

Ventilating Pig Buildings

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Providing optimum living conditions for pigs



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Section #1

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Ventilation



Chapters

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- #1.1 What is ventilation?
- #1.2 Air movement
- #1.3 Heat production
- #1.4 Cooling effect of air speed
- #1.5 Sprays & sprinklers

#1.1

What is ventilation?



Ventilation systems are intended to provide optimum living conditions for pigs.

A well-managed, functioning and efficient ventilation system effectively draws fresh air into a building and removes stale air containing a proportion of microbes, dust, harmful gases and water vapour. Inefficient ventilation is detrimental to pig and staff performance (particularly on hot days) and costs more to run.

Poor air quality can increase the risk of respiratory disease. Even at very low temperatures air exchange must still take place and, during cooler periods, heat produced by the pigs helps to keep the building temperature within the pigs' thermoneutral zone. Some heat is lost naturally through the walls and roof, but heat loss is predominantly through exhaust air. During hotter periods, the ventilation system has to remove heat as well as gases and water vapour.

All the various type of ventilation systems that are in use across pig farms today have three main aims:

- 1) Provide fresh air for the pigs to breathe
- 2) Provide the correct temperature for the pigs' thermal comfort
- 3) Remove stale air containing microbes, dust, harmful gases and water vapour from the pigs' environment.

If it is too hot, appetite will be suppressed, the air quality will deteriorate and pigs will be more susceptible to disease. If the minimum ventilation rate is set too high, excessive heat will be lost and feed energy will be used by pigs to keep warm. If the environment is not maintained correctly, pigs can become stressed, leading to outbreaks of respiratory disease and tail biting.

#1.2

Air movement



To understand how a ventilation system works, we first need to understand how air moves.

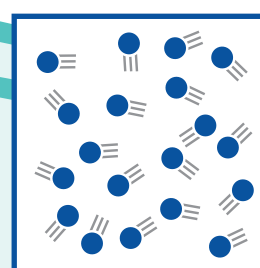
Under normal conditions, air movement cannot be seen but in many ways it flows like water. Any force exerted on it can make it change direction and any restriction in its flow can make it speed up, for example, you can feel a draught when air enters a building through a narrow opening but not so much when it enters through a wide one.

When air moves over a surface or through a duct, drag or friction occurs between the air close to the surface and the surface itself, this slows the air down and if it is a fan moving the air its efficiency is reduced. Shapes or sudden changes in direction also cause turbulence and friction losses.

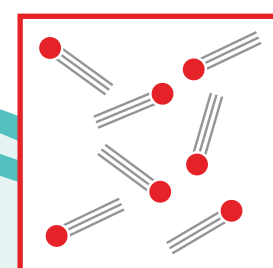
Air moves from areas of high pressure to areas of low pressure in order to maintain equilibrium. The greater the pressure difference, the faster and the more compressed the high pressure air will flow to the low pressure area. Restrictions, changes in direction and friction losses act to slow the flow down.

Key point:

Air also moves if it has a different density or buoyancy than the mass of air around it, eg cold air versus hot air.



Cold air



Hot air

#1.3

Heat production



The amount of heat produced by individual pigs depends on their body size, feed intake and the feed ingredients. The normal body temperature of a pig ranges from 38.7°C-39.8°C.

Pigs maintain a relatively constant internal body temperature, within 1-2 degrees of this range, by balancing internal heat production and heat loss to the environment.

The heat produced by pigs is conducted from their core to the skin where it is transferred to the atmosphere as sensible heat by means of conduction, convection and radiation or as latent heat through evaporation of moisture from the lungs by breathing or, if conditions are particularly warm, by panting.

Sensible Heat

The heat absorbed or given off by a substance that is NOT in the process of changing its physical state. Sensible heat can be measured with a thermometer and the addition or removal of sensible heat will always cause a change in the temperature of the substance.

Latent Heat

The heat absorbed or given off by a substance while it is changing its physical state. The heat absorbed or given off does NOT cause a temperature change in the substance.

Sensible heat produced by the pigs has to be removed by the ventilation system. The amount produced is dependent on the size of the pigs and how much they are eating.

Table 1: Example of sensible heat production levels from pigs at 30°C

Liveweight (kg)	Feed intake x maintenance	Sensible heat (Watts)
7 (pre-weaning)	2	24.4
7 (post-weaning)	1	18.6
20	2.5	47
30	3	66
50	3	92
85	3	127
110	3	151
140 (gilts)	2	144
180 (dry sows)	2	174
180 (lactating sows)	4	274
200 (dry sows)	2	189
200 (lactating sows)	4	297

Source: Extrapolated from Bruce, J. R., Nottingham Easter School, 1980

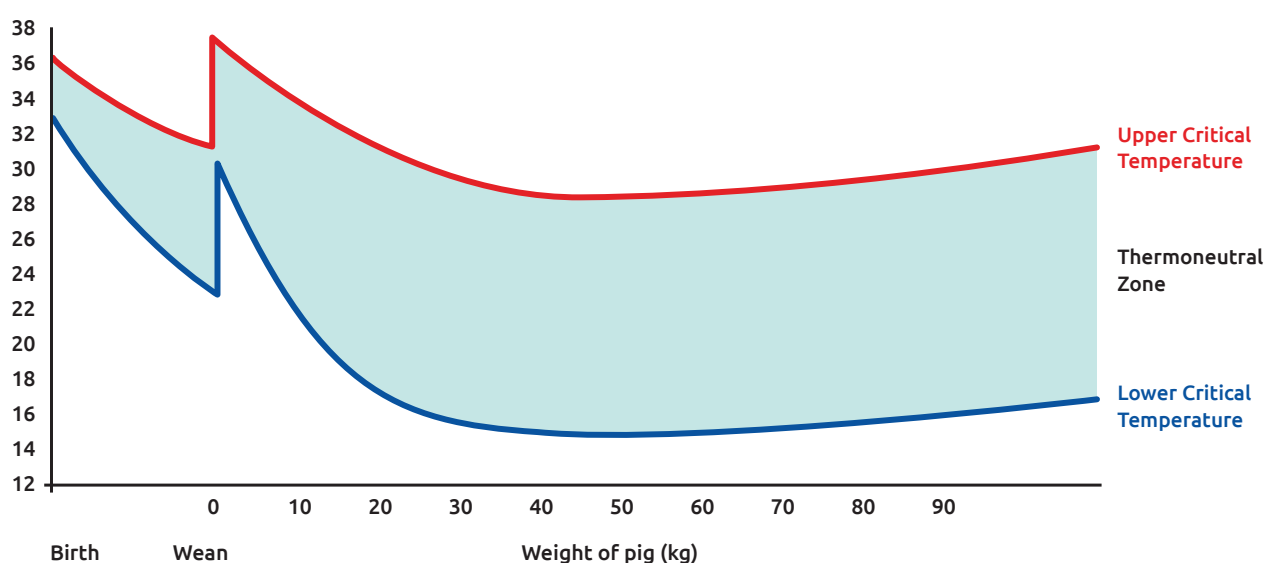
For every pig, there is a temperature below which it has to use food energy to keep warm, this is referred to as the Lower Critical Temperature (LCT). The actual temperature varies according to the size of the pig, how much it is eating and how much comfort it can get from its environment.

A straw-bedded pig in still air will have a higher LCT than the same pig on a slatted floor with a draught blowing over it. At the other end of the scale,

each pig has a temperature point above which it uses food energy to get rid of heat (usually by panting), this is referred to as the Upper Critical Temperature (UCT).

At temperatures above the UCT, food intake is reduced until eventually the pig becomes severely distressed and stops eating altogether; this is referred to as heat stress. The range between the LCT and the UCT is known as the thermoneutral zone and when pigs are within this they are able to make optimal use of the feed provided.

Figure 1: An example of a thermoneutral zone



Source: Ministry of Agriculture, Fisheries and Food (1983). Pig Environment. Great Britain: MAFF. (Volume 2410)

It is important to house pigs within their thermoneutral zone, however, there are times when we might wish to keep the temperature closer to either the UCT or LCT.

These factors demonstrate the need to be able to identify thermoneutral zones in specific circumstances in order to select air temperatures that will allow for maximum comfort and performance at minimal cost.

Reasons to keep the temperature closer to the Lower Critical Temperature:

- Feed intake decreases as temperature increases
- Lying space requirements increase as temperature rises
- Pigs housed on solid floors tend to foul their bed as the temperature approaches UCT
- If supplementary heating is used, the costs will rise as the temperature is increased
- If outside temperatures are low, higher internal temperatures are achieved by restricting ventilation; this will lead to increased levels of airborne pathogens, dust and odour

Reasons to keep temperature closer to the Upper Critical Temperature:

- High outside temperatures make low internal temperatures difficult to achieve
- If maximum feed intake is not essential there is no reason to keep temperatures close to the LCT during hot ambient conditions
- Energy costs will increase when trying to lower internal temperatures during periods of hot ambient conditions with fan-powered ventilation

One of the most important factors in determining critical temperatures is feed intake. At any given liveweight, the higher the level of feeding, the higher the level of heat produced and the lower the thermoneutral zone.

Table 2: The influence of feed level on critical temperatures

Weight of pig (kg)	Feed level	Feed/day (kg)	LCT (°C)	UCT (°C)
5	Low	0.13	30	34
	High	0.8	25	32
80	Low	2.3	15	29
	High	3.2	11	26
140 (sow)	Low	1.8	22	32
	High	6.0	8	25

Source: Ministry of Agriculture, Fisheries and Food (1983). Pig Environment. Great Britain: MAFF. (Volume 2410)

The practical implication of the feed level effect is that when feed intake is restricted by illness, appetite or feeding system breakdown, the air temperature requirement will increase, therefore:

- Piglets usually have a much higher LCT after weaning, while feed intake is low
- Finishing pigs on a restricted feed scale have a higher LCT than those fed ad-lib
- The LCT of sows is much higher during pregnancy than during lactation.

Key points:

Many factors contribute to the UCT and LCT and must be taken into account when setting ventilation rates, for example:

Draughty Pen

LCT increases by **3°C**

Straw Bedding

LCT decreases by **5°C**

Low Stock Density

LCT increases by **3.5°C**

Kennelling

LCT decreases by **3°C**

Restrict Feeding

LCT increases by **3.5°C**

Source: Controlled environments for livestock, FEC

When setting/checking the set temperatures in buildings, take the UCT and LCT set out in the Defra Code of Recommendations for the Welfare of Livestock (Pigs) into account, as well as the factors listed above.

#1.4

Cooling effect of air speed



Where high air speeds occur in the form of draughts, at very low temperatures their influence will be much greater. Research into the effects of air speed on pig performance has been reported by Mount et al (1980) and Close et al (1981).

The clear practical implications of these effects are that, when operating temperatures are selected they must take account of air speed at pig level. The cooling influence of high air speeds can be used to assist heat loss where high air temperatures cannot be avoided (MAFF, 1983, p.11-12).

#1.5

Sprays & sprinklers



Evaporative cooling can be used to reduce the effects of high temperatures on pigs. When pigs become too hot outside, their natural behaviour is to create a wallow; latent heat is then lost through evaporation. This also happens in solid-floored systems where pigs use the dung and urine in their pens to wallow and cool off, however, it is not desirable from the point of health, hygiene and odour, and the ventilation system should be designed to remove the need for pigs to exhibit this type of behaviour.

On slatted floors it is not possible for pigs to create a wallow, however, it is possible to provide evaporative cooling, allowing the pigs to lose latent heat and control their body temperature.

Spray systems which come on in hot weather and spray atomised mist over where the pigs usually dung will wet the pigs' skin and allow them to lose heat.

An alternative to this is spraying a fine mist of water across incoming air in powered ventilation systems. This system cools the room as the water evaporates.

Key point:

It is important that the sprays are only directed into part of the pen so that pigs can move from under them once sufficiently cool.

Section #2

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Insulation



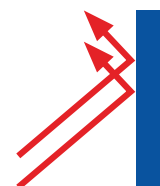
Chapters

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#2.1 Insulation

#2.1

Insulation



Insulation reduces the amount of heat lost through the structure of a building in cooler weather and reduces the amount of heat coming into a building in warm weather.

It is important, particularly during periods of cold weather, to retain the heat produced by the pigs within the building in order to warm the cooler air coming in from outside. If a lot of heat is lost through the walls of the building, additional supplementary heat will be required, which will increase costs.

By modern standards, older buildings were poorly insulated when they were built, usually with only 50mm of glass fibre between the two skins/walls.

Over time, this glass fibre slumps in the walls and rodents destroy it, which reduces the effectiveness of the insulation.

The benefits of good insulation are largely lost unless the ventilation rate is accurately controlled. Similarly, good ventilation control is only fully exploited with good insulation.

Key point:

The most common way for producers to address this problem is to reduce the size of ventilation openings, slow down fan speeds and block up vents. This will raise the temperature but at the expense of air quality and pig health and performance.



Insulation damaged by rodents

Measurements of insulation value

The heat loss through the structure of a building or its resistance to heat flow, is measured by its 'U' value.

This is the total energy difference, measured in watts per square metre per degree centigrade, between the inside and outside temperatures which passes through the wall, window, roof or openings. For example, if a wall has a U value of 1.0 it means that a surface measuring 1m² will let 1 watt pass through

it for every 1°C difference between the air on either side. It is normal to think of heat loss from inside to outside, however, in hot weather this may be reversed.

Almost every building wall is made up of layers of materials, each of these materials will conduct energy through it. The rate of this conductivity is known and can be looked up in readily available tables. This thermal conductivity value is known as the 'K' value. Metals are generally more conductive than insulants like polystyrene.

The thickness of the material influences the rate or time taken, for heat energy to pass through the material. The thickness of these layers is then taken into account

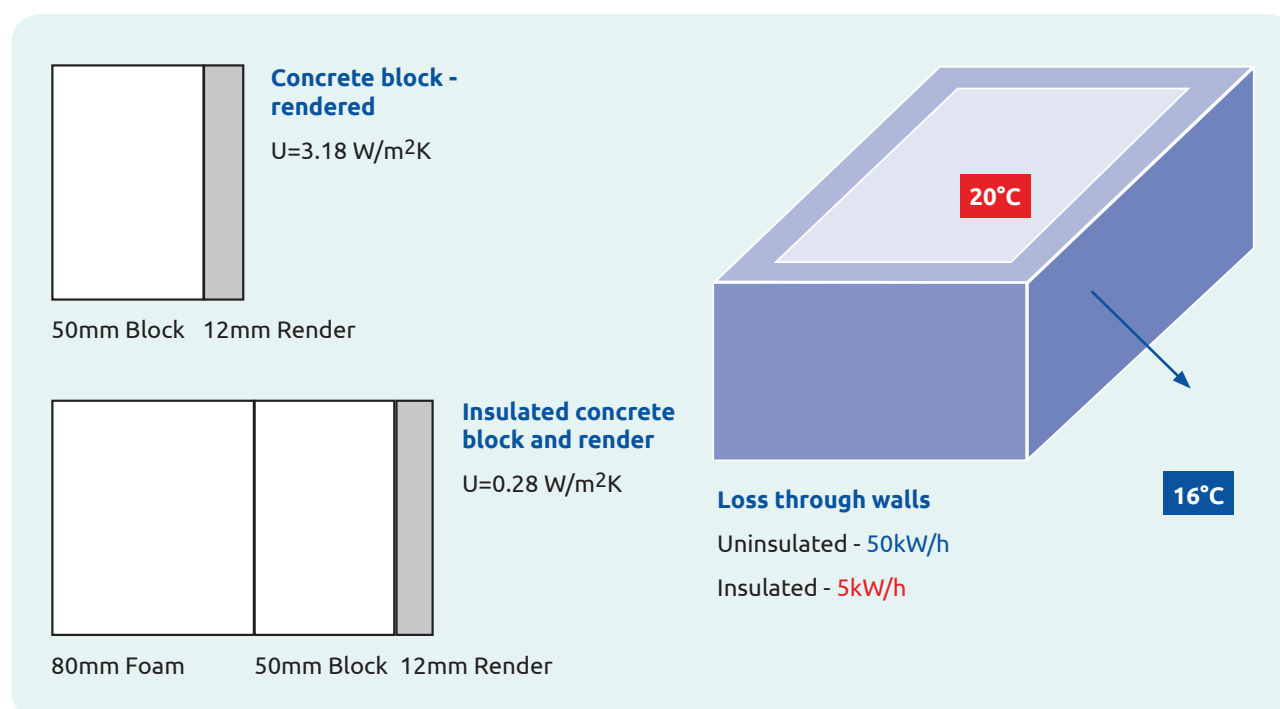
and used to produce an 'R' value. The sum of the R values is used to create the U value. The lower the U value, the less heat passes through the surface.

Table 3: R values for materials commonly used in pig buildings

Material	R Value
100mm concrete blocks	0.25
150mm concrete blocks	0.30
100mm insulation blocks	0.7
150mm insulation blocks	1
80mm polystyrene panel	2.78
80mm polyurethane panel	3.45

Source: Various building suppliers

Insulation example



If you wish to maintain a 4°C difference in temperature (internal to ambient) in a $50\text{m} \times 20\text{m} \times 4\text{m}$ high shed, without insulation you would need 50kW of heat input. With insulation only 5kW of heat input would be required.

Based on electricity costing 9p per unit, the addition of insulation would, therefore, equate to a saving of £4 per hour in fuel costs. This would vary depending on the type of fuel used.

Calculation example

Where a combination of materials is used, for example, an insulated wall, all the individual R values have to be summed together as shown below. The lower the U value, the better the thermal performance.

Taking the R values from Table 3 and other manufacturers for the following materials:

Material	R Value
150mm concrete blocks	0.30
12mm cement render	0.024
80mm polyurethane	3.45

Note: These figures are indicative only, check with individual manufacturers

Combination of materials

U value where $U = 1R$

Concrete block and render	Insulated block and render
$1/(0.3+0.024) = 3.1$	$1/(0.3+0.024+3.45)=0.26$



Building materials commonly used in pig buildings

Table 4: U values for typical walls used in pig buildings

Wall Construction	U value
Double skin building with 50mm glass fibre insulation	0.65
Double skin building with no insulation	2.33
100mm concrete blocks alone	4.00
150mm concrete blocks alone	3.30
100mm insulation blocks alone	1.44
150mm insulation blocks alone	1.00
80mm polystyrene panel	0.36
80mm polyurethane panel	0.29

An example of the calculation of heat loss from a building is shown in Appendix 2.

Condensation

Air has the potential to carry varying amounts of water vapour depending on its temperature. Warm air can hold more water vapour than cold air; this is the principle when using a heater to dry a room or clothing.

When warm air comes into contact with a colder surface it cools down and is no longer able to hold the same amount of water vapour. The excess water vapour is then released as water droplets on the cold surface, this process is called condensation. The point at which water vapour condenses is called the 'dew point'.

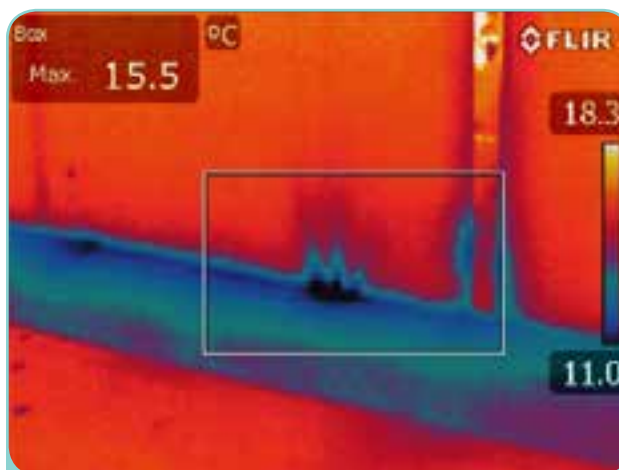
One function of insulation in a building is to prevent condensation, particularly on the inner surfaces of walls, windows, roofs and metal roof supports.

The insulation reduces the rate of heat loss, keeping the temperature of those surfaces above the dew point. During periods of cold weather, condensation will start to form in buildings which have inadequate insulation. If condensation starts to form around timber purlins it can cause them to rot which will eventually affect the structural integrity of the building.

In an insulated building, condensation can still form in areas known as 'thermal bridges'. A thermal bridge is formed when there is a part of the building structure which passes through the insulation material. One of the most common thermal bridges found is in portal frame buildings, where the RSJ steel uprights are exposed to the outside and are not covered with insulation on the inside.



Photograph of a concrete fillet which is acting as a thermal bridge



Thermal image of the concrete fillet showing how cold it is compared to the wall (blue vs red)

Key point:

A good way to prevent thermal bridges is to make sure the building insulation covers any part of the structure which could be exposed to both inside and outside temperatures.

Thermal bridges can affect the heat loss by as much as 25% in well-insulated buildings, as well as causing damage to walls from condensation.

