Irrigation Systems

CEU 257

Continuing Education from the
American Society of Plumbing Engineers

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Note: In determining your answers to the CE questions, use only the material presented in the corresponding continuing education article. Using information from other materials may result in a wrong answer.

The function of an automatic irrigation system is to provide and distribute a predetermined amount of water to economically produce and maintain ornamental shrubs, cultivated lawns, and other large turf areas. Other benefits of an automatic irrigation system include convenience, full landscape coverage, simple control for overnight and early morning watering, and minimized plant loss during drought.

This chapter discusses the basic design criteria and components of irrigation systems for ornamental lawns and turf. Among the factors considered are water quality and requirements, soil type, system concepts, and system components. A design information sheet is also provided in Appendix 4-A to assist the plumbing engineer in the orderly collection of the required field information and other pertinent data.

WATER QUALITY AND REQUIREMENTS

In urban areas where the source of the water supply is often the municipal water system, the plumbing engineer typically does not need to be concerned with the quality of the water. In cases where private or reclaimed water sources are used and the water quality is unknown, the water should be analyzed by the appropriate local health authority prior to use.

The main areas of concern are:

- Any silt content that, if high, may result in the baking and sealing of soil
- Any industrial waste that may be harmful to good growth
- Any soluble salts that may build up in the root area

The most common solution for handling excessive amounts of silt is the construction of a settling basin, usually in the form of a decorative lake or pond. In areas where the salt content is excessive, 1,000 parts per million (ppm) or more, the inability of the soil to cope with the problem may require the use of special salt-tolerant grasses.

The quantity of water required for an effective irrigation system is a function of the type of grass, the soil, and local weather conditions. The quantity of water is usually expressed as the depth of the water applied during a given period over the area to be covered. The amount of water applied to a given area can be controlled easily by adjusting the irrigation system's length and frequency of operation. An efficient irrigation system takes into consideration the rate of water application, usually expressed in inches per hour, and attempts to match the application rate with the absorption rate of the soil. Often, this condition is achieved through frequent, short watering cycles.

Table 4-1 Net Amount of Water to Apply per Irrigation Cycle

Soil Profile	Amount, in. (mm)
Coarse, sandy soil	0.45 (11.43)
Fine, sandy loam	0.85 (21.59)
Silt loam	1.10 (27.94)
Heavy clay or clay loam	0.90 (22.86)

Note: The net amount of moisture required is based on a 12- inch (304.8-mm) root depth.

SOIL CONSIDERATIONS

Sandy, porous soils have relatively high absorption rates and can handle high sprinkler output. Steep slopes and very tight, nonporous soils require low flow rates to prevent erosion damage and wasteful runoff.

A sufficient amount of water must be applied during each irrigation period to ensure penetration to the root zone. Table 4-1 suggests guidelines for several soil profiles (the net amount of water to apply per irrigation cycle). In the absence of any specific information on the soil and local weather conditions, the irrigation system may be designed for 1½ inches (38.1 mm) of water per week.

The plumbing engineer should consult with the local administrative authority to determine compliance with the applicable codes in the jurisdiction. The engineer can obtain specific information on the soil and local weather conditions by contacting a local weather bureau, a university, or a state engineer.

SYSTEM CONCEPTS

The three basic system concepts that can be used by the engineer in the design of an irrigation network are the block method, the quick-coupling method, and the valve-per-sprinkler method.

The block system is an approach in which a single valve controls the flow of water to several sprinklers. It is ideal for residential and other small turf areas. Either manual or automatic valves may be used in the block system. As the irrigation area increases or where high-volume sprinklers are employed, the block system becomes less attractive to the engineer because of the large valves and pipelines required. Examples of the block system are shown in Figure 4-1.

