Powder Coatings
Contents

1. Introduction

There are two principal technologies that are the back-bone of the coatings industry:

- ✓ Liquid coating technology (wet), which has been applied for more than two centuries
- ✓ Powder coating technology (dry), which has been applied on an industrial scale for some 30 years.

The global average annual growth for powder coatings has been approximately 7-9% over the last 10 years. From country to country worldwide these figures have varied considerably. This relatively high performance has been achieved by autonomous growth on the one side and by replacing liquid coatings on the other.

This guide is meant to provide background and supporting information for those entrepreneurs who have already elected to switch to powder coating technology, or who are about to make that decision.

When the opportunity arises for coating technology selection, there are a multitude of factors that need to be considered and judged for their importance and weight of impact. We discuss in this guide:

1) Applied materials
2) Application techniques
3) Health, safety and environmental implications
4) Quality achievements
5) Economic advantages.

Although thermoplastic resins were initially employed, the thermosetting powders that were later developed and applied have opened up much wider fields of use. The accelerated application of thermosetting powder coatings have therefore been a logical development in light of the more stringent environmental requirements and the demand for more commercially attractive alternatives compared to conventional industrial liquid coatings.

There are many advantages that make the choice of applying thermosetting powder coatings so attractive to the coating company:

1) Powder is immediately ready for use
2) Less powder wastage during the application process
3) Reduced health hazard in case of exposure of operators
4) Superior cured-film properties
5) Lower capital investment costs.

Today, many of the advantages of powder coatings are no longer actively promoted as powder has secured its place within the finishing industry. Advances in powder technology have brought new opportunities, such as:

1) Low film thickness powders
2) Substrates other than metal can be coated
3) Low curing temperatures can be achieved.

Today, the selection of a powder coating is dependent upon:

1) Market demand
2) Industry requirements and standards
3) Price and finished cost.

This section describes the manufacturing and quality control process for powder coating materials.

The state of the art technology used for producing industrial powder coatings consists of several distinct stages, namely:

1) Weighing, premixing and size reduction of raw materials
2) Extrusion of pre-mix, cooling and crushing of the extrudate into chips
3) Micronising the chips into the final powder
4) Post mixing, packaging and storage.

At each stage of the production process the quality must be checked because once the powder coating material has been produced, it cannot be changed or adjusted in any significant way. The formulation and the manufacturing conditions are therefore critical. Reworking of an ‘out of specification’ product is difficult and costly. (See Figure 1 for a simplified flow sheet of the powder coating material production process).

Weighing, premixing and size reduction of raw materials - Raw materials typically consist of resin, curing agents, pigments, extenders and additives such as flow and degassing aids. Each raw material must pass their individually pre-set quality controls.

Each component is then weighed with the necessary degree of accuracy (which may be to the nearest ten-thousands of a gram). All pre-weighed components are placed in a mixing container according to the formulation. The container is then attached to the mixing drive and the raw materials are thoroughly mixed by the specially designed premixer cutting blades for a pre-set period of time. The raw materials can also be reduced in size to improve the melt mixing later in the process.

Quality control
A final sample of the raw material pre-mix is checked for conformity and processed through a small laboratory extruder and grinder. The resulting powder is then applied onto a test panel, cured in the oven and subjected to various tests:

1) Colour, surface flow and gloss
2) Mechanical performance (including curing)
3) Gel time.

If adjustments are required both the mixing process and quality control procedures are repeated until the powder achieves the specification.

No further modification to the powder can be made after this stage in production.

Extrusion of the premix - The mix is fed into the dosing system of the extruder. The extruder barrel is maintained at a predetermined temperature (between 70 & 120ºC, depending on the product type). The barrel temperature is set so that the resin is only just liquefied and its contents are mixed using the screw in the barrel. Consequently, the individual ingredients are dispersed and wetted by the resin, which produces a homogeneous composite. The feed rate of the dosing equipment and the speed of the extruder screw are balanced to ensure that the screw is kept loaded within the extruder barrel.

The conditions of high shear and intimite mixing are maintained within the extruder by precise adjustments of these three parameters.

The molten mass produced in the extruder barrel is forced to cool down via a cooling-transporting device. The solidified material is then broken up and reduced in size through a crusher into workable chips of 5 to 10mm in size.

Quality Control
At this stage in the process the product quality is tested using a sample of the chips. The laboratory grind the chips to a powder and prepare a test panel using the material. The intermediate product is then checked for quality against the following criteria:

1) Colour, gloss, appearance and flow
2) Mechanical and reactive properties
3) Application.

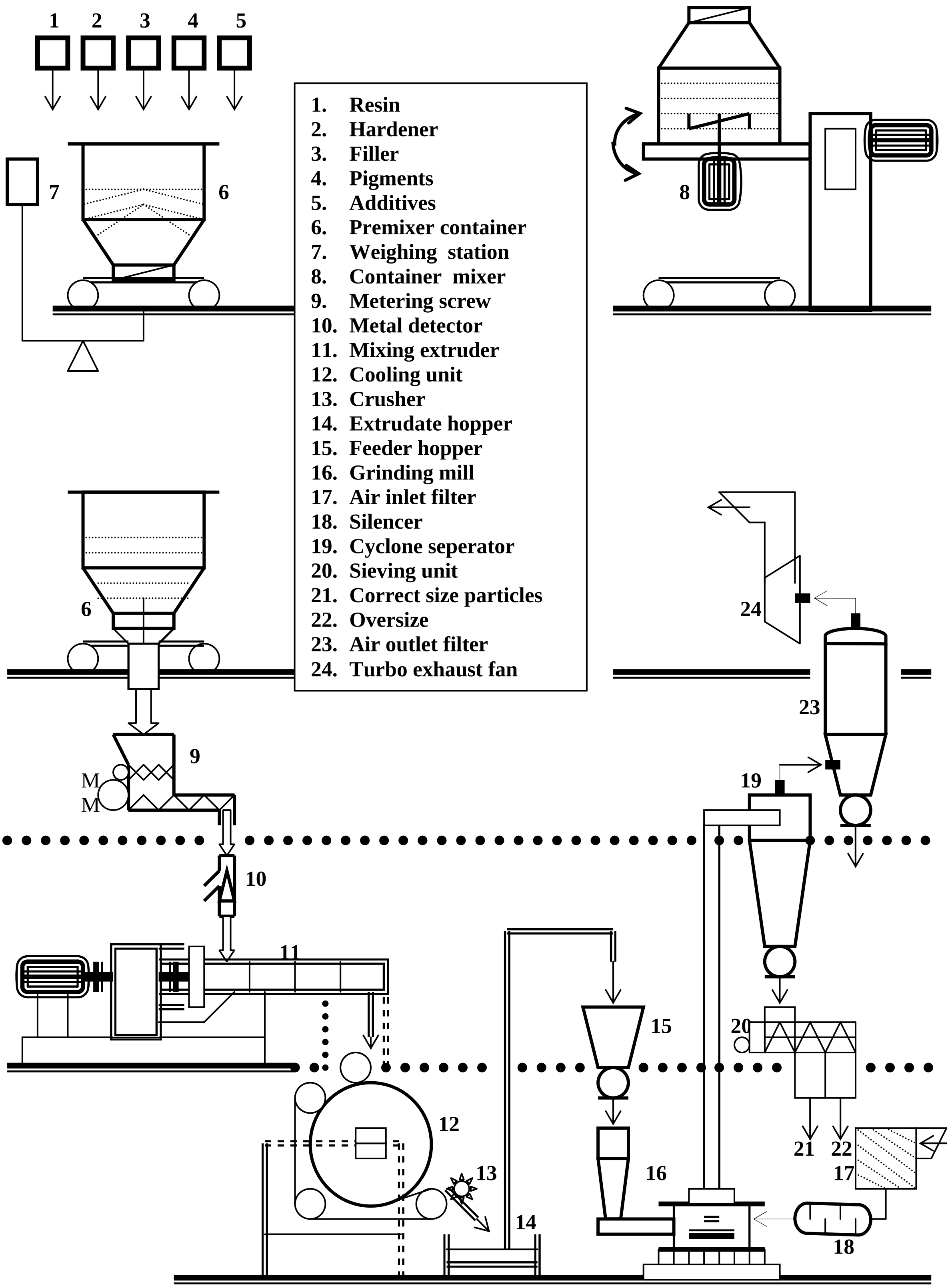
Too high a temperature in the extruder barrel will not only result in a low melt viscosity, low shear forces and poor pigment dispersion, but will also in turn produce a low gloss coating. The resin and hardener in the premix may also start to react in the extruder, which will also have a detrimental effect on the product performance.

It is not possible to make changes to the formulation at this stage in the production process. It is also easier to handle the extruded chip as a re-work raw material if manufactured ‘out of specification’ than once the powder has been micronised.

Micronising of the chip into the final powder - The chips are ground to the required particle size in a grinding mill. The chips are fed onto an enclosed grinding wheel with stainless steel pins, which breaks the chips down creating a powder. The powder is carried through a classifier into a cyclone collection system via a regulated air flow.

In order to achieve the optimal particle size distribution (psd) further treatment may be needed which can consist of cycloning, classifying, filtering or sieving.

Figure 1: Simplified flow-sheet of the Powder Coating Material Production Process



In modern plants the rejected oversize from the sieving operation is automatically fed back into the feedstream of the micronising mill. The typical particle size range for electrostatic application methods should be within 10 to 100 microns. Deviation from this psd can result in poor performance and appearance of the powder.

<u>Quality Control</u>
The final powder coating is as rigorously quality control tested as the extrudate to ensure it meets the specification of the customer or market. As the particle size distribution is a critical factor in the successful use of the powder the particles are analysed for their precise particle size distribution.

Post mixing, packaging and storage - In order to meet the customer specification or special conditions of use additives may have to be mixed through the final product.

Powder packaging is provided in:
- ✓ carton boxes - up to 25kg
- ✓ bags - 400 to 900 kg
- ✓ metal/plastic containers (Durabins)

The powder can be safely stored if kept in its unopened packaging in a dry, cool place (30ºC) for upto 12 months. Higher temperatures and longer storage periods will result in absorption of moisture. Storage conditions can vary for some powders so the product data sheet should be referred to at all times.

<u>Quality Control</u>
It is advisable to check the powder after 6 months of storage to ensure no quality problems have occurred.

Modern powder coating materials from Akzo Nobel can achieve the same quality standards as liquid coatings for appearance, chemical and mechanical resistance for many applications. Once a product has completed the development stage and its formulation and manufacturing procedures have been approved, it will be available for manufacture in any of Akzo Nobel's Powder Coating manufacturing plants worldwide.

Akzo Nobel Group produces both thermoplastic and thermosetting powder coatings, the majority of demand in the market being for thermosetting products.

Thermoplastic coatings do not chemically react upon temperature increase, but they melt and flow out onto the substrate. Application is usually in the industrial market coating wire, pipes and accessories. The thickness of these coating films is typically around 250 microns or more.

Thermosetting coatings also melt upon temperature increase, but under go a simultaneous chemical reaction and polymerise through cross-linking into a resistant film. Once this chemical reaction has occurred the powder coating film cannot melt again. These coatings are used in both the decorative and the industrial markets.

For decorative thermosetting coatings film thickness ranges from 20-80 microns. Functional thermosetting coatings require film thickness' from microns up to several millimetres (depending on application).

Properties of thermosetting decorative powder coatings based upon the formulation - Chapter 1 discusses the raw materials that are required for the production of powder coatings, these being resin, curing agents, pigments, extenders and additives. The selection of the individual components and their composition (formulation) will be influenced by:

1) The ultimate film properties required including gloss, hardness, flexibility, adhesion, chemical and corrosion resistance
2) Application technique
3) Curing conditions including type of oven, curing time and temperature
4) Production procedures and conditions.

Below we detail how component properties influence the quality of the ultimate powder coating material.

Resin**:** the selection of the correct grade of resin or blend of resins is very important, as these form the basic properties of the powder coating material and also control the film properties such as melting point, flow and levelling. Relatively low molecular weight resin, as solid grades, have a softening point between 60ºC & 110ºC.

Low melting points can result in a tendency for powder to 'cake' during storage. They also have an extreme degree of flow on curing where a low degree of 'sharp edge coverage' is obtained due to the coating flowing away from the edges.

Usual resins include epoxies, polyurethane, polyester and acrylics.

Curing Agent *(also known as hardener)***:** the hardener is used to cross-link the resin at a given temperature. The degree of cross-linking can also be used to determine the gloss level, degree of surface 'orange peel' and other aspects including structure and texture effects. The curing agent should be unreactive at room temperature, remaining latent upto 100ºC and should react fully between 100ºC & 180ºC. This reaction should not be so rapid as to prevent complete flow out of the fused resin and not so slow that it creates commercial implications.

Usual crosslinkers are amines, anhydrides and blocked isocyanates. Catalysts are used to accelerate the curing speed.

Pigments and extenders**:** pigments must be inert, fast to light and heat resistant. As with most coatings they are used to create a decorative effect.

- ✓ Titanium dioxide creates white, pastel and light tints
- ✓ Carbon black creates blacks and greys
- ✓ Phthalocyanine creates blues and greens
- ✓ Aluminium and bronze creates metallic effects.

Organic pigments have to be handled with care as some of them can react during processing and curing. This can result in loss of brightness and cleanliness and in these cases alternative pigmentation have to be used.

Certain inorganic extenders can be incorporated into the formulations without reducing the film quality. Usually extenders are of high specific gravity and although they reduce the raw material cost they can adversely affect the area covered by the powder.

Additives**:** even after the optimum resin, hardener and pigments have been selected, adjustments to the formulation may still be required to modify flow and film properties to suit the application and curing conditions (i.e. Thixotropic agents to slow down the flow and UV stabilisers). Other functions of additives are:

- ✓ Increase/decrease electrostatic attraction
- ✓ Increase/decrease surface levelling
- ✓ Creation of decorative effects
- ✓ Decrease stoving temperature requirement
- ✓ Changing conductivity
- ✓ Increase re-coatability
- ✓ Increase surface hardness.

Below are five types of thermosetting powder coatings and a comparison of their main properties (also see Table 1).

Powder Coatings
3. Properties & Selection

Epoxy powders**:** can be formulated to give high gloss and smooth coatings with excellent adhesion, flexibility and hardness as well as solvent and chemical resistance. The main deficiencies are their poor tolerance to heat and light as well as their pronounced tendency to yellow at elevated temperatures and exposure to diffused day light.

Acrylic powders**:** are widely used in surface coatings. They have good gloss and colour retention on exterior exposure as well as heat and alkali resistance.

Polyester powders**:** general performance can be categorised between epoxy and acrylic powders. They have excellent durability and a high resistance to yellowing under ultra-violet light. Most coatings used on buildings today are based on linear polyesters cross-linked with TGIC. Today modern polyester powders are TGIC-free

Epoxy polyester hybrid powders**:** are epoxy powders by origin containing a high percentage of special polyester resin (sometimes exceeding 50%). These hybrids have properties similar to those of epoxy powders, however, their additional advantage is that they have improved resistance to overbake yellowing and improved weatherability. Hybrid powders are now regarded as the main backbone of the powder coatings industry.

Polyurethane powders**:** provide good all-round physical and chemical properties as well as giving good exterior durability.

Table 1: Main Properties of Different Types of Thermosetting Powder Coatings

	Properties of Thermosetting Powder Coatings				
Property	**Epoxy**	**Acrylic**	**Polyester**	**Hybrid**	**Polyurethane**
Weatherability	Poor	Excellent	Excellent	Fair-Poor	Good
Corrosion Resistance	Excellent	Good	Very Good	Excellent - Very Good	Very Good
Chemical Resistance	Excellent	Very good	Very Good - Good	Very Good	Very Good
Heat Resistance	Very Good	Good	Good	Very Good - Good	Very Good
Impact Resistance	Excellent - Very Good	Good-Fair	Good	Very Good	Very Good
Hardness	HB-5H	HB-4H	HB-4H	HB-2H	HB-3H
Flexibility	Excellent - Very Good	Good-Fair	Very Good	Very Good	Very Good
Adhesion	Excellent	Good-Fair	Excellent	Excellent	Very Good

Influence of the particle size distribution upon the properties of thermosetting decorative powder during the coating application process - Approximately 12 stages of the powder application process are sensitive to the substrate to be coated and also to a large extent to the particle size of the powder. In its original state this can only be influenced by the powder producing company.

