DRIP IRRIGATION SYSTEM MAINTENANCE

/ Handbook

2022
v 1.0

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FOREIGN LANGUAGES

In the event that you are reading this manual in a language other than the English language, you acknowledge and agree that the English language version shall prevail in case of inconsistency or contradiction in interpretation or translation.

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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 natural watering by floods or rain.

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

The nature of agricultural water sources, nutrient injection practices, natural limitations of filtration equipment and the general agricultural growing environment make maintenance a priority.

For optimal performance, drip irrigation systems require routine system maintenance. It is imperative to implement all the instructions in this handbook for proper maintenance of the drip irrigation system.

→ Aim of this Document

The purpose of this document is to present a comprehensive approach to the maintenance of a drip irrigation system and to familiarize the reader with the maintenance procedures regarding the various components and functions of the system.

It is intended for farm managers and agricultural and technical personnel.

The importance of thorough knowledge of the subjects discussed in this document for the effective operation and 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™ makes every effort to provide its clients all over the globe with concise, comprehensible documentation in order to facilitate the operation and maintenance of the drip irrigation system while maximizing the ensuing benefits - higher yield of superior quality crops with higher market value and higher ROI.

Netafim's personnel and its representatives and agents around the world should make sure to read and understand this entire document thoroughly prior to advising their clients on issues regarding the operation and maintenance of a Netafim™ drip irrigation system.

It is the responsibility of Netafim's representatives and agents to make sure that, upon delivery of a drip irrigation system, the client is familiar with all the operational and maintenance considerations, as discussed in this document.

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

ATTENTION

This document is not a user manual. For detailed instructions on the operation, maintenance and troubleshooting of the components of the Netafim™ drip irrigation system, refer 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™ 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.

INTRODUCTION

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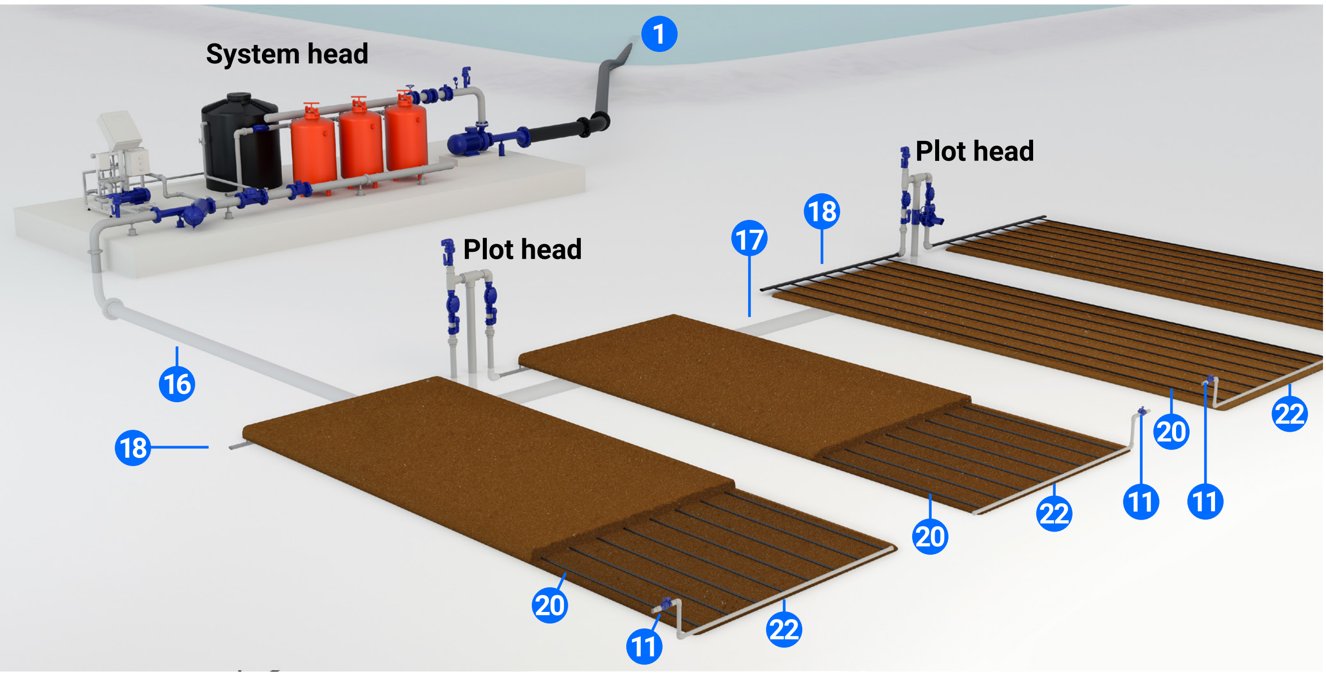
→ Preventive and Corrective Maintenance 10

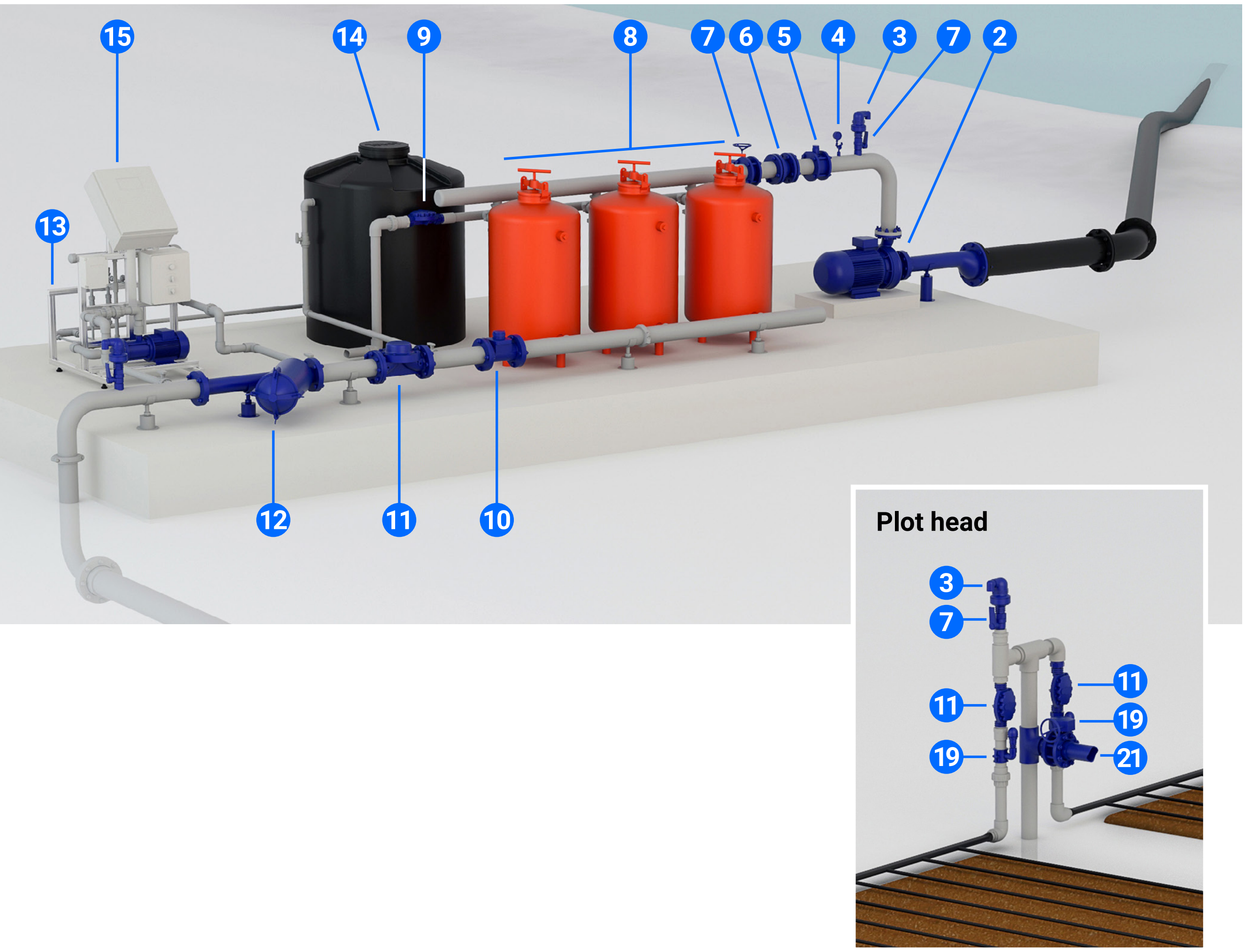
→ Maintenance Timetable 11

→ Structure of the Drip Irrigation System

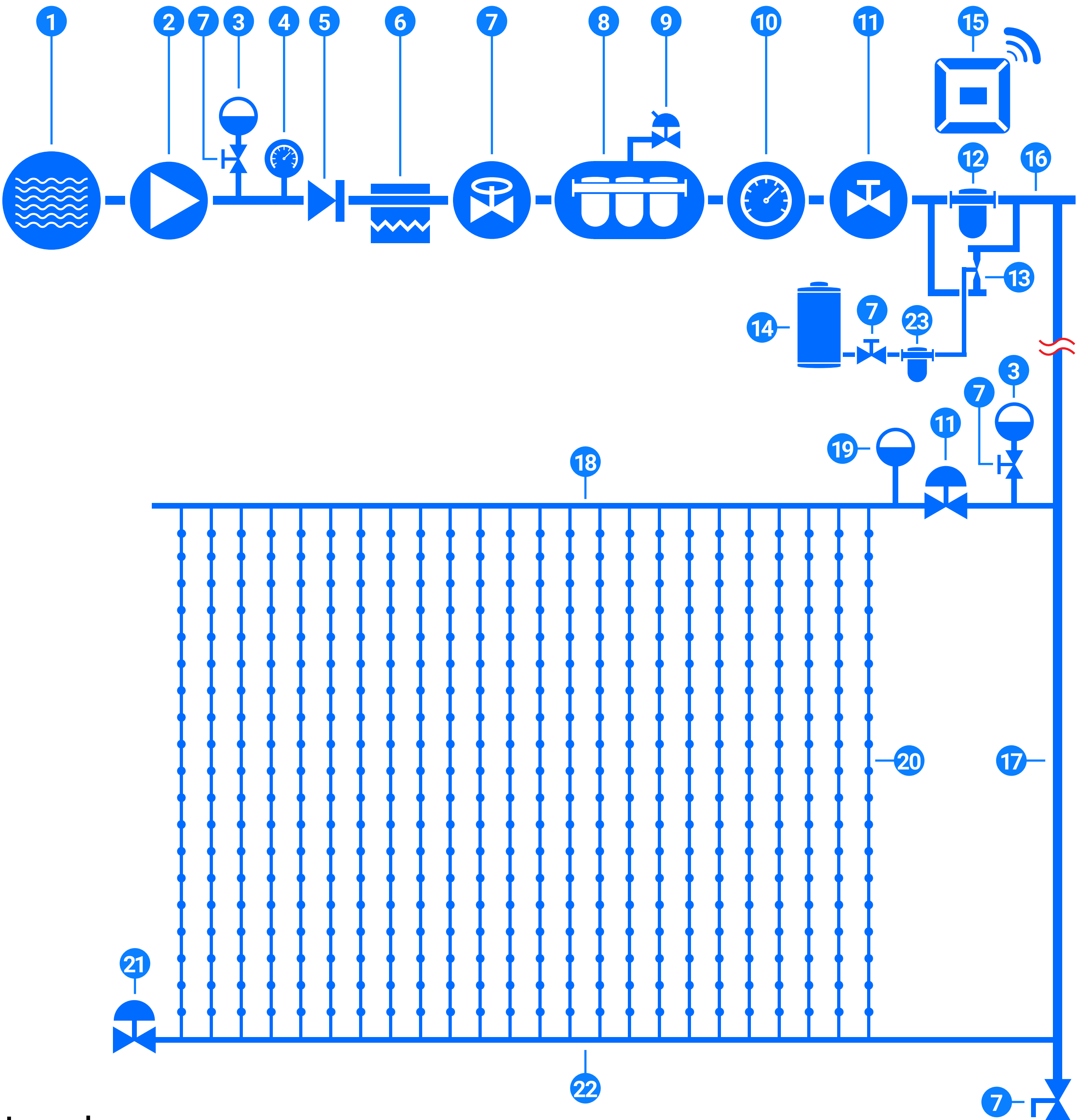
A drip irrigation system is comprised of many components, each of which plays an important part in the operation of the system.



System head



Schematic diagram



Legend

1 Water source
2 Pumping station
3 Air valve
4 Pressure gauge
5 Check valve
6 Shock absorber
7 Manual valve
8 Main filtration unit
9 Main filtration automatic drainage valve
10 Water meter
11 Hydraulic valve
12 Secondary filtration unit
13 Dosing unit
14 Fertilizer tank
15 Irrigation controller
16 Main line
17 Sub-main line
18 Distribution line
19 Kinetic valve (vacuum breaker)
20 Dripline
21 Flushing valve
22 Flushing manifold
23 Fertilizer filter

The implementation of a simple yet strict maintenance program for drip irrigation systems will achieve the following:

- Keep the system operating at peak performance.
- Increase the system's work life expectancy.

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 document.

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.

WARNING

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

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

→ Preventive and Corrective Maintenance

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. For introductory guidance on irrigation scheduling, see the Drip Irrigation Handbook.

- **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, 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 0ºC (32ºF).

REGULAR SYSTEM INSPECTION

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- Inspection of the Filter ... 13
- Inspection of the Valves ... 14
- Inspection of Main, Sub-main, Distribution lines and Flushing Manifolds ... 15
- Inspection of Driplines (Laterals) ... 15

Regular baseline readings and monitoring of flow, pressure and flush water condition will guide your maintenance scheduling.

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

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.

→ Inspection of the Pump

Once a month:

- Visually inspect the pump for integrity and for leaks from its impeller chamber (if applicable), inlet, outlet pipes and accessories.
- Make sure the pump and its immediate environment are clean and free of any unrelated objects that might obstruct proper aeration of the pump's motor or block accessibility for maintenance.
- Check the screen at the pump's inlet for clogging.
- Check for rust on the pump and its accessories.
- Make sure the electrical supply to the pump is properly isolated and protected from moisture.
- Make sure the pump starts smoothly (In the long term, start up vibrations might damage the pump).
- Check that the pump sounds as usual, free of hiss or irregularity that might suggest stress or a mechanical problem within the pump.
- Check the flow rate and the pressure at the pump's outlet and compare the results to the benchmark data (see Hydraulic conditions checklist, page 82).

→ Inspection of the Filter

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).

NOTE
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.

The pressure differential in a filter might be higher than the allowed maximum due to the development of biofilm, scale or mineral sedimentation in the filter.

The pressure differential in a filter might be lower than the allowed minimum due to poor operation and maintenance practices or improper calibration of the automatic flushing control unit.

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.

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
- The filtration unit or medium remains clogged after flushing. - The pressure range is incorrectly set in the controller. - Faults in automation or sensor.	- The filtration unit or medium is breached or leaking. - Faults in automation or sensor. - Mechanical failure.	- Faults in automation or sensor. - Mechanical failure.

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.

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/or cracking** and should be adequately cleaned during the automatic back-flush cycles.

***Caking:** The gravel in the filter sticks together, forming a clod and making water passage through the filter difficult. Check it by inserting a fist (or an object of similar size) into the medium. A good condition medium should be penetrable. If the medium is hard to penetrate, it might be caking.

****Cracking:** Cracks and fissures appear on the medium's surface. Check it visually.

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 and smooth like beach sand. The sharp edges promote better filtration. The gravel/sand will wear smooth over time. If this has occurred, replace the gravel/sand.

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

→ Inspection of the Valves

Once a growing season:

- Visually inspect each valve for integrity and for leaks.
- Activate each valve - manual, hydraulic or electrical - and make sure it opens and closes according to its specific function and purpose.
- Visually inspect air relief valves for dripping that might suggest faulty sealing of the valve mechanism.
- If pressure-regulating valves are installed, check the pressure at the outlet of each one of them and compare it to the benchmark data.
- Make sure the flushing valves installed at the dripline flushing manifold open when dripline flushing is initiated.

→ Inspection of Main, Sub-Main and Distribution Pipes and Flushing Manifolds

- Visually inspect the main, sub-main and distribution pipes and the dripline flushing manifolds for integrity, for leaks and for damage from agricultural machinery or from rodents and pests.

