Chemical Injection Methods

- Centrifugal Pumps
- Positive Displacement Pumps
- Pressure Differential Methods

- Suction Line Injectors
- Discharge Line Injectors

Venturi Injectors
A positive displacement pump moves a certain, constant volume of fluid from the intake side of the pump to the discharge side of the pump. Theoretically, the volume displaced by the pump should be independent of the pressure encountered at the discharge point.
Reciprocating Pumps
Reciprocating pumps are pumps in which a piston or a diaphragm displaces a given amount of chemical with each stroke.
Diaphragm pump – discharge stroke

Diaphragm pump

Double acting piston pump
ROTARY PUMPS

Rotary pumps transfer chemical from suction to discharge through the action of rotating gears, lobes or other similar mechanisms.
Lobe pump

Positive Displacement Pumps

Reciprocating Pumps
  - Piston
  - Diaphragm
  - Piston/Diaphragm

Rotary Pumps
  - Gear
  - Lobe

Miscellaneous Pumps
  - Peristaltic

Peristaltic pump
Chemical Injection Methods

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Pressure Differential Methods

- Suction Line Injection
- Discharge Line Injection
  - Pressurized Mixing Tanks
  - Proportional Mixers

Suction line injection

**Pressurized mixing tank**

*Diagram showing pressurized mixing tank with labels for low pressure, high pressure, regulating valve, chemical solution, and water.*

**Proportional mixer**

*Diagram showing proportional mixer with labels for low pressure, high pressure, regulating valve, chemical solution, and water.*

**Chemical Injection Methods**

- Centrifugal Pumps
- Positive Displacement Pumps
- Pressure Differential Methods
  - Suction Line Injectors
  - Discharge line Injectors
- Venturi Injectors
This section summarizes backflow prevention requirements when chemicals are applied through Florida irrigation systems. The sources of information are the Chapter 487 of the Florida Statutes and previously Amended Administrative Rule 5E-2.030.

Equipment requirements vary depending upon the types of chemicals injected. The two general types of chemicals are (1) pesticides and (2) chemicals other than pesticides. Also, pesticides are classified as either Chemical Toxicity Category-I (CTC-I) pesticide products or general use pesticides.

1. Check Valve
2. Low Pressure Drain
3. Vacuum Breaker
4. Injection Line Check Valve
5. Chemical Supply Shut-off Valve
6. Interlocked Injector
1. Check Valves
2. Low Pressure Drains
3. Vacuum Breakers
4. Injection Line Check Valve
5. Chemical Supply Shut-off Valve
6. Interlocked Injector
7. Pressure Switch
8. Appropriate Signage
Many chemicals used in agriculture are supplied as a percentage by weight of a dry or liquid mixture and initial calculations must be performed to determine how much of the mixture must be used to deliver a certain amount of a specific chemical to the crop. For example, most of the fertilizers are supplied as a mixture of some form of nitrogen, potassium, and phosphorus. Very common ingredients of a mixture are: some form of nitrogen (N), phosphorus oxide (P₂O₅), and potash (K₂O).
Fertilizer Nutrients

Their approximate values are N (14), P (31), O (16), and K (39). Based on these, the equivalent gram molecular weight for each compound can be calculated.

44% of the weight of P₂O₅ is P, and 83% of the weight of K₂O is K.

Fertilizer Nutrients

Atomic weight of P₂O₅ is approx. 142.
Atomic weight of 2 P is approx. 62.

\[
\frac{62}{142} = 44\%
\]
Atomic weight of K₂O is approx 94.
Atomic weight of 2 K is approx 78.

\[
\frac{78}{94} = 83\%
\]

N-P-K Analysis

20-10-15

20% is N, 10% is P₂O₅, 15% is K₂O and 55% is inert or other material.
N is 20% of the total.
P is 44% of P₂O₅, which is 10% of the total, so P 4.4% of the total.
K is 83% of K₂O which is 15% of the total, so K 12.5% of the total.
N-P-K Loading

