LEARNER GUIDE

Irrigation

Level 2

P.O. Box 461, Hillcrest, 3650
(031) 313-3364

Title:		**Operate and Maintain Specific Irrigation Systems**					
Applied Title:		**Operate and Maintain Irrigation Systems Specific to Citrus Orchards**					
Field:		Agriculture and Nature Conservation					
Sub-Field:		Primary Agriculture					
SETA (SGB):		AgriSETA					
Skills Area:		Irrigation					
Context:		Citrus Production					
US No:	116066	**Level:**	2	**Credits:**	3	**Notional Hours:**	30
Author:		F. Kruger (BSc Agric (Mechanised Agriculture))					

Based on the Production Guidelines of:

citrus research international

Supported by:

Citrus Growers' Association OF SOUTHERN AFRICA
Grower levies working for you!

Unit standard alignment and assessment tool development:
Cabeton Training and Development

Project coordinator:
Jacomien de Klerk

Disclaimer

By accepting this document and reading its contents you agree to be bound by the terms of this disclaimer.

The use of the contents of this document is at your own risk. Neither the Citrus Academy nor the CRI or the CGA warrant that the content of this document is suitable for your intended use or that it is free of inaccuracies or omissions. The opinions and advice expressed in this document are not necessarily those of the Citrus Academy, the CRI or the CGA. The Citrus Academy, the CRI and the CGA, their directors, officers, employees, agents and contractors shall not be liable for any loss or damage of any nature suffered by any person as a direct or indirect result of the use of, or inability to use any advice, opinion or information contained in this document, or any misrepresentation, misstatement or omission, whether negligent or otherwise, contained in this document.

You indemnify the Citrus Academy, the CRI and the CGA against any claim by any third party against the Citrus Academy , the CRI or the CGA, their directors, officers, employees, agents or contractors arising from, or in connection with, the use of, or reliance on, the contents of this document. It is your responsibility to determine suitability of the contents of this document for your intended use.

Table of Contents

Directions

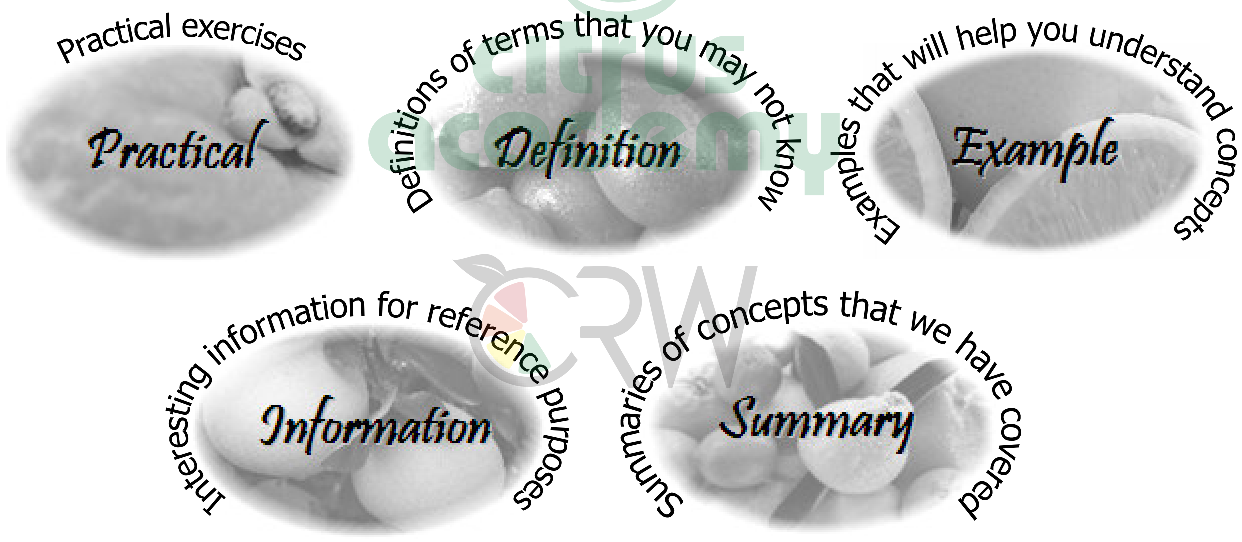
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

The learner guide is accompanied by a Learner Assessment Guide. Please ensure that you have access to this guide as well.

The learner guide was designed to be used by a learner during the presentation of a skills program based on the unit standard, and to be kept afterwards by the learner for reference purposes. The learner assessment guide was designed to be completed during and after the presentation of the skills program, and forms part of the assessment process.

Although this learner guide contains all the information required for attaining competency in this unit standard, references to additional resources, both printed and electronic, are provided for further study by the learner.

Information in boxes is indicated by tags that show:



Introduction

1. Purpose

A learner achieving this unit standard will be able to, under supervision, efficiently irrigate a variety of crops, using a specific type of irrigation system. He will also be able to carry out relevant basic operational and maintenance procedures.

Learners will gain specific knowledge and skills in irrigation and will be able to operate in a plant production environment implementing sustainable and economically viable production principles.

They will be capacitated to gain access to the mainstream agricultural sector, in plant production, impacting directly on the sustainability of the sub-sector. The improvement in production technology will also have a direct impact on the improvement of agricultural productivity of the sector.

2. Learning Assumed to Be in Place

It is assumed that the learner has successfully completed the unit standards listed below:

NQF Level	***Unit Standard Number***	***Unit Standard Description***
1 (ABET 4)	Literacy and Numeracy	
1	116202	Operate and maintain irrigation systems
2	116060	Utilise and perform minor repair and maintenance tasks on implements, equipment and infrastructure

Introduction to Citrus Production

1. Introduction

This learning material has been developed in the context of citrus production, which means that the skills area is dealt with in terms of and as applied to citrus production. To help the learner place the material in the right context, it is necessary for the learner to understand the background to citrus production, and the manner in which a citrus plant produces fruit.

2. Background

Citrus originates from the subtropical regions of south-east Asia. In the wild, citrus trees in these regions produce fruit all year round, and the fruit are small, poorly coloured and blemished. In the absence of effective production practices, citrus trees do not produce fruit suitable for the market.

Citrus production is largely concerned with management of the practices and processes that manipulate the tree to produce high yields of marketable fruit. Production management, together with the selection of superior varieties and plant improvement, can be seen as an on-going effort to influence the natural tendencies of the tree.

Consumers want the fruit of their choice to be available at all times. Fruit should look good, be unblemished, well-coloured (superior exterior quality), taste good (high interior quality) and be of the right size. At the same time, the citrus producer wants orchards that will provide high yields over an orchard lifespan of 18 to 30 years. On top of all this, the citrus orchard must be managed in such a way that production practices have the least possible impact on the natural environment. Commercial citrus production management is about achieving these objectives efficiently and cost effectively.

3. Citrus Planting

Citrus trees are planted in rows in orchards. The planting distance, also called tree spacing or espacement, between rows and between trees within rows, is determined by numerous factors including climate, variety, and soil type. A typical tree spacing is 6m between rows by 3m between trees, meaning that 555 trees per hectare (ha) are planted (1ha = 10,000 m^2).

Once planted, trees take three or more years before bearing fruit that can be marketed. Thereafter, per tree and per hectare yields steadily increase to 40 to 70 t/ha – depending on cultivar and variety – after a further 4 to 7 years. If the trees are well looked after, this level of production will remain fairly constant until trees start to decline naturally.

Yield

Yield refers to the amount of fruit produced, and can be expressed in terms of:

Tree yield	kg per tree	kg/tree
Orchard yield	tons per hectare	t/ha
Export yield	15kg carton equivalents per hectare (10kg carton equivalents for soft citrus)	cartons/ha

4. Lifespan

The average economic lifespan of a commercial citrus orchard varies between 18 and 30 years, and can be as high as 30 to 60 years in hot, dry areas. Citrus is therefore viewed as a long-term crop. For citrus production to be profitable, the orchard must produce high yields of quality fruit every year, and do this consistently over a long period of time.

In citrus production the challenge is therefore to make production decisions and take actions to ensure high annual production of marketable fruit, while ensuring that these decisions and actions contribute to the long-term sustainability of the orchard.

5. Citrus Plant Phenology

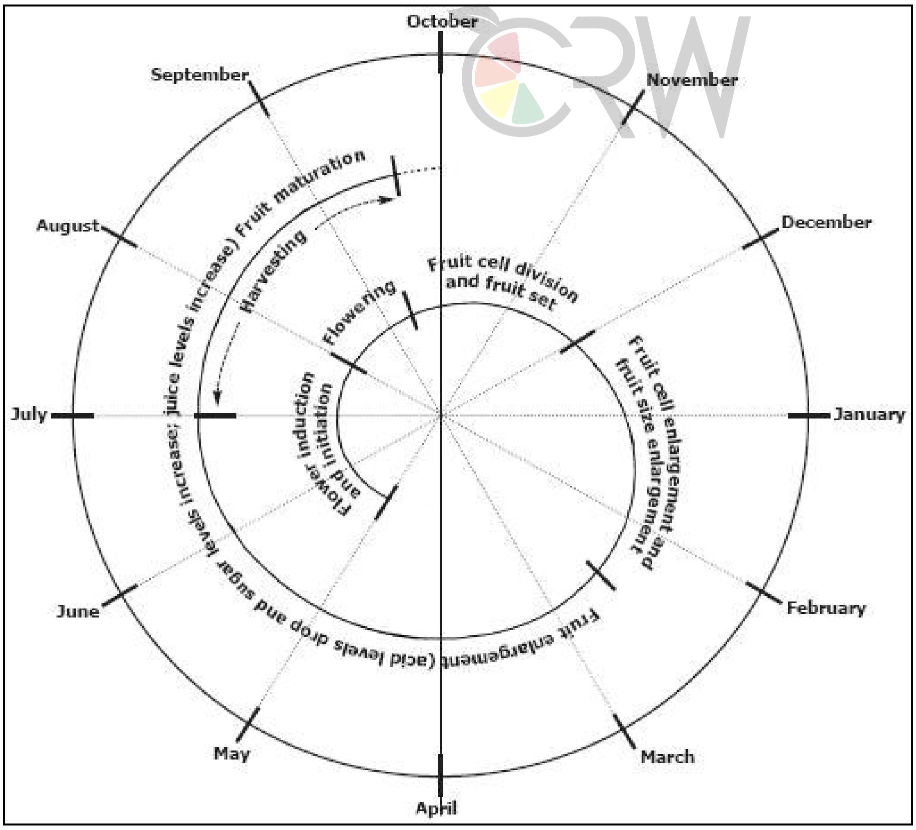
Definition

Phenology

Phenology refers to regularly recurring biological phenomena and the environmental and climatic factors that influence them. In citrus, phenology specifically refers to the annual cycle of the citrus tree.

