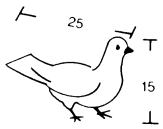
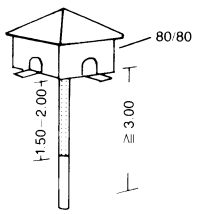
SMALL ANIMAL STALLS



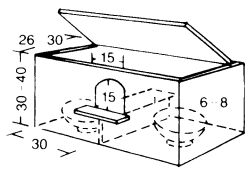
stall area per pair 0.15–0.20 m²
(more for purebred pigeons)
1 pair carrier pigeons 0.5 m³ airspace
1 pair purebred pigeons 1.0 m³ airspace
15–20 pairs of purebred pigeons in one stall
20–50 pairs of ordinary pigeons in one stall

① **Pigeons**



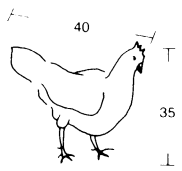
on 3–4 m high posts, fitted with 1.5 to 2.0 m of metal sheeting to thwart predators, or attached to the east or south side of a house

② **Dovecote**



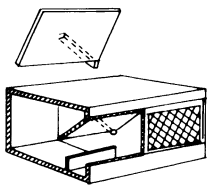
twin nesting box can be on the floor or on a special stand per pair of pigeons; feed using wooden boxes with small openings, drinking vessels with similar openings

③ **Nesting box (Fulton type)**



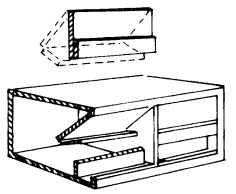
scratching area for 5 hens ≥ 3 m²
scratching area for 10 hens ≥ 5 m²
scratching area for 20 hens ≥ 10 m²
sleeping area for 5–6 lightweight hens or 4–5 heavy hens on 1 m of perch, 10–12 hens per 1 m²

④ **Chicken (Orpington hen)**



the laying nests are built into breeding stalls with a doorflap, which either hangs loosely from a hook or consists of two connected flaps; when the hen goes into the nest the flap is lifted and then

⑤ **Open laying nest**



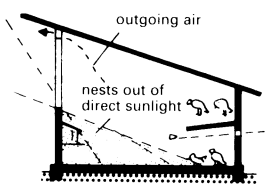
closes; the nest boxes can be on the floor or stacked three above each other; the nest size is 35 × 35 to 40 × 40 cm for the base area and 35 cm inside height

⑥ **Laying nest with flap**

Small stalls for use by hobbyists and smallholders require careful arrangement and construction if animals are to be kept successfully. They should be well ventilated but draught-free, dry, thermally insulated and easy to clean. Wooden construction with thermal insulation layers is preferred and the window area should be no more than 10% of the stall floor area. Discharge facilities must be provided for removing droppings. Adjacent rooms are needed for feed preparation and storage.

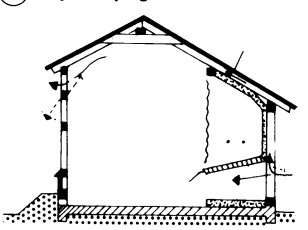
The design must consider the position of the sun: windows to the south, door to the east, laying nests in the darkest place. The stall is divided into a scratching area with a covering of straw and a droppings pit with perches fitted above → ⑩ + ⑪. Ideally, the outside run will be of an unlimited size but the essentials are a grassy surface with a tree for shade, a compost heap and a sandbath.

With an unlimited size of run, five birds may be kept per m² of stall area; two birds if the run is smaller than four times the stall area. Places for perches, droppings pit, feed and drink containers are included in the surface areas.



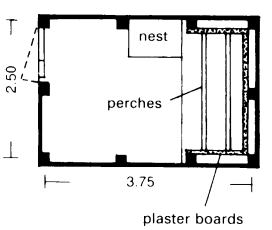
should be well ventilated but draught-free; closable ventilation flaps on the sunny side; laying nests facing away from the window; scratching area should be at outside temperatures, while the sleeping area must be warm and is, therefore, often separated by a curtain and built with special thermal insulation

⑦ **Henhouse (Peseda type)**



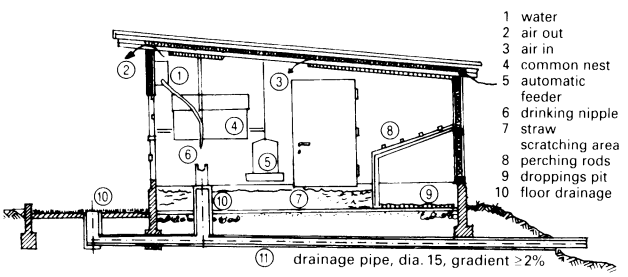
henhouse for 20 hens with separate, thermally insulated sleeping alcove, inclined droppings plate and wall ventilation; hen entrance/exit 18 × 20 to 20 × 30 cm, draught-proofed by side boarding and closed by a slider

⑧ **Section → ⑨**

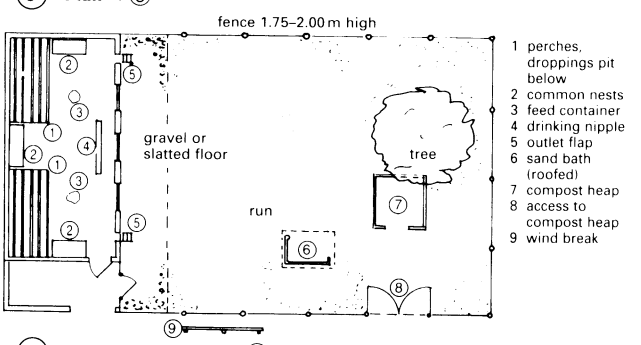


perches, according to the size of the hens, 4–7 cm wide, 5–6 cm high and 3.5 m unsupported length; they should be easy to remove, 4–6 hens per 1 m of perch

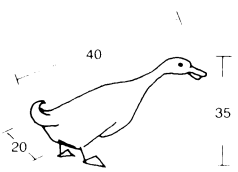
⑨ **Plan → ⑧**



⑩ **Cross-section of henhouse → ⑪**

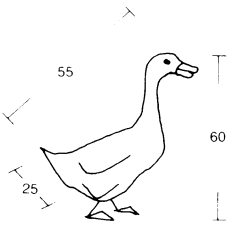


⑪ **Henhouse and run → ⑩**



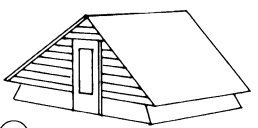
stall area (4–5 ducks) 1 m²
stall height 1.7–2 m
maximum stall occupancy: 1 drake and 20 ducks
base of stall should be solid, secure against rats, dry and airy, and have an outlet to water; ideal location is a marshy area

⑫ **Duck (Peking)**

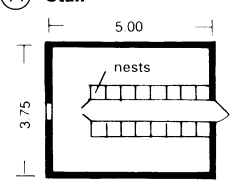


similar conditions as for ducks; for fattening purposes the animals are put in individual cells 40 cm long, 30 cm wide, with a droppings tray below and a feeding bowl at the front

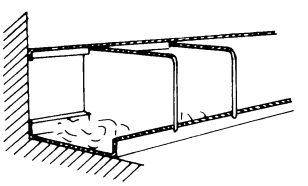
⑬ **Goose (Pomeranian)**



⑭ **Stall**



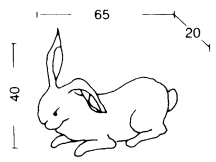
⑮ **Plan of stall**



nest size 40 × 40 cm
1 nest per duck → ⑭ – ⑮

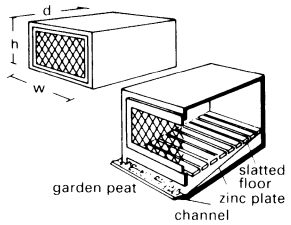
⑯ **Laying stall for 4–5 ducks**

SMALL ANIMAL STALLS



hutch area per animal 0.65–1.0 m²; should be well ventilated, dry and protected from sun and predators (rats); hutches usually made of wood with drainage → ②, 5% gradient

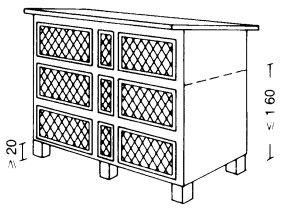
① **Rabbit (Belgian giant)**



	w	d	h
small purebreds	80	80	55
medium purebreds	100	80	65
large purebreds	120	80	75

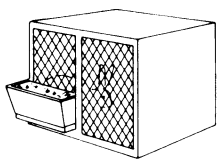
(depth is the same to ease subdivision)

② **Size of rabbit hutches (cm)**



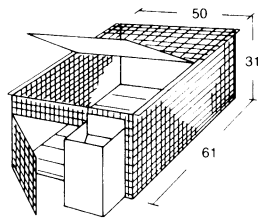
for small purebreds three tiers, for large purebreds two tiers within above limits (length unlimited); slatted floor → ② with drainage facilities and common urine collection channel below

③ **Three tier rabbit hutch**



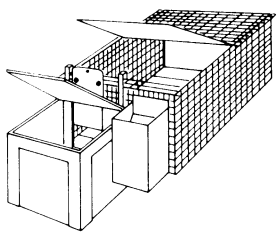
opening front or front section between two hutches → ③; front wall of galvanized wire netting; hutches for female hares with dark netting and 10cm high bed

④ **Feed trough in the hutch**



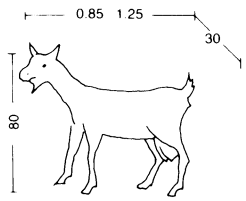
cage is made enitery from galvanised wire netting, mesh size 25 × 25 or 12 × 70mm

⑤ **Wire cage with automatic feeding device**



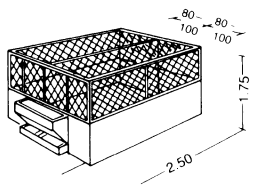
wooden or polyurethane nesting boxes for young animals: floor of nesting boxes at least 70 mm below base of cage

⑥ **Breeding cage with nesting box and automatic feeder**



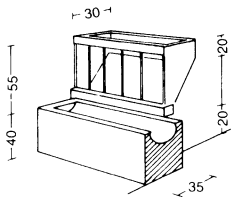
stall area per animal	1.5–2.0 m²
stall width per animal	0.75–1.00 m
stall depth, tethered	1.8 m
stall depth, free	2.5–2.8 m
stall height	1.7–2.5 m
stall temperature	10–20°C

⑦ **Goat (German Saanen goat)**



wire mesh above the rack level; tiled flooring at a gradient, with a channel for urine; feed rack and water trough serve both stalls

⑧ **Modern twin goat pen**



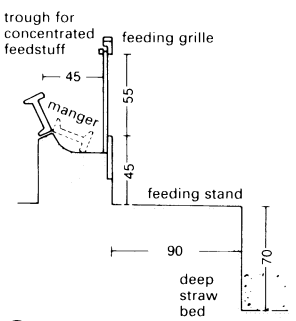
standard dimensions of a feeding rack and drinking trough in the feeding aisle (transverse aisle); daily requirements per goat: 1.2kg hay, 2.3kg of root crop, 2–3l of water

⑨ **Feed rack and water trough for a goat pen**

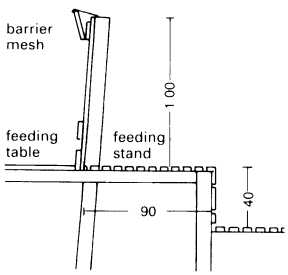
Rabbit hutches → ② + ④ are usually free-standing and are positioned against the back of stalls or buildings so as to be sheltered from the wind. They must be protected against the weather, as well as rats and mice, and should be easy to clean, with good urine drainage → ②. They must also be well ventilated because rabbits are sensitive to poor air conditions, more so than pigs and chickens, for instance.

Thermally insulated hutches with forced-air ventilation are ideal for breeding and fattening. The temperature in the breeding hutch should be between 10 and 28°C, with an optimum of 18°C. In the fattening hutch, 20°C is desirable.

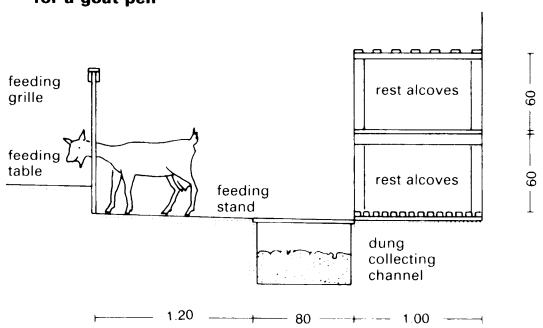
Goat sheds should be east or south facing. They need to be dry, with good ventilation and natural lighting (window area 5–7% of the floor area). For intensive accommodation of tethered goats (pens are preferred) the stalls should be 75–80 cm wide and 1.50–2.00 m deep, excluding the necessary aisles in front and behind. If possible, include a run on the south side, adjoining the shed.



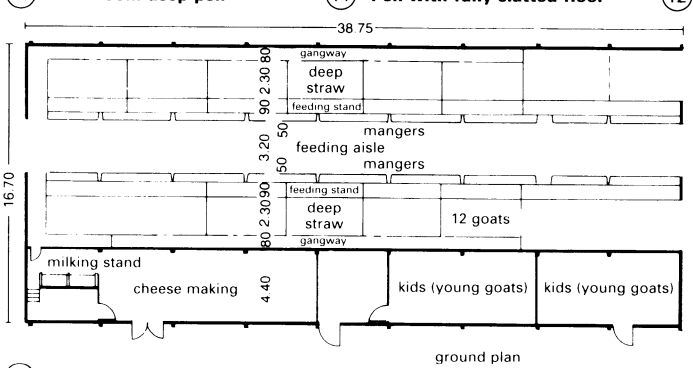
⑩ **Twin-room deep pen**



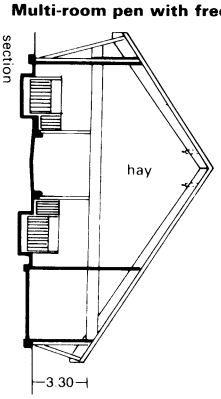
⑪ **Pen with fully slatted floor**



⑫ **Multi-room pen with free-standing rest alcoves**



⑬ **Twin-room deep pen**



required sizes	pen (m²)	rack (cm)	tethered stall width (cm)	tethered stall length (m)
lamb	0.7–1.2	20–40	50	1.5
kid	1.5	40–50	50–70	1.5
billy goat	2.2–4.0	80	60	1.8

windows: 5–7% of stall area
stall height 1.70–2.50 m
drinking facilities: one trough for 30 animals
0.4 kg straw/day, 0.15 t per annum/animal
stall dung accumulation 0.7–1.5 t/goat

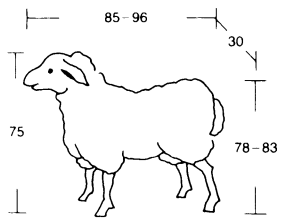
⑭ **Goat keeping**

SMALL ANIMAL STALLS

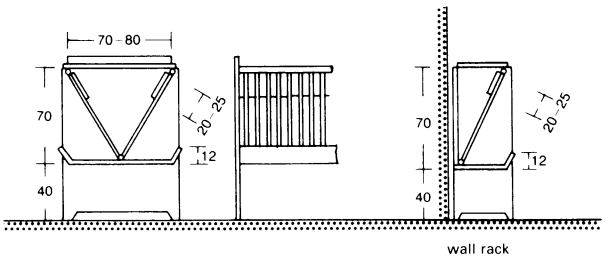
Small sheep sheds should face towards the east or west and have many similar features to goat sheds → p. 406. For intensive sheep farming, large free-standing sheds must offer different stabling options according to the time of year (winter, spring, during and after lambing), allowing segregation according to age and gender using versatile dividing fences.

