:

- **BY CONVECTION:**
  The surface-treated goods are heated by circulating hot air through a room or by transporting them through a tunnel equipped with circulating hot-air.

  The heat generated by domestic radiators is mainly in the form of “free” convection, when air circulates in the room. Go one step further and add a fan, to force air past a radiator (as in an Aerotemper), and the result is forced convection. This accelerates the heating process, with maximum heat transfer achieved at air velocities of 15 m/sec.

- **BY RADIATION**
  Energy is generated electromagnetically. When the radiation strikes a surface it is absorbed and converted into heat. Infra-red (IR) radiation is a typical example. The distance between the radiation source and the object to be heated is crucially important. Only those sides which face the radiation source become heated. Compare with solar radiation or thermal radiation from an open fire.

  IR-radiation is subdivided into short-wave, medium-wave and long-wave radiation.

- **BY CONDUCTION**
  In the furniture industry, conduction heat is used to pre-heat the products in convection or radiation ovens. The film of lacquer is then heated by the substrate, causing rapid evaporation of the solvents, and the curing process starts.
CHAMBER DRIERS AND DRYING ROOMS

In chamber driers and drying rooms, the lacquered goods are wheeled in on trolleys, placed on trestles or on the floor. This type of drying unit is most appropriate for small industrial operations with very mixed production.

TUNNEL DRIERS

Tunnel driers, which may be described as a further development of a drying room, consist of a tunnel. The lacquered goods are transported through this tunnel on trolleys, stands or suspended from an overhead conveyor. Tunnel driers are normally organized into different temperature zones. Starting at 20°C, the temperature increases from zone to zone, rising to a maximum of 70-80°C. A cooling zone, which uses air at the prevailing outdoor temperature to cool the goods, is normally placed at the end of the tunnel. Most tunnel driers are equipped with some form of drive chain, to move the drier trolleys through the tunnel.

VERTICAL DRIERS

The vertical drier has become an increasingly popular solution in recent years. This is partly because it is extremely compact compared to other driers. The vertical drier can easily be combined with other driers and with automated spray units. It offers low energy consumption, an extremely favourable drying curve for lacquers and is especially appropriate for waterborne lacquers. It can also easily be combined with various forms of combustion- or catalytic cleaning systems. The lacquered goods are fed into the drier on transporters, after which they are moved vertically, on pallets, through the drier. The drier can simply be divided into different temperature zones. The speed at which the air circulates is also simple to adjust. Maximum temperature can be varied, although 50°-70°C is most common.

FLAT DRIERS

Flat driers feature a through conveyor for continuous curing of lacquers at increased temperatures. A finishing line often utilises all forms of heat transfer (convection, radiation and conduction). Extremely short curing times can be obtained with driers equipped with medium-wave (IRM) or short-wave (IRS) IR-curing units. Modern finishing lines are often equipped with pre-heating driers, which heat the goods to accelerate solvent evaporation and thereby the curing process. Flat driers are used mainly for flat goods but, when combined with new types of transversal automatic spraying units, they can now also be used for composite items of furniture such as bed ends, slatted doors etc. Special stain driers have been developed for stained goods, in which the drier and the pre-heating drier normally comprise a single unit, since staining is carried out prior to clear lacquering.

Flat goods should not normally be stacked at temperatures in excess of 35°C (polyesters and acid-curing finishes) or 25°C for waterborne, NC or PU finishes.

Nozzle-cooling zones, in which air is forced at high velocity through narrow slots or nozzles onto the surface of the goods, are a favoured way of cooling the goods. Flat driers are normally combined with application and sanding equipment to form complete finishing lines.
**SPEED OVENS**

Modern flat driers have been further modified to accelerate evaporation of water from waterborne lacquers: speedy removal of water reduces swelling and fibre raising in the substrate. In these “Speed ovens”, the air is forced through nozzles directly onto the newly lacquered goods. Older (“laminar air flow”) driers merely swept a stream of air over the goods. In the new Speed ovens, the speed of the air forced onto the goods is stringently regulated by frequency-controlled motors. Normally, the “airspeed” in the initial section is low, while the latter section can feature very high airspeeds (>15 m/sec). The latter section is also equipped with IR lamps, placed between the nozzles (“combi-ovens”). A number of equipment suppliers sell IR lamps that feature a longer wave-length than traditional IRM lamps, as these have proved more effective at removing water from the surface. Suppliers recommend that IRM lamps are equipped with adjustable controls, however, to regulate the amount of radiation.

Progress in curing waterborne products in modern Speed ovens has also had a spin-off effect, now that it is clear that this type of oven also speeds curing of solvent-borne lacquers. Since solvent evaporates very quickly, the curing process starts very early. These curing ovens can also be complemented with a UV unit for final curing of waterborne lacquers.

**UV-CURING OVENS**

The term “UV-curing ovens” refers to curing ovens in which UV-reactive materials are cured by radiating them with ultraviolet light. This produces very brief curing times. UV lamps may be mercury-vapour lamps, which are most appropriate for clear lacquers, or gallium lamps, which are necessary for curing paints.

The power and wave-lengths of lamps may vary. The quality and light-intensity of the lamps must be checked regularly, to ensure that production equipment that operates on a daily basis can maintain consistent production and good curing results. The lamps must also be cleaned regularly, at least once a week.

With UV-curing, there is normally no need to preheat the substrate or build evaporation or cooling zones. Consequently, finishing lines that include a UV-curing unit can be made much shorter and much more energy-efficient than lines of corresponding capacity that feature conventional ovens. Old-style UV lamps generate more IR- than UV radiation. This also has a bearing on the stacking temperature of the goods.

