

Texas Agricultural Extension Service

Chemigation Equipment and Safety

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Chemigation

Chemigation is the process of injecting an approved chemical into irrigation water and applying it through the irrigation system to a crop or field. Chemigation is not a new concept, but has been used for years. Recent progress in chemigation equipment and know how allows for more effective chemigation through drip and sprinkler irrigation systems, particularly center pivots.

The earliest work applying chemicals through sprinklers was with fertilizers, known as *fertigation*. *Herbigation* soon followed, which is the application of herbicides through an irrigation system. Next came *insectigation* with insecticides, *fungigation* with fungicides and *nematigation* with nematocides. The term chemigation describes the application of all these chemicals through the irrigation system.

Advantages of chemigation

Uniformity of application - With a properly designed sprinkler irrigation system, both the water and chemicals can be uniformly applied, resulting in excellent distribution of the water-chemical mixture.

Precise application - Chemicals can be applied where they are needed and in the correct concentrations.

Economics - Applying chemicals through chemigation is usually less expensive than conventional application methods. Often, the amount of chemicals needed can be reduced.

Timeliness - Chemicals can still be applied when other methods cannot be used due to wetness, excessive wind, applicator availability or other factors.

Reduced soil compaction and crop damage - Conventional in-field spray equipment is not needed, often

resulting in less soil compaction from tractor wheels and crop damage.

Operator safety - Because the operator is not continuously in the field during applications, reduced human contact with the chemicals from drift, frequent tank fillings and other exposures occur.

Disadvantages of chemigation

High management - Chemical application requires safe use of chemicals, skill in calibration, knowledge of the irrigation and chemigation equipment and understanding of irrigation scheduling concepts.

Additional equipment - Proper injection and safety devices are essential. Legal equipment requirements have been established and must be used.

Legal Requirements

The U.S. Environmental Protection Agency's Label Improvement Program (LIP) became effective in April 1988. Pesticide labels must now state whether the product is approved to be applied through the irrigation system. If so, application instructions are provided. In addition, the label improvement program requires the use of specific safety equipment and devices designed to prevent accidental spills. These requirements also aid the grower by providing for consistent, precise and continuous chemical injection, thus reducing the amounts (and cost) of chemicals applied.

Figure 1 illustrates some of the required safety equipment. A summary of chemigation pumping and safety equipment requirements is shown in Table 1. A list of alternate chemigation equipment approved by EPA is provided in Table 2.

CHEMICAL INJECTION SAFETY CONNECTIONS

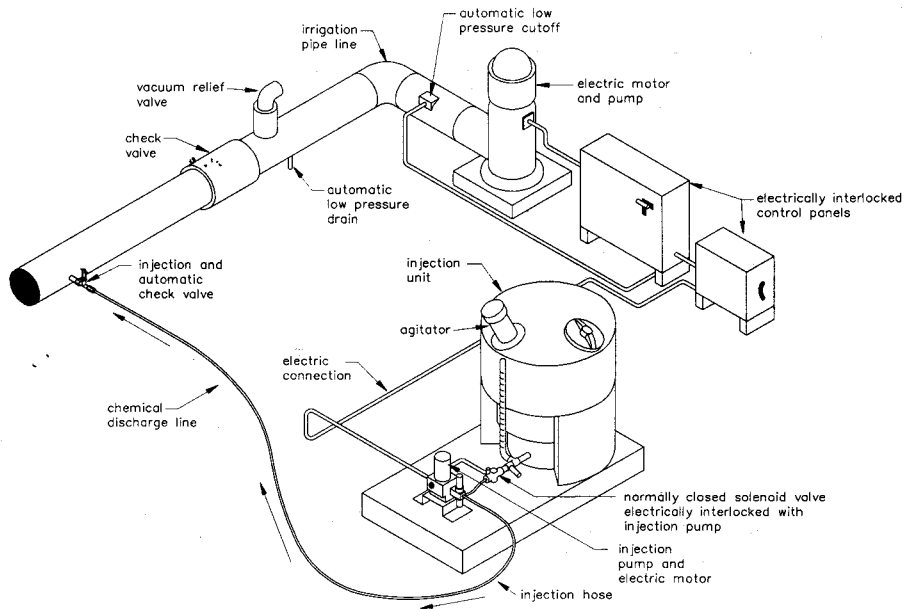


Figure 1. Chemical injection equipment for chemigation, showing some of the approved safety connections.

Table 1. Summary of Chemigation Equipment Requirements.

