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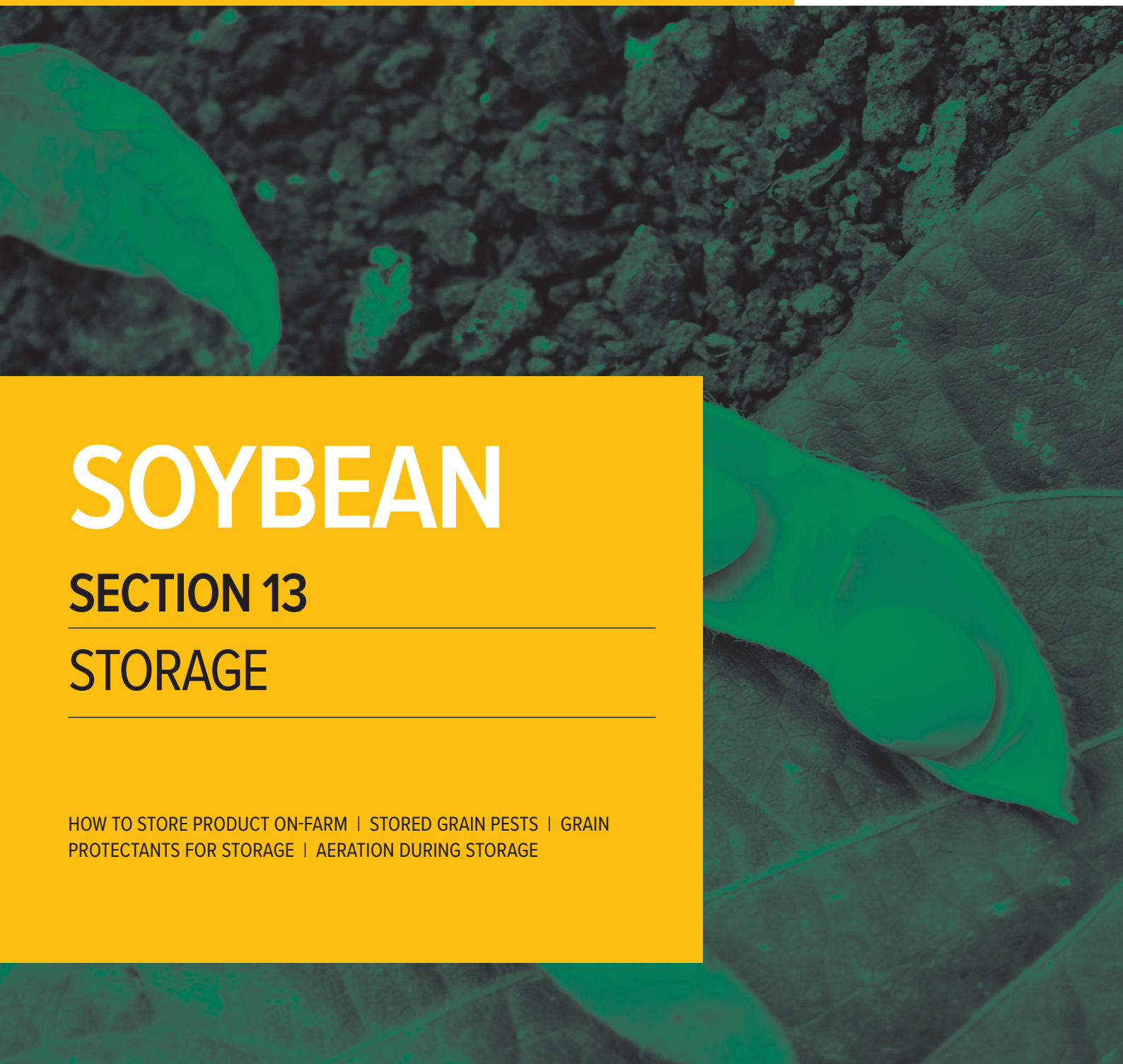

# SOYBEAN

## SECTION 13

## STORAGE

HOW TO STORE PRODUCT ON-FARM | STORED GRAIN PESTS | GRAIN PROTECTANTS FOR STORAGE | AERATION DURING STORAGE

SECTION 13

# Storage

## 13.1 How to store product on-farm

Choosing to store oilseeds on-farm requires attention to detail as there are limited tools available when compared to storing cereal grains.

