

PREFACE

The principal aim of managing grain in storage should be to maintain and/or improve the grain quality whilst it is being kept in storage.

In my opinion the application of modern grain aeration technology, which was developed by the CSIRO in the seventies, is the most significant step forward in grain storage management since the adoption of bulk grain handling.

Adoption of this technology has been a very slow process over the past 20 years but in recent years its use in silos has seen a steady increase.

I have been asked many and varied questions about grain aeration, its design and management, but there remains a great deal of misunderstanding about its purpose and control methods.



In addition to the application of aeration, sealable silos have been introduced in the past 5 years and an attempt to explain the use and management of these silos is included.

This publication attempts to provide the reader with answers to some of the most commonly asked questions about these subjects and grain storage management generally.

T. Fusae (2001)

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A word of warning:

Controlled aeration has proven to be a highly effective means of controlling insect pests in stored grain, as well as assisting in preserving germination rates in stored seeds, and helping to control the growth of moulds and mildews. **PLEASE NOTE - The use of these systems does not guarantee that you will have NO insects in your grain.** Grain which is stored during prolonged periods of high ambient temperatures will be impossible to cool to the point where insect activity ceases (less than 15°C), regardless of the method of control.

Storage trends in Australia

Grain has a very important role in our society because it is a basic food which can be traded, transported relatively easily and, with good management, it can be kept for long periods of time. On the other hand, grain under poor storage condition can be ruined in a matter of hours. Correct storage management is vital in maintaining grain condition. An understanding of the matters associated with grain storage is necessary for all those involved with grain storage.

With the deregulation of the grain industry there is an increase in storers and places where grain is being kept. Whereas in the past, most of the bulk grain grown in Australia had been stored in centralised facilities, it is now being kept on farms and on smaller regional facilities. Many of these places were in the past only for intermediate storage or to temporarily manage the surge of grain volume during harvest and before delivery to central facilities for “permanent” storage.

Grain Management Objectives

There are numerous objectives. Some possibilities are:-

- To manage a grain harvest
- To hold grain for later use or sale
- To consolidate grain into larger quantities
- To segregate quality or variety lots
- Disinfestation of grains

In dealing with these objectives grains of varying and different moisture contents will need to be managed. Early harvesting is desirable to ensure maximum quantity and quality from a crop, and this leads to the need to manage grains of higher than saleable moisture contents.

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Consolidation and holding grain for sale will allow for mixing/blending prior to sale or use.

Equipment used comprises silos (both unsealable and sealable), sheds for storage, aeration and aeration controllers for cooling, and grain dryers for reducing moisture contents to saleable levels.

Good grain storage management principles.

Good grain storage management principles should be aimed at maintaining and/or improving the grain quality whilst it is being kept in storage.

It is well known that the agents which cause grain quality loss are, in the main, insects and mould. Both of these agents like warm damp conditions. Therefore if dry cool conditions are maintained throughout the grain mass the grain quality should at least be maintained. Thus ***the prime aim of good grain storage management is to maintain even, cool and dry conditions within the grain bulk.***

The nature of grain

Grain is a living seed, it breathes (respires) consuming some of its internal store of starches and converting it to energy and respired gases. To keep it fresh the air around the grain should be replaced regularly with fresh air of suitable condition. The respiration rate increases with temperature.

Therefore it is necessary to ventilate more at higher temperatures. If the temperature is low enough, air replacement requirements may be so low as to allow for no air replacement over time. However, under all circumstances care must be taken to ensure that moisture migration by air convection is not occurring.

Grain always has air around it.

A bulk of stored grain comprises grain and air in the space around the grains. In a 100 tonne silo there is a total volume of about 130 cubic metres of which 50 is air and the grain 80. If air movement does not occur this entrapped air will, within hours, naturally reach a moisture state in equilibrium with the grain moisture.

Grain Moisture Air Moisture Relationship

Equilibrium Moisture Content						
Generalised Table (25-30 degrees C)*						
Relative Humidity %	Wheat	Barley	Maize	Sorghum	Sunflower	Soyabeans
90	20	23	21	19	18	20
80	16	17	16.5	16	11	15
70	14	15	15	14	9	12
60	13	13	13	12	7	9
50	12	11.5	12	11	6.5	8
40	11	10	11	10	5.5	7

*The figures are only approximate since the equilibrium moisture contents of a given kind of seed vary with several factors such as variety and location,

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and especially with whether the grains or seeds are absorbing or losing moisture to attain the equilibrium.

What these figures mean.

If air of 80%RH is continuously passed through a mass, of wheat, the wheat will stabilise at a moisture content of 16%. Similarly, if air of 70%RH is continuously passed through a mass of sunflower seed, the sunflower seed will stabilise at a moisture content of 9%.

