BCF

BRITISH COATINGS FEDERATION

coatings care

The BCF Code of Safe Practice: Powder Coating

Application of coating powders by electrostatic spraying

British Coatings Federation · Riverbridge House · Guildford Road · Leatherhead · Surrey · KT22 9AD
Tel: 01372 365989 · email: enquiry@coatings.org.uk · www.coatings.org.uk

Ref: HS 004 version 3 August 2015 Replaces version v.2.1 December 2004

The information contained in this publication is believed at the time of publication to be true and accurate. It is based on general principles and is intended for general guidance and information only. Its applicability to individual circumstances must be considered, having full regard to the specific prevailing conditions. All recommendations contained in this publication are made without guarantee and the British Coatings Federation cannot accept any liability in respect of consequences arising (whether directly or indirectly) from use of such advice.
© BCF 2015

INDEX

Foreword

This Code of Safe Practice contains recommendations and guidance for the safe application of coating powders by electrostatic spraying. It covers both thermosetting and thermoplastic powders.

This guidance does not cover the application of coating powders containing lead chromate pigments or TGIC[1] . The HSE offers advice on such 'specialist powders' on its webpage - www.hse.gov.uk/surfaceengineering/health-topics.htm.

The Health and Safety Executive was consulted in the production of this publication. It endorses the sensible, proportionate, reasonable and balanced advice to owners and managers on managing the risk from powder coating as set out in the guidance.

Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and Safety Executive inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

The Code takes into account the requirements of relevant UK legislation including:

- The Health and Safety at Work etc Act 1974
- The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)
- The Equipment & Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 and amendments (EPSR)
- The Control of Substances Hazardous to Health Regulations 2002 and amendments (COSHH)
- The Electricity at Work Regulations 1989
- Pressure Systems and Transportable Gas Containers Regulations 1989
- Management of Health and Safety at Work Regulations 1999 and amendments
- Provision and Use of Work Equipment Regulations 1998 (PUWER)
- Personal Protective Equipment at Work Regulations 1992
- Workplace (Health, Safety and Welfare) Regulations 1992
- Regulation (EC) No. 1272/2008 on the classification, labelling and packaging of substances and mixtures ("CLP")

Recommendations contained in the 7th edition of the Safe Powder Coating Guideline published by the European Council for Paint and Printing Ink Manufacturers (CEPE) are also taken into account (ref. 1).

The guidance in this Code is applicable to all electrostatic application methods, including triboelectric charging (and equipment related to this technique) and secondary charging of powder particles. It applies to single and multiple, automatic and hand held application equipment. This Code is applies both to the application of thermosetting and thermoplastic coating powders.

[1] TriGlycydyl IsoCyanurate, a resin previously used in some coating powders

1. Introduction

1.1 Industrial coating powders are typically produced by blending and extruding together resins, pigments and additives. For thermosetting coating powders, curing agents are also included. The resultant matrix is ground into fine discrete particles; in this form it is known as a coating powder. Such powders are applied to a substrate or workpiece via a pressurised spray application system, complete with electrostatic charging of the coating powder to charge the particles and effect a high level of transfer on to the work piece. (This application process is referred to as powder coating.)

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

Air pressures in the order of 0.8-2.0 bar (10-30 psi) and electrical potentials in the order of 10-90 kV at a current between 1.5 (tribo) and 100 microamps are typically employed.

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

2. Hazards

2.1 The main hazards involved in the electrostatic application of coating powder are from:
- dust explosion
- fire
- electrical shock
- exposure to hazardous substances
- compressed air

2.2 **Dust explosion and fire hazards**

Causes

2.2.1 Coating powders, being fine organic materials, can give rise to dust explosions. A dust explosion may occur when both:
(i) the concentration of dust in the air is above the lower explosive limit (LEL) 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) static discharges.

2.2.2 A fire may occur when a layer of deposited coating powder or a cloud comes into contact with an ignition source such as those listed in 2.2.1 (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.

Prevention

2.2.3 DSEAR (ref. 2) requires a risk assessment, showing that the explosion risks have been identified and controlled, to be carried out. The Regulations also require:

- classification of hazardous areas into zones, details of which are recorded;
- marking of hazardous areas with the yellow triangular (EX) sign;
- electrical and mechanical equipment must be suitable for the zones and comply with the safety requirements of EPSR (often called 'ATEX-Compliant Equipment). Work equipment must also comply with PUWER.
- arrangements for first aid, safety drills and warning and communication systems;
- information and training on the risks and precautions must be provided;
- containers and pipes must be labelled to indicate the hazard of their contents.

2.2.4 An explosion can be prevented if both or either of the conditions shown in 2.2.1 are prevented. 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. This can be achieved by ensuring that the air concentration is kept below 50% of the LEL (however, see 2.4.6 on Workplace Exposure Limits).

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

2.2.5 Determined LELs on the range of typical coating powders lie between 20 $g.m^{-3}$ and 70 $g.m^{-3}$ dependent on the specific chemical and physical properties.

It is recommended that a twofold safety margin is applied to maximum dust concentrations. Spray booths and associated equipment such as dust collectors, should, therefore, be designed and constructed to ensure that dust concentrations never exceed 50% of the lowest LEL likely to be used (usually 10 $g.m^{-3}$). Dust concentrations should be reduced as far below this value as is reasonably practicable.

The LEL of most coating powders is relatively unaffected by particle size, if the material has a particle size distribution predominately between 20 and 75 microns. Coating powders with a particle size distribution, or a significant proportion, below this range can produce increased explosive effects when ignited. Spray plants using such coating powders should be designed to accommodate these effects. Information of the particle size distribution can be obtained from the supplier.

2.2.6 Whenever new types of coating powders are introduced into a coating plant, the maximum dust concentration limits should be confirmed with the supplier by reference to product safety data sheets (see 2.2.4).

2.2.7 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 stated values to ensure that airborne concentrations do not exceed 50% of the LEL.

2.2.8 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 of the equipment. The temperature of external surfaces, or surfaces liable to be exposed to dust, of electrical equipment should not exceed 270^{o} C. This value is 2/3 of the minimum ignition temperature of a layer of a typical coating powder.

2.2.9 The use of compressed air or dry brushing for cleaning up of spills or for cleaning down equipment should be strictly forbidden, as these methods can distribute dusts into the atmosphere and can result in airborne dust concentrations exceeding workplace exposure limits or LELs.

2.2.10 Suitably designed dust-tight vacuum cleaners to Standard IP6X, as defined in BS EN 60529 (ref. 8) or wet brushing are preferred methods. In the latter case, care should be taken to ensure that dusts are fully wetted and are not allowed to dry out. Spillages of coating powders should be cleaned up immediately. Dependent on the quantity and type of spillage, it may be necessary to evacuate the area and initiate emergency procedures. Rubber squeegees can be used to remove deposits adhering to e.g. the sides of the booths.

2.2.11 Smoking should be strictly prohibited and all sources of ignition, such as matches and lighters, should be excluded. 'No smoking' notices should be prominently displayed in all areas where coating powders are stored, handled and used. Naked flames and operations likely to produce sparks, such as welding and cutting should be excluded whilst spraying is in progress. A hot-work permit should be obtained before work involving cutting is carried out on or near to any equipment that has contained coating powders.

