# DRIP IRRIGATION UNDERSTANDING THE BASICS







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# **About this document**

# Use of symbols

#### The symbols used in this handbook refer to the following:



#### WARNING

Contains instructions aimed at preventing bodily injury or direct damage to the crops, the automation system and/or the infrastructure.



### CAUTION

Contains instructions aimed at preventing unwanted system operation, installation or conditions that, if not followed, might void the warranty.



### ATTENTION

Contains instructions aimed at enhancing the efficiency of usage of the instructions in the manual.



#### NOTE

Contains instructions aimed at emphasizing certain aspect of the operation of the system or installation.



### ACID HAZARD

Contains instructions aimed at preventing bodily injury or direct damage to the crops and/or the irrigation system in the presence of acid..



#### **ELECTRICAL HAZARD**

Contains instructions aimed at preventing bodily injury or direct damage to the irrigation system components in the presence of electricity



#### SAFETY FOOTWEAR

Contains instructions aimed at preventing foot injury.



#### WARNING

Contains instructions aimed at preventing damage to health or bodily injury in the presence of nutrients, acid or chemicals.



#### EXAMPLE

Provides an example to clarify the operation of the settings, method of operation or installation.

The values used in the examples are hypothetical. Do not apply these values to your own situation.



#### TIP

Provides clarification, tips or useful information.

Irrigation is the watering of land by artificial methods. Without irrigation, agriculture is limited by the availability and reliability of naturally occurring water from floods or rain.

Drip irrigation is widely accepted as the most efficient irrigation technique as it allows high uniformity of water and nutrient application.

# Aim of this document

This document's purpose is to present the basic concepts regarding drip irrigation, to familiarize the reader with the components of a drip irrigation system and their functions, and to provide understanding of the basic operational and maintenance issues regarding the system.

It is intended for Netafim's personnel, its representatives and agents all over the globe and for its clients, irrigation systems managers and operational personnel.

The importance of thorough knowledge of the subjects discussed in this document for the effective operation and preventive maintenance of the drip irrigation system cannot be overemphasized.

Drip irrigation is the most advanced and the most efficient of all irrigation methods. However, its exceptional capabilities cannot be effectively implemented if the user is not familiar with the related knowledge and does not implement it in the current operation and maintenance of the drip irrigation system.

Netafim<sup>™</sup> makes every effort to provide its clients all over the globe with concise, comprehensible documentation with the intent to facilitate the operation and maintenance of the drip irrigation system while maximizing the ensuing benefits - higher yield of superior quality crop with higher market value and shorter ROI.

Netafim's personnel and its representatives and agents all over the globe should make sure to read and understand this entire document thoroughly prior to advising their clients on issues regarding the purchase, installation, operation and maintenance of a Netafim<sup>™</sup> drip irrigation system.

It is the responsibility of Netafim's representatives and agents to make sure that, prior to purchase, the client's decision makers are familiar with the installation, operational and maintenance considerations regarding a drip irrigation system, as discussed in this document.

The clients' irrigation systems managers and operational personnel should be familiar with the components of a drip irrigation system and their functions, and study in depth all the operational and maintenance issues discussed in this document prior to first operation of a new Netafim<sup>™</sup> drip irrigation system.

# P ATTENTION

This document is not a user manual. For detailed instructions for the operation, maintenance and troubleshooting of the components of the Netafim<sup>™</sup> drip irrigation system, reffer to the user manuals and documentation of each component supplied with the system.

This document should be kept available to the farm's personnel at any time for consultation on issues regarding the current operation and maintenance of the drip irrigation system.

In addition, Netafim's irrigation products department is at the client's service for any inquiry, advice or additional information needed after reading this document.

# Safety Instructions

All local safety regulations must be applied when installing, operating, maintaining and troubleshooting the Netafim<sup>™</sup> drip irrigation system and its components.



# WARNING

In an agricultural environment - always wear protective footwear.



### WARNING

Only authorized electricians are permitted to perform electrical installations! Electrical installations must comply with the local safety standards and regulations.



### WARNING

Measures must be taken to prevent the infiltration of nutrients, acids and chemicals into the water source.



# ACID HAZARD

When not handled properly, nutrients, acids and chemicals may cause serious injury or even death. They may also damage the crop, the soil, the environment and the irrigation system.

**Proper handling of nutrients, acids and chemicals is the responsibility of the grower.** Always observe the nutrient/acid/chemical manufacturer's instructions and the regulations issued by the relevant local authority.



# WARNING

When handling nutrients, acids and chemicals, always use protective equipment, gloves and goggles.



# CAUTION

When opening or closing any manual valve, always do so gradually, to prevent damage to the system by water hammer.

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# / Drip irrigation system overview

# Structure of the drip irrigation system

A drip irrigation system is comprised of many components, each of which plays an important part in the operation of the system.



System head





- 2 Pumping station
- 3 Air valve
- 4 Pressure gauge
- 5 Check valve
- 6 Shock absorber
- 7 Manual valve
- 8 Main filtration unit

- 10 Water meter
- 11 Hydraulic valve
- 12 Secondary filtration unit
- 13 Dosing unit
- 14 Fertilizer tank
- **15** Irrigation controller
- 16 Main line

- 18 Distribution line
- 19 Kinetic valve (vacuum breaker)
- 20 Dripline
- 21 Flushing valve
- 22 Flushing manifold
- 23 Fertilizer filter

# Water source

There are basically two main types of water sources: groundwater and surface water:

Many existing and potential water supply sources for irrigation systems are derived from surface water, which does not tend to have high levels of salts (with the exception of some coastal areas), and thus systems are usually less prone to formation of precipitates in drippers when using a surface water source.

**Surface water**, however, tends to introduce biological hazards. If wastewater is being considered as a source, quality and clogging potential will vary depending upon the extent of treatment.

**Groundwater** is generally of higher quality than surface water. However, iron and manganese levels should be measured, as high levels may lead to dripper clogging, and treatment may be required.

# Energy consumption in irrigation

All irrigation systems require energy, which is dissipated along the system. This is the base for uniform water application. The difference between systems lies in the amount of energy needed and the way it is dissipated. While traditional systems used only gravity to convey water to the fields, modern systems generally require external sources of energy. The designing of modern pipe irrigation systems, either collective networks or application systems, is based on energy criteria by setting head loss limits. The same applies, for instance, to the selection and dimensioning of filters and emitters. Moreover, irrigation energy use depends not only on the design of the system but also on how it is operated and maintained. Thus, the carrying out of audits is becoming increasingly common for assessing energy use efficiency and identifying ways to reduce energy consumption and costs. Such an analysis cannot be separated from agricultural water use efficiency.

Modern irrigation systems consume energy at the pumping stations (to lift water from the source and to pressurize it in the distribution network), to filter the water, to flow them along the pipes, when the water flows across ancillary network components, and to apply the water uniformly.

A high pressure is associated with a long application distance, so that limited investments are necessary to cover large areas.

# Pumps and pumping stations

Unless the water at the source is supplied at an adequate flow rate and pressure (by municipal or other entity supply, a pre-existing pump upstream from the irrigation system or gravitational pressure\*), a pump will be needed to push water from the source through the pipes and drippers.

Most irrigation systems include pumps as an integral part of the drip irrigation system.

# 

There are cases where the irrigation system is designed based on Low Energy (LES), or gravity fed irrigation system, in which water is fed into the system by gravity at low head, and the irrigation uniformity in the field is build from the field topography, this is especially on those fields that were flooded beforehand.

**\*Gravitational pressure** (also known as hydrostatic pressure) is the pressure at a point in a fluid at rest due to the weight of the fluid above it. If the water source is at a higher elevation than the drippers in the field, the elevation difference between them will determine the gravitational pressure in the system (e.g. the water level in a tank is 5 meters above the elevation of the pump's axis, the gravitational pressure is 5 meters = 0.5 bar = 7.25 PSI).

Selecting a pump for an irrigation system requires an understanding of the water conditions and local system requirements.

Poor pump selection can lead to high operating costs and shortened pump life; this in turn impacts on the performance and reliability of the whole irrigation system.

When a pump site is selected it is necessary to consider a range of factors, including availability of power, proximity to the development site and water quality issues.

#### Power source for the pump

The power source for the pump will depend on the availability and accessibility of the energy resource in the local area.

In most instances, electricity is preferred because of reduced labor requirements and higher efficiency, resulting in lower energy cost. Three-phase power is usually required to operate over 10 horsepower (hp) irrigation pumps.

If electricity is not available, alternative power sources such as diesel, gasoline, or solar may be used. The most common alternatives are gasoline engines for small pumps and diesel engines for larger pumps and recently the solar energy is gaining popularity especially in small to mid size fields.

#### Hydraulic power calculations

#### Efficiency and input power of the pump

A pump is a basic but important mechanical device that supplies the force to move fluid (in our case water) at a specific flow rate. Like any device that does work (transfers energy across a distance), its effectiveness is measured in power. Although watts and kilowatts are more common units of power measurement, horsepower is still commonly used for high-output electrical devices. In this context, 1 horsepower is equal to 746 watts. The work performed by the pump is equal to the weight of liquid pumped in unit time multiplied by total head in meters.

However the pump capacity in m<sup>3</sup>/h and liquid specific gravity are used rather than weight of liquid pumped for work done by the pump.

The input power "P" of a pump is the mechanical power in watt, kW or hp taken by the shaft or coupling.

Hydraulic power is defined as flow multiplied by pressure. The hydraulic power supplied by a pump is:

P in kW = 
$$\frac{Q \times H \times d}{367 \times \eta}$$

Here  $\mathbf{Q} = \text{Flow rate in } (\text{m}^3/\text{h})$ 

H = Total developed head in meters

 $d = Density in kg/dm^3 (1 kg/m^3 = 0.001 kg/dm^3)$ 

 $\mathbf{n}$  = Efficiency between 0 and <1 (not in %)

# 🖹 ΝΟΤΕ

As in this Handbook we are always talking about water, and its density is 1 (one) we will not take this data into account when we present the examples/calculations.

# EXAMPLE

if a pump delivers 48 m<sup>3</sup>/h and the pressure is 35 meter, then the hydraulic calculation for prime mover power of the pump is:

Power = (48 \* 35) ÷ 367 = 4.58 kW \*\*

\*\* based upon 100% efficiency;

90% efficiency would equate to  $4.67 \div 0.9 = 5.09$  kW. This would always depend on the type of pump being used (gear, vane, piston, etc.)

The total pump efficiency,  $\mathbf{\eta}$  total, must be included when calculating the power input to the pump. Power input = Power output ÷  $\mathbf{\eta}$ total.

The total system efficiency (without including the pressure drop within the pipes and valves) will end up at approximately 0.75. Moreover, the general power loss in a hydraulic energy transmission is around 25%.

Therefore, as a "rule of thumb", based in our example here above:

Power = 4.58 / 0.75 = 6.10 kW

And as in all irrigation systems cases we will take 25% efficiency loss we can simplify the formula and use the following:

# $P(kW) = \frac{Q(m^{3}/h) * P(m)}{275}$

\*Note: 275 = 367 \* 0.75

How to convert kilowatts to horsepower One horsepower is equal to 0.7457 kilowatts: 1 hp = 745.699872 W = 0.7457 kW

So the power conversion of kilowatts to horsepower is given by: P(hp) = P(kW) / 0.7457

# Example

Convert 6.1 kW to horsepower: P(hp) = 6.1 kW / 0.7457 = 8.18 hp

How to convert horsepower to kilowatts One horsepower is equal to 0.7457 kilowatts: 1 hp = 745.699872 W = 0.7457 kW

So the power conversion of horsepower to kilowatts is given by: P (kW) = 0.7457 \* P(hp)

# Example

Convert 8.18 hp to kW: P (kW) = 0.7457 \* 8.18 hp = 6.1 kW

If we wanted to calculate directly in units of horsepower (hp) and knowing that the value of the conversion, the following formula can be applied:

$$P(hp) = \frac{Q(m^3/h) * P(m)}{205}$$

\*Note: 205 = 275 \* 0.7457

# 🖹 ΝΟΤΕ

In all the examples presented we have rounded the results.

# TIP

In the field, or in a meeting with a farmer, where we must give a fast representative data, we can use  $P(hp) = Q(m^3/h) * P(m) / 200$ .

This formula is much easier to remember and gives us an approximate data very close to the true final data.



#### Calculation:

What will be the energy needed to energize a flow of 41.7 liters per second at 4.5 bar pressure?

#### First step

We must convert the data to the units required by the formula  $41.7 \text{ I/s} = 41.7*3600/1000 = 150 \text{ m}^3/\text{h}$ 4.5 bar = 45 meter

#### Second step

Now we can use the formula

 $P (kW) = \frac{Q (m^{3}/h) * P (m)}{275} = \frac{150 \times 45}{275} = 24.55 kW$ 

#### Pump types

In most irrigation applications, centrifugal pumps are used.

A centrifugal pump is a rotodynamic pump that adds energy to the water using a rotating impeller. It may be either horizontal-shaft or vertical-shaft (including submersed pumps).

Horizontal pumps are more frequently used to pump water from surface sources such as ponds.

#### Horizontal-shaft pump



#### Vertical-shaft pump

Vertical-shaft submersed pump





#### **Pump capacity**

When selecting a pump, four basic factors must be considered:

- Pump discharge (flow rate) defines the quantity of water supplied by the pump during 1 time unit (units: m<sup>3</sup>/hour, liter/second or gallons/hour).
- Pressure (pressure head) defines the internal energy of a fluid due to the pressure exerted on its container's walls (also known as static pressure head or static head) (units: bar or psi. 1 bar = 14.5 psi).
- Net Positive Suction Head (NPSH) is the required head value (suction lift) at the inlet of a horizontal pump enabling it to pull water upwards while keeping the water from cavitating\* (inherently limited to 0.8 bar net).

**\*Cavitation** - The formation of vapor cavities ("bubbles" or "voids") in a liquid. It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. When subjected to higher pressure, the voids implode and can generate an intense shockwave causing significant damage to the pump's impeller and chamber.

 Friction head - Head loss caused by the friction between the fluid and the inner walls of the shaft enclosure of a vertical pump (or in the outlet pipe of a vertical submersed pump) which pulls the water upwards. Friction loss increases with run length and by the square of the fluid velocity. It affects the required pressure and flow rate.



NPS

The output pressure of a pump is dependent on pressure head and flow rate (a higher flow rate causes a lower pressure and vice versa, all other variables being unchanged).

Make sure the pump is able to deliver adequate flow rate and pressure for the application. Obtain a performance curve for the pump and have modifications made if it is not adequate - the energy savings alone will easily pay for any upgrades required, which will also improve system operation and crop production, resulting in a shorter ROI.

#### Pump selection

The irrigation system design will specify the required pump duty (flow rate and pressure head). The best pump choice is the pump in which the Best Operating Point (BOP) occurs at this flow rate and pressure head and that can operate at the available suction head.

# 

The farther the pump's Operating Point is from the BOP, the higher the operating costs, the lower the efficiency and the shorter the life expectancy of the pump.

#### Main considerations:

- How the pump is to be installed and what the suction lift will be.
- The performance required in terms of flow rate and pressure head.

#### Constraints

Pump operating constraints may affect the supply of water and must be considered for effective planning. Common constraints include:

- Energy constraints that do not enable operation of the pump during certain hours of the day.
- Economic constraints that prevent the pump from being operated due to prohibitively high costs of electricity at certain times (days of the week or hours during the day).
- Time constraints where the water source may be unavailable at certain times or days of the week due to the sharing of resources amongst different growers.

# ΝΟΤΕ

In order to extend the lifespan of a pump, it should be operated as continuously and evenly as possible (e.g. uninterrupted operation without extreme variations in flow rate).

# 

To ensure flow rate stability, the consumption of the individual irrigation shifts should be as equal as possible. wherever possible, It is strongly recommended that the consumption of the smallest shift should not be less than 75% of the consumption of the largest shift.

#### The pump's performance curve

Each pump must be supplied with its performance curve, as an integral part of the product and the supplier/ manufacturer must commit to the data presented in it.

It is very important to keep the pump data documentation available for the whole lifetime of the pump.

The performance curve of the pump (flow rate / pressure range) is indispensable for the design and the construction of the entire irrigation system.

The pump outlet pressure is related to the discharge rate. A change of the flow rate will cause a change in the working pressure. Changes in the flow rate and pressure may be critical, when considering the relationship between the flow rate, the working pressure and the pump's efficiency curve in the planning process.

The steeper the pump's operating curve, the more a change in flow rate will affect the working pressure.

# 

Select a pump with as flat an operating curve as possible.

# EXAMPLE



#### Steep operating curve



#### Reconstruction of the pump's performance curve

If the performance curve of the pump is not obtainable, it can be reconstructed as follows:

#### To measure the pump's flow rate and pressure, install the following accessories on the pump outlet pipe:

- A water meter.
- A pressure gauge.
- A manual valve to regulate the water flow.



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Disconnected the pump outlet from the irrigation system. Water should flow freely from the outlet pipe.

#### Perform the folowing steps:

- Use a grid where the horizontal axis represents flow rate and the vertical axis represents pressure.
- ✓ Turn on the pump.
- ✓ Wait a few minutes for the flow to stabilize.
- Fully open the manual valve and mark the point representing the flow rate and pressure on the grid.
- Repeat the action with the manual valve open 3/4, 1/2 and 1/4 turn - in that order.
- Connect the points on the grid with a continual line.



# Filtration

Filtration is critical in any drip irrigation system. Effective filtration is essential for proper irrigation system operation and long-term performance, as it prevents the irrigation water from clogging the drippers.

#### Water quality

The concept "water quality" relates to the variety and concentration of the dissolved and suspended components in the water.

#### Water requirements for drip irrigation

The quality of water for irrigation relates to the parameters required to maintain the crop's health and the integrity of the irrigation system. Every type of pressurized irrigation system requires attention to the water quality to avoid clogging of the irrigation components in order to enable orderly long-term irrigation according to the irrigation program.

Water quality will dictate filtration requirements, chemical injection requirements, and management of the irrigation systems to prevent dripper clogging.

Causes of dripper clogging in systems may be chemical (precipitates or scale), physical (grit or particulates such as sand and sediment) or biological (such as algae or bacteria).

The water's chemical characteristics are influenced by the variety and concentration of the substances dissolved in it. These dissolved substances include ions of dissolved salts such as chloride, sodium and nutrients (nitrogen, phosphorous, potassium and others). Calcium and magnesium influence the hardness of the water, iron and manganese are liable to be found either dissolved or as a residue, along with other dissolved organic compounds and even poisonous substances.

The biological characteristics of the water quality include a variety of living organisms such as microorganisms, including bacteria, viruses, single celled entities, algae and zooplankton, which develop in open water along with creatures developing within the water transport system itself.

The water quality is expressed by the physical conditions and the variety and concentration of its constituents.

# The quality of the water is determined by a wide variety of parameters (measured or calculated) affecting the crop, the soil and the irrigation system. Some of them are listed below:

- ✓ EC (electrical conductivity)
- ✓ pH (level of acidity or alkalinity)
- ✓ Ca (calcium hardness of the water)
- ✓ Mg (magnesium)
- ✓ Na (sodium)
- ✓ K (potassium)
- ✓ HCO<sub>3</sub> (bicarbonate)
- CO₃ (carbonate)
- ✓ Alk (alkalinity)

- ✓ CI (chloride)
- SO₄ (sulfate)
- ✓ PO₄ (phosphate)
- **N-NH**₄ (nitrogen-ammonium)
- ✓ N-NO<sub>3</sub> (nitrogen-nitrate)
- **B** (boron)
- Section (iron)
- ✓ Mn (manganese)

- **TSS** (total suspended solids)
- TDS (totally dissolved solids)
- Turbidity
- Algae and Chlorophyll
- Zooplankton
- **BOD** (biochemical oxygen demand\*)
- COD (chemical oxygen demand\*)
- **VSS** (volatile suspended solids)

\*When waste, industrial effluent and/or recycled waters are used.

The water quality required for drip irrigation cannot always be defined in terms of particle sizes or the concentration of any specific factor, because of the complexity of the clogging factors and the changes occurring in them as they travel through the irrigation system. Changes such as water temperature, water pressure and flow rate all have an influence on the crystallization of suspended dissolved compounds, their unification and settling.

The most suitable way of defining the required quality of irrigation water is based on knowledge of all the clogging factors and determination of upper permitted threshold value for them in water arriving at the distribution system without fear of clogging or damage to the system.

#### Water Contamination

For use with a drip irrigation system, irrigation water must be filtered to remove:

- **Physical material** Silt, clay, mud, etc.
- Chemicals Iron, calcium, manganese (these sometimes combine to form conglomerates), etc.
- **Organic material** Plankton, etc.
- **Biological material** Algae, etc.

#### Common clogging factors in water sources

Water source	9	Clogging factor (according to prevalence)				
		Physical	Chemical	Biological		
Ground	Wells	Sand	Calcium*, Iron, Sulfide, Manganese	Ferric and manganese bacteria, Sulfur bacteria		
	Springs	Sand, silt	Calcium*, Iron, Sulfide, Manganese	Protozoa, Bryozoa, Ferric and manganese bacteria, Sulfur bacteria		
Surface	Lakes and Reservoirs	Sand, silt, algae, zooplankton	Calcium*, Sulfide, Iron and Manganese**	Protozoa, Bryozoa, Sulfur bacteria		
	Rivers	Sand, silt, clay	Calcium*, Iron, Manganese	Protozoa, Bryozoa		
	Canals	Sand, silt, clay, algae, zooplankton	Calcium*, Iron and Manganese**	Protozoa, Bryozoa		
Reclaimed wastewater	Non- Accumulating***	Suspended organic material	Sulfide	Protozoa, Bryozoa, Bacterial silt		
	Accumulating****	Algae, zooplankton, suspended organic material	Sulfide	Protozoa, Bryozoa, Bacterial silt		

\*Depending on the pH and temperature of the water.

\*\*Iron and manganese may appear when the water pH is low.

\*\*\*Non-accumulating-effluent emerging from a mechanical biological wastewater treatment plant.

\*\*\*\*Accumulating-effluent after processing in pools, or sewage from reservoir.

