INTERNATIONAL STANDARD

ISO 24120-2

First edition
2023-01

Agricultural irrigation equipment — Guideline on the implementation of pressurized irrigation systems —

Part 2:
Drip irrigation

Matériel agricole d'irrigation — Lignes directrices relatives à la mise en œuvre des systèmes d'irrigation sous pression —

Partie 2: Irrigation goutte à goutte

Reference number
ISO 24120-2:2023(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 18, *Irrigation and drainage equipment and systems*.

A list of all parts in the ISO 24120 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Dwindling vital natural resources, such as land and water, and rising world population, pose a constant threat that can develop into a future food and water crisis. Given the limited availability of water and land resources, the amount of food grown today needs to be increased to meet the demands of tomorrow. Reduction of available water for human consumption needs to be addressed. As direct consumption of fresh water by populations cannot be decreased, the amount of water consumed by agricultural uses needs to be reduced and allocated for domestic or industrial use.

Drip irrigation addresses water scarcity and other environmental considerations. Its use can save large amounts of water (over 50 % of water can be saved for certain crop types) and increase yields.

Drip irrigation not only addresses the need to reduce water consumption and increase yield, but also requires less labour and energy for operation, leading to lower costs to farmers due to reduced usage of labour, fertilizers and other chemicals.

Drip irrigation relates to sustainability agriculture issues, and can be used in dry areas, in saline soil with saline water, and in steep-sloped topographies, where other irrigation methods cannot be practiced without using pressure compensated units.

Drip irrigation is easy to handle and operate once installed. It is suitable for automation and remote operation by computer or mobile phone. The system's simplicity makes it easy to install, operate, maintain and repair.

Other than irrigation, the drip irrigation method is used as a delivery system for fertilizers and other agrochemicals. Drip irrigation's advantage as a delivery system is its ability to optimize fertilizer usage, and distribute it exactly where needed, in the root zone, while minimizing its release to the environment.

Adoption of drip irrigation can help achieve sufficient fresh water availability for domestic use and sufficient food quantity and quality and quality for reasonable pricing, while increasing farmers' income with yield increases and cost reduction, and ensuring food security.

Drip irrigation systems also have limitations mainly related to high investment costs and extensive maintenance requirements necessary to achieve and maintain the irrigation system performance. Maintenance routines include water filtration, field inspection, maintenance of driplines, main line flushing, and chemical water treatment.

The purpose of this document is to provide a guideline on the implementation of drip irrigation.

Agricultural irrigation equipment — Guideline on the implementation of pressurized irrigation systems —

Part 2: Drip irrigation

1 Scope

This document provides a guideline for the implementation of pressurized drip irrigation systems.

It is applicable to both small-scale family agriculture and large-scale commercial agriculture, in open fields or within enclosed growing structures (e.g. greenhouse, net house).

This document is intended for the use of agriculture ministries, agronomists, irrigation planners, farmers and other end-users.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
anti-siphon dripper
anti-siphon emitter
dripper (3.3) with an interior mechanism which prevents suction of pollutants from outside the dripper line

3.2
chemigation
application of any chemical through an irrigation system

3.3
emitter
dripper
device fitted to an irrigation lateral and intended to discharge water in the form of drops or continuous flow at flow rates not exceeding 24 l/h, except during flushing

[SOURCE: ISO 9261:2004, 3.1]

3.4
fertigation
injection of soluble fertilizers into the irrigation system together with irrigation water

3.5
on-line emitter
on-line dripper
emitter intended for installation in the wall of an irrigation lateral, either directly or indirectly by means such as tubing

[SOURCE: ISO 9261:2004, 3.3]

3.6
regulated emitter
emitting pipe
pressure compensating emitter/emitting pipe
emitter/emitting pipe which maintains a relatively constant flow rate at varying water pressures at the emitter/emitting pipe inlet within the limits specified by the manufacturer

[SOURCE: ISO 9261:2004, 3.7]

3.7
regulated non-leakage dripper
compensated non-leakage (CNL)
emitter/emitting pipe whose flow is zero whenever the pressure at the inlet of the emitter/emitting pipe is lower than a value (other than zero) declared by the manufacturer

[SOURCE: ISO 9261:2004, 3.9, modified — Term name has been changed.]

3.8
unregulated dripper
non-pressure compensating emitter
emitter/emitting pipe whose flow rate varies with inlet water pressure

[SOURCE: ISO 9261:2004, 3.10]

4 Principles of drip irrigation

4.1 General

This document relies on the main principles of drip irrigation as set forth in ISO/IWA 20 and ISO 9261.

