Pork Industry Handbook: Building Materials and Equipment for Swine Facilities

Michigan State University
Cooperative Extension Service

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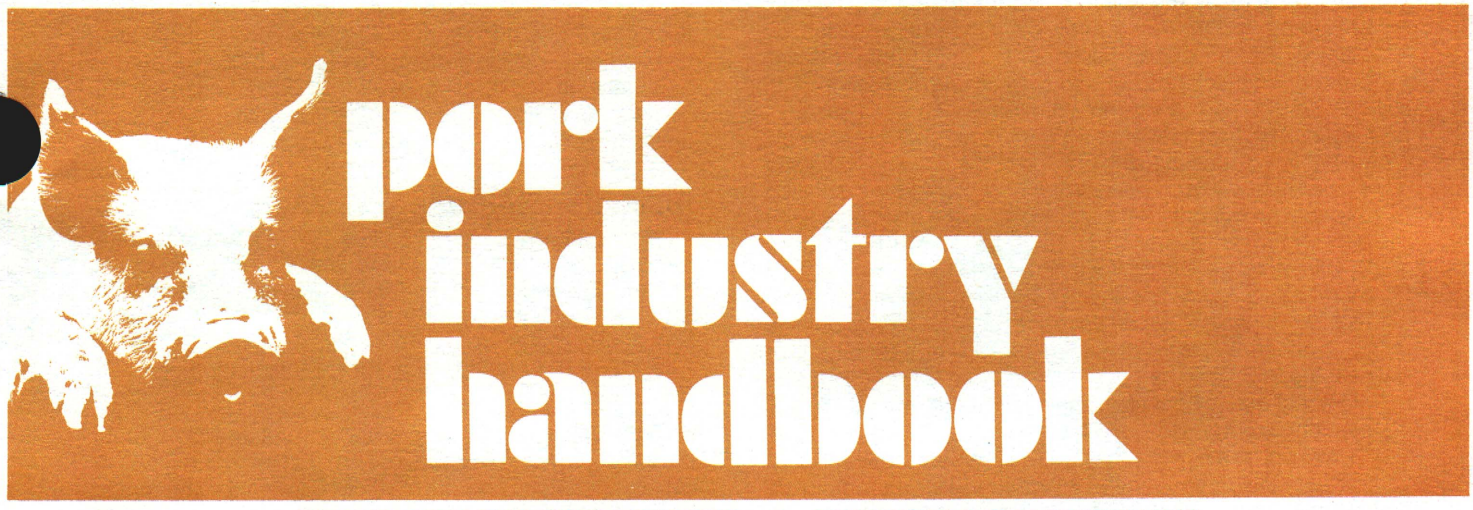

COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

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Producers who have invested in new swine facilities are often disappointed by the severe deterioration of their facilities after just a few years of use. Much of the deterioration could have been prevented if the producer had taken into account—during planning and selection of materials for the new facility—the corrosiveness of the environment within the facility and the pigs' destructive nature. These problems are generally more pronounced when pigs are crowded in confinement facilities but can occur in all types of units. The greatest and most rapid deterioration takes place near the floor because of wetness, chemical corrosion and physical destruction, but the effects of a corrosive environment can also be observed elsewhere within the building, especially on unprotected metal. The latter point is particularly characteristic of facilities with a poorly designed ventilation system (See *Pork Industry Handbook* Fact Sheets on ventilation.)

When planning your building, select materials that are corrosion-resistant and durable enough to withstand the rugged pushing, rubbing and chewing activities of the pigs. Materials within the building but outside the pens are not as vulnerable to physical deterioration, such as caused by chewing, but can have a relatively short life because of corrosion. If alleys are to be used for hog movement, the materials along the alleys will be subjected to some physical abuse from the pigs besides that resulting from moving equipment along the alleyways. Consequently, care is necessary in selecting equipment and materials regardless of their intended use or location.

Floors

Manure acids corrode concrete. Thus, a good, high-quality concrete mix is necessary. As a minimum, solid floors should be made from a mix which will yield a 3,500-psi concrete (maximum of 5 gal. of water per bag of cement). It is also recommended that air entrained concrete be used for all installations where the concrete will be subjected to freezing temperatures. For further protection, the concrete can be coated with a more corrosion-resistant material such as Agri-500® or Duratroff®. Another alternative is to place a lower strength, less expensive concrete as a base and then add a higher strength concrete over the top as a wear surface. This approach can work quite satisfactorily where a layer of concrete is placed and rough graded, then a steel reinforcement mesh is placed, and, finally, a finish layer of concrete. The savings in material cost should be evaluated in light of possible inconvenience during placement of the concrete and/or higher labor costs.

