Floor Heat for Swine
Michigan State University
Cooperative Extension Service

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COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

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Floor heating systems are used in swine housing to provide a warm environment for the pigs without excessive heating of the entire building. The most extensive applications of these systems is for heating baby pig creep areas in farrowing houses. Floor temperature up to 95 F. can be maintained in the creep area while the building is kept at a lower, more comfortable temperature for the sow. In housing without floor heating, the surface temperature of the floor is usually between 50-60 F.—too cold for baby pigs. While dry bedding can be used to keep pigs more comfortable, it is expensive, sometimes unavailable, increases labor requirements, and is not compatible with facilities using slotted floors and liquid manure systems. Floor heating is a logical and relatively low-cost substitute for dry bedding to provide the necessary warm, dry sleeping area required by the pigs.

Floor heating has its disadvantages, however. It increases the cost and construction difficulty of a swine facility, and additional management and maintenance will be required once the system is in place. Some options, such as a totally slotted floor, may not be feasible.

This fact sheet will provide some important points to help you select, design, install and operate floor heating systems.

Options

Either electric or hot water floor heating systems may be used in most types of buildings. The fixed and operating costs for floor heating systems should be about 3-5% greater than for a building without floor heat. In general, oil or gas-fired hot water floor heating will be slightly less costly to install and operate than electric resistance heating systems. Using solar energy to preheat water also appears to have promise as this technology continues to develop. All components in hot water systems except the pipe are easily accessible for maintenance or replacement. Control of heat to individual pens is generally not possible with hot water systems.

Electric floor heating systems have the advantage of more flexibility because it is possible to maintain individual or groups of pens at different temperatures. This is an important point to consider if a portion of the building is empty or if several groups of pigs having substantially different heat requirements are to be in a building at the same time. Maintenance of electric floor heating systems involves only the control system because the heating cables are embedded in the concrete. Therefore, careful selection and installation of quality materials are extremely important if years of trouble-free service are to be obtained from these systems.

Planning and Management

When installing a floor heating system, heat only the pigs' resting area. Avoid placing the floor heat under normally wet areas in a pen, such as waterers and dunging areas, and drain as much water and urine from the floor as possible. Excess liquids evaporated into the air can overtax ventilation systems, increase the odor and moisture level and require additional floor and supplemental heat.

The amount of heated floor space provided is also important. Too much heated area wastes energy and increases costs. Heated areas that are too small, however, encourage pigs to pile up, resulting in injuries and/or suffocation of the animals. Some guidelines for the amount

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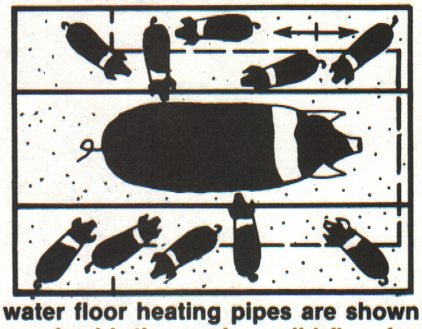
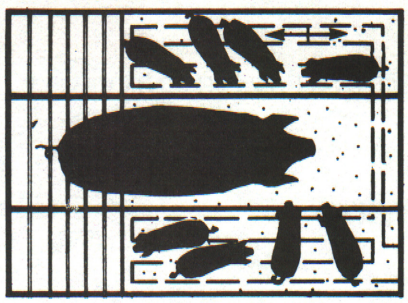
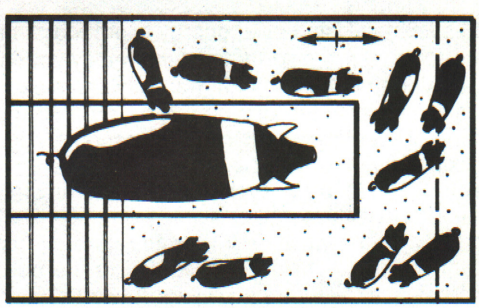


a. Hot water floor heating pipes are shown in the creep areas beside the sow in a solid-floor farrowing system.



b. Electric floor heating cables are shown in the pig creep areas beside the sow in a partially-slotted floor farrowing system.



c. Hot water heating pipe is shown in the creep area in front of the sow in a partially-slotted floor farrowing system.

d. Electric floor heating cables are shown in the creep areas beside the sow in the double partially-slotted floor farrowing system.

Figure 1. Four different typical farrowing crate systems. The floor heating systems in the crates are shown with dashed lines. The arrows indicate the direction of the floor slope.

