Category 14: Chemigation

Chemigation Learning Objectives

After studying this section, you should be able to:

- Explain the Worker Protection Standard (WPS) and how it relates to chemigation.
- Describe three things that may happen if chemigation safety hardware is not installed properly.
- List chemigation safety hardware and its location in the chemigation system.
- Describe the purpose of chemigation hardware.
- List the advantages and disadvantages of chemigation pesticide applications.

Category 14 Chemigation

Chemigation is the process of applying agricultural fertilizers and pesticides through flood, drip, sprinkler and other types of irrigation systems. This category describes the safe and efficient application of pesticides through sprinkler irrigation systems and focuses on protecting water resources from pesticide contamination related to chemigation. In this chapter, the term “chemigation” will be used for the application of pesticides through irrigation water. For information on calibrating your chemigation equipment, see “Calibration of Chemigation Equipment” under the “General Knowledge: Guidelines for the Safe Use of Pesticides” section of this manual.

Advantages of pesticide chemigation: Chemigation offers several distinct advantages in comparison to conventional application methods.

- Soil compaction is avoided, as heavy spray equipment never enters the field.
Chemigation may save time (labor) and money by reducing the need for personnel and equipment.

- Crops are not damaged by root pruning, breaking of leaves or bending over the shoots, as occurs with conventional spray equipment and techniques.
- Less equipment may be required to apply the pesticides.
- Less energy is expended in applying the chemical, as vehicles do not have to traverse the field.
- Less labor is needed to apply and supervise the pesticide application.
- Capitol, maintenance and labor costs are reduced.
- The application of pesticides can be more carefully regulated and monitored.
- Pesticides can be applied quickly before a disease or insect infestation spreads.
- Pesticides can be more evenly distributed throughout the target site, preventing "skipping" through the field.
- Pesticides can be applied to the crop or soil when crop or soil conditions would otherwise prohibit entry into the field with conventional spray equipment.
- Requires less mixing and loading, reducing applicator exposure.

Disadvantages of pesticide chemigation:

- Specific safety precautions, specialized equipment and training are required for chemigation.
- The initial cost of equipment is high, but with long-term use there may be significant savings in labor and other equipment costs.
- Potential for contamination of water sources is higher with chemigation than with other application methods.
- Some pesticides are not approved for application through chemigation systems.

A major drawback of chemigation is the increased potential for contamination of water sources. Because irrigation water, livestock water and domestic water may come from the same source, it is essential that applicators using chemigation comply with specific rules to protect water sources.
Chemigation and Irrigation

Fertilizers have been applied through many types of irrigation systems for many years. With the introduction of center pivots and linear move (wheel line) irrigation systems, the application of various pesticides has become more widespread. Significant advancements have been made to the designs of equipment to enhance chemigation, including under-canopy spray heads to apply insecticides to the under sides of leaves and high-speed gearboxes for the drive units. This enables the irrigation equipment to move faster across the field for a light application of pesticide(s). Center pivots and linear moves have peculiar traits that affect pesticide application that are not common to other irrigation methods. They do not require the presence of people in the field during irrigation. They are capable of quick, small and very uniform applications of water and therefore pesticides. Furthermore, these systems wet the leaves of the crop that surface (flood or furrow) irrigation does not.

The use of drip and micro irrigation has boomed in the last few years. This has stimulated a parallel growth in the use of chemigation. An increasingly wide range of fungicides, herbicides and insecticides are injected through drip and micro irrigation systems in the United States.

Worker Protection Standard

The Worker Protection Standard (WPS) is a regulation issued by the U.S. Environmental Protection Agency. It covers the use of pesticides in the production of agricultural plants on farms, forests, nurseries and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use pesticides, or (2) employ workers or pesticide handlers who are exposed to pesticides. If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide the items listed below to your employees and, in some cases, to yourself and to others.

Information about exposure to pesticides: To ensure that employees will be informed about exposure to pesticides, the WPS requires:

- Pesticide safety training for workers and handlers.
- Display of a pesticide safety poster for workers and handlers.
- Access to pesticide labeling information for pesticide handlers and early-entry workers.
- Access to centrally-located information detailing pesticides applications that have occurred on the establishment.

The Worker Protection Standard (WPS) applies to workers on farms, forests, nurseries and greenhouses.