Understanding the phenology of the citrus tree is essential to understanding the reasoning behind many of the practices and actions employed in citrus production. For example, the timing of fertiliser applications is linked to the phenology of the tree, with most fertilisers being applied at appropriate times to optimise flowering, fruiting, fruit development and fruit maturation.

The figure and table below set out the annual cycle of the citrus tree with regard to fruit production. Please note that this figure and table reflect the approximate flower and fruit development cycle of a valencia orange tree, and that the phenology of various cultivars differ.



Stage	*Description*	*Time Period*
Flower Induction and Initiation	Flower initiation is the induction and differentiation of vegetative buds into flower buds at a cellular level, and cannot be seen with the naked eye.	May to July
Flowering	Flowering or "bloom" is when blossoms appear on the tree.	August to Mid-September
Cell Division and Fruit Set	Cell division is the period when cells making up the fruit increase in number. Fruit set is the period from flowering or "bloom" until the end of fruitlet drop, after which the final fruit load is determined.	Mid-September to November
Cell Enlargement and Fruit Growth	Cell enlargement is the period during which cells making up the fruit increase in size. Fruit growth is the period during which the fruit grows and develops.	December to Mid-February
Fruit Maturation and further Fruit Growth	During this period fruit enlarges further and matures internally, meaning that the flavour, sugars and acids reach their optimum levels.	Mid-February to September
Harvest		July to September

It is important to note the term **citrus season** refers to the period from when flower initiation begins to the harvest. The season is generally from the beginning of August of one year to the end of July of the next year, although harvesting may extend to September and October for late cultivars.

6. Citrus Learning Material

The following citrus specific learning material is available from the Citrus Academy:

Skills Area	*Description*
Enterprise Selection, Planning and Establishment	Concerns itself with identifying the various components of an agricultural enterprise, and with the selection and planning processes for a new enterprise, and looks at the physical layout of a farm, with specific reference to infrastructure, orchard layout, etc.
Propagation	Concerns the various methods and requirements for the multiplication of plant material of specific varieties that possess desired qualities.
Crop Establishment	Concerns the establishment of a new citrus orchard, in terms of the physical planting of trees and the care for young trees.
Plant Structures and Functions	Considers the structure and function of various plant parts and the manner in which nutrients, water, air and sunlight is taken up and processed.
Plant Nutrition and Soil Management	Concerns itself with plant nutrients, in terms of the requirements of the citrus plant and the supplementation of nutrient elements through fertilisation, with specific reference to the timing and manner of application.
Water Quality	Considers the various factors that influence water quality and manners in which water quality can be measured and controlled. Considers furthermore the effect of water quality on tree and fruit growth and development, in combination with effective irrigation, fertilisation and pest control.

Skills Area	***Description***
Plant Manipulation	Concerns various types of physical and chemical plant manipulation, with specific reference to pruning, girdling and the application of plant growth hormones, and tools and equipment used for this purpose.
Irrigation	**Looks at the technical aspects of orchard irrigation, with reference to the types of irrigation systems, the installation of new irrigation systems, and the repair and maintenance of an irrigation system. Also concerns irrigation scheduling, and measures to ensure effective irrigation.**
Pests, Diseases and Weeds	Concerns the identification of pests, diseases and weeds that threaten citrus production. Also considers various methods of effective control, and the planning required for this purpose.
Crop Protection	Looks at the practical application of crop protection agents through various methods, with specific reference to tools and equipment used, and health and safety requirements.
Food Safety	Concerns the requirements in terms of health and safety, and environmental control for ensuring food safety and hygiene.
Harvesting	Looks at the process of determining fruit maturity through maturity indexing, the harvesting of fruit, and the tools and equipment used for this purpose.
Conservation	Considers the impact of farming practices on the environment, with reference to the measures required to minimise this impact and protect the environment.
Marketing	Concerns the factors influencing citrus marketing, and the development of an effective marketing plan.
Production Management	Concerns the actions and processes involved in effective production management, with specific reference to the coordination of the various production tasks and processes and the creation of a strategic plan for the enterprise.
Industry Overview	An overview of the citrus industry and the various institutions involved.
Packhouse Practices	Concerns the specific principles and practices that are employed in the packhouse environment, and specifically: • Citrus Product Characteristics • Understanding Citrus Fruit Markets • Health and Safety in the Packhouse • Personal Hygiene Requirements for Packhouse Personnel • Understanding and Maintaining the Cold Chain • The Role of Quality Checks in the Packing Process • The Application of Fruit Treatments • The Application of Pre-Sorting Prior to Packing • Receiving Fruit into the Packhouse • Grading Fruit in the Packhouse • Packing and Packaging Materials • Palletisation of Packed Fruit • Storage of Fruit • Dispatch and Transportation of Packed Fruit • Understanding Automated Packing Solutions

Chapter 1

After completing this chapter, the learner will be able to:

Perform pre-start-up inspection applicable to the relevant irrigation system

1. Introduction

In citrus production farmers depend on irrigation to supplement rainfall to supply the water requirements of the tree crop. Proper operation and maintenance ensures that an irrigation system performs optimally.

2. The Irrigation System

A basic irrigation system consists of the following components:

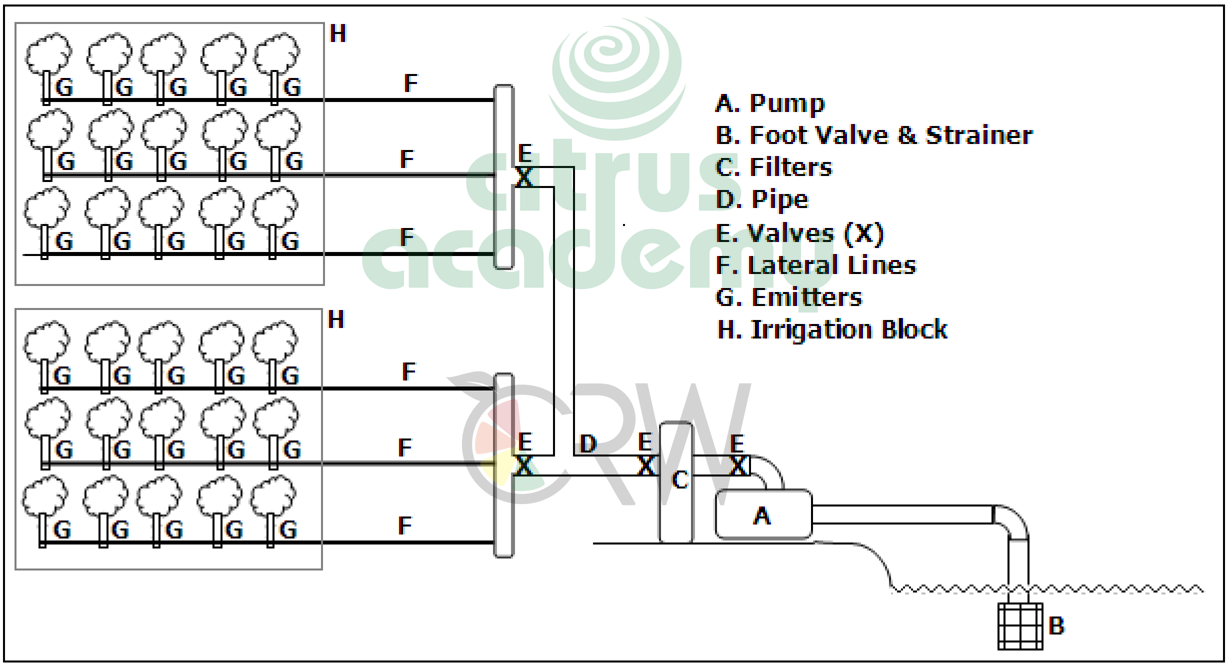


Figure 1.1: Basic Components of an Irrigation System

2.1. Pumps

Almost all irrigation systems, except gravity feed systems, rely on pumps to pump water to the orchards and supply pressure to the emitters to work properly. The pump moves, or displaces, water by sucking water from the source, such as a river, dam, reservoir, etc., and propelling in through the irrigation system.

Pumps come in a wide range of shapes, sizes and types, such as centrifugal, submersible, and positive displacement pumps. They are driven by either diesel engines or electrical motors. The most commonly used pumps are single and multi stage centrifugal pumps driven by electrical motors. Single stage pumps have only one stage containing a single impeller, while multi stage pumps have two or more stages and delivers higher pressures where required.

