Many surveys show that 10 to 20 percent of all replacement heifers die before they reach six months of age. Many of these losses can be directly attributed to inadequate housing and improper ventilation of the housing provided for replacement heifer programs. At the present time, economics favor dairymen who raise their own replacements compared to dairymen who buy springing heifers. The importance of providing proper facilities for raising dairy calves in order to control diseases and reduce early death losses cannot be overemphasized.

**TYPE OF HOUSING**

Calf housing may be of either a "cold" or "warm" type. The "cold" type may consist of stalls, sheds, etc., that are well bedded and free of drafts, though they must have adequate natural fresh air ventilation. The "warm" type requires an insulated building with fan ventilation and a supplemental heating system. The dairymen can do a good job in Kentucky with either type of facility if he understands the calf's needs and operates the building accordingly.

Cold Housing:

The "cold" type building, as represented by Figure 1, may be a converted shed or similar space that is already available. The added investment in this arrangement may be quite small, but more labor and management are needed to properly care for the calves, especially during sub-freezing temperatures.

In a "cold" type barn the important factor is to keep the calves clean, dry, and out of drafts. Calves do not seriously suffer from a cold temperature if kept dry and out of drafts. Properly bedded pens in a building where cracks or openings are sealed to prevent drafts on the calf satisfy the minimum requirements. Manually-operated windows or vent panels high up in the sidewall or eave and ridge openings, as shown in Figure 2, are acceptable. The temperature of the "cold" type housing is not controlled but usually follows outside conditions. Do not try to close or seal the building too tightly as moisture will increase and may lead to respiratory diseases. Exposed metal roofing or siding is not desirable, because condensation will occur more readily.

"Cold" facilities may require some local radiant heat (heat lamps, infrared heaters, radiant gas units, etc.) for very small, weak, or sick calves. Suspend the heaters above the calves where they cannot reach or damage the devices.
as shown in Figure 3. Use the heat for the first week on extremely weak calves or in real cold weather.

Figure 3: Suspended infrared heater for extra warmth and dryness of calves in "cold" type housing.

Warm Housing:

In "warm" or "environmentally controlled" calf housing, as represented in Figure 4, more environmental "mechanization" is substituted for the labor of bedding and ventilator manipulation. Figure 5 illustrates a typical set of controls and heating equipment in a "warm" calf barn. Warm housing is generally used only when you have more than 25 calves to care for. Proper design and sizing of fans, insulation, supplemental heat, and controls are necessary for a satisfactory system. Waste handling methods must be thoroughly considered, planned, and included in the facility layout. Other advantages offered by the "warm" type building include:

1. greater work comfort for the operator;
2. a more even and comfortable environment for the animals; and
3. greater animal capacity in a given floor space, as illustrated in Figure 6.

Figure 4: "Warm" or "environmentally controlled" calf housing is insulated.

Figure 5: Typical controls and heating equipment required in an insulated, "warm" type calf barn.

Figure 6: Concentrated calf stall arrangement in a "warm" type calf barn.

The initial and operating costs of a "warm" calf barn are generally higher than those of a "cold" barn because of the need for insulation and the mechanical equipment required for heating and ventilation. Fewer calf losses, lower medical bills, and faster calf growth usually offset these costs over a period of time.
THE ENVIRONMENTAL SYSTEM

Fans should be sized and selected to provide several stages of ventilation, from the winter minimum to the summer maximum. You may use two-speed fans, modulated variable speed fans, several single speed fans or a combination of these to achieve the ventilation required. Thermostats are necessary to provide automatic control of the fans, as illustrated in Figure 5.

Several widely-used heating and ventilation systems recommended by commercial organizations or universities will perform successfully. Good design, quality equipment, proper installation, and a knowledgeable operator enhance success of the system. Conversely, poor design, poor equipment, poor installation or poor management will never give reliable service.

