Micro, Drip and Sprinkler Application Technology

Basic Knowledge

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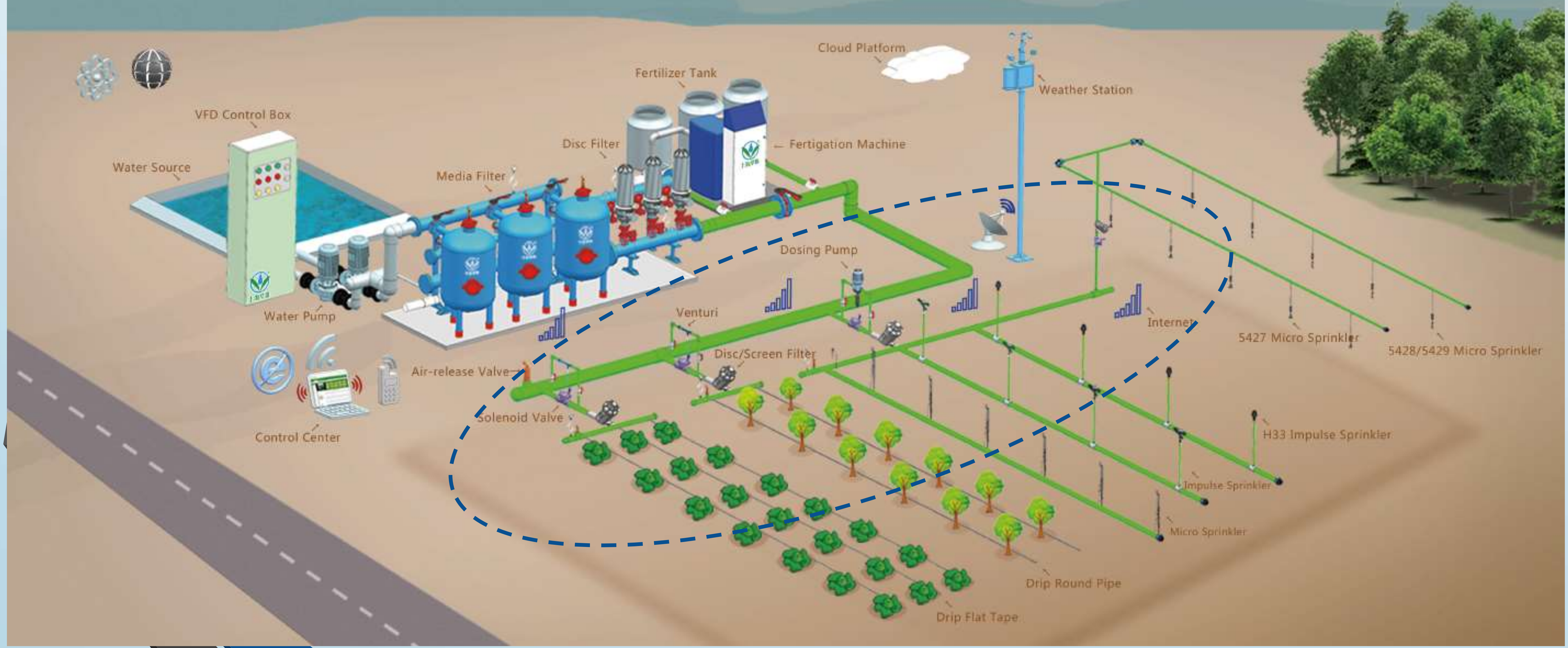
Pipeline Network

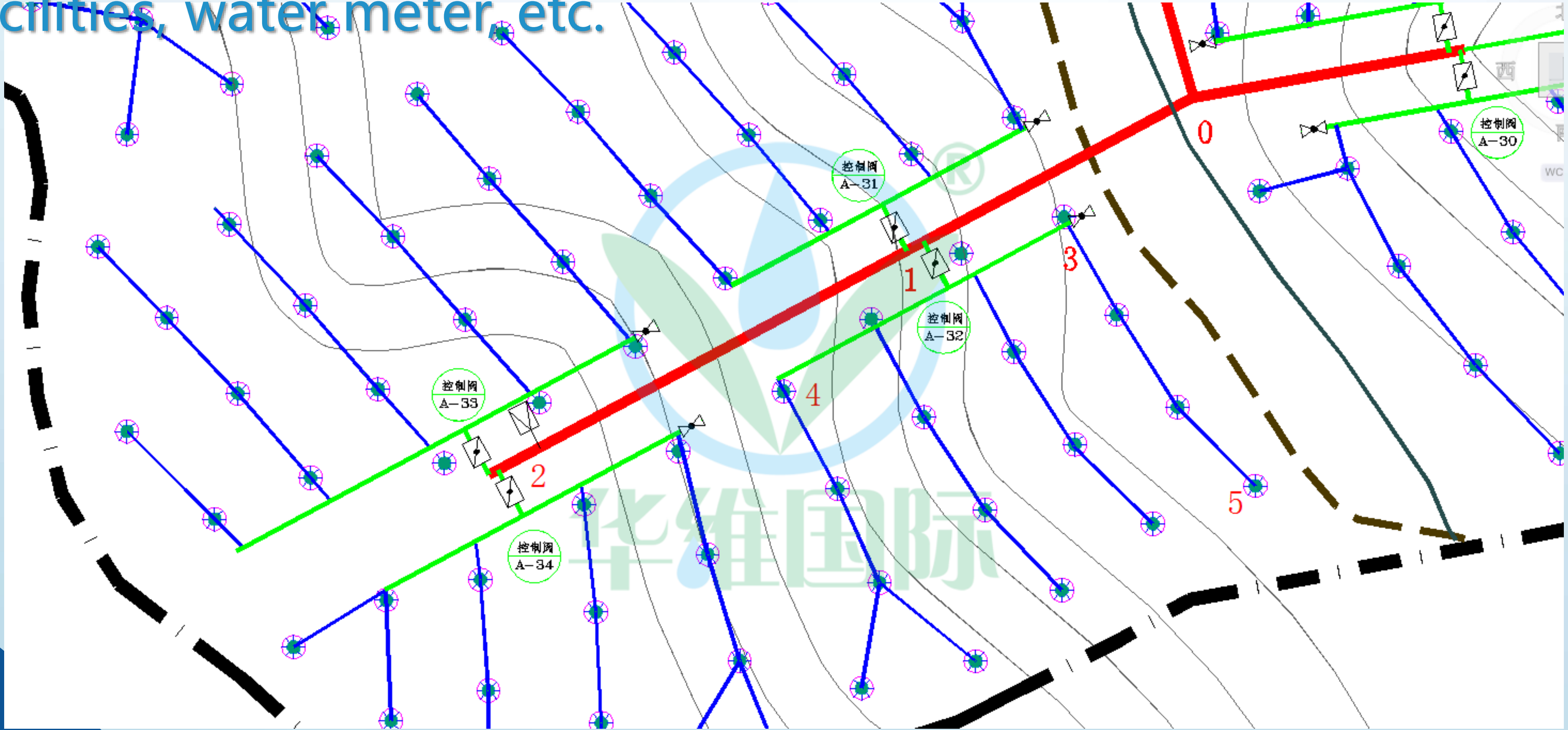
On Field Pipeline Network --- A general term for pipes, fittings and valves at all levels that take water from the source and transport and distribute it step by step into the field.

High Efficient Irrigation and Fertilization Model



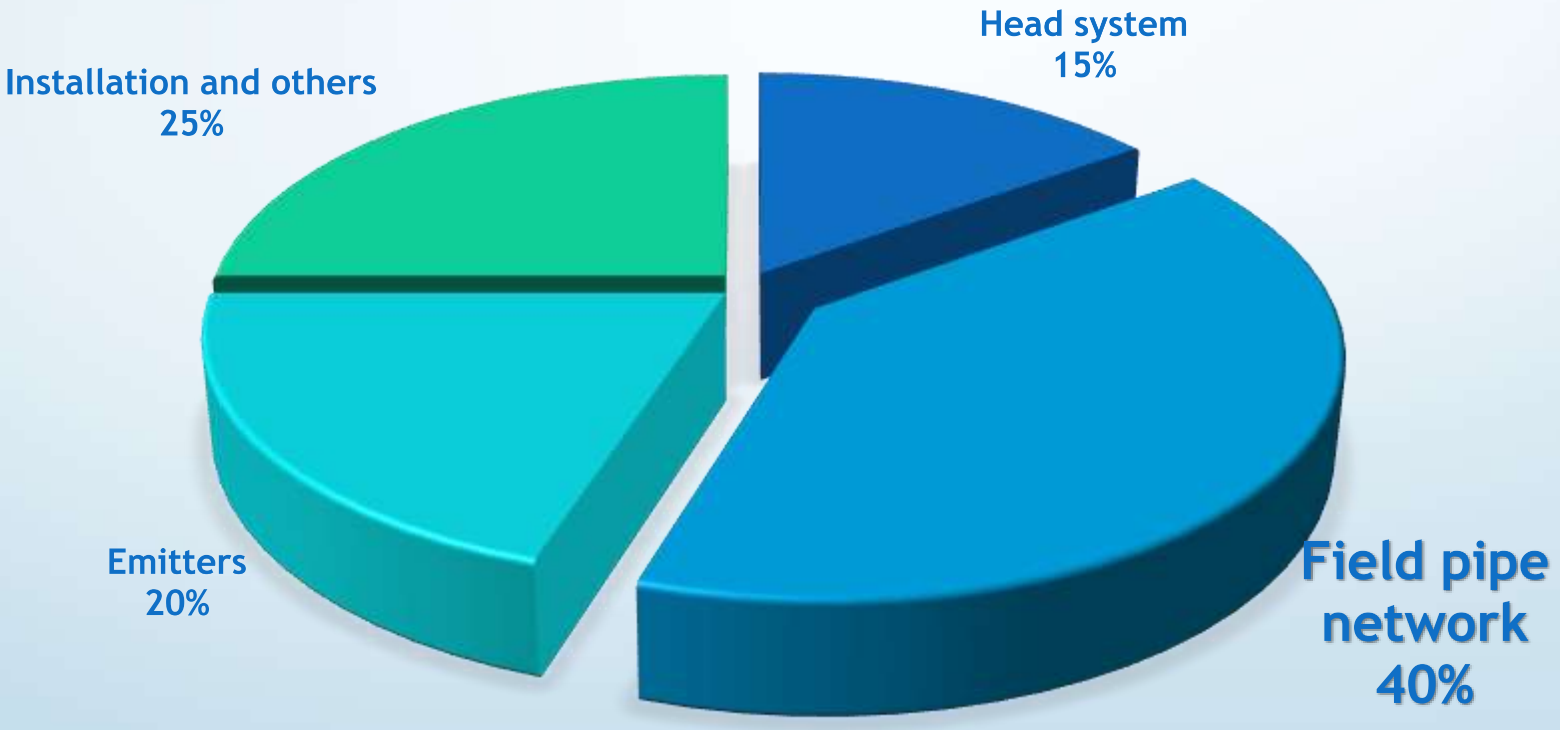
Cost less Harvest more

Water transport: main pipe, submain and manifold pipe -- pipe upstream of irrigation valve.
Water distribution: lateral pipe and dripline downstream of irrigation valve.
Accessories: fittings, valves, (flow, pressure) regulators, safety facilities, water meter, etc.



The proportion of the cost for each part of irrigation system

DRIP IRRIGATION PROJECT WITH TOTAL COST OF ABOUT 500 THOUSAND RMB AS AN EXAMPLE.

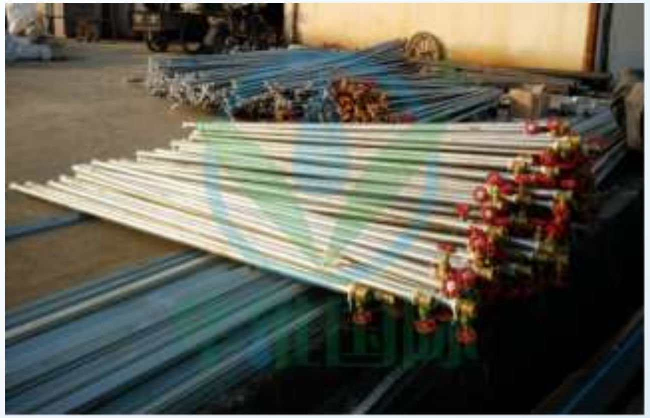


Pipes for agricultural irrigation

Micro irrigation

Pipes to be used

Cement pipe



Metal pipes: steel pipes, cast iron pipes, copper pipes, aluminum alloy pipes, etc.

The above pipe irrigation system is rarely used, commonly used is **plastic pipes.**

Pipes to be used

- In China, the main pipes used in agricultural irrigation are PE pipe (HDPE, LDPE), PVC-U for water transport pipe.
- Steel pipes and PPR pipes will also be used under special circumstances.

PVC-U Pipe

- PVC pipe occupies more than 60% of the plastic pipe on field. It is also widely used in irrigation in China and is often used as main pipes.
- PVC-U pipe is light weight, long service life, cheaper than HDPE, more expensive than LDPE, relatively good tensile and compressive strength, but relatively brittle at low temperature, low temperature resistance and toughness than PE pipe, easy broken when freezing.

On field installation for PVC

PVC pipes are hard, rigid, tougher than PE pipes, vulnerable to freezing at low temperatures, not suitable for bare surface, need to be buried in installation, buried depth must be below the local frozen soil depth.
In particular, the micro sprinkler system is broken during the freezing season.

By comparison, the PE pipe is less threatened in freezing season, so the micro spraying system adopts LDPE.

PE Pipes

- PE pipe is the second largest consumer in the world, and it is also the most widely used pipe in HEIS in China. PE pipes used in irrigation system are LDPE pipes and HDPE pipes. They are light weight, corrosion resistant, non-toxic, flexible, anti-aging, anti-ultraviolet radiation relatively, low temperature resistance and toughness than PVC pipes.

PE盘管系列

PE热熔直管系列

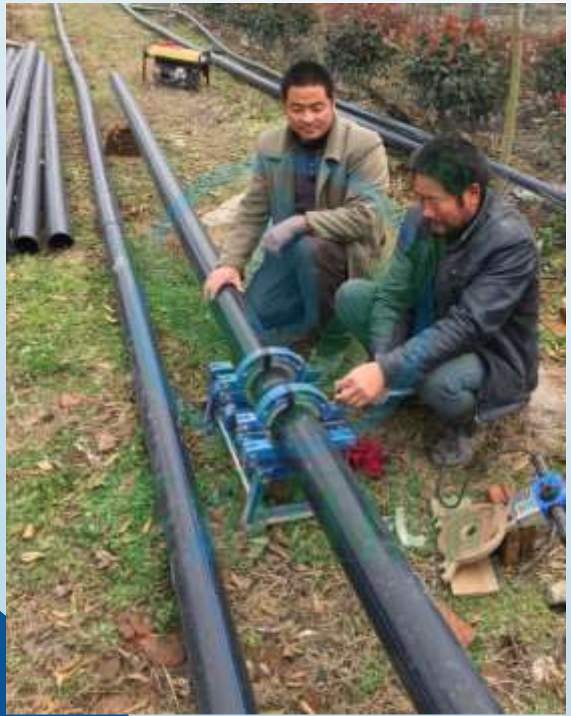
CPVC PLASTIC PIPE DATA Schedule 40 & 80						
Nominal Pipe Size	CPVC PIPE OD inches	CPVC PIPE OD mm	Schedule No.	Wall Thickness	Weight Per Foot (lbs) Pipe	Weight Per Foot (lbs) Pipe filled with water
3/8"	0.675	17.15	40	0.091	0.122	0.205
			80	0.126	0.154	0.215
1/2"	0.840	21.34	40	0.109	0.180	0.312
			80	0.147	0.225	0.326
3/4"	1.050	26.67	40	0.113	0.239	0.469
			80	0.154	0.305	0.491
1"	1.315	33.40	40	0.133	0.352	0.726
			80	0.179	0.449	0.760
1 1/4"	1.660	42.16	40	0.140	0.475	1.122
			80	0.191	0.618	1.173
1 1/2"	1.900	48.26	40	0.145	0.568	1.450
			80	0.200	0.751	1.516
2	2.375	60.33	40	0.154	0.761	2.213
			80	0.218	1.040	2.319
2 1/2"	2.875	73.03	40	0.230	1.201	3.273
			80	0.276	1.584	3.418
3"	3.5	88.90	40	0.216	1.572	4.772
			80	0.300	2.124	4.984
3 1/2"	4	101.60	40	0.226	1.905	6.185
			80	0.318	2.607	6.642
4"	4.5	114.30	40	0.237	2.239	7.749
			80	0.337	3.105	8.085
5"	5.563	141.30	40	0.258	3.062	11.722
			80	0.375	4.343	12.213
6"	6.625	168.28	40	0.280	3.945	16.455
			80	0.432	5.929	17.219
8"	8.625	219.08	40	0.322	5.920	27.520
			80	0.500	9.051	28.851
10"	10.75	273.05	40	0.365	8.406	42.506
			80	0.593	13.429	44.529
12"	12.75	323.85	40	0.406	11.172	59.672
			80	0.687	18.458	52.458
14"	14	355.60	40	0.437	13.262	71.762
			80	0.750	22.224	73.424
16"	16	406.40	40	0.500	17.312	93.812
			80	0.843	28.557	98.257

HDPE Pipe

- HDPE pipe has good toughness, many pressure specifications (Schedule), more expensive than LDPE pipe, but also expensive than PVC-U pipe, can be welded connection, that is irrigation system pipe of choice.

HDPE Pipe

- High technical requirements when installation, technical requirements for installation personnel, strict compliance with the welding process, docking method, cooling time, especially pay attention to the control of welding temperature.
- For installation environment, there must be power supply.
- Under normal conditions, the service life can usually reach 30~50 years.



PE Pipes

- LDPE pipe has good toughness, weatherability and anti-aging ability, the conventional pressure of 0.6 MPa or 0.8 MPa, the price is relatively affordable, usually as lateral of water distribution, or installation with drip irrigation, drip irrigation tape, dripper, drip arrow, micro-spray, sprinkler and other irrigation devices, can also be used as a small system main pipe. Most of them adopt lock type movable jointer.

PE Pipes

- PE pipe has flexibility, strong adaptability to uneven settlement of pipe foundation, it can be buried to installed, or dig ditches, can also be installed on the surface on open field, when meet obstacles by changing the way of pipeline.

LDPE usually adopts PP hoop type quick pipe connection.

- What are the PP lock quick fittings?
- What's good about the PP hoop connection?
- Which places can be used?
- Is it worthwhile to use it?

