



## FEEDLOT DESIGN AND CONSTRUCTION

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# 33. Hay storage and processing

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## Introduction

Good quality hay and straw are used in feedlot production, particularly when cattle are introduced to grain based rations. Poor quality hay may inhibit intake, or be rejected and sorted out by the animals

Hay should be processed to a fibre length of 50–100mm so it can be thoroughly mixed in the ration and allow accurate measurement of daily feed intake. Processing can occur during baling (pre-conditioned or pre-cut), or in a tub grinder before being loaded into a feed mixer.

Hay and straw are bulky commodities that require a significant area and weather proof storage to maintain desired feed quality.

## Design objectives

The design objectives when storing hay are to

- Provide an all-weather, well drained and trafficable storage site that is near to the feed processing area.
- Maintain hay quality.
- Ensure the space provides for efficient and safe storage.
- Provide sufficient storage capacity for expected feedlot demand.
- Minimise the risk of fire.
- Provide a supply of pressurised water.

## Mandatory requirements

Council development or planning approval may be needed, unless already addressed as part of the feedlot approval.

Building approval is sometimes needed for farm sheds, depending on local council requirements and the location and size of the shed. Consult your local council in the planning stage.

## Design choices

Functional design for hay storage implies convenience of access, ease of handling, good site preparation and base material and appropriate building design/covering to prevent weather damage to the hay. Outlined below are the key elements that should be considered when designing a hay storage facility.

### Site selection

Most hay storage facilities at feedlots are permanently set up. General site considerations are discussed in *Section 28 – Feed preparation and storage* and *Section 2 – Feedlot site layout*. The additional factors that should be considered when selecting a hay storage site are outlined below.

### Accessibility

The storage site is usually located close to the feed processing facility/commodity shed, but at a sufficient distance to minimise damage to infrastructure if the hay spontaneously combusts or catches fire.

Sufficient space should be provided for vehicle manoeuvring and truck turning, unloading delivery trucks and transferring hay to the feed

processing area. *Section 13 – Access and internal roads* provides further information about turning areas for typical feedlot vehicles.

### Topography and drainage

Rainwater from the surrounding area and roof (if covered) must be drained away. Uncovered hay storage areas should be formed as a series of corrugations, rather than as a single plane, with a drainage path between each pair of corrugations. Each corrugation should be large enough to accommodate at least two rows of hay stacks (large square or round bales) and have a uniform cross fall of about 1% towards the drainage line.

Hay stacks should be aligned parallel with the longitudinal slope, with the corrugated cross-section allowing water to quickly drain away from each stack (rather than down a plane across multiple stacks).

The storage floor should be crowned about 200–300mm above the surrounding ground level. The storage area should have a longitudinal fall of 0.3–0.5%.

### Building separation and expansion

Hay storage should be located near the feed processing area for efficient transport. However, as hay can occasionally catch fire (self-combust), there should be a space of at least 15m between hay storage and other buildings. This is a compromise between safety and efficiency.

Pressurised water hydrants next to hay storage areas will provide some control in case of fire.

Additional space should be allowed for future expansion if required.

### Overhead powerlines

Sites near overhead powerlines should be avoided to remove any safety risk with machinery associated with hay stacking and unloading (e.g. telescopic loaders).

### Storage types

Hay storages can include

- Buildings – options for permanent hay storage structures include steel sheds with an iron roof and exposed sides, or iron roof with three enclosed sides. End bales stored in open-ended buildings can be covered with tarps or cloth, or doors installed to prevent bleaching.
- Semi-permanent covers – these include plastic panels or reusable heavy duty tarpaulins that cover the top bales in the stack, or tarpaulins that are stretched over a steel frame. These covers should be treated to avoid photo-degradation by UV light and should have some means of distributing the strain of tie-downs across the length of the stack. The tarpaulins are usually made from polyethylene or polypropylene, and should last five to seven years.
- Uncovered pads – bales stacked on the ground with no cover are the cheapest method of hay storage, but have the highest potential of weathering loss. Much of this loss occurs on the bottom of the bale where moisture levels remain highest and air movement is lowest. Outside storage losses can be reduced by selecting a well



*Fire hydrant located near the hay storage area.*

drained site and placing coarse gravel or materials such as timber to break the contact with the damp soil and provide air space between the bottom of the bale and the soil surface.

