COURSE ON POWDER COATING

INDEX

What is Powder Coating?

Powder coating is by far the youngest of the surface finishing techniques in common use today. It was used in Australia about 1967.

Powder coating is the technique of applying dry paint to a part. The final cured coating is the same as a 2-pack wet paint. In normal wet painting such as house paints, the solids are in suspension in a liquid carrier, which must evaporate before the solid paint coating is produced.

Powder coating is a dry finishing process, using finely ground particles of pigment and resin that are generally electro statically charged and sprayed onto electrically grounded parts. The charged powder particles adhere to the parts and are held there until melted and fused into a smooth coating in a curing oven. Before coating the part to be coated are first pre-treated similarly to conventional liquid coated parts. The pre- treatment process is normally conducted in series with the coating and curing operations.

Ways of powder coating Applying

There is essentially two common ways of applying powder coating: by electrostatic spray and by fluidized bed powder coating. There are several other processes that have been developed, but they are far less used. These include flame spraying, spraying with a plasma gun, airless hot spray and coating by electophoretic deposition.

The **fluidized bed** is the original powder coating technique. It is still the primary technique used for the application of thermoplastic powder. The fluidized bed is also used for the application of some thermo set powders where high film build is required. Thermo set powders designed for electrical insulation often use the fluidized bed technique. The parts are pre-heated to a temperature significantly higher than the melting point of the powder. The parts are then immersed into a “fluidized bed” of the coating powder where the plastic powder is melted onto the part.

Electrostatic spray is the primary technique used for thermo set powder. The parties of powder are given an electrical charge in the powder coating gun. The target part is attached to a fixture that is grounded. The electrically charged powder particles are attracted to the grounded part and attach themselves like little magnets to the part. The particles build-up on the surface of the part until it is covered with charged particles and the part surface is charged. At this point the oncoming particles are actually repelled by the charged particles on the part and the coating process stops. This provides and even film thickness.

The part is then placed in an oven and the powder particles melt and coalesce to form a continuous film.

Materials

There are two types of powder coating thermoplastic and thermosetting

A ***thermoplastic powder coating*** *is one that melts and flows when heat is applied,* but continues to have the same chemical composition once it cools and solidifies. Thermo plastic powder exhibit excellent chemical resistance, toughness and flexibility. They are applied mainly by the fluidized bed application technique, in which heated parts are dipped into a vat where the powders are fluidized by air and are used in many thick film applications. They are generally applied to a surface that has been preheated to a temperature significantly higher than the melting point of the powder. As a thermo plastic powder material is applied to the hot surface it will melt and "fusion bond" to the surface and then "flow out" into a strong, continuous film. As the film cools it develops its physical properties. Nylon powder coating materials are the most commonly used thermo plastic powder.

Thermosetting powder coatings are based on lower molecular weight solid resins, and melt when exposed to heat. After they flow into a uniform thin layer, however they chemically crosslink within themselves or with other reactive components to form a reaction product of much higher molecular weight. These newly formed materials are heat stable and unlike the thermo plastic products after curing, will not soften back to the liquid phase when heated. Thermosetting powder is derived from three generic types of resins: **epoxy, polyester and acrylic.** From these resin types, several coating systems are derived. Resins used in thermosetting powder can be ground into fine particles necessary for spray application and a thin film finish. Most of the technological advancements in recent years have been with thermosetting powder.

Epoxy: Epoxy powder coating exhibit inherent toughness, corrosion resistance, chemical resistance, flexibility, adhesion and abrasion resistance. Epoxy powder is normally used where a tough durable film is required and the product will not be exposed to direct sunlight for long period of time. An epoxy coating will from a chalk like appearance on the surface with lengthy exposure to sunlight.

Typical applications include:

- Appliances
- Business machines
- Electrical enclosures
- Hospital equipment
- Office furniture
- Oil filters
- Powder tools

- Shelving
- Tool boxes

Urethane powder coating feature characteristics of excellent gloss retention and long term resistance to humidity and corrosion in thin film applications.

Typical applications include:

- Agricultural Equipment
- Air conditioners
- Construction Equipment
- Electrical Enclosures
- Lawn and garden Equipment
- Lawn furniture
- Light fixtures
- Office furniture
- Recreational Equipment
- Under-hood Automotive
- Wheel and Rims

Polyester Powder Coating feature characteristics of long-term exterior durability, high performance mechanical properties and over back resistance. Polyester powder is widely used for decorative components where good resistance to the ultraviolet rays from sunlight is important. Many automotive trim components and other exterior components are coated with polyester powder.

Typical applications include:

- Agricultural Equipment
- Appliances
- Construction Equipment
- Electrical Enclosures
- Lawn and Garden Equipment
- Lawn Furniture
- Recreational Equipment
- Under-hood Automotive
- Wheel and Rims

Acrylic powder is specified where the decorative requirements and resistance to ultraviolet rays from sunlight for a longer period of time is critical. Many critical automotive trim components are coated with acrylic powder.

Preparation:

The basis of any good coating is preparation. The vast majority of powder coating failures can be traced to a lack of a suitable preparation.

The preparation treatment is different for different materials.

In general for all applications the **preparation treatment for aluminium** is as follow:

Clean	**or**	**Clean**
Rinse		**Rinse**
Etch		**Etch**
Rinse		**Rinse**
Chromate		**Phosphate**
Rinse		**Rinse**
Demin Rinse		**Demin Rinse**

Oil and greases are removed in weak alkali or neutral detergent solutions and the surface is etched to remove heavy oxide. After rinsing the aluminium is dipped into a chromate or phosphate solution to from a conversion coating on the aluminium. This film is chemically attached to the aluminium. After rinsing the aluminium is finally rinsed in demineralised water. Some non-chrome, dried in place pre-treatment is beginning to come onto the market, currently these are not recommended for exterior applications.

The conversion coating has two functions:

- The presents a surface to the powder which favours adhesion more than the oxides that from vary readily on aluminium surfaces and
- It reduces the incidence of under film corrosion, which may occur at holiday in the coating.

The use of demineralised water reduces the presence of chemical salts on the aluminium surface. These salts have been found to cause fill form corrosion in humid conditions.

For steel the preparation for interior applications may be:

- **Clean**
- **Rinse**
- **Derust**
- **Rinse**
- **Iron Phosphate**
- **Acidulated Rinse**

For exterior applications:

- **Clean**
- **Rinse**
- **Etch**
- **Rinse**
- **Grain Refine**
- **Zinc Phosphate**
- **Rinse**
- **Acidulated Rinse**

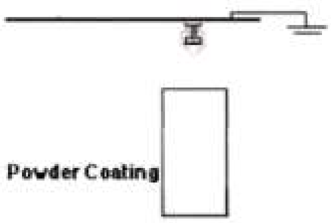
The grain refiner is used after cleaning of steel surfaces and before zinc phosphating otherwise the zinc phosphate coatings produced will be very coarse with low adhesion. The powder coating applied to a coarse phosphate will produce tough coating (a little like “sandpaper”) and possess low adhesion.

For hot dipped galvanized coatings, which have been stored for more than about 4 hours before powder coating, the following process is necessary for exterior applications.

- **Clean**
- **Rinse**
- **Etch**
- **Rinse**
- **Grain Refiner**
- **Rinse**
- **Zinc Phosphate**
- **Acidulated Rinse**

The etch is required to remove the zinc corrosion products which begin to form almost immediately the zinc is removed from the galvanizing kettle. The grain refiner ensures a fine phosphate is produced.

How is it done – electrostatic spray?



The powder is applied with an electrostatic spray gun to a part that is at earth (or ground) potential.

Before the powder is sent to the gun it is fluidised:

- To separate the individual grains of powder and so improve the electrostatic charge that can be applied to the powder and
- So that the powder flows more easily to the gun.

Because the powder particles are electro statically charged the powder wraps around to the back of the part as it passes by towards the air off take system. By collecting the powder, which passes by the job and filtering it the efficiency of process can be increased to 95% material usage.

The powder will remain attached to the part as long as some of the electrostatic charge remains on the powder. To obtain the final solid, tough, abrasion resistant coating the power coated items are placed in an oven and heated to temperatures that range from 160 to 210 degrees C (depending on the powder).

Under the influence of heat a thermosetting powder goes through 4 stages to full cure.

Melt, Flow Gel, Cure

The final coating is continuous and will vary from high gloss to flat matt depending on the design of the powder by the supplier.

Powder coating funs

There are at least three types of electrostatic funs in use:

- Corona charging guns where electric power is used to generate the electrostatic charge. Corona guns are either internal or external charging.
- Tribo charging guns where the electrostatic charge is generated by friction between the powder and the gun barrel.
- “Bell” charging guns where the powder is charged by being “flung” from the perimeter of the “bell”

Not all powder is applied using guns. One system makes use of electrostatic tunnels.

How is colour introduced?

Colour is added to powder coating during the manufacturing process, i.e. before the powder reaches the powder coater. There is little that can be done to changes the colour consistently, once the powder leaves the manufacturing plant.

Why powder coat?

Powder coating produces a high specification coating which is relatively hard, abrasion resistant (depending on the specification) and tough. Thin powder coating can be bent but this is not recommended for exterior applications.

The choice of colours and finishes is almost limitless, if you have the time and money to have the powder produced by the powder manufacturer.

Powder coating can be applied over a wide range of thickness. The new Australian Standard, “AS/NZS 4506 – Themoset powder coating” will recommend 25 micron minimum for mild interior applications and up to 60 micron minimum for exterior applications. Care must be exercised when quoting minimum thickness because some powder will not give “coverage” below 60 or even 80 micron. “Coverage” is the ability to cove the colour of the metal with the powder. Some of the white colours require about 75 micron to give full “coverage”. One of the orange colours must be applied at 80 micron.

Colour matching is quite acceptable batch to batch.

