TIGER Drylac® Powder Coatings

FAQs

Frequently asked questions

Tips & Tricks for TIGER Drylac® Powder Coating

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Tips & Tricks for TIGER Drylac® Powder Coating

Dear valued Clients,

The technology of powder coating in terms of application as well as the actual paints has seen rapid advancements, a development that requires experience and knowledge to keep on pace. This knowledge has become an essential "commodity" within the company. In the future, "knowledge" as a coefficient of productivity inherent in every product, service and the structures and processes of the company, will surpass the significance of "work" and "capital", the traditional factors in productivity.

Having to apply knowledge accumulated throughout the years, experiences gathered and effects of learning curves has become a new and sophisticated challenge for businesses. Against the backdrop of intensive regional and global competitive structures in the field of industrial surface finishing, employees with their expert knowledge of their particular coating system and the special features of a broad range of different paint systems represent a crucial competitive edge.

Thus, this manual entitled "Tips & Tricks for TIGER Drylac® Powder Coating" represents of our efforts to catalog the treasure trove of experiences we gathered throughout the years in the field of Powder Coating Technology and make it available to you in condensed form.

It includes many of the potential causes for errors for coaters working on the system as well as the multitude of detailed questions - from A like Application to Z like Zinc.

We believe this manual provides valuable support for your production process and project planning and look forward to continuing our cooperation as partners.

Your TIGER team

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1. Pretreatment as a cause for errors

TIGER Coatings does not produce pretreatment chemicals. Consequently, the following explanations for pretreatment of the most common substrates are intended to provide a brief overview of potential causes for errors. It goes without saying that this topic has to be addressed in a more thorough and differentiated way. However, the principle below applies every time: The best and most expensive powder coating cannot make up for sound pretreatment!

1.1 Chromating of aluminum, zinc and magnesium

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Rinse water beading** • **Substrate not completely wet**	• Inadequate degreasing effect *Fig. 1.1.1*	• Increase temperature of degreasing bath • Increase concentration of degreasing agent • Extend process times • Increase spraying action or circulation speed in immersion bath • Wetting check with distilled water
• **Conversion layer (chromating) uneven or spotty** *Fig. 1.1.2*	• Degreasing effect not adequate	• Increase temperature in degreasing zone • Increase chemical concentrations • Extend exposure times • Increase mech. spray action or • circulation in immersion bath
	• Oxide layers not removed completely	• Check pickling solution • Increase concentration of acid or lye, if applicable • Increase temperatures of baths • Extend exposure time
	• Drying between individual baths	• Reduce transfer times in immersion systems • Risers and spray nozzles
	• Delay of pretreatment *Fig. 1.1.3*	• Change suspension • Avoid stopping the conveyor
• **Conversion layer (chromating) not firmly adhering and/or cannot be wiped of**	• Composition of bath not in order	• Correct composition of bath • Possibly a new batch
	• Exposure time too long	• Reduce treatment time
	• Rinsing baths excessively loaded	• Increase dripping time between baths • Increase rinse water volume
	• Spray action not adequate	• Increase mechanical impact (Poor impengment – increase pressure) • Increased circulation in immersion baths • Increase rinse times

Fig. 1.1.1 Poor (no) chromating

Fig. 1.1.2 Spotty chromating

Fig. 1.1.3 Potential transfer of pretreatment media

1.2 Chromium-free pretreatment for aluminum and magnesium

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Rinse water beading – (poor water break)** • **Substrate not completely wet**	• Inadequate degreasing effect	• Increase temperature of degreasing bath • Increase concentration of degreasing agent • Extend process times • Increase spraying action or circulation speed in immersion bath
• **Powder-coating film detaches during boiling water test.** • **Powder-coating film detaches from substrate when exposed to humidity.** • **Generally poor mechanical adhesion of the paint film**	• Degreasing effect not adequate	• Improve degreasing process
	• Pickle rate not adequate	• Ensure higher pickle rate

	• Conversion layer not thick enough and revealed selectively only
	Fig. 1.1.4
		• Check the entire pretreatment
		  • Degreasing
		  • Pickling
		  • Processing times

	• Conversion layer too thick and therefore brittle *Fig. 1.1.5*	• Determine thickness of conversion layer as exactly as possible (photometric methods / x-ray fluorescence analysis)

Fig. 1.1.4 Conversion layer not thick enough.

Fig. 1.1.5 Conversion too thick

1.3 Phosphate-coating steel and galvanized steel

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Conversion layer (phosphate-coating) not continuous** • **Uneven or spotty** • **Rinse water is beading and not completely wetting the surface**	• Temperature of degreasing bath too low	• Increase temperature
	• Retention time in degreasing system too short *Fig. 1.3.1*	• Increase retention time
	• Degreasing effect not strong enough *Fig. 1.3.2*	• Addition of degreasing boosters
	• Floating grease	• Skimming grease, if necessary
	• Degreasing bath depleted	• Prepare a new bath
	• Degreasing chemicals not suitable *Fig. 1.3.3*	• Use of a more suitable degreasing system, if necessary
	• Plant-related errors	• Check nozzle alignment and correct, if necessary • Clean clogged nozzles • Optimize part orientations • Improve position of surfaces • Ensure downtimes between baths are reduced • Inadequate drying *Fig. 1.3.4*
• **Conversion layer (phosphate-coating) too thick** • **Dusty film**	• Treatment times too long	• Adjust treatment times
	• Accelerator volume too high	• Comply with specified bath composition
• **Corrosion on substrate** *Fig. 1.3.5; 1.3.6; 1.3.7*	• Conveyor standstill • Chemicals become tacky	

Fig. 1.3.1 Grease residues after pretreatment

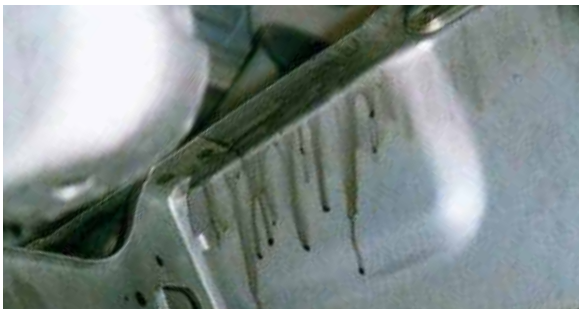


Fig. 1.3.2 Deep-drawing lubricants resistant to pretreatment

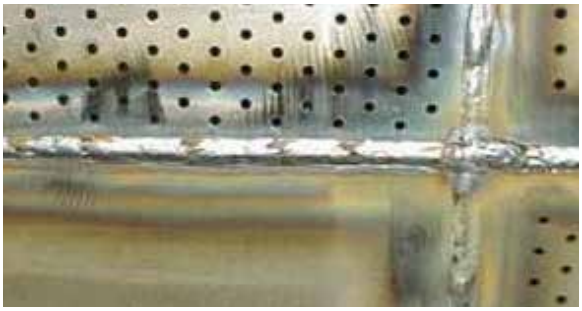


Fig. 1.3.3 Carbon due to welding work

Fig. 1.3.4 Poor rinsing, subsequently stored wet

Fig. 1.3.5 Corrosion due to Fe-phosphate coating on sandblasted workpieces

Fig. 1.3.6 Corrosion of sandblasted workpieces after pretreatment

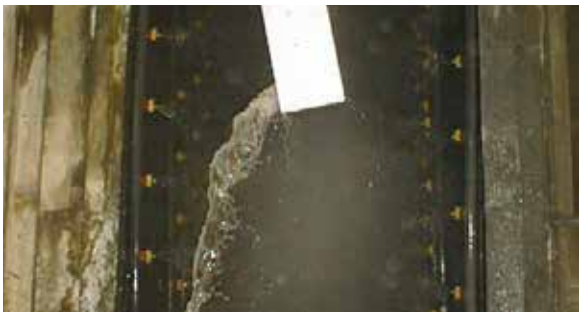


Fig. 1.3.7 Potential transfer of pretreatment media

2. Application process

2.1 Inadequate fluidization

Powder in fluidization hopper - simmer Insufficient fluidization can be recognized by a sluggish and discontinuous transfer of the powder coating from the reservoir to the spray guns; there is no formation of an even powder cloud. Surging & spitting of powder

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder coating is not "flowing" in the reservoir** *Fig. 2.1.1* • **Formation of small craters in the reservoir** *Fig. 2.1.2* • **Uneven powder cloud** *Fig. 2.1.3*	• Not enough fluidization air	• Air volume increase
	• Fluidized bed defective	• Replace fluidized bed
	• Fluidized bed clogged	• Clean fluidized
	• Powder too fine (reclaiming) • High overspray ratio	• Add fresh powder • Replace powder coating, if necessary
	• Moisture in powder	• Store powder dry and at room temperature
	• Powder coating heavily compacted already in carton	• Screen the powder coating • Do not keep box vibrators working in continuous operation
	• Ambient temperatures in coating plant too high	• Aerate • Cool down • Structural measures, if necessary
	• Powder coating ground too finely	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• No or not enough fluid additive in powder coating	• Contact TIGER Coatings (customer-service@tiger-coatings.com)

Fig. 2.1.1 Fluidization - powder must flow like water

Fig. 2.1.2 Poor fluidization

Fig. 2.1.3 Poor fluidization; powder volume too large

2.2 Sintering in injectors, hoses and spray guns

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder coating sintering in injectors, hoses and spray guns** • **Sintering dislodge and result in contamination of the powder coating**	• Conveying air too high *Fig. 2.2.1*	• Reduce pressure
	• Moisture present in air supply – water, oil	• Check cryogenic dryer and air filter
	• Inefficient routing of hose, tight radii	• Optimize routing of hose
	• Fine particle ratio of powder coating too high *Fig. 2.2.2*	• Reclaim ratio suggested – 70% virgin 30% reclaim • Contact TIGER Coatings about grinding, if necessary (customer-service@tiger-coatings.com) • Check screen analysis
	• Material not suitable for catch nozzles (glass, polyamide)	• Use catch nozzles made of Teflon, if possible
	• Catch nozzles ground out, therefore increased air pressure required	• Replace catch nozzles
	• Unsuitable hose material *Fig. 2.2.3* • Unsuitable hose diameter	• Contact plant manufacturer • Adjust material and diameter of hose
	• Room temperatures and atmospheric humidity in coating plant too high	• Cool, dehumidify ambient temperature • Structural measures, if necessary
	• Powder coating does not include an adequate volume of fluid additive and/or unsuitable fluid additive	• Contact TIGER Coatings (customer-service@tiger-coatings.com) • Add suitable fluid additive to the mixture, if necessary