Table 1. Advantages and disadvantages of various types of hay storage

	Solid roof	Semi-permanent roof	Uncovered
Advantages	Lowest dry matter losses (5–10%), higher nutritional value, digestibility and palatability. Shed has other potential uses (other than hay storage).	Lower dry matter losses than uncovered stacks. Tarpaulins are relocatable, quick to install, multi-purpose cover or liner.	Simple, low capital cost
Disadvantages	Fixed, hay has to be transported to and from the shed. High capital cost.	Wind can affect security of the cover. Rainfall can collect on the cover UV exposure and birds can decrease life span.	Highest dry matter losses (30–60%) Greater losses from round bales (loss increases with smaller bale diameter) Regions with higher rainfall and humidity have higher rates of hay spoilage and/or dry matter losses.
Life span	20+ years	2–10 years (depending on the use of UV stabilisers)	Highly variable depending on the climate and site preparation/maintenance

### Storage capacity

Hay is often available once each year (typically at grain harvest), so storage volume may need to be large enough to last for a whole year.

The amount of hay storage needed depends on the quantity to be fed, the timing of hay being economically or seasonally purchased, storage type, space available for storage and bale type and size. Hay stored undercover can maintain its quality for more than 12 months, but hay stored outdoors without cover will show significant reductions in quality, dry matter and nutrients over time. Hay can typically be stored outdoors and uncovered for up to three months, with a maximum of six months.

Hay bales typically have a density of about 160–190kg/m<sup>3</sup>, but high density bales can be up to about 240–280kg/m<sup>3</sup>. Rectangular bales have higher bulk density than round bales. Denser bales create a more stable stack and will shed more rainwater if stored uncovered.

Stacks of rectangular bales require less space and so, by volume and mass, are cheaper to transport and stack in a covered storage system.

Building dimensions should be based on multiples of the size of bales to be stored plus 500mm at each outside wall. Many designs accommodate three layers of bales.

Adequate clearance to the bottom of the roof trusses, or other structural members, will allow for tilting of hay handling equipment (e.g. fully loaded front end loader). For most applications, this requires a minimum roof truss height of about 5.4m and 0.6m clearance between the top of the stack and the roof line.

### Building design

Hay storage areas can be ‘partially enclosed’ or ‘roof only’ structures.

Partially enclosed structures are usually open at one end, or side, for ease of filling, but are otherwise totally enclosed. These offer full protection from weather (e.g. rain, sunlight and bleaching),



A steel framed, fixed roof open shed. Bales are more likely to be stacked on the stringed side to increase stack stability (as opposed to the unbraced side).

but are more expensive and may have more restrictive structural requirements than open walled buildings. These structures may also have poorer ventilation than roof only structures.

The building should be constructed square, true and level and have a weather tight roof. Structural needs are relatively simple, with the main requirement being ability to withstand wind loads. The wind force on side walls and the overturning wind forces are much greater for fully enclosed buildings than for similar buildings with open sides.

Many commercially manufactured rigid frame farm buildings will make excellent and economical hay storage areas. The wind loading should be appropriate for the locality and site and base preparation specified for the storage of hay.

Most shed companies provide a holistic design, structural design and manufacture service, but structural design requirements may be obtained from a consulting structural engineer. Further information about farm building construction techniques can be found in *Section 40 – Machinery workshops*.

### Floor and base material

The floor of hay storage areas should be constructed to a finished height of 200–300mm above the surrounding natural surface level to prevent entry of stormwater run-off. Alternatively, shed walls and/or bunding can be used to exclude run-off. Water absorbed by bales at the bottom of the stack can not only cause spoilage, but also comprise the structural integrity of the stack and possibly result in the top bales tilting off.