For further information on the WPS, consult the US EPA web publication “How To Comply With the Worker Protection Standard for Agricultural Pesticides: What Employers Need to Know” at http://www.epa.gov/agriculture/htc.html
Protection from exposures to pesticides: To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying pesticides in a way that will expose workers or other persons to them.
- Exclude workers from areas being treated with pesticides.
- Exclude workers from areas that remain under a restricted-entry interval (REI), with narrow exceptions.
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI, including providing special instructions related to correct the use of Personal Protective Equipment (PPE).
- Notify workers about treated areas so they can avoid inadvertent exposures.
- Protect handlers during handling tasks, including monitoring while handling highly toxic pesticides and providing special instructions related to correct use of Personal Protective Equipment (PPE).

Mitigation of pesticide exposures: To mitigate pesticide exposures that employees may receive, the WPS requires that:

- Decontamination supplies are made available to all workers. Employers must provide pesticide handlers and workers an ample supply of water, soap and towels for routine washing and emergency decontamination.
- Emergency assistance information is made available to all workers. Employers must make transportation available to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide and must provide information about the pesticide(s) to which the person may have been exposed. Bring the pesticide container to the medical care facility with label intact.

Protecting Water Resources

Protecting the environment is an essential requirement of all pesticide applications, and chemigation is no different. Water and pesticides are applied through sprinkler systems for most chemigation applications in Nevada. Groundwater is the most frequently used water source in many locations. Water used for chemigation is pumped from a groundwater well and applied directly through a sprinkler system. Groundwater may also be pumped into a ditch or canal and then pumped out of the ditch into a sprinkler system.

Surface water sources, such as rivers or streams, may be diverted into irrigation ditches where water can be pumped into a sprinkler system. All water sources must be protected, regardless of the origin.
After pesticides are applied, they are eventually broken down by sunlight, chemical or microbial activity. If pesticides reach the groundwater, they will be broken down very slowly due to low temperatures, absence of sunlight and lack of microbial activity.

Some pesticide labels do not allow for application by chemigation. For products that do allow application by chemigation, specific instructions will be listed on the label. Many of the instructions are related to backflow hardware that must be installed in the chemigation system. To protect water resources, applicators must read and carefully follow all chemigation requirements on pesticide labels.

**Chemigation Safety Hardware**

Chemigation requires that two separate hardware systems be joined together: the chemical injection system and the irrigation system. Properly functioning anti-pollution devices must be correctly installed in both systems to effectively prevent groundwater contamination.

The following sketch shows a chemigation layout that includes the United States Environmental Protection Agency’s (EPA) required safety devices.
### Table 14.1 Description of required safety devices

<table>
<thead>
<tr>
<th>Devices</th>
<th>Description/Location</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation check valve*</td>
<td>Between well and injection points</td>
<td>Prevents pesticide from flowing backwards and entering the water source</td>
</tr>
<tr>
<td>Injection line check valve</td>
<td>At the injection point. A one-way valve with a 10 psi spring that closes when not under pressure</td>
<td>Prevents water from flowing backwards into the chemical tank, causing the tank to overflow</td>
</tr>
<tr>
<td>Vacuum relief valve</td>
<td>Between the check valve and the well</td>
<td>Prevents a vacuum when pump shuts off; reduces chance of backflow</td>
</tr>
<tr>
<td>Low pressure cutoff</td>
<td>On irrigation pipeline</td>
<td>Turns off injector power when irrigation water pressure is low</td>
</tr>
<tr>
<td>Low pressure drain*</td>
<td>Between well and irrigation line check valve</td>
<td>Discharges any water that might leak through the check valve after irrigation pump is shut off</td>
</tr>
<tr>
<td>Normally closed solenoid valve*</td>
<td>Between injection pump and pesticide tank</td>
<td>Prevents tank from emptying unless injector is working</td>
</tr>
<tr>
<td>Interlock</td>
<td>Between injection pump and irrigation pump panels/power</td>
<td>Prevents injection if irrigation pump stops</td>
</tr>
</tbody>
</table>

*These devices may be replaced with an alternative device listed in Table 14-2.

### Table 14.2. Approved alternative devices for chemigation equipment.

<table>
<thead>
<tr>
<th>Original Device</th>
<th>Approved Alternative Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normally closed, solenoid-operated valve located on the intake side of the injection pump</td>
<td>Spring-loaded check valve with a minimum of 10 psi cracking pressure</td>
</tr>
<tr>
<td></td>
<td>Normally closed, hydraulically opened check valve</td>
</tr>
<tr>
<td></td>
<td>Functional vacuum relief valve located in the pesticide injection line between the positive displacement pesticide injection pump and the check valve.</td>
</tr>
<tr>
<td>Functional main water line check valve and main water line low pressure drain</td>
<td>Gooseneck pipe loop located in the main water line immediately downstream of the irrigation water pump</td>
</tr>
<tr>
<td>Positive displacement pesticide injection pump</td>
<td>Venturi system 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</td>
</tr>
<tr>
<td>Vacuum relief valve</td>
<td>Combination air and vacuum relief valve</td>
</tr>
</tbody>
</table>
The devices listed in table 14.1 are intended to protect water sources from pesticide contamination. They are listed on labels of pesticides that are approved for chemigation and must be installed on systems that are used to chemigate those products.

