Photo: Ben White

Keeping aeration under control

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At a glance

- Grain aeration allows growers to maintain grain quality by regulating moisture and temperature.
- As the range of chemical control options dwindles, grain aeration provides a powerful non-chemical stored grain insect management tool.
- Grain aeration systems can perform both cooling and drying functions — but each requires different management approaches.
- Growers looking to invest in a grain aeration system need to determine the primary function required — grain drying or grain cooling
- Grain drying rates depend on fan capacity, depth of grain, grain moisture and the inlet air temperature and relative humidity.
- Grain aeration controllers reduce the need for constant monitoring of ambient conditions and regulation of aeration fans.
- Available controllers differ in their methods of trigger points for fan initiation.
- A maximum relative humidity trigger of 85% will reduce the risk of grain damage during storage.
- For multiple storage facilities, a single controller that manages all storage sites can be more cost-effective than multiple controllers.

Grain aeration is a popular grain storage tool offering harvest flexibility, increased marketing opportunities and better control of grain quality, both at harvest and during storage. But as Kondinin Group researcher Chris Warrick explains, no two systems are alike and growers need to be clear on the key functions they require before investing in a grain aeration controller.

The 2009 Kondinin Group National Agricultural Survey (NAS) revealed that 26 per cent of respondents currently use a grain aeration system on farm. As climatic conditions continue to vary and stored grain insect control options dwindle, the rate of on-farm aeration is set to increase.

Grain aeration provides growers with a powerful tool to maintain grain quality during harvest and storage.

Aeration can be used to preserve grain quality attributes, prevent spoilage during storage, suppress insect activity and dry wet grain.

A grain aeration controller provides additional power to any system, reducing the need for manual operation while safe-guarding grain quality.

Through drying and cooling grain aeration can manipulate temperature and moisture in the grain stack to deliver an optimal storage environment.

However, grain aeration systems are generally designed to carry out either a drying or cooling function — not both. Growers looking to invest in a grain aeration controller need to determine the main function they require for their system before selecting and setting up an appropriate unit.

The following report explains the key processes involved in grain drying and cooling and delivers testing results for accuracy and operational capabilities of four key grain aeration controllers currently in the marketplace.

Quality control

Research carried out by the Department of Employment, Economic Development and Innovation,(DEEDI) Queensland shows that with the support of an aeration controller, aeration can rapidly reduce stored grain temperatures to a level that helps maintain grain quality and inhibits insect development.

During trials grain was harvested at 30 degree Celcius and 15.5% moisture. Grain temperature rose to 40°C within hours of being put into storage. An aeration controller was used to rapidly cool grain to 20°C and then hold the grain between 17–24°C during November through to March.

Before replicating similar results on farm, growers need to:

- Know the capacity of their existing aeration system.
- Determine whether grain requires drying before cooling can be carried out.
- Have an understanding of the effects of relative humidity and temperature when aerating stored grain.
- Determine the target conditions for the stored grain.

While grain aeration controllers take much of the guesswork out of aeration management a basic understanding of the grain drying and cooling processes will ensure a unit is selected that best matches on-farm requirements and budgets.

About aeration

Aeration of stored grain has four main purposes — preventing mould, inhibiting insect development, seed viability and moisture reduction.

Without aeration, grain is an effective insulator and will maintain its temperature for a long time. Like housing insulation, grain holds many tiny pockets of air within a stack — 100 tonnes of barley requires a silo with a volume of about 130 cubic metres, 80m^3 is taken up by grain and the remaining 50m^3 (38%) is air space around each grain.

Without circulation, this air surrounding the grain will reach a moisture (relative humidity) and temperature equilibrium within a few days.

These conditions provide an ideal environment for insects and mould to thrive and without aeration the grain is likely to maintain that temperature and moisture for months.

TABLE 1 The effect of grain temperature and moisture on stored grain insect development

Grain temperature (°C)	Insect and mould development	Grain moisture content (%)
40–55	Seed damage occurs, reducing viability.	
30–40	Mould and insects are prolific.	>18
25–30	Mould and insects active.	13–18
20–25	Mould development is limited.	10–13
18–20	Young insects stop developing.	9
<15	Most insects stop reproducing, mould stops developing.	<8

Source: Kondinin Group

The drying process

Grain is often harvested at high moisture levels to prevent damage during harvest and to beat the race against the weather if large areas are under crop.

As such, reducing grain moisture is often the first point of action at the initiation of grain storage to reduce deterioration of grain quality during storage through moulding and inhibition of insect activity (see Table 1).

Grain moisture levels below 13% will ensure mould development is limited.

Research has shown common grain pests multiply by 20–25 times per month at temperatures of 30–35°C and grain moisture levels of 14–16%. Grain moisture levels of 9% will discourage insect breeding.

At low temperatures insect pest activity is reduced and reproduction can even stop if temperatures are reduced far enough. For example, at 35°C and 70% relative humidity, flour beetles can develop in three weeks but at 22.5°C and 70% relative humidity it takes 10 weeks.

While adult insects can still survive at cool temperatures, young insects stop developing at temperatures below 18–20°C. At temperatures below 15°C weevils stop developing and most insects stop reproducing.

Cooling may not eliminate the need for insect control but will dramatically slow their development.

Stored grain deteriorates with time in any condition, but poor storage conditions, high in temperature and moisture, accelerate deterioration markedly.

DEEDI trials showed that wheat stored at 12% moisture content and 20°C had a seed viability decrease of only 1% after 150 days in storage. The same wheat stored at 12% moisture content and 30°C, had a germination decrease of 21% after 150 days in storage.

Aeration cooling and aeration drying — what's the difference?

While many growers attempt to use their aeration systems for both drying and cooling, systems are generally not designed to carry out both functions.

Aeration drying can be achieved with fans delivering 15–25 litres per second per tonne but rapid drying requires flow rates up to 30 L/sec/t (see Figure 1). The exact aeration flow rate required will depend on the ambient conditions.

Typical fans for aeration drying are powered by 7 kilowatt (10 horsepower) electric motors. Low-capacity fans cannot push this drying front through the grain fast enough to dry grain on the top of the stack before it goes mouldy.

Aeration cooling can be achieved with air-flow rates of 2–3L/sec/t delivered from fans driven by an 0.37kW (0.5hp) electric motor.

Both drying and cooling fan requirements are determined by grain storage capacity.

Air movement within the grain stack

Grain at the top of the stack is the hottest, as heat rises through the grain and it is exposed to the head space in the silo, which can get very hot during summer (see Figure 2).

As the air in the head space heats up and cools down each day, it creates ideal conditions for condensation to form and wet the grain on the top of the stack.

Aeration drying requires a system specifically designed for drying and is a much slower process than aeration cooling or hot-air drying.

