Manure Management Technology Development Team
East National Technology Support Center

Compost Bedded Pack Dairy Barns

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What is a "compost barn"?

A compost barn, composting bedded pack barn, or CBP barn, is a loose-housing type of facility bedded with fine, dry sawdust. Cows rest on the bedding when not feeding or being milked. While the cows are being milked, the bedded pack is tilled or cultivated to incorporate the urine and manure that accumulate between milkings. Tillage is done with a skid steer, small tractor, or even an ATV equipped with a variety of tools— field cultivators, harrows, and rototillers have been employed. Manure handling on a daily basis takes about the same time as maintaining a freestall barn.

What is the advantage of housing cows in a CBP barn?

Cow comfort

Although manure storage is a major benefit of housing cows on bedded pack, the primary motivation for most farmers to switch to this housing type is cow comfort. In a freestall barn, each cow lies facing in the same direction and mingles with other cows only when standing in the aisle. The concrete aisles may be wet or slippery. Standing on concrete for long periods causes lameness. Bedding is changed frequently but can still be fairly thin over the concrete surface of the stalls.

On a bedded pack, cows lie wherever they want to and congregate in social groups. They are able to carry out mutual grooming and other natural behaviors. The bedded pack, which is tilled twice a day, is fluffy and soft and conforms to their bodies when they lie down, and provides insulation against cold floors or surfaces in winter. It provides good footing with no danger of slippage when getting up. Farmers do not report any increase in stepping on udders or other injuries from having the cows on pack.

Figure 1. Cows at rest in a composting bedded pack barn [courtesy Univ. Minnesota]

Since cows are less likely to become lame, have sore hocks, or be under stress, they are healthier and resist infection well. It may even be possible to keep cows in the herd longer. Most operators also report a significant increase in milk production.

Manure storage

Storing manure within the same barn where cows are housed keeps the manure in solid form (no rainfall or flush water added). It eliminates the need for additional storage structures or earthen pits [with the exception of the manure scraped from the feed alley and travel lanes]. With adequate capacity, it provides the operator with flexibility in removing the material for land application. If the operator wants to compost or otherwise process the manure, it is already in the proper form.

What are the disadvantages?

Management

Managing CBP barns is demanding and not very forgiving. The bedding material has to be tilled up twice a day, fresh bedding needs to be added regularly, and falling behind in either practice has unpleasant consequences. Some additional considerations:

- A piece of equipment has to be dedicated to doing the tillage, in addition to the labor cost.
- The operator may have handled manure as a liquid previously, and will have to adjust to a different manure handling system.
- There will still be ordinary manure cleaning and storage needs associated with the feeding alley, transfer areas, and milking parlor.
- Cow hygiene at milking is extremely important with cows housed on bedded pack, so cow washing and teat prep practices may have to be upgraded. This is due to the high bacteria count in the bedding. In spite of the bacterial population, operators usually report lower somatic cell counts on bedded pack as compared to freestalls or tie stalls.
- It remains to be seen whether this system will work in warm climates. It would probably not be feasible to use misters on the cows when keeping the pack surface dry is so important; also, the pack generates heat and humidity even in summer.

Figure 2. CBP housing in a hoop structure [http://www.ansci.umn.edu/compostbarnconf.htm]

Space requirements

The minimum space per (Holstein) cow for a compost barn is 85 sq. ft., up to 100 sq. ft. or more. This may result in a larger space under roof than is needed for free stall housing.

Separating cows within the herd is problematic on bedded pack, because the whole point of the system is to have one large open area that can be easily maintained. Operators have used temporary fencing and other devices to separate cows that are being managed in groups (by age, production, or health). Given this restraint, the CBP barn system is probably best suited to small herds – 50 to 250 cows – in which the herd is managed as a unit.

Is it really compost?

Since only the top 10-12 inches of the pack is tilled daily, the lower portions of the pack may be anaerobic, and may be too dry to support rapid bacterial activity. The rate of decomposition is likely not high enough to generate mature compost. Some activity certainly does occur – the packs heat up, with temperatures of 90 to 130 ^{o}F reported. In addition, the volume of the pack does not increase much during the summer months, as it does in winter, indicating that composting is reducing the volume of the pack. However, the material is not uniformly heated to the extent necessary to be sold commercially as compost, and would not meet USDA Organic Certification requirements for pathogen reduction. If the operator wants to market the material as compost after removing it from the barn, it would need to be further processed.

What about germs, odor, and flies?

