Mineral Products Association

Guidance for prevention of storage silo over-pressurisation during road tanker deliveries of non-explosive powders

V1

Introduction

The Mineral Products Association and its members have committed to Vision Zero to ensure that everyone goes home safe and well every day. A key part of Vision Zero is the continuing focus on 'The Fatal 6', the high-consequence health and safety hazards that account for most serious injuries and fatalities within the minerals sector. Through a range of strategies and measures, the aim is to eliminate deaths and injuries linked to 'The Fatal 6' causes by 2025.

Pneumatic discharge of powders into silos takes place hundreds of times every day across the industry.

Deliveries that are not well controlled and monitored or silos that are not correctly equipped and maintained present a significant risk of silo over-pressurisation, risking workers being struck by flying or falling objects - one of the MPA 'The Fatal 6' hazards.

Training drivers and operators to spot the danger signs and understand the root causes of silo pressure issues is critical. Coupled with the deployment of suitable safety equipment, this is the only way to prevent future incidents.

Hycontrol, in conjunction with the MPA, has produced this guide to provide information on silo pressurisation and outline how to eliminate or reduce risks by providing appropriate monitoring and detection systems, regular checks and maintenance and safe working practices.

Contents

Over-pressurisation poses two main risks:

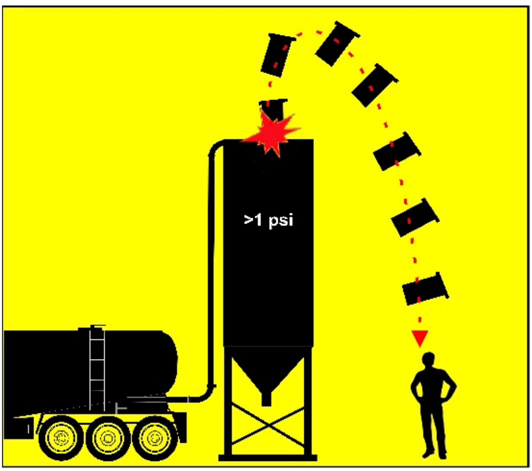
SILO FAILURE / DANGER TO PERSONNEL - Most cement, lime, and GGBS silos are not pressure vessels. It will only take a small pressure increase during a fill to buckle and weaken the silo, cause it to rupture, or even blow the filter off the silo roof.

If a filter unit (which may weigh over 100 kg) falls from the silo-top onto an area where site personnel are working, it could cause severe injury or a fatality.

ENVIRONMENTAL POLLUTION - If the filling process is not properly controlled, the resulting over-pressurisation often leads to clouds of powder blowing out of the silo.

Leaking product will eventually block pressure relief valves, accelerating the risk of a full-blown over-pressurisation event.

Furthermore, corrosive or hazardous products leaking will cause considerable environmental damage. This can result in fines or the removal of permits to operate.



What are the signs of over-pressurisation?

The most common indicator of silo over-pressurisation is powder on and around the pressure relief valve (PRV). A common misconception is that when PRVs vent powder, it is due to overfilling or that it shows that the system is doing its job correctly.

Neither of these is the case. Venting powder is a sign that the silo protection system has failed. Product is escaping because the silo is under **too much pressure.** Vented powder is dangerous if left to pile up, as it will solidify and block the PRV completely.

A powder blow-out is a warning sign of faults in the silo system and requires immediate investigation. The pictures below illustrate signs of over-pressurisation - **NOT overfilling.**

Tanker deliveries and pressures

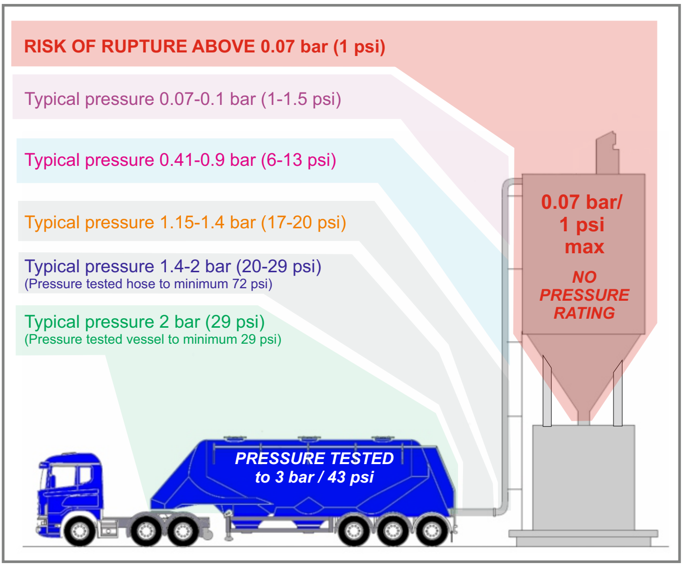
Tanker deliveries happen every day in the minerals industry. To safely control a delivery, it is important to understand the delivery procedure.

After arriving on-site, the tanker connects to the silo with a hose. An onboard compressor (known as a blower) pressurises the vehicle's tank, containing the powder. It is then fluidised at the bottom of the tank and blown through the connecting tube up into the silo. At this stage, drivers should read instruction signs, as well as unlocking inlet padlocks (if in place) and securing pipe whip arresters. They should check the alloy Camlock fittings are compatible and will permit coupling. These fittings are equipped with rubber sealing rings and locking levers which permit rapid connection between the tanker and silo fill pipe.

Modern tanker vessels can usually hold up to 40 m^3 of product. Road tankers of this kind are classified as certified pressure vessels and tested to ensure they are safe to deliver at pressures up to 2 bar/29 psi. The hose and couplings have a higher pressure rating (5 bar/72 psi and 8 bar/116 psi respectively).

Unlike tankers, hoses and couplings, it is important to note that the majority of silos are not pressure-rated. Silos can be damaged by pressures as low as 1 psi/0.07 bar.