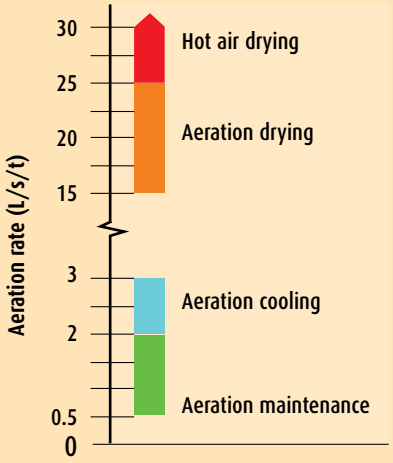
In some situations cooling can reduce grain moisture slightly but they cannot reliably reduce grain moisture to a safe level.

The rate of drying depends on the fan capacity, duct size, depth of grain, grain moisture and the inlet air temperature and moisture.

Heaters can be added to an aeration drying system to speed up the process but growers will need to seek more specific advice on drying grain to avoid damage from overheating.

Seed viability can be damaged if the grain is heated above 40°C depending on the type of grain and the time held at high temperature.

FIGURE 1 Aeration rates for grain drying and cooling



Source: Kondinin Group

The cooling process

When grain is at a desired moisture level, cooling can be initiated.

The process of cooling grain occurs in three stages — continual, rapid then maintenance.

The initial aim is to get maximum air flow through the grain bulk as soon as it goes into storage, to stop it from sweating and heating. Without aeration, grain typically increases in temperature immediately after it goes into storage.

When first loading grain into storage, run the aeration fans continuously from the time the grain covers the aeration ducts for 24–48 hours.

However, do not operate the aeration fans on continuous mode if the ambient relative humidity is higher than 90% as this will wet the grain. Note that even an aeration controller with a relative humidity override, will not stop the fans if it is set on continuous mode.

After the aeration fans have been running continuously to flush out any warm, humid air for a day or two, run time can be reduced to 9–12 hours per day for the next seven days.

This next phase, labeled differently by each manufacturer, is the 'rapid' or 'purge' stage where the coldest 12 hours of air is selected each day. The goal is to quickly reduce the grain temperature from the mid 30°Cs to the low 20°Cs.

An initial reduction in grain temperature of 10°C ensures it is less prone to damage and insect attack while further cooling becomes a more precise task.

After seven days of aeration on 'rapid' cooling setting the aeration fans are set to 'maintenance' where the temperature is gradually reduced as low as possible and then maintained throughout the storage period. Manufacturers can refer to this stage as 'normal' or 'protect' mode.

During this final stage, aeration controllers generally run fans during the coolest periods of the day for an average total of 24 hours per week.

This is where aeration controllers really make a difference, automating the switching process and accurately selecting the best time to turn fans on and off.

Cooling or drying — making a choice

Knowing whether grain needs to be dried or cooled can be confusing but there are some simple rules of thumb.

If grain moisture needs to be lowered then grain needs to be dried before it is cooled. Delaying the drying process greatly increases the risk of mould development and there is no point cooling grain then heating it again to reduce moisture.

Grain that is dry enough to meet specifications for sale (12.5% for wheat or 13.5% for sorghum) can be cooled, without drying, to slow insect development and maintain quality.

Grain of moderate moisture (up to 15% for wheat and sorghum) can be either cooled for short period to slow mould and insect development or, dried providing the right equipment and conditions are available.

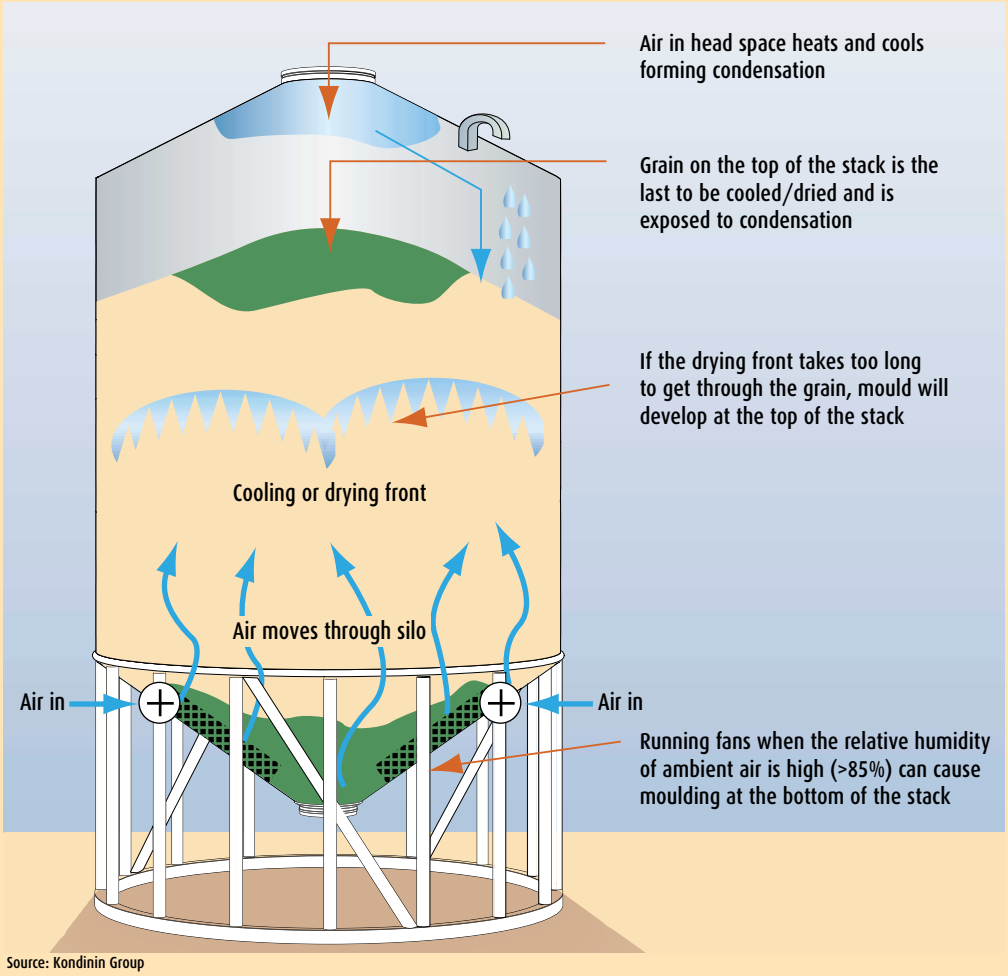
After drying to the required moisture content, grain can be cooled to maintain quality.