→ Inspection of Driplines (Laterals)

Once a week:

- At the start of the irrigation sequence, when the flow and pressure are stabilized, visually inspect the driplines for integrity and for leaks. (In SDI systems, check for puddles that might suggest the existence of leaks.)
- Check the pressure at the end of the furthest dripline when the flow and pressure are stabilized.
- At the end of the irrigation sequence, visually inspect the wetting pattern on the soil. Dry areas or an uneven pattern might suggest clogging in the dripline.

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. The ends of the driplines should be opened regularly (in extreme cases this might be required as often as each irrigation) and the contents emptied into the hand or a jar for visual inspection of water quality.

Clean water

Degraded water

SYSTEM FLUSHING

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→ Flushing the Driplines (Laterals) 23

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

The system must be flushed at regular intervals. The frequency depends mainly on the water quality and the maintenance program.

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 - should be back-flushed periodically to clear out any precipitate of 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 non-disposed 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 irrigation.

Many filter systems are automated and will self-clean via an electric or hydraulic 3-way back-flush valve when a pre-set filter pressure differential is reached.

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

Each type of filter has a different flushing mechanism

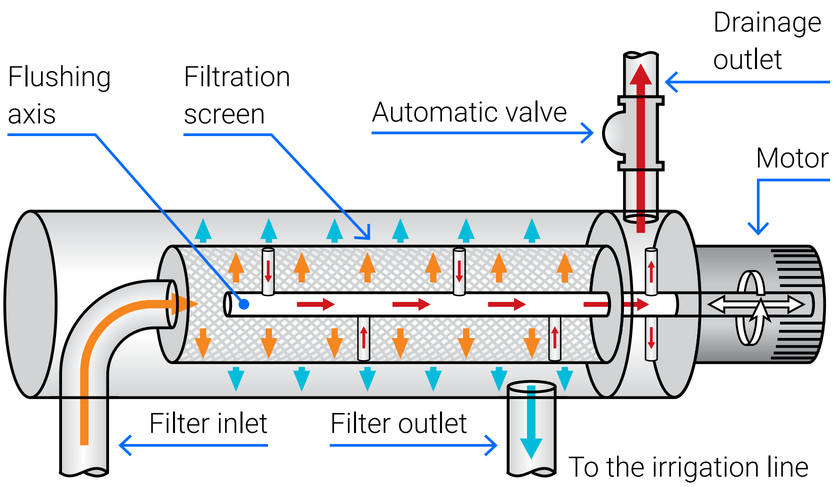
The typical flushing mechanism of each type of filter is described below.
However, for flushing a specific filter, always refer to its user manual.

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.

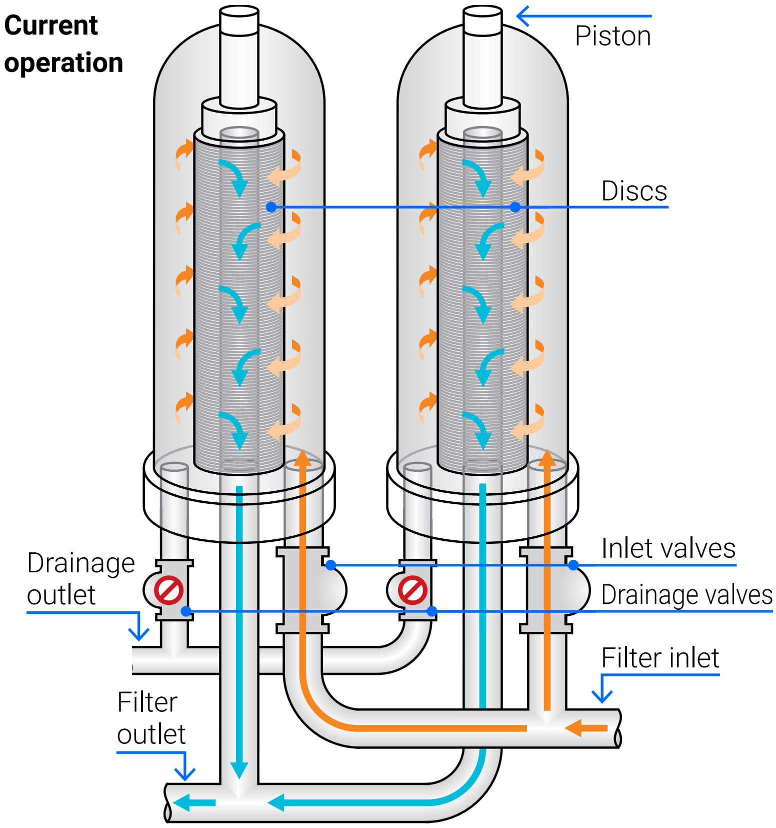


Disc filter

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 disks into the irrigation line.

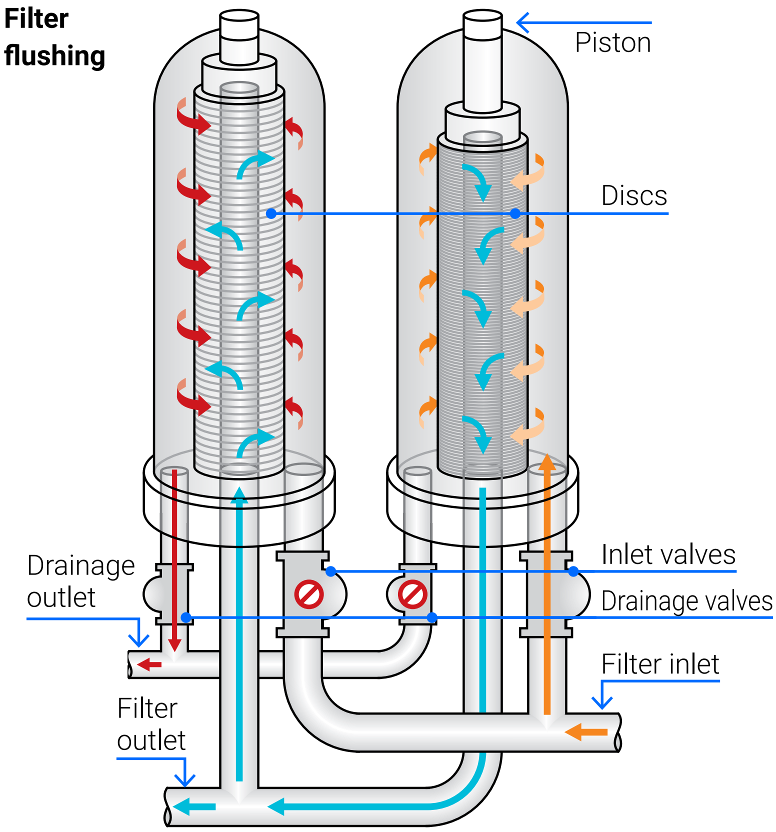


During the flushing operation, the piston at the top of one of the filters in the array spreads the discs to allow the water flowing between them to pick up the dirt from the grooves in the discs.

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.

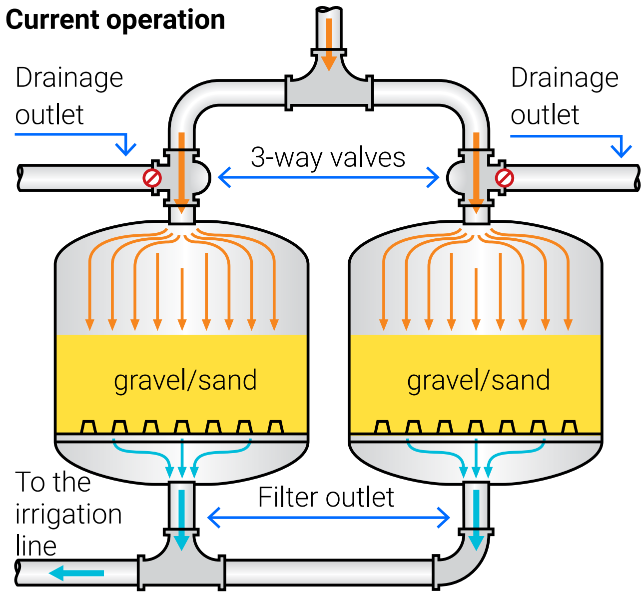
Filters in an array are flushed in sequence.

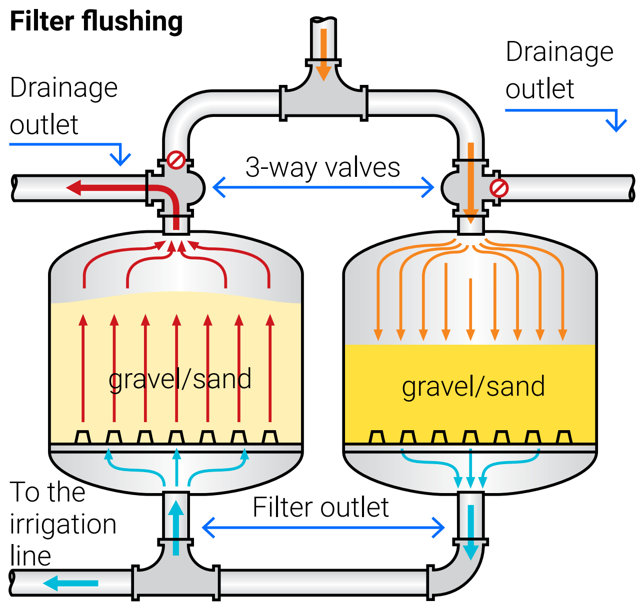


Gravel/sand filter

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.

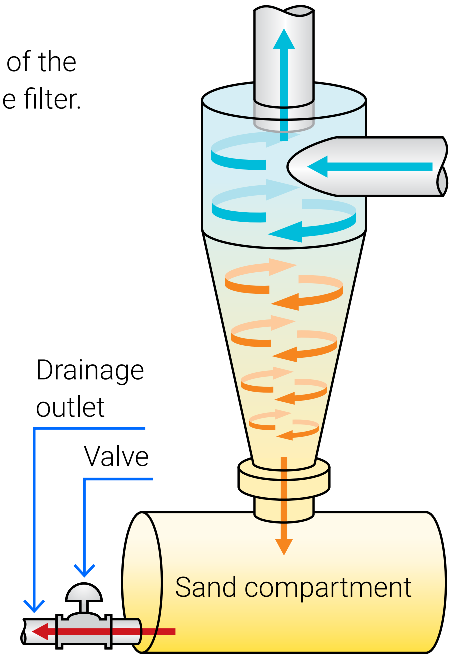
When filter flushing is performed, the automatic 3-way valve of one of the filters opens the drainage outlet while blocking the water inlet to the filter.
The opened drainage outlet creates a pressure differential across the filter, allowing water to flow into the filter through its outlet and out of 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.



→ Periodic Filter Maintenance

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

Gravel/sand filter

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.

- While flushing, check the water at the filter's drainage exit by touch to detect loss of gravel/sand medium.

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 disk remains dirty repeat the last step.

***solution for surface water with organic and biological residue:**
Make a 10% peroxide solution. Pour 7 liters of water into a container and add 3 liters of hydrogen peroxide (35%) or pour 8 liters of water into the container and add 2 liters 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 of water into a container and add 3 liters 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.

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 (see Advancement time, page 47).

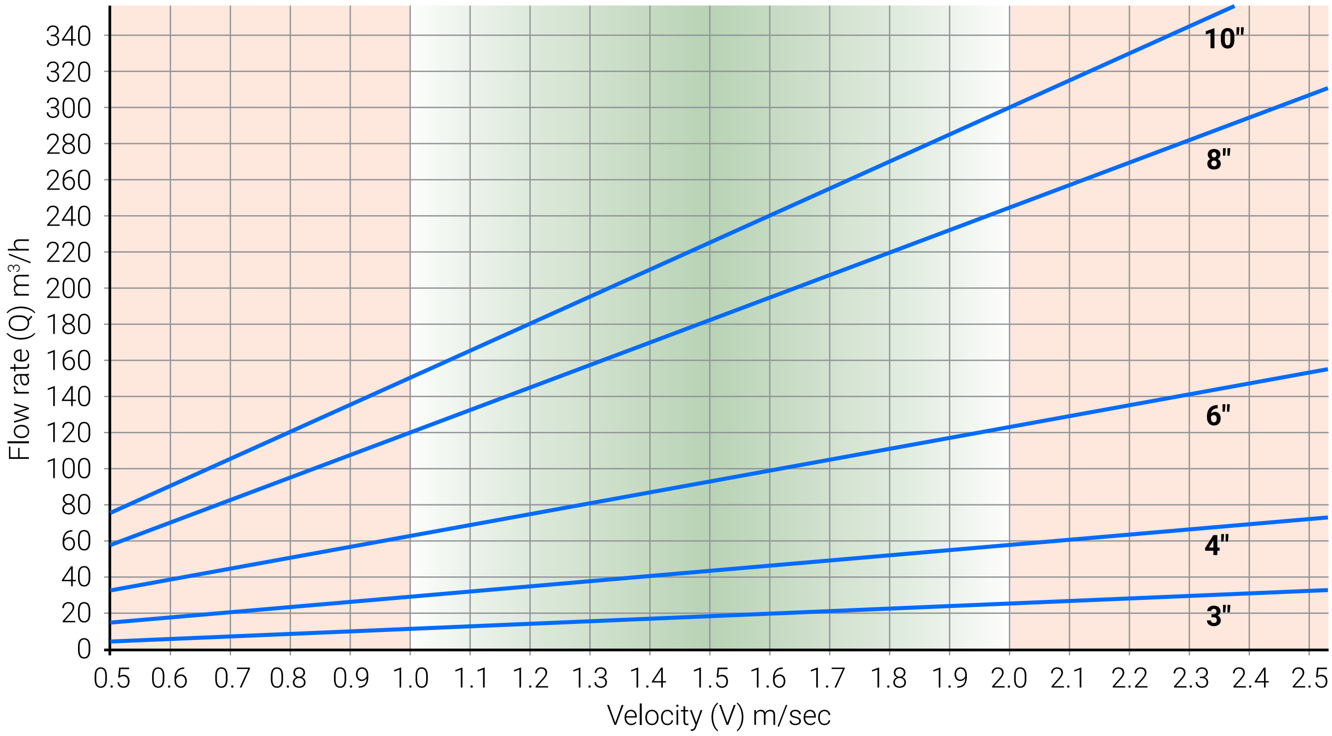
- Identify the diameter of each pipe section to be flushed separately using the table below, which presents the most common diameters of pipes used for main, sub-main and distribution lines:

Nominal pipe diameter - inches (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 at 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. The allowed velocity range for flushing is 1.0-2.0 m/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, find the actual internal diameter of the pipe in the pipe documentation and calculate the velocity using the following formulas:

Calculating the area of the pipe's cross-section (A)

$$A = \pi * r^2$$

- π = 3.1416
- ID = Inside diameter (m)
- r = ID / 2 (m)

The pipe's inside diameter (ID) varies according to the pipe's material, standard and model.
See the actual inside diameter of a particular pipe in its product documentation.

Velocity within blank pipes (meter/second)

The table below represents the velocities in pipes of one specific standard among many:

Nominal diameter (inches)	Inside diameter - ID (mm)	Inside area (m^2)	Flow rate (m^3/h)																
			20	40	60	80	100	120	140	160	180	200	250	300	350	400	450	500	550
			V -velocity in the pipe (m/sec)																
2"	52.51	0.002	2.57																
3"	77.93	0.005	1.16	2.33															
4"	102.26	0.008	0.68	1.35	2.03	2.71													
6"	150.06	0.018	0.31	0.63	0.94	1.26	1.57	1.88	2.20	2.51									
8"	202.72	0.032	0.17	0.34	0.52	0.69	0.86	1.03	1.20	1.38	1.55	1.72	2.15	2.58					
10"	254.51	0.051	0.11	0.22	0.33	0.44	0.55	0.66	0.76	0.87	0.98	1.09	1.37	1.64	1.91	2.18	2.46		
12"	304.08	0.073	0.08	0.15	0.23	0.31	0.38	0.46	0.54	0.61	0.69	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.10
14"	336.55	0.089	0.06	0.12	0.19	0.25	0.31	0.37	0.44	0.50	0.56	0.62	0.78	0.94	1.09	1.25	1.41	1.56	1.72

Calculating flow velocity in a pipe (V)

Velocity (speed) is the distance water passes in one unit of time in a pipe (meters per second)

$$V = (Q / A) / 3600$$

- V = Velocity (m/sec)
- Q = Flow rate (m^3/h)
- A = Area of the pipe inside cross-section (m^2)
- 3600 = Constant for conversion of the result from m/h to m/sec

→ Flushing the Driplines (Laterals)

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.