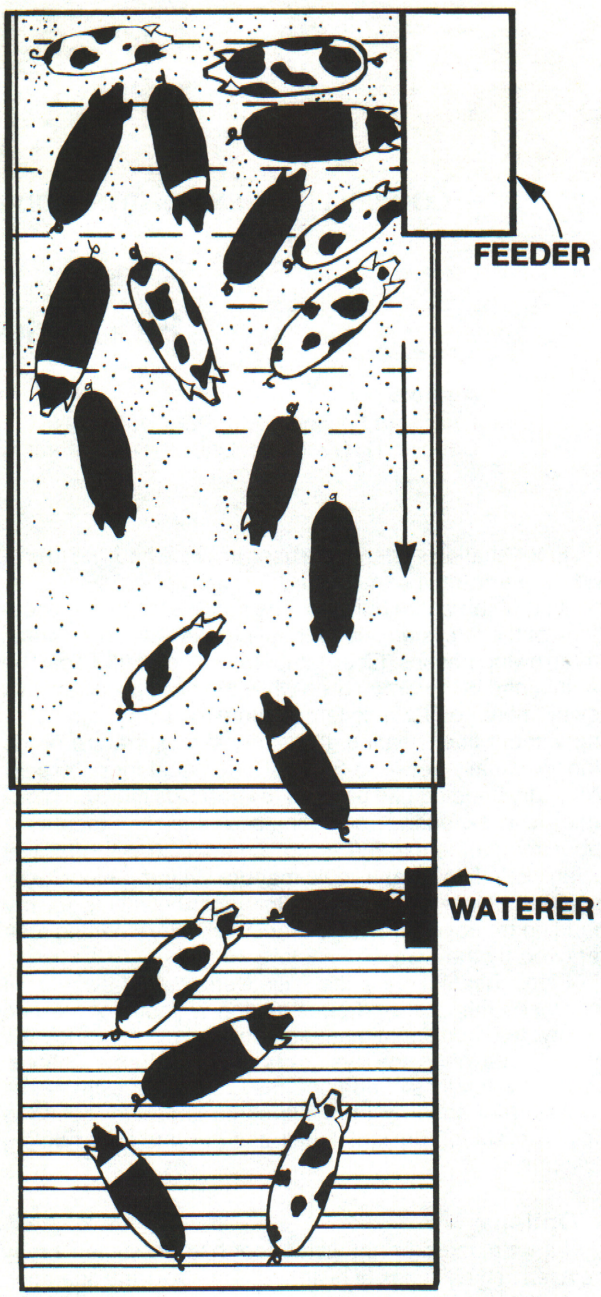


Figure 2. The dashed lines indicate hot water floor heating pipes in the resting area of a partially-slotted floor swine nursery. The arrow indicates the direction of the floor slope.

of heated floor area that should be provided for pigs at given weights are given in Table 1.

Table 1. Heated floor space guidelines for pigs at different weights.

Weight or age	Heated floor space ft.²
Birth to weaning	6-15/litter
Weaning to 60 lb.	1-1½/pig
60 to 125 lb.	2-2½/pig
125 lb. to market	3-3½/pig

Swine producers are finding that hovers at least 1 ft. above the heated floor in a creep or resting area in farrowing or nursery facilities provide an almost perfect temperature for baby pigs. However, *do not expect the floor heating system to provide the total heat requirement of the building.* Supplemental air heat is essential for proper ventilation of farrowing and nursery facilities. *Floor heat alone will not be sufficient for proper operation of the ventilation system.*

Farrowing facilities. Floor heating systems can be used in many types of farrowing facilities. Four typical farrowing crate systems are shown in Figure 1. When creep areas are provided only alongside the sow, as in Figure 1 (a), (b) and (d), it is desirable to heat both creep areas. A heated forward creep area is illustrated in Figure 1 (c) and provides for greatly simplified installation of the floor heating system. The overall building width will be increased, however, to accommodate this system. In all systems, it is important that the proper floor slope be provided, as noted on the sketches. Slope specifications are found in a later section of this fact sheet entitled, "Installation of Floor Heating Systems."

Either electric heating cable or circulating hot water systems may be used in most farrowing facilities. When hot water heat is used, it is best to install the pipe that crosses the sow area at the front of the crate. This positioning minimizes evaporation of urine into the air and does not attract pigs to the rear of the sow where they are more likely to be crushed when the sow lies down. *Heating pipes across the sow area must be insulated* with at least 1-1/2 in. of rigid, non-deteriorating insulation. A special problem is encountered when using hot water heat with the floor plan in Figure 1 (d) because the hot water pipe must pass directly under the sow area. Electric heating cable is better adapted to this floor plan, because it avoids the problem of placing added heat directly under the sow.

Nurseries. Figures 2 and 3 show a heated floor in two typical types of nurseries. The pens shown in Figure 2 are normally 5-7 ft. wide and 10-16 ft. long with the floor sloped toward the manure collection area. The heated floor area can be covered with a hover to provide a better environment for baby pigs. This type system is often used for a dual purpose; in addition to serving as a nursery for weaned pigs, one or two sows and litters may be moved into the pens from farrowing stalls when the pigs are at least a week old. The hovered, heated floor area also serves as a protected creep and allows the overall building temperatures to be adjusted for sow comfort.

