Student Workbook

Irrigation Components

Residential/Small Commercial Systems

By
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Edited by
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About the Author

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Kurt Thompson's career in the landscape and irrigation industry spans more than 29 years. He graduated from Washington State University with a bachelor's degree in business administration with an emphasis on small business and economics.

Thompson's experience in the Green Industry includes working for landscape and irrigation contractors in Northern California and the Rocky Mountains, with specific experience in public works landscape and golf course construction and renovation projects. His career has also included working in management for an irrigation distributor, as well as national marketing and sales positions for an irrigation manufacturer. After seven years in manufacturing, Thompson became the national irrigation product manager for a Fortune 500 company. He then became the vice president of sales for the master Toro distributor in the seven Gulf Coast states. Thompson currently owns the consulting firm K Thompson and Associates, LLC.

For over 19 years, Thompson has contributed to the education programs of the Irrigation Association, the Golf Course Superintendent's Association of America, and many state and local organizations. He has helped develop national certification programs, coauthored training manuals, and designed many training classes for IA. He was a contributing author of *Irrigation, Sixth Edition*.

Thompson's speaking and training resume includes many of the national Green Industry associations, state irrigation and turfgrass associations, as well as state universities and community colleges. He has also been involved with water management districts around the country providing input on landscape and golf course water use.

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Introduction

The purpose of any irrigation system is to supply water that plants need for healthy growth. The methods to accomplish this must incorporate product technology along with design, installation, and maintenance techniques with the intent to reduce water use. The mission statement for irrigation professionals should be the following:

Deliver the minimum amount of water to keep plants healthy using the most efficient design, installation, maintenance, and management methods and products.

To achieve this goal, the design and installation should utilize the proper equipment, be regularly maintained to ensure correct functioning, and be managed to adjust to the changing seasonal plant water needs. This process begins with an understanding of each component and its role in the complete irrigation system.

Objectives

At the completion of this laboratory exercise, the student will have

- an understanding of how the main components operate.
- familiarity of the basic installation methods.
- an awareness of the features and performance characteristics.
- knowledge of industry standard terminology.
- a comprehension of product application for standard situations.

The Residential Irrigation System

The components of a residential irrigation system can be divided into five groups:

- water source
- sprinklers
- valves
- pipe and fittings
- wire and controllers

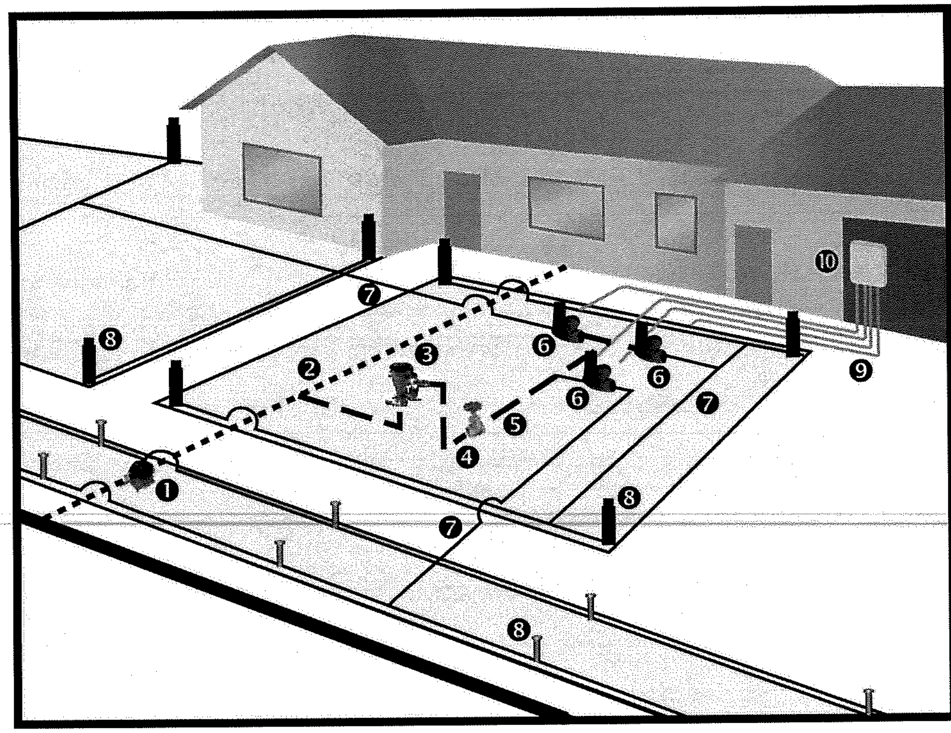
Note: While low volume irrigation (drip, microirrigation, etc. — aka xerigation) components are commonly used in residential irrigation systems, they are so diverse that it requires a separate discussion not included in this manual.

Notes

✍ Notes

The conceptual drawing in figure 1 is a representation of the main components that make up a residential irrigation system and where they are located in relationship to each other.

Figure 1. The 10 basic system components



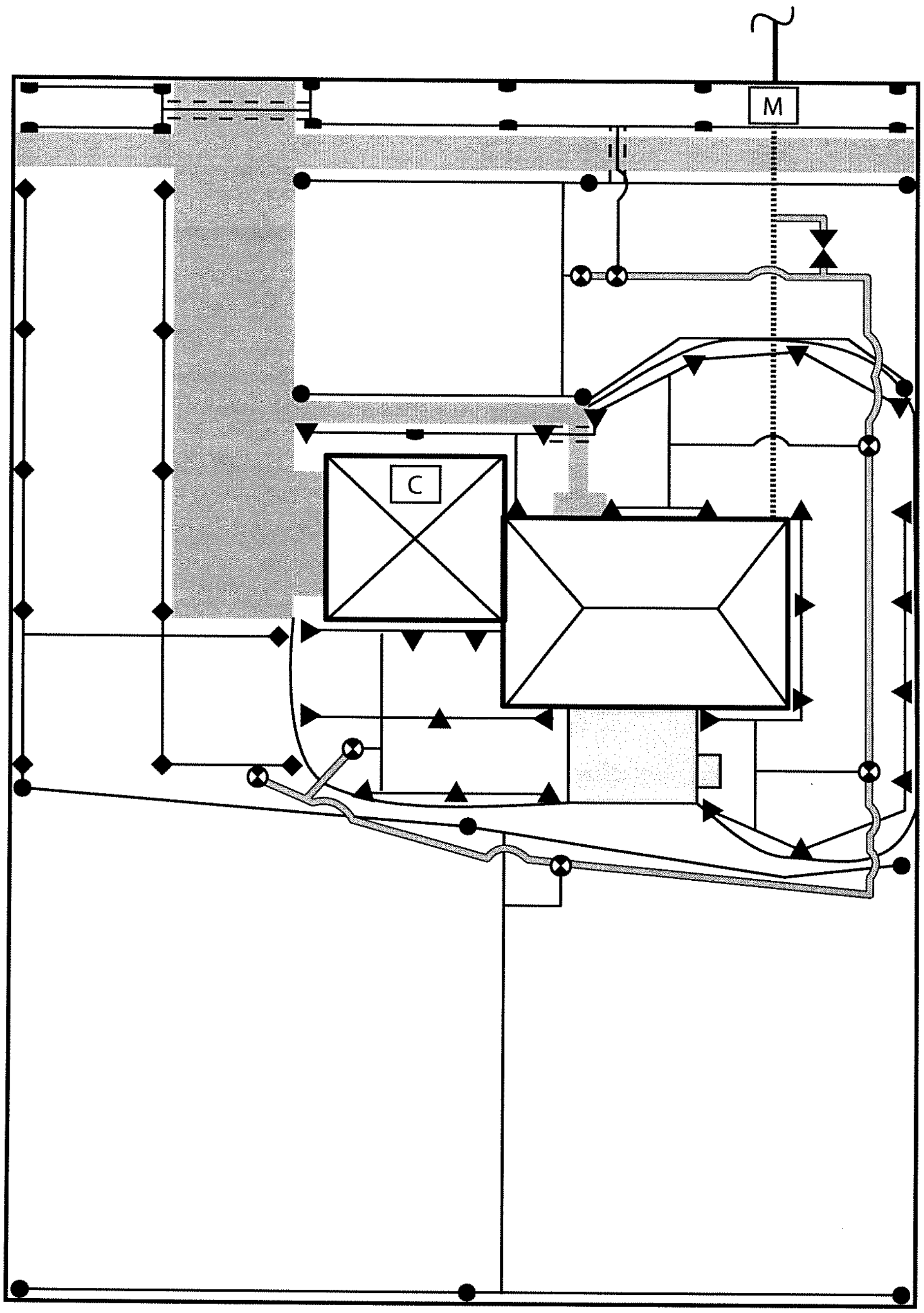
1. City main and meter for house
2. House service line
3. Backflow prevention device
4. Manual master valve
5. Irrigation main line
6. Zone valves
7. Lateral line
8. Sprinklers (rotors and sprays)
9. Irrigation wires
10. Controller

The system shown in the schematic in figure 2 is a typical residential system drawing that an irrigation designer would generate to show the location of the major components. Each component is represented by a different symbol. These symbols are defined with descriptions for each. They are shown in the plan's legend.

Also found in or near the legend is the scale of the plan. While this plan is not to the scale shown in figure 2, the scale shown is 1" = 10' 0". This means that each inch measured on the plan equals 10 feet. Common scales for residential irrigation plans are 1:10, 1:20, ¼:1, and ⅛:1.

Irrigation plans are considered to be schematic in nature. This means that the locations of many of the components are for clarity rather than for installation. In many cases, pipe, wire, and other components are drawn in sidewalks or driveways or even through parts of a building so they can be more easily read. There will typically be notes in the specifications or on the plans to indicate that when a contractor builds the irrigation system the components will be installed to cover or function properly.

Figure 2. Typical residential system drawing



Legend, 1" = 10' 0"

- ● Gear rotor model B
- ▲ Spray with X nozzle
- ◆ Spray with Y nozzle
- ▬ Spray with Z nozzle
- ⊗ 1" valve model Q
- ⧓ Backflow device
- Mainline pipe
- Laterals pipe
- House service pipe
- Sleeves
- City main pipe
- M City meter
- C Controller

Notes

✍ Notes

The purpose of any irrigation system is to deliver the minimum amount of water to keep the plants healthy and to do this in the most efficient manner possible.

An irrigation system has five main components: water source, piping and fittings, valves, sprinklers, and the control system.

Water Source

The source for an irrigation system and its performance characteristics must be defined before starting any irrigation design or installation. Each source has a limit to the amount of water it can deliver, called flow, which is measured in gallons per minute {gpm}. The source also has a limited amount of pressure it can deliver, measured in pounds per square inch {psi}. A system cannot be designed or installed that requires more pressure or flow than the source can provide.

Typical water sources for irrigation are as follows:

- potable water (municipal water that is drinkable)
- nonpotable water (treated or reclaimed water that is not drinkable)
- surface water (lake or pond)
- subsurface water (well water)

In many states, ordinances require that only the lowest quality water available be used for irrigation. Each source has its own set of concerns that will dictate the design and/or installation that an experienced professional must consider prior to starting the work.

The potable water sources have national and local ordinances requiring that the source be protected from the possibility of contamination or pollution. This is done by installing a backflow prevention device [BPD] downstream from the point of connection into the pipe carrying the potable water. There are many different types of BPDs manufactured, but the local ordinance will mandate a specific type of device and how it should be installed.

A nonpotable source is a supply separate from the potable water source. While the nonpotable water is treated and safe to be used around humans, it is not drinkable. Most irrigation systems using reclaimed water have municipal ordinances governing how the public is made aware that the water is not potable. This is typically accomplished through signage on the property being irrigated and by having various components with purple or lavender markings. These requirements may include purple markings on the pipe used, the top of the valves or sprinklers, or the valve boxes. It also may require that tags are placed on the valves indicating reclaimed water is being used.

For either surface or subsurface water sources, a pump must be installed to meet the pressure and flow requirements of the irrigation system. An electrical line must be available to operate the pump. There must also be either a pump start relay or a pressure tank with a pressure control switch to activate the pump when the pressure and flow is needed by the irrigation system. A complete discussion of pumps can be found in the *Fundamentals of Pumps* manual.

Sprinklers

The determining factors guiding the selection of sprinklers for a particular application are the following:

- the area the sprinklers need to cover
- the amount of water available for the sprinklers to use
- the pressure that is available to the sprinklers

Residential/light commercial landscapes consist of turf areas and shrub areas that are relatively small. Therefore, the sprinklers used for a home (or small office building) do not need to throw water great distances or require large supplies of water. Two types of sprinklers are illustrated in figures 3 and 4. Table 1 outlines the types of sprinklers used for res/com irrigation systems.

Table 1. Performance ranges of irrigation systems

Sprinkler type	Performance range		
	Distance {ft}	Pressure {psi}	Flow {gpm}
Sprays	5–17	15–30	0.1–4
Bubblers	1–3	15–30	0.25–2
Rotors	8–50	20–65	0.16–12.2

Figure 3. Rotating nozzles

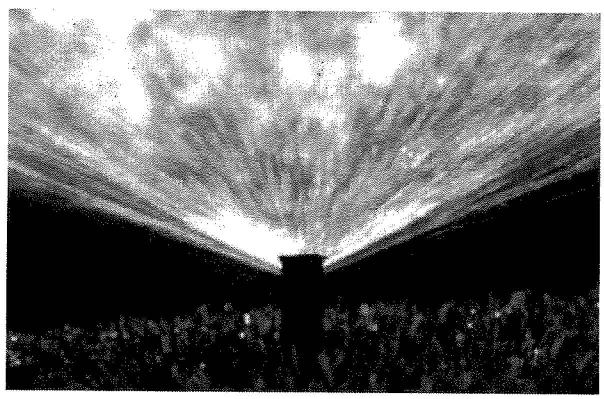


Figure 4. Spray nozzles

Spray Sprinklers

Spray sprinklers are also known as sprays, spray heads, misters, and mist heads depending on the region of the country. They are used in the smaller areas of a residential landscape. There are two types of sprays: fixed and pop-up.

Pop-up spray sprinklers pop up when the water is turned on and spray water out of a variety of nozzles. They retract when the water is turned off, which keeps them out of sight and out of the way when not in use. The direction and distance the water travels is determined by the size and type of nozzle installed on the spray sprinkler. Standard spray bodies are sold without nozzles. (Additional information provided in the "Spray Nozzles" section that follows.) There are also spray sprinklers that come with either built-in nozzles or factory-installed nozzles.

Notes

✍ Notes

Fixed sprays are spray nozzles attached to a stationary riser using a special fitting called a shrub adapter (see figs. 5 and 6). These are best suited for areas where they are not a tripping hazard or where they can be easily hidden and not detract from the landscape.

Figure 5. Shrub adapter and fixed nozzle on riser

Figure 6. Pop-up spray body with fixed nozzle

Photo courtesy of Rain Bird®.

Sprays are available in various pop-up heights (see fig. 7). Most manufacturers offer 3-, 4-, 6-, and 12-inch heights as well as a shrub adapter. Some also offer a 2-inch pop-up height for very short turf. The shrub adapter is to put a spray nozzle on a fixed riser.

Figure 7. Spray pop-up heights

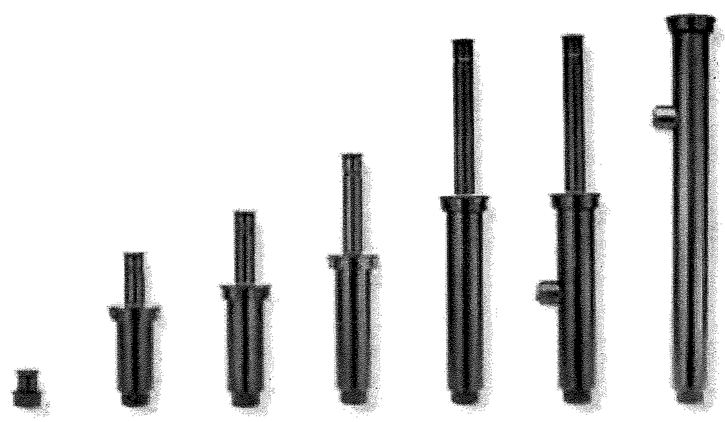


Photo courtesy of Hunter®.

Most models of 6- and 12-inch pop-up heights can be purchased in a version with a second inlet on the side of the sprinkler body to make the connection to the piping system easier. The side inlet will have a threaded plug installed from the factory that will need to be moved to the bottom inlet.

The different sizes are for different heights of plant material. The 2- and 3-inch pop-up heights are used for turf that is maintained at short heights such as Bermuda. The 4-inch height has historically been used for longer turf such as bluegrass or fescue when those types of turf were mowed to 2 inches high. But now that the cultivation practices have changed to mow the turf to 3 to 4 inches, the standard has changed to 6-inch pop-up heights in many areas of the country. In other areas, the 4-inch pop-up continues to be used because of economic reasons. The 6-inch pop-up height can also be used for low ground cover or to irrigate underneath shrubs. The 12-inch height is used for taller ground covers and in shrub beds where the sprinkler can be placed at a distance away from the shrubs as to not be blocked.

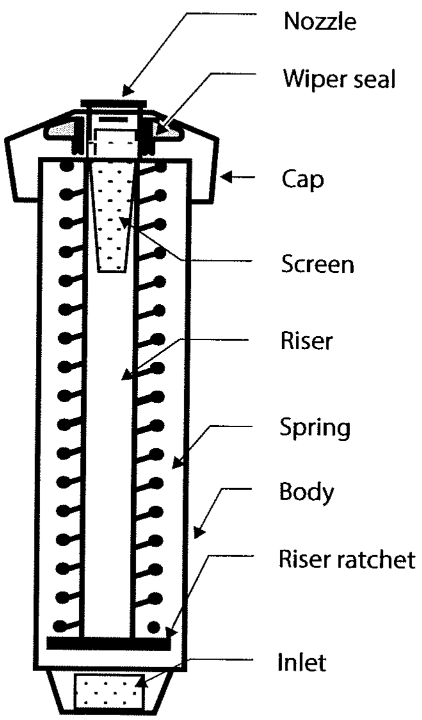
For areas that do not require the spray to be hidden by a pop-up body, there is the shrub adapter. This is a fitting that attaches the nozzle onto a ½-inch stationary riser within a shrub bed.

Parts of a Pop-up Spray Sprinkler

The standard parts of a pop-up spray sprinkler are illustrated in figure 8 and include the following:

- ***nozzle*** — Threads onto the riser with very fine threads. The majority of nozzles are female threads, except Toro® which have male threads.
- ***wiper seal*** — A flexible plastic seal that fits into the cap and seals off the water as the riser pops up.
- ***cap*** — Holds the wiper seal and screws onto the body like a lid of a jar.
- ***screen*** — Filters the debris that would clog the nozzle. It fits into the riser under the nozzle. (Also referred to as the strainer or filter.)
- ***riser*** — Pops up when the water is turned on. It is threaded at the top to accommodate a nozzle. (Also referred to as the tube.)
- ***spring*** — Wraps around the riser and supplies the force to retract the riser when the water is turned off.
- ***body*** — Holds the spring and the riser. (Also referred to as the can.)
- ***riser ratchet*** — The mechanism that holds the riser secure once it has been rotated to aim the nozzle.
- ***inlet*** — The point of connection to the piping system. It has a ½-inch female thread. Some models have a second inlet on the side.

Figure 8. Parts of spray sprinkler



The majority of these parts are made of plastic. The spring is stainless steel and the wiper seal is made of a flexible plastic.

Notes

Notes

Features and Options

Flush Caps

Each pop-up spray body comes with a flush cap installed where the nozzle will go. The flush cap is designed to keep dirt and debris from entering the pop-up after it is installed but before the sprinklers are flushed out. The flush cap allows water and dirt in the pipes (from installation) to flush out and not let new dirt back in. When the nozzle is ready to be installed, the flush cap is removed by either pulling it off or unthreading it off (depending on the model). The nozzle can then be threaded on. Figure 9 illustrates different types of flush caps.

Figure 9. Different types of flush caps

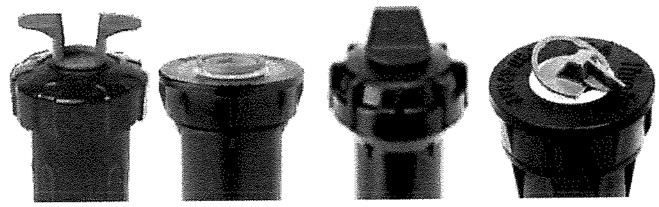


Photo courtesy of Weathermatic®, Rain Bird®, Toro®, and Hunter®.

Pressure Regulation

The pressure regulator is built into the riser. Most brands will operate up to 70 psi while regulating the pressure to 30–40 psi for the nozzle. In addition, if the nozzle is broken off, the pressure regulator will reduce the flow out of the sprinkler by 70 percent. This will reduce the amount of water wasted until the sprinkler can be repaired (see ❶ in fig. 10).

Drain Check

This is a rubber disc or o-ring that is attached to the bottom of the tube and seals off the bottom of the sprinkler to prevent the water from draining out of the lowest sprinklers on the lateral line. Some models of sprays are made so that a check can be added in the field by removing the riser from the body and snapping the check onto the bottom of the riser. With other brands, the check can only be added in the factory (see ❷ in fig. 10).

Caps for Reclaimed Water

Some brands offer a field-installable lavender plastic cap that snaps onto the regular spray cap to mark the sprinkler as using reclaimed or effluent water. Other brands make a lavender cap that replaces the regular cap.

Flow Shutoff

This feature virtually stops the flow of water out of the riser if the nozzle is removed by vandals or broken off, reducing wasted water or erosion damage. The spring check valve is held open by the nozzle and screen. When the nozzle is removed or knocked off, the screen is ejected and the check closes and seals off the flow out of the riser (see ❸ in fig. 11).

Figure 10. Pressure regulation and drain check

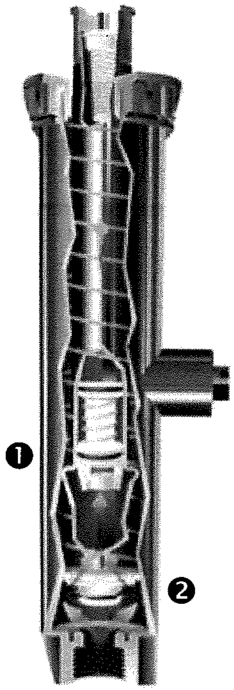


Photo courtesy of Rain Bird®.

Figure 11. Flow shutoff

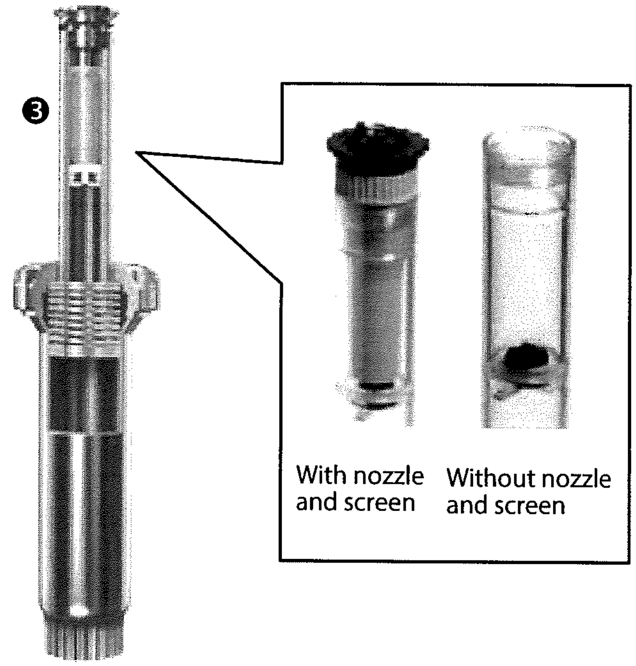
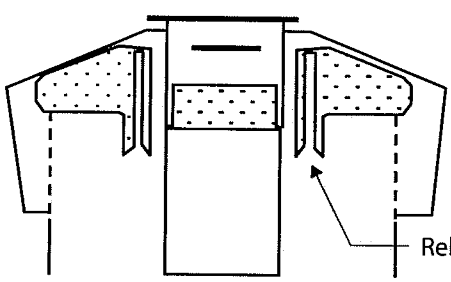


Photo courtesy of Toro®.