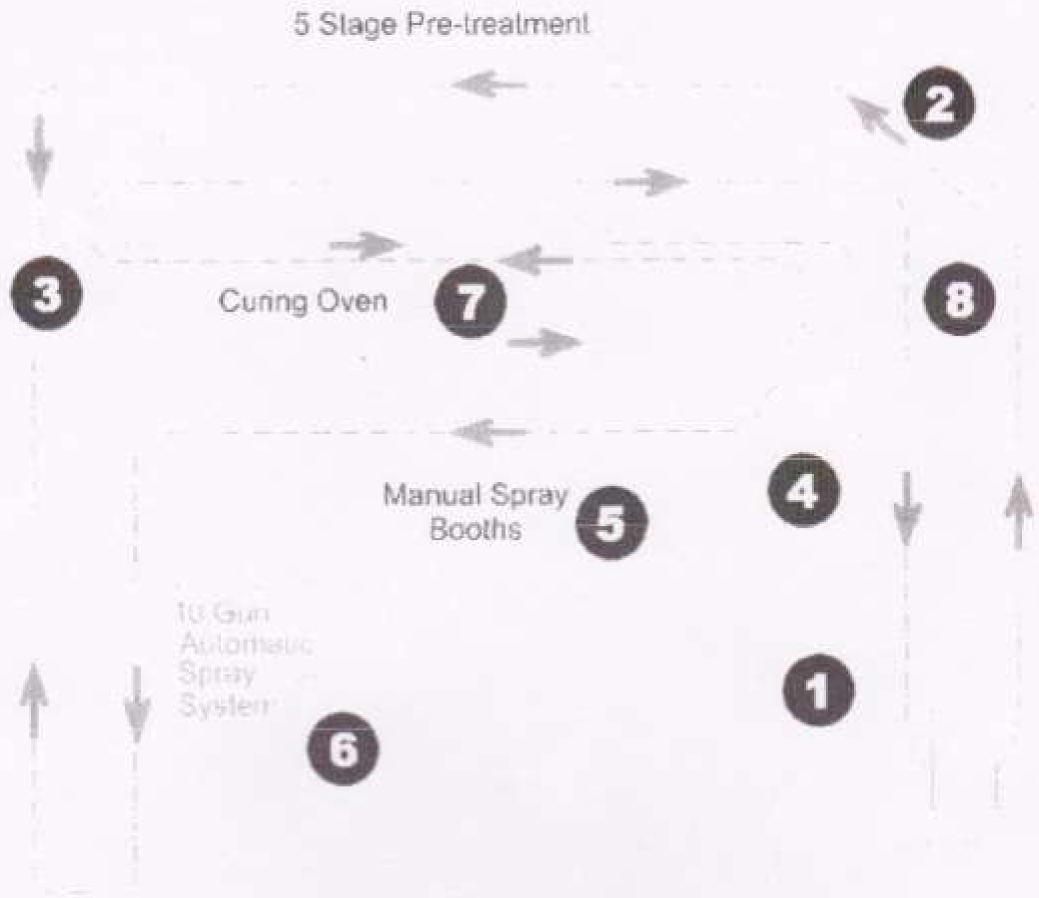
Installation and maintenance:

During installation the powder coating should be protected from damage due to abrasion and materials of construction such as mortar and brick cleaning chemicals.

Once installed, maintaining the initial appearance of a powder coating is a simple matter. The soot and grime which builds up on surfaces from time to time contains moisture and salts which will adversely affect the powder coating and must be removed. Powder coating should be washed down regularly (at least once each 6 months in less severe applications and more often in marine and industrial environments) the coating should be washed down with soapy water – use a neutral detergent – and rinsed off with clean water.

When powder coated items are installed without damage to the powder coating they are maintained regularly, they should be relatively permanent. The correctly applied coating, although not metallurgic ally bonded to the metal will not crack, chip or peel as with conventional paint films.

Flow diagram for powder coating



Process Flow

1. Part loading
2. Pre-treatment
3. Quality control
4. Dry off oven
5. Manual booths
6. Automatic booth
7. Curing oven
8. Final inspection

Moisture Separator

Flow diagram for powder coating

Putting down a nice paint job on that project car you have been working on is hard enough without having the aggravation of air line contaminants ruining it.

Preventing moisture and oil from contaminating your air line and subsequently your pain job is all a matter of having the right equipment and using it properly. The key to keeping moisture out of your air line is to separate the moisture from the air entering your paint gun with an in-line air water separator and filter.

Instructions:

Locate a suitable position to mount the wall-mounted in-line air water separator and filter unit in your air supply line a few feet from the air compressor itself. This unit will remove most of the moisture from your air supply line and will also remove all other contaminants and leave you with a nice, clean air supply to not only your spray gun but your other tools.

Mount the tool-mounted mini in-line air water separator between your paint gun and the clean, dry air hose you will use only for painting. This mini air water separator will remove the last traces of moisture that may be in the air supply line just before it enters your spray gun

Open the drain petcock value on your compressor to drain any water from your compressor tank. Close the valve when the water is drained.

Test your new moisture-free air supply line to make sure it’s leak-free and that the filters and separators work properly according to their instructions. Begin painting.

Different treatment steps in powder coating

Pre-treatment of profiles is usually carried out by dipping the profiles (a jig) into a sequence of tanks containing different chemical solutions. Most of the producers use chromating as conversion coating and therefore chromating will be discussed in this manual.

The following sequence of stems is normally used to pre-treat aluminium prior to powder coating.

Degreasing: In the degreasing step oil, grease and other surface contaminations are removed from the profile surface to obtain a clean surface prior to etching. Inhibitors are often added to protect the metal surface from attack during this cleaning operation.

Rinsing:

There is usually a rinsing step (or more) after each process step to remove chemicals from the profile surface and prevent carry over and contamination of solution. Mains water is normally good enough after the first pre-treatment steps, but in the final rinsing step the water should be very clean to avoid adhesion and corrosion problems. In this case the conductivity of the rinsing water (do-ionised water) should not exceed 30 µS/cm. This de-ionised water rinse is extremely important, as salts (calcium) caused by hard water dried on the extrusion surface can be the starting point of corrosion and lacquer blistering. There are no limits regarding the rinsing temperature of the first rinsing baths, but the temperature of the water in the rinsing steps after chromating should not exceed 50ƒC. If the rinsing water is too hot the chromate layer could be washed off. The rinsing time is usually a few minutes. Agitation of the jig (profiles) and/or air agitation of the water is an advantage to get better rinsing.

Etching:

The thin natural oxide coating on the aluminium surface has to be removed before the chromating. Inhibitors are often added to protect the metal surface from attack during this etching operation. Temperatures between 50ƒC and 70ƒC are normal. The cleaning time is from 3 to 4 minutes and higher dependent on the surface conditions.

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Deoxidisation:

In the deoxidisation process any smut resulting from insoluble from the etching is removed. This smut layer consists of oxides like magnesium oxide, intermetallics, silicon etc. which are not soluble in alkaline solutions. Smut is removed by a dip in an acid solution such as nitric acid or sulphuric acid, but many producers of coated aluminium profiles use special deoxidisation products from chemical suppliers in coated aluminium profiles use special deoxidisation products from chemical supplier in addition to nitric acid. These deoxidisation products may consist of chromate in order to inhibit the deoxidisation process on the aluminium surface and fluorides to remove silicon. The dipping time may vary from 30 seconds up to 5 minutes dependent on the smut layer the solution and the alloy. The deoxidization process is usually carried out at room temperature.

Rinsing (double rinsing):

There is usually a rinsing step (or more) after each process step to remove chemicals from the profile surface and prevent carry over and contamination of solution. Mains water is normally good enough after the first pre-treatment steps, but in the final rinsing step the water should be very clean to avoid adhesion and corrosion problems. In this case the conductivity of the rinsing water (de-ionised water) should not exceed 3µS/cm. This de-ionised water rinse is extremely important, as salts (calcium) caused by hard water dried on the extrusion surface can be the starting point of corrosion and lacquer blistering. There are no limits regarding the rinsing temperature of the first rinsing baths, but the temperature of the water in the rinsing steps after chromating should not exceed 50ƒC. If the rinsing water is too hot, the chromate layer could be washed off. The rinsing time is usually a few minutes. Agitation of the jig (profiles) and/or air agitation of the water is an advantage to get better rinsing.

Drying:

Prior to powder coating the profiles have to be completely dry. Moisture on the surface will interfere with the coating process. The temperature of the profile surface should not be too high in the drying oven. The breakdown temperature for the yellow chromate coating is about 65ƒC and about for the green chromate coating. If the drying temperature exceeds these limits the conversion coatings may give an inferior corrosion resistance.

Powder Coating:

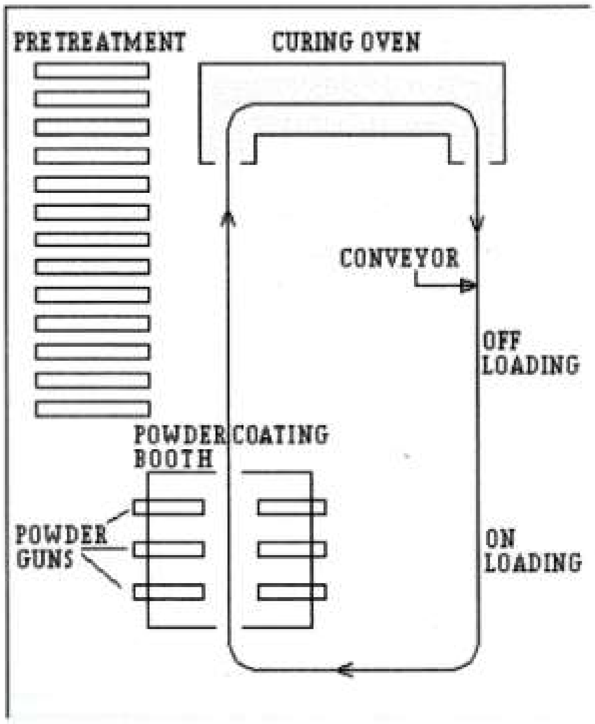
Before powder coating the profiles, which have been pre-treated by dipping, must be rejigged. The conveyor system in the powder coating/curing lines does not fit the jigging system in the pre-treatment lines. The profiles are jigged horizontally during powder coating, as they are in the pre-treatment process. The speed of the conveyor is related to powder application parameters and coring conditions (oven length and temperature).

The powder coating operation is carried out in special spray booths. There are many types of spray booths on the market, but the two kinds more commonly used are cartridge filter booths and cyclone booths. The cartridge filter booth has the advantage of high recovery and of being gentler to the powder, producing less files. On the other hand, it is practically impossible to clean, so a separate filter system for every colour is needed.

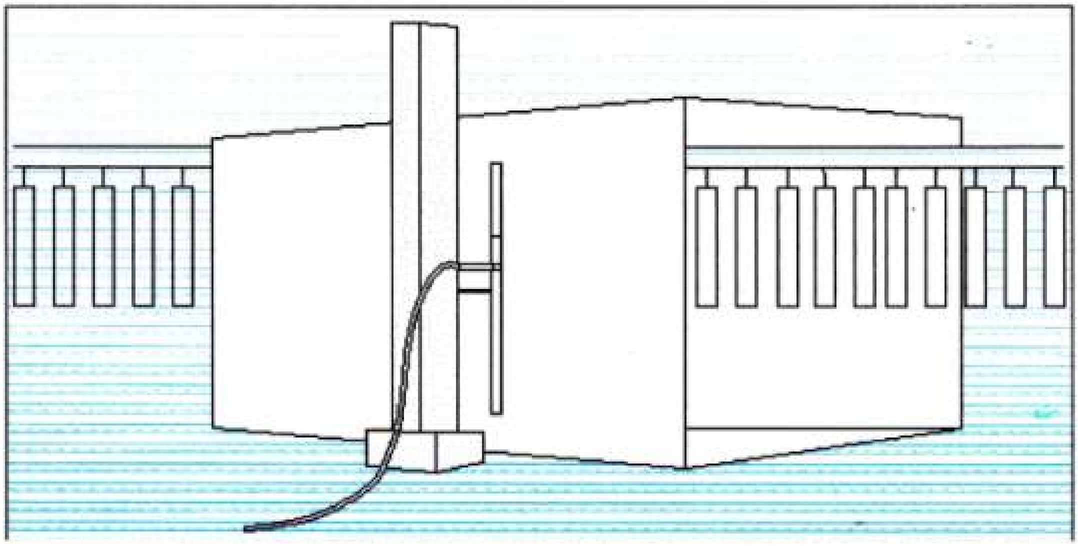
Colour changing is paramount in coating extrusions, so may be the cyclone booth is more suitable. The losses in the cyclone are heavily reduced by using tribomatic guns, as these have a very high first pass transfer efficiency, so that only a relatively small proportion of powder arrives at the cyclone at all. It may be added that as cyclones lose the fines, there are no quality problems due to fines.