2.2.12 General advice on the explosibility of dusts can be obtained from the Loss Prevention Council (ref. 3). Specific information on the products in use is contained in product safety data sheets.

2.3 Electrical hazards

Causes

2.3.1 The main sources of electrical hazard are:

(i) inadequate or defective earthing 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

Prevention

2.3.2 The contact between the workpiece, carrier jigs and conveyor should be designed and regularly tested (ref. 4) 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 efficacy of the earthing system between the jig and the conveyor.

2.3.3 The object to be coated should have a resistance to earth not exceeding 10^{6} ohm.

2.3.4 Floors and other surfaces with which operators can make contact should be conductive and have a resistance not exceeding 10^6 ohm (ref. 5). Non-conductive materials can be coated with conductive floor compounds and coatings. Such surfaces should be kept regularly clean and the conductivity regularly checked. A method is given in Appendix 2. Figure 1 shows examples of antistatic floor layouts.

2.3.5 The high voltage (HV) power supply unit and any other associated electrical equipment should be earthed in accordance with the requirements of the current edition of the Regulations for Electrical Installations published by the Institution of Electrical Engineers (ref. 6).

2.3.6 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.

Various methods of earthing the bonding conductors are available. The method used should be selected and designed to ensure that earth loops are excluded, thereby preventing circulating currents.

2.3.7 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 workpiece.

2.3.8 Conveyors should be designed to minimise swinging of the workpiece.

2.3.9 Dusts are thermal insulators and, if allowed to build up in substantial deposits on electrical equipment, can result in overheating and breakdown of the equipment.

2.3.10 Plant should be designed so that electrical equipment is not sited in inaccessible areas (e.g. exhaust ducting) where dusts can build up or where there is exposure to dusts.

2.3.11 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.

2.3.12 Only the spray gun(s) and associated electrical cables and powder supply hoses should be sited inside the booth (see 3.4 for appropriate standards).

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 BS EN 61241 (ref. 7) and must be dust tight to Standard IP6X (ref. 8). This requirement applies to any equipment within 1.0m of any booth opening, including the gun slots. This 1.0m zone is only applicable if the spray gun nozzle is inside the booth. Figure 2 in Appendix 3 shows some typical zoning configurations.

2.3.13 Normal industrial electrical standards apply to electrical equipment sited outside the 1.0m zone. However, electrical equipment elsewhere in the plant which is likely to be exposed to dust generated from the handling of coating powders (e.g. hopper filling) must meet the requirements of BS EN 61241and be dust tight to Standard IP6X.

2.3.14 Operatives should wear anti-static overalls, non-insulating gloves and anti-static footwear.

2.4 Health hazards

Causes

2.4.1 Health problems when handling or using a coating powder may arise through exposure to hazardous substances, which may be contained in the coating, or to the coating powder itself as a low toxicity dust under certain conditions of exposure.

Prevention

2.4.2 The Health and Safety at Work etc. Act (ref. 10) and subsequent regulations provides the framework under which employers are required to ensure that materials in the workplace are used safely and without risk to health.

Being industrial products, coating powders are subject to the provisions of such legislation. The Control of Substances Hazardous to Health Regulations (COSHH), (ref. 11) will usually apply either because the powder contains specific hazardous substances and/or because it can form dusts.

2.4.3 The label on the product and the safety data sheet will clearly identify whether the coating powder contains any hazardous substances.

2.4.4 COSHH requires that an employer carry 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.

The applicability of the requirements of COSHH will be determined by the results of this assessment.

Approved Codes of Practice and other publications from the Health and Safety Executive give detailed advice and guidance on the various requirements of these regulations (ref. 11).

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

Coating powders are classified and labelled in accordance with the EC regulation on the classification, labelling and packaging of substances and mixtures ("CLP" - (ref. 16)), which suopersede the Chemicals (Hazard Information and Packaging for Supply) Regulations on 1st June 2015. Coating powder manufacturers provide health and safety data in a standardised form based on the requirements of these and the EC REACH Regulation (ref 12).

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 substances

(ii) guidance on health hazards associated with the product and substances

(iii) guidance on workplace exposure limits (WELs)

(iv) advice on safe handling and use

(v) advice on precautions necessary to avoid exposure.

2.4.6 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, the Workplace Exposure Limit for low toxicity dust given in HSE Guidance Note EH40 (ref. 37) or any in-house occupational exposure limits, action must be taken to prevent or control exposure. The WEL is based around what is inhalable or respirable so particle size is important. Respirable dust and inhalable dust are those fractions of airborne dust which will be collected when sampling is undertaken in accordance with the methods described in MDHS14/3 General methods for sampling and gravimetric analysis of respirable and inhalable dust. (ref.37b)

(ii) Substances that have been assigned a WEL are subject to the requirements of COSHH. These Regulations require employers to prevent or control exposure to hazardous substances. Under COSHH, control is defined as adequate only if a) the principles of good control practice are applied, b) any WEL is not exceeded and c) exposure to asthmagens, carcinogens and mutagens are reduced as low as is reasonably practicable.

(iii) Coating powder dusts may cause adverse skin or respiratory reactions, including sensitisation in certain cases. Refer to the product safety data sheet for specific information.

(iv) Hazardous products of degradation may be formed during the burning off of powder coating deposits from jigs and hangers. Refer to the supplier for more information on these if required.

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

(i) Design and operate processes and activities to minimise emission, release and spread of coating powders.

The installation of properly constructed spray booths with exhaust ventilation equipment to capture and control dusts to minimise exposures.

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 workpiece as possible.

The air velocity necessary for adequate control will be dependent on a number of factors including booth design, system of work, coating powder application rates and dimensions of the objects being coated. It is unlikely that an extraction velocity less than 0.5 $m.s^{-1}$ measured as a mean value over the face area of the booth will give effective control. The air flow should be uniform ($\pm$20% of the mean value) across the face of the booth. Excessively high air velocities (above 1.0 $m.s^{-1}$) are likely to be counterproductive as turbulence, eddies and deadspots can result.

The operation and effectiveness of extraction and ventilation systems should be inspected, tested and maintained in accordance with the requirements of COSHH.

(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 in relation to the requirement of COSHH

(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 of packages, loading of hoppers, collection of unused powders should, wherever possible, be contained to prevent the escape of dusts. Local exhaust ventilation and appropriate PPE should be provided in the event this is not practicable.

(v) Particular care should be taken for plant clean-down activities as these have the potential for high exposure to dust (see also 2.2.8).

(vi) Take into account all relevant routes of exposure – inhalation, skin and ingestion – when developing control measures

Where possible, handling of coating powders should be prevented. Where not possible, all employees should be provided with anti-static coveralls designed to prevent ingress of the powder. Suitable gloves (e.g. nitrile) should be provided to minimise skin contact. Gloves which insulate spray operatives from the gun must not be used.

(vii) 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.

All RPE should be CE-marked and be both adequate and suitable. It must only be used by properly trained people who are supervised. It must be properly stored, cleaned and checked regularly to ensure it remains effective. A useful guide to the selection of RPE is given in ref. 18.