The U.S. EPA has approved a list of alternative chemigation safety equipment that can be used in the place of specific equipment as required by pesticide labeling (Table 14.2). Any chemigation equipment that is required on pesticide product labeling but has no listed alternative(s) is still required as a component of the chemigation system.

Protecting the water supply from contamination should be a top priority when setting up pesticide injection equipment. Without the proper safety equipment (Table 14.1 or approved alternate devices in Table 14.2), any of the following scenarios may occur:

1. An unexpected shutdown of the irrigation pump could cause concentrated pesticides and water to be drawn into the well and aquifer.

2. The irrigation pump shuts down while the pesticide injection pump continues to operate. This can cause pesticides to backflow into the well and groundwater supply, or force high levels of pesticides to flow into the irrigation pipe and distribution system, damaging the crop and environment.

3. The pesticide injection system stops while the irrigation pump continues to operate. This causes water to backflow through the pesticide supply tank and overflow onto the ground.

Description of Chemigation Safety Devices

Check Valves and Vacuum Relief Valves: Check and vacuum relief valves (anti-siphon devices) are required on the irrigation pipeline. They keep water and/or pesticide and water from backflowing or siphoning back into the irrigation water source should the irrigation pump shut down. Both of these valves must be located between the irrigation pump outlet and the point of pesticide injection. The check valve must have a positive closing action and a watertight seal. It should be easy to repair and maintain. The vacuum relief valve allows air into the pipeline when the water flow stops, preventing the creation of a vacuum that could lead to siphoning.

A second backflow device in addition to, or in place of, a normally closed solenoid valve in the pesticide injection line is needed for two purposes: 1) to prevent the water from flowing into the pesticide supply tank when the pesticide injector is shut off, and 2) to prevent gravity flow from the pesticide supply tank into the irrigation pipeline after an unexpected
Chemigation safety devices must ensure that if the irrigation pump stops, the pesticide injection also stops.

shutdown. The backflow device is required to be spring loaded, and have a minimum of 10 psi cracking pressure. This device is generally preferred by growers throughout the United States over the normally closed, solenoid-operated valve located on the intake side of the injection pump. Several manufacturers sell a combination check valve/injection port device that is located at the discharge end of the chemical hose. This combination device provides the safety feature required by EPA, and also places the pesticide into the midstream of the irrigation water flow, which provides better chemical mixing.

**Low Pressure Cutoff:** Low pressure cutoff turns off the power to the injectors in the event the water pressure drops in the main irrigation line.

**Low Pressure Drain:** An automatic low pressure drain is used for monitoring check valve performance. This device should be placed on the bottom side of the irrigation pipeline. In the event that the main line check valve leaks slowly, the water or pesticide and water will drain away from, rather than flow into, the water supply. The location of the drain should be at least 20 feet from the well, between the irrigation pump and the main line check valve. In some cases placement of the valve may be more feasible downstream of the main line check valve. However, it should always be placed on the irrigation pipeline before the point of injection.

**Solenoid Valve:** A normally closed solenoid valve can be electrically interlocked with the engine or motor driving the pesticide injection pump. This valve, located on the inlet side of the injection pump, provides a positive shut-off on the pesticide injection line. Neither the pesticide nor the water can flow in either direction if the pesticide pump stops.

**Interlock:** Electrical interlock connects the irrigation pump to the chemical injection device so in the event of an irrigation pump failure, the pesticide injection pump will also stop. This prevents the pesticide from being pumped from the supply tank into the irrigation pipeline after the irrigation pump stops.

For internal combustion engines, the pesticide injection pump can be belted to the drive shaft or an accessory engine pulley. Other possibilities include operating the injection pump from the engine electrical system (12-volt). **In all cases, it is essential that if the irrigation pump stops, the pesticide injection also stops.** In addition to interlocks, additional protection is provided by a low-pressure shutoff switch that turns off the pump should water pressure drop and the pesticide is no longer being applied at label rates. This switch triggers all other pumps to shut off.
Pesticide Labels

Labels for pesticides that are chemigated must provide detailed information regarding application rates, re-entry intervals, personal protective equipment and clothes, etc. Each pesticide label must state that the pesticide product can be chemigated and applicators must adhere to the instructions provided on the pesticide container labels. Chemicals are registered in each state for specific crops and methods of application.

