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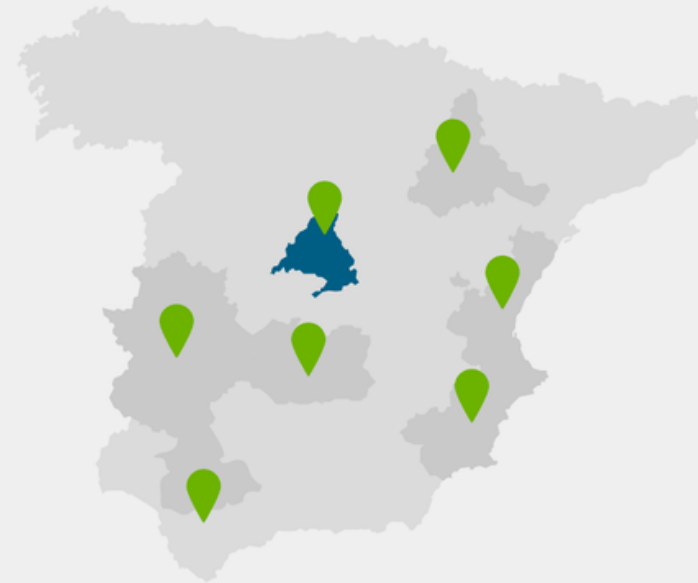
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**PATHFINDER**  
PRO

**PATHFINDER**  
**XPRO**

**MANUAL OF  
INSTALLATION, ASSEMBLY  
AND MAINTENANCE**

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PATHFINDER  
PRO

PATHFINDER  
X PRO



## 1. PATHFINDER DRIP TAPE

PATHFINDER drip tape is manufactured under a high-tech extrusion process. Its patented manufacturing system allows the conformation of with the same accuracy of an injection process and with the continuity of the continuous extrusion processes.

PATHFINDER tape is manufactured in various thicknesses, flow rates and distances between emission points as specified in the tables.

### 1.1 TEMPORARY STOP OF THE IRRIGATION SYSTEM

Before stopping the system for a period of time, some steps must be followed in order to minimize as much as possible the appearance and growth of contaminants in the network. These steps are:

- Make sure that the crop and other plants are not alive before closing the system to prevent root intrusion.
- Thoroughly clean the filters, main, secondary, tertiary and lateral pipes.
- Carry out a pressure cleaning of the emitters, pressurizing the system up to values of 1.2 kg/cm<sup>2</sup> in order to carry out adequate cleaning.
- Carry out a random inspection at various points on the farm to determine the degree and type of dirt in the pipes.
- Finish by filling the network with water, sodium hypochlorite (10 ppm) and acid that reduces the pH to a value between 5.5 and 6 to avoid the proliferation of bacteria and algae inside the net during the rest period.
- When the system starts up again, filters, pipes and sides.
- In cold climates, follow the steps in the following section to prevent damage during winter.



### 5.1.2 How to detect obstructions

As stated, inspecting the transparent emitter gives us an idea of the clogging probabilities and the cause. The coarser particles usually remain in the center line of the labyrinth, and this indicates a failure in the filtering system or a breakage of the nozzles in the sand filters if there are any.

The presence of algae is detected at the edges of the labyrinth. When they exist, appropriate treatment should be done to prevent their proliferation (see table VII). If there is a lot of sediment at the end of the side, it indicates that cleaning cycles should be done more frequently.

If proliferation of matter is observed, it is necessary to identify what type of matter it is. A dilute acid solution is applied to a sample and its reaction is observed. The presence of gas bubbles indicates that it is calcium or magnesium carbonate. See Table VII to plan treatment.

The determination of organic matter however is more difficult. The washing water from one or more sides will be collected in a jar. Any particles that cannot be classified as sand will be observed. If these particles break when touched and do not react to the test for calcium salts described above, then it will be organic matter. Treatment is described in Table VII.

### 5.2 INITIAL CLEANING OF THE INSTALLATION

Before connecting the tape to the supply pipes, the installation will be cleaned with pressurized water, unscrewing the main and secondary pipes to eliminate any impurities that may have entered the installation during its assembly. It is also recommended to clean the installation at the beginning of the irrigation campaign to eliminate impurities that may have entered or formed in the network.

