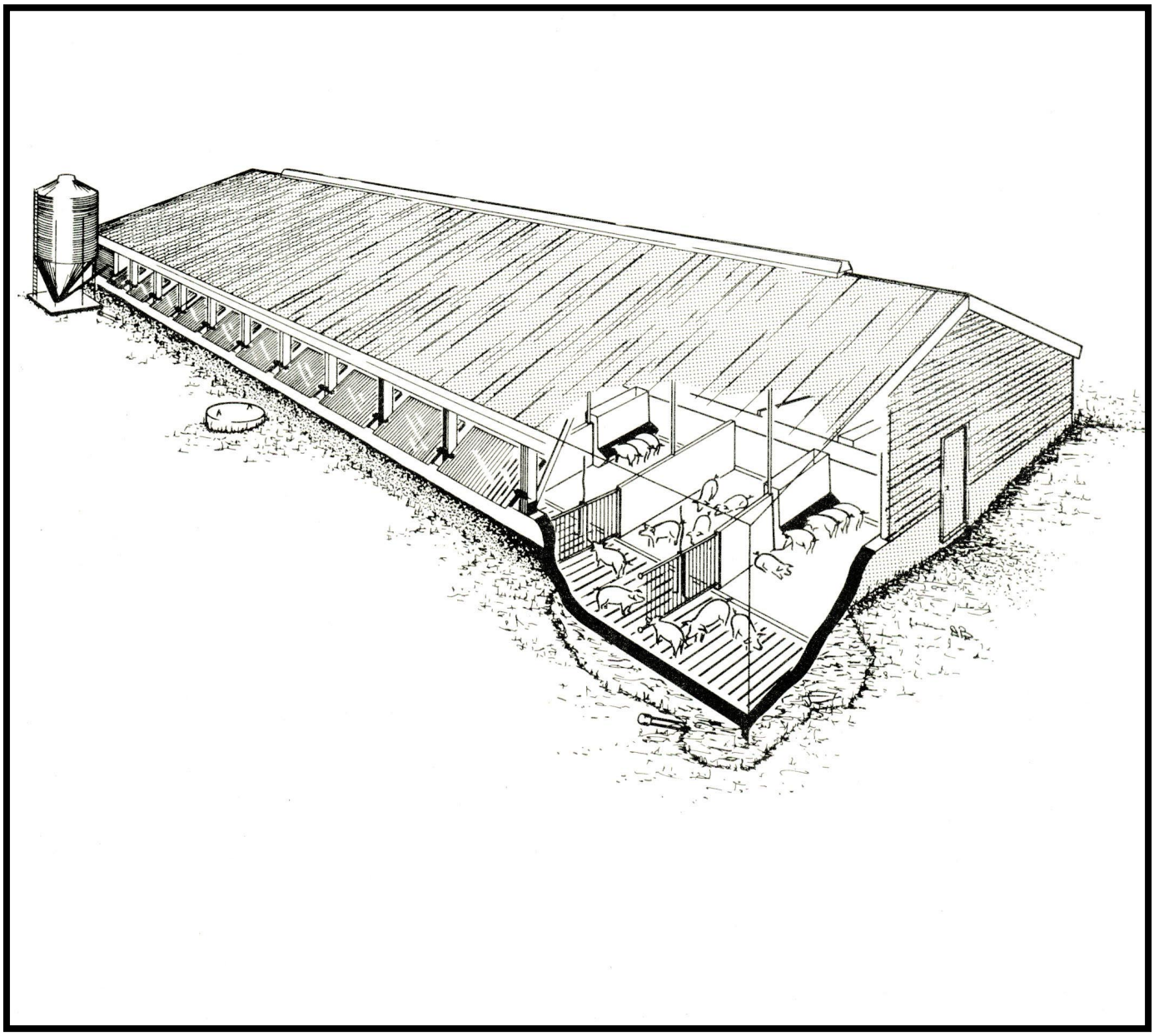
BRITISH COLUMBIA Ministry of Agriculture, Food and Fisheries
Agricultural Building Systems Handbook
PLAN
362-52

NATURALLY VENTILATED GROWER-FINISHER BARN



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362-52

NATURALLY VENTILATED GROWER-FINISHER BARN

CPS
PLAN M-3433 NEW 84:07

This plan describes a swine barn with natural ventilation openings at the two long walls and the roof ridge. The pen part is 12 x 28.8 m, with two rows of pens and a center alley. This will house about 650 pigs from 23 to 90 kg liveweight. Continuous production (based on 14 weeks growing-finishing period) could yield up to 2400 pigs marketed per year, although 1950-2000 per year would be typical. Building length can be adjusted in increments of 2.4 m (the interval of the building frames).

