The practicalities and economics of dust suppression

By Peter Guttridge, Guttridge Ltd and Ian Walton, DSH Systems Ltd

Dust is a widely recognised industrial hazard. Capable of forming an explosive cloud, it also presents an inhalation danger for operational personnel, and can create visibility problems. Controlling dust is crucial for health, safety and environmental reasons and may also be driven by economics. Dust spreading through an operating area is lost product and has an associated value.

One of the routine operations capable of creating problematic clouds of dust is bulk material intake or outloading, from a lorry into a storage building, for example, or vice versa as product is released from a factory for distribution. During this operation even granular products such as grain, fertiliser, sand and salt can release significant quantities of dust, inhibiting the efficient and safe progress of the task. Such dust release can be especially problematic in certain areas – close to urban centres, for example – where there is particular sensitivity to air pollution.

In this paper, Peter Guttridge, Chairman of Guttridge Ltd, and Ian Walton (CEO, DSH Systems Ltd) examine the issue of dust release during bulk material loading, why it happens and the problems it creates. The limitations of conventional equipment are considered within this context alongside the potential benefits of adopting alternative, more modern dust suppression technology. Example data illustrate the cost savings associated with dust suppression and the factors that should be taken into account when evaluating an associated investment.

The issue of dust release

Transferring and transporting granular products is a daily task for many processors but the associated release of dust, typically defined as particles in the 1 – 100 micron size range, can be problematic. Figure 1 provides a clear illustration of why.

Figure 1: The release of dust during bulk outloading can present a major health, safety or environmental hazard

The dust cloud visible here consists of fine particles that are escaping from the bulk material flow. These may originate from the ‘as manufactured’ product, which may have a defined fines content, or may result from attrition during transit. Many grain feeds may be transported in an ‘as harvested’ state that includes significant quantities of fine dusty dirt. In each case, as the material flows, these fine particles escape from the bulk, spreading into the surrounding environment on air currents induced by the bulk flow, and any prevailing wind. The result is a dust cloud that can present difficulties for a number of reasons:

- *Environmental contamination*

  From an environmental perspective the release of dust is, most immediately, an issue of air contamination. This is an important and growing problem as the potential hazards of respirable dust are recognised, and population centres develop around facilities that may, in the past, have been some distance from a community of any size. However, fugitive dust emissions are also a potential source of watercourse degradation and their monitoring is becoming increasingly stringent for this reason too. Tackling environmental issues is becoming critical for facilities anxious to secure good community relationships and an on-going licence to operate in the face of tightening legislation.

- *Explosion hazard*:

  The fine nature of particles present in a dust can, under certain circumstances, promote very rapid reaction/combustion, which is why dust clouds formed from flammable materials have explosive potential. The lowest concentration of dust in air that is capable of supporting an explosion[1] (the “lower explosive limit”) varies from material to material but typically lies in the range 10 to 500 g/m^3. While this figure may seem quite low, it represents a relatively dense fog of particles and so, in practice, is relatively rarely exceeded during routine loading operations.

- *Operator safety*

  Certain dusts are known to have a direct effect on health and consequently have well-defined exposure limits. Silicosis, for example, is an occupational lung disease attributed to the inhalation of crystalline silica which, as a result, carries a NIOSH recommended exposure limit of 50 µg/m^3 (TWA (time weighted average) for a working day of up to 10 hours, 40 hour working week).[2]

  More broadly however, even non-toxic dusts may be associated with a decline in lung function[3] making it essential for bulk material handlers to install appropriate control and exposure prevention strategies.

- *Damage to machinery*
  Machinery that has to operate in a dusty environment may be prone to low reliability caused by, for example, inhibited lubrication and enhanced wear. The frequent change out of filters designed to protect equipment is also a time-consuming task in dusty environments. One way to prevent such problems, and to simultaneously improve the operating environment, is to adopt an effective clean-up policy, but this too is manually intensive, adding to the overall cost of operation.

- *Loss of product*
  Especially for a valuable product, the amount of material lost through fugitive dust emissions can be surprisingly high, and may justify expenditure in superior bulk handling equipment. Most bulk materials are relatively low cost but even with these products the annualised overall cost of losses can be significant.