### 5.3 PERIODIC CLEANING OF THE INSTALLATION

The filters are capable of retaining particles the size of fine sand (see section 3), however silt and clay pass into the interior of the network and accumulate at the ends of the pipes. If these fines are not flushed regularly, the buildup will reach a degree that will cause a clog. In addition, these particles can interact with each other or with chemical precipitates or organic elements, forming larger particles and significantly increasing the risk of clogging. The cleaning of the installation will affect all the distribution pipes and the lateral ones. The system will therefore be designed to facilitate this task by arranging the necessary accessories in the distribution pipes and on the laterals. These, if they are buried, will necessarily be joined to a cleaning pipe;

The optimum cleaning speed on the side is 0.45 m/s. With the Pathfinder program, the cleaning speed and flow can be obtained for the field conditions of the lateral. A practical way to check the cleaning speed is by unscrewing the end of one side and raising the end about 30 cm from the floor. Under these conditions the stream must reach a length of at least 30 cm from the end of the tape.

If the speed is less than 0.45 m/s, that is, the jet does not reach 30 cm in length, some sides will be closed or the pressure will increase at the beginning of the line. If the adjacent laterals have an adequate cleaning speed then there will be a leak in the lateral being measured, either a fold or an obstruction that hinders the passage of water.

### 1. PATHFINDER TAPE: OVERVIEW

Pathfinder Drip Tape is manufactured using a high-tech extrusion process. Its patented manufacturing system allows the formation of a labyrinth with the same accuracy of an injection process and with the continuity of continuous extrusion processes.

Pathfinder tape is manufactured in various thicknesses, flow rates and distances between emission points as specified in the table.

CODIGO	PRODUCTO	Diámetro Interior (DI)	Espesor (mil/mic)	Distancia entre emisores	Caudal L / Emisor	Caudal L / Metros	Longitud rollo
16060610	Pathfinder Pro 6	16mm	6mil [150mic]	10cm	0,6l/h	6l/h/m	3000m
16060615	Pathfinder Pro 6	16mm	6mil [150mic]	15cm	0,6l/h	4l/h/m	3000m
16060620	Pathfinder Pro 6	16mm	6mil [150mic]	20cm	0,6l/h	3l/h/m	3000m
16060630	Pathfinder Pro 6	16mm	6mil [150mic]	30cm	0,6l/h	2l/h/m	3000m
16080610	Pathfinder Pro 6	16mm	8mil [200mic]	10cm	0,6l/h	6l/h/m	2500m
16080615	Pathfinder Pro 6	16mm	8mil [200mic]	15cm	0,6l/h	4l/h/m	2500m
16080620	Pathfinder Pro 6	16mm	8mil [200mic]	20cm	0,6l/h	3l/h/m	2500m
16080630	Pathfinder Pro 6	16mm	8mil [200mic]	30cm	0,6l/h	2l/h/m	2500m
16061010	Pathfinder Pro 10	16mm	6mil [150mic]	10cm	1,0l/h	10l/h/m	3000m
16061015	Pathfinder Pro 10	16mm	6mil [150mic]	15cm	1,0l/h	6,5l/h/m	3000m
16061020	Pathfinder Pro 10	16mm	6mil [150mic]	20cm	1,0l/h	5l/h/m	3000m
16061030	Pathfinder Pro 10	16mm	6mil [150mic]	30cm	1,0l/h	3,5l/h/m	3000m
16081010	Pathfinder Pro 10	16mm	8mil [200mic]	10cm	1,0l/h	10l/h/m	2500m
16081015	Pathfinder Pro 10	16mm	8mil [200mic]	15cm	1,0l/h	6,5l/h/m	2500m
16081020	Pathfinder Pro 10	16mm	8mil [200mic]	20cm	1,0l/h	5l/h/m	2500m
16081030	Pathfinder Pro 10	16mm	8mil [200mic]	30cm	1,0l/h	3,5l/h/m	2500m
16061510	Pathfinder Pro 15	16mm	6mil [150mic]	10cm	1,5l/h	15l/h/m	3000m
16061515	Pathfinder Pro 15	16mm	6mil [150mic]	15cm	1,5l/h	10l/h/m	3000m
16061520	Pathfinder Pro 15	16mm	6mil [150mic]	20cm	1,5l/h	7,5l/h/m	3000m
16061530	Pathfinder Pro 15	16mm	6mil [150mic]	30cm	1,5l/h	5l/h/m	3000m
16081510	Pathfinder Pro 15	16mm	8mil [200mic]	10cm	1,5l/h	15l/h/m	2500m
16081515	Pathfinder Pro 15	16mm	8mil [200mic]	15cm	1,5l/h	10l/h/m	2500m
16081520	Pathfinder Pro 15	16mm	8mil [200mic]	20cm	1,5l/h	7,5l/h/m	2500m
16081530	Pathfinder Pro 15	16mm	8mil [200mic]	30cm	1,5l/h	5l/h/m	2500m