The Operation of a Pop-Up Spray Sprinkler

The wiper seal is designed to seal against the riser when the water is turned on. When the water is off, the seal is relaxed away from the riser while the riser in held in the down position by the force of the spring (see fig. 12).

Figure 12. Wiper seal with the water off



Notes

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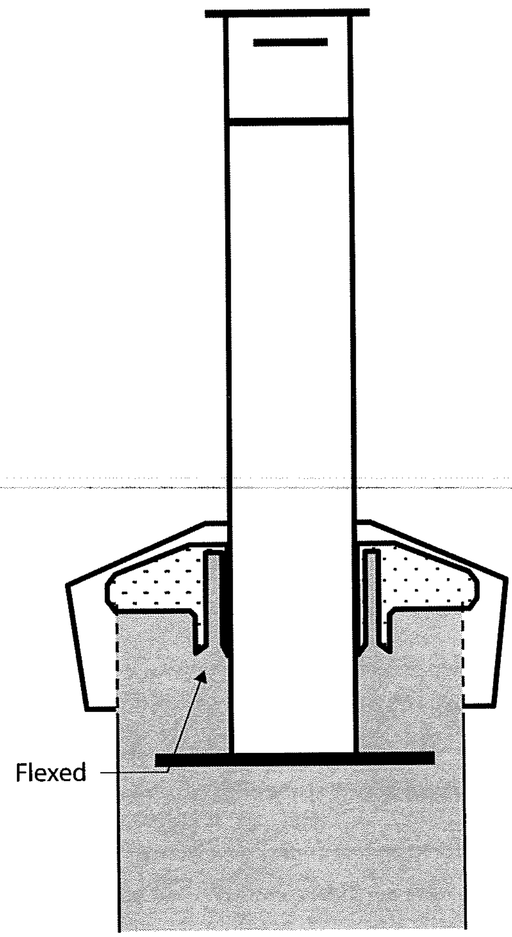
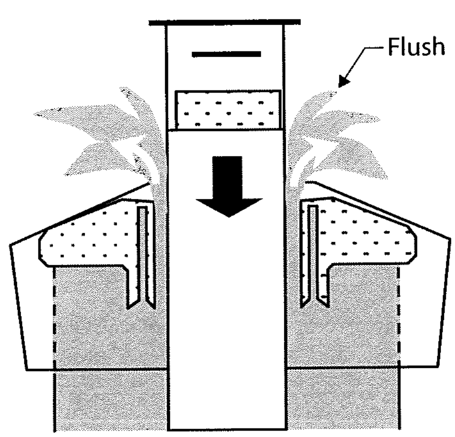
When the water is turned on, there is a momentary delay in creating the seal to allow a small amount of water to flush away any debris. As the water reaches the space in the wiper seal, it forces the wiper against the riser, sealing off the flushing of water, and the riser pops up (see fig. 13).

Figure 13. Wiper seal with the water on



When the water is shut off, the force of the water is lowered and the wiper relaxes away from the riser. This causes a small amount of water to flush out around the riser that washes away debris while the riser retracts under the force of the spring (see fig. 14).

Figure 14. Flush as riser retracts



Shrub Adapters

Shrub adapters are special fittings that provide a means to attach a spray nozzle to a fixed riser such as a polyvinyl chloride [PVC] pipe nipple or PVC pipe with male adapter fitting (see figs. 15, 16, and 17). They have a ½-inch pipe thread on the inlet and a spray nozzle thread on the outlet. These are typically used in shrub beds where the stationary riser will not be damaged or is aesthetically acceptable.

Figure 15. Shrub adapter with nozzle on PVC pipe nipple

Figure 16. Shrub adapter with nozzle on PVC pipe with male adapter fittings

Figure 17. Shrub adapter with nozzle

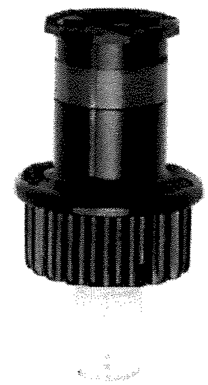


Photo courtesy of Toro®.

Spray Nozzles

Nozzles determine the distance the sprinkler distributes water (radius of throw), the portion of a circle that the water covers (degree of arc), how high into the air the stream of water travels (angle of trajectory), and, in conjunction with the pressure of the water flowing into the nozzle, how much water flows out of the nozzle {gpm}. Table 2 provides spray nozzle performance information.

Table 2. Spray nozzle performance

Radius of throw {ft}	Nozzle trajectory {degrees}		
	Standard angle	Low angle	Flat
5			0–5
8			0–5
10		10–15	
12	22–30		
15	22–30		
17	22–30		

Nozzles are purchased separately from the spray bodies for most models of sprinklers. There are some models that are made with the nozzles built into the riser of the spray body. For these models, the entire sprinkler must be replaced if a different nozzle is desired or if it is damaged.

Notes

✍ Notes

Spray nozzles can be made out of plastic or brass. Plastic is the most popular because of its lower cost. Both are very susceptable to too much pressure distorting the spray pattern. The maximum pressure for spray nozzles is 30 psi. Any higher and the quality of the water distribution (uniformity) deteriorates. Excessive pressure is indicated when the spray nozzle "fogs" because water droplets become very small instead of spraying.

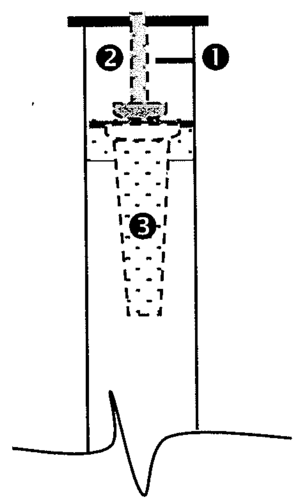
The pressure can be maintained at 30 psi using a number of different techniques:

- A pressure regulator can be placed on the lateral piping going to the spray zone.
- A spray body can be used that has the pressure regulator built into it.
- A pressure compensation filter can be installed in place of the regular filter.
- A pressure compensating disc can be placed between the filter and the nozzle on some brands.

Pressure compensating filters [PC filter] are purchased separately from the nozzles. They can be somewhat complicated to use as each nozzle needs a different PC filter depending on the radius and the degree of arc. The PC filters are color coded to identify which filter goes under the corresponding nozzle.

The nozzles are made with either a female thread or a male thread. The majority of sprays use the female thread. A nozzle has the following three main parts, as shown in figure 18:

Figure 18. Parts of a spray nozzle

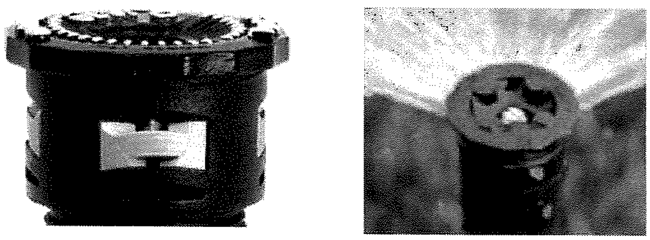


❶ The orifice is the opening where the water exits the nozzle (see figs. 19 and 20). The shape of the orifice determines the degree of arc or how much of a circle the sprinkler sprays water. Depending on which nozzle is selected and at what pressure the nozzle operates, the orifice also determines how far the sprinkler discharges the water. Some models of nozzles have two orifices. The second opening is called the undercut (see fig. 21).

❷ The radius adjustment screw (see fig. 19) allows for a minimal amount of adjustment to the radius of throw. This is achieved in combination with the filter. The radius screw is set full open by the manufacturer. When the radius screw is turned down (using a small screwdriver or factory tool), the opposite end is moved closer to the opening of the filter. This reduces the area for the water to flow past the bottom of the screw and the filter. This restricted flow reduces the radius of throw out of the nozzle. Note: It is best to use the radius adjustment screw to make only 1- or 2-foot adjustments. Select a smaller nozzle for greater changes.

❸ The filter or screen is used to keep debris from clogging the nozzle orifice and to allow the radius adjustment screw to function. The filters are included with the purchase of each nozzle.

Figure 19. The nozzle orifice and radius adjustment screw



Photos courtesy of Toro®.

Nozzles can be categorized into four groups: fixed arc, variable arc, bubblers, and multistream rotating nozzles. Within these groups are subgroups of nozzles that are based on the types of spray patterns.

Fixed Arc Nozzles

The first subgroup of the fixed arc category consists of the most common and widely used nozzles: the ***standard nozzles***. Table 3 shows the different patterns and performances (at 30 psi). Many of the manufacturers color code the nozzles to identify the radius.

Table 3. Standard fixed arc nozzles

Pattern	Description	Performance (radius @ 30 psi)
	Full-circle (360°)	5', 8', 10', 12', 15', 17'
	Three-quarter-circle (270°)	5', 8', 10', 12', 15', 17'
	Two-thirds-circle (240°)	5', 8', 10', 12', 15', 17'
	Half-circle (180°)	5', 8', 10', 12', 15', 17'
	Third-circle (120°)	5', 8', 10', 12', 15', 17'
	Quarter-circle (90°)	5', 8', 10', 12', 15', 17'

Notes

Notes

The standard spray nozzles are made in two different configurations. The single orifice spray nozzle is the most common (see fig. 20). It has a single opening in the nozzle to create the spray pattern. The undercut spray nozzle has a second orifice under the main one to provide enhanced close-in watering (see fig. 21).

Figure 20. A standard single orifice spray nozzle

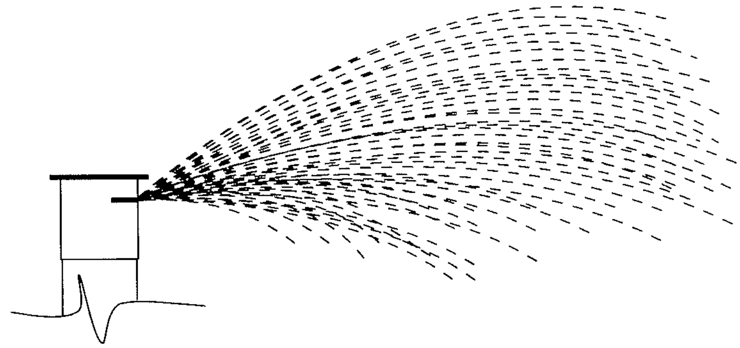
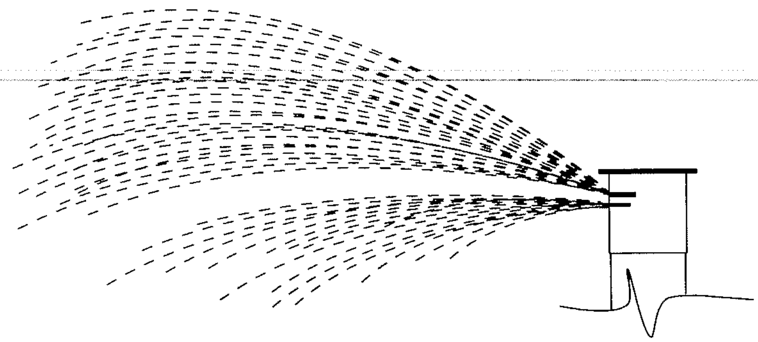
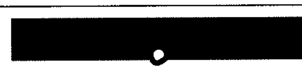
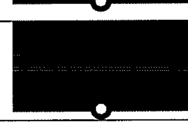


Figure 21. An undercut spray nozzle with two orifices



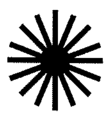
The second group of fixed arc nozzles is the ***strip nozzles***. These are specialty nozzles designed to irrigate rectangular-shaped areas. Care must be taken to ensure proper sprinkler placement for overlap. Each pattern type and performance is shown in table 4.

Table 4. Strip nozzles

Pattern	Description	Performance (width × length @ 30 psi)
	Right corner strip	4' × 15'
	Left corner strip	4' × 15'
	Side strip	4' × 30'
	2' side strip	2' × 15'
	4' × 18' side strip	4' × 18'
	9' side strip	9' × 18'
	End strip	4' × 15'
	Center strip	4' × 30'

Stream spray nozzles are fixed arc nozzles that are not true spray nozzles in the sense that they have multiple orifices that distribute the water in a number of streams instead of one fan spray. Stream spray nozzles are not designed to be used on turf applications. The performance is shown in the table 5.

Table 5. Stream spray nozzles

Pattern	Description	Performance (radius @ 30 psi)
	Quarter-circle (90°)	8', 16'
	Half-circle (180°)	8', 16'
	Full-circle (360°)	8', 16'

Variable Arc Nozzles

Variable arc nozzles or *adjustable arc nozzles* [VAN] are similar to a fixed arc nozzle, but instead of having to use a different nozzle for each degree of arc, the variable arc nozzles can be adjusted from 0° to 360° (see table 6). Variable arc nozzles are purchased by the distance they need to cover (radius of throw). They have the radius adjustment screw that can be used when a filter is installed to reduce the radius up to a maximum of 25 percent.

Table 6. Variable arc spray nozzles

Pattern	Description	Performance (radius @ 30 psi)
Adjustable from 0° to 360°	VAN	4', 6', 8', 10', 12', 15', 17'

Bubbler Nozzles

Bubbler nozzles are specialty nozzles that can be threaded directly onto ½-inch male iron pipe size [IPS] risers. They do not thread onto a spray body. Rather than a longer radius stream or spray pattern, bubblers distribute very close to the sprinklers (1–2 ft) as a trickle or umbrella pattern in a full circle, as shown in figure 22. It is because of this watering pattern that these nozzles are often referred to as flood bubblers. Bubblers can be purchased in a pressure compensating and a nonpressure compensating configuration. Additionally, most models have adjustable flow rates from approximately 0.25 to 2.0 gpm. Manufacturers now have bubbler nozzles that thread on to a spray body.

In one version of bubbler, the water is directed in streams rather than an umbrella of water. These are called stream bubblers (see fig. 23). They still distribute the water close to the sprinkler, but in center strip, quarter-, half-, and full-circle stream patterns.

Notes

✍ Notes

Figure 22. Flood bubbler

Photo courtesy of Toro®.

Figure 23. Stream bubbler

Photo courtesy of Hunter®.

Bubblers are used to irrigate only nonturf areas. They are installed on a PVC riser and placed near the base of the plant in a plant basin around the plant. Table 7 includes information about the use of various bubblers.

Table 7. Bubblers

Pattern	Description	Performance (radius @ 30 psi)
Full-circle	Flood bubbler	1'–2' trickle or umbrella
Full-circle	Pressure compensating bubbler	1'–2' trickle or umbrella
Quarter-circle	Stream bubbler	1'–2' stream
Half-circle	Stream bubbler	1'–2' stream
Full-circle	Stream bubbler	1'–2' stream
Center-strip	Stream bubbler	1'–2' stream

Multistream Rotating Nozzles

Multistream rotating nozzles are a category of nozzles also referred to as rotators, rotating nozzles, and rotary nozzles. They are basically miniature drive systems that fit onto a spray body in the same manner that a fixed spray nozzle does. As shown in figure 24, they have multiple streams of water that rotate to distribute the water.

Figure 24. Rotator nozzle

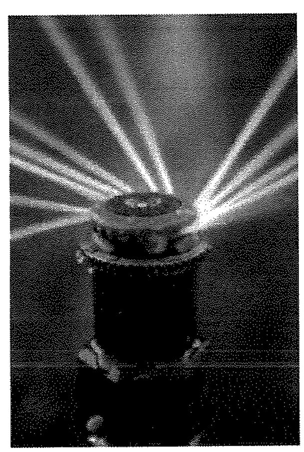


Photo courtesy of Hunter®.

The following features and performance vary by manufacturer and model:

- fixed arc for each nozzle (same as spray nozzles)
- limited variable arc for part-circle models (different models for different ranges of arc adjustment)
- different models for different ranges of radius
- radius adjustment down to 25 percent
- operate in pressures from 20 to 55 psi
- matched precipitation rates

Multistream rotating nozzles have an advantage over traditional spray nozzles because they can cover the same area with a lower precipitation rate (see fig. 25). This makes them closer to the lower precipitation rates of a gear rotor. The lower precipitation rates mean they can be used in small areas where a traditional spray nozzle would be used, but more sprinklers can be put on one valve. This can reduce the cost of a system by reducing the number of valves (or zones) required. The maximum flow per zone can be determined using the "rule of three," and it is likely that many more rotators can be installed on one valve than spray nozzles because of the reduced flow rate per device. Table 8 provides information about the various uses of multistream rotating nozzles.

Figure 25. Multistream rotating nozzle on spray body

Photo courtesy of Rain Bird®.

Notes

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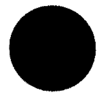
Table 8. Rotating nozzles

Pattern	Description	Performance: Small	Performance: Medium	Performance: Large
	Fixed full-circle (360°)	8'–15'	13'–21'	17'–30'
	Fixed part-circle (270°)	NA	13'–18'	17'–24'
	Fixed part-circle (240°)	NA	13'–18'	17'–24'
	Fixed part-circle (180°)	NA	13'–18'	17'–24'
	Fixed part-circle (120°)	NA	13'–18'	17'–24'
	Fixed part-circle (90°)	NA	13'–18'	17'–24'
	Adjustable part-circle (210°–270°)	8'–15'	13'–21'	22'–30'
	Adjustable part-circle (90°–210°)	8'–15'	13'–21'	22'–30'
	Adjustable part-circle (45°–105°)	8'–15'		
	Right strip	5' × 15'		
	Left strip	5' × 15'		
	Side strip	5' × 30'		

Rotary Sprinklers

The determining factors guiding the selection of sprinklers for a particular application are the following:

- the area the sprinklers need to cover
- the amount of water available for the sprinklers to use
- the pressure available to the sprinklers

For turf and shrub areas that would require several rows of spray heads, rotary sprinklers can be used which will help reduce the cost of installation and facilitate maintenance because fewer sprinklers are required to adequately irrigate the area. The types of rotary sprinklers used for larger areas in a res/com irrigation systems are outlined in table 9.

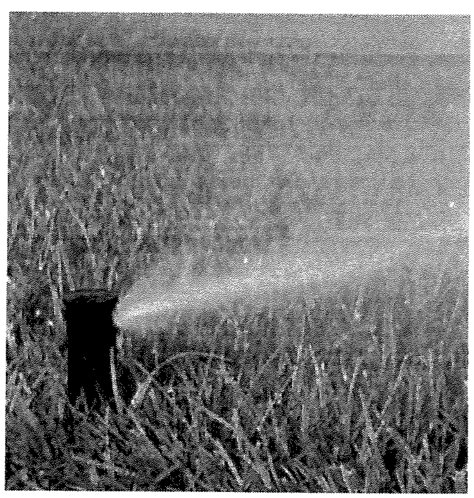
Table 9. Rotor sprinkler head ranges

Sprinkler type	Performance range		
	Distance {ft}	**Pressure {psi}**	**Flow {gpm}**
Small rotors	13–35	25–55	0.5–5
Medium rotors	25–50	25–65	0.75–9.5
Impact rotors	22–45	25–65	1.5–8.4

Gear Driven Rotors

Gear driven sprinklers are also referred to as gear rotors, gear drives, rotors, rotary heads, and gear heads (see fig. 26). Gear rotors operate similar to spray sprinklers in that they pop up when the water is turned on, spray water through the nozzle, then retract or "pop down" when the water is turned off. The main operational difference is that the stream of water coming out of gear rotor nozzle moves to distribute the water using a series of gears that are driven by the flow of the water to rotate or turn the nozzle to cover the portion of the circle (degree of arc) necessary.

Figure 26. Standard rotor



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There are many different brands and models of rotors, but the rotors used in res/com applications can be grouped into two sizes based on the distance they distribute water: small rotors and medium rotors. Small rotors are for areas where the sprinklers are spaced from 13 to 35 feet. Medium rotors are for sprinkler spacings of 25–50 feet.

In addition to the size distinction, there are two types of spray patterns created by the nozzles. The most common spray pattern is referred to as single stream. The single stream nozzle can have multiple openings (known as orifices) to create a specific distribution pattern, but it looks like one single stream. (There are multiple nozzle rotors used in sports field and golf applications, but not for residential.) Unless otherwise specified, the single stream rotor is what is meant by a gear drive.

The other type of spray pattern is a multiple stream pattern. Another trade name for this type of gear drive is a stream rotor. The stream rotors produce multiple streams of water of varying length that rotate within the degree of arc of the nozzle. To get a desired radius and degree of arc, both the nozzle (controls the distance) and the arc disc (controls the degree of the circle) must be installed into the body of the stream rotor. As with a spray sprinkler, they must also be ordered in addition to the rotor body.

Besides being an efficient sprinkler, stream rotors offer an aesthetically pleasing display of moving streams of water interacting with one another (see fig. 27).

Figure 27. Stream rotors

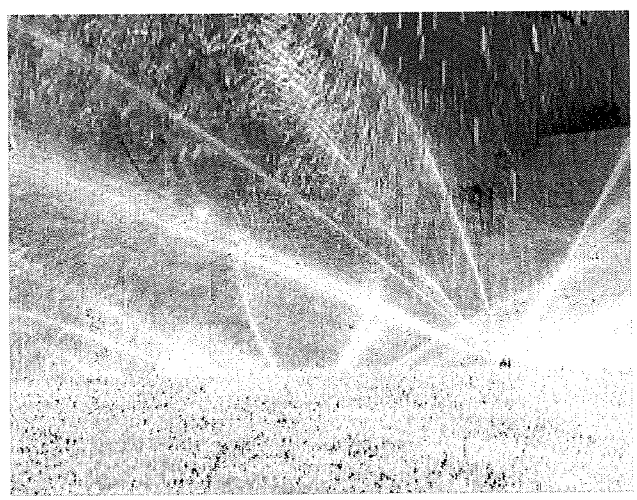

Photo courtesy of Toro®.

As illustrated in figure 28, the following are the standard parts that make up a gear rotor:

- ***rubber cover*** — Covers the nozzle turret and provides a cushion against injury. It is also the access point for all adjustments (see fig. 30).
- ***cap*** — Holds the wiper seal and screws onto the body like a lid of a jar.
- ***wiper seal*** — A flexible plastic seal that fits into the cap and seals off the water as the riser pops up.
- ***nozzle*** — Inserts into riser and held in place with the break-up screw.
- ***nozzle turret*** — Attached to the top of the riser and holds the nozzle. It is the part that rotates.
- ***riser*** — Pops up when the water in turned on. It is attached to the nozzle turret.
- ***gear box*** — Holds the turbine and the gears which rotate the sprinkler
- ***body*** — Holds the spring and the riser. (Also referred to as the can.)
- ***spring*** — Wraps around the riser and supplies the force to retract the riser when the water is turned off.
- ***stator*** — The flow regulator that keeps the gears turning at the right speed regardless of the nozzle size.
- ***filter basket*** — Filters the debris that would clog the nozzle. It fits into the riser and is removable.
- ***inlet*** — The point of connection to the piping system. It has a ¾-inch female thread. Some models have a second inlet on the side.

Figure 28. Parts of gear rotor

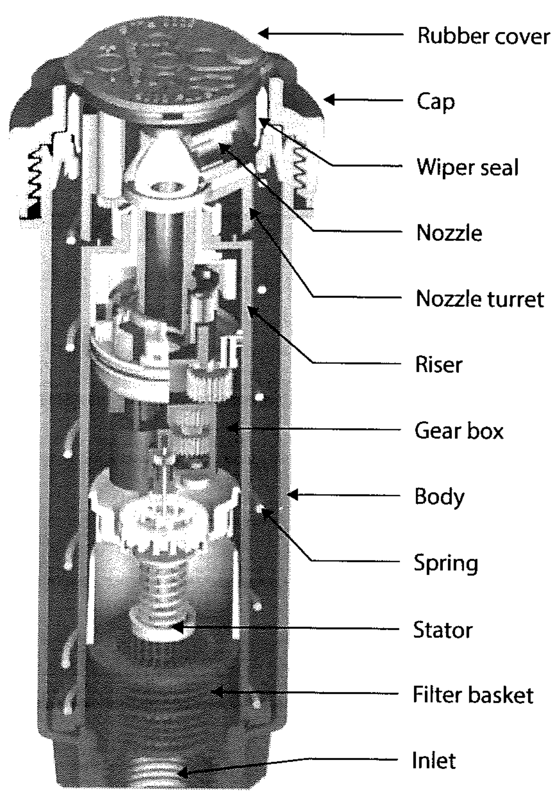

Photo courtesy of Rain Bird®.

