Chapter 10
Livestock housing

INTRODUCTION

The main purpose of livestock production is to convert the energy in feed into products that can be utilized by human beings, such as milk, eggs, meat, wool, hair, hides and skins, draught power and manure (fertilizer). Traditional, extensive livestock production involving indigenous breeds and low-cost feeding will usually have low performance and can therefore only justify minimal, if any, expenditure for housing. However, where improved breeds, management and feeding are available it will usually be economically beneficial to increase the production intensity.

Although this can be facilitated by, among other things, the construction of buildings and other livestock structures to provide for some environmental control, reduced waste of purchased feedstuffs and better control of diseases and parasites, this rule is not invariable. For example, it is difficult to identify an economic benefit in sheep production arising from the use of anything but the least expensive buildings. At the other end of the scale, a relatively expensive farrowing house, providing a high level of environmental control, may improve the survival rate in piglets sufficiently to justify the cost and add to the profitability of the production unit.

The planning and design of any structure for a livestock production system involves many alternatives for each of numerous variables and can therefore be turned into a complex and theoretical subject, but is usually far simpler in reality. However, every facet of the design, including the production system, equipment, building materials, layout and location, will play a part in determining the profitability of production and any variation in one of them may significantly affect the profitability of the whole.

One special difficulty when designing livestock structures for tropical climates is that, up to now, most research and development has been concerned with the conditions in temperate or cold climates. Any recommendations derived from such experiments and applied uncritically in warm climates may result in an adverse environment for the animals and in very high building and operating costs.

ANIMAL BEHAVIOUR

Introduction

A basic understanding of domestic animal behaviour and the relationship between human beings and farm animals can contribute greatly to increased economic benefit in animal husbandry and to easier handling of the animals. The importance of animal behaviour aspects in the design of animal housing facilities generally increases with the intensity of production and the degree of confinement. Many modern farming systems greatly reduce the freedom of animals to choose an environment in which they feel comfortable. Instead they are forced to resort to an environment created by humans.

Animals that can exercise their natural species-specific movements and behaviour patterns as far as possible are less likely to be stressed or injured and will therefore be more productive. However, in the practical design of an animal production system and any buildings involved, many other factors, such as feeding, management, thermal environment, construction and economics, can be equally or even more important. The animals can, to some extent, adapt their behaviour to suit a bad design and, on a long-term basis, they can be changed by breeding and selection, but generally it will be much easier to tailor the husbandry and building design to the animals.

The lifespan of a building is usually 5 to 15 years, which makes it clear that even a small increase in production or decrease in the frequency of injury and disease, feed waste or labour requirements for animal handling will repay all the thought and care that has been put into the design, layout and construction of the building. Furthermore, it may cost as much to construct a building that is poorly designed and equipped for the animals as one that works well.

Behaviour patterns

Farm animals are born with certain fixed behaviour patterns, such as pecking in chickens and nursing in mammals, but most behaviour patterns develop through play and social contact with other animals of their kind and under the influence of environmental stimulation and genetic factors. Although behaviour variation within a species is caused mainly by differences in the environment and between the sexes, breed, strain and individual variance also have an influence. Domestic animals show great ability to modify their behaviour patterns in relation to environments and to learn from experience.

Animals often form a daily cycle of habits caused by the uniformity of husbandry; for example, the regular variation in light during night and day relate to internal physiological rhythms. This is why cows gather around the barn just before milking time. Some behaviour patterns change from season to season, partly in response to the changing weather. Cows tend to be more active during the night in the hot season and, if outside, spend less time lying down during the wet season. Many domestic animals show a slight seasonal breeding pattern.

Domestic animals under conditions of close captivity frequently display abnormal behaviour such as stereotyped movements or inappropriate sexual behaviour, particularly if they are unable to escape from, or adapt to, the situation. However, many disturbed behaviours have more complex causes. For example, tail and ear biting in pigs may be associated with boredom, breakdown of social order, an excessively high stocking rate, insufficient fibre content in the feed, malnutrition, poor ventilation leading to high humidity and overheating, lack of bedding, inadequate trough space and watering points, skin disease, parasites, teething problems, etc.

Social rank order

Domestic animals are highly sociable and naturally form groups. Males and females form separate groups, except during the breeding season, and the young tend to form small groups in the proximity of the female group. When strange adult animals meet for the first time they are likely to fight to establish dominant/subordinate relationships. The resulting pecking order, or social rank order, in which one or two animals are invariably dominant is usually formed quickly. While physical age and weight are the main factors determining social rank, sex, height and breed can also be an influence. The group can live in relative harmony as long as each animal knows its place and gives way to animals of higher rank. However, the order is seldom strictly hierarchic or static. Some animals of low rank may dominate others whose positions are normally higher, and fast-growing and maturing animals may move up the ladder.

The introduction of new animals into a group or the mixing of groups will normally lead to fighting until a new social order is established, and this may cause a growth check as well as injury.

The normal response to aggressive behaviour in a group with an established social order is for the subordinate animal to move away. The building layout must allow space for this and therefore narrow passages and corners where one animal can be trapped by another should be avoided in pens and yards. The order usually remains stable provided the group is small to ensure that all animals in it can remember the positions of the others, i.e. fewer than 80 cows, between 12 and 15 pigs or about 100 chickens.

Animal behaviour studies

Experiments intended to improve the design of animal housing, its furnishing and equipment, usually employ one of the following methods:

(a) A choice of environment is provided for the animals and their preference for the different facilities is recorded.

(b) The behaviour of animals in an experimental environment is studied and the result is compared with the behaviour of animals in a reference system, on a free range, or that of their wild relatives. Often the study is confined to activities such as resting, eating, standing/walking, but sometimes the frequency of other behaviour patterns, such as investigative, agnostic, sexual, care-giving, care-soliciting or eliminative behaviour is also included.

In addition, productivity and the frequency of injuries and disease outbreaks are recorded.

Animal behaviour and building design

Animal behaviour can influence the design of structures, as demonstrated in the examples given below. More examples will be given when housing facilities for the various species are described later in this chapter.

Cattle normally live in herds but, when giving birth, cows attempt to find a quiet, sheltered place away from the disturbance of other cows and humans. The cow needs to be alone with her calf for some time after birth for the cow/calf bond to be established. When a cow that is confined in a loose housing system is approaching calving, it should be removed from the herd and placed in an individual pen.

Hens spend considerable time in the selection of a nest, which is on the ground. Nesting is characterized by secrecy and careful concealment. Hens in deep-litter systems therefore, sometimes lay eggs on the floor instead of in the nest boxes, especially if the litter is quite deep or there are dark corners in the pen.

To avoid this, plenty of fresh litter is provided in the nests, and they are kept in semidarkness and fitted with a rail in front so that birds can inspect the nests prior to entry. An additional measure is to start with nest boxes on the floor and slowly raise them to the desired level over a period of days.

Sows are nest-builders and should be transferred to clean farrowing pens one to two weeks before giving birth, and given some bedding with which they can build a nest. Oestrus, especially in gilts, is increased by the smell, sight and physical presence of a boar. Gilts and sows awaiting mating should therefore be kept in pens adjoining the boar pen.

Cattle prefer to be able to see while drinking, therefore more animals can drink at once from a long, narrow trough than from a low round one. With cattle (and hens), feeding is typically a group activity, therefore space at the feed trough must be provided for all the animals at one time. At pasture, undersized feed or water troughs can result in inadequate feeding and watering of the animals that are lowest in rank because these animals could well be excluded from the trough but, despite this, they still tend to leave with the rest of the herd after feeding or watering.

To prevent wasting feed, a trough should be designed to suit the particular behaviour pattern that each species exhibits while feeding, i.e. pecking in hens; rooting with a forward and upward thrust in pigs; and wrapping their tongue around the feed (grass) and jerking the head forward in cattle.

Artificially reared calves bunt the bucket instead of the cow's udder, and this requires a sturdy holder for the bucket. The habit of suckling each other is a problem in dairy calves. The problem can be reduced by making the calves suckle harder and longer for their feed by using a rubber teat rather than a bucket and by giving them access to dry feed. Assuming intersuckling is not a problem, a group pen for calves is more natural than individual pens, and helps to ensure normal activity and resting.

Sheep are vigilant and tight-flocking, and respond to disturbances by fleeing. When designing handling facilities, these characteristics should be taken into account. A race should be straight, level, fairly wide, have no blind ends, and preferably have close-boarded sides. Sheep that are following should be able to see moving sheep ahead, but advancing sheep should not see the sheep behind as they will tend to stop and turn around.

Sheep move best from dark into light areas and dislike reflections, abrupt changes in light contrast and light shining through slats, grates or holes. Handling facilities should be examined from the sheep's eye level, rather than from human eye level to detect flaws in the design.

ANIMAL ENVIRONMENTAL REQUIREMENTS

The capacity of an animal to produce differs between species, breeds and strains as a result of genetic factors. However, a complex set of interrelated animal husbandry factors will influence the animal's ability to utilize that capacity for growth, development and production.

Progress in breeding and feeding to further increase production and efficiency can be limited by environmental factors. Research into these factors has therefore been increasing in recent years, especially in countries with intensive animal production systems.

Animal housing design is mainly concerned with the physical environment, in particular climatic and mechanical factors. However, all other factors should also be considered in order to create a good layout, where healthy, high yielding animals can be provided with correct feeding, can be easily handled and can produce without stress or suffering physical harm.

Heat regulation

All domestic livestock are *homeotherms,* that is to say, they maintain a relatively constant internal body temperature, usually within a 1–2 °C range. The normal body temperatures of some domestic animals and humans are given in Table 10.1.

TABLE 10.1
Normal body temperatures of domestic animals and humans

	Temperature (°C)	
Animals	**Average**	**Range**
Dairy cow	38.6	38.0–39.3
Beef cow	38.3	36.7–39.1
Pig	39.2	38.7–39.8
Sheep	39.1	38.3–39.9
Goat		38.7–40.7
Horse	37.9	37.2–38.2
Chicken	41.7	40.6–43.0
Human	37.0	

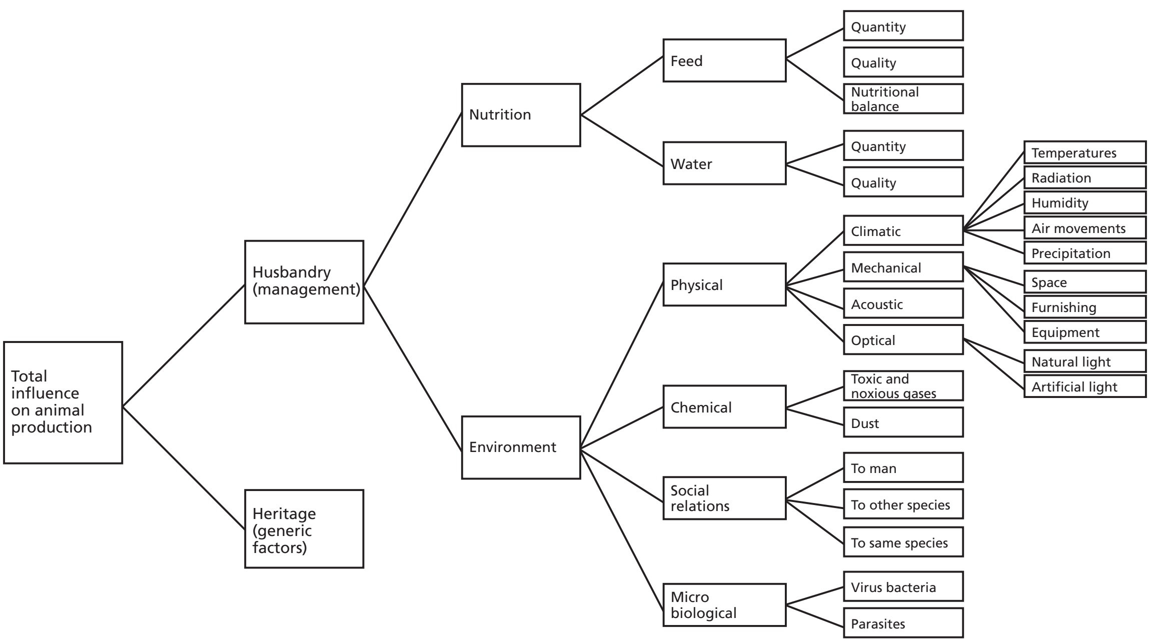


Figure 10.1 **Classification of factors influencing livestock production**

The body temperature of most domestic animals is considerably higher than the environmental temperature to which they are exposed most of the time. They maintain their body temperature by balancing internal heat production and heat loss to the environment. The *hypothalamus gland* acts as a body thermostat by stimulating mechanisms to counteract either high or low ambient temperatures. For example, increased conversion of feed-to-heat energy is used to counteract low ambient temperatures, while increased respiration (rate and volume) and blood circulation in the skin counteracts high ambient temperatures.

Varying the temperature also results in changed behaviour. Most animals reduce their level of activity in a hot environment and, for example, pigs lie clustered in a heap at low temperatures, while they lie spread out with extended limbs at high temperatures. This would suggest an increased space requirement for pigs in a warm, tropical climate. The body can tolerate short periods of heat stress but if the ambient temperature exceeds the body temperature for an extended period, it may prove fatal.

When feed is converted by the animal's metabolism for the production of milk, eggs, meat, offspring, etc., heat is produced as a by-product. An increased production level (and hence feed requirement) will therefore result in increased internal heat production. High-yielding animals are consequently more likely to suffer from heat stress in a hot climate than low-yielding ones.

Feeding fibre-rich, low-digestible feedstuffs, such as hay, will result in high heat-production because of increased muscular activity in the alimentary tract and, in ruminants, increased micro-organism activity in the rumen. An increased share of concentrates in the feed may therefore reduce heat stress in an animal under hot climatic conditions.

Animal moisture and heat production

Heat is produced centrally in the deep body. The surplus is conducted to the skin surface where it is transferred to the atmosphere as sensible heat by means of convection, conduction and radiation, and as latent heat through the evaporation of moisture from the lungs and skin. Increasing the ambient temperature, resulting in a smaller temperature difference between the body surface and the air, will decrease the amount of heat that can be emitted as sensible heat. Instead, a larger proportion is given off as latent heat, that is to say, heat employed to vaporize moisture.

Table 10.2 lists values for animal heat and moisture production at various temperatures. The heat and moisture produced by the animals confined in a structure must be removed by ventilation. In the tropics, sufficient air flow is usually provided by the use of open-sided structures.

However, if an enclosed building is used, a range of ventilation flow rates must be provided for in the building design. The minimum ventilation rate should remove the moisture produced, but retain as much sensible heat as possible during cold periods. The maximum ventilation rate should remove enough of the sensible heat produced so that a small temperature difference, usually 2–4 °C, can be maintained between inside and outside. It should be noted that ventilation alone can maintain the building at only slightly above ambient temperature. Ventilation is discussed in more detail in Chapter 13.

Climatic factors

Temperature

The overriding environmental factor affecting the physiological functions of domestic animals is temperature. For most farm animals, a mean daily temperature in the range 10–20 °C is referred to as the 'comfort zone'. In this range, the animal's heat exchange can be regulated solely by physical means, such as the constriction and dilation of blood vessels in the skin, ruffling up the fur or feathers and regulation of the evaporation from lungs and skin.

At the upper and lower critical temperatures, physical regulation will not be sufficient to maintain a constant body temperature and the animal must, in addition, decrease or increase its metabolic heat production A further decrease or increase in temperature will eventually bring the temperature to a point beyond which not even a change in heat production will be sufficient to maintain *homeothermy*.

A very young animal, lacking fully developed temperature-regulating mechanisms, particularly the ability to increase heat production by increased metabolism, is much more sensitive to its thermal environment and requires higher temperatures.

Humidity

Poultry do not have sweat glands, so all evaporative heat loss must originate from the respiratory tract. Other livestock species have varying abilities to sweat and, in descending order, they are as follows: horse, donkey, cattle, buffalo, goat, sheep and pig.

In a hot, dry climate evaporation is rapid but, in a hot humid climate, the ability of the air to absorb additional moisture is limited and inadequate cooling may result in heat stress.

Excessively low humidity in the air will cause irritation of the mucous membranes, while excessively high humidity may promote the growth of fungus infections. High humidity may also contribute to decay in structures. If possible, keep the relative humidity in the range of 40 percent to 80 percent.

Radiation

The heat load on a grazing animal can be increased considerably by direct solar radiation and radiation reflected from clouds or the ground. A white hair coat will absorb less radiant energy than a dark one, but the heat penetrates deeper into a white, loose coat. Air movements will dispel the heat and reduce the differences. Solar radiation may also adversely affect the animal's skin, in particular breeds with unpigmented skin.

Heat gain by radiation can be effectively reduced by the provision of a shaded area. It must, however, be sufficiently large to allow space between the animals to avoid reducing heat loss by other means. Grass-covered ground in the surroundings of the shade will reflect less radiation than bare soil.

Air movements

Air movements assist heat loss by evaporation and by conduction/convection, as long as the air temperature is lower than the skin temperature. When the air temperature approaches skin temperature, rapid air movements are experienced as comfortable but, at low temperatures, they lead to excessive cooling of unprotected skin areas (cold draught).

In addition, air movements are required to remove noxious and toxic gases and to supply the animal with fresh air for breathing. A wind velocity of 0.2 m/s is generally regarded as a minimum requirement, but it can be increased to 1.0 m/s when the temperature is nearing the upper critical level, or more when it rises beyond that.

Precipitation

Heavy rain may penetrate the fur of an animal and decrease its insulation value. In such circumstances, a strong wind can lead to excessive cooling. However, a naturally greasy hair coat will resist water penetration and with the provision of a shelter for the animals the problem may be avoided altogether.

TABLE 10.2
Animal heat and moisture production

Livestock	Weight (kg)	Ambient temperature* (°C)	Moisture (g/h–animal)		Sensible heat (W/animal)		Total heat[1] (W/animal)	
			*°C	25 °C	*°C	25 °C	*°C	25 °C
Dairy cow	400	12	410	835	685	395	960	960
	500	12	445	910	745	430	1 045	1 045
	600	12	485	985	805	465	1 130	1 130
	700	12	515	1 045	855	495	1 200	1 200
Dairy calf	50	12	70	105	70	75	115	145
	75	12	185	365	220	120	345	365
	150	12	205	365	280	170	420	420
	200	12	160	330	270	155	380	380
	300	12	220	450	370	215	520	520
	400	12	275	565	460	265	645	645
Swine	5	27	30	-	20	-	40	-
	10	24	35	40	35	35	60	60
	20	20	60	70	55	50	95	95
	30	16	65	90	80	65	125	125
	50	16	75	120	125	85	175	165
	70	16	100	150	145	105	215	205
	90	16	115	170	165	120	245	235
Dry sow	180	12	85	165	210	135	270	245
Sow one week prior to birth	180	12	120	220	285	185	365	335
Sow with piglets	180	16	175	300	340	245	460	450
+W36 pullets	0.04	32	0.35	-	0.1	-	0.3	-
	0.8	21	3.5	-	4.1	-	6.4	-
Laying hen	1.4	24	5.6	-	5.5	-	9.1	-
	1.5	20	5.2	6.5	6.6	5.7	10.1	10.1
	2.0	20	6.0	7.6	7.6	6.6	11.7	11.7
Broilers	0.1	32	3.1	-	0.9	-	3.0	-
	1.0	20	5.0	6.5	6.6	5.6	10.0	10.0
	1.5	20	6.2	8.0	8.1	6.9	12.3	12.3

* Referring to temperature stated in the column 'ambient temperature';
[1] Total heat equals sensible heat plus latent heat (latent heat equals moisture in g/h × 0.675 Wh/g);
+ Data adapted from Chepete *et al*., 2004 – ASHRAE Transactions.

Effect of climatic factors on livestock performance

In tropical and subtropical countries, an animal may often be under heat stress. When the environmental temperature exceeds the upper critical level (18 °C to 24 °C, depending on the species) there is usually a drop in production or a reduced rate of gain. Furthermore, when the temperature falls outside the comfort zone, other climatic factors assume greater significance. Humidity becomes increasingly important, as do solar radiation and wind velocity.

Dairy cattle show a reduced feed intake under heat stress, resulting in lower milk production and reduced growth. Reproduction is also adversely affected. There are, however, important differences between breeds. European cattle (*Bos taurus*) produce well at temperatures ranging from 4 °C to 24 °C, even at high humidity. Much lower temperatures (-10 °C) have little effect, provided that fluctuations are not too rapid or frequent.

On the other hand, a drop in milk production results when temperatures exceed 25 °C. The drop may be as much as 50 percent at temperatures of 32 °C or higher. In contrast, zebu cattle (*Bos indicus*), which are native to warm climates, have a comfort zone of 15–27 °C and milk production begins to drop only when temperatures rise above 35 °C.

It is important to note some of the physical differences between these two types of cattle that make each suited to its climate of origin. The zebu is characterized by a hump, large ears and loose, thin skin with a prominent dewlap. These characteristics promote heat loss by convection and evaporation and thus efficient body temperature regulation under hot climatic conditions. In addition, the zebu has less subcutaneous fat, a lower body volume for the surface area, and short, smooth hair, all of which contribute to the animal's comfort under hot conditions.

On the other hand, the European breeds have thick skin held tightly to the body, long hair and a large amount of fat, which serve as insulators and are desirable traits for cold or temperate climates. Although there is a considerable range in size within each breed, the zebu is a relatively small animal (a fully grown bull rarely exceeds 700 kg), while the European cattle are large, reaching 1 000 kg live weight. Figure 10.2 illustrates the configurations of the two types of cattle. Calves seem most sensitive to cold draughts and poor ventilation, but are quite tolerant of a wide range of temperatures.

Beef cattle make their best weight gains at temperatures below 25 °C. They can easily tolerate temperatures below 0 °C if they have a good supply of feed.

Pigs require a change in ambient temperature as they age and grow and, like cattle, they show a decreased feed intake when under heat stress. Piglets survive and develop best at 30–32 °C initially, followed by a gradual reduction to 20 °C over the first three weeks. Feeder pigs (weighing 30–65 kg) make good gains in the temperature range 10–25 °C, with 24 °C reported to be optimum. The optimal ambient temperature for pigs weighing 75–120 kg is 15 °C.

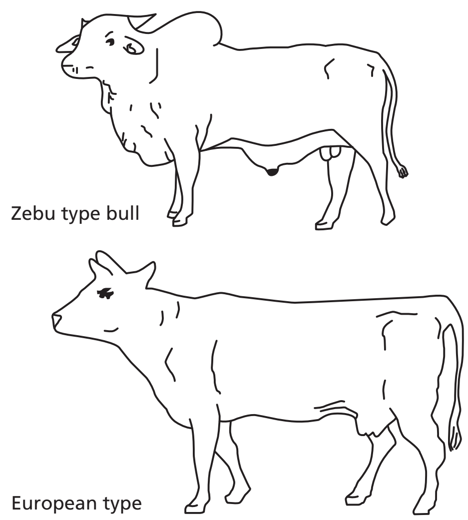


Figure 10.2 **Characteristic appearances of zebu and European-type cattle**

Brood sows do well at 15 °C but suffer badly at 25 °C and above because they do not perspire when hot. Reproduction rates fall under heat stress, and sows are more apt to trample their baby pigs during the discomfort of hot weather.

Sheep can tolerate a wide range of temperatures but should be protected from wind and rain. However, a long period of high ambient temperatures inhibits reproduction. Heat stress also reduces the lambing percentage, decreases the incidence of twinning, and decreases the birth weight of lambs. When temperatures are below 7 °C at breeding time, ewes show improved reproductive efficiency.

Goats are affected by temperature, humidity and rain. In hot , goats need shelter from intense heat during the day. In humid areas, they need protection from prolonged heavy rain. Excessive wetting from rain can cause pneumonia and an increase in parasitic infestation.

Poultry environmental requirements vary with age. Chicks should be started at 35 ºC. As from one week, the temperature is reduced gradually to 24 °C by the fifth week. Broilers and young turkeys reared at ambient temperatures below 18 °C are heavier than similar stock reared within the 18–35 °C range, but their feed conversion efficiency will be lower. Laying birds produce the greatest number of eggs and the largest-sized eggs at 13–24 °C. The best feed conversion efficiency is achieved between 21 °C and 24 °C.

An increase in the ambient temperature will result ina decrease in feed intake and in behaviour alterations. Within the temperature range 5–30 °C, there is a reduction of about 1.6 percent in feed intake for every

10 °C increase in ambient temperature. Above 24 °C, there is a reduction in egg production and egg size. A continued rise in temperature to 38 °C or more may prove lethal. High humidity at high temperatures creates conditions that are more likely to be lethal because of a breakdown in body-cooling through respiration.

Rabbits are affected the most by sun and heat, wind, rain and draughts. Sunlight is of benefit to breeding stock and to the growing young, but it will also fade the coat of coloured rabbits and discolour a white one. While rabbits enjoy the sun but they must be given the opportunity to keep out of the direct rays. Owing to their thick fur coats they tolerate cold better than extreme heat, but they are susceptible to chilling from draughts. Rabbits also need protection from rain and dampness.

Horses do not require warm surroundings, but they do not easily tolerate draughts, dampness and high humidity. When exposed to high temperatures and vigorous exercise, horses sweat, and the evaporation of this perspiration cools the skin and helps to maintain normal body temperature.

Humans: The subject of rural housing is covered elsewhere in the book, so human comfort zones will be discussed briefly here. Humans have the ability to become acclimatized to a constant temperature. Thus people living in cold climates easily tolerate low temperatures, just as people living in tropical climates do not mind the heat.

In temperate climates, most sedentary people dressed in light clothing find optimum comfort at approximately 26 °C. However, relative humidity of over 70 percent may produce discomfort. At 22 °C people may feel cool, regardless of humidity. Above 26 °C they are likely to feel warm and, as the relative humidity rises above 45 percent, discomfort increases. People who are dressed warmly and doing active work can be comfortable in temperatures as low as 0 °C and below.

Microbiological environment

Disease remains a major profit-limiting factor in animal production in many tropical countries. Sanitary control measures should be incorporated into any building design, so that a good hygienic standard can be easily maintained. An animal that is well fed and watered, as well as being in good condition, will have high resistance to disease. Good management can do much to remove or reduce the effects of adverse environmental factors, such as climatic stress, which would otherwise weaken the body's natural defences.

Newborn stock should always receive colostrum (first milk), which contains antibodies. It takes time for an effective immune system to develop in an animal and therefore good hygiene is of special importance in facilities for young animals. Pens, in particular those for calving and farrowing, should be constructed of easily cleaned and disinfected materials and be free from corners and recesses where manure and dirt can accumulate.

The whole building should be cleaned and disinfected periodically, and any pen that is emptied should be thoroughly cleaned before other animals are transferred to it. Rearing and fattening of young animals should be organized so that the building can be emptied, cleaned and disinfected between batches. This 'all-in, all-out' policy is particularly beneficial for disease control, where the animals are bought from outside the farm, and in finishing units for pigs, as well as broiler and layer houses.

Diseases are transmitted in many ways, including direct contact between animals, airborne micro-organisms, biting insects and ticks, manure, soil, contaminated feed and water, birds and rodents, as well as the stockperson's boots. Direct contact between animals can be reduced by decreasing the number of animals in each group and by constructing solid partitions between pens. However, solid walls may obstruct air movement and thus contribute to heat stress. Ideally, the waste handling system should prevent animals of different groups from coming into contact with one another's manure. Young animals, in particular, must be protected from contact with manure from adult animals.

Good husbandry includes regular observation of the animals to detect any change in behaviour that could indicate disease. Sick animals should be separated from the herd immediately to prevent further spread of infectious disease and to allow them to rest. The sick animal should be isolated in a pen kept especially for this purpose, which should ideally be in a separate building.

Newly acquired animals, and animals returning from a market or any other place where they may have been exposed to the risk of infection, must be quarantined for an adequate length of time to detect any disease that they may be carrying before they are allowed into the herd.

Other environmental factors

As far as we know, *acoustic factors* have only a marginal effect on the animal's development and production. Nervous animals may, however, react adversely to intermittent sudden noises. Pig squeals prior to feeding can become a hazard to the stockperson's hearing. Soft radio music in a milking parlour may have a soothing effect on the cows.

Day length or photoperiod varies with latitude and season and has a direct influence on animal performance, especially on the breeding season for sheep and poultry egg production. Under natural conditions, there is a correlation between the length of day and the rate of laying. Artificial light is used in the temperate zone to equalize egg production throughout the year. Additional hours of light before dawn and after dusk are recommended in hot climates to encourage the hens to eat during the cooler hours.

Dust can carry micro-organisms, which may cause an outbreak of disease.

Toxic and noxious gases are produced by manure that accumulates in buildings or storage facilities, especially during the agitation of manure slurry stored in a pit in a building, when harmful amounts of gas can be released. However, problems with gases are not likely to arise in the open-sided buildings used in the tropics.

CATTLE HOUSING

Cows play an extremely important role in most African cultures. The ownership of cattle will often be the deciding factor in a person's social position in the community because the herd may be the only practical way of accumulating wealth. However, of greater importance is the fact that cattle represent a source of high-protein food, in the form of both milk and meat.

This section focuses on housing requirements for cattle kept primarily for milk production. Little or no housing is required for herds maintained only for beef production, and special handling and support facilities are discussed separately.

Much of the dairy farming in east and southeast Africa occurs at elevations of 1 500 metres or more. European breeds have been successfully established under these circumstances. However, European bulls crossed with zebu cows have produced animals that are more tolerant of high temperatures than the European breeds and are significantly better producers than zebu.

Whether purebred or crossbred, they will not provide a profit to the farmer if they are left to find their own feed and water and are milked irregularly. Experience has shown that cattle respond favourably to good management, feeding and hygiene, all of which is possible in a system with suitable housing.

Herd profiles

The composition and management of cattle herds varies considerably. At one extreme, nomadic herdsmen graze their entire herd as one unit. Smallholders with only a few head may keep their heifer calves for replacements or sell them. Commercial dairy producers typically have about four-fifths of their cows milking and one-fifth waiting to calve, while heifers of 10 months to calving age, plus calves of various ages, will approximately equal the number of milkers. Mature dairy cows are bred annually and are milked for 300–330 days after calving.

On closer examination, several factors will be found to influence the number of animals of various categories found in a dairy herd. In a herd of say, 24 cows, with calving evenly distributed throughout the year and a 12-month calving interval, an average of two calves will be born per month. The calves are normally kept in individual pens for two to three months. There is therefore a requirement for four to six pens in a herd of 24 cows. However, the need for calf pens is halved in herds where the bull calves are sold or otherwise removed from the herd at one to three weeks of age. A longer calving interval and high mortality among the calves will decrease the required number of calf pens, while concentration of the calving season in the herd will increase the pen requirements. If all calving is concentrated in six months of the year, the requirement for calf pens will be doubled.

A number of cows in a dairy herd will be culled each year because of low milk yield, infertility, disease, old age, etc. These cows are best replaced with young stock from their own herd, because any animals acquired from outside the farm may bring disease to the herd. Cows are commonly culled after three to five lactations, corresponding to a replacement rate of 20 percent to 30 percent per year.

In herds with very intensive production there is a tendency towards a higher replacement rate, but it cannot exceed 40 percent if the heifers are obtained exclusively from the herd itself. This is due to the fact that only about half of the calves born are female, and some of these will die or be culled before first calving as a result of disease, infertility or other factors.

The number of maturing heifers will increase in line with an increase in the age of heifers at first calving, a higher replacement percentage and a shorter calving interval. Concentrated calving may slightly increase the number of animals during some periods of the year, and will greatly affect the distribution of animals in the different age groups. The age at first calving of heifers of European breeds is typically 24–27 months, while heifers of the slower-maturing zebu cattle are often aged 36 months or more.

Maturing heifers require little or no housing facilities in the tropics. Knowledge of their exact number and distribution in various age groups during different months is therefore not as important to a building designer as to the manager of the herd.

Heifers should be introduced into the dairy herd at least a couple of months prior to their first calving, to enable them to learn and become adjusted to the handling and feeding routines. In loose housing systems with free stalls (cubicles), or in tie-barns, this may slightly increase the need for stalls, but normally the heifer will simply take over the stall used by the culled cow that it replaces.

In herds where cows are taken to a special calving pen during calving, one such pen per 30 cows is sufficient, because the cow and her calf will spend only a few days there. However, in herds where calving is concentrated in a short period, the requirement can increase to one calving pen per 20 cows. The pen should be at least 3.3 metres by 3.3 metres.

General housing requirements

As has already been pointed out, cattle will produce milk and reproduce more efficiently if they are protected from extreme heat, i.e. temperatures of 25–30 °C, and particularly from direct sunshine. Thus in tropical and subtropical climates, providing shade becomes an important factor.

If cattle are kept in a confined area, it should be free from mud and manure in order to reduce hoof infection to a minimum. Concrete floors or pavements are ideal where the area per cow is limited. However, where ample space is available, an earth yard, properly sloped for good drainage, is adequate.

Shade from the sun

With these needs in mind, a shade structure allowing 2.5–3 square metres per animal will give the minimum desirable protection for cattle, whether for one animal belonging to a smallholder or many animals in a commercial herd. A 3 metre by 7 metre roof will provide adequate shade for up to eight cows. The roof should be a minimum of 3 metres high to allow air circulation.

If financially feasible, the entire area that will be shaded at some time during the day should be paved with good-quality concrete. The size of this paved area depends on the orientation of the shade structure. If the longitudinal axis is east to west, then part of the floor under the roof will be in shade all day. Extending the floor by approximately one-third of its length on the east and on the west, as shown in Figure 10.3, results in a paved surface being provided for the shaded area at all times.

If the longitudinal axis is north to south, the paved area must be three times the roof area i.e. one-third to the east, one-third to the west and one-third underneath. Obviously this means an increase in the cost of paving. When deciding on which orientation to use, the following factors should be considered:

1. With the east-west orientation, the feed and water troughs can be under the shade, which will allow the cows to eat and drink in shade at any time of the day. However, the shaded area should be increased to 3–4 metres per cow. By locating the feed and water in the shade, feed consumption will be encouraged, but more manure will be dropped in the shaded area, which in turn will lead to dirty cows.
2. With the north-south orientation, the sun will strike every part of the floor area under and on either side of the roof at some time during the day. This will help to keep the paved area dry. A shaded area of 2.5–3 metres per cow is adequate if feed and water troughs are placed away from the shaded area.
3. If paving is considered to be too costly, the north-south orientation is the best choice in order to keep the area as dry as possible.
4. In regions where temperatures average 30 °C or more for up to five hours per day during some period of the year, the east-west orientation is the most beneficial.

Figure 10.3 shows shade patterns at various times and orientations at a location at latitude 10 degrees. A gable roof shade is shown in Figure 10.4. The gable roof is more wind resistant than a single pitch roof and allows for a centre vent. A woven mat of local materials can be installed between the rafters and the corrugated iron roof to reduce radiation from the steel and to reduce temperatures just below the roof by 10 °C or more.

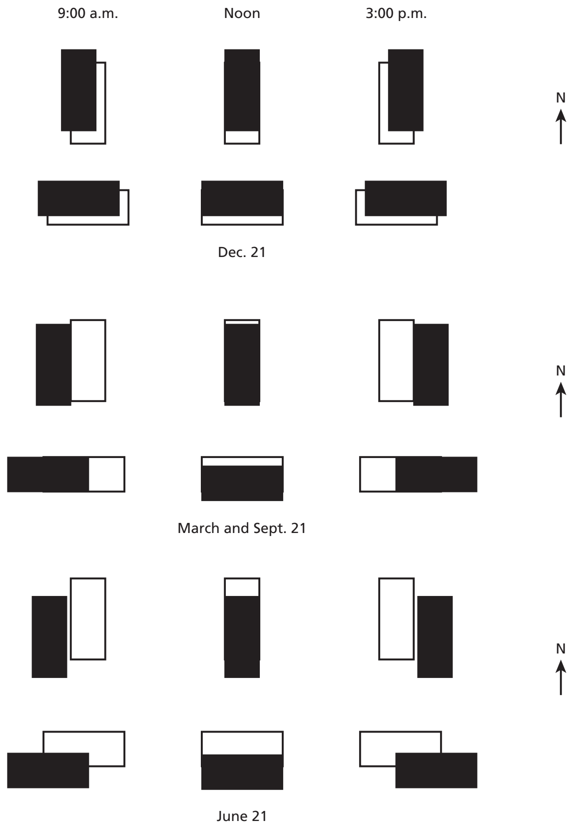


Figure 10.3 **Shadows cast at various times and dates at latitude 10 degrees south**

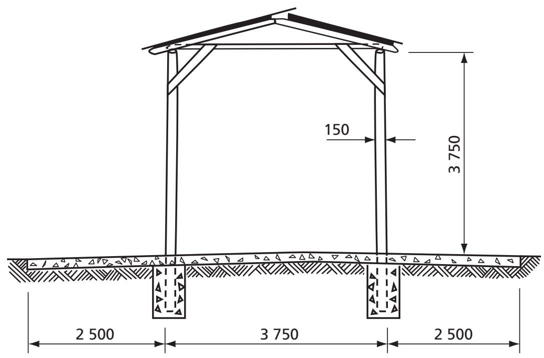


Figure 10.4 **Sunshade with insulated corrugated steel roof**

Yards

If space is severely limited and only 4–5 square metres per cow is available, then concrete paving is highly desirable. If 40–60 square metres per cow is available, then unpaved yards should be quite satisfactory, provided that the feed and shade areas are paved and the yard is graded for good drainage.

If the smallholder is unable to afford an improved structure, such as a shade or a paved area for feeding, then conditions can be prevented from becoming intolerable by building mounds of earth in the yard with drainage ditches between them, as shown in Figure 10.5. Between 20 square metres and 30 square metres per cow will keep the animals out of the worst of the mud. The soil in the mounds can be stabilized by working chopped straw, or straw and manure, into the surface. A number of trees in the yard will provide sufficient shade.

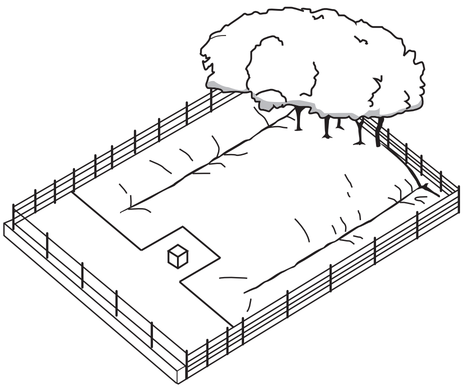


Figure 10.5a **Yard with fence-line feed trough, paved feed area and earth mound**

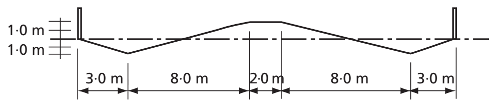


Figure 10.5b **Dimensions for an earth mound**

Deep-bedded sheds

In a deep-bedded system, straw, sawdust, shavings or other bedding material is periodically placed in the resting area so that a mixture of bedding and manure builds up in a thick layer. Although this increases the bulk of manure, it may be easier to handle than wet manure alone. This system is most practical when bedding is plentiful and cheap.

Table 10.3 gives the space requirements for various ages of animals when there is access to a yard. By designing the building to be partially enclosed on the east and west, the shading characteristics can be improved. Where a well-drained earth floor is quite adequate, such a building will compare favourably in cost with a paved shaded area.

Loose housing with free stalls (cubicles)

Although simple yard and shade, or yard and bedded-shed, systems are entirely satisfactory in warm climates, particularly in semi-arid areas, some farmers may prefer a system with somewhat more protection. A loose housing yard and shed with free stalls will satisfy this need. Less bedding will be required and less manure will have to be removed. Free stalls must be of the right size in order to keep the animals clean and to reduce injuries to a minimum.

When stalls are too small, injuries to teats will increase and the cows may also tend to lie in other areas that are less clean than the stalls. If the stalls are too large, cows become dirty from manure dropped in the stall and more labour will be expended in cleaning the shed area. A bar placed across the top of the free stalls will prevent the cow from moving too far forward in the stall for comfortable lying down movements, and it will encourage her to take a step backwards when standing so that manure is dropped outside the stall.

However, the bar must not interfere with her normal lying and rising movements. Table 10.3 lists recommended dimensions for stalls. The floor of the stall must be of a non-slippery material, such as soil. A good foothold is essential during rising and lying-down movements to avoid injury. A 100 mm ledge at the back edge of the free stall will prevent any bedding from being pulled out into the alley.

The number of stalls should ordinarily correspond with the number of animals housed, except that in large

TABLE 10.3
Area for bedded sheds and dimensions of free stalls (cubicles)

Animal	Age (months)	Weight (kg)	Bedded shed area per animal (m^2)		Free stalls Dimensions (m)	
			A	B	Length	Width
Young stock	1.5–3	70–100	1.5	1.4	1.2	0.6
Young stock	3–6	100–175	2.0	1.8	1.5	0.7
Young stock	6–12	175–250	2.5	2.1	1.8	0.8
Young stock	12–18	250–350	3.0	2.3	1.9	0.9
Bred heifers and small milking cows		400–500	3.5	2.5	2.1	1. 1
Milking cows		500–600	4.0	3.0	2.2	1.2
Large milking cows		> 600	5.0	3.5	2.3	1.2

A = enclosed and fully covered bedded shed. B = bedded shed in conjunction with exercise yard.

herds (80 or more) only about 90 percent of the animals need to be accommodated at one time. Figure 10.6 shows two free-stall designs. Young stock may be held in yards with shade, or in sheds with either free stalls or deep bedding. The alley behind the free stalls (cubicles) must be wide enough to allow the cows smooth passage, and the minimum widths applicable are shown in Table 10.4.

