# Aeration for cooling and drying

*Department of Agriculture and Fisheries, Queensland Government*

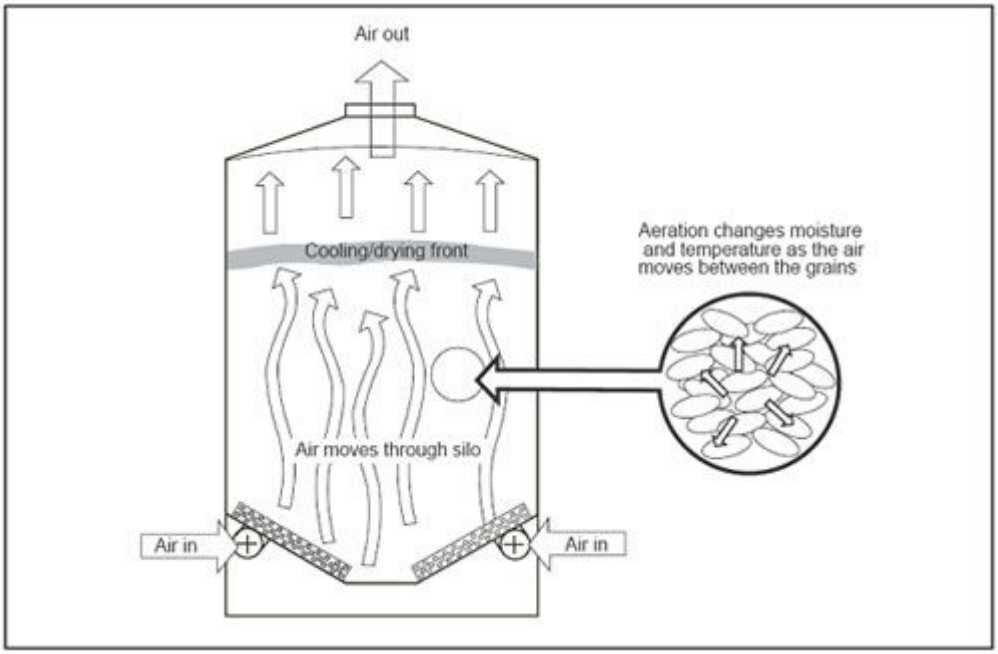


Diagram outlining the cooling/drying fronts occurring in the aeration process of stored grain within silos

## Key points

- Aeration uses fans and ducting to blow outside (ambient) air through grain. For aeration cooling, small fans and ducts are sufficient. Ambient air selected will usually be from cool night and morning times with a relative humidity (RH) of less than 85%.
- For aeration drying, larger fans and ducts are required with much longer running times. A large quantity of ambient air with low to moderate RH is utilized to push drying fronts through grain. For most inland grain growing regions, fans should run for most of the day and night apart from short periods of high RH.
- Aeration ´cooling controllers´ designed to automatically switch fans on and off, provide the most reliable grain cooling results.
- Aeration ´drying controllers´ are also available. These utilize settings designed to select air for drying grain rather than cooling.
- Running fans at the wrong time of the day or during unsuitable weather conditions can rapidly reheat or slowly rewet grain. Automatic controllers help reduce problems and increase efficiency of fan run times.

Aeration of grain to promote uniform, cool and dry storage conditions should be a key strategy for any business looking to maintaining grain quality and market value.

It is normally a relatively low cost investment in equipment, however obtaining good advice on fitting the right equipment for the desired purpose will enhance outturn results over many years.

Eighty percent of grain storage pest control problems can be overcome by combining a high standard of hygiene for storages & grain handling equipment along with well managed aeration cooling. A high priority should be given to aeration of freshly harvested grain and aeration during the storage months that follow.

# Why aerate grain

Aeration cools grain and slows most quality deterioration processes:

- Germination and seed vigour is maintained for longer when cool and dry.
- When grain temperatures are below 15-20°C grain storage pests´ life cycle slows or stops. Aeration can deliver these temperatures in winter and summer.
- Wheat bread-making flour quality and Barley malting quality can be maintained.
- Oil quality of oilseeds - free fatty acid, rancidity, colour and odour - can be maintained.
- Pulse grains (mungbean, chickpeas) maintain grain colour, reduce moulds risk.
- Mould development slows when grain moisture is uniform and below 13% mc.