Cost less Harvest more

PP lock hoop quick fittings family

90°TEE

тройник

等径三通

Size/размер

20	25	32	40	50	63	75	90	110

90°REDUCING TEE

тройник редукционный

异径三通

Size/размер

25x20x25	32x20x32	32x25x32	40x20x40
40x25x40	40x32x40	50x20x50	50x25x50
50x32x50	50x40x50	63x20x63	63x25x63
63x32x63	63x40x63	63x50x63	75x50x75
75x63x75	90x50x90	90x63x90	90x75x90
110x63x110	110x75x110	110x90x110	

MALE THREADED TEE

тройник с наружной резьбой

阳螺纹三通

Size/размер

20x1/2 20x3/4 20x1 25x1/2 25x3/4 25x1
32x1/2 32x3/4 32x1 32x11/4 40x1 40x11/4
40x11/2 50x11/4 50x11/2 50x2 63x11/2
63x2 63x21/2 75x2 75x21/2 90x21/2 90x3
110x3 110x4

FEMALE THREADED TEE

тройник с внутренней резьбой

阴螺纹三通

Size/размер

20x1/2 20x3/4 20x1 25x1/2 25x3/4 25x1
32x1/2 32x3/4 32x1 40x1 40x11/4 40x11/2
50x11/4 50x11/2 50x2 63x11/2 63x2
75x2 75x21/2 90x21/2 90x3 110x3 110x4

MALE THREADED ELBOW

угол с наружной резьбой

阳螺纹弯头

Size/размер

20x1/2 20x3/4 25x1/2 25x3/4 25x1 32x1/2
32x3/4 32x1 32x11/4 40x1 40x11/4 40x11/2
50x11/4 50x11/2 50x2 63x11/2 63x2 63x21/2

90°ELBOW

угол 90

等径弯头

Size/размер

20 25 32 40 50 63 75 90 110

COUPLING

муфта

等径直通

Size/размер

20 25 32 40 50 63 75 90 110

REDUCING COUPLING

муфта редукционный

异径直通

Size/размер

25X20, 32X20, 32X25, 40X20, 40X25,
40X32, 50X20, 50X25, 50X32, 50X40,
63X20, 63X25, 63X32, 63X40, 63X50,
75X50, 75X63, 90X63, 90X75, 110X75,
110X90

MALE THREADED COUPLING

муфта с наружной резьбой

阳螺纹直通

Size/размер

20x1/2 20x3/4 20x1 25x1/2 25x3/4 25x1
32x1/2 32x3/4 32x1 32x11/4 40x1 40x11/4
40x11/2 50x11/4 50x11/2 50x2 63x11/2
63x2 63x21/2 75x2 75x21/2 90x21/2 90x3
110x3 110x4

FEMALE THREADED COUPLING

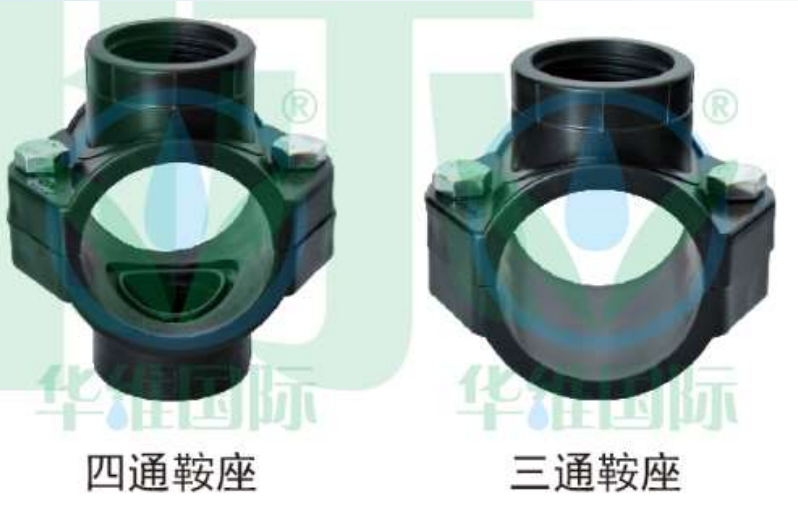
муфта с внутренней резьбой

阴螺纹直通

Size/размер

20x1/2, 20x3/4, 20x1, 25x1/2, 25x3/4,
25x1, 32x1/2, 32x3/4, 32x1, 40x11/4,
40x11/2, 50x11/4, 50x11/2, 50x2,
63x11/4, 63x11/2, 63x2, 75x2,
75x21/2, 90x21/2, 90x3, 110x3, 110x4

Saddle: instead of variable diameter threaded tee, suitable for PVC pipes, PE pipes, PPR pipes and other pipelines, covering 200 specifications, affordable price, no need to cut off the main pipe.



Basic of pipe selection

Pipe selection - let each pipe appears in the most desirable place.

- PE pipe
- Light weight, good toughness, low temperature resistance, non-toxic, cheap, high impact strength, but low compressive and tensile strength
- **HDPE: hot melt welding, flange thread.**
- **HDPE is often used as main pipe.**

- **LDPE: quick lock joint.**
- **LDPE often used as lateral pipe and dripline.**

Pipe selection

- PVC-U Pipe
- It has good tensile and compressive strength, but its flexibility is not as good as other plastic pipes, good corrosion resistance, the price is cheaper, but at low temperatures easy broken.
- Connection: Adhesive, looper, flange thread.
- Often be used as main pipe

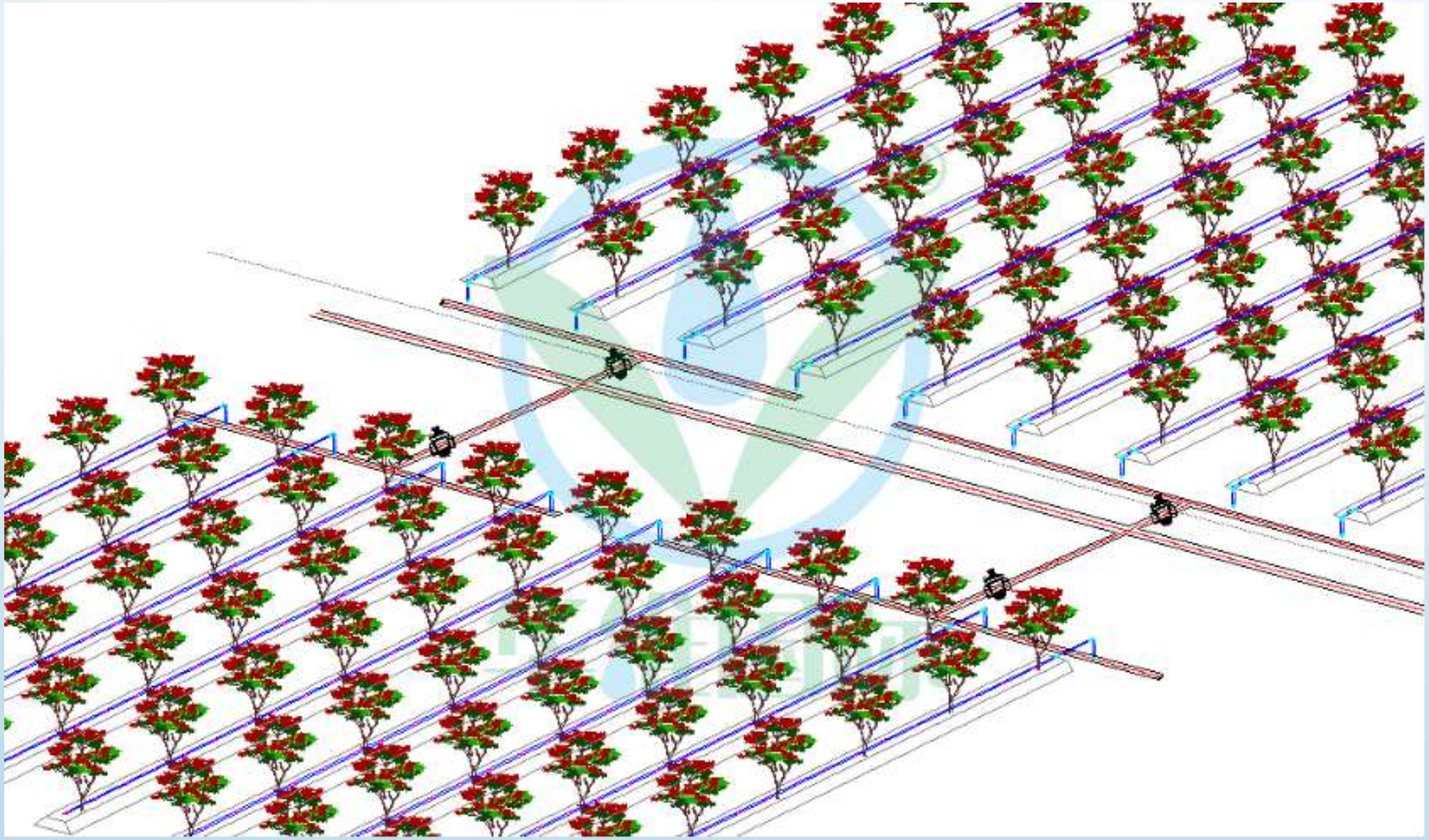
Pipe selection

- PPR Pipe
- Good corrosion resistance, good strength, high surface hardness, with a certain degree of high temperature resistance.
- Connection: Similar to PE pipe, hot-melt welding, flange, thread.
- Generally use as main pipe.

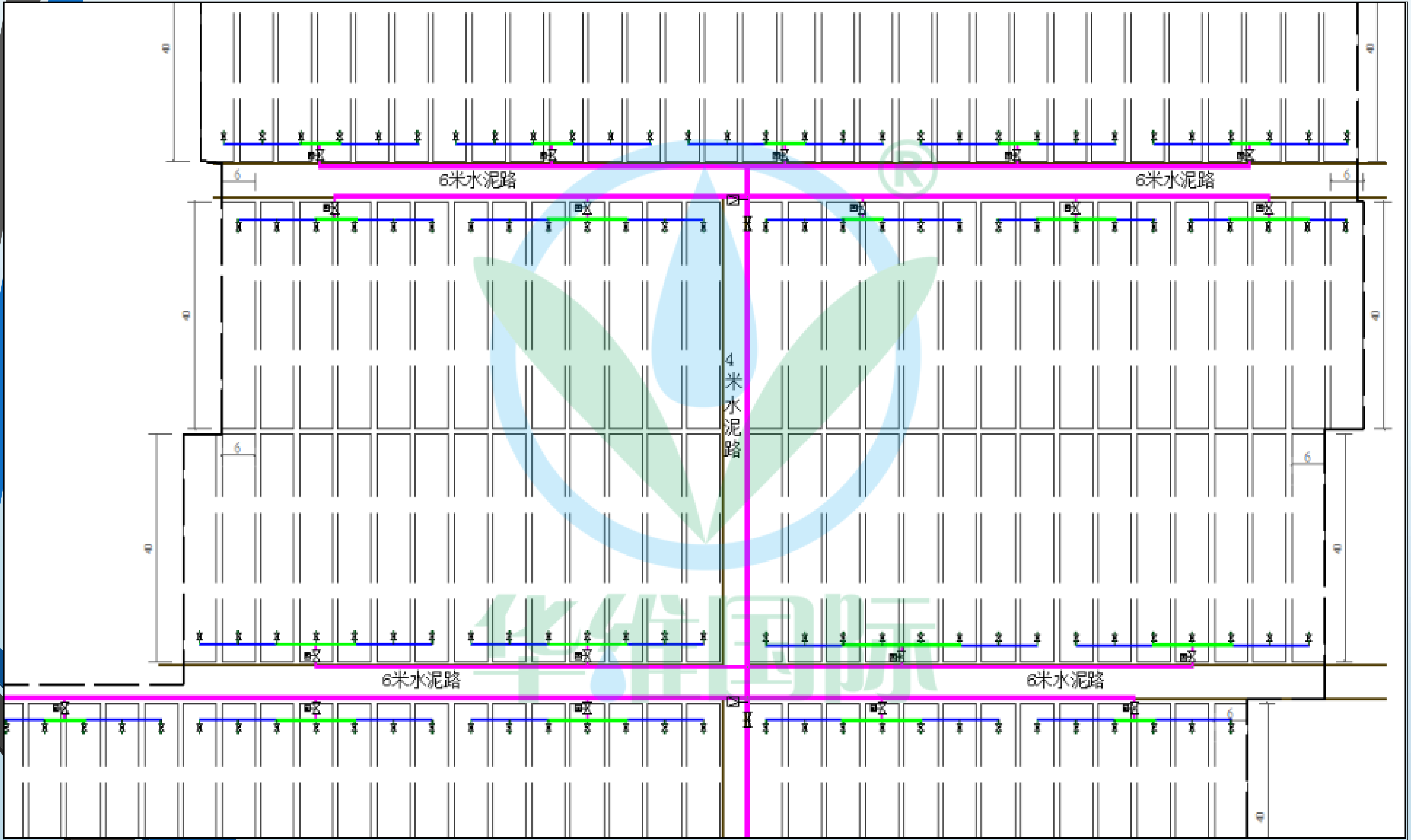
- Steel Pipe; cross the road, etc. steel pipe as protective bushing; wire / cable: flame retardant as electric pipe for casing.

Diameter selection

- Looking for a balance between investment and irrigation area, consideration of flow and allowable water loss is jointly determined.



Cost less Harvest more



Piping pressure-bearing

- Related to working pressure


Piping network accessories

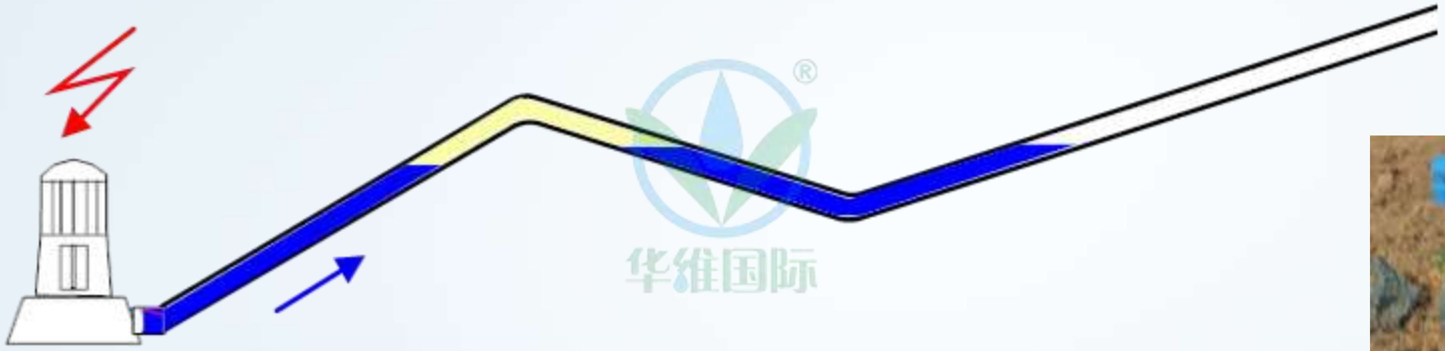
- Accessories
  - Tees, elbows, reduce, joiner
- Control valve
  - Gate valves, butterfly valves, ball valves, solenoid valves, electric valves.
- Protector
  - Safety valve, check valve, pressure reducing valve, air valve
- Regulating device
  - Pressure / flow regulator.
- Measuring instrument
  - Pressure gauge, flowmeter, etc.

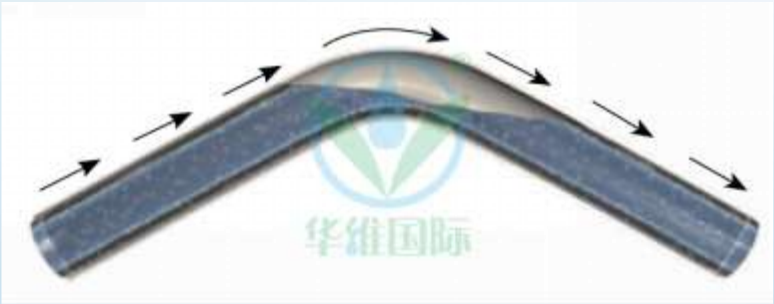
Piping network accessories

solenoid

Application of vacuum valve / solenoid valve (field head)

Air valves - Safety Guards for pipe networks





Safety Guards

Water Hammer

- Water hammer occurs when the flow of water in a pipe is abruptly changed or stopped
- When water hammer occurs, a high intensity pressure wave travels back through the piping system until it reaches a "point of relief"
  - valve, sprinkler, elbow, poor glued joint, stressed pipe

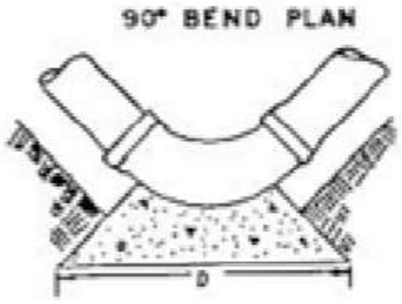
Causes of water hammer

1. Valve closure
2. Uncontrolled flow velocity in empty pipes
3. Trapped air in long runs of pipe
4. Reverse flow when pumps stop

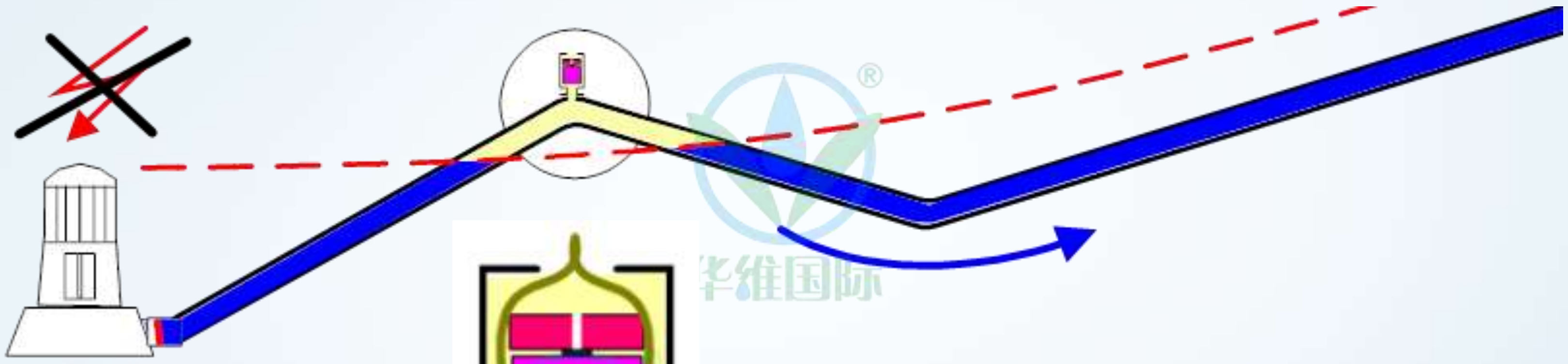
Safety Guards

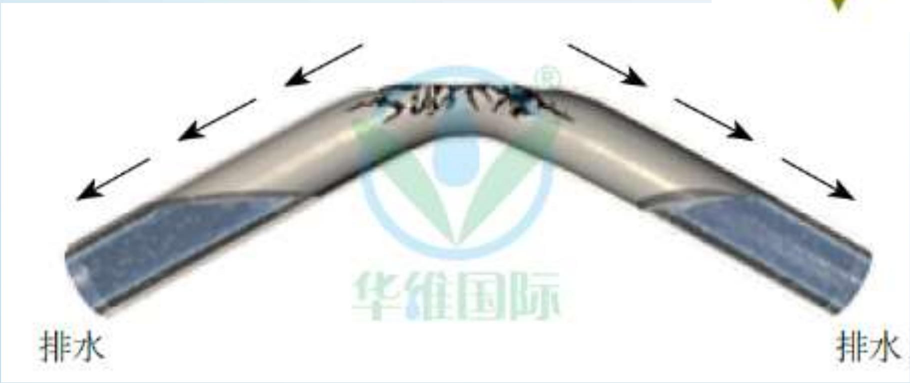
Avoiding water hammer

- 5 ft/s maximum design
- Thrust blocking
- Air relief valves
- Check valves



Vacuum valve





PPCM

Efficiency = Project × Material × Install × Maintain

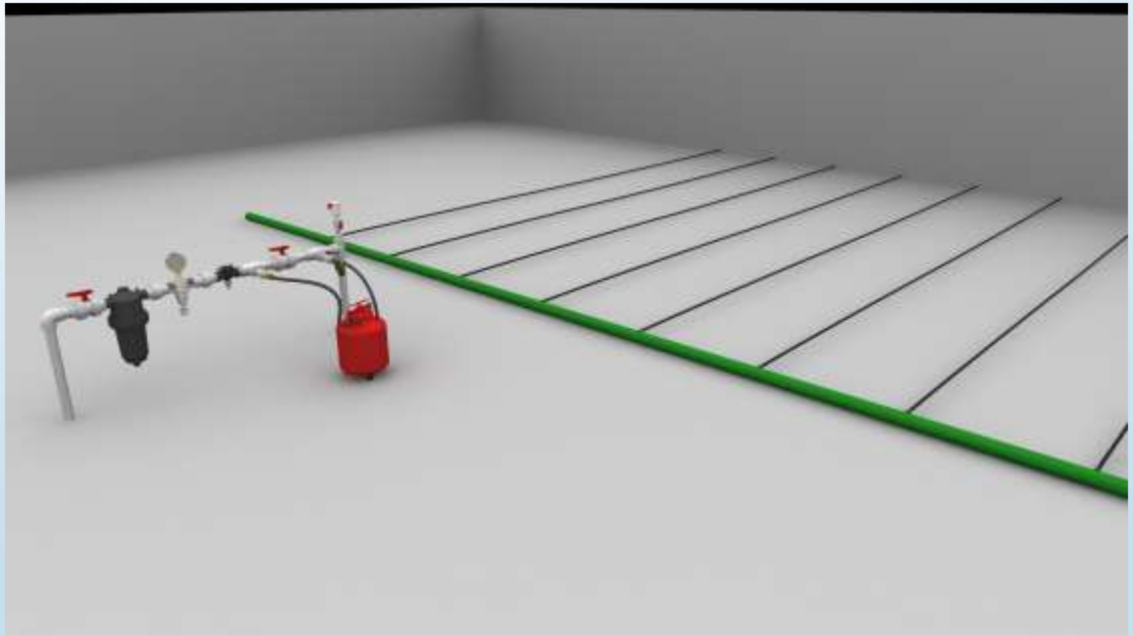
81% = 95% 95% 95% 95%

Cost less Harvest more irrist

- Why consider drip irrigation?
- Drip irrigation can help you use water
- efficiently. A well-designed drip irrigation system
- loses practically no water to runoff, evaporation,
- or deep percolation in silty soils. Drip irrigation
- reduces water contact with crop leaves, stems,
- and fruit. Thus, conditions may be less favorable
- for disease development. Irrigation scheduling
- can be managed precisely to meet crop demands,
- holding the promise of increased yield and
- quality.
- Growers and irrigation professionals often
- refer to “subsurface drip irrigation,” or SDI.
- When a drip tape or tube is buried below the soil
- surface, it is less vulnerable to damage due to UV
- radiation, cultivation, or weeding. With SDI,
- water use efficiency is maximized because there
- is even less evaporation or runoff.
- Agricultural chemicals can be applied more
- efficiently through drip irrigation. Since only the
- crop root zone is irrigated, nitrogen already in the
- soil is less subject to leaching losses, and applied
- fertilizer can be used more efficiently. In the case
- of insecticides, less product might be needed.
- Make sure the insecticide is labeled for

Basic Knowledge

- Basic knowledge prepared to assist with the correct use of High Efficient Irrigation, Sprinkler or Micro Irrigation, either On-Surface Drip Irrigation (OSDI) or Sub-surface Drip Irrigation (SDI).). Included Hydraulic in Irrigation, technical data.



