

Unpowered Terracotta Irrigation Controller

User Manual

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Above ground installation of the
Unpowered Terracotta Irrigation Controller



In ground installation of the
Unpowered Terracotta Irrigation Controller

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1. Introduction

It is recommended that you watch the YouTube video about the Terracotta Valve:

<https://www.youtube.com/watch?v=A90f5aAxvHA>

The Unpowered Terracotta Irrigation Controller is suitable for automatic sprinkler irrigation or drip irrigation, and can be installed either above ground or in ground. The Unpowered Terracotta Irrigation Controller includes a valve that operates with water supply pressure in the range 10 kPa to 800 kPa. The interval between irrigation events responds automatically to the on-site prevailing weather conditions (namely, evaporation and rainfall). For in ground installation, the interval between irrigation events also responds automatically to the transpiration requirements of your plant at their current stage of growth.

Terracotta is porous and so the water level in the pot falls as water seeps through the pot. A float inside the pot floats on the water. When the water level reaches the low level, a magnet inside the float activates the valve so that the valve opens and the irrigation starts. During the irrigation event a control dripper drips water into the pot and the water level rises. When the water level reaches the high level, the magnet inside the float disengages from the valve so that the valve closes and the irrigation stops.



Unpowered Terracotta Irrigation Controller showing the float and the water level



Float showing the ring magnet at the bottom of the float

This remarkable low-cost invention may enable poor smallholders in remote locations to grow higher-valued crops cost-effectively.

The valve under the Unpowered Terracotta Irrigation Controller has a 15 mm inlet and outlet, and so it is not suitable for large irrigation applications that require a bigger valve. If the flow rate through the valve is inadequate, you may wish to subdivide the irrigation application into zones with one Unpowered Terracotta Irrigation Controller for each zone.



Unpowered Terracotta Irrigation Controller showing the valve and the 15 mm inlet and outlet

2. Above ground installation of the Unpowered Terracotta Irrigation Controller

For above ground installation, position the Unpowered Terracotta Irrigation Controller in a suitable location in your garden so that the evaporation matches the evaporation at your plants.

Connect the water supply to the inlet pipe and connect the irrigation application to the outlet pipe (note that the control dripper is connected to the outlet pipe).



Connect the water supply to the inlet pipe



Connect the irrigation application to the outlet pipe

3. In ground installation of the Unpowered Terracotta Irrigation Controller

In ground installation is ideal for drip irrigation of row crops. Follow the installation steps below.



Step 1. Dig a hole midway between two adjacent plants. There should be no irrigation drippers near these two plants.



Step 2. Adjust the inlet and outlet pipes so that they are vertical. Position the controller in the hole so that rim of the pot is above ground level. Back fill the soil around the pot.



Step 3. Connect the water supply to the inlet pipe and connect the irrigation application to the outlet pipe.

Because the terracotta pot is in the ground near the roots of plants, the Unpowered Terracotta Irrigation Controller responds to changes in plant transpiration. As the crop grows and requires more water, the irrigation frequency increases automatically.

4. How to use the Unpowered Terracotta Irrigation Controller

Turn on the water supply and the irrigation starts immediately. The control dripper drips water into the terracotta pot during the irrigation. The irrigation stops automatically after the control volume of water has dripped into the pot. The **control volume** is defined as the volume of water that seeps through the terracotta pot between irrigation events.

The irrigation starts again automatically after the control volume of water has seeped through the pot. The cycle continues indefinitely and so you can leave your garden unattended for months on end. A saucer sits on top of the pot so that the water in the pot is protected from algae, mosquitoes and thirsty animals. There are 6 small drain holes in the saucer.

When using a conventional irrigation controller, you need to set the start time and the end time for each irrigation event. However, with the Unpowered Terracotta Irrigation Controller you don't need a timer. The duration of the irrigation event is the time it takes for the control volume of water to drip into the pot, and the interval between irrigation events is the time it takes for the control volume of water to seep through the terracotta pot.

It is important to note here that the control dripper is adjustable. If you reduce the flow rate of the control dripper, it takes a lot longer for the control volume of water to drip into the pot and so the duration of the irrigation event increases and your plants get more water. On the other hand, if you increase the flow rate of the control dripper, the control volume of water drips into the pot more quickly and so the duration of the irrigation event decreases and your plants get less water. Adjust the control dripper so that the irrigation delivers the appropriate amount of water to your plants at their current stage of growth.



