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Gravity handling for dairy manure

R.E.Graves
Department of Agricultural Engineering, Penn State University, University Park, Pa., USA

ABSTRACT: Dairy farmers in North America are increasing the use of gravity for removing manure from barns and transferring it to storage. Gravity methods include gravity flow channels, gravity flow pipes and flush pipes. In some cases, gravity is also used to unload manure storages.

ABREGE: L'industrie laitière en Amerique du Nord accroit l'utilisation de la pésenteur pour enlever le fumier des étables et pour le transferer à l'entreposage. Les méthodes de pesenteur comprennent des canalisations d'ecoulement par gravite, des tuyaux d'écoulement par gravité et des tuyaux d'évacuation. Dans certains cas, la pésanteur est aussi utilisée pour décarger les entreposages de fumier.

ABRIß: Bauernhöfe mit Milchvieh in Nordamerika erweitern die Nutzung von Schwerkraft für die Beseitigung von Naturdünger aus Ställen und zum Transport zur Lagerung. Zu den Methoden, die sich die Schwerkraft nutzbar machen, gehören Abflußkanäle, Abflußrohre und Spülrohre. In manchen Fällen wird Schwerkraft auch dazu benutzt, Düngerbehälter zu entleeren.

1. INTRODUCTION

Use of gravity in manure handling on dairy farms is not new. Early New England barns had second story stables with scuttle holes placed to allow the convenient pushing of manure through the floor to storage. Bates (1973), proposed a similar system utilizing continuous openings with grates behind cows and a liquid storage beneath the barn. Under barn storage is expensive and raises concerns about sanitation and gas and odor problems.

Higher producing cows, problems acquiring bedding, and additional waste water from outside lots and milking centers has resulted in more farmers adopting liquid or semi solid manure handling systems. Farmers in the northeastern U.S. and eastern Canada are rapidly adopting gravity methods for moving this semi solid or liquid manure in and around barns. These gravity systems are handling semi solid or liquid manure from tie stall barns, free stall barns and youngstock barns. Gravity flow channels, large diameter low head gravity flow pipes, and high head flush pipes are being used to move manure from cows to outside manure storages.

2. GRAVITY FLOW CHANNELS

Gravity-flow channels, also called gravity gutters, step-dam gutters, Dutch gutters, overflow slurry channels and continuous-flow slurry channels provide a simple alternative for transporting dairy cattle manure. The idea is believed to have come from Europe, the first unit recorded in the U.S. was in Ohio in 1965 (Bigalow, 1965).

A 70 -200 mm high dam holds back a lubricating layer of manure in a level, flat-bottomed channel (figure 1). Manure deposited onto this layer builds up in a wedge shaped mass. When the top of the manure reaches a slope of 1-3 % it begins to flow. Because the manure moves by its own weight, no mechanical equipment or electrical power is required. A downward step at the dam allows manure to flow away from the dam. From here it may flow along a second section of channel, drop into a drain pipe or go directly into a manure storage. (Graves,1986)

The most common use of gravity flow channels is removing manure from tie stall and stanchion barns. Gravity-flow channels are also used for removing manure from under slatted-floor areas in free stall barns, around feed bunks, or in youngstock housing facilities; and transferring manure from various types of barns to a manure storage unit.

2.1 Tie stall and stanchion barns

The Northeast Dairy Practices Council (NDPC) published guidelines for the design and construction of gravity-flow channels in tie-stall or stanchion barns (NDPC, 1983). The following material has been excerpted from those guidelines.

2.1.1 Construction of gravity-flow channels

Channel depth depends on channel length, slope of the manure surface, height of the dam, and allowance for grates and freeboard. Depth = dam height + (length X % slope ÷ 100) + freeboard

Manure slopes vary from 1 to 3 percent depending on diet, bedding use and dilution water. A 3% slope is normally used for design purposes.

In barns where milking is done, the maximum gutter length between dams can not exceed 36 m (120 feet) (USDHHS, 1983). Typical distances between dams range from 12 to 24 m (40 to 80 feet). Dam spacing is usually determined based on sidewall construction, site conditions, channel depth and tradition. In operation dam spacing doesn't appear to have any affect(Cermak, ,Meyer et al, 1983).