The following steps of the application process represent the most sensitive stages:

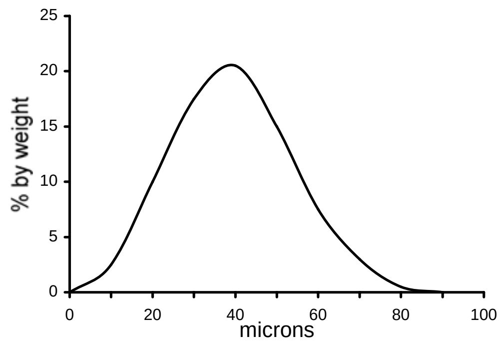
1) Transportation of the powder
2) Electrostatic charging of the powder particles and faraday cage penetration
3) Formation of a uniform powder cloud in the surrounding air
4) Deposition and build up rate of the powder onto the substrate
5) Transfer efficiency.

Thermosetting powders are applied electrostatically, therefore the powder particles must be able to charge in an electrostatic field or through Tribo static (friction) charging. This charge must be sufficient to attract adequate particles to the surface and edges of the substrate. However, the deposition of the powder should not be so insulating that it prevents adequate film build up.

The fluidity of the powder must meet all internal and external transportation demands. The particle size determines to a great extent the tendency of the powder to be free flowing. This fluidity depends not only upon the powder material but also upon the shape and size of the particles.

Most commercial powders have a particle size between 10 and 100 microns. Graph 1 represents this typical psd for a pigmented epoxy powder. If the range was too wide it could result in an increased mass of powder to be recovered and recycled, which would effect transfer efficiency.

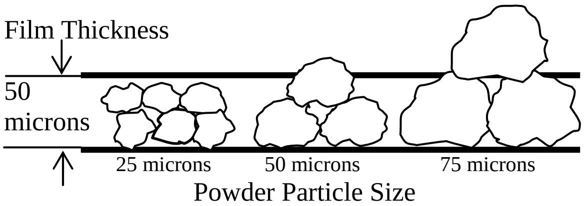
Graph 1: Typical particle size distribution for a pigmented epoxy powder



Relationship between the particle size distribution of the powder and the powder coating film formation during the application process - to enable the formation of smooth, non-porous films the powder deposited during the application process should be as densely packed as possible onto the substrate surface prior to fusion and cross-linking in the oven. This will ensure that shrinkage and the formation of voids, pinholes and orange peel should be minimised.

The importance of the relationship between the powder particle size and the coating film thickness after curing is also shown in Figure 2. It illustrates the difficulty in achieving a uniform 25 micron coating layer with particles larger than 50-75 microns (unless the polymer has exceptionally good flow out).

Figure 2: Relationship Between Particle Size & Film Thickness



Packed, uniform spheres result in void spaces of upto 48%. Thermosetting powders however consist of irregular multi-sided particles of varying size and psd. When these powder particles are deposited in a layer the void volume will be greater. Therefore, before melting and cross-linking the powder film can be between three and seven times the actual thickness of the final coating film after curing.

The technology is not yet available to reduce the void volume in the deposited layer using existing methods. However, it is generally easier to obtain a smoother coating film with a lower particle size and a smaller psd. Unfortunately, it is extremely difficult to apply these smaller particle sizes.

The melt-flow index rate of cure of the powder and the particle size are critical properties in achieving a smooth coating film while maintaining adequate edge cover.

The selection of the type and grade of raw materials and their use in the formulation is of great significance to the quality of the powder coating material. Together with the powder particle shape, size and psd they will influence the quality, appearance and performance of the powder coating film on the substrate.

Akzo Nobel Powder Coatings have the facilities to assist both powder coating applicators and equipment manufacturers in their selection of the most suitable powder coating materials.

4. Application of Powder on Objects

Powders are applied to metal and non-metal substrates which have been either pre-formed or post-formed which are used in most decorative and functional segments of the industrial coatings market:

- ✓ appliances: *coolers, freezers, washers, microwaves, conditions*
- ✓ architectural: *extrusions for windows and door frames, panelling*
- ✓ lawn and garden: *outdoor furniture, garden tools and tractors*
- ✓ leisure time: *bicycle and vehicles frames, hand tools*
- ✓ anti-corrosion: *drill pipes, rebars, valves and fixtures, motor blocks*
- ✓ automotive: *truck primers/surfacers, wheels, bumpers, mirrors*
- ✓ office furniture: *desks, filing cabinets, book cases, computer related equipment*
- ✓ electrical: *cabinets, components, cable trays, lamp housing*

The majority of objects are electrostatically powder coated, therefore they must be electrically conductive and so are generally metallic. Akzo Nobel are currently producing several commercially operational product series for non-metallic substrates (including glass, ceramics, plastics and wood), several others are also in the development stage.

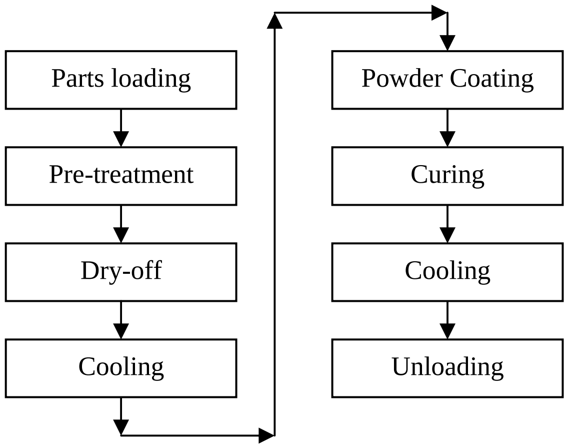
Metallic substrates - Product characteristics to be considered are:

- ✓ Variations in size
- ✓ Configuration
- ✓ Construction and quantity
- ✓ Size, height, width, length:
  - very large and heavy (upto 10m long/wide)
  - weighing several tons or more
  - small and light, short and weighting just a few grams.
- ✓ Configuration
  - flat panels and round stock to be formed later through bending, punching, drill etc.
  - boxes, wire goods and intermediates (pre-formed parts) to be assembled to complete articles
- ✓ Materials of construction
  - various metals which may have different alloys
  - multimetal substrates
- ✓ Quantity
  - anything from one single custom-made item to several thousands in one order.

Preferably prior to the start of application, the coating material supplier must be informed of the composition and condition of the substrate in order to prevent potential problems. Depending upon the substrate's quality, a powder coating type can be selected to help alleviate or lessen any problems. Low quality, porous castings for instance tend to gas out during the curing phase in the oven resulting in bubbles and blisters.

A typical process flow block-diagram for a powder coating line in given in Figure 3.

Figure 3: Process Flow Block-Diagram



Pre-treatments - In the past decade pretreatment has been converting to environmentally friendly methods and materials in conjunction with the general industrial trend.

The selection and intensity of surface preparation is closely related to the original state and nature of the substrate, the type of contamination and the desired result of the final product. It is essential to undertake a process of pretreatment of the surfaces to be coated prior to the actual powder application in order to achieve the full potential of the selected powder coating materials.

The objectives of pretreatment of metal surfaces are:

- ✓ Removal of impurities, including soil, welding splatter, scale, grease, oil etc
- ✓ Conditioning of the surface for optimum adhesion of the coating film
- ✓ Obtaining uniformity throughout the entire treated surface of the substrate.

These objectives can generally be achieved when a well selected pretreatment process has been carried out. Not all of these methods work on all surfaces. The pretreatment will vary depending on the required final use of the substrate. A complete pretreatment process will consist of:

- ✓ Cleaning
- ✓ Rinsing
- ✓ Conversion coating
- ✓ Seal rinsing
- ✓ Drying
- ✓ Cooling.

Chemical solutions applied include alkaline, acid, emulsion and solvent cleaners (iron-chromium or zinc phosphates).

Cleaning - Cleaning methods originally consisted of either chemical or mechanical preparation, however now the untreated raw materials delivered from the supplier are usually of such quality that additional mechanical preparation can be omitted and we can confine the cleaning process to just chemical treatment.

The most common substrate for electrostatically applied powder coatings material is metal. Future chapters will cover the general cleaning concerns and characteristics of substrates including steel, aluminium and zinc substrates such as galvanised steel.

***Steel*:** is widely used in the construction and manufacturing industry. During milling to size the steel is hot rolled and because of this process mill scale is formed. This scale can usually be removed in the steel mill during the process of pickling. The steel is then coated in an oilfilm as a corrosion preventative during the subsequent storage period. This oilfilm and other contaminates (including drawing marks, shop dirt and welding splatter) which adhere to the steel during fabrication prior to coating must be removed in the first stage of the pretreatment process using a selection of cleaning solutions.

***Aluminium*:** is commonly utilised in the building, automobile and aerospace industries. An oxide-layer forms on the surface of aluminium and is an effective protective film when exposed to air. Cleaning the aluminium surface and removing the oxide-film is a sensitive process because the aluminium will react with the alkaline and acidic cleaning products. Therefore, the selection of the composition of the cleaning solutions (inhibitors) and the process temperature is critical. Once clean the surfaces are easily powder coated with excellent adhesion results.

***Galvanised steel*:** zinc based substrates, such as galvanised steel, are used in the manufacturing industry in the form of appliance housings or profiles for building purposes. Galvanised steel is a layered metal substrate where a zinc-layer is bonded to the steel through either hot dipping or electro-coating. The zinc-layer like aluminium forms an oxide-layer when in contact with oxygen. Consequently, the cleaning of galvanised steel is more critical than the process for steel.

Cleaning is the removal of all organic and inorganic contamination on the surface of the metal substrate to be coated. In the usual aqueous cleaning system surfactants play an important role in the process such as wetting, emulsifying, neutralising and dissolving etc. The first step is usually the removal of oil and grease by either detergent, solvent, emulsion or alkali cleaners. The cleaning operation can be undertaken by immersion or spray processes, in both cases, usually involving a number of tanks in sequence. The selection of the correct method depends not only on the nature and degree of contamination, but also upon the scale of operation and required result. An additional acid cleaning step may be necessary when rust and scale needs to be removed.

It is recommended that the coating company creates a practical or scientific method of analysing the cleanliness of a surface which can be used to set reproducible quality standards.

Rinsing - It has been demonstrated that when aqueous cleaning is used, high quality water rinsing of the surfaces is necessary. The objective of rinsing is to flush away the remaining ‘drag-out’ from the previous bath and to neutralise the surface. It must be ensured that the cleaned and dried substrate is not contaminated with alkali, acid or any other components. The critical factors in undertaking a high quality rinsing process are:

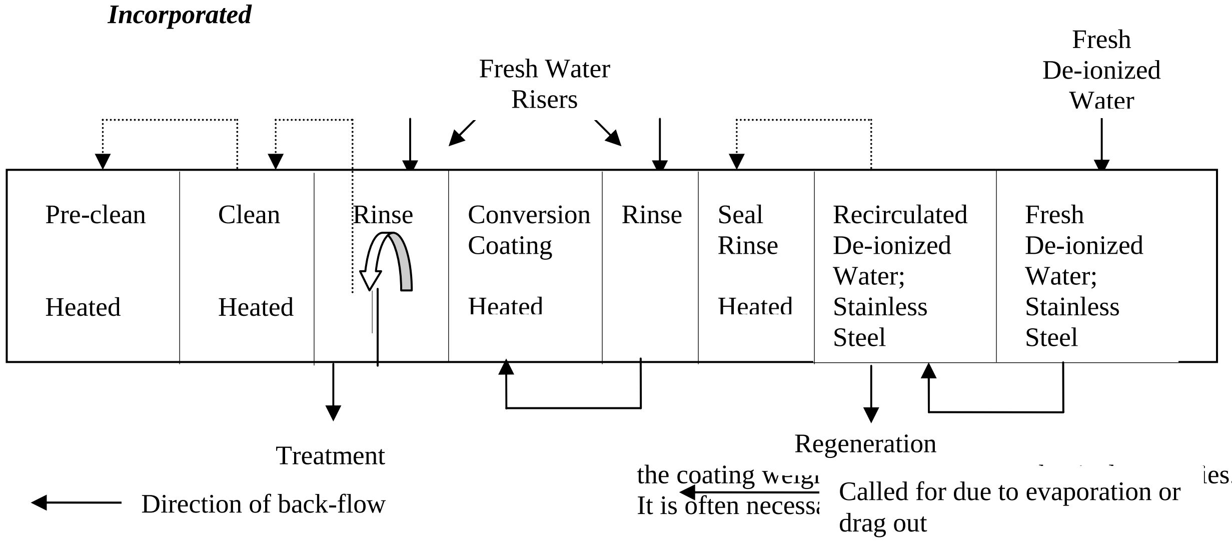
- ✓ Quality of fresh water
- ✓ Quantity of the water contacting the substrate
- ✓ Duration of water contact
- ✓ Rinsing method (immersion or spray)
- ✓ Object configuration.

The volume and quality of this rinse water is of great importance to the quality of final rinsed substrate surface i.e. the substrate cannot be any cleaner than the water used for rinsing! The water volume and quality needs to be maintained at certain levels to ensure that rinsing is at its optimum performance. Monitoring the cleanliness of the water by measuring the total dissolved solids (tds) and alkalinity (pH) with reliable, automatic devices is an effective control.

A proven concept for optimum use of water is the ‘back-flow system’ where fresh water enters at the last stage of rinsing and flows counter-current to the parts which are already treated.

Water with a hardness higher than 250ppm $CaCO_3$ and combined chlorides and sulphates higher than 100ppm should not be used. De-ionised water is often drawn from, and recycled to, a separate installation.

Figure 4: Schematic Pretreatment Process Diagram with Back-Flow Design and Two Rinsing Steps Incorporated



Conversion Coating - Once all impurities on the metal surface have been removed the surface is ready to be conditioned for optimal adhesion of the coating film.

In powder coating, the most common application for extended corrosion resistance relies on conversion coating. The different methods available are iron, zinc and chromium phosphating. Selection depends on the substrate and the ultimate requirements, for example which particular market is being served and which specification is required to be met.

Because of environmental issues, the trend in certain countries is to consider the elimination of heavy metal containing conversion coatings or to convert from zinc to iron or from chrome to non-chrome. It is important that the finisher checks to see whether such substitution is allowed by their customer's specification.

With any performance specification of 200-800 hours salt spray and a well designed 5 or 6 stage pre-treatment system with good cleaning and rinsing, there would not be any need for zinc or chrome based conversion coatings. In such cases, iron phosphate will be adequate, provided a powder coating is applied which is designed for the required corrosion resistance. When the clean metal comes into contact with the slightly acidic phosphating solution pickling starts, iron is dissolved, hydrogen is liberated and the phosphate coating is deposited. The purpose of the phosphate coating is to bond the powder coating film to the metal surface. As such, it should provide a uniform, tightly bonded phosphate throughout the entire treated surface of the substrate resulting in the absence of flash rust, powdering and windowing.

The greater the weight of the phosphate coating, the higher the corrosion resistance is created and the lower corrosion resistance and mechanical properties. Experience has shown that a fine grain iron-phosphate is recommended with coating weights of 300-900 mg/m².

The conversion coating process can be either a spray or an immersion system, which generally comprises of a five-stage operation.

A schematic example of a pretreatment process with a conversion coating and a seal rinse is indicated in Figure 5.

Seal Rinse - The purpose of a seal rinse is to provide a final passivation. Non-reacted chemicals and other contaminants are removed, any bare spots in the coating are covered and the metal surface is prevented from flash rusting. A dilute solution of low electrolyte concentration is used. Instead of the conventional chromium compounds, sealers are applied which are not based on chromium - these are more environmentally friendly. See Figure 5.

Specified Cleaning and Pretreatment - There are certain specific market requirements:

a) *Architectural* **-** Specifications will vary from country to country but will usually specify a minimum requirement for cleaning and chemical conversion eg.
   British Standards BS6496 (chrome 6 conversion)
      1000 hrs salt spray
   British Standard BS6497 (zinc phosphate)
      500 hrs salt spray
   European Qualicoat, Class 1 (chrome or non chrome)
      1000 hrs salt spray

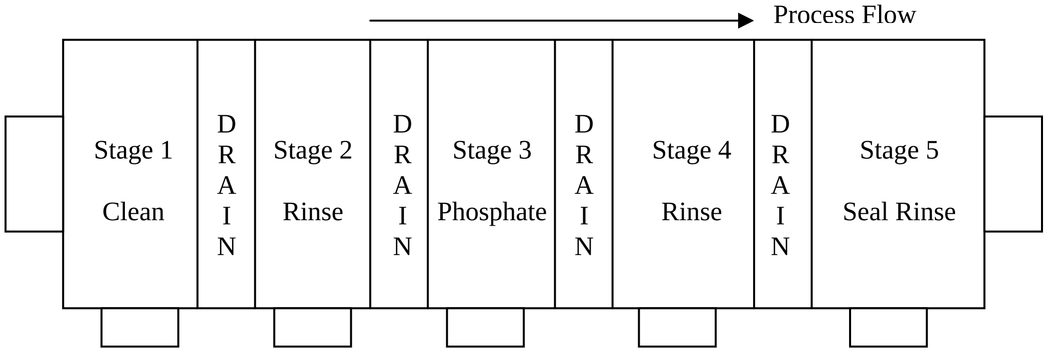
European Qualicoat, Class 2 (chrome or non-chrome)
3000 hrs salt spray
GSB Europe (chrome or anodising)
1000 hrs salt spray
American AAMA 2604-98 (chrome or non-chrome)
3000 hrs salt spray
American AAMA 605.2-92 (chrome 6 conversion)
3000 hrs salt spray.

b) *Automotive/Domestic Appliance* OEM's usually have their own specification which includes a minimum requirement for cleaning and pretreatment.

c) *Other Applications* Industrial markets exhibit a very wide range of applications involving a variety of substrates, a range of performance requirements as well as a range of environments in which these performance requirements must be met.