These facts can be used to manage grain aeration systems to maximise the cooling or drying effect.

For example:-

For cooling wheat of moisture content 12% with some slight wetting allowed, a RH limit of 55% could be set.

Or

For cooling wheat of moisture content 12% with no wetting allowed, a RH limit of 50% could be set.

Or

For cooling wheat of moisture content 14% with some drying to 12% desired, a RH limit of 55% could be set.

Note:

For managing the aeration of grains having high moisture contents, maximum cooling effect should always be chosen because high moisture grain will quickly heat and spoil. Best cooling results are obtained by setting the RH limit as high as possible so that the aeration system is not stopped from running during high moisture times.

For example, to ensure cooling is at a maximum for grain at 16% (which is in equilibrium with 80% RH air) then a set point of say 75% would ensure a maximum running time for cooling but little drying effect. A Progressive reduction of this RH set point can be made as time goes on to ensure that temperature is kept low and some drying is achieved.

Extreme care must be taken in trying to achieve drying in silos in Australia as higher temperatures can and do lead to failures. For more information on managing drying see "Grain Drying and FAQs" by the same author.

There is always water in the grain

All grain, whether it is 20% or 10% moisture content, has water in it. For example, grain at 12 % has by definition 12% water. This means that in a 100 tonne grain silo of 12% grain there is 88 tonnes of "dry matter" and 12 tonnes of water. 12 tonnes of water is 12,000 litres of water (ie 60 x 200 litre drums of water).

This water can and does move from place to place within the grain bulk. It does so by moving from the grain to the air immediately around the grain. This air containing the moisture from the grain moves by convection to another location where it may pass on its moisture to another drier grain, or condense on a cool surface. This effect is called moisture migration and occurs in most grain bulks. Aeration cooling can reduce these undesirable effects.

Moisture migration

What is it?

Moisture migration is the term given to the phenomenon of moisture moving from place to place within a grain mass.

How does it occur?

Grain tends to maintain a moisture equilibrium between the moisture within it and the moisture content of the air surrounding the grain. In a mass of grain this effect means that if the air immediately surrounding the grain has slightly less moisture than the grains "equilibrium moisture content", the grain will give up some moisture to the air. If this air then moves by way of convection caused by temperature difference in the grain mass, the moisture moves with it. The overall effect is that moisture in grain moves into the air then to some other place in the mass. If this place has a low enough temperature, condensation may occur whereby free water will appear on these cool surfaces or possibly rewet grain in this cool zone.

Grain is an excellent insulator

If insects and mould did not attack grain, it could be used in the walls and ceilings of houses as thermal insulation. Being a good insulator means that grain is difficult to heat up or cool down. When grain is stored in bulk, this property means that parts of the bulk may be at a totally different temperature to other parts of the bulk. If this situation is left unattended it is likely to become worse over time - the hot spots become hotter and may become so hot as to completely ruin the grain and ultimately ignite.

The insulation property of bulk grain can be used as a benefit if the grain is cooled to a safe level because once the temperature is reduced it will remain at this level for long periods of time. Properly controlled aeration cooling makes use of this important bulk grain property.

Warm air and cool surfaces

Warm air will release water when it comes into contact with cool surfaces. This is the effect that takes place on the bathroom mirror. Where moist warm air meets the cool mirror surface, water which exists as a vapour in the air condenses into liquid water. Likewise, air from within a grain bulk will carry *water from the grain* to a cool surface where it will condense. Silo walls and shed roofs at night show this effect. Maintaining grain at low and even temperatures will dramatically reduce these undesirable effects.

Agents of grain deterioration

Insects and Mould

Insects and mould are the main agents causing grain quality loss whilst in storage. The relationship between these agents and the grain moisture content and temperature are given in the generalised tables below. It should be noted that, by far, the main problem in Australia is temperature, not moisture content.

Grain storage insects are generally tropical in origin and they prefer conditions which are "tropical" in nature. Most grow and prosper in environments of 30 to 32 degrees Celsius and relative humidities of 65% and above.

Therefore, for the optimal growth and development of grain storage insects, the provision of a food source (grain) and the appropriate environment as above is required. In fact, in Australia, when grain is placed into bulk storage conditions are very likely to be ideal for insect development! If these conditions are not initially within the stored grain there are many mechanisms within stored bulk grains which can, in a short period of time, develop into these conditions.

Temperature of grain

Temperatures in excess of 15 degrees Celsius is the most important factor causing grain quality damage. Temperatures around 30 degrees are the most conducive to damaging grain by the action of moulds and insects.

