RISCAuthority

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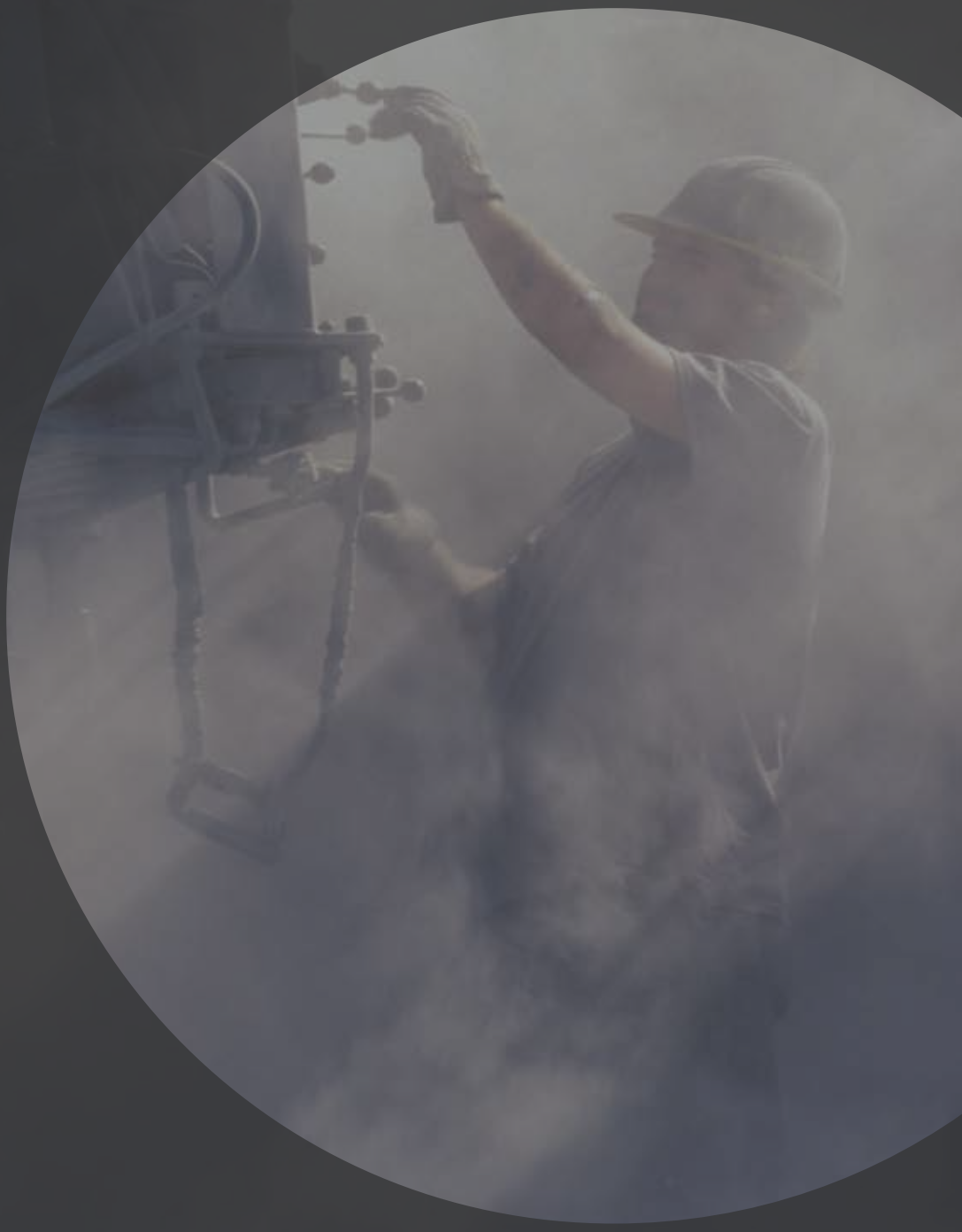
FPA Fire Protection Association

RC12: Recommendations for the prevention and control of dust explosions



Version 3, Published 2015

Acknowledgements

Figure 3 has been supplied Courtesy of RS Components Ltd.

Contents

Summary of Key Points

This document has been developed through the RISCAuthority and published by the Fire Protection Association (FPA). RISCAuthority membership comprises a group of UK insurers that actively support a number of expert working groups developing and promulgating best practice for the protection of people, property, business and the environment from loss due to fire and other risks. The table below summarises the key points of the document.

Comply with the law	• In addition to a suitable and sufficient fire risk assessment, carry out an assessment in compliance with the Dangerous Substances and Explosive Atmospheres Regulations where combustible dusts are processed or formed. • Apply the acronym VICES when planning control measures.
Ensure the continuity of the business	• If it is intended that equipment using or producing combustible powder or dust is to be left operating without staff in attendance then the insurers of the property should be consulted and a specific risk assessment for the process undertaken following the advice set out in RISCAuthority recommendations RC42.
Manage the handling of powders effectively	• At the outset, attention should be given to eliminating combustible powders from the workplace wherever possible. • Particular care should be taken when working with, or producing, metallic dusts as their properties may be quite different from organic powders. • The workplace should be kept clean and tidy and any accumulations of dust should be removed regularly. • Employees should be given induction training so they understand the hazards associated with the materials they are using and the relevant control measures.
Provide adequate ventilation	• Buildings housing dusty processes or plant should be provided with general exhaust ventilation by fans and ducting to collectors in order to reduce potential accumulations of dust or powder on surfaces.
Eliminate and minimise potential ignition sources	• The possibility of the ignition of accumulations of dust or powder on hot surfaces should be minimised by eliminating horizontal surfaces as far as possible at the design stage and by regular removal of the residues.
Establish effective containment	• Serious consideration should be given as to whether the process can be economically undertaken using less hazardous materials.
Isolate stocks of combustible powders	• Store stocks of combustible powders in non-combustible cabinets or bins.
Provide control measures in case of an explosion	• Explosion control measures to be considered should include venting, inert gas protection, suppression, containment and dilution.

Symbols used in this guide


Good practice


Bad practice


Discussion topic

Frequently asked question

1 Synopsis

These recommendations provide advice for reducing the incidence and consequences of explosions resulting from the handling and release of powders and creation of dusts in the workplace. The hazards associated with secondary explosions and the prevention of these incidents, which may cause more damage than the primary event, are also addressed.

2 Scope

These recommendations apply to workplaces and open process areas where explosible concentrations of dusts and powders may occur. They do not extend to mines and quarries.

Apart from the safety issues arising from their combustion and exposiblity, concentrations of dusts and powders in the atmosphere often have associated health hazards. The exposure of employees and other persons to these hazards is controlled under health and safety legislation (refs 1 and 2) and is outside the scope of these recommendations.

3 Definitions

Classification of hazardous areas (BS EN 60079-10) (ref 3).

(This classification refers to areas in which open processes are carried out; areas in which closed processes are undertaken should be subject to a risk assessment.)

- Zone 20: A place in which an explosive atmosphere in the form of a cloud of combustible dust (or powder) in air is present continuously, or for long periods of time or frequently.
- Zone 21: A place in which an explosive atmosphere in the form of a cloud of combustible dust (or powder) in air is likely to occur occasionally in normal operation.
- Zone 22: A place in which an explosive atmosphere in the form of a cloud of combustible dust (or powder) in air is not likely to occur but, if it does, will be present for a short period only.

4 Introduction

In this document the terms dusts and powders are used interchangeably although in industry the term powder is often used for a material used in a process or that forms an end product, whereas a dust is formed as a result of an unintentional release of fine particles.

There is a wide range of materials that, when dispersed in the air in certain conditions may burn or explode on the introduction of an ignition source. The ease of ignition occurs because the dust particles present a much larger surface area to the atmosphere than the solid materials from which they are formed. Explosible dusts can arise during the handling of materials and in processes such as milling, grinding, mixing and drying. Dust may also present a hazard when collected in extraction systems.

Although an explosion hazard arises from suspensions of dust in air, this scenario is often the result of disturbance of a settled layer to form an explosible cloud. Materials that are combustible when in bulk form will almost certainly form explosible suspensions in air (for example wood and sawdust). However, some materials that are not normally combustible in bulk form may also produce explosible dusts if the particle size is sufficiently small. For example, a bar of aluminium metal is not readily ignitable but aluminium powder is extremely flammable and explosible in confined spaces. Examples of some common materials that will form combustible dusts are set out in Table 1.

