

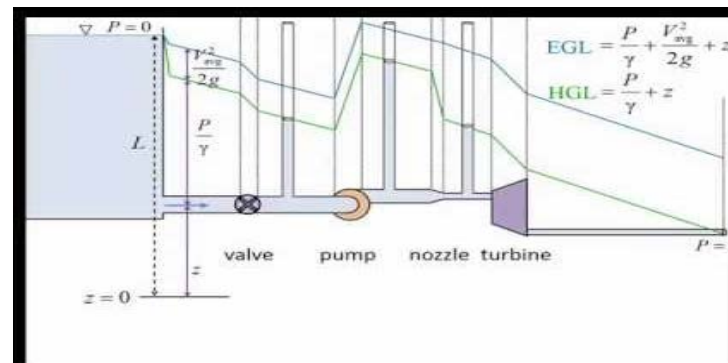


Sprinkler Irrigation - Pipeline Hydraulics

Sprinkler and Micro irrigation Systems

Pressure and Head Relationship

