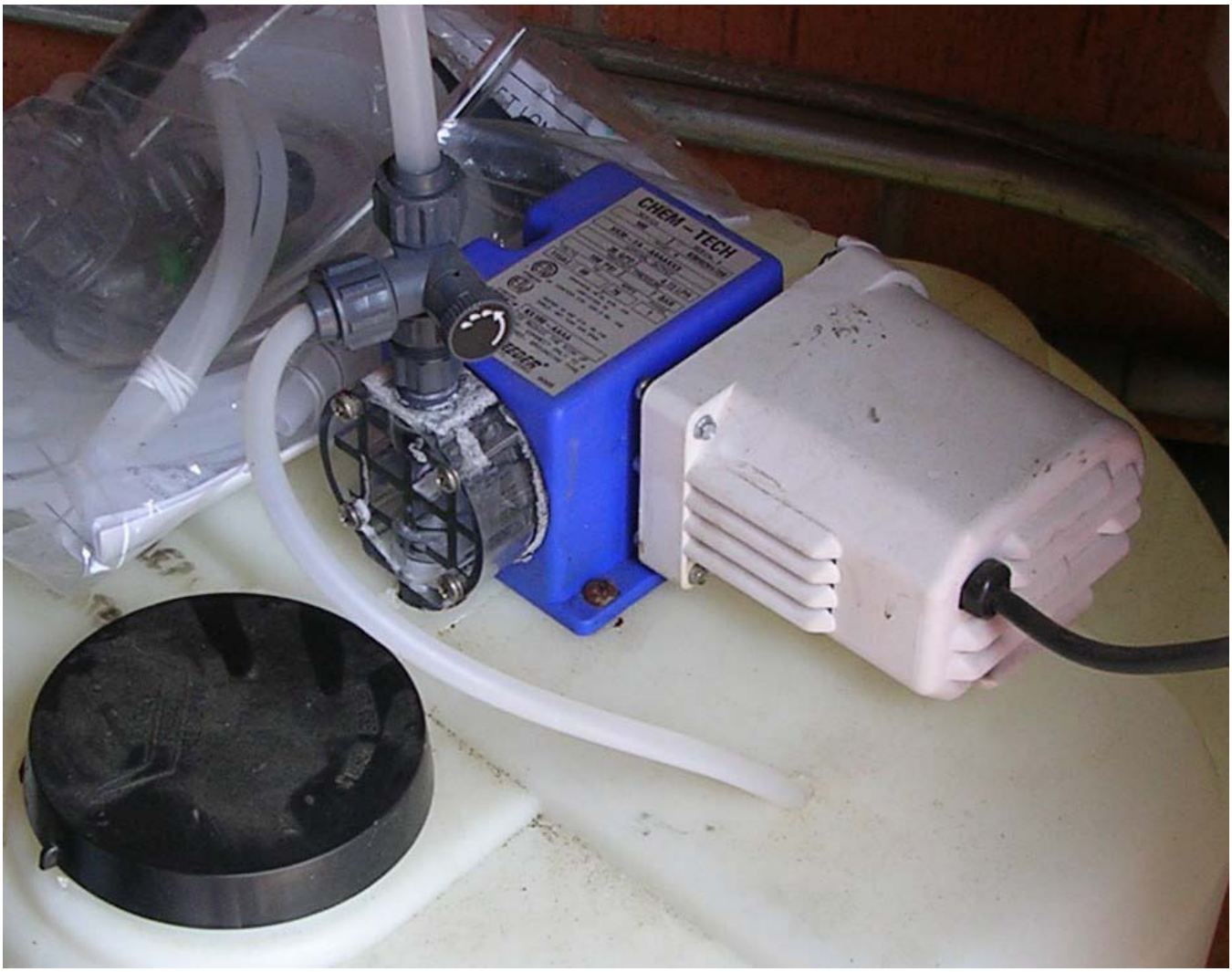

Chlorine Pump Calibration for Controlled Disinfection

Hip Pocket Tools for Operators

Catalog No. HTO/004/2007

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Safe Drinking Water for a Healthy Virginia

At the end of this session…

You will be able to calibrate your chlorine solution pump, calculate the required ratio of chlorine and water to be added to your chlorine solution tank to achieve a desired chlorine residual, and understand the variables affect the chlorine residual of your water system.

Why calibrate your chlorine solution pump?