Pressure Network Hydraulics

- “Network Hydraulics Theory”
- “The Energy Equation”
- “Hydraulic and Energy Grades”
- “Conservation of Mass and Energy”
- “The Gradient Algorithm”
- “Derivation of the Gradient Algorithm”
- “The Linear System Equation Solver”
- “Pump Theory”
- “Valve Theory”

Network Miscellaneous

- **Pipes**—Transport water from one location (or node) to another.
- **Junctions/Nodes**—Specific points, or nodes, in the system at which an event of interest is occurring. This includes points where pipes intersect, where there are major demands on the system such as a large industry, a cluster of houses, or a fire hydrant, or critical points in the system where pressures are important for analysis purposes.
- **Reservoirs and Tanks**—Boundary nodes with a known hydraulic grade that define the initial hydraulic grades for any computational cycle. They form the baseline hydraulic constraints used to determine the condition of all other nodes during system operation. Boundary nodes are elements such as tanks, reservoirs, and pressure sources.

Network Miscellaneous

- **Pumps**—Represented as nodes. Their purpose is to provide energy to the system and raise the water pressure.
- **Valves**—Mechanical devices used to stop or control the flow through a pipe, or to control the pressure in the pipe upstream or downstream of the valve. They result in a loss of energy in the system.

The Energy Principle

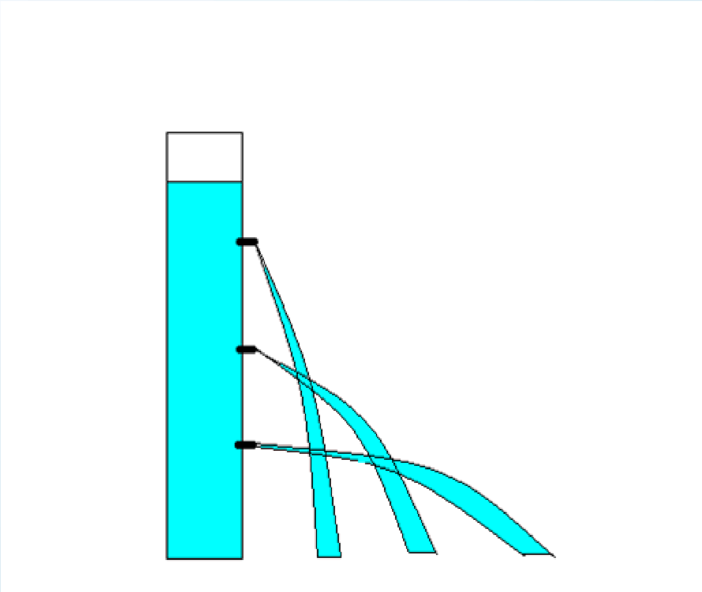
In hydraulic applications, energy is often represented as energy per unit weight, resulting in units of length. Using these length equivalents gives engineers a better feel for the resulting behavior of the system. When using these length equivalents, the state of the system is expressed in terms of head. The energy at any point within a hydraulic system is often represented in three parts:

These quantities can be used to express the headloss or head gain between two locations using the energy equation

Pressure Head:		p/γ
Elevation Head:		z
Velocity Head:		$V^2/2g$
Where:	p	=Pressure (N/m^2, $lb./ft.^2$)
	g	=Specific weight (N/m^3, $lb./ft.^3$)
	z	=Elevation (m, ft.)
	V	=Velocity (m/s, ft./sec.)
	g	=Gravitational acceleration constant (m/s^2, $ft./sec.^2$)

Understanding basic hydraulics

"How can I get rid of these brown spots?" is a question you have probably asked yourself. To find the answers, it will help to understand something about basic irrigation hydraulics — the movement of water through a piping system.

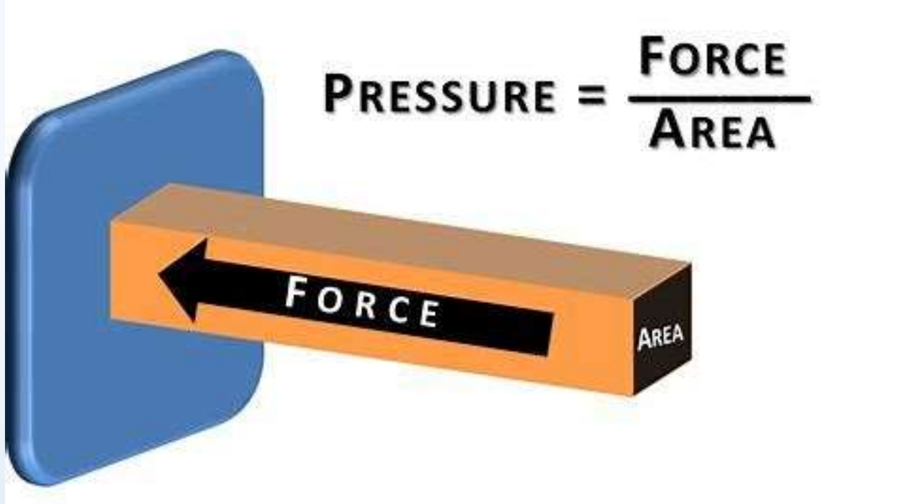


Basic hydraulics

- Hydraulics is defined as the study of fluid behavior, at rest and in motion. Properly designed piping, with sound hydraulics, can greatly reduce maintenance problems over the life of an irrigation system. Controlling the water flow velocity, holding velocity within proper limits, reduces wear on the system components and lengthens service life.
- Poor hydraulic design results in poor performance of the irrigation system, leading to stressed crop growth, or even broken pipes and flood damage.
- Hydraulic analysis is important to minimize financial risks, produce efficient designs and eliminate waste.

Basic hydraulics

- Water exerts pressure — defined as the force of water exerted over a given area. The formula for water pressure looks like this:



- $P = F \div A$
- P= pressure in pounds per square inch (kilograms per square centimeter)
- F = force in pounds (kilograms)
- A = area in square inches (square centimeters)

Basic hydraulics

Water Fundamentals: *Weight, Pressure, and Volume*

- Water…..
  - 8.34 lbs/gallon
  - 7.48 g/ft^3
  - 62.4 lbs/ft^3
  - 1000 kg/m^3

Water Fundamentals: *Variables and Units*

- Cross sectional area of a pipe

$$A = \pi * r^2$$

$$A = \pi * d^2/4$$

Basic hydraulics

Water Fundamentals: *Weight and Pressure*

- Water exerts a force on it's surrounding
- Pressure: psi (lbs/in2), kPa, bars
  - 2.31 ft of water provides 1psi
  - 23.1 ft of water provides 10 psi
  - 1ft of water provides 0.433 psi
- Elevation (ft) = pressure (2.31 ft/psi)
- *Metric: 1m of water = 9.81 kPa*

Water Fundamentals: *Weight and Pressure*

- Static Pressure
  - *Pressure in a system when water is motionless*
  - *Will vary at different locations in system due to differences in elevation*
- Dynamic Pressure
  - *"Operating" or "Working" pressure*
  - *Pressure exiting any point in a system when it is operating*
  - *DP < SP due to resistance and friction losses*

Basic hydraulics

Water Fundamentals: *Flow*

- *Velocity* is the speed of water as it moves through a pipe system. We use "average" velocity (feet per second, fps, ft/s, m/s).

  1 ft/s = 0.305 m/s

- *Flow* (flowrate) is a measure of the amount of water moved during a period of time (gallons per minute, gpm, ft^3/s, m^3/s).

  $1 ft^3/s = 449/gpm$

Water Fundamentals: *Flow*

- Relationship between velocity, flow, cross-sectional area of a pipe:

$$q = va$$

$$q = 2.448 * v * D^2$$

q = gpm ; v = ft/sec; D= in

Basic hydraulics

Water Fundamentals: *Flow*

- *Example:* Schedule 40 pipe, 2" nominal pipe size (NPS), 3 feet per second. What is the flowrate in gpm?

$q = va$

$q = 3\ ft/s * 60\ s/min * \pi * (2/2)^2\text{-}in^2 * 1ft^2/144in^2$

$q = 3 * 60 * 3.14 * 1^2 * 0.00694$

$q = 3.92\ ft^3/min$

$q = 3.92\ ft^3/min * 7.48\ gal/ft^3$

$q = 29.3\ gpm$

Water Fundamentals: *Energy*

- Energy Head = the amount of energy associated with the combination of elevation, pressure, and velocity

- Neglecting velocity head (small contribution):

H (energy head) = p (pressure) + E (elevation)

$H(ft) = p\ (psi) * 2.31\ ft/(1\ lb/sq.in.) + E\ (ft)$

Basic hydraulics

Consider a 1 in^2 (1 cm^2) container filled with water to a depth of 1 ft (50 cm). One foot (50 cm) of water creates a pressure of .433 psi (0.05 bar) at the base of the container. It makes no difference if the 1 ft (50 cm) of water is held in this narrow container or at the bottom of a 1 ft (50 cm) deep lake. The area is concerned with only 1 in^2 (1 cm^2) at the bottom of either container.

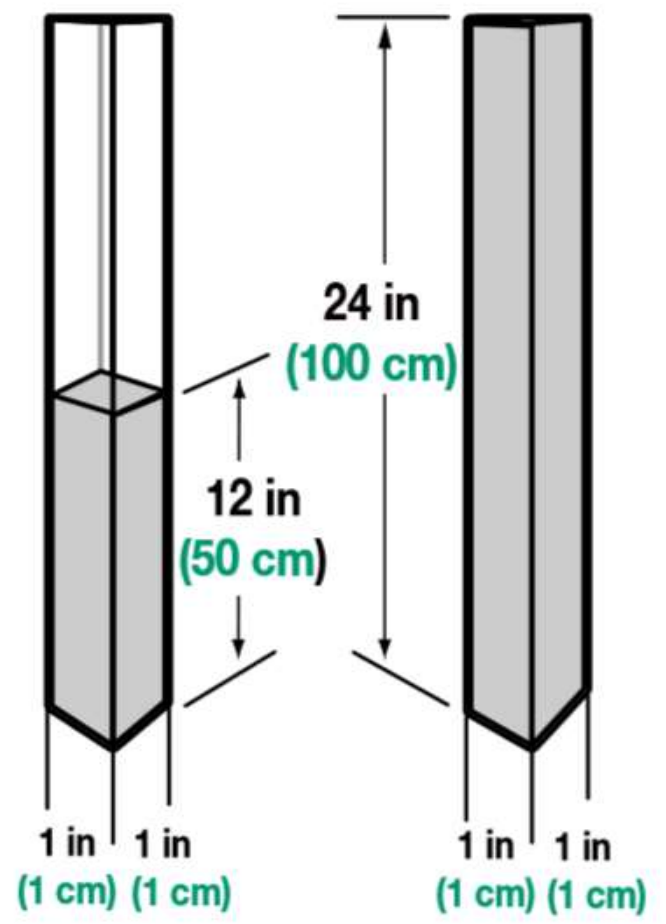


Figure 1: Water towers filled at 12 in and 24 in (50 cm and 100 cm)

Basic hydraulics

- The word hydrostatic refers to the properties of water at rest. We will be discussing static water pressure as a starting point for hydraulic design of an irrigation system.

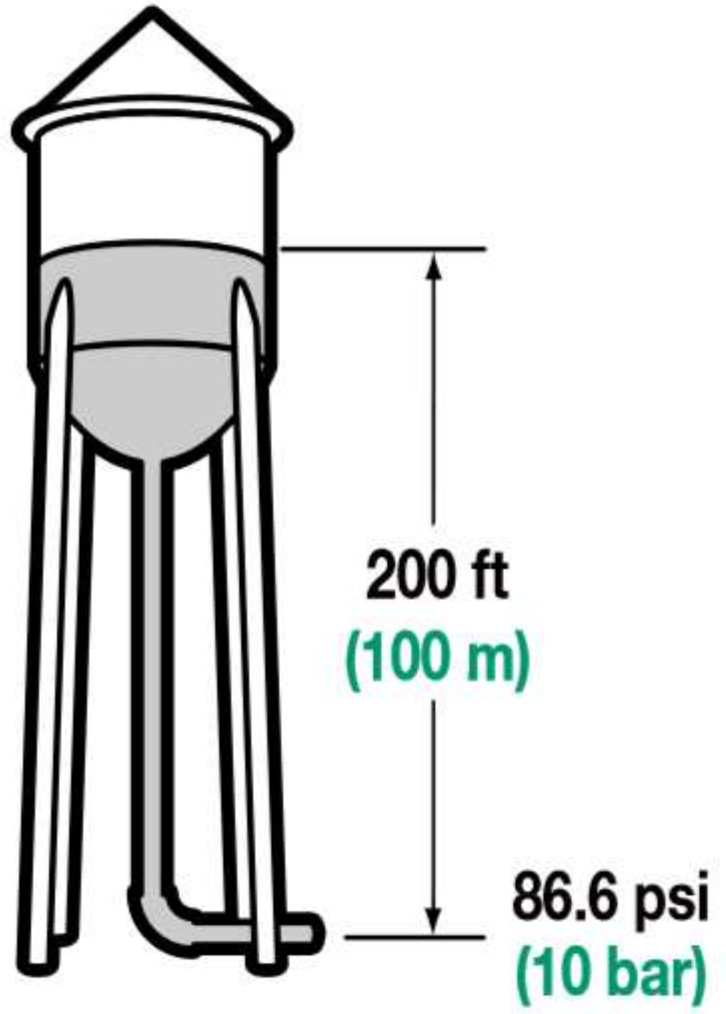
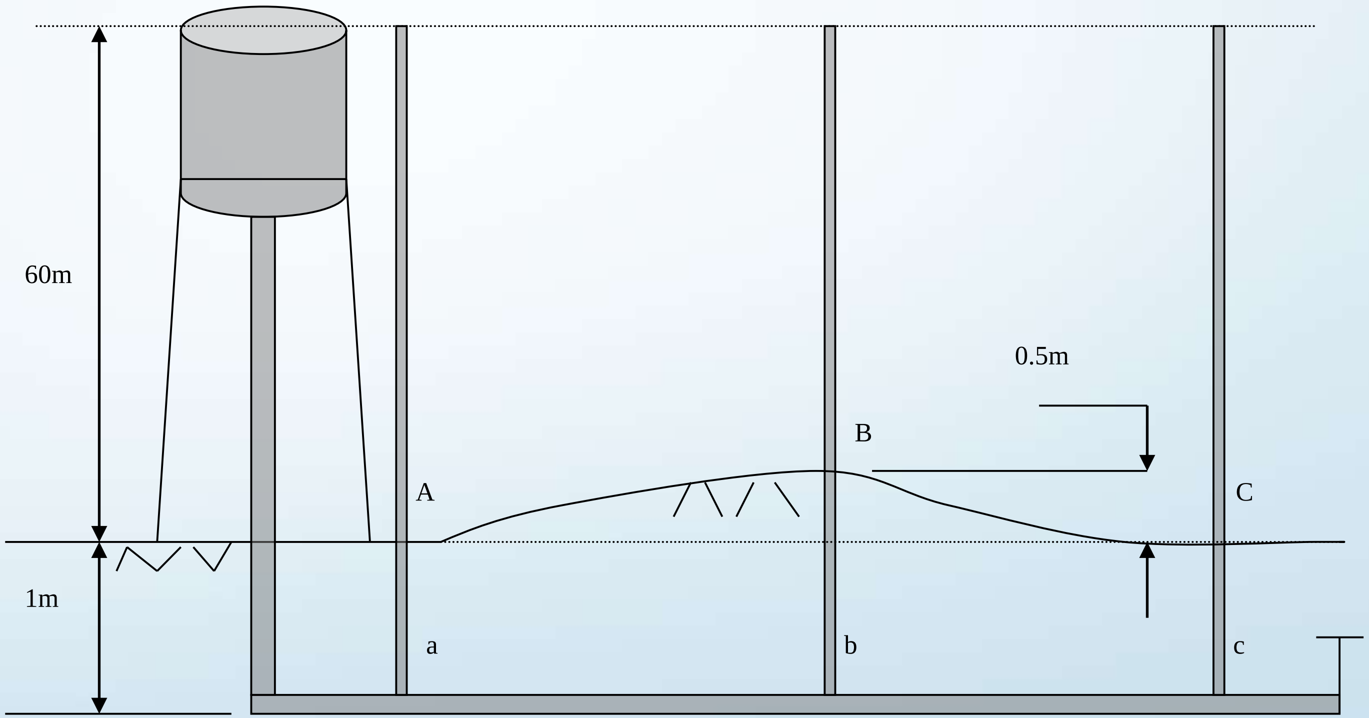


Figure 2: Water tower – 200 ft (100 m)

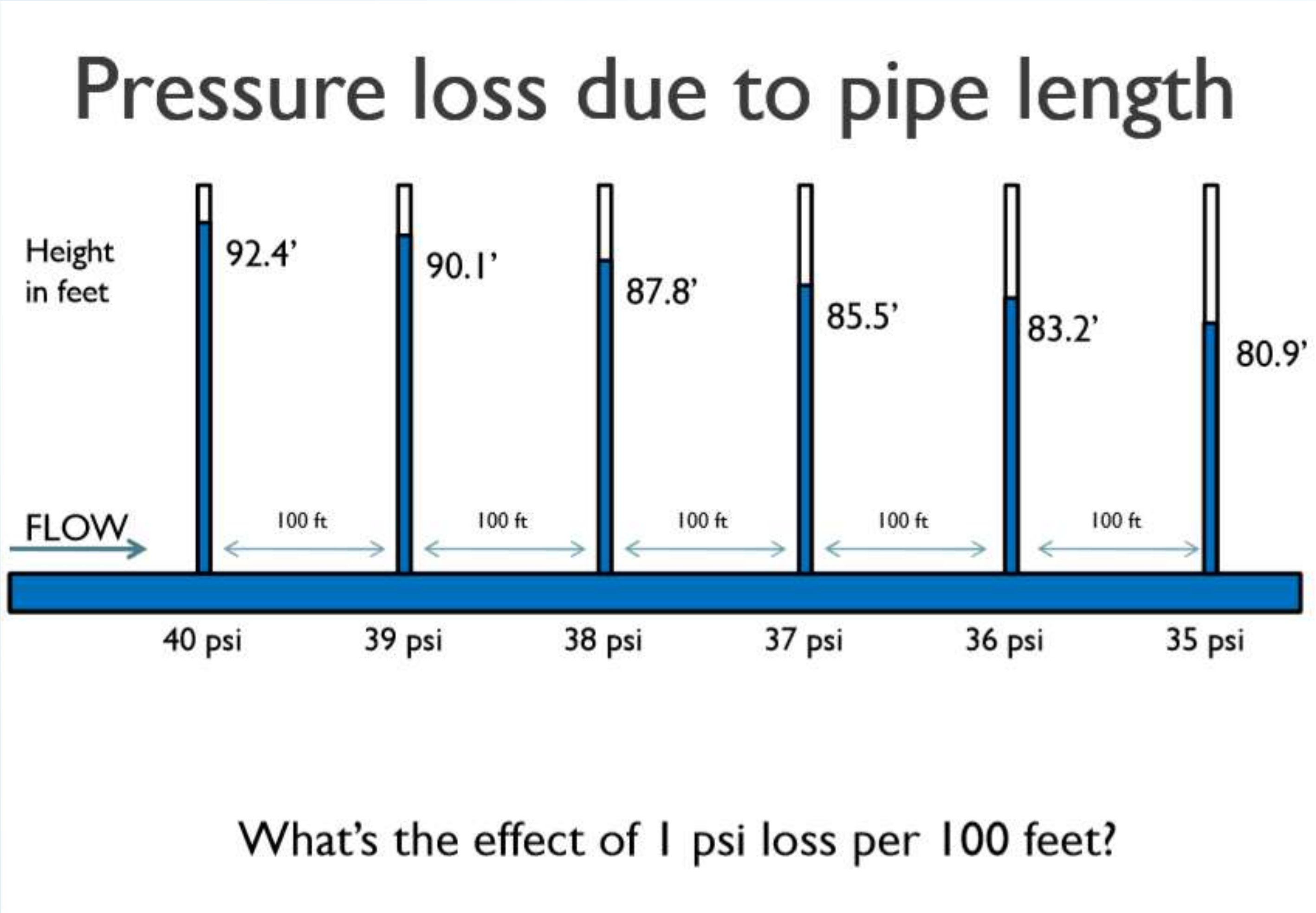
Basic hydraulics

- Static water pressure refers to the pressure of a closed system with no water moving. A water-filled main line, with all valves closed, would experience full static pressure with only pressure variation due to elevation. Static water pressure is an indication of the potential pressure available to operate a system.