Agricultural products	Agricultural dusts	Chemical dusts	Plastic dusts
• Egg, white • Milk, powdered • Milk, non-fat, dry • Soy flour • Starch, corn • Starch, rice • Starch, wheat • Sugar • Sugar milk • Sugar, beet • Tapioca • Whey • Wood flour	• Potato flour • Potato starch • Raw yucca seed dust • Rice dust • Rice flour • Rice starch • Rye flour • Semolina • Soybean dust • Spice dust • Spice powder • Sugar • Sunflower • Sunflower seed dust • Tea • Tobacco blend • Tomato • Walnut dust • Wheat flour • Wheat grain dust • Wheat starch • Xanthan gum	• Adipic acid • Anthraquinone • Ascorbic acid • Calcium acetate • Calcium stearate • Carboxy-methylcellulose • Dextrin • Lactose • Lead stearate • Methyl-cellulose • Paraformaldehyde • Sodium ascorbate • Sodium stearate • Sulphur	• (poly) Acrylamide • (poly) Acrylonitrile • (poly) Ethylene low-pressure process • Epoxy resin • Melamine resin • Melamine, molded (phenol-cellulose) • Melamine, molded (wood flour and mineral filled phenolformaldehyde) • (poly) Methyl acrylate • (poly) Methyl acrylate, emulsion polymer • Phenolic resin • (poly) Propylene • Terpene-phnol resin • Urea-formaldehyde/cellulose, molded • (poly) Vinyl acetate/ethylene copolymer • (poly) Vinyl alcohol • (poly) Vinyl butyral • (poly) Vinyl chloride/ethylene/vinyl acetylene suspension copolymer • (poly) Vinyl chloride/vinyl acetylene emulsion copolymer

Agricultural dusts	Carbonaceous dusts	Metal dusts
• Alfalfa • Apple • Beetroot • Carrageen • Carrot • Cocoa bean dust • Cocoa powder • Coconut shell dust • Coffee dust • Corn meal • Cornstarch • Cotton • Cottonseed • Garlic powder • Gluten • Grass dust • Green coffee • Hops (malted) • Lemon peel dust • Lemon pulp • Linseed • Locust bean gum • Malt • Oat flour • Oat grain dust • Olive pellets • Onion powder • Parsley (dehydrated) • Peach • Peanut meal and skins • Peat • Potato	• Cellulose • Cellulose pulp • Charcoal, activated • Charcoal, wood • Cork • Corn • Coal, bituminous • Coke, petroleum • Lampblack • Lignite • Peat 22% H_2O • Soot, pine	• Aluminum • Bronze • Iron carbonyl • Magnesium • Zinc

Table 1: Common materials that will form combustible dusts (taken from USA Occupational Safety and Health Administration poster)

An explosion will only propagate through a cloud if the concentration of particles lies within certain limits. The lower of these limits is normally well defined and may be as low as 10g/m^3 in air. More typically these limits will be 30g/m^3 to 60g/m^3 for particle sizes in the region of 100 micrometres diameter. Sugar and caster sugar are typical of these particle sizes. Table 2 illustrates the wide range of properties of materials that are widely used in industry.

Dust	Lower explosive limit (g/m^2)	Ignition temperature of dust cloud (°C)	Minimum ignition energy of a cloud (millijoules)	Maximum explosion pressure (kPa) [psi]
Alfalfa	100	460	320	607 [88]
Aluminium (flake)	45	610	10	876 [127]
Cellulose acetate	25	320	10	758 [110]
Coal (37% volatiles)	35	610	60	586 [85]
Cork	35	470	45	689 [100]
Egg white	140	610	640	399 [58]
Flour (wheat)	50	380	50	752 [109]
Magnesium	20	520	40	655 [95]
Milk powder (skimmed)	50	490	50	655 [95]
Phenolic resins	25	460	10	552 [80]
Polyethylene	20	450	30	552 [80]
Polystyrene	20	490	15	621 [90]
Polyurethane	30	510	20	621 [90]
Rubber	25	350	50	552 [80]
Sawdust	50	430	50	669 [97]
Sugar	35	350	30	621 [90]
Sulphur	35	190	15	552 [80]
Titanium	45	330	10	552 [80]
Zirconium	45	20	5	517 [75]

Table 2: Indicative properties of some dusts

As in the case of flammable vapours, there are upper limits for the concentration of dust in the air above which an explosion may not occur. These upper limits are quoted in the region of 2000g/m^2 to 6000g/m^2 but are often not as closely defined as the lower explosion limit; this is because the practical measurement of these levels is difficult. Upper values for the explosion limits quoted in literature should thus be used with caution and in practice any dust concentration above the lower limit should be treated as potentially hazardous.

Explosive concentrations of dusts and powders should not arise in open areas of the workplace during normal working conditions but may occur within enclosed plant. Thus the greatest risk is for a primary explosion to occur within an item of plant. However, there is also a risk from secondary explosions caused by the ignition of a layer of dust disturbed by the force of a primary explosion. Experience has shown that greater damage is often caused by such secondary explosions than by the primary event.

Dust and powder explosions can cause injury and loss of life. In addition, explosions and subsequent fires may cause substantial damage to property and result in significant business interruption. Measures to prevent explosions and restrict their effects are thus an essential part of modern risk management.

The life safety issues of dust explosions have been recognised in a European Directive known as the ATEX Directive (ref 4). This Directive is implemented in the UK through the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref 5). These Regulations require that where a dangerous substance such as an explosible dust or powder is present, or likely to be present, a formal risk assessment should be carried out by a competent person and measures implemented to remove, reduce or replace the materials that give rise to the risk. Many of these measures are also relevant to property protection and business interruption and are described below.

- Eliminate the use of combustible powders in the workplace, and replace them with non-combustible alternatives where possible
- Minimise the quantities of necessary combustible powders and dusts in use in the workplace.

5 Recommendations

5.1 Compliance with fire safety legislation

5.1.1 A suitable and sufficient fire risk assessment should be undertaken for all premises to which the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) applies (refs 6-10).

5.1.2 In areas where combustible powders are being handled and a dust explosion may occur, an assessment should be undertaken in accordance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref 5). In common with the fire risk assessment, this should be undertaken by a competent person; it should identify any hazard zones in the workplace and control and mitigating measures that may be taken to reduce the risk.

5.1.3 It is recommended that when such assessments are carried out in business critical areas the implications for property protection and business continuity, as well as life safety, should also feature prominently in the assessment.

5.1.4 Risk assessments should be the subject of periodic review, including at the time when any changes to the process, the use of powders or potential production of dust are being considered.

5.1.5 The response by fire and rescue services to 999/112 calls and signals routed via fire alarm monitoring organisations varies widely throughout the UK, and differs from day to night time. Fire safety managers should refer to their local authority fire and rescue service to make themselves aware of the levels of response in the areas in which their premises are located and consider this information when undertaking and reviewing their fire risk assessments.

- In the event of a spillage of a combustible powder, train staff not to use brushes, brooms and vacuum cleaners not specifically designed for use in a potentially explosive atmosphere.
- Never blow dust off a surface to establish how much has accumulated.

5.2 Business continuity

Even a small fire or explosion can have a disproportionate effect on a business if it occurs in a critical area. The use of powders and dusts can produce serious hazards and must be carefully managed to avoid unnecessary disruption to the efficient functioning of the business.

5.2.1 In commercial premises where processes routinely involve the use of powders or generation of dusts, the fire hazards and thus the threat to the business may be increased if the processes are allowed to continue unattended. If it is intended that equipment is to be left operating without staff in attendance then this should be taken into consideration at the time of the assessment undertaken in compliance with the DSEAR Regulations. Note should also be made of the guidance set out in RISCAuthority recommendations RC42 (ref 11).

5.2.2 If a change in procedures is to result in a process involving the use of powders to continue unattended then the insurers of the property should be consulted and the DSEAR assessment reviewed.

5.2.3 All businesses should take steps to maintain the continuity of their operations by making a suitable emergency plan. Guidance for this is set out in **Business resilience: A guide to protecting your business and its people** (ref 12). The emergency plan should address the implications of a fire, explosion, flood or other perceived disaster on all facets of the business model. It should indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of replacement equipment.