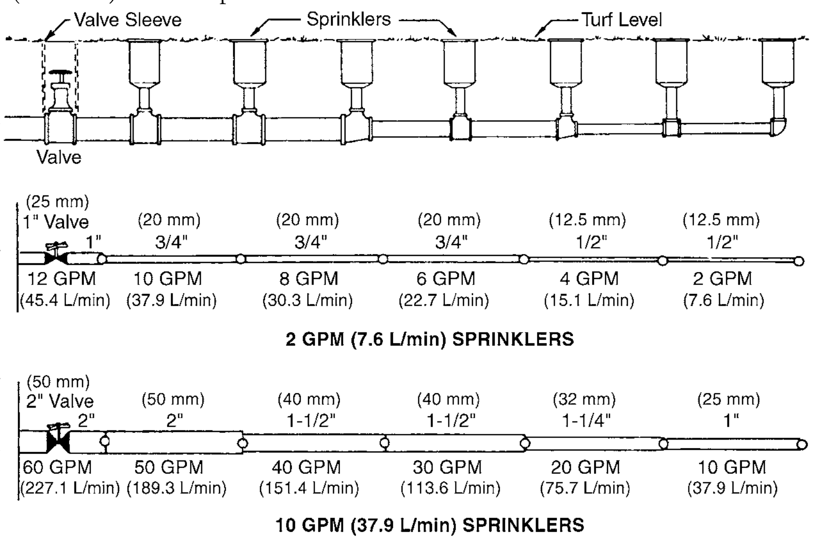


Figure 4-1 Examples of a Block System

The quick-coupling irrigation system is an alternative to the high cost incurred on large block system projects because the quick-coupling valve (see Figure 4-2) provides more flexibility. The valve is located underground but can be activated from the surface. Where manpower is not critical and security is reasonable, the quick-coupling irrigation system may be considered by the engineer.

The last concept in sprinkler system design is the valve-per-sprinkler method (see Figure 4-3). Small actuator valves, operated at low voltage, provide great flexibility and control. Sprinklers in diverse areas having the same (or similar) water requirements may be operated concurrently. In other applications, such as quarter applications covering quarter circles or half circles, the irrigation sprinklers may be piped, wired, and operated together through system programmers. The valve-per-sprinkler system provides the opportunity to standardize the pipe sizes by selecting the appropriate sprinklers to be operated at any given time.

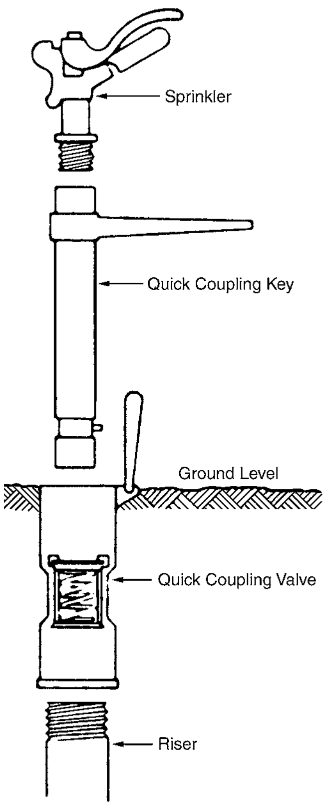


Figure 4-2 Quick-Coupling Valve

Figure 4-4 Pop-up Spray Heads
Photo courtesy of Rain Bird Corporation

Figure 4-5 Impact Sprinkler
Photo courtesy of Rain Bird Corporation

SYSTEM COMPONENTS

Sprinklers

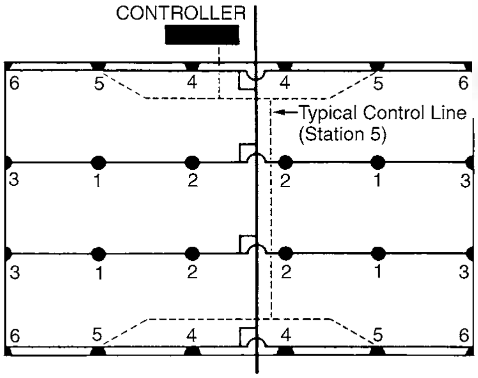
One of the most important steps when designing an irrigation system is selecting the sprinklers, which are mechanical devices with nozzles used to distribute water by converting water pressure to a high-velocity discharge stream.

Many different types of sprinklers are manufactured for a variety of system applications. The plumbing engineer should become knowledgeable of the various types before selecting the sprinklers, as the flow rates and operating pressures must be nearly the same in each of the irrigation system's circuits.

