7 Manure Application Equipment

The manure application method has considerable impact on nutrient retention and loss. Liquid manure application technology has improved in the past few years. Newer systems can apply liquid manure in a way that maximizes nutrient recovery, minimizes odour, and reduces the risk of runoff, compaction and soil disturbance.


Drag hose injector applying into stubble

The development of manifold distribution systems has allowed liquid manure to be delivered to a toolbar that can apply the manure close to the ground or through direct injection into the soil. Low-level application reduces odour and ammonia volatilization compared to traditional broadcast systems or irrigation. Injection reduces odour, volatilization and runoff risk and maximizes nutrient utilization. If the manure is supplied with a drag hose, soil compaction can also be significantly reduced.

Openers commonly employed to inject liquid manure include sweeps and low-disturbance systems using chisel or disc openers. The low-disturbance openers are suitable for liquid manure application into post-emergent forage and annual crops as well as pasture, zero tillage or reduced tillage systems. One disadvantage of injection is the potential for nutrient stripping if row spacing is wide (e.g. 60 cm/24 inches).

Solid manure application generally involves broadcasting with or without incorporation. Due to the rather inconsistent nature of most solid manure, uniformity is often an issue. Incorporation of solid manure helps to reduce odour, conserve ammonium, increase the manure-to-soil contact for decomposition, and to prepare a suitable seed-bed. However, incorporation of solid manure may require an additional tillage pass. This would increase the amount of time required for manure spreading and may increase soil compaction.

7.1 Calibrating Manure Application Equipment


Loading a Manure Tanker

"Calibration" refers to the combination of settings needed to deliver manure at a particular rate. The only way to know how much manure is actually being applied to the field, and to meet the calculated manure application rate, is through calibration of the manure application equipment. The calculation of manure application rates is of little value if the equipment is not properly calibrated to deliver the required application rate.

Solid, semi-solid and liquid manure spreaders can discharge manure at various rates, depending on speed of travel, PTO speed, gear-box setting, discharge openings, width of spreader, overlap patterns and other parameters.

The following equations (metric) are used to calibrate liquid and solid manure application equipment. Imperial calculations can be found in **Appendices E and F**.

7.1.1 Calibrating Liquid Manure Applicators

Liquid Manure Tankers

The actual volume of manure that is contained in a liquid manure tanker is often less than the manufacturer's rated volume due to foaming and splashing. Ninety per cent of the manufacturer's rated volume is a reasonable approximation of the actual volume in a full load.

- **Calculate an application rate, using the actual tanker volume, emptying time, ground speed and spread width.**

$$\text{Application Rate (L/ha)} = \frac{\text{Actual Tanker Volume (L)} \times 36{,}000}{\text{Emptying Time (s)} \times \text{Ground Speed (km/h)} \times \text{Spread Width (m)}}$$

Example: If the manufacturer's rated volume for a tanker is 20,000 L, emptying time is 7 minutes (420 s), ground speed is 5.5 km/h and the spread width is 7 m, the application rate is calculated to be:

$$\text{Application Rate} = \frac{(20{,}000 \times 90\%) \times 36{,}000}{420 \times 5.5 \times 7} = 40{,}100 \text{ L/ha}$$

- **Adjust the ground speed to achieve a target application rate using the actual tanker volume, emptying time, target application rate and spread width.**

$$\text{Ground Speed (km/h)} = \frac{\text{Actual Tanker Volume (L)} \times 36{,}000}{\text{Emptying Time (s)} \times \text{Application Rate (L/ha)} \times \text{Spread Width (m)}}$$

Example: If the manufacturer's rated volume for a tanker is 20,000 L, emptying time is 7 minutes and the spread width is 7 m, to achieve a target application ate of 60,000 L/ha the appropriate ground speed is calculated to be:

$$\text{Ground Speed} = \frac{(20{,}000 \times 90\%) \times 36{,}000}{420 \times 60{,}000 \times 7} = 3.7 \text{ km/h}$$

