Unit 5. Backflow Prevention

Learning Objectives

After studying this unit, you will be able to:

• Define backflow, backsiphonage, and backpressure.
• Understand why backflow prevention is important and required by law.
• Name and describe the various types of antipollution (safety) devices.
• Identify which safety devices are required on chemigation systems.

Injecting a pesticide into an irrigation system can pollute the water source if safeguards are not in place. To prevent water pollution, federal and state laws require all chemigators to install backflow prevention equipment on their irrigation systems. In this unit, you will learn about backflow and how it can threaten public and private water supplies. The unit will list the basic types of safety equipment required by the federal Label Improvement Program (LIP), also known as Pesticide Registration (PR) Notice 87-1. You will also learn about alternatives to the standard backflow prevention devices such as a two-pump system with an air gap. This unit will discuss the various backflow prevention devices, how they work, and where they are located. These devices play a crucial role in safe and effective chemigation.
Terms to Know

Atmospheric Port—Located on a reduced pressure-principle backflow preventer, it prevents leaked pesticide and water from backflowing by ejecting the fluid into the atmosphere.

Automatic Low-Pressure Drain—This device intercepts leakage past the mainline check valve and discharges the leakage from the main line. It is always located upstream of the point of pesticide injection.

Backflow—The movement of a liquid in reverse of the normal direction of flow in a piping system. In chemigation systems, backflow can also occur in the injection line, causing the pesticide supply tank to overflow.

Backpressure—The higher pressure from a pump or elevated tank, compared to the pressure in the water supply piping system to which the pump or tank is connected. Backpressure could cause backflow.

Backsiphonage—The type of backflow caused by the reduction of pressure (vacuum or partial vacuum) in the piping system.

Check Valve—A device that provides quickacting, positive (absolute) closure. It prevents the backflow of water when the irrigation or injection system fails, resulting in the loss of system pressure.

Cross Connection—A connection, either direct or indirect, between a potable water supply and a system or device that could contain nonpotable water.

Interlock—The electronic or hydraulic interconnection of irrigation pumps and pesticide injection units. If the system pressure or flow rate drops below a certain level, the injection system (or the injection and irrigation systems) will shut down.

Opening (Cracking) Pressure—The pressure required from the pesticide supply pump (or tank, if gravity pressure) to open a spring-operated injection-line check valve.

Potable Water—Water that is suitable for human use and consumption.

Reduced-Pressure Principle Backflow Preventer—A device made of two spring-loaded check valves and a high-flow atmospheric port between them. (The port is controlled by a pressure differential valve.) It is required for all municipal (public) water supply hookups.

Vacuum Relief Valve—A device that automatically breaks the vacuum in an irrigation pipeline or injection line. This valve helps prevent backsiphonage.

Venturi—An injector device that operates on a pressure differential between the inlet and outlet of the injector. It creates a vacuum, which results in suction or a “venturi” effect.
Backflow

“Backflow” is the flow of a liquid through a hose or pipe in reverse from its normal direction. Backflow can occur in the pesticide injection line, causing the pesticide supply tank to fill and overflow with water from the water supply line to which the tank is improperly connected. Backflow may result from either “backsiphonage” or “backpressure.”

Backsiphonage

“Backsiphonage” is the type of backflow caused by the reduction of pressure (vacuum or partial vacuum) in the piping system.

Some common causes are:

• high liquid velocity in pipelines,
• a line break or repair that is lower than a service point,
• lowered main pressure due to a high rate of water withdrawal (ex. fire fighting), and
• reduced supply pressure on the suction side of the booster pump.

The main characteristic of backsiphonage is a vacuum within a supply line. This vacuum creates a siphoning effect. Backsiphonage can also occur if a lot of water is withdrawn at once. If the water is flowing through the pipeline at high speed, the pressure on the line drops. This difference in pressure can cause backsiphonage into the pipeline.

Backpressure

“Backpressure” is a cause of backflow. Backpressure can cause backflow when a supply line is connected to a high-pressure system and the system’s pressure exceeds the pressure of the supply line.

