

GUIDANCE NOTES FOR STORING FERTILISER IN SILOS

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1. BULK HANDLING SYSTEMS

These days, most fertilisers in Australia are handled in bulk.

Bulk or Tonne Bags have proven popular in the horticultural, sugarcane and dairying industries.

Most grain growers use true bulk systems, often making use of existing bulk handling equipment.

In grain crops, there is often a narrow window of time in which to apply fertiliser, e.g. at planting, whereas other primary producers may apply fertiliser over a period of many months. To ensure fertiliser is on hand when required, it is often purchased in advance of peak demand periods and stored on farm. It would be physically impossible to meet the demand, i.e. dispatch and arrange transport, if growers only ordered their fertiliser when it was needed.

On farm storage systems are required.

Ideally, bulk fertilisers should be stored in properly constructed bays in closed sheds.

Such facilities, and the equipment to handle fertiliser in this way, e.g. end-loaders, are not available on most grain farms.

Instead, most grain growers make use of silos and belt conveyors or augers to store and handle fertiliser on farm in bulk.

These Guidance Notes have been prepared to help fertiliser Agents, Dealers and farmers manage bulk fertiliser in silos.

Only certain fertilisers can be stored in silos, and then only for a short period of time. Fertiliser should be purchased as close as possible to the time that it will be needed, and not stored in silos from one season to the next.

Regrettably, due to inherent variability in fertiliser quality and other external factors, e.g. prevailing weather patterns and the condition of the silo, problems may occasionally be experienced after only a short period of time in storage, e.g. product setting and hanging up in the silo. Sometimes, this may occur within a matter of days.

Blends do not store as well as straight fertilisers. Blends should be ordered as required, and only placed in silos as an interim measure.

2. CONVEYORS and AUGERS

Ideally, bulk fertiliser should be moved with a belt conveyor, e.g. Multiveyor, rather than a screw auger. The latter are much more likely to damage or crack the fertiliser granules.

Handling, and the use of screw augers in particular, can generate dust. The dust may be left intermingled with the fertiliser granules. It may also congregate in parts of the silo when it is being filled or emptied. The presence of dust, either in layers or throughout the product, may cause the fertiliser to set in storage. Dust has a greater surface area than granules, and therefore absorbs atmospheric moisture more readily.

Excessive handling can also reduce the effectiveness of coating agents and oils used on some fertilisers to help prevent moisture absorption.

Fertilisers should not be moved around any more than is absolutely necessary.

If a screw auger is used, make sure it is in good condition. Worn augers are more likely to damage the fertiliser, i.e. crack granules and generate dust.



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Silos should be located well away from powerlines to ensure conveyors, augers and bulk tippers do not come in contact with live wires.

3. SILOS

3.1 Design

Manufacturers of silos must be able to produce documentary evidence that the silos have been designed and constructed in accordance with the relevant Australian Standards. These include:

- AS 1170 SAA Loading Codes;
- AS 1170.1 Part 1 : Dead and Live loads and load combinations;
- AS 1170.2 Part 2 : Wind loads;
- AS 3774 SAA Loads on bulk solids containers;
- AS 3773 SAA Bulk solids containers – Safety requirements;
- AS 1657 SAA Fixed platforms, walkways, stairways and ladders.

AS 3773 states that manufactured bulk solids containers shall have a plate permanently affixed to the container giving the following information:

- Manufacturer's name;
- Model type;
- Maximum load in tonnes;
- Cubic capacity, in cubic metres;
- Serial number.

Also included in AS 3773 is a clause which states "*containers (silos) shall not be used or modified for the storage of materials other than that for which they had been designed*". This is particularly relevant if grain silos are being considered for the storage of fertilisers.

The top cone of fertiliser silos should be 30 degrees to accommodate a load where belt conveyors are used. Belt conveyors should not exceed 30 degrees in elevation.

It is recommended that fertiliser silos be designed with a base cone of not less than 45 degrees.