PENS Each pen is 2.4 x 5.3 m, or 12.72 m^2. This handles 36 growers at 0.3 m^2/pig, or 18 finishers at 0.7^2 m/pig. Unlike plan M-3434, this pen size cannot be altered without drastically changing the posts, walls and roof structural details.

CPS Plan M-3434 (with a truss roof) offers another alternative if you want pens narrower than 2.4 m.

To help minimize fighting and stress, it is good practice to move groups of 36 'familiarized' weanlings into each empty pen without adding any 'strangers' to the group. Filling a growing pen thus represents one week's production from Plan 362-32, 'Three-room Farrowing, Three-room Weanling Unit'. Similarly one week's production from Plan 362-33, 'Five-room Farrowing, Five-room Weanling Unit' would fill two growing pens.

As soon as more pens are emptied, groups of 36 growers are split into uniform groups of 18, doubling the space per pig. Since all pens are identical, this makes a flexible operating plan that keeps the barn full, yet allows some variation in pig production. Reduce the finishing groups to about 14 pigs (0.9 m^2/pig) in hot weather, and especially when finishing to the full 100 kg allowed by the grading rules.

There is good evidence that the 'housekeeping' habits of the pigs can be improved by good pen design. These pens have solid doors at the alley and solid partitions at the front. This will cut drafts and eliminate socializing across the feed alley and from pen to pen in the solid floor area, creating a quiet, 'clean' area for resting and feeding. At the rear of the pens the floor is slotted for a dunging area; here the waterers are hung on open steel gate pen partitions, to encourage active inter-pen socializing. It also seems to help if the dunging area is kept a little cooler than the comfortable resting temperature maintained at the front of the pens (see VENTILATION, below).

FEEDING Floor feeding may be used, or double sided self-feeders may replace the front part of alternate solid pen partitions. The building posts are located to fit a standard 12-hole double sided self-feeder (1.8 m long).

CONSTRUCTION For the rectangular stop-and-flow gutter option, start by excavating the two long manure trenches and placing concrete slabs to serve as trench bottoms as well as wall footings.

Foundation walls are cast-in-place insulated concrete sandwich. Special patented form-ties have stamped steel spacer tabs welded to them; these tabs are slipped between the edges of extruded polystyrene insulation board (Dow 'Styrofoam SM', or equal), then bent over to fix the Styrofoam midway between the concrete forms while the concrete is being placed. For this plan, a foundation wall 250 mm thick allows for 50 mm of Styrofoam, plus two 100-mm faces of reinforced concrete. This is not cheap construction, but it gives good insulation plus assured durability against penetration by rodents and chewing by pigs. For pouring the concrete, a special 'splitter box' is slid along the top of the forms; this equalizes the concrete pressures on both sides of the insulation so that it doesn't get pushed off center.

The insulated foundation extends up to almost 1.2 m above the slotted floor, and insulated flap doors close the rest of the sidewalls above. Thus insulated stud walls are needed only at the ends of the barn, a big simplification. To support each roof rafter beam, short laminated posts are anchored with nailed steel U-clips which are bolted to the reinforcing steel in the foundation. These posts also carry the hinges for the sidewall doors, mounted on the outside so that only one external cable-and-pulley set is needed to operate all the doors on one side of the barn. Some builders may prefer to buy prefit insulated doors made for natural ventilation, especially if the doors are to be automated to open and close with a commercial compressed-air system.

For natural ventilation, some prefer the sloping cathedral ceiling provided by this post-and-bean construction, as compared with the flat ceiling obtained with standard roof trusses. This cathedral ceiling construction starts with steel pipe columns cast into the interior pen partitions; these in turn carry laminated-plank roof beams spaced at 2.4 m and following the roof slopes. These beams are stagger-laminated from 4.8 m plank lengths to make beams 6.4 m long (from eave to ridge). On top of the beams an insulated roof is built up, starting with ceiling, vapor barrier, wood roof purlins (on edge), batt insulation, and finally, steel roofing. The depth and spacing of the roof purlins in this case is determined by insulation requirements, not roof snow load as usual. Roof purlins 38 x 140 mm give just enough space for RSI-2.1 batts plus a little breather-space under the roofing.

for colder parts of Canada (Prairies, northern Ontario and Quebec), 38 x 184 mm purlins and RSI-2.5 insulation are better.

With a little ingenuity, a builder with a good shop could prefabricate all the wall, beam and roof parts except the steel roofing itself.

NATURAL VENTILATION The large sidewall doors (mentioned above) are intended as air inlets, and a continuous slot at the roof ridge serves as an air outlet. Using strictly 'natural' ventilation in winter, the sidewall doors are adjusted slightly open, admitting a trickle of cold air over the dunging areas. This cold dense air settles towards the slotted floor area while mixing more-or-less with warm room air. Meanwhile the naturally-buoyant warm air inside (as compared with the cold air outdoors) tends to float upwards towards the outlet slot in the roof. If the side walls remain closed for the winter, air will enter (as well as exit) at the peak. This cold incoming air will settle down in the sleeping area as a draft, leading to dirty pens and/or health problems. Thus, with the center alley pen layout, it is absolutely essential that some air always be admitted at the sidewalls, and that the ridge vent be adjusted to function as an outlet only.

