CHAPTER 6

Irrigation Application Calibration Methods

Bryan Smith and John P. Chastain

In order to apply animal manures and lagoon effluents properly the systems used must first be calibrated. This calibration allows the producer to determine the actual application rate of the equipment, which in turn prevents over-application and insures proper utilization of the manure or effluent. Regulation 200.100.B.5 requires the annual calibration of equipment used more than once per year, with equipment not used yearly to be calibrated before each use. Producers are required to retain the two most recent calibration records for review upon request.

There are several types of irrigation systems used to apply swine waste effluent to crop land. This chapter section will address a manual calibration method that works on almost any irrigation system and then discuss specific calibration equations for two types of irrigation systems.

THE “CAN” METHOD

The “Can” or “rain gauge” method of system calibration is very simple and works on almost any irrigation system. However, it does require operation of the system - preferably with clean water - to determine the application rate. The system uses a number of straight-sided cans of equal size (coffee cans work well) placed in the area to be watered. Rain gauges may also be used instead of cans if desired, provided they are also of equal size. The system is then operated for a period of time (solid-set systems) or for the time needed for the system to travel completely over the “cans” (traveler or center pivot). The water in the “cans” is then poured into one can, the depth of water measured, and then this depth is divided by the number of cans used to obtain the actual average irrigation amount. It is recommended that at least 6 cans be used, although more than 12 cans may add needless work unless the system is quite large.

For solid-set sprinkler systems:

(1) Place 6 or more evenly-spaced cans on a straight line between any two sprinklers.
(2) Turn the system on for a given amount of time.
(3) Turn the system off and collect the cans. Pour the water from all cans into a single can.
(4) Measure the depth of the water in the can with a ruler or tape measure.
(5) Divide this depth by the number of cans used to get the actual amount of water applied.
(6) If the time used was in minutes, divide this time by 60 to get hours.
(7) Divide the depth found in step 5 by the hours operated to obtain an application rate.

Example:
We place 8 cans between two sprinklers and operate the system for 45 minutes. After collecting the cans, pouring the water into a single can, and measuring the water we find we have a total of 2.2 inches.

2.2 inches ÷ 8 cans = 0.275 inches per can

45 minutes ÷ 60 minutes per hour = 0.75 hours

0.275 inches ÷ 0.75 hours = 0.36 inches per hour

So in this example the system applies 0.36 inches of effluent per hour. If we have previously determined how much effluent we need to apply, we can determine how long to operate the system by simply dividing the desired inches by the application rate. Say we determine that we want to apply 1.5 inches of effluent:

1.5 inches ÷ 0.36 inches per hour = 4.16 hours

To apply 1.5 inches in this example, we would have to operate the system slightly more than four hours. We may not be able to do this all at one time - depending on the moisture in the ground and the soil type and slope, runoff may occur during the application. In that case we would need to operate the system until runoff began to occur, then stop the system and operate it again later. This may require that we operate the system two, three, or four times or more to apply the needed amount of effluent without runoff. There are worksheets at the end of this section with blanks for all the numbers needed and an example to make these calculations (and all others presented in this Chapter) easier.

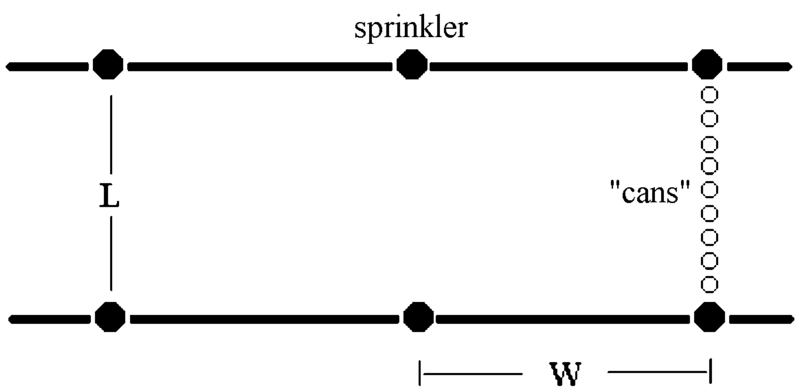

Figure 1. Typical rectangular sprinkler spacing with “cans” in place. “L” and “W” measurements explained later in text.