There is powder guns placed on both sides of the booth, usually at the middle of the booth walls (see figures blow). The number of guns is dependent on the shape of the profiles and the type of powder. Tribostatic powder coating need at least twice as many guns as electrostatic powder coating. But the number of guns is also dependent of demands regarding the surface finish of the profiles. When using a greater number of guns the air and powder pressure could be decreased. That will cause a raise in surface quality, but also a less wear on the powder hoses.

Powder coating line including pre-treatment steps



Powder coating booth



Normally some of the powder guns are in fixed position, while the most of the guns move automatically slowly up and down. Adjustment of the guns is – as mentioned above – dependent on the shape of the profile, but also dependent on which coating thickness and finish which are requested.

Curing:

The curing operation is carried out in curing ovens. A curing oven should:

1. Be energy efficient
2. Have the same temperature across the length or the height of the extrusion
3. Not have too much turbulence, so that powder isn't blown away.

The two last conditions are contrasting, as uniformity of temperature is often obtained by strong air recirculation. This means that air speed s in the oven must be well calculated.

The energy required for the curing operation is given by supplying heat in two different ways:

- Hot air convection heating
- IR (infra-red) radiation

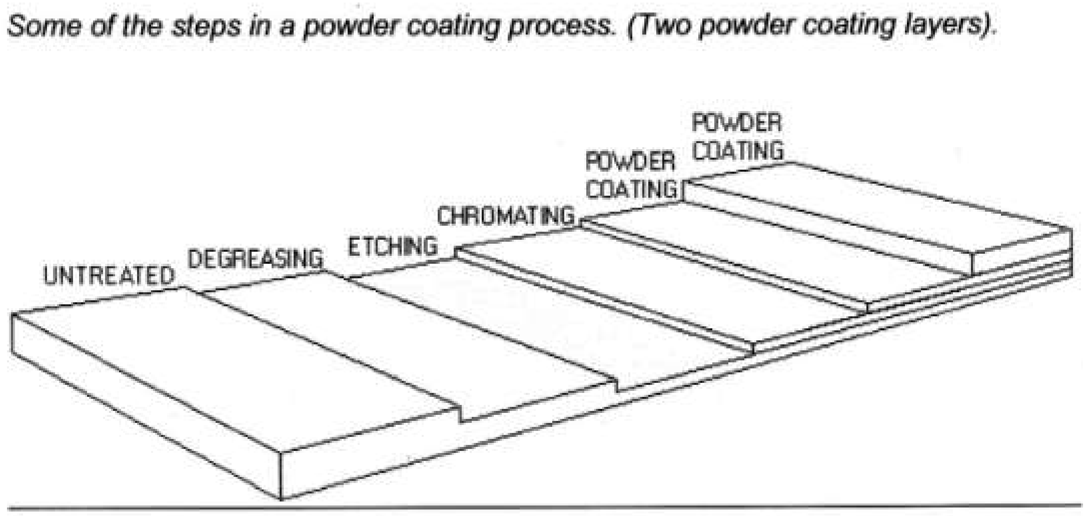
Some producers of powder coated profiles use both hot air convection heating and IR radiation. The IR-elements are placed in the entrance of the curing oven in order to give a rapid and effective energy transfer in the reaction of the powder coating. Thereby minimising the chance of powder being blown off

Normally the temperature to get proper coring of a powder coating is around 200ƒC, and the curing time may be 10-1 minutes.

To obtain a powder coating with good level or flow properties – that means without any orange peel – the temperature has to be at the correct level at the entrance of the oven to ensure a proper melting of the powder. After melting there is a reaction between the resin and the cross linking agent and a chemical bonding takes place between molecules. This is the reason for the good wear resistance and surface hardness of the thermosetting powder lacquers compared with the thermoplastic powders, where only a fusion of powder particles occurs during the curing reaction.

The powder coating process is also visualized in the figure below.

Some of the steps in a powder coating process (Two powder coating layers)



Electric Ovens:

Electric ovens se electric infrared elements or sources. Electric infrared sources are heated by current flowing through a resistance heating element. The element and the material surrounding the element are heated to an incandescent temperature.

All well designed electric ovens exhibit the following characteristics:

- Vertical and horizontal zoning: To provide an effective, flexible and efficient application of electric infrared heating to a specific process.
- Precise layout and distribution of elements: To incorporate shape factors, overcome and edge effect and provide greater flexibility.
- Insulated reflective panels to reradiate heat: To provide reradiation, even when panels may be dirty.
- Insulated element wiring to provide additional life: To extend significantly the life of the infrared elements.
- Non-contact temperature sensors for control: To provide the optimum in temperature control.
- Rigid, non-vibrating structure: To lengthen the life of the elements.
- Custom control: To meet the specific needs of the process and the operators.

Equipment for drying:

The provision of an oven in a production shop ensures speeding up of the drying operation. Depending upon the rate of production the oven can be either batch type of tunnel type.

Batch type electric oven:

This type of oven is largely used where there is batch production and where the volume does not justify a conveyorised installation.

Example: general engineering workshops and fabrication shops, where different types of equipment are manufactured and production volume is low.

Tunnel type electric oven:

This type of oven is preferred where production volume is fairly large and continuous.

Example: Continuous production plants manufacturing sheet metals components for

Tractor two – wheelers, power tillers, typewriters, fans, refrigerators, air conditioners etc.

Stoving Method:

Stoving involves heat transfer from the heat source to the coating or paint film and two methods in general use for this purpose are convection and radiation. The method of stoving is recommended after taking into consideration the size, weight, shape and material of the component to be dried.

Convection heating:

Convection heating is carried out by heating the air surrounding the article to be stove. This is generally done by having a heating chamber where air is heated and the heated air is circulated inside the oven chambers by means of fans. Normal sources used to heat to heat the air are electricity, gas, steam or oil.

Convection ovens are suitable for both batch continuous operations depending on the work load.

A limitation of the convection type oven is that it will usually required to be started from 20 minutes to half an hour before stoving operations can begin. This is because the air inside the oven will have to be heated to the required temperature and this takes time.

Normally the temperature in a convection oven is thermostatically controlled, so that the heat and therefore the fuel consumption is regulated depending upon the amount of work entering the oven.

As the object is heated by circulation of air, any shape and size of object can be dried by convection heating.

This method is generally used for drying of large castings, machined components and objects having a non uniform weight distribution.

Radiation Heating:

This is attained by heating the source so that the source starts emitting infrared radiation and this radiation heats up the paint film. The infra-red emission can be directed towards the object to be heated by means of suitably shaped reflectors if necessary. The absorption of the radiation takes place at the surface of the charge and infra-red heating is thus essentially a surface heating process.

Since infra-red radiation is emitted in straight lines from the source or reflector, plain surfaces are most readily treated. In infra-red paint stoving the temperature attained by the paint film depends upon the intensity of radiation on the painted surfaces, the time of exposure and mass of the article. The colour of the paint also plays a part in the speed with which the surface is heated. Black paints tend to absorb more heat, whereas a glossy white paint requires a longer time of exposure.

For infra-red heating, infra-red gas burners working of LPG gas, infra-red bulbs or infra-red electrical heaters can be used.

Safety Precaution: Do and don’t

DO

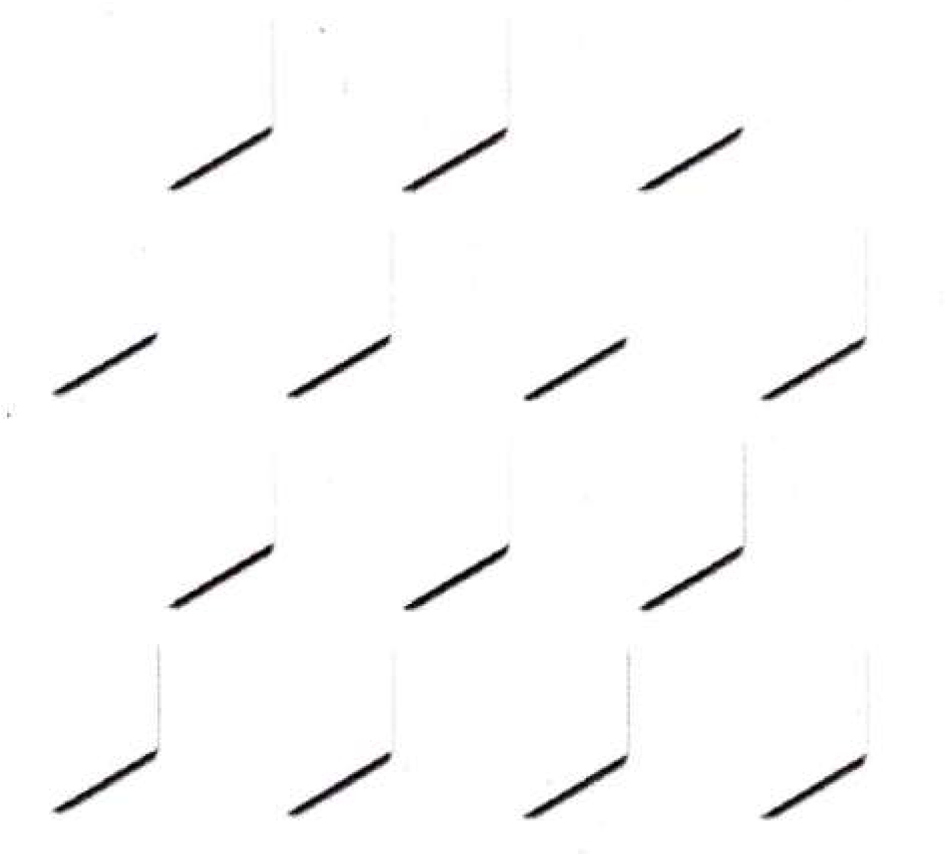
1. Check operation of safety devices and interlocks regularly.
2. Check for leaks and abnormal pressure drop across filters.
3. Checks sieve in the automatic powder retum system. Where applicable, make sure that air bearings are supplied with clean, dry air.
4. Check ground connections regularly, including ground between work-piece and hangers.
5. Lubricate electrical motors regularly and check for overheating.
6. Rough-clean booth and area daily with squeegee and non-sparking vacuum cleaner. Clean thoroughly every week.
7. Clean and drain compressed air filters regularly. Replace ad necessary.
8. Strip hangers regularly to make sure that part and properly grounded.
9. Remove foreign objects which may fall into booth immediately.

DON’T

1. Spray powder with the booth air exhaust and powder recovery system off.
2. Let spray guns approach grounded objects too closely.
3. Permit foreign objects to remain in the booth.
4. Permit smoking in area.
5. Let powder accumulate anywhere.
6. Permit fan motor bearings to become contaminated with powder.
7. Use recovery system hoppers as powder storage reservoirs.
8. Clean spray booth with rags or brushes. Block pressure relief vents

Quality Checks

Testing Types



Salt Spray (FOG) Testing:-

Salt Spray (FOG) Testing involves submitting test pieces, parts or panels (coupons) to a precisely-controlled accelerated corrosive environment (a salt spry cabinet) to evaluate the relative corrosion resistance of the coating or part. Because the environment inside the cabinet is warm, moist and a little bit salty, it's almost like taking your car to the beach for few months to see how much it will rust. Although no direct correlation can be made between number of hours in Salt Spray and number of hours, day or years in the real world (or other media before corrosion, the test has been used as a standard for evaluation of the corrosion resistant properties of coatings for many years. Alike in many ways, Salt Spray testing generally considered more extreme than High Humidity testing (link).