#### Definition of water quality and treatment requirements for drip irrigation

Parameter		Potential clogging risk			Treatment	
		Low	Medium	High		
Suspended solids (mg/l)		<20	20-60	>60	Filtration*	
Sand (mg/l	)	<1	1-5	>5	Hydrocyclone sand separation and filtration*	
Silt and Cla	y (mg/l)	<20	20-60	>60	Filtration*	
Calcium co (as CaCo₃)	nc. (mg/l)	<50	50-300	>300	pH rectification	
Iron (mg/l)		<0.3	0.3-0.5	>0.5	Oxidization and iron removal	
Manganese	e (mg/l)	<0.2	0.2-0.5	>0.5	Oxidization and manganese removal	
Sulfide (mg	/l)	<0.2	0.2-0.5	>0.5	Oxidization and purification	
Algae (Chlorophyl	A) (mg/l)	<0.1	0.1-0.3	>0.3	Treatment at water source; Filtration and chlorination	
Plankton	Plankton	<2	2-20	>20	Treatment at water source and filtration	
(details)	Copepod	<5	5-50	>50	Treatment at water source and filtration	
	Rotifer	<50	50-200	>200	Filtration (low concentration)	
	Dissolved oxygen (mg/l)**	>8	8.0-2.0	<2	Treatment at water source; pumping point (add if higher concentration)	
рН		pH rectification to required level according to crop and soil				
Phosphoro	us (mg/l)	<1	1-10	>10	Treatment at water source (nutrients or sewage)	
Hetrotropic (bacterial s	bacteria lime)	0	Presence	Colonization	Treatment at water source; purification	
Sulfuric bac	oteria	0	Presence	Colonization	Sulfide removal and purification	
Iron and Manganese bacteria		0	Presence	Colonization	Iron and manganese removal and purification	
Col. Protozoa		0	Presence	Colonization	Regular purification	
Bryozoa		0	Presence	Colonization	Purification and filtration	
Snails and s	shells	0	Presence	Colonization	Avoid development	
BOD sewag	ie (mg/l)	<10	10-50	>50	Sewage treatment, filtration and chlorination	

\*In extreme cases sedimentation prior to filtration is required.

\*\*Although it does not lead directly to clogging of the drippers, a lack of oxygen in the water usually indicates the presence of sulfide. A lack of oxygen in sewage indicates a poor level of sewage treatment.

#### Water analysis

A water analysis is necessary in order to select the appropriate type of filtration system, to prescribe a suitable maintenance program, to select the type of driplines and to prescribe an appropriate Nutrigation<sup>™</sup> plan (see Water analysis, page 79).

#### **Types of filters**

The types of filters used most often in drip irrigation systems are:

**Media filters** (gravel or sand) are necessary for any surface water source and especially so for wastewater. They consist of a metal or plastic enclosure incorporating small gravel stones or sand, which traps the dirt. This filter includes a flushing system for washing the gravel or sand and returning the dirt to the water source.



# $\rho$ attention

It is highly recommended to install a screen filter downstream the media filter in order to prevent infiltration of filter medium into the system in the event of a malfunction of the media filter.

**Disc filters** are used with surface water systems, wells or municipal water sources. These filters are comprised of a series of grooved plastic discs stacked together with a total equivalent screen size ranging from 40 to 400 mesh.

These filters enable deep three-dimensional filtering (e.g. allow entrapping of more particles as water passes through the pores created by the grooves in the surfaces of the filtering discs stacked together in the filter). Having more surface area than screen filters, disc filters are better suited for higher flow rates.

**Screen filters** are used mainly as secondary filters with surface water systems or as primary filters with well or municipal water sources. A screen filter is comprised of a cylinder with a net that traps the dirt. This filter is intended for relatively clean water; its use is less common with water from a reservoir or pumped water.

# P ATTENTION

In any type of filter, the dirt returned to the water source should be discharged as far as possible from the suction point. In a streaming source (e.g. a river) the discharge point should be downstream from the suction point.

**Hydrocyclone sand separators** are used as a preliminary stage of filtration in the presence of sand or other heavy particles (50 micron or bigger) in the source water. It utilizes centrifugal force to separate the particles from the water. The separated material drops down into a tank or reservoir where it can be removed later.

It is not a true filter, since there is no physical barrier to separate out the particles, but it is often used before a filter to first remove the bulk of the contaminant, where the filter does the final cleaning. This type of design reduces the time required to flush and clean the main filter. Each hydrocyclone model has its specific operation flow rate range, it will not perform outside this range.







#### Filter screen/disc size

The relevant term for drip irrigation is the size of the gaps between fibers in the filter, in **Micron** (1/1000 mm). **Mesh size** represents the number of pores (openings) per linear inch (typically 40-200) but does not represent the size of each pore.

Since the filtration industry traditionally uses mesh size, see the table below for **Micron/Mesh** conversion:

Micron (µm) = size of gaps between fibers	400	250	177	125	105	100	74
Mesh = number of pores per linear inch	40	60	80	120	140	150	200

\*The mesh to micron conversion is not a proper mathematical conversion but a commercial approximation.

#### Considerations for comparison between automatic filters

Consideration	Component	Gravel/Sand	Disc	Screen	
Removal efficiency	Suspended solids (general)	•••		•	
of different	General filter level	•••	••		
particles and	Sand (following hydrocyclone)	•	••	•••	
general operation	Silt and clay	•••	••		
	Algae (< 40 micron)	•••	••		
	Zooplankton	••	•••	•••	
	Iron and manganese (after oxidization)	•••	••	••	
	Slime	•	••	•••	
Technical	Low supply capacity	••	•••		
and hydraulic	Very high supply capacity		••	•••	
considerations	Minimum flushing pressure (bar)	2.0	1.5	2.0	
	Quantity and cost of flushing water	•••	•	•	
	Water in flushing cycle	•••	••	•	
	Capacity required for flushing	•••		••	
	Complexity of system	••	••	••	
	Corrosion proof	•	•••	••	
Operational	Operational and maintenance requirements	•••	•	•	
and maintenance	Frequency of operational failures	•••			
considerations	Expertise required	••	••	••	
	Cost of maintenance	Check and compare			
Financial	Cost of system	t of system Check and compare			
considerations	Cost of accessories (pressure, capacity and non-return valves)	Add to cost of system			
	Cost of m <sup>3</sup> /hr of filtered water	m <sup>3</sup> /hr of filtered water Total cost of supply in m <sup>3</sup> /hr			
	System depreciation Add to calculation				

#### **Filtration requirements**

The design of a filtration system involves selection of filter type and filter size (capacity) depending on the water source and the amounts of particulate matter, carbonates and iron in the water supply and the kinds (if any) of nutrients and/or chemical stock solutions to be injected.

The type of filtration to be used is carefully selected at the planning stage according to the general quality of the irrigation water, and the presence of various substances in it, with respect to the specific requirements of the irrigation system.

# 🖹 ΝΟΤΕ

If a hydrocyclone sand separator is required, make sure it suits the flow rate range of the planned system.

Water quality and drippers specifications will determine the filtration type, level (effective mesh size) and quantity. Most drip irrigation systems require filtration of 130 micron (120 mesh) or higher (filters may also be specified by the maximum particle size that will pass it - in microns).

# ATTENTION

Standard irrigation filters will NOT remove salt or dissolved solids.

# ATTENTION

Always install a filter when setting up a drip irrigation system. Even if potable water is used, a basic screen filter is still required.

#### A well planned drip irrigation system includes 2 stages of filtration:

#### Main (Primary) filtration

- Responsible for filtering relatively large particles near the water source.
- Comprised of a media or disc filter.
- A hydrocyclone sand separator should be place before the main filter in cases where sand or other heavy particles (50 micron or bigger) are present in the source water.

#### **Secondary filtration**

- Responsible for filtering relatively small particles remaining after the main filtration stage.
- Two types of filters can be used for secondary filtration:
  - Screen filter
  - Disc filter

# Main, sub-main, distribution pipes and fittings

#### Main, sub-main, distribution pipes

Pipelines carry water through the entire irrigation system, from the pump through the filters, the valves, and onward to the drippers.

# ATTENTION

All pipelines and fittings should be properly sized to withstand maximum operating pressures and convey water without excessive pressure loss or gain.

PVC piping may be used throughout the system or combined with steel piping at the pump station. PVC, polyethylene (PE) or flexible pipes (FlexNet<sup>™</sup>) are used for sub-mains and distribution pipes.

# ATTENTION

Be sure to consider the expansion and contraction that occurs under normal on-surface operating conditions (each type of pipe is affected to a different degree).

# P ATTENTION

Pipelines are connected to one another with welds, glue or friction fittings, according to the type of piping in use, and are anchored to the infrastructure supporting them. Make sure all pipelines are properly secured and anchored.

# 

In a sub surface drip irrigation (SDI) system, the pipeline is more difficult to access and repair. Making sure all fittings are secure at installation can save significant repair issues later. Particular attention is required especially after the initial growth stage of the crop.

In irrigation design, pipe sizes are specified based on economic, friction loss, water hammer considerations and flushing concerns. As pipe size increases, friction loss decreases (reduced pumping cost) but initial cost increases.

# 副 ΝΟΤΕ

In most cases the distribution pipe is installed below the elevation of the driplines so that solids will tend to collect in it rather than in the driplines.

Irregular field shapes are common due to topography and property boundaries. At the planning stage, care is taken to properly size sub-main and distribution lines where field shape varies. Sub-main and distribution lines for irregularly shaped fields are designed based on actual flow rates of the driplines and not on an "average" flow rate of the system.

# 

The piping system must be designed not only to allow the flow rate necessary for normal irrigation but also to allow sufficient flow rate for proper flushing velocities in the system (recommended minimum: 0.3 meter/sec; 1 foot/sec).

(For flushing instructions see Flushing the main, sub-main and distribution lines, page 75).

Design objectives for flushing may result in different pipe diameters being selected than those selected in the design process for normal operation. This is because the flushing flow rate required for achieving a desired flushing velocity in any section of a main, sub-main or distribution pipe may be different than the design flow rate for regular operation.

#### Structure of the cross section of a pipe

- The Outside Diameter (OD) of the pipe is the distance between the outside walls of the pipe, measured perpendicularly to the pipe's axis.
- The Inside Diameter (ID) of the pipe is the distance between the internal walls of the pipe, measured perpendicularly to the pipe's axis.
- ✓ Wall Thickness (WT)

#### Pipe's Inside Diameter = ID = OD - (2 \* WT)



Pipe's Wall Thickness = WT =  $\frac{OD - ID}{2}$ 

# 

The relevant pipe diameter or calculations regarding flow rate and velocity in a pipe is the Inside Diameter (ID).

# EXAMPLE

A selection of polyethylene (PE) pipes demonstrating the relation of the pipe's Inside Diameter (ID) to the Outside Diameter (OD):

Pipe diameter/class*	Outside Diameter (OD) (mm)	Wall Thickness (WT) (mm)	Inside Diameter (ID) (mm)
63/12	63	4.70	53.60
75/12	75	5.60	63.80
90/12	90	6.70	76.60
110/12	110	8.10	93.80
125/12	125	9.20	106.60
140/12	140	10.30	119.40
160/12	160	11.80	136.40
200/12	200	14.70	170.60
225/12	225	16.60	191.80
250/12	250	18.40	213.20

\*By international standard ISO 4427/07.

For more info, see Netafim<sup>™</sup> Polyethylene Rigid and Flexible Pipes - Product Catalog.

#### **Fittings**

A wide variety of fittings are available to fit any drip irrigation system and any type of pipes used. The selection of fittings is a planning issue defined by the project's BOM (Bill of Material). For more info see Netafim™ Fittings and Accessories Product Catalog.

# Water meters and pressure gauges

Make sure your system has a water meter and pressure gauges in working order! Although simple, these gauges are often overlooked or not maintained. These monitoring devices are essential to proper system operation. System flow rate helps detect leaks or clogging, and must be known to determine the application rate for irrigation scheduling purposes. System pressure also helps detect leaks or clogging, and is essential for managing filters, chemical injectors and the whole system within its operating range.

#### Water meters

Water meters provide information regarding water application that is essential for irrigation scheduling, and for the monitoring of dripper clogging. Propeller meters are the most common type in agricultural applications.

# 

All types of water meters require regular maintenance. Follow the manufacturer's recommendations for required maintenance.

A water meter installed at the head of a drip irrigation system or small water meters placed at the head of selected driplines can help in detection of dripper clogging.

A single, large water meter at the head of the drip irrigation system monitors the flow rate to the entire system. Most water meters incorporate a totalizing register that records the total flow ( $m^3$ , gallons) passing through the meter. Some meters also have an instantaneous flow rate indicator (measured in  $m^3/h$ , GPM).

Make sure that the pipe in which the water meter is installed is flowing full (the water flowing fills the entire cross section of the pipe without air pockets) and that there is not excessive turbulence in the pipe. A water meter installed close to a valve, elbow, or tee (T) may not provide accurate information. If the meter has an instantaneous (e.g.  $m^3/h$ , GPM) indicator, an excessive fluctuation of the indicator needle is a sign of excessive turbulence in the meter.

To detect clogging or leaks in the irrigation system, check the flow rate in the system weekly (see Preparation and Use of a Hydraulic Conditions Checklist, page 77). A decrease in flow rate over time may indicate clogging. Before checking the flow rate, check that the pressure in the system is as planned. For accurate and useful data about the drip irrigation system to be acquired, the operating pressure of the system must be as initially planned each time the flow rate is checked. If the operating pressure is allowed to vary, the acquired flow rates will be valid but will not be usefully compared for the purpose of clogging detection.

Using a number of small water meters (throat size 5/8" or 3/4") to monitor flow rate to individual driplines (laterals) provides greater sensitivity to clogging than does a single, large water meter at the head of the system. Especially recommended in large projects - over 100 Ha (250 acres).

Most small water meters have only a totalizing register, so you will need to keep track of the system operating time between water meter readings (if installed, a controller does it automatically (see Controller, page 45). As with the large water meter, for acquired data to be valid the operating pressure needs to stay constant over time.

Drip irrigation system overview





# Pressure gauges

Pressure gauges are essential components in a drip irrigation system. Providing vital information concerning the irrigation system, they help in the detection of leaks and clogging and in the management of filters, chemical injectors and in keeping the system in its operating range.

To acquire as accurate as possible data always use a pressure gauge with a scale representing the pressure range of the system. The typical pressure in the system should be roughly at the midpoint of the gauge's scale.

#### Pressure loss across a filter

To avoid inaccuracies in the reading of the pressure loss across a filter, use a single pressure gauge connected to a three-way selector valve, as shown.

# ATTENTION

Reading the pressure loss across a filter with two different pressure gauges installed at the inlet and at the outlet of the filter might result in inaccurate reading due to calibration difference between the two gauges.

It is important to measure the pressure at a variety of key points along the irrigation system: at the head of the system, at the head of each irrigation zone and at the inlet and end of selected driplines in the field.



Netafim<sup>™</sup> offers a variety of nozzle adapters to be connected at the key points in the system, enabling the use of a single hand-held pressure gauge equipped with an insertion needle.

#### Pressure gauge nozzle adapters

With barb connector for use with PE pipes (i.e. driplines).



With thread connector for use with PVC pipes.









# Valves

In an irrigation system, water flow rate and pressure throughout the system should be precisely controlled to ensure efficient and timely water application; therefore proper selection and placement of valves is critical.

Valves play key roles in controlling pressure, flow and distribution under different conditions to optimize performance, facilitate management, and reduce maintenance requirements.

# P ATTENTION

Valve sizes, maximum working pressure and valve materials should be selected properly to meet the system demands. Oversized valves may not open or close properly while undersized valves may restrict flow and cause excessive pressure loss.

#### Valves used in a drip irrigation system include:

#### Manual control valve

4 common types of manual control valves are used in drip irrigation systems:

#### **Ball valve**

The ball valve is a quarter-turn valve. In a ball valve the closing mechanism is a sphere (ball) with a port through the middle, connected to a lever in line with it that shows the valve's position. Rotating the lever turns the ball so that when the port is in line with the pipe, flow will occur, and when perpendicular to the pipe, flow is blocked. Designed to be fully opened or closed and is not suitable for regulating the flow.

#### **Butterfly valve**

The butterfly valve is a quarter-turn valve. Operation is similar to that of a ball valve. The closing mechanism takes the form of a disc positioned in the center of the pipe. A rod connected to the lever passes through the middle of the disc is. Rotating the lever turns the disc either parallel or perpendicular to the flow. Unlike a ball valve, the disc is always present within the flow; therefore a slight pressure drop is always induced in the flow, regardless of valve position. Designed to be fully opened or closed and is not suitable for regulating the flow.

#### Gate valve

The gate (sluice) valve opens by lifting a gate (wedge) out of the path of the fluid. When the gate valve is fully open, there is no obstruction in the flow path, resulting in very low friction loss. Designed to be fully opened or closed and is not suitable for regulating the flow.

#### **Globe valve**

A globe valve is the only type of manual valve recommended for regulating the flow with minimum friction loss. It consists of a movable disc plug aligned with a fixed ring located in the stream. Operated by screw action using a handwheel.

#### Check valve (One-way valve)

The function of the check valve is to prevent water flow in the opposite direction to that desired. It serves various purposes:

- Installed at the outlet of a pump that pumps water to a field at a higher elevation protects the pump from the back wave of water hammer.
- Installed at the outlet of a filter, which conveys water to a higher field prevents water from flowing back through the system's head components.
- Installed upstream from a dosing unit prevents fertilizers and chemicals infiltration of the water source.
- Installed on the inlet pipe of a pump, as a foot valve, enables priming of the inlet pipe.













#### Hydraulic control valve

Opens and shuts off in response to a local or remote pressure command.

#### Pressure Reducing Valve (PRV)

Reduces higher upstream pressure to lower constant downstream pressure regardless of fluctuating demand, and opens fully upon line pressure drop.

For optimal operation the pressure ratio across a PRV should not be higher than 1:4.

#### Pressure relief/sustaining valve

Can fulfill either of two separate functions:

- When installed in-line, it sustains minimum preset upstream pressure regardless of fluctuating flow or varying downstream pressure.
- When installed as a circulation valve, it relieves line pressure in excess of preset.

#### Pressure reducing and sustaining valve

Fulfills two independent functions at the same time:

It sustains minimum preset upstream pressure regardless of fluctuating flow or varying downstream pressure and it prevents downstream pressure from rising above maximum preset, regardless of fluctuating flow or excessive upstream pressure.

#### **Pressure relief valve**

Relieves excessive line pressure when it rises above the preset maximum. It responds to a rise in system pressure immediately, accurately and with high repeatability, by opening fully.

#### Booster pump control valve

A double chambered, active check valve that opens fully or shuts off in response to electric signals. It isolates the pump from the system during pump starting and stopping, to prevent pipeline surges.

#### Surge anticipating valve

An off-line valve, sensing line pressure. It opens in response to the pressure drop associated with abrupt pump stoppage. The pre-opened valve dissipates the returning high pressure wave, eliminating the surge. The valve also relieves excessive system pressure.

#### Air valves

#### Combination air release valve

Evacuates large volume of air during pipeline filling and network draining and allows efficient release of air pockets from pressurized pipelines.



#### Kinetic air valve

Evacuates large volume of air during pipeline filling and network draining.



# **Dosing unit**

A dosing unit serves Nutrigation<sup>™</sup> and chemigation:

#### Nutrigation™

The most effective way to increase the yield and quality of a crop is by feeding the plant according to its specific, ever-changing needs. This means delivering the right amount of water and nutrient at the right time. Nutrigation<sup>™</sup> refers to injection of nutrients for the plant.

#### Nutrigation $\ensuremath{^{\rm M}}$ is comprised of three stages:

- Oissolving soluble fertilizers (if required).
- Injecting nutrients according to the desired dosing ratios.
- Delivering the precise quantity of nutrients to the plant's root zone.

#### Chemigation

Chemigation refers to injection of chemicals to prevent or reduce dripper clogging (addition of chlorine, hydrogen-peroxide, acid or others), and the injection of chemicals for crop and soil concerns (herbicides, pesticides and others).

Because the water passages in drippers are relatively small, they can be clogged; therefore, along with filtration, the capability to inject chemicals for dripper clogging control is an important feature.

#### Benefits of Nutrigation<sup>™</sup> and/or chemigation:

- Uniform and timely application of nutrients and chemicals.
- Reduced soil compaction due to reduced traffic in fields.
- Reduced labor requirements, reduced exposure to chemicals.
- Reduced environmental contamination.

The design of a chemical injection system involves the selection of injector type and capacity. If the injection system is to be used for Nutrigation<sup>™</sup>, the injection unit is sized for this use since injection rates for nutrients are usually much higher than injection rates for chemicals such as liquid chlorine or acid.

Any components coming in contact with nutrients, chlorine, or acid should be resistant to corrosion. Some countries require specific types of injectors for agrochemicals. Always follow local laws and chemical labeling requirements.

#### Nutrients and chemicals may be injected into pressurized drip systems via a variety of methods:

Netafim<sup>™</sup> offers a comprehensive array of dosing systems to ensure precise nutrient delivery for any crop, plot size and application.

#### **Relevant terms:**

- Single dosing channel for injection of only one type of fertilizer solution at the same time.
- Multiple dosing channels for injection of several fertilizer solutions at the same time or of a single fertilizer solution at a higher rate.
- Sulk/Quantitative Nutrigation<sup>™</sup> The entire amount of fertilizers is injected in one shot.
- Proportional Nutrigation<sup>™</sup> The fertilizers are injected at a constant ratio relative to the flow of irrigation
  water in the main line.
- ✓ Nutrigation<sup>™</sup> based on EC and pH control Nutrigation<sup>™</sup> is constantly adjusted in order to keep a steady EC and pH level according to the plant's needs.

Can be conveniently accomplished with a controller on the dosing system and EC and pH sensors on the dosing unit.

#### Fertilizer tank

A fertilizer tank mixes water with fertilizer for quantitative Nutrigation<sup>™</sup>. It is operated by the hydraulic pressure in the irrigation system and does not need an external energy source (subject to excess pressure available in the system). The desired amount of fertilizer placed in the tank is dissolved and injected into the irrigation system.

Can be connected to the irrigation system in two ways:

- Inline installed directly on the main line (typical of very low capacity systems).
- Bypass installed as a bypass from the main line, a manual or hydraulic pressure reducing valve (PRV), installed on the main line, produces the required pressure differential to operate the fertilizer tank (typical of high capacity systems).

Fertilizer tanks are simple to use and maintain.

#### Hydraulic piston motor injector

Its linear hydraulic piston motor is powered by the hydraulic pressure in the irrigation system, and does not require any other energy source for injecting fertilizer into the pressurized irrigation line.

Water enters the injector through the upstream inlet and exits it to the drain line through the water outlet. The fertilizer is injected at twice the pressure of the irrigation line, generated by the hydraulic piston motor itself.

The liquid fertilizer enters the injector through the suction port positioned inside the fertilizer tank and is injected through the injection outlet, downstream, into the irrigation line.

The water consumption of the hydraulic motor is 3 times the quantity of the chemical injected and it can produce an injection flow rate of up to 320 liter/hour (1.4 GPM), depending on the inlet pressure and the pump model.

Can be operated manually or automatically by an irrigation controller.