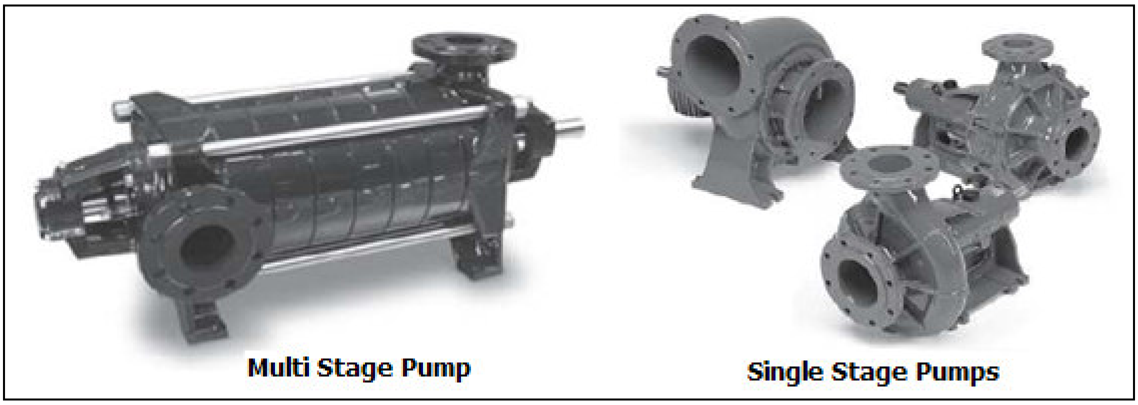


Figure 1.2: Single and Multi Stage Pumps

Pumps consist of various components, including the motor that drives the pump, the suction and delivery pipes, and various valves. Figure 1.3 shows the various components of a standard pump.

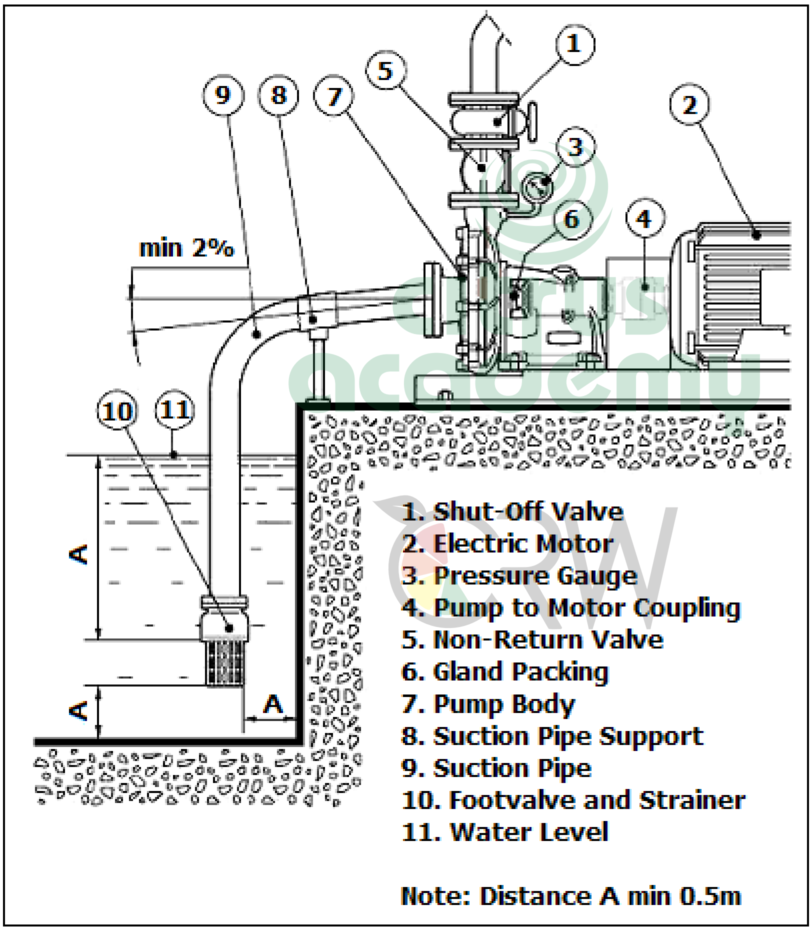


Figure 1.3: Basic Components of a Pump System
Courtesy of Rovatti Pumps

Practical

Pump System

Visit the pump installation on a citrus farm and identify the various components of the pump system with the help of the supervisor or irrigation manager.

2.2. Filters

Filters clean the water from suspended material that can block emitters. Suspended material consists of clay, silt, sand, and organic debris from plant and animal origin that do not dissolve in water. Filters cannot remove materials that are dissolved in water.

Various types of filters are used, most commonly sand, disc and screen filters.

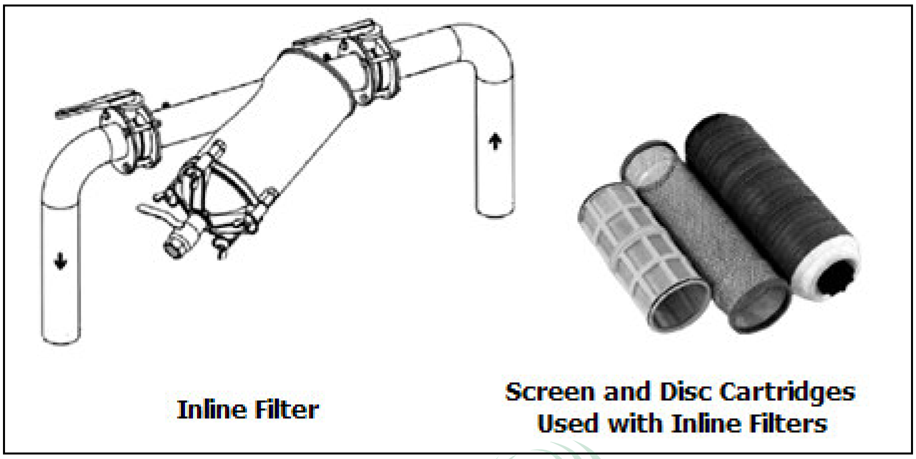


Figure 1.4: Inline Filter and Filter Cartridges

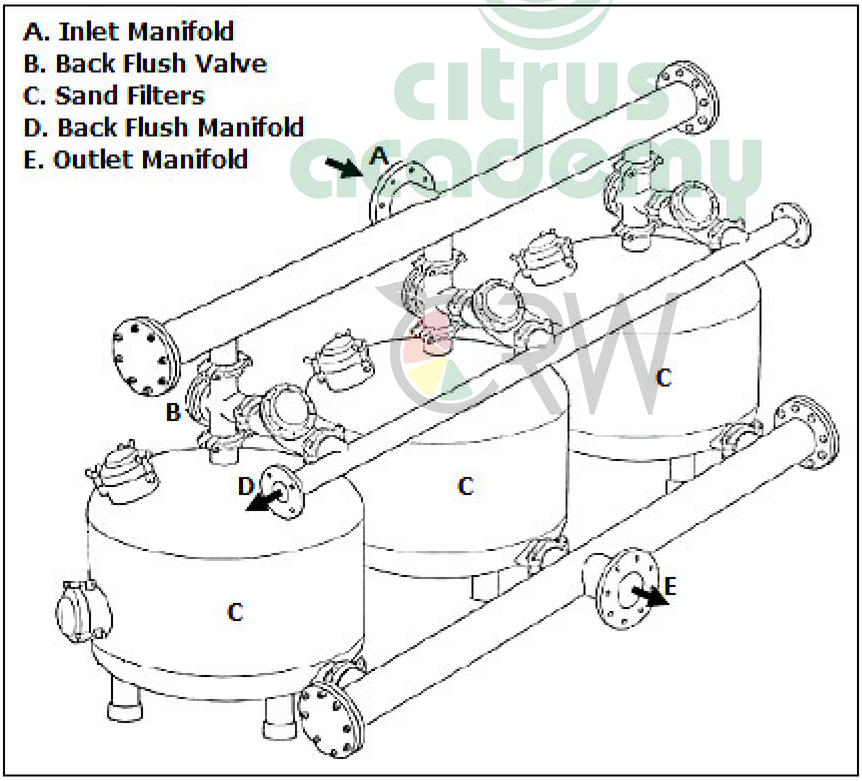


Figure 1.5: Sand Filter Bank

2.3. Pipes

The pipeline channels water between points, such as from the water-source to the pump, from the pump to the main lines and from the mainlines to the trees.

A wide range of pipes is available and used on citrus farms. For main and sub-main lines PVC, steel and fibreglass pipes are used. In some older installations, asbestos or cement pipes are still in use. These pipes are unsuitable where acid is introduced into the irrigation water for fertigation purposes.

Poly-pipe is used for lateral lines, which are a specific type of pipeline that moves water into the orchards.

2.4. Valves

Valves control the flow of water by opening or closing, thereby allowing water through or cutting it off. Various types of valves are used.

- **Gate** and **butterfly** valves are used to open or close a pipeline;
- **Pressure control** valves are used to regulate pressure and flow rate;
- **Non-return** valves are used to prevent the reverse flow of water when the pump is switched off;
- **Air** and **vacuum** valves are used to expel air in the pipeline and to prevent a vacuum from forming after a line is closed or the pump is switched off.