There are many standard specification detailing cabinet parameters, length of time in the cabinet, evaluation of corrosion and the amount of allowable corrosion per part per test length, including military, commercial and industrial specs. Some of the very common Salt Spray tests are run to confirm to MIL-C-5541/BAC5719 for chromate conversion coating. MIL-A-8625/BAC 5019 for anodizing and TT-C-490 for phosphating and paint. We also have a great deal of experience in assisting customers with designing a set of parameters to meet individual research or production needs. In addition to the above applications Salt Spray can also be used to evaluate the performance of assembled electronic equipment.

Ashley Laboratories Ltd. maintains a cabinet conforming to ASTM B-117 (latest revision 365 days a year. Our turnaround is rapid, parts often go into the cabinet the same day they are received, parts are evaluated the same day testing is completed and reports are quickly generated. Most tests run for intervals of 24 hours. We are an approved vendor for Salt Spray testing of the Boeing Corporation (insert Boeing link here www.boeing.com) and others. We offer individual attention to our wide base of clients from across the globe.

High Humidity Testing

High Humidity Testing, like Salt Spray (FOG) Testing (link here) is a form of evaluating coatings or electronic equipment performance, after exposure to a precisely-controlled accelerated environment. Unlike Salt Spray, the cabinet generally maintains a moist and warm environment, but without the additional corrosively of the salt. For that reason, High Humidity is generally considered a bit less harsh a test than Salt Spray. Both the temperature and the relative humidity of the cabinet are adjusted to conform to the desired specification to which parts are to be tested.

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Solution Analysis

Solution analysis in one of the essential services provided by Ashley Laboratories Ltd. Whether you need regular checks for solution control or specific analyses to assure compliance with specification requirements Ashley's analysts provide quick, careful and accurate attention to all your solution analysis needs. With our vast experience and background we can assist you with solution analyses from the most routine daily, weekly or monthly solution controls for in-house quality requirements to quality system procedures to support the needs of the FAA, NASA or the aerospace industry from periodic checks against in-house testing kit types of analyses to individually designed research projects.

Waste water analysis/environmental testing

In our effort to offer comprehensive soup-to-nuts service for our customers, Ashley Laboratories Ltd. offers a full range of waste water, effluent and other environmental testing to meet your waste water discharge permit needs and more. We have built a wide range of clients from all manner of metal finishers (job shop platers, aircraft engine and landing gear refurbishes, pc board manufacturers, machine shop etc) to soft drink bottlers from bakeries and laundries to real estate auction houses. Look to Ashley first for your Fed EPA, state or local regulatory permit-required effluent testing, in-house studies of your waste treatment systems, TCLP leach ate testing and other environment service. All tests are performed where in accordance with current EPA approved methods (including 40 CFR part 136, 600-4-79-020). Our rigorous quality program includes in-house and EPA round robin blind studies.

Abrasion resistance (Taber) Testing

Abrasion resistance (Taber) testing is a regulated wear test used to evaluate the durability of coatings and materials. Most commonly associated, in our industry, with hard coat anodize (MIL-A_8625, typeII) this test is internationally recognized for its accuracy and reliability as an indication on the quality of a wear resistant coating. A coated test panel (or section of material) is weighed, then rotated and abraded by specially designed grit-embedded wheels for a specific number of cycles (the aforementioned MIL-A-8625 requires 10,000 cycles) and weighed again to determine coating weight loss and/or wear index. Ashley Laboratories Ltd. provides regular testing to existing specification. We also have and will gladly assist in designing individual research projects for new or experimental coatings.

Adhesion Testing

Metal finishing have a wide variety of adhesion testing from the ability of a plated coating to stick to substrate to a painted surface's integrity to the reliability of aerospace parts to maintain a tenacious adherence between the substrate, a chromate conversion coating and the primer and paint layers. Ashley Laboratories Ltd. offers the full gamut of adhesion testing: wet tape, dry tape bend, knife, cross hatch, scribe etc.

Knife Test

This simple test requires the use of a utility knife to pick at the coating. It establishes whether the adhesion of a coating to a substrate or to another coating (in multi-coat systems) is at a generally adequate level. Performance is based on both the degree of difficulty to remove the coating from the substrate and the size of removed coating.

Using the knife and cutting guide, two cuts are made into the coating with a 30-45 degree angle between legs and down to the substrate which intersects to from an "X". At the vertex, the point of the knife is used to attempt to lift up the coating from the substrate or from the coating below.

This is a highly subjective test and its value depends upon the inspector's experience. A coating which has a high degree of cohesive strength may appear to have worse adhesion than one which is brittle and hence fractures easily when probed. There is no known correlation to other adhesion test methods (pull-off, pate etc.)

Tape Test

On metal substrates, a more formal version of the knife test is the tape test. Pressure sensitive tape is applied and removed over cuts made in the coating. There are two variants of this test; the X-cut tape test and the cross hatch tape test.

The X-cut tape test is primarily intended for use at job sites. Using a sharp razor blade, scalpel, knife or other cutting device, two cuts are made into the coating with a 30-45 degree angle between legs and down to the substrate which intersects to form an "X". A steel or other hard mental straightedge is used to ensure straight cuts. Tape is placed on the centre of the intersection of the cuts and then removed rapidly. The X-cut area is then inspected for removal of coating and rated.

The cross hatch tape test is primarily intended for use in laboratory on coating less than 5 miles (125 microns) thick. It uses a cross-hatch pattern rather than the X pattern. A cutting guide or a special cross-hatch cutter with multiple preset blades is needed to make sure the incisions are properly spaced and parallel. After the tape has been applied and pulled off, the cut area is then inspected and rated.

Pull-Off Tests

A more quantitative test for adhesion is pull-off where a loading fixture, commonly called a dolly or stub, is affixed by an adhesive to a coating. By use of a portable pull-off adhesion tester, a load is increasingly applied to the surface until the dolly pulled off. The force required to pull the dolly off or the force the *dolly withstood, yields the tensile strength in pounds per square inch (psi) or* mega system comprised of the dolly, adhesive, coating system, and substrate , and will be exposed by the fracture surface.

This test method maximize tensile stress as compared to the shear stress applies by other method , such as scrape or knife adhesion, and results may not be comparable. Further, pull-off strength measurements depend upon the instrument used in the test. Results obtained using different devices or results for the same coating on substrates having different stiffness may not be comparable.

Solder ability Testing

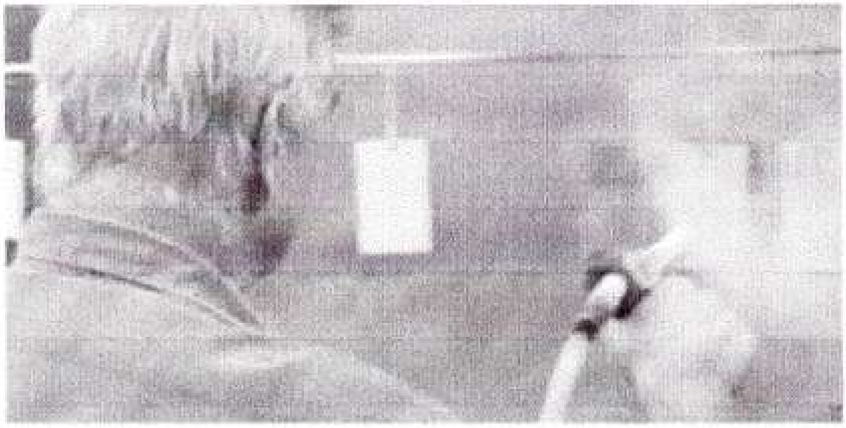
Solder ability testing is performed to assure the ability of the coated parts to be soldered successfully in assembly for *electronic performance.* Ashley Laboratories offers solder ability testing to individual coating specification such as MIL-T-10727 and QQ-S-365 or for broader test method standards such as MIL-STD-202 method 208. Following strictly scripted laboratory procedures, we test actual parts or test coupons, per your requirement, to these and other rigorous standards.

Porosity Testing

Ashley Laboratories, Ltd. also offers porosity testing in our full line of testing procedures for coated products. As its name implies, porosity testing assesses the integrity of the coated surface, by revealing holes or pores in the coating. A common porosity test is the ferroxyl test for chromium coatings as detailed in QQ-C-320. Other tests are also available.

Powder Coating Thickness Measurement
Updated December 2010

DeFelsko manufactures instruments that measure the thickness of powder coating on a variety of substrates before or after cure. This article describes measurement solutions and lists appropriate ASTM testing documents.



Overview

Thickness measurement of powder can be taken before and after curing. Substrate type, thickness range, part shape, and economics determine the best method to be employed.

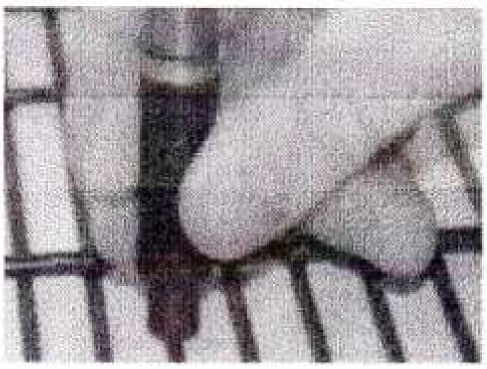
For uncured applied powders, height measurement can be performed with powder combs and with magnetic gages employing special powder probes. These techniques are destructive and may require recoating the part. Coating powders generally diminish in thickness during the curing process so these procedures require a reduction factor be determined to predict cured firm thickness.

Ultrasonic instruments also measure uncured powder, but do so without touching the surface. Instead of measuring powder height, they automatically display a predicted cured thickness result.

For after –cure measurement, a variety of hand held instruments are available. These non-destructive instruments employ either magnetic, eddy current or ultrasonic principles depending on the substrate. Less common method include micrometer measurement, destructive dry film methods such as cross-sectioning and gravimetric (mass) measurement.

Measurement AFTER cure

We begin with a discussion of post-cure measurement simply because cured thickness targets are the value most often supplied by both powder manufacturing and coating specifies. Dry film thickness (DFT) instruments are common, affordable, non-destructive, and easy to operate. They employ magnetic, eddy current or ultrasonic principles depending on the substrate.



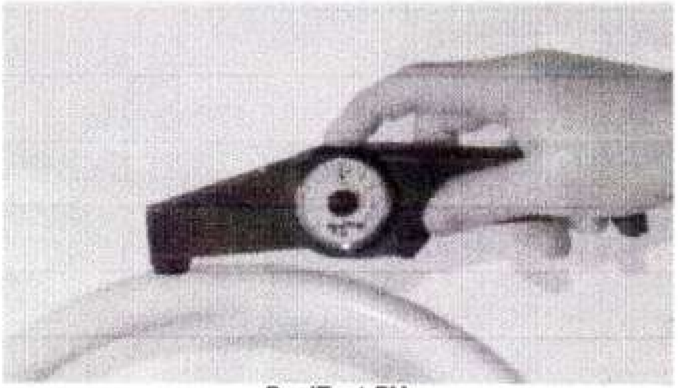
Three principles of operation are employed. A ***magnetic*** principles is used to measure non-magnetic coating on steel parts for the other metal, an **eddy current** principles id used provides the coating is non-conductive. For non-metals, an ***ultrasonic*** principle is used.