Angle of Repose

Most fertilisers have an angle of repose of around 35°. Not only does this vary with the type of fertiliser, but also with the quality of the fertiliser and its granule sizing and structure.

To ensure fertiliser flows freely from the silo, the angle of the base or cone must be appreciably greater than the Angle of Repose of the fertiliser. For fertiliser silos, the minimum cone angle is 45°.

Grain silos have a 35 – 40° cone.

It is recommended that an inspection opening be designed into the base cone with the cover being a flush fit with the internal surface.

If possible, the outlet slide gate should be 300 mm square and made of stainless steel. All nuts and bolts should also be made of stainless steel.

Generally, clearance of about one metre is needed under the outlet of the silo to accommodate a load – out conveyor.

The lid at the top of the silo should be able to be lifted by a linkage or cables operated from ground level to avoid the need to climb on to the silo. Any access ladder or platform must comply with AS 1657.

Qualified advice should be sought on the construction of the foundations, which must be designed and correctly installed to support the maximum possible load.

The design and capacity of the silo should be discussed with the manufacturer. The silo should be designed to handle the densest fertiliser that will be used.

The bulk densities of some commonly used fertilisers are given in Table 1. The density can vary, and sometimes may fall outside the stated range.



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Table 1: Bulk Density of some commonly used fertilisers.

Incitec Product	Bulk Density (kg/m ³)
Granulated Urea	700 – 780
Gran-am	850 – 900
MAP	900 - 1 050
Triple Super	1 050 – 1 150

If the formulation is known, the bulk density of a blended fertiliser can be estimated from the data in the above table. Incitec Pivot Limited can assist you in this task.

The figures at the top end of the stated ranges should be used when determining the maximum load or weight of fertiliser in the silo when full, to ensure the silo meets the Design Standards.

If a denser fertiliser (with a higher bulk density) is used in the future, it will not be possible to fill the silo to its full capacity. The silo must only be filled within its design strength, i.e. it can only be partly filled with a very dense fertilisers which exceeds the original design specifications to ensure it is not overloaded.

When determining the volumetric capacity of a silo for a given amount or a truckload of bulk fertiliser, use the figures at the lower end of the range. This helps ensure that product is not left over that can not be fitted into the silo.

Fertilisers are corrosive. The internal surfaces of the silo should receive two coats of epoxy paint to provide protection against corrosion. Silos constructed of stainless steel or fibreglass do not require internal protection.

The safety and operational directions provided by the manufacturer of the silo should be adhered to at all times.

3.2 Maintenance

Silos generally require minimal maintenance.

However, there are some essential checks for trouble free operation and a long life expectancy.

- Inspect the foundations for signs of sinking or cracking.
- Inspect and keep the lower slide openings clean by removing built-up fertiliser. This usually needs to be done once or twice a year, but may need to be done more regularly if the silo is in constant use or the fertiliser is unusually dusty or has attracted moisture.
- Regularly inspect the external walls and steel base of the silo for signs of corrosion, e.g. to structural welds and joints.
- At the end of the season, empty and clean the silo. Do not wash out. Check internally for signs of rust.
- Before entering silos, refer to the Australian and New Zealand Standard **AS/NZS 2865:2001** on “**Safe Working in a Confined Space**”. This is a regulatory requirement under various State Legislation and Acts.
- The atmosphere in confined spaces such as silos can be dangerous, while high internal temperatures can result in heat stress.
- Repair corrosion as it is found to prolong the life of the silo.
- If a silo, its supports or foundations are damaged in any way, e.g. by a truck or auger when transferring fertiliser, it must be inspected by a qualified engineer to ensure it is safe to continue to use, or whether repairs are necessary.

3.3 Operation

Storage problems can be minimised by good management and housekeeping, keeping the following points in mind:

- Do not put damp or wet fertiliser into silos. The fertiliser may not flow evenly when emptying which can cause serious damage to the silo if product falls suddenly. In the event that the fertiliser hangs up on one side of the silo, the silo itself may become unstable.
- Do not fill the silo to the extent that fertiliser comes in contact with the silo roof. Moisture condensation off the roof can have a detrimental affect on the product.