High moisture grain (for example, 16% and over for wheat and sorghum) will require immediate moisture reduction before cooling for maintenance.

Aeration cooling process

1. **Continual aeration** — running fans for the first 24–48 hours.
2. **Rapid mode aeration** — running fans for the coolest 9–12 hours per day for seven days.
3. **Maintenance aeration** — running fans for the coolest periods, averaging 24 hours per week.

FIGURE 2 Air movement within an aerated silo



Source: Kondinin Group

Timing keeps grain safe

Aeration uses air from outside the storage (ambient air) to carry out the cooling process. The selection of suitable ambient air during maintenance aeration is critical to ongoing grain quality.

Forcing moist air into the silo can increase the grain moisture content — particularly at the bottom of the stack, around the aeration inlet ducts.

If this grain at the bottom of the stack does not dry out quickly, it will go mouldy and create an ideal

TABLE 2 The relationship between air temperature and relative humidity and grain moisture content

Inlet air	Resulting temperatures in wheat at varying moisture contents (%)				
Temperature (°C)	Relative humidity (%)	10	12	14	16
15	30	15	12	10	9
	45	17.5	14	12	11
	60	20	16	13.5	12.5
	75	22	18	15.5	14.5
20	30	20	16	13.5	12.5
	45	22.5	18.5	16.5	15.5
	60	25	21	18.5	17.5
	75	27.5	23	21	19.5
25	30	24	20	17.5	16.5
	45	27	23	20.5	19.5
	60	30	25.5	23.5	22
	75	32.5	28	25.5	24
30	30	28	24	22	20
	45	31.5	27	25	23.5
	60	34.5	30.5	28	26.5
	75	37.5	33	30.5	29

Source: DEEDI

Wet bulb and dry bulb temperature

Dry bulb temperature is the measurement we are most familiar with and it's what most common thermometers measure.

Wet bulb temperature, most accurately measured with a sling psychrometer, uses the same thermometer as dry bulb but with a wet wick over the measuring end and a constant flow of air past it.

The difference between wet and dry bulb temperature can be used to calculate relative humidity.

Most aeration controllers measure dry bulb temperature and relative humidity to calculate web bulb temperature.

Using wet bulb temperature for aeration trigger points is a more accurate method of control because it accounts for air temperature and moisture.

breeding environment for insects, which will then spread throughout the grain.

When operating in cooling mode, aeration controllers turn fans on during the coldest times of the day, when relative humidity is generally highest, so any damp grain is unlikely to dry quickly.

A worst-case scenario occurs if fans are run for extended periods in conditions of high relative humidity, such as rain or fog. Grain around the aeration inlet ducts can mould, germinate and form a crust. This crust can cause choking of the aeration inlet ducts preventing any further aeration for cooling or maintenance.

Crusted grain on the bottom of the silo may also move when the storage is being emptied, blocking the grain outlet making it difficult to empty the silo.

Selecting the right air, by choosing the time to run aeration fans, is not as simple as it may seem.

Different ambient conditions affect stored grain differently depending on the combination of temperature and relative humidity outside the silo and the temperature and moisture content of the stored grain (see Table 2).

Grain with a higher moisture content can be cooled more quickly than drier grain due to the evaporative cooling effect that occurs inside the storage. Air passing around moist grain will have a greater cooling effect than air passing over drier grain.

The relative humidity of the ambient air also affects the efficiency of grain cooling.

In most areas of Australia, with the exception of costal regions, when temperatures are lower overnight relative humidity increases.

In an ideal world we would select air for cooling that is low in temperature and low in relative humidity but these conditions are very rare.

Removing the risk

Aeration controllers are designed to automatically select the best time to run aeration fans. Fans only run when the conditions will benefit the stored grain.

Running aeration fans on timers that are pre-set for the same time each day will not ensure the selection of the most appropriate air for grain quality maintenance.

However, trying to manually calculate the ambient conditions and turning fans on and off, sometimes in the middle of the night, is neither practical or efficient.

With the exception of the set-point controller from Smallaire, the controllers tested for this report all measure the temperature and relative humidity of ambient conditions and continually calculate the best air to use for cooling.

Recording: *During the two-week test period Tinytag data loggers were use to record temperature, relative humidity and aeration run time.*

Photo: Ben White

Photo: Ben White

Aeration controllers uncovered

Sneak peak: *Taking a closer look reveals how aeration controllers operate.*

With only a few aeration controllers currently available on the local market, it is the small differences that will determine a buying decision. The following section provides a run-down on aeration controller operation and tips from telling a great unit from a good one.

The main difference between currently-available controllers is the way they determine when to turn aeration fans on and off.

Set-point controllers

Starting with the simplest system — the set-point controller from Smallaire uses set points to trigger fan operation.

Operators select a specified temperature and relative humidity that will trigger fan operation — the set point.

For example, for cooling, the operator might set the controller to only run the fans if the temperature is below 23 degrees Celcius and relative humidity is below 85 per cent.

Time proportioning controllers

Time proportioning controllers (TPC) from Customvac and Agridry Rimik both use algorithms to select the coolest air to run the fans for an average total of 24 hours per week.

Ready, set, go: *A set-point aeration controller uses fixed trigger points set by the operator.*

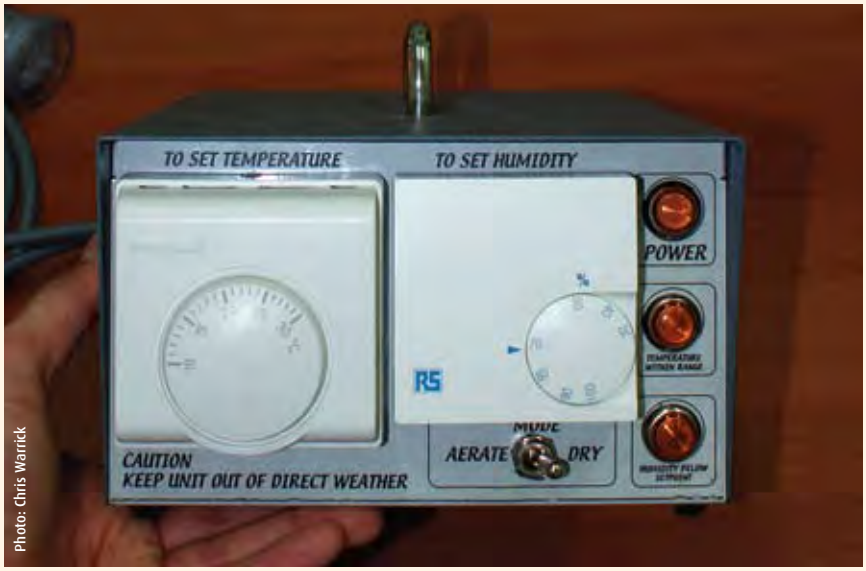


Photo: Chris Warrick

Time proportioning controllers measure relative humidity and dry bulb temperature of the ambient conditions and use these to calculate wet bulb temperature.