- **Calculate an application rate, using the actual tanker volume, spread width and spread length.**

$$\text{Application Rate (L/ha)} = \frac{\text{Actual Tanker Volume (L)} \times 10{,}000}{\text{Spread Width (m)} \times \text{Spread Length (m)}}$$

Example: If it takes two loads with a 20,000 L tanker (manufacturer's rating) to cover an 800 m length of field with a 7 m width of spread, the calculated application rate is:

$$\text{Application Rate} = \frac{(20{,}000 \times 90\%) \times 2 \times 10{,}000}{800 \times 7} = 64{,}300 \text{ L/ha}$$

Drag Hose System

Drag hose systems pump manure through flexible hoses or umbilical pipe from the storage to a tractor powered injector. This system combines the time savings features of an irrigation system with the benefits of direct injection.

- **Calculate an application rate using the flow rate, ground speed and spread width**

$$\text{Application Rate (L/ha)} = \frac{\text{Flow rate (L/h)} \times 10}{\text{Ground Speed (km/h)} \times \text{Spread Width (m)}}$$

Example: If the flow meter indicates a pumping rate of 225,000 L/h, the ground speed is 3.5 km/h and the spread width is 5.5 m, the application rate is calculated to be:

$$\text{Application Rate} = \frac{225{,}000 \times 10}{3.5 \times 5.5} = 116{,}900 \text{ L/ha}$$

Low disturbance injection into grassland

Post emergent injection with a modified aerway system

- **Adjust the ground speed to achieve a target application rate using the flow rate, target application rate and spread width**

$$\text{Ground Speed (km/h)} = \frac{\text{Flow Rate (L/h) x 10}}{\text{Application Rate (L/ha) x Spread Width (m)}}$$

Example: If the flow meter indicates a pumping rate of 225,000 L/h and the spread width is 5.5 m, a target application rate of 80,000 L/ha is achieved with a ground speed calculated to be:

$$\text{Ground Speed} = \frac{225{,}000 \text{ x } 10}{80{,}000 \text{ x } 5.5} = 5 \text{ km/h}$$

7.1.2 Calibrating Solid Manure Spreaders

Truck mounted solid manure spreader

Solid manure spreaders usually are rated in cubic feet or bushels for struck-load and heaped-load capacities. A struck-load is a load that is level with the top of the box, and a heaped-load is heaped as high as the box will hold. Since the box will probably be heaped as much as possible when hauling manure, the heaped load capacity is the most useful value.

Although the spreader boxes have a volume rating, application rates are usually expressed as mass (i.e. in tonnes) per unit area (i.e. hectare). If truck scales are available, determine the mass of manure in a full load by finding the mass of the manure spreader empty and then full. The mass of the manure is the difference between the two.

- **Calculate an application rate using the net mass per load, the spread width and the spread length for a given load**

$$\text{Application Rate (t/ha)} = \frac{\text{Net Mass per Load (t) x 10,000}}{\text{Spread Width (m) x Spread Length (m)}}$$

Example: If the net mass per load is 3.5 t, the spread width is 3 m and the spread length is 300 m, the application rate is calculated to be:

$$\text{Application Rate} = \frac{3.5 \text{ x } 10{,}000}{3 \text{ x } 300} = 39 \text{ t/ha}$$

If truck scales are not available, the mass of the manure in a full load must be calculated from the known volume and an estimated density because:

Density = Mass/Volume
and therefore
Mass = Density x Volume

To determine the density of the manure:

1. Get a pail of known volume in cubic meters (m^3). If the volume of the pail is in litres, use the conversion table in **Appendix A** to convert to cubic metres.
2. Fill the pail with a typical sample of manure, and pack it in the pail to a density similar to that in the spreader box.
3. Weigh the pail full and then empty the manure and weigh the pail empty.
4. For the mass of the manure, take the difference between the full pail mass and the empty pail mass. [Manure Mass = Full Pail Mass – Empty Pail Mass]
5. Repeat steps 2 to 4 three times to obtain three manure masses.
6. Take the average of the three manure masses.
7. Take the average manure mass (in kg) and divide by the pail volume (in m^3) to get the density of the manure. [Density = Mass/Volume]

