Image: Leaked powder

OVER-PRESSURISATION:

A serious risk for powder storage silos in the food industry

by Mark Stevenson, Hycontrol, UK

A lack of adequate safety and protection measures on many powder storage silos has resulted in considerable potential risks that the food processing and production industry must face up to.

Many vital ingredients are stored in silos which do not have sufficient pressure safety coverage and are often also inadequately maintained. Silo over-pressurisation often forces open blast panels on ATEX silos resulting in pollution and product loss and can even put lives at risk. However, this can be avoided by implementing proper protection.

As with other vessels storing powdered products in other industries such as lime or cement, silos containing flour, sugar, starch or other ingredients are susceptible to over-pressurisation arising from filtration blockages or excessive input pressures from delivery tankers. This results in many serious problems for sites, like powder escaping into the environment; damage to equipment and buckling of the silo; and, in the worst possible cases, the potential rupturing of the silo or the filter unit being blown off the roof by pressure build-up.

However, with ATEX silos in the food industry, there is an additional problem as pressure will often blow open the vital safety blast panels leaving the contents of the silo exposed to the elements. In many cases, the pressure required to open the blast panels is lower than that required to open the pressure relief valve!

Level measurement specialist Hycontrol has designed silo protection systems for over twenty years and has witnessed first-hand the potential problems.

"The photos taken by our survey engineers speak for themselves," says Hycontrol Managing Director, Nigel Allen. "We regularly see silo-tops covered in a thick layer of powder, often blowing across the site in great clouds during a fill. We see damaged, untested pressure sensors.

"We see air vent/filter units that are so clogged with powder that they are effectively useless. Companies in the food processing industry and others like it are worryingly ignorant about the consequences of poorly maintained, poorly monitored silos. It's quite frightening that operators accept pressure blowouts via the pressure relief valve, saying 'It's OK - the PRV is doing its job'.

"This couldn't be further from the truth: PRVs are there as a last resort. In a healthy silo system, pressure during a delivery should never reach a level where the PRV is forced to open. A PRV blowing is the final symptom of a pressure safety problem, and the integrity of the silo itself is at risk. It is also likely that an ATEX silo's blast panels will be blown by a pressure build-up, which could result in huge levels of product loss."

In the worst examples of neglected silo protection, trapped air pressure can result in filter units being literally blown off the silo roof, causing massive damage and potentially putting the lives of workers in the yard below at risk. However, a far more common symptom of failing silo protection is product leakage.

"There is a common misconception that the biggest risk to silos comes from overfilling, which is simply not the case," states Allen. "Pressure is the real issue and the cause of the majority of leaks. Without an understanding of how silo over-pressurisation occurs or the effects it can have, silo owners will forever be

attempting to paper over the cracks rather than fix things.

"We have even started to see a trend of sites erecting scaffolding around silos and covering it in plastic sheeting, in an attempt to trap powder blowing out of the silo. This is in itself almost comical, but it also shows the lengths to which those responsible for powder storage silos are attempting to turn a blind eye to the root problems. Ultimately it will not work, and things will get worse."

What causes over-pressurisation problems?

To address this problem, one must first understand how excessive pressure in a silo occurs.

Product is pneumatically transferred into a silo by fluidising it with compressed air and then blowing it in. If the air used to pneumatically convey the powder can exit the silo without restriction via its venting unit then there will be no over-pressurisation issues.

Silo over-pressurisation only occurs when the volume of air entering the silo exceeds the volume of air that can escape it. This occurs by either the airflow out of the filter being restricted in some way or the pressure blowing in from the tanker exceeding the filter's maximum capability.

Filter housings at the top of the silos are designed to vent the silo during filling, whilst preventing dust escaping into the atmosphere. Normally

ATEX SPS panel

these are fitted with some form of self-cleaning system, typically mechanical shakers or reverse jet systems.

Although filter manufacturers give recommended check routines and filter replacement schedules, in practice it would appear these are regularly ignored. Faulty operation can be caused by a range of issues, including blockages or the fitting


Leaked powder


ATEX SPS


Blocked PRV

of incorrect filters. Many powdered ingredients form hard compounds when mixed with water from the atmosphere, further limiting venting efficiency.