Fixings, such as metal bolts, should not pass directly through a wall. Wall ties used in construction are usually made of low conductivity materials, such as plastic or incorporate a 'thermal break' comprising a section of low conductivity material.

Section #3

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Ventilation rate



Chapters

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#3.1 Setting the ventilation rate

#3.1

Setting the ventilation rate



Maximum ventilation rate

The maximum ventilation rate is used to remove heat from buildings during hot periods and to maximise the cooling effect of the system.

Maximum ventilation rates are determined by calculating the heat output from the pigs and balancing that with the amount of air which has to pass through the building to remove surplus heat, once losses have been taken into account.

When the temperature of the incoming air is higher than the optimal temperature inside the building, the amount of air required to remove all the heat would be too high for fans to economically move.

Key point:

As a general rule, every 1kg liveweight requires a ventilation rate of 1.0m³/hr (weaner-grower) - 1.6m³/hr (finishers). This will result in a temperature lift of about 4°C during periods of maximum summer temperatures experienced in the UK.

It is, therefore, normal to allow the temperature inside the building to rise by 3-4°C above the outside temperature, this is called the 'temperature lift'. It may be acceptable for buildings with younger pigs in them to have a higher temperature lift than one with older pigs in.

Such figures can be a useful guide but appropriate calculations of ventilation rate should be done in order to optimise building and pig performance.

A formula to calculate maximum ventilation rate is shown in Appendix 3.

When deciding on the figures to use in the calculation, it is important to take into account whether the pigs are housed on an all-in all-out (AI-AO) basis or if the building has a continuous flow of pigs through it.

Key point:

It is important to do this calculation, as a decision to limit the temperature rise to 3°C rather than 4°C requires up to 30% extra ventilation capacity.

AI-AO buildings

AI-AO buildings require a higher maximum ventilation rate than those with a continuous flow of pigs. This is because the average weight in a building, when it is used continuously, will be an average of the start and end weight, whereas in an AI-AO building, the final liveweight for all the pigs must be used for the calculation. An example illustrating this is shown in Appendix 6.

The affect of overstocking on ventilation rates

An example of the impact overstocking will have on ventilation rates

If a building is overstocked by 50 pigs of 110kg liveweight, the additional ventilation rate required will be 5,663m³/h. While running below the maximum ventilation rate, the system will manage to ventilate satisfactorily. However, once the maximum ventilation rate is needed, it will not be possible to keep the building temperature at the required level; this could lead to pigs overheating and becoming heat stressed.

Minimum ventilation rate

The minimum ventilation rate is used during cold periods to maintain air quality and humidity within the building while minimising heat loss through the ventilation system.

The outside air temperature should not be used to control minimum ventilation rates without taking other factors into consideration. If temperature was the only factor used to set the minimum ventilation rate and if temperatures fell below freezing, vents would fully close and fresh air would not be brought into the building. This would lead to a build-up of noxious gases, humidity and condensation. Despite low temperatures outside, it is vital to maintain the minimum ventilation rate to keep fresh air circulating through buildings.

If the heat produced by the pigs is insufficient to maintain the temperature within the building, supplementary heat must be used; in the UK this is usually provided by electric or water-based radiant heaters. Some of this heat will be lost through the exhaust air and, therefore, minimum ventilation rates should be set in accordance with the manufacturer's guidelines. This setting is, typically, between 3% and 15% of the maximum ventilation rate.

Pigs exhale CO₂ and, as there is no other source of it in the pig building, it is, therefore, possible to control the ventilation rate on this basis. This method of controlling ventilation is based on air quality and it may offer energy savings compared to systems which are responsive to temperature only.

Key point:
One method of controlling the ventilation rate is by measuring the level of carbon dioxide (CO₂) in the room or building and adjusting the ventilation to keep levels within set limits.

It is possible to predict the theoretical ventilation rate needed to maintain the desired CO₂ level, taking into account liveweight and feeding level; the formula to calculate the minimum ventilation rate based on CO₂ levels can be found at Appendix 7.

When selecting a minimum ventilation rate, it is important to establish what the percentage figure given means in that system. It is usually a percentage of the maximum ventilation rate.

If, at some point in time, the fan, or its motor, have been changed to one of a different type or specification, there may be a difference in performance and perhaps performance characteristics. If the fan supplier's information is not available, airflow measurements need to be taken and the controllers must be reset for the fans installed.

The judgment of the stockperson, who can carefully monitor the temperature experienced by the pigs, must take priority over any preset percentage in the controller when setting the minimum ventilation rate and the original supplier should always be consulted for the installation specification.

Another problem that may be encountered is where the use of a building has changed but the ventilation hasn't, for example, a building housing pigs of a different age or weight range to what it was originally built for. Other problems include buildings being modified or expanded. In all of these situations, new calculations and resetting, if not modification, of the ventilation system, will be needed.

Neutral zone

Controlled ventilation systems work with what is called a neutral zone. Typically, this is a range of 2°C, or 1°C either side of the set temperature, over which the inlets and fans operate as the set temperature. This prevents the inlets and fans from continually cycling and resetting themselves, so maintains a level of stability. It is often a result of what is known as hysteresis of the thermostat.

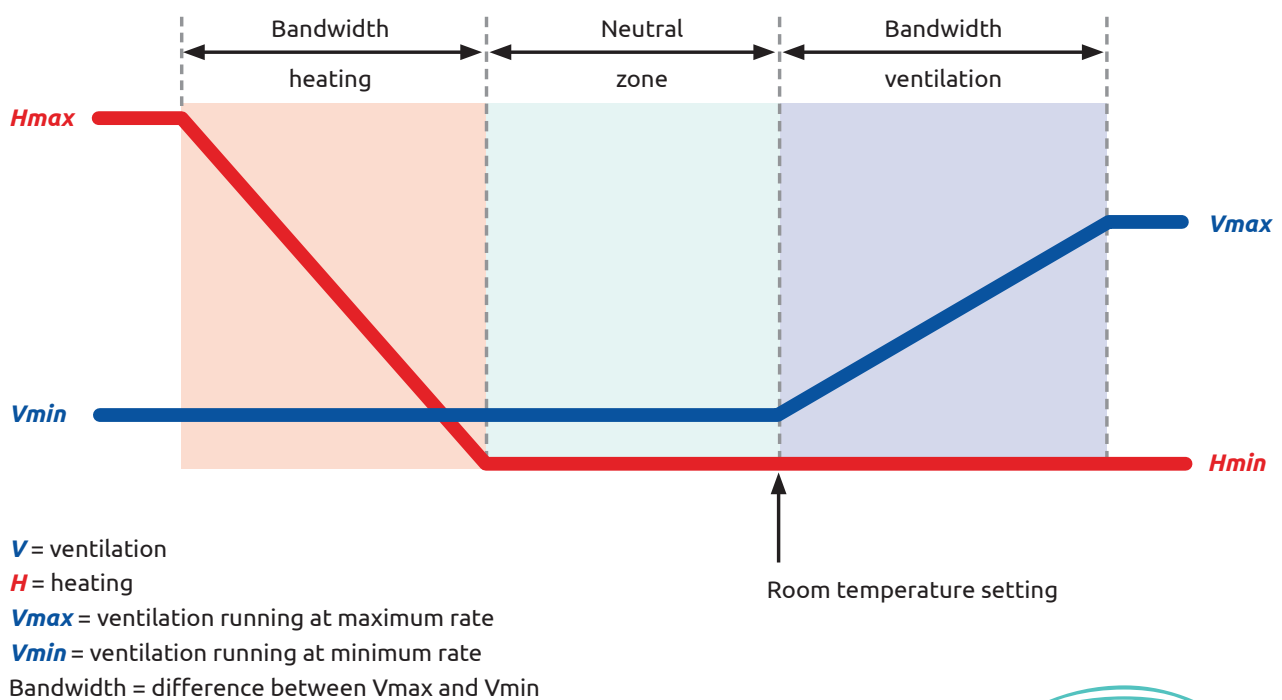
Bandwidth

The bandwidth is the temperature difference (in degrees) between the minimum and the maximum speed for variable speed fans.

It allows for gradual changes in the ventilation rate when the room temperature rises above the set temperature, rather than sudden changes which might stress the pigs.

In buildings that use artificial heat, there is often a heating bandwidth used for the range between the minimum and maximum heating. This allows the heating to come on gradually as the temperature falls below the set temperature.

Figure 2: Example graph showing bandwidth on ventilation and heating



Key point:

The bandwidth is often adjustable and can range from 2-6°C.

Temperature Curve

Computer controllers have settings which allow the set temperature to be automatically adjusted according to the age of the pig, these are referred to as temperature curves.

Temperature curves are useful as they ensure the set temperature in a room decreases as the pigs grow, without relying on human intervention. However, it is still important to check the settings regularly to ensure that no one has interfered with them. Be aware that pigs of a different average weight to normal and/or sick pigs, might need a different temperature to the one set in the curve.

When pigs enter a new building, particularly after weaning, it may take some time for them to get used to the new feeders and drinkers, leading to reduced feed intake. As a result, their temperature requirement will be higher than it was in the previous building and it may stay high for several days after the move. Every situation is different and the temperature curve must be adjusted appropriately.

Key point:

When setting up a temperature curve, try to keep the temperature constant for the first two to three days.

Table 5: Recommended temperature curve for weaner/growers

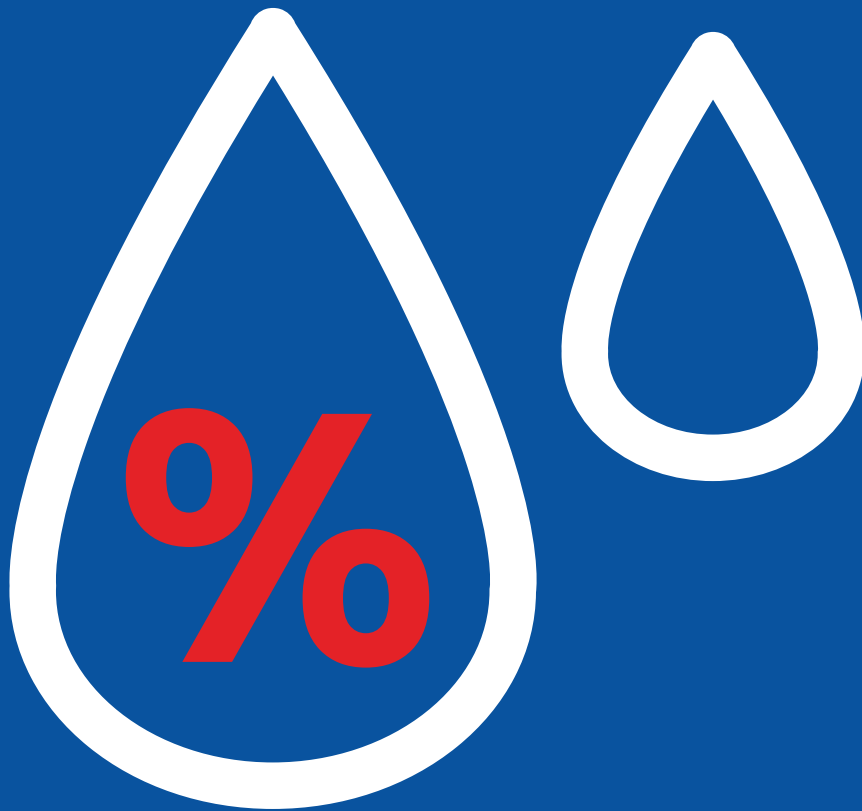
Day	Weight (kg)	Temperature (°C)
1	7	28
3	7	28
7	9	27
14	11.5	25
28	15	23
35	19	21
42	23	21
49	27	20
56	32	20
63	37	20

Source: John Chambers, personal communication, 2015

Section #4

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Humidity & maintenance



Chapters

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#4.1 Relative humidity

#4.2 Maintenance

#4.1

Relative humidity



Relative humidity (RH) is the ratio of the amount of water vapour in the air at a specific temperature to the maximum amount that the air could hold at that temperature; it is expressed as a percentage.

Pigs are able to tolerate a wide range of RH, provided the temperature is normal, but the RH is a useful indicator of the air quality in a building as it depends on the heat and moisture balance of the accommodation.

Key point:
A reading of 100% RH means that the air is totally saturated with water vapour and cannot hold any more at that temperature.

A very dry environment adversely affects the nasal mucosa of the pig and increases the risk of airborne infections. In wet environments, pathogens may be transferred through the water droplets. Therefore, it is important to try to keep the RH within a range of between 60-90%.

RH is often a problem in nursery buildings when the pigs are first introduced in cold weather and when the

room is still too cold. In this situation, the ventilation system will limit the amount of fresh air entering the room in order to reach the set temperature. This can result in a build-up of RH in the room which will promote respiratory problems and reduce the growth rate of the pigs. It is important that a minimum airflow is maintained to prevent this from happening, even if it requires using some temporary space heaters to raise the room temperature before the pigs enter.

Some computer controllers work on both temperature and humidity. In rooms or buildings being controlled by these systems, there are both temperature and humidity sensors. Humidity sensors can easily be damaged, especially during washing and cleaning. Their function should be checked regularly, for example, by using a portable relative humidity measuring device or a wet and dry bulb thermometer.

Raising the air temperature will cause its relative humidity to fall. When controlling a room using relative humidity it is important to have heaters in place so the air can be warmed up if necessary to keep within the desired relative humidity range.

#4.2

Maintenance



Flaps, cables, wires, strings and inlets

Controlled ventilation systems use mechanical systems to control the opening and closing of air inlets.

It is important that these systems operate at a precise level; if the openings are too small, energy will be wasted trying to draw air into the building.

If the openings are too wide, the pigs may be exposed to draughts and/or the air will not move around the house as intended; this may mean that the pigs' behaviour changes, with designated lying and dunging areas becoming less defined and incorrectly used.

The mechanisms involved in ventilation systems, for example, actuators, flaps, cables, wires and strings, are all vulnerable to damage, wear and tear. Routine maintenance should check the function of motors, winches and actuators as well as the tension of ropes and the condition of pulleys and flaps. The openings, apart from the 'lead' flap should all be equal if this is how the manufacturer designed the system.

A routine programme of checks and maintenance should be put in place with records kept of faults and common problems so they can be reviewed and solutions sought with the aim of improving the system.



Wall inlet

It is important to ensure that inlets are set up correctly at minimum ventilation, as cables often stretch with time, leading to inlets closing up altogether, causing poor airflow and air distribution through the room. If the inlets have a deflector fitted on top



Ceiling inlets

(similar to the one in the wall inlet photo) to deflect the air upwards onto the ceiling, regularly check that they have not become dislodged, particularly after pressure washing. If they are dislodged and not reset, it will result in poor air distribution around the room.

Fans

Any air control systems within fan chimneys need to be checked regularly as they can seize up and motors can fail. This can result in over-ventilation of the building if the control system has failed in the open position or under ventilation if in the closed position.



Roof mounted exhaust ventilation fans showing control flap within the chimney. Also shown is the rain trap dish below the fan chimney.

Fans need to be clean to work correctly; a build-up of dust and debris on the fan blades and in the chimneys can decrease their efficiency by 20% or more. Most modern fans and fan shafts can be cleaned with gentle power washing but it is important to check with the equipment supplier to confirm whether it is safe to do so and how much pressure can be used.

When new fans are running on three phase electricity or if electrical work on the supply circuit has been carried out, the fan rotation must be checked. It is not unknown for fans to be running in reverse, leading to environment problems within the area they are supposed to be ventilating.



Very poorly maintained fan

Winches and electrical actuators

Winches and electrical actuators open and close the automatic inlets in fan ventilation systems and adjust the flaps in automatically controlled natural ventilation (ACNV) systems; many UK systems rely on electric, low voltage, actuators.

Both winch motors and actuators can fail from time to time but it is not always easy to notice, their operation should, therefore, be checked regularly by overriding the automatic control and forcing them to work manually.



Winch motor



Actuator

Temperature sensors

Temperature sensors are very reliable but they can occasionally go wrong.

The most common results of failure are that they no longer read the correct temperature in the room or are not sending any signal back to the controller. This can be checked by placing a maximum/minimum thermometer beside the sensor and checking the reading against the temperature shown on the controller. Errors of 1-2°C are not a problem, provided the stockperson is aware of this and they judge the reaction of the pigs to the room temperature.

Placing the sensors in the right place can be difficult. Ideally, they should be recording the temperature where the pigs are lying and to do this they would have to be at pig height in the lying area. In this position, however, unless they are very carefully protected, the sensors will be damaged by the pigs. Therefore, they should be placed as close to the pig as possible above the lying area but high enough to prevent the pigs reaching them.



Temperature sensor incorrectly located by a vent

Key point:

Temperature sensors should not be placed in areas where they will be affected by any incoming air from the vents, as in the case of the picture above, or by a heater. A common problem in poorly performing buildings is that temperature sensors are placed far too high.

Computer controllers

Most modern systems use computer technology to control them. Consequently, some have a lot of functions which allow a trained operator to achieve a very good degree of control of the pigs' environment, regardless of the external atmospheric conditions.

These control parameters may include:

- Adjustable minimum and maximum ventilation rates (fan and inlet control)
- Temperature curves – lowering the set temperature as the pigs grow
- Adjustable bandwidths on the ventilation and heat settings – the range between which the system should operate.

Key point:

The system and any back up equipment needs checking regularly under the welfare regulations.



Ventilation control computer and other electrical panels



Ventilation control computer

These systems need to be set up correctly when they are installed. When purchasing or introducing new operators, training from the supplier or a competent person should be provided; it is important to allocate sufficient time for this. Training needs to cover how the system works, its design parameters (animal capacity) and the adjustments which are possible and the consequences of any changes that are made. It is a good idea to check the computer settings regularly in case a staff member has inadvertently changed them.

All ventilation systems require routine maintenance and it is recommended that a regular on-farm inspection by the system's supplier or other competent electrical engineer, is carried out to ensure that it is all working correctly. This is particularly important with systems that have battery back-up as the batteries will need to be replaced from time to time.

Section #5

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Alarms & back-up ventilation



Chapters

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#5.1 Alarms & back-up ventilation

#5.1

Alarms & back-up ventilation



The Defra Code of Recommendations for the welfare of livestock (Pigs) (2003) states:

"Where the health and well-being of the animals is dependent on an artificial ventilation system –

(a) provision shall be made for an appropriate back-up system to guarantee sufficient air renewal to preserve the health and well-being of the animals in the event of failure of the system; and

(b) an alarm system (which will operate even if the principal electricity supply to it has failed) shall be provided to give warning of any failure of the system."

The back-up system shall be thoroughly inspected and the alarm system shall each be tested at least once every seven days in order to check that there is no defect in the system and, if any defect is found (whether when the system is inspected or tested in accordance with this paragraph or at any other time) it shall be rectified immediately."

Under these regulations, all artificial ventilation systems require an alarm to let you know if they are not working, even if there is a power cut, and there must be a fail-safe or backup system to prevent the pigs from suffering if the ventilation fails.

Most modern installations have built-in alarms and fail-safe systems, which usually contain a battery backup that starts once the power has been cut. This battery backup provides power to open the inlets and fan chimney baffles.



Ventilation control system

Where no standby generator is available, drop-out panels controlled by electromagnets can be satisfactory, provided someone can arrive on site in an emergency in time to ensure the pigs do not suffer.

The problem with dropout panels is that they have to be individually reset once the emergency is over; this can be time-consuming, particularly if there are a lot of them. Fitting magnets onto the doors of the rooms, so they are pulled open by a weight on a cord whenever the magnet loses its current, provides a good fail-safe system; these magnets will be tested every time the building is entered.



An emergency ventilation drop-out panel controlled by an electromagnet

Warning

If flaps open when the outside air temperature is low it can result in pigs becoming cold very quickly. Staff should be aware of these dangers and be instructed on how to manage such situations.

Modern alarm systems can be linked to communication that alerts the farm management of faults and activations. These alerts can help staff check the buildings quickly and avoid problems such as piglets becoming chilled.

Section #6

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Ventilation systems



Chapters

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#6.1 Ventilation systems

#6.1

Ventilation systems



There are two main types of ventilation system used in the UK: natural ventilation and fan ventilation.

