KOTZUR

DESIGNING THE FUTURE

Silo Operation Manual

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Kotzur Pty Ltd ABN: 16 079 134 802
56-60 Commercial Street, Walla Walla NSW 2659
T (02) 6029 4700 F (02) 6029 2307
E info@kotzur.com www.kotzur.com

Silo Operation Manual

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1 Introduction

Since 1990 there have been a number of codes or practice and legislative initiatives which are aimed at improving safety in the work place and which also place specific requirements on the design and operation of silos. Obligations are placed on manufacturers, installers and operators

At Kotzur Pty Ltd we recognise the importance of safety in the workplace, and support the improved safety levels brought about by the current requirements.

Silos, similar to many other aspects of farm and commercial operations, present a risk to those working with them and also to innocent bystanders. Experience has shown that too often children are the casualties of silo related accidents. With the increasing need for on-farm storage and the not so obvious risks associated with silos, it is important that human life be protected, by adopting safe practices.

Your new “KOTZUR” silo has a number of safety features which will assist you, the owner, to provide a safe working environment for yourself, your family, your employees and visitors. These features will not necessarily prevent accidents unless those using the silo are aware of the risks and operate it accordingly. Many of these risks are highlighted by the use of warning notices on the silo.

Also included in this document is a section under Item 7 Silo Maintenance which refers to older silos. This will help you identify the risks, which may be associated with older silos and how to make those silos safer.

Please read this manual carefully and completely. If there are parts that you do not understand.....ASK, ring us, talk to your Agriculture Department or your nearest Government Department which is responsible for workplace safety.

The important things to consider;

- **ALWAYS THINK SAFETY**
- **AVOID ENTRY INTO SILOS UNLESS IT IS SAFE**
- **ONLY TRAINED OPERATORS SHOULD BE NEAR SILOS IN USE**
- **SILOS MUST BE PROPERLY INSTALLED BEFORE USE**

2 Installation

There are a number if important factors to consider when selecting a site and installing a silo. They are: -

Accessibility

There needs to be access for trucks and equipment used during filling and emptying. In most cases, the site must be accessible during the dry and wet months of the year.

Suitability of Soil

The foundations need to be constructed according to the foundation plan applicable to the model of silo being installed. The soil must have a bearing capacity stated in the foundation plan. IF IN DOUBT, CONTACT AN EXPERT AUTHORITY.

The ground must not be susceptible to subsidence. The foundations must be excavated to suitable compacted soil. The area must be drained so that surface water is diverted around the site and no water can lie within 5 metres of the foundations. Ensure that burrowing animals, such as rabbits or pigs do not undermine the foundations. DO NOT place silo on an existing slab foundation unless the foundation suitability is verified by an expert.

Overhead Power Lines

AVOID PLACING SILOS ANYWHERE NEAR OVERHEAD POWERLINES – a number of fatalities have been attributed to trucks and augers contacting power lines while being moved. Silos should be placed well away from power lines, to avoid the need to operate augers, trucks or other equipment under or near them.

Placing Silo on Foundation

The silo should be placed on the foundation so that it sits evenly. If there are gaps between the silo and concrete these MUST be packed using STEEL packers. No gap should be more than 1.5mm. Silos must not be placed on timber.

Ancillary Equipment

Unless specifically designed and approved by Kotzur, additional equipment, such as conveyors or walkways must be attached so that they DO NOT place any load on the silo or transfer any vibration to the silo structure.

Shelter from the Elements

To assist in maintaining grain quality, it is desirable to shelter the silo from the sun as much as possible. Shading silos helps to passively reduce the grain temperature in the silo.

For sealed silos, the extremes of cold, which cause wide fluctuations in internal temperature are also to be avoided. Therefore, where possible make use of trees, hills and other silos to shelter a silo. It is best to put silos in rows east to west as only the end silos receive morning and afternoon sun. Trees on the western side protect silos from the hot afternoon sun in summer.

3 Operation

Prior to the release of the N.S.W Code of Practice for Grain Silos, it was assumed that silo operators/owners would know how to operate a grain silo. A number of problems can occur, which are not always obvious to the operator, therefore it is important that the following procedures be understood.

Pre-filling Checks

Before filling a silo it is important to check the silo and its surrounds. The following checklist will assist you in checking your silo before filling.

FOUNDATIONS: The silo foundations are extremely important. Before filling check that they are not cracked, that they have not sunk (if they have sunk on one side the silo will lean), that they have not been “undermined” by animals or surface run off and that the drainage around the site is functioning to keep water away from the foundations. Check that the silo is sitting evenly on the concrete without any gaps.

SILO STRUCTURE: The silo structure must be sound. Check that there is no evidence of corrosion, damaged supports, rivets/bolts loose or missing and that the silo is in good condition. Corrosion is most commonly caused by high moisture grain sweating or releasing organic acids. Some of the grain protectant chemicals used can also cause corrosion. Therefore it is most important to check the silo internally. Most models of “KOTZUR” silos are fully galvanized to minimise internal corrosion. Silo supports can be damaged in a number of ways. The most common damage is caused by trucks or other equipment, or foundation subsidence. A support can only perform its function if it is straight; therefore damaged supports must be repaired prior to filling the silo. BEFORE REPAIRING ANY SILO, CONSULT THE MANUFACTURER. Rivets and bolts can be checked randomly with a spanner or screwdriver to ensure that they are tight, not sheared or corroded. This is particularly important with older silos. Part of the structural check is to ensure that all safety devices are operating correctly and all warning devices are legible.

GRAIN HYGIENE: Grain should only be introduced to a clean silo. “KOTZUR” silos are designed so that they can be washed out after emptying. Normally a high-pressure washer or fire hose is used. After washing, a structural pesticide is applied in and around the silo. The silo should be left closed up when clean to avoid birds entering and soiling the inside of the silo. Before filling, check that the inside of the silo is clean and that the area around the silo is free of rubbish and grass, as these may harbour grain insect pests.

HATCHES AND OUTLETS CLOSED: Immediately prior to filling, check that all outlets and also the base manhole are closed.

WITH SEALED SILOS CHECK FOR PROPER OPERATION: It is recommended that sealed silos be tested once a year. Also check that the relief valve is filled with oil to the correct level and that the air passages are not blocked by debris. Please refer to Appendix 3.

BEFORE FILLING GRAIN INTO SILO ENSURE THAT NO-ONE IS IN THE SILO; As part of this check it is important that all people present are warned about the risks associated with stored grain. Children, in particular those too young to comprehend the risks must be kept away from silos and equipment in use.