Every industrial operation that uses UV-radiation equipment should have access to metering equipment to control its process function, to ensure that complete curing is always achieved.
The furniture industry is constantly demanding ever finer and more beautiful finishes. This development is perhaps best illustrated by comparing the different types of sanding material used for final sanding. About ten years ago, final sanding was carried out using material with a grain size of 400-500. Today, the industry is using grain sizes down to a superfine 1000 grade to obtain the specified high gloss finish.

There are two primary reasons for sanding: to create the best possible surface, by removing raised fibres, burls, excess lacquer and any surface defects; and to ensure good adhesion between different coats of lacquer.

Generally speaking, sanding includes the sanding of filler, primer or sealer. Finishing (application of lacquer and numerous sanding stages) should be conducted on the same day as fine sanding of the wood substrate, or at least as soon as possible, to protect workpieces from dirt and to inhibit raised fibres caused by the absorption of atmospheric moisture. Ideally, the finishing line should be directly adjacent to the wood fine-sanding unit.

When using two-pack acid-curing lacquers, sanding of the lacquer must be conducted on the same day/same shift as the next stage in the finishing process, if adhesion problems are to be avoided.

Well sanded wood, meticulously cleaned workpieces and uniform application of primer reduces the need for subsequent sanding of the lacquer to remove surface defects. An additional benefit is reduced cost, thanks to reduced lacquer consumption and fewer rejects.

Workpieces that are completely clean are essential to ensure correct lacquering, and antistatic sanders form the basis of a thoroughly dust-free process.

Care in fine-sanding the wood substrate and thorough inspection prior to finishing always pay dividends.

There is a general misconception that defects and damage incurred during the finishing process can be repaired. Rather the reverse, in fact. However excellent the finishing material, it can never compensate for poor fine-sanding of the wood or for a standard substrate.

If the sanding is not fine enough, the lacquer cannot fill the scratches left by sanding. This will result in a “thin” surface. The most common defects on newly finished furniture are sanding scratches, “thin” surfaces and sections where the lacquer has “run”.

Sanding the wood is designed to ensure that the lacquer adheres well to the substrate. The entire surface must therefore be sanded clean. Most modern lacquers are not especially sensitive to solvents, making sanding between coats essential to achieve satisfactory adhesion.

The way lacquers are applied, dried and cured is what determines the actual service life of sanding tools. Sanding poorly dried workpieces, or workpieces with excess lacquer, can clog the sanding medium and thereby reduce the service life of the sanding belt.

The way the lacquer is sanded has a decisive effect on the quality of the final finish. It is important to ensure that no scratches or sanding patterns arise in con-
nection with sanding. A clogged sanding medium can destroy an otherwise good finish.

When staining, uniform sanding of the wood is important to ensure that the stained colour appears consistent and uniform. Cutter marks in the surface can, for example, result in lighter-coloured lateral streaks on the “peaks” of the workpiece, where sanding has removed the stain.

These cutter marks absorb varying amounts of stain and thereby enhance the uneven impression given by the workpiece’s surface. This type of surface defect remains visible even after clear lacquering and top coating.

Sanding lacquer with a broad-belt sander demands a special technique. This requires a correctly adjusted sander with variable belt speed, low belt tension and a pliable sanding shoe.

As in wood sanding, using a cross-sanding unit on the primer improves the final finish.

The belt speed should be low when sanding any type of lacquer: less than 12 m/sec and adjustable down to 1 m/sec, according to type of lacquer and curing stage. Fully cured and hard polyester lacquer can quite safely be sanded at 12 m/sec. The fresher the film of lacquer, the more belt speed must be reduced.

Sanding two-pack and UV-lacquers is a relatively simple process. Thermoplastic and waterborne lacquers, however, are often more difficult to sand. One possible approach which can prevent problems arising is to keep the sanding belt at a very low speed, adapting it to the predetermined feed-speed of the production line.

Where possible, the sanding belt should run counter to the direction of the feed conveyor, to ensure a finish that is satisfactory in every respect. This is as important when sanding lacquer as when sanding wood.

Grain size is determined by several factors. Silicon carbide is still the most popular choice for intermediate sanding of lacquers. It produces the finest finish thanks to the shape of the silicon carbide grain. A surface finish of this quality is sometimes necessary prior to applying a topcoat, such as in the case of high-gloss paints, especially in darker colours, or in cases where the topcoat will be polished to a high gloss.

A good alternative for intermediate sanding is the corundum grain. Its pointed, sharp-edged form ensures less glazing, less friction and reduced temperature fluctuation. The reason is that a somewhat lower sanding pressure and belt speed is common when using corundum compared to silicon carbide sanding belts. This often increases the service life of the sanding belt. Corundum produces slightly deeper surface scoring than silicon carbide.

Corundum is often the best solution, for waterborne lacquers in particular and for thermoplastic lacquers in general. When waterborne lacquers are used, a well-sanded wood surface is even more crucial to the quality of the final finish than when using conventional lacquering systems.
TROUBLESHOOTING

ORANGE PEEL

Cause:
- Use of insufficient or incorrect thinner.
- Excessive temperature difference between the surface to be lacquered and the lacquer.
- Incorrect spray pressure or the spray gun has been held at the wrong distance from the surface.
- Excessive air circulation (draught) in the spray and drying areas.
- Lacquer too cold.

Solution:
- Sand down the defective surface.
- Remedy defects as described above.
- If necessary, change to slower-acting thinner.

“SPLITTING” DURING CURTAIN COATING

Cause:
- Excessive air supply, which causes bubbles and foam formation.
- Lacquer has incorrect surface tension.