Grain temperature C	Grain condition stored in bulk	Comments
65	All stages insects killed and grain proteins start to be damaged	High temperature disinfestation conditions
60	Adult insects killed	Some limited effect in hot air grain dryers
55 - 40	Seed viability becomes damaged	Depends on time duration at the temperature
40 - 35	Harvest temperatures in Qld summer time	Expect problems within hours of placing grain in storage
30	Insect and mould growth optimal	This temperature to be avoided at all costs!
25	Insect and mould grow well	Common temperatures in unaerated bulks
20	Insect and mould grow well Qld Winter harvest temperatures	Any reduction in bulk temperature to below 30 C is desirable
15	Insects stop breeding, but slime and low temp moulds keep growing	Grains at 12% moisture content keep well in bulk storage at below 15 C
10 - 5	Most biological activity including grain respiration is so low that grain in bulk storage is commercially "safe"	Unaerated bulks will store well

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Moisture content

Moisture in grain is closely associated with the moisture in the air surrounding the grain. The table below indicates a generalised grain moisture and condition relationship.

Grains having less than 10% moisture keep well, whilst grains having moistures of 12% and above are at risk in most Australian conditions because of our relatively high ambient temperatures.

Conditions and comments apply to hard wheats and most starchy grains, not oil seeds.

Moisture content	Grain Condition	Insects and mould activity	Comment
30	Physiologically mature grain in field	Field attack	Highest possible dry matter "yield" at this point
20 - 19	Usually too wet to thrash satisfactorily	Field attack	Can be swathed
18 - 13	Thrashable for most grains reduced thrashing damage	Grain storage insects and mould very active	Requires wet grain management in store and subsequent drying
12	Thrashing damage increases - front losses begin to increase	Grain storage insects and mould active	Commercially saleable grain moisture - not "safe" in unaerated storages in NSW - Qld
11 - 9	Field losses begin to be significant	Some limited grain storage insect activity Grain respiration rates are low	Loss of income from lost weight and quality
8	Difficult to harvest with conventional equipment	Too dry for most moulds and insects	Large loss of income from lost weight

Hot spots

Hot spots in stored grain are caused by the action of moulds and insects. They are usually a result of initial uneven temperatures in the grain mass causing moisture migration which produces favourable conditions to encourage these damaging agents.

Trash admixture

Admixture and trash in grain will encourage the growth of moulds and some insects, whilst cracked and broken grain particles form perfect food for other insects and provide an ideal substrate for the establishment of moulds and slimes.

Moisture contents

It is well known that the agents which cause grain quality loss are in the main insects and mould. Both these agents thrive in warm damp conditions. Therefore, if dry, cool conditions are maintained within stored grain, it will reduce their activity.

Best stored grain management is to keep grain clean and cool in storage.

At what moisture content can grain be safely stored?

There is no simple answer to this question but it may be stated that regardless of moisture content, grain keeps better at lower temperatures. Therefore, by using controlled aeration to lower the average temperature and keep temperature differences to a minimum, it can be said that whatever the moisture content, grain under aeration will be safer and keep longer. Some guide lines are discussed below. For an explanation of the aeration modes and methods mentioned please refer to the later sections.

Grains less than 12% to 15% mc (wheat equivalent)

Use standard aeration (2l/s/t)

Freshly harvested

Immediately aerate as soon as aeration ducts are covered. Aerate continuously until harvest temperature is reduced to ambient average. This is usually at least 24 hours.

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Change to RAPID mode until second cooling front passes through grain.
This is about when the temperature reaches a figure half way between the daily average and daily minimum.

Change to NORMAL mode for the rest of the storage period.

Keep a routine check on the condition at least once a week.

Long term storage of even moisture/even temperature grain

Use NORMAL mode for extent of storage period.

Keep a routine check on the condition at least once a week.

Grains 15% to 18% mc

Use double aeration (4 l/s/t)

Grain this wet is subject to rapid heating and deterioration whilst in storage.

It can be kept for some time under double aeration until dried in a dryer.

Constant checks must be made on its condition in case of problems. There is no "safe storage period".

Immediately aerate as soon as aeration ducts are covered.

Aerate continuously until harvest temperature is reduced to ambient average. Usually at least 24 hours.

Change to RAPID mode for the rest of the storage period.

Check condition of grain every day.

Dry in grain dryer as soon as possible to below 15% then use the recommendations above.

Grains more than 18% mc

Grain this wet is not storable and is liable to heat and become ruined within hours of storage.

Use treble aeration (6l/s/t)

Check condition of grain every day.

Continuously aerate until grain is dried in grain dryer to below at least 15 % then use the recommendations above.

(Drying techniques and equipment are discussed in another publication, "Grain Drying and FAQs" by the same author).

