

Part 9: Chemigation

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This chapter provides information for producers who irrigate and are considering chemigation as a way to apply some pesticides. The chapter will help you decide if a given irrigated field and irrigation system can use chemigation and, if so, what practices to follow. While irrigation systems may also be used to apply fertilizers, this chapter will discuss only chemigation of pesticides.

General chemigation safety measures and management practices are discussed. These practices can help minimize the possibility of creating a public health problem. They reducing the risk of accidentally allowing any injected chemical to flow back into the irrigation well or surface water sources, or discharge onto the land where not intended. **Owners/operators of any chemigation system today must have a Minnesota Department of Agriculture chemigation system user permit, install several safety antipollution and safeguard devices, comply with Minnesota Department of Health's well separation distance rules, and implement several management measures.** Details about specific chemigation systems must be obtained from their respective manufacturers.

This chapter does not discuss every protection requirement for chemigation systems connected to a potable well or public water supply system. For specific details on required safety devices and measures for systems connected to public water supplies contact the Minnesota Department of Health.

*The discussion on chemigation in this chapter can also be partially reviewed via three video tapes: "Chemigation Management," "Chemigation Equipment," and "Chemigation Calibration." Videotapes can be rented from the University of Minnesota Extension Service Distribution Center (612-625-8173) at 3 Coffey Hall, University of Minnesota, 1420 Eckles Avenue, St. Paul, MN 55108. These video tapes **do not** discuss requirements under Minnesota laws and regulations.*

What Is Chemigation?

Chemigation is the process of applying an agricultural chemical (fertilizer or pesticide) to the soil or plant surface with an irrigation system by injecting the chemical into the irrigation water. Depending on the type of agricultural chemical being applied, chemigation may be referred to as fertigation, herbigation, insectigation, fungigation, etc. Only pesticides labelled for chemigation and certain fertilizer solutions can be applied by injecting them into an irrigation system. It is estimated that less than 1

percent of the conventionally irrigated land in Minnesota has the proper equipment to apply a pesticide (usually insecticides or fungicides) by chemigation. However, more than two-thirds of the sprinkler irrigation systems in Minnesota have been used to apply liquid nitrogen at one time or other.

In 1987 the Minnesota legislature directed that chemigation regulations and a permit program be developed for pesticide application. In 1989 chemigation regulations were expanded to include fertilizers. The MDA put the pesticide chemigation regulations in effect in January 1989, and adopted fertilizer regulations in fall of 1992. The Minnesota Department of Health (MDH) also has adopted rules for the chemical storage tanks, chemigation systems, and water wells (irrigation, potable, and public water systems) referred to in the MDA regulations.

Advantages, Limitations, and Risks

Chemigation, like other methods of application, has advantages, limitations, and risks that a producer must consider when deciding the best way to apply the desired pesticide. Chemigation can be an effective way of applying certain agricultural chemicals to some irrigated crops if the irrigation system can apply the pesticide/water mixture uniformly and at the proper amount. The greatest risk of chemigation is the potential for accidental backflow of chemical into the irrigation water source. To minimize this risk to the water source, you must use all of the required anti-pollution safety devices and the chemigation system must be properly set up, operated, and maintained.

Limitations and risks

- Uniform chemical application depends on uniform water distribution from the irrigation system.
- Application time is longer than most other chemical application methods.
- Most pesticide compounds are not approved for application with irrigation water.
- Potential risk exists for all or a part of the chemical to flow back into the irrigation water source (ground or surface) if two or more of the required safety devices malfunction while chemigating.
- Farm managers/operators must take time to learn about chemigation safety devices, calibration, and management practices.
- Extra investment must be made for chemigation system and for safety equipment.
- A chemigation permit from the MDA is required.

Advantages and benefits

- Provides uniform distribution of chemicals when the irrigation system's nozzling package is properly selected and maintained.
- Offers more flexibility in timing the chemical application, especially when the field is too wet for a tractor or an aircraft is unavailable.
- May increase pesticide activity and effectiveness for some compounds.
- May reduce the application cost in some situations.
- May reduce mechanical damage to plants caused by ground sprayer wheels.
- May reduce the risk of soil compaction caused by ground application methods.

To Chemigate or Not to Chemigate?

In deciding whether or not to use chemigation many factors must be considered. Consider at least the following factors before deciding to chemigate:

Pesticides

Some, but not all, pesticides can be applied through an irrigation system. Check the pesticide label. In April 1988, the EPA required all pesticide labels to state if they are allowed to be applied through an irrigation system. The label also lists minimum safety devices needed for the irrigation system (for states that do not have their own regulations).