#### Netafim<sup>™</sup> Venturi Injector - up to 2"

A Venturi injector uses excess pressure in the irrigation system to create a low pressure zone, or vacuum, in the injector throat. This vacuum efficiently draws chemicals into the pressurized water line, eliminating the need for a separate chemical injection pump.

Venturi injectors are the most cost-effective method of introducing chemicals into a pressurized irrigation system, popular because of their simplicity, reliability and low cost, and because they don't require a power source.

Can be easily connected to the irrigation system in two ways:

- Inline installed directly on the main line
  - (typical of very low capacity systems).
- Bypass installed as a bypass from the main line, a manual or hydraulic pressure reducing valve (PRV), installed on the main line, produces the required pressure differential to operate the Venturi injector (typical of high capacity systems).

Venturi injectors include no moving parts and require little maintenance. They supply an extremely uniform injection rate from start to finish at nominal system flows rates.

Chemical injection capacity: 30 - 1200 l/h (8 - 320 GPH) depending on injector size and operating pressure.

Can be operated manually or automatically by an irrigation controller.







#### Electric dosing metering pump

Intended for flow rates up to 25 l/h (6.6 GPH), the electric pump is usually used for injection of chemicals and acids for system maintenance.

Maximum pressure: 10 bar (145 PSI).



#### Hydraulic fertilizer injector (proportional)

Applies fertilizers and chemicals proportionally to the water flow through an irrigation system in the slow and constant quantities required for steady growth. Widely used in open fields, orchards and landscaping to inject an additive into a water line at a consistent injection rate under varying water pressure and flow rates. This process, injecting additives using only water power, is accurate and simple.

- ✓ Water driven, non-electric.
- Piston driven by water flow.
- Solution is added in proportion to water flow for accurate mixing.
- Solution is constantly added as water flows through the unit.
- Ratio of additive remains constant.

#### Single channel kit

Venturi injector with booster. This method is used when the pressure differential in the main line is not sufficient to activate a basic Venturi dosing unit. The booster pump creates additional pressure to activate the Venturi while preventing head loss to the system. Supplied with selected size of Venturi (up to 3/4"). A check valve should be installed upstream from the bypass. Can be operated manually or automatically by an irrigation controller.



#### FertiKit3G™

The FertiKit3G<sup>™</sup> is a highly versatile and precise dosing system suitable for an unrivaled range of irrigation system capacities. Covers all applications ranging from open fields to intensive horticulture. Requiring a minimal investment, the FertiKit3G<sup>™</sup>, a CE-compliant modular system, is the industry's most cost-effective

dosing system, whether used for small or large-scale applications. **Flexible:** Works with a very wide range of dosing

- channel flow rates up to 6 units of 50 to 1000 l/h.
- Scalable: For systems from 1 m<sup>3</sup>/h to 700 m<sup>3</sup>/h capacity and pressures up to 8.0 bar.
- **Cost-effective:** Requires minimal investment with rapid ROI.
- Modular: Available in four models including two that do not require a booster pump.

#### NetaFlex3G<sup>™</sup>

The NetaFlex3G<sup>™</sup> is a reliable, state-of-the-art, open-tank dosing system ensuring very precise and even nutrient dosing for greenhouse crops.

A CE-compliant modular system, the NetaFlex<sup>™</sup> easily integrates with multiple Netafim<sup>™</sup> and third-party control and monitoring systems, while delivering a uniform quantity or ratio of nutrients.

- Productive: Employs precise EC and pH control to assist in delivering a high-quality product with outstanding yields.
- Uniform: Delivers a consistent quantity or ratio of nutrients in a homogenous solution thanks to an open mixing tank design.
- Flexible: Works with a wide range of dosing channel flow rates up to 8 units of 50-600 I/h (Standard) or up to 5 units of 1000 I/h (HF)
- Scalable: System flow rates from 5 m<sup>3</sup>/h to 60 m<sup>3</sup>/h capacity.
- Security Focused: Made for greenhouse applications.

#### NetaJet4G<sup>™</sup>

The NetaJet4G  $^{\rm M}$  is a uniform low-energy dosing system featuring a state-of-the-art mixing chamber.

It provides the highest level of dosing precision and uniformity for greenhouse and open-field crops.

A CE-compliant modular dosing system, the NetaJet4G<sup>T</sup> easily integrates with multiple Netafim<sup>T</sup> and third-party control and monitoring systems.

- Productive: Employs precise EC and pH control to deliver consistently high-quality product with outstanding yields.
- Uniform: Delivers a consistent quantity/ratio of nutrients thanks to an innovative mixing chamber while maintaining perfect EC and pH control.
- Flexible: Works with a wide range of dosing channel flow rates up to 5 units of 1000 l/h dosing channels.
- Cost-efficient: Using a single pump for mixing and injection of nutrients, the NetaJet4G is designed to accurately dose with low levels of energy consumption.
- Scalable: Scales from 5 m<sup>3</sup>/h to 400 m<sup>3</sup>/h capacity and pressures up to 6.5 bar.
- Versatile: Suitable for applications ranging from greenhouses to net houses.







		<pre>/ Recommended for:</pre>						
	Number of dosing that the	ps Real	ured energy	open field	al orchard	areenhouse for	ouse oiless ments	
	Fertilizer tank	Ø	•			Will work of inlet and o	only if the pressure difference between utlet is at least 0.3 bar (3 meters).	
	Hydraulic piston motor injector		•			Consumes water 3 times the quantity of the chemical injected.		
gle	Netafim™ Venturi injector	P				Requires 1 operation,	5-75% pressure differential for optimal according to the required injection rate.	
Sin	Electric dosing pump	6						
	Hydraulic fertilizer injector (proportional)	P				Requires 1 operation,	5-30% pressure differential for optimal according to the required injection rate.	
	Single channel kit	6				Le	gend:	
e	FertiKit3G™	<b>6</b> or <b>9</b>		•		6	Electricity is available on site.	
Multiple	NetaFlex3G™	6		•	•		Extra pressure is available in the	
	NetaJet4G™	6		•	•		system in addition to the required pressure for current irrigation.	

For detailed technical data, see the product's datasheet.

For clarifications or in case of doubt consult a Netafim<sup>™</sup> expert.

# **Driplines (laterals)**

Driplines are at the heart of a drip irrigation system. In any irrigation system, the design process starts at the plant and proceeds to dripline design. It is important to know what to take into consideration during dripline design: dripline selection, wall thickness, dripper flow rate, spacing between drippers, spacing between dripline, and specification of dripline insertion depth (in SDI).

#### Basic terms regarding driplines:

#### Structure of the cross section of a pipe

- The Outside Diameter (OD) of the pipe is the distance between the outside walls of the pipe, measured perpendicularly to the pipe's axis.
- The Inside Diameter (ID) of the pipe is the distance between the internal walls of the pipe, measured perpendicularly to the pipe's axis.
- ✓ Wall Thickness (WT).

Pipe's Inside Diameter = ID = OD - (2 \* WT)

Pipe's Wall Thickness = WT = OD - OD

The area of the inside pipe's cross-section = A =  $\frac{\pi ID^2}{4}$  =  $\pi r^2$ 

✓ π = 3.1416
 ✓ r = ID/2

#### Uniformity and efficiency

**Uniformity** saves water and fertilizer and improves yield, resulting in shorter ROI.

Efficiency saves resources and preserves the environment while optimally serving the crop's needs.

### ATTENTION

Low startup costs can result in high annual operating costs. When designing a drip irrigation system it is important to consider uniformity and efficiency in order to keep total cost low.

# 

By international standards, 10% flow variation is considered uniform irrigation.

#### Drippers

The drippers incorporated at uniform spacing along the dripline deliver water and nutrients directly to the plant root zone.

A typical drip irrigation system includes thousands of drippers. Each dripper should be durable, resistant to clogging, and emit the same amount of water. Wide water passages guarantee long-term trouble-free performance.

The flow rate and spacing of the drippers is important in determining the wetting pattern and for the prevention of runoff or deep percolation.

A properly operated and maintained drip irrigation system provides water and nutrients to the crop root zone without runoff or deep percolation.

#### Two types of integral drippers are available:

#### Non pressure compensated drippers

Non-PC drippers supply a flow rate that is based on the working pressure.

- The dripper flow rate, pipe diameter and dripper spacing determine the pressure head losses in water flow within the dripline.
- Olifferences in topographic heights also affect the system.

These two factors produce small differences in the dripper flow rates within the same dripline.

#### Pressure Compensated (PC) drippers

As long as the working pressure remains within the allowable pressure range, PC drippers provide uniform irrigation by maintaining a constant flow rate regardless of the working pressure.

The diaphragm is activated by the continual differential pressure created by the dripper's labyrinth, thus maintaining a constant dripper flow in a wide pressure range.

Thanks to the free-floating diaphragm, the dripper's action is precise, immediate, sensitive, continually selfadjusting and constantly self-flushing. Particles that cause clogging will either be flushed out through the wide water passages or increase the pressure differential. This causes the diaphragm to momentarily increase the cross-section volume for outgoing water, and thus flush the dirt out of the system.

PC Dripper

The diaphragm movement maintains constant differential pressure within the water passage, resulting in a uniform flow rate at a wide pressure range.

Additionally, Netafim<sup>™</sup> PC drippers have the added benefit of the exclusive constant self-flushing feature, which aids in the prevention of clogging.

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PC drippers deliver the same flow rate regardless of the dripline length (as long as the drippers operate within its working range as determined by the manufacturer).



#### Drippers and driplines for particular applications:

**AS:** Anti-siphon mechanism blocks contaminants from being drawn into the dripper from outside, makes it a critical addition to driplines installed below the surface, i.e. sub surface drip irrigation (SDI).

**CNL:** Also called Anti-drain, is an anti-drainage mechanism. When the pressure in the pipes drops (after valves shut-off at the end of an irrigation cycle) and the desired pressure is achieved, the CNL mechanism closes the water passage, hence pipes remain full of water and are ready for the next cycle, this makes it ideal for pulse irrigation (irrigation in short frequent cycles) in greenhouses, nurseries, and fruit trees.

**HCNL:** Also called High Level Anti-drain, is anti-drainage mechanism, similar to the CNL, but with higher shut-off pressure.

This mechanism provides two main benefits:

Allows installation of non-leakage systems in areas with steeper slopes, thereby improving system efficiency, and reducing the number of DNL's (Dripline Non-Leakage Valves).

Enables maintaining a higher pressure within the driplines used in pulse irrigation, hence allowing mixing and circulating water and nutrients in the system prior to an irrigation event. This makes it ideal for pulse irrigation (irrigation in short frequent cycles) in greenhouses, nurseries, and fruit trees.

AS XR: Reduces significantly the risk of roots penetrating and clogging the drippers by incorporating copper oxide that inhibit root growth within the dripper. This innovative resin is mixed in the dripper cover to offer long lasting effect throughout the dripline life. AS XR drippers are available in both UniRam<sup>™</sup> and DripNet PC<sup>™</sup>. UniRam<sup>™</sup> also includes physical root barrier.

**AS XRS:** Drippers are protected against root intrusion better than all other options, utilizing a patented root inhibitor within the dripper cover that prevents root intrusion into the dripper labyrinth also combines external stripe that prohibits root strangulation of the pipe. Better protection against root intrusion and strangulation without reliance on chemicals.

**Flap:** Located in the same place, instead of a open hole outlet, the dripline wall is punched in a special shape. During irrigation the water pushes the flap open to allow drip. It acts also as physical barrier when there is no water to prevent root intrusion, and keeps drippers clean when installed from sand penetration. Flap exist only in TWD, except very unique cases.

**ReGen™:** Driplines that are ReGen<sup>™</sup> marked are driplines that contains recycled materials in the pipe raw material composition, this in the name of sustainability and without compromising quality, meeting all the international standard for drip irrigation and others.

**HCR:** High Chlorine Resistance for permanent drip applications using waste water or continuous dose of chlorine. Delivering long-lasting uniform water and nutrient distribution, resulting in excellent crop yields season after season.
#### Determining the type of dripper to use

The type of drippers to be used should be selected according to the project's needs and characteristics. Although it is up to the grower to decide which type of drippers to use for a specific crop, the following recommendations should be considered:

#### It is strongly recommended to use PC drippers when:

- ✓ The terrain slope is greater than 2%.
- There are topographic variations along the dripline.
- For long driplines.
- The crop is highly sensitive to excessive or insufficient irrigation.
- In orchards, where poor irrigation uniformity would cause inequality in growth of individual perennial plants (the longer the plant's life, the greater the disparity between individual plants).
- Perfect water distribution and uniformity are required.

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For sub surface systems always prefer anti-siphon (AS) drippers.

#### On line drippers

Netafim<sup>™</sup> offers a comprehensive line of on line drippers with all the features and benefits of its integral drippers. Designated mainly for greenhouse, nursery and fruit tree aplications.

Netafim's on line pressure-compensated (PC and PCJ) drippers ensure precise, efficient and uniform flow distribution over the entire growing area and high resistance to common chemicals and nutrients.

#### Spider assembly

Netafim<sup>™</sup> offers growers a range of micro tubes, manifolds and/or end-line products which, when connected to on line drippers can be used to direct water flow to a specific location or to irrigate a variety of points.

#### Dripline selection and layout design

With any irrigation system, the design process starts at the plant and works "upstream". Hydraulically speaking, this means that the first part of the design process of an irrigation system is dripline design consisting of dripline selection and spacing between driplines in the field.

Dripline selection involves consideration of spacing, pipe diameter and wall thickness, and dripper flow rates.

Consideration must also be given to connections between the driplines to the supply and flushing manifolds.

Dripper spacing depends on flow rate and soil characteristics. In general, coarser textured (sandy) soils will require shorter dripper spacing than a finer textured (clayey) soil, since coarse soils allow less lateral water movement.

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The driplines must be selected not only to allow the flow rate necessary for normal irrigation but also to allow sufficient flow rate for proper flushing velocities in the system. (see Flushing the dripperlines, page 76).

Dripline spacing depends on the crops to be grown, the processing method and the agro-machinery to be used.

Oftentimes there will be a critical crop in rotation that will dictate spacing. In rotations that include a row crop, dripline spacing is most often a multiple of the row spacing.

Dripline length is determined by field length and layout, allowable pressure (and therefore flow) variation within a zone, and flushing considerations.

Dripline length also needs to be specified; along with dripline's diameter, this will affect flow rate uniformity and impact flushing requirements and flow variations (particularly with drippers that are not Pressure Compensated).

When determining the type of dripline to be used and deciding on the distance between driplines, also consider the plot geometry and the work practices.

In some regions, many fields are irregularly shaped, and therefore may have driplines of different lengths.

#### Netafim<sup>™</sup> offers a wide selection of driplines suitable for various irrigation needs

#### Thin-walled driplines for short crop cycles

- Suitable for 1-3 growing seasons.
- Sepecially fit for vegetables and field crops.
- Can be deployed at the beginning, and rolled-up at the end of each growing season.

#### Medium-walled driplines for semi-permanent applications

- ✓ Suitable for 4-9 growing seasons.
- Designed for on-surface and sub surface (SDI) applications.
- For perennial plants, row crops and industrial row crops.

#### Thick-walled driplines for permanent applications

- Suitable for 10 or more growing seasons.
- Obsigned for a working life of many years in on-surface and sub surface (SDI) applications.
- For perennial plants, fruit trees, vineyards and the like.

#### Decoding the commercial name of Netafim<sup>™</sup> dripline models:

The name consists of 5 digits.\*

#### Thin- and medium-wall driplines

- The first two digits represent the pipe's inside diameter (ID) rounded.
- The three last digits represent the pipe's wall thickness (WT) in mil.
  - (1 mil = 1/1000 inch = 25.4/1000 mm = 0.0254 mm).

#### **Thick-wall driplines**

- The first two digits represent the pipe's outside diameter (OD) rounded.
- The three last digits represent the pipe's wall thickness (WT) in millimeters (mm).

\*The 5-digit commercial names of the dripline models in the tables opposite are intended for identification purposes only and do not represent the exact diameter and wall thickness of each dripline. For accurate data, refer to the Technical Datasheet of the specific product.

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The maximum allowed flushing pressures in the tables are valid when flushing for a maximum of half an hour consecutively, with the end of 5 or more driplines kept open.

#### Thin-walled driplines

Dripline	Dripline inside	Wall thickness		Max. working pressure	Max. flushing pressure	
model	diameter (ID) (mm)*	(mm)	(mil)	(bar)	(bar)	
12060	12	0.15	6.0	1.6	1.8	
12080	12	0.20	8.0	1.9	2.2	
12125	12	0.31	12.5	2.5	2.9	
12150	12	0.38	15.0	3.0	3.5	
16050	16	0.13	5.0	0.8	0.9	
16060	16	0.15	6.0	1.0	1.2	
16070	16	0.18	7.0	1.1	1.3	
16080	16	0.20	8.0	1.2	1.4	
16100	16	0.25	10.0	1.4	1.6	
16125	16	0.31	12.5	1.8	2.1	
16150	16	0.38	15.0	2.2	2.5	
16180	16	0.45	18.0	2.5	2.9	
22050	22	0.13	5.0	0.7	0.9	
22060	22	0.15	6.0	0.8	0.9	
22070	22	0.18	7.0	0.9	1.0	
22080	22	0.20	8.0	1.0	1.2	
22100	22	0.25	10.0	1.1	1.3	
22135	22	0.34	13.5	1.5	1.7	
22150	22	0.38	15.0	1.8	2.1	
22180	22	0.45	18.0	2.1	2.4	
25135	25	0.34	13.5	1.2	1.4	
25150	25	0.38	15.0	1.4	1.6	

## Medium-walled driplines

Dripline model	Dripline inside diameter (ID) (mm)*	Wall thickn (mm)	ess (mil)	Max. working pressure (bar)	Max. flushing pressure (bar)
12200	12	0.50	20.0	3.0	3.9
12250	12	0.63	25.0	3.5	4.6
16200	16	0.50	20.0	2.5	3.3
16250	16	0.63	25.0	2.8	3.6
16008	16	0.80	32.0	3.0	3.9
22200	22	0.50	20.0	2.0	2.6
22250	22	0.63	25.0	2.5	3.3

#### **Thick-walled driplines**

Dripline model	Dripline inside diameter (OD) (mm)*	Wall thickn (mm)	ess (mil)	Max. working pressure (bar)	Max. flushing pressure (bar)
12000	10	0.00	25.0	20	4.0
12009	12	0.90	33.0	3.0	4.9
12010	12	1.00	39.0	4.0	4.6
16009	16	0.90	35.0	3.0	3.9
16010	16	1.00	39.0	3.5	4.6
16012	16	1.20	47.0	4.0	5.2
20010	20	1.00	39.0	3.5	4.6
20012	20	1.20	47.0	4.0	5.2

\*The outside diameter (OD) and the inside diameter (ID) of the dripline models and the data in the tables above are intended for identification purpose only and do not represent the exact diameter and wall thickness of each dripline. For accurate data, refer to the Technical Datasheet of the specific product.

## Connectors

Netafim's comprehensive range of dripline connector systems is made of high resistance and high durability polymers. They are functional and viable, moulded under the highest market standards and available for all dripline types. Use the catalog to select the right line for your application: barb connectors, fast ring connectors, flare connectors and a vast family of start and reducing connectors.

#### **Connectors technical data**

#### Connectors for thick walled driplines

Dripline			Sub surface installation		Features	
Commercial name	Inside Diameter (ID) (mm)	Wall Thickness (WT) (mm)	Deep insertion	Shallow insertion	Allow laying/retrieving	Reusable
Barb						
12	10.2	1.0-1.2	•	•	<b>O</b>	<b>—</b>
16	14.2	0.9-1.2	<b>O</b>	•	•	<b></b>
17	14.6	1.2	•	•	<b>O</b>	<b>•</b>
20	17.5	1.0-1.2	<b>•</b>	•	¢	<b>•</b>

#### Connectors for thin/medium walled driplines

Dripline			Sub surface installation		Features	
Commercial name	Inside Diameter (ID) (mm)	Wall Thickness (WT) (mil)	Deep insertion	Shallow insertion	Allow laying/retrieving	Reusable
Ring fast connectors						
16 blue ring	16.2	6.0-25.0	9	•	<b>O</b>	•
16 black/ white ring	15.5	27.0-32.0	9	¢	•	¢
22 blue ring	22.2	8.0-25.0	1	•	<b>e</b>	•
25 black ring	25.0	13.5-15.0	1	Ð	<b>O</b>	•

Suitable

Not suitable

Suitable but not recommended

For full information, see Netafim<sup>™</sup> Connectors Catalog.

# End of driplines

#### Dripline flushing manifold

The flushing manifold at the end of the driplines is fitted with a flushing riser and valve to allow flushing of the driplines. When the flushing valve is opened, flow rate and velocity through the driplines are greater than those in normal operational mode. The higher flow velocity allows removal of settled solids and precipitants from the system, preventing them from clogging the drippers.



Flow regimes may be quite complicated in irregularly-shaped fields with different dripline lengths within the same irrigation zone.

Since SDI zones with flushing manifolds are closed-loop systems, pressure tends to equilibrate and zones with differing dripline lengths are designed using an average dripline length. Flushing manifold pipe sizes are determined in consideration of the flow through the end of the driplines during flushing.

The flushing manifold is sized for a flow velocity of at least 0.5 m/sec (1.65 ft/sec) through the driplines to ensure sediment removal.

Flushing will temporarily increase the flow requirements of the system, which in turn will decrease the system pressure. In some cases, in order to achieve the desired velocity, especially with pressure regulated zones or with irregular field shapes, the planning of the system may require large amounts of piping to connect the ends of all the driplines in a particular section or zone.

A careful balance between flushing velocities in the manifolds and in the driplines is critical.

When zones are relatively large, to enable the pumping system to supply the flow rate required to achieve the desired flushing velocity at the ends of the driplines, the irrigation zone is divided into two or more flushing manifolds. This separation will allow maintenance of a proper flushing pressure.

Another solution to supply the flow rate required for flushing is to use an additional pump at the head of the system. The additional pump will be activated only during flushing to add the missing flow rate.