Grain infested with insects

Disinfest by fumigation using a sealable silo and phosphine according to the manufacturers instructions.

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After fumigation is completed, open the silo and aerate to remove fumigation gases and revert to aeration methods described previously.

See further notes under Fumigation.

Uneven moisture content grains

Aeration is an excellent way of allowing safe management of mixed and variable moisture content grains. Grain of uneven moisture can be placed into an aerated silo and the even flow of controlled air will smooth out moisture and temperature differences. This may take some days depending on the grain's initial conditions, but with properly managed aeration, in the long run, the whole bin of grain will reach an even temperature and moisture profile.

This effect makes managing a difficult harvest easier, and at the same time provides a big benefit to grain dryer operators in allowing them some "breathing time" prior to having to dry the grain. In some cases well managed blending and aeration can eliminate the need to dry.

Inspection and records

Always inspect your grain at regular intervals and record your findings for reference. An example of a suitable record sheet might be:-

Storage identification number:										
Date	Time	Ambient Location			Grain Type			Smell insects/ mould		Aeration hours
		Temp	R H	Wet Bulb	Temp	R H	Wet Bulb			

Fumigation

What is it?

In general the reason for fumigating grain is to disinfest it of insects. Insects have life cycles in which there exists three distinct life forms - eggs, pupae and adult insects. These three forms of the insect have very different abilities to withstand adverse living conditions and poisons.

Eggs are able to survive for extended periods of time given unfavourable and extreme conditions. The success of insects on our planet has depended on this characteristic and some species of insect's eggs can survive adverse conditions for years and still remain viable.

Pupae are less able to withstand extreme conditions and the adult forms are most likely to succumb to adverse conditions.

How to fumigate

Follow the instructions of the manufacturer.

The principle goal is to kill all the insects which means killing eggs, pupae and adults. This means you effectively control the development of future generations of insects.

Killing adults alone is easy and unfortunately encouraged by present receival practices of looking only for "live" insects or adults and ignoring the eggs and pupae. Fumigations which kill adults alone are usually of such low concentration that they allow some adults to survive and most certainly allow pupae and eggs to survive. This practice allows the rapid development of fumigant resistance in the insect population on your property, and therefore jeopardizes future insect management strategies in your storages.

Sealable (sealed) Silos

What is a sealable (sealed) silo?

A sealable silo is a grain storage silo which can be sealed to a gas tightness which reduces the loss of fumigants. The degree of gas tightness is defined by stating a time over which the pressure in the silo reduces to half its initial value. A typical test would be to seal up the silo and pump it up using air to a value like 50 mm water gauge and then measure the time it takes for this initial pressure to fall to 25mm water gauge. A typical time may be 15 minutes.

Sealable silos are usually made from standard silos by using some sort of sealing material in all the joints and by providing special air tight caps for grain inlet and outlet holes. There is also some provision to measure and limit the internal pressure which is in the form of a water or oil trap connecting the inside space of the silo to the atmosphere. This device is very important for both controlling the internal pressure and acting as a safety blow off valve in case of an excessive internal pressure build up. If it is not working properly the sealability of the silo is lost.

What are they for?

Recently there has been a trend for silo manufacturers to offer sealable silos to their customers. This has come as a result of the public promotion of this technology. Unfortunately there is some misunderstanding about the use of these silos which has led to failures in the management of stored grain.

The purpose of these silos is to form an efficient fumigation chamber by retaining the fumigant gases within the silo.

Grain of "normal" storage moisture contents should not be stored in silos which are sealed. Uneven temperatures will occur in the grain mass resulting in moisture migration, heating, and subsequent development of moulds and insects followed by complete loss of the grain quality.

Stored grain should be kept as cool as possible using modern, properly controlled aeration. Sealable silos can be used for this purpose by equipping them for aeration which means fitting sealable fan duct systems along with matching vents.

Every grain storage facility should include one or more sealable silos for use when fumigation becomes necessary. If you have any doubts on how to manage your silos or storages please request more information from us at RFM Australia Pty Ltd Toowoomba Qld Australia.

Fumigating in a sealable Silo

A sealable silo is a good place to fumigate using phosphine tablets. Follow the manufacturer's instructions carefully. This gas is highly dangerous and very poisonous!

Suggested method:-

- Ensure silo sealing is satisfactory by testing using the silo manufacturer's recommended method.
- Close all vents, hatches and openings.
- Place the tablets on a tray with a means of recovery so that the residue left after the tablets are exhausted can be removed from the silo. (Phosphine tablet residue is undesirable in grain and it is detectable by buyers of grain).