If other floor finishes such as slats are to be used, they should be designed for corrosion resistance as well as strength. Where rubber mats are used, as in a farrowing facility, it is generally best to select a style with rubber lugs on the back. The mats should be placed in the fresh concrete and worked enough to assure full contact on the back. Additional flooring design details can be found in *Pork Industry Handbook* Fact Sheet 10, entitled "Swine Farrowing Units."

Walls

Concrete and wood-frame are both satisfactory for exterior walls. A choice should be made after considering both first cost and maintenance costs when exposed to normal conditions expected within the facility. Consider also the work required to provide openings in the wall, such as for ventilation.

Concrete is one of the most durable materials for use in walls that are subjected to animal and equipment contact. However, concrete has little thermal insulating value. Where warm interior temperatures are to be maintained, as for a farrowing or nursery facility, additional insulation is recommended. In cold climates additional insulation is desirable also in growing/finishing buildings to retain animal heat. In milder climates, concrete walls without insulation are satisfactory for some phases of a hog production installation.

Sandwich panel construction has been found to be an effective means of providing a durable interior and exterior

surface and, at the same time, improving the thermal efficiency of the wall. Sandwich panels are formed by placing a foam board insulation material within the wall during casting of the concrete. This can be done either with cast-in-place walls or precast, tilt-up panels.

Another alternative which can be used where animals do not have access to the outside of the building is to erect a concrete wall and apply a spray-on urethane insulation material on the outside. In such cases, the insulation must be painted or otherwise protected to retard destruction by ultraviolet light from the sun. As with all foam insulation materials, a fire risk is involved with this technique. The risk, however, is reduced because the insulation is outside of a concrete wall. For added protection and still lower risk, the foam can be covered with ¼-in. layer of spray-on plaster or gunite concrete. The result is a durable, thermally efficient, stucco-like wall.

Wood-frame walls may be of either conventional stud frame or pole construction. In either case, where animals do not have access to the wall, a wide range of materials is available for enclosing the frame. Among the materials which have been used successfully are ribbed steel or aluminum, composition boards such as particle board or hardboard, plywood and boards. As with the basic wall construction, both initial and maintenance costs, as well as useful life, should be considered in deciding on the material to use.

With either type wall—stud or pole—thermal insulation can be added easily so long as appropriate construction plans are followed, such as planning stud or girt spacings to accommodate standard widths of insulation materials. As with exterior coverings, the range of insulation materials is broad and includes fiberglass blankets, pour insulation, foam boards and spray-on foams. Regardless of the insulation material chosen, an interior protective covering is necessary.

Where walls are exposed to personnel only and will not be subjected to hog contact or vehicular traffic, the choice of interior covering materials would include the same materials as for exterior surfaces plus such materials as asbestos-cement board. The brittleness of asbestos-cement board makes a solid sheathing underlying it necessary.

The potential for both vehicular traffic and animal contact at some time during the life of a facility makes the use of the more durable interior coverings desirable. For occasional contact such as along alleys used for hog movement, ribbed sheet metals, plywood, wood boards and composition boards are good choices. For continual contact, as in pens, the use of solid coverings—hardwood, steel sheets or panels, or fiberglass-impregnated plastics such as Glasboard® or Kemply®—is recommended. Work at Iowa State University indicated that porcelain-on-steel and stainless steel panels also effectively withstand corrosion and abrasion. Some aluminum alloys show promise of providing the desired characteristics.

On wall areas above the reach of the animals (usually considered to be about 4 ft.), most common building materials can be used. However, since sanitation is important in a swine building, these lining materials should be nonporous and durable enough to withstand cleaning with water discharged from a high-pressure cleaning system.

Ceilings

The main requirements for a ceiling material are cleanability and corrosion resistance. Like wall sections above the hog contact areas, most common building materials can be used. Although they are somewhat limited in their ability to withstand washing with a high-pressure cleaning system, vinyl-clad insulation boards have been used successfully.

