Protect your Silos from Over Pressurisation During Filling

Within the powder processing industry, there have been a number of serious accidents involving silos that have become over-pressurised by tankers. As a result, the Health and Safety Executive (HSE) has issued a guidance note for bulk Cement silos, PG 3/1 (2001), issued by the Secretary of State on this subject. Although initially aimed at the cement, concrete and quarrying industries, the guidance has clear implications for all industries that utilise tanker-filled silos.

Background to the Guidance Notes

In each of the incidents examined, the silos became pressurised during pneumatic filling by a road tanker. The connection between the reverse jet filter and the silo roof was identified as the weak point, resulting in the filter unit weighing around 250kg being dislodged. In at least one case, the dislodged filter seriously injured the tanker driver. The underlying issue in each case was the pressure relief valve, which was undersized for the maximum airflow entering the silo. These problems were exacerbated by a lack of maintenance and by silo overfilling.

The guidance note recommends overall management control at the offloading point and a documented maintenance regime for both the filter unit and safety pressure relief valve. These recommendations are largely uncontroversial, however, there is also a requirement to select appropriately sized vent filters and pressure relief valves for the anticipated peak airflow rate. It is the quantification of this flow rate that was contentious, along with the requirement for an automatic shut-off system in the fill line.

The peak airflow occurs when the tanker depressurises in an uncontrolled manner at the end of delivery. The higher the tanker pressure or the shorter the delivery line, the greater the airflow. While uncontrolled depressurisation is regarded as poor practice and should be prevented through management controls, accidental occurrences must still be anticipated. In the HSE guidance note, the peak flow is calculated using standard fluid dynamics. A 2 bar(g) road tanker depressurising through a 10-metre inlet pipe with one 90° bend can result in an airflow of up to 13,000 m^3/hr – significantly higher than the 2,000 m^3/hr typically used by the industry. This discrepancy led to scepticism and slow adoption of the HSE's recommendations.

A series of tests to investigate the actual behaviour was undertaken of airflows during tanker discharge. These tests aimed to measure airflow and surges at the end of the conveying cycle. Although the measured values were lower than calculated, the differences were mostly attributable to friction losses in unpolished pipes and the vehicle's onboard pipework and flexible hose. Given that pipework can become polished over time and that losses vary between vehicles, the calculated values represent a conservative but realistic basis for equipment sizing.

Silo Vent Filter

Despite the large airflow, the implications for filter sizing are not as severe as expected – because essentially, nothing has changed. Filters have traditionally been sized based on empirical rules that consider the large surge at the end of discharge. Though the numbers have changed, they have changed on both sides of the equation. A survey of numerous silo installations revealed that filter size alone is not the most critical factor. For instance, bag filters as small as 10 m^2 performed well after 20 years, whereas larger, newer filters performed poorly.

While filter media area is important, the overall filter design, maintenance, and silo size are equally crucial.

Pressure/Vacuum Relief Valve

The ideal valve should ideally be spring-loaded for both pressure and vacuum relief, with long-travel springs for maximum opening. A well-designed weather cover is essential to prevent powder build-up and minimise isokinetic crashing. The valve should be easy to remove without tools to facilitate weekly testing, as required by the HSE. Most importantly, the valve must be tested and certified at peak airflow rates. Certificates must confirm testing at the relevant flow rate and set pressure points. The pressure accumulation during operation must be less than the silo's design pressure.

Automatic Shut-Off System

The guidance stipulates an actuated valve in the fill line, operated by pressure and level sensors. This prevents filter damage, reduces nuisance PRV operation, and limits dust emissions. While such a system could, in theory, replace the PRV as the primary safety mechanism, it would require fail-safe circuitry and duplicated instrumentation to justify the risk level. In practice, it is more realistic to use a correctly sized PRV for primary protection and a simpler shut-off system to safeguard the filter and prevent dust release. A two-stage alarm system for level and pressure should be installed to allow the tanker driver time for controlled shutdown before automatic valve closure.

Management Control at the Offloading Point

Clear written instructions must be provided for the tanker driver, including a prohibition on uncontrolled venting through the silo. Drivers must be trained to initiate a controlled shutdown in response to an alarm before the shut-off valve engages. Documented Maintenance Weekly maintenance should include PRV operation checks and reverse jet filter inspection. Filter bag condition can be monitored by measuring the differential pressure across the filter, which must be done during silo filling. A gauge or display for differential pressure is best located at ground level, near the filling point, rather than on the silo roof.

Summary

A reverse jet filter of around 20 m^2 should be considered for new installations. The exact area and filter media depend on the dust type. The number of cleaning valves and a generously sized casing are also important. A combination pressure/vacuum relief valve, sized for the peak flow rate, must be provided. The set pressure should prevent dust leaks (typically ~500 mm WG), and the pressure accumulation must remain below the silo design pressure (~1000 mm WG). The valve must be certified for 13,000 m^3/hr airflow and be dust tolerant. An automatic shut-off system, comprising a control unit and actuated valve, should be included. Operated by pressure and level sensors, this protects the filter. Clear, written instructions should be displayed at the offloading point for the tanker driver and a documented maintenance regime must ensure regular inspection of the PRV, filter, and shut-off system. For more information visit the technical section on the SHAPA website at https://shapa.co.uk/technical.php where a full list of free to download papers on all areas of solids and bulk handing can be found