The controller continually adjusts a wet bulb temperature trigger point based on the trends it measures.

Put simply — time proportioning controllers operate like a self-adjusting thermostat.

Even though these controllers only use wet bulb temperature as a continually moving trigger point, relative humidity is accounted for because wet bulb temperature is a measure of dry bulb temperature and relative humidity.

Operators set a relative humidity override to stop the fans running in high humidity air, regardless of the temperature trigger point.

Time proportioning controllers use two moving temperature trigger points for 'rapid' (purge) and the second for maintenance (normal or protect) cooling.

The rapid trigger point is calculated in the same way as the maintenance trigger point, but widens the window of opportunity for fans to run as it is less selective with the air that it pushes through the grain.

Operating on rapid as the second stage of the cooling process increases the average total run time to 84 hours per week (9–12hrs/day).

Adaptive discounting controllers

The adaptive discounting controller (ADC) from Aeration Control Australia does not use any manually set or moving trigger points to operate fans.

Photo: Chris Warrick

Time proportioning controllers: *Calculated by measuring dry bulb temperature and relative humidity, wet bulb temperature is used as a continually moving trigger point.*

This system relies on the operator entering all the parameters of the grain, the targets and the storage facility to calculate the best times to run fans.

When the Aeration Manager is set up the operator enters the capacity of the storage and the aeration system. When grain goes into storage the operator enters the grain moisture and temperature as well as a target grain moisture and temperature.

The adaptive discounting controller then measures the ambient relative humidity and dry bulb temperature to calculate a wet bulb temperature.

Using the grain parameters and targets set by the operator, the controller then runs the fans at any time the ambient conditions are calculated to cool or dry the grain closer to the target levels.

As time passes the controller estimates the effect it has had on grain moisture and temperature so far and gets more selective with the air it uses.

Internal sensing controllers

The more complex aeration systems operate in a similar way to the adaptive discounting controller but have sensors inside the storage to monitor the grain temperature and humidity.

Having sensors inside the grain storage means the operator only has to input targets for the grain moisture and temperature and the controller measures and calculates when to run the fans.

The effect the aeration has on the grain over time can then be measured not estimated.

These types of controllers are predicted to be a more accurate and efficient way of cooling and drying grain but are generally more expensive and complex to install.

At the time of testing only one of these types of controllers was available in the Australian market — the mDhT sold by Astonville steel.

Despite the efforts of Kondinin Group researchers the manufacturer of the mDhT controller refused to participate in the testing and as such results are not included in this report.

Features

Four aeration controllers were tested for this report, each have various levels of complexity and pricing (see Table 3).

Fan control

While the units varied in their methods of fan control all have cooling functions and except the Rimik AC20 were available with some level of drying function.

The Aeration Manager has the most comprehensive drying function, using adaptive discounting to determine the best times to run drying fans.

If installed as an option, the drying function on the Grainsafe 3000 only uses ambient relative humidity as a maximum limit.

After a desired maximum relative humidity limit is set, the Grainsafe 3000 will run drying fans for any period of time the ambient conditions are below

TABLE 3 Aeration controller specifications

	Aeration Manager	Grainsafe 3000-4	Rimik AC20 10-4	Smallaire
Control method	ADC	TPC	TPC	Set point
Cooling	✔	✔	✔	✔
Drying	✔	Optional[1]	✘	✔
Run-time meter	✔	✔	✔	✔
Manual fan control	✔	✔	✔	✘
Data recording for download	✘	✘	✔	✘
Display of ambient conditions	✔	✔	✔	✘
Three-phase switching ability	✔	✔	✔	✘
Generator start	✔	✔	Optional[1]	✘
Heater control	✔	✘	✘	✘
Staggered fan starting	✔	✔	✔	✘
Delayed switching	✔	✔	✘	✘
Relative humidity limit (%)	90[2]	90[2]	85–99	35–100
Base number of storages controlled	8[5]	4[3]	4[4]	1
RRP inc GST, including cabinet	$10,175	$5010	$6094	$1980

Notes: [1] Available as an optional extra. [2] Can be changed by manufacturer on request. [3] Can control up to 48 individual storages. [4] Can control up to 12 individual storages in standard models but able to adapt to control more. [5] Can expand in blocks of eight.

Source: Kondinin Group

that relative humidity limit, regardless of temperature.

Cooling often occurs during the early hours of the morning. In the absence of physically monitoring the system, a run-time meter is the only way of gauging fan operation and run time. All units tested contained a run-time meter.

As well as checking run time it's also important to turn fans on with the manual run function to check they are getting power and operating as required.

The Smallaire controller is the only unit not capable of manually turning fans on and off without changing set points or unplugging it.

Data management

Unique to the Rimik AC20 is a data recording and downloading feature. Up to three months of records, including ambient conditions, moving trigger points and operation times are logged every half hour, can be downloaded onto a secure digital (SD) card and uploaded to a computer as a comma separated values (CSV) file.

Web-based control

The Aeration Manager has a unique web-based remote control feature available as an optional extra.

By connecting the controller to the internet, the operator can log into it from any web browser and see the operational status, monitor ambient and calculated grain conditions and make adjustments to parameters for each storage.

While not vital to operation, a display of current ambient conditions is a handy feature available on all controllers accept the Smallaire.

Monitoring if fans should be on or off by looking at the current conditions is not possible with the adaptive discounting and time-proportioning controllers because temperature trigger points continually change.

But occasionally checking they are not running in high-humidity conditions (above 85%) is important, so a display of ambient conditions is handy.

Power play

The Smallaire controller is not set up to switch drying fans on three-phase power but can be used to activate a three-phase switching relay in the same way as the other controllers.

In the case where no mains power is available and fans are powered by a generator, the Aeration Manager, Grainsafe 3000 and the Rimik AC20 (if fitted with the option) can start a generator to run fans.

The Aeration Manager can start and stop heaters for grain drying.

During start-up, electric motors put a load on electrical circuits far greater than the load under normal operation.

When an aeration controller is managing several storages, and especially when operating larger fans, staggered starting is necessary.

When the ambient conditions trigger the controller to turn the aeration fans on, there is a short delay (usually a few seconds) between starting each storage unit.

It was pleasing to see the staggered starting feature on all controllers designed to control multiple storages.

The other important start-up feature is the delay between switching a storage unit on and off.

If ambient conditions hover close to the trigger point it would wear-out fans constantly flicking on and off.