How can you, the dairyman, tell the difference between good and bad systems? Obtain a complete engineering design and set of specifications for your facility and equipment. Valid blueprints are available from many agricultural engineering departments at land grant universities and reputable commercial companies. Obtain literature, equipment recommendations, and quotations from two or three companies, preferably those representatives or suppliers who provide good installation and service in your locality. Visit other facilities in operation to learn of their performance. With this background, you should be able to purchase, install, and operate your environmental system successfully.

Blueprint number 832-1 of the Agricultural Engineering Plan Service, University of Kentucky, shows three recommended environmental systems for calf barns and gives specifications of equipment required.

CALF PENS AND STALLS

Inside the building, two types of pens may be used: bedding-on-earth pens, shown in Figure 7, and elevated slatted-floor tie stalls, shown in Figure 8. Each type has its advantages and specific characteristics, so the operator must make the decision as to which he prefers or which works best with his facility.

Bedded pens on dirt floors, as shown by Figure 7, can be used for small as well as large calves and are mainly used in "cold" type buildings. Consider the following guidelines:

1. Use adequate bedding and add to, clean, and/or replace as required. Bedding may be straw, sawdust, shavings, old hay, etc.—anything that is absorbent.
2. Loose-run pens for individual young calves should be 15 to 20 sq. ft. in size. We do not recommend grouping calves until they are weaned.
3. Group pens should allow 15 to 20 sq. ft. per calf. Do not group calves until they are weaned (to cut down on sucking). Do not group more than 6 calves per pen, with a maximum age difference of 1 to 2 months.
4. Older calves should have the following space allocations:
   - 1½ to 10 months: 30 to 40 sq. ft./calf
   - 20- to 24-inch stanchion space/calf
   - Over 10 months: 30 to 40 sq. ft./calf
   - 24- to 30-inch stanchion space/calf
5. Heifers from 10 months to freshening are normally provided separate, loose housing.
6. All pens should have movable or swinging partitions so manure can be removed by machine.
7. Pen heights: 4' for young calves, 4 1/2' for older heifers.
8. Gate width: 3' to 3 1/2'
9. Alleys: Normally 4' wide, short alleys, 2' to 3'.
Elevated Tie Stalls:

Elevated tie stalls, as shown by Figure 8, are almost always used in "warm" calf confinement facilities and sometimes in "cold" housing. The stalls are approximately 22 to 24 inches wide, 4 to 4 1/2 feet long, with the bottom 10 to 12 inches above the floor, and slatted sides 3 to 3 1/2 feet high, giving a total height of 4 to 4 1/2 feet. The rear legs of the stall should set close to the edge of a gutter, as shown in Figure 9, so most of the manure will fall directly into the gutter. Some stall bottoms have given unsatisfactory performance because: slats that are too wide and spacings that are too narrow clog with manure; and stall bottoms that are too long (over 4 1/2 feet) allow manure to fall on the rear slats and dry without being worked through by the calf's feet. The more favorable types of stall bottoms are narrow wood slats, expanded metal, or rods adequately supported at the rear of the stall where manure will freely pass through without clogging. Narrow wood slats (1" x 2") are acceptable for the stall, provided a 1 to 1 1/4 inch space is left between slats and excessive length of the floor bottom does not cause an overhang where manure collects. The front portion of the stall bottom must be smooth enough to prevent knee injury to the calf. Two Agricultural Engineering Plan Service blueprints, numbers 772-33 and 772-34, give recommendations for wooden calf stall construction. Figure 10 shows these two designs. Commercial metal stalls are readily available and easier to clean, although they are more costly than most wooden stalls.

Calves are generally contained in the stalls with neck chains. The feed bucket, or trough, and water pail should be on the outside of the stall front as shown in Figures 3, 8 and 10. If you choose to put these on the inside, make the stall longer to provide adequate space.

Replacement heifer calves are fed milk replacer for the first 4 to 8 weeks and usually put on dry feed and hay within 1-2 weeks. They are then moved to group pens after weaning. Vealers are fed milk replacer or other special formulas for 10 to 12 weeks or until they reach approximately 250 to 285 pounds.