CAUTION

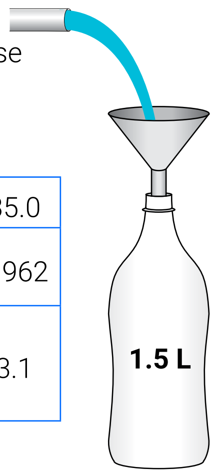
Flushing will temporarily increase the flow requirements of the system, which in turn will decrease the system pressure. In some cases, in order to supply the flow rate required for flushing, an additional pump at the head of the system is used. The additional pump will be activated only during flushing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

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

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.

Dripline ID (mm)	11.8	14.2	16.2	17.5	20.8	22.2	25.0	35.0
Quantity of water per 1 meter of dripline length (liters)	0.109	0.158	0.206	0.241	0.340	0.387	0.491	0.962
Maximum time for filling of bottle (seconds) for a velocity of at least 0.5 m/sec	27.4	18.9	14.6	12.5	8.8	7.8	6.1	3.1



Thin-walled driplines

Dripline model	Pipe's inside diameter (ID) (mm)*	Wall thickness (mm)	Wall thickness (mil)	Max. working pressure (bar)	Max. flushing pressure (bar)
12060	12	0.15	6.0	1.4	1.6
12080	12	0.20	8.0	1.7	2.0
12125	12	0.31	12.5	2.5	2.9
12150	12	0.38	15.0	3.0	3.5
16060	16	0.15	6.0	0.8	0.9
16080	16	0.20	8.0	1.0	1.2
16100	16	0.25	10.0	1.2	1.4
16125	16	0.31	12.5	1.8	2.1
16150	16	0.38	15.0	2.2	2.5
22080	22	0.20	8.0	0.8	0.9
22100	22	0.25	10.0	1.0	1.2
22135	22	0.34	13.5	1.5	1.7
22150	22	0.38	15.0	1.8	2.1
25135	25	0.34	13.5	1.2	1.4
25150	25	0.38	15.0	1.4	1.6
35135	35	0.34	13.5	0.9	1.0
35150	35	0.38	15.0	1.0	1.2

Medium-walled driplines

Dripline model	Pipe's inside diameter (ID) (mm)*	Wall thickness (mm)	Wall thickness (mil)	Max. working pressure (bar)	Max. flushing pressure (bar)
12200	12	0.50	20.0	3.0	3.5
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
16007	16	0.70	27.0	2.9	3.8
16008	16	0.80	32.0	3.0	3.9
22250	22	0.63	25.0	2.5	2.9

Thick-walled driplines

Dripline model	Pipe's outside diameter (OD) (mm)*	Wall thickness (mm)	Wall thickness (mil)	Max. working pressure (bar)	Max. flushing pressure (bar)
12010	12	1.00	39.0	3.5	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
17012	17	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
23009	23	0.90	35.0	3.0	3.5
23010	23	1.00	39.0	3.0	3.5

*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.

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.

Flushing is more effective when the flow rate within the driplines is increased and allows flushing contaminants from the driplines' internal walls. In some cases, the downstream pressure must be increased in order to enable these flow rates in the driplines. The pressure should not exceed the value indicated in the tables on the previous page, according to the dripline's wall thickness.

Dripline flushing pressure

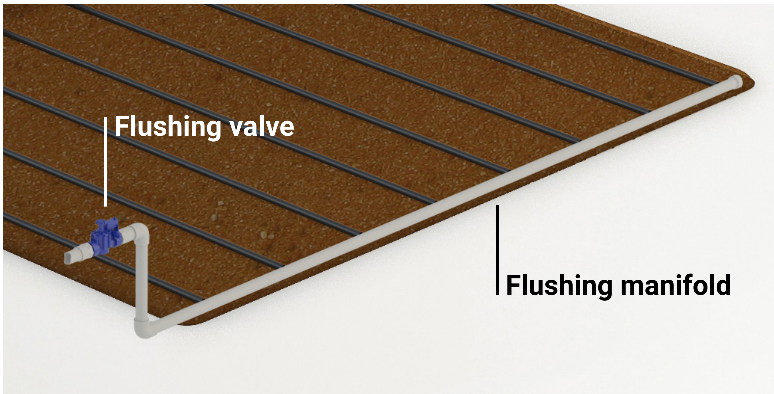
> **NOTE**
> The maximum allowed flushing pressures in the tables on the previous page are valid when flushing for a maximum of half an hour consecutively, with the end of 5 or more driplines kept open.
> To avoid exceeding the allowable pressure in the system, a minimum of 5 driplines should be open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

Dripline flushing with flushing manifolds

Some drip irrigation systems are equipped with flushing manifolds to simplify the dripline flushing process. This method is common mainly in SDI systems, but is also implemented in above ground systems.

Its purpose is to facilitate the task of dripline flushing and save labor hours.

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 efficient removal of settled solids and precipitants from the driplines, preventing them from clogging the drippers.



The flushing manifold is sized for a flow velocity of at least 0.5 m/sec at the end of 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 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.

During dripline flushing, carefully monitor the water flowing out of the flushing valve. Do not close the flushing valve before the water is satisfactorily clean.

PREVENTING CLOGGING IN THE SYSTEM

→ Reducing Water pH....................27

→ Preventing Sand Particle Penetration Into the System....................27

→ Preventing Root Intrusion in SDI Systems....................29

→ Reducing Water pH

Water pH level must be considered since it affects many aspects of cultivation.

- Study the water analysis and get to know and manage the pH levels (See Water analysis, page 86).
- Rectify water pH to the required level according to crop and soil.

Fertilizer 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 water hardness or high pH level, 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.

ATTENTION

- PC drippers may be damaged if in contact with low pH irrigation water for an extended period of time, mainly when the water contains disinfestation products.
- Non PC drippers can be in contact with any pH level for any period of time.

To avoid possible damage to the drippers observe the following guidelines:

Pressure-compensated (PC) drippers

If irrigation water pH is lower than 3.0 (as a result of punctual acid treatment injections):

- Do not irrigate for more than one hour consecutively;
- After each hour of irrigation immediately flush the system with clean water (pH 5.5-7.5) free of chemicals, until total evacuation of substances from it.

If irrigation water pH is lower than 5.5:
Do not inject any substance (fertilizers and/or disinfestation product) into the system.

If irrigation water pH is higher than 5.5:
It is allowed to inject substance (fertilizers and/or disinfestation product) into the system with strict attention that the pH remains between 5.5 and 8.0 at all time.

Compensated Non-Leakage (CNL) drippers

- After each irrigation sequence immediately flush the system with clean water (pH 5.5-7.5) free of chemicals, until total evacuation of substances from it.
- It is recommended to open the ends of the driplines.

→ Preventing Sand Particle Penetration into the System

During system installation or repair

The biggest threat is sand particles coming from the soil, which might enter the system directly through the driplines during their installation or repair.

NOTE
Sand particles are especially harmful for the drippers. They do not decompose. Once they penetrate any type of dripper, they cannot be removed or dissolved using chemical products.

Sand particles can penetrate the system in two ways: with the water flow or directly from the soil.

> **NOTE**
> When water is pumped from a reservoir, river or canal (not from a well), the water should preferably be pumped from a floating point at 0.5 to 1.0 meters depth below the water's surface.

Filtering the water supply will keep sand particles out of the system.

> **NOTE**
> Hydrocyclone sand separators are adequate for separating sand particles from the water.

The best way to prevent damage caused by the penetration of sand particles during installation or repair is to take suitable preventive actions. Implement the following steps:

- Check that the system's filtration system is complete and functioning properly, to ascertain that sand particles will not penetrate the system.
- Attach end connectors immediately after installing the pipes.
- After completing the installation, flush the system using the maximum allowed pressure.
  Start by flushing the main pipes and continue with the sub-main pipes.
- Verify that both the main and the sub-main pipes are clean.
- Do not leave any pipe inlets or outlets open, even for short periods of time.
- Install start connectors and connect the driplines immediately after making the holes in the distribution lines.
- Flush the driplines, 5 driplines at a time or with the flushing manifold, if installed.
- Check the flow velocity at the end of the dripline.

> **NOTE**
> Never leave pipes with open holes in the soil.

In irrigation systems using well water, the presence and concentration of sand particles must be verified and a hydrocyclone sand separator should be installed if necessary.

Soil particles may also penetrate the drippers if a vacuum is formed within the dripline (may be caused by an air valve that is faulty or not operated properly).

> **NOTE**
> It is highly recommended to use AS drippers as an additional precaution.

When the sub surface driplines are empty

Sand particles might penetrate the drippers when the soil is oversaturated due to rainfall. If these conditions are foreseen, Netafim™ recommends using anti-siphon (AS) drippers.

If AS drippers are not used, when the sub surface driplines are empty and the soil becomes oversaturated due to rainfall, water could flow in the opposite direction, from the soil to the dripper outlet, bringing sand particles with it. Under these circumstances, the driplines act as small draining tubes.
The small particles of sand that are carried towards the dripline may eventually clog the drippers.
Irrigating during the rain event will help flush the sand particles from the driplines and prevent clogging of the drippers. During irrigation, the pressure in the driplines exceeds the pressure exerted by the water present in the surrounding soil, preventing the sand particles from penetrating the drippers.

In case of a very intense and long rainy period, it is recommended to flush the system prior to the beginning of the next irrigation sequence. Activating the system for a period of 10 minutes (after pressurizing) is recommended, in order to flush out the accumulated sand particles.

→ Preventing Root Intrusion in SDI Driplines

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.

One of the main causes of root intrusion is insufficient irrigation. This occurs when the plant's water consumption exceeds irrigation. Under these conditions, the roots tend to develop near the dripper and eventually penetrate it. Gradually, the roots may grow into the dripper, blocking the water passage in the dripper.

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).

If a crop requires a stress period:

- A precise dosage of herbicide should be injected to prevent rootlet ends from growing near the dripper, without damaging the plant itself.
- Chemical treatment should be executed prior to the start of the stress period.
- For surface systems with root penetration potential, especially those where the irrigation line is covered by plastic sheets, foliage, etc., it is recommended to move the driplines slightly away from the roots.

Herbicides and dosage

The table presents examples of commercial products used for the prevention of root penetration.
The percentage of active substance is determined by the manufacturer.

Brand name	Active substance
Treflan	Trifluralin 48%
Stomp	Pendimethalin 33%
Alligator	Pendimethalin 40%
Prowl	Pendimethalin 40%

To calculate the amount of commercial product to be injected through the drip system, proceed as follows:

- Use the coefficient of 6 (six)* and divide by the percentage of active substance in the commercial product.
- The result of this calculation is the volume in cubic centimeters (cc) of the commercial product to be injected per dripper.
- Multiply the number of drippers per surface unit to be treated by the volume of the commercial product calculated below.

  * The number 6 is a coefficient that simplifies unit conversion.
  6 / % active substance in the commercial product = cc product per dripper.

CAUTION

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

Examples of commercial products dosage:

- **Treflan:** 6 / 48 = 0.125 cc*/dripper. Therefore, 1.0 liter of Treflan is enough for 8,000 drippers.
- **Stomp 330:** 6 / 33 = 0.182 cc*/dripper. Therefore, 1.0 liter of Stomp 330 is enough for 5,945 drippers.
- **Alligator 400:** 6 / 40 = 0.150 cc*/dripper. Therefore, 1.5 liters of Alligator 400 are enough for 10,000 drippers.
- **Prowl 400:** 6 / 40 = 0.150 cc*/dripper. Therefore, 1.5 liters of Prowl 400 are enough for 10,000 drippers.

* 1cc = 1ml

NOTE

In cases where the number of drippers per lineal meter of dripline exceeds 3, the number of drippers noted for herbicide dosage calculation will still be 3 drippers per meter and not according to the actual number of drippers.

EXAMPLE

One (1) hectare with 6,500 meters of driplines and dripper spacing of 0.20 meters:
6,500 meters divided by 0.20 meters equals 32,500 drippers per hectare (actual quantity).

Based on the above, as this case has 5 drippers per lineal meter of irrigation line, i.e., more than 3 drippers/meter, the calculation will be made according to 3 drippers per lineal meter of irrigation line.

Thus, 6,500 meters multiplied by 3 drippers equals 19,500 drippers per hectare (quantity calculated for application).

The dose to be injected will be 19,500 drippers multiplied by the volume in cubic centimeters (cc) per dripper of the commercial product calculated above, depending on the active ingredient of the said product.

Determining the quantity and frequency of treatments

The number of treatments per season with one of the above-mentioned herbicides should be 1 or 2, depending on the type of soil, unplanned or induced irrigation interruptions, and duration of the irrigation and the Nutrigation™ seasons.

In perennial fruit trees, the recommendation is for up to two treatments per season, starting from the second year of age. The first treatment should be implemented in the first third of the irrigation season. The second treatment should be implemented when beginning reduction of water applications to the crop towards the end of the irrigation season.

Young trees are vulnerable to these chemicals. In the case of new plantations and plantations of up to one year of age, consult Netafim's Agronomy Division.

In open field crops (seasonal or perennial), it is highly recommended to implement the treatment once a year. The time for this mandatory treatment is when beginning reduction of water applications to the crop towards the end of the irrigation season.

Certain crops will require one additional treatment during the irrigation season, because previous interruptions or reductions of water volume that were carried out increase the potential for root penetration into drippers.

In the case of sandy soils (more than 70% sand and less than 8% clay), regardless of the type of crop, it is recommended to execute the herbicide treatment, dividing the application into two injections, each of which should be half of the dose calculated for a single application. The interval between these two injections should be two (2) weeks.

For any query, please contact the Agronomy Division at Netafim™.

When not to use herbicides to prevent root intrusion

The treatment is contraindicated under the following conditions:

- When the soil is saturated (due to rain or irrigation).
- Near the time of crop planting or sowing and/or when the volume of the roots is very small.
- In soilless substrates.
- When the relevant authorities prohibit the specific treatment.
- When driplines are not evenly inserted in the soil.
- When driplines are covered by a plastic sheet.

Before treatment

Perform the following tests a few days before the scheduled treatment:

- Turn the water on for 20 minutes. If puddles appear, the soil is too wet and not suitable for treatment.
- Check the driplines for leaks and bursts. Repair all defects before the treatment.
- In grass, verify that the driplines are properly inserted and are not located between the surface of the soil and the grass carpet.
- Verify that the pump and the central controller are in proper working condition.

> **NOTE**
> The soil must not be too wet during treatment. If the soil is too wet, it is recommended to partially dry the soil by postponing an irrigation cycle intended to be performed before the treatment.

EXAMPLE

Calculate the minimum amount of Stomp 550 plus water required for an injection lasting 20 minutes in accordance with the dosing unit's specifications:

Stomp 550 required per dripper:	6/55 = 0.11 cc
Total number of drippers in the system to be treated:	10,000 drippers
Total required amount of Stomp:	10,000 x 0.11 cc = 1,090 cc = 1.09 liters
Dosing unit's flow rate:	240 liter/hour

20 minutes = 60/3
240 l/h / 3 = 80 liters
This dosing unit can supply 80 liters in 20 minutes.
These 80 liters are composed of 78.91 liters of water plus 1.09 liters of Stomp 550.

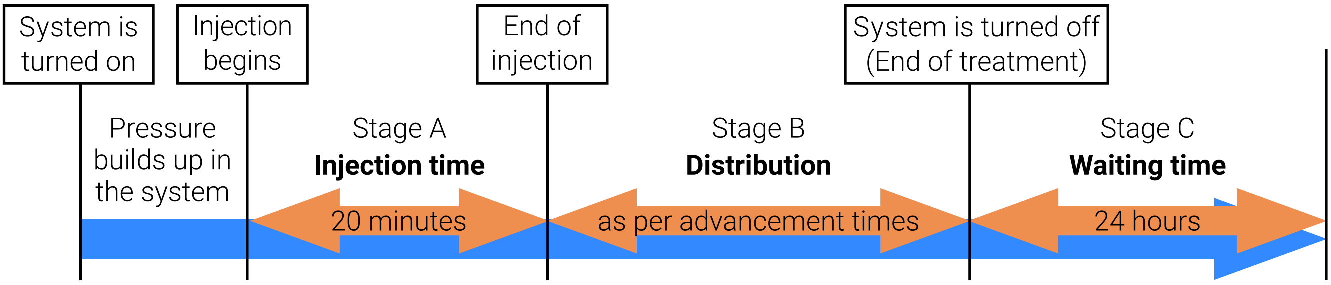
Treatment procedure

- Turn the water on and let it flow until pressure stabilizes.
- Fill a clean tank with a volume of water equal to the volume required for an injection lasting 20 minutes (78.91 liters in the example above).
- Immediately add the herbicide to the water in the tank.
- Inject the mixture from the tank into the system. If the solution was calculated correctly, the injection will end in 20 minutes.
- Before turning off the system, allow the water to continue flowing through it during the required period of time (see Advancement time, page 47).