Cleaning and chemical conversion may be critical in the successful achievement of this performance.

Figure 5: Pretreatment process with conversion coating and seal rinse



Drying and Cooling - After the final rinsing and before any parts are powder coated, the parts must be completely dry and cool. Two methods used for this type of drying are the blow-off method and the dry-off oven.

One problem that occasionally occurs is that parts are insufficiently drained. This can normally be resolved by altering the hanging method or drilling a drain hole. In certain cases a blow-off system will be inevitable.

Dry-off ovens should heat the parts to be coated sufficiently to evaporate the surface water. Convection ovens and infra-red radiation ovens are both used for this purpose. It is important that the parts are cooled prior to entering the powder spray booth, otherwise the powder can start to melt on the surface of the coated part and then the performance of the powder coating film may be adversely affected.

Pretreatment application systems - this covers the selection of the best methods of application equipment and systems, including:

- ✓ Nature, type, configuration and quantity of parts to be coated
- ✓ Logistics for production, equipment, conveyor and labour
- ✓ Consequences on quality, environment, health, safety and utilities
- ✓ Sensitivity in operation, maintenance and reliability in service.

The pretreatment chemicals industry has been proactive in the introduction of environmental improvements, which have been driven internally through Research and Development and externally through market competition. Much research is now being undertaken into eliminating chromate in the process of steel passivation and the chemical conversion of the surface of aluminium in order to reduce the problems of chemical waste and pollution problems in water supplies.

For medium to large industrial pretreatment processes, methods can be divided into 'Immersion' and 'Re-circulating Spray' systems, with some of their advantages and disadvantages shown in Table 2 & 3.

Table 2: Immersion Pretreatment System

Advantages	Disadvantages	
✓Low cost installation ✓Can be off line (space saving) ✓Better protection in difficult areas ✓Small components easily batched ✓Simple to maintain ✓Flexible chemistries can be used.	× Not easy to automate × Slow processing × Tends to give dusty coating × Large tanks require long heat up time × Use more energy × Quality can vary as manual operation is used.	
Typical Example for Aluminium		
Chromate		
a) Alkali degrease/light etch	30-50°C	1 minute
b) Cold water rinse	Room temp.	1 minute
c) Cold water rinse	Room temp.	1 minute
d) De-smut (nitric acid)	Room temp.	1 minute
e) Cold water rinse	Room temp.	1 minute
f) Chromate	25-35°C	2 minutes
g) Cold water rinse	Room temp.	1 minute
h) Hot water rinse	75-85°C	1 minute
i) Hot de-ionised water rinse	75-85°C	1 minute
j) Dry off oven	85-100°C	3-4 minutes

Note: The final temperature used to dry the work-piece before coating should be maintained below 110°C to ensure crystallisation of the chromate does not occur as this would significantly effect the performance of the powder coating.

Table 3: Re-circulated Spray Pretreatment System

Advantages	Disadvantages
✓ Can be easily automated ✓ Plant can be built in line with application of powder coating ✓ Better cleaning ✓ Lower chemical cost ✓ Increased throughput ✓ Less energy for heating.	× Higher capital and maintenance cost × More difficult to protect deep recesses or difficult shapes × Small items pre-treated less efficiently × Troubleshooting with more expertise.

Two Typical Examples for Steel		
Iron Phosphate		
a) Degrease and iron phosphate	30-50°C	1 minute
b) Degrease and iron phosphate	30-50°C	1 minute
c) Cold water rinse	Room temp.	1 minute
d) Water/chromate rinse	60-70°C	1 minute
e) Dry off oven	140-150°C	4-5 minutes
Zinc Phosphate		
a) Alkali cleaner	45-70°C	1 minute
b) Cold water rinse	Room temp.	1 minute
c) Hot water rinse	50-60°C	1 minute
d) Zinc phosphate	55-65°C	1-2 minute
e) Cold water rinse	Room temp.	1 minute
f) Cold water rinse	Room temp.	1 minute
g) Water/chromate pass	60-70°C	1 minute
h) Dry off oven	140-150°C	4-5 minutes

Note: The above is only indicative to pretreatment. Advice should be obtained from your pretreatment chemical supplier. As with all coating, the overall quality of the finish is only as good as the initial metal preparation.

We advise consulting your chemical supplier to obtain the correct conditions to meet the required specifications. We stress that all chemical pretreatment processes must be maintained to the chemical suppliers specification to ensure continuous quality powder coating.

When cleaning has taken place on steel substrates by applying strong acids and/or heat there may be an increase in the surface layer concentration of carbon smut. Removal of this smut may require a compound of cleaning materials and the physical action of spray impingement.

The re-circulating spray system is the most popular substrate pretreatment process because of the efficient, continuous operation. The process has circulation systems for each stage of cleaning, rinsing and conversion. Normally a 5, 6 or 7 stage pretreatment system is required when the customer wants a higher quality coating.

Figure 6 shows a simplified drawing of a 3 stage system. For a system with more stages the layout is principally the same.

Figure 6: Simplified Drawing of a 3 Stage Re-circulating Spray Pretreatment System

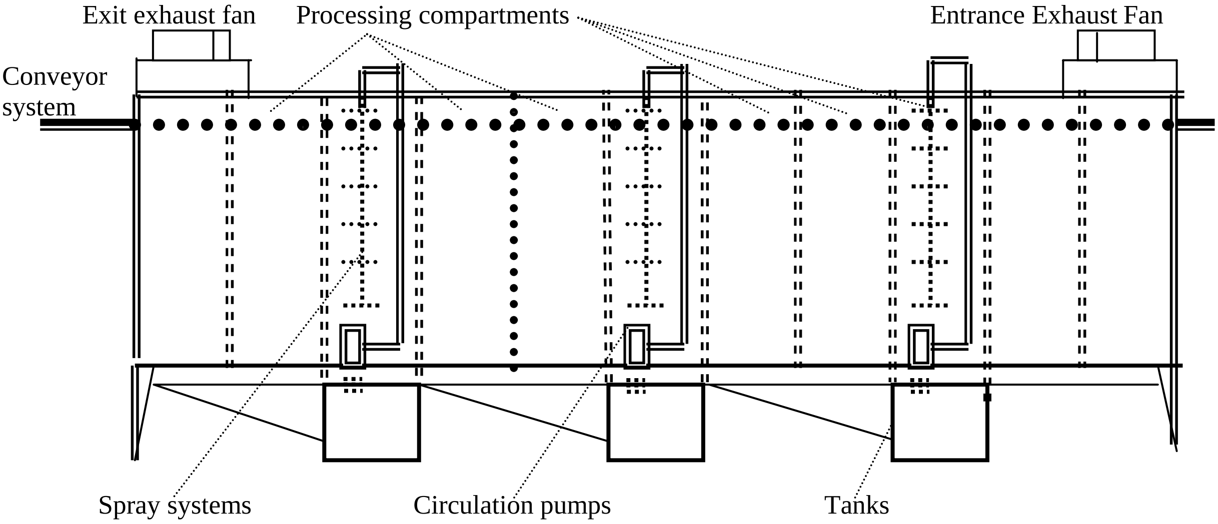
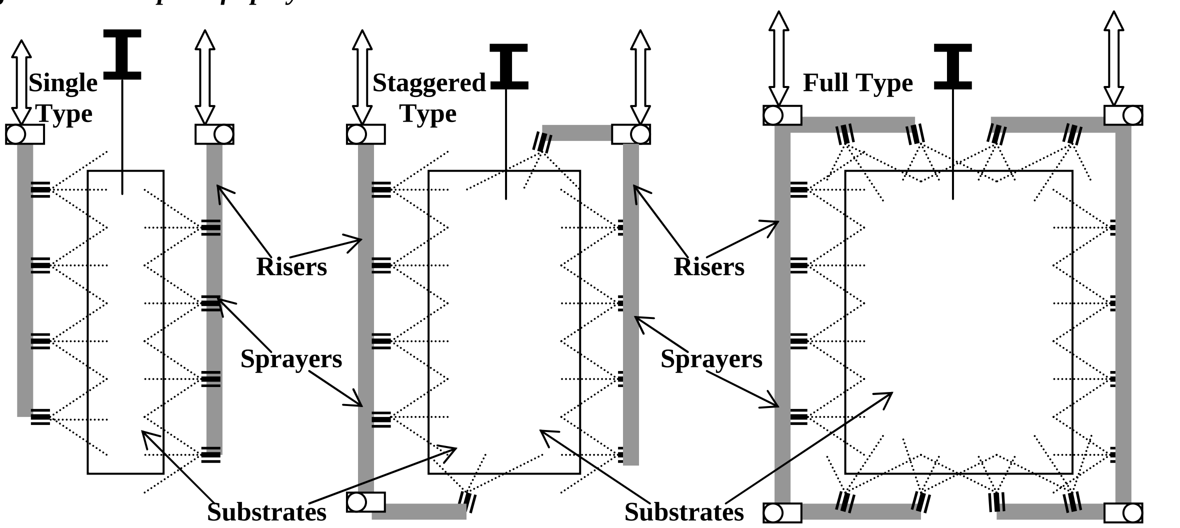


Figure 7: Examples of Spray Risers



Each process compartment forms a unit with its reservoir at the bottom. A top pull-out pump circulates the chemical solution through piping and risers. On the riser a series of nozzles are attached that spray the solution onto the substrate. Three types of riser are shown in Figure 7.

The stage length is a function of the processing time and the conveyor speed. A 90 second rinsing time for a system with a conveyor speed of 3 m/min requires a stage length of 4.5 meters.

Waste treatment - As a result of the pretreatment process there will be the need to drain some of the rinsing solutions or sludge from the reservoirs. The chromate and zinc phosphate baths are seldom dumped.

However, when they are, the solutions have to be treated and the local national and/or regional environmental laws and regulations must be followed and adhered to strictly. The iron phosphate solutions are easier to dispose of because they operate in the pH range of 4-6. The local authorities may allow the industrial user to raise the pH to 6-9 and dispose of it into the local drainage system.

Powder application - For most coating requirements powder is sprayed and charged electrostatically through spray guns onto the workpiece. Other methods include fluidiised bed dipping, powder cloud and electrostatic brush application. Most of the methods used fall into one of the following processes:

1. Electrostatic spray process
   - Corona spray gun
   - Tribo spray gun
2. Fluidised bed process.

The selection of the application method for a processing plant is often guided by particular needs being identified via a market survey and plant management considerations such as:

- ✓ Nature and size of the parts to be coated
- ✓ Specification of the coating film
- ✓ Variety of colours used and number of colour changes
- ✓ Processing quantities per order and per year
- ✓ Powder material and parts conveying logistics
- ✓ Available processing surface and volume
- ✓ Delivery time of powder coating equipment.

The advantages and disadvantages of the electrostatic spraying process and fluidized bed process are compared below. It is clear that both methods have their typical fields of application. In most cases, the electrostatic spray process is more flexible and versatile.

Electrostatic Powder Spraying:

<u>Advantages</u>

1) Difficult shapes can be coated
2) Film thickness between 30-250
3) Simple and low cost for automation
4) Colour can be changed relatively simply
5) No pre-heating of components required

<u>Disadvantage</u>

1) Cost of equipment is higher than a fluidised bed.

***Fluidised Bed Process*:**

<u>Advantages</u>

1) Very high film thickness (>250µ) can be applied in one application and curing cycle
2) Uniform film thickness can be achieved
3) Low initial plant cost and maintenance.

Disadvantages

1) Relatively large volumes of powder are required to charge the plant
2) The work-piece must be pre-heated and in some cases post cured in order to obtain the required result
3) This application can only be used where relatively thick films are required
4) The components should be of simple shape
5) Thin guage material can not be coated by this method due to its low heat capacity
6) A film thickness of between 200-250 microns is average
7) Colour change is a massive undertaking.

Electrostatic spray coating process - Electrostatic spraying, which is the most widely applied coating method, is not only more versatile, but generally provides better control of the powder coating properties. The electrostatic spray process makes use of electrically charging the powder particles.
The powder is contained in a hopper in a fluidised state and is held adjacent to the application booth. It is delivered by a powder pump and a transport air flow system to the electrostatic spray gun. The particles are charged on emission from the gun and with the help of the transport air move in the direction of the grounded work-piece. As the charged particles come close to the grounded workpiece, electrostatic attraction causes the particles to deposit and adhere to the work piece. This process is shown in Figures 8a and 8b in a simplified form.

There are two distinct methods for building up the charge on the particle surfaces. The Corona charging method (See Figure 8a) makes use of a high voltage generator (80-100 kv) to bring an electrostic charge (mostly negative) onto the powder particles through the intermediate process of creating oxygen ions.

In the Tribo method (see Figure 8b) the electrostatic charge (positive particles) is built up by the particles rubbing with increased velocity along a specially selected material (e.g. teflon) inside the spray gun for sufficient time, without the use of a high voltage generator. (See Figure 8b). Both spraying methods have their own typical powder cloud build up (compare Figures 8a & 8b).