The shed floor is 50–60 cm below ground level and the door threshold 20 cm above ground level. The height difference of 60–80 cm is filled with dung, which is left in place for 3–4 months. Feeding racks therefore have to be adjustable, either round (2.20 m diameter) or elongated mangers (3.4 m is sufficient for 25–30 sheep). All wooden elements of the building need to be raised 15–20 cm above the dung level because dung is highly saline.

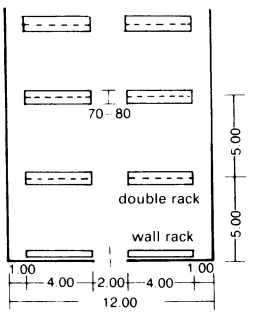
The main door should be at least 2.50 m wide and 2.80 m high to facilitate the removal of dung. A shed height of 3.30–3.50 m is recommended. The windows must be high up the wall, with a tilting opening section, and occupy the equivalent of 4–5% of the shed floor area. Between 6 and 10% of the pen area should be designated as a feed mixing area and 3.00 m³ per sheep allowed for storing hay or straw.



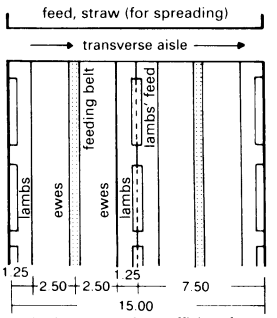
① **Sheep**



② **Ladder rack with trough**

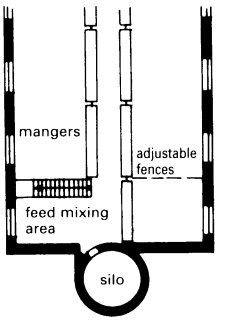


③ **Shed without feeding aisle**

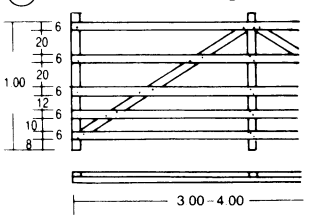


15 m shed cross-section sufficient for four groups of ewes with lambs

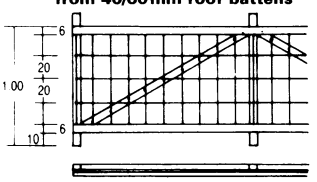
④ **Shed with transverse aisle**



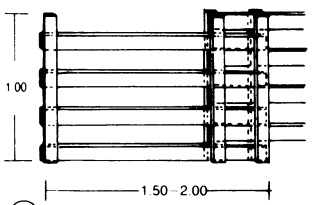
⑤ **Good arrangement of silo and feed mixing area**



⑥ **Shed dividing fence made from 40/60 mm roof battens**



⑦ **Dividing fence: roof battens and knotted network**



⑧ **Extendable fences**

prone, open pen and feeding area requirements for sheep

animal	pen and prone area (m^2 per animal)	feeding area width (m^2 per animal
ewes up to 70 kg	0.85	0.4
ewes over 70 kg	1.00	0.45
ewes with lambs	1.2–1.6	0.6
lambs to 8 weeks	0.3–0.4	0.15
market/store lambs	0.4–0.5	0.2
yearling	0.7–0.8	0.3
stud ram in single stall	3.0–4.0	0.5
stud ram in common stall	1.5–2.0	0.5

dimensions and weight of the two most important sheep breeds

merino country and black-headed sheep	weight (kg)	wither height (m)	body length (m)
ram	120–130	0.83	0.96
ewe	65–80	0.78	0.85

net surface area required for sheep in groups on fully slatted floors

animal	m^2/animal
ewe	0.8
ewe with lambs	1.2
store lamb	0.5
yearling	0.6
ram	1.5

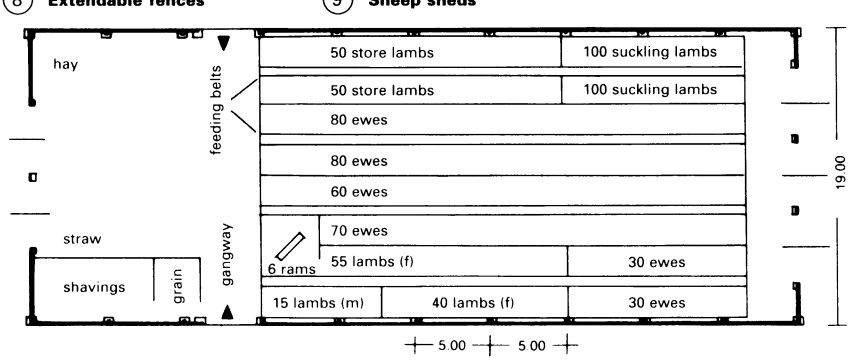
optimum shed climate

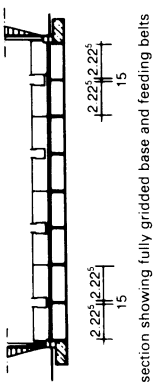
shed area for:	temperature in (°C)	relative humidity (%)
ewes	8–10	60–75
lambs and store	10–14	60–75
rearing	14–16	60–70

storage required per ewe (with lamb) in winter stall period

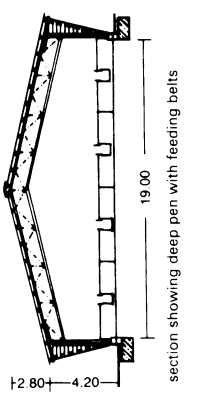
stored material	volume required (m^3)
hay (for pure hay feeding)	3.3
hay (for hay-silage feeding)	1.0
silage	1.0
spreading straw (incl. 30% empty space addition)	1.5
concentrated feed (incl. 120% empty space addition)	0.2

⑨ **Sheep sheds**





section showing fully gridded base and feeding belts



section showing deep pen with feeding belts

⑩ **Sheep shed for 350 ewes, 110 lambs and 200 suckling lambs, 100 store lambs**

POULTRY FARMS

Henhouses constructed as free-standing sheds have largely become the norm in all areas of poultry keeping. For intensive farming with hens kept on the floor, the smallest unit when building from new is based on a shed width of 7 m; if battery coops are used, the shed width is 6–15 m. The sheds must be thermally insulated, the optimum shed temperature, according to the application, being between 15 and 22°C.

During pre-planning it is necessary to decide on the method of removing droppings because the size of a cellar or droppings pit depends on this. Shed ventilation is another element that requires careful planning: fundamentally, they should be designed with ventilators for forced ventilation ① - ④.

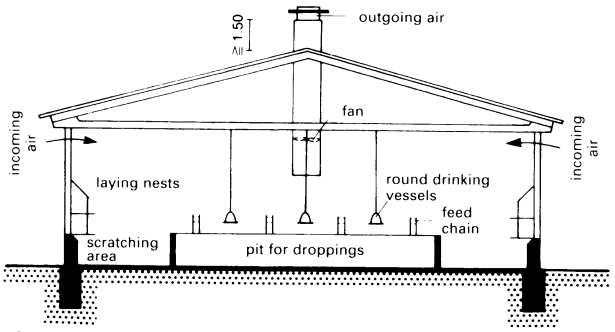
Cellars for droppings below the battery coops need a longitudinal air extraction system under the service aisles.

Ventilation systems need to have the following capacity:

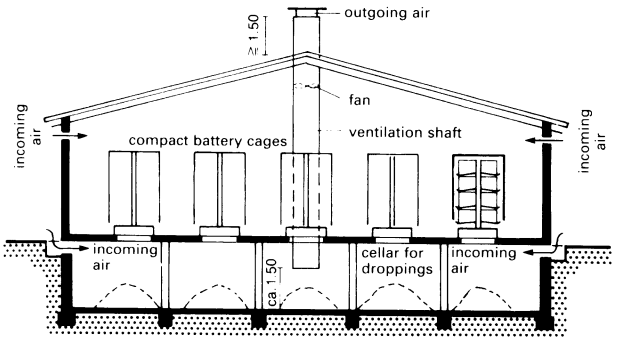
- air entry speed: 0.30 m/s (maximum 0.50 m/s)
- in summer, air circulation for laying hens reaches a maximum of 10 m^3/h/kg bird;
- for young hens and broilers, it is 4.00 m^3/h/kg bird.

Failure of the ventilation equipment can have a devastating effect in a very short time so it must have suitable warning mechanisms. A plan for emergency ventilation should also be drawn up.

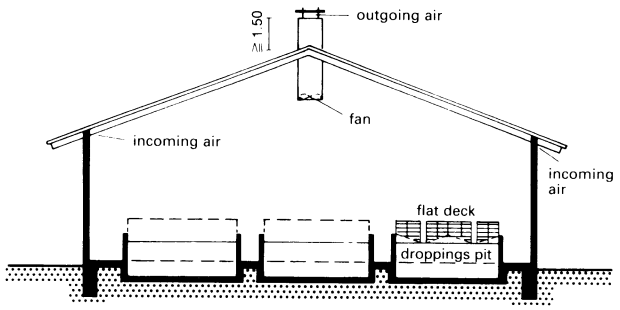
An automated round drinking trough unit is sufficient for 75–100 hens; with channel troughs, allow 1.00 m for 80–100 hens. A tubular feeding unit is adequate for 25 hens per round trough (diameter 30 cm).



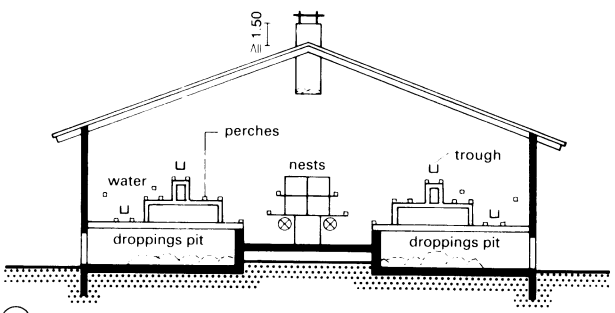
① **Henhouse: laying hens kept on the floor**



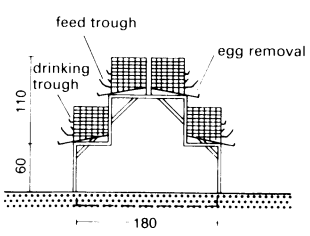
② **Battery henhouse with cellar for droppings**



③ **Flat cage system (flat deck arrangement)**

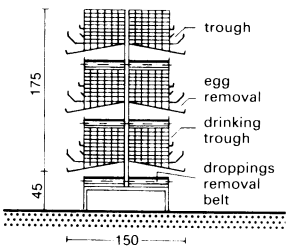


④ **Aviary system**



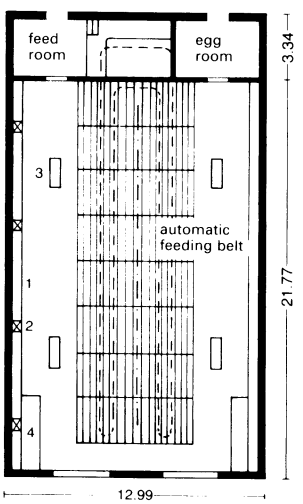
occupation density: 8–13 hens/m^2 of shed area

⑤ **Stepped cages**



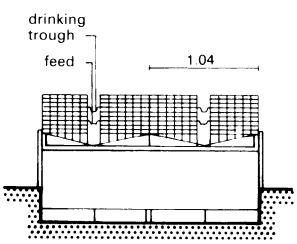
occupation density: three tiers 20–23 hens/m^2; four tiers 27–30 hens/m^2; minimum size, 3000 animals per shed

⑥ **Tiered cages**



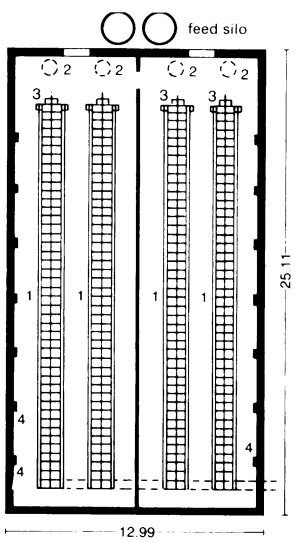
1 laying nests; 2 ventilation shaft; 3 feed trough; 4 dust bath

⑦ **Henhouse for 1600 laying hens on the floor**



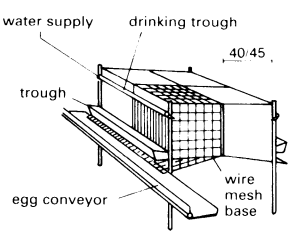
occupation density: 13–14 hens/m^2 (low density); can easily be mechanised

⑨ **Flat deck cages**



1 battery coops; 2 water storage containers; 3 feed trolleys; 4 ventilation and extraction

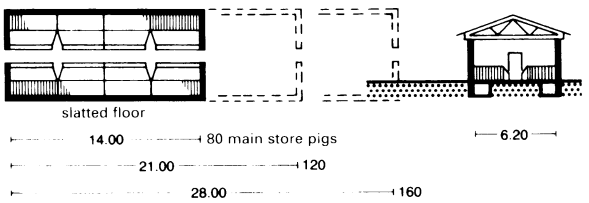
⑧ **Battery system, three tiers, about 4800 birds**