> **NOTE**
> - Observe the irrigation and injection advancement time.
> - Do not delay or advance the system's shut down.
> - After treatment, wait at least 24 hours before the next irrigation cycle.

Treatment summary

- Fill the system until pressure is stable.
- **Stage A:** Inject the solution for 20 minutes.
- **Stage B:** Solution is distributed through the system; allow water to continue flowing as per the advancement times (see the driplines' Technical Datasheet and Advancement time, page 47).
- **Stage C:** Turn off the water. Do not delay water turn-off. Wait 24 hours before the next irrigation cycle.



See Advancement time, page 47.

NUTRIGATION™ AND ACID TREATMENT

→ Nutrigation™ 34

→ Acid Treatment 38

→ Organic Nutrigation™ 41

→ Acid Treatment in Organic Agriculture 42

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.

→ Nutrigation™

Nutrigation™ is comprised of three stages:
- Dissolving soluble fertilizers (if required).
- Injecting nutrients according to the desired dosing ratios.
- Delivering the precise quantity of nutrients to the plant's root zone.

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. (see Drip Irrigation Handbook).

Limitations of Nutrigation™ via a drip irrigation system

- Only water-soluble fertilizers that are free of impurities are allowed to be used in drip irrigation.
- Some fertilizers, although water soluble, may not be compatible with the method of Nutrigation™, such as fertilizer that raises the pH of the irrigation water so high that precipitation occurs in the system.
- Use acid fertilizers in the case of hard water, alkaline water or where pH is higher than 7.
- Certain fertilizers are corrosive to metal parts of the equipment, therefore the parts of the system coming in contact with these fertilizers should be made of materials resistant to corrosion.

NOTE
Do not inject ionic iron (iron sulfate, iron chloride) into the drip irrigation system. Ionic iron will damage the system. Always use iron chelates.

- Phosphoric fertilizers can cause the formation of phosphoric salts, such as calcium, magnesium, etc., increasing the potential of clogging the emitters.
- Use only phosphoric fertilizers based on orthophosphates. Do not use phosphoric fertilizers based on polyphosphates.

Characteristics of fertilizers used in Nutrigation™

Knowing the characteristics of the fertilizers to be used in Nutrigation™ is essential for making the right choice of fertilizers and application, in order 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; these are generally not used in Nutrigation™.

Form

- **Solid state fertilizers** may be granulated or powdered.
- **Liquid state fertilizers** 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.

> **WARNING**
> Only fertilizers that are water-soluble and completely free of impurities 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™. Some fertilizers (such as single and triple superphosphate, for example) have a solubility level so low that they are classified as water-insoluble and their use in irrigation systems is not allowed.

Fertilizer interaction with irrigation water

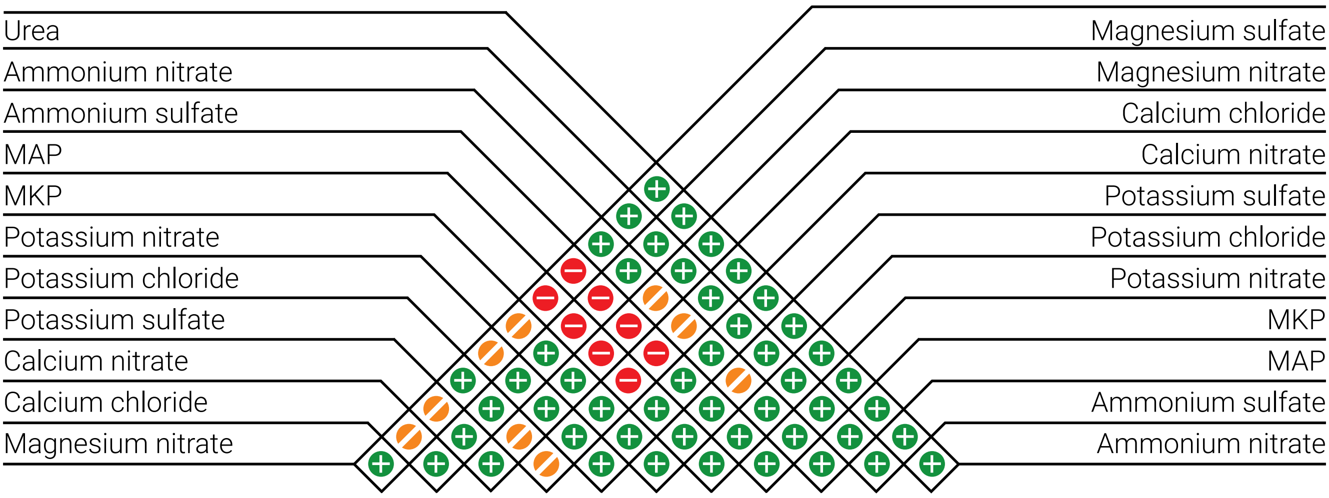
Fertilizers are salts that react with other salts found in the irrigation water. Therefore, it is important to consider the chemical composition of the water to be used for preparing the liquid fertilizers.

For example: under conditions of water with high alkalinity, 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 must not be used in 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 nutrients.

Compatibility of the most common soluble fertilizers:



Compatible, Limited compatibility, Incompatible

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 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™ 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™ 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™ 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™ 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.

TIP

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

- Upon completing the injection of fertilizers, continue irrigating with water only for as long as necessary to remove all residues of the product from the system (See Advancement time, page 47).

→ Acid Treatment

Acids may be used for dissolving, preventing and/or decomposing salts, carbonates, phosphates, hydroxides, etc.

NOTE
Acid treatment is ineffective on most organic substances.

Safety

ACID HAZARD
Acids, when not handled properly, 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 acid manufacturer's instructions and the regulations issued by the relevant local authority.

- Always add acid to water - NEVER add water to an acid.
- Avoid contact with the eyes. Any contact of acid with the eyes may cause blindness.
- Avoid contact with the skin. The contact of acid with the skin may cause burns.
- Use protective clothing when working with acid: goggles, gloves, a mask, long pants, a long-sleeved shirt, and closed high shoes.
- Avoid swallowing and inhaling. Swallowing of acid or inhaling its fumes could be fatal.
- During acid treatment, a second operator must be present who can, if necessary, provide first aid.
- Remain on site throughout the acid treatment. Keep all unauthorized personnel away from the treatment area.

Injecting acid into the system

In order to apply an acid treatment to the system, the following steps must be taken:

- Verify that the injection pump is acid-resistant and of sufficient capacity for the task.

NOTE
Acids are very corrosive on materials such as steel, aluminum, asbestos cement, etc.
PE and PVC tubing are resistant to acids. Consider these factors before planning the treatment.
In case of doubt, always consult Netafim™.

- Before beginning the treatment, flush all the components of the system thoroughly using maximum flow.

NOTE
Flushing the system before using acid is essential, to prevent damage to the system.

- Inject the acid into the irrigation system for the time required to attain the desired concentration during the stipulated treatment time.
- Turn off the injection pump.
- Continue irrigation for the time required according to the Advancement Timetable (see Advancement time, page 47).
- Flush the injection pump with clean water after every use.

Acid concentrations

The concentration of acid added to the irrigation water depends on the type of acid being used and its percentage.

NOTE
Acids must be free of insoluble impurities, such as gypsum, oils, etc.

Recommended acid concentrations

Acid	Percentage of acid	Recommended concentration in treated water
Hydrochloric acid	33%	0.6%
Phosphoric acid	85%	
Nitric acid	60%	
Sulfuric acid	65%	

If the acid used has a percentage different from the data included in this table, adjust the concentration according to the percentage relative to the concentrations recommended above.

Calculate the acid concentration when a different initial concentration is used:

EXAMPLE

98% sulphuric acid is available. What percentage (X) must be used?

X * 98% = 0.6% * 65%

X = (0.6% * 65%) / 98% = 0.4%

Recommendations for the acid injection process

Prevent incrustations of salt in water with a high potential for formation of salt with low solubility:

- The pH of the water must be reduced continuously or at a predetermined frequency.
- The required pH level will be determined according to the water quality.

To calculate the required pH level, it is recommended to titrate the irrigation water with the acid to be used.

Determining the titration curve or table

Required equipment

- Acid
- Bucket
- pH digital meter, or litmus paper
- 10 liter of the irrigation water to be used

Procedure

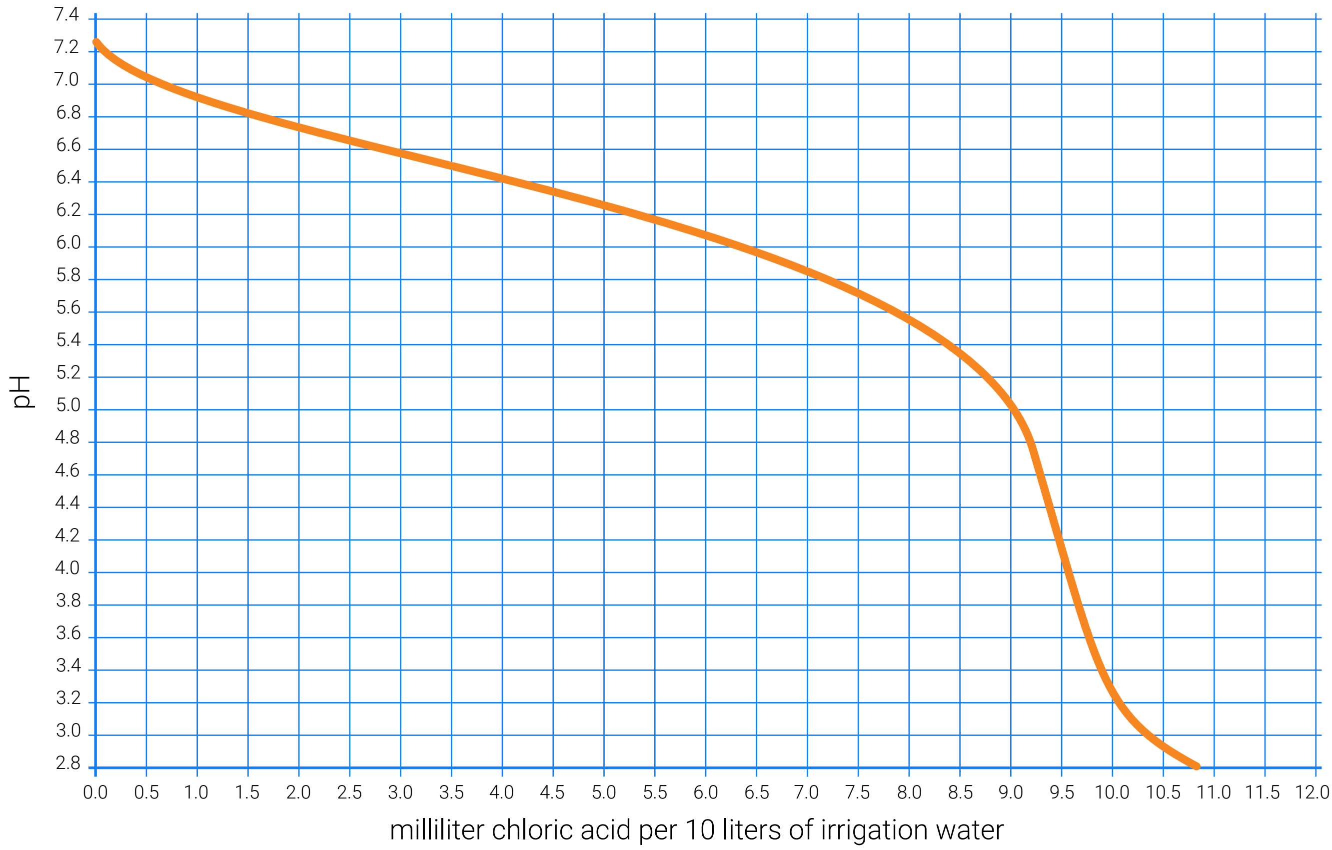
1. Pour 10 liter of irrigation water in the bucket.
2. Record the pH level of the water.
3. Add 1 cc of the acid and mix the solution.
4. Record the pH level of the solution.
5. Repeat steps 3 and 4 until the desired pH level is obtained.

NOTE
If the pH level changes abruptly, it is recommended to dilute the acid with water or use a larger volume of water.

6. Construct the curve or table using the variation from the initial pH in coordination with the volume of acid as parameters.
7. The result will provide an approximation of the amount (in cc or ml) of acid per liter of water needed to reduce the pH to the required level.
8. 1 cc (ml) of acid per 10 liter of water = 1.0 liter of acid per m^3 of water.

EXAMPLE

Titration curve of water with chloric acid (33%)



Dissolving the incrustations of salts of low solubility in irrigation systems

The recommended concentration of acids is 0.6%.
In order to attain this 0.6% concentration of acid in the water, inject 1.0 liter of acid for every 1.0 m^3/h (cubic meter per hour) to be treated for 10 minutes.

> **NOTE**
> In order to verify that the treatment is efficient, the pH value at the furthest point should be less than 3 for at least 3 minutes.

EXAMPLE

- Flow rate of the equipment: 50 m^3/h
- Necessary acid: 50 liters
- Injection time: 10 minutes

> **NOTE**
> If the injection pump capacity is lower than required and it will not be capable of injecting all the required acid within the specified time, an extra injection pump must be added.
> If the capacity of the injection pump is larger than necessary, add water to the tank with the solution until reaching the volume necessary to ensure 10 minutes of solution injection.

→ Organic Nutrigation™

The application of organic nutrients through the drip irrigation system requires special attention.

- Organic nutrient solutions are usually less soluble in water and frequently contain high concentrations of suspended solids, which may cause sedimentation, with consequent damage to the irrigation system.
- The application of combinations of organic nutrients shall be avoided, and the preparation of adequate solution must be ensured.
- Effective filtration and system maintenance are prerequisites for the success of the crop.
- System flushing and disinfection treatments are essential when organic nutrients are used, to ensure the system's longevity.

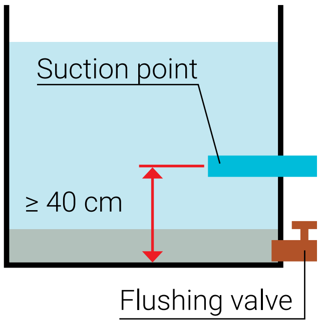
Permitted organic nutrients that are commonly applied through the drip irrigation system (partial list):

- Guano (marine bird manure) and Urine Slurry.
- Amino acids (from the epithelial enzymatic hydrolysis of cattle).
- Humic acids.

Proper nutrient solution preparation

Solid organic nutrients must be dissolved in water in the correct concentrations, for example:

- Guano (marine bird manure). Mix with water at a ratio of 1:10 (100 liters of guano per 1000 liters of water).
- The solution should stand sufficient time (7-10 days, depending on the season and on the quality of the product), until a solution free of suspended solids is obtained.
- The tank suction point must be located horizontally, at no less than 40 cm from the bottom of the tank in order to prevent suction of the sediments.
- The tank flushing valve must be located at the bottom of the tank to allow full evacuation of the sediments.
- The sediments from the tank may be used for spreading in the field.



CAUTION

Organic nutrients should never be applied in combination with inorganic fertilizers.

EXAMPLE

If humic acids applied as nutrients in agriculture are combined with an inorganic nutrient, this will cause flocculation.

Humic acids + N or K or Ca = Flocculation => Clogging!

Another problematic interaction frequently occurs between materials injected into the system and microorganisms living inside the system or that are injected into it. Organic nutrients injected into a system contaminated with bacteria are likely to develop bacterial slime, which may cause dripper clogging.

NOTE

Avoid mixing organic nutrients in the fertilizer tank.