The commercial name of the Pathfinder tape responds to a code that is detailed in the following example:  
Code16-06-30-340-3000R3200

Tabla III: Nomenclatura comercial						
Especificación	Diámetro	Espesor	Distancia entre emisores	Caudal	Paso	Longitud del rollo
Unidad de medida	mm	mil.	cm	l/h. 100m a 0,55 kg/cm²	—	m
Código	16	06	30	340	3000	R3200

The tape is mainly used to irrigate horticultural and industrial crops: tomato, strawberry, pepper, melon, watermelon, potato, aubergine, pumpkin, zucchini, lettuce, cauliflower...

## treadmill operation

The water is pre-filtered through the inlet holes of the emitter, then it goes into the labyrinth where it loses pressure and, once in the discharge chamber, it comes out in the form of drops. Figure 1 details the components of the emitter.

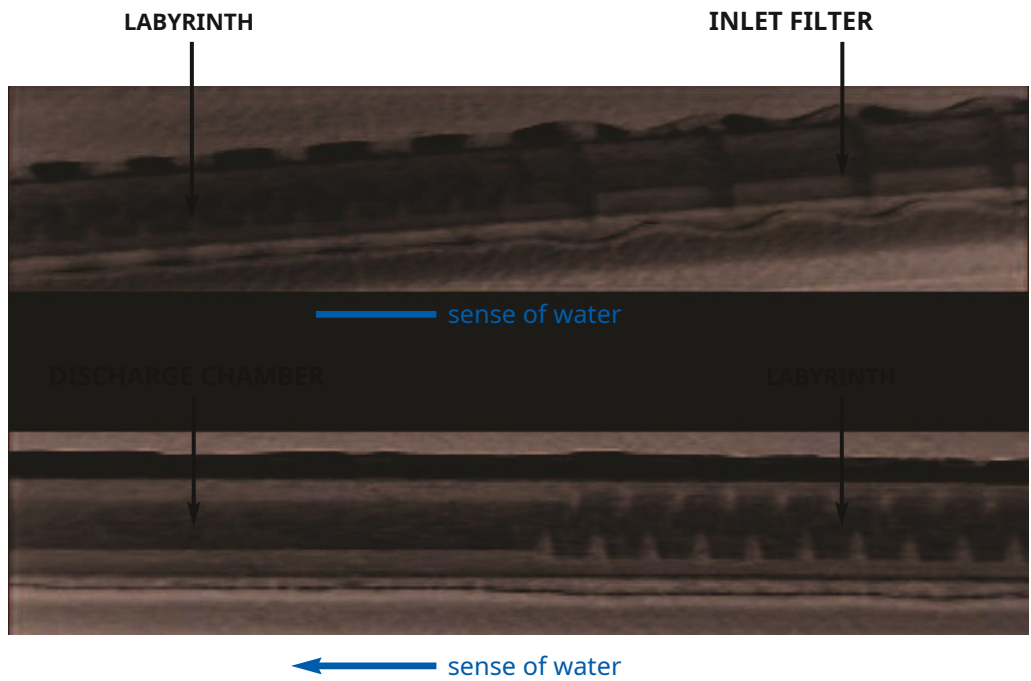


Fig. 1: Inside the emitter

Table VIII: Obstructions according to the origin of the water and its treatment

Procedencia del agua	Causas comunes de obstrucción	Tipo de filtros recomendados	Tratamientos contra la obstrucción
SUPERFICIAL	Ríos, riachuelos	Arenas, limos, arcillas, materia orgánica	Filtro de malla FMA 2000
	Canales	Arenas, limos, arcillas, materia orgánica	Filtro de arena + filtro de malla FMA 2000
	Balsas	Materia orgánica : algas, bacterias, restos de insectos o plantas	Filtro de arena + filtro de malla FMA 2000
	Pozos cavados	Arenas, limos, arcillas, calcio (carbonatos)	Hidrociclón + filtro de malla FMA 2000
SUBTERRÁNEA	Pozos perforados	Arenas, limos, arcillas, calcio (carbonatos) y hierro	Hidrociclón + filtro de malla FMA 2000

• Contra las algas que puedan formarse en la balsa, el tratamiento consiste en añadir 2 ó 3 gramos de sulfato de cobre ( $\text{CuSO}_4$ ) por metro cúbico de agua embalsada. En aguas alcalinas el sulfato de cobre puede precipitar, por lo que se recomienda utilizar carbonato básico de cobre.