For traveling gun systems:

Many of the same steps apply that apply to the solid-set system. The differences are the operating time and can placement.

The cans should initially be placed on the ground in a line perpendicular to the direction of the traveler "run", and should be placed between the traveler and the gun cart where they will not be initially wetted. You must be careful not to place the cans in an area that would normally be "overlapped" by another adjacent run of the traveler. If you do decide to place cans in the overlap area, you must also operate the traveler on that adjacent run to get an accurate measurement.

For the operating time, the gun cart and sprinkler should advance over the cans as the system operates, "watering" the cans as it travels. The system must be operated until the gun cart has moved past the cans and all cans are completely out of the watering pattern of the sprinkler, which may take some time.

Example:
We place 8 cans between the gun cart and the traveler, being careful to place them so that they are not in a normally "overlapped" area and that the cans are not in the path of the gun cart tires. We then operate the system until the water no longer touches the cans, then collect the cans. After pouring all of the water in one can, we measure the depth and find it to be 6.4 inches.

$$6.4 \text{ inches} \div 8 \text{ cans} = 0.80 \text{ inches}$$

So in this case we have applied 0.80 inches of effluent. Please note that there are no further calculations - this is the actual amount of effluent applied to the land. No operating time adjustments are needed.

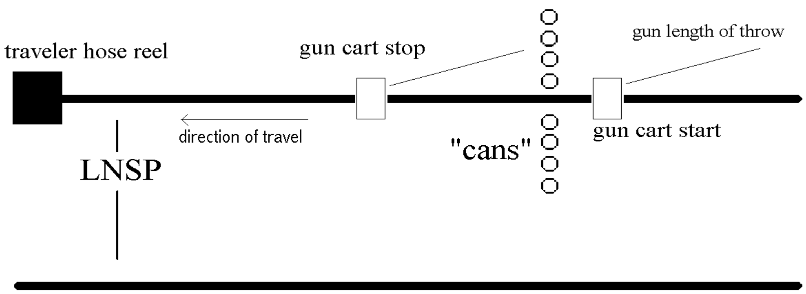

Figure 2. Typical traveling gun lane spacing with "cans" in place. "LNSP" measurement explained later in text.

For center pivot systems:

Use the same steps used for the traveling gun. Be sure to place the cans in a straight line under a pivot span (or spans) so that the line of cans will be parallel with the pivot as it passes directly overhead. Begin irrigation with the cans positioned so that water does not initially touch them, and continue to operate the pivot until it has passed completely over the cans and the water no longer touches the cans. Make sure that no cans are placed in the path of a tower wheel. The calculations are identical to those used for the traveling gun.

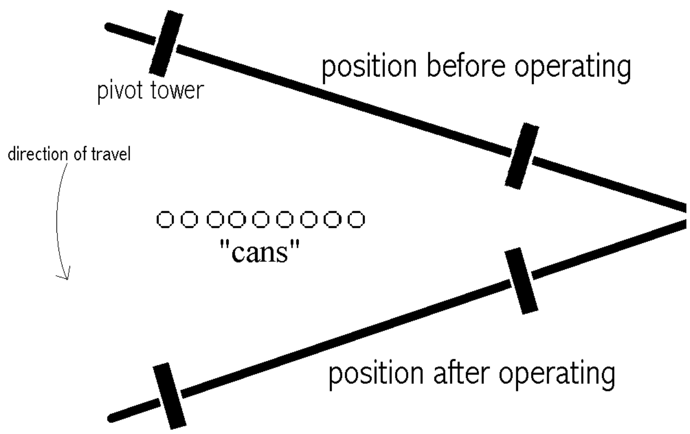

Figure 3. Typical center pivot system with "cans" in place. Positions shown before and after operation of pivot.