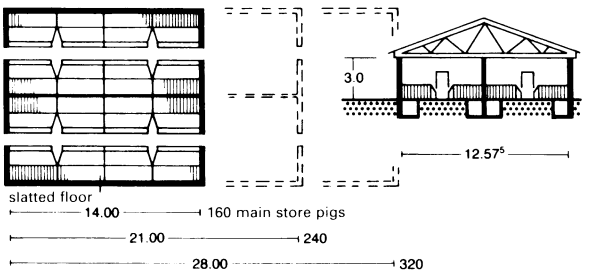
cage floor area: 430–450 cm^2/hen
cage depth: 40–45 cm, sometimes more
cage height: front 50 cm, back 40 cm
trough length: 10–12 cm/hen

⑩ **Single cages**

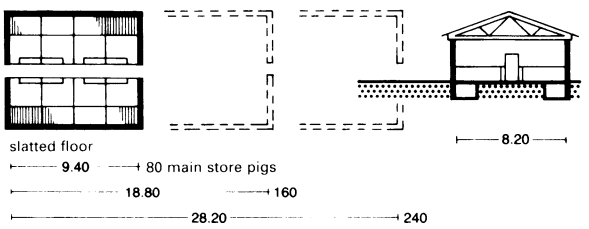
PIG SHEDS: FATTENING



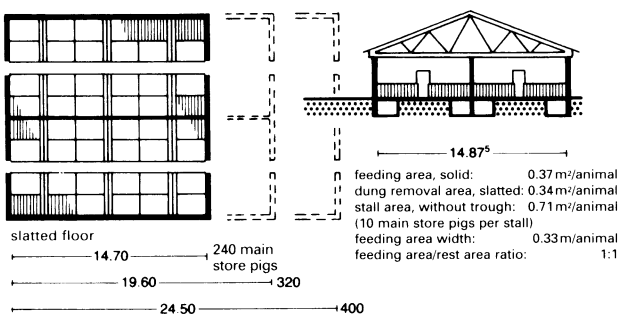
① **Store pig shed: two rows, short stalls, longitudinal troughs (80–160 animals)**



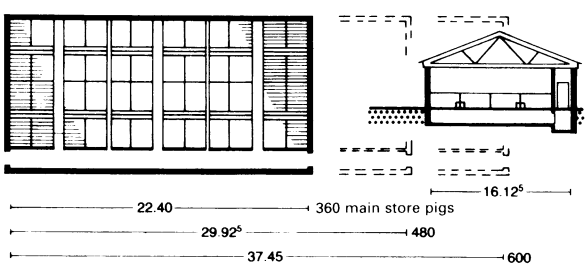
② **Store pig shed: four rows, central wall (160–320 animals)**



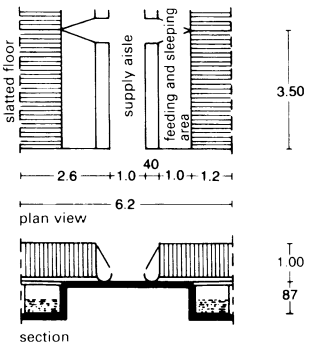
③ **Store pig shed: two rows, long stalls, automatic feeding**

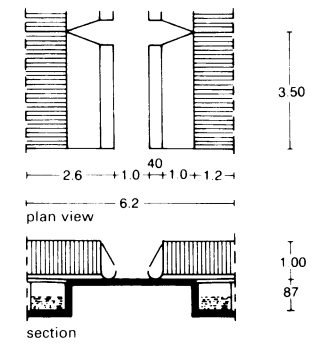


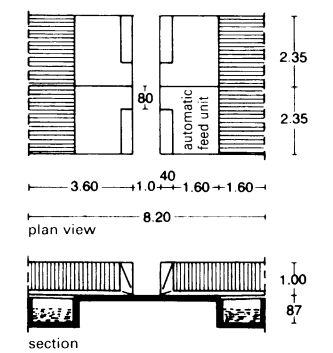
④ **Store pig shed: four rows, central wall, long stalls, transverse troughs**

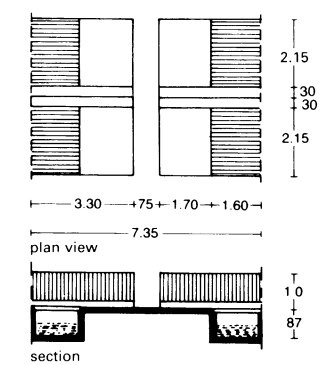


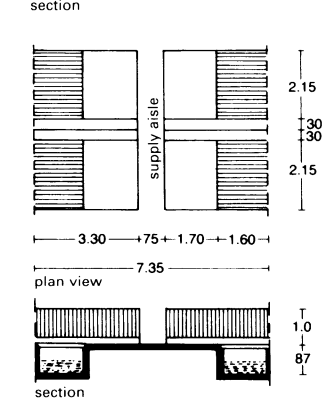
⑤ **Store pig shed with rack stalls (120 animals per section)**











Roughly three-quarters of total farm turnover comes from animal products and about half is from the keeping of animals for milking and store pig production.

Good planning of agricultural buildings is a decisive factor in maintaining the livelihood of the farmer and this is particularly so for pig production. Specialisation and mechanisation of the production sequences will have the greatest influence on the plans. For instance, a vital factor in the planning process is to provide separate pig sheds for fattening and breeding operations. The considerations include:

- how the pigs will be kept, which could determine the number of shed changes needed during the fattening period of 150–160 days;
- feeding techniques – by hand or mechanical trough/ground feeding;
- removal of dung – dry dung/liquid dung (slurry).

Intensive fattening is divided into two periods (pre-fattening and main fattening) and should not involve changing sheds within each period. The shed stalls have partially or fully-slatted floors.

The two fattening periods can be distinguished as follows:

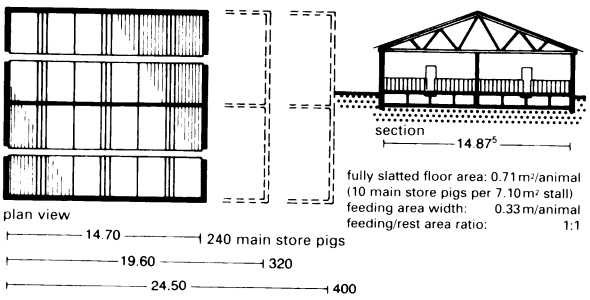
pre-fattening period: approx. 50 days
weight in this period: 20–40 kg
group size: 20 animals/stall
width of feeding spaces: 16.5 cm/animal

main fattening period: approx. 100 days
weight in this period: 40–100 kg
group size: 10 animals/stall
width of feeding spaces: 33 cm/animal

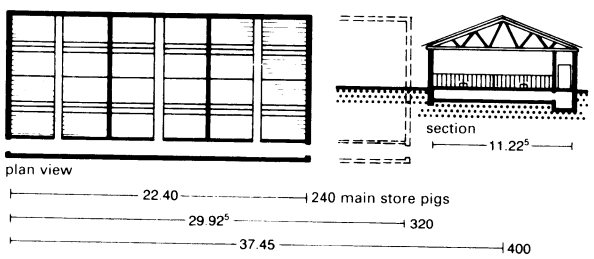
Dimensions for short-stall sheds → ① are:

feeding area, solid: 0.34 m²/animal
slatted dung area: 0.42 m²/animal
shed area, without trough: 0.76 m²/animal
(10 main store pigs per stall)
feeding area width: 0.32 m/animal
feeding/rest area ratio: 1:1

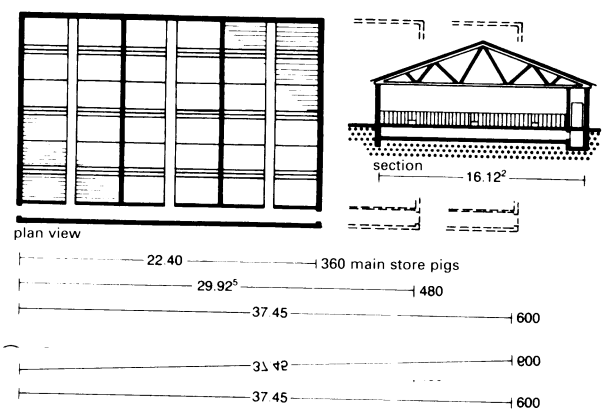
PIG SHEDS: FATTENING



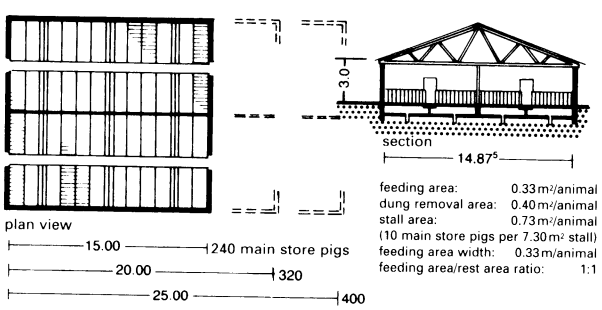
① **Store pig shed: longitudinally divided by centre wall, 2 × 2 rows, long stalls, transverse troughs, fully slatted floor**



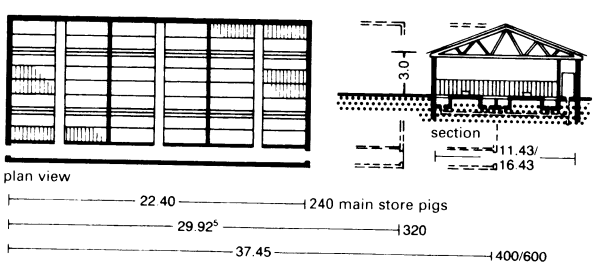
② **Store pig shed: rack stalls, 80 pigs per section, long stalls, transverse troughs, fully slatted floor**



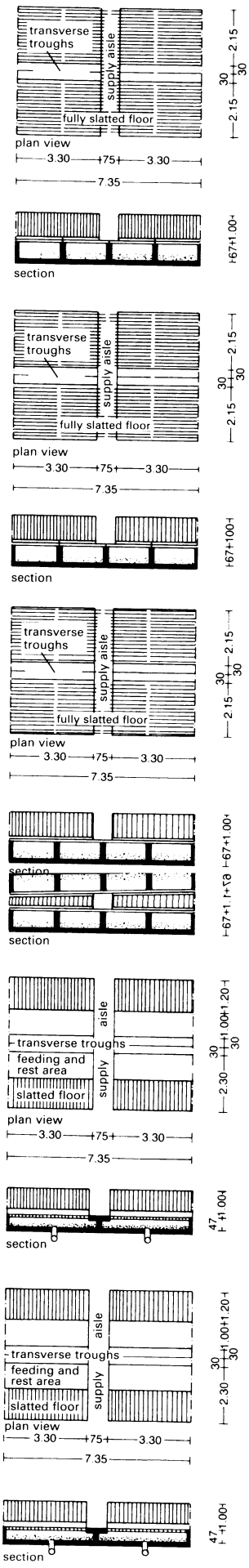
③ **Store pig shed: rack stalls, 120 pigs per section, long stalls, transverse troughs, fully slatted floor**



④ **Store pig shed: longitudinally divided by centre wall, 2 × 2 rows, long stalls, transverse troughs, partially slatted floor, solid floors parallel to troughs**



⑤ **Store pig shed: rack stalls, 80 pigs per section, long stalls, transverse troughs, partially slatted floor, solid floors parallel to troughs**



Fattening sheds for pigs must be of solid construction and have adequate thermal insulation to maintain the desired temperature. During the second, or main, fattening period, the store pigs are kept ten to a stall and fed dry or liquid feed from a trough. The quantity is rationed and feed apportionment can be partly or fully mechanised: this must be taken into consideration. The feeding area should have enough space for a double trough. Deep bowls or drinking nipples can be used to deliver drinking water.

Shed occupation during the main fattening phase can be an 'all in, all out' process or based on a batch system. The most important factor is that the pigs should not undergo shed changes during this 100-day period. By the end of this phase the animals achieve weights of up to 100kg.

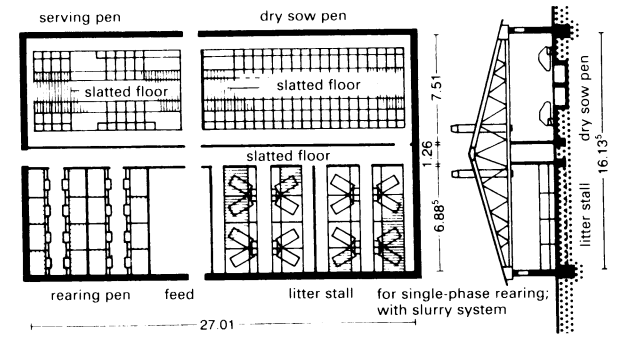
No straw is spread out on the slatted floors so liquid dung (slurry) can be removed via collection channels. It is stored for four, six or eight months in high or deep containers, or in plastic-lined reservoirs dug in the earth. The area in which the pigs lie down should ideally not have a slatted floor to make it more comfortable.

Sheds of the size shown have space for 20 animals in the pre-fattening phase. Pre-fattening spaces are normally installed in special shed sections, often in any available old buildings. Store pigs in the pre- and main fattening phases are kept in different conditions. The diagrams and information shown here refer only to the main fattening phase.

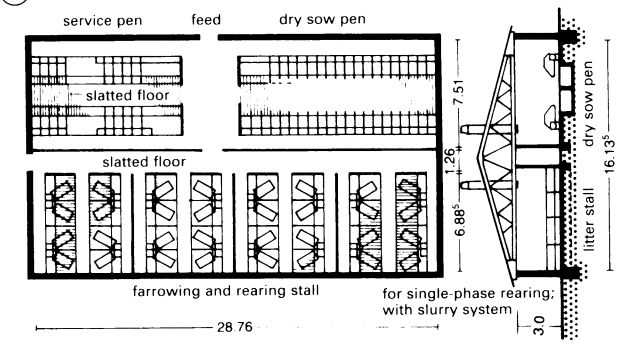
For aisle floors use 2.5cm compound cement/sand screed on 10cm of subconcrete and a 25cm sand bed. The fully slatted floor surface should be finished with reinforced concrete sections.

For the outside walls use 24cm lime-sand brick walling, flush jointed, with 6cm of insulation, a 4cm air gap and 11.5cm fair-faced masonry (cavity wall). The windows should be double glazed, with plastic frames, and be around 75 × 100cm in size.

