



Safe Handling Powder Coatings Guideline 9th Edition

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1. Introduction

Industrial thermosetting powder coatings are typically produced by blending and extruding together resins, curing agents, pigments and additives. The resultant matrix is ground into fine discrete particles. Such powders are applied to a substrate or workpiece via a pressurised spray application system, complete with electrostatic charging of the powder coating to charge the particles.

Application can be via either fully automated or manual systems, with the workpiece transported through a coating booth containing a number of guns and into a stoving oven via an overhead conveyor.

The total air volume to the spray gun varies between 2 – 4 Nm³/min. High-voltage charging (corona) works with voltages up to 100 kV and currents up to 100 µA. Frictional charging (tribo) results in currents up to 5 µA.

Systems are designed to minimise the amount of overspray. Excess powder is removed by exhaust extraction and collected for re-use or disposal.

From the information in this Guide relating to safe working procedures, it is clear that there is a lower level of hazard when using powder coatings compared to conventional solvent-based paints. Dust clouds in air require 50-100 times the energy necessary to ignite a solvent vapour/air mixture, and are therefore inherently more difficult to ignite. Also powder mixtures in air need to be above a certain concentration, known as the lower explosion limit (LEL) before ignition or explosion can occur.

However, certain hazards do exist when using powders depending on various factors. Precautions must be taken to avoid them, and these are referred to here as safe working procedures. If these are followed, any risk should be reduced to a minimum. Nevertheless, the aspects listed in this guide do not claim to be exhaustive; the information contained in the relevant laws, regulations, etc. must be given priority. It is possible that country-specific requirements other than those listed in this guide may apply.

The main hazards involved in the electrostatic application of powder coatings are:

- (i) Dust explosion and fire
- (ii) Electrical shock
- (iii) Exposure to hazardous substances
- (iv) Compressed air

2. Dust explosion and fire hazards

2.1 Causes

2.1.1 Powder coatings are powdery mixtures of substances, mainly of an organic nature, with a particle size distribution of 0 - 120 µm. Together with air, such products can form an explosive dust/air mixture. A dust explosion may occur when both:

(i) the concentration of dust in the air is between the Lower Explosive Limit (LEL) and Upper Explosion Limit (UEL).

and

(ii) a source of ignition of the required energy for the dust cloud is present. Such sources of ignition can include:

- (a) hot surfaces or flames
- (b) electrical discharges or sparks
- (c) electrostatic discharges

2.1.2 A fire may occur when a layer of deposited powder coating or a cloud comes into contact with an ignition source such as those listed in 2.1.1 (ii) above. A fire within the powder coating system may result in a dust explosion if either burning particles are allowed to enter confined sections of equipment, such as dust collectors, or if burning dust deposits are disturbed.

2.2 Prevention of powder dust explosion

2.2.1 An explosion can be prevented if both or either of the conditions shown in 2.1.1 are avoided. Powder coating systems should be designed to prevent both conditions occurring, but due to the difficulty of totally eliminating sources of ignition, more reliance should be placed on the prevention of explosive concentrations of powder. A method for determining the concentration of combustible powder coating with regard to the lower explosion limit is described in the European standard DIN EN 16985.

Appendix 1 describes how the concentration of the powder coating, which may be present in the spray booth, can be calculated.

- 2.2.2 The lower explosion limit of typical powder coatings calculated from the heating value in accordance with DIN EN ISO 8130-4 is between 20 g/m³ and 80 g/m³, depending on the specific chemical and physical properties.

In powder coating booths, the technical ventilation must be such that an average concentration of powder coating in the air of 50 % of the lower explosion limit is not exceeded. If there is no reliable value for the lower explosion limit, the mean concentration shall not exceed 10 g/m³.

According to DIN EN 16985, the "average concentration" is defined as the mass of the powder coatings used in the powder coating facility divided by the volume of air extracted during the same period by the technical ventilation system.

Calculation examples for determining the concentration of powder coatings in coating facilities are given in the appendix to the European standard DIN EN 16985.