To retain soybean market value care must be directed at maintaining seed quality, visual appearance and freedom from contaminants such as mould, insects and unregistered chemicals.

The handling of whole soybeans involves conveying and transporting from the farm to end-user. It is possible for soybeans to be handled as many as 5 times from the time they leave the farm until processing.

The structure of a soybean seed makes it susceptible to splitting and breakage during mechanical handling. The percentage of broken soybeans can be as high as 4.5% with a free fall drop of 30 metres. Bucket elevators and belt conveyors result in less damage when compared to the standard auger. When augers are used, run them to capacity to reduce seed damage.

Over-dry soybeans or soybeans that have been subjected to a number of rain events just prior to harvest are also more likely to split. The storability of soybeans is affected by the degree of damage to the seed coat. Damaged seed favours storage insect pest and moulds. Inspect soybeans for mechanical and other forms of damage prior to storage. If the amount of broken or split soybeans is high, it may be prudent to separate the broken or split grains by grading. Gradings can then be sold or used first rather than stored with the original better quality seed.[1]

### 13.1.1 Types of storage

Ideal storage for soybeans is a well designed cone based “sealable” silo with “aeration”.

The aim is to minimise damage to seed when moved, ease of cleaning/hygiene for empty storages and suitability of effective use of aeration cooling.

If seed requires insect control, the silo is then sealed (gas tight) for the required period as stated on the pesticide label (usually 7-10 days) to enable effective phosphine fumigation to take place.

For all storages types, extra caution should be taken to prevent storm/rain water ingress into storages.[2]

[1] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[2] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

*Figure 1: Standard aeration cooling fan. (Photo: Australian Oilseeds Federation)*

### 13.1.2 Deterioration indicators

#### *Heating*

Heating is a common indicator of a problem in stored grains and oilseeds. High grain temperatures normally indicate high grain moisture, microbial or insect activity. If left unchecked, this may lead to heat-damaged or charred grains.

Heating in cereal grains peaks at about 58°C then declines to ambient temperature. At the peak temperature, insects and moulds are killed, thus making the process self-limiting. In soybeans, however, as heating progresses above 50°C, the oxidation of oil in soybeans becomes a self-sustaining process. Temperatures above 150°C may occur. At this extreme temperature, charring occurs and spontaneous combustion is possible, if sufficient oxygen is present at the hot spot. Hot spots must be cooled or dissipated promptly. Moving the seed is one strategy. Do not aerate soybeans if a fire has already started, this makes the situation worse. A temperature monitoring system in bulk soybean storage is valuable.[3]

#### *Change in colour and general appearance*

In general, sound soybeans are plump with bright, uniform colour and free from unusual spots and shrivelled appearance. Discoloured soybeans are usually associated with inferior quality and lower market value. The change in colour is usually associated with higher moistures, temperatures and presence of moulds. This deterioration process can be detected by periodic drawing of samples from the stored soybeans. If detected, undertake aeration cooling or transfer the grain to another silo which cools the soybeans and break up hot spots during the conveying process. This may, however, be a less desirable choice due to the likelihood of increasing broken or split soybeans.[4]

#### *Mustiness and off-odour condition*

Musty odour usually indicates an advanced stage of insect or mould infestation and should be dealt with immediately. The soybeans should be aerated to remove the bad odour and to cool the seed. Beans should then be used at the earliest opportunity. Grain should be fumigated if insects are present. A sharp odour may indicate rancidity due to chemical changes in the oil component.[5]

[3] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[4] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[5] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

## *Presence of storage insects*

Regular monthly inspections and sampling of all storages is essential to check both grain quality and for the presence of storage pests. Sieve grain samples from the top and bottom of storages and use reference material to correctly identify any pests detected. The use of probe or pitfall insect traps located in the grain surface is also a helpful additional tool for early detections of storage pests.[6]