Elevated stalls are normally used with concrete floors, as shown in Figure 11, to permit wash-down, but some dairymen are successful with stalls on dirt floors, using straw bedding under the stalls. Daily addition and/or replacement of the straw is usually necessary to maintain clean and dry conditions.

Concrete Floors:

Concrete floors are quite helpful for sanitation and cleaning when using elevated stalls. The floor under the stall should slope toward a rear gutter at the rate of 1/4 inch per foot to provide good drainage, as shown in Figure 9. A gutter approximately 6 to 12 inches wide immediately behind the stall's rear legs receives and drains liquids to a waste storage and/or treatment unit. The rear of the stall should sit at the edge of this gutter so most of the droppings will fall directly into the gutter, thus reducing scraping and cleaning. Periodic cleaning and/or washing down of the manure from under the stall and the gutter and aisle is required. Most producers do this washdown approximately twice per week.
Temperatures of "Warm" Calf Barns:

In winter, the inside temperature of a "warm" barn is usually maintained around 40 to 50 F; in summer, 70 to 75 F is normal, or as cool as maximum ventilation capacity permits on hot days (usually 2 to 4 F below the outside air temperature). More specifically, a winter temperature of 40 to 45 F is suitable for replacement heifers; 55 to 65 F gives better growth for vealers. The fan ventilation and supplemental heating equipment must provide low rates of winter ventilation and suitable heating for precise control of temperature, moisture, and removal of odors. For most facilities, a minimum winter ventilation rate of 1/10 cubic foot of air per minute (CFM) per pound of calf weight is recommended. For example, 50 calves averaging 150 pounds would require approximately 750 CFM minimum continuous winter ventilation for moisture control. If odors are stronger than desirable, a higher ventilation rate can be used. Proper ventilation and waste management must work together to provide suitable conditions. Uniform air mixing and distribution are essential in winter to prevent chilling drafts and damp, stagnant spots in the building.

Supplemental Heat of "Warm" Calf Barns:

Supplemental heat, as illustrated in Figure 5, is mandatory in "warm" or environmentally-controlled calf barns to maintain winter temperature minimums and permit evaporation and removal of moisture. Calves do not produce enough body heat to allow for the control of winter temperature and moisture at the same time by ventilation alone. Stopping fans to maintain warmth is the wrong thing to do, because humidity and odors will increase, likely resulting in condensation and respiratory diseases. Electric, vented gas, or oil-fired heaters may be used to provide the required heat. Plan for supplemental heat or your ventilation system will not maintain warm and healthful conditions simultaneously during winter weather.

Summer Ventilation of "Warm" and "Cold" Barns:

Adequate summer ventilation is vital to cool calf housing, preventing heat stress on the calves, and to provide fresh air to prevent respiratory ailments (note fans in Fig. 12). A maximum summer ventilation rate of approximately 1 to 1 1/4 air changes per minute for the entire building is recommended. Good air mixing and turbulence throughout the building is important to provide healthful conditions for all calves.

Insulation of "Warm" Calf Barns:

A "warm" building must be insulated and have an effective vapor barrier as part of the total environmental system. Good insulation helps to maintain uniform temperature, reduces heat losses in winter, and keeps the inside wall surface warm enough to prevent visible surface condensation. Insulation also blocks heat gain in summer, keeping the building cooler.

A vapor barrier must be included with, or added to, the warm (inside) surface of the insulation (or wall). If vapor migrates into the wall interior in winter, it eventually becomes hidden condensation, which deteriorates the structure and reduces the insulation's effectiveness. Rigid insulation boards of the expanded polystyrene or polyurethane types are resistant to moisture migration and do not require an additional vapor barrier, provided the joints are tightly sealed (use mastic, adhesive stripping, etc.). For the small added cost, it is generally best to apply a plastic film vapor barrier along with rigid insulation board to ensure adequate moisture protection.

Table 1 lists some general insulation, ventilation, and heating data that may be used as guidelines for facilities in Kentucky.