#### Other flushing solutions

It is possible to flush the driplines manually. There are a number of ways to do this:

Solution	Description	Advantages	Disadvantages
Folded dripline end	<ul> <li>Cut a 5 cm sleeve from the end of the dripline.</li> <li>Fold the end of the dripline in the shape of a "z" and slip the sleeve over the end.</li> </ul>	<ul> <li>Least expensive solution.</li> <li>Allows flushing of the driplines one by one under optimal conditions.</li> </ul>	<ul> <li>Requires extensive labor time.</li> <li>Reinstalling the sleeve while the dripline is still pressurized is difficult.</li> </ul>
End of line removable connector	<ul> <li>Slip one loop of the connector onto the dripline.</li> <li>Fold the end of the dripline and slip it into the connector's other ring over the end.</li> </ul>	Allows flushing of the driplines one by one under optimal conditions.	Requires extensive labor time.
Dripline manual valve	Pulling the orange handle to the upwards position opens the end of the dripline for flushing.	<ul> <li>Allows flushing of the driplines one by one under optimal conditions.</li> <li>Requires less labor time.</li> </ul>	✓ None.
Automatic flushing valve	Flushes all the driplines of the irrigation shift at the start of each irrigation event without human intervention.	<ul> <li>All driplines are flushed at the start of each irrigation event.</li> <li>Excellent flushing frequency.</li> </ul>	<ul> <li>All driplines in each irrigation shift are flushed at the same time.</li> <li>For correct operation an additional flow rate of 300 l/h is required for each automatic flushing valve operated in the irrigation shift.</li> </ul>
NetFlush <sup>™</sup> controlled flushing valve for drip irrigation	<ul> <li>Allows growers to flush driplines frequently, at the right timing intervals.</li> </ul>	<ul> <li>Efficient flushing hydraulic conditions: velocity, flow rate, pressure and volume.</li> <li>Significantly reduces the time and effort invested in the line flushing process.</li> <li>Reduces labor time by ~90% compared to other end line devices.</li> </ul>	It requires a pressurized microtube that carries the signal to each of the valves.

## Sensors

In order to make full use of the advantages of a drip irrigation system, it is important to regularly monitor the actual condition of the soil, the irrigation water and the crop. To easily collect useful data for the management of the irrigation system, Netafim<sup>™</sup> offers a comprehensive range of high-quality sensors, either standalone or connectable to a Netafim<sup>™</sup> controller.

#### Tensiometer

A tensiometer measures soil moisture. It is an instrument designed to measure the tension or suction that a plant's roots must exert to extract water from the soil. This tension is a direct measure of the availability of water to a plant.

Tensiometers may be used in any irrigated crop; however, it is with horticultural crops in particular that they provide a suitable method to aid irrigation decisions.

The measurement of soil moisture with a tensiometer provides a valuable tool to schedule irrigation. Tensiometers are particularly useful to determine when to irrigate, and can be used to support a schedule based on estimation of crop water use from reference crop evapotranspiration (EVT) data.

A tensiometer consists of an air tight, water filled tube with a porous ceramic tip at the bottom and either a vacuum gauge at the top or a re-sealable rubber bung designed to insert a portable vacuum meter. During the irrigation season the tensiometer is partly inserted into the soil to a suitable depth and, when used properly, will enable improved irrigation management by accurately determining when water should be applied to maintain optimum crop growth and how much water should be applied to avoid over-irrigating.

#### **Placement of tensiometers**

It is recommended to use 3 tensiometers in each tensiometer station. Correct placement is very important. Each tensiometer should be installed with its ceramic tip at a different depth (e.g. 30, 60 and 90 cm or 12, 24 and 36 inches) according to the type of crop (consult an agronomist).

**The upper tensiometer** placed at the top of the root zone, provides data regarding the development of the wetted bulb in the soil and indicates when it is time to irrigate.

**The middle tensiometer** placed at approximately the midpoint of the main fibrous root system (where irrigation water is certain to wet the soil), provides data regarding the wetness of the soil in the root zone. Placement too deep in a shallow rooted crop will result in the crop being irrigated too late and suffering water stress. Shallow placement in a deep rooted crop may result in excessive irrigation and water logging of the deeper roots.

**The lower tensiometer** placed at the bottom of the root zone serves as a safeguard against excessive irrigation by providing data regarding runoff or deep percolation. Used to determine if too much (never reads above 15 kPa) or too little water (continues to rise) is being applied in each irrigation.



Vacuum

gauge

Water

Porous

ceramic

tip

filled tube

φand

#### Locating tensiometer stations

In most situations two sites will be needed for each major species or variety and soil type. Avoid high or low locations, zones of poor water infiltration, and areas that are lightly watered because of bad irrigation distribution patterns. All tensiometers must be marked clearly to avoid damage from traffic, workers and cultivation.

For tensiometer operation and reading, see page 100.

#### **Pressure sensor**

The pressure sensor, installed on a specific lateral, main or submain line, provides actual and accurate reading of water pressure. Netafim's electrical pressure sensor is available in 2 models: 0-6 bar and 0-2 bar.

When connected to the real-time crop management

decision support system, pressure can be presented graphically or in a detailed report.

This data is critical for cross-referencing between irrigation events, filter blocking, etc.

The pressure sensor can be used to measure the level of water in a storage tank and the level of liquid solution in a fertilizer tank.

#### Ech<sub>2</sub>o sensor

The Ech<sub>2</sub>o soil moisture probe is a capacitance-type sensor that measures the dielectric constant or permittivity of the material in which it is inserted, by finding the rate of change of voltage on the sensor that is embedded in the medium. Water has a permittivity of about 80, while the value for soil minerals is around 4, and for air is 1. The high permittivity of water relative to soil minerals and air results in relatively large changes in the permittivity of soil when the water content changes.

The Ech<sub>2</sub>o sensor is designed to remain in the soil permanently or for an entire growing season and requires no maintenance.



#### NetaSense sensor

The NetaSense sensor is a volumetric soil moisture sensor based on TDT (Time Domain Transmission) technology that provides an immediate and accurate response to changes in soil moisture levels.

This sensor is able to indicate changes in moisture by means of measuring the speed of an electromagnetic wave.

The sensor is designed to be installed and left in the soil for the entire duration of the crop, or permanently. The sensor components are stainless steel and all interfaces are sealed in epoxy to provide years of reliable service. The sensor is reliable in any type of soil.

The NetaSense sensor is capable of measuring a large soil volume at a 5-cm (2-inches) radius from its elements. It reports the average soil moisture along its active length - about 30 cm (12 inches), whether the sensor is installed vertically or horizontally.





# Controller

The best way to make full use of the advantages of a drip irrigation system is by controlling it using an irrigation controller.

Netafim<sup>™</sup> offers an extensive range of controllers for precise monitoring and management of water and nutrient supply to the field, making full use of the exceptionally high efficiency and uniformity capacity of the drip irrigation method.

- Lower water, nutrient, chemicals and energy usage.
- ✓ Lower labor requirements.
- Real-time corrective actions.
- Greater crop sustainability.
- Increased productivity.
- Enhanced yields.
- Rapid ROI.

Netafim's irrigation controllers are modern irrigation control systems with advanced features for handling irrigation main lines including pumps, filters, fertigation systems and other accessories related to the full comprehensive solution for farm management. The Netafim<sup>™</sup> line of controllers offers a range of optimal solutions for open field, greenhouse and nursery applications.

#### **Controls:**

- Irrigation valves Irrigation control based on time and quantity.
- Irrigation pumps Optimized pump control according to flow and pressure.
- Selfer flushing Based on time or pressure differential between the filter inlet and outlet.
- **Pressure sustaining valves** Adjustment of the main line pressure when filter flushing is in process.
- Sertilizer pumps Control of fertilizer injection according to the type of fertilizer pump and its flow rate.
- Fertilizer tank selector Optimization of the fertilizer usage when various crop varieties require different recipes.
- Fertilizer agitation Control the agitators in the fertilizer tanks to maintain homogeneous solution.
- Cooling system For greenhouse and nursery applications. Operates Netafim's sprinklers to cool down the greenhouse temperature according to the plant needs.
- Misting system For greenhouse and nursery applications. Operates Netafim's sprinklers to increase the relative humidity according to the plant needs.
- Alarm device Generates an alarm in the occurrence of a malfunction or any unusual event. Alarm can pop up on the computer screen, be e-mailed or sent as an SMS or push notification to smartphones.

#### Monitors:

- Water meters Monitor the irrigation volume and flow rate. Makes sure that water in the system is flowing as planned with no leakages or clogging issues.
- Fertilizer meters Monitor the fertilizer flow rate and amount.
- **EC and pH sensors** For advanced and accurate fertilizer control.
- **Temperature and humidity sensors** For cooling and humidification.
- Weather station For irrigation control based on evapotranspiration and for frost mitigation.
- **Pressure sensors** For filter flushing and irrigation control.
- **Tensiometer sensors** Measure water tension in the soil for the assessment of the field capacity.
- Soil moisture sensors Measure the volumetric water content in the soil for correct timing and precise volume of irrigation.
- General purpose sensor Netafim's controllers can monitor any type of 0-5 VDC or 4-20 mAmp sensor according to customer needs.

#### Netafim<sup>™</sup> NMC irrigation controllers

#### **NMC Pro**

- Top of the line irrigation controller.
- Features powerful hardware and software for greenhouse and open field applications.
- Meets the most modern demand for smart, efficient irrigation.
- Can manage up to 255 irrigation valves.

#### **NMC Junior**

- Multi-function irrigation controller for small applications.
- Can manage up to 15 irrigation valves.
- Advanced solution for simple greenhouse applications.

#### Netafim<sup>™</sup> NMC climate controllers

#### **NMC Climate**

- Comprehensive solution for greenhouse applications.
- Can manage up to 50 greenhouses simultaneously.
- Controlled by advanced PC software with a user-friendly interface.

#### **Mist-Guard**

- Option 1: Misting controller for cooling applications.
- Option 2: Ultimate stand alone controller for high precision with built in temperature and humidity sensors.

#### Netafim<sup>™</sup> NMC multi main lines irrigation controller

#### NMC XL

- Multi main lines irrigation controller.
- Optimal solution for open field application.
- Controls up to 25 central Nutrigation<sup>™</sup> stations.
- Controls up to 128 irrigation lines including flow measurement, filter flushing and local Nutrigation™.

#### Netafim<sup>™</sup> NMC remote terminal units (RTU)

#### RadioNet

- Continuous wireless monitoring and ultimate control at distance.
- Easy-to-use modular system ensuring reliable and flexible control over remote terminal units to increase productivity and address constantly changing needs.
- Multi interface enables connection to a wide range of controllers.
- Up to 254 remote units including S&F.

#### SingleNet

- ✓ Up to 10 Km cable length.
- Reduced installation and cable cost.
- Multi interface enables connection to a wide range of controllers.
- ✓ Up to 128 remote units.













# Accessories and add-ons

For ease of implementation, current operation and maintenance of a Netafim<sup>™</sup> drip irrigation system, Netafim<sup>™</sup> offers a wide variety of useful accessories and add-ons designed to facilitate day to day tasks and to allow the addition of practical functions to the system. Below is a shortlist of selected accessories and add-ons; for the full range see see Netafim<sup>™</sup> Fittings & Accessories Product Catalog.

#### Dripline Non Leakage valve (DNL)

A spring-loaded diaphragm actuated valve that opens upon pressurizing the irrigation system and shuts



off drip-tight when the system reaches closure pressure. For intensive irrigation and sloped fields, where irrigation precision is imperative.

#### **Direct pressure regulator**

A spring-actuated control regulator that reduces higher upstream pressure to lower constant downstream pressure, and opens fully upon line pressure drop.



#### Hanging accessories, stakes and spikes

For a well implemented installation and ease of operation and maintenance, Netafim<sup>™</sup> offers a wide variety of hanging accessories, stakes and spikes, enabling professional and convenient installation.

#### Pressure flag-indicator

Provides visual indication of water pressure in all drip applications. Installed on driplines at the farthest end of the irrigated plots, enables quick and easy inspection of proper delivery of water through the system from a distance.



#### Adapters and manifolds

A vast line of complementary products, families of models and sizes.



#### Punches and tools

To facilitate the installation and the current maintenance of the irrigation system, Netafim<sup>™</sup> offers a variety of dedicated tools for ease of work and prevention of damage to the system components.

# Agro-machinery

Netafim<sup>™</sup> is the global leader in irrigation solutions and as a solution provider we strive to help growers achieve greater efficiencies, reduction in costs and labor, and improvements in sustainability through equipment (agro machinery) that reduce or replace labor intensive field practices with highly efficient mechanized solutions. Netafim<sup>™</sup> developed a variety of application tools and auxiliaries designed to simplify and support working with drip irrigation systems.

- 1. Installation machinery
- 2. Extraction machinery
- 3. Retrieval machinery
- 4. Accessories & spare parts

#### 1. Installation Machinery

#### Laying machinery

Laying machines are designed to perform on surface installation of thin, medium and heavy wall driplines in a proper, speedy and safe manner. Multi optional mounting of laying units on toolbar frames enables Netafim<sup>™</sup> to offer a wide variety of products and modular units according to the grower's specific requirements. Also available are auxiliary tools such as operator platform, storage device for spare dripline coils, markers, cover legs and more.



#### Sub surface insertion machinery

Sub surface insertion machines enable any grower to install driplines in a cost effective, efficient manner and ensure that the dripline insertion procedure is done accurately. A special plastic guide located on the insertion shank will eliminate problems associated with twisted and/or kinked driplines. A wide variety of machines is available for thin, medium and heavy wall driplines in open fields, row crops, orchards, sugarcane and many other options.

#### 2. Extraction machinery

Extraction machines are designed for growers who wish to extract driplines from sub surface installation or through growing or lodged crop cover for reuse or recycling. There are multiple types of machines according to the field condition and dripline insertion depth. A control system matches extraction speed to tractor speed and controls pulling tension.





#### 3. Retrieval machinery

The features incorporated in our range of retrieval machines ensure dripline retrieval for reuse and/or recycling is performed quickly and properly across a variety of field conditions and requirements. The following auxiliary tools can be mounted on the machines to optimize procedures and make your field work smarter, with less effort: brush, arranger, pulling device ensuring the constant maximal pulling force permitted for retrieving the driplines and more.



#### 4. Accessories & spare parts

Netafim<sup>™</sup> offers a wide variety of mountable accessories. These can be purchased as spare parts for agro machines and can also be used in the assembly of integrated machines.



# $\rho$ ATTENTION

\*In order to avoid damage to the driplines in the insertion or laying process, always use a Roller Box and an Insertion Shank supplied by Netafim<sup>™</sup>. These two accessories are especially engineered and made of wear resistant materials to guarantee the integrity of the inserted dripline of any type or grade.

See Instructions for dripperline insertion and laying, page 66.

For further information about agro-machinery see the Netafim<sup>™</sup> Agro-Machinery Catalog or call your local Netafim<sup>™</sup> representative.

# / DRIP IRRIGATION MANAGEMENT AND OPERATION

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# / Drip irrigation management and operation

The aim of this chapter is to provide guidelines and useful tips for the proper management and operation of a drip irrigation system.

## Irrigation

#### Hydraulic parameters

The following hydraulic parameters are considered when designing an irrigation system. All are inter-related and a change in one parameter will affect system results:

Parameter	Definition	Measurement	Units
Q	Dripper flow rate	Amount of water provided by the dripper at a given time unit during the irrigation process	l/h - liters per hour
E	Distance between drippers	Distance between two drippers on a dripline	m - meters
D	Distance between driplines	Distance between two driplines	m - meters
Pr	Precipitation rate	The amount of water per area for a specified period of time	mm/h - millimeters per hour
HIR	Hourly irrigation rate	Quantity of water the system will irrigate during one hour for a specified area	m³/ha/h - cubic meter per hectare per hour
DWR	Daily water	Quantity of water the crop requires per day	mm/d - millimeters per day,
	requirement	(based on pan evaporation or the Penman - Montieth equation, see page 97)	or m³/ha/d -cubic meter per hectare per day (mm/day * 10)
Т	Irrigation time	Time required to irrigate a certain area	h - hours
S	Shift number	Shift number of each irrigation shift into which the irrigation time is divided	Integer
Ν	Daily shift hours	Total number of hours per day that the system irrigates the project	h - hours

#### Hydraulic requirements

The hydraulic specification of an irrigation system must allow it to deliver the required amount of water to the crop at the time it needs it.

The most important aspect of crop water use for the design of a drip irrigation system is the "peak" water requirement or the amount of water that a crop uses during its highest water use period. This is because it is during this period that the system must deliver the greatest amount of water.

While rain may be factored in to reduce the irrigation requirement for a season, it should not be factored in when calculating a peak use rate.

Different crops and different planting dates will result in different water requirements. The irrigation system may be intended to irrigate more than one crop (rotation), in which case the crop with the highest water demand must be the design criterion.

#### **Uniformity and efficiency**

#### $\rho$ ATTENTION

Low startup costs can result in high annual operating costs. When designing a drip irrigation system it is important to consider uniformity and efficiency in order to keep total cost low.

**Uniformity** is the ability of the irrigation system to deliver water and fertilizer as equally as possible to all the plants in the field or orchard. Uniformity saves water and fertilizer and improves yield, resulting in shorter ROI.

**Efficiency** is the ability of the irrigation system to deliver water and fertilizer according to the crop's needs as exactly as possible. Efficiency saves resources and preserves the environment while optimally serving the crop's needs.

**Irrigation efficiency** describes a field's performance. Water use efficiency is the ratio of the amount of irrigation water applied that is beneficially used by the plant, to the total amount of irrigation water applied.

🖹 ΝΟΤΕ

The higher the uniformity, the more efficient the use of water and energy.

**Irrigation scheduling** determines the actual overall efficiency of the irrigation system. If irrigation is improperly timed, in either frequency or duration, the field capacity of the soil in the root zone will be exceeded and the water will be lost to runoff or to deep percolation (see Field Capacity, page 92).

Depending on the crop, this may affect or not affect the crop negatively, but in any case will cause unnecessary costs.

Even with an irrigation system perfectly planned for high efficiency, improper duration of irrigation will eliminate most advantages gained by the design of the system.

Flow variation (FV) and emission uniformity (EU) play an important role in the overall uniformity of a drip irrigation system. These are the most applicable terms to drip irrigation systems; they are defined by the design of the system and are critical to its performance as it applies to irrigation efficiency.

**Flow Variation (FV)** expresses the flow variation between the dripper "sensing" the highest pressure and the one "sensing" the lowest pressure in an irrigation block (zone). These drippers will not always be the first and last drippers on the dripline.

 $FV \% = \frac{Q \max. - Q \min.}{Q \max.} * 100$ 

#### **Emission Uniformity (EU)**

Emission uniformity is calculated using four main variables:

- Q minimum = the minimum flow rate in the irrigation block.
- ✓ Q average = the average flow in the irrigation block.
- CV = the manufacturing variation of the emission device, which should represent the manufacturing variation of the finished products that will be in the field.
- n = number of drippers per plant in the irrigation block (for permanent crop systems 'n' is the number of drippers per plant, where in row crops "n" carries a value of 1 due to the fact that a single dripper might be servicing multiple plants).

EU % = 100 \* 1 - 
$$\left(1.27 * \frac{\text{CV}}{\sqrt{n}}\right) * \frac{\text{Q min.}}{\text{Q average}}$$

If a designed irrigation block is calculated to have 15% flow variation, then the lowest flow point in this block is receiving 15% less water than the highest flow point in it.

## P ATTENTION

If an irrigation block design is calculated to have 90% emission uniformity, it is inaccurate to assume that the minimum flow point in the block is 10% lower than the high flow point in the block. A rule of thumb is that for every one (1) point change in EU there are approximately two points change in FV. Therefore a EU of 90% (10% below 100%) would have a FV closer towards 20%, meaning the lowest flow point in the irrigation block would actually have a flow rate closer to 20% lower than its highest flow point.

#### Hydraulic calculations

# EXAMPLE

#### Calculating the Precipitation Rate (Pr)

#### Data

Dripper flow rate:	Q = 0.5  l/h
Distance between drippers:	E = 0.5 m
Distance between dripperlines:	D = 1.8 m

#### Calculation

Calculate the hourly irrigation rate as follows:

Precipitation rate (Pr) = 
$$\frac{Q}{(E \times D)}$$
 =  $\frac{0.5}{(0.5 \times 1.8)}$  = 0.55 mm/h

#### Calculating the irrigation rate

There are two ways to calculate the irrigation rate.

#### Calculate the hourly irrigation rate (HIR) in cubic meters:

Hourly Irrigation Rate (HIR) =  $\frac{0.55 \text{ mm}}{\text{ha x 10}}$  = 5.5 m<sup>3</sup>/ha/h

Alternatively, we can calculate the hourly irrigation rate (HIR) by multiplying the number of drippers per hectare by the hourly flow rate.

#### Calculate the hourly irrigation rate based on the number of drippers per hectare:

#### Data

Dripper flow rate	Q = 0.5 l/h
Distance between drippers	E = 0.5 m
Distance between dripperlines	D = 1.8 m

#### Calculation

a. Calculate the total length of the driplines:

Dripline length/ha = 
$$\frac{10000 \text{ m}^2}{1.8}$$
 = 5555 m

**b.** Calculate the total number of drippers per hectare:

Drippers/ha =  $\frac{5555 \text{ m}}{0.5}$  = 11,111 drippers

c. Calculate the hourly irrigation rate:

Hourly Irrigation Rate (HIR) =  $\frac{11,111 \text{ drippers } * 0.5 \text{ l/h}}{1000}$  = 5.5 m<sup>3</sup>/ha/h

#### Calculating the Daily Water Requirement (DWR):

Pan evaporation*	EVTo = 8.4 mm/d
Crop coefficient*	Kc = 0.75

\*see Water budgeting, page 96.

DWR = 8.4 \* 0.75 = 6.3 mm/d = 63 m<sup>3</sup>/ha/d

#### Calculate the required irrigation duration (hours/day):

Hourly irrigation rate  $H IR = 5.5 \text{ m}^3/\text{ha/h}$ 

Irrigation time =  $\frac{\text{DWR}}{\text{HIR}}$  =  $\frac{63 \text{ m}^3/\text{ha/d}}{5.5 \text{ m}^3/\text{ha/h}}$  = 11.45 hours (11 hours 27 minutes\*\*)

\*\*Conversion of decimal hours to minutes:  $\frac{\text{decimal hours}}{100} * 60$   $\frac{0.45}{100} * 60 = 0.27 = 27 \text{ min}$ 

#### Conclusion

Based on the calculations, it takes less than 12 hours to irrigate the required area (63 m<sup>3</sup>/ha/d). This means that the effective crop area can be doubled if the equipment is operated twice per day.

#### Calculating the maximal irrigation area based on water supply

Knowing how much water is available per hour and the required quantity of water in m<sup>3</sup>/ha/h enables us to calculate the maximal area that could be irrigated at once.

