



Ag Irrigation



Aqua-Traxx[®] PC

Design, installation & maintenance guide.

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Chapter 1



PRINCIPLES OF OPERATION

Aqua-Traxx PC is a *seamless, extruded* drip tape with a *molded* emitter inserted in a tube. The emitter is made up of the following:

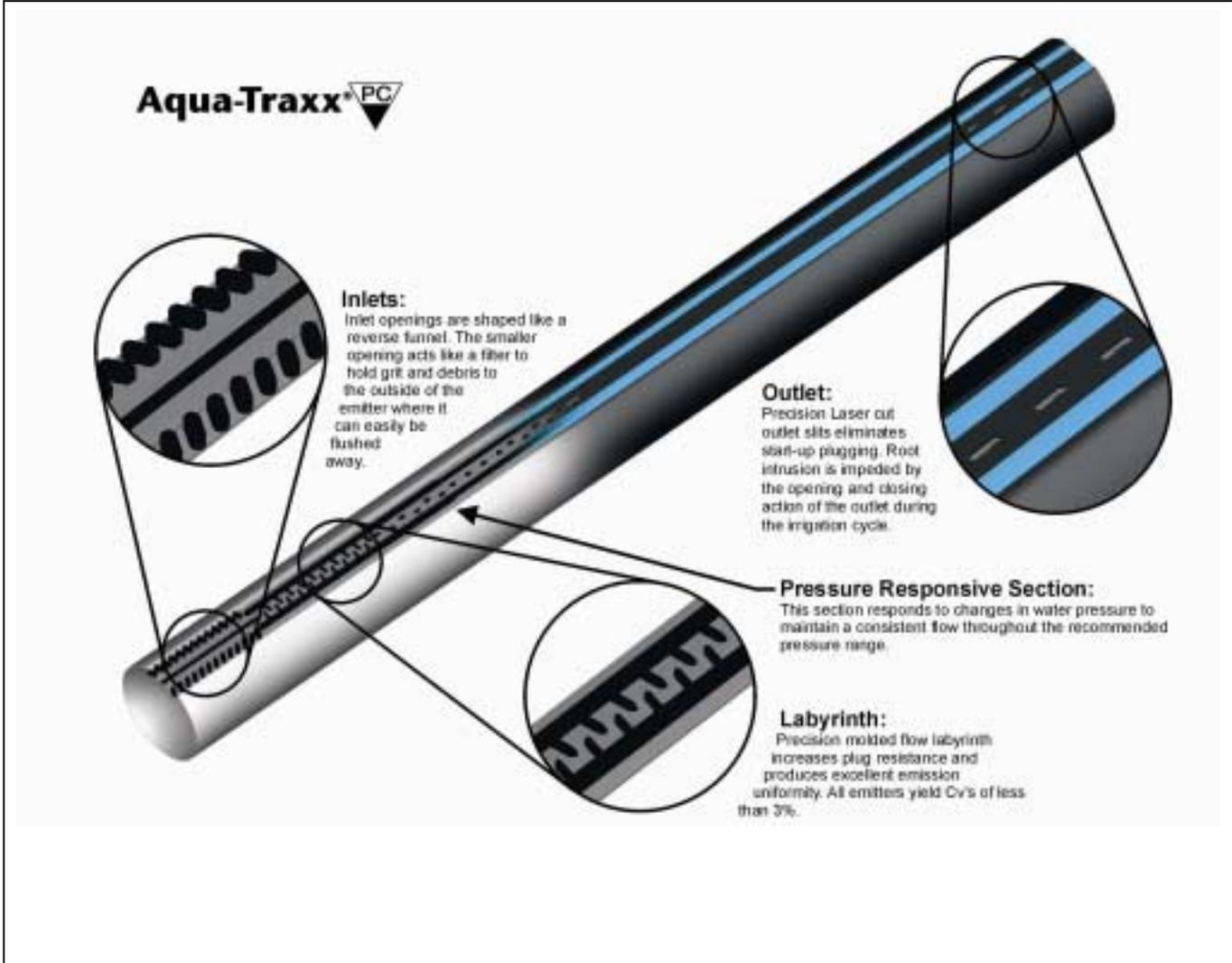
- Filter inlets that which reduce the amount of debris that enter the emitter.
- Turbulent flow path.
- Pressure compensating chamber.
- Unique multiple laser slit outlets.