The control dripper is adjustable.

The time it takes for the control volume of water to seep through the pot depends on the prevailing on-site weather conditions. When it is hot and dry, the water seeps more quickly and so the interval between irrigation events is shorter. When it is cool and overcast, the water seeps more slowly and so the interval between irrigation events is longer.

If it rains, rainwater collects in the saucer and drains into the pot. This means that the start of the next irrigation event is delayed. In addition to the control volume of water that needs to seep through the pot between irrigation events, any rainwater that has entered the pot between irrigation events also needs to seep through the pot.

To avoid irrigating during the heat of the day, you can turn off the water supply. Alternatively, a tap timer can be used so that water is only available between sunset and sunrise.

The Unpowered Terracotta Irrigation Controller uses on-site weather data (namely, evaporation and rainfall). Most smart irrigation controllers do not use on-site weather data. Instead they use weather data from the Bureau of Meteorology.

The Unpowered Terracotta Irrigation Controller can be used for both gravity feed and pressurised irrigation. It can be used with pressure compensating drippers and non pressure compensating drippers. It can also be used with weeper hose or soaker hose.

You can irrigate directly from a rainwater tank by gravity feed without using a pump provided that the water level in the tank is at least 1 metre higher than the valve at the bottom of the Unpowered Terracotta Irrigation Controller.

It is recommended that you adjust the interval between irrigation events before adjusting the water usage rate. You may need to adjust the interval between irrigation events and the water usage rate as the plants grow and their water requirements change.

Note that the term **water usage rate** refers to the number of litres per week used by the irrigation system.

How to adjust the interval between irrigation events

You can adjust the interval between irrigation events by adjusting the gap between the upper and lower floats. The interval between irrigation events is the time it takes for the control volume of water to seep through the porous terracotta pot. To adjust the gap by 4 mm, rotate the upper float by two and a quarter turns.

Adjusting the interval between irrigation events does not change the water usage rate. For example, if you decrease the interval between irrigation events by increasing the gap between the upper and lower floats, the amount of water used during the irrigation event increases automatically to ensure that the water usage rate (litres per week for example) remains the same.



To adjust the interval between irrigation events, adjust the gap between the upper and lower floats

The following table shows the control volume for various values of the gap between the upper and lower floats.

gap between the upper and lower floats	control volume
zero gap	77 ml
4 mm	109 ml
8 mm	141 ml
12 mm	173 ml
16 mm	205 ml
20 mm	237 ml
24 mm	269 ml
28 mm	300 ml

Table 1. Control volume for various gaps between the upper and lower floats

How to adjust the water usage rate

Position an empty measuring container under one of the drippers so that water drips into the container during the irrigation event. At the end of the irrigation event check the amount of water in the measuring container. You should also check the moisture in the soil.

If your plants are not getting enough water, reduce the flow rate of the control dripper. Reducing the flow rate of the control dripper increases the duration of the irrigation event and so your plants get more water. If your plants are getting too much water, increase the flow rate of the control dripper.

Adjusting the water usage rate does not affect the interval between irrigation events.

5. When is dripper discharge independent of pressure?

Conventional drip irrigation systems control the volume of water discharged by a dripper by using PC (pressure compensating) drippers to control the flow rate and an irrigation controller to control the time. In a domestic garden with mains water supply, many zones are usually required to ensure that the pressure in each zone does not fall below the lower limit for pressure compensation. The irrigation controller is programmed so that each zone is irrigated at a different time.

With identical NPC drippers (including the control dripper) at approximately the same level and negligible variations in the pressure within the zone due to frictional head loss, the Unpowered Terracotta Irrigation Controller ensures that the volume of water discharged by each dripper during the irrigation event is approximately the same regardless of the pressure. If the water supply pressure decreases, the flow rate of the NPC drippers also decreases. However, the duration of the irrigation event increases automatically to ensure that the control volume of water is discharged by each dripper. For domestic gardens on level ground, the irrigation system can usually be designed so that variations in pressure within the zone due to frictional head loss are negligible.

By using the Unpowered Terracotta Irrigation Controller in this way, many zones with PC drippers can be combined into a single zone with NPC drippers and a single Unpowered Terracotta Irrigation Controller, and so the cost of the irrigation system can be reduced dramatically.