Organic nutrients must be filtered before they are injected in the irrigation system.

The injection point of an organic nutrient must be located before the main filtration system in order to prevent dripper clogging.

→ Acid Treatment in Organic Agriculture

Acids permitted for use in organic agriculture:

- Acetic
- Citric
- Oxalic
- Para-acetic

It is possible to use chlorine, hydrogen peroxide, etc., for disinfection/oxidation, depending on local standards.

In organic agriculture, processes must be performed according to the pertinent regulations in each country and according to the certifying authorities.

CHEMIGATION

→ Chemical injection 44

→ Advancement time 47

The irrigation system is used also as a method for distributing products with the irrigation water.

These products, such as fertilizers, insecticides, fungicides, nematicides, herbicides, etc., must be totally soluble in the water and are injected into the system at a selected point, penetrating into the soil through the system.

If there is any doubt whether a certain product can be injected through the irrigation system, consult a Netafim™ specialist.

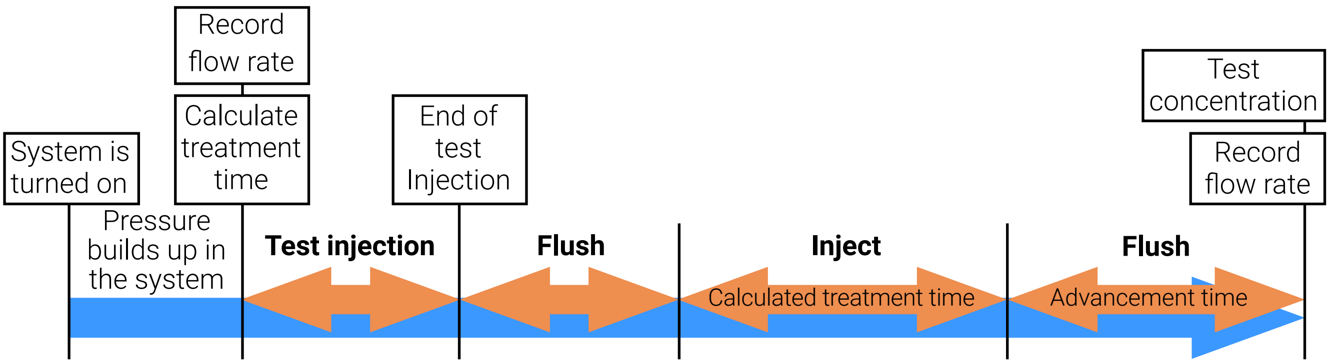
CHEMICAL HAZARD
When not handled properly, nutrients, acids and chemicals may cause serious injury or even death. They may also damage the crop, the soil, the environment and the irrigation system.
Proper handling of nutrients, acids and chemicals is the responsibility of the grower.
Always observe the nutrient/acid/chemical manufacturer's instructions and the regulations issued by the relevant local authority..

→ Chemical Injection

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

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 agronomic and technical data, product properties (see the product documentation) and the instructions of the relevant authority.
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 chapter System Flushing, page 17.
5. Inject the chemical according to the calculations (point 2) above, depending on the specific treatment.
6. Flush the system, taking into account the advancement times (See Advancement time, page 47).
7. Upon completing the injection of products (fertilizers, disinfectants, oxidants, herbicides, etc.), continue irrigating with water only for as long as necessary to remove all residues of these products from the system (See Advancement time, page 47).

Flow chart for chemical treatment



Determining the chemical substances for injection

There is a large variety of chemicals and disinfectants, in solid, liquid and gaseous states worldwide.
Due to the different chemical techniques used in their preparation, as well as the various concentrations and dosages of minerals, emulsions and coagulants, it is impossible to provide a pre-approved list of permitted or prohibited products and manufacturers.

NOTE

Before injecting any chemical product into your system, determine its degree of compatibility.The injection of incorrect chemical substances may be harmful to the system.

When inappropriate products are injected, the following problems may be expected:

- Sedimentation in the drippers due to the reaction between the water and the chemical products.
- Physical and/or chemical damage to the emitters.

Permitted chemical products

NOTE

Netafim™ 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 usage, to ascertain that they are safe for use with Netafim's systems.

When contemplating the use of any other chemical product or combination of products:

- Consult the Agronomy Division of Netafim™.
- Send the new chemical product/s to Netafim™ for complete testing.

NOTE

Before using any chemical product, it is essential to obtain information from its manufacturer with respect to its chemical quality, purity, recommended dosage, solubility, EC-pH as well as method and order of preparation.

NOTE

Remove the membrane or oily surface layer formed after the preparation of any product.

NOTE

Any product not included in this list requires prior approval from Netafim™.

The following chemical products (liquid or highly soluble) are permitted for injection in drip irrigation systems:

N - Nitrogen

- Urea
- Ammonium nitrate
- Nitric acid
- Ammonium sulfate
- Mono-ammonium phosphate (MAP)

P - Phosphor

- Phosphoric acid
- Mono-ammonium phosphate (MAP)
- Mono-potassium phosphate (MKP)

K - Potassium

- Potassium nitrate
- Potassium chloride
- Potassium sulfate
- Mono-potassium phosphate

Micro-elements

- Chelates, EDTA, DTPA, EDDHA, HEDTA, ADDHMA, EDDCHA, EDDHSA, boric acid

Fungicides, herbicides, insecticides and disinfectants authorized by Netafim™

- Metam sodium
- Telone II
- Formaldehyde

There are additional options; contact the Agronomy Division of Netafim™ for details.

After chemigation it is necessary to continue irrigation with water that is free of chemical products. Verify the flushing duration and timing (see Advancement time, page 47).

In irrigation systems with anti-drainage 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™, 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).

Forbidden chemical substances

The use of the following chemical products in drip irrigation systems is strictly forbidden:

- Poly-phosphates
- Red potassium chloride
- Borax
- Organic products with a high content of suspended solids (without preliminary treatment)
- Products or fertilizers with low solubility, e.g., gypsum
- Oily chemical products, oily solvents, petroleum products or detergents
- Mineral fertilizers together with organic fertilizers

Applying herbicide by chemigation via drip irrigation

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.

TIP

The herbicide injection should take place towards the end of the irrigation event.
Example: if you plan to irrigate 300 m^3/ha water, the herbicide will be applied once a quantity of aproximately 250 m^3 has been irrigated.

→ Advancement Time

When products are injected into the water, they will flow through the system at the same rate as the water.

The time it takes for a product injected into the pressurized system to arrive at a given point can be calculated and must be taken into account, in order to allow the injected product to reach its final destination out of the pipe. This calculated time is called "advancement time."

→ The Advancement Time may be Divided into Three Phases

- **Time I** is the calculated time in which the water passes between the injection point and the valve in the field. In the case of several valves, the most distant valve must be taken into account.
- **Time II** is the calculated time in which the water passes the distance between the valve and the end of the sub-main pipe.
- **Time III** is the time that passes between the moment when the product enters the dripline and the moment it reaches the last emitter (dripper, micro-sprinkler or sprinkler).

The total relevant advancement time will be calculated according to the location of the injection point.

Observe the advancement time of the clean irrigation water (without products) flowing in the pipes after the treatment in order to clear the system of all residues of the injected product.

The advancement time is a calculated time, and will be minimally influenced by the physical and chemical properties of the product. For practical purposes, it may be assumed that the product advances in the system at the same rate as water.

The advancement time is calculated when the system is pressurized and stable. The advancement time should not be confused with the system filling time.

The filling time is the time required for an empty system starting to fill, until it reaches a stable, pressurized state, and is quite different from the advancement time.

It is recommended to be aware of the advancement time for each part of the irrigation system, according to its hydraulic design.

→ Advancement Time in Main, Sub-Main and Distribution Pipes

The advancement time in a blank pipe (a pipe without outlets) can be calculated by the following steps:

Calculating the area of the pipe's cross-section (A)

$$A = \pi * r^2$$

- $\pi = 3.1416$
- ID = Inside diameter (m)
- $r = ID / 2$ (m)

The pipe's inside diameter (ID) varies according to the pipe's material, standard and model.
See the actual inside diameter of a particular pipe in its product documentation.

Velocity within blank pipes (meter/second)

The table below represents the velocities in pipes of one specific standard among many:

Nominal diameter (inches)	Inside diameter - ID (mm)	Inside area (m^2)	Flow rate (m^3/h)																
			20	40	60	80	100	120	140	160	180	200	250	300	350	400	450	500	550
2"	52.51	0.002	2.57					V -velocity in the pipe (m/sec)											
3"	77.93	0.005	1.16	2.33															
4"	102.26	0.008	0.68	1.35	2.03	2.71													
6"	150.06	0.018	0.31	0.63	0.94	1.26	1.57	1.88	2.20	2.51									
8"	202.72	0.032	0.17	0.34	0.52	0.69	0.86	1.03	1.20	1.38	1.55	1.72	2.15	2.58					
10"	254.51	0.051	0.11	0.22	0.33	0.44	0.55	0.66	0.76	0.87	0.98	1.09	1.37	1.64	1.91	2.18	2.46		
12"	304.08	0.073	0.08	0.15	0.23	0.31	0.38	0.46	0.54	0.61	0.69	0.76	0.96	1.15	1.34	1.53	1.72	1.91	2.10
14"	336.55	0.089	0.06	0.12	0.19	0.25	0.31	0.37	0.44	0.50	0.56	0.62	0.78	0.94	1.09	1.25	1.41	1.56	1.72

Calculating flow velocity in a pipe (V)

Velocity (speed) is the distance water passes in one unit of time in a pipe (meters per second)

$$V = (Q / A) / 3600$$

- V = Velocity (m/sec)
- Q = Flow rate (m^3/h)
- A = Area of the pipe inside cross-section (m^2)
- 3600 = Constant for conversion of the result from m/h to m/sec

The flow rate in a pipe with no outlets is constant throughout the length of the pipe, and is independent of the pipe's diameter or of the area of the pipe's cross section. If the pipe's cross-section changes, the flow velocity changes accordingly, but the flow rate remains constant.

Consequently: $Q = A_1 * V_1 = A_2 * V_2 = A_3 * V_3 = \text{constant}$

Calculating the advancement time in a pipe

The time it takes for water to pass the length of a pipe segment (seconds).

$$At = L / V$$

- At = Advancement time (sec)
- V = Velocity (m/sec)
- L = Length of pipe segment (m)

Calculating advancement time in a telescoped pipe

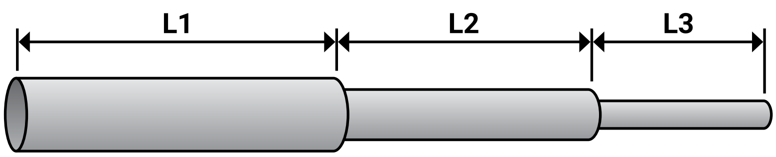
Calculate the advancement time for each segment separately and add up the results to obtain the total advancement time of the whole telescoped pipe.

EXAMPLE

Assume the telescoped pipe is comprised of 3 segments (each segment of a different length).

The calculated advancement time for each pipe section is assumed to be:

- **L1** = 55 seconds.
- **L2** = 40 seconds.
- **L3** = 25 seconds.



The total advancement time of the whole telescoped pipe will be:

55 + 40 + 25 = 120 seconds = 2 minutes

→ Advancement Time in Driplines

Advancement time (minutes - rounded) in thin- and medium-walled driplines

Distance between drippers (m)		0.2						0.4						0.6						0.8					
Dripper flow rate (l/h)		0.6	1.0	1.6	2.0	3.0	3.8	0.6	1.0	1.6	2.0	3.0	3.8	0.6	1.0	1.6	2.0	3.0	3.8	0.6	1.0	1.6	2.0	3.0	3.8
Dripline 12 mm - ID = 11.8 mm																									
Dripline length (m)	100	15	9	6	4	3	2	27	16	10	8	5	4	37	22	14	11	7	6	47	28	18	14	9	7
	200	16	10	6	5	3	3	30	18	11	9	6	5	42	25	16	13	8	7	53	32	20	16	11	8
	300	17	10	6	5	3	3	31	19	12	9	6	5	44	27	17	13	9	7	57	34	21	17	11	9
Dripline 16 mm - ID = 16.2 mm																									
Dripline length (m)	200	31	18	12	9	6	5	56	34	21	17	11	9	79	47	30	24	16	12	101	60	38	30	20	16
	300	32	19	12	10	6	5	59	36	22	18	12	9	84	50	31	25	17	13	107	64	40	32	21	17
	400	34	20	13	10	7	5	62	37	23	18	12	10	87	52	33	26	17	14	112	67	42	34	22	18
Dripline 22 mm - ID = 22.2 mm																									
Dripline length (m)	300	61	37	23	18	12	10	111	67	42	33	22	18	157	94	59	47	31	25	201	121	75	60	40	32
	400	63	38	24	19	13	10	116	69	43	35	23	18	164	98	62	49	33	26	210	126	79	63	42	33
	500	65	39	24	19	13	10	119	71	45	36	24	19	169	102	63	51	34	27	217	130	81	65	43	34
Dripline 25 mm - ID = 25.0 mm																									
Dripline length (m)	400	80	48	30	24	16	13	147	88	55	44	29	23	208	125	78	62	42	33	266	160	100	80	53	42
	500	82	49	31	25	16	13	151	91	57	45	30	24	215	129	80	64	43	34	275	165	103	82	55	43
	600	84	50	31	25	17	13	154	93	58	46	31	24	220	132	82	66	44	35	282	169	106	85	56	45

Advancement time (minutes - rounded) in thick walled driplines

Distance between drippers (m)		0.2						0.4						0.6						0.8					
Dripper flow rate (l/h)		0.6	1.0	1.6	2.0	3.0	3.8	0.6	1.0	1.6	2.0	3.0	3.8	0.6	1.0	1.6	2.0	3.0	3.8	0.6	1.0	1.6	2.0	3.0	3.8
Dripline 12 mm - ID = 10.2 mm																									
Dripline length (m)	100	11	7	4	3	2	2	20	12	7	6	4	3	28	17	10	8	6	4	35	21	13	11	7	6
	200	12	7	5	4	2	2	22	13	8	7	4	3	31	19	12	9	6	5	40	24	15	12	8	6
	300	13	8	5	4	3	2	23	14	9	7	5	4	33	20	12	10	7	5	42	25	16	13	8	7
Dripline 16 mm - ID = 14.2 mm																									
Dripline length (m)	200	24	14	9	7	5	4	43	26	16	13	9	7	61	36	23	18	12	10	77	46	29	23	15	12
	300	25	15	9	7	5	4	45	27	17	14	9	7	64	39	24	19	13	10	82	49	31	25	16	13
	400	26	15	10	8	5	4	47	28	18	14	9	7	67	40	25	20	13	11	86	52	32	26	17	14
Dripline 20 mm - ID = 17.5 mm																									
Dripline length (m)	300	38	23	14	11	8	6	69	41	26	21	14	11	98	59	37	29	20	15	125	75	47	37	25	20
	400	39	24	15	12	8	6	72	43	27	22	14	11	102	61	38	31	20	16	130	78	49	39	26	21
	500	40	24	15	12	8	6	74	44	28	22	15	12	105	63	39	32	21	17	135	81	51	40	27	21
Dripline 23 mm - ID = 20.8 mm																									
Dripline length (m)	400	55	33	21	17	11	9	101	61	38	30	20	16	144	86	54	43	29	23	184	111	69	55	37	29
	500	57	34	21	17	11	9	104	63	39	31	21	16	149	89	56	45	30	23	190	114	71	57	38	30
	600	58	35	22	17	12	9	107	64	40	32	21	17	152	91	57	46	30	24	195	117	73	59	39	31

Interpolation can be used to calculate advancement time for driplines, distances between drippers, dripper flow rates or dripline lengths not mentioned in the above tables.

EXAMPLE

Example 1:

- A thin-walled dripline - OD = 12 mm, ID = 11.8 mm
- Distance between drippers - 0.5 m (not mentioned in the table)
- Dripper flow rate - 1.6 l/h
- Dripline length - 200 m

According to the advancement time in the table on thin- and medium-walled driplines, the advancement time will be between 11.1 and 15.7 minutes.

