Handling Sand-Laden Dairy Manure From Barn To Storage

Manure handling is not an obstacle when proper design, equipment and management are employed

By Curt Gooch and Andrew Wedel

Introduction

Are you a producer who would like to bed your cows with sand but have heard horror stories regarding handling of sand-laden dairy manure (SLDM)? Or are you currently bedding with sand but looking for ways to improve you manure system? Would you like to separate bedding sand from manure? If so, then read on to get the real scoop on dealing with SLDM efficiently and reliably.

Basic Characteristics of SLDM

SLDM is a complex mixture of two vastly different materials. “Raw” manure is essentially a combination of water and undigested feed. When manure—a material that is pumpable—is mixed with sand—a material that is stackable, the result is a mixture that can neither be readily pumped nor stacked. Take for instance 115 lb of manure at 15% solids content and a bulk density of 62 lb/ft^3 mixed with 55 lb of sand at 95% solids content and a bulk density of 110 lb/ft^3. When added in these proportions the result is 170 lb of SLDM at approximately 40% solids content and a bulk density of about 72 lb/ft^3.

Relative flowability of manure has traditionally been used to predict potential manure handling methods. For instance, traditional flowability standards suggest manure at 35% solids content (bedded pack manure) is stackable and can be handled as a solid. However, at 35%, SLDM is not stackable nor is it readily pumpable. The difference in flowability between manure mixed with sand and manure mixed with organic bedding stems from the fact sand does not absorb liquid. Organic bedding does. SLDM flowability is function of manure sand content, moisture content of the excreted manure, ambient environment, etc. Manure with minimal amounts of sand can be handled using regular manure handling systems. However, from the standpoint of cow comfort, minimization of sand usage is not recommended.

Collection Within the Shelter

Sand is readily dragged from and kicked out of freestalls by cows as they enter, use, and exit the stall. This is a good thing to happen from a cow comfort/udder health standpoint as sand bedding can be contaminated with manure, urine, and/or dripped milk.

After leaving the stall, sand is readily mixed with manure and urine by cows’ hooves and manure removal equipment to a near homogenous mixture. Typical equipment used to collect and remove liquid manure from the barn should be evaluated in regards to its ability to deal with the abrasive nature and the extra

weight of SLDM. While this equipment may initially function as desired, longer-term performance is virtually non-existent without significant maintenance.

The best mechanical method to clean shelter alleys is with a rubber scraper blade mounted to a skid-steer loader or small farm tractor. The rubber scraper is durable and can withstand the abrasive nature of sand. It also creates less wear on the flooring surface than steel scraper blades. SLDM can be scraped to a conveyance device or directly outside to a push off ramp with storage located below.

Alley scrapers are popular with many dairy producers because they can be adjusted to frequently clean floors resulting in improved foot health with minimal daily labor. However, most alley scrappers are typically not designed to handle SLDM, especially for long alley applications with minimal drops to across-the-shelter reception gutters. These conditions result in a large accumulation of SLDM being pulled by the drive equipment for which it may not be designed to handle. Also, the steel blades on alley scrapers will wear quicker – consideration should be given to replacing the steel blades with hard rubber. One farm in central Michigan uses alley scrappers to remove SLDM from their barn with success. The scraper blades are extra heavy duty and a heavy chain is used in lieu of a lighter cable. The farmer reported the chain lasts about 6 years.

Flush cleaning the barn with a wave of water is also an option to consider for new facilities or those that are extensively upgrading their manure system. Flush water volumes need to be adequate to ensure proper removal of manure from the alley. Required water volumes are determined by three variables: length, width and slope of the alley as well as the size of the sand grains that must be cleaned from the alleys. Complete removal of the manure component of SLDM is essential to clean the shelter but residual sand left in the alley is acceptable as it enhances traction. For additional general information on flush systems check out University of Missouri Extension publication No. WQ 314 - “Basic Requirements for Flushing Dairies” available at the following web address: http://muextension.missouri.edu/xplor/waterq/wq0314.htm or contact a qualified agricultural engineer working in this field.

Conveying To Storage/Separation Area

Conveying SLDM can be achieved by numerous means. In some cases where the separation or storage area is in proximity to the barn, SLDM may be scraped directly to the storage or separation area using a rubber scraper mounted on a tractor or skid-steer loader. No matter what, **gravity flow is not recommended with SLDM** since sand settles and clogs channels and pipes.

Some types of pumps are capable of conveying manure from barn to storage. Piston pumps are a type of pump commonly used for this function. Centrifugal pumps may also be used to convey SLDM, however, since centrifugal pumps generally operate at high speeds and small clearances, they are very susceptible

to wear and clogging. Piston pumps operate essentially like a very large syringe drawing and discharging material. Large intake and discharge lines and few moving make piston pumps relatively well-suited for handling SLDM. The drawback of piston pumps stems from the fact, piston pumps do not provide a continuous high velocity flow and therefore clogged pipes may result from their use. Where pump discharge pipes are buried it is recommended clean-outs be spaced liberally (every 60') throughout the system.

Horizontal manure augers may also be used to convey SLDM from barn to storage or separation system. Augers are typically placed in a trough in the floor of the freestall cross alley. Augers potentially eliminate the need to "turn" or "chase" manure out of the barn. Manufacturers experienced with SLDM can design augers to be highly wear resistant. Horsepower requirements range from five to fifteen horsepower depending on auger length which is usually limited to 120 feet. However, multiple horizontal augers can be positioned end-to-end or in "piggy back" fashion to achieve lengths in excess of 120 feet.