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- Place the tray with tablets on top of grain bulk and close hatch. Leave for manufacturer's recommended period. This time will depend on grain bulk temperature and moisture content.
- After "treatment time" is complete, open vents and maintain treated grain under "cooling aeration management" using automatic time proportioning control as indicated in our publication, "Managing Cooling Aeration".
- Remove the tray containing residues.

Fumigating with aeration

Do not use aeration systems to fumigate grain in storages. Fumigation gases should be "sealed in" to give proper treatment (see fumigating in a sealed silo).

The practice of placing phosphine tablets in front of a normal aeration fan intake is **not recommended** and the use of such methods will lead to insect resistance development and excessive and inefficient use of the poison by the gas being diluted by the aeration air. Often this process will result in a knock down of some live insects near the aeration air inlets, thereby satisfying the buyer's standards. This can only be regarded as a very poor and irresponsible use of such fumigants.

Use of aeration fans for this purpose has been mixed up in the minds of some operators with **recirculation** of fumigants. Recirculation uses fans in properly equipped, sealed or semi sealed silos or sheds where fumigant concentrations are maintained and distributed by the recirculation system at appropriate levels for the recommended times.

What is aeration?

Aeration is the process of forcing air through grain whilst in storage. There are several purposes in aerating grain. Typically these are:-

- to improve the grain condition
- to cool and even-out moisture content of freshly harvested grain
- to dry the grain
- to cool the grain after it has been dried in a grain dryer
- to maintain the grain condition over a long time
- to lower the temperature below average ambient conditions
- to reduce insect and mould activity

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There are varying methods of managing aeration systems. According to the objective required the aeration equipment is selected and managed accordingly.

Careful selection and management is essential to achieve success and expert advice should be sought in both selecting the correct equipment and choosing the management method.

Aeration cooling

Small controlled amounts of cool ambient air is passed through the stored grain to cool it as much as possible.

Typical air flow rates are 0.5 to 2.5 litres per second per tonne.

What is it for?

Simply put, aeration cooling is for keeping the grain in good condition whilst it is in storage.

Grain keeps well if it is -

COOL
LOW IN MOISTURE
LOW IN INSECT ACTIVITY
LOW IN MOULD ACTIVITY

Keeping grain cool will -

REDUCE INSECT ACTIVITY
INCREASE INSECTICIDE LIFE
REDUCE MOULD GROWTH
ALLOW HIGHER MOISTURE
EVEN-OUT TEMPERATURE
EVEN-OUT MOISTURE

Aeration cooling usually means using air which is naturally available, not artificially cooled air as in refrigeration aeration.

Insecticides in aerated grain

In many cases controlled aeration alone will provide sufficiently good control of insects to allow chemical free storage of grain.

If chemicals are used with aeration, the benefit is two fold - the chemicals last longer, which leads to less chemicals being used (saving costs). At the same time, there is a reduction in the exposure of the chemical to the insect which reduces the resistance build up in the insect population.

Will aeration cooling dry grain?

Sometimes when ambient air conditions are suitable some slow drying can take place. This takes place over a very long time and very slowly.

The opposite also applies in that wetting can occur over long times of wet conditions. However, the benefit of having the grain cooled to lower temperatures usually far outweighs the small increase in moisture.

With grain harvested at relatively high moisture and using specially designed aeration systems, a good deal of drying can be achieved. BUT the problem is always ensuring this grain can be kept from spoiling before the moisture and temperature can be reduced to safe limits.

In silos using aeration cooling, usually the effect most noticed while "drying" is the ability of aeration to even-out moisture and lower temperatures. Freshly harvested grain is usually quite uneven in moisture content and when this is measured in most moisture meters the reading can be quite misleading. Wetter kernels can make the readings indicate an average moisture content much higher than really is the case.

After a period of controlled aeration, individually wetter grains tend to pass on their excess moisture to the drier grains and an average below that which is indicated by the initial moisture measurements is achieved. In this common case, little or no drying has occurred but a beneficial averaging and cooling has resulted.

Managing cooling aeration

Aeration is an excellent way of allowing safe management of mixed and variable moisture content grains. Grain of varying moisture can be placed into an aerated silo and the even flow of controlled air will smooth out moisture and temperature differences. This may take some days, depending on the grain's initial conditions, but with properly managed aeration, in the long run, the whole bin of grain will reach an even temperature and moisture profile.

When should the fans run?

In managing an aeration system using only natural occurring air conditions, the fan operating times are critical. Fans operating at inappropriate times can reverse any cooling previously achieved and good opportunities for cooling can be lost.

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To be effective, aeration needs to be accurately controlled. This means it needs to be turned on and off at times which achieve the best results. In natural air systems the choice of running time is vitally important and this subject has been extensively studied by the CSIRO leading to their development of the time proportioning controller.

