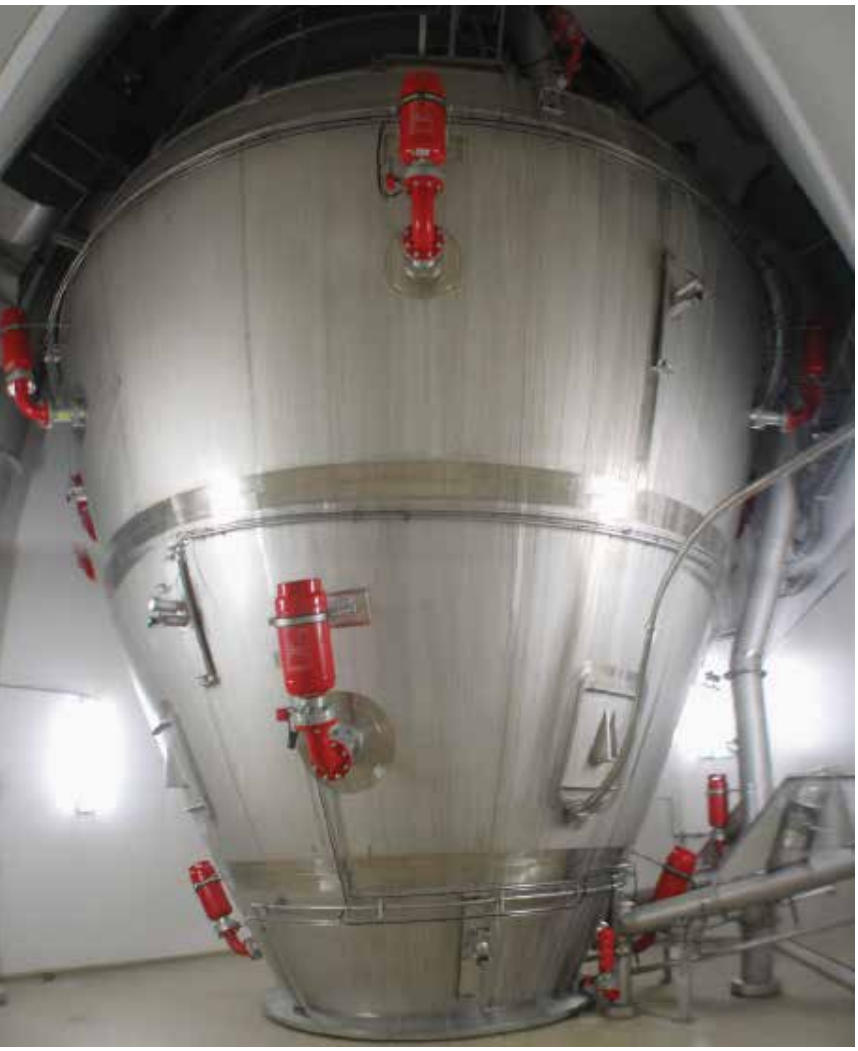
Proven protection

Dr Rob Lade discusses explosion suppression design considerations for large volumes and elongated vessels

Addressing the deflagration threat in large volume applications such as silos and large spray driers, although challenging, can be achieved using the proper explosion suppression technology. This requires a unique comprehension of both the pressure and flame growth characteristics within these extremely challenging vessels.

It is well documented that the performance of an explosion suppression system to reduce explosion pressure (P_{red} – reduced explosion pressure due to activation of the suppression system) is dependent upon the dust hazard (K_{st} – explosion rate of pressure rise; P_{max} – maximum explosion pressure) and the shape and volume of the vessel being protected.



Large volume spray drier protected by an array of explosion suppressors

The need to deliver adequate suppressant quickly enough throughout the protected vessel to achieve a successful suppression is a clearly accepted principle, however, less well understood is the relationship between the final P_{red} value and the overall discharge characteristics of the suppression system. These discharge characteristics are multi-parametric and include:

- Suppressant throw – volume enveloped by the suppressant at the correct concentration, which is in part dependent on the nozzle design as well as suppressor placement on the vessel
- Mass flow rate of suppressant – throw as a function of time pertinent to the explosion development and mitigation. Suppressor charge pressure as well as diameter of suppressor valve are key parameters of mass flow rate.
- Particle size distribution of the suppressant – small particles have a larger surface area and hence a more efficient heat exchange with the fireball, whilst large particles can be 'thrown' further

IEP Technologies has developed a range of suppressor valve sizes and testing has proven that smaller (75mm) diameter valves were ineffective against explosions in large volumes (>~100m^3; K_{st} = 300bar.m/s) due to the reduced suppressant throw and mass flow rate, which is limited by the valve diameter – not the suppressant cylinder size as commonly (yet incorrectly) believed.

The IEP Technologies 125mm suppressor valve is designed for large volumes such as spray driers and silos where its discharge characteristics deliver low P_{red} values. The 125mm valve is typically used with a 45 litre capacity cylinder, filled with 35kg of suppressant and pressurised to 60 bar with nitrogen as a propellant. The 60 bar charge pressure was determined to be optimum based on explosion suppression tests as lower charge pressures did not generate adequate throw or mass flow rate compared to the explosion development, whilst higher pressure started to induce increased turbulence and therefore increased explosion severity.

Both vertical mounting on top of a vessel and mounting in conjunction with a 90° elbow can be accommodated to project the suppressant vertically down or horizontally as the application dictates.

Full-scale explosion tests have been conducted in a 250m^3 vessel with the 125mm suppressor valve and suppression efficacy was demonstrated against quiescent propane as well as ST1 and ST2 limit dust explosions.

This valve has been used successfully on a number of tall, elongated silos in the grain industry. The silos have a cylinder length of ~12m and a total volume of ~150m^3. They are 0.3 bar strong and nested together with no space between each. This is a challenging application since suppressant coverage is key for providing efficacious explosion suppression and here the suppressors can only be mounted on top of the silos discharging the suppressant downwards. With its vast expertise in this sector, IEP Technologies was able to calculate the expected Pred and adjust the nozzle configuration and detection points to meet the silo strength criteria.

With the large 125mm valve and 60bar charge pressure, the first 27kg of suppressant is rapidly discharged in <200msec, delivering a Pred value well below the 0.3 bar(g) required. Due to the multi-modal particle size distribution, full concentration of suppressant is maintained at the furthest point of discharge, i.e. the silo cone, thereby taking account of all ignition source locations and ensuring an aggressive explosion suppression solution to the silo.

This explosion suppression system has been verified by an independent Notified Body as part of IEP Technologies' ATEX compliance, resulting in full compliance when protecting volumes up to and including 1,000m^3.

When deflagration venting cannot be safely applied for explosion protection of a large volume application, explosion suppression is usually a viable option. It's critical that an effective explosion suppression design is based not only on adequate agent concentration, but also on other factors such as effective throw, mass flow rate of the suppressant, as well as its effective distribution. ■

Large volume vessel showing top mounting location of explosion suppressors directing suppressant throw downward into the vessel volume

For more information ✔ at www.engineerlive.com/epe

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