5.2.4 Tabletop exercises should be held periodically to test the effectiveness and suitability of the emergency plans.

5.2.5 Consideration may be given to applying commercially available computer programmes, such as the ROBUST software (Resilient Business Software Toolkit) that is available free of charge (ref 13), or similar product, to develop and check the adequacy of the plan.

5.3 Fire safety management

5.3.1 At the outset, attention should be given to eliminating combustible powders from the workplace wherever possible. Serious consideration should be given to the need for the use of such materials in the process and the possibility of replacing them with suitable alternatives that would reduce the risk of an explosion.

5.3.2 Particular care should be taken when working with, or producing, metallic dusts as their properties may be quite different from organic powders (see tables 1 and 2).

5.3.3 The hazard zones identified as a result of the DSEAR assessment should be identified and recorded on plans (see BS 60079-10) (ref 3). A copy of the plan showing the hazard zones should be available, together with a copy of the emergency plan, for the fire and rescue service on their arrival in the event of a fire or explosion on site.

5.3.4 Where appropriate, areas classified as zones 20, 21 or 22 should be marked at their entrance points by the sign prescribed in Schedule 4 of DSEAR which also complies with BS ISO 3864-1 (ref 14); see figure 1.

5.3.5 Management procedures should ensure that the following fire prevention measures are in place:

- good housekeeping;
- appropriate maintenance and service contracts including contracts with specialist companies for explosion suppression and venting systems;
- a permit to work scheme which incorporates the auditing of permits;
- regular monitoring of any changes of activities or processes in or near hazard zones;
- a formal programme for cleaning and the checking of equipment that is recorded and audited for compliance.

Figure 1: Example of explosive atmosphere hazard sign

5.3.6 Wherever practicable, hot work should be prohibited in areas where there could be a release of combustible dust. Instead, the equipment should be removed to a safe environment, such as a workshop, for the work to be carried out.

Where there is no alternative to hot work, it should be subject to a risk assessment and strict implementation of the necessary control measures. Any hot work should be conducted by a competent person under an effective Permit to Work system and in strict accordance with the RISCAuthority document **RC7: Recommendations for hot work** (ref 16).

5.3.7 The local fire and rescue service should be encouraged to make familiarisation visits to the premises to acquaint themselves with the nature of the processes and location of the hazard zones.

Good housekeeping

FAQ

- How often should I clean the workplace to prevent significant residues of dust from forming? (See section 5.3.9.)
- Can I handle combustible dusts in the designated hazard zones that are identified for flammable liquids? (Hazard zones for flammable liquids and combustible dusts should be assessed and identified separately, they are not interchangeable.)

5.3.8 The quantities of powders stored and in use in production areas should be limited to the minimum amounts necessary for the period of work or to a day's usage.

5.3.9 The workplace should be kept clean and tidy. The development of dust or powder deposits should be regularly monitored and any areas where accumulations are greater than normal should be subject to cleaning more frequently on a risk assessed basis. The reasons for the build-up should be investigated and suitable remedial action taken.

5.3.10 Good housekeeping is essential to prevent the accumulation of dust and powder; this will reduce the risk of secondary explosions. Manual cleaning of hazard zones using a suitable vacuum cleaner specially designed for removing combustible dusts should be carried out on at least a daily basis.

Particular care should also be taken to monitor and safely remove accumulations of dust on high ledges, beams, ducts, pipes, light fittings and other horizontal surfaces that are not normally accessible. This is to prevent these deposits contributing to a secondary explosion. The frequency of cleaning should be determined by risk assessment.

5.3.11 Blowing down techniques must not be used as they will disperse dust in the atmosphere.

5.3.12 Brushing and sweeping should be avoided if at all possible. Where there is no practical alternative to using these techniques to remove dust or powder deposits, care should be taken to minimise the production of dust clouds.

5.3.13 Washing down may be considered as a cleaning method provided that the components of the dust or powder are compatible with water and other cleaning materials used and there are no environmental issues.

5.3.14 Damping of layers of dust, where appropriate, may also allow them to be swept up safely where vacuum cleaning is not possible.

5.3.15 Material collected during cleaning should be disposed of immediately in lidded, non-combustible containers, preferably constructed of metal, located outside the building.

5.3.16 To minimise the accumulation of dust deposits, horizontal exposed surfaces should be eliminated from the design of the work area wherever possible.

Maintenance

5.3.17 All equipment that uses a powder as a feedstock or may produce dust should be maintained and serviced according to the manufacturer's instructions so as to minimise the dispersion of dust in the air. Where appropriate, filters should be cleaned or replaced on a regular basis.

- How can the workplace be designed to minimise the accumulation of dust?
- How can the workplace be heated while at the same time minimising hot surfaces that may be a potential ignition source for combustible powders?

Training

5.3.18 Personnel working in areas where explosible dusts or powders are or may be present should be given practical training in the use of fire extinguishing equipment. This is particularly important to ensure that the correct types of extinguishers are used and the manner of use of an extinguisher does not produce a cloud of dust by disturbing deposits.

5.3.19 New employees should be given induction training so that they understand the hazards associated with the materials that they are using and the relevant control measures.

5.3.20 Periodic refresher training should be given to all staff and in particular to those involved with inspection, maintenance and the operation of permits to work.

5.3.21 Staff should be trained in good practice relating to the opening and handling of containers of powdered products where these may form explosible concentrations in air.

5.3.22 All staff should be familiar with the hazards associated with powdered products in the workplace and the actions to be followed in the event of a fire or spillage. These include how to:

- raise the alarm;
- ensure all staff evacuate the workplace;
- call the fire and rescue service;
- attack a fire if it is safe to do so; and
- contain and recover spillages and dispose of the spilled materials safely.

5.3.23 Staff should be made aware of the hazards of deliberate fire raising, which may be carried out by staff and visitors as well as by intruders.

5.4 VICES

5.4.1 The HSE guidance in booklet HSG51 (ref 15) suggests the use of the acronym VICES to help apply five basic principles which ensure that any flammable or highly flammable liquid that is absolutely necessary in the workplace is used and stored with appropriate care. The same principles may be applied to reduce the risk of explosions involving combustible dusts.

5.4.2 Suitable staff training should be in place to ensure all personnel are aware of the hazards in the workplace and apply VICES to ensure a safer working environment for all.

5.4.3 The acronym may be explained as follows:

V Ventilation (see section 5)

- Is the ventilation controlled to ensure that in the event of a spillage, powder is not distributed to form a combustible mixture in the air?

I Ignition (see section 6)

- Have all possible ignition sources been removed?
- Have hot surfaces been eliminated as far as possible? (See figure 2)
- Is the electrical equipment used in this area appropriate for the hazard zone?

C Containment (see section 7)

- Are powders stored in suitable containers?
- Have staff been trained to handle stocks of powder with care?
- Are staff trained in the actions to take in the event of a spillage?
- Is suitable equipment available to safely remove spilled powder?
- Have suitable catchment devices been installed and maintained where appropriate?

E Exchange (see section 8)

- Can combustible powders be eliminated from the process?
- Can a powder be replaced by one that is less combustible?

S Separation (see section 9)

- Are incompatible materials suitably separated?
- Are physical barriers (for example walls, doors, cabinets and bins) present as required?

5.5 Ventilation

5.5.1 Generally, concentrations of powder sufficient to produce an explosion in the workplace are significantly higher than the occupational exposure limits allowed under health and safety legislation and are at levels where visibility would be significantly impaired. Thus it is not normally necessary to provide ventilation to control explosive limits as legislative health requirements are far more stringent. Buildings housing dusty processes or plant should, however, be provided with general exhaust ventilation by fans and ducting to collectors in order to reduce potential accumulations of dust or powder on surfaces.

5.5.2 Processes that may lead to accumulations of powder or dust should not be located immediately adjacent to external doors due to the possibility of dust being blown into the atmosphere when the doors are opened. Where this is not possible, the doors should be lobbied.

Note: Ventilation of the workplace should not be confused with providing vents on vessels and equipment to control an explosion (see paragraphs 5.10.1—5.10.8).

