LANDSCAPE TRAINING MANUAL FOR IRRIGATION TECHNICIANS

The essential how-to resource for landscape irrigation written by experienced industry professionals!

“Being a properly trained technician increases your chances of getting and retaining a job. Today’s employers can’t afford mistakes made by their employees. Training helps reduce those mistakes and makes you a more valuable asset. This study manual is a great tool to enhance your skills in the landscape industry, and helps prepare you for the Landscape Industry Certified Technician-Exterior exam.”

Clifford D. Ruth, Landscape Industry Certified Manager & Technician
North Carolina Cooperative Extension Service-Henderson County
Hendersonville, North Carolina

“In our company, good training and certification have always been top priorities. The training manuals are an important back-up to the hands-on training that we do to prepare our employees for their jobs and for certification testing.”

Jesus “Chuy” Medrano, Landscape Industry Certified Technician
President, Cocal Landscape Services, Denver CO

“To be successful in any certification exam, the candidate needs to be prepared. This training manual really provides relevant information that will benefit even the most experienced technician. It’s a great tool to help people at all levels become more prepared for the certification program and to be a true landscape professional.”

David Iribarne, Landscape Industry Certified Technician
City of Petaluma, Petaluma, California
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Irrigation System Components & Maintenance

What You Will Learn

After reading this chapter, you will be able to:

- Define point of connection and state why a backflow preventer is placed there.
- List the two causes of backflow and four types of backflow preventers.
- Describe two basic types of controllers.
- Describe the function and capabilities of a central control system.
- Describe the purpose of environmental sensors and how they work.
- Define mainlines and laterals.
- Describe the purpose of remote control valves, shut-off valves and quick couplers.
- Describe two common methods for wiring.
- Describe the difference between spray heads and rotors.
- List at least three irrigation components specifically used with low-volume systems.
- State three different materials from which irrigation pipes are made and the differences in how each is installed.
- Describe how to repair damaged pipes.
- Describe how to solder copper pipe and fittings.
- Describe four common problems that field diagnostics can help identify.
- State why winterizing is important and how to do it.
Overview

A well-designed and maintained irrigation system is supposed to be a supplement to rainfall, not a substitute. Ideally, the system ensures the optimum amount of water for turf and landscaped bed areas so they will grow and thrive. Irrigation needs are dependent on various factors, including soil type, plant moisture requirements and climate. This chapter provides a description of the major components of an irrigation system, as well as general maintenance and troubleshooting procedures.

Most irrigation systems using city water systems are similar in their basic design. (Note: This chapter does not cover pump and well systems). A typical irrigation system works as follows:

- A water supply is connected to an irrigation supply pipe called a mainline.
- The water supply has a backflow preventer so water cannot flow backward and contaminate the supply.
- The mainline distributes water through remote control valves to a network of smaller pipes called laterals or lateral lines.
- Laterals bring water to individual sprinkler heads or other water-emitting devices.

Ordinarily, there is not enough water available to supply and operate the entire irrigation system at the same time. Therefore, the system is divided into different sections, called zones or stations. The zones operate one at a time according to a preset schedule entered into a programmable timer called a controller. Valves may also be operated manually using the controller or the valve itself.

More detailed information is presented in the sections that follow.

Point of Connection and Backflow

Before describing the major hardware components of an irrigation system, it is helpful to understand the importance of avoiding contamination of water sources by preventing backflow.

Point of connection

The point of connection (POC) is the location where an irrigation system taps into an existing water supply. This can be located in different places, including the house gate valve (may be a ball valve), on an underground water line near a sidewalk, house or building; in a basement, crawl space or any other convenient location. A backflow preventer (see next section) is installed near the point of connection to protect the water supply from contamination.

The point at which a non-potable water source connects to a potable water supply is referred to as a cross-connection. This occurs at the point of connection for an irrigation system.

Backflow prevention

The unwanted reversal of the flow of water through a cross-connection is called backflow. Backflow prevention devices are mandatory on all irrigation systems connected to municipal water supplies, to prevent backflow from occurring. Water in an irrigation system is subject to contamination from pesticides, fertilizers, manures, etc. This means that the potable water supply from which the irrigation system draws its water is in danger of contamination if water from the irrigation system flows back into the source piping (usually the city piping system). The contaminated water can cause illness or even death. For this reason, backflow prevention is an important part of an irrigation system. There are specifications and legal codes that need to be followed when
installing or maintaining a backflow prevention device. Always check local codes and regulations prior to designing and installing an irrigation system.

Backflow preventers are usually installed near the point of connection. They should be installed in an accessible location to facilitate servicing, testing and inspection, and they should be protected from freezing. Backflow prevention devices are directional. Therefore, it is important to make sure the arrow points in the direction of flow when they are being installed.

Backflow preventers contain seals, springs and moving parts that are subject to wear and fatigue, so periodic testing is required by code. Backflow can occur in two different ways, as described in the following paragraphs.