Fig. 2.2.1 Sintering on flat spray nozzle

Fig. 2.2.2 Sintering on impact mill

Fig. 2.2.5 Unsuitable hose material

2.3 Powder coating trickling off the part

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder coating fails to separate or adequately separate from the part** • **Powder coating trickling off the part** • **Complete powder layer or a part thereof slides off the part** *Fig. 2.3.1, 2.3.2*	• No or insufficient grounding *Fig. 2.3.3, 2.3.4*	• Measure electrical resistance between part and ground/mass • Improve grounding, if necessary
	• Voltage too low or interrupted	• Spray gun (cascade), high voltage, check cable
	• Particle size distribution, powder coating too fine	• Regular addition of fresh powder coating, if necessary contact powder manufacturer regarding grinding
	• Particle size distribution, powder coating too coarse	• Contact powder manufacturer regarding particle size
	• Severe vibrations during transport of powder-coated parts	• Make sure that there is as little vibration as possible while the workpieces are transported
	• Layer thickness too high *Fig. 2.3.5*	• Reduce layer thickness
	• Conveying and secondary air resulting in blow-off effects	• Reduction of air volumes
	• Powder output per spray gun too high	• Reduce powder volume
	• Not enough space between spray gun and workpiece • Blow-off effects	• Increase space
	• Faraday areas	• Optimize suspension and positioning, if possible • Change design

Fig. 2.3.1 Parts of the powder layer slip off

Fig. 2.3.2 Powder layer slips off entirely

Fig. 2.3.3 No grounding or inefficient grounding

Fig. 2.3.4 Experiment with additional grounding

Fig. 2.3.5 Powder layer too thick

2.4 Insufficient wrap-around

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Absence of powder on the rear in case of one-sided spray gun arrangement**	• Powder output too low or too high	• Optimize powder output
	• Insufficient grounding of workpiece	• Check grounding and optimize, if necessary
	• Spray gun air too high or too low	• Select air setting as per spray gun manufacturer's specifications
	• Particle size of powder coating not suitable	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Spray gun voltage too low	• Increase voltage
	• Insufficient charge of powder coating	• Optimize current and voltage settings
	• Incorrect positioning of workpieces *Fig. 2.4.1*	• Optimize positioning of workpieces, if possible
	• Spray gun defective	• Maintenance service, contact spray gun manufacturer

Fig. 2.4.1 Incorrect positioning of workpieces

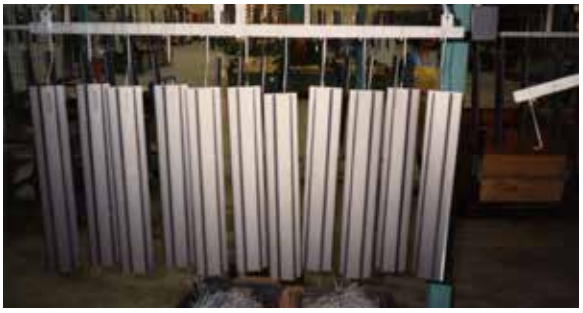


Fig. 2.4.2 Incorrect positioning of workpieces

2.5 Clumping in carton

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Clumping of powder coating in carton** *Fig. 2.5.1*	• Improper storage • Ambient temperatures in storage area too high • Product stored too long	• Ensure that storage conditions are suitable • Screen powder coating prior to processing • Perform requalification checks (checking flow and mechanical properties)
	• Moisture in powder coating	• Ensure dry transport and storage conditions
	• Extended transport • Ambient temperatures during transport too high	• Screen prior to use • Perform requalification checks • If necessary, contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Powder coating ground too finely	• Contact powder manufacturer
	• No or not enough fluid additive in powder coating	• Contact powder manufacturer

Fig. 2.5.1 Clumping in carton

2.6 Powder cloud pulsing, stops intermittently

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder cloud pulsing, stops intermittently**	• Inadequate fluidization	• See 2.1
	• Great hose lengths • Angular hose routing • Tight hose radii	• Hose lengths as short as possible • Great radii when routing hoses • Adjust hose diameter
	• Catch nozzles of injector frayed	• Renew catch nozzles
	• Powder pumps / Dense-phase conveying technology	• Perform service, contact device manufacturer

2.7 Insufficient ability to penetrate faraday areas

Despite the physical conditions (Faraday cage, ionized air), a particular minimum thickness must be achieved in corners and cavities for the most part. Poor penetration behavior is demonstrated by falling far short of possible powder penetration depths.

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder coating is poorly penetrating corners and cavities** *Fig. 2.7.1*	• Conveying air speeds too high resulting in blow-off effects	• Reduction of air speeds
	• Excessively high powder output per spray gun	• Reduction of powder output
	• Powder output per spray gun too low	• Increase of gun output
	• Spray gun nozzles not suitable	• Improved results mostly with flat spray nozzles
	• Insufficient charge of powder coating	• Increase current and voltage setting • Check the gun
	• Voltage and current too high	• Reduction of current and voltage settings
	• Faraday cage effect *Fig. 2.7.2*	• Use of triboelectric spray gun eliminates Faraday cage effect; insert corona spray gun deeper into the cavity

	• Grounding of workpieces not adequate	• Check grounding, optimize if necessary
	• Particle size of powder coating not suitable	• Conduct experiments with more coarse or finer grinding • Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Space between spray gun and workpiece too small or too large	• Optimize spacing
	• Ionized (charged) air in cavities	• Use of ion conductors • Test Supercorona, Coronastar

Fig. 2.7.1 Powder coating is poorly penetrating corners and cavities

Fig 2.7.2 Faraday cage effect

3. Surface imperfections

3.1 Powder splotches on workpieces

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder splotches are small powder accumulations on workpieces that when cured appear as hill-shaped bumps**	• Poor fluidization	• See 2.1
	• Powder hose too long • Diameter too large • Possibly Powder sedimentation in tight hose radii – (impact fusion)	• Optimize hose diameter • Shorten hose • Structural measures
	• Powder coating too fine due to reclaim operation	• Add fresh powder coating
	• Uneven powder delivery	• Check compressed air for fluctuations
	• Sintering in hose, spray gun, nozzles *Fig. 3.1.2*	• See 2.2
	• Powder dropping off the goods carrier and/or conveyor	• Strip the paint off goods carriers (suspensions) and/or clean them • Check grounding

	• Powder dropping off the spray gun nozzles *Fig. 3.1.3*	• Increase nebulizer and/or rinsing air • Clean nozzles regularly
	• Powder dropping off other workpieces	• Check grounding
	• Catch nozzle frayed	• Check catch nozzles (order test mandrels from spray gun manufacturer) • Replace catch nozzles, if necessary
	• Spray gun nozzle defective	• Check nozzle • Renew, if necessary
	• Damp powder coating	• Ensure that powder is dry, store in dry location
	• Metallic pigment splotches *Fig. 3.1.1*	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Airborne particulates, dust in the coating hall	• Ensure cleanliness • Turbulence caused by draft, fork lifts, etc.

Fig. 3.1.1 Metallic pigment splotches

Fig. 3.1.2 Sintering in the spray gun

Fig. 3.1.3 Powder splotches due to deposits on spray guns

3.2 Craters

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Crater-shaped depressions up to several mm in diameter** • **Some of them extend down to the substrate** *Fig. 3.2.1*	• Insufficient pretreatment, e.g. grease and oil residues	• Check pretreatment • Contact chemical supplier, if necessary
	• Chemical residues • Pretreatment NOK	• Check pretreatment • Contact chemical supplier, if necessary
	• Corrosion residues • Rust, white rust on workpieces *Fig. 3.2.2, 3.2.3, 3.2.4*	• Ensure that surfaces are free of corrosion • Grind or blast, if necessary
	• Oil in compressed air	• Check compressed air filter and cryogenic dryer
	• Silicone, welding spays • Greasy hand cream *Fig. 3.2.5, 3.2.6*	• Avoid using such substances in the entire coating area
	• Incompatibility with other powder coatings, such as acrylate powder coating	• Clean coating plant thoroughly • Check compatibility with other powder coatings in advance by adding small volumes
	• Outgassing from workpiece (casting materials, zinc layers)	• Use of powder coatings optimized for outgassing • Addition of outgassing additives • Tempering workpieces • Hot coating, if necessary
	• Ambient air contaminated, e.g. from welding sprays	• Check plant for contaminated materials and remove them
	• Workpiece still damp	• Optimize the time and temperature for drying
	• Wet paint and powder coatings in the same plant	• Check compatibility of individual paints • Process them at different times, if necessary • Structural changes in the plant
	• Applying a coat on putty	• Thoroughly dry putty • Temper, if necessary • Check that putty is suitable
	• Applying coats to surfaces painted with wet paints	• Check that wet-paint coats are suitable for applying powder coatings
	• Substrate was cleaned with slow-acting volatile solvents	• Allow to dry • Temper, if necessary

	• Substrates sandblasted too coarsely *Fig. 3.2.7*	• Use finer blasting material • Measure peak-to-valley surface roughness - profile
	• Spray-back effects, dielectric breakdowns	• Reduce current and voltage settings • Check grounding • Use ion conductor systems (Supercorona, Coronastar), if necessary • Check use of triboelectric spray guns
	• Craters in case of rough-texture powder coatings	• Increase layer thickness • Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Craters on hot-dipped galvanized parts	• Use AGF powder coatings • Tempering • Zinc layer too thick
	• Defect in substrate *Fig. 3.2.8, 3.2.9*	• Fill with putty