The decay of pressure during a fill means that, by the time the pressurised air and fluidised product reaches the top of the silo, the pressure has significantly dropped because air is constantly venting freely from the air vent filter unit. This gradual decline is illustrated below.



How does over-pressurisation occur?
1 - Filter blockage

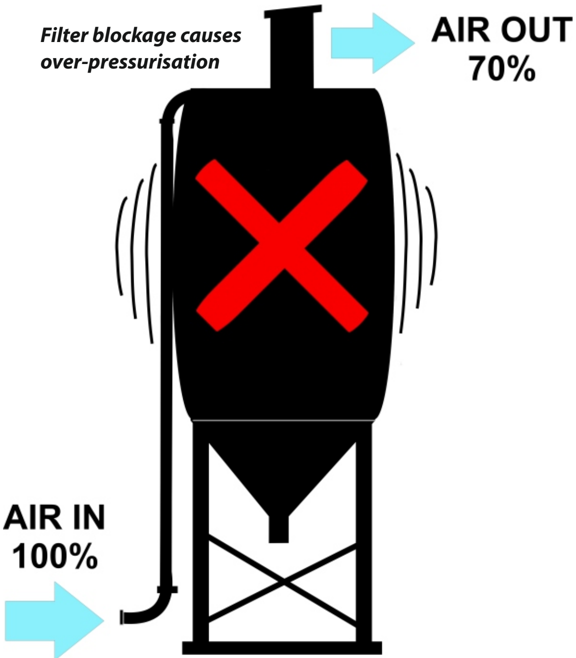
There are two equal risks to a silo while it is being pneumatically filled from a tanker:

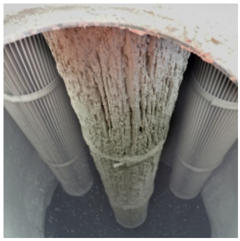
1 - **A filter restriction or blockage, or**
2 - **An uncontrolled discharge from the tanker.**

The diagram below shows a simple example of a silo in danger due to a filter restriction. The reduced airflow out of the silo results in an increasing build-up of pressure inside it.

There are several possible causes for this: the filter may be faulty or too small, the safety equipment may be poorly maintained, or over-filling may have caused powder to reach the filter and blind it. Regardless of the cause, the effect is the same - air is trapped in the silo, over-pressurising it.

An increase in pressure above 1 psi inside a silo can cause severe damage. There is a high risk that this will result in rupturing the silo or blowing the filter off the silo roof.





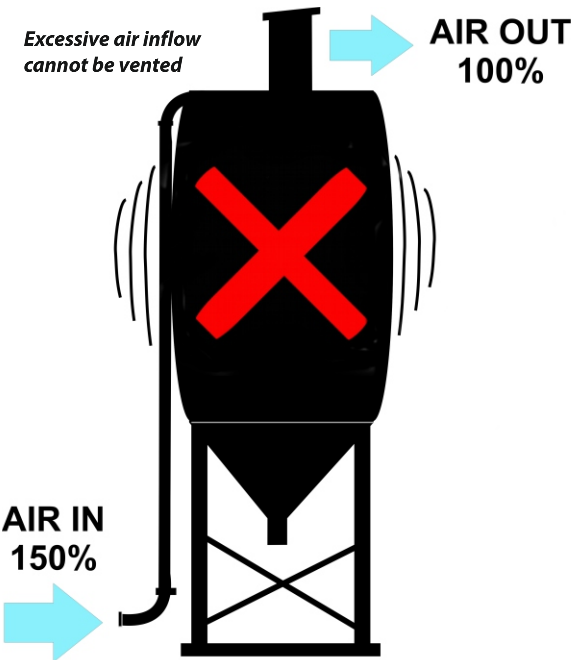
How does over-pressurisation occur?
2 - Uncontrolled discharge

Tanker drivers have a responsibility to fill silos in a controlled manner.

Manually controlling a fill is a hands-on process, reliant on the driver listening for a the blower to change pitch as the pipe empties, feeling the line (with a foot on the pipe), or simply striking the side of the tanker with a mallet to determine the powder level. **Uncontrolled discharge of pressurised air from the tanker during a fill is very dangerous and is a risk during every delivery.**

This problem usually arises at the end of a delivery when the silo is almost full, the tanker almost empty, and the truck has a high internal pressure with no product left to flow. If the driver releases air from the empty tank, the flow rate can reach 13,000 m^3/hr, far exceeding the 1750-2000 m^3/hr exhaust capacity of a typical filter unit. This volume of air trying to escape through a restricted orifice causes a back-pressure, over-pressurising the silo enough to blow the filter from the roof.

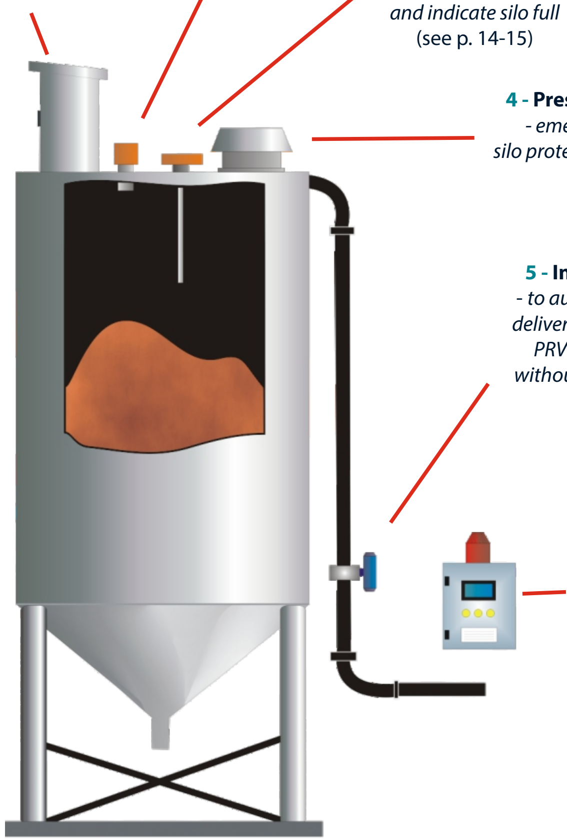
The residual build-up of pressure should be vented through the tanker in a controlled, safe manner, and *not* through the silo. **Airflow into the silo should never exceed the maximum possible airflow out of the silo.**



Tanker drivers should be trained in silo protection and must be aware of the causes of silo over-pressurisation.