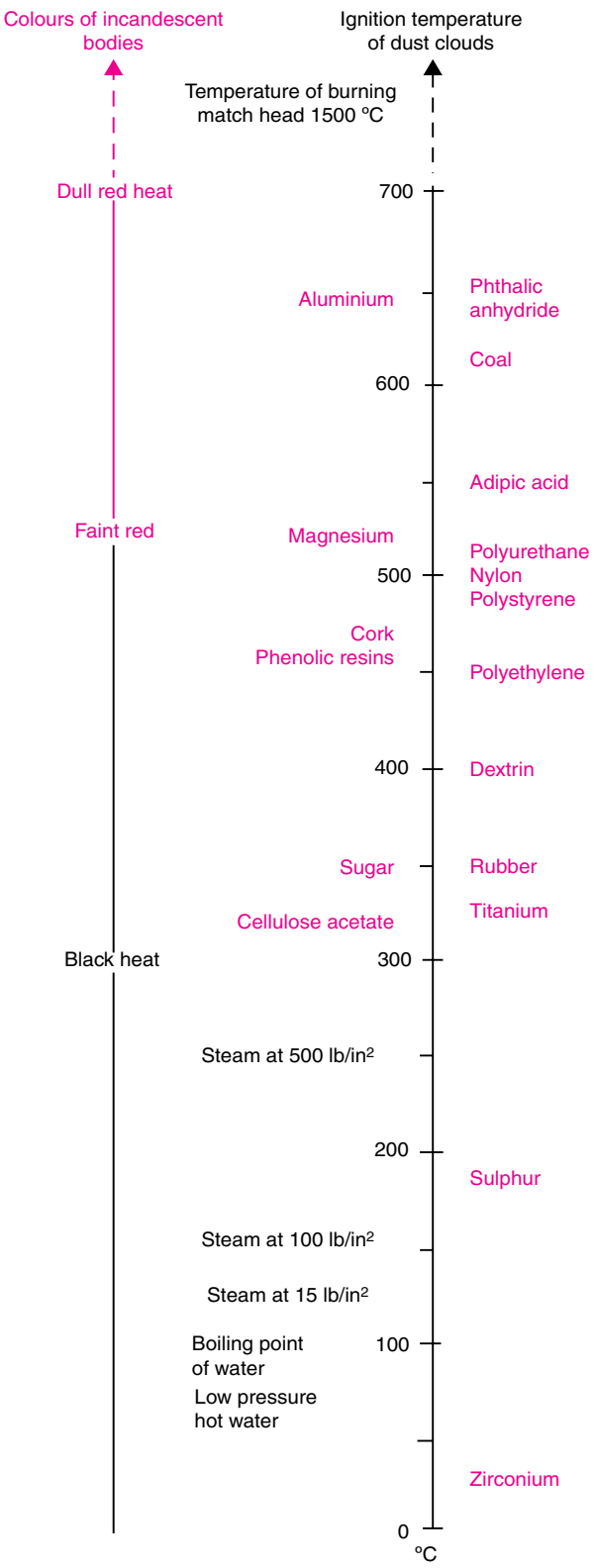


Figure 2: Surfaces that are not red hot are still capable of igniting dust clouds

5.6 Ignition

5.6.1 Care must be taken to exclude all potential ignition sources from dusty environments. These include:

- open flames;
- welding, cutting and other hot work;
- explosions from another source (secondary explosions);
- heat and sparks caused by friction, impact or electrical equipment;
- static electricity;
- hot electrical components;
- hot surfaces;
- smouldering sources, such as cigarettes or smouldering layers of dust; and
- spontaneous combustion.

5.6.2 The possibility of spontaneous combustion of dust or powder residues should be considered and any likelihood of this occurring should be eliminated. Spontaneous ignition may arise because layers of many forms of dust (but not all) have a lower ignition temperature than dust clouds (see table 3); the difference in some cases can be very significant (over 100°C). The problem may be accentuated when relatively thick layers of dust are allowed to accumulate on surfaces which may normally be at a safe temperature as these may have an insulating effect allowing smouldering to occur. If these layers are disturbed, particles may subsequently serve as an ignition source for a dust cloud.

Material	Ignition temperature of dust cloud (°C)	Ignition temperature of a 1.3cm layer (°C)
Alfalfa	460	200
Alkyd resin	500	270
Aluminium (flake)	610	320
Cellulose	410	300
Coal (37% volatiles)	610	170
Flour (wheat)	380	360
Milk powder	490	200
Soya flour	550	340
Sugar	370	400
Sulphur	190	220
Yeast	520	260
Zirconium	20	220

Table 3: Comparison of ignition temperature of clouds and layers of some dusts

5.6.3 A planned, preventive maintenance programme should be specified for all machinery and plant to minimise the possibility of overheated bearings and other potential ignition sources.

5.6.4 Suitable magnetic and/or pneumatic separators should be provided on the material inlet side of machinery to prevent ingress of foreign material and eliminate frictional sparking.

5.6.5 Gas and electrical welding and cutting, and the use of blowtorches should be restricted to designated areas such as workshops wherever possible. Where there is no alternative to carrying out a welding task in a hazardous area a strict permit to work system such as a hot work permit scheme described in RISCAuthority recommendations RC7 (ref 16) should be used.

5.6.6 Measures should be taken to prevent the accumulation of static electricity and resultant sparking discharges. (See section 5.7.)

5.6.7 Non-electrical equipment for use in explosive atmospheres should comply with the relevant parts of BS EN 13463 (ref 17).

Electrical installation

5.6.8 Wherever possible, electrical equipment should be located outside areas in which concentrations of explosible dust or powders may occur. Where it is not practicable to site electrical equipment outside these areas, expert advice should be sought.

5.6.9 Electrical equipment for use in potentially explosive atmospheres should comply with the requirements of Schedule 3 of DSEAR and be selected according to the appropriate hazard zone.

Schedule 3 of DSEAR requires that electrical equipment used in areas in which concentrations of explosible dust or powders may occur should be selected as follows:

- Zone 20 – category 1 equipment;
- Zone 21 – category 1 or 2 equipment; or
- Zone 22 – category 1, 2 or 3 equipment.

5.6.10 Equipment that is intended for use in an area where flammable atmospheres may occur should be labelled in accordance with the requirements of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (the EPS Regulations) (ref 18). This includes a requirement that it is marked with the CE conformity symbol, with the 'Ex' mark and the letter D where the product is suitable for use in dusty atmospheres.

The letter G designation indicates protection for use in explosive gas atmospheres and is not appropriate where a dust hazard may exist. Marking with the designation M indicates a level of protection intended for use in mines and should only be found on Group I equipment.

The label should also include other details such as the temperature group and protection levels for which it is certificated (see figure 3).

Advice on selection, installation and maintenance of certain types of protected equipment is given in BS EN 60079 (ref 3).

5.6.11 The electrical installation in the workplace should conform to the current edition of BS 7671 (The IET Wiring Regulations) (ref 19).

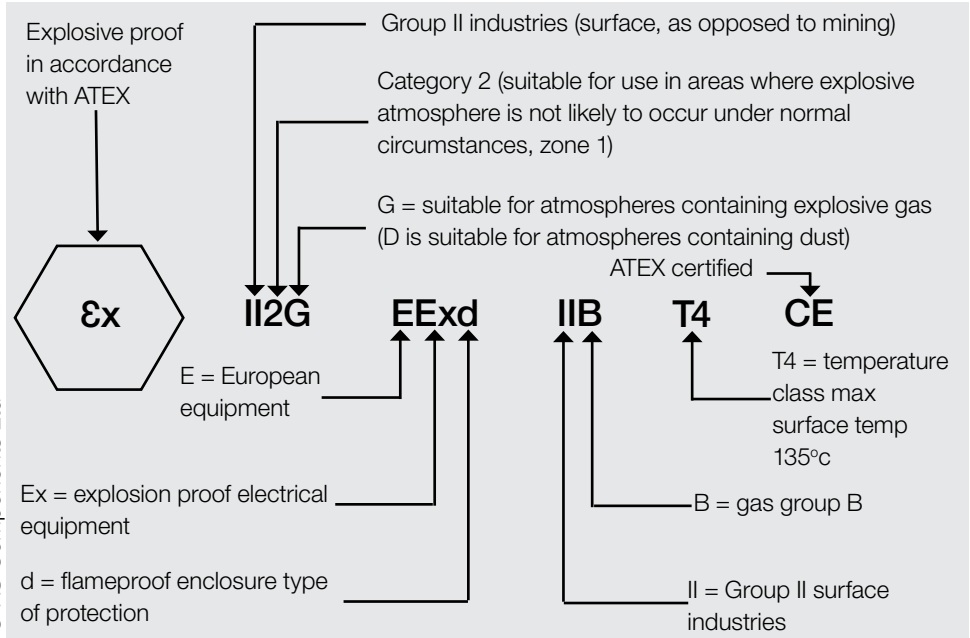


Figure 3: Example of labelling for an item of equipment certificated for use in a potentially explosive atmosphere

Static electricity

5.6.12 Casing, trunking, storage vessels and other items of plant, including plastic pipework, should be bonded and earthed to prevent the accumulation of electrostatic charges during the handling of dusts (ref 20).