TABLE 10.4
Alley widths in conjunction with free stalls (cubicles)

Alley between a row of free stalls and a trough (increase to 4.0 metres if there are more than 60 cows in the group)	2.7–3.5 metres
Alley between a row of free stalls and a wall	2.0–2.4 metres
Alley between two rows of free stalls	2.4–3.0 metres
Alley between a feed trough and a wall	2.7–3.5 metres

TABLE 10.5
Tie-stall system dimensions (metres)

	Cow live weight		
Stall section	**450 kg**	**550 kg**	**650 kg**
Platform width	1.1	1.2	1.3
Platform length[1]	1.6	1.7	1.8
Manger width	0.5	0.6	0.65
Platform slope		2–4%	
	Nose-out system		Nose-in system
Flat-manger feed alley	1.7–2.0		1.6–2.0
Feed alley (excluding step manger)	1.2–1.4		1.2–1.4
Service alley width		1.4–2.0	
Manure gutter width		0.4–0.7	
Depth		0.25–0.35	

[1] If cows are allowed to lie with their heads over the trough, otherwise add 0.4–0.5 metres to the length

Tie-stall sheds

Only in the case of purebred herds, where considerable individual attention is given to cows, can a tie-stall system be justified in tropical areas. If such a system is chosen, stalls and equipment may be purchased, in which case floor plans and elevations may be available from the equipment supplier. However, if equipment is to be manufactured locally, Table 10.5 provides some typical dimensions.

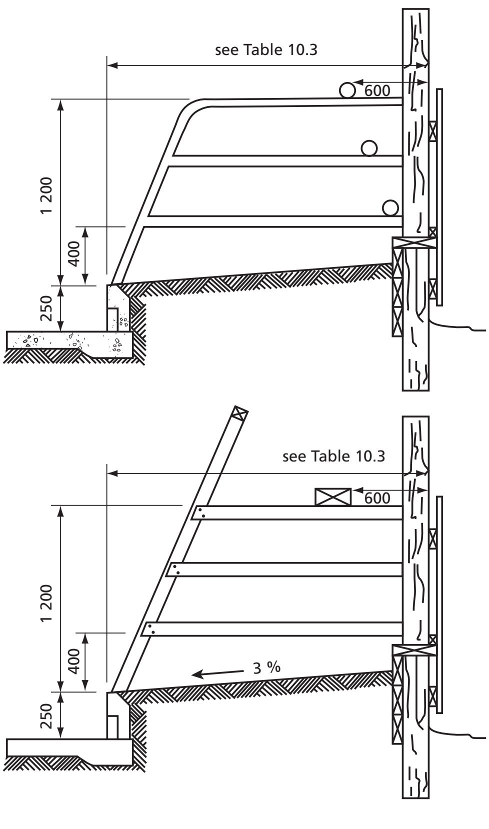


Figure 10.6 **Free-stall cubicle designs**

The tie-and-feed-barrier construction must allow the cow free head movements while lying down as well as standing up. However, it should prevent the cow from stepping forward into the feed trough. Most types of yoke restrict the cow's movements too much. A single neck rail, set about 1 metre high and 0.2 metres over the manger may bruise the cow's neck when it pushes forward to reach the feed.

The feed barriers that best meet the requirements are shoulder supports and the comfort stall, shown in Figure 10.7. Note the fixing rods for the cross-tie, which allows for vertical movement of the chain. Stall partitions should be used at least between every second cow to prevent cows from trampling each other's teats and to keep the cow standing straight so that the manure falls in the gutter (Figure 10.7c).

Bull pens

A bull pen should have a shaded resting area of 12–15 square metres and a large exercise area of 20–30 square metres. The walls of the pen must be strong. Eight horizontal rails made of minimum 100 mm round timber or 50 mm galvanized steel tubes to a total height of 1.5 metres, fixed to 200 mm timber posts not more than 2 metres apart, will be sufficient.

The gate must be designed so that the bull cannot lift it off its hinges, and there should be at least two exits where the herd worker can escape. A service stall where the cow can be tethered prior to, and during, service is usually provided close to the bull pen. The stall can have ramps at the sides to support the bull's front feet.

Calf pens

Calf mortality is often high in tropical countries, but proper management and suitable housing that protects the calf from climatic stress, infections and parasites can reduce this. Individual pens for calves from birth to two to three months of age are often built with an elevated slatted floor. This floor, which is best constructed from sawn timber boards measuring 37–50 mm by 75–100 mm, leaving a 25–30 mm slit between each board, will ensure that the calf is always dry and clean.

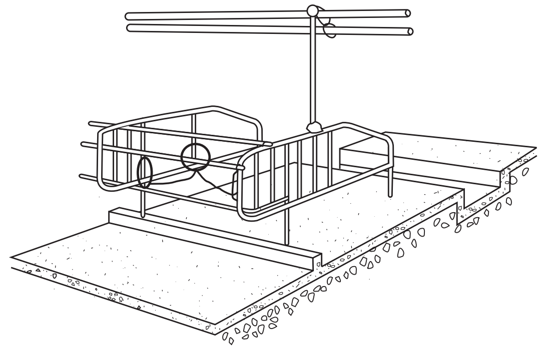


Figure 10.7b **Comfort stall**

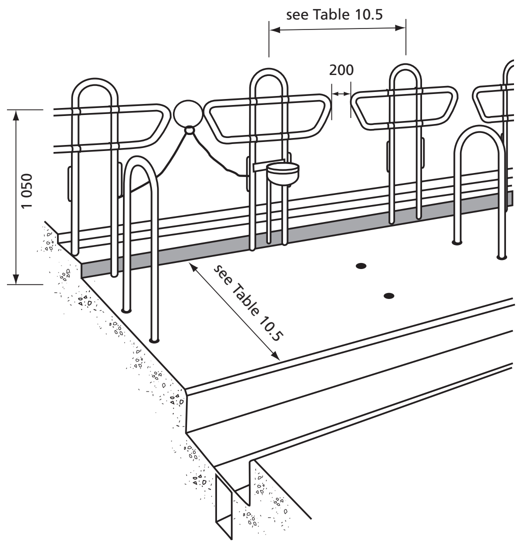


Figure 10.7a **Shoulder support system**

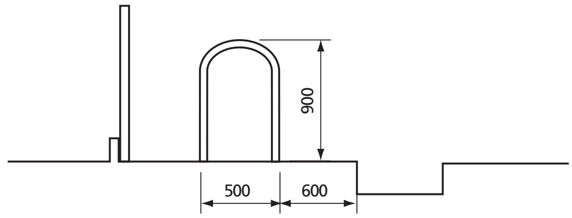
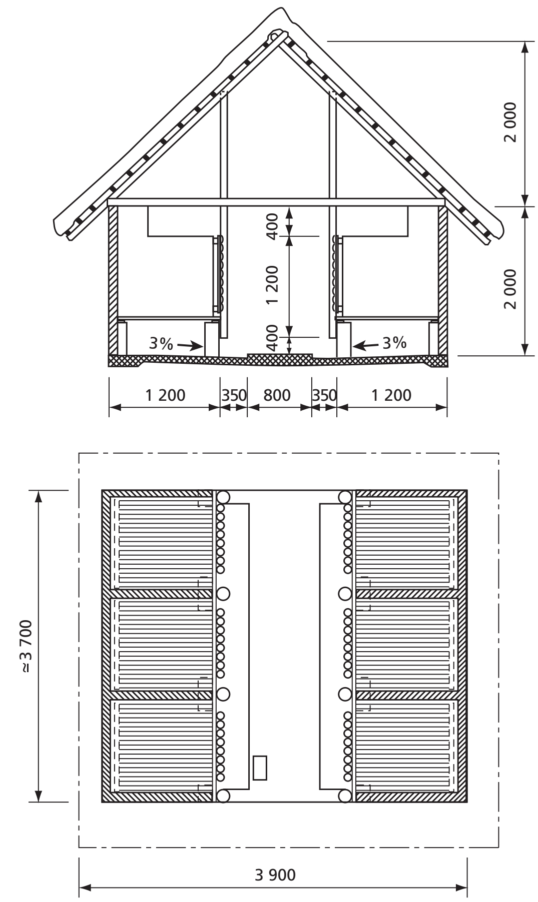
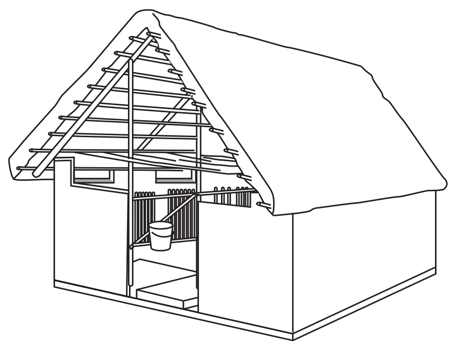


Figure 10.7c **Stall partitions**





Description:

Floor: Concrete floor, 80 mm on firm ground, sloping towards the centre line with an elevated pavement along the same line. Slotted wooden floor in the pens elevated 400 mm, made of 25 × 100 mm sawn timber with spacing of 25 mm.

Walls: The pens can be made of gum-poles and offcuts, bricks or concrete blocks plastered on both sides, or any other locally available material.

Roof: The structure in this case is made of treated gum-poles and thatched grass

Figure 10.8 **Calf shed**

The required minimum internal dimensions for an individual calf pen are 1 200 mm by 800 mm for a pen where the calf is kept to two weeks of age¸1 200 mm by l 000 mm where the calf is kept to six to eight weeks of age; and 1 500 mm by 1 200 mm where the calf is kept from 6 to 14 weeks of age. Three sides of the pens should be enclosed to prevent contact with other calves and to prevent draughts.

Draughts through the slatted floor may be prevented by covering the floor with litter until the calf is at least one month of age. The front of the pen should be made so that the calf can be fed milk, concentrates and water easily from buckets or a trough fixed to the outside of the pen, and so that the calf can be moved out of the pen without lifting. The milk or milk substitute fed to the calf will not provide it with enough liquid and therefore it should be given fresh, clean water daily, or preferably have continuous access to water in a drinking nipple.

All calves, but especially those that are weaned early, should have access to good-quality forage as soon as possible to stimulate rumen development. Forage can be supplied in a rack placed above the side wall of the pen. Figure 10.8 shows a thatched shed with six slatted-floor calf pens. This construction, with a feed alley, will be rather expensive but can be cheaper if calves are fed from outside. Calf pens are recommended where the cows are kept in a semizero-grazing or zero-grazing system.

Another system that works well is the use of individual hutches, as shown in Figure 10.9. The hutch must be thoroughly cleaned and set up in a new location every time a new calf is housed in it. Plenty of litter is placed directly on the ground inside the hutch. Protection from wind, rain and sun is all the calf requires, but the key to success is to always move the hutch to clean ground.

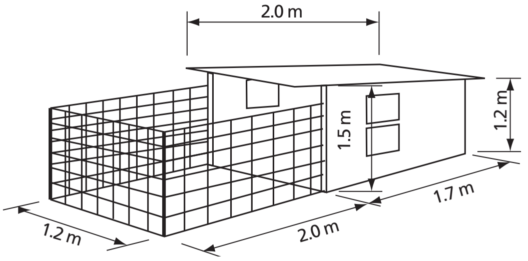


Figure 10.9 **Calf hutch**

Housing for the small herd

For the smallholder who wants to make the very best use of his crop land and to provide his cattle with good housing that will encourage high production, a zero-grazing system is recommended.

Figure 10.10 shows perspective, elevation and plan views of a zero-grazing unit for three cows, two heifers and a young calf. Additional stalls can be added up to a total of about 10. For any more than that, consideration should be given to two milking places and a larger feed store.

Gum-poles may be used instead of the cedar posts and sawn rafters, but any wood in contact with, or within 50 cm of, the ground should be well treated with wood preservative. It is desirable to pave the alley but, if that is not possible, the distance between the free stalls (cubicles) and the feed trough should be doubled or tripled.

A concrete pit or sloping slab in which to accumulate manure is essential. If the alley is paved, the pit can also collect urine. In fact, paving the alley not only saves space, but the value of the urine will help to pay for the paving.

The circular manure tank shown in Figure 10.10 has a volume of 10 cubic metres. This will be adequate to store the manure produced during one month, plus any rainfall collected in the alley. If more stalls are added, the capacity of the tank will need to be increased or the interval between emptying shortened.

A water tank to collect water from the roof can be very useful unless there is an abundant supply of water nearby.

Housing for medium to large herds

For the farmer with up to about 30 cows, a yard with a paved shade and feed area would be suitable. The yard and feeding area may alternatively be combined with an open-sided barn designed for deep bedding or equipped with free stalls and, where the herd consists of high-yielding cows, the milking shed may be equipped with a bucket milking machine. Some farmers with up to 30 cows may even consider using an open-sided tie-stall shed.

In general a medium- or large-scale dairy unit may include the following facilities:

1. Resting area for cows:
   (a) paved shade; or
   (b) deep bedding in an open sided barn; or
   (c) free stalls in an open-sided barn.
2. Exercise yard (paved or unpaved).
3. Paved feed area:
   (a) fence-line feed trough (shaded or unshaded); or
   (b) self-feeding from a silage clamp.
4. Milking Centre:
   (a) milking shed or parlour; and
   (b) collecting yard (part of the exercise yard); and
   (c) dairy, including milk store; and
   (d) motor room.
5. Bull pen with a service stall.
6. Calving pen(s).
7. Calf accommodation.
8. Young stock accommodation (yard with paved shade and feed area).
9. Bulk feed store (hay and silage).
10. Concentrate feed store.

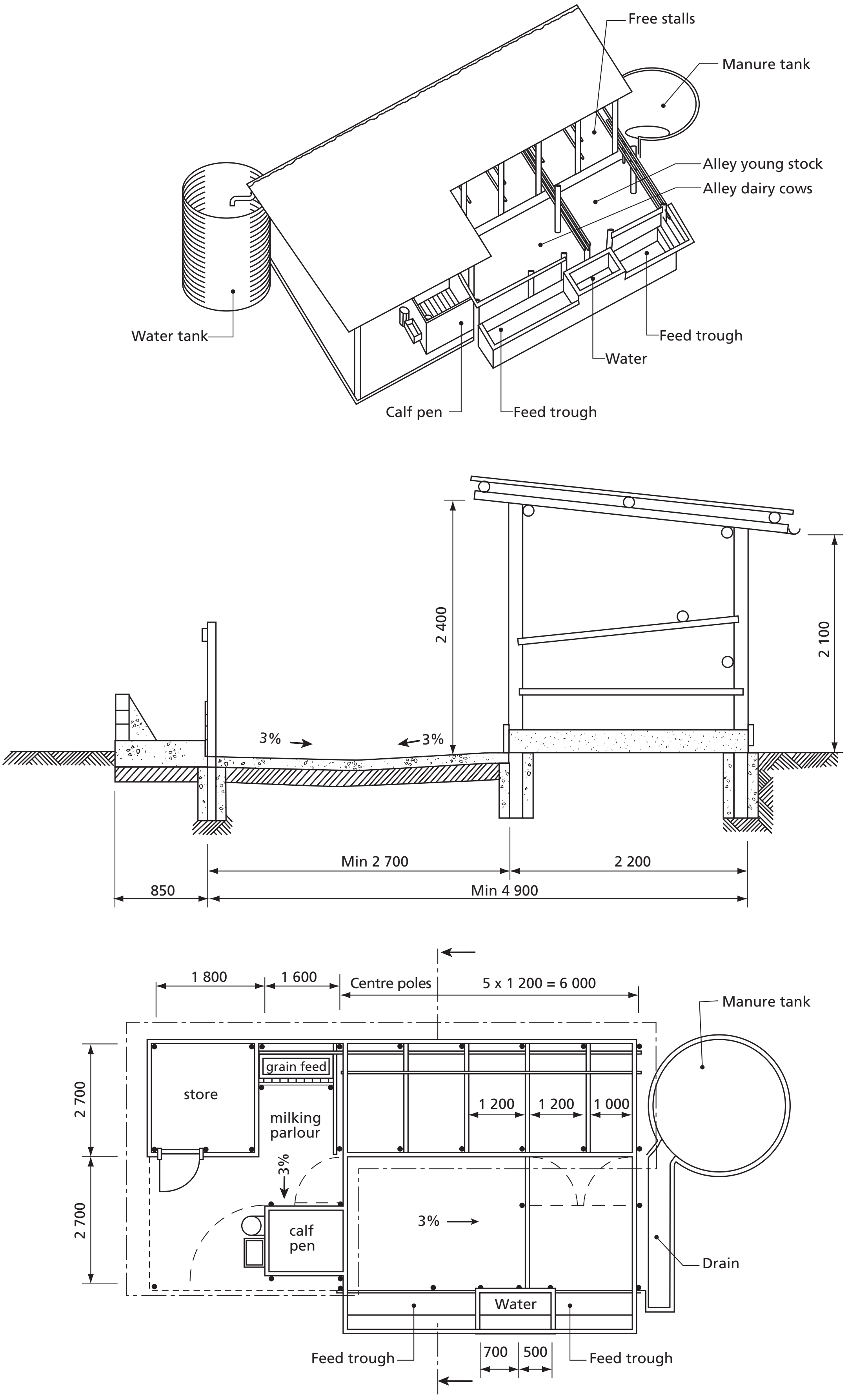


Figure 10.10 **Zero-grazing system for the smallholder**

11. Veterinary facilities:
    (a) diversion pen with artificial insemination stalls; and
    (b) isolation pen.
12 Waste store:
    (a) slurry storage; or
    (b) separate storage of solids and effluents.
13 Office and staff facilities.

Each of the parts of the dairy unit may be planned in many different ways to suit the production management system and the chosen method of feeding. Some requirements and work routines to consider when the layout is planned are:

1. Movement of cattle for feeding, milking and perhaps to pasture.
2. Movement of bulk feed from store to feeding area, and concentrates from store to milking shed or parlour.
3. Transfer of milk from milking shed or parlour to dairy and then off the farm. Clean and dirty activities, such as milk handling and waste disposal, should be separated as far as possible.
4. The diversion pen, with artificial insemination stalls and any bull pens, should be close to the milking centre because any symptoms of heat or illness are commonly discovered during milking, and cows are easily separated from the rest of the herd when leaving the milking area.
5. Easy and periodical cleaning of accommodation, yards, milking facilities and dairy, and transfer of the waste to storage and then to the fields.
6. Movements of herd workers. Minimum travel to move cows in or out of the milking area.
7. Provision for future expansion of the various parts of the unit.

Milking and milk handling

Hand milking versus machine milking

In developed countries, where labour is scarce and expensive, machine milking has become very widespread and it is also practiced on many large commercial dairy farms in the tropics. Milking machines not only reduce labour requirements and eliminate the drudgery of hand milking but, in most cases, perform a better quality milking operation than would be done by hand.

However, most of the many small dairy farms in developing countries have a surplus of cheap labour, and the number of cows milked at each of them is not sufficient economically to justify the installation of a machine. Furthermore, machines require power and are more expensive to purchase than the few pieces of equipment needed for hand milking. In many developing countries there is an irregular supply of spare parts and a lack of skilled mechanics.

Machine milking gives good quality and operates with a uniform vacuum of 275–350 mm of mercury,

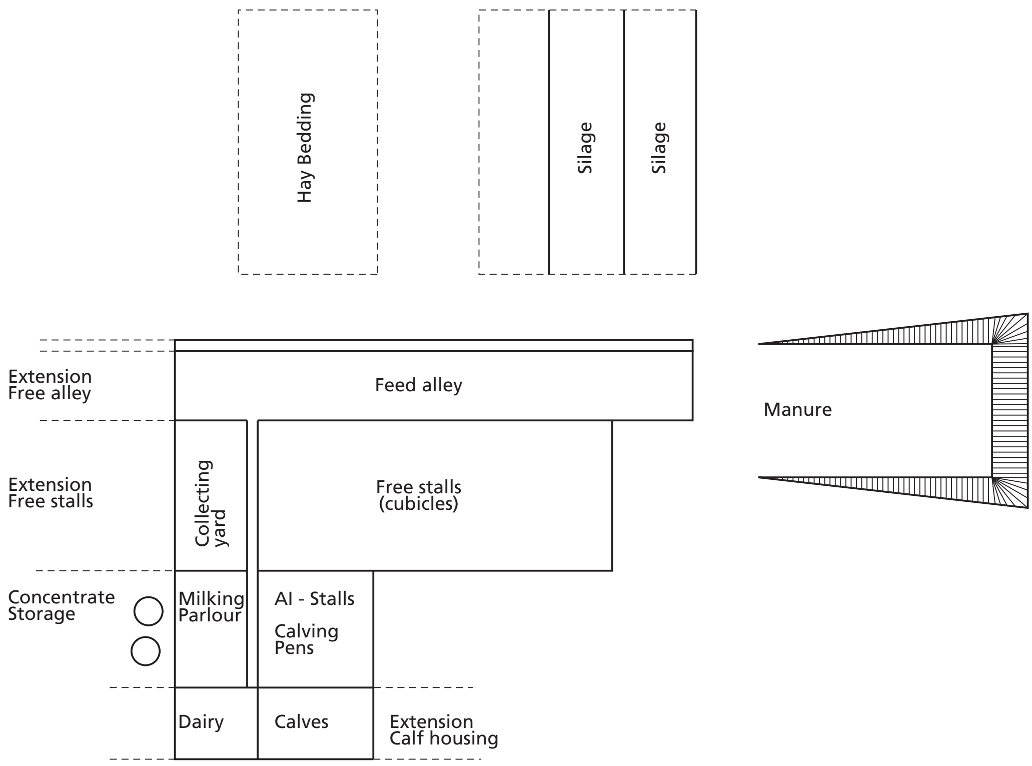


Figure 10.11 **Basic sketch of a layout for a medium- to large-scale dairy unit, showing the relative location of the various parts and a suggestion for extension (not to scale)**

provides a massaging effect on the teats, and is easy to clean. The milking machine simulates nursing by the calf. Two vacuum lines lead to the teat cups. A pulsator supplies an intermittent vacuum to one line at the rate of 45–60 pulses per minute.

The line, connected to the shell of the teat cup, causes the teat inflation (rubber liner) to alternately expand and collapse. This massaging action promotes normal blood circulation in the teat. The second line maintains a continuous vacuum on the teat and carries the milk either to a stainless steel bucket or through a pipeline directly to the milk cooler.

A *bucket milking machine* as shown Figure 10.12 is the simplest and least expensive to install, but the milk must be carried by hand to the cooler. This type of system is often chosen for the small- and medium-size herd and where the cows are milked on a level floor of a stable or milking shed.

The labour of carrying the milk to the cooler can be avoided by installing a transfer system. This consists of a 30-litre receiving tank, including a built-in filter, mounted on wheels so that it can be moved around the stable. It is connected to the cooler with a plastic hose and the milk is drawn to the cooler by vacuum from the milker pump. The hose is reeled in or out as necessary as the cart is moved around the stable.

A *pipeline milking plant* transports the milk through a pipe direct from the cow's udder to the milk cooler. Figure 10.13 illustrates such a system. Pipeline milking systems are usually installed in milking parlours, where the operator stands below the level of the cows.

Although they are expensive, they reduce the backbreaking tasks and are usually designed to be cleaned in place, a feature that not only saves labour but also helps to ensure good sanitation. They may also be installed in stanchion or tie-stall barns but the extra pipeline needed makes the system even more expensive.

Milk room and cooler

Sanitation is the primary consideration in the handling of milk, whether it is from one or two cows belonging to a smallholder or from a commercial herd supplying milk for the city. In either case, an adequate supply of potable water is essential for cleaning the milking equipment immediately after use. Hot water (85 °C), mixed with a chemical detergent, is required for effective cleaning, and cold water is used for rinsing.

Milk should be handled in a separate area that is easy to clean and is free of insects, birds, rodents and dust. A smallholder producing milk only for the household may be able to process, curdle, or consume the milk within a short time so that cooling is not necessary.

Selling milk to the public requires higher standards of sanitation and more elaborate facilities. Whether the cows are hand- or machine-milked, a separate milk room adjacent to the milking stalls or milking parlour is needed. This room should be well ventilated and designed with a concrete floor with a slope of 20 mm/m to a drain and masonry walls with a smooth, water-resistant surface that can be easily and thoroughly cleaned.

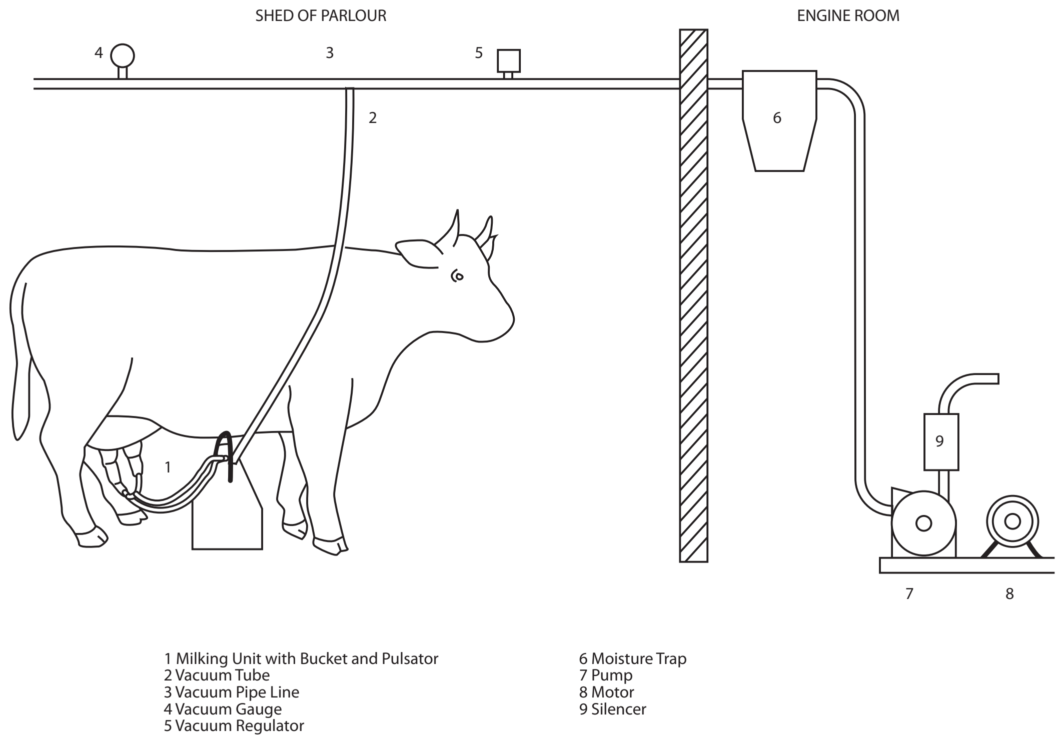
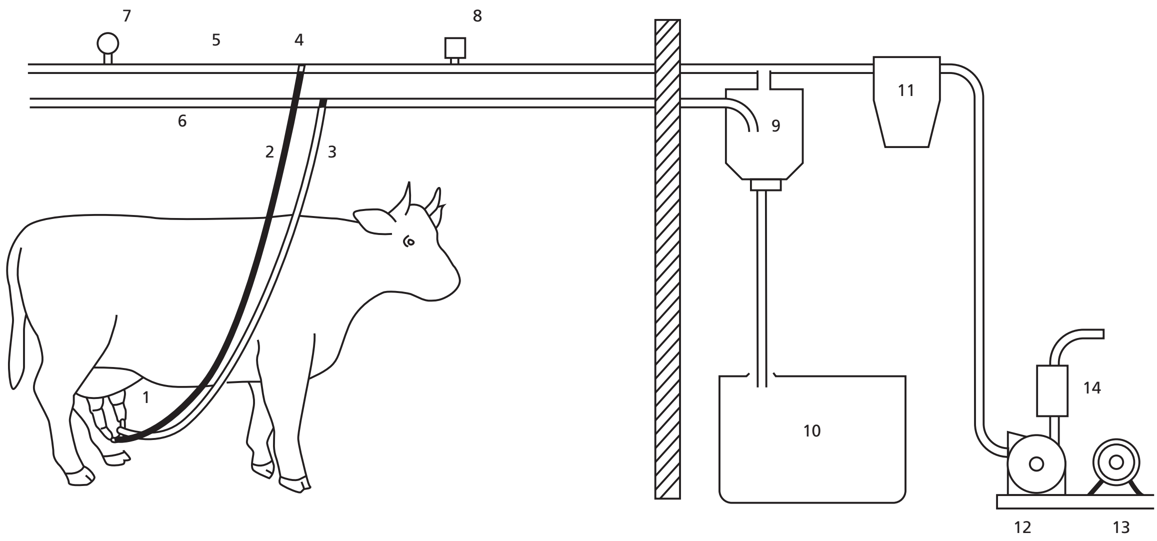


Figure 10.12 **Bucket milking machine**



1 Milking Unit
2 Vacuum Tube
3 Milking Tube
4 Pulsator
5 Vacuum Pipe
6 Milk Pipe
7 Vacuum Meter
8 Vacuum Controller
9 End Unit
10 Milk Tank
11 Vacuum Trap
12 Pump
13 Motor
14 Silencer

Figure 10.13 **Pipeline milking system**

TABLE 10.6
Minimum water requirements for parlour and milk-room washing

	Hot water (at 85 °C) (litres)	Warm water (at 40 °C) (litres)	Cold water (at 4–10 °C) (litres)
Hand milking equipment	10/wash		20/wash
Bucket milking equipment	20/wash		40/wash
Pipeline milking equipment	30/wash		60/wash
Cooling of milk in			2–3 times the
Plate-type milk cooler			amount of milk
Parlour floor wash		$1/m^2$ per day	$3–6/m^2$ per day
Milk-room floor wash		$1/m^2$ per day	$1–3/m^2$ per day
Car wash	3/car		60/car
Bulk tank wash	25–40/wash	20–30/wash	25–35/wash
Miscellaneous	20–50/day		30–100/day

Milk is strained and cooled in this room in preparation for selling. As soon as the cow has been milked, the bacteria in the milk start to multiply, but cooling the milk to about 4 °C within two hours will drastically reduce bacterial growth. However, proper cooling is a very difficult problem for the small-scale producer. The only practical solution for individual farmers in an area may be to bring their milk to a central collection depot for cooling immediately after milking (see Figure 10.14).

On dairy farms of sufficient size and where power is available, the milk can be cooled by cold water circulated between an evaporative water cooler and a milk cooler (plate heat exchanger), through which the milk is passed until it is adequately cooled. Where milk is stored and transported in cans, cooling can be accomplished by immersing the full cans in a water-filled refrigerated cooler or by passing cold water through a coil, which is immersed in the can. Large-scale dairy farms with a pipeline milking system and milk collection by road tanker require a refrigerated cooler and holding tank.

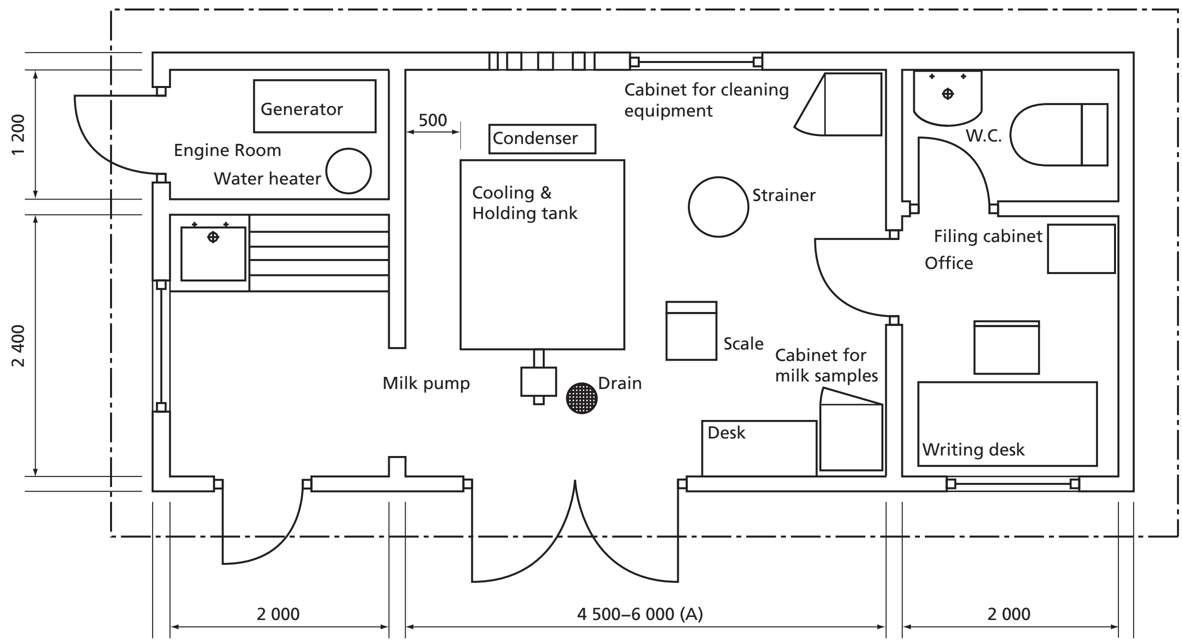


Figure 10.14 **Milk collection centre. The dimensions (A) will vary depending on the capacity of the cooling and holding tank**

Milking parlour for a medium-size herd

For farmers with between 10 and 30 cows and a yard with a paved shade and feed area, the milking parlour shown in Figure 10.15 provides a suitable design. Two stands will be sufficient where the herd numbers 8 to 14, but more stands should be added as indicated when the herd number increases. Hand milking would probably be used for an operation of this size.

If machine milking is installed, the vacuum pump and the engine that powers it can be placed in the engine room, which is indicated in outline in the plan view. This is arranged by closing off a portion of the store room with a simple partition.

A milk cooler will be necessary to cool and hold the milk for pick-up. The milk cooler and facilities for washing and storing the milking equipment will be accommodated in the milk room, while concentrates are kept in the store room.

A milk room should face the prevailing wind to ensure good ventilation and to keep it as cool as possible, but any openings should be screened with insect mesh.

Milking parlour

On commercial farms where several cows are milked at the time, a milking parlour becomes a feasible investment. Several types of milking parlour are in use in dairy regions throughout the world. Figures 10.16a, 10.16b, 10.16c and 10.16d, illustrate some of the most common types.

Any type of parlour should have a high quality concrete floor and metal railings for durability and ease of cleaning. Walls are not required but, if supplied, they should at least be plastered masonry walls. The pit where the milker stands should have a floor level 900 mm below that of the cattle stands to ensure the most comfortable work position.

The number of stands is determined by the allowable milking time of the herd or the time taken to eat the concentrate ration.

Abreast parlour

The abreast parlour allows cows to enter and leave individually. The variation of this parlour shown here, in which the front of the stands can be opened to allow the cows to proceed forward out of the parlour after milking, has proved effective. The main drawback with the abreast parlour is the relatively long distance to walk between milking points, and cows obstructing the herd worker, as they share the same floor space.

The stands should be 1.0 metres to 1.1 metres wide when a bucket milking machine is used or when hand milking is practiced, while 0.7 metres to 0.8 metres is adequate when a pipeline milking system is installed. In both cases, the width for the milker should be 0.6 metres to 0.8 metres. A two-level abreast parlour, in which the milker works at a lower level than the cows, is more difficult to construct and has no great advantage over the single-level type. The abreast parlour has been common in east Africa for herds of more than 40 cows, but its use is decreasing and giving way to the double herringbone parlour.

Tandem parlour

The tandem parlour also allows for individual care of the cows. It is used mostly for smaller commercial

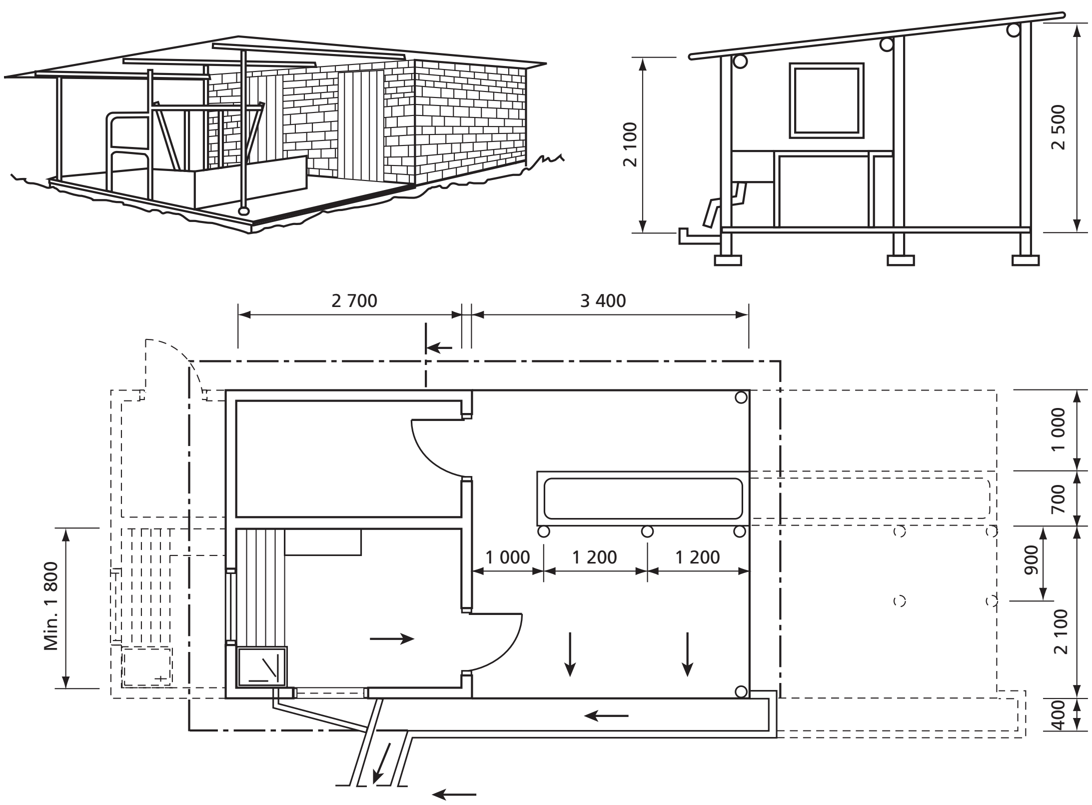


Figure 10.15 **Milking parlour for a medium-size herd**

herds and, in particular, for herds with high-yielding cows. The main drawbacks with this type of parlour are its larger space requirement and more expensive construction when compared with other types of parlour of similar capacity. The parlour capacity in terms of cows milked per hour and labour efficiency compares with that of a small herringbone parlour.

Walk-through parlour

In walk-through or chute parlours, cows enter and leave in batches. They have been used mainly for small herds. Their narrow width can be an advantage where a parlour is to be fitted in an existing building, but it is inferior to other types in most other respects. However, it is cheaper to construct than a tandem parlour.

Herringbone parlour

The herringbone parlour layout results in a compact working area and allows feeders to be fixed to the side walls. Four stands on each side of the pit, as shown in Figure 10.16c, is the minimum size for this type of parlour to ensure high labour efficiency. If the herd has fewer than 80 cows, then a double-three parlour will keep the investment lower, with only a small decline in labour efficiency.

The popularity of the herringbone parlour stems mainly from its simplicity and its high capacity measured in the number of cows milked per staff-hour. (A staff-hour is the equivalent of one person working for one hour). However, the risk of cows kicking the herd worker is greater in the herringbone parlour than in parlours where the person stands alongside the cow.

Double 6-, 8-, 10- and even 12-stand parlours are used for very large herds. Although these larger parlours allow more cows to be milked per hour, because of the need for more workers and the increased waiting time to allow all cows on one side to finish before they are released, the output per staff-hour is usually lower.

Grain feeders

It is advantageous to equip milking parlours with grain feeders that allow each cow to be fed in proportion to her production. As cows are more likely to enter the parlour when they expect to be fed, some labour will be saved. Manual distribution of the concentrates with a measuring scoop is recommended, except in the largest herds. Semiautomatic and automatic systems are expensive to install and require spare parts and mechanics for their maintenance, and these may not be available when needed.