(viii) Check and review regularly all elements of control measures for their continuing effectiveness

(ix) Inform and train all employees on the hazards and risks from substances with which they work, and the use of control measures developed to minimise the risks

(x) Ensure that the introduction of measures to control exposure does not increase the overall risk to health and safety

2.4.8 Employees exposed to hazardous substances should be considered for health surveillance. Regulation 11 of COSHH give more details of situations where health surveillance is appropriate.

Further information and advice on appropriate health surveillance can be obtained Occupational Health Inspectors in the HSE.

2.5 Compressed air hazards

Causes

2.5.1 Compressed air can be dangerous in a number of 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 airstream can damage eyes

(iv) pressurised systems can explode with violent effect when ruptured or damaged.

Prevention

2.5.2 Compressed air should never be used for cleaning of clothing or skin

2.5.3 Compressed air systems are subject to The Pressure Systems and Transportable Gas Containers Regulations 1989. Guidance on safe practices and inspections is given in various publications (refs. 21, 22, 41, 42, 43). In particular, users must ensure that:

(i) 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;

(ii) the pressure system is maintained in good repair;

(iii) a written scheme for the periodic examination of the pressure system is drawn up and certified as being suitable by a competent person;

(iv) examinations under the written scheme are carried out by a competent person (ref. 41).

3. Construction of Plant and Equipment

3.1 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.

All equipment used in hazardous (zoned) areas must be 'ATEX Compliant' and be suitable for the zone in which it is used (see Appendix 3).

3.2 Spray booths

3.2.1 The spraybooths should be located as closely as possible to an outside wall of the building. This will reduce the length of any extract ducting to a minimum.

It should be a purpose designed enclosure, constructed of non-combustible materials, the surfaces of which will not accumulate electrostatic charges which could lead to ignition. All conducting parts should have a resistance to earth of less than 10^6 ohm. Design features should ensure that horizontal surfaces are excluded wherever possible to prevent build-up of deposits of dusts on ledges and sills etc.

Internal surfaces should be as smooth as possible to make cleaning easy. Flanges, braces etc. should ideally be located on the outside faces of the booth.

Any openings in the walls of the booth designed for the ingress and egress of workpieces should be as small as possible. They should not be used for access by operators. The presence of large conducting surfaces, insulated from earth, within the booth, should be avoided.

3.2.2 Where plastic sheeting is used to line the inside of such booths for ease of cleaning, the material should be at least 9mm thick. If it is less than this thickness high energy propagating brush discharges may occur.

3.2.3 Tunnel booths (booths constructed from inert, insulating materials and which contain directing electrodes fixed in the walls) should be constructed so that external electrostatic effects are avoided. The plastic sides of such booths should ideally be of a minimum 9mm thickness. The presence of any insulated metal plates in the booth should be avoided.

Directing electrodes should be positioned so that any sparks generated in the presence of an earthed article do not have an energy greater than 1 mJ.

3.2.4 Booth application systems should be designed to avoid the build-up of potentially explosive concentrations of dust in the booth and the exhaust ductwork.

The quantity of coating powder being sprayed into the booth and the position of the electrostatic application equipment should be controlled to maximise deposition on the workpiece and to minimise deposition in the booth and exhaust ductwork.

The exhaust ventilation system should be capable of extracting the maximum output of coating powder from the application units and maintaining the

concentration below 50% of the LEL in all parts of the extraction system (see 2.2.4).

3.2.5 Where manual spraying work is undertaken, the operator should be outside the booth and should spray through an aperture of the minimum size practicable for the operation. Powder should only be sprayed within the booth as spraying outside the booth or its entrance/exit will result in high levels of airborne powder in the workplace.

Touching-in operations using hand held guns should only be carried out through properly constructed access points. Extraction systems should be installed to ensure the air flow is from behind the operator, across the workpiece and into the extract duct. Air flow rates between 0.5 and 1.0 $m.s^{-1}$ are normally satisfactory (see 2.4.7 (i)).

3.2.6 Interlocks, preventing entry of personnel into the spray enclosure of automatic plant when spraying is in progress, should be installed where practicable. Further information on the choice of interlock systems for existing plant can be found in PD 5304 (ref. 23). For new plant which should comply with The Supply of Machinery (Safety) Regulations, guidance on interlocking can be found in BS EN 292, BS EN ISO 14119 and BS EN 60204 (refs. 45, 46).

3.2.7 The ventilation system should start up before spraying commences and allowed to run on after spraying is shut down. Up to 5 minutes would be an appropriate period in each case.

Manual spray booths should additionally be designed and constructed so that the air flow is from behind the operator, over the workpiece and into the exhaust ducts. More detailed information on air velocities is given in paragraph 2.4.7 (i).

3.2.8 The power 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 power 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.

3.2.9 A fire detecting device, interlocked to shut off power and coating powder supplies and ventilation may be installed in the booth and coating powder processing areas as an additional precaution, as advised by the Fire Authority.

A flame detection device is recommended for fully automatic booths. 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.

3.2.10 Automatic sprinkler systems, providing a water spray, may be installed as an additional precaution, as advised by the Fire Authority. They should be constructed in accordance with the Loss Prevention Council "Rules for automatic sprinkler installations" (ref. 24) but not to interfere with the operation of the sprinkler head. A way of achieving this is to cover the head with a paper bag, which should be changed before it becomes too contaminated.

Gas flooding extinguishing systems are not recommended, unless specifically approved by the appropriate authorities, as secondary fires or explosions can be caused by dusts disturbed by their action.

In the case of local or small fires of coating powders outside the spray area, alcohol resistant foam, CO_2 blanket, or water spray/mist can be used. Care should be taken to ensure that powder deposits are not disturbed by the action of the extinguisher.

3.2.11 A CEN Standard, BS EN 12981:2005+A1:2009 Coating plants. Spray booths for application of organic powder coating material. Safety requirements gives the appropriate safety requirements

.

3.3 Stoving ovens

3.3.1 Stoving ovens and exhaust stacks should be designed and operated in accordance with the emission requirements of the BCF Code of Practice for the Manufacture of Coating Powder (ref 37a) or Process Guidance Note PG6/31 Powder Coating Processes (ref. 38).

3.3.2 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 not constructed to BS EN 61241-10:2004(ref. 7) and dust tight to standard IP6X (ref. 8).

3.3.3 The clean air change requirements of the oven should be known and visibly marked on the oven.

3.3.4 Gas fired ovens should be installed according to the requirements of BS 5885. Oil fired plants should be installed in accordance to BS 5410 and oil fired equipment should meet the requirements of BS 799 or BS EN 298 (refs. 25-27).

3.3.5 Direct fired ovens should be provided with explosion relief panels or openings which can operate effectively to prevent the pressure in the oven building up to dangerous levels in the event of a gas of fuel oil explosion. There are a number of methods of calculating the requirements of explosion relief, but generally it should occupy an area equivalent to not less than half the area of the top or the longest side.

3.3.6 The explosion relief on the oven should be located so as not to discharge towards the powder spraying installation or into occupied areas.