Seamless construction eliminates seam failures, and reduces the incidence of root intrusion. *Extrusion* technology utilizes high-quality, extrusion-grade engineering polymers renowned for their toughness and flexibility. These polymers were developed specifically for use in harsh industrial and agricultural environments.

The exclusive flowpath *molding* process creates crisp, well-formed physical features, resulting in excellent repeatability and high emission uniformity (EU). The *turbulent* flowpath design reduces clogging in the flow channel. **Pressure responsive section** provides a relatively constant flow rate within the operating pressure range allowing for longer lengths of run and/or significant elevation changes. (Flow exponent of 0.2).



Broccoli in Salinas, Ca.



Aqua-Traxx Pc emitter

Aqua-Traxx PC emitter As shown above, water enters the flow path through the filter inlets which are shaped like a reverse funnel. This keeps debris to the outside of the emitter where it can be flushed away. Next, the water flows through the turbulent flow channel before entering the pressure responsive section. The pressure responsive section responds to changes in water pressure to maintain a constant flow throughout the operating pressure range. Finally, the water exits through the laser-made multiple slit outlets to the crop. The multiple slits ensure the proper function of the emitter and also provide the added benefit of significantly reducing the effect of water running down the tube on slopes.

FEATURES AND ADVANTAGES

- Precision molded emitter for high uniformity.
- Seamless construction for greater reliability.
- Multiple laser slit outlet Reduces startup clogging and impedes root intrusion.
 - Dramatically reduces the water running down the tube on slopes.
- Turbulent flow path provides reduced clogging.
- Pressure compensating chamber provides increased Emission Uniformity (EU) throughout the operating pressure range.
- Available in a wide range of wall thicknesses, outlet spacings and flow rates.
- Highly visible blue stripes for quality recognition and Emitter UP indicator.
- Superior tensile and burst strength.
- Tough, abrasion-resistant material reduces field damage.



Aqua-Traxx PC installation in Salinas, Ca.

SPECIFICATIONS

Aqua-Traxx PC Diameter & Wall Thickness Dimensions

Diameter	Wall (mils)	Min PSI	Max PSI	Reel Length	Reel Weight
5/8"	8	4	16	7,500'	63 lbs
	10	4	20	6,000'	60 lbs
	12	4	22	5,100'	58 lbs
	15	4	25	4,000'	61 lbs
7/8"	10	4	18	4,400'	65 lbs
	12	4	20	4,000'	61 lbs
	15	4	22	3,000'	62 lbs

Flow Rates

Part Number	Emitter flow rate @ 10 psi	Spacing, inch	Q-100 GPM/100' @ 10psi
0.20 gph emitter @ 10 psi			
EAPXxx0667	0.20 gph	6	0.67
EAPXxx0850	0.20 gph	8	0.50
EAPXxx1234	0.20 gph	12	0.34
EAPXxx1625	0.20 gph	16	0.25
EAPXxx1822	0.20 gph	18	0.22
EAPXxx2417	0.20 gph	24	0.17
0.27 gph emitter @ 10 psi			
EAPXxx0690	0.27 gph	6	0.90
EAPXxx0867	0.27 gph	8	0.67
EAPXxx1245	0.27 gph	12	0.45
EAPXxx1634	0.27 gph	16	0.34
EAPXxx1830	0.27 gph	18	0.30
EAPXxx2422	0.27 gph	24	0.22

(Check Toro Ag price list for available stock)

Flow path Specifications & Dimensions

Coefficient of Variation (CV)	All emitters	0.03
Flow Exponent	All emitters	0.2
Nominal Pressure	All emitters	10 psi
Inside diameter	5/8	0.635"
Inside diameter	7/8	0.875"
Operating Pressure Range	4 – 25 psi	See chart for different mil thickness
Hazen-Williams C Factor	Main Tube	140
Minimum filtration requirement	All emitters	200 mesh (74 micron)

USE AND SELECTION

Wall Thickness

8 mil - Intermediate products for general use in longer-term crops and average soil conditions. Has an operating pressure range: 4 to 16 psi.

10 -15 mil - Heavy wall designed to be used in rocky soils, where insects and animals may cause damage, or where the tape is to be used for more than one season. Increased wall thickness provides for a wider operating pressure range. (See specifications for mil thickness vs. operating pressure range.)

Spacing

6 and 8 inch - Used in closely spaced crops, on sandy soils, or where higher flow rates are desired.