The Grainsafe 3000 and the Aeration Manager have built-in delays so fans will only switch on or off if the ambient conditions are constantly above or below the trigger point for a period of time.

Relative advantage

A relative humidity limit on aeration controllers stops the fans forcing wet air into stored grain.

Specialists in the grain storage field have varying opinions on what the relative humidity limit should be set at but a safe guide is 85%.

Being able to adjust the relative humidity limit to 85% would therefore be desirable. But sensor accuracy is the key to humidity control (see test results page 46).

Price point

Individual control of multiple storages can make aeration controllers more cost effective.

Indicative recommended retail prices (RRP) given in Table 3 are for the minimum number of storage controls , but more storages can be added to all of the controllers except the Smallaire.

The prices provided include a weatherproof cabinet and specifications as shown, but do not include the cost of installation and wiring to aeration fans, accept the Smallaire and Grainsafe 3000 controllers, which are ready to plug in.

If looking to buying a cabinet separately, take into consideration the cost of the relays and getting an electrician to wire the controller into the cabinet. For example the Grainsafe 3000 is available bare for $3080 inc GST and the same size and brand cabinet can be bought from a retailer for $390 but there is a considerable amount of wiring, relays and sockets to mount the controller.

NOTE ▶ Shortly after the testing for this report was completed, an aeration controller from Total Grain Handling and Construction Pty Ltd became available.

Imported from the United States, the Integris controller appears to operate similar to an adaptive discounting controller, but with the addition of sensors inside the grain storage plus additional control options.

A follow-up article will cover this controller but it was not available for inclusion in this report.

Photo: Ben White

Controllers contrast in complexity and capability

Operation: *With more features and capabilities comes more complexity in operation.*

Four commonly-used aeration controllers were put to the test to monitor their operation in ambient conditions during a two-week period. Here are the results and the researcher's overall impression of each unit.

Testing aeration controllers in a comparative, working environment is not practical due to the number of variables in grain, grain storages and aeration systems.

For this research, all four controllers were 'bench tested' side-by-side to monitor operation under the same ambient conditions during a two-week period.

Because each controller operates differently and not all units could be set with the same uniform parameters, they have been evaluated in the same environment but each on their own merit.

Temperature and relative humidity sensors were monitored for accuracy and operation times were logged for comparison with the ambient conditions recorded on-site.

Sensor accuracy

All controllers except the Smallaire have digital displays of the current ambient conditions. During the two weeks of testing, temperature and relative humidity readings were recorded twice daily. A benchmark measure was taken using a sling psychrometer, checked against five Tinytag temperature and relative humidity loggers to reduce the risk of reading or calculation error.

Temperature accuracy testing revealed consistent results with average readings within one degree Celcius on each of the three controllers (see Figure 3). This is as accurate as possibly measurable with the equipment available.

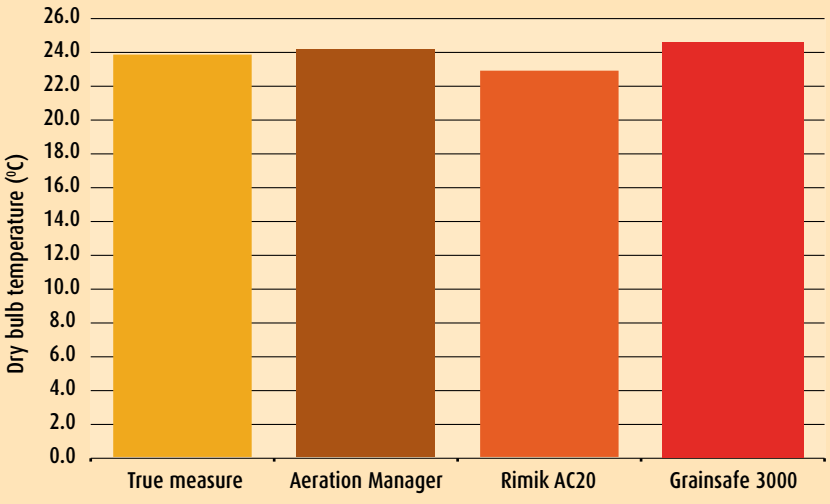
Measuring relative humidity precisely is much more difficult than temperature and error margins can be greater.

When relative humidity exceeds 90 per cent most humidity measurement devices become less precise, including the benchmark measure from the sling psychrometer.

Taking this into consideration, the three controllers monitored gave readings inside 3.3% relative humidity increments from the benchmark reading, which is considered as accurate as measurable.

The only concern regarding relative humidity was that the Aeration Manager and Grainsafe 3000 are supplied with limits set at 90%, which are not adjustable by the operator.

FIGURE 3 Temperature accuracy testing results for aeration controllers



Source: Kondinin Group

With a fixed limit as high as 90% there is no room for error in readings before the fans should be turned off to prevent moist air being forced through the grain stack.

Having controller limits set to 85% relative humidity allows tolerance for variances and ensures fans are turned off before relative humidity reaches 90%.

Considering relative humidity measures are less accurate at levels of 90% and above a limit set this high is concerning.

Both the Aeration Manager and the Grainsafe 3000 relative humidity limits can be adjusted by the manufacturer.

Unless there are other location-specific considerations, consider asking the manufacturer to reduce the limit to 85% if buying these controllers.

The Smallaire controller does not display current ambient conditions so could not be included in the accuracy comparison based on manual readings.

Unlike the other controllers, the Smallaire could be set to turn on and off with manual set points, so accuracy was measured with data loggers during testing to determine if the unit switched on and off at the desired set points.


Photo: Ben White

Measuring sensor accuracy: *Temperature and relative humidity were measured during testing with a sling psychrometer and checked against five Tinytag loggers.*

Photo: Ben White

Smallaire: *Small price tag — small in features and accuracy.*

Smallaire

The Smallaire controller was set to run when both the relative humidity was below 85% and dry bulb temperature was below 23°C.

On Figure 4 these limits are represented by the black line and the top of the green bars.

If the controller is accurate it should turn the aeration fan on only when the temperature and humidity (represented by the red and blue lines) are both above the set point (black line).

The green bars represent when the controller actually ran the aeration fans.

Looking first at the temperature line, testing revealed that the Smallaire controller turned on when temperature was below the set point and off when it was above the set point.

This demonstrates the controller's temperature sensor is accurate and operating as designed.

Concern arises when looking at relative humidity however, as the controller should only turn the fan on if both temperature and relative humidity are below the set point.

As shown on the Figure 4 there are six times when the relative humidity (blue line) is above the set point (black line) and the controller continued to run the fan (green bars).

The most concerning failure was during the last day-and-a-half of testing, when relative humidity was well above the set point for an extended period of time and the controller continued to run the fan.