Natural ventilation

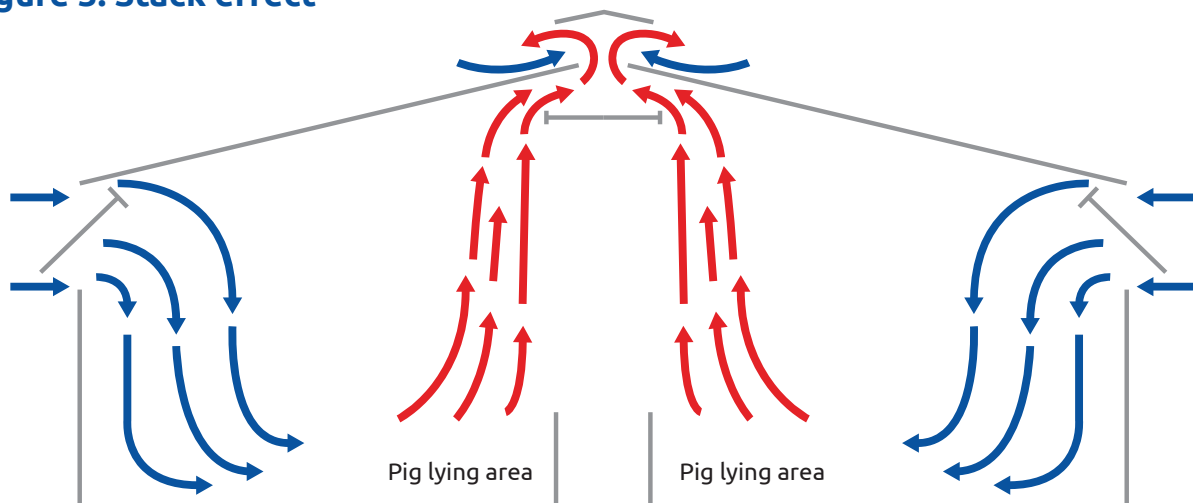
Natural ventilation is the process of supplying air to and removing air from an indoor space without using mechanical systems. Naturally ventilated buildings tend to have large openings, if these were left open all the time the buildings would become very cold once the outside air temperature dropped. The size of the openings is often adjusted with flaps, vents or curtains to control the temperature inside the building. This type of ventilation is referred to

as automatically controlled natural ventilation (ACNV). Positioning of the inlets (openings) is critical to achieve the most efficient air exchange.

Stack effect

The stack effect uses the principle that warm air inside a building is less dense than the cooler air outside. If there is an opening available, the warm air will leave the building, eg through the roof ridge or a high point in the gable end wall. As the warm air leaves, it creates negative pressure inside the building, this causes cooler air to be drawn in through openings in the side walls.

Figure 3: Stack effect



If a building has to rely entirely on stack effect ventilation, for example, if it is very close to other buildings or is in a sheltered valley, it is important to calculate the correct size of the ridge opening. This is calculated using a number of factors:

- The amount of sensible heat coming off the pigs
- Temperature curves
- The required ventilation rate
- The difference in height between the top of the outlet opening and the bottom of the inlet.

The formula for calculating the size of the ridge outlet for a building using stack effect ventilation can be found in Appendix 5. The size of the inlets along the sides of the building can then be calculated, being twice the size of the ridge outlet.

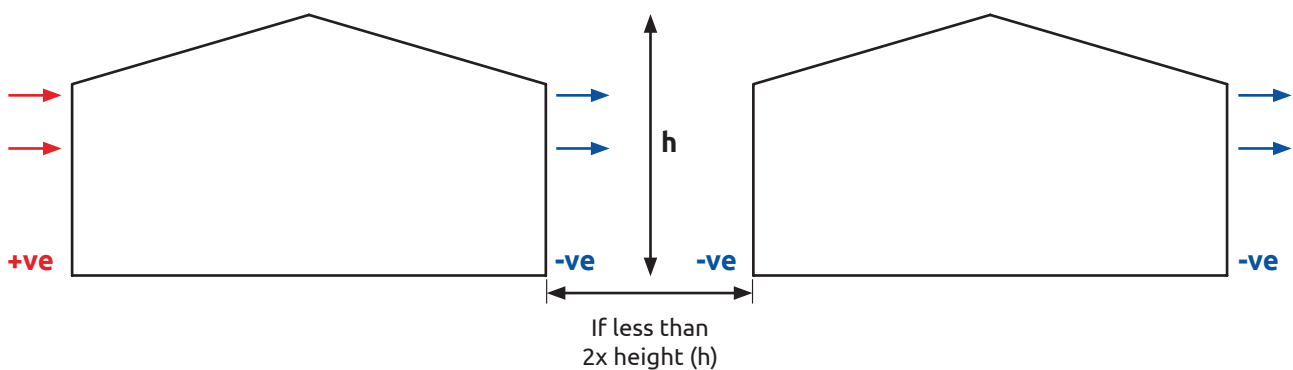
Wind effect

As wind flows around a building it affects the air pressure. In general, the pressure is positive on the windward side, resulting in an inflow of air, and negative on the leeward side, resulting in an outflow of air.

Wind flow can, therefore, be used to change the air inside a building using side-to-side ventilation.

When considering erecting a new building which is going to use natural ventilation, it is important to bear in mind its positioning in relation to wind exposure and shelter. Ideally, the building should be situated so the ridge is perpendicular (at a 90° angle) to the prevailing summer winds. Thought must also be given to the impact that a new building may have on any existing ones nearby.

Figure 4: Effect of one building on the adjoining one



Historically, it has been recommended that, when pig buildings are situated side by side, adjoining buildings should be positioned at least six metres apart so that natural ventilation will work successfully throughout the year.

Research carried out by Abel-Rehiem and Douglas (1976) shows that, unless adjoining sheds were sited at least double the ridge height apart, all surfaces on the leeward side (the side sheltered from the wind) would be under negative pressure.

Some modern buildings are much wider, with higher eaves and ridges, than was previously commonplace, in these situations advice from suppliers of ventilation equipment should be sought to confirm the minimum desirable separation distance.

A formula developed by the Scottish Farm Buildings can be used to calculate the size of the openings needed in each side of a building to cope with different wind speeds. In the past, most buildings were designed to operate with an outside wind speed of at least 1 metre per second (m/s).

The formula for this calculation is shown in Appendix 4. Some modern ventilation control systems will monitor wind speed and direction, and control the inlets on each side of the building in response to these measurements.

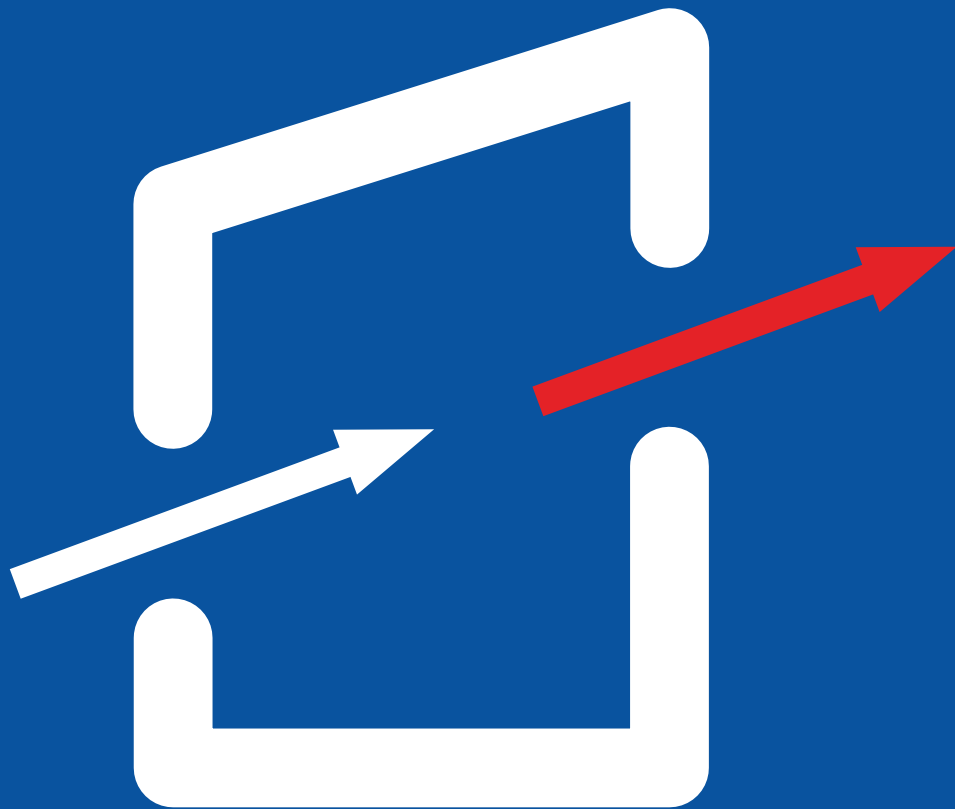


Buildings should be situated a minimum of 6m apart

Section #7

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Natural ventilation



Chapters

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#7.1 Naturally ventilated buildings

#7.1

Naturally ventilated buildings



Traditional monopitch buildings

The ventilation in monopitch buildings is simple; the front flap is adjusted to allow more or less air out as required.

These buildings usually have a small rear flap which can be opened, if necessary, particularly during periods of high temperatures.

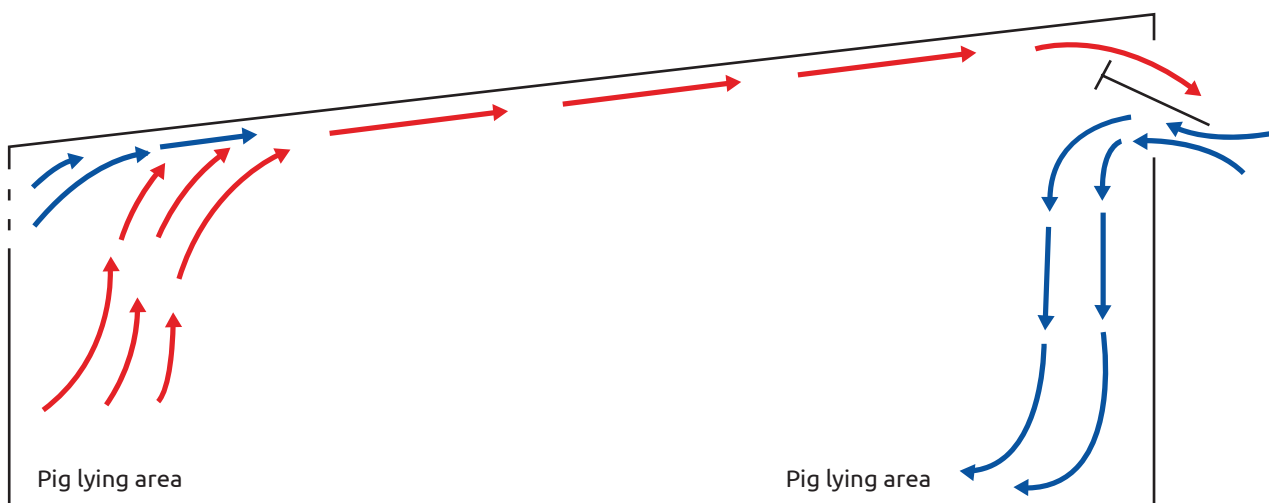
Most of the fresh air enters the pen over the front gate and falls immediately to the floor, this makes it the coolest part of the pen and, in normal conditions, where the pigs should dung.

Consequently, the pigs will lie at the back of the pen and the warm air that rises off them flows up to the ceiling and leaves through the front of the pen as quickly or as slowly as the position of the front flap allows. There is usually some sort of control on these flaps to allow for adjustment, according to the pen temperature.



Monopitch building - In older buildings, both the front and rear vents are usually opened at the same time by a rope and pulley system from a single electric actuator.

Figure 5: Diagram of airflow in monopitch house



Modern monopitch buildings

These fully slatted, modern buildings are similar to the traditional monopitch buildings but have a higher roof and larger, automatically controlled vents at the top of both the back and front walls.

They usually have a passageway through the length of the building but some are built with a passageway outside, giving direct access into each pen through the front wall.



Modern monopitch building with an exterior access passage



View of the inside of a modern monopitch building showing the front and rear vents and the rope and pulley system linking them

The ventilation system works by the warm air from the pigs rising up to the ceiling and flowing out through the front vent. Fresh air should then enter both through the bottom of the front vent and through the rear vent. In practice, the wind has a marked influence on the airflow within the building and, with both the front and back vents open, the wind direction alters this airflow pattern.

As a result, both the back and the front of the pen are likely to have areas of cool, fresh air falling into them, depending on the wind direction.

Key point:

The variability of the 'wind effect' means there can be a constantly changing warm area in the building which can lead to pigs becoming stressed, often leading to tail biting.

ACNV side-to-side buildings

Many buildings in the UK rely on side-to-side ventilation, where the main openings are positioned down each side of the building.

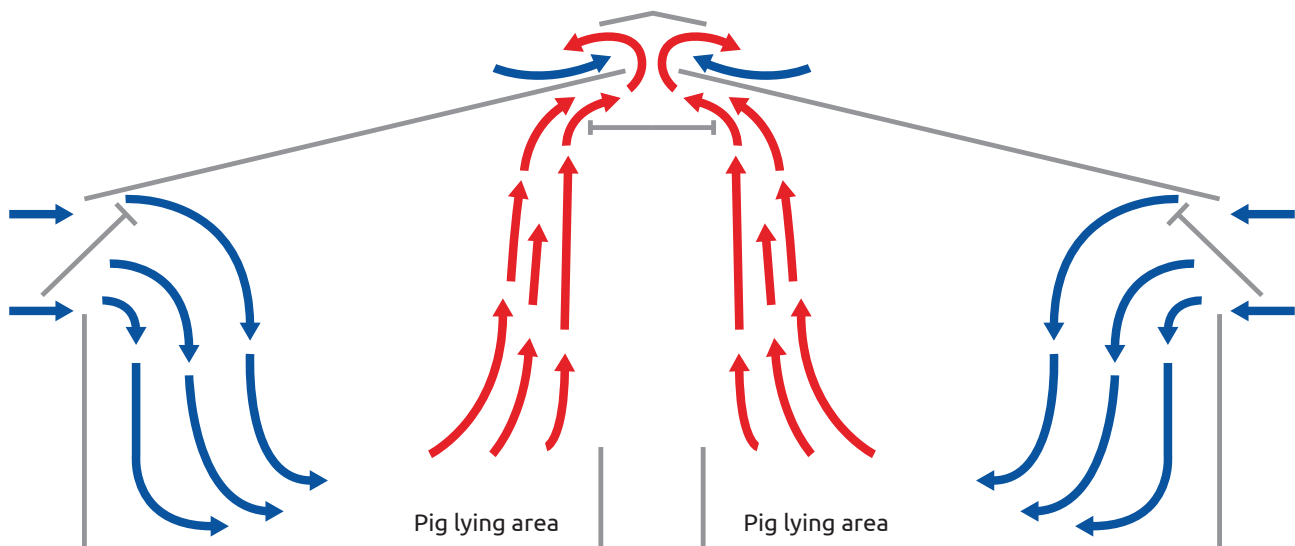
This is similar to how we ventilate our homes in hot weather by opening windows on opposite sides of a room.

This reliance on wind speed makes the system less than ideal for buildings in sheltered spots, where other buildings are close by and on hot, still summer days.



ACNV side-to-side building showing the wall vents

Figure 6: Drawing of ACNV side inlet and roof outlet showing where air falls



ACNV combined side-to-side and stack effect buildings

The best naturally ventilated buildings combine side-to-side and stack effect ventilation.

When the wind is blowing, side-to-side ventilation will be operating, in addition there will be stack effect ventilation through the ridge of the building using the natural rising of hot air produced by the pigs. Stack effect ventilation is particularly important when there is no wind blowing.

Most of the original side-to-side buildings currently in use have had ridge openings added to try to provide some stack effect ventilation.



A modern, side-to-side, ACNV building with ridge outlets

The formula for calculating the size of the ridge outlet for a building using stack effect ventilation alone can be found in Appendix 5. The side inlets (Yorkshire Boarding), or curtains and the ridge outlet, should not run right up to the end of the building. A third of the first bay at each end of the building and the same amount of ridge should be closed. This is to prevent the effect of airflow around the building disrupting airflow within. When calculating openings, the building length should, therefore, be reduced by this amount.

Key point:

On hot, still days or if the building is very sheltered or situated in a valley, even the improved number of hand-operated ridge outlets may not be adequate.



The inside of a building with both automatic ridge and side-to-side ventilation

It is important when using stack effect ventilation that the large ridge openings are automatically adjustable. This is so that the heat loss through the ridge can be controlled to maintain the temperature in the house and to create a build-up of warm air at the ridge before it opens.

The build-up of warm air means that when the ridge opens, it will only allow the warm air to escape, and prevents any cold air from entering and falling into the middle of the room, upsetting the pigs' behaviour.

Initially, these buildings work using side-to-side ventilation, with the ridge closed until the room gets too warm.

Key point:

The temperature setting for the ridge adjustment is usually programmed at 2-3°C higher than the set temperature for the side inlets, this ensures that the ridge opening stays closed until absolutely necessary.

Deep straw pens

A lot of pigs in the UK are kept in deep straw accommodation.

There is usually very little ventilation control used in this type of building, other than Yorkshire (space) boarding which can often be closed up during the winter and removed during the summer. Pigs adjust the temperature of their immediate surrounding by using the deep straw bedding as a blanket and huddling together under it when it is very cold. The build-up of straw-rich dung in the lying area usually ferments, producing heat and can act like a heat pad for the pigs to lie on. The system uses a lot of straw which can be a problem if straw is in short supply.



Deep straw pens in general purpose building



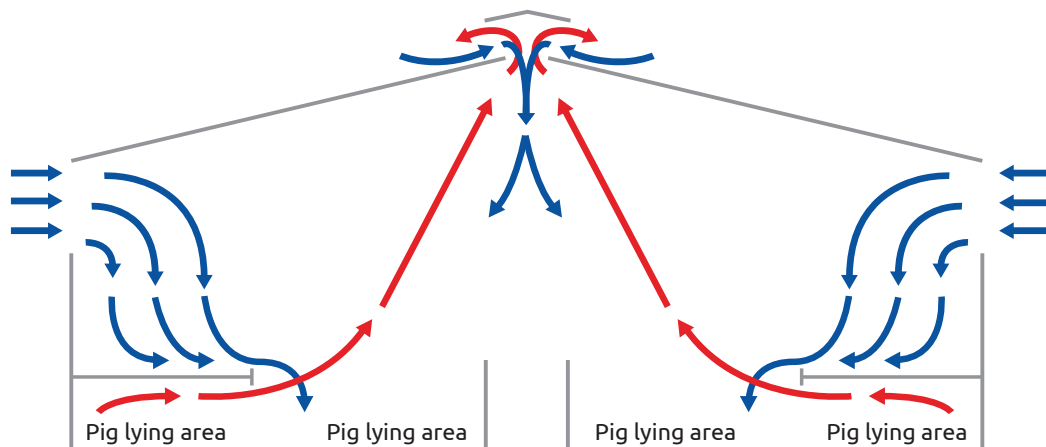
View of a kennel at the back of a straw-based pen

The best designed deep straw buildings employ some sort of kennel system. This provides the pigs with a warm kennel to lie under, leaving the rest of the building to eat and dung in. This allows the pigs to choose the temperature of their environment, the warm kennel or the cooler, uncovered area.

Ventilation in these buildings works simply by warm air escaping through openings in the roof or through the top of the space boarding in the walls or eaves, while cooler air enters through the space boarding or other inlets in the walls.

If kennels are placed against the outer walls, under the space boarding, it stops cold air from falling straight onto the pigs as it is deflected across the kennel lid. The warm air from the pigs lying in the kennel will rise to the top of the kennel and escape out of the front, deflecting the cold air that is falling off the top of the kennel away from the pigs.

Figure 7: Diagram showing kennel airflow



During summer, the kennel often becomes too hot for the pigs to lie in, even if the space boarding on the main building has been removed and any inlets fully opened. This causes the pigs to lie elsewhere in the pen, eg in the dunging area and to dung in the kennel.

The kennel should be constructed so it can be lifted out of the way, or uncovered, to stop the build-up of heat underneath it in warm weather. The simplest way to do this is to lift and lower the front edge of the kennel to allow the air underneath to escape more easily. This process can easily be automated by using motor to adjust the lids, controlled by a temperature sensor under one of the kennels.



Two views of an automatic kennel lid control system showing the motor and shaft winding up the cable attached to the lid (left) and the cable attached to the lid (right)

Straw-based pens with scraped passages

Combining a kennel system with a tractor-scraped dung passage provides pigs with a warm kennelled lying area while the regular removal of the dung means that less straw is required to soak up the wet dung.