The base material should maintain the quality of the baled hay and provide a durable all-weather surface that can withstand heavy point loadings (e.g. from fully loaded hay trucks and handling equipment) and the impacts of machinery dry-steering.

The best base for hay storage is a compacted granular material that provides good drainage. Larger rocks (up to cricket ball size), provide the best aeration and separation of the hay from damp earth or sub-base material. The gravel pavement should have a thickness of 200–300mm to support typical vehicle loadings and allow access after wet weather.

Condensation from concrete floors can cause spoilage but this may be prevented by spreading a layer of hay over the floor before placing the bales. Storing hay directly on an earth floor results in significant spoilage, with dry matter and nutrient losses.

### Ventilation

Hay quality is compromised by moisture and poor air exchange. The storage must allow natural ventilation to remove moisture from several sources including

- Hay that is not completely dry.
- ‘Sweating’ due to respiration and microbial activity in the hay.
- Moisture that accumulates due to ‘moisture migration’ from warmer to cooler areas of a stack.
- Condensation that forms on the underside of steel roofs and drips on to the hay.



*The large span of a steel framed, fixed roof open shed provides unrestricted access. Downpipes take roof water away from the storage area.*



*Fixed roof, open sheds vary in structural design and geometry.*



*Fixed solid roof, supported by concrete encased steel columns*



*Hay storage area – Bales are placed on a raised area with drainage lines on each side. Space between bales allows air flow and ventilation.*



*Semi-permanent PE tarpaulin with tie-downs attached to truck tyres. Stack size is based on transport load size.*



*Uncovered stack with round bales stacked in rows. Space between rows assists air flow and ventilation.*

The open side of a three-sided shed, or covered stack, should face away from the prevailing wind to minimise weather exposure to stored hay and straw during storms and rain.

Adequate space between stacked bales improves ventilation and air flow.

### Bale arrangement

Rectangular bales are best stacked in rows for ease of covering. Bales should be stacked so that each separate layer is stepped forward or back on the below bales to increase the stability of the stack.

When using semi-permanent covers, round bales can be stacked as high as is practical and safe (usually in a 3-2-1 pyramid design, with three bales in the bottom layer, two in the second layer and one on top). This arrangement minimises the size of the tarp needed relative to the volume of hay stored and forms a natural peak that will effectively shed water.

Falling hay bales, or the collapse of stacks, can cause injuries - and even potentially death - to personnel and damage to equipment. Stacks can become unstable if bales are stacked too high, the stack base is compacted or settles unevenly or the stack is exposed to weather.

A stable stack height should be determined before starting stacking, with regard to bale condition, terrain and equipment to be used.

For outdoor storage areas, a north-south orientation of stacks will increase the incidence of sun exposure on all exposed parts of the bales.

Round bales stored outdoors and uncovered are best stacked on their sides, end-to-end and in long rows orientated north-south to increase sun exposure to all exposed parts of the bales. Individual rows should be separated by at least 1m to promote drainage of rainfall and enhance air flow and ventilation that removes moisture expiring from the bales or ground surface.

If round bales are stored under cover, they can be stacked on their ends, several rows high and with each separate layer stepped forward or back on the below bales to increase stack stability. Alternatively, they can be stacked in rows on top of each other to form the 3-2-1 pyramid shape.

Another arrangement that does not require a loader attachment is a 3-2 pyramid. This lacks the natural peak that would more effectively shed water. Stacks of bales should be placed on a slope, running the direction of the length of the stack so that water would drain off the end of the tarp. This design reduces storage capacity by 17%, compared to the 3-2-1 stack, but requires a slightly smaller tarp.

Another alternative solution is to place square bales in the middle of the upper layer to construct a middle peak to the stack. The cost and trouble of the extra labour would have to be considered.

Bales should not be stacked against the side walls or end walls of buildings, as most sheds are not designed for the horizontal loads exerted by the bale stack.