12 inch - Used on crops in medium soils and average crop spacings.

16 inch - Used on wide spaced crops where a longer length of run is desired.

24 inch - Used for widely spaced crops, heavy soils, long run lengths.

Flow Rate

0.27 gph Flow - Normally recommended for most crops and soils.

0.20 gph Flow - Recommended for longer runs on most crops and soils.

Diameter

5/8" - Used for average run lengths (0 to 1,000 ft).

7/8" - Used for long run lengths (up to 2,500 ft).

Slopes

Aqua-Traxx PC can be used in downward sloping, undulating or flat topographical conditions. The pressure compensating feature allows for an operating pressure range from 4 psi to 25 psi depending on the wall thickness. Use Aqua Flow program for detailed hydraulic information.

Chapter 2

Aqua-Traxx PC SYSTEM DESIGN

Selecting Aqua-Traxx PC Products

Aqua-Traxx PC is manufactured in a wide range of diameters, wall thicknesses, outlet spacings, and flow rates to meet the specific requirements of various crops. Designers should consider the following when selecting Aqua-Traxx PC products.

1. **Diameter** - Aqua-Traxx is available in two diameters: 5/8" (0.635" I.D.) and 7/8" (0.875" I.D.) and will fit standard fittings. The standard 5/8" diameter is used in applications calling for standard run lengths of up to 1,000 feet depending on topographical conditions. The 7/8" diameter is used on long run lengths of up to 2,500 feet or longer, again, depending on topographical conditions. Use the Aqua Flow program for specific hydraulic information.



Aqua-Traxx PC on tomatoes in San Clemente, Ca.

2. **Wall Thickness** determines how rugged and durable the product will be. In addition, the upper range of the operating pressure range is also determined by the wall thickness. (See specifications for more detailed information.) For short-term vegetable crops, the experienced grower will generally be able to use the lightest weight tubing. For longer-term crops a heavier wall thickness will be more resistant to mechanical damage. Aqua-Traxx PC is manufactured in a range of wall thicknesses: 8 mil, 10 mil, 12 mil, and 15 mil (one mil is 0.001 inch).

3. **Flow Rate** selection will depend upon water quality, the availability of water, the desired length of the tape, and the crop water requirement. Aqua-Traxx PC is available in two emitter flow rates. These two flow rates are designated as 0.20 gph @ 10 psi and 0.27 gph @ 10 psi. It is advantageous to choose the lowest flow rate that will do the job, because low flow rates minimize friction loss and allow for longer runs and better uniformity. However, low flow rates may require a higher level of filtration.
4. **Outlet Spacing** selection is often based upon the initial germination or growth needs of the crop. For seeds or seedlings that are planted in a closely spaced pattern, it is advantageous to use a tape product with closely spaced outlets. Soil type plays a major role in the determination of outlet spacing, since the soil texture and condition determines water movement and the shape of the wetted profile.