Under field conditions this would mean the Smallaire controller would of been forcing damp air (up to 99% relative humidity) through the grain for 35 hours.

Running fans while the air is above 85% relative humidity for less than one hour is considered acceptable, but running a fan for 35 hours at up to 99% relative humidity has the potential to seriously damage grain quality.

Total run time of aeration fans with the Smallaire manual set-point controller is dependent on parameters set and ambient conditions at the time.

During testing, with relative humidity limit set at 85% and dry bulb temperature limit set at 23°C, the Smallaire controller ran the aeration fan for 192 hours during the two-week testing period.

Overall impression — Smallaire

Simplicity is the key feature of the Smallaire controller a result of a basic functional ability. As such it cannot be compared with the other featured controllers on price.

Without continually altering the temperature set point it will run the aeration fan too little and not cool the grain quickly enough, or it will run the fan too much and continually cool then heat the grain, wasting power.

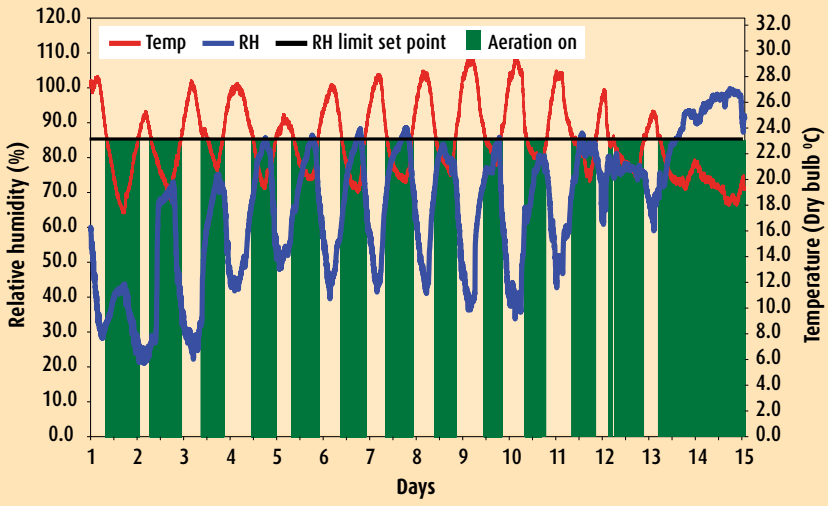
The size and weight of the controller and the handle makes it easy to carry between silos.

The Smallaire controller does have a built-in circuit breaker, which is an essential safety feature.

Accuracy of the temperature sensor tested well but accuracy of the relative humidity sensor was poor — a serious concern with this controller.

While there is no display of the current ambient conditions, the Smallaire controller does have a power light and a light to indicate if the temperature and relative humidity are within range for the fan to be turned on.

FIGURE 4 Smallaire test results



Source: Kondinin Group

Manufacturer's comment

Recommended retail price for the Smallaire controller is $1980 inc GST.

Test done outside recommended guide for drying and aeration.

We recommend the following parameters:

— Maximum humidity for drying 65%.

— Maximum temperature for drying 20°C.

— Maximum humidity for aeration 55%.

— Maximum temperature for aeration 22°C.

After initial two weeks of aeration reset temperature lower by 2°C then back to 10°C over the months leading into winter as each month gets cooler nights.

If high humidity continues for three days and fans have not come on and you know grain is high in moisture run fans for one hour to freshen air in silo.

Smallaire
(03) 5382 5688
www.smallaire.com.au

Aeration Manager: *For operators who have the time and need, the Aeration Manager is feature rich.*

Aeration Manager

Remembering that the Aeration Manager is an adaptive discounting controller (ADC), with continually changing trigger-points, determining when fans should run cannot be monitored.

For the testing period the controller was set with the following parameters to monitor fan operation in a scenario of cooling wheat immediately after loading into a silo — 120 tonnes of wheat at 11% moisture at 32°C.

The target was to maintain grain moisture content at 11% and reduce temperature to 18% using an aeration cooling fan capable of two litres per second per tonne.

After 20 hrs the Aeration Manager estimated it had cooled the grain to between 24–28°C (see Figure 5).

The grain reached a minimum, between 23–27°C after 44 hours and was maintained between 25–29°C for the remainder of the two-week testing period.

After the Aeration Manager ran almost constantly during the first few days, it calculated there were no conditions after day six of testing that could produce further cooling so the fans didn't run again.

As previously stated, the Aeration Manager uses a fixed limit at 90% for relative humidity, which is only adjustable by the manufacturer. While the controller didn't run the fan under any high-humidity conditions it is theoretically possible it could run fans at up to 90% relative humidity, which is undesirable.

Given the parameters set to simulate stored grain being cooled straight after harvest, the Aeration Manager performed as expected, running fans almost continuously for the first few days then reducing run time for maintenance cooling.

Total run time of the aeration fan for the testing period was 94 hrs.

Overall impression — Aeration Manager

The Aeration Manager is the most complex controller to set up and operate.

The 15 centimetre touch-screen display is nice to use but the controller requires operators to enter a lot of information.

The heavy reliance on information entered by the operator is a concern as if a small mistake is made on a vital piece of information the controller will do what it calculates is best, but may damage the grain if the base information was incorrect.

While the Aeration Manager can cool and dry, there is no option to manually switch fans for cooling or for drying. The controller determines the aeration mode from the parameters of the grain and the targets set by the operator. If the initial entered grain moisture content is lower than the entered target moisture, the controller will operate in cooling mode.

Conversely, if the initial entered grain moisture content is higher than the entered target moisture the controller will operate in drying mode before it starts cooling.

In a situation where the controller is only connected to an aeration cooling fan with capacities too small for drying, the controller will still attempt to run the fans for drying. Because small fans will not be able to push a drying front through the grain quickly enough to reduce the moisture content, it will just keep the grain warm for an extended period, potentially causing many problems.

With the right fans in place, the Aeration Manager does have extensive grain drying capabilities with a feature to switch dryers on and off.