Fig. 3.2.1

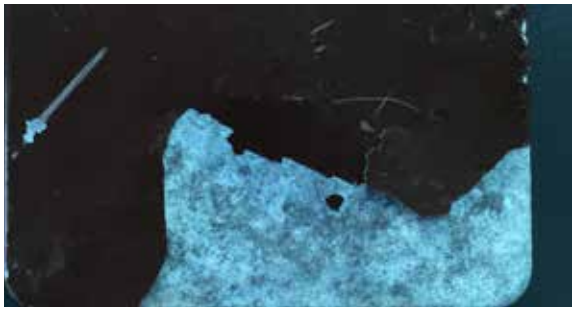


Fig. 3.2.2 White rust on workpieces

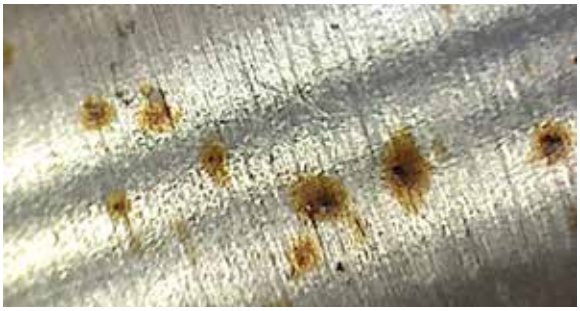


Fig. 3.2.3 Rust on workpieces

Fig. 3.2.4 Craters in powder coating film due to corrosion

Fig. 3.2.5 Fingerprint under a clear coat

Fig. 3.2.6 Fingerprint with hand cream

Fig. 3.2.7 Poor rinsing sandblasted, e-coat as base

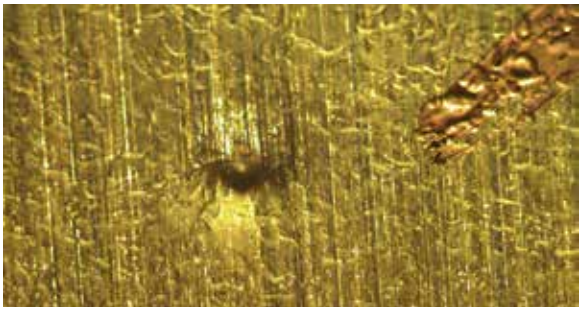


Fig. 3.2.8 Defect in substrate

Fig. 3.2.9

3.3 Pinholes

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Pinhole-shaped pores, up to 1 mm in diameter**	• Excessively high powder coating layers, especially with primide-curing polyester powder coatings due to poly-condensation	• Reduce layer thickness
	• Object temperatures too high when curing	• Avoid object temperatures >200°C
	• Highly porous workpieces	• Ensure workpieces are perfect (cast) • Avoid excessive peak-to-valley surface roughness (pretreatment of surface with sandblasting)
	• Outgassing from porous substrates (cast components)	• Use powder coatings optimized for outgassing • Add outgassing additive • Tempering • Hot coating
	• With rough-texture powder coatings only pinholes and craters instead of formation of texture	• Increase layer thickness
	• Lack of compatibility between powder coatings	• Clean plant thoroughly • Contact powder coating supplier, if necessary
	• Pre-reacted powder coatings	• Observe the defaults regarding duration and temperature of storage • Perform requalification check, if necessary
	• Moisture content of powder too high	• Store in dry conditions • Avoid switching between extremely cold and warm temperatures

3.4 Picture Frame Effect

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Greater powder-coating layer thickness at the edge of the workpiece, resulting in unevenly smooth flow and in visible differences between surface and edge area** *Fig. 3.4.1, 3.4.2, 3.4.3*	• Powder wrap-around from opposite side	• Reduce layer thickness on secondary exposed surfaces
	• Voltage setting too high	• Try reducing it to 30-50 kV
	• Current setting too high	• Try reducing it to 5-10 µA • Use ion conductor systems (Coronastar, Supercorona), if necessary
	• Space between spray gun and workpiece too large or too small	• Reduce, optimize spacing
	• Particle size of powder coating too rough and/or not ideal for application	• Contact powder coating manufacturer
	• On occasion with the use of ion conductors (Supercorona, Coronastar)	• Try removing ion conductors

Fig. 3.4.1

Fig. 3.4.2

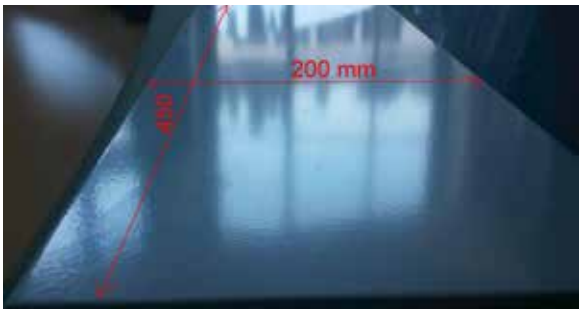


Fig. 3.4.3

3.5 Bumps, inclusions (other colors), impurities

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Contamination embedded in the powder-coating film**	• Impurities from conveyor, transport chain, etc.	• Thorough cleaning of plant, possibly "roofing" individual goods carriers
	• Contamination of paint surface from dirt raised outside the coating booth (room air, floor, grinding jobs, blasting plant, etc.) *Fig. 3.5.1*	• Shield/encase coating booth • Avoid high air speeds in hall • Avoid tasks that generate dirt (grinding, blasting) in coating hall
	• Fibers, lint from cleaning rags and work clothing *Fig. 3.5.2*	• Use cleaning rags and work clothing that are lint-free
	• Pre-reacted powder coating • Powder pinholes • Extruder pinholes *Fig. 3.5.3*	• Screen, if necessary • Use new carton • Contact powder coating manufacturer
	• Inadequately finished weld seams • Metal shavings, beads of weld metal, aluminum die pick-ups, rolling defects *Fig. 3.5.4*	• Check production process • Improve grinding or cleaning process, if necessary
	• Input of dirt when cleaning the plant	• When cleaning the booth with compressed air, powder coating should not be dispersed in the hall
	• Blow-off effects from workpiece at furnace opening resulting in contamination of differently colored workpieces	• Reduction of air speeds in the area of the furnace entry • Separate the area of the furnace entry, if necessary • Pre-gelling zone
	• Sintering of powder particles and dust when removing the workpieces from the furnace while they are still hot	• Create dust-free conditions in the removal area
	• Transfer of powder dust when coating booths are situated in close proximity *Fig. 3.5.5*	• Check suction capacity of booths, clean carefully • Separate spaces, if necessary
	• Contaminations when storing the powder coating *Fig. 3.5.6*	• Ensure proper storage • Always close powder bags • Close cartons, store by type

	• Inadequately cleaned spray guns and hoses (especially problematic with rough-texture powder coatings)	• Thorough cleaning • Use different hoses for different shades, if necessary
	• Dirt particles from curing furnace	• Clean oven from time to time • Check use of dirt absorption films
	• Pretreatment residues	• Ensure perfect pretreatment
	• Gel particles in powder coating *Fig. 3.5.7*	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Rust particles in powder coating	• Lack of pretreatment
	• Deficient hot-dip galvanizing *Fig. 3.5.8*	• Ensure improved quality, clean zinc-coating

Fig. 3.5.1 Contamination of paint surface from grinding jobs

Fig. 3.5.2 Fibers, lint from cleaning rags and work clothing

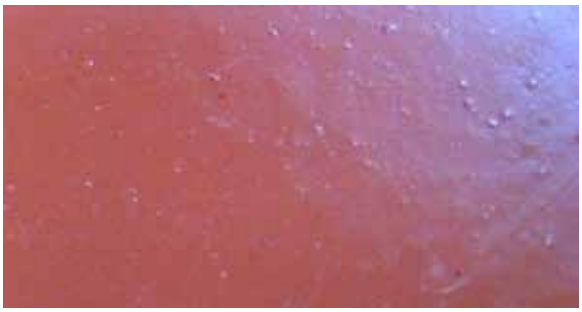


Fig. 3.5.3 Powder pinholes

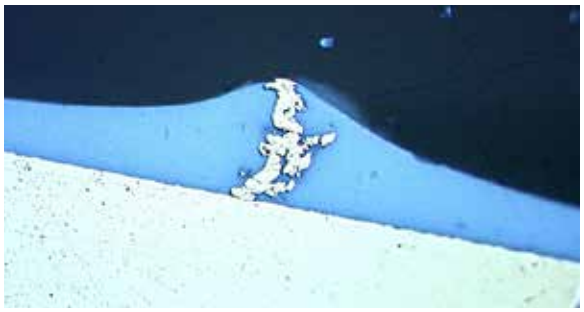


Fig. 3.5.4 Shavings in coat

Fig. 3.5.5 Transfer of powder dust - situated too closely together

Fig. 3.5.6 Contamination when storing powder coating

Fig. 3.5.7 Gel particles in powder coating

Fig. 3.5.8. Deficient hot-dip galvanizing

3.6 Blisters

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Blisters of varying sizes on the painted surface**	• Remnants of water on the workpiece	• Optimize the time and temperature for drying • Modify suspension of parts, if necessary
	• Water in scooping workpieces	• Change suspension • Drill holes for drainage • Optimize drying
	• Corrosion, grease and oil residues	• Optimize pretreatment
	• Top-coating	• Ensure perfect substrate
	• Placing a top-coat on wet paint layers	• Check suitability of wet paint layer for applying powder coating
	• Applying a coat on putty	• Drying or tempering of putty • Check that putty is suitable for powder coating
	• Salt residues or remnants of chemicals • Malfunction in wetting	• Check pretreatment • Avoid chain stoppages in pretreatment • Ensure adequate rinsing
	• Very high layer thickness, e.g. due to powder having trickled off in corner s of workpiece	• Check application settings • Carefully blow any powder coating that trickled off out of the corners
	• Outgassing from substrate material (casting materials, zinc layers)	• Tempering • Addition of outgassing additives (AGA)

3.7 Formation of drops and beads

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Heavy formation of beads or even drops on the workpiece**	• Layer thickness too high *Fig. 3.7.1*	• Reduce layer thickness
	• Heat-up rate of workpieces extremely fast or very slow (effect depends on reactivity and viscosity of powder coating)	• Optimize oven settings • Contact powder coating supplier, if necessary
	• Unsuitable powder coating (viscosity and/or reactivity too low)	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Powder coating accumulations in corners due to powder that trickled off *Fig. 3.7.2*	• Optimize application (grounding, charge, spray-gun air)
	• Workpiece temperatures too high during coating, therefore layer thickness that is too high	• Allow workpieces to cool off below 40°C • When using hot-coating, apply powder coating sparingly
	• Powder coating accumulations at the border and edges	• See 3.4 Picture-frame effect

Fig. 3.7.1 Layer thickness too high

Fig. 3.7.2 Powder-coating accumulation in corners due to powder that trickled off