Calibrating your chlorine solution pump allows you control the amount of chlorine being added to the water with precision. Precise control of the solution pump will enable you to determine how much chlorine must be added to achieve the desired chlorine residual concentration for your system.

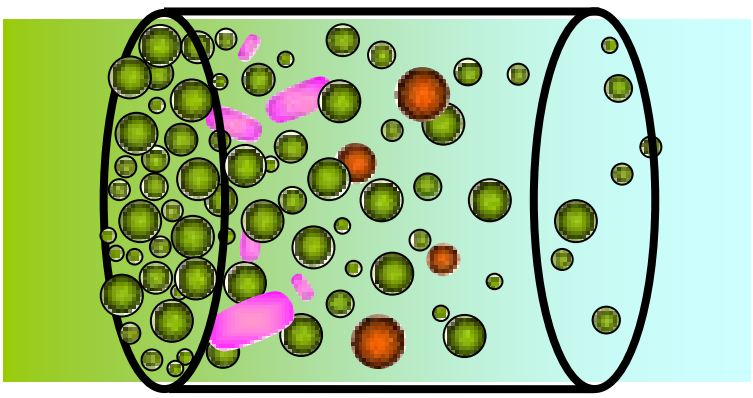
What factors affect the chlorine concentration?

The chlorine concentration is directly affected by numerous physical and chemical factors. Physical factors include the well pump and solution pump rates, the percentage of chlorine in the chlorine product you purchase, and the proportions of chlorine and water in the chlorine solution tank.

The chlorine concentration is also affected by the concentrations of microorganisms and dissolved chemicals in the water. As chlorine reacts with these substances, the amount of chlorine that is available to destroy microorganisms drops. The substances that reduce the amount of available chlorine create chlorine demand. The amount of chlorine available in the water after demand has occurred is called the chlorine residual.

Chlorine demand is commonly caused by substances that occur naturally in water, such as iron and manganese. Carbon from organic matter (such as leaves) or manmade contaminants also produce chlorine demand.

Chlorine kills the bacteria in your drinking water system that may otherwise cause your customers to become sick. If you do not add enough chlorine to maintain an adequate residual concentration, those bacteria may not be killed. Adding too much may lead to customer complaints of taste and odor problems.



What you will need…

1. Chlorine residual test equipment and reagents
2. Measuring cup holding no more than 2 cups and divided into ounces
3. Medicine dropper marked in fractions of an ounce or milliliters
4. Stopwatch
5. A one-gallon jug, measured pitcher, or other one-gallon container
6. A five-gallon bucket
7. A well pump meter (or a five-gallon bucket and stopwatch)
8. A calculator, or a computer with Microsoft Excel software installed
9. The percentage hypochlorite of the chlorine you add to the solution tank (this is usually found on the chlorine container)
10. A desired final chlorine residual concentration

Step 1 - Measure the well pump rate

Using the stopwatch, time the well's metered flow for one minute while the well is pumping. (If more than one well is chlorinated with the same chlorine solution pump, measure the pumping rate for each well. Add the individual well pump rates to calculate the total well pumping rate associated with that chlorinator.)

If your well does not have a meter, run water from a tap in the well house, and use the stop watch to measure how many minutes it takes to fill a five-gallon bucket. By dividing five gallons by the minutes it takes fill the bucket, you can roughly determine how many gallons per minute your well is pumping.

Calibrate your five-gallon bucket by filling it one gallon at a time, using a one-gallon milk jug. Use a permanent marker to mark the water level at one-gallon increments.

Record the well pump rate on **Line 1** on the Calibration Calculation Worksheet (Pages 4 and 5 of this booklet).

Useful Tip: When more than one well is being chlorinated with the same solution pump, the wells should always pump at the same time. Alternating use of one well and then the next will provide inconsistent chlorine residuals unless the well pumping rates are exactly the same, which is highly unlikely.