Example: When a pesticide injection pump fails, pressure drops in the pesticide injection line and, as a result, water from the irrigation mainline abnormally flows “upstream” through the pesticide injection line and possibly, even further into the pesticide supply tank.

Some common causes of backpressure are:

• booster pumps,
• connections to boilers,
• cross connections with another system running at a higher pressure, and
• elevated piping.

Backpressure is most likely when the irrigation water distribution system is subjected to a pressure higher than its regular operating pressure. A booster pump, for example, might generate enough pressure to force water back to source of the irrigation water.

Cross Connection

A “cross connection” is any physical connection between a public water system and a source of nonpotable liquid, solid, or gas. A connection that has the potential to cause backflow is also a cross connection.

Cross connections include:

• hose-end sprayers (hydraulic aspirator connections)
• submerged hoses
• removable sections
• changeover or swivel devices

Refer to the Manual of Cross-Connection Control, 9th edition (Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, December 1993, p. 10) for more information on the above terms.

Source Water and the Law

Since 1964, pesticide use in the United States has tripled. Between 1.1 and 2.5 billion pounds per year are applied to plants and animals. Using pesticides greatly improves the yield and quality of food and fiber. This, in turn, improves public health.
The widespread use of pesticides and other chemicals, however, makes many people worry about the quality of their land, water, food, and air. Chemigation, closely linked with water sources, is an obvious target of concern for water purity. Both groundwater and surface water can be at risk.

**Groundwater and Surface Water**

Groundwater moves below the earth’s surface between rocks, gravel, sand, and silt. Half of the U.S. population relies on groundwater for its source of drinking water. Many rural residents use groundwater as a source for drinking water and to irrigate crops. In Hawaii, about 90% of the drinking water comes from groundwater sources. This heavy dependence on groundwater makes protecting Hawaii’s groundwater especially critical. Improper use of pesticides can pollute not only groundwater but also lakes, streams, and ponds. If pesticides leach through the soil, pass the effective rooting zone of the crop, or run off the target site, they can taint the groundwater supply.

As discussed in Unit 3 (Safety Considerations) and Unit 4 (Application Systems and Equipment), wise management can limit environmental dangers from chemigation. Always:

- follow label directions,
- mix and calibrate accurately,
- prevent spills and backflow,
- dispose of waste properly, and
- follow integrated pest management (IPM) techniques.

Under federal law, pesticide labels must state which safety equipment is required for chemigation of the product. Chemigation systems that draw from a domestic or municipal water supply must have a reduced pressure-principle backflow preventer or an air gap system between the domestic or municipal water supply and the chemical injection point. Chemigation systems that use surface water must include a check valve. We will discuss this equipment in more detail below.

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**Label Improvement Program (PR Notice 87-1)**

As you learned in Unit I (Introduction), the federal Label Improvement Program (LIP) requires that all pesticides registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) include label instructions about chemigation. The label must either forbid chemigation or allow it. In addition, if chemigation is approved, the label must list the safety devices required for the irrigation system. On the irrigation pipeline, these include:

- a check valve,
- a vacuum relief valve, and
- an automatic low-pressure drain.

On the injection line, there must be:

- an automatic, quick-closing check valve and
- a normally closed solenoid valve.

*NOTE. An injection-line check valve (with 10 psi opening or crack3ing pressure) is often substi-tuted for these two devices.*

The system must also contain:

- interlocking, automatic shutoff controls;
- a pressure switch; and
- a metering-type injection pump or device. This type of pump allows the operator to meter, or measure, the pesticide flow to the irrigation line.

The LIP requires this equipment in order to prevent backflow into the water source. However, these requirements help chemigators in other ways. For example, they may encourage users to inject chemicals consistently and precisely. This, in turn, reduces the amount—and cost—of chemicals applied. See Unit 1 (Introduction) for more information about state and federal laws to protect source water.
Schematic of a pesticide injection system with the eight required items*

(A) Mainline Single Check Valve  (E) Interlocking System Controls
(B) Low Pressure Drain  (F) Solenoid Operated Valve
(C) Air/Vacuum Relief Valve  (G) Pesticide Injection Pump
(D) Pressure Switch  (H) Injection Line Check Valve