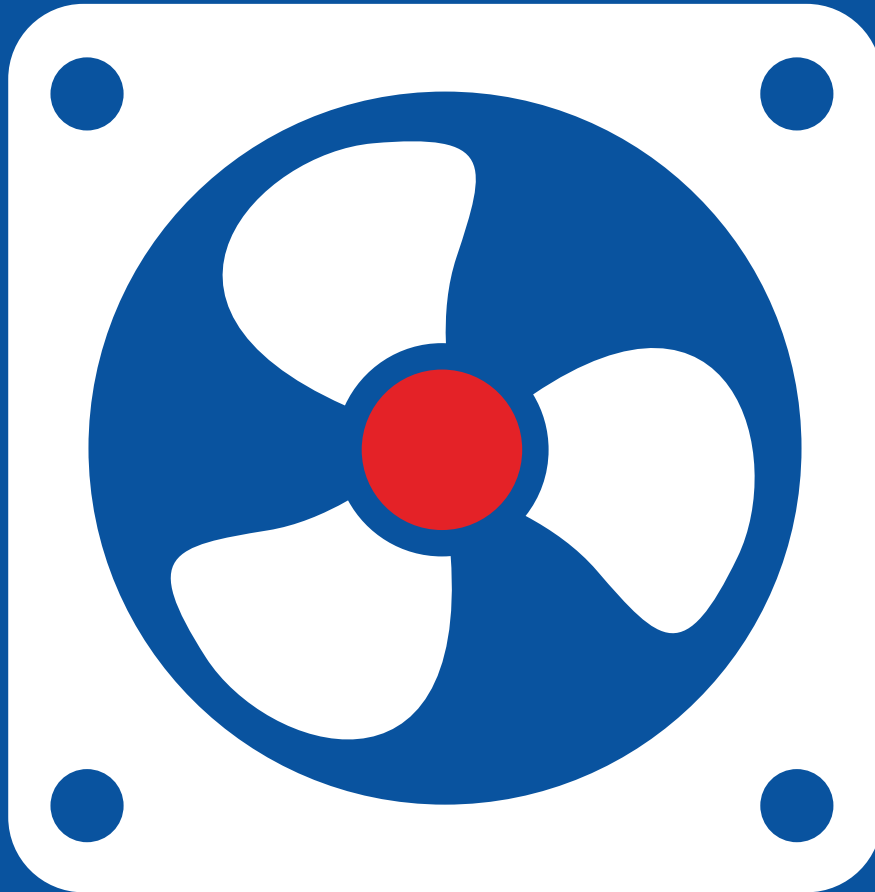


View of a kennel system with a tractor scraped dung passage

Section #8

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Fan ventilation



Chapters

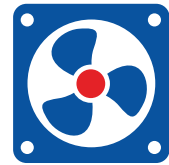
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#8.1 Fan ventilation

#8.2 Fan ventilation systems & buildings

#8.1

Fan ventilation



This type of ventilation uses fans to force air through the building.

As fans can move a greater volume of air than any natural system, the ventilation openings in these buildings are much smaller than in naturally ventilated systems.

Fan ventilation allows buildings that are close together to be ventilated properly; they are much less affected by wind and are more easily controlled.

Fans

Fans are used either to draw air out of the building through the roof or walls or they can be used to blow air into the building, usually through an opening in the roof or ceiling, or through a ducting system.

The initial installation costs of fan ventilation are higher than for natural ventilation systems and they have higher running costs, but they can offer greater control of the pigs' environment.

Axial propeller fans are the most widely used fans in the pig industry. They consist of 2, 6 or more blades.



Axial propeller fan

In general, the more blades the fan has, the greater the pressure it will develop.

The best propeller fans have a close fitting, curved, 'bell mouth' inlet shroud or inlet ring which improves the overall efficiency. These fans are the least expensive, easiest to install and are commonly used in pig buildings.

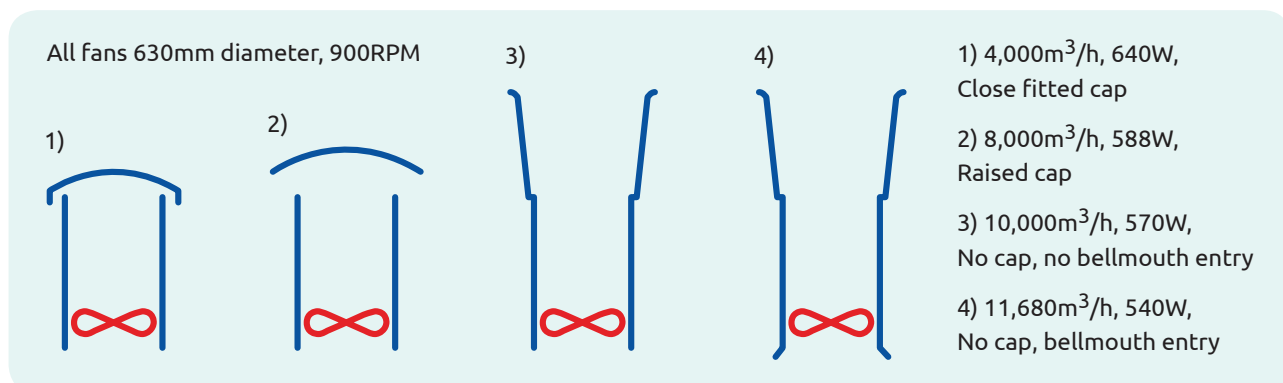
Fan chimneys

The design of the fan chimney is very important for the overall efficiency of the fan.

Figure 8 shows the effect of having a chimney cap and a bell mouth entry on fan performance.

Fans fitted with back draught shutters are less efficient due to the increase in back pressure from the shutters, however, they are essential if the fans are fitted into walls where they can easily stall if the wind is blowing directly towards them.

Figure 8: The effect of chimney design on fan performance



Inlets and outlets

In fan ventilated systems, the fan is either extracting the air from the building (negative pressure ventilation) and drawing air in through inlets or it is blowing air into it (pressurised ventilation) and the outlets let it out.

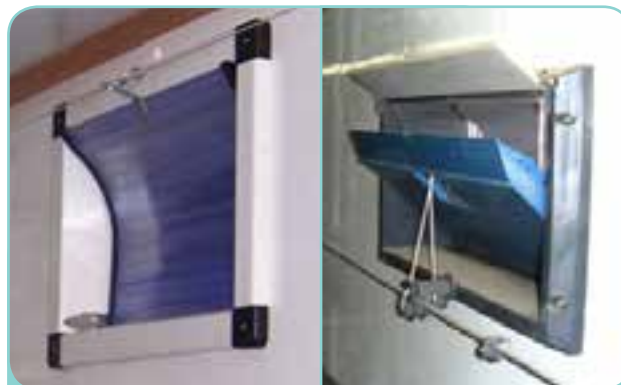
Negative pressure ventilation

In negative pressure ventilation systems, the fan draws air out of the building creating a negative atmospheric pressure inside, ie lower than atmospheric pressure.

The difference in pressure between outside and inside draws air into the building through the inlets. The principal factors affecting airflow into the building are the volume, speed and direction of the incoming air, which means that the size, location and configuration of the inlets are very important when designing the distribution system.

When air enters a building through an inlet it is cooler than the air inside and, being heavier than the air in the room, will start to drop as soon as it leaves the inlet. The force of the air and the design of the inlet will direct the air into the room but the speed of the air and its volume will determine how far into the room it will travel before it drops to the floor.

Consequently, the amount of negative pressure in the room determines the speed and volume of the air coming through the inlets and this is adjusted by changing the relationship between the size of the inlets and the fan speed. If the air is allowed to cling or adhere to a smooth ceiling it will travel further into the room, which is why it is important to have no obstructions on the ceiling which will deflect the airflow off the ceiling prematurely and allow it to fall into the pigs' lying area.



Typical inlets for fan ventilation systems

In order to create the correct airflow patterns in a pig building, it is important to have automatically adjustable inlets which are controlled by the same control unit as the fans. The number and size of inlets varies with each manufacturer but each inlet has an optimum airflow through it which allows the installer to fit the correct number of inlets for the fan capacity in the building.

Key point:

It is also vital that the building is well sealed, with no gaps or cracks around panels or roof linings, to prevent draughts.

The installer will make sure that the air from the inlets follows the same airflow pattern inside the building at all stages of the ventilation, from minimum to maximum.

This is done by altering the relationship between the inlets and the fans as they speed up. Once these settings are established, the airflow pattern inside the building should not change unless there is a fault or lack of maintenance on the system.

It is possible to use the negative pressure in fan ventilated buildings to set the inlet adjustment. A manometer or draught gauge can be used to measure the pressure difference between the inside and outside of the building.

Again, once they are set correctly by the installer using this system, the manometer should show a negative pressure inside the building of 10-20 Pa and, if left in position after installation, this can be a useful indicator of whether the pressure inside has altered due to a fault. Most new fan-ventilated buildings use this type of ventilation.



A manometer or pressure gauge

Pressurised ventilation

In pressurised ventilation systems the fan is the inlet, blowing air into the building directly or through some form of ducting or trunking which pressurises the building.

The fan and any ducting have to be placed in such a way as to make sure the incoming air is distributed evenly round the room.

The contaminated air leaves the building through outlets either beneath the slatted floors, in an attempt to drive any foul air off the slurry, or in the walls. The outlets have to be baffled against any wind which might override the contaminated air coming out and create draughts within the building.



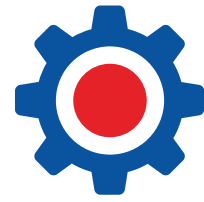
A pressurised building showing an air spreader board under the fan inlet to spread the air evenly around the building

Key point:

In negative pressure buildings, the inlets, rather than the outlets, control air movement patterns whereas, in pressurised systems, the fans or the ducting from the fans control the air movement.

#8.2

Fan ventilation systems & buildings



There are two main negative pressure designs in use in the UK:

- Fan outlet in the roof with the inlets in the side walls
- Fan outlet in the walls with roof ridge inlets

Fan outlet in the roof with the inlets in the side walls

In this system, air is extracted from the building by fans at the ridge, creating a negative pressure in the building.

This creates a vacuum in the room which draws air into the building through the inlets in the walls to replace the air being expelled through the ridge. If the system is correctly adjusted, the incoming cold air will be directed into the middle of the room where it will fall to the ground.

This will result in the pigs dunging in the middle of the room where it is cooler and lying against the outer wall under the inlets. The pigs will then radiate heat which will rise and mix with the incoming air.



Photo showing side inlets for ridge extraction



Ridge extraction fans in the roof

Fan outlet in the walls with roof ridge inlets

In this case, the building is still under negative pressure from the fans, which are usually fitted into the walls, but the inlets are in the ridge directing the air down the ceiling.

The cold air falls against the outer walls making this a cold area where the pigs will dung and they will then lie in the middle of the room. Heat from the pigs will rise towards the ridge where it will mix with the cold, incoming air and return down the ceiling.

The most common design used in these buildings is for pens to run at right angles off a centre passage, running down the length of the building as shown in the photos.

In buildings with both types of inlet, there will be a clearly designated cooler area for dunging and a warmer area for lying. In buildings with wall inlets, the cooler area is against the centre passage and in buildings with ridge inlets, the cooler area is against the outer walls.

Either system works well if the building or room has one airspace and if it is occupied by pigs of the same age. Large buildings will, therefore, be divided into multiple rooms to match the number of groups of pigs entering. If the building is operated on an all-in all-out system then it may be ventilated as a single airspace.

It is also important that each room, or ventilated airspace, is separated from other rooms being controlled by different fans and controllers. There should be no openings in walls between adjacent rooms and slurry pits should be divided so that air is not drawn beneath the floor from one room to another.

Where a building is arranged as a series of rooms off a long passageway, all staff and pig movements have to pass through rooms of pigs of different ages and possibly of differing disease status or susceptibility. For this reason, buildings are often now being built with rooms off a passage at the side of the building; each room is divided by a passage running across the house with pens either side.



Pictures showing ridge inlets (top) and side extraction (bottom)

Figure 9: Ventilation pattern with roof inlet and side outlet

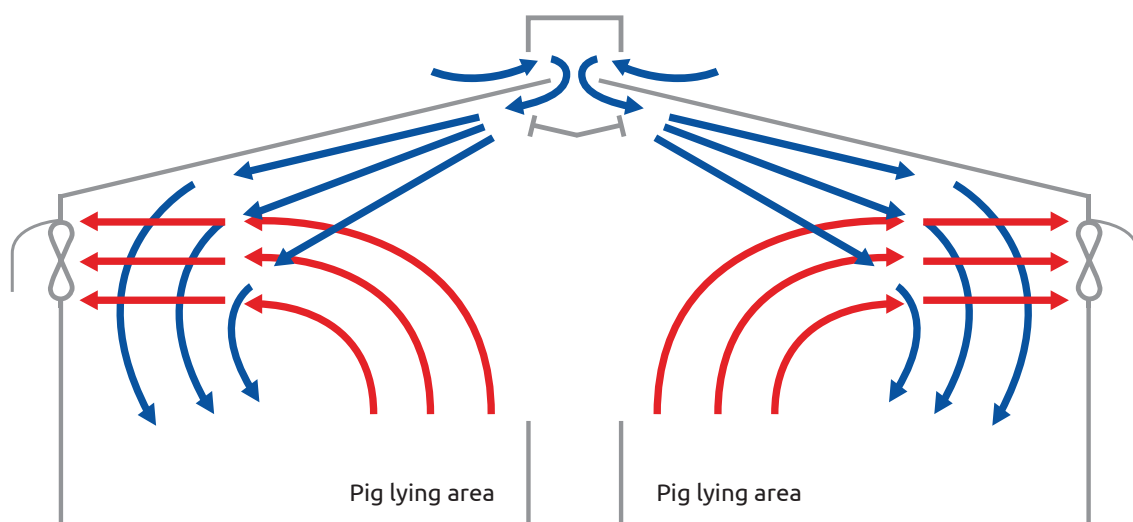
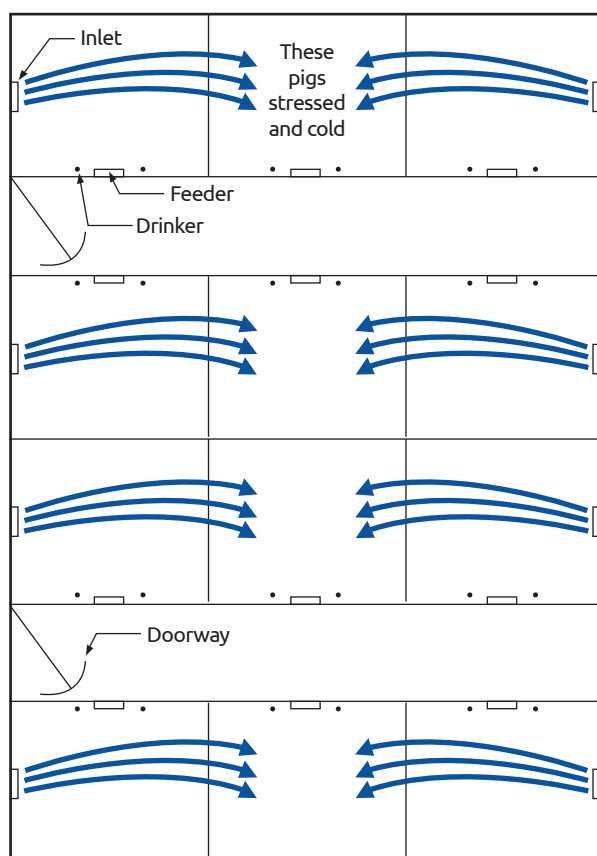


Figure 10: Diagram illustrating pen layout for buildings with side inlets and cross passages, which may lead to a more uncertain air pattern and mixing

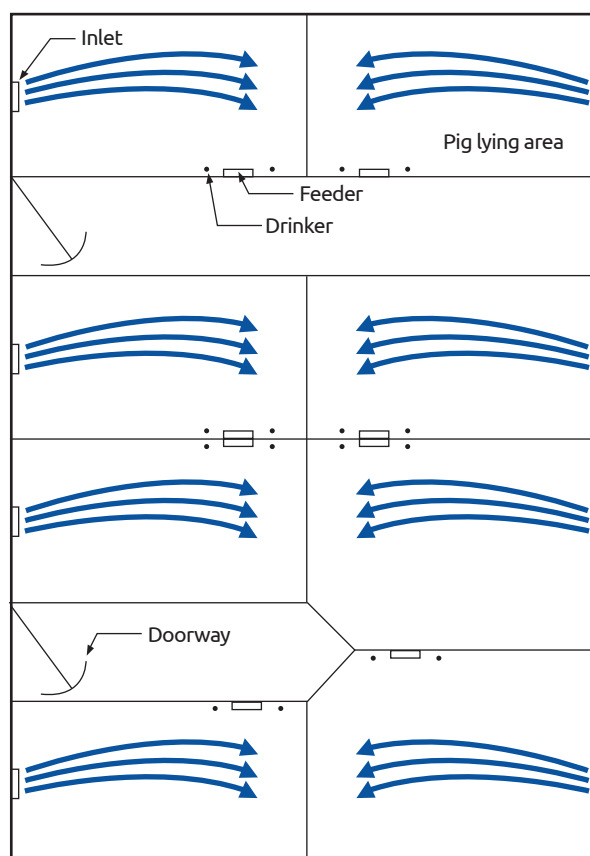


This design must still take into account the airflow pattern from the inlets, whether in the ridge or walls. The cooler air will still be falling against the outer walls from the ridge inlet system and in the middle of the room in the wall inlets system.

If there are more than two pens on each side of the passage it is possible that the pigs in different pens will experience different temperatures and draughts. This is because in a wall inlet system the pens in the middle of the building will have all the cooler air from the inlets falling into them and the pigs in the outer pens under the inlets will have hardly any fresh air falling into them and could become too hot.

The reverse is true of rooms with ceiling inlets where the cooler air falls in the outer pens, making them cooler and the pens in the middle of the room will be warmer. In simple terms, some of the pigs will be living in the lying area and others will be living in the dunging area; neither situation is ideal.

Figure 11: Preferable - diagram illustrating pen layout for buildings with side inlets and cross passages, which may lead to a more certain air pattern and mixing



The solution to this problem is to have only one or two pens on each side of the room passageway.

With wall inlet rooms, this would allow the pigs in all the pens to lie against the outer walls, under inlets and dung at the opposite end of the pen, in the middle of the room where it is cooler.

With ceiling inlet rooms, the pigs would be able to lie in the middle of the rooms where it is warmer and dung against the outer walls where it is cooler and draughtier.

Key point:

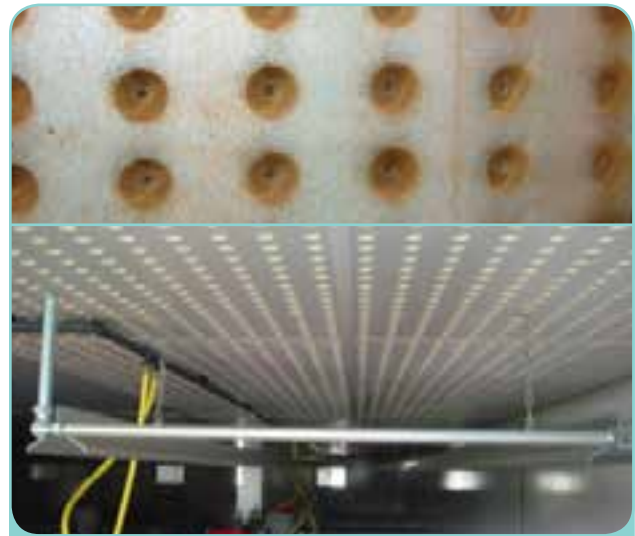
The feeders and drinkers may need to be relocated as they may be in the middle of the new lying area once the changes are made.

Negative pressure perforated ceiling ventilation

This type of system, widely used in Europe and Ireland, involves air being extracted from the room by fans and fresh air being drawn into the room through the ceiling from a loft above it.

The loft has air inlets from the outside, usually at the top of the eaves. The ceiling has either many 15mm holes or is made of a permeable material which allows the air to pass through. This ensures a low air velocity when air enters the building, preventing the risk of draughts.

The ceilings can restrict airflow due to high back pressure on the fans, so for periods of warm weather, ceiling inlets can be placed in the false ceiling. This gives sufficient air velocity for the hot weather and has the additional benefit of being able to direct the air from the ceiling inlets onto the pigs, ensuring an adequate cooling effect. This type of system is very common in new Danish pig buildings.