First decide which pesticide product is best to use to protect the crop from a potential problem, regardless of application method. Chemigation then can be considered if the label of the chosen pesticide allows for chemigation. If you only consider those products that are labeled for chemigation, you may limit your options for the most effective, economical, or safest control. Chemigation is an application option for only some irrigated fields and situations and will not be right for all situations.

Effectiveness of any chemigated pesticide depends on the ability of the irrigation system to apply the recommended amount of water uniformly throughout the field. For example, a pre-emergence herbicide may work with 0.4 to 0.75 inch of water, while some fungicides will only work best with 0.15 inches of water.

Regulations

Regulations governing pesticide applications sometimes change. Before you do any chemigation, check with the Minnesota Department of Agriculture (651-297-2614) or with the Minnesota Extension Service.

Minnesota pesticide and fertilizer chemigation regulations require that the owner/operator of any irrigation system who intends to chemigate obtain a MDA chemigation system user permit, pay a fee, install several

safety antipollution and safeguard devices, comply with MDH's well separation distance rules, and implement several management measures.

A chemigation user permit application form and details on safety equipment requirements is available from the Minnesota Department of Agriculture— Pesticide and Fertilizer Management Division at 625 Robert Street, St. Paul, MN 55155. Phone 218-863-2984.

The MDA staff will help identify the proper equipment and will inspect chemigation systems on both a routine and a complaint basis.

Field posting

Minnesota chemigation rules require that the treated field be posted at all times during the chemigation and for the specified re-entry time on the label. See page 9 - 12 in this chapter for more information on posting chemigated fields.

Site location

Do not chemigate with pesticides if the irrigation system will cause off-target spray or drift on adjacent homes or occupied buildings, surface water sources, wetlands, neighboring crops, or roadways.

Land and soil characteristics

Certain soils and topographies are not suitable for chemigation. For example, if the land is very hilly with a lot of variation in elevation the irrigation system may not distribute the chemical-water mixture uniformly on the plant or soil surfaces.

Hilly land may also cause the chemical-water mixture to run down the sloping areas and cause injury to the crop where it ponds. This situation may also cause some chemical either to leach into the groundwater in the areas where the water ponds or to run off the field into surface water.

Type of irrigation system

Pesticide application with irrigation water should only be done with systems that can apply water uniformly over the entire field at an application rate that does not exceed the intake rate of the soil. Distribution of an injected pesticide through an irrigation system is no better than the same system's water distribution.

An irrigation system which causes water to flow down plant rows is exceeding the intake rate of the soil and will not provide an adequate distribution of soil-applied pesticides. This may cause some chemical to either leach into groundwater in the areas where the water ponds or to run off into adjacent surface waters.

An irrigation system should be able to apply water at various application depths. Some pesticides only work when applied with a very light application depth of water (.15 to .25 inches). If an irrigation system is three or more years old, evaluate the water distribution pattern with an in-field catch can test before using chemigation. Specific characteristics of different types of irrigation systems are discussed later in this chapter.

Injection and antipollution equipment

Special equipment is needed for injecting chemicals into the irrigation system to prevent accidental backflow of pesticides into the water supply. The MDA's chemigation regulations require that anyone who intends to

chemigate must install several safety (antipollution and safeguard) devices, comply with MDH's well separation distance rules, and implement several management measures. Specific safety equipment is described later in this chapter.

Note: The owner/operator of the injection equipment and safety devices must take the time to regularly inspect, maintain, and when necessary repair each component to assure correct and safe application of the pesticide.

Calibration

The chemigation operator must be able to calibrate the irrigation and chemigation systems to achieve an accurate application of pesticide. The injection pump must be easy to calibrate and adjust during application. An in-line calibration tube should be used to assist in calibration. Details on how to calibrate are given later in this chapter.

Weather

Winds can cause irrigation water droplets to drift. Strong winds will also cause uneven application of water and chemicals. Do not chemigate if winds are strong enough to cause drift onto non-target areas.

Irrigation Systems

Sprinkler systems like the center pivot (electric or oil drive) and the linear move can provide a very even distribution of water and chemical if the sprinkler package is properly selected and maintained. Water-driven center pivots, however, should not be used because the rate of application around each drive tower is usually much higher than between the towers. Center pivots and linears can be equipped with several types of sprinkler packages (10 to 60 psi) and both can provide adequate water distribution. Spray packages that direct the flow of water downward to the plant or soil surface give the least risk of wind drift.

The end gun on a center pivot should be operated during chemigation only if it can provide uniform application of water and can be controlled to spray within the field boundaries.

Traveling guns and set move sprinkler systems (sidewheel roll, hand move lateral) produce overlapping water patterns between moves and therefore do not distribute water over the whole field as evenly as center pivots. These systems should not be used to apply pesticide, but may be used to apply fertilizer when the wind is very low and no other method is available.