Causes of backflow

Backpressure
Backpressure occurs when the pressure in the irrigation system downstream is greater than the pressure in the water supply upstream. This can be caused by a decrease in pressure in the water supply, an increase in the downstream pressure or both. A booster pump in the irrigation system can cause backpressure.

Backsiphonage
Backsiphonage is the reversal of normal flow in the system caused by negative or reduced pressure in the water system. Some possible causes include undersized piping, a line break lower than the service connection or a high water withdrawal rate from firefighting, pipe flushing, etc.

Backflow prevention devices are discussed in more detail in the next section.

Major Components

An efficient irrigation system consists of a carefully matched assembly of pipes, valves, sprinklers, wires and other hardware. In the following sections, the function of each major irrigation component is described and some installation guidelines are given. Separate sections are provided for each of these major components:

- Backflow prevention devices
- Controllers
- Piping
- Valves
- Wiring systems
- Sprinkler heads and other irrigation options

Backflow Prevention Devices

Local codes may vary regarding selection and installation of backflow prevention devices. Check local regulations before installing any backflow prevention device.

Types of backflow prevention devices

There are four basic types of backflow prevention devices in common use today. Each is described below.

Pressure vacuum breaker (PVB)
PVBs have a spring-loaded check valve and a spring-loaded air inlet valve. They are designed to prevent backflow from backsiphonage only and are not effective against backflow due to backpressure.

Install backflow prevention devices near the point of connection and where they are accessible for inspection and servicing.

Shutoff valves are located at each end of the assembly and the units are equipped with test cocks. PVBs must
be installed at least 12” (30 cm) above the highest outlet in the system.

**Atmospheric vacuum breaker (AVB)**

AVBs have a float check, a check seat and an air inlet valve. The air inlet valve opens if there is a loss of pressure in the supply pipe. This allows air (atmosphere) into the outlet piping, preventing backflow. AVBs should not be under constant pressure for more than 12 consecutive hours. Like PVBs, AVBs are designed only to prevent backflow caused by backspionage.

**Reduced pressure assembly (RPA)**

RPAs have two spring-loaded check valves with a pressure differential relief valve between them. They maintain a pressure differential of not less than 2 PSI between the supply (upstream) side and outlet (downstream) side. If pressure builds up on the outlet side, the relief valve discharges water to relieve pressure. Shutoff valves are located at each end of the assembly and the units are equipped with test cocks. RPAs are effective against both backpressure and backspionage and are approved to protect water systems from substances hazardous to health. They should be installed 12” (30 cm) above the grade, but do not have to be higher than sprinklers or other outlets.

**Double-check valve assembly (DCA)**

DCAs have two spring-loaded check valves. Shutoff valves are located at each end of the assembly and the units are equipped with test cocks. These backflow preventers are effective against both backpressure and backspionage. However, they are not approved to protect water systems from substances considered health hazards. Again, check local regulations.

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**Anatomy of a Sprinkler System**

![Diagram of a Sprinkler System]

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*Image courtesy of Hunter Industries*
Irrigation controllers are used to schedule when an irrigation system waters by automatically opening and closing remote control valves according to a programmed schedule. Controllers are connected to valves by wire. The two basic types of controllers in common use are electro-mechanical and electronic.

**Controllers and types**

**Electro-mechanical controllers**

Electro-mechanical controllers have been in use for many years. They are driven by motors and gears and are considered dependable, but they have limited features and are relatively inflexible in their ability to set different watering rates for different watering zones.

**Electronic (solid state) controllers**

Electronic controllers are more complex and are controlled by microprocessors. They are also called solid state controllers. They have more sophisticated programming capabilities and allow for more flexible irrigation schedules.

**Programming controllers**

Electro-mechanical controllers are programmed using a series of dials and switches. Electronic controllers are programmed through a keypad or a dial and keypad interface. Though different controllers have different methods of programming, they all require the following information to be entered:

- Current day and time
- What days to water
- What time of day each cycle should begin
- How long each zone should operate

When a controller is programmed, be sure to modify the program as evapotranspiration (ET) rates change, that is, as weather conditions change. This could be weekly, bi-weekly or monthly. It is usually not necessary to completely reprogram the controller to make adjustments in a program. For example, as weather conditions change — and therefore ET rates change — adjust the amount of time or number of days to irrigate. The easiest way to modify the base program is to adjust run days or run times.

Many controllers have a seasonal adjusting feature that is initially set to 100 percent. For example, to reduce all station run times by half, set the water budgeting percent key to 50 percent. To double the run time of all zones, set the water budgeting percent key to 200 percent.

Most controllers also have a semi-automatic mode that allows a watering cycle to be started manually. In semi-automatic mode, after a program (for example, Program A) is activated manually, the controller will run

«Note: Most controllers have basic instructions on the inside panel of the door.»
all zones in that program sequentially, then reset to run existing programs normally. Most controllers have a manual mode, as well, that allows a selected zone to be started manually.

Multiple program controllers allow you to enter different programs for different groups of zones. For example, Program A can irrigate turf zones, Program B can irrigate low water use shrubs and Program C can irrigate trees.