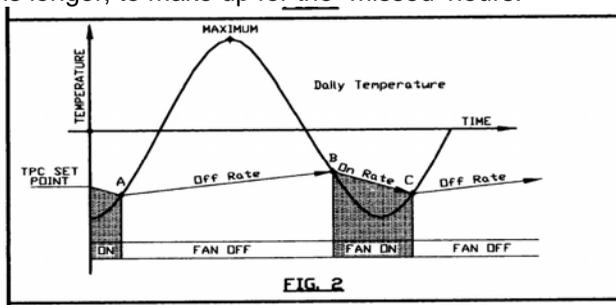
The CSIRO invented the time proportioning controller to make it easy to ensure that the best use is made of natural conditions, at the same time being simple and reliable with no complex sensors in the grain to fail or maintain. The system needs no maintenance except for making sure it is functioning and making a regular check on the grain condition.

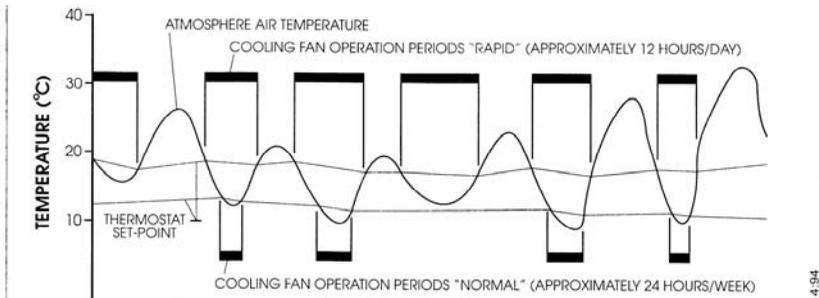
RFM Australia Pty Ltd produces the CSIRO based RIMIK time proportioning controller. Using this controller means that there is little intervention needed and the system has a predictable running cost under all weather conditions.

How does the RIMIK controller work?

In simplified terms the Rimik AC12 time proportioning controller works by monitoring the ambient Relative Humidity and Wet Bulb Temperature, and selecting the coldest air that is available. You can liken it to a “self-adjusting thermostat” which adjusts its cut in and cut out temperatures to suit the prevailing weather conditions.

When first initialised the AC12 establishes a “set point” – the temperature at which it will turn off. If the temperature is falling, this set point is slowly adjusted downwards, until such time as the temperature equals the set point, and the controller switches the fans off. The set point is then adjusted slowly upwards until the ambient temperature equals the set point, and the fans are switched on again. This process is continuously repeated. The AC12 is smart enough to know that if the ambient temperature does not come down as low as the set point, the fans stay off, but when they next come on, it will run the fans longer, to make up for the “missed” hours.





This graph helps illustrate the operation of the “set points”:

The current model AC12 controller uses what is known as the “wet bulb” temperature for its set point, which helps to accelerate the cooling process. This is because the controller tends to select dryer air than it would using “dry bulb” temperature. This dry, cool air tends to take some moisture from the grain, causing an evaporative cooling effect which assists in cooling the grain.

Can a time clock be used ?

No! this is the worst type of control for aeration. A time clock will simply turn the fans on/off at a predetermined time regardless of the ambient conditions. Often this means the fans will operate to “undo” any good which may have been achieved from previous running. Time clocks run regardless of temperature and they will produce alternate cooling and heating fronts within the grain causing a difference in temperatures - the very thing that is to be avoided! It is far better to control the fans manually by making a judgment each day/evening whether to operate the fans or not, based on your record or knowledge of immediate past operating conditions. That is, whether the air condition is close to, or at least as cool as last time, and whether the average operating hours are sufficient or not. Time clocks may be cheap but they are not aeration controllers.

The best way to control aeration cooling

The simple answer is to use an automatic controller specially designed for the job. This controller is the CSIRO based RIMIK time proportioning controller.

Features of the RIMIK time proportioning controller

- Simple and reliable - automatic solid state device

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- Predictable running cost (limited running hours)
- Always uses coldest air
- Always runs a predetermined number of hours
- No sensors in grain
- Cooling effect is better than other control systems.

Development of the time proportioning controller and its availability for use has been the single most important factor in the general success and acceptance of grain aeration systems in the last 10 years.

Using the RIMIK time proportioning controller

In all cases when grain is loaded into a storage, start the aeration as soon as the ducting is covered.

The RIMIK time proportioning controller has two modes of operation which, when wired as recommended, are selectable by the storage manager. They are RAPID MANAGEMENT which selects the coolest 50% of the time available and NORMAL MANAGEMENT which selects the coolest 14% of the time available.

Along with these modes there should be a means of running the fans manually and not under the control of the controller. The purpose of these modes is described below.

