FEEDLOT DESIGN AND CONSTRUCTION

28. Feed preparation and storage

AUTHORS: Rod Davis and Ross Stafford

Introduction

Cattle in feedlots require a nutritionally and scientifically formulated grain based diet to meet production targets.

Metabolisable energy (ME), crude protein (CP) and fibre are the major components, with smaller quantities of minerals and vitamins added. The proportions of the commodities used in the formulated ration will depend on the desired level of cattle performance, the nutrient content of the individual feed commodity, the quantity of the feed commodity available, the current price of each commodity and the desired beef carcase conformation.

Ration preparation and delivery systems

For small feedlots

A pre-prepared or pre-mixed grain and supplement ration is delivered to the feedlot and fed out on site. The pre-mixed ration may be purchased from a commercial stockfeed manufacturer or from a feed mill on a neighbouring feedlot. Bulk storages are needed for the prepared rations, with storage for silage and/or hay to supplement the pre-prepared ration and a system for delivering the rations to the feed bunks. This option consists of a few simple structures and handling components.

For medium to large feedlots

Rations are prepared on site in a facility with associated commodity storage, handling and ration delivery infrastructure. The size and configuration of the system depends on the size of the feedlot and type of animals to be fed.

On site feed preparation and commodity storage requires an integrated system of components and processes. The basic components of an on site feed preparation facility include

- Grain storage and handling
- Grain processing
- Other commodity storage and management
- Silage storage and management
- Hay/straw storage and management
- Storage and handling of liquid ingredients and supplements
- Ration mixing and delivery systems.

The integrated components may include storage structures (such as silos, bunks and sheds), handling equipment (such as augers and conveyors) and grain processing, feed mixing and delivery operations.

Design objectives

The feed preparation and handling systems should be designed, constructed, operated and maintained to ensure

- The overall system meets the feedlot requirements for preparation and delivery of mixed rations.
- Good accessibility and traffic flow around the feedlot and within individual facilities.

- The design of each component meets the working needs of the facility and ensures efficient and use of resources.
- Pre-prepared rations, grain and other commodities are unloaded, stored and handled to maintain product quality and minimise safety risks.
- Waste is minimised.
- Feed efficiency is maximised.
- Designated cattle performance is achieved.
- Suitable and convenient access for people and equipment (trucks and trailers) even in adverse weather.
- Allowance for unexpected interruptions in feed commodity deliveries due to industrial action or natural disasters.
- Potential expansion of feedlot capacity.

Mandatory requirements

The building elements, such as concrete footings, floor slabs and steel structures, shall achieve the structural provisions of the Building Code of Australia (BCA) and local building regulations and be designed in accordance with the relevant Australian standards.

Storage of industrial quantities of flammable and combustible liquids held in steel horizontal, rectangular and vertical tanks must comply with the methods described in the relevant Commonwealth, State and local authority codes, regulations and relevant Australian Standards (*see Section 38 – Fuel and gas storage*).

Compliance with relevant Commonwealth, State and local authority codes, regulations and relevant Australian standards for installation and operation of boilers. This includes boilers for the generation of steam, heating of water at a pressure above that of the atmosphere and boilers having any of the following sources of energy input – gas fuel, oil fuel, solid fuels, waste heat fuels, solar energy and electric power.

Compliance with the legal obligations to provide for the health and safety of workers within work health and safety regulations and legislation (Work Health and Safety Act 2011/Work Health and Safety Regulations 2011).

Grain handling and storage facilities need all-weather access, and should not interfere with operational traffic to pens.

Design choices

Location on site

The location of the feed storage, handling and processing facilities on the overall feedlot site is critical. See *Section 2 - Feedlot site layout* for details about overall site layout considerations.

The most important considerations in selecting a location for these components are outlined below.

Accessibility and traffic flow

Grain and commodity receival and storage facilities will need all-weather access for varying sizes of grain and commodity transport vehicles. The receival and storage areas should be easily accessible and not affect the flow of operational traffic around the feedlot during placement and removal.