Aeration capacity provides multiple benefits around harvest time:

- Ability to harvest early to reduce risk of weather damage causing quality and yield losses.
- Safely store grain at moisture levels a little above receival standards until blended with dryer grain.
- Hold high moisture grain safely for short periods prior to drying or blending.
- Return to harvesting earlier after rain delay.
- Gain extra harvesting hours each day.

# Basic equipment choices

## Aeration cooling

Fan/s providing low air flow rates around 2-4 litres per second per tonne (l/s/t) can both cool grain and create uniform grain temperature and moisture conditions in the storage. This reduces the risk of ´hot spots´ developing leading to damaging moulds and insects. If used correctly, flow rates of 2-6 l/s/t can, in addition to cooling grain, enable the safe storage of grain for weeks to months at moisture levels a little above receival standards.

## Aeration drying

Well designed - purpose built high flow rate aeration drying silos with air flow rates of 15-20 l/s/t and higher, can dry grain from higher moisture contents, provided air of suitable relative humidity (RH) and temperature is available. Aeration drying requires careful management over several days and sometimes weeks depending on starting grain moisture and ambient conditions.

Note: It is vital to understand that aeration cooling equipment with low airflow rates of 2-4 l/s/t will not reliably dry grain and if used for this purpose, places the grain at significant risk.

For all aeration systems, provide adequate venting to ensure fan performance and air flow rates are not unnecessarily restricted.

### Automatic controllers

Often ´aeration cooling´ fans are simply turned off and on manually or utilize a time clock. However there is a lot to be gained by investing $3000 to $4000 in an automatic controller that selects the best days and times to run fans. The controller continually monitors air temperatures and RH and may select air from only 2 or 3 days in a week or fortnight that has the lowest minimum temperatures and a safe RH during that period. A single aeration automatic cooling control unit usually controls fans on 4 or 8 silos, so the capital costs are spread over many tonnes.

Automatic control equipment designed to assist with ´aeration drying´ utilizes settings that are very different from the settings used for aeration cooling. Aeration drying requires a high proportion of lower humidity air often during the warm part of the day. During aeration drying, fans are designed to force much larger volumes of air through the grain bulk for much longer periods of time to ensure drying fronts are pushed quickly through.

Note: When purchasing automatic controllers it is important you choose a unit with a good quality humidity sensor as some units on the market do not fit accurate sensors that reliably detect high humidity conditions.

### Fumigation silos

A ´sealable silo´ (gas-tight) is essential for effective results when fumigating with phosphine to control live grain insect pests.

It is wise to fit aeration cooling fans to sealable silos at the time of purchase because these fans can be used for additional functions. Following a standard fumigation the fan can be used to clear silos of phosphine gas prior to loading trucks. An aeration fan also enables a simple pressure test to be run on the sealed silo to check the gas tight standard.

## Aeration - how it works

When a silo is full of grain there is a surprising amount of space taken up by air gaps between the grains. For example, if you store 100 tonnes of barley it will require a silo volume of about 130 $m^3$. Of that volume around 80 $m^3$ is taken up by grain. The remaining 50 $m^3$ is air space between the individual grains.

We are interested in this air surrounding the grain when it comes to aeration cooling or drying.

With no movement of air in the silo, this entrapped air around the grain slowly (over a few days) comes into equilibrium (balance) with the grain temperature and moisture. For example, if we filled the silo with freshly harvested wheat at 14% mc and with a typical grain temperature at harvest of around 30°C, the relative humidity of the air surround the grain in the silo would move to approximately 73% relative humidity (RH) and grain temperature may rise towards approximately 35°C due to grain respiration activity. These dangerous grain

storage conditions would remain unless we introduce outside (ambient) air that has a lower temperature and preferably a lower RH than the equilibrium that has been reached.

Well managed cooling aeration typically reduces grain temperature to the safe level of 20°C and below within days. However, reducing grain moisture to safe long-term storage levels generally takes one to four weeks utilizing much larger air flow rates to reliably achieve the desired result.

Aerating moist grain with low humidity air has a very useful evaporative cooling effect. See tables 1 and 2 that show the result of using various air qualities.