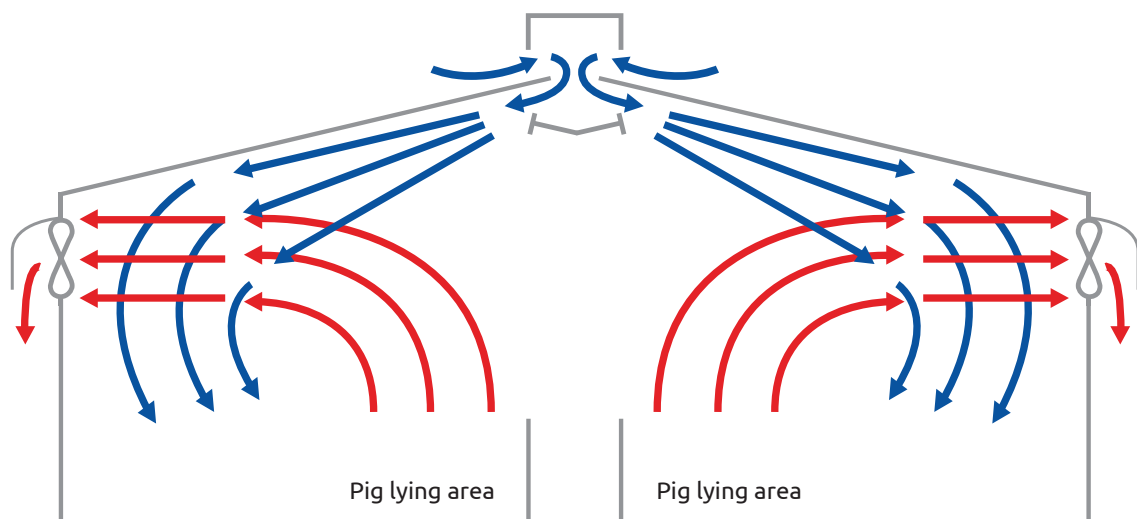


Perforated ceiling using punched insulation sheets



Danish permeable ceiling showing a fan (left) and air inlets (right)

Figure 12: Diagram showing air coming in through ceiling



Negative pressure perforated ceiling ventilation

Door ventilation is a very simple system originally developed in the Netherlands.

Fans extract the air from the room in the normal manner, usually through the roof. Air enters the room through an opening at the bottom of the door into a passage and fills the passage with fresh air. Once the passage is full to the top of the pen fronts, the air flows over them into the pens.

This makes the front of the pens cool where the pigs will dung and they will then lie at the back of the pen where they will create upward warm air currents to complete the ventilation cycle. However, in Flanders it is common to have a narrow slatted area for dunging against the back wall in order to provide low emissions housing.

The system has distinct rules which must be met to make the system work.

- The passage floor and the pen fronts must be solid
- The ventilation opening in the door must not be higher than the pen fronts
- The airspeed in the passage must not exceed 3m/second at maximum ventilation rate and should ideally be less than 2.5m/second
- The fan must have a baffle control system in order to prevent over-ventilation at minimum ventilation rates
- Wall heaters can be used when heat is needed
- Unless the passage is unusually large, the airspeed requirement means the system is most suited to rooms with a low ventilation requirement such as farrowing or first stage weaner rooms.



A door ventilation opening



Wall heater

Key point:

The opening in the door usually has a manual slide to adjust the size of aperture, depending on the external air temperature and pigs' needs; fully open when hot and closed to minimum, but not shut, when cold.

Under passage ventilation

Under passage ventilation is a development of door ventilation, enabling larger rooms with more pigs to use the same concept.

Fans extract air from the rooms in the normal way, usually through the roof. Fresh air is drawn from a chamber under the slatted, central access passage connected to the outside.

Fresh air fills the chamber and the passage above until it flows over the pen fronts into the pens. As with door ventilation, this will make the front of the pen cold, encouraging pigs to dung there and lie towards the back of the pen where they radiate warm air, completing the ventilation cycle.



Under passage ventilation inlet

Under passage ventilation has similar rules to the door ventilation system:

- The pen fronts must be solid and the passageway slatted
- The area outside the building must have a slatted channel with access to the under-passage duct to allow air to be drawn into the building
- The airspeed in the passage must be no more than 3m/second and preferably 2.5m/s, this also applies to the air in the outside channel
- The passageway tank must be completely separate from the slurry tank underneath the pigs' pens
- The fan must have a baffle control system in order to prevent over-ventilation at minimum ventilation rates.

Key point:

The depth of the air chamber under the central passage allows more air to enter the room than in door ventilation, this means that more pigs can be housed in a room before the 3m/s rule is broken, making the system more useful for growing and finishing pigs.



Under passage ventilation system

Pressurised ventilation (positive pressure)

In a pressurised system, the fan blows air into the building either directly or through inlet openings, creating a positive pressure inside that pushes air out of the building through the outlet openings; in older systems these used to be under the slats.

In most modern systems, the incoming air is spread around the room by a spreader plate situated under the fan, which often incorporates a recirculation fan to try and help mix the cold incoming air with warm recirculated air before it falls onto the pigs.

In older systems, the fan would blow into a duct or trunking which would distribute the air throughout the room. This allows more air to enter the room than in door ventilation, which means that more pigs can be housed in a room before the 3m/s rule is broken, making the system more useful for growing and finishing pigs.



Positive pressure ventilation building

Figure 13: Positive pressure ventilation



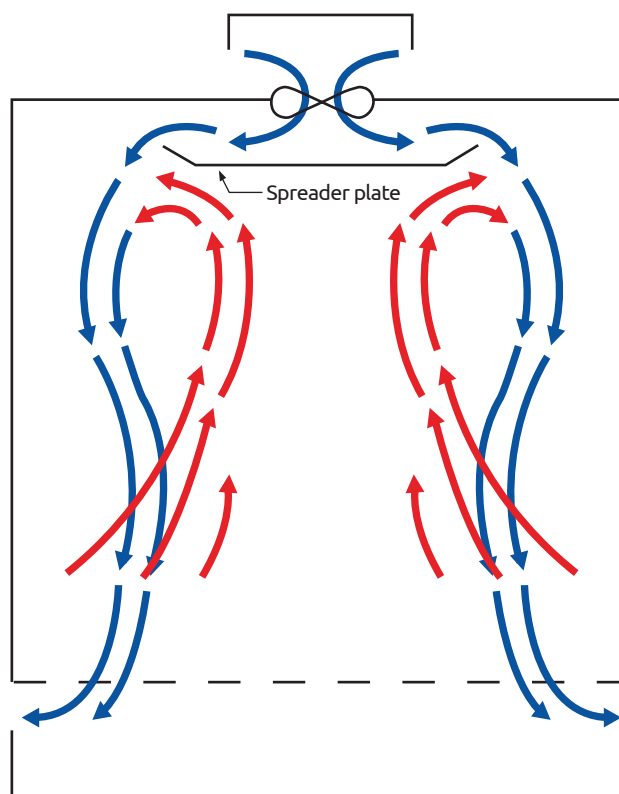
Automatic recirculation unit

These systems are less popular now, as, without any recirculation system incorporated into them, they tend to drop the air close to the inlet when they are running slowly but blow it towards the walls of the room when they are running at maximum.

This creates a poor environment for the pigs as the cold areas in the pen where the air falls onto the floor change with the fan speed.

Key point:

The units with recirculation systems incorporated into them are much better at giving a constant airflow pattern with the added advantage of warming the incoming air at low ventilation rates.



Section #9

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Ventilation problems



Chapters

.....

#9.1 General ventilation problems

#9.1

General ventilation problems



Problems with temperature sensors

Temperature sensors are the most important part of any ventilation control system as they measure the actual temperature the pigs are experiencing.

It can be difficult to measure this as, if the sensors are placed too near the pigs they will be damaged by them, so they are usually placed as low as possible in the building without the pigs being able to reach them, and as close to the lying area as possible.

This means that the sensors are rarely providing an exact temperature reading to the controller, and the stockperson must use their judgement as to how the pigs react to the set temperature and adjust it accordingly.

Key point:

In some circumstances, the sensors can give a very inaccurate reading, for example, if they are positioned too close to the heaters or if they are placed in the incoming air current.

Problems maintaining temperature in a farrowing house

The heat output from sows before farrowing and in the first few days during lactation is quite low (160-180W).

This amount of heat alone is unlikely to be able to maintain a satisfactory pre-farrowing temperature during cold weather, without reducing ventilation below a satisfactory level, even in well-insulated rooms. Any heat lamps or creep heating used before the sows start to farrow will help to keep the farrowing house warmer but even this amount of artificial heat might not be enough to keep the room warm enough before farrowing.

Once the sows start to eat more after farrowing and as the piglets grow, the overall heat output will increase very quickly and the room will be warmer.

Problems with draughts

Leaks

It is important that in any building using negative pressure fan ventilation, it is properly sealed.

Any gaps or cracks in the structure of the building will let in air, usually at a very high speed. A simple way to spot these gaps is to look for a build-up of dust in areas where there is no seal present.

A build-up of dust can be caused due to cold air coming through the gaps cooling the surface of the wall and forming condensation, the dust in the building sticks to this, highlighting gaps in the structure. Make sure any building is properly sealed during construction and keep an eye out for any new gaps.



Draughts are entering the building along the junction of the roof and the side wall

Obstructions on the ceiling

Any obstructions, such as purlins, water tanks, strip lights or feed and water pipes, which run across the incoming air from the inlets, whether in the ridge or walls, will deflect the cold air down into the pen.

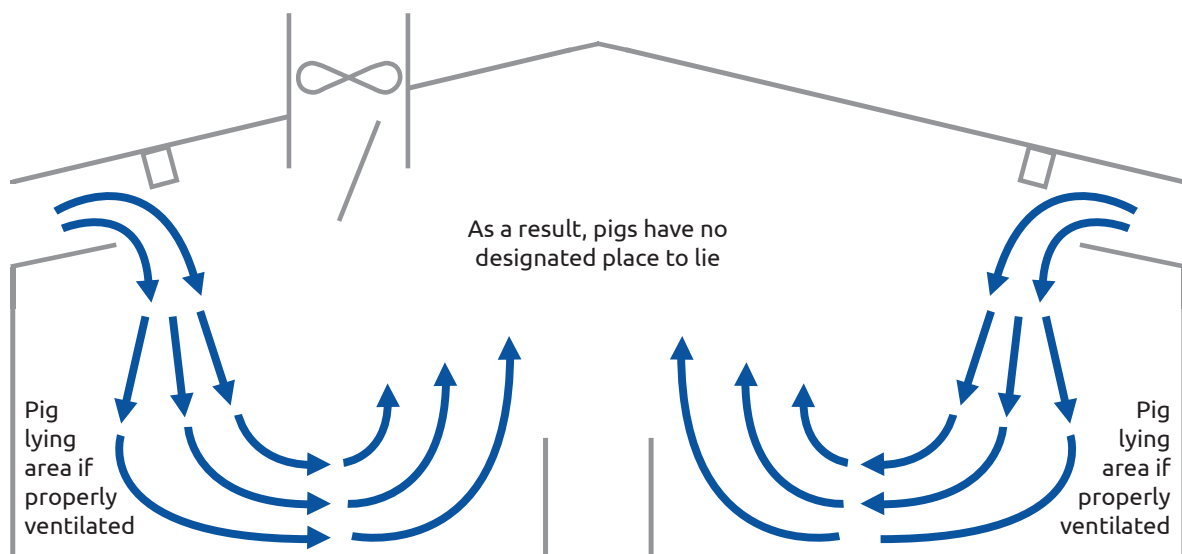
If this is onto the pigs' lying area, it will cause the pigs to become stressed and could lead to tail biting.

Make sure that the underside of any ceiling is smooth, with no obstructions. Fix strip lights so they are parallel to the airflow or hang them on chains so they don't interrupt the airflow. Look out for pipes and feed lines which have to run across the airflow and ensure they are out of the way of any air from the inlets.



A water tank and supply pipe which could affect the airflow from the adjacent inlets

Figure 14: Diagram of fan ventilation with side inlet with purlin in the way



Section #10

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Case studies



Chapters

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#10.1 Traditional monopitch buildings
#10.2 Modern monopitch buildings (1)
#10.3 Modern monopitch buildings (2)
#10.4 ACNV side-to-side buildings
#10.5 Deep straw pens
#10.6 Straw-based pens with scraped passages

#10.7 Fan ventilation
#10.8 Airflow (1)
#10.9 Airflow (2)
#10.10 Airflow (3)
#10.11 Pressurised recirculation unit
#10.12 Temperature sensors

#10.1 | Case Studies

Traditional monopitch buildings

Unit and issue

Pigs in a row of newly built monopitch pens are not growing as quickly as those in a much older row, despite the new pens being much better insulated.

The building

Both rows of pens have a large ventilation opening above the gate at the front and a smaller ventilation opening at the back. The new pens are fully slatted and measure 1.2 metres high at the back and 2 metres high at the front. The old pens are party slatted and measure 0.9 metres high at the back and 1.8 metres high at the front. The rear ventilation openings are much smaller in the new pens.

Findings

There are two likely problems with the ventilation in the new pens: the size of the ventilation openings and the type of ventilation control (manual versus automatic).

- The smaller rear ventilation openings in the new pens mean that airflow is slower compared to the older ones
- The front ventilation flaps are manually controlled in the new pens, whereas the old pens have an automatic adjustment system fitted.

The reduced growth rate of pigs in the new pens is noticeable throughout the year, this indicates that the main cause of the problem is likely to be the lack of automatic control on the front vent flaps; some of the time the flaps are too far open, cooling the pigs excessively and at other times they are too far closed leading to the pigs becoming too warm.

The smaller rear vent in the new pens means the pigs will be warmer in hot weather than the pigs in the older pens but to some extent this is countered by the fully slatted floor, the higher insulation level in the walls and the larger air space.

Recommendations

The front flap should be fitted with automatic control, acting independently of the rear flap. Ideally, the rear ventilation opening could be made larger in the new pens, but this will be difficult as the rear wall is a prefabricated panel, without the necessary supports to fit the new vent to.



View of the old pens (top) and the new pens (bottom)



Interior of the old pens (top) and the new pens (bottom)

#10.2 | Case Studies

Modern monopitch buildings (1)

Unit and issue

Constant outbreaks of tail biting.

The building

The two buildings are of an early, modern, monopitched design with a roof about 3 metres high at the front and 2 metres high at the back. The top section of the front and back walls has automatically adjusted natural ventilation vents, both opening and closing at the same time off the single actuator. The buildings are on an exposed site, 5 metres apart.

Findings

The exposed site means that the wind has a significant effect on the ventilation in both buildings. With the vents at the front and rear of the pens opening together, the wind can blow straight through, causing the temperature to drop quickly; the vents then close up to allow the inside temperature to rise. The cool air entering the rooms falls to the floor in different areas of the pens depending on the wind direction and how wide the flaps are open. These rapid air changes within the rooms, followed by a period of still air, are unsettling for the pigs and are likely to be causing the tail biting.

Recommendations

The ventilation system needs to be improved so that the pigs can establish a warm lying area at the back of the pens at all times, irrespective of the position of the vents and direction of the wind. The ventilation system should be changed so that it works with the front and rear flaps being adjusted independently.

Initially, the front flap should be the only ventilation opening, allowing the back of the pen to become a warm area where the pigs will establish a lying area. The fresh air will enter the building through the bottom of the front flap and will fall at the front of the pens. The back flap will only need to be opened when the front flap is fully open and the temperature in the room is still increasing.

The best way to achieve this is to fit a separate actuator onto the rear vents which can be controlled automatically, usually by the existing controller. The temperature setting on the controller will need to be adjusted so that the majority of the ventilation is provided through the front



Typical exterior view (top) and interior view (bottom)



Drinkers at the back of the pen in the new lying area (top) and the new lying pattern when the drinkers are moved to the front of the pen (bottom)

vent, with the rear vent opening only as the temperature rises beyond what can be controlled by just the front vent. This will usually mean that the rear vent will open when the internal temperature is about 3°C above the setting for the front vent.

Any drinkers or feeders at the back of the pen will need to be repositioned towards the front of the pen so they are not in the pigs' new lying area at the back of the pen.

#10.3 | Case Studies

Modern monopitch buildings (2)

Unit and issue

Poor airflow through the building.

The building

The building is an early version of the modern monopitch building, 3 metres high at the front, 2 metres at the back, both with automatically controlled vents at the top operating from a single electric actuator.

The building was constructed several years ago. Another building is situated behind it and a second-hand lorry container, used as a store, has been placed against the front.

Findings

In order for the building to work as designed, in terms of ventilation and temperature control, it should be situated away from other buildings; it is currently recommended that naturally ventilated buildings are located at least 6 metres apart. This building was built far too close to the one behind it and as a result there is very little airflow through the rear vents. In addition, the lorry body has blocked a further 6 metres of the front vents. In cooler weather, when much less ventilation is required, there are sufficient openings to provide adequate ventilation but as soon as the ambient temperature rises, the ventilation system is incapable of maintaining the inside temperature at a satisfactory level.

Recommendations

The lorry container should be removed to allow full ventilation through the front vents. Unfortunately, there are no practical ways of improving the airflow through the rear vents.

The building should be changed to a fan ventilated system, the fans extracting the air and the rear vents becoming the inlets. Fans could be fitted through the roof near the top of the monopitch or in the top of the front wall, with the front vents closed and sealed. The rear inlets should be changed to a hopper style inlet to direct the incoming air upwards and towards the front of the pens. Any obstructions on the ceiling, eg purlins, lights, etc. should be either positioned parallel with the airflow from the inlets or covered to make the ceiling smooth. The rear vents will need to be controlled automatically to allow them to adjust as the fan speed increases.



View of the lorry container in front of the building



View of the adjacent building behind

These changes will involve a lot of expense in an old building. An alternative and more practical, but less effective, solution would be as follows.

The lorry container should be removed and the vents made to work as well as possible by removing dust, dirt and any obstructions. A spray cooling system could be fitted above the front area of the pens which switches on whenever the outside temperature becomes too warm (usually above about 20°C but depending on the individual site). The water spray will cool the pigs using evaporative cooling and can reduce the temperature the pigs are actually feeling (effective temperature) by up to 4°C.

As a final step, a series of fans could be installed along the back of the pens to blow air into the pens from the rear vents, effectively replacing the non-existent natural airflow from the rear vents.

#10.4 | Case Studies

ACNV side-to-side buildings

Unit and issue

Poor ventilation when the wind is not blowing.

The building

The building is a side-to-side ventilated ACNV house with some small, hand operated openings in the roof. The building is ventilated very well whenever the wind is blowing but becomes stuffy and dusty on still days.

Findings

The calculations indicate that the ventilation inlet openings in the side walls were adequate for side-to-side ventilation to work well. However, the sizes of the outlet air openings in the roof were far too small for effective stack-effect ventilation to occur whenever the wind stopped.

Recommendations

The existing outlet air openings need to be replaced either by a chimney with greater cross-sectional area or by an open ridge. Ready-made cylindrical chimney ducts are now available with an adjustable flap (shutter) which can be linked to the computer controller operating the side inlets. There are several advantages of this system over the existing openings:

- The higher position of the chimney can increase the draw and stack effect
- The controllable flap can keep the open cross-sectional area of the chimney constant in relation to that of the inlets; as a rule of thumb the cross-sectional open area of the inlets should be twice that of the outlets
- The flap also prevents cold air falling back into the building during periods of cold weather when there is insufficient body heat loss from the animals to drive air up and out of the building.

If the ridge opening option is chosen, then the open area needs to be half as wide as the side openings are high along almost the whole length of the building to give adequate stack-effect ventilation. It is preferable to fit this opening with automatic control, again linked to the side inlets, to keep the ratio of open area consistent. This will prevent heat loss through the opening at lower ventilation rates and prevent cold air flowing in when external temperatures are low.



View of the main vents from the outside



Roof outlets

Both the open ridge and the side openings need to stop 3 metres short of the end of the building. These end spaces should be enclosed to stop air turbulence around the building ends from causing unstable airflow within the building.

This alteration to an existing, insulated structure is likely to be quite difficult and expensive. An alternative option, which will give reliable performance in all weather conditions, is to install a series of fans with butterfly flaps in the bottom of their chimneys in the ridge. The number and size of fans will depend on the number and maximum weight of the pigs inside. There should be the same number and size of fans if fully fan ventilated.

The fans should be automatically controlled so that they only start to work as the temperature rises above the expected temperature lift in the house. This means that their set temperature should be about 4°C above the main house set temperature. Whenever the fans are not running, the butterfly flaps in the bottom of the fan chimneys must be closed and should then open automatically at the same rate as the fan speed increases. The butterfly flaps are important to stop cold air flowing into the building when the fans are either stopped or running at very low speeds.

#10.5 | Case Studies

Deep straw pens

Unit and issue

Tail biting, particularly during winter months.

The building

The building is a clear span, portal framed, uninsulated structure with straw-based pens. The dung from the area at the front of the pens is scraped out, so it is important that the pigs dung at the front and lay at the back.

All of the walls at the back of the building have 'space boarding' above the concrete block walls to keep the pigs in.

Findings

The pen layout encourages the pigs to dung, drink and eat towards the front of the pens and to lie at the back.

In cold weather, the fresh air from outside falls through the gaps in the space boarding, directly onto the straw bed at the back of the pens. This makes the area against the back wall very draughty and cold so the pigs won't lie there and it is used as a dunging area instead. As a result, the pigs are forced to lie in the middle of the pens, away from the back wall and away from the feeding, drinking and dunging areas.

The middle area of the pen is not big enough to accommodate all of the pigs as they grow and some of them are forced to lie in the colder areas at the front and back of the pen, this leads to the pigs becoming stressed and to start tail biting.

