GRAIN, FORAGE & FEED STRUCTURES GENERAL INFORMATION

COMPLETE INSTRUCTIONS

Good storage for farm crops is a sound investment, whether the material being stored is for use on the farm or for sale. Inadequate facilities and improper management can lead to substantial losses due to spoilage, insect and rodent damage, and fire from spontaneous combustion.

Before building new storage facilities, a complete storage and handling system should be designed to meet both present and future requirements and to maximize mechanization.

The number and size of storage buildings depend on the quantity and kinds of grain to be stored. In addition to single-purpose circular grain storage, consider the various rectangular multipurpose buildings; these often provide cheaper grain storage in the larger sizes, and can also be used for temporary storage of implements, fertilizer, bagged seed, etc. Concrete or steel silos are sometimes used for storing dry or high-moisture grains.

PLANNING GRAIN STORAGES

BUILDING SITE Surface and groundwater drainage is essential. Choose an elevated site or, if necessary fill the site with compacted gravel or sand before building. If poor drainage and high groundwater problems are expected, do not construct bin hoppers, leg elevator pits or other facilities below grade.

Arrange the buildings so that grain can be moved mechanically from one to another, or from any building to a vehicle. The storage area should have access to a public road.

STRUCTURAL REQUIREMENTS

FLOORS AND FOUNDATIONS Since grain is heavy, a reinforced concrete floor on the ground is recommended and is usually the most economical. The concrete floor should always be placed over a moisture barrier (such as a sheet of polyethylene) on compacted sand fill. Where grain must be stored overhead, have a qualified engineer design the supporting structure and footings.

ANCHORING Anchor all bins securely so that no shifting is caused by wind when empty or by the grain when filled. Wood wall studs must also be securely fastened to the sill and plate. In some cases, steel cables or tie-rods must be connected and adjusted tight before grain pressure is applied to the walls.

GRAIN HANDLING Grain is easy to handle mechanically. Arrange bins systematically so that the grain can be moved from one bin to another by horizontal or inclined conveyors (such as augers), often combined with a bucket elevator for vertical lift. Mechanical handling is essential for moving grain from trucks to storage quickly and efficiently, particularly during harvesting and drying operations when time is critical.

Unloading grain from the side of storage bins causes a sharp increase in outward pressure and vertical friction loads on the walls. Always unload flat-bottom bins from the center, not at the wall or access door. If the only available opening is at the side access door, insert an auger into the bin to unload most of the grain from the center.

CARE OF DRY STORED GRAIN Grain should be stored clean and dry, and inspected periodically for hot spots, dampness or other signs of moisture migration or spoilage. Storages over 100 m^3 (2800 bu) should have perforated floor ducts for periodic fan aeration, to redistribute or remove moisture that migrates within the grain mass. This moisture may accumulate locally and cause spoilage. Aeration fans should be sized to draw about 1.5 L/(s.m^3) (or 0.1 cfm/bu) through the grain. When grain insects or other infestations occur, treat the condition promptly.

RODENTS To control rodents, clean up weeds and debris that can provide hiding places around the grain center. Build all access openings rodent-tight (for example, use galvanized steel flashings, carefully fitted). Build concrete floors and foundations that discourage tunneling underneath. Use modern poisons if necessary.

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CLEANING EQUIPMENT Grain to be stored for over 1 month should be rough-cleaned. Advantages of pre-cleaning grain for storage are:

- reduced bulk (screenings removed may be used for livestock feed);
- easier drying (foreign matter contains moisture and blocks air flow);
- less dust; and
- easier mechanical handling (straw and debris can block conveyors).

MEASUREMENT OF GRAIN

The following are the basic units for measuring grain. Grain is traded in metric tonnes (t), weighed to three decimal places; this is equivalent to measuring the 'mass' of grain to the nearest kg.

Mass: 1 000 kilograms (kg) = 1 tonne (t)
Length: 1 000 millimetres (mm) = 1 metre (m)
Volume: 1 000 litres (L) = 1 cubic metre (m^3)
1.28 cu ft = 1 bu = 0.036 m^3

Bulk density is a convenient measurement for determining capacity of storages – see the following table for typical bulk densities of grains, forages and feeds.