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The Operation of a Gear Drive Sprinkler

The gear rotor pops up in the same way as the spray sprinkler. Figure 29 illustrates this process. The water enters into the sprinkler and the wiper seal (❶) flexes out to seal against the riser. When the water is turned off, the wiper seal relaxes and flushes water out from around the riser as it retracts.

The gear rotor rotates as a result of water flowing through the turbine (❷) and causing the turbine to rotate as the water goes through the fins of the turbine. The rotating turbine drives the gears (❸), which rotates a shaft attached to the nozzle turret (❹).

Standard configurations for gear rotors are full-circle and part-circle models. The full-circle model has no arc adjustment, as it continuously rotates around 360 degrees. The part-circle models can be set by the user to rotate to a certain portion of a circle. When the turret completes the degree of arc rotation set by the user, the reversing mechanism switches the direction of rotation.

The water flow drives the gears. Because gear rotors can accept a wide range of nozzles, there is a stator (❺) in the rotor to regulate how much water drives the gears. Without a stator, the larger nozzles would make the rotor turn much faster than with the small nozzles. The stator allows some of the water into the gears and the rest bypasses the gears. All of the water joins back up at the nozzle to flow out of the sprinkler.

Figure 29. The operation of a gear rotor

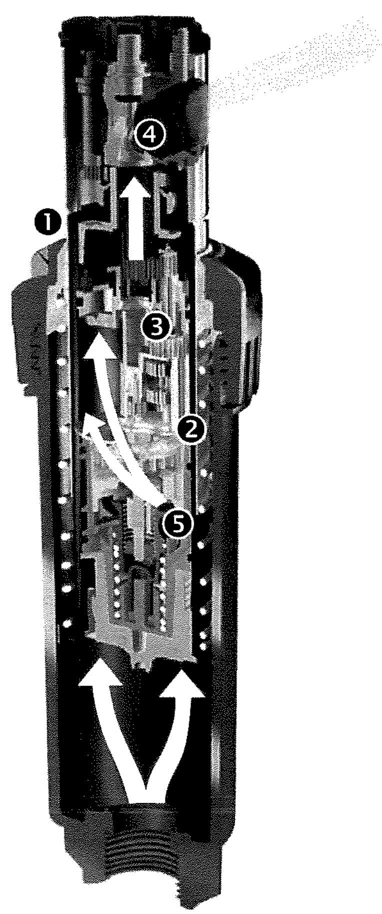
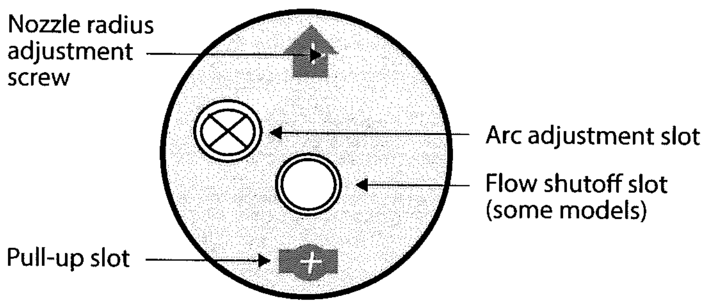


Photo courtesy of Rain Bird®.

The methods used to adjust the degree of arc of the rotation are different for each brand. In general, there is a fixed side, or the 0° position, and an adjustable side. Some brands start at the 0° position and open to the right (clockwise), and other brands open to the left (counter clockwise). The degree of arc is made by opening or closing the adjustable side to the desired portion of the circle the sprinkler is to cover. Some rotor brands require either a hex wrench or small flat screwdriver to unlock the arc adjustment and lock it once the arc is set. Others require no tools at all to set the arc and even have icons on the sprinkler to indicate the portion of a circle the sprinkler will cover. Figure 30 provides an example of the top of a gear rotor.

Figure 30. Example of the top of a gear rotor



Most brands of rotors, the adjustments are made from the top of the sprinkler. The rotor has a slot to insert a tool that will allow the riser to be pulled up out of the body when the sprinkler is installed in the ground. Some brands offer a clip that is used to slip onto the riser to hold it up (in the popped up position) to install the nozzle.

There is also a place to insert a hex wrench or small screwdriver to access the radius adjustment screw. The radius adjustment screw, also referred to the break-up screw, has a dual function. It is the means to hold the nozzle in the turret, and it also serves to reduce the radius of the sprinkler.

To insert a nozzle (see fig. 31), insert the tool that comes with the rotor through the rubber cap into the slot just above the opening in the turret for the nozzle. (The slot is usually in the direction arrow on the top of the rotor.) Back out the radius adjustment screw until it no longer obstructs the opening for the nozzle in the turret. Remove the desired nozzle from the "nozzle tree" and push it into the opening in the turret so that the slot on the nozzle is at the top (the 12 o'clock position). Tighten the radius adjustment screw (see fig. 32) to retain the nozzle, but not enough to disrupt the nozzle stream.

Figure 31. Inserting the nozzle

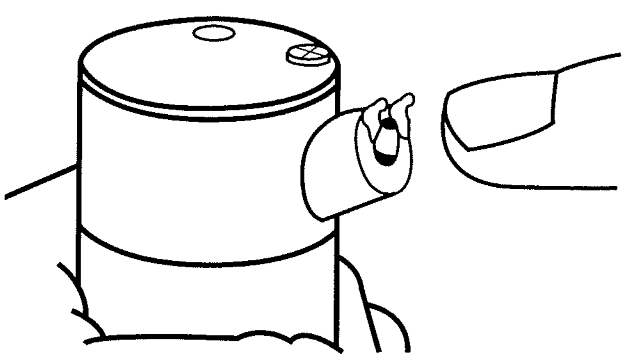


Photo courtesy of Hunter®.

Figure 32. Radius adjustment screw

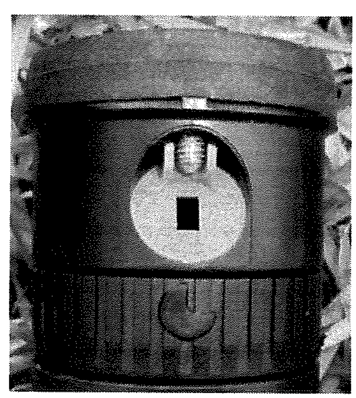


Photo courtesy of Weathermatic®.

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The radius of the sprinkler can be reduced by using the radius adjustment screw. Insert the tool into the same slot. Turning the screw clockwise will move the screw into the nozzle stream, causing the stream to break up. This will slowly reduce how far the nozzle throws the water. The farther the screw goes into the stream, the more the stream breaks up and the radius is reduced. The maximum reduction is 25 percent. Reducing the stream further will result in very poor uniformity of coverage.

Most brands of gear rotors are available in a number of different pop-up heights (see fig. 33). The standard pop-up height is 4 or 5 inches. There are some brands offering a 6-inch pop-up height. All of these are for applications in turf. There is a model that pops up 12 inches for use in shrub areas. A shrub rotor is a special rotor that does not pop up. Shrub rotors thread onto a fixed riser for nonturf applications Each sprinkler includes a set of nozzles called a nozzle tree. The number of nozzles on a tree varies from 8 to 12, depending on the brand and model of sprinkler. Many of the brands combine standard angle and low angle nozzles on the same tree. Others offer the low angle nozzles at an additional cost. The lower angle nozzles are used to go under tree limbs or to reduce the distance without using the radius adjustment screw.

Figure 33. Sizes of gear rotors and nozzle tree

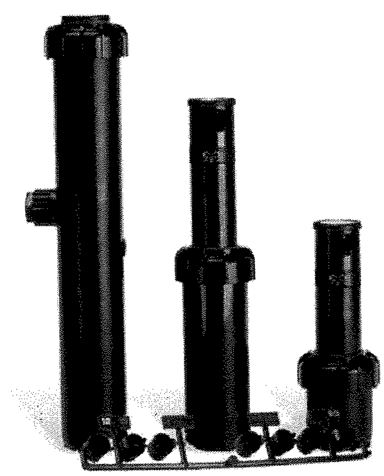

Photo courtesy of Toro®.

Features and Options

The features of gear drives vary by brand and model. Figure 34 illustrates various rotor nozzle configurations and table 10 provides information about gear rotor nozzle performance. Following are some standard features in common with all residential gear rotors:

- adjustable rotation from part of a circle to a full circle
    - smallest arc of 0° to 45° and largest of 360°
- radius adjustment to reduce the radius up to 25 percent
- rubber cap on the top of the riser
- a set of nozzles on a "tree" are included with each sprinkler
    - between eight and 12 nozzles per tree standard
- pop-up heights of 4-, 5-, 6-, and 12-inch and shrub
    - 4-inch through 6-inch used for turf
    - 12-inch used for shrubs
    - shrub rotor threads directly on a riser and does not pop up

Table 10. Gear rotor nozzle performance

Rotor type	Stream type	Radius {ft}
Small	Standard rotor	13–35
	Stream rotor	15–33
Medium	Standard rotor	25–50
	Stream rotor	28–43

Figure 34. Rotor nozzle configurations

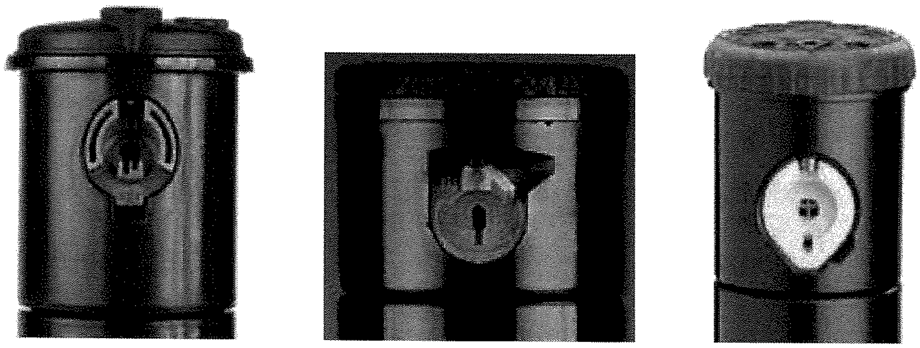

Photo courtesy of Toro®, Hunter®, and Rain Bird®.

Other features that can be standard for some models or brands or options for others include the following:

- ***internal pressure regulation*** — The pressure regulator is built into the riser. Most brands will operate up to 75 psi while regulating the pressure to 45 psi for the nozzle.
- ***interchangeable internal assemblies*** — A rotor internal that will fit directly into the body of another brand of rotors.
- ***flow shut off*** — Turns the sprinkler off manually while in operation.
- ***drain check valve*** — To prevent water loss by low head drainage. Some brands allow check to be activated in the field, and others require them to be installed at the factory.
- ***self-realigning arc*** — Automatically returns to the original arc.
- ***stainless steel riser*** — A stainless steel sleeve covering the riser to resist abrasions and increase durability.
- ***reclaimed water*** — Lavender-colored cap for installations using reclaimed (nonpotable) water.

Impact Rotors

Impact rotors were the original rotating sprinklers. Today, there are two configurations of impact sprinklers used in residential applications. A stationary impact sprinkler is used for nonturf application. It has a male thread used to attach the sprinkler to a fixed riser, usually ½- or ¾-inch for residential use. While still in use, the small stationary impacts are used primarily in nursery and agricultural applications or as a hose end sprinkler for use in residential applications.

The other configuration is pop-up impact sprinklers used for turf applications (see fig. 35). For a residential sprinkler system, these sprinklers typically have a ½- or ¾-inch female threaded inlet to attach the sprinkler to a flexible connection to the piping system. There are still some areas in the country where these are the

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standard residential rotors. While the uniformity of coverage of an impact sprinkler is very good, the design of a pop-up impact allows for debris to enter the case or body, causing the sprinkler to stick up.

Both configurations of impacts are available in full-circle and part-circle versions. Most impacts used in res/com applications are made primarily of plastic. There are also small stationary impacts made of bronze or zinc. Most versions have interchangeable nozzles.

Figure 35. Pop-up impact

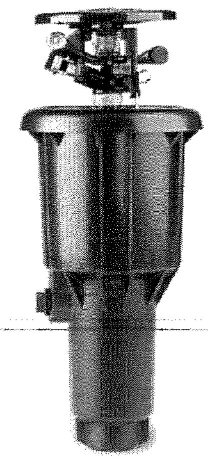

Photo courtesy of Rain Bird®.

As illustrated in figures 36 and 37, the following are standard parts that make up an impact sprinkler:

Figure 36. Parts of an impact sprinkler

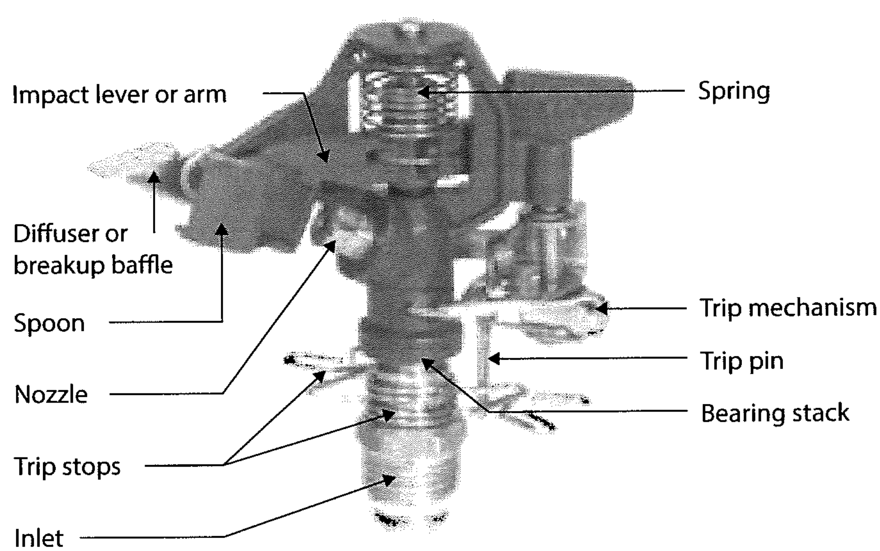

Photo courtesy of Buckner®.

- ***impact lever*** — Swings back and forth, impacting the stream of water to drive the rotation of the sprinkler.
- ***spoon*** — Part of the impact lever that impacts the water stream to drive the rotation of the sprinkler.
- ***diffuser*** — Used to adjust the distance the sprinkler distributes water.
- ***spring*** — Provides the power to swing the impact lever back into the stream.
- ***nozzle*** — Threads or clips into the sprinkler body.
- ***trip mechanism*** — Mechanically switches the direction of the sprinkler's rotation.
- ***trip pin*** — The part of the trip mechanism that contacts the trip levers to reverse the sprinkler.
- ***trip stops*** — Set the right and left stop points for the sprinkler's rotation.
- ***inlet*** — The threaded connector to attach the sprinkler to the piping system.
- ***bearing stack*** — The washers that allow the sprinkler body to rotate.

The Operation of an Impact Rotor

The trip stops are set to the limits of the sprinkler's rotation. When the water is turned on, it enters through the inlet of the sprinkler, travels through the body of the sprinkler, and is discharged through the nozzle.

The stream of water exiting the nozzle impacts the spoon on the impact lever. The force of the water pushes the lever away. As the lever swings out, it coils the spring until the energy in the spring stops the lever and swings it back toward the stream.

As the returning lever strikes the stream of water with the spoon, it pushes the sprinkler a small amount. The stream of water again forces the lever to swing out and the process is repeated, rotating the sprinkler on the bearing stack. For a full-circle sprinkler, this continues until the water is turned off.

Figure 37. Stationary impact

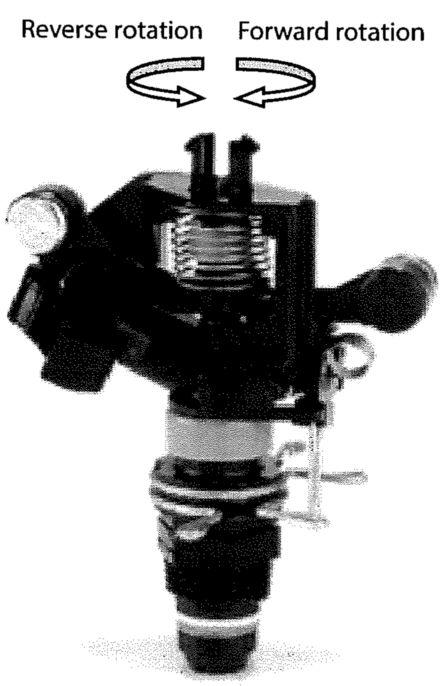

Photo courtesy of Rain Bird®.

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For a part-circle sprinkler, this continues until the sprinkler rotates far enough for the trip pin to push against the trip stops. As this happens, the trip mechanism switches so that the lever cannot swing as far away from the stream. This causes the lever to pull the rotation of the sprinkler in the opposite direction and the rotation of the sprinkler is reversed with every short swing of the lever. This continues until the trip mechanism pushes against the opposite trip stop. This causes the trip mechanism to switch back to the position for forward rotation. The lever now is allowed to swing away from the sprinkler as far as the spring will allow, and the sprinkler rotates slightly forward with each impact of the lever until the trip mechanism switches the direction again.

Valves

The valves used in a residential irrigation system can be grouped into two different categories based upon the application. Automatic valves are those valves that are used to turn water on and off on a set schedule using an irrigation timer or controller. Manual valves are used where the need to turn the water off or on is infrequent or for special purposes.

Within the group of automatic valves, the most common is the electric diaphragm valve. These valves get their name because a diaphragm inside the valve moves up and down to turn the water on and off. A diaphragm valve used to control a group of sprinklers is also called a zone valve, control valve, remote control valve, or an electric valve. A hydraulic valve is also a diaphragm valve and is used as a zone valve. Hydraulic valves are no longer a standard for installation in new residential irrigation systems, but they can still be found in many existing systems and are made by some manufacturers. An indexing valve is a valve that indexes or moves from one station to the next each time the water to the valve is turned off. It does not require any electrical power. These are used to disperse water from condensation of heating and cooling systems or similar water sources that purge water on a regular cycle using an irrigation system.

Manual valves are those such as ball valves, gate valves, and quick coupling valves. Gate valves and ball valves are both used as isolation valves to separate one section of piping from another. A quick coupling valve is used as an access point to the main line, much like a hose bib, spigot, or water faucet. The applications for these valve types are provided in table 11.

Table 11. Valve applications

Valve type	Application	
	Automatic	Manual
Electric diaphragm valve	✓	
Hydraulic diaphragm valve	✓	
Indexing valve	✓	
Ball valve		✓
Gate valve		✓
Quick coupler valve		✓
Hose bib		✓

Electric Diaphragm Valves

Electric diaphragm valves (see fig. 38) are made in different sizes to handle different amounts of flow in gallons per minute. Valve sizes for residential and commercial valves are ¾-, 1-, 1¼-, 1½-, and 2-inch. The most common size for residential use is 1 inch. The dimension of the valve refers to the size of the inlet. Some models of valves are only made with 1-inch inlets.

Figure 38. Residential diaphragm valve

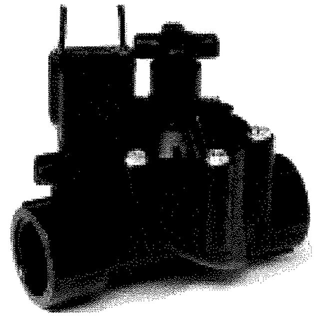


Photo courtesy of Weathermatic®.

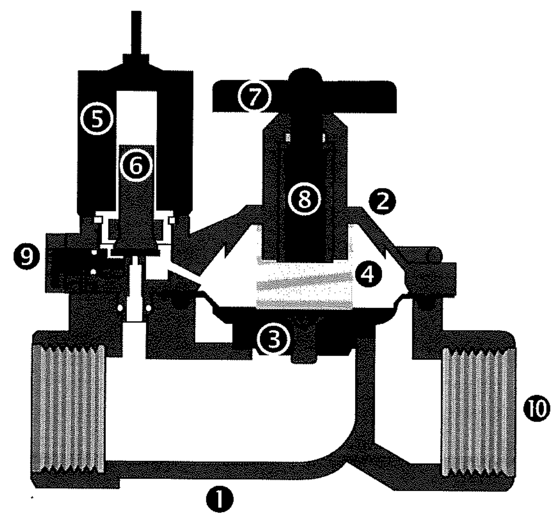
Valves are constructed out of different types of plastic or bronze. The plastic valves are most popular because they are economical as well as durable. Bronze valves are rarely used in residential applications. The plastic used is either a UV-resistant PVC for the standard valves or a glass-filled nylon resin for the heavy duty valves.

The Parts of a Diaphragm Valve

The major parts shown in figure 39 are common among all diaphragm valves.

Figure 39. Parts of a diaphragm valve

1. Body
2. Bonnet
3. Diaphragm
4. Diaphragm spring
5. Solenoid and spring
6. Solenoid plunger
7. Flow control handle
8. Flow control stem
9. Manual operator (manual bleed)
10. Inlet



Redrawn from Weathermatic®.

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The body of the valve and the bonnet of the valve are held together with screws or bolts for the majority of the models of valves. There is one style of diaphragm valve where the bonnet threads onto the body like a lid of a jar. These valves are called jar-top valves (see fig. 40).

Figure 40. A jar-top valve

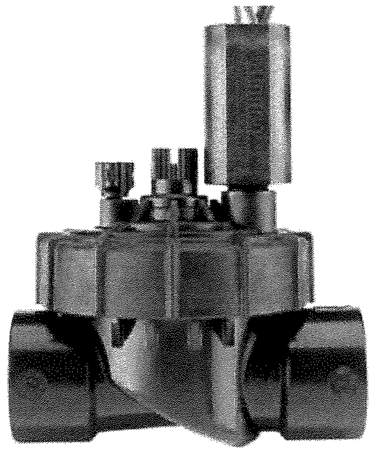


Photo courtesy of Hunter®.

The diaphragm is the flexible divider between the bonnet and the body. It is held in place using the force that holds the bonnet to the body. The diaphragm is made of different kinds of flexible plastic or rubber and serves to both start and stop the flow of water out of the valve. It also acts as the seal between the bonnet and body. The diaphragm spring helps the valve close by keeping the diaphragm from being stuck to the top of the inside of the bonnet.

The flow control handle is attached to the flow control stem. The stem is threaded into the bonnet so that it can move up and down as the handle is turned. The purpose of the flow control stem is to adjust the valve to the amount of water flowing through it when open. If the flow control is all the way open and the flow through the valve is not at the upper limits of its flow range, the valve may take too long to shut off or may even stay open when automatically turned off.

The flow control is NOT the emergency off handle. Turning down the flow control handle will force the diaphragm down until it sits on the body to stop the flow of water. If the valve is staying on because of a rock or other debris stuck between the diaphragm and the body, this will crush the debris and possibly damage the diaphragm or the body of the valve where the diaphragm makes the seal — sometimes both. A damaged diaphragm is a relatively simple repair, but replacing the valve body because the diaphragm seat has been chipped means digging up and cutting out the valve.

The solenoid is the device that activates the hydraulic movements of opening and closing the valve when the irrigation system is running in automatic. It has coiled wire inside (see fig. 41) that creates a magnetic field when energized with a low voltage current (less than 30 volts) sent by the irrigation controller. This magnetic field acts to lift the solenoid plunger and holds it up to keep the valve on. There are two wire leads that come out of the solenoid that are connected to the field wires coming from the irrigation controller.

The valve can also be operated manually. Depending on the brand and model of the diaphragm valve, the manual operator (or bleed screw or bleed plug) turns the valve on or off in one of two ways. If the valve has a little lever (see fig. 42) outside the solenoid it can operate the valve by pushing up the plunger in the solenoid, similar to the way the magnetic field does. Turning the lever up moves the solenoid plunger up and the valve turns on. Turning the lever back down turns it off.

