TORO. Count on it.

Irrigation Solutions

What Is Drip Irrigation?

Conserve Water And Irrigate Intelligently

Drip irrigation, also known as micro-irrigation or trickle irrigation, is a remarkable water technology first developed decades ago. Today, it is commonly used all over the world in agricultural, nursery, greenhouse, landscape and a variety of industrial applications. In recent years, the demand for drip irrigation has grown rapidly and for good reason – the technology can help solve serious problems associated with water use. The following will assist in understanding drip irrigation such that a system may be chosen, and ultimately operated, intelligently.

Drip irrigation allows for targeted water applications, where runoff, leaching and wetting of non-targeted areas is avoided or completely eliminated.

Advantages of Drip

Today it is more important than ever to use water resources wisely and to irrigate intelligently. Intelligation™ refers to the process of taking full advantage of the benefits drip irrigation offers. For instance, many farmers have enjoyed improved profitability with drip by increasing crop yield and quality while at the same time reducing costs from water, energy, labor, chemical inputs and water runoff. Many landscapers have also enjoyed significant water and capital investment savings using drip, while simultaneously improving plant vigor by delivering water and nutrients directly to the plant roots and avoiding unnecessary wetting of plant leaves. In addition, drip irrigation allows for targeted, intelligent water applications, where runoff, leaching and the wetting of non-targeted areas such as roads, plant leaves, tree trunks, sidewalks, cars, windows and buildings are avoided or completely eliminated.

Whether the motivation is improved profitability or better resource use, Intelligation™ clearly makes sense.

To irrigate intelligently, one must first choose the right system and then use it properly. Choosing a system can be complicated because each application is slightly different and there are many options available. However, regardless of application, it is very important that the system delivers a very high application uniformity that will distribute water evenly throughout the system. In general, gravity irrigation systems deliver relatively low application uniformity, sprinklers deliver relatively moderate application uniformity, and drip systems deliver relatively high application uniformity. A thorough understanding of drip irrigation will assist the end user in making the right choices for virtually any crop or terrain.

Components of Drip/Micro-Irrigation System

Drip irrigation systems consist of emission devices serviced by a water distribution network that ideally includes control zone equipment. At the water source, water is controlled with automatic valves, sometimes amended with nutrients or chemicals, filtered and regulated at levels suitable for the emission devices chosen and plants being grown. From there, water is delivered to each of the emission devices through a network of PVC and PE pipes. The emission device, whether it is drip tape, a drip emitter, jet or micro-sprinkler, then delivers water and nutrients to the soil where plant roots may nourish the plant. All components have attributes that affect performance, and that are traded off with initial, installation, operation and maintenance costs. A thorough understanding will assist in selecting the proper equipment to achieve desired expectations for the given application. Drip systems are durable and are built to withstand outdoor conditions for reasonable lengths of time, but care should be taken to avoid damage by wildlife, foot traffic or field equipment. In many cases, the environmental conditions will dictate the choice of emission device for any given application. A brief description of the three equipment classes follows:

Drip systems are durable and are designed to withstand and perform in outdoor conditions.

1. Emission Devices

Emission devices vary according to their flow rate, hydraulic characteristics and wetting pattern. The ideal emission device is durable (withstands outdoor conditions), resistant to clogging (large internal passageways, self flushing), insensitive to pressure variation that occurs as a result of slope and/or lengths of run (pressure compensating), accurate (low manufacturing Coefficient of Variation, or CV) and economically affordable. Drip emission devices are typically installed on the surface such that there is flexibility in placement, and convenience for management. These attributes are achieved via advanced plastics, hydraulics and injection molding technology.

- **Drip Tape** is a "line-source" product that incorporates a series of relatively inexpensive, engineered emission devices into a thin walled tube. Water is distributed evenly along the length of the tube through emission devices which may be spaced anywhere from 4" to 24" apart. To accommodate various crops and terrain, tube wall thicknesses are available from .004" to .015" (4 mil to 15 mil), emitter flow rates from .07 - .34 gph, and pipe diameters from 5/8" to 1 3/8". Drip tape is available in standard and pressure compensating models, and is used extensively for vegetable and field row crop cultivation. It may be installed above or below the ground, and may be retrieved for multi-season reuse or disposed at the end of each season. Drip tape is relatively inexpensive and is ready to install without any additional emission device installation labor.

Drip emission devices are designed to deliver the same amount of water from each outlet, ensuring even distribution and high uniformity.