Calculate the actual advancement time using the formula:

$$\frac{11.1 + 15.7}{2} = 13.4 \text{ minutes}$$

Round the result to the next whole number, in this case, **14 minutes.**

Example 2:

- A thick-walled dripline - OD = 16 mm, ID = 14.2 mm
- Distance between drippers - 0.6 m
- Dripper flow rate - 2.0 l/h
- Dripline length - 350 m (not mentioned in the table)

According to the advancement time in the table on thick-walled driplines above, the advancement time will be between 19.3 and 20.1 minutes.

Calculate the actual advancement time using the formula:

$$\frac{19.3 + 20.1}{2} = 19.7 \text{ minutes}$$

Round the result to the next whole number, in this case, **20 minutes.**

HYDROGEN PEROXIDE TREATMENT

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→ Safety

> **WARNING**
>
> 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.

- Before filling any tank with hydrogen peroxide solution, flush it thoroughly to remove any traces of fertilizers.
- Avoid contact with the eyes. The contact of hydrogen peroxide with the eyes can cause blindness.
- Avoid contact with the skin. The contact of hydrogen peroxide with the skin can cause burns.
- Use protective clothing when working with hydrogen peroxide. Use goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes.
- Avoid swallowing or inhaling. Swallowing hydrogen peroxide or inhaling its vapors could be fatal.
- During treatment, a second operator must be present who can, if necessary, provide first aid.
- Remain on site during the entire duration of the treatment. Keep all unauthorized personnel outside the treatment area.

> **WARNING**
>
> Direct contact between hydrogen peroxide and fertilizers or other chemical products could create a thermal reaction which could cause the tank to explode. This is highly dangerous.

> **NOTE**
>
> The injection of hydrogen peroxide into irrigation water containing fertilizers is not dangerous.

→ Hydrogen Peroxide (H_2O_2) as an Oxidizing Agent

For more than a decade, the use of hydrogen peroxide for disinfecting and oxidizing irrigation water has become increasingly widespread.

Prior to this, chlorine was used but it was found that after the oxidation and disinfection process, organic chlorides, which produce carcinogenic compounds, such as Trichloromethane, started to appear, and the process also contaminates the environment.

In fact, many countries have passed laws against chlorinating water and this is a growing trend.

Nowadays, hydrogen peroxide is used for cleaning screen, disc and gravel filters. It is also used as an oxidizing agent for fruits and vegetables prior to storage, and for disinfecting public premises.

Hydrogen peroxide is a strong oxidizing agent. It releases oxygen atoms that react quickly, oxidizing organic matter.

The advantages of hydrogen peroxide

- Quick reaction speed
- Environmentally safe
- Does not generate dangerous by-products.

Hydrogen peroxide is environment friendly, does not contaminate the soil, does not harm the aquifer, and indirectly makes more oxygen available for the soil and the plants.

The oxidation reaction is quick, so the hydrogen peroxide is consumed immediately upon contact with the irrigation water, and it is biodegradable. Its speed enables the use of the hydrogen peroxide for quick oxidation and disinfection of the water source and also in close proximity to the filters.

Hydrogen peroxide is also suitable for oxidizing iron and manganese.

Hydrogen peroxide is commonly used in greenhouses, net houses and tunnels, or on substrates, where the irrigation systems traverse only short distances. Chlorination could cause significant damage to the roots in substrates.

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 cc (ml) of hydrogen peroxide (active agent) are required for each cubic meter of water (1 to 10 PPM).

→ Uses of Hydrogen Peroxide

Hydrogen peroxide is a powerful oxidizing agent and is effective for the following:

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

Hydrogen peroxide is one of the most powerful known oxidizers. It always decomposes in an exothermic reaction into water and gaseous oxygen.

$$2\ H_2O_2 \Rightarrow 2\ H_2O + O_2$$

NOTE

Do not use hydrogen peroxide if the pipes and/or storage tanks are made of steel or asbestos cement or if they are covered with cement.Hydrogen peroxide is not effective for preventing or dissolving scale sediments, sand, etc.

Physical and chemical properties of hydrogen peroxide

Concentration	35%	50%
Physical state	Liquid	
Color	Colorless	
Characteristic odor	Yes	
Molecular weight H_2O_2	34.01	
Boiling point	108°C	114°C
Freezing point	-32°C	-51°C
Vapor pressure at 25°C	23 mm Hg	18 mm Hg
Specific gravity (H_2O = 1)	1.132	1.195
pH	<5	<4

NOTE

Due to reasons of safety and cost, Netafim™ recommends using a concentration of no more than 50% hydrogen peroxide.

→ Terminology

Injected hydrogen peroxide is the concentration (ppm) of the product, calculated at the injection point.

Residual hydrogen peroxide is the concentration (ppm) of the product, measured at the furthest treatment point.

Hydrogen peroxide requirements are high for waste water and industrial residual water, and low for potable water and other types of water with no organic load.

For waste waters or industrial residue conditions, it is not possible to calculate the required concentration of hydrogen peroxide. Therefore it is necessary to inject an arbitrary quantity, use the testing kit to verify the residual concentration at the end of the system, and correct the dosage accordingly.

For potable water or water without biological load, it is easy to calculate the quantity of hydrogen peroxide to be injected into the system.

→ Application Methods

There are two methods for applying hydrogen peroxide:

1. Continuous injection with low dosage

Hydrogen peroxide is injected continuously during the entire irrigation cycle. This is the most efficient method, but the consumption of hydrogen peroxide is the highest.

2. Selective injection

The frequency of this selective treatment should be determined according to the water quality in the system, and could be daily, weekly, monthly, etc.
Hydrogen peroxide is injected during the last hour of irrigation. Do not forget to take into account the time required by the hydrogen peroxide to reach the end of the system (see Advancement time, page 47).
With this method, both the consumption and the efficiency are lower than with continuous low dosage injection of hydrogen peroxide.

NOTE
The removal of all residual hydrogen peroxide from the system should be verified at its most distant point. Open the end of the third, fourth or fifth dripline from the end of the system, and let the water flow for 10 seconds before taking samples.

→ Designating the Injection Point

The hydrogen peroxide may be injected into a system at two different points. Each point has advantages and disadvantages.

Injection point location	Remarks
As close as possible to the irrigation system pump	Prevents the growth of bacterial slime in the main pipe and protects the irrigation system.
Far from the pump and as close as possible to the treated plot	Does not protect the main pipe and is not recommended in cases of effluent water, sulfur, iron and/or manganese.

→ Dosage

The required quantity of hydrogen peroxide depends on the water quality, the cleanliness of the pipes and the driplines, and the size of the system.

NOTE

Measure the hydrogen peroxide concentration using a hydrogen peroxide testing kit.
After injection, measure the residual concentration and adjust the dosage as follows:
- If the residual concentration is too low, increase the injected concentration.
- If the residual concentration is too high, reduce the injected concentration.

Recommended levels of hydrogen peroxide concentration before and after injection

Dosage of hydrogen peroxide

Injection method/purpose	Injected concentration (ppm)	Residual concentration (ppm)*
Continuous injection	< 50	0.5
Selective injection	50 - 100	2 - 3
Annual maintenance treatment of the irrigation system	200 - 500	8 - 10

*Measurements must be taken at the point furthest from the injection point.

Measuring the hydrogen peroxide concentration in a system

Controlling the quantity of residual hydrogen peroxide is an integral part of the treatment. Follow the guidelines below in order to ensure that the correct dosage is being used.

1. When using the continuous injection method, the hydrogen peroxide concentration must be examined regularly, at least once or twice a week. In addition, the injected quantity must be adjusted according to the residual concentration.
2. The concentration of hydrogen peroxide at the injection point should not be more than 500 ppm.
3. The residual concentration of hydrogen peroxide must be checked at the most distant point of the system.
4. Before taking a sample, open the final end of the dripline and allow the water to flow freely for 10-15 seconds.
5. Use the reagents in the hydrogen peroxide kit for measuring hydrogen peroxide concentrations.
6. If the hydrogen peroxide concentration in the water is higher than the testing kit capacity, the sample must be diluted with distilled water. To determine the concentration, multiply the result by the dilution factor.

Determining the quantity of hydrogen peroxide to inject into the system

The following examples show how to calculate the initial dosage for various concentrations of hydrogen peroxide. After injection, it may be necessary to adjust the quantity for future injections based upon the residual concentrations.

where:
- **V** = Volume (cc) of hydrogen peroxide to be added to the irrigation water for 45 minutes.
- **C** = Desired concentration of hydrogen peroxide in the water (ppm).
- **Q** = Flow rate of the treated system per hour (m^3/h).

- In order to calculate the required volume of hydrogen peroxide (35%) to be injected into the irrigation water for 45 minutes, use the following formula: V (cc) = 2.5 x C (ppm) x Q (m^3/h)
- In order to calculate the required volume of hydrogen peroxide (50%) to be injected into the irrigation water for 45 minutes, use the following formula: V (cc) = 1.8 x C (ppm) x Q (m^3/h)

EXAMPLE

Calculate the required volume of hydrogen peroxide (50%) to be injected into the irrigation water using the following data:

- Q = 100 m^3/h
- The required hydrogen peroxide concentration in the water and the system = 68 ppm
- The residual concentration of hydrogen peroxide is = 2 ppm
- C = 68 + 2 = 70 ppm
- V (cc) = 1.8 x C (ppm) x Q (m^3/h)
  = 1.8 * 70 * 100 = 12,600 cc
  = 12.6 liters of hydrogen peroxide (50%), to be injected for 45 minutes into a system with a flow rate of 100 m^3/h

NOTE

The recommended duration of injection is minimum 45 minutes and maximum one hour.

CHLORINE TREATMENT

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→ Safety

WARNING
Chlorine (liquid, solid or gaseous) is toxic and dangerous to humans.
Before using chlorine, read all the instructions for treatment with chlorine and follow all the local legal regulations and the manufacturer's instructions.
Proper handling of chlorine is the responsibility of the grower.

- Before filling any tank with chlorine solution, it must be flushed thoroughly to remove any remaining fertilizer or other chemical products.
- Avoid contact with the eyes. If chlorine comes in contact with the eyes, it can cause blindness.
- Avoid contact with the skin. If chlorine comes in contact with the skin, it can cause burns.
- Use protective clothing when working with chlorine: goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes.
- Avoid swallowing or inhaling. Swallowing chlorine or inhaling its vapors could be fatal.
- During treatment, a second operator must be present who can, if necessary, provide first aid.
- Stay in the location during the full duration of the treatment. Keep all unauthorized personnel away from the treatment area.

WARNING
Direct contact between chlorine and fertilizers might cause an explosive thermal reaction.
This is extremely dangerous!

NOTE
The injection of chlorine into irrigation water containing fertilizers is not recommended.

NOTE
When using anti-drain irrigation systems (CNL), the maximum recommended chlorine concentrations may be different and it is necessary to consult with Netafim™ before applying it.

→ Chlorine Injection into Drip Irrigation System

Chlorine is a strong oxidant. It is very useful for the following purposes:

- To prevent and eliminate the growth of organic slime, ferrous slime and sulfurous slime.
- To oxidize elements such as iron, sulfur, manganese, etc.
- To clean organic sedimentation and bacterial slime from irrigation systems.
- To improve filtration efficiency, especially for gravel or sand filters.

NOTE
Chlorine is effective only on organic matter.
Chlorine is ineffective against inorganic materials, such as sand, silt, minerals, scale, etc.

→ Products

Chlorine is available for commercial use in gaseous, liquid or solid state. Each type has its advantages and disadvantages. The suitability, availability and price of each material must be taken into account before deciding which to use.

Commonly available forms usually include:

- Gaseous chlorine (Cl_2, 100% active chlorine).
- Solid chlorine (calcium hypochlorite, contains 60-85% active chlorine).
  If the water contains high alkaline levels, hardness and/or high pH, it is recommended not to use this form.
- Liquid chlorine (sodium hypochlorite, contains 7-13% active chlorine). Liquid chlorine is unstable and decomposes quickly in the storage tank, depending on time, temperature and solar radiation.

NOTE

Do not store liquid chlorine for long periods of time. Keep the storage tank in the shade.If it must be kept under direct sunlight, paint the storage tank with white paint.

→ Application Methods

Use one of the two following chlorination methods:

Continuous injection

Chlorine is continuously injected during the entire irrigation cycle. This is the most efficient method, but chlorine consumption is the highest.

Selective injection

The frequency of this selective treatment will be determined according to the water quality in the system, and could be daily, weekly, monthly, etc.

Chlorine is injected during the last irrigation hour. Take into consideration the time it takes for chlorine to get to the end of the system (see Advancement time, page 49). With this method, both chlorine consumption and efficiency are lower than with continuous chlorination.

→ Designating the Injection Point

Chlorine can be injected at two different points of the system. Each position has its advantages and disadvantages.

Injection point location	Remarks
As close as possible to the irrigation system pump	Prevents the growth of bacterial slime in the main pipe and protects the irrigation system.
Far from the pump and as close as possible to the treated plot	Does not protect the main pipe and is not recommended in cases of effluent water, sulfur, iron and/or manganese.

→ Dosage

NOTE

It is dangerous to inject chlorine and acid into the same injection point at the same time.When it is necessary to reduce the pH using acid injection, chlorine and acid must be injected at two different points, with at least 3 meters between the two points.

The acid injection point must be upstream from the chlorine injection point.

During chlorine injection, it is forbidden to reduce the pH level of the water to below 6.

The required quantity of chlorine depends on the water quality, the cleanliness of the pipes and driplines, and the size of the system.

Measuring the chlorine concentration in the system

Controlling the level of residual chlorine is an integral part of the treatment. Follow the guidelines below in order to ensure that the correct dosage is applied.

1. Chlorine concentration

Type of irrigation and dripper	Chlorine concentration at the injection point
With non compensated drippers	Limited by crop sensitivity
With pressure compensated drippers	< 30 ppm + limited by crop sensitivity
Pulse irrigation with pressure compensated anti-drain (CNL) drippers	< 10 ppm + limited by crop sensitivity (flush driplines after treatment)

2. The chlorine concentration must be checked regularly, at least once or twice a week.
When the continuous injection method is used, the injected quantity must be adjusted initially according to the residual concentration.

3. The residual concentration of chlorine must be checked at the point furthest from the injection point within the system.

Residual chlorine = Injected chlorine – Chlorine demand in the system

4. Before taking a sample, open the end of the dripline and allow the water to flow freely for 10 seconds.

5. The chlorine testing kit has two reagents, in order to measure both the free chlorine and the combined chlorine.
When chlorine is tested in drainage, treated and/or residual water, or when a fertilizer with an ammonium base is injected to the system, measure the combined chlorine.

6. If the chlorine concentration in the water is higher than the capacity of the testing kit, the sample must be diluted using distilled water only.
In order to determine the concentration, multiply the result by the dilution factor.

The residual chlorine measured with the kit is the result of the injected quantity of chlorine less the quantity of chlorine consumed during the treatment due to its action, mainly on the existent organic/biological matter.

NOTE
The residual chlorine must be verified at the furthest point of the system. Open the end of the fourth or fifth dripline from the end and let the water flow for 10 seconds before taking the sample.

NOTE
Measure the chlorine concentration using a chlorine testing kit.

Chlorine dosage

The following table lists the recommended chlorine concentration levels to be injected and the required residual concentration of chlorine.

Injection method/purpose	Concentration to be injected	Residual concentration*
Continuous injection	10 ppm	0.5 - 1.0 ppm
Selective injection	30 ppm	2.0 - 3.0 ppm

*The measurement must be taken at the point furthest from the injection point.

After injection, measure the residual concentration and adjust the dosage as follows:

- If the residual concentration is too low, increase the injected concentration or extend the injection time.
- If the residual concentration is too high, decrease the injected concentration.

Determining the quantity of chlorine to inject into the system

The quantity of chlorine to be injected will depend on the type of chlorine used.

Gaseous chlorine

When gaseous chlorine is used, the dosage is based on a chlorinator. A chlorinator controls the gas flow. The calculation is simple since the material is pure (100%).

1 g of gaseous chlorine in 1 m^3/h of water = 1 ppm

Calculate the flow rate of gaseous chlorine in the system, as follows:

Flow rate of the treated system	100 m^3/h
Desired residual chlorine at the end of the system	1 ppm
Chlorine demand in the system	4 ppm
Concentration required at the injection point	5 ppm (1 + 4)

The flow rate of gaseous chlorine in the system = 5 * 100 = 500 gr/h (grams per hour).

Liquid and solid chlorine

Liquid chlorine is much less stable than solid chlorine. Do not store liquid chlorine for long periods of time.