When entering multiple programs, be careful not to overlap run times. If the run time of one program overlaps the start time of another program, the second program will most likely run at the end of the first program.

New weather-based and moisture sensor-based irrigation controllers (“smart” controllers) will automatically adjust run times based on current weather conditions and/or moisture levels. Consult local irrigation suppliers or distributors for more information. Also, refer to the next section, entitled “Smart controllers.”

Also see the chapter “Water Management and Auditing” for more information about irrigation scheduling.

Smart controllers
“Smart” controllers, as defined by the Irrigation Association, are controllers that automatically update the watering schedule to allow for changes in water needs throughout the year.

Smart controllers estimate or measure depletion of available plant soil moisture in order to operate an irrigation system, replenishing water as needed while minimizing excess water use. Smart controllers use sensors and weather information to manage and adjust watering schedules. There are several methods by which smart controllers receive information needed to modify watering times. For example, information can be weather-based (using an on-site weather station or using nearby weather stations), based on soil moisture monitored in the root zone, or tied to historical weather data. A properly programmed smart controller requires initial site-specific set-up that includes information such as soil type, plant type and slope. Then it will make irrigation schedule adjustments to run times and required cycles, based on changes in weather, soil moisture or other changing data, throughout the irrigation season without human intervention.

Environmental sensors
Environmental sensors are devices that interface with controllers, shutting down an irrigation system when water is not needed. Different sensors are available that can monitor rainfall, soil moisture, humidity, air flow (wind) and temperature. Sensors can be integrated into a complete irrigation management system using smart controllers.

Rain sensors are the most common type of sensors. These sensors have a collection device that gathers rainwater. When enough rainwater is collected, it disables the controller so the system can’t operate. Some rain sensors are adjustable so that light showers
will not shut down the system. When rainwater evaporates, the controller again operates as programmed.

Central control systems
Central control systems are sophisticated computer-based systems that operate controllers, sensors and other parts of irrigation systems from a central location. These high-tech systems provide an extremely efficient means of controlling large or complex irrigation installations.

A central control system has a central computer that can be placed in a remote location. This computer communicates (using various methods, such as hard wiring, radio, phone lines or the Internet) with an on-site control device that monitors and controls the various components of the irrigation system.

Central control systems can be programmed off site.

Actions that affect an entire system, such as adjusting watering times for different seasons, can be programmed from a central control system. Some systems can interface with sensors that monitor wind, weather, rain and soil moisture. If environmental conditions exceed pre-defined limits, the central control system responds by adjusting watering schedules.

Piping

Mainlines
The mainline is a pipe that carries water from the backflow prevention device to the remote control valves. Typically, piping used for mainlines is made of polyvinyl chloride (PVC) or a semi-rigid plastic, although copper or galvanized steel pipe also has been used in the past. If reclaimed, non-potable water is supplying the system, purple PVC mainline and valve boxes are required. Poly (polyethylene) pipe is acceptable in certain regions with little or no ground freeze, or in residential installations.

The mainline is under constant pressure when the system is charged and is usually the largest pipe in an irrigation system.

Laterals
Lateral lines are the pipes that supply water to sprinklers or emitters. Lateral are under pressure only when an irrigation valve is activated. They are located downstream from remote control valves. PVC or poly pipes are generally used for laterals. Lateral are placed in a trench dug by hand or with a trencher, backhoe/excavator, or installed with a pipe puller. When using a pipe puller, tape or plug the end of the pipe and insert fully into the gripper. When entering or exiting the ground, the pipe should be at a slight angle to avoid excess stress on the pipe. For more information on trencher and pipe puller operation and safety, refer to the chapter, “Landscape Equipment Safety and Maintenance.”
After digging or trenching, clean and level the trench, install the pipe heads and then backfill and compact soil by puddling (applying water to the top of the backfill), jetting (injecting water below the surface of backfill) or tamping (compacting soil with some type of compaction device). This may have to be done in several lifts (layers), depending on the depth of excavation.
Valves

Valves are devices that regulate the flow of water in an irrigation system. There are many types of valves, including main valves, master valves, flow valves, isolation valves and drain valves. Some valves are operated manually, while others are electronically controlled. Most valves are directional, so when installing a valve, make sure the arrow points in the direction of flow. Valves are usually installed in a buried valve box—a plastic box with a green lid (or purple lid for non-potable water)—providing easy access for maintenance or repair. Several valves often share the same valve box. The most commonly used valves are described below.

Water then enters the lateral lines, which are the pipes that supply water to sprinklers or emitters.

Remote control valves are available with or without flow control. Valves with flow control have a stem on the top that allows water flow to be adjusted manually.

Shut-off valves
Shut-off valves are manually operated valves and can be gate valves, ball valves, disk valves or butterfly valves. When installed near the water source, they can shut off an entire system in case work is needed on the mainline or control valves, or in case of emergencies. They are not intended for frequent use. Gate valves should not be left in the fully open position or damage to the seals can occur.