Components must include:

1. Irrigation Pipeline

- Check valve between well and injection points.*
- Vacuum relief valve between check valve and well.
- Low pressure cut off.
- Low pressure drain.*

2. Injection Hose

- Anti-back flow injection valve - 10 psi.
- Normally closed solenoid valve between injection pump and chemical tank.*
- A metering type injection pump.*

3. Power Interlock

- Interlock injection pump and water pump power.
- Interlock normally closed solenoid valve and injection pump power.

* Alternative safety equipment may be substituted according to regulations approved by the EPA in March 1989. See Table 2.

The *check valve* in the irrigation pipeline prevents chemicals from going into the well if the irrigation pump inadvertently stops. The *vacuum relief valve* prevents a vacuum from being formed that could draw chemicals through the check valve. Small amounts of chemicals that may leak by the check valve are disposed of through the *low pressure drain*. The power

supply of the injection and irrigation pumps must be interlocked. When properly interlocked, the *low pressure cut off* will stop the injection pump should the irrigation pump's power fail.

The *anti-backflow injection valve* prevents water from flowing backward into the chemical tank should the injection pump fail. The *10 psi spring* prevents gravity flow of the chemical into the irrigation pipeline when both the injection pump and irrigation pump are shut down. The *normally closed solenoid valve*, or other alternatives, further ensure that no water will flow into the chemical tank and that no chemical will leave the tank unless it is pumped. *Power interlocks* ensure that all other power will be shut down should any equipment fail, including the center pivot.

Management Practices for Chemigation

Flushing injection system - Flush the injection system with clean water after use to prevent accumulation of precipitates and contamination of the equipment, and to support future operation.

Flushing irrigation system - After injection is completed, operate the irrigation pump for at least 15 minutes to flush the chemical from the irrigation system. If the irrigation system stops automatically, flush the system as quickly as possible after the shutdown is

Table 2. Alternative Chemigation Equipment Approved by the USEPA, March, 1989.

A. Original Device - Functional normally closed, solenoid-operated valve located on the intake side of the injection pump.

Alternative Device 1 - Functional spring-loaded check valve with a minimum of 10 psi cracking pressure.

Notes: The valve must prevent irrigation water under operating pressure from entering the pesticide injection line and must prevent leakage from the pesticide supply tank on system shutdown. This valve must be constructed of pesticidal resistant materials. (Note: This single device can substitute for both the solenoid-operated valve and the functional, automatic, quick closing check valve in the pesticide injection line.)

Alternative Device 2 - Functional normally closed hydraulically operated check valve.

Notes: The control line must be connected to the main water line such that the valve opens only when the main water line is adequately pressurized. This valve must prevent leakage from the pesticide supply tank on system shutdown. The valve must be constructed of pesticidal resistant materials.

Alternative Device 3 - Functional vacuum relief valve located in the pesticide injection line between the positive displacement pesticide injection pump and the check valve.

Notes: This alternative is appropriate for only those chemigation systems using a positive displacement pesticide injection pump and is not for use with venturi injection systems. This valve must be elevated at least 12 inches above the highest fluid level in the pesticide supply tank and must be the highest point in the injection line. The valve must open at 6 inches water vacuum or less and must be spring loaded or otherwise constructed such that it does not leak on closing. It must prevent leakage from the pesticide supply tank on system shutdown. The valve must be constructed of pesticidal resistant materials.

B. Original Device - Functional main water line check valve and main water line low pressure drain.

Alternative Device 1 - Gooseneck pipe loop located

in the main water line immediately downstream of the irrigation water pump.

Notes: The bottom side of the pipe at the loop apex must be at least 24 inches above the highest sprinkler or other type of water emitting device. The loop must contain either a vacuum relief or combination air and vacuum relief valve at the apex of the pipe loop. The pesticide injection port must be located downstream of the apex of the pipe loop and at least 6 inches below the bottom side of the pipe at the loop apex.

C. Original Device - Positive displacement pesticide injection pump.

Alternative Device 1 - Venturi systems including those inserted directly into the main water line, those installed in a bypass system, and those bypass systems boosted with an auxiliary water pump.

Notes: Booster or auxiliary water pumps must be connected with the system interlock such that they are automatically shut off when the main line irrigation pump stops, or in cases where there is no main line irrigation pump, when the water pressure decreases to the point where pesticide distribution is adversely affected. Ventures must be constructed of pesticidal resistant materials. The line from the pesticide supply tank to the venturi must contain a functional, automatic, quick closing check valve to prevent the flow of liquid back toward the pesticide supply tank. This valve must be located immediately adjacent to the venturi pesticide inlet. This same supply line must also contain **either** a functional normally closed solenoid-operated valve connected to the system interlock **or** a functional normally closed hydraulically operated valve which opens only when the main water line is adequately pressurized. In bypass systems as an option to placing both valves in the line from the pesticide supply tank, the check valve may be installed in the bypass immediately upstream of the venturi water inlet **and** either the normally closed solenoid or hydraulically operated valve may be installed immediately downstream of the venturi water outlet.