Figure 41. What a solenoid looks like inside

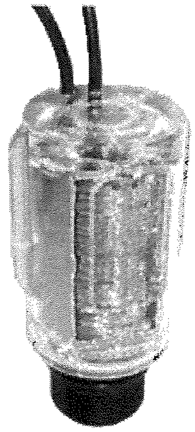
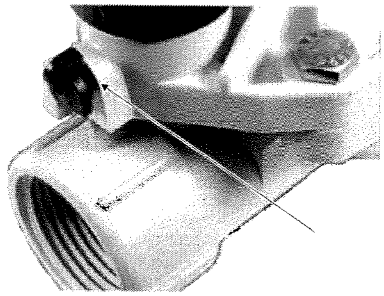


Figure 42. Solenoid bleed lever



All brands of valves can be manually operated by simply twisting the solenoid open a quarter or half turn until the valve turns on (see fig. 43). Unscrewing the solenoid accomplishes the same as the lever in that it lifts the solenoid plunger to turn on the valve. Tightening the solenoid back down will turn off the valve. Twisting the solenoid open too far will cause it to come off the bonnet. Stop when water begins to weep out from under the solenoid. Do not use a tool when tightening; hand tightening will provide enough force to create a seal. Some brands mold manual activation method instructions into the side of the solenoid.

Some brands or models use an external bleed screw to manually operate the valve. This screw can be located either on the top of the bonnet or in the middle of the flow control handle (see fig. 44). To manually operate the valve using the bleed screw, twist the screw by hand until water begins to weep out around the screw and the valve turns on. To turn the valve off manually, hand-tighten the screw. A small rubber o-ring on both types of the bleed screws provides the seal. Many brands and models offer two types of manual operation such as the external bleed screw and twisting solenoid (see figs. 43 and 44).

Figure 43. Valve manual operation

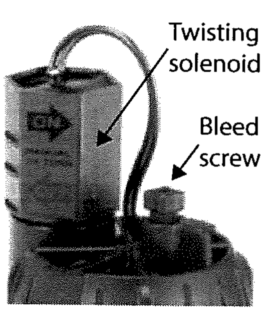


Photo courtesy of Rain Bird®.

Figure 44. Valve manual operation

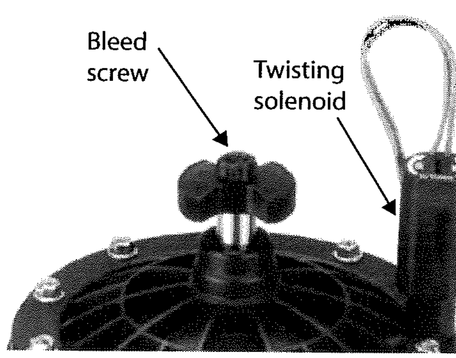


Photo courtesy of Hunter®.

Notes

Notes

The following are a number of different configurations of diaphragm valves to fit different applications:

- globe valve
- angle valve
- globe/angle valve
- anti-siphon valve

The globe configuration for a diaphragm valve is the most common (see fig. 45). The flow enters the inlet on the side of the valve and exits on the opposite side. All valves have a direction arrow molded into the plastic on one side of the valve indicating the direction of the flow. Check for the direction of the flow when installing each valve.

Figure 45. Globe valve

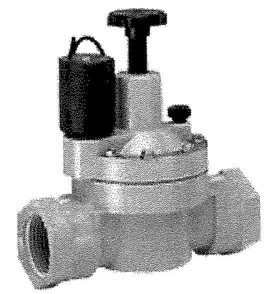


Photo courtesy of Irritrol®.

There are two versions of globe valves:

- forward flow
- reverse flow

Both versions operate in exactly the same way. The difference is how the water flows through the valve. In a forward flow valve, the water is ported through the diaphragm in the center. In a reverse flow valve, the diaphragm port is located on the outer edges. In practical terms, this is only evident if the diaphragm is torn. The forward flow valve will stay on with a torn diaphragm and the reverse flow valve will stay off. Knowing the difference is important when troubleshooting a valve.

An angle valve is made to have the flow enter the valve from the bottom inlet and exit the valve on the side (see fig. 46). The configuration allows the installer to aim the valve in any direction and it takes up less room in the valve box.

The globe/angle configuration is a combination of both (see fig. 47). The valve is made so it can be used like an angle valve with the flow entering from the bottom inlet or like a globe valve through the side inlet. A threaded plug comes with each globe/angle valve to install into the inlet that is not being used.

The anti-siphon valve combines a diaphragm valve and an atmospheric pressure vacuum breaker, or backflow preventer (see fig. 48). This is used on systems where a single backflow prevention device for the entire system is not practical. This valve must be installed so that it is at least 6 inches above the highest sprinkler on the zone it controls. Local plumbing codes will dictate whether or not an anti-siphon valve may be used.

Figure 46. Angle valve

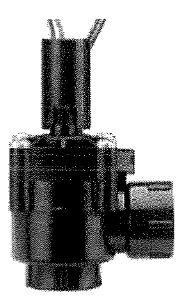


Photo courtesy of Hunter®.

Figure 47. Globe/angle valve

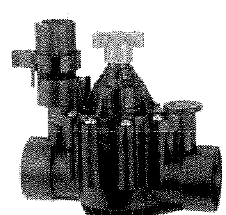


Photo courtesy of Rain Bird®.

Figure 48. Anti-siphon valve

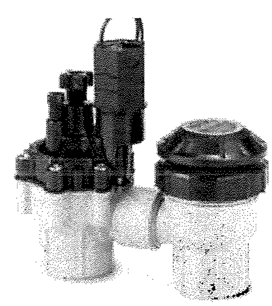


Photo courtesy of Rain Bird®.

Notes

The standard method of connecting the valve to the pipe is using a threaded fitting (see figs. 49 and 50). Therefore, the standard for diaphragm valves is a female threaded inlet that will accommodate the threaded fitting that is cemented onto the pipe. There are also configurations of some brands that have male threaded inlets.

Another type of connection is solvent weld. Most manufacturers offer their 1-inch models of valves in a slip or socket version that is connected to the pipe using the same solvent weld cement that is used to connect the PVC pipe to the PVC fittings (see fig. 51). This also eliminates the need for a fitting to cement onto the pipe before attaching to the pipe.

Some brands have a 1-inch valve configured with a barbed fitting on the outlet and a 1-inch male thread on the inlet for systems using polyethylene [PE] pipe (see fig. 52).

Figure 49. Female thread

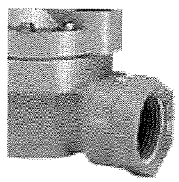


Photo courtesy of Irritrol®.

Figure 50. Male x male threaded

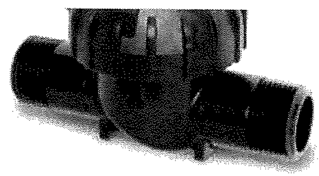


Photo courtesy of Rain Bird®.

Figure 51. Solvent weld

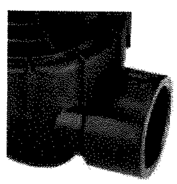


Photo courtesy of Hunter®.

Figure 52. Barb x male threaded

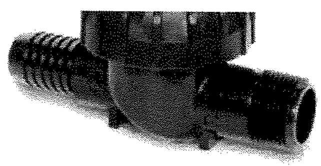


Photo courtesy of Rain Bird®.

Operation of a Diaphragm Valve

A diaphragm valve with an electric solenoid is just a hydraulic valve that is electrically actuated (turned on and off). The electric diaphragm valve and the hydraulic diaphragm valve operate using exactly the same principles of physics.

$$\textbf{force} = \textbf{pressure \{psi\}} \times \textbf{area \{in.}^2\textbf{\}}$$

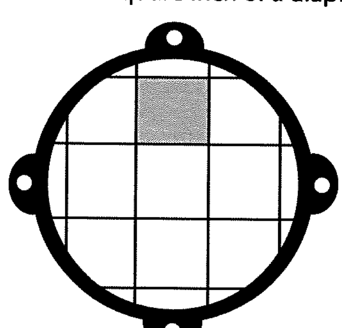
If 60 psi is pushing on 1 square inch (see fig. 53), then:

$$\text{force} = 60 \times 1 = 60 \text{ pounds of force}$$

If 60 psi is pushing on 10 square inches, then:

$$\text{force} = 60 \times 10 = 600 \text{ pounds of force}$$

Figure 53. One square inch of a diaphragm



Notes

If the area of a diaphragm that was in contact with water measured 3.4 inches by 3.4 inches, then:

$$3.4 \times 3.4 = 11.56 \text{ square inches in contact with the water}$$

If a water pressure of 60 psi is pushing on those 11.56 square inches of a diaphragm (see fig. 54), then:

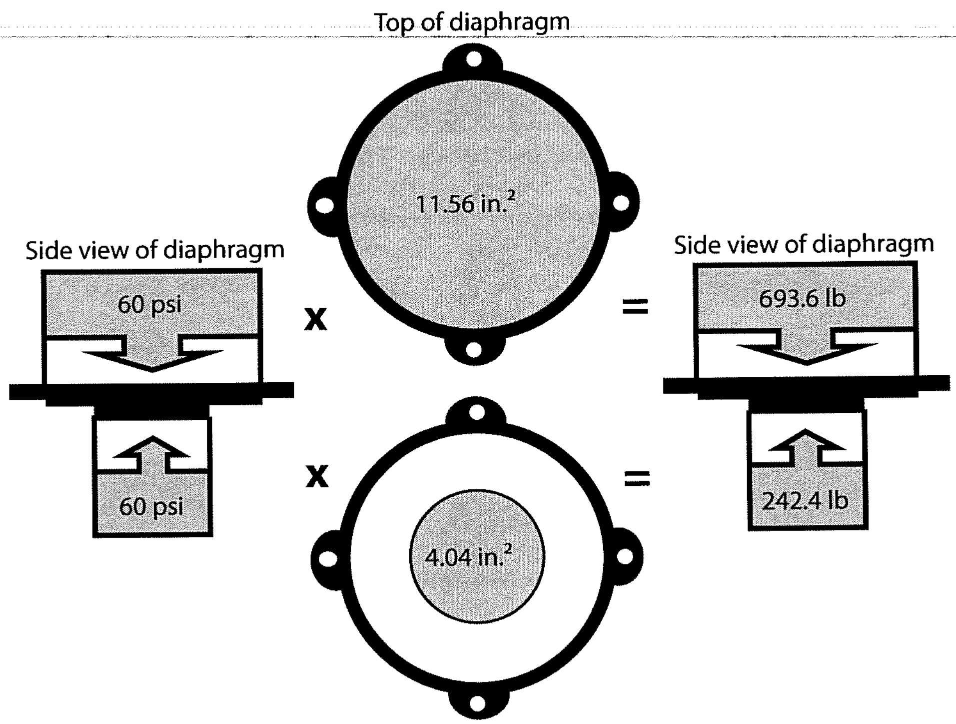
$$60 \times 11.56 = 693.6 \text{ pounds of force from the water pressure}$$

And, if the bottom of the diaphragm only had water contacting 4.04 square inches (because the valve was designed that way) and the water pressure was 60 psi, then:

$$60 \times 4.04 = 242.4 \text{ pounds of force from the water pressure}$$

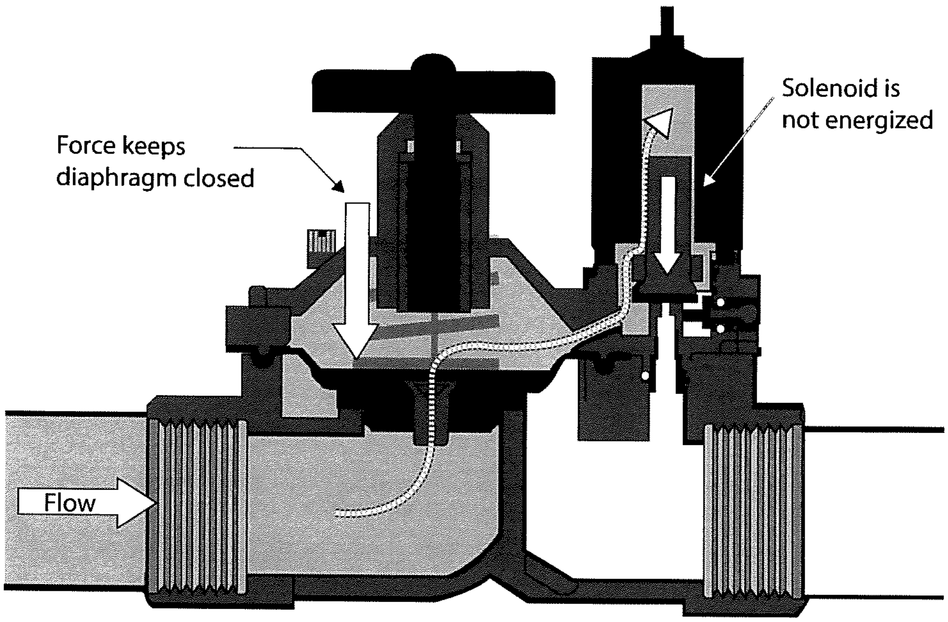
With 693.6 pounds of force pushing down on the top of the diaphragm and 242.4 pounds of force pushing up on the bottom of the diaphragm, the diaphragm will stay down (closed).

Figure 54. Surface areas of a diaphragm



This is the principle of hydraulic force that keeps the valve closed. Figure 55 is a cutaway of a forward flow valve. The water travels into the valve and then up through the center of the diaphragm into the bonnet area above the diaphragm. It also flows through another port in the bonnet into the solenoid area surrounding the solenoid plunger. Because the solenoid plunger is not energized, it is seated, plugging the exhaust port below the solenoid plunger. This allows the water to fill the area above the diaphragm. The static water pressure is 60 psi on top of the diaphragm and below. But because the 60 psi is pushing down on more square inches on top of the diaphragm than on the bottom, the valve stays closed.

Figure 55. Forward flow valve closed

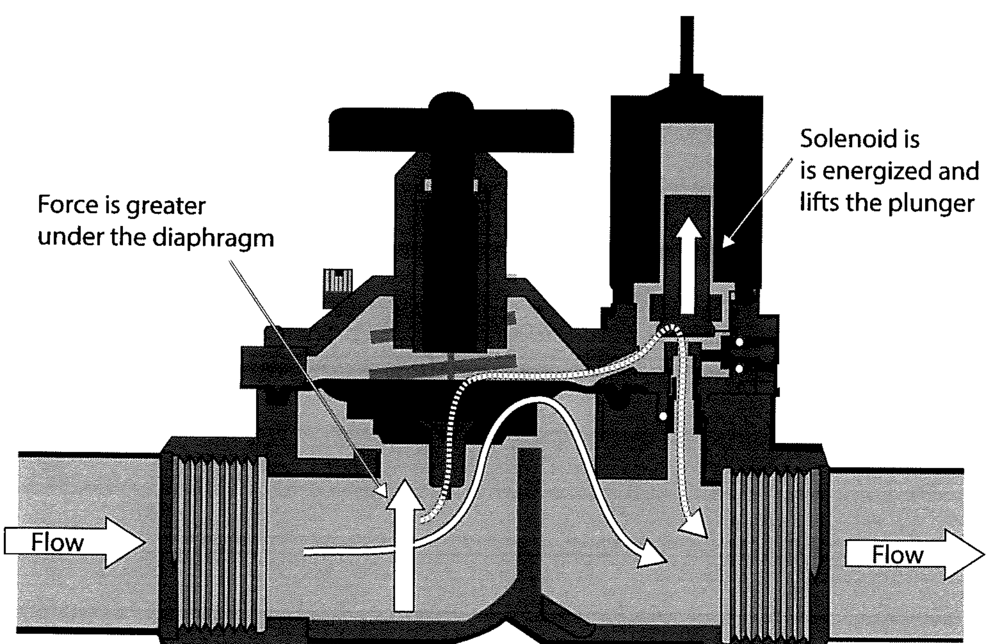


Redrawn from Weathermatic®.

When the force of the water on the top of the diaphragm is greater than the force on the bottom, the diaphragm seals against the inside of the body (the diaphragm seat) to keep the valve closed (see fig. 55).

When the solenoid is energized by the irrigation controller, a magnetic field is created and the solenoid plunger inside the solenoid lifts just enough for water to travel down the exhaust port below it. As the water is discharged from the area in the bonnet above the diaphragm, the force on top of the valve is reduced. The force below the diaphragm is now greater than the force on top; the diaphragm flexes up off the diaphragm seat and the water flows up and over to exit the valve (see fig. 56).

Figure 56. Forward flow valve open



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Notes

✍ Notes

When manually operating the valve by twisting the solenoid, the solenoid plunger is lifted off the seat in the same manner as the magnetic force created by the solenoid. When using the bleed plug to manually operate the valve, the force is relieved directly outside the bonnet instead of out the exhaust port under the solenoid. It accomplishes the same reduction of the force above the diaphragm and the valve opens. Water will continue to weep out of the bleed plug.

The operation of a reverse flow valve is identical to the forward flow valve. There are two main differences between the two. In a forward flow valve, the water is pushing on the bottom of the diaphragm in the center (see fig. 57). In a reverse flow valve, the water is pushing on the bottom of the diaphragm in a ring around the outside of the valve (see fig. 58). If the diaphragm tears or gets a hole in it, a forward flow valve will stay on, but a reverse flow valve will shut off.

Figure 57. Bottom of a diaphragm for a forward flow valve

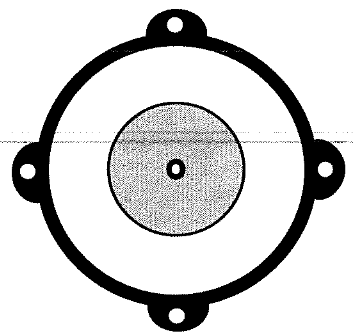
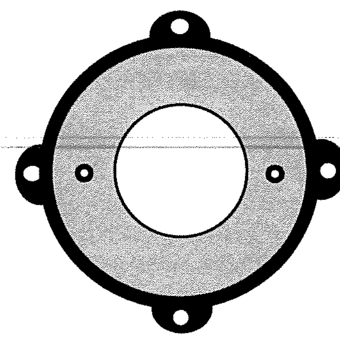


Figure 58. Bottom of a diaphragm for a reverse flow valve



The second difference between a reverse and forward flow valve is the way the water is ported through the diaphragm to get into the bonnet area. The diaphragm of a forward flow valve is ported through the center. A reverse flow valve diaphragm is ported from the outside. It can have one or two ports depending on the design. When the valve is open, water continues to flow through these ports. Either valve type has some method of keeping the port from clogging. (If the port clogs, the valve will not close.) This is accomplished in one of three ways: a filter is inserted into the port and the flow of the water when the valve is open cleans the filter; a metering pin attached to the flow control stem goes through the port and keeps the port clean as the diaphragm moves up and down; and the port is placed where the diaphragm flexes to dislodge any debris.

The reverse flow valves in figures 59 and 60 show the flow path of the water to close and open the valves. Notice that the water flows through the diaphragm through the outside areas and not the middle. This flow through the diaphragm, into the solenoid, then out the exhaust port continues while the valve is open.

Figure 59. Reverse flow valve closed

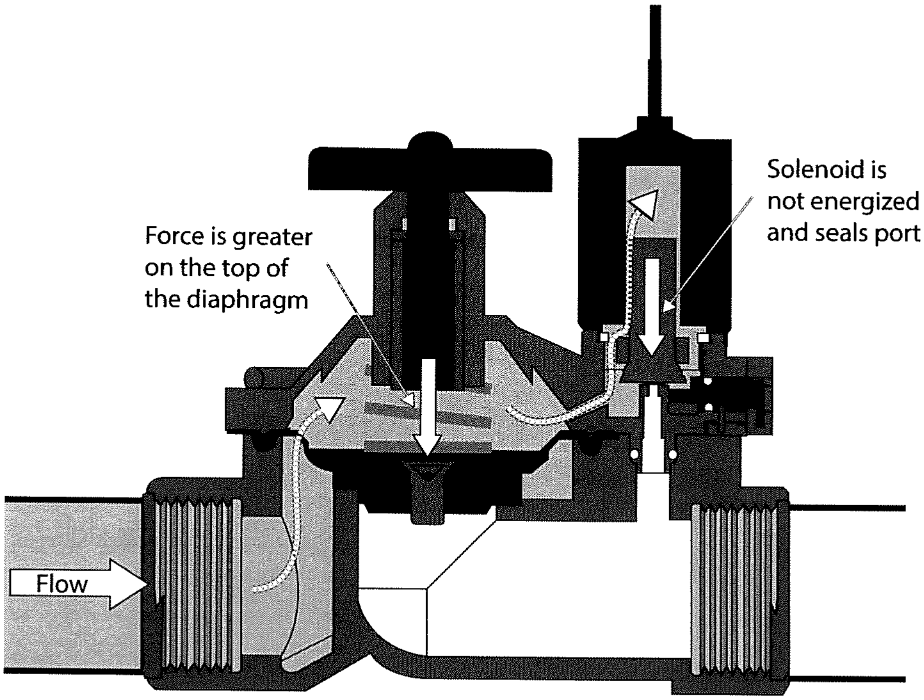


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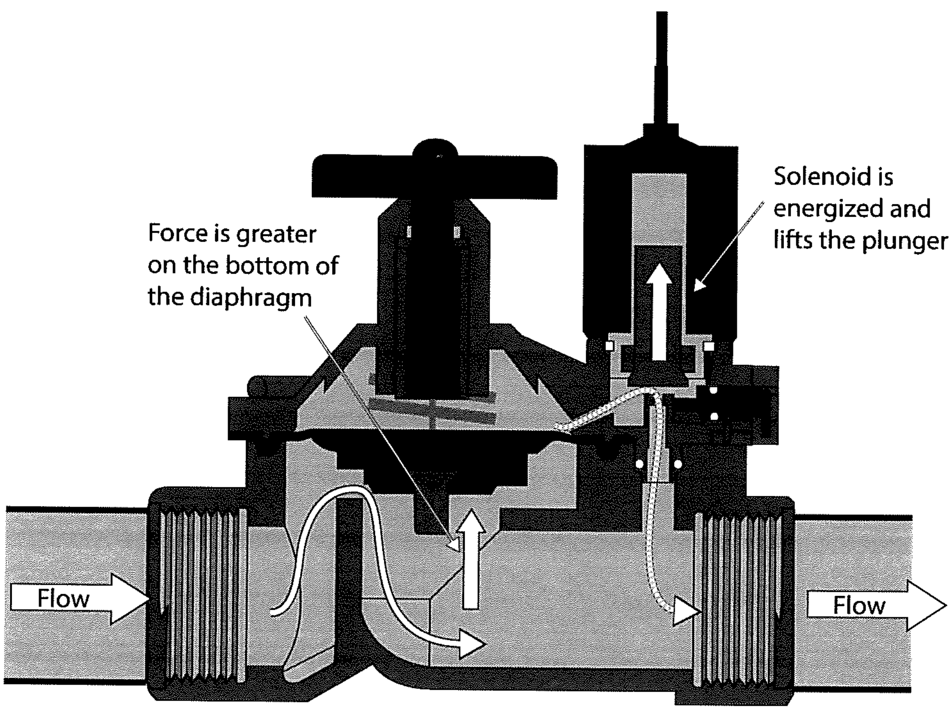
Figure 60. Reverse flow valve open



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Notes

✍ Notes

A valve size is selected based on the flow of water (gallons per minute) and the amount of pressure loss resulting from that flow. The optimal pressure loss for a valve is between 2 to 5 pounds, but if a manufacturer shows a pressure loss value on their chart for a specific model of valve, then the valve will work properly.

Table 12 shows example valve pressure losses. This indicates that for this model of valve, the 1-inch size can be used for flow of between 1 and 40 gpm. The optimum flow would be 1–20 gpm. The valve will still function fine at flows of 30 and 40 gpm, but the system must be designed to allow for the higher pressure losses. This 1-inch valve would not be used for flows of 50 gpm or higher.

Table 12. Valve pressure loss example

Flow {gpm}	1"	1½"	2"
1	3.2		
5	3.6		
10	4.0		
20	5.0		
30	6.3	1.8	
40	7.5	3.4	1.4
50		4.9	1.6
75		11.8	3.1
100		18.7	5.3
125			8.5
150			12.3

The 1½-inch would be used for flows of 30–100 gpm, but not above or below that range. Similarly, the 2-inch sized valve could be used between 40 and 120 gpm, but not above or below that flow range. A minimum valve pressure loss is necessary for the valve to operate properly, so valves should not be used for flows below the listed flow.

Note: The proper hydraulic calculation must be done to ensure the irrigation design can support whatever pressure loss is created by a valve.