Separation Options

Sand separation systems can be classified as mechanical or non-mechanical. Non-mechanical separators rely on sedimentation - the process of utilizing water as a media to separate various materials based on their specific weight and size. A sand trap is a non-mechanical separation means that is used exclusively with flush systems. Sand traps function by slowing a flush wave to a velocity of less than 1 foot per second for a retention time of approximately 1 minute thereby allowing sand grains to settle. At this velocity, most sand grains and some manure solids settle. The effectiveness of a sand trap is limited by how it is managed since as sand accumulates in the trap, separation efficiency is reduced. In order for a sand trap to function as it was designed it must be emptied on regular intervals. The amount of sand captured depends on the type of sand used. Sand with large quantities of fines is not recommended since fine particles tend to remain in suspension with manure that passes through the trap. The sand recovered from a sand trap contains some organic material and is generally not suitable for reuse. Sand trap design can be performed by a qualified consulting engineer based on flush volumes and sand types.

Mechanical sand-manure separators (SMS) separate sand from scraped or flushed manure. Mechanical SMS should not be confused with mechanical manure separators. The distinction being, sand-manure separators separate sand that is recyclable from manure and water whereas manure separators separate manure solids and some sand which is not recyclable from water. SLDM is usually delivered to a sand-manure separator by an inclined auger. Once in the separator, SLDM is mixed with air and recycled water which suspend the manure solids. Sand is allowed to settle in the separator and is recovered by a mining-duty auger. Sand is discharged at 10 to 12% moisture with less than 2% organic matter and can be reused for bedding. As with non-mechanical separators, sand with minimal fines is preferred. Recovery efficiency of 90% or

greater is attainable when an SMS is used in conjunction with the proper sand gradation which is also optimal for the cow. The manure discharged from mechanical separators is relatively sand free and can be pumped or allowed to gravity flow to storage.

Storage

Storage options for SLDM vary depending on topography, existing equipment on hand or willingness to purchase, method of conveyance from the shelter, soil characteristics, depth to groundwater, and CAFO regulations specific to your State.

The manure fraction of SLDM that has gone through an effective sand-manure separation process can be stored long-term in structures typically designed to handle liquid dairy manure.

"Raw" SLDM can be effectively stored for short periods of time (about 2 to 3 weeks) without significant settling of sand particles given that no significant dilution water is added. Possible sources of dilution water include milking center wastewater, direct rainfall, and rainwater runoff. The short-term storage option works well if you can spread manure on a frequent basis year-round and desire to handle SLDM primarily with one line of manure equipment. As a precaution, a short-term storage should be designed so that an excavator or large backhoe can "mine" settled sand from all portions in the event significant dilution water ends up in the storage.

If short-term storage is not an option or you desire to have long-term storage, than settling of sand from SLDM by addition of dilution water is inevitable and must be accounted for during storage design. Access ramps for pay loaders or the like need to be incorporated to allow for efficient removal of settled sand.

SLDM storages that are located in close proximity to the shelter can be loaded directly with rubber blade skid steer loader or with augers. Remote storages are most efficiently loaded with a pumping system. Design the remote storage so the fill pipe discharges about 1/3 the length of the storage from one end through the floor.

Structures designed to handle SLDM are either constructed in the ground or with a small amount exposed above the ground so settled sand clean-out can be easily accomplished. Storage construction material options include reinforced concrete walls and floors or inclined earthen walls with a concrete floor.

Storage Unloading

Unloading of short-term SLDM storage can generally be accomplished with a pumping system discharging in liquid manure tankers. Alternatively, a pay loader can be used to load box type manure spreaders. Augers can also be employed.

In most cases, long-term SLDM storage unloading generally requires two lines of manure equipment – equipment to handle the "liquid component" (water, floating solids, and some settled solids) and other equipment to handle the "solids component" (settled sand with incidental manure solids). The liquid component can be pumped off and hauled as liquid manure and the solids component is handled with box or "V" spreaders.

However, Stonyvale Farms in Maine successfully manage a long-term SLDM storage with one line of manure hauling equipment. They use liquid manure equipment mounted on tandem axial trucks to initially haul the more liquid component and then towards the end of storage cleaning the more solids component. A loader tractor is used to push the solid component towards the unloading pump when material flowability decreases. Liquid tanks are cleaned once the unloading process is complete and the centrifugal pump is rebuilt for about $800 twice a year.

Agitation of both a short and long-term storage is not desired – in fact it significantly hinders the overall unloading process. Oftentimes, agitation accelerates settling by breaking up the manure mass that was otherwise holding the sand in suspension. Agitation of SLDM quickly results in "sand dams" formed around the pump/agitation unit. These dams prohibit the flow of new material to the pump resulting in a storage structure that can not be cleaned until the pump is moved or the dam is destroyed.

Equipment Overview

There is a noticeable distinction between manure and sand handling equipment. Manure equipment is usually constructed from mild steel whereas sand equipment is comprised of abrasion resistant alloys. Manure equipment relies on close tolerances and high speeds whereas sand equipment uses large tolerances that prevent sand grains from grinding between metal surfaces. When purchasing equipment for handling SLDM consider equipment designed specifically for sand. Manufacturers experienced with handling sand are knowledgeable of manufacturing techniques and raw materials which when used together result in machinery that stands up to the abrasiveness and weight of sand.

Curt Gooch is a professional engineer in Cornell's department of agricultural and biological engineering and heads up the dairy facilities component of the PRO-DAIRY program.

Andrew Wedel is a professional engineer with the McLanahan Corporation located in Hollidaysburg, PA.