Silo over-pressurisation directly endangers not only the driver but others on site as well.

To protect your silo from over-pressurisation, a silo protection system (SPS) needs to be installed. These are the essential safety components of a system:



1 - Filter unit
often referred to as a dust collector, bin vent or reverse jet filter
(see p. 10-11)

2 - Pressure sensor
- detects dangerous increases in pressure to shut down the delivery before the PRV lifts
(see p. 12-13)

3 - High-level sensor
- to stop filter blinding and indicate silo full
(see p. 14-15)

4 - Pressure relief valve (PRV)
*- emergency back up for the silo protection system - this opens if all else fails**
(see p. 16-17)

5 - Inlet shut-off valve
- to automatically stop the delivery on a high-pressure, PRV lift or a high-level, without driver intervention
(see p. 18-19)

6 - Silo protection control panel at fill point
often referred to as an auto shut-off panel
- connects to sensors and shut-off valve to monitor and control the process. Provides audio/visual alarms for the silo and essential information
(see p. 20-21)

* Note that the pressure relief valve is a safety redundancy for the system; a last line of defence should all other safety controls fail. Under normal circumstances, the PRV should *never* open.

Essential silo protection components
1 - Air vent filter unit (dust collector/bin vent)

LOCATION: **Silo roof.**

FUNCTION: To exhaust air blown in during a delivery while keeping the powder and dust inside the silo.

SIZING: Must be correctly sized to be able to vent sufficient quantities of air during the filling process - between **1700-2000 m^3/hr** (twice the recommended safe tanker blower output level). Handling this volume typically requires a filter surface area of **21-24.5 m^2.**

OPTIONS: Most modern filter units use compressed air and reverse jet tubes to blow entrained powder out of the cartridges back into the silo.

COMMON PROBLEMS:

Air supply failure, preventing reverse-jet self-cleaning.

Damaged or blinded filters trapping air in the silo.

Dirty or contaminated air supply (e.g. through water in the line).

Undersized filter unit which is incapable of passing the safe blower flow output.

Lack of maintenance and inspection. Cartridges should be replaced in accordance with the manufacturer's guidelines.

Inappropriate **filter fixing arrangement** such as a banded connection.



Typical reverse -jet filter examples

The following images illustrate some of the most common filter problems.

This cartridge has blown out due to excessive air pressure through the reverse jets. Cartridges damaged in this way allow powder to escape, leading to further problems. Small tears will get worse over time, eventually rendering the whole cartridge useless. Inspect cartridges fully during maintenance.

Blown filter cartridge

Blown cartridge

Loss of air supply to the reverse jets will render a filter unable to self-clean. The cartridges will quickly become congested, trapping pressure in the silo.

Polluted air supply (in this case, oil)

Damaged air jet

Blocked cartridges are the most commonly-seen filter failure. Even with a fully-functioning cleaning system, cartridges will deteriorate over time. If this is missed during maintenance, it will soon result in pressure problems. Inspection and cleaning must be routinely carried out, and worn-out cartridges replaced.

Blocked cartridge

Essential silo protection components
2 - Pressure sensor

LOCATION: **Silo roof.**

FUNCTION: To detect pressure increases above **40 millibars (0.58 psi)** so that the pressure alarm triggers before the emergency PRV needs to open (at 50 mbar/0.72 psi).

ALARM ACTION: If the sensor detects a rise in the silo's internal pressure above the maximum safe level, it signals the control panel to close the inlet valve immediately. This signal should also trigger an audible alarm and flashing beacon to alert site staff.

FAILURE MODE: **Failsafe -** a fault with the pressure sensor should instantly close the inlet valve and alert site to protect the silo from potential over-pressurisation.

OPTIONS: **Ground level test (GLT) facility -** test sensor functionality without having to climb the silo and remove the sensor before every delivery.

Self-cleaning - reduce maintenance requirements.

COMMON PROBLEMS: Pressure sensor is **not failsafe**, usually resulting in undetected unit failure.

Sensor set-point is incorrect.

Pressure ports are blocked (may indicate lack of maintenance).

Sensor **not fitted.**

Never removed and tested for correct operation.

Poor maintenance fails to detect failed sensors.

Pressure Transmitter

Pressure Switches

Why the pressure sensor is essential

There is a common misconception that the biggest risk to silos comes from overfilling.

Understandably, one might think product on top of a silo is caused by overfilling, but this is due to over-pressurisation. The damage that can be caused by over-pressurising a silo far outweighs the problems of overfilling. Therefore, it is critical that the pressure sensor be tested regularly to make sure it is functioning correctly, in accordance with the manufacturer's recommendations/PPC permit requirements (whichever is more frequent).

Until recently, all pressure sensors on silos would need to be removed to be checked. As this was difficult and time-consuming, the pressure sensor was often overlooked, resulting in problems going undetected. However, pressure sensors are available which have been specifically designed for this application and can be tested remotely from ground level to confirm they are operational.

It should be noted that pressure spikes during a delivery occur too quickly for a human to react to and shut the system down. This is why it is essential that the safety system provides an automatic shut-off when a pressure spike is detected.