The main principles of drip irrigation are described in ISO 24120-1.

4.2 Water sources

The main types of water sources for drip irrigation are:

— surface water sources,

— groundwater sources,

— brackish water,

— treated wastewater (TTW), and

— desalinated water.

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

Some surface water sources, however, tend to introduce biological hazards, as well as silt. If TWW is considered as a source, quality and clogging potential will vary depending upon the extent of treatment.

Groundwater is generally of higher quality than surface water. However, iron, manganese, hydrogen sulfide, pH, soluble salts, hardness, and alkalinity levels should be measured, as levels that are higher than values determined as acceptable irrigation water quality can lead to dripper clogging and treatment can be required.

4.3 Water distribution network

4.3.1 Main line, sub-main, distribution pipes

Main lines carry water through the entire irrigation system, from the pump through the filters, valves and drippers.

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

PVC piping may be used throughout the system, or in combination with steel piping at the pump station. Polyethylene (PE) or flexible pipes may be used for sub-mains and distribution pipes. PE and PVC piping should be UV protected or buried. Pipes from other materials are permitted if they comply with local requirements.

Thermal expansion and contraction that occur under normal on-surface operating conditions should be taken into consideration (each type of pipe material is affected to a different degree), when designing and installing the system.

Main lines are connected to one another with welds, glue or friction fittings, according to the type of piping in use, and are anchored to the infrastructure supporting them. All main lines should be properly secured and anchored.

In a subsurface drip irrigation (SDI) system, the main line is more difficult to access and repair. All fittings should be secured at installation, to save significant repair issues later. After the initial growth stage of the crop, on-going maintenance should be implemented.

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

If water quality is poor, particularly in wastewater, the designer should consider increasing the water velocity in mains and submains to avoid sedimentation in the pipes. In most cases, the distribution pipe is installed above the elevation of the dripper lines.

Irregular field shapes are common due to topography and property boundaries. At the planning stage, care should be taken to properly size sub-main and distribution lines where field shape varies. Sub-main and distribution lines for irregularly shaped fields are designed based on actual flow rates of the dripper lines.

The piping system should be designed not only to allow the flow rate necessary for normal irrigation but also to allow sufficient flow rate for proper flushing velocities in the system (recommended minimum: 1 m/s).

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

4.3.2 Drip irrigation laterals (dripper lines)

Dripper lines are the heart of a drip irrigation system. In any irrigation system, the design process starts at the last plant and proceeds to the head system.

In the design of a dripper line, the following should be considered: dripper line selection, wall thickness, diameter, nominal pressure, dripper flow rate, spacing between drippers, spacing between dripper lines, and specification of dripper line insertion depth (in SDI).

4.3.3 Weather conditions

4.3.3.1 General

For surface and subsurface main pipe, attention should be given to two operating conditions listed in 4.3.3.2 and 4.3.3.3.

4.3.3.2 High temperature areas

The operating temperatures recommended by the manufacturer should not be exceeded. The manufacturer's responsibility normally applies to the pipe and all its connectors.

4.3.3.3 Low temperature area

In countries where temperatures in winter can be below 0 °c, water should be drained from the pipes of any irrigation system and dripper lines, to protect the main and submain pipes.

5 Drippers classification

5.1 General

Drippers incorporated at uniform spacing along the dripper line deliver water and nutrients directly to the plant root zone.

A typical drip irrigation system includes thousands of drippers. Each dripper should be durable, resistant to clogging, and emit the same amount of water under the same conditions and over time. Good design of the emitter can increase its long-term trouble-free performance.

The flow rate, working pressure and spacing of the drippers should be considered in determining the wetting pattern and to prevent runoff or deep percolation.

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

Two types of integral drippers are available, as described in 5.2 and 5.3.

5.2 Unregulated drippers

Unregulated drippers supply a flow rate that is based on the working pressure.

As long as the working pressure remains within the allowable pressure range, unregulated drippers provide uniform irrigation by maintaining a limited differential flow that was designed and installed for (10 % desirable, or in accordance with national or international standards), from the first lateral dripper to the last one in the same cycle operation.

The dripper flow rate, pipe inside diameter, dripper spacing, and dripper design determine the pressure head losses within the dripper line.

Differences in elevation also affect the system.