Trickle systems can provide adequate distribution of water when properly designed and operated, but can only be used to apply soil contact pesticides.

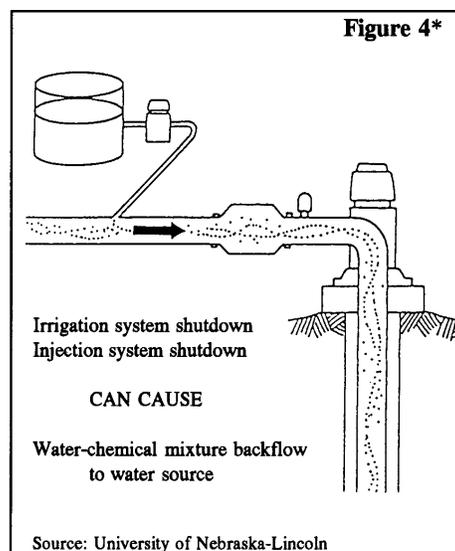
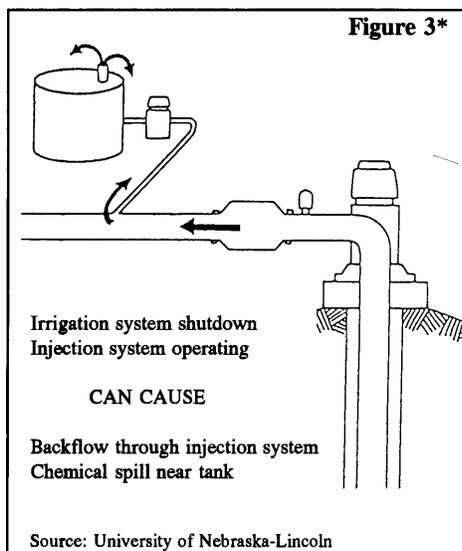
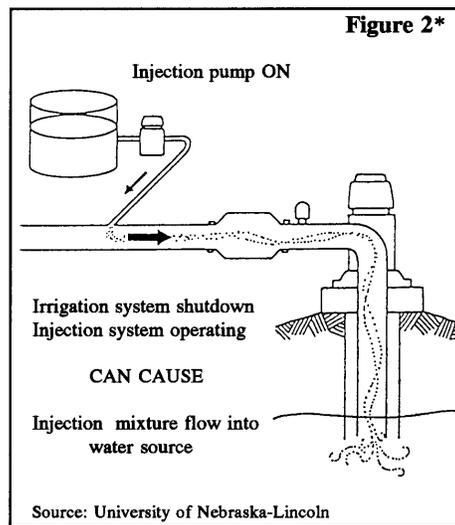
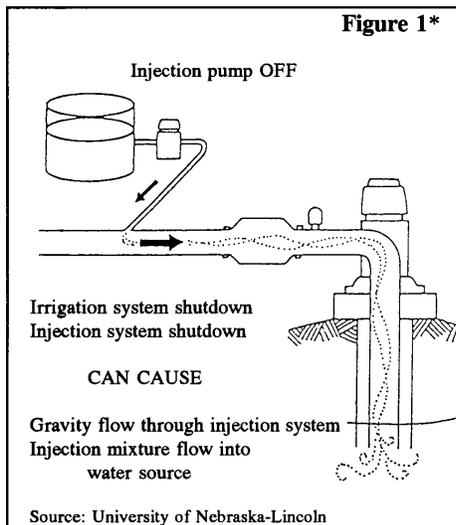
Note: Always check the pesticide label to see if a particular type of irrigation system can be used to chemigate.

Chemigation Equipment

For safe and effective chemigation, the irrigation system must be equipped with the correct chemical injection system and MDA-approved antipollution devices and safeguards. The system must also be able to apply the pesticide uniformly to the targeted field only and be easily calibrated.

Chemigation can potentially pollute the irrigation water source if not protected with the proper functioning safety devices. Three main ways pollution could occur are:

- The chemical in the supply tank and in the irrigation pipeline could flow or be siphoned back into the water source when the irrigation system shuts down (*Figure 1 and Figure 4, page 9-7*).
- The chemigation system could continue to inject chemical into the irrigation pipe line when the irrigation system shuts down. This causes the chemical solution to flow back into the water source or spill onto ground (*Figure 2*).



- The chemigation system could shut down while the irrigation system continues to operate and force water back into the chemical supply tank. This would cause the tank to overflow and spill onto the ground (Figure 3).

The chemigation operator and farm manager/owner are responsible for seeing that these and other pollution risks are minimized by using proper injection equipment, safety devices, and management measures. Before injecting any pesticide, always do a trial run with water to check the performance of the irrigation system, injection equipment, and safety devices.

