

TROUBLE SHOOTING GUIDE FOR POWDER COATING



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1. SUBSTRATE PRETREATMENT 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, eg. 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 pretreatment should impart uniformity throughout all treated workpiece 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 pretreatment stage is essential in order to achieve the full potential of the powder coating.

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

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

Substrates - Steel, aluminium, copper, zinc alloys 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 alloys - With all zinc based substrates such as Zintec, Mazac and Galvanised Steel a suitable phosphate coating is recommended.

Porous castings and 'blast cleaned' surfaces - 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.

Oxide and scale removal - This can be achieved by mechanical scuffing, wire brushing or for larger 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 abrasives which took over from sand are now augmented by a whole range of ultra-fine abrasives, ranging from 600 mesh fused aluminous oxide (which is as fine as talcum powder), soft 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 $3-5\mu$, while with glass beads it would be $1-1.5\mu$.

Oil and grease removal - This is usually the first step in the preparation of metallic surfaces 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 workpiece 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. Thereafter this method will only spread the grease and for really effective cleaning the rags and solvent will have to be replaced frequently. If only loose dust is the contaminant, 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 workpiece is immersed in a tank of solvent and after withdrawal, when the solvent has evaporated, all oil and grease 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 redeposited 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.

Again, depending on the solvent used it can be a health or fire hazard. Neither the solvent wipe or solvent dip methods are recommended.

Solvent vapour degreasing - Using this technique the workpiece is suspended in the vapour of a chlorinated solvent such as trichlorethylene in a specially designed plant and the metal is degreased by the condensation of the vapour on its cold metal surface, which solubilises the oils 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 workpiece can be dipped into 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.

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

Alkali cleaners - Again the workpiece 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 is cheaper as higher operating temperatures (70-90°C) 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 can disperse the grease and oil by emulsifying them into the solution. Alternatively 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 contaminants. These cleaners often

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 cleaners suitable for light alloys, zinc, galvanised metal or aluminium which are all attacked by alkali.

Acid cleaning - Acid pickling using 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 care 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 if a conversion coating system does not follow on in sequence the work must be dried rapidly and effectively to prevent rusting of the surface.

Phosphating conversion coatings - The recognised pretreatment 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. It is therefore necessary to select a compromise between mechanical properties and corrosion resistance. High phosphate coating weights can give trouble with powder coatings in that crystal fracture can occur when the coating is subjected to locally applied mechanical forces, eg. bending or impact.

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

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

A fine 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 made by spray or dip. Chromate passivation is not usually necessary.

Iron phosphate coatings are 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, ie. alkali degrease, rinse, zinc phosphate, two water rinses.

It is essential that the workpiece after phosphating is powder coated as soon as possible after drying.

Pretreatment for zinc surfaces - A lightweight zinc phosphate coating is recommended. Generally electro-deposited zinc coatings present no pretreatment problems but hot dipped galvanised coating can affect adhesion. Increasing degree of spangle decreases adhesion characteristics.

Chromate conversion coatings - The main conversion coating for aluminium and its alloys 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 its 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 coatings or merely dried-on films with some reaction with the substrate but the advantages of needing no rinse are obvious.

Heavy-metal free pretreatments - The increasingly strict environmental standards in the developed world mean that there is a move away from heavymetal containing pretreatment, particularly chromate. Early chromate-free pretreatments had poor performance but more recently standards have improved with the first approvals 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 cautious as to what effluent they will accept.

Generally iron phosphate solutions can be passed to drain without treatment, zinc phosphate solutions usually have to be below a specified concentration level 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.

2. 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.

<i>Possible Causes</i>	<i>Explanation</i>
Powder level too low	Add powder to the normal level
Fluidizing air too 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	I. Manually loosen powder in hopper. II. Check compressed air for quality
Oil remnants in compressed air	Check filter in front of coating booth
Fluidizing plate clogged / defective	Clean plate or Exchange the plate

2.2 Clogging of the powder feed hoses:

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.