Freshly harvested grain (12%-15%)

For all freshly harvested grains, run the fans continuously until the harvest heat has been removed. Then revert to RAPID MANAGEMENT.

For grains which are at average ambient temperature, firstly use RAPID MANAGEMENT until the first cooling front emerges from the top of the grain mass.

Then change your routine to operate under NORMAL MANAGEMENT for the rest of the storage time.

Over the total storage time you should always regularly check at the top of the grain mass for any signs of problems. (heating, insects or mould - one of the best guides is smell).

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For wetter grain (15-20%)

Operate fans for 24 hours until the initial heat is removed from the grain. Check the cooling front progress. After the first cooling front is known to have passed through the grain mass change your routine to RAPID MANAGEMENT for the next few days until you note that the next cooling front has moved through the grain.

Then change to NORMAL MANAGEMENT.

Because of the higher moisture of these grains a daily check should be maintained throughout the whole storage period.

What are the alternatives?

There is no really satisfactory alternative to the controller. However, if you cannot afford the cost of the controller there are some guidelines (see section 4.1 Manual methods) which may help, but keep in mind that operating an aeration system to obtain its maximum benefit can be rarely achieved using manual methods, simply because it would take a lot of management time to make the correct decisions.

Control of aeration systems is vital, as poor or no control can lead to disasters - Complete loss of grain, bursting of silos, insect resistance development, operator poisoning, to mention a few!

What to do when it is raining

This is a frequently asked question and one about which there is a great deal of misunderstanding. Natural air aeration is for cooling grain in order to provide the best possible storage situation for any given naturally occurring climate.

The CSIRO time proportioning based RIMIK aeration controller often calls for the fans to operate during cool times of the day when the RH is high. Early dewy mornings, and when the temperature drops just before rain storms, are times when the controller may operate the fans. Under these conditions there will be some transfer of moisture into the grain at the same time as a lot of cooling is taking place.

Usually there is a great gain in cooling during these times and the amount of wetting occurring is small. In any case, this wetting is usually dried out during times of drier operation. In most parts of Australia the amount of time that the atmosphere is dry, rather than wet, is much higher. Therefore,

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usually an overall drying will result over any given time, even though the fans are allowed to operate in those wet times.

There is another effect allowing the operation of the fans during wet periods and that is the drying fronts travel through the grain mass much faster than the wetting fronts to the extent that it takes about 1 hour operating in drying conditions, to dry out the wetting caused by 3 hours of wetting conditions.

Checking cooling front progress

Make sure the fans are operating.

Go to the top of the silo and lift the manhole cover.

Using a metal rod left in the grain for 30 minutes, or a thermometer, check the temperature of the grain mass as far down into the heap as possible.

Make a note of this condition.

Do this every day and record your results.

At sometime you will note a distinct change in the temperature and a change in the smell of the air. It should become cooler and fresher smelling. This change occurs when an aeration induced cooling front passes through the mass at the point of the temperature measurement.

Regular checks and records

With all stored grain a physical inspection and check must be made regularly.

The main principle here is to be on the lookout for CHANGES in the condition within the grain.

The things to check and record are: - temperature, insect activity, and smell. A written record of these conditions should be kept.

Typically, deterioration of grain begins with some small problem occurring somewhere unseen deep within the grain mass. It is vitally important to keep regularly checking the smell of the air exiting the silo. This is the best "first indication" of problems. Aeration air travels throughout the whole grain mass and carries with it the smell from within the grain so that running the fans and checking the smell of the air is a good indication of condition.

Manual methods

These methods follow the same principles of the CSIRO based time proportioning controller of getting the temperature of the grain down as fast as possible, then maintaining it as cool as possible over the storage period,

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at the same time avoiding alternating cooling and heating fronts in the grain mass.

Rapid mode management

Run fans for the coolest half of the total time (this means for each week $0.5 \times 24 \times 7 = 84$ hours per week on the average) making sure that the ambient air temperature at the time of running is not significantly different from the last time the fans were running.

This does not simply mean running the fans for 12 hours, each and every day. In fact, if you do this you will probably do more harm than good to the grain conditions!

If you run the fans when the temperature is significantly above the temperature when the fans were last run, you undo all the good cooling effect you may have already achieved. At the same time you will have produced a warming front which will have to travel all the way through the grain mass. It is just like having to start from the beginning situation all over again. The temperatures will vary causing uneven moisture and migration of moisture from place to place.

Normal mode management

Operate fans when the air temperature is approaching the lowest for the day and make sure this temperature is not much different from the temperature at the time the fans were last operated.

The problem here is that if you operate the fans at a temperature well above the last time, you will undo all the good you did the last time. Back to square one!