Bottom widths of 750 - 900 mm (30 to 36 inches) are recommended in tie stall barns. If a channel is too narrow, sidewall friction may stop the flow of manure. The depth and width of channels requires grates for cow and worker safety. Flat grates are recommended if cows must stand on them. To reduce the size and cost of grates, however, the top width may be reduced to 500 - 600 mm (20 to 24 inches) (figure 2).

2.1.2 Management

Channels should be filled with 75 - 150 mm (3 to 6 inches) of water before manure is allowed in a gravity-flow system. Bedding must be given careful attention, especially the type and amount used. Small amounts (500 grams per day) of sawdust, fine-cut shavings, peanut hulls, or chopped straw bedding may be used. Long straw or larger amounts of bedding increase the stiffness of the manure and may clog the channels. Cow mats allow minimum use of bedding. Water may have to be added to channels, depending upon the feed ration and amount of bedding used. Milk-house wastewater is sometimes directed into the upper end of the channel to provide extra water.

Excessive amounts of solid materials such as feed, soil, and barn lime may settle to the bottom and clog a channel. Clumps of material such as hay and silage may stick to the sides of the channel, especially where excess bedding or feed builds up. These clumps should be cut free.

Grates in milking barns require regular cleaning--preferably daily. A broom connected to a water hose makes the job easy and adds dilution water. Powered rotary brush grate cleaners are also available. Flies cause little or no problem in gravity-flow systems. If rat-tailed maggots are present, biodegradable oil, such as mineral oil, may be applied to the manure surface to control them.

Odor is not a problem in barns with good ventilation; there is no need to install special fans to ventilate channels. Channels should not empty into large sumps or pits within, or having direct openings into, the barn. These storages produce gas and odors that can be drawn into the barn by the ventilation system.

2.2 Slatted floor housing

Gravity flow channels can also be used to remove manure from under slatted floor animal units, including slatted floor free stall housing for milking cows or young stock, partially slatted-floor counter-slope units, and slatted floors around feed bunks (Meyer et al 1983, Graves, 1986, Collins & Mason, 1989). The channel width for these units can vary from 1.2 to 3 m (4 to 10 feet) depending on the slat construction. The basic design is similar to channels in tie stall barns.

Start up of gravity-flow channels under slats often requires addition of extra water for the first several weeks to ensure that manure does not dry and stick to channel surfaces. The consistency and movement of manure should be carefully watched at all times because the wider channels expose a larger manure surface to the air for drying. Units that have solid floor areas next to the slats result in large amounts of manure getting into the channel along the side wall. This can cause problems because manure tends to build up on the channel's side walls. It may also be necessary to add water during dry periods or to get a channel moving again after prolonged cold weather and freezing. Collins and Mason (1989) indicate that problems resulted when leaky dams failed to hold sufficient water to form the lubricating layer.

2.3 Gravity flow into storage

A gravity-flow channel may also be used to convey manure into storage from an in barn gravity flow channel, a gutter cleaner discharge or from tractor-scraped areas (Graves, 1986). A wider channel (1.2 - 1.8 m, 4 to 6 feet) may be needed to provide additional surge area for manure as it is first discharged from a gutter cleaner or tractor scraper. Otherwise it may be necessary to slow down the gutter cleaner or clean more often. Gravity flow channels from in barn gravity flow channels can be the same dimensions as the channels in the barn.

The outside portion of channels should be covered to prevent freezing. Removable insulated covers allow convenient access to a channel. A drop structure at the end of the channel will allow bottom loading of the storage and will keep cold air from blowing back up the channel. Large amounts of bedding, hay, or pen manure should not be allowed to flow into the channel. Addition of milk-house wastewater at the loading point can help dilute the manure.