<i>Possible Causes</i>	<i>Explanation</i>
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 venturi or pump	Replace worn parts
Too fine powder	Decrease amount of reclaim to hopper Optimize virgin powder plus reclaim ratio
Feed hose too long	Minimize feed hose length

2.3 Poor attraction of the powder to the component:

The powder coating, which should electrostatically 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 hangers
Worn venturi 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 pretreatment

2.4 Poor Wrapping:

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

Possible Causes	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 power 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
Powder flow too high	Adjust equipment controls to suit the parts
Poor grounding	Check and improved grounding
Insufficient charging of powder / defective gun	Adjust voltage, contact equipment manufacturer
Incorrect spray pattern / spray too wide	Try different spray nozzle
Too high voltage	Reduce voltage, so that surfaces closest to the gun do not repel powder
Poor gun placement	Adjust gun position to enter more directly into recessed area
Powder too fine	Reduce ratio of 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	I. Reduce powder feed to gun II. Increase distance between gun and c Component
Coating time too long	Lower the coating time
Unfavorable 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	I. Set correct powder feed pressure II. Check if powder venturi 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	Remove 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 hopper	Check minimum indicator

2.8 appearance looks uneven and broken before curing:

Possible Causes	Explanation
Back ionisation	I. Reduce voltage II. Check if grounding points are clean III. Reduce deposition rate, and film thickness IV. Ensure no moisture is entering the system V. Move gun further away from component

**2.9 Powder dusting out of hopper:
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	I. Decrease amount of reclaim to hopper II. Check ratio of virgin powder

3. SURFACE DEFECTS:

3.1 Powder puffs on the work piece:

Powder puffs are powder clusters 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 too 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 falls 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 craters:

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

Possible Causes	Explanation
Insufficient pretreatment (e.g. oil and grease residues)	Test pretreatment if necessary, contact pretreatment supplier
Rust, white rust on parts	Assure clean surface, apply recommended pretreatment
Incompatibility with powder coatings 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 air.
Deposits from dust and particles in the oven	I. Do not cure other colour at the same time II. Reduce air speed.
Deposits of dust and powder on cured object	Dust free cooling zones, avoid drafts.

3.6 Blistering:

Elevations 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 pretreatment
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 pretreatment, final rinse stage

3.7 Poor Adhesion:

Possible Causes	Explanation
Under cure film	I. Increase oven temperature II. 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 powder 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
Pretreatment residues	Final rinse de-ionised water
Displaced oils or greases in pretreatment excessive film build	Pretreatment, Check oil separator
Gummed oils, greases or separating compounds, insoluble extrusion oils	Check pretreatment or change, use different extrusion oils or separating

3.10 Gloss too High:

Possible Causes	Explanation
Cure temperature too low	I. Increase air temp. and metal temperature II. Decrease line speed
Oven cycle too short	I. Decrease line speed II. Increase oven temperature

3.11 Gloss too Low:

Possible Causes	Explanation
Oven temperature too high	I. Reduce air temp. and check metal temp. II. Increase line speed
Time in oven too long	I. Increase line speed II. 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 Colour difference:

Continuous or suddenly appearing changes in color or 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 colours	Use substrates of same type for comparisons
Film thickness too thin	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
Colour deviations due to curing technique or oven atmosphere	Use suitable powder coatings, 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	Optimise film thickness

4.3 Insufficient Coverage:

Possible Causes	Explanation
Film thickness too low	Assure appropriate film thickness
Film thickness varies greatly from part to part	Optimise system parameters
Differing materials and material colours	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	Observe curing parameter of powder coating manufacturer
Oil, grease, extrusion oils, dust on the surface	Optimize pretreatment
Differing materials and material colours	Insufficient pretreatment
Incompatible pretreatment and powder coating	Adjust pretreatment 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 - white 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 coatings from different manufacturers	Use only powder coatings from one manufacturer at the same time in an oven Consult powder manufacturer
Powder coating not sufficiently cured	Observe curing parameters

5.3 Lifting of the powder coat layer:

Possible Causes	Explanation
Under or over curing of the powder coating film	Observe curing parameters
Insufficient/inappropriate pretreatment	Adjust pretreatment to job at hand
Scale, surface rust on the work pieces	Use "fresh" work pieces or store in dry environment; mechanical pretreatment
Oxide layer on the work pieces, white rust on zinc plating	Use suitable pretreatment materials Use mechanical pretreatment
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 pretreatment	Check pretreatment chemical and process
Film Thickness too high	Optimize the thickness of film
Poor Properties of powder coating material / resin	Consult with the powder supplier