3.3.7 For conveyor ovens 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.

3.3.8 The oven should be constructed to allow easy cleaning.

3.3.9 The temperature of the oven should be controllable and one or more safety switches provided to prevent the maximum air temperature exceeding 240^{o}C

3.4 Application equipment

3.4.1 All handheld spray guns should conform to the requirements of EN50050 (ref. 5). Automatic guns should meet the requirements of BS EN 50177 (ref.51). This will ensure that an incendive spark is not produced when the gun comes close to an earthed article. Safety is assured on the basis of energy limitation through conformity to this standard.

3.4.2 High voltage cables, particularly those leading to automatic reciprocating guns, must be protected against mechanical damage.

3.4.3 Wherever practicable, only the spray guns and associated cables should be allowed inside the booth (see 2.3.11).

3.4.4 Wherever practicable, high voltage equipment should be located separately from other electrical equipment. It should be clearly marked. This will assist in isolating the electrical hazards of shock and fire.

3.4.5 All electrical equipment should be capable of being isolated from a safe position in the event of a fire or emergency.

3.5 Ventilation and ducting

3.5.1 Ventilation systems are required to maintain the concentration of airborne dusts below the WEL in occupied work areas. This should also take them below one half of the LEL in enclosed areas.

3.5.2 Ventilation ducts should be constructed of 2mm (14SWG) steel with welded sections. Any flanges should be on the outside of the ducting. Access should be provided for inspection and cleaning via securely fastened ports.

3.5.3 Ducting should be of as short a run as possible and not be constructed with sharp bends.

3.5.4 Discharge points should be located in accordance with the requirements of the Process Guidance Note PG6/31 (ref. 38). Discharge points should be positioned so that there is no entry of discharges back into buildings or workplaces. Suitable arrestment plant should be installed to meet to the emission limits specified in the Guidance Note.

3.5.5 Motors for extraction fan units should be located outside the duct.

3.5.6 All ventilation and ducting associated with local exhaust ventilation should be maintained and inspected in accordance with the requirements of COSHH (Detailed guidance is given in refs. 28 and 47).

3.6 Coating powder collection equipment

3.6.1 The collection equipment shall be designed and operated to control releases to the environment in conformity with the requirements of the BCF's Code of Practice for the Manufacture of Coating Powders, E022 (ref 37a) or the Process Guidance Note PG6/31, under the Environmental Permitting Regulations (ref. 38). This will include controlling particulate emissions to the environment to 10mg.m^{-3} and monitoring where appropriate.

3.6.2 Any coating powder collectors should be situated so as to reduce the length of ventilation ductwork required to a minimum.

3.6.3 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 the 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. Filter membrane collectors ("sock collectors") should be

contained in an enclosure capable of withstanding an internal pressure of at least 7kN.m^{-2} (1 psi) and provided with explosion relief.

3.6.4 The explosion relief provided should have low inertia. The area of relief required for structures capable of withstanding the pressures of 7-14 kN.m^{-2} typically generated by coating powders is 1m^2 for every 4.5m^3 of the enclosed volume of the plant. The relief should vent at as low a pressure as practicable and not more than 3.5kN.m^{-2} above the normal working pressure. For stronger structures it may be possible to design the plant to have a smaller vent than that given by this simple 1:4.5 ratio. Appropriate design methods, allowing for the over pressure that would result during an explosion, should be used (refs 29-32). The relief should be situated on the 'dirty' side of the filterbags.

3.6.5 If the collector or cyclone is sited indoors, a straight duct, less than 3m in length and equal in cross sectional area to the explosion vent, should discharge the relief to the open air. The explosion relief duct should be as strong as the enclosure; as a general guide it should be constructed of 2.5mm (12SWG) steel and should be of all welded construction with flanged joints. Where it is not practicable for either the duct to be straight or no longer than 3m, special design considerations will be necessary to take account of the higher pressures which would otherwise be involved (refs 32 and 33).

3.6.6 Ideally, the relief should not be allowed to vent into the work areas. In certain circumstances it may be acceptable either to allow the relief to vent at high level into the workroom or not to enclose secondary filters. Factors which should be taken into account include size and construction of the work area, the proximity of personnel, cleanliness, protective screens and dust loading.

3.6.7 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 power 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.

(ii) directly into a strong metal container clamped firmly to the discharge outlet.

4. Systems of Work

4.1 This section summarises from the previous sections the advice and guidance concerned with systems of work. More detail and sources of information will be found in the relevant earlier paragraphs.

4.2 The Management of Health and Safety at Work Regulations (ref 13) require every employer to make a suitable and sufficient assessment of the risks to the health and safety of his employees to which they are exposed whilst they are at work, for the purposes of identifying the measures he needs to take to comply with other legislation. This risk assessment is an essential first step in establishing those activities for which safe systems of work are of particular importance.

4.3 The Management of Health and Safety at Work Regulations and COSHH require that employees are given the appropriate information, instruction and training in relation to risks to health and safety, including exposure to substances hazardous to health and on measures to prevent or control risks identified.

4.4 Procedures should be established to ensure that personnel are trained in all aspects of handling and use of coating powders and application equipment. Spraying should only be carried out by trained operatives. Where appropriate, records should be kept of all training given.

4.5 Health surveillance systems including records should be introduced where required under COSHH.

4.6 A regular maintenance and cleaning schedule should be introduced to prevent accumulation and build-up of dusts.

4.7 Any engineering equipment associated with the control of exposure to hazardous substances must be inspected, tested and maintained in accordance with the requirements of COSHH.

4.8 Operatives should be provided with appropriate personal protective equipment when handling coating powders. Such equipment should be selected in accordance with recommendations contained in suppliers' safety data sheets, HSE guidance and trade association literature.

4.9 Employees should be prohibited from eating, drinking and smoking in work areas. Such activities should only be allowed in separate, designated areas. Suitable washing and showering facilities should be provided and overalls and other protective equipment be removed before eating, drinking or smoking. Suitable, segregated storage should be provided for all overalls and other personal protective equipment. Appropriate laundering facilities for overalls should be provided.

4.10 Flammable materials and sources of ignition should be prohibited in the spraying area. Welding and cutting should not be permitted during spraying operations. A hot work permit system should be instituted in relation to all work in areas where dusts and flammable or explosive atmospheres are present or likely to be present.

4.11 Where work is being carried out in confined areas and there is a likelihood of contact with earthed metalwork e.g. ventilation ducts, either a dust-tight battery hand lamp or a dust-tight portable lamp fed from a low voltage isolating transformer should be used. The recommended maximum voltage is either 25 volts DC or AC centre tapped to earth.

4.12 Moving parts of equipment associated with electrostatic spraying equipment (e.g. fan impellers on recovery plant) must be protected to prevent access whilst operational. Covers must be securely attached with a fastening requiring tools for their removal, and be interlocked electrically with the equipment. Notices should be displayed warning that the equipment must be isolated before removing the cover.