Since roof trusses are usually spaced 4 ft. on center, the cost of any additional nailers required for installation of a particular ceiling product should also be considered as part of the ceiling cost. Materials such as ribbed metal can be attached directly to truss chords without additional nailers.

Insulation and Vapor Barriers

Where insulation is to be used, select it by considering not only its purchase price but also its installation cost, required coverings, and thermal effectiveness. In measuring thermal effectiveness, it is recommended that insulation or "R" values as given by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) be used (see Table 1).

The high moisture levels and the related high vapor pressures in swine facilities require that appropriate vapor barriers be used. These are needed to reduce the movement of water vapor through a wall or ceiling. Allowing water vapor to move into a wall will result in condensation within the wall or ceiling assembly. The condensation will result in a reduction of thermal efficiency and possible destruction of the insulation material. In general, a plastic (polyethylene) vapor barrier should be used with all insulation materials for, even with vinyl-clad foam boards, it is impossible to maintain all joints in a water vapor-tight condition. In all cases the vapor barrier should be located on the warm side (inside) of the wall or ceiling just outside or behind the interior covering.

Figure 1 illustrates the procedures for determination of the R value for a concrete block wall using the data in Table 1. Figure 2 shows how to calculate the R value of a ceiling.

Figure 3 indicates in a general way the insulation zones in the United States. An insulation value of R=14 in walls and R=23 in ceilings is suggested for heated buildings in a cold zone. Values can be lower in the mild zone but should be no lower than R=9 in the walls and R=12 in the ceiling. In all cases, local weather records and standard construction practices for similar facilities should be considered.

Mice and other rodents can seriously damage insulation and appear to be impartial as to the type of insulation material they destroy. If ribbed metal is used for inside wall linings, the end openings of the ribs should be closed to discourage the entrance of rodents. A good rodent control program is essential since they seem to find any small openings into the wall cavities. It is also important to recognize that birds are attracted to many types of spray-on insulation materials. Field experience has shown that birds, like rodents, are not partial to a particular insulation material. In some cases insulation is consumed directly as food, while in other cases it is used as a nesting location, a material for nest building at a remote location, or simply something to play with to pass the time. Consequently, an effective bird control program should also be a part of the building plan.

Pen Partitions

Pen partitions must be durable enough to resist rubbing, chewing and pushing by pigs, and, at the same time, to resist the corrosion of the environment and manure that comes into contact with them. The choice of materials depends partially on whether open or solid partitions are used and whether the partition is permanent or must be movable. Partitions are generally not insulated.

The durability and general corrosion resistance of concrete makes it an excellent choice for partitions (minimum of 2500 psi—7 gal. water per bag of cement—concrete is recommended). Concrete blocks, cast-in-

Table 1. "R" values and water vapor transmission characteristics for selected materials.

Material	"R" value per 1-in. thickness	"R" value per Thickness noted	Water vapor transmission Permeability* (perm-inch)	Water vapor transmission Permeance† (perms)
Fiberglass	3.5 approx.		116	
Rockwool	3.30		116	
Vermiculite	2.27		---	
Polystyrene	3.57-5.6		1.2	
Urethane	6.25		0.4-1.6	
Urea-tripolymer foams	4.48		16	
Urea-formaldehyde foams	5.0		32-38	
Fiberboard sheathing	2.5			
4" concrete masonry		0.71		
8" concrete masonry lightweight		2.00		
8" concrete masonry		1.11		2.4
12" concrete masonry lightweight		2.27		
12" concrete masonry		1.28		
4" CIP or precast concrete		0.32	3.2	
6" CIP or precast concrete		0.48	3.2	
8" CIP or precast concrete		0.64	3.2	
1/4" plywood (exterior glue)		0.31		0.7
1/2" plywood		0.62		
Hardwoods	0.91			
Softwoods	1.25			
Particleboard (medium density)	1.06			
1/8" hardboard:				
standard		0.17		11.0
tempered		0.12		5.0
1/8" cement asbestos board		0.03		0.54
Polyethylene:				
4 mil				0.08
6 mil				0.06
8 mil				0.04
10 mil				0.03
Single pane glass		0.04		
Double pane welded glass		0.87		
Single pane with storm window		0.94		
Air film:				
Outside, 15 mph wind		0.17		
Inside, still		0.68		
Inside, moving, due to ventilation inlets		0.17		
Air space:				
3/4"		0.87	120	
4"		0.95	120	

*Permeability is the rate of moisture movement through an inch of the material.
†Permeance is the rate of moisture movement through the thickness noted.