To find the capacity of a grain storage, measure the container in metres, m (or ft), calculate the rated volume, m^3 (or cu ft), and then convert as follows:

In metric tonnes (t), bin capacity is

$$t = \frac{\text{rated volume } (m^3) \times \text{bulk density } (kg/m^3)}{1\,000}$$

or in Imperial units,

$$\text{bin capacity (bu)} = \frac{\text{rated volume (cu ft)}}{1.28}$$

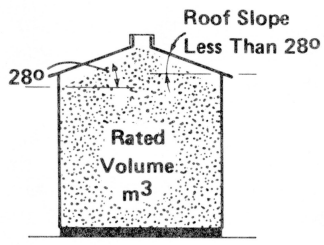


Figure 1

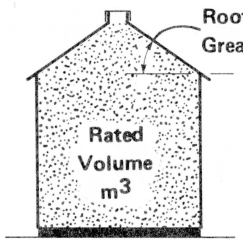


Figure 2

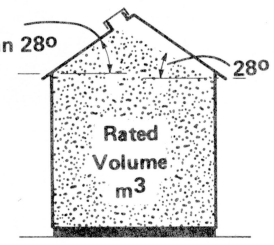


Figure 3

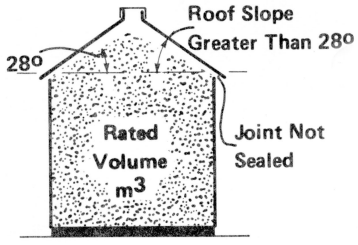
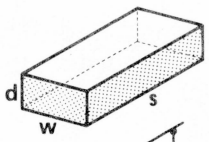


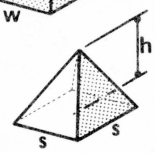
Figure 4

FORMULAE FOR CALCULATING RATED VOLUME



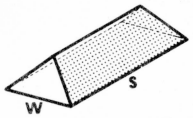
Rectangular solid,
$V = s\ w\ d$

where V = volume, m^3 (cu ft)
s = side, m (ft)
w = width, m (ft)
d = depth, m (ft)



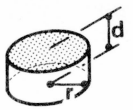
Square cone,
$V = 1/3\ s^2h$
where cone sides slope 28°,
$V = 0.08867\ s^3$

where s = length of each side, m (ft)
h = height from base to point of cone, m (ft)



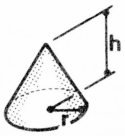
Rectangular pile, ends and sides sloped 28°,
$V = 0.133\ w^2\ (s-w) + 0.08867w^3$

where s = length, m (ft)
w = width, m (ft)



Cylinder,
$V = \pi\ r^2d$

where π = 3.1416
r = radius = 1/2 diameter, m (ft)
d = depth, m (ft)



Circular cone,
$V = \pi\ r^2h/3$
where cone sides slope 28°,
$V = 0.557r^3$

where π = 3.1416
r = radius = 1/2 diameter, m (ft)
h = cone height m (ft)
r = radius, m (ft)

'Rated volume' must be calculated for that part of the grain which fills the storage up to the eaves, as well as the heap or cone of grain which can be piled in the roof-space. To standardize the surface slope of this cone of grain, 28^{o} is suggested for the 'angle of repose'. This angle may or may not control, depending on roof slope and the type of joint between walls and roof. Figures 1 to 4 show how to rate the bin volume for various roof configurations typical of both round and rectangular storages.

HORIZONTAL SILOS

These may be the trench or pit silo, made either by excavating earth below grade or by making an earth embankment, or the bunker silo, made by erecting concrete or timber retaining walls above grade. Some of the major considerations for horizontal silos are:

- The access end of the silo should face south to minimize freezing at the feeding face.
- Walls must be strong enough for packing with a tractor, and as airtight as possible. They may be vertical, or sloped outwards at the top; a slight outward slope makes packing easier.
- Site and silo floor should slope diagonally outwards for drainage; the floor should never slope towards the silage feeding face.
- A paved floor is essential for operating a tractor-mounted silo unloader, to prevent mixing earth and silage.
- The silo should be proportioned so that at least 75 mm (3 in.) can be cut from the vertical feeding face per day, or at least 100 mm (4 in.) if summer feeding.