Appropriate Materials for Hardware

Hoses: In most cases, hoses should be constructed of reinforced-braided Ethyl Vinyl Acetate (EVA). EVA is:

- Flexible at a wide range of temperatures.
- Capable of working at pressures up to 200 psi.
- Stable under UV radiation. It does not deteriorate after prolonged exposure to sunlight.
- Chemically compatible with pesticides.
- Available in thicknesses that work under suction without collapsing.

Inspect hoses regularly for leaks and cracks. Flush hoses and injection equipment at the end of every injection with clear water. When hoses and chemigation equipment are not in use, cover them with a tarp or similar material.

Fittings: When injecting pesticides into an irrigation system, the material of choice is generally 316 stainless steel, as some pesticides can destroy PVC fittings. To be safe, contact the manufacturers of both the pesticide and the injection equipment to determine compatibility of the pesticide being injected with the equipment being used and the potential for corrodibility or other adverse chemical reaction.

Tanks: Avoid mild steel tanks! Construct tanks of poly or fiberglass, as mild steel can corrode. If stainless steel is used, it should be constructed of 316 stainless. There should always be an on/off valve attached to the tank itself so that the injection mechanism can be removed. An easily cleaned 40 to 80 mesh filter should be attached downstream of the on/off valve.

Containment Structures: If a pesticide could potentially be hazardous in the event of a spill, it is recommended the chemical tank be located within a containment structure. A containment structure may simply be a larger poly tank that essentially acts as a "double-hulled" unit (a chemical tank inside the poly tank), a containment unit constructed of cinder block walls around a concrete pad, or at the very least, a soil wall around the chemical tank.
Neatness: Neatness counts! For safety reasons, it is important to maintain a neat chemigation area. With a neat chemigation area, spills and leaks are easy to identify, isolate and correct. Messy chemigation areas encourage lax operation that is hazardous to the operator and the environment.

Chemical Safety: Always follow label instructions for safety. It is essential that the manufacturer’s guidelines be followed when mixing fertilizers and pesticides together. Many fertilizers and pesticides cannot be mixed together, or must be mixed in a certain order. If the manufacturer’s guidelines are not followed, there is a potential for dangerous reactions.

Chemical Injectors: There are many ways to inject pesticides into irrigation systems. The choice of methods and equipment used depends on the individual operator’s skills and preferences as well as initial and maintenance costs.

The following may need to be considered when choosing the way to inject pesticides:

- Differences between injecting liquids, such as flowable (F) products, suspended concentrates (SC), or emulsifiable concentrates (EC) versus injecting non-liquids, such as wettable powder (WP) or soluble powder (SP) pesticides. Liquid pesticides may not need agitation or mixing in the field, whereas non-liquid pesticides require mixing and agitation.

- Wear on the system components. Non-liquid products increase wear to nozzles and valves compared to liquid materials.

- Potential hazards of the pesticide. All pesticides have special precautions to be followed, especially for worker safety.

- Availability of power.

- Portability versus permanent installations.

Injector types: There are many injectors on the market. Some require power and others do not. Below are examples of different types of injectors that are available. Some injectors are specific to an irrigation method, such as drip, open ditch, center pivot, wheel lines and solid sets.

- In-line pressure differential
- Venturi bypass systems
- Bypass pumps
- Float valves (open canal or ditch)
- Differential pressure tanks
• Nitrogen gas powered pumps
• Nitrogen pressurized tanks
• Water powered pumps
• Diaphragm and piston pumps

Diaphragm pumps have been used in the chemical industry for many years, but have only been actively marketed for chemigation during the last few years. The advantages of using diaphragm pumps over piston and venturi units are:

- They have a small number of moving parts.
- A limited area of the unit is exposed to the pesticide being injected.
- The design of the pump makes it easy to adjust the injection rate while the pump is running.

Piston pumps were the earliest available and actively marketed injection pumps for agricultural chemicals. Both single and dual piston units are available in a wide range of capacities. These types of pumps commonly have two distinct disadvantages for when used for chemigation:

- Piston pumps are subject to accelerated wear of the piston seals.
- Calibration of piston pumps is relatively time-consuming.

Conclusion

Chemigation is the application of any chemical through irrigation water. This includes insecticides, herbicides, fumigants, nematicides, fertilizers, soil amendments and other compounds. Read, understand and follow all label directions. Make sure the pesticide you choose is labeled for chemigation use.
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