Figure 3 shows a nursery pen that is completely slotted except for a small heated floor section that is adequately

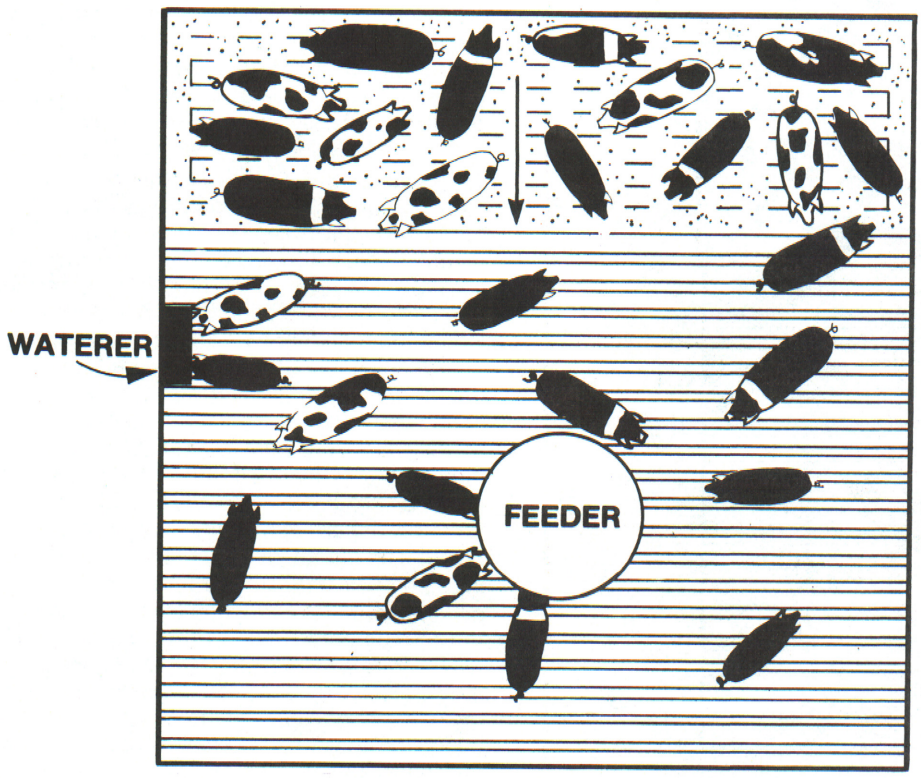


Figure 3. A typical swine nursery pen that is completely slotted except for the sloping, narrow, solid concrete pig-resting area. Electric floor heating cables are indicated with dashed lines. The arrow indicates the direction of the floor slope.

Table 2. Desired floor temperatures, typical hot water pipe spacing, and electric heat requirements for pigs of various ages and weights.

Weight or age	Desired floor temperature, degrees F.	Hot-water pipe spacing, in.	Electric heat watts/sq. ft.
Birth to weaning	75 - 95	12	30 - 40
Weaning to 60 lb.	70 - 75	15	25 - 30
60 to 125 lb.	60 - 70	15	25 - 30
125 lb. to market	50 - 60	18	20 - 25

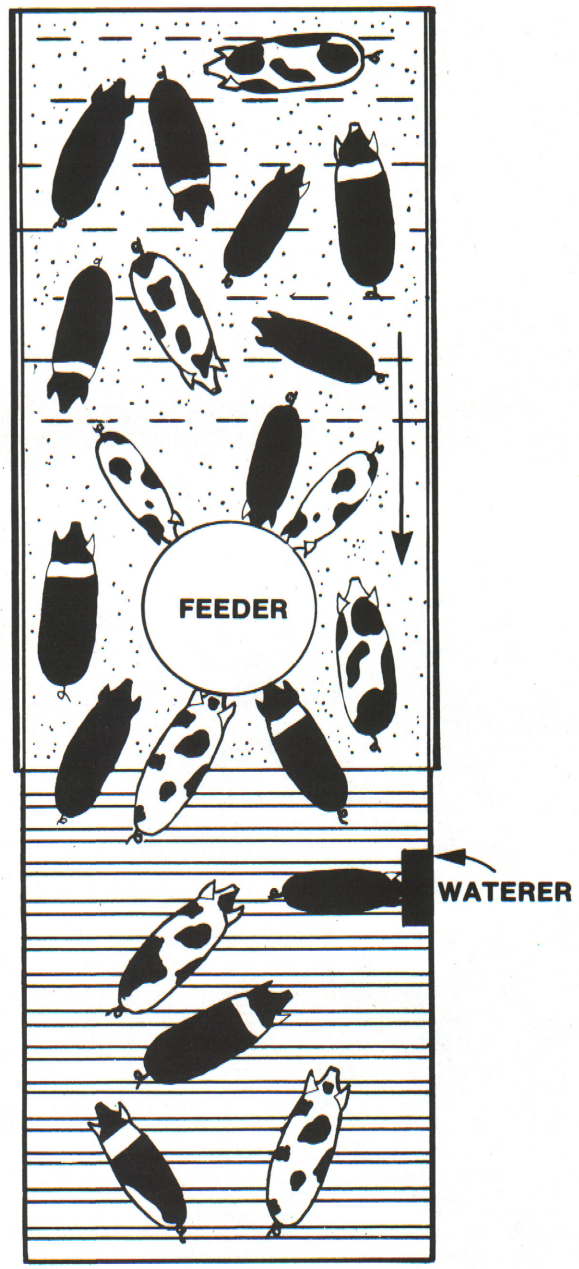


Figure 4. Typical partially-slotted floor swine finishing pen with hot water floor heating pipes shown with dashed lines. The arrow indicates the direction of the floor slope.

