DPI&F note

Grain storage – basic design principles

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Grain storage involves more than just placing grain in a suitably sized receptacle until it is needed. The grain is a major asset in which the grower has invested preparation, sowing and harvesting costs. The asset must be protected because while grain is in storage its quality and value deteriorate.

Grain storage principles

High temperature and high moisture are the most significant factors affecting grain quality in storage. Each can cause rapid decline in germination, malting quality, baking quality, colour, oil composition, and many other quality characteristics.

Insects and moulds impair the quality of grain directly by their feeding and development, and indirectly through generation of heat and moisture. High temperatures and moistures favour development of insects and moulds. Development of insects is limited by temperatures below 15^{o}C, and by moistures below 9% in cereal grains. Development of moulds is limited by temperatures below 10^{o}C, and by moistures below 13% in cereal grains.

Spraying with insecticides or fumigating minimises insect problems but leaves chemical residues in grain, which break down with time. Presence of residues, and their concentration, affects acceptability of the grain to markets. Some markets prefer grain without residues. Grain buyers will not knowingly accept grain treated at rates higher than those specified on the label, or within the specified withholding period.

How to maintain quality of grain in storage

Moisture management

High moisture grain should not be stored long-term. Accepted moisture limits for trading and storage of grains (Table 1) are generally below the limits at which moulds develop.
Moisture moves around inside a silo. Daily and seasonal temperature changes near the silo walls set up air movements that carry moisture to the coolest parts of the grain.
Pockets of high moisture grain (eg. grain harvested early in the season, late at night, early in the morning, or soon after rain) or inclusion of green leaf material with the grain can affect quality of all the grain in a storage because of moisture movement.

Table 1. Upper moisture limits for trading and storage of grains, based on National Agricultural Commodities Marketing Association standards

Grain	Moisture limit (% dry weight)
sunflower	9
barley (malting), faba beans, mungbean, oats	12
barley (feed), wheat	12.5
chickpea, pigeon pea, soybean	13
sorghum	13.5
maize	14

Note No: ……..
ISSN 0155 – 3054
Created: Feb. 2007
No of page: 5

Produced by: Food Protection Team, Plant Science

Queensland Government
Department of Primary Industries and Fisheries

- Aeration will slow the rate of deterioration of high moisture grain, but if the moisture is more than two or three percent above the limits in Table 1 it should be dried before long term storage.
- Early harvesting of grain at higher moistures produces higher quality and higher yield of grain, but those advantages are lost unless aeration and drying are used to minimise losses in storage.
- Hot-air drying is necessary to maintain the quality of high moisture grain. However, holding grain at too high a temperature for too long in the dryer will reduce grain quality. Operate the equipment according to specifications of the dryer manufacturer. Using higher airflow rates is a safer way to speed up drying than increasing temperature.
- Selling grain at a moisture content below that allowed by market results in economic loss. Grain loses approximately 1.2% of its weight for every 1% of moisture content reduction (for example, selling grain with a 9% moisture content when up to 12% is allowed means a loss of about 3.6% of the value).

Temperature management

Aeration will markedly reduce grain temperature, and so minimise the deterioration of grain quality. Aeration will also even out temperature differences that result in moisture migration from warmer to cooler patches in the grain. A zincalume or white finish on the silo will also contribute to a reduction in temperature.

Insects and chemical residues management

Good hygiene is an essential component of insect control in stored grain. Other options for insect control include:

- cooling grain with aeration,
- treating storages and equipment with inert dusts or residual chemicals,
- treating grain with inert dusts or residual chemicals,
- treating infested grain with dichlorvos,
- fumigation (bombing) with phosphine, or
- controlled atmosphere treatment (e.g. carbon dioxide).

Good hygiene combined with automatically controlled aeration is sufficient for some growers to maintain grain quality without using any residual treatment. Fumigation with phosphine leaves minimal residues, provided tablet formulations are not mixed with the grain. Check with buyers before spraying grain with insecticides.

For details on insect control see the DPI&F Note ‘Grain Storage - Insect Control in Stored Grain’, available at www. (Insert new web address)

Inspect grain frequently during storage

Stored grain should be inspected frequently. Insect or mould activity gives a distinct odour to air moved through the grain. By operating the aeration system and smelling the air coming through the grain, storage problems can be detected. Any `hot spots' should be cooled as soon as possible by aeration. If the problem is due to insect activity, the grain should be fumigated.

Storage capacity

Different grains have different densities and settle to different angles in the bulk pile. As well, the angle changes with moisture content. The grain also settles during storage. Therefore, all figures given are approximate. To obtain storage capacity in tonnes, multiply the storage facility volume (in cubic metres) by the appropriate conversion factor from **Table 2**.

Example: A silo with a heaped grain volume of 124 cubic metres will hold 93 tonnes of wheat (124 m^3 x 0.75 = 93 tonnes).
*To convert tonnes of one grain in storage to tonnes of another crop **divide** the tonnes of the first crop by its conversion factor and **multiply** by the appropriate factor for the second crop*.

Example: A storage holding 93 tonnes of wheat will hold:
93 x 0.62

0.75

=76.88 tonnes barley

Table 2 Factors for converting capacity in cubic metres to tonnes for selected grain products.