GENERAL POINTS OF OPERATION: There are a number of important practices that, must be adopted when operating a silo. These are:-

1. Silos should only be filled using the centre filling hole, to maintain an even load on the silo.
2. When unloading, the centre-emptying outlet must be used. THE SIDE BAGGING (where fitted) OUTLET MUST NOT BE USED UNTIL THE FIRST 5 TONNES OF GRAIN HAVE BEEN REMOVED. Research has shown that the loading on parts of a silo increases by a factor of three (3) as unloading commences. Therefore care must be taken at this time. It is important that a top hatch be opened prior to unloading a sealed silo.
3. When a silo is not in use, make sure that the outlet slide lever is secured with the chain held tight. Ensure that the ladder cover plate is closed. A padlock (not supplied) can be used on the catch if necessary.
4. Confirm that all grills in place over roof inspection openings are securely fixed.
5. To open the ladder cover plate, open the catch and hinge. Make sure that the bar to hold the cover open is put in place before climbing the ladder. This prevents it closing accidently. Ensure that the cover is securely closed after descending from the silo.

DO NOT OVER FILL THE SILO: Each silo has a maximum allowable capacity in tonnes. This is the designed safe working load of the silo when correctly installed on the recommended foundations. This maximum tonnage MUST NOT BE EXCEEDED. In general, all of the general purpose grain storage silos are designed to carry their full volume in the heavier grains such as wheat or lupins. A number of the special purpose silos are NOT designed to be filled with such grains or superphosphate. Always check the maximum allowable weight before filling. If it is not possible to weigh the grain or other material into the silo, the following formulae can be used. The silo specifications are on the Silo Identification Plate on the silo.

The formula for calculating the mass of grain in a silo is;

The formula for calculating the mass of grain in a silo is;

$$\frac{(m^3 \times d_{KG})}{1000} = W$$

Where : m^3 = Silo Capacity in cubic metres
D_{KG} = Product Density in kilograms per cubic metre
W = Weight in Tonnes

To convert product density from tonnes per cubic metre to kilograms per cubic metre

$$D_{KG} = D_T \times 1000$$

Where : D_T = Product Density in tonnes per cubic metre
D_{KG} = Product Density in kilograms per cubic metre

To convert product density from kilograms per hectolitre to kilograms per cubic metre

$$D_{KG} = D_{HI} \times 10$$

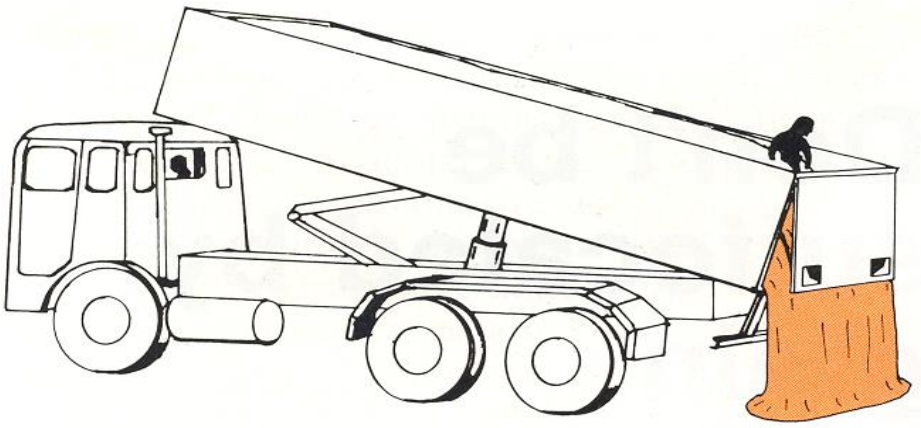
Where : D_{HI} = Product Density in kilograms per hectolitre
D_{KG} = Product Density in kilograms per cubic metre

Always add approximately 10% to the calculated weights to allow for grain compaction. If the resulting weight exceeds silo maximum design load, only part fill the silo. **DO NOT OVERLOAD THE SILO**.

- For a list of indicative bulk densities of various products refer APPENDIX 1.
- For the capacity of an unknown silo, use the calculator on the Kotzur web site www.kotzur.com

4 Safety

There are a number of risk's which are associated with using grain silos. They are listed here so that you are aware of them and can avoid dangerous situations when using your silo.



Don't ride on loads of grain.

DON'T GET CAUGHT IN MOVING GRAIN

It is possible to walk on a mass of grain, such as in a silo or a truck, so long as the grain is not moving. MOVING GRAIN IS A KILLER. When grain begins to move, such as when a silo is being emptied, it can no longer support a person standing on it. Grain empties from a silo in a "funnel flow" fashion. This means that the grain on top comes out first by forming a flow of grain down the centre of the silo. A person standing on the grain is very quickly sucked into the grain and may not be able to escape, (a person can be fully submerged in the rain in less than 30 seconds). Once submerged in grain, suffocation can occur. The steps to avoid grain entrapment are:-

- **DO NOT STAND ON GRAIN THAT IS LIKELY TO START MOVING**
- **DO NOT ALLOW OTHER PEOPLE (ESPECIALLY CHILDREN) ACCESS TO A SILO**
- **CHECK SILO BEFORE BEGINNING TO EMPTY IT**
- **THIS SAME ADVICE APPLIES TO GRAIN BINS, TRUCKS AND HEADER BOXES**
- **AVOID STANDING ON GRAIN THAT CAN COLLAPSE**

“FUNNEL FLOW” of Grain out of a typical silo.

The last grain in is the first grain out.

WHAT TO DO IF CAUGHT IN GRAIN

All possible steps must be taken to avoid you or anyone else being caught in grain. If however this does occur there are a number of ways in which a fatality may be prevented.

Save yourself from suffocation

If you are about to be trapped in moving grain you need to take steps to prevent suffocation. The main cause of death is the combination of pressure on the chest cavity, which makes breathing difficult and inhaling grain which blocks the air passages to the lungs. (see diagram on next page).

TO AVOID SUFFOCATION

- **LEAN FORWARD TO ALLOW ROOM FOR YOUR CHEST TO EXPAND WHILE BREATHING**
- **COVER YOUR FACE WITH YOUR SHIRT TO FILTER THE AIR YOU BREATHE**
- **TRY NOT TO PANIC; REMAIN CALM AND MAINTAIN A SLOW BREATHING RATE**

(See diagram below)

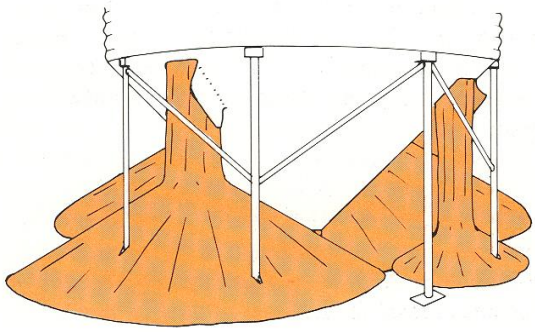
Cover your face if you are trapped in grain.