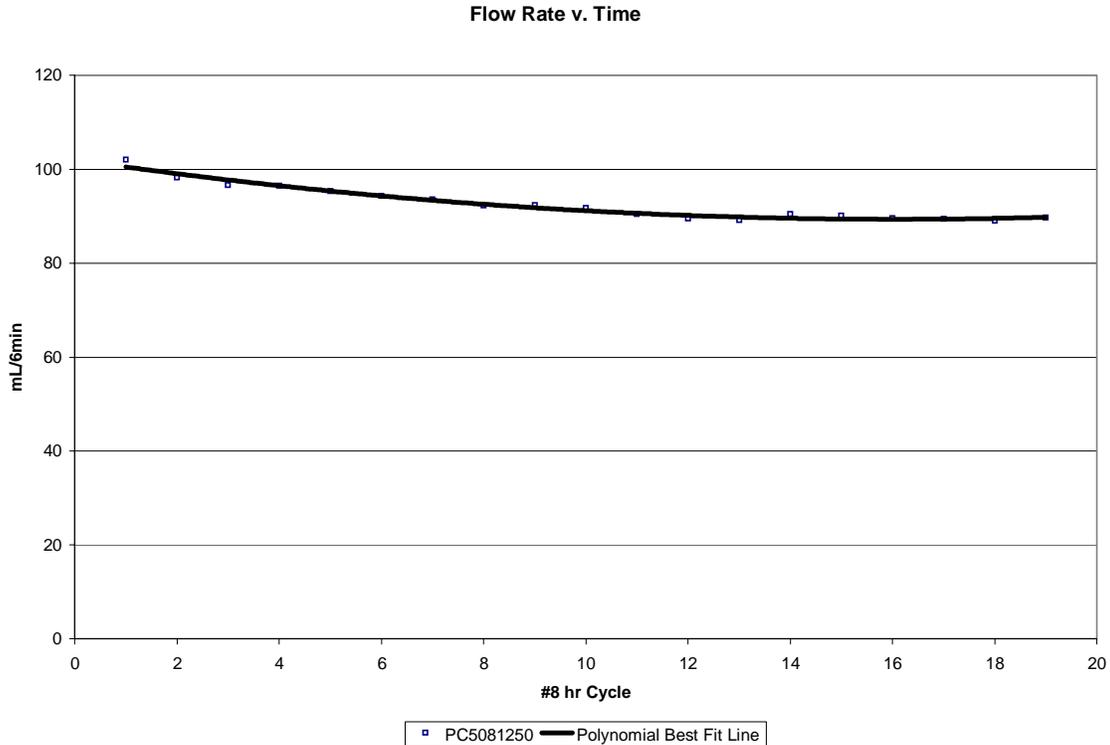
Computer Program AquaFlow

AquaFlow provides designers with the information they need to design an Aqua-Traxx PC tape system for optimum performance. AquaFlow provides system operators with the information necessary to operate the system, efficiently applying the desired amount of water and nutrients to the crop.

AquaFlow will help you to design a complete Aqua-Traxx PC, Aqua-Traxx classic, Dura-Traxx, Drip In classic and Drip In Pc systems. In addition, the AquaFlow program will also calculate the flushing velocities and chemical travel time of the lateral. The program also allows for the sizing of submains and mainlines. The AquaFlow program includes both metric and U.S. measurement units in the graphic screens for pressure profile and flow profile curves. Metric units are given in kPa and meters. U.S. units are given in psi and feet. Contact a Toro Ag Irrigation representative to get a copy of AquaFlow.

Design Considerations

1. **System capacity computations.** It is recommended that the designer reduce the design application rate by 5 percent when calculating system capacity to account for the expected flow-rate decay of Aqua-Traxx PC. The flow rate will slowly decrease over time to a value approximately 10% below the initial flow rate. Manufacturing QC specifications are adjusted above the stated nominal flow rate to compensate for the decrease in flow resulting in a flow rate of 5% below nominal.



Graph shows a decrease in flow rate over time of approximately 10%

2. **Filtration requirement:** Aqua-Traxx PC has a minimum filtration requirement of 200 mesh (74 micron). As with any micro irrigation product, water conditions may require water treatment in addition to 200 mesh (74 micron) filtration.

3. **Lateral selection:** Laterals are the length of tubing with emission devices or emitters along that deliver the water to the crop. Aqua-Traxx PC is a drip tape with emitters evenly spaced from 6 inches up to 24 inches. In selecting a lateral it is recommended that the Emission Uniformity (EU) of a single lateral be greater than 90% in order to allow for some pressure variation in the submain if possible. (Consult the AquaFlow program for more specific hydraulic information).

4. **Lateral ends:** Because Aqua-Traxx PC can be used on significant slopes, the affects of system draining to the lowest points may be problematic and should be considered in the design. Limiting the size and number of laterals on the submain will reduce this affect. Also, using automatic flush caps at the end of the lateral and directing the water that drains away from the crop.



Installation in Salinas, Ca. Lateral ends have automatic flush caps installed to reduce the effect of drain down at system shutdown.



Close-up picture of automatic flushing caps. This cap requires 2.5 psi to close or almost 6 ft of head.

5. **Submains** provide water to individual field blocks, distributing water at a uniform pressure to the lateral lines. Submains may be constructed of PVC pipe, PVC Layflat hose, or Oval Hose™.