#### Data

Dripper flow rate:	0.5 l/h
Distance between drippers:	0.5 m
Distance between driplines:	1.8 m
Hourly irrigation rate:	0.55 mm/h
Daily return (equal to HIR):	6.3 mm/d
Daily hours/shift:	11.45 h
Possible number of shifts in 24 hours:	2
Pump discharge:	(10 l/sec) 36 m³/h

#### Calculation

Calculate the maximal area that can be watered in 24 hours based on the data above:

## Pump discharge per hour \* Daily hours/shift \* Numbers of shifts

Daily return

# = $\frac{36 \text{ m}^3/\text{h x 11.45 hours/shift x 2 shifts}}{63 \text{ m}^3/\text{ha/d}}$ = 13 ha

# Nutrigation<sup>™</sup>

Crops require a balanced diet of essential nutrients throughout their growth cycle.

Many plant foods can be found in the soil, but often in insufficient quantities to sustain high crop yields. Soil and climatic conditions can also limit a plant's uptake of nutrients at key growth stages.

Crop scientists recognize that plants need 13 essential minerals, all of which play a number of important functions. If any of these is lacking, plant growth and yield suffer.

#### Major nutrients

#### Nitrogen (N)

Is often required in the greatest quantity by crops, primarily for vigor and yield. Nitrogen plays a key role in chlorophyll production and protein synthesis. Chlorophyll is the green plant pigment responsible for photosynthesis. When nitrogen is deficient, plants develop yellow or pale leaves and their growth is stunted.

#### Phosphorus (P)

Is a vital component of adenosine triphosphate (ATP), which supplies the energy for many processes in the plant. Phosphorus rarely produces spectacular growth responses, but is fundamental to the successful development of all crops. For example, maize or other corn crops that lack phosphorus during the growing season achieve lower yields.

#### Potassium (K)

Is needed by virtually all crops and often in higher rates than nitrogen. Potassium regulates the plant's water content and expansion. It is key to achieving good yield and quality in cotton and critical for increasing the size, juice content and sweetness of fruit.

#### **Secondary nutrients**

#### Calcium (Ca)

Is perhaps the most important secondary nutrient. Calcium strengthens cell walls, helping to reduce bruising and disease in fruit, salad and vegetable crops. This means that a good supply of calcium produces food crops that are less prone to damage and have a longer shelf life. Crops with a calcium shortage will have growth disorders such as corky skin.

#### Magnesium (Mg)

Is also important for crop quality, and is also a key component of leaf chlorophyll and the enzymes that support plant growth. Low magnesium leads to reduced photosynthesis, which severely limits crop yields. Grain fill in rice and dry matter content of potatoes can be significantly reduced if magnesium is undersupplied.

#### Sulfur (S)

Is an essential part of many amino acids and proteins. Without both S and Mg, crops suffer; growth slows and leaves turn pale or yellow. Sulfur is particularly important for ensuring the protein content of cereal crop grains.

#### **Micronutrients**

Reinforce and supplement the strong plant growth and structures provided by major and secondary nutrients.

#### Manganese (Mn)

Influences photosynthesis, the process whereby plants use sunlight for growth.

#### Copper (Cu)

Influences photosynthesis, the process whereby plants use sunlight for growth.

#### Iron (Fe)

Influences photosynthesis, the process whereby plants use sunlight for growth. Deficiencies are common – for example in seed fruits – where the effect is to reduce production of chlorophyll. As a result, crops struggle and younger leaves develop a severe yellowing or chlorosis.

#### Boron (B)

Is needed for the development of shoots and roots, and is essential during the flowering and fruiting phases of crops.

#### Zinc (Zn)

Is needed for the production of important plant hormones, like auxin. Zinc deficiency leads to structural defects in leaves and other plant organs.

#### Molybdenum (Mo)

Is involved in plant enzyme systems that control nitrogen metabolism.

#### Element content (%) in fertilizers -·· · · · .....

Element content (%) in fertilizers - Suitable for Nutrigation™		Elemo	ent	otallo	us pente	oxide	Lotine	HUM	onesit	.T.
Fertilizer	Formula	¥ N	P205	× <sup>0</sup> γ <sup>α</sup> K <sub>2</sub> 0	Ca		Na Na	Ma	S S	SO4
Urea	CO(NH <sub>2</sub> ) <sub>2</sub>	46						5		
Urea ammonium nitrate	CO(NH <sub>2</sub> ) <sub>2</sub> NH <sub>4</sub> NO <sub>3</sub>	32								
Mono ammonium phosphate MAP	NH4H2PO4	12	61							
Ammonium nitrate	NH4NO3	32								
Potassium nitrate	KNO₃	13		46						
Calcium nitrate	Ca(NO <sub>3</sub> ) <sub>2</sub>	15			19					
Calcium chloride	CaCl <sub>2</sub>				27	63				
Potassium chloride	KCI			61		47				
Potassium sulfate	K2SO4			51					55	18
Mono potassium phosphate MKP	KH₂PO₄		52	34						
Ammonium sulfate	(NH4)2SO4	21							24	73
Magnesium sulfate	MgSO <sub>4</sub>							16	16	49
Calcium sulfate	CaSO₄				19				8	26
Magnesium nitrate	Mg(NO <sub>3</sub> ) <sub>2</sub>	11						10		
Sulfuric acid	H2SO4								33	
Phosphoric acid	H3PO4		61							
Nitric acid	HNO₃	13								
Sodium chloride (salt)	NaCl					62	38			

#### Crop needs

Each crop needs a different range of nutrients at every critical stage of its development.

For example, nitrogen and phosphorous are often more critical at early stages of growth to fuel root and leaf development, whereas zinc and boron are important during flowering.

Cereal crops use nutrients for growth, progressively moving them from the roots, to the stems and leaves until the dying off and harvesting of the grain.

Tree crops have different nutrient requirements than field crops. They can store nutrients like nitrogen within their trunk, branches and leaves and then redistribute them at key points during the growth cycle. It is important, however, to supply trees with replacement levels of the nutrients removed in the harvested fruit and those that are critical for growth but can't be recycled.

#### The influence of soil pH on nutrient availability

Soil pH level has a specific influence on the availability of each nutrient to the crop (see page 93).

# Nutrigation<sup>™</sup> via a drip irrigation system

Nutrigation<sup>™</sup> is the combined application of water and nutrients to a crop - a mix of fertilization and irrigation. It can be adapted to all types of crops.

# 

When not handled properly, nutrients, acids and chemicals may cause serious injury or even death. They may also damage the crop, the soil, the environment and the irrigation system.

#### Proper handling of nutrients, acids and chemicals is the responsibility of the grower.

Always observe the nutrient/acid/chemical manufacturer's instructions and the regulations issued by the relevant local authority.

In drip irrigation, the roots are concentrated in a limited soil volume compared to the volume of soil that these roots occupy if the irrigation isn't localized. For this reason, during the irrigation season, relatively small quantities of fertilizers should be applied frequently.

In traditional fertilization methods, some of the fertilizer is applied outside the volume of soil occupied by the roots and thereby wasted.

#### Advantages

#### Increased efficiency of fertilizer application

- Fertilizer application with irrigation water provides a better distribution and greater application uniformity.
- The total dose of the applied fertilizers is divided into several smaller portions allowing better retention of the fertilizers in the soil and greater availability.
- Losses due to volatilization are avoided, as with fertilizers containing nitrogen compounds.
- Outrigation<sup>™</sup> permits the application of nutrients according to crop requirements; there is also a possibility of varying the ratio between nutrients during different phenological stages, such as the vegetative stage, flowering, fruit setting, fruit filling and maturation.

#### Savings in fertilizer and labor

- Due to the conditions of application by irrigation water and the various forms of losses avoided, the amount of fertilizer used to achieve the same production level is reduced.
- Preparation and application of fertilizers in a drip irrigation system cost less compared to the traditional implementation.

#### **Operational advantages**

- Health hazards are avoided since workers do not come in contact with the injected fertilizers and chemical.
- Since Nutrigation<sup>™</sup> does not require traffic in the field, damage to plants and soil compaction are avoided.
- ✓ Nutrigation<sup>™</sup> can maintain appropriate nutrient content in soils with low nutrient holding capacity, allowing cultivation in types of soil otherwise not cultivable.
- O The contamination of groundwater by elements of fertilizer occurs in many places where flood irrigation is used. Nutrigation™ applies the amount of fertilizer and water in more frequent, smaller portions to prevent runoff or deep percolation.
- There is the possibility of applying other chemicals through the system, such as soil disinfectants, systemic products against crop diseases and pests.

#### Limitations

- Only water-soluble fertilizers are allowed to be used in drip irrigation.
- Some fertilizers, although water soluble, may not be compatible with the method of Nutrigation<sup>™</sup>, such as fertilizer that raises the pH of the irrigation water so high that precipitation occurs in the system.
- Certain fertilizers are corrosive to metal parts of the equipment, therefore the parts of the system coming in contact with those fertilizers should be resistant to corrosion.

#### Characteristics of fertilizers used in Nutrigation™

Knowing the characteristics of the fertilizers to be used in Nutrigation<sup>™</sup> is essential for making the right choice of fertilizers and application, to provide the right elements to the plant at the right time.

#### **Chemical composition**

Fertilizers can be simple or compound:

- Simple fertilizers: are fertilizers that consist of a single product. For example: urea, ammonium nitrate, potassium chloride.
- Compound fertilizers: are the products that are obtained by mixing several simple fertilizers, and generally, can be easily seen in the mixture; these are generally not used in Nutrigation<sup>™</sup>.

#### Form

- Solid state: in this case, the fertilizer may be granulated or powdered.
- Liquid state: are fertilizers that can be injected directly into the irrigation system.
   Some fertilizers need to be dissolved in water to reduce the concentration prior to injection.

#### Solubility

Solubility is one of the most important characteristics to be considered in preparing liquid fertilizers. Every fertilizer has a level of solubility, which is influenced by the temperature of the water in which it dissolves.

Only water-soluble fertilizers are allowed to be used in drip irrigation.

Some fertilizers are very easy to dissolve in water and others are more difficult, but still can be used in Nutrigation<sup>™</sup>. There are fertilizers having a solubility level so low that they are classified as water-insoluble and their use in irrigation systems is not allowed, for example, simple and triple superphosphate.

#### Interaction with irrigation water

Fertilizers are salts that react with other salts found in the irrigation water. Therefore, it is important to consider the chemical composition of the water to be used for preparing the liquid fertilizers.

For example, under conditions of high alkalinity water, the phosphorus of a phosphate fertilizer precipitates with calcium and magnesium present in the water. These precipitates can be seen at the bottom of the fertilizer tank.

#### Interaction between fertilizers

There are fertilizers that are not be mixed on the same mixture, as they are incompatible. In some cases, when mixed, those fertilizers immediately induce crystallization and cause clogging in the irrigation system. In other cases the reaction between two incompatible fertilizers causes the loss of nutritional ingredients to the plant.

#### Compatibility of the most common soluble fertilizers:





#### Jar test

To avoid injecting products that might clog or otherwise damage the irrigation system, perform the simple jar test described below before injection of fertilizer, acid or any chemical. This is especially important if it is the first time a specific product or mixture of products is used, or when using a product supplied by a new vendor.

#### To perform the jar test:

- ✓ Use a clean, transparent glass container of 2 liters (0.5 gallons) minimum.
- Fill it with the same water used for irrigation, taken at the point of injection in the system.
- Add the product/s to the water in the container at the exact ratio prescribed for injection.
- Manually mix the contents of the container until the products are completely dissolved.
- If the products do not dissolve after mixing for a few minutes, do not inject the product or mixture into the irrigation system and call your local Netafim<sup>™</sup> representative for advice.
- If the products dissolve properly, place the container to rest, uncovered, for 24 hours at ambient temperature, protected from direct sunlight.
- After 24 hours, visually examine the contents of the container against the light and check for any type of sedimentation, coagulation or floating solids.
- If any of these are present, do not inject the product or mixture into the irrigation system and call your local Netafim<sup>™</sup> representative for advice.

#### Corrosivity

Most fertilizers, both solid and liquid, attack metals in the irrigation and fertilization systems. Generally, the higher the acidity of the solution, the greater the corrosive effect.

For example: the combination of potassium chloride and phosphoric acid is extremely corrosive.

#### Volatilization

Fertilizers containing urea and ammonium nitrogen can be lost by volatilization of ammonia. The tanks storing liquid fertilizer mixtures for longer than 4 days must be sealed.

#### Fertilizer pH

Liquid fertilizers have different pH levels that may affect the crop and the drip irrigation system. The acceptable pH level for crops is 5 - 7.

The effect of fertilizers with different pH levels on the irrigation system:

pH level		Effect on the irrigation system
up to 5	Acidic	May damage the PC drippers and system components made of materials containing Acetal, depending on the duration of exposure to the substance and the ambient temperature.*
5 - 6	Mildly acidic	When combined with certain nutrients, may damage the PC drippers and system components made of materials containing Acetal, depending on the duration of exposure to the substance and the ambient temperature.*
6 - 8	Neutral	All the components of a Netafim <sup>™</sup> drip irrigation system are resistant to pH levels of 6 and up.
8 and up	Basic	When combining certain nutrients, sedimentation might occur, causing clogging of the drippers and other components.*

\* Consult a Netafim<sup>™</sup> expert.

#### Salinity

Fertilizers are salts that contribute to the increased salinity of the irrigation water. The level of EC (electrical conductivity) reflects water salinity, and is measured with simple instruments in the field and in laboratory.

#### Hygroscopicity

Solid fertilizers have the property of adhering to moisture; this stiffens the granules and makes them difficult to handle afterwards. It is important to keep them in a closed container in order to avoid this phenomenon.

#### **Liquid fertilizers**

#### **Preparation of liquid fertilizers**

The temperature of the water in which it dissolves influences the amount of fertilizer to dissolve, as shown in the following table.

#### Effect of temperature (°C) on the solubility of fertilizers (fertilizer grams in one liter of water)

	Temperature °C					
Fertilizer grams / liter water	0	5	10	20	25	30
Urea	680	780	850	1060	1200	1330
Ammonium sulfate	700	715	730	750	770	780
Potassium sulfate	70	80	90	110	120	130
Potassium chloride	280	290	310	340	350	370
Potassium nitrate	130	170	210	320	370	460
Mono-ammonium phosphate	227	255	295	374	410	464

It can be observed that the temperature of the fertilizer solution strongly affects fertilizer solubility, as in the case of urea. In contrast, the characteristics of ammonium sulfate are almost not affected by temperature.

Generally, the water temperature, under field conditions, is higher than 20°C. Therefore, it might seem logical to assume that at the time of preparing a liquid fertilizer, that the higher the water temperature, the greater the amount of fertilizer that can be dissolved. But a crucial parameter has been ignored...

When fertilizers are mixed with water, a reaction between the water and the product occurs, which cools the mixture. This is called **endothermic reaction**. Because of the lowered temperature of the water, the entire amount of product calculated according to the original temperature of the water before mixing cannot be dissolved anymore. This occurs with fertilizers containing nitrogen compounds such as ammonium nitrate and urea.

# 

When dissolving a fertilizer, do not exceed the amount permitted for 10°C, according to the table above.

#### Choosing the point of injection of liquid fertilizer

The mixture can be injected at various points of the system, according to the need for it. The fertilizer injected into the irrigation system moves with the irrigation water from the point of injection downstream, therefore, when irrigating, the part of the system downstream from the point of injection will also receive fertilizer.

#### Three injection points can be listed:

#### A. In the irrigation head

Fertilizer injected at this location reaches all valves that receive water from the irrigation head.

#### B. A valve in a specific plot

Fertilizer injected before a specific valve will reach the part of the plot irrigated by the said valve.

#### C. Between the irrigation head and a group of valves

This is the location between the two points above; it should be used to fertilize a group of valves that irrigate at the same time.

#### Equipment for liquid fertilizer injection



#### Management of drip Nutrigation™

Taking an overview of the irrigation and fertilization program, proceed to analyze whether the program is technically and agronomically acceptable.

#### First, two important rules must be met:

The injection of liquid fertilizer will begin only when the irrigation system is fully pressurized and stabilized, that is, when the water has reached the farthest dripline with the required pressure. The duration of fertilizer injection depends on the size and design of the system, but as a general rule it should not in any case be less than 0.5 hours (half an hour).

✓ Fertilizer injection should not be stopped before the required quantity of fertilizer water exits the farthest dripper. This also depends on the project size, length of the driplines and the design of the system.
 See Advancement Time in the Netafim<sup>™</sup> Preventive Maintenance Guide.
 If needed, call a Netafim<sup>™</sup> expert to calculate fertilizer injection time for your specific system.

Knowing the start time and the end time of fertilizer injection, and the time that fertilization can be performed, proceed according to the calculations and the injection equipment.

#### Setting the fertilizer application time during irrigation:

The injection time of liquid fertilizer should be determined according to the run time for fertilization to be best exploited, avoiding waste of fertilizer due to water excess, or failure to complete the fertilization program due to irrigation time. **Therefore, a schedule must be made.** 



#### Steps to follow in setting the injection duration and timing

# 

#### A. Calculate the amount of the pure element. Example: Nitrogen

Ouantity of pure nitrogen per month:	50 Kg per hectare.

Total days in the month: 30 days.

Quantity of pure nitrogen per day: 50/30 = 1.66 Kg/ha/day

#### B. Calculate how many liters of liquid fertilizer will be needed

- For 100 liters of final mixture (water and fertilizer) 20 Kg of urea or ammonium nitrate equivalent, 27.8 Kg are dissolved.
- ✓ That amount of urea or ammonium nitrate represents 9 Kg of pure nitrogen (20 Kg \* 45%).
- If in 100 liters of liquid fertilizer there are 9 Kg of pure nitrogen, it follows that 1 (one) Kg of pure nitrogen equals 11.1 liters of the mixture (100/9 = 11.1).
- Size of the plot to be irrigated: 20 hectares.
- Total injected liquid fertilizer every day will be: Total hectares \* Kg of pure nitrogen in irrigation \* liters of fertilizer per Kg of pure nitrogen = 20 ha \* 1.66 kg N per irrigation \* 11.1 liters = 368 liters of fertilizer per irrigation.
- ✓ Irrigated every two days; therefore 736 liters (368 \* 2) must be applied.

#### C. Required duration of irrigation

- Calculated hourly irrigation capacity of the system:
  - The dripper flow is 0.8 liters per hour.
  - The distance between drippers is 0.50 meters.
  - The distance between the driplines is 1.60 meters.
  - The hourly capacity irrigation is =  $0.8 / (0.5 \times 1.6) = 1.0$  mm per hour or  $10.0 \text{ m}^3$  per hectare per hour.
- ✓ Daily evaporation tank as Class "A" is 8 mm.
- Replacement coefficient (Kc) = 0.8
- Solution Amount of water to irrigate per day =  $8 \text{ mm x } 0.8 = 6.4 \text{ mm or } 64 \text{ m}^3 \text{ per hectare.}$
- Run time per day = Total water to irrigate in mm / Irrigation Hourly capacity in mm / hour =
  - 6.4 mm / 1.0 mm per hour = 6 hours 24 minutes.
- However, as it is irrigated every other day, irrigate duration should be set for 12 hours and 48 minutes.

#### D. Required injection time

- ✓ In this example, the fertilizer injector is capable of injecting 100 liters per hour.
- ✓ Total fertilizer to be injected is 736 liters (step B).
- Time to be injected: 736 liters fertilizer / 100 liters per hour = 7.36 hours (7 hours and 22 minutes).

#### E. Injection program

Having calculated all the above data, the next step is to decide the timing of fertilizer injection during irrigation.



#### Proposed program:

#### Nutrigation $\ensuremath{^{\mathrm{M}}}$ in the rainy season

It may happen that, after a rainfall, fertilization should be performed, applying the amount of fertilizer that could not be applied during the days without irrigation. For this purpose the liquid fertilizer mixture may be modified by concentrating more for the same amount of nitrogen.

# Example

If you must fertilize to complete the dose of 4 days, but with an amount of water equivalent to 1 (one) day of watering, you can proceed as follows:

- Amount of water: 6.4 mm
- Run time: 6 hours 24 minutes
- ✓ Nitrogen dose per day: 1.66 Kg per hectare.
- Replenish fertilization days: 4 days.
- In the liquid fertilizer tank, fertilizer can be prepared in either of the following ways:

At the same concentration, which means that in 11 liters of the mixture there is 1 Kg of pure nitrogen.
 Increasing the amount of urea, for example,

add 30 Kg of urea-equivalent, 13.5 Kg ( $30 \times 0.45 = 13.5$ ) pure nitrogen into the 100 liters mixture.

This means one (1) Kg of nitrogen to 7.4 liters of liquid fertilizer.

If the project size is 20 hectares, the injection quantity depends on whether it continues with the same concentration of nitrogen in the tank or is increased, as explained in the previous section. Then:

1.66 kg N/day x 20 hectares x 11 l/kg N x 4 days = 1461 liters.

I.66 kg N/day x 20 hectares x 7.4 l/kg N x 4 days = 982 liters.

- The injection time can be 4 to 5 hours, which would require modifying the flow of the fertilizer injector, according to the following calculation:
  - ✓ 1461 liters / 4 hours = 365 liters per hour.
  - 1461 liters / 5 hours = 293 liters per hour.
  - 982 liters / 4 hours = 245 liters per hour.
  - 982 liters / 5 hours = 196 liters per hour.

Choose the option that fits the system's capacities and the soil moisture, and allows irrigation with acceptable electrical conductivity (EC).

# Chemigation

Chemigation<sup>™</sup> refers to injection of chemicals to prevent or reduce dripper clogging (addition of chlorine, hydrogen-peroxide, acid or others), and the injection of chemicals for crop and soil concerns (herbicides, pesticides and others).

# CHEMICAL HAZARD

When not handled properly, nutrients, acids and chemicals may cause serious injury or even death. They may also damage the crop, the soil, the environment and the irrigation system.

#### Proper handling of nutrients, acids and chemicals is the responsibility of the grower.

Always observe the nutrient/acid/chemical manufacturer's instructions and the regulations issued by the relevant local authority.

# 

Netafim<sup>™</sup> authorizes the use of certain chemical agents. Products that are not authorized in this summary must pass a control test in Netafim's laboratory prior to being utilized, to ascertain if they are safe for use with Netafim's systems.

#### Fungicides, herbicides, insecticides and disinfectants authorized by Netafim™

- Metam sodium
- Telone II
- Formaldehyde

There are additional options; contact the Agronomy Division of Netafim<sup>™</sup> for details.

After chemigation it is necessary to continue irrigation with water that is free of chemical products. Verify the flushing duration and timing with the tables showing the advancement times.

In irrigation systems with anti-drain drippers (CNL), in addition to the previous instruction, it is necessary to open the ends of the driplines for flushing.

#### Possible product issues

In general, products, both those approved and not approved by Netafim<sup>™</sup>, contain approximately the same percentage of active material. The differences between the various products are:

- The quality of the product.
- ✓ The storage time.
- The dosage.The quality of the emulsion.