Table 1. Suggested Design Data for Environmentally Controlled Calf Facilities in Kentucky

<table>
<thead>
<tr>
<th>Temperature (Winter)</th>
<th>Replacement Heifers</th>
<th>Vealers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 to 45 F</td>
<td>55 to 65 F</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Generally try to keep under 85%</td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walls</td>
<td>R = 6 to 10</td>
<td></td>
</tr>
<tr>
<td>Ceiling</td>
<td>R = 8 to 12</td>
<td></td>
</tr>
<tr>
<td>Vapor barrier on inside surface of wall and ceiling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td>1/10 CFM/lb. (15 CFM per avg. 150 lb. calf)</td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>1 to 1 1/4 air changes per minute in building</td>
<td></td>
</tr>
<tr>
<td>Fans</td>
<td>All A.M.C.A. Certified ratings at 1/10 or 1/8 inch static pressure (Water Column)</td>
<td></td>
</tr>
</tbody>
</table>

Supplemental Heat

Amount (BTU/hr.) calculated for your building:
Total wt. of calves, lb. X 4 = __________
Wall area, sq. ft. X 50 = __________ R. Value
Ceiling area, sq. ft. X 50 = __________ R Value
Glass area, sq. ft. X 25 = __________
TOTAL = __________ BTU/hr.*

*Select a heating unit which will provide 10-25% more heat than the calculated value to allow for recovery and aging of the equipment.
Do not set the rear legs of the stall on the outer side of the gutter; or cleaning will be most difficult! The gutter should be a minimum of 2 to 3 inches deep at the shallow end and slope 1/8 inch per foot toward a tile drain that exits the building. To avoid excessively deep gutters, a center drain is necessary for buildings 50 to 100 feet long. A 6 to 8 inch diameter clay, concrete, PVC or similar tile with smooth interior and water tight joints should be used underground going out of the building. Both ends should be accessible to permit unclogging, and the entire length of the tile should slope 1/4 inch per foot. A grated or perforated cover can be used at the gutter drain to block trash or large solids from entering and clogging the tile.

Obviously, a good water supply and pump are necessary for cleaning. Sufficient water volume sometimes is not available for the operator to flush all the solid manure through the tile successfully. If your water supply is limited, shovel a portion of the solids from the gutter for removal from the building, then flush down the remainder.

Elevated Stalls in a “Cold” Building:

Sometimes elevated stalls are used in “cold” buildings. Many dairymen learn to manage this arrangement successfully; however, others continually have problems with calf sickness due to high moisture, and never manage the manure and odor problems successfully. If you use elevated stalls in a “cold” building, a concrete floor is advisable for manure drainage and cleaning. With a dirt floor, considerable bedding and daily management would be required to avoid sizeable manure accumulation under and around the stalls.

Don’t try to control the temperature of a “cold” building by closing it too tightly. This merely traps the moisture. If natural air leakage is not sufficient, provide manual openings, without drafts, so moisture and odors will dissipate, as shown in Figure 12. Let the inside temperature closely equal outside conditions. (Protect or drain water-lines or anything else that might freeze.)

Buildings with wood siding and a loft work best to help moderate the temperature and allow air leakage. Buildings with exposed metal siding and roof provide a tighter enclosure but are almost sure to have undesirable condensation on the inside surfaces. Insulation or other sealing is necessary.

BLUEPRINT PLANS

A floor plan for bedded pens is shown in Figure 13.

A cross-section of a confinement calf barn showing the concrete floor, gutters, stalls, aisles, and other features is illustrated in Figure 14.

Blueprint number 772-36 gives construction details of the concrete block controlled environment calf barn shown in Figure 15.

All blueprints listed in this publication, as well as others of related nature, are available from the Agricultural Engineering Plan Service, University of Kentucky, or through your local Cooperative Extension county office.
Figure 14: Cross-section of a "warm" type confinement calf barn.

Figure 15: Concrete block construction "controlled environment" calf barn (see UK Plan 772-36).

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