Solution:
- Reduce the drop height of the curtain.
- Check that the paint groove in the curtain head is in position.
- Check that the splash plate in the return tank is in position.
- Ensure there is nothing that can obstruct smooth paint circulation.
- Remove bubbles and foam by, for example, using a stocking as a filter at the outlet.
- Ensure that the curtain head is filled and that lacquer runs smoothly through an overflow valve.
- Ensure there is no pump leakage which can inject air into the lacquer.
- Contact Becker Acroma for advice.

BUBBLE FORMATION

Cause:
- Leakage in the spray gun channels or in the suction hose for the high-pressure spray.
- Use of incorrect thinner.
- Air from the substrate.
- Curing temperature too high.
- Air in the lacquer film, due to poorly adjusted curtain coater.

Solution:
- Check spray equipment or curtain coater settings.
- Contact Becker Acroma if you cannot trace the cause of the defect.

BUBBLE FORMING DURING DRYING

Cause:
- Temperature too high or air velocity too high in the evaporation zone.
- Setting time between application of lacquer and temperature increase in the curing zones is too short.
- Unsuitable combination of solvents. The lacquer film sets before slower solvents have evaporated.

Solution:
- Reduce the temperature in the evaporation zone.
Extend setting time by, for example, lowering the speed of the conveyor belt.

Many bubble problems connected with drying can be remedied by choosing the right solvent.

CELL FORMATION ON MATT LACQUER

Cause:
- Application of excessively diluted lacquer.
- Application of too much lacquer.
- Some dust may be statically charged.
- Very high atmospheric humidity.

Solution:
- Dilute as specified in instructions.
- De-ionize.

POOR DRYING AND THROUGH-CURING

Cause:
- Curing is incomplete because the temperature was too low or the belt speed too high.
- Temperature too low during the night.
- Temperature too low during preheating or during curing.
- Incorrect quantity of hardener used.
- In the case of a PU-lacquer, the hardener may have been affected by moisture.

Solution:
- Check throughput times and curing temperatures. Remedy any temperature variations, since low surface temperatures delay the curing of the finish.
- Check the surface temperature of the workpieces after the preheating, evaporation, drying and cooling zones. Low speeds and a limited air-change rate result in poor heat transfer to the workpieces and excess solvent content.
- Check the air-change rate and air circulation in the curing oven. Fans in all the oven and cooling zones must function satisfactorily, and filters must not be clogged.
- Check that the correct quantity of hardener has been added to two-pack finishes. Too much hardener can result in a temporarily softer film. Check the hardening of the lacquer film by scraping it with your nail or a coin.

GREY PATCHES

Cause:
- Priming has failed to wet the bottom of the pores.
- Substances in the wood have rejected the lacquer coat (common when using polyester lacquer, for example).
- The lacquer used was subject to high shrinkage.
- Too much moisture. In or on the wood substrate, or in the ambient air.

Solution:
- Use priming lacquer with good wetting properties.
- Use a coat of sealer on substrates such as teak, palisander, etc.
- Seal with urethane lacquer prior to applying a polyester finish.
- Remove the source of moisture or use a thinner specially tailored to these conditions.
PINHOLING

Cause:
- Insufficient and excessively dry spraying of substrate.
- Excessive application at high temperature or on heated substrate.
- The substrate (fibreboard, chipboard etc.) may be porous.
- Incorrect thinning.

Solution:
- Rub down the defective surface.
- Check the viscosity of the finish.
- If necessary, use a slower thinner.
- Introduce other changes/measures to inhibit pinholing.

EDGE RUN

Cause:
- Transport speed too high when operating curtain (excessive air movement).
- Wrong thinner has been used in the lacquer.

Solution:
- Always contact Becker Acroma.

VARIATIONS IN TONE AND GLOSS

Cause:
- The jaws of the curtain coater, or the rollers of the roller coater, are not parallel, resulting in uneven application.
- Uneven overlap when spraying.
- Variations in the quantity of finish applied.
- Different types of thinner have been used in applications.
- The temperature of the finish was too low on application.
- The temperature of the substrate was too high after preheating.
- “Aged” lacquer mixtures.
- The substrate is defective or absorbs unevenly after sand-through of sealer.

Solution:
- Adjust slot gap. In some cases, you will have to grind or replace the jaws.
- Check nozzle and spray gun settings.
- Check the viscosity and speed of the conveyor belt.
- Warm the lacquer prior to application. It should be at a temperature of no less than 20°C.
- Reduce the surface temperature of the goods.

LIFELESS STAINED PATTERN

Cause:
- High pigment content in stain solution.
- Stain solution has not penetrated the pores (no contrast).
- Excessive spray pressure (dry spraying).

Solution:
- Mechanical after-treatment of the wet film with, for example, a roller brush.
- Change to a stain with a lower pigment content.

LIFTING OR FIBRE RAISING

Cause:
- Application of excessively thick topcoat.
- Topcoat applied before underlying coat is fully cured.
Unsuitable combination of primer and topcoat (can also apply to pretreated substrate).

The products have been too tightly stacked during drying, or air-circulation in the drying area was inadequate.

Solution:
- Rub down to clean wood surface.
- Contact Becker Acroma if unable to determine the cause of the defect.

**MATT PATCHES**

**Cause:**
- Bubbles that have burst too late leave matt patches. This occurs most often with curtain coating.

**Solution:**
- Reduce bubble formation in the curtain coater.
- If necessary, use a slower thinner.
- Contact Becker Acroma.