CALIBRATION EQUATIONS

The "can" method is very accurate when applied correctly, and will also allow for factors such as wear and evaporative losses. It should be used to check actual system performance. However, in many cases it is more convenient to calibrate the system by first calculating the expected application rate. Calibration equations for two systems are provided.

Solid-set systems with rectangular spacing

The equation used to determine application rates of solid-set irrigation systems on a "square" spacing is:

$$Inch/Hour = \frac{96.3 \ x \ GPM}{L \ x \ W}$$

In this equation, GPM is the flow rate of one sprinkler in gallons per minute, L is the distance between rows of sprinklers in feet, and W is the distance between sprinklers in the row in feet.

Example:
We have a solid-set system that has sprinklers spaced 60 feet by 40 feet. Each sprinkler has a flow rate of 7.2 gallons per minute. The application rate would be:

$$Inch/Hour = \frac{96.3\ x\ 7.2\ gpm}{60\ feet\ x\ 40\ feet} = 0.289\ inches/hour$$

Now, if we want to apply 1.7 inches of effluent, we would need to operate the system for:

1.7 inches / 0.289 inches/hour = 5.88 hours

Please note that this equation as presented above works for systems that are spaced on "square" or "rectangular" spacing. Triangular-spaced systems use the same equation, but care must be taken when determining the "L" and "W" dimensions. The "L" dimension is again the distance between the rows of sprinklers in feet, and "W" is the distance between sprinklers in the row in feet. The difference is that measuring the distance between the rows can be tricky, since this measurement is not taken directly from one sprinkler in a row to another sprinkler in an adjoining row, but rather from the centerline of one row of sprinklers to the center line of the adjacent row of sprinklers.

Traveling gun systems

The equation used to determine the application amount (note that's not the application *rate* as in solid-set systems) is:

$$Inches = \frac{19.26\ x\ GPM}{LNSP\ x\ TSPD}$$

In this equation, GPM is the flow rate of the "gun" or sprinkler in gallons per minute, LNSP is the space in feet between the "lanes" or "runs" of the traveler, and TSPD is the travel speed of the gun cart in inches per minute.

Example:
We have a traveler that is applying 245 gallons per minute of water. The traveler lanes are spaced at 230 feet, and the traveler is reeling in the gun cart at 15 inches per minute. The application depth is:

$$Inches = \frac{19.26 \; x \; 245 \; gpm}{230 \; feet \; x \; 15 \; inch/\text{min}} = 1.37 \; inches$$

If we want to know the travel speed needed to apply 1.5 inches of effluent, we can first re-arrange the equation to read:

$$TSPD = \frac{19.26 \; x \; GPM}{LNSP \; x \; Inches}$$

And then, using the same information provided above:

$$Inches/\text{min} = \frac{19.26 \; x \; 245 \; gpm}{230 \; feet \; x \; 1.5 \; inches} = 13.6 \; inches/\text{min}$$

This speed may or may not be possible on this traveler. Traveler speed ranges will vary depending on manufacturer, traveler model, and drive type. If the traveler would not travel this fast, we would simply widen the lane spacing, being careful to stay within spacings recommended by the manufacturer to ensure good uniformity of application. If the traveler would not travel this slowly we would “narrow” the lane spacing until the appropriate application amount is reached, again staying within the recommendations of the manufacturer.

CAUTIONS

The equations presented in this section are all based on clean water irrigation. Manure effluents have a higher solids content than clean water, and therefore may have a slightly different specific gravity. This means that if you calibrate your system based on clean water formulas, or using the “can” method and clean water, the actual performance of the system may be slightly different when actual effluent is applied. Clean water calibration provides an excellent starting point, but a “can” calibration using the actual effluent will be the most accurate way to determine your application rates and amounts.

Since lagoon effluents usually contain some amount of solids, there is a potential plugging problem for turbine-driven travelers and pumps with totally-enclosed impellers. Travelers used in lagoon effluent applications should then be of the engine-driven type instead of the normal turbine-driven type. The engine-driven travelers lack the restrictions and small passages present in the turbine-driven systems, which allows them to operate without plugging. Pumps used in such systems should contain semi-open impellers, which pass larger solids (and pass them more easily) than totally-enclosed impellers.