Figure 8a: Corona Type Electrostatic Spray Coating

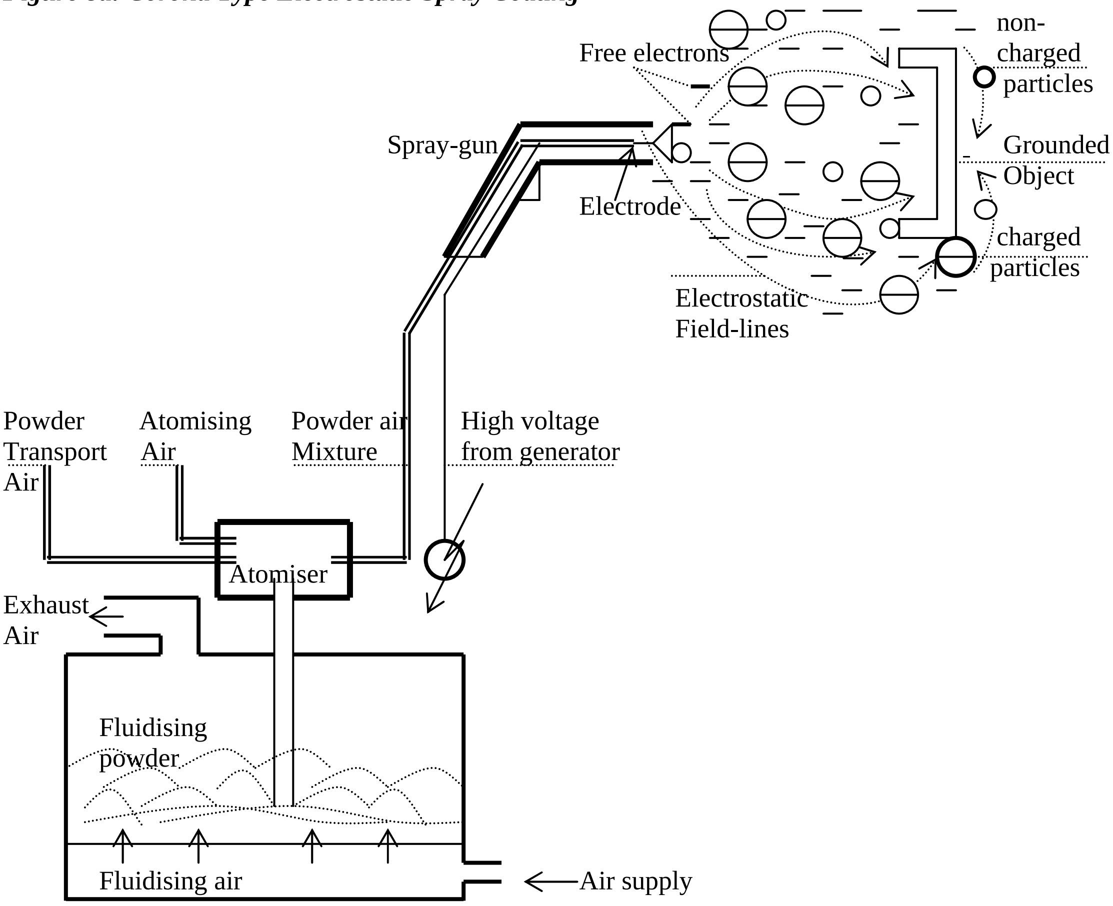
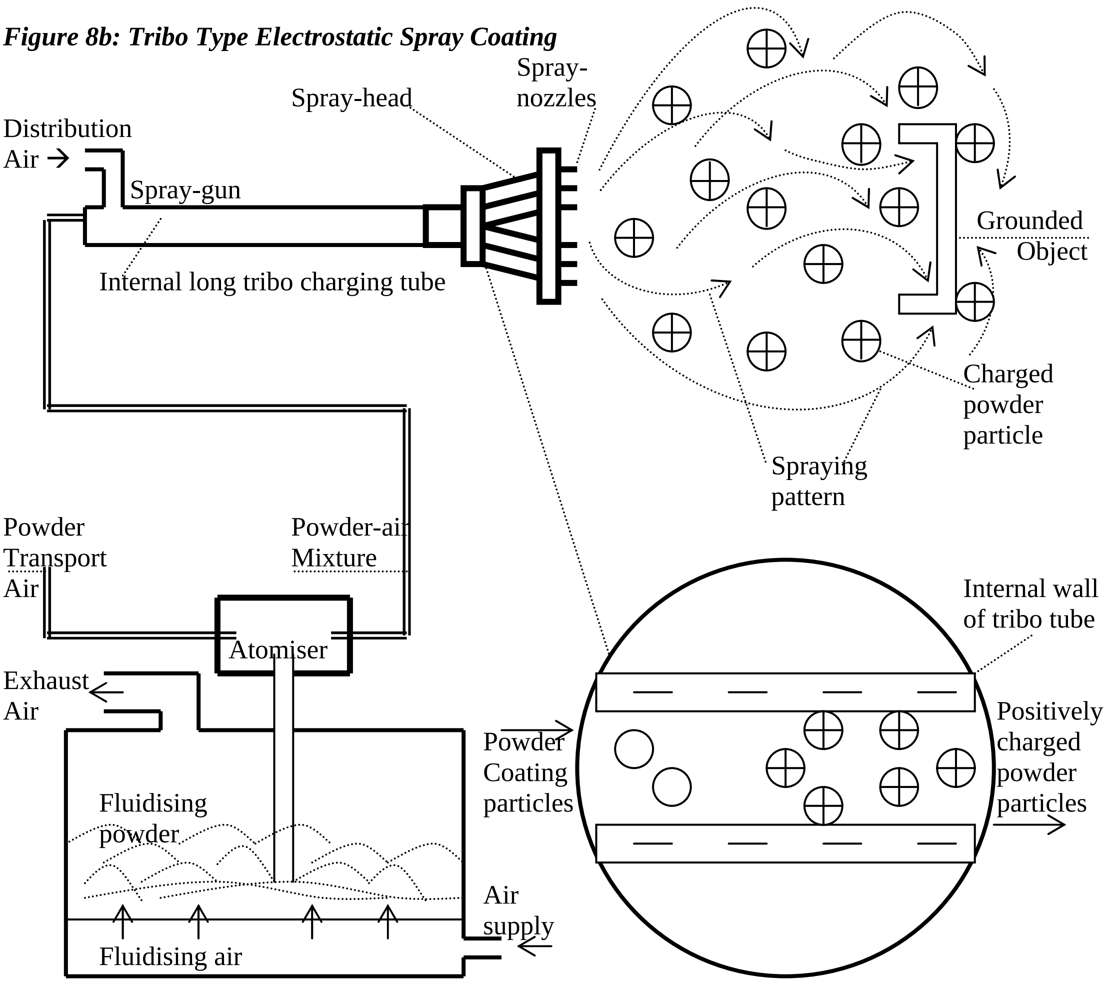


Figure 8b: Tribo Type Electrostatic Spray Coating



To guide your decision whether to select a Corona or a Tribo application method, listed below are the advantages and disadvantages of both:

***Corona Charging*:**

Advantages

1) Strong electrostatic field results in effective charging and higher deposition
2) Electrostatic fieldlines support the powder particles to move towards the work-piece
3) Simple repairs of the powdered surface are possible
4) Light, robust spray gun
5) Accepts different types of powder materials and particle sizes
6) Film thickness can be simply changed by voltage variations
7) Simple construction is suited for fast colour changes.

Disadvantages

1) Redundant ions generate a self-limiting effect
2) Strong fieldlines lead to Faraday effect (irregular coating, corners and crevices are not properly covered)
3) These effects can be reduced or eliminated respectively by voltage changes or use of anti-ionisation rings (to reduce Faraday and Orange peel effect).

***Tribo Spray*:**

Advantages

1) No Faraday effect; deep crevices, corners and hollow spaces can be better penetrated
2) Powder can be better directed by the use of directional finger sprayers and aerodynamics
3) Less, if any, fatty edges on the coated surface
4) Uniform coating
5) Very good automation possibilities
6) Higher charging effect without high voltage generator
7) Higher deposition effect
8) Higher productivity by closer arrangement of objects
9) More optimal film thickness build-up
10) Better flow; practically no orange peel effect
11) Reduced risk for back-ionisation
12) Lower powder consumption

<u>Disadvantages</u>

1) Performance is strongly influenced by uncontrolled air-streams
2) Special powder is necessary; formulation must be adapted to the Tribo charging process
3) Particles smaller than 10 microns are difficult to charge
4) Charging of particles takes more time and efficiency reduces during long runs
5) Colour changes take a long time
6) Higher investment cost for equal capacity output
7) More wear and so shorter life time of gun internals and other parts such as powder pump venturi inserts
8) More precise specifications for the cleanliness and humidity of the compressed air
9) Comprehensive training of the application personnel is recommended.

Note: Industries using the tribo method of application are usually in Northern Europe where the humidity is more constant and the temperature lower in summer months.

In both electrostatic spray processes there is the possiblity to recover and re-use the powder that is not deposited on the object

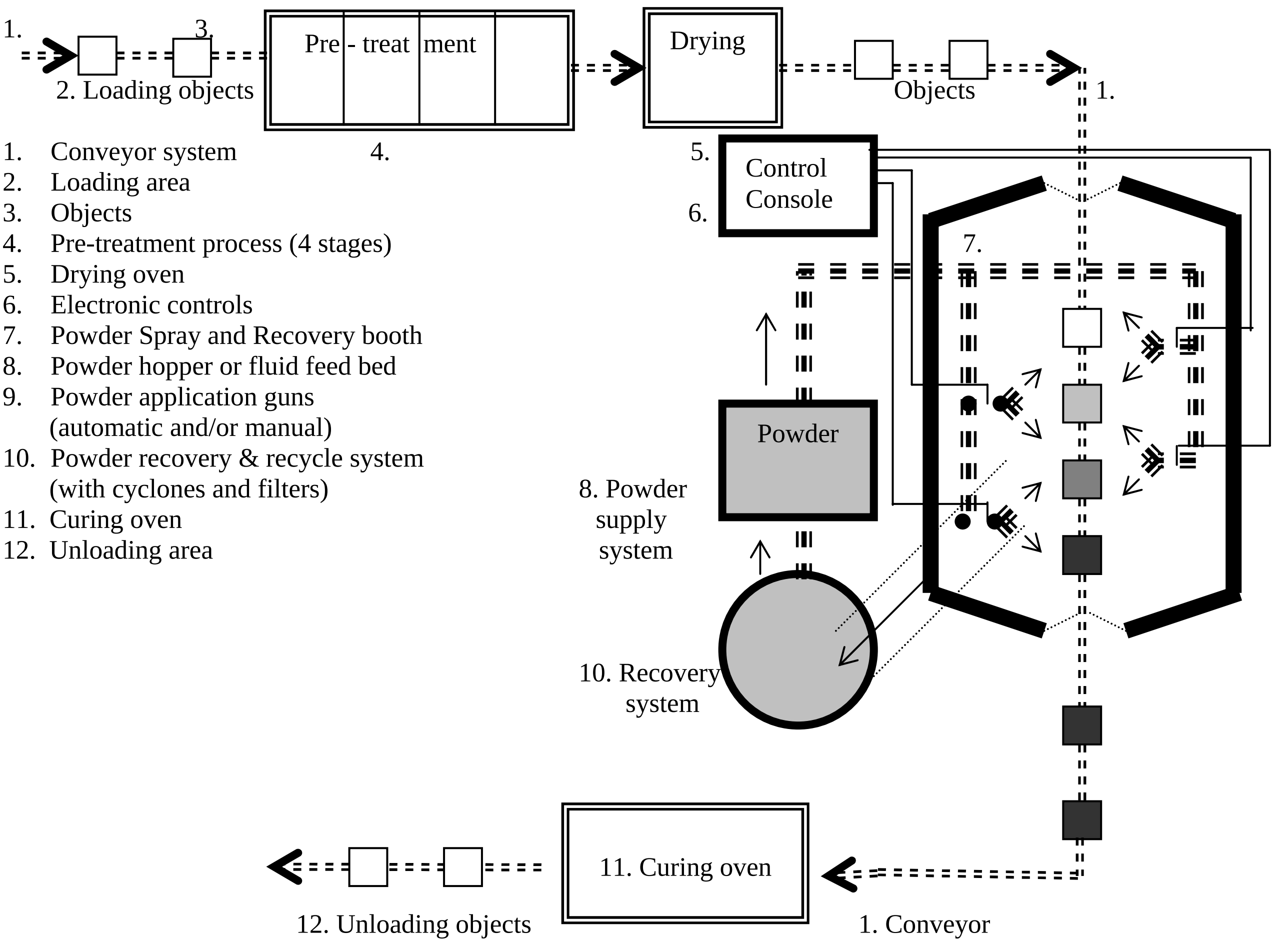
Transfer Efficiency is the weight of powder transfered to the workpiece from the total weight of powder that is passed through the powder spraygun in the same period expressed as a ratio. After powder application fusion takes place in an oven. (See Figure 9).

Many manufacturers, both European and Worldwide offer a range of equipment as described above. This includes complete conveyor lines, pre-treatment systems, drying/curing ovens or indiviual items such as powder pumps, spray guns or even their adaptor parts.

Each part of the coating system may be purchased from a specialist in that field (eg ovens, conveyors, booths) or the whole plant can be purchased from one ‘turn-key supplier’ who takes overall responsibility for the complete installation.

The level of resourced powder in the system will be affected by transfer efficiency.

Figure 9: Typical Layout of an Automatic Powder Coating Line



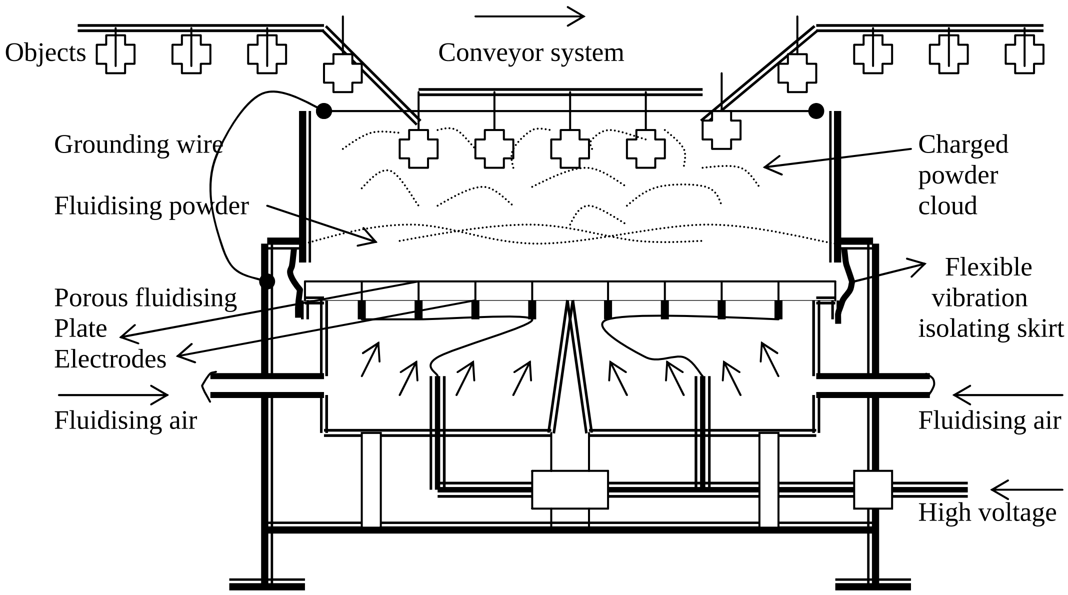
Fluidised bed coating process - Although the electrostatic spray method is the primary process for powder application, we will also be covering the fluidised bed coating method as one of the alternative coating processes.

In the case of thermoseting powders, this is almost exclusively carried out with epoxy resin based powders for large work-pieces such as pipe line valves, fence posts etc. or small articles from the eletronic industry for insulation. The majority of fluid bed coating is used for thermoplastic application. These coatings usually provide a thick tough coating film with excellent corrosion resistance and very good mechanical, electrical insulation and chemical properties.

Fluid bed coating does not need electrostatic charging of the powder particles and can take place with either pre or post-heated objects. When electrostatic charging a fluid bed safety measures should be taken to avoid risk of explosion.

The fluid bed is usually constructed as a container, the bottom part of which is an air plenum chamber and the top part is a porous plate. The area above the plate is filled with a certain volume of powder, which is fluidised by air from below. The resulting electrically charged cloud of powder is attracted to and deposits on an object when it is hung in the powder cloud.

Figure 10: Typical Electrostatic Fluidised Bed for an Automated Application Process

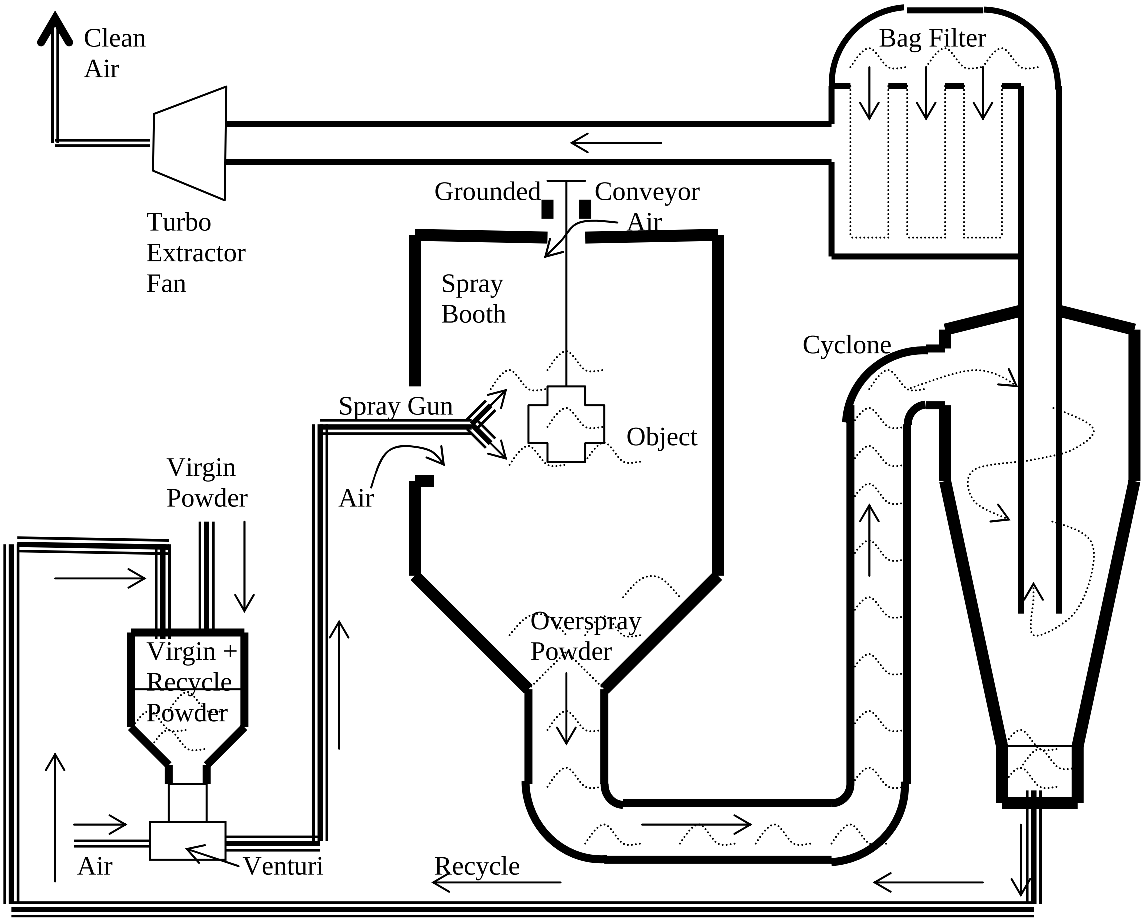


Powder spray booth - The powder that is not deposited onto the objects in the spray booth (overspray) is not wasted. It is recovered and re-used in the process. A spray booth should ensure that the overspray powder is contained, transferred and collected efficiently for recycling into the feed system. As such, the combination of these procedures ensures the optimum efficiency of the entire powder application operation. This recovery process is driven by an exhaust air ventilator that provides an airstream powerful enough to flow through the related extractor equipment such as a cyclone and filters. (See Figure 11).