5.6.13 People working in hazardous areas should be equipped with appropriate anti-static clothing as determined by the risk assessment.

5.6.14 Particular care is needed where manual dispensing of dusts and powders is required.

5.6.15 Flexible Intermediate Bulk Containers (FIBCs), often known as 'Big-Bags', are often used for the transportation of powdered and granular materials. The action of filling or emptying an FIBC can generate electrical charge thus FIBCs within hazardous areas should incorporate interconnected conductive threads or fabric which are suitably earthed.

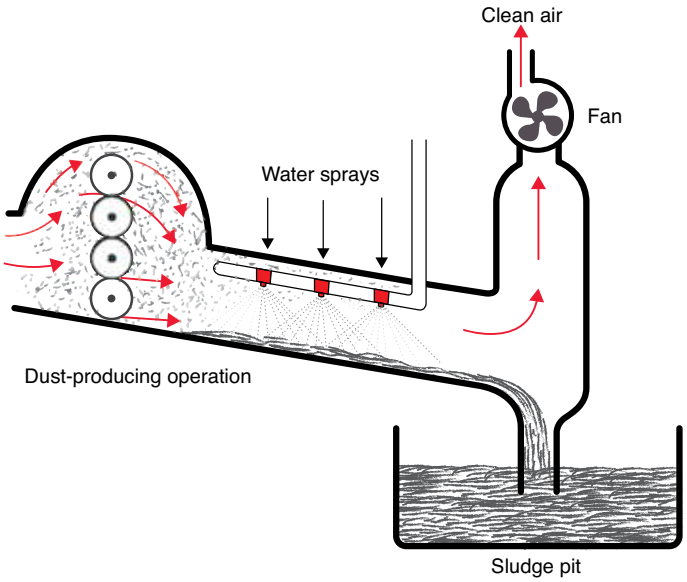


Figure 4: Wet recovery and collection of dust prevents escape into the atmosphere

5.7 Containment

5.7.1 Fully enclosed plant should be used wherever possible.

5.7.2 New plant and modifications to existing plant should be designed to:

- reduce the escape of dust or powder from within the plant to a minimum.
- prevent the accumulation of dust or powder in inaccessible areas where spontaneous ignition might occur.

5.7.3 Where only partial enclosure of the plant can be achieved, local mechanical exhaust ventilation should be provided as close as possible to the points of particle emission. Particles should be conveyed via metal ducting to suitably sited collectors. The use of portable dust collectors designed and built for the purpose may be appropriate for exhaust ventilation of small items of plant.

5.7.4 Fixed dust collectors should be suitably sited, preferably outside the building. Where this is not possible, cyclones and collectors should be sited with at least 1m of clear space from production plant and any fixed sources of ignition.

5.7.5 Dust collection ductwork should, where possible, not penetrate a fire compartment wall. If this is not possible, fire dampers should be installed in line with the compartment boundary to preserve the integrity of the compartment in the event of a fire.

Figure 5: Dust cyclone

5.7.6 Where external dust collection is in place and a risk assessment identifies the extraction duct as a possible route for fire spread into the plant, a fire damper should be installed to prevent burn back into the building.

5.7.7 The use of fire dampers in dust extraction ductwork should take into account the effects of dust deposits on the damper operating mechanism. (Specially designed dampers are available in which parts likely to be adversely affected by dust are mounted out of the airstream.)

5.7.8 Consideration should be given to wet recovery methods where appropriate as these eliminate many of the problems associated with the handling of recovered dust.

5.7.9 Any spillage of combustible powder should be removed promptly by use of a vacuum cleaner that is specially designed for this purpose. The material collected should be deposited in an enclosed non-combustible bin located outside the building to await safe disposal.

5.8 Exchange

5.8.1 When a new process is being designed or changes made to an existing process the use of alternative, less hazardous materials or procedures should be assessed and the process be made as safe as reasonably practicable. (For example, can a process using powder as a raw material be replaced by one using pellets or paste?)

This assessment should be undertaken before significant investment is made in dust or powder handling systems and explosion control equipment.

Note: Containment of combustible powder in the workplace should not be confused with containing an explosion within a reaction vessel or item of plant (see paragraphs 5.10.14 to 5.10.16).

5.9 Separation

5.9.1 Powders that are incompatible should be stored separately and handled in different areas of the plant.

5.9.2 Areas in which combustible powders are handled should be separated effectively from other fire compartments by elements of construction and self-closing fire doors that provide at least 30 minutes' fire resistance.

5.9.3 Stocks of combustible powders should be stored in non-combustible cabinets or bins.

5.10 Control of explosions

Venting

5.10.1 Properly designed and located explosion vents should be provided on vessels and equipment to relieve the pressure resulting from an explosion thus preventing or reducing damage. Proprietary venting devices are available for both buildings and equipment. The required area of explosion vents depends on the expected intensity of an explosion, the strength of the structure and the type of vent closure, together with other factors.

5.10.2 Buildings may also require vents; windows, doors, skylights and sections of walls or roofs can sometimes be adapted to serve as explosion vents in buildings provided that this would not introduce a hazard to staff or other people either within or outside of the premises.

5.10.3 Venting should be to a safe place, normally in the open air, taking into account the locations of people and property in the immediate vicinity.

5.10.4 Venting to the open air should not be considered if the material to be vented is toxic, radioactive, corrosive or hazardous in other ways.

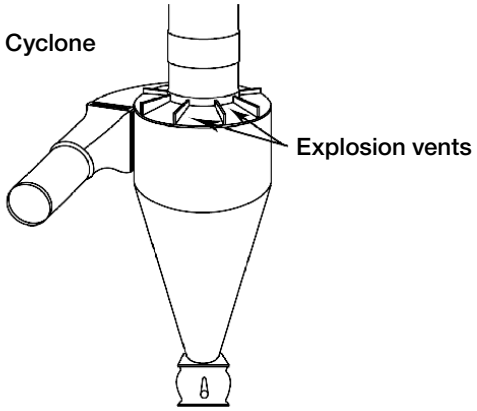
5.10.5 Where vent panels are in roofs or similar areas that may be susceptible to build up of snow, ice or other materials that could impair their function, procedures should be in place to ensure that the vents are monitored and any such accumulations are cleared as soon as possible.

5.10.6 The function of the explosion vents should be explained to all employees working in the area and the need to keep the immediate vicinity clear of obstructions, including fittings and services, such as pipework and cabling, must be made clear.

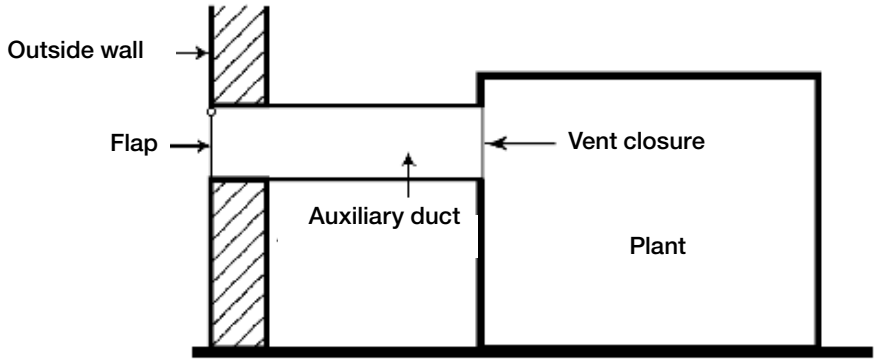
5.10.7 Vent sizing is a specialist field and calculations should be verified by a qualified, competent person such as a chemical engineer. In the event of the process, plant or buildings being altered the vent sizing should be re-assessed.