*Figure 2: Grain spear and insect sieve. (Photo: Australian Oilseeds Federation)*

*Figure 3: Grain insect sieve. (Photo: Australian Oilseeds Federation)*

[6] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

### *Lumping and caking*

Lumping and caking indicates an advanced stage of fungi invasion in soybeans. In metal silos, caking usually occurs on the walls or grain surface as a result of "sweating" or moisture condensing on inner surfaces of cold silo walls/roof. The condensing moisture is absorbed by the adjacent grains resulting in either sprouting or mould growth. A leaky silo roof/hatch may also be the cause of lumping and mould.[7]

### *Chemical changes in storage*

Stored soybeans may undergo chemical changes even under ideal storage conditions. One common indicator of chemical change is the level of free fatty acid (FFA) present. An increase of FFA above 1% may translate into lower quality of its oil content. Decline in soybean seed germination and vigour can be rapid. Careful attention to storage temperature and moisture conditions has the largest influence on minimising problems.[8]

## 13.2 Stored grain pests

There are a number of insect pests that will infest stored oilseeds, usually favouring the grain surface. These are bruchids (*Callosobruchus spp.*), rust-red flour beetle (*Tribolium castaneum*), Indian meal moth (*Plodia interpunctella*), warehouse moths (*Ephestia spp.*) and psocids (*Liposcelis spp.).*

*Figure 4: Bruchids (Callosobruchus spp.). (Photo: Australian Oilseeds Federation)*

[7] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[8] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

*Figure 5: Rust-red flour beetle (Tribolium castaneum). (Photo: Australian Oilseeds Federation)*

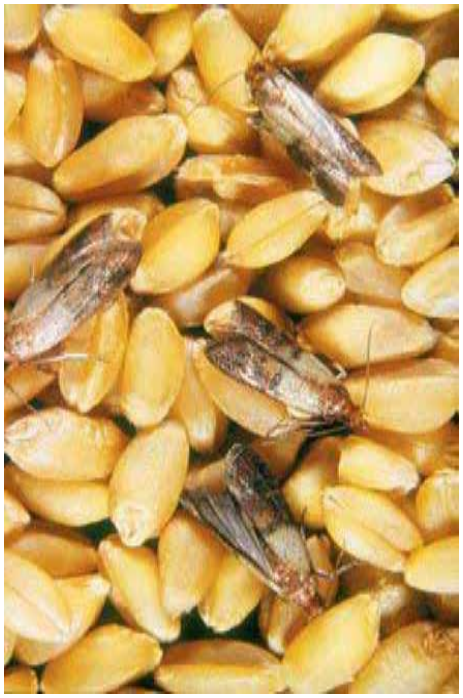

*Figure 6: Indian meal moth (Plodia interpunctella). (Photo: Australian Oilseeds Federation)*

*Figure 7: Warehouse moths (Ephestia spp.). (Photo: Australian Oilseeds Federation)*

*Figure 8: Psocids (Liposcelis spp.). (Photo: Australian Oilseeds Federation)*

These pests multiply rapidly given food, shelter and warm, moist conditions. They can complete their full life cycle in about 4 weeks under optimum breeding conditions.

Only a few treatments are registered for insect control in stored oilseeds. Phosphine, Pyrethrins, Diatomaceous Earth (DI) and Ethyl Formate as VapormateR. Pyrethrins and DI use should be limited to storage area treatments and Vapormate is restricted for use by licenced fumigators only. This leaves phosphine as the key farm storage treatment for oilseeds storage pests.

Phosphine fumigation must take place in a gas tight, well sealed silo. If the silo passes a standard three minute pressure test, it shows there are no serious leakage points. Given this, phosphine gas can be held at high concentrations in the silo for sufficient time to kill all the life stages of the insect pest (eggs, larvae, pupae, adults).