Magnetic Gages – Mechanical

When the parts of steel, measurement are made with a magnetic thickness gage using either ***mechanical*** or ***electronic*** operation.

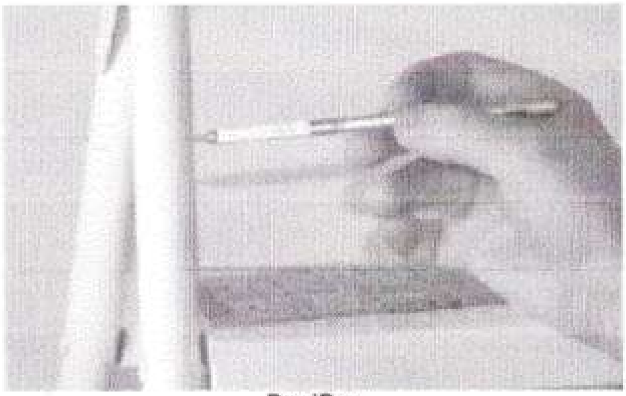
Mechanical pull-off gages use a permanent magnet. Cured thickness is determined by measuring the force required to pull that magnet from the coated steel surface. Magnetic pull-off gages are rugged, simple, inexpensive, portable, and usually do not require any calibration adjustment .They are a good, low-cost alternative in situations where quality goals requires only a few readings during production.

Defelsko manufacturing two mechanical instruments. The PosiTest FM is a rollback dial model comprised of a magnet attached to one end of a pivoting balance arm and connected to a calibrated hairspring. By rotating the dial with a finger, the spring increases the force on the magnet and pulls it from the surface. It is safe in explosive environment and is commonly used by painting contactors and smell powder coating operations .mlt has a tolerance of ±5%.



PosiTest FM

Pencil-type models like our PosiPen use a magnet this is mounted to a helical spring that works perpendicularly to the coated surface. Ideal for small part or for quick quality checks, the ***posiPen_*** *has* a smaller probe tip allowing it to be placed with pin-point accuracy on small parts, hard to reach areas and curved surfaces. The temperature range of -100 to 230 ºC (-150 to 450º F) makes it ideal for taking measurements on hot parts fresh out of the oven. It has a tolerance of ± 10%



PosiPen

Electronic Instruments

A variety of electronic instruments are available for measuring on metal parts. They use a principles when measuring on steel and an eddy-current principles on aluminium. Measurement results are displayed on an easy-to read liquid crystal display (LCD). Typical tolerance is between ±1 and 3%

Our basic electronic solution is called the PosiTest DFD. Two models are available, each capable of measuring up to 1000 microns (40 miles). The ***PosiTest DFT Ferrous*** model is recommended for steel substrates, while the ***PosiTest DFT COMBO*** model is ideal for measuring on all metal substrates.

PosiTest DFT

Our most popular instrument for powder coaters are the PosiTest or 6000 u series of gages .They are ideal for the non-destructive measurement of powder coating thickness on metal substrates, an **N series** for non-steel substrates such as aluminium, and an **FN series** for measuring either application.

Higher accuracy ferrous or non-ferrous **Microprobes,** with a range up to 625 microns (25 miles), are available for measuring in smaller, hard to reach areas. Advanced models can store and print/download reading. As more customers purchase coating thickness gages to verify the quality of incoming products, it is becoming increasingly important that powder coaters have the ability to permanently record quality control data. Some powder coaters have even taken the nest step of providing their customers with unsolicited reports showing the coating thickness reading as evidence of their process quality.

ASTM practice D7091 describes non-destructive measurement over metal substrates made with magnetic and eddy current coating thickness gages.

PosiTector 6000

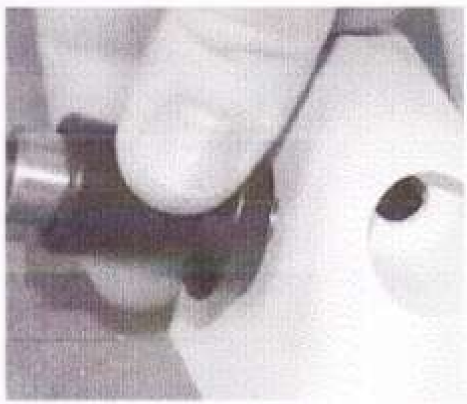
Coatings on Non-metal substrates

Magnetic and eddy current instrumentals measure powder over **metal.** Non-metal applications such as coated plastic and wood require an ultrasonic pulse –echo technique.

Ultrasonic testing works by sending an ultrasonic vibration into a coating using a probe (transducer) with the assistant of a gel (or drop water) temporarily applied to the surface.

This relatively new advancement allows industries to perform non-destructive quality control at an affordable price. A benefit to this measurement technique is the possibility of measuring the individual layers in multi-layer coating system.

Our ultrasonic PosiTector 200 B std is ideal for measuring the thickness of powder coating applied to non-metal substrates. It has a range of 13 to 1000 µm (0.5 to 40 miles). ASTM D6132 describes this test.



While most powder coating specification give cured thickness targets, it is possible to determine of applied powder is within thickness specification before the finality of curing and cross linking.

There are good reasons for wanting an accurate prediction of cured thickness, especially on moving lines. Depending upon the length of the oven, that is the number of parts being cured, as well as the time required for the curing process and for manual film thickness measurement after curing, there is a considerable delay before the operator can intervene in the application process to make any necessary changes.

If coating defects are discovered, a considerable number of coated parts have to be reworked in a repair loop or if reworking proves to be too expensive, they may even have to be scrapped. For some operations, these disadvantages are no longer acceptable for meeting the demands of modern finishing processes.

Measuring power in the pre-cured, pre-gelled state helps insure correct cured film thickness. It enables the application system to be set up and fine-tuned prior to curing. In turn, this will reduce the amount of scrap and over-spray. Accurate predictions help avoid stripping and re-coating which can cause problems with adhesion and coating integrity.

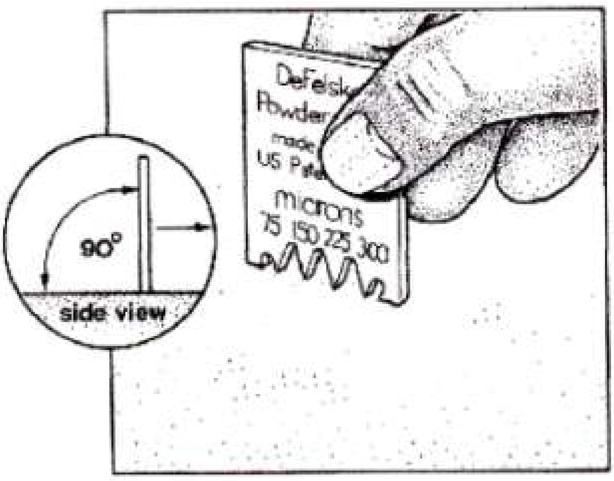
ASTM Test Procedures

ASTM D7378 describes three measurement methods for the thickness of applied, pre-cured coating powder to predict cured thickness.

A. Rigid metal notched (comb) gages.
B. Electronic coating gages with a special powder probe.
C. Non-contact ultrasonic instruments.

Procedure A uses the inexpensive DeFelsko Powder Comb which much the same way as a wet film gage. The comb is dragged through the uncured powder and powder height is considered to be a range value between the highest numbered tooth that made a mark and has powder clinging to it, and the next highest tooth that left no mark and has no powder clinging to it.

These gages relatively inexpensive with an accuracy of ±5μm. Various **Powder Comb** models are available allowing measurements from 75 to 1250 microns (3 to 50 miles) on any substrate. They are only suitable as a guide since the cured film may be different after flow. Marks left by the gage may affect the characteristics of the cured film.



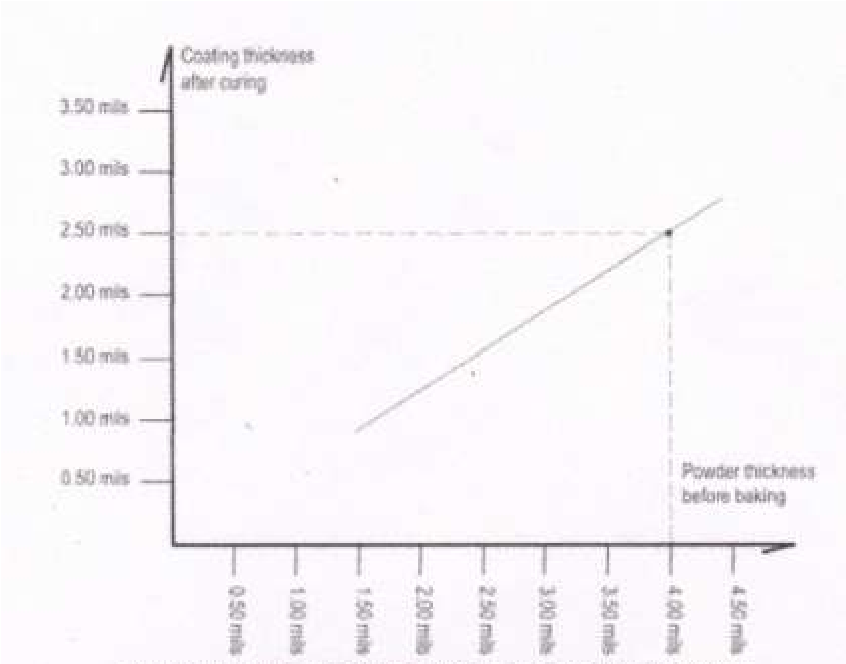
Powder Comb

Procedure B uses a conventional magnetic or eddy current coating thickness gage but with a specially designed powder probe to measure the thickness of the coating powder. Three micro pins, which are integrated into the probe, penetrate the coating powder down to the substrate. The probe is manually pressed down to the surface of the powder to effect a height measurement. This procedure is applicable to metal substrates only. Marks may be made in the powder that may not be covered when the powder flows in the cure process.

Procedure A and Procedure B result in only a **height** measurement of the uncured coating powder. But thickness specifications are most often stated in cured powder thickness. Since coating powders generally diminish in thickness during the curing process, these two procedures require a reduction factor be established to predict cured film thickness for each particular coating powder.

This reduction factor is obtained by measuring the cured powder thickness at the same location where the uncured powder thickness measurement was taken. For best accuracy, measurements before and after curing should be taken for different thicknesses.

A sample plot of measurement results is shown here. From this plot a reduction factor can be determined and applied to all future dry coating powder thickness measurements to predict cured thickness.



Typical Correlation Between Pre- and Post-cured Powder

Procedure C of ASTM D7378 describes a relatively new type of instrument the PosiTector PC Powder Checker. It is an ultrasonic device that can be used non-destructively on uncured powder to predict the thickness of the cured film.