5.3 Regulated drippers

5.3.1 General

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

A regulated dripper contains a diaphragm, which is activated by the continual differential pressure created by the dripper's labyrinth, thus maintaining a constant dripper flow within the limits specified by the manufacturer.

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

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

Regulated drippers deliver the same flow rate regardless of the dripper line length (as long as the drippers operate within its working range as specified by the manufacturer).

5.3.2 Regulated drippers for particular applications

5.3.2.1 Anti-siphon (AS) drippers

The mechanism of anti-siphon (AS) drippers prevents suction of the outside dirt into the dripper line, providing critical protection against dripper clogging. It is ideal for subsurface drip irrigation (SDI) and can be used in on surface (orchards, plantation) and subsurface (SDI).

Irrigation systems do not usually operate during rain. Rain often causes saturation of the soil or standing water around the dripper lines. Between irrigation cycles, when the system is not pressurized, it acts as a drainage system. If particles are drawn into the dripper under negative pressure, it can lead to the drippers clogging.

To overcome this problem, the mechanism of anti-siphon drippers seals the dripper when the system is not pressurized, thus preventing pollutants from entering the system.

Suction of contaminants into the pipe can also happen when the dripline is emptying, creating a vacuum that sucks dirt through the hole onto the dripper, which risks clogging it.

5.3.2.2 Regulated non-leakage drippers/ CNL drippers

The compensated non-leakage (CNL) feature prevents system drainage between irrigation cycles, when the system is not fully pressurized. It ensures uniform water and nutrient distribution during pulse irrigation.

Dripper lines remain full between irrigation cycles, eliminating drainage and refill of the dripper lines, thus making the application more uniform.

It is recommended to use pressure-compensating (PC) drippers when the terrain slope is greater than 2 %.

CNL drippers are more sensitive to clogging and require more frequent maintenance routines, particularly for crops sensitive to excessive or insufficient irrigation.

For subsurface systems, AS drippers are be preferred.

5.3.2.3 On-line drippers

On-line drippers are used mainly for greenhouse, nursery and fruit tree applications. On-line emitters are emitters that are inserted into a regular pipe at different spacing according to the agronomical requirements.

On-line pressure-compensating (PC) drippers may be used for precise, efficient and uniform flow distribution over the entire growing area and for high resistance to common chemicals and nutrients.

6 Drip irrigation safety

When designing, installing, operating, maintaining, and troubleshooting the drip irrigation system:

— local safety regulations should be determined;

— measures should be taken to prevent the infiltration of nutrients, acids and chemicals into the water source.

When installing electrical installations:

— only authorized electricians should perform the installation,

— local safety standards and regulations should be determined.

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

The grower should be responsible for the proper handling of nutrients, acids and chemicals.

The nutrient/acid/chemical manufacturer's instructions and the regulations issued by the relevant local authority should be determined.

Protective equipment, gloves and goggles should be used when handling nutrients, acids and chemicals.

