Calibrating Liquid Manure Tank Applicators

As crop production technology, livestock production practices, and environmental regulations have changed over the years, so has the role of manure as a nutrient source for crops. Liquid manure can supply all the nutrients needed to attain optimum crop growth. However, knowing how much manure to apply per acre and what nutrients are available in what quantity, are keys to successfully using manure for crop production.

Why calibrate?

Using correct application rates for manure has become critical. State and federal regulations require management of phosphorus, which for most manure applications could mean lower application rates than those allowed based on nitrogen. The responsibility of livestock producers is not limited to just completing manure management plans. Producers also have a responsibility to make sure application rates in the field comply with their approved manure management plan. Producers or custom applicators must be familiar with their application equipment and manure characteristics to ensure accurate application rates in the field.

Liquid manure applicators generally have a liquid tank fitted with a pump that feeds into the manifold chamber, which in turn distributes manure to different points on the toolbar. A liquid tank is designed to hold a specific quantity of manure. However, due to manufacturing variations, manure foaming, and solids build-up, the liquid tank may not be filled to the rated capacity. Because of these inconsistencies, it is important to know how many gallons a given liquid manure tank can hold. Inaccuracies may result in under-application that may affect crop yields or an over-application that is not allowed by the manure management plan and can be harmful to crops and the environment. Calibration of an overall application rate in gallons per acre can be achieved by using an area-volume (AV) method. This method provides a good measurement of the application rate across the entire field. It does not address any variability across the toolbar points within the same swath. Calibration of the application rate is essential to ensure that the manifold chamber is pressurized to the greatest extent possible and is experiencing the appropriate manure flow rate. Once calibrated for application rate, the manure distribution across the toolbar swath can then be addressed.

The AV calibration method

Producers and custom applicators can easily calibrate their manure applicators. The AV method requires weighing the applicator (full and empty), measuring the density of manure, and measuring the application spread pattern (length and width of spread). These measurements and computations for correct manure application rates can be recorded on the enclosed calibration worksheet. A completed sample of the calibration worksheet is provided on page 4 of this publication.

STEP 1. WEIGHING THE APPLICATOR

Manure applicators can be weighed at local elevators. This requires two trips to the elevator, once to weigh the applicator full with manure and again to weigh the empty applicator. An alternative is to use weigh pads in the field or at the confinement site. Weigh pads to be used for calibrating manure applicators should have enough capacity to weigh each tire without the tires squatting over the pad and touching the ground (Figure 1). When using weigh pads, weigh each wheel and the hitch without any weight on the tractor drawbar (Figure 2). Record both the empty and full weights for each axle tire and hitch on the provided calibration worksheet (Refer to publication AE 3601B **https://store.extension.iastate.edu/Product/14724** for a blank worksheet). If weighing on a scale that measures the complete unit, record the total full weight and total empty weight. Disregard hitch weights when using a scale that measures the complete unit provided the hitch weight is not being transferred to an off-scale tractor.

Figure 1. Weigh pad used to weigh a manure tank wagon.

Figure 2. Weighing the hitch on a manure tank wagon.

STEP 2. MEASURING MANURE DENSITY

Water weighs 8.34 pounds per gallon under standard conditions. However, liquid manure may weigh more based on the presence of organic solids and heavier solids like sand and silt. Since all livestock operations are managed differently, this number will most likely vary from one operation to another. To calculate the density of manure, perform a five-gallon bucket test. The test requires a five-gallon bucket, a one-gallon measuring flask, and a scale. Fill the measuring flask up to the one-gallon mark with water and pour it into the five-gallon bucket. Repeat this process four more times. Place a mark in the bucket at the five-gallon level. Now, empty the bucket and weigh it empty to get a tare weight. Then, fill it with manure up to the five-gallon mark and weigh it on a scale. Repeat the process to get at least three weight readings.

STEP 3. MEASURING SPREAD PATTERN

A spread pattern refers to how wide an applicator applies manure and how much linear distance it takes to empty the liquid tank. To calculate the spread pattern width, you will need to know the knife spacing and the number of knives on the applicator (Figure 3). To measure the length of spread pattern, or the swath width, use a measuring tape, measuring wheel, or range finder. Measuring tapes may not be available in the length you will need. Range finders generally require a reflective surface to provide a measurable reading. Therefore, measuring wheels may be most practical, although their use does require walking the whole length of application.

Figure 3. Measuring the application swath width.

Calibrating the application rate

After all measurements have been made and recorded in the calibration worksheet, application rate can be calculated for a liquid tank application. Use the calibration worksheet to calculate the rate at which the manure has been or will be applied.

