

DISCIPLINE INFORMATION NOTE

Flammable Solids & Dusts

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To: Process Safety Inspectors HID and FOD.

FIRE HAZARDS OF STORED POWDERED PRODUCTS BY ALAN TYLDESLEY

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1. The causes and consequences of dust explosions have been well documented, and almost always these events start inside the process where powder is being moved or processed so that a cloud is formed. In a static storage situation, the risks are normally much less, and in many cases, if an ignition source is applied to the surface of a pile of powder, any fire will develop very slowly.

INCIDENTS

2. Two incidents and some research completed recently in July 2003 by the Health and Safety Laboratory have highlighted circumstances in which the fire risk may be considerable, particularly in large warehouses. This circular is intended to alert inspectors and those in control of premises to the risks, and suggest alternatives for controlling those risks.
3. Two fatal fires have resulted in circumstances where powdered product flowed into a growing fire.
4. The first of these, at a factory producing plastic packaging, seems to have started with a fire in an air filter associated with a pneumatic conveying system. Adjacent to this was a small aluminium hopper, fed from above by a flexible intermediate bulk container, resting with its outlet untied on the hopper top. The powdered product involved was a fine free flowing polymer additive. As a result of the fire at the air filter the aluminium hopper failed, probably when some of the metal melted. This allowed powder to escape into the fire already present, and more powder to flow into the top of the hopper from the flexible intermediate bulk container above.
5. The consequence of this was the formation of a dust cloud, an explosion in the failed hopper, and extensive burn injuries to the plant operator. The particular circumstances of this incident are most unusual, and some uncertainty remains about the events leading to the fire, but it demonstrates one possibility when powder flows in a sudden and uncontrolled way into an existing fire.

6. The second incident involved 25kg paper bags of rubber crumb, stored on pallets. A pallet loaded with 46 bags in a stack 2m high was ignited by a flame gun used for shrink-wrapping, but the operator did not immediately notice the fire. As the pallet was being moved using a forklift truck into a storage area, an extremely rapid fire growth then occurred. The fire at this stage had spread to involve other pallets loaded with bags of 70 tonnes of rubber crumb.

INVESTIGATION AND LABORATORY WORK

7. Subsequent HSL reconstruction trials with this rubber crumb showed that under some circumstances, a fire which starts at the base of a pile of bags made from combustible packaging, can grow up the outside of a stack, causing a series of bags at higher level to fail, and allow powdered material to flow into the fire. Some of this powder burns before it reaches the floor. This results in a fire, which grows much more rapidly, involving neighbouring stock, than would be possible if the burning powder formed a simple heap on the floor.
8. Further HSL trials were undertaken to examine how other powdered products behave in similar circumstances. Products that were used in the tests were wood, coal, maize starch and three synthetic polymers. It was anticipated that the powder particle size, the ability of the product to flow freely, the melting or softening point, and the nature of the combustion products would all influence the results.
9. Not all the tests produced the rapid fire growth that is a consequence of burning of powder that is either falling from a burst bag, or being carried upwards on convection currents from the fire. Lower fire growth rates sometimes occurred because the powder softened and would not flow, because it charred and did not flow, or because the inherent cohesive forces within the powder did not permit free flow.
10. It is postulated however, that under slightly different conditions, any of the products tested could be capable of burning effectively as a dust cloud and cause the rapid fire growth rate seen in the original incident. For a large range of powdered products it must be assumed that a tall stack of bags, or a release from tall single container caused by fire at low level can create a fire capable of growing very suddenly, with a risk to people in the vicinity. Normal provision of means of escape might not be adequate.

FABRIC FLOUR SILOS AND FLEXIBLE INTERMEDIATE BULK CONTAINERS

11. This type of risk was anticipated when fabric flour silos were first introduced in the UK, and HSE's response at the time (1982), was to recommend either installation in an outbuilding dedicated for the purpose, or a fire separated enclosure, containing no electrical equipment. This advice remains current and is contained in the National Association of British and Irish Millers guide to fire and dust explosion precautions published in 1992.

PRECAUTIONS

12. Where flexible intermediate bulk containers (FIBCs) are handled, or stacks of bags create a similar vertical surface there are a range of possible precautionary measures. The simplest is to change the packaging. Can a metal tote bin be used in place of an FIBC, or can steel drums replace paper sacks? Often there will be economic objections to this, and the next alternative is to avoid storage arrangements that create a vertical combustible surface taller than necessary.

13. Because different dusts will behave differently, no figure can be given for the maximum acceptable stack height for sacks, but the starting point is to avoid storing pallets loaded with sacks on racking or otherwise above floor level. The original rubber crumb incident occurred with a single 2m stack, but experimental work shows that the rate of temperature rise can be ten times as fast where the stack is kept above floor level. FIBCs should, whenever practicable all be stored directly on the floor.
14. In all cases where powders are kept in combustible packaging with a tall vertical face, a very high standard of control over ignition sources is needed, particularly any that can occur near the stack and near to the ground. Easily combustible waste must be kept clear from the area.
15. Fire resisting partitions as required for fabric flour silos may have some advantages, in protecting a store from a greater fire risk in a process area. Conventional sprinklers are not likely to be effective unless they are designed to address a fire of this type, and no design criteria are available. In-rack sprinklers would have the best chance of success, but in most circumstances, it would be hard for HSE to justify their installation on life safety grounds, and certainly not just as an alternative to other precautionary measures described.
16. Staff may need to be warned they should not tackle fires involving a stack with portable fire extinguishers under any circumstances. Rapid escape from the area must be the priority, with facility to raise the alarm from a safe place.
17. Consultation with the local fire authority is recommended, particularly over issues concerning means of escape.