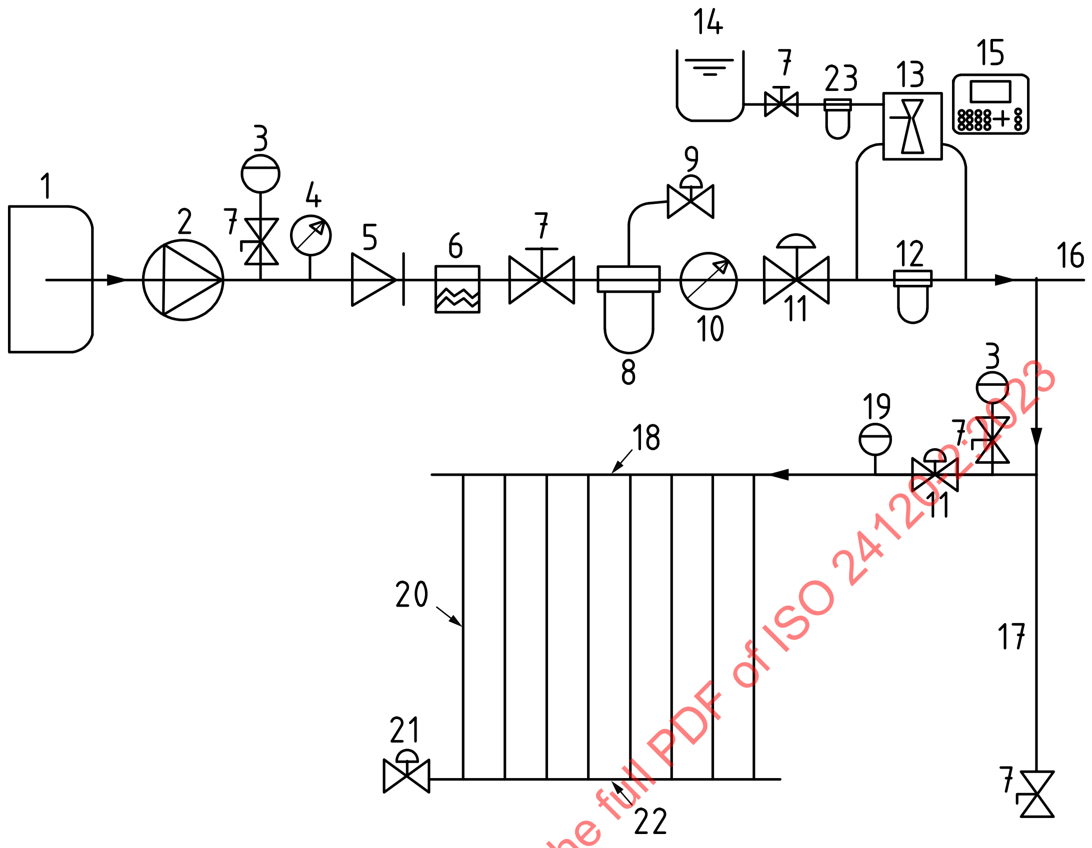
In an agricultural environment, protective footwear should be worn.

Opening or closing of any manual valve should be gradual, to prevent damage to the system by water hammer.

7 Control head

7.1 General

The control head should include a manual valve, air relief valve, hydraulic valve, water meter, pressure gauge, pressure regulator, filters, automation fittings and other accessories, see Figure 1.



Key

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 dripper line
21 flushing valve
22 flushing manifold
23 fertilizer filet

Figure 1 — Control head scheme

7.2 Water meters

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

To detect clogging or leaks in the irrigation system, the flow rate in the system should be checked often.

A variation in flow rate over time can indicate clogging. Before checking the flow rate, it should be confirmed that the pressure in the system is as designed. For accurate and useful data about the drip irrigation system, the operating pressure of the system should be as initially designed.

If the operating pressure is allowed to vary, the acquired flow rates will be valid but not usefully comparable for the purpose of clogging detection.

7.3 Valves

7.3.1 General

In an irrigation system, water flow rate and pressure throughout the system should be precisely controlled to ensure efficient and timely water application, therefore valves should be properly selected and placed.

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

It is not recommended to use oversized valves due to reduction of the flow velocity, as well as undersized valves which restrict flow rate and cause excessive pressure loss.

7.3.2 Types of valves used in a drip irrigation system

7.3.2.1 Manual control valve

The following common types of manual control valves are used in drip irrigation systems.

a) Ball valve

Ball valve is a quarter-turn valve. In a ball valve, the closing mechanism is a sphere (ball) with a port through the middle, connected to a lever in line with it that shows the valve's position. Rotating the lever turns the ball so that when the port is in line with the pipe, flow will occur, and when perpendicular to the pipe, flow is blocked.

b) Butterfly valve

Butterfly valve is a quarter-turn valve. Its operation is similar to that of a ball valve. The closing mechanism takes the form of a disc positioned in the centre of the valve. A rod, connected to a lever or a wheel, passes through the middle of the disc, rotates the lever, turning the disc either parallel or perpendicular to the flow.

Unlike a ball valve, the disc in a butterfly valve is always present within the flow, therefore a slight pressure drop is always induced in the flow, regardless of valve position.

c) Gate valve

Gate (sluice) valve opens by lifting a gate (wedge) out of the path of the fluid. When the gate valve is fully open, there is no obstruction in the flow path, resulting in very low friction loss.

The gate valve is designed to be fully opened or closed and may not be used to regulate the flow.

d) Globe valve

Globe valve is operated by screw action using a handwheel and may be used to regulate the flow or the pressure with minimum friction loss.

It consists of a movable disc plug aligned with a fixed ring located in the stream.

7.3.2.2 Check valve (non-return valve)

7.3.2.2.1 General

The function of the check valve is to prevent water flow in the opposite direction to that desired.

It serves various purposes.

— When installed at the outlet of a pump that pumps water to a field at a higher elevation, it protects the pump from the back wave of water hammer.