IF SOMEONE IS TRAPPED IN THE SILO YOU ARE OPERATING

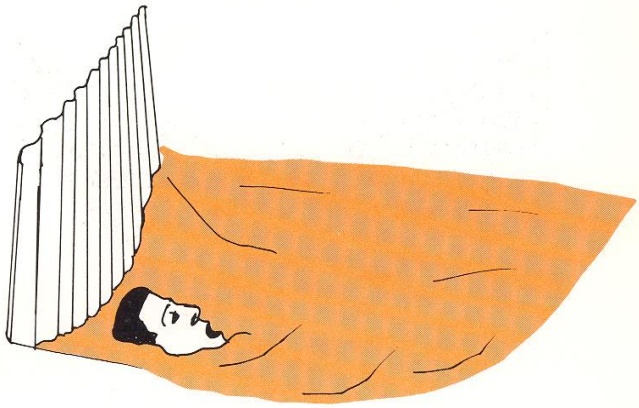
1. Stop the flow of grain immediately if someone is in the grain.
2. Empty the silo whatever way possible, but NOT from under the victim eg: cut holes in the side of the silo. There is a risk of silos collapsing win uneven unloading, but this measure may be considered to avoid a tragedy. Try to unload silo evenly from all sides.

   Try to reach the victim's head to allow them to breath. Use a cofferdam eg: a piece of sheet metal, to keep the grain away. Clear the victim's air passages if grain has been inhaled. Try to relieve pressure on the upper body to assist breathing.

If the victim is submerged cut holes in the silo to empty it quickly.



Use a coffer dam to hold back grain.



A SILO IS A CONFINED SPACE

Because a silo is a fully enclosed space there are a number of safety precautions to be taken before entering a silo. The most common risk is that of the internal atmosphere being poisonous, unable to support respiration or a risk to people with health conditions, outlined as follows:

1. The air may lack oxygen due to biological activity (fungi, insects) depleting the oxygen from the air.
2. There may be poisonous gases (eg: sulphur dioxide) present from grain decay. If auger exhausts are not vented away from the silo, carbon monoxide can build up in the silo.
3. There may be poisons present from grain treatment. These may be present as gas or as find dust in the air.
4. Grain dust can trigger sinus and asthma complaints.
5. A person working in a hot silo can be overcome by heat exhaustion, even after a short period of time.

THE NECESSARY PRECAUTIONS ARE:

- **TO AVOID ENTRY INTO A SILO WHEREVER POSSIBLE**
- **DO NOT ENTER A SILO UNLESS IT IS KNOW TO BE SAFE**
- **WEAR THE APPROPRIATE BREATHING EQUIPMENT (DUST MASKS, AIR SUPPLIED BREATHING MASKS, ETC)**
- **DO NOT ENTER A SILO FOR EXTENDED PERIODS IN HOT WEATHER**

EQUIPMENT ASSOCIATED WITH GRAIN STORAGE IS DANGEROUS

Much of the equipment used in conjunction with grain storage has it's own associated risks. Trucks, augers and elevators have moving parts etc. Most at risk are children and people who do not treat such equipment with the necessary respect.

THEREFORE:

- **KEEP CHILDREN AWAY**
- **DO NOT REMOVE MACHINERY GUARDS**
- **DO NOT TAKE RISKS**

AND

- **REMEMBER ALSO TO BEWARE OF OVERHEAD POWERLINES AROUND SILOS**

GRAIN DUST CAN EXPLODE

Around the world, grain dust explosions continue to result in significant damage, death and injury every year. Grain dust in a confined space has the potential to explode if there is an ignition source. Such an ignition source can be a cigarette, welder, oxyacetylene flame, heating due to mechanical failure (eg: a bearing in a conveyor), power tool (eg: and angle grinder) or an electrical spark. Therefore it is important that any potential ignition source be kept well away from a grain silo.

All electrical installation around silos and grain handling facilities must be installed in accordance with AS 4745 Handling Combustible Dusts.

Where the surrounding environment (eg: inside sheds etc) is dusty, a proper housekeeping system must be put in place. The shock from an initial explosion will raise further dust and result in subsequent explosions.

POTENTIAL FROM IMPLOSION

Air must be allowed to replace grain as a silo is being emptied. This is particularly important for sealed silos. It is important that one of the top hatches be open when emptying sealed silos.

RISK OF FALL FROM A SILO

When working on a silo, always wear appropriate footwear and take care at heights. The use of a safety harness with appropriate training is essential for carrying out any work at heights and not confined within the ladder cage/handrails.

MAINTAINING THE SILO

A latter section of this handbook points out the key aspects of silo maintenance. The maintenance of your grain silo is important for the safety of those using it.

5 Grain Storage Practice

One of the most important aims when storing grain is to maintain the quality of that grain. Grain deterioration is costly. The main causes of loss in quality are insect attack, decay (due to micro organisms), moisture damage and heat.

INSECT PESTS

Cleanliness is the key to avoiding insect damage. All equipment used such as header, auger, truck and silo must be cleaned. The use of approved surface insecticides will also help reduce insect populations. Remember particularly, to clean the area around the silo by reducing grass, immediately clear up spilled grain and the use of approved chemicals in the silo vicinity can help reduce insect populations.

When filling the silo, there is a number of contact pesticides which are available for use. Remember to use only chemicals recommended for the purpose for which you wish to use them and always READ AND FOLLOW THE INSTRUCTIONS.

At the time of writing, all contact pesticides available for use in Australia have been found to have resistance in some regions. Avoid using chemicals that are known to have resistance in your area. Phospine fumigants must not be used in unsealed silos, as its use in unsealed structures will not kill all stages of the insect pest life cycle and will contribute to phosphine resistance.

Sealed silos offer much more reliable pest control. For further information on fumigation in sealed silos, refer to appendices at the end of this manual. A sealed silo for fumigation must comply with AS 2628-2010 Sealed grain-storage silos – Sealing requirements for insect control.

To reduce the chance of costly damage to grain it is important to INSPECT THE GRAIN REGULARLY. In the warmer months, when insect populations multiply rapidly, this should be at least every 4 weeks.

Refer also to “Aeration for Pest Control” at the end of this section.

GRAIN MOISTURE

Apart from insect damage, moisture is perhaps the greatest cause of damage to grain. Moisture affects grain by causing fungi (moulds) to flourish and will often cause the grain to sprout as well as promoting rapid increase in insect populations.