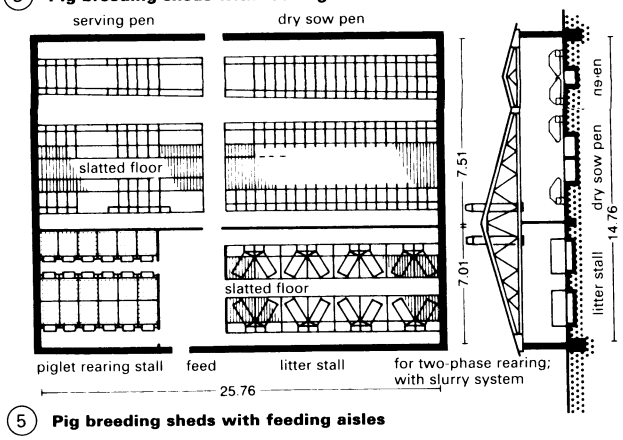
PIG SHEDS: BREEDING



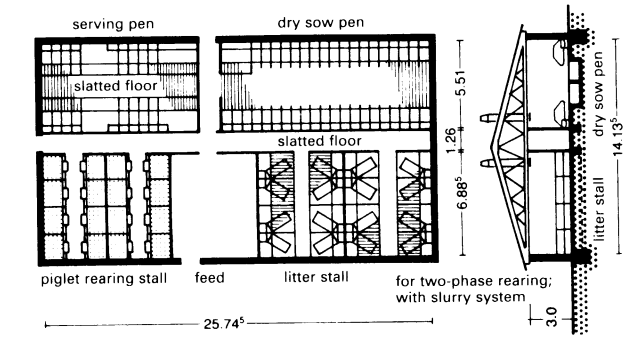
① **Pig breeding sheds without feeding aisles**



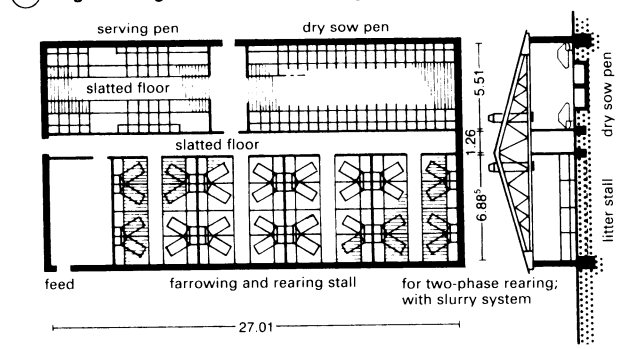
③ **Pig breeding sheds with feeding aisles**



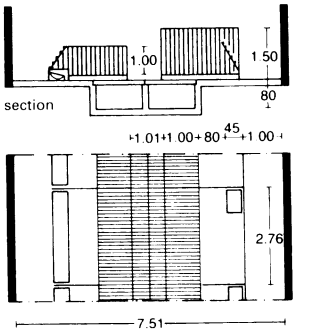
⑤ **Pig breeding sheds with feeding aisles**



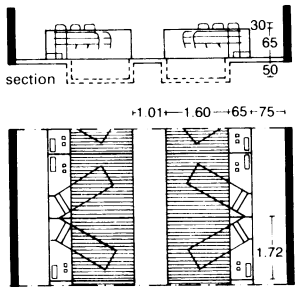
⑦ **Pig breeding sheds without feeding aisles**



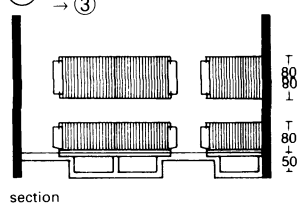
⑨ **Pig breeding sheds with feeding aisles**

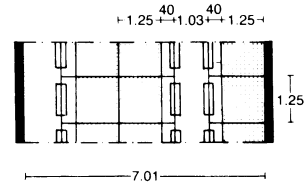


② **Stall arrangement in service pen → ③**

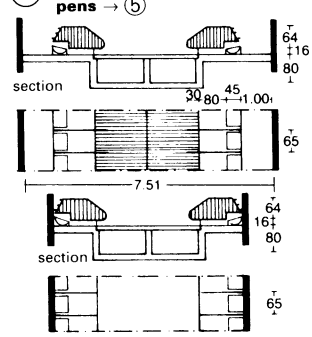


④ **Farrowing and rearing pen → ③**





⑥ **Three-row piglet rearing pens → ⑤**



⑧ **Sow stalls with and without feeding aisles → ① + ②**

The breeding pens shown for 64 productive sows can be correspondingly extended to accommodate 96 or 128 sows. An allowance should also be made for gilts (young sows), corresponding to approximately 5% of the number of productive sows, and boars (one boar pen per 25 productive sows).

The breeding shed requires separate pen sections (serving pen, dry sow pen, farrowing pen and piglet rearing pen) and aisles to allow movement of the animals. Feeding aisles are often also included. No straw is spread on the partially or fully slatted stall floor and slurry is collected in channels.

With the all in, all out procedure and twin-phase piglet breeding, piglets can be weaned after 4–6 weeks. Piglets are ready for sale when they reach approximately 20 kg.

sows and boars

	temp. zone (°C)	air renewal rate (m³/h)	
animal weight (kg)		100	300
winter	−10 −16	12.3 10.9	29.9 26.3
summer	≥26 <26	109–146 73–88	271–361 180–216

piglets

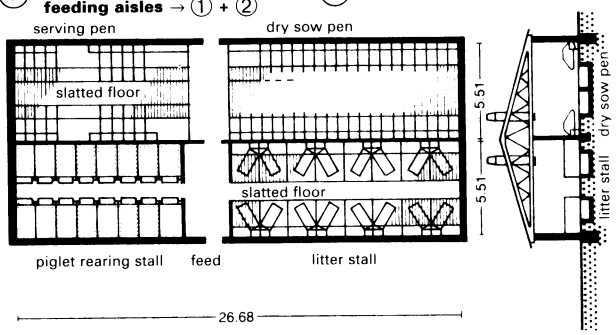
	temp. zone (°C)	air renewal rate (m³/h)	
animal weight (kg)		10	20
winter	−10 −16	3.0 2.8	3.6 3.4
summer	≥26 <26	26–34 17–20	38–50 25–30

(individual site-related testing could be necessary)

⑪ **Ventilation data for sheds**

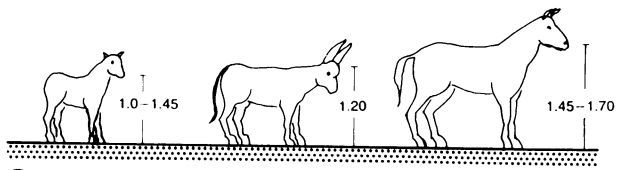
required storage capacity for 28 days' stock			
productive sows	64	96	128
sow feed (m³)	10.2	15.3	20.4
piglet feed (m³)	5.8	8.7	11.6

⑫ **Feed storage needs**

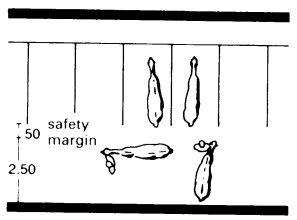


⑩ **Pig breeding sheds without feeding aisles for 40, 55 and 64 productive sows**

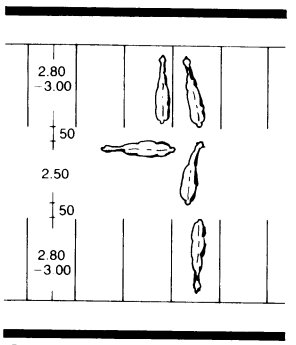
STABLES/HORSES



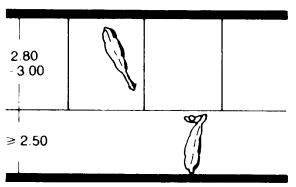
① Pony, donkey, horse



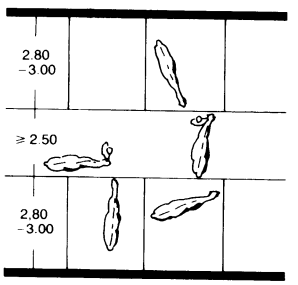
② Stable: single row, tethered



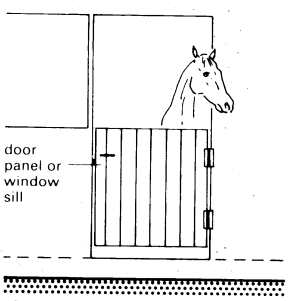
③ Stable: twin row, tethered

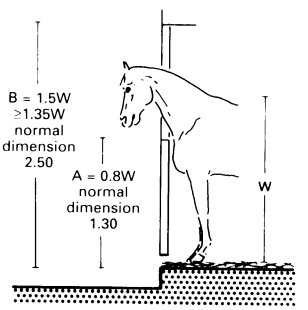


④ Single-row box stable

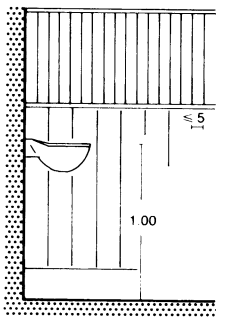


⑤ Twin-row box stable

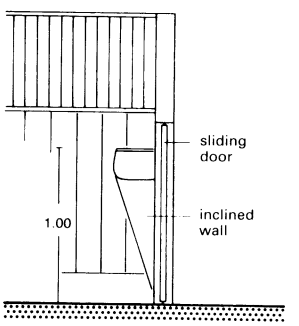




⑥ Dimensions of stable doors



⑦ Drinking bowl



⑧ Trough height

Stables in which the animals are tethered in stalls are not generally suitable for horses which are ridden → ② + ③: box stalls are preferable. Although there might be some breed-related behavioural features to be considered, the appropriate floor area of the box stall is usually based on the body length of the horse. However, because the length of horses is not measured, the wither, or stock, height is used as the reference dimension. As a rule of thumb, the box plan area is given by:

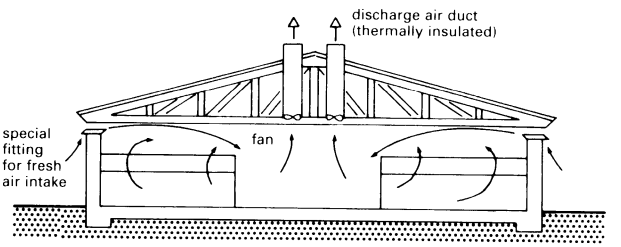
stall area = $(2 \times W)^2$

where W is the wither/stock height. A working value for the minimum length of the short sides of the stall is given by 1.5 × W. → ④ + ⑤ Common wither heights of horses that are ridden are 1.60–1.65 m, giving a stall floor area of approximately 10.5 m^2.

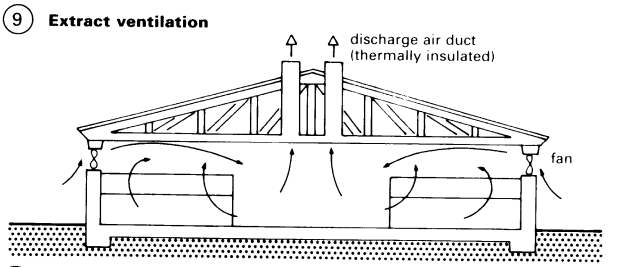
To turn a horse safely, a stable aisle width of at least 2.50 m is required → ② – ⑤. In stables with tetherering stalls, provide an extra safety margin of 50 cm for each row → ② + ③.

In addition to the stalls or boxes, consideration needs to be given to a saddle room, forge, sick stall and feed storage rooms. The saddle room should be 15 m^2 or more, depending on the number of horses. For stables housing more than 20 horses a forge (5.0 × 3.6 m) and a stall for sick animals should be provided.

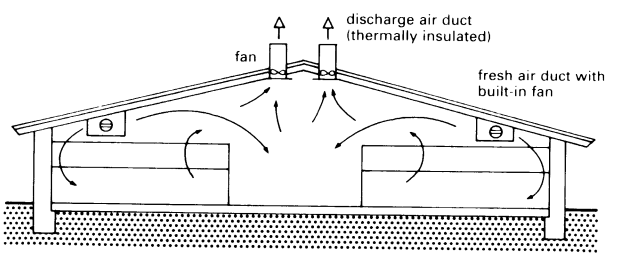
Although horses are insensitive to wind (indeed, they are reported to have physiological need for moving air), draughts should be avoided. This is achieved using artificial ventilation equipment and air ducting → ⑨ – ⑪. It is not practical to attempt to create an 'ideal' stable temperature. Nor is it crucial because, with appropriate preparation and expert care, any horse can withstand winter stable temperatures as low as a few degrees below zero.



⑨ Extract ventilation



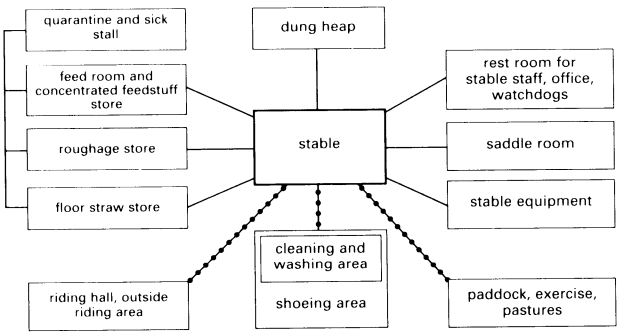
⑩ Pressurised ventilation



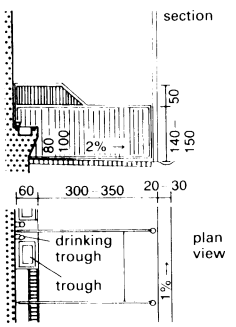
⑪ Balanced pressure ventilation

STABLES/HORSES

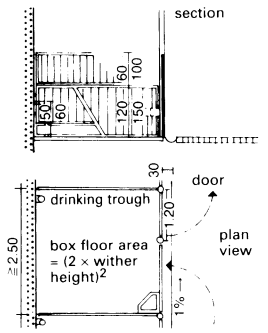
The needs of the horses are paramount in designing stables and the methods of keeping them. Good design is a precondition not only for maintaining health, race competitiveness and longevity but also for ensuring the animals have an even temperament. Surprisingly, the requirements of horses today are not very different to those of the horses from the Asian plains which were first domesticated 5000 years ago.



