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Chemigation: Calibrating System for Center Pivot Irrigation

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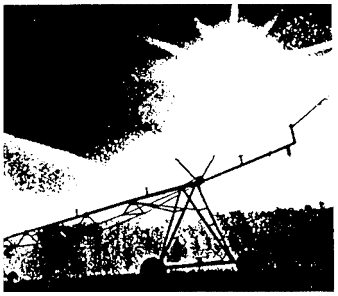


IRRIGATION
FACTS

Cooperative Extension Service
South Dakota State University

FS 863

Chemigation:

Calibrating Systems for Center Pivot Irrigation

by Hal Werner, Extension irrigation engineer

Chemigation is the application of agricultural chemicals such as pesticides or fertilizer with irrigation water. When used properly, chemigation is an environmentally sound and cost-effective way to apply many chemicals during the growing season.

Safe and effective chemigation is accomplished by combining both good management and good equipment. A very important part of management is accurate calibration. This fact sheet covers procedures for calibrating chemigation when using center pivot irrigation machines.

Chemigation calibration is the process of establishing how fast the center pivot will cover the field and adjusting the injection pump to apply the desired quantity of chemical per acre. Calibration insures that the proper amount of chemical is being applied thereby giving the highest economic gain and minimizing environmental risks. Calibration is especially important when applying pesticides where specific label rates must be followed. The procedure for calibration is straight-forward, but it does involve a significant time commitment, an understanding of chemigation concepts, and basic mathematical skills. You will need to spend time and effort calibrating before any chemical is applied.

It is necessary that all parts of the irrigation and chemical injection system are operating properly. All chemigation safety equipment should be installed and operating (see FS 860 Chemigation Safety).

Always check the irrigation system for operating problems and uniformity of water distribution. Some older-style systems such as water drives may not have good water distribution because more water from the drive goes near the wheel track. Make sure that the nozzles are not worn and that all sprinklers are operating properly. Remember that the chemical can be applied only as uniformly as the water applied.

The irrigation system and the injection system must be calibrated. You need to know the following information when calibrating:

- Acres covered
- Time to cover the field
- Depth of water applied
- Chemigation application rate
- Amount of chemical
- Injection rate

Besides the chemigation equipment, other items to help with calibration include a stopwatch, calculator, long measuring tape, marking stakes or flags, and a calibration tube.

Calibrating the Irrigation System

The irrigation system determines the length of time it takes to apply the chemical. Area covered and rotation time of the center pivot are required for calibration. Gallons per minute (GPM) pumped does not affect calibration, but it does determine the amount of water applied per acre.

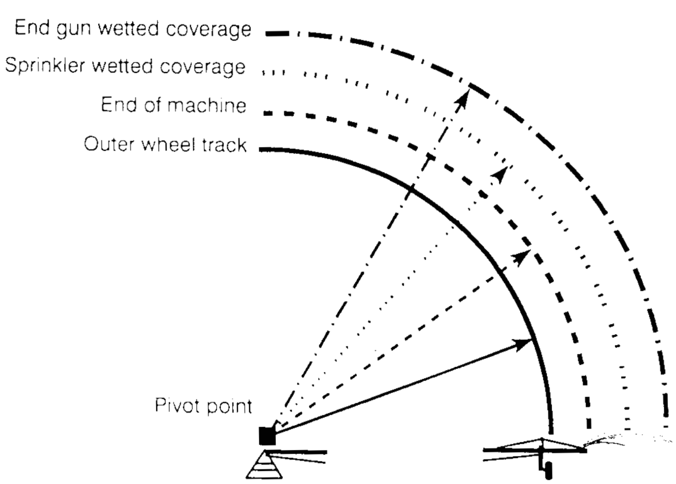


Figure 1. Lengths and sprinkler coverages for a center pivot.

Calibrating the irrigation system requires three steps.

Determine the area covered.