— When installed at the outlet of a filter, which conveys water to a higher field, it prevents water from flowing back through the system's head components.

— In irrigation system when installed upstream from a dosing unit, it prevents fertilizers and chemicals infiltration of the water source.

— When installed on the inlet pipe of a pump, as a foot valve, it enables priming of the inlet pipe.

7.3.2.2.2 Back flow prevention valve

Backflow is the undesirable reversal of flow of a liquid into the drinking water supply system. A backflow preventer is designed to keep this from happening.

7.3.2.3 Hydraulically operated, diaphragm-actuated control valves

Hydraulically operated, diaphragm-actuated control valves may serve different purposes according to the layout of the valve's control loop.

a) Hydraulic control valve

Hydraulic control valve opens and shuts off in response to a local or remote pressure command.

b) Pressure reducing valve (PRV)

PRV reduces higher upstream pressure to lower constant downstream pressure regardless of fluctuating demand, and opens fully upon line pressure drop. For optimal operation, the pressure ratio across a PRV should not be higher than 1:4.

c) Pressure sustaining valve

Pressure sustaining valve can fulfil either of two separate functions:

— When installed in-line, it sustains minimum preset upstream pressure regardless of fluctuating flow or varying downstream pressure.

— When installed as a circulation valve, it relieves line pressure in excess of preset.

d) Pressure reducing and sustaining valve

Pressure reducing and sustaining valve can fulfil two independent functions at the same time.

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

e) Pressure relief valve

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

f) Surge anticipating valve

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

7.3.2.4 Booster pump control valve

Booster pump control valve is a double chambered, active check valve that opens fully or shuts off in response to electric signals.

It isolates the pump from the system during pump starting and stopping, to prevent main line surges.

8 Filtration systems

A drip irrigation system should include filtration in accordance with ISO 9912-1, ISO 9912-2, ISO 9912-3 and ISO 9912-4.

9 Design

9.1 General

The design of a pressurized irrigation system integrates all required parts from the water source to the irrigation system in the field.

9.2 Design principles

The design is the result of a process that includes collection of data about soil, water, crops field shape, etc. The designer should implement the collected data before designing the hydraulic system.

9.3 Design of water source

9.3.1 Design of surface water sources

Global water resources are in a steady state position or even diminishing. It is expected that in the future, the source that will take a growing share in supplying water for irrigation will be treated wastewater.

In the planning of surface water sources, factors that the designer should consider are the dynamic changes that occur in agriculture, as well as those indicated in 9.4.

9.3.2 Design factors

Factors that should be considered in the design of secondary water sources (thermal water, brackish water and effluent) are:

— soil;

— water sources;

— crops;

— climate condition;

— water quality.

Before initiating the design, maximum information should be gathered about the water quality at the different sources:

— water source

— water quality

— crop types

— soil.

9.3.3 Changes in water quality

In all water sources, changes in water quality can occur on daily and up to yearly frequency.

9.3.4 Treated wastewater (TWW)

See definitions in ISO 16075-1.

9.3.5 Parameters to consider before initiating design

The following parameters should be considered:

— treatment at water source;

— location of pumping point in water source;

— filtration in water source;

— filtration at control head;

— check device (filter) should be located close to the plot;

— monitoring;

— pipes network from water source to irrigated area;

— sub main pipes at various plots;

— irrigation system (mainly drip);

— physical treatments (see ISO 20419:2018, Clause 10);

— chemical treatments (see ISO 20419:2018, Clause 11).

9.3.6 Pumping from rivers

Before reaching a decision about pumping location from a river, information should be gathered about the velocity of the water flow.

When pumping from rivers, the water should not be delivered directly to the field, but through an operational pond. The water should be pumped from the top of the operational pond. The settling of the pond capacity should be designed according to the amount of time desired to maintain 2 h to 6 h.

9.3.7 Pumping from canals

The flow velocity in canals varies according to seasons and water consumption by the farmers. Low velocity can cause the development of algae and zooplankton (depending on water temperature).

The treatment of this source is similar to the handling of reservoirs.

9.3.8 Factors affecting the quality of surface water sources

In reservoirs, the pumping point should be protected from suspension of organic material such as leaves.

To pump water from reservoir, water should be pumped between 1 meter below the surface and 1 meter above the bottom.

To achieve better water quality, water should be pumped from the top of the reservoir using a floating unit.