Quick couplers
Quick couplers on the mainline allow water from an irrigation system to be instantly available for a variety of uses. They are valves connected directly to the pressurized mainline, allowing immediate access for the attachment of a hose or a sprinkler, even while the system is operating. Some have a notched key or lug arrangement and some have threaded keys and valve bodies.
Wiring Systems

Two basic forms of wiring are used with irrigation systems. The first is a multi-strand or multi-wire system and the second is a two-wire decoder system. Note: Regardless of the type of wiring system used, be sure that the controller is unplugged from the power source before beginning any wiring tasks.

Multi-strand system
The multi-wire system consists of one common wire, usually white, and any number of other zone wires, each dedicated to an individual valve. Each individual zone wire in the multi-wire system is then connected to a singular terminal at the controller. Wire is installed along the mainline for easy access and to minimize damage. Wire for irrigation must be jacketed with an approved direct burial coating. Wire should be snaked under piping. This provides extra wire to prevent stretching or breaking as the ground expands and contracts due to moisture and temperature changes. It is also a common practice to include one or two extra wires for maintenance or expansion of the system.

All wire connections and splices should be made with watertight connectors and housed within a valve box. When splicing wire, always use wire that matches the gauge and color of existing wire.

Two-wire decoder system
The two-wire decoder system is popular in the industry world wide. This system consists of two wires that are run continually from the controller to the end of the system and are connected to a decoder at each valve. Each decoder is assigned an individual address that is recognized by the controller. The same two wires connect the controller, decoders and components from three to more than 50 zones. The system can be compared to a telephone system in that each decoder is assigned a number and the controller can send an electronic signal to individual valves or to multiple valves depending on the information provided by the programmer. The system is more versatile than the multi-wire system because the wires can be stubbed off at the end of the irrigation system for future expansion. In addition to ease of expansion, the two-wire decoder system is easier and less costly both to install and maintain.
Sprinkler Heads and Other Irrigation Options

Sprinkler heads emit a spray of water on turf areas and planting beds. They attach to laterals using either a rigid PVC riser or swing pipe as specified by state or provincial code. Sprinkler heads are available in many varieties to match different site conditions, available water pressure, etc. The two main types of sprinkler heads that are described in this section are spray heads and rotors. (Refer to the detailed drawings that show proper sprinkler head installation).

These two different types of sprinkler heads should not be installed on the same lateral unless MPR (matched precipitation rate) nozzles are utilized on the entire zone. It is best to design systems where different types of sprinklers are on separate lateral zones.

Low-volume systems and components and other irrigation options are also discussed in this section.

Spray heads
Spray heads discharge a continuous spray of water at distances typically ranging from 5 – 15’ (1.5 – 5 m). The two main types of spray heads are risers and pop-ups.

Note: If an irrigation system is supplied with non-potable water, the caps on the heads must be purple. This color is a standard indicator of non-potable water.

Risers are fixed heads mounted on pipes projecting out of the ground. Since they are permanently installed above the height of surrounding plants, they are best suited for planting beds or other areas where they will not appear unsightly, create a hazard or be subject to damage.

Pop-up spray heads are installed below the turf line or at grade. When the water is turned on, they pop up and spray. When the water is turned off, they retract. They are available in different spray patterns, including full-circle, half-circle, quarter-circle, fully adjustable and in special patterns for long, narrow strips. Pop-ups are commonly used in lawns and planting beds. Refer to the diagrams showing the details.
**Rotating multi-stream nozzles**

Multi-stream nozzles can be retrofitted to any existing pop-up spray nozzles providing improved coverage and using much less water. These nozzles can be used to improve or revitalize older irrigation systems without requiring new valves or lateral lines, which is a great economical advantage as well.

**Rotors**

Two basic types of rotors are impact rotors and gear-driven rotors. Rotors rotate in a full or partial circle. They have a larger spraying radius than risers or pop-ups and are best suited for large turf areas. Rotors tend to be more costly than spray heads, but fewer heads are needed to cover a given area. Rotors are available in pop-up models and in fixed versions for mounting on risers.

**Impact rotors** have a spring-loaded arm that swings sideways when contacted by water sprayed through the nozzle. When the arm swings, it impacts the sprinkler body, causing it to rotate a small amount. Each time it rotates, a new section of lawn receives water. Impact sprinklers can be adjusted to rotate in a full or partial...
Drip valve assembly
Each zone has a drip valve assembly usually, but not always, contained within a valve box. Each assembly is made of the following components:

- Remote control valve
- Filter — Low-volume systems include emitters with small openings that can easily become clogged. To prevent clogging, filters are usually installed.
- Pressure regulator — Most low-volume irrigation systems are designed to operate at pressures below that of the typical water supply. To keep water pressure within the design limits of the system, a pressure regulator is installed.

Drip tubing and piping
Drip tubing and piping is thin-walled poly tubing that supplies water to emitters or microsprays (see below). Diameters range from 1/8 – 1" (3 – 25 mm).