If it is windy, air pressure on the windward wall (and corresponding suction on the leeward wall) can cause a powerful cross-flow that can easily over-ventilate the barn. When this occurs it is often necessary to almost close the windward wall flaps to maintain reasonable uniform temperature inside. Zone thermostats and compressed-air door controllers can be purchased to automate these adjustments.

Similarly, there are several ways to adjust the air outlet size at the ridge. The plan shows a popular commercial double-flap design, as well as a cable-adjusted pipe valve with optional rain-cap above. The rain-cap can be omitted in dry climates.

With all-natural ventilation in regions where winter temperatures often go below –15^{o}C, some supplementary heating is required. The best way to do this is use hot water piping under the front 1.2 m of the pen floors.

In hot summer weather, vastly increased ventilation is required and the inside temperature will be almost the same as outside. Now the 'chimney effect' of the inside air is almost nil, and wind is the only driving force for ventilation. With sidewall doors wide open, even a breeze will move much more air than any reasonable number of fans could handle.

NATURAL VENTILATION WITH POWERED WINTER VENTILATION In regions where temperatures can stay below –15^{o}C for long periods, growing pigs alone cannot produce enough body heat to maintain adequate ventilation. This is equally true for both natural and mechanical ventilation!

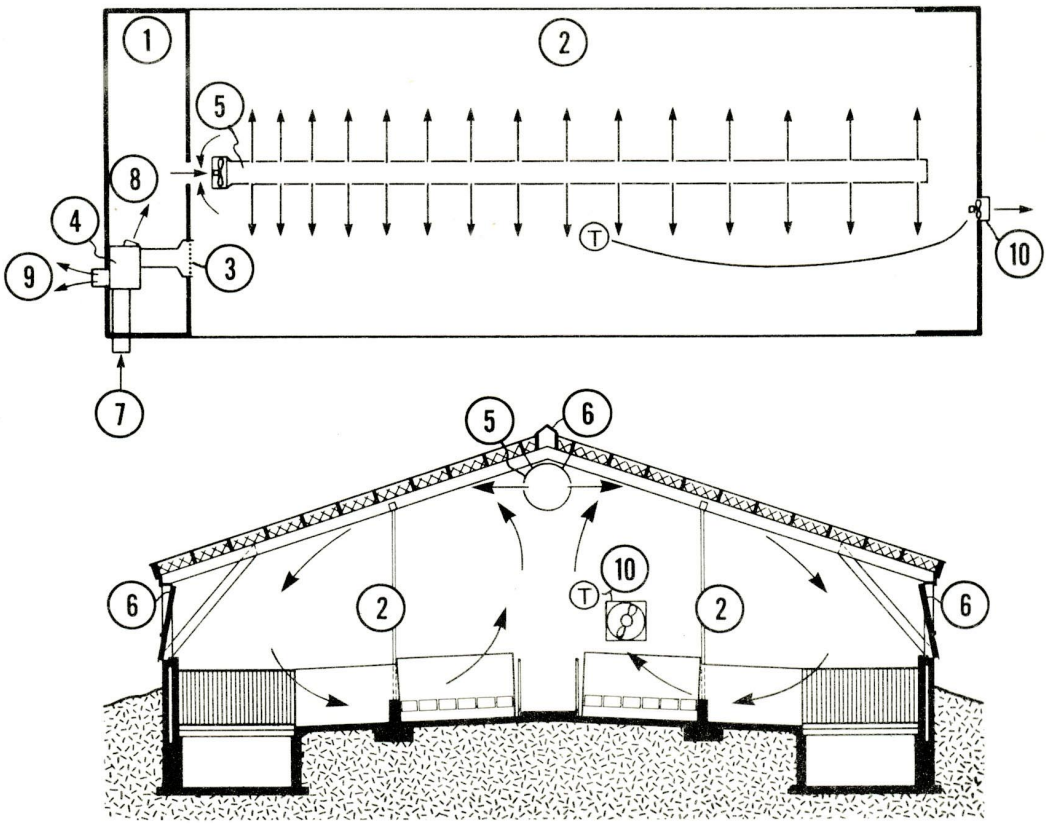
An optional arrangement of equipment provides natural ventilation for mild to hot weather, with provision for switching to powered recirculating ventilation for cold weather.