3.8 Orange peel, poor flow

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Poor flow** • **Uneven surface** • **Orange peel-like surface**	• Work pieces heating up too slowly	• Determine heat-up rate of workpieces by means of measuring object temperature • Adjust furnace temperatures
	• Highly reactive powder coatings - powder coating in liquid phase very briefly	• Lower curing temperatures • If necessary, contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Back-spray effects / dielectric breakdowns (charging the powder coating too much will result in dielectric breakdowns)	• Reduce voltage and/or electric charge (µA) • Increase distance between workpiece and spray gun • Check use of ion conductors (Supercorona/ Coronastar)
	• Layer thickness too high or too low	• Keep layer thickness within the range of 60-120µm, if possible
	• Powder coating pre-reacted, is over-stocked	• Check powder coating at usual layer thickness and curing conditions • Reject, if necessary
	• Particle size not suitable	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Textured surfaces of workpieces; the flow is predetermined by the substrate surface	• Pay attention of workpiece surface

3.9 Malfunction in wetting

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Large areas of discontinuity that fail to exhibit a paint film** *Fig. 3.8.1*	• Gummy oil, grease or release agent • Insoluble drawing agents	• Check pretreatment • Optimize pretreatment, if necessary • Using other drawing agents
	• Pretreatment residues	• Ensure adequate rinsing
	• Displaced oil/grease in pretreatment	• Check and/or optimize pretreatment and oil separation
	• Charging problems or powder coating discharged too quickly • If the powder coating is not charged enough, it will not adhere sufficiently to the work pieces • If the powder coating is discharged too rapidly, it will lose its capacity for adhesion after some time	• Check grounding, increase current and voltage settings • Contact powder coating supplier, if necessary

	• Contamination of workpieces due to hand sweat, contaminated gloves, hand cream, etc. *Fig. 3.8.2*	• Do not touch pretreated workpieces with your bare hands or contaminated gloves
	• Dried workpieces in pretreatment	• Avoid chain standstill

Fig. 3.8.1 Large areas of discontinuity that fail to exhibit a paint film

Fig. 3.8.2 Contamination due to hand sweat, hand cream, ...

3.10 Formation of bubbles

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **bubbling powder layer coming to a boil** • **In practice, only primide-curing polyester powder coatings are affected**	• Layer thickness too high, >120µm for the most part	• Reduction of layer thickness
	• Accumulation of powder coating trickled off in workpieces	• Ensure proper charge • Parts should be transported with as little vibration as possible • Suction powder accumulations carefully, of necessary
	• Excessively high object temperatures during the curing process	• Avoid object temperatures >200°C when bubbling occurs
	• Parts to be coated heat up extremely quickly	• Adjust curing conditions

4. Deviations in the surface of the powder-coating film

4.1 Deviations in shade

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Continuous or sudden changes in shade compared to master samples or the start of the coating process**	• Considerable fluctuation in layer thickness *Fig. 4.1.1*	• Ensure that layer thickness is as even as possible
	• Overcuring of powder coating, especially of paints with organic pigments (bright red, orange, yellow and violet shades)	• Avoid object curing temperatures >200°C and retention times in the furnace • Comply with the defaults of TIGER Coatings
	• Different curing conditions with identical workpieces	• Ensure that the curing conditions are the same • Avoid conveyor standstill
	• Fluctuations in shades due to furnace technology (gas oven with direct/indirect heat, infrared ovens, forced-air ovens)	• Use suitable powder coatings • Determine deviations from shade in advance with testing
	• Paint films that are too thin and do not cover *Fig. 4.1.2*	• Comply with manufacturer data for minimum layer thickness
	• Different curing conditions on a workpiece because the thickness of the material varies greatly	• Avoid higher recirculation air temperatures 180-190°C • Ensure adequate curing by extending the retention times in the furnace
	• Different suppliers and/ or powder coating manufacturers	• Always use paint from one manufacturer for one project
	• Inadequate of incorrect pigmentation of powder coatings	• Contact TIGER Coatings (customer-service@ tiger-coatings.com)
	• Different substrates and their natural colors (black steel, aluminum, brass)	• For comparison, use the same substrates
	• Pronounced rough textures (inadequate coverage of substrate in the texture's valleys)	• Increase layer thickness • Select a different type of powder coating, if necessary
	• Metamerism, deviations in shade due to different light sources (sunlight, light bulbs, fluorescent strip lights)	• Evaluate coated parts with a defined light source (mostly daylight); otherwise it will be necessary to define the subsequent location where the parts are used and that location's light source.

	• Different surfaces and reflectivity of the substrate (ground, sandblasted, chromated)	• For comparison, use the same substrates as well
	• Powder delivery directly from the carton (applies only to metallic powder coatings)	• Use fluid container

Fig. 4.1.1 Different color due to varying layer thickness

Fig. 4.1.2 Paint films that are too thin and do not cover

4.2 Clouding

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Unequal light to dark and/or matte to glossy impression on the workpiece**	• Not enough space between spray gun and workpiece	• Increase space
	• Sine curves of the individual spray guns fail to pass over the workpieces evenly	• Synchronize speed of lift and chain (special calculation programs are available • contact spray gun manufacturer)
	• Uneven powder delivery	• Check fluidization, lengths and routing of hose • Check injector, compressed air and fluid container
	• Subsequent manual coating	• Manual pre coating rather than subsequent manual coating
	• Uneven powder charge	• Check voltage and electric charge of spray guns
	• Layer thickness fluctuates significantly (especially with matte powder coatings)	• Ensure that layer thickness is as even as possible
	• Separation resulting from reclaiming (especially with matte powder coatings)	• Ensure consistent ratio of fresh and reclaimed powder

4.3 Lack of covering power

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Insufficient coverage of substrate by paint layer**	• Layer thickness too low	• Increase layer thickness
	• Layer thickness fluctuates significantly	• Ensure that layer thickness is as even as possible
	• Different substrates and natural colors (steel, aluminum, brass)	• Increase layer thickness until it reaches its full capacity for coverage
	• Pigmentation of powder coating not adequate or incorrect	• Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Incorrect ratio of lift to chain speed (uneven distances of sine curves in automatic booths)	• Synchronize speed of lift and chain
	• Different surfaces and reflectivity of the substrate	• Perform comparisons on identical substrates only • Increase layer thickness until it reaches its full capacity for coverage, if necessary

4.4 Deviations in gloss rate

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Deviations and/or fluctuations from specified gloss rate**	• Curing conditions that are too high or too low	• Observe the manufacturer's specifications
	• Pinholes (especially with primide-curing polyester paints)	• Observe targets for maximum layer thickness and max. curing temperatures with anodized material (compaction)
	• Layer thickness too high or too low	• Pay attention to defaults
	• Incompatibility with other powder coatings (dulling)	• Clean coating plant thoroughly
	• Gas furnaces with direct heat, infrared furnaces	• Tailor furnace conditions to powder coating • Use better suited powder coating, if necessary
	• Powder coating pre-reacted and/or is overlaid	• Check whether the powder coating still meets all requirements. • Reject, if necessary
	• Unsuitable cleaning agents on paint surface	• Follow the powder-coating manufacturer's recommendations for cleaning

	• Separation of 2K matte powders due to reclaiming operation	• Forgo reclaiming, if necessary
	• Sweating of paint additives (waxes, outgassing additives, etc.) *Fig. 4.4.1*	• Pay attention to furnace parameters • If necessary, contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Powder coating insufficiently dispersed • Lack of paint homogeneity	• Contact TIGER Coatings (customer-service@tiger-coatings.com)

Fig. 4.4.1 Blooming effect - sweating of paint additives

4.5 Yellowing, discoloration

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Yellowing, discoloration** *Fig. 4.5.1*	• Incorrect curing condition, mostly too high	• Comply with the defaults of TIGER Coatings
	• Powder coating not heat stabilized	• Use stabilized powder coatings • Contact TIGER Coatings
	• Gas furnaces with direct heat • IR curing furnaces	• Use powder coatings that are matched to these curing conditions
	• Liquid paint components, felt-tip pen, stamp colors, markers diffused into paint film *Fig. 4.5.1*	• Thoroughly remove residues prior to coating
	• Oils, solvents in furnace	• Ensure that the curing oven is clean!

Fig. 4.5.1 Yellowing, discoloration

4.6 Layer thickness too high

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Layer thickness created is too high by far**	• Powder output too high	• Reduce powder output
	• Coating time too long	• Reduce coating time
	• Workpieces too hot during coating, powder melts on the substrate immediately	• Avoid workpiece temperatures >40°C in booth
	• Disadvantageous shape of workpieces	• Optimize application • Modify orientation of work pieces, if necessary
	• Tribo application allows for significantly higher layer thickness than Corona application	• Be mindful of the peculiarities of the tribo application

4.7 Layer thickness too low

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Low layer thickness** • **Uneven flow** • **Poor covering power**	• Coating time too short	• Increase coating time
	• Powder output too low	• Increase powder output
	• Distance between spray gun and workpiece too great	• Reduce distance
	• Grounding not adequate	• Optimize grounding
	• Powder coating charge too week	• Increase current and voltage settings • Check spray guns
	• Particle size too fine (high overspray ratio, high ratio of reclaimed powder)	• If the ratio of fine powder continues to rise, pay attention to steady addition of fresh powder • Empty reservoir
	• Suction capacity/air speed in booth too high	• Contact plant engineer
	• Disadvantageous shape of workpieces	• Optimize suspension
	• Fluidization of powder coating not optimal	• Improve fluidization
	• Powder hose too long, diameter too large	• Optimize length and diameter

	• Changed powder exit due to sintering in spray guns, hoses, nozzles • Injector catch nozzles ground out	• Remove sintering • Check catch nozzles and renew, if necessary
	• Lack of power in powder container	• Refill powder coating • Check minimum probe
	• With multiple coats and/ or double coating, the first layer acts as insulation. Result: charge quantities on surface are too large	• Reduce current and high voltage settings • Increase distances from spray guns to parts • Check on use of an ion conductor system (Coronastar, Supercorona)

4.8 Layer thickness distribution uneven

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Greatly uneven layer thickness distribution on workpiece**	• Disadvantageous spray gun arrangement in automatic booth or incorrect ratio of chain and lift speed	• Determining the correct spray gun distances and also the ratio of lift and chain speeds using calculation programs (e.g. Gema, Wagner)
	• Insulating effect from initial coating	• Reduction of current and voltage settings • Increase distance between spray gun and workpiece • Use of ion conductor (Coronastar, Supercorona), if necessary
	• Heavily fluctuating ratio of fresh and reclaimed powder in reservoir	• Continuous and/or steady addition of fresh powder that is adjusted to the actual powder volume needed
	• Uneven powder delivery	• Checking fluidization (see 2.1), injectors (or powder pumps), as well as routing, lengths, diameters of hoses
	• Disadvantageous shape of workpieces (cavities, Faraday cage)	• See 2.7 (Insufficient ability to penetrate cavities)
	• Geometry of workpieces varies greatly	• Optimize spray gun and plant settings for the workpiece