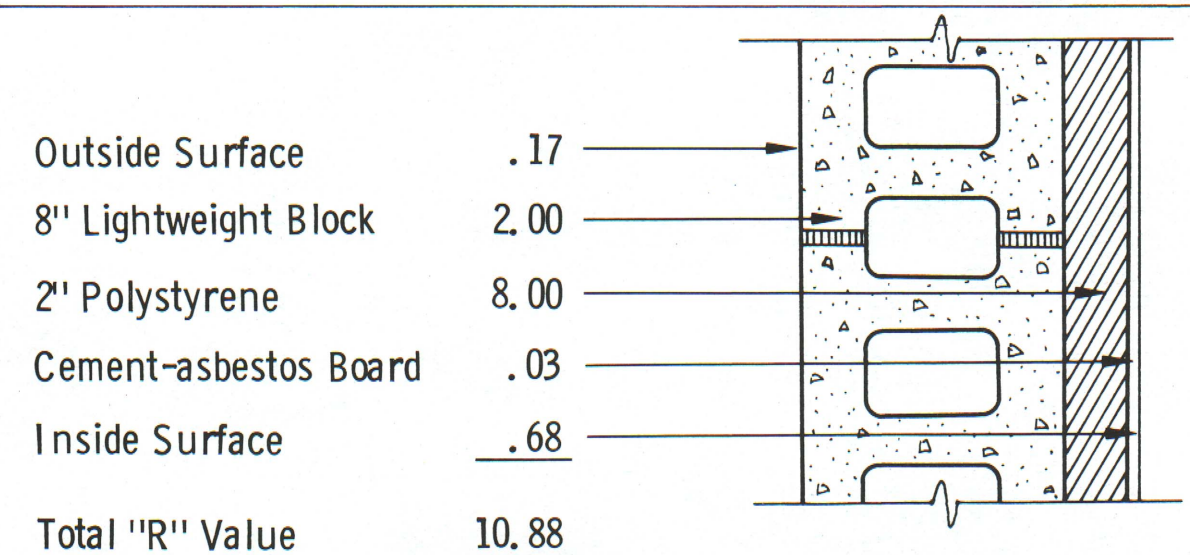

Figure 1. Insulated masonry wall. Omitting polystyrene foam insulation would reduce insulation R value to 2.88. This masonry block wall with only the cores filled with vermiculite provides a total R of 5.88.