Moisture can come from one of four sources:

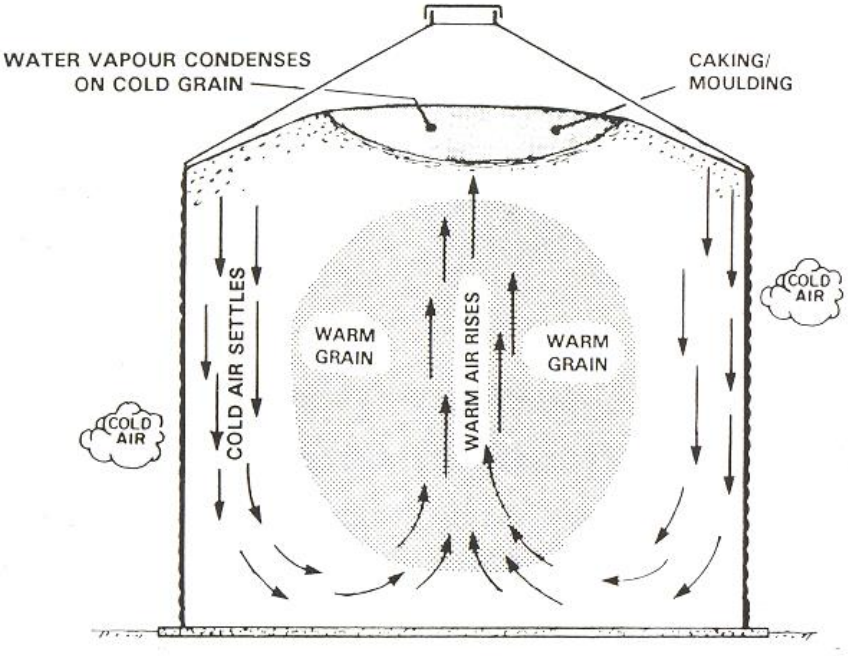
1. It is introduced with the grain ie: the grain had a high moisture content.
2. The silo has a leak.
3. As a result of insect respiration.
4. From the air in humid climates.

The last factor is not normally a problem with Australia’s dry climate, but rather is restricted to the warm, humid climates where storing grain in silos is very difficult.

CEREAL GRAINS MUST ALWAYS BE STORED DRY, USUALLY BELOW 12% MOISTURE CONTENT (M.C)

Other crops, such as Canola, have different safe storage moisture levels. Low moisture levels are even more important when storing in sealed silos. If grain is stored with high moisture levels the problem will normally become evident in the autumn when temperatures get cooler and relative humidity increases. Even cereal grain that is below 12% M.C, can set up a moisture migration cycle during cool weather. It is important to INSPECT GRAIN REGULARLY.

Moisture migration occurs when grain causes a steady air flow up through the grain, causing moisture to condense on the cool roof of a silo. Droplets of water then run down the underneath side of the roof into the grain. The tell-tale signs are wetness on the under side of the roof early on cold mornings and a large area of dampness on top of the grain, especially around the walls. Grain may begin to sprout. Large patches of dampness on the walls, particularly where a silo catches the morning or afternoon sun, may also suggest condensation.



If moisture migration or condensation is a problem in a silo, it is best to remove the damp grain and transfer it to another silo. Often transferring the grain on a cold, dry day will cause it to cool down and overcome the problem.

Experience has shown that prepared feeds such as pellets need to be monitored closely, particularly if they are warm and moist when put into the silo. Where possible ventilate the silo by leaving the top lids open on dry windy days.

If a silo has a leak, it is evident from a local patch of damp grain. On the walls of a silo this would appear as a tear drop shaped stain or grain crust and on top of the grain this would appear as a small area of damp or sprouting grain. The remedy is to fix the leak and remove damp grain from the silo.

A large infestation of weevils can create “hot spots” within the grain mass. These areas are usually warmer than the surrounding grain and weevils can thrive even when the rest of the grain has cooled to the point where they no longer remain active. The warmth and moisture that is released from insect respiration can also start a process similar to moisture migration where the combination of the moisture and the insect activity multiplies rapidly. If this problem is evident, it is best to transfer the grain to another silo (on a cold dry day if possible) and threat the grain to remove the weevils. This serves to break up the “hot spots” and remove the cause.

For higher moisture grain, aeration is essential to ensure safe storage.

HEAT IN STORED GRAIN

Heat in stored grain is a problem because it compounds the problems of insect and fungal activity and assists the moisture migration cycle. Grain viability is better maintained at lower temperatures. Therefore grain being used for seed or barely for malting must be kept cool.

Insect and fungal activity thrives in the 25 to 35 Celsius temperature ranges. Grain stored below 15 degrees will cause insects to remain dormant and fungal activity will be negligible at normal moisture levels.

There are a number of passive and active ways to keep grain cool. They are:-

1. For small silos <100T if it does not have a white or Zincalume finish, paint it white.
2. Place the silo where it has maximum shade from direct sunlight.
3. Try to put grain into storage when it is cool eg: at night or early morning.
4. Install and aeration system.

The first three options are best where suitable as they require little of no initial cost and have no running costs. Aeration, however, has an important role to play in ensuring grain quality is maintained, particularly for larger silos, high value commodities, oil seed storage and where grain is higher in moisture content.

AERATION FOR PEST CONTROL

There has been, in Australia, an increasing awareness of the Northern Hemisphere practice of using aeration as the prime insect pest control method. Relying on aeration for insect pest control, in Australian conditions, is limited and has a level of risk which must be understood. This has been shown by the number of cases where stored grain has been decimated by weevils, despite being under aeration.

The impact of temperature in stored grain insects is well understood, and can be summarised as follows:-

Above 35ºC -	Population growth limited as temperature increases
25ºC - 35ºC -	Optimum for population growth
15ºC - 25ºC -	Slower population growth as temperature decreases
10ºC - 15ºC -	Generally population growth ceases at these temperatures
0ºC - 10ºC -	Low temperatures lead to eventual death of storage insects
Below 0ºC -	Results in “quick” kill of storage insects

6 Responsibility of Parties

SITE OCCUPIER (or owner if in residence)

The occupier is responsible for ensuring that staff operating the silo, do so in a safe manner consistent with the operating instructions provided in this handbook. This requires the employer to provide the necessary training to ensure the silo and associated equipment is operated safely.

Employers have an over-riding duty (duty of care) to take reasonable care for the health and safety of their employees. This duty extends to the elimination of foreseeable risks including:-

1. Safety of the premises
2. Acts carried out by persons employed on the premises
3. Work practices and procedures
4. The condition of the equipment being used

EMPLOYEES

Employees carry the responsibility of co-operating with their employer to operate the silo in a safe manner as per their training.

These responsibilities are outlined in state OHS Legislation.

7 Silo Maintenance

MAINTENANCE ON NEW SILOS

New silos must be regularly checked for structural problems as outlined in the pre-filling checklist. If any problems become evident, always consult the manufacturer for advice.