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- Keep silos locked when unattended or deny access, e.g. by placing covers over ladders, to prevent accidental entry by children. Ensure external ladders start above child height.
- Ensure covers are tightly closed when not in use to prevent exposure to the elements.
- Some silos are fitted with vacuum top lids. Such silos minimise uptake of atmospheric moisture, and are preferred if not essential in some circumstances, e.g. for blended fertilisers.
- It is extremely important that the lids of these silos are in the fully open position during unloading operations.
- If this is not done, a vacuum may form inside the silo causing it to implode. This can result in serious damage to the silo.
- Do not store fertiliser in silos longer than necessary.
- Do not store fertiliser from one season to the next.

3.4 Silo Safety

Silos are legally regarded as Confined Spaces and should not be entered under normal conditions. Guidance can be found in “AS/NZS 2865:2001 – Safe Working in a Confined Space”.

If work needs to be done in a silo, at least two people must be in attendance, with one person remaining outside the silo at all times.

Never enter a silo while fertiliser is being emptied from the silo.

Before entering the silo, turn off conveyors and augers. Make sure no one can start filling or emptying the silo while someone is inside.

If you are working alone outside the silo let someone know what you are doing, and how long you expect it to take to complete the task.

Climbing silo ladders and operating from or walking along walkways can be dangerous. Full concentration and awareness are required.

Operators should ensure they have the appropriate safety clothing, foot ware, safety harness and lanyard.

3.5 What to do if Fertiliser “Hangs Up” in a Silo?

Fertiliser setting or hanging up in a silo can be life threatening. It can result in serious injury or death, e.g. should fertiliser hang up on one side of the silo while it is being emptied, causing the silo to collapse on its side.

Before taking any action, refer to the silo manufacturer’s advice on how to deal with the situation, and follow their instructions.

People in the area should be advised to keep away or to remain at a safe distance.

Before you or others approach and work on or near the silo, make sure there is a clear exit or escape route should it be required.

People should not be allowed on top of or underneath the silo if there is any chance of it collapsing.

Do not enter silos to try and start fertiliser flowing or to clear a blockage.

If working through the bottom chute, do not open it any more than is necessary, to minimise the risk of large lumps striking the operator.

The most common method used to start fertiliser flowing is to tap the cone of the silo with a rubber mallet.

Do not strike the silo with a steel hammer or other like objects. This may damage the internal protective lining (epoxy surface).

Some silos are fitted with vibrators that may help get fertiliser which has sett to flow again.

4. PRODUCT CONSIDERATIONS

Not all fertilisers can be stored in silos.

Those that can should only be stored for a short period of time. They should be ordered close to the time of intended use, and not stored from one season to the next.

Many factors influence how well and for how long a fertiliser will store in a silo.

One of these is the “Critical Relative Humidity” of the fertiliser.



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The Critical Relative Humidity is the relative humidity above which a fertiliser readily absorbs moisture from the atmosphere, and below which it will not absorb atmospheric moisture.

Fertilisers with a high Critical Relative Humidity generally have good storage characteristics.

The Critical Relative Humidity of various fertilisers is shown in Table 2.

Table 2: Critical Relative Humidity of commonly used fertilisers.

Critical Relative Humidity (%)	Incitec Product
80 - 85	Single Superphosphate (SSP)
70 – 75	Urea, Gran-am, MAP.
< 70	DAP, Triple Super (TSP).
55 - 60	Zinc Sulfate Monohydrate
50 - 60	Cal-Am

The Critical Relative Humidity of Blends is usually no better than that of the ingredient with the lowest Critical Relative Humidity, and is often depressed below this figure.