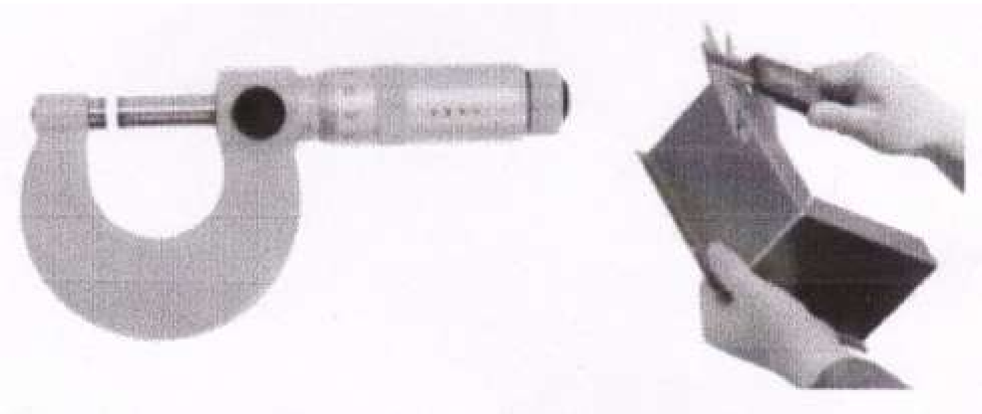
The Powder Checker is hand-held battery powered and works right out of the box for most powders. It's simplicity of operation and rugged design allows it to be used quickly and efficiently by line operators.

Non-contact coating thickness instruments have the advantage of being non-destructive. This means that after measurement, the measured components can be re-introduced into the process without being damaged.

PosiTector 200 B Std

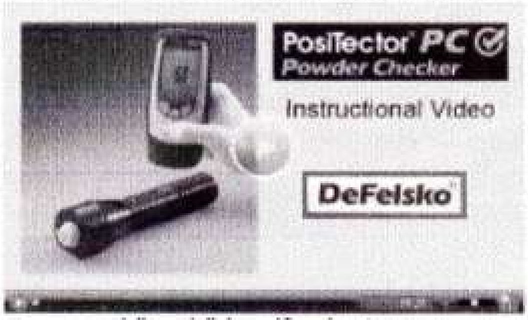
Other Methods

Micrometers are sometimes used to check coating thickness. They have the advantage of measuring any coating/substrate combination but the disadvantage of requiring access to the bare substrate. Two measurements must be taken: one with the coating in place and the other without. The difference between the two readings, the height variation, is taken to be the coating thickness.



The destructive techniques are available. One is to cut the coated part in a cross section and measure the thickness by viewing the cut microscopically. The other technique uses a scaled microscope to view a geometric incision through the cured coating. This method is used when non-destructive methods are not possible or as a way of confirming non-destructive results. ASTM Test Method D4138 describes destructive measurements over rigid substrates made with cross sectioning instruments.

PosiTector PC Instructional Video



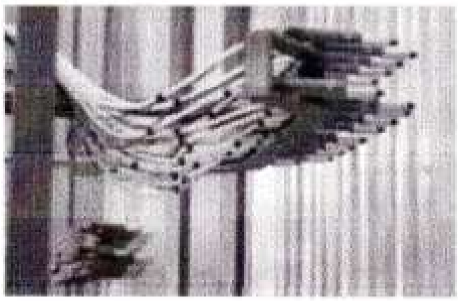
View Video (8 minutes

Appendix

Units of measurement

The normal standard used in powder thickness measurement is the mil, where 1 mil is equal to a thousandth of inch (1/1000”). So if the manufacturer’s specified thickness is 2 to 5 mils, the final cured thickness of the powder should be between 0.002 and 0.005 of an inch. The metric unit of measurement is called the micron where 25.4 micron is equal to 1 mil. Applications must apply the powder evenly and according to the product specification sheet.

Background on Powder Coating



Powder coating continues to be the fastest growing of all the finishing technologies. It is an attractive paint like protective finish that is long lasting and highly resistant to chips, scratches and fading. It provides a seamless coating from virtually unlimited selection of colours, textures and finishes.

Powder coating is a coat effective, one step process that doesn’t require successive coats and long curing times. Powder particles used are a mixture of finely ground pigment and resin particles. Charged powder particles are transferred onto an electrically grounded surface. A variety of processes exit for powder application. These applications range from electrostatic spraying for thinner coating (0.001” – 0.010”) to dipping in a fluidized bed for thicker coatings (0.007” – 0.040”)

During the curing process the powder is fused into a smooth coating. Dependent on the process, powders are either thermal cured (convection or infrared) or UV-cured. The powders used may be either thermoplastic (same chemical composition after reflowing) or thermosetting (chemically cross linked with themselves or other reactive components)

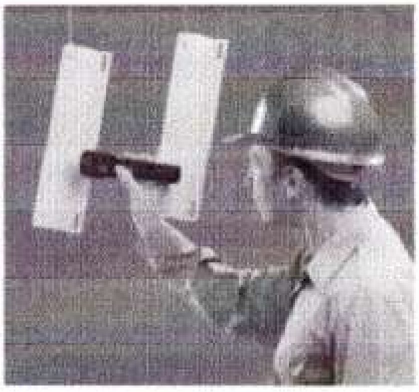
UV-Curing

Unlike Thermal Cured powders, UV Curable powders separate the melting and film formation stages from the final curing stage. Short wave infrared and convention heat allows relative low temperatures to be used for the melting process. The result is lower temperature curing with improved flow. The UV wavelength and time required for curing is based on the colour and expected film thickness. Coating thickness can range from 20 to 100 micron (1 to 4 mils). The most significant challengers of UV-curing are the current cost of the powders required as well as a need a position the UV light to ensure 100% coverage.

Since UV-curing does not require high temperatures to cure, a significant reduction can be attained in required space, conveyors and racking for the cooling process. Unlike thermal, UV provides instant curing which significantly increases throughput. Process saving are significant due to the decrease in energy and equipment required for heating. UV powder also easy to clean and recycle in energy providing a VOC-free process.

Available markets are expanded as lower process temperatures allow heat sensitive substrates (e.g. medium density fibreboard and plastics) to be powder coated. The cost of powder coating large mass parts (e.g. engine blocks) that act as heat sinks for thermal curing is also greatly reduced using UV curving.

Why Measure Thickness?



Coatings are designed to perform their intended function best when applied within a tight thickness range as specified by the manufacturer. This ensures optimum product performance. Many physical and appearance properties of the finished coating are affected by film thickness. Film thickness can affect the color, gloss, surface profile, adhesion, flexibility impact resistance and hardness of the coating. The fit of pieces assembled after coating can be affected when film thickness is not within tolerance. Therefore, coating must be applied within certain minimum and maximum film thickness specifications to optimize their intended use.

When insufficient powder coating is applied it does not provide adequate coverage and protection. For example metals require a sufficient coating thickness for adequate protection from environmental effects such as corrosion (steel) or oxidation (aluminium). In addition, inadequate powder coating thickness may result in poor surface finish and undesirable appearance or color.

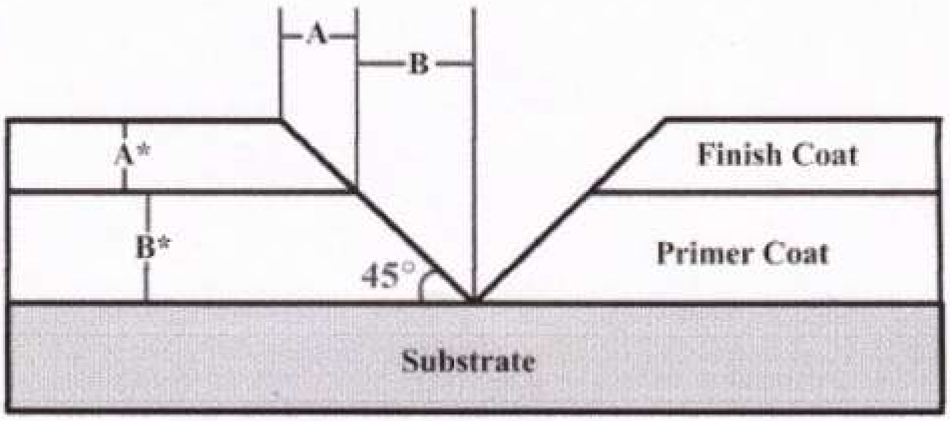
Powder Coating thickness may also affect the application's impact resistance, flexibility, hardness, edge coverage, chip resistance, weathering, resistance to salt spray and ability to retain gloss. Manufacturers provide a production specification sheet for powder coating measurements enable the coater to adjust their coating process in process in accordance to the specifications. On medium density fibreboard (MDF) for example powder coating thicknesses typically range between 1 and 8 mil (25 to 200 microns) or even higher for thermoplastic coating. Usually the finish is made more durable with thicker mil coverage. Factory specifications often determined by just looking at it.

There are other benefits to precisely measuring finish thickness whether to meet ISO, quality and customer requirements for process control or to control costs. When companies fail to check and verify coating quality of incoming material they waste money reworking product. By checking their application equipment they ensure the coating is being applied incompliance with the manufacturer recommendations. Applying excessive film thickness risks the possibility of incomplete cure and can drastically reduce overall efficiency. Too much powder coating may result in poor adhesion and tends to peel or chip from the substrate. Regular testing can reduce the number of internal reworks and customer returns due to finish defects.

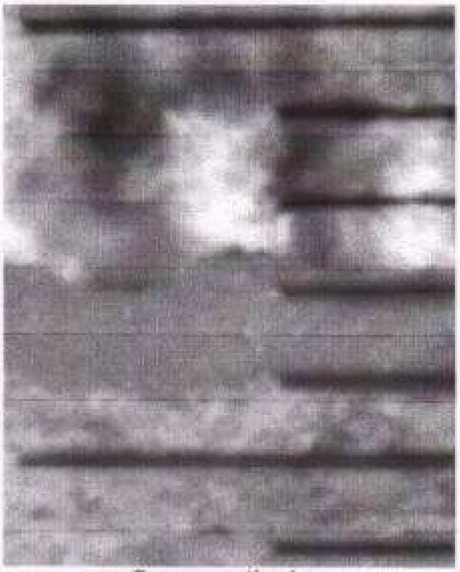
Affordable

High-tech quality-control equipment can help companies maximize coating usage and boost their bottom lines. In the past, costly and complex color and thickness testing equipment primarily catered to larger companies with bigger budgets. However, in the past few years, quality-control testing equipment has decreased in price while advancing technologically, which makes purchasing the equipment more practical and affordable for smaller companies on tighter budgets.

Technology, advancements have been the key to the growing availability of thickness testing equipment. These improvements have helped manufacturers produce devices that are smaller and more portable, rugged and simple to use. Thickness gauges have also dropped in price because the materials used to produce them are more abundant. The same materials are mass produced for use in cell phones, PDAs and computers.



A = A* = Finish Coat Thickness
B = B* = Primer Coat Thickness


Cross sectioning

Measurement BEFORE Cure

Measurement methods described so far take place **after** the powder coating has cured. But if a coating has been improperly applied, correction after cure requires costly extra labour time, may lead to contamination of the film and may introduce problems of adhesion and integrity of the coating system. Measuring film thickness **before** cure can determine the need for immediate correction and adjustment by the applicator.

Measuring Dry Applied Powder

Again, depending on the solvent used it can be a heath or fire hazard. Neither the **oxide and scale removal** this can be achieved by mechanical scuffing, wire brushing or for large areas, by abrasive blasting. Sand as an abrasive material has **solvent vapour degreasing-** using this technique the work piece is suspended in the vapour of a chlorinated solvent such as trichloroethylene in a specially designed plant surface, which solubilises the oil and grease which run off the parts with the liquid as it returns to the sump.