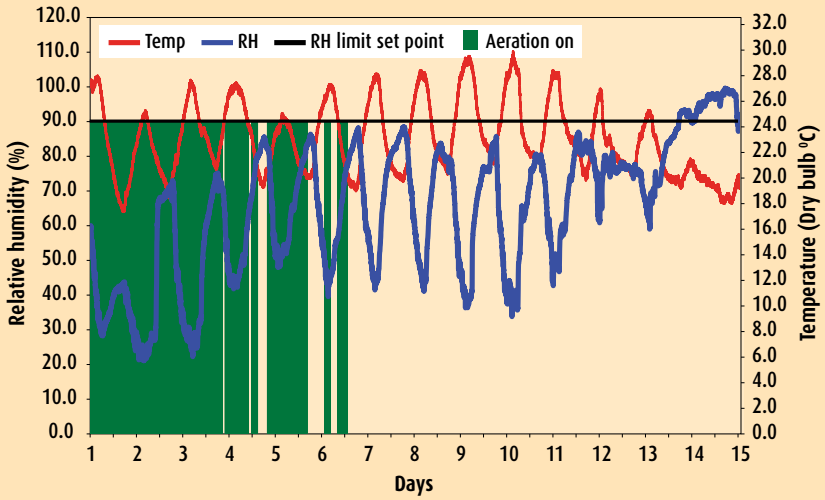
Quality of build was acceptable but could have been improved with a steel cabinet instead of Acrylonitrile Butadiene Styrene (ABS) plastic, and a stronger mounting box for the touch-screen.

When the controller arrived for testing, a wire on the temperature sensor had come off during transit, which was easy to fix but does reflect some lack of attention to detail in build quality.

Growers willing to spend extra time to set up this controller with all the parameters for each storage will be rewarded by not having to go back and change the settings for each stage of the cooling process.

The Aeration manager undoubtedly has more features and capabilities than the other controllers tested, the trade-off being complexity in set-up and operation.

Figure 5 Aeration Manager test results



Source: Kondinin Group

Manufacturer's comment

Recommended retail price for the Aeration Manager is $10,175 inc GST mounted in an ABS plastic cabinet.

Despite the fact that the Aeration Manager is the most feature-rich controller on the market it is almost the cheapest at $1272 per silo.

In addition:

- It is the only controller in the survey to switch the fans based on the grain condition.
- It shows you the front progress.
- It tells you the condition of the grain (temperature and moisture).
- It is the easiest to operate with all the information on just three screens per silo.
- It treats every silo differently based on grain type, fan size and fill percentage.

Aeration Control Australia
(08) 9300 1844
www.aerationcontrol.com

Grainsafe 3000 and Rimik AC20

The Grainsafe 3000 and the Rimik AC20 are the only two controllers tested that can fairly be compared because both are time proportioning controllers. Both units were set to capture the coolest 24hrs of air per week.

The Rimik AC20 referred to this setting as 'normal' and on the Grainsafe 3000 the setting is called 'protect'.

In the field, when grain is first loaded into storage, both controllers would be set to run continuously for the first 1–2 days, after this the Rimik AC20 would be set to 'rapid' and the Grainsafe 3000 set to 'purge' for the next 2–4 days, running fans for an average of 12hrs a day.

For the testing period, the controllers were set to 'normal' and 'protect' simulating the maintenance phase of the cooling process to test their ability to select the coolest air.

Trigger points were recorded at set-up. The Rimik AC20 had a wet bulb trigger point of 18.7°C and the Grainsafe 3000 at 18°C.

Both controllers had a relative humidity limit set at 85% and neither unit ran fans above this point.

The Rimik AC20 and the Grainsafe 3000 ran continuously for the first two days of testing making use of the cool, lower relative humidity air at the time (see Figures 6 and 7).

After fans had been running for a relatively intense period, both controllers had been recalculating trigger points to be more meticulous with the ambient air selected.

By day three the wet bulb trigger points on the Rimik AC20 and the Grainsafe 3000 were down to 14.7°C.

After day three the two controllers constantly recalculated the trigger points getting less selective with the air they needed to use.

By day 11 both controllers had increased wet bulb trigger points to 17.9°C, enabling them to run airflow though the storage again.

Both controllers turned on at the start of day 14, continuing to run the aeration fans as the temperature (red line) dropped, but then turned the fans off when the relative humidity exceeded the 85% limit.

On the graphs this event can be seen at the point where the fans stopped (green bar ends on day 14) and the relative humidity line (blue line) crosses above the black line (relative humidity limit).

The result from monitoring the moving wet bulb trigger point and relative humidity limit is that both the Rimik AC20 and Grainsafe 3000 operated as expected.

Using the same control system and starting at the same trigger points they were expected to operate similarly — they did.

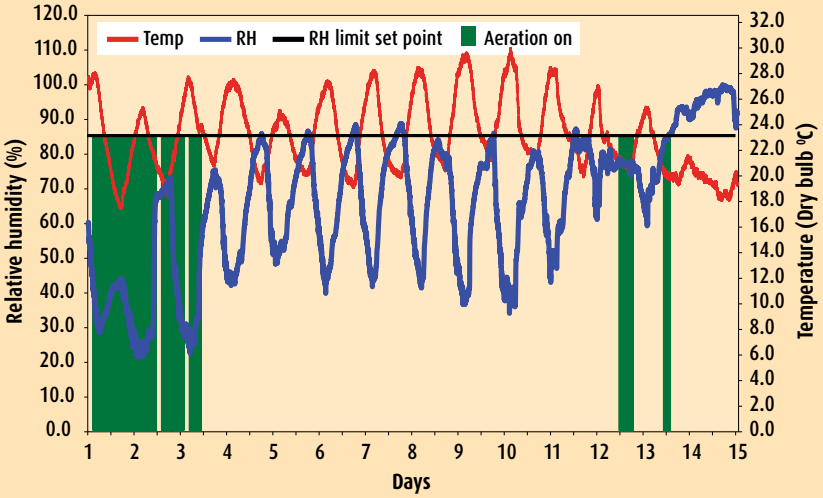
There is no reason to doubt the operation of either machine, providing the relative humidity limits are set at 85%.

In order to determine average run time of the fans, time proportioning controllers need to be run for at least one month to check they achieved the target average of 24hrs/wk.

TOP: **Grainsafe 3000:** *Time proportioning controller with drying feature.*

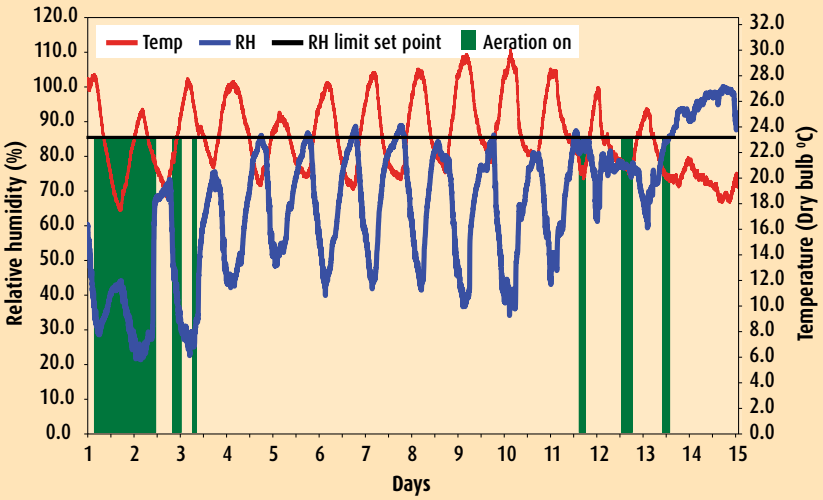
LEFT: **Rimik AC20:** *Simple to operate time proportioning controller for aeration cooling.*

FIGURE 6 Rimik AC20 test results



Source: Kondinin Group

FIGURE 7 Grainsafe test results



Source: Kondinin Group

Average weekly fan operating time on the Grainsafe 3000 was 19hrs/wk and the Rimik AC20 26hrs/wk.