Low-volume systems and components
Low-volume irrigation systems for beds and plantings in native areas require additional equipment compared to sprinkler head irrigation systems and are discussed in more detail in the “Irrigation Concepts” chapter. The additional components for low-volume systems are described below.
Emitters

Emitters are devices that drip water at a slow rate. Output for drip emitters is measured in gallons per hour (gph), with discharge rates generally ranging from ½ – 2 gph (a 1 gph emitter discharges 3.75 litres/hour).

Emitters are typically installed in a location that delivers water to the base of plants. On sloping terrain, they should be placed on the uphill side of the area to be watered.

Emitters are purchased separately and installed along drip tubing wherever water is needed. As plants grow, emitters should be added and extended out with root growth. Pressure-compensating emitters are available for use where water pressure is reduced on long runs or on sloping terrain.

In-line emitter tubing and laser soakér line

In-line emitter tubing has individual drip emitters incorporated into the drip tubing. Emitters are spaced at different intervals (typically 6" or 12" intervals or 15 cm – 30 cm). The tubing comes in ¼", ⅜" or ½" diameter. Rather than supplying water to individual plants, this tubing supplies more uniform water to a larger area for smaller plants, such as annuals and perennials. See also the “Subsurface low-volume systems” section below.

Laser soakér line is drip tubing with regularly spaced laser-drilled holes that emit water. In-line and laser line can be laid on the surface or buried in the ground or under mulch, and is designed to operate at pressures up to a range of 20 – 40 psi.

Many low-volume system components are directional. When installing components make sure the arrow points in the direction of flow.

Microsprays

Microsprays have characteristics of ordinary spray heads but operate at lower pressure, have lower discharge rates and a smaller spray radius. Microsprays are more efficient than surface spray irrigation and less efficient than drip irrigation.

Bubblers

Bubblers are similar to drip emitters, but with a higher discharge rate. Their output can be adjusted from 2 – 6 gallons per minute (gpm) or 7.5 – 22.5 litres per minute. Since this exceeds the soil infiltration rate, they are used to flood small areas. After the bubbler is shut off, water infiltrates the soil. They should only be used in locations where standing water is contained and the surface is flat.

Soaker hoses

Soaker hoses are porous hoses that continuously sweat water. Soaker hoses can be cut to desired length and plugged with an end cap. They operate best on flat sites and work well in raised planters or flower pots.
Rain barrels and cisterns
In some regions, rain barrels and cisterns are becoming more popular for capturing rainwater for landscape needs. Rainwater “harvesting” is best done in regions that have frequent rain. Rain barrels are usually about 60 gallons (227 litres), whereas cisterns can have a capacity of 1000 or up to 100,000 gallons or more (3785 – 378,500 litres).

There are several benefits to capturing or harvesting rainwater, including reducing stormwater runoff and its potential for polluting waterways, reducing the demand on municipal water and providing a more natural source of water (no fluoride or chlorine). In addition, they are easy to install. Rain barrel water should be used within a week or two to discourage the growth of algae. Some cisterns may incorporate water filtration and treatment systems.

Note: In some areas, rainwater collection is illegal or otherwise regulated. Check local regulations.

Subsurface low-volume systems
Subsurface drip irrigation (SDI) systems are low-pressure, low-volume irrigation systems that use buried drip tubes. With subsurface systems, water is provided directly to the root zone. There is no evaporation, no runoff (which means reduced soil erosion) and water use efficiency is very high (up to 97 percent). SDIs may use from 30 percent to 70 percent less water than conventional irrigation systems. The benefits of SDI systems make them a great water conservation and management choice.

Installing Pipes and Fittings

The section “Piping” described the primary piping used in a typical irrigation system — the mainline and laterals. This section describes how to install pipes and fittings. These basic procedures also apply to repairing pipes and fittings covered in a later section.

Polyvinyl chloride (PVC) pipe
The best way to join PVC pipe and fittings is to use PVC primers and cement. A wide variety of products is available for this purpose. Note: Before using any adhesives, read and follow the manufacturer’s instructions.

Follow these steps when installing PVC pipe:

- Remove any burrs or rough edges from ends of pipe with sandpaper or with gloved hand.
- Be sure all pipe and couplings are dry.
- Clean the two surfaces to be joined and apply primer or cleaner.
• Allow primer to sit for the length of time recommended by the manufacturer, then apply the cement. Be sure the surfaces to be joined are completely covered.
• Avoid over- or under-application of cement. Excessive cement can damage pipes and couplings, while too little cement won’t produce a strong joint.
• Insert coupling into pipe.

• Join the pieces together, turning the coupling slightly to spread cement evenly. Remove any excess cement from the seam.
• Hold the pieces together to allow cement to set up. Refer to and follow the manufacturer’s recommendations.
• Repeat to attach the other pipe.
• Allow sufficient time for curing before burying or charging the line. Again, refer to the manufacturer’s recommended time.

Safety guidelines for working with primers and cement

The major hazards from working with adhesives include noxious fumes and irritation from contact with skin.

Avoid using primer and cement in an enclosed area, when possible. Watch for signs of headaches, which can indicate overexposure.