Hydraulic Valves

Hydraulic valves are the same type of valve as a diaphragm valve. The only difference is that the hydraulic valve is not actuated at the valve electrically. Instead of wire from the controller to the valve, a hydraulic valve is connected to the controller by ¼-inch hydraulic tubing. The tubing carries water that is ported into the bonnet area on top of the diaphragm. This water creates the force to keep the diaphragm down and the valve closed. When the controller turns off the water in the ¼-inch tubing, the force on the bottom of the diaphragm becomes greater than on top and the diaphragm lifts to open the valve.

Indexing Valves

Indexing valves are specialty valves that operate automatically without electricity. This is accomplished with a cam that enters the indexing valve and exits to zone one when the water is turned on at the source. When the water source is turned off, the water stops and the cam switches or "indexes" over to zone two. When the water source is turned on the next time, the water enters the indexing valve and exits to zone two. When the water source is turned off, the cam indexes the water to zone three. This continues advancing each time the water is turned off and then back on.

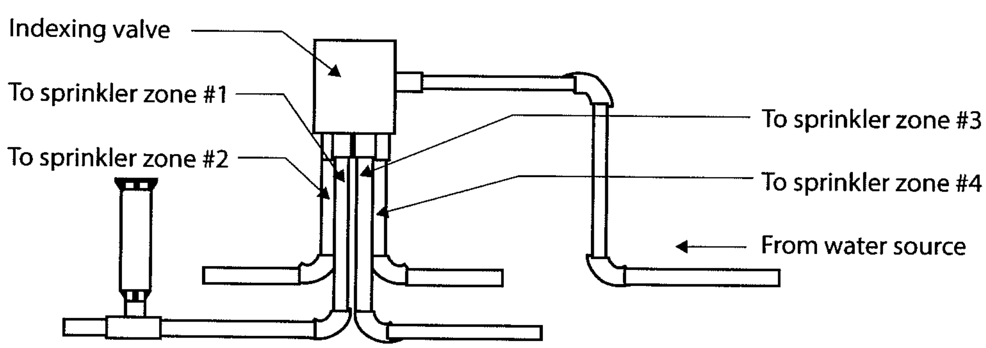
The indexing valve can be piped directly from the pump or a regular diaphragm valve. This valve can also be used with an alternate water source such as the discharge of a heating and cooling system that uses a pump to regularly drain water from the HVAC system.

These valves can be purchased in 4-zone (see fig. 61) and 6-zone models. If only two zones are required, a 6-inch section of pipe with a cap is installed in the unwanted outlets of the valve. Figure 62 illustrates an example installation.

Figure 61. Four-zone indexing valve

Photo courtesy of K Rain®.

Figure 62. Example of 4-zone indexing valve installation



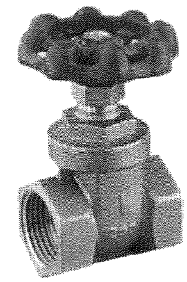
Notes

Gate Valves

Gate valves used in residential irrigation systems are typically used to isolate sections of a piping system, as a main shutoff valve located near the water source for the irrigation system or as a manual zone valve if no automatic operation is required.

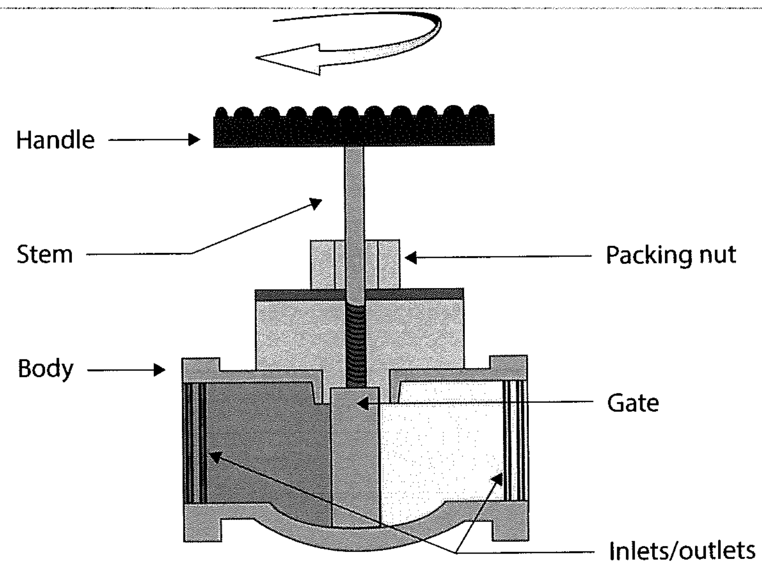
Gate valves are made of PVC or bronze (also referred to as brass), but bronze gate valves are the preferred material because of its durability (see fig. 63).

Figure 63. Bronze gate valve



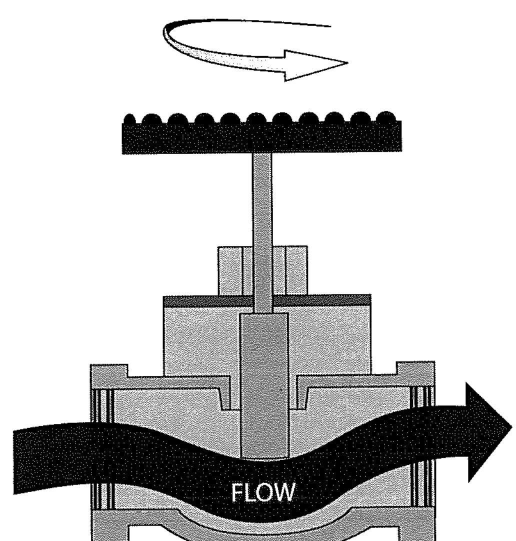
The handle of the gate valve is attached to the stem, which is attached to the gate and seals against the body when closed. The valve operates by turning the handle counterclockwise to open. As the handle turns the stem, the gate rises and allows the water to flow through the body (see figs. 64 and 65). The packing nut is filled with a packing material to keep the water from leaking out by the stem. With frequent operation, the packing may need to be replaced; therefore, gate valves are ideal for infrequent use.

Figure 64. Gate closed



There are two types of gate valves: rising stem and nonrising stem. The stem and handle on the rising stem valve move up with the gate as the valve is opened. Only the gate moves up on the nonrising stem valve. The nonrising stem gate valve is preferred because it simplifies the clearance requirements for installing the valve in a valve box.

Figure 65. Gate open



Ball Valves

Ball valves are another type of manual valve. Ball valves are made in various sizes. The most common sizes for resi/com applications are ¾-, 1-, 1¼-, 1½-, and 2-inch.

The bodies of ball valves are made of PVC or bronze (see figs. 66 and 67). The ball is a Teflon® coated plastic. PVC ball valves are standard with a T handle and bronze valves with a lever handle. Either type can be ordered with other handle styles. PVC ball valves have either threaded connections or a socket to connect directly to the pipe without a fitting. Bronze valves are threaded only.

True union ball valves have a threaded union incorporated into the valve (see fig. 68). The inlets to the unions can be either threaded or socket (for solvent welding the pipe directly in the top of the valve).

Figure 66. PVC ball valve

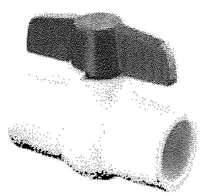


Figure 67. Bronze ball valve

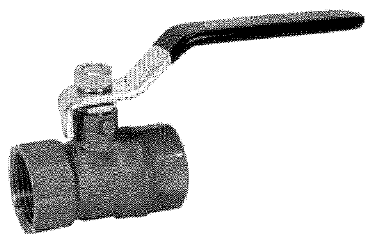


Figure 68. True union PVC ball valve

Photo courtesy of Spears®.

The seal between the ball and the ball seat on the inside of the body of the valve is created by an o-ring. Inexpensive ball valves will have rubber o-rings, while the better grades will be synthetic such a Viton® or EPDM.

Ball valves have a ball with a port through it that is attached to the stem and handle (see fig. 69). When the port is aligned with the inlet and outlet, water can flow through the valve. When the handle is turned a quarter turn, the ball rotates and the port is oriented to 90° to the inlet and outlet (see fig. 70). With the port in this position, no water can flow through the valve.

Figure 69. PVC ball valve cutaway — open

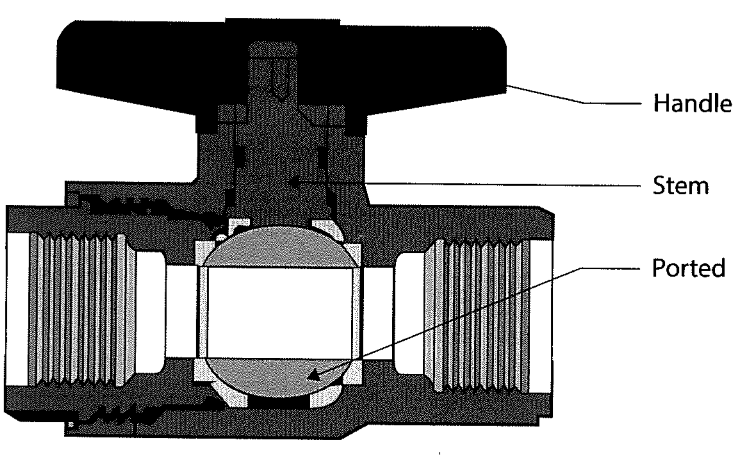
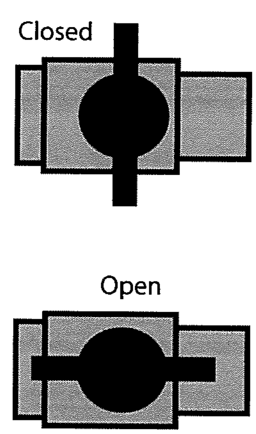


Figure 70. Ball valve handle operation



Notes

Notes

Quick Coupler Valves

Quick couplers are manual valves that allow an access point to the water in the irrigation system and are also referred to as snap valves. A quick coupler valve is shown in figure 71. A garden hose or sprinkler can be attached to a quick coupler key. In a residential irrigation system, a quick coupler is usually located wherever a hose bib would be, such as along a driveway, next to a patio area, in the back portion of a garden, etc. Quick couplers are sized by the inlet dimensions. The size range includes ¾-, 1-, 1¼-, and 1½-inch, with the ¾-inch size being the most common for residential applications. The valves are made in one- and two-piece versions. The two-piece models can be taken apart to replace the o-rings on the piston.

Figure 71. Quick coupler and single lug key

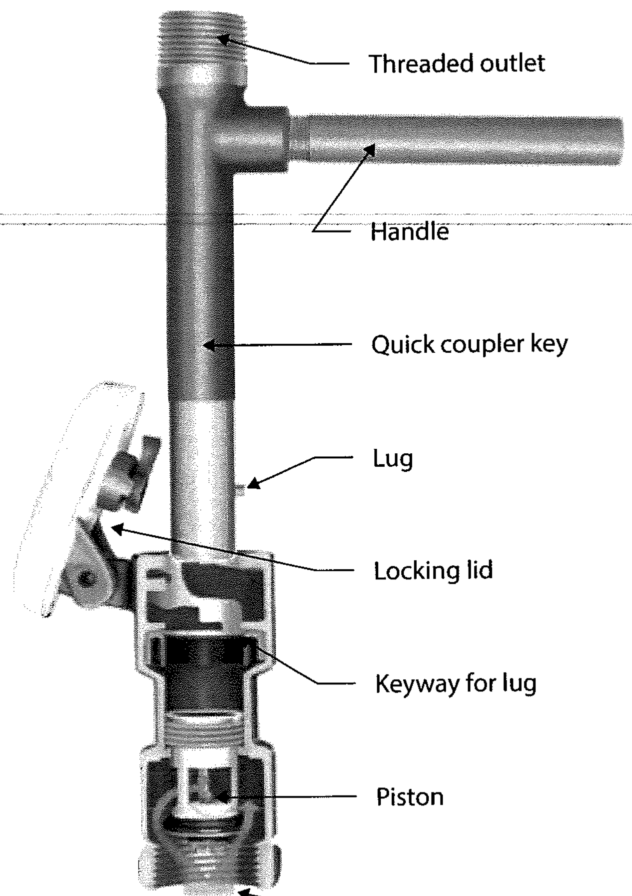


Photo courtesy of Rain Bird®.

The valve is manually operated by inserting the quick coupler key into the key inlet at the top of the quick coupler valve and rotating. As the key is turned, the lug on the side of the key follows the keyway inside the valve, and the bottom of the key pushes down the spring-loaded piston to open the valve. When the quick coupler key is reversed, the spring pushes the piston against the seat and the rubber o-ring seals off the water to close the valve.

The quick coupler key is threaded on the top end to attach a sprinkler or a garden hose (using a hose swivel). The key and hose swivel must be purchased separately. Quick couplers and keys are made with either one lug or two. The double lug key is better for constant use and the single lug key is ideal for occasional use. Keys are sized by both the corresponding quick couple valve size and the threaded outlet dimensions.

As an example for a residential application, the ¾-inch quick coupler will accept a ¾-inch quick coupler key. The ¾-inch key will have a ¾-inch male thread on the top with a ½-inch female thread on the inside. It will accept the ¾-inch hose swivel.

The quick coupler has a hinged top to keep the opening from becoming compacted with soil and to mark the location. A locking lid is an option for some models and a standard feature for others. Even with the top, quick couplers are frequently installed in a valve box.

Some brands offer a model that has two "wings" as part of the valve body that keep the valve from spinning loose when removing the quick coupler key (see fig. 72). There is also an aftermarket accessory made to bolt onto a standard quick coupler valve body to keep it from twisting when the quick coupler key is inserted to activate water flow.

There is also a model of quick coupler valve that uses an Acme thread instead of a lug (or lugs) to attach the key into the valve. The Acme thread is a coarse thread that allows the key to push down on the piston more gradually than with a lug. This means the key rotates more like a faucet and takes at least one full rotation to fully open the valve compared to a standard key with a lug which is fully open with a quarter turn.

Figure 72. Quick coupler with stabilizing wings, key, and hose swivel

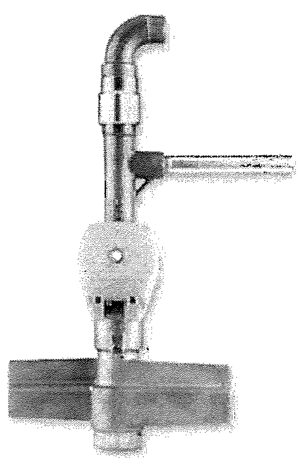


Photo courtesy of Hunter®.

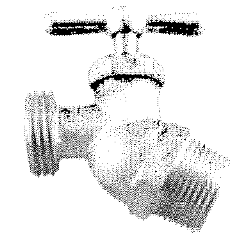
Notes

✍ Notes

Hose Bibs

Hose bibs, shown in figure 73, are used in residential irrigation systems like a quick coupler. They are often added as an extra hose connection away from the house. Hose bibs also serve as a separate water source for manual irrigation such as drip irrigation for a vegetable garden (see fig. 74).

Figure 73. Hose bib



When not mounted on a house, hose bibs are installed on a ½- or ¾-inch riser secured to a wooden post or a metal stake in the ground for stability. Hose bibs for residential applications should be made of bronze and require protection from winter freezing in northern climates along with the rest of the irrigation system.

Figure 74. Hose bib in the garden adapted to be the water supply for a manual drip irrigation system

Air Vent and Vacuum Relief

Combination air release valves perform the function of both an air and vacuum valve and an air release valve within one single body. Such valves should be installed at the high points of the system and near the end of the pressurized main line.

Valve Boxes

The primary purpose of a valve box is to provide easy access to an underground component, such as a zone or manuals valve. Having a valve in a valve box can also make it easier to locate the valve in the landscape and can provide a level of security against vandalism with the right options.

It is important to consider that a valve box must be suitable for the application in order to prevent injury. An improvised valve box has the potential to collapse under the weight of a human, vehicle, or mowing equipment. It is always best to use a box manufactured for the intended use with the proper fitting lid.

Boxes used in nonvehicular areas are typically made of polyethylene. Valve box options include colors to blend into the landscape (green, black, and tan) or lavender to identify reclaimed water, bolt-down lids for security, and extensions to increase the height.

Standard in-ground box sizes and their functions are listed below:

- 6-inch round (approx. 6–7 inches) (see fig. 75)
    - manual valves, quick couplers, and wire splices
- 10-inch round (approx. 10–12 inches) (see fig. 76)
    - one 1-inch electric valve
- standard rectangle (approx. 12–14 inches × 15–19 inches) (see fig. 77)
    - one 1-inch valve with a y-filter and pressure reducer for drip
    - two to three 1-inch valves (see fig. 78)
    - one 1½-inch or 2-inch valve
- jumbo rectangular (approx. 17 inches × 30 inches)
    - two to three 1½-inch or 2-inch valves
- valve box extensions (see fig. 79)
    - used to raise the height
    - typically 6 inches tall
    - fits into top of valve box and lid fits into top of extension box

The proper size of the box allows for easy access for maintenance. Boxes that are too small or have too many components jammed into them will require the box to be dug up before any maintenance can be performed. This is costly and unsightly.

Figure 75. 6-inch box (not for zone valves)

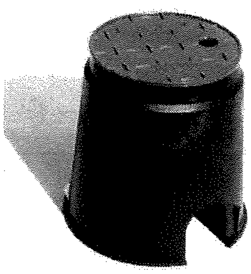


Photo courtesy of Old Castle-Carson.

Figure 76. Single valve in 10" valve box

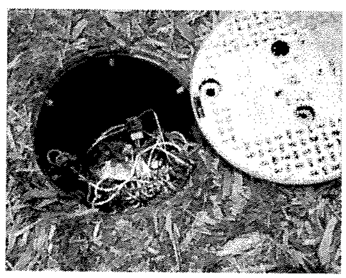


Figure 77. Standard rectangular valve box

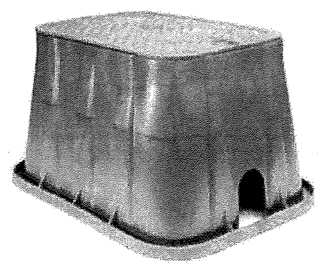


Photo courtesy of NDS.

Figure 78. Multiple valves in rectangular box

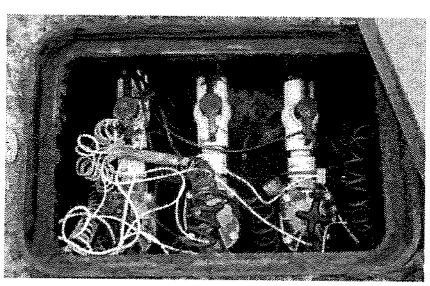


Figure 79. Valve box extension

Photo courtesy of Rain Bird®.

Notes

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Controllers and Wiring

The control system of a residential or commercial irrigation system consists of the controller, the wires from the controller to the zone valves, and the rain switch or other sensors that provide input to the controller. Recent advances in technology have introduced a new group of controllers that monitor conditions and automatically adjust system operations based on the programming in the controller. These are called smart controllers.

Controller Configurations

Controllers can be classified into two different types: electromechanical and solid state. Electromechanical controllers are the original type of electronic controller for irrigation prior to the use of solid state circuitry. The electromechanical controller used an electric motor to turn an hour wheel that kept the hour of the day, which then turned the day wheel and kept the day of the week. The motor also turned the timing wheel that regulated how long each station operated.

These controllers are no longer manufactured in a version that operates multiple irrigation zones, but there are thousands still in operation on irrigation systems everywhere. One of the industry's most famous electromechanical controllers is the Rain Bird RC 7 shown in figure 80.

Figure 80. Electromechanical controller

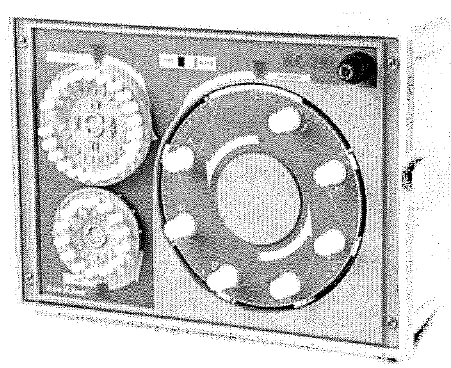

Photo courtesy of Rain Bird®.

The controllers in the solid state category can be divided into two different groups: dial and keypad. Dial controllers, often called hybrid controllers, use a dial as the main method of selecting programming to enter into the controller in combination with a few buttons or keys. A keypad controller includes a keypad instead of a dial to enter the programming.

Controllers are manufactured for two different applications: indoors and outdoors. Indoor configurations are not made to be exposed to the elements. They characteristically have external transformers that plug directly into a wall receptacle. As a result, indoor controllers must be placed inside a pump house, garage, mechanical room, or a weatherproof enclosure.

Outdoor controllers are enclosed in a weatherproof cabinet with the transformer inside the cabinet (see fig. 81). The valve wires and power wires go through openings in the bottom of the cabinet. If the controller is installed outdoors, these wires must be in conduit and the conduit must have the proper fittings to secure it to the cabinet and make it weatherproof as per electrical codes. If these outdoor controllers are installed indoors, many local electrical codes will permit the use of a pigtail. The pigtail has bare wires on one end to be wired into the controller's transformer and a male plug on the other end that is plugged into a wall receptacle. Note: The actual connection of the line voltage wires (120 volts) may need to be made by a licensed electrician. Check local electrical codes.

Figure 81. Outdoor controller

Photo courtesy of Hunter®.

Parts of an Irrigation Controller

The irrigation controller is also called the timer or clock. It is the control center that activates the zone valves telling them when to turn on and when to turn off. The decision of which controller brand or model to select is driven by the application requirements for programming capabilities, location of the controller, and size and layout of the irrigation system. The modern controller is constructed of robust electronics capable of withstanding most weather conditions.

Controllers have the following four basic components:

- The ***cabinet*** or ***enclosure houses*** all of the electronics and connections. The outdoor models have doors and most are lockable.
- The ***face plate*** is the front of the controller and contains the buttons, dials, and displays used to program and manually operate the controller.
- The ***transformer*** steps down the line voltage (120 volts) to under 30 volts.
- The ***output board*** has the terminal strip where the wires to the valves attach to the controller and the lighting protection circuitry. Some models have a cover over the terminal strip and others have hinged face packs that swing out of the way to provide access to the terminal strip. Depending on the make and model, some controllers separate the terminal strip from the output board and others combine the output board and the face plate.

✍ Notes

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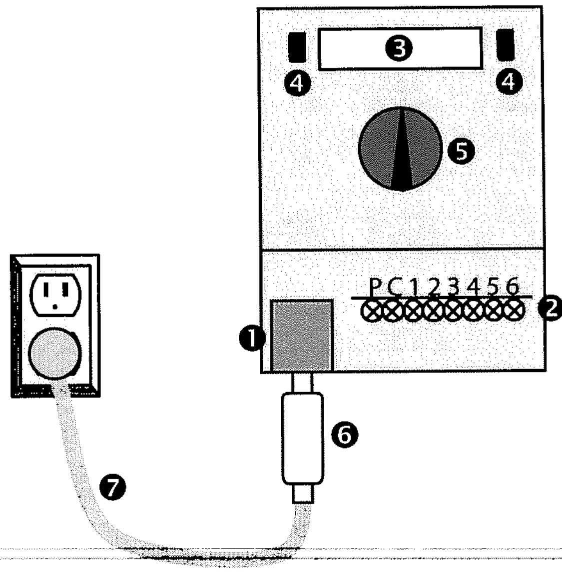
Figures 82 and 83 outline the typical arrangement on the inside of two different types of controllers.