4.9 Waxy coatings on surface

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Waxy coatings on surface that can be wiped off**	• Additives "sweat" from paint film	• Replace powder coating • Use suitable powder coating • Optimize curing conditions
	• Powder coating not cured	• Pay attention to curing conditions
	• Blooming effect, whitish coatings that can be wiped off resulting from long furnace retention times at low furnace temperatures of about 100-140°C (affects primarily colorful/dark polyester powder coatings) *Fig. 4.9.1*	• Increase of furnace temperatures
	• Insufficient air exchange in curing furnace	• Improvement of air exchange

Fig. 4.9.1 Blooming effect

5. Deficiencies in mechanical properties and chemical resistance

5.1 Inadequate mechanical properties and chemical resistance

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Nonconformity with required properties with respect to mechanical characteristics and chemical resistance**	• Powder coating not sufficiently cured *Fig. 5.1.1*	• Comply with the curing conditions of TIGER Coatings • Determine temperature curves on the individual work pieces, if necessary • Comply with data sheets
	• Unsuitable powder coating	• Request information about suitability of powder coating with respect to specific technical properties from TIGER Coatings (customer-service@tiger-coatings.com) or verify suitability on your own
	• Faulty pretreatment, unsuitable pretreatment	• Check suitability and execution of pretreatment

Fig. 5.1.1 Not sufficiently resistant to cleaning agents

5.2 Chipping of paint film

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder coating layer chipping when part is subjected to mechanical impact (blow, deformation)**	• Under-curing or heavily over-curing will downgrade the mechanical properties *Fig. 5.2.1*	• Comply with specified curing conditions
	• Pretreatment unsuitable or insufficient *Fig. 5.2.2*	• Check pretreatment • Optimize, if necessary (see 1.1 and 1.2)
	• Scale, flash rust, white rust, dust on the workpiece *Fig. 5.2.3*	• Remove corrosion products with mechanical means prior to coating

	• No adhesion on laser-cut edges due to oxide film (applies only to oxygen laser, not to nitrogen laser	• Remove oxide layers by mechanical means, if necessary • Use nitrogen laser
	• Powder coating properties are not tailored to the application	• Use suitable powder coatings • If necessary, contact TIGER Coatings (customer-service@tiger-coatings.com)
	• High powder coating layers dramatically downgrade the mechanical properties	• Keep layer thickness at <100µm, if possible
	• No or poor adhesion of intermediate layer (e.g. to primer) *Fig. 5.2.4*	• Check intermediate layer adhesion between two paints in advance • Sand down first layer, if necessary • Especially in gas ovens with direct heat
	• No adhesion of powder coating to wet paint layers (e-coat, wet paint primer)	• Check suitability in advance • Sand down, if necessary
	• Break in zinc, conversion or primer layer	• Tailor pretreatment and substrate to powder coating
	• Contaminated workpieces	• Ensure that workpieces are clean

Fig. 5.2.1 Deteriorated mechanical properties

Fig. 5.2.2 Pretreatment unsuitable or insufficient

Fig. 5.2.3 Scale, flash rust, white rust

Fig. 5.2.4 No or poor inter-coat adhesion

5.3 Inadequate scratch resistance

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Poor resistance of paint film to scratching**	• Powder coating not adequate cured	• Comply with specified curing conditions
	• Powder coating too soft and/or sensitive to scratching	• Use suitable powder coating • Contact powder coating manufacturer
	• Packaging and/or shipping containers not suitable *Fig. 5.3.1*	• Use suitable packaging material or shipping containers *Fig. 5.3.2*
	• Incorrect and/or abrasive cleaning agents	• Use suitable cleaning agents

Fig. 5.3.1 Packaging material not suitable

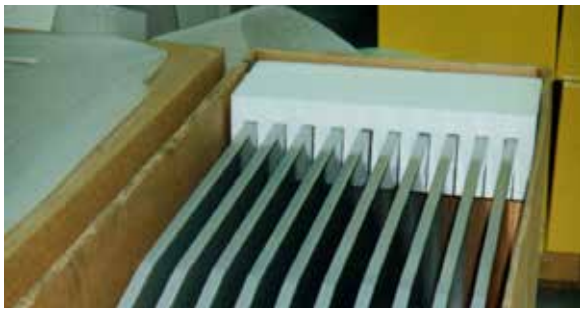


Fig. 5.3.2 Use suitable packaging material

6. Special features with applications that include reclaiming

6.1 Contaminations on paint surface (addition to section 3.5)

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Reclaiming causes contaminations of the paint surface from powder or foreign particles**	• Powder remnant or dirt in coating booth, the cyclone separator or on the filter *Fig. 6.1.1*	• Clean plant thoroughly
	• Powder remnant in application devices • Powder sintering from injector, hose or spray gun	• Clean application devices thoroughly • Several hoses for different shades, if necessary
	• End filter defective, powder is blown into the room	• Check end filter
	• Potential transfer of powder from one booth to another *Fig. 6.1.2*	• Clean booths carefully and without excessively high air pressure • If necessary, separate booths by using structural means

Fig. 6.1.1 Powder remnant or dirt in coating booth

Fig. 6.1.2 Potential transfer of powder from one booth to another – cross contamination

6.2 Poor processing properties

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Continually or suddenly deteriorating ability to process the powder coating**	• Changes in particle size due to reclaiming	• Optimize cyclone settings • Ensure that the ratio of fresh and reclaimed powder remains consistent • Make sure to avoid overspray (hanging tightly, no gaps) • Ensure even removal of overspray from booth

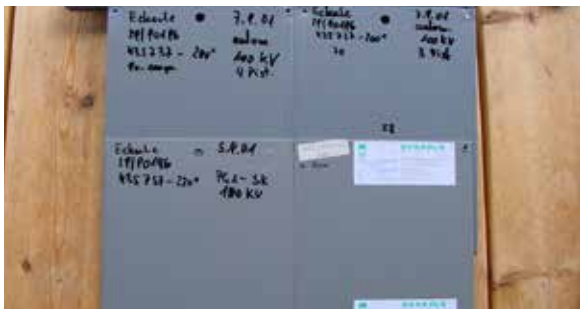
6.3 Continuous changes in shade

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Continuous or sudden changes in shade compared to master samples or the start of the coating process**	• Separation and/or changes in particle size due to reclaim operation	• Ensure that the ratio of fresh and reclaimed powder remains consistent
	• Powder remnant in the plant	• Clean booth thoroughly before start-up of new production
	• When delivering the powder from the box, consistent mixing of fresh and reclaimed powder is not ensured	• Use fluid container
	• Powder transfer from one booth to another due to different suction systems	• Ensure structural separation
	• Reclaimed powder is not added consistently	• Ensure consistent ratio of fresh and reclaimed powder

7. Peculiarities with applications that include metallic powder coatings

7.1 Deviations in shade from color chart or master sample

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Result of coating not identical to original or to sample of color/effect**	• Some of the different application techniques (tribo, corona application or use of ion conductor systems greatly impact the shade/effect	• Always use the same application technology for long-term projects and coatings related to an object • Always compare to the original (regularly)
	• Different current, voltage, air settings and distances between spray gun and work piece that vary greatly	• Always use the identical application parameters for long-term projects and coatings related to an object
	• Fluctuations in powder coating batch *Fig. 7.1.1*	• If possible, use only one batch for object-related orders • Contact TIGER Coatings (customer-service@tiger-coatings.com)
	• Defective spray guns	• Check the spray guns for current and voltage
	• Inadequate grounding	• Ensure consistently sound grounding
	• Color sample or color chart fails to match the powder coating used from the outset *Fig. 7.1.1*	• Use only samples that were actually produced from the powder coating
	• Layer thickness too low	• Comply with the minimum layer thickness specified by TIGER Coatings



7.1.1 Sample fails to match the powder coating from the outset

7.2 Fluctuations in shade during the coating process

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Creeping or sudden changes in shade or effect**	• Powder delivery from box	• Use fluid container
	• Separation of base powder coating and metallic pigments during application	• Use the same application devices • Avoid high mechanical loads, high air speeds in hoses, hours-long fluidization (without powder consumption) of the powder
	• Separation of base powder coating and metallic pigments due to reclaim operation *Fig. 7.2.1*	• Ensure that there is a consistent ratio of fresh and reclaimed powder • If necessary, forgo recovery in case of very stringent requirements for consistency of shade • Use only very well bonded powder coatings
	• Change of batches during the coating process *Fig. 7.2.2*	• Use only the same batch for closed sales orders
	• Insufficient bonding of powder coating	• Contact TIGER Coatings (customer-service@tiger-coatings.com)

Fig. 7.2.1 Separation due to reclaiming

Fig. 7.2.2 Switching batches during coating process

7.3 Clouding and streak formation

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Light-dark deviations on work pieces** *Fig. 7.3.1*	• Spray gun distances to workpieces too short	• Increase distances, >40cm are sufficient for the most part
	• Distances of the sine curves of individual spray guns uneven	• Determining the correct spray gun distances and also the ratio of lift and chain speeds using calculation programs (e.g. Gema, Wagner)
	• Uneven powder delivery	• Check fluidization, injectors as well as lengths, routing and diameter of hose.