Water-mixing systems may be used to prevent algae from developing, thus improve the quality of water.

9.3.9 Fish in reservoirs

Specific types of fish may be used to help reduce the amounts of algae and zooplankton in reservoirs.

9.4 Network design in irrigation systems

In the design of the water network to the irrigation plots, three factors should be taken into account:

— topography;

— velocity;

— pipes chemical resistance.

9.5 Velocity

Velocity in the main pipes and collecting pipes is the dominant factor in the protection of network clogging. At low velocity, precipitation is established on the pipes and build-up like "shrubs" of organic matter. The build-up causes pressure reduction and ineffective irrigation, with clogged dripper lines and collectors.

In the design, a velocity of 1,5 m/s up to 2,5 m/s in the main pipes and up to 1,0 m/s in collectors should be taken into account.

9.6 Location of head system

It is recommended that field control head will be in the highest point in the field.

9.7 Air valves and vacuum valves

Air valves and vacuum valves should be designed so as to prevent air problems in the system. If required by the topography of the field, lateral and sub-main lines draining into the lower points of the plot should be prevented, to avoid death of trees. A vacuum valve should be installed on the pipe that delivers the water to the drippers (submain line), see ISO 9635-4.

9.8 Filtration method

See ISO 9912-1, ISO 9912-2, ISO 9912-3 and ISO 9912-4.

9.9 Type of main line and relevant equipment

The type of main line pipes should be selected according to the pipe diameter, quality of the water and the required chemical treatments. The grade of the main line should be adjusted to the operation pressures of the irrigation system.

The loss of pressure due to main line should be as low as possible.

After the laying of the main line, the following should be assured:

— the main line was laid in accordance with the plan, in terms of diameter and location;

— there are no leakages from joints and welds.

For sub-surface drip irrigation, it should be assured that the joints do not allow leakages.

The diameter of the pipe should be selected according to current pressure, flow and economic considerations, while taking into account the pressure loss of the pipe, water hammer resistance and flow velocity during the flushing of the system.

In the design of distribution system, all design parameters should be considered, e.g. water quality, flow velocity, to prevent creation of biofilm in the pipe.

In topographic terrains, the main line and the distribution main line should be located in the highest points in the terrain. To prevent drainage from the main lines and the sub-mains to the edges of the plot, which can cause damage to the last trees in the plot, a non-leakage valve should be used, in accordance with the levels of pressures in the field. A professional should be consulted.

During the design, the system's designer should be consulted with the flow and velocity to set the wash velocities in the pipes.

In a water supply system, all types of main lines may be used, as there is no involvement of a chemical treatment. In on-surface/sub-surface drip irrigation, Polyethylene or PVC pipes may be used, as there is intensive involvement of chemical treatment.

9.10 Irrigation method

Surface irrigation or sub-surface irrigation should be selected according to the type of crops and soil.

9.11 Dripper flow rate

The flow rate of the dripper should be selected according to the soil, irrigation times and types of crops.

9.12 Dripper line length

9.12.1 Potable water

The dripper line length should be in accordance with the manufacturers' recommendations.

9.12.2 Wastewater

If secondary water quality is used, the optimal dripper line length should not exceed 100 m to 150 m. Longer dripper line will create high build-up of sedimentation in the irrigation system because of low flow. This effect is highly dependent on pipe diameter, flow, dripper type, spacing, inlet pressure, etc.

The dominant factor here is not the velocity in the pipes network during irrigation, but the velocity in the irrigation system during the flushing the dripper line and supplying network.

9.13 Main line, secondary distribution pipeline and joints

The nominal pressure of the main lines, secondary distribution pipeline and joints should be selected considering the maximum static and operational pressures of the irrigation system.

10 Monitoring

10.1 General

The main targets in irrigation system monitoring should be to operate and control the proper functioning of the irrigation system.

10.2 Crops data

The quantity of irrigation water should be determined according to data such as: daily evapotranspiration, crops coefficients, field cropping history, and special conditions, such as sensitivity to heat or frost.

10.3 Soil moisture monitoring

Soil moisture measurement instruments should be located among the plants, in the soil, in various depths, to measure the soil moisture.

10.4 Water monitoring

A water meter should be located on the control head, adjacent to the irrigation system.

The water meter measures the flow quantities of water used in an irrigation cycle.

10.5 Weather station

A weather station should be located in an open area, characteristic of the weather conditions in the irrigated plot.