Spray Sprinklers

Surface-type spray and pop-up spray sprinklers (see Figure 4-4) produce a single sheet of water and cover a relatively small area, about 10 to 20 feet (3.05 to 6.10 m) in radius. These sprinklers can operate on a low-pressure range of 15 to 35 pounds per square inch (psi) (103.4 to 241.3 kPa). They apply water at a high rate of application—1 to 2 inches per hour (25.4 to 50.8 mm/hour)—and are most economical in small turf or shrub areas and in irregularly shaped areas.

Due to the fine spray design, the pattern can be easily distorted by the wind; therefore, these sprinklers should be installed in protected areas.



1. Main can supply four 20 gpm (75.7 L/min) sprinklers at one time.
2. 60' (18.3 m) square spacing
3. Maximum loss per station = 2.3 psi (15.9 kPa)
4. Six control stations required.
5. Similar numbered heads on same control station.
6. All lateral pipe is 1¼" (32 mm).

Figure 4-3 Valve-in-Head System

Impact Sprinklers

Impact sprinklers (see Figure 4-5) can be permanent or movable and either the riser-mounted type (see Figure 4-2) or the pop-up rotary type (see Figure 4-6).

Impact sprinklers have an adjustable, revolving water stream and are available in both single-nozzle and double-nozzle designs. These devices can operate at a high pressure (25 to 100 psi [172.3 to 689.5 kPa]) and cover large areas (40 to 100 feet [12.2 to 30.5 m] in radius). The water is applied at a low rate (0.20 to 0.5 inches per hour [5.08 to 12.7 mm/hour]). Because of its larger, more compact stream of water, this sprinkler is not easily distorted by the wind and is most economical in large, open turf areas.

Figure 4-6 Rotary Sprinkler—Arcs and Full Circles
Photo courtesy of Rain Bird Corporation

Freestanding sprinklers are not desirable where they are exposed. In such cases, the pop-up, rotary-type sprinkler shown in Figure 4-6 may be used. These nozzles rise above the ground level only when the water is being delivered to the unit.

Half-circle rotary sprinklers can discharge the same volume of water as full-circle units, covering half the area as full-circle units, thus doubling the application rate. Quarter-circle sprinklers will quadruple the application rate. Some equipment manufacturers use different nozzles to compensate for the reduced area and to provide a uniform application rate. If compensating nozzles are not used in half-circle sprinklers, these units must be valved and operated separately for a balanced application of the water.

Shrub Sprinklers

Several types of shrub sprinklers are available, including bubblers (see Figure 4-7), flat-spray sprinklers, and stream-spray sprinklers. Shrub sprinklers can be mounted on risers to spray over plants. If the plants are tall and not dense near the ground, shrub sprinklers can be used on short risers, and the spray can be directed under the plants. The spray also can be kept below the plant. Flat-spray shrub heads are best employed for these applications.

Figure 4-7 Bubbler Sprinkler Heads
Photo courtesy of Rain Bird Corporation

Trickle Irrigation

Trickle irrigation is commonly used in vineyards and orchards and routed through tubing with special emitters installed at each planting. Most emitters have flexible orifices and may have provisions for adding fertilizer.

These irrigation systems have a low-volume usage and usually are not installed in conjunction with conventional lawn sprinkler systems.

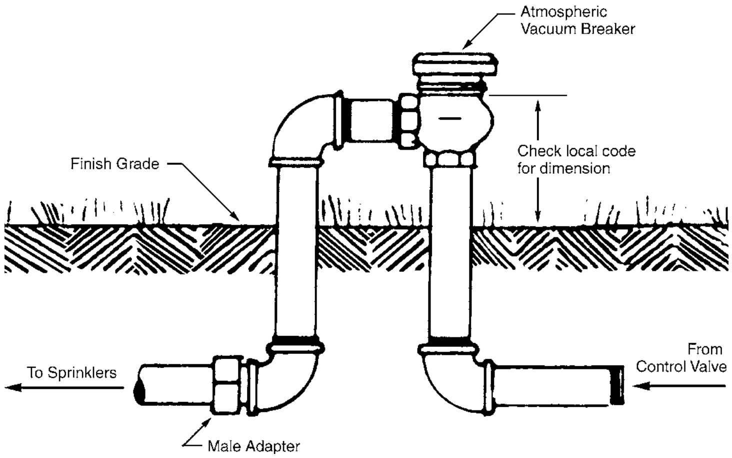


Figure 4-8 Installation of an Atmospheric Vacuum Breaker

Valves

Remote-control valves are generally classified into three basic categories: electric, hydraulic, and thermal hydraulic. The electrically operated valve receives an electric signal from the controller that actuates a solenoid in the valve. This solenoid opens and closes the control valve. The hydraulic control valve is operated by the water pressure and has control tubing from the controller to the valve. The thermal-hydraulic control valve uses an electric signal from the controller to heat up the components of the valve to open the unit. The most common use of this valve is to control water usage to different zones.