The severity of the problem will depend on the relative temperatures between the inside and outside of the building, which explains why the issue occurs mainly during the winter months.

Recommendations

Covering the space boarding in cold weather would stop the cold air from falling into the pens but, unless the covers are automatically adjusted and easily fitted, they may not actually be installed until after the problems have started and could be left in place for too long.

A kennel over the back part of the pen, under the space boarding, would stop draughts and cold air from dropping straight into the pens. The kennel would not need to be very wide (1–1.5 metres) but should be big enough for all the pigs to get underneath when they



View of the space boarding at the back of the pens



View of the feeders at the front of the pens

are first put into the building. As the pigs grow, they will overflow from this area, but the heat coming from under the kennel will stop any cooler air from falling onto these pigs. Making the kennel easily raised and lowered (preferably automatically, according to the temperature underneath) will also help stop the pigs from dunging underneath it in hot weather, when they won't lie underneath it because it is too hot.

#10.6 | Case Studies

Straw-based pens with scraped passages

Unit and issue

Pigs dunging in the middle of the building and in their lying area.

The building

This is a portal framed, uninsulated building with a high roof. The pens in this building are arranged across its whole width with scraped dunging passages at each of the ends against the walls. The side walls are fitted with automatically adjustable curtains to control ventilation and the building has an open ridge (fixed opening). There are two walkways in the building, 2.4 metres wide, about 2 metres above the pigs. There are no kennels.

The building is ventilated using a combination of side-to-side and stack-effect ventilation. It has large side wall openings which are automatically adjusted using curtains and a permanently open ridge with a weather cap over it.

Findings

The open ridge lets warm air from the building escape but it also lets cooler air in which then falls into the middle of the building directly below it. Even in warm weather this air will be much cooler than the temperature of the pens it is falling into, creating draughts. This makes the middle part of the pen uncomfortable for the pigs to lie in so they find somewhere else more comfortable to lie and dung in the middle of the building.

Note

The buildings are subject to the operator's health and safety risk assessment. Walkways (as illustrated) should be fitted with handrails and toe boards to prevent falls. Children and unauthorised individuals must be prevented from gaining access to these areas.



Internal view showing the two walkways, the side curtained openings and the open ridge



The dirty lying areas in the middle of the building

Recommendations

- This is a common problem with open ridges in naturally ventilated buildings and there are two possible solutions that can be implemented to stop the pigs dunging below the ridge.
- Fit an automatic adjustment control on the ridge inlets which only opens them as the temperature in the building begins to rise. This solution will help stop the pigs from dunging in the middle of the lying area and it will also improve control of the ventilation by reducing the heat loss via air escaping through the open ridge in cooler conditions.
- Alternatively, a walkway or kennel can be placed down the middle of the building over the pens. This will prevent the cold air from the open ridge from falling directly into the bed by deflecting it to the edge of the kennel. The warm air produced from the pigs lying underneath the kennel will rise out from under it and will mix with this cold air and carry it away, preventing it from falling straight to the ground near the edge of the kennel
- Kennel roofs which can be used for access must have adequate guarding to prevent falls.



Controlled ridge ventilation in a fully slatted building



A walkway could be built directly under the open ridge. An automatically adjustable kennel lid would also provide better temperature control for the pigs in cooler weather.

#10.7 | Case Studies

Fan ventilation

Unit and issue

Pen layout inappropriate for the ventilation system in use and tail biting.

The building

This building has side wall inlets and exhaust fans in the roof. There is a passage running down one side of the building with a series of rooms off it. Each room has a passage running across the building from the door to the opposite wall. On each side of the room passage, there are four pens, making a total of eight in the room.



View of the building showing the fan chimneys for the six rooms accessed from the passageway running down the side

Findings

The pen layout is not ideal for this type of inlet ventilation system. The incoming air is designed to fall in the middle of the room, making that area cooler and preferable for dunging in. The room temperature on each side will be warmer, making it preferable for the pigs to lie at each side, beneath the air inlets. Each room is split into four pens, therefore the outer two pens are in the warm position and the inner two are in the cooler position.

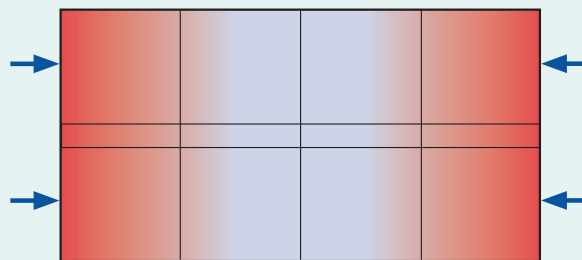


Diagram showing pen layout within the room. Cooler air falls in the central pens while the outer pens remain warmer

Recommendations

The pigs in the middle pens will need a much higher temperature to cope with the draughts and cooler air from the vents and those in the outer pens will require a much lower temperature as they can't escape the warm area of the room.

If the room is kept cooler to benefit the pigs in the outer pens, the pigs in the middle pens could become stressed which may result in the tail biting and poor performance. If the room is kept warm enough for the pigs in the middle pens to be comfortable, the pigs in the outer pens will be too warm and are likely to eat less and grow more slowly.

The divisions between the two outer pens and the middle pens should be removed to create just two pens on each side of the centre passage. The drinkers from the outer pens should be relocated next to the existing drinkers. The feeders do not need to be moved as they are in a satisfactory position. Following these changes, the pigs should lie in the 'old' outer pen and dung in the 'old' middle pen. Tailbiting should be reduced, the pigs will be more content and growth rates should improve.



Interior of the building, showing the four pens to the right-hand side of the centre passage and the inlets in the side wall

#10.8 | Case Studies

Airflow (1)

Unit and issue

Tail biting and dunging in the wrong areas of the pens.

The building

The building houses weaner pigs and has side inlets with fan extraction in the ridge. The pens are the full width of the building with a heated, solid, concrete floor pad in the middle. The feeders and drinkers are placed between the heated floor pad and the outside walls of the building.

Findings

When the pigs are first put into the pens, the system appears to work fine with the pigs lying and dunging in the correct areas.

The ventilation system is designed to direct incoming air up towards the ceiling so that it then falls to the floor in the middle of the room, unfortunately this is where the heated floor pad is placed. Initially, the amount of heat rising off the pad and the pigs is sufficient to deflect this cool draught.

As the pigs grow and the temperature of the floor pad is reduced, there is insufficient warm air rising off the floor to deflect the cool air. Consequently, the pigs try to lie against the outer walls rather than on the pad in the centre of the room which is draughty. The draughts result in the pigs becoming stressed and they begin tail biting, and once they abandon the concrete pad they start to dung and urinate on it.

Recommendations

The heated concrete pad is an integral part of the building and cannot be moved, this means that the airflow pattern in the room needs to be altered to fit the pen layout. A simple cowl, fitted over the inlets, will direct the incoming air down onto the slatted floor below them. This should stop the airflow into the middle of the room and keep the concrete pad draught free, meaning that the pigs are less stressed. The floor area under the inlets against the outer walls will become much cooler and will become the dunging area.



Views of the inside of the problem pens showing a dirty lying area (top) and a clean one (bottom)

#10.9 | Case Studies

Airflow (2)

Unit and issue

A newly converted, fully slatted, grower house is not holding a satisfactory temperature lift in cooler weather despite being well insulated.

The building

The layout of the pens is very good. There is a lying area at the rear of the pen under hand-operated inlet vents and the fronts of the pens are available for the pigs to dung in. The feeders are positioned in the correct location, about one-third of the way into the pen from the front, and were not interfering with either the lying area or the dunging area. The drinkers are also located at the front of the pen. The fans are fitted into the ceiling of the room, extracting air through a fan chimney in the roof.

Findings

The pen layout is, in theory, very good but because the inlets at the back of the pen are hand controlled, the airflow through them does not reflect the fan speed, which is adjusted automatically according to the room temperature. Consequently, air from the inlets sometimes reaches the correct area at the front of the pen before it falls to the floor and, at other times, it falls to the floor quite quickly, making the back of the pen cooler.

The fan chimney doesn't have a baffle on it which means there is no control of airflow up the chimney when the ventilation is running at minimum speed. This can lead to quite a strong current of air rising through the chimney due to the stack effect between the bottom of the hand controlled inlets and the top of the fan chimney above the ridge of the building. This can result in too much air passing through the room during periods of cold weather and the temperature dropping below the set level.

Recommendations

A baffle, shutter or flap (similar to picture right) should be fitted to base of the chimney. This should be controlled automatically, in conjunction with the speed of the fan, so that when the fan is off or running at minimum ventilation the baffle closes up the chimney to prevent over ventilation.



Interior view of the pens showing the hand operated vents at the back of the pen and the feeder (top) and the fan in the ceiling (bottom)



Exhaust fan chimney fitted with a control flap. Both fan speed and degree of flap opening are controlled by a computer to ensure the room is maintained at the optimum temperature for the age and category of pig housed

#10.10 | Case Studies

Airflow (3)

Unit and issue

Incorrect pig lying pattern, tail biting and poor growth rate and feed conversion.

The building

This finishing house has a series of inlets above the centre passage, drawing air in through the ridge, with the fans placed very low in the side walls. The pigs lie at the back of the pen and tend to dung at the front, next to the passage. The inlets should direct the incoming fresh air towards the back of the pen, meaning that the pigs should lie towards the front of it and dung at the back.

Findings

A smoke test shows that at minimum ventilation there is very little airflow coming through the inlets and, what there is, falls straight onto the floor of the pens adjacent to the front passage.

As minimum ventilation is the most likely rate that will be used when pigs are first put into the building, this establishes the front of the pen as a cold area and the back as a warmer area, which explains why the pigs lie at the back of the pens and dung at the front.

However, at maximum ventilation rates, the reverse happens. A smoke test showed the airflow coming strongly through the inlets and jetting along the ceiling at high speed, hitting the outside wall and falling to the floor at the back of the pen. Unfortunately, this cold air falls where the pigs have already established their lying area.

In this particular building, the fans also changed from minimum speed to high speed very quickly, subjecting the pigs to a long period of minimal air movements followed by short periods of high air speed and draughts.

In addition, the fans themselves create an airflow at the back of the pens which is very strong at maximum ventilation rate.



Internal views showing the centre passage and pen layout (top), the inlets above the passage (middle) and the fans low in the outer walls at the back of the pens (bottom)

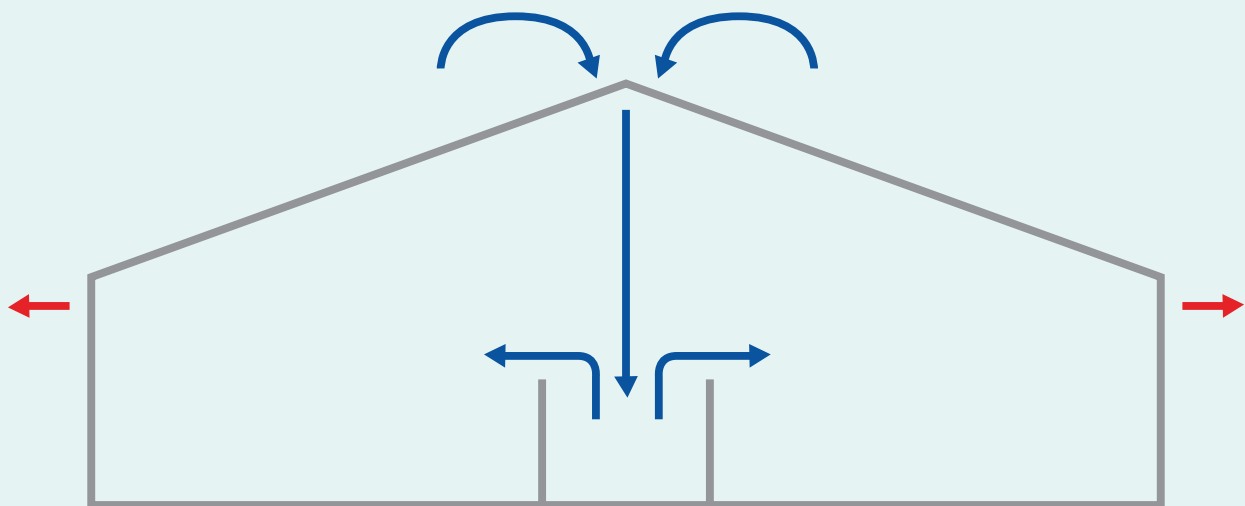
Recommendations

The ventilation should be changed so the airflow pattern in the building is constant. The ideal solution is to fit inlets along both sides of the buildings, put new fans in the ridge and close up the existing ridge inlets and fan holes. This will make the incoming air from the inlets fall in the middle of the room all the time, so the pigs will lie against the outside walls under the proposed inlets, and dung at the other end of the pens without any cold air falling on them in their lying area, regardless of the ventilation rate.

This would be an expensive alteration for an old building and there is no room to fit conventional inlets between the tops of the divisions and the eaves of the roof without them sustaining damage from the pigs.

As a result, the incoming cold air from the ridge needs to be directed into the dunging area at the front of the pens, near the passageway.

To achieve this, the only solution is to extend the existing inlet so it faces down, to direct the incoming cold air onto the passage. The passageway needs to be changed to a solid floor, so the cold air will build up and spill over into the front of the pen in a similar way to door ventilation, or a cellar inlet passage with slatted floor. The inlets will also need some sort of control so they close up when the fan is running slowly and open when it speeds up. This could be a simple butterfly valve in the inlet, opened and closed by an actuator or winch in parallel with the fan speed.



Inlet system showing airflow from the inlet into the access passage

#10.11 | Case Studies

Pressurised recirculation unit

Unit and issue

Unsettled, stressed pigs with some tail biting.

The building

This finishing building has a pressurised, recirculation, ventilation unit in each room.

All the ventilation units are placed in a central position, meaning that air is distributed in a circle around them. Adjustable flaps in the air outlets of the fan units can be set to increase or decrease the air speed through them, enabling air to reach the corners of the rooms.

In some of the rooms, the unit has been replaced with a fan which has a spreader board underneath, these still pressurise the room but cannot be adjusted.

Findings

The fan unit contains a recirculation unit within its mechanism, this allows warmed air from the rooms to be mixed with the incoming air to give a constant airflow with a variable amount of recycled air, this helps to maintain the correct room temperature.

In this case, the recirculation units are not functioning and, as a result, the airflow from the units is restricted to fresh air only. This means that at low ventilation rates there is very little airflow from the units, only reaching the pens directly below them. At higher ventilation rates, the airflow is much stronger and the air reaches the outer walls of the room.

Once the ventilation rate increases, the area against the outer walls becomes draughty and the pigs change their lying pattern, lying under the recirculation fan unit and dunging against the outer walls. This situation can change multiple times during the day in changeable weather, causing the pigs to become stressed, unsettled and to tail bite.

Recommendations

The recirculation fan units should be repaired or replaced so they operate correctly.

In the other rooms, with the simple fan and spreader board, the cause of the irritation and tail biting in the pigs is the same as in the recirculation fan rooms. The air is falling straight to the floor under the fans on minimum ventilation but reaching the outer walls of the



Pressurised recirculation unit



Pressurising fan with a spreader board beneath

room whenever the fans are running faster. The options available to improve these rooms include either refitting a new recirculation fan unit, which would then give a better airflow pattern or replacing the whole ventilation system with a negative pressure inlet type system, which could be set up to give a constant air flow pattern that would suit the room layout in this instance.

#10.12 | Case Studies

Temperature sensors

Unit and issue

A 72-sow farrowing house with ridge extraction and side inlets becomes very stuffy and warm as the pigs get towards the end of their period of occupation and at all times during warmer weather.

The unit has a secondary problem with regard to maintaining a satisfactory room temperature before the sows farrow and for the first few days afterwards during periods of cold weather.

The building

The first step is to check if there is sufficient fan capacity installed to keep the room temperature at the desired level in warm weather. This room contained 3x 630mm diameter fans, which are capable of moving 11,300m³/hr of air at 20pa pressure difference each, giving a total potential maximum air movement of 33,900m³/h (9.42m³/s).

Using the formula shown in Appendix 4, it is possible to calculate what the maximum ventilation rate should be for this building.

The farrowing house has 72 sows with 12 piglets per pen just before weaning, when the piglets are at their biggest and the maximum sensible heat output from the animals is at its greatest.

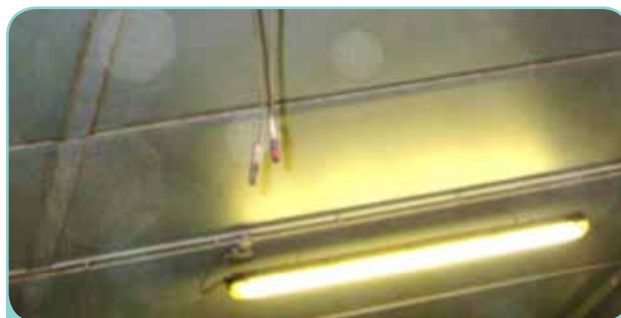
Assuming each sow gives off 270W, each piglet gives off 20W and the heaters are off, the ventilation system is capable of keeping the room temperature lift down to 3.25°C above the outside temperature, which is more than adequate.

This would mean that if the ambient temperature was 25°C, the room temperature would be 28.25°C.

Findings

The temperature sensors in the room are located high up in the ceiling and quite close to the outside wall of the building.

A smoke test showed that at minimum ventilation the air falls into the pens well away from the temperature sensor. However, as the ventilation rate increases the incoming airflow from the inlets is directed straight at the sensor.



Incorrect position of temperature sensor



The ideal position of temperature sensor in an ACNV building

This leads to the sensor registering the temperature of the air coming into the building, rather than the air temperature actually in the room.

This in turn means that the controller registers that the room is colder than it actually is and decreases the ventilation rate until the airflow from the inlets doesn't reach the sensor. As a result, the ventilation system runs on minimum ventilation for most of the time with only short bursts at a higher ventilation rate.

Recommendations

Temperature sensors should be positioned so they are suspended just above pen height where the pigs are lying, but not too low so the pigs can reach them. They should also be out of any airflow from the inlets so they are recording the temperature of the pigs' actual environment.

The best way to address the secondary problem and to help maintain the temperature before the sow farrows is to use thermostatically controlled space heaters. These will only work when the room temperature drops below the required temperature. The heaters are portable so they can be used in any room during the pre-farrowing period.

Section #11

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Appendices



Chapters

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#11.1 Calculating the volume of air flow

#11.2 Calculations for determining the heat loss from a building

#11.3 Calculations for determining the maximum ventilation rate for pigs

#11.4 Formula to calculate the size of ACNV wall (side) inlet openings

#11.5 Formula to calculate the size of opening for natural ventilation with stack effect

#11.6 Calculating the maximum ventilation rate for a continually stocked building with 500 pigs from 40-110kg

#11.7 Formula to calculate minimum ventilation rate based on CO₂ levels

#11.1 | Appendices

Calculating the volume of air flow

Formula

$$Vs \text{ (m}^3/\text{s)} = A \text{ (m}^2) \times S \text{ (m/s)}$$

Variables

Vs	= Volumetric air flow (m ³ /s). This is the volume of air which flows through an opening per second
A	= Cross sectional area of the opening (m ²) eg the open area of an inlet vent or fan shaft
S	= Airspeed (m/s)

Example

Calculating the volume of air being extracted per hour through a 600mm diameter fan shaft where the air speed has been measured at 7m/s.

Step 1: Calculate cross sectional area of fan shaft

Formula

$$A \text{ (m}^2) = \pi r^2$$

Where

r = radius

$$r \text{ (mm)} = \frac{600}{2} = 300\text{mm}$$

$$r \text{ (m)} = \frac{300}{1000} = 0.300\text{m}$$

$$A = 3.14 \times 0.3 \times 0.3 = 0.283\text{m}^2$$

Step 2: Calculate airflow

$$Vs = 0.283 \times 7 = 1.98\text{m/s}$$

Step 3: Convert to volume of airflow per hour

$$Vs - 1.98 \times 60 \text{ (seconds)} \times 60 \text{ (minutes)} = 7,132\text{m}^3/\text{hour}$$

#11.2 | Appendices

Calculations for determining the heat loss from a building

In order to determine the heating required for young pigs, where it is important that air spaces are kept at a required temperature, it is important to carry out a heat balance calculation.

To do this calculation it is important to work out the following:

- The heat loss through the fabric of the building and the ventilation system
- The heat production of the animals
- Heat produced by equipment such as lighting.

As shown in Section 2 (Insulation), calculate the U value of the building fabric to determine the amount of heat lost through one square meter of building for every °C difference between inside and outside ($\text{W/m}^2 \text{ } ^\circ\text{C}$).

