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Irrigation of Liquid Manures with a Traveling Gun

F 255

Albert R. Jarrett, Professor, Agricultural and Biological Engineering
Robert E. Graves, Professor, Agricultural and Biological Engineering

This fact sheet emphasizing how to check a traveling gun liquid manure system for appropriate application rates is part of a fact sheet series. If you have not read, or are not familiar with, fact sheet F-254 *Irrigation of Liquid Manures: Basic Principles and Procedures*, please read it before trying to use the information in this fact sheet.

A traveling gun is a sprinkler containing a large (>0.5-inch diameter) nozzle mounted on a wheeled unit that is propelled through the field at a speed set by the operator, see Figure 1. Most traveling guns or travelers have a range of speeds created by the manufacturer when the unit is built. Liquid manure is pumped through a flexible hose to the sprinkler mounted on the traveler, see Figure 1. The sprinkler may rotate through a full-circle or may only rotate through a portion (usually 230 to 270 degrees) of the arc. Travelers either have the sprinkler mounted on the take-up reel unit and is pulled through the field as the take-up reel shortens the length of pipe to the hydrant at the edge of the field or the sprinkler is mounted on a separate rig, see Figure 1, that is drawn to the reel unit anchored at the field edge.

Figure 1. Traveler.

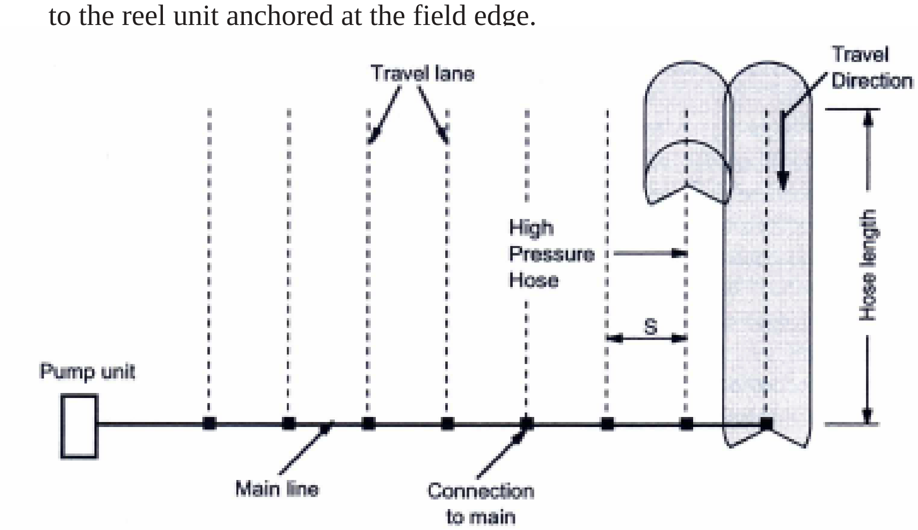

Figure 2. Operation layout for a traveling gun system. (Adapted from Pair, 1975)

Traveling guns are often used to apply liquid manure to fields. Their primary advantage is that they have a large nozzle that can pass some solids without clogging. Generally manures of solids content as high as 8% can be applied through a traveler if the manure is well mixed and the solids have been reduced to small particles.

There are also several disadvantages to using traveling guns to apply manure. These include uneven distribution of liquid; in other words not all areas of the field will receive the same depth of manure. This problem can be compensated for by overlapping the paths about 20%, see Figure 2. Another disadvantage of traveling guns is the large droplets that are formed as the manure exits the nozzle. These large droplets hit the crop or soil surfce with a great deal of energy; energy that can damage crops or compact the soil.

Table 1. Desirable sprinkler spacings for traveler-type sprinklers as a percentage of the sprinkler's wetted diameter. (Adapted from Pair, 1975)

Wind Speed	Percent of Wetted Diameter
No Wind	80
Up to 5 mph	70to 75
Up to 10 mph	60 to 65
>10 mph	50 to 55

Application Depth. The depth of manure applied to the field during each pass of the traveller (the application depth, A_d) can be estimated by first determining the sprinklerís discharge in gpm, the speed the traveller moves through the field S_d in ft/min, and wetted diameter of the sprinkler, W_d in feet. From these data, the depth of manure applied during each pass through the field can be determined by

$$A_d = \frac{1.6\ Q}{W_d S_p} \qquad (1)$$

Where A_d = application depth (inches)
Q = sprinkler discharge (gpm)
W_d = sprinkler wetted diameter (feet)
S_p = traveler speed (ft/min)
1.6 = unit conversion factor

Equation 1 was developed under the assumption that the distance between the traveller paths in the field was equal to the sprinklerís wetted diameter, W_d. Many traveller systems are designed using this assumption to minimize the number of passes required to cover a field. Because sprinklers do not apply water, or manure, uniformly and wind distorts even the best sprinkler distribution, sprinklers are usually spaced so they are some percentage of the sprinklerís wetted diameter apart. Table 1 shows the percent spacings recommended for large sprinklers as a function of wind speed. For conventional center irrigation systems travelers are not placed more than 80% of the wetted diameter apart. This means that a sprinkler with a wetted diameter of 190 feet (W_d = 190 feet) would not be placed more than 0.8(190) = 152 feet apart and this assumes there is no wind.