- 2.2.3 The application unit should be clearly marked with the capacity of the extraction unit and the maximum number and capacity of the spray guns. The configuration of the unit and coating powder usage should be regularly checked against the stated values to ensure that airborne concentrations do not exceed the values listed under 2.2.2.
- 2.2.4 In compliance with the intervals specified by the manufacturer, a regular maintenance and cleaning schedule should be introduced to prevent accumulation and build-up of dusts. In the case of electrical equipment, build-up of dusts can result in their ignition through overheating. The maximum temperature of surfaces liable to be exposed to dust, shall not exceed 2/3 of the minimum ignition temperature (= lowest temperature of a hot surface where the most ignitable dust/air mixture is still ignited). Typical powder coatings usually have an ignition temperature of approx. 420-470 °C.
- 2.2.5 Safety instructions for the handling of powder coating fine dusts from final filters:

The recycling of the final filter dusts is strongly discouraged for safety reasons, unless risk assessments to mitigate explosion risks are processed. Due to the high fine particle content of dust from cyclone final filters, it is important to know the risk of ignition increases with increasing particle fineness.

Although some superfine clearcoats, especially acrylic- and epoxide-based, can have very low Minimum Ignition Energy (MIE) values (< 3mJ MIE), most powder coating fine dusts have a MIE of 3 mJ < MIE < 10 mJ.

- 2.2.6 The use of compressed air or dry brushing for cleaning up spills for cleaning down equipment should be avoided.

Preferred cleaning methods are the use of suitably designed industrial vacuum cleaners, or wet brushing.

- 2.2.7 Smoking should be strictly prohibited and all sources of ignition, such as matches and lighters, should be excluded.

- 2.2.8 The principles of avoiding the creation of dust clouds together with ignition sources are equally applicable to general handling as well as to cleaning and maintenance processes.

3. Electrical hazards

3.1 Causes

The main sources of electrical hazard are:

- (i) inadequate or defective earthing (grounding) systems leading to build-up of static and subsequent sparking or shock.
- (ii) breakdown or overheating of the electrical equipment leading to fire or shock.

3.2 Prevention

- 3.2.1 The contact between the workpiece, carrier jigs and conveyor should be designed and regularly tested to ensure an adequate earth is maintained at all times. Jigs should be designed to avoid any unnecessary build-up of coating. They should be cleaned on a regular basis to maintain correct contact.

Automatic cut-out or warning systems should be installed, wherever practicable, to constantly monitor the efficiency of the earthing system between the jig and the conveyor.

- 3.2.2 Metal objects to be coated should have a resistance to earth not exceeding $10^6 \Omega$ to ensure proper grounding and safety during the powder coating process.
- 3.2.3 Floors and other surfaces with which operators can make contact should be conductive and have a resistance not exceeding $10^6 \Omega$. Non-conductive materials can be coated with conductive floor compounds and coatings.
- 3.2.4 As an additional precaution, all components of the spraying facility should be connected together through an equipotential bonding system. This should include all electrical equipment enclosures, metal floors, ceilings, fences, partitions, and conveyors as well as the HV generator.
- 3.2.5 As an alternative to physical earthing of the workpiece, ionising devices can be used to discharge any accumulated electrostatic charges. The device should be sited as near as possible to the work piece.
- 3.2.6 Conveyors should be designed to minimise swinging of the work piece.
- 3.2.7 Regular maintenance and cleaning programmes should be introduced to ensure that dusts are not allowed to build up on electrical equipment and that ventilation ducts and cooling fins are kept clean and unobstructed.

- 3.2.8 Only the spray gun(s) and associated electrical cables and powder supply hoses should be sited inside the booth.

If the siting of other electrical equipment, including the HV generator, in the booth or adjacent areas is unavoidable, this equipment must meet the requirements of DIN EN 50050 (handguns) and DIN EN 50 177(automatic guns) and must be dust tight to Standard IPX.

- 3.2.9 Operatives should wear anti-static overalls, non-insulating gloves and anti-static footwear meeting the requirements of BS ISO 2023 and DIN EN ISO 20344.

- 3.3 All relevant EU directives, such as the Machinery Directive 2006/42/EC, the Low Voltage Directive 2014/35/EU, the ATEX Directive 2014/34/EU, the Electromagnetic Compatibility Directive 2014/30/EU, the Pressure Equipment Directive 2014/68/EU and the resulting laws, standards and regulations must also be followed. This is largely already achieved by the manufacturers of the corresponding electrical equipment. Their safety requirements must be followed.

4. Health Hazards

4.1 Causes

Health problems when handling or using a powder coating may arise through exposure to hazardous substances, which may be contained in the coatings, or to the powder coating itself.

4.2 Prevention

4.2.1 Implemented EU legislation requires that an employer carries out an assessment of the nature and extent of exposure to hazardous substances in the workplace and the measures necessary to prevent or control exposure.