MAINTENANCE ON EXISTING SILOS

There are a large number of silos on Australian farms which were installed prior to the present safety regulations coming into force. If you have other grain storage's that you operate, the following section will alert you to some of the problems which may be encountered. Parts of this section applies to "KOTZUR" silos, and also covers other silo designs and makes.

Perhaps the single most important danger is that the older silos may not have been correctly installed on adequate concrete foundations. Therefore it is important that new foundations be laid if there are any signs of cracking or subsidence, or if there is any doubt about the foundations.

FOUNDATION FAILURE IS THE MOST COMMON CAUSE OF SILO COLLAPSE

This can be by way of complete silo collapse, the silo walls failing due to high stresses or the silo blowing over in a severe windstorm.

A number of older silos may not have been designed for heavier grains, such as wheat and lupins. For example, silos designed for fed pellets or oats may have only half the load rating necessary for lupins. If in doubt, check before filling a silo. It has been found that all silos particularly older ones, must be unloaded from the centre only when filled with heavier grains.

Always look for signs of corrosion in older silos, particularly silos that have not been manufactured from galvanized steel. Corrosion in the support structure of the lower areas of the silo must be remedied. If you have an oder type silo made using vertical sheets of corrugated iron (not Kotzur), it is important that the bands that hold the silo together are free from rust. Examine where the bands are joined for evidence of corroded spot welds or boltls.

Check the fasteners, which hold the silo together. Around the lower areas of the silo where they are particularly stressed they must be free of corrosion and must be firmly in place. If rivets are corroded or loose they must be replaced. Older style riveting systems may have a limited life when subject to years of unloading, expansion, contraction and exposure to the elements.

IF YOU HAVE AN OLDER KOTZUR SILO

If you have a “KOTZUR” silo, which has s serial number prior to 794772, we do recommend that they have regular maintenance on the riveting system and that they are upgraded. In general most of the silos are believed to have been upgraded as all original purchasers have been informed of this need. If, however you have an older “KOTZUR” silo and are in doubt as to whether it has been upgraded, please contact us on 0260 294 700.

UPGRADE THE SAFETY FEATURES ON YOUR EXITINGS SILOS

Kotzur Pty Ltd can supply a number of safety components to upgrade most makes of silos. These include manhole safety grilles, base manhole kits, roof safety rails, warning labels, etc. Many of these features not only make your silos safer, but also more convenient to use.

8 Appendix 1 – Typical Bulk Densities

Bulk Densities of products will vary widely. For example, grain size and shape will vary each season, different grain varieties etc. For manufactured products (such as plastic pellets and feed pellets) the actual density can vary widely according to the manufacturing process and ingredient mix. When material is stored in a silo, typical compaction figures of between 3% and 10% can be expected.

GRAINS		**OTHER PRODUCTS**	
	Bulk Density		Bulk Density
Product	(kg/m³)	Product	(kg/m³)
Barley	770	Mash – Feed	450
Canola	720	Pellets – Pig	620
Corn	900	Pellets – Dairy	400 – 450
Lupins	770	Pellets – Poultry	480 – 610
Mash	480		
Maize	750	Fertiliser – Urea	710 -780
Oats	580	Fertiliser – Double	970
Peas	800	Fertiliser – MAP	840 – 1000
Peanuts	380	Fertiliser – DAP	850
Rice	580		
Rye	740	Woodchip	480
Sorghum	800	Palm Kernel Meal	600 – 650
Soybeans	750	Polymer (PP/PE)	560
Sunflower	600		
Triticale	720		
Wheat	810		

9 Appendix 2 – Fertilizer in Silos

Following are some important points on the safe and correct storage of fertilizers.

1. Only store fertilizers in silos designed for that purpose.

2. Store only granulated fertilizers in silos. Standard single superphosphate should not be stored in silos. The high “fines” dust content prevents it from flowing from the silo and, if stored for a longer period, it may set hard in the silo. Fertilizers that do not flow properly from a silo have caused instances of major structural damage to the silo.

3. If you are supplied granulated fertilizers with high “fines” or dust content, this should not be stored in a silo, for the reasons mentioned in point 2 above.

4. Many of the nitrogen fertilizers (especially Urea and DAP) are hygroscopic, which means that they readily pick up moisture from the air. This can cause them to “cake” or set hard. For this reason, they should only be stored for short periods or stored in silos that are sealed airtight. Ensure that these fertilizers are very “dry” when put into storage.

   If storing these fertilizers for longer periods, it is advisable to only ”part fill” the silo. This reduces the pressure on the fertilizer at the bottom of the silo and hence its tendency to “cake”.

5. Fertilizers are highly corrosive. Your “KOTZUR” fertilizer silo walls have a Colourbond finish internally and externally and the galvanized hopper is coated with a high build, amide cure (epoxy) coating. This protects the floor and walls from abrasion and corrosion. This coating will, however, need maintenance as necessary. An inspection prior to filling will determine when the coating needs to be re-applied. Some fertilizers (e.g. Ammonium Nitrate although no longer available) are highly aggressive and should only be stored in stainless steel silos. Confirm with your supplier

6. Further to point 5 above, always ensure that any dust which may settle on the outside of your silo at time of filling is swept away. If this dust remain it can, if combined with moisture, cause rapid corrosion. The roof is the most important area to inspect after filling.

7. It is strongly recommended that silos be completely cleaned, inside and outside, at the end of each season. Washing with high pressure water (eg: fire hose) is suggested ensuring that the bin is allowed to completely dry after washing.

8. Prior to using a fertilizer silo for grain storage, it mush be thoroughly cleaned to avoid grain contamination, this will involve sweeping to remove dust and fertilizer granuals. If the silo has been used to store treated fertilizer (eg: with “impact” fungicide) washing is essential, however the fertilizer supplier should be consulted to verify the cleaning method require to make the silo suitable for grain storage.

9. If you have any queries regarding fertilizer storage, please contact the manufacturer on 0260 294 700.

10 Appendix 3 – Sealed Silos & Fumigation

Sealed silos offer the most reliable and lowest cost insect pest control available.

They also offer the added benefit of being able to treat grain without chemical residues. A correctly sealed silo maintains high levels of fumigant inside the silo for long periods of time. This ensures that all stages of the insect life cycle are killed resulting in weevil free grain. Using fumigants in unsealed silos will not kill the early stages of the insect life cycle and there is a significant risk of causing insect resistance to fumigation.

It is important that a silo is not sealed up unless full of grain.

The head space air in any empty or partly filled silo will expand faster than the relief valve can dissipate the pressure. This will result in the oil being expelled from the valve and structural damage to the silo may result.

Always open a roof hatch prior to emptying a sealed silo.

A large amount of air is required to replace grain as it is being emptied from a silo. The relief valve is not designed to carry this volume, therefore failure to open the top of the silo may result in negative pressure inside the silo and cause major structural damage.

