DPI&F note

Grain storage - aeration for cooling or drying

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Key points

- Aeration uses fans, ducting and switches to blow outside air through grain.
- Heat and moisture move between the grain and the air that passes through the grain, but moisture exchange is slower than heat exchange.
- Depending on the temperature and moisture of air blown through the grain, and the moisture of the grain, aeration can heat or cool the grain and dry or wet it.
- For aeration-cooling small fans and ducts are sufficient, and the best time for cooling is usually early morning.
- For aeration-drying larger fans and ducts are needed, and the best time for drying is usually the afternoon.

Getting the best from aeration

Aeration is the movement of outside (ambient) air through grain in storage. Fans blow (usually) or suck (uncommonly) air through ducts which distribute the air to all parts of the storage. As the air moves through the grain, heat and moisture are exchanged with the grain resulting in:

- an initial averaging out of temperature and moisture between grains
- followed by a change in temperature
- followed by a slower change in moisture.

The initial evening-out of moisture can appear to be a drying process. At harvest individual grains vary in moisture, and some moisture meters are sensitive to the highest moisture grains. As the moistures even out, the moisture meter reads the average moisture.

Aeration can be used to cool or to dry grain, but it can heat and wet grain if not used carefully. To get the best out of your aeration system to cool or dry you need to:

- understand the capacity of your aeration system
- decide whether you should cool or dry the grain
- switch it on at the most appropriate times for cooling or drying.

Capacity of aeration systems

Almost all aeration systems are designed with sufficient capacity to push *temperature* changes through the storage in an acceptable time.
Not all systems have the capacity to push *drying* changes through moist grain before moulds develop. The rate of drying depends on fan capacity, duct size, depth of grain, grain moisture, and inlet air temperature and moisture. A particular fan, duct and storage combination may be suitable for drying 15% grain under all conditions and 17% grain when air humidities are low, but may not dry 17% grain during a period of high humidity sufficiently to prevent mould development. Even with this combination, 17% grain may be dried during a period of high humidity if the storage is only partly filled.
You may know the drying capacity of your aeration system from experience. If you need more information, contact the supplier of your system for specific advice. As a general guide in engineering terms, a system delivering 1-2 litres of air/second/tonne storage capacity is adequate for aeration-cooling but is not adequate for

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reliable aeration-drying. For more reliable aeration-drying a system delivering 10 - 20 litres of air/second/tonne capacity is needed.

Whether to cool or dry grain

Cooling and drying preserve grain quality during storage and limit insect and mould development. Under hot, moist conditions grain quality deteriorates rapidly, mould problems can develop within days and insect problems in a month or two. Drying to moistures below 14% in cereal grains can prevent mould development.
Following are some broad guidelines for when aeration-cooling or aeration-drying are appropriate:

- Grain that is dry enough to meet specifications for sale (eg 12.5% for wheat or 13% for sorghum) can be aeration-cooled to slow insect development and maintain quality.
- Grain of moderate moisture (eg up to 15% for wheat and sorghum) can be
  - aeration-cooled to slow mould and insect development or,
  - if it is to be sold, aeration-dried if the aeration system has sufficient capacity and if suitable dry ambient air is available, and then it should be aeration-cooled.
- Grain with high moisture (eg 16% and over for wheat and sorghum) should be dried immediately, or cooled immediately then dried quickly. High capacity aeration systems minimise the risks of mould development in high moisture grain. Hot-air drying is a more reliable drying system in areas with high humidity or rainfall during and after harvest.

These guidelines are cautious; for instance, aeration drying is used for high moisture grain but there is a risk of mould problems. You should modify the guidelines on the basis of your experience with your aeration system and your or your neighbours' experience in your area.

Strategies for aeration cooling

The best cooling conditions generally occur late at night and early in the morning.
For grain that is unlikely to go mouldy in the short term, ie dry or of moderate moisture:

- During the first week of storage, run the aeration fans for 9-12 hours each night to even out temperature and moisture and to begin the cooling process. If this strategy is continued a wetting moisture front could be forced through the grain.
- After the first week, reduce the fan hours to the coolest 3-4 hours each night (2am to 5-6am) to cool as much as possible.