Cost less Harvest more

Basic hydraulics

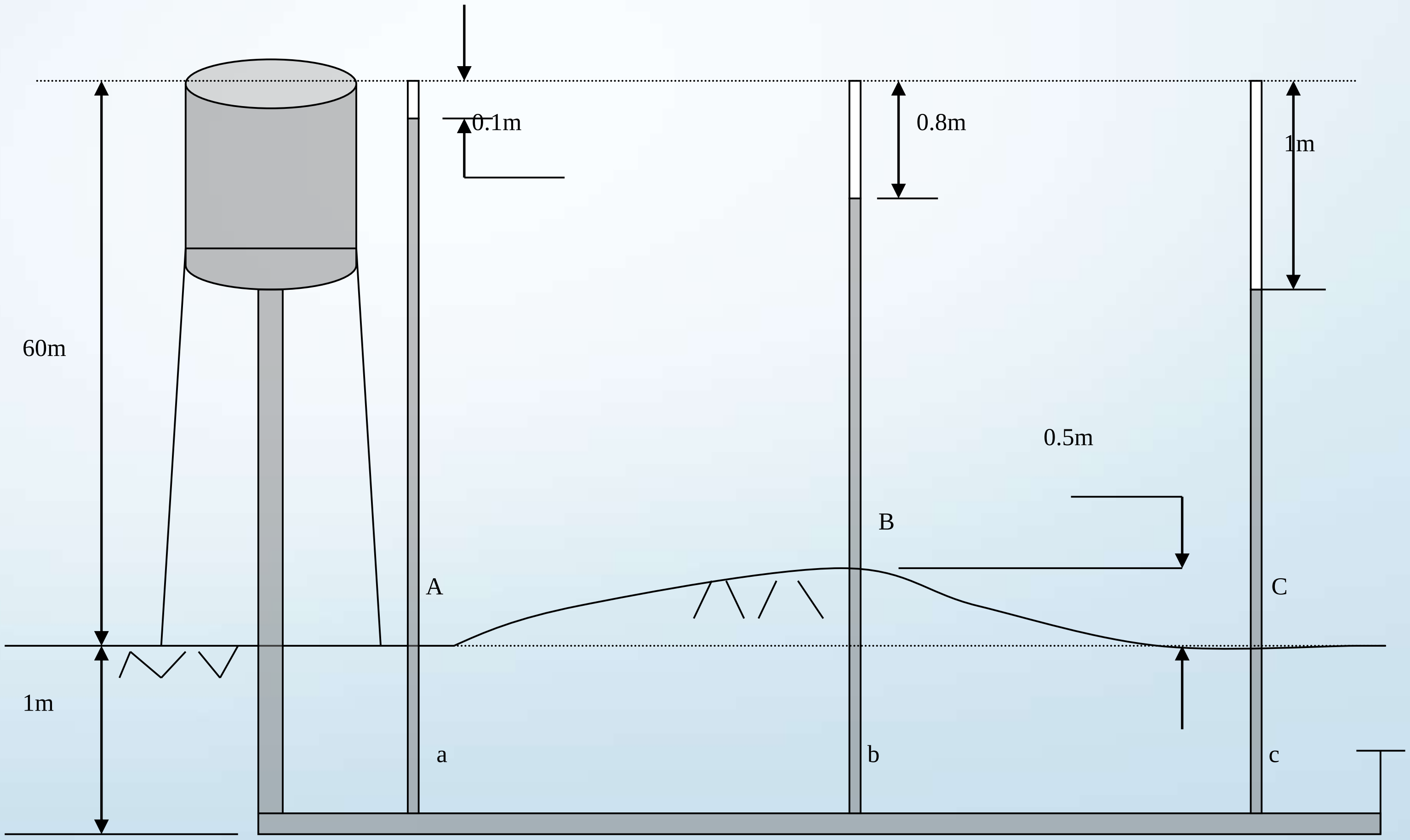


Cost less Harvest more

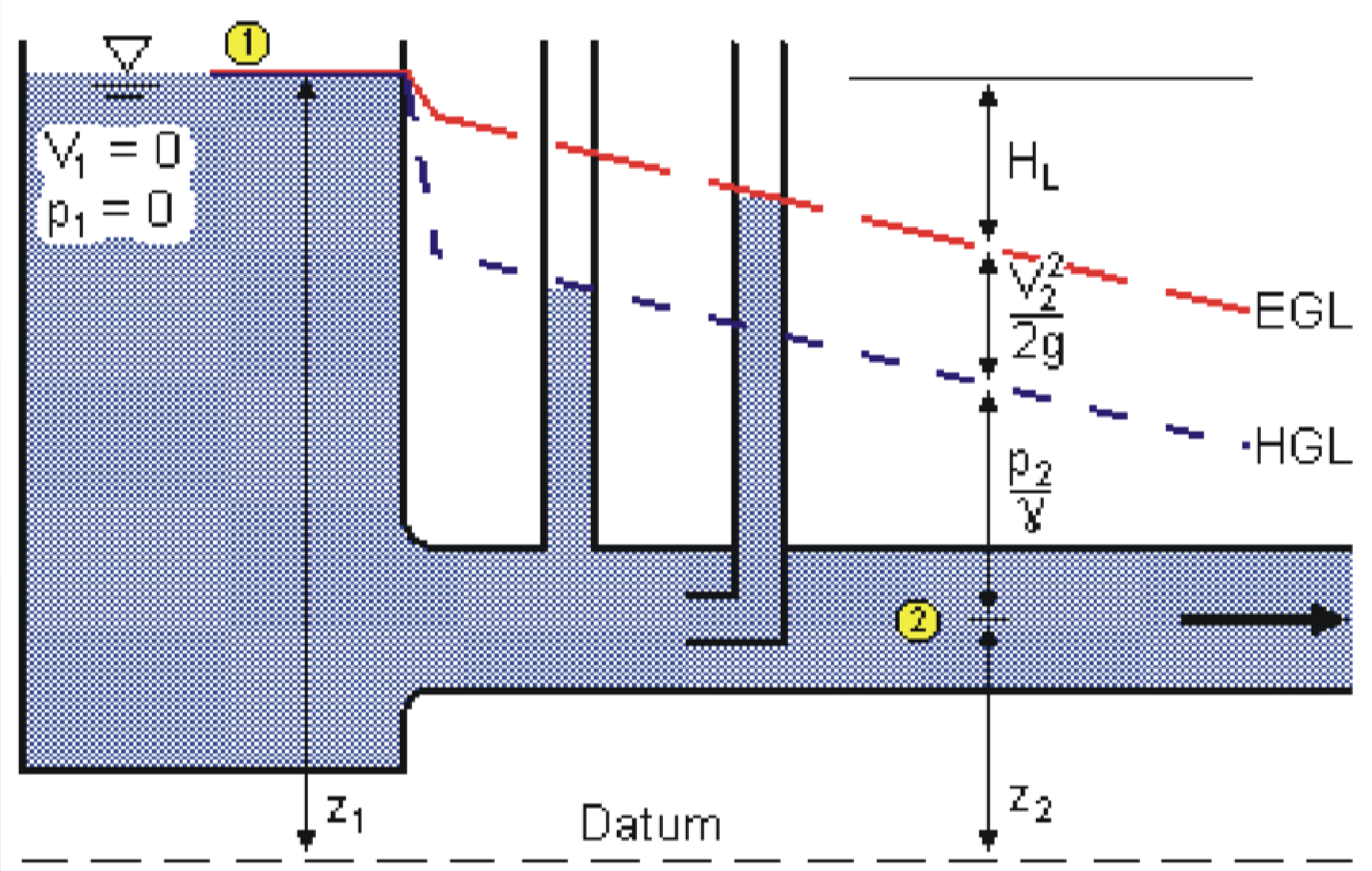
irrist

Basic hydraulics

- Hydrodynamic refers to the properties of water in motion. Moving water, at the correct flow and pressure, to where it's needed is the hydraulic basis of irrigation design.

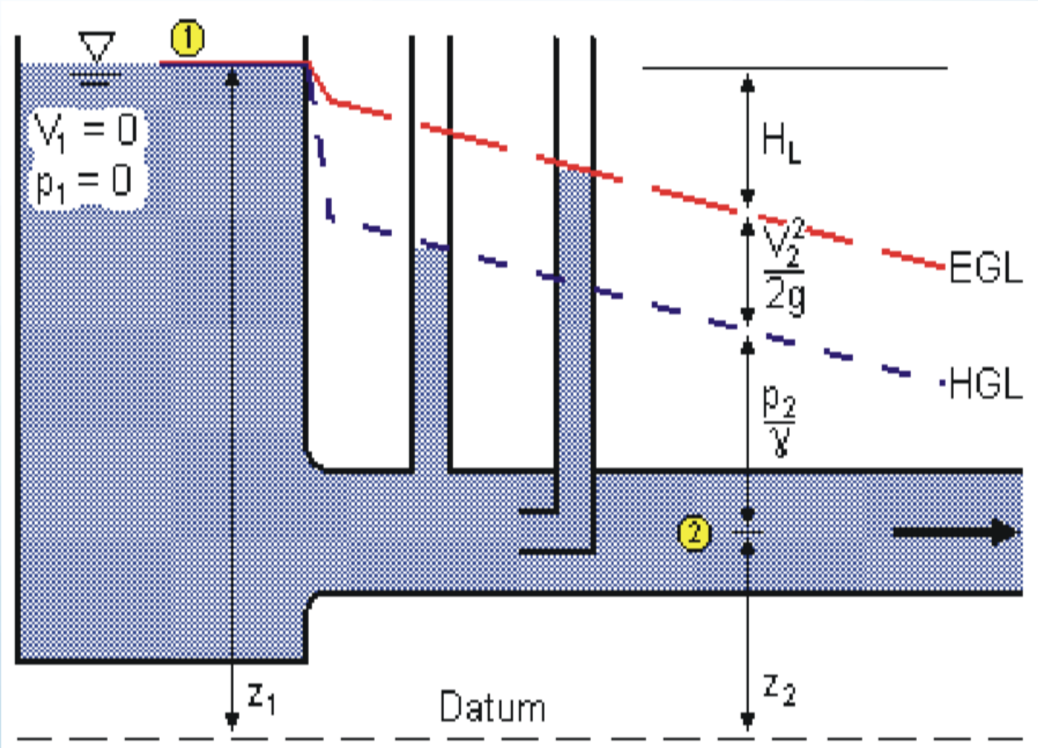


Hydraulic and Energy Grades



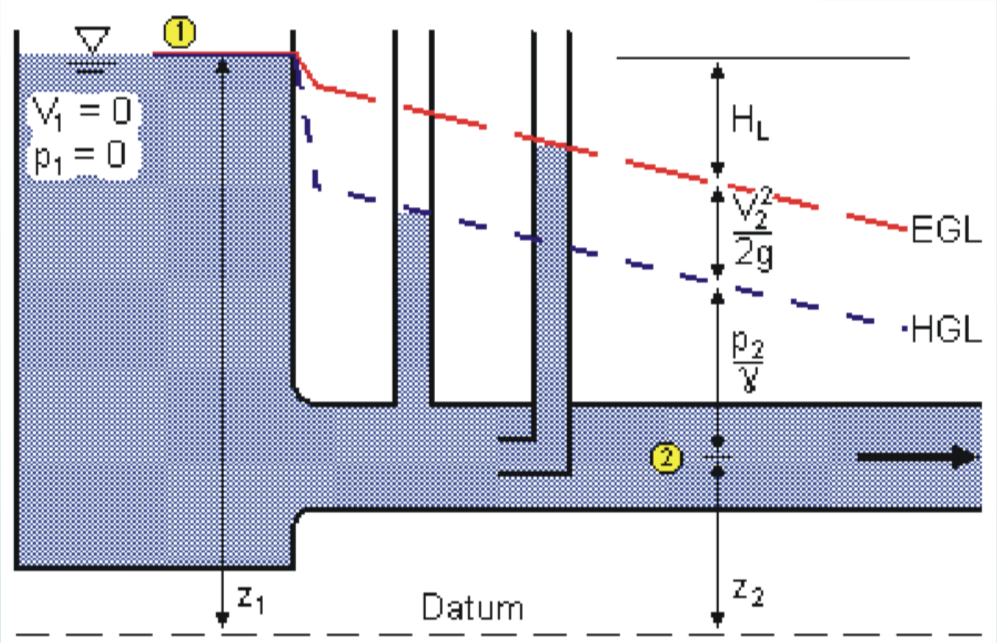
Hydraulic Grade

- The hydraulic grade is the sum of the pressure head (p/g) and elevation head (z). The hydraulic head represents the height to which a water column would rise in a piezometer. The plot of the hydraulic grade in a profile is often referred to as the hydraulic grade line, or HGL.



Energy Grade

- The energy grade is the sum of the hydraulic grade and the velocity head ($V^2/2g$). This is the height to which a column of water would rise in a pitot tube. The plot of the hydraulic grade in a profile is often referred to as the energy grade line, or EGL. At a lake or reservoir, where the velocity is essentially zero, the EGL is equal to the HGL, as can be seen in the following figure.



Basic hydraulics

Water Fundamentals: *Friction Loss*

- Water flowing in pipes looses energy
- Any change in flow, restriction, causes of additional turbulence, etc., will result in a decrease in energy
- Factors affecting friction loss
  - velocity
  - pipe diameter
  - pipe roughness (type)
  - length

Water Fundamentals: *Friction Loss*

- Velocity Affects
  - Maximum?
  - Minimum?
- Recommended ranges of velocities in plastic pipe?
- Costs?

1 in. diameter PVC

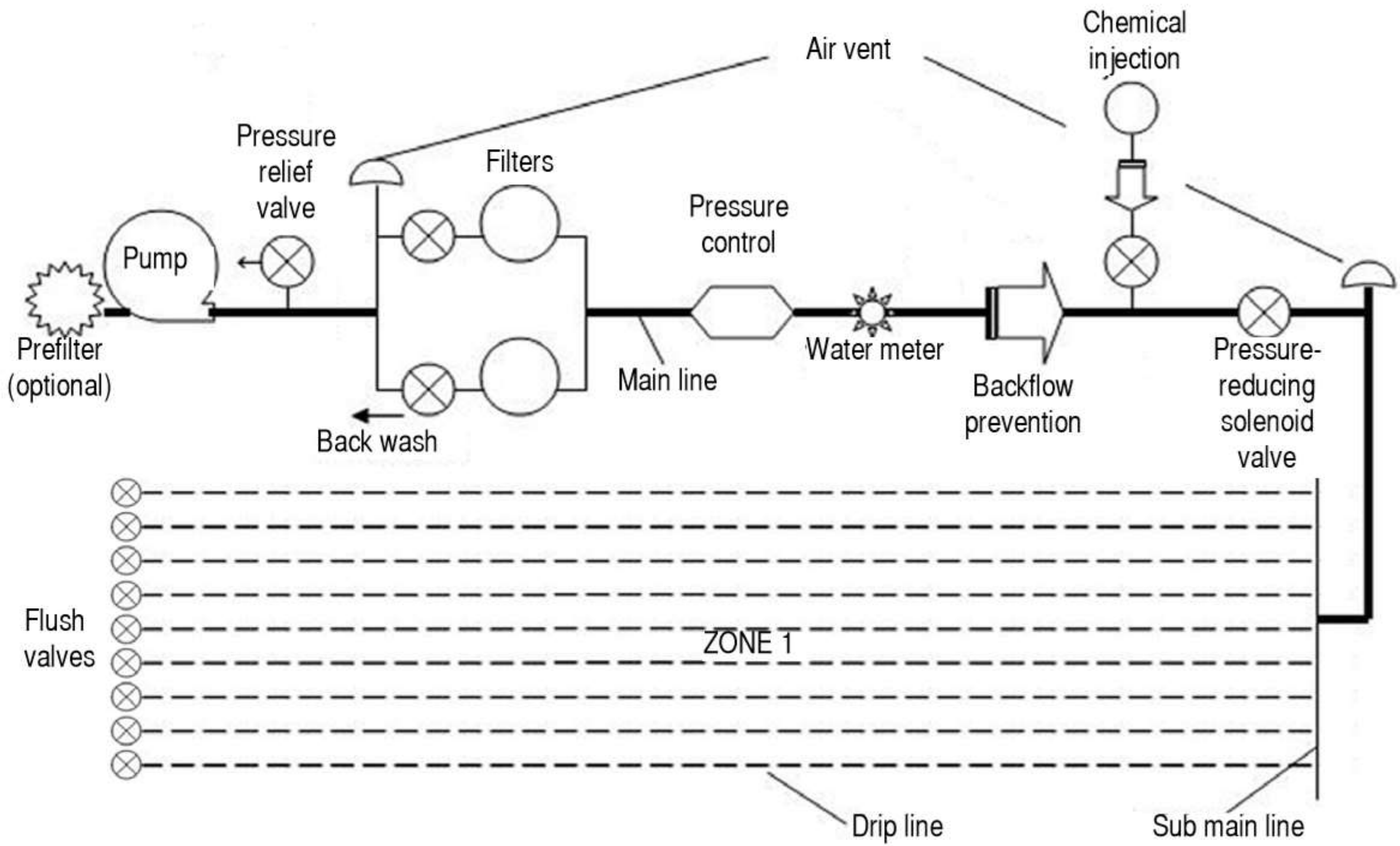
Schedule 40 (450 psi)	$7.00/20 ft
Thin wall (315 psi)	$3.60 /20 ft