D. Original Device - Vacuum relief valve.

Alternative Device 1 - Combination air and vacuum relief valve.

discovered, and extend the flushing period to a minimum of 30 minutes.

Monitoring - Periodic monitoring of the irrigation system and chemical injection equipment helps assure proper operation during any chemical application.

Calibration check - The pivot should be checked for uniform application and overall flow rate to make

sure the pivot system is performing as specified. A high uniformity coefficient is needed to ensure even coverage and to prevent either excessive or inadequate concentrations of chemicals in certain areas of the field.

Drive units - High speed center pivot drive units are desirable with some chemicals so lighter applications of water can be made.

Chemical compatibility - Check compatibility of the chemical with the water supply to prevent precipitate that could clog nozzles on the system.

End guns - Check the uniformity and application under the end gun, and shut it off if it is not desirable. Uniformity should match the system. However, in most cases, it is recommended to shut off the end gun during injections.

Chemical labels - Follow the label directions. Use only chemicals that are specifically labeled for chemigation. If a failure occurs, the user is liable.

Runoff - Manage the irrigation system to prevent runoff of the water-chemical mixture. If runoff occurs, take precautions to prevent it from leaving the field. With a given sprinkler package on a center pivot, reducing the amount or depth of application (i.e., making a faster revolution) reduces the potential for runoff.

Application to surface water - Avoid application of chemicals on fields with permanent or semi-permanent surface water areas. Such applications may affect wildlife, other nontarget plants and animals and groundwater quality.

Chemigation Pumps

Three types of injection units are used for chemigation. The two types of *mechanical units* are piston (or positive displacement) pumps and diaphragm pumps. Both can be powered by belt drive or an electric or hydraulic motor and can be adjusted for various flow rates within a designed range.

Chemigation pumps should be selected so that chemicals can be applied at the appropriate rate. Injection pumps are commonly purchased with two heads, one for injection of low applications of insecticide and herbicide, and the other one for injection of 20 to 30 pounds of nitrogen per acre. With proper plumbing, both heads can be used simultaneously. Usually a single injection pump with two heads is available to apply appropriate quantities of two chemicals.

A single pump with two heads costs less than two injection pumps. When dual head pumps are used for simultaneous injection of two chemicals, install an injection and automatic check valve and injection hose for each head.

Positive displacement pumps are typically used to inject nitrogen fertilizer and usually cannot be easily adjusted to inject appropriate quantities of insecticide, fungicide and herbicide. There are various size pistons and pump arm assemblies available that can be

used to inject the correct amount of chemical and to accommodate the desired travel speed of the center pivot. Piston sizes 1/4 to 5/8 inch are more appropriate for low-rate injection and sizes 3/4 inch to 1 1/4 inches for intermediate and high chemical injection rates. Positive displacement pumps are stopped when changing injection rates, so more time may be required to set the accurate rate.

Diaphragm pumps are used extensively for low-rate chemical injection. Changes in injection rates can be made while running so accurate injection can be more conveniently established. In some cases, diaphragm pumps can be added to existing higher capacity injection units.

The third unit, the *venturi meter*, is a tube with a reduced diameter in the throat. Velocity changes in the throat create a vacuum that pulls the chemical into the water stream. Venturi meters require a constant water supply from an external water source, or may be equipped with a bypass and a small booster pump for use of water from the system. An additional pump or booster pump must be used for maintaining steady flow through the venturi at a higher pressure than the pivot. A small valve is used on the suction line to regulate the injection rate. Any variations in flow rate from the water supply will change the vacuum and the rate of injection.

All three pumps are satisfactory for injection of chemicals. Each should be calibrated and set for the volume of chemical to be injected and rechecked periodically. Clean carefully after use. If chemicals stay in the pumps, their useful life is short, and there are problems from failure of valves, seals, hoses or other mechanical parts. Diaphragm pumps are more popular because of ease of calibration, maintenance and the lack of external leaks.

Some important characteristics and components of chemigation pumps include:

1. Accuracy to within ± 0.5 percent
2. Calibration tube
3. Adjustable while running
4. Durable - stainless steel valve balls
- Niton seals
5. Agitation capability
6. Accessibility of repairs
7. Appropriate size chemical tank/tanks

Injection pumps should operate within ± 0.5 percent accuracy, utilize stainless steel and other non corrosive material where there is direct contact with chemicals. Repair should be accessible. Appropriate

size chemical tanks equipped for agitation and a calibration tube are important to successful chemigation. Complete chemigation units that provide these features are available.