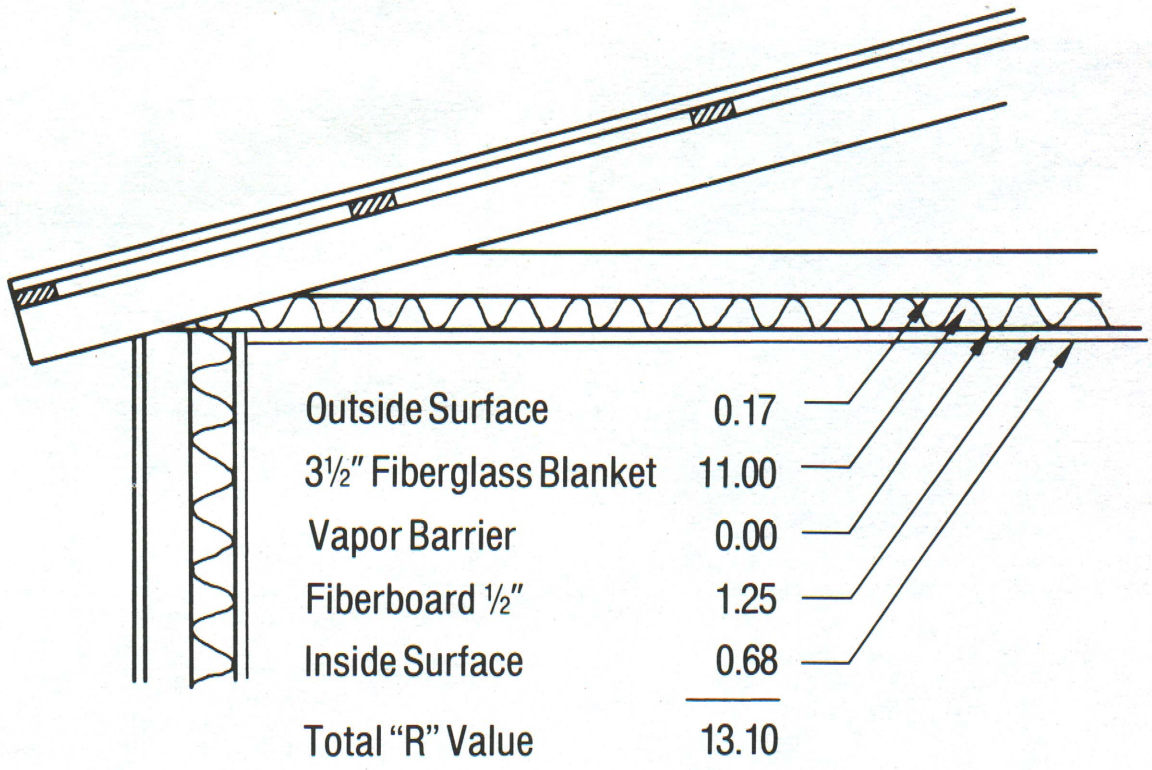

Figure 2. Insulated wood frame ceiling. Reducing the insulation to 1½ in. of fiberglass blanket reduces the ceiling R to 7.35. Changing ½ in. fiberboard (1.25 R) to ½ in. plywood (.62 R) and using only 6 in. of rockwool insulation (19.80 R) increases the ceiling R to 21.27.