Over-pressurisation not overfilling

Powder being forced out of a PRV

Silo over-pressurising

Essential silo protection components
3 - High-level sensor

LOCATION:	**Silo roof.**
FUNCTION:	To detect when the product reaches a maximum safe level, typically 1 to 1.5 metres from the top of the silo. Prevents overfilling, which causes filters to blind, leading to over-pressurisation.
ALARM ACTION:	If a high-level condition is detected, the signal from the probe to the control panel will activate an alarm immediately and close the inlet valve after a 30 second interval.
FAILURE MODE:	**Failsafe -** a fault with the level sensor should **close the inlet valve** after 30 seconds to protect the silo from risk.
OPTIONS:	**Ground level test (GLT) facility** - test the sensor's functionality without having to climb the silo and remove the probe. **Self-cleaning** - reduce maintenance requirements (for vibrating probes this is a by-product of normal operation).
COMMON PROBLEMS:	Level sensor is **not failsafe;** increased risk of overfill and over-pressure. **Damaged, worn or broken** probe parts, for example rotary paddle blades missing. **Incorrect** sensor length. Sensors **incorrectly located** on silo roof, preventing material detection before filter blinding.

Paddle Switch

Capacitance Switch

Vibrating Switch

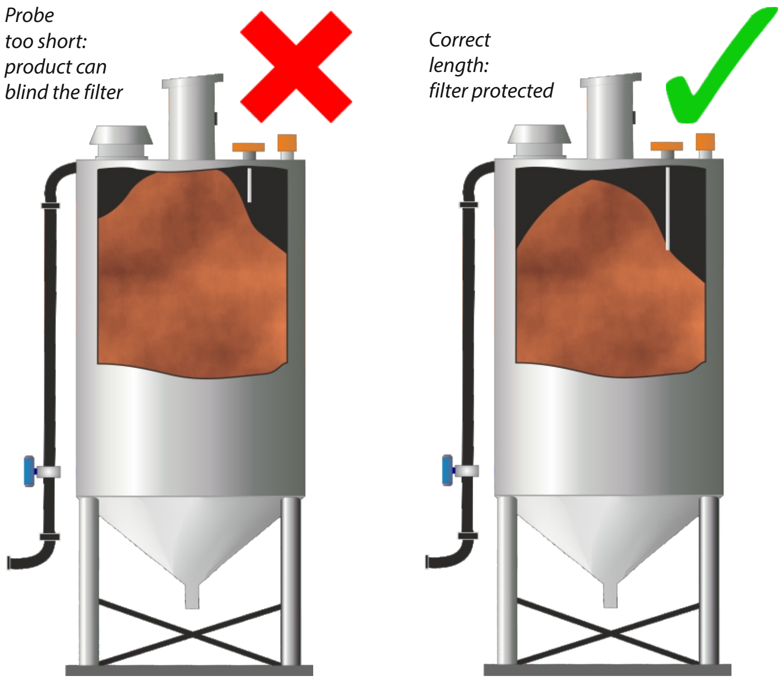
Correctly positioning the high-level sensor is crucial for protecting the filter cartridges from becoming blinded by powder that gets into the filter housing - which can cause over-pressurisation.

During transfer of bulk solid material into and out of storage silos, the shape of the material surface changes. These shifts can make a reliable reading of the product difficult if the level probe is not correctly located. It should be mounted away from the fill point, as exposure to product flow can cause premature wear on the probe.

By positioning the level measurement probe at a position of 2/3rd of the silo's radius, the user will generally have more accurate level readings, taking into account natural conical peaks and troughs that arise during the filling and emptying procedures.

If this position is also near the filter housing, then it is ideally placed for protecting the cartridges from blinding.

As illustrated in the examples below, it is also very important that the high-level probe be of a sufficient length to detect the rising product level before it can reach and enter the filter housing.



Essential silo protection components
4 - Pressure relief valve (PRV)

LOCATION: **Silo roof.**

FUNCTION: The last line of defence for the silo if the protection system should fail. It is designed to vent dangerous pressure quickly from the silo. **The PRV should only open in an emergency.**

SIZING: Must be capable of **venting up to 13,000 m^3/hr.**

CALIBRATION: The opening relief pressure should be **50 millibars** (0.73 psi). This is 10 mb above the set-point of the pressure sensor.

OPTIONS: **Ground level test (GLT) facility** - cycles the valve open and closed, confirming that it is fully functional and is not coilbound or seized closed.

Many PRVs have the option to fit a **proximity switch** to the lift plate, providing an additional alarm action if the PRV opens during a fill. Opening indicates over-pressurisation and likely a failed pressure sensor. The switch on the PRV will signal the inlet valve to close, providing a secondary safety measure.

COMMON PROBLEMS: **Regularly using the PRV** for control will lead to a **blocked or seized valve**, indicating a **serious problem** - *see opposite.*

Undersized valves cannot deal with the maximum uncontrolled airflow from a tanker, leading to the over-pressurisation of the silo.

Incorrect set-point leading to blockage and premature failure.

Damaged or worn flanges allow product to escape.

Insecure **banded connections** to the silo.

There is a commonly-held belief that a PRV constantly venting powder is normal and that this means it is operating correctly. But a PRV is an emergency device, similar in a way to a parachute; relying on it as part of normal operation indicates that something is dangerously wrong.

The PRV is designed to open should the silo protection system fail. The open pressure must be set at **50 millibars (0.73 psi)**, ten millibars above that of the high-pressure sensor. Therefore, the inlet valve should receive a signal to close **before** the PRV exhausts powder into the atmosphere.

This lifting pressure must be accurate. If both the PRV and pressure sensor have the same set-point, then the PRV will open constantly. Constant use will lead to premature valve failure with cement preventing the lift plate from opening - *see photo below.*

Any issue significant enough to open the PRV and vent powder is a threat to the silo and should be considered a near-miss event. **As such, a PRV opening must be investigated. Something has failed on the silo protection system.**

A PRV blowing continuously will fail

Essential silo protection components
5 - Inlet shut-off valve

LOCATION: **Fill point.**

FUNCTION: Automatically controls the delivery process, removing the risk of human error by closing when an alarm condition arises.