Calculate the acres (A) covered by the center pivot. Add sprinkler wetted coverage to the center pivot length to get an effective center pivot wetted radius. You may need to measure the length of the pivot. See Figure 1. High pressure sprinklers cover about 30 to 50 feet past the end of the pivot while spray sprinklers only cover 10 to 20 feet. For pivots that run full circle, the area covered is found by the following formula or Table 1.

Area covered (A) =
(Wetted radius in ft)^2 x 3.14/43560

An example with an effective center pivot wetted radius of 1320 ft:

Area covered = 1320^2 x 3.14/43560 = 125.6 acres

The 3.14 is equal to π and 43,560 is the number of square feet in an acre. The 1320^2 is the same as 1320 x 1320. This is the maximum-sized circle that can fit into a quarter section without watering across the property lines. Where the area covered is only a part of the circle, multiply by the proportion of the full circle. For example, a half circle from above would be one-half of 125.6 or 62.8 acres.

Finding the area when an end gun is used is more difficult. You need to know the effective coverage of the end gun beyond the normal sprinkler wetted radius and also the proportion of time that the end gun is on. Don't use the maximum wetted coverage of the end gun but only the area that gets well-watered. An example is shown for an end gun that covers effectively 60 feet beyond the normal sprinkler wetted radius and is operating for one-third of the circle.

Area covered (end gun on) = 1380^2 x 3.14/43560 = 137.3 A

Then the area covered accounting for two-thirds of the circle with normal sprinkler coverage and one-third with end gun coverage is:
Adjusted area covered = (125.6 x 2/3) + (135.3 x 1/3) =129.5 A

If you need assistance calculating areas, contact the Cooperative Extension Service, SCS, or your irrigation dealer.

Determine the time required to cover the field.

For chemigation calibration, you need to know how much time is required for the pivot to cover the circle or part of the circle. Two methods can be used to time the center pivot application.

Table 1. Acres covered by a full-circle center pivot for various sprinkler effective wetted coverages.

	Effective pivot wetted radius (feet)								
	620	660	700	1200	1240	1280	1320	1360	1400
Acres Covered	27.7	31.4	35.3	103.8	110.8	118.1	125.6	133.3	141.3

Table 2. Example of net irrigation depth in inches for a 125 acre pivot at 85% apllication efficiency.

	Rotation time, hours per 125 acre circle								
GPM	12	18	24	36	48	60	72	96	120
600	.11	.16	.22	.33	.44	.54	.65	.87	1.09
700	.13	.19	.25	.38	.51	.63	.76	1.02	1.27
800	.15	.22	.29	.44	.58	.73	.87	1.16	1.45
900	.16	.25	.33	.49	.65	.82	.98	1.31	1.63
1000	.18	.27	.36	.54	.73	.91	1.09	1.45	1.81

Acres/hr	10.4	6.9	5.2	3.5	2.6	2.1	1.7	1.3	1.04

The first method involves running the system across the field. Operate the system wet at the same speed (% timer setting) that you will when chemigating. Record the setting and the time it takes for one revolution or to cover the desired part of the field.

The second method involves measuring the distance the pivot travels during a measured time period. Measure the distance from the pivot point to the outer wheel track. Operate the system running wet at the same speed (% timer setting) as when chemgating. You can choose to measure either a preset distance (100 to 200 ft) along the outer wheel track using stakes or flags to mark it and time how long it takes to travel between the stakes. Or, another way is to place a stake at the wheel in the outer wheel track and run the system a preset time (at least 15 to 20 minutes). Then mark how far the wheel has moved with another stake and measure the distance between the stakes.

To calculate the time to cover a circle, use the following formula:
Wheel track circumference (ft) = 3.14 x 2 x distance from pivot to outer wheel track

Rotation time = Wheel track circumference x time between stakes/distance traveled.

An example has a pivot to wheel track length of 1280 ft and 32 minutes to travel 200 ft.

Wheel track circumference = 3.14 x 2 x 1280 = 8038 ft

Rotation time = 8038 x 32 min/200 ft = 1286 minutes

To convert minutes to hours, divide by 60, then . . .