This is a much more efficient process because the solvent is continuously boiled up to replace the vapour that condenses.

On its own this method will degrease effectively but any solid particles left on the surface may remain there after all the oil and grease has been removed.

Improvements can be obtained by including a boiling liquor stage or by the use of ultrasonic agitation. In addition special additives can be put into the chlorinated. Solvent to improve efficiency

Detergent: The work piece can be dipped in to or preferably sprayed with a solution of a suitable detergent in hot water and then rinsed and dried. This will effectively remove light contamination but will not deal with aged oil, grease or heavy soils.

Emulsion cleaners: Emulsion cleaners are usually pre-emulsified kerosene/water emulsions, or kerosene-based concentrates which emulsify when added to water. Like the alkali cleaners, emulsions are most efficient when used in spray equipment but can be quite effective as immersion cleaners in many instances.

Emulsions, cleaners normally operate at lower temperatures than the alkali type and in some cases can be used at ambient temperatures.

Alkali cleaners: Again the work piece can either be dipped or sprayed with a hot aqueous solution of a suitable alkali mixture and then rinsed twice and dried. Spray application is more effective than dipping and it cheaper as higher operating temperatures (70-90ºC) and concentrations have to be used with the latter .spray application varies in time from 5-60 seconds whereas dip takes from 1-5 minutes. Immersion cleaners are available which separate the oil into a layer so that it can be floated off the cleaner surface over a suitable weir.

Alkali cleaners can effectively remove oil, grease and soils and will cope readily with the heaviest contaminants.

There is a wide variety of alkali cleaners whose properties can be adjusted to give effective cleaning from any set of contaminates. These cleaners often

Oxide and scale removal: This can be achieved by mechanical scuffing, wire brushing or for large areas, by abrasive blasting. Sand as an abrasive material has been banned in the UK as well as in many **European countries.**

The coarse expendable types of abrasive or re-usable metallic abrasive which took over from sand are now augmented by a whole range of ultra-fine abrasives, **ranging from 600 mesh fused aluminous oxide** by a whole range of ultra-fine abrasives, vegetable abrasives such as **walnut shell and peach stones, through to tiny glass** spheres less than 25μ in diameter with these extremely fine abrasives a complete surface uniformity can now be achieved.

Obviously using a very fine grit the rate of scale removal is rather slow, whereas a too coarse grit will give such a rough surface that the flow of the powder during stoving will be inhibited with consequent loss of gloss accompanied by an extremely rough surface profile.

To provide some idea of the relative surface roughness on a steel surface which has been shot blasted the 'peak to valley' measurement would be about 100μ. with fused aluminous oxide (grade 180/220) it would be 3-5*μ, while with* glass beads it would be 1-1.5μ.

Oil and grease removal: This is usually the first step in the preparation of metallic surface for coating there are numerous ways of carrying out this operation and some of the more common methods are briefly enumerated below.

Solvent wipe: Grease removal can be achieved by wiping the work piece with a cloth soaked in a suitable solvent. This method will remove grease and solid matter fairly efficiently until first the cloth and then the solvent become dirty rags and solvent will have to be replaced frequently. If only loose dust is the contaminate, tack-rags are often used.

Although this method is quick and convenient for small scale production, it suffers from high labour and material costs and, depending on the solvent selected, can be a fire or health hazard.

Solvent dip: With this method the work piece is immersed in a tank of solvent and after withdrawal, when the solvent has evaporated, all oil and greases should have been removed.

This method remains effective until, like the solvent wipe, contamination has built up in the solvent dip tank and an equilibrium is reached whereby as much oil or grease is redeposit on the work as it takes off. The only difference between the two methods is that this oil is spread over the whole component.

Better results can be obtained by having a number of tanks in line on a cascade principle, but this takes up considerable space and is expensive as solvent losses due to evaporation are high.

Iron phosphate coating is normally spray applied in a three or four stage operation. The work usually passes through two water rinse sections before drying.

Zinc phosphate can be either spray or dip applied in a five stage operation, i.e. alkali degrease, rinse, zinc phosphate, two water rinses.

Pre-treatment for zinc surface – A lightweight zinc phosphate coating is recommended. Generally electro-deposited zinc coatings present no pre-treatment problems but hot dipped galvanised coating can affect adhesion. Increasing degree of spangle decreases adhesion characteristics.

Chromate conversion coating – The main conversion coating for aluminium and its allows is a chromate coating which can be colourless or of the yellow chromium oxide or green chromic phosphate type. The coating weight recommended is 0.1 – 0.5g/m2

The five stage process normally consists of an alkali degrease, rinse, chromate conversion, followed by two rinses.

Again the chromate coating should be of low film weight for maximum adhesion.

For high quality applications it is usually necessary to employ a final rinse with demineralised water. The conductivity of the final rinse bath is then monitored to ensure it cleanliness.

No-rinse systems – one way of avoiding the need for this is to use a dry-in-place or no-rinse process. These are predominantly a form of chromate. It is arguable whether they are true conversion coating or merely dried-on films with some reaction with the substrate but the advantages of needing no rinse are obvious.

No-rinse system – One way of avoiding the need for this is to use a dry-in-place no-rinse process. These are predominantly a form of chromate. It is arguable whether they are true conversion coatings or merely dried-on films with some reaction with the substrate but the advantages of needling no rinse are obvious.

Heavy-metal free pre-treatments – The increasingly strict environmental standards in the developed world mean that there is a move away from heavy metal containing pre-treatment, particularly chromate. Early chromate-free pre-treatments had poor performance but more recently standards have improved with the first approval for use on architectural aluminium applications being awarded by the Qualicoat organisation in 1996

.

Effluent disposal – Local authorities work to different standards in dealing with effluent discharge. However they are all becoming more stringent and cautions as to what effluent they will accept.

Include grain refining agents to ensure that phosphate coatings subsequently applied to steel surfaces have a fine grained crystal structure.

In addition to the alkali the mixtures contain detergents, emulsifiers, sequestering and chelating agents and occasionally water-softening additives.

It should be noted that only under controlled conditions are alkali cleaner suitable for light alloys, zinc, galvanised metal or aluminium which are all attacked by alkali.

Acid Cleaning – Acid pickling sing either inhibited sulphuric or hydrochloric acid can completely remove rust and scale and can also condition the surface. This method is usually confined to iron or steel surfaces.

It is of paramount importance that when aqueous cleaning methods are employed great card be taken to ensure that subsequent water rinsing is of high standard to ensure that the dried and cleaned components are not contaminated with acid, alkali or emulsion. Also it a conversion coating system does not follow on in sequence the must be dried rapidly and effectively to prevent rusting of the surface.

Phosphating conversion coatings – the recognised pre-treatment for steel substrates just prior to application of powder is phosphating which can vary in coating weight.

The greater the conversion coating weight the greater the degree of corrosion resistance achieved; the lower the coating weight the better the mechanical properties and corrosion resistance. High phosphate coating weights can give trouble with powder coating in that crystal fracture can occur when the coating is subjected to locally applied mechanical forces, e.g. bending or impact.

Due to the excellent adhesion of the powder coating to the phosphate coating, disbandment will usually occur at the phosphate/metal substrate interface rather than at the phosphate/powder coating interface.

Phosphate coating are covered by BS3189/1959, class C for zinc phosphate and class D for iron phosphate.

A find grain crystalline zinc phosphate is recommended at coating weights of 1-2g/m2 and for iron phosphate at 0.3-1g/m2. Application can be spry or dip. Chromate passivation is not usually necessary.

Porous casting and ‘blast cleaned’ surface these surfaces can give considerable difficulty with ‘blowing’ of the powder coating due to entrapment of air. The profile of the metal and thickness of coating must therefore be strictly controlled. Preheating for a few minutes sometimes overcomes this defect

Substrate Pre-treatment prior to Coating

The main aims in the preparation of a metal surface prior to powder coating may be defined as follows:

1. The complete removal of all foreign matter e.g. scale, grease, cutting, oil, soil, welding splatter etc.
2. The conditioning of the surface so as to render it suitable for the coating that is to be applied.
3. The pre-treatment should impart should impart uniformity throughout all treated work piece surfaces, irrespective of the source of the metal or of the contaminants that might adhere.

As with other methods of organic finishing attention to the pre-treatment stage is essential in order to achieve the full potential of the powder coating.

Surface pre-treatment may vary depending upon the specific end-use requirements of the finished products – from a single-step cleansing operation to a multi-stage sophisticated pre-treatment which deposits a conversion coating on the surface of the metal.

Application of coating of electro statically charged particles to an earthed metal surface can only be achieved if the surface if free of any composition which has a high electrical resistance. The presence of any insulating film on the surface of the work piece to be coated will limit or in some cases prevent powder being deposited.

Substrates – steel, aluminium, copper, zinc allows and galvanised steel are common metals on which powder is used. In a number of cases where normal service conditions apply, satisfactory properties can be obtained on thoroughly cleaned metal.

Steel – for iron/steel surfaces maximum corrosion and salt spray resistance are given by a zinc phosphate conversion coating.

Aluminium – for aluminium and its alloys, although the clean surfaces are easily coated and adhesion is excellent, performance can be upgraded using a proprietary chromate conversion coating.

Zinc allows – with all zinc based substrates such as Zintec, Mazac and Galvanised Steel a suitable phosphate coating is recommended.

Porous castings – and ‘blast cleaned’ surface – These surface can give considerable difficulty with ‘blowing’ of the powder coating due to entrapment of air. The profile of the metal and thickness of coating must therefore be strictly controlled. Preheating for a few minutes sometimes overcomes this defect.

Generally iron phosphate solutions can be passed to drain without treatment, zinc phosphate solutions usually have to be below a specified concentration lever which can normally be achieved by diluting in ordinary water.

Some final rinse solutions contain chromate, which requires special treatment because of its toxic effects on marine life.

Powder Application

2.1 Poor fluidization in powder hopper:

Powder is supposed to flow like water in the fluid container (boil). Poor fluidization is recognizable in a slow and non-continuous transportation of the powder coating from the fluid container to the guns. No homogenous powder cloud is achieved.

Possible Causes	Explanation
Powder level too low	Add powder to the normal level
Fluidizing air low or too high	Change pressure use larger hose diameter
Oil remnants in compressed air	Check filter in front of coating booth
Compact or damp powder	1. Manually loosen powder in hopper 2. Check compressed air for quality
Oil remnants in compressed air	Check filter in front of coating booth
Fluidizing plate chogged / defective	Clean plate or exchange the plate

2.2 Clogging of the powder feed houses

Deposits (agglomerates) form in the powder feed hoses, which sporadically are freed by delivery air and appear as powder puffs on the work pieces. After curing these powder puffs appear as faulty surface elevations.

Possible Causes	**Explanation**
Feed air pressure too high/too low	Reduce/increase pressure
Delivery air moist or oil in pressurized air	Check in-line filters and moisture traps
Material choice of hoses	Check hoses for material quality
Worn venture or pump	Replace worm parts
Too fine powder	Decrease amount of reclaim to hopper Optimize vergin powder plus reclaim ration
Feed hose too long	Minimize feed hose length

2.3 Poor attraction of the powder to the component

The powder coating, which should electro statically adhere to the substrate, falls off no relevant coating thickness can be achieved.