Injection Equipment

A chemical injection system consists of an injection meter/pump, chemical supply hose, supply tank, calibration equipment, and antipollution and safety devices. Any equipment that comes in contact with chemicals, including hoses, seals, and gaskets, must be resistant to all formulations being applied. This includes emulsifiers, solvents, and other carriers as well as the active ingredient.

Injection meter/pump

The chemical injection meter or pump should be easy to adjust for different injection rates. It should be sized to meet the injection rates of the specific system and chemical. No single pump can do all jobs, since application rates may range from pints to several gallons an hour. Do not operate a pump at its maximum or minimum setting. This may result in inaccurate injection rates. A strainer should always be located on the inlet side of the suction line to prevent the pump and injection hose check valves from clogging.

The main types of metering devices are diaphragm pumps, piston pumps, and venturi injectors. **Diaphragm pumps** are the best all-round metering device for chemigation, even though they are more expensive than piston or venturi units. They have fewer moving parts, are less subject to corrosion and leaks, and are easily adjusted during chemigation.

Piston pumps can not be easily recalibrated during a chemigation event and the piston parts are more likely to wear faster where they come in contact with the chemical. They must be stopped to make a calibration adjustment. **Venturi injection units** are usually lower in cost, but it may be harder to maintain an accurate or consistent injection rate with this type of pump.

Supply tank

The chemigation supply tank should be made of noncorroding materials such as stainless steel, fiberglass, nylon, or polyethylene. Avoid materials like iron, steel, copper, aluminum, or brass, which can corrode. Depending on the pesticide formulation used, the tank may need mechanical or hydraulic agitation to keep the chemicals mixed. The outlet of the tank should contain a manual control valve.

Injection line strainer

A chemical resistant strainer should be located on the chemical suction line/hose to remove foreign materials that could plug or damage the injection meter/pump or chemical injection line check valve.

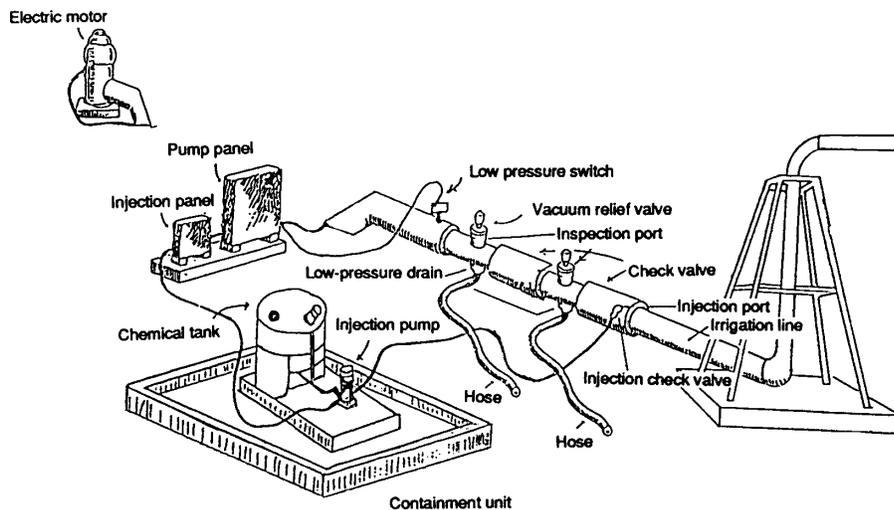
Hoses, clamps, and fittings

All components that come in contact with the chemical mixtures should be constructed of materials that are resistant to chemicals and to sunlight degradation. The pressure rating of all components should be adequate to withstand all operating pressures. Hoses and fittings should be protected from mechanical damage.

Calibration equipment

A calibration tube or in-line flow meter installed on the chemigation injection hose line provides an easy way to measure the rate of flow of the chemical being injected into the irrigation system. The tube, with the necessary valves and fittings, should be placed on the suction side of the injection device so the injection rate can be checked during a chemigation. A calibration tube is typically a clear tube with markings in milliliters or fluid ounces. It is used with a stop watch to measure the flow rate.

An in-line flow meter can be used on either the suction or discharge side of the injection device. It is typically marked in flow units of volume per time.



Required Antipollution Devices and Measures

MDA Required Devices and Safeguards

The Minnesota pesticide and fertilizer chemigation regulations of 1992 require that the owner/operator of any irrigation system who intends to chemigate (pesticide or fertilizer) obtain a MDA chemigation system user permit, install several safety (antipollution and safeguard) devices, comply with MDH's well separation distance rules, and implement several

management measures. The safety devices are necessary to prevent pollution of the water supply via the ways described in Figures 1-4 on page 9-149.