Figure 82. Outdoor controller components



Outdoor "dial-type" controller

❶ Transformer (internal)

❷ Terminal strip

❸ Display

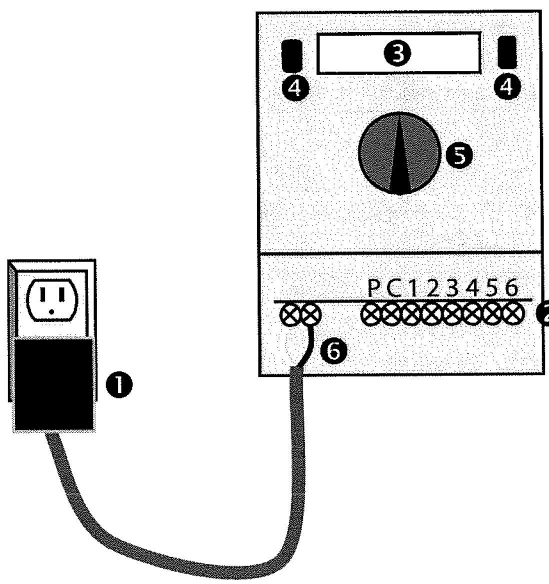
❹ Selector buttons

❺ Dial

❻ Junction box

❼ Pigtail (indoor) or wire conduit (outdoor)

Figure 83. Indoor controller components



Indoor "dial-type" controller

❶ Transformer (external)

❷ Terminal strip

❸ Display

❹ Selector buttons

❺ Dial

❻ Transformer terminals

There are a variety of connector types used on the terminal strip to attach the valve wires. The clip- or snap-type terminals (see fig. 84) provide for easy and fast installation but may have limitations as to the maximum gauge of wire or the number of wires they will accept. The screw terminal (see fig. 85) can accept a variety of wire sizes. There are also modular terminal strips that allow a controller to be expanded in 3 or 4 station increments (see fig. 86). The actual wire connections are often clip-type.

Figure 84. Clip-type terminal strip

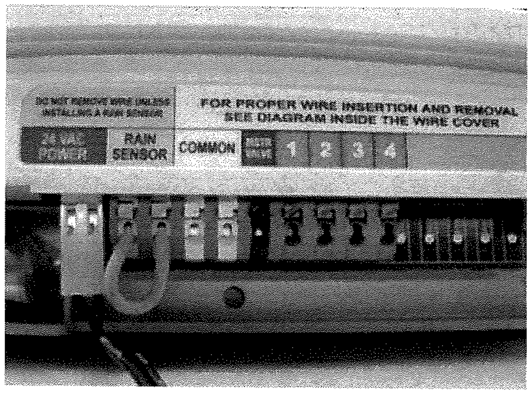


Figure 85. Screw-type terminal strip

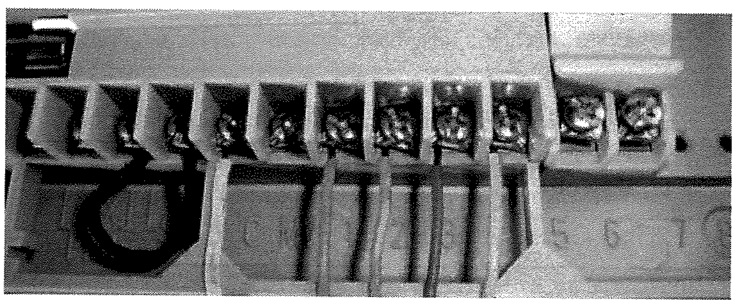
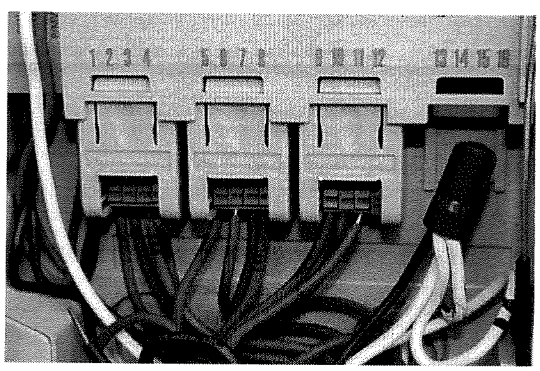


Figure 86. Modular terminal strip



✍ Notes

✍ Notes

A controller normally has one or two common terminals and one terminal for each station. Check the operating instructions to determine the electrical capabilities of the controller and how many valves can be operated by one station. Also, check how many stations can be electrically operated at the same time, including the pump start or master valve.

All controllers have a terminal for a pump start or master valve. When using a pump start relay, the controller can turn on the pump when it turns on the station to activate the zone valves. A master valve is an outstanding way to protect against catastrophic failures such as a mainline break or valve that sticks on. It accomplishes this by only supplying water to the main line when the water is needed by the controller. When the controller is off — so is the water at the source.

Some terminal strips have a place to attach rain switches. These controllers have a factory-installed jumper wire connecting the two rain sensor terminals. This allows the controller to function if there is not a rain sensor attached. The jumper is removed when the rain sensor wires are installed.

There can be terminals to access the 24-volt power of the controller for powering wireless rain switches and soil moisture sensors. On indoor controllers, there is typically a terminal for attaching the external transformer.

The circuitry required for protection against electrical surges or lightning is not available on the least expensive controllers, and it would not make financial sense to include it. The cost of such circuitry would be more than the cost for the entire controller. For a typical residential irrigation controller, any surge protection is built in to keep people and property safe and not to protect the controller, wire, or solenoids from being damaged.

Standard Programming Capabilities

Each controller has a number of basic programming functions that are standard on nearly every brand and model. These functions and their general capabilities are outlined in table 13.

Table 13. Standard programming capabilities

Calendar	Holds the time of day like a standard clock, as well as the day of the week and the day, month, and year. This information is held in the controller during a power outage as long as the backup battery has power (usually one 9-volt or two AA cells).
Program	Most controllers have three or four programs. Each one can be programmed to start independently of or concurrently with other programs. This feature will allow the turf valve to turn on three times per week on one program and the shrub valves to turn on once per week. Each program has its own schedule of days to operate.
Schedule	The days that a program is to operate. Typically, the options are to run the program by the day of the week, such as every other day on odd days, every other day on even days, or at a programmable interval (e.g., once every second day, third day, fourth day, etc. up to once every 30 days).
Start time	The time of day that a series of stations will automatically come on and run in sequence according to their numerical order (e.g., station 3 runs then turns off and station 4 comes on immediately). Each program typically has multiple start times available for use.
Station run time	The duration the station will run. Only stations with time programmed will operate automatically. There is typically only one zone valve wired to each station, but there are occasions to have two.
Manual start	Starts the sequence of station run times manually for a specified run time per station. This run time is selected or there is a default time, typically 10 minutes per station. Once each station operates in sequence for the manual run time, the controller returns to automatic.
Run	This sets the controller to operate automatically according to the information entered into the program. Some controllers require that a setting is in Run or the programming will not happen automatically. Most will run in automatic unless the controller is set to Off.
Off	The manual setting that prevents the controller from operating any station automatically. It will not affect the programming held in the controller. For the controller to run automatically again, it must be manually switched to Run.
Seasonal adjust	This sets the controller to operate automatically according to the information entered into the program. Some controllers require to be set in Run or the programming will not happen automatically. Most will run in automatic unless the controller is set to Off.

Each brand and model of controller could have many other functions in addition to those in table 13. In regions that are subject to water shortages or restriction, the features required for the controller to meet those restrictions affect the complexity of the programming and the cost of the controller. There is generally a direct relationship between the capabilities of the controller and the difficulty of programming. The controller's capabilities also affect its cost.

Notes

Notes

These basic functions work in a hierarchy that can be difficult to comprehend. It is important to understand how each function is related to other functions to prevent programming errors that either apply too much or not enough irrigation water. In either case, the landscape plant material could be put in danger and possible water damage to structures and hardscape could occur if the programming is not done correctly. Table 14 provides an example of controller programming hierarchy.

For example, a controller has six stations and three programs with three start times per program. The Run and Off functions affect all programs and all start times. The calendar is for all programs to use. Each of the three programs has its own schedule.

For the controller in the example to operate automatically, the following must be completed:

- the time, day, month, and years must be set
- one program must have at least one start time set to the time of day the stations are to start operating
- all stations that are desired to operate must have time entered into the program
- the controller must be set to Run (or for some models, not set to Off)

Table 14. Example of controller programming hierarchy

Run/Off		
Calendar Date — day, month, year		
Program A	**Program B**	**Program C**
Schedule	Schedule	Schedule
Start time 1	Start time 1	Start time 1
Station run time 1	Station run time 1	Station run time 1
Station run time 2	Station run time 2	Station run time 2
Station run time 3	Station run time 3	Station run time 3
Station run time 4	Station run time 4	Station run time 4
Station run time 5	Station run time 5	Station run time 5
Station run time 6	Station run time 6	Station run time 6
Start time 2	Start time 2	Start time 2
Station run time 1	Station run time 1	Station run time 1
Station run time 2	Station run time 2	Station run time 2
Station run time 3	Station run time 3	Station run time 3
Station run time 4	Station run time 4	Station run time 4
Station run time 5	Station run time 5	Station run time 5
Station run time 6	Station run time 6	Station run time 6
Start time 3	Start time 3	Start time 3
Station run time 1	Station run time 1	Station run time 1
Station run time 2	Station run time 2	Station run time 2
Station run time 3	Station run time 3	Station run time 3
Station run time 4	Station run time 4	Station run time 4
Station run time 5	Station run time 5	Station run time 5
Station run time 6	Station run time 6	Station run time 6

The Valve Wire

There are a number of sizes and types of wire used to connect the zone valves to the controller (see fig. 87). The most important characteristic is that the wire is rated for direct burial. This will be indicated by a "UF" or "Underground" stamped on the wire, which stands for underground feeder (see fig. 88). This means that the outside coating of the wire, called the jacket, is waterproof and resistant to chemicals normally found in the soil. The jacket on UF wire is made from PVC or PE, with PE becoming more predominant because of cost.

The copper wire, called the conductor, can be either solid or stranded. A solid conductor is the most common for wiring between the controller and the valves. It has one single copper strand covered by the UF jacket. Stranded wire is a bundle of smaller wires twisted together to make up the conductor. This type of wire is most commonly used for the wire connected directly to the solenoid of a valve. While it is not typically used for the valve wiring, it is the standard for wire used in low voltage landscape lighting.

Figure 87. Standard irrigation wire gauges
(L to R: 18-8 multiconductor, 18 AWG, 14 AWG)

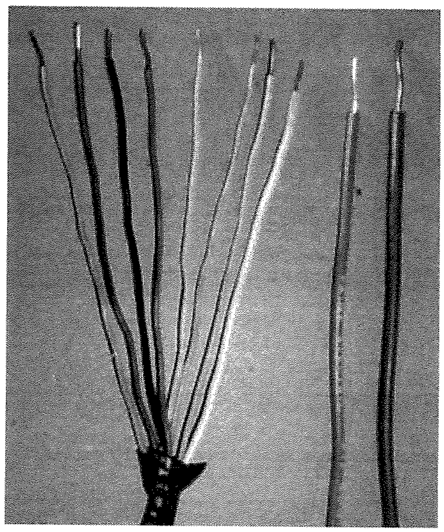
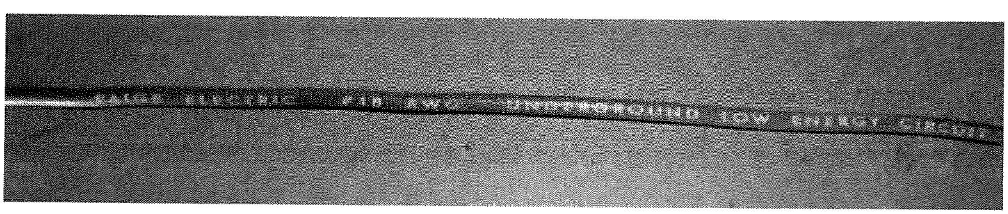


Figure 88. Labeling on irrigation wire

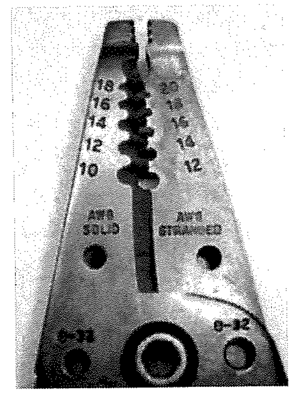


Notes

✍ Notes

The size of the solid conductor is referred to as the gauge of the wire and is designated by the American wire gauge (AWG) number. The smallest size of wire used for irrigation is 18 AWG and the largest is typically not larger than 12 AWG (found on commercial, golf, and sports field irrigation systems). The smaller sized wire has the larger AWG number — 18 AWG is smaller than 14 AWG. The actual diameter of solid conductor wire is slightly smaller than the same gauge of stranded wire. This fact is shown on wire strippers (see fig. 89).

Figure 89. AWG sizes



Wire used in an irrigation system is single conductor wire (one jacketed wire) or multiconductor. Multiconductor wire consists of two or more 18-gauge jacketed wires enclosed in one outer jacket. Multiconductor wire is made with multiple conductors ranging from 2 to 25 conductors (18–2 to 18–25 multiconductor). It is common to use one more conductor than the total number of valves, plus one for the common wire. For example, for a 6-zone system, there would be six valve wires, one common wire, and one spare wire for a total of eight conductors; therefore, 18–8 multiconductor wire would be used.

Irrigation wire is available in many different colors. The standard application of colors is to use a white wire for the common wire and red wires for the power wire to each valve. The common wire is connected to the controller at the common terminal designated with a C on the terminal strip and one solenoid wire for each of the valves. Each of the power wires is connected to each of the station terminals on the controller and runs to each individual valve (see fig. 90). Some installers prefer to use a different color of single conductor wire (other than white) for each zone valve.

When multiconductor wire is used, the white wire is connected to the common C terminal, and a different colored wire is used for the power wire to each valve (see fig. 91).

Figure 90. Valve wiring using single conductor wire

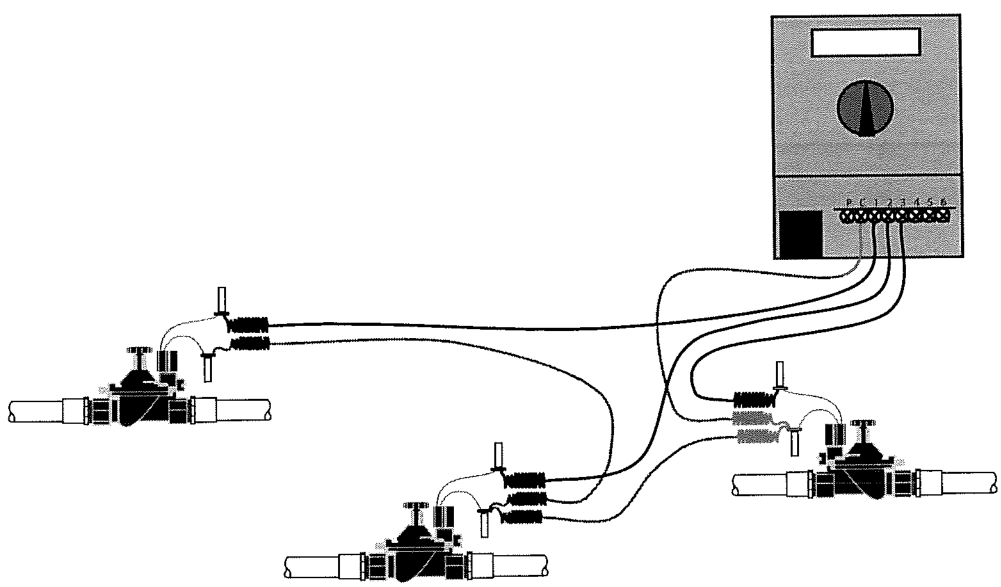
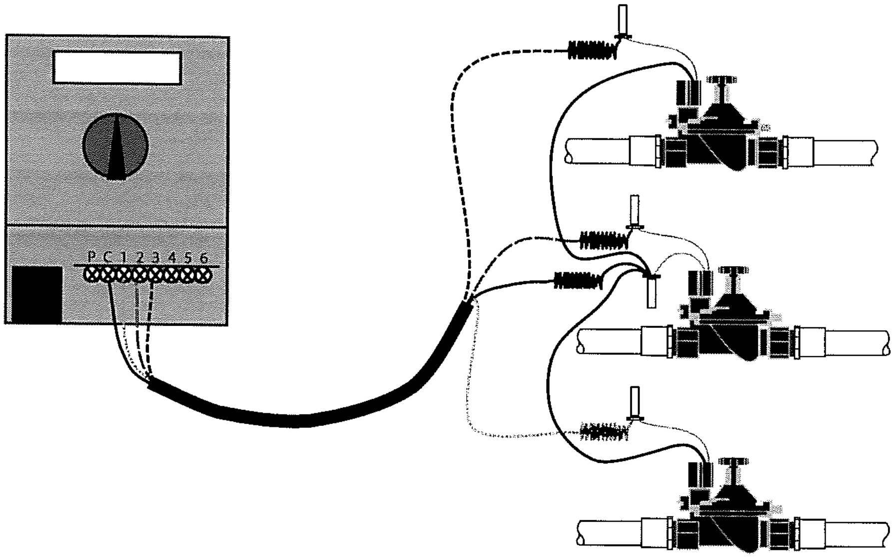


Figure 91. Valve wiring using multiconductor wire



Notes

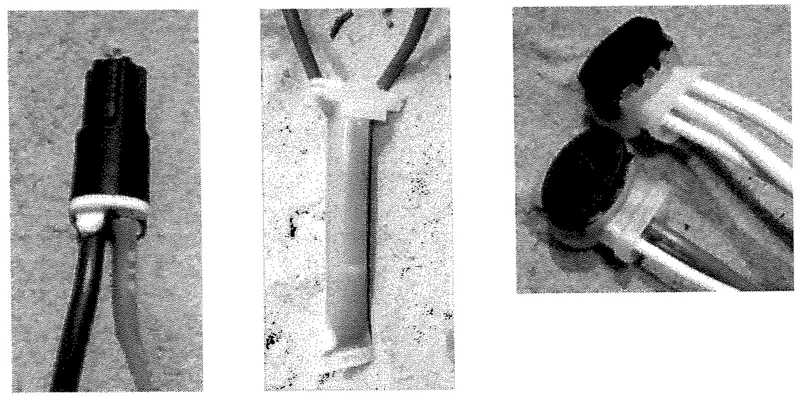
The wire splice is typically the weakest point of the electrical circuit. It is also the least costly to make correctly, but an incorrect splice is the most expensive to find and repair. Whether for a repair or an installation, it is critical to make the proper splice every time two wires are connected. (Be sure to place all splices in a valve box or splice box.)

A proper wire splice consists of correctly removing or stripping the insulating jacket off the conductor, mechanically holding the conductors together to make an electrical connection, and then waterproofing the splice. The components used to make a proper splice are called waterproof connectors.

There are two types of waterproof connectors. A one-step connector combines the gripping of the two conductors to hold them together and the waterproofing using a gel (also called grease or paste) to form a waterproof environment around the jacket and conductor. One form of these connectors is similar to an oversized wire nut filled with waterproofing gel (see fig. 92, left). Another form has self-stripping contacts inside the connector filled with waterproofing gel (see fig. 92, right). The contacts pierce the insulating jacket of the wire and grip the conductors to make the electrical connection.

A two-step connector uses a standard wire nut to hold the two conductors together and then the wire nut is inserted into a tube filled with waterproofing gel (see fig. 92, center). It is important to select a brand of two-step connector that has a suitable quality waterproofing gel and that the tube is deep enough so the insulating jacket can be well covered by the gel.

Figure 92. Waterproof connectors



When using any waterproof connector, the key to the waterproofing process is to make sure the gel covers not only the copper conductor but also overlaps to cover the insulating jacket. It is the bond between the gel and the insulating jacket that seals out the moisture. The more area of the wire jacket that is covered by the gel, the better the seal and the splice.

Sensors

While there are a number of different types of sensors that can be installed on an irrigation system, the sensors typically installed on a residential system can include a rain sensor (see fig. 93), a weather sensor, and/or a soil moisture sensor.

The rain sensor is also called a rain switch. It is designed to interrupt or prevent the irrigation system from operating when there has been enough rain. They are an important part of even the most basic water conservation program. Many states have regulations in place requiring a rain sensor on every irrigation controller.

Rain sensors are made in two configurations: wired and wireless. The wireless rain sensors require a connection to the 24-volt power at the controller. Both configurations of sensors must be placed where the rain can hit them and the sprinklers cannot. Rain sensors should also be located where they can be checked periodically to ensure proper functioning.

The most common rain sensors have a stack of disks that are made to absorb rain and dry out like turf (see fig. 94). As the disks absorb the rain, they swell until they open a normally closed microswitch. This opens the circuit in the common between the controller and the valves, so no power can reach the valves. When the disks dry enough, the microswitch closes and the controller can operate the valves. This operation does not affect the controller.

The method to test a rain sensor is to manually turn on a station from the controller, then press and hold the small stem sticking up from the middle of the top cap (see fig. 95). This procedure will open the microswitch and the sprinklers will turn off. Release the pressure on the stem, the microswitch closes, and the sprinkler comes back on.

Notes

Figure 93.
Rain sensor

Figure 94.
Disk stack

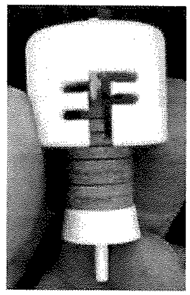
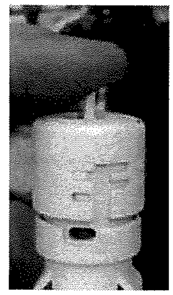


Figure 95.
Testing a rain sensor



Notes

Soil moisture sensors [SMS] have been greatly enhanced as a result of improved technology. They can be added to an existing controller, regardless of make or model, or they can be an integral part of an SMS controller that is designed to work with a soil sensor (see "Smart Controller" section to follow). Soil moisture sensors work much like a rain sensor in that they measure the moisture in the soil and do not allow irrigation if soil moisture is greater than a specified level.

In general, the sensor is buried 4–6 inches in the ground at a location that is representative of the average soil and exposure conditions of the turf (see figs. 96 and 97). The sensor is wired to the controller either by a separate wire or by wiring the sensor to the closest zone valve. The add-on sensor wire connects to an interface next to the controller, which is wired to the controller. The SMS controller does not require an interface.

The soil around the sensor is soaked overnight and the interface either manually or automatically reads the amount of soil moisture. The interface is then programmed to a certain percentage of the full moisture level to prevent the irrigation controller from turning on valves when soil moisture is at or above this predefined level.

Figure 96. Soil moisture sensor installed

Photo courtesy of Baseline™.

Figure 97. Soil moisture sensor

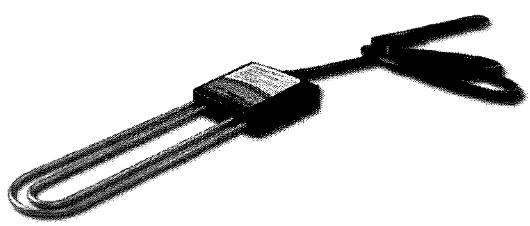


Photo courtesy of Acclima.

Smart Controllers

The term ***smart controllers*** has come to be associated with an irrigation controller that monitors the actual growing conditions and then automatically adjusts water application for each zone for the conditions present in the zone. Smart controllers might water three times one week and only once the next week based on the plant needs and environmental factors. These controllers take careful and accurate programming and should only be adjusted by highly trained professionals — not homeowners. It only takes a small mistake to negate the outstanding efficiencies provided by these smart controllers.

✍ Notes

Smart controllers can determine the water needs of the plants either by using the weather to calculate the evapotranspiration [ET] rate or an SMS to measure the amount of water in the soil. Some controllers can use both.

The controllers using ET (see figs. 98 and 99) can have an attached ET sensor or receive ET information via satellite broadcast. The ET sensor models have one sensor per controller located in a full-sun exposure where rainfall can be measured. Some models have a wireless sensor. Typically, the ET controller is programmed with soil, sprinkler, plant, and exposure data for each station. It reads the weather information and calculates when and how much water to apply for each station.

ET controllers receiving the ET data via satellite communication function the same way as those with their own ET sensor. Usually there is a minimal subscription cost to be connected to the information system that broadcasts the ET data.

Controllers that monitor soil moisture use the same sensors as described in the previous "Sensors" section. The advantage of an SMS controller (see fig. 100) over an add-on interface is that the SMS controller can control the amount of water applied based on the moisture needed in the soil and not just suspend irrigation when the soil moisture is above the specified level. The SMS controllers are also programmed with the soil, sprinkler, plant, and exposure data for each station. The SMS controller reads the moisture level for one or multiple sensors (depending on the model) then calculates when and how much water to apply.