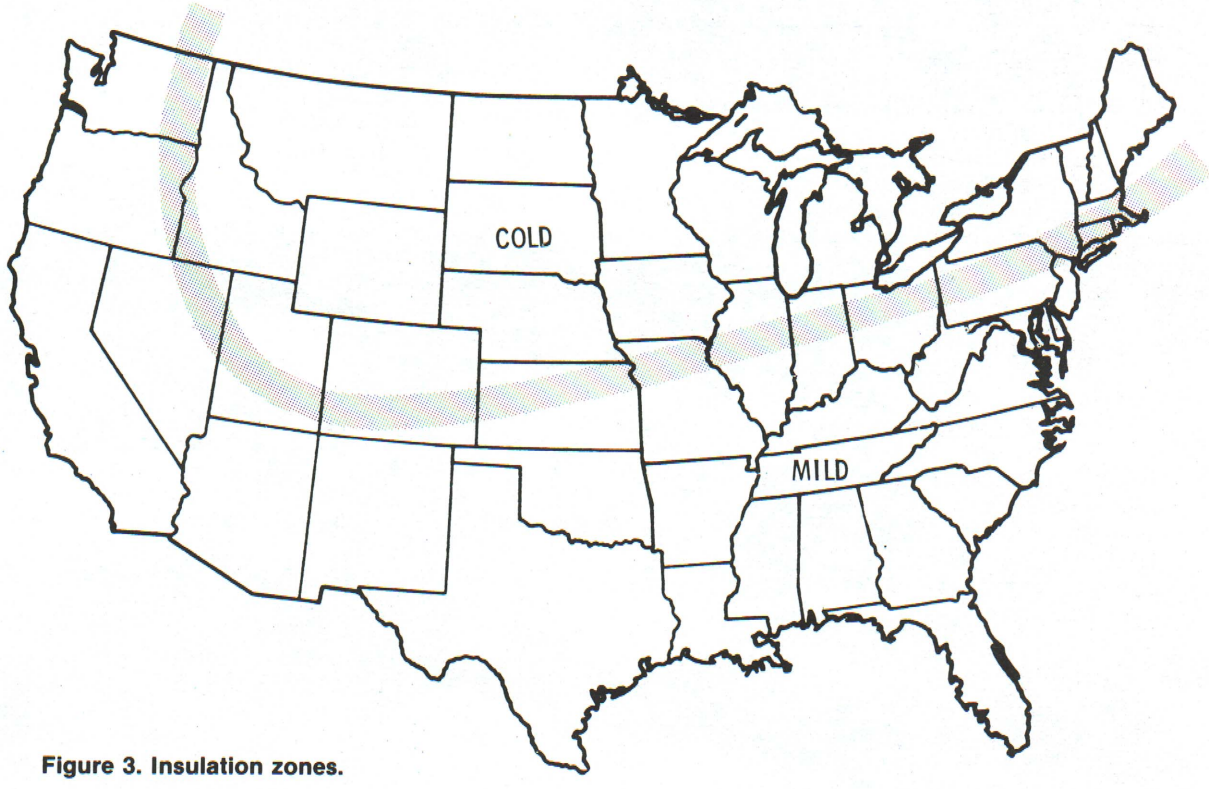

Figure 3. Insulation zones.

Figure 4. Concrete block partitions on the solid portion of the floor with open gates over the slats.

place concrete or precast concrete panels can be used (Fig. 4). As with exterior walls, steel reinforcing bars or mesh should be a part of all concrete partitions to afford greater strength and to fasten partitions securely to the floor. Where a partition must be movable or where an open partition is used, precast concrete "rails" have been satisfactorily used.

Some woods such as oak and southern yellow pine have lasted fairly well when used as pen partitions. A key requirement with wood is to assure that pigs are restricted from getting started chewing. This can be achieved by using tongue-and-grooved planks or wall-matched planks to reduce access to edges where chewing can start. Softwoods will probably have a useful life of 2 years or less. Hence, their use should be restricted to temporary shelters. As with exterior walls, the life of partitions can be extended by overlaying the basic wood partition with such materials as fiberglass-reinforced plastics, steel sheets or mesh. Where wood is in contact with the floor, ground or generally wet conditions, the use of pressure preservative-treated lumber is recommended for a longer useful life.

Both solid steel sheets and open welded wire mesh have been used successfully for pen partitions. The most common steel panels use vertical rods or tubing. The life of these materials depends on how well they can resist corrosion and flexing due to pushing by the pigs. To reduce the maintenance of partitions and the incidence of damage to pigs, all joints must be securely welded and protected from corrosion. Plain steel panels can be fairly satisfactory if well protected by a long-lasting coating. Unfortunately, the abrasive action of hogs wears away rather rapidly most post-installation coatings such as paint or epoxy. Also, once corrosion starts, it tends to work under the remaining coating and lift it away. Hence, the use of hot-dipped galvanized or porcelain coatings is recommended on all metal surfaces accessible to the pigs. Stainless steel is more expensive but might be worth the additional cost in permanent structures subjected to intensive use.

Roof Coverings

The most common covering materials used are plain or painted ribbed aluminum or galvanized steel sheets and asphalt shingles. The use of corrugated asphalt materials such as Onduline® is also increasing for both wall and roof coverings. All of these are satisfactory if good quality materials are purchased and properly applied.

Figure 5. Zinc Institute grade stamp.

With galvanized steel, the use of sheets bearing a Zinc Institute, Inc. grade stamp is recommended. Exposure studies at The Pennsylvania State University revealed that sheets with a 2-oz. zinc coating (Fig. 5) and a "Seal of Quality" grade stamp required 15 years of exposure before the first signs of rust. Sheets with a 1.25-oz. zinc coating began to rust after 7 years. Sheets with less zinc per square foot than these industry standards are available at a lower cost and will have a correspondingly shorter life before the first signs of rust. It is not possible to determine the amount of zinc coating by visual inspection. Even where baked-on enamel finishes are used, the heavier zinc coatings should be used.

Bear in mind that galvanized steel is sold on the basis of thickness or gage. Gages most commonly available are 28 and 29. Lower gage numbers indicate greater thickness. Success has been good with both gages. A choice should include consideration of required roof design loads in the area and the load-carrying capacity of the roofing sheets. Manufacturers' literature and local codes can provide the required information.

In selecting aluminum roofing sheetings, the ease of installation should be considered. The use of high-strength alloy sheets of less thickness might be a disadvantage since their greater brittleness tends to cause them to split rather than dent if hit too hard or stepped on improperly.