Rotation time = 1286/60 = 21.43 hr or 21 hrs and 26 min

Since the percent timer setting is hard to reset exactly the same again, it is best to leave it set the same until you chemigate. If you need to change it and you have an electric drive pivot, you may want to first use a stop watch to check exactly how many seconds the end tower runs each time the motor is on. Then when you need to reset the system at a later time, you can use the stop watch to check the timer setting. Some of the newer model pivots have digital timers which can be set the same each time and may even have settings that let you set the number of hours to circle the field. The rotation time still should be checked when running wet on your field.

Determine the depth of water applied.

It is important to know the depth of water applied when planning the application of certain chemicals. For example, labels for certain pesticides may require a specific depth of water. Liquid nitrogen fertilizer can be applied with almost any depth of water.

Depth of water applied can be determined by placing several rain gages around the field or by calculating it. When measuring depth in the field, always keep the timer setting on the pivot the same as will be used for chemigation. The equation to determine depth applied is as follows:

Table 3. Gallons per acre of two common nitrogen solutions based on the intended nitrogen rate per acre.

		Pounds of N per acre			
		10	20	30	40
Fertilizer	% Nitrogen	Gallons per acre of solution			
Urea/Ammonium nitrate	28	3.3	6.7	10.0	13.4
Urea/Ammonium nitrate	32	2.9	5.7	8.6	11.4

Depth (inches) =
GPM x rotation time x 0.85/acres/450

Depth is the net depth applied assuming an 85% (0.85) application efficiency. GPM is gallons per minute. Table 2 gives an example of net irrigation depths versus GPM and rotation time for a 125 acre circle and 85% application efficiency.

An example using the equation with 800 gpm and a 2 day (48 hour) rotation:

Depth = 800 x 48 x 0.85/125 /450 = 0.58 inches

You may also want to know the gallons per acre of water applied. Multiply the depth applied by 27,154 to get gallons per acre.

Calibrating the Injection System

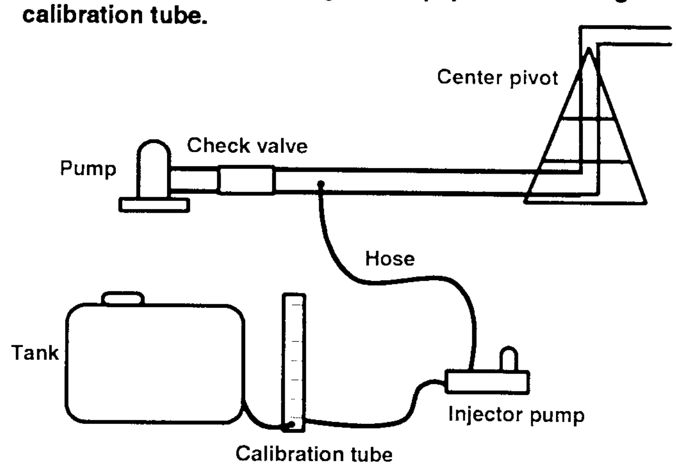
Determine the chemigation application rate.
The chemigation rate is the volume of chemical or chemical mixture that is required per acre. For pesticides you need to find the information on the label such as quarts per acre or gallons per acre. Some pesticides may not be in liquid form or may be in concentrated formulations that make it necessary to mix with water before injecting. You need to determine the mixing rate and volume of the chemical and water mixture prior to calibration since that volume will be used to calculate the injection rate. Also include any adjuvants or additives when calculating the volume.

For liquid nitrogen fertilizer, Table 3 gives the gallons per acre of nitrogen solutions that need to be injected based on the intended nitrogen application rate per acre.

Determine the amount of chemical.
You need to know the total amount of chemical applied to the field to size the storage container and to calculate the injection rate. The amount of chemical is the chemigation rate multiplied by the number of acres covered. For example, a pesticide rate of 1.5 pints per acre multiplied by 125 acres is 1.5 x 125 = 187.5 pints or 23.4 gallons. Another example using 28% nitrogen with 20 pounds of N per acre desired for 125 acres (6.7 gallons per acre from Table 3), the total amount of 28% solution is 6.7 x 125 = 871 gallons.