5.10.8 If venting alone is deemed to provide inadequate or unsafe protection, for example due to insufficient design strength of the vessel, additional measures such as inerting or suppression should be adopted (see below).

Figure 6: Examples of venting



The disruptive effects of an explosion can be materially reduced by providing vents which open when an explosion occurs. They should be designed to open at a pressure well below that which would severely strain or distort the structure. The hot gases and other materials can then escape.



Vents should be as close as practicable to likely points of ignition. They should be placed so that they do not discharge burning material into workrooms or into places where a secondary explosion or injury to persons could result.

Inert gas protection (inerting)

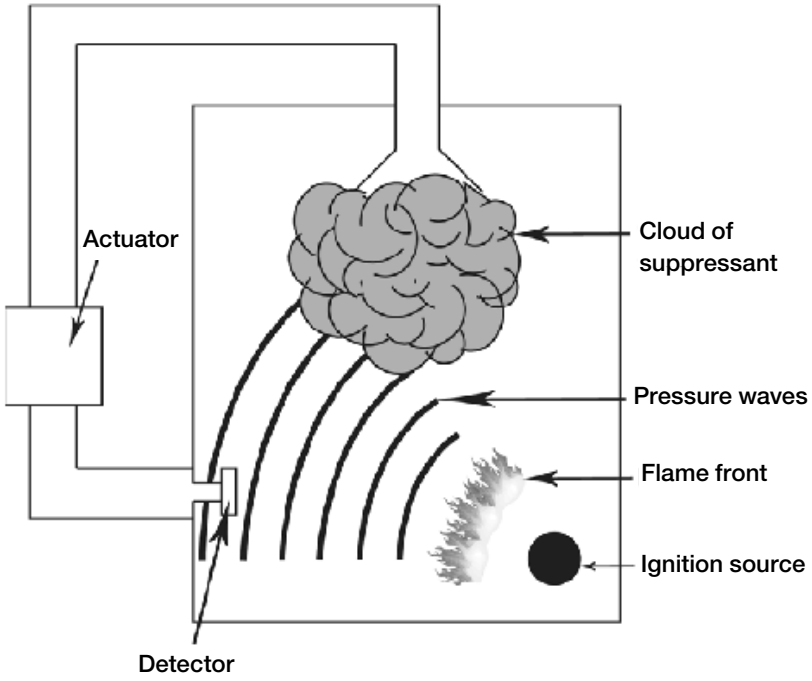
5.10.9 Explosions may be prevented in many plants and processes where the powder is confined within an enclosure by the replacement of the normal atmosphere in the reaction vessel with an inert gas. Gases such as nitrogen or carbon dioxide are commonly used and have the additional benefit of lowering the upper explosive limit of the dust in the atmosphere.

5.10.10 Expert advice should be sought from a qualified chemist or chemical engineer familiar with the materials in use. This is particularly important where metal dusts are concerned, as some of these are sufficiently reactive to ignite in the presence of some common inerting gases.

5.10.11 Provision of an explosion suppression system is recommended for suitably enclosed plant. There may be limitations on the size of vessel that can be protected in this way. Experience has shown that vessels up to 250m^3 can be protected but it is theoretically possible to protect vessels up to 1000m^3.

5.10.12 In these systems, sensitive pressure detectors are installed inside the plant. The detectors are connected to a reservoir of inerting agent. The detectors are able to detect an incipient explosion and the system can react with sufficient speed to inject the inerting agent into the plant and disrupt the explosion flame front before dangerous pressures are reached.

Figure 7: Explosion suppression



The very brief interval of time between first ignition and the attainment of peak pressure in an explosion can be utilised to suppress the explosion. A quick-acting pressure switch can be installed which will respond to the initial and comparatively slow increase in pressure. The switch releases a chemical to suppress the explosion.

Containment

5.10.13 Where it is not possible to control the risk of explosion using venting, inerting or suppression systems, precautions should be taken to ensure that:

- vessels and equipment are designed to withstand the maximum pressures that can be generated in an explosion; and
- any explosion is prevented from spreading within the plant.

This can be achieved by:

- the use of individual vessels isolated from other plant; or

- by the sub-division of continuous plant with rotary valves, rapid-action valves or similar barriers.

5.10.14 Other separating systems taking the form of chokes include:

- screw conveyors with a section of the flight removed; and
- a baffle plate within a screw conveyor (for horizontal applications only).

5.10.15 It is important to ensure that where vessels are protected by containment they may be isolated from the rest of the plant at upstream and downstream connections, for example by rotary valves (see figure 9).

Dilution

5.10.16 For some processes it may be possible to reduce the risk of explosion by diluting the explosible material below its explosive limit with an inert powder.

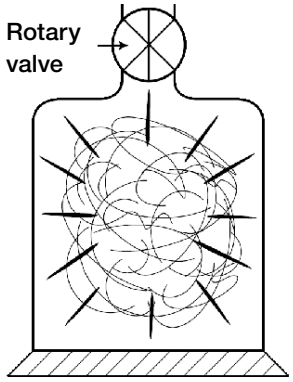


Figure 8: Containment pressures of 7bar may be generated in an explosion. Plant of certain types of operation, eg grinding and pneumatic conveying, can be made to withstand and contain dust explosions of this order

5.11 Fire protection

5.11.1 Fire protection measures for areas where combustible dusts are being stored, handled or used should be proportionate to the risk and be based on the findings of the risk assessments undertaken in compliance with fire safety legislation and DSEAR (refs 5-10).

5.11.2 The production area should be protected by an automatic fire detection and alarm system (AFD). To minimise unwanted alarm signals serious consideration should be given to installing detector heads with multiple sensors that require more than one form of response before going into alarm mode (eg smoke, heat or carbon monoxide).

5.11.3 The AFD system should be installed by an engineer with certification from an independent UKAS accredited third party certification body. The system should be to a recognised category of installation in accordance with BS 5839-1 (ref 21) as determined by a risk assessment and in consultation with the insurer.

5.11.4 The automatic fire detection and alarm system should be monitored either on-site or by an off-site alarm receiving centre with accreditation by an independent UKAS accredited third party certification body and operating in accordance with BS 5979 (ref 22).

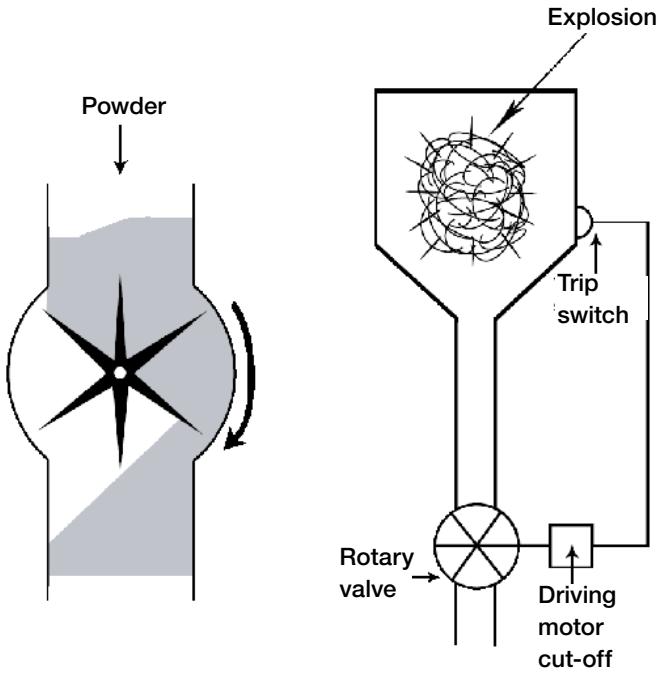
5.11.5 Consideration should be given at the design stage to providing a suitable automatic fire suppression system. This should be designed, installed, commissioned and maintained by an engineer certificated by a UKAS accredited third party certification body.

5.11.6 Where the risk assessment or consultation with the insurer determines that water sprinklers should be installed, the installation should be designed, installed, commissioned and maintained in accordance with the **LPC Sprinkler Rules incorporating BS EN 12845** (ref 23).