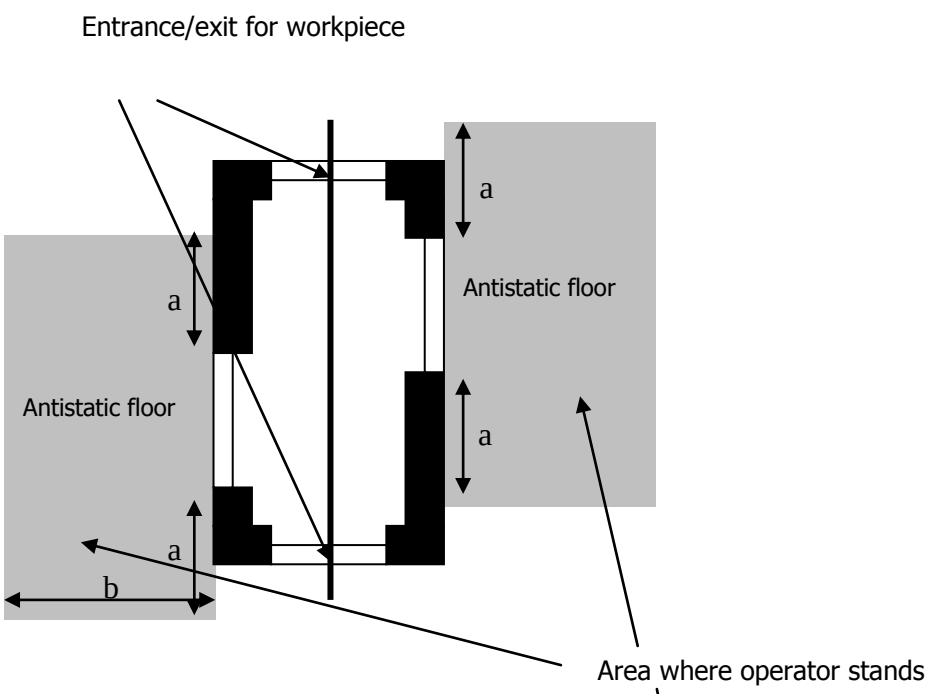
4.13 Regular (e.g. daily) inspection of the coating powder collection unit must be carried out to ensure that it is functioning correctly, particularly if air passing through it is recirculated to the plant. A Tyndall beam, or other suitable lamp giving a bright, fairly parallel beam, will assist in this inspection by revealing leakages of dust from the system (ref. 48).

4.14 Collected wastes should be disposed of in accordance with the requirements of the relevant waste regulating authority regarding disposal of controlled wastes (ref. 34).

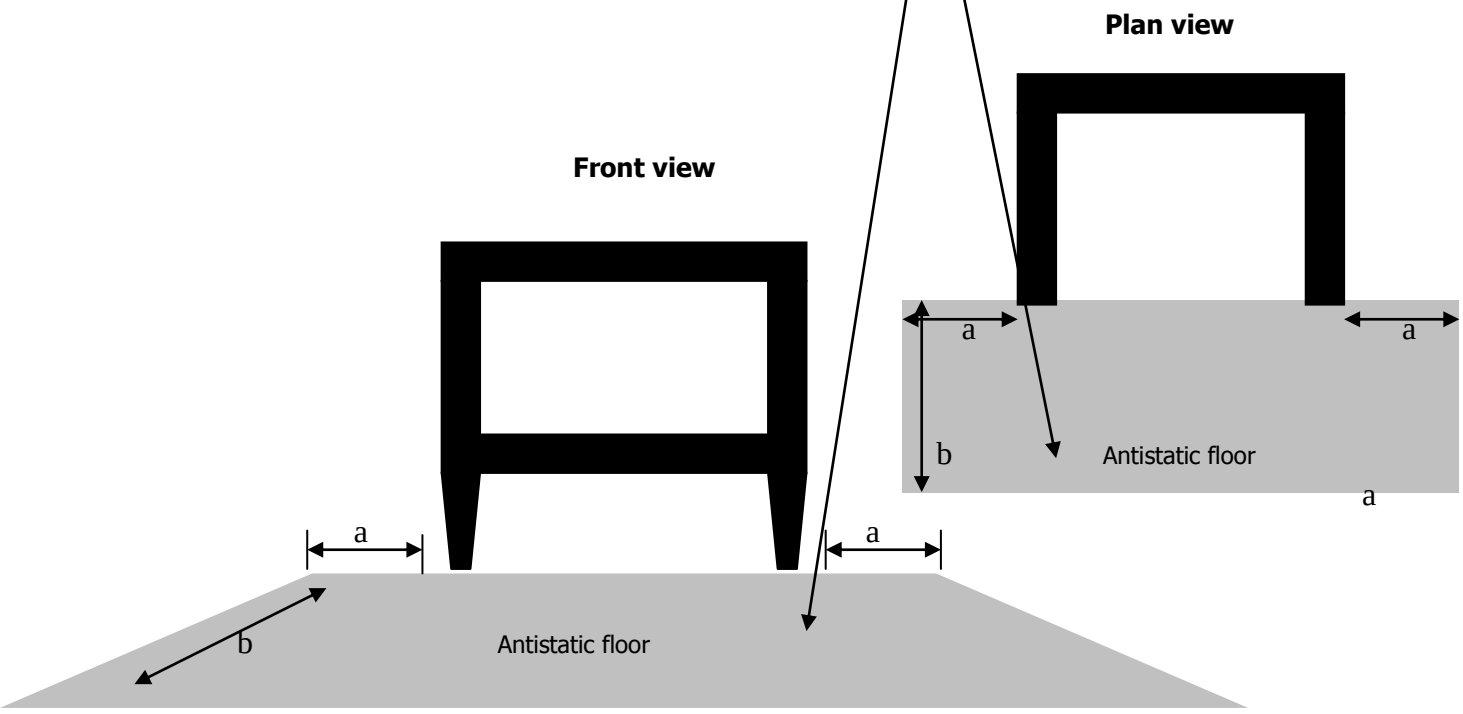
Figure 1
Examples of antistatic floor layouts around spraybooths

1. Conveyorised Booth

Plan view



2. Manual Booth



In all cases, a = 1.5 m, b = 2.5 m

APPENDIX 1

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

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

$$C = M/V$$

where

C is the concentration of powder in the spray booth;

M is the mass of coating powder 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 coating powder 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.

APPENDIX 2

Method for the determination of the electrical resistance of floors

i) Wipe the spot to be tested with a dry cloth.

ii) Place a circular electrode of 50 mm diameter with a force of 10N on the spot to be tested with a piece of blotting paper moistened with tap water between.

The edge of the electrode should not extend beyond the blotting paper.

iii) Measure the resistance between the electrode and a reliable connection to earth. An applied voltage of not less than 100V and not more than 1000V from a safe source (e.g. a megger or ohm meter) should be used.

The measurement should be made at about every square metre of the floor, and the measuring spots should be distributed evenly over the floor.

iv) The resistance to earth shall not exceed 10^6 ohms on any measurement.

APPENDIX 3

Hazardous Area Classification and Equipment Selection

Hazardous area classification (zoning) is the method used to identify areas where flammable concentrations of gases, vapours, mists or dusts are likely to be present. The aim is to reduce to a minimum acceptable level the probability of a flammable atmosphere coinciding with an electrical or other source of ignition. It is normally used to select fixed electrical equipment but it can also be used in the control of other potential ignition sources such as portable electrical equipment, hot surfaces and vehicles. Advice is available in BS EN 60079-10-2 Explosive atmospheres. Classification of areas. Combustible dust atmospheres *(ref. 49).*

Zoning of Areas

Zoning is applicable to areas potentially containing clouds of combustible dust.