The air in the spray booth where the powder cloud is built up and moving should ideally be static. The electrostatic forces related to the powder particles, combined with the projectional velocity of the particles leaving the spray gun (upto 60 m/sec), will perform a controlled movement of particles towards the object to be coated. This ideal situation can not be maintained for three reasons:

1) The recovery need (as mentioned above)
2) Spraying of powder is carried out and supported by a compressed air flow. This airflow must be removed by the exhaust ventilator
3) The need to maintain a negative pressure in the spray booth to prevent the powder from escaping through openings of the booth into the working environment. Therefore negative pressure is maintained and air is allowed to enter the booth through the booth openings and this air has to be exhausted as an additional volume as well.

Figure 11: Schematic Flow-Diagram of PowderApplication and Recovery System



Carefully controlled air movements and a clear compromise in the operating conditions in and around the spray booth and the recovery system have to be decided. In critical areas inside the spray booth an air velocity is maintained of 0.4 to 0.5 m/sec which is low enough not to interfere with the projectional velocity of the particle leaving the spray gun.

For safety reasons a maximum of 10g/m³ of powder in the air is required and legally accepted to avoid risk of explosion. *See the Safe Handling of Powder Coatings as provided by CEPE.*

Powder recovery - The function of a powder recovery system is to collect the overspray material and render it suitable for recycling and at the same time to remove the powder particles from the exhaust air stream before discharge into the atmosphere**.**

There are two types of collectors:

- ✓ Cyclone collectors
- ✓ Cartridge collectors

(there are more designs of collection systems which use these two principles).

Cyclone collectors:

The input to the cyclone is connected to the booth while the output is connected to a suitable exhaust fan. The overspray powder arrives at the cyclone inlet at a velocity of about 20 metres per second.

On entering the cyclone chamber tangentially the air/powder mixture is given a rotary motion which creates a centrifugal force on the particles. The larger and heavier particles tend to be ejected to the outside walls of the chamber and fall to the bottom where they are collected. The lighter fractions will stay suspended in the air stream which on reaching the bottom is deflected by a conical tail air/powder mix into a rising spiral which is then carried through the central stack to a filter collector.

For a standard powder the recovery efficiency can be as high as 95%. For lines that have a high % of particles <10µ in the recovered powder the recovery efficiency will be reduced (as low as 85%). Inevitably therefore a cartridge filter is used in conjunction with a cyclone solely to prevent discharge of the fine powder to the atmosphere.

An additional advantage of cyclone recovery, with particular reference to colour change, is that due to frictional contact of powder particles, one with another and 'bounce-back', little or no adherence of powder particles occurs on the cyclone wall. This means that in many cases only the powder collection hopper need be thoroughly cleaned between colour changes. In many cyclones cones are removable and substitutes can be made as required if spares are held in stock. The contaminated cone can then be cleaned while the replacement is in operation.

The recovered powder is removed from the cyclone by means of a rotary valve and is then passed through a sieve to remove any agglomerates and foreign matter. The recovered powder is then blended with the virgin material in predetermined proportions. Virgin: Reclaim mix ratio should always favour virgin.

As cyclone efficiency depends on maintaining a high particle size velocity through the cyclone, the cartridge filter following the cyclone must be designed to maintain the stability of the required velocity throughout the system.

The filter media should permit easy and frequent cleaning. The fabric filters which historically were used collected powder on the inside of the bag which does not fit with high production requirements as the bags have to be periodically cleaned down.

A superior method is to arrange a series of cartridge filters within a metal enclosure so that the powder collects on the outside of the filters and are then cleaned by a reverse compressed air flow which operates about every 30 seconds to provide an air counter current to the powder air flow. The total resistance of this multi cartridge system can be balanced with that of the cyclone so that the cyclone efficiency can be maintained.

Cartridge filters:
In this technique the overspray powder from the application booth arrives at an enclosure containing a number of cartridge filters.

Typical filter materials:
- Paper cartridges
- Scinter lamellar (plastic)
- Polyester cloth.

The cartridge filters separate the powder from air by causing the powder/air mix to pass from the outside of the cartridge to the inside through a layer of filter material which retains the powder and allows the air to permeate through and on to the atmosphere.

As filtering continues the retained powder accumulates on the upstream side of the cartridge and forms a powder layer which, being permeable to air flow, increases filtration efficiency albeit at the expense of increased resistance to air flow. This powder layer must be continuously removed to control filter resistance. The retained powder particles are periodically removed from the outside of the filters by reverse air jet blowing. The high speed, high-pressure reversing jets operate for less than 0.2 seconds at 30 second intervals and, because they are applied to only part of the filter for a brief dwell time, they have no practical effect on the main air flow, thus giving a continuous filtration characteristic.

The powder particles released from the cartridge filter then drop into a hopper to be sieved and returned to the system.

Cartridge filters are extremely effective being up to 99% efficient. The degree of efficiency depends on the type of filter employed and the regularity of its cleaning.

Attached to the material discharge of either cyclone or cartridge filter recovery system must be a dust tight seal, ie. a rotary valve, with which the reclaimed powder can be metered after passing through an inline sieve into the virgin material.

Curing ovens - To polymerise the powder applied to the substrate we must heat both to a high temperature for a few minutes. This is the curing process.

As powder coatings do not contain solvents (unlike liquid coatings) a flash zone is not required in the curing oven. The volume of exhaust gases is also substantially lower which can also substantially lower operational costs.

The formulation of the powder coating material determines to a large extent the curing time and temperature of the coated object. It will also result in the specified film properties.

At present we can select from several curing oven types:

***Convection oven*:**
Is most frequently used and can be divided into directly fired and in-directly fired ovens. Fuel options are natural gas, propane, oil or electricity. In the case of a directly fired oven combustion gases can interfere seriously with the powder during curing and with film properties thereafter.

In any oven care should be taken that no high air velocities exist or are created that could damage the virgin, or not yet solidified, powder coating layer. Acceptable air velocities are in the 1 to 2m/sec range.

***Infra-Red oven*:**
Uses radiant energy to heat a product through electromagnetic waves. Infrared heating works very quickly. There are three types of emitters - short, medium and long wave length. Their main performance differences are operating temperature (some 2000, 1050 and 600°C respectively) and radiation efficiency (80, 60 and 50% respectively). Higher temperatures result in faster heating rates and a lower efficiency which results in a higher loss through convection heat.

***Dual or combination oven*:**
Both infra-red and convection are applied. In the infra-red section the powder film is melted to avoid powder being blown off in the convection section where additional time is available to complete the entire crosslinking process.

***Induction oven*:**
Heat is generated in the metal object through induction of eddy currents. The advantage being, as with infra-red, the powder coating can start reacting before contact with gas combustion components can take place.

Medium temperature radiation offers the most effective source of heat for curing thermosetting powders. Gas fired emitter panels present a panel surface temperature of 900°C. Electric panels give a surface temperature of approximately 800°C. The work-pieces should be maintained at a distance of approximately 300mm from the emitter panels. Substrates coated with darker colour powder absorb more infra-red radiation, while objects with light coloured powder do not heat up as quickly. It is therefore recommended that each individual powder. is tested in combination with the curing oven to evaluate the curing performance.

Akzo Nobel Powder Coatings have a complete commitment to quality within every aspect of its powder coatings operation. This is encapsulated within its global "Progress Through Quality" programme which deals with all aspects of quality, not only in manufacturing but also in development, sales, administration and management. Amongst the various elements of this programme is a commitment to ISO9001 in all of its facilities. The majority of its customers and suppliers are similarly certified to ISO9000 standards.

Testing - The cured powder coating film can be checked for a wide range of characteristics. Depending upon the specification, various tests need to be carried out on test panels of each production batch before the coated product can be shipped to the customer. See Table 4 for a listing of some of these testing methods.

For most tests there exists a value with a negative and a positive tolerance. The actual figure should always be within the tolerance range. Many of the performance criteria have internationally standardised procedures for the test methods and can therefore be easily compared.

Details of some of the most common tests used across a range of industries are listed below together with examples of relevant testing standards.

It is important to note that for any particular powder coating application there may be a technical specification or quality standard to be met which refer to specific tests and testing equipment.

Table 4: Test Methods – Comparisons

Test Method	ISO	DIN	ASTM	BS	NFT
Film Thickness	2178 2360		D1186 D1400	3900D5	
Gloss	2813	6730	D 523		
Colour - Visual - Colorimetric	3668 7724		 D2244	3900D1	
Adhesion (Cross-hatch)	2409		D2197 D3359	3900E6	
Impact Resistance	6272		D2794	3900E3	
Cylindrical Bend Test	1519	53152	D1737	3900E1	30040
Conical Bend Test	6860		D 552		30078
Edge Coverage			296		
König Pendulum Hardness	3711	53157			
Persoz Pendulum Hardness	1552				30016
Buchholtz Indentation	2815	53153		3900E9	
Scratch Resistance	1518		D2793	3900E2	
Erichsen Cupping Test	1520	50102		3900E4	30019
Pencil Hardness			D3363		
Taber Abrasion Resistance		53774	D 968 D4060		30015
Humidity Resistance	6270	5017		3900F2	
Kesternich Sulphur Test	3231	50018		3900F8	
Salt Spray Test	9227	50021	B 117		
Acetic Acid Salt Spray	3769			6496 C15	

During the powder application process faults can occur, as with any other process. Coated parts can develop noticeable faults which places one or more quality characteristic outside the usual tolerances, causing items to be rejected.

If the part can not be utilised in a less critical or sensitive situation it must be either repaired or scrapped. The part should only be repaired if it is a relatively easy and a cheap process. A small repair could mean a simple touch-up, a more intensive repair could be a complete re-coat. The decision to repair or scrap the part is a matter of comparing total repair costs versus total scrap costs. The scrapping costs would be the addition of at least the material cost plus the total variable product, storage and disposal cost.

In the case of a rework, costs incurred would be (depending upon the nature of the fault) the sum of one or more possible actions, such as touch up, sanding, stripping, recoating or recurring. It is recommended to test the selected working method at each stage in order to ensure success.

Sanding - Contamination of the substrate surface beneath the coating film which creates rough spots are more difficult to repair. Sanding can be successful as long as the sanding paper is carefully selected and handled.

Touch-up - The repair of small defects, light spots or hanger marks can easily be carried out with liquid touch-up paint (applied by small brush or spray). The selection of the correct touch-up material is critical. The paint must be a perfect match with the already used powder. Factors to be considered are:

1) Original specification of the coating film
2) Intended use or exposure
3) Chemistry of the powder and its curing process
4) Number of parts to be repaired
5) Time constraints.

Recoating - With powder coating it is possible to apply a second coating layer on top of the first without influencing the properties of the film. Confirmation should be gained from the supplier. Recoating should be carried out on the entire work-piece and not just part of it, using the normal film thickness.

Double-curing - If a part is insufficiently cured it can be oven cured a second time. A careful check of the results is recommended before larger quantities are handled this way. If in doubt ask your powder supplier.

Stripping - In serious cases the entire first coating layer must be removed by either chemicals, mechanical methods or burn-off processes. After stripping it is essential that the objects are cleaned and washed or under go the complete pre-treatment process again before recoating.

Many problems can easily be avoided if procedures are followed and attention is paid to what we and others are doing. However, complications may also arise due to imperfections in any of the stages of the powder coating application process. This could be the pre-treatment section, the powder recovery system or in any of the utility supplies. These complications can have adverse effects on the functioning of these and other systems and can also negatively influence the quality of the coated parts.

Tables 5 to 10 provides a series of recommendations in a troubleshooting guide covering a number of the sections of the powder application plant. Recommendations are divided into 6 sections:

1) Powder supply, hoses, pumps and venturis
2) Electrostatic powder application process
3) Recovery and recycle of reclaim
4) Curing of the powder coating
5) Contamination of substrate or powder film
6) Complications with metallic powder.

Note: Operating and maintenance instructions received with equipment, chemicals and powder coating materials from suppliers should always be adhered to in addition to this information and guidance.

Table 5: Powder Supply, Hoses, Pumps and Venturis

Trouble	Possible Causes	Solution
Poor fluidisation in powder hopper	Powder level too low	Add powder to the normal level
	Compact or damp powder	a) Manually loosen powder in hopper b) Check compressed air for quality
	Partly plugged membrane	Check bottom of hopper and membrane for obstructions
	Powder particle size	a) Decrease amount of reclaim to hopper b) Check psd of virgin powder
Blocked hoses, powder pump or venturi	Normal build-up	Clean or replace parts
	Too high air pressure	Reduced air pressure on pump and gun
	Air supply moist	Check air supply for quality
	Material choice of hoses	Check hoses for material quality
	Powder hoses too long	Modify layout and/or shorten hoses
	Worn venturi or pump	Replace worn parts
	Too fine powder	a) Decrease amount of reclaim to hopper b) Check psd or virgin powder
Powder dusting out of hopper	Too high air pressure	Reduce air pressure to fluid bed
	Too fine powder	a) Decrease amount of reclaim to hopper b) Check psd of virgin powder

Table 6: Electrostatic Powder Application Process

Trouble	Possible Causes	Solution
Poor attraction of powder to the component	Incorrect voltage at the gun	Check voltage, clean or replace gun
	Poor grounding	Clean grounding points and hangers
	Excessive build-up of cured powder coating on hangers	Clean hangers
	Moisture in booth air	Check booth air supply for quality
	Gun air-pressure too high	Reduce forward air pressure
	Incorrectly positioned guns	Reposition offending guns
	Poor hanger design	Re-design hangers to reduce shielding
Film thickness on component too low	Powder delivery too low	a) Set correct powder feed pressure b) Check if powder venturi is the correct size, clean and set correctly
	Insufficient coating time	a) Increase time component by slowing the conveyor speed b) Increase voltage and forward air flow, reposition guns
	Faraday cage effect	Adjust voltage and forward air flow, reposition guns
	Surface area of hanger too large compared to the surface area of work-piece	Reduce size of hangers
	Damp powder	Remove powder and replace. Ensure all powder coatings are kept sealed until required in use
Film thickness on component too high	Excessive powder delivery	a) Reduce powder feed to gun b) Increase distance between gun and component
	Gun voltage too high	Reset gun voltage
	Excessive coating time	Reduce time of component in front of the gun by: a) Increasing the conveyor speed b) Increasing the reciprocator speed
	Too much pre-heat (if used)	Reduce pre-heat cycle
Varying emissions from gun (surging and spitting)	Damp air supply	a) Check air drier b) Install refrigeration unit c) Empty water taps
	Varying air supply	Check the compressor is not overloaded
	Damp powder	Remove powder, clean plant and replace powder with new supply. Ensure the powder remains in a sealed container until wanted for use
	Powder too fine	Check ratio of recovered powder to virgin powder. Adjust if necessary.
Poor penetration	Too low powder delivery	Increase powder flow
	Poor grounding	Check and improved grounding
	Incorrect spray pattern	Try different spray nozzle
	Too high voltage	Reduce voltage, so that surfaces closest to the gun do not repel powder
	Incorrect powder delivery velocity	Reduce air setting, so powder-air stream does not blow powder away
	Poor gun placement	Adjust gun position to enter more directly into recessed area
	Powder too fine	a) Reduce ratio of reclaim to hopper b) Check psd of virgin powder
Appearance looks uneven and broken before curing.	Back ionisation	a) Reduce voltage b) Check if grounding points are clean c) Reduce deposition rate, and film thickness d) Ensure no moisture is entering the system e) Move gun further away from component f) Check for build-up of metallic particles within the gun; clean if necessary