Great efforts have been made by the big gun manufacturers to create sprinkler nozzles that have the ability to produce a nearly uniform distribution at relatively low pressures. When these nozzles are used correctly sprinkler spacings of about 70 to 80 percent of the wetted diameter yield acceptable uniformity.

When the influence of pressure and wind are added to Equation 1 as the sprinkler wetted diameter, W_d is replaced with the spacing between the towpaths S, which is usually from 70 to 80% of the sprinklerís wetted diameter. Thus the total depth of manure applied per irrigation event (or pass) is

$$A_d = \frac{1.6\ Q}{S S_p} \qquad (2)$$

Where A_d = application depth (inches)
Q = sprinkler discharge (gpm)
S = towpath spacing (feet)
S_p = traveler speed (ft/min)
1.6 = unit conversion factor

An example will demonstrate the use of Equation 2.

Example 1. A trveler is to be used to apply liquid manure to a pasture area planted in mixed grasses in early spring. The soil in this field is a slit loam. The sprinkler on the traveler discharges 200 gpm and throws water 95 feet (so the two radii equal a wetted diamter, Wd of 190 feet). The sprinkler is set to travel through the field at a speed of 3 ft/min and rotates through 230 degrees of arc. This means the sprinkler will traverse a 1,380-foot long field in 460 min (7.7 hr). Determine the depth of water applied in one pass assuming the psrinkler paths are 150 feet apart.

Solution: To use Equation 2, we need the sprinkler discharge, Q = 200 gpm, the towpath spacing, S= 150 feet, and the traveler speed, S_p = 3 ft/min. By substituting these values into Equation 2 we can compute the total depth of water applied to any point in this field as

$$A_d = \frac{1.6\,(200\ \text{gpm})}{(150\text{ft})\,(3\text{ft/min})} = 0.71\ \text{inches}$$

Thus one pass of this traveler will apply an average depth 0.71 inches of liquid manure. It should be noted that the uniformity of this depth may vary greatly depending on the sprinkler's operating pressure.

Application Rate. The application rate, Equation 1, is the rate at which water (or manure) is applied to any given point in the field. This is also the rate that the soil must absorb the water (or manure) so that none of the water (or manure) runs off the field. Therefore, the reason applcation rate is important in a manure irrigation system design is to prevent loss of manure as runoff from the field or into a stream.

In a field where a traveler is used to apply mnaure, each traveler operates independently, so it is possible to estimate the application rate, A_r for a traveler based on the sprinkler's discharg, Q in gpm, the sprinkler's wetted radius, R in feet, adn the portion of the cricle, φ in degrees receiving liquid manure as

$$A_r = \frac{96.3Q}{\pi\,(0.9R)^2} \times \frac{360}{\varphi} = \frac{13624Q}{R^2\varphi} \qquad (3)$$

where A_r = application depth (inches)
Q = sprinkler discharge (gpm)
π = the constant 3.14
R = the sprinkler's radius, whichis equal to $W_d/2$ in feet
φ = portion of circle receiving liquid manure in degrees
96.3 = unit conversion factor
360 = the number of degrees in a circle
13624 = unit conversion factor

Example 1. (continued)

Determine the application rate for the field application of liquid manure situation described in Example 1.

Solution: The application rate is determined by applying Equation 3 using the parameters given in Example 1. Thus the application rate can be computed as

$$A\,r = \frac{13624 \quad (200)}{95^{\,2} \ (230)} = 1.31 \quad \text{in/hr}$$

It should be noted that the application rate computed in Example 1 was 1.31 in/hr. Before proceeding with the liquid manure irrigation design, it is very important that you determine if this application rate exceeds the soil's ability to avsorb liquid manure. Suggested resources include Table 1, 2 and 3 of Fact Sheet F-254 or a qualified soil scientist. When Tables 1 and 2 of Fact Sheet F-254 are examined, it is obvious that 1.31 in/hr is greater than the infiltration rate listed for a silt loam soil. Thus, **some runoff of manure would be expected** unless there was additional data to show that this particular field had infiltration rates greater than 1.31 in/hr.

References

Pair, C. H. 1975. Sprinkler Irrigation. Sprinkler Irrigation Association, 13975 Connecticut Avenue, Silver Springs, MD 20906

Evaluating a Travelling Gun or Traveller Liquid Manure Irrigation System

Assessment Data. To be able to fully assess the suitability of a liquid manure application system using a travelling gun or traveller, the following information should be provided:

1. Sprinkler Discharge (Q) = _______________ gpm

2. Sprinkler Wetted Diameter (W_d) = _______ feet; Sprinkler Wetted Radius (R) = _______ feet

3. Sprinkler Pressure = ________________psi

4. Traveller Speed (S_p) = _____________ ft/min

5. Arc of circle Receiving Manure (φ) = ______ degrees

6. Spacing between traveller paths (S) = ______ feet

7. A sketch of the field where the traveller will be used along with indications of where the traveller will track through the field. Indicate slopes and changes in elevation along these paths.

8. A sketch of the field and all environmentally sensitive features within 1,000 feet of the field including streams, waterways, ponds, lakes, wells, springs, sinkholes, rock outcrops, homes, roads, subdivisions, steep slopes etc. Also show slope direction.

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