**DISCOLOURATION OF FINISH OR SUBSTRATE**

**Cause:**
- When resinous redwood is finished in an acid-curing clear lacquer, the resin may migrate to the surface after extended storage or if stored in direct sunlight. NB: Certain types of rapid-growing redwood are always discoloured by acid-curing lacquers.
- Excessive dosing of hardener.
- The mix has become discoloured after storage in a tin (Clear lacquers turn brown or black. White lacquers turn pink).

**Solution:**
- Sand products prior to lacquering. Avoid storage between woodworking and lacquering, and in hot, bright premises. Cover the products with black plastic.
- Carefully check the amount of hardener added. Use an accurate measure.
- Always store acid-curing lacquer mixtures in containers of stainless steel or polyethylene. Pump parts and agitators must also be made of stainless steel.

**PINHOLING ON COARSE-GRAINED VENEERS**

**Cause:**
- The primer is absorbed by the veneer, resulting in unfilled pores.
- The topcoat cannot fill the pores.
- The primer is dissolved by the topcoat.
- Roller application (pore filling) with rapid-curing, full primer lacquer (SH or UV), which is not dissolved by the subsequent topcoat.

**Solution:**
- Use another primer.

**UNEVEN FILM, “STREAKY” FINISH**

**Cause:**
- Incorrect spray gun settings, defects or impurities in the spray nozzles can produce a “streaky” finish.
- Conveyor belt speed not synchronized with spray guns’ transversal speed.

**Solution:**
- Check and adjust spray gun settings. Check and clean spray nozzles. Check spray guns’ relative placement. Check spray cone for each spray gun.
- Synchronize the spray guns’ movements with the speed of the conveyor belt.
IMPURITIES IN THE FILM

Cause:
- These are usually lacquer residues from pressure container hoses etc., which are dissolved when the lacquer is changed.
- Dust particles which have fallen into the wet film of lacquer, due to static electricity.
- Polluted compressed air, due to neglected maintenance of air filter.

Solution:
- Careful cleaning of spray equipment or curtain coater with a high solvent-power thinner. If necessary, hoses should be replaced.

IRREGULARITIES WHEN STAINING

Cause:
- Too much stain applied.
- First application of lacquer dissolves film of stain.
- Incorrect priming.

Solution:
- Use a stain solution which is not dissolved by the subsequent primer.
- Use a sealer after staining.

RUNS OR SAGS

Cause:
- Applied lacquer is too runny.
- Lacquer viscosity is too low.
- Spray distance is too short or, alternatively, the spray gun is incorrectly angled to the surface, leading to surplus lacquer where the spray jet is closest to the surface of the object.
- The nozzle of the spray gun may be defective, producing an incorrect spray pattern.
- The thinner used evaporates too slowly.

Solution:
- Check viscosity. If necessary, select a faster thinner.
- Reduce supply of finish or increase spray rate.
- Check spray gun nozzle and spray pattern.

WRINKLING

Cause:
- Lacquer has been applied far too thick.
- Use of incorrect thinner.
- Solvents evaporate too slowly during drying.
- Unsuitable combination of primer and topcoat.

Solution:
- Rub down defective surfaces.
- Reduce quantity of lacquer applied.
- If necessary, replace thinner.
- Increase spacing between products in the drying stands and between individual drying stands.

SILICONE PROBLEMS

These appear in the form of “fisheyes” or, in severe cases, as creepage on the wet film of lacquer.

Cause:
- Lacquered products have been contaminated by silicone from lubricants, compressed air or hand creams.
Solution:
- If the source of contamination is on the premises, they must be cleaned thoroughly.
- Call Becker Acroma's engineers immediately for advice.

SINKING IN (MATT PATCHES)

Cause:
- The finish is absorbed into the surfacer or filler.
- The topcoat is sprayed on before the primer has dried completely.

Solution:
- Change to denser surfacer or filler.
- If necessary, increase the quantity applied.
- Allow the surfacer to dry out before applying topcoat.

PEELING

This defect does not normally appear until the film of lacquer has been thoroughly cured. Adhesion between films of lacquer is poor, and they separate from each other.

Cause:
- Some foils are unsuitable for lacquering without hard sanding.
- Poor or no sanding between applications of lacquer.
- Too much time has passed between sanding and lacquering.
- Spraying has been too dry, insufficient, or the wrong thinner has been used.
- Too much hardener has been added.
- Use of an “old” lacquer mix.

Solution:
- Implement the appropriate countermeasures.

SWEATING

This defect appears as matt patches on cured surfaces.

Cause:
- Too much acid hardener.

Solution:
- Carefully measure amount of hardener to be added.
- Agitate the lacquer mix.

SWEATING (COATING)

Cause:
- Paraffin or wax in the substrate (e.g. chipboard).
- Acid-sensitive substances in the priming process.
- Too much acid hardener.

Solution:
- Carefully measure amount of hardener to be added.
- Always contact Becker Acroma.

BLUSHING

Cause:
- Spraying in very moist weather, with excessive relative humidity. This applies primarily to cellulose-based lacquers, or lacquers featuring a high aromatic solvent content.
- Use of unsuitable thinner.
- Moist substrate (e.g. after application of waterborne stain).

Solution:
- Change to slower thinner.
- Ensure that substrate is dry.
SURFACE FINISHING 
AND ECONOMY

When comparing the cost of different finishing systems, you must take several factors into account: type of product, the product’s dry content, density, dilution curve etc. We should here like to highlight a few factors to keep in mind when analysing your surface finishing requirement.

PRODUCTION TIME
How can you achieve the desired result in the minimum of time with different lacquers? This may mean faster drying times, fewer coats, faster paint changes etc.

