HSE Health & Safety Executive

Dust explosions in the food industry

Food Sheet No 2

Introduction

Dust explosions in the food industry have caused serious industrial accidents resulting in multiple fatalities and severe structural damage. Explosible dusts in the food industry include flour, custard powder, instant coffee, sugar, dried milk, potato powder and soup powder.

Common processes generating explosible dust in the food industry inc!ude flour and provender milling, sugar grinding, spray drying of milk and instant coffee, conveyance/storage of whole grains and finely divided materials.

A dust cloud of any flammable material will explode where:

1 The concentration of dust in air falls within the explosive limits.

2 A source of ignition of the required energy is present.

Prevention concentrates upon exclusion of one or preferably both of these conditions. Further precautionary measures include inerting, prevention of secondary explosions, explosion relief, explosion suppression, explosion containment and building design.

This information sheet summarises some recent developments in this subject and offers guidance on several areas specific to the food industry. It should be read along with HS(G)103 *Safe handling of combustible dusts - precautions against explosions*[1].

Classification of dusts according to their explosibility

Design of protection measures is best based upon the results of the 20 litres sphere test as such results can be reliably scaled up to apply to industrial sized vessels. Such tests enable the Kst value (maximum rate of pressure rise when tested), a measure of a dust's explosibility, to be established. Dusts may be classified as follows.

Dust explosion class	*Kst (Bar m s^{-1})*	*Characteristics*
St 0	0	No explosion
St 1	>0 <200	Weak explosion
St 2	>200 <300	Strong explosion
St 3	>300	Very strong explosion

Most dusts in the food industry are Class St 1.

Dust explosion precautions

The following precautions are commonly applied to plant for storage and handling of both whole grains, for example maize, barley wheat, oats, rye soya beans, sorghum (milo) and explosible meals and flours.

1 Locate plant in the open air or in a lightweight building so that the roof and wall cladding panels can act as explosion relief. On older brick/stone built premises, provide the maximum area of explosion relief which is reasonably practicable. Aim for a minimum of 1 m^2 per 24 m^3 of building volume.

2 Enclose plant and equipment to prevent escape and accumulation of dust in the building.

3 Maintain scrupulous cleanliness including, normally, a centralised piped vacuum cleaning system.

4 Maintain slight negative pressure on storage vessels such as bins and silos.

5 Provide adequate arrangements for separating powder from its transporting air when pneumatic conveyor systems are used.

6 Fit silos or bins with explosion relief.

7 Equip dust collecting silos with explosion relief and a rotary valve at the base to act as an explosion choke. If the explosion relief is located above the vortex finder it is essential that the strength of the

vortex finder ('thimble') is adequate to withstand an explosion within the cyclone without collapsing. If it collapses, the explosion relief would be useless.

8 Totally enclose dust collecting filter units and fit with explosion relief.

9 Equip bucket elevators (unless wooden) with explosion relief at the head of the elevator. Fit each leg of the elevator with explosion relief equal in area to the cross sectional area of the leg at least at 6 m intervals from the top of the elevator.

10 Preferably, fit bucket elevators with underspeed switches and alignment monitors.

11 Exclude obvious ignition sources. Use electrical equipment dust protected to IP5X or IP6X (see BS 6467 Parts 1 and 2), depending on dust levels. Surface temperatures should be controlled to a maximum of 200°C (lower for milk powder, some fish meals and other products with unsaturated oils in them). Prohibit use of inspection lamps with flexible cables. To check levels in bins use explosion-proof battery hand lamps secured against accidental dropping or tripods with fixed lamps placed over inspection hatches.

12 Use an effective permit-to-work system to control hot work, welding etc.

13 Equip all explosion reliefs with index switches to close down the plant in the event of explosion relief being activated to prevent the onward transmission of burning material.

Pneumatic conveying systems

These systems are often equipped with under and over pressure sensors to close down the system. An under pressure would occur downstream of any substantial leak which developed. An over pressure would be caused if someone tried to overfill a receiving vessel. Vessels supplied by pneumatic conveying systems must have adequate air stripping capacity and are normally fitted with level gauges to prevent overfilling.

To prevent arcing from static electricity all metalwork of powder handling systems, including delivery tankers, should be electrically bonded and earthed. The resistance to earth should not exceed 10 ohms.

Chokes

Rotary valves with rubber edged blades or with excessive gaps between vanes and casing do not act as an effective choke.

Where space does not allow fitting of a rotary valve, chemical flame suppressant barriers may be used. Explosion detectors are located in both vessels. Triggering of either of these releases suppressant material (eg sodium bicarbonate) under pressure into the ducting of the pipework connecting two vessels.