* Figure 5, in "Core Training Manual For Backflow Prevention In Chemigation of Pesticides" (revised 3/17/03). David F. Zoldoske, Director, Tim Jacobson, Education Specialist, and Edward M. Norum, Agricultural Engineer (The Center for Irrigation Technology, California Agricultural Technology Institute, California State University, Fresno), for California Environmental Protection Agency, Department of Pesticide Regulation, Environmental Monitoring Branch. <http://www.cdpr.ca.gov/docs/gwp/chem/grower_manual.pdf>
**Backflow Prevention Systems**

If your chemigation system is connected to a domestic or municipal water supply, you must use either a:

- two-pump system with an air gap or
- an approved reduced pressure-principle backflow preventer.

Install effective safety devices between the irrigation pump discharge and the point of pesticide injection (unless you are using a two-pump system with an air gap). You should also put safety devices between the pesticide supply tank or container and the point of pesticide injection (except for venturi meters). Venturi systems use positive pressure to apply pesticide. They also have different backflow prevention requirements. These devices are discussed in detail below.

**Who Is Affected?**

Anyone who chemigates—ex. farmers, greenhouse growers, nursery operators, and golf course caretakers—must comply with state and federal chemigation safety laws. This includes operators of all types of irrigation systems.

There are two exceptions:

- When an air gap exists.
- When the fill tube or spout does not contact or fall below the water level of the application equipment.

**Backflow Safety Equipment**

The following devices are either required or recommended for chemigation systems.

Refer to the pesticide label to find out which safety equipment is required for chemigation of the product.

**Reduced Pressure-Principle Backflow Preventer**

The reduced pressure-principle backflow preventer is located upstream of the point of injection. It is also called a reduced-pressure backflow assembly (RPBA) or a reduced pressure zone valve (RPZ). This device consists of two spring-loaded check valves. They have an atmospheric port between them. Whenever pressure drops at one of the valves, the port opens and water drains out. In this way, the check valves prevent backflow, and the atmospheric port prevents backsiphonage. The reduced pressure principle backflow preventer is required if your irrigation system is connected to a domestic or municipal water supply.

**Irrigation Mainline Check Valve**

The irrigation mainline check valve is located between the irrigation pump discharge and the point of injection into the irrigation pipeline. It is required on all chemigation systems, with two exceptions:

- if you use the reduced pressure-principle backflow preventer, or
- if you use a two-pump system with an air gap.

The mainline check valve works closely with the vacuum relief valve and the automatic low-pressure drain.

The irrigation mainline check valve has a crucial role to play. Along with the vacuum relief valve and the low-pressure drain, it is the heart of the antipollution system. It keeps the pesticide mixture from draining or siphoning back into the water supply. These valves must be spring loaded and have a watertight seal. They should also be easy to inspect, maintain, and repair. Make sure your check valves have fittings so you can remove them easily. Inspect the mainline check valve before each chemigation.

**Vacuum Relief Valve**

The vacuum relief valve allows air into the irrigation pipeline when its pressure drops below atmospheric pressure. This prevents formation of a vacuum that could cause backsiphonage. It also
helps prevent collapse of the irrigation line. Like the irrigation mainline check valve, it, too, is required on all chemigation systems, with two exceptions:

- if you use the reduced pressure-principle backflow preventer, or
- if you use a two-pump system with an air gap.

The vacuum relief valve is located on top of the horizontal irrigation pipeline. It is usually on the chemigation valve on the upstream side of the “flapper.” It should lie between the waterline check valve and the water supply. Check the valve from time to time to make sure it is working properly and that no debris has entered the valve.

The opening to the vacuum relief valve should be at least 3/16 the diameter of the irrigation pipe minimum. The American Society of Agricultural Engineers (ASAE) recommends that the vacuum relief valve be at least 3/4 inch in diameter. You could mount the valve on the inspection port as long as it does not prevent inspection of other safety devices.

**Automatic Low-Pressure Drain**

The automatic low-pressure drain is a self-activating device that helps prevent backflow of pesticide/water mixture into the water source. It must be placed on the bottom side and lowest point of the irrigation pipeline between the irrigation pump and the mainline check valve and upstream of the point of pesticide injection.