	• Subsequent manual coating	• With metallic powder coatings, if possible, apply only pretreatment coat manually
	• Electric charge on individual spray guns uneven • Spray guns may be defective	• Verification of actual quantities of current and of voltage
	• Insufficient grounding of work pieces	• Ensure consistently sound grounding of all work pieces
	• Thickness of layers fluctuates greatly	• Ensure compliance with minimum layer thicknesses specified
	• Powder delivery from box	• Use fluid container
	• Spray gun nozzles not suitable	• Mostly good results with flat-spray nozzles with very difficult metallic powder coatings • Use impact disc nozzles, if necessary
	• Air speeds from spray gun too high • Powder cloud that is too hard and directional	• Ensure that the powder cloud is as soft and even as possible • High air speeds are to be avoided

Fig. 7.3.1 Light-dark deviations on workpieces

7.4 Charging problems

Fault Profile	Potential Causes	Elimination | Experiments | Measures
• **Powder is trickling from the workpiece or slides off the workpiece from large areas**	• Grounding not adequate, especially with particularly dry air in winter	• Ensure consistently sound grounding
	• Powder coating is not adequately charged by the spray guns	• Check spray guns, experiment with high current and voltage settings, remove ion conductor systems (Coronastar, Supercorona), contact powder manufacturer, if necessary
	• Powder coating "discharges" much too quickly on the workpiece and loses adhesion	• Contact powder manufacturer

7.5 Processing guidelines for powder coatings with metallic effect

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Metallic Pulverbeschichtungen

Verarbeitungsrichtlinien für Pulverlacke mit Metallic-Effekt
Merkblatt 36

Dieses Merkblatt soll für den Anwender eine Hilfestellung beim Beschichten sein und darüber hinaus über jene Verarbeitungsparameter informieren, die einen wesentlichen Einfluss auf das Beschichtungsergebnis haben. Bei der Verarbeitung von Pulverlacken mit Metallic-Effekt ist besondere Vorsicht angebracht. Vor der Anwendung ist die Eignung der gesamten Beschichtungsanlage durch Vergleich mit dem Referenzmuster des Pulverlackherstellers zu überprüfen. Andernfalls kann keine Gewähr für den Farbton und den Metallic-Effekt gegeben werden. Um ein zufriedenstellendes Ergebnis zu erreichen, müssen die nachfolgenden Empfehlungen beachtet werden:

FARBTON-ABWEICHUNG

Pulverbeschichtungen werden nach definierten Farbstandards, z.B. RAL rezeptiert und hergestellt. Trotz sorgfältigster Arbeitsweise sind Farbton- bzw. Effektunterschiede **verschiedener Chargen** nicht vermeidbar. Zur genauen Beurteilung des Farbtones bzw. Effektes einer bestimmten Ch arge werden vom Hersteller über Anfrage Musterbleche zur Verfügung gestellt. Die vom Lieferanten bedingten Farbtonunterschiede zwischen verschiedenen Chargen von Metallic-Pulverlacken liegen in einer ähnlichen Größenordnung wie für Pulverlacke ohne Metalliceffekt. Der fertigungsbedingte Farbabstand zweier unterschiedlicher Pulverlack-Chargen kann – je nach Farbton – bei hellen Farbtönen bei ca. 1-2 ΔE, bei dunklen auch deutlich darüber liegen. In dieser Bewertung sind prozessbedingte Farbtonabweichungen beim Beschichter noch nicht enthalten. Die Bewertung der Abweichung nach KFZ-Maßstäben ist nicht zulässig. Der erzielte Farbton/Effekt hängt aber auch von der Beschichtungsanlage ab. Vor der Verarbeitung ist daher eine Eingangsprüfung auf der Beschichtungsanlage durchzuführen. Die durch die Anlage bedingten Farbton-/Effektunterschiede – insbesondere den **Anteil an Rückgewinnungspulver** betreffend – sind durch die Anfertigung von Grenzmustern zu bestimmen. Um die anlagenbedingten Farbton-/Effekt-Unterschiede möglichst gering zu halten, muß die gesamte Beschichtung auf der gleichen Anlage, möglichst ohne Unterbrechung, bei konstanten Anlagenparametern und bei konstantem Rückgewinnungsanteil (Richtwert: 30%) durchgeführt werden. Bei Handbeschichtungen ist, wegen ungleichmäßigem Pulverauftrag mit Farbton bzw. Effektschwankungen zu rechnen. **Handbeschichtungen** müssen daher mit dem Ergebnis der Beschichtung des Automaten abgestimmt werden. Auf gleichmäßige **Schichtdicke** ist zu achten: Zu große Differenzen verursachen Farbton-/Effekt- und Glanzgrad-Unterschiede. Zur Vermeidung von Oberflächenstörungen (z.B. Stippen), die durch die entsprechende Größe der effektgebenden Pigmente (z.B. Spearkling-Effekte) bei dünneren Schichten entstehen können, **wird eine Schichtdicke von zumindest 70 bis 90µm empfohlen**. Im Zweifelsfall **ist der Vertrieb des Pulverlackherstellers zu kontaktieren**.
Die Ursache der Farbton- und Effektempfindlichkeit von Metallic-Pulverlacken kann vor allem mit dem Gehalt an Metallicpigment erklärt werden. Das Metallicpigment wird überwiegend in Form feiner Blättchen eingesetzt. Der Metalliceffekt, aber auch der Farbton hängen von der Orientierung dieser Blättchen in der Lackschicht ab. Wie die Erfahrung zeigt, haben alle **Verarbeitungsparameter** einen Einfluss auf die Lage der Metallicblättchen und damit auf den Farbton und den Effekt der Lackschicht. Bei Metallic-Pulverlacken muß daher besonders darauf geachtet werden, dass beim Bearbeiten einer bestimmten Kommission keine Änderungen an der Anlage – welcher Art auch immer – vorgenommen werden. Das Beschichten auf verschiedenen Anlagen ist zu vermeiden, und wenn, dann nur nach genauer Abstimmung und Anpassung der Ergebnisse zulässig. Inwieweit auch durch die spezielle Teilegeometrie Farbtonabweichungen zu erwarten sind, muss durch gezielte Versuche ermittelt werden.

RÜCKGEWINNUNG

Um einen gleichmäßigen Farbton / Effekt zu erreichen, ist die **Frischpulver-Zudosierung** vom Beschichter festzulegen und gleichmäßig während der ganzen Fertigung einzuhalten, sollte aber 70% nicht unterschreiten. Mehrmaliger oder ausschließlicher Einsatz von Rückgewinnungspulver ist nicht zulässig. Da nicht alle Metallic-Pulverlacke gleich rückgewinnungsstabil sind, ist der Frischpulverprozentsatz zusätzlich über **Farbton-/Effekt-Grenzmuster** festzulegen. Die **Ausgangskontrolle** auf Farbtontreue ist dennoch unabdingbar.

BESCHICHTUNGS-ANLAGE

Unterschiedliche **Pistolentypen, Anlagen und Sprühparameter** sind oft für ein unterschiedliches Ergebnis verantwortlich. Es ist daher darauf zu achten, daß nur mit Pistolenmundstücken gearbeitet wird, die für Metallic-Pulverlacke empfohlen werden. Je nach Art des zu beschichtenden Objektes sollten Flachstrahl- bzw. belüftete Prallteller eingesetzt und mit gleichmäßiger Pulverwolke gearbeitet werden. Die **Erdung** und die **Aufladung** der Pulverwolke sind regelmäßig zu kontrollieren. In die regelmäßige Prozessüberwachung fallen auch die **Zwischenreinigung** der Pulverschläuche und das Entfernen von Ablagerungen auf Pistolensprühkegeln und in Kabinen. Die Metallic-Beschichtung sollte ausschließlich aus **fluidisierten Behältern** erfolgen. Da Metallic-Beschichtungen sensibler auf unterschiedlichen Rückgewinnungsanteil reagieren, sollte die Beschichtung schon von Anfang an mit ca. 30% Rückgewinnungspulver (anfängliches Beschichten ohne Teile) erfolgen.

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AUFLADUNG

Grundsätzlich sind nur wenige Metallic-Pulverlacke **tribostatisch** versprühbar. Die entsprechende Eignung muß vor der eigentlichen Verarbeitung auf der Beschichtungsanlage geprüft werden. Wegen der unterschiedlichen Aufladefähigkeit von Pulverlack und Metallicteilchen werden nicht alle Metallicpartikel zum Beschichtungsobjekt transportiert. Auch daraus kann eine Verschiebung des Farbtones/Effektes resultieren. Der Wechsel von elektrostatischer zu tribostatischer Aufladung ist nicht zulässig. Bei Metallic-Pulverlacken ist auf besondere Reinheit der Anlage zu achten, um Sinterungen und dadurch ausgelöste Kurzschlüsse im Pistolenbereich zu vermeiden. Auf die Wichtigkeit der regelmäßigen Kontrolle der Aufladung der Pulver wolke wird noch einmal hingewiesen.

ERDUNG

Bei der Anwendung von Metallic-Pulverlacken ist darauf zu achten, dass die Pulversprühanlage und das Beschichtungsobjekt ausreichend geerdet sind. Diese Maßnahme trägt wesentlich zur **Konstanz** der **Farbton-/Effekt-Bildung** bei.

BESTÄNDIGKEIT

Grundsätzlich wird die Beständigkeit von der Verarbeitung – Einschicht- oder Zweischichtverfahren – bestimmt. Die Beständigkeit von Metallic-Pulverlacken ist **produktabhängig** und daher, bezogen auf den Anwendungsfall vom Hersteller zu erfragen, wobei auf spezielle Anforderungen wie z.B. Abrieb und Kratzfestigkeit, Art der Reinigung, Farbtonstabilität und chemische Beständigkeit hinzuweisen ist. Eine effektive Beratung durch den Hersteller bedingt genaueste **Kenntnis aller Belastungen**, denen die Pulverbeschichtung im Einsatz ausgesetzt wird. Dazu zählen alle Stoffe mit denen die Beschichtung bei der Montage in Kontakt kommen wird, wie z.B. auch Einglasungshilfsmittel. Werden Stoffe eingesetzt, deren chemischer Einfluss nicht bekannt ist, sind nach Rücksprache mit dem Beschichtungsstoffhersteller Versuche durchzuführen. Im Bedarfsfall kann daher eine farblose Überbeschichtung notwendig werden, um Einflüsse, die zu einer Farbton bzw. Effektverschiebung führen können von der Lackoberfläche (Metallic-Teilchen) fernzuhalten. Bei der Anwendung von 2-Schicht-Systemen sind die dafür gültigen Einbrennbedingungen zu beachten.

REINIGUNG

Die **Reinigung** von Metallic-Beschichtungen muss **regelmäßig** und ehebaldigst nach einer Verschmutzung erfolgen. Eingetrocknete, alte Verschmutzungen sind nur abrasiv, das bedeutet unter Verletzung (Verkratzung) von der Beschichtung zu entfernen. Die **Reinigungsempfehlungen** des Herstellers sind in jedem Fall zu beachten.