Collecting yard

The cows are normally assembled in a collecting yard (holding area) before milking. This may be a portion of the yard that is temporarily fenced off with chains. The collecting yard should have a minimum size of 1.1 metres to 2.0 metres per cow. Large horned cows

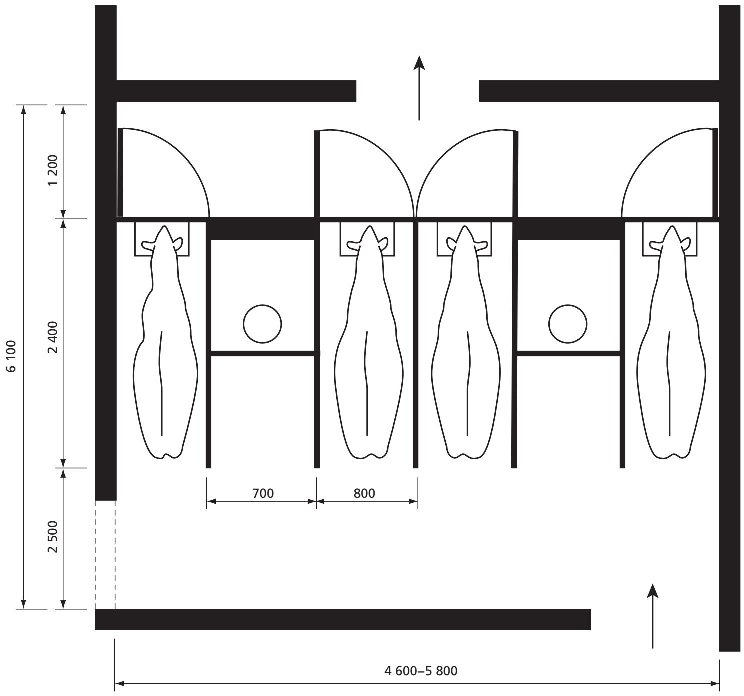


Figure 10.16a **Abreast parlour**

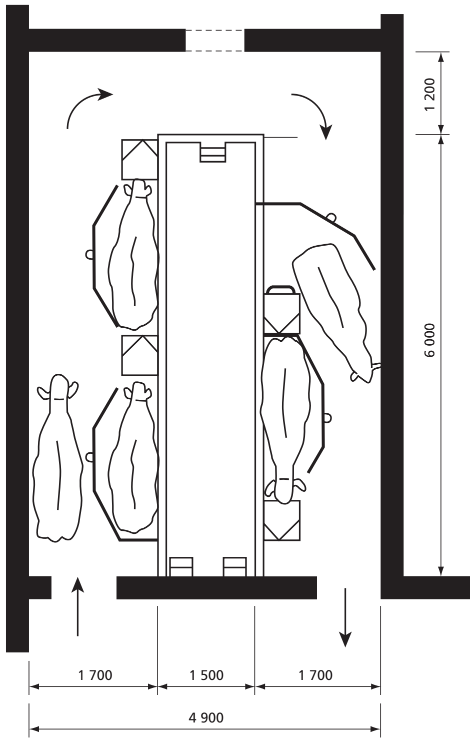


Figure 10.16b **Tandem parlour**

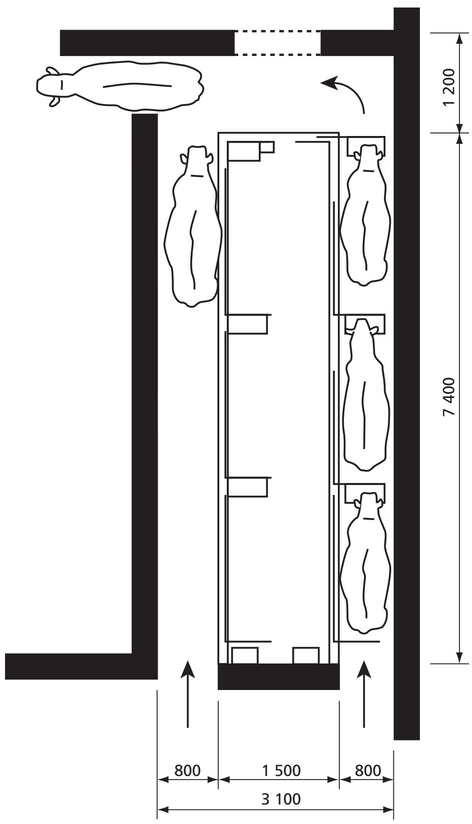


Figure 10.16c **Walk-through parlour**

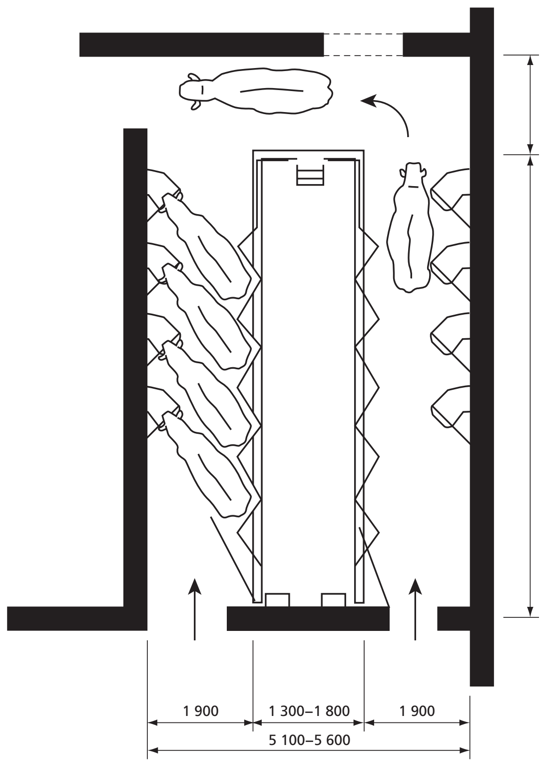


Figure 10.16d **Herringbone parlour**

and a low herd number will require the largest space per cow. Water must be provided for cows waiting their turn to enter the parlour.

The area should slope away from the parlour with an incline of 20–100 millimetres per metre. This not only improves drainage but also encourages the cows to face the entrance. The collecting yard should be paved for easy cleaning and to ensure sanitary conditions in the parlour. A roof is desirable for shade and to avoid wet cows entering the parlour in the rainy season. It will also reduce the amount of rainwater that has to be stored in the manure pit.

Entrance and exit

A straight entrance into the parlour (no turns) ensures smooth and convenient operation. Once trained, cows and heifers will walk readily into the parlour. A single step of about 100 mm will help to keep manure from being carried into the parlour.

An exit leading into an area that is not crowded will facilitate animal flow. A straight exit is desirable but not as important as a straight entry. If exiting alleys are needed they should be narrow (700 mm to 900 mm, depending on cow size), to prevent the cows from turning around.

Feeding equipment

One advantage of loose housing of cattle is the opportunity to construct the feed trough in the fence to allow easy access for filling. The simplest type of manger consists of a low barrier with a rail fixed above. The drawback is that cattle have a tendency to throw feed forward while eating, but a wall in front, as shown in Figure 10.18, will reduce this problem.

The dimensions of the trough must be chosen to conform with the required height, reach and width of the feeding space for the animals to be fed, while providing enough volume for the amount of feed distributed at each feeding time (as shown in Figures 10.17, 10.18 and 10.19).

Although timber construction is simple to install, concrete should be considered because of its greater durability. When timber is used, the base should be well treated with wood preservative. However, the preservative should not be used on any surface that cattle can reach to lick, as some preservative materials are toxic to animals.

When concrete is used, the grade should be at least C20, or a nominal mix of 1:2:4, because a lower grade concrete would soon deteriorate as a result of chemical attack by feedstuffs and the cow's saliva. The cows will press against the barrier before and during feeding, so the head rail must be firmly fixed to the vertical posts, which are set immovably in the ground.

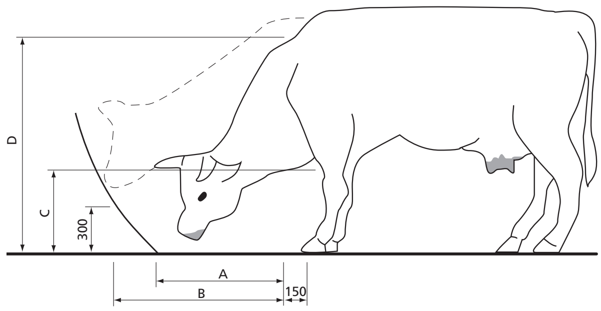
A 2.5 metre-wide concrete apron along the feed trough will reduce the accumulation of mud. A narrow step next to the trough will help to keep the trough free from manure, as animals will not back onto such a step. The bottom of the feed trough should be at a level 100 mm to 400 mm above the level at which the cow is standing with her front feet.

A slightly more elaborate feed trough separates the cattle by vertical rails or tombstone barriers, as shown in Figure 10.19, to reduce competition during eating. The tombstone barrier may also reduce fodder spillage because the cow has to lift her head before withdrawing it from the trough.

A simple roof constructed over the feed trough and the area where the cows stand to eat will provide shade and encourage daytime feeding in bright weather, while protecting the feed from water damage in rainy periods.

Watering equipment

Drinking-water for cattle must be clean. Impurities may disturb the microbiological activities in the rumen. Table 10.7 shows the drinking-water requirement, but a hot environment may considerably increase it. In dairy cows, the need for water will increase with milk yield.



		Calves	Heifers	Mature cows
A	Reach at ground level	550	650	700
B	Reach at 300 mm above ground level	700	850	900
C	Trough height	350	500	600
D	Height to the withers	1 000	1200	1 300
—	Width of feeding space: when all animals feed at once	350–500	500–650	650–750
	Feed always available	100	150	220
—	Level of feed trough bottom above level of stand	50–200	100–300	100–400

Figure 10.17 **Dimensions for feed trough design for cattle**

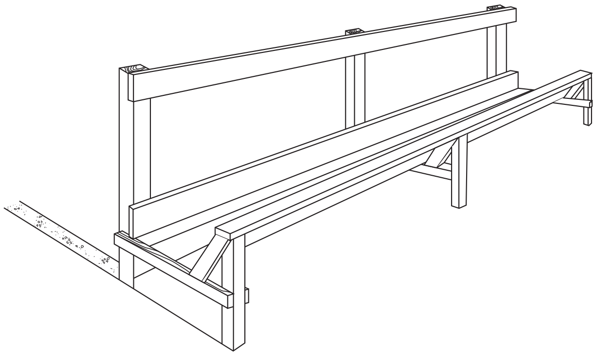


Figure 10.18a **Perspective view of timber feed trough**

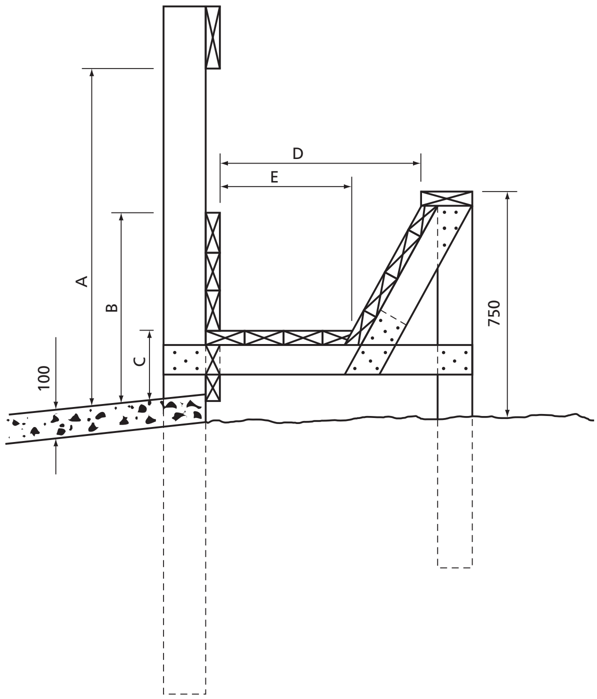


Figure 10.18b **Timber trough**

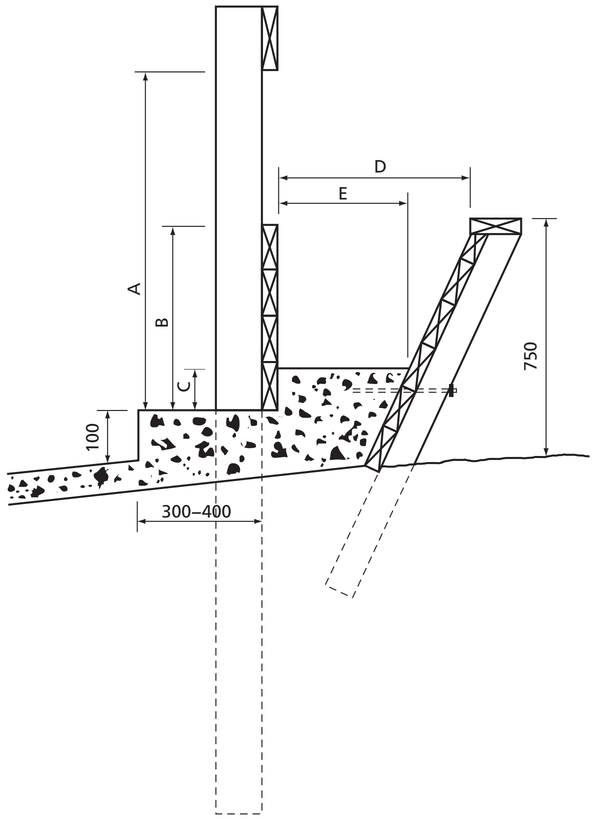


Figure 10.18c **Concrete trough with a step in front of the trough**

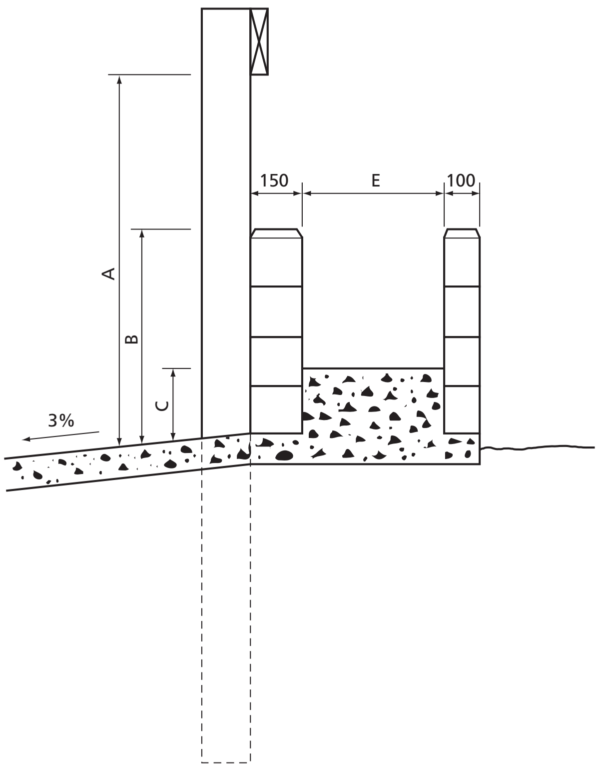


Figure 10.18d **Masonry walls in the trough**

Dimension	Calves	Heifers	Mature cows
A	800–900	900–1 000	1 000–1 200
B	300	400	500
C	50–200	100–300	100–400
D	500–700	650–850	700–900
E	300–550	400 –650	450–700

Figure 10.18 **Simple feed trough**

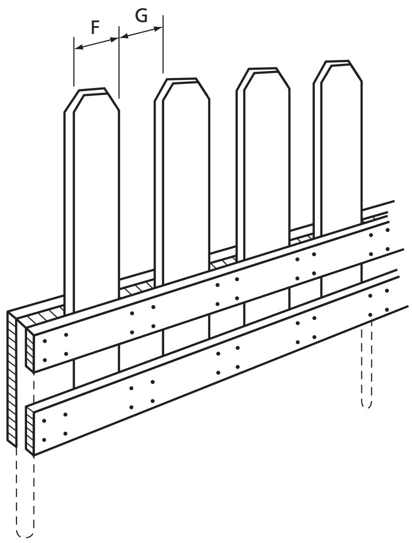


Figure 10.19a **Perspective view**

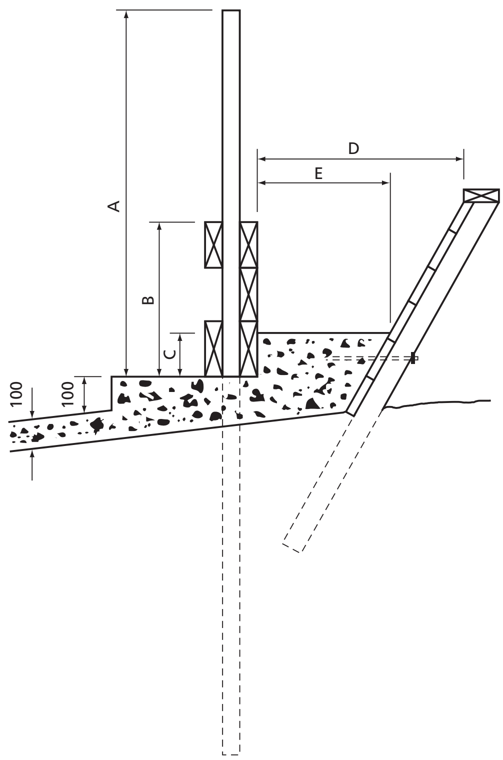


Figure 10.19b **Section**

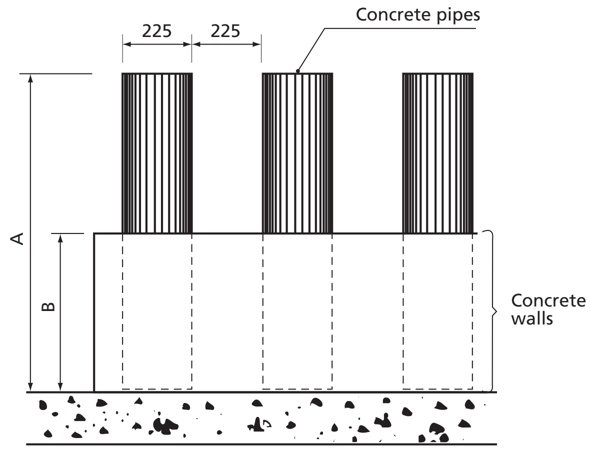


Figure 10.19c **Alternative design**

Figure 10.19 **Tombstone feed fence**

Dimension	Calves	Heifers	Mature cows
A	850–950	1 000–1100	1 100–1 200
B	350	450–500	550
C	50–200	100–300	100–400
D	500–700	650–850	700–900
E	300–550	400–650	450–700
F	150–250	150–450	500
G	130–150	170–200	200

TABLE 10.7
Drinking water requirement for cattle

	Litres/day
Calves	10
Young stock (average)	25 (8–12 per 100 kg body weight)
Heifers	35–45
Beef cows	30–45
Beef cattle	15–30 (30–60 in a hot environment)
Dry dairy cows	40–60
Milking cows	50–100

Water troughs

The size of a water trough depends on whether the herd is taken for watering periodically or is given water on a continuous basis. If water is limited, the length of the trough should be such that all the cows can drink at the same time. A trough space of between 60 cm and 70 cm should be allowed for each cow. For free choice, the trough should be sized for two to three cows at a time. One trough should be provided for every 50 animals. Figures 10.20a and 10.20b show a well-designed trough made of concrete. The length may be increased if necessary.

A float valve installed on the water supply pipe controls the level automatically. A minimum flow rate of 5–8 litres per minute for each cow drinking at any one time is desirable. To prevent contamination of the water trough with manure, the trough should preferably have a 300–400 mm-wide step along the front. The animals will readily step up to drink, but will not back onto the raised area. An alternative is to make the sides facing the cattle sloping, as shown in Figure 10.20c.

Young stock in a loose housing system require one water trough for every 50–60 animals. A 60 cm height is satisfactory. A minimum flow rate of 4–5 litres per minute for each animal drinking at any one time is desirable.

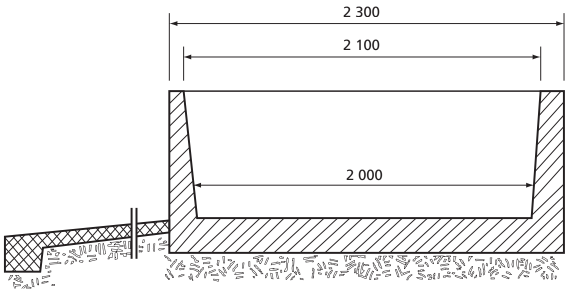


Figure 10.20a **Length section**

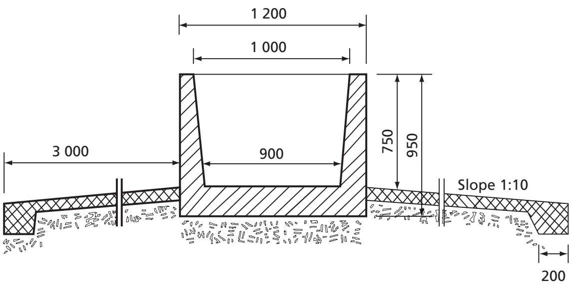


Figure 10.20b **Cross-section (without step)**

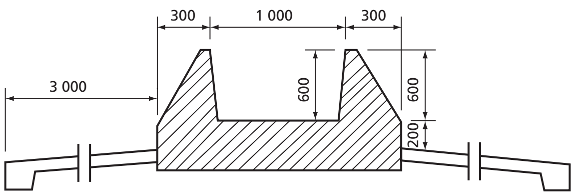


Figure 10.20c **Alternative cross-section**

Figure 10.20 **Concrete water trough**

Automatic drinkers

Automatic drinkers activated by the animals provide a hygienic means of supplying water for cows and young stock (see Figure 10.21). When used in loose housing systems for cows, the bowl should be placed at a height of 100 cm and be protected by a raised area beneath it (1 metre wide and 150–200 mm in height). One bowl should be provided for every 10–15 cows.

A nipple drinker without a bowl provides the most hygienic means of watering for young stock, but most nipples have a limited flow rate and can therefore not be used for calves older than six months.

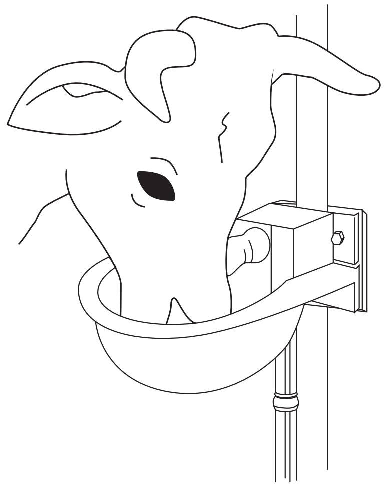


Figure 10.21 **Automatic water drinkers**

Feed handling

The types and quantities of feedstuffs to be handled vary greatly from farm to farm.

Dry hay or forage

If an adequate supply of green forage can be grown throughout the year, then only temporary storage and space for chopping is required. On the other hand, if a prolonged dry season makes it necessary to conserve dry forage, a storage method that will prevent spoilage is essential. A raised slatted floor with a thatched or corrugated steel roof will provide good protection for hay. A simple storage similar to the sunshade shown in Figure 10.4 will be adequate.

If the store is filled gradually, it may help to have some poles in the top of the shed on which to spread hay for final drying before it is packed into the store. Loose hay weighs about 60–70 kg/m^3. Although requirements will vary greatly, a rough guide is 3–5 kilograms of hay or other forage per animal per day of storage.

Silage

Good-quality silage is an excellent feed for cattle. However, it is not practical for the smallholder with only a few cows because it is difficult to make small quantities of silage without excessive spoilage.

Successful silage-making starts with the right crop. The entire maize plant, including the grain, is ideal, as it has enough starch and sugar to ferment well. In contrast, many grasses and legumes do not ferment well unless a preservative, such as molasses, is added as the forage is placed into the silo.

It takes a good silo to make good silage. The walls must be smooth, airtight and, for a horizontal silo, the walls should slope about 1:4 so that the silage packs tighter as it settles. The forage to be made into silage should have a moisture content of about 30–50 percent and must be chopped finely and then packed tightly into the silo. The freshly placed material must be covered and sealed with a plastic sheet. Failure at any step along the way spells disaster.

The large commercial farmer, with well constructed horizontal or tower silos and the equipment to fill them, has the chance to make excellent feed. However, good management is no less important, regardless of size.

Concentrates and grains

Again, the amount to be stored is highly variable. The method of storing is similar to that for food grains, and suitable storage facilities are discussed in Chapter 16.

Manure handling

Careful waste management is needed to:

- utilize the fertilizing qualities of the manure, urine and other waste;
- maintain good animal health through sanitary facilities;
- avoid pollution of air and water and to provide good hygiene around the farmstead.

The method of disposal depends on the type of waste being handled. Solids can be stacked and spread on fields at the optimum time of year, while liquids must be collected in a tank and may be spread from tank-wagons.

Manure from a livestock production unit may contain not only faeces and urine, but also straw or other litter materials, spillage from feeding, and water. If silage is produced on the farm, the runoff from the silos should be led to the urine collection tank. Depending on the wilt, the amount of effluent can vary from 0 m^3 to 0.1 m^3 or more per tonne of silage, but the normal storage allowance is 0.05 m^3 per tonne.

Manure is handled as a solid when the dry matter content exceeds 25 percent. In this condition, the manure can be stacked to a height of 1.5–2 metres. This condition of the manure is obtained only when urine is drained away immediately and a prescribed amount of litter, such as straw or sawdust, is used. The use of 1–2.5 kilograms of litter per cow per day ensures that the manure can be handled as a solid.

Manure with less than 20 percent solids has the consistency of thick slurry. It must be collected in a tank or pit but is too thick to handle effectively with pumps. It must be diluted with water to less than 15 percent solids before it can be pumped with a conventional centrifugal pump. If diluted in order to use irrigation equipment for spreading liquid manure, the content of solids must be below 4 percent.

The amount of manure and the composition vary depending upon factors such as feeding, milk yield, animal weight, position in the lactation period and the health of the animal. Cattle fed on 'wet' silage or grass produce more urine. Table 10.8 shows the manure production in relation to the weight of the animals.

To estimate the volume of manure and bedding, add the volume of manure from Table 10.8 to half the volume of bedding used. Heavy rain requires the removal of liquid for stacked manure during the storage period. The storage capacity must then be increased by about 50 percent, or a roof should be built over the storage for slurry or liquid manure.

Example

Find suitable dimensions for a slurry manure pit with an access ramp, given the following:

Animals: 5 dairy cows 500 kg
Storage period: 30 days
Maximum slope of access ramp: 15%

Storage capacity *(V)* needed (see Table 10.8);

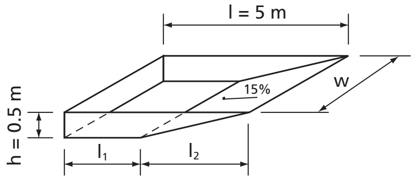
Therefore $V = 5 \times 30 \times 0.055 = 8.25\ m^3$

TABLE 10.8
Manure production in cattle

Weight of animal	Faeces	Urine	Total manure storage capacity to allow for*	
(kg)	(kg/day)	(kg/day)	(kg/day)	(m^3/day)
Dairy cattle				
50	2.7	1.2	3.9	0.004
100	5.2	2.3	7.5	0.009
250	14	6	20	0.025
400	23	10	33	0.045
600	35	1 5	50	0.065
Beef cattle				
350	15	6	21	0.025
450	19	8	27	0.035
550	24	10	34	0.045

* These values are for manure only – no bedding is included. Washing water used in the milking parlour may amount to as much as 300 litres/stall/milking. Usually allow for 50 litres/head/day (normal variation can be as much as ±20 percent of the table figures).

Assume the pit will be 0.5 metres deep and 5 metres long (see sketch)



Total width *(W)* will then be:

$$W = \frac{V}{(l_1 + 0.5 l_2)\,h}$$

$$l_2 = \frac{h}{0.15} = \frac{0.5}{0.15} \approx 3.3 \text{ m}$$

$$l_1 = l - l_2 = 5 - 3.3 = 1.7 \text{ m}$$

$$W = \frac{8.25}{0.5(1.7 + 0.5 \times 3.3)} = 4.9 \text{ m}$$

A pit 5 × 5 × 0.5 metres with an access ramp slope of 15 percent is chosen.

Cattle dips

Ticks continue to be one of the most harmful livestock pests in east Africa. As vectors of animal disease, ticks have been a great hindrance to livestock development, especially in areas where breeds of cattle exotic to the environment have been introduced.

At present the only effective method of control for most of these diseases is to control the vector, i.e. the ticks. Dipping or spraying with an acaricide is the most efficient way of reducing the number of ticks.

Siting a dip

The ground where a dip is to be built, and the area around it, should be slightly sloping and as hard as possible, but not so rocky that a hole for the dip cannot be dug. Laterite (murram) soil is ideal. The ground must support the structure of the dip, be well drained and not become muddy in wet weather. It must also be resistant to erosion or gullying of cattle tracks.

Cattle must not be hot or thirsty when they are dipped, so it is important to have a water trough inside the collecting yard fence.

Waste disposal and pollution

All dipping tanks need to be cleaned out from time to time with disposal of the accumulated sediment. It is normal for all the waste dip-wash to be thrown into a 'waste pit' that is dug close to the dip. In addition, dipping tanks may crack with the resulting leakage of acaricide.

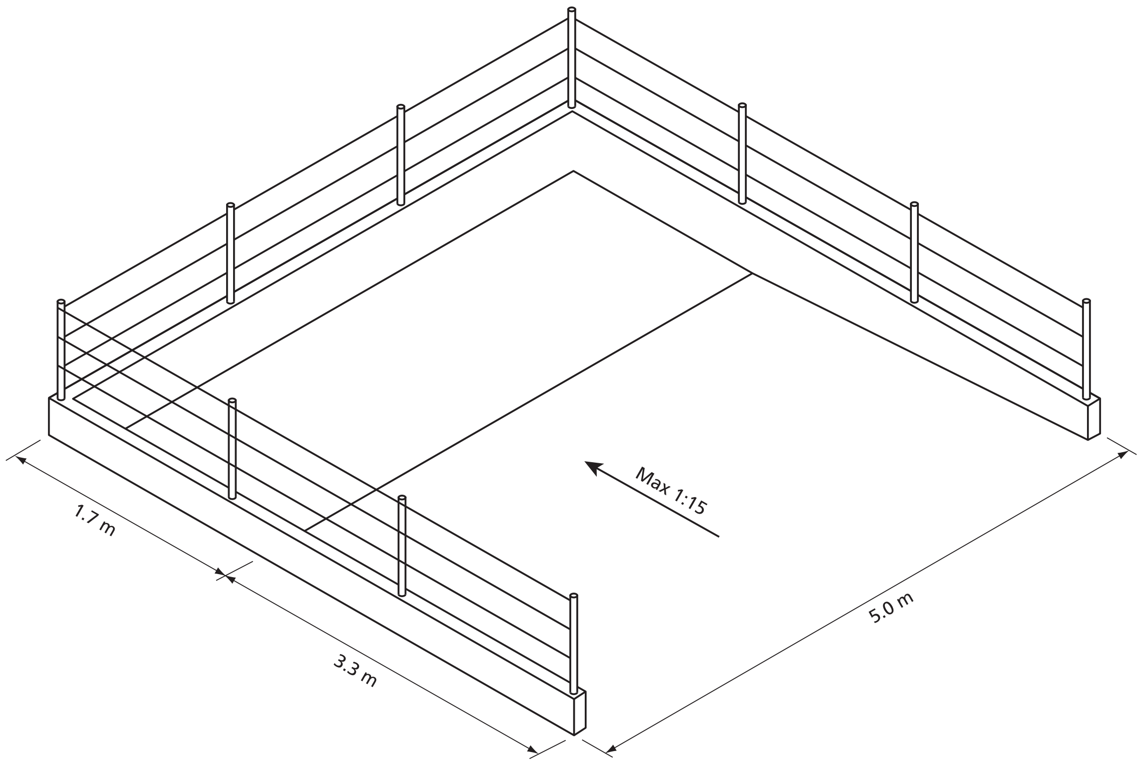


Figure 10.22 **Manure pit with access ramp**

The dip and the waste pit must therefore be sited to ensure that there is no risk of acaricide polluting drinking-water supplies, either by overflowing or by percolating through the ground. The waste pit should be at least 50 metres from any river or stream, 100 metres from a spring or well, and considerably more than that if the subsoil is sandy or porous. Figure 10.23 shows a typical site layout and describes the features in the order that the cattle come to them.

Footbaths

Footbaths are provided to wash mud off the feet of the cattle to help keep the dip clean. At least two are recommended, each 4.5 metres long and 25–30 cm deep but in muddy areas it is desirable to have more. Up to 30 metres total length may sometimes be required (see Figure 10.23). The floors of footbaths should be studded with hard stones set into the concrete to provide grip, and to splay the hoofs apart to loosen any mud between them.

The footbaths should be arranged in a cascade, so that clean water added continuously at the end near the dip overflows from each bath into the one before it, with an overflow outlet to the side near the collecting pen. Floor-level outlet pipes from each bath can be opened for cleaning. If the supply of water is extremely limited, footbath water can be collected in settling tanks and reused later.

Jumping place

A narrow, steep flight of short steps ensures that:

- animals can grip and jump centrally into the dip;
- their heads are lower than their rumps at take-off;
- they jump one at a time;
- dip-wash splashing backwards returns to the dip.

The lip of the jumping place experiences extreme wear and should be reinforced with a length of 10 cm-diameter steel pipe.

Figure 10.24 shows the jumping place 40 cm above the dip-wash level. While such a height is desirable to give maximum immersion, there could be some danger to heavily pregnant cows if the water level should fall a further 40 cm. (The dipping of 1 000 cattle without replenishment would lower the water level to 60 cm below the jumping place.)

Splash walls and ceiling are provided to catch the splash and prevent the loss of any acaricide. The ceiling protects the galvanized roof from corrosion. The walls can be made of wood, but masonry is more durable.

The dipping tank

The dipping tank is designed to a size and shape to fit a jumping cow and allow her to climb out, while economizing as far as possible on the cost of construction and the recurrent cost of acaricide for refilling. A longer tank is needed if an operator standing on the side is to have a good chance of reimmersing the heads of the animals while they are swimming, and increased volume can slightly prolong the time until

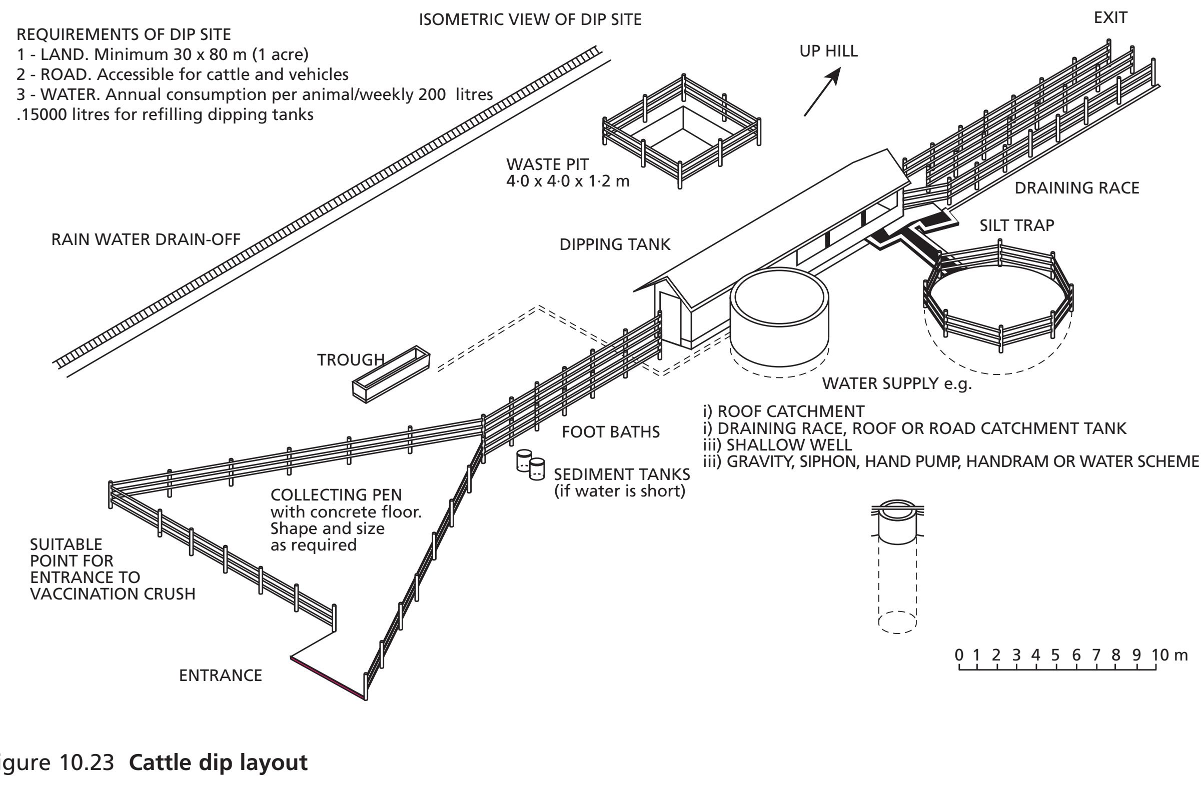


Figure 10.23 **Cattle dip layout**

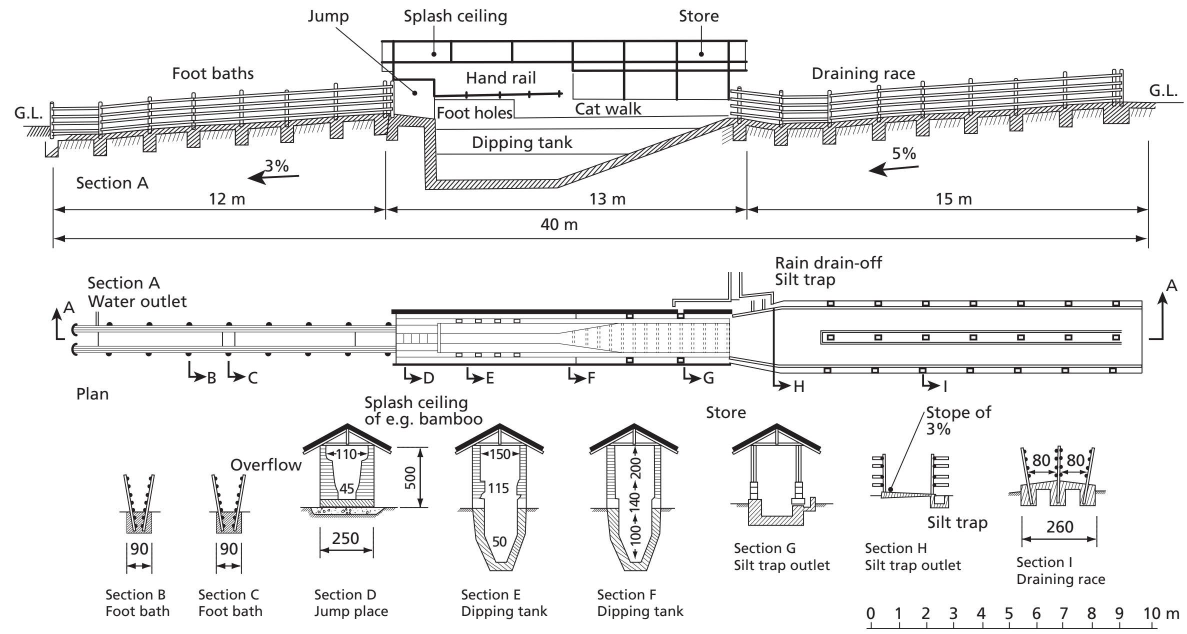


Figure 10.24 **Cattle dip**

the dip must be cleaned out. In areas with cattle of the 'Ankole' type with very long horns the dip-tank needs to be much wider at the top.

Poured reinforced concrete is the best material to use in constructing a dipping tank in any type of soil. While it is expensive if only a single tank is to be built because of the cost of the formwork involved, the forms can be reused. If five tanks are built with one set of forms, the cost per tank is less than the cost of building with other materials, such as concrete blocks or bricks. A reinforced concrete dipping tank is the only type with a good chance of surviving without cracking in unstable ground. In areas prone to earthquakes, a one-piece tank is essential.

Catwalks and handrails are provided to allow a person to walk between the splash walls to rescue an animal in difficulty. In addition to providing shade, a roof over the dipping tank reduces evaporation of the dip-wash, prevents dilution of the dip-wash by rain, and in many cases, collects rainwater for storage in a tank for subsequent use in the dip.

Draining race

The return of surplus dip-wash to the dipping tank depends on a smooth, watertight, sloping floor in the draining race. A double race reduces the length and is slightly cheaper in materials, but a very long single race is preferable where large numbers of cattle are being dipped.

Side-sloping of the standing area towards a channel or gutter increases the backflow rate. The total standing area of the draining race is the factor that limits the number of cattle that can be dipped per hour, and the size shown in the drawings should be taken as the minimum.

A silt trap allows settling of some of the mud and dung from the dip-wash flowing back to the tank from the draining race. The inlet and outlet should be arranged so that there is no direct crossflow. Provision must be made to divert rainwater away from the dip.

Cattle spray race

A spray race site requires the same features as a dip site and these have already been described. The only difference is that the dip tank has been changed for a spray race. The race consists of an approximately 6-metre long and 1-metre wide tunnel with masonry side walls and a concrete floor. A spray-pipe system with a length of 3–3.5 metres in the tunnel with 25–30 nozzles placed in the walls, ceiling and floor, discharges dip liquid at high pressure and exposes the cattle passing through to a dense spray.

The fluid is circulated by a centrifugal pump giving a flow of 800 litres per minute at 1.4 kg/cm^2 pressure. Power for the pump can be supplied by a 6-horsepower to an 8-horsepower stationary engine, a tractor power take-off, or a 5-horsepower electric motor. The discharged fluid collected on the floor of the tunnel and draining race is led to a sump and recirculated.

In addition to being cheaper to install than a dipping tank, the spray race uses less liquid per animal and operates with a smaller quantity of wash, which can be freshly made up each day. Spraying is quicker than dipping and causes less disturbance to the animals. However, spray may not reach all parts of the body efficiently or penetrate long hair. The mechanical equipment used requires power, maintenance and spare parts, and the nozzles tend to become clogged and damaged by horns.

Hand-spraying is an alternative method that can work well if carried out by an experienced person on an animal properly secured in a crush. The cost of the necessary equipment is low, but the consumption of liquid is high as it is not recirculated. The method is time-consuming and therefore only practicable for small herds where there is no communal dip tank or spray race.

PIG HOUSING

Pig farming is relatively unimportant in most regions of Africa, as in most tropical countries except China and South-East Asia. However, pig production is increasing in many tropical countries as processed pork finds an increasing market, and pig production yields a relatively rapid rate of return on the capital employed. Pigs are kept primarily for meat production, but the by-products, such as pigskin, bristles and manure, are also of economic importance. To some extent, pigs compete with humans for food, but they can also utilize by-products and human food waste.