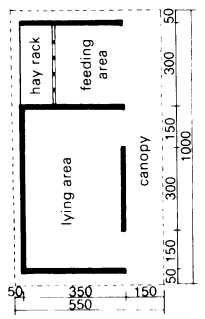
(1) **Function diagram of a horse stable**



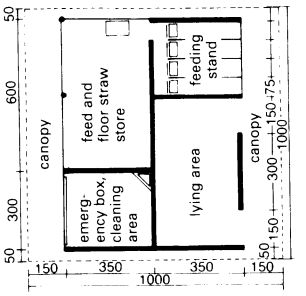
(2) **Tethered stall arranged as box stall**



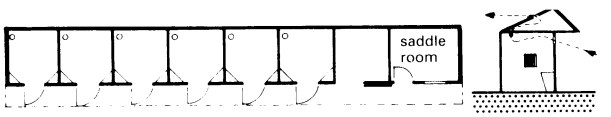
(3) **Box stall**



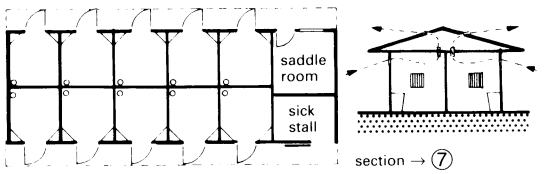
(4) **Small shelter**



(5) **Large shelter**



(6) **Single row, outside boxes**



(7) **Twin row, outside boxes**

material; storage; density (kg/m³)	required storage space with 20–30% empty space (m³)	
	200 days [1]	365 days [2]
Hay, long quality (75)	17–20	30–36
HD bales, non-stacked (150)	9–11	15–18
HD bales, stacked (180)	7–9	12–14

[1] corresponds to 1000–1200 kg

[2] corresponds to 1800–2200 kg

(9) **Space requirement for hay storage at 5–6 kg/horse/day**

material; storage; density (kg/m³)	required storage space with 20–30% empty space (m³) for 3 months [1]
straw, long quality (50)	22
HD bales, non-stacked (70)	15
HD bales, stacked (100)	11

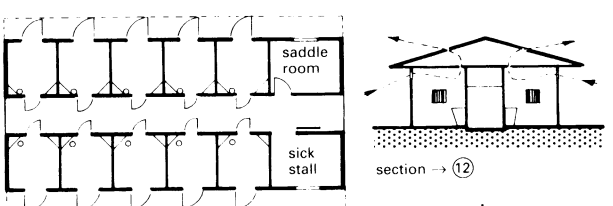
[1] corresponds to 900 kg

(10) **Space requirement for straw storage at 10 kg/horse/day**

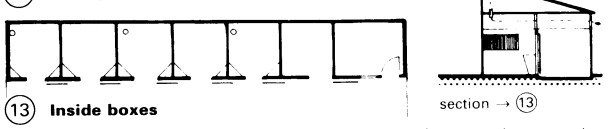
	floor area (m²)	box size (m)	box height (m)
riding horses	10.00 12.00	3.30 × 3.30 3.50 × 3.50	2.60–2.80
dam and stallion	12.00 16.00	3.50 × 3.50 4.00 × 4.00	2.60–2.80
small horse (W ≤ 1.30 m)	4.00 5.00	2.00 × 2.00 2.25 × 2.25	1.50
small horse (W > 1.30 m)	6.00 9.00	2.45 × 2.45 3.00 × 3.00	1.50–2.00

W = height of horse at the withers

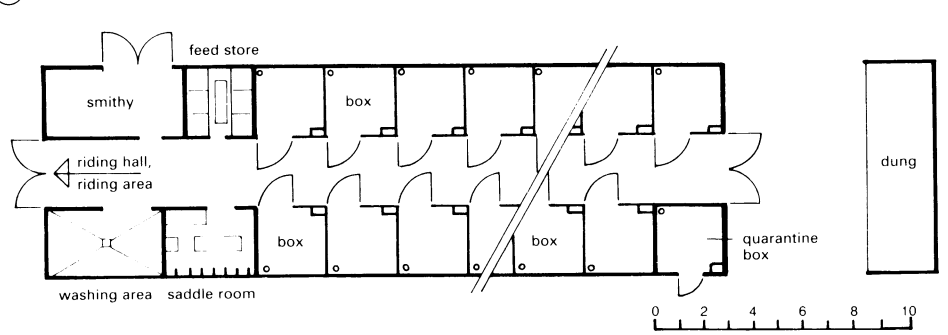
(11) **Dimensions of horse boxes**



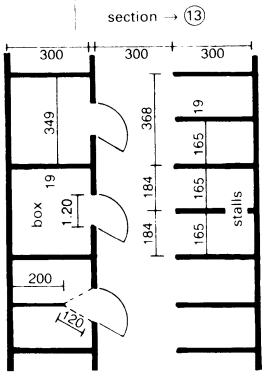
(12) **Inside/outside boxes**



(13) **Inside boxes**

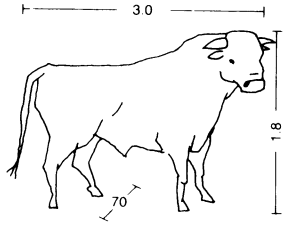


(8) **Example layout of associated rooms for a horse stable with 20–30 boxes**



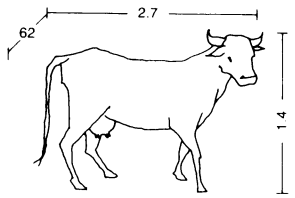
(14) **One box is as wide as two stalls**

CATTLE



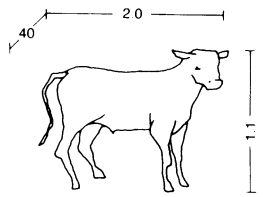
stall width: 1.25–1.37 m per bull

① **Bull**



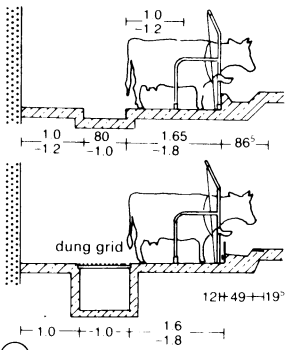
stall floor area: 5.0–9.0 m²/cow
stall width: 1.05–1.25 m
calving stall width: 1.50 m

② **Cow**

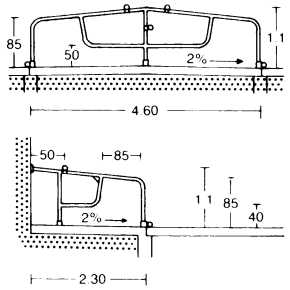


stall floor area:
under 1 year, 3.1–3.5 m²
1–2 years, 3.5–4.5 m²

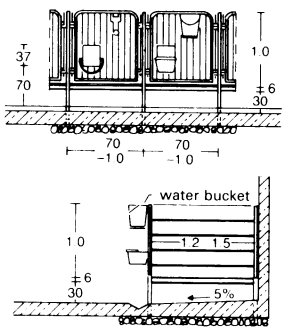
③ **Young cattle**



④ **Short stand**



⑤ **Lying boxes for cows**



⑥ **Single stalls for calves (14 days to 10 weeks)**

A differentiation is made here between tethering stalls and box pens, the latter being generally confined to dedicated milking sheds. In the tethering stall the cow is tied to one spot – here it stands, rests, drinks, urinates, defecates and can also be milked in some circumstances. The stall is 1.10–1.20 m wide and 1.40–1.80 m long, depending on the size of the animal (a factor of breed and age) as well as the type of stall → ⑨ + ⑩. For examples of box pen layouts → ⑦ + ⑧.

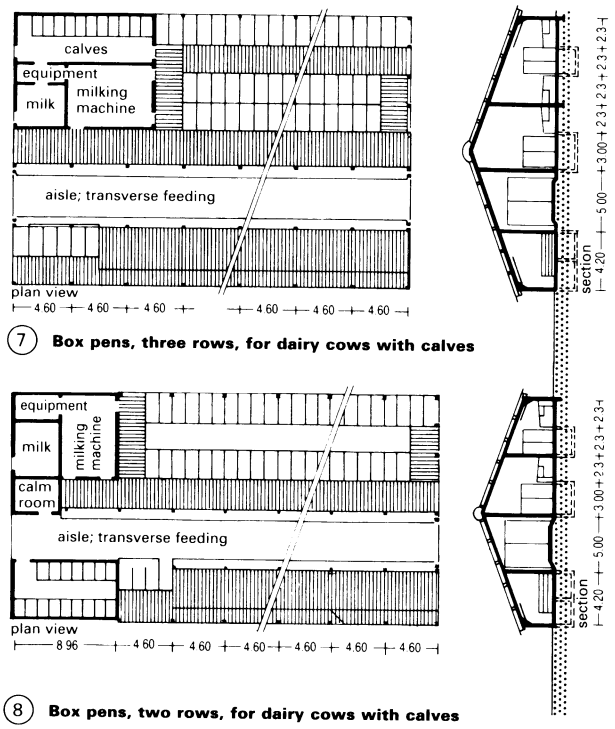
Illustration ④ shows short stalls with feeding stages 1.60–1.80 m long. These are often spread with straw, which gives a solid dung layer of 2–4 kg of straw/cow/day, but it is increasingly common to have low straw (0.5 kg straw/cow/day) or no straw sheds.

Even with small herds, it is desirable to mechanise the dung removal process. The dung removing equipment determines the height and width of the dung pit → ④. No straw should be used in short stalls with a droppings grid because it could limit the slurry removal system.

Single-row stall arrangements are not economical. The best use of space in a cow shed is made with a twin row of stalls, a central feeding aisle and outer dung collection channels.

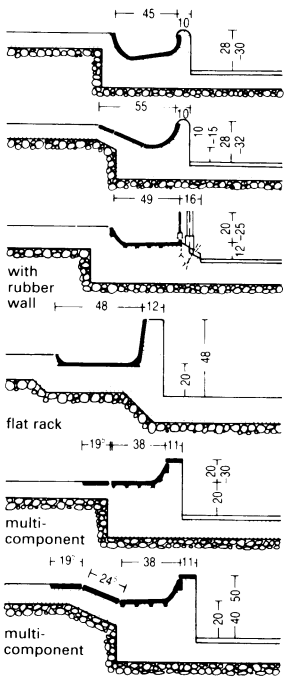
The level of feeding mechanisation can have a bearing on shed widths and must be considered early in any new project. Minimum widths range from 10 m to 12 m.

To allow future longitudinal extension of the shed, one gable end should be left free. This means that storage areas, equipment and machinery, and associated rooms should be located at one gable end.

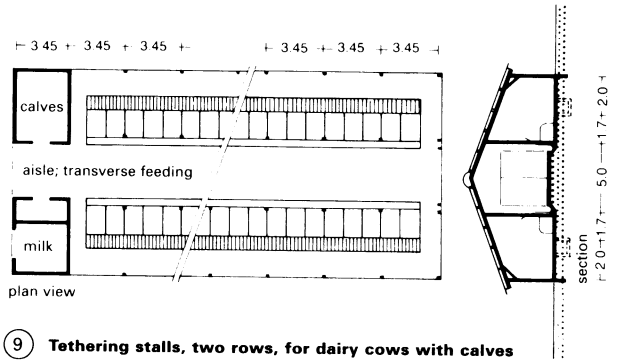


⑦ **Box pens, three rows, for dairy cows with calves**

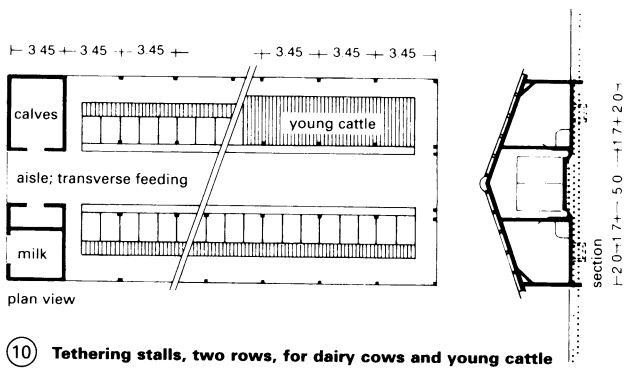
⑧ **Box pens, two rows, for dairy cows with calves**



⑪ **Shapes for milking cattle, tethered or pen stalls**



⑨ **Tethering stalls, two rows, for dairy cows with calves**



⑩ **Tethering stalls, two rows, for dairy cows and young cattle**

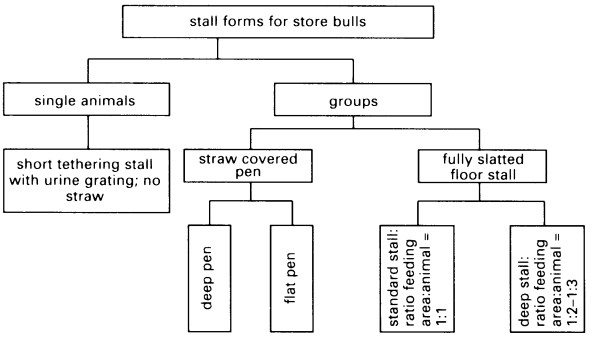
CATTLE: STORE BULLS

There are two methods of keeping store bulls: they are either kept singly or in groups → ①. Keeping the animals singly requires constant adaptation of the stall to match the rapid growth of the bull and, therefore, a range of tethering stalls is necessary for the different age groups. Short stalls are recommended for this purpose → ② and it is important to ensure that the single pens have good drainage to remove urine from the lying area. The advantage of keeping the animals separately is that it eliminates herd behaviour.

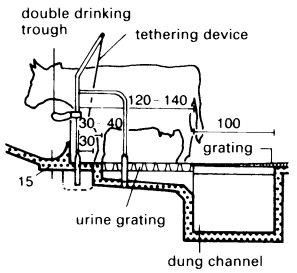
An important precondition for keeping bulls in groups (6–15 animals of the same age and weight) is that they must have become accustomed to one other from the time they were calves.

A distinction can be made between deep and flat pens according to the straw quantities and dung removal system. In deep pens the whole stall serves as the movement and lying area and has a straw covering whereas in flat pens the lying and feeding areas are separated. The standard feed for special store bulls is maize silage.

When planning for store bulls, bear in mind that it must be possible to move single animals or whole groups into and out of the fattening stalls easily and in safety. Ventilation equipment such as convectors and extractor fans are recommended and these function best with a roof slope of around 20 degrees.

