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**Separate Ways  
Keeping Manure Solids and Liquids Apart Benefits Transport**

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Research by a graduate student in 1995 led to a design for the Michigan State University (MSU) swine research facility that has a radically different manure handling system than typically found in the United States.

The new system keeps feces separate from urine, which reduces transportation costs.

MSU graduate student Carrie Tengman, working with professor Howard Person, showed that about 94 percent of phosphorus (P) in swine excrement is in the feces and 6 percent is in urine. (See Table 1.) When deciding how much manure to apply to fields, farm managers generally consider nitrogen (N), (P) and potassium levels. Most state regulations are based on N or P for determining how much manure is to be applied.

When manure is distributed to meet a plant's N needs, excess P is applied because the manure N to P ratio is less than the ratio used by the plant. Also, most manure handling systems are not designed to conserve N. Because P is conserved, the N to P ratio decreases. This imbalance increases for manure as applied.



Figure 1. In the MSU manure handling system, a conventional dairy scraper collects feces and transports the material outside the building to be taken to a compost facility.

In 1980, Michigan adopted Right to Farm legislation and a few years later adopted Generally Accepted Agricultural Management Practices (GAAMPS) for managing manure. Fundamental to the GAAMPS is that manure application to crop land be based on the soil Bray P1 test value. If the test value for P 2 O 5 is less than 75 parts per million (ppm) — 150 pounds per acre (168 kilograms per hectare) — manure may be applied at N use rates. However, if the test is more than 75 PPM, manure may only be applied at crop P 2 O 5 use rates. Once the test exceeds 150 PPM, no manure may be applied.

As researchers contemplated applying manure to match P use by plants, and considered that basing manure application on P use meant transporting nutrients longer distances, incentive increased to keep manure free of water. Tengman's research shows there are advantages to a system that prevents the two excrement streams from mixing. Fecal matter is easier to transport without the urine.

**Table 1. Partitioning of nutrients between urine and feces as excreted for swine and dairy cattle**

Species	Nitrogen		Phosphorus	
	Feces	Urine	Feces	Urine
Swine	55%	45%	94%	6%
Dairy	45%	55%	98%	2%

The incentive in Michigan for keeping the two nutrient sources separate is that manure application regulations are based on P levels. Michigan is one of the first states to adopt P-based manure application practices, which have become the trend throughout the United States. Many other states have since adopted a P standard and the U.S. Environmental Protection Agency recently proposed regulations calling for a federal P standard.

Compliance difficulty arises in most cases in Michigan because P is expensive to transport when it is mostly water. Most swine manure handling systems in the United States are designed for such liquids.

When presented with Tengman’s data, Maynard Hogberg, chairman of MSU’s animal science department, recalled a similar system he had seen about 10 years earlier in Japan. This system isolated the solid from liquid fraction of manure. The Japanese concept has grated floors, as is typical for deep-pit, under-floor systems. However, beneath the slats a concrete V-shaped floor is slanted toward a central notch. A cable system pulls a scraper across the V to move feces to one end for easy transport as a solid. (See Figure 1.)

Urine and waste water dribble onto the floor and flow into a notch in the V then into a slotted PVC pipe. As the scraper moves, a plug attached to the scraper mechanism ensures that liquid flows out the end of the pipe to a separate holding tank.

In the MSU system, a conventional dairy scraper collects feces and transports the material outside the building to be taken to a compost facility.