The adjustable control dripper has been replaced by an on-line irrigation dripper.



The adjustable control dripper has been replaced by an in-line irrigation dripper.

The terracotta pot is quite small and so the control volume is restricted to the range 77 ml to 300 ml. Because each irrigation dripper discharges the control volume of water during the irrigation event, the water usage rate is often insufficient for your plants at their current stage of growth.

There are two methods that may be used to increase the discharge from the irrigation drippers during the irrigation event.

Method 1

This ingenious method uses identical NPC irrigation drippers to assemble a special control dripper called a **fractional dripper**. The flow rate of a fractional dripper is a fixed fraction of the flow rate of the irrigation drippers **regardless of the pressure**. For example, if the control dripper is a fractional dripper with one quarter of the flow rate of an irrigation dripper, then the volume of water discharged by each of the irrigation drippers is 4 times the control volume regardless of the pressure.

For more information about fractional drippers, see the User Manual for the Unpowered Terracotta Irrigation Controller. The User Manual can be downloaded from the Measured Irrigation website:

<https://www.measuredirrigation.com/>

Method 2

The discharge of the irrigation drippers can be increased by connecting additional terracotta pots to the original terracotta pot so that the water level is the same in all pots. With one additional pot the discharge is slightly more than doubled. With two additional pots the discharge is slightly more than trebled. Continuing in this way the discharge continues to increase.

One way of connecting the pots is to drill a 10 mm hole in the bottom of the pots and to use 6 mm ID (10 mm OD) rubber grommets, 6 mm barbed elbows and 6 mm flexible tubing. The drain hole in the additional pots should be sealed.



With two additional pots the discharge during the irrigation event is slightly more than trebled.



The pots are connected by 6 mm flexible tubing so that the water level is the same in all the pots.

Using different NPC drippers

We now consider a method of using different NPC (non pressure compensating) drippers for the irrigation application so that dripper discharge remains largely unaffected by changes in pressure. NPC drippers are usually available with flow rates of 2 L/H, 4 L/H and 8 L/H (at a pressure of 100 kPa). Suppose that a combination of these drippers is used for the irrigation application (including the control dripper). Provided that all drippers have the same emitter discharge exponent (see the manufacturer's specifications), that all drippers are at approximately the same level, and that variations in pressure within the zone due to frictional head loss are negligible, then the Unpowered Terracotta Irrigation Controller ensures that the volume of water discharged by an irrigation dripper during the irrigation event remains approximately constant within the manufacturer's recommended pressure range. For example, if the gap between the upper and lower discs is 16 mm, the control dripper is 2 L/H (at 100 kPa) and the irrigation drippers are 8 L/H (at 100 kPa), then the control volume is 205 ml and the dripper discharge from the irrigation drippers is approximately 820 ml. It should be emphasised that the pressure should be kept with the range recommended by the manufacturer to ensure that the control dripper and the irrigation drippers have the same emitter discharge exponent.

The control volume for the Unpowered Terracotta Irrigation Controller is in the range 77 ml to 300 ml. The control volume for the Large Unpowered Terracotta Irrigation Controller is in the range 400 ml to

2300 ml. This means that you increase the discharge of the irrigation drippers during the irrigation event by using the Large Unpowered Terracotta Irrigation Controller instead of the Unpowered Terracotta Irrigation Controller.

In practice the emitter discharge exponent for drippers with a different flow rate is unlikely to be exactly the same. It is therefore preferable to use identical drippers throughout the irrigation zone.

For some applications it may be difficult to source suitable drippers that have exactly the same emitter discharge exponent. In general, the ratio of the flow rate of two emitters with different emitter discharge exponents can be calculated by the following formula.

$$\frac{q_2}{q_1} = r \left(\frac{100}{p} \right)^{x_2 - x_1}$$

where q_2 is the flow rate of the high flow emitter at 100 kPa

q_1 is the flow rate of the low flow emitters at 100 kPa

r is the ratio of the high flow rate to the low flow rate at 100 kPa

p is the pressure in kPa

x_2 is the emitter discharge exponent of the high flow emitter

x_1 is the emitter discharge exponent of the low flow emitter

This formula can be used to determine whether the variations in the ratio of the flow rates for different pressures are acceptable.