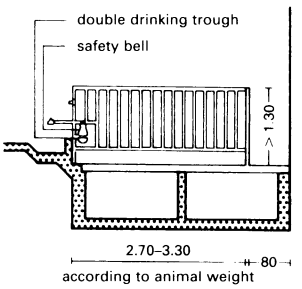


① **Stalls for store bulls**

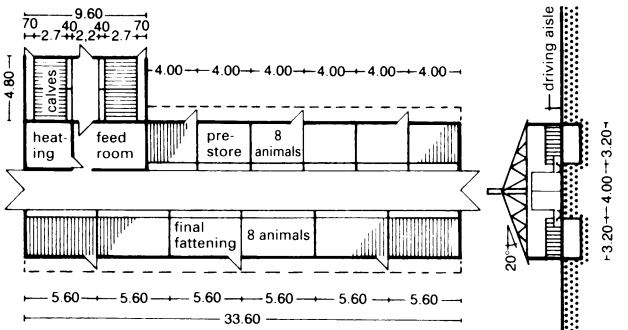


animal weight	length	width
up to 300 kg	120cm	70–80cm
up to 600 kg	140cm	90–100cm

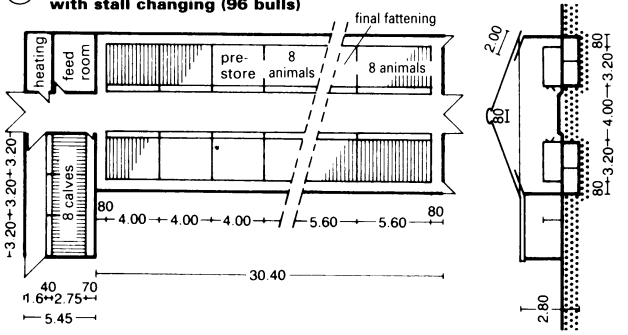
② **Short stall without straw**



③ **Stall with fully slatted floor**



④ **Stalls with fully slatted floors and external driving aisle; with stall changing (96 bulls)**



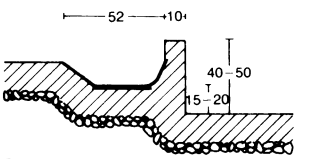
⑤ **Stalls with fully slatted floors and driving aisle behind the stalls; with stall changing (96 bulls)**

	maize silage			hay		
	(kg/day)	(kg/year)	storage req'd/year (m^3)	(kg/day)	(kg/year)	storage req'd/year (m^3)
first fattening section 125–350 kg	12	4380	6.15	0.5	180 (HD bales)	1.2
final fattening section 350–550 kg	22	8030	11.15		-	

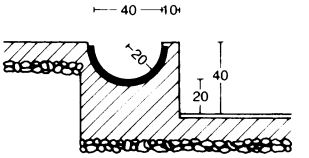
⑦ **Feeding requirements per animal**

weight section (kg)	stall area (m^2)	feeding area width/animal (cm)	slatted floor dimensions: req'd widths (mm) step	gap
125–150	1.20	40		
150–220	1.40	45		
220–300	1.50	50	1.20	
300–400	1.80	57	up to	35
400–500	2.00	63	1.60	
>500	2.20	70		

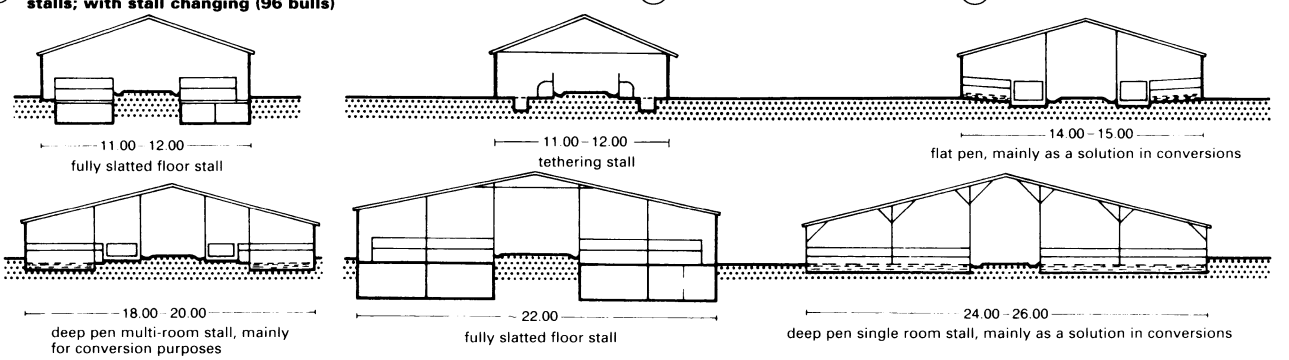
⑧ **Space requirement and slatted floor dimensions for store bull sheds**



⑨ **Fodder rack**

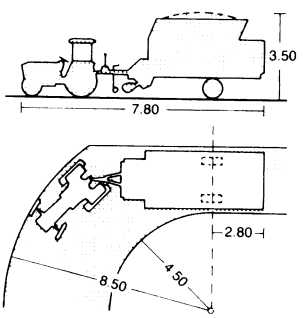


⑩ **Fodder rack**

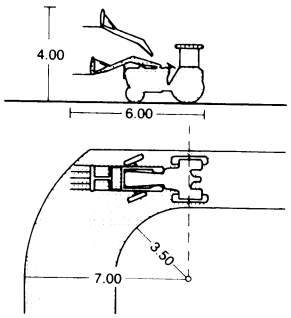


⑥ **Shed cross-sections for various forms of stall**

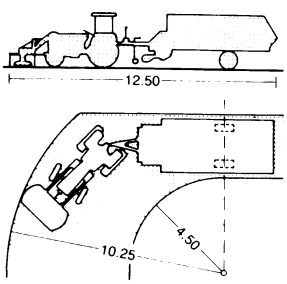
BUILDINGS FOR FARM VEHICLES



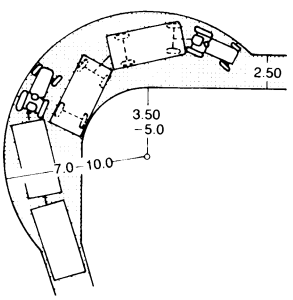
① **Tractor with trailer**



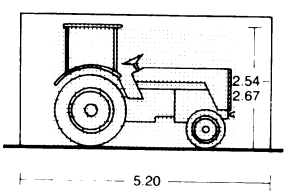
② **Tractor with front loader**

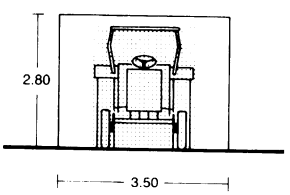


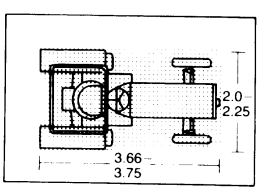
③ **Tractor with push reaper and trailer**



④ **Minimum space required for traffic**

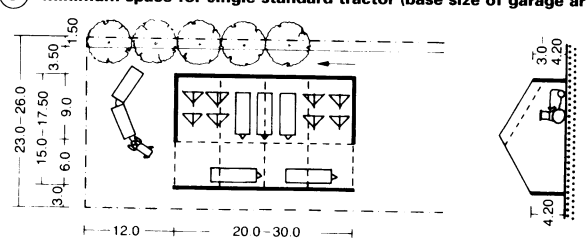




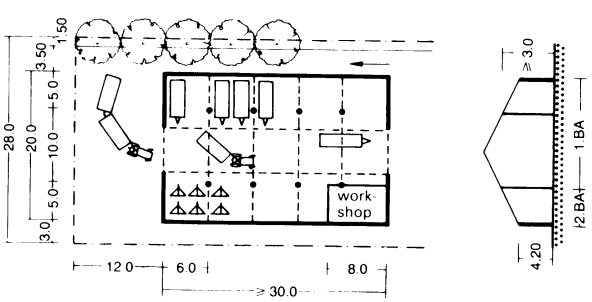


trailer	(m³)	length	width	height
green fodder	12	6.95	2.35	2.26
dry fodder	19			2.94
green fodder	11	7.80	2.46	2.45
dry fodder	17			3.10
green fodder	12	7.25	2.25	2.30
dry fodder	18			3.25
green fodder	14	8.00	2.35	2.25
dry fodder	20			2.90
guide size for trailers	13–20	7.70	2.40	3.10
guide for shed areas		8.70	3.40	3.40

⑤ **Minimum space for single standard tractor (base size of garage area)**



⑥ **Small machine shed with side gangway**



⑦ **Large machine shed with central gangway: supported structure**

building type: use/type of farm	reference dimension	farm size 10 ha	15 ha	20 ha	30 ha
garage for tractors and motor mower	floor area (m²)	26	43	44	62
	depth (m)	5.0	5.2	5.2	5.4
	height (m)	2.7	2.8	2.8	2.9
garage for mountain farm transporter with loader; motor mower and belt reaper	floor area (m²)	46			
	depth (m)	7.3			
	height (m): transporter	2.9			
	motor reaper	2.2			
workshop	floor area (m²)	12	12	14	16
barns for purely stock farms	floor area (m²)	160	230	260	350
	depth (m)	7.6	8.7	8.7	9.5
	height (m)	3.3	3.4	3.4	3.5
barns for mixed stock/ arable farms	floor area (m²)	180	310	370	520
	depth (m)	7.6	8.7	8.7	9.5
	height (m)	3.3	3.5	3.5	3.6
barns for purely arable farm	floor area (m²)		240	340	450
	room depth (m)		8.0	8.0	9.7
	height (m)		3.5	3.5	5.8
barns for mountain farms	floor area (m²)		120		
	depth (m)		8.3		
	height		3.2		

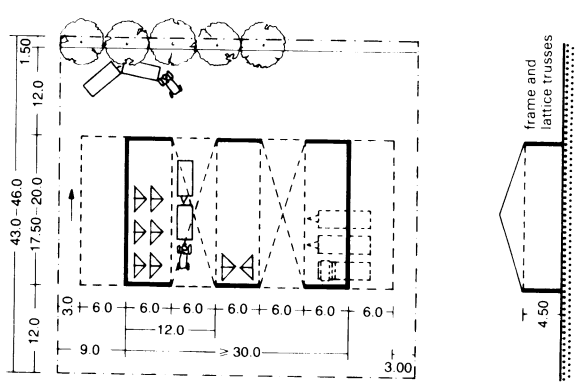
⑧ **Guideline space requirements for garages and sheds**

Unlike farms in other European countries, British farms tend to be larger than 30 ha. This might be partly due to differing inheritance practices.

machine		l (m)	w (m)	h (m)
tractors (with safety hooks)				
standard tractor	up to 60 hp	3.30–3.70	1.50–2.00	2.20–2.60
4-wheel drive tractor	60–100 hp	4.00–5.00	1.80–1.40	2.50–2.80
(incl. row-crop tractors)	120–200 hp	5.50–6.00	2.40–2.50	2.50–2.90
carrier:				
low-loader	up to 45 HP	4.50	1.70	2.50
transporter (with towing claw) twin-axle trailers				
flat-bed trailer	up to 3 t	ca. 6.00	1.80–1.90	ca 1.50
flat-bed trailers	3–5 t	ca. 6.50	1.90–2.10	ca 1.60
and tippers	5–8 t	ca. 7.00	2.10–2.20	ca 1.80
single axle trailers	up to 3 t	ca. 5.00[1]	1.90–2.10	ca 1.60
(with scraper floor)	3–5 t	5.00–5.50[1]	2.10	ca 1.60
or tippers	5–8 t	5.50–6.00	2.20–2.25	ca 2.00
slurry tank trailer	3–6 m³	5.50–6.50	1.80–2.00	1.80–2.20
earth tilling equipment (in transport mode)				
general purpose plough (mounted)	2 blades	ca. 2.00	ca 1.20	ca 1.20
	3 blades	2.70–3.30	1.30–1.50	ca 1.20
	5 blades	4.50–5.50	2.00–2.50	ca 1.20
reversible plough (mounted)	2 blades	ca. 2.30	ca. 1.10	1.30–1.70
	3 blades	2.90–3.30	1.40–1.60	1.30–1.70
	5 blades	4.50–5.50	2.00–2.50	1.30–1.70
grubber		1.50–3.00	2.30–3.00	0.60–1.10
disk harrow		3.20–3.50	1.70–3.50	0.70–1.10
combination device		2.70–3.00	1.10–1.30	
rotary hoe		1.10–1.40	2.00–3.00	1.10–1.20
vibrating harrow		0.80	up to 3 m	1.00
rotary harrow		2.00–3.00	up to 3 m	0.80
rollers	3-part	2.50	up to 3 m	0.80
mineral fertilizer spreader				
box spreader		0.70–1.20	2.70–3.00	0.70–1.20
centrifugal spreader	(mounted)	1.00–1.50	1.40–1.50	0.90–1.40
large capacity spreader	(towed)	4.30–5.50	1.80–2.80	1.70–2.00

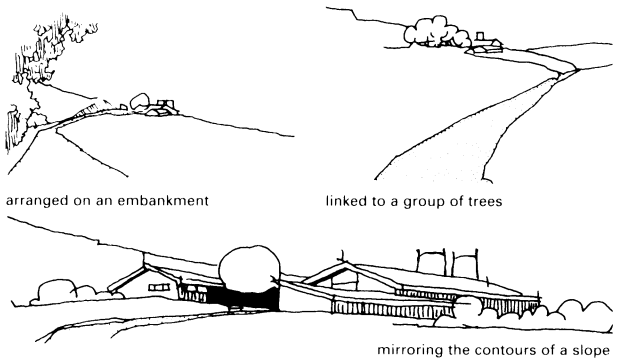
[1] stable dung spreader approximately 0.5 m longer

⑨ **Dimensions of agricultural equipment**

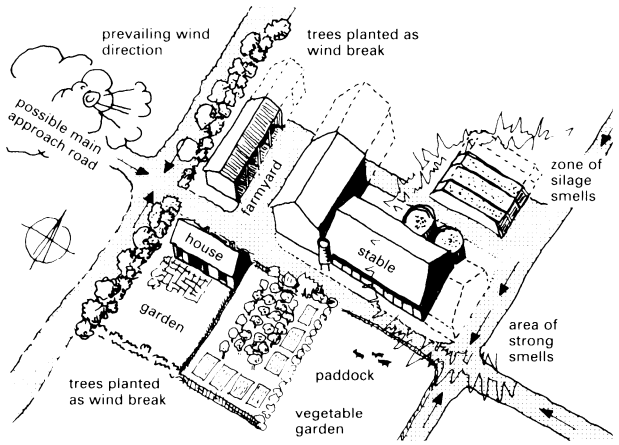


⑩ **Large machine and equipment shed with through-gangways**

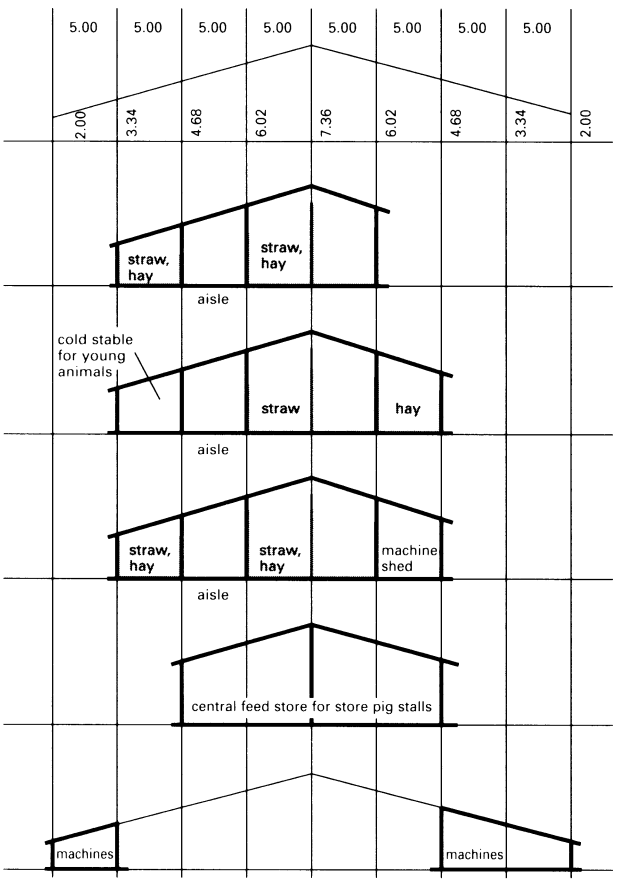
FARM FACILITIES



① **Using natural features, buildings can be blended into the landscape**



② **Schematic layout of the elements of a farm**



③ **Planning system for a flexible range of barns**

Design considerations

There are numerous factors that can influence the design of farm buildings. For individual buildings, it is necessary to consider the requirements of the following: Planning Authorities, Building Regulations, Water Authorities, Ministry of Agriculture, Health and Safety Executive, Milk Marketing Board, Dairy Husbandry Advisers, Welfare Codes, Farm Building Design Code and electricity, gas, telephone and water companies.