Figure 5 shows a typical arrangement of the basic safety devices. Some installations will have different requirements depending on the kind of water supply system and the location of the water source. Alternative safety devices can only be used if approved in advance by MDA staff. The actual MDA chemigation regulations can be found in Minnesota Rules, parts 1505.2100–1505.2800. MDH regulations relating to well separation distances from potential contamination sources are listed in Minnesota Rules, part 4725.4450.

Figure 5. Chemigation safety equipment arrangement when applying a pesticide with an irrigation system connected to an irrigation well. (Diagram adapted from South Dakota Cooperative Extension Service Fact Sheet 860).

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Basic safety devices and measures outlined in the MDA chemigation regulations to protect the irrigation water source from pollution are:

Irrigation main pipeline check valve

An MDA-approved reduced pressure zone (RPZ) backflow preventer, or two check valves in series, must be installed in the main irrigation water supply pipeline of any system that will be injecting pesticide that is directly connected to an irrigation water well or a surface water source. A single MDA-approved check valve may be used in the main pipeline only if you intend to inject fertilizer solely.

The check valve(s) or RPZ assembly must be located between the point of chemical injection and the irrigation water supply pump. Their main purpose is to keep the water and chemical mixture from flowing back or being siphoned back into the water source. Check valves should be installed with fittings that allow you to easily remove them for maintenance or repair. The check valve(s) assembly may be installed as a portable unit and moved to other irrigation systems where permitted by MDA.

Each **check valve assembly** must contain an air vacuum relief valve and an automatic low pressure release drain immediately upstream of the check valve flapper. The check valve assembly must also have an inspection port that is easy to open to inspect the check valve flapper and the low pressure drain when the irrigation system is shut down.

The **vacuum relief valve** allows air to enter the pipeline when the water stops flowing. This prevents the creation of a vacuum that could cause siphoning of the water-chemical mixture downstream of the check valve back into the water supply.

The **low pressure drain** must be located on the bottom of the pipeline on the supply side of the check valve and have a fully functioning drain opening at least 3/4-inch in diameter. It must open automatically whenever the irrigation water flow stops. This provides a secondary safety backup to prevent any chemical and water mixture from entering the water source if the check valve should leak. The drain outlet must be

positioned, or the drainage directed to flow, away from the well or surface water source during shutdown. A hose, pipe, or open conduit can be used to direct the drain discharge.

Approved check valve assemblies must meet MDA design and operating standards and be certified by an independent testing laboratory. **A list of currently approved check valve models can be obtained from the MDA.** Check valve assemblies must be quick-closing by spring action and must provide a watertight seal. They must be constructed of material resistant to corrosion, or be protected to resist corrosion, and be easy to maintain and repair.

System interlock

The chemigation injection system must be interlocked with the irrigation system's power or water supply so it will shut down any time the irrigation system or pumping plant stops operating or the water flow is disrupted. In all cases this measure must prevent chemical from the supply tank being injected into the main irrigation pipeline after the water supply stops flowing.

If electric motors are used for both the irrigation and chemigation systems, the control panels for the two systems must be interlocked. This interlock must be set up so the injection pump motor stops whenever the irrigation system or pump stops.

Irrigation pumps driven by an internal combustion engine can be interlocked with an injection pump by being belted to the drive shaft or an accessory pulley on the engine. If the injection pump is electrically powered, it should be connected to the engine's generator or electrical control system.

Some chemigation systems use flowing water or water pressure to power the injection meter or pump. In most cases these systems will stop injecting a chemical when the irrigation water supply stops flowing.

If chemical flow from the supply tank could possibly continue after shutdown, a normally closed solenoid valve should be installed in the chemical injection line, preferably on the suction side of the injection meter. The solenoid valve must be interlocked with and powered by the irrigation system control panel, water supply pressure, or the injector power supply.

Chemical injection line check valve

The chemical injector's discharge line/hose must contain a positive-losing check valve that will not allow flow either way when the injection system is not operating. The check valve must be located between the injection meter and the point of the chemical injection into the irrigation pipeline.

This valve should: 1) stop flow of water from the irrigation system into the chemical supply tank if the injection system stops; and 2) prevent gravity flow from the chemical tank into the irrigation pipeline following an unexpected shutdown. To provide two way protection the valve must have a watertight sealing check valve with a minimum opening (cracking) pressure of 10 pounds per square inch. It should also be constructed of an agricultural chemical corrosive-resistant material.

If irrigation water is allowed to flow back into the chemical supply tank it could overflow the tank causing chemical to spill onto the ground. If

chemical in the supply tank is allowed to flow into the irrigation pipeline by gravity or be siphoned when the irrigation system is not operating, it could damage the crop or leak on the ground, possibly getting into a surface water or groundwater source.