Delivery tankers are pressure-tested vessels typically capable of withstanding up to two bar (29 psi) pressure. Storage silos, on the other hand, are not. As little as one-to-two psi above atmospheric pressure can rupture them.

It is therefore easy to understand how complacency or haste on the part of drivers can lead to fill pressures greater than the silo can handle. Statistics collated by Hycontrol suggest that slightly over half of all silo over-pressurisation incidents can be attributed to poor driver behaviour, although this has hitherto been difficult to manage.

Essential safety equipment must be tested

To prevent problems during deliveries all silos fed from a road tanker should have safety systems installed on the silo-top, including a pressure relief valve, pressure sensor, level probe and air filter. However, this creates an additional concern in the shape of working at height.

The equipment forming these silo-top systems can only be tested in situ, effectively meaning that silos must be climbed before every delivery to perform a functionality test. Even with correct safety gear, working at height is very dangerous. Falls from height are the largest single cause of UK workplace fatalities according to the HSE, accounting for an average of 37 deaths per year between 2013 and 2018. Therefore, the dilemma is a choice between neglecting safety equipment or creating working at height risks.

Aside from the risks of working at height, we have to ask: what can engineers actually do when they are at the top of the silo? And furthermore, how do you physically test the operability of a relief valve or pressure transmitter without removing them from the silo?

Industry guidance, or lack thereof

The Mineral Products Association (MPA) publishes comprehensive guidelines for silo protection systems in quarries and cement works, but there are little or no such recommendations for powder silos used in other industries, including food processing.

However, the principles are the same for protecting pneumatically filled silos anywhere: pressure and level during filling must be monitored, there must be a suitable filtration unit, and a pressure relief valve as a final defence. There should also be alarm systems and automatic shut-off valves to protect the integrity of the silo.

However, any silo safety protection system is only as reliable as the last time all the components were fully tested, and as we have seen this is frequently neglected.

Testing from ground level

The solution is to incorporate ground-level testing (GLT) at the heart of silo protection design, whereby the crucial safety components can be tested by operatives with both feet on the ground prior to each fill. This not only removes working at height risks but guarantees full protection system functionality every time the silo is used.

Only when all the safety devices have passed the checks should the safety interlock allow the silo inlet valve to open and the delivery to commence. Testing is essential but has often been ignored by staff as it is time-consuming, or it has not been practical in the past. With a GLT-based system, a silo cannot be filled without a full test operation.

However, in the food industry, the common problem of over-pressurisation is further complicated by the fact that flour and other crucial ingredients are potentially explosive substances. Therefore, ATEX safety precautions are essential. All ATEX-area equipment should be fully certified and installed by qualified and competent engineers.

As an added benefit, an effective protection system can serve as a powerful predictive maintenance diagnostic tool by recording critical near-miss events that occur during the filling process.

This information allows managers to carry out effective predictive maintenance by means of a logical step-by-step root cause analysis (RCA) process to understand why the problems are arising. In the case of SHIELD Lite, the system not only records critical events but also helps identify filter blockages or driver behaviour problems.

If there are excessive high-pressure or relief valve events the system will lock, forcing corrective action. Hycontrol recommends that systems are serviced by ATEX-trained engineers every six months to ensure optimum performance, including checking ingredients like fine flour are not impeding the PRV or the filter unit.

A comprehensive silo protection system can offer more than just a barrier to the risks of over-pressurisation; it can actually improve site safety, reduce maintenance requirements and working at height, and self-diagnose faults before they become problematic.

Conclusion

There is strong evidence that many powder storage silos are disasters waiting to happen. Pressures as low as one or two psi can rupture a vessel or eject congested filter housings. These severe risks, coupled with the costs arising from near-constant product loss as a result of over-pressurisation, means that silo pressure safety is something that the food industry needs to start taking considerably more seriously.

It is imperative that any silo pressure safety system be easily verified by testing critical components before each and every delivery – without having to climb to the top of the silo.

By using systems that monitor and control deliveries effectively and self-diagnose issues before they become problems, it is possible for food manufacturing sites to achieve total silo safety – preventing product loss and protecting the environment, site personnel and the public.

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