Table 7: Recovery and Recycle of Reclaim

Trouble	Possible Causes	Solution
Poor containment of powder booth	Primary air-filters damaged or blocked	a) Clean or replace filter bags b) Check reverse air cleaning system c) Check compressed air for quality
	Secondary air-filters overloaded due to damaged main filters	a) Inspect and replace bag filters b) Clean or replace cartridges
	Spray booth openings too large	Reduce open area in housing
	Improper gun position	Re-align spray gun
	Powder delivery too high	Reduce number of spray guns
Contamination of work-piece surface	Powder or foreign particles falling from conveyor or hangers	Clean conveyor regularly and strip hangers
	Contamination through reclaim powder; in-line sieve damaged	Replace torn sieve screen
	Contamination through foreign bodies from work-floor entering booth	Check parts from preceeding process steps for cleanliness
	Contamination through compressed air supply	Check compressed air for quality
Contamination by recycled powder	Ineffective cleaning of recovery and recycle system	Clean entire system according to suppliers instructions
Powder recovery below specified rate	Air velocity too low	Compare air flow with specification
	Powder too fine	Check psd of powder; contact supplier

Table 8: Curing of the Powder Coating Layer in the Oven

Trouble	Possible Causes	Solution
Gloss too high	Cure temperature too low	a) Increase air temperature and metal temperature b) Decrease line speed
	Oven cycle too short	a) Decrease line speed b) Increase oven temperature (Oven check)*
Gloss too low	Oven temperature too high	a) Reduce air temperature and check metal temperature b) Increase line speed
	Time in oven too long	a) Increase line speed b) Decrease oven temperature (Oven check)*
	Contamination with a powder which is incompatible	Clean all equipment including gun, booth and recovery system and re-charge with virgin powder
	Contaminated with solvent which may contain chlorinated hydrocarbons	Check proximity of vapour degreasing plant; restrict the air movement to powder coating application area
Poor flow	Heat up rate of the metal too slow	Increase temperature at the first stage of the oven (Oven check)*
Poor hammer, or texture development	Heat up rate too slow	Increase temperature at the first stage of the oven (Oven check)*
	Too much reclaim	Reduce the amount of reclaim by addition of virgin powder.
Poor adhesion	Under cure film	a) Increase oven temperature b) Decrease line speed
	Poor pre-treatment	Check pre-treatment, adjusting tanks to suppliers recommendations
Even discoloration	Cure temperature too high	Reduce oven temperature, or increase line speed (Oven check)*
Patchy discoloration	Inadequate pre-treatment	a) Check evenness of pre-treatment b) Check and adjust chemical balance of pre-treatment c) Check final rinse water and drying
	Corrosion products on the metal surface	Clean off with chemical pre-treatment inadequate. Check final rinse for contamination.
	Powder contamination	Check cleanliness of plant and recycling system

** Oven should be checked for air and metal temperature using a recommended oven temperature recorder, operated by a qualified technician. Temperature should be adjusted to the recommendations of the powder manufacturer.*

Table 9: Contamination of Substrate or Powder Film

Trouble	Possible Causes	Solution
Foreign matter in film	Inadequate cleaning	a) Check or adjust flow rate, spray nozzle position and temperature in each pre-treatment stage b) Check or adjust operating specifications for chemicals c) Clean guns, booth and recovery system
	Powder is too coarse or not sieved	Sieve all reclaim powder, check for holes in sieve, and check or change sieve mesh size
	Virgin powder is bitty	Contact supplier
Chemical cross-contamination	Improper parts loading or spacing	a) Check and adjust parts for maximum drainage b) Check and adjust drain time between stages
Contamination of colour	Poor housekeeping, when colour changing	Totally clean plant, gun and recycling equipment and recharge with new powder
	Cross contamination at manufacture	Contact powder supplier
Pinholes in the film	Silicone contamination	Locate and remove source
	Oil contamination	Check degreasing plant
	Oil/water in the air supply	Check oil/water separators on air supply

Table 10: Metallic Powders

Trouble	Possible Causes	Solution
"Back tracking"	Excessive metallic content	Contact suppliers
	Damp powder	Remove powder, clean all equipment and replace with virgin powder. (See advice on 'damp powder')
	Excessive reclaim	Check ratio of reclaim to virgin powder
	Poor grounding	Check all grounding of the sprayer, the spray equipment and the component
	Free metal in powder	Contact supplier.

Coating costs are questioned now more than ever before. Many coaters want to know how powder coating compares to liquid coating economically?

To answer the question, each and every individual case must be assessed. There are many aspects and factors that should be considered in order to judge the entire economics of a project.

Some aspects are tangible and are specific such as technical, technological and investment factors. Others are intangible, for example hazard, risk and quality.

The following offers guidance in the selection of powder coating.

Advantages of Powder Coating

1. Powder is immediately ready for use:

- ✓ There is no need to mix powder with solvents or catalysts, or make any adjustment prior to use
- ✓ This eliminates any risk on the factory floor or in the paint shop and reduces rejects due to mistakes in the adjustments needed for wet paint prior to use.

2. Reduction of fire risks:

- ✓ No solvent is used which reduces the risk of fire. This presents cost savings on both regulatory safety measures and a reduction of insurance premiums
- ✓ It eliminates the need for protected wiring and special light and power supplies in the storage area and application booths
- ✓ Care should be taken to ensure that naked flames and heat soures do not come into contact with the powder coating material.

3. No solvent waste problems:

- ✓ Powder coatings do not use solvents for thinning, spraying or cleaning thus reducing waste disposal problems
- 4 No solvent/paint waste disposal costs.

4. Reduced health risk in case of operator exposure:

- ✓ The ommission of solvents in powder coatings reduces the amount of inhalable hazardous materials
- ✓ Contact with skin produces less hazourdous effects and is easily washed off
- ✓ No need to use solvents or emulsifying soap to clean skin. Barrier cream is sufficient to prevent infection or irritation upon contact.
- ✓ A face mask will prevent powder-dust from being inhaled
- ✓ Very little smell (if any) is produced, reducing the need for ventilation.

5. Low waste of powder in the application process:

- ✓ Utilisation factors of 96 to 98% are possible, using a well maintained recovery and recycling system in the spray booth.
- ✓ No powder emulsions or powder sludge need to be discharged. No costly waste of solvent and no need for expensive solvent recovery systems.
- ✓ Unused powder can be collected and recycled, reducing potential environmental problems.

6. Superior powder film properties:

- ✓ Improved performance can be achieved in comparison with many conventional paints
- ✓ Improved appearance and performance can be achieved using one coat application
- ✓ Adhesion and corrosion resistance are improved as a result of easier curing control
- ✓ Powder film has minimal shrinkage during curing resulting in excellent edge cover. Polymer weight loss during stoving is less than 1%.
- ✓ More uniform and higher film thickness (35 upto 250 microns) can be obtained and controlled without special training
- ✓ Provided the related equipment is well controlled it will ensure that the required film thickness is maintained and repeatable in automated production
- ✓ High gloss, semi gloss, matt, metallic and textured coatings can be achieved in one application.

7. Easy powder-film repair:

- ✓ If one or more spots of the film are damaged before curing the powder can easily be removed from the surrounding area with air or a vacuum
- ✓ Rectification of the damaged area takes place by re-spraying
- ✓ The removed powder can also be recycled and re-used.

8. Housekeeping:

- ✓ The powder coating booth is easily cleaned using air or a vacuum. Simple cleaning tools can be used to clean booth walls and floors
- ✓ It is not necessary to use cleaning solvents and rags as with liquid coating booths
- ✓ Manufacturers safety instructions must always be followed
- ✓ Good housekeeping practices must be maintained at all times.

9. Additional capital investment and economic advantages:

- ✓ Simple automatic equipment enables easy application
- ✓ Less need for skilled sprayers and operator training
- ✓ Simple pretreatment will normally suffice. For most applications degreasing and phosphating will be suffucient
- ✓ Processing time is generally reduced (in comparison to liquid coatings) as a result of not having to ‘flash off’ the solvents before curing
- ✓ Less space is required for equipment because there is no ‘flash off’ period
- ✓ No solvents or hot solvent laden air needs evacuation which reduces energy requirements
- ✓ ‘Flash off’ dust is not created and therefore does not adhere to coatings reducing surface defects and rejects
- ✓ Less air is required for replacement in the oven and plant resulting in reduced heat loss
- ✓ Less storage space is requird for powder coatings without special fire precautions such as anti flash fittings
- ✓ No special solvent stores are required as powder is ready for use
- ✓ A powder plant is simpler and cheaper to operate than a liquid paint application plant.

In conclusion, the major benefits for selection of powder coatings are:

1) Tangible capital cost reductions
2) Tangible operationl cost reductions (energy, labour, efficiency)
3) Intangible technological cost reductions (quality, hazards, environmental).

Specific cost considerations - At the end of the coating line the most important figure is the all-in net cost per m² for a powder coating film. To evaluate this cost we should consider and analyse the entire powder coating system starting at the raw material entrance of the application plant and finishing with storage and shipping activities. This is a very difficult task.

Table 11 illustrates how such calculations are carried out:

Table 11: Simplified calculation of powder coating material cost and consumption per m²
(As powder coatings contain no solvent and require no mixing or thinning, it is relatively easy to calculate the weight of powder required to coat a given work-piece surface. From this the cost can also be calculated):

Specific Gravity x Film thickness (microns)=Grams of powder per square meter coated	
- Given a white powder with a specific gravity of:	**1.65g/c³**
- Volume of powder on 1m² with 1 micron thickness:	**1c³**
- Assuming a film thickness of 60 microns the amount of powder per m² equals:	**1 x 1.65 x 60.00 = 99 grams**
- The area covered with 1 kilo of this powder would be:	**1000/99 = 10.10m²**
When all operations and equipment in the plant are well maintained and controlled a theoretical powder utilisation of 97% could be expected in continuous production. This efficiency factor must also be taken into account.	
- Thus giving:	**97/100 x 10.10 = 9.797m² coated surface**
- We assume that the powder is purchased for a net price of:	**Euro 15**
- The final coating cost is therefore:	**15/9.797 = Euro 1.531/m²**

Notes:

1. *Errors can be made in calculating the surface area that requires coating. The total surface area must include both sides of the component back and front, or if one side coating is required the wrap around effect must be included in the calculation eg. with a multipication factor per running meter edge length*
2. *Inefficiencies take pace in every plant at certain times in in varying degrees. For short runs it may not be feasible to optimise the efficiency factors*
3. *Akzo Nobel are able to provide technical assistance to optimise plant efficiencies.*

Table 12: Powder Material Cost

Line	Determining Factor	Reference	Case 1	Case 2	Case 3
1	Powder cost	NLG per kg	15.00	16.50	16.50
2	Specific gavity	G/c³	1.65	1.65	1.65
3	Volume of powder c³/m²	With thickness of 1 micron	1	1	1
4	Film thickness in microns	Average	60	60	70
5	Theoretical coverage m²/kg	1000 / (line 3 x line 2 x line 4)	10.10	10.10	8.66
6	Theoretical material efficiency in %	Normal range 95 – 98	97	97	97
7	Theoretical coverage in m²/kg	Line 6 / 100 x line 5	9.80	9.80	8.40
8	Material cost NLG/m²	Line 1 / line 7	1.53	1.68	1.96

Table 12 shows the same analysis in the form of a matrix calculation. The advantage of this method of calculation is clear when used for several cases at the same time (See Case 1, 2 and 3 to follow). A selected determining factor can be varied and the final result is available immediately.

We recommend an identical analysis and calculation matrix for each of the following steps in your powder coating application process. Akzo Nobel can provide technical assistance to help optimise the calculations for your own plant.

Chemical cost for pretreatment - In most pretreatment processes, chemicals are used such as cleaners, surfactants, ion exchange chemicals and phosphates etc

Energy cost - This represents the additional cost of large energy consumables such as:

Curing oven**:** The powder curing oven requires less exhaust air than the liquid coating alternative. Although powder formulations typically need higher curing temperatres, the overall energy requirement is still less than with liquid coatings.

Conveyor system**:** Not only is energy required to drive the conveyor it is also required to compensate for heat loss to the conveyor and parts.

Energy for air circulation**:** Powder systems circulate air but do not require make up air which has to be heated. A powder coating application system requires that a specified circulation of air is maintained in the spray booth, through the recovery, air filter systems and back into the building.

General utilities costs - Is dependant on the heating method used in the curing oven ie. natural gas, oil or electricity. Additionally, compressed air, water and a general quota for electric power consumption for other consumables would be required.

Labour and maintenance costs - Working hours and hourly labour costs for operations and maintenance would be a factor to be included here, if necessary split per process step. Also replacement parts (filter elements, sieves) and parts (bearings, conveyor, pump, spray gun, instrumentation parts) need to be incorporated.

Powder coating material is generally not classified as hazardous to the operator in the application plant. Usually, it is considered as dust that has to be kept away from personnel, equipment and the environment. However, according to the 'Fire Protection Handbook' combustible organic powder is classified as hazardous because it can burn vigorously when suspended as airborne dust and can explode when confined.

In an electrostatic powder application plant a number of preventive actions must be taken which are as stringent as those in the powder coating material manufacturing plant in order to minimise health, safety and environmental hazards connected with the handling of coating powders.

In all industrial countries there will be safety standards and agencies (state, local or city level) who will govern the installation and operation of powder coating application plants. These agencies will issue relevant laws and regulations for behaviour in the fields of health, safety and environment.

We will cover a number of issues based upon known regulations in the USA and/or the UK. However, we do advise that this chapter is in no way a complete guide to the matter. We recommend you further investigate relevant legislation in the country where you may initiate a powder coating application plant.

Conducting a business into the 21st century requires a company policy that covers the health and safety of the personnel and their neighbours and also gives balanced attention to the protection of the environment. It must be considered part of our responsibility to ensure that our activities are not only concerned with economical, financial, technical and social aspects but just as much with aspects of health, safety and the environment.

It is now inevitable that many in the industry adhere strictly to these regulations and often even beyond that. The industry now has a commitment to put in place preventative measures rather than corrective action once problems have arisen.

Equipment suppliers will be fully able to provide you with details on the safety requirements connected with all the steps of the implementation of your powder coating application plant. Akzo Nobel Powder Coatings representatives will also be happy to discuss with you how to handle hazards, utilising our many years experience in this field worldwide.

Health and Safety: The British Coatings Federation (BCF) have published a booklet 'Code of Safe Practice' covering the 'Application of thermosetting coating powders by electrostatic spraying'. Other European countries recommendations are contained in 'Safe use of Powder Coatings' which is issued by the Confederation of European Paint Manufacturers (CEPE).

In the USA the installation and operation of powder coating systems are controlled by several governmental agencies such as the Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFPA).

These directives and guidelines have recommendations based upon older regulations (1960-1970), but also contain more recent regulations (1990>).

These recommendations have been issued (amongst others) in relation to:

1) The design and lay-out of factories in general
2) Specific design and safe use of utility systems for electricity, compressed air etc
3) Personal protection equipment
4) Workplace design and ergonomics
5) Management and control of hazardous substances.

Health and safety hazards - The main hazards involved in powder coating arise from the possibilities of dust explosion, fire, electric shock, exposure to hazardous materials, compressed air etc. Heavy metals along with a range of other hazardous chemicals have all been banned from the powder coating industry. Obviously, as in any other industrial operation, there are general safety procedures to prevent personnel from getting injured - hands, feet and the head are the most frequently injured parts of the body. General safety precautions will not be covered in the guide.

Dust explosion and fire hazards - Processes which involve mixing air and combustible organic powders can be dangerous. The use of thermosetting powders for surface coatings presents much fewer hazards than solvent based paints. There are no flammable vapours in the powder coating process. The energy required to ignite a dry cloud of air-suspended powder coating material is from 100 to 1000 times higher than that required to ignite a volatile vapour / air mixture.
A dust explosion may take place when both:

1) The concentration of powder in the air is above the lower explosive limit (LEL)
2) A source of ignition with the required degree of energy is present at the dust cloud; such sources of ignition can be hot surfaces, open flames, electrical or electrostatic discharges.

A fire can occur when a layer of deposited powder material or a powder cloud comes in contact with an ignition source mentioned in b) above. This type of fire can result in an explosion.

Thermosetting powders are only hazardous when within a certain range of powder-air mixture concentrations. In a well designed and operated powder coating plant these concentrations can only occur within the spraying and recovering system and this is therefore taken into account in their design.

Ignition temperature for usual powder-air concentrations is very high. A typical epoxy powder ignition temperature is approximately 500ºC in comparison to solvent vapour air mixtures which are approximately 30 to 40ºC.

The risk of fire or explosion can be reduced when any of the conditions listed in a) and b) above can be excluded. This can be done by:

1) Introducing regular maintenance and maintaining a clean working environment
2) Omitting dry brushing or using compressed air to clean up spilled powder
3) Using specially designed vacuum cleaners or wet cleaning
4) Prohibiting open fires and smoking
5) Designing and maintaining not more than 50% of the lower explosion limit (LEL) in the spray booth and recovering systems
6) Communicating specific information on products in use such as LEL and ignition temperature.