With good-quality emulsion, the active components in the product mix with the water without creating layers of different compositions. When these conditions are not fulfilled, the contact of high concentrations of the product's active ingredients with various parts of the system, such as valves, drippers, flow meters, etc., could damage them. These products are very corrosive to some metals and also react with various polymers (depending on the product).

#### Applying herbicide by chemigation via drip irrigation

Chemigation is done by a dosing unit. For the full range of dosing units and how to choose the suitable one, see Dosing Unit, page 30.

#### Advantages

- Avoids crop damage and contamination of foliage, flowers and fruits caused by spraying.
- Application is local and avoids damaging the neighboring crops.

#### Herbicide injection process

Herbicide should be diluted to obtain an aqueous solution prior to injection.

- Inject herbicide into the system at the head of the relevant plot.
- Start the injection of herbicide only after half, but before two-thirds of the planned irrigation time, based on the advancement time, has elapsed, in order to ensure that the whole quantity of injected herbicide has been evacuated from the system through the drippers.
- After injection of the required amount of herbicide, irrigation should be continued for at least 15 minutes in order to flush herbicide residues out of the system.



The herbicide injection should take place towards the end of the irrigation event.

**Example:** if you plan to irrigate 300 m<sup>3</sup>/ha water, the herbicide will be applied once a quantity of approximately 250 m<sup>3</sup> has been irrigated.

# Dripline insertion or laying

It is important to lay or insert the driplines with the drippers facing upwards. This prevents sediments present in the driplines from penetrating the drippers and extends the life of the driplines.

# 

When inserting or laying heavy wall driplines, it is impossible to ensure that the drippers will uniformly face upwards.

When inserting driplines, a **Netafim<sup>™</sup> Roller Box** with Okolon rollers must be installed on the insertion machine to straighten the driplines in order to prevent their bending, ensuring that drippers always face upwards.

# 

Bends in the dripline interfere with the regular flow of water and might block the passage of water down the driplines.

#### Use Netafim's dedicated insertion shank

- ✓ Diameter: 2".
- Seamless, schedule 40 steel pipe, without any inner protrusions that might damage the driplines.
- Conic pipe inlet to allow smooth feeding of the dripline throughout the entire deployment of the dripline from the coil.
- Allows deep insertion while ensuring that the shank's inlet is above ground level to prevent soil from entering the shank's pipe.
- The shank's outlet is beveled to ensure smooth emission of the dripline without damaging the drippers.



The dripline coil must be installed so that it rotates in the opposite direction to the tractor's movement as indicated by the arrow on the side of the coil. This way the dripline enters the conic pipe inlet of the shank at a correct angle.



# 

Installing the dripline coil the wrong way will result in damaging the drippers while they enter the conic pipe at a too steep angle.pipe at a too steep angle.

See an overview of Netafim's agro-machinery for dripperline insertion, laying and retrieving on page 48. For further information about agro-machinery see the Netafim<sup>™</sup> Agro-Machinery Catalog or call your local Netafim<sup>™</sup> representative.

# / DRIP IRRIGATION SYSTEM MAINTENANCE

$\rightarrow$	Maintenance timetable	68
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# / Drip irrigation system maintenance

The aim of this chapter is to provide guidelines and useful tips for the proper maintenance of a drip irrigation system.

# 副 NOTE

For the correct operation of the irrigation system it is imperative to implement all the instructions for proper maintenance of the drip irrigation system in this chapter.

For optimal performance, drip irrigation systems require routine system maintenance. Even though recent innovations in dripper design have made clog-resistant driplines readily available, the nature of agricultural water sources, nutrient injection practices, natural limitations of filtration equipment and the general agricultural growing environment make maintenance a priority.

# 

In extreme cases of negligence to perform routine system maintenance, a clogged drip irrigation system might cause the lost of the current crop and even necessitate replacement of the driplines.

Taking baseline readings and monitoring flow, pressure and the condition of flush water regularly will provide guidance for maintenance scheduling.

In addition to flow, pressure and condition of flush water, the overall condition of the pump station and distribution system should be routinely inspected and/or calibrated including control equipment engines, motors, reservoirs, injectors, pipelines, valves, fittings, flow meters and pressure gauges.

Broken or dysfunctional equipment should be immediately repaired or replaced with the same or similar equipment that will perform the same function according to system design criteria.

Aside from making equipment adjustments or repairs, the majority of system maintenance activities are: applying chemicals, flushing the system and controlling pests.

#### Maintenance consists of two categories:

Preventive maintenance, aimed at preventing clogging of the drippers, can be divided in three categories:

- Flushing the system.
- Chemical injection.
- Irrigation scheduling\*.

\*Irrigation scheduling is not a distinct maintenance practice, and therefore it is not discussed in this book. However, the application of an orderly irrigation plan is of utmost importance to the prevention of clogging of the drippers.

**Corrective maintenance** consists mainly of removal of obstructions already present in the drippers:

Flushing the system.

- And one or more of the following practices according to the nature of the obstruction:
- Organic formation treated with hydrogen peroxide.
- Mineral sedimentation treated with acids (or a combination of acid and hydrogen peroxide).
- Organic formation and mineral sedimentation treated with a combination of acid and hydrogen peroxide.

# Maintenance timetable

#### When operating a new system for the first time

- Flush the piping main line, sub-mains and distribution pipes.
- ✓ Flush the driplines.
- Check actual flow rate and working pressure for each irrigation shift (when the system is active for at least half an hour).
- Compare the data collected to the data supplied with the system (planned). The tolerance should not be greater than ±5%.
- Write down the newly acquired data and keep it as benchmark for future reference.
- If the flow rate and/or the working pressure at any point in the system differ by more than 5% from the data supplied with the system, have the installer check the system for faults.

#### Once a week

- Check actual flow rate and working pressure for each irrigation shift under regular operating conditions (i.e., when the system is active for at least half an hour and stabilized).
- Compare the data collected to the benchmark data.
- Check that the water reaches the ends of all the driplines.
- Check the pressure differential across the filters.

A well-planned filtration system should lose 0.2 - 0.3 bar (when the filtration system is clean).

If the pressure differential exceeds 0.8 bar (11.6 PSI), check the filter/s and their controller for faults.

#### Once a month

- Check the pump's flow rate and pressure at its outlet.
- ✓ Flush the driplines.
  - (A higher or lower frequency may be required, depending on the type and quality of the water.)
- If the filtration system is automatic, initiate flushing of the filter/s and check that all the components work as planned.
- If pressure-regulating valves are installed, check the pressure at the outlet of each one of them and compare these figures with the benchmark data.

#### Once a growing season

In some cases the following need to be performed twice or three times in a growing season, depending on the type and quality of the water used.

- Check all the valves in the system.
- Check the level of dirt in the system (carbonates, algae and salt sedimentation).
- Check for occurrence of dripper clogging.
- Flush the piping main line, sub-mains and distribution pipes.
- If necessary, inject hydrogen peroxide and/or acids as required.

#### At the end of the growing season

- Inject chemicals for the maintenance and flushing of the main line, the sub-main lines, the distribution pipes and the driplines.
- ✓ Flush the driplines.
- Prepare the system for the inactive period between the growing seasons.
- Perform winterization of the system in regions where the temperature might drop below 0°C (32°F).

# System flushing

Flushing the irrigation system reduces to a minimum the accumulation of pollutants, pushing them out of the system.

#### Flushing of the irrigation system is comprised of 3 processes:

- ✓ Filter back-flushing.
- Flushing main and sub-main lines.
- Flushing driplines.

#### Filter back-flushing

## ATTENTION

For effective filtration, filters must be back-flushed whenever they become dirty.

Filters - whether disc, screen or media (see Types of filters, page 20) - should be back-flushed periodically to clear out any collected particulate or organic matter. Clogged filters can reduce pressure to the system, lowering the water application rate.

The filter's performance depends on the efficiency of its flushing and cleaning. Any accumulation of nondisposed material will eventually lead either to clogging of the filter or, in a gravel/sand filter, to the release of the filtering material along with the filtered water during migration.

When designing a filtration system, filter flushing must be considered. Most filtration systems are designed for either manual, semi-automatic or automatic flushing. Flush cycles for manual and semi-automatic systems are manually activated, while flush cycles for automatic systems are activated either when a pre-set pressure differential across the filters is exceeded, or by a pre-set operational time interval. Selection of filtration automation depends upon cost and labor considerations.

Flowing water or well water usually requires a sand separator to remove sand before it enters the filtration system (see Hydrocyclone Sand Separator, page 20).

#### Pressure differential across a filter

Every filter must cause a loss of pressure in the system while filtering. This loss of pressure is demonstrated by the pressure differential across the filter (between the inlet and the outlet of the filter / filtration array).

# 🖹 ΝΟΤΕ

Check the filter documentation for the allowable pressure differential across the filters.

Most filters are subject to an increasingly higher pressure differential between inlet and outlet due to friction as the filter becomes clogged. Monitor the filter pressure differential frequently, especially as water conditions change in the course of the season.

#### Check the pressure differential across the filter (according to the filter documentation)

Filter	Higher than the maximum	Lower than the minimum
Gravel/sand	Partial or total clogging of medium.	Tunnels in the medium or breakage and loss of medium.
Screen	Screen clogging.	Screen ripping or bursts through the screen (meat grinder).
Disc	Clogging of filtration grooves	Leakage through discs due to solids trapped between the discs (preventing the discs from being pressed close together and causing gaps in the disc array).

A pressure differential that is higher or lower than the recommended range for the specific filter may lead to debris passing through the filters and/or poor irrigation system performance.

# P ATTENTION

Too frequent automatic flushing occurs when the filter is not properly cleaned and the pressure differential across the filter remains high immediately after flushing.

#### Visual inspection

Visually inspect the filtration unit or medium and all other filter components and accessories for mechanical integrity.

#### **Automatic flushing**

Check the frequency of automatic flushing

Flushing frequency is too high	Flushing frequency is too low	Automatic flushing is not triggered
<ul> <li>The filtration unit or medium remains clogged after flushing.</li> <li>The pressure range is incorrectly set in the controller.</li> <li>Faults in automation or sensor.</li> </ul>	<ul> <li>The filtration unit or medium is breached or leaking.</li> <li>Faults in automation or sensor.</li> <li>Mechanical failure.</li> </ul>	<ul> <li>Faults in automation or sensor.</li> <li>Mechanical failure.</li> </ul>

#### Once a month

If the filtration system is automatic, initiate flushing of the filter/s and check that all the components work as planned.

#### Gravel/sand filter

Check the water at the filter's drainage exit by touch to detect loss of gravel/sand medium.

#### Filter flushing techniques

Many filter systems are automated and will self-clean via an electric or hydraulic 3-way back-flush valve when a pre-set filter differential is reached. For this procedure, the water flow is reversed for a short time to carry away debris through a back-flush line.

# 

To prevent loss of nutrients, if a filter is installed downstream from a dosing unit, set the controller to pause Nutrigation<sup>™</sup> or chemigation during filter back-flushing. Always give priority to filter back-flushing. Do not perform Nutrigation<sup>™</sup> or chemigation during filter back-flushing.

#### Each type of filter has a different flushing mechanism

The typical flushing mechanism of each type of filter is described below. However, for flushing a specific filter, always refer to its user manual.

#### Screen filter

Flushing is performed during the filter's current operation.

The automatic valve opens the drainage outlet, which creates suction in the flushing axis.

The motor rotates the flushing axis and moves it back and forth, drawing the dirt from the entire inside surface of the filtration screen.



#### **Disc filter**

During current operation, the piston at the top of all the filters in the array holds the discs pressed close together.

All the automatic inlet valves are open and the drainage valves are close.

Water flows through the discs into the irrigation line.



During the flushing operation, the piston at the top of one of the filters in the array spreads the discs to allow the water flowing between them to pick up the dirt from the grooves in the discs.

The automatic inlet valve is close and the drainage valve is open.

The opened drainage outlet creates a pressure differential across the filter, allowing water to flow into the filter through its outlet and out of the drainage outlet, back-flushing the filter discs.

Filters in an array are flushed in sequence.


#### **Gravel/sand filter**

During current operation, the automatic 3-way valves close the filter's drainage outlets. Water flows through the gravel/sand medium into the irrigation line.

When filter flushing is performed, the automatic 3-way valve of one of the filters opens the drainage outlet while blocking the water inlet to the filter.

The opened drainage outlet creates a pressure differential across the filter, allowing water to flow into the filter through its outlet and out of the drainage outlet, back-flushing the filter's gravel/sand medium. Filters in an array are flushed in sequence.





#### Hydrocyclone sand separator

To flush the sand accumulated in the sand compartment at the bottom of the hydrocyclone sand separator, open the valve at the drainage outlet of the filter.



# 

Before starting filter maintenance, make sure the system is not under pressure.

#### **Gravel/sand filter**

Periodic inspection of the medium in gravel/sand filters is an essential maintenance task that is frequently neglected. Gravel/sand should not be caking and cracking and should be adequately cleaned during the automatic back-flush cycles.

The filter might lose some gravel/sand during the back-flush cycles, so even if the filter is in proper working order, it may require additional gravel/sand from time to time.

During inspection examine the gravel/sand by touch. The gravel/sand grains should be sharp edged, not rounded smooth like beach sand. The sharp edges promote better filtration but backwash cycles will wear the gravel/sand smooth over time. If this has occurred, replace the gravel/sand. The rounding of gravel/sand edges may take a number of years, but it will eventually happen.

#### Screen filter

Take the screen out of the filter casing and clean it with pressurized water and brushes.

Visually inspect the screen for breaches and cracks and replace the screen if damaged.

#### **Disc filter**

- Open the filter's casing and release the piston holding the discs pressed close together.
- Take the discs out of the filter casing.
- Thread the discs on an acid-resistant rope and tie the ends of the rope to form a loop. Do not thread too many discs on one loop; it is important that the cleaning solution reaches all the disc surfaces.
- Soak the discs in this solution,\* making sure the discs are loose and have good contact on both sides with the solution. Do not put too many discs in at one time.
- If the disc remains dirty repeat the last step.

#### \*solution for surface water with organic and biological residue:

Make a 10% peroxide solution. Pour 7 liters (1.8 gallons) of water into a container and add 3 liters (0.8 gallons) of hydrogen peroxide (35%) or pour 8 liters (2.1 gallons) of water into the container and add 2 liters (0.53 gallons) of hydrogen peroxide (50%) to the water.

#### \*solution for well water with manganese, iron or carbonate deposits:

Make a 10% hydrochloric acid solution. Pour 7 liters (1.8 gallons) of water into a container and add 3 liters (0.8 gallons) hydrochloric acid (30-35%) to the water.

- Stir the discs in the solution a few times. Total soaking time should be 1 to 3 hours.
- If the solution is no longer cleaning the discs, replace it with a new mixture.
- Visually inspect the discs for cleanliness and for dents and cracks and replace any damaged discs.
- Rinse the discs with clean water.
- Put the discs back in the filter. Make sure to put back the same number of discs that have been taken out. Tighten the piston holding the discs pressed close together and close the filter casing.
- Flush the filter a few times to remove all chemicals.

#### Flushing the main, sub-main and distribution lines

Flushing the main, sub-main and distribution lines is an important operation that often doesn't get the attention it requires. Even with a primary filter at the head control station, small particles can get by and should be physically removed from the piping system.

Flushing the main, sub-main and distribution lines will considerably reduce the accumulation of organic and mineral materials in the system. This will prevent those materials from reaching the drippers and eventually clogging them, thus minimizing the quantity of chemical products required to maintain the system. Regular flushing of the main, sub-main and distribution lines will result in a significant saving of labor time and chemicals.

The main, sub-main and distribution lines in the system should be flushed in sequence. Each one of them should be flushed for at least two minutes or until the flushed water runs clear.

## ATTENTION

The pipes must be flushed at regular intervals. The frequency depends mainly on the water quality and the maintenance program (minimum: once a growing season).

Flushing is effective only when the flow rate within the main, sub-main or distribution line is sufficient to allow for proper flushing velocities in the system.

#### Manual flushing of main, sub-main and distribution lines

Flushing may be automatic or manual.

Manual flushing of main, sub-main and distribution lines should be carried out as follows:

- Flush the pipes in this order: main line, sub-main lines, distribution lines.
- Open the flushing valves of each one of them in turn while under pressure.

#### The process of flushing the main, sub-main and distribution lines consists of two waves for each:

- The first wave removes contaminants collected at the end of the pipe.
- The second wave removes contaminants from the pipe.
  - The color of the water is not as dark as in the first wave, but the process takes more time. Flushing must be continued until the water is visually clean.

#### Obtain the velocity of the water flowing in the pipes

The velocity of the water in a pipe depends on the flow rate and the internal diameter of the pipe.

Identify the diameter of each pipe section to be flushed separately using the table below, presenting the most common diameters of pipes used for main, sub-main and distribution lines:

Nominal pipe diameter - Inch (mm)	3 (75)	4 (110)	6 (160)	8 (225)	10 (250)
Actual internal pipe diameter - mm	67.8	101.6	147.6	207.8	230.8

\*The table represents the inside diameters (ID) in pipes of one specific standard among many.

- Check the flow rate in each pipe section to be flushed separately with the closest water meter installed upstream from it.
- Knowing the diameter of the pipe and the flow rate, use the graph below to derive the velocity for each pipe section to be flushed. The recommended flushing velocity is 1.5 m/sec (5 ft/sec). The allowable velocity range for flushing is 1.0-2.0 m/sec (3.3-6.6 ft/sec).

#### Velocities in pipes of various diameters at various flow rates\*



\* The graph represents the velocities in pipes of one specific standard among many.

If the pipe used in the system's main, sub-main or distribution lines does not appear in the above table and graph, call your local Netafim<sup>™</sup> representative.

#### Flushing the driplines

Driplines in both surface and SDI systems require periodic flushing to purge them of settled debris, organic or mineral, and of any residues of chemicals injected into the system.

In SDI systems, dripline flushing must be given high priority since frequent dripline replacement is impractical and driplines are expected to last up to 20 years or even longer. Even for short-term dripline use, flushing is important to maintain irrigation uniformity.

Flushing should be performed as often as needed to keep the driplines clean; this depends on seasonal water quality and the effectiveness of the system filter.

All the driplines in a plot should be flushed in sequence in a single flushing event.

Driplines should be flushed until the flushed water runs clear.

Flushed water should be disposed of properly to avoid deteriorating the system's inlet water quality and/or the quality of the environment surrounding the site.



Flushing will temporarily increase the flow requirements of the system, which in turn will decrease the system pressure. In some cases, in order to supply the flow rate required for flushing, an additional pump at the head of the system is used. The additional pump will be activated only during flushing to add the missing flow rate.

The length of driplines affects the required flushing duration. Longer driplines need longer flushing durations.

#### Visual inspection of water quality

As often as each irrigation, the ends of driplines should be opened and the contents emptied into a jar for visual inspection of water quality. System maintenance should be performed as soon as water quality begins to degrade, as shown by color, grit, organic or any solid materials in the flush water.

#### Verification of the flow velocity in the dripline during flushing

Place the open end of the dripline over a 1.5-liter bottle, using a funnel. Verify that all the water enters the bottle. Measure the time (in seconds) it takes to fill the bottle, and use the following table in order to make sure that the velocity is at least 0.5 m/sec (1.65 ft/sec).

Dripline ID (mm)	11.8	14.2	16.2	17.5	20.8	22.2	25.0
Quantity of water per 1 meter of dripline length (liters)	0.109	0.158	0.206	0.241	0.340	0.387	0.491
Maximum time for filling of bottle (seconds) for a velocity of at least 0.5 m/ sec (1.65 ft/sec)	27.4	18.9	14.6	12.5	8.8	7.8	6.1



#### The dripline flushing process consists of two waves:

- The first wave removes contaminants collected at the end of the dripline.
- The second wave removes contaminants from the dripline.
  - The color of the water is not as dark as in the first wave, but the process takes more time. Flushing must be continued until the water is visually clean

#### Netafim<sup>™</sup> driplines - maximum flushing pressure:

For dripperline characteristics see tables on page 39.

## 

The maximum allowed flushing pressures in the tables on the previous page are valid when flushing for a maximum of half an hour consecutively, with the end of 5 or more driplines kept open. To avoid exceeding the allowable pressure in the system, a minimum of 5 driplines should be open at any time during flushing.

## Preparation and use of a hydraulic conditions checklist

Keeping track of the system's hydraulic conditions - flow rate and pressure, is of utmost importance for the detection of malfunction, clogging and leaks in the system.

Prepare a hydraulic conditions checklist (in the form of a table) representing the flow rate and pressure at the head of the system and at the head of each plot.

Fill in the table's first row with the system's planned data received from Netafim™.

Fill in the table's second row with the benchmark data recorded at the time of initial operation of the system (record the data after the system's flow rate and pressure are stabilized).

The benchmark data should not deviate from the planned data by more than  $\pm 5\%$ .

If a deviation greater than ±5% is recorded at any point in the system, call your local Netafim<sup>™</sup> representative.

Fill in the following rows with the actual data recorded each time the system is checked during regular operation according to the maintenance timetable see page 69.

If a deviation greater than  $\pm 5\%$  is recorded at any point in the system, troubleshoot the problem and record the hydraulic conditions again after troubleshooting.

If, at any point in the system, hydraulic conditions within ±5% deviation of the benchmark data cannot be restored, call your local Netafim<sup>™</sup> representative.

The hydraulic conditions checklist should be filled in regularly and kept for future reference.

## Chemical injection for system maintenance

The injection of different treatments may prevent, eliminate, dissolve or solve occurrences of clogging. The following flow chart is a guide for determining the order in which to perform chemical injection:

- **1.** Begin by recording the system's flow rate at operating level.
- 2. Calculate the dose to be injected, based on the recommendations in Netafim<sup>™</sup> Maintenance Handbook.
- **3.** Perform a test injection, in order to verify and/or rectify the correct functioning and the respective flow rate of the injection system.
- 4. Flush the system according to the instructions in the section System flushing, page 70.
- 5. Inject the chemical calculated in step 2 above, depending on the specific treatment.
- 6. Flush the system, taking into account the advancement times.

#### Removal of chemical residues from the system

Upon completing the injection of products (fertilizers, disinfectants, oxidants, herbicides, etc.) continue irrigating only with water for as long as necessary to remove all residue of these products from the system.

#### Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) treatment

Hydrogen peroxide is used for disinfecting and oxidizing the irrigation water, for cleaning screen, disc and gravel/sand filters, and as an oxidizing agent for fruits and vegetables prior to storage.

Hydrogen peroxide is a strong oxidizing agent. It releases oxygen atoms that react quickly, oxidizing organic matter (also suitable for oxidizing iron and manganese). It decomposes in an exothermic reaction (a chemical reaction that releases energy in the form of heat) into water and gaseous oxygen.