The insulated vestibule at one end of the barn provides a service room. This can also serve as a clean, dry preheat chamber for winter ventilation air. With the arrival of cold weather, the sidewalls and ridge openings are shut tight, and a commercial polyethylene tube recirculation system is started. The required fresh air supply is drawn through an opening in the inside vestibule wall, centered in line with the intake of the fan-jet recirculation unit. The fan-jet system does two important tasks; it distributes fresh tempered air uniformly to all pens in the barn, and it supplies enough fan energy to 'turn over' the room air. This is necessary to overcome the natural 'layering' effect, where cool dense air collects near the floor where the pigs are, and warm air floats useless to the ceiling. Air-handling capacity of the fan-jet unit should be about 4 L/(s · pig), or at least double the exhaust capacity of the heat exchanger (mentioned later).

A commercial heat exchanger draws a controlled amount of stale warm air from the barn, and an equal quantity of warmed fresh air is replaced from the preheat vestibule via the fan-jet. There is no need for an automatic damper in the inlet opening from the preheat room provided that the heat exchanger fans run continuously, and that the recirculation capacity of the fan-jet significantly exceeds the exhaust capacity of the heat exchanger.

Fresh supply air must be heated somehow to at least –15^{o}C as it mixes and goes through the preheat vestibule. See Figure 2; heat is removed from the exhaust air by the heat exchanger and transferred to the incoming cold air, which is in turn discharged into the preheat room and passed through the fan-jet system to the pig room. The exhaust part of the heat exchanger should be designed to handle the minimum cold weather ventilation requirement (about 1.5 L/s per pig, or about 1000 L/s in this case). If you want to keep the vestibule warmer, it can be separately heated, and the warmed fresh air from the heat exchanger is ducted directly to the wall opening in front of the fan-jet intake.

At the lowest ventilation rate, the air pressure in the pig room will be about equal to outdoors. When pig heat production brings the barn temperature up to the set temperature, another exhaust fan at the opposite end of the barn starts automatically, reducing the air pressure in the room to below that outdoors and drawing some more fresh cold air from the wall ventilation flaps (closed, but *not* airtight), thus regulating barn temperature. This concept requires expert advice in the selection of suitable components to match your ventilation requirements.



The smooth, high cathedral ceiling of this plan is uniquely adaptable to a combined natural/mechanical ventilation system. The ability to add required supplemental heating at one convenient point in the air supply system is a distinct advantage of the powered winter ventilation. The extra mechanical parts of this system may cost little more than full automation with compressed air (or other automatic systems) for controlling the sidewall and ridge vents.

STOP-AND-FLOW LIQUID MANURE SYSTEM At the back of the pens, 1.8 m of the pen floor is slotted. The usual floor system here is reinforced concrete slats 200 mm wide with slots 25 mm wide at the top edge, and with edges pencil-rounded. Precast slotted-floor grids up to 1.2 m wide are more popular than single slats.Under the slotted floor, liquid manure accumulates in a rectangular gutter. Whenever the gutter fills to about 200 mm below the slats, plug-valves are pulled open and manure quickly drains into a sewer pipe crossing the barn under the gutters. To keep each gutter as short as possible, the sewer pipe usually crosses the barn at mid-length. Check occasionally for manure solids that may accumulate in the gutter bottom if flushing is incomplete. Emergency cleanout pipes are suggested at the 'far' end of each gutter, for back-flushing and pumpout with a vacuum tanker in case solids start building up. An option is to add crossover gutters connecting the long gutters at the remote ends of slotted floors. Then the plug valves can be opened alternately so that flushwater flows back and forth between the remote ends of the gutters. This helps remove the dead-end sludge buildup often seen with stop-and-flow gutter systems.

Another gutter option is a V-bottom. This reduces manure storage time by half (less odor and manure gas), and improves flushing action when the valves are pulled (higher velocity flows at the critical bottom part where solids can accumulate). The only problem is that it requires unconventional concrete formwork (or hand plastering) to slope the gutter sides at 45°.
Whichever system is used to remove manure from the barn, a long-term separate storage is required to hold a winter's manure production. Many operators even prefer storage sized for 9 months or more, to avoid having to spread manure on frozen snow-covered ground in winter, or on growing crops in the spring and summer.

1. vestibule serves as a preheat room
2. growing and finishing pen area
3. washable exhaust air filter, to (4)
4. air-to-air heat exchanger, exhaust capacity 1.5 L/s per pig, or 1300 L/s for 650 pigs
5. fan-jet unit; housing, fan, air-straightener, and polyethylene tube suspended on wires; hole spacing varies to give uniform air distribution; air capacity of fan-jet about twice the exhaust capacity of (4)
6. ridge and side vents closed
7. fresh outside air enters heat exchanger
8. warmed fresh air from heat exchanger to (1)
9. cooled exhaust air from (4) to outdoors
10. step 2 exhaust fan 1.5 L/s per pig, controlled by thermostat near center of room

Figure 2. Winter ventilation with air-to-air heat exchanger and fan-jet air mixing system