Smart controllers are at the center of the conservation efforts of many water agencies and embraced by progressive irrigation companies as a solution to water restrictions. They are a powerful management tool when combined with proper design, quality installation, and regular maintenance programs.

Figure 98. ET-based smart controller

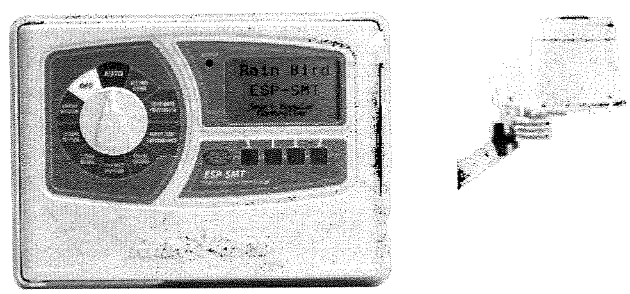


Photo courtesy of Rain Bird®.

Figure 99. ET-based smart controller

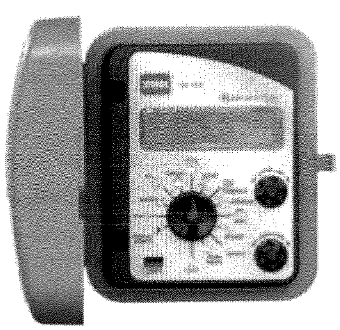


Photo courtesy of Toro®.

Figure 100. SMS controller and sensor

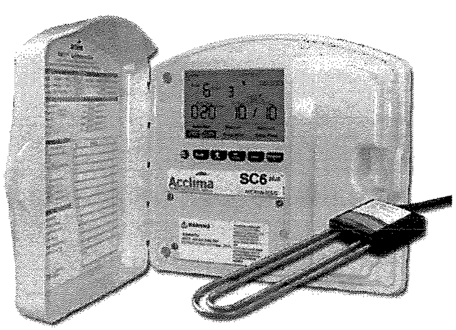


Photo courtesy of Acclima.

The Pipe and Fittings

The piping system of an irrigation system is the labyrinth of pipes and fittings that deliver the water from the source to the sprinklers. The residential piping system has two principle components: the ***main line*** and the ***laterals***. The main line is the pipe that is connected to the water source and runs to each zone valve; it is under constant pressure whether the irrigation system is operating or not. The zone valves are one of the principle components connected to the main line. The pipe and fittings that make up the assembly connecting the valves to the main line is called a ***manifold***. Other components also connected to the main line can be manual valves (isolation valves), pressure regulators, filters, quick coupler valves, the backflow prevention device, etc.

The lateral lines are the sections of pipe coming out of each zone valve and connecting to each of the sprinklers within that zone. There will be a section of laterals (lateral lines) for each zone valve. All of the connections of pipe to other pipe and pipe to other irrigation components require the proper type and size of fitting, as well as the proper joint sealant or cement.

The standard pipe and fittings used in a landscape irrigation system are made of either PVC or PE. Galvanized steel was once the standard, but it is no longer preferred because of the cost of the materials and installation, as well as the limited hydraulic performance. To better understand the terminology associated with pipe and fittings, refer to table 15 as the definitions of the terminology are provided in the following section.

Table 15. Example of a friction loss chart

Irrigation Association Friction Loss Chart 2008

Class 200 PVC IPS Plastic Pipe

ANSI/ASAE S376.2 ASTM D2241 SDR 21 C=150

psi loss per 100 feet of pipe

Nominal size	Shown for convenience Class 315 1/2"		3/4"		1"		1-1/4"		1-1/2"		2"	
Avg. ID	0.696		0.910		1.169		1.482		1.700		2.129	
Pipe OD	0.840		1.050		1.315		1.660		1.900		2.375	
Avg. wall	0.072		0.070		0.073		0.089		0.100		0.123	
Min. wall	0.062		0.060		0.063		0.079		0.090		0.113	
Flow {gpm}	Velocity {ft/s}	psi loss	Velocity {ft/s}	psi loss	Velocity {ft/s}	psi loss	Velocity {ft/s}	psi loss	Velocity {ft/s}	psi loss	Velocity {ft/s}	psi loss
1	0.84	0.25	0.49	0.07	0.30	0.02	0.19	0.01	0.14	0.00		
2	1.68	0.90	0.99	0.24	0.60	0.07	0.37	0.02	0.28	0.01	0.18	0.00
3	2.53	1.90	1.48	0.52	0.90	0.15	0.56	0.05	0.42	0.02	0.27	0.01
4	3.37	3.24	1.97	0.88	1.19	0.26	0.74	0.08	0.56	0.04	0.36	0.01
5	4.21	4.89	2.46	1.33	1.49	0.39	0.93	0.12	0.71	0.06	0.45	0.02
6	5.05	6.86	2.96	1.86	1.79	0.55	1.11	0.17	0.85	0.09	0.54	0.03
7	5.90	9.12	3.45	2.47	2.09	0.73	1.30	0.23	0.99	0.12	0.63	0.04
8	6.74	11.68	3.94	3.17	2.39	0.94	1.49	0.30	1.13	0.15	0.72	0.05
9	7.58	14.53	4.43	3.94	2.69	1.17	1.67	0.37	1.27	0.19	0.81	0.06
10	8.42	17.66	4.93	4.79	2.99	1.42	1.86	0.45	1.41	0.23	0.90	0.08
12	10.11	24.75	5.91	6.71	3.58	1.98	2.23	0.63	1.69	0.32	1.08	0.11
14	11.79	32.93	6.90	8.93	4.18	2.64	2.60	0.83	1.98	0.43	1.26	0.14
16	13.48	42.16	7.88	11.44	4.78	3.38	2.97	1.07	2.26	0.55	1.44	0.18
18	15.16	52.44	8.87	14.23	5.37	4.21	3.34	1.33	2.54	0.68	1.62	0.23
20			9.85	17.29	5.97	5.11	3.72	1.61	2.82	0.83	1.80	0.28

Notes

✍ Notes

Terminology of Pipe and Fittings

The term ***nominal size*** refers to the size of the pipe. It is used as a comparative reference rather than the actual size. For example, what is referred to as 1-inch pipe is not actually 1 inch in diameter. Referring to table 15, 1-inch CL 200 PVC pipe is actually 1.315 inches on the outside and 1.169 inches on the inside. In this case, 1 inch is the nominal size.

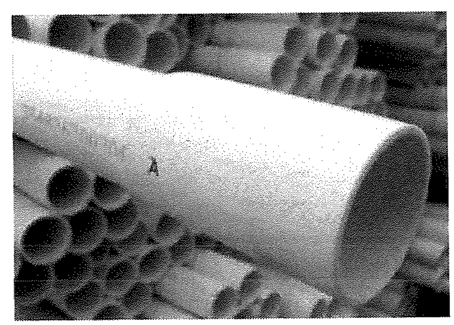
The standard nominal pipe size used in residential irrigation systems varies slightly by region, based on local cultural practices. Some areas use ½- and ¾-inch pipe, but other regions do not use any pipe smaller than 1 inch to keep the number of fittings to a minimum. Many areas will use 1¼-inch pipe, but some skip 1¼ inch and go to 1½ inch. Only the largest residential systems will use 2-inch pipe.

There are different terms when referring to the actual dimensions of pipe. The ***outside diameter*** [OD] is the actual dimension of the outside of the pipe. It is represented as a decimal, not a fraction. The ***wall thickness*** is the actual measure of the pipe wall. It is a key factor in the pressure rating and tensile strength of the pipe. The ***inside dimension*** [ID] of the pipe is determined by the wall thickness. As the wall thickness increases, the ID becomes smaller. Pipe used for irrigation is made to the OD of wrought iron pipe (the predecessor of modern piping) and is referred to as ***iron pipe size*** [IPS]. IPS pipe can be made out of any material. The PVC irrigation pipe is IPS pipe. The pipe used for plumbing such as copper tubing or CPVC is ***copper tube size*** [CTS]. A 1-inch IPS pipe is larger than a 1-inch CTS. ***Working pressure*** is the internal water pressure the pipe can withstand without damage.

Polyvinyl Chloride Pipe

Polyvinyl chloride [PVC] is the most common pipe in residential irrigation. It is manufactured in two different configurations: with or without a belled end. Bell end pipe is made with one end of the pipe belled out to form an integral coupler (see fig. 101). This allows sections of pipe to be connected end-to-end without a separate fitting. Bell end pipe is the standard for irrigation and is manufactured in 20-foot lengths. Most retail sales locations offer pipe in 10-foot lengths with no bell end.

Figure 101. Bell end PVC pipe



There are two classifications or ratings of PVC pipe used for irrigation systems.

PVC Schedule Rating

Schedule rating was the original rating system. All nominal pipe sizes within the schedule rating have the same wall thickness. This constant wall thickness means that as the pipe gets larger in diameter, the working pressure rating gets lower. For example, referring to table 3-16, 1-inch Schedule 40 pipe has the same wall thickness as 3-inch Schedule 40, but the pressure rating goes from 450 psi for 1-inch Schedule 40 to 260 psi for 3-inch Schedule 40. If Schedule 40 pipe is used for residential irrigation, it is used for the main line and not the laterals and should not be used in rocky or severe soil conditions.

Table 16. Working pressure

Working Pressure {psi} By size and type of PVC pipe			
Nominal size	Cl 160 (SDR 26)	Cl 200 (SDR 21)	Sch 40
¾"	160	200	480
1"	160	200	450
1¼"	160	200	370
1½"	160	200	330
2"	160	200	300
2½"	160	200	280
3"	160	200	260
4"	160	200	220
6"	160	200	180

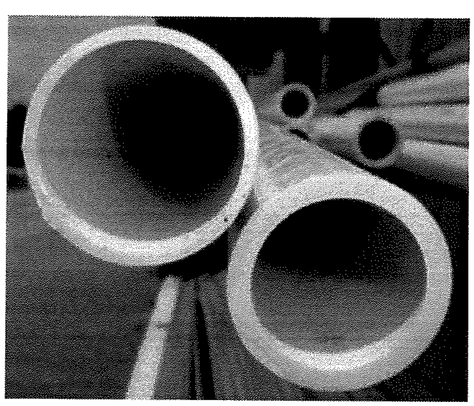
PVC Class Rating

Class rating was created in 1963 to provide a pressure rating system. All nominal sizes of pipe with a class rating have the same working pressure. For example, 1-inch Class 200 has the same working pressure rating as 3-inch Class 200. As the nominal pipe size increases, the wall thickness increases to maintain the same pressure rating.

For residential irrigation, Class 200 is the most common, with Class 160 used in some areas. The smallest size in Class 160 is 1 inch and the smallest size in Class 200 is ¾ inch. Half-inch pipe would be Class 315. Class pipe is also known as PR pipe in some regions (e.g., PR 200 pipe is Class 200 pipe). Class pipe is also referred to as SDR pipe. SDR stands for standard dimensional ratio and is calculated by dividing the outside diameter by the wall thickness (SDR = OD ÷ wall thickness). Class 200 is SDR 21, and Class 160 is SDR 26.

The difference between class pipe and schedule pipe is the wall thickness. For example, figure 102 shows 1-inch Class 200 (left) and 1-inch Schedule 40 pipe (right). The difference in wall thickness can be clearly seen. Since the wall is thicker on the Schedule 40 pipe and the outside diameter is the same, the inside diameter of the Schedule 40 1-inch pipe is smaller that the Class 200 1-inch pipe and it would have greater friction loss.

Figure 102. 1-inch Class 200 and 1-inch Schedule 40 PVC pipe



Notes

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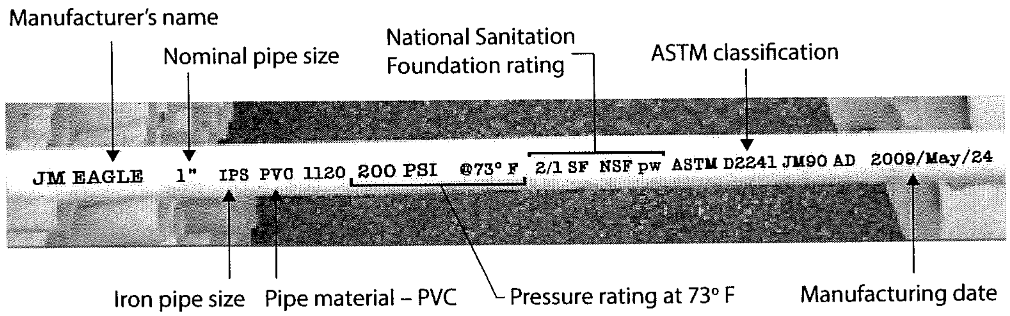
PVC pipe is stamped by the manufacturer to indicate the specific information about the pipe. Figure 103 is an example of typical markings.

Figure 103. Typical PVC pipe markings



PVC pipe is assembled using a solvent weld connection, often referred to as a glued joint. While this term is widely used, there is no glue used in making a proper PVC joint. The products used are PVC cements that actually fuse the PVC components together and fill in the gaps of the joint with PVC resin that is in the cement. More information is provided in the "Fittings" section.

When using a nonpotable water source such as effluent water, local code may require that the pipe be lavender in color to designate that it carries nonpotable water. The lavender pipe is also called purple pipe in many regions. Both class and schedule pipe is made in lavender.

Polyethylene Pipe

Polyethylene [PE] pipe, also called poly pipe, is made in low density, medium density, and high density. The higher the density, the higher the pressure rating will be, but the flexibility will be lower. PE pipe can be made to meet strict engineering specifications (i.e., ASTM standards), or it can be made in a utility grade. For an irrigation system, the utility grade is most often used because of the lower cost. The utility grade has a pressure designation such as 80 psi or 100 psi. This is the working pressure that the pipe can meet.

The inside diameter of PE pipe is the controlling factor. As the pressure rating gets larger and the wall thickness increases, the inside diameter stays the same, but the outside diameter gets larger. As a result, a 1-inch insert fitting will work on all pressure ratings of 1-inch PE pipe.

PE pipe can be found in different places within a residential irrigation system (see figs. 104 and 105). In freezing climates, PE pipe is used for lateral piping. The flexible nature of the PE pipe makes it resistant to breaking and cracking when water freezes in the pipe. When used as lateral piping, the connections of PE pipe are made using an insert fitting and a stainless steel clamp to secure the pipe to the fitting.

Figure 104. Polyethylene [PE] pipe

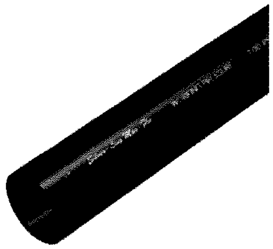


Photo courtesy of Silver-Line®.

Figure 105. Roll of PE pipe

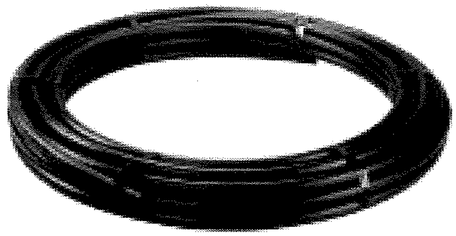


Photo courtesy of Silver-Line®.

Notes

The polyethylene pipe should only be used for the lateral lines of an irrigation system and not the main line because laterals are not under constant pressure. As discussed in the "Fittings" section, the type of joint used to connect PE pipe cannot withstand constant pressure conditions. When used in lateral lines, PE pipe is an excellent alternative for PVC because PE is manufactured in 100-foot rolls and is flexible for installing with a vibratory plow (referred to as pulling in pipe).

PE pipe is also used in the irrigation system in the form of drip tubing used in a microirrigation zone. The drip (also called microirrigation or low volume) tubing is a low density pipe with a thin wall to be used in lower pressures and to allow emitters to be installed by being "punched" into tubing. The connections are made using compression fittings or clamp fittings around the outside of the pipe.

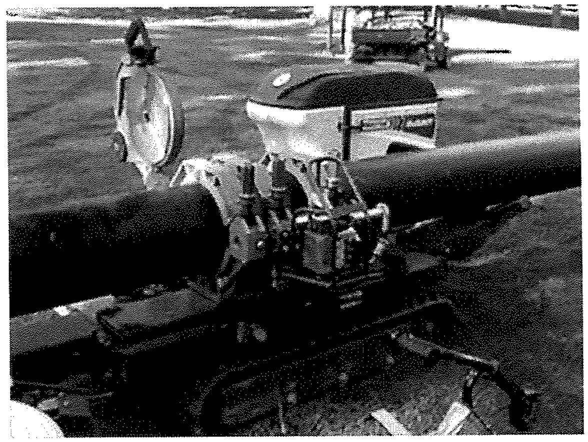
The flexible pipe used to make a swing joint is also PE pipe. Some models of this tubing have other plastics blended with the polyethylene to make it resistant to kinking when it is bent. More information is provided in the "Swing Joints" section of this manual.

High-Density Polyethylene Pipe

Specifications of high-density PE [HDPE] pipe can be found in chapter 9 of *Irrigation, Sixth Edition*. HDPE pipes for irrigation applications are typically sized 2 inches and above. Pipe and fittings are joined by a variety of methods including thermal fusion, electrofusion, and an assortment of mechanical fittings and saddle clamps. Thermal fusion requires the use of a fusion machine that prepares the two ends to be joined, heats them under controlled temperatures, and thermally joins the ends under a controlled preset pressure. Figure 106 shows HDPE pipe being joined with a thermal fusion machine. Electrofusion utilizes a processor that uses electricity to heat wires embedded in a special fitting, fusing the fitting to the HDPE pipe. Thermal fusion and electrofusion should be done only by installers trained and certified in the use of the special equipment and procedures.

Notes

Figure 106. HDPE pipe being joined with a heat fusion machine



The use of mechanical fittings and saddles on HDPE pipe requires special attention. Only fittings designed for HDPE pipe should be used, and provisions must be made to prevent the pipe from pulling out of the fitting. Pipe stiffeners should be inserted in the HDPE prior to installing a compression fitting. HDPE pipe has a rate of thermal expansion/contraction three times that of PVC. Fitting pullout is prevented by either the use of a fitting that has a built-in restraint or the addition of a joint restraint. Figure 107a shows a transition from PVC to HDPE pipe utilizing a mechanical coupling with joint restraints. Figure 107b shows a similar transition with a flange adapter and joint restraints.

Figure 107a. Transition from HDPE to PVC with mechanical fittings and joint restraints

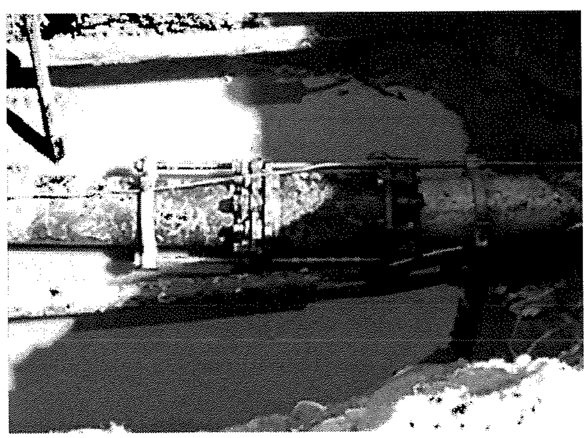
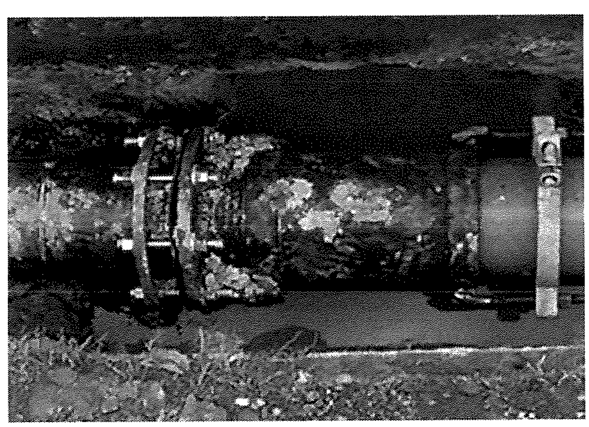


Figure 107b. Transition from HDPE to PVC with flanged adapter, gasketed push-on coupling, and joint restraints

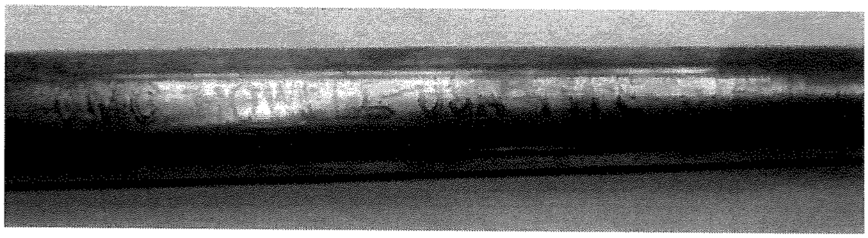


Before installing saddles on HDPE pipe, the pipe should be checked for roundness. This is a particular problem when the HDPE pipe is supplied in coils. Before being installed, the pipe should be run through a "line tamer" of appropriate size that straightens and rerounds the pipe.

Copper Tubing

The copper tubing found in a residential irrigation system is usually limited to the supply lines to the house or coming out of the water meter. This is where the irrigation system will be connected to the water source and is called the point of connection [POC]. Making the proper connection at the POC will be critical to the integrity of both the copper supply line and the irrigation system. Copper tubing is not used in the irrigation system except as risers for the backflow prevention device or fixed spray heads. Figure 108 shows an example of copper pipe.

Figure 108. Copper pipe



There are three types of copper tubing found in supply lines: Type K, Type L, and Type M. Type K has the highest pressure rating because it has the thickest wall. Type M has the lowest pressure rating of the three. Copper tubing is made in straight lengths if it is the rigid variety and in coils if it is soft-annealed.

Connecting copper tubing typically consists of a soldered joint. Buried soldered joints should be made with silver solder. They are also made with flare or compressions fittings.

Galvanized Pipe

Galvanized iron [GI] pipe was the original pipe used for irrigation systems. With the introduction of PVC, the use of galvanized pipe for residential irrigation has been all but eliminated. That, however, does not mean that it does not still exist. There are many homes that have GI pipe in an old irrigation system or as part of the supply line that also serves the PVC irrigation system. These conditions exist in many older sections of town.

A shortcoming of GI pipe is that the inside corrodes and causes rust and flaking that can clog the sprinkler system's components. Mineral deposits also accumulate on the inside of the pipe, slowly narrowing the inside diameter (see fig. 109). When working on a system with GI piping supply lines, the irrigation professional needs to consider installing a filter immediately downstream from the POC.

Notes

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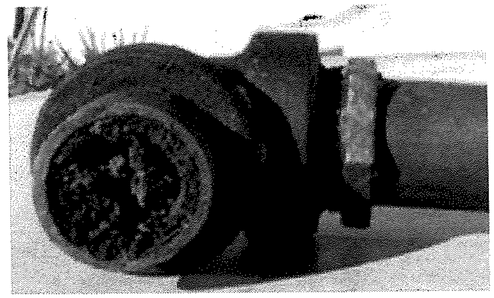
Figure 109. Corrosion plugged galvanized pipe



Galvanized pipe has been used in a modern PVC piping system where extra strength against breaking was required (e.g., nipples for risers and valve connections). The better alternative is to use Schedule 80 PVC or copper.

Sleeving

When pipe is used as a conduit underground it is referred to as sleeving. A sleeve provides a passageway or conduit under a road, driveway, or sidewalk, as shown in figure 110. Any type of pipe can be used for sleeving as long as it has the proper inside diameter to allow for all the other pipe and wire that needs to go through the sleeve. When putting other piping through a sleeve, be sure to account for the OD of any fitting that may have to pass into or through the sleeve. A separate sleeve may be necessary for wire and must comply with local codes. Additionally, the sleeve may require the correct crush strength to withstand the traffic above it. Municipal codes will specify the type of pipe in those cases.

Figure 110. Sleeve under sidewalk

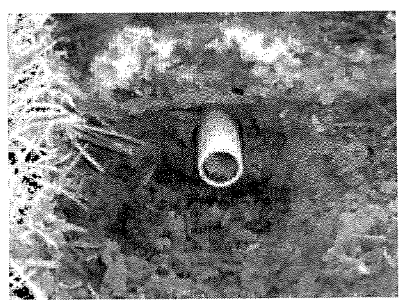


Photo courtesy of Sidewalk Sleever®.