~ 49 % reduction in cost

6. Frictional Head Loss Chart

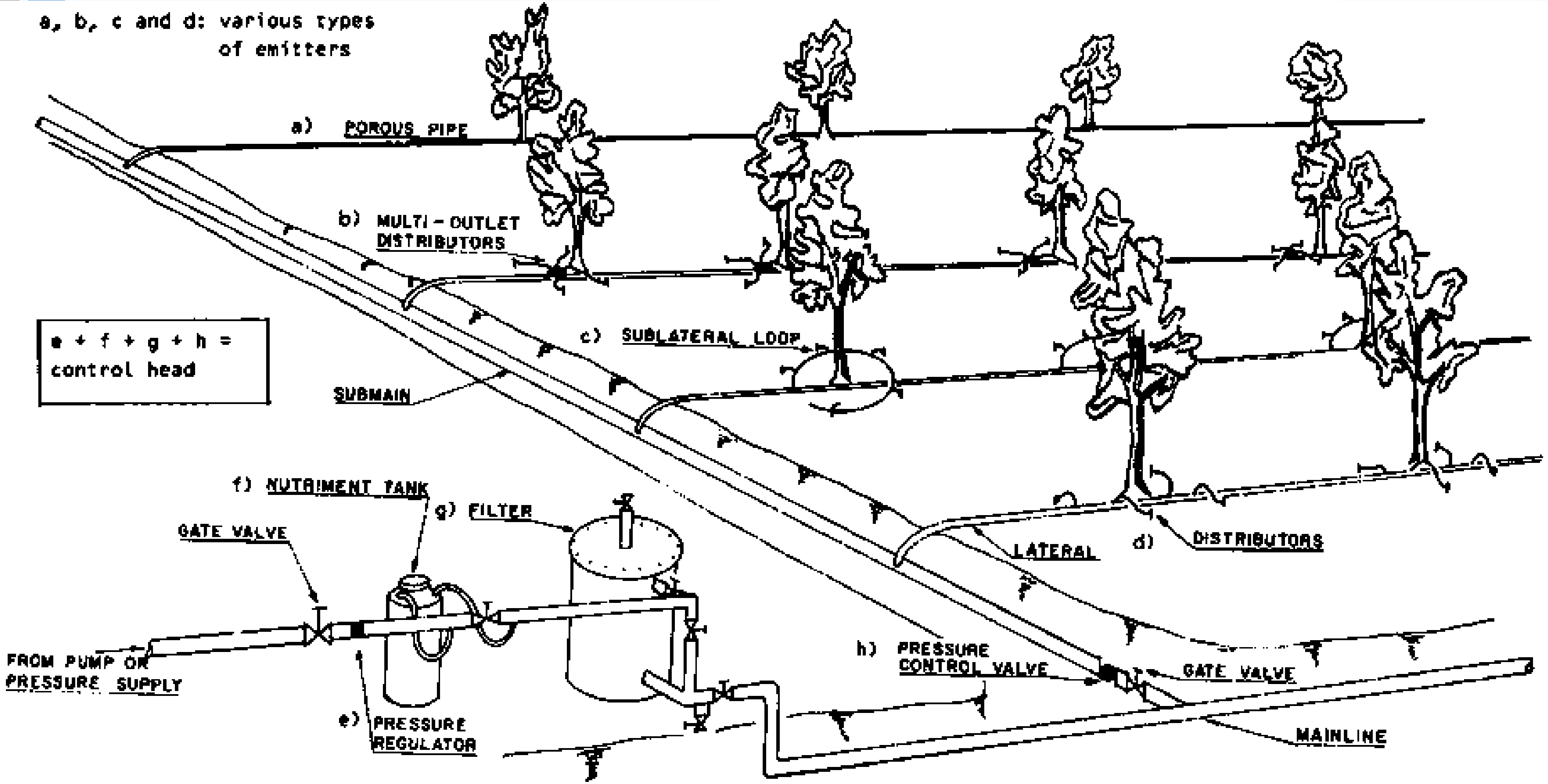
Size		13mm (1/2")		19mm (3/4")		25mm (1")		32mm (1 1/4")		38mm (1 1/2")		50mm (2")		63mm (2 1/2")		75mm (3")	
ID (cm)		1.326		2.093		2.664		3.505		4.089		5.250		6.271		7.793	
Flow GPM	Flow LPS	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m
1	0.06	0.32	1.05	0.18	0.26	0.11	0.09	0.06	0.02	0.05	0.00	0.03	0.00				
2	0.13	0.64	3.77	0.37	0.96	0.23	0.30	0.13	0.09	0.09	0.04	0.06	0.02				
3	0.19	0.96	7.99	0.55	2.04	0.34	0.62	0.20	0.17	0.14	0.09	0.09	0.02	0.06	0.00		
4	0.25	1.28	13.61	0.73	3.47	0.45	1.07	0.26	0.28	0.19	0.13	0.12	0.04	0.08	0.02		
5	0.32	1.61	20.57	0.92	5.23	0.56	1.63	0.32	0.43	0.24	0.19	0.14	0.06	0.10	0.02	0.06	0.00
6	0.38	1.93	28.85	1.10	7.35	0.68	2.27	0.39	0.60	0.29	0.28	0.17	0.09	0.12	0.04	0.08	0.02
7	0.44	2.25	38.38	1.28	9.77	0.79	3.02	0.46	0.79	0.33	0.39	0.20	0.11	0.14	0.04	0.09	0.02
8	0.50	[illegible]	[illegible]	1.47	12.52	0.90	3.86	0.52	1.01	0.38	0.47	0.23	0.15	0.16	0.06	0.10	0.02
	0.57	[illegible]	[illegible]	1.65	15.56	1.01	4.80	0.59	1.26	0.43	0.60	0.26	0.17	0.18	0.06	0.12	0.02
10	0.63	[illegible]	[illegible]	1.83	18.90	1.13	5.85	0.65	1.54	0.48	0.73	0.29	0.21	0.20	0.09	0.13	0.02
11	0.69	[illegible]	[illegible]	2.02	22.57	1.24	6.96	0.72	1.84	0.52	0.86	0.32	0.26	0.22	0.11	0.14	0.04
12	0.76	[illegible]	[illegible]	2.20	26.51	1.35	8.19	0.78	2.16	0.57	1.03	0.35	0.30	0.24	0.13	0.16	0.04
14	0.88	[illegible]	[illegible]	2.56	35.27	1.58	10.89	0.91	2.87	0.67	1.35	0.41	0.41	0.28	0.17	0.18	0.06
16	1.01	[illegible]	[illegible]	2.93	45.15	1.81	13.95	1.04	3.66	0.77	1.74	0.46	0.51	0.33	0.21	0.21	0.09
18	1.14	[illegible]	[illegible]	3.30	56.17	2.03	17.36	1.17	4.56	0.86	2.16	0.52	0.64	0.37	0.28	0.24	0.09
20	1.26			3.66	68.28	2.26	21.09	1.30	5.55	0.96	2.61	0.58	0.77	0.41	0.32	0.26	0.11
22	1.39			4.03	81.46	2.49	25.16	1.43	6.62	1.06	3.13	0.64	0.92	0.45	0.39	0.29	0.13
24	1.51			4.40	95.69	2.72	29.55	1.57	7.78	1.15	3.69	0.70	1.09	0.48	0.45	0.32	0.15
26	1.64			4.76	101.8	2.94	34.29	1.70	9.02	1.25	4.26	0.76	1.26	0.53	0.54	0.34	0.19
28	1.77			5.13	127.3	3.17	39.32	1.83	10.35	1.34	4.89	0.81	1.46	0.57	0.62	0.37	0.21
30	1.89			5.50	144.7	3.40	44.68	1.96	11.77	1.44	5.55	0.87	1.65	0.61	0.69	0.40	0.24
35	2.21					3.95	59.45	2.28	15.67	1.68	7.39	1.02	2.19	0.71	0.92	0.46	0.32
40	2.52					4.52	76.14	2.61	20.06	1.92	9.47	1.16	2.81	0.81	1.18	0.53	0.41
45	2.84					5.08	94.70	2.94	24.73	2.16	11.79	1.31	3.49	0.92	1.48	0.59	0.51
50	3.15					5.64	115.1	3.26	30.30	2.40	14.32	1.45	4.24	1.02	1.78	0.66	0.62

Polyethylene (PE) SDR-Pressure Rated Tube [(2306, 3206, 3306) SDR 7, 9, 11.5, 15 C=150]

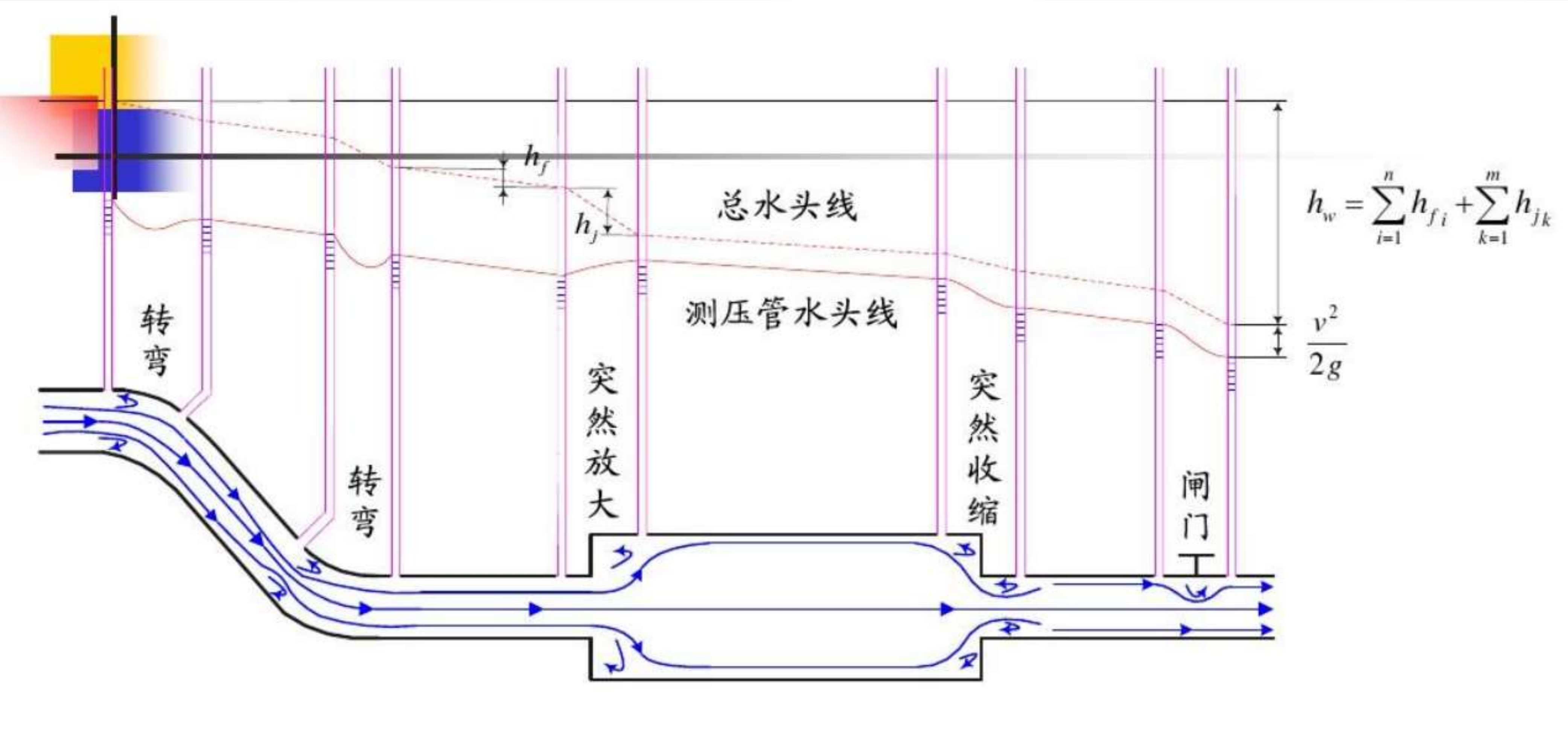

Air vent
Chemical injection
Pressure relief valve
Filters
Pressure control
Pump
Prefilter (optional)
Main line
Water meter
Backflow prevention
Pressure-reducing solenoid valve
Back wash
Flush valves
ZONE 1
Drip line
Sub main line

Basic hydraulics

- Drip irrigation system with a prefilter, pump station with backflow prevention, and chemical injection.
- A pressure control valve is recommended to adjust the water pressure as desired before it enters the drip lines.
- A water meter can be placed after the pressure control or between a solenoid valve and each zone.
- An air vent provides vacuum relief. Vacuum relief is necessary between the solenoid valve and the drip tapes to avoid suction of soil into the emitters when the system is shut off


a, b, c and d: various types of emitters
a) POROUS PIPE
b) MULTI - OUTLET DISTRIBUTORS
e + f + g + h = control head
c) SUBLATERAL LOOP
SUBMAIN
f) NUTRIMENT TANK
g) FILTER
GATE VALVE
LATERAL
d) DISTRIBUTORS
FROM PUMP OR PRESSURE SUPPLY
h) PRESSURE CONTROL VALVE
GATE VALVE
e) PRESSURE REGULATOR
MAINLINE

Head Loss in Piping System



Experimental method of measuring coefficients of losses:

1: Measure the total pressure drop with singular element.
A length of pipe is added to take into account
the perturbations around the element
(2times the diameter upstream and 10 times the diameter downstream)

2: Measuring the regular (major) head loss of
the length of pipe added (equal to 12 times the diameter)

3: Calculation of singular (minor) head loss coefficient :
Singular (minor) head loss = total loss - regular(major) head loss = Example: = 0.0002bars 0.003bars-bar = 0.0028 0.0028 = 280 000 p
Section m^2 = (Diameter m / 2) ^{2} x 3.1416 = Ex (0.1 / 2) ^{2}x 3.14 = 0.0025x3.14 = 0.00785m^2
Qvm3_sec = flow m3_h/3600 = Ex: 10 m3h / 3600 = 0.002777 m3_sec
fluid velocity m_sec =Qv (volumetric flow m3_sec) / Section_m ^{2} = Ex: 0.002777/0.00785 = 0.35 m / sec
Dynamic pressure (Pa) = 0.5 x density x kgm3 (fluid speedm_sec) ^{2} = Ex: with water = 0.5 x 1000 x 0.35 ^{2} = 61.25 pascals

Coefficient of singular pressure loss = Loss singular (pascals) / dynamic pressure (Pa) = Ex: 61.25/ 280 = 0.218

Dynamic water pressure

- Dynamic water pressure or "working pressure" differs from static pressure because it varies throughout the system due to friction losses, as well as elevation gains or losses.

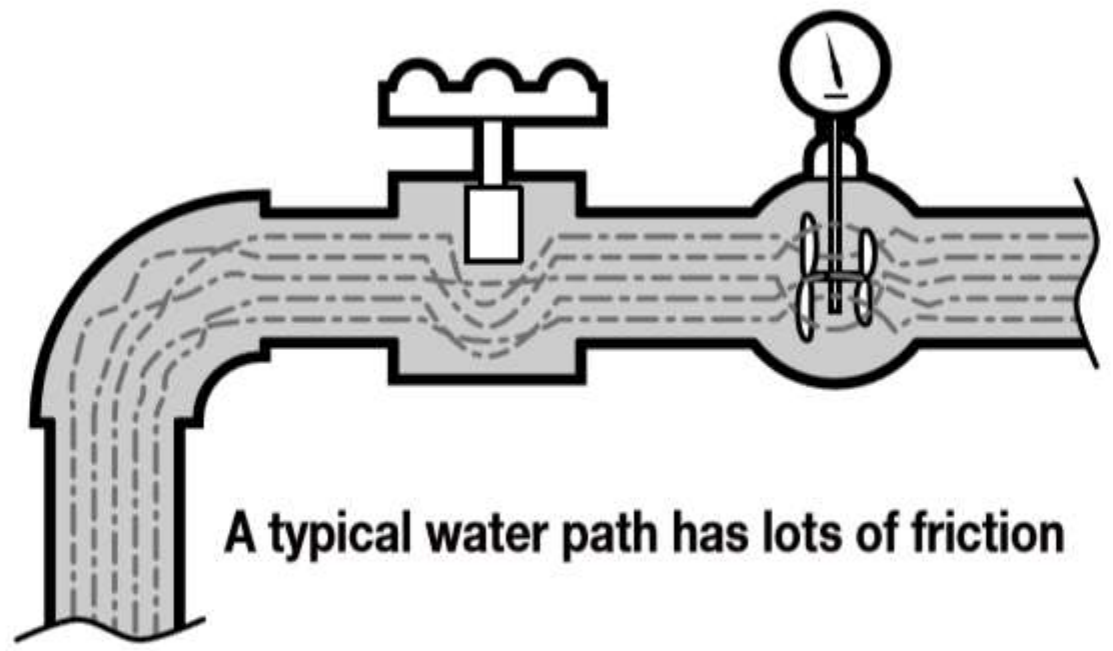
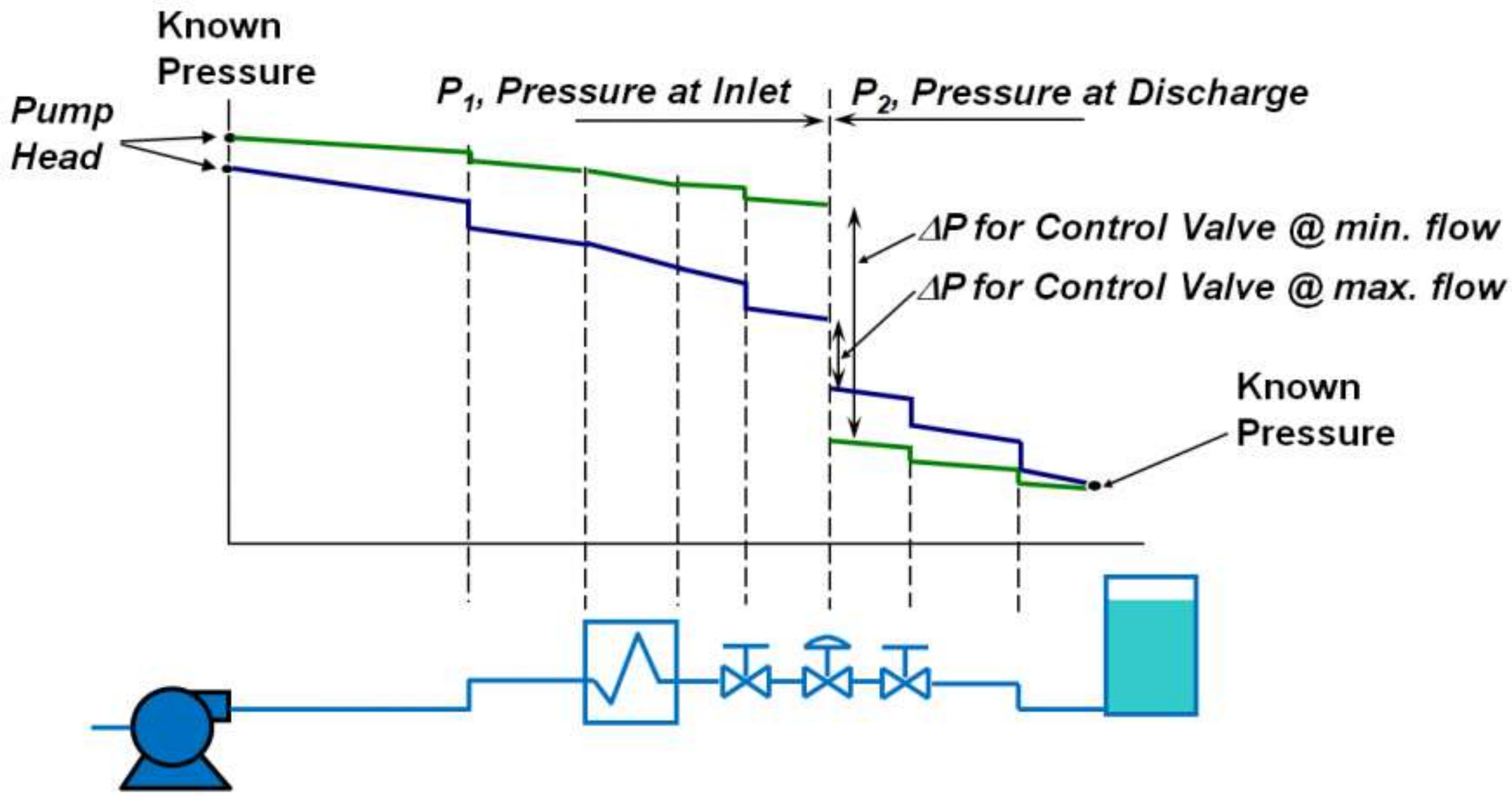