ALLGEMEINE HINWEISE

Schwierig zu beschichtende Teile sollten vorbeschichtet werden. Ein nachträgliches Ausbessern kann zu Wolkenbildung führen. Bei beidseitig zu beschichtenden Teilen sollte die Hauptansichtseite zuletzt beschichtet werden. Die **Lage** von Fassadenblechen ist vor der Beschichtung festzulegen – senkrecht oder waagrecht – und darf während des Beschichtens nicht mehr verändert werden. Unterschiedliche **Aufheizgeschwindigkeiten** sind zu vermeiden: **Dünn- und dickwandige** Teile dürfen nicht miteinander vermengt der Beschichtung zugeführt werden. Hinweise dazu im Pulverlack-Merkblatt sind zu beachten.

Der Einsatz von Metallic-Pulverlacken erfordert genaues Arbeiten. Alle Hinweise dieses Merkblattes müssen befolgt werden. Ganz besonders wichtig ist in diesem Zusammenhang der Informationsfluss zwischen Beschichter und Auftraggeber, aber auch zwischen Beschichter und Lackhersteller, damit alle Bedingungen für eine einwandfreie Beschichtung erfüllt werden.

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8. Glossary

Below is a brief explanation of the most important and common key words in the powder coating sector. Please note that these explanations are not scientific nor do they comply with the standards. Instead, they reflect the language commonly used in practice, with the focus on general understanding.

A

Ability to Penetrate
Ability of coating to get into corners, recesses and cavities

Abrasion resistance
Resistance of powder film to abrasive media, e.g. sand, liquid scouring cleaner, cardboard, wood, paper

Absolute Filter (superfine mesh filter)
Also final filters of coating plant for superfine particles not separated by the recycling process

Accumulations
Powder that does not adhere to the workpiece and/or does not enter the powder cycle but is left behind in the booth

Additives
Additions used in powder coating manufacturers aimed at optimizing the application or the powder coating film

Adhesion
Strength (quality) of bond (mechanical anchoring and/or chemical compound) at the interface of powder coating layer and workpiece surface

Adhesive Remnants
Residues that cannot be removed by pretreatment; result in surface imperfections and problems with adhesion

Adhesive Water Dryer
Furnace (chamber) for drying the workpieces coming from wet chemical pretreatment at 70 - 130 °C

Agglomerations
Sintering of powder in the delivery system, application technology or in recycling

AGA additive
(AGA = Outgassing arm) Additive to reduce the occurrence of outgassing in the powder coating film

Anodizing
Anodic oxidation of aluminum, also referred to as anodizing; as a pretreatment of aluminum without sealing the oxide layer

Anodic Oxidation
Surface finish for aluminum, creating a (colored) aluminum oxide film and its subsequent compaction (see anodizing)

Application
Technology, spray guns, charging device, injectors, hoses, etc. directly needed for powder coating

Atomizer Air
To support the spray cloud, also to prevent sintering at Corona needle and impact disc

Automatic System
Application in conjunction with automatic spray guns (arranged in fixed positions on lifting stand or robot)

B

Binding Agent
Primary component of powder coating, resins like epoxy, polyester, PUR or acrylic

Blisters
Bumps in powder coating film caused by drops of water, salt and/or oil residues, etc.

Blooming Effect
Formation of a white, waxy film on the powder-coated surface that can be wiped off; occurs in case of cross-linking in the lower temperature range

Booths
Cabinets fitted with technical equipment for coating (steel, stainless steel sheeting, plastic)

Bubbling
Outgassing of the actual powder, especially with very high layer thicknesses (starting at 150 µm; particularly TGIC-free and in IR furnaces)

Buchholz Hardness
Test procedure to determine the resistance of powder-coated surfaces to pointed loads; DIN 53 153

C

Cavities
Interior spaces that cannot be reached with powder coating (see Faraday cage), such as profile pipes, welded structures

Charge
Electrostatic charge of powder by means of Corona or Triboelectric charge

Chipping
Burnt-in powder flakes off the workpiece under mechanical loads (e.g. When creased, cut or milled)

Chalking
Degradation of resin and pigments being bleached by UV light or chemicals

Cleaning
Cleaning the plant when switching colors: a necessary evil of powder coating

Clot
See powder splotches

Clumping
Agglomeration of powder coating in carton due to vibration, inflow of water, Corona charge or heat

Coat
Floating additives on powder coating film, e.g. AGA additive

Color Deviation
Difference of the shade between original and sample (color chart to workpiece or workpiece I to workpiece II)

Color
Sensation transmitted through the eye which is triggered by light sources and light reflexes

Color Standard
Official color charts representing industry norms (RAL, NCS, Pantone, RAL-Design, Sikkens, HKS, British Standard, etc.)

Conveyor
Transport rail for transporting workpieces and suspension gear (manual sliding technology)

Conveying Air
Required air for transporting powder coating to the spray gun, increase conveying air = increased powder volume

Conveying Hose
For transporting the powder-air-mixture from powder container to the spray gun

Conveyor
Delivery facility for transporting workpieces through the coating plant, see also Conveyor

Conveyor standstill
Very costly stoppage of conveyor due to potential faulty coating (plant failure)

Contamination
See Dirt

Corona charge
See E-Static

Corona Charge
See Corona Charge

Corrosion
Reactions of a metallic material to its environment resulting in a measurable change to the material and functional impairment

Cracks
Surface imperfection of coating; cracking as a result of insufficient cross-linking after mechanical stress

Craters
Surface imperfection extending through the powder coating film down to the workpiece surface

Cross-linking
Irreversible chemical reaction of thermoset plastics

Curing
Complete cross-linking of the powder coating; process requires minimum temperature and minimum time

Cyclone
Facility to return overspray in the powder cycle; always needs a final filter (See Filter)

D

Deionized Rinse
Final pretreatment rinse with fully desalinated water (max. 30 µs)

Dense-Phase Conveying
Method for transporting powder to the coating plant

Distance I
Distance of spray gun to work piece

Distance II
Distance between workpieces

Dissolving partially
Softening the powder coating film with solvent

Dirt
Primarily contributes to a lower coating quality (dust, fibers, shavings)

Dosing Air
Supply air for controlling the powder volume in the spray gun; increase in dosing air will result in less powder coating and a less dense powder cloud

Drop Formation
Sagging of powder coating at the bottom edges in the liquid stage

Drawing Agent
Oils and grease used as lubricants when shaping (extruding, stretching) profiles

E

Edge Configuration
Powder accumulation at workpiece border

Edge Deposit
Accumulation of powder coating at edge of the workpiece (see Edge deposits)

Environmental Influences
Climate and environmental parameters existing in the coating room

E-Static
Electro-static charging of powder particles in the area of a Corona discharge; its high voltage is generated with a cascade in the spray gun or supplied to it via cable

F

Faraday Cage
Physical phenomenon, screening of electric fields in case of closed designs

Film Thickness
Thickness of powder-coated film

Final Filter
See Absolute Filter

Fineness
Area of grain distribution of powder coating (< 10 µm)

Filiform Corrosion
Thread-like formation of metal oxides (no Al_2O_3) on aluminum that appear as thin, clearly defined threads under the powder coating film

Film
Undesirable, veil-like surface coat

Filter
Used to separate the powder-air mixture (overspray) in suctioning (plate, bag or cartridge filter)

Fish Eyes
See cratering

Flow
Smoothness of powder coating film

Fluid Bed
Air-permeable sintering material in powder reservoir; the powder turns into fluid (fluidized) as a result of inflowing air (0.3 - 0.5 bar)

Fluidization
Fluidizing powder coating in the fluid hopper or powder container using compressed air

Freshwater Rinse
Rinse step within pretreatment for removing cleaning chemicals with tap water

Friction Charge
See Tribo

G

Galvanizing
Electrodeposition of corrosion protection layer (zinc) of approx. 5-15 µm from aqueous, acidic or alkaline zinc electrolytes

Application of a corrosion protection layer (Zn) on steel (hot-dip galvanizing, galvanizing or Sendzimir galvanizing)

Gel Particles
Uncooked resin particles in powder coating

Glass-transition temperature
Transition of powder coating into liquid phase

Gloss
Reflectivity of a surface, in case of powder coating glossy to flat matte

Grain size and/or spectrum
Distribution of powder particles by size and proportion

Grease Remnants
Residues on workpiece not removed by the pretreatment (wool grease, gummy grease, drawing lubricants, etc.)

Grounding
Contact of workpiece and system parts with (grid) ground

Ground
See Substrate

Gumming
Dried-up grease and oil residues

H

Heat-up Rate
Time needed to heat-up the object to the required temperature

Heating
...of adhesive water and powder dryer; direct/indirect gas and oil, electric, IR

High Voltage Discharges
Star-shaped surface tension craters caused by inadequate grounding

Hose
See Delivery Hose

Hot-Dip Galvanizing
Corrosion protection, application of zinc layer roughly 30 - 80 µm thick, using the dipping method at about 400 °C

I

Immersion Pretreatment
Pretreatment of workpieces, not always suitable with pronounced scooping parts

Injector
Venturi pump for powder delivery

Insulation of workpieces
Inadequate grounding caused by excessively high layers on workpiece or suspension gear

Incompatibility
Impairment of surface due to uncontrolled chemical reactions

Intercoat Adhesion
Adhesion between first and second coat

Ionization charge
See E-Static

M

Maintenance
Plant service that was never or rarely performed on at irregular intervals (also see Plant Service)

Material Selection (powder coating)
Powder coating suitable for the intended application (exterior and/or interior grades, effects, etc.)

Material selection (substrate)
Materials suitable for the intended application (steel, aluminum, glass, MDF)

Mechanical Values
Required powder coating properties (test acc. to DIN, e.g. mandrel bending or impact test, Erichsen cupping, etc.)

Metallic Pigments
Conductive and non-conductive effect particles in powder coating

Metallic powder coatings
Effect powder coatings with a surface that looks like shiny metal (pearl gloss, glitter, glimmer, etc.)

Metal shavings
Processing residues on workpieces (cutting, grinding, milling, drilling, etc.)