Management improvements

In many tropical countries pigs roam freely as scavengers or are raised in the backyard where they depend on waste for feed. Little attempt is made to obtain maximum productivity. However, a few simple management practices can help to improve the productivity and health of these pigs. They include:

1. Fenced paddocks with shade and water where:
   - (a) Pigs are protected from direct sun, which will cause sunburn and sometimes sunstroke, particularly with white-skinned pigs.
   - (b) Pigs can be fed supplementary feed secure from neighbouring pigs.
   - (c) Some basic measures to control disease and parasites are possible to reduce the often very high mortality rate and to improve the poor reproductive and growth performance and inferior quality of meat found in traditional pig production in the tropics. The paddock can be subdivided into four to six smaller areas to enable pigs to be moved from one enclosure to another at two-week intervals.
   - (d) Sows can be bred to selected sires.

2. Simple semicovered pens constructed of rough timber with a thatched roof and concrete floor, as shown in Figure 10.25. An earth floor can be used, but is more difficult to keep clean and sanitary. Several pens can be arranged in a row as required. The main disadvantage with this type of accommodation is the relatively high labour requirement for cleaning.

3. Wallows or sprinklers can be provided to alleviate heat stress. Being unable to sweat sufficiently, pigs have a natural instinct to wallow to increase the evaporative cooling from the skin.

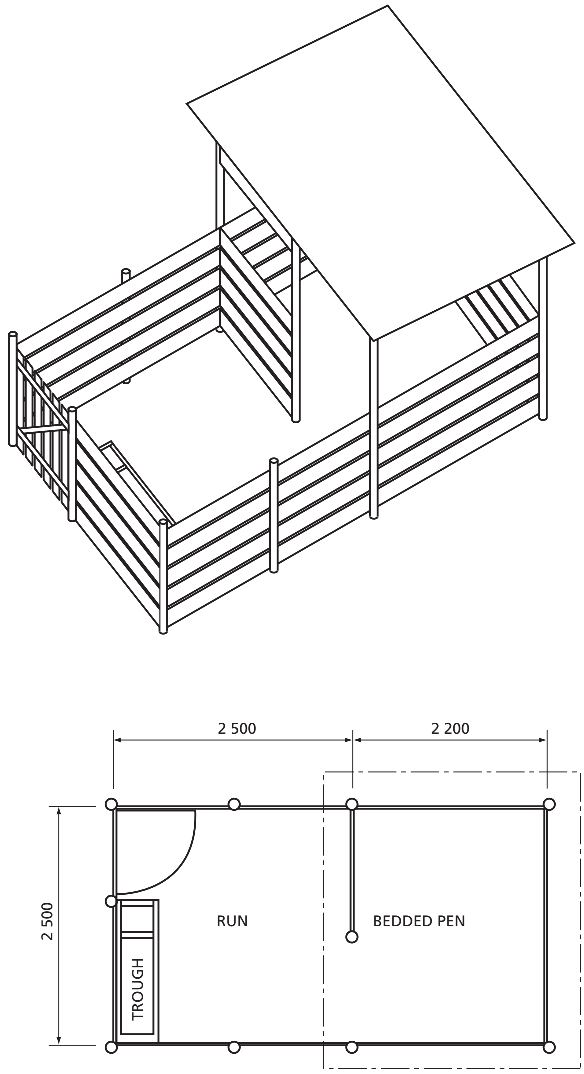


Figure 10.25 **Smallholder's pigsty for one sow with litter, or four to five fattening pigs**

While such improvements have the advantage of low investment in buildings and less need for balanced-feed rations, they should only be regarded as first steps in raising the general level of the present primitive systems.

Raising pigs in confinement is gradually replacing the old methods because of lower production costs, improved feed efficiency and better control of disease and parasites. The confinement system is therefore usually advisable in circumstances where:

- good management is available;
- high quality pigs are introduced;
- farrowing occurs at regular intervals throughout the year;
- land is scarce or not accessible all the year;
- balanced rations are available;
- labour is expensive;
- parasite and disease control is necessary;
- the target is commercial production;
- the herd size is reasonably large.

Some systems keep only part of the herd in confinement. The order of priority for confinement housing for the different classes of animal is usually as follows:

1. Growing/finishing pigs (25–90 kg or more live weight) for higher control of daily gain, better feed conversions and parasite control.
2. Farrowing and lactating sows, to reduce preweaning mortality and for higher quality weaners.
3. Gestating sows, to allow individual feeding and better control of stock.

Management systems in intensive commercial pig production

There is no standard type or system of housing for pigs. Instead, accommodation and equipment are selected to suit the type of management system adopted. However, there are certain similar principles and practices in most systems. These stem from the fact that most pig units will contain pigs of different ages and classes, as shown in Figure 10.26.

Farrowing/suckling pens

In small- and medium-scale intensive pig production units, a combined farrowing, suckling and rearing pen is normally used. The sow is brought to this pen one week before farrowing and stays there, together with her litter, for five to eight weeks, when the piglets are weaned by removing the sow. The sow is often confined in a farrowing crate a few days before, and up to a week after, birth to reduce piglet mortality caused by overlaying or trampling (see Systems I and II in Figure 10.27).

Early weaning after a suckling period of five to six weeks, or even less, can only be recommended where management and housing is of good standard.

The piglets remain in the farrowing pen after weaning and until they are 12–14 weeks of age, or weigh 25–30 kilograms.

Group keeping of farrowing/suckling sows that have given birth within a two- to three-week interval is possible, but is unusual in intensive production. However, there are few acceptance problems, and the litters cross-suckle and mix freely. The pen should have at least 6 square metres of deep litter bedding per sow, with an additional creep area of 1 metre.

In a large-scale unit with a separate farrowing house, sometimes one of the following two alternative systems is used instead of the system described before.

The first alternative (System III in Figure 10.27) is similar to the system already described, but the piglets are moved two weeks after weaning to a weaner pen, where they may remain either until they are 12–14 weeks of age (25–30 kilograms) or until 18–20 weeks of age (45–55 kilograms). Note that the piglets should always remain in the farrowing/suckling pen for a further one to two weeks after the sow has been removed to avoid subjecting them to any new environmental or disease stress while they are being weaned. The weaning pens can contain one litter or 30–40 pigs. The pigs are often fed *ad libitum*.

In the second alternative (System IV in Figure 10.27), the sow is placed in a farrowing crate in a small pen one week prior to birth. Two weeks after farrowing, the sow and the litter are moved to a larger suckling pen. The piglets may remain in this pen until 12–14 weeks of age, or they are transferred to weaner accommodation two weeks after weaning.

Dry sow pens

After weaning, a sow will normally come on heat within five to seven days and thereafter at three-week

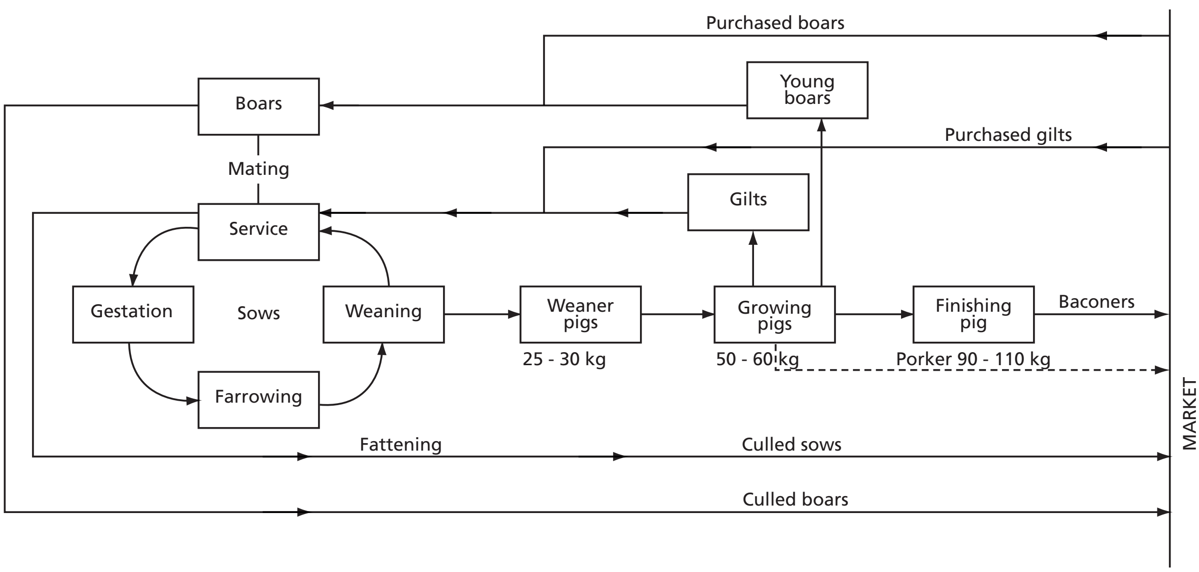


Figure 10.26 **Flowchart of the life cycle of pigs**

intervals until successful mating. The average weaning-to-conception interval can vary between 8 days and 20 days depending on management. If the period until pregnancy has been ascertained, the sow is best kept in a pen or stall in close proximity to the boar pen.

Gestating sows are kept in yards or pens in groups of 10–12 sows that will farrow within a two- to three-week interval. They can also be kept in individual pens confined in stalls or tethered in stalls.

Weaner and fattening pens

The weaners, whether they come from a farrowing pen or a weaner pen, at 12–14 weeks of age will be sufficiently hardened to go to a growing/finishing pen. Finishing can be accomplished either in one stage in a growing/finishing pen from 25 kg to 90 kg (Systems I and IV in Figure 10.27 – or in two stages so that the pigs are kept in a smaller growing pen until they weigh 50–60 kg and are then moved to a larger finishing pen, where they remain until they reach marketable weight (System II in Figure 10.27).

In large-scale production, the pigs are arranged into groups of equal size and sex when moved into the growing/finishing pen. Although finishing pigs are sometimes kept in groups of 30 or more, pigs in a group of 9–12, or even less, show better growth performance in intensive systems. An alternative, where growing and finishing are carried out in the same facility, is to start about 12 pigs in the pen and later, during the finishing period, reduce the number to nine by taking out the biggest or smallest pigs from each pen.

Replacement pens

In intensive systems a sow will, on average, produce three to six litters before it is culled owing to infertility, low productivity or age. Young breeding stock should be separated from the rest of the litter at about three months of age, because they should be less intensively fed than the fattening pigs.

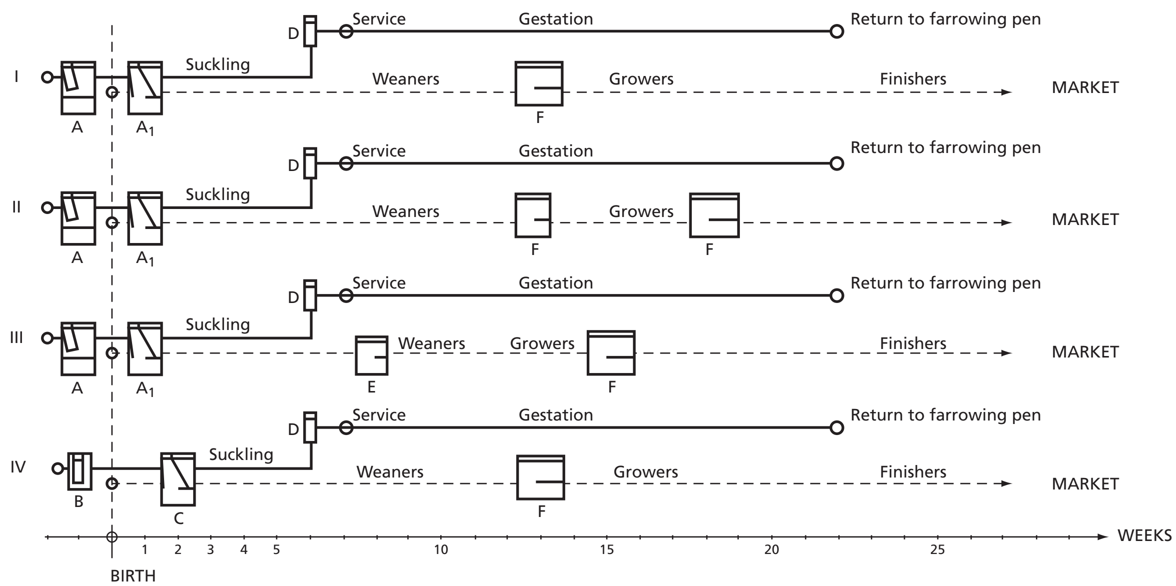
Gilts are first mated when they are seven to nine months of age, or weigh 105–120 kg. After mating, they can either be kept in the same pen up to one week before farrowing, or kept in the gestating sow accommodation, but in a separate group.

Boars in the tropics are usually quiet if run with other boars or with pregnant sows, but may develop vicious habits if shut up alone.

Determining the number of pens and stalls required in a pig unit

One objective of planning a pig unit is to balance the accommodation between the various ages and numbers of pigs. Ideally, each pen should be fully occupied at all times, allowing only for a cleaning and sanitation period of about seven days between successive groups.

In the following example, we determine the number of different pens required in a 14-sow herd where eight-week weaning is practiced.



A - Combined farrowing suckling pen (A_1 - after the crate has been opened or removed);
B - Specialised farrowing pen;
C - Suckling pen;
D - Gestation accommodation;
E - Pen for weaners;
F - Growing/finishing pen

Figure 10.27 **Flowchart of four different pig production management systems**

1. Determine the farrowing interval and number of farrowings per year.

Average weaning-to-conception interval	20 days
Gestation	114 days
Suckling period (7 × 8 weeks)	56 days
Farrowing interval	190 days

Number of farrowings per sow per year: 365 / 190 = 1.9

2. Determine the number of farrowing pens.

The piglets remain in the farrowing pen until 12 weeks of age.

Before farrowing	7 days
Suckling period	56 days
Rearing of weaners	28 days
Cleaning and sanitation of pen	7 days
Occupation per cycle	98 days

Thus one farrowing pen can be used for:
365 / 98 = 3.7 farrowings per year.

A 14-sow herd with an average of 1.9 farrowings per sow per year requires (14×1.9) / 3.7 = 7 farrowing pens.

3. Determine the number of servicing/gestating pens.

Average weaning-to-conception interval	20 days
Gestation period minus 7 days in farrowing pen	107 days
Cleaning and sanitation of pen	7 days
Occupancy per cycle	134 days

Thus one place in the servicing/gestation accommodation can be used for: 365/134 = 2.7 farrowings per year.

With a total of 27 farrowings a year, then 27/2.7 = 10 places would be required.

4. Determine the number of places for replacement stock.

Assuming that the sows have an average of five litters, then 20 percent of all litters will be from gilts.

Rearing of breeding stock (12–35 weeks)	168 days
Gestation period minus 7 days in farrowing pen	107 days
Cleaning and sanitation of pen	7 days
Occupancy per cycle	282 days

About 30 percent more animals are separated than the required number of gilts, therefore the required number of places in a 14-sow herd will be:

(14× 1.9 × 0.2×1.3 ×282) / 365 = 6 places

5. Determine the number of places in the growing/finishing accommodation:

One-stage finishing:	
Fattening of pigs 12–27 weeks of age (25–90 kg)	105 days
Extra period for last pig in the pen to reach marketable weight	21 days
Cleaning and sanitation of pen	7 days
Occupancy per cycle	133 days

Assuming that eight pigs per litter will survive to 12 weeks of age, the number of places required in the finishing accommodation will be:

(14 × 1.9 × 8 × 133) / 365 = 78

That is eight pens with 10 pigs in each, or 10 pens if each litter is to be kept together.

Two-stage growing/finishing unit:
Growing pigs 12–20 weeks of age will occupy a growing pen for 63 days, including 7 days for cleaning. Thus:

(14 × 1.9 × 8 × 63) / 365 = 37 places are required in the unit.

Finishing pigs 20–27 weeks of age will occupy a finishing pen for 70 days, including 14 days for the emptying period and 7 days for cleaning. The emptying period will be shorter if the pigs are sorted for size while being transferred from the growing to the finishing pens. Therefore:

(14 × 1.9 × 8 × 70) / 365 = 41 places are required in the unit.

From the above example it will be appreciated that the number of pens of various kinds required in a pig unit is based on a number of factors. Therefore it is not possible to lay down hard and fast rules about the relative number of pens and stalls. However, a guideline to the requirement of pens in herds with average or good management and performance in tropical conditions is given in Appendix VI.

Space requirement

In intensive pig production systems, all pigs should be raised on concrete floors to ensure a clean and sanitary environment. In semi-intensive systems, a concrete floor is used only in the pens for finishing pigs and perhaps in the farrowing pens, whereas an earth floor or deep-litter bedding is used in other pens and yards. Litter may or may not be used on a concrete floor, but its use is desirable, particularly in farrowing pens.

The cost of a concrete floor is relatively high, resulting in a tendency to reduce the floor area allowed per animal. However, excessively high stocking densities could retard performance, increase mortality, health and fertility problems, and result in a high frequency of abnormal behaviour, endangering the welfare of the animals. An increase in the stocking density must be accompanied by an increased standard of management and more efficient ventilation and cooling.

In particular, to aid cooling, finishing pigs kept in a warm tropical climate should be allowed more space in their resting area than is normally recommended for pigs in temperate climates. Table 10.9 lists the recommended space allowance per animal at various stocking densities. The figures listed for high stocking density should only be used in the design of pig units in cool areas and where the management level is expected to be above average.

The dimensions of a pen for fattening pigs are largely given by the minimum trough length required per pig at the end of their stay in the pen (see Table 10.10). However, the width of a pen with low stocking density can be larger than the required trough length. This will reduce the depth to 2.0–2.4 metres, and run the risk of having the pigs create manure within the pen.

TABLE 10.9
Dimensions and area of various types of pig pen

	Units	Stocking density		
		Low	Medium	High
A. Farrowing/suckling pen.				
Resting area, if weaner pens are not used	m^2	10.0	7.5	6.0
Resting area, if weaner pens are used	m^2	8.0	6.0	5.0
Manure alley width	m	1.7	1.5	1.3
Farrowing pen (System IV)	m^2	-	4.5	4.0
Farrowing crate, length excluding trough	m	2.0	2.0	2.0
Width depending on size of sow	m	0.65–0.75	0.6–0.7	0.55–0.65
Free space behind the crate	m	0.4	0.35	0.3
Piglet creep (incl. in resting area)	m^2	2.0	1.5	1.0
B. Boar pen				
1. Pen with yard				
Resting area (shaded)	m^2	6	5	4.5
Yard area (paved)	m^2	12	10	08
2. Pen without yard	m^2	9	8	7
C. Gestating sow pens				
1. Loose in groups of 5–10 sows				
Resting area (shaded)	m^2	2.0	1.5	1.1
Yard area (paved)	m^2	3.5	3.0	2.5
Feeding stalls, depth by width	m	2.0 × 0.6	1.8 × 0.55	1.7 × 0.5
2. Individual stalls with access to manure alley, length of stalls excluding trough	m	2.2	2.1	2.0
Width of stalls	m	0.65–0.75	0.60 – 0.70	0.55–0.65
Width of manure alley	m	1.5	1.4	1.3
3. Confined in individual stalls length by width of stalls	m	2.2 × 0.70	2.1 × 0.65	2.0 × 0.60
D. Weaner pen (to 25 kg or 12 weeks)				
Resting area excluding trough	m^2/pig	0.35	0.30	0.25
Manure alley width	m	1.0	1.0	1.0
E. Growing pen (to 40 kg or 17 weeks)				
Resting area excluding trough	m^2/pig	0.5	0.45	0.40
Manure alley width	m	1.1	1.1	1.1
F. Finishing pen, resting area excluding trough				
For porkers (to 60 kg or 21 weeks)	m^2/pig	0.70	0.60	0.50
For baconers (to 90 kg or 27 weeks)	m^2/pig	0.90	0.75	0.60
For heavy hogs (to 120 kg or 33 weeks)	m^2/pig	1.0	0.85	0.70
Manure alley width	m	1.2–1.4	1.2–1.3	1.2

Furthermore, this increases flexibility in the use of the pen and the extra trough space allows additional animals to be accommodated temporarily or when the level of management improves.

Sometimes finishing pens are deliberately overstocked. The reason for this is that all pigs in the pen will not reach marketable weight at the same time and the space left by the pigs sent for slaughter can be utilized by the remainder. Such overstocking should be practiced only in very well managed finishing units.

TABLE 10.10
Minimum trough length and height of partitions in various types of pig pen

		Minimum trough length	Minimum height of pen partitions
		m/pig	m
Sow in farrowing pen		0.7	1.0
Loose dry sows in pens		0.5	1.0
Stall for dry sows		0.5	1.0
Boars		0.6	1.2
Piglets	10 kg	0.14–0.15	0.6
Piglets	15 kg	0.16–0.17	0.7
Pigs	25 kg	0.18–0.20	0.8
Pigs	40 kg	0.22–0.24	0.9
Pigs	60 kg	0.25–0.27	0.9
Pigs	90 kg	0.30–0.32	0.9
Pigs	120 kg	0.35–0.37	1.0

General requirements for pig housing

A good location for a pig unit meets the following requirements: easy access to a good all-weather road; well-drained ground; and sufficient distance from residential areas to avoid creating a nuisance from odour and flies.

An east-west orientation is usually preferable to minimize exposure to the sun. Breezes across the building in summer weather are highly desirable. A prevailing wind during hot weather can sometimes justify a slight deviation from the east-west orientation. Ground cover, such as bushes and grass, reduces the reflected heat considerably, and the building should be located where it can benefit most from surrounding vegetation. A fairly light, well-drained soil is preferable, and usually the highest part of the site should be selected for construction.

Pig houses should be simple, open-sided structures because maximum ventilation is needed. A building for open confinement is therefore essentially a roof carried on poles. The roof supporting poles are placed in the corners of the pens where they will cause least inconvenience. A free-span trussed roof design would be an advantage but is more expensive.

In some circumstances it may be preferable to have solid gable ends and one enclosed side to give protection from wind or low temperatures, at least for part of the year. If such walls are needed, they can often be temporary and be removed during hot weather to allow maximum ventilation. Permanent walls must be provided with large openings to ensure sufficient air circulation in hot weather. If there is not sufficient wind to create a draught in hot weather, ceiling fans can improve the environment considerably.

The main purpose of the building is to provide shade, and therefore the radiant heat from the sun should be reduced as much as possible. In climates where a clear sky predominates, a high building of three metres or more under the eaves gives more efficient shade than a low building. A wide roof overhang is necessary to ensure shade and to protect the animals from rain.

A shaded ventilation opening along the ridge will provide an escape for the hot air accumulating under the roof. If made from a hard material, the roof can be painted white to reduce the intensity of solar radiation. Some materials, such as aluminium, reflect heat well provided that they are not too oxidized.

A layer of thatch (5 cm), attached by wire netting beneath a galvanized steel roof, will improve the microclimate in the pens. A roof of thatch is excellent in hot climates, particularly in non-confined systems, but cannot always be used because of the fire hazard and because it attracts birds and rodents. A pig house with two rows of pens and a central feeding alley would require a ridge height of 5–6 metres if covered with thatch.

The pen partitions and the 1-metre wall surrounding the building, which serves to reduce heat reflected from the surrounding ground, can be made of concrete blocks or burnt clay bricks for durability, or perhaps soil-cement blocks, plastered for ease of cleaning. Regular whitewashing may improve the sanitary conditions in the pens.

Doors have to be tight-fitting and any further openings in the lower part of the wall surrounding the building should be avoided in order to exclude rats. Apart from stealing feed and spreading disease, large rats can kill piglets.

For all types of confinement housing, a properly constructed, easily cleaned concrete floor is required. A 80–100 mm layer of concrete on a consolidated gravel base is sufficient to provide a good floor. A stiff mix of 1:2:4 or 1:3:5 concrete, finished with a wood float, will give a durable non-slip floor. The pen floors should slope 2–3 percent towards the manure alley, and the floor in the manure alley should slope 3–5 percent towards the drains.

Housing for a small-scale pig unit

For units with 2–15 sows, specialized buildings for the various stages of production may not be practical or desirable. For the smallest units of two to six sows, a kind of universal pen can be erected about 2.7 metres wide and 2.8–3.0 metres deep (including feed trough), which can be used for:

1. one sow and her litter; or
2. one litter of weaned piglets; or
3. up to four gestating sows; or
4. growing/finishing pigs up to 90 kg live weight or 1 boar.

This type of pen, shown in Figure 10.28, provides a high degree of flexibility but usually does not allow such efficient use of the building space as the more specialized pens.

When used for farrowing, the pen should be adapted with guard rails 25 cm above floor level and 25 cm from the wall to protect the piglets from being crushed, as shown in Figure 10.28b. However, confinement farrowing is one of the most efficient ways of reducing piglet losses. An arrangement with fixed or removable rails, which divide the pen, as shown in Figure 10.28c, will offer some degree of confinement.

In some climates it may be desirable to give sows with litter access to exercise yards. However, for the relatively short suckling period (six to eight weeks), it is usually considered best to keep the sows confined in pens with their litters.

A creep for the piglets is arranged in one corner of the pen. It is recommended to construct a temporary ceiling (e.g. wire netting covered with straw) 50–60 cm above the floor in the creep area to prevent draughts and to ensure warmer temperatures for the piglets during their first weeks of life. Where electricity is available, heating with an infrared lamp may be used instead. Piglets are fed in the creep area out of reach of the sow.

Figure 10.29 shows a single-row pig unit for two sows and fattening pigs, and Figure 10.30 shows a double-row pig unit for four sows with a central feeding alley. The semicovered manure alleys are arranged along the outside walls, separated from the resting area of the pen. This arrangement allows rainwater to help flush away the waste to the drain channel and on to the manure store, which needs to have extra capacity for this water. However, in the four-sow unit the furrowing pens have fully covered manure alleys for increased protection of the piglets.

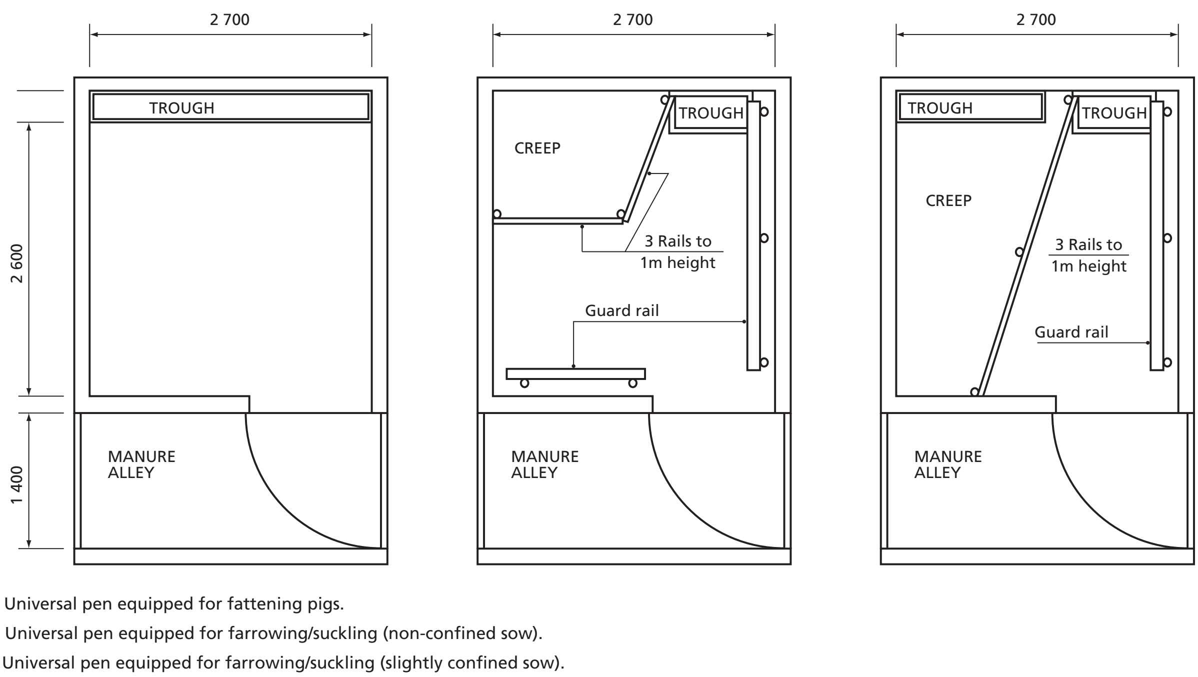
The roof may be equipped with gutters so that rainwater can be drained away separately or collected for use as drinking-water for the pigs.

A single tubular steel or round timber rail 20 cm above the outside rear wall (1 metre high) is desirable to increase security without interfering with ventilation.

Both buildings shown in Figures 10.29 and 10.30 can be extended to accommodate two to four more sows by adding two pens for fattening pigs at one end every time a farrowing pen is added at the other end.

Housing for the medium-scale pig unit

In pig units for more than six sows, it becomes feasible to construct specialized pens for the various production stages, but these can still be accommodated under the same roof. A larger production volume can be accommodated by extending the unit shown in Figure 10.31 up to about 15 sows. Any further increase should then be accomplished by building an additional separate unit of this type with up to 15 sows, as too many animals in one building creates a potential health hazard.

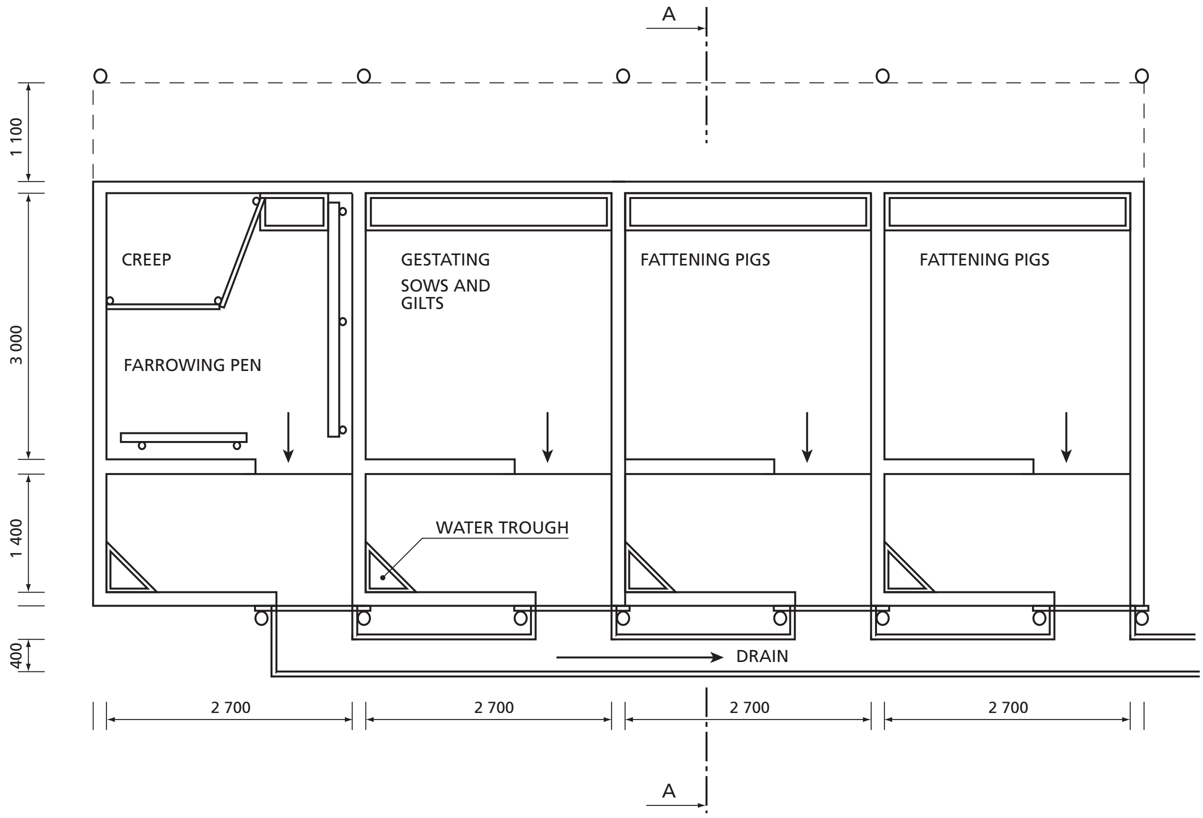


a - Universal pen equipped for fattening pigs.

b - Universal pen equipped for farrowing/suckling (non-confined sow).

c - Universal pen equipped for farrowing/suckling (slightly confined sow).

Figure 10.28 **Universal pen**



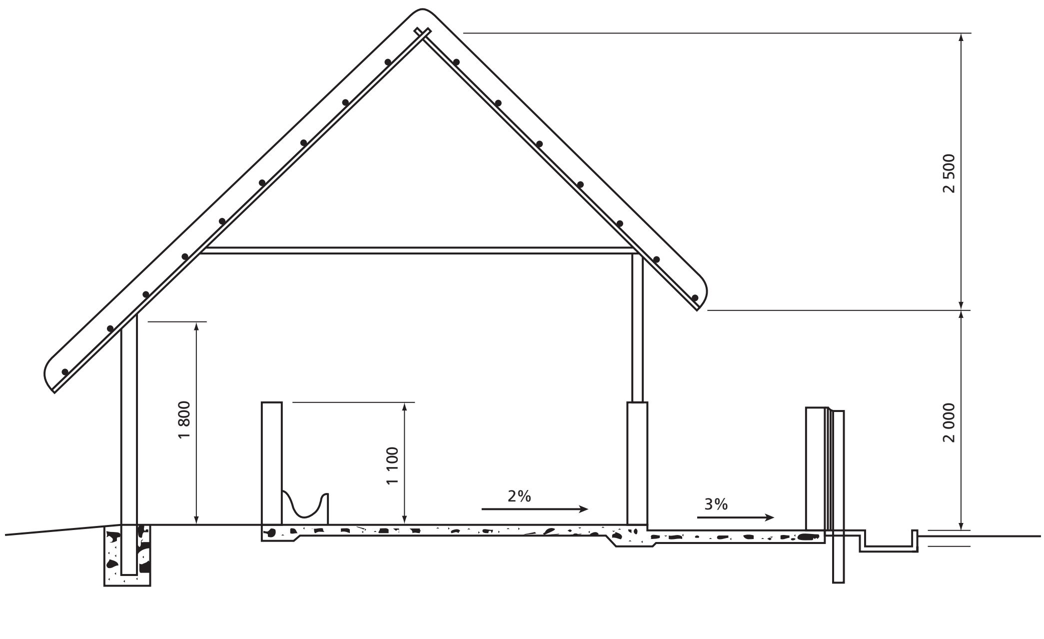


Figure 10.29 **Single-row pig unit for two sows and fatteners**

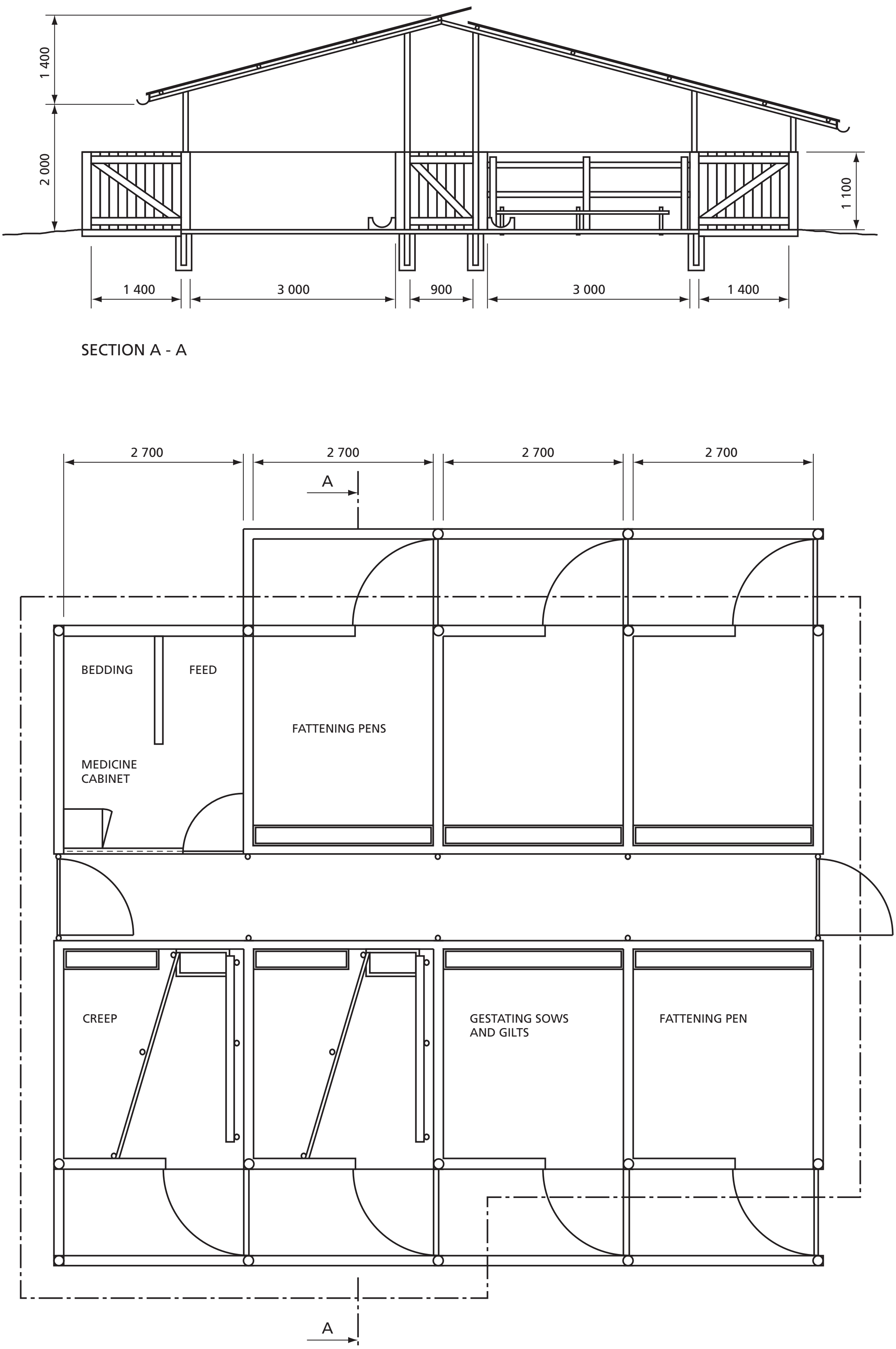


Figure 10.30 **Double-row pig unit for four sows and fatteners**

Housing for the large-scale pig unit

In large scale units, special provisions must be made for efficient health control. This means: not too many animals in one building; animals of approximately the same age housed together; using an 'all-in, all-out' system with thorough cleaning and disinfection of every house between each batch of pigs; placing the buildings 15–20 metres apart and surrounding the entire site with a secure fence.

Specialized pens located in separate houses assigned to the various stages in the production cycle are normally feasible in units of 20–30 sows. Each type of pen can be designed with dimensions for the most efficient use of the building space, as it is not necessary for them to fit in a layout with other types.

Farrowing house

The type of farrowing pen shown in Figure 10.32 offers a relatively high degree of confinement, as the sow is restrained in a farrowing crate during farrowing. Between 5 and 10 days after farrowing, the crate is removed or opened to free the sow, as indicated in the figure. Although a slightly askew arrangement of the farrowing crate will allow for a longer trough for the piglets in the front of the pen, it is more complicated to construct.

A reduction in space requirements can be achieved by putting the sow in a farrowing pen, consisting merely of a farrowing crate with 0.5 metre- and l metre-wide creep areas on either side, one week prior to farrowing. Two weeks after farrowing, the sow and piglets must be transferred to a suckling pen equipped as in the pen shown in Figure 10.52b, but with the dimensions 2.3 metres wide by 2.35 metres deep and with a 1.4-metre wide manure alley.