Grain product	Conversion factor
Barley	0.62
Canary	0.70
Chickpea	0.60
Faba Bean	0.75
Linseed	0.73
Lupin	0.75
Oat	0.50
Pea	0.75
Rapeseed	0.67
Rye	0.71
Safflower	0.53
Triticale	0.69
Wheat	0.75

Determining storage capacity

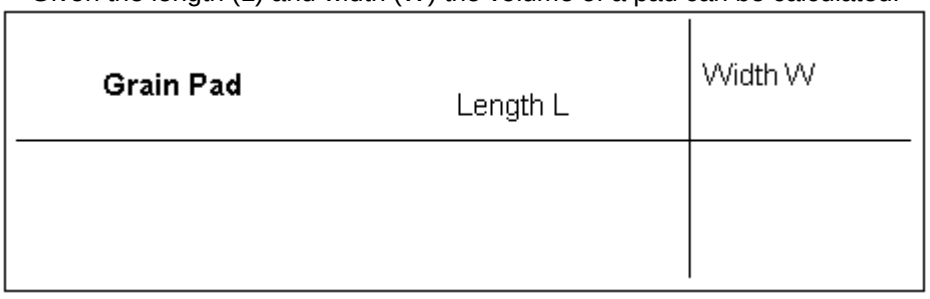
Flat pads

When working out the volume of grain stacked on a pad, the **angle of repose** for each grain type must be known. **Table 3** gives angle of repose for grain stored at safe moisture contents. These angles will increase for wet grain and may also vary slightly depending on grain quality and its admixture content.

Table 3 Angle of repose for different grains, and coefficients based on the angle for calculating volume of grain.

Grain	Angle	Grain coefficient
Barley	30^0	0.578
Linseed	25^0	0.466
Safflower	24^0	0.445
Wheat	28^0	0.531

Given the length (L) and width (W) the volume of a pad can be calculated.



Volume of pad $= \frac{W^2 \times (L - W) \times C}{4} + (1.05 \times C \times (\frac{1}{2}W)^3)$

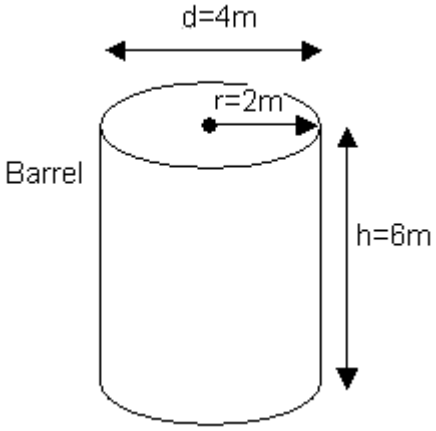
Where: W= width of pad
L = length of pad
C = grain coefficient

Example: Volume of wheat

Pad dimensions: width = 10m
length = 30m
Grain coefficient : 0.531
Volume = $\frac{10^2 \text{ x } (30 - 10) \text{ x } 0.531)}{4}$ + (1.05 x 0.531 x (5^3))
= 265.5 + 69.7
= $\underline{335.2 m^3}$

Tower silo

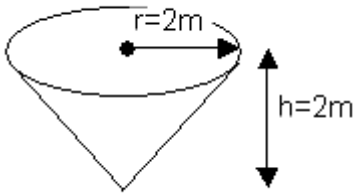
To determine the storage capacity of a tower silo, segment the silo into a barrel or cylinder and a cone.



The barrel's flat circular end has a:

- diameter (d) — 4m
- radius (r) (half the diameter) — 2m
- barrel height (h) — 6m.

The flat circular top of the cone has similar dimensions to the barrel:



- diameter (d) — 4m
- radius (r) — 2m
- cone length (h) — 2m

The volume of the barrel of the silo = $\pi r^2 h$
= 22/7x2x2x6

= $\underline{75.4 m^3}$

The volume of the cone of the silo = $\underline{1/3}\ \pi r^2 h$

= $\underline{1/3}$ x 22/7 x $\underline{2x2x2}$

= $\underline{8.4 m^3}$

Therefore, total volume of the silo = (75.4 + 8.4)m^3
= $\underline{83.8 m^3}$

Grain storage facilities

There is a range of grain storage facilities which can be used for on-farm grain storage. They all vary in their cost and the length of time they will be used for storage.

For information on grain storage facilities, see 'Storing, handling & drying grain: A management guide for farms' by A. Andrews and T. Jensen (QI 96081) which is available from DP&F Client Service Centres.

Short-term storage

Listed below are some forms of short-term storage facilities together with sources of information available on their construction and use.
Types of short-term storages are:

- Steel mesh silos: see DPI Note 'Steel-mesh silos for on-farm grain storage', on the PrimeNotes CD ROM (available from DPI&F Client Service Centres) and,
- Plastic covered bunker storage *and* ground dumps: see DPI&F Note 'Temporary storage of grain', on the PrimeNotes CD ROM (available from DPI Client Service Centres)
- DPI&F's web site: www.dpi.qld.gov.au/fieldcrops/3947.html

Long-term storage

Types of long-term storage are:

- Prefabricated steel silos *and* grain sheds: see 'Storing, handling & drying grain: A management guide for farms', by Alan Andrews and Troy Jensen (QI 96081) which is available from DPI&F Client Service Centres.
- Underground pits: see DPI&F Note 'Underground pit storage of grain', on the PrimeNotes CD ROM available from DPI Client Service Centres, through the DPI Call Centre ph: 13 25 23, and DPI's web site: www.dpi.qld.gov.au/fieldcrops/3947.html .

Further information

If you require further information:

- DPI&F website www.dpi.qld.gov.au/fieldcrops/3947/html .
- 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
- Or, contact one of the National Grain Storage Extension Team

Qld	Peter Hughes or Ken Bullen	07 4688 1200
Qld	Philip Burrill	07 4660 3620
Vic.	Peter Botta	03 5761 1647
SA	Peter Fulwood	08 8568 6422
WA	Chris Newman	08 9366 2309
NSW	John Cameron	02 9482 4930

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