As a general rule:

- Straights will store better than Blends;
- MAP and MAP Blends store better than DAP and DAP Blends. The latter (DAP based products) are not recommended for use in silos;
- Cal-Am and Blends containing Zinc Sulfate Monohydrate should not be stored in silos.

Table 3 lists those Incitec Pivot products that might be stored for a short period of time in silos, and those that should not be placed in silos. If a product is not listed, it should be regarded as being unsuited to storage in silos.

Table 3: Silo Storage Guidelines for Incitec Pivot Products.

Incitec Pivot products that may be stored in silos for a limited time.	Incitec Pivot products that should not be stored in silos.
<p>Straights</p> <p>Granulated Urea</p> <p>Gran-am (granulated ammonium sulfate)</p> <p>MAP</p> <p>Granulock Products</p> <p>Triple Super</p> <p>SuPerfect (ex Geelong and Portland)</p> <p>Blends</p> <p>Urea Gran-am Blends</p> <p>Urea MAP Blends</p> <p>Urea Granulock Blends</p> <p>Urea Gran-am Granulock Blends</p>	<p>Cal-Am</p> <p>Cal-Am Blends</p> <p>DAP</p> <p>DAP Blends</p> <p>Sugarcane NPK Blends</p> <p>Blends containing Zinc Sulfate Monohydrate</p> <p>SuPer - ex Newcastle*</p> <p>SSP Potash Blends</p>

* The Single Superphosphate produced at Cockle Creek, Newcastle, has not been dried to the same extent as SuPerfect, which is manufactured at Geelong and Portland. It has a higher moisture content and should not be stored in silos.

BLENDS

Blends require very careful management.

They should be ordered when required, i.e. for immediate use,
and only stored in silos as an interim measure.

Blends should not be purchased and stored in advance of the season.

If you are unsure of the formulation of a Blend, Incitec Pivot Limited can advise you on
what ingredients are used.

While the Critical Relative Humidity of a fertiliser is of importance, many other factors influence how well a product will store in a silo, including:

- The moisture content of the fertiliser. In general, the higher the free moisture content of a fertiliser, the worse it will store. As an example, Single Superphosphate, which is mainly used for pasture topdressing, has a Critical Relative Humidity of 80 – 85%, higher than the other fertilisers listed in Table 2. However, unless it has been dried to a low moisture content, as in the case of SuPerfect, it should not be placed in silos. The Single Superphosphate manufactured at Newcastle is not suitable for storage in silos.
- The presence of fines in fully granulated fertilisers. Fines will increase absorption of atmospheric moisture, cause bridging between fertiliser granules and product setting.
- Use of coating agents. Many fertilisers are waxed or oiled to reduce moisture ingress and improve storage characteristics. Over or under oiling, however, can be detrimental.
- The chemical characteristics of the fertiliser. Impurities such as magnesium and iron present in the phosphate rock from which phosphorus fertilisers are made can affect their critical relative humidity and storage characteristics.
- Excessive handling of the fertiliser resulting in granule breakdown.
- The age and state or repair of augers used to handle the fertiliser.
- Exposure of the fertiliser to the elements during handling, in transit and at the time the silo was filled.
- Prevailing weather conditions (temperature, humidity) during storage.
- The age and condition of the silo.

The physical quality of the fertiliser should be noted at the time of delivery when it is being put into the silo. Fertiliser granules that have been physically degraded and/or contain fines will absorb moisture more quickly than non-degraded product.

If the product is degraded or dusty, endeavour to use it as quickly as possible, even if this means delaying the use of product of better quality stored in other silos until later in the season.

5. MANAGEMENT TIPS

- Silos can be dangerous. Follow safe working practices and ensure the health and safety of yourself and others.
- Only use properly designed silos. Grain silos should not be used to store fertiliser. Fertilisers are typically more dense than grain, requiring a silo of sturdier construction. Fertilisers do not flow as readily as grain, so a greater incline is required at the base of the silo.
- Keep silos locked and closed when unattended.
- Inspect the foundations and silo regularly. Check for corrosion, and ensure welds and seals are intact so that rain and condensation cannot enter the silo.
- Purchase fertiliser close to the time of intended use, do not store from one season to the next.