Housing for growing/finishing pigs

Growing/finishing pens 2.8 metres wide by 1.9–2.2 metres deep and with a 1.2-metre manure alley can accommodate the following number of pigs, according to their weight:

up to 40 kg – 12 pigs
40–90 kg – 9 pigs
over 90 kg – 7 pigs

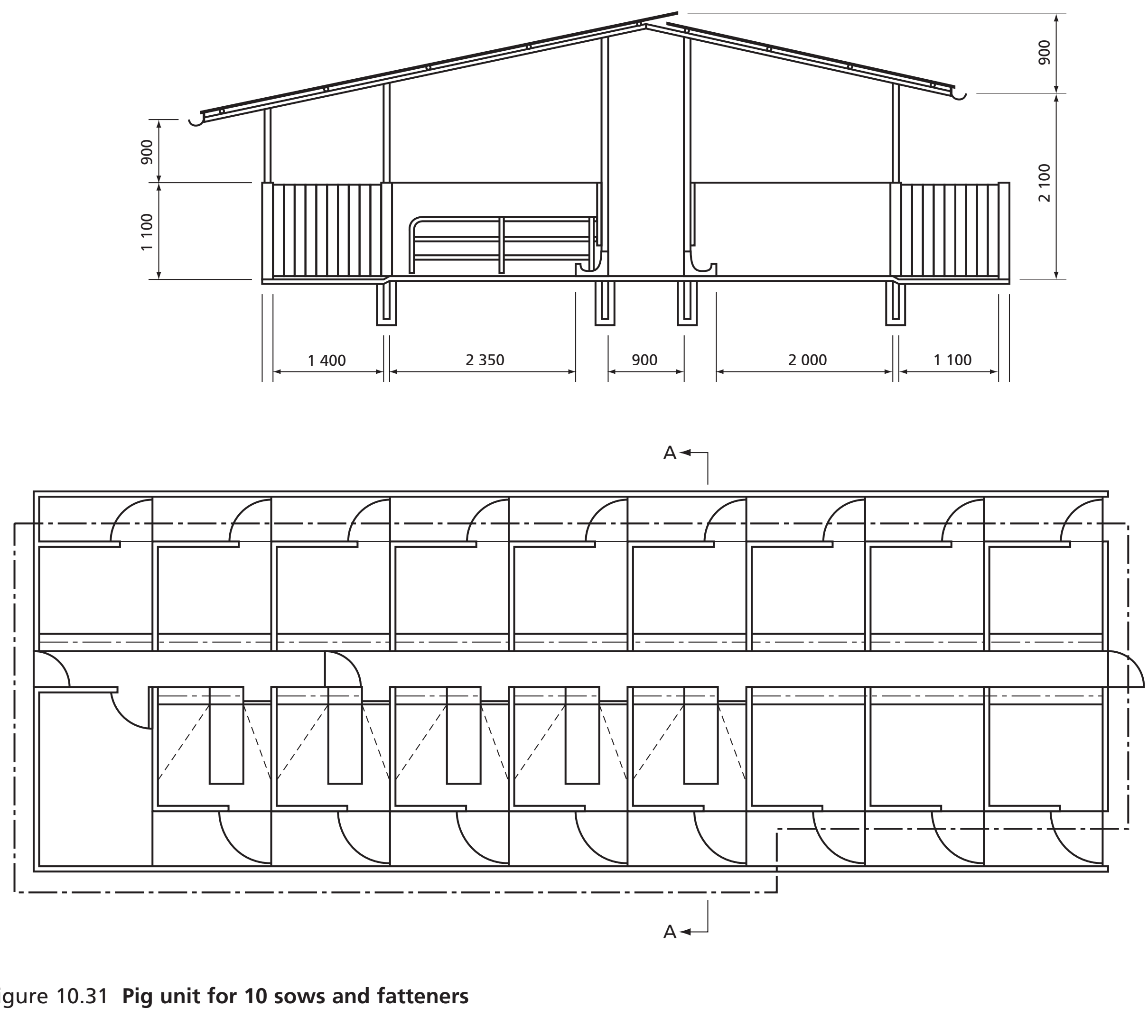


Figure 10.31 **Pig unit for 10 sows and fatteners**

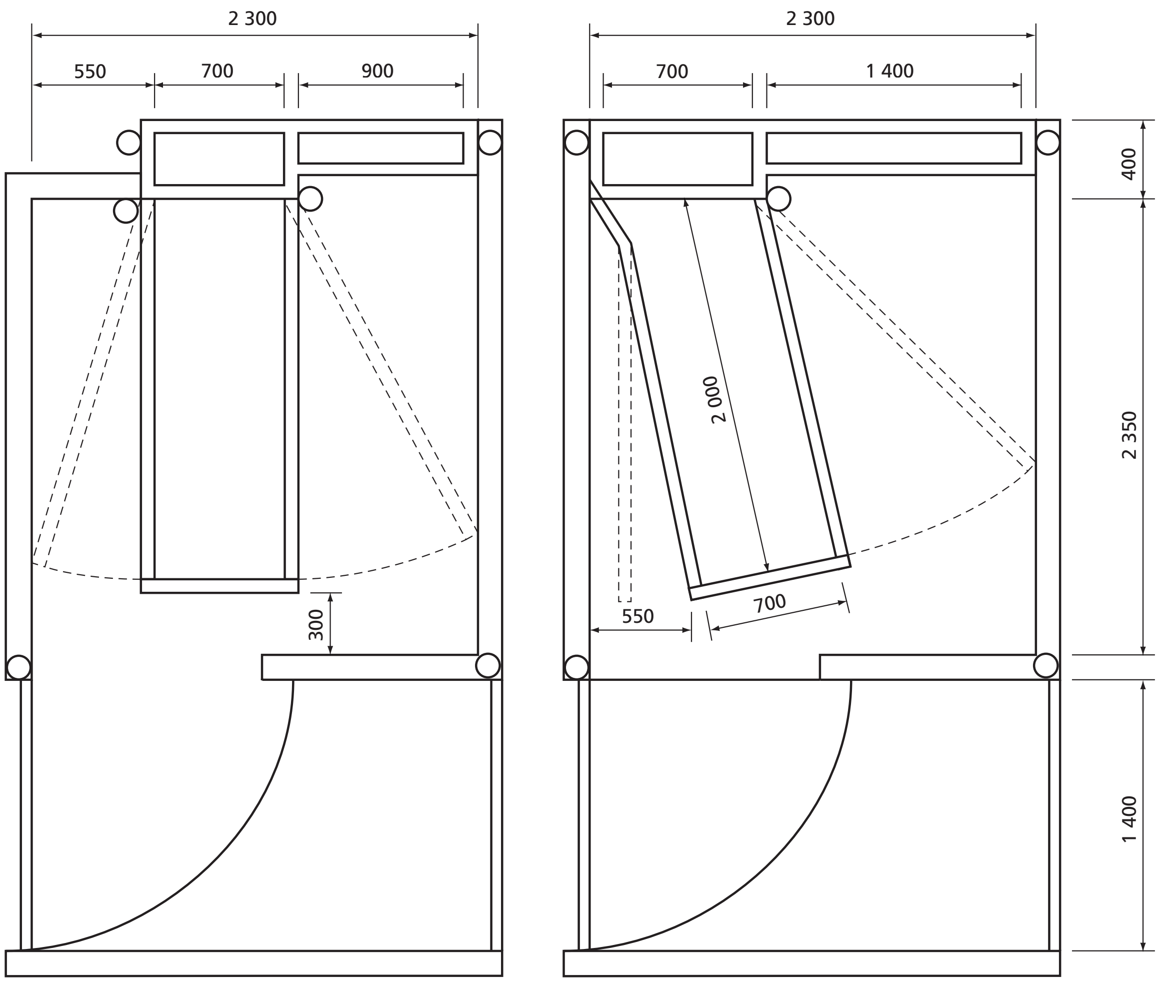


Figure 10.32 **Farrowing pens with crates for confinement of the sow during birth**

Where it is very hot, it is preferable to reduce the number of pigs per pen below the numbers given here. The manure alley must be well drained, preferably by a covered drain, but an open drain will also serve, provided that it is outside the pen to prevent urine from flowing from one pen to another. Bedding in the pens is preferable for the animals' comfort and to reduce stress, as the bedding will provide them with something to do. Controlled feeding is important to ensure the best possible feed conversion.

Housing for gestating sows

Gestating sows are usually the last group in a pig herd to be considered for confinement housing. However, there are obvious advantages in doing so, which could greatly influence production efficiency when sows are confined and controlled during gestation.

As their litters are weaned, sows can be returned to the gestating-sow structure and placed in one of the pens arranged on either side of the boar pens for easy management of sows in heat. After mating and the three-week control period, the sows should be regrouped according to the actual farrowing dates.

The type of accommodation shown in Figure 10.33a will always have four sows per group, as the gates in the manure alley are used to enclose the sows in their stalls while cleaning the pen. The stalls, which are used for both feeding and resting, should be 0.60–0.75 metres wide, depending on the size of the sows.

With the type shown in Figure 10.33b, the numbers in the groups can vary according to the size of the herd and farrowing pattern, but sows in one group should be in approximately the same farrowing period (within about 10–15 days of each other).

The feeding stalls should be 50 cm wide, with a bar that can be lowered after all the sows have entered the stalls. This arrangement will prevent sows from backing out of their assigned stall, and from biting and stealing feed from other sows. When all the sows have finished eating, the bar is lifted and they can leave the feeding stalls.

Behind the feeding stalls there is a manure alley with gates across, which can close the opening of the resting area in order to confine the sow while cleaning out the manure alley. The width of the manure alley can be increased from 1.5 metres to 2.5 metres if desired, so that cleaning can be carried out by a tractor-mounted scraper.

Where exercise yards are considered feasible, they can be arranged behind the building in both types of pen.

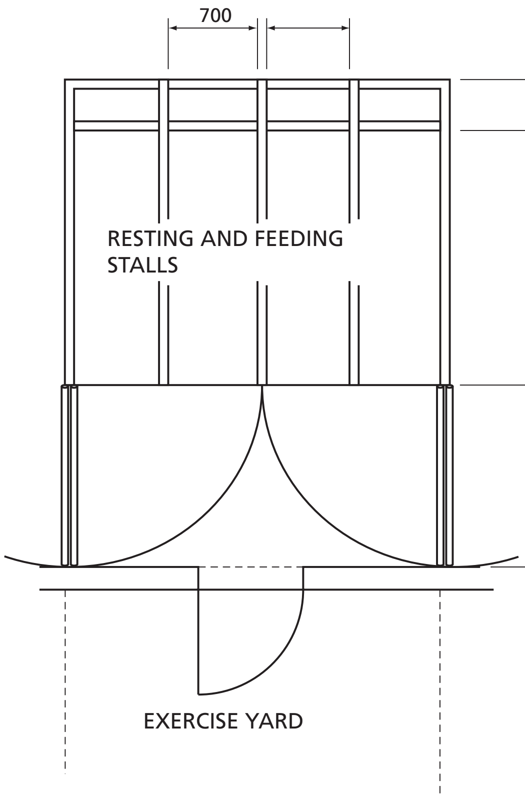


Figure 10.33a **Groups of four sows in resting and feeding stalls with access to a manure alley**

Special arrangements for warm climates

Many of the principles discussed above apply equally to hot and temperate climates and are basic requirements for the housing of pigs. While the open type of confinement system has its limitations, when applied in many warm areas it leads to a major improvement in production.

Complete control of the environment in animal houses is generally far too expensive to be feasible, in particular for non-confined systems. However, provisions for shade, proper roof colour and material, and controlled air movements, which have already been discussed, can be both practical and economic.

A spray or a wallow can considerably reduce heat stress in pigs. A wallow can be anything from a water-filled hole in the earth to a concrete trough. While wallows are effective and need not be expensive, they tend to become unsanitary if not regularly cleaned.

From a hygienic point of view, sprinklers that spray water onto the pigs are preferable, but water consumption can be up to four times greater than with a wallow. Water consumption is about 20 litres per pig per day for 10 hours of continuous spraying, compared with 5 litres per pig per day using a wallow. However, a spray system can be operated intermittently by a timer that can limit use to about 2 litres per pig per day. The spray should be directed onto the pigs and not into the air.

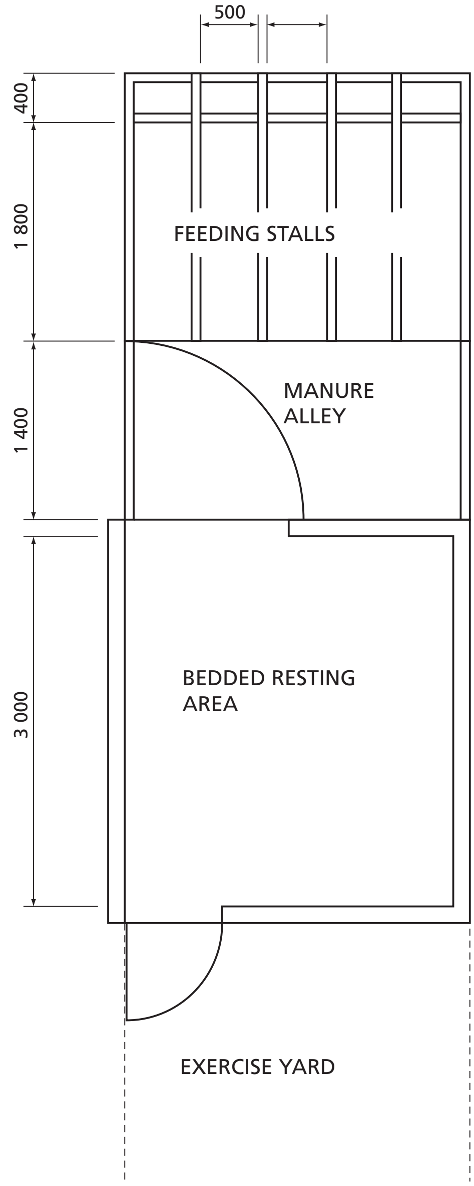
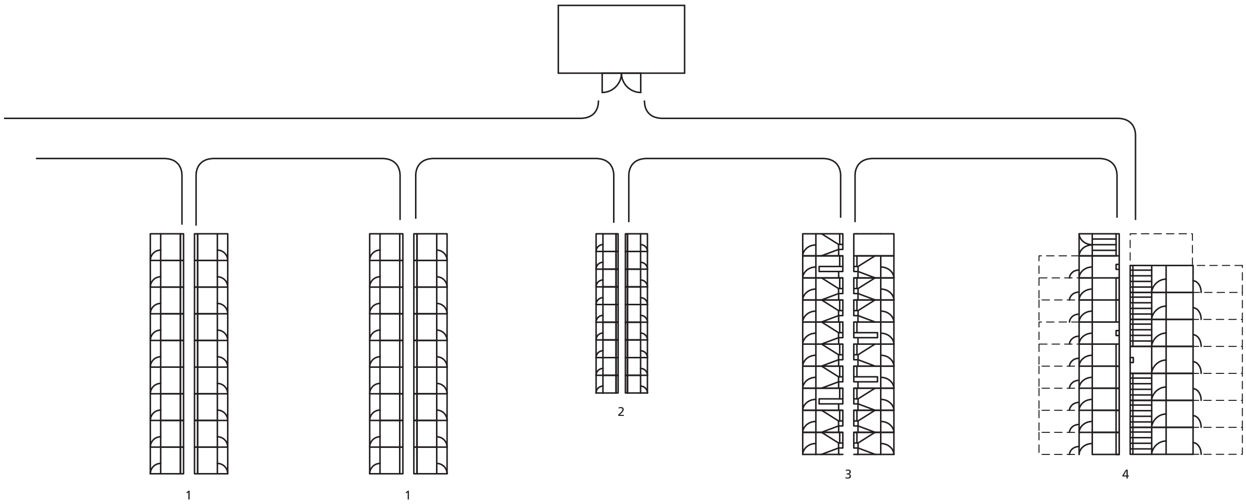


Figure 10.33b **Groups of five sows with access to feeding stalls and a bedded resting area, where they are enclosed during cleaning**

Figure 10.33 **Pens for gestating sows**

The spray system can be effectively used with all categories of pig, except very young piglets. A sprinkler in the manure alley of the farrowing pen, operated from the time the litter is about two weeks old, may help the sow to maintain her feed intake. Hosing pigs once or twice a day is a great deal less effective than a spraying system.



1 - Fattening house
2 - Weaner house
3 - Farrowing house
4 - Breeding house for gilts, gestating sows and boars with exercise yards

Figure 10.34 **Layout of a 50-sow unit**

Feed troughs and feed storage

Efficient pig production requires a reliable supply of water and feed for a balanced diet. A large range of feedstuffs, including by-products and crop surpluses, may be used, provided they are incorporated into a balanced diet. Feed requirements change as pigs grow and depend on the stage of production in sows. Table 10.11 shows the requirement where the feeding is based on a mix of meal feeds, and can be used to estimate the required storage capacity for supply between deliveries.

A wide variety of feeding equipment is available for pig operations. The easiest to clean and sanitize are made from concrete, metal or glazed burnt clay.

TABLE 10.11
Feed and water requirement for pigs

Animal		Feed intake (meal feed) (kg/pig)	Drinking water requirement (litres/day)
Sow in farrowing pen		5–7	22–27
Gestating sow		2–3	12–17
Boar		2.5–3.50	10
Piglet	10 kg	0.60	1.0
Piglet	15 kg	0.75	1.5
Pigs	25 kg	1.10	2.5
Pigs	40 kg	1.70	4.0
Pigs	60 kg	2.30	6.5
Pigs	90 kg	2.90	7.0
Pigs	120 kg	3.10	7.0

Concrete troughs are commonly used and can be prefabricated using a metal mould. The trough is often placed in the front wall of the pen as shown in Figures 10.35d, 10.35e and 10.35f.

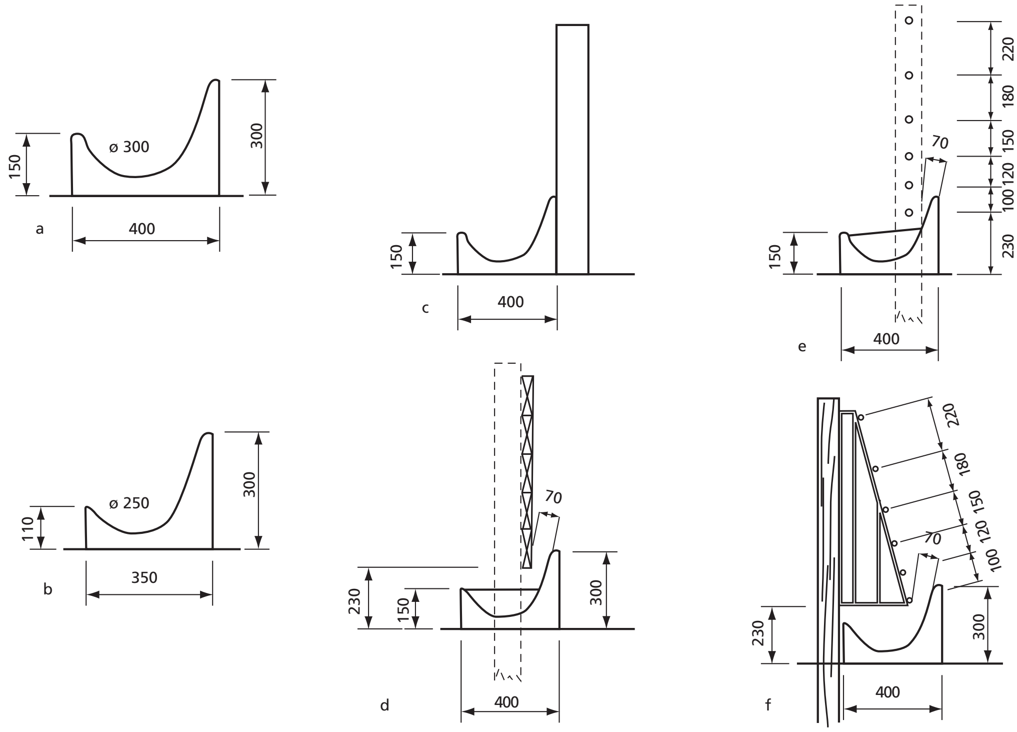
Although such an arrangement involves more difficult construction than having the trough inside the pen it is usually preferred for easier feeding and also preventing the pigs from stepping into the trough. The wall above the trough can be made either solid or open and can be either vertical or sloping inwards to the pen.

An open front improves ventilation in the pen but it is more expensive than a close-boarded wooden front as galvanized steel pipes have to be used for durability. In particular a sow confined in a stall of a farrowing crate will feel more comfortable if it is able to see in front of her. A sloping front will more effectively discourage pigs from stepping into the trough but it is more complicated and expensive to construct.

Two piglet feeders for use in the creep area are shown in Figure 10.36. The same types can be used for growing pigs up to 40–50 kg, but the dimensions will need to be increased. Metal is preferred, although a feeder made of wood can be satisfactory if cleaned regularly and thoroughly.

Watering equipment

The drinking-water requirement is shown in Table 10.11. It is preferable to mix feed meal with 1.5–2.1 litres of water per kilogram of feed. The rest of the water can be given in the trough between feedings or in special drinkers. Clean water must be available to the pigs at all times, including the piglets in a farrowing pen.



a. Feeding trough for pigs over 30kg
b. Feeding trough for piglets up to 30kg
c. Trough outside the pen, vertical close boarded front
d. Trough partly in the pen, vertical close boarded front
e. Trough partly in the pen, vertical open front of pipes
f. Trough outside the pen sloping open front of pipes

Figure 10.35 **Feeding equipment**

Automatic drinkers are the most hygienic and can be used where piped water is available. There are two types: one is placed above the feed trough and sprays into the trough when pushed by the pigs; the other type is operated by the pigs biting around it. This latter type is often placed in the manure alley or in the pen close to the manure alley to prevent the pigs from making the resting area wet.

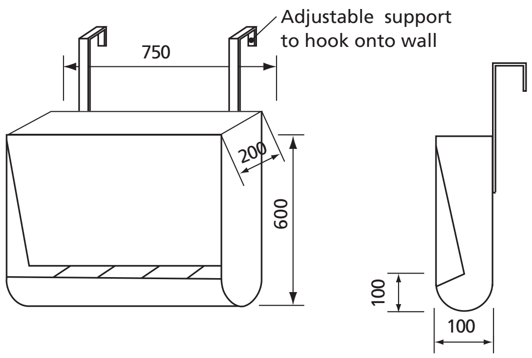


Figure 10.36a **Overall dimensions of a sheet metal feeder**

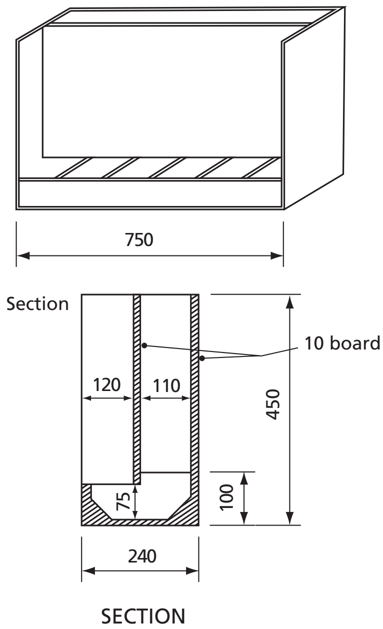


Figure 10.36b **A wood feeder suitable for home construction**

TABLE 10.12
Rates of manure production for pigs

	Wet solid manure (kg/day)	Urine (kg/day)	Total (kg/day)	Storage requirement for slurry m^3 per day of storage
Dry sow and boar	2.0–2.5	4–5	6.0–7.5	0.011 or 0.013 per sow in the herd
Sow with litter	2.5–3.0	8–10	10–13	0.018
Farrowing pigs (45 kg)	0.8–1.0	2.5	3.3–3.5	0.004 or 0.006 per growing/finishing pig
Finishing pigs (45–90 kg)	1.5–2.0	4–5	5.5–8.0	0.008

Manure handling

The pig pens must be cleaned once or twice a day. Provided sufficient bedding is used and the urine is drained away separately to a urine storage tank, the solids may have a consistency that allows stacking on a concrete slab. Where little or no bedding is used or the urine is not separated, a manure storage slab of the type shown in Figure 10.22 can be used. Table 10.12 shows the rates of manure production.

POULTRY HOUSING

Poultry (which includes chickens, turkeys, ducks and geese) offers one of the best sources of animal protein, in the form of both meat and eggs, at a cost most people can afford. Chickens are the most widely raised and are suitable even for the smallholder who keeps a few birds that largely forage for themselves and require minimum protection at night.

At the other extreme, commercial farms may have highly mechanized systems housing thousands of birds supplying eggs and meat to the city market. In between are farm operations in a wide range of sizes, with varying types of housing and management systems proportionate to the level of investment and the supply of skilled labour available.

No single system of housing is best for all circumstances, or even for one situation. Some compromise will invariably be required. Here we discuss the needs of chickens and other classes of poultry and a number of housing systems, along with the principal advantages and disadvantages of each.

General housing requirements for chickens

Proper planning of housing facilities for a flock of laying hens requires knowledge of management and environmental needs during the various stages of the chicken's life. A typical life cycle is illustrated in Figure 10.37.

The laying period may be up to 16 months but, in flocks kept for commercial egg production, the hens are normally culled after a laying period of 11–12 months, or when production has dropped to a point where the number of eggs collected per day is about 65 percent of the number of hens in the flock.

The hens may come into production again after a moulting period of a couple of months, but the production then is not as high and the egg quality is generally not quite as good as in the first laying period. Where prices of poultry meat are reasonable, it is usually more economic to cull all the hens after one year of egg production.

Site selection

The best site is one that is well drained, elevated but fairly level, and has an adequate supply of drinking-water nearby.

Regardless of the type or size of the housing system, the site for construction should be selected to provide adequate ventilation, but be protected from strong winds. An area under cultivation, producing low-growing crops, will be slightly cooler than an area of bare ground. High trees can provide shade while at the same time actually increasing ground-level breezes. Bushes planted at one windward corner and also at the diagonally opposite corner will induce air currents within the building to reduce the effect of the heat from direct solar radiation.

As all buildings used for poultry housing tend to produce odours, they should be located well downwind of nearby dwellings. If there are several poultry buildings in a group, it is desirable to have them separated by 10–15 metres in order to minimize the possibility of spreading disease.

Brooding buildings should be isolated from other poultry buildings by 30 metres or more, and be self-contained in terms of feed supplies and storage of equipment. If the same person cares for both layers

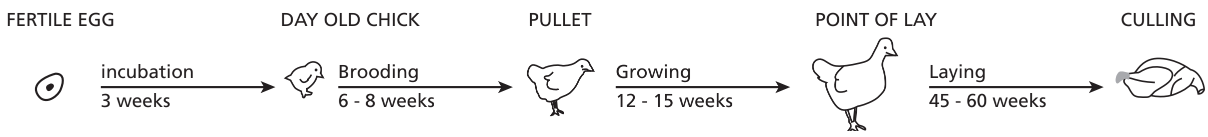


Figure 10.37 **Typical life cycle of a laying hen**

and growing birds, a disinfectant foot bath at the entrance to the brooding area is an added precaution. All buildings should be constructed on well-drained sites where drives and paths between buildings will not become muddy, even during the rainy season.

Environmental requirements

The effects of temperature and humidity on the birds make it apparent that in most areas of east and southeast Africa. the principal environmental concern is to keep the flock as cool as possible. Shade, good ventilation with natural breezes, freedom from roof radiation and the indirect radiation from bare ground are all important. Only in a few high altitude areas does protection from wind and low temperatures become a significant consideration.

Humidity seems important in only two respects. Very low humidity causes objectionably dusty conditions and high humidity, combined with temperatures above 27 °C, seems to interfere with the physiological cooling mechanism and increases the possibility of death. Day-old chicks require a temperature of 33–35 °C. This temperature is maintained for a week and is then gradually lowered to the ambient temperature by the end of five weeks.

In addition to providing a good environment, the housing should offer protection from predators and theft, as well as keeping out rodents and birds. Not only do they carry diseases, they can also consume enough feed to make a significant economic difference.

The effect of light on egg production has been discussed earlier. Additional hours of light can be achieved by installing one 40-watt electric light bulb per 15 square metres of floor space in a position about 2.2 metres above floor level. More important than the hours of light, however, is maintenance of the lighting schedule, because any sudden change in the length of the photo-period is likely to result in a significant drop in production.

Fourteen hours of light throughout the laying period is optimum. A schedule with gradually decreasing hours of light may be used in windowless houses for maturing pullets. This postpones laying but results in larger eggs being produced from the start of laying.

However, in warm climates near the equator, houses are open for natural ventilation and the length of the day is close to 12 hours throughout the year. The result is that pullets start to lay at 14–18 weeks of age and egg size, which is small at first, gradually increases during the first three months. Broiler houses are often lighted 24 hours a day to encourage maximum feed consumption and rate of gain.

Proper design and management of the poultry house can effectively contribute to disease prevention in the flock. In general, it is best if the litter is dry but not too dusty. If no litter is used, the floor and wall surfaces should be designed so that they can be cleaned easily between flocks and stay reasonably clean during use.

Construction details

In most hot climates there will be many more days when a cooling breeze is needed rather than protection from a chilling wind. A wall construction consisting of a solid base, which protects against indirect radiation from the ground, and an open space covered with mesh above it, is therefore preferred for all four walls in most types of chicken house.

A hessian or reed curtain that can be dropped on the windward side will offer extra protection and, if installed on the east and west orientation, it may also protect from direct sunshine. An arrangement where the top end of the hessian is fixed to the wall plate and the bottom end is attached to a gum-pole, around which it can be rolled when not in use, provides for smooth operation. In high altitude areas, offcuts may be used on the gable ends, but 15–20 mm spaces should be left between them to improve ventilation. The width of the building should not exceed 9 metres for efficient cross-ventilation.

The lower wall design, up to 1 metre of solid wall, can be made of any available masonry units. Bag-washing will give a smooth, easily cleaned finish, but adobe blocks will require the extra protection of plastering to prevent the birds from destroying the wall by pecking.

The upper wall design to the total height of the wall, including the solid base, should be about 2 metres. gum-poles treated with wood preservative and set 500 mm deep in concrete provide a practical means for supporting the roof and upper wall structure. Eighteen-millimetre wire mesh is small enough to keep out rodents and birds. A tight-fitting door is essential.

The floor in a poultry house may consist of gravel or well-drained soil, but concrete is desirable because it is easy to clean, durable and considerably more rat proof. A concrete floor should be 80–100 mm thick and be made of a stiff 1:2:4 or 1:3:5 mix, laid on a firm base at least 150 mm above ground level, and given a smooth finish with a steel trowel.

Roof structures with a free span are desirable to avoid any inconvenience from roof-supporting poles inside the building. Corrugated steel sheets are the first choice for roofing material because they are much easier to keep clean than thatch. Insulation under the metal roofing will improve the environment in the house. However, a thatched roof may result in even better conditions and can be used on narrow buildings.

The roof overhang should be 500 mm or more in order to give adequate protection from sun and rain. A ventilation opening along the ridge is usually supplied in layer houses, but not in brooding houses.

Housing systems for layers

The pullets are transferred from the rearing accommodation to the laying accommodation at the age of 17–18 weeks and start laying when they are 20–24 weeks old. At the time of transfer, they should be grouped according to size and stage of maturity.

TABLE 10.13
Recommended minimum floor, feed and water space for chickens

	Floor space stocking density		Feeder space		Water space (birds/m)
	Low (birds/m²)	High (birds/m²)	Trough (birds/m)	Tube (birds/m)	
Chicks and pullets					
1–4 weeks of age	15–20	25–30	40	40	150
5–10 weeks of age	8–11	12–15	15–20	25	75
11–15 weeks of age	5–6	7–8	9–10	12	50
16 + weeks of age	3–4	5–7	7–8	10	40
Breeders	3–4	5–6	6–8	9	15
Layers	6–7	8	10–20		
Semi-intensive					
House-run					
• house	3	4–5			
• run	0.04–0.08	0.10–0.13			
Straw-yard					
• house	3	4–5			
• yard	1.5	2.5			
Fold system	2	2			
Intensive					
Deep-litter floor	3–4	5–7			
Wire floor	7–8	9–10			
Combination floor	5–6	7–8			
Cages, including alleys	8–12	15–25	7–10		

There are five major systems used in housing for layers: semi-intensive; deep litter; slatted or wire floor; a combination of slatted floor and deep litter; and a cage or battery system.

Having considered the factors that affect the comfort, protection, efficiency and production of the birds, it is also important to design a system that is labour-efficient, reasonable in terms of investment and easy to manage. How well each of the systems fills the needs of both the chickens and the people supervising the operation should be the determining factor in the selection of an appropriate system for a specific situation.

Semi-intensive systems

Semi-intensive systems are commonly used by small-scale producers and are characterized by having one or more pens in which the birds can forage on natural vegetation and insects to supplement the feed supplied. It is desirable to provide at least two runs for alternating use to avoid a build-up of disease and parasites. Each run should allow at least 10–15 square metres per hen and be fenced, but a free-range run allowing 40–80 square metres per hen will be required where the hens are expected to obtain a substantial part of their diet from foraging.

A small, simple house, which allows 0.3–0.4 square metres per bird and has a thatched roof, a littered earth floor and slatted or chicken wire walls on at least three sides, will provide protection from inclement weather and from predators at night, as well as providing shade in the daytime. The shelter should be large enough for entry to collect eggs and be equipped with nest boxes, feeders, drinkers and perches. For convenience, the house should be situated so that access to each of the runs can be provided with small outlet doors or 'popholes'.

Figure 10.38 shows another type of shelter for roosting and laying that can be used in combination with daytime foraging by the hens. The legs of this structure have rat guards and ant protection and may be equipped with skids or wheels to make the whole unit easily movable between runs. Feed and water are provided in troughs outside the house.

This system is low in cost, but bird growth and egg production are likely to be lower than with systems offering closer confinement and better feed. Losses may be caused by birds of prey and by failure to find eggs laid in bushy areas. The poultry run requires a considerable amount of fencing.

A fold unit is a house and run combined, part of which is covered with chicken wire and the remainder with solid walls. The unit should allow 0.5 square metres per bird and must be moved each day over an area of grassland. A unit 6 metres by 1.5 metres will take

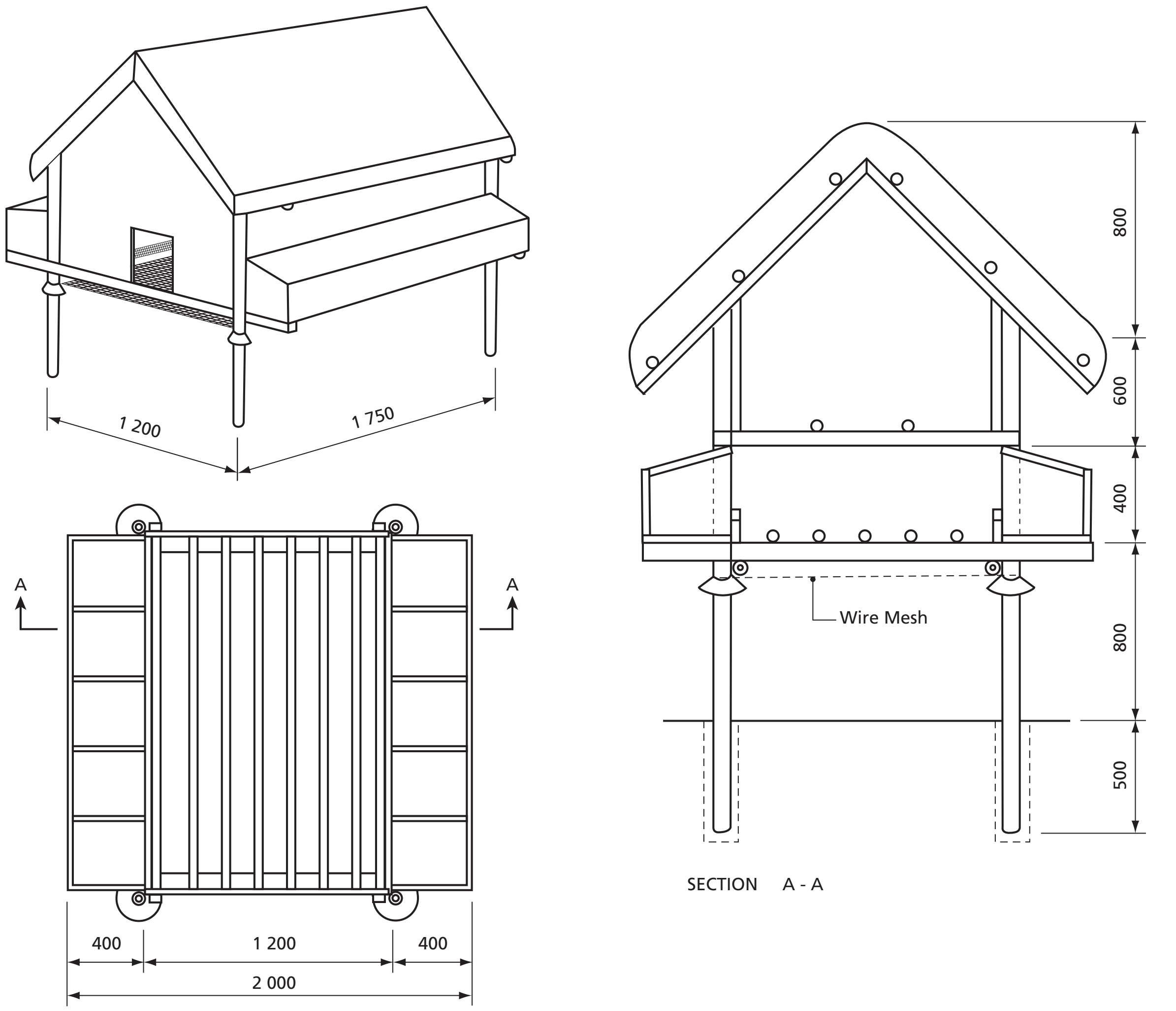


Figure 10.38 **Poultry shelter for 50 layers**

16–18 birds and can normally be handled by one person. For larger flocks, several such units will be used.

Portable units are generally more expensive than permanent houses and may decay quickly because of contact with the ground. The hens have reasonable protection against birds of prey and inclement weather, as well as parasites if the unit is not returned to the same area within 30 days.

In areas where grassland is limited, a yard deeply littered with straw and allowing only 0.4–0.7 metres per bird will provide an outdoor exercise area. This system is similar to the deep-litter system, but requires more space, a considerable amount of litter for the yard, and the fresh green food has to be carried to the birds.

Deep-litter system

Deep-litter houses, as shown in Figure 10.40, confine the birds in a building that offers good protection with a reasonable investment. If well designed, with low masonry walls set on a concrete floor and wire mesh completing the upper part of the walls, the building will keep out rats and birds.

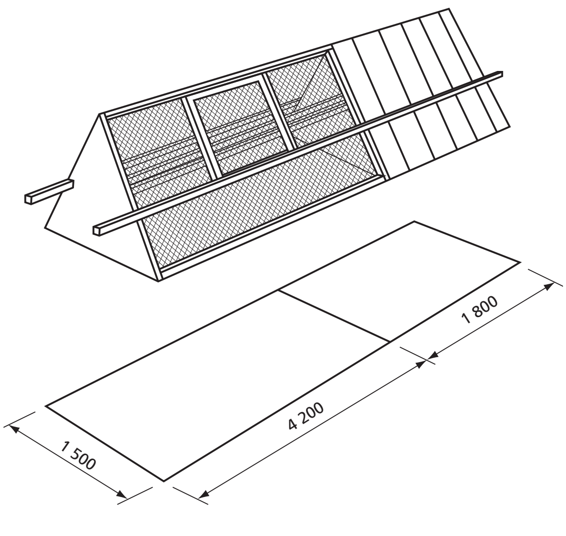


Figure 10.39 **Fold unit for 18 layers**

The principal advantages of this system are easy access for feeding, watering and egg gathering, good protection and reasonable investment. The principal disadvantage is the need for high quality litter. If this is produced by the owner, it is of little significance but, if it must be purchased, it becomes an economic factor. In either case, the litter and manure must be removed periodically.

The deep-litter house can be designed up to 9 metres in width and any length that is needed. A satisfactory density is approximately 4–5 birds per square metre of floor area.

Slatted or wire-floor system

A small house of this type with a slatted floor is shown in Figure 10.41. Alternatively, wire mesh can be used for the floor. It is built on treated wooden piers 0.8–1 metres above the ground. Ventilation and manure removal are both facilitated, no litter is required and bird density can be 6–8 per square metre.

Feeding, watering and egg-gathering are all efficiently handled from the outside. Either a double-pitch thatch roof or a single-pitch corrugated steel roof may be installed, with the eaves about 1.5 metres above the floor. If the latter is used, some insulation under the roof is desirable.

The feed troughs should be equipped with hinged covers, and rat guards should be installed at the top of each pier. The width of this type of building should be limited to about 2 metres to allow easy removal of manure and adequate wall space for feed and nests. The building should be oriented east and west and may be of any length. However, if it is more than 5 metres long, nests will need to be put on the sides, and all remaining wall space on either side used for feeders in order to allow the required 100 mm/bird (see Table 10.13).

If using a slatted floor sufficiently strong for a person to walk on, then a wider building is feasible, as feeders can be placed completely inside where the chickens have access to both sides of the trough. The floor is sectioned for easy removal during cleaning out of manure.

This type of house is said to be cooler than other types, but the building cost is high and management is more complicated.