Low pressure shutdown switch

The irrigation system must contain a low pressure shutdown switch or device with similar operating characteristics on the main pipeline. This will shut down the irrigation system and the chemigation system if the operating pressure drops to an unsatisfactory level for proper agricultural chemical distribution.

Chemical supply tank

The chemigation supply tank must not be located closer to an irrigation well than the distance specified in the MDH rules chapter 4725, and must be safeguarded according to the MDA specifications described in the following paragraphs. All preparation or filling of a chemical tank must be done at least 150 feet from a wellhead unless properly safeguarded.

The separation distance from a surface water source must likewise be no less than that specified for an irrigation well unless other state/federal regulations are more applicable. The supply tank should be placed away from the water source in such a way that, if a spill occurs, the chemical will not move directly to the source.

According to MDA chemigation rules, a chemigation supply tank must be housed in a secondary containment unit if the tank storage meets at least two of the following conditions: 1) the supply tank has a rated capacity of more than 1,500 gallons; 2) the tank is located within 100 feet of a water supply; and 3) the supply tank storage is located at the site for more than 30 consecutive days.

The minimum required capacity for a secondary containment unit is 125 percent of the tank capacity (110 percent if it is under a roof). Its walls and base may be made of ferrous metal, reinforced concrete, solid reinforced masonry, synthetic lined earth or prefabricated metal, or synthetic materials. Synthetic liners must have a minimum thickness of 30 mils.

The unit must be leakproof and built to withstand the hydrostatic pressure from the release of a full tank. The walls or base must not contain a drain. Design specifications for some types of units are described in MidWest Plan Service Bulletin #37 *Designing Facilities for Pesticide and Fertilizer Containment*. This bulletin is available at county extension offices.

The chemical supply tank must be constructed from material such as fiberglass, polyethylene, or stainless steel that is resistant to the chemical being stored and resistant to degradation by sunlight. If not contained in a secondary unit, the tank should be located and landscaped so if a leak develops it will direct any leakage away from entering the water source. The tank should also be protected from damage from farm machinery and livestock.

Posting of field

All sites being treated with a pesticide through the irrigation water must be posted with signs during the entire chemigation treatment. Signs must contain the signal word from the pesticide label, name of the pesticide, date of treatment, and re-entry date as described by the pesticide label. An example of a sign can be obtained from the MDA.

Signs must be posted at usual points of entry and at property corners immediately adjacent to public transportation routes or other public or private property. Signs must be placed no farther than 100 feet apart for a field that is located adjacent to a public area such as a park, school, or residential area. If more restrictive instructions for posting are described on the label, those restrictions must be followed.

The new federal Worker Protection Standards sometimes require posting as well as notifying any agricultural employees of the pesticide application. See Worker Protection Standard in Part 2—Pesticide Laws and check with your local county extension office or the MDA for more information.

Additional Protection Measures

There are several other devices and measures that make management of the chemigation operation easier and also reduce the potential risks to the environment. These include:

Portable chemigation system and chemical supply tank: Install the chemigation injection meter/pump and chemical supply tank on a portable trailer or truck. Construct a secondary containment unit of appropriate size on the bed of the trailer or truck.

Injection meter/pump: Place the injection meter or pump within the chemical supply tank containment unit when possible.

Chemigation system location: When developing a new irrigation system always try to locate the irrigation water supply at least 150 feet from the chemigation system, chemical supply tank, injection port, and power interlock controls.

Bleed valve: Locate a bleed valve upstream from and next to the injection line check valve to assist in relieving any “locked-in” pressure in the chemical injection line when the injection line is disconnected. This will prevent the operator from being sprayed with the chemical in the line during line removal.

Injection port location: When possible, locate the port for chemical injection higher than the chemical supply tank but lower than the lowest sprinkler outlet to prevent siphoning from the tank. In all cases the injection port must be located downstream from the main pipeline check valve.

Injection line flow sensor: An injection line flow sensor installed just upstream from the chemical injection line check valve and interlocked with the injection device can be used to shut down the injection system if flow in the injection line ceases. This safety measure will prevent continuous operation if the injection device loses prime or fails, the supply tank is emptied, the injection port becomes plugged, or the lines or hoses rupture or become disconnected. The flow sensor could also be interlocked with the irrigation system to shut down the whole system if injection line flow stops.

Two-way interlock: A two-way interlock arrangement between the irrigation system and the injection system will stop either system if the other system also stops. This eliminates untreated areas in the field because it stops the irrigation pump and sprinkler system if the injection system stops or malfunctions. The interlock can be done electrically or by using a flow sensor on the discharge side of the chemical injection device.