- **On-line Emitters** are small plastic devices which convey small streams of flow from polyethylene (PE) tubing to the soil. Water then moves through the soil via capillary flow and creates a wetted circle, the size of which is dependent upon the soil type, flow rate and irrigation schedule. On-line emitters are attached to the PE tubing wall by inserting the emitter's barb shaped base through a precisely punched hole. On line emitters offer the user the advantage of installing an emission device exactly where wanted, and if the emitter is "take-a-part", it may also be serviced. The disadvantage is that the end user must manually insert each emitter. Note: Although the ability to self-clean an emitter is an attractive feature, it should be viewed as an occasional event that is no substitute for proper filtration and maintenance. Drip systems may employ hundreds or even thousands of emitters, a quantity impractical to flush by hand.

- **In-line Emitters, or Dripline**, consists of small plastic emission devices similar in function to on-line emitters, but in this configuration they are pre-inserted into the PE tubing at specified intervals during the tubing extrusion process. The emitters may be cylindrical or flat "boat shaped", and are attached to the inner tube wall via a controlled heating/adhesion process. Labor savings for the end user may be substantial since emitters are factory pre-installed. Flexibility is not affected since additional emission devices are easily added to the tubing in the field if desired. The drawback is that emission devices may exist where unneeded, and they are not serviceable. Unlike all other classifications of emission devices, dripline may be installed below the surface such that the soil surface may be kept dry and surface damage may be avoided.

Drip application rates can be tailored to fit the soil and plant type, allowing for flexible water applications above or below the soil surface.

- **Foggers** are small plastic devices that emit water as a fairly confined mist, or fog, via a small plastic online device. In addition to irrigation water being applied to the soil, temperature may be manipulated and/or a humid environment may be created. Foggers were originally developed for the citrus industry, but work well for potted plants or hanging baskets as well where confined roots require frequent wetting.

- **Jets** are small plastic devices mounted on risers and/or stakes that jettison water through the air as separate streams which create finger shaped patterns of water in the soil. A variety of finger patterns are available including full circle, half circle, hi/low trajectory, butterfly, etc. The versatility of patterns provides a great deal of flexibility for the end user to accurately apply water only where wanted, such as enveloping each tree in an orchard without wetting the trunk, or in landscape beds with odd shapes, or in potted plants.

- **Micro-sprinklers** are small plastic devices that emit water in a full circle spray/sprinkler pattern through the air via a rotating spinner. The device is attached to the PE lateral tubing via a separate plastic stake or via a combination of a plastic stake fitted with a length of PE micro-tubing. The advantage is that water is applied over a larger area using only one emission device, and that operating pressures and application rates are low. A possible drawback is that, similar to conventional sprinklers, water is delivered through the air and may be applied to non-target areas such roads, tree trunks, foliage or other non-target areas. In addition, water applied through the air is affected by wind. It should be noted that a performance overlap exists where the higher flow rate ranges of micro-sprinklers approach the lower flow rate ranges of conventional sprinklers.

2. Distribution System

Once the emission device is chosen, a system of filters, chemical injectors, pipes, valves and fittings must be constructed to deliver water reliably, safely and efficiently to each outlet, and to facilitate system maintenance. The major categories are as follows:

- **Filters** are used to remove organic and inorganic debris from the water that could potentially clog the emission devices. In agriculture, sand media filters, screen filters or disk type filters are commonly used, and may be cleansed manually, semi-automatically or automatically. Even where potable water is used, which is typical of landscaping applications, disc or screen filters should be installed since scale and chemical precipitants may occur which present a potential clogging hazard. Depending on the

emission device chosen, the degree of filtration should be 80-200 mesh.

- **Chemical Injectors** are typically installed in drip irrigation system in order to facilitate system maintenance with chlorine or acid, and also to supply nutrients or other liquid or gaseous substances to the plants being irrigated. Whatever type of injector chosen, extreme care should be taken to ensure that the system includes proper safety and backflow prevention devices.

- **Pipe** – PVC pipe is widely used to transport water from the water source to irrigation equipment of all types. In drip/micro-irrigation systems, it is typically used in the control zone and in the delivery network as both mainline and sub-mainline. In some cases, it may also be used as the lateral servicing the emission devices. White PVC pipe is not UV resistant.

- **Tubing** – PE tubing is widely used as the lateral pipe servicing the emission devices. It is available in numerous diameters, wall thicknesses and reel lengths with varying pressure ratings and hydraulic characteristics. PE tubing, regardless of the color, is UV resistant.

- **Fittings** – PVC pipe connections are typically made using solvent welded fittings, while PE tubing is usually connected via compression, insert or ring-lock type fittings.