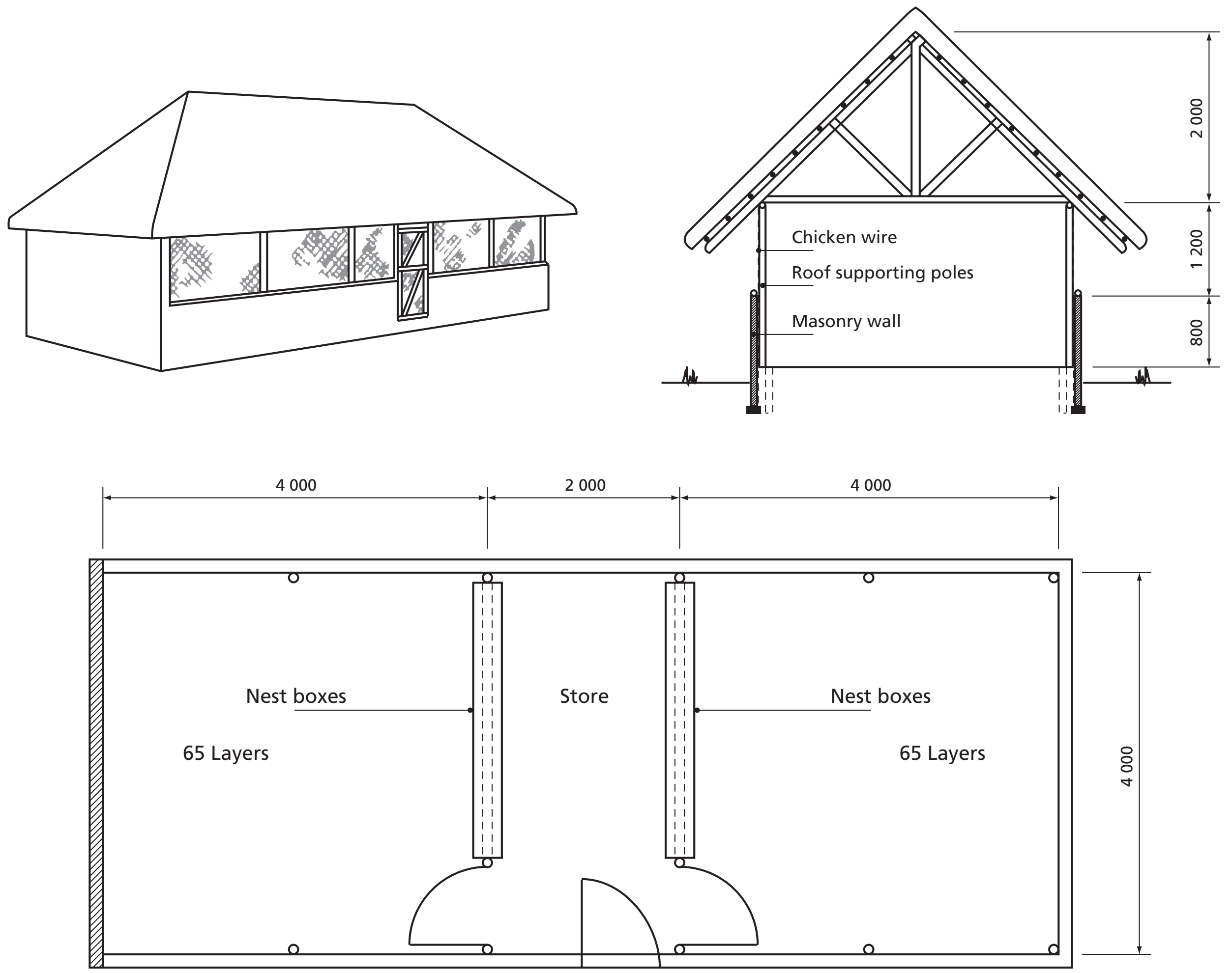


Figure 10.40 **Deep-litter house for 130 layers (or 350 broilers): note the solid wall facing the prevailing wind**

Combination of slatted floor and deep litter

A combination deep-litter/slatted-floor house offers some advantages over a simple deep-litter house, but with some increase in investment. Figure 10.42 shows a house of this type for the small producer.

Approximately half of the floor area is covered with small gum-pole slats or with wire mesh. This area is raised above the concrete floor by 0.5 metres or more to make it possible to clean under the slatted portion from the outside. Waterers and feeders are placed on the slatted area. This type of house is limited in width to 3–4 metres to enable feeders and waterers to be handled from the litter area, and manure beneath the slatted area can be easily removed from the outside without moving the slats or disturbing the birds. Although this system entails added expense for materials and labour to install the slats, the bird density can be increased to 5–7 per square metre, so there is little difference in the cost per bird. This system saves on litter, increases litter life, reduces contact between birds and manure, and allows manure removal without disturbing the hens. Ventilation is improved by the slatted floor. Perhaps the biggest disadvantage is the limited width for convenient operation and the need for some litter.

In medium- to large-scale houses of this type, the slatted floor must be made removable in sections, and at least part of it made strong enough to walk on. However, this results in increased building cost and more complicated management. The house shown in Figure 10.43 has slats over two-thirds of the floor area.

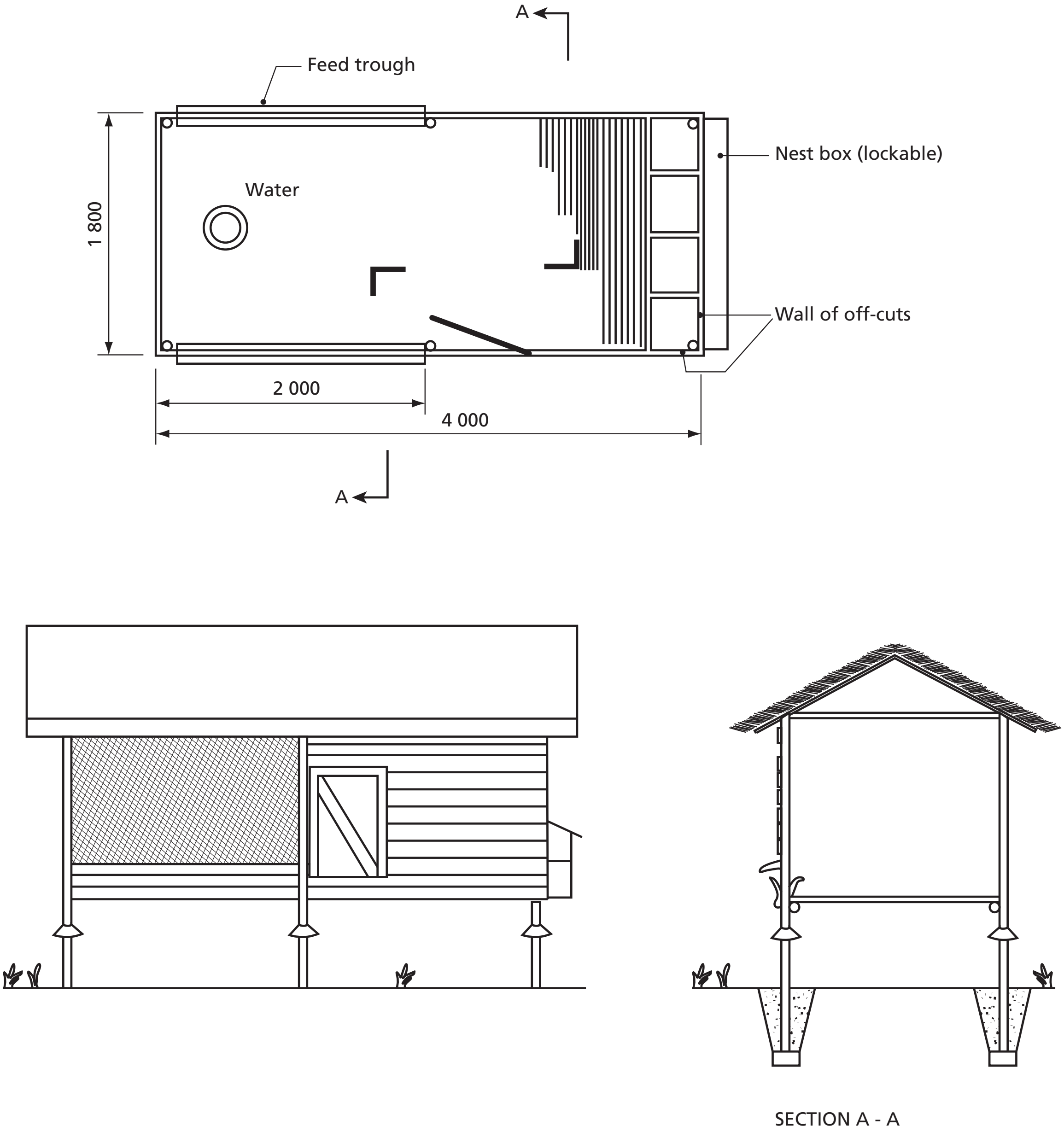


Figure 10.41 **Slatted-floor house for 50 layers**

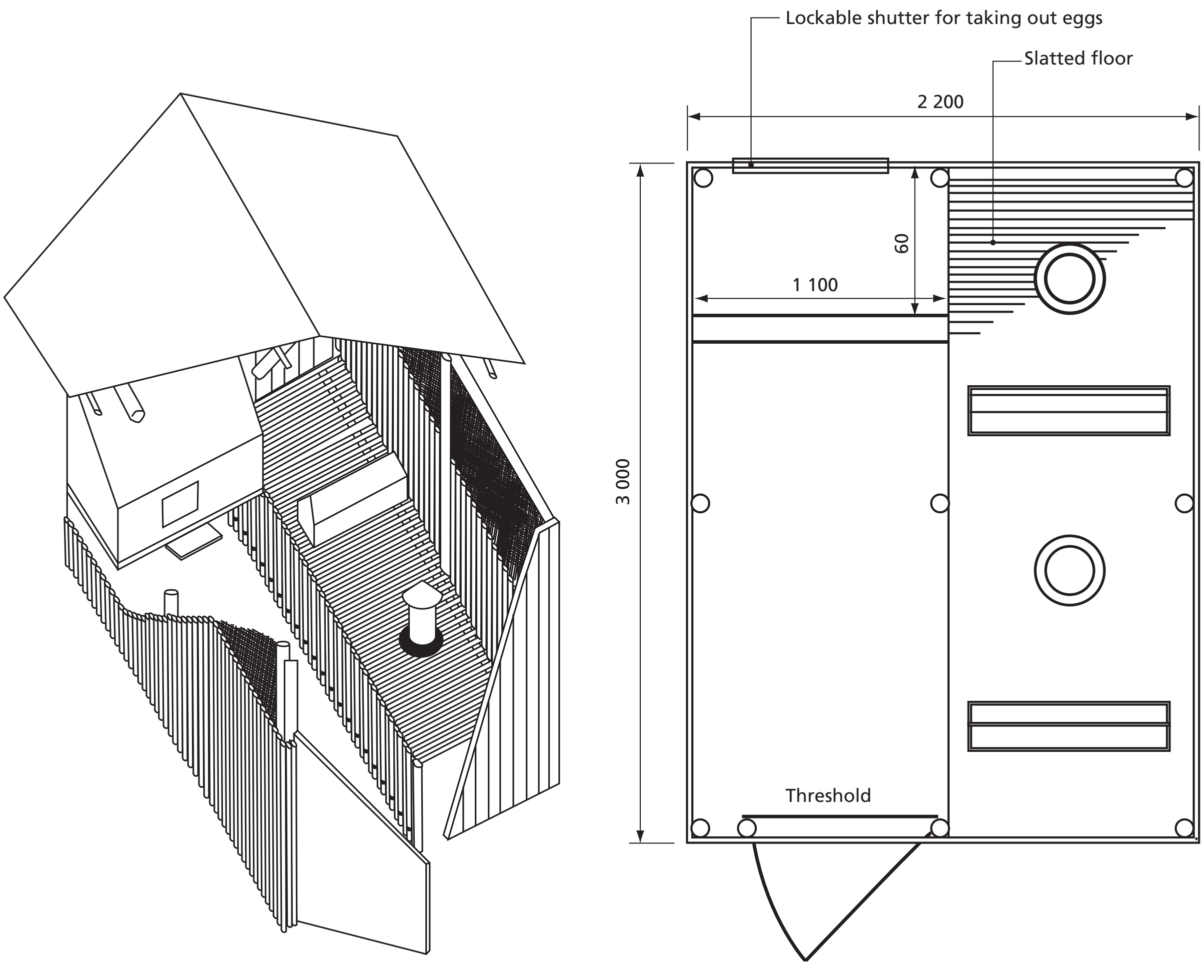


Figure 10.42 **Poultry house for 40 layers, half deep-litter/half slatted-floor**

This is generally considered the maximum for this type of house and allows for a stocking density of up to eight birds per square metre. Automatic tube feeders are placed on the slatted floor. One such feeder, with a bottom diameter of 0.6 metres can serve 60–75 birds, depending on the size of the breed.

The water troughs are suspended from the ceiling. The nest boxes are doubled by arranging them back to back, and have one end resting on the slatted floor and the other suspended from the ceiling. Egg-collection can be facilitated by the use of a trolley, which is supported on a rail just below the ceiling. A tractor shovel can be used for cleaning out between batches if all furnishings and part of the end walls are made removable.

Cage or battery systems

Cage management of layers in very large, well-insulated, windowless buildings has become standard practice in much of Europe and the colder parts of the United States. With complete mechanization of feed, water, egg-collection, manure removal and environmental control, two to three people can care for thousands of birds.

It should be noted that a very large investment is made in order to obtain labour efficiency and ideal environmental conditions. East and southeast Africa currently have relatively low labour costs and a mild climate, which could make a mechanized cage system in an insulated building unnecessary and impractical.

Nevertheless, there are much simpler cage systems that may work very well for commercial growers in this region. These consist of rows of stair-step cages in long, narrow shelters (Figure 10.44). The thatch roof, or insulated metal roof shelter, can be completely open on the sides, with perhaps some hessian curtains in areas where cold winds are experienced. The buildings should be oriented east to west, and be designed to provide shade for the cages near the ends.

A 3.4-metre width can accommodate four cages without overlap and an alley of about 0.9 metres. While a concrete floor makes cleaning easy, smooth, hard soil is less expensive and quite satisfactory. A little loose sand or other litter spread on the soil before the manure collects will make manure removal easier. The building posts should be treated with wood preservative and be sturdy enough to support the cages. Rat guards should be installed on the posts at a height of 0.8–1 metre.

A cast-concrete central alley raised 20 cm is easy to clean and keeps manure from encroaching on the work area. Feeding and egg-collecting are easily done by hand, while watering may be either by hand or with an automatic system. It is important for the watering trough to be carefully adjusted so that all birds receive water. The simplest method of supplying water automatically, or by hand at one end, is to slope the entire building and row of cages by 10 mm per 3 metres of length.

The trough can then be attached parallel to the cages. Water must run the total length of the trough and it is inevitable that some will be wasted. Consequently a good water supply is essential.

Even though feed is distributed by hand, feed stores should be built convenient to each building to minimize carrying. Eggs can be collected directly on 'flats' stacked on a cart that is pushed down the alley. The cart can be made self-guiding by means of side rollers that follow the edge of the feed troughs or the raised central alley.

Cages that are equipped with pans to catch the manure are not recommended because they restrict

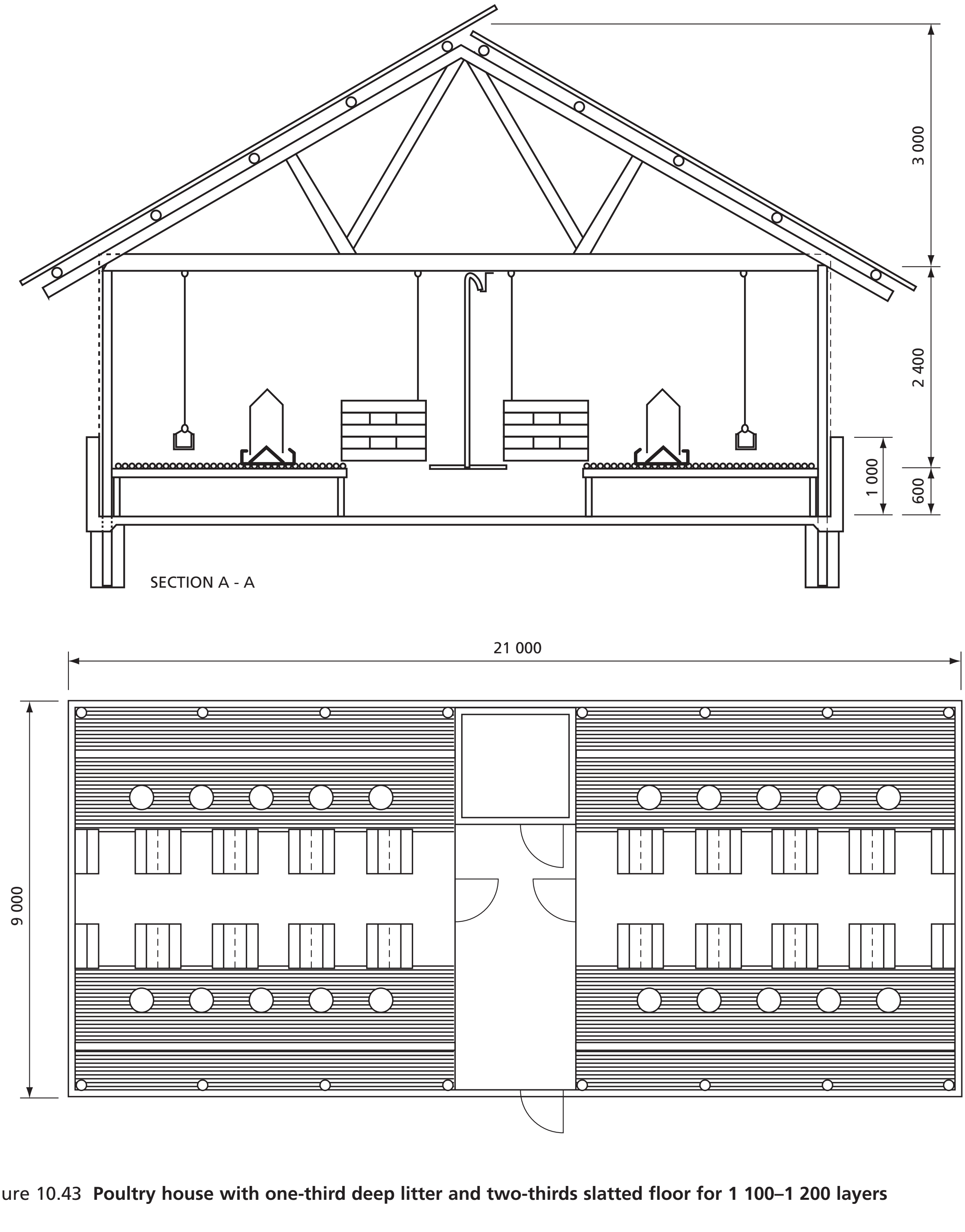


Figure 10.43 **Poultry house with one-third deep litter and two-thirds slatted floor for 1 100–1 200 layers**

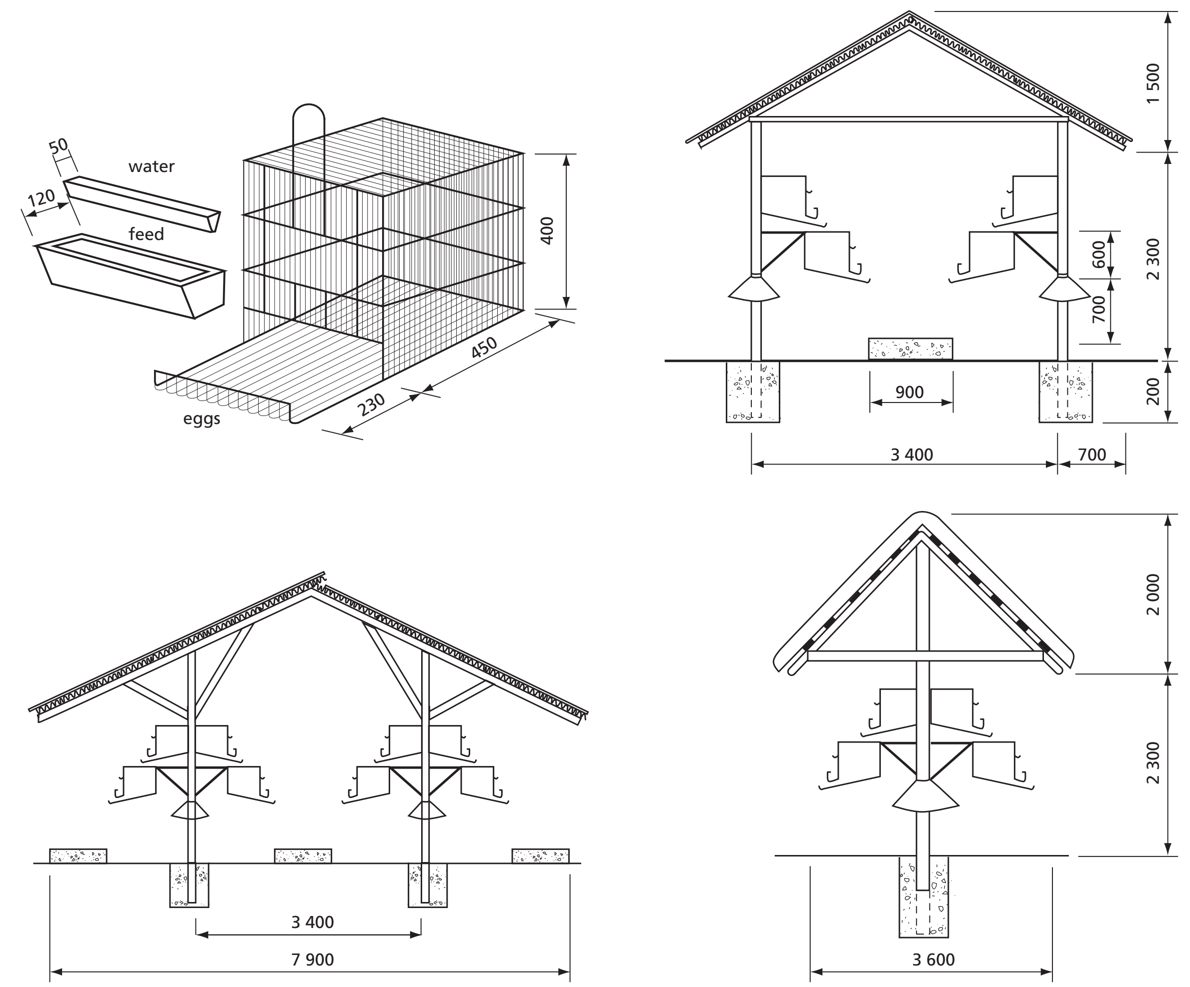


Figure 10.44 **Cage compartment and various arrangements of cage tiers in open-side houses**

TABLE 10.14
Recommended minimum dimensions of cages for laying hens

Layers per cage	Cage area[1] per bird	Width	Depth	Height		Floor slope
				Front	Back	
(number)	(cm^2)	(mm)	(mm)	(mm)	(mm)	(%)
1	1 100–1 300	250	450	500	400	11–15
2	700–900	360	450	500	400	11–15
3	600–750	450	450	500	400	11–15
4	550–650	530	450	500	400	11–15
5	500–600	600	450	500	400	11–15
20	800–900	2 000	850	650	500	15–20

[1] Depending on the size of the breed

ventilation. Previously used cages should be considered only if they are of a suitable design, and have been carefully inspected for condition prior to purchasing.

Summary

The housing systems for layers described should meet the needs of most situations encountered in east and southeast Africa. In the few cases where much colder weather occurs, the buildings described should be built with one or more enclosed walls. However, it must be emphasized that chickens tolerate cold weather better than wet, sticky, foul-smelling litter resulting from inadequate ventilation. If the temperature falls below freezing it is essential for the chickens to have a continuous supply of free-flowing water (not ice), and eggs must be collected frequently enough to avoid freezing.

Planning for continuous production

Producers who can supply their market with either eggs or meat on a regular and steady basis will undoubtedly find their produce in demand at the best market prices. Planning the poultry housing system has much to do with steady production.

A programme for 1 000 layers is shown in Figure 10.45. A larger or smaller operation can be designed with the same number of buildings, but of a different size.

It is assumed that the brooder house is large enough for brooding only, and that pullets will be transferred to a laying house for growing to laying age. New chicks are started every 13 weeks, brooded for 7–8 weeks, and then transferred to the laying house. After approximately 11 weeks they will start a laying period of 52 weeks, after which they are sold and the house is cleaned and rested for two weeks before the cycle is renewed.

Five laying houses are required. At any one time, four will have layers in full production and the fifth will be either housing growing pullets or empty for cleaning. Each house is on a 65-week cycle: 11 weeks for growers; 52 weeks for layers; 2 weeks for cleaning. The brooder house is on a 13-week cycle: 7–8 weeks for brooding; 5–6 weeks for cleaning and resting. A suggested housing layout is shown in Figure 10.46.

Housing for breeders

Breeders must be housed in one of the floor systems because cocks need to run with the hens. One cock per 5–10 hens is sufficient. Special emphasis is placed on disease control, so often a partially or completely slatted floor design is preferred. Few commercial producers breed their own replacements, but instead buy day-old chicks from a commercial hatchery.

However, most chicks of indigenous breeds are produced by natural incubation in small-scale farms. Although a hen sitting on some 8–10 eggs needs little feed and even less attention, breeding results may be improved by a cool, clean nest at ground level that is enclosed to protect the hen, and later the chicks, from insect pests, vermin and predators, and by a supply of feed and clean water.

Brooders

Naturally hatched chicks are reared and protected by the broody hen and can be left undisturbed, provided that their yard is protected from predators, is of a good sanitary standard and has a supply of feed and water.

Artificially incubated chicks must be started under gas-fired or oil-fired brooders to compensate for the absence of a natural mother, and to keep them warm without crowding together. If electricity is available, a 250-watt infrared lamp is a more reliable and comfortable solution, but it is also more expensive.

A cheap, simple but still efficient brooding arrangement that will serve for about 100 chicks is shown in Figure 10.47. The hover, which prevents the heat from

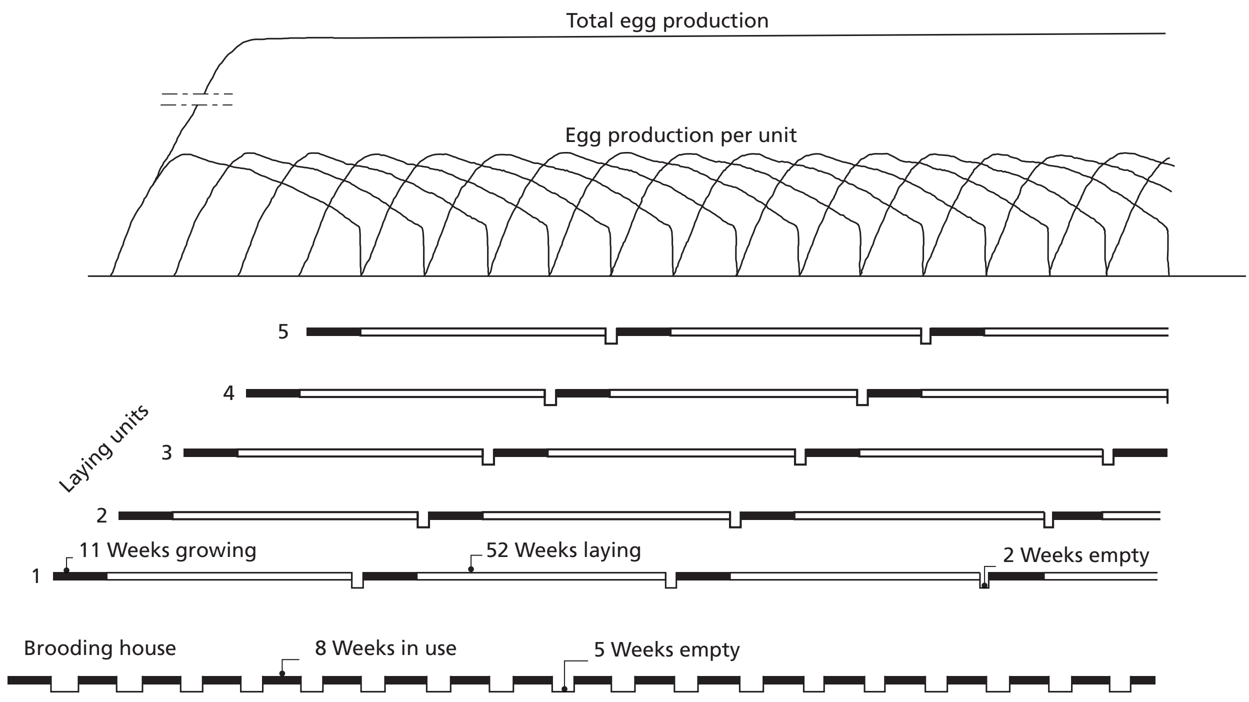


Figure 10.45 **Production flow when starting chicks every three months**

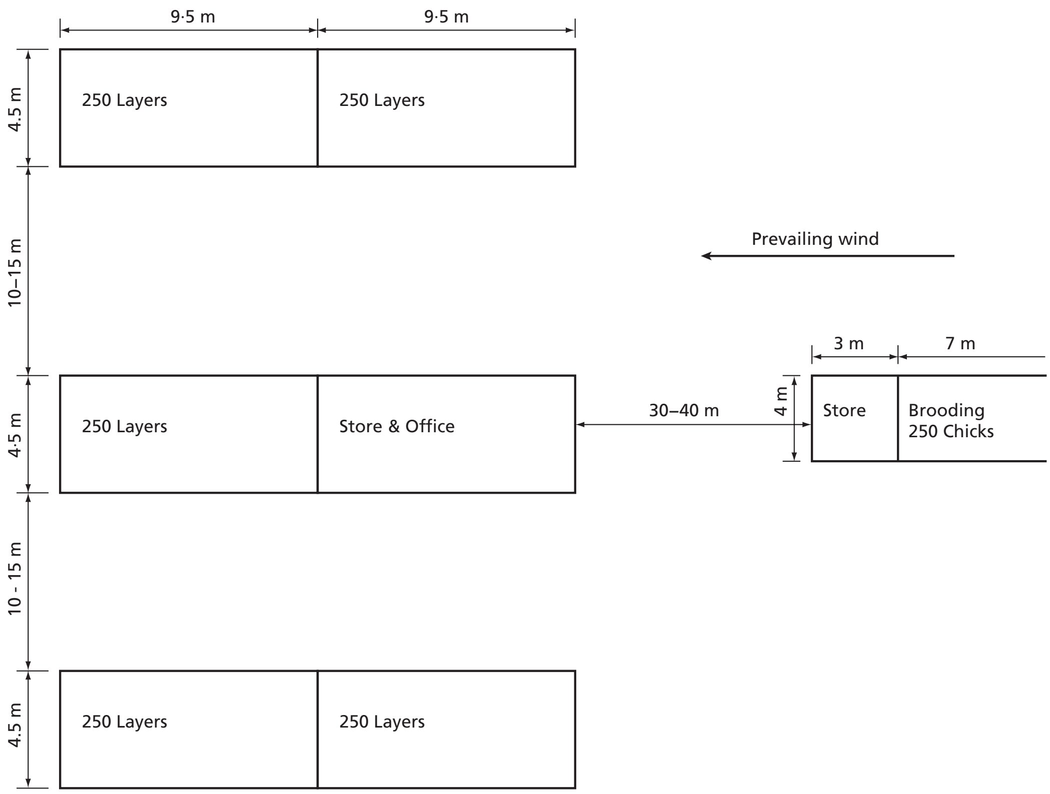


Figure 10.46 **Layout of buildings for 1 000 layers and brooder house for replacements**

escaping and protects the chicks from draughts, is made from a halved oil drum and is equipped underneath with two heaters, e.g. kerosene storm lanterns protected by netting. The hover is suspended by chains from the roof structure, and its height over the floor is adjusted to achieve the required temperature.

A similar but larger brooder for 400–500 chicks has a hover made from two 3-metre long corrugated roofing sheets equipped with six heaters, has a proportionally larger area enclosed by the 60 cm wall, and is supplied with ten water founts and ten feed troughs.

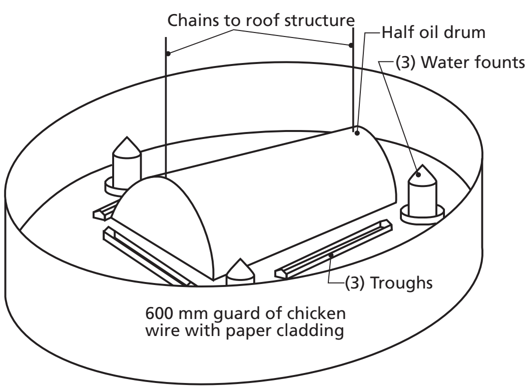


Figure 10.47 **Brooding arrangement for approximately 100 chicks**

Housing for pullets and broilers

In the past, poultry meat has been derived chiefly from culled layers. This is still the main source of poultry meat in most developing countries, although there is an increasing shift towards rearing chickens specifically for meat. Broilers, the common term for meat birds, are fast-growing strains that reach market weight of 1.6 kg in 8–12 weeks. The commercial production of poultry meat is now based primarily on broilers.

In a semi-intensive system, the growing pullets may obtain part of their food by scavenging for forage, seed, etc. A fenced yard allowing 5–8 square metres per bird is preferable to open land. At least part of the yard should have shade cover, and a simple building in which the birds can be enclosed at night will be required. The building should allow 0.2 square metres per bird, have good ventilation and perches for roosting, and offer protection against predators and inclement weather. The birds should be moved at regular intervals to a different yard in order to avoid a build-up of worm infestation.

There is little difference between the system for rearing chicks to become pullet replacements for the laying flock and the system for rearing broilers for market. The same environment and housing are suitable, so they will be considered together.

Brooding and rearing are floor-managed operations. It is common practice to keep broilers or pullets in the same house from the time they are one day old: first on newspapers or thinly spread litter, and later on deep litter. When broilers are marketed at 8–10 weeks of age, or when pullets are transferred to the laying house at 16–18 weeks of age, the litter is removed so that the house can be thoroughly cleaned and disinfected. The house should therefore be designed and built to allow for easy and efficient cleaning. Pullets and broilers are not grown together owing to the difference in the length of their growing periods and differing schedules for artificial lighting.

Chicks are started in a brooder, which may be of the type discussed in the previous section, and remain there for 6–8 weeks. During this time it is desirable to conserve heat and to prevent draughts and, in this respect, the building design can be an important factor. A method that is widely used in the United States, called 'end-room' brooding, works well and seems adaptable to warm climates as well.

By taking advantage of the fact that chicks up to four weeks old require only one-third to half as much floor space as they will need later on, one end and enough of the adjacent sides are closed in tightly to provide 0.05 square metres of floor space per chick to be brooded. Offcuts, with low thermal capacity, are ideal for enclosing the wall. A hessian curtain forms the fourth (interior) wall to complete the temporary enclosure. The baby chicks can then be confined in the space around the brooder in the enclosed end of the house (see Figure 10.48).

The remaining walls are covered with 18–25 mm wire mesh. At the end of the brooding period, the brooder is raised to the ceiling for storage, the hessian curtain is lifted and the chicks are allowed into the rest of the house, which should provide from 0.08 square metres/bird for broilers, to 0.17 square metres/bird for pullets.

Depending on the maximum temperatures expected, it may be necessary to provide some ventilator openings in the enclosed walls. An adjustable gable-end ventilator is particularly desirable, as the roof will not have a ridge vent for brooding operations. If cool, breezy weather is expected, one or more of the screened sides may be equipped with hessian curtains.

Equipment and stores

In addition to what has already been described, the chicken house will require equipment such as waterers, feeders and a feed store, and perhaps perches for roosting. Houses for floor-managed layers or breeders will require nest boxes. A store for eggs may be required in any laying house. There should be sufficient feeders and waterers for easy access (particularly important for young chicks), long enough for each bird to have its place, and with sufficient holding capacity. Tables 10.13 and 10.15 provide some information relevant to their

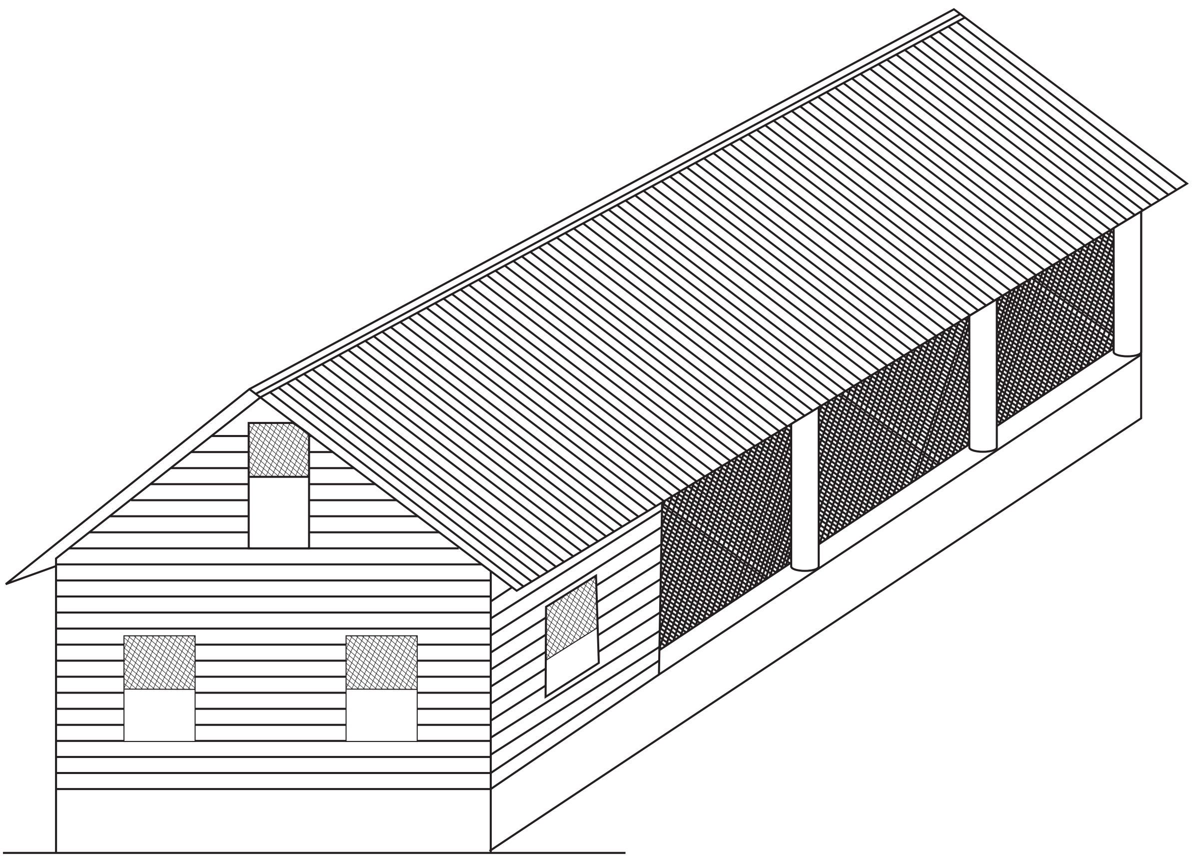


Figure 10.48 **A closed end brooder and growing house**

design. Most chickens in intensive production are fed water and mash on a free-choice basis.

Note: The cumulative feed consumption in pullets from one day to the point of laying at the age of 20–24 weeks is 10–12 kg. The rearing of one broiler from one day old to marketable weight (2 kg live weight) at 9–12 weeks of age requires 4–6 kg feed.

Feeders

Either trough or tube feeders are used for day-old chicks, growing birds and layers, but their size must be selected to suit the birds to be fed. The number of feeders should be such that the distance to the nearest feeder does not exceed 2 metres from any point in the house. A trough should be not too wide, easy to clean and designed to prevent the hens from leaving their droppings in it.

TABLE 10.15
Feed and water requirement for pullets and broilers relative to their age, and for layers relative to their weight and egg production

Chickens	Feed requirements (kg/week per bird)			Water requirement (litres/day per bird)
	Pullets	Broilers		
Rearing birds				
1–4 weeks of age	0.07–0.20	0.10–0.40		0.05–0.15
5–8 weeks of age	0.26–0.36	0.50–0.90		0.16–0.25
9–12 weeks of age	0.40–0.49	1.00–1.10		0.20–0.35
13–20 weeks of age	0.51–0.78	-		0.25–0.40
Egg production: No. of eggs/year				
Layers	100	200	300	
Light breed	0.54	0.65	0.78	0.25–0.35
Medium breed	0.69	0.82	0.94	0.27–0.40
Heavy breed	0.84	0.96	1.10	0.30–0.45

Figure 10.49a shows a good trough design that can be made by the farmer. If used outside in a run, the trough should be sheltered by a roof. Small trough feeders for chicks are used on the floor, but the larger ones are usually mounted on a stand to prevent the chickens from kicking litter into them, and have perches where they can stand while eating (see Figure 10.49b). Tube feeders, as shown in Figure 10.49c, are suspended from the ceiling and are easily adjusted for height (0.3 metres above ground is recommended for mature birds).

Drinkers

An ordinary 10-litre or 15-litre bucket serves very well as a drinker for layers. If it is sunk into the floor or ground so that only about 10 centimetres shows above ground, it may be used for chicks as well. Another arrangement for chicks consists of a shallow bowl supplied with water from an upside-down bottle, as shown in Figure 10.62. Water fountains of the type shown in Figure 10.49d are available in sizes for all ages.

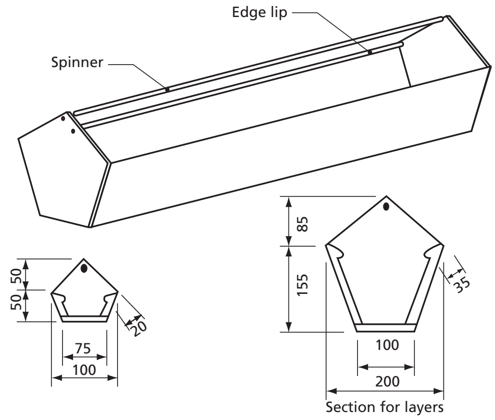


Figure 10.49a **Trough**

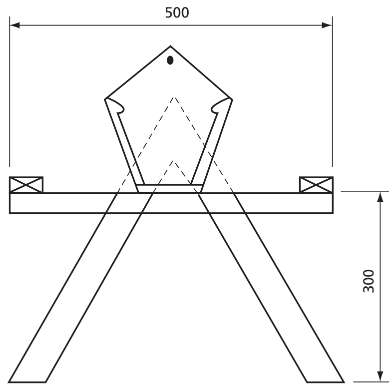


Figure 10.49b **Trough on a stand**

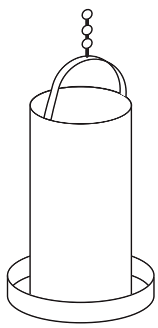


Figure 10.49c **Tube feeder**

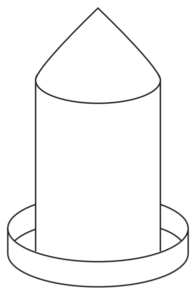


Figure 10.49d **Water fountain**

Figure 10.49 **Feeders and waterer**

Just like feeders, they are used on the floor for small chicks and on stands for older birds. The number of drinkers should be such that all chickens have access to one within a distance of 3 metres.