También puede utilizarse contra las algas o las bacterias ferruginosas hipoclorito sódico ( $\text{NaOCl}$ ) durante el riego, con dosis de 1 a 5 partes por millón según gravedad y una frecuencia media de una vez por semana.

• Contra la formación de carbonato cálcico en el orificio de salida de los goteros, lo más efectivo es utilizar un ácido que disuelva el carbonato. Se recomienda ácido nítrico o fosfórico con dosis de 0'2 % mínimo a 1 % según gravedad y durante un tiempo medio de treinta minutos. La frecuencia es variable: 1 vez por semana o bien 1 vez cada quince días.

• Para prevenir la formación de óxidos insolubles de hierro o de manganeso, puede incluirse en la instalación un tanque de retención para oxidación.

Before the end of the campaign, or when required, the end of several laterals can be inspected by cutting a piece and observing the condition of the emitter at least once a month during the first campaign (1 or 2 times per campaign in the successive years). The patented transparent labyrinth allows and simplifies this inspection operation, being able to clearly observe its condition.



Fig. 13: «Inspections of the interior of the belt are necessary to prevent or combat clogging. Pathfinder tape features a transparent labyrinth to facilitate this operation.»

The presence of sand is a symptom that there may be a break in the nozzles of the sand filters, or that the mesh of a filter could be broken or deteriorated. The presence of algae indicates that a chemical treatment must be applied to the irrigation water to prevent a possible obstruction.



### 5.1.1 Types of obstruction

Obstructions can be EXTERNAL and INTERNAL and normally when the problem occurs, it is always a combination of both or each other.

The **external obstruction** they are due to the entry of particles during the stop suction and the intrusion of roots. The solutions to both cases have already been discussed in this manual.

Regarding **internal obstructions** They are classified into three types:

- Physical obstruction, due to silt, sand, organic matter,...
- Biological obstruction, due to algae, bacteria,...
- Chemical obstruction, due to salt precipitates (calcium, magnesium,...) and chemical products from fertigation.

The presence of calcium or magnesium precipitates is detected by the formation of small bubbles at the water outlet in the emitter when the water is treated with acid.

The physical obstruction originates outside the network, and enters the installation through the irrigation water, while the other two types occur inside the network. There are a number of solutions to avoid and combat these obstructions that are summarized in the following two tables.

Table VII: Obstructions inside the installation and their treatment

Localización de la obstrucción	Tratamiento
Algas microscópicas y bacterias en tuberías y filtros	<b>Hipoclorito sódico (NaOCl)</b> La dosis utilizada normalmente oscila entre 20 y 50 partes por millón dejándose en la tubería un mínimo de media hora.
Carbonato cálcico en el orificio de salida de los emisores	<b>Ácido nítrico o fosfórico</b> Se utilizan dosis del 0'2 al 1 % con una duración de media hora. No realizar la cloración al mismo tiempo que la fertirrigación con abonos nitrogenados.
Precipitados químicos en los goteros procedentes de los elementos fertilizantes	<b>Lavado con agua</b> Regar con agua sola tras la fertirrigación.
Sedimentos acumulados en tuberías	<b>Limpieza a presión</b> Se realizará en todas las tuberías, comenzando por el cabezal de riego, desenroscando los finales de línea y a una presión de 1 - 1,2 kg/cm <sup>2</sup>

To carry out these treatments, the circulation time of the water inside the lateral will be taken into account according to the Pathfinder computer program.

## 2. BASIC INSTALLATION REQUIREMENTS

- The presence of insects and rodents that can damage the tape must be known. If this threat exists, measures will be taken to drive them away or eliminate them.
- It is necessary to know the texture and structure of the soil, especially if the tape is going to be buried.
- The water will be analyzed, since its quality is the most critical characteristic of the system.
- Precise data on the relief of the plot will be provided.

## 3. FILTRATION NEEDS

The following tables specify the MINIMUM degree of filtration and the RECOMMENDED degree of filtration according to the pitch of the belt. The selection of the degree of filtration depends on the quality of the water and the type and amount of contaminants it contains, therefore it will be necessary to analyze the water to determine the filtration needs.