Calculate the flow per hour of injected chlorine solution, as follows:

Flow rate of the treated system	100 m^3/h
Concentration of injected chlorine solution	10%
Desired residual chlorine at the end of the system	1 ppm
Chlorine demand in the system	4 ppm
Concentration required at the injection point	5 ppm (1 + 4)

Formula for calculating the chlorine solution injection:

$$\text{Flow rate of injected chlorine solution in l/h} = \frac{\text{Required chlorine concentration (ppm)} * \text{Flow rate of treated system (m}^3\text{/h)}}{\text{Concentration of injected chlorine solution} * 10}$$

The number 10 in the formula is a coefficient that simplifies the conversion of units.

$$\text{Flow rate of the chlorine solution injected into system} = \frac{5\text{ ppm} * 100\text{ m}^3\text{/h}}{10 * 10} = 5\text{ l/h of chlorine solution}$$

NOTE
The recommended injection time is at least 45 minutes.

NOTE
All the recommendations and examples presented here refer to open field crops (fruits, grains, vegetables, etc.). For treatments in protected crops (greenhouses, tunnels, etc.), consult with the Netafim™ Agronomy Division.

IRON AND MANGANESE REMOVAL

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WARNING
Chlorine (liquid, solid or gaseous) is toxic and dangerous to humans.
Before using chlorine, read all the instructions for treatment with chlorine and follow all the local legal regulations and the manufacturer's instructions.
Proper handling of chlorine is the responsibility of the grower.

- Before filling any tank with chlorine solution, it must be flushed thoroughly to remove any remaining fertilizer or other chemical products.
- Avoid contact with the eyes. If chlorine comes in contact with the eyes, it can cause blindness.
- Avoid contact with the skin. If chlorine comes in contact with the skin, it can cause burns.
- Use protective clothing when working with chlorine: goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes.
- Avoid swallowing or inhaling. Swallowing chlorine or inhaling its vapors could be fatal.
- During treatment, a second operator must be present who can, if necessary, provide first aid.
- Stay in the location during the full duration of the treatment. Keep all unauthorized personnel away from the treatment area.

WARNING
Direct contact between chlorine and fertilizers might cause an explosive thermal reaction.
This is extremely dangerous!

NOTE
The injection of chlorine into irrigation water containing fertilizers is not recommended.

NOTE
When using anti-drain irrigation systems (CNL), the maximum recommended chlorine concentrations may be different and it is necessary to consult with Netafim™ before applying it.

Hydrogen peroxide

WARNING
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.
Proper handling of hydrogen peroxide is the responsibility of the grower.

- Before filling any tank with hydrogen peroxide solution, flush it thoroughly to remove any traces of fertilizers.
- Avoid contact with the eyes. The contact of hydrogen peroxide with the eyes can cause blindness.
- Avoid contact with the skin. The contact of hydrogen peroxide with the skin can cause burns.
- Use protective clothing when working with hydrogen peroxide. Use goggles, gloves, mask, long pants, long-sleeved shirts, and high closed shoes.
- Avoid swallowing or inhaling. Swallowing hydrogen peroxide or inhaling its vapors could be fatal.
- During treatment, a second operator must be present who can, if necessary, provide first aid.
- Remain on site during the entire duration of the treatment. Keep all unauthorized personnel outside the treatment area.

WARNING

Direct contact between hydrogen peroxide and fertilizers or other chemical products could create a thermal reaction which could cause the tank to explode. This is highly dangerous.

NOTE

The injection of hydrogen peroxide into irrigation water containing fertilizers is not dangerous.

Other substances

Other substances such as potassium permanganate, chlorine dioxide, ozone and other oxidizing agents are metioned in this chapter. When using these substances, strictly observe the related safety instructions.

WARNING

When not handled properly, 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 chemicals is the responsibility of the grower.

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

→ Introduction

Iron and manganese are metals commonly found in soil, and therefore also in water. They are usually in reduced form in groundwater, but as soon as the water is pumped up for irrigation, partial oxidation occurs. In this state, these metals present a potential clogging hazard to the irrigation system if they are not treated.

Although iron and manganese are present in surface water, as well, they are usually completely oxidized; this significantly reduces the potential of clogging and facilitates treatment.

Iron and manganese are liable to cause dripper clogging because of their residue, as well as the combination of iron and manganese bacteria with other chemical residues. Even in very low concentrations, including those lower than the accepted standard for drinking water of 0.3 mg/liter, iron and manganese can block micro-irrigation systems.

However, in some cases we don't anticipate any problems with using water with a high iron concentration (above 1 mg/liter), based on consideration of all the physical, organic and biological parameters, and not only the iron concentration. Even water from the same source might react differently at different times.

Netafim™ has determined that the accepted thresholds in water for use in drip irrigation systems are 0.3 mg/l of iron and 0.2 mg/l of manganese.

Iron is found in water in two different states of oxidation: a reduced state (ferrous iron) as a water-soluble bivalent ion - Fe+2, or an oxidized state (ferric iron) trivalent hydroxide - Fe+3, which is insoluble in water.

Manganese is also found in water in a soluble reduced form - Mn+2 - or in an oxidized state - Mn+4, as a residue of manganese.

Iron and manganese bacteria are chemotropic bacteria capable of oxidizing bivalent iron and manganese in aerobic situations and exploiting the energy for their own development. These bacteria can cause the accumulation of oxidized metal residues among the bacterial waste, creating a large quantity of sticky residue (slime) that blocks the irrigation system.

→ Removal Process

The removal of iron and manganese from the water is performed in two stages, chemical and physical:

Chemical stage

The oxidation of reduced soluble iron or manganese into insoluble compounds, such as ferric hydroxide or manganese dioxide, according to the following formulas:

$$2Fe^{+2} + \tfrac{1}{2}0_2 + 5H_2O \leftrightarrow 2Fe(OH)_3 + 4H^+$$

$$Mn^{+2} + \tfrac{1}{2}0_2 + H_2O \leftrightarrow MnO_2 + 2H^+$$

Physical stage

The removal of ferric and manganese deposits by means of of sedimentation and filtration.

In irrigation water, the removal of oxidized iron is usually incomplete because of the high flow rate; it is still necessary to oxidize all of the iron and achieve maximum removal.

The oxidation of iron and manganese is a very important, fundamental step in their removal from irrigation water. After oxidation, ferric and manganese residues transform into inert small-grained particles, which pose a smaller risk of clogging even if they are not completely removed from the water. Oxidation also prevents the development of iron and manganese bacteria, which together with other metal residues represent a clogging factor for micro-irrigation components.

Iron and manganese can be oxidized using air or other oxidizing materials, such as chlorine, hydrogen peroxide (H_2O_2), potassium permanganate ($KMnO_4$), chlorine dioxide, ozone or a combination of aerobic oxidation and the use of an oxidizing agent.

Iron oxidation by air is a relatively swift process that depends on the pH of the water. Under neutral or basic conditions (pH = 7), over 70% of the iron is oxidized when exposed to air for only 30 minutes. The oxidation of manganese by air takes much longer.

When the pH is high, the oxidation of iron and manganese by air is faster, and when the pH is low, the process is slower. The opposite is true for oxidation by chlorine.

Iron oxidation by air can be executed in an open system, in an aeration unit sometimes used for sedimentation, or in a closed system where compressed air is introduced into the water treatment system connected to the irrigation system. When iron is oxidized by means of pressurized air, the oxygen concentration in the water rises in direct proportion to the air pressure in the system. The rise in oxygen concentration increases the iron oxidation rate considerably.

Manganese oxidation requires a substantial time span; therefore, it is only recommended in aeration or sedimentation units.

In acidic water with a pH level lower than 5.8, iron is found in a dissolved state and is very difficult to remove, but in small concentrations it does not lead to clogging. The addition of fertilizer or a basic agent is liable to raise the water pH and cause the iron to settle.

The aim of treating iron and manganese in an open system is to expose the water to atmospheric oxygen, causing iron and manganese oxidation, and thereby enabling sedimentation of the majority of the iron and manganese in the oxidation unit. In many cases, in addition to aerating the water and increasing the concentration of dissolved oxygen, the exposure of water to air leads to the release of CO_2 and reduced soluble compounds, making the pH level rise. This, in turn, accelerates the rate of iron and manganese oxidation. In order to attain better aeration and efficient iron oxidation, the water is poured into the iron removal unit via steps and waterfalls or through different types of sprinklers. This generates maximal surface-area exposure and contact time.

The volume of the oxidation unit must to be planned according to the capacity of the water pumping system, to allow the contact time necessary for total oxidation of the iron and manganese, according to the water pH.

It is advisable to plan a larger volume reservoir, allowing a delay time of a day or more, in order to attain sedimentation in addition to oxidation.

In a closed system, iron removal is accomplished by the introduction of an oxidizing agent (compressed air), an oxidizing product or a combination of the two into the water system. After the oxidizing agent is introduced, the water passes through a hydrocyclone and undergoes vigorous mixing, thereby oxidizing the iron. Following oxidation, the water passes through a gravel filter for iron removal. Oxidation by compressed air is suitable for iron removal only when the pH is higher than 7.5; it is unsuitable for manganese oxidation because of the long period of time required.

In irrigation systems that use compressed air for oxidation, vigorous mixing is required to ensure that the air dissolves and remains in the water for a long time, in order to oxidize the iron prior to water filtration. It is recommended that the air or the oxidizing agent be introduced close to the water source and the filter battery be installed at the head of the irrigation plot to ensure maximum time for oxidation.

The addition of a hydrocyclone before the gravel filters ensures that the air or oxidizing agent is mixed well into the water and that some of the iron deposits are already separated. The addition of a long piece of wide-diameter (low velocity) pipe or a pressure tank can offer a simple and inexpensive solution for extending the total oxidation time.

→ Filtration

Following the oxidation of iron and manganese by means of an oxidation basin, compressed air, or chemical oxidation, it is necessary to remove the iron and manganese from the water using physical methods, including initial treatment by sedimentation or rapid hydrocyclonic mixing, mainly by filtering.

It is very important to remove the majority of the oxidized particles even though they are often very small, because these particles are liable to amalgamate to form larger particles or become reintroduced into the irrigation water, thus re-oxidizing in the drippers and developing ferric and manganese bacteria.

The oxidized particles are very small and composed of an agglomeration of very brittle particles. Therefore, only gravel or sand filters can efficiently remove iron and manganese; screen and disc filters are not suitable for their removal. The long period of time the water spends in the gravel filters also contributes to oxidation and assimilation of the iron while in the filter.

The efficiency of iron and manganese removal in a gravel filter is influenced by four main factors. They are presented below in the order of their importance.

1. Filtering flux

As in all gravel filtration, the filtering rate has a critical effect on the quantity of particles removed. A lower filtering flux leads to better assimilation of the particles in the gravel and thus more efficient removal. Complete iron and manganese removal requires low velocity filtration, not exceeding 12.5 m/h.
When filtering water for irrigation, it is not economically feasible to work at such low rates, so the flow rate should be adapted according to the manufacturer's recommendations for high-limit velocity filtration of about 30 m/h.

2. Gravel size

The smaller the gravel size, the more effective the removal of iron and manganese. The size of the gravel affects the filter's absorption and the planned flow rate. Thus it is not viable to use too fine a grain in irrigation filters. For the accepted flow rate described above, quartz sand with grains of 0.65 - 0.85 mm in diameter can be used.

3. Gravel depth

The depth of the gravel influences filtering efficiency: the deeper the gravel, the more efficient the removal. Increasing gravel depth also increases the contact time for iron oxidation in closed systems and improves its removal by filtration. For iron and manganese filtration, it is possible to use a standard agricultural gravel filter with a depth of only 40 cm, although it is sometimes advisable to use a deeper filter, containing at least 60 cm.

4. Sand type

The advantage of catalytic sand is that this medium is capable of removing both iron (Fe) and manganese (Mn) simultaneously through catalytic oxidation and retention of precipitate. In this way, the two processes - oxidation and filtration - are performed together.

PEST CONTROL

→ Rodent Control 69
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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.

CAUTION
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

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™ 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™ 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™ (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) (see Advancement Time, page 49).
- In CNL systems, open the end of the driplines for flushing the system after completing the plain water irrigation cycle..

/PERIODS OF SYSTEM INACTIVITY

→ Preparing the System for Periods of Inactivity 75

→ Winterization of the System 75

→ System Startup Procedures 78

→ Preparing the System for Periods df Inactivity

Whenever a drip irrigation system is expected to be inactive for more than 60 days it should be prepared to withstand the period of inactivity.

The following procedures must be implemented:

- Chemical injection (see Chemical injection, page 44).
- Filter back-flushing (see System flushing, page 17).
- Flushing the main, sub-main, distribution lines and flushing manifold (see System flushing, page 17).
- Flushing the driplines (see System flushing, page 17).
- Preparation of the pumping system (see Pumps, page 76).
- Preparation of water tanks: Make sure the tanks are constantly full of water and the liner is securely tied.

→ Winterization of the System

Winterizing guidelines for irrigation systems in regions with freezing hazards

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 subsurface pipes and driplines 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 subsurface pipelines.

Water tanks and soil reservoirs coated with PE or PP liners

The optimal condition for a water tank to be in is full of water, throughout the year.
The water will prevent wind damage to the liner and to the metal walls of the tanks.

Wintertime regulations

The same recommendations apply for the freezing period in winter, with the addition of the following instructions:

- The liner becomes very sensitive to movements, strikes and vibrations when the temperature drops below 0°C (32°F). Therefore it is important to keep it still, with minimum movements caused by the wind.
- The wind tends to penetrate the gap between the liner and the metal walls, and blow the liner off. The best way to avoid this is by keeping the tank full with water.
- According to manufacturers' experience, the ice will not damage the metal walls or the liner, unless water is pumped/drained from the bottom of the tank when a layer of ice exists on the top water surface. In such case - a hole should be drilled in the ice layer and a pipe of a diameter suitable for the filling flow rate should be inserted into it. Water should be added through the pipe to avoid an air cavity between the ice and the water.

- If the intake and the supply line to the pumps are steel pipes - no special preparations are required to protect them. If they are PVC lines - they should be drained and then sealed to prevent water penetration during the winter.
- To avoid penetration of water into the supply line, a manual valve should be installed at the water tank outlet and kept closed during the freezing period.

Pumps

Proper preparation of the pumping system for extended periods of non-use in freezing as well as non-freezing climates is important in order to preserve the system's performance and duty-life expectations. Investing a short amount of time and following the procedures below will preserve the pumping system's performance and longevity.

General preparation

- Disconnect the power to the pumping system before beginning any work.
  Ensure that the winterized pump cannot be accidentally activated and insulate any exposed leads.
- Remove exterior dirt and grime and any substance that may trap moisture. Exposed metal is subject to oxidation; prime and repaint as necessary. Ensure motor vent screens are clear of debris.
- Flush suction and discharge lines. Check for leaks and replace any worn gaskets.
- Drain the pump by opening the air bleed valve or port plug on top of the pump impeller chamber and remove the port plug closest to the bottom of the chamber (if applicable).
- Flush the pump and clean rust and debris that may have accumulated in the impeller chamber (if applicable).
- Precaution must be taken to ensure that the exposed tank(s) (if applicable) and piping are also drained.
  A low pressure (3.5 meters), high-volume blower may be used to purge the system with air.
- If the pump is to be stored wet, do not use anti-freeze solutions other than propylene glycol.
  Propylene glycol is non-toxic and will not damage components in the pump and/or pumping system.
  Use a 40% propylene glycol / 60% water solution to protect the pump at temperatures down to -45ºC.
- Lubricate bearings (refer to the Pump Owner's Manual).
- Keep the pump clean and dry during the storage period to guard against corrosion.
  Shelter the pump from elements when possible.
- To avoid condensation and corrosion problems, do not wrap or seal the pump with plastic.
  Air must be permitted to circulate around the pump.
- Rotate the pump's axle periodically to prevent freeze up of internal components and keep bearings coated with lubricant to prevent oxidation and corrosion.
- Grease the pump according to the instructions in the pump manual.
  (If the pump is equipped with grease nozzles, it may be serviced with a grease gun.)

Removal of pump from installation site (if applicable)

- Place fittings (bolts, nuts, shims (spacers), wire nuts, pipe fittings, etc.) in a heavy gauge plastic bag and attach it to the pump. Remove the pressure gauge from the system (and others gauges if necessary) and store them with the pump.
- Seal all open ports to keep out foreign objects, insects, rodents, dust and dirt.
  Replace gaskets as necessary.
- Disconnect all suction piping from water reservoir (if applicable) to prevent freeze damage,
  or alternatively drain all suction piping.