# 

Hydrogen peroxide  $(H_2O_2)$  is toxic and dangerous for humans.

Before using hydrogen peroxide, read all the instructions for hydrogen peroxide treatments, the local legal regulations and the manufacturer's instructions.

#### Advantages of hydrogen peroxide

#### Environment friendly

Does not contaminate the soil, is biodegradable, does not harm the aquifer, does not generate dangerous by-products and indirectly makes more oxygen available for the soil and the plants.

#### Quick oxidation reaction

Consumed immediately upon contact with the irrigation water. Suitable for quick oxidation and disinfection of the water source (also in close proximity to filters).

Hydrogen peroxide is commonly used in greenhouses, net houses and tunnels, or on substrates, where the irrigation systems traverse only short distances.

## 

Never perform chemical treatment(s) while plants are actively growing in an artificial growing medium or limited root zone.

The required concentration of hydrogen peroxide at the system inlet depends on the water quality (oxidation potential and the reduction and concentration of organic matter in the water). In general, between 1 and 10 PPM (parts per million) of hydrogen peroxide (active agent) are required.

#### Uses of hydrogen peroxide

- Prevent the accumulation of bacterial slime in the sub-main pipes and driplines.
- Clean irrigation systems of accumulated organic deposits and bacterial slime.
- Oxidize micro-elements (such as iron and sulfur) and trace elements (such as manganese), and prevent bacterial propagation.
- Improve the main and secondary filtration under high organic load conditions.
- O Disinfect and treat irrigation water, waste water, sewage, drinking water and swimming pools.
- Prevent and eliminate water odors and interference with biological activity.
- Reduce BOD/COD values by oxidizing organic and inorganic polluting materials.

See instructions and calculation for hydrogen peroxide injection in Netafim<sup>™</sup> Maintenance Handbook.

## Water analysis

Analyze the water used in the irrigation system and determine its quality.

The water quality refers to the concentration of chemical substances dissolved and suspended in the water, as well as the physical and biological properties of the water.

A water analysis is necessary in order to select an appropriate type of filtration system, to prescribe a suitable maintenance program, to select the type of driplines and to prescribe an appropriate Nutrigation<sup>™</sup> plan.

#### For agriculture, water quality is defined according to the following criteria:

Agronomic water quality - the extent to which it is compatible with the type of soil and with the crop.
 Water quality for irrigation - the extent to which it induces clogging of the irrigation system.

The source of water may be: potable water, waste water, residual water, wells, reservoirs, canals or drainage water. Each one requires different levels of treatment before being used.

It is recommended to analyze the irrigation water at least once a growing season and, if needed, in the course of the growing season, considering meteorological and environmental factors that potentially influence the water quality. Consult Netafim's Agronomy Division (especially recommended for new projects).

Water quality is not controllable; it varies with time for a variety of reasons. This means that different treatments are required at different times in order to ensure that water quality is suitable for the irrigation system.

Therefore, it is recommended to analyze the water occasionally in order to constantly adjust the treatment.

Other factors that affect the water quality and must be taken into account are the fertilizers and chemical products used in the same system for various treatments.

#### Taking water samples:

- **1.** Before taking a water sample, flush a clean one-liter bottle, using water from the source to be sampled.
- **2.** Fill the bottle so that no air at all remains inside the bottle (if possible, squeeze the bottle to expel any remaining air).
- **3.** Close the cap firmly and store the sample in a clean place in the shade.
- **4.** Send the sample to a local authorized laboratory as soon as possible after taking the sample.
- 5. Write the following data on the sample bottle:
  - ✓ Grower's name.
  - Location.
  - ✓ Water source.
  - Date sample was taken.
- **6.** Request an analysis of all the following parameters:
  - EC (electrical conductivity)
  - ✓ pH (level of acidity or alkalinity)
  - **Ca** (calcium hardness of the water)
  - ✓ Mg (magnesium)
  - ✓ Na (sodium)
  - 🕑 **K** (potassium)
  - ✓ HCO₃ (bicarbonate)
  - CO₃ (carbonate)
  - ✓ Alk (alkalinity)

- ✓ CI (chloride)
  ✓ SO₄ (sulfate)
- **PO₄** (phosphate)
- ✓ N-NH₄ (nitrogen-ammonium)
- ✓ N-NO₃ (nitrogen-nitrate)
- Section B (boron)
- Section (iron)
- ✓ Mn (manganese)

- TSS (total suspended solids)
- TDS (total dissolved solids)
- Turbidity
- Algae and Chlorophyll
- Zooplankton
- **BOD** (biochemical oxygen demand\*)
- COD (chemical oxygen demand\*)
- **VSS** (volatile suspended solids)

\*When waste, industrial effluent and/or recycled waters are used.

All the above parameters are essential for a correct analysis.

In some cases, additional parameters will be needed in order to complete the correct interpretation of the water quality, for example: dissolved oxygen, redox, etc.

If in doubt, consult the Netafim<sup>™</sup> laboratory regarding water quality.

- 7. Taking a sample from the end of a dripline:
  - ✓ Wait until the pressure has stabilized.
  - Open the end of the dripline and let water flow for 2-3 minutes before taking the sample.
- 8. Taking a sample from the head control outlet: To estimate the filtration efficiency, the sample should be taken downstream from the head control outlet, after the system has been working for at least one hour.

## 副 NOTE

Take the samples downstream from the pump, but as close to it as possible.

If the field to be irrigated is located more than 1 km away from the pump, take another sample of water at the head of the plot.

In new irrigation projects, water samples should be taken as close as possible to the planned suction point.

## Sampling drippers

In order to verify the performance of the drippers, sampling of the driplines should be performed.

#### To sample the driplines, perform the following steps:

- Cut a 20 cm dripline sample from the 4<sup>th</sup> and 5<sup>th</sup> driplines at the beginning and at the end of the dripline.
- The driplines to be sampled are those located in the 4<sup>th</sup> and 5<sup>th</sup> places at the beginning and the end of the plot.
- Each sample must be comprised of: the dripper and at least 10 cm of the tube on either side of the dripper.
- Wrap the 16 samples firmly with wet paper and put them in a plastic bag.
- Send the samples to Netafim<sup>™</sup> for analysis.
- Repair the driplines in the field.
- When the area is composed of several plots, take the samples from one representative plot.



If a different sampling procedure is used, it is very important to describe the process used, and attach this description to the samples.

## 

These instructions are suitable both for integral drippers and for on line drippers. When taking samples of on line drippers, they should be sent together with a pipe sample of at least 20 cm, in the same way as done for integral drippers.

# PEST CONTROL

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## **Rodent control**

Unmanaged populations of rodents in agricultural fields can cause significant damage and loss of productivity in a wide range of crops.

A wide variety of rodents may inhabit agricultural lands, including:

#### ✓ Voles ✓ Mice ✓ Rats ✓ Ground squirrels ✓ Gophers

Small rodents such as mice and voles damage young and older trees alike in nurseries and orchards by girdling the tender saplings and branches. Studies in New York have shown up to a 66% reduction in apple yields as a result of girdling by an overpopulation of voles.

In field crops, these small mammals love to unearth and devour newly planted seeds and snack on the young seedlings that survive.

Larger rodents such as pocket gophers damage field crops by eating the root system out from under the plant.

Rodents can also cause damage to farm equipment and infrastructure. They may gnaw on small-diameter cables and irrigation pipes.

The mounds created by larger rodents can damage or disrupt harvesting equipment, while the tunnels can cause leaks in irrigation channels and even small earthen dams.

In general, rodents responsible for the majority of damage to agricultural crops and systems live underground for at least part of their lives. A physiological feature of rodents is that their teeth grow continuously. As a result, these animals must chew to wear down their teeth so that they fit in their mouth; otherwise the animal will starve. Both the feeding and the need to gnaw cause damage to crops and equipment.

There is no single, simple method for managing rodent overpopulation on agricultural lands. Control of these potential pests requires a well-designed plan that is executed on a consistent basis.

The formation of a systematic plan for managing rodents in subsurface drip irrigated fields requires research into the predominant species in the region and formulation of rules regulating how these populations may be managed. The aim of this chapter is to outline the components of a well-designed rodent control plan, and to help growers formulate such a plan.

#### Rodent management plan

Management of rodent populations on agricultural land generally falls into the following categories:

- Habitat modification and exclusion to reduce population pressure.
- Trapping and removal.
- ✓ Use of repellants to deter invasion.
- ✓ Use of repellants to deter gnawing.
- Extermination.

Each category is discussed with respect to protecting crops and equipment.

#### Habitat modification to reduce rodent pressures

Existing rodent pressures either from surrounding fields or within a newly planted field are the first source of conflict between rodents, crop, and equipment.

A cultivated zone surrounded by unkempt ground or by open fields infested with rodents represents a continuous battle. Thus, the first step in an integrated rodent management program is to reduce the pressure of high rodent populations in the entire area.

First take a visual count of rodent presence in the surrounding fields. Large rodents such as pocket gophers will leave tell-tale mounds. Smaller animals such as mice and voles will not be as obvious. The presence of "runways" in grassy areas is one sign of small rodent activity.

Assessing the rodent population in the general area will provide an indication of the intensity of the management required to protect the crop and the irrigation system.

After assessing the situation, establish a buffer zone around the field. Elimination of weeds, ground cover and litter around the field will reduce habitat suitability. Cultivating this area is a good deterrent for small rodents as it destroys runways and may eliminate them outright.

Larger animals such as pocket gophers can burrow under this area, but the lack of food may slow them down.

If cultivation is not an option, weed control is still imperative especially for pocket gopher management. Weeds often have large tap roots which are the preferred food for gophers, while fibrous rooted grasses are less appealing. The opposite is true for smaller rodents, which enjoy the cover that grasses provide. Thus, in fields of corn, which has a fibrous root structure, the main rodent pressure may be mice and other small rodents.

#### **Trapping and removal**

Trapping can be an effective method to reduce the population of large rodents such as pocket gophers in small to medium-sized fields (< 20 hectares).

Trapping is also effective to clean up remaining animals after a poison control program. In the case of smaller rodents such as mice, trapping is not usually cost effective because these animals have such rapid reproduction rates.

Body-gripping traps work exceptionally well for capturing pocket gophers. Traps can be set in the main tunnel or in a dripline, preferably near the freshest mound. Consult a specific pocket gopher control guide for details on how and where to set these traps.

Gophers usually visit traps within a few hours of setting, so newly placed traps should be checked twice daily. If a trap has not been visited within 48 hours, move it to a new location.

Trapping is usually most effective in the spring and fall, when the gophers are actively building mounds.

#### Repellants

Rodent repellants can be divided into two large categories, those that affect the population at large and those that repel the rodent from gnawing on cables or small-diameter tubing such as a dripline.

Two repellants that have proven effective in reducing rodent populations over a large area are owl boxes and wet soil.

Owl boxes are being employed in greater numbers as part of rodent management programs. The principle is simple: the higher the owl population, the fewer the rodents. The application of owl boxes to deter rodents is becoming more prevalent. This technique works especially well for small-bodied rodents such as mice but also affects larger rodents because owls prey on the young. Consult the local extermination service for the design and placement of owl boxes appropriate for the area.

Wet soil, but not flooded, can be an effective deterrent for rodents that spend much of their time in tunnels. The repellant effect of wet soil seems to be the result of poor oxygen transfer through it. Rodents that live in tunnels depend upon the air traveling through the soil for oxygen. In wet soils, the rate of oxygen diffusion is greatly reduced and produces an environment that is inhospitable to the rodents.

Flooding the soil to drown the rodents is not as effective. The rodents are mobile enough to avoid drowning, and most have tunnels designed to avoid the wettest areas in the field in the case of heavy rains.

The soil need not be saturated to affect the population. In practice, the use of soil wetness to repel rodents is limited because many crops require soil drying before harvest and because the irrigation system is turned off for a period of time.

Other general repellants are less effective in rodent management over a large area.

Sound or ultrasound generators have not been proven effective in driving out rodents.

Taste repellants such as capsicum may affect some rodents such as voles, but have less effect on pocket gophers.

Targeted repellants applied on or around the object to be protected, such as a sapling, cable or dripline, may be effective when combined with a plan to reduce overall populations.

Proper dripline installation practices can reduce rodent damage, particularly by mice. When inserting thin-walled driplines in deep installations, the insertion shank can leave cracks in the soil and a path down to the dripline that mice love to follow, chewing as they go. Best installation practices dictate that these installation cracks in the soil be sealed by running a tractor tire over cracks created by the plow. This will close the opening in the soil and cut off easy access by mice or voles to the loose soil around the dripline.

#### Preventive installation procedures

The following installation procedures can significantly reduce potential rodent damage to subsurface driplines. It is highly recommended that all these procedures be followed:

- Prepare a buffer zone around the field and apply rodenticides according to a plan drawn up with the local extension agent if rodent pressures are high.
- Have the field as free of crop residue as possible. Field mice are especially fond of plant residues.
- Insert driplines as deep as practical for the crop being grown. Driplines inserted at depths greater than 30 cm exhibit less rodent damage.
- Apply a repellant or toxicant when inserting the dripline.
- Seal the slit made by the shank by using front tractor tires to reduce ready-made paths for small rodents. The front tires should be narrow, single-ribbed, cultivating tires and the front of the tractor must be weighted. This operation must be completed on the same day as the dripline insertion.
- Operate the irrigation system for 12 hours per zone within two weeks of completing the installation.
  Do not reach a situation where the driplines are inserted in the fall and the first irrigation is performed in the spring.

Rodents, especially pocket gophers, are often most active in the fall and early spring. It is often at these times, when the irrigation system is not being used, that the most damage occurs. Experience has shown that rodent damage when the system is shut down can be reduced by properly applying an acid treatment. As acidification of the dripline is standard practice for end-of-season cleaning, a slight modification of this process may also help to protect driplines from rodent damage.

#### Follow these guidelines:

Flush each zone at the recommended pressure.

If the field is dry, pre-irrigate each zone for 6 hours.

 Inject N-pHuric\* at 200 ppm for 1 hour before shutting down each zone. Shut down zones leaving N-pHuric in the lines.

\*N-pHURIC combines the benefits of both urea and sulfuric acid while virtually eliminating the undesirable characteristics of using sulfuric acid alone.

Chemigating with a properly labeled pesticide that has a strong odor or fumigation effect will cause many rodents to keep away from subsurface driplines.

This may be an effective technique for early season deterrence.

Make sure the pesticide is properly labeled for use in the area.

#### Extermination

Several rodenticides, including toxicants and anticoagulants, are in current use for managing rodent populations.

#### 

Consult the local authority for approved rodenticides - toxicants and anticoagulants - in the country/area and always follow the application directions.

In general, placing approved baits around the perimeter of the field prior to irrigation system installation will reduce rodent pressures on a new field.

For pocket gophers, a mechanical "burrow builder" that releases bait is effective in perimeter applications. Hand baiting tunnels is time consuming but effective if done by a trained applicator.

The usual treatment for gophers is bait plowed in every other furrow and around the perimeter of the field. Fumigants applied in the tunnels are usually not as effective as toxicants and trapping because they tend to diffuse, giving the gopher enough time to escape.

#### Rodent management action plan

An integrated approach must be taken to reduce rodent damage to crops and equipment. This plan must involve reducing acceptable habitats for rodents close to the field and may involve trapping or poisoning to control active populations. In addition, the dripline itself can be protected by using the repellant effect of some pesticides and slightly acidifying the soil around the driplines.

Fall and spring are the seasons when rodents are most active and may cause the most damage. Therefore, any management program must focus on these seasons. Do not underestimate the wealth of reference materials and the help of local extension agents and pest control specialists. Many growers have implemented successful plans for rodent management on their fields, protecting the investment in their irrigation system and improving yields.

To be effective, any rodent control plan must be diligent and consistent in a timeframe determined by the extent of the rodent pressure in the surrounding area.

## Insect control

# A warning and disclaimer

- 1. Read the label Always observe the pesticide manufacturer's registration label and Instructions and be aware of the regulations issued by the relevant local regulatory authority. Use the pesticide only as permitted under its label. The use of the pesticide is under your sole resonsability.
- 2. Netafim<sup>™</sup> shall not be liable for any damage or loss cuased to you or to any third party resulting from the use of a pestecide or any other substance streamed via the drip system.
- 3. In no event shall Netafim<sup>™</sup> be liable to supplier or to any other person or entity under any equity, common law, tort, contract, estoppel, negligence, strict liability, or other theory, for any special, indirect, incidental, punitive, consequential or contingent damages, or any damages resulting from loss of sale, business, profits, data, opportunity or goodwill, even if netafim has been advised or knew or should have known of the possibility of such damages.
- 4. You shall defend, indemnify and hold harmless Netafim<sup>™</sup> (and its officers, directors agents, representatives and affiliates) from and against any and all claims, suits, losses, penalties, damages (whether actual, punitive, consequential or otherwise) and associated costs and expenses (including attorney's fees, expert's fees, and costs of investigation) and all liabilities that are caused in whole or in part byany actual or alleged infringement of any pesticide manufacturers or distributor label or of any law, regulation or registration.
- Most pesticides are comprised of an active substance and an emulsifier. They are usually marketed in the form of powder, grains, or liquid.
- Pesticides in the form of powder or grains are banned for use through drip irrigation systems because they do not dissolve efficiently in the irrigation water. Their use does not allow determination of the exact concentration of active substance in the solution, and in addition, the active substance may damage the drippers' diaphragm and even clog the drippers.
- Insect treatment products are to be applied externally, by scattering or spattering them on the ground and insects' nests.
- These products are to be applied only if approved for the use described in this manual, as approved and only in the concentration indicated by the producer.
- There are several active substances that are suitable for insect treatment: Diazinon, Chlorpiryfos, Fipronil, Buprofezin, Cypermethrin, Imidacloprid (against termites), etc.
- If products in emulsion liquid form, such as the Chlorpiryfos and Buprofezin, are to be used through a drip irrigation system, the product must be injected at a maximum concentration of 0.1% to prevent damage to PC dripper diaphragms and other accessories of the system.
- The manner of application and the product quantity will be as recommended by the manufacturer, and the mother-solution should be applied as to allow a concentration of no more than 0.1% of the active substance in the irrigation water.
- In PC systems, in case the manufacturer recommends concentration of less than 0.1%, follow the manufacture recommendation, however, in case the manufacturer recommends more than 0.1% concentration, do not exceed 0.1% as this might be harmful for the membranes in PC driplines.
- It is necessary to continue irrigating with plain irrigation water for the time necessary to flush the entire quantity of the injected product out of the irrigation system and ensure it exited from the lines/pipes (this depends on the system size).
- In CNL systems, open the end of the driplines for flushing the system after completing the plain water irrigation cycle..

## Root intrusion prevention in sub surface drip irrigation (SDI) systems

Plant roots can penetrate the drippers, causing a reduction in the flow rate and possibly an obstruction. This is known as root intrusion.

The intrusion of roots may occur when the plant suffers water stress and the roots are searching for moisture.

Maintaining proper humidity in the surroundings by means of adequate irrigation planning allows the roots to spread and use the entire available moistened soil volume, instead of concentrating around the dripper. Continuous soil humidity monitoring allows better control over the moistening pattern, thus maintaining optimal soil humidity within the dripper's surroundings.

#### Water stress may be:

- Planned at the farmer's discretion.
- Caused by a lack of water or a faulty water supply.
- Due to an unforeseen increase in water consumption by the crop (example: a few consecutive days of unexpected exceptionally high temperatures, without proper irrigation to compensate for the higher water consumption during those days).

#### Chemigation for the prevention of root intrusion

Injection of herbicides is useful for the prevention of root intrusion. There are a number of commercial products available for this purpose.



Consult the local authority for approved herbicides in the country/area and always follow the application directions.

For detailed instructions for the implementation of effective root intrusion prevention, see the Netafim<sup>™</sup> Maintenace Handbook.

## Contamination from external particles in SDI

In rainy periods, when the soil becomes oversaturated due to rain and the sub surface driplines are empty, water may flow in the opposite direction, from the soil to the drippers' outlet, bringing soil particles with it. Under these circumstances, the dripline act as draining tubes. The small particles of soil that are carried towards the drippers may, if they are allowed to dry, eventually clog them.

Introducing a short irrigation cycle soon after the rain ends will help flush the small particles from the drippers and prevent clogging.

When there is a very intense and long rainy period, it is recommended to flush the driplines prior to the beginning of the next irrigation season.

If these conditions are foreseen, using anti-siphon (AS) drippers is recommended.

In drip irrigation systems not equipped with anti-siphon drippers, activating the system for a period of 10 minutes (after pressurizing) is recommended, in order to flush out the accumulated dirt particles.

For further information, see the Netafim<sup>™</sup> Maintenace Handbook.

## Periods of system inactivity

#### Winterization of the system

Winterizing the system is necessary in climates where water may freeze and expand, possibly damaging plastic and metal system components.

Water from filters, valves, chemigation equipment, pressure regulators and sub surface pipes should be emptied, especially at lower ends of the field where water typically accumulates.

Polyethylene driplines are not subject to damage from freezing since drippers provide drainage points and polyethylene is somewhat flexible.

#### Prior to a winter shut-down period:

Perform chemical injection, flushing of all pipes and driplines, and cleaning of the filters.

Empty filters, valves, chemigation equipment, pressure regulators and sub surface pipes.



Pressure regulators and sub surface pipes. can be easily and efficiently emptied using a blower or an air compressor providing high flow rate and low pressure.

An adapter is required, consisting of the following parts:

- ✓ 3/4" Brauckman pressure regulator.
- ✓ Galvanized conical connector 3/4".
- ✓ 1/2"F 3/4"M brass coated bushing.
- ✓ 10 cm galvanized 1/2" pipe.
- Stainless steel band clamp.
- ✓ 3/4" transparent pipe (12 m).
- ✓ 1/4" F \*1/2"M brass coated bushing.
- ✓ Pressure gauge 250 GLZ 6 bar 1/4" BSP.
- $\checkmark$  3/4" ball valve with long handle.
- Suitable connector.

For full assembly and operation instructions consult Netafim's irrigation products department.

#### System startup procedures

Startup procedures after a period of inactivity are similar to those performed after system installation.

In summary, the system should be carefully pressurized and inspected for leaks and system integrity. This includes verifying the functionality of all system components including filters, valves, controllers, chemigation equipment, flow meters, pressure gauges, pressure regulators and flush valves.

Once the system is operational, chemicals should be injected if necessary, and then the system should be thoroughly flushed.

Baseline readings should then be recorded and compared with benchmark data, and adjustments made if needed.



# / WATER/SOIL/PLANT RELATIONSHIP

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# / Water/soil/plant relationship

The aim of this chapter is to provide vital information concerning the soil condition, the water availability and the needs of the crop, and guidelines for planning and management of a drip irrigation system.