*Figure 9: Phosphine tablets are placed in trays. (Photo: Australian Oilseeds Federation)*

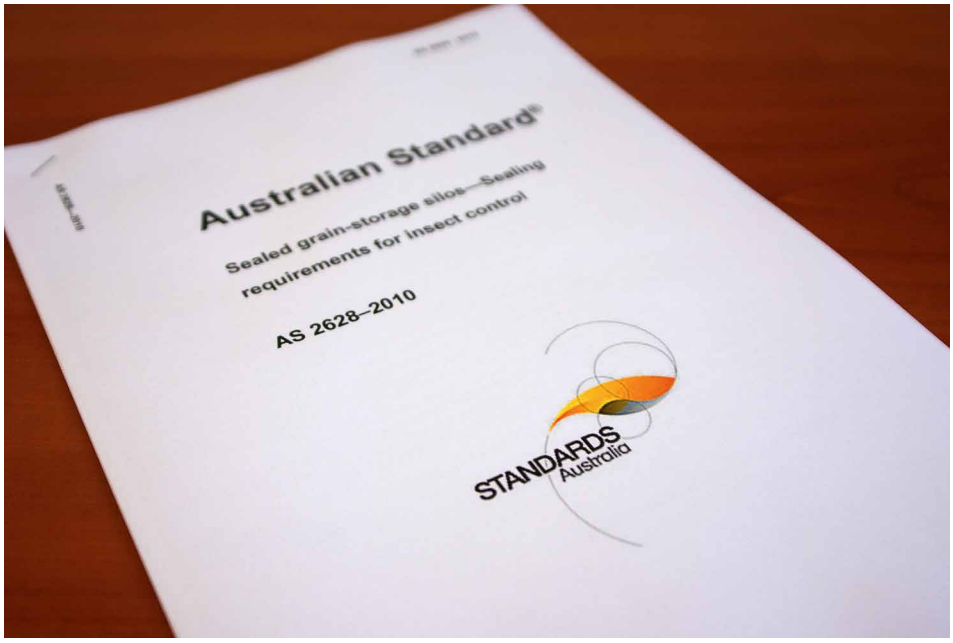


*Figure 10: Australian standards for sealed silos. (Photo: Australian Oilseeds Federation)*

When purchasing a new silo that may be used for fumigation, ensure the silo manufacturer builds it to meet the Australian standard. A number of silo manufacturers now make an aeratable, sealable silo which passes the Australian Standard (AS 2628-2010) for sealed silos.

Like most oilseeds, soybeans have the ability to absorb phosphine gas and so it is important to use the full, correct label dose rate.

By using phosphine bag-chains, belts or blankets, placement and removal of the treatment is simplified. If using the standard phosphine tablets, ensure tablets are kept

separate from the seed by using trays so the spent tablet dust can be removed after fumigation.

If aeration cooling has been in use and the seed temperature is less than 25°C, ensure the exposure period is 10 days or more. Refer to phosphine label for further directions and information.

Once the fumigation exposure period is completed, release the top lid, vent the gas for the required period and return the stored soybeans to aeration cooling.[9]

## 13.3 Grain protectants for storage

Most chemical surface treatments cannot be used on storages to be used to hold soybeans. Soybeans are classified as an oilseed, with limited chemical treatment registrations. Due to the oil content within the seed they are prone to absorbing chemical treatments. Following soybean processing, chemicals can be detected in the final oil product.

Warning–if unregistered chemical residues are detected by seed buyers, this can have serious long term consequences for both the domestic and export market.

Inert dust or Diatomaceous Earth (amorphous silica) is a naturally occurring mined product with insecticidal properties. Products such as DryacideR can be applied as a dust or slurry spray onto internal surfaces of storage areas and equipment. Once grain residues and dust have been physically removed or washed out of silos and equipment, DryacideR can be applied as a 'non-chemical' treatment to reduce insect pest carry over.