Avoid the use of extremely long sheets because of changes in length with variations in temperature. This results in tearing out of nail holes or bending or extraction of nails or other fasteners. Fewer roof leakage problems are generally experienced where the length of roofing sheets is kept at 24 ft. or less. To prevent corrosion of metal roofing through galvanic action, it is imperative that the correct kind of fasteners be used with each kind of metal and that galvanized and aluminum sheets not be placed in contact with each other. Where it is necessary to mix galvanized and aluminum products, they should be separated by a non-metallic intermediate material.

If fiberglass-reinforced plastic sheets are to be used for light, care should be exercised during installation to assure a good seal. A bead of good quality sealant, such as polyurethane or silicone, should be run around all sides and all holes should be pre-drilled to reduce splitting. Except on very wide buildings—over 60 ft.—it is recommended that such skylights be eliminated from the roof and placed in the sidewall instead. On buildings over 60 ft. wide, a combination of sidewall translucent panels and skylights near the ridge of the roof should be used. Another alternative is to use translucent panels to enclose the ends of the building.

The use of at least 235-lb. asphalt shingles is recommended for all permanent structures. Self-sealing tabs are a good investment.

Regardless of the roofing material used, the limitations of its use as related to roof slope should be recognized. Table 2 lists recommended minimum roof slopes for several common roofing materials.

Table 2. Minimum recommended roof slopes for selected roofing materials.

Material	Slope (minimum)
Ribbed metal	3:12
Asphalt shingles	4:12
Roll roofing	3:12
Double coverage roofing	1:12
Corrugated asphalt	3:12

Plumbing

Because of the corrosive atmosphere within swine facilities, metal pipe should be used with caution. Copper pipe usually has a short life when exposed in a swine building. If galvanized or black iron pipe is used, some type of coating should be applied at the threads since this part of the pipe is most subject to deterioration and failure. PVC or similar plastic pipe is probably the most suitable for a swine building environment.

In warm facilities, plumbing can be run overhead to reduce contact with animals and manure. Although overhead pipes can be used in cold buildings, such placement requires use of electrical heat tape and pipe insulation to prevent freezing. Consequently, in cold facilities the use of underground plumbing is recommended. Where pipes are brought to the surface, they can be run through a larger diameter plastic pipe to reduce corrosion and provide easier maintenance.

In cold facilities, built-in heating units are suggested where cup waterers are used. Nipple waterers generally do not require additional freeze protection beyond that provided on the pipe up the nipple. In all cases, a durable high-strength cover is required over pipe insulation and heat tape to reduce damage by pigs and reduce the potential of electrocution of pigs. Adequate grounding of all electrical equipment is an absolute MUST. Good-quality waterers should be selected to reduce maintenance costs, extend the useful life of the waterers and reduce water usage and manure hauling costs resulting from leaking valves.

Electrical

This may be the most critical component of a swine building since corrosion can create conditions that increase the risk of fire and electrical shock. Electrical materials installed inside a swine building should be designed for damp or wet locations. Thin-wall metal conduit has a short life. Fittings, outlet boxes and switches not designed for waterproof locations may create an unsafe condition after several years. If conduit is used, it should be plastic. Type UF cable with waterproof fittings is another option. If at all possible, locate the entrance box in a dry annex or office room to avoid rapid corrosion. In cold climates, problems can be reduced if all conduit is installed within the warm part of the building. When conduit extends from the warm building up into the cold loft or attic, condensation can occur and the resulting moisture can move back to a fitting and cause corrosion or shorts. If a pressure ventilation system is used, be sure that no moist, corrosive air can be pushed into electrical boxes.

As noted in the discussion on plumbing, grounding of all electrical equipment is a MUST. This applies to all switches, receptacles and appliances since wet floors increase the continual threat of shock and possible electrocution of both personnel and animals.

Feeders

A low-quality feeder doesn't survive long in a hog house. The increased moisture level near the floor speeds up corrosion. The activity of the pigs causes rapid wear. The upper part of the feeder may last more than 10 years, but this helps little if the bottom has failed.

When purchasing a metal feeder, look for stainless steel or cast iron bottoms. Wood feeders are improved by covering the wooden trough with a more durable material such as fiberglass or metal.

As with plumbing and electrical lines, the running of feed conveyance equipment through a ceiling should be minimized to reduce the risk of moisture migration and the loss of heat.

Ease of adjustment in a feeder is as important as durability. If a feeder cannot be easily adjusted to prevent feed waste, it can easily cost its owner many times its replacement value.

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