Metamerism
Effect of color science, difference in shade at various lighting scenarios

Moisture
Absolute water content in powder coating

Multiple Coats
Application of a second powder coating layer

N

Nozzles
Various attachments on the spray gun (impact discs, finger nozzles, round and flat spray nozzles)

O

Oil Carbon
Burnt oil or grease on the workpiece, with welding processes "burnt-in"

Oil Remnants
Residues on workpiece not removed by pretreatment

Opacity
Ability of the powder to completely cover the natural shade of a substrate with a reasonable minimum layer thickness

Orange Peel
Waviness (short or long) on powder-coated surface

Outgassing
Substrate ingredients escaping through the melting powder layer (water vapor, air, gases, etc.) and cause surface imperfections in the powder coating film

Overspray
Powder coating not taken up by the workpiece during application

Oven
See Powder Dryer

Oven Types
Differences in terms of design and heating, e.g. chamber furnace, continuous furnace, forced-air furnace, IR furnace (see also heating system, quality of gas)

Over-curing
Excessively high object temperatures in the curing oven

Oversized Particles
Powder particles larger than the mesh size of the screen that are separated during the screening process

Oxide Layer
Corrosion residues on workpiece

P

Paint Film
Desired formation of the surface of the cross-linked powder coating

Paint Adhesion
See Adhesion

Pickling Solution
Water-based cleaning method for metal removal that takes off oxide layers, rust, pressed-in contamination and foreign particles

Picture Frame Effect
Higher powder-coating layer thickness at the edges of the workpiece due to high field strength at edges, e.g. notable with fine-texture and metallic powder coatings

Pigments
Chromophoric substances in powder coating

Pimples
Bumps in powder-coated surface

Pinholes
Surface imperfection, formation of fine pores in powder coating film

Plant Service
Necessary upkeep of the plant to be performed regularly by the manufacturer

Plasticizer
Additives used for production of plastics

Pressure Points
Visible indentations in the powder coating film caused by excessive compressive loads, especially with high layer thickness

Pretreatment
Cleaning and conversion layer formation with wet chemical process (dipping, spraying) or with dry method, e.g. sandblasting

Propagating brush discharge
High-energy discharge of plastic surfaces which carry an electrical charge may ignite powder-air mixtures.

Polishing Marks
Mechanical surface treatment; may be detected through powder coating film

Powder
In this case powder coating, dry thermosetting plastics in form of dust

Powder Delivery
Transport of powder coating from reservoir to the spray gun

Powder Circulation
Transport of powder that was not applied by way of reclaiming for reuse (see overspray)

Powder Hose
See Delivery Hose

Powder Splotches
Agglomerates of powder coating on powder-coated surface

Powder Dryer
Facility needed for cross-linking and curing the powder coting film (see furnace types)

Powder Center
Compact device for delivering powder from container with integrated cleaning system

Powder Remnants I
Contaminated powder coating from reclaiming

Powder Remnant II
Powder coating in box or warehouse that cannot be used commercially any more

Q

Quality of Gas
Gas used for heating adhesive water and powder dryer (natural gas, city gas, butane, propane); the decisive factors are thermal value and composition

R

Reclaiming
Facilities for re-use of overspray

Release Agent
Sprays used in metal processing to reduce adhesion of sweat residues, those containing Silicon not suitable

Release Agent II
Liquid used in casting to reduce adhesion between casting and mold

Resistance
Consistent resistance as required, e.g. to chemicals, weather or UV light

Resistance to Solvents
Powder coating resistance to various solvents

Retraction Effect
See Wetting

Return Point
Top and bottom return point of spray guns with lift frames

Retention time
Time of coated workpieces in powder dryer

Rinsing
Removal of pretreatment residues using fresh or deionized water with spraying or dipping

Runs
Powder-coated film dripping over the workpiece (i.e. not purely wet-paint-specific)

Running Away
Retraction of powder layer from the edge of the workpiece, especially with workpieces having sharp edges (burr)

Rust
Corrosion products created as a result of corrosion or steel

S

Safety Regulations
The plant engineer and operator has to comply with domestic and European safety standards (see ZH 443 – 444, EN 50050, EN 50053, EN 50177, prEN 12891)

Screening Analysis
Determination of grain distribution (see Grain Size)

Screening Equipment
Screening the powder coating as part of reclaiming; can also be done separately (screen mesh at least 200 µm)

Screen Tear
Damage to the screen used to screen the powder coating; it may result in oversized particles getting into the powder and cause disruptions in the flow

Sensitivity to scratching
Resistance of powder-coated surface (see abrasion resistance)

Shade
Designation of color, see color standard

Short Circuit
Uncontrolled (current) contact between high voltage and ground

Snowboard Effect
Powder fails to adhere to the workpiece: it slides off in sheets, see also trickle-off effect

Sinusoidal Flow
Spray pattern with spray gun arrangement in lift frames influenced by conveyor and lift speed

Shavings
Fine, distracting particles from chipping and/or cutting production (metal, wood or plastic)

Spikes
See Pinholes

Splotches
Agglomerations of powder coating in powder coating film (see also attachment)

Spray Gun
Charging and spraying device needed to apply the powder coating (Corona charge / Tribo)

Spraying
Application of powder coating by means of spray guns onto workpiece

Spray Scrubber System
Pretreatment of workpieces via spraying method (approx. 1.5 bar), mechanical cleaning effect

Substrate
Workpiece, material to be coated (steel, aluminum, stainless steel, glass, plastic, MDF)

Subsurface Corrosion
Formation of corrosion due to humidity and salts (osmosis) between powder coating and part

Surface imperfections
Impairment of visual properties of the powder-coated film

Suspension Gear
For positioning workpieces during the coating process

Streak Formation
Uneven layer thickness with irregular sine curve

Sweeping
Sandblasting the work pieces, mechanical fine-grain removal of corrosion layers, especially from hot-dip galvanized parts, max. 30 µm surface roughness

T

Temperature Curve
Increase and decrease of object temperature during the cross-linking process in the furnace

Textures
Surface formation of surface, rough and/or fine texture

TGIC (Triglycidyl isocyanurate)
Hardener system for polyester powder used for many years (had to be identified as toxic since 1998)

TGIC-free
Alternative hardeners to previously used TGIC (Primid, PT910, PU)

Thermoplastic
Reversibly formable plastics can be liquefied and processed again when heated

Thermosetting Plastics
Irreversibly cross-linked plastics, cannot be re-shaped by heating

Tribo charge
Powder particles are positively charged via charge separation (PTFE rod or pipe) and transported to the object

Trickle off
Powder fails to adhere to the workpiece: it falls/trickles off; see also snowboard effect

U

Ultrasound Screen
Inserted for fresh and/or recycled powder coating when preparing the powder coating

Use of Adhesives
Very broad spectrum, check for suitability prior to use

V

Voltage
In this case: High voltage electricity needed for charging

W

Wall Thickness
Thickness of workpiece material

Wetting
Adhesion of powder coating on workpiece, prerequisite for adequate adhesion; requires suitable pretreatment

Weld Points
Surface treatment, may be visible through powder coating film; problem with oil carbon, especially if processed with an angle grinder

Workpieces
See Substrate

Wrap-around
Powder coating build-up on the back of the workpiece

Y

Yellowing
Change in shade due temperature that is too high, retention time that is too long and/or furnace atmosphere in gas furnace with direct heat

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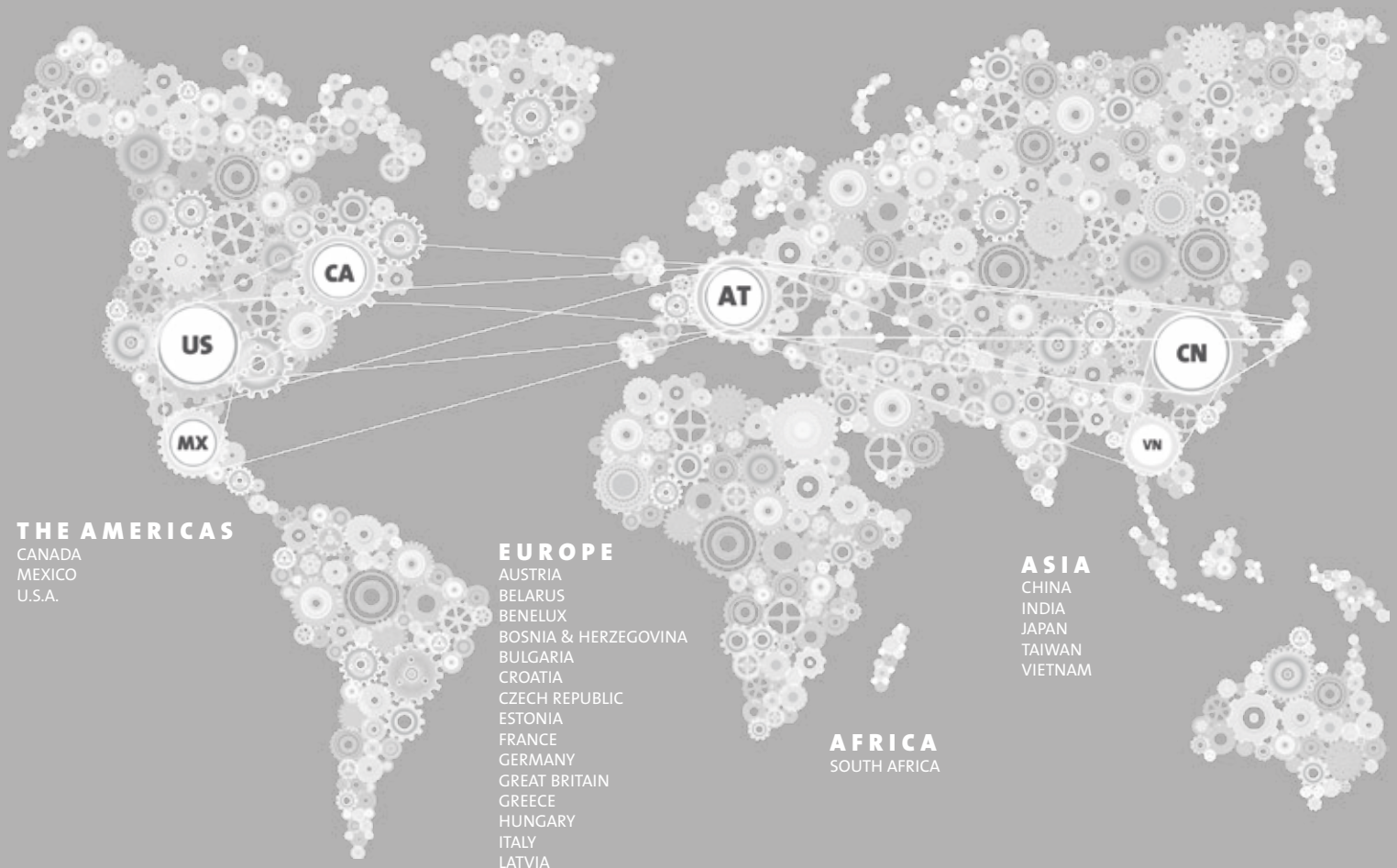

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