These devices should be installed with access for maintenance. Most control valves have some provisions for manual operation. In some systems, manual control valves are installed in pits or vaults with a long T-handle wrench used to activate each circuit.

An irrigation system may be installed with an automatic check valve on the sprinkler heads. When a zone is installed on sloping terrain, these valves will close when they sense low pressure at turnoff, preventing the supply pipe from draining through a sprinkler head installed in a lower area.

Atmospheric vacuum breakers (see Figure 4-8) must be installed on every sprinkler circuit downstream of the control valve to eliminate the possibility of backsiphonage into the potable water system. Many (if not all) local jurisdictions require this type of valve. The plumbing designer should consult with the local administrative authority and check all applicable codes for such requirements.

Pressure-reducing valves are installed where high street pressures are involved and also are commonly used to maintain a constant pressure where the inlet pressure may vary. Some manufacturers offer remote-control valves with pressure regulation.

Low-flow control valves may be installed to prevent damage to the piping or tubing from pressure surges during the filling of a dry system. This control valve allows a slow filling of the piping or tubing until the pressure is established.

In climates where freezing conditions may occur, automatic-type drain valves should be installed at low points of the system to allow for drainage. This control valve will open automatically when the water pressure drops below a setpoint. In heavy or dense soils, a pit of gravel should be provided for quick drainage.

Backflow Devices

The use of pressure vacuum breakers to eliminate the possibility of backsiphonage into the potable water system is the minimum level of backflow prevention accepted by most jurisdictions. Typically a double check valve device is installed to satisfy the authority having jurisdiction (AHJ). The plumbing engineer should consult with the local administrative authority and check all applicable codes for such requirements.

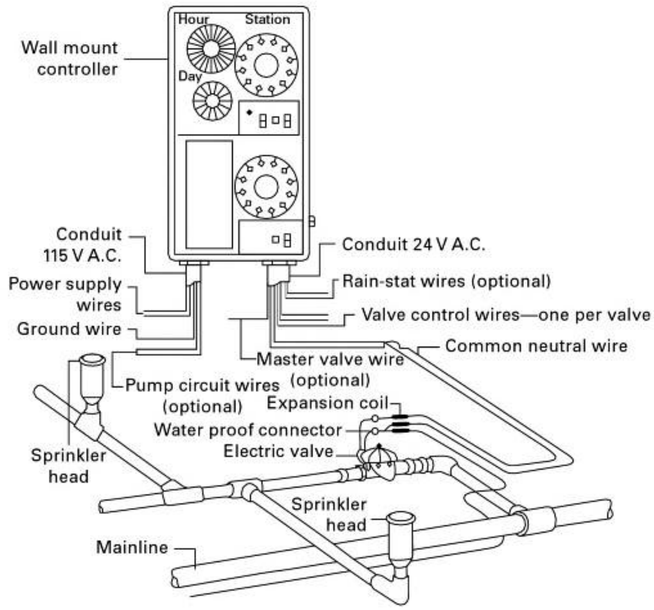


Figure 4-9 Surface-Mounted Irrigation Sprinkler Controller

Controllers

Many types of controllers for irrigation systems are available. Selection of this device is based on the specific application involved.

Controllers are programmed to activate each irrigation zone at a specific time and also to control the length of time that each zone is activated. Some controllers have a calendar that allows the irrigation system to be used only on certain days. Other types of controllers have manual (or automatic) overrides to shut down all systems during rain or to turn on specific zones for extra water. Some controllers have soil moisture monitors, which turn on zones only when needed.

Controller panels can be surface mounted (see Figure 4-9), recessed mounted, or pedestal mounted.