Cover the exposed top and face of the silage at each pause in filling, and seal the silage with airtight plastic film as soon as filling and packing is complete. Secure the plastic down tightly with ropes, used tires, baled straw, or heavy materials such as soil, sawdust or low-grade silage to prevent billowing in the wind. Keep ropes tightened during settlement by suspending used tires on the rope ends.

TOWER SILOS

Tower silos are built with cast-in-place concrete, concrete staves or steel. They may be exposed to outside air at the top (with top-unloader), or sealed to control the inside atmoshphere (usually with bottom-unloader).

A tower silo is heavy; design the foundation to support its mass when full, when the soil underneath is soft and wet. Softer soils and taller silos require a wider footing and more reinforcing steel.

For sizing ordinary top-unloaded silos, base the height on removing at least 50 mm (2 in.) of silage depth per day in winter, or 100 mm (4 in.) in summer. Base the diameter on this minumum depth and on the volume to be fed per day. Silo height equals the daily depth removed times days feeding period, plus allowance for silage settlement as well as clearance for the top-unloader.

If possible, whole-plant silages should be matured or field-wilted to 65% moisture before storing, otherwise seeping silage juices cause nutrient losses, damage to concrete, softening of the foundation soil and winter freezing problems.

Concrete silos intended for wet silage (over 65% moisture) should have at least the lower third of the walls sealed to prevent damage by acids. Increase the reinforcing steel at the bottom to handle the over-pressure from silage saturated with juice.

A watertight floor or membrane, together with perimeter floor drains connected to liquid manure storage, prevent silage juices from penetrating and softening the soil under the foundation.

Inside silo walls should be smooth, plumb and circular, for proper operation of the unloader.

HAY AND STRAW STORAGE

To reduce spoilage and weathering of hay and straw, provide some form of shelter. Simple pole-type construction with a plywood or metal roof is economical and reasonably effective. Select a well-drained site to prevent water accumulation at the base of the feed piles.

CORN CRIBS

Locate ear-corn cribs in a north-south direction on a well-drained site with year-round accessibility. Place them at least 20 m (65 ft) from other farm buildings to ensure maximum wind effects and to minimize snow drifts.

Because the moisture content of corn is usually high at harvest, cribs in most of the growing areas are limited to about 1.5 m (5 ft) maximum width to allow for natural drying. A concrete floor will reduce losses due to rodents. It is also recommended that corn cribs be roofed. Extend the roof beyond both sides of the crib.

TYPICAL SETTLED BULK DENSITIES OF GRAINS, FORAGES AND FEEDS

	kg/m^3	(lb/cu ft)
Barley	640	(40)
Flaxseed	720	(45)
Oats	400-560	(25-35)
Rapeseed	640	(40)
Rye	720	(45)
Soybeans	770	(48)
Wheat	770	(48)
Corn (shelled) –15.5% moisture	720	(45)
–24% moisture	740	(46)
–28% moisture	750	(47)
–32% moisture	760	(47)
(ground) –25% moisture	840	(52)
(husked ear corn)	450	(28)
Concentrates – pelleted	590-620	(37-39)
– crumbled	540	(34)
Long hay	64-80	(4-5)
Chopped hay	130-160	(8-10)
Square-baled hay	100-160	(6-14)
Round-baled hay	80-195	(5-12)
Wafered hay	320	(20)
Long straw	56-64	(3.5-4)
Chopped straw	100-130	(6-8)
Loose-baled hay	110	(7)
Baled wood shavings	320	(20)

Silage in tower silos (65% moisture)

Depth		Alfalfa		Corn	
m	(ft)	kg/m^3	(lb/cu ft)	kg/m^3	(lb/cu ft)
9	(30)	640	(40)	570	(36)
12	(40)	670	(42)	610	(38)
15	(50)	740	(46)	660	(41)
18	(60)	800	(50)	700	(44)
21	(70)	850	(53)	740	(46)
24	(80)	910	(57)	770	(48)

Silage in horizontal silo

Depth		65% Moisture		Dry matter	
m	(ft)	kg/m^3	(lb/cu ft)	kg/m^3	(lb/cu ft)
Packed 3-6	(10-20)	620	(39)	210	(14)
Unpacked 3-6	(10-20)	450-540	(28-34)	160-190	(10-12)