Symbol	Units	Description
k	W/mK	Thermal conductivity. A measure of the material's ability to conduct heat. It is the quantity of heat which will pass through a 1m thickness of the material for one kelvin (degree centigrade) difference between the two sides. It is measured in watts per meter kelvin ($\text{W}/(\text{mK})$).
r	Km/W	Thermal resistivity. The opposite of thermal conductivity (k).
C	W/K	Thermal conductance. The quantity of heat that passes in unit time through a material of particular area and thickness when its opposite faces differ in temperature by one kelvin (one degree centigrade). For a material of thermal conductivity k, area A and thickness L, the conductance calculated is kA/L . The unit of measurement is W/K (equivalent to watts/degree Celsius).
R	K/W	Thermal resistance. This is the opposite of thermal conductance. It is a measure of the resistance of a material to the flow of heat. The unit of measurement is K/W (degree Celsius/watt). When thermal resistances occur in series, they are additive.
U	$\text{W/m}^2\text{K}$	Thermal transmittance (U value). A coefficient, the reciprocal of thermal resistance (R). The amount of heat which will flow across a square metre of a given thickness of material for every degree Celsius (K) difference between the faces. The unit of measurement is watts per meter squared kelvin ($\text{W}/\text{m}^2\text{K}$).

The U value is calculated by looking at the individual components of the building. The table below shows how to calculate the U value for a composite unit wall panel, as found in many pig buildings.

Example values of typical wall panel

	k	r (1/k)	Depth (mm)	R (K/W)
Exterior surface				0.13
GRP External coat	0.04	25	6	0.15
Extruded polystyrene	0.033	30.30	80	2.424
Polypropelene layer	0.22	4.54	3	0.014
Internal surface	-	-	-	0.04
Total combined for panel	-	-	-	2.758

In this example the R value for the wall panel is 2.758K/W

This calculation is made for the different parts of the building (walls, roof, doors, and windows). It is then possible to calculate the overall rate of heat loss by using the R value and surface area for each, as shown below.

Therefore the composite U value is
 $1/R = 1/2.758 = 0.36 \text{ W/m}^2\text{K}$

This means that for every kelvin (degree Celsius) difference in temperature between the inside and outside of the building 0.36W is lost for every square metre of wall panel.

Structural heat loss

Calculate the structural heat loss for each building component.

Heat loss per degree Celsius =
surface area (m²) x U value (W/m²K)

Note

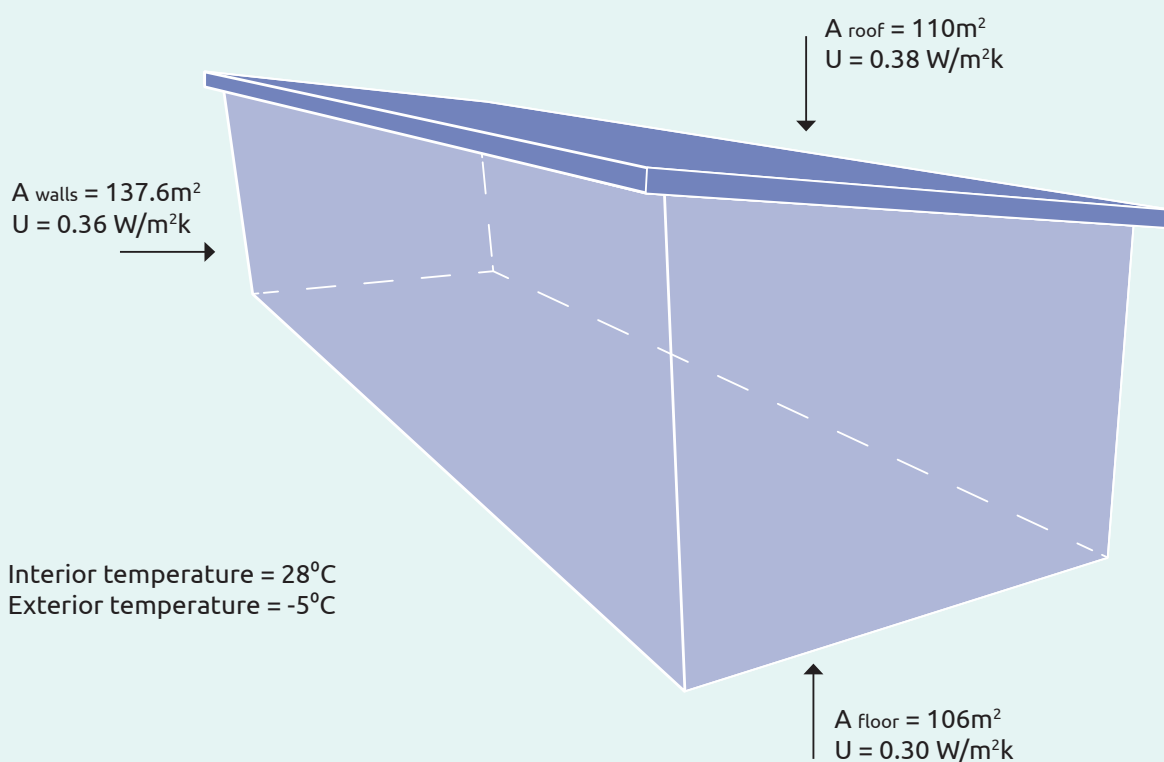
It is good practice to warm the room to operating temperature prior to pigs entering the room. Therefore, the maximum heat need for the room should be calculated based on no pig heat input.

Example

To calculate the structural heat loss in a fully slatted weaner grower building containing 240 pigs (8-40kg)

1. Free standing building with no adjoining buildings (all external walls) – 4 external walls
7.2m wide x 15m long x 2.5m high (to rear eaves) x 3.7m high (to front eaves)

Weaner building example



Heat loss from a fully slatted weaner grower building containing 240 pigs (8-40kg)

	Surface area (m^2)	U value ($\text{W/m}^2\text{K}$)	Heat loss (W) per $^\circ\text{C}$ temperature difference between inside and outside (surface x heat loss (W/K))
1. External walls	137.6	0.36	49.5
2. Roof	110	0.38	33.0
3. Floor	106	0.30	31.8
Total	-	-	114.3

To calculate the total structural heat loss, the total needs to be multiplied by the difference between the internal and external temperature.

Total structural heat loss = (internal temperature - external temperature) x structural heat loss per kelvin (degree Celsius).

In this weaner building if the internal temperature was 28°C and the external temperature was -5°C, the total structural heat loss through the combined external walls, roof and floor is:

Total structural heat loss =
(28-(-5)) x 114.3 = 3772W = 3.8kW

To then calculate the supplementary heat that would be required, add the total structural heat loss and the ventilation heat loss.

Ventilation heat loss (W) = 0.35 x minimum ventilation rate (m³/hr) x difference between internal and external temperature K (°C).

Presuming the required minimum ventilation rate for 240 x 8kg weaners is 312m³/hr, with the external temperature at -5°C and internal temperature at 28°C:

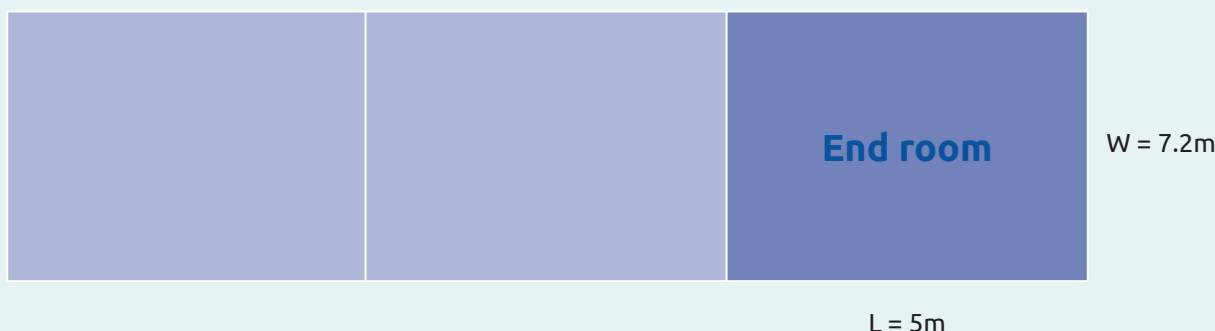
312 x 0.35 x (28-(-5)) = 4.62kW

Therefore, total heat loss = Structural heat loss + Ventilation heat loss.

In the case of this example: to 3.8 + 4.62 = 8.42kW

2. Free standing building with 3 rooms (outer rooms)

End room: 3 x external walls and 1 x internal wall

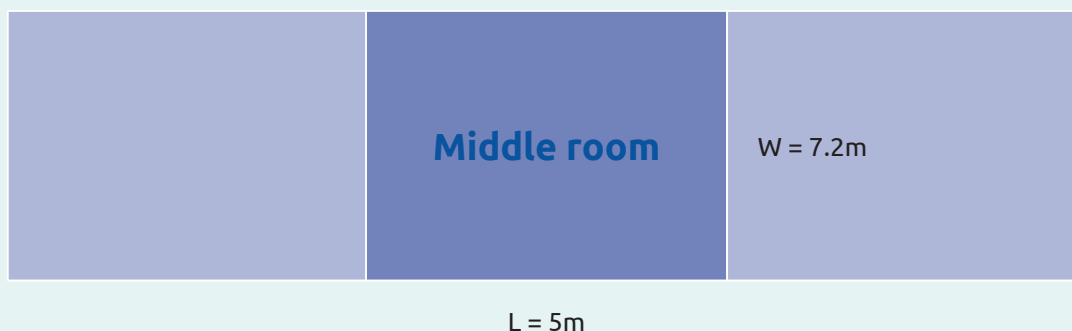


	Surface area (m²)	U value (W/m²K)	Temperature difference (°C)	Rate of heat loss (W)
External walls	43	0.36	23	356
Internal wall (uninsulated)	18	0.80	6	86.4
Roof	36.3	0.38	23	317.3
Floor	36.3	0.30	23	250.5
Total	-	-	-	1,010

The rate of heat loss from the end room is 1.01KW

3. Free standing building with 3 rooms (internal room)

Middle room: 2 x external walls and 2 x internal walls



	Surface area (m ²)	U value (W/m ² K)	Temperature difference (°C)	Rate of heat loss (W)
External walls	25	0.36	17	153.0
Internal wall (uninsulated)	18	0.80	-3	-43.2
Internal wall (uninsulated)	18	0.80	-6	-86.4
Roof	36.3	0.38	17	234.5
Floor	36.3	0.30	17	185.1
Total	-	-	-	443.0

Internal wall temperature difference is negative as heat is flowing from the two end rooms. The rate of heat loss from the middle room is 0.4kW

Often the heat output for the pigs was included to calculate the supplementary heat requirement but current practice is to install satisfactory heating capacity to get the room up to temperature without including heat output from the pigs. Often space heaters or additional heaters are used to achieve this.

The figure of 31kW calculated above would be to achieve the set temperature of 28°C with an external of -5°C. In practice this is not installed. With weaner/grower rooms obviously the surface area of the room is greater than that of a purely weaner building hence the need for greater installed heat capacity.

With adjoining rooms the heat loss is calculated by looking at temperature the next room is likely to be at its lowest set point, say 22°C and calculating heat loss through that wall. End rooms will require a higher heat input, as shown in examples above, but in practice this doesn't usually happen, but monitoring shows that end rooms do struggle to maintain temperature.

#11.3 | Appendices

Calculations for determining the maximum ventilation rate for pigs

Formula

$$VR (m^3/sec) = \frac{H_s + H_a + (UA \times T)}{T \times 1,200}$$

Variables

H_s	= sensible heat produced from the pigs (W)	T	= difference in internal and external temperature
H_a	= artificial heat (supplementary heat)(w)	1,200	= a constant
UA	= heat gain through the shell of the building		

Source: Scottish Farm buildings Institute, 1970

Example of sensible heat production levels from pigs at 30°C

Liveweight (Kg)	Feed intake x maintenance	Sensible heat (Watts)
7(pre weaning)	2	24.4
7 (post weaning)	1	18.6
20	2.5	47
30	3	66
50	3	92
85	3	127
110	3	151
140 (gilts)	2	144
180 (dry sow)	2	174
180 (lactating sow)	4	274
200 (dry sow)	2	189
200 (lactating sow)	4	297

Source: Extrapolated from Bruce, J.R. Nottingham Easter School 1980

Example

Calculation to show the maximum ventilation rate required for 500 pigs at 110kg on an all-in all-out (batch) basis.

Assumptions

The sensible heat output from a 110kg pig on 3 x maintenance feeding level is 151 watts (W)

The building is fully insulated so no heat gain through the shell of the building has been included.

Limit of temperature lift is 4°C.

Formula

$$VR = \frac{H_s + H_a}{T \times 1,200}$$

Where

$$H_s = 151 \text{ Watts}$$

$$H_a = 0$$

$$T = 4 \text{ (temperature lift limit)}$$

$$VR \text{ (max ventilation rate)} = \frac{(151 \times 500)}{4 \times 1,200} = \frac{75,500}{4,800} = 15.73 \text{ m}^3/\text{s}$$

Most fan capacities are quoted in m³/hour.

15.73m³/s equates to 56,628m³/hour (15.73 x 3,600)

Refer to manufacturer's fan tables to achieve the required capacity.

For example in this case 56,628m³hr would be satisfied by 5 x 630mm

Typically a temperature lift of 4°C is used to calculate UK ventilation rates.

Conversely, in summer when the outside air temperature is close to or above that desired within the house, cooling the incoming air may be beneficial. This may be achieved by the use of evaporative misting.

These systems create a mist of very fine water droplets in the incoming airstream which evaporate very quickly, cooling the air. It is important that very fine droplets (mist) are used, large droplets, as produced by washing sprinkler systems, have a large surface area so they cannot take up sufficient heat energy to vaporise quickly enough and fall to the ground wetting the floor and walls.

The principle of evaporative misting is to transfer the heat energy in the air to the fine water droplets. When this energy exceeds the latent heat of evaporation (2257KJ/kg) of the water it vaporises and we are left with cool air.

Warm air is able to carry more moisture before condensation occurs than cool air, so provided the relative humidity of the air stays below the "dew point" we do not get precipitation or condensation. This is the same principal as using warm air to dry grain for example.

The effect can be noticed if on a warm day you are in close proximity to a crop irrigator, you can observe a noticeable cooling effect.

To calculate the quantity of water needed to cool the incoming air, calculations and the use of a psychrometric chart will be required, which are beyond the scope of this document, but ventilation suppliers should be able to do these for your specific situation.

#11.4 | Appendices

Formula to calculate the size of ACNV wall (side) inlet openings

Formula

$$A_1 = \frac{V_1}{1 \times 0.6}$$

This formula calculates the total cross sectional area (m²) size of the openings in one wall; for side-to-side ventilation, equal sized openings must be made in the opposite side wall.

Variables

A₁	= area of opening in one side of the building (m ²)
V₁	= ventilation rate required
1	= assumed external wind speed (m/s)
0.6	= a constant

#11.5 | Appendices

Formula to calculate the size of opening for natural ventilation with stack effect

Formula

$$A_2^{0.67} = \frac{V}{0.382 (H \times Q)^{0.33}}$$

Variables

A_2	= area of ridge outlet
V	= total ventilation rate required in m ³ /second (for all pigs in the building), as derived from the equation in appendix 11.3.
H	= height difference between the top of the outlet and the bottom of the inlet (m)
Q	= rate of total sensible heat addition in kW
0.382	= a constant

Example 1

To calculate the ridge width required for **1,035** pigs up to 110kg, in a building 61.1m x 15.2m, with a height difference of 3m between the top of the ridge and the top of the side walls, below any opening.

Step 1

Determine ventilation rate.

$$VR = \frac{H_s + H_a}{T \times 1,200}$$

Working on 3 times maintenance and 4°C temperature lift.

Therefore

$$VR = \frac{(1,035 \times 151)}{4,800} = 32.56 \text{ m}^3/\text{s}$$

Note: sensible heat output from from table in appendix 3 = 151W per pig

Step 2

Rate of heat addition (sensible heat x number of pigs in kW) is 156.29 kW

Height difference between top of outlet and bottom of inlet is 3m.

$$A_2^{0.67} = \frac{32.56}{0.382 (156.29 \times 3)^{0.33}} = \frac{32.56}{2.91} = 11.20$$

Therefore $A_2 = 36.81\text{m}^2$ of ridge is required.

The building is 61m long, but the first third of each end bay is closed to prevent interference by wind currents, therefore the effective open length is 57m.

The width of the open ridge is therefore:

$$\frac{36.81}{57} = 0.645\text{m} = 645\text{mm}$$

The size of inlet area will need to be $A_2 \times 2 = 1,290\text{m}^2$, which means that the height of the inlet area just below the eaves, along each side of the building, needs to be 645mm.

The important thing to remember when using the stack effect is that as the height between the bottom of the inlet and the top of the outlet increases, the size of the ridge outlet decreases.

Example 2

To calculate the ridge and inlet width for same size shed as in Example 1, with same number of pigs and a height of 4.5m.

Where

$$V = 32.56\text{m}^3/\text{sec}$$

$$H = 4.5$$

$$Q = 156.29\text{ kW}$$

$$A_2^{0.67} = \frac{32.56}{0.382 (156.29 \times 4.5)^{0.33}} = \frac{32.56}{3.32} = 9.80$$

Therefore $A_2 = 30.14\text{m}^2$ of ridge opening is required.

And the width of the ridge needs to be

$$\frac{30.14}{57} = 0.530\text{m} = 530\text{mm}$$

The area of inlet required is $469 \times 2 = 938\text{m}^2$, therefore the height of each inlet needs to be 469mm high along the length of the building.

Width of open ridge for different weight categories of pigs and building ridge height

Pig weight (kg)	Height to Ridge (m)	
	3	4.5
7	0.08	0.07
30	0.26	0.21
50	0.39	0.32
85	0.54	0.44
110	0.65	0.53

From the table above it is apparent that the ridge opening should be altered for the age of pig housed and for the internal temperature lift required. This highlights the limitations of a fixed open ridge when the house is used for the entire growing period on a batch basis.

#11.6 | Appendices

Calculating the maximum ventilation rate for a continually stocked building with 500 pigs from 40-110kg

With a continual flow of pigs through the building this would lead to an average weight of say 80kg. Using the same calculation as in Appendix 4, with a batch stocked building and limiting temperature lift to 4°C.

Using only pig heat output for 80kg pig (123W).

$$VR = \frac{H_s + H_a}{T \times 1,200}$$

$$VR \text{ (max ventilation rate)} = \frac{(151 \times 500)}{4 \times 1,200} = \frac{75,500}{4,800} = 15.73 \text{ m}^3/\text{s}$$

12.81m³s is 46,116m³hr for a continually stocked building taking pigs from 40 to 110kg (4 x 630mm diameter fan) compared to 56,628m³hr for a batch stocked building (5 x 630 fans).

Notes

In the UK, batch filling rooms is common practice, rather than having continually stocked rooms. If a decision is made to change to this system then thought must be given to the installed ventilation capacity with the existing system.

Also, finishing weights are increasing, so in older buildings checking installed capacity to calculate temperature lift is important.

#11.7 | Appendices

Formula to calculate minimum ventilation rate based on CO₂ levels

Some systems now allow for minimum ventilation control based on carbon dioxide levels, to allow minimum practical heat loss through the ventilation system.

Formula

$$V_{\min} \text{ (m/s)} = \frac{H_t \times 45 \times 10^{-9} \times 100}{(C - 0.034)}$$

Variables

H_t	= total heat produced by the pig (sensible + latent in W per pig)
C	= required concentration of CO ₂ (typically between 0.2 - 0.3%)
45	= a constant

CO₂ concentration of ambient air is 0.034% (340 parts per million)

Section #12

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Supplementary information



#12 | Supplementary Information

Ventilation videos

Find the videos at: <http://practicalpig.ahdb.org.uk/ventilation>



Maintenance and zeroing



Cleaning fans



ACNV curtain systems



Door maintenance



Alarms



Passive inlets



Autotest



Temperature lift



Checking heaters



Motor and winch limit switches



Cleaning and maintenance of controlled inlets

Key Targets

- 1 A finisher (30kg–110kg) growth rate > 750g/day with an

FCR better than 2.6



- 2 To reduce respiratory disease levels



- 3 To maintain ventilation systems in good condition



- 4 To reduce energy bills



Ventilation

Ventilation systems are intended to provide optimum living conditions for pigs. A well-managed, functioning, efficient ventilation system effectively draws fresh air into a building and removes stale air containing a proportion of microbes, dust, harmful gases and water vapour. Inefficient ventilation is detrimental to pig and staff performance (particularly on hot days) and costs more to run.

Although there are many types of ventilation system, fully controlled and automatically controlled natural ventilation (ACNV) are widely used and are the focus of this factsheet.

The ventilation rate is normally adjusted in relation to temperature, which in turn is related to the age of pigs within the building.