Table IV-A: **MINIMUM REQUIRED** according to size of Filtration passed

	Paso 500	Paso 1000	Paso 2000	Paso 3000
Mesh	200	120	120	120
mm	0,080	0,125	0,125	0,125

Table IV-B: Degree of **RECOMMENDED** according to size of filtration passed

	Paso 500	Paso 1000	Paso 2000	Paso 3000
Mesh	250	155	155	155
mm	0,060	0,100	0,100	0,100

**1micron =0.001mm**

**Mesh = number of holes per linear inch counted from the center of a filter wire. =2.54**

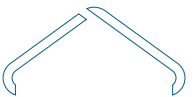
**1 inch**

**centimeters=25.4 millimeters**

	Equivalencias de grado de filtración					
Mesh	30	50	75	120	155	200
Micras	500	300	200	130	100	80
mm	0,50	0,30	0,20	0,13	0,10	0,08

The dimensions of the particles of the finest elements are as follows: • Very fine sand diameter: 0.1 - 0.05 mm  
• Silt diameter: 0.05 - 0.002 mm  
• Clay diameter: < 0.002 mm

Depending on the origin of the water and its quality, the filtering station will be designed. If the water comes from a well with a sand and silt content greater than 50 mg/l, a battery of hydrocyclones will be installed prior to the mesh filters. If the water comes from rivers, canals or ponds, it is advisable to install a battery of sand filters and then the mesh filters.



## Characteristics of Mesh Filters GRUPO CHAMARTÍN, SA-STF



### FILTRATION DEGREES

MALLA FILTRANTE DE ACERO INOXIDABLE										
	DE TIPO "REPS"					DE PASO LIBRE				
	34	63	75	100	125	200	300	500	800	1.000
micras										
mm	0,015	0,063	0,075	0,1	0,125	0,2	0,3	0,5	0,8	1
MESH equivalentes	400	250	220	155	120	75	50	30	20	10

### FLOW RATES

Modelo	Aguas de Calidad muy baja (m³ / h)	Aguas de Calidad media (m³ / h)	Aguas de Calidad alta (m³ / h)
FMA - 2000 - 4"	50	65	80
FMA - 2000 - 6"	90	120	150
FMA - 2000 - 8"	120	160	200
FMA - 2000 - 10"	180	240	300

## 4. INSTALLATION

### 4.1 SYSTEM ELEMENTS

#### 4.1.1 Water

As already mentioned, it is very important to analyze irrigation water to determine its quality, type and size of particles and to adequately design the water filtering and treatment system.

#### 4.1.2 Pressure

The working pressure of the tape is low (from 0.4 to 1 kg/cm<sup>2</sup>). Therefore, it will be necessary to have the necessary elements (reducing valves, pressure reducers, manometers) to control and measure the operating pressure of the system. The limit and recommended pressure values are the following:

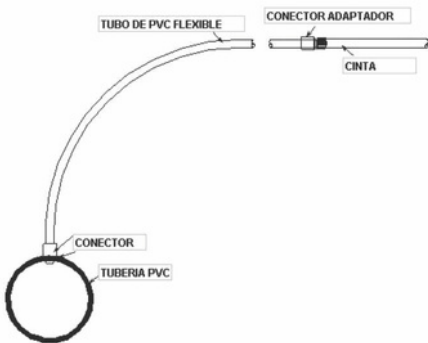


Fig. 10: PVC tape connection

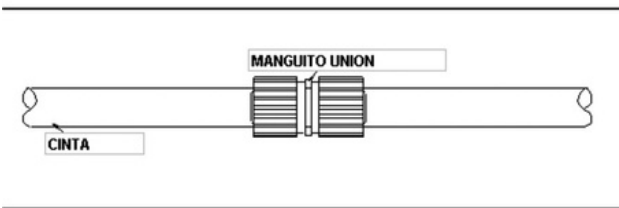


Fig. 11: Tape connection used during REPAIRS

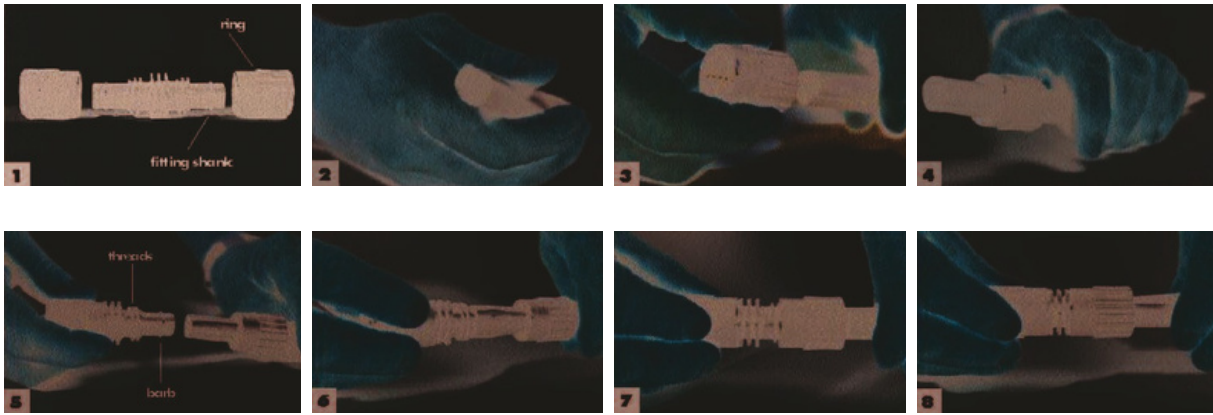


Fig. 12: Procedure for connecting TAPE to TAPE

## 5. MAINTENANCE

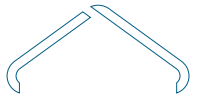
### 5.1 OBSTRUCTIONS

To prevent obstructions in the system, it is necessary to know the quality of the irrigation water. The composition of the water can lead to subsequent obstructions depending on the amount of contaminants it carries. The following table lists the probability of system clogging according to the composition of the water.

Table VI: Probability of obstruction according to water quality

	Probabilidad de obstrucción		
	Baja	Media	Alta
Arenas, limos, arcillas	50 mg/l	50 – 100 mg/l	> 100 mg/l
pH	7	7 a 8	> 8
Carbonatos	100 mg/l	100 a 200 mg/l	> 200 mg/l
Calcio	10 mg/l	10 a 50 mg/l	> 50 mg/l
Hierro	0'1 mg/l	0'1 a 1'5 mg/l	> 1'5 mg/l
Manganeso	0'1 mg/l	0'1 a 1'5 mg/l	> 1'5 mg/l
Substancias en solución	500 mg/l	500 a 2.000 mg/l	> 2.000 mg/l
Bacterias / centímetro cúbico	10.000	10.000 a 50.000	> 50.000

The analysis of the water will determine the type of treatment that must be done to prevent clogging.



## 4.6 PROCEDURE

- In buried systems, as has already been commented, the Pathfinder tape will be installed before opening trenches for the supply pipes.
- A sufficient piece of tape will be left to make the connection to the supply pipe loosely without producing tension.
- In the buried part, do not form an excessive loop to prevent the tractor implement from getting caught during the tillage of the plot.
- In superficial installation, leave sufficient length of tape at the end of the sides so that dirt accumulates and to be able to check the interior of the tape.
- The Pathfinder tape will be installed in all cases with the emitter facing up.
- The Pathfinder tape will be installed in all cases with well-cultivated soil and when it is relatively dry and compacted.
- It will not be excessively compacted above the buried tape so as not to restrict the expansion of the lateral when it enters load.
- The filling of the trench will be taken care of so as not to produce partial obstructions in the tube that joins the buried supply pipe with the tape.
  - In buried installation it is important to put the system into operation as soon as possible and pressurize the installation to allow the expansion of the lateral and for it to acquire its shape inside the ground.

## 4.7 CONNECTIONS

There are various options for connecting the tape to the feed pipe and to the cleaning pipe. In any case, they must be carried out carefully so as not to cause tensions in the pipe that joins the lateral to the supply and cleaning pipes, nor pinching or bending in the lateral.

The connection can be made from a PE pipe (flat or rigid) or from a PVC pipe. The following diagrams illustrate the types of connection as well as the connection between laterals and end of lateral.