Gravity feed irrigation from a rainwater tank using identical NPC drippers

Suppose you are using gravity feed drip irrigation on level ground from a rainwater tank without using a pump. If you are using a conventional irrigation controller, you are faced with the problem that the dripper discharge decreases as the water level in the tank falls. This problem is solved by using the Unpowered Terracotta Irrigation Controller where the control dripper is an irrigation dripper or a fractional dripper assembled from irrigation drippers. The volume of water discharged by each dripper during an irrigation event is independent of the water level in the tank. The water level in the tank should be at least one metre higher than the valve at the bottom of the Unpowered Terracotta Irrigation Controller. A header tank on a stand at least 1 metre is ideal. A low cost transfer pump can be used to fill the header tank between irrigation events.

The Unpowered Terracotta Irrigation Controller is a **game-changer** for automated gravity feed irrigation on level ground from a rainwater tank.

When is sprinkler discharge independent of pressure?

Within their operational pressure range, sprinklers have an emitter discharge exponent of 0.5.

Therefore the sprinkler discharge during the irrigation event is independent of pressure provided that the emitter discharge exponent of the control dripper is also 0.5.

6. Key features of the Unpowered Terracotta Irrigation Controller

1. Unpowered (no batteries, no solar panels, no electronics, no computers, and no WiFi)
2. Water supply pressure 10 kPa to 800 kPa
3. Use for sprinkler irrigation or drip irrigation
4. Use for gravity feed or pressurised irrigation
5. Use with PC (pressure compensating) drippers or NPC (non pressure compensating) drippers
6. Adjust the water usage rate by adjusting the control dripper
7. Adjust the interval between irrigation events by adjusting the float
8. Adjusting the water usage rate does not affect the interval between irrigation events, and adjusting the interval between irrigation events does not affect the water usage rate
9. Responds automatically to on-site evaporation and rainfall
10. The irrigation frequency increases significantly during a heat wave
11. Install above ground or in ground
12. For in ground installation the controller responds automatically to plant transpiration
13. Provided the same drippers are used throughout the irrigation application (including the control dripper), the water usage rate is independent of the water supply pressure
14. Irrigate directly from a rainwater tank without using a pump
15. Water in the terracotta pot is protected from algae, mosquitoes and thirsty animals
16. Simple, unpowered, and low tech, and therefore fewer things can go wrong
17. Leave your irrigation application unattended for months on end

7. Conclusion

The Unpowered Terracotta Irrigation Controller uses a radically different approach to irrigation scheduling called Measured Irrigation. See the Measured Irrigation website for more information: www.measuredirrigation.com.au

Conventional irrigation systems **indirectly** control the volume of water discharged by a dripper by using PC drippers to control the flow rate and an irrigation controller to control the time. However, Measured Irrigation **directly** controls the volume of water discharged by a dripper, rather than controlling the flow rate and the time. Because it is no longer necessary to control the flow rate, one can use NPC drippers as well as PC drippers.

PC drippers stop working altogether at low pressure. Provided that the PC drippers continue to discharge water, they can be used outside the pressure range recommended by the manufacturer. NPC drippers can be used with any water supply pressure in the range 10 kPa to 800 kPa.

The Unpowered Terracotta Irrigation Controller uses on-site weather information rather than information from the Bureau of Meteorology, and so it is ideal for greenhouse applications.

The Unpowered Terracotta Irrigation Controller is a game-changer for automated irrigation on level ground from a rainwater tank. If you are using pressurised irrigation with pressure compensating drippers, the following items are required.