A Zone 20 area is one in which an explosive atmosphere, in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.

Note. People should not work in a Zone 20 area.

A Zone 21 area is one in which an explosive atmosphere, in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.

A Zone 22 area is one in which an explosive atmosphere, in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Note that layers, deposits or heaps of combustible dust must be considered as having the potential to form an explosive atmosphere.

Zone (Dusts)	Examples
20	- inside dust handling plant e.g. silos, hoppers, cyclones, filters, enclosed recovery system
21	- inside some equipment e.g. filling/emptying points if only occasionally accessed - up to 1m from the source (and vertically down to a solid floor) e.g. outside access doors subject to frequent opening, areas where dust layers accumulate and are likely to be disturbed
22	- within spray booth if dust kept <50% of LEL - up to 1m from the source e.g. outside access doors opened infrequently, outlets from bag filter vents (where failure can cause dust emission) - wherever dust layers occur

Figure 2 shows examples of zoning for spray booths.

Selection of Equipment

Equipment Category

Anyone specifying or purchasing electrical or mechanical equipment must have knowledge of DSEAR and the EPSR and be deemed competent in these matters.

Zone (Dusts)	Equipment Category
20	1
21	2
22	3

Equipment (often called 'ATEX-Compliant Equipment) must show the following markings:

1. 'CE' mark
2. {εx} symbol
3. Equipment Group II - non mining use
4. The category 1 - Zone 20 use
   2 - Zone 21 use
   3 - Zone 22 use
5. Type of atmosphere D - Dusts

Surface Temperature of Equipment

In addition to the above, the Temperature Class must be quoted when specifying equipment. This can be determined as follows.

The maximum surface temperature of any equipment in the presence of dust clouds must not exceed two-thirds of the Minimum Ignition Temperature (MIT) of the powder.

Also, the maximum surface temperature of equipment in the presence of dust layers must not exceed a value 75 degrees below the Layer Ignition Temperature, for a 5mm layer, (LIT) of the powder.

Once these two temperatures have been determined, the lowest one is used to specify the Temperature Class of the equipment.

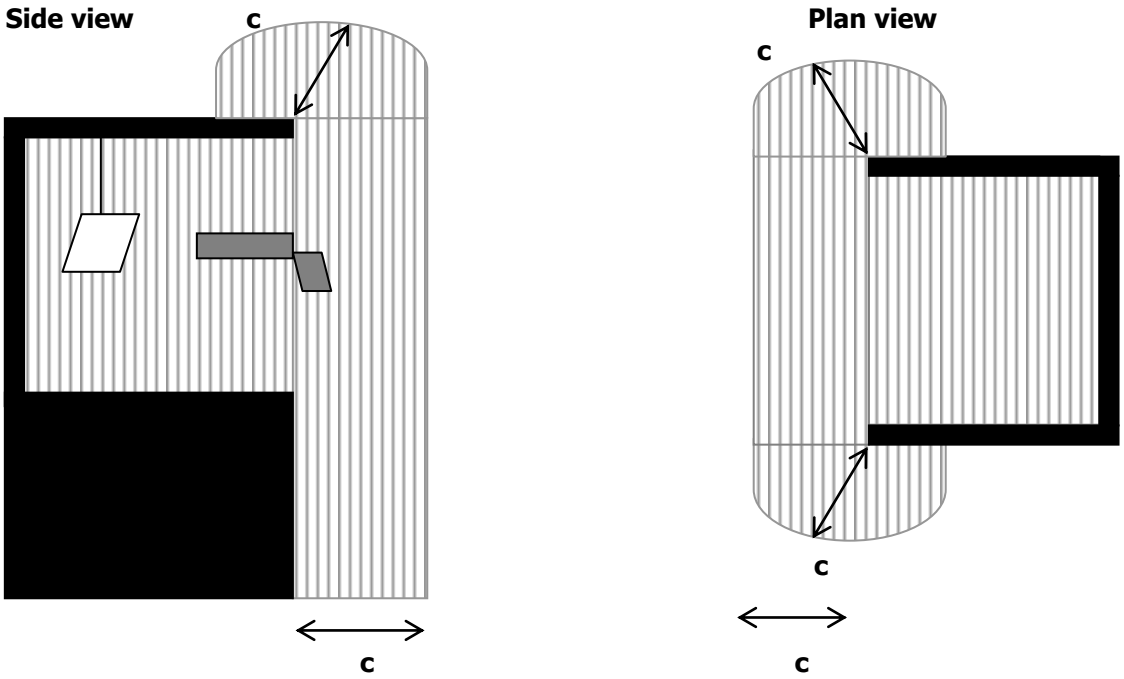
The following table lists the maximum surface temperature of electrical equipment under a fault condition.

Class	Max surface temp ^{0}C
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

Figure 2

DSEAR zoning requirements for spray booths

1. Static Booth with Manual Spraying



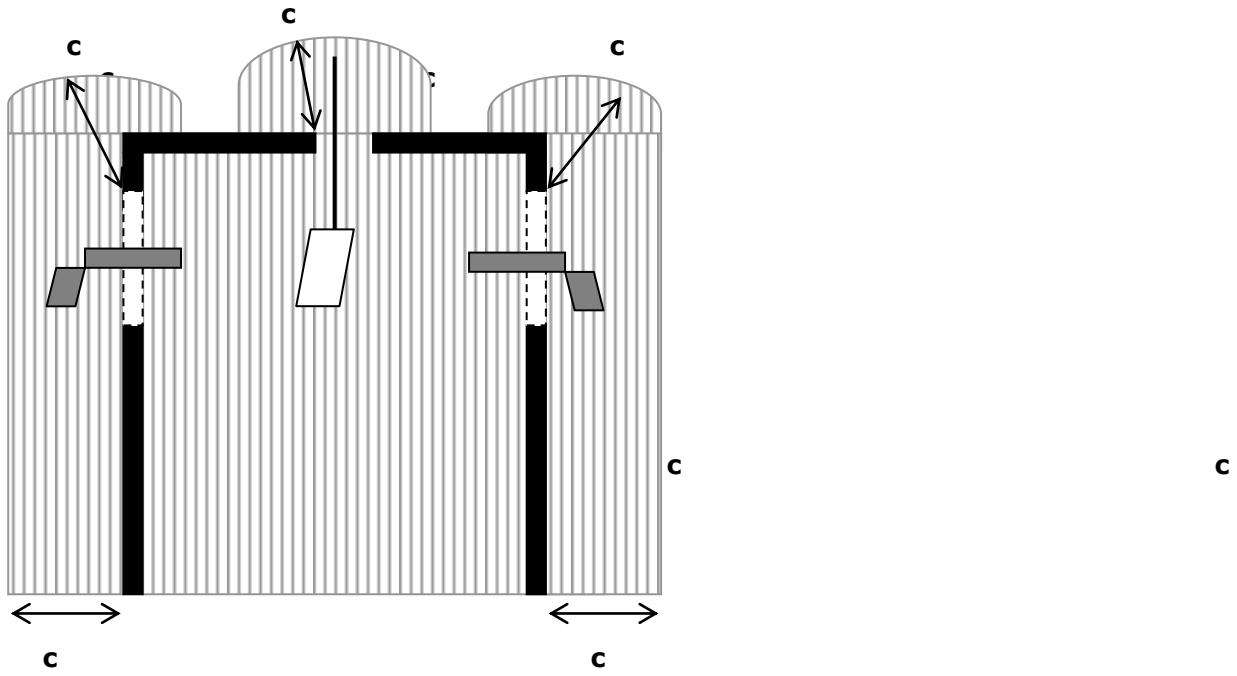
In all cases, **c** = 1.0 m

Zone	Zone markings for diagrams
22	

Note: The zoning above is based on ventilation preventing the concentration of powder in air exceeding 50% of the LEL.