Determine the injection rate.
The injection rate is the volume of chemical solution divided by the rotation time or time to cover the desired part of the field. An example using the rotation time example of 21.43 hours and the 23.4 gallons of pesticide:

Figure 2. Layout of chemigation equipment showing calibration tube.



CONVERSIONS

To convert:

Square feet	to	acres	divide by	43560
GPM	to	acre-in/hr	divide by	450
Pints	to	gallons	divide by	8
Gallons	to	ounces (oz)	multiply by	128
Gallons/hr	to	oz/min	multiply by	2.133
Gallons/hr	to	ml/min	multiply by	63.07
Acre-in of water	to	gallons	multiply by	27154

Injection rate = volume of chemical + rotation time

Then injection rate = 23.4 / 21.43 = 1.1 gallons per hr or
injection rate = 1.1 gal/hr x 63.07 = 69 milliliters per min where the 63.07 is from the conversion table above.

It is important to select an injection pump that has a rating similar to the required injection rate. Accuracy of the calibration may be affected if the injection rate is different from the rating of the pump. The injection rate must fall within the recommended range of pumping rates for the pump. If the required injection rate does not match the performance of the available pump, use a different pump or the chemical may need to be diluted with water, and the injection rate will need to be adjusted accordingly.

Calibrate the injection pump.
The chemical injection pump must be adjusted to deliver the injection rate, especially when using products with labeled rates. A rough calibration setting should use the information provided with the pump or from a previous chemigation. Always do the first calibration using water. Make adjustments with the pivot pressurized or rig a pressure regulator downstream from the injection pump. You may want to calibrate the injection pump at the same time the center pivot is being run when obtaining the rotation time.

Convert the injection rate in gallons per hour to ounces or milliliters per minute (see example above). Start with an initial injection pump setting and check to see how close the setting is to that required. A calibration tube and a stopwatch are helpful when doing this.

A calibration tube is a clear plastic tube such as a large graduated cylinder. (See Figure 2.) Connect the tube to the intake side of the injection pump. It is handy to have fittings and valves that permit switching between the calibration tube and the main supply tank without shutting off the injection pump.

To obtain the final calibration, connect the injection equipment to the irrigation pipeline, pressurize the center pivot, and operate the injection pump with the chemical solution. Check the calibration and, if necessary, adjust the injection pump. Piston type pumps must be shut clown to adjust while diaphragm pumps can be adjusted “on-the-go.” Venturi injector units also can be adjusted while the unit is operating.

Monitoring During Chemigation

Check the calibration regularly while chemigating. Having the calibration tube installed simplifies these checks.

It is also important when chemigating to monitor the other parts of the chemigation setup. Make sure all safety equipment is operating properly and that there are no leaks in hoses and connections. Maintain agitation for any chemicals or solutions requiring it.

For Additional Information

- FS 860 Chemigation Safety
- FS 862 Chemigation Management

CHEMIGATION WORKSHEET

Center Pivot:

1) Area covered = (Wetted radius)^2 X 3.14 ÷ 43560 = _________ acres

2) Rotation time

a) Measure time to cover field ___________ hours or

b) Calculate time

Wheel track circumference = 3.14 X 2 X distance from pivot to outer wheel track
= _______ ft

Rotation time = circumference X time between stakes ÷ distance between stakes
= _______ minutes
= _______minutes ÷ 60 = _______ hours

3) Depth applied = GPM X rotation time X 0.85 ÷ acres ÷ 450 = _______ inches

Injection System:

4) Chemigation application rate ___________ gal/acre

5) Amount of chemical solution = rate X acres = _________ gallons

6) Injection rate = amount of chemical ÷ rotation time = _________ gal/hour
= _________ gal/hour X 2.133 = ________ ozs/minute or
= _________ gal/hour X 63.07 = ________ ml/minute

7) Adjust injection pump to the injection rate

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