Figure 5: Water path with friction

Water Head Loss Models

- Darcy-Weisbach
- Hazen-Williams
- Chezy-Mannings

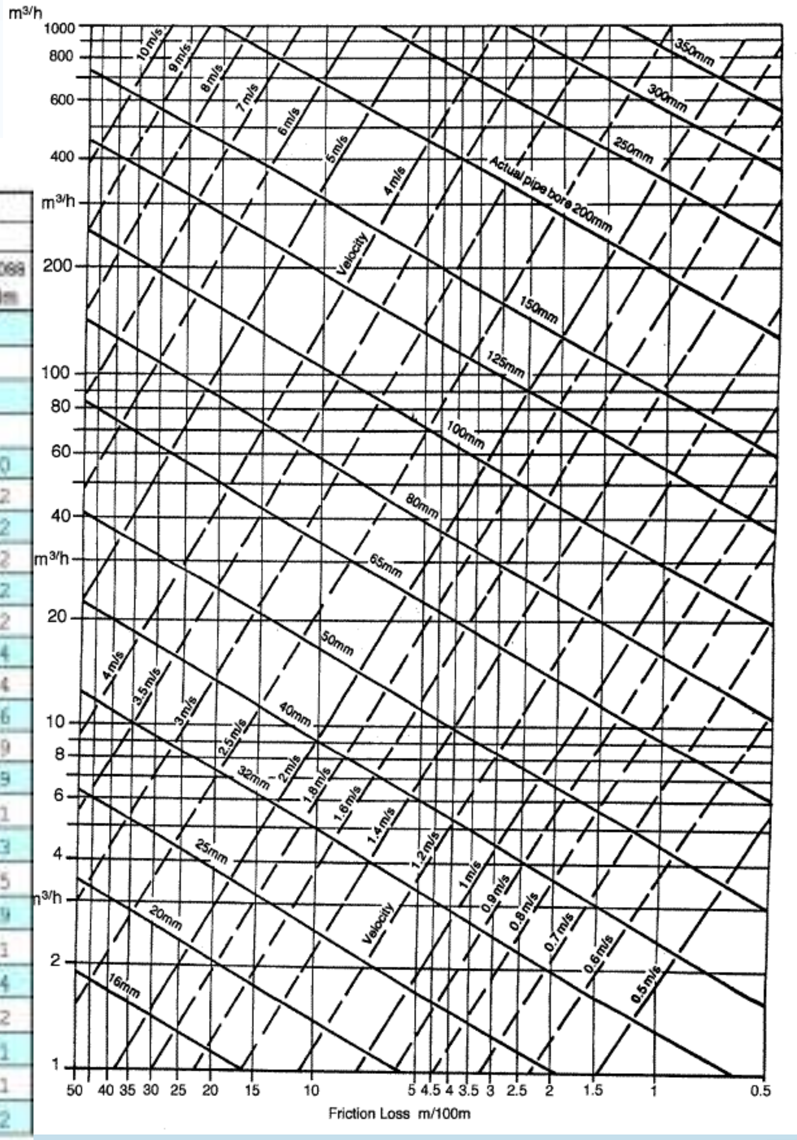


Major Loss

6. Frictional Head Loss Chart

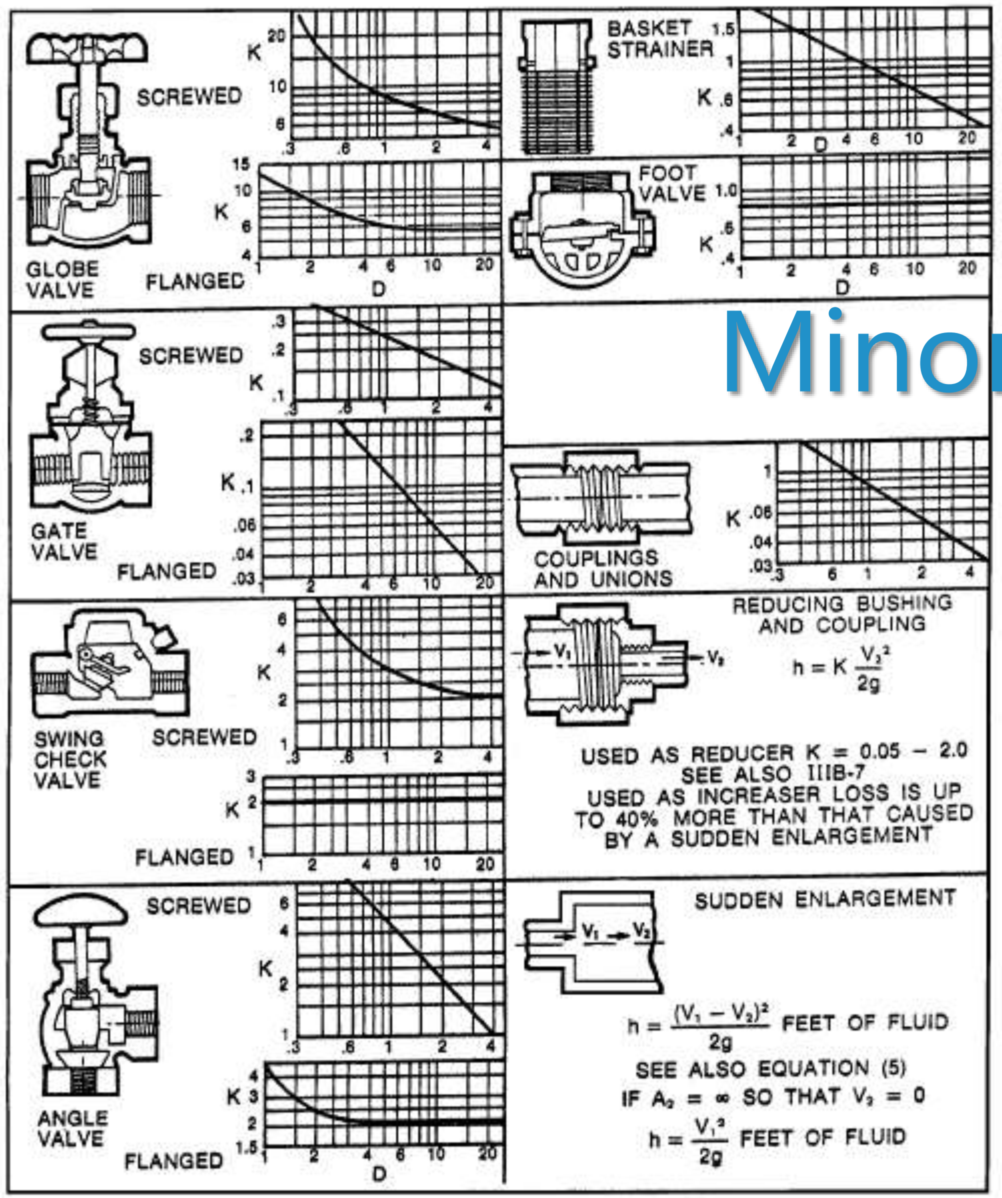
Size		13mm (1/2")		19mm (3/4")		25mm (1")		32mm (1 1/4")		38mm (1 1/2")		50mm (2")		63mm (2 1/2")		75mm (3")	
ID (cm)		1.326		2.093		2.664		3.505		4.089		5.250		6.271		7.793	
Flow GPM	**Flow LPS**	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m	Velocity m/s	Head loss m/100m
1	**0.06**	0.32	1.05	0.18	0.26	0.11	0.09	0.06	0.02	0.05	0.00	0.03	0.00				
2	**0.13**	0.64	3.77	0.37	0.96	0.23	0.30	0.13	0.09	0.09	0.04	0.06	0.02				
3	**0.19**	0.96	7.99	0.55	2.04	0.34	0.62	0.20	0.17	0.14	0.09	0.09	0.02	0.06	0.00		
4	**0.25**	1.28	13.61	0.73	3.47	0.45	1.07	0.26	0.28	0.19	0.13	0.12	0.04	0.08	0.02		
5	**0.32**	1.61	20.57	0.92	5.23	0.56	1.63	0.32	0.43	0.24	0.19	0.14	0.06	0.10	0.02	0.06	0.00
6	**0.38**	1.93	28.85	1.10	7.35	0.68	2.27	0.39	0.60	0.29	0.28	0.17	0.09	0.12	0.04	0.08	0.02
7	**0.44**	2.25	38.38	1.28	9.77	0.79	3.02	0.46	0.79	0.33	0.39	0.20	0.11	0.14	0.04	0.09	0.02
8	**0.50**	2.57	49.14	1.47	12.52	0.90	3.86	0.52	1.01	0.38	0.47	0.23	0.15	0.16	0.06	0.10	0.02
	0.57	2.89	61.23	1.65	15.56	1.01	4.80	0.59	1.26	0.43	0.60	0.26	0.17	0.18	0.06	0.12	0.02
10	**0.63**	3.21	74.30	1.83	18.90	1.13	5.85	0.65	1.54	0.48	0.73	0.29	0.21	0.20	0.09	0.13	0.02
11	**0.69**	3.54	88.64	2.02	22.57	1.24	6.96	0.72	1.84	0.52	0.86	0.32	0.26	0.22	0.11	0.14	0.04
12	**0.76**	3.86	104.2	2.20	26.51	1.35	8.19	0.78	2.16	0.57	1.03	0.35	0.30	0.24	0.13	0.16	0.04
14	**0.88**	4.50	138.5	2.56	35.27	1.58	10.89	0.91	2.87	0.67	1.35	0.41	0.41	0.28	0.17	0.18	0.06
16	**1.01**	5.14	177.4	2.93	45.15	1.81	13.95	1.04	3.66	0.77	1.74	0.46	0.51	0.33	0.21	0.21	0.09
18	**1.14**	5.79	220.7	3.30	56.17	2.03	17.36	1.17	4.56	0.86	2.16	0.52	0.64	0.37	0.28	0.24	0.89
20	**1.26**			3.66	68.28	2.26	21.09	1.30	5.55	0.96	2.61	0.58	0.77	0.41	0.32	0.26	0.11
22	**1.39**			4.03	81.46	2.49	25.16	1.43	6.62	1.06	3.13	0.64	0.92	0.45	0.39	0.29	0.13
24	**1.51**			4.40	95.69	2.72	29.55	1.57	7.78	1.15	3.69	0.70	1.09	0.48	0.45	0.32	0.15
26	**1.64**			4.76	101.8	2.94	34.29	1.70	9.02	1.25	4.26	0.76	1.26	0.53	0.54	0.34	0.19
28	**1.77**			5.13	127.3	3.17	39.32	1.83	10.35	1.34	4.89	0.81	1.46	0.57	0.62	0.37	0.21
30	**1.89**			5.50	144.7	3.40	44.68	1.96	11.77	1.44	5.55	0.87	1.65	0.61	0.69	0.40	0.24
35	**2.21**					3.95	59.45	2.28	15.67	1.68	7.39	1.02	2.19	0.71	0.92	0.46	0.32
40	**2.52**					4.52	76.14	2.61	20.06	1.92	9.47	1.16	2.81	0.81	1.18	0.53	0.41
45	**2.84**					5.08	94.70	2.94	24.73	2.16	11.79	1.31	3.49	0.92	1.48	0.59	0.51
50	**3.15**					5.64	115.1	3.26	30.30	2.40	14.32	1.45	4.24	1.02	1.78	0.66	0.62

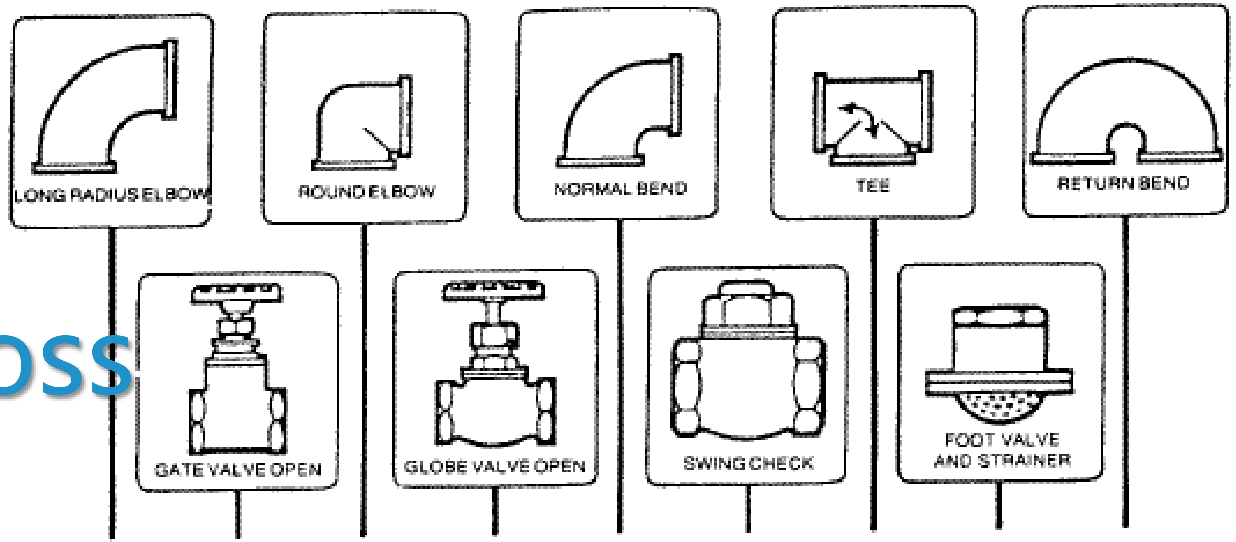
Polyethylene (PE) SDR-Pressure Rated Tube [(**2306, 3206, 3306) SDR 7, 9, 11.5, 15 C=150**]



Minor Loss

RESISTANCE COEFFICIENTS FOR VALVES AND FITTINGS





Pipe size mm	Equivalent length of straight pipe in metres, for calculating friction loss								
20	0.3	0.3	0.6	6.7	0.5	1.5	1.5	1.5	1.5
25	0.3	0.3	0.8	8.2	0.5	2.0	1.8	2.3	2.0
32	0.3	0.6	0.9	11.3	0.8	2.6	2.4	2.7	2.6
40	0.4	0.6	1.1	13.4	0.9	3.1	2.7	3.4	3.1
50	0.5	0.8	1.4	17.4	1.1	4.0	3.4	4.6	4.0
65	0.6	0.9	1.7	20.1	1.4	5.2	4.3	5.5	4.6
80	0.8	1.1	2.1	26.0	1.5	6.1	5.2	6.7	5.5
100	1.1	1.5	2.7	34.0	2.1	8.2	6.7	8.8	7.3
125	1.2	1.8	3.7	43.0	2.7	10.0	8.2	11.0	9.5
150	1.5	2.1	4.3	49.0	3.4	12.2	10.0	14.0	11.0
200	2.1	3.1	5.5	67.0	4.3	16.5	13.4	18.0	15.0
250	2.4	3.7	7.3	85.4	5.5	20.0	16.5	22.0	19.0
300	3.1	4.3	8.5	98.0	6.7	24.4	20.0	27.4	23.0

Darcy-Weisbach

Darcy Weisbach Friction Coefficient Equation

$h_f = f\,(L/d)VP$

Where

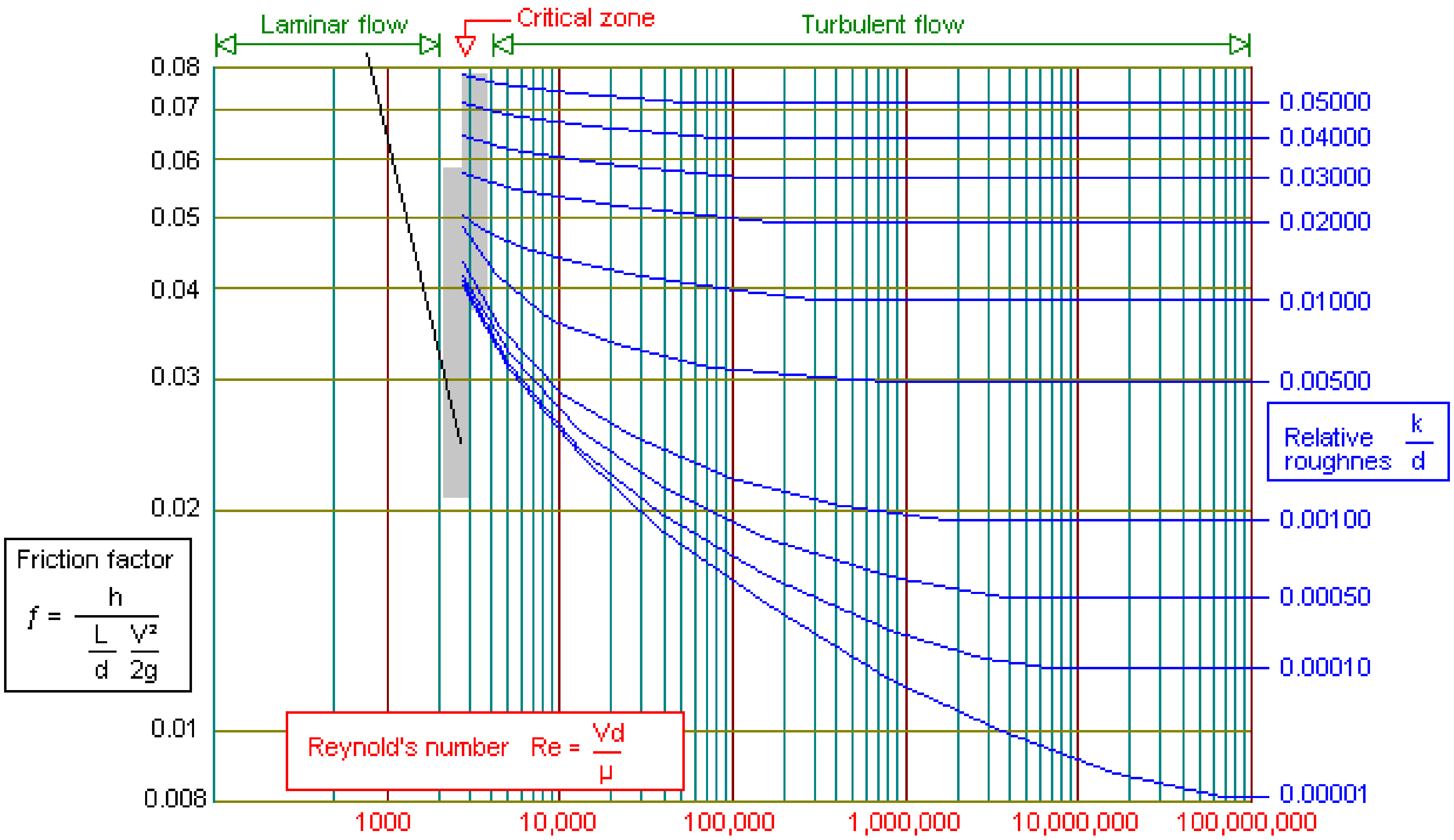
h_f = friction losses in a duct, "wg

f = friction coefficient (dimensionless)

L = duct length, ft

d = duct diameter, ft

VP = velocity pressure, "wg



Hazen-Williams

Hazen-Williams Loss Equation

Empirical frictional head loss calculation

$$H_L\ [m] = \frac{10.472}{C^{1.852}} \cdot \frac{Q^{1.852}}{d^{4.871}} \times L$$