When it comes to tackling a potential dust control problem there are three possible strategies: prevention, isolation and/or control. Conventional technology is typically based on the second and third approaches while more modern, dust suppression systems tackle the problem at source.

Conventional bulk loading equipment
Retractable or telescopic bellows are the traditional choice when it comes to loading operations. The mode of operation of this technology is relatively simple and illustrated in figure 2. Telescopic bellows provide an enclosed route from the source of the material to its destination via a series of conical shaped ducting elements that slot into one another. These allow the length of the overall ducting to be varied to fit the application, and during loading. Bellows, around the central duct, minimise material loss.

With telescopic bellows, emptying cannot take place with the assembly fully up. The outlet is lowered as close as possible to the receiving vessel, to control material flow, but there remains a gap that is sufficient to allow dust release.

Figure 2: Conventional telescopic bellows have inherent limitations when is comes to limiting dust release

Telescopic bellows are well established and relatively inexpensive, despite having a complex mechanical design to allow for the lifting up and down involved with their use. However, cables, pulleys and associated electrics are required for operational control and these, in addition to the number of moving mechanical parts, impose a substantial maintenance burden.

From a practical perspective, telescopic bellows are a flexible choice for different loading operations, but troublesome for lorries with cross members, since these bars can inhibit optimal positioning. Furthermore, as product emerges from telescopic bellows in an aerated state, air-induced segregation, the separation of dissimilarly sized particles, is also a potential problem. This can compromise the homogeneity, and value, of a product, and cause flow problems during discharge.

For many the biggest drawback of telescopic bellows, though, is the issue of dust release. In some installations this is tackled with integral dust extraction systems, others employ air extraction to minimise dust generation, or filter out fines ahead of transport. Stringent clean-up procedures are an important control measure in many facilities. But all these complexities add to the overall cost of operation and highlight the multiple advantages of applying a solution based on prevention, rather than isolation and control.

Introducing the Dust Suppression Hopper (DSH)

The Dust Suppression Hopper (DSH) prevents the formation of dust clouds during the transfer of granular solids. Figure 3 shows a DSH operating in the exact same environment as the telescopic bellows shown in figure 1, demonstrating its performance.

Figure 3: With a Dust Suppression Hopper (DSH) the clouds of dust visible in figure 1 are simply eliminated at source.

Originally developed to tackle dust emissions at a fertilizer plant, the DSH is now used for a range of materials including:

- Foodstuffs – salt, sugar
- Minerals and quarry products – bauxite, gravel, kaolin, sands, soda ash
- Grains and stock foods – corn, barley, sorghum, soya beans, wheat
- Fertilisers– superphosphates, lime, potash

This list is far from exhaustive and recent additions include compressed wood pellets and other pelleted products for the biomass industry. In general suitable materials are dry, granular and free-flowing, as fine, sticky powders do not perform so well.

The design of the DSH marks a radical departure from conventional telescopic bellows (see figure 4) and produces a denser, less aerated flowing material phase.

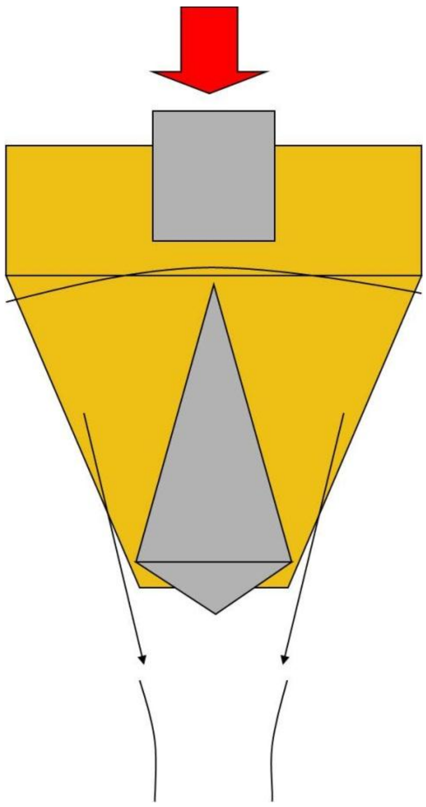

Figure 4: Schematic showing the operating principle of the DSH

A conical outer hopper is suspended from the top frame of the unit by a number of springs, and a safety chain. Within the hopper is a central plug which remains stationary at all times. As material flows into the DSH its weight causes extension of the springs and the outer hopper lowers relative to the stationary central plug. This opens up an annulus, allowing the material to discharge. However, flow is maintained only if there is a sufficient head of material to provide the downward force necessary to extend the springs. If not then the annulus will close. In practice the outer cone gently oscillates up and down during discharge, as the balance of forces between the non-linear springs and weight of material fluctuates. This action maintains the characteristic solid-looking stream of product.