Following this strategy will produce fairly good results. However, a hot spell will result in warming of the grain.

Automatic controllers

A controller that automatically selects the coldest 50% or 15% of the time to turn on the aeration fan is available from aeration suppliers. Use of an automatic controller is generally the best strategy for cooling.
For wet grain at moistures above 15-16% run the aeration continuously to cool the grain and prevent or slow mould development. This may also dry the grain, but not under humid conditions.
The grain temperature resulting from aeration is determined by temperature and humidity of the air and moisture of the grain, but not by the initial grain temperature (Table 1). Part of the change in temperature is similar to evaporative cooling from a canvas waterbag. Aeration of high moisture grain results in greater cooling than low moisture grain - aeration of 14% grain results in temperatures 4-5 ^{o}C cooler than aeration of 10% grain with the same air. Aeration with dry air results in greater cooling than humid air - aeration of the same grain with 30% humidity air results in temperatures 3-5 ^{o}C cooler than aeration with 60% humidity air.

Table 1: Grain temperatures that would result from aeration with air at various temperatures and humidities passing through wheat at various moistures

Inlet air		Resulting temperatures in wheat at moisture content %			
Temperature °C	**Relative humidity %**	**10**	**12**	**14**	**16**
10	30	10.5	7.5	5.5	5
	45	12	9.5	7.5	6.5
	60	14	11	9	8
	75	16	12.5	10.5	9.5
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
35	30	32.5	28	25.5	24
	45	36	31.5	29	27.5
	60	39.5	35	32.5	31
	75	43.5	39	36.5	35

Strategies for aeration drying

Aeration drying is only effective if low humidity air is available. This is unlikely during a wet harvest when drying is most needed. Aeration drying is less reliable than hot-air drying.

Aeration drying is much slower than hot-air drying. Wet grain at moistures above 16% could go mouldy in the upper layers before a moisture change front is forced through the grain in low capacity aeration systems designed for cooling. If aeration is to be used for drying, check with your aeration supplier that the fan and ducting have sufficient capacity to force a moisture change front through the grain in your silo quickly enough to prevent mould development.

Strategies and automatic controllers for best performance of aeration drying are currently being developed. The aim of the strategies will be to run the fans for as many hours as possible to force a drying front through the grain, but to avoid periods of high humidity that would wet the grain. The only generalisation that can be made at this stage is that the best drying conditions generally occur during the afternoon.

If you know the moisture of your grain, both at the top and bottom of your silo, and air temperature and humidity you can calculate from Table 2 whether running your aeration system will wet or dry your grain. At this stage basing your aeration drying strategy on this information will produce best results.

Table 2: Grain moistures in wheat that would result from aeration with air at various temperatures and humidities.

Temperature °C	**Relative humidity %**			
	30	**45**	**60**	**75**
15	10.1	11.2	12.8	15.1
20	9.9	11.0	12.7	15.0
25	9.7	10.8	12.5	14.8
30	9.5	10.6	12.3	14.5
35	9.3	10.4	12.0	14.3
40	9.1	10.2	11.7	14.0

Further information

For general information on drying and cooling see:

- "Storing, handling & drying grain: A management guide for farms" by Alan Andrews and Troy Jensen (QI 96081), a book available from DPI&F Client Service Centres
- DPI&F Call Centre open from 8.00am to 6.00pm Monday to Friday (telephone 13 25 23 for the cost of a local call within Queensland; interstate callers 07 3404 6999) or email callweb@dpi.qld.gov.au
- the Agridry Australia website www.agridry.com.au
- the Customvac Australia Pty Ltd website www.customvac.com.au
- GRDC website: http://www.grdc.com.au/growers/as/advice.html l (recent Update Advice papers, 'Aeration in on-farm storage – what's possible?, and 'How aeration works').

For other information on a wide range of grain storage issues, see:

- The book, "Insect pests in stored grain" by Eric Sinclair and Graham White (QI90021), www.dpi.qld.gov.au/shop.
- The DPI&F website www.dpi.qld.gov.au/fieldcrops/3947.html ■