The weather station monitors the wind speed, radiation, temperature, air humidity and rain, to allow the farmer to reach the right decision in regard to the irrigation cycle.

11 Chemical injection system design

11.1 General

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

Any components that comes in contact with nutrients, chlorine, or acid should be resistant to corrosion. Some countries require specific types of injectors for agrochemicals. Local laws and chemical labelling requirements should be determined.

Nutrients and chemicals may be injected into pressurized drip systems via a variety of methods. Different manufacturers offer a comprehensive array of dosing systems to ensure precise nutrient delivery for any crop, plot size and application.

11.2 Fertigation

Fertigation (injection of nutrients to the plant) is an effective way to increase the yield and quality of a crop by feeding the plant according to its specific, ever-changing needs.

Fertigation should include 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.

11.3 Chemigation

Chemigation (the injection of chemicals to prevent or reduce dripper clogging) may be achieved by adding chlorine, hydrogen-peroxide, acid or other dripper cleaning chemicals, or injecting of chemicals for crop and soil concerns (herbicides, pesticides and others).

Because the water passages in drippers are relatively small, they are prone to clogging; therefore, along with filtration, the possibility of injecting chemicals for dripper clogging control should be considered.

11.4 Dosing unit

A dosing unit serves both fertigation and chemigation.

11.5 Benefits of fertigation and/or chemigation

See benefits of fertigation and/or chemigation (chemical treatment) in ISO 20419:2018, Clause 11.

11.6 Chemical application units

11.6.1 General

Fertigation is the supply of fertilizing through the irrigation system. Chemigation is the supply of chemicals through the irrigation system. These may be applied with the use of the units described in 11.6.2 to 11.6.6.

11.6.2 Fertilizer tank

A fertilizer tank mixes water with fertilizer for quantitative fertilizer. It is operated by the hydraulic pressure in the irrigation system and does not need an external energy source.

11.6.3 Hydraulic fertilizer pump

A hydraulic fertilizer pump is operated by the hydraulic pressure, injecting fertilizer to the irrigation system.

Its linear hydraulic piston motor is powered by the hydraulic pressure in the irrigation system, and does not require any other energy source.

11.6.4 Venturi injector

A Venturi injector uses excess pressure in the irrigation system to create a vacuum in the injector throat. This vacuum efficiently sucks the product to inject the pressurized water line, eliminating the need for a separate chemical injection pump.

11.6.5 Electric injection pump

An electric injection pump may be used to inject fertilizer into the irrigation system.

11.6.6 Hydraulic fertilizer injector

A hydraulic fertilizer injector applies fertilizers and chemicals directly or proportionally to the water flow through an irrigation system.

12 Pump station

12.1 General

A pump station should be sized for water withdrawal from the water sources (underground, river, lake, etc.) and to pressurize the irrigation system.

12.2 Power source for the pump

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

In most instances, electricity is preferred because of reduced labour requirements and higher efficiency, resulting in lower energy cost. Three-phase power is usually required to operate over 7 460 W (10 hp) irrigation pumps.

If electricity is not available, alternative power sources such as diesel, gasoline, natural gas, propane or solar may be used. The most common alternatives are gasoline engines for small pumps and diesel or natural gas engines for larger pumps.

12.3 Pump types

In most irrigation applications, centrifugal pumps are used.

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

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

12.4 Pump capacity

When selecting a pump for irrigation, the following basic factors should be considered:

— pump flow rate;

— pump total dynamic head;

— pump efficiency;

— net positive suction head required by the pump (NPSH) to avoid cavitation.

For a given centrifugal pump model running at its nominal speed, the irrigation system flow rate will influence the pump total dynamic head, its efficiency, and the net positive suction head requirement.

It should be made sure that the pump is able to deliver the required values of flow rate and total dynamic head with high efficiency. Obtain a performance curve for the pump and have modifications made if it is not adequate - the energy savings alone will easily pay for any upgrades required, which will also improve system operation and crop production, resulting in a shorter return on investment (ROI).

12.5 Pump selection

The required pump duty (or operating point) should be specified according to the irrigation system design.

The operating point results from the intersection of the pump curve and the system curve. The best operating point (BOP) occurs at a flow rate that results in the pump maximum efficiency. Pumps should be selected to provide high efficiency at the operating point.

Select a pump with a NPSH available at least 2 m higher than NPSH required by the pump, to prevent cavitation. The NPSH required by the pump varies according to the system flow rate.