sized for a sleeping area (see Table 1). Although the heated floor section is shown adjacent to one pen partition, which could also be next to an alley, it may be located in the middle of the pen if there is adequate structural support. The solid heated floor surface should not be flat, but should slope as indicated by the arrow on the sketch.

Growing-Finishing. There is little research to indicate the exact benefits of floor heat for growing-finishing pigs. In general, less benefit can be expected as the pigs increase in weight. The floor temperatures required for animal comfort also decrease as the pigs get larger (see Table 2). Warming the floor before pigs are moved into the pens can encourage the development of good dunging habits. It can also help minimize the stress on newly-purchased feeder pigs. Floor heat for swine finishing is used only in open-front or modified open-front facilities and should not be installed in environmentally-controlled buildings.

A finishing pen with floor heat is shown in Figure 4. Remember that it is important to provide adequate heated floor area for larger animals (see Table 1). Local winter temperatures, building construction and management practices will also influence the design criteria for floor heating in finishing facilities.

Management. Since sows are most comfortable at an air temperature 30-40 F. lower than that needed for a newborn pig, the farrowing house (or sow-pig nursery) air temperature should be set for her comfort. Adjust the floor temperature to 90-95 F. for the newborn pig. The floor temperature can be lowered about 3-5 F. per week to 70 F. This floor temperature should be maintained for pigs up to 40 lbs.

Although many producers completely eliminate bedding, others find that a little bedding in the farrowing house during the first 24-48 hrs. after the pigs are born improves the pigs' comfort. Similarly, heat lamps supplement the effectiveness of floor heat during the first 48 hrs. At farrowing time, the heat lamp should be at the rear of the sow. After farrowing, place the lamp in the creep area for a day or two to help attract the pigs to this area. Adjust the farrowing house air temperature to maintain sow comfort. This adjustment will lower operating costs and encourage pigs to use the heated floor for their resting area.

Floor heat is also effective during the summer to keep the pigs comfortable and to attract them away from under the sow where they might be crushed. If floor heat is used during the summer, be sure there is adequate ventilation or cooling to keep the sow cool.

Most pigs can be trained not to dung in their resting area, but some pigs are strictly uncooperative. Manure dropped on the heated floor will dry and may accumulate several inches thick if not promptly removed. A dried manure pack not only interferes with the operation of floor heat