Q = flow rate [$m^3 s^{-1}$]

L = length of pipe [m]

d = diameter of pipe [m]

C = roughness coefficient (PVC = 150, steel = 100)

Hazen-Williams Factors

Pipe material / D (mm)	75	150	300	600	1200
Uncoated cast iron	121	125	130	132	134
Coated cast iron	129	133	138	140	141
Uncoated steel	142	145	147	150	150
Coated steel	137	142	145	148	148
Galvanised iron	129	133	-	-	-
Uncoated asbestos cement	142	145	147	150	-
Coated asbestos cement	147	149	150	152	-
Concrete, min. values	69	79	84	90	95
Concrete, max. values	129	133	138	140	141
Prestressed concrete	-	-	147	150	150
PVC, brass, cooper, lead	147	149	150	152	153
Wavy PVC	142	145	147	150	150
Bitumen/cement lined	147	149	150	152	153

Source: Bhave, 1991

HW Online Calculation

http://m.guangaidashi.com/col.jsp?id=114&_sc

Chezy-Mannings

TABLE 3.3 Manning's Roughness Coefficient, *n*, for Pipe Flows

Type of Pipe	*Manning's n* Min.	Max.
Glass, brass, or copper	0.009	0.013
Smooth cement surface	0.010	0.013
Wood-stave	0.010	0.013
Vitrified sewer pipe	0.010	0.017
Cast-iron	0.011	0.015
Concrete, precast	0.011	0.015
Cement mortar surfaces	0.011	0.015
Common-clay drainage tile	0.011	0.017
Wrought iron	0.012	0.017
Brick with cement mortar	0.012	0.017
Riveted-steel	0.017	0.020
Cement rubble surfaces	0.017	0.030
Corrugated metal storm drain	0.020	0.024

图 1 人工粗糙壁管道阻力系数的尼库拉德塞图

- **Manning**

$$V = \frac{1}{n} R_h^{2/3} S^{1/2}$$

$$R_h \rightarrow \text{hydraulic Radius} = \frac{\text{wetted A}}{\text{wetted P}} = \frac{D}{4}$$

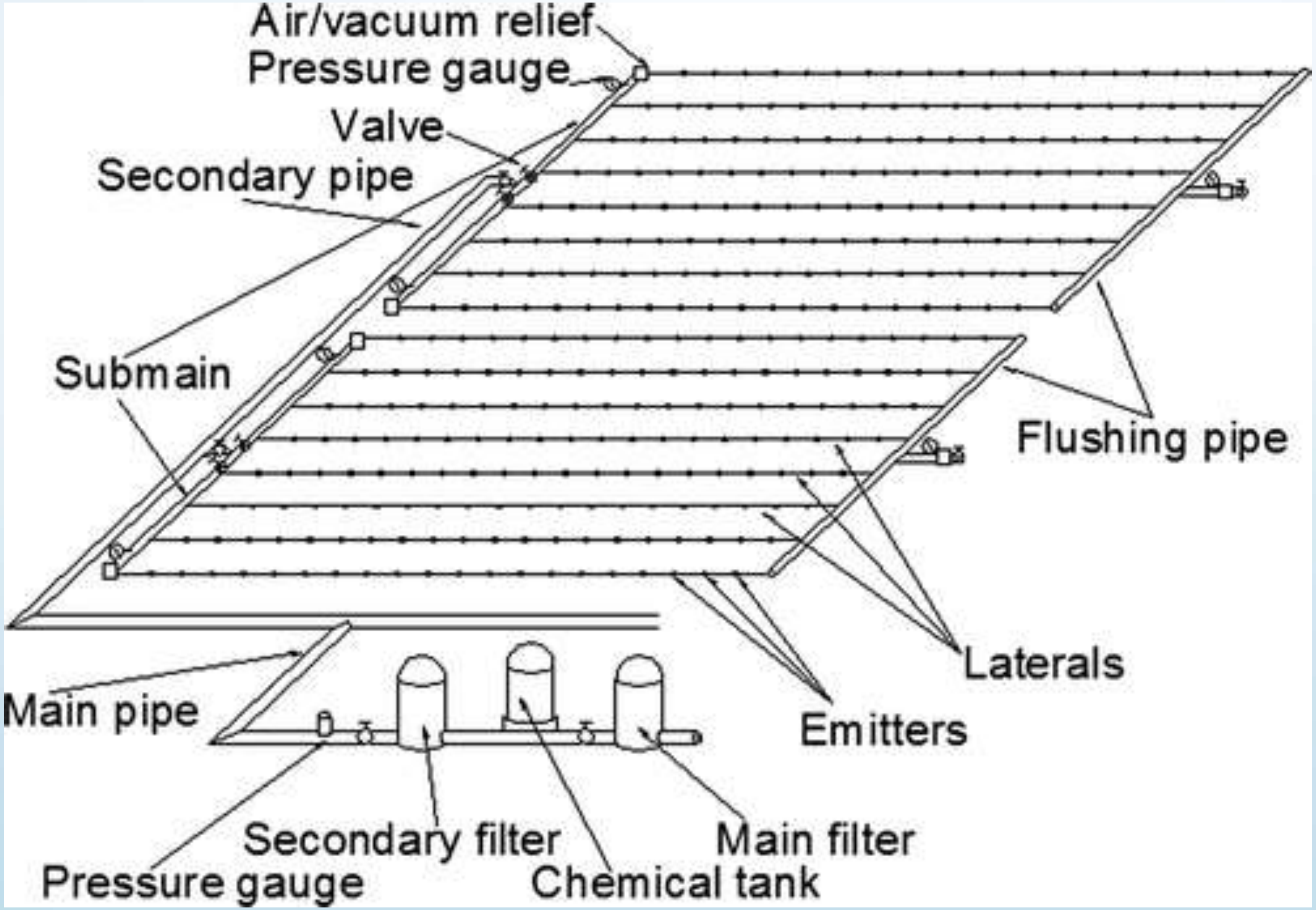
$$S = \frac{h_f}{L}$$

$$n \rightarrow \textit{Manning}\ \text{Coefficient}$$

Simplified

$$h_f = \frac{10.3\, L\, (nQ)^2}{D^{5.33}}$$ SI Units

Irrigation System Layout



Water Flow in Pipe

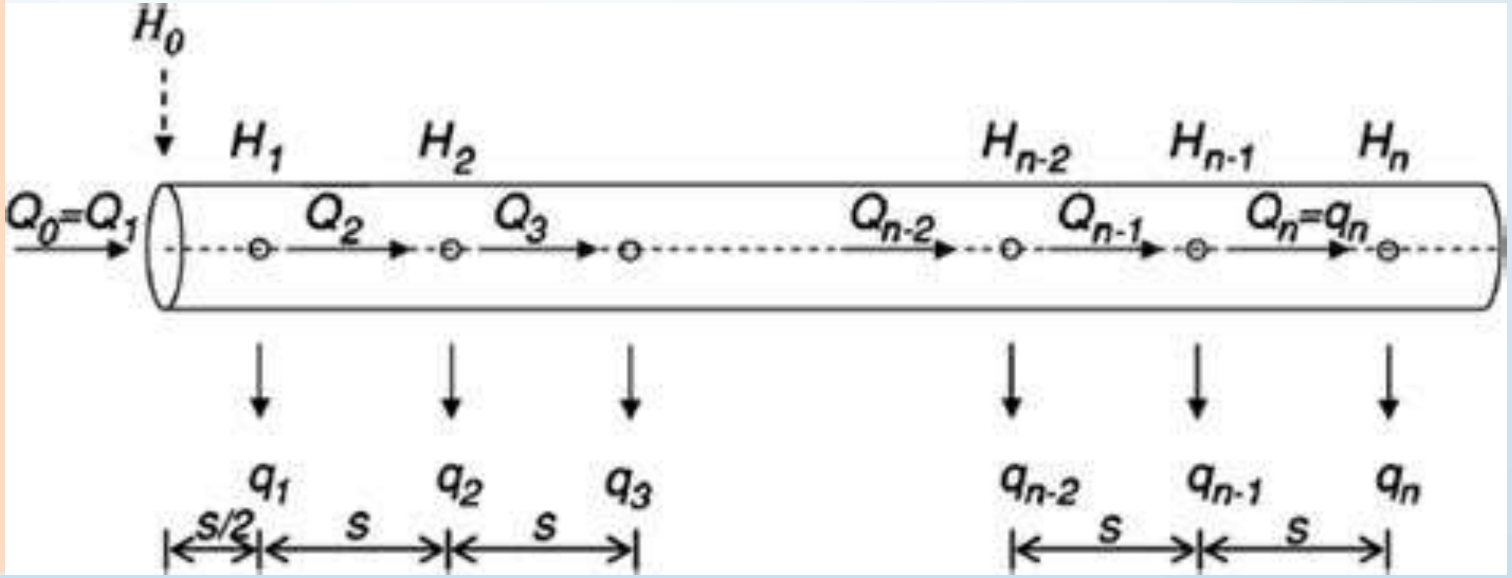
THERE ARE TWO EQUATIONS AVAILABLE FOR FRICTIONAL LOSS CALCULATIONS.

- ✓ Darcy-weisbach
- ✓ Hazen-williams equation

FRICTION LOSS

Friction loss in plain pipes

$$\Delta H = \frac{(1.22x10^{10}Q^{1.852}XL)}{C^{1.852}XD^{4.87}}$$



Later Pipe Head Loss

Head loss in drip lateral pipe

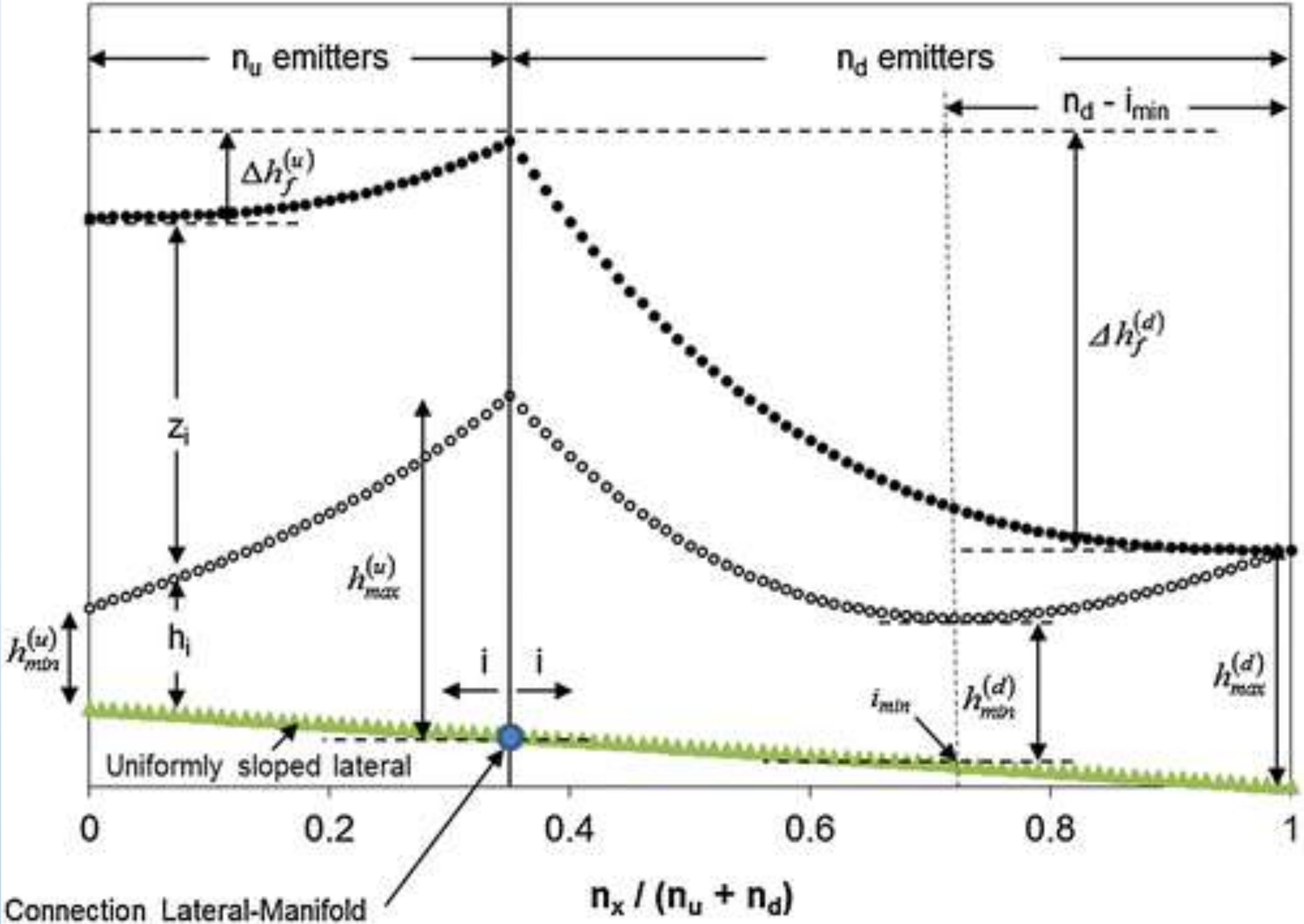
- A modified Hazen-Williams head loss equation:

$$H_L = 2.78 \otimes 10^{-6} \otimes F \otimes \frac{L}{D^{4.87}} \otimes \left(\frac{N \otimes q}{C}\right)^{1.85}$$

H_L = head loss along a lateral drip line
L = lateral length (m)
D = internal diameter (m)
N = number of emitters
q = average emitter flow rate (m^3/h)
C = Hazen-Williams coefficient (130 - 120 for polyethylene pipe with ID < 16 mm)
F = 0.37 for more than 20 emitters

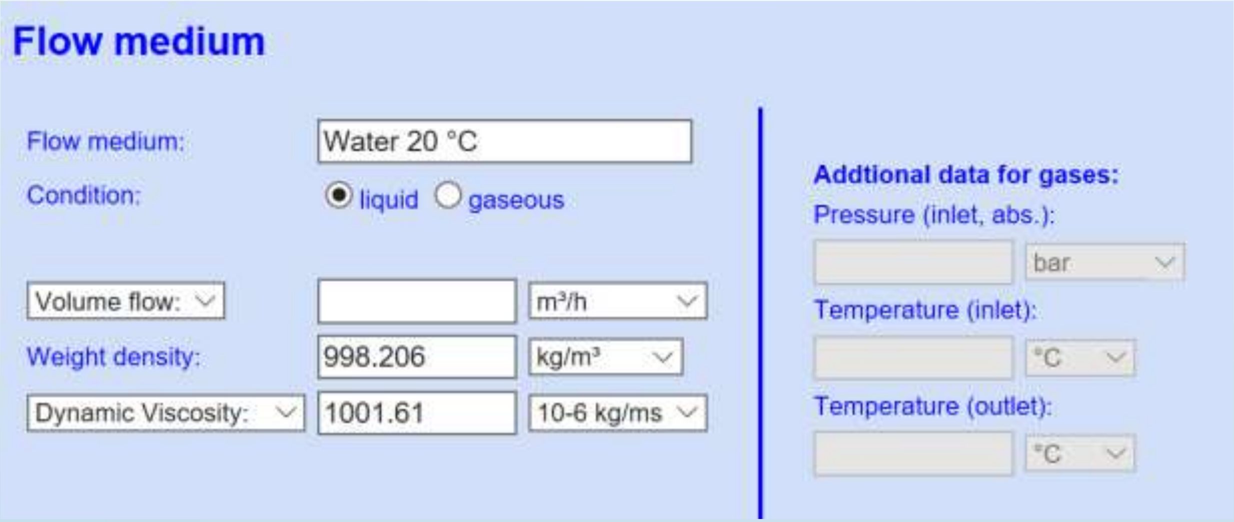
Hydra.lnk

Lateral Hydraulics



Online Hydraulics

- http://hawsedc.com/engcalcs/Manning-Pipe-Flow.php
- http://www.pressure-drop.com/Online-Calculator/



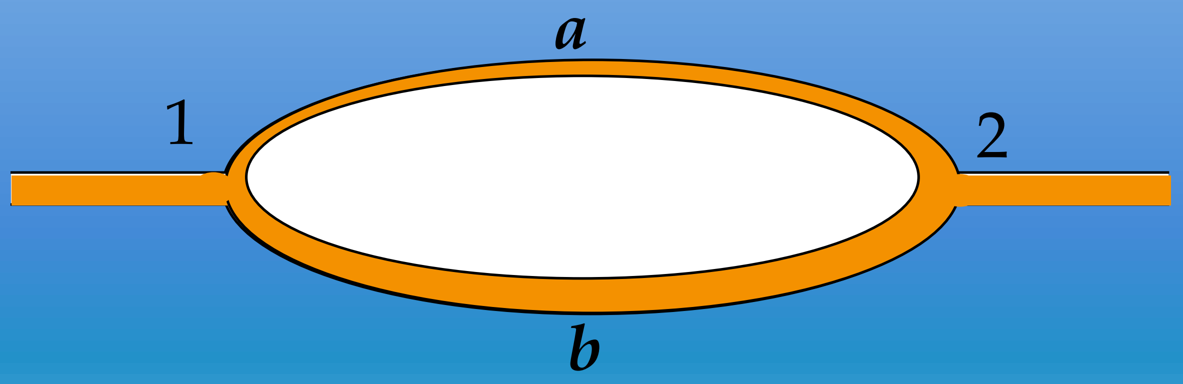
Pipeline systems
Pipe networks

- Water Distribution System Assumption

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\frac{p_2}{\gamma} - \frac{p_1}{\gamma} = \frac{V_{1_a}^2}{2g} + z_1 - \frac{V_{2_a}^2}{2g} - z_2 - h_{L_a}$$

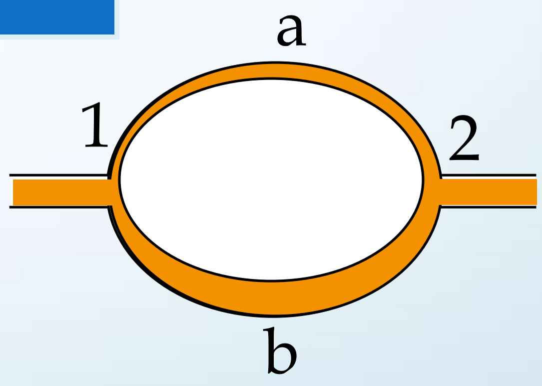
- Each point in the system can only have one pressure
- The pressure change from 1 to 2 by path ***a*** must equal the pressure change from 1 to 2 by path ***b***



Water Distribution System Assumption

$$\cancel{\frac{V_{1_a}^2}{2g}} + \cancel{z_1} - \cancel{\frac{V_{2_a}^2}{2g}} - \cancel{z_2} - h_{L_a} = \cancel{\frac{V_{1_b}^2}{2g}} + \cancel{z_1} - \cancel{\frac{V_{2_b}^2}{2g}} - \cancel{z_2} - h_{L_b}$$

Pressure change by path a



Or sum of head loss around loop is zero.