Sizing of explosion reliefs

A variety of approaches to sizing of explosion reliefs exists and these are described in Part 1 of the Institution of Chemical Engineers Guide[2]. In the past, reference has been made to the vent ratio method which stipulates a given explosion relief area for a given volume of vessel as shown below.

Volume (m^3) range	*Modification*
30-300	Vent ratio reduced linearly from 1 m^2/6 m^3 to 1 m^2/25 m^3
300-600 (silos)	Half area of top (full area for more explosive dusts)
700	Full area of top

This method may continue to be used but there is a general preference for the precise nomograph or cubic law method. This allows more careful tailoring of vent sizing for the vessel concerned. The method requires prior knowledge of the vessel size and strength and the explosibility characteristics (Kst value) of the dust to be handled. Smaller vent sizes for the same size vessel may be predicted in some cases.

Explosion reliefs for small vessels

There is no established size of vessel below which explosion reliefs are not required. In each case the consequences of an explosion need to be considered and Figure 1 sets out the factors to take into account.

Ducting explosion reliefs to open air

As a general rule explosion reliefs should be ducted directly to open air by means of a strong straight duct not much longer than 3 m. Longer ducts involving bends may still be effective provided they are within the detailed parameters described in Part 3 of the Institution of Chemical Engineers Guide[2].

Milling and grinding

Feed stock is now very commonly treated by screening, de-stoning, pneumatic separation and magnets to remove foreign bodies before milling. Hammer mills are usually strong enough to contain a dust explosion. Associated cyclone/dust collector units are usually not and should be equipped with explosion relief and a rotary valve at the discharge.

Bulk tank deliveries

Some fires and minor explosions have occurred involving the pneumatic blower unit on the discharging vehicle. The problem appears to stem from product getting into the blower fan causing frictional heat or blinding of the clean air intake filter or both, resulting in ignition of filter material. It seems likely that non-return valves downstream of the blower are ineffective, particularly if the vehicle driver switches off the blower and relies on residual pressure within the bulk tank to discharge the last of the product. This may cause product to enter the blower. Warn drivers of the danger and tell them to keep blowers going until discharge is fully complete.

Fabric topped silos

These are occasionally used for storage of flour. The top of the silo acts as an explosion relief and should, where reasonably practicable, be ducted direct to open air. If not, the silo should be treated as for fabric silos.

Fabric silos

The main fire and explosion risk is involvement in an external fire resulting in melting and burning of the fabric and the release of large quantities of flour which form an explosible dust cloud.

Where open air location is not practicable, preferably site the silo in a room which has adequate fire separation from the rest of the premises and is fitted with explosion relief.

If siting the silo in a process area is unavoidable, it should be partitioned by an enclosure of at least half hour fire resistance. Aspirated air from the enclosure should preferably be vented outside the building but where this is not reasonably practicable, a fully or partially open top may be permissible. Space is needed around the silo for observation during filling, inspection, maintenance and cleaning. Preferably there should be no electrical equipment within the enclosure but any necessary should have dust-tight construction and a low surface temperature.

Flat floor grain storage

Dedicated storage buildings are normally used with no processing plant installed or other work activities carried on in them. Eliminate high level horizontal surfaces where possible, eg by use of sloping surfaces to minimise dust accumulation.

Fluorescent tubes with enclosures of IP5X at roof level would appear to be satisfactory light fittings.

Measurements of dust levels during grain handling have shown that explosible concentrations are not likely to be reached unless substantial deposits of fine dust are disturbed. Grain throwers could pose a risk and should not be used. Dust levels in the building are, however, likely to be a health hazard. Roof or side wall extraction ventilation fans with electrical enclosure to IP6X standard may be installed.

Grain heaps should be aerated to prevent self heating and may be monitored to detect any temperature rise.

Sources of further information

1 *Safe handling of combustible dust - precautions against explosions* HS(G)103 1994 ISBN 0 7176 0725 9

2 The Institution of Chemical Engineers *Guide to Dust Explosion Prevention and Protection*

Part 1 *Venting*

Part 2 *Ignition prevention, containment, inerting, suppression, and isolation*

Part 3 *Venting of weak explosions and the effect of vent ducts*

Institution of Chemical Engineers, 165-171 Railway Terrace, Rugby, Warwickshire CV21 3HQ

3 *Dust explosions* by P Field (1982), Volume 4 of the *Hand book of powder technology,* Elsevier.
ISBN 0 444 407 464