ALARM ACTION: If the silo's internal pressure exceeds the maximum safe level, the inlet valve will close immediately because of the pressure spiking. If a high-level condition is detected, the inlet valve will close after a 30 second interval; this is because the powder level increases at a slower rate, giving the driver time to react.

FAILURE MODE: **Failsafe closed** - any failure of the air or power supplies must close the valve. The inlet valve must fail in a closed position to protect the silo from the risk of uncontrolled filling.

OPTIONS:

Tamper detection to highlight bad practice.

The valve must be **tamper-proof** to prevent bypass of the safety system.

Open/close position feedback for failure diagnostic.

Wear indication for maintenance assistance.

COMMON PROBLEMS:

Not failsafe closed design.

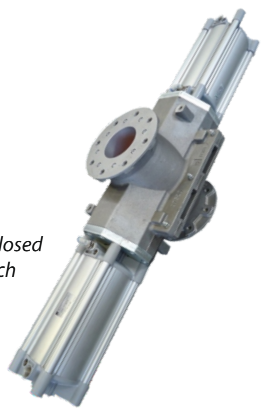
No valve fitted at all.

Forced bypass of pinch valves - *see page opposite.*

Failure to detect worn valves.

Normally-closed failsafe butterfly valve

Normally-closed failsafe pinch valve

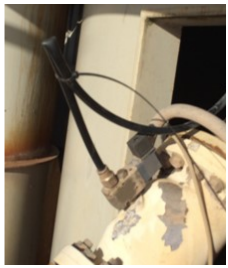


Normally-open pinch valves are by far the most popular type of inlet valve in the cement industry. They are simple and very low cost - but they are NOT failsafe and are easily bypassed or overridden.

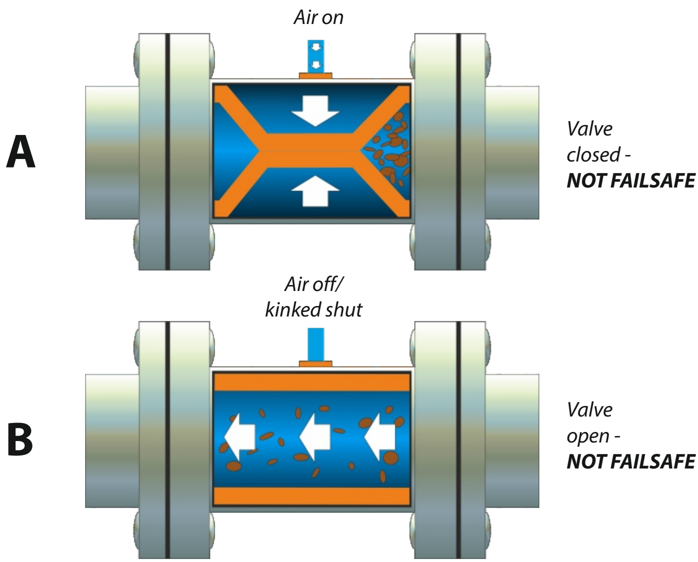
They work by applying pressurised air to a diaphragm to close the fill line, *as shown in figure A below*. However, this design of valve has limitations. These valves are normally-open, so if they fail (*as shown in figure B*), the inlet pipe is left open. They do not control or stop the fill process, rendering silo safety equipment ineffective.

Besides being susceptible to air pressure failures, these valves are easily overridden by deliberately cutting the air supply off. Kinking or tying off airlines to open inlet valves is unfortunately common, occurring in an attempt to speed up deliveries. Evidence of a forced bypass, such as a kink in the airline *as shown on the right*, can be found on many sites. This is not only bad practice, but it's also dangerous.

Because this type of valve is not failsafe, it can no longer be recommended as best practice for silo protection applications.



Above: *this airline has been kinked to bypass the valve*



Essential silo protection components
6 - Silo protection control panel

LOCATION: **Fill point.**

FUNCTION: The panel provides the essential logic functions to control the system and should give users easily-interpretable information about the status of the silo protection system. It must provide simple operation with clear instructions. Even so, system training should be provided.

ALARM ACTION: **A high-pressure event** must trigger an alarm and beacon and close the inlet valve immediately; this is safety-critical, and there is no time for human intervention with high-pressure spikes.

A high-level event must trigger an alarm beacon and siren immediately then close the inlet valve after 30 seconds, giving the driver time to clear his blowing lines safely and shut down.

A PRV opening must trigger an alarm and beacon and close the inlet valve immediately. Again, there is no time for human intervention with high-pressure spikes. Requires a proximity switch to be fitted to the PRV.

FAILURE MODE: **Failsafe** - alerts users to system failure; does not allow filling until addressed.

OPTIONS: **Ground level test (GLT) facility** - tests all safety components.

Event logging to assist maintenance by highlighting issues.

COMMON PROBLEMS: **Misleading panel information** - for example, test buttons only providing a lamp test, or generic panel displays showing probes which may not even be installed on the safety system.

Incorrect valve closure timings.

Damaged or faulty display, broken alarms or beacons.

Poor logic programming.


Typical control panel examples

Many panels have a test button, but in some cases all this does is test that the beacon and alarm are working. It is important to know the difference: a lamp test does not confirm functionality of the critical safety sensors on the silo top.

A true ground level test (GLT) allows the complete functional testing of the essential silo protection components *in situ*, with both feet firmly on the ground. It significantly reduces unnecessary working at height risks and promotes a safer working environment on site.

A true GLT function enables site operators to check safety equipment fully before every delivery takes place, guaranteeing all the system components are working. To ensure a safe delivery, the SPS must keep the inlet valve closed until the GLT has been passed. If a fault is detected, it should be investigated before the delivery is allowed.

GLT should not be considered a substitute for routine maintenance checks. However, by testing the pressure sensor, level sensor and pressure relief valve, the air supply to the filter's self-cleaning mechanism, and the position of the inlet valve before filling, site staff can be confident that the delivery can commence in safety.