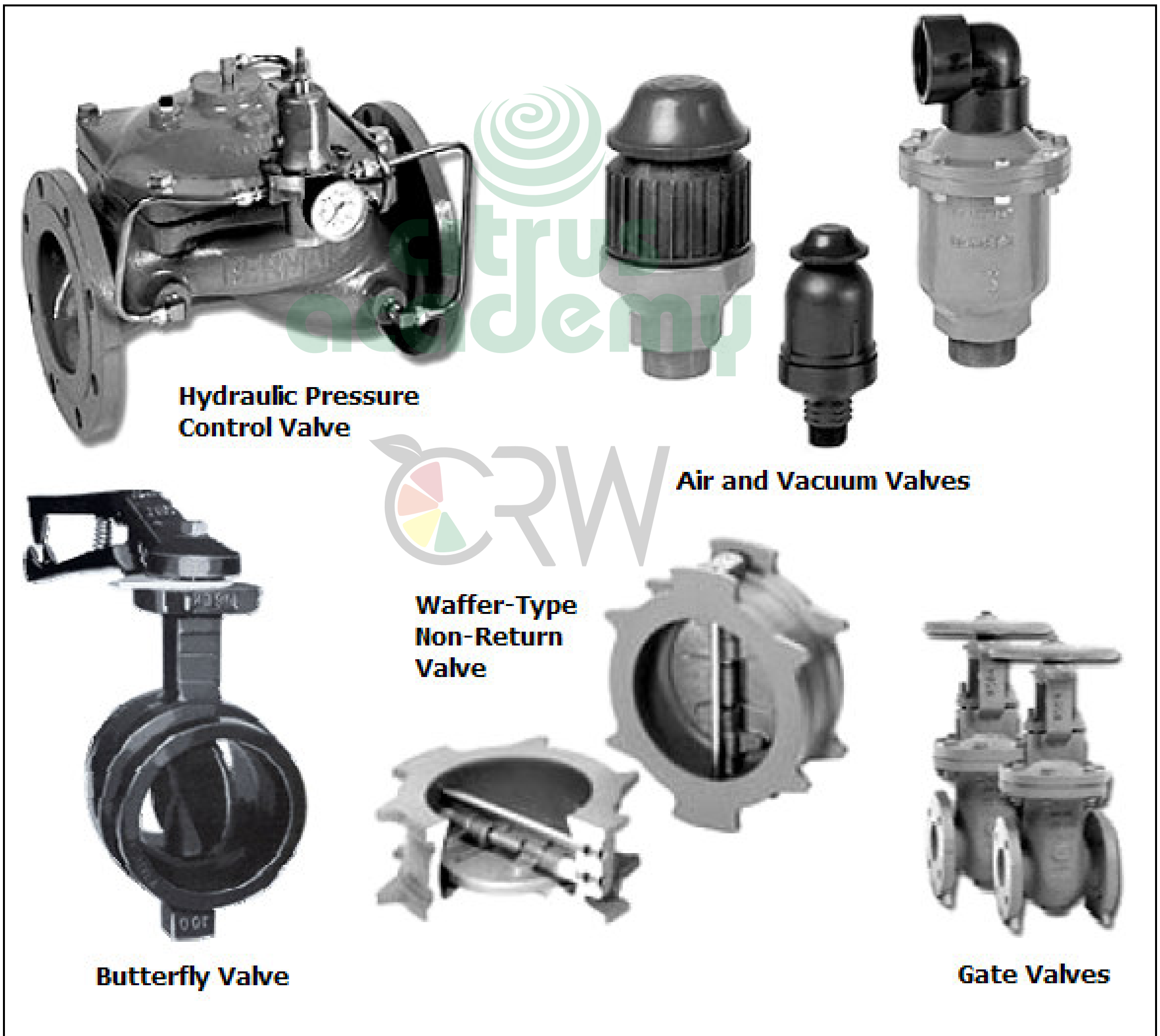


Figure 1.6: Examples of Various Types of Valves

2.5. Emitters

Emitters are placed in lateral lines and apply water to individual trees in a uniform and efficient manner. Examples of emitters are micro-jets, drippers and sprinklers.

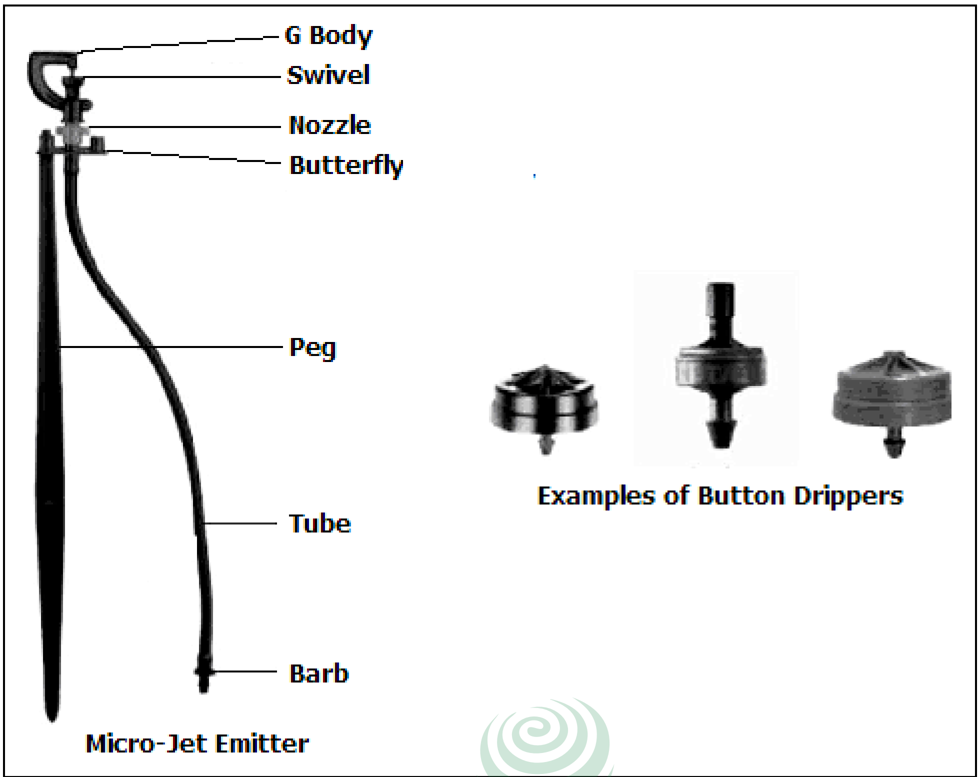


Figure 1.7: Micro-Jets and Drippers

3. Pre-Start-Up Inspection

Before starting up the irrigation system, a number of pre-start-up checks must be performed, being:

- Assessing water availability
- Checking and cleaning the pump, filters and valves

3.1. Assessing Water Availability

It is very important to ensure that there is enough water in the source, such as the river, canal, dam or pit, before starting the pump. If there is not enough water, the pump will suck air, which will cause cavitation. Cavitation is very destructive and can cause damage to the pump.

Cavitation

Cavitation is caused when there are air bubbles in the water. When air bubbles hit the impeller, the section of the pump that rotates and moves the water, they implode on the impeller and break the parts of the impeller.

Cavitation is one of the greatest dangers to the pump. Cavitation can be caused by:

- The water level in the water source being too low
- The filter in the inlet system being blocked or dirty
- Water being lost through leakages in the suction pipe or one of its connections. The suction pipe is under negative pressure and water will therefore not leak out, but air will be sucked in at any perforation or opening, which causes cavitation.

All of these factors must be checked carefully as part of the pre-start-up procedure. Note that cavitation can also occur when the pump sucks air because of not being properly primed. Make sure the pump is primed properly.

Cavitation will only become evident once the pump is running, when it will show symptoms such as loss of pressure, excess vibration and the pump body becoming warm. If this occurs, the pump must be switched off immediately.

Make a visual inspection of the water level before starting the pump. The water level must be above the minimum water level mark, which should be marked by the irrigation manager. The recommended minimum depth of the inlet is 500mm below the surface.

If the water level is near or below this mark, do not start the pump. If the water level is too low to start the pump, or if water levels fell below the minimum water level mark while the pump was running, report it to the irrigation manager or supervisor.

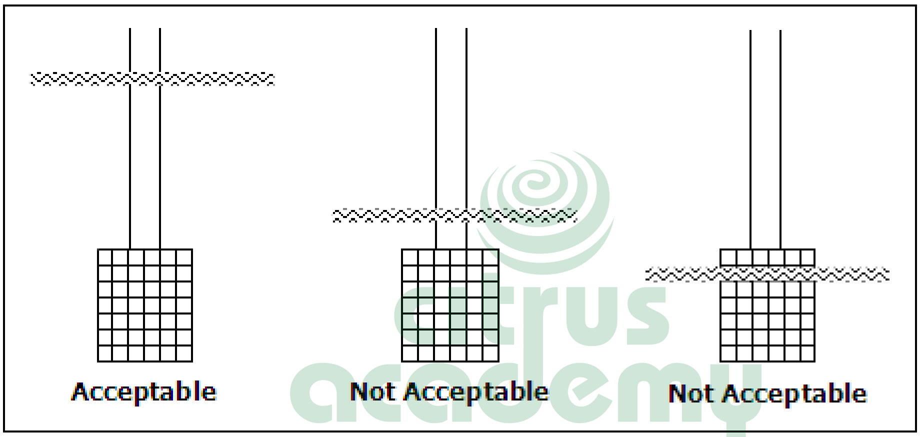


Figure 1.8: Acceptable Water Levels at the Suction Pipe

Figure 1.8 gives an indication of what constitutes an acceptable water level. The picture in the middle is unacceptable, because even though the water level is above the intake, the pump will suck air as soon as it is started and the water level drops.

If orchards are irrigated from a borehole, a water level switch inside the bore hole will prevent the pump from starting.

3.2. Checking and Cleaning Components

The various components of the irrigation system must be checked before the system is started. Never start the pump system to check that it is working properly, as damage may be caused to a component. A visual check of the various components is essential.

3.2.1. Pump

Pumps and motors run on bearings that need lubrication by either grease or oil. Failing to lubricate the pump and motor can result in a serious damage.

Bearings that are lubricated by oil have a dipstick that indicates the oil level. Before the pump is started, remove the dipstick and check the oil level. The oil level should be between the minimum (*Min*) and maximum (*Max*) marks. If the oil level is above the *Max* or below the *Min* marks, report it immediately to the manager. In addition, visually check that the oil is clear. If the oil is milky, grey or black, report it immediately to the manager before starting the pump.

Where pumps and motors are fitted with grease nipples, the pump and motor must be greased regularly. Consult the manager for the intervals, as they vary between different makes of pumps and motors. Note however that some motors are fitted with sealed bearings that do not need to be greased.

