chemical application (daily, semi-weekly, weekly, etc.) and the maximum time allocated per irrigation zone. For example, for daily chemical applications the number of irrigation zones multiplied by the injection period per zone cannot exceed 24 hours. Furthermore, if the injection period exceeds the maximum irrigation period which results in over-irrigation and leaching, then split chemical applications are necessary.

The injection period is generally determined from the volume of chemical to be applied and the rate of injection. As was previously mentioned, some chemical applications require that a specific concentration be maintained for a particular application or injection period. In this case the injection period is already pre-set.

The injection volume was discussed in the previous section. Injection rate may be provided by the supplier of the injection system. However, whether the injection rate is already available or not, calibration is required. Calibration should be performed on the irrigation system which is to be used with the injection system. Also, because irrigation system operating pressures and flow characteristics may influence injection rates, calibration should be performed while the irrigation system is operating.

One simple calibration procedure involves placing a flow meter on the injection line and then measuring the volume of chemical injected in a specific period. A measurement period of 2 to 5 minutes should suffice, however longer measurement periods provide better results. Also, three or more replications of the measurement should be performed to obtain an accurate calibration and to eliminate measurement error or discrepancies. The quality of the flow meter will influence the quality of the calibration. Therefore, use a good flow meter sized to operate in the estimated flow range of the injection system and manufactured for use with the chemicals being injected. Corrosion of the flow meter could alter the injection rate and possibly result in damage to some other part of the irrigation system. Also, be sure that the flow meter can operate under the higher pressures associated with some injectors.

A second calibration procedure involves physical measurement of the injected volume during the measurement period. This procedure can be performed using one of two methods. In each method a container is filled with a known volume of the chemical to be injected. Water or colored water may be substituted for the chemical but may not provide accurate results with some injectors if the viscosity is very different from that of the chemical.

The first method measures the time required to inject all of the known chemical volume and then uses the following formula to determine the injection rate

$$Q_i = \frac{V_i}{T_i} \tag{9}$$

where Q_i = Injection rate (gpm),
V_i = Injected volume (gal), and
T_i = Time required (min) to inject volume V_i.

The second method measures the initial volume and the final volume after a specified injection period. The injection period should be at least several minutes but short enough that all of the chemical has not been injected. Calculation of the injection rate is similar to the above procedure with a slight modification of Equation (9) as follows:

$$Q_i = \frac{V1 - V2}{T_i} \tag{10}$$

where Q_i = Injection rate (gpm),
V1 = Initial chemical volume (gal),
V2 = Final chemical volume (gal), and
T_i = Injection measurement period (min).

If a positive displacement type of pump is used, the injected volume can be determined by counting the number of piston strokes in the measurement period and then multiplying the number of strokes by the displacement volume per stroke. The displacement volume per stroke should be measured periodically to insure proper operation.

Once the injection rate is known, the injection period for any chemical volume can be determined from rearranging Equation (9) as follows:

$$T_i = \frac{V_i}{Q_i} \tag{11}$$

where T_i = Required injection period (min),
V_i = Volume of chemical to be injected (gal),and
Q_i = Injection rate (gpm) of the system.

For example, the vegetable grower in the previous fertilizer example has a piston injection pump