

Flammable Solids & Dusts

DIN No	TD5/028	Issue Date	2 October 2000
Open Government Status	Fully Open	Review Date	30 November 2003

DEFLECTOR PLATES AND BUCKET ELEVATORS

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During 1998 a number of research projects relating to dust explosions have been completed. This note summarises the conclusions of 2 projects, and suggests how they should influence the advice given in particular circumstances

Deflector Plates for Explosion Vents

We have recognised for a long time that when an explosion vent opens, the emerging fireball of burning and unburnt dust can be very large. Ideally the vent should open only to a safe place in the open air, but all inspectors will have seen locations where this is simply not possible. Where occupancy levels are low, the fall back position has sometimes been to recommend a deflector plate, so that someone who does have to pass close to the vent is less likely to be caught in the direct line of the flames. This idea is illustrated on p13 of HSG 103 and p186 of the I Chem E Guide to Dust Explosions part 1, with specific dimensions given. This design was suggested to the CEN standards committee currently working on explosion venting, but was rejected as having no basis.

Accordingly a short research programme was approved, based on explosions vented from a 6.5m³ test vessel. Tests were carried out with coal and toner dusts, using plates at different distances, angles and sizes and with different sized vents on the vessel. A total of 52 experiments were completed. Without a deflector plate, the measured flame lengths were up to 12m long.

The experiments showed that the deflector did provide some protection in the area beyond the vent. The optimum position was 0.5m beyond the vent, and a plate at 60° to the horizontal tended to reduce the flame length more than the 45° angle (less steep) recommended previously. A plate that had an area of 3 times the area of the vent gave better results in most cases than the 2 times figure suggested in the I Chem E book. The influence on the reduced explosion pressure within the vessel was minimal in most cases. With the deflector plate in this position, no flames extended beyond 7m in any experiment. These results have now been passed to the CEN working group and seem very likely to appear in a technical standard within the next year or so.

Bucket Elevators

Bucket elevators are widely used for elevating free flowing powders and granular products in a range of industries. In particular they are found in flour mills and animal feed mills, where whole grain is being transferred into intake silos. They have traditionally been seen as a potential site for dust explosions, and Factory Inspectorate guidance as far back as 1963 recommends explosion vents, and where possible siting of these units outside buildings.

Since 1981, HSE standard advice has been to fit explosion relief panels at the top and at intervals not exceeding 6m down each leg. The basis for that more specific advice was unclear, and so it was studied at a recently completed major research project involving a number of

outside sponsors. The work completed at Buxton examined the venting requirements of two elevators.

Accident reports to HSE over the last 10 years indicate very few incidents involving bucket elevators, although a recent explosion incident that spread through a number of storage bins at an animal feed mill seems to have been caused by ignition within an elevator that had been badly maintained. American experience from their very large grain industry, however, continues to report bucket elevators as a prime site of initial explosions.

It is not possible to tell from our accident records whether the lack of incidents reflects a better standard of construction and maintenance, or perhaps explosions have vented safely and are not then reportable, or whether other protective features incorporated into these units have prevented them causing ignitions.

The project completed by HSL used two old second hand units. A 25m tall single leg elevator was fitted with buckets connected by chains, and a 17m tall twin legged elevator had the buckets attached to a rubber belt. This is more typical of those found in the food and animal feed industries.

Dusts used in the tests were coal and cornflour. The the dusts had explosion properties in the range KST 147 - 211 bar.m/s and Pmax 7.7 - 8 barg. The advice which follows cannot be easily extrapolated to much livelier dusts, but very few bucket elevators handle more hazardous products.

SINGLE LEG ELEVATORS

The single leg elevator has a substantial open area down the centre, in which a dust cloud can form, and an explosion propagate. Tests were carried out with a variety of venting combinations, using both thin plastic sheet, and commercial metal panels. The opening pressure of the vents made a significant difference to the measured peak pressures in the elevator.

To protect elevators rated at a pressure of more than 300 mbar, handling dusts with KST values up to 150, vents should be provided in line with earlier advice: at the top and bottom, and at intervals not exceeding 6m. Panels should have an area equal to the cross sectional area of the leg, and open at pressures as low as possible, preferably not exceeding 0.05 bar. For dusts with KST values in the range 150-200, the table below shows the relationship between the expected pressure and vent spacing. In many cases vents more closely spaced than 6m will be needed.

K_{st} bar.m/s	P_{stat} barg	P_{red} barg	Vent spacing (m)
150	0.05	1	19
		0.5	10
	0.1	1	14
		0.5	7
175	0.05	1	7
		0.5	4
	0.1	1	5

		0.5	4
200	0.05	1	5
		0.5	3
	0.1	1	4
		0.5	3

This advice may be considered enforceable.

TWIN LEGGED ELEVATORS

These have comparatively little free volume within them and it proved difficult experimentally to generate a dust cloud within the whole system. In 45 tests using either coal dust, or a less reactive grade of corn flour, only one explosion propagated round the system. However, with a more reactive cornflour, 12 explosions propagated from 16 tests, and pressures up to 800 mbar were reached as the vents were progressively closed off.

Distortion to the casing occurred at pressures of 500 mbar, and rupture at higher pressures. It was noted that in many cases explosion vents failed to open although recorded pressures exceeded the expected opening pressure. This seems to be a result of shielding of individual vents by buckets which had a size similar to the panels.

The flour millers (nabim) representative expressed reservations about this project at various stages, and criticised the work as trying to create an explosion at all costs. The dust injection system is obviously not typical of normal operation, but it is not simple to construct a test rig which mimics full size plant in all respects. He did identify that the buckets in the twin legged elevator were of mixed sizes, and suggested that some under sized buckets allowed the flames to propagate more easily than they would in real plant. He also complained that explosion vents that opened at 0.04 bar were impracticable and unrealistic, but this view was not supported by all equipment suppliers.

As a result of these objections, I have agreed that for the moment we should not adopt the venting recommendations given in the HSL report. However, we do have clear information about the need for vents at the elevator boot. Vents at the boot of an elevator have always caused problems, as they are often close to a regularly occupied area, or they may be below ground floor level at a grain intake point. Experimental results suggest however that a vent at the bottom is important, and that without it uncontrolled rupture of the casing a little higher up becomes more likely. There is no simple solution to this problem.

To resolve the issues raised by the flour millers, a further project using a new twin legged elevator has been approved and has attracted support from 11 industrial sponsors. It is due to be completed during 2000.

The I Chem E Guide part 2 lists various features designed to reduce the risk of an explosion in a bucket elevator. Some of these are commonly provided, while others are offered only as additional features at extra cost. The extent to which any of these features should be seen as enforceable on new plant under the machinery directive has been discussed with TD E2 and others, but to date no clear policy has been agreed. A European standard EN 618 covering mechanical conveying plant for powders and granular materials is expected to be published in final form during 2000.