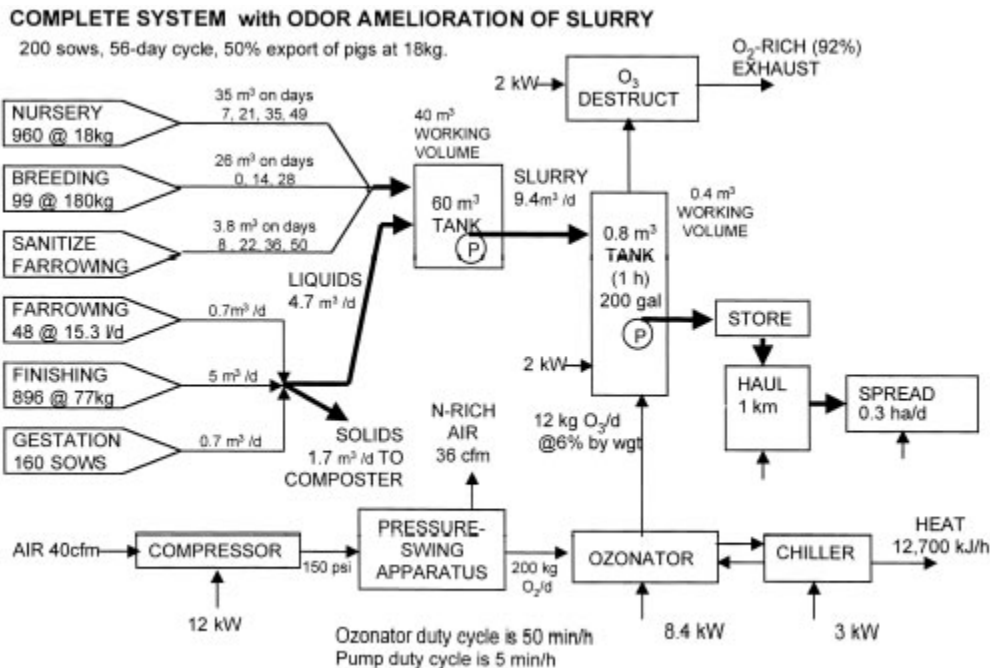


Figure 2. This schematic shows how the liquid fraction from the isolation system merges with the entire manure flow from the rest of the system and is passed through the contactor tank.

The most obvious advantage of the new system is that the feces, which bears most of the P, remain separate from the liquid so transportation is easier. Also, less weight is transported when moving the P.

Another benefit to the system is that it prevents a chemical reaction that normally occurs when the urine and feces mix. Urine contains urease, an enzyme that causes ammonia to be released from the feces. When the urine and feces are kept apart, no ammonia is released.

Hogberg and ASAE member Robert von Bernuth, then chair of agricultural engineering at MSU, arranged for several university representatives to visit Japan to learn more about that system. ASAE member Jerry Wille of Curry-Wille & Associates, designed the system for the new MSU facility — a 250 sow farrow-to-finish operation with scrapers beneath the gestation, farrowing and finishing rooms.

MSU researchers have added one more step to the process of handling the isolated liquid fraction of manure at the facility. The liquid is pumped through an ozone contactor tank then stored in a large commercial steel storage tank for later land application.

Professors Mel Yokoyama of MSU's animal science department, Susan Masten of civil and environmental engineering, and ASAE members John Gerrish and Person of the agricultural engineering department designed the ozone system based on bench-scale work. A schematic of the system is shown in Figure 2. The schematic shows how the liquid fraction from the isolation system merges with the flow from other areas of the facility and is passed through the contactor tank.

The ozone, if allowed adequate contact with the slurry, removes odor from the slurry. The bench-scale research showed that ozonation removed more than 90 percent of odor. Also, most of the pathogenic activity is terminated by the ozone.

The swine facility was completed in 1998. However, the ozone system has recently been added so no data is available on its operation. The system has undergone startup tests and is expected to be fully operational soon. Designing the facility to accommodate the isolation and scraper system presented minor challenges to Wille and construction posed some challenges to the contractor. However, designing and constructing the ozone facility presented major challenges to its creators. Consulting firms and contractors who typically work on university facilities were unfamiliar with handling livestock waste, the programming logic used and extra safety considerations needed for handling ozone.

Figure 2 shows that the system isolates urine from feces in the facility's gestation, finishing and farrowing areas. Manure from the breeding and nursery areas are handled as liquid and mixed with the isolated liquid from other areas. Using the partitioning values shown in Table 1, the composite liquid has an N to P ratio of 2.85. The plant use N to P ratio for a corn, soybean and wheat rotation is about 2.9, leaving the animal production and crop production system in balance when the composted feces are exported.

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