3 GRAVITY FLOW PIPES

In the late 1970s large diameter (.6 m to 1 m, 24 - 42 inches) under ground pipes were used to convey manure by gravity from free stall barns to manure storages in New York State (figure 3) (Guest,1981). Guest (1981, 1984) indicates that a site that slopes away from the barn 10% is normally adequate for installation of a gravity pipe system. This provides 1.2 to 1.8 m (4 to 6 feet) of elevation drop or head between the barn floor and the full storage level and is adequate for manure to flow 30 m (100 feet) or more. The pipe slope is not as important as the total head difference.

Factors that determine how well the manure flows include:

- amount and consistency of manure
- type and amount of bedding
- water added (if any)
- temperature and uniformity of the mix
- pipe size, type, and length.

In 1984 Graves et al reported that large diameter pipes were also being used to convey manure from tie stall barn gutter cleaners to storages.

Recent reports (Fisher, 1989; Kintzer, 1989; Slater, 1989) indicate rapid adoption and refinement of this technique, because of its simplicity and low operating cost. Fisher reports that many Vermont farmers are converting pump loaded systems to gravity where site conditions permit.

3.1 Pipe

Early installations used 750 - 1050 mm (30 - 42 inch) pipe. It was felt that the bigger the pipe the less chance for problems. Kintzer reports that larger pipes caused problems due to the length of time it takes manure to pass through the pipe. Current recommendations vary from 600 - 900 mm (24 to 36 inches)(Fisher, Guest, Kintzer,Slater).

Almost every kind of large diameter pipe has been used, price and availability being the main determinant. Problems have been observed with poor joints that allowed liquid to escape and with concrete pipes that absorbed liquid thus changing the consistency of the manure and hindering flow (Kintzer, 1989). Most regularly used pipe materials are concrete pipe "seconds", smooth walled PVC, and double walled (corrugated outside for strength and smooth inner lining) high density polyethylene pipe. The plastic types are preferred because of cost, ease of installation, fewer joints, and smooth nonabsorbent inside surface.

Pipe has been installed at slopes from 0 - 20%. Most recommendations indicate that the total head available between the design full level of the reception pit and the storage is the important feature. Whenever possible the pipe should be placed in a straight line. Sharp deviations in slope have resulted in air lock problems.

3.2 Reception pit

Early recommendations were that the reception pit or loading hopper be designed large enough to hold one day's manure to minimize interference of slowly flowing pipes with barn cleaning operations (Guest 1984, Graves et al, 1984). More recent authors (Fisher, Kintzer, Slater) report problems with manure adhering to corners or other blind areas of the reception pit and drying out. Subsequent release of large chunks of this dried manure may result in plugging. It is recommended that the transition from the vertical pit to the pipe be made as smooth as possible (Kintzer recommends a bottom slope of 10%). Slater (1989) indicates that a smooth transition is more important than holding capacity. His preferred method is a 30 inch diameter vertical pipe and elbow directly to a 30 inch discharge pipe thus removing corners and ledges (Figure 4). If necessary a sloped hopper can be placed at the top to accommodate loading equipment. In all cases it is recommended that water be available at the reception pit if necessary. Whenever possible milk house waste water is added to the system at the reception pit. Fisher (1989) reports that the preferred method is to collect this water in a holding tank and add it to the reception pit during barn cleaning operations.

3.3 Pipe depth and outlet

The discharge pipe should be installed below the frost line. The pipe outlet into the storage should be under manure during cold weather to prevent freezing problems. This also reduces problems of air flow up partially filled pipes and subsequent drying of manure or odor transport to the barn. Early installations placed the invert of the pipe at the elevation of the storage floor. With large diameter pipes and large storages this often resulted in long periods with the pipe exposed. Kintzer recommends discharging the pipe into a sump approximately 3 m by 3 m and about pipe radius in depth. This sump can also be used as a pump out sump. Fisher reports that this practice results in plugging problems due to build up of grit, sand and soil from the manure at the discharge point. Slater recommends a submerged outlet and makes no mention of problems with plugging. (Figure 3,4)

3.4 Management.

The most important point when using gravity flow pipes is maintaining manure flowability. It is important that large amounts of frozen or dry manure not be put into the system. Alternative handling methods should be available for this type of manure.