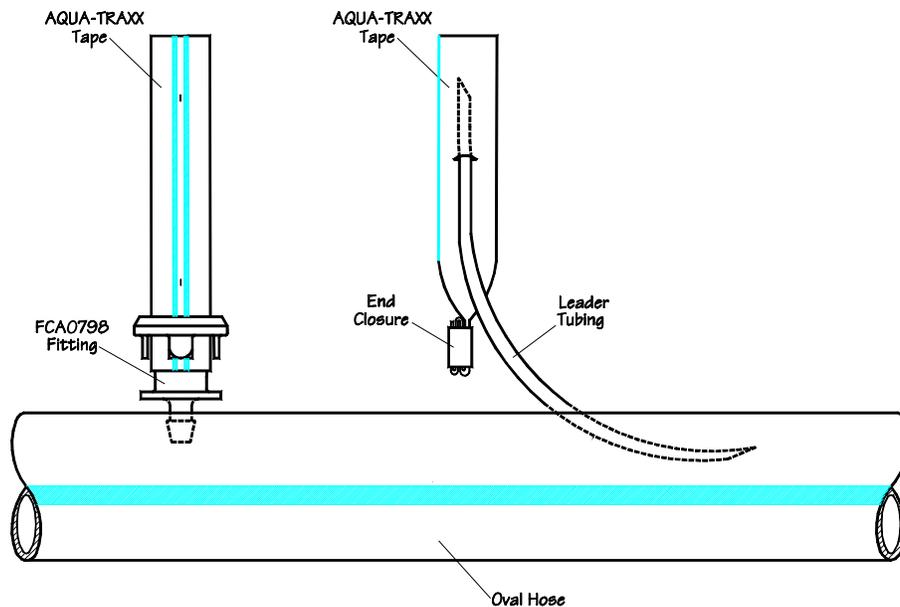
Oval Hose is a popular and widely used choice for submains because it is economical, rugged, and easy to handle and install. Oval Hose can be retrieved from the field and used again year after year. Oval Hose is manufactured in a round configuration, and subsequently flattened and wound on reels or in coils for ease of handling and compact shipment. After it is installed in the field and pressurized,

Oval Hose returns to its round configuration. Aqua-Traxx PC tape may be connected to Oval Hose submains using barbed connectors (FCA0798) or leader tubing.

Good submain design incorporates a flush out valve at the end of the submain. Submain sizing: Because Aqua-Traxx PC can be used in difficult topographical conditions, significant elevation changes along the submain need to be considered in the design if they exist. (Consult the AquaFlow program for more specific hydraulic information).

6. **Connections:** Aqua-Traxx PC can be connected in many different ways depending on the submain material, PVC, Lay Flat, Oval hose, to name the most common. Because Aqua-Traxx PC is a pressure compensating tape, longer runs and greater flow rates per lateral are likely. The designer should be mindful of pressure losses in the connections and a chart is provided below for illustrating flow vs. pressure loss for the Toro oval hose fitting. If other fittings are used, contact the manufacture to get flow loss data.

Aqua-Traxx PC tape is connected to Oval Hose submains using either a plastic fitting or a length of leader tubing, as shown in Fig. 2. Fittings are popular because they are quickly and easily installed, they provide a strong and rugged connection, and they can be re-used for many years.



Methods of Aqua-Traxx Tape Connections. Friction loss table for Toro Ag Irrigation oval hose fitting part number, FCA0798 on next page.

Flow Rate (GPM)	FCA0798
1	0.23 psi
1.5	0.49 psi
2	0.83 psi
2.5	1.25 psi
3	1.74 psi
3.5	2.31 psi
4	2.95 psi

Friction Losses in PSI through Tape Connections

7. Submain Riser Design

A submain riser serves to regulate water flow from the mainline to the submain. A typical submain riser assembly will normally consist of:

1. A manual or pressure regulating valve to control the flow rate.
2. A vacuum relief valve to prevent suction in the submain and tape lines.
3. A Schrader valve to be used as a pressure test point.

8. **Flushing requirements and flushing submains:** As a general rule, flushing velocities of one foot per second or greater are required to ensure proper flushing of a lateral. With a single lateral with a design Emission Uniformity (EU) of 90% or greater will almost always have a flushing velocity of 1 foot per second or greater when a single lateral is flushed. (For detailed flushing data consult the AquaFlow computer program.) If a flushing submain is going to be used elevation changes must be considered to ensure that the lower areas do not have too much pressure. In most cases there will be little to not friction loss in the flushing submain since there is no flow during operation. Other considerations need to be considered when designing a flushing submain to ensure that all the lateral are adequately flushed during the flushing event and are as follows:

- Friction loss (Hf) through the valve or valves on the flushing submain.
- Elevation Hf of the valves or valves on the flushing submain.
- Hf of the flushing submain during the flushing event.
- Hf of the lateral during the flushing event.
- Hf of the delivery submain during the flushing event.
- Hf of the valves that control the delivery submains during the flushing event.
- Hf of mainlines, filters and any other devices in the system during the flushing event.
- And finally, is the necessary water available and can the pump deliver the water at the required pressure during the flushing event?