Grease the bearing with a grease gun until the old grease is expelled from the casing. Clean the nipple before greasing and wipe off the old grease with a rag. Beware of over-greasing electrical motors, as the excess grease can end up inside the motor windings and cause the motor to burn out. Make sure grease is clean, free of grit and sand, and of the right type.

In additional, the following checks must be made before starting the pump:

1. Check for excessive water inside the pump house. If excessive water is found, try to establish where the water is coming from.

2. Check the oil levels.

3. Inspect the pump for leaks at flanges and leaks on the pump body. Flanges are the metal discs on the pipes that are bolted down on to the pump. A gasket is inserted between the two flanges and leakage can occur if the gasket is worn or if the flanges are not properly tightened.

4. Inspect the gland packing around the pump shaft. The gland packing is the seal at the pump shaft and seals of the water inside the pump. It is marked as item 6 in figure 1.3.

5. Check the rubber coupling at the pump and motor shaft for signs of wear and cracks.

6. Check for loose mounting bolts, which are used to attach the pump to the platform.

7. Turn the pump with your hand to ensure that it rotates freely.

8. Check that the motor is not wet.

9. Check that the starter panel is not wet.

10. Check for signs of vandalism, e.g. forced entry, missing cables, broken panels and mountings.

3.2.2. <u>Filters</u>

Filters are used to remove suspended solids and other debris from irrigation water. Filters cannot remove dissolved material such as salts. There is a filter, called a suction filter, strainer or screen, in the suction pipe before the water enters the pump. There are also filters in the delivery pipe after the pump.

It is important to ensure that the filters are working properly, otherwise pipes or emitters can be blocked by debris or other suspended solids. If the suction strainer is broken or missing, the pump can be damaged and caused to fail by a blockage of the impeller.

The suction strainer is under water and can be checked only by removing it. This is done once a year or on instruction from the manager. At these times, inspect the strainer for damage and blockages, and clean it if necessary.

Perform the following checks on the filters before starting up the pump system.

1. Check the filter valves.

2. Check that the filter lids are bolted or clamped down.

3. Check the lid-seal or rubber ring for cracks.

4. Check flanges for leaks.

5. If the filter is fitted with hydraulic valves, check the small inline filter and clean if necessary.

If the filters in the filter bank after the pump delivery are dirty, there will be a pressure loss in the field. This can only be assessed when the pump is running. Filter-banks are cleaned by back-flushing them with the pump running. This procedure is described in detail in chapter 4.

3.2.3. Valves

For manual valves, being gate and butterfly valves, check the following:

1. Check the valves manually to see if they open and close as they should.

2. On gate valves, check whether the spindle rises or drops, as this can be indication of a broken thrust washer, in which case the valve will not open or close.

3. Check if the spindle keeps on rotating. This indicates a stripped nut, in which case the valve will not open or close.

4. Check for leaks at the gland packing, spindle seal, flanges and casing.

5. Check for signs of vandalism, such as a missing wheel or vandalised parts.

For hydraulic valves check the following:

1. Check to see if the 3-way valve is able to turn between open, close and auto, and return it to original setting.

2. Check the rest of the valve for damage to the tubing, fittings, solenoids and wires.

4. Reporting on the Pre-Start-Up Inspection

A pre-start-up checklist should be used to record the findings of the pre-start-up procedure. When the pre-start-up checklist has been completed, it is handed to the supervisor or manager. Matters that require urgent attention is reported verbally to the supervisor as well.

On the next page is an example of a pre-start-up checklist.

Example

Pre-Start-Up Checklist

Pre-Start-Up Checklist			
Pump Station:		**Date:**	
Item	***Checked***	***Comments***	
Water Level			
Pump			
Excessive Water			
Oil Levels			
Flanges			
Gland Packaging			
Couplings			
Mountings			
Free Rotation			
Motor/Starter Panel Dry			
Other Comments:			
Filters			
Valves			
Lids			
Seals			
Flanges			
Inline Filter (Hydraulic Valves)			
Other Comments:			
Valves (Manual)			
Manual Open/Close			
Spindle			
Leaks			
Other Comments			
Valves (Hydraulics)			
Settings			
Other Damage			
Other Comments			
Checked By:		**Signed:**	

5. Priming Pumps

Priming means to fill the pump with water so that all air is expelled. If the pump is not primed, it will not be able draw water from the water source, which will result in cavitation. If the pump is fully primed, it will be able to draw and pump water. Centrifugal pumps must be fully primed in order to work properly.

To check whether the pump is primed, open the cock valve on the delivery side of the pump. This is a small valve that is used to expel air and to check whether the pump is full of water. If water squirts form the valve, the pump is primed, but if no water is present, the pump still has to be primed.

There are various methods that can be used to prime a pump. To prime a pump that is below the water level, for example a pump at the bottom of the dam wall, simply open the cock valve and keep it open until all the air has escaped and only water squirts out. Once the cock valve has been closed again, the pump is primed.

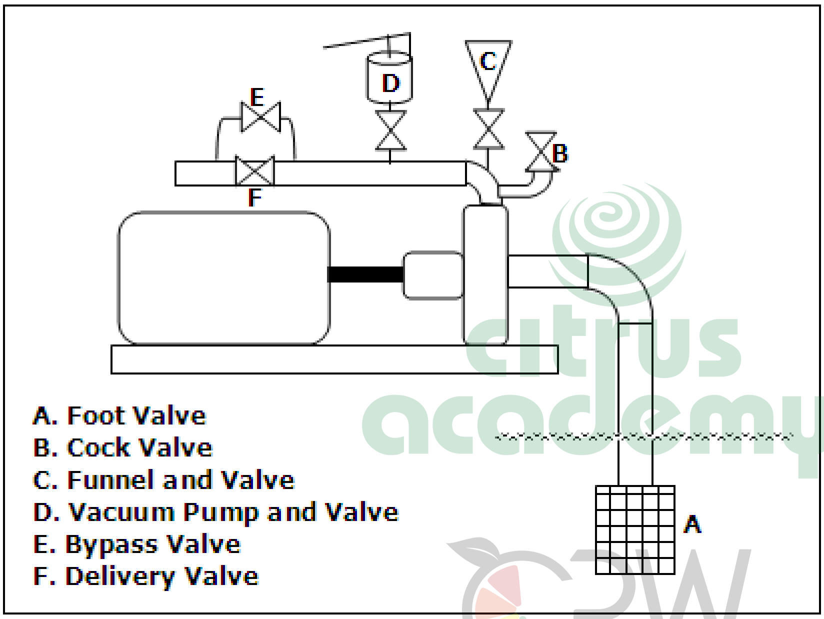


Figure 1.9: A Pump with Different Configurations for Priming

If the pump is above the water level, the pump can be primed using the funnel, the vacuum pump or the line pressure.

To prime the pump using the funnel:

- Ensure that the delivery valve is closed;
- Open the valve below the funnel;
- Pour water into the funnel using a bucket. The water go into the pump and the air will be expelled through the funnel;
- Continue to fill the pump until the funnel is brimming with water and no more air is expelled;
- The pump is now primed and the valve below the funnel can be closed.

To prime the pump using the vacuum pump:

- Ensure that the delivery valve and all other valves are closed;
- Open the valve below the vacuum pump;

- Use the handle of the vacuum pump to pump all the air out;
- The pump is now primed and the valve below the vacuum pump can be closed.

When the main line is filled with water, the line pressure can be used to prime the pump. If a non-return valve is fitted at the delivery valve, the bypass valve as well the cock valve must be opened. Air will blow from the cock valve. When water squirts from the cock valve, the pump is primed and the cock and bypass valves can be closed.

In some instances the pump won't prime, which could be due to either a leak on the suction pipe or a faulty foot valve. Report such an incident immediately to the supervisor or manager.

Chapter 1

- An irrigation system consists of a pump system, filters, pipes, valves, lateral lines and emitters.
- Pump systems pump water from the water source into the pipes that lead to the orchards.
- Water passes through filters before passing into the pipes. The filters clean the water from suspended solids.
- Water is pumped through pipes to the orchards. There are various types of pipes, including mainlines, sub-mainlines, mother lines and lateral lines.
- Valves can open and close, thereby cutting water off or letting it through. Valves are also used to control the water pressure.
- Emitters deliver water to individual trees. Micro-jets and drippers are commonly used.
- During the pre-start-up inspection, the water level must be checked, and the pump, filters and valves must be checked and cleaned.
- The water level in the water source must be such that the pump will not run dry, as this can lead to cavitation.
- The pump must be checked for leaks, vandalism, loose bolts, etc., cleaned and oiled or greased (if necessary) before being started.
- Filters must be checked for leaks and other damage. Filters must also be cleaned through back-flushing if necessary.
- Valves must be checked to ensure that they open and close properly and that they are not leaking.
- A pre-start-up inspection checklist is completed before the pump is started.
- A pump must be primed before being started, meaning that it must be filled with water so that all air is expelled.

Complete activities 1 and 2 in the **Learner Workbook**.

Chapter 2

After completing this chapter, the learner will be able to:

Perform start-up and shutdown procedures applicable to the relevant irrigation system

1. Starting Up and Shutting Down Pumps

Proper starting up and shutting down of pumps ensure that the pump operate optimally and extend the operational life of the pump.

It is very important that the delivery valve must be closed before the pump is started or shut down. If the delivery valve is open during start-up, the pump will need more energy to start, resulting in a bigger electricity bill. If the pump is shut down with an open valve, water hammer can occur, which can damage the internal parts of the pump.

Definition

Water Hammer

Water hammer occurs when a pump is stopped abruptly, and the column of pumped water stops and flows backwards towards the pump because of the pressure inside the pipe line.