4.2.2 As part of the assessment, reference should be made to the label on the package, the accompanying safety data sheet and other information provided by the supplier.

Coating powders are classified and labelled in accordance with the regulation on classification, labelling and packaging of substances and mixtures – CLP regulation. Coating powder manufacturers provide health and safety data in a standardised form based on the requirements of this regulation.

Due account should be taken of information given in the safety data sheet when carrying out the assessments. Information contained in these will include:

- (i) details and information on any hazardous substance
- (ii) guidance on health hazards associated with the product and substances
- (iii) guidance on occupational exposure limits
- (iv) advice on safe handling and use
- (v) advice on precautions necessary to avoid exposure

4.2.3 The following should also be borne in mind when carrying out the assessment:

- (i) Coating powders can create airborne dusts and these may present a health hazard. Where airborne concentrations of individual substances exceed, or are likely to exceed any exposure limit, as is mentioned in the national legislation or any in-house occupational exposure limit, action must be taken to prevent or control exposure.

4.2.4 Powder coatings containing PT 910/912

Classification and labelling of powder coatings containing PT 910/912

Concentration limit (% w/w)	Classification	Labelling		
		H Phrases	Danger symbol	Indication of danger
$\geq 1 \%$	Skin irritation, category 2	H315		Causes skin irritation
$\geq 3 \%$	Serious eye damage, category 1	H318		Causes serious eye damage
$\geq 1 \%$	Skin sensitization, category 1	H317		May cause an allergic skin reaction
$\geq 10 \%$	Specific target organ toxicity after repeated exposure, category 2, central nervous system	H373		May cause damage to organs through prolonged or repeated exposure if swallowed
$\geq 0,3 \%$	Reproductive Toxicity, category 1B	H360F		May damage fertility.
$\geq 2,5 \%$	Hazardous to the aquatic environment with long lasting effects, category 3	H412		Harmful to aquatic life with long lasting effects.

4.2.5 Measures which should be introduced to prevent or adequately control exposure include the following:

- (i) Installation of properly constructed spray booths with exhaust ventilation equipment to extract dust and maintain airborne concentrations below the occupational exposure limits valid in the various countries within the workplace.

Where manual application techniques are in use, the direction of the air flow should be from behind the operator, over the workpiece being coated and into the exhaust ducts. These should be situated as close to the workplace as possible.

The operation and effectiveness of extraction and ventilation systems should be inspected, tested and maintained in accordance with national legislation.

Allergy sufferer and people who have difficulty in breathing should not work in a powder coatings line.

- (ii) Installation and design of stoving ovens should be such that any by-products or volatile components are exhausted to a safe place and prevented from escaping or returning into the work area.

Ovens should be inspected, tested and maintained to ensure their operational effectiveness.

- (iii) Facilities for jig cleaning should, wherever possible, be fully contained systems, with exhausts properly ventilated to a safe place. Where this is not practicable, employees should be provided with appropriate personal protective clothing (PPE), including respiratory protective equipment (RPE) if necessary.
- (iv) All other stages in the handling of coating powders e.g. opening the packages, loading of hoppers, collection of unused powders should, wherever possible, be contained to prevent the escape of dust. Local exhaust ventilation and appropriate PPE should be provided in the event this is not practicable.
- (v) All employees involved in the handling of coating powders should be provided with anti-static coveralls designed to prevent ingress of the powder. Suitable gloves should be provided to minimise skin contact.

Where engineering controls are inappropriate or not possible for reducing exposure to the required levels, suitable RPE must be provided. Depending on the circumstances either dust respirators or air fed respiratory equipment will be required. In either case an adequate level of protection must be ensured.

- (VI) Eating, drinking and smoking should be strictly prohibited within the workplace.

4.2.6 Employees exposed to hazardous substances should be considered for health surveillance according to national legislation.

5. Environmental Hazards

5.1 Causes

Powder coatings meet the definition of Synthetic Polymer Microparticles (SPM) to the Reach restriction. The use and placement on the market of SPM is generally forbidden, unless the use is derogated from this ban. The use of SPM by Powder Coatings is derogated, because after curing, the particles have been permanently modified in such a way that SPM do no longer exist; the microparticles are transformed into a coating film on a substrate.

For such derogated uses legal obligations apply on information which must be provided through the supply chain to the end-user and there are reporting obligations for industrial users on the estimated releases of SPM to the environment. For such uses the annual releases to the environment have to be reported to the Chemicals Agency ECHA. Guidance on the reporting can be obtained from your supplier.