## Safe storage

Hay that has high moisture content when baled can heat up and spontaneously combust when stacked. Hay bales should be tested for internal moisture content before being placed in the storage area. Fire risk can be reduced by providing good ventilation (including leaving air space between rows of stacked bales) and by reducing the stack height, which lessens the mass loading on the bottom bales in the stack. Pressurised water hydrants would prevent fire spreading, but would be unlikely to extinguish a major fire.

Compliant mufflers/spark arrestors should be fitted to all hay handling and processing equipment and all machinery should be equipped with a portable fire extinguisher.

Signage should alert people to the dangers of approaching the hay storage area (e.g. bales falling from the stack and limited visibility of the machinery operator when stacking/unstacking hay).

## Processing

Hay is processed to reduce the fibre length to 50–100mm. This allows good mixing with other ration ingredients and prevents animals separating out feed in the bunk. Feeding hay separately may result in a variable nutrient intake and production.

Processing methods are outlined below.

### *Pre-conditioning during baling*

Bale conditioners cut hay into predetermined lengths during the baling process. Pre-conditioned bales are denser and this helps to reduce freight costs. Depending on cut lengths, pre-conditioning can eliminate the need for any further processing before feed out.

### *Tub grinding*

Tub grinders use gravity and tub rotation to feed hay into a series of cutting knives, or a hammer mill at the base of the tub. The screen size of the hammer mill should be large to optimise fibre length without being too fine.

Hay hammer-milled or chopped hay is less dense at 100–150kg/m<sup>3</sup>.

Tub grinders quickly and effectively grind large volumes of hay, but have high power requirements. The speed at which a tub grinder is driven and the rate at which hay is fed into it can vary the fibre length. Typically, tub grinders are power take-off (PTO) driven by electric motors, tractors or diesel engines. These may be portable or permanently stationed.

Tub grinders should be located outside commodity sheds, as grinding can heat the material so that it can start smouldering, spontaneously combusting or catching fire. Fire fighting equipment should be provided and maintained next to the machine and a buffer allowed between other buildings and commodity storage areas.

Roughage can be thrown into the air above the tub and lost between the tub base and conveyor, or blown off the conveyor during unloading. Losses can be as high as 30% from dust and fine particles of hay. Dust may be a problem with tub grinding equipment. The direction of prevailing winds needs to be considered when locating permanently set equipment.



*Diesel powered portable tub grinder. This model incorporates a dedicated power plant, but tractor-driven PTO systems are also available.*



*Electric powered semi-permanent tub grinder.*



*A permanently positioned electric powered tub grinder with the discharge conveyor set below ground level. This arrangement inside the commodity shed presents a greater fire hazard than a portable self contained unit that is easy to access and clean down.*

*Mixer processors*

The most common type is the vertical mixer. These mixers can process and mix hay, eliminating the need for additional processing before feed out. These work best for mixing and feeding with low percentage hay rations and for small feedlots, where the overall quantity of rations fed out each day is low. For high percentage hay rations, cutting and mixing takes a long time and chop length may be inconsistent.

## Quick tips

- Storing hay under cover preserves dry matter, nutrients and quality and may reduce shrinkage by 30%.
- Storing hay under cover reduces spoilage and contamination.
- By volume and mass, rectangular bales are more cost effective to transport and stack in a covered storage system.
- Exposed hay or shed openings should face away from the prevailing wind to minimise rain damage.
- Uncovered storage areas should be gravelled to accommodate vehicle loadings and all weather access.
- Uncovered or temporary storage areas should have a corrugated cross-section to help drainage.
- Orientate uncovered hay in rows running north-south to increase the bale exposure to the sun.
- Stacks of hay should be separated to increase air flow between bales, provide good ventilation and allow access for tying down tarpaulins.
- Tub grinders have high power requirements and increase shrinkage of hay during processing.
- Tub grinders can cause fires. Fire fighting equipment and proximity to buildings should be considered when setting up this machinery.

## Further reading

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