Step 2 - Measure the chlorine solution pump rate

Remove the suction tube from the solution tank, and place the end of the tube into the measuring cup. Fill the measuring cup to the eight ounce level with chlorine solution from the solution tank. (Instructions continued on Page 6)

Calibration Calculation Worksheet

Line 1 Well Pumping Rate	Well 1 _____ gpm (gallons per minute) + Well 2 _____ gpm + Well 3 _____ gpm = TOTAL _____ gpm pumped
Line 2 Chlorine Pumping Rate	Ounces pumped _____ ÷ Minutes pumped _____ = Ounces per minute pumped _____ oz./min
Line 3 Percent Chlorine	_____ % Sodium hypochlorite or Calcium hypochlorite (circle product used)
Line 4 Desired Chlorine Residual	_____ ppm
Line 5 Chlorine Demand	Enter the initial chlorine residual concentration, and the final three stabilized chlorine residuals, taken at five minute intervals. Subtract the last result from the first result to determine the actual chlorine demand for this system. Initial result _____ ppm Final three results _____ ppm _____ ppm _____ ppm } If chlorine demand has stabilized these results should be the same First result _____ ppm – Last result _____ ppm = Chlorine demand _____ ppm
Line 6 Target Chlorine Residual	Desired chlorine residual [Line 4] _____ ppm + Chlorine demand [Line 5] _____ ppm = Target chlorine residual _____ ppm
Line 7 Gallons of water pumped per cycle	Total contact tank size _____ gallons OR 1/3 pressure tank size _____ gallons OR working volume of storage tank _____ gallons OR use an estimated fixed value of 1500 gallons

Calibration Calculation Worksheet

Line 8 Minutes to pump one cycle	Gallons pumped per cycle [Line 7] _____ gallons ÷ Well pumping rate [Line 1] _____ gpm = Minutes to pump one cycle _____ minutes
Line 9 Gallons chlorine and water pumped per cycle	Minutes to pump one cycle [Line 8] _____ minutes x Chlorine pump rate [Line 2] _____ oz./min ÷ 128 ounces = Gallons chlorine and water per cycle _____ gallons
Line 10 Chlorine concentration needed in solution tank for target residual	Target residual [Line 6] _____ ppm + ((target residual [Line 6] _____ ppm x _____ gallons of water pumped per cycle [Line 7]) ÷ _____ gallons of chlorine and water pumped per cycle [Line 9]) = _____ ppm **Useful Tip:** Do all of the calculations shown inside parentheses before those shown outside. If the equation shows nested parentheses, do the innermost calculations (( )), before the outermost calculation ((( ))).
Line 11 Ounces of liquid chlorine (sodium hypochlorite) to add to solution tank for desired residual	(1280 x chlorine concentration needed in solution tank for target residual [Line 10] _____ ppm) ÷ ((chlorine concentration % [Line 3] _____ x 10,000) – chlorine concentration needed in solution tank for target residual [Line 10] _____ ppm) = _____ oz.
Line 12 Chlorine to water ratio	Ounces of chlorine to add to solution tank [Line 11] _____ oz. ÷ 10 = Ounces of chlorine per gallon of water added to solution tank _____ oz.
Line 13 If powdered chlorine (calcium hypochlorite) is used	((Chlorine concentration needed in solution tank for target residual [Line 10] _____ ppm x 8.34) x (0.000001÷ calcium chlorine concentration % [Line 3] _____) x 100) = _____ lbs. of chlorine product per gallon of water

Turn on the chlorine solution pump. Use the stopwatch to time the solution pump for four minutes. Divide the number ounces of chlorine solution pumped out of the measuring cup by four to calculate the chlorine solution pump rate in ounces per minute.

Record this number on **Line 2** on the Calibration Calculation Worksheet

Solution pumps are usually wired for simultaneous activation when the well pump is running; turning on the well pump will start the chlorine solution pump. If the well pump does not have a hand switch control, the well pump can be started by running enough water from the pressure tank to activate the pressure switch.

Useful Tip: Make sure the suction tube is fitted at the end with a check valve device before removing it from the solution tank. If not, or just to be careful, submerge the measuring cup into the solution tank and move the end of the suction tube into it while keeping the open end of this tube always under water. You can then pour out the excess water from the measuring cup leaving just eight ounces in it.

Step 3 – Determine the chlorine product concentration

The percentage concentration of sodium hypochlorite or calcium hypochlorite of the chlorine product you use should be displayed on the product container and/or the Material Safety Data Sheet (MSDS).

Enter this number on **Line 3** on the Calibration Calculation Worksheet.

Step 4 – Record the desired chlorine residual

Record the desired chlorine residual concentration in parts per million (ppm) on **Line 4** of the Calibration Calculation Worksheet. Parts per million is equivalent to milligrams per liter (mg/L).