To achieve the best results, sealed silos do required regular maintenance. This includes an annual test to ensure that the silo meets the required sealing standard.

REGULAR MAINTENANCE CHECKS

1. Check all hatch and cover seals for visible damage which may allow leakage.
2. Check that oil bath relief valve is in good condition.
3. Check that the oil bath is filled to the correct level. This is marked on the valve body and should be 25mm above the top of the Vee notches in the chamber baffle. The relief valve **MUST NOT** be overfilled. Overfilling will result in increased pressure in the silo and may cause major structural damage.
4. Check that the oil is clean and has not thickened due to age/contamination. Oil will generally require changing every 2 – 4 years. Replacement oil should be a straight mineral oil (no synthetic additives) of 15 or 30 grade. Suitable oil is Caltex Rando 32 or Automatic Transmission oil meeting the requirements. Heavier or contaminated oil will result in increased pressure in the silo and may cause major structural damage.
5. Perform a silo pressure test to ensure that the silo is sealed to the minimum standard. This is explained in detail in the next section.

Important Note: This silo is gas sealed and used for fumigation. Fumigants such as phosphine will cause damage to electrical equipment. To prevent fumigant being transferred to other electrical equipment, all connection must be suitably vented to atmosphere. Conduits must not be used for electrical wiring.

PRESSURE TESTING THE SILO

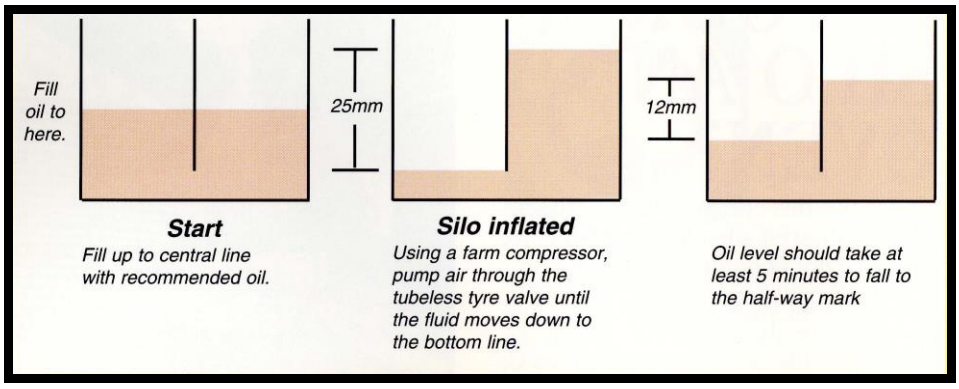
The silo is tested by pressurising the silo and timing the pressure drop. If the silo loses pressure too quickly, it is "too" leaky , and any attempt at fumigation has a high probability of failure. The steps are as follows:-

1. Testing should only be carried out under stable weather conditions. The best time to test is just before sun rise on a day when there is no wind. Windy or days of fluctuating cloud/sun will result in erratic pressure test results.

2. Inflate the silo until the oil bath shows a 25mm (1") difference in pressure (ref: diagram). "KOTZUR" silos can be inflated in one of two ways. Smaller silos are fitted with a tubeless tyre valve and require an air compressor. Larger silos are fitted with a 25mm ball valve and require a blow gun or a reversible vacuum cleaner. Silos fitted with aeration systems may be inflated using the aeration fan. **Take extreme care not to over-inflate if using an aeration fan as major damage to the silo may result.**

3. When the silo is inflated, remove the inflating device (and close ball valve on larger silos) and commence timing.

4. If the pressure has dropped to less than 12mm after 5 minutes, the silo is not sealed to the required standard. Leaks may be found by spraying soapy water over suspect areas or allowing the silo to pressurise itself at sunrise. The second method involves sealing the silo (including the relief valve inlet inside the silo) prior to sunrise. As the sun comes onto the silo, it will pressurise and a leak can often be heard providing there is not background noise. **Take extreme care not to over pressurise the silo**. Pressure will build up very quickly and too much pressure will cause major structural damage.



FUMIGATION

Phosphine is the most common fumigant used in silos and is described here in detail. Other fumigants or controlled atmospheres may be used. For further information contact the company or the fumigant supplier.

Phosphine is Poisonous

- It should be handled with protective equipment (eg: gloves, correct type of mask and eye protection).
- Containers must only be opened in the open air (and not carried inside a motor vehicle).
- A silo under fumigation must not be entered and must be signed to prevent unsuspecting persons entering.
- Before out loading a silo, the grain must be vented to allow gas absorbed by the grain to dissipate. Opening all hatches and allowing natural ventilation for 7 to 10 days is required. Aeration, if fitted to the silo, may be used to reduce the ventilation period. On larger silos (say above 500 tonnes) aeration is strongly recommended.
- Remove the phosphine tablet/sachet residue before emptying. Be careful with this residue as it may still be lethal.

Phospine Application

Phosphine comes in either tablet or sachet form. It must be placed in the silo headspace to allow for the proper circulation of the gas. Tablets must be placed on the metal tray (to prevent residue in the grain) while sachets may be hung from the safety grill in the centre fill hole.

Ensure that the label is read and all directions are properly followed. In general, fumigation must not be carried out under 15º Celsius and **it is very important not to "under dose"**. Applying less than the recommended quantity may result in a sub lethal dose, causing an incomplete kill, leading to resistance. **Always dose for the full silo size, not for the amount of grain that is in the silo if it is only part filled.**

For further information on fumigating, contact Kotzur Pty Ltd at 0260 294 700, the fumigant supplier or an agricultural extension officer.

11 Appendix 4 - Aeration

It is not intended here to cover the operation of aeration, however this will outline the applications for aerating stored grain and some key operating procedures. Refer also section under Grain Storage Practice, outlining aeration for pest control.

Modes of Aeration

Aeration is described according to three categories based on the required outcome and air flow rates. These categories are:

Maintenance Aeration

- Low airflow rates (typically 1 – 2 litres of air per second per tonne of grain)
- For maintaining the quality of otherwise good quality, storable grain (eg: clean and lower moisture)
- Stabilising dry grain with some higher moisture material present (eg: green grains, week matter such as wild turnip)

Cooling Aeration

- Medium air flow rates typically 2 – 8 litres/second/tonne)
- Cooling hot grain
- Rapid cooling of grain to reduce insect activity where fumigation is not an option (eg: older, unsealed silos)
- Storing grain at high moisture (eg: cereals above 12% moisture content, typical summer crops above 14.5%)

Drying Aeration (eg: KOTZUR Drying Silos)

- High air flow rates (typically 8 – 30 litres/second/tonne)
- Drying down high moisture grain using ambient or heated air

Aeration Control

When considering aeration of grain storage an automated control system should be considered essential. Whether drying or cooling is required, an automated control system takes out the “guess work” and variability associated with a system which relies on human intervention to start/stop the fans.