Electrical hazards - The main sources of electrical hazard are:

1) Improper or defective grounding systems that may lead to the build-up of electrostatic electricity and subsequent sparking or shock
2) Broken-down or overheated electrical equipment that could lead to fire or shock.

The risk of shock or fire can be reduced when the above conditions are excluded by:

1) Maintaining adequate grounding of all conductive objects including the high voltage power supply unit
2) Inspecting and cleaning all moving parts of excess coating or dust
3) Providing conductive floors, tools and personal protective equipment for the operators
4) Designing conveyors to minimise swinging of the work-pieces
5) Not allowing dust build-up on electrical equipment and ventilation ducts
6) Keeping cooling fans clean and unobstructed
7) Instructing operators to wear anti-static overalls, non-insulating gloves and anti-static footwear.

Note: Manual and/or automatic fire extinguishing equipment should be available at regular distances in the powder coating application plant, notwithstanding the above preventive measures.

Exposure to hazardous materials - Powder coating materials contain six or more different components, as discussed in chapter 3. Some of these substances may, depending upon the formulation, present a health hazard to the operating personnel, but only if they are allowed to escape into the working area because of improper handling or insufficient ventilation.

A particularly hazardous component in the powder coating material, if any, must be indicated by the supplier of the material on the product label and on the provided 'Material Safety Data Sheet' (MSDS). A guidance will be included on the 'Occupational Exposure Limits' (OEL) and the precautions will be indicated which have to be taken in case of skin contamination or respiratory inhalation.

See the Akzo Nobel Powder Coatings format of a Manufacturer's Safety Data Sheet (MSDS) and the format of the American OSHA in Appendix 1 and 2.

The risk of health hazards in connection with the exposure to powder coating materials can be considerably reduced, if not prevented by comprehensive analysis of the work place, the protective requirements of the operators and the issue of instructions on how to work safely eg:

- ✓ Do not to eat or drink at the work place
- ✓ Wear protective clothing with long sleeves
- ✓ Wear long gloves that cover the under-arm
- ✓ Wear mouth/nose dust-mask and safety goggles
- ✓ Wear full face respirator mask,
- ✓ Provide washbasins for proper washing of hands, especially prior to eating and drinking in the canteen, and dispensers with moisturising cream to be used after washing
- ✓ Provide facilities for washing other areas of local skin or the entire body with soap and water.

Any person who will handle a hazardous product must be informed of the hazard as soon as the hazard has been formally determined. Although the information itself is standardised, the way of communication is a non-standardised format. (See Appendix 1 and 2 for examples).

Compressed air, pressurised water and other utilities - Pressurised media systems can be dangerous:

- ✓ The air pressure can cause part of the system to rupture if it hasn't been installed, maintained or operated correctly
- ✓ The medium enters the body through mouth, nose, ears etc causing internal damage
- ✓ The medium can injure or penetrate the skin and eyes
- ✓ Foreign particles in the medium can cause infection

For these reasons the pressurised media should always be kept away from the body. Maintenance and operation of pressurised systems are subjected to national regulations and guidance from the country of installation. They control the safe practice during use, handling and inspection in normal and emergency situations.

Basic design considerations - The following criteria should be seriously considered in the design, contruction and installation of a powder coating application plant in relation to health and safety issues:

1) Adequate ventilation and extraction from all working areas
2) Easy access to all first aid and fire extinguishing equipment in case of emergency
3) Sufficient provsion for safe means and routes to evacuate in case of danger.

Spray booths and application equipment

- ✓ Properly constructed spray booths should be installed with exhaust ventilation equipment to extact dust and maintain the airborne powder concentration inside the equipment below 50% of the LEL and outside in the workplace below the Occupational Exposure Limit (OEL)
- ✓ Manual touch-up operations require suitable access openings, large enough to allow efficient repair. The direction of the air should be from behind the operator (in case of manual application) in the direction of the spray booth and into the exhaust ducts
- ✓ The required air velocity for adequate control will be dependanet on a number of factors such as spray booth design, powder coating applicaton rates and dimensions of the objects being coated
- ✓ Usually an effective control will be obtained when the extraction velocity is between 0.5 m/s and 1.0 m/s measured as a mean value over the face area of the booth
- ✓ The operation and effectiveness of extraction and ventilation systems should be inspected, tested and maintained in accordance with the local regulations
- ✓ The spray booth and the downstream equipment should be constructed of non-combustible materials
- ✓ The surfaces should not build up electrostatic charges and all conducting parts should be properly grounded
- ✓ Horizontal surfaces shuld be excluded to prevent dust depositions and inside surfaces should be as smooth as possible to allow easy cleaning
- ✓ The electrical powder supply and the powder coating feed should be interlocked with the air extraction volume in such a way that the power supply and the powder feed are cut off in case the ventilation fails
- ✓ Flange connections and bracing should be constructed outside the spray booth
- ✓ High voltage cables must be protected gainst mechanical damage
- ✓ Spray guns must be installed and protected to conform to the relevant regulations for electrical installations
- ✓ All electrical equipment should be capable of being isolated in a safe way in case of emergency
- ✓ As the spray booth is usually integrated with the recovery system the entire operation should be provided with an explosion relief system designed and constructed with the local regulations. The relief should not be allowed to vent into the building and work area
- ✓ Automatic sprinkler systems may be installed in the building upon the advice of the local fire authority. For localised small fires a CO_2 blanket or a water mist may be used effectively.

Ovens

- ✓ The design and installation of curing oven should be according to the national emission requirements regulations and be constructed so that products or volatile components are exhausted to a safe place and prevented from escaping or returning into the work place
- ✓ Ovens should be regularly inspected, tested and maintained to ensure the operational effectiveness and efficiency in accordance with the local regulations
- ✓ At all stages in the handling of powders eg. Opening of boxes, loading of hoppers, collection of unused powders these activities should be carried out in a contained area and/or with proper dust exhaust equipment in order to prevent the dust escaping
- ✓ The temperature of the oven should be controllable and several high temperature safety switches should be installed and set at a maximum of 240ºC
- ✓ Conveyor ovens should have an interlock provided to shut down or reduce the heat source in case the conveyor is stopped in order to prevent the overheating of the parts inside
- ✓ The entire oven should be designed and constructed in such a way that easy cleaning is possible whenever necessary.

Recovery and recycle system

- ✓ The recovery and recycle equipment should be constructed of non-combustible materials
- ✓ The surfaces should not build up electrostatic charges and all conducting parts should be properly grounded
- ✓ The layout of the system should be such that the length of the ductwork is maintained to a minimum
- ✓ The entire system should be designed and constructed in such a way that easy cleaning is possible whenever necessary
- ✓ Access handholes should be provided for inspection and cleaning purposes
- ✓ Horizontal surfaces should be excluded to prevent dust depositions and inside surfaces should be as smooth as possible to allow for easy cleaning
- ✓ The operation and effectiveness of extraction and ventilation systems should be inspected, tested and maintained in accordance with the local regulations
- ✓ Flange connections and bracing should be constructed outside the equipment
- ✓ The dust discharge collect should be carried out via a tight connection into a strong metal container
- ✓ The recovery system is usually integrated with the spray booth, the entire operation shold be provided with an explosion relief system designed and constructed with the local regulations. The relief should not be allowed to vent into the surrounding work place unless filtered adequately.

Environment - The authorities of many countries have issued a 'National Environmental Policy Plan' which describes the main environmental policy directives and guidelines. It was produced to help in the battle against the many emissions (including waste streams) that negatively influence our environment. It requires a structural adaption of economical production processes and claims that a 'good and healthy environment' is a pre-requisite for continuing economical development.

The authorities expect that every company co-operates in the implementation of the following directives:

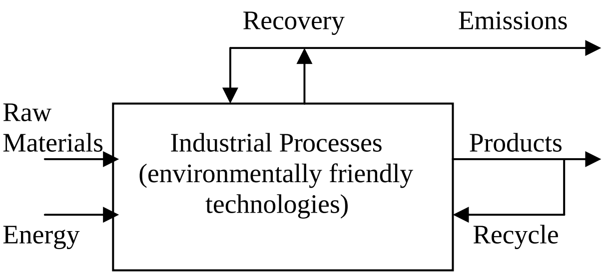
1) Adaption of product processes to environmentally friendly technologies
2) Attack problems together with the authorities, in particular:
   - analyse company tasks
   - develop plans for:
     i) the prevention and recycling of waste products
     ii) saving of energy and soil sanitation
   - introduction of an internal environmental management system
   - stimulation and support of environmentally friendly technolgies
3) Consideration of all environmental aspects during the investment related decisions.

In the USA this regulation is known as the 'Resource Conservation and Recovery Act' (RCRA). The above also implicates the effective and continuous operation of an 'integral environemntal protection management system', whereby:

1) Raw materials and energy are reduced
2) Emissions are primarily prevented, reduced and recovered
3) Inevitable emissions are handled according to the relevant regulations
4) Product mastering is obtained by full product control and recycling

This is illustrated in Figure 12.

Figure 12: Integral Environmental Protection Management System



At the start of this chapter we stressed that the application of powder material is pre-eminently the optimal choice of technology for an industrial coating process. The health, safety and environmental advantages are clearly predominant in comparison with liquid coating materials (see Chapter 8).

Most modern powder formulations do not contain volatile organic compounds (VOCs), hazardous air pollutants (HAP), heavy metals such as lead, chromium, mercury and cadmium or curing agents which are believed, by some experts, to have a degree of carcinogenic or mutagenic behaviour.

The mentioned CRA also regulates the identification, collection, transportation, storage, treatment and disposal of hazardous wastes in general. It covers several hundred of these hazardous wastes, including chemicals. Of these identified wastes and chemcials none are used in the manufacture of powder coatings. The waste from powder coating application plants is therefore judged to be non-toxic or non-hazardous by the RCRA. When in doubt check the material safety data sheet or enquire via a HSE specialist.

In summary:

1) Akzo Nobel gives high priority to health, safety and the environment and adheres to the current regulations in the interest of the environment and the health and safety of the personnel in the coating industry
2) When designed and operated properly the powder coating application process generates very little waste materials when compared to liquid coatings. The waste which is generated is not a toxic or hazardous material
3) Akzo Nobel technical assistance can be made available to support you with the optimisation of your local powder coating application plant.

Appendices

According 93/112/EEC

1. IDENTIFICATION OF THE SUBSTANCE / PREPARATION AND OF THE COMPANY

Product name: **Product code:**

Address: **Sub Business-Unit: Powder Coatings (Europe)**

EMERGENCY TELEPHONE NUMBER:

2. COMPOSITION / INFORMATION ON INGREDIENTS

Substances representing a hazard within the meaning of the dangerous substance directive 67/548/EEC

Components	% w/w	EEC number	CAS number	Symbols	Risk phrases	TLV mg/m^3
Fine dust						5
Total dust						10

3. HAZARDS IDENTIFICATION OF THE PREPARATION

Based on the composition and performed toxicity studies with the product, the preparation can be considered as an inert dust.

4. FIRST AID MEASURES

General
In all cases of doubt, or when symptoms persist, seek medical attention. Never give anything by mouth to an unconscious person.
Inhalation
Remove to fresh air, keep patient warm and at rest. If breathing is irregular or stopped, administer artificial respiration. Give nothing by mouth. If unconscious, place in recovery position and seek medical advice.
Eye contact
Contact lenses should be removed. Flush copiously with clean, fresh water for at least 10 minutes, holding the eyelids apart. Seek medical advice.
Skin contact
Remove contaminated clothing. Wash skin thoroughly with soap and water or use recognised skin cleanser. Do NOT use solvents or thinners.
Ingestion
If accidentally swallowed, obtain immediate medical attention. Keep at rest. Do NOT induce vomiting.

5. FIRE-FIGHTING MEASURES

Extinguishing media
Recommended: water/spray mist, fire extinguishing powder, CO_2 -blanket, alcohol resistant foam.
Not to be used: high pressure inert gas, water jets; do not stir up the powder coating.
Recommendations
Fire will produce black dense smoke. Exposure to decomposition products may cause a health hazard. Appropriate breathing apparatus may be required. Cool closed containers exposed to fire with water. Do not allow run-off from fire fighting to enter drains or watercourses.

6. ACCIDENTAL RELEASE MEASURES

Exclude sources of ignition and ventilate the area. Exclude non-essential personnel. Avoid breathing dust. Refer to protective measures listed in sections 7 and 8. Contain and collect spillage with an electrically protected vacuum cleaner or by wet brushing and place in container for disposal according to local regulations (see section 13). Do not use a dry brush as dust clouds can be created. Do not allow entering drains or watercourses.
If the product contaminates lakes, rivers or sewage, inform appropriate authorities in accordance with local regulations.

7. HANDLING AND STORAGE

Persons suffering from respiratory problems or allergic response should not be exposed to, or handle, powder coatings.

Handling
Precautions should be taken to prevent the formation of dust in concentrations above flammable, explosive or occupational exposure limits.
Electrical equipment and lighting should be protected to appropriate standards to prevent dust coming into contact with hot surfaces, sparks or ignition sources.
Preparation may charge electrostatically: always use earthing leads when transferring from one container to another. Operators should wear anti-static footwear and clothing and floors should be of conducting type.
Keep containers tightly closed. Isolate from sources of heat, sparks and open flame.
Smoking, eating and drinking should be forbidden in application area.
For personal protection see section 8.

Storage
Observe label precautions. Store in a dry well-ventilated place away from sources of heat, ignition and direct sunlight. No smoking.
Prevent unauthorised access. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures
Avoid inhalation of dust. Where reasonably practicable, this should be achieved by use of local exhaust extraction and good general ventilation. If these are not sufficient to maintain exposure to dust below the exposure limits, suitable respiratory protection must be worn.

Personal protection
<u>Respiratory protection:</u>
When workers are facing dust concentrations above the exposure limit, they must use appropriate certified respirators (P1 grade) being effective against this type of material.
<u>Hand protection:</u>
For prolonged or repeated contact, use barrier cream or suitable gloves.
<u>Eye protection:</u>
Safety eyewear should be used when there is a likelihood of exposure.
<u>Skin protection:</u>
Personnel should wear protective clothing and all parts of the body should be washed after contact. Care should be taken in the selection of protective clothing, to ensure that inflammation or irritation of the skin at neck and wrists through contact with the powder is avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

		Test Method
Physical state:	fine powder	
Odour:	not unpleasant	
Real density 23°C:	1,2-1,9 g/cm^3	ISO 8130-2/-3
Bulk density 23°C:	400-1000 kg/m^3	
Lower explosion limit of dust/air mixture: (recommended value for powder in air for plant design: not to exceed 10 g/m^3)	35-90 g/m^3	ISO 8130/4
Solubility in water:	insoluble	
Softening point:	> 50°C	hot plate
Ignition temperature of a dust/air mixture:	450-600°C	VDE 0165
Vapour pressure:	none	
pH-value in water:	pH-value of water will not change	
Flash point:	none	

Thermal decomposition; hazardous decomposition products; hazardous reactions: not applicable in normal usage. In case of doubt, refer to the powder supplier.

10. STABILITY AND REACTIVITY

Stable under recommended storage and handling conditions (see section 7). When exposed to high temperatures hazardous decomposition products may be produced, such as carbon monoxide and dioxide, nitrogen oxides and smoke.

11. TOXICOLOGICAL INFORMATION

There is no further data available on the preparation itself.
Animal tests and long term use of powder coatings containing no dangerous substances have shown no specific risk.
Powder coatings can cause localised skin irritation in folds of the skin or in contact with tight clothing.

12. ECOLOGICAL INFORMATION

There is no data available on the preparation itself.
Tests and long term use of powder coatings have, in general, shown no specific risk.
If powder coatings are applied and stoved according to the recommendations, emissions will be within the legal limits. The extract of a typical powder coating with rainwater shows that a deposit will not affect ground or surface water substantially.

13. DISPOSAL CONSIDERATIONS

Do not allow into drains or watercourses. Waste and empty containers should be disposed of without creating dust according to local legislation.

14. TRANSPORT INFORMATION

In general, powder coatings can be transported without restrictions.

15. REGULATORY INFORMATION

In accordance with EC-Directive 93/18/EEC the product is labelled as follows:

Danger classification:	none	
Safety phrases:	S20/21:	When using, do not drink or smoke
	S22:	Do not breath dust
	S38:	In case of insufficient ventilation, wear suitable respiratory equipment

16. OTHER INFORMATION

The information given in this SDS represents to the best of our knowledge the state of the art of today and does not imply any warranty as to the use, sufficiency, merchantability, or fitness for any purpose whatsoever of the goods supplied. Except in case of gross negligence or wilful misconduct on the part of AKZO NOBEL, AKZO NOBEL's liability shall not exceed the net sales price of the goods concerned. In no case, shall AKZO NOBEL's liability include direct or consequential damages.