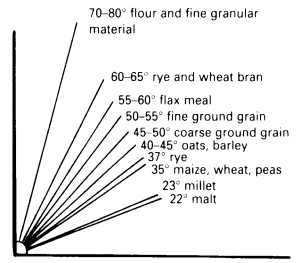
Planning considerations

In selecting the location a balance should be found between topographical and climatic conditions on the one hand and the business requirements on the other. For instance, stables require almost the same climatic conditions as domestic buildings so exposed areas prone to extreme weather should be avoided. The position of the buildings with respect to each other, and relative to any adjoining housing estates, and orientation to the prevailing wind direction must be carefully considered. Note that the prevailing wind direction in summer is more important than that in winter.

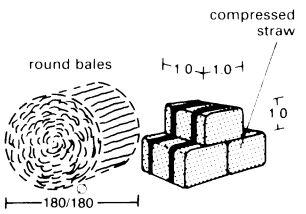
Vehicles should be able to move around the farm without needing to use public roads. However, an effective link to the public road network is obviously necessary to allow supplies to be brought in and produce to be shipped out. Commercially, this connection is more important than arranging the farm buildings so as to be close to the fields. The gradients of farm roads should not exceed the following maxima: 5% for manually operated vehicles, 10% for motorised vehicles, with an absolute maximum of 20% for short stretches.

In laying out the buildings the following minimum spacings should be maintained: at least 10 m between all buildings and 15 m between the farmhouse and stables or sheds → ②.

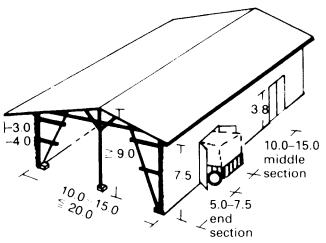
For a farmhouse and garden, about 1000 m² is required. The garden should be located to the south or west of the house if possible and can be used also for growing fruit and vegetables. Typical allowances are 50–60 m² of vegetable plot per person and approximately 100 m² of orchard per person.



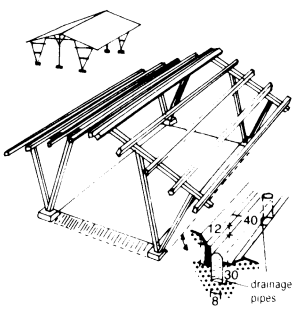
④ **Angle of repose for agricultural crops**



⑤ **Straw**



⑥ **Barn with transverse aisles**



⑦ **Field barn**

FARM FACILITIES

The tables presented here give guidance on the minimum required sizes of plot for different types of farming. Alternative values may be encountered depending on the assumptions. For example, the required plot area can be reduced by:

- using tower silos instead of flat silos
- the use of loft space instead of floor area for storage
- storing liquid manure under the slatted floor instead of in outside containers
- building up to the borders etc.

The plot sizes given in the tables do not take into account the area required for storage of farm machinery, workshops or dwelling areas because these do not have to be immediately beside the buildings involved directly in production.

area requirement (m^2)	tethering feeding/ lying stall for (no.) cows			box pen stall for (no.) cows			
	40	60	80	50	80	120	200
stalls	250	380	500	400	640	960	1600
milking area	10	20	30	50	80	120	200
low-level silo	200	300	400	250	400	600	1000
roughage	80	120	160	100	160	240	400
liquid manure store	160	240	320	200	320	480	800
roadways	400	600	720	500	720	960	1400
farmyard area	800	1050	1200	1250	1760	2400	3000
required total area (m^2)	1900	2710	3330	2750	4080	5760	8400
required plot width (m)	33	33	33	45	45	45	45

(1) **Dairy cows without calves**

area requirement (m^2)	tethering feeding/ lying stall for (no.) cows			box stall for (no.) cows			
	40	60	80	50	80	120	200
stalls	320	470	630	440	700	1050	1750
milking area	20	20	30	60	80	80	80
low-level silo	250	380	500	310	500	750	1250
roughage	100	150	200	130	200	300	500
liquid manure store	200	300	400	260	400	600	1000
roadways	500	750	900	620	900	1200	1750
farmyard area	1000	1270	1500	1560	2200	3000	3750
required total area (m^2)	2390	3340	4160	3380	4980	6980	10080
required plot width (m)	33	33	43	45	45	45	45

(2) **Dairy cows with calves**

area requirement (m^2)	store calves: single boxes for (no.) calves				store bulls pen; fully slatted floor for (no.) animals			
	100	200	300	400	100	200	300	400
stalls	340	640	930	1200	400	940	1410	1880
roughage	–	–	–	–	50	100	150	200
low-level silo	–	–	–	–	560	1000	1250	1500
liquid manure store	50	100	150	200	120	200	300	400
roadways	200	200	200	200	650	560	750	850
farmyard area	1110	1600	2200	2640	1210	2100	3140	2170
required total area (m^2)	1700	2540	3480	4240	2990	4900	7000	7000
required plot width (m)	45	45	45	45	35	35	50	50

(3) **Store cattle**

area requirement (m^2)	sow stalls: for (no.) sows				sow stalls for S sows, with P store places for piglets		
	80	100	120	150	46S 400P	88S 800P	142S 1200P
stalls	720	850	1020	1200	880	1760	2640
liquid manure store	90	100	110	120	240	400	600
roadways	230	250	270	300	240	400	480
farmyard area (including run)	1600	1850	2100	2400	1480	2640	3120
required total area (m^2)	2640	3050	3500	4020	2840	5200	6830
required plot width (m)	45	45	45	50	45	45	50

(4) **Piglet rearing (with stores)**

area requirement (m^2)	store pig shed for (no.) animals			
	500	1000	1500	2000
stalls	850	1700	2500	3400
liquid manure store	250	400	600	800
roadways	240	400	440	400
farmyard area	1300	2300	2700	3000
required total area (m^2)	2640	4800	6290	7600
required plot width (m)	35	35	55	55

(5) **Store pigs**

area requirement (m^2)	laying hens, three-tier cages for (no.) animals			store chickens, cages for (no.) animals		
	10000	50000	100000	10000	50000	100000
stalls	630	3000	6000	400	2000	4000
egg sorting room	–	400	800	–	–	–
liquid manure store	110	550	1100	50	250	5000
roadways	200	1200	1800	100	500	1000
farmyard area	1260	5050	8000	1000	4000	7000
required total area (m^2)	2200	10200	17700	1550	6750	12500
required plot width (m)	35	100	100	35	80	80

(6) **Hen keeping**

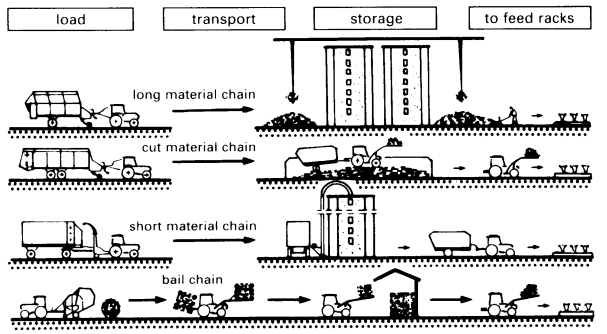
area requirement (m^2)	root crop, cereal cultivation for (ha)			cereal feed cultivation on (ha)		
	60	80	100	80	100	120
machine hall	250	290	320	230	270	120
bulk storage area	250	250	250	250	250	250
roadways and machine storage	180	200	220	180	200	220
farmyard area	200	230	250	200	230	250
required total area (m^2)	880	970	1040	860	950	1020
required plot width (m)	33	33	40	33	33	40

(7) **Market crop cultivation**

FARM FACILITIES

form of fodder	dimensions (cm)	fresh	wilted (35%)	hay	straw	handling method
long	ca. 25	170	120–150	50	30	in portions (grab)
cut	4–8	200	150–180	80	40	bulk material (dosing rollers)
short	4	350	250–300	60–100	50–80	bulk material (blower, cutter)
small bales	35 × 50 × 80	–	250–300	100–150	80–130	bulk material (manual)
large bales	Ø 180–150	–	300	80–180	60–130	bulk material (front loader)
large bales	150 × 150 × 240 (160 × 120 × 70)	–		60–90	70–130	bulk material (front loader)

(1) **Forms of harvested fodder (kg/m³)**



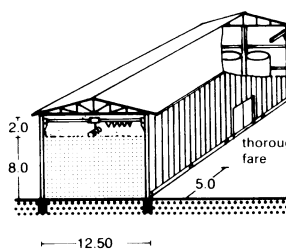
(2) **Storage and feed preparation**

Flat silos for storing silage require ducts to allow the liquor to drain off. The walls must be able to withstand the lateral pressure of silage depths ranging from 2.0 to 3.5 m so the detailed design work should be done by a structural engineer.

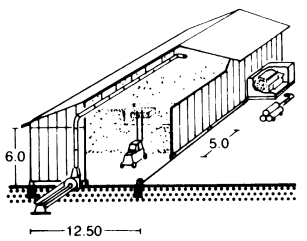
fodder		space required (when storing before setting (m³/t)
hay:	long material (quality good to very good; stack height 2–6 m)	17–10
	chaff material (5 cm; quality good to very good; stack height 2–6 m)	13–10
	HD bales, non-stacked	9–7
	HD bales, stacked	8–6
	aerated hay	10–7
	hay tower	8–7
	dry grass (cobs)	2–1.7
silage:	wilted silage (35–25% moisture content)	2–1.6
	maize silage (28–20% moisture content)	1.8–1.5
	turnip leaves	1.3–1.2
feed turnips		1.6–1.4
concentrated feed (coarse ground)		2.2–1.9
dry feedstuff		3.8–3.4

the figures above do not include space for getting material into and out of storage (e.g. halls, aisles, space for crane etc.); they do, however, include a filling supplement of 20% for hay and concentrated feedstuff and 10% for silages

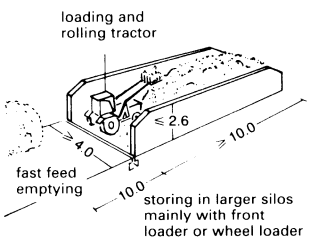
(9) **Complete storage of animal feed**



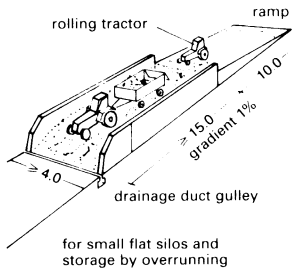
(3) **Hay storage barn with overhead loader**



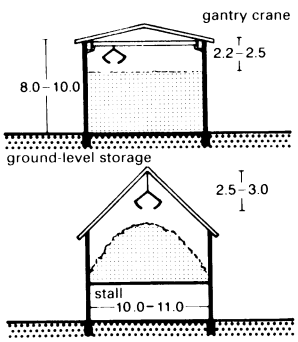
(4) **Hay storage barn**



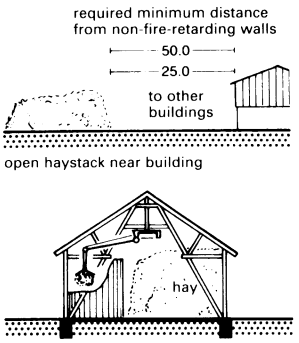
(10) **Flat silo**



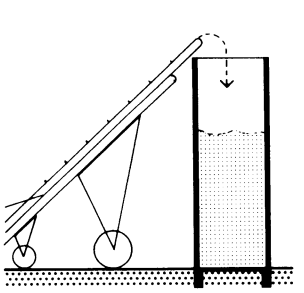
(11) **Flat silo with ramp**



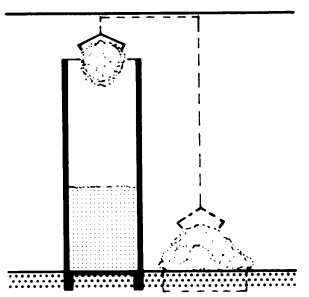
(5) **Hay loft**



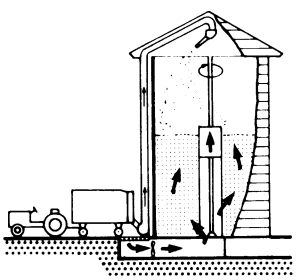
(6) **Hay storage**



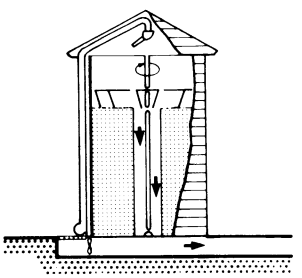
(12) **Tower silo: filling with conveyor belt**