Operating a Silo with Aeration

There are several important precautions that must be observed when aerating grain in a silo;

1. Ensure that the silo is adequately vented for the aeration airflow. A higher pressure aeration fan can pressurise a silo beyond its structural design capacity. Ensure that the aeration fan is not able to operate

unless the silo is vented (this is particularly important with sealed silos).

2. All electrical connections must be safe and in accordance with electrical standards. There should not be any electrical equipment and connections inside the silo unless they are manufactured to the appropriate standard.
3. To avoid damage to grain (eg: re-wetting) the operator must understand the aeration systems design and limitations and operate it accordingly.
4. Ensure that aeration equipment is not operated when rapid re-wetting can occur which could cause expansion of the stored grain. Grain expansion (eg: if aeration is turned on in fog conditions) will over stress the silo and may cause silo failure.
5. When operating an aeration system with multiple fans, all fans should be operated simultaneously. Operating some fans and not others, may result in air not passing through the grain evenly, venting of air out of the non-working fans and inadequate grain protection. Further information should be obtained from the manufacturer if intending to operate the system without all fans running.

Further information

Kotzur Pty Ltd are happy to provide advice on aeration design, control and operation.

12 Appendix 5 – Feed Pellet Storage

Storage

Feed Pellets are often supplied by the manufacturer at higher temperatures and moisture levels than is ideal for long term storage. This is because, in general, feed pellets are used in the period immediately after they are supplied. In general, pellets produced during periods of high humidity and/or low temperature (ie winter) are more likely to be higher in moisture levels due to difficulty in drying product during production.

This moisture may be a problem under a number of circumstances. If the pellets are not managed, spoilage of the product and corrosion of the silo may result.

To avoid problems, the following steps are suggested:

1. Monitor feed pellets at delivery and note if they are warm or feel damp.
2. Regularly inspect the roof headspace, particularly in cold (frosty) weather.
3. Regularly inspect pellets if they will be stored for more that 2 – 3 weeks.
4. Avoid storage of high moisture pellets in sealed silos unless using aeration.

If pellets become moist or “lumpy” it is strongly suggested to immediately empty and clean the silo. Moist/damp pellets can cause corrosion of the silo and the feed may become toxic due to fungal and bacterial activity (eg salmonella). This can be harmful/fatal to stock.

Filling

When pneumatically filling silo, ensure that the vent pipe is clear (if silo is not fitted with a vent pipe, ensure one or more top hatches are open) to avoid pressurising the silo.

Contact Kotzur Pty Ltd on 0260 294 700 for further information.

13 Appendix 6 – Mobile Field Bins

Operation of all Mobile Field Bins

Mobile field bins are very different from conventional silos and have a number of specific operational and safety issues. The following points should be observed as part of the good management and risk assessment of field bin operation.

- Do not set up bins and use augers in the proximity of power lines
- Ensure that filed bins are set up on a level site so that all parts of the base are sitting snug on the ground and the bin is level.
- Only firm, dry ground should be selected and the site should be adequately drained in case of rain/storm water. Where field bins are located on ground which softens with moisture, the bin should be emptied prior to any rain.
- Observe the recommendations in the “safety” section of this manual.
- Where using mobile augers or fixed augers, precautions must be taken to avoid entanglement and crush injuries due to moving parts of the drive or the auger flight.
- Ensure all covers and guards are in place.
- With field bins fitted with spring assisted wheel lift, care must be taken to avoid injury associated with the spring releasing energy. **In particular, take care when changing wheels!** Do not allow bystanders, especially children, too close to where work is being undertaken.
- For Field Bins fitted with auger with 45º Gearbox;
  Gearbox is designed to be packed with grease.
  Check gearbox every month and/or 10 hours of operation.
  Use Caltex Lipex II or equivalent.
  To pack with grease, remove vent screw and fill using grease gun. When grease appears out of vent or pressure starts to build, stop greasing and replace vent screw.
- Standard 300mm (12”) augers should be operated in the range of 250 to 350 rpm.
- Do not attempt to move field bins with grain in them. The wheel system is designed to carry only the load of the empty bin.
- A tow hitch must be free (adjustment screws loose or detach from towing vehicle) before filling.
- Any modifications to the bin structure must only be undertaken after consultation with the manufacturer.

Maintenance of Field Bins – General

Similar to silos, it is important that regular inspection of bins be undertaken and any structural damage, such as rivets missing or sheared, bent supports, cracked welds be repaired immediately. Further specific maintenance should be carried out.

- Regular inspection of tyres for damage and any deterioration.
- The wheel lift mechanism must be regularly lubricated. In the case of the older style spring assist, the pivot should be oiled weekly. For the manual screw lift, the screw thread must be kept clean and oiled, at least weekly, to prevent the thread binding.

Maintenance of Field Bins with Fixed Augers

- Ensure all covers and guards are in place prior to use.
- Inspect universal joints, bearings and the gearbox (later models) for signs of wear, rough running and heat during running.
- Grease universal joints daily and bearings weekly.
- Gearbox Lubrication;
    - For Auger gearboxes supplied prior to April, 2011 (With Grease Nipple Fitted), grease weekly with a low viscosity grease (Caltex EP C2 or similar)
    - For auger Gearboxes supplied May 2011 and later, check oil weekly. Use SAE 80W-90 Gear Oil (Caltex Delo Gear Lubricant ESI 80W-90 or similar)

PLEASE NOTE: Failure to ensure regular and adequate lubrication of gearbox may cause over heating and failure.

Contact Kotzur Pty Ltd on 0260 294 700 for further information.

14 Appendix 7 – Sample Risk Assessment

A risk assessment is necessary for each business enterprise to meet their obligations in providing a safe working environment. The following sample is provided to assist the clients in the preparation of their own risk assessments. It cannot replace a purpose developed risk assessment which should take into account the unique conditions that are present at each site. Further information can be found at the NSW Workcover website http://www.workcover.nsw.gov.au or by contacting your local Workplace Safety office.

The following covers new silos. For existing silos, these should be assessed according to their individual design and installation. The following documents (on NSW Workcover Website) will assist in undertaking a risk assessment for existing silos.