SUBSTRATE
Choosing the correct substrate and the most appropriate pretreatment will save primer. This will improve total economy.

COATING EQUIPMENT
The efficiency of different types of coating equipment can vary considerably. Avoid conventional spray coating if airmix spraying is available and, when coating components, use a curtain coater or roller coater in preference to automatic spray booths.

SANDABILITY
Good sandability extends the useful life of sandpaper. This can have a major impact on total economy. A lacquer system which makes sanding unnecessary means ever greater savings.

POT LIFE
A lacquer with a short pot life can often lead to substantial lacquer loss. Always mix the right quantity: there’s money to be saved here! Finishing equipment that includes a recycling system is usually a good investment.

ENERGY COSTS
Investment in systems that feature low energy consumption can generate major savings. This may involve the energy requirement for the curing process alone, or the ventilation requirement associated with different types of lacquer. Radiation-curing lacquers (e.g UV lacquers) normally require less energy than other types of reaction-curing lacquers. Low solvent-content finishes demand less energy in the form of ventilation systems, etc.

CLEANING
Paint changes that involve a long and comprehensive cleaning process take time, and often require expensive cleaning fluids.

EMISSIONS REGULATIONS
Ever tougher emissions regulations require that users adopt a clearer policy on the types of lacquers they mean to use. In future, it will be impossible to use solvent-based systems without some form of cleaning system. Solutions based on low-solvent or solvent-free systems will therefore become highly competitive.
INSURANCE COSTS

Savings can be made here, both with respect to production and storage, if a solvent-free, non-flammable system is used.

REDUCED COST OF PREMISES

Production based on solvent-free systems (e.g. waterborne or 100% UV-curing systems) requires no separate production facilities for finishing and other production processes. Once again, this means savings.

These are just some examples of factors affecting your total finishing cost. To accurately determine your total finishing cost, you must know how to calculate it correctly. Generally speaking, you can never hope to achieve an accurate evaluation of two different types of lacquer if you merely compare them on the basis of price per litre or kilo. To assess costs correctly, you must always break them down into cost per square metre of finished surface. To calculate this effectively, you must have some fundamental data:

- The lacquer or finisher’s mix ratio.
- The price of the finish per litre.
- The density of the finish.
- The solid content of the finish.
- The amount of finish applied in g/m².

The following example illustrates how the finishing cost can vary if you base your calculation on finishing cost per square metre as opposed to price per litre. In this example, we have chosen an NC-lacquer applied in a thickness of 120 g/m², and compared it with a waterborne lacquer and a UV-lacquer. All three examples have one factor in common: they contain the same dry content per square metre.

<table>
<thead>
<tr>
<th>NC CLEAR LACQUER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price/Litre, US$</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Lacquer</td>
</tr>
<tr>
<td>Thinner</td>
</tr>
<tr>
<td>Volume, litres</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Lacquer</td>
</tr>
<tr>
<td>Thinner</td>
</tr>
</tbody>
</table>

Price per litre mixed finish: 33,29/13,0 = 2.56US$
Price per kilo mixed finish: 33,29/11,49 = 2.90US$
Price per square metre, applied at 120 g/m²: 0.120 x 2.90 = 0.35US$
Solid content of finish by weight: 2.52/11.49 x 100 = 22%
Dry film by weight/gram: 120 x 0.22 = 26
These examples give the cost of lacquer per square metre in a direct comparison between three different finishing systems. For a complete cost analysis, additional costs such as cleaning thinners must be included among the above mentioned costs.

**WATERBORNE CLEAR LACQUER**

<table>
<thead>
<tr>
<th>Price/litre, US$</th>
<th>Solid content (weight)</th>
<th>Density</th>
<th>Mix ratio, by volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacquer</td>
<td>3.90</td>
<td>37%</td>
<td>1.04</td>
</tr>
<tr>
<td>Water</td>
<td>–</td>
<td>–</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Volume, litres</strong></td>
<td><strong>Weight, kg</strong></td>
<td><strong>Weight, non-volatile</strong></td>
<td><strong>Price, US$</strong></td>
</tr>
<tr>
<td>Lacquer</td>
<td>10.0</td>
<td>10.4</td>
<td>3.85</td>
</tr>
<tr>
<td>Water</td>
<td>0.4</td>
<td>0.4</td>
<td>–</td>
</tr>
</tbody>
</table>

Price per litre mixed finish: 39.00/10.4 = 3.75US$
Price per kilo mixed finish: 39.00/10.8 = 3.61US$
Price per square metre, applied at 74 g/m²: 0.074 x 3.61 = 0.27US$
Solid content of finish by weight: 3.85/10.8 x 100 = 35.6%
Dry film by weight/gram: 74 x 0.356 = 26

**SOLVENT-FREE UV-CURING LACQUER**

<table>
<thead>
<tr>
<th>Price/litre, US$</th>
<th>Solid content (weight)</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lacquer</td>
<td>15.50</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.28</td>
</tr>
</tbody>
</table>

Price per kilo mixed finish: 15.50/1.28 = 12.11US$
Price per square metre, applied at 26 g/m²: 0.026 x 12.11 = 0.31US$
Dry film by weight/gram: 26 x 1.00 = 26

Once you have completed your total cost analysis, you can determine which lacquer system or systems are the most economical. Becker Acroma will be pleased to help you obtain the necessary data for a realistic cost analysis.
Paints and lacquers have many positive properties. They engage our senses, they broaden our aesthetic perceptions and they create an attractive environment. In wood finishing, their primary function is to protect the substrate, simplify cleaning and thereby extend the life of the individual product. By handling paints and lacquers in a correct and safe manner, and by employing finishing techniques that minimise environmental impact, we create a safer and cleaner work environment and ensure a better external environment.