Germs -- The bacteria count in the pack is very high. Many of these bacteria are related to the decomposition of the manure and sawdust and are not disease-related. However, since the manure is essentially being stored under the cow, there is a risk of disease, specifically mastitis, if the cows are not healthy and well cared for. Cows housed on bedded pack, like all dairy cows, should be managed with a pathogen prevention plan developed by the herd's veterinarian. Milking hygiene is extremely important, as is overall herd health. There is some thought that the reduction in stress and lameness allows the cow's immune system to function more effectively than in other types of housing, leading to the observed reductions in somatic cell count.

Odor – The barns do not have strong odors (such as the smell associated with ammonia production) but they still smell like barns. The sawdust absorbs and holds organic and ammoniacal nitrogen, a large source of odor. As in any animal housing, ventilation is an essential part of the design to prevent odor from accumulating.

Flies – The system seems to lead to some reduction in fly numbers. Twice-a-day tillage, along with the drying effect of the sawdust, apparently deters fly eggs from hatching. Fly control is still required.

What happens to the nutrients?

University of Minnesota conducted tests on a number of barns in 2006 to see what was in the manure at cleanout. N-P-K content, on average, was 22-7-15. Nitrogen varied with the ration fed to the cows and in relation to the quality of bedding. Bedding with small particle sizes retained nitrogen better than bedding with wood chips, long fibers, or wood additives.

Raw sawdust has a C/N ratio of 400/1. This ratio needs to fall to below 30/1 in order to prevent nitrogen being 'tied up' in the crop field after land application. Manure from the barns sampled in fall 2006 showed C/N ratios averaging around 19/1. This indicates that the sawdust was at least partially decomposed and nitrogen from the manure was being retained in the pack. Research on this issue continues.

How are these barns constructed?

- Size – there are different figures in the literature. Depending on the size and breed of cow, and the cow's age and condition, space needs range from a low of 65 sq ft/cow (Jerseys) to 140 sq ft/cow (convalescent Holsteins) Research your type of herd and try to view existing operations.
- Feed access – most CBP barns have a feed alley along one side of the barn or, occasionally, down the center. Cows exit the bedded pack off either end, down ramps formed from bedding material. Very long barns may need additional access ramps to the feed alley. The feed alley should be a minimum of 12 feet wide, or 14 feet if watering tanks are on the opposite side of the alley from the feed bunk.
- Other manure – manure from the feed alley, which may be as much as 25% of the day's production, is usually scraped to a separate storage structure or mini-pit. Provisions for transferring and storing this manure should be part of the design.
- Ventilation -- In summer, provide adequate ventilation to remove cow heat and moisture as well as the heat and moisture generated by the biologically active pack. In winter, provide sufficient air exchange to remove moisture from the pack and extend time between bedding additions. When relying on natural ventilation, locate the barn in an open area where summer winds can blow through the structure. A 16-foot sidewall is recommended to allow for a four-foot concrete wall holding the bedded pack. The open area above the wall allows for good aeration, room to hang fans if needed, and room for cleaning and incorporation equipment to pass freely.
- Watering – Many barns have the waterers along the retaining wall, between the pack and the feed alley, usually within an indented space. The drawback, however, is that it is difficult to keep the water clean once the manure pack builds up and cows are standing higher than the water surface. An operation with a drive-by feeding system on one side of the barn placed the water troughs along the outside of the barn in the feed alley. This allows the water to remain cleaner longer and keeps the cows from putting their feet in the waterer as they sometimes do during warm weather.

Figure 3. Four-foot wall separating pack and alley [http://www.extension.umn.edu/dairy/Publications/compostbedded.htm]

- Height of bedded pack enclosure walls -- Experience on farms with compost dairy barns indicates four feet to be the right height. Taller walls may block airflow through much of the barn. Lower walls allow the pack to start overflowing by springtime. Current management practices call for hauling a few loads of material out of the barns in the spring before planting and doing a full cleanout in the fall. With fall cleanout, the walls are at full height for the cold time of the year when airflow over the pack surface is not as critical. The pack seems to build up rapidly during the winter and then hold in place during the warm summer months,

presumably due to decomposition of the manure and sawdust.

- Flooring – Floors can be either concrete or packed clay. University of Minnesota experience shows that packed clay works well. Sawdust is able to absorb and hold a great deal of liquid. Producers have reported that at cleanout they find a clean layer of sawdust at the bottom of the compost pack that appears as fresh as the day they laid it down months before. This indicates that very little liquid is penetrating the entire pack.
- Future usage – the facility should be dimensioned so it can be converted to a conventional freestall barn in future if the operator finds the CBP system inappropriate for his herd, the herd size changes, or an economical source of sawdust is no longer available.
- NRCS planners should advise producers to recruit experienced consultants to oversee the building design process.