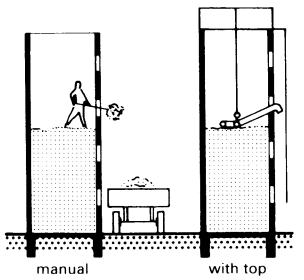
(13) **Tower silo: filling with overhead loader**



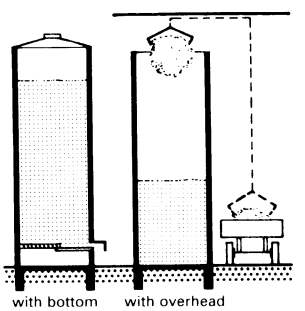
(7) **Hay tower: filling and ventilation**



(8) **Hay tower: emptying**



(14) **Tower silo: extraction**



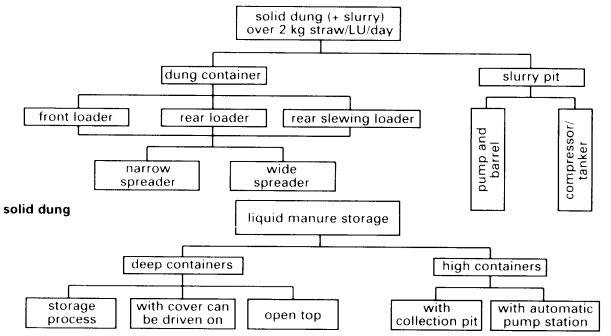
(15) **Tower silo: extraction**

Waste Water and Sewage

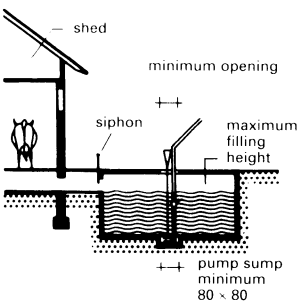
The amount of droppings and urine collected from farm animals depends upon the type of animal and its live weight (expressed in livestock units, 1 LU = 500 kg live weight), as well as the type and composition of the feed and drink. Because the composition of animal feed varies substantially throughout the year, the composition figures given here are averages.

With normal straw quantities of 1.5 to 2 kg of straw per LU/day, a volume of 1.00–1.25 m^3/LU/month is required for solid dung storage. With slurry (liquid manure), typical figures for dairy cattle are 1.4 m^3/LU/month while for maize-fed store cattle the volume is reduced to 1.0 m^3/LU/month.

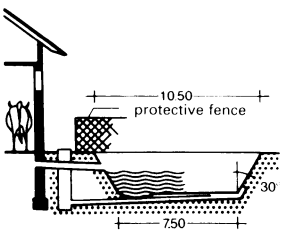
Among the most frequent causes of pollution from farms are structural failure of slurry and effluent stores, mismanagement and lack of maintenance of slurry handling systems and problems with dirty water disposal. National regulations have been tightened to prevent such problems. In England and Wales the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations, 1991, set legal minimum standards of design and construction for silage, slurry and agricultural fuel installations. An important condition that affects the siting of any such installation is that it must not be constructed within 10 metres of watercourses (including land drains) into which silage effluent, slurry or oil could enter.



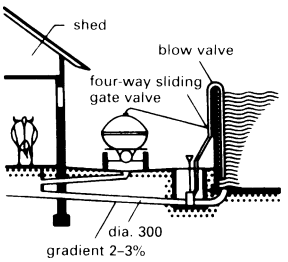
(1) **Summary of solid dung, slurry and liquid manure storage and removal**



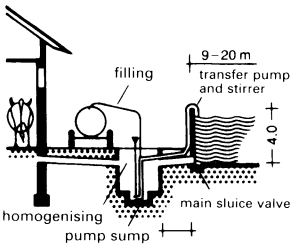
(2) **Underground tank (solid)**



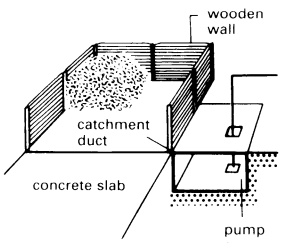
(3) **Earth tank with plastic sealing layers**



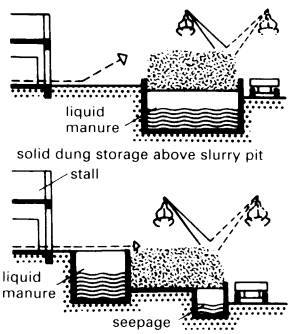
(4) **High container with pumping station**



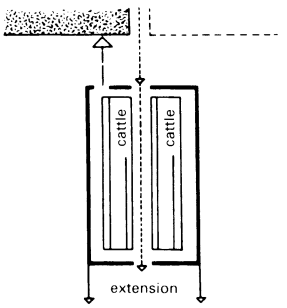
(5) **High container with collection pit**



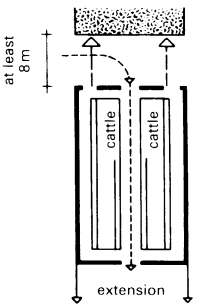
(6) **Solid dung store combined with liquid manure pit**



(7) **Solid dung stores with liquid manure pits**



(8) **Solid dung store to front**



(9) **Solid dung store to front**

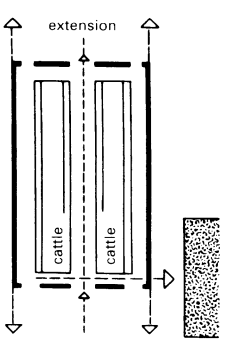
type of animal	solid dung (kg/LU/ month)	solid dung (m^3/LU/ month)	slurry (m^3/LU/ month)	nutrients contained in solid dung (kg/LU/month) N	P_2O_5	K_2O	CaO	MgO
horse	750	1.0	0.1	4.5	2.1	4.0	1.8	1.05
cattle, in tethering stall	900	1.2	0.6	4.5	2.3	5.9	1.8	1.8
fattening bull, tethering stall	900	1.2	0.6					
fattening bull in deep straw	1500	2.0	[1]					
sheep	650	0.9	[1]	5.2	1.5	4.4	2.1	1.2
pig	500	0.6	0.6	2.8	3.8	2.5	2.0	1.0
pig in deep straw	1000	1.2	[1]					
laying hens (dry droppings 80% total solids)	460	0.4		16.3	21.4	11.2	55.8	
laying hens (ground-kept, droppings 78% total solids)	550	0.7		14.3	18.7	10.5		
fattening hens (ground-kept, droppings)	590	0.8						
rabbit (dry droppings)	330	0.4		1.7	1.5	4.0	2.1	

[1] bound in ground straw

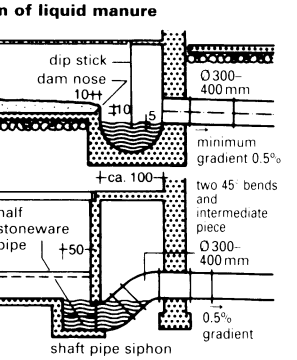
(10) **Amount and average composition of solid dung**

type of animal	slurry arising (m^3/LU/ month)	TS (total solids) content (%)	nutrients N	P_2O_5	K_2O	CaO	MgO (kg/m^3)	N	P_2O_5	K_2O	CaO	MgO (kg/LU/month)
cattle	1.4	10	4	2	6	2	1	5.6	2.8	8.4	2.8	1.5
pigs	1.4	7	6	4	3	3	1	8.4	5.6	4.2	4.2	1.4
laying hens	1.9	15	8	8	5	15	2	15.2	15.2	9.5	28.5	3.8

(11) **Amount and average composition of liquid manure**



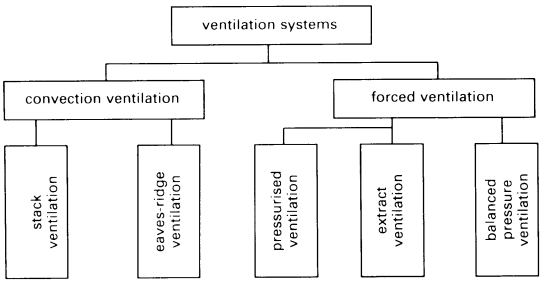
(12) **Solid dung store to side**



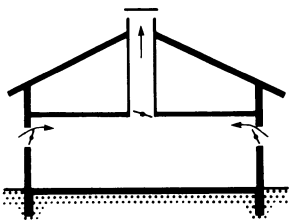
(13) **Gas traps and slurry channels for liquid manure pits**

VENTILATION SYSTEMS

The stable climate (temperature, air composition and humidity) has a decisive role in maintaining the health of animals and ventilation is, therefore, one of the most important considerations in shed design. The objectives of ventilation in livestock buildings are to supply the oxygen needed by the stock, remove waste (mainly heat, water, carbon dioxide and ammonia) and keep down the level of airborne micro-organisms or pathogens. Ventilation systems may be natural, relying on convection and wind currents, or forced (mechanical), using fans to propel air through the building.

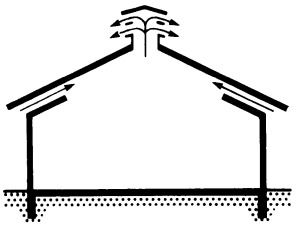


(1) **Classification of ventilation systems**



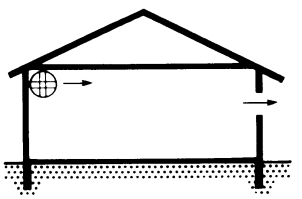
at least 5 m stack height required; works only with low outside temperatures; no energy costs

(2) **Stack ventilation**



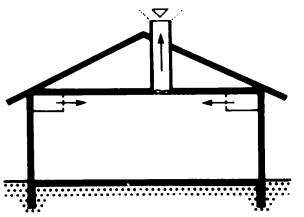
precondition: roof = ceiling; difficulties with inverted weather conditions; the supply air must be regulatable

(3) **Eaves-ridge ventilation**



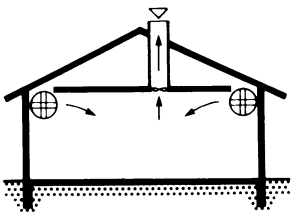
problems with wind direction; no specific outgoing air; good when used in connection with heating; energy requirement: 105–125 kWh/LU/year

(4) **Pressurised ventilation**



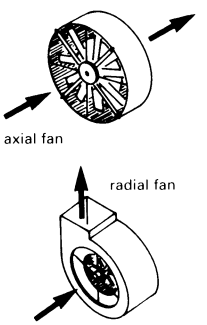
simple system; specific outgoing air (environmental protection); difficult to combine with heating; energy requirements: 98–105 kWh/LU/year

(5) **Extract ventilation**

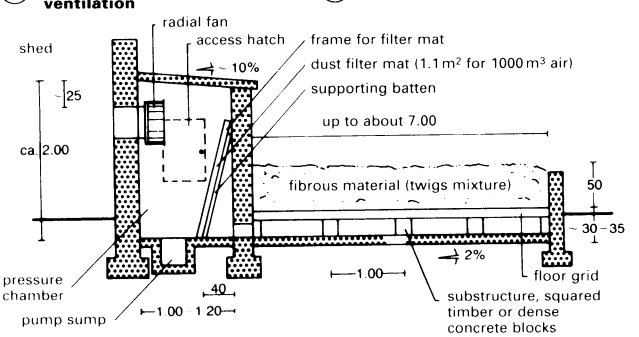


expensive system; safe air distribution; functions independently of weather; simple to combine with heating; high capital cost (1.5 to 2 times that of extract ventilation); energy requirement: 205 kWh/LU/year

(6) **Balanced pressure ventilation**



(7) **Types of fan**



(8) **Earth filter system (design according to Zeisig)**

air temp. (°C)	recommended air speed (m/s)
under 18	0.15
20	0.20
over 22	0.24
24	0.35
26	0.50

(9) **Recommended air speed depending on temperature**

	for animals l/m³	MWC* value
carbon dioxide	3.50	5.00
ammonia	0.05	0.05
hydrogen sulphide	0.01	0.01

* MWC = maximum workplace concentration

(10) **Permissible concentrations in stable air**

Planning should start with a calculation of the size of the inlet and outlet air openings, as for mechanical ventilation. They should be calculated according to the summer air rates and in the case of no wind according to the following formula:

$$w = \frac{g \cdot H \cdot \Delta t/T1}{1 + F_1/F_2} \text{ (m/s)} \qquad F_2 = \frac{Vi}{3600 \cdot w} \text{ (m}^2\text{)}$$

w = speed of outgoing air in the ridge opening (m/s)
g = acceleration due to gravity (9.81 m/s²)
H = height from stable floor to ridge opening (m)
T_1 = external temperature (K) (add 273 to find temperature in °C)
Δt = temperature difference between internal and external air (K)
Vi = summer air renewal rate (m³/h)
F_1 = inlet air area (m²)
F_2 = outlet air area (m²)

(for simplicity $\frac{F_1}{F_2}$ can be set to 1)

stable for:	optimal area for animals		recommended calculation value in winter	
	air temperature (°C)	relative humidity (%)	air temperature (°C)	relative humidity (%)
dairy cows, suckling calves, fattening bulls, young breeding cattle and calves	0–20	60–80	10	80
young store cattle, store bulls	12–20*	60–80	16	80
store calves	16–20*	60–80	18	70
gilts, dry and carrying sows, boars	5–15	60–80	12	80
store pigs	15–20*	60–80	17	80
sows and piglets:				
sows	12–16	60–80		
piglets at birth (when using zone heating)	30–32	40–60		
piglets up to 6 weeks	20–22	60–70		
market piglets and pre-store up to 30 kg	18–22*	60–80	20	60
cage-reared from about 5 kg to about 20 kg (2–8 weeks)	22–26*	40–60	26	60
hen chicks with zone heating; temperature in chick zone reduced by 3°C per week alive	32–18*	60–70	26	60
young and laying hens	15–22	60–80	18	70
turkey chicks with zone heating; temperature in chick zone reduced by 3°C per week alive	18–36*	60–80	22	60
store turkeys >7 weeks	10–18*	60–80	16	80
ducks	10–30*	60–80	20	60
workhorses	10–15	60–80	12	80
ridden horses	15–17	60–80	16	80
breeding sheep	6–14	60–80	10	80
store sheep	14–16*	60–80	16	80

* with increasing animal age the air temperature should be gradually reduced from the higher to the lower value

(11) **Air temperature and relative humidity in different stalls**