5.2 Prevention

For the safe use of Powder Coatings, by which emissions to the environment can be efficiently minimized, users can follow the advice in this document. Especially the sections 2.2 and 7 should be carefully read and followed.

Proper Hygiene rules must be followed during your uses. Always avoid the transfer of powders from the application room or booth to the other rooms. Keep doors closed during operation and use aids (e.g. sticky door mats) to avoid contamination from workers walking in and out the room after the application. Use room ventilation also during clean-up. It is a mandatory obligation for suppliers of powder coatings to provide Instructions for use and disposal (IFUD) to their industrial downstream users to minimize the emissions of SPM to the environment as much as possible. Additional information on IFUD will be found in the Safety Data Sheet.

As stated earlier, cured powder coating paint films are no longer SPM; however, during handling powder coatings process, emissions may be possible. So uncured and waste powder coatings material has to be handled with great care to avoid dusting. Waste handling has to comply with local and national waste regulations for hazardous materials and incineration of collected waste will be the preferred route.

When filters are cleaned or replaced, there is a high risk for spreading powder coatings in the air. Replacing the filters has to be done according to the instructions from the filter suppliers (or according to your own internal procedures) to avoid emissions of filtered particles into the air. Replaced filters have to be treated as hazardous waste.

Always use the appropriate type of filters for your uses. Your supplier will know which types to use.

6. Compressed Air

6.1 Causes

6.1.1 Compressed air can be dangerous in several ways:

- (i) it can enter the body via orifices such as the mouth, ears etc. causing internal injury.
- (ii) it can penetrate the skin causing embolisms.
- (iii) particles in the air stream can damage eyes.
- (iv) pressurised systems can explode with violent effect when ruptured or damaged.

6.2 Prevention

- 6.2.1 Compressed air should not be used for cleaning of clothing or skin.
- 6.2.2 The pressure system should be maintained in good repair and subject to periodic inspection.
- 6.2.3 Suitable and adequate instructions for the use of the pressure system are provided to any person operating it. The instructions must include the action to be taken in the event of an emergency.

7. Construction of Plant and Equipment

7.1 Full guidance

Full guidance is contained in the Standards DIN EN 16985 and DIN EN 50177 as well as in the ATEX Workplace directive 1999/92/ECC (addresses operators of plants in which explosive atmospheres may occur) or directive 2014/34/EU (addresses installers or distributors of plants in which explosive atmosphere may occur). Reference should be made to these before installation and operation of any powder coating plant and equipment.

7.2 The spraying facility

The spraying facility should be located taking the following into account:

- (i) provision of safe means of escape.
- (ii) ventilation of, and extraction from, the area.
- (iii) ready access for emergency services in the event of fire.

7.3 Spray Booths

- 7.3.1 The powder supply and coating powder feedlines should be interlocked with the air extraction system, so that, in the event of failure of the ventilation system, the coating powder and powder supplies are cut off. Airflow monitor switches are the preferred method of detecting failure of the ventilation system. Such equipment will also be sensitive to blocked filters and broken or loose fan blades.
- 7.3.2 A fire detecting device, interlocked to shut off powder and coating powder supplies and ventilation must be installed in the booth and coating powder processing areas as an additional precaution.
- 7.3.3 A flame detection device is recommended for cabins with automatic application and open recovery system. It should be sited inside the booth and be interlocked with the high voltage supply, the coating powder feed line and the fans in the extract system.

7.4 Stoving Ovens

- 7.4.1 The stoving oven should be situated at least 1m from the powder spraying installation and arranged so that powder cannot accumulate

or be spilled near to the oven, its air intakes, hot surfaces or any electrical apparatus. Air movement within the oven should not be so high as to blow off powder from the workpiece before fusion.