Wear appropriate eye protection.

Avoid contact with skin. Wear rubber gloves and other proper protective equipment.

If you get adhesive on your skin, remove it with a mild cleanser. Avoid using an abrasive cleanser or solvent.

Keep containers closed when not in use.

If applicators are supplied, use them to apply products.
Polyethylene (poly) pipe

Follow these steps when installing poly pipe:
1. Remove any burrs or rough edges from ends of pipe.
2. Position clamp(s) loosely over the ends of the two sections of pipe.
3. Insert couplings into each pipe as far as they will go.
4. Tighten the clamps to secure the couplings. If using worm drive clamps, a screw driver or nut driver can be used. If using pinch clamps, a specialized crimping tool must be used to ensure a secure connection.
5. Double clamping may be necessary when using pinch clamps with high water pressure, when using poly pipe that is greater than 1 1/4” (4 cm) diameter or at valve connections and fittings within 10 ft (3 m) of an automatic valve. When double clamping, offset the tightening points of clamps.

Copper pipe and fittings

Installing copper pipe and fittings requires soldering skills, soldering equipment and additional safety precautions.

Soldering equipment

Irrigation installation often requires copper fittings to be permanently joined by soldering or brazing. Soldering uses metals that have a melting point below 800° F (427° C). Brazing uses metals that have a melting point above 800° F (427° C). Equipment commonly used for soldering and brazing includes mapp (methylacetylene-propadiene) gas torches and acetylene B-tanks. Special safety precautions must be followed when using any soldering or brazing equipment.

Mapp gas

Mapp gas is a blend of liquefied petroleum and methylacetylene-propadiene. Mapp gas produces a hotter flame than some other gasses used for soldering and brazing. Mapp gas is available in hand-held 1-pound (0.5 kg) canisters that are easily portable and can accept a variety of torch tips.

Acetylene B-tanks

B-tanks are gas containers filled with acetylene. Like mapp gas canisters, they can be used with different torch tips. At almost two feet tall (60 cm), a B-tank is not as portable as a mapp gas canister.
How to solder

Before beginning any soldering activities, be sure to wear proper eye and hand protection and other protective clothing, and follow the safety guidelines under “Safety Guidelines for Soldering.”

Follow these steps when soldering copper pipe and fittings:

1. If this is a repair, excavate an area large enough to comfortably undertake the repair. The excavation depth should be approximately 2" (5 cm) below the bottom of the pipe, the width should be approximately four times the pipe diameter (min. 4" or 10 cm), and the length should be at least 24" or 60 cm (longer if needed).
2. Cut pipe to length using a proper tool, such as a tubing cutter or hacksaw.
3. Using an Emory cloth, sand cloth or wire brush, remove any burrs or rough edges and clean the surfaces to be joined. If soldering to make a repair, remove water from the pipe since water cools the pipe and may not allow a proper seal.
4. Apply soldering flux to the surfaces to be joined.
5. Place the fitting on the end of the pipe.
6. With a torch, apply heat to the fitting so that the flux begins to bubble.
7. Place solder on the joint. As the fitting is heated, the heat will melt the solder and draw it into the joint. Don’t heat the solder directly. Move solder around the joint until the whole joint is covered.
8. While still hot, remove excess solder with a damp rag.

Installing threaded fittings for all pipes—PVC, poly or copper

Threaded fittings are joined by applying pipe dope (thread sealant) to threads or wrapping the male threads with Teflon tape then screwing the fittings together. Tape should be applied in a clockwise direction so it does not unravel when fittings are joined. Care should be taken not to over-tighten fittings, which can damage threads or crack fittings or valves.

Common Abbreviations and Terms Used with Pipe Fittings

- **C** = Copper
- **Comp** = Compression
- **Flg** = Flanged
- **Flr** = Flared
- **Fpt** = Female pipe thread (threads are not exposed or on the inside the fitting)
- **Ins** = Insert (polyethylene pipe)
- **Mpt** = Male pipe thread (threads are exposed or on the outside of the fitting)
- **Reducer** = Reduces from one size to another
- **Rt** = Ringtite (gasketed joint pipe)
- **S** = Slip (around PVC pipe)
- **SDR** = Sewer and Drain
- **Spg** = Slip (into fitting, as in bushing, used with PVC pipe and fittings)
Safety guidelines for soldering

The major hazards from soldering and brazing are the harmful fumes produced by gas and metals, and extreme heat from open flames and hot surfaces.

Note: Before using any soldering equipment or combustible gas, read and follow the manufacturer's instructions and Material Safety Data Sheets (MSDS).

- Wear proper eye, ear and body protection.
- Keep body parts away from open flame and avoid contact with hot materials.
- Use only in a well-ventilated area. Metals and gas can produce harmful or deadly fumes.
- Keep your head away from fumes.
- Properly dispose of used containers. Note: It is illegal to have some types of gas containers refilled. Know the regulations for the type of gas container you are using.
- Store all combustible gases in a cool, well-ventilated area out of direct sunlight and away from any source of heat, sparks or flame. Use a restraining device to hold tanks in place and prevent them from falling over.