In some instances the lagoon to be pumped is agitated before application. This will typically increase the solids content in the liquid from approximately 0.5% to the 1% to 3% concentration found in agitated systems. Center pivots designed with supernatant application in mind should work well for the 0.5% solids, but care should be taken before introducing the higher solids contents of agitated systems into a center pivot or small-sprinkler solid set system. Traveling guns and large-sprinkler solid set systems with their large nozzles (0.7 inches or larger) provide a much larger travel path for the effluent with less opportunity for blockages due to solids.

(CAMM Poultry Chapter 6, last edit - January, 2003 wbs)

WORKSHEET 6-1

Farm Name:		Date:
Person(s) Calibrating:		Manure Type:
Description of Equipment:		
Fill in all that apply:	Pressure at Sprinkler:	
	Pressure at Pump:	

"Can" calibration method for solid-set sprinkler system:

		Example Problem			**Your Numbers**	
1	Number of cans	8				
2	Total depth of water poured into one can	2.2	inches			inches
3	Average application depth (#2 ÷ #1)	0.275	inches			inches
4	Time system was operated	45	minutes			minutes
5	Time in hours (#4 ÷ 60)	0.75	hours			hours
6	Application rate (#3 ÷ #5)	0.36	inches per hour			inches per hour
7	Desired application depth	1.5	inches			inches
8	Total required operating time (#7 ÷ #6)	4.16	hours			hours

WORKSHEET 6-2

Farm Name:		Date:
Person(s) Calibrating:		Manure Type:
Description of Equipment:		
Fill in all that apply:	PTO rpm:	Pressure at gun:
	Travel Speed:	Pressure at pump:

"Can" calibration method for traveling gun or center pivot system:

		Example Problem			**Your Numbers**	
1	Number of cans	8				
2	Total depth of water poured in one can	6.4	inches			inches
3	Average application depth (#2 ÷ #1)	0.8	inches			inches

WORKSHEET 6-3

Farm Name:	Date:
Person(s) Calculating:	Manure Type:
Description of Equipment:	

Solid-set sprinkler calibration equations:

			Example Problem			**Your Numbers**	
1	Sprinkler Size		#30				
2	Sprinkler Nozzle	(Main)	3/16	inch			inch
	Sprinkler Nozzle	(Spreader)	none	inch			inch
3	Sprinkler Pressure (from gauge)		50	psi			psi
4	Sprinkler Flow (from chart)		7.2	gallons per minute			gallons per minute
5	Sprinkler Spacing	Length	60	feet			feet
6	Sprinkler Spacing	Width	40	feet			feet
7	First Calc. (96.3 x #4)		693.3				
8	Second Calc. (#5 x #6)		2400				
9	Application Rate (#7 ÷ #8)		0.289	inches per hour			inches per hour

10	Desired Application Depth		1.7	inches			inches
11	Total Required Operating Time (#10 ÷ #9)		5.88	hours			hours

WORKSHEET 6-4

Farm Name:	Date:
Person(s) Calculating:	Manure Type:
Description of Equipment:	

Traveling gun calibration equations:

			Example Problem			Your Numbers	
1	Sprinkler Nozzle	(Main)	1.18	inch			inch
	Sprinkler Nozzle	(Spreader)	none	inch			inch
2	Sprinkler Pressure (from gauge)		70	psi			psi
3	Sprinkler Flow (from chart)		245	gallons per minute			gallons per minute
4	Traveler Lane Spacing		230	feet			feet
5	Traveler Speed		15	inches per minute			inches per minute
6	First Calc. (19.26 x #3)		4718.7				
7	Second Calc. (#4 x #5)		3450				

8	Application Depth (#6 ÷ #7)		1.37	inches			inches
9	Desired Application Depth		1.5	inches			inches
10	First Calc. (19.26 x #3)		4718.7				
11	Second Calc. (#9 x #4)		345				
12	Required travel speed (#10 ÷ #11)		13.6	inches per minute			inches per minute