### Soil

Soil characteristics influence the choice of crop and variety to be grown, and the planning of irrigation and Nutrigation<sup>™</sup>.

#### Soil composition

In general, soil is composed of three components: sand, silt and clay. The relative amount of these components affects the soil's texture, influencing its water retention rate.

In most soil types the particles form bigger units, known as aggregates. Aggregates stick together and form clods. Between the particles, aggregates and clods there are pores.



#### Soil texture

The distribution of pores in the soil is important. Pores are characterized by two sizes: small and big. Small pores are known as "capillary pores". In sandy soil the porosity is permanent and stabilized. In heavy soil the porosity changes depending on changes in the moisture of the soil.

Water retention is affected by the soil texture and type. For example, 15% moisture volume in a light soil will be adequate for crops to flourish, whereas the same percentage in a medium soil would be borderline and in a heavy soil it would not sufficient for plant survival.

The water is trapped in the pores and accumulates as a thin liquid layer around the soil particles. When the soil dries out as a result of percolation, evaporation and root uptake, the water is first extracted from the large pores, while still clinging to the small ones. When the plant needs water, it draws it from the pores starting with the larger ones first.

The mechanism of water retention around soil particles is based on the retention on the surface area of these particles. Sand, silt and clay particles build up and form aggregates, known as the soil structure. Well-structured soils have more pores and retain more water than compact soils.

Silty soils have high water retention rates (they consist of very small particles and display a large surface area). Light soils have low retention rates (they consist of larger particles and display a smaller surface area).

#### Soil texture affects irrigation scheduling in two important ways:

- It determines how quickly the soil accepts water, and it should be known prior to design of a drip irrigation system since it influences dripper flow rate and spacing.
- It determines how much water the root zone water reservoir holds, and how much of that water is available to the plant.

#### Soil water content

The relationship between water/soil/plant is important to understand. The following three states have an enormous impact on the crop.

#### Saturation

Occurs when all pores in the soil are filled with water.

#### **Field capacity**

Occurs when the maximum amount of water that the field can hold is reached. As percolation proceeds, the soil reaches the point where it does not lose any more water. This is the optimal condition for crop development, as the water is held at a force that is easily overcome by the uptake power of the roots, and at the same time the soil is sufficiently ventilated to enable the roots to breathe.

#### Wilting point

The state of the water in the soil that defines the point at which the plant no longer has the ability to absorb water from the soil. Beyond the wilting point, the plant cannot survive and crop wilting is irreversible.



#### Water availability

Water availability is the difference between field capacity and the wilting point. Field capacity is defined as the state at which the field has reached the point at which the maximum amount of water can be held. The wilting point is defined as the state at which the field contains the minimum amount of water required for a plant to survive.



\*In a saturated field, much of the water is lost to gravity and cannot be used for plant growth.

#### Soil salinity

The higher the concentration of salts in the soil solution, the greater the electrical current that can be passed through it. Therefore, the electrical conductivity (EC) of the saturation extract is used as an indicator of soil salinity.

Rates of soil classification in terms of salinity and levels considered critical to assess tolerance of cultures to excess salts are based on the electrical conductivity of the saturation extract (ECe) at 25°C (77°F).

In the past, the unit used to measure the EC was mmhos/cm (milimohs per centimeter), but today the unit used is dS/m (deciSiemens per meter).

#### 0 Decrease in crop yield (%) 10 20 30 40 50 60 70 80 90 100 2 8 10 12 0 4 6 14 16 18 20 ECe (dS/m)

# The decrease in crop yield varies with the level of soil salinity

#### 1dS/m = 1mmhos/c = 1 mS/cm = 100 mS/m.

High soil salinity is typical of low rainfall level.

#### Soil pH

The soil pH is a measure of the acidity or basicity (alkalinity) in soils. pH is defined as the negative logarithm (base 10) of the activity of hydronium ions (H+ or, more precisely,  $H_3O$ +aq) in a solution.

In water, it normally ranges from 1 to 14, with 7 being neutral. A pH below 7 is acidic and above 7 is basic.

Soil pH is considered a master variable in soils as it controls many chemical processes that take place. It specifically affects plant nutrient availability by controlling the chemical forms of the nutrient. The optimum pH range for most

#### The influence of soil pH on nutrient availability\*

Range of acidity/alkalinity (pH)



\*Not applicable for soilless.

plants is between 5.5 and 7.0; however many plants have adapted and thrive at pH values outside this range.

#### Soil requirement

A well drained, deep, loamy soil having adequate aeration (10 to 12%) with a ground water table below 1.5 to 2.0 m from soil surface, a bulk density of 1.4 g/cm<sup>3</sup> and an available water holding capacity of 15% (15 cm of water per meter depth of soil) or more is considered optimal.

Chemical constraints in the soils, such as acidity and low fertility, are relatively easy to correct or control by means of the precise nutrients and acid injection option offered by the drip irrigation system.

Although poor physical properties of soil are more difficult to ameliorate, and are widely accepted as a limiting factor in crop growth, drip irrigation is able to counter them by means of precise control of irrigation quantification, frequency and scheduling.

#### Soil analysis

A soil analysis is necessary in order to prescribe an appropriate irrigation and Nutrigation<sup>™</sup> plan, to determine the dripline characteristics (dripper spacing and flow rate) and the proper spacing of the driplines in the field.

#### **Required tools:**

- ✓ 2 (two) 10 liters (2.5 gallons) buckets.
- A hoe/shovel.
- ✓ A soil drill.

#### Taking a soil sample:

- ❷ Walking along the field's diagonal, take soil samples every 50-100 meters, depending on the field's size.
- 2 samples are to be taken at each sampling point:
  - at a depth of 0-30 cm (0-1 foot) and at a depth of 30-60 cm (1-2 feet).
- Put all the shallow-taken samples in one bucket and all the deep-taken samples in the other.
- Thoroughly mix the content of each bucket.
- Take 1.5 kg (3 pounds) of the mixture from each bucket, and put these in sealed plastic bags.
- Mark the 2 bags with the necessary identifying data and the depth of sampling.
- Mark the required parameters to be analyzed in the accompanying document.
- Send the samples to a laboratory certified by the local relevant authority.

#### The mandatory parameters to analyze:

- Soil mechanical composition
- EC and pH
- NPK
- 🗸 Ca
- ✓ Mg

Many other parameters can be analyzed at the grower's request (consult an agronomist).

#### Soil survey

In new projects a soil survey is also necessary. It is important for the understanding of the soil's water holding capacity and of water percolation in the soil.

#### The soil survey consists of:

- Digging pits with a backhoe in selected locations in the field, depending on the field's size and the varying characteristics of the soil.
- The pits should be dug so that they expose the soil cross-section, revealing the various soil layers, generally to a depth of 2 meters (7 feet) depending on the crop to be grown.
- 3 soil samples are taken from each pit shallow, middle and deep. Each sample is packed separately and identified.
- The samples are sent to a certified laboratory for analysis.

For full details consult a Netafim<sup>™</sup> expert.

## Water budgeting

Calculate the daily water ration to be returned to the crop by tracking daily additions and losses of water and balancing them. The losses are due to crop water use and leach (percolation) requirements. The additions are due to irrigation and rainfall.

The objective of water budgeting is to maintain soil moisture near the optimum level by keeping track of crop water use and then irrigating to replace the water used. Knowledge of crop water use is essential to water budgeting (see Calculating the Daily Water Requirement, page 54).

Crop water use is also called the evapotranspiration rate (EVT). The term evapotranspiration refers to the combined loss of water through evaporation from the soil and from water taken up and evaporated from the plants (transpiration). The rate at which plants use water is determined by the growth stage of the plant and the weather. Plants generally use more water the hotter or dryer the conditions are. Wind and clouds also affect the evaporation rate.

The water budgeting method for irrigation is relatively straightforward, but must be adjusted for crop growth stage and environmental conditions such as rain.

To effectively plan irrigation, growers need to account for crop water use measured as evapotranspiration (EVTc). Daily crop water requirements (EVTc) are calculated by multiplying the reference crop evapotranspiration (EVTo) at each stage of development by the crop coefficient (Kc).

The reference evapotranspiration rate (EVTo) can be calculated from weather data or measured as evaporation from a calibrated pan of water. Both methods give a close approximation of the environmentally induced evaporation rate from a given area of soil. Real pan evaporators are still used in many parts of the globe. However, in recent years the EVTo is increasingly estimated based on weather data, which includes temperature, relative humidity, wind velocity and solar radiation using the Penman-Montieth equation, which relates these variables to evaporation rate.

Actual crop water usage is usually not exactly the same as the reference evapotranspiration rate (EVTo). First, plants regulate the quantity of water they require by closing or opening stomata (small pores in their leaves used to maintain appropriate water levels in the plant). The difference between the actual peak crop water use and the pan evaporation rate is referred to as the crop coefficient (Kc). The EVT of the crop expressed as EVTc can be calculated from the EVTo using the following formula.

#### EVTc = EVTo \* Kc

#### Calculation of the required irrigation time according to reference evapotranspiration:

## EXAMPLE

The crop coefficient (Kc) is 0.8. If the EVTo, either measured by means of an evaporation pan or calculated with the Penman-Monteith equation, is 7.5 mm/day, then the crop will be using:

#### EVTc = 7.5 \* 0.8 = 6 mm/day



#### Daily water usage of 4 crops per crop development stage over a growing season



#### **Evaporation pan**

An evaporation pan is used to hold water for observations aimed at determining the quantity of evaporation at a given location. Such pans are of varying sizes and shapes, the most commonly used being circular. The best known of the pans is the "Class A" evaporation pan. Often the evaporation pans are automated with water level sensors and a small weather station is located nearby.



A cylinder with a diameter of 47.5 in (120.7 cm) and a depth of 10 in (25 cm). The pan rests on a carefully leveled, wooden base and is often enclosed by a chain link fence to prevent animals drinking from it.

Evaporation is measured daily at the same time as the depth of water evaporated from the pan. The measurement day begins with the pan filled to exactly 2 in (5 cm) from the pan top. 24 hours later, the amount of water needed to refill the pan to exactly 5 cm (2 in) from its top is measured.

If precipitation occurs in the 24-hour period, it is taken into account in calculating the daily evaporation.

If the precipitation that occurred is greater than the pan capacity, the excess water should be emptied and the level of water in the pan should be reset to enable measurement in the next 24 hours.

The Class A Evaporation Pan is not usable on days with rainfall events of more than the pan capacity. Evaporation cannot be measured in a Class A pan when the pan's water surface is frozen.

#### The Penman-Monteith equation

The Penman-Monteith equation (after Howard Penman and John Monteith) predicts net evapotranspiration (EVT), requiring as input: daily mean temperature, wind speed, relative humidity and solar radiation.

The Penman-Monteith equation is increasingly common as evaporation evaluation method nowadays, also due to the use of meteorological stations in agricultural projects.

The United Nations Food and Agriculture Organization (FAO) standard methods for modeling evapotranspiration use the Penman-Monteith equation.

#### Glossary

**Crop coefficient (Kc):** The ratio of evapotranspiration (EVT) to reference evapotranspiration (EVTo) for a given crop when growing in large fields under optimum growing conditions.

**Pan coefficient (kp):** The ratio of reference evapotranspiration (EVTo) to pan evaporation (Eo) for the same period.

**Pan evaporation (Eo):** The depth of water that evaporates from an evaporation pan during a certain period in mm/day or mm/month.

#### The relation between pan evaporation and calculated evaporation

It is important to understand that there are differences in the values obtained by the two methods of evaporation evaluation, and thus the crop coefficient (Kc) will vary according to the method used for evaporation evaluation.

However, assuming the quantity of water needed by the plant on any day is the same, it is necessary to find a ratio between the two methods in order to calculate correct quantities of water.

Namely, if the evaporation is established by the Penman–Monteith calculation method, the Irrigation Crop coefficient (Kc) should be in accordance with the evaporation calculation method (Penman–Monteith).

The crop coefficient (Kc) obtained with the Class A pan evaporation method is different from the Kc obtained when using the Penman-Monteith calculation method.

## EXAMPLE

In order to determine the new coefficients, data of the two methods were continuously gathered from 18 meteorological stations during 5 to 10 years (2000-2009).

Generally, the evaporation values obtained with the Penman-Monteith method are lower than the values derived with the Class A pan evaporation method, but the data behavior differs from one region to another.

Ratio of evaporation value - Class A pan evaporation / Penman-Monteith calculated evaporation (1/x) in the same area throughout the year:

#### Ratio of evaporation value

Class A pan evaporation/Penman-Monteith calculated evaporation (1/x) in the same area throughout the year:

The values of the evaporation ratios of the two methods must be calculated for each area separately. It is not advisable to use values taken in different areas because the values differ from one area to another and change during the year in the same area.

Loo	cation	June	July	August
А		0.60	0.58	0.59
В		0.77	0.76	0.76
С		0.89	0.90	0.89

#### **Calculation:**

- Class A pan evaporation = EVTo pan Class A
- Evaporation according to Penman-Monteith = Kc A

If the quantity of water the crop requires is the same, the following ratio is obtained:

#### EVTo pan Class A \* Kc A = EVTo Penman-Monteith \* Kc Penman-Monteith

Consequently, the following ratio may be inscribed:

EVTo PnMo	_	Kc A
EVTo A		KcPnMo

And according to the table above, the ratio EVToPM / EVTo A is always lower than one (1).

The following table shows that if the irrigation coefficient according to Class A pan evaporation (Kc A) and the calculated evaporation (EVTo Penman-Monteith) are available, it is possible to use the ratio between calculated evapotranspiration and pan evapotranspiration (EVTo PM / EVTo A) to calculate the value of the crop coefficient (Kc) according to Penman-Monteith and to calculate the quantity of irrigation water.

# Example

Finding the crop coefficient (Kc) according to Penman-Monteith and the quantity of irrigation water (mm/day) where the values for pan evaporation coefficient (Kc A), calculated evapotranspiration (EVTo Penman-Monteith) and evapotranspiration ratio are given.

Atribute	Description	Value		
		June	July	August
Pan evapotranspiration coefficient	КсА	0.25	0.25	0.30
Calculated evapotranspiration	EVTo Penman-Monteith (mm/day)	6.0	6.0	5.4
Evapotranspiration ratio	EVTo Penman-Monteith / EVTo Pan Class A	0.65	0.69	0.68
Penman-Monteith evapotranspiration coefficient	Kc Penman-Monteith = Kc A / (EVTo Penman-Monteith / EVTo Pan Class A)	0.385	0.362	0.441
Total irrigation water (mm/day)	X mm/day = EVTo Penman-Monteith X Kc Penman-Monteith	2.31	2.17	2.38

The above is just an example. There is not only one Kc value for each crop in each area, many factors can influence this value, the specific Kc value should be based on data from a local meteorological station.

#### Summary

If evaporation data are used for the calculation of the irrigation water consumption of a specific crop, on a particular day or over a certain period of time, the data-obtaining method has to be known, and the appropriate crop coefficient (Kc) to be used is to be selected accordingly.

If ratio values between Class A pan evaporation (Kc A) and calculated evapotranspiration (EVTo Penman-Monteith) are to be calculated, local or zonal values must be used.

## Tensiometers

When buried in the soil, the ceramic tip of the tensiometer allows water to move freely in or out of the tube. As the soil dries, water is sucked out through the porous ceramic tip, creating a partial vacuum inside the tensiometer which is read on the vacuum gauge. When the soil is wetted by sufficient rainfall or irrigation, water flows back into the tensiometer, the vacuum decreases and the gauge reading is lowered.

## 

Tensiometers do not operate in dry soil because the pores in the ceramic tip drain and air is sucked in through them, breaking the vacuum seal between the soil and the gauge on top of the tensiometer.

#### What do the tensiometer readings mean?

Vacuum gauges are normally calibrated in kilopascals (from 0 to -100 kPa). Tensiometers operate successfully up to approximately -75 kPa. A reading of 0 kPa indicates saturated soil in which plants will suffer from lack of oxygen. Optimum plant growth occurs when the soil is kept wetter than:

- ✓ -15 to -25 kPa for coarse textured soils (sands).
- •20 to -30 kPa for medium-textured and heavy-textured soils.

Readings in excess of -70 kPa indicate that the soil is dry enough to reduce growth.

In most situations two sites will be needed for each major species or variety and soil type in the field or the orchard. Avoid high or low sites, zones of poor water infiltration, and sites not representing the entirety of the field or the orchard.



All tensiometers must be marked clearly to avoid damage from traffic, workers and cultivation.

#### Irrigation timing with tensiometers

Tensiometers placed at about the mid-point of the main fibrous root system are used to determine when to irrigate. This is particularly important during the period when the water requirement of the tree (or crop) is highest and yields are most sensitive to water shortage. During this period tensiometers should be read daily. Tensiometer readings indicate how hard the plant/tree is working to extract moisture. Following irrigation the tensiometer's reading will be lower. Daily readings should continue to determine when irrigation is required again.

For tensiometer description see page 43.

## Unit conversion tables

DISTANCE			
1 kilometer (km)	= 0.621 mile (mi)	1 mile (mi)	= 1.609 kilometers (km) = 1609.344 meters (m)
1 meter (m)	= 3.281 feet (ft)	1 foot (ft)	= 0.305 meter (m)
1 meter (m)	= 39.370 inches (in)	1 inch (in)	= 0.025 meter (m)
1 centimeter (cm)	= 0.394 inch (in)	1 inch (in)	= 2.54 centimeters (cm)

AREA	
1 hectare (ha) = 2.471 acres (ac)	1 acre (ac) = 0.4047 hectare (ha)
1 hectare (ha) = 10,000 square meters (m²)	1 square meter (m²) = 0.0001 hectare (ha)
1 acre (ac) = 4,047 square meters (m²)	1 square meter ( $m^2$ ) = 0.00025 acre (ac)
1 hectare (ha) = 0.004 square mile (mi²)	1 square mile (mi²) = 259 hectares (ha)
1 hectare (ha) = 15 mu	1 mu = 0.0666 hectare (ha)
1 square kilometer (km²) = 0.386 square mile (mi²)	1 square mile (mi²) = 2.59 square kilometers (km²)
1 square centimeter ( $cm^2$ ) = 0.155 square inch (in <sup>2</sup> )	1 square inch (in <sup>2</sup> ) = 6.452 square centimeters (cm <sup>2</sup> )
1 square foot (ft <sup>2</sup> ) = 0.155 square inch (in <sup>2</sup> )	1 square meter (m²) = 10.76 square foot (ft²)

FLOW	
1 cubic meter per hour (m³/h) =	1 gallon (USG) per hour (gph) =
264.1721 gallons (USG) per hour (gph)	0.0038 cubic meter per hour (m³/h)
1 liter per hour (l/h) =	1 gallon (USG) per hour (gph) =
0.2641721 gallon (USG) per hour (gph)	3.785 liters per hour (I/h)

PRESSURE	
1 bar = 14.50377 pounds per square inch (psi)	1 pound per square inch (psi) = 0.06894757 bar
1 bar = 100 kilopascals (kPa)	1 kilopascal (kPa) = 0.01 bar
1 PSI = 6.894757 kilopascals (kPa)	1 kilopascal (kPa) = 0.145 pound per square inch (psi)

VOLUME	
1 gallon (USG) = 3 785 liters (L)	1 liter (L) = 0.264 gallon (USG)

#### WEIGHT

1 kilogram (kg) = 2.205 pounds (lb)

1 pound (lb) = 0.454 kilogram (kg)

TEMPERATURE			POWER						
°Celsius °Fahrenheit			1 kilowatt (kW) = 1.341022 horse power (HP)						
0	=	32	1 kilowatt (kW) = 56.91965 British thermal units per minute (BTU/min)						
5	=	41	1 horse power (HP) = 0.7456999 kilowatt (kW)						
10	=	50							
15	=	59							
20	=	68							
25	=	77							
30	=	86							
35	=	95							

FILTRATION*											
Micron (µm) = size of gaps between fibers	400	250	177	125	105	100	74				
Mesh = number of pores per linear inch	40	60	80	120	140	150	200				

\*The mesh to micron conversion is not a proper mathematical conversion but a commercial approximation.

## Further reading

This appendix provides the reader with links to recommended complementary documents discussing drip irrigation-related subjects at length.

#### Irrigation Systems Maintenance

The implementation of a simple yet strict maintenance program for drip irrigation systems will keep the system operating at peak performance and increase the system's work life expectancy.

This handbook will guide you in determining the correct procedure and its implementation. The best way to determine if your maintenance program is effective is to constantly monitor and record the flow rate and pressures in the system.

#### Sub surface Drip Irrigation (SDI)

SDI manual is an irrigation management tool that enables consistently high yields, better water and fertilizer management and reduced fertilizer and water usage.

This guide describes the specifications, design, installation, operation, and maintenance of an SDI system. It is intended as an aid in the selection of sub surface drip irrigation and the management of the system to obtain the desired results.

#### Driplines, drippers & other emitters - Product catalog

This catalog is an aid to enable to find basic data on each of the drip products within a hand's reach. The catalog describes the main applications of the item displayed, its features and benefits, technical data of drippers and driplines, a table of all active catalog numbers and basic packaging data.

#### Fittings & Accessories - Product Catalog

Netafim<sup>™</sup> Accessories and Fittings Components product families are designed to complement and support efficient and professional utilization of dip irrigation systems.

Netafim<sup>™</sup> accessories are an integral part of the irrigation system. Each component is manufactured under the strictest quality control standards ensuring maximum system performance and reliability.

The catalog presents Netafim's wide variety of Manifolds; Driplines accessories; Holders; Clips; Adaptors and Plugs; Stakes and Spikes; Pressure Regulators; Product Assemblies; Tools.

#### Agro-Machinery - Product Catalog

Netafim<sup>™</sup> offers a wide variety of application tools and auxiliaries designed for simple, rapid and efficient installation and retrieving of driplines avoiding damage to the drippers and maintaining their integrity. The catalog presents Netafim's line of insertion, extraction, laying and retrieval machinery and accessories.

#### **Connectors - Product Catalog**

Netafim<sup>™</sup> comprehensive range of pipe connector systems is made of high resistance and durability polymers. Use the catalog to select the right line for your application: barb connectors, fast ring connectors, Twist Lock connectors and a vast family of start and reducing connectors.

#### Polyethylene Rigid and Flexible Pipes - Product Catalog

For use in agricultural irrigation systems, water delivery systems, sprinkler and micro-sprinkler stands, assembly dripper sets and automation application.

The catalog presents Netafim's range of standard irrigation pipes, tubes and Micro-tubes 3\*5, 4\*6.5, 6\*8, 9\*12 and Micro-tubes 8 mm.



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