Example of a simple one-key GLT operation

PRESSURE SENSOR	LEVEL SENSOR	PRV	INLET VALVE	DISPLAY PANEL
✓	✓	✓	✓	✓

ALL 100% TESTED BEFORE A DELIVERY

Sites often misunderstand silo protection, leading to ineffective systems being installed.

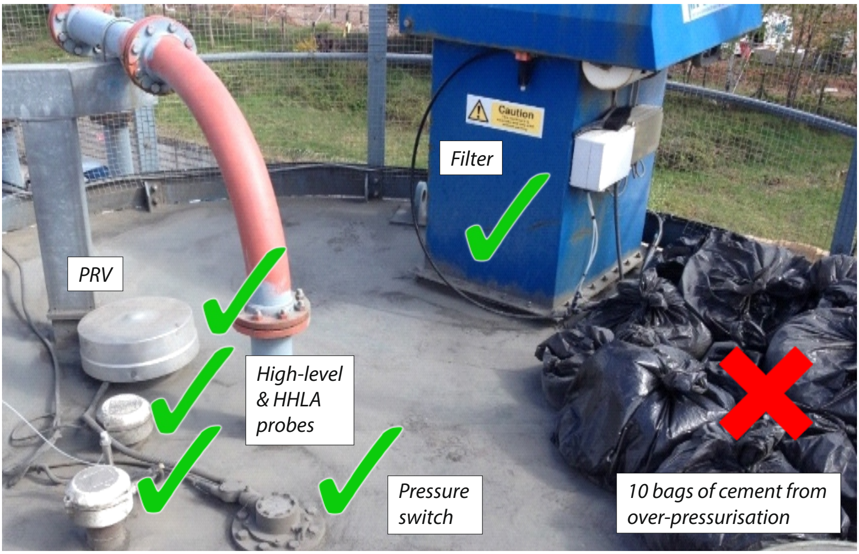
In the photo below, all the components detailed previously have been installed, including an air filter, pressure sensor, pressure relief valve, and level sensor, as well as a shut-off valve and control panel. However, powder continues to be emitted from the PRV, and has to be bagged up (*as seen on the right*) and cleared away regularly as the fitted components are not effective. Having equipment fitted is in itself not the answer - it must be failsafe and designed for the application.

This is a common mistake when trying to implement silo protection: systems assembled using off-the-shelf general-purpose sensors, which are unlikely to be failsafe. As such, they are likely to stop working without site staff being aware. These systems increase risk rather than limiting it.

Any safety protection equipment must be designed failsafe so that if it fails, it notifies the user. An everyday example of failsafe design would be the low battery indicator on a domestic smoke alarm, which alerts the user before the device stops working. In this respect, a silo protection system is very similar.

Installing a failsafe silo protection system is essential to ensure silo safety.

Any critical safety system must be regularly tested.



Competent maintenance of the system

Even the best-equipped system is only as good as the last time it was tested. Silo protection systems must be regularly inspected to ensure that they are operating efficiently and to address any issues before they become problems.

These checks must include the PRV, pressure sensor, filter and the high-level sensor: all essential for maintaining a healthy and reliable silo safety system.

Silo servicing checks must be carried out by trained, competent engineers, thoroughly inspecting and testing all the essential items and maintaining them appropriately. They should follow this guide and adhere to relevant checklists. Records must be kept and any required action taken as soon as it is highlighted.

On pages 26 and 27, you will find examples of basic maintenance checklists.

Competent maintenance will ensure continued safety for everyone working with silos.

A PRV being tested on site

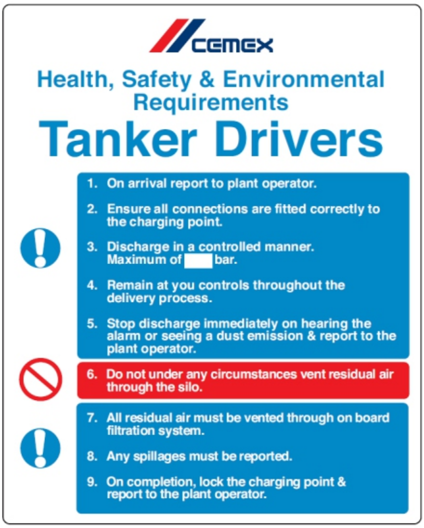
Signage

Information about operating the silo pressure safety system must be displayed at the fill point to guide users and promote safe practice. The HSE states: "Employers must provide safety signs if there is a significant risk [...] Safety signs and signals are required where, despite putting in place all other relevant measures, a significant risk to the health and safety of employees and others remains."

Operational signage must explain clearly and concisely how to operate the system in the correct, safe way and instruct the user what to do in the event of an alarm condition. It should be large enough for users to read from a distance, and should stand out against the background so it cannot be ignored.

After consultation with the delivery company, sites must display information at each silo filling point. Instructions should include: reporting to the control point before delivery commences, the maximum tanker discharge pressure and flow rate, ensuring all connections are securely fitted at the charging point, stopping and reporting in the event of level or pressure alarms, spillage procedures, venting residual pressure (which must never be through the silo), locking the fill point when the delivery is complete and reporting back to the control point. Silo inlets should be clearly identified with the silo number and product identity.

All safety signs should be of a standardised, consistent format, permanent and weather resistant. If the signs become damaged over time (for example by sun bleaching) they should be replaced. Labelling should conform to ISO 7010.



Risk assessments are an essential part of modern production, especially when working on a potentially dangerous site. With powder storage silos, monitoring, controlling and assessing any element that could create problems, both at the fill point and on the silo top, is necessary. As we have seen, failure to do so could have grave consequences.