Head control

- The head control and particularly the filters should be examined for dirt and sediments and treated accordingly (chlorine or acid treatment).
- For gravel filters, the final result of the treatment should be clean, loose gravel, with no caking or cracking.
- After the treatment, the filters, the fertilizer injection unit and all the components of the head control should be flushed with clean water.
- Then, the head control should be emptied of water, so that all the components are dry: filters, manifolds, water meters and valves.
- The fertilization system should be protected from the elements.
- The openings in the system (as a result of removing the accessories), need to be well covered to prevent dirt and animals from getting inside; however, air should be permitted inside to avoid condensation.

Main line

- All main lines, sub-mains and driplines should be flushed (see System Flushing, page 17).
- Then, the flushing valves should be opened at the low points to enable the water in the pipes to flow out.
- In freezing areas - If water still accumulates at the end of the lines, and the lines do not drain completely, it is necessary to expel the remaining water from the pipe.
- All openings in the main line (due to valve removal) should be covered by a plastic bag to avoid penetration of animals and dirt.

Risers and valves

It is necessary to ensure that no water remains in the valves and their risers.

> ⚠ **WARNING**
> At low temperatures, PVC risers can break, even if touched lightly.

- The location of PVC risers should be marked by 4 colored (red and white) high posts around the risers.
- It is important to let the water out of the command chamber of the valves and from the command tubes.

Sub-mains

- It is necessary to drain the sub-main pipes of water towards the lower points, and if water remains at the line ends, it should be pumped out.
- The line ends of the sub-mains should be marked by 4 colored (red and white) high posts.

Driplines

There is no special winter preparation for driplines, besides the standard hydrogen peroxide/acid treatments and flushing, as the driplines drain through the drippers, and even if some water remains, it will not damage the driplines.

TIP

Pressure regulators and sub surface driplines 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 (12m)
- 1/4” F *1/2”M brass coated bushing
- Pressure gauge 250 GLZ 6 bar 1/4” BSP
- 3/4” ball valve with long handle
- Flare 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.

FORMS

→ System Description Form 80

→ Hydraulic Conditions Checklist 82

→ Maintenance Activities Monitoring Form 83

→ System Description Form

When Netafim's support or advice are needed, complete the System Description Form with regard to the plot in question.

<table>
<tr><td colspan="2">Name:</td><td>Country:</td></tr>
<tr><td colspan="3">Definition of the Problem: ☐ Clogging, ☐ Routine test,
☐ Other:</td></tr>
<tr><td colspan="3">General Information</td></tr>
<tr><td colspan="3">Type of irrigation: ☐ PC, ☐ UniRam™, ☐ MegaNet™,
☐ Other:</td></tr>
<tr><td colspan="2">Age of the equipment:</td><td>Size of the system (ha):</td></tr>
<tr><td colspan="2">System flow rate (m³/h):</td><td>Total length of dripline per hectare (m):</td></tr>
<tr><td colspan="3">Location of the driplines: ☐ Surface, ☐ Sub surface - depth (m):</td></tr>
<tr><td colspan="2">Emitter flow rate (l/h):</td><td>Average length of dripline (m):</td></tr>
<tr><td rowspan="2">Operating pressure:</td><td colspan="2">Downstream from the head control filter (bar):</td></tr>
<tr><td colspan="2">At the end of the dripline with the lowest pressure (bar):</td></tr>
<tr><td colspan="3">Irrigation frequency (specify units, for example hours/day, days/week, pulses):</td></tr>
<tr><td colspan="3">Soil composition: ______ % sand, ______ % silt, ______ % clay</td></tr>
<tr><td colspan="3">Crop:</td></tr>
<tr><td colspan="3">Water source: ☐ Well, ☐ River, ☐ Lake, ☐ Dam, ☐ Reservoir, ☐ Canal,
☐ Other:</td></tr>
<tr><td>Reservoir size:</td><td>Holding time:</td><td>Maximum water depth:</td></tr>
<tr><td colspan="3">Pump Data</td></tr>
<tr><td colspan="3">Type of pump: ☐ Horizontal, ☐ Vertical, ☐ Other:</td></tr>
<tr><td colspan="3">In case of a floating suction point -
Pumping depth (in relation to the surface of the water):</td></tr>
<tr><td colspan="3">In case of a permanent suction point -
Location of the suction point (Distance between the surface and the suction point):</td></tr>
<tr><td colspan="3">Direction of suction: ☐ Vertical upwards, ☐ Horizontal, ☐ Vertical downwards</td></tr>
</table>

Pipe Data	
Distance between the water inlet and the pumping point:	
Length of the blank pipe from the pump to the plot head:	Pipe diameter:
Type of pipe: ☐ Steel, ☐ PVC, ☐ PE, ☐ Cement, ☐ Other:	
Filter Data	
Working pressure at the head control filter inlet and outlet (bar) - Inlet: _____ Outlet: _____	
Main filters: ☐ Gravel, ☐ Disc, ☐ Screen, ☐ Hydrocyclone sand separator	
Control or sub-main filters: ☐ Screen, ☐ Disc, ☐ Other - specify type:	
Filtration level (microns):	Filters flushing frequency:
☐ Filtration system works properly. ☐ Automatic filter works properly but the control filters clog quickly. ☐ Automatic filter clogs quickly and is back-flushed frequently.	
Data on injecting fertilizers and chemical products	
Specify the type of fertilizer/chemical product injected into the system:	
Concentration of fertilizer/chemical product/s injected into the system:	
Dose of fertilizer/chemical product injected into the system (l/m^3/h):	
Specify the formula used for injection:	
Specify any additional chemical product injected into the dripping systems:	
Water Treatments: ☐ Chlorination, ☐ Acid Treatment, ☐ Other:	
Information about emitters	
Specify the number of clogged emitters: ☐ Many, ☐ Some, ☐ Few, ☐ None, %: _____	
Indicate the location of the obstructed emitters: ☐ The last dripline, ☐ The last drippers of a few driplines, ☐ Uniform dispersion in the plot	

→ 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.

Use 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 planned system 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 ±5%.

If a deviation greater than ±5% is recorded at any point in the system, call your local Netafim™ 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, page 11).

If a deviation greater than ±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™ representative.

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

	At the pump outlet		Filter		Plot name/number:	
Date	**Flow rate** (m^3/h or l/sec)	**Pressure** (bar)	**Inlet pressure** (bar)	**Outlet pressure** (bar)	**Pressure after the plot valve** (bar)	**Pressure at the end of the furthest dripline** (bar)
Planned* __ / __ / __						
Benchmark** __ / __ / __						
__ / __ / __						
__ / __ / __						
__ / __ / __						
__ / __ / __						
__ / __ / __						
__ / __ / __						
__ / __ / __						
__ / __ / __						

→ Maintenance Activities Monitoring Form

Keeping track of the system's hydraulic conditions - flow rate and pressure - immediately after each maintenance activity is of utmost importance for the proper maintenance of the system along its many years of service.

Use the Maintenance activities monitoring form to keep track of all the maintenance activities performed on the system.

Fill-in the table's first row* with the planned system 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).

Key Maintenance activities

Flushing

- Pump
- Filter
- Main line
- Sub-main line
- Driplines

Substance injection

- Hydrogen peroxide
- Acid
- Pesticide
- Root intrusion prevention

Fill in the following rows with a description of each maintenance activity, concentration of the substance (in case of injection) and the actual hydraulic conditions data recorded immediately after the maintenance activity.

If a deviation greater than ±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™ representative.

The Maintenance activities monitoring form should be filled in regularly and kept for future reference.

Date	Maintenance activity	Substance concentration (in case of injection)	At the pump outlet		Filter		Plot name/ number:	
			Flow rate (m^3/h or l/sec)	**Pressure** (bar)	**Inlet pressure** (bar)	**Outlet pressure** (bar)	**Pressure after the plot valve** (bar)	**Pressure at the end of the furthest dripline** (bar)
Planned* __ / __ / __								
Benchmark** __ / __ / __								
__ / __ / __								
__ / __ / __								
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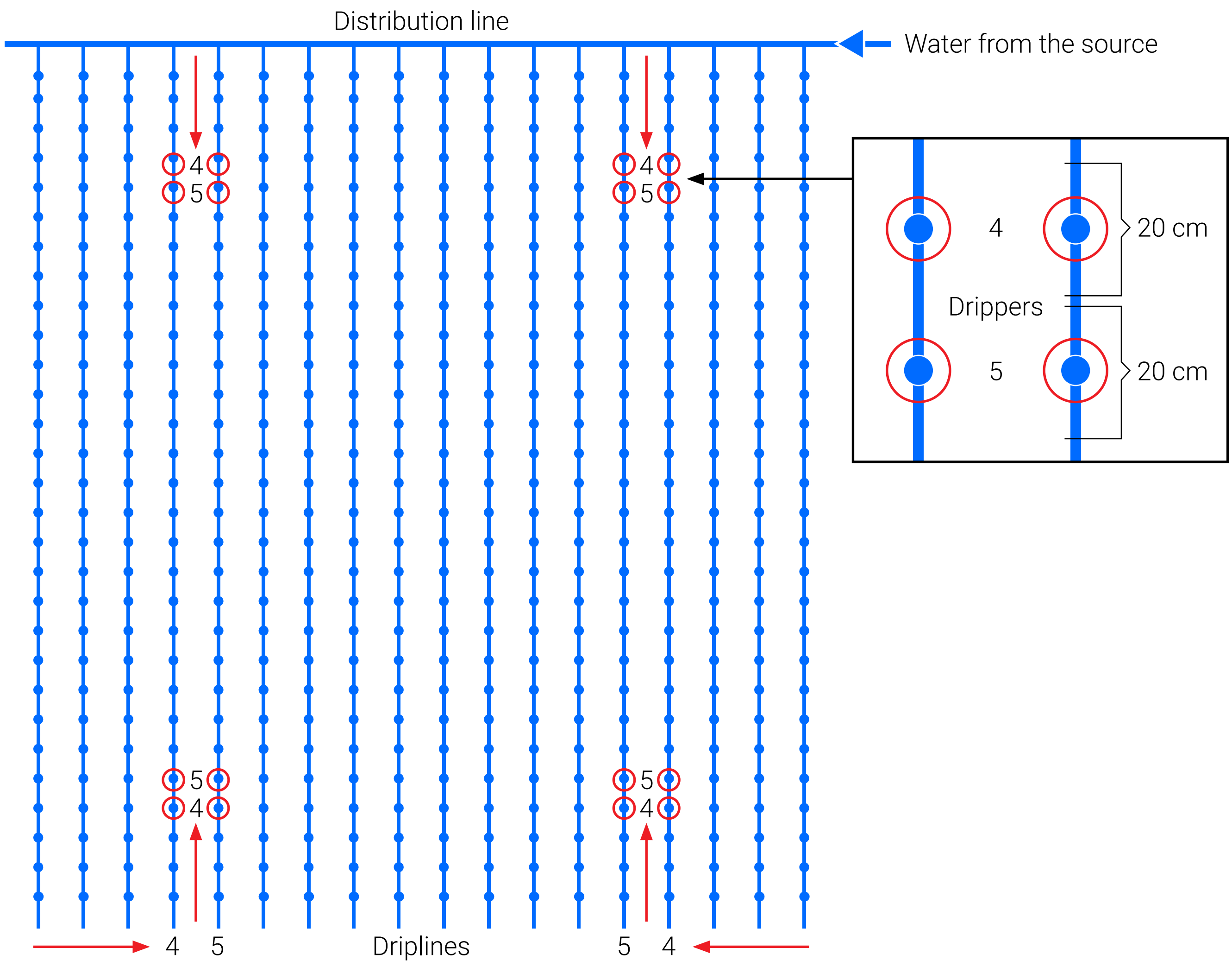
→ Sampling Drippers

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 4th and 5th driplines at the beginning and at the end of the dripline.
- The driplines to be sampled are those located in the 4th and 5th 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™ 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.

NOTE

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 dripline sample of at least 20 cm, in the same way as done for integral drippers.

→ 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™ 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)
- **HCO_3** (bicarbonate)
- **CO_3** (carbonate)
- **Alk** (alkalinity)
- **Cl** (chloride)
- **SO_4** (sulfate)
- **PO_4** (phosphate)
- **$N\text{-}NH_4$** (nitrogen-ammonium)
- **$N\text{-}NO_3$** (nitrogen-nitrate)
- **B** (boron)
- **Fe** (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™ 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.

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.

→ 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 (m^2)	1 square meter (m^2) = 0.0001 hectare (ha)
1 acre (ac) = 4,047 square meters (m^2)	1 square meter (m^2) = 0.00025 acre (ac)
1 hectare (ha) = 0.004 square mile (mi^2)	1 square mile (mi^2) = 259 hectares (ha)
1 hectare (ha) = 15 mu	1 mu = 0.0666 hectare (ha)
1 square kilometer (km^2) = 0.386 square mile (mi^2)	1 square mile (mi^2) = 2.59 square kilometers (km^2)
1 square centimeter (cm^2) = 0.155 square inch (in^2)	1 square inch (in^2) = 6.452 square centimeters (cm^2)
1 square foot (ft^2) = 0.155 square inch (in^2)	1 square meter (m^2) = 10.76 square foot (ft^2)

Flow	
1 cubic meter per hour (m^3/h) = 264.1721 gallons (USG) per hour (gph)	1 gallon (USG) per hour (gph) = 0.0038 cubic meter per hour (m^3/h)
1 liter per hour (l/h) = 0.2641721 gallon (USG) per hour (gph)	1 gallon (USG) per hour (gph) = 3.785 liters per hour (l/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		
°Celsius		°Fahrenheit
0	=	32
5	=	41
10	=	50
15	=	59
20	=	68
25	=	77
30	=	86
35	=	95

Power
1 kilowatt (kW) = 1.341022 horse power (HP)
1 kilowatt (kW) = 56.91965 British thermal units per minute (BTU/min)
1 horse power (HP) = 0.7456999 kilowatt (kW)

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 section provides the reader with links to recommended complementary documents that discuss drip irrigation-related subjects at length.

Drip Irrigation Handbook

The document presents the basic concepts regarding drip irrigation, familiarizes the reader with the components of a drip irrigation system and their functions, and provides understanding of the basic operational issues regarding the system.
It is intended for Netafim's personnel and its representatives and agents throughout the world, and for its clients, their decision makers, managers and operational personnel.

Sub surface Drip Irrigation (SDI)

SDI 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 for locating 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 specifications of drippers and driplines, a table of all active catalog numbers and basic packaging data.

Fittings & Accessories - Product Catalog

The Netafim™ Fittings and Accessories product families are designed to complement and support efficient and professional utilization of dip irrigation systems.
The Netafim™ Accessories and Fittings 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™ offers a wide variety of application tools and accessories designed for simple, rapid and efficient installation and removal of driplines while 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's comprehensive range of pipe connector systems is made of high-resistance and high-durability polymers. Use the catalog to select the right line for your application: barb connectors, fast ring connectors, flare 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 and 9*12 and 8-mm micro-tubes.

→ Frequently Asked Questions (FAQ)

Operational issues

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How should I plan an efficacious maintenance program for my drip irrigation system? 10

How should I monitor the performance of the various components of my drip irrigation system? 13

Is regular flushing of the various components of a drip irrigation system an intricate task? 15

My drip irrigation system is going to be inactive for a prolonged period - are there any specific preparations to make? 75

My field is in a cold area susceptible to freezing temperatures during the winter; are there any special precautions to take when the system is inactive? 75

How do I restart the drip irrigation system after a period of inactivity? 78

Nutrigation™ and chemigation issues

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Why it is important to reduce water pH? 27

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Can I apply organic nutrients through my drip irrigation system? 41

In organic agriculture, is it possible to apply acid treatment through the drip irrigation system? 41

Is it possible to apply chemicals such as insecticides, fungicides, nematicides, herbicides, etc., through the drip irrigation system? 44

What is “advancement time”? 47

What precautions should I take when applying hydrogen peroxide treatment? 52

What are the hazards of chlorine injection through a drip irrigation system? 58

Pest and rodent issues

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Dripper clogging issues

How can I prevent soil/sand particles from clogging the drippers? 27

How can I reduce roots from penetrating the drippers? 29

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