Irrigation System Repair and Maintenance

Nearly all irrigation systems require periodic maintenance due to wear and tear on equipment, electrical disruptions, damage from landscape equipment or vandalism, changing environmental conditions and other causes. In this section, pipe repair, sprinkler head troubleshooting and repair and winterizing the system is discussed. Controller, valve and all electrical-related maintenance and troubleshooting is covered in the chapter, “Wiring & Electrical Troubleshooting.”

Pipe repair
This section describes how to repair pipe and fittings. These basic procedures are similar to those used for installation (see earlier section, “Installing Pipes and Fittings”).

Excavation
For all pipe repairs, excavate an area large enough to comfortably undertake the repair. The excavation depth should be approximately 2" (5 cm) below the bottom of the pipe, the width should be approximately four times the pipe diameter (min. 4" or 10 cm), and the length should be at least 24" or 60 cm (longer if needed).

PVC pipe repair
Components used to repair PVC are joined with adhesive cement. Always read and follow manufacturer’s instructions and safety precautions when using any adhesives. The steps for repairing a broken section of PVC pipe are very similar to those used when first installing PVC pipe and fittings. Follow these steps:

- Excavate as instructed above.
- Cut out the damaged section of pipe. Use a PVC saw or pipe cutters and make sure the cut is straight.
- Remove any burrs or rough edges where the pipe has been cut.
When repairs are complete, holes or trenches should be backfilled and compacted. Compact soil by puddling (applying water to the top of the backfill), jetting (injecting water below the surface of backfill) or tamping (compacting soil with some type of compaction device). This may have to be done in several lifts (layers), depending on the depth of excavation.

- Be sure all pipes and couplings are dry. You may need to use repair couplings or compression fittings to provide the necessary play needed for this repair. A slip-fix is generally used only on non-gasket fitting laterals, rarely on mainline repairs.
- Clean the two surfaces with a rag (and water if needed), wipe dry and apply primer.
- Allow primer to sit for the time recommended by the manufacturer, then apply cement. Be sure the surfaces to be joined are completely covered. Don’t over- or under-apply. Excessive cement can damage pipes and couplings, while too little cement won’t produce a strong joint. Avoid contact with skin. Wear rubber gloves and other proper protective clothing.
- Insert the coupling into the pipe.
- Join the pieces together, turning the coupling one quarter around to spread cement evenly. Remove any excess cement from the seam.
- Hold the pieces together for about a minute, or according to the manufacturer’s instructions, to allow cement to set up.
- Repeat the above to attach a coupling to the other section of pipe.
- Cut a piece of pipe the same length as the section you removed in Step 1.
- Attach the new section of pipe to couplings using the same procedure you used to attach couplings to old sections of pipe.
- Allow sufficient time for curing before burying or charging the line. Again, refer to the manufacturer’s recommended time.
Poly pipe repair
Follow these steps when repairing a broken section of poly pipe:

- Excavate as instructed previously.
- Cut out the damaged section of pipe. Use a poly cutter and make sure the cut is straight.
- Remove any burrs or rough edges where the pipe has been cut.
- If using pipe clamps, position clamps loosely over the ends of the two sections of pipe or use compression couplings to connect the new section of pipe.
- Insert couplings into each pipe as far as they will go.
- Tighten the clamps to secure the couplings.
- Cut a piece of pipe the same length as the section you removed.
- Position two clamps on each side of the cut, loosely over the new piece of pipe.
- Insert the ends of the new piece of pipe over the two couplings.
- Tighten all four of the clamps to secure the new pipe.

Repairing copper pipe and fittings
Follow the steps listed under “Copper pipe and fittings,” with the following additions:

1. Excavate an area large enough to comfortably undertake the repair. The excavation depth should be approximately 2" (5 cm) below the bottom of the pipe, the width should be approximately four times the pipe diameter (4" or 10 cm), and the length should be at least 24" or 60 cm (longer if needed).
2. Remove any water that may be in the pipe as this cools the pipe and may not allow a proper seal.

Troubleshooting and repairing sprinkler heads
Problems with a sprinkler head are often detectable either by a distorted spray pattern or by the presence of brown grass around the head. Some problems can be easily corrected with simple adjustments. Depending on the type of head, it may be possible to adjust the spray angle and radius. The method for adjusting varies with the type of head and the manufacturer. Refer to the table on page 70 for troubleshooting recommendations.
## Troubleshooting Chart for Sprinkler Heads