Insects survive in sheltered places with grain residues, including grain hoppers, field bins and inside headers. All these attractive locations should be cleaned as soon as storages are empty or equipment (headers, field bins, etc) are no longer in use. A pre harvest storage and equipment inspection and final clean is time well spent.[10]

*Figure 11: Poor grain hygiene. (Photo: Australian Oilseeds Federation)*

[9] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[10] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Some Pyrethrin + piperonal butoxide based products (such as Rentokil's Pyrethrum spray–mill specialR or Webcot's S-Py natural pyrethrum insecticideR) are registered for moth control in oilseed storage areas and sheds. They can be applied as structural surface spray or fogging/misting treatment. These are not grain treatments and should only be used as the label directs. Prior to using these insecticides in storages for export soybeans, it is important to check the buyer and importing country accept their use and have appropriate MRLs in place.

As a guide, the following Australian government DAFF web site lists various countries' grain, pulse, oilseeds MRLs for a range of chemicals:[11]

http://www.daff.gov.au/agriculture-food/nrs/industry-info/mrl

### 13.3.1 Fire Risk

The dust and admixture associated with soybeans presents a fire risk. Harvesting and drying operations are high risk operations where constant vigilance is required. Good housekeeping in and around equipment and keeping a close eye on problem sites reduces the threat.

In case of a fire, ensure appropriate equipment is at hand and a response plan is understood by all operators.

Without careful management, high moisture content soybeans and/or high admixture pose a risk of mould formation, heating and fire through spontaneous combustion.[12]

## 13.4 Aeration during storage

Aeration should be considered as an essential storage tool for soybeans.

Aeration benefits:

- maintains grain quality (e.g. colour, oil quality)
- reduces risks of hot spots, moisture migration and mould development
- slows or stops storage insect breeding cycles by maintaining cool grain temperatures
- maintains germination and seed vigour[13]

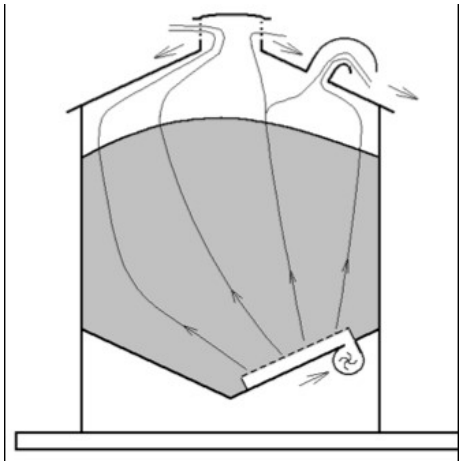

*Figure 12: Air flow through grain bulk. (Photo: Australian Oilseeds Federation)*

[11] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[12] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[13] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

### 13.4.1 Aeration cooling

Fans that provide low air flow rates of around 2-4 litres per second per tonne (L/s/t) can both cool seed and provide uniform moisture conditions in the storage. If managed correctly, aeration allows safe storage of grain at moisture levels a little above receival standards for several weeks.

Well managed cooling aeration typically sees seed temperatures fall safely to around 20°C and below within days.

Regular checking of soybeans in storage is essential. Make visual inspections, check grain moisture, sieve for insects, use a temperature probe or temperature cables inside silos to monitor seed temperatures.[14]

*Figure 13: Standard aeration cooling fan. (Photo: Australian Oilseeds Federation)*

### 13.4.2 Automatic controllers

Often aeration cooling fans are simply turned on and off manually or a timer clock is used. However, there is a lot to be gained by investing $5000 to $7000 in an automatic controller that selects the optimum run times and ambient air conditions to have fans operating. It has the ability to control fans on multiple silos. The controller continually monitors ambient air temperature and relative humidity and may select air from only 2 or 3 days in a week or fortnight. On average it runs cooling fans for approximately 100 hours per month.[15]

[14] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[15] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production


*Figure 14: Automatic aeration controller. (Photo: Australian Oilseeds Federation)*

### 13.4.3 Standard aeration fans operation

- Run fans 24 hours per day during the first 2-3 days when grain is first put in the silo. This removes the "harvest heat'. Smell the air coming from the silo top hatch. It should change from a warm humid smell to a fresh cool smell after 3 days. The first cooling front has moved through.
- For the next 3-5 days set the controller to the "Rapid or Purge" setting. This automatically turns the fans on for the coolest 9 to 12 hours of each day to further reduce the grain temperature.
- Finally set the controller to the "Normal or Continuous" mode. The fans are now automatically turned on for approximately 100 hours per month, selecting the coolest air temperatures and avoiding high humidity air.