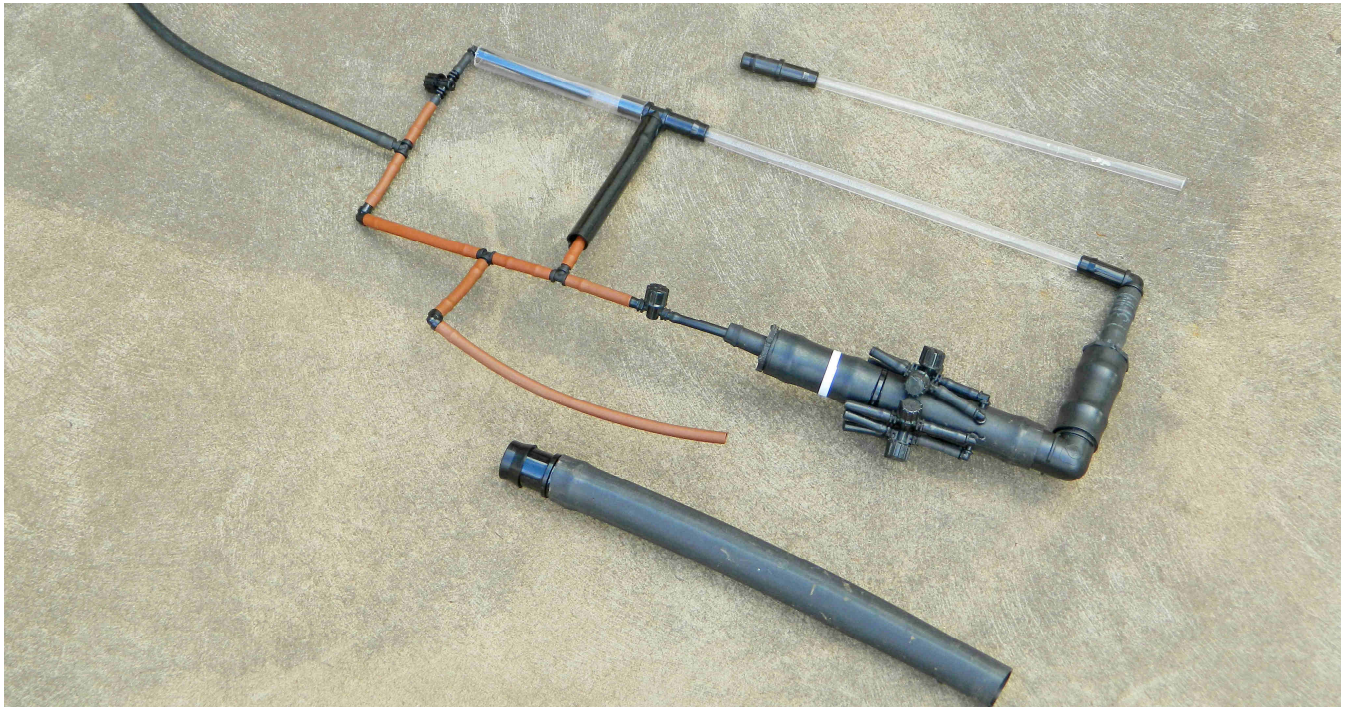
- Pump for the rainwater tank
- Additional solenoid valves (one needed for each additional zone)
- Conventional irrigation controller
- Hose clamps

None of these items are required when you use the Unpowered Terracotta Irrigation Controller, and so the cost of installing and running the irrigation systems can be reduced dramatically.

Appendix. Fractional drippers

To ensure that each irrigation dripper discharges the appropriate volume of water during the irrigation event regardless of the pressure, you can use a control dripper that delivers a fixed fraction of the volume of water discharged by an irrigation dripper. This can be done for either PC (pressure compensating) drippers or NPC (non pressure compensating) drippers.

If you are using PC drippers, then the pressure at the drippers does not need to be within the pressure range specified by the manufacturer for pressure compensation. However PC drippers stop working altogether at low pressure so when using a fractional dripper always check that the drippers are working.



Fractional dripper tool

Fractional dripper tool

The fractional dripper tool may be purchased from the Measured Irrigation website. The construction of the fractional dripper tool is an excellent DIY project.

Fitting drippers to the fractional dripper tool

To use the tool you require 10 identical irrigation drippers. If you are using dripline, you can prepare 10 identical irrigation drippers by cutting the dripline into short lengths with one dripper per length and sealing one end.

Two of the drippers are used as **upper drippers** and the remaining 8 drippers are used as **lower drippers**. One of the upper drippers is connected inside the 25 mm polypipe so that the outlet of the dripper is at the level of the white line. To access this dripper you need to disconnect the 25mm polypipe at the joiner just below the white line. You also need to disconnect the 4mm micro valve from the dripper. The other upper dripper is outside the 25mm polypipe and the outlet of the dripper is also at the level of the white line.



To access the first upper dripper, disconnect the 25 mm polypipe at the joiner just below the white line and disconnect the 4mm micro valve from the dripper.



The other upper dripper is outside the 25 mm polypipe and the outlet of the dripper at the same level as the outlet of the first dripper.