- **Calculate the manure density**

Density = Mass/Volume

Example: If a 0.02 cu.m pail weighed 1 kg empty and 8 kg (on average) full, the density would be:

$$\text{Density} = \text{Mass/Volume} = \frac{(8\text{-}1)\text{ kg}}{0.02\text{ cu.m}} = 350\text{ kg/cu.m}$$

- **Calculate an application rate using the spreader box volume, manure density, spread width and spread length**

$$\text{Application Rate (t/ha)} = \frac{\text{Box Volume (cu.m) x Manure Density (kg/cu.m) x 10}}{\text{Spread Width (m) x Spread Length (m)}}$$

Example: If the box volume of a spreader is 8 cu.m, the manure density is 350 kg/cu.m, the spread width is 3 m and the spread length is 175 m, the application rate is calculated to be:

$$\text{Application Rate} = \frac{8 \times 350 \times 10}{3 \times 175} = 53\text{ t/ha}$$

- **Calculate an application rate using the spreader box volume, manure density, emptying time, ground speed and spread width**

$$\text{Application Rate (t/ha)} = \frac{\text{Box Volume (cu.m) x Manure Density (kg/cu.m) x 36}}{\text{Emptying Time (s) x Ground Speed (km/h) x Spread Width (m)}}$$

Example: If the box volume of a spreader is 8 cu.m, the manure density is 350 kg/cu.m, the emptying time is 70 s, the ground speed is 8 km/h and the spread width is 3 m, the application rate is calculated to be:

$$\text{Application Rate} = \frac{8 \text{ x } 350 \text{ x } 36}{70 \text{ x } 8 \text{ x } 3} = 60 \text{ t/ha}$$

- **Adjust the ground speed to achieve a target application rate using the spreader box volume, manure density, emptying time, target application rate and spread width**

$$\text{Ground Speed (km/h)} = \frac{\text{Box Volume (cu.m) x Manure Density (kg/cu.m) x 36}}{\text{Emptying Time (s) x Application Rate (t/ha) x Spread Width (m)}}$$

Example: If the box volume of a spreader is 8 cu.m, the manure density is 350 kg/cu.m, the emptying time is 70 s and the spread width is 3 m, to achieve a target application rate of 50 t/ha the required ground speed is calculated to be:

$$\text{Ground Speed} = \frac{8 \text{ x } 350 \text{ x } 36}{70 \text{ x } 50 \text{ x } 3} = 9.6 \text{ km/h}$$

Alternatively, an application rate can be calculated without knowing the manure density. Instead, the rate is estimated based on the measured mass of manure spread over a small, known area. In the field, the manure spreader passes over a sheet of plastic cut to specific dimensions (eg. 1 m x 1 m). The manure on the plastic sheet is picked up with the sheet and its mass determined using a scale. These steps are repeated several times so that an average application rate can be determined.

- **Calculate an application rate using the mass of manure and sheet area.**

$$\text{Application Rate (t/ha)} = \frac{\text{Net Mass of Manure (kg)} \times 10}{\text{Sheet Area } (m^2)}$$

Example: If the net mass of manure on a 1 m x 1 m plastic sheet is 5 kg, the application rate is calculated to be:

$$\text{Application Rate} = \frac{5 \times 10}{1} = 50 \text{ t/ha}$$

7.2 Uniformity of Application

Uniformity of application is also important for optimum crop response. Uniformity is important because the manure nutrients need to be applied to the entire crop to avoid stripping or overlapping. Uniform application requires that the manure application equipment delivers nutrients evenly across the spreading width, and that the driving pattern avoids gaps and overlaps in application.

Tractor pulled solid manure spreader