5.11.7 A suitable number of appropriate portable fire extinguishers should be provided. The extinguishers should be approved and certified by an independent, third party certification body and be installed in accordance with BS 5306-8 (ref 24).

5.11.8 Portable fire extinguishers should be inspected and maintained by a competent engineer in compliance with BS 5306-3 (ref 25).

Figure 9: Rotary valves



This valve consists of a number of vanes on a spindle rotated by a motor. The vanes are enclosed and just clear the casing. There is no direct passage between the inlet and outlet of the valve. On rotation it allows the downward movement of powders but prevents the direct passage of an explosion flame front. Burning particles could be carried through the rotating valve, however, and to lessen this risk a trip switch can be used to cut off the valve motor.

6. Checklist

		Yes	No	N/A	Action required	Due date	Sign on completion
6.1	**Compliance with fire safety legislation**						
6.1.1	Has a suitable and sufficient fire risk assessment been undertaken for all premises to which the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) applies? (5.1.1)						
6.1.2	In areas where combustible powders are being handled and a dust explosion may occur has an assessment been undertaken in accordance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)? (5.1.2)						
6.1.3	Do the implications for property protection and business continuity, as well as life safety, feature prominently in the assessments? (5.1.3)						
6.1.4	Are the risk assessments the subject of periodic review, including at the time when any changes to the process, the use of powders or potential production of dust are being considered? (5.1.4)						
6.1.5	Has liaison been established with the fire and rescue services to become aware of the levels of response in the areas in which their premises are located? (5.1.6)						
6.2	**Business continuity**						
6.2.1	If it is intended that equipment processing dusts is to be left operating without staff in attendance then was this taken into consideration at the time of the DSEAR assessment? (5.2.1)						
6.2.2	If a change in procedures is to result in a process involving the use of powders to continue unattended then will the insurers of the property be consulted and the DSEAR assessment reviewed? (5.2.2)						
6.2.3	Have steps been taken to maintain the continuity of operations by making a suitable emergency plan? (5.2.3)						
6.2.4	Are tabletop exercises held periodically to test the effectiveness and suitability of the emergency plan? (5.2.4)						
6.2.5	Has consideration been given to applying commercially available computer programmes, such as the ROBUST software (Resilient Business Software Toolkit) that is available free of charge (ref 13), or similar product, to develop and check the adequacy of the plan? (5.2.5)						
6.3	**Fire safety management**						
6.3.1	Has attention been given to eliminating combustible powders from the workplace wherever possible? (5.3.1)						
6.3.2	Is particular care taken when working with, or producing metallic dusts as their properties may be quite different from organic powders? (5.3.2)						
6.3.3	Are the hazard zones identified as a result of the DSEAR assessment identified and recorded on plans with a copy of the plan showing the hazard zones being available for the fire and rescue service? (5.3.3)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.3.4	Where appropriate, are areas classified as zones 20, 21 or 22 marked at their entrance points by the sign prescribed in Schedule 4 of DSEAR? (5.3.4)						
6.3.5	Do management procedures ensure that measures are in place to ensure good housekeeping (including cleaning and the checking of plant), appropriate maintenance and service contracts (including contracts with specialist companies for explosion suppression and venting systems), a permit to work scheme and regular monitoring of any changes of activities or processes in or near hazard zones? (5.3.5)						
6.3.6	Is hot work prohibited in areas where there could be a release of combustible dust, with the equipment being removed to a safe environment, such as a workshop, for the work to be carried out?						
6.3.7	Is the local fire and rescue service encouraged to make familiarisation visits to the premises to acquaint themselves with the nature of the processes and location of the hazard zones? (5.3.7)						
6.3.8	Are quantities of powders stored and in use in production areas limited to the minimum amounts necessary for the period of work? (5.3.8)						
6.3.9	Is the workplace kept clean and tidy with the development of dust or powder deposits regularly monitored and any areas where accumulations are greater than normal being subject to more frequent cleaning? (5.3.9)						
6.3.10	Is manual cleaning of hazard zones undertaken using a suitable vacuum cleaner specially designed for removing combustible dusts on at least a daily basis? (5.3.10)						
6.3.11	Are blowing down techniques prohibited as they will disperse dust in the atmosphere? (5.3.11)						
6.3.12	Are brushing and sweeping avoided if at all possible? (5.3.12)						
6.3.13	Is washing down considered as a cleaning method provided that the components of the dust or powder are compatible with water and other cleaning materials used and there are no environmental issues? (5.3.13)						
6.3.14	Is damping of layers of dust, where appropriate, used to allow deposits to be swept up safely where vacuum cleaning is not possible? (5.3.14)						
6.3.15	Is material collected during cleaning disposed of immediately in lidded, non-combustible containers, preferably constructed of metal, located outside the building? (5.3.15)						
6.3.16	To minimise the accumulation of dust deposits, are horizontal exposed surfaces eliminated from the design of the work area wherever possible? (5.3.16)						
6.3.17	Is all equipment that uses a powder as a feedstock or may produce dust maintained and serviced according to the manufacturer's instructions so as to minimise the dispersion of dust in the air? (5.3.17)						
6.3.18	Are personnel working in areas where explosible dusts or powders may be present given practical training in the use of fire extinguishing equipment? (5.3.18)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.3.19	Are new employees given induction training so that they understand the hazards associated with the materials that they are using and the relevant control measures? (5.3.19)						
6.3.20	Is periodic refresher training given to all staff and in particular to those involved with inspection, maintenance and the operation of permits to work? (5.3.20)						
6.3.21	Are staff trained in good practice relating to the opening and handling of containers of powdered products where these may form explosible concentrations in air? (5.3.21)						
6.3.22	Are all staff familiar with the hazards associated with powdered products in the workplace and the actions to be followed in the event of a fire or spillage? (5.3.22)						
6.3.23	Are staff made aware of the hazards of deliberate fire raising, which may be carried out by staff and visitors as well as by intruders? (5.3.23)						
6.4	**VICES**						
6.4.1	Are staff familiar with the acronym VICES to help apply five basic principles which ensure that any combustible dusts that are absolutely necessary in the workplace are used and stored with appropriate care? (5.4.1)						
6.4.2	Is suitable staff training in place to ensure all personnel are aware of the hazards in the workplace and to apply VICES to ensure a safer working environment for all? (5.4.2)						
6.4.3	Ventilation: (5.4.3) • Is the ventilation controlled to ensure that in the event of a spillage, powder is not distributed to form a combustible mixture in the air?						
6.4.4	Ignition: (5.4.3) • Have all possible ignition sources been removed? • Have hot surfaces been eliminated as far as possible? • Is the electrical equipment used in this area appropriate for the hazard zone?						
6.4.5	Containment: (5.4.3) • Are powders stored in suitable containers? • Have staff been trained to handle stocks of powder with care? • Are staff trained in the actions to take in the event of a spillage? • Is suitable equipment available to safely remove spilled powder? • Have suitable catchment devices been installed and maintained where appropriate?						
6.4.6	Exchange: (5.4.3) • Can combustible powders be eliminated from the process? • Can a powder be replaced by one that is less combustible?						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.4.7	Separation: (5.4.3) • Are incompatible materials suitably separated? • Are physical barriers (for example walls, doors, cabinets and bins) present as required?						
6.5	**Ventilation**						
6.5.1	Are buildings housing dusty processes or plant provided with general exhaust ventilation by fans and ducting to collectors in order to reduce potential accumulations of dust or powder on surfaces? (5.3.1)						
6.5.2	Are processes that may lead to accumulations of powder or dust located away from external doors to prevent the possibility of dust being blown into the atmosphere when the doors are opened? (5.5.2)						
6.6	**Ignition**						
6.6.1	Is care taken to exclude all potential ignition sources from dusty environments? (5.6.1)						
6.6.2	Has the possibility of spontaneous combustion of dust or powder residues been considered and any likelihood of this occurring been eliminated? (5.6.2)						
6.6.3	Has a planned, preventive maintenance programme been specified for all machinery and plant to minimise the possibility of overheated bearings and other potential ignition sources? (5.6.3)						
6.6.4	Have suitable magnetic and/or pneumatic separators been provided on the material inlet side of machinery to prevent ingress of foreign material and eliminate frictional sparking? (5.6.4)						
6.6.5	Have gas and electrical welding and cutting, and the use of blowtorches been restricted to designated areas such as workshops wherever possible? (5.6.5)						
6.6.6	Have measures been taken to prevent the accumulation of static electricity and resultant sparking discharges? (5.6.6)						
6.6.7	Does non-electrical equipment for use in explosive atmospheres comply with the relevant parts of BS EN 13463? (5.6.7)						
6.6.8	Wherever possible, is electrical equipment located outside areas in which concentrations of explosible dust or powders may occur? (5.6.8)						
6.6.9	Does electrical equipment for use in potentially explosive atmospheres comply with the requirements of Schedule 3 of DSEAR and selected according to the appropriate hazard zone? (5.6.9)						
6.6.10	Is equipment that is intended for use in an area where flammable atmospheres may occur labelled in accordance with the requirements of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (the EPS Regulations)? (5.6.10)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.6.11	Does the electrical installation in the workplace conform to the current edition of BS 7671? (5.6.11)						
6.6.12	Is all casing, trunking, storage vessels and other items of plant, including plastic pipework, bonded and earthed to prevent the accumulation of electrostatic charges during the handling of dusts? (5.6.12)						
6.6.13	Are people working in hazardous areas equipped with appropriate anti-static clothing as determined by the risk assessment? (5.6.13)						
6.6.14	Is particular care taken where manual dispensing of dusts and powders is required? (5.6.14)						
6.6.15	Do FIBCs used in hazardous areas incorporate interconnected conductive threads or fabric and are they appropriately earthed? (5.6.15)						
6.7	**Containment**						
6.7.1	Is fully enclosed plant should used wherever possible? (5.7.1)						
6.7.2	Is new plant and any modification to existing plant designed to reduce the escape of dust or powder to a minimum and prevent the accumulations in inaccessible areas where spontaneous ignition might occur? (5.7.2)						
6.7.3	Where only partial enclosure of the plant can be achieved, is local mechanical exhaust ventilation provided as close as possible to the points of particle emission? (5.7.3)						
6.7.4	Are fixed dust collectors suitably sited, preferably outside the building? (5.7.4)						
6.7.5	Is dust collection ductwork routed so as to avoid penetrating fire compartment walls? (5.7.5)						
6.7.6	Where external dust collection is in place and a risk assessment identifies the extraction duct as a possible route for fire spread into the plant, has a fire damper been installed to prevent burn back into the building? (5.7.6)						
6.7.7	Does the use of fire dampers in dust extraction ductwork take into account the effects of dust deposits on the damper operating mechanism? (5.7.7)						
6.7.8	Has consideration been given to employing wet recovery methods for dust? (5.7.8)						
6.7.9	Is any spillage of combustible powder removed promptly by use of a vacuum cleaner that is specially designed for this purpose and deposited in an enclosed non-combustible bin located outside the building? (5.7.9)						
6.8	**Exchange**						
6.8.1	When a new process is being designed or changes are being made to an existing process is the use of alternative, less hazardous materials or procedures assessed to make the process as safe as reasonably practicable? (5.8.1)						
6.9	**Separation**						
6.9.1	Are powders that are incompatible stored separately and handled in different areas of the plant? (5.9.1)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.9.2	Are areas in which combustible powders are handled separated effectively from other fire compartments by elements of construction and self-closing fire doors that provide at least 30 minutes' fire resistance? (5.9.2)						
6.9.3	Are stocks of combustible powders stored in non-combustible cabinets or bins? (5.9.3)						
6.10	**Control of explosions**						
6.10.1	Are properly designed and located explosion vents provided on vessels and equipment to relieve the pressure resulting from an explosion? (5.10.1)						
6.10.2	Are buildings provided with vents in the form of windows, doors, skylights or suitable sections of walls or roofs? (5.10.2)						
6.10.3	Does venting occur to a safe place, normally in the open air, and take into account the locations of people and property in the immediate vicinity? (5.10.3)						
6.10.4	Is venting to the open air not undertaken if the material to be vented is toxic, radioactive, corrosive or hazardous in other ways? (5.10.4)						
6.10.5	Where vent panels are in roofs or similar areas that may be susceptible to build up of snow, ice or other materials that could impair their function, are procedures in place to ensure that the vents are monitored and any such accumulations are cleared as soon as possible? (5.10.5)						
6.10.6	Has the function of the explosion vents been explained to all employees working in the area and the need to keep the immediate vicinity clear of obstructions been made clear? (5.10.6)						
6.10.7	As vent sizing is a specialist field are calculations verified by a qualified, competent person such as a chemical engineer? (5.10.7)						
6.10.8	If venting alone is deemed to provide inadequate or unsafe protection, for example due to insufficient design strength of the vessel, are additional measures such as inerting or suppression adopted? (5.10.8)						
6.10.9	Explosions may be prevented in many plants and processes where the powder is confined within an enclosure by the replacement of the normal atmosphere in the reaction vessel with an inert gas. Where this is to be employed has the use of gases such as nitrogen or carbon dioxide been considered? (5.10.9)						
6.10.10	Has expert advice been sought from a qualified chemist or chemical engineer familiar with the materials in use? (5.10.10)						
6.10.11	Has an explosion suppression system been provided for suitably enclosed plant? (5.10.11)						
6.10.12	Where appropriate, are sensitive pressure detectors installed inside the plant to detect an incipient explosion and allow the system to react with sufficient speed to inject the inerting agent and disrupt the explosion flame front before dangerous pressures are reached? (5.10.12)						

