WASHINGTON STATE UNIVERSITY EXTENSION

CHEMIGATION OR FERTIGATION INJECTION PUMP CALIBRATION

Chemigation Calculation Worksheet Series

By
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WSU PEER REVIEWED

FS230E

Chemigation or Fertigation Injection Pump Calibration

This worksheet helps with the calculations required for a **chemigation pump injection rate calibration check** using a calibration check tube. The meters on most injection pumps are inexact. The actual chemigation pump injection rate changes with fluid viscosity, temperature, pump wear, supply line diameter and flow resistance, and myriad other factors. Therefore, it is important to check, or calibrate, the injection rate (Figure 1). There are many types of injection pumps that operate slightly differently. But the procedure to calculate the injection rate is principally the same. Please refer to the pump's user manual for instructions on how to operate the pump.

Figure 1. Performing a chemigation injection pump calibration.

To check the pump's calibration, you must have an accurate measurement of the volume pumped and an accurate measurement of the time during which it was pumped.

$$Injection\ Rate = \frac{Volume}{Time}$$

This can be done two ways: using a stopwatch to time the pumping of a fixed volume, or measuring the volume pumped during a fixed amount of time. Here, we demonstrate a method that can be used with any tube, including the tank level sight tube, as in Figure 2. In our example, the injection pump rate is adjusted by selecting and modifying a percentage of the maximum rated output of the pump.

Figure 2. Applicator is measuring the distance that the fluid level changed in the external site tube during the calibration time period.

Before you begin, you need to know three things:

1. The initial pump setting (Table 1),
2. How much volume is pumped per inch of calibration tube length (Table 2), and
3. The fluid level difference in the tube that you *should* find after the calibration pump check time period if the injection pump is calibrated correctly (Table 3).

Find an initial pump setting.

Table 1. INITIAL ESTIMATE FOR PUMP SETTING: The starting percentage setting to try on the injection pump.		
	Example	**Your System**
A. Target Injection Rate The exact desired pumping rate.	**10.3 gal/hr**	
B. Maximum Pump Capacity If not known, measure by setting the pump to 100% and follow the procedures below.	**27.0 gal/hr**	
C. Initial Pump Speed Setting Set estimated % pump setting and determine output. Target flow ÷ Maximum flow × 100. (C = A ÷ B × 100)	10.3 gal/hr ÷ 27 gal/hr × 100 = **38%**	
Note: For accurate injection rates, it is recommended that most pumps be operated between 30% and 70% of the pump's maximum capacity. Rates less than 20% or greater than 80% are not recommended because many pumps are less accurate at those extremes. If the required pump setting is too low, then water can be added to dilute the chemical to increase the injection rate. If the required pump rate is too high, a larger capacity pump must be used.		

Find how much volume is pumped per inch of tube length. Calibration tubes typically have a scale in units of volume (pints, ounces, milliliters, etc.) that can be read directly on the side of the tube. The following example is based on a simple tube lacking such a scale.

Table 2. LENGTH TO FLUID VOLUME CONVERSION FACTOR, CLTV, for the calibration tube used.		
	Example	**Your System**
D. Measure Tube Inside Diameter Inside diameter in inches. Measure accurately!	**1 and 5/16 in**	
E. Unit of Measurement Conversion Convert inside diameter to decimal inches. Inches + Divided fraction of an inch.	1 + (5 ÷ 16) = **1.3125 in**	
F. Tube Cross Sectional Area Area = $\pi E^2/4$. π=3.14. (F = $\pi \times E^2 \div 4$)	3.14 × 1.3125 × 1.3125 ÷ 4 = **1.352 in²**	
G. Tube Length to Fluid Volume Conversion (C_{LTV}). Area × 0.554 for fluid ounces per inch, or Area × 16.4 for milliliters per inch. (G = F × 0.554, or G = F × 16.4)	1.352 in² × 0.554 fl oz/in³ = **0.749 fl oz/in**	
Note: This number, C_{LTV}, is a function of the tube diameter and won't change. So it is suggested that this be written on the tube or somewhere you can easily reference it later (Figure 5).		

Find the fluid level difference that you should find if the injection pump is calibrated correctly.

Table 3. CALCULATE TARGET DISPLACEMENT LENGTH on the tube for time period.		
	Example	**Your System**
H. Target Injection Rate Gallons per hour. Same as (A) above.	**10.3 gal/hr**	
I. Check Time Period (chosen)	**60 sec**	
J. Convert Injection Rate Units Gallons per hour × 0.0356 = fluid ounces/second. (J = H × 0.0356) Gallons per hour × 1.05 = milliliters/second	10.3 × 0.0356 = **0.367 fl oz/sec**	
K. Target Displacement Length in inches Difference between before and after (K = J × I ÷ G)	0.367 fl oz/sec x 60 sec ÷ 0.749 fl oz/in = **29.37 in**	
L. If Necessary, Convert Decimal to 16ths.	29.37 = 29 + 0.37 0.37 in × 16 = ~ 6/16 in or 3/8. so **29 and 3/8ths in**	

This is the distance on the tube between the level at the start time and the level after the check time (60 seconds in our example) has passed. If this distance is longer than the calibration tube because the injection rate is too great, or the tube being used isn't large enough, then a shorter, 30-second interval can be used. However, if this is done, at least three calibration check measurements (Step 3) should be taken and averaged.

After these three things are calculated, perform the calibration check by following these steps:

Step 1. Start the irrigation system and injection pump at the initial percentage setting from Table 1. After the pump has "settled down," or run for a while, continue with the following steps to do the calibration check and make adjustments.

Step 2. Choose a check time period. Calibration checks should be performed using a one-minute interval if possible. We chose 60 seconds in our example in Table 3.