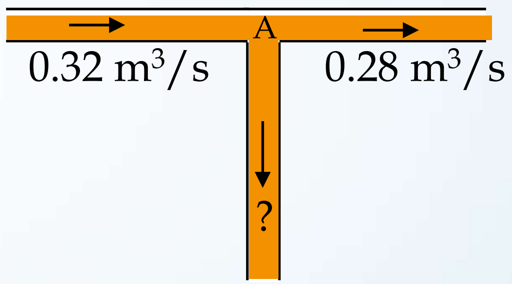
$$h_{L_a} = h_{L_b}$$

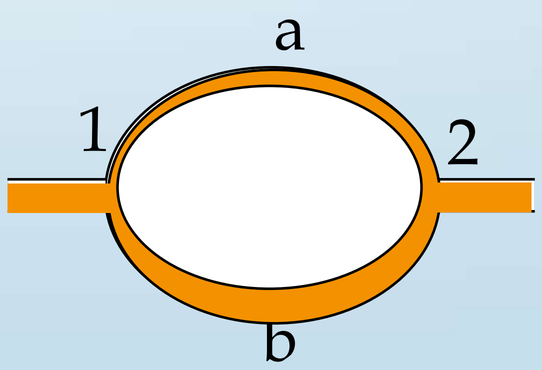
(Need a sign convention)

- Pipe diameters are constant
- Model withdrawals as occurring at nodes so V is constant

Networks of Pipes

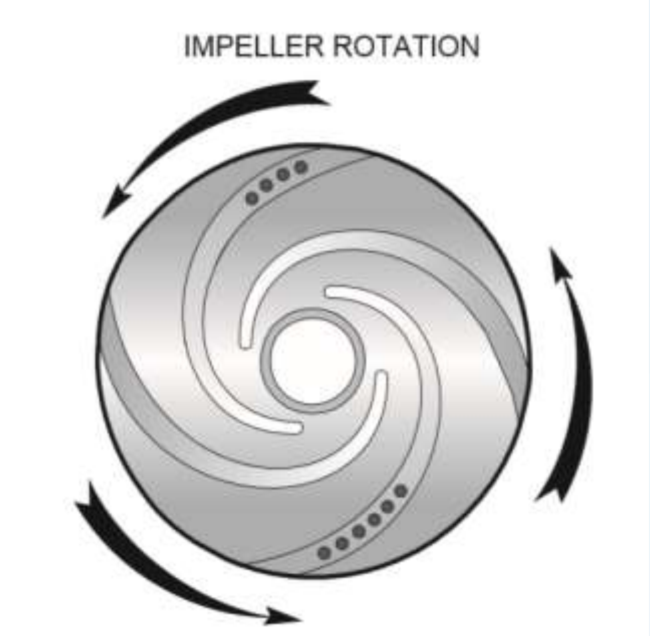
- Mass conservation at all nodes
- The relationship between head loss and discharge must be maintained for each pipe
  - Darcy-Weisbach equation
    - Swamee-Jain
  - Exponential friction formula
    - Hazen-Williams



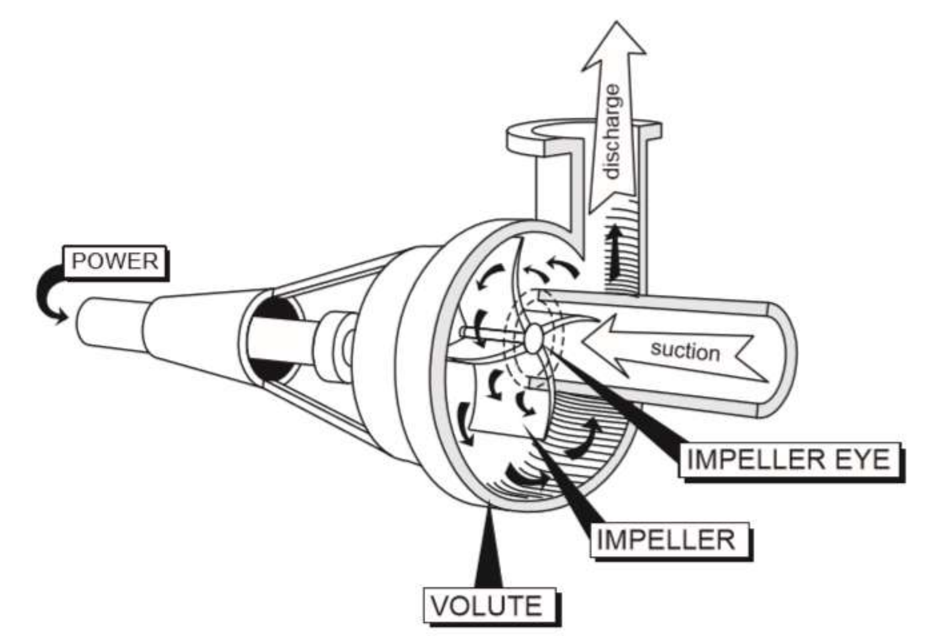


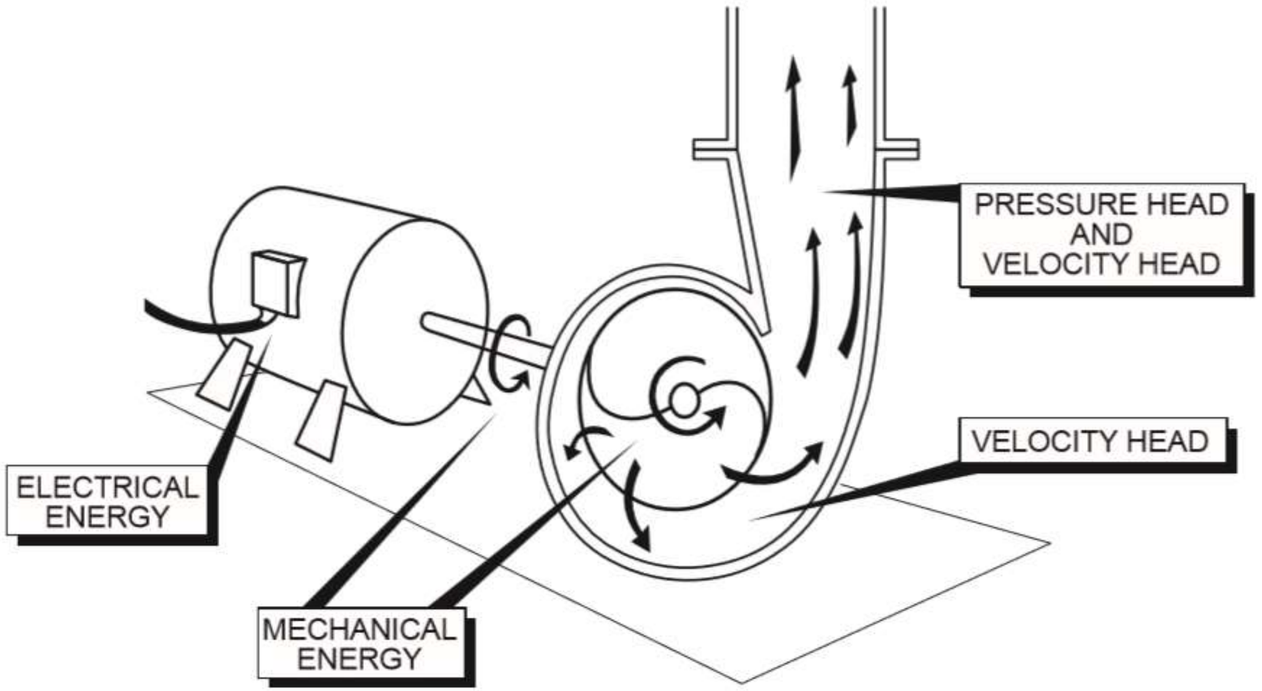
Water Resource

Pump Theory



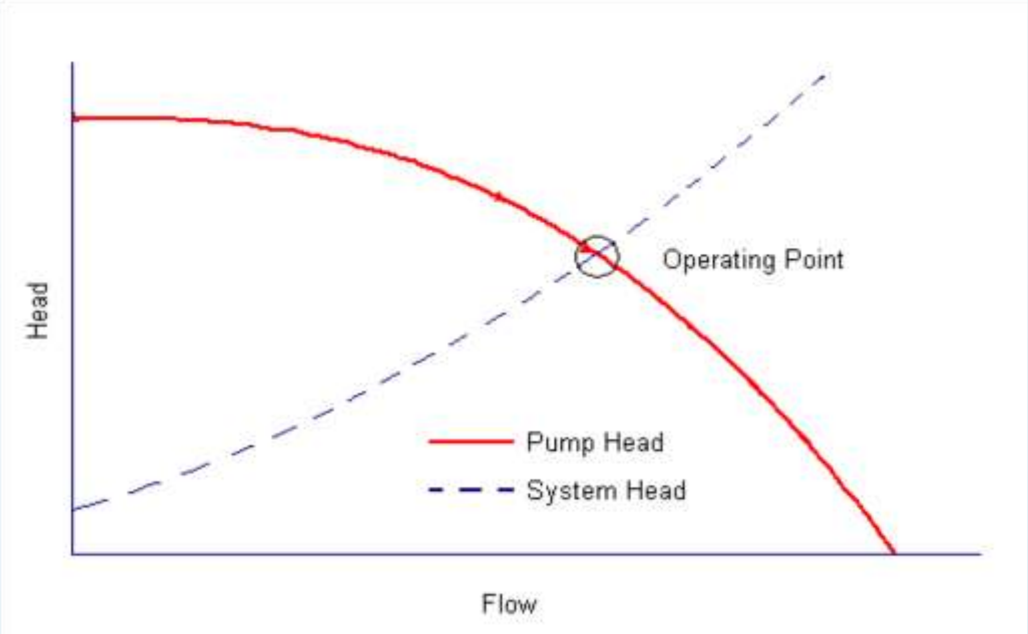
As the moving pump part (impeller, vane, piston diaphragm, etc.) begins to move, water is pushed out of the way. The movement of water creates a partial vacuum (low pressure) which can be filled up by more water.





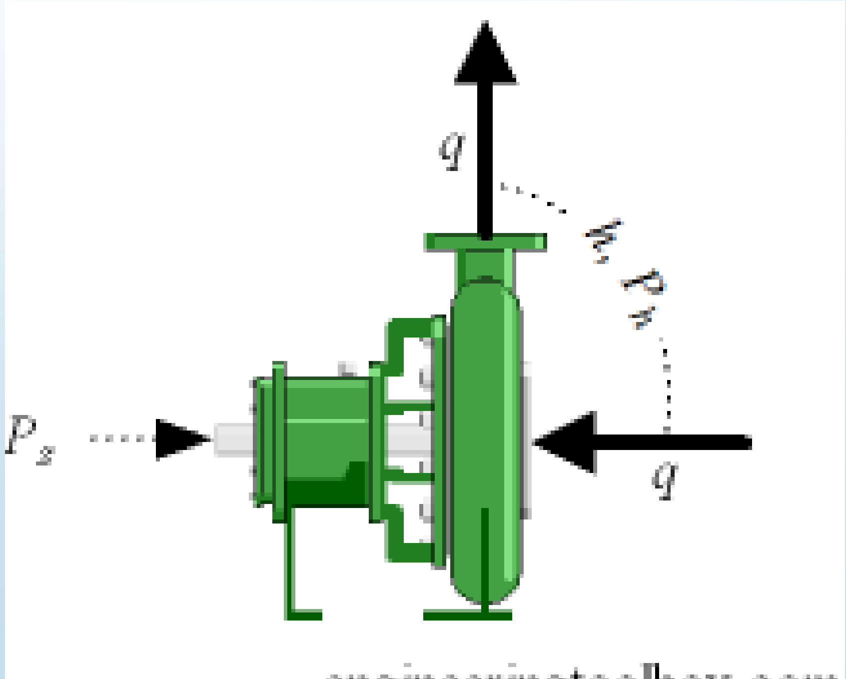
Pump Theory

- Pumps are an integral part of many pressure systems. Pumps add energy, or head gains, to the flow to counteract headlosses and hydraulic grade differences within the system.
- A pump is defined by its characteristic curve, which relates the pump head, or the head added to the system, to the flow rate. This curve is indicative of the ability of the pump to add head at different flow rates. To model behavior of the pump system, additional information is needed to ascertain the actual point at which the pump will be operating.
- The system operating point is based on the point at which the pump curve crosses the system curve representing the static lift and headlosses due to friction and minor losses. When these curves are superimposed, the operating point can easily be found. This is shown in the figure below.



Pump Power Calculator

- The ideal hydraulic power to drive a pump depends on
- the mass flow rate the
- liquid density
- the differential height



Either it is the static lift from one height to an other or the total head loss component of the system - and can be calculated like

$P_{h(kW)} = q\, \rho\, g\, h / (3.6\ 10^6)$ (1)

where

$P_{h(kW)}$ = *hydraulic power (kW)*

q = *flow capacity* (m^3/h)

ρ = *density of fluid* (kg/m^3)

g = *gravity* (9.81 m/s^2)

h = *differential head (m)*

The hydraulic Horse Power can be calculated as:

$P_{h(hp)} = P_{h(kW)} / 0.746$ (2)

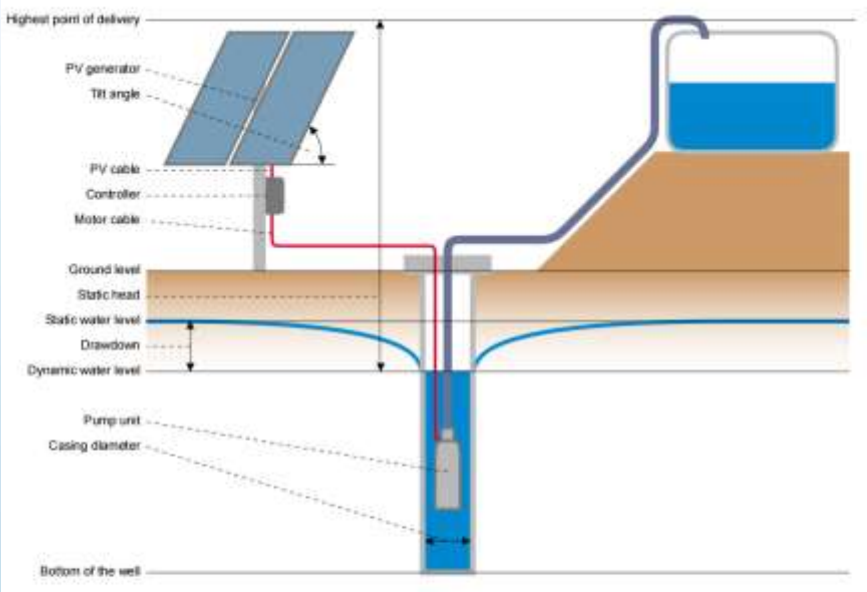
where

$P_{h(hp)}$ = *hydraulic horsepower (hp)*

Example - Power pumping Water

- *$1\ m^3/h$* of water is pumped a head of *$10\ m$*. The theoretical pump power can be calculated as
- $P_{h(kW)} = (1\ m^3/h)\ (1000\ kg/m^3)\ (9.81\ m/s^2)\ (10\ m)\ /\ (3.6\ 10^6)$
- $= \underline{0.027}\ kW$

Solar pump layout sketch



Shaft Pump Power

The shaft power - the power required transferred from the motor to the shaft of the pump - depends on the efficiency of the pump and can be calculated as

$$P_{s(kW)} = P_{h(kW)} / \eta \qquad (3)$$

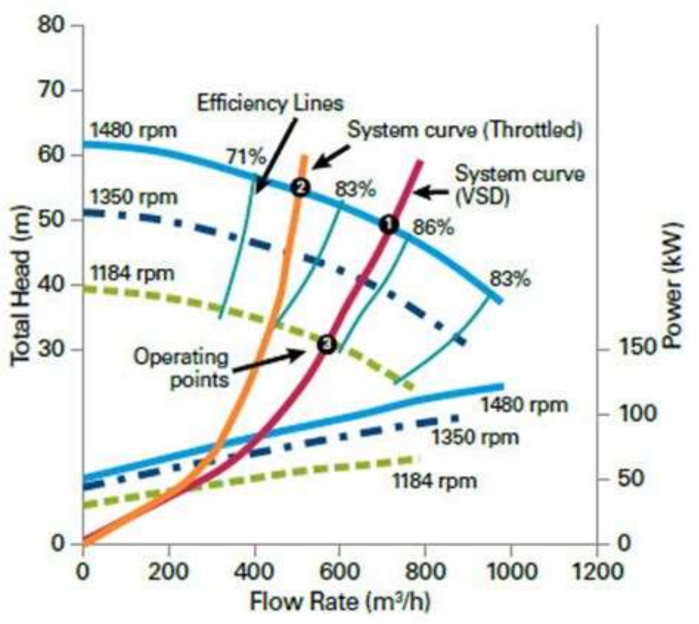
where

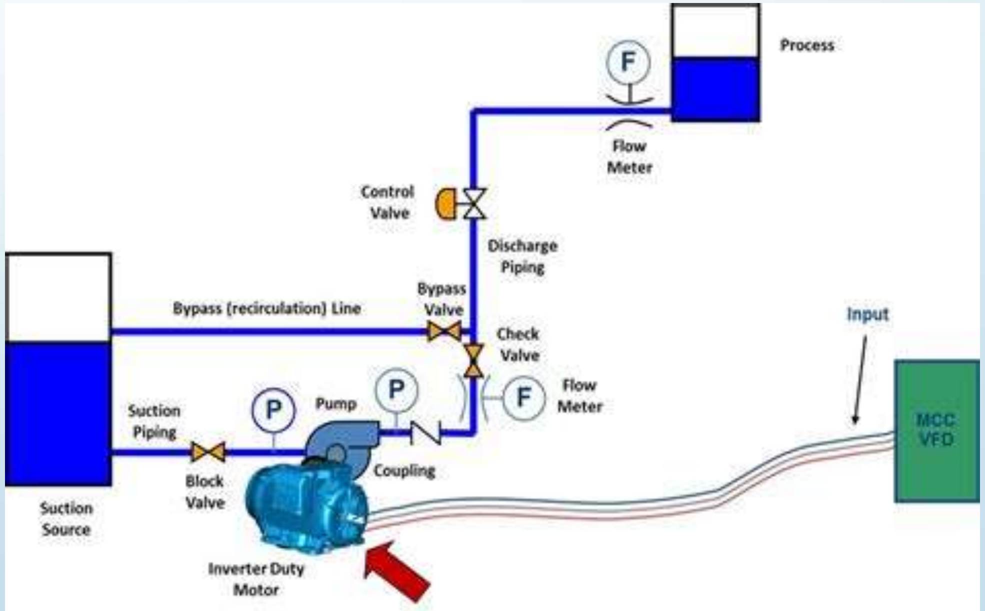
$P_{s(kW)}$ = *shaft power (kW)*

η = *pump efficiency*

Variable Speed Pumps

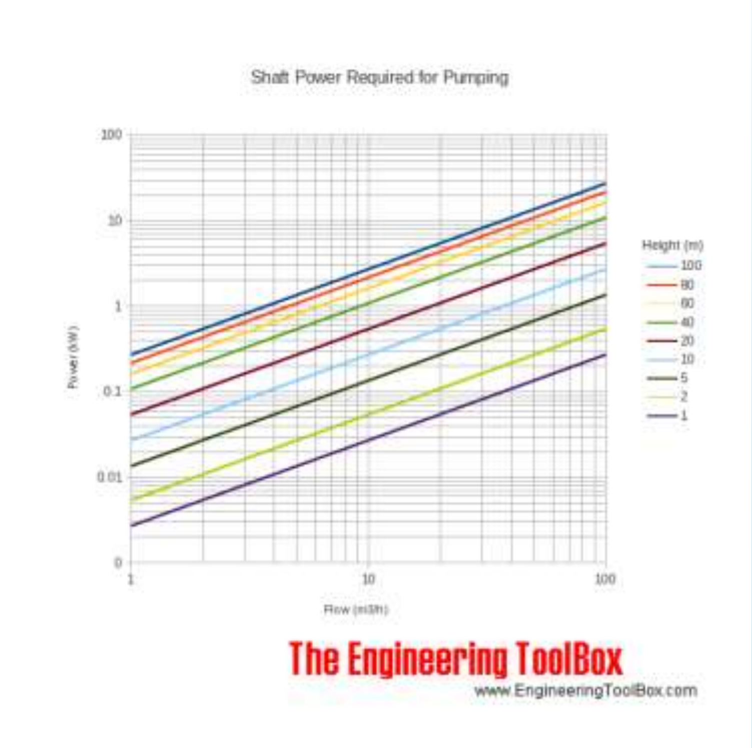
- A pump's characteristic curve is fixed for a given motor speed and impeller diameter, but can be determined for any speed and any diameter by applying the affinity laws.





Online Pump Calculator - SI-units

- Online Pump Calculator - SI-units
- https://www.engineeringtoolbox.com/pumps-power-d_505.html



Cost less Harvest more

Thank You!