<table>
<thead>
<tr>
<th>Problem</th>
<th>Likely Cause</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distorted spray pattern</td>
<td>Nozzle is clogged with debris</td>
<td>Clear debris. You may need to detach nozzle to remove obstruction. Spray heads have a filter screen under the nozzle. If it becomes clogged, it should be cleaned or replaced.</td>
</tr>
<tr>
<td>Heads discharge large drops</td>
<td>Nozzle is clogged with debris</td>
<td>Clear debris. You may need to detach nozzle to remove obstruction. Spray heads have a filter screen under the nozzle. If it becomes clogged, it should be cleaned or replaced.</td>
</tr>
<tr>
<td>Water pressure is too low</td>
<td></td>
<td>Check for leaks in the system. If the system is not leaking, you may need heads that operate at lower pressure.</td>
</tr>
<tr>
<td>Heads discharge a fine mist</td>
<td>Water pressure is too high</td>
<td>Install remote control valve with flow control. Install pressure regulator valve on mainline.</td>
</tr>
<tr>
<td>Rotary sprinklers do not rotate or rotate too slowly</td>
<td>Water pressure is too low</td>
<td>Check for leaks in the system.</td>
</tr>
<tr>
<td></td>
<td>Bad gear-drive mechanism (gear-drive sprinklers only)</td>
<td>Replace gear drive.</td>
</tr>
<tr>
<td></td>
<td>Break-up pin is improperly adjusted (impact sprinklers only)</td>
<td>Adjust break-up pin.</td>
</tr>
<tr>
<td></td>
<td>Insufficient water is contacting lever (impact sprinklers only)</td>
<td>Adjust lever.</td>
</tr>
<tr>
<td></td>
<td>Lever is impacting back of sprinkler head (impact sprinklers only)</td>
<td>Adjust lever.</td>
</tr>
<tr>
<td>Pop-up sprinkler will not pop up</td>
<td>Water pressure is too low</td>
<td>Check for leaks in the system.</td>
</tr>
<tr>
<td></td>
<td>Dirt or other debris in the spindle sleeve area</td>
<td>Remove debris. Internal unit may need to be disassembled for cleaning.</td>
</tr>
<tr>
<td>Pop-up sprinkler sticks in up position</td>
<td>Dirt or other debris in the spindle sleeve area</td>
<td>Remove debris. Internal unit may need to be disassembled for cleaning.</td>
</tr>
</tbody>
</table>
Basic field diagnostics
Looking at an irrigated area can sometimes reveal problems with an irrigation system. Below are some conditions that may indicate problems.

- If water continues to come out of a head after the zone is shut off, this can indicate a leaking or weeping valve. However, a head located in a low point where water from the entire zone will drain can also cause this. This is called low head drainage and can be eliminated with the use of check valves. A check valve prohibits water from leaving the head when the system is not pressurized.

- If one part of the irrigated area is constantly wet, there may be a leak in the mainline.

- If grass in a particular zone is brown, the zone is not receiving adequate coverage. Some possible causes include:
  - Faulty valve
  - Faulty wiring
  - Broken lateral
  - Broken sprinkler head, which reduces pressure to the entire zone
  - Insufficient watering time on controller
  - If grass is brown around a single sprinkler head, likely causes are a faulty head or a clogged or broken nozzle.

Winterizing an irrigation system
In climates where freezing temperatures are common, irrigation systems should be winterized to avoid costly damage. This is done by blowing water out of the system using an air compressor. If water remains in the system, it will expand when frozen and can crack pipes, valves and fittings.

Follow these steps to winterize the irrigation system:

- Turn off the water supply to the system. If the main shutoff valve is outdoors, it should be insulated to protect it from freezing.

- Connect the proper size air compressor to the downstream side of the backflow preventer. Most backflow preventers have a point of connection (POC) with a small valve for connecting an air compressor.
Use the controller to open the remote control valve furthest from the point of connection. This will help clear water from the mainline as you proceed.

Start the air compressor and slowly increase pressure.

When only air is coming out of the sprinklers, turn off the compressor and shut the remote control valve.

Repeat for each valve in the system.

Set the controller to rain mode. This will shut down the signals to the valves without losing the programming. Alternatively, you can turn off the power to the controller. If you do this, you will need to reprogram the controller in the spring.

Drain the backflow preventer and open any drains at the point of connection.

After winterizing, all valves—except the main supply valve—should be left in a slightly open position to prevent damage to the seals.

Summary

Irrigation systems continue to evolve, favoring more sustainable options. All conventional irrigation systems have several common components, including backflow prevention, piping, valves, emitting devices, wiring and controllers. Various options are available for each of these components.

Smart controllers are becoming more common and can conserve water and save money and time. After programming, smart controllers can use information from environmental sensors and/or the weather to manage watering schedules for optimal irrigation—not too much, not too little.

Low-volume systems use different piping and tubing solutions and various drip emitters to reduce water loss by evaporation. Subsurface drip irrigation systems are even more efficient by eliminating evaporation and reducing irrigation needs by supplying water directly to the roots.

Irrigation systems typically require periodic troubleshooting, repair and other maintenance due to wear and tear or damage. Field diagnostics, meaning watching the irrigation system in action, can often indicate the likely problem. Leaks in the mainline or laterals require excavation. Often sprinkler head issues can be solved by cleaning and removing obstructions. Valve or valve parts may occasionally have to be replaced.

Protect irrigation systems by properly winterizing them in areas where freezing temperatures are sustained through winter.