The AquaFlow program will not design a flushing submain; however, the flushing program will provide all the information from a lateral that is required for an experienced designer to design a flushing submain.

9. **Mainline design:** The initial stage of mainline design consists of determining its location. Laying out the route for the mainline to follow is often a trial-and-error procedure, involving analysis of the costs and benefits of a number of alternative routes. Once the mainline route has been chosen, the proper pipe sizes must be specified.

For small systems the mainline can often be designed without an elevation drawing. However, for large or complex systems it is best to prepare an elevation drawing of the topography that the mainline will traverse. The required submain pressure in feet is superimposed on the drawing to indicate the minimum allowable pressure at any point. Then, the proposed hydraulic grade line may be drawn in, from the inlet of the mainline to the end.

Once the proposed hydraulic grade line has been drawn and the required flow rates calculated, individual sections of the mainline are sized, each section being designed to most closely adhere to the specified hydraulic grade line. The designer must also compute static pressures in the pipelines, and check each section to ensure that the average water velocity does not exceed a specified limit, usually 5 to 10 feet per second. This is done to minimize the damaging effects of waterhammer.

AquaFlow will help you to size the mainline once the maximum velocity, hydraulic grade line and flow rates are specified. AquaFlow utilizes the Hazen-Williams equation to compute friction losses, which is recalled here for PVC pipe (C=150) as,

$$H_f = 0.000977 \{ Q^{1.852} / D^{4.871} \} L \quad \text{Eq. 5}$$

Where: H_f = Friction Loss (feet of water)
 Q = Flow Rate (gpm)
 D = Actual Pipe I.D. (inches)
 L = Length of Pipe (feet)

Velocity of flow in a pipeline may be computed as follows,

$$V = 0.4085Q/D^2 \quad \text{Eq. 6}$$

Where: V = Velocity (ft per second)
 Q = Flow Rate (gpm)
 D = Actual Pipe I.D. (inches)

Chapter 3

INSTALLATION AND STARTUP PROCEDURES

INSTALLATION

The following recommendations apply to the installation of Aqua-Traxx PC tape:

1. Store tape reels in a covered area, protected from sunlight and rain.
2. Install tape with the blue stripes and outlets facing upwards. Fine soil particles in the incoming water will normally settle to the bottom of the tape. Installation of tape upside down may result in clogging if there is any contamination in the incoming water.



Aqua-Traxx PC, install Blue Stripes up

3. An air/vacuum relief valve should always be installed at the submain riser to prevent suction from occurring in the tape when the system is shut down. Suction in buried tape will tend to draw muddy water back into the tubing through the outlets, causing contamination.

4. Tape may be laid on the surface or buried. Burial is preferred where possible, since it protects the tubing from accidents and animal damage, reduces clogging, maintains tape location and alignment, reduces surface evaporation, and insures that water is applied at the desired location.
5. Tape must be buried when used under clear plastic mulch. Condensed water droplets on the underside of clear plastic will focus sunlight like a magnifying glass, burning holes in the tape.
6. Care should be taken during installation to prevent soil, insects, and other contaminants from getting into the tape. Ends should be closed off by kinking or knotting until the tape can be hooked up to the system.
7. Mainlines and submains should be flushed thuraly before Aqua-Traxx PC is connected. After flushing Mainlines and submains the Aqua-Traxx PC laterals can be connected and flushed to ensure that the system is free form contamination.
8. Tape must be monitored as it is injected into the soil. Someone should be watching to insure that the tape maintains its blue stripes upwards orientation, to assist in case the tape becomes tangled in the injector, and to signal the tractor driver when the tape reel is empty and must be replaced.

Initial startup:

1. Flow rate: The first time you run Aqua-Traxx PC you may experience a flow rate that is approximately 5% higher than nominal. As previously stated in Chapter 2, Aqua-Traxx PC will have decay in the flow rate over time of approximately 10%. The production QC has been adjusted to 5% higher than nominal to account for this.
2. Startup squirting: The first time Aqua-Traxx Pc is charged to begin irrigating a small amount of squirting out of the emitters may occur for the first one or two irrigations before diminishing to no squirting. The squirting is normally no more than one or two inches high and will diminishes as the laser outlets relax.