Water Metering

The municipality may charge sewage fees for water used in an irrigation system because the water ends up in the building drainage system and eventually in the sewage treatment plant. Because of this, it is good practice to provide a second water tap and a second meter connected to the irrigation system. This meter will gauge the amount of water used for irrigation, and the user will not be charged for sewage fees.

Rain Shutoff Device

A rain shutoff device should always be installed on an irrigation system. This device, which is tied to the controller, detects rainfall and prevents the controller from operating and wasting water.

DESIGN INFORMATION

When designing an underground sprinkler system, the plumbing engineer should consider the following factors: the site plan, type of plants, type of soil, type and source of water, and system location.

Site Plan

An accurate site plan, preferably laid out to scale, should show all buildings, shrubs, trees, hedges, walks, drives, and parking lots as accurately as possible. The site plan also should include any buried utilities such as electrical wiring and gas lines and their depth. Areas where overspray is undesirable, such as on walkways and buildings, should be clearly noted. Property lines also should be shown on the site plan. The heights and diameters of shrubs and hedges should be indicated.

The engineer should show the areas that will be irrigated on the site plan as well as the areas that will be omitted. Those areas that require a different style of sprinkler and separate zoning also should be indicated.

When an irrigation system is installed on a site with an existing irrigation system, the plumbing designer should review the existing irrigation plans and connect to the existing system to avoid another water tap.

Types of Plants

Some plants require more frequent watering than others; therefore, they will require a separate zone and control valve. The engineer should determine whether the plants allow spray on their leaves (or any other special type of spray) and should select the sprinklers accordingly.

Type of Soil

The type of soil determines the proper rate of application of water to the soil. The length and frequency of the applications can be determined by considering the soil and the types of plants.

A sufficient amount of water must be applied during each irrigation period to ensure penetration to the root zone. Table 4-1 recommends acceptable guidelines for several types of soil profiles. Where available, the engineer should secure local soil and weather conditions by contacting the local state extension engineer, a university, or the weather bureau. The local weather bureau usually publishes an evapotranspiration guide, which shows the deficit water required to maintain turf grass. This value is compiled by measuring the rainfall minus the evaporation taking place during a particular period. The balance is the amount of water required. In the absence of any specific information on local soil and weather conditions, the irrigation system should be designed for a minimum of 1½ inches (38.1 mm) of water per week.

Sandy, porous soils have relatively high absorption rates and can handle high sprinkler output. Steep slopes and very tight, nonporous soils require low precipitation rates to prevent erosion damage and runoff.

Type and Source of Water

The source of the water should be located on the site plan. If the water source is a well, the pump capacity, well depth, pump discharge pressure, and other pertinent data should also be recorded. If the water source is a city water main, the location, size, service line material, and length of piping from the service line to the meter should be researched by the plumbing engineer. The water meter size and the static water pressure of the city main are also needed. The engineer should determine whether special meter pits or piping arrangements are required by the utility company.

System Location

Due to the influence of physical and local climatic conditions, the general area may require specific design considerations, such as drain valves on systems subjected to freezing temperatures. Windy areas require close spacing of sprinklers and the wind velocity and direction must be considered. For areas on sloping terrain, the outlet pressure will differ from the inlet pressure, and consideration must be made for system drainage.

The engineer must review the local codes to determine acceptable piping materials, installation requirements, and the approved connection to the municipal water works.

APPENDIX 4A:
SUGGESTED INFORMATION SHEET FOR SPRINKLER SYSTEM DESIGN

All available information should be contained on this sheet, the plot plan, or both.

1. Project name: ______________________________________

   Address: ____

2. Water supply: ______________________________
   - Location and size of existing tap, meter, pump, or other: _________________________
   - Existing meter, pump, or tap capacity: Residual pressure ___________
   - Gallons per minute: ___________
   - Power supply: Location ___________________ Voltage ______________
   - Length, type, location, and size of existing supply line (identify on plan)

3. Area to be watered: Identify all planted areas whether shrubbery or trees; indicate clearance under trees (identify on plan).