History

Date of first issue: 08-Jun-94 **Revision date: 10-Feb-96**

Revision: 2

OSHA MATERIAL SAFETY DATA SHEET

Chemical manufacturers shall obtain or develop a Material Safety Data Sheet for each hazardous chemical they produce. It must contain the following information:

- **IDENTITY OF PRODUCT**
  - Single Substance
    Chemical/common name of hazardous chemical
  - Mixture Tested As A Whole
    Chemical/common name of mixture and chemical/common name of ingredients which contribute to hazard
  - Mixture Not Tested As A Whole
    The chemical/common name(s) of all ingredients which have been dertermined to be health hazards and which comprise 1% or greater of the composition; chemicals identified as carcinogens if they are present at 0.1% or greater.
- **PHYSICAL & CHEMICAL CHARACTERICS (VAPOUR PRESSURE, FLASH POINT, ETC.)**
- **PHYSICAL HAZARDS INCLUDING POTENTIAL FOR FIRE, EXPLOSION AND REACTIVITY**
- **HEALTH HAZARDS INCLUDING SIGNS & SYMPTONS OF EXPOSURE AND ANY MEDICAL CONDITIONS WHICH ARE GENERALLY RECOGNISED AS BEING AGGREVATED BY EXPOSURE TO THE CHEMICAL**
- **PRIMARY ROUTE(S) OF ENTRY**
- **THRESHOLD LIMIT VALUE OR ANY OTHER RECOMMENDED EXPOSURE LIMITS**
- **A DETERMINATION THAT THE CHEMICAL IS LISTED (OR NOT) AS A CARCINOGEN**
- **GENERALLY APPLICABLE PRECAUTIONS FOR SAFE HANDLING**
- **GENERALLY APPLICABLE CONTROL MEASURES SUCH AS ENGINEERING CONTROLS, WORK PRACTICES OR PERSONAL PROTECTIVE EQUIPMENT**
- **EMERGENCY FIRST AID PROCEDURES**
- **DATE OF PREPARATION OF MATERIAL SAFETY DATA SHEET**
- **UPDATE AS REQUIRED**

Powder Coatings
Appendix 3 – Definitions/Terms

A

Accelerator	A material that accelerates the crosslinking, hardening or curing reaction of a mixture of polymers or resins.
Acrylic	A powder coating material with a high content of a polymer consisting of short chain esters of several acrylic monomers.
Additive	A material added to a powder coating material to improve one or more properties.
Adhesion	The ability of a coating film to maintain attachment to the next underlaying film or substrate.
Air, compressed	Air at any pressure higher than the atmospheric pressure.
Alkaline	An environment that has the characteristic of being strongly basic (high pH).
Anti-oxidant	A compound added to powder coating materials to slow down the oxidation.
Application	The process of applying a powder coating material onto a substrates surface.
ASTM	American Society for Testing Materials, being the institute that controls standards for materials, systems and services.

B

Back-ionization	May take place during the application of powder coating material on a substrate when powder particles have build up in excess which is limiting the further build up of powder and may reverse the electrical charge of the powder already deposited.
Binder	The resin(s) as the main component of the powder that will polymerize later and binds the other components into the solid powder coating film.
Blooming	A haze on the surface of a coating film that may have been caused by over- or under-curing.
Bonding	The firmly joining together of a powder coating film to the substrate or of two coating films.
Brightness	The degree to which a surface reflects light (see Gloss).
Bulk density	Mass per unit of volume including the air filled voids in the bulk material.

C

Caking	Agglomeration of individual powder particles or sticking of powder to walls or components of equipment.
Cartridge filter	A filter construction containing one or more cartridges that function as a filtering element.
Catalyst	See Accelerator.
Chalking	Loss of colour and gloss on a coating surface as a result of degradation due to the UV component in the sunlight.
Chromatation	Preparation process for metal substrates, in the form of a conversion coating using chromium, and forming an inert chromate coating film, prior to the application of powder coating material.
Classifier	An equipment to separate particles from another fluidum, much like a cyclone, whereby the seperation cut is adjustable, within a range, with an additional device.
Clean Air Act	Act which empowers the EPA to improve the quality of air through enforcement of the developed pollution standards.
Clear coat	A non-pigmented coating applied on a base metal such as aluminium or over a previously applied pigmented coating.
Coating powder	Powder material being a mixture of resin, pigment, filler and additives, for application on substrates with the objective to form a coating film thereafter. See also powder coating material.
Compatibility	The property of powders to be used and applied in a mixture of any composition, without any visible or mechanically measurable differences of the resulting powder coating film when compared to the virgin materials.
Composition	The parts of a mixture, formulation or recipe, usually expressed as percentages.
Contamination	Any foreign material, such as soil, dirt or unwanted chemicals, that deteriorate the quality of the coating film.
Conversion coating	Preparation process for metal substrates, with the help of iron, chromium or zinc, prior to powder coating application.
Conveyor	A chain mechanism that transports the parts to be coated, in a hanging position, through all steps of the application process.
Corona charging	The process of transfering a static electric charge on powder particles while they are passing through an electrostatic field generated by a high voltage.
Cracking	The arising of crevices or cuts in the surface of a coating film by chemical or mechanical influences.
Cratering	The appearance of tiny pitts (like mini craters) visible to the trained eye without enlargement at the surface of a powder coating film, usually due to some form of incompatibility.
Cross contamination	The deterioration of a coating film occurring when powders are used in mixed form when they are not compatible.
Cross hatch	A testing method to investigate the adhesion properties of a coating film.
Crosslinking	The multi-directional linking together of resin molecules through chemical reactions, stimulated by a curing agent.
Curing	The hardening or cross-linking process.
Curing agent	A crosslinker or hardener that stimulates the curing of a binder system.
Curing oven	An oven in which the powder coated parts are exposed at the required temperature so that the cross-linking reaction can take place for a pre-determined time.
Cyclone	A cylindrical type of equipment for separating particles from another fluidum applying centrifugal forces.

D

De-ionized water	Water which has been treated such that it does not contain water foreign ions.
Dispersion	A suspension or mixture of particles in another fluidum.
DSC	A Differential Scanning Calorimeter can measure several thermodynamic properties of chemicals.
Dust	Particular matter which is, or has been, airborn with a particle size below 75 micron.
Dust explosion	The confined rapid combustion of dust particles which are airborn causing strong expansion effects.

E

Edge coverage	The ability of a powder coating material to flow over, build up to sufficient thickness during curing and adhere to sharp edges and corners.
Electrostatic charging	The process of transfering a static electric charge on powder particles.
Electrostatic spraying	A process of transfering spraying and depositing electrostatically charged powder particles on a grounded substrate.
EPA	The Environmental Protection Agency is a USA Government Institute which regulates and controls organisations influencing the environment.
Epoxy resin	A thermosetting resin, produced on the basis of epichloro-hydrin, which can be further polymerized by the addition of a hardener.
Extender	A type of pigment which also transmits special properties to a powder coating material.
Extrudate	The resulting product coming out of an extruder, be it in the initial molten form or the solidified state thereafter.
Extruder	A machine that mixes solid particles by using mechanical kneading and the subsequent heat-development until a molten fluidum is created of a homogeneous composition.

F

Faraday cage	An area of a metallic construction that, due to its geometric configuration, is shielded from electrostatic fields from external sources. Electrostatic spray coating becomes more difficult.
Fatty edge	Thicker than usual coating film to be found along edges of a flat substrate.
Ferrous	Metal containing an amount of iron.
Field lines	Imaginable lines of force in an energy field (e.g. electrostatic).
Filler	Inorganic inert material; also extender or certain pigments.
Film thickness	Height of a cured coating film measured in microns.
Flash off	The process-step in liquid coating application of allowing the solvent to evaporate prior to curing.
Flash rust	A molecular film of rust appearing on a steel surface within minutes after pre-treatment.
Flexibility	The ability of a cured coating film to be bent without cracking.
Fluidized bed	Container in which powder is kept suspended in air continuously.
Fluidity	The degree to which powder coating material can be brought to fluidization.

G

Galvanized steel	Steel coated with a thin layer of zinc.
Gel time	The time required to bring a dry solid powder to a gel-like condition at a standardised temperature.
Gloss	The degree to which a surface reflects light.
Grounding	The principle of bringing the electrical potential in equilibrium with a neutral mass.

H

Hardener	See curing agent.
Hardness	The ability of a cured powder coating film to withstand the penetration of a standardised object.
Hazardous	A condition of contact or case of presence in which a risky, dangerous or less healthy or toxic situation is created.
Hiding power	The ability to which a powder coating film conceals the underlaying surface at a standardized film thickness.
Hybrid	A polyester or acrylic powder coating material which has been epoxy-modified.

I

Incompatibility	The impossibility of powders to be used and applied in a mixture of any composition, without any visible or mechanically measurable differences of the resulting powder coating film when compared to the virgin materials.
Infrared radiation	Energy in the infra-red region of the electromagnetic spectrum just above the visible light range.
Inhibitor	An additive used to delay or neutralize a chemical reaction.
Inorganic	The sort of materials not containing carbon compounds such as metals and its derivatives.
Intercoat adhesion	The ability of two coating films to adhere to each other.

K

Karl Fisher test	Chemical testing method to determine the moisture content of powdery materials.

L

LEL	The Lower Explosive Limit is the lowest concentration of organic powder suspended in air which can be brought to explosion when ignited by a standardised energy source.
Leveling	The ability of a layer of powder coating material to flow out to a smooth and uniform coating film.

M

Mandrel bend test	A mechanical method for testing the flexibility of a coating film applied on a standardised sample plate.
Metamerism	A definition applicable to a coating film when its colour appears different when viewed in light of varying wavelenghts.
Micron	Standard unit of measuring a coating film thickness. (1/1000 of 1mm)
Micronizing	Grinding powder to the range of microns.
Monomer	A molecule that has the ability to chemically react with another monomer by forming a long chain of identical sections, the socalled polymer.
MSDS	A Material Safety Data Sheet provides the hazardous components, other safety and health hazards, protection equipment and first-aid procedures.

N

NFPA	The National Fire Protection Association is a USA organisation that indicates the health, reactivity and flammability hazards of chemicals.
Non ferrous	A material containing no iron.

O

OEL	The Occupational Exposure Limit relates to the exposure limit by inhalation and refers to the concentration of hazardous materials in the atmospheric air.
Orange peel	A surface appearance which has an irregular appearance similar to the skin of an orange and is generally caused by restricted the limited flowing ability of the powder coating material.
Organic	The sort of materials containing carbon compounds such as many resins, certain pigments and additives, etc.
OSHA	The Occupational Safety and Health Administration is a USA organisation for the control of safety and health issues.
Overcuring	The application of higher than recommended curing–values (temperature, time or both).
Overspray	Powder coating material that has not deposited on the substrate to be coated but ends up in the recovery and recycle system.

P

Particle size	The average (arithmetic) diameter of an irregular particle measured by specialised equipment.
Passivation	Chemical treatment of a metallic surface with the objective to make it less reactive.
Penetration	Ability of particles to penetrate towards and onto the surfaces of Faraday cage like areas such as cavities and recesses.
Phosphating	Preparation process for metal substrates, in the form of a conversion coating using iron (chromium) or zinc, and forming an inert phosphate coating film, prior to the application of powder coating material.
Pickling	A cleaning step of hot rolled steel plate, usually carried out in the steel mill, to remove the milling scale before the metal is oiled to protect it from corroding.
Pinhole	The appearance of tiny holes (like from a needle) visible to the eye without enlargement at the surface of a powder coating film, usually due to the insufficient ability of gasses to escape from the molten film during curing.
Plate flow	A test to measure the ability to flow during the curing of a powder during which a compressed pil of powder is placed on an inclined plate that is subjected to a preset temperature.
Polyester	A thermosetting resin, saturated carboxyl or hydroxyl terminated, which can be further polymerized by the addition of a hardener.
Polymer	A long molecule that has been formed out of a large series of monomers by a chemical reaction.
Polymerisation	The reaction in which a large molecule (polymer) is formed by chemically binding identical sections (monomers) to a long chain.
Powder coating	The application of powder coating material on substrates in order to form a coating film thereafter.
Powder coating material	The ultimate dry solid compound including all necessary ingredients, ground to powder and ready to be applied as a coating material on a given substrate.
Powder pump	A lifting and moving device that applies air for transporting either powder from one container to another or towards an operating device.
Premixing	The mixing and size reduction of all necessary raw materials for the production of powder coating material prior to feeding them to the extruding step.
Pretreatment	The preparation of the surface of a part to be coated, prior to the actual powder coating application process.
Primer	A first groundlayer of a special coating material applied on a substrates surface to increase the corrosion resistance or to improve the adhesion with the metal.

R

Radiation curing	The application of energy-rays of a particular range of the electromagnetic spectrum for curing of a coating layer.
Reclaim	See recovery.
Recovery	The entire process step of the powder application process in which the non-deposited powder is reclaimed, recycled and added to the virgin powder for re-use.
Recycling	The action in the powder recovery step of the powder application process by which the reclaimed powder is fed back.
Resin	A thermosetting resin is an organic material, be it from a natural or a synthetic source, can be further cross-linked or polymerized by the addition of a hardener.
Respirator	Safety breathing face-mask.
Rework	A correction procedure to correct shortcomings on a powder coated article.

S

Salt spray test	Testing procedure to check the corrosion resistance of coating films on a series of standard sample panels under conditions of a standardised corrosive environment.
Scale	Rustlayer on steel originating from the hot roll steel-milling process.
Seal rinse	A step in the pre-treatment process where the metal surface is passivated to prevent corrosion prior to the powder coating of substrates.
Shelf life	The determined time a product can be kept in stock and when subsequently used be still in good condition and provide good quality.
Sieve	A screening mechanism applying a wire mesh to separate a certain portion out of too coarse or contaminated material.
Softening point	The temperature at which a resin or a powder coating material first starts to melt.
Soil	Any foreign material that adheres to a substrates surface prior to the pre-treatment.
Solvent	A liquid of one or more components often applied in the liquid paint industry to dissolve paints.
Spray booth	A special cabin in which powder coating material is sprayed, manually or automatically, onto substrates under strictly controlled conditions.
Stripping	The procedure to remove a coating film from a substrate in order to be recoated.
Substrate	The article or product to be powder coated.
Surfactant	Chemical additive to control the surface tension of a material.

T

TGIC	Triglycidyl Isocyanurate is a curing agent for carboxyl terminated resins.
Thermoplastic	A powder coating material that will solidify when cooled and melt when heated.
Thermosetting	A powder coating material that will chemically react into a solid coating film when heated the process of which can not be reversed.
TLV	The Threshold Limit Value is the concentration of chemicals in air to which persons may be daily exposed without harm.
Touch-up	The repair of small damages on a coating film or the paint to be used for that purpose.
Toxic	Poisonous.
Transfer efficiency	The relation between the amount of powder coating material deposited on a substrate to be coated and the total amount that was directed towards that substrate by the spraying gun(s).
Tribo charging	The process of transfering a static electric charge on powder particles by rubbing along a special non-conductive material.

U

Ultra violet radiation	Energy in the ultra-violet region of the electromagnetic spectrum just below the visible light range.
Ultra violet stabilizer	A chemical additive that absorbs part of the UV radiation in the sunlight.
Undercured	The application of an insufficient curing temperature, time or both.
UEL	The Upper Explosive Limit is that concentration of organic powder suspended in air above which the mixture will not explode if ignited by a standardised energy source.
Urethane	A thermosetting hydroxyl functional resin, usually reacted with an isocyanic curing agent.

V

Venturi	A special shaped restriction in a powder pump body.
Vibratory box feeder	A moving device that applies vibration for transporting powder from a box container to another hopper.
Virgin powder	Fresh powder coating material directly from the supplier not containing any reclaim.
VOC	Volatile Organic Compounds are components with a low boiling point thus evaporating, under atmospheric pressure, at temperatures lower than the curing temperature.

W

Washer zone	The immersion or recirculating spray cleaning step of the pre-treatment system.
Weather resitance	The ability of a coating film to maintain its quality within agreed tolerances when exposed to specified weather conditions.
Weld splatter	Contaminations left behind on a metal surface after welding such as slag or beads.
Wrap around	The ability of powder coating particles during application to curve around corners by following electrostatic field lines and thus providing a good coverage, anywhere general and on the edges.

Y

Yellowing	Appearance of a yellow shade on a coating film particularly in light colours often seen on overstoving or as a result of ageing.