The drain opens automatically when pressure drops in the irrigation main line. This means that the pesticide–water mixture in the irrigation line cannot drain into the water supply. Instead, the pesticide and water flows away from the irrigation line between the flapper or check valve and the irrigation pump or water source. Use a hose or pipe to discharge the drainage at least 20 feet away from the water source. Do not allow water from the hose or pipe to flow toward the source.

The low-pressure drain should have an opening at least 3/4 inch in diameter. It should be level and not extend beyond the inside surface of the bottom of the irrigation pipe. The outside opening of the drain must be at least 2 inches above the grade. Often, the mainline check valve, the vacuum relief valve, and the low-pressure drain are sold as a package. Together, they comprise the chemigation valve. Inspection and injection ports may also be included as part of the chemigation valve.

**Injection-Line Check Valve**

The check valve on the pesticide injection line has two main purposes. First, it prevents the pesticide supply tank from overflowing due to backpressure. It is necessary on all chemigation systems. The check valve keeps the irrigation water from flowing back through the injection line into the pesticide supply tank. If this valve were not in place and the injection pump shuts down, the pesticide supply tank could overflow.

Second, the valve will prevent gravity flow from the pesticide supply tank into the irrigation pipeline if the pump shuts down. The injection-line check valve should be spring loaded with a minimum opening (cracking) pressure of 10 psi. The check valve should be as close as possible to the point of pesticide injection. It should also be made of chemical-resistant materials. Inspect this valve for damage or other problems before each chemigation.

**Simultaneous Interlock**

The simultaneous interlock is also called the functional systems interlock. It ensures that the chemical injection pump will stop whenever the irrigation pump does. Such pump failure is generally the result of loss of pressure in the irrigation main line. This interlock is required on all chemigation systems. It prevents pesticide from flowing into the irrigation pipeline if the irrigation water stops flowing.

**Engine-Driven Pump**

If you have a system with an enginedriven irrigation pump, belt the injection pump to the drive shaft or to an accessory pulley of the engine. You could also run the injection equipment from the engine’s electrical system. Once you do this, you
have interlocked the irrigation and injection systems. When the engine stops, the injection pump also stops.

**Electric Motor-Driven Pump**

The interlock works differently for irrigation pumps driven by electric motors. Generally, you need a separate, small electric motor to drive the injection pump. The electrical controls for both motors must interlock so that if the irrigation pump stops, the injection pump also stops. Make sure all wiring conforms to the National Electric Code. Some pesticides are flammable. Consult the label for details on any special precautions or safety guidelines.

**Other Interlock Systems**

The “dual interlock” system will shut off the irrigation system if the injection pump stops or malfunctions. This type of interlock can show you where the chemical application ended if the system shuts down. When the flow stops in the injection line, the irrigation system shuts down.

Another type of injection pump uses flowing water to power the pump. When the water flow stops, so does the injection pump. These water pumps are used when there is no other source of power at the injection point.

**Pressure Switch**

The irrigation pipeline or water pump must include a pressure switch. For automated control, the pressure switch should be electrically interlocked with the control panel on the irrigation system. This switch will stop the irrigation system and the injection pump if pressure drops in the injection discharge line.

**Normally Closed Solenoid Valve**

The normally closed solenoid valve is required for pesticide injection. (See Appendix D for EPA-approved alternatives to this valve.) It is also called the flow interrupter. It can be electrically interlocked with the engine or motor driving the injection pump. Or, it can be hydraulically controlled from the irrigation main line. It is located on the inlet side of the pump. This valve shuts off all pesticide from the injection line.

Make sure the solenoid valve is compatible with the product you plan to use. It will contact the pesticide concentrate and must be resistant to these chemicals. Inspect the valve often to make sure it is working properly.

**Flow Sensor**

The injection-line flow sensor shuts down the injection pump if there is no flow in the injection line. The sensor will also shut down the pump if the flow falls below a preset level. Place the sensor just upstream from the injection-line check valve. The flow sensor should interlock with the injection pump so that the system will shut down if

- a hose plugs up or breaks,
- the pump stops, or
- the pesticide supply tank is empty.