**Before connecting the laterals to the cleaning pipe, they must be pressure cleaned.**

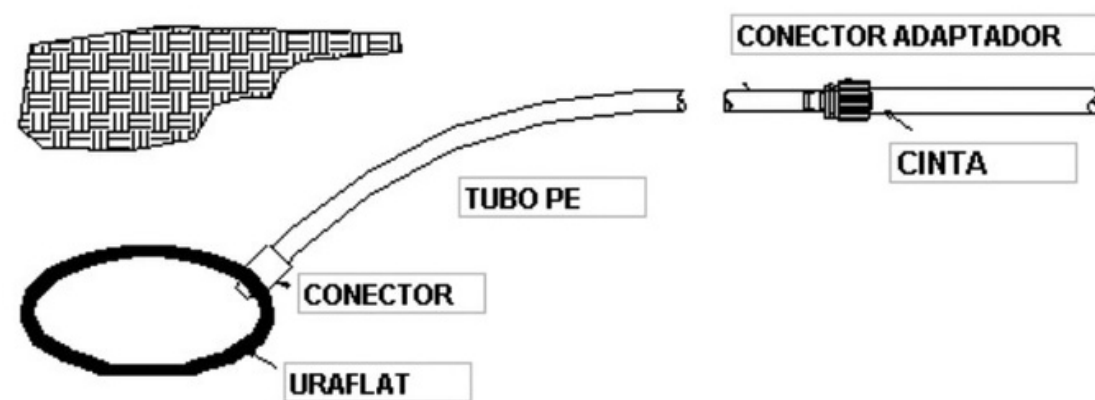


Fig. 9: Uraflat connection to tape

VA table: Values	LIMIT of pressure of functioning	
	Presión mínima (kg/cm <sup>2</sup> )	Presión máxima (kg/cm <sup>2</sup> )
	0,2 - 0,3	1,2
		1,4

VB table: Values	RECOMMENDED of pressure of functioning	
	Presión mínima (kg/cm <sup>2</sup> )	Presión máxima (kg/cm <sup>2</sup> )
	0,4	1,0

An operating pressure of 0.2 kg/cm<sup>2</sup> has the drawback of increasing the probability of clogging since the regime inside the emitter is less turbulent.

Operating pressure greater than 1.2 - 1.4 kg/cm<sup>2</sup> will deteriorate the tape and could cause bursts in the tube wall.

### 4.1.3 Air

The suction cups are the mechanisms in charge of eliminating the air pockets that form inside the pipes. These bags can cause a reduction in the circulating flow and pressure spikes that can damage the installation materials.

**Inburied installations**It is very important to have suction cups to eliminate the problems of particle entry due to suction when the irrigation equipment is stopped. They will be located in the chest of each irrigation block.

### 4.1.4 Cleaning

The cleaning system is as important as the filtration system to prevent clogging. The main, secondary and tertiary pipes will be cleaned as well as the laterals. These will be connected to the cleaning pipe when the installation is buried. The Pathfinder computer program reports on this aspect as will be seen later.

### 4.1.5 Chemigation

Any addition of chemical products to the installation (fertilizers, herbicides, phytosanitary products...) must be done carefully following the instructions on the label or the manufacturer, respecting the proportions of the product and mixing under the conditions indicated. Likewise, the possible attack of mixtures on the installation materials should be taken into account if the percentage of active matter exceeds a certain value.

## 4.2 GENERAL CONSIDERATIONS

Pathfinder Tape can be installed above ground, hung (attached to a trellis) or, as is the case in most cases, buried.

**In all cases, the tape will be placed with the water outlet facing up.**

When the tape is **surface installed**, care should be taken with contractions and expansions due to temperature changes during the day and night. It must be taken into account that low-density polyethylene has a coefficient of linear expansion of 0.17 mm/my °C.



## PATHFINDER TAPE Installation, Assembly and Maintenance Manual



For example, in 150 meters of lateral and for a temperature variation of 20°C (max t°: 30°C day 7 min t°: 10°C night), the dilation would be:  
Dilation = 0.17 mm/m °C x 150 mx 20°C = 510 mm (51 cm; 0.5 m).

If the tape is installed in mulch cultivation, it will necessarily be buried.

In buried installations you have to anticipate root treatments and the placement of suction cups at the entrance of each irrigation sector. The anti-root treatment consists of applying 0.25 cc of trifluralin per emitter once every 6 months.

The burial depth and spacing between emitters will depend on the type of soil and crop rotation. The type of soil will decisively influence the shape and size of the wet bulb. The movement of water to the root zone will therefore be affected by soil conditions. It will be buried at a depth that does not interfere with tillage.

Germination or emergence is one of the most delicate stages in the development of a crop. The ground will have to be well compacted around the seed to favor the movement and arrival of the water from the emitter and the tape will be placed close enough for the wet bulb to reach the seed.

### 4.3 PATHFINDER PROGRAM

The Pathfinder computer program offers the possibility of calculating maximum branch lengths depending on the circulating flows and the positive or negative slopes of the terrain. It also informs us of the cleaning flows of the lateral pipes to size the cleaning network.