Each of the lower drippers is connected to 4 mm polypipe connected to a 4 mm micro valve so that the outlet of the dripper is at the same level as the 4 mm elbows inserted in the 25 mm polypipe.



Each of the lower drippers is connected to a 4mm micro valve

The fractional dripper needs to be suspended above the terracotta pot. The irrigation system provides the water supply for the fractional dripper.

A clear tube allows the user to view the water level in the 25 mm polypipe. The water level should always be below the white line. An extra length of 25 mm polypipe and an extra length of clear tube are provided so that the 25 mm polypipe can be extended to ensure that the water level is below the white line. Provided that the water level is low enough, it is preferable not to use the extension.

When using the fractional dripper, it is preferable that the upper drippers are at the same level as the irrigation drippers. For this to be the case, you may need to relocate the Terracotta Irrigation Controller to a location in your garden where the pot is low enough.

You can use the fractional dripper tool to make a fractional dripper with any of the following fractions of the flow rate of the identical irrigation drippers:

$\frac{1}{8}$, $\frac{1}{7}$, $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{2}{7}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{3}{7}$, $\frac{1}{2}$, $\frac{4}{7}$, $\frac{5}{8}$, $\frac{5}{7}$, $\frac{3}{4}$, $\frac{4}{5}$, $\frac{5}{6}$, $\frac{6}{7}$, $\frac{7}{8}$

The fractional dripper has almost the same emitter discharge exponent as the identical irrigation drippers. Therefore the flow rate of a fractional dripper is a fixed fraction of the flow rate of the irrigation drippers used to assemble the fractional dripper, regardless of the pressure.

To make a fractional dripper for dripline you need to cut the dripline into short lengths with one dripper per length and one end blocked.



The fractional dripper is suspended above the terracotta pot

The following table provides the setup details for the available fractions for the fractional dripper.

Fractional dripper fraction	Number of closed lower drippers	Number of open lower drippers	Number of open lower drippers supplying the output of the fractional dripper
1/8 (0.125)	0	8	1
1/7 (0.143)	1	7	1
1/6 (0.167)	2	6	1
1/5 (0.200)	3	5	1
1/4 (0.250)	4	4	1
2/7 (0.286)	1	7	2
1/3 (0.333)	5	3	1
2/5 (0.400)	3	5	2
3/8 (0.375)	0	8	3
3/7 (0.429)	1	7	3
1/2 (0.500)	6	2	1
1/2 (0.500)	4	4	2
4/7 (0.571)	1	7	4
5/8 (0.625)	0	8	5
5/7 (0.714)	1	7	5
3/4 (0.750)	4	4	3
4/5 (0.800)	3	5	4
5/6 (0.833)	2	6	5
6/7 (0.857)	1	7	6
7/8 (0.875)	0	8	7

Table 2. Fractional dripper setup details

Flow rate of the upper drippers

The flow rate of the irrigation drippers and the upper drippers should all be approximately the same. You may wish to use the following procedure to increase the flow rate of the upper dripper inside the 25 mm polypipe to match the flow rate of one of the irrigation drippers more precisely.

Measure the flow rates of the irrigation dripper and the upper dripper outside the 25 mm polypipe. If the flow rate of the irrigation dripper is greater than the flow rate of the upper dripper, calculate the difference in flow rates. The 4 mm micro valve above the clear tube can then be used to provide the extra flow rate to the upper dripper inside the 25 mm polypipe so that it exactly matches the flow rate of the irrigation dripper.

The following pictures provide examples of fully assembled fractional dripper being used as the control dripper for the Terracotta Irrigation Controller.



Fraction 1/8 for online drippers (8 open lower drippers, one lower dripper as control dripper) water supply pressure 40 kPa



Fraction 1/8 for online dripper, water supply pressure 100 kPa. The extension tube is used so that the water level showing in the clear tube is below the white line.



Fraction 1/4 for online dripper (4 closed lower drippers, 4 open lower drippers and one open lower dripper as control dripper) water supply pressure 100 kPa



Fraction 1/2 for 13mm dripline (4 closed lower drippers, 4 open lower drippers and 2 open lower drippers as control dripper) water supply pressure 100 kPa



Fraction 2/7 for 8mm Netafim dripline (1 closed lower dripper, 7 open lower drippers and 2 open lower drippers as control dripper) water supply pressure 100 kPa. This setup is used for a garden in Adelaide with more than 400 drippers.