Note that some pump installations are equipped with automated hydraulic valves. These valves open and close automatically when the pump is switched on and off.

1.1. Starting Up

1. Perform the pre-start-up inspection.
2. Check that the pump is properly primed.
3. Close the delivery valve.
4. Start the pump by pushing the start button and remain at the panel until the pump runs smoothly (10-20 seconds). If any unusual noise or vibration occurs, immediately press the stop button.
5. If the pump runs normally, open the delivery valve slowly.

1.2. Shutting Down

1. Close the delivery valve slowly, preventing water hammer.
2. As soon as the valve is closed, switch off the pump.

Note that just before shutting down the pump is an ideal time to take pressure readings on the filter bank and to back-flush the filters.

2. Motor and Pump Working Characteristics

Most pump installations are equipped with the following gauges:

- The **amp meter** is located on the electrical panel and measures the current that is used;
- The **volt meter** is located on the electrical panel and gives a reading of the voltage, e.g. 400V;
- The **pressure gauge** is located on the delivery pipe and gives a reading of the pressure in kPa or Bar;
- The **flow meter** is installed on the delivery pipe and measures the flow in cubic meters (m^3). Mechanical flow meters have a dial gauge on the meter, while electronic flow meters have a digital readout in a special panel.

Although all pump stations will not necessarily have volt and flow meters, it should at least be equipped with an amp meter and pressure gauge.

The normal readings, or norms, differ from pump to pump. The supervisor or manager should give the norms for amps, volts, pressure and flow. Actual readings are compared with the norms to establish whether the pump and motor are running optimally, and to assist with determining the pump and motor characteristics.

There are three possible scenarios:

- $\text{Amps}_{\text{motor}} = \text{Amps}_{\text{normal}}$
- $\text{Amps}_{\text{motor}} > \text{Amps}_{\text{normal}}$
- $\text{Amps}_{\text{motor}} < \text{Amps}_{\text{normal}}$

2.1. $\text{Amps}_{\text{motor}} = \text{Amps}_{\text{normal}}$

This is the normal operating condition for the pump. Note that the pressure and flow readings will also be normal.

2.2. $\text{Amps}_{\text{motor}} > \text{Amps}_{\text{normal}}$

This is referred to as an overload condition. When the control panel detects an overload, it automatically shuts down the pump.

If the pressure reading is lower than the norm and the flow is higher than normal, it means that too many valves are open or that a pipe has burst. If the pressure and flow is normal, it means that mechanical failure has occurred, for example a ceased bearing causing excessive friction. This will be coupled with noise and vibration. The pump must be switched off and the situation reported to the supervisor or manager.

2.3. $\text{Amps}_{\text{motor}} < \text{Amps}_{\text{normal}}$

This is referred to as an under-load condition.

If the pressure is high and the flow is low, it could be that too many valves are closed, that the filter bank is blocked, or that a valve is malfunctioning or stuck. If the pressure is very high and near the same reading as when the valve is closed, switch off the pump, according to the shut-down procedure, because the pump will overheat due to the low flow. Report these deviations to the manager.

If the pressure and flow are low, the pump is cavitating, causing the pump to vibrate and be noisy. Switch the pump off immediately according to the shut-down procedure. The pump could have sucked air or have a blocked impeller or suction strainer. Report the situation to the manager.

3. Opening and Closing Pressure Control Valves

Pressure control valves are hydraulic valves fitted with a pilot valve and is used to regulate pressure and flow. The pilot valve is a device that regulates the pressure inside the hydraulic valves.

These valves are controlled by a 3-way valve. The 3-way valve is marked *Open*, *Close* and *Auto*. To open the pressure, simply turn the dial to *Open* and to close the valve, turn the dial to *Close*. To regulate the pressure, or for other automated functions, turn the dial to *Auto*.

Keep in mind that turning the dial to open could burst a pipe because of high pressure. The pilot should also only be adjusted by the supervisor or manager. Some valves are fitted with pressure points. See section 6 of this chapter for more information on the use of these pressure points.

4. Possible Problems

After a pump is started in the morning, it must be monitored during the day to ensure that it is running smoothly. Always check the perimeter and working characteristics of the pump as described in previous sections. Also pay attention to vibration, noise, leaks, burst pipes, smoke, sparks, fire, etc. Switch off the pump immediately if any of this should occur and report it to the supervisor or manager.

5. Infield Valves

Hydraulic, gate or butterfly valves are used as infield valves. Hydraulic valves are opened as described in section 3 of this chapter, while gate valves are opened and closed using a wheel. To open a gate valve, turn the wheel anticlockwise and to close the valve, turn the wheel clockwise.

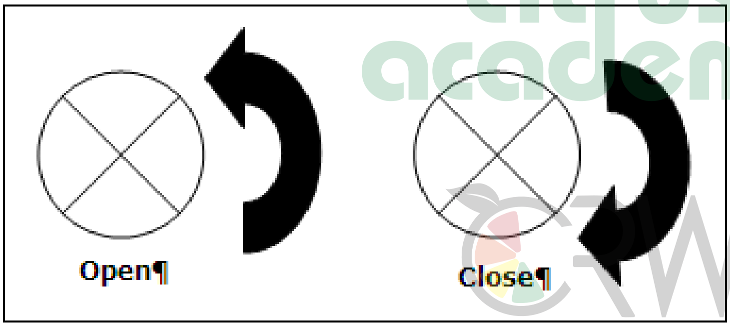


Figure 2.1: Opening and Closing Direction for Gate Valves

Butterfly valves are equipped with a handle. To open the valve, turn the handle until it is in line with the pipe. To close the valve, turn the handle until it is perpendicular to the pipe. Some butterfly valves are equipped with a wheel and dial. When the wheel is turned, the dial indicates if it is opening or closing.

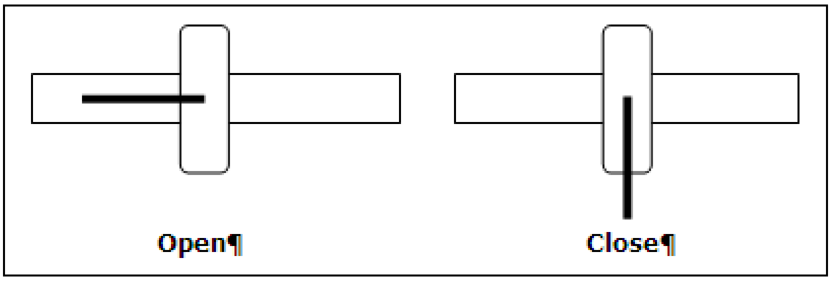


Figure 2.2: Opening and Closing Positions for Butterfly Valves

To set the flow rate for an irrigation block, the pressure needs to be adjusted by opening or closing the valve. To reduce the pressure, close the valve more, and to increase the pressure, open the valve more. See section 6 for the measuring and regulating of the pressure.

6. Regulating Infield Valve Pressure

It is very important that the pressure on infield valves is regulated properly and set to the required levels, as the pressure determines the flow rate and the even distribution of water in the irrigation block.

If the pressure is too low, the hydraulics of the system is upset, resulting in uneven distribution of water. Some trees will receive too little water, resulting in water-stress that can impact negatively on yield.

If the pressure is too high too much water is delivered to the trees, which not only causes water wastage, but also excessive misting which increases evaporative losses. Too high pressure will also extend the wetting diameter of micro-jets, applying water to the rows between the trees and not only to the root-zone.

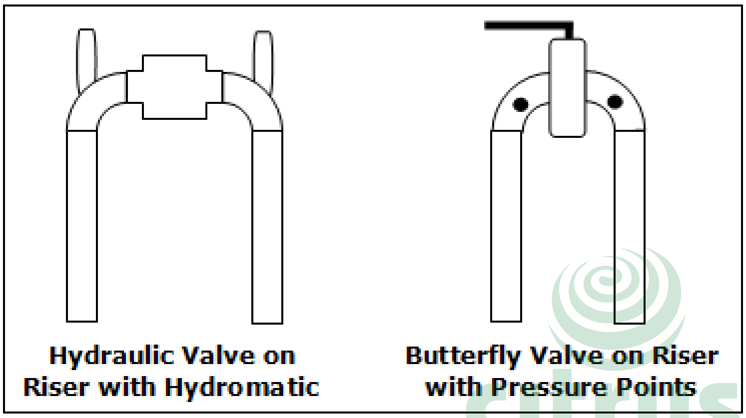


Figure 2.3: Examples of Valve Risers

The correct pressure levels for infield valves are determined and prescribed by the irrigation manager or supervisor. The supervisor or manager will also set the pilot valves that are used on hydraulic valves, and no other person should be allowed to adjust the settings.

Infield valves are located on valve risers or valve clusters. Usually, these risers consist of riser pipes, a valve (hydraulic, gate, butterfly) and either hydromatics or pressure points. A hydromatic is type of quick coupler that is used for pressure readings.

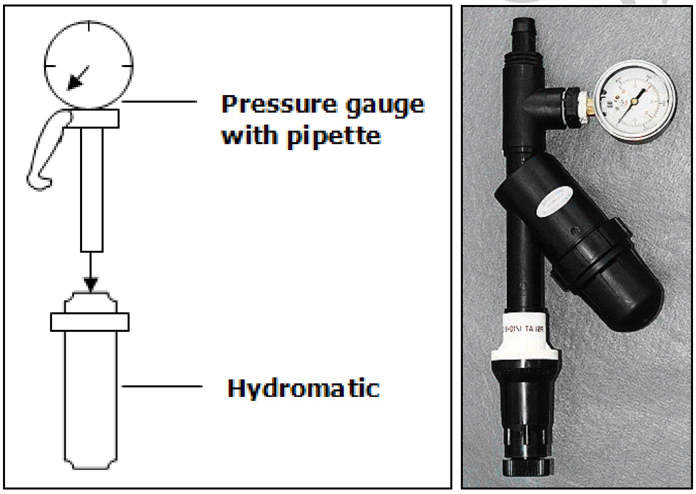


Figure 2.4: Example of Pipette and Hydromatic

The hydromatic and pressure points are used to measure the pressure. To measure the pressure using the hydromatic:

- Fit a pressure gauge to a pipette, which fits into the hydromatic, and not to be confused with a pipette that it used in chemistry

- Insert the pipette with the gauge into the hydromatic
- Make sure the latch on the pipette locks on to the hydromatic
- The pressure will register on the gauge
- To release the pipette, push it down, unlock the latch and remove it

To use the pressure point, the gauge must be fitted with a special needle. To take a pressure reading:

- Insert the needle carefully into the pressure point, as carelessness can damage the silicon nipple inside the pressure point.
- The pressure will register on the gauge.
- Remove the gauge by simply pulling the needle out of the pressure point. Be careful when inserting the needle.