- **Flush Valves** are used to periodically cleanse the conveyance and emission device components of organic and inorganic debris that could clog the emission devices if left unchecked. They may be simple manual valves fitted at the ends of mainlines, sub-mainlines and/or laterals, semi-automatic valves that flush only at start-up or shut-down, or fully automated solenoid valves.

- **Air/vacuum Relief Valves** – To avoid general equipment failure, pipe rupture or pipe blockage, A/V relief valves are used to expel air that builds up in the pipeline network during startup and operation. A/V relief valves are also used to allow air to enter the pipeline network as water exits at shutdown. This avoids undesirable vacuum suction in both the pipelines and the emission devices. A/V relief valves are typically installed at high elevation points, at control points, and at periodic pipeline intervals.

- **Pressure Regulators** are installed to protect downstream components from excessive pressures. They are especially important in drip/micro systems because the plastic and PE construction materials typically have lower pressure ratings than conventional sprinkler systems.

In addition to water, drip irrigation systems may be designed to efficiently deliver fertilizers and/or protective chemicals directly to the plant's root zone.

3. Control Zone Equipment

Now the drip irrigation system must be monitored and operated. It cannot be stressed enough how important the first two categories (flow meters and pressure gauges) are to assess performance and guidance for operation, and how important the last two categories (valves and controllers) are to deriving the maximum benefit from a drip irrigation system.

Drip irrigation systems can be fully automated, offering an unprecedented degree of control over water and power costs, and over the crop's growing conditions.

- **System Flow Meters** are available in a range of sizes and types, and commonly provide both instantaneous and cumulative water flow with an accuracy of approximately two percent. Flow meters may also be fitted with electrical analog conversion units that are capable of transmitting flow rate data to a centralized irrigation control computer.

  A micro-irrigation system offers the user an unprecedented degree of control over his water and power costs, and over the growing conditions of his crop. To take full advantage of this ability to control the irrigation system, it is necessary to have useful feedback information on flow rates and total water applied during a given time period. Accurate flow rate information is also indispensable for the analysis of crop response to water and nutrients, and for monitoring the continuing performance of the irrigation system. A good quality system flow meter is therefore an essential part of a well designed micro-irrigation system.

- **Pressure Gauges** are an essential item for drip systems since visual monitoring is often impractical or impossible. Pressure gauges placed at the pump station, before and after the filter station, and upstream and downstream of each control valve will provide an immediate indication of system performance. If pressures are too low, a leak could be indicated, a filter plugged or a valve jammed. If pressure are too high, the system could be plugged or a valve may be set incorrectly. Similar to a flow meter, accurate pressure information is essential part of a well designed and operated drip system.

- **Zone Control Valves** are used to control the flow of water to the various blocks or network zones. They may be simple manually operated valves, or fully automated solenoid activated on/off or pressure reducing valves. They may be co-located at the pump station or other Point of Connection (POC), or may be dispersed throughout the farm or landscape.

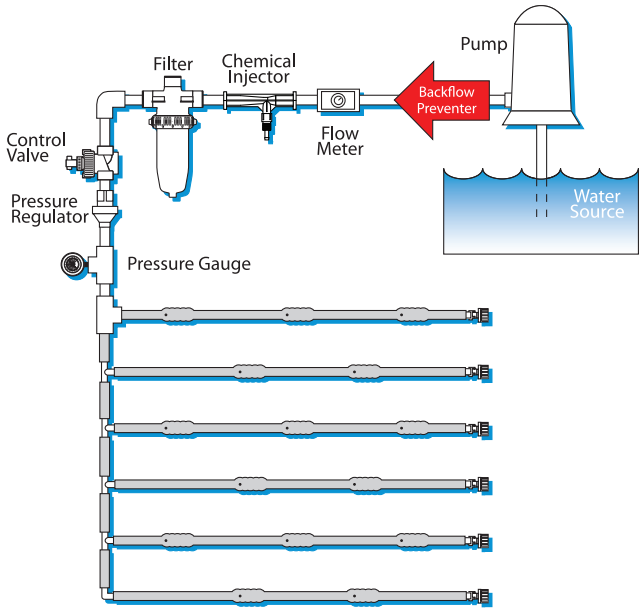
- **Irrigation Controllers** are used to automatically start and stop irrigation events by sending electronic current to solenoid activated valves. The electronic current is controlled by a user defined schedule that is entered for each zone control valve. More sophisticated controllers may allow automatic adjustment of the program based on sensor inputs such as weather (plant water use or rain), system flow or system pressure.