Step 5 – Determine the chlorine demand of your water

If you know or suspect that iron or manganese are present in your water, calculate the chlorine demand caused by these substances. If these contaminants are not present, or if their concentrations are very low, you may choose to skip this step.

Iron and manganese concentrations can be found on the lab report for the waterworks' most recent metals sample

Fill the five gallon bucket with five gallons of raw, un-chlorinated water. Using the table below, add the amount of chlorine in ounces to this bucket of water needed to achieve a 2.0 ppm chlorine residual, based upon the percentage of chlorine in

your chlorine product. (Use liquid sodium hypochlorite for this process, even if you normally use calcium hypochlorite to disinfect.)

If the percentage of sodium hypochlorite in your chlorine product is…	…add the following number of ounces, milliliters, or drops of chlorine to your five-gallon bucket		
	ounces	milliliters	drops
3.2%	0.040	1.183	19
5.24%	0.024	0.710	12
6.0%	0.021	0.621	10
6.25%	0.020	0.591	10

As soon as the chlorine is added, immediately test the chlorine residual, and record this result on **Line 5** of the Calibration Calculation Worksheet.

Then, use the stopwatch to time how long the chlorine has been in the bucket. Measure chlorine concentrations (in ppm) every five minutes, until the chlorine concentration stabilizes for three consecutive five-minute readings. Record the last three measurements on **Line 5** of the Calibration Calculation Worksheet. Obtain the chlorine demand for your system by subtracting the last chlorine residual you measured from the first chlorine residual.

On **Line 6** of the Calibration Calculation Worksheet, add this number to the desired chlorine residual from **Line 4** to determine the target residual. For example, if the desired residual is 1.0 ppm, and the chlorine demand of your water is 0.5 ppm, your target residual concentration is 1.5 ppm – which is the amount of chlorine that will be needed to always achieve the desired concentration, and overcome the effects of chlorine demand.

Useful tip: If the initial chlorine residual is zero, add twice the amount of chlorine added to the 5-gallon bucket (from the table above) to raise the calculated expected residual from 2 ppm to 4 ppm. Add the extra 2 ppm to the final demand calculated. You may need to do this several times if chlorine demand is very high.

Step 6 – Determine the chlorine to water ratio

On the Calibration Calculation Worksheet, record tank sizes (**Line 7)**. Use a calculator to complete all of the calculations on **Lines 8 through 13** to determine the ratio of chlorine to water that will be mixed in the solution tank to achieve the target chlorine residual at the current chlorine pump setting.

For complete chlorine pump calibration, record the ounces per minute pumped for the current chlorine pump settings. Then change the settings on your chlorine pump to the lowest setting, another intermediate setting, and the highest settings, and repeat **Step 2** for each of those settings. You may then repeat the rest of the steps for each of those chlorine pumping rates to determine the ratio of water to chlorine needed to be added to the solution tank at each of these settings. You should record each of these values for later use. If you have already determined the chlorine demand of the water, it will not be necessary to repeat **Step 5**.

You can use these values if you ever desire to change the chlorine pumping rate and need to calculate the new chlorine to water ratio added to the solution tank, or increase the chlorine residual by increasing the pumping rate while leaving the ratio of chlorine to water the same.

To compare various pump settings and different chlorine to water ratios, use the Excel spreadsheet to simplify the calculations and save time

Useful Tip: Most chlorine pumps are designed to work best when set near the middle of their setting ranges. In most cases it is more effective to select a chlorine pump setting in the middle range, and adjust the chlorine to water ratio if changes need to be made to the target residual concentration.

Step 7 – Develop Standard Operating Procedures

Now that you have selected your chlorine pump setting, taken into account chlorine demand, and calculated the chlorine to water ratio required to achieve the desired chlorine residual, you are ready to develop standard operating procedures (SOPs) to simplify the maintenance of your desired chlorine residual.

By following this guide, you have calculated your chlorine to water ratio as ounces of chlorine per gallon of water at your selected chlorine pump setting. Use a permanent marker to mark the level on the two-cup measuring cup, indicating the ounces of chlorine to be added to each gallon of water. Keep the measuring cup in the well house with the one-gallon jug or pitcher, so the solution tank can always be refilled by adding one gallon of water and the proper measurement of ounces of chlorine each time you prepare chlorine solution.

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