Aqua-Traxx PC in Bell Peppers, Woodland, Ca.

Chapter 4

OPERATION AND MAINTENANCE

COMPUTING IRRIGATION TIME

Once ET has been determined, the irrigation time T may be computed. In order to perform the calculation, it is necessary to know the average Q100 flow rate (gpm per 100 feet) and the system Emission Uniformity EU.

For row crops on Aqua-TraXX tape, the irrigation time T may be computed from the following formula:

$$T = 1.04 \times \frac{S \times ET}{Q-100 \times EU} \quad \text{Eq. 7}$$

- Where T = Irrigation Time (hours)
S = Average Tube Spacing (feet)
ET = Evapotranspiration (inches)
Q-100 = Average Q100 Flow Rate (gpm per 100 feet)
EU = System Emission Uniformity (decimal)



Aqua-Traxx PC in Tomatoes in San Clemente, Ca.

EXAMPLE:

In a field of Pima cotton growing in Arizona, the previous day's ET value was found to be 0.221 inches. The cotton rows are spaced 40 inches (3.33 feet) apart with Aqua-TraXX tape buried under each row. The average flow rate is 0.30 gpm per 100 feet, and the system emission uniformity is 90 percent. Find T:

SOLUTION:

$$T = 1.04 \times \frac{3.33 \times 0.221}{0.30 \times 0.90} = 2.8 \text{ hours}$$

On newly planted acreage, the computed ET, and therefore the irrigation time T, may be quite low. Nevertheless, because the young plants are not likely to have extensive root systems, it is best to apply this small amount on a frequent basis rather than attempting to apply more water less frequently. On established crops, however, it is usually best to have a minimum irrigation period of one hour or longer. This minimizes uneven distribution due to mainline fill and drain times and establishes a larger wetting pattern under each tape outlet. For example, if the irrigation time is determined to be 35 minutes for a given day, it would probably be better to accumulate the time for two days and irrigate 70 minutes every other day.

MONITORING SYSTEM PERFORMANCE

The well-designed micro-irrigation system will have built-in diagnostic tools that will allow the operator to monitor the performance of the system, and to detect possible problems in the early stages. Included in this category are flow meters, pressure gauges, and submain riser filters.

Flow Meters

System flow meters should be installed on the main supply lines, and should provide readings of both instantaneous and cumulative flow. These meters should be read regularly and the readings kept in a logbook. Variations in the system flow rate may indicate that something in the system is amiss.

For example, a gradual decline in system flow rate as measured by the flow meters may indicate a problem with the pumping station or a clogging problem in the field. On the other hand, an unexpected increase in the system flow rate might be an indication of a pipeline break or the presence of leakage in the system. Measurements of cumulative flow will serve to verify water application schedules.

Pressure Test Points

The system should have sufficient pressure testing points so that an overall check of the system pressures can be made. Widely differing pressures in different sections of the system may indicate that some blockage, leakage, or other problem has arisen in some section of the system. Pressure checks should be regularly made, and the pressures recorded.

Submain Riser Filters

Submain riser filters are small, in-line or “wye” strainers installed at each submain riser. Under normal conditions these filters, which are usually 80 - 120 mesh, will collect few if any contaminants because the main filtration system will normally have removed this material. Periodic examination of these riser filters can be a valuable indication that the system is contaminated. In the case of a pipeline break or a failure of the main filter station, riser filters will help to prevent foreign material from entering the tape lines.

MAINTENANCE PROCEDURES FOR Aqua-Traxx PC Tape

Flushing

In many micro-irrigation systems it has been found that provisions must be made to flush submain lines and lateral lines to remove settled sediments, and flushing constitutes an important maintenance routine. Research has shown that most settled sediments can be flushed from pipe or tubing with a flow velocity of one foot per second, which is referred to as the "scour velocity". In standard half-inch lateral lines, the 1 ft/sec scour velocity is equivalent to a flow rate of 1 gpm at the downstream end.

Mainlines, submains and lateral lines should be flushed thoroughly prior to system startup, and tape lines should be regularly flushed during the season. Open the ends of the lateral lines while the system is running and allow water to run into a container until it runs clear. Collect some of the dirty water in a glass jar, and examine it carefully. Take note of the nature of the impurities in the water. If there is a significant amount of contaminant in the flush water, find out what it is. Does it appear to be a bacterial slime? Are large aggregated particles present? Is there evidence of iron precipitation? Is there any material which could be sand from the media filter?