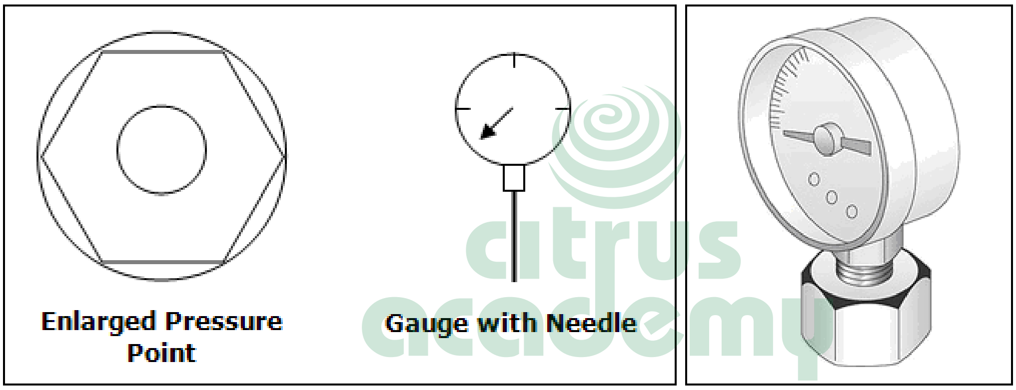


Figure 2.5: Pressure Point and Gauge with Needle

Where a hydraulic valve is used, the pilot valve is set to regulate the pressure for the irrigation block. It is good practise to take a reading once the valve is open and the pressure is stable, around 10-20 minutes after opening.

The norm is 1.8 to 2.3bar where micro emitters are used, but can vary depending on the characteristics of the block. It is however important to note that if the pilot valve is set to for example 2bar, the reading should not be lower than 1.8bar or higher than 2.2bar, which is a 10% tolerance. If the reading is outside this range, it must be reported to the supervisor or manager.

Where a gate or butterfly valve is used, the pressure must be set manually. Insert the gauge into the riser and open the valve slowly. Once the lateral lines in the block have filled with water and the pressure has stabilised, regulate the pressure by turning the wheel, thereby opening and closing the valve.

If the required pressure is for example 2bar, and the reading on the gauge is 1.7bar, open the valve slowly until the pressure is 2bar. If the reading is 2.3bar, close the valve slowly until the reading is 2bar.

Find and identify different types of valves in the irrigation system on your farm. Open and close the valves, and measure and regulate the pressure to the prescribed levels.

7. Measuring Infield Filter Pressure

In some irrigation systems, secondary inline filters are fitted. Using the same techniques as for the valves, measure the pressure upstream, being before the filter, and downstream, being after the filter. The difference between the two readings should not be more than 0.5bar.

Example

Infield Filter Pressure

Upstream pressure = 4bar
Downstream pressure = 3.7bar
The difference is smaller than 0.5bar, the filter is clean.

Upstream pressure = 4 bar
Downstream pressure = 3.4 bar
The difference is greater than 0.5bar. The filter is dirty, and must be cleaned.

If the inline filters are in a bank, i.e. two or more filters are in parallel, the filters can be back-flushed (see section 1 of chapter 4). After back-flushing, take a pressure reading again. If the difference is still greater than 0.5 bar:

- Close the filter inlet valve;
- Remove the filter lid;
- Remove the elements from the filter;
- Clean it with a brush (see the manual for the specific filter);
- Re-insert the elements;
- Replace the filter lid;
- Open the inlet valve.

Take a pressure reading again. If the difference is still larger than 0.5 bar, report this to the supervisor or manager.

Summary

Chapter 2

- Following proper start-up and shut-down procedures will ensure that the pump will work well and prolong its lifespan.
- Readings are taken from the amp meter, volt meter, pressure gauge and flow meter after the pump system has been started to ensure that it is working properly.
- If the amp reading is higher than expected, it is referred to as an overload situation, and if the amp reading is lower than expected, it is referred to as under-load.
- Pressure control valves are hydraulic valves that control water flow from the pump.
- Gate valves are opened and closed by turning the wheel clockwise or anticlockwise.
- Butterfly valves are opened and closed by turning the handle to be in line with or perpendicular to the pipe.
- In-field valves must be regulated to the correct water pressure, in accordance with the irrigation system design.
- Water pressure is measured on in-field valves by using either a hydromatic or pressure point.
- A pressure gauge is fitted in a pipette that is inserted into a hydromatic to measure pressure.
- A pressure gauge fitted with a special needle is inserted into a pressure point to measure pressure.

- Valves are opened or closed until the correct pressure is measured through the hydromatic or pressure point.
- Pressure is measured at inline filters using the same methods as is used for valves.
- The difference between the pressure reading taken before and after inline filters should not be more than 0.5bar. If it is more, the filter must be cleaned through back-flushing.

Practical

Complete activities 3 and 4 in the **Learner Workbook**.

Chapter 3

After completing this chapter, the learner will be able to: **Irrigate crop according to given guidelines**

1. Monitoring Irrigation Quality

In citrus production, it is important to have a constant irrigation pattern in all orchards. The same part of the root-zone around every tree must be wetted constantly. Regular quality checks on the system are essential to ensure that the prescribed standards are maintained.

It is important to distinguish between micro-jet and drip systems when prescribing inspection procedures. While a block is being irrigated, a visual inspection must be done, and the vital points to focus on that are applicable to drip and micro-jets systems are:

- Leaks
- Runoff
- Pressure
- Emitter delivery

1.1. Leaks

Any leak, large or small, must be repaired immediately using a suitable joint or fitting. Leaks that cannot be repaired must be reported immediately to the supervisor or manager. If there is a large leak or a burst pipe, close the infield valve that controls the flow to the irrigation block immediately and report it to the supervisor.

1.2. Runoff

Runoff occurs when water is no longer absorbed into the soil. The water collects in puddles on the surface of the soil and runs off.

Runoff may be an indication of over-irrigation. Make sure that the irrigation schedule is being implemented correctly, that the pressure is not too high and that the standing time is not too long. Runoff may also be a result of crusting of the soil.

If the irrigation schedule is being implemented correctly, report the situation to the supervisor for investigation.

1.3. Pressure

In the previous chapter we looked at how the infield water pressure is regulated and monitored. During a visual inspection, misting is an indication of too high pressure, and the cause must be investigated.

Overlapping can also occur when the radius of the spreader or spinner increases due to pressure being too high, which may coincide with misting. Check the pressure, make the necessary adjustment, and report the matter to the manager.

1.4. Emitter Delivery

The delivery of emitters can be visually monitored in the field by checking for dry spots, overlapping and over- and under- irrigation.

While irrigating, one should always be on the lookout for dry spots, which are spots where water was previously delivered but that are now dry. Determine the cause of the dry spot, which may be a clogged micro or dripper, or a faulty spreader. If the micro is blocked, remove the micro from the peg, remove the head and clean the nozzle.

If a dripper is blocked, tap the dripper with your finger. If it stays clogged, report it to the supervisor or manager. Never use a sharp object to unclogged the dripper as this will damage or puncture the dripper. Dry spots can also occur due to swivels that remain stationary, spreaders that spray skew or micros that have fallen over. Make sure that the peg is upright, that the spreader sprays in the right direction and pattern, and that the swivels are turning.

Most irrigation systems have a small degree of overlapping. Be on the lookout for excessive overlapping on the one side of a tree and a dry spot on the other. Move the emitter more to the centre.

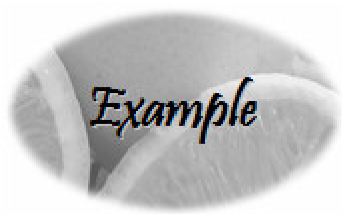
2. Irrigation Scheduling

Irrigation scheduling consists of two parts, being how much water to apply and when to apply the said volume of water. **How much** water is determined by the water holding capacity of the soil and the size of the root-zone. The volume of water to be applied (how much) is also referred to as the standing time. The standing time is fixed and should never vary.

When to apply the water is determined by the tree and climate. This is expressed in hours or mm water. When to apply the water is also referred to as the intervals or irrigation cycle. The intervals are flexible and vary according to the water demand as is determined by season, climate and condition of the trees.

The irrigation schedule is determined and prescribed by the irrigation manager. Keeping to the irrigation schedule ensures that irrigation is effective.

Remember that the time required to open valves vary between farms and irrigation designs. It is important to open the valve of the specified block at the right time, and to close it at the right time. Failing to do so will affect the crop negatively.