Fittings

Fittings used in a res/com irrigation system can vary depending on the type and condition of the connection being made. Since PVC and PE are the two predominant types of pipe for res/com systems, this section concentrates on the fittings for those two types.

Pipe is connected to other pipe or irrigation components using different types of fittings, depending upon the industry standards and needs of the connection. The principal forms of fittings for residential irrigation systems are the following:

- solvent weld fittings
- threaded fittings
- insert fittings (or barbed fittings)

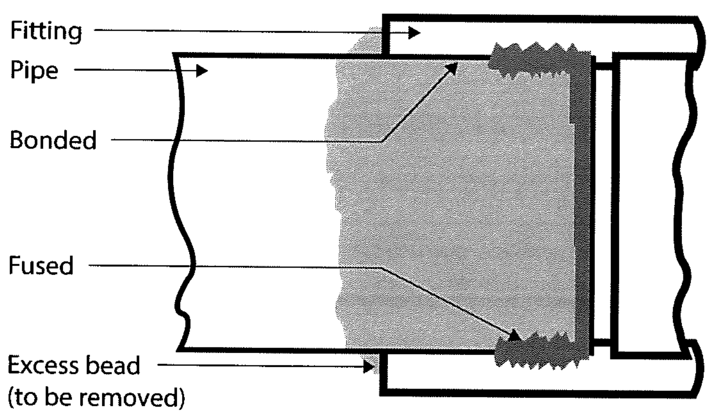
Solvent Weld Fittings

The most common fittings used for connecting PVC pipe are solvent weld fittings. These are PVC fittings that have at least one opening to receive the pipe called a socket. The process that holds the pipe in the fitting is called the solvent weld. Solvent welding is a two-step process that uses a primer to prepare the plastic and a cement to bond the two surfaces.

Solvent weld fittings are often referred to as slip fittings because the pipe slips into the fitting. This term is also used to describe the configuration of the fitting. For example, if a PVC coupler is used to connect two sections of pipe and has two sockets, the coupler is called a slip-by-slip coupler (or just a slip coupler). If a coupler has one ¾-inch socket and one ¾-inch threaded opening, then it is called a ¾-inch slip-by-threaded coupler and would be written as: ¾-inch ST Coupler. (It is more commonly called a female adapter.) If a 1-inch PVC tee is called a slip-by-slip-by-thread tee, then the inlet and outlet have sockets and the side outlet is threaded. This would be written as: 1-inch SST Tee. If a 1-inch tee has a ½-inch threaded side outlet, then it would be written as: 1-inch × 1-inch × ½-inch SST Tee. The configuration of the side outlet is always listed last.

The process of solvent welding actually creates a chemical bond between the pipe and the fitting that is stronger that either one, if done properly. Glued fitting is another term for a solvent weld fitting even though there is no glue used in making the connection between pipe and fitting. The primer and cement are placed on both the outside of the pipe and the inside of the slip fitting. While the cement is still wet, the pipe is inserted into the fitting with a quarter turn until the pipe contacts the stop on the inside of the fitting (see fig. 111).

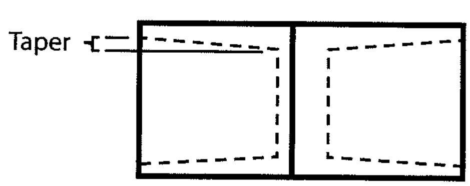
Figure 111. Solvent weld joint



Redrawn from Spears®.

The inside of all solvent weld fittings are tapered (see fig. 112) so that the PVC surfaces will tightly fit together to allow the cement to fuse the plastic of the pipe to the plastic of the fitting. Interference fit refers to fittings that are tapered inside. After the pipe is seated into the fitting, any excess solvent around the joint should be removed by wiping with a rag.

Figure 112. PVC solvent weld coupler



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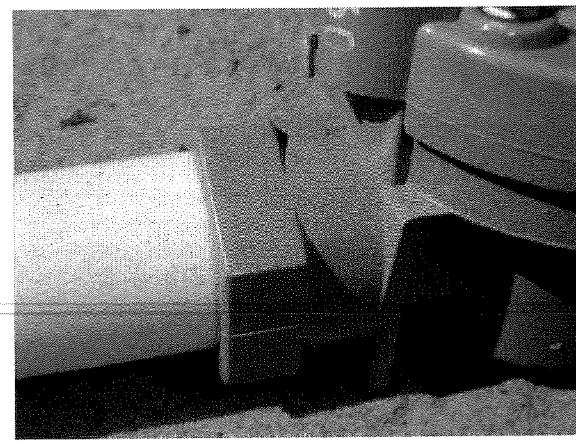
Some models of zone valves are made with sockets instead of threads to connect the pipe to the valve. These valves are often called slip valves. This enables the pipe to be connected to the valve without any fittings (see fig. 113). This configuration is only available on ¾- and 1-inch standard-duty valves and is commonly used in residential systems. The only shortcoming with this type of connection is that it cannot be taken apart like a threaded connection, though this is usually not an issue with residential valves. Slip valves also provide some cost and production economies as there are fewer materials used for installation because there are no fittings and they are faster to put together.

Figure 113. Slip valve



PVC ball valves are also in a configuration with solvent weld sockets instead of a threaded connection, and they are used in residential or other light-duty applications.

Care must be exercised when solvent welding the pipe into the valve to make sure no excess cement gets pushed into the valve that would cause a malfunction.

Threaded Fittings

Threaded connections are most commonly found on zone valves, quick couplers, backflow prevention devices, filters, and sprinklers. To connect pipe to these components requires a fitting that also has threads to match. As discussed in previous sections, standard irrigation pipe and fittings are iron pipe size [IPS].

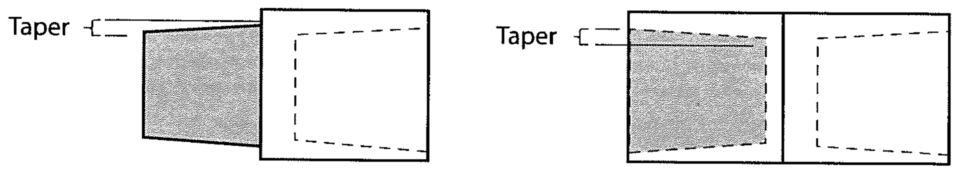
The threads of these fittings must be sealed to prevent leaks. Because an irrigation system has components that have small openings, it is NOT recommended that paste-type sealants be used. Teflon tape is the recommended method of sealing threaded fittings.

In most cases, a threaded fitting is used because it will allow the joint to be disassembled. In other cases such as fittings in a swing joint, the threads need to be able to move to relieve the strain on the pipe. The Teflon tape will keep the threads from becoming stuck or frozen and unable to move.

Notes

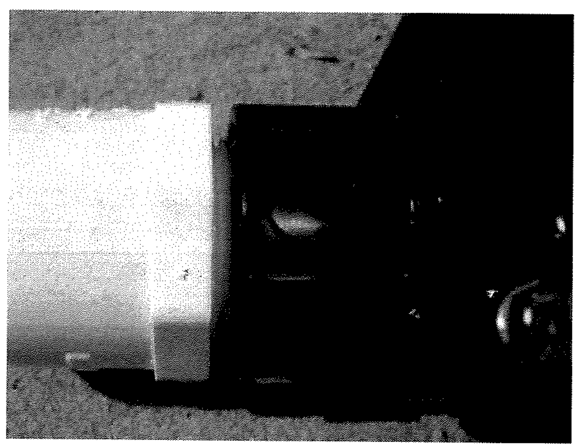
Threaded fittings, both male and female orientations, have a slight taper that causes the threaded connection to get progressively tighter the farther the male fitting is threaded into the female fitting (see fig. 114). When it comes to PVC or other plastic fittings and components, it is not advisable to tighten the threaded fittings until they bottom out against the stop. It may not crack immediately, but there is a high probability that it will in the future from the mechanical stress from over tightening. It is advisable to only hand tighten PVC fittings unless otherwise directed by the manufacturers.

Figure 114. Threaded fittings — male (left) and female (right)



Threaded connections are the most common configuration for zone valves. For residential zone valves, the Schedule 40 male adapter is the fitting used to connect the pipe to each side of the valve (see fig. 115).

Figure 115. Threaded valve with male adapter



Although the advantage of a threaded fitting on a valve is that it will allow the valve to be removed from the pipe, the shortcoming is that the threads must be sealed to avoid leaking.

All sprinklers have a threaded inlet to attach to some type of flexible connection (or swing joint). The barbed-by-threaded fittings used to make up a flexible connect for a sprinkler do not require any type of thread sealant or tape (see fig. 116).

Notes

Threaded connections are also the standard on backflow prevention devices. Be aware of local ordinances governing the installation of a backflow prevention device. Many states require that only a licensed plumber install them. Other ordinances require only copper or other metal pipe and fittings be used to plumb the device (see fig. 117).

Figure 116. Threaded connection on sprinkler

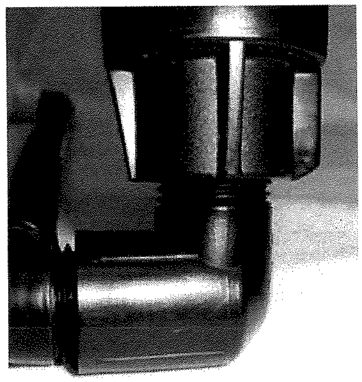
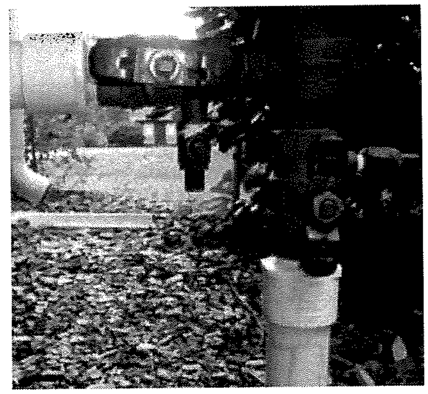


Figure 117. Threaded connections on backflow device

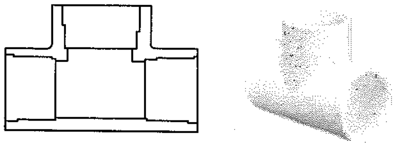


The basic configurations of fittings are based on the directional change, the type of junction, the type of joint, or the dimensional change. Fittings used to change the direction of the pipe are usually an elbow (referred to as an "ell"). The 45- and 90-degree ells are the most common. Fittings that connect intersecting pipes are called tees or crosses.

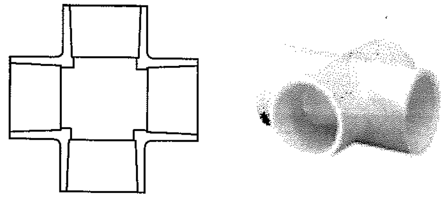
Reducer fittings have different sized openings to be used to connect different sized pipe. Reducer ells and reducer tees are used in connecting sprinklers to lateral piping. It is common to use a standard fitting with a reducer bushing in the outlet for the smaller pipe. There are also caps and plugs.

Figure 118 includes photos and cutaway line drawings of the more common fittings used in a residential system. The conventional name is in parentheses.

Figure 118. Examples of Schedule 40 fittings

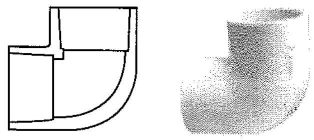


SSS tee (slip tee)

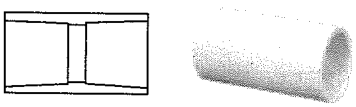


SSSS cross (slip cross)

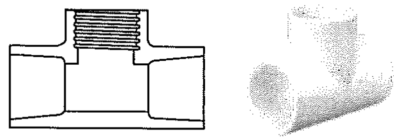
ST male adapter



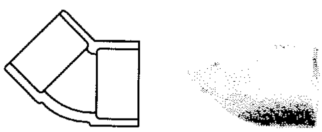
SS 90° ell (slip 90)



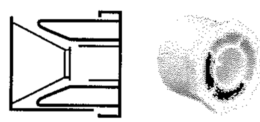
SS coupler (slip coupler)



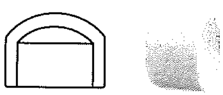
SST tee



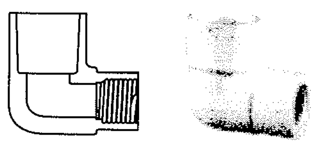
SS 45° ell (slip 45)



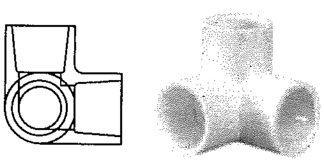
SS reducer brushing



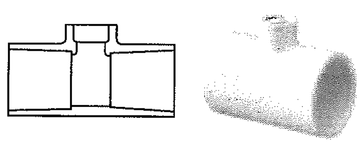
S cap (slip cap)



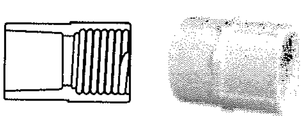
ST reducing 90° ell



SSS side outlet tee



SSS reducer tee



ST female adapter

Photos courtesy of LASCO® and Spears®.

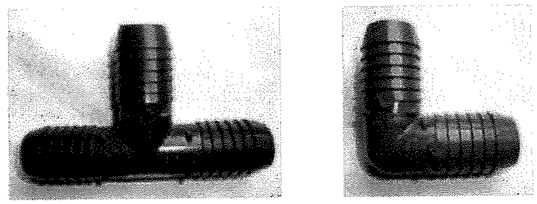
Notes

✍ Notes

Insert Fittings

Insert fittings are used with PE pipe (see fig. 119). They are also referred to as barbed fittings or barbed insert fittings. Insert fittings get their name from their application — they are inserted into the PE pipe. The barbs on the fittings are at angles to allow the fitting to be pushed into the PE pipe and then grab onto the inside of the pipe to help stay in place.

Figure 119. Insert fittings



A clamp must be added to tighten the pipe around the fitting's barbs to hold against the water pressure of an irrigation system. Clamps used for irrigation systems are made of stainless steel and usually are either ear clamps or screw clamps (see fig. 120). It is important to use properly sized clamps with the proper pressure rating. Insert fittings with clamps should only be used with pipe that is not under constant pressure — lateral lines and NOT main lines.

Figure 120. Stainless steel clamps

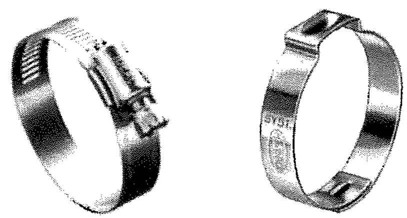


Photo courtesy of Oetiker®.

Specialty Fittings

Compression fittings can be used with PVC or copper pipe. Inside these fittings is a rubber seal that goes around the outside of the pipe and is compressed by the tightening of the compression ring or collar.

The two main configurations of compression fittings are couplers and tees. The main purpose of a compression coupler (see fig. 121) in a residential irrigation system is to make repairs. A compression tee is commonly used to make the connection (called a tap) into the water service line to the house for the irrigation system. The side outlet on the compression tees is threaded.

Telescopic repair couplers (see fig. 122) are the preferred fitting to make repairs on pipe. There are two parts to a telescopic coupler. The tube is the same size as the pipe and is made to slide in and out of the body of the fitting. The tube utilizes o-rings to allow it to move while maintaining a seal.

Once the damaged or defective section of the pipe is cut out, the body of the telescopic coupler is cemented onto one end of the pipe. With the tube pushed all of the way in, a Schedule 40 coupler is cemented onto the end of the tube of the repair coupler. The tube with the coupler attached is then cemented to the pipe by pulling out the tube to extend it to meet the pipe and push the coupler onto the pipe.

Figure 121.
Compression couplers

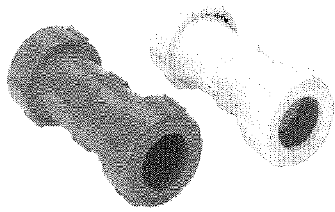


Photo courtesy of Spears®.

Figure 122.
Telescopic repair coupler

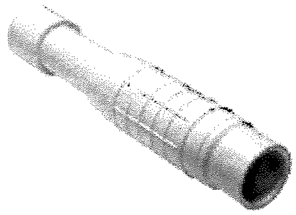


Photo courtesy of Spears®.

Unions are typically used where a connection will need to be reentered (or taken apart). These fittings are made out of either Schedule 40 or Schedule 80 PVC (see fig. 123). Schedule 80 PVC (colored dark grey) has a thicker wall than Schedule 40 (colored white), making it stronger and more resistant to breaks. Schedule 80 fittings should be used where a threaded connection is required and Schedule 40 for a solvent weld connection.

Figure 123. Threaded Schedule 80 PVC union (left), slip Schedule 40 PVC union (right)

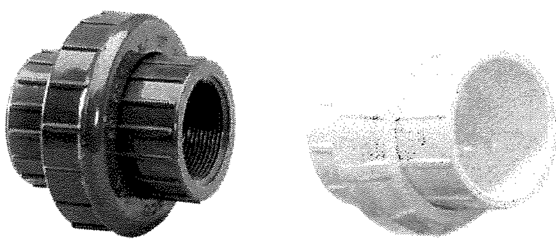
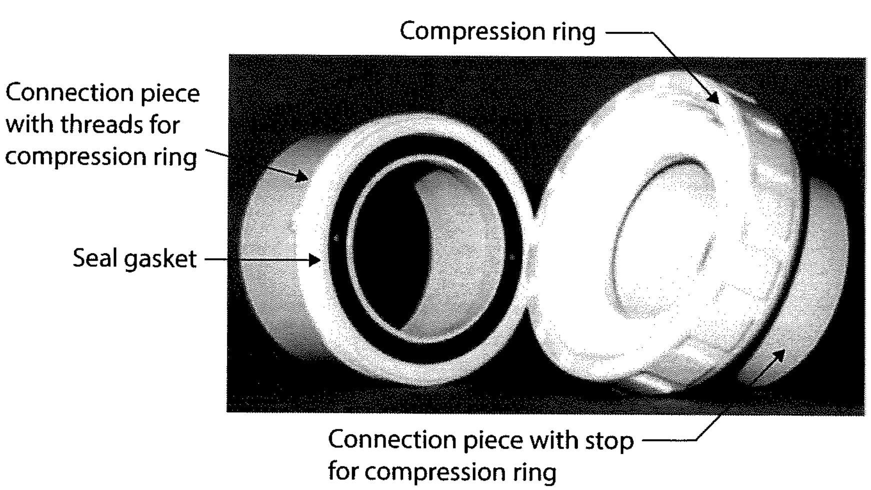


Photo courtesy of LASCO®.

A union has three main parts (see fig. 124). Two connection pieces have a threaded or socket connection to attach to the pipe. The third part is the compression ring and has female threads on one side. One of the connection pieces has a gasket and additional threads for connecting to the compression ring. The other connection piece has a stop on which the compression ring can pull. The compression ring slides over the connecting pieces with the stop and threads onto the other connecting piece with the male threads. As the compression ring is tightened, it pulls the two connecting pieces together, compressing the gasket to make the watertight seal.

Figure 124. Parts of a union



Notes

Notes

Pipe Nipples

Pipe nipples are small sections of pipe that are threaded on one or both ends that are used as fittings to transition between threaded connections. Pipe nipples are manufactured out of many different materials, but the most common material for residential systems is PVC and PE. PVC nipples are pressure rated and either Schedule 40 or Schedule 80 (see fig. 125). The PE nipples are nonpressure rated. Schedule 80 PVC is a dark grey in color, but not all dark colored PVC are Schedule 80 PVC. Be sure to check if the strength of Schedule 80 PVC is needed for the application.

Sizes of PVC nipples for irrigation start at ½-inch diameter and are made in lengths from Close to 48 inches. The term "Close" refers to the smallest length for the respective nipple diameter and is represented by C. For example, a ½-inch × C nipple is 1-1/8 inches long, and a 1-inch × C is 1½ inches long. Starting at a 2-inch Close nipple, the Close length is the same measurement as the diameter (e.g., 2-inch × C is 2 inches long). PE nipples are usually only made in ½- and ¾-inch diameters and lengths starting at Close and going to 24 inch.

PVC nipples that have threads on both ends are called TBE nipples (i.e., threaded both ends). The nipples that are threaded on only one end are called TOE nipples (i.e., threaded one end).

There is a version of a nipple called a poly cutoff riser or cutoff riser (see fig. 126). These are made of a flexible PE and configured such that one end can be cut to length in approximately ¾-inch increments. Cutoff risers are used to connect sprinklers to threaded fittings.

Figure 125. Sch 80 PVC nipple

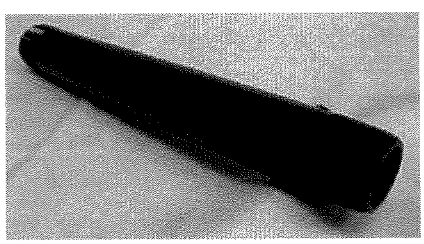
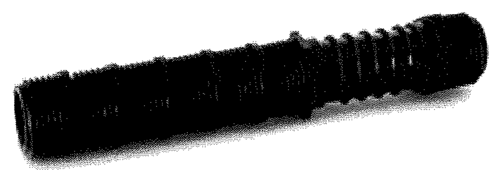
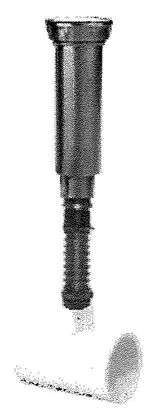


Figure 126. Poly cutoff riser



The shortcoming of a cutoff riser is that it only provides flexibility side-to-side. It does not provide any flexibility from forces from the top, which are the most prevalent in a landscape. If mowing equipment drives over a sprinkler installed similar to what is shown in figure 127, the downward force can crack the tee or the pipe right at the fitting and cause a leak or washout.

Figure 127. Cutoff riser with sprinkler on PVC tee



Swing Joints

Swing joints are a combination of pipe and fittings to make an assembly that provides a flexible connection between the piping system and a sprinkler. This is important as the sprinkler is subjected to forces that cause it to move. These forces are from mowing equipment, foot traffic, and even the frost heave of the soil. Without this flexible connection, these forces would cause stresses in the fitting and the pipe that can cause cracking or breaking. The connections in figure 128 are incorrect because both have no flex in the joint.

Figure 128. Incorrect sprinkler connections

The most common swing joint for residential systems is an assembly that uses PE pipe called swing pipe or funny pipe (see fig. 129). It is manufactured in 100-foot rolls and can be cut to the desired length. The fitting used in this assembly is typically a threaded-by-barbed ell, but can also be a threaded-by-barbed adapter similar to a male adapter in configuration.

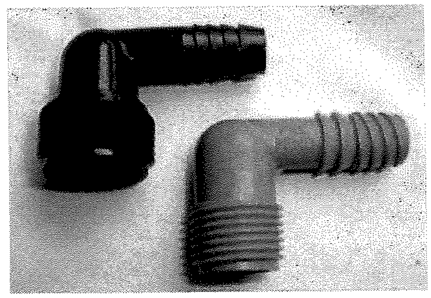
Figure 129. Rotor on swing pipe (left), spray on prefab swing joint (right)

✍ Notes

✍ Notes

These barbed ells have either a ½- or ¾-inch thread (see fig. 130). The flexible nature of the swing pipe allows the sprinkler to be positioned in any manner. This type of swing joint can be used for sprays or rotors.

Figure 130. Barbed ells, L – ¾-inch, R – ½-inch



As an alternative to cutting swing pipe and installing the barbed ells, there are preassembled swing joints called prefabricated swing joints. These are made as a double swing joint (one barbed ell on each end) or as a triple swing joint (similar to a double but with a street ell threaded on one end). The triple swing joint adds an extra pivot point to flex (see fig. 131).

In some areas, swing joints are assembled using three Marlex® or PE street ells and a PVC nipple. The softer plastic of the Marlex or PE street ells seals on the threads of the nipple while still providing a flexible joint (see fig. 132).

Figure 131. Prefab triple swing pipe

Figure 132. Three Marlex streets ells with PVC nipple

Summary

This workbook is intended to give the student the understanding of how the components of a residential irrigation system operate and how they are installed. The manual describes the important performance characteristics and should give the student the understanding of how products are applied for specific designs and desired operating characteristics. Equally important, the manual uses the terminology that is standard in the industry.

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