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- If more than one type of fertiliser is to be stored, manage the use of silos so that those products with the poorest storage characteristics, e.g. Blends, are stored for the least amount of time.
- Choose MAP in preference to DAP as a phosphorus planting fertiliser. DAP and DAP Blends should not be placed in silos.
- Ensure fertiliser does not get wet in transit or during handling, e.g. when filling the silo.
- Observe the quality of the fertiliser when it is being put into the silo. Fertiliser granules that have been physically degraded and/or contain fines will absorb moisture more quickly than non-degraded product. Consider alternative storage arrangements if possible. If placed in silos, use degraded product as quickly as possible, even if this means that product of better quality in other silos needs to be stored a little longer.
- Avoid excessive handling, e.g. through Screw Augers. Worn auger flights will damage (grind) the fertiliser, cracking granules and generating dust.
- Belt Conveyors will cause less damage than Screw Augers.
- Do not enter silos unless you have to. If there is a need to work in a silo, this should be done in compliance with the Australian and New Zealand Standard “AS/NZS 2865:2001 – Safe Working in a Confined Space”.
- Never enter a silo when the bottom chute is open.

6. OTHER SAFETY AND PRODUCT STEWARDSHIP ISSUES

6.1 Bulk bags

Incitec Pivot Limited strongly advises against the practice in some areas of using bulk bags to fill silos. Working beneath a suspended bulk bag above a silo is an unsafe practice. Bulk bags should be used to store fertiliser on farm, and be then emptied directly into the applicator using a properly designed lifting device.

6.2 Grain Storage

If a fertiliser silo is used out of season to store grain, ensure the silo is free of fertiliser before placing grain in it, and free of grain before placing fertiliser in it.

Unwanted grain may constitute a weed threat in crops in which the fertiliser is used, while the dust from phosphorus fertilisers may add to grain cadmium concentrations. If the grain is used for human consumption, this may contribute to a violation of the cadmium food standards.

6.3 Fumigants

If a fumigant has been used to control grain insects while grain has been stored in the silo, refer to the product label and the Australian and New Zealand Standard AS/NZS 2865:2001 on “Safe Working in a Confined Space” before re-entering the silo.

Where Phosphine has been used, it is recommended that its level within the confined space be checked. In the absence of sophisticated testing equipment, the silo should be allowed to vent naturally for 7 to 10 days, depending upon wind conditions and the size of silo, before entering it.

An approved air respirator should be worn when working in a silo that has been fumigated. The appropriate respiratory protective equipment is a full-faced respirator fitted with an appropriate filter cartridge to provide protection against Phosphine vapours. Self-contained breathing apparatus should be available for emergency use by a stand-by observer.



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7. WARNING

The information contained in this publication is for use as a guide only.

Belt conveyors, augers and silos should be operated in strict accordance with the manufacturer's instructions.

Many factors can influence fertiliser quality, and its suitability for use and storage life in silos.

These factors extend from the manufacturer or supplier of the fertiliser, through the supply and distribution chain, to the type of equipment used on farm and the prevailing weather conditions.

They include such factors as the source of raw materials, manufacturing process, use of coating agents and oils; shipping, bulk storage and transport conditions; the type and condition of equipment used by Dealers and on farm, temperature, humidity and exposure to the elements.

Incitec Pivot Limited both manufactures and sources fertilisers from other suppliers.

Because the fertiliser supply chain extends beyond our control, Incitec Pivot Limited hereby expressly disclaims liability to any person, property or thing in respect of any of the consequences of anything done or omitted to be done by any person in reliance, whether wholly or in part, upon the whole or any part of the contents of this article.

Problems may occasionally be encountered with fertiliser products that can usually be stored in silos without mishap.

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