Step 3. Open the valve to fill the calibration tube with the injected chemical. Close the valve. Mark the starting level of fluid in the tube. Start your stopwatch at the same time that you open the valve to pump only from the calibration tube instead of the tank. Pump for the chosen time period (**60 seconds**), and then immediately close the valve. Mark the fluid level in the tube and measure the difference. In our example we measured a fluid level difference of 28 and 3/8 inches.

Step 4. Determine the revised pump setting using Table 4 and adjust the pump accordingly.

Step 5. Repeat steps 2–4 until the calibration remains constant (M = L or N = K). Then use a longer time set (3 to 5 minutes) as a confirmation check. In verifying pump output, at least three calibration checks should be made to account for calibration disparities.

Figure 3. Notice bands that are used to delineate fluid level in calibration tube at the start and then at the end of the calibration timeframe.

Table 4: DETERMINE REVISED PUMP SETTING to better match target rate.

	Example	Your System
M. Displaced Height Difference The measured distance between the starting and ending fluid levels in the tube (in inches)	**28 and 3/8 in**	
N. Convert Tube Height to decimal inches. Inches + Divided fraction.	28 + 3/8 = **28.38 in**	
O. New Setting in % Target ÷ Measured × Current or latest setting. (O = K ÷ N × C)	29.37 ÷ 28.38 × 38% = **39%**	

Figure 4. Because of large volumes, some applicators construct their own calibration tubes.

Figure 5. The applicator calculated the volume in the large tube to be 4.17 fluid ounces or 123.1 milliliters per inch, as measured from the external site tube. In this case, because there are two tubes being pumped from, the cross-sectional areas of the site tube and the metal tube must be added together (Table 2, parts D through F).

If you wish, you can also calculate your actual injection rate from your measured fluid level difference. This can then be used to adjust the percentage setting.

Table 5. Calculate Actual Injection Rate

	Example	Your System
P. Displaced Height Difference in inches The distance between the starting and ending fluid levels in the tube. (P = N)	**28.38 in**	
Q. Volume of Fluid Displaced in fluid ounces. Height diff. × C_{LTV}. (Q = P × G)	**28.38 in × 0.749 fl oz/in =** **21.3 fl oz**	
R. Measured Time during which known volume (P) was pumped.	**60 sec**	
S. Actual Injection Rate Volume ÷ Time. (S = Q ÷ R)	21.3 fl oz ÷ 60 sec = **0.354 fl oz/sec**	
T. Unit Conversion Fluid ounces per second ÷ 0.0356 = gallon per hour (T = S ÷ 0.0356). Or, if S is in milliliter per second then S ÷ 1.05 = gallon per hour	0.364 fl oz/sec ÷ 0.0356 = **9.95 gal/hr**	
U. New Setting in % Target ÷ Measured × Current or latest setting. (T = A ÷ T × C)	10.3 ÷ 9.95 × 38% = **39%**	
Note: The revised setting above (U) is the same as that calculated in Table 4 (O).		

Figure 6. A graduated calibration check tube.

When using a graduated calibration check tube (Figure 6) set your initial pump setting similar to what was done in Table 1. Fill the calibration tube with product. Then measure the volume displaced in the tube during the chosen run time, which is ideally 1 minute or greater. Use those numbers to calculate your injection rate (volume divided by injection time). Do this two or three times to get an average number since there is variability in timing, valve closure, etc. Convert the injection rate (depending on the units on the calibration check tube) to gallons per hour (see the helpful conversions below) and compare that to the target injection rate. If it is significantly different, multiply the current pump setting by the ratio of the target flow rate divided by the measured flow rate (similar to what was done in Table 4 step O and Table 5 step U) to estimate a revised pump setting and do another calibration check to see if the measured injection rate is equal to the target injection rate. If it is, do a final five-minute verification check.

Additional Information

Some helpful conversions for calibration testing:

Multiply the:	By:	To Get:
gallons/hour	2.13	fluid ounces/minute
gallons/hour	63.09	milliliters/minute
gallons/hour	0.0356	fluid ounces/second
gallons/hour	1.05	milliliters/second
fluid ounces/minute	0.469	gallons/hour
milliliters/minute	0.01585	gallons/hour
fluid ounces/second	28.09	gallons/hour
milliliters/second	0.952	gallons/hour
milliliters/minute	0.0338	fluid ounces/minute
fluid ounces/minute	29.57	milliliters/minute

Additional Resources

Carpenter, J., and W.S. Johnson. 1997. Pesticide Chemigation through Pumped Irrigation Systems. *University of Nevada Cooperative Extension Publication* FS-97-37. University of Nevada.

DeValerio, J., D. Nistler, R. Hochmuth, and E. Simonne. 2015. Fertigation for Vegetables: A Practical Guide for Small Fields. *University of Florida IFAS Extension Publication* HS1206. University of Florida.

Haman, D. Z., and F. Zazueta. 2014. Chemigation Injection Methods for Irrigation. *University of Florida IFAS Extension Publication* CIR864. University of Florida.

Hanon, B., N. O'Connell, J. Hopmans, J. Simunek, and R. Beede. 2006. Fertigation with Microirrigation. Oakland: University of California Agriculture and Natural Resources.

Kranz, W., C. Burr, J. Hay, J. Schild, and D. Yonts. 2016. Using Chemigation Safely and Effectively: Training Manual. University of Nebraska Extension.

Liu, G., and G. McAvoy. 2015. How to Reduce Clogging Problems in Fertigation. *University of Florida IFAS Extension Publication* HS1202. University of Florida.

Peters, R.T., T. Hoffmann, and W.H. Neibling. 2011. Calculating Chemigation Injection Rates. *Washington State University Extension Publication* FS035E. Washington State University.

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