How do you manage a compost barn?

Bedding

- Good quality dry sawdust and/or wood shavings work the best for bedding material. An 18 to 24" layer of bedding is laid down before cows are introduced to the barn.
- Producers have tried alternative materials such as corn stalks and various types of straw. Corn stalks hold water up to a certain point, and then as cell walls deteriorate, release the water and leave the pack too wet. Some sawdust will inhibit bacterial growth, such as cedar. Straw, old hay, and soybean residue tangle in the tillage equipment unless ground very fine. Finely ground corncobs work, but the supply is usually insufficient to meet the need.
- Do NOT use green sawdust (from green lumber). It must be no more than 18% moisture.
- Keep the pack level, and a little higher against the walls; slope the pathway down to the feed alley gradually. In spite of their intelligence, cows can find ways to get in trouble, like rolling into a hole near the barn wall and not being able to get up.
- Expect to use a lot of sawdust. Add dry bedding when the pack begins to stick to the cows and expect to add 4 to 8 inches every 2 to 5 weeks. In spells of rainy or humid weather, much more sawdust is required than in warm dry weather. If you wait too long to add fresh material, it will take more sawdust to catch up and get the pack into good condition again. Some farmers have erected sheds to store sawdust purchased during summer, when it may be cheaper, against the needs of winter.
- Research is being conducted at UMN to look at other possibilities for bedding to reduce the expense of using pure sawdust.

Maintaining the pack

- Till or cultivate the pack twice a day to incorporate oxygen and keep the materials well mixed. Insufficient tillage leads to dirty cows and slows aerobic microbial activity in the pack.
- Till to a depth of at least 10-12". Tilling reduces compaction and provides a comfortable resting area for the cows. Depth of tillage is critical because oxygen is needed in the pack to prevent formation of ammonia.
- Operators have used cultivators, rippers, and other equipment to till the pack. There is no piece of equipment made just for this purpose. Usually some existing equipment is retrofitted to meet the needs of the specific barn.

Figure 4. Tilling the pack [Darren Hickman, NRCS]

- Add sawdust when the pack material gets moist enough to start sticking to the cows. Adding sawdust or shavings will make the barn air dusty, so do it when cows are out. Till the fresh material to mix it with the older pack and reduce dust.
- Good ventilation is critical in a compost barn, to clear the dust, remove any gasses produced from the depths of the pack, and keep the pack surface dry.

Cow cleanliness

- Properly tilled and mixed bedding should leave the cows quite clean when they go to milking. The comfort and freedom of the bedded pack housing reduces stress on cows, enabling the immune system to function well, reducing lameness and hock sores, and facilitating maximum time in herd.
- However, since the bacterial count in the pack is high, excellent milking hygiene is essential in keeping somatic cell counts and mastitis incidence low. Well-run dairies usually see a reduction in somatic cell count when switching from tiestalls to bedded pack, but these gains can be wiped out by poor udder management.

Figure 5. Barn designed to allow room for ventilation fans
[http://marathon.uwex.edu/ag/modern/compostbarntour.html]

- To remove heat and maintain a dry bedding surface excellent ventilation is critical. Drying at the bedded surface will retard bacterial growth and keep cows cleaner since dry bedding does not stick to teat or leg surfaces.

Removing the pack

Operators in Minnesota have been removing a portion of the pack for land application in Spring, and doing a complete cleanout in the Fall. While this works well for manure management, it presents concerns for nutrient management, since manure applied in Fall may lose nitrogen over the winter. The rationale for Fall cleanout is that the operators want maximum manure storage over the winter, when the pack does not decompose as rapidly as it does in the summer.

If the material removed from the barn is going to be land applied immediately, it should be thoroughly sampled and tested for nutrient and salt content and used in accordance with the farm's nutrient management plan. If it will be stored or composted before spreading, the sampling and testing should be done as close as feasible to the time of application.

Additional information

----Visit the compost barn website at the University of Minnesota to read the monthly newsletter, news about tours and workshops, the latest research, and stories from producers.

http://www.extension.umn.edu/dairy/management/compostbarns.htm

----Virginia Cooperative Extension has some guidelines on sizing and planning a CBP barn:

http://www.ext.vt.edu/pubs/bse/442-124/442-124.html

----A university farm's experience with CBP barns:

http://www.uwrf.edu/pa/2006/0612/1204061.htm

References

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