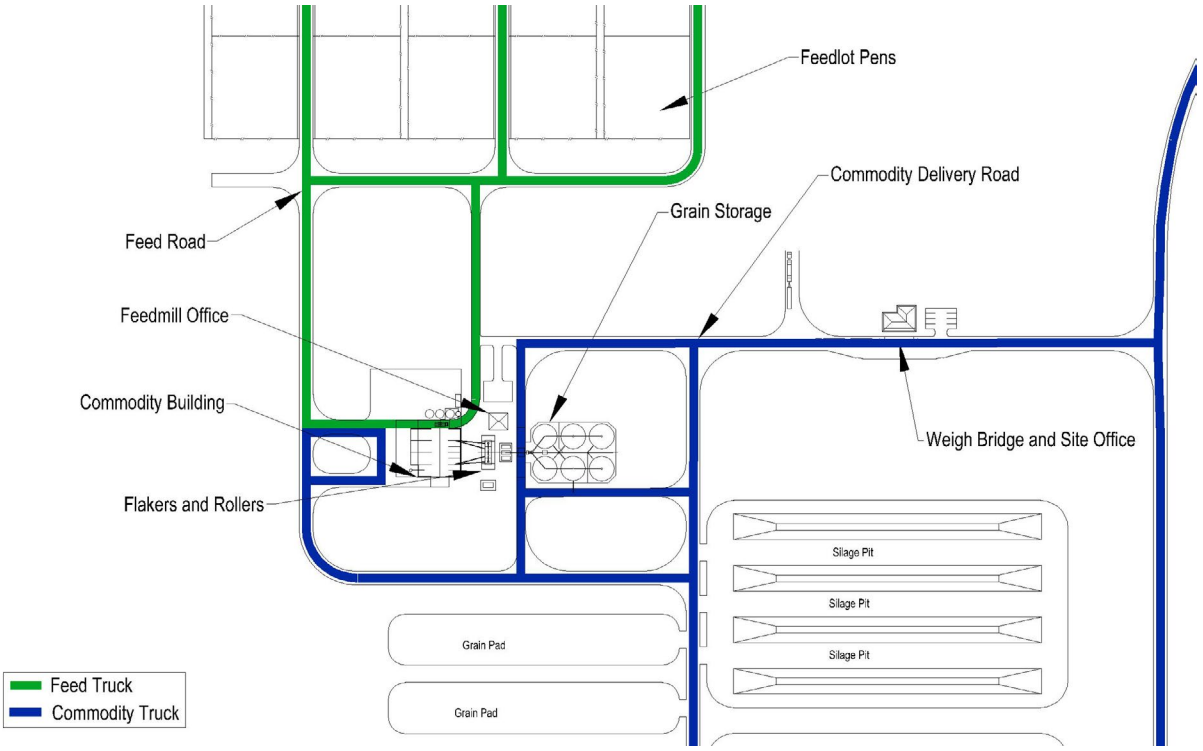

Figure 1. Paths for receival and storage areas should not affect the flow of operational traffic around the feedlot.

Hay/straw storage areas should be located close to the feed processing facility/commodity shed, but at sufficient distance to minimise damage to infrastructure in the event the forage catches fire.

Grain and commodity transport vehicles require sufficient area for manoeuvring and loading/unloading. *Section 13 – Access and internal roads* provides further information about turning areas for typical feedlot vehicles.

The grain and commodity receival and storage facilities should not be isolated from the feedlot during periods of severe wet weather or flooding.

Feed mill (centre) located next to pens in a large feedlot.

The feed storage, handling and processing facilities should be integrated into the overall site layout to ensure good traffic flow around the site. The number of vehicle crossover/intersections should be minimised, and grain and commodity delivery vehicles paths should be separated from mixed ration delivery and livestock vehicles paths.

Traffic through the feed storage, handling and processing facilities should be limited to that directly involved with the feeding system. Other traffic should be directed around this area.

Separate paths for pedestrians will result in less interference and reduce potential for accidents.

Layout should allow feeding system vehicles to move in a forward direction, but with adequate space and reference markers if reversing is required. Storage locations for spare feeding equipment should not interfere with other vehicle or pedestrian traffic.

Proximity to production pens

Locating the feed preparation and commodity storage facilities near the production pens will reduce travel distances and minimise the

cost of delivering feed to cattle. But some distance may be needed to ensure the ration is correctly mixed.

Services

Electricity will be the main source of power for grain handling, grain and roughage processing equipment and associated control systems. The electricity supply system must be appropriate and should take into consideration possible future expansion. Some storage areas (e.g. silage and hay) should not be situated near overhead power lines because of the risk from machinery associated with hay stacking (e.g. telescopic loaders). Some other forms of energy may require dedicated storage facilities, such as vessels for LP gas.

Water will be required for some grain processing methods, general cleaning purposes and fighting potential fires at hay stores and tub grinders.