Typical questions that need answering to complete an effective delivery risk assessment of a silo should include:

- **When was the filter last serviced and the cartridges changed?**
- **How many silo high-pressure events in the last service period?**
- **When was the level probe tested and confirmed working?**
- **What is the set-point of the pressure sensor and PRV, and when were they last checked?**
- **Is there a pressure relief valve fitted and what flow rate will it pass?**
- **When were the springs last changed on the PRV?**
- **Are the components failsafe, and if not, when were they last tested?**
- **What are the timings for closing the valve?**
- **When was the last internal inspection of the inlet valve?**
- **Do the pipe unicone ends have the correct flare to prevent decoupling?**
- **Is there sufficient lighting to work safely?**

As a minimum, all of these questions need to be answered before a delivery to assess the risk. If a site already has a comprehensive silo servicing regime in place that is carried out by competent engineers, most of this information can be taken from the most recent service sheet.

Maintenance checklist

The following checklist is not exhaustive; it is intended to highlight key areas of silo protection system upkeep.

Frequency of servicing will depend on the frequency of deliveries and the equipment that is fitted. For example, a testable, failsafe system may only require checking once every twelve months; a non-failsafe system may require weekly checks. Here are some essential checks for your silo (you may wish to engage a competent service company to carry these checks out):

PRESSURE RELIEF VALVE

- ☐ Make sure the pressure relief valve has not seized shut with dried cement or other such product.
- ☐ Clean in and around the PRV to eliminate any build-up that has accrued.
- ☐ Check the PRV lifts at the correct pressure (50 millibars/0.73 psi).
- ☐ Check size and flow rate for maximum flow conditions of 13,000 m^3/hr
- ☐ Check and replace valve springs and gaskets as per manufacturer (typically every 24 months). Assemble and calibrate as per instructions.

PRESSURE SENSOR

- ☐ Check that the set-point is correctly set at 40 millibars/0.58 psi.
- ☐ Check the sensor closes the inlet valve immediately and sounds the alarms when the set-point is reached.
- ☐ Test failsafe functionality (disconnect and see if the alarm triggers).
- ☐ Physically test it is fully operational and measuring pressure changes.

HIGH-LEVEL SENSOR

- ☐ Check the sensor has not been damaged and clean if required.
- ☐ Ensure the high-level sensor is functional by removing and activating as though in a product; for example, if you are using a paddle switch, stop it rotating to ensure it triggers the high-level alarm.
- ☐ Ensure probe length is adequate to prevent filter blinding (typically 1-1.5 metres).
- ☐ Test and ensure the failsafe functionality.

CONTROL PANEL

- ☐ Check the panel is located by the fill point.
- ☐ Test that the system panel's visual alarms and sounder beacons are working.
- ☐ Check that the alarms and beacons activate on the correct timings when the sensors are tested. Over-pressure should stop the fill instantly. High-level should have a 30-second warning delay.
- ☐ Check the panel information display is clear, with easily-understood instructions.
- ☐ Power off the control panel to test that the inlet valve closes.

FILTER VENTING UNIT

- ☐ Confirm that the air supply to the air filter venting unit is on and is working at the correct pressure. For a typical reverse jet filter, this should be 5-6 bar (72-87 psi).
- ☐ Check and drain accumulated moisture out of the reservoir trap on the filter systems.
- ☐ Ensure the filter cartridges are clean, that there are no leaks or splits, and that the seals are in good condition (note that they are designed to work with a fine layer of dust).
- ☐ Check the reverse jet solenoids pulse for each column at the correct interval.
- ☐ Check the reverse jet filter nozzles and manifolds for any blockages, damage or leaks.
- ☐ Change cartridges after 2,000 hours of operational use (this is the average lifespan of normal reverse jet filter cartridges).

INLET VALVE

- ☐ Check the condition of the inlet valve, making sure that it is undamaged and has not seized shut with dried cement.
- ☐ Look for any signs of tampering (such as crimped airlines) or attempts to force the valve, indicating dangerous malpractice. If there is a problem, report it to site management immediately.
- ☐ Inspect for wear on the inside of the valve wafer.
- ☐ Test failsafe functionality by removing the air supply and/or removing the power to the valve - it should fail closed.

GENERAL

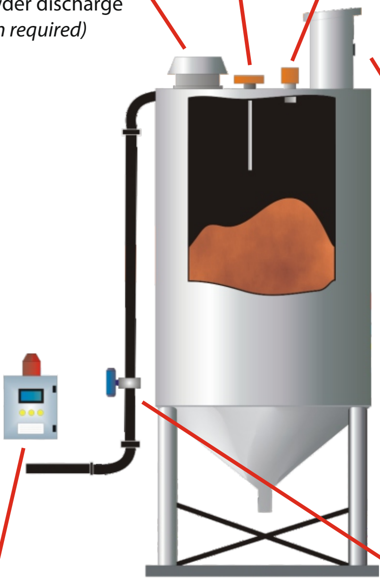
- ☐ Confirm schedule of silo servicing (e.g. three months, six months, twelve months) and when last service was conducted.
- ☐ Check signage is clear and up-to-date, and that driver/operator warning signs are visible to users.
- ☐ Confirm fill point and silo top have sufficient lighting for safe operation.
- ☐ Check that necessary fill point padlocks are in-place and secure to prevent unauthorised discharge or discharging into the wrong silo.
- ☐ Ensure whip arrester is attached and secure.
- ☐ Ensure correctly-rated hoses and couplings are used and are not worn or damaged.
- ☐ Confirm seals and clamps are not worn or damaged.
- ☐ Check discharge valves are working correctly and do not leak.
- ☐ Check the pipe unicone ends to ensure they are the correct flare to prevent de-coupling.