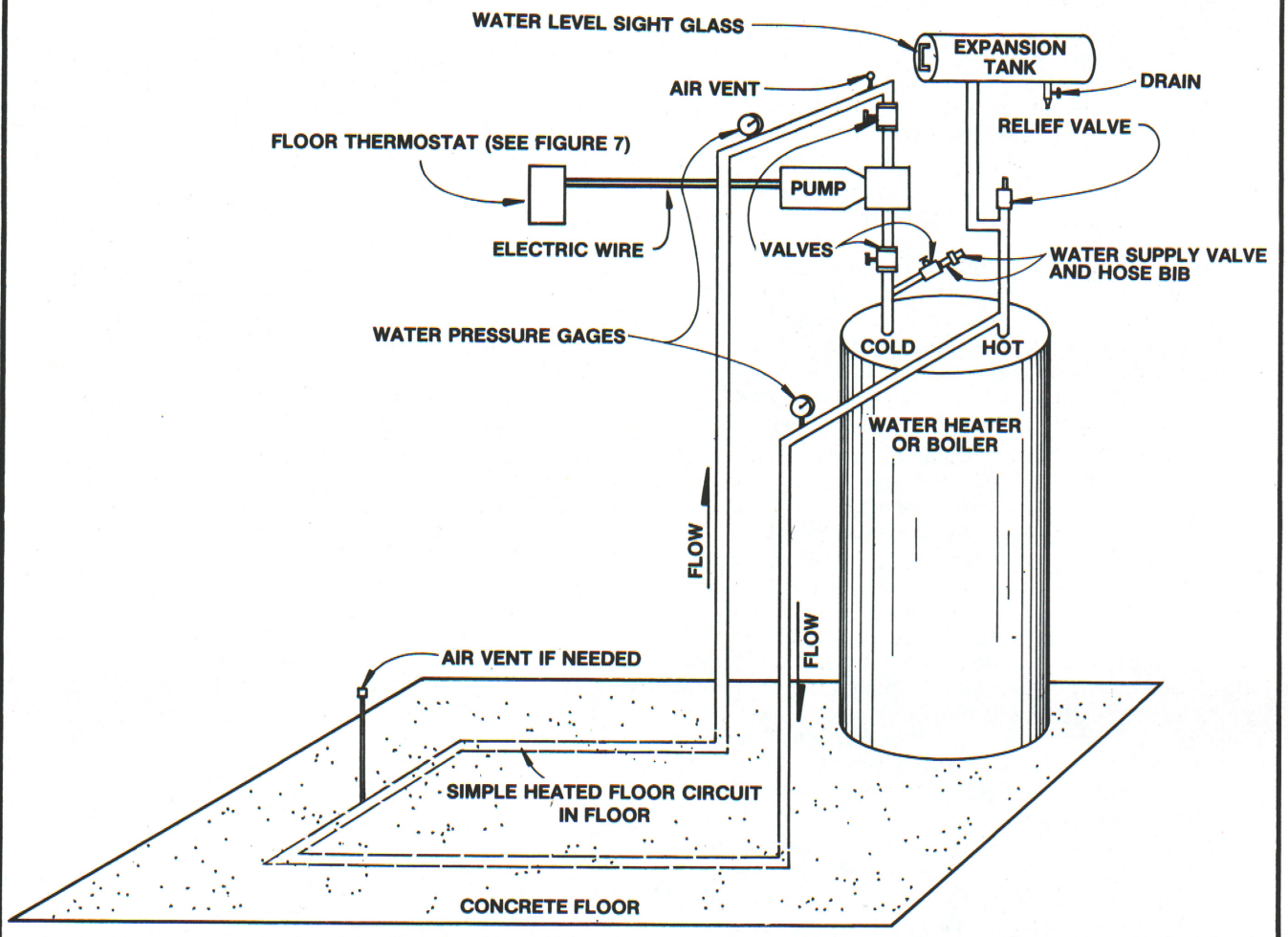


Figure 5. Typical hot water floor heating system with one floor heating circuit shown for simplicity. More than one circuit can be operated from the same heating and pumping system. The air vent shown at the end of the floor circuit is needed only if that end is the highest end of the circuit.

but is also very difficult to remove. It is particularly important that no manure be permitted to accumulate on the floor over the remote temperature sensing bulb of the thermostat.

Hot Water Systems

Equipment. Figure 5 shows the equipment necessary for a hot-water heating system. The source of heat may be a water heater or a boiler. Water heaters are most appropriate for capacities up to about 60,000 BTU per hr. Boilers are used for greater heating requirements. When electric water heaters are used, they must be equipped for fast recovery.

Water is circulated in a closed-loop pipe system. There should be little need for adding water to the system. The valve shown on the water supply line is used to close the system. If water needs to be added, a temporary water connection can be made between a cold water supply and the hose bib. The relief valve, such as those used on home water heaters, permits water to be automatically released in case of excessive pressure. Install the valve outlet so released water will not burn pigs or people.

The expansion tank permits expansion of the water as it is heated in the system. An expansion tank kit can include a sight glass to show the water level in the expansion tank. When water in the system is cool, the water level should be near the bottom of the sight glass; when the desired operating temperature is reached, water will be near the top of the sight glass. The sight glass should be checked periodically to be certain that the system is properly filled.

The expansion tank kit can also include a drain and air vent. A drain is used to remove excess water from the system. An expansion tank should be located at the highest point in the supply line so the air vent can release excess air from the system.

Select a circulating-type pump designed for high-temperature water and continuous duty. The pumping resistance in hot water floor systems will normally be between 5-10 ft. (2-5 psi) of head. Pumps must be selected to furnish the desired rate of water flow at the required head

loss. The total head loss in the floor heating system should be checked (preferably by a heating contractor) to select the correct pump. Operation of the pump and water circulation through the pipes is controlled by the thermostat. The pump should be "ON" when floor temperature is below the thermostat set point.

The valves shown on both sides of the pump permit convenient removal of the pump for servicing without draining the system. Gate valves are preferred because they offer the least resistance to flow when open.

The two water pressure gages are used as a continuous check to determine when the system needs maintenance. One gage is located in the supply side of the system, and the other is on the return side. A new system, operating at optimum conditions, will have a specific difference between the two gage pressures. When the difference in pressure decreases noticeably, it is an indication that the pump is becoming worn or that the system has an air blockage. An increase in the pressure difference indicates that the system is restricted by sediment, an incompletely opened valve or some other obstruction.

The example in Figure 5 shows a single circuit of hot water pipes in the floor. This illustrates that the fluid *must travel* in a complete circuit. More than one pipe circuit may be operated from a single heater and pump system.