At the same time as ensuring the operation is at or near the lowest temperature, the number of hours the fans operate must be around $1/7$ the total storage time. This does not mean simply running the fans for $24/76 = 3.5$ hours each day.

Summary of modes

Keep in mind the following objectives

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- Reduce the temperature as quickly as possible
- Aim to keep the temperature as low as possible
- For RAPID run fans for about HALF the total time.
- For NORMAL run the fans for 1/7 the total time.
- Use correct fan sizes.
- Keep a check on the condition of the grain by inspection.
- Keep a record
- Avoid too much or too little running.

Equipment and costs

Agridry Rimik cooling system

An aeration system comprises fans, ducting and controller working together to provide a predetermined amount of aeration air over a known period of time, always selecting operating times to optimise the cooling effect available.

In the main, the amount of air and its temperature determine the cooling effect. Therefore to obtain the best effect from natural conditions there are two extreme options for fan size and operation. Either use a huge fan for a short time at or near the minimum temperature, or use a small fan operating over a long time.

It can be seen that the huge fan operating at the minimum temperature has the best chance of reducing the temperature to near this minimum.

For practical reasons of cost and physical arrangement, a compromise is struck between the cost and performance in the AGRIDRY RIMIK aeration system. The system is matched for best results at an affordable price.

Always seek expert advice when considering the purchase of aeration system components.



The RIMIK time proportioning aeration cooling controller.



The RIMIK switch panel for switching control modes for multiple silos.



A typical aeration cooling fan mounted on an elevated grain silo.

Cost of aeration cooling equipment

Whatever money is spent on a controlled aeration system it is usually the smallest single cost of a storage installation. The actual cost of an installation will depend on the size of the storages, their type and the quantity at one site. A quotation is easily obtained by calling us and giving us some details of your storages.

Often it will cost less than 10% of the cost of the silo installation and it will be the single most important item in the storage system to ensure better management of the grain.

Equipment size

There is a specific and correct size unit for each size and shape of storage. Make sure your supplier has all the relevant details and he can advise you. Details usually required are:-

Silos: Diameter, wall height, base angles, in ground or elevated or flat floor, sweep unloaders if any.

Sheds: Width, length, wall height and height of grain up wall, positions of sweeps/unloaders, position of wall girts and frames, wall material profile.

The type and purpose for the aeration determines the air flow rates needed.

Running costs

With an Agridry Rimik system controlled with the RIMIK time proportioning controller the running cost is predictable. The cost is around 4 cents per tonne per month.

Example: 100 tonne silo
 0.37kW aeration fan
 10 cents/kWh electrical cost
 25 hours per week running on NORMAL for 4 weeks

Aeration cost per month = $0.37 \times 10 \times 25 \times 4 / 100 = 3.7$ cents/month/tonne

Other types of aeration

Refrigeration

Air cooled by a refrigeration plant is used to cool stored grain to temperatures below that possible with ambient air.

This type of aeration can cool grain to very low temperatures and is used where ambient conditions may not allow natural air to be used effectively, such as in hot or tropical climates. Air flow rates are similar to aeration cooling but the running costs are very high by comparison.

Typical air flow rates are 0.5 to 2.5 litres per second per tonne.

Plant comprising refrigeration plants complete with aeration fans and controllers are available and their cost may be justified by the value of the stored product in a difficult location.

Maintenance aeration

This aeration is for maintaining the condition of grains over long periods of time. Selected amounts of ambient air are passed through stored grain to maintain both its coolness and moisture content over long periods of time.

This type of aeration uses the same air flows as aeration cooling but may be managed to maintain grain moisture content by selecting ambient air relative humidity limits. Typical air flow rates are 0.25 to 1.5 litres per second per tonne.

Reducing moisture content

To keep grain under aeration at the same time as trying to reduce its moisture content, a relative humidity override controller is available from

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Agridry Rimik. It can be added to our current time proportioning aeration controller. The controller operates normally, picking the coolest times to work the fans, but because the Relative humidity override can be set to prevent the fans from operating at a time when the time proportioning controller alone may require them to operate, the fan running time will be reduced and the cooling effect will be reduced. *Therefore it should be noted that a controller with this override does not optimise the cooling effect.*

Drying aeration (drying in storage)

Larger volumes of selected air are passed through stored grain to lower its moisture content. Typical air flow rates are 5 to 20 litres per second per tonne.

Controllers which allow the grain storage manager to select drying conditions are available. However, with all in - storage drying, it should be noted that the main challenge facing the grain manager is to ensure the grain does not spoil before drying and cooling has occurred. *Warm moist grains are at risk of spoilage within hours of placing in storage* and in general the practice of trying to dry in storage is not recommended in Australia.