Basic silo safety audit checklist

High-level sensor
- [ ] Failsafe design
- [ ] Date tested
  __/__/____

Pressure sensor
- [ ] Set-point 40 mb
- [ ] Failsafe design
- [ ] Date setpoint tested
  __/__/____

PRV
- [ ] Flow rate 13,000 m^3/hr
- [ ] Set-point 50 mb
- [ ] Date springs changed
  __/__/____
- [ ] Signs of powder discharge
  (investigation required)



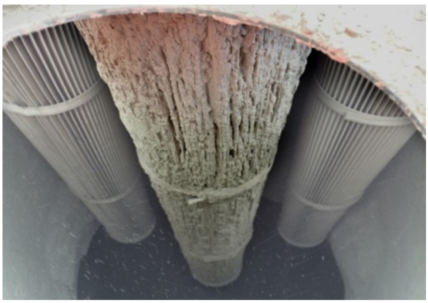
Reverse jet filter
- [ ] Correctly sized
- [ ] Air supply 5-6 bar
- [ ] Date cartridges changed
  __/__/____
- [ ] Clean filter media
- [ ] Checked air reservoir water trap
- [ ] Reverse jet manifold working
- [ ] Confirm no air leaks
- [ ] Solenoids pulsing OK

Control panel
- [ ] Failsafe design
- [ ] High-pressure valve closes immediately
- [ ] High-level valve closes after 30 seconds
- [ ] Siren and beacon operational

Inlet shut-off valve
- [ ] Failsafe design
- [ ] Check internal wear
- [ ] Check open/close operation
- [ ] Any signs of override
  (kinked airline)

These items are critical for achieving silo safety. If any components are missing, there is a high risk of silo failure.

Warning signs of silo protection failure



Six tips for safer deliveries

Tip 1 Train Your Staff

Ensure all site staff and drivers understand the dynamics of deliveries and are familiar with the silo protection system, both in terms of how it works and what the purpose of the equipment is. Cement delivery drivers must be aware of the risk when delivering bulk powder products, especially as they are the most at risk during the delivery process.

Tip 2 Test the System Regularly

Either the delivery supervisor or the driver must test all the silo protection system elements before the fill takes place, ideally immediately before. Tests must include the pressure sensor, pressure relief valve, and the high-level sensor, combined with the control panel. A lamp test is not sufficient.

Tip 3 Control the Fill

If you are a delivery driver, make sure you keep the fill pressure at a safe level. Do not allow the fill to go unattended or try speeding up the delivery by increasing the pressure – this is dangerous. Any alarms must be reported and investigated as they may indicate problems with the silo.

Do not vent any residual pressure left in the truck into the silo!

Tip 4 Have a Service Plan

Ensure regular silo servicing to maintain the safety equipment - see the example checklist on the previous pages. Experienced, competent engineers should conduct all servicing, and it should never be just a 'box-ticking exercise'. Merely cleaning the equipment *does not* count as a service! A thorough silo protection service requires around 50-70 individual checks as a minimum.

Tip 5 Stay Alert to Danger

Train personnel to spot signs of pressure issues, including dust build-up around the PRV, multiple high-level alarms and PRV lifts. Any release of product must be investigated. PRV lifts indicate near-miss events and are warnings of danger, so do not ignore them - report them to site management for urgent investigation and corrective action.

Tip 6 Use the BAT

Using the best available technology (BAT) will remove many of the operational headaches associated with silo over-pressurisation and safe filling. Ground level testing (GLT) is recognised to reduce risk by warning of failed equipment before it causes a dangerous issue.

All safety equipment must be failsafe.

The MPA has partnered with Hycontrol to access the largest database of silo event statistics and associated photographic examples of problems and failings within the quarry and cement industry.

Hycontrol has over 40 years of experience in silo instrumentation and safety systems design and is committed to silo safety worldwide.

The company is committed to educating the industry to remove the risk of silo over-pressurisation. Hycontrol provides the following services:

- **MPQC-audited training courses on silo pressure safety.**
- **Accident investigation and root cause analysis.**
- **Complete on-site silo safety assessments.**
- **Design, build, supply and support a range of silo safety equipment.**
- **Silo maintenance and servicing.**

For further information and instructional videos, please visit the following websites:

www.siloprotection.com

www.hycontrol.com

References:

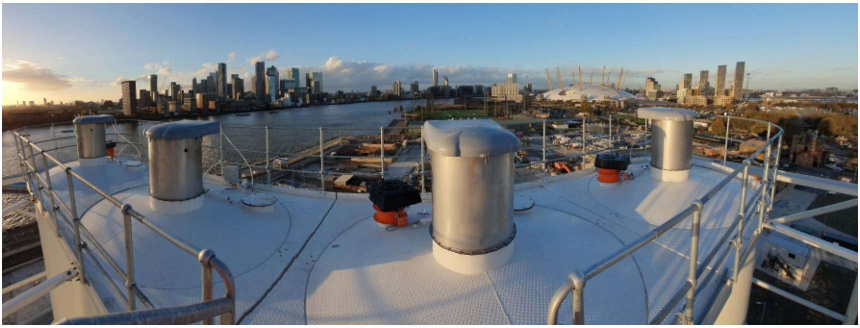
Mineral Products Association

www.mineralproducts.org

www.safequarry.com

www.safeprecast.com

'Guidance to prevent over-pressurisation of storage silos during the delivery of (non-explosive) powder in the cement, concrete and quarrying industries' - Mineral Products Association 2011



'The FATAL 6'

1. *Contact with moving machinery and isolation*
2. *Workplace transport and pedestrian interface*
3. *Work at height*
4. *Workplace Respirable Crystalline Silica*
5. *Struck by moving or falling object*
6. *Road Traffic Accidents*

Mitigating high consequence hazards

Please ensure that you report all accidents or incidents. If you see anything on your sites or customer sites that you think is unsafe, it is okay to stop and report it as a near miss.

VISION ZERO
SAFE & WELL EVERY DAY

One Vision

One Outcome

Everyone

Safe & Well Every Day

mpa
essential materials
sustainable solutions

Mineral Products Association
38-44 Gillingham Street
London SW1V 1HU

Tel 020 7963 8000
Fax 020 7963 8001
info@mineralproducts.org
www.mineralproducts.org

The Mineral Products Association is the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries.

For further MPA information visit www.mineralproducts.org