Possible Causes	Explanation
Incorrect Voltage at the gun	Check voltage, clean or replace gun
Insufficient Grounding	Clean grounding points and hangers
Excessive build-up of cured powder coating	Clean hanger
Worn venture or pump	Replace worn parts
Too much powder out put	Reduce air flow / powder flow
Gun distance to part too close, blast effect	Adjust the distance
Gun air-pressure too high	Reduce forward air pressure
Film build too high	Reduce powder flow
Insufficient wetting	Check pre-treatment

2.4 Poor Wrapping

With one sided gun positioning only minimal film thickness can be achieved on opposite side.

Possible Cause	Explanation
Powder flow too low or too high	Optimize system parameters, adjust air flow
Insufficient grounding	Use clean hooks
Supplemental air flow is too high or too low	Adjust air speed and powder cloud
Gun voltage too high	Adjust voltage to suit parts
Insufficient charging of the powder	Adjust high voltage; consult powder manufacturer
Poor or wrong positioning of the parts	Adjust hanging configuration

2.5 Poor penetration into recesses
Despite the physical condition it is possible to achieve a minimum coating thickness in the corners. Extreme film thickness variations are noticeable.

Possible Causes	Explanation
Too low powder delivery	Increase powder flow
Air speed too high	Adjust equipment controls
Poor grounding	Adjust equipment controls to suit the parts
Insufficient charging of powder/ defective	Check and improved grounding
Incorrect spray pattern / spray to wide	Adjust voltage, contact equipment
Too high voltage	Try different spray nozzle
Poor gun placement	Reduce voltage so that surface closest to the gun do not repel powder
Powder too fine	Adjust gun position to enter directly into recessed area
	Reduce ration to reclaim to hopper, contact powder manufacturer

2.6 Film thickness on component too high
Powder coat layer shows uneven surface prior to curing after curing shows orange peel or pinholes

Possible Causes	Explanation
Excessive powder delivery	1. Reduce powder feed to gun 2. Increase distance between gun and component
Coating time too long	Lower the coating time
Unfavourable geometry of parts	Change hanging or gun configuration
Gun voltage too high	Reset gun voltage
Too much pre-heat (if used)	Reduce pre-heat cycle

2.7 Film thickness on component too low Substrates shows through and powder coat has grainy flow	
Possible Causes	**Explanation**
Powder delivery too low	1. Set correct powder feed pressure 2. Check if powder venture is the correct size, clean and set correctly
Insufficient coating time	Increase time component by
Insufficient charging of powder	Test and adjust voltage
Faraday cage effect	Adjust voltage and forward air flow
Surface area of hanger too large compared to the surface area of work piece	Reduce size of hangers
Damp powder	Remover powder and replace, ensure all powder coatings are kept sealed until required in use
Insufficient grounding	Use clean hooks, avoid thin hooks
Lower level of powder in fluid hoper	Check minimum indicator

2.8 Appearance looks uneven and broken before curing	
Possible Causes	**Explanation**
Back ionisation	1. Reduce voltage 2. Check if grounding points are clean 3. Reduce deposition rate and film thickness 4. Ensure no moisture is entering the system 5. Move gun further away from component

2.9 Powder dusting out of hoper Dusting of powder comes out of hopper which disturbs others	
Possible Causes	**Explanation**
Too high air pressure	Reduce air pressure to fluid bed
Too fine powder	1. Decrease amount of reclaim ho hopper 2. Check ration of virgin powder

3. Surface Defects

3.1 Powder Puffs on the work piece

Powder puffs are powder cluster that in an improperly fused condition are visible as powder hills in the powder film. After curing these powder puffs appear as disturbing elevations on the surface

Possible Causes	Explanation
Powder hose too long or diameter to large	Change hose diameter, shorten hose
Powder too fine (reclaim)	Add virgin powder
Powder falls off booth ceiling	Adjust/increase frequency of booth cleaning intervals
Powder fails off work piece	Test grounding, check diameter of hoses
Gun nozzle defective	Check nozzle, replace
powder moist	Use dry powder, check air filter and moisture traps in compressed air system

3.2 Crater

Defect – blank area in the powder coat, which extends all the way to the substrate (diameter up to 2mm)

Possible Causes	Explanation
Insufficient pre-treatment (e.g. oil and grease residues)	Test pre-treatment of necessary, contact pre-treatment supplier
Rust, white rust on parts	Assure clean surface, apply recommended
Incompatibility with powder coating from other manufacturers	Cleaning of coating and application equipment, contact powder coating supplier
Surrounding air contaminated	Balance air flows in plant, avoid cross drafts
Work piece moist/wet	Increase drying time/temperature
Liquid and powder paint in same plant	Definitely avoid – reconfigure plant
Base coat was cleaned with solvents	Preheat work piece or avoid solvents

3.3 Pinholes in the film

Development of fine pores on the surface also leads to change in gloss level

Possible Causes	Explanation
Silicone contamination	Locate and remove source
Oil contamination	Check degreasing plant
Moisture content of powder too high	Testing through drying of powder/test storage conditions
Oil/water in the air supply	Check oil/water separators on air supply
Film build too high	Note recommendations of powder manufacturer minimize film thickness
Very porous work pieces	Check for satisfactory work pieces, possible surface is too rough from sand blasting.

3.4 Picture Framing Effect Higher film build of coating on the edges of the part due to wrap, therefore uneven flow	
Possible Causes	**Explanation**
Powder particles too rough/unsuitable for particular application	Strain powder to optimize particle distribution consult powder coating manufacturer
Voltage too high	Adjust voltage to suit part
Distance from gun to work piece too low	Adjust/increase distance
Feed air / powder flow too high	Adjust powder flow

3.5 contamination of colour	
Possible Causes	**Explanation**
Poor housekeeping, when colour changing	Totally clean plant, gun and recycling equipment and recharge with new powder
Cross contamination at manufacture	Contact powder supplier
Contamination from equipment cleaning	Vacuuming is more effective than 8air
Deposits from dust and particles in the oven	1. Do not care other colour at the same time 2. Reduce air speed
Deposits of dust and powder on cured object	Dust free cooling zones, avoid drafts

3.5 Blistering Elevation of differing size in the powder coat no adhesion due to enclosures at the part surface	
Possible Causes	**Explanation**
Water on work piece	Check dryer and hanging configuration
Corrosion, oil and grease residues	Optimize pre-treatment
Over coating	Assure flawless first coat
Film thickness too high, powder accumulations	Check system parameters, reduce film thickness
Salt residues or chemical remnants on	Check pre-treatment, final rinse stage

3.7 Poor Adhesion	
Possible Causes	**Explanation**
Under cure film	1. Increase over temperature 2. Decrease line speed
Poor pre-treatment	Check pre-treatment adjusting tanks to suppliers recommendations

3.8 Orange peel Poor flow (orange peel look) short or long waviness of powder coat layer, noticeable only after curing	
Possible Causes	**Explanation**
Heat up cycle of parts too slow	Determine heat up curve and increase
Substrate temperature exceeds the melt temperature of the powder, causing	Check substrate temperature, increase cool down phase
Powder coating material too reactive	Consult powder manufacturer
Film thickness too high or too low	Check system parameters
Incompatibility with other powder	Clean booth, check compatibility
Voltage too high	Optimize voltage
Textured work piece surface	Optimize texture, check work piece surface
Unsuitable particle size distribution	Optimize particle size distribution consult manufacturer

3.9 Insufficient wet out of the substrate Poor or no adhesion of powder coat to the parts surface, large area lifting of cured powder coat	
Possible Causes	**Explanation**
Per-treatment residues	Final rinse de-ionised water
Displaced oils or greases in Per-treatment excessive film build	Per-treatment, check oil separator
Gummed oils, greases or separating compounds, insoluble extrusion oils	Check Per-treatment or change, use different extrusion oils or separating

3.10 Gloss too High	
Possible Causes	**Explanation**
Cure temperature too low	1. Increase air temp and metal temperature 2. Decrease line speed
Oven cycle too short	1. Decrease line speed 2. Increase oven temperature

3.11 Gloss too low	
Possible Causes	**Explanation**
Oven temperature too high	1. Reduce air temp. and check metal temp. 2. Increase line speed
Time in oven too long	1. Increase line speed 2. Decrease oven temperature
Contamination with a powder which is incompatible	Clean all equipment including gun, booth and recovery system and re-charge with virgin powder

4. SURFACE VARIATIONS IN THE POWDER COAT

4.1 Color difference: Continues or suddenly appearing changes in color at effect compared to original sample part or compared to first parts coated	
Possible causes	**Explanation**
Film thickness varies greatly	Assure constant film thickness
Differing substrates and substrate color	Use substrates of same type for comparisons
Film thickness too him	Apply higher film thickness
Not sufficient or wrong pigmentation in the formulation	Consult powder coating manufacturer
Over curing of powder coating (especially with organic pigments	Observe curing parameters of powder manufacturer
Varying film thickness with over coating	Assure even film thickness
Color deviation due to curing technique or oven atmosphere	Use suitable powder coating, control oven use outside air supply for burner

4.2 Cloud Formation: Uneven light to dark or matte to glossy effect of the coating on the work pieces.	
Possible Causes	**Explanation**
Gun distance from part too great or small	Test distance
Uneven powder transport	Introduce sufficient virgin powder
Manual touch-up	If possible pre-coat
Uneven charging	Test application
Uneven grounding of parts	Test grounding
Strongly varying film thickness	Optimize film thickness

4.3 Insufficient coverage:	
Possible causes	**Explanation**
Film thickness to low	Assure appropriate film thickness
Film thickness varies greatly from part to	Optimize system parameters
Differing materials and metal colors	Use same materials for comparison

5. LOSS OF MECHANICAL & CHEMICAL PROPERTIES:

5.1 Poor Mechanical properties and chemical resistance: Insufficient compliance with the necessary technical properties of the powder coating	
Possible causes	**Explanation**
Too/high too low heat up temperature or time	Observed curing parameter of powder Coating manufacture
Oil, grease ,Extrusion oils, dust on the surface	Optimize pre-treatment
Differing materials and material color	Insufficient pre-treatment
Incompatible pre-treatment and powder coating	Adjust pre-treatment method Consult chemical and powder supplier

5.2 Greasy surface Haze like film on the surface, which can be wiped off	
Possible Causes	**Explanation**
Blooming effect- which film on the powder coating surface, which can be wiped off	Change powder coating formula Increase curing temperature
Insufficient air circulation in the oven	Increase air circulation
Contamination on the surface because of incompatible powder coating from different manufactures	Use only powder coating from one Manufacture at the same time in an oven Consult powder the manufacturer
Powder coating not sufficiently cured	Observe curing parameters

5.3 Lifting of the powder coat layer:	
Possible causes	**Explanation**
Under or over coating of the powder coating film	Observe curing parameters
Insufficient/inappropriate parameter	Adjust pre-treatment to job at hand
Scale, surface rust on the work pieces	use “fresh” work piece or stone in dry environment; mechanical pre-treatment
Oxide layer on the work pieces, white rust on zinc plating	Use suitable pre-treatment materials Use mechanical pre-treatment
Film thickness too high	Reduce film thickness or use more

5.4 Poor impact Resistance / poor flexibility:	
Possible causes	**Explanation**
Under curing of the powder coating film	Optimize curing parameters
Poor cleaning or pre-treatment	Check pre-treatment chemical and process
Film thickness too high	Optimize the thickness of film
Poor properties of powder coating material/resin	Consult with the powder supplier