When there is no flow in the injection line, the irrigation system and pumping plants will shut down.

Solenoid valve: A normally closed solenoid valve installed on the suction side of the injection device can provide a good back-up. It acts as an automatic shutoff valve on the injection line when the injection pump is not in use. The solenoid valve must be interlocked with the injection device power supply to open or close properly.

Calibration

Proper calibration of the irrigation system and chemigation injection pump is essential for a effective, safe, and economical application. Minor differences in calibration and application rate over a period of time can cause the pesticide application rate to be too high or too low. Too high a rate is potentially damaging to the crop or the environment. Too low an application rate may make the pesticide treatment ineffective.

It is important to have accurate in-field measurement of the field size, travel time to cover the field at the desired water depth, and amount of chemical required per acre for accurate calibration of the equipment and the whole system.

Listed below are the typical steps to take to calculate the proper chemigation injection rate for a center pivot with a given situation. Examples are given for fertilizer and pesticide.

Steps	Examples	Yours
	Nitrogen	Pesticide
1. Number of acres under center pivot	128 acres	128 acres
2. Amount of chemical/acre (example: 30 lb of 28% N per acre = 10.0 gal and pesticide of 2 pt + 2 pts of oil = 2 qts per acre)	10.0 gal (30 lbs)	2 qt
3. Multiply step 1 by 2	1,280 gal	256 qt
4. If chemical needs some dilution with water, enter total amount of solution	----	175 gal
5. Select water application depth per product recommendation	0.75 inch	0.2 inch
6. Determine travel time of center pivot for one revolution to apply water depth in step 5	72 hr	1,153 min (19.2 hrs)
7. Determine injection rate by dividing step 3 or 4 by step 6 (1 gal = 3,785 ml)	12.7 gal/hr	9.11 gal/hr (575 ml/min)** (100 ml in 10.4 sec)***
**ml per min: $\frac{9.11 \text{ gal/hr} \times 3,785 \text{ ml/gal}}{60 \text{ min/hr}} = 575 \text{ ml/min}$		
***sec per 100 ml: $\frac{100 \times 60 \text{ seconds/min}}{575 \text{ ml/min}} = 10.4 \text{ sec per 100 ml (100 ml in 10.4 sec)}$		
8. Select injection pump dial per manufacturer's		

curve for step 7 and check delivery rate of the injector with calibration tube to make certain it is injecting at the proper rate. Adjust rate dial as needed to obtain calculated injection rate.

7.5 90% _____

Notes for Calibration Step 1: If acreage of field is not known, the area should be calculated. For example, for a center pivot that runs a full circle, the area covered in acres can be found by the following formula.

$$\text{Area covered} = \frac{\text{Wetted radius (ft)} \times \text{Wetted radius (ft)} \times 3.14}{43,560 \text{ ft}^2 \text{ per acre}} = \text{Acres}$$

Where the area covered is only a part of a circle, multiply the full circle area by the percentage of the coverage. If an end gun or corner system is used, calculate the area of both wetted radii and estimate the percentage of each operation. For example, assume 2/3 of the circle with normal sprinklers and 1/3 with end gun.

If further assistance is needed in calculating the area, contact your equipment dealer, local Extension office, or SWCD office.

Notes for Calibration Step 6: Knowing the correct travel time to cover the field is very important in making an accurate calibration. There are two methods that can be used to time the application of a center pivot.

First method: operate the system wet at the same travel speed (% timer setting) that is planned for chemigation and measure the time to make one revolution or to cover the desired part of the field.

Second method: measure the distance from the pivot point to the outer tower wheel tracks. Then operate the system wet at the desired travel speed (% timer setting) that is planned for chemigation and measure the time it takes the outer tower to travel a preset distance, say 100 feet. To calculate the time to cover a circle, use the following formulas:

$$\text{Wheel track circumference (ft)} = 3.14 \times 2 \times \text{distance from pivot to outer wheel track.}$$

$$\text{Rotation time} = \frac{\text{Wheel track circumference (ft)} \times \text{time (min) between stakes}}{\text{Distance traveled between stakes (ft)}}$$

For example: A center pivot with a 1,250 ft length to the outer track takes 14.69 minutes to travel 100 feet. <Paragraph 3>Wheel track circumference = $3.14 \times 1250 \times 2 = 7,850 \text{ ft}$.

$$\text{Rotation time} = \frac{7,850 \times 14.69 \text{ min}}{100 \text{ ft}} = 1,153 \text{ minutes or } 19.2 \text{ hrs} = \frac{1,153 \text{ min}}{60 \text{ min/hr}}$$

Summary

A chemigation system requires regular maintenance and supervision to apply a pesticide safely and effectively. The owner or operator is responsible for making sure that all equipment and components function properly and the pesticide application is done according to label directions. Listed below are several management tips that should be reviewed each time a chemigation system is used to apply a pesticide.