Many pump injection rates are available. It is essential that the pump selected has capacity to apply the appropriate amount of chemical. Injection pumps are usually rated in gallons per hour. The pump rating is the maximum injection rate. Typically, the minimum adjustable injection rate of a single pump is approximately 10 percent of the maximum rating. It is usually worthwhile to project the range of probable injection rates of likely chemicals prior to purchasing an injection pump.

Calibration

Accurate calibration of injection equipment is essential for safe and proper application. Small differences in injection rates can make large differences in the total amount of chemical applied and could cause insufficient or excessive application. The following conversions and equations are useful for calibration of chemigation equipment:

450 gallons/minute = 1 acre-inch/hour

27,000 gallons = 1 acre-inch

Amount of Irrigation Water

The amount of water applied during a single irrigation is determined by three factors:

- the water pumped or system flow rate in gallons per minute (gpm)
- time pumped in hours
- acres on which water is pumped during time (b), expressed as:

Equation 1

$$\frac{\text{depth of irrigation (inches)}}{\text{(inches)}} = \frac{\text{system flow rate (gpm)} \times \text{time (hours)}}{450 \times \text{acres irrigated}}$$

Conversely, the amount of time to apply a given amount of water is:

Equation 2

$$\text{hours} = \frac{(\text{inches of irrigation})}{(\text{system gpm})} \times 450 \times \text{acres}$$

Injector Calibration

Correct injector calibration is necessary so that the chemical solution is injected at a rate that ensures that the proper amount of chemical will be applied (gallons per acre).

The total amount of chemical solution (gallons) is first calculated by multiplying the amount of chemical solution needed per acre (gallons) by the total number of acres; or

Equation 3

$$\frac{\text{total chemical solution needed (gallons)}}{\text{(gallons)}} = (\text{acre}) \times \frac{\text{amount of chemical solution per acre}}{\text{(gallons)}}$$

The injection rate (gallons per hour) is then based on the total solution needed (gallons) divided by the irrigation time (hours) necessary to apply the targeted depth calculated in Equation (1) and (2); or

Equation 4

$$\frac{\text{injection rate (gal per hour)}}{\text{(gal per hour)}} = \frac{\text{total solution chemical and mix (gal)}}{\text{revolution or irrigation time (hours)}}$$

To set calibration, use a stopwatch and a tube or other container of known-volume graduations. Usually a graduated cylinder marked in milliliters or ounces is used. Convert the injection rate from gallons per minute using the following formulas:

Equation 5

If using a milliliter graduated cylinder:

$$(\text{gal per hour}) \times 63.09 = \text{ml per min}$$

Equation 6

If using an ounce graduated cylinder:

$$(\text{gal per hour}) \times 2.133 = \text{oz per min}$$

Example:

Use 32 percent urea ammonium nitrate to apply 10 pounds N per acre through a 1320 foot center pivot covering 125.5 acres at 900 gallons per minute. The fertilizer is applied with 0.50 inches of water. Note: 32 percent urea ammonium nitrate weighs 11.06 lb/gal and has 3.54 lb N/gal.

Step 1. Compute time to make one circle and apply 0.5 inches with equation (2).

$$\frac{(0.5 \text{ in}) \times 450 \times 125.5 \text{ ac}}{900 \text{ gpm}} = 31.4 \text{ hours per circle}$$

Step 2. Convert pounds of N per acre to gallons per acre:

$$10 \text{ lb N/ac} + 3.54 \text{ lb N/gal} = 2.82 \text{ gal solution/ac}$$

Step 3. Calculate total chemicals needed with equation (3).

$$125.5 \text{ ac} \times 2.82 \text{ gal N solution/ac} = 353.9 \text{ total gal fertilizer solution}$$

Step 4. Calculate injection rate with equation (4).

$$353.9 \text{ gal} \div 31.3 \text{ hours} = 11.3 \text{ gal/hour injection rate}$$

Step 5. Identify injection rate in ounces per minute with equation (6).

$$11.3 \times 2.133 = 24.12 \text{ oz/min of fertilizer solution}$$

Step 6. Set pump injection rate to 24.12 oz/min.

Step 7. Set center pivot speed control to 31.4 hours/per revolution or circle

For More Information

More detailed information on chemigation regulations and calibration are given in TAEX publication B-1652, *Chemigation Workbook*.

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