**WORK ENVIRONMENT**

When working with paint and lacquers, a user can be exposed in various ways to potential health risks.

- **Inhalation** of fumes from evaporating solvents, spray mist or dust from sanding.

- **Direct contact** with the products, during handling, either via the skin or eyes. This may take the form of direct contact with liquid paints and lacquers, or with sanding dust from lacquer that is not fully cured.

**INHALATION**

The most obvious and best known risk associated with working with paint and lacquers is the threat posed to health by overexposure to solvents. However, other substances can also pose a health risk. For this reason, it is important to adopt protective measures in the form of sealed systems and ventilation/air-cleaning systems, and to use personal protection, such as various types of masks.

On people, the initial effect of inhaling large quantities of organic solvents is a form of inebriation, which reveals itself in the form of impaired judgement, slowed reactions, clumsiness and tiredness. Extended exposure to concentrated solvent emissions can result in chronic damage to the liver, kidneys and brain. However, all solvents are not equally dangerous.

To ensure safety at work, public authorities cooperate with medical expertise on a continual basis, to determine Occupational Exposure Standards for substances that can be dangerous if inhaled.

The legal requirements vary from country to country. Most countries apply limit values to the substances. These limit values are often expressed as averages over specified time periods, e.g. 8 hours or 15 minutes. Sometimes the limit values must not be exceeded, sometimes they must be observed only if technically and economically reasonable.

Air pollutants consist of a combination of different substances. Exposure readings taken at the place of work are based on all substances present in the air, after which the cumulative effect on health can be assessed.
The cumulative effect may be measured against the Occupational Exposure Limits (OEL) of the substances by the formula $C_1/L_1 + C_2/L_2 + C_3/L_3$, where $C_1$, $C_2$, $C_3$ are the concentrations of respective substances, and $L_1$, $L_2$, $L_3$ are the OEL values of these same substances. In most countries the sum must be less than 1 to be deemed acceptable.

In recent years, the risks posed by inhalation of various types of dust have attracted increasing attention. Such risks are associated primarily with dust that is respirable, i.e. formed of dust particles that are so small that they can penetrate deep into the lungs. The afflictions that can arise, such as asthma or cancer, can be caused by a number of different factors. In some cases, the condition is the result of a toxic reaction, when particles are partially or completely dissolved in the lungs. In other cases, damage to the lungs may derive from strictly physical injury (e.g. silicosis). Sometimes, health may be damaged when other substances attach themselves to the surface of inhaled particles, and therefore remain trapped in the lungs longer than if they had simply been inhaled in a gaseous form. It is therefore important to protect oneself against over-intense exposure to dust, of whatever type. The list of limits states general hygienic limits for dust and defines specific limits for a number of special substances.

**Direct Contact**

Solvent dries out the skin by dissolving its natural oils. Some solvents can be absorbed directly through the skin, and thereby contribute to the total quantity of solvent to which the body is subjected. With some types of solvent, such as those found in waterborne paints and lacquers, a considerable amount of the total exposure is via the skin. In most countries these solvents are flagged with a skin notation in the comments column of the list of limit values.

Damage to the skin can be avoided by the use of protective gloves. The gloves chosen should be of good quality, and the material should be appropriate for the type of solvent handled. Use only CE-marked gloves, and consult the supplier about the quality and choice of material. It is normally advisable to use thin cotton gloves inside protective gloves, since certain glove materials (such as rubber) may cause an allergic reaction. When contact with finishing materials is relatively modest, barrier creams – which can be rubbed into the hands prior to starting work – can be an acceptable alternative to gloves. If you get paint on your skin, it can then be washed away with soap and water, or solvent-free cleaning creams can be used instead of soap. After work, it is a good habit to use a hand cream to re-moisturize your skin. This will reduce the risk of skin complaints.

**NB: Never clean your skin with solvent!**

In general, UV-lacquers contain substances that irritate the skin ("unsaturated acrylates") and that can cause allergies. Labels and data sheets on products and substances that pose an increased allergic risk contain the warning: "May cause sensitization by skin contact". Unsaturated acrylates have the same de-fattening properties as solvents, and can therefore penetrate the skin. Becker Acroma has produced special information and training materials that deal with the handling of UV-curing products. If instructions about protective measures are carefully observed, risks to personnel are minimal.

The use of waterborne paints and lacquers is on the increase. These waterborne products lead to a reduction in solvent emissions, with
respect to both outdoor and indoor environments, and even reduce the risks that can arise from contact with skin. However, the fact remains that these paints are designed to be applied on wood, not human skin. Most waterborne paints contain small quantities of solvent, often of the type that can be absorbed by the skin. Careless handling can mean that the user is exposed to more solvent from absorption through the skin than from inhalation. It is therefore important to prevent contact with the skin, even when working with waterborne paints and lacquers.

The above-mentioned types of paint include a number of variants with different properties as well as hybrids which are like mixtures of the main types, such as waterborne UV-curing paints and lacquers. These hybrids possess the technical properties of the “parent products”. In developing waterborne UV lacquers, the goal has been to retain the beneficial properties of UV-curing products while combining the benefits of waterborne products. However, with such cross breeding, it is impossible to avoid inheriting some of the less attractive properties. This even applies to their environmental qualities. Compared to conventional UV lacquers, waterborne UV lacquers considerably reduce the risk of sensitization and skin complaints, but they pose a greater risk than waterborne lacquers.