One easy way to adjust application rates is to change the driving speed. Drive slower to increase application rates by reducing spread pattern length. Alternatively, drive faster to lower application rates by increasing spread pattern length. Automation of flow control coupled with global positions systems (GPS) can help to limit the need for the application rate calibration. Automation helps to achieve relatively more accurate application rates and provides flexibility to make adjustments while applying manure. Commonly used flow control methods include a flow meter coupled with a hydraulically controlled pump or valve. In a typical application, the operator enters the target application rate and the toolbar knife spacing information into the flow controls mounted in the tractor cab. A drive speed can also be provided as an input if GPS is not activated or used to determine the drive speed. As the application proceeds, the output from the flow meter is used with the area covered information to calculate the application rates being achieved, which is then checked against the target application rate. In case of a variable speed pump, the pump is throttled up or down to vary its speed causing the flow rate to change. In case of the hydraulically controlled valve attached to a single speed pump, the change in flow rate is achieved with change in the valve opening. Precautions should however be exercised to validate the automatic flow controls to ensure that the application rate being targeted is being delivered to the application manifold.

Validating automation

Operator inputs of the targeted application rate, toolbar knife spacing, and the drive speed into the flow controls should be as accurate as possible. As the flow controls use this information for calculating the application rate being achieved, any incorrect entries can lead to inappropriate application rates.

The second key component of the flow controls is the flow meter which provides a critical flow rate measurement. This measurement should be validated, at least once a year, to ensure that the flow meter is functioning properly. This validation can be achieved by first completely draining a tank wagon in the field after an application run. This empty tank wagon can then be loaded and weighed using the weigh pads as explained earlier in Step 1 under calibration on page 2 of this publication. Compete the manure application using this loaded and weighed tank wagon. After the manure application is complete and prior to re-loading the tank wagon, weigh the empty tank wagon. The weight of manure applied, after subtracting the tare weight, should then be converted to volume of manure applied using the liquid manure density as described earlier under Step 2 on page 2. This calculated volume applied can then be validated against the flow meter reading to ensure the flow meter is functioning properly. In case the flow meter is not functioning properly, it should be repaired prior to use or replaced with a different flow meter.

The last component of the flow controls is the validation of the drive speed. In case drive speed is an operator input into the flow controls, the operator should drive the tractor and lock the speed as close to the input value as possible. In case a GPS system is used to input the drive speed into the flow controls, the accuracy of the horizontal distance measurement of the GPS signal must be checked. Typically, this horizontal accuracy of the GPS signal is known prior to use. The tractor mounted with the GPS system can be driven a known distance and this distance can be verified against the GPS measurement. Poor horizontal accuracy in the GPS signal (due to several reasons not discussed here) can lead to inaccurate area calculations resulting in improper application rates and should be avoided.

Operator inputs, flow meter measurements, and drive speed validations can help improve the accuracy of the application rate being achieved. The methods explained in this publication help achieve a more accurate application rate. In addition to the application rate calibration, the distribution of liquid manure uniformly across the tool-bar points should also be considered (refer to ISU Extension and Outreach publication AE 3600 for further details on manure distribution). For more information, contact your **ISU Extension and Outreach county office** to reach the field agricultural engineer in your area.

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Additional resources

Distribution of Liquid Manure Application (AE 3600)
https://store.extension.iastate.edu/Product/14891

Calibration and Uniformity of Solid Manure Spreaders (PM 1941) **https://store.extension.iastate.edu/Product/5536**

How to Sample Manure for Nutrient Analysis (PM 1558)
https://store.extension.iastate.edu/Product/5059

Using Manure Nutrients for Crop Production (PMR 1003)
https://store.extension.iastate.edu/Product/12874

Additional resources may be found on the Iowa Manure Management Action Group (IMMAG) web page at **http://www.agronext.iastate.edu/immag** or by visiting the ISU Extension and Outreach web page at **www.extension.iastate.edu**.

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Calibration worksheet

Name:______________________________Tank ID:______________________________

Applicator description (including brand name, model number, expected gallons, number of axles, how applied, number of injectors, injector spacing, width of application, etc.):

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Target application rate per acre:______________________________

Net tank weight	Axles	Hitch	Other	Total	Line
Full tank weight (pounds)	67,200	3,500	N/A	70,700	(1)
Empty tank weight (pounds)	11,800	600	N/A	12,400	(2)
Net Tank Weight (pounds) (line 1 minus line 2)				58,300	(3)
Liquid manure density	**Rep 1**	**Rep 2**	**Rep 3**	**Average**	
Full bucket weight (pounds)	48.6	35.2	47.0	43.6	(4)
Empty bucket weight (pounds)	2.2	2.4	2.3	2.3	(5)
Net manure weight (pounds) (line 4 minus line 5)				41.3	(6)
Manure density (pounds per gallon) (divide line 6 by five)				8.3	(7)
Gallons applied (divide line 3 by line 7)				7,025	(8)
Application area					
Width of application (feet)				18	(9)
Length of application (feet)				5,750	(10)
Acres applied (multiply line 9 by line 10 and then divide by 43,560)				2.38	(11)
Manure application rate (gal/acre) (divide line 8 by line 11)				2,952	(12)
N, P_2O_5, or K_2O value per 1,000 gallons				N = 55	(13)
Nutrient rate per acre (pounds/acre) (multiply line12 by line 13 and then divide by 1,000)				162.4	(14)