2. Conveyorised Booth with Manual Spraying

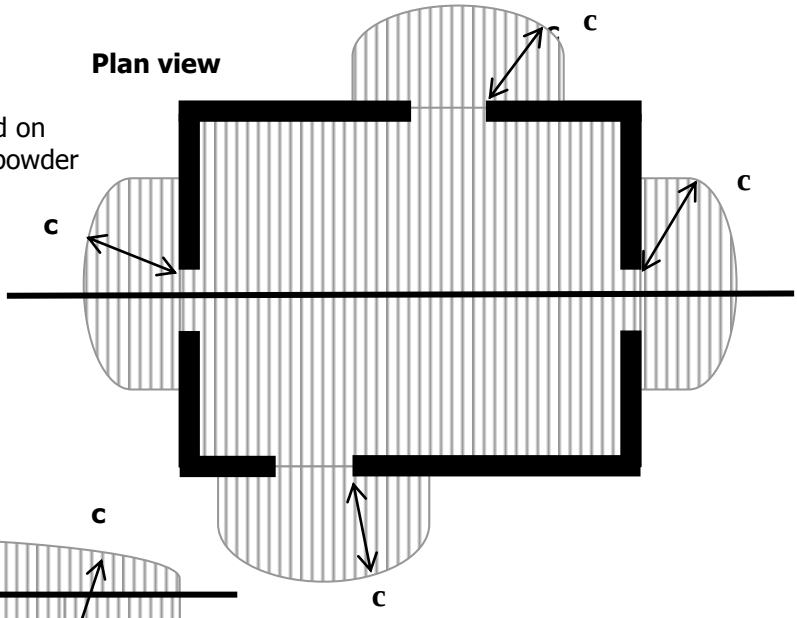
Side view



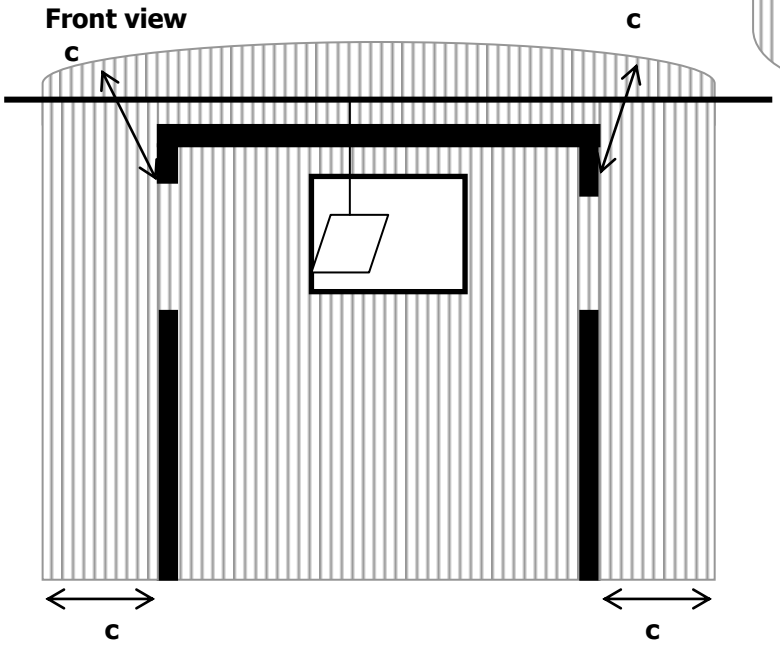
In all cases, **c** = 1.0 m

Note: The zoning in these examples is based on Ventilation preventing the concentration of powder in air exceeding 50% of the LEL.

Plan view



Front view



APPENDIX 4

Explanation of terms

Powder coating

"Powder coating" (or "powder") is commonly used as a generic term to cover the expressions "coating powders" and "powder coatings".

A **coating powder** is defined as finely divided particles of resin, either thermoplastic or thermosetting, which generally contain pigments, fillers and additives which remain finely divided during storage under suitable conditions

A **powder coating** is a coating which is protective or decorative, or both, formed by the application of a coating powder to a substrate and fused in a continuous film by the application of heat or radiant energy.

Dust

Dust is defined in BS 2955: Glossary of Terms Relating to Particle Technology (ref. 35), as particulate matter which is, or has been, airborne and passes through a 75 micron BS test sieve. Electrostatically sprayed powder coatings generally contain particle sizes up to 100 microns and strictly are not covered by this definition. They are however still capable of giving rise to dusts which could lead to a dust explosion hazard.

Dusts can also be hazardous to health as a result of exposure. Information is given in HSE Guidance (ref. 36). Of particular relevance is the importance of particle size in determining whether and where particles are deposited in the respiratory tract.

Dust explosion

A dust explosion comprises the rapid combustion of particles of dust suspended in air resulting in thermal expansion effects arising principally from the heat developed. These expansion effects, or the pressure rise if expansion is restricted, represent the principal hazards from dust explosions.

In practical terms this means that in an unconfined situation a dust explosion will result in mainly localised flames and low pressure effect ('flash fire'). In a confined situation, such as a dust collector or cyclone, the pressure rise may be enough to rupture the containing vessel.

Primary and secondary explosions

Dust explosions can be divided into two types referred to as primary or secondary explosions. If a primary explosion occurs in an enclosure, pressures capable of rupturing the enclosure may be produced. The consequent turbulence of the surrounding atmosphere resulting from the rupture can cause dust which has been ejected and dust which may have been allowed to settle and accumulate on floors, ledges etc. to be dispersed into a dust cloud. If this dust is subsequently ignited then the resultant secondary explosion can be more violent and extensive than the primary explosion.

Lower explosive limit (LEL)

The concentration of flammable coating powder in air below which an explosion atmosphere will not be formed. It is expressed in grams per cubic metre ($g.m^{-3}$)

Minimum ignition energy of a dust cloud

The minimum energy required to ignite a combustible dust cloud under defined conditions. It is expressed in millijoules (mJ).

Minimum ignition temperature of a dust cloud

The lowest temperature at which ignition of a combustible dust/air mixture occurs under defined test conditions.

Minimum ignition temperature of a dust layer

The minimum temperature of a hot surface which will result in the ignition of a layer of particulate solid or dust of a given thickness deposited on it.

Workplace Exposure Limits

Workplace Exposure Limits (WELs) are atmospheric concentrations of substances which have to be referred to when determining the adequacy of the control of exposure to substances hazardous to health. They relate to exposure by inhalation WELs are concentrations of hazardous substances in the air, averaged over a specified period of time, referred to as a time-weighted average (TWA). Two time periods are used: long-term (8 hours); and short-term (15 minutes).