### 13.4.4 Aeration drying

Well designed, purpose built high flow rate aeration drying systems with air flow rates of 15-25 L/s/tonne can dry soybeans reliably. During aeration drying, fans should force large volumes of air through the seed bulk for long periods of time. This ensures drying fronts are pushed quickly through so the grain at the top of the silo is not left sitting at very high moisture contents.

Soybeans are well suited to this form of drying as ambient air at 30-60% relative humidity will reduce moisture content without the excessive heat risks associated with hot air driers. Monitor regularly and take care that grain in the silo base is not over dried.

Do not rely on aeration cooling equipment with low airflow rates of only 2–3 L/s/t to dry high moisture soybeans.

Automatic aeration controller models are also available that will run fans at optimum ambient air conditions for either cooling or drying functions. Ensure the controller is fitted with a good quality humidity sensor.[16]

[16] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

### 13.4.5 Heated air drying

For hot air drying of soybeans, fixed batch, recirculating batch or continuous flow dryers are all suitable for reducing moisture content.

Always consider the blending option first if low moisture seed is available.

Close attention must be given to temperature control and duration to ensure grain is not over dried. A wise precaution is to use the minimum amount of additional heat.

The following points are useful for heated air drying:

- Use air temperatures in the 40°–50°C range.
- Stay close at hand and monitor moisture content every 15 minutes.
- For batch dryers when moisture content reading reaches 13.5% turn off heat source and move to the grain cooling phase with fan only. Retest once cooled.
- Over-dried soybeans will split easily when moved and this damage could cause soybeans to fall outside of edible grade receival standards.
- Run auger full when moving soybeans to reduce seed damage and splitting.
- Aim to make good use of aeration fans, both before and after the drying operations.[17]

### 13.4.6 Moisture content

Moisture is perhaps the most important single factor affecting storage of soybeans. Soybean moisture content at harvest time usually ranges between 12% to 15% (wet basis). Soybeans above 13% should be dried to reduce the risk of deterioration. At higher moisture contents, there is a rapid increased in seed respiration leading to spontaneous heating, mould development, germination damage and oil quality deterioration. For long term storage ( > 6 mths) below 12% is recommended.

Like all grains, soybeans is hygroscopic and will either lose (desorb) or gain (adsorb) moisture from the surrounding air. With soybeans in storage, aeration system require careful management as fans left running for too long under certain temperature and relative humidity conditions can result in damage by adding significant moisture to stored seed.

*Table 1: Soybean equilibrium moisture content (EMC) at various temperature and humidity conditions. Example: If soybeans were constantly aerated with ambient air at 20°C and 70% relative humidity the soybeans would gradually move toward a moisture content of 12.8%.*

| Temperature (°C) | Relative Humidity (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 50 | 60 | 65 | 70 | 75 | 80 | 90 |
| 0 | 10.0 | 11.8 | 12.7 | 13.7 | 14.9 | 16.2 | 19.8 |
| 5 | 9.8 | 11.5 | 12.5 | 13.5 | 14.6 | 15.9 | 19.6 |
| 10 | 9.5 | 11.2 | 12.2 | 13.2 | 14.4 | 15.7 | 19.4 |
| 15 | 9.2 | 11.0 | 11.8 | 13.0 | 14.1 | 15.5 | 19.2 |
| 20 | 9.0 | 10.7 | 11.7 | 12.8 | 13.9 | 15.2 | 19.0 |
| 25 | 8.7 | 10.5 | 11.4 | 12.5 | 13.6 | 15.0 | 18.8 |

### 13.4.7 Temperature

Temperature is another important factor influencing soybean storage. Growth of fungi and undesirable oil quality changes can increase with higher temperatures in both meal and whole beans. Insect pests in storage also develop and reproduce best between 25 and 35°C. Below 15°C insects become inactive and breeding ceases. Exposure to temperatures greater than 60°C kills most storage pest species in a few minutes.