Definition of Drip

Drip may be defined according to a number of performance parameters including flow rates, wetting pattern, pressure rating and construction material. Regardless of the specific type, make or model of a drip irrigation system or component, its performance is typically characterized as follows:

- **Water is applied at a low flow rate** – emission device flow rates are typically measured in gallons per hour (GPH), resulting in low application rates.
- **Water is applied for long periods of time** – irrigation duration may be hours rather than minutes when the application rate is low.
- **Water is applied frequently** – irrigation events may occur daily, or even multiple times per day, when the application rate is low.
- **Water is applied at low pressure** – operating pressures typically range between 10-30 psi, rarely exceeding 60 psi, for most emission devices.
- **Water is applied directly to the soil and the plant's root zone** – water drips, or sprays, directly onto the soil and into the targeted plant's root zone without wetting the plant or non-target areas, and without regard to the presence of wind. Depending on soil type and emission device, wetting patterns typically range from 0.5-6.0 feet for emitters and up to 40 feet for micro jets or sprays.
- **Water is applied through numerous emission devices** – in point source drip, each plant is fitted with at least one emission device to service the plant's water needs. In broadcast drip, a gridwork of emission devices wets the entire area, servicing all plants within the wetted area.
- **Water is filtered** – to avoid plugging the relatively small passages inside drip emitters, 150-200 mesh filters are used to remove mineral or organic materials from the irrigation water.
- **Fertigation is enabled** – since water is applied directly to the root zone, there is an opportunity to apply nutrients along with the water.
- **Operation can be automated** – drip irrigation systems are often controlled with solenoid enabled valves that can be automatically actuated according to a user defined program entered into an irrigation controller.

Typical Layout of a Drip Irrigation System



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Comparison with Gravity and Sprinkler Irrigation

Since sprinkler irrigation is commonly used in both agriculture and in the landscape, one can further define drip by comparing it directly to sprinkler irrigation performance parameters. Conventional sprinklers typically apply water at a flow rate measured in gallons per minute (GPM) rather than GPH. As a result, application rates are generally higher, causing irrigation duration to be shorter and irrigation events less frequent. Higher application rates may also result in runoff if they exceed the soil and slope's ability to absorb water. Sprinklers typically operate at pressures ranging from 35-90 psi or more, spreading water through the air via spray or rotor type mechanical devices with wide distribution patterns. Thus, the plant material is typically wetted before water reaches the soil and root-zone, and non-targeted areas such as roads may be wetted as well. Since sprinkler irrigation systems apply water through the air, wind may affect wetting patterns as well.

Gravity irrigation is commonly used in agriculture to irrigate crops via a network of ditches, pipes, furrows and/or basins. After leaving ditches or pipelines, unpressurized water flows down furrows or across basins from one end of the field to the other, using gravity and a slight elevation drop for propulsion. On the positive side, gravity irrigation does not consume energy to pressurize the water and does not require high capital investments. However, the drawbacks to gravity versus drip include relatively poor application uniformity, high evaporative losses, unsuitability for hilly terrain, long lengths of run or sandy soils, and the inability to target the crop's rootzone or to spoon feed applications as needed on a frequent basis.

Drip irrigation provides superior uniformity, reduced evaporation, and less disease than other irrigation methods.

The following chart summarizes the basic performance characteristics of drip/micro, sprinkler and gravity irrigation:

Comparing Drip/Micro to Sprinkler and Flood Irrigation			
	Drip/Micro	**Sprinklers**	**Gravity**
Emission device flow rate	GPH	GPM	N/A
Operating pressure	4-60 psi	30-90 psi	Low
Duration of irrigation	seconds, minutes, or hours	minutes	hours, days
Frequency of irrigation	daily	weekly	monthly
Filtration	150-200 mesh	none	none
Quantity of devices	More	Less	N/A
Size/cost of each device	Less	More	N/A
Wetting patterns	.5-40 feet	5-100 feet	Broadcast
Wetting plants	Typically no	Typically yes	Typically no
Wetting non-targeted areas	Typically no	Typically yes	Typically yes
Runoff on slopes	Typically no	Typically yes	Typically yes

In summary, utilizing drip irrigation may be advantageous in many applications. Whether the end user wishes to improve profitability or simply reduce water use, there are a variety of emission devices and supporting system components to choose from such that plants may be irrigated efficiently, regardless of type or quantity. Once the drip system itself is more thoroughly understood, the next step is to use the system properly such that all potential benefits may be realized.

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