Many ventilation controllers allow the set temperature to be programmed to decrease as the pigs grow and have lower temperature needs; this is referred to as the **set temperature curve**. Generally, ventilation rates increase as pigs get larger on account of their higher respiratory and heat output.

HUMIDITY

- Some ventilation systems control the relative humidity (RH) within the building as well as temperature
- Heating incoming humid air will reduce the RH, increasing its capacity to remove water vapour from within the building, producing a cooling effect and a healthier atmosphere, without having to increase ventilation rate
- Pigs can tolerate a wide range of RH, from **60** to **90%**.

SET TEMPERATURE

- The set temperature will vary from farm to farm
- You should be able to control the temperature within pig buildings for most of the year

- When the outside temperature is between **-5°C** and **+14°C** it should be possible for the ventilation system to keep the building at the optimum, set temperature
- Sensors should detect deviations from the set temperature and automatically adjust fan speed/flaps as necessary
- The set temperature needs to be between the upper and lower critical temperatures (UCT and LCT), ie within the pigs' thermoneutral (comfort) zone
- Many factors contribute to the UCT and LCT and must be taken into account when setting ventilation rates, for example:
 - Draughty pen ➔ LCT increases by 3°C
 - Straw bedding ➔ LCT decreases by 5°C
 - Low stocking density ➔ LCT increases by 3.5°C
 - Kennelling ➔ LCT decreases by 3°C
 - Restrict feeding ➔ LCT increases by 3.5°C.

(source: Controlled environments for livestock, FEC)

When setting/checking the set temperatures in buildings, take into account the UCT and LCT set out in the Defra Code of Recommendations for the Welfare of Livestock (Pigs), as well as the factors listed above.

A well-managed, functioning, efficient ventilation system effectively draws fresh air into a building and removes stale air



CONTROLLING TEMPERATURE THROUGH VENTILATION

Remember that poor air quality can increase the risk of respiratory disease and, even at very low temperatures, air exchange must still take place.

- During cooler periods, heat produced by the pigs helps to keep the building temperature within the pigs' thermoneutral zone
- Some heat is lost naturally through the walls and roof, but heat loss is predominantly through exhaust air
- During hotter periods, the ventilation system has to remove heat as well as gases and water vapour
- If it is too hot, appetite will be suppressed, the air quality will deteriorate and pigs will be more susceptible to disease
- If the minimum ventilation rate is set too high, excessive heat will be lost and feed energy will be used by pigs to keep warm
- As a rule of thumb, airspeeds of $1\text{m}^3/\text{s}$ give the feeling of an air temperature up to 3°C cooler than the actual temperature. This may benefit larger pigs in summer; however, small pigs may suffer discomfort
- Pigs are sensitive to draughts and have a limited ability for thermoregulation; newborn and early weaned pigs are the most sensitive to temperature fluctuations and poor air quality
- A draught can be defined as air moving in excess of only 0.15m/s ; this is very slow – the equivalent of taking nearly seven seconds to cover a metre
- Signs to look out for which potentially indicate too high an airspeed:
 - Pigs moving away from a given area
 - Pigs huddling together
 - Pigs dunging and urinating in the lying area
 - Poor pig performance.

MAINTENANCE

Ventilation systems will only work properly and efficiently if they are kept in good condition. Consider the following common maintenance errors, faults and inefficiencies. There is room for you to record when you carry out checks.

- Worn fan bearings
- Burnt out fans
- Inlets blocked with rubbish
- Damaged, dirty/rusty blades
- Poorly fitting doors
- Broken windows
- Damaged/poorly maintained controllers.

CHECK

DATE (dd/mm/yyyy)

Are fans installed correctly (eg for direction of flow) without obstruction to air flow?	/ /	/ /	/ /	/ /	/ /
Are fans and louvres cleaned regularly to prevent build-up of dust and grime?	/ /	/ /	/ /	/ /	/ /
Are sensors working properly? Test them regularly and keep spare sensors to hand	/ /	/ /	/ /	/ /	/ /
Are alarms fitted in every building to alert staff of system failure or if the temperature rises/falls outside the recommended band? Alarms must be tested weekly	/ /	/ /	/ /	/ /	/ /
Is an annual service carried out by the manufacturer?	/ /	/ /	/ /	/ /	/ /

INVESTIGATING AIRFLOW PATTERNS

You can check how air is moving in your buildings using a smoke plume. By placing the smoke source at various points, eg inlets, outlets and within pens, you can check that the ventilation system is working correctly and where there are any draughts.

For more information on controlling the environment of pig buildings, refer to:

- AHDB Pork's Ventilating Pig Buildings guide
- Practical Pig App <http://practicalpig.ahdb.org.uk/>



Broken flaps are a common maintenance fault



Check movement of air by using a smoke plume

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MAINTENANCE CHECKLIST FOR VENTILATION SYSTEMS

CHECK	DATE (dd/mm/yyyy)
Are fans installed correctly (eg for direction of flow) without obstruction to air flow?	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
Are fans and louvres cleaned regularly to prevent build-up of dust and grime?	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
Are sensors working properly? Test them regularly and keep spare sensors to hand	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
Are alarms fitted in every building to alert staff of system failure or if the temperature rises/falls outside the recommended band? Alarms must be tested weekly	/ /
	/ /
	/ /
	/ /
	/ /
	/ /
Is an annual service carried out by the manufacturer?	/ /
	/ /
	/ /
	/ /
	/ /
	/ /

**PROVIDING PIGS WITH
GOOD VENTILATION
IN STRAW-BEDDED
GENERAL PURPOSE
BUILDINGS**

PROVIDING GOOD NATURAL VENTILATION IN STRAW-BEDDED GENERAL PURPOSE BUILDINGS

Introduction

Many growing and finishing pigs in the UK are kept in straw-bedded pens in naturally ventilated general purpose buildings. The pigs are usually provided with some sort of kennelled area within the building for warmth (see below) and an area for dunging and exercise which is cleaned out either frequently with a tractor scraper or at the end of the batch with a tractor loader. It is important that the ventilation functions properly so that the natural dunging/lying behaviour of pigs is achieved with the two areas of each pen clearly defined. If pigs dung in the lying area, they can become dirty and this may give rise to higher than desirable levels of odour. Also, the pigs' health may be compromised and straw usage is increased.

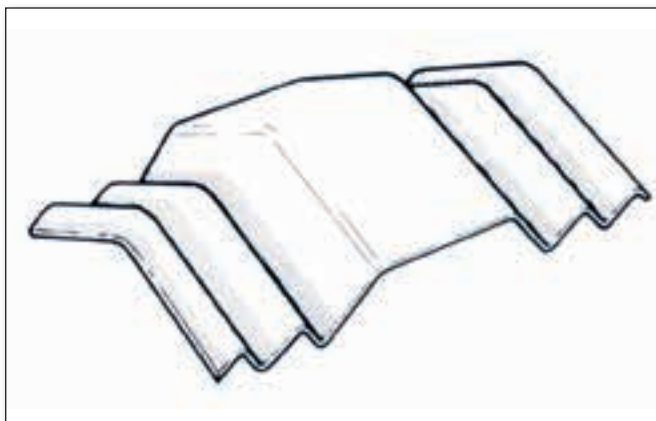


A naturally ventilated general purpose building



Kennelled area within the building for warmth

Ventilation is usually provided by space boarded panels (Yorkshire boarding), in the side and end walls of the building plus a few raised ridge sheets with small openings at each side often called a 'crown cranked' ridge.



'Crown cranked' ridge



The temperature within the building is not controlled and is usually a degree or two above the outside temperature. In cool weather, the pigs huddle up together under the kennelled area in plenty of straw for warmth.

The climate in the UK is generally without any extremes of temperature, however, it is becoming increasingly common to see changes with rapid fluctuations in temperature and humidity in a matter of a few days, rather than more marked seasonal changes. This is putting increased pressure on building ventilation and those responsible for managing it. Extremes of weather, hot or cold, can cause problems affecting pig behaviour and reduce feed conversion efficiency and pig growth rate.

- Hot weather – the pigs tend to wallow in the dung and urine to keep cool, lie outside the kennel and dung underneath it. This results in dirty pigs, wasted bedding and possibly increased odour levels. This can lead to a reduction in feed consumption and growth rates
- Cold weather – the pigs will use more of their food for maintenance, ie to keep warm and consequently grow more slowly.

Improving summer ventilation

There are two main sources of heat in a general purpose building:

- Pigs
- Roof – radiates heat into the building, particularly in strong sunshine.

It is possible to improve the air flow through these large buildings and consequently lower the temperature inside but it is never possible to reduce the air temperature inside the building to less than the exterior temperature!!

Ventilation amount can be increased by:

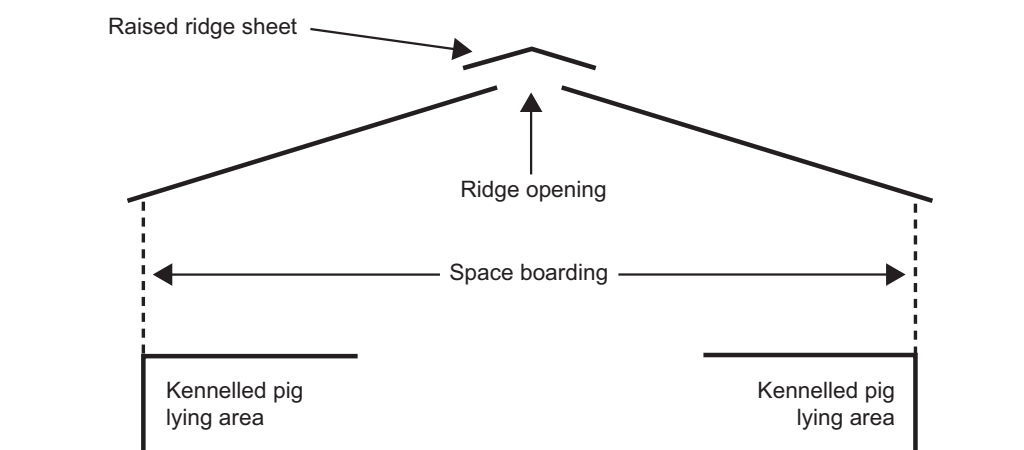
- Opening in the ridge of the building over the 'standard' crown cranked ridge.

The size of the opening needs to be calculated and the following information is required:

- Number and size of the pigs being housed
- Height of the building
- Height of the solid side walls below the space boarding.

Usually, the easiest way to create the extra ventilation in the ridge is to remove the ridge cap sheet with the crown cranked openings in it and replace it with a raised ridge cap, see *Figure 1*.

Figure 1 Ridge opening



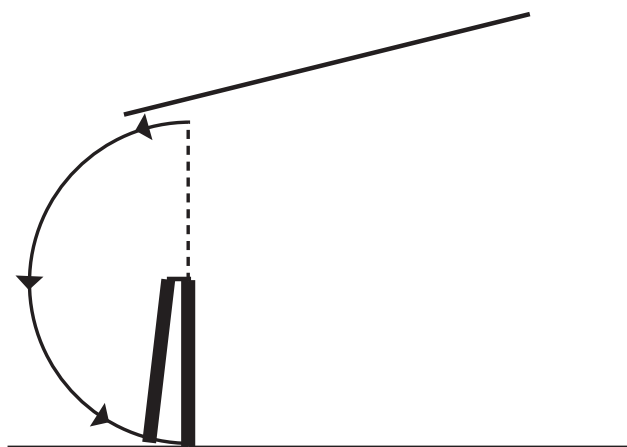
The cap must be high enough off the roof to allow the exhausted air to escape easily which means it must be at least as high as half of the width of the roof ridge opening (see *Figure 1*). The top purlins often restrict the width of this opening but any opening down the full length of the ridge will be better than those in the standard crown crank ridge sheets often provided with a building.

An open ridge allows heat from the pigs to be removed and is a very efficient way to allow the hot air from under the sun heated roof sheets to escape from the building without heating up the whole space. Correctly designed, they do not give rise to rainfall entering the building and making the bedding wet.

It is also beneficial to increase the amount of air entering the building from the side walls. If any of the space boarding is blocked up either deliberately for the winter or accidentally with undergrowth or trees, it should be opened up, or action taken, to ensure the maximum air flow possible.

In periods of hot weather, it is beneficial to have sections of the cladding which can be opened up fully; this is particularly important if the building has some solid cladding. The best way to do this is to have hinged 'drop down' panels in the space boarding which can be opened as required (see *Figure 2*).

Figure 2 Drop down side panels



The other problem in hot weather is the build-up of heat under any kennelling which can make the pigs dung under it and lie in the rest of the pen. In reality, the kennel is not needed whenever the weather is warm but it often has to be there to give the pigs a warm lying area in cooler weather or at night – so what can be done?

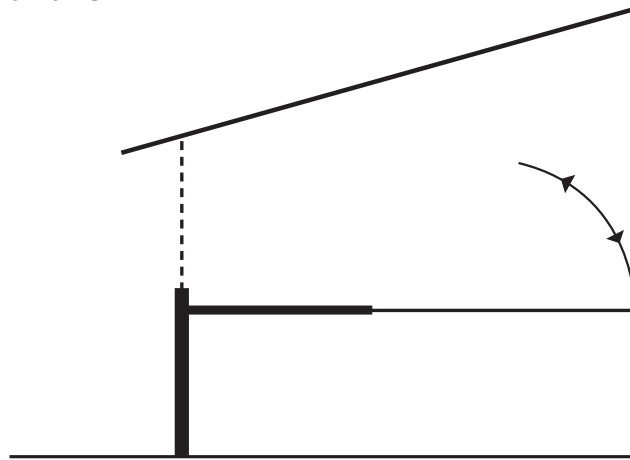
Improving temperature control in the kennel

Many kennels in this type of building are extremely strongly constructed to allow straw bales to be stored on the lid which makes them very difficult to remove or to adjust their height.

Storing straw on the kennels is not advised. The insulation value is good but there is a real fire risk from storing straw above the pigs and it will become a haven for rodents. It would be much better to construct the kennel lid of lightweight framing and cladding with a sandwich of insulation material such as polystyrene or polyurethane in-between. The structure would then be light enough to be adjusted easily to allow more or less ventilation which is the only way to ensure a better temperature under the kennel.

To aid kennel movement, further simple ropes, pulleys and counterweights could be used. The key is not to try to lift the entire kennel lid but to have a fixed part small enough to allow the fore end loader of the tractor to still reach the back of the pen when cleaning out and have the rest adjustable (see Figure 3).

Figure 3 Adjustable kennel lid



The kennels can be lifted individually or with a bit of ingenuity, all together by turning a winch handle. The utmost benefit would come from adjusting the lids on a group of kennels with similar aged pigs in them with an electric winch motor controlled from an ACNV control unit controlled in turn by a temperature sensor under one of the kennels.

How to keep pigs warmer in winter

The main part of the building is unlikely to be very much warmer in winter than the outside temperature. This is usually because:

- There is no insulation in either the walls or the roof
- There is little or no control of the amount of air passing through the building.

It is important to make sure that the worst of the winter weather is kept outside the main building and this can be done by:

- Closing up any extra summer ventilation panels in the space boarding
- Closing up some of the gaps in the space boarding if calculations show this is necessary to keep out the wind.

This is particularly important in the space boarding above where the pigs usually lie if there are no kennels for them to get under, as cold air from the gaps may drop straight onto the pigs' backs even with a straw bed (see below).



Below are two ways of closing up space boarding:

- Have two space board panels, one inside the other, with one of them made to slide so that it can be moved sideways to cover the gaps in the fixed panel
- Fixing a sheet of weatherproof material over the panels works just as well but is more time-consuming to install and remove.

Once any draughts are stopped and the wind kept out of the building, the main way the pigs are kept warm enough is either by providing them with extra straw to burrow down into on cold days or with the use of kennels.

Straw

Using lots of straw is fine and has the additional benefit of a 'heated floor' created by the heat of the fermented 'deep straw' bed under the pigs. Unfortunately, it does consume a lot of straw to work properly and is not a realistic option for many producers who are buying in straw or have limited supplies of their own.

Kennel management

By far the best way to ensure pigs are warm enough in cold weather in a general purpose building is to create a kennel over the lying area. The kennel should be big enough for all the pigs to lie under when they are fully grown. Many kennels are made with a straw layer or straw bales as insulation to keep the pigs warm but, as mentioned before, straw is a definite fire hazard and using it also means it is not possible to adjust the kennel lid height easily. If the lids are made of an insulated 'sandwich', it is possible to raise and lower the lids with a winch motor or by hand.

In order to keep the pigs warmer under the kennel many farmers close up part of the front of the kennel to keep the pigs warmer when they first go in. Methods of achieving this are listed below:

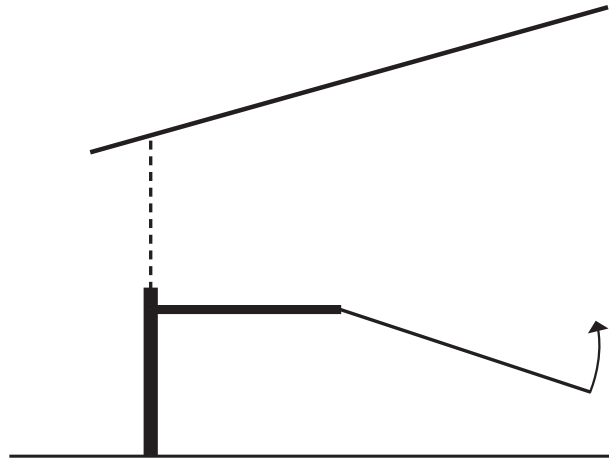
Method	Pros/Cons
Clear plastic sheets hung from the front of the lid	Often become damaged or torn
Place straw bales over part of the front opening (see below)	Pigs destroy bales, which can help as they need more ventilation as they grow, however, bales are often destroyed too soon and end up too cold

If the kennel is light enough to be raised and lowered easily either with a hand or motorised winch, it is also possible to allow the lid to be lowered so that the front is quite low to the floor which will also keep the heat under the kennel (see Figure 4).



Straw bales placed over part of the front opening

Figure 4 Lowered kennel lid for extra warmth



It is very important to make sure that the pigs can be inspected under the kennel; the only way to do this with most kennels is to crawl inside under it but if they can be raised and lowered easily, the lid can be lifted up for inspection and lowered again straight afterwards, all of which is much easier!

Summary of key points

- Having the correct ventilation within a kennel will improve:
 - Lying/dunging behaviour and in turn improve pig and kennel cleanliness
 - Food intake and growth rate
- Ventilation amount can be increased by opening in the ridge of the building over the 'standard' crown cranked ridge
- Ventilation can also be controlled by increasing or decreasing the amount of air entering the building from the side walls
- Storing straw on top of kennel lids is a fire risk, instead construct the kennel lid of lightweight framing and cladding with a sandwich of insulation material such as polystyrene or polyurethane in between
- Manually control kennel lids to alter ventilation rates
- In cold conditions close up part of the front of the kennel to keep the pigs warmer when they first go in.

Ventilation case study: Deep straw pens

Unit and problem

Tail biting, particularly during winter months.

The building

The building is a clear span, uninsulated structure with straw-based pens. The dung from the area at the front of the pens is scraped out, so it is important that the pigs dung at the front and lay at the back. All of the walls at the back of the building have 'space boarding' above the concrete block walls to keep the pigs in.

Findings

The pen layout encourages the pigs to dung, drink and eat towards the front of the pens and to lie at the back.

In cold weather, the fresh air from outside falls through the gaps in the space boarding, directly onto the straw bed at the back of the pens. This makes the area against the back wall very draughty and cold so the pigs won't lie there and it is used as a dunging area instead. As a result, the pigs are forced to lie in the middle of the pens, away from the back wall and away from the feeding, drinking and dunging areas.

The middle area of the pen is not big enough to accommodate all of the pigs as they grow and some of them are forced to lie in the colder areas at the front and back of the pen, this leads to the pigs becoming stressed and to start tail biting.

The severity of the problem will depend on the relative temperatures between the inside and outside of the building, which explains why the issue occurs mainly during the winter months.

Recommendations

Covering the space boarding in cold weather would stop the cold air from falling into the pens but unless the covers are automatically adjusted and easily fitted, they may not actually be installed until after the problems have started and could be left in place for too long.

A kennel over the back part of the pen, under the space boarding, would stop draughts and cold air from dropping straight into the pens. The kennel would not need not be very wide (1–1.5 metres) but should be big enough for all the pigs to get underneath when they are first put into the building. As the pigs grow they will overflow from this area, but the heat coming from under the kennel will stop any cooler air from falling onto these pigs. Making the kennel easily raised and lowered (preferably automatically, according to the temperature underneath) will also help stop the pigs from dunging underneath it in hot weather, when they won't lie underneath it because it is too hot.



Views of the building showing the space boarding at the back of the pens (L) and the feeders at the front (R)



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