**FIRE RISKS**

Incorrect handling of flammable products can result in severe injuries to people and damage to equipment. When accidents occur, they almost always arise from incorrect handling. Materials can burst into flame of a flammable mixture of air and solvent comes into contact with an igniting source. This may be a naked flame, a hot surface or a spark generated by static electricity or a tool. Flammable products should therefore always be stored at special locations where the risk of combustion is minimal. The equipment used should be explosion-proof and the ventilation system (such as that used for spray booths) must be adjusted so that the solvent level of ventilated air is kept well below a combustible level. Obviously, no smoking can be allowed when working in premises where flammable products are handled, and measures must be taken to limit risks associated with static electricity. When pouring a flammable liquid from one container to another, always ensure that the containers are linked to each other and grounded. By limiting the pouring height, you also limit the risk of sparks. Shoes and clothes should be of anti-static material.

**OUTDOOR ENVIRONMENT**

When talking about risks to the outdoor environment, we are talking about many different things. It may be a question of suspected health risks to neighbouring residents because of solvent emissions, or fears that groundlevel ozone (formed by the breakdown of solvents and other hydrocarbons in air) might pose a health risk or damage plant life. It may even involve the risk of disturbing the ecological balance. To evaluate the potential risk to, first and foremost, water-living organisms, a number of screening tests are used to determine parameters such as the toxicity, biodegradability and possible bio-accumulation levels of various substances. The results of these tests are then used when labelling the tested substances (see below). Before finally determining the potential risks to the outdoor environment, additional tests may be necessary. It is also important to determine the extent to which such substances may be disseminated in the environment, the manner in which they are spread and where they spread to. The amount of paint and lacquer products for industrial wood finishing that find their way into the outdoor environment is highly limited, since most wood products end up being burnt,
which is an efficient way of breaking down the environmentally dangerous substances they may contain. Although this type of product may appear to contain fairly limited amounts of environmentally harmful substances, it is nevertheless good policy to avoid landfilling this type of waste and to limit the amount released as effluent. Incineration, which should be carefully supervised, is definitely preferable, especially since this also permits recovery of the energy contained in waste paint.

The primary reason for reducing solvent emissions is a desire to reduce levels of ground-level ozone. The formation of this ozone is the product of many different factors, such as climate and the levels of airborne hydrocarbons and nitrogen oxide. The problem is not one that arises locally, where the emission occurs, but after a certain period of time, as when solvent emissions have had time to spread over a very large area, and have thereby been diluted to extremely low densities. For this reason, measures that deal with individual emission sources seldom achieve any measurable effects. A reduction in the formation of ozone will not be noticeable until total emissions have been reduced over very large areas. Different solvents form different amounts of ozone. Choice of solvent is therefore relevant to the health of the outdoor environment.

**Labelling**

A brief description of the labelling system for health and environmental warnings on paints and lacquers is given below. Although there are other symbols and hazard warnings (subtexts), these are seldom used for the wood finishing industry’s paint and lacquers.

**Toxic Properties**

Substances with toxic properties or which pose a substantial risk of sensitization when inhaled are marked with one of these symbols (in descending order of danger).

The subtexts define the nature of the hazard/hazards.

![Very toxic/Toxic](image)

R26 Very toxic by inhalation. R27 Very toxic in contact with skin.
R28 Very toxic if swallowed.
R23 Toxic by inhalation. R24 Toxic in contact with skin. R25 Toxic if swallowed.
R39 Danger of very serious irreversible effects.
R45 May cause cancer. R49 May cause cancer by inhalation.
R48 Danger of serious damage to health by prolonged effects.
R46 May cause heritable genetic damage. R60 May impair fertility.
R61 May cause harm to the unborn child.
Harmful

R20 Harmful by inhalation. R21 Harmful in contact with skin. R22 Harmful if swallowed. R40 Possible risks for irreversible effects. R48 Danger of serious damage to health by prolonged effects. R42 May cause sensitization by inhalation. R62 Possible risk of impaired fertility. R63 Possible risk of harm to the unborn child. R65 Harmful: May cause lung damage if swallowed.

CORROSIVE AND IRRITANT PROPERTIES

Corrosive

R34 Causes burns. R35 Causes severe burns.

Irritant

R36 Irritating to eyes. R37 Irritating to respiratory system. R38 Irritating to skin. R41 Risk of severe damage to eyes. R43 May cause sensitization by skin contact.
RISK OF COMBUSTION, STRONG REACTIONS OR CORROSION DAMAGE

Highly flammable

R11 Highly flammable. Note that flammable liquids with a flash-point of 21-55°C are not labelled with a flame symbol but with the risk phrase:
R10 Flammable.

Oxidising

R8 Contact with combustible material may cause fire.

ENVIRONMENTALLY HAZARDOUS PROPERTIES

At present, products which contain a mixture of substances are not labelled with this symbol. For the time being, "environmentally hazardous" labelling is reserved for substances in their “pure” form only, but is soon to be introduced for mixed products as well.

Dangerous for the environment

R50 Very toxic to aquatic organisms. R50/R53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment. R51/R53 Toxic to aquatic organisms, may cause long-term effects in the aquatic environment. R54 Toxic to flora.
R55 Toxic to fauna. R56 Toxic to soil organisms. R57 Toxic to bees. R58 May cause long-term adverse effects to the environment.

Furthermore, a number of risk phrases are printed without an accompanying hazard warning symbol:
R52 Harmful to aquatic organisms. R52/R53 Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment. R53 May cause long-term adverse effects in the aquatic environment.
SURFACE RESISTANCE

When selecting the finishing material, it is of crucial importance to know the way in which the furniture will be used — its type and the environment in which it will be placed. This is decisive in selecting a finishing material that offers the appropriate wear resistance.