Review operation of irrigation system

Periodically observe the irrigation system's water distribution pattern and conduct a water distribution test of the spray pattern. Remember that the

uniformity of the chemical distribution will be no better than the distribution of the water.

Adjust the irrigation system (such as the end gun) to prevent spray going beyond the boundaries of the target field. Shut down the irrigation system if wind will carry chemical drift off target. Manage the irrigation system so runoff or deep percolation of the water-chemical mixture does not occur.

Do not chemigate in areas containing wetlands and other surface water bodies. Do not apply any pesticide that is not labelled for use in an irrigation system. Such applications are illegal and may adversely affect wildlife, non-target plants, and water quality.

Inspect safety and antipollution equipment before each use

Inspect all components of the chemigation and irrigation system before each use. Components not working at the time of inspection should be repaired or replaced before chemigating. Routine inspections should minimize the potential for failure of any component during chemigation.

To inspect the irrigation pipeline check valve, low pressure drain, injection line check valve, low pressure switch and the power interlock follow the procedures listed below. RPZ backflow preventers and some other types of check valves will require a different approach to inspection. Contact MDA staff for directions on inspecting if assistance is needed.

- Connect the chemigation system to the irrigation system, but leave the chemical injection line/hose disconnected from the injection port check valve.
- Start the irrigation pump and pressurize the irrigation system to its normal operating pressure.
- Observe the injection line check valve to see if any water is leaking back out the inlet side of the check valve. There should be no leakage observed when the irrigation system is operating or when shut down.
- Connect the chemical injection hose to the injection check valve and start up the chemigation system. **The chemigation system should be operated only with clean water or nothing.**
- Close the main pipeline control valve (reducing the operating pressure) until the low pressure switch shuts down the irrigation system. The pressure switch should be set to cause the irrigation pump and system to shut down when the normal operating pressure has been reduced by 15 to 25 percent. If no flow control valve is present, shut power off to the pump and/or irrigation system and go to the next step.
- Immediately after shutdown, observe if any water is flowing from the low pressure drain(s). Some drainage for a short period of time after shutdown is normal, but then drainage should stop.
- Check to see if the chemigation injection device has stopped operating. This device should stop when the irrigation system and pump shut down. If the chemigation system has an agitation system this unit does not have to shut down when the injection device stops.
- Open the inspection port at the main pipeline check valve assembly after the low pressure drain has stopped flowing. Inspect for any leakage from the check valve flapper. There should be no leakage from the

downstream flapper. Also check for proper functioning of the flapper valve assembly.

Fill supply tank and mix agricultural chemicals

Chemigation supply tanks should be located at least 150 feet from any water well during filling unless housed in the appropriate safeguard unit defined by the MDA and MDH. The supply tank condition and plumbing fixtures should be inspected closely each time before it is filled. Fill supply tank no more than 95 percent of capacity. Monitor the supply tank during chemigation for development of any leaking.

Triple-rinse pesticide containers at time of use and add the rinse water into the supply tank. Rinse over the opening of the supply tank to minimize risk of spilling on the ground.

Keep the chemigation site uncontaminated

To make monitoring the chemigation operation safe and easy, do not allow the irrigation system to spray water and chemical into the chemigation equipment area. This may mean plugging a few nozzles on the irrigation system near the chemigation site.

Calibration

Accurate calibration of the chemical injection device is essential for proper application. Recheck the calibration setting of the injection device periodically. Follow calibration procedures described by the chemical label, chemigation equipment manufacturer, or the Minnesota Extension Service. Minor differences in injection rate over an extended period can cause too high or too low a chemical application rate. This may produce unsatisfactory results when too low, or cause potential pollution or crop damage when too high applications are made.

Empty chemigation supply tank

Leftover pesticide mixtures should be removed from the supply tank and stored in an appropriate place for later use or immediately applied to another crop or site listed on the label. The empty tank should be rinsed out and rinsing water applied to the irrigated crop or another labelled site.

Flush injection equipment

Flush the chemigation injection device, hoses, and check valve with clean water after each use. Flush cleaning water into the irrigation system while it is operating so the cleaning water will be applied to the field. Clean strainer after each chemigation.

Flush irrigation system

After chemigation is completed and the chemigation system is cleaned and flushed, operate the irrigation pump as long as necessary to flush the irrigation system free of chemical. This may take 10 to 15 minutes for most systems.

Report accidental spills

If an accident occurs, regardless of size, avoid personal contamination. Take action to keep the spill to a minimum, and report the incident to the MDA immediately. Phone 1-800-422-0798 for assistance.

For More Information

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