WELs are published by the HSE in Guidance Note EH40 Workplace Exposure Limits (ref. 37).

Equipotential Bond

Electrical connections putting the various exposed conductive parts of the electrical installation and of other conductive parts at a substantially equal potential.

APPENDIX 5

Checklist of working precautions

Constantly

1. No smoking. No naked flames.

2. Only gun and necessary cables in booth: all other electrical equipment to be outside booth. Dust-tight electrical equipment within 1.0 metres of booth to meet BS EN 50281-1-1 requirements and be dust tight to IP6X.

3. Check extraction is efficient and that no powder accumulates in any part of the booth.

4. Check workpiece, jigs and conveyors to ensure adequate earth. Check cabling and connections of all electrical equipment.

5. Ensure operator is properly earthed. Do not use insulating gloves or footwear.

6. Do not enter automatic spray booths when in operation. Ensure interlock system is operating before entering.

7. Do not use compressed air to clean spray booths. Use squeegee and/or suitable vacuum cleaner. Do not use compressed air on clothing or skin.

8. Suitable respiratory protective equipment and protective clothing must be worn by all persons likely to be exposed to powder concentrations above the relevant WEL.

9. Keep floors clear within 5 metres of the spraying area, and keep area clean with a suitably designed industrial vacuum cleaner.

10. Keep light fittings and other electrical equipment clean.

11. Wash hands and face after work and prior to eating or drinking. Do not eat or drink in the workplace

Daily

1. Check recovery units work properly and that recycled filtered air is clean. Check emission monitoring device when installed to comply with EPA.

2. Check that emergency exits and fire-fighting equipment are not obstructed.

3. Check earthing connections of electrical equipment and spray guns. Check that HV cables are intact.

4. Clean flame detectors if installed.

Weekly

1. Check all safety equipment.

2. Clean extraction plant (more frequent attention may be required).

3. Examine safety panels to ensure there are no obstructions.

4. Check filters. Replace or clean if necessary.

5. Clean ovens and burners.

APPENDIX 6

References

1. Safe Powder Coating Guideline (7th edition), [CEPE]
2. Dangerous Substances and Explosive Atmospheres Regulations 2002: Approved Code of Practice, L138, [HSE]
3. Loss Prevention Council, Bucknalls Lane, Garston, WD25 9XX (Tel: 01923 664000)
4. Reference not used
5. BS EN 50050-2:2013. Electrostatic hand-held spraying equipment. Safety requirements. Hand-held spraying equipment for ignitable coating powder [BSI]
6. IET Wiring Regulations (current edition), Institution of Engineering and Technology
7. BS EN 61241-10:2004. Electrical apparatus for use in the presence of combustible dust. Classification of areas where combustible dusts are or may be present [BSI]
8. BS EN 60529:1992+A2:2013 . Degrees of protection provided by enclosures (IP Code) [BSI]
9. Reference not used
10. The Health and Safety at Work etc. Act, 1974, [TSO].
11. COSHH Regulations 1999: Approved Codes of Practice, L5 [HSE].
12. Annex II of the REACH Regulation (EC) No 1907/2006, as amended
13. Managing for Health and Safety (also known as HSG65) [HSE]
14. Provision and Use of Work Equipment Regulations 1992: Guidance on Regulations [HSE]
15. Personal Protective Equipment at Work Regulations 1992: Guidance on Regulations[HSE]
16. Regulation (EC) No. 1272/2008 on the classification, labelling and packaging of substances and mixtures ("CLP")
17. Reference not used
18. Respiratory protective equipment at work - A practical guide (HSG53) [HSE]
19. Contact via the local HSE Area Office
20. Results of the experimental toxicological studies on thermosetting powder coatings, published by CEPE [BCF]
21. Compressed air safety, HSG39, [HSE]
22. BS EN 1012-1:2010 Compressors and vacuum pumps. Safety requirements. Air compressors [BSI]
23. BS 5304:1988 Code of practice for safety of machinery [BSI]
24. Sprinkler systems explained: A guide to sprinkler installation standards and rules, BRE Global

25. BS 5885: part 1: 1988. Automatic gas burners. Specification for burners with input rating 60kW and above; BS 5885: part 2: 1987. Automatic gas burners. Specification for packaged burners with input rating 7.5kW up to but excluding 60kW [BSI]

26. BS 5410-3:1976. Code of practice for oil firing. Installations for furnaces, kilns, ovens and other industrial purposes [BSI]

27. BS 799: parts 2-5, 7, 8 and BS EN 298:2012 Automatic burner control systems for burners and appliances burning gaseous or liquid fuels [BSI]

28. Controlling airborne contaminants at work: A guide to local exhaust ventilation (LEV), HSG258 [HSE]

29. Dust explosions, P. Field, Handbook of Powder Technology, Volume 4, 1982, Rlsevier Scientific Publishing Co., Oxford (out of print)

30. An Introduction to Dust explosions, Institute of Chemical Engineers

31. NFPA 68: Standard on Explosion Protection by Deflagration Venting, National Fire Protection Association, Boston, USA.

32. Pressure release of dust explosions, VDI Richtlinien 3673, 2000, VDI Verlag GmbH, Dusseldorf.

33. Dust Explosion Prevention and Protection - A Practical Guide, Institute of Chemical Engineers.

34. The Controlled Waste (England and Wales) Regulations 2012 , SI2012: 811 and amendments and The Hazardous Waste (England and Wales) Regulations 2005 (SI2005:894) and amendments

35. BS 2955:1993. Glossary of terms relating to particle technology [BSI]

36. Working safely with coating powders, INDG 319 (leaflet); and HSE Powder Coating website - www.hse.gov.uk/surfaceengineering/health-topics.htm

37. Workplace Exposure Limits, EH40, [HSE].

37a. Code of Practice for the Manufacture of Coating Powder. BCF

37b. General methods for sampling and gravimetric analysis of respirable and inhalable dust MDHS14/3 (Third edition) HSE

38. Environmental Permitting Regulations 2010. Process Guidance Note PG6/31: Powder Coating Processes [Defra]

39. Reference not used;

40. Workplace (Health, Safety and Welfare) Regulations 1992: Approved Code of Practice and Guidance[HSE]

41. Written schemes of examination Pressure Systems Safety Regulations 2000 , INDG 178 [HSE]

42. Pressure Systems a brief guide to safety , INDG 261, [HSE]

43. Safety of pressure systems Pressure Systems Safety Regulations 2000. Approved Code of Practice and guidance on Regulations [HSE]

44. Reference not used [BSI]

45. BS EN ISO 14119:2013 Safety of machinery. Interlocking devices associated with guards. Principles for design and selection [BSI]

46. BS EN 60204: Safety of machinery. Electrical equipment of machines. [BSI]

47. HSE Local exhaust ventilation web pages[HSE]

48. HSE Wood dust web pages [HSE]

49. BS EN 60079-10-2:2015 Explosive atmospheres. Classification of areas. Combustible dust atmospheres [BSI]

50. Reference not used

51. BS EN 50177:2009+A1:2012 Stationary electrostatic application equipment for ignitable coating powders. Safety requirements [BSI]