4. Soil type: Light _____ Medium _____ Heavy _____

5. Hours per day and night allowed for irrigation: _______

6. Amount of precipitation required per week: _______

7. Area to be bordered or not watered (identify on plan)

8. Elevations and prevailing wind conditions (identify on plan)

9. Type of system:

_____ Automatic electric

_____ Automatic hydraulic

_____ Manual pop-up

_____ Manual quick-coupling

_____ Other: ___________________

10. Indicate equipment preference: ____

11. Indicate preferred location for valves and controllers: ___________________________

12. Indicate vacuum breaker and/or drain valve requirement: __________________________

13. Indicate pipe material preference:
    - 2½ inches and larger ____________ ____________
    - 2 inches and smaller _________________________

14. Indicate any preference for sprinkler riser types: _________________________________

15. Special Notes (use an additional sheet if necessary)

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Expiration date: Continuing education credit will be given for this examination through **March 31, 2019**.

CE Questions — "Irrigation Systems" (CEU 257)

Test written by Rob Westphal, PE, CPD, LEED AP

1. Which of the following describes the correct primary function of an automatic irrigation system?
   a. provide a convenient watering of landscape
   b. provide a convenient watering during drought conditions and at night
   c. provide an efficient use of graywater
   d. distribute a predetermined amount of water to economically produce and maintain landscaping

2. The quantity of water required for an effective irrigation system is a function of ________.
   a. type of grass and soil
   b. local weather conditions
   c. both a and b
   d. none of the above

3. Which of the following soil considerations must be accounted for during the design?
   a. Sandy, porous soils have relatively high absorption rates and can handle high sprinkler output.
   b. Steep slopes and very tight, nonporous soils require low flow rates to prevent erosion damage and wasteful runoff.
   c. A sufficient amount of water must be applied during each irrigation period to ensure penetration to the root zone.
   d. all the above

4. In the absence of specific information on the soil and local weather conditions associated with the amount of water to apply per irrigation cycle, the plumbing engineer should do which of the following?
   a. Contact the local AHJ to obtain design information.
   b. Use the average the values shown in Table 4-1.
   c. Use the value for "fine, sandy loam" in Table 4-1,
   d. Apply the rule of thumb of 1½ inches of water per week.

5. The valve-per-sprinkler system concept provides which of the following advantages?
   a. A single valve controls the flow of water to all sprinklers.
   b. Sprinklers in diverse areas having similar water requirements may be operated concurrently.
   c. The quick-coupling valve is located underground but can be operated from the surface.
   d. none of the above

6. One of the most important steps when designing an irrigation system is selecting the sprinklers.
   a. true
   b. false

7. Which of the following statements regarding impact sprinklers is false?
   a. They are only riser mounted but can be either permanent or movable.
   b. They can operate at high pressures (up to 100 psi) and cover large areas (up to 100 feet in radius).
   c. Water is applied at a low rate (0.2 to 0.5 inches per hour).
   d. Their compact stream of water is not easily distorted by wind.

8. Regarding shrub sprinklers, is the following true or false? They are available in bubblers, flat-spray, stream-spray and they should always be mounted on risers to spray over plants.
   a. true
   b. false

9. Which of the following is false regarding control valves?
   a. They are controlled by either electricity or water pressure.
   b. The solenoid opens and closes the valve portion of the electrically operated valve.
   c. Their most common use is to control water usage to different zones.
   d. They should be direct buried to lower project cost.

10. Pressure-reducing valves are only installed when unacceptably high street pressure is encountered.
   a. true
   b. false

11. Which is the correct design approach for irrigation system backflow prevention code compliance?
   a. Atmospheric vacuum breakers should be used on every sprinkler circuit upstream of the control valve.
   b. Always use reverse pressure backflow prevention (RPBP) devices because these devices will be accepted by any AHJ.
   c. Double check valve backflow devices should be used downstream of the control valve.
   d. Check with the local AHJ and all applicable codes for requirements.

12. Which of the following is not irrigation design information considered by the plumbing engineer?
   a. The site plan should show all buildings, trees, walks, drives, underground utilities, and property lines.
   b. Research which plants allow water spray on their leaves so sprinklers can be selected accordingly.
   c. Water must be applied during each irrigation period but not more than allowed to obtain LEED points.
   d. An evapotranspiration guide will show the deficit water required to maintain turf grass.