Most systems experience at least one failure do to plugging before the operator learns how to mange it. Two methods have been reported for reestablishing manure flow. A high pressure water hose (or plastic pipe) can be worked into the plugged area to provide extra water and increase flow. Some farmers leave this hose in place for future use. Another method is to pull a large cable through the pipe before it is placed in operation. If a plug occurs, an appropriate sized tire is attached to the cable and pulled through with a tractor. Air lock problems can be often be cured by working a pipe through the manure with water pressure to the air lock. The water is shut off and the air allowed to escape. Some installations install permanent air bleeds at points where drastic changes are made in pipe slopes.

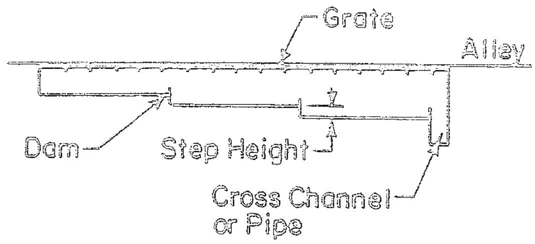

Figure 1. Stepped gravity-flow channel.

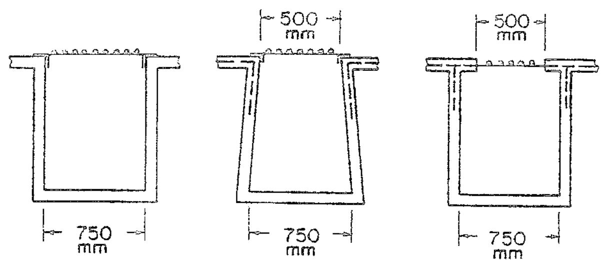

Figure 2. Alternate gutter cross-sections.

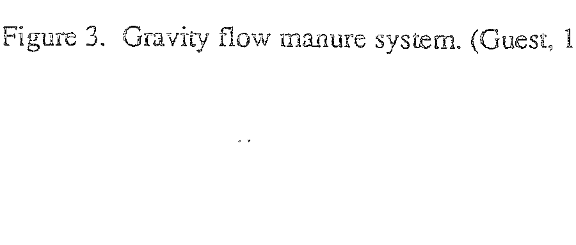

Figure 3. Gravity flow manure system. (Guest, 1981)

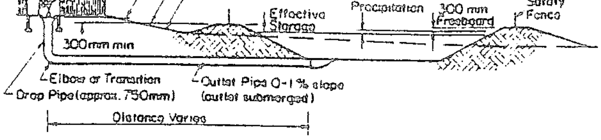

Figure 4. Gravity flow pipe. (Slater, 1989)

4 STEEP GRADE, FLUSH SYSTEM

Sites with a large difference in elevation between the cow barn and manure storage location can also use a holding tank and large diameter pipe. These systems normally consist of a holding tank at the barn sized to hold 7 - 10 days of manure production. A 300 - 900 mm (12 - 36 inch) diameter pipe with a guillotine valve at the holding tank control manure flow to the storage (Slater et al and Fisher 1989). When the holding tank is full the valve is opened and the contents are flushed to the storage. Slater et al recommends that the tank be 2.4 - 3 m (8-10 feet) deep to provide adequate head to flush out tank contents. The full level of the manure storage must be below the bottom of the holding tank. Construction of the valve is important to insure that it maintains its seal yet can be operated under the pressure of the manure. Hydraulically operated valves are used. If the pipe does not enter the storage below the manure level it is important that the pipe drain free to prevent freezing.

5 CONCLUSIONS

Gravity can be an effective and efficient method for moving manure on the dairy farm. As with anything the successful operation of gravity manure systems depends on good management. Farmers who have utilized this method point out the importance on recognizing what forms of manure will and won't successfully flow by gravity. As more experience has been gained with these systems, earlier more conservative recommendations are being relaxed. Smaller pipes and receptions pits have been found to be satisfactory. Also lower top slopes are often found on gravity flow channels. The biggest problem with gravity systems has been allowing too dry a material to enter the systems.

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