Irrigation Schedule

Stand Time: 2 hours 50 minutes
Time to change valves: 10 minutes
Number of blocks: 3

Implementing this irrigation schedule involves the following steps:

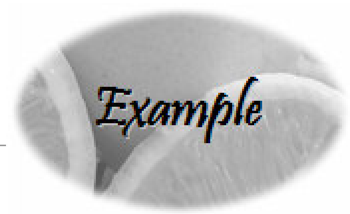
- 06h00 – Open block 1
- 08h50 – Close block 1 and go to block 2
- 09h00 – Open block 2
- 11h50 – Close block 2 and go to block 3
- 12h00 – Open block 3
- 14h50 – Close block 3

3. Monitoring Operational Parameters

Operational parameters are the parameters within which the irrigation system should operate to ensure that it functions effectively. These parameters include operating pressures, standing times, intervals and the quality checks as set out in section 1 of this chapter.

During irrigation these parameters must be monitored and recorded. Recordkeeping of these parameters is important, as this helps the manager to manage the irrigation effectively and to detect possible problems early. The following information is noted and recorded:

- Date
- Block number
- Pressure at pump and / or filters
- Block pressure
- Time when irrigation started
- Time when irrigation stopped
- Comments on quality checks
- Pressure at some of the emitters
- Delivery rate at some of the emitters



Operational Parameters Report

Date	25/03		
Pressure at Pump	6.5 bar		
Pressure at Filter	5.5 bar (pressure difference means back flushing is required)		
Block Number	**C 12**	**C 13**	**D 1**
Block Pressure	1.9 bar		
Time Irrigation Started	12h00		
Time Irrigation Stopped	14h50		
Pressure at Emitter	1.8		
Delivery Rate at Emitter	38 l/h		
Dry Spots	Yes rows 10 – 13		
Overlapping	None		
Over- / Under-Irrigation	None		
Flushing	None		
Comments	Blocked micros cleaned		

Comments can include information on the occurrence of dry spots, overlapping, over- or under-irrigation, and flushing, and general comments and observations.

On most farms more than one block is irrigated at a time, and the report can therefore be extended to record the information for more than one block. Below is an example of a sheet with the operational parameters recorded.

Summary

Chapter 3

- While a block is being irrigated the factors that must be monitored through a visual inspection are leaks, runoff, pressure, and delivery rate.
- The irrigation schedule determines how much water to apply and when to apply the water. The operating schedule prescribes when to open and close the irrigation to different blocks.
- The operational parameters are the parameters within which the irrigation system functions effectively.
- Operational parameters must be monitored, noted and reported on whenever the irrigation system is in operation.

Practical

Complete activity 5 in the **Learner Workbook**.

Chapter 4

After completing this chapter, the learner will be able to: **Care and maintain equipment and tools used during irrigation**

1. Flushing and Cleaning Filters

Primary filters are usually in banks and can be either sand or disc filters.

Filters in banks are back-flushed using hydraulic valves. In a sand filter, water enters through the inlet and is filtered through the sand during normal operation with back-flush valves closed. The clean water exit through the outlet and the dirt and impurities stay trapped in the sand. The more the filter is used, the dirtier the sand will become.

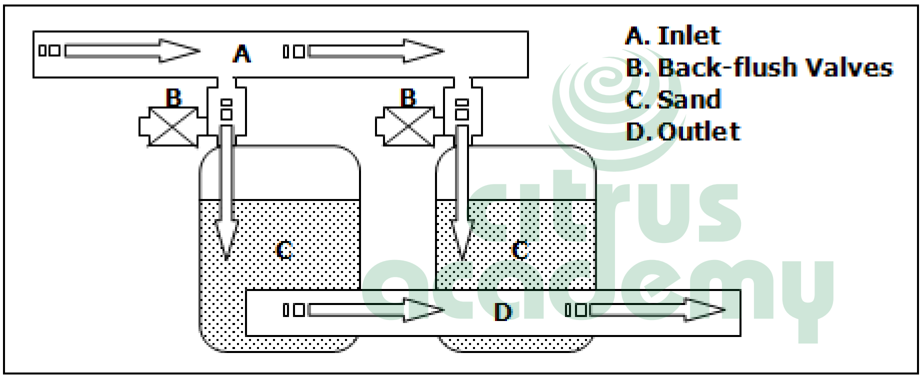


Figure 4.1: Normal Filtration in Sand Filter

If the sand has become dirty to a point where water cannot pass through it easily any longer, a pressure differential between the in- and outlet of greater than 0.5bar occur. The filter needs to be back-flushed.

If filters are not back-flushed regularly in the prescribed manner, dirt will accumulate in the filter, causing holes in the sand. The accumulated dirt cause irregular flow inside the filter. This irregular flow blow holes inside the sand. The water will move through the holes and not the sand, meaning that the water will not be filtered properly.

Filters are flushed up to five times a day or even more, depending on the water quality. It is good practice to also flush the filter once a week with the main valve closed. This will create extra pressure to flush out the filter. Once a month the filter lid must be opened and the inside inspected. Remember not to do this while the filter is under pressure. Check that the sand is loose and not caked. Caked sand will not break up during back flush, so the dirt stays inside the filter. If the sand is caked, report it to the manager.

The filters in the bank are flushed one at a time. During the back-flush, the inlet of the filter is closed and the back-flush valve is opened. Clean water from the other filter flows back through the filter that is being flushed. The dirt is washed out with the waste water. The filter must be flushed for no less than 60 seconds. If the water is brown and muddy, it is a good indication that the filter is doing its job. Flushing must continue until the water is clear.

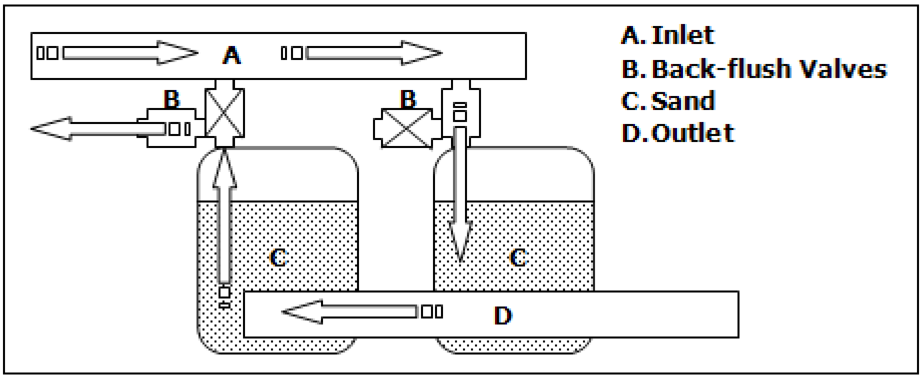


Figure 4.2: Back-Flushing of Sand Filter

Disc filters use discs to filter water in stead of sand. If the filters are in a bank, they can be back-flushed in the same manner as sand filters. If the filter is a single inline type, it can be cleaned by removing the filter element or cartridge, as follows:

- Loosen the filter element
- Remove the individual discs
- Scrub each disc with a brush and water
- Replace in the same way and with the same amount in the filter element
- Reinsert the filter element into the filter
- Close the lid

The filter elements are removed and cleaned on a weekly to monthly basis, depending on water quality.

2. Pipeline Maintenance

Leaks in pipes, connections and flanges must be repaired as soon as they are detected. Basic repair and replacement items must be kept on the farm for this purpose.

It is important to flush the mother-lines and lateral lines regularly. The intervals between flushing vary depending on the season, being weekly in mid-summer and monthly in winter. Proper flushing reduces emitter blockage and forms an essential part of the maintenance program. The supervisor or manager will prescribe the appropriate flushing interval.

3. Tool Maintenance

Proper care and maintenance of tools prolongs their lifespan, and will help to ensure that they work properly. Follow these guidelines:

- **Hand Tools** includes pliers, spanners, screwdrivers, spades and any other hand tools. After use, wash, clean and dry the tools if required, otherwise wipe them with a rag. Regularly following this procedure will prevent rusting. When tools are dry and clean, store them in the proper place that prevents theft and accidents.

- **Pressure Gauges** – Keep gauges away from high temperatures, and protect them from bumps and shocks. If the gauge is filled with fluid, keep it ¾ full with glycerine. Never use a low pressure gauge to measure high pressure as this will damage the gauge and make it inaccurate.

- **Grease Guns and Oil Cans** – Keep grease guns and oil cans free of sand and grit. Always wipe the tip of the grease gun before use to remove any sand or grit. Wipe off excess grease and oil after use, and after filling the cans.

Tools must be stored in a shed or an enclosed area that can be locked. This prevents theft of tools. A system must be in place to ensure that tools are returned after being used. It is helpful to have designated areas for the different tools marked on a board, to which the tools can be returned. This not only keeps the tool shed tidy, but allows one to see at a glance if a tool is missing.

4. Reporting

Using defective tools and equipment can be very dangerous and costly. It is good practice to learn to be sensitive to the tools and equipment you use. Usually there is a symptom before a breakdown or problem occurs, for example a pump will make noise or vibrate if something is wrong, or the secondary filters will need cleaning within a shorter period of time, because something is wrong with the primary filter.

It is very important that worn, defective tools and equipment be reported to the manager. Any unusual events or problems must also be reported to the manager.

Chapter 4

- Filters must be back-flushed on a regular basis to clean them from accumulated debris.
- Depending on the water quality, inline filters must be opened and cleaned on a weekly to monthly basis.
- The pipeline must be monitored for leaks constantly and any leaks must be repaired as soon as they are detected.
- Mother-lines and lateral lines must be flushed on a regular basis.
- Hand tools must be cleaned and dried properly, and stored in a safe, secure place.
- Pressure gauges must be protected from shocks and protected from high temperatures.
- Grease guns and oil cans must be kept clean and free of sand and grit.
- All tools and equipment must be monitored for possible damage, which must be reported to the manager or supervisor immediately.

Complete activity 6 in the **Learner Workbook**.

Bibliography

Irrigation Operation Manual, F.H. Koegelenbergh, 2003, ARC Institute for Agricultural Engineering, ARC-ILI
Irrigation Design Manual, J.H. Burger et al, 2003, ARC Institute for Agricultural Engineering, ARC- ILI