During the short testing period available these run times are within the expected range.

Overall impression — Rimik AC20

Operating the Rimik AC20 was simple with an easy-to-follow instruction manual.

After the time and date is set and the controller is initialised, storages can be controlled easily with each individual control switch.

The main control has a test function, which will turn on all fans set to normal then all fans set to rapid to check they are all connected and working.

The AC20 has a unique feature in its ability to store up to three months worth of logged data, which can be downloaded to a secure digital (SD) card and viewed on a computer as a comma separated values (CSV) file.

During testing there was an issue with the SD card reader being unable to format some cards but after several attempts with different brands of cards, it worked.

This issue also highlighted a potential problem in that the Rimik AC20 can only take SD cards up to 1GB capacity but the smallest size card sold in most shops is now 2GB.

Agridry Rimik does sell 1GB SD cards so it would be advisable to purchase a card and a spare if buying a Rimik AC20 and make sure they are formatted to the controller.

Hour meters on each storage control are a good feature but would be improved if they could be reset to zero.

The Rimik AC20 can control an unlimited number of silos by adding more relays to the cabinet. This means there is plenty of room for expansion.

Only designed for aeration cooling, the controller can not be upgraded for aeration drying.

Overall impressions — Grainsafe 3000

The Grainsafe 3000 took a little while to get used to operating, with five multi-function buttons to control each individual storage. When familiar with the system it becomes easier to operate and view the settings of each storage.

The Grainsafe 3000 has clear instructions, including some handy reference tables in the back that can be stored with the controller in a pocket on the inside of the door.

Expanding the Grainsafe 3000 involves a software upgrade and additional relays but extra storages added are still controlled through the same screen.

A basic aeration drying function can also be added, which runs fans at any temperature providing the relative humidity is below the limit set by the operator.

The only issue with the Grainsafe 3000 is the preset relative humidity limit of 90% in cooling mode.

Growers would be advised to request the manufacture reduce this limit to 85% when buying the controller, unless there are other considerations specific to the location where it is being used.

There is a manual continuous run mode on the Grainsafe 3000, but it has to be selected individually for each storage then returned back to the function they were each operating on.

The addition of a test function to run all fans for a short period to check they are all connected and working would be a welcome addition.

Quality of build is excellent with attention to detail second-to-none.

The Grainsafe 3000 is mounted in a steel cabinet with a clear inspection window, which can be quickly opened to operate the controller without opening the main door. FA

Manufacturer's comment

Recommended retail price for the Rimik AC20 supplied in a cabinet with switching for four storages is $6094 inc GST.

If growers want to arrange to have the controller mounted in another cabinet, the recommended retail price for the controller is $2170 inc GST and $835 per a panel of four switches.

Agridry have recently released an updated version of the AC20 — the AC20+, which offers a basic drying control function. An extra humitter sensor monitors the exhaust air from the drying bin, and compares ambient humidity with exhaust humidity, allowing the fans to run only when the exhaust air is wetter than ambient. It can monitor one bin only, and can be switched from drying to cooling mode using the software.

An update is planned to allow the SD card writer on the AC20 to allow for the use of the higher capacity cards now available.

Agridry Rimik
(07) 4631 4300
www.agridry.com.au

Manufacturer's comment

Recommended retail pricing for the Grainsafe 3000 mounted in a steel cabinet set-up to control four silos for cooling only is $5010 inc GST.

The GRAINSAFE-3000 Aeration Controller has been developed to protect stored grain quality using the tried and proven time proportioning control method.

As standard the GRAINSAFE 3000 has staggered start of each storage, visual indication of storage status, resettable hour meters, storage overview screens and ease of expansion to 48 storages.

A set point drying mode is available as an option to control fans in high airflow storages.

The GRAINSAFE 3000 can be purchased separately, or to reduce site costs, mounted in a weatherproof electrical cabinet complete with all necessary documentation, safety and fan control equipment to suit individual sites.

Customvac Australia Pty Ltd
1800 242 699
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Aeration controllers and systems

Agridry RFM Australia
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Kotzur Limited
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www.silovent.com

ACKNOWLEDGEMENTS ▶ GRDC Grain Storage Extension Project, Philip Burrill, DEEDI, Peter Botta, PCB Consulting, Chris Newman, Department of Food and Agriculture Western Australia (DAFWA), Ben White, Kondinin Group, Mark Conway, Control Unlimited, Henk de Graaf, Aeration Control Australia, David Atkins, Agridry, Jock Baker, Smallaire, Andre Farley Silo Sealing and Waterproofing.

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Installation and maintenance tips

Before buying an aeration controller be aware that, except for the Smallaire and Grainsafe 3000 controllers which are ready to plug in, they need to be installed by an electrician.

The preferred mounting location for aeration controllers is in a well-ventilated area out of direct sun as much as possible and sheltered from rain and prevailing winds.

Mounting of the weatherproof cabinets is not the main consideration. The temperature/humidity sensor needs to be shaded, sheltered from the rain, protected from dust accumulation and in a well-ventilated area where it can measure ambient conditions.

Grain storages tend to be dusty places and always pose the risk of dust explosions given an ignition source. To avoid the chance of a dust explosion avoid installing aeration controllers in a confined space.

Ensure your electrician installs wiring properly insulated and protected from potentially damaging equipment such as augers. Maintain or replace electric motors and switches as they age to avoid a potential ignition source.

Monitoring a must

Aeration controllers reduce the amount of time operators need to physically monitor grain storages and turn fans on and off, but units and storage facilities still need to be checked regularly.

Hour meters are fitted to all tested controllers, allowing run times to be checked to ensure they are within range of the expected total average hours per week.

Check fans to ensure they are connected and operating normally.

Power leads can fall out and fan blades or bearings can fail so regularly check these components. (Turn off or disconnect fans before inspecting blades and bearings)

Keeping grain at the right moisture and temperature levels will reduce the likelihood of insect infestations, but stored grain still needs to be sampled regularly and monitored for any changes.

Having an aeration controller will undoubtedly preserve grain quality and provide another tool to minimise insects.