Security and biosecurity

Visitor access to feed preparation and storage facilities should be restricted to reduce interference with feedlot operations, enhance safety and minimise the risk of product contamination.

Good biosecurity management will minimise feed contamination and the introduction and spread of noxious weeds.

Topography and drainage

The feed preparation and storage areas (e.g. silage pits) should be well drained and within the controlled drainage area of the feedlot.

Storage sites should be located well away from gullies or other places where storm water run-off can flow into feed preparation and storage areas. Storm water run-off should be diverted away from feed preparation and storage structures. This may require additional earthworks and/or control structures (e.g. culverts) at the time of site preparation.

Above or below ground constraints

Above or below ground constraints should be avoided. Above ground constraints include overhead power lines and trees. Below ground constraints include underground services, such as power, gas, water and telephone infrastructure.

Feedlot undergoing expansion. The old feed preparation and storage area is next to existing pens and a new feed mill is being constructed central to both new and old pens.

Geotechnical

The physical properties of the soil at the site should be assessed to determine suitability for the storage base and building foundations. Avoid areas with rock, as these may increase costs of earthworks and building foundations.

Building separation and expansion

Space should be left for potential future expansion of the feed preparation and storage facility.

As hay/straw has a low bulk density and is a significant component of some feedlot diets, this should be stored near the feed processing area. However, a compromise between efficiency and safety requires a space of at least 15m between storage of this material and other buildings due to the potential risk of spontaneous combustion.

Provision for fire protection (e.g. water hydrants) should also be considered for hay/straw storage areas.

Groundwater and surface water protection

The feed preparation and commodity storage facilities should be situated so that the risk of groundwater and surface water contamination is minimal. Some parts of the facilities, such as silage pits and liquid commodity storages, may need to be situated within the controlled drainage area of the feedlot (see *Section 10 – Pen and drainage systems*).

Large feed mill and commodity storage.

Flooding

The feed preparation and commodity storage facilities should be above a one in 100-year average recurrence interval (Q_{100}) flood height, unless protected by extra levees or similar structures. Local guidelines should be consulted to determine flood heights and if flood protection structures are permissible.

Provision for future expansion

Adequate room should be allowed for expansion and flexibility in the commodity storage and feed preparation facility design. Any plan based only on current needs will be difficult and expensive to expand. The rule of thumb is to undertake projections for feedlot needs out by five years and then double this. This leaves room for future expansion, even though the capital investment will cover immediate or near-term needs.

Facility design and layout

No single facility design will be suited to all feedlots. Each design must be evaluated on the basis of the requirements of an individual feedlot system. Important factors to consider are outlined below.

Feed mill on small feedlot.

Nutritional considerations

- The effect of various ration designs on feed intake, rate of gain and feed efficiency. Will increased cattle performance more than offset any increase in capital and /or operating cost?
- Response of type of grain to processing. Is feed efficiency improved and/or feed consumption reduced?
- Uniformity and quality of finished product. Are the amounts of fines, separation, palatability, surface area, density or weight acceptable?
- Influence on beef quality. Is meat colour, fat colour or marbling affected?
- Can a range of different commodities and liquid feedstuffs be stored and various rations be produced and distributed?

Non-nutritional considerations

- The required design capacity of the system.
- The capital cost of the system.
- Size of feedlot. Is the feedlot large enough to justify investment in grain processing equipment?
- The estimated operating and maintenance costs of the proposed equipment.

- The labour requirements to operate the system.
- Potential spoilage, wastage, losses and grain degradation.
- Inventory shrink.
- The process flow/layout requirements of the system.
- Access for commodity delivery and ration delivery vehicles. Ideally no reversing, which can be achieved with continuous loop roads.
- Protection from the weather.
- The level of automation possible and capital cost.
- Availability of services (e.g. water and mains power supply).
- Energy costs.
- Location of weighbridge (see *Section 27 – Truck weighbridges*).
- Ease and safety of operation.
- Operational safety of vehicles and people.
- Allowance for future expansion.
- Worker safety in terms of machine guards, walkway handrails and ladders.
- All foundations, concrete footings of heavy and/or silo-type structures designed by a geotechnical/structural engineer.
- The facility is located so that it is 200–300mm above natural surface to prevent entry of run-off.
- A suitable stormwater drainage system is provided around the facility.

Roller mill for processing grain.