Air will collect at high spots in the system. Install pipes on a uniform grade to avoid high and low spots. Manual or automatic air vents must be installed at high spots in the supply-and-return side of the circuit so the collected air can be bled off. An air vent is shown at the end of the example floor circuit farthest from the pump. That vent would not be needed if the pipe *at that point* is level or lower in elevation than the rest of the circuit. If the example pipe loop is essentially level and lower than the water heater, only the air vent shown above the pump and the one on the expansion tank would be needed.

Design Criteria. Each floor heating circuit can be selected to use 3/4-in. diameter pipes. Black iron pipes are most common, but wrought iron or copper can be used. *Do not use galvanized pipe.* If plastic pipe is used, it should be rated for water temperatures up to 160 F.

Arrange *each* floor heating circuit in a farrowing house or nursery to be up to about 200 ft. long. Circuits in finishing buildings may be up to 400 ft. in length. Longer circuits require larger pipe or a higher head pump.

To maintain adequate and uniform floor temperatures, provide a water heater or boiler that will furnish a *minimum output of 50 BTU per hr. per ft. of pipe.* Heat output of a gas-fired water heater will be about 75% of the input rating. The water temperaure for floor heat should be a maximum of 140 F. In farrowing houses and nurseries, the water tempature should not drop more than 10 F. from the supply line to the return line. To achieve this condition, *pumps must circulate at least 1 gal. per min. for each 5,000 BTU per hr.* to be furnished to each circuit. The tolerated temperature drop in heated floors in a finishing house can be greater. Therefore, a pump can be selected to circulate 1 gal. per min. for each 10,000 BTU per hr.

The air expansion tank should have about 10% (0.1) as much liquid capacity as the total liquid capacity of the system. A boiler will normally hold 12-15 gal. of water. A water heater will hold the rated capacity of the heater, 30 gal. for a 30-gal. heater, etc. About 36 ft. of 3/4-inch pipe will hold 1 gal. of water.

Pipe spacing in the floor can be varied according to the type of building and the size of the animals. Table 2 can be used as a guide to determine the appropriate spacing.

Example Calculations. Calculate the size of the major equipment for a hot water floor heating system in a 20-sow farrowing house that has an estimated 20 ft. of ¾ in. floor heating pipe per stall.

Step 1: No. stalls per circuit
= 200 ft./circuit ÷ 20 ft./stall
= 10 stalls/circuit

Step 2: Total pipe length
= 20 ft./stall x 20 stalls
= 400 ft.

Step 3: Floor heat required
= 400 ft. x 50 BTU/hr./ft.
= 20,000 BTU/hr. output

Step 4: Gas-fired water heater size
= 20,000 BTU/hr. ÷ 0.75 (efficiency)
= 26,667 BTU/hr. input

Electric water heater
= 20,000 BTU/hr. ÷ 3,412 BTU/kw.-hr.
= 5.9 kilowatts

(A 30-gallon gas-fired or high-recovery electric water heater should be adequate.)

Step 5: Pumping capacity
= 20,000 BTU/hr. ÷ 5,000 BTU/hr.-gpm
= 4.0 gal./min.

Step 6: Total water capacity
= 30 gal. + (400 ft. ÷ 36 ft./gal.)
= 30 + 11.2
= 41.2 gal.

Step 7: Expansion tank size
= 41.2 x 0.1
= 4.1 gal.

Hot Water Supplemental Heat Systems. Although not common, water unit heaters can be used for supplemental air heat. One hot water boiler can be used for both floor heat and the necessary supplemental air heat. The boiler should be located in a room with fire walls that is separated from the rest of the building and the pigs.

Combination systems have some features that must be carefully designed. For example, 200 F. water is circulated through the air-heating circuits while 140 F. water is circulated in the floor-heating system. Correctly selected, installed and operated pumps and water temperature mixing valves are required for these systems to operate simultaneously.

Start-Up and Operation. Concrete is dense and has a tremendous capacity to absorb heat. It normally requires 2-3 days for a floor to heat up (or cool down). Therefore, turn on the heating system at least 2 days before the time it will be needed.

For maximum trouble-free system operation, first clean and flush the system with clean water. Then fill the system with soft water that is low in chloride and sulfate ions. Use corrosion-inhibiting ethylene glycol antifreeze to protect the system against freezing if it is shut down during cold weather. Check the concentration of the inhibitor according to the recommendations of the ethylene glycol manufacturer. If antifreeze is used, it should reduce the freezing temperature of the solution to 20 or 25 F. above the lowest temperature expected in your area. To lower the freezing

temperature in the system down to 0 F. would require about 30% (0.3) of the total solution volume to be ethylene glycol. In the previous 20-sow farrowing house example, 12.4 gal. (41.2 gal x 0.3) of antifreeze would have been needed to achieve a 0 F. freezing point.

The entire hot water floor heating system should initially be pressurized to about 5 psi. Always operate the system under pressure so that air will not be drawn into the lines if a leak should develop. After the floor is warm, make final adjustments such as balancing the temperature in each circuit and bleeding all air from the air vents. Record the difference between the pressure gage readings for future reference to check the system. Expect extra attention during the first season until you become familiar with the characteristics of your particular system.