		Yes	No	N/A	Action required	Due date	Sign on completion
6.10.13	Where it is not possible to control the risk of explosion using venting, inerting or suppression systems, have precautions been taken to ensure that vessels and equipment are designed to withstand the maximum pressures that can be generated in an explosion? (5.10.13)						
6.10.14	Where appropriate, has consideration been given to employing other separating systems such as a screw conveyor with a section of the flight removed or a baffle plate within a screw conveyor? (5.10.14)						
6.10.15	Where vessels are protected by containment are they able to be isolated from the rest of the plant by upstream and downstream connections, for example by rotary valves? (5.10.15)						
6.10.16	Is it possible to reduce the risk of explosion by diluting the explosible material below its explosive limit with an inert powder? (5.10.16)						
6.11	**Fire protection**						
6.11.1	Are the fire protection measures for areas where combustible dusts are being stored, handled or used proportionate to the risk and based on the findings of the risk assessments undertaken in compliance with fire safety legislation and DSEAR? (5.11.1)						
6.11.2	Is the production area protected by an automatic fire detection and alarm system using detector heads with multiple sensors that require more than one form of response before going into alarm mode? (5.11.2)						
6.11.3	Has the AFD system been installed by an engineer with certification from an independent UKAS accredited third party certification body? (5.11.3)						
6.11.4	Has the AFD system been installed to a recognised category as defined in BS 5839-1 as determined by a risk assessment and in consultation with the insurer? (5.11.3)						
6.11.5	Is the automatic fire detection and alarm system monitored either on-site or by an off-site alarm receiving centre with accreditation by an independent UKAS accredited third party certification body and operating in accordance with BS 5979? (5.11.4)						
6.11.6	Has consideration been given at the design stage to providing a suitable automatic fire suppression system designed, installed, commissioned and maintained by an engineer certificated by a UKAS accredited third party certification body? (5.11.5)						
6.11.7	Where the risk assessment or consultation with the insurer determines that water sprinklers should be installed, has the installation been designed, installed, commissioned and maintained in accordance with the **LPC Sprinkler Rules incorporating BS EN 12845**? (5.11.6)						
6.11.8	Have a suitable number of appropriate portable fire extinguishers been provided and installed in accordance with BS 5306-8? (5.11.7)						
6.11.9	Are portable fire extinguishers inspected and maintained by a competent engineer in compliance with BS 5306-3? (5.11.8)						

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24. BS 5306-8: 2012: **Fire extinguishing installations and equipment on premises. Selection and positioning of portable fire extinguishers. Code of practice**. British Standards Institution.
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Further reading

HSG103: **Safe handling of combustible dusts: Precautions against explosions**, Second edition 2003, Health and Safety Executive.

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RC12 First Published 1991 Version 3

Web version only