Automatic drinking nipples may be used for layers in cages. There should be at least one nipple for every two hens. It is desirable for every hen to have access to two nipples, as clogging of a nipple is not always easily detected.

Nest boxes

Layers and breeders, except those managed in cage systems, should have access to nest boxes in which they can lay their eggs. The nests can be used by one or more birds at a time. Single nests commonly have the dimensions 250–300 mm wide, 300–380 mm deep and 300–350 mm high. They have a 100 mm litter-retaining board across the bottom of the opening and a perch 150–200 mm in front of the entrance.

Communal nests should have a space allowance of at least 0.09 square metres per bird. The top of the nest should be steeply sloped to prevent birds from roosting there. One nest should be supplied for every five birds in the flock. Figure 10.50 shows a two-tier nest box arrangement. The bottom row of nests should be 450–600 mm from the floor.

Perches

Chickens have a natural instinct to roost in trees at night. To provide for this, perches are commonly installed in chicken houses from six to eight weeks of age or more, in particular in semi-intensive systems. Perches for young birds should have a diameter of about 35 mm and provide 0.1–0.15 square metres of space per bird, while adult birds need about 50 mm diameter and 0.2–0.3 square metres of space. The perches should be fixed to solid stands 0.6–1 metres above the floor and 0.35–0.4 metres apart, preferably placed lengthwise at the centre of the house. A deck about 200 mm underneath to collect manure is desirable.

Feed stores

Grain stores are discussed in Chapter 16. The feed stores required for a small flock are very similar to those for food grains. For commercial flocks, the type of store depends on how the feed is handled. If it is purchased in bag lots, then a masonry building with an iron roof that is secure against rodents and birds is most suitable. If feed is delivered in bulk, then one or more overhead bins, from which the feed is removed by gravity, will be convenient and safe.

The size of the store required depends entirely on the frequency and size of deliveries, but can be estimated as 0.0035 m^2 floor area per bird in the flock where feed is purchased in bags. If part of the grain is produced on the farm, then some long-term storage of the type shown in Chapter 16 will be required.

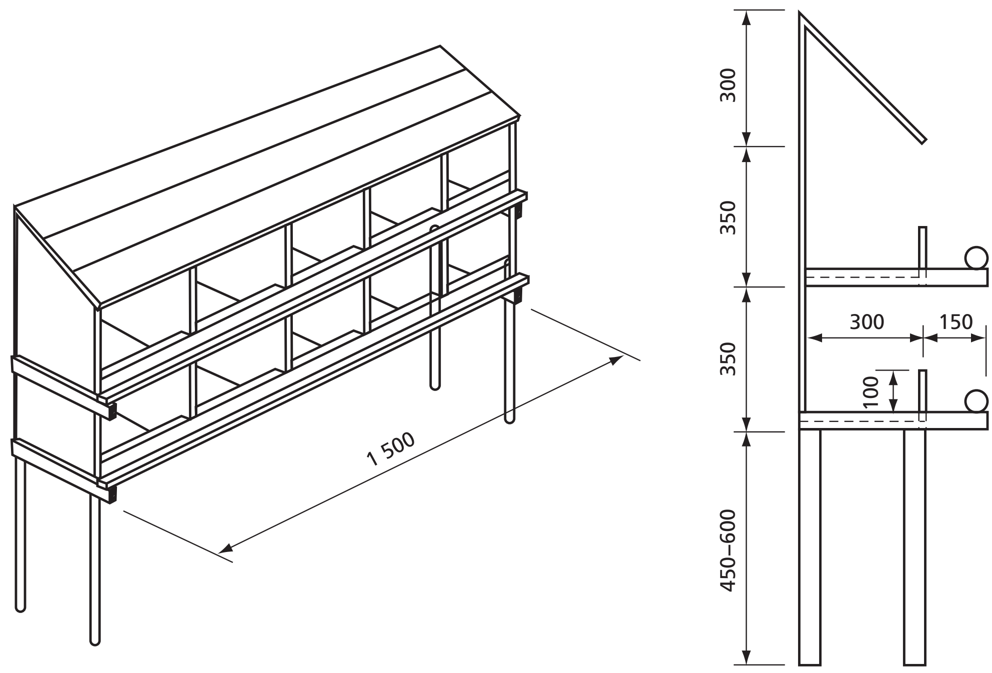


Figure 10.50 **A battery of single laying nests for 50–60 hens**

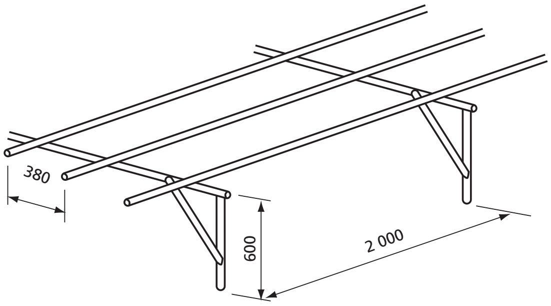


Figure 10.51 **Perches**

Manure handling

A layer is estimated to produce an average of 0.15–0.20 kg manure per day, and a broiler produces 0.08–0.12 kg of manure per day. In deep-litter systems, the litter used may more than double these amounts. Poultry manure is commonly allowed to accumulate in the house under a wire or slatted floor, or as deep litter, for quite extended periods, but alternatively it may be cleaned out regularly and stored in a concrete pond. It is an excellent form of fertilizer. Processed poultry manure has successfully been fed to cattle, sheep and fish as a portion of their total ration.

Egg handling

Eggs are an excellent source of animal protein and are usually less expensive than meat. If properly handled under sanitary conditions, they store well for short periods and reach the consumer in good condition. However, eggs are perishable and possible carriers of salmonella, a serious food poison, so the need for clean conditions and refrigeration cannot be overemphasized. The following list includes several recommended practices and facilities:

1. A clean nest and floor litter will minimize the number of dirty eggs.
2. The egg-handling and storage building should be screened, free of rodents and other vermin.
3. The water supply should be potable and ample.
4. Lavatory and toilet facilities should be available.

Egg-cooling for large commercial laying operations requires approximately 0.25 m^3 of cool store per 1 000 layers per day of storage. For smaller flocks, the store will need to be proportionately larger.

Figure 10.52 shows an *evaporative charcoal cooler* for small farms. A store measuring 100 × 100 cm (for example) is covered by a water tray, from which cloth strips or 'wicks' drip water down into side frames. The frames consist of a 5 cm layer of broken charcoal, sandwiched between 1.25 cm chicken wire mesh. A hinged and latched door is constructed similarly to the sides. The action of water evaporating from the charcoal cools the interior of the box.

Other methods for short-term storage of eggs at the small poultry unit include underground cellars, storage in lime water and storage after dipping in water glass.

For longer periods of storage, a refrigeration system and a well-insulated room is required to maintain a storage temperature of 5–10 °C. To allow storage for six to seven months, a temperature of between -1.5 °C and 0 °C will be required. The refrigeration capacity needed is approximately 200 watts for 5 000 layers, or 300–400 watts for 10 000 layers. Other capacities would be proportionate.

Custom-designed systems with generously sized evaporators should be installed. Room air-conditioners do not provide the desirable humidity for storage. The evaporator is too small and operates at a low temperature, removing too much moisture from the air.

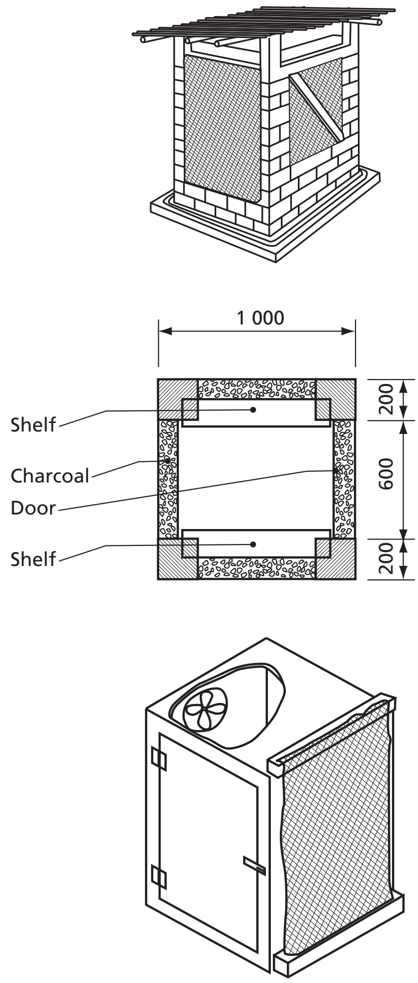


Figure 10.52 **Evaporative cooler for eggs, milk and other foodstuffs. Where electricity is available, a fan-controlled air flow will provide more efficient operation**

Duck housing

Although ducks are kept for both meat and egg production, commercially there is much more demand for meat than for eggs.

On the other hand, egg production does provide a valuable contribution to the family income and diet for the small-scale farmer. Ducks lay more and larger eggs than indigenous chickens. Raising ducks is encouraged in African countries because they are hardy and are easy to raise and manage.

To a large extent they can feed on grass, vegetables and grains produced on the farm. Housing is also quite simple and inexpensive. For these reasons, small-scale farmers would benefit from keeping ducks instead of hens, which are more prone to disease and malnutrition.

Brooding and rearing

Brooding ducks have similar requirements to chickens and the same temperatures are used: 35 °C for the first week, thereafter reduced by 3 °C at weekly intervals until normal air temperature is reached.

Ducklings grow very rapidly, and floor and trough space on deep litter should be provided according to Table 10.16.

TABLE 10.16
Recommended minimum floor and feed space for ducks

	Floor space[1]		Feed trough space
	(m^2/bird)	(birds/m^2)	(birds/m)
1–2 weeks	0.05	20	14
3–4 weeks	0.1	10	11
4–7 weeks	0.2	5	9
7 weeks to market	0.3	3–4	8
Mature birds	0.3–0.4	2.5–3	7–8

[1]Refers to deep litter; on a wire mesh floor the stocking rate can be doubled.

Litter materials include straw, sawdust, shavings and sand. The large quantity of water that ducks drink produces wet manure that causes problems with almost any form of litter. A wire mesh floor is therefore a desirable alternative. The 12.5 mm mesh of 8-gauge wire is suitable.

Fresh air is important and, after a few days, ducklings can be let out in fine weather. They should, however, not be allowed to become wet before feathering is complete on their backs, at about six weeks of age. Ducklings should also be shaded during hot weather to prevent sunstroke.

Housing

Housing for ducks can be very simple (see Figure 10.53). The house should be situated on a well-drained and preferably elevated area.

The *floor* should be raised at least 15 cm above the surrounding ground level to help keep it dry. Ducks tend to be dirty, and plenty of clean litter must be used in floored housing.

Although a concrete floor can be installed for easy cleaning, it is not necessary. If part of the floor is of wire mesh and the ducks have to cross it on their way to the nest boxes, their feet will be cleaned so they do not make the nests and eggs dirty.

Solid walls: Walls 60 cm high are adequate. They may be made from any material, provided that it keeps the ducks in and predators (such as dogs, snakes, rats and wild birds) out. The space between the wall and the roof is covered with wire netting, with a mesh not larger than 25 mm. Total wall height need not exceed 150–200 cm.

A *roof* made of thatch is a fully adequate and inexpensive covering for a duck house. Metal sheets can also be used, but insulation should be installed under the sheets.

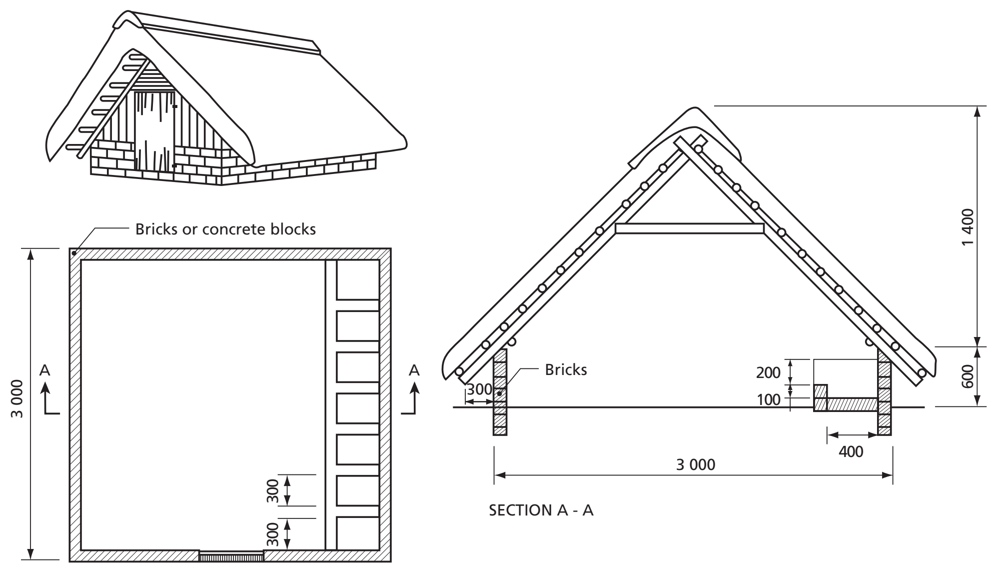


Figure 10.53 **Duck house for 25 ducks**

Nest boxes 30 cm wide, 40 cm deep, and 30 cm high should be provided for every four ducks. The front should be l5 cm high. The nest boxes are placed either on the floor or 30 cm off the floor against a side or rear wall. Although nesting boxes off the floor release more floor space, the ducks may lay their eggs under the boxes.

A *run and fencing* should provide a minimum of 1 square metre per bird, but 2–3 square metres or more will keep the ducks cleaner and give more space for grazing. On open-range pasture the ducks should be allowed 20 square metres per bird.

Feed and water equipment

Duck feeders need to be somewhat wider than chicken feeders to allow for their 'shovelling' eating habits. For the first two weeks, preferably the food should be supplied as crumbs or wet mash. Later the food is best given in the form of pellets. The required trough space is included in Table 10.16. Adult ducks normally consume about 0.2 kg of feed per day, but some ducks in full lay may require up to 0.3 kg per day.

Ducks of all ages drink large quantities of water. Waterers must be designed to allow easy access for the birds and easy cleaning for the farmer.

As ducks like to swim, if possible they should have access to a stream or pond. Contrary to popular belief, there seems to be little benefit in providing for swimming, except that, with water available, the ducks are able to keep themselves cleaner and somewhat higher egg fertility may result.

Geese housing

Geese are foragers and can be allowed to graze on succulent grass as early as three weeks of age. Therefore more encouragement should be given to the development of meat production from geese in east and southeast Africa.

Unless there are a large number of geese, natural hatching will take place. A goose will sit on 10–15 eggs. The sitting goose should be allowed to use her regular nesting place for incubating the eggs.

Rearing goslings is relatively easy if proper care and attention is given. The goose should be confined to a clean coop for the first 10 days while the goslings have access to a small run. Chick mash can be fed for the first three to four weeks, along with succulent grass. After three weeks of age the goslings will graze, but supplementary feed must be given if the grazing is poor.

Geese are selective grazers and will quickly return to newly grown grass after recent grazing. If the geese are herded, a much wider range of grazing is possible.

Housing for geese is very simple, if any is required at all. In tropical areas, geese appear to be quite content left outside at all times of the year. However, there is often a danger of theft and attack by predators, so the geese should be herded into a shelter at night for protection. The shelter can be simple and cheap as long as it serves this purpose.

A wooden framework surrounded by wire mesh is quite adequate. Wooden rails or bamboo can also be used in place of the wire mesh. The same materials can be used for the roof, as a waterproof roof is not necessary. There is no need for a floor, but the ground should be elevated to avoid flooding.

Housing for turkeys

In recent years there has been a steady increase in turkey production. The main demand is still at Christmas and New Year, but the better hotels and restaurants require supplies throughout the year. The demand is only for turkey meat. All the eggs produced are used for incubation by hatcheries.

The production of turkeys should be confined to commercial enterprises. As chickens carry diseases that affect turkeys, the small farmer should not grow the two together.

Brooding and rearing methods for turkey poults are similar to those for chickens, but the brooding temperature is higher. The recommended temperature for the first week is 35–38 °C, after which it can be reduced by 4 °C per week until ambient temperature is reached.

Adequate floor space in the brooder house is important, as the turkey poults grow rapidly. Table 10.17 provides information on space requirements.

At about 10 weeks of age, turkeys are put out on range in a fenced enclosure. In the interest of disease control, it is essential to use clean land that has not carried poultry, turkeys, sheep or pigs for at least two years. Approximately 20 square metres of pasture should be allowed for each bird.

A range shelter with 20 square metres of floor area is suitable for 100 poults up to marketing age. Dry, compact soil is adequate for a floor. The frame should be made of light material, covered with wire mesh, so that the shelter can be moved to clean range each year. The roof, which should be watertight, can be made of thatch or metal sheets. Perches, made from 5 × 5 cm square rails or round rails 5 cm in diameter, should be installed 60 cm from the ground and 60 cm apart, allowing 30–40 cm of length per bird.

The turkey breeder flock can be confined in a deep-litter house similar to the one shown in Figure 10.40 for chickens. Recommended floor, feed and water space for turkeys is given in Table 10.17. Approximately 23 kg of feed is required to produce a 6.4 kg turkey at 24 weeks of age. Adult birds require 0.12–0.3 kg per day depending on the size of the breed.

Early mortality in turkey poults caused by a lack of drinking or feeding is a constant problem and can only be prevented by good management and reliable equipment. Young poults must be coaxed to eat by making sure they have plenty of feeding places and can see the food easily. The same applies to water.

TABLE 10.17
Recommended floor, feed and water space for turkeys

	Brooding 0–6 weeks	Growing 6–12 weeks	Breeding
Floor space	0.1 m^2	0.4–0.6 m^2	0.7–0.9 m^2
Roosting space	-	30–38 cm	30–38 cm
Nests	-	-	60 × 150 cm
		(for 20–25 hens)	
Feeders	4–8 cm	10 cm	12 cm
Water	2 cm	3 cm	4 cm

It is important to keep turkeys from being frightened by people, animals or machines. When alarmed, turkeys have a tendency to stampede, pile up and smother.

SHEEP AND GOAT HOUSING

Sheep and goats are important sources of milk and meat. Both readily adapt to a wide range of climates and available feed supplies. They also have similar housing requirements and will therefore be treated together.

Management systems

Depending primarily on the availability and use of land, three systems of production are practiced:

1. Subsistence, in which a few animals are tethered during the day and put into a protective shelter at night.
2. Extensive, in which the flock/herd grazes over large areas of marginal land unsuitable for agriculture. The flock is usually shut into a yard at night. Both these systems are practiced extensively in East Africa.
3. Intensive, in which the animals are confined to yards and shelters, and feed is brought to the flock. This system offers the greatest protection for the flock from both predators and parasites. Although it may make the best use of limited land resources, this system also increases labour and the capital investment required for facilities.

Housing

Housing in tropical and semitropical regions should be kept to a minimum, except for the more intensive

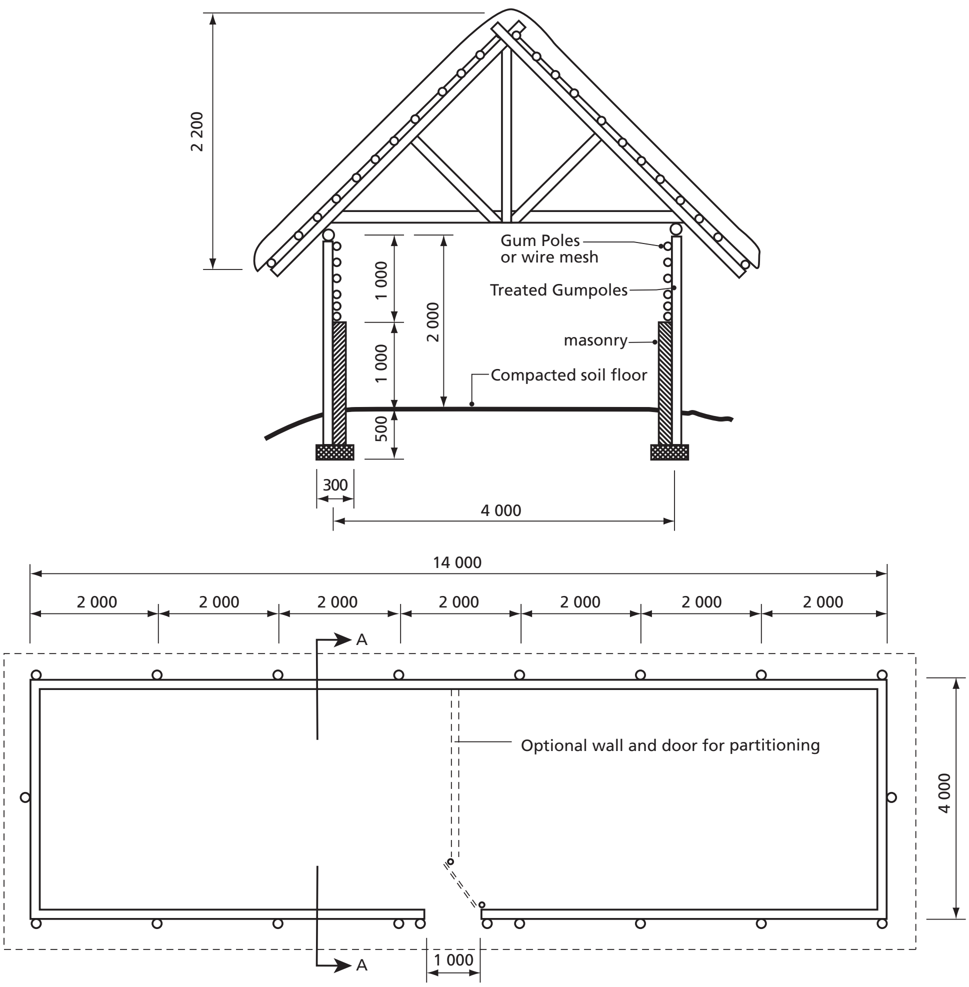


Figure 10.54 **Sheep/goat house for 100 animals. In a warm climate gum-pole rails instead of the masonry walls provide better ventilation**

TABLE 10.18
Recommended floor and trough space for sheep/goats in intensive production relative to live weight

	Weight (kg)	Floor space: Solid floor (m^2/animal)	Floor space: Slatted floor (m^2/animal)	Floor space: Open yard (m^2/animal)	Trough space (m/animal)
Ewe/doe	35	0.8	0.7	2	0.35
Ewe/doe	50	1.1	0.9	2.5	0.40
Ewe/doe	70	1.4	1.1	3	0.45
Lamb/kid		0.4–0.5	0.3–0.4	-	0.25–0.30
Ram/buck		3.0	2.5	-	0.5

Slats should be 70–100 mm wide, 25–30 mm thick and laid with 25-mm spaces. Individual lambing pens should be 1.5–2.2 m^2, depending on the weight of the ewe and number of lambs expected. A feed trough should be 0.3–0.4 metres deep front to back, and have a 0.5–0.6 metre high front wall facing the feed alley

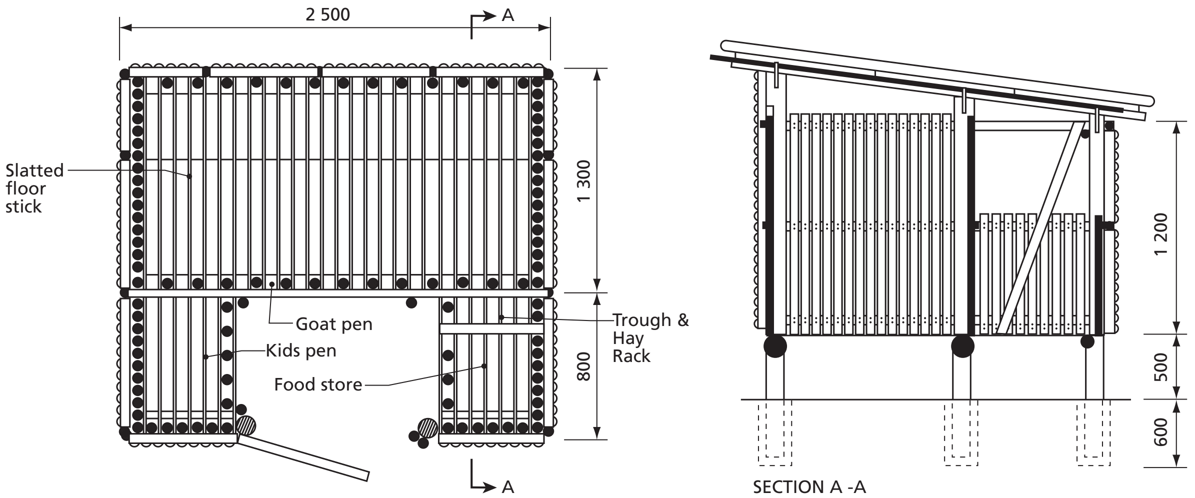


Figure 10.55 **House for two to four sheep/goats in intensive dairy production**

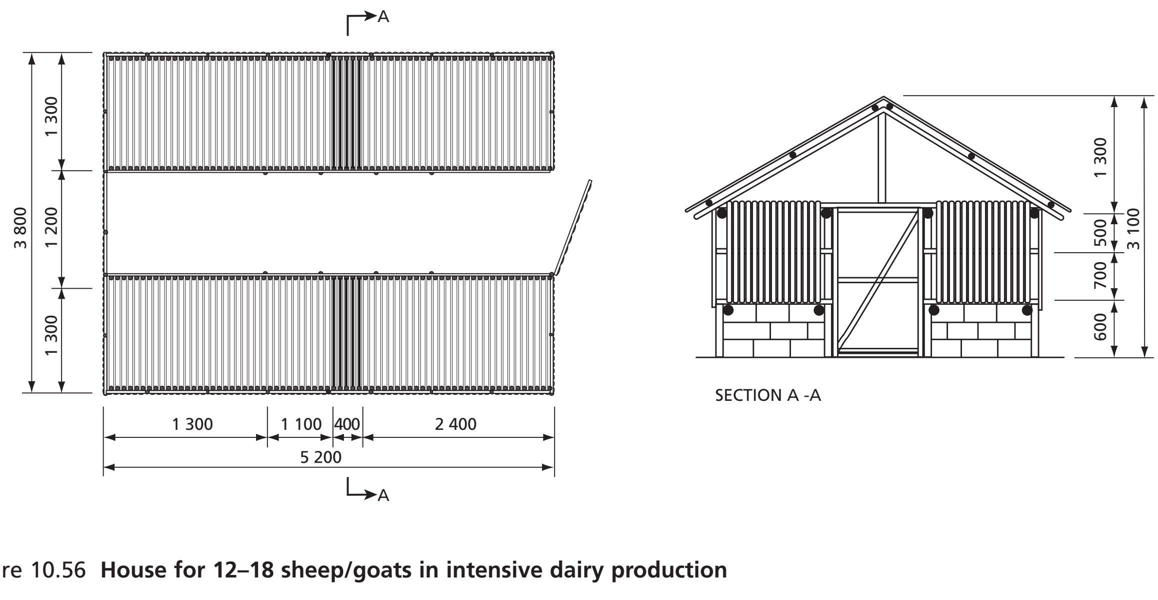


Figure 10.56 **House for 12–18 sheep/goats in intensive dairy production**

systems of production. In the arid tropics, no protection other than natural shade is required. In humid climates, a simple thatched shelter will provide shade and protection from excessive rain. As sheep and goats do not tolerate mud well, yards and shelters should be built only on well-drained ground.

Figure 10.54 shows a sheep/goat house for 100 animals. Unless predators are a serious problem, gum-poles can be substituted for the brick walls. If thatching is difficult to obtain, a lower-pitch roof of galvanized steel is feasible, but some insulation under the roof is desirable.

Where housing facilities are provided, in addition to water, feed troughs and permanent partitions, it will be necessary to provide temporary panels to help divide and handle the flock when necessary, in order to carry out such operations as disease treatment, docking, shearing, milking and lambing.

In temperate climates and at high altitudes, a more substantial structure may be needed. An open-front building facing north provides wind protection and a maximum of sunshine. A rammed-earth floor with a slope of 1:50 towards the open front is recommended. A concrete apron sloped 1:25 and extending from 1.2 metres inside to 2.4 metres outside will help maintain clean conditions in the barn.

In areas of high rainfall it may be desirable to keep the animals off the ground. Stilted houses with a slatted floor raised 1–1.5 metres above the ground, to facilitate cleaning and the collection of dung and urine, are shown in Figures 10.55 and 10.56.

Milking can be facilitated by providing a platform along the feeding fence where the animals can stand while being milked from behind. Such a platform should be 0.8 metres deep and elevated 0.35–0.5 metres above the floor where the milker stands.

Parasite control

A dipping tank and crush are essential in the layout for a large flock, or for a community facility for the use of many smallholders. A typical dipping tank is shown in Figure 10.57. In areas where the bont tick is a

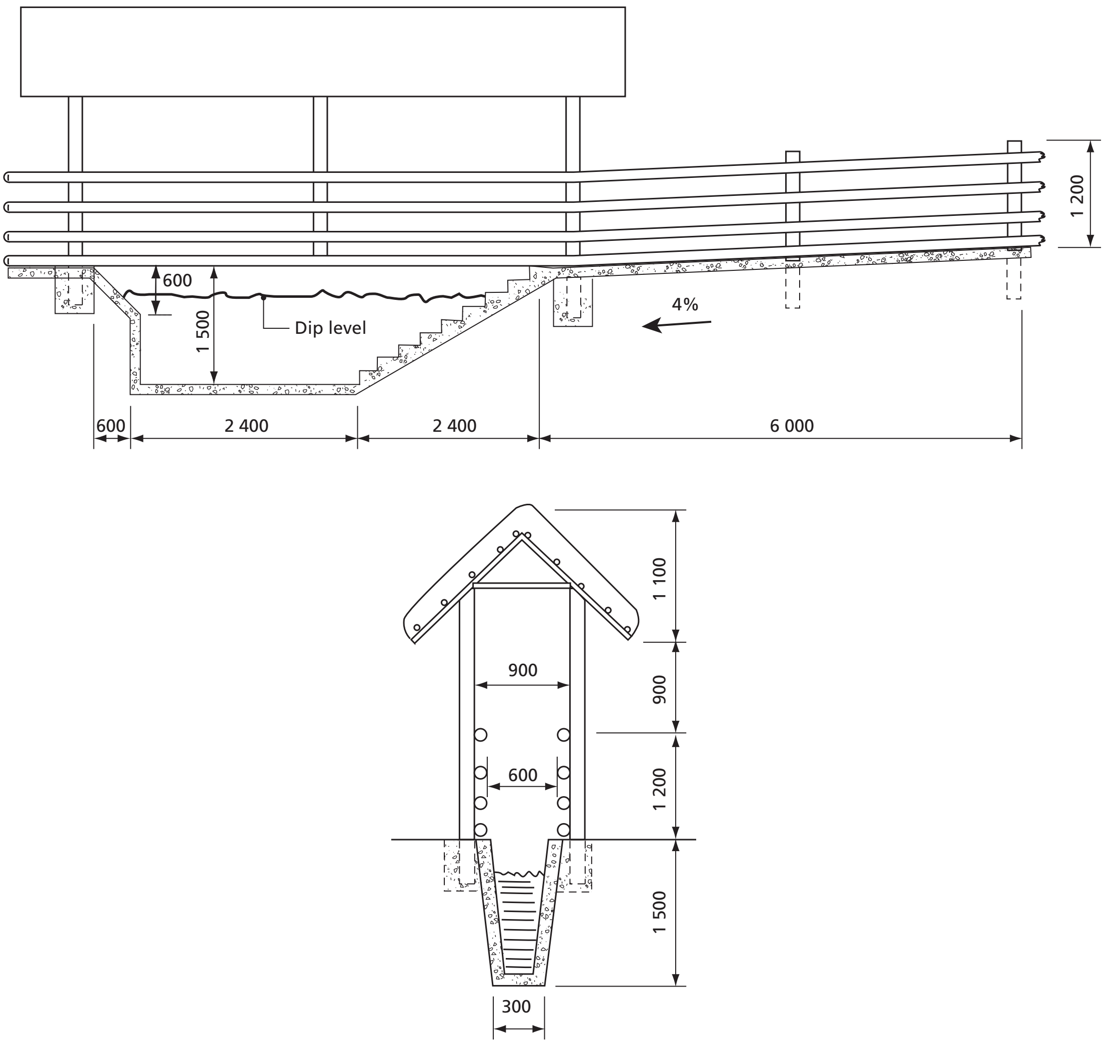


Figure 10.57 **Sheep-dipping tank**

problem, simple walk-through tanks or footbaths may be needed. Figure 10.58 shows plans for a footbath.

RABBIT HOUSING

There are few if any countries where domestic rabbits are not kept for meat and pelts. It is widely recognized that a few rabbits can be kept at low cost to produce a fair quantity of wholesome and tasty meat. However, to raise rabbits successfully one must begin with healthy animals, provide a good hutch, clean and nutritious feed, and take good care of the rabbits.

Management systems

Rabbits, like other domestic animals, may be bred and reared at various intensities. Table 10.19 shows some rabbit production characteristics. Rabbits can be mated at almost any time and, when mating is successful, the doe will kindle 30–32 days later. The doe should be checked for pregnancy 10 days after mating and, if necessary, remated. A shorter interval between kindling and mating will obviously result in a higher number of litters per doe per year.

Commercial producers aim for at least six litters per year, with seven kids weaned per litter, i.e. 42 kids per doe each year. However, with intensive production, the

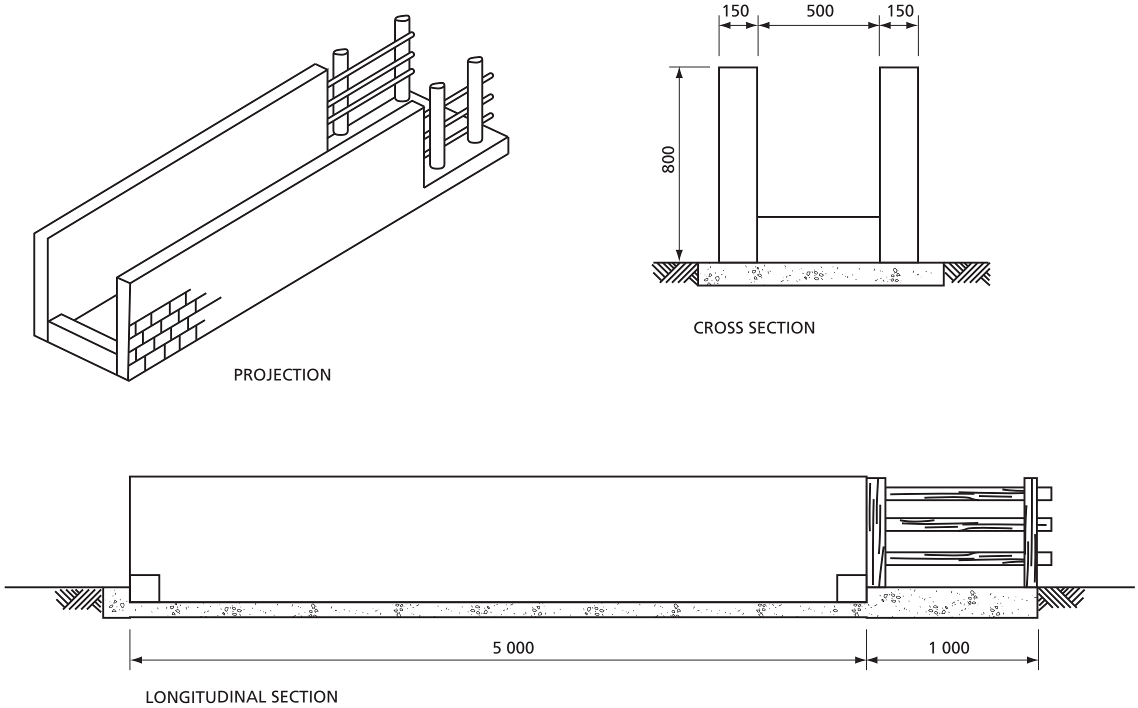


Figure 10.58 **Footbath and drain crush for sheep/goats**

TABLE 10.19
Management practices and production efficiency related to the intensity of rabbit production

	Feed time between kindling and mating		
	Extensive greens (8–10 weeks)	Semi-intensive greens/ concentrates (4–6 weeks) (or remating 1–2 days after weaning)	Intensive concentrates (1–2 weeks)
Age of young at weaning	8–10 weeks	6–8 weeks	4–5 weeks
Number of litters per doe/year	3–4	5–6	8–10
Number of young weaned per doe/year	10–20	30–40	50–65
Age of young at slaughter	20–30 weeks	12–15 weeks	10–13 weeks
Daily grain during fattening	10–15 g	20–30 g	25–30 g
Production of cold-dressed meat per doe/year	15–25 kg	40–60 kg	75–100 kg

breeding doe may have to be replaced every 1–1.5 years, while, in a semi-intensive system, it may last for three years. Replacement does can be bred for the first time at five months of age.

A balanced diet fed in adequate amounts, good sanitation, disease control, appropriate housing and equipment, and good care are all important factors when aiming at lower mortality and higher daily gain. The mortality in a well-managed rabbit unit should be below 20 percent from birth to slaughter among the young, and below 20 percent annually among the adults, but at present many extensive producers in east and southeast Africa experience mortality of up to three times that.

In semi-intensive systems, a substantial part of the diet for rabbits consists of greens, such as grass, browse, weeds, vegetable waste, roots, tubers and vegetables. This usually necessitates longer breeding intervals and results in lower daily gain than intensive systems where the rabbits are fed with only rabbit pellets or chicken mash. However, because the feeding cost is lower, the farmer may gain an equally large profit.

Hutches

While there are a great many types of hutch, any well-designed hutch should provide certain essential features:

1. Enough space for the size of the rabbit.
2. Fresh air and light, but exclusion of direct rays from the sun.
3. Protection from wind and rain.
4. Sanitary conditions and ease of cleaning.
5. Sound but cheap construction; free from details that could injure the animals.
6. Convenience of handling.
7. A cage for each adult rabbit.

Space requirements

Each adult rabbit must have its own cage or compartment. Domestic rabbits vary in weight from 2–7 kilograms, depending on the breed, so the size of cage may be determined by allowing 1 200–1 500 cm^2 of clear floor space per kilogram of adult weight. This means that a cage for a medium-breed buck should provide a minimum of 80 × 80 cm. However, cages for females should allow extra space for the nest box and the litter, hence 80 cm by 115 cm should be regarded as the minimum for a medium breed doe.

Young rabbits reared for meat can be kept in groups of 20–30 animals until they reach four months of age. The weaned young kept in one group should be about the same age and weight. Such colony pens should allow 900–1 200 cm^2 of floor space per kilo of live weight.

The cages should not be deeper than 70–80 cm for ease of reaching a rabbit at the back of the cage. The floor-to-ceiling height of the cages should be minimum 45–60 cm, and it is desirable to have the floor of the cages 80–100 cm off the ground to handle the rabbits comfortably.

Hutch modules

Any size rabbit unit is conveniently made up from two-doe or four-doe modules. The number of cages required in each of these modules is shown in Table 10.20.

The small-scale producer may only have one such module, covered with its own roof placed directly on the cages, as shown in Figures 10.59 and 5.60, while the medium- to large-scale producer may have several modules placed under a separate roof on posts or in a shed, as shown in Figure 10.61.

Construction details

Proper ventilation of the rabbitry is essential. The walls, roof and door of the hutch can be covered with chicken-wire netting (37 mm mesh), or made from wood or bamboo placed 20 mm apart.

In high altitude areas with lower temperatures, it may be desirable to have a solid wall in the direction facing the prevailing wind. Temporary protection from strong winds, low temperatures and rain can be provided with curtains of hessian, reeds, grass, plastic, etc. The roof of the rabbit unit should be leakproof and can be made of thatch or metal sheets with some insulation underneath.

Ease of management depends to a great extent on the construction of the floor. It may be solid, perforated, or semisolid. Each has its advantages and disadvantages:

TABLE 10.20
Number of hutches required in two- and four-doe modules depending on the intensity of feeding and breeding

	Cage for buck	Cages for does	Cages for fattening weaners	Total number of cages per module
Two-doe modules				
Extensive production	1	2	1	3 (or 4)
Semi-intensive production	1	2	1	4
Intensive production	1	2	2	5
Four-doe modules				
Semi-intensive production	1	4	3	8
Intensive production	1	4	4 (to 5)	9 (or 10)

Note: The cages for fattening weaners allow space for one litter.

A solid floor can be made from wood, plywood or different kinds of board. It allows bedding to be used, eliminates draughts through the floor and causes less trouble from hock sores, but is difficult to clean. The use of a solid floor will permit the hutches to be stacked in two or three tiers, with the bottom row 30 cm off the ground, and this may save some building space. However, a solid floor in the hutch frequently leads to outbreaks of coccidiosis, a disease causing diarrhoea, loss of appetite and often death, because of a build-up of manure in corners of the cage and contamination of feed and water.