When the floor does not need to be heated, adjust the pump thermostats downward, and leave the rest of the system unchanged. Operate the pump at least 15 min. each week to minimize sedimentation which can block the lines. If blockage does occur, attach a pressurized water supply to flush the system. Vent air from the system following each shutdown and startup.

Electric Floor Heating Systems

Equipment. Electric heating cables provide a fairly inexpensive and easily controlled floor heating system. The cables operate at relatively low temperatures. If properly installed, they rarely burn out and should last for years with no maintenance.

The cable used should be approved by its manufacturer for installation in concrete in livestock buildings. The type of heating cable most commonly used is covered with polyvinylchloride (PVC), which is usually rated from 2-7 watts per linear ft. Lead-sheathed and silicone rubber heating cables may also be used. They are normally rated at 7-10 watts per linear ft.

Design. The heating cable must be correctly spaced to provide the right amount of heat. Prefabricated blankets or pads are available in various sizes and wattages to simplify installation. Follow the guidelines in Table 2 to select the correct wattage per sq. ft. for the animals involved.

Swine buildings built for electric floor heat should have a properly sized 240-volt, 3-wire service entrance. A 100-amp service entrance is usually considered the minimum size for buildings with electric floor heating systems.

All stalls controlled by one thermostat should be on a No. 12 wire, 120-volt circuit protected with a 20-ampere fuse. There should be a maximum of four or five stalls on each circuit.

Above-Floor Heating Pads. Several types of above-floor electric heating pads are also available for use on either solid concrete or slotted floors. These systems are best suited for use in farrowing house creep areas. They should provide at least 90 F. but no more than 95 F. surface temperatures when the farrowing house air temperature is about 60 F.

Durability should be a major consideration in selection. Sows and larger pigs may chew and damage these pads. Take special precautions to isolate all electrical leads from the animals. Anchoring the pads in place will help minimize damage.

Despite the disadvantage of limited durability, the above-floor pads can be a good alternative for totally-slotted or existing floors that do not have an in-floor heating system. Since most above-floor heat pads deliver a fixed amount of heat, many producers use them only as a temporary heat source for newborn pigs and remove the pads when the pigs are a week to 10 days old.

Installation of Floor Heating Systems

A good heating or electrical contractor is very valuable in helping with the final equipment selection and the installation of a floor heating system. Keep in mind that the contractor may have had most of his experience with residential or commercial applications, some of which have different requirements than swine buildings. Specifically, systems for swine use 140 F. water and a 10 F. temperature drop instead of the 200 F. water and 20 F. temperature drop typically used in residential and commercial systems.

Under all floor heating systems, use a base of 4-6 in. of compacted fill sand. Place a 4- to 6-mil plastic vapor barrier over the fill sand. Rigid insulation, such as 1-2 in. of polystyrene, installed between the vapor barrier and concrete floor, will minimize downward heat loss. *Perimeter insulation should also be used and is especially important when the heated floor is adjacent to the foundation.* See PIH-65, "Insulation in Swine Housing" for information on perimeter insulation.

Floor Construction. Since the correct shape and finish of the floor is essential, a person skilled in working with concrete is needed. Heated floors should be sloped so liquids and manure move away from the heated area. Farrowing and finishing buildings usually have floors sloped about 1/2 in. per ft. and nursery floors are sloped about 3/4 in. per ft.

Rough surfaces restrict floor drainage and contribute to severe skinned-knee problems with baby pigs. The surface need not be a glass-smooth finish but should be properly troweled to eliminate rough surfaces. Concrete above hot water pipes or electric heat mats should be of uniform thickness to prevent hot spots. Do not use the floor heating system for at least 2 wks. after the concrete is poured.

Figure 6 shows a typical installation of two heating pipes covered with 2½ -3 in. of concrete. *Always pressurize the completed pipe circuits with water to check for possible leaks before any concrete is poured.* Leaving the pipes filled with water helps to hold them in place while pouring the concrete cover.

Electric mats should be completely wired and tested before any concrete is poured to be certain there are no short circuits or poor connections. While pouring the 1½-2 in. of finish concrete over the mats, *be certain that each wire is surrounded by concrete* so heat will be conducted away from the wires. *Do not staple heating cable to insulation boards.* If any of the wires are surrounded by air or are resting on insulation, they will become excessively hot and eventually burn out. Never cross or shorten the length of the heating wires. Figure 6 also shows the proper installation of an electric floor heating system.

Installation of Temperature Controls

Figure 7 is an example installation of a thermostat with a remote temperature sensing bulb used to control floor temperatures. The sensing bulb and the connecting tube should be installed in a conduit attached to the wall (or to a post) so that the thermostat and sensing bulb can be removed for maintenance. Locate the temperature sensing bulb about 1 in. below the surface of the heated floor and 4-6 in. from a heat pipe or electric resistance wire. The bulb should be located so that pigs cannot lie directly over it. Close to, directly under or just outside of pen partitions are good locations. The bulb and the connecting tube to the thermostat must be filled with a fluid that reacts properly to the temperature range at the sensing bulb location. Manufacturers should include such information with their control.