Soybeans with a higher moisture content (e.g. 14-14.3%) can be stored for over two years without mould damage if maintained at cold temperatures of 5-8°C. In contrast

[17] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

bulk soybeans stored at 30°C can lead to mould development in some areas of the storage in a few weeks and severely damaged the seed in a few months. Dry soybeans (e.g. 10.5%) are unlikely to have mould problems develop.

Aim to store soybeans at less than 20°C and if possible less than 15°C as this will limit insect breeding, mould development and oil quality deterioration.

Aeration cooling of soybeans in bulk storage helps maintain seed quality. Using automatic aeration controllers to select the optimum fan run times adds an improved level of safety and reliability to achieving desirable storage conditions.

### 13.4.8 Duration of storage

Deterioration of soybeans and soybean meal in storage is a combined function of its moisture content, temperature, and duration of storage. Therefore to reduce the risk of seed quality damage, a combination of low product moisture, low temperature, and a short storage period is desirable.

### 13.4.9 Foreign material present

Foreign material in soybeans is defined in the standards as all materials that pass through a 3.2 mm round-hole sieve and all materials other than soybeans remaining on the sieve. Fine foreign materials tend to segregate during bin loading and occupy void spaces in the central region of the grain mass. Meanwhile, the large and lighter materials will accumulate close to the walls of the silo (Figure 15).

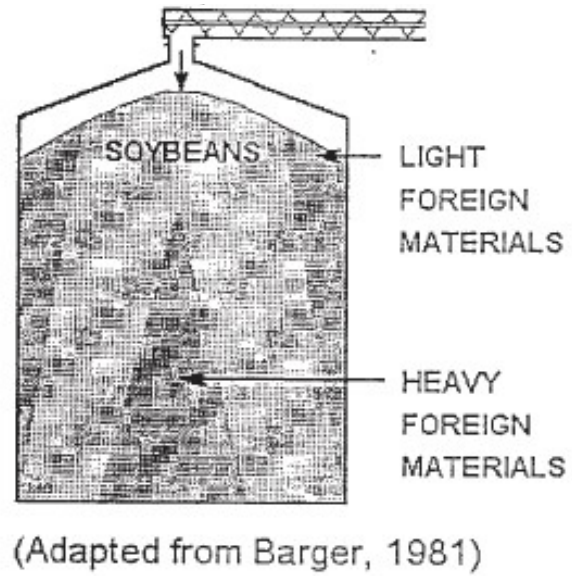


*Figure 15: Schematic diagram of how light and heavy foreign materials segregate when grain is loaded into a storage silo. (Photo: Australian Oilseeds Federation)*

During aeration, the air will flow around spots with higher concentration of fine foreign materials and favour moving through pockets of high concentration of large foreign materials. Under these conditions there is a non-uniform flow of air during aeration.

Consequently, the areas of reduced air flow in the grain mass are potential sites for hot spots that provide an ideal environment for insects and moulds. Hence, cleaning soybeans prior to storage minimizes this risk. Pre-storage cleaning could be a valuable component of quality maintenance for processing companies.

### 13.4.10 Product condition and history

Sound whole soybean kernels will store better than kernels damaged by cracking, splitting, insects and fungi. While storage pest insects will attack whole soybeans and cause significant damage, it is the split kernels that provide a very attractive food source to a larger range of storage pests and fungi.

## More information

GRDC Factsheet Storing Oilseeds

GRDC Grain Storage Fact Sheet: Grain Storage Pest Control Guide Northern and Southern Regions

GRDC Grain Storage Facilities: Planning for efficiency and quality

Grain Storage: Grain Fumigation Guide

A sound seed coat provides some degree of protection against attack. A grain handling system that minimizes cracking and splitting of soybeans is an advantage. Belt conveyors are recommended as they handle grain gently. They are also valuable for moving grains over greater distances without damage. The amount of broken and split kernels increases with every handling operation between harvest, processing and export.[18]

[18] Better Soybeans, Australian Oilseeds Federation