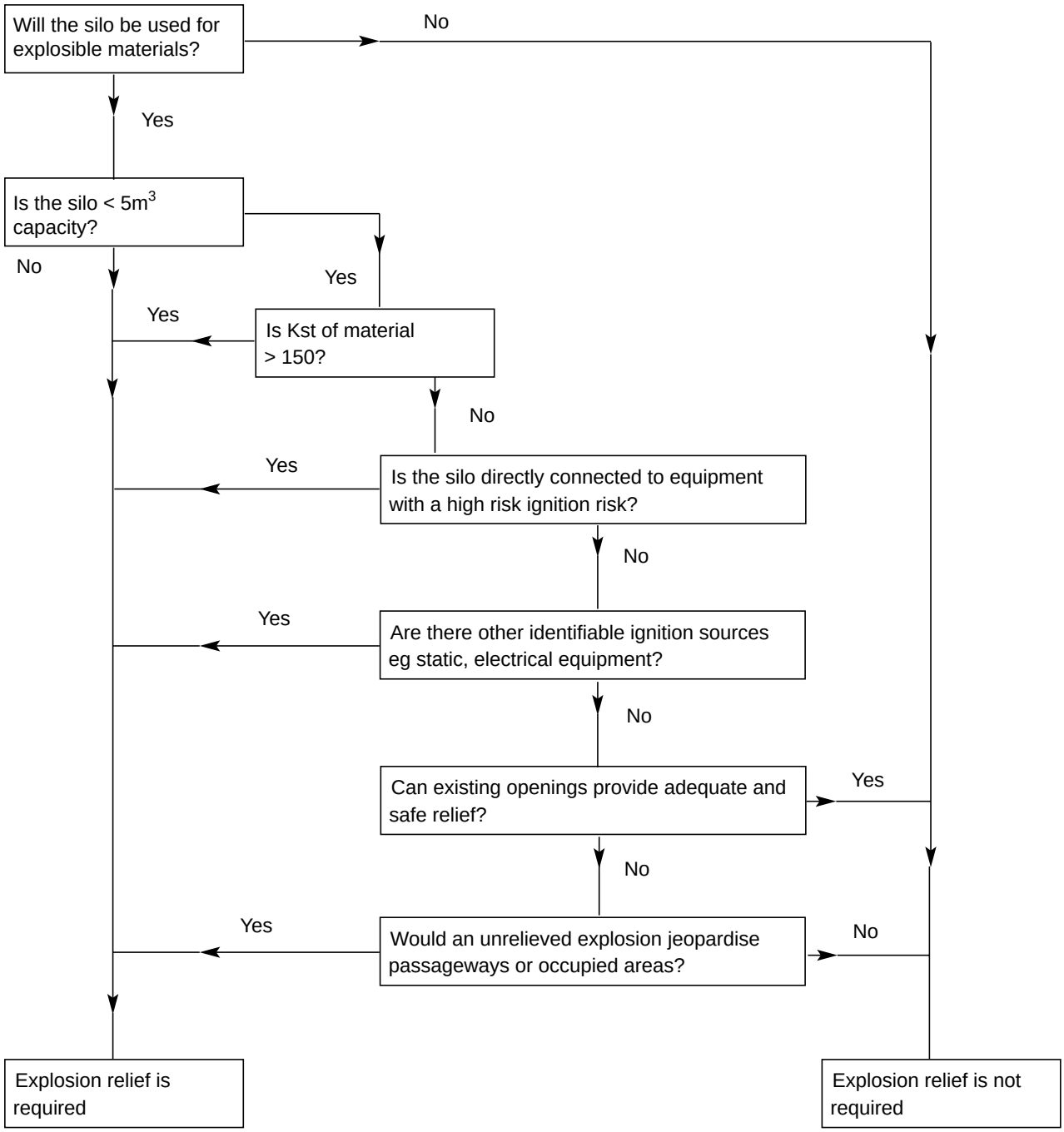
4 *The prevention of fire and dust explosions in flour mills and bulk flour containers* published by the Incorporated National Association of British and Irish Millers Ltd, 21 Arlington Street, London SW1A 1RN

5 *The explosibility of dispersed flour dust* published by the Incorporated National Association of British and Irish Millers Ltd, 21 Arlington Street, London SW1A 1RN

6 *Prevention of fire and explosion in spray drying plant - a Code of Practice for designers, manufacturers, suppliers and users* published by the Association of British Preserved Milk Manufacturers, 19 Cornwall Terrace, London NW1P 4QP

7 *Storekeepers Charter: guidance for storekeepers of grain, oil seed rape, pulses etc,* published by the United Kingdom Agricultural Supply Trade Association Ltd (UKASTA), 3 Whitehall Court, London SW1 A 2EQ.

Figure 1 Explosion relief for small bins and silos: factors to take into consideration



This guidance is issued by the Health and Safety Executive. 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 inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

Printed and published by HSE 2/96 NIS/21/02 C30