Safe Use of Bulk Solids Containers and Flatbed Storage including Silos, Field Bins and Chaser Bins: Code of Practice
http://www.workcover.nsw.gov.au/NR/rdonlyres/B27C3D2B-0557-4923-98D3-62F232D5B50F/0/safe_use_of_bulk_solids_containers_and_flatbed_storage_including_silos_field_bins_and_chaser_bins_co.pdf

Safe Use of Silos, Augers, Field Bins and Chaser Bins on Farms: Checklists
http://www.workcover.nsw.gov.au/NR/rdonlyres/543C04AF-A9FC-4E00-B594-C69FA0A421F2/0/safe_use_of_silos_checklists_5043.pdf

Safe use of Bulk Solids Containers and Flatbed Storage: Frequently Asked Questions
http://www.workcover.nsw.gov.au/NR/rdonlyres/3ED09C42-40CB-445A-9090-55F2A3FFCA73/0/safe_use_bulk_solids_containers_flatbed_storage_faq_5009.pdf

A sample risk assessment follows:

	Consequence		Likelihood or Probability				
			A	B	C	D	E
	People	Environment	Almost Certain	Likely	Moderate	Unlikely	Rare
1	No Incident or First Aid Injury	Negligible Impact or Waste Discharge	3	2	2	1	1
2	Medical Treatment	Minor impact or Minor Quantities of Discharge	3	3	2	1	1
3	Alternate Work or Lost Time Injury	Moderate Breach of Environmental Statutes	4	3	3	2	2
4	Serious or Permanent Injury	Major Breach of Environmental Statutes	4	4	4	3	2
5	Fatality	Shutdown of Project Due to Environmental Breach	4	4	4	4	3

Probability Ranking	Probability Description
Almost Certain	Is expected to occur
Likely	Will probably occur
Moderate	Might occur - has happened
Unlikely	Could occur – known to happen
Rare	Practically impossible

Risk Ranking	Risk Score	Risk Description
Low	1	Monitor, manage and carryout activity in accordance with identified controls.
Medium	2	Implement control measures to reduce risk to as low as reasonably practical. Documented.
High	3	Implement control measures to reduce risk to as low as reasonably practical. Safe Work Method (SWMS) Statement required.
Extreme	4	Stop. Activity must not commence. Eliminated hazard or introduce controls to reduce risk to as low as reasonably practical. SWMS required.

Risk Assessment Record

Activity: Operations and Use of Kotzur Grain Storage Silo

Assessment Conducted by: Phil Kibby

Assessment Reviewed by: Andrew Kotzur

Date Approved: 18th June 2010

Work Sequence/Basic Job Steps	Hazards Identified	Risk Assessed	Risk Controls Implemented	Reviewed Risk	Notes
Inspecting silos and any equipment at heights	Fall from heights	4	Where no ladders fitted, use EWP for maintenance, etc Silos w/ladders – stay within cages when climbing silo Use remote devices (eg sight glasses, remote lids, fumigation) Operator trainings	2	Ladders/cages are designed for protection
Silo entry, inspecting or cleaning	Breathing difficulties, suffocation, toxic gases	4	Confined space training for operators Avoid entry to inside of silo where possible Test/check silo atmosphere prior to entry Use observer and have safety procedures in place Wear breathing apparatus appropriate for conditions	3	Beware grain dust, toxic gases and/or depleted oxygen may be present inside the silo
Operating ancillary equipment	Electric Shock	4	Ensure all leads/cabling is in sound condition Use Residual Current Device (portable if none installed) Locate all grain handling operations away from powerlines Avoid damage to leads (elevated off ground)	3	Aeration fans, on-ground silo unloaders, ancillary equipment and hand tools may be electric powered. Overhead powerlines are a serious hazard
Silo Inspection or cleaning	Grain entrapment/suffocation	4	Confined space entry requirements Do not enter silo above grain during out loading Ensure that grain is not bridged before entering silo Operator training	2	Children have died after being trapped by moving grain

Work Sequence/Basic Job Steps	Hazards Identified	Risk Assessed	Risk Controls Implemented	Reviewed Risk	Notes
Silo sweeping or cleaning	Amputation/laceration from moving equipment	4	Do not enter silo with an unloader or sweep operating	2	Moving parts include; on-ground silo unloaders, aeration fans and associated equipment such as augers/tractors/ grain vacs
Silo operations	Noise	3	Ensure all guards are in place Operator training Wear ear protection Avoid long exposure	2	Noise sources include aeration fan (especially high pressure drying fans), augers, unloaders, tractors
Operating ancillary equipment in dusty or grain environments	Dust explosion	4	Ensure all electrical equipment inside is properly rated All hot work (welding/cutting) using suitable procedures Operator training	2	Any ignition source in a dusty, grain environment may cause a dust explosion
Facility visitors	Injury to visitors/children	4	Secure area to prevent unauthorised access Keep children and visitors away from grain storage Lock off the bottom 2 metres of ladders Operator training	3	Visitors and children will not understand the risks associated with grain storage

15 Appendix 8 – Thermosiphon, Phosphine Fumigation Procedure

The Kotzur Thermosiphon Fumigation System has been developed over a number of years – beginning with initial trials in 2004. The use of this system allows for optimal fumigation with the added safety of being able to conduct the fumigation from ground level.

The steps to undertaking fumigation are as follows;

1. **Ensure that the silo is sealed**. Silo is tested, openings sealed etc.
2. **Read the label and ensure all safety precautions and PPE requirements are met**.
3. **Remove the thermosiphon chamber cap**. (Including the metal bag chain support)
4. **Install the bag chain on the metal support.** (As Shown)
5. **Insert the bag chain and close the cap.** The system must remain sealed for the period of the fumigation (refer label)
6. **At the end of the fumigation.** Vent the silo (ref. to Appendix 3), remove the bag chain and dispose of (refer to label)

   **** Important Note.** This system is designed for use with phosphine Bag Chains only. Do Not use tablet or pellet formulations.

Install Bag Chain on Metal Support

Insert Bag Chain into Chamber

Acknowledgements and Further Reading

The author would like to thank the following for their assistance:

NSW Department of Agriculture, Communications Unit for use of information and diagrams from;

Agfact P1.E.2 – Grain Silos Failures first ed. 1987.

Authors G Quick, A Andrews and A McLean

Agfact E3.10 – Don't be Suffocated by Grain first ed. 1988

Author F E Kernebone

Information Sheet – Moisture in Sealed Silos 1989

Author A Andrews

Workcover Authority of NSW for the use of information included in:

Codes of Practice

1. Safety aspects for the design and installation of on-farm silos.
2. Safety aspects for the operation of on-farm silos.

Workcover NSW for assistance with Sample Risk Assessment Development

Kotzur Pty Ltd ABN: 16 079 134 802
56-60 Commercial Street, Walla Walla NSW 2659
T (02) 6029 4700 F (02) 6029 2307
E info@kotzur.com www.kotzur.com

KOTZUR

DESIGNING THE FUTURE

Kotzur Pty Ltd ABN: 16 079 134 802
56-60 Commercial Street, Walla Walla NSW 2659
T (02) 6029 4700 F (02) 6029 2307
E info@kotzur.com www.kotzur.com