Supply a field 100 lbs of N per acre using 20-10-15 source.

\[
\frac{100 \text{ lbs-N/acre}}{0.20 \text{ N/source}} = 500 \text{ lbs-source/acre}
\]

\[
500 \text{ lbs-source/acre} \times 0.10 \text{ P/source} \times 0.44 \text{ P/P} = 22 \text{ lbs-P/acre}
\]

\[
500 \text{ lbs-source/acre} \times 0.15 \text{ K/acre} \times 0.83 \text{ K/K} = 62 \text{ lbs-K/acre}
\]

N-P-K Loading

Supply a field 50 lbs of P per acre using 20-10-15 source.

\[
\frac{50 \text{ lbs-P/acre}}{0.10 \text{ P/source}} = 500 \text{ lbs-source/acre}
\]

\[
500 \text{ lbs-source/acre} \times 0.20 \text{ N/source} \times 0.44 \text{ P/P} = 227 \text{ lbs-N/acre}
\]

\[
500 \text{ lbs-source/acre} \times 0.15 \text{ K/acre} \times 0.83 \text{ K/K} = 141 \text{ lbs-K/acre}
\]

Concentrations

Given in percent for solid materials.
Typically given in ppm for liquid mixtures.

\[
1 \text{ g-chemical} / 1,000 \text{ L-water} = 1 \text{ ppm}
\]

\[
1 \text{ g-chemical} / 1,000,000 \text{ mL-water} = 1 \text{ ppm}
\]

\[
1 \text{ g-chemical} / 1,000,000 \text{ g-water} = 1 \text{ ppm}
\]
Injection Rates

- The desired chemical concentration after injection into an irrigation is found from

\[ X = \frac{\dot{m}_c}{m_{sw}} \quad (24.1) \]

- Given that solutions can only be injected into an irrigation system directly (i.e., dry chemical must be mixed with a solvent before injection) the desired chemical concentration is

\[ X = \frac{\dot{m}_c}{\dot{m}_c + m_s} \quad (24.2) \]

Injection Rates

- The desired chemical concentration in terms of volumetric flow rate gives

\[ X = \frac{\rho_c Q_c}{\rho_s Q_s + \rho_i Q_i} \quad (24.3) \]

- Solving for the injection rate the equation becomes

\[ Q_i = \frac{\rho_i Q_i X}{\rho_i (C_r - X)} \quad (24.4) \]

Injection Rates

- If the desired chemical concentration is given in terms of parts per million the equation becomes

\[ Q_i = \frac{\rho_i Q_i X}{\rho_i (10,000 C_r - X)} \quad (24.5) \]
**Injection Rates**

What is the injection rate necessary to deliver 8 ppm through an irrigation system that delivers water at 1,200 gpm. The stock solution has a density of 10 lbs/gal at 20% concentration.

\[
Q_i = \frac{(8.3 \cdot 1,200 \cdot 8)}{10 \cdot (20 \cdot 10,000 \cdot 8)} = 0.04 \text{ gpm}
\]

**Injection Period**

- Given a chemical supply tank volume, and the injection rate the injection period is simply

\[
t = \frac{V_s}{Q_i}
\]

(24.6)

**Solution Volume – Rate Basis**

How long would it take to empty 150 gallon tank when the injection rate is 6.67 gpm?

\[
V_s = Q_i \cdot t
\]

\[
t = \frac{V_s}{Q_i}
\]

\[
t = \frac{150 \text{ gal}}{6.67 \text{ gpm}} = 22.5 \text{ min}
\]
Lateral Travel Time

- The time the irrigation system should remain on after the supply tank has been emptied is given from:

\[ T = \frac{ma^2 l}{4Q_w} (0.577 + \ln n) \quad (24.7) \]

Flushing velocity

- The flushing velocity must be a maintainable 1 fps at the end of an open lateral, in order to flush out any remaining chemical along the lateral. At 2 fps and all grit and sand would be removed through the lateral as well, though is harder to maintain.