Table 1. Approximate grain temperatures that would result from aeration with air at various temperatures and relative humidity (RH) passing through wheat at various moistures

| **Inlet air** | | **Approximate resulting temperatures in wheat at moisture content %** | | | |
|---|---|---|---|---|---|
| **Temperature °C** | **Relative humidity %** | **10%** | **12%** | **14%** | **16%** |
| 10° | 30% | 10.2 | 8.5 | 7.7 | 5.6 |
| 10° | 45% | 12.0 | 10.0 | 8.3 | 7.3 |
| 10° | 60% | 14.0 | 11.06 | 10.0 | 8.7 |
| 10° | 75% | 15.3 | 13.0 | 11.0 | 9.0 |
| 20° | 30% | 18.7 | 16.1 | 14.2 | 13.0 |
| 20° | 45% | 21.8 | 18.8 | 16.8 | 15.6 |
| 20° | 60% | 24.1 | 21.0 | 18.8 | 17.5 |
| 20° | 75% | 26.4 | 23.2 | 21.0 | 19.5 |
| 30° | 30% | 27.4 | 24.3 | 22.0 | 20.0 |
| 30° | 45% | 30.8 | 27.5 | 25.0 | 23.5 |
| 30° | 60% | 34.0 | 30.4 | 27.9 | 26.5 |
| 30° | 75% | 36.7 | 33.2 | 30.5 | 29.0 |

Example: If we aerate wheat at 14% mc with ambient air (inlet air) with a temperature of 30°C and a RH of 45%, the resulting grain temperature is 25°C.

Table 2. Approximate moisture of wheat resulting from aeration with air at various temperatures and humidity (equilibrium grain moisture content)

| **Temperature (°C)** | **Relative humidity (%)** | | | | |
|---|---|---|---|---|---|
| | **30%** | **40%** | **50%** | **60%** | **70%** |
| 15° | 9.8 | 11.0 | 12.1 | 13.4 | 15.0 |
| 25° | 9.0 | 10.3 | 11.4 | 12.8 | 14.0 |
| 35° | 8.5 | 9.7 | 10.7 | 12.0 | 13.5 |

Example: If we continuously aerated wheat with ambient air that was 25°C and 70% RH, the wheat would eventually reach a moisture content of 14%.

# Aeration cooling fan run times - practical management

The following notes are guidelines only and rely on the operator **regularly monitoring** the condition of stored grain.

Cereal grains in the 12-14% mc range can generally be considered to be safe to hold under standard aeration cooling management. Cereal grain above 14% mc should also be cooled quickly but may require higher capacity fans and will certainly require moving into a grain drying system (high flow aeration or heated air drying) if grain is to be held in storage for a number of months.

Warning: High moisture grain will spoil rapidly if not carefully managed.

Freshly harvested grain from the paddock normally has a similar temperature to the ambient air temperature (e.g. wheat and barley in November, 28° to 32°C). There is also considerable grain moisture variation coming in from various part of the paddock. The aim is to create cool, uniform moisture conditions in the silo as quickly as possible.

### Manual operation of fans

For example, no automatic control unit; fan output in the 2-4 l/s/t range.

a. Turn aeration fan on while filling silo. Run continuously until the first cooling front comes through the top of the grain bulk. Usually this takes 2-3 days. If safe, go to the top of the silo and see if the air coming out has changed from a warm, humid smell to a fresh, cool smell. Check the grain temperature.
b. Once this has occurred, run the fans for approximately 12 hours per day for the next 3-5 days. Select the cooler temperatures but avoid any extended periods of high humidity which may rewet and reheat grain. Avoid fog, misty or rain conditions.
c. Check the grain temperature and condition. Grain temperature should be around 20°C or below. Now operate fan for approximately 48 hours total time per fortnight selecting cool, mostly dry air from a few days to maintain cool (< 20°C) uniform grain conditions.

## Automatic controller operation of cooling fans

For example, automatic control unit fitted, fan output 2-4 l/s/t.

The operations manual and instructions for the equipment should be consulted first and if they are not available contact the equipment manufacturer. The following is a brief guideline only.

Before using the fans, the Auto Controller should be turned on for 3-4 weeks. The Auto Controller needs to record a log of weather data prior to operating fans to correctly switch fans on at the best times.

a. When filling silo, switch controller to MANUAL setting and run and monitor grain as for section (a) in ´manual operation of fans´ above (2-3 days).
b. Switch to RAPID setting, which will automatically select approximately 12 hours per day of the most suitable air (3-5 days).

c. Check grain temperature and condition. Switch to NORMAL setting. This will automatically select approximately 48 hours per fortnight of cool air without excessive humidity.