**Freshwater Faucet**

A freshwater faucet is not a safety device. However, it is a convenient source of water for cleanup and for rinsing empty pesticide containers. Install the faucet well upstream from the chemical injection point. If possible, the faucet should also be upstream of the irrigation mainline check valve. In this way, you can prevent backflow into the faucet. Never use the faucet as a port for injecting any pesticide. Label it as nonpotable water so that it is clearly not a source of drinking water.

**Injection-Line Strainer**

You may need a strainer to prevent clogging of the injection pump, check valve, or other equipment. Place it between the pesticide supply tank and the injection pump. The mesh size will depend on which pesticide you use. A manual valve on the pesticide supply tank outlet to shut off flow is useful. Strainers are required on all chemigation systems used to inject fertilizers.
Water Supply Filter

You also need a filter in the waterline, upstream from the injection point, to collect sediment and other debris that may come from the water source. This is especially true if you use water from a pond or open storage tank.

Injection Hoses, Clamps, and Fittings

Inspect all hoses, clamps, and fittings before each chemigation. Replace any that are defective or damaged. Make sure that any components that contact pesticides concentrated or dilute—are made of noncorrosive materials.

Inspection Port

The inspection port should lie between the irrigation pump and the mainline check valve. It should be at least 4 inches in diameter. The port allows you to inspect the check valve for leaks and soundness before each chemigation. You may also be able to inspect the low-pressure drain. Often, you can use the vacuum relief valve connection as the inspection port. If you remove the vacuum relief valve, you can put your hand into the opening to manipulate the valve. This allows you to check whether the closure on the irrigation mainline check valve is working properly.

Injection Port

The injection port is where the pesticide enters the irrigation pipeline. It must be downstream from the water outtake and the mainline check valve. The injection port is where the injection-line check valve attaches to the irrigation waterline or chemigation valve.

Alternative Safety Designs

The equipment described above is either required or recommended for most chemigation systems. The pesticide label will tell you which safety devices are required for chemigation of the product. However, other methods to prevent water pollution are acceptable to the Environmental Protection Agency (EPA). These include the following:

- Two-pump system with an air gap.
- Separate pipelines for chemicals and water.
- Injection point higher than the pesticide supply tank.

See Appendix B for a list of alternative chemigation safety equipment.

Two-Pump System with an Air Gap

One way to prevent water pollution is to use a two-pump system with an air gap between the discharge of one pump and the intake of the other. One pump discharges water into a reservoir, and the other pump draws water from it. Make sure that the air gap between the end of the fill pipe and the top rim of the reservoir tank is at least twice the inside diameter of the fill pipe. The air gap should not be less than 1 inch. Since you inject the chemicals after the second pump, the chemicals and the water source are not directly connected. The physical water break eliminates backflow if it is installed correctly.

The air gap system has its drawbacks. It is not always practical and may require extensive modification. You may need to resize pumps, power units, and reservoirs for it to work. It may also expose water to dust, debris, and other contaminants. The air gap may not be as effective if it is near an obstruction. Obstructions can hamper the flow of air into the outlet pipe. This, in turn, increases the chance of backsiphonage.

Separate Pipelines for Chemicals and Water

Another way to prevent a crossover between chemicals and the water source is to use a separate pipeline on a center pivot for the chemical. To do this, you will need to add two items to your center pivot system:

- a second (smaller diameter) pipeline, and
- a spray nozzle system.
Having two pipelines means you cannot mix the chemical with the water supply. However, as with the air gap system, it requires many changes to your existing system. In addition, the separate-pipeline system tends to give poor results in application uniformity.

Injection Point Higher Than the Pesticide Supply Tank

One of the ways that chemicals can end up in the irrigation system—and the water source—is through gravity flow. You can solve this problem by locating the injection point (port) higher than the pesticide supply tank. The chemicals will then flow down, away from the water source, even if the system shuts down. If the pesticide supply tank is below the injection point, you must add 1 psi per 1-foot rise in elevation to the 10 pound (psi) cracking pressure of the injection-line check valve.