Unlike a telescopic bellows a DSH is installed directly beneath a feed point, suspended at some height above a target, such as a lorry filling bay. Aside from the constrained up and down movement of the hopper this height is maintained throughout discharge. Most of the complexities associated with the telescopic bellows design are therefore eliminated. The DSH has no internal moving parts and requires no utilities for operation.

The way in which the DSH operates leads to material discharge in the form of a densified, almost solid stream containing very little air. As material flows into the hopper, from the feed silo, natural agitation and settling lead to limited air release. Then, because the material is pushed out of the annulus against the opposing pressure of the springs it undergoes a further ‘squeezing’ action. The result is a ‘condensed’ stream of material that is extremely tolerant of fall height. During transfer any dust present is entrained, and drawn down into the material column, and there is minimal dust emission when the product hits the ground. The squeezing out of air also largely eliminates segregation.

The simplicity of the DSH translates into low maintenance costs and the almost complete prevention of dust release for a many industrially significant bulk materials. However, the DSH, like many newer technologies, carries a higher upfront capital cost. This raises the question of how to financially assess different options for bulk materials loading and how to put a value against the potential benefits afforded by alternative systems.

Putting a value on dust suppression

Right at the beginning of this paper we discussed the reasons why dust control is important. Returning to this list of reasons helps to formulate a strategy for assessing the value of dust suppression technology and to highlight areas where value might accrue. Where dust suppression measures make the difference between a site maintaining its license to operate, or not, then their value is clearly very high. The need to meet regulatory controls is similarly non-negotiable. In other instances though the arguments are more nuanced, creating a requirement to quantify the value of mitigation measures against their costs. The following simple calculations illustrate how savings can be calculated for some of the potential benefits.

- *Reducing clean-up costs*

A daily discharge operation results in two hours of clean-up for one operator.
Assuming an hourly rate of £10.00 per hour and weekday operation this equates to £5,200 per year.
If the dust suppression technology can reduce the amount of cleaning effort required by 85% then this equates to an annual saving of £4,420.

- *Eliminating fugitive fines*
  An operator handling product in 26 tonne loads estimates that each load contains 50 kg of fugitive fines. 10 trucks are loaded each day, for five days a week, for 48 weeks of the year. In the course of the year the total amount of fugitive fines potentially lost is therefore 120 tonnes.
  The cost of the product is £100 per tonne so if dust suppression technology reduces this figure by 90% that equates to an annual saving of £10,800

- *Overall product loss*
  A potash manufacturer transports product by truck, rail and container. The scale of the operation is 35,000 tpa of product which has a sale price of around £300 per tonne. Estimates suggest that across the operation product losses may be reduced from 0.1% to 0.05 with the installation of dust suppression technology.
  Halving the product loss reduces the cost associated with it from 35 to 17.5 tonnes per year, producing an annualised saving of £5,250

In conclusion

For many bulk material handlers dust control is a critical issue, especially during loading operations. Being a 'good neighbour' is increasingly important for companies with strong ethical policies and on a more pragmatic basis can play a crucial role in operational longevity. Stringent health, safety and environmental laws are a powerful driver for improvement in many countries.

The Dust Suppression Hopper (DSH) prevents the formation of dust during loading operations tackling this potential problem at its source. Experience suggests that this technology not only solves critical HSE issues but also pays its way with economic benefits accruing in the form of reduction in clean-up, maintenance and product loss.

References:

[1]http://www.dustexplosion.info/dust%20explosions%20-%20the%20basics.htm

[2]http://www.silicosis.com/niosh/

[3]http://www.iom-world.org/media/93355/ioms_position_on_oels.pdf