A perforated floor is self-cleaning, as manure and urine pass through to the ground, and this assists in disease control but, if not properly constructed, it may injure the animals. It can be made of woven or welded wire of not less than 16 gauge. Suitable mesh sizes are 12 mm for small and medium breeds, and 18 mm for large breeds. Chicken wire can be used, but its thin wires may cause sore hocks, and the urine can corrode the wire to failure within a year. The wire netting is stretched over a wooden frame, trimmed flush with the bottom edge, and stapled every 5 cm. Where it is fastened to posts, the wire edges should be turned down to avoid injury to the rabbits. A self-cleaning floor is usually recommended.

Equipment and store

Drinkers

A doe with litter may require up to 5 litres of water a day if fed only rabbit pellets or chicken mash. Rabbits receiving fresh greens daily will require less water, but all rabbits should have access to clean drinking-water at all times.

An automatic waterer can be made from a large bottle and a small tin can (see Figure 10.62a). Fasten

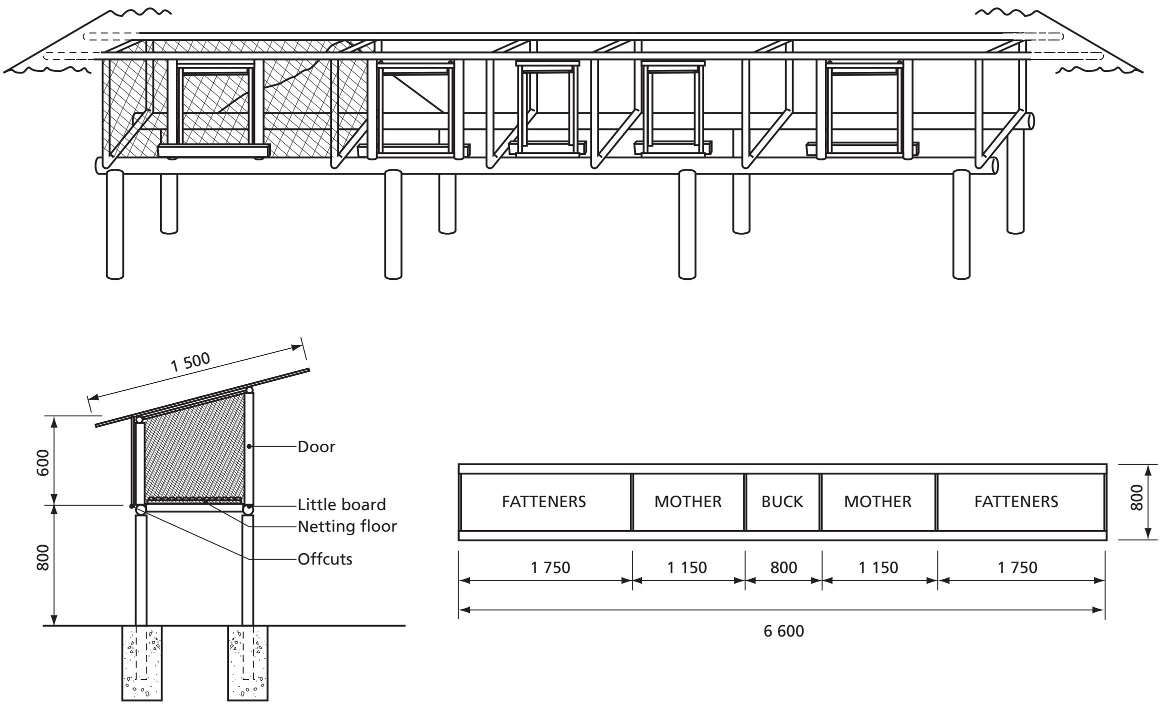


Figure 10.59 **Rabbit unit for two does, one buck and fatteners**

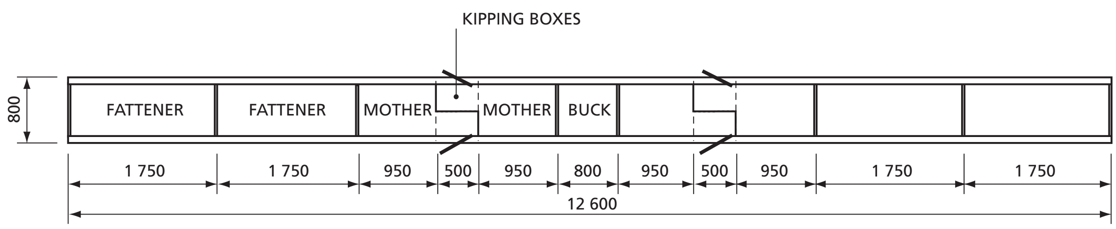


Figure 10.60 **Plan view of rabbit housing module for four does, one buck and fatteners. Kindling boxes are permanently installed with access from each cage for a doe. The kindling boxes have outside doors to facilitate cleaning. The cross-section is similar to the one shown in Figure 10.59.**

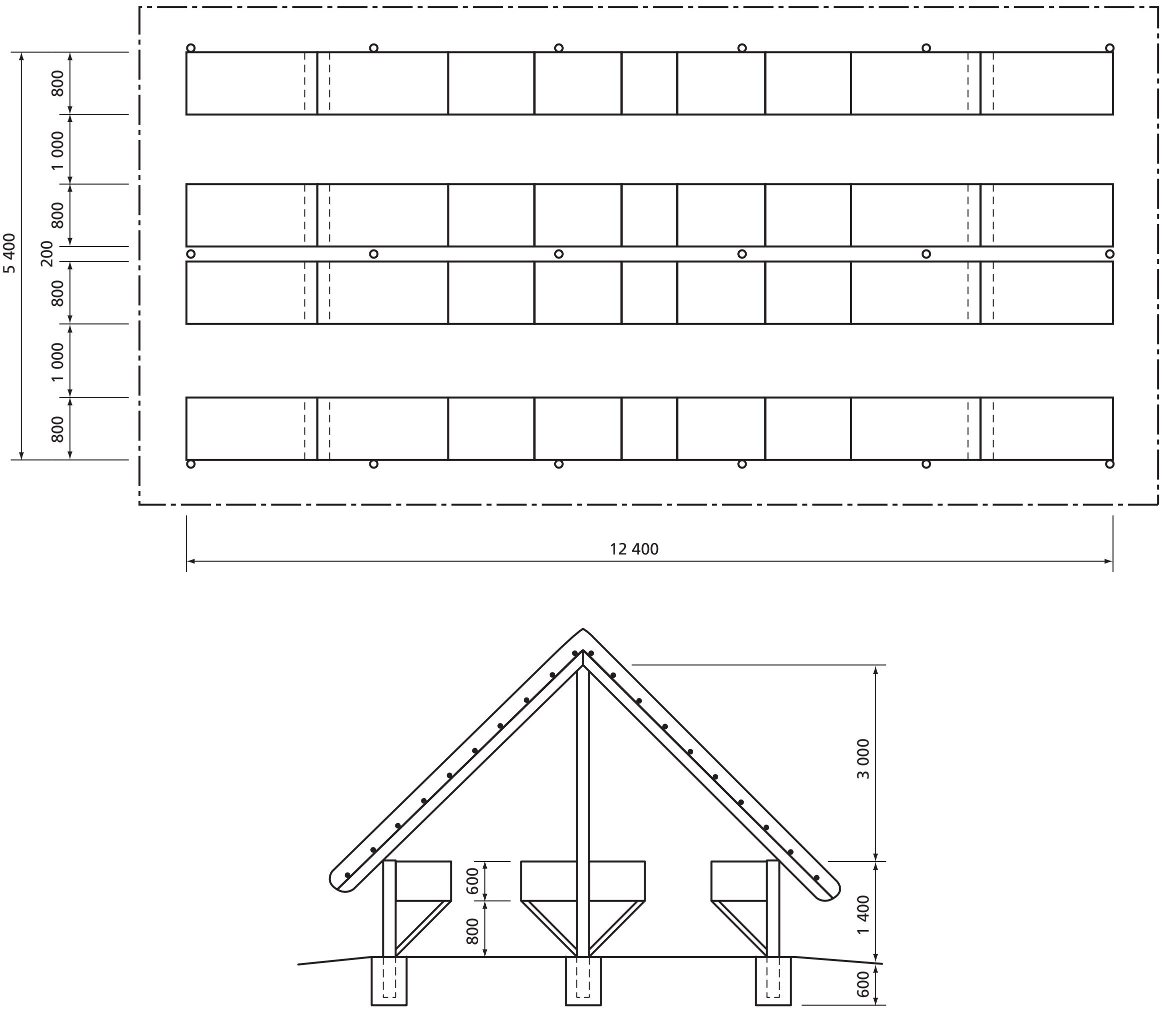


Figure 10.61 **Rabbit house for 16–18 does, 2–4 bucks and approximately 100 fatteners. Note that hay racks have been installed between the cages for fatteners.**

the bottle to the inside of the hutch so that the lip of the bottle is about 1 cm below the rim of the can. Fill the can and the bottle with water and replace the bottle. As the rabbit drinks from the can, the water will be replaced from the bottle.

Alternatively, a nipple drinker made from a bottle, a pierced rubber cork and a piece of 6–8 mm steel pipe can be used, as shown in Figure 10.62b. This allows the bottle to be placed outside the cage for easier refilling, and there is less risk of the water becoming contaminated, as the rabbits drink by licking the nipple.

Feeders

Heavy earthenware pots, measuring about 8 cm deep and 10–15 cm in diameter, make good dishes for feeding grain, pellets and mash because they are not easily tipped over. Tin cans, free of sharp edges, or open sections of bamboo nailed to a small board, can also be used. However, rabbits like to scratch out feed with their feet and, to avoid this, a feed hopper tied to the side of the hutch can be made from an empty 5-litre oil tin, as shown in Figure 10.62c. A flap measuring 6 cm by 12 cm is cut 6 cm from the bottom and strengthened with a piece of timber, and then bent inwards. The top of the tin is removed and the edges bent in against the inside of the tin.

A manger made out of a piece of wire mesh, measuring 40 cm by 40 cm, can be fixed to the door of the cage for feeding greens or hay. This allows the rabbit to pull forage into the cage as it feeds. Greens should not be put on the cage floor as this increases the risk of disease. The remains of greens left on the floor must be removed every day.

Nests

Does like to kindle in a private place. A nest box should be placed in the doe's cage five to seven days before birth. A box for medium-sized breeds should be about 30 cm wide, 40–50 cm long and 20–30 cm high. A lid is sometimes supplied, as some does prefer the nest box to be dark and, in cold weather, the lid will conserve some heat for the babies. Although straw or grass lining of the box is generally not necessary, it will provide extra protection in cold weather. The box can be made of plywood, hardboard, wooden planks or even bamboo but, whichever is used, it must be easy to clean.

Feed storage

The storage requirement for feed to all categories of animal in a rabbit unit can be determined by multiplying the following figures by the number of does in the unit and the number of days in the storage period:

- In intensive production, each doe unit requires 1.3–1.8 kg of pellets or mash per day.
- In semi-intensive production, each doe unit requires 0.3–0.5 kg of pellets or mash per day.

No storage is required for greens, as they should be fed fresh every day but, if hay is used instead of greens, each doe unit will require 0.1–0.15 kg per day.

SLAUGHTER SLABS AND SLAUGHTERHOUSES

In rural areas of developing countries, the slaughter of animals for meat consumption is often carried out under less than ideal conditions. Where there are no facilities, slaughtering is likely to take place under a convenient tree, where an animal can be hoisted for skinning and evisceration. Meat produced under such conditions lacks veterinary inspection, is often contaminated and must be considered a hazard to human health.

Most countries have a meat control act providing for meat inspection aimed at the control of meat-borne diseases and the protection of consumers from meat of inferior quality or that has not been hygienically slaughtered and handled. The act may state minimum requirements for the design and operation of slaughtering facilities, and must therefore be carefully studied before any construction commences.

While only basic design requirements are discussed here, the throughput and sanitary conditions of a slaughterhouse also depend greatly on equipment, staffing and work organization. Therefore it is advisable to seek the advice of specialists whenever a slaughtering facility is to be planned, especially if the required killing capacity is more than a few animals per day or if other facilities, such as meat processing, are to be included at the same location.

Gantry hoist

In areas where population density is low and relatively few animals are slaughtered, a simple and inexpensive slaughtering facility is desirable. As animals must be hoisted immediately after stunning, to ensure proper bleeding, and then remain in a hanging position during the dressing operation to ensure sanitary conditions, a first step in improving facilities is to build a wooden or steel gantry hoist. While a single gallow should be at least 3.7 metres above floor level, two levels of suspension are desirable: 4.5 metres for bleeding cattle and 3.5 metres for dressing operations. Sheep and goats

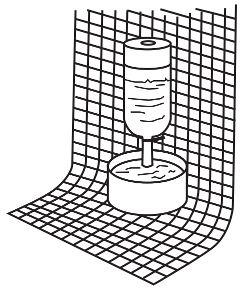


Figure 10.62a **Bottle and tin waterer**

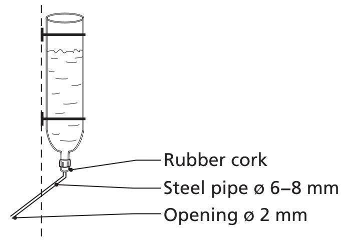


Figure 10.62b **Nipple waterer**

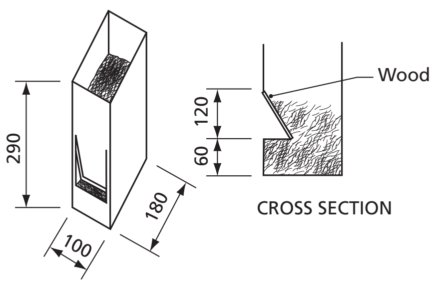


Figure 10.62c **Feed hopper made from a 5-litre tin**

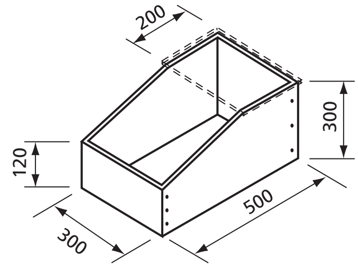


Figure 10.62d **Kindling box**

Figure 10.62 **Home-made feeder, waterer and kindling box** can be suspended from a rail at a height of 2 metres at the side of the gantry hoist.

Although a mobile gantry hoist that can be transported easily and reassembled is feasible in the first stage towards improved slaughtering, a permanently installed facility will normally be the minimum requirement, as this allows for the construction of a concrete floor and a metal roof. The roof gives protection from sun and rain and allows slaughtering to take place in all weathers.

Whether temporary or permanent, the site should be fenced to prevent access by stray animals and unauthorized persons. Dogs and jackals, in particular, must be prevented from accessing offal and condemned meat. These products may contain the parasite that causes hydatid disease, and infected dogs are a very common vector for transmitting the disease to humans.

Slaughter slabs

After the initial installation of a gantry hoist, concrete slab and metal roof, gradually the facility can be converted into an economical, low-throughput slaughter slab. There should be floor rings to hold animals, skinning cradles for cattle and small stock, rails for hanging the carcasses, and an adequate and convenient water supply.

Satisfactory waste disposal is a requirement from the outset. The slab can be surrounded by a wall 1.5 metres high, and partitions can be installed between clean and dirty operations areas. A lairage should be constructed for both cattle and small animals. Drinking-water should be available for the animals at all times.

Paving the area immediately surrounding the slaughter slab with either concrete or bitumen will improve both sanitary and working conditions. An extended overhead rail allows the carcass to be moved from one operation to the next, until it reaches the dispatch area. Improved sanitation and management are possible using separate bays for cattle and small stock. However, this is a design feature that must be considered at the very outset, when the floor slab is poured.

Slaughterhouses

In areas where a large number of animals are slaughtered, a fully equipped slaughterhouse should be provided, i.e. a large slaughter hall where animals are stunned, bled, slaughtered, flayed and dressed in successive operations. In such a system, live animals enter one end of the building and emerge as dressed carcasses at the other. Capacity can be increased by using more than one bay for each kind of animal. A freezing room is normally included in a slaughterhouse, but only the largest factory abattoirs have facilities for the processing and large-scale storage of meat, and the utilization of inedible by-products.

Pig slaughter

Out of consideration for the Muslim population, pigs should be handled separately in a slaughterhouse

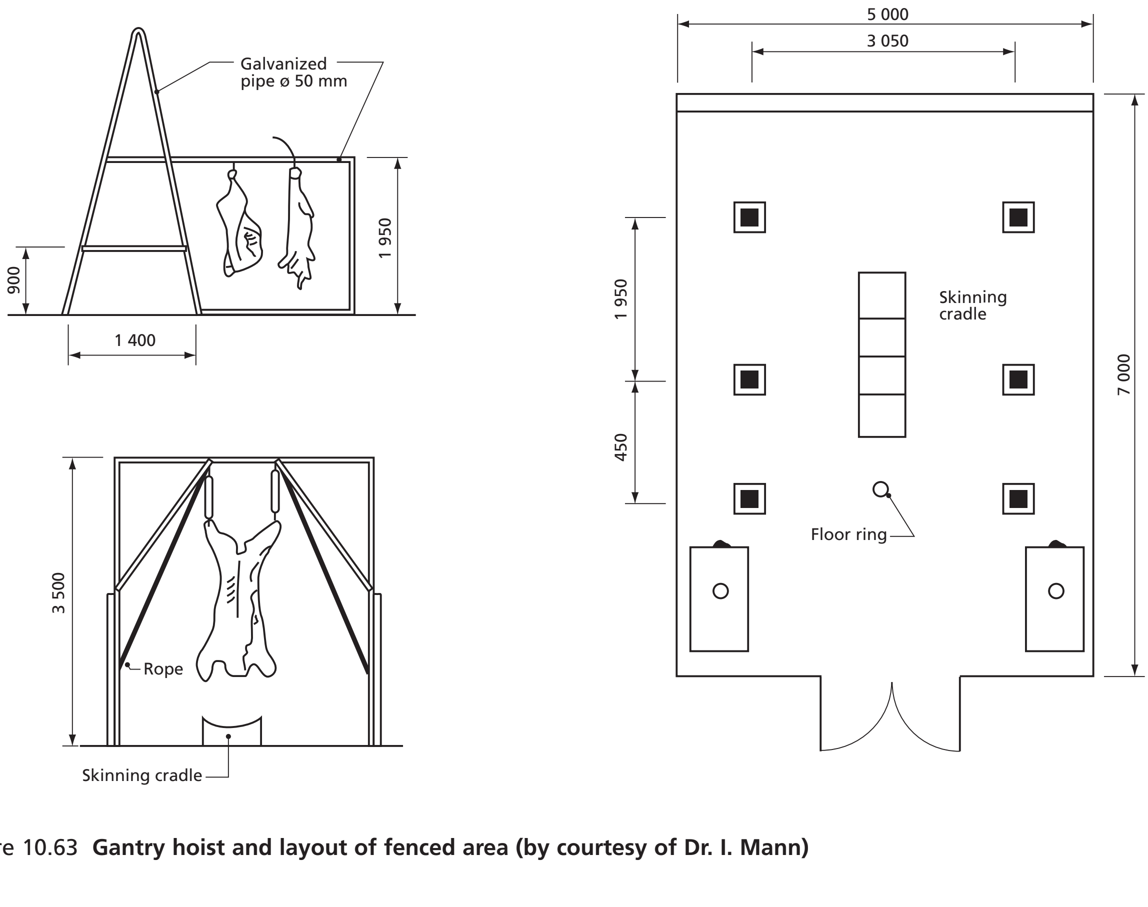


Figure 10.63 **Gantry hoist and layout of fenced area (by courtesy of Dr. I. Mann)**

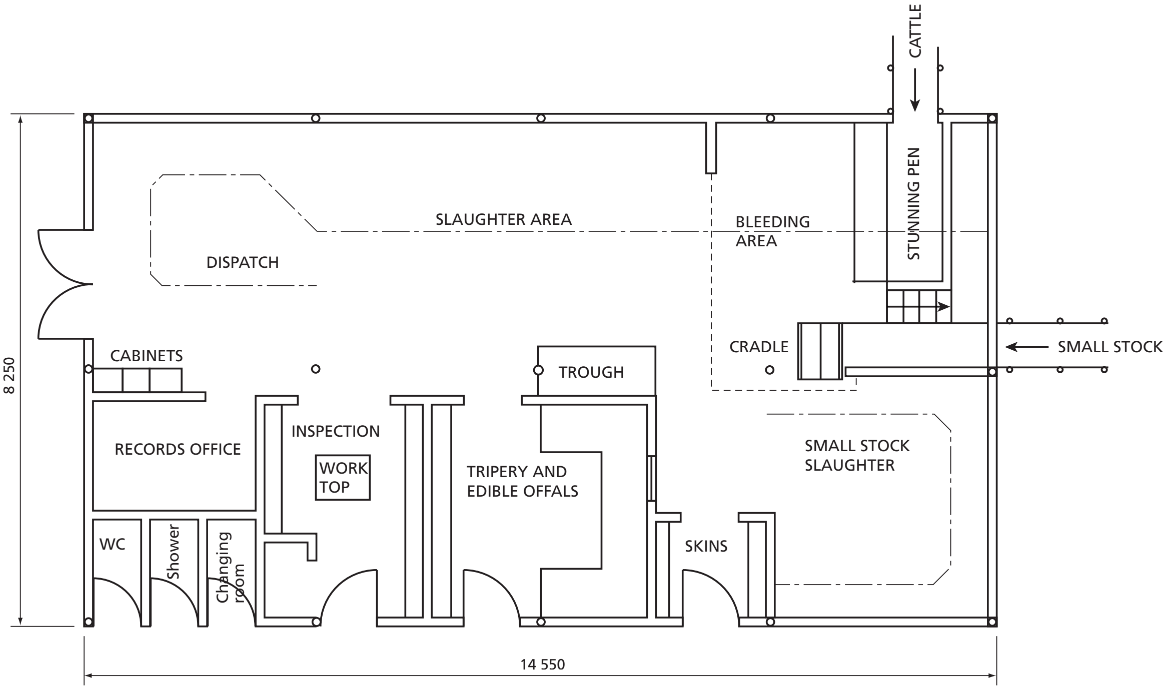


Figure 10.64 **Slaughter of 20 cattle and 40–50 sheep/goats per day (by courtesy of the Ministry of Local Government, Kenya)**

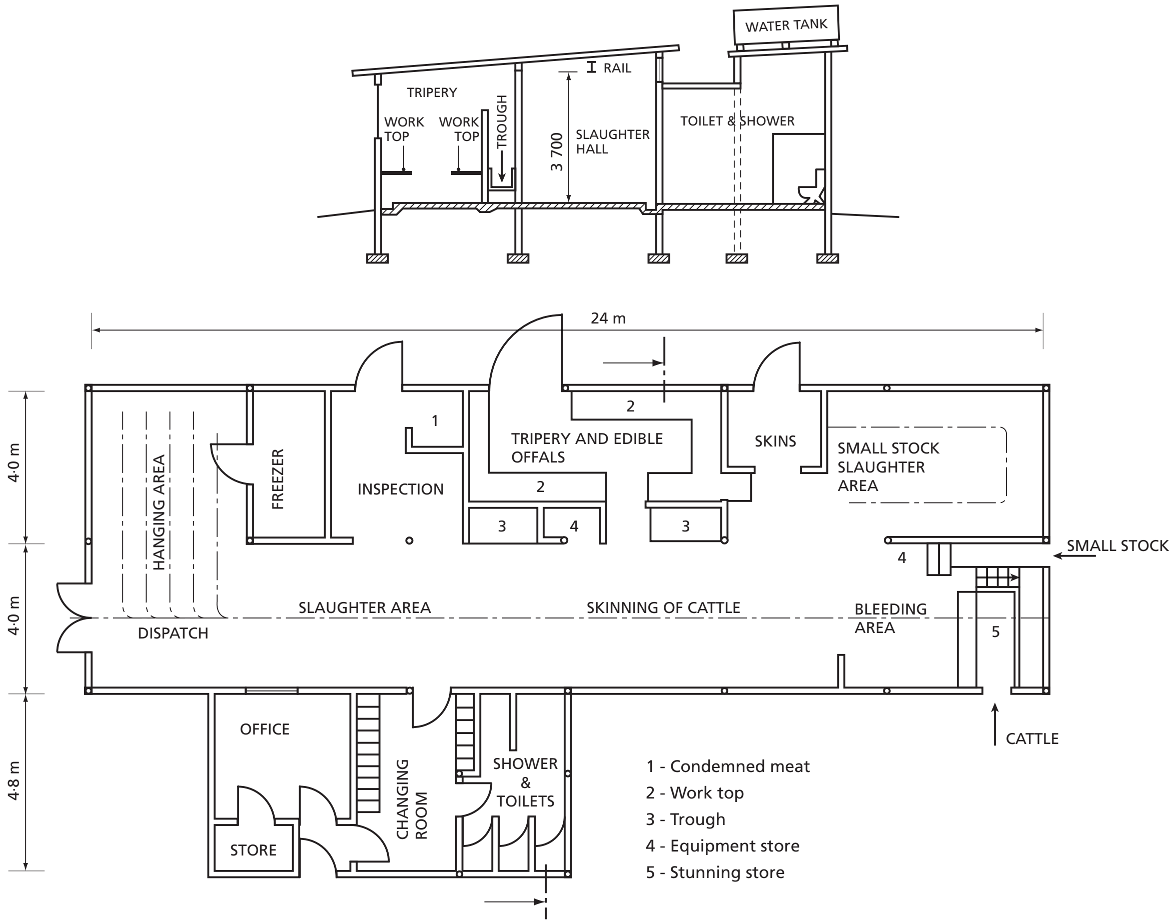


Figure 10.65 **Slaughterhouse for slaughter of 40 cattle and 40–60 sheep/goats per day (by courtesy of the Ministry of Local Government, Kenya)**

designed and used only for that purpose. There are reasons other than religious ones that make it desirable to separate pig slaughtering. The steam from the scalding vats creates adverse conditions for the setting of meat, and the scurf accumulated from scraping pig carcasses is heavily contaminated with meat spoilage organisms. Pig slaughterhouse designs follow the same basic pattern as those for cattle, with provision for the separation of clean and dirty activities. The gallows and rails need to be 3.9 metres above floor level in the bleeding area, and 2.5 metres in the slaughter hall. A water boiler is required to supply the scalding vat with water at a temperature of about 80 °C.

Poultry slaughter

Most poultry for local meat supply in rural areas is slaughtered singly or in small batches as the need arises, and this is often carried out in the kitchen.

It will be feasible to build a slaughterhouse for poultry only in areas where poultry is produced on a medium to large scale to supply meat to an urban area.

General recommendations for design and construction

The site for a slaughter facility should be on ground that is higher than its surroundings, to facilitate drainage. An adequate water supply must be available nearby to allow the slaughtering operations to be carried out under sanitary conditions. An all-weather road ensures timely dispatch of the meat throughout the year. All trees and bushes within 20 metres of the fenced area should be cleared to discourage birds, insects, etc.

In tropical countries, slaughterhouses should be as open to the air as possible, and the building designed in such a way that even a light breeze will produce a ventilating draught. The openings should not be glazed but should be screened, together with grills in the roof ridging, to prevent the entry of insects. The grills allow the warm air to escape and cooler air to be drawn in through the windows.

For sanitary reasons, floors and walls should be easy to clean, impervious to water, and rodent-proof. Concrete floors should be finished smoothly, but not so smooth that they become slippery, and should slope towards the open drains along the walls. Concrete blocks or stone building blocks are preferred for wall construction. All joints should be finished smoothly, and wall and floor junctions will be much easier to keep clean if they are finished with a coving.

The meat must not come into contact with any wooden surfaces or equipment. Steel is prone to rust, and stainless steel is generally very expensive. Hence concrete should be used wherever practicable and, in particular, for such items as troughs for intestines and offal, and for workbenches. If wood is used for doors, a galvanized steel sheet should be fixed to the bottom of the door on the outside for protection against rodents. The layout should be designed to permit expansion without basic alterations to the original structure or suspension of operations (see Figure 10.68).

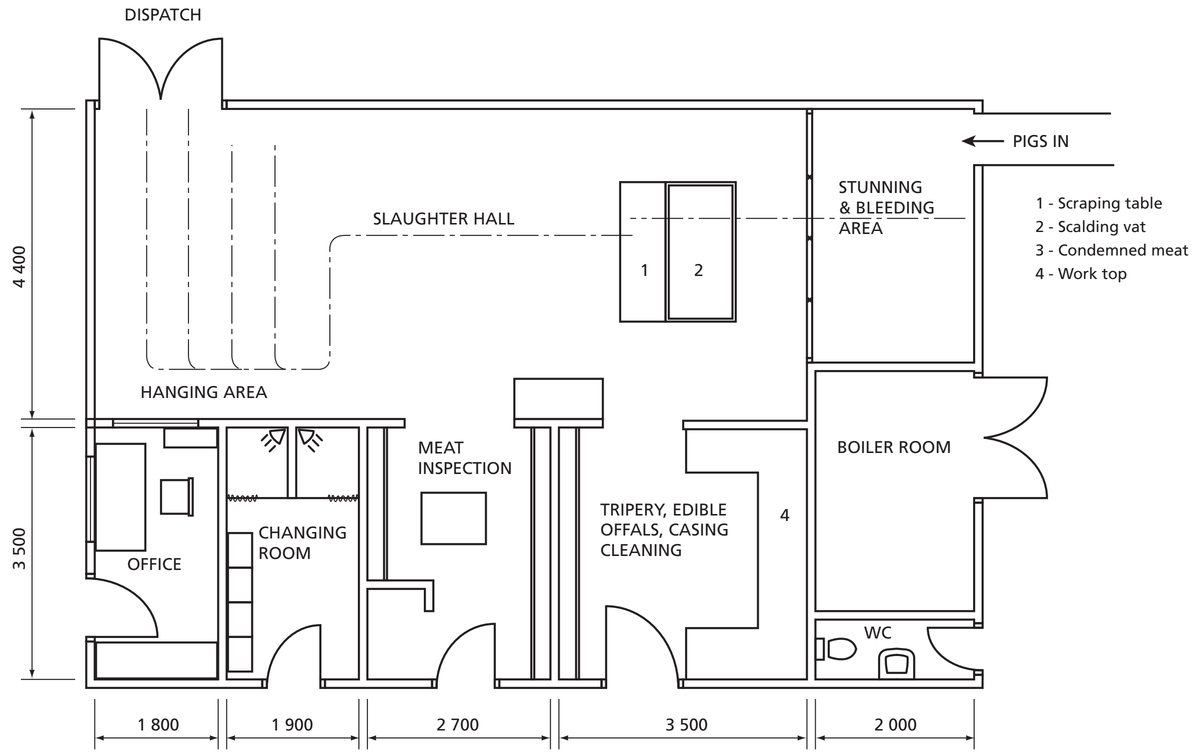


Figure 10.66 **Pig slaughterhouse for 20–30 animals per day**

Lairage

A lairage with a capacity of 1.5 days' kill should adjoin the slaughterhouse. Here the animals are allowed to rest and recover from stress before slaughter, thereby improving the setting quality of the meat. Each pen in the lairage should hold about 15 cattle, allowing at least 2.3 square metres for each animal. At least 0.6 m^2 should be allowed for small animals. While the lairage should be an integral part of the slaughterhouse complex, it should be at least 10 metres distant, and connected by a long, straight cattle race 75 cm wide at the top, narrowing to 45 cm at the bottom, to prevent the cattle from turning around.

The lairage should provide shade and clean drinking-water and a hard, impervious, well-drained floor sloping towards open drains. A separate area, where animals showing signs of sickness or fatigue can be detained for observation and control, is desirable. A holding pasture where the animals are allowed to graze until 24 hours before slaughter should be available. A clean lairage ensures that the animals will enter the slaughtering area as free as possible from contamination.

Water supply

Obtaining an adequate supply of potable water will often be the greatest problem to overcome when constructing a slaughterhouse in a rural area. The following minimum quantities should be available for each animal slaughtered:

1 000 litres for cattle;
100 litres for small animals;
450 litres for pigs.

Although water from wells is best, in many cases it will be necessary to use water from lakes and rivers. Should the quantity of potable water be insufficient, it may be necessary to install a dual water system, with the potable water being used for carcass and edible offal and non-potable water used for watering stock, washing skins, cleaning, etc.

If a water tower is required, the simplest procedure is to purchase a prefabricated steel tank of the correct size. If, on the other hand, an underground tank is installed, it can be made of reinforced concrete. If it is impossible to provide a supply of potable water, it is preferable to use a 'dry' slaughtering method, ensuring that no water comes in contact with the meat. However, the dry-kill method should be used only when a maximum of two animals per day are killed. Water will still be needed for washing floors, walls, etc.

Blood disposal

The large quantities of blood collected from the bleeding area should not be allowed to enter the main drainage system and cause pollution, and must not be mixed with water. Therefore, all the effluent from the stunning and bleeding area should be collected separately and led to an underground tank situated outside the building. The tank should be built with a tight-fitting, removable cover and be constructed in such a way that the liquid can seep through the sides into the surrounding soil. The blood will eventually decompose and it should be necessary to clean the tank only occasionally.

To avoid objectionable odours, the tank should be equipped with a screened ventilation pipe. In tropical areas, the air in the pipe and the upper part of the tank

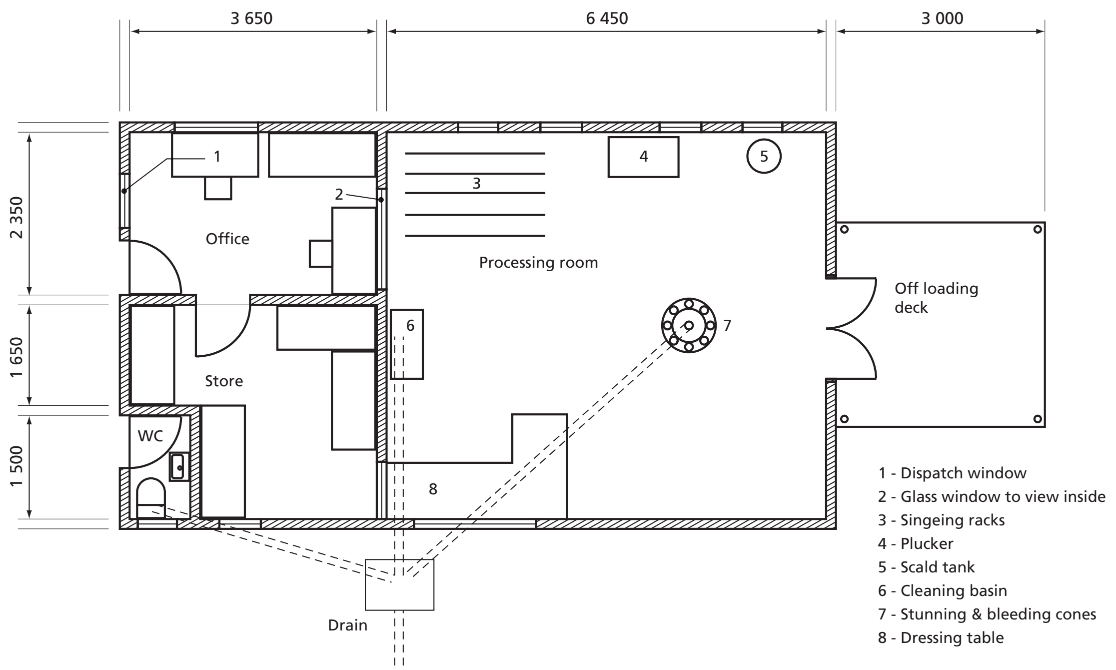


Figure 10.67 **Slaughterhouse for poultry**

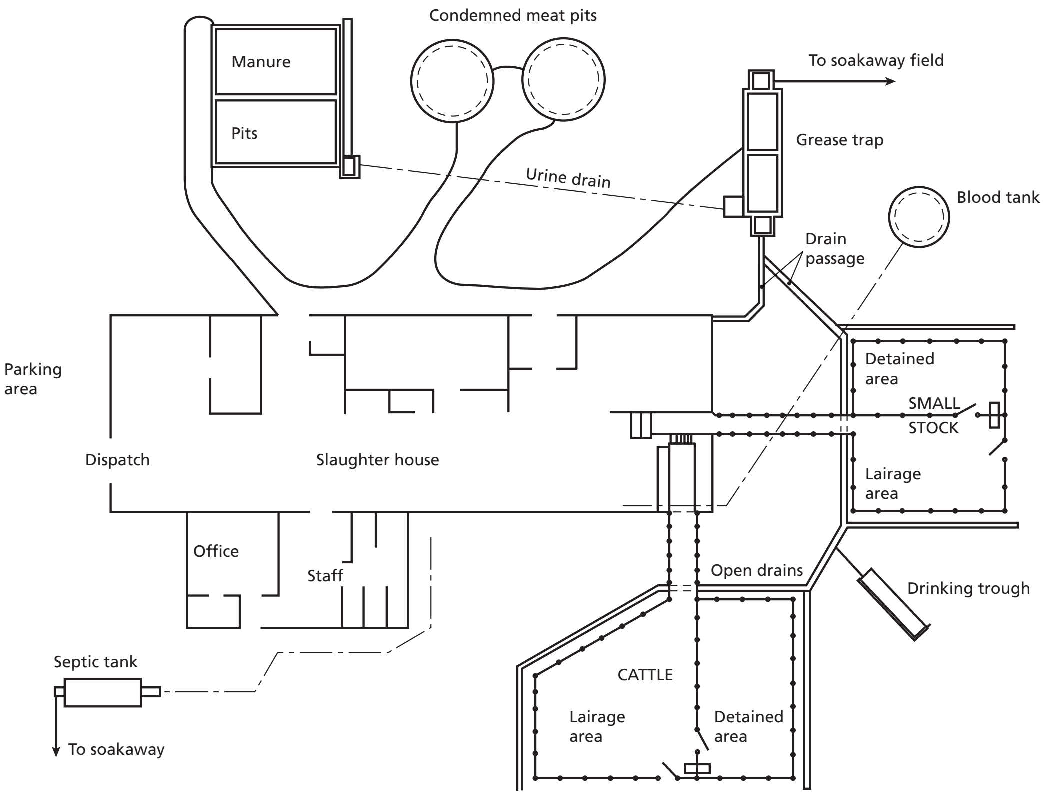


Figure 10.68 **Slaughterhouse with essential facilities**

will be warmed sufficiently during the day to cause circulation and air renewal in the tank.

The blood tank will operate satisfactorily only if the ground water level is below the level of the tank and the surrounding soil is pervious to water.

Removal of manure and condemned meat

The carcass should be dressed out rapidly, and the offal inspected and taken to a separate room where it can be cut up and the stomach and guts opened, cleared of manure and flushed with water. The manure is taken to a manure pit outside the building, whereas the rinsing water is directed into the main drainage system.

Suspect or condemned material is taken to the room set aside for this purpose. At the end of the day, it is disposed of, together with inedible offal, in two concrete pits outside the building. The pits should be equipped with airtight, lockable covers.

Most of the material will slowly decompose and it will not be necessary to empty the pits. Incineration is not recommended, as efficient incinerators are expensive both to buy and to operate, and simple incinerators do not work satisfactorily and burn out quickly.

Drains

As running water is used during slaughtering, and floors are flushed clean, the floors should be sloped so that water and effluent run into open drains placed along the walls. All these drains should be connected by a central drain to a trap for greases and solids. From this trap, the remaining effluent is led either into an evaporation pan, where bacterial action will break down most of the effluent in 20–30 days or, alternatively, into a subsurface seepage field, designed with a series of herringbone-patterned trenches filled with stones.

Soakage pits not less than 6 metres deep and 1.8 metres in diameter and covered with a concrete top are satisfactory for only the smallest units.

Open drains are recommended for the effluent from the slaughterhouse for the following reasons:

(a) It is often difficult to obtain the right type of piping in rural areas, whereas open drains can be cast as the floor is installed.
(b) The quantity of water available is sometimes insufficient to ensure that a system using closed pipes is adequately flushed, and clogged pipes may result.
(c) It is often difficult to obtain sufficient slope to allow the flushing action to take place by gravity, requiring the installation of automatic pumps, which is expensive and impractical for a small slaughter operation.

To prevent rodents from entering, a screen should be fitted to the open drain, where it passes through the slaughterhouse wall, in such a way that it can be easily removed for cleaning.

Cooling, chilling and freezing rooms

As soon as the carcasses have been dressed, they should be removed from the slaughter hall to avoid prolonged exposure to its atmosphere and thereby reduce the development of microflora in, and on, the meat. Most meat in the tropics is distributed, still warm, for consumption on the same day it is slaughtered.

Hence a cooling room will normally not be required. Instead the meat is transferred directly to a dispatch area. This practice implies that the work must start sufficiently early, and the slaughter slab, or slaughterhouse, must have sufficient capacity for slaughtering operations to be finished by about ten o'clock in the morning.

It is desirable to have a freezing room in all but the smallest slaughterhouses. The freezer can be used to sterilize measled meat, because some types of meat parasite are destroyed by the low temperature. It also helps to match the supply of meat more closely to demand. Refrigeration units are expensive and a chill room where meat can be ripened and tenderized can be justified only where there is a demand for meat treated in such a way.

REVIEW QUESTIONS

1. Why is it necessary to consider behaviour patterns of animals when planning and designing animal housing?
2. Which factors influencing animal production should be considered in animal housing?
3. How does climate influence livestock performance?
4. Outline the general requirements for cattle, poultry and rabbit housing.
5. Outline the parameters to consider when determining the number of pens and stalls required in a pig unit.
6. Briefly describe four factors which need to be considered in the design and construction of a slaughter house.

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