Grain processing

Processing grain improves the digestibility of grain starch, feed efficiency and animal performance.

Grain processing methods can be broadly categorised as 'wet' (e.g. steam flaking, reconstitution or tempering) and 'dry' (rolling). Wet processing grain provides higher digestibility but is generally more expensive in terms of both capital and operational costs.

It may be more economical for smaller feedlots to obtain processed grain off site, either as a single commodity or in a pre-mixed ration. Larger feedlots need a processing system on site because of the large quantities of grain and other commodities required each day.

Grain processing methods are outlined in *Section 29*.

On-site grain storage facility.

Grain storage and handling

Grain based rations typically contain more than 80% cereal grains on a dry matter basis. This means infrastructure associated with grain handling, storage and processing is a dominant component of the feed preparation facility.

Feedlots with on site feed processing require bulk storage and grain handling. Feedlots using commercial pre-mixed feed will also need on site bulk storage.

The storage and handling of grains requires systems that are compatible with each grain type and grain characteristic. Consideration should be given to whether the grains to be handled are whole grains, ground grains or processed grains.

Grain storage and handling is outlined in *Section 30*.

Commodity storage shed with multiple storage bays.

Silage bunks.

Hay storage in open-sided shed.

Liquid supplement storage and dispensing system at small feedlot.

Commodity storage and management

Facilities for the bulk storage and handling of feed commodities are needed when the ration is processed on site. The required type of storage ranges from dry feed commodity storage, fermented feeds (including silage and high moisture corn), by-products, processed roughage, liquid feedstuffs (such as molasses) and liquid supplements.

The bulk storage and handling of these feed commodities depends on many factors, including the range of commodities to be stored, the storage volume, the length of time the commodity is to be stored, the processing systems, the loading systems, the capital investment and the operational and maintenance costs of the facilities and equipment.

Commodity storage and management is outlined in *Section 31*.

Silage storage and management

Roughage, or fibre, is essential in the diet of lotfed cattle to enable normal rumen activity and may be provided as silage, hay or straw.

Silage typically contains higher levels of ME and CP than hay and is considered more palatable and digestible.

The silage making process, design and management of storage are critical to ensure the highest quality product, while minimising losses during storage and feeding. Good quality silage, correctly harvested and stored, maintains its quality for a long time.

Where the local environment or feed processing equipment is not suited to growing and/or handling silage, a feedlot may feed hay instead.

Silage storage and management is outlined in *Section 32*.

Hay and straw storage and management

Hay or straw is best fed in a chopped form when mixed with the grain and other commodities to ensure even intake of the concentrate and roughage.

In an on site feed processing facility, the relatively high percentage of roughage in a typical ration requires significant amounts of hay (and/or silage) to be stored on site.

Hay storage and management is outlined in *Section 33*.

Storage and handling of liquid feedstuffs

Liquid feedstuffs are used for conditioning rations, improving palatability, reducing dustiness and providing vitamin and mineral nutrients to cattle. Many liquid by-product materials are available, along with commercial liquid supplement products that incorporate minerals, vitamins and enzymes.

When liquid feeds are used in rations that are prepared on site, these need special equipment. This includes tanks and pumps designed to handle liquids.

Storage and management of liquid feedstuffs is outlined in *Section 34*.

Ration mixing and delivery

In feedlot production, it is important to maximise dry matter intake. This is influenced by the method that is used for mixing and delivering feed to the feed bunk. The greatest control over intake can be achieved with a total mixed ration where feed ingredients are batched together by weight, then mixed and delivered to the cattle.

The components of the feeding system are feed storage areas, a feed batching and mixing area and equipment to deliver the feed to the pens. Mixing and delivery are usually performed with a tractor-trailer unit, or a truck with a mounted feed mixing/delivery bin. Stationary mixers and bulk feed delivery vehicles can also be used.

The equipment required for ration mixing and delivery depends on the type of ration preparation system (pre-mixed or prepared on site), the feeding system (bunk or self-feeders) and the feeding strategy (uniformity, quality of finished product and number of feed deliveries per day).

Ration mixing and delivery is outlined in *Section 35*.

Commodities and liquid supplements being loaded into feed-mixing and delivery truck.