Examine the contaminant under a microscope. Put samples of the dirty water into two small jars or test tubes. Treat one with a few drops of chlorine bleach and the

other with a few drops of hydrochloric acid. Note any changes: chlorine will attack organic matter, while acid will dissolve many inorganic precipitates. Acid or chlorine will not affect soil and sand particles.

Prevention of Clogging

The biggest potential problem facing the operator of a micro-irrigation system is clogging. Because the water passages in most tape emitters are very small, they easily become clogged by particles of mineral or organic matter. This can reduce emission rates, cause non-uniformity of water distribution, and thereby cause stress and damage to the crop.

Growers sometimes inadvertently cause clogging by injecting inappropriate chemicals or other substances into their systems.

In some cases, contaminants are present in irrigation water delivered to the user and are not adequately filtered out. These contaminants may include soil particles, living or dead organic materials, and scale from rusty pipes. In other cases, contaminants enter the system during the installation phase, and are not adequately flushed out of the system. Included in this category are insects, Teflon tape, PVC pipe shavings, and soil particles. Pipeline breaks often result in system contamination with soil, causing subsequent clogging problems.

In buried systems, soil particles may enter, or be sucked into, tape outlets. Roots may grow into these buried outlets to plug them.

Finally, contaminants may grow, aggregate, or precipitate in water as it stands in the lines or evaporates from tape outlets between irrigations. Iron oxide, manganese dioxide, calcium carbonate, algae, and bacterial slimes can form in micro-irrigation systems under certain circumstances.

The solution to a particular clogging problem must be based upon the nature of the problem. Acid treatment has been used successfully to dissolve calcium precipitates, and chlorine is frequently used to decompose organic materials.

Once a system is badly clogged, there is usually little that can be done to fix it. Therefore, the wisest course is to prevent clogging in the first place. Experience has shown that most clogging problems can be avoided by following a few simple rules:

1. Analyze the source water for suspended and dissolved solids, and design the irrigation, chemical injection, and filter systems accordingly.
2. Install secondary filters on submain risers to protect the system from pipeline breaks or filter system failures.
3. Install vacuum breakers on submain risers to prevent suction in lateral lines.

4. Take care during installation to minimize contamination by soil, insects, pipe dope, PVC pipe shavings, and the like.
5. Thoroughly flush the system before connecting tape to submains.
6. Practice regular chemical treatment (acid or chlorine).
7. Flush tape lines on a regular basis.

Prevention of Insect Damage

Ants, wireworms, and other insects may cause damage to tape. Insect damage typically takes the form of holes chewed through the sides of tape. Researchers have noted that insect damage is most severe in tape having wall thicknesses of less than 10 mils (0.010 inches).

Insect damage has been successfully controlled with insecticides. However, these chemicals are highly toxic and persist in the environment. For this reason, growers are advised to select a tape with sufficient wall thickness to prevent insects from making holes through the wall of the tubing.

Prevention of Root Intrusion

In micro-irrigation systems utilizing buried tape, plant roots may grow into tape outlets, effectively clogging them. This so-called “root intrusion” into tape outlets may be widespread throughout the field, severely compromising the effectiveness of the irrigation system. In advanced cases, there is no alternative but to replace the tape.

The tendency for root intrusion to occur varies widely according to crop type, the type of system components selected, depth and placement of the drip tape, and irrigation scheduling practices. It is known that moisture stress encourages plant root structures to expand more aggressively, seeking water. It is also known that roots will find and follow a seam on buried drip tape, and grow into outlets if they are placed along this seam.

Two of the most effective preventive measures against root intrusion are to schedule irrigation in such a way as to avoid moisture stress, and to select tape types which do not have a seam. Drip tapes employing slit type outlets are considerably less susceptible to root intrusion than are those with hole type outlets.

Other measures employed against root intrusion are chemical treatments with acid, acidic fertilizers, chlorine, or chemicals, which retard root growth. It must be noted that this type of chemical treatment, because it is used to retard the roots of the crop, may lead to serious crop damage if done incorrectly. Growers are strongly encouraged to seek expert advice before attempting chemical treatments to discourage root intrusion.