The input data for the calculation are the following:

- Tape type selection
- Inlet pressure on the side
- Side length
- Number of slopes and values

The results given by the program once the starting data have been entered are:

- Values of maximum, minimum and average pressure on the side
- Percentage of pressure variation
- Emission uniformity coefficient
- Maximum, minimum and average flow values on the side
- Percentage of flow rate variation
- Inlet flow in the branch
- Pressure at the end of the branch
- Travel time of the water in the branch

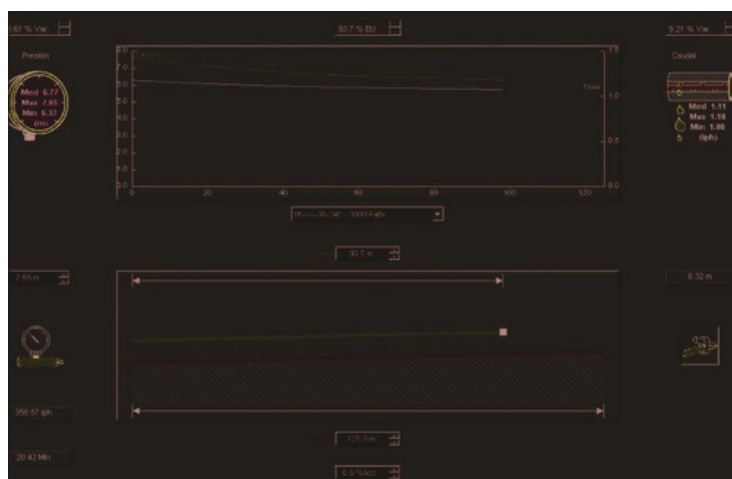


Fig. 2: Pathfinder belt side calculation program screen

## PATHFINDER TAPE Installation, Assembly and Maintenance Manual



The program gives us the possibility of making the assumption of cleaning the branch. In this case, the results offered for the dimensioning of the cleaning network are the following:

- Inlet flow in the branch
- Travel time of the water in the branch
- Cleaning flow
- Speed of the water in the branch

The time elapsed from when the water enters the lateral until it reaches the end must be taken into account to calculate the washing time of the branches after the fertilizer and chemical treatments.

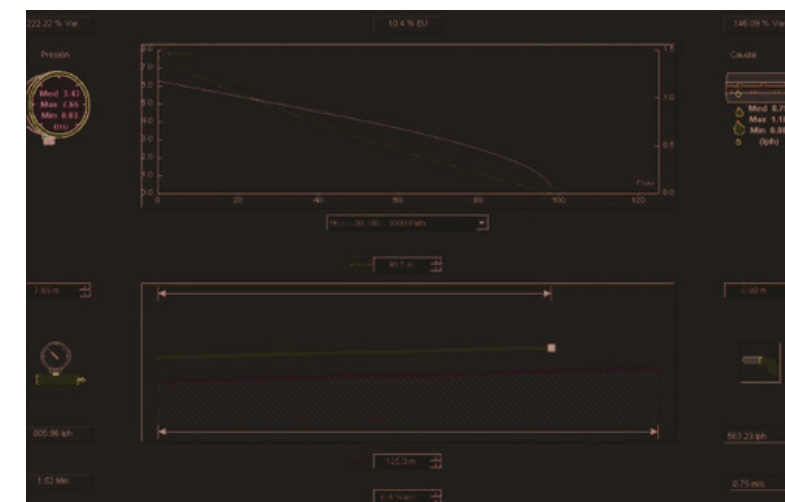


Fig. 3: Side in cleaning position. pathfinder program

### 4.4 INITIAL PREPARATIONS

The coils will be protected from humidity and sunlight. They will be stored under cover until use. Regarding the soil, the land where the tape will be installed will be tilled to favor the movement of moisture in the soil and the creation of a regular humid bulb. This tillage will be carried out with dry land to reduce air cavities. It will be compacted to reduce these air cavities and bind the aggregates to allow water to flow both horizontally and vertically. For this work, chisel plows or cultivators will be used. Compaction and lump breaking will be carried out with compacting rollers. (Machine speed: 5 - 7 km/h).

### 4.5 MACHINERY FOR THE BURYING OF THE TAPE

For the installation of the buried belt, a tractor will be used with a tool attached to the linkage consisting of bars with tube guides through which the belt will circulate. During this operation, avoid subjecting the belt to tensions that could damage it, friction or snags. The tape will be installed before the supply pipes (tertiary, secondary and main) since the trenches that are opened to install the pipe network would interfere in the process of laying the tape.



Fig. 4: Guide tube for installation; Fig. 5: Coils for installation; Fig. 6: Implement for installation; Fig. 7: Detail of the implement; Fig. 8: Tape arranged for its connection to the pipe.