There are many specified standards for surface resistance. These include Germany’s DIN 68 861 standard, Möbeloberflächen, Verhalten bei Chemischer Beanspruchung; IKEA’s surface resistance standard, the American standard, ANSI/KCMA A161.1, “Recommended Performance and Construction Standard for Kitchen and Vanity Cabinets” and the British FIRA.6250, “Performance requirements for Domestic and Contract Cabinet Furniture”.

VARIED RESULTS

Occasionally, furniture fails to satisfy even the lowest surface-finish requirements, which can come as an unpleasant surprise to the manufacturer, who may earlier have had his products approved to a much higher surface standard.

What could cause such varied results? The nature of the substrate and its specific properties, the type of finish and the quantity applied are all highly important, as well as the care taken in conducting the entire finishing process.

In the wood finishing industry, differences in local temperature, ventilation efficiency, humidity, curing-oven temperature and drying times can be considerable when processing and surface treating products. All such variations affect the final result, as well as the eventual properties of a given lacquer when tested to determine compliance with various standard specifications.

THE IMPORTANCE OF THE SUBSTRATE TO THE TEST RESULT

Preparation of the substrate prior to finishing is extremely important in creating the conditions essential for a satisfactory final result. The wood and primer must be very carefully sanded.

The nature and properties of the base are also of critical importance:
- All softwood is sensitive to scratches and impacts. Solid redwood seldom tolerates scratching. But redwood veneer on chipboard does.
- It is difficult to satisfy the requirements for the grease test on beech, since the fibre structure of beech allows grease to spread beneath the film of lacquer, something that is especially conspicuous on beech.
- Porous woods with deep pores must be treated with a primer that has strong wetting properties. Liquids may otherwise penetrate the substrate and spread beneath the finish.
- The red core and growth rings in redwood can be discoloured when tested with alcohol. An unsatisfactory result may also be caused by solvent action on...
When marks appear on dark woods or dark-stained furniture after liquid or heat tests — but not on light-coloured woods that have been surface treated in the same manner — it is quite simply because dust and dirt are more conspicuous on dark, gloss surfaces. The same patches are there on light-coloured woods, but are less conspicuous against the light background.

**FINISHING MATERIALS**

General properties of the most common finishes:

- Nitro-cellulose-based finishes dry by solvent evaporation. They satisfy simpler standard requirements, but are not fully up to the demands made on table surfaces etc.
- One-pack acid-curing finishes contain a weak acid which initiates the curing process once the solvents have evaporated. Curing can be accelerated by efficient ventilation and additional heat. These lacquers normally satisfy more stringent demands than nitro-cellulose lacquers.
- Two-pack acid-curing lacquers cure rapidly when the solvents evaporate. The hardener functions as an accelerating agent. At room temperature, most of the curing process is completed during the first 24 hours. This curing process can be speeded up considerably with efficient ventilation and additional heat. The better the drying conditions (ventilation and heat), the better these finishes can meet the various demands placed upon them. This group comprises a wide range of products with different levels of surface resistance, some of which meet all combinations of standard requirements.
- Polyurethane lacquers are cured as a result of a chemical reaction between the binders in the finish and the hardener, in relation to relative humidity. Drying and curing time can be reduced with good ventilation and additional heat. The hardener is highly sensitive to moisture. Once opened, packages must therefore be resealed immediately the desired dosage has been removed. In general, hardener cannot be stored for an extended period. Pure urethane lacquers offer exceptional surface resistance.
- Waterborne lacquers may not be subjected to low temperatures when being applied or dried. Drying at increased temperature and with good ventilation ensures the best film formation and surface resistance. Today’s waterborne lacquers often satisfy very high resistance requirements.
- UV-curing lacquers are cured by ultraviolet radiation in special ovens. These lacquers often have a very high dry content and produce a full-bodied film in spite of the low quantity applied. Shelf-life is more limited than for other lacquers, about 3-4 months. They normally satisfy the most stringent requirements.
**PREPARE, APPLY, DRY AND CURE IN THE CORRECT WAY!**

Always carefully observe the treatment and mixing instructions given in Becker Acroma’s data sheets.

**STACKING AND PACKING**

Even if the finish film appears to be cured, high humidity, low oven temperatures, poor ventilation or low nighttime temperatures can halt the curing process or leave it incomplete.

If stacking is carried out too early, it may cause defects in the form of glossy patches and stickiness. It may also cause the remaining solvent to bind with the finish film, impairing adhesion of the primer to the substrate.

Similar defects can arise if furniture is packaged in corrugated cardboard before the finish film has been thoroughly cured.

For these reasons, it is important to introduce production routines that ensure satisfactory curing. It is equally important to avoid “cold storage” of newly lacquered goods.

For advice, call us at Becker Acroma.

**SUMMARY**

If instructions concerning the treatment process are rigorously observed, the result will be a highly resistant finish.

If tests indicate that the lacquered surface fails to meet the desired standard, check the following to determine whether some important point has been overlooked:

- Poor ventilation, low temperature or high humidity during the finishing process.
- Moist substrate, water staining or unsuitable storage in high humidity.
- Excessively thin coating.
- Stacking or packaging too early.
- Inadequate agitation of lacquer prior to application.
- Use of “old” finish mix or old one-pack lacquer.
- Too much or too little hardener.
- Microscopic air bubbles in the finish film, due possibly to a substrate that was too cold, incorrect thinning, high viscosity on application, defective application equipment etc.
- Unsuitable substrate.
- “Old” or unsuitably stored urethane hardener.
- Unsuitable finish or combination of finishes.