Quick tips

- The site for on site feed storage and processing needs to consider traffic flow patterns and proximity to production pens.
- Allow sufficient area for vehicle manoeuvring and turnarounds.
- Evaluate the effects of the design and layout of on site feed storage and processing infrastructure on non-nutritional and nutritional considerations.
- Allow sufficient area for the storage of required volumes of roughage.
- Feed processing and delivery is the largest consumer of energy at a feedlot. Poor facility design and/or poor location can lead to increased operational costs.
- Locate hay storage and processing equipment away from the main feed preparation facility to minimise the risk of fire spreading.
- Consider future expansion of the feedlot capacity.

Further reading

Appel, W B. 1985, Physical Properties of Feed Ingredients. Feed Manufacturing Technology III. pp 557-562 American Feed Industry Association. Arlington VA.

Bath, D J. Dunbar, J. King, S. Berry, R O. Leonard, and S. Olbrich. 1990. Byproducts and unusual feedstuffs. Feedstuffs Reference Issue. Feedstuffs 62 (3 1):32-37.

Campling, R C. 1991. Processing cereal grains for cattle — a review. Livestock Prod. Sci. 28:223-234.

GRDC, 2012, Grain storage facilities Planning for efficiency and quality A Grains Industry Guide, Grains Research and Development Corporation , Canberra, ACT.

Guyer, P Q, "G73-14 Grain Processing for Feedlot Cattle" (1973). Historical Materials from University of Nebraska-Lincoln Extension. Paper 249.
http://digitalcommons.unl.edu/extensionhist/249

NRC 1984 "Nutrient Requirements of Beef Cattle". National Academy Press.

Macken, C N., Erickson, G E. and Klopfenstein, T J. 2006. The cost of corn processing for finishing cattle. The Professional Animal Scientist 22:23-32.

Mathison et al. 1997. Effect of tempering and degree of processing of barley grain on the performance of feedlot cattle. Can. J. Anim. Sci. 77:.

McEllhiney, R.R (ed) 1994, Feed Manufacturing Technology IV, American feed Industry Association Inc, Arlington, VA.

McKinney, L.J. Grain processing: particle size reduction methods, Kansas State University Manhattan, KS

Newman, C. 2003, Grain storage: Handling and maintenance, Farmnote No. 66/2003.

Owens, F N., Secrist, D S., Hill, W J. and Gill, D R. 1997. The effect of grain source and grain processing of performance of feedlot cattle: A review. J. Anim. Sci. 78:868-879.

Standards Australia 2010, AS 2628-2010 Sealed grain-storage silos - Sealing requirements for insect control

Standards Australia 1989, AS 3729-1989 Farm Silos – Determination of storage capacity

Standards Australia 2002, AS/NZS 1170.1:2002 Structural design actions – Permanent, imposed and other actions

Standards Australia 2007, HB 867-2007 Supplementary information for design of farm structures

Standards Australia 1992, AS1657-1992 Fixed platforms, walkways, stairways and ladders – Design, construction and installation.

Standards Australia, 2009, AS3600-Concrete Structures

Standards Australia 2003, AS3850- 2003 Tilt-up concrete construction

Standards Australia 2004, AS1940-2004, The storage and handling of flammable and combustible liquids.

Standards Australia 2002, AS/NZS 1596:2002 The storage and handling of LP Gas.

Standards Australia, 1992, AS1657 -1992 Fixed platforms, walkways, stairways and ladders – Design, construction and installation.

Standards Australia, 2009, AS2865-2009 Confined Spaces.

Standards Australia (1998). Steel structures, AS 4100-1998, Sydney, NSW, Standards Australia.

Standards Australia (2002). Dead and live load combinations, AS/NZS 1170.1-2002, Sydney, NSW, Standards Australia.

Standards Australia (2005). Cold formed steel structures, AS/NZS 4600-2005, Sydney, NSW, Standards Australia.

Standards Australia (2009). Concrete construction (including reinforced and prestressed concrete), AS 3600-2009, Sydney, NSW, Standards Australia.

Standards Australia (2011). Masonry (including masonry-veneer, unreinforced masonry and reinforced masonry), AS 3700-2011, Sydney, NSW, Standards Australia.

Standards Australia (2011). Wind Loads, AS 1170.2-2011, Sydney, NSW, Standards Australia.

Theurer, C B (1986). "Grain processing effects on starch utilization by ruminants". J. Anim. Sci. 63:1649.

Williams, D L, 1991,Handling and Storage of Alternative Feeds. University of Wisconsin-Madison.

Zinn, R A. 1994. Influence of flake thickness on the feeding value of steamrolled wheat for feedlot cattle. J. Anim. Sci. 72:21-28.