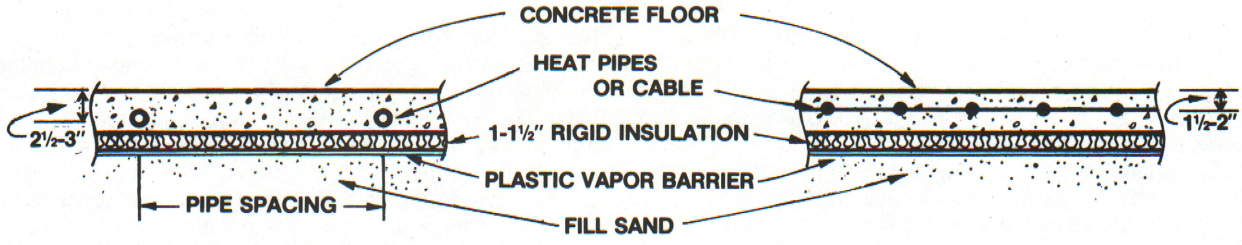


Figure 6. Typical cross-sections of concrete floor heated with both hot water pipes and electric cables. See Table 2 for correct pipe spacing or electric floor heating density. Note that the heat pipes and electric heating cables are not directly on the insulation.

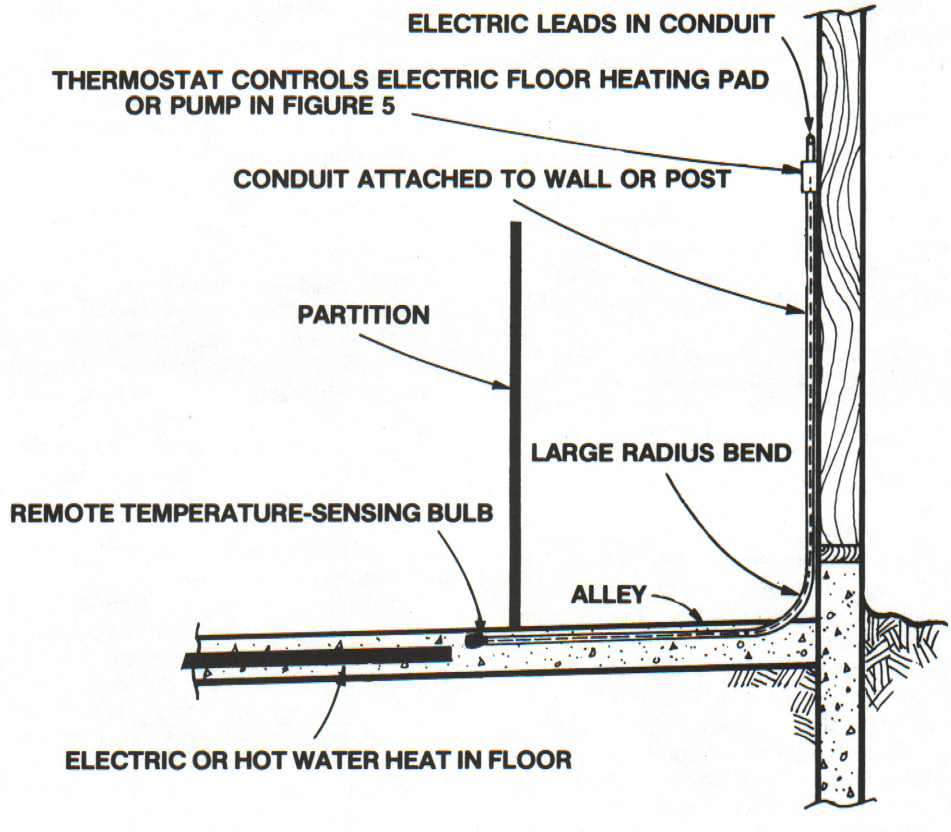


Figure 7. Typical floor temperature-sensing thermostat installation.

The thermostat must be wired close to the electric circuit to start the circulation pump or to turn on the electric floor heating pads when the temperature drops below the set point.

Summary

A well-planned, properly-installed floor heating system can be a beneficial management tool. Little maintenance should be required. Some important points to remember are:

1. Provide both the right amount of heat and the correct amount of heated floor space for the size animals involved.
2. Do not try to provide the total building's heat requirements with a floor heating system.
3. Trowel concrete floors, and slope heated areas to provide drainage.
4. Locate the heated area in the pigs' resting or sleeping area.
5. Install perimeter insulation around the building.
6. Select durable equipment rated for continuous operation in moist and corrosive environments.
7. *Install systems carefully!* Mistakes are difficult to correct after the concrete is poured.

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