- 7.4.2 The clean air change requirements of the oven should be known and visibly marked on the oven.
- 7.4.3 For conveyor ovens and especially those using radiant heat sources, an interlock should be provided to significantly reduce or shut down the energy source if the conveyor stops, in order to prevent overheating and possible ignition of the coating powder or workpiece.
- 7.4.4 Gas- and oil-fired ovens should be provided with explosion relief panels which can operate effectively to prevent the pressure in the oven building up to dangerous levels in the event of a gas or fuel oil explosion. The explosion relief should be located so as not to discharge towards the powder spraying installation or into occupied areas.
- 7.4.5 Beware of hot surfaces! To protect against skin burns and to avoid contact with any viscous coating material, the regulations for personal protective equipment (PPE) should always be observed. PPE should consist of long working clothes and thermally insulated protective gloves. All accessories burnt in together with the coated components, such as hooks and product carriers, also pose a risk of burns when heated.
- 7.4.6 Condensates from the baking process leak permanently from the baking chamber, especially when the oven doors are opened. If possible, they should be removed technically.¹
- 7.4.7 Deposits on the inner oven walls and adjacent components must generally be removed at regular intervals. They may represent a considerable fire load. Suitable cleaning procedures must be selected depending on the size of the plant and the oven layout and may include dry ice blasting, removal with suitable solvents or gentle mechanical removal. When removing condensates, care must be taken to protect the skin and respiratory tract.
- 7.4.8 Burn-in systems should be regularly checked to ensure that the set temperature is reached and that the heat distribution within the baking chamber is as homogeneous as possible. A suitable method is the oven temperature measurement with several sensors, which should be distributed over the entire maximum effective width and height of the oven. The dimensions of the effective width and height should be adapted to the spectrum of components to be coated; the largest components with the highest wall thickness form the reference to ensure a sufficient baking temperature and holding time.

¹ See also: VdL information note „Emissions from the baking process of powder coatings”.

7.5 Application Equipment

- 7.5.1 All application devices in use, which are suitable for manual application, must comply with the respective national regulations as well as the manufacturer's specifications and must have the certified conformity according to SN EN 50053. The requirements of DIN EN 50177 for automatic system components in stationary also apply.
- 7.5.2 Prior to each use of an appropriate and standard-compliant application unit, the completeness of the equipment must be ensured. All union nuts and all attachments must be brought to their respective end positions and checked for correct positioning to avoid arcing during the electrostatic powder coating application.
- 7.5.3 A technical switch-off device for the coating equipment must always be directly accessible in the close proximity of the current working position. The functional scope of the switch-off system includes first and foremost the release of the application equipment from the power supply. Do not apply any coating if there is a reason to doubt the functionality of an application device or an important accessory.

7.6 Ventilation and ducting

- 76.1 Ventilation systems are required to maintain the concentration of airborne dusts below the OEL in occupied work areas and below one half of the LEL in enclosed areas.

7.7 Ventilation and powder collection system

- 7.7.1 Enclosed filter membrane collectors and cyclone collectors should be provided with explosion relief unless the openings provided give sufficient protection. The collection unit should preferably be located outside in a safe place, with minimum of enclosure required for weather protection. If it is necessary for the dust collection unit to be sited indoors, it should be in a separate area away from the working area.
- 7.7.2 The dust collector should be discharged by one of the following methods:
 - (i) via a rotary valve with a sufficiently fine clearance between the valve blades and rotor casing or other suitable choke to prevent passage of an explosion flame front. A suitable limit switch should be provided, arranged so that the powder supply to the valve is cut off in the event of an explosion to prevent burning particles being carried through by rotation of the valve. Ideally, the emptying

chute feeds directly into a big-bag or via a collection container with fluidising function via a pump into a big-bag. The rotary valve must be kept closed during operation to prevent further distribution of powder in the event of an explosion.

- (ii) directly into strong metal container clamped firmly to the discharge outlet.
- (iii) where powder is to be recycled, before mixing with fresh powder it should be sieved to remove foreign bodies. Where recycling is automatic, the sieve should be in-line between the recovery system and the powder hopper.
- (iv) Powder hoppers and recovery systems should be designed and located to ensure filling, emptying and cleaning operations can be carried out with minimum discharge of powder into surrounding areas. Local exhaust ventilation should be provided where necessary to reduce dust levels in air.
- (v) All components must be perfectly grounded. Suitable hoses with strands should be used for powder transport in pump operation. Particular attention must be paid to grounding, especially when emptying and decanting manually.

APPENDIX

Method for the calculation of the concentration Of a powder coating in the spray booth

The maximum concentration of powder coating that can be present in the spray booth is determined from the formula:

$$C = \frac{M}{V}$$

Where

- C is the concentration of powder in the spray booth;
- M is the mass of powder coating emitted from the gun(s) in a unit time at the maximum emission rate of the gun(s). No allowance should be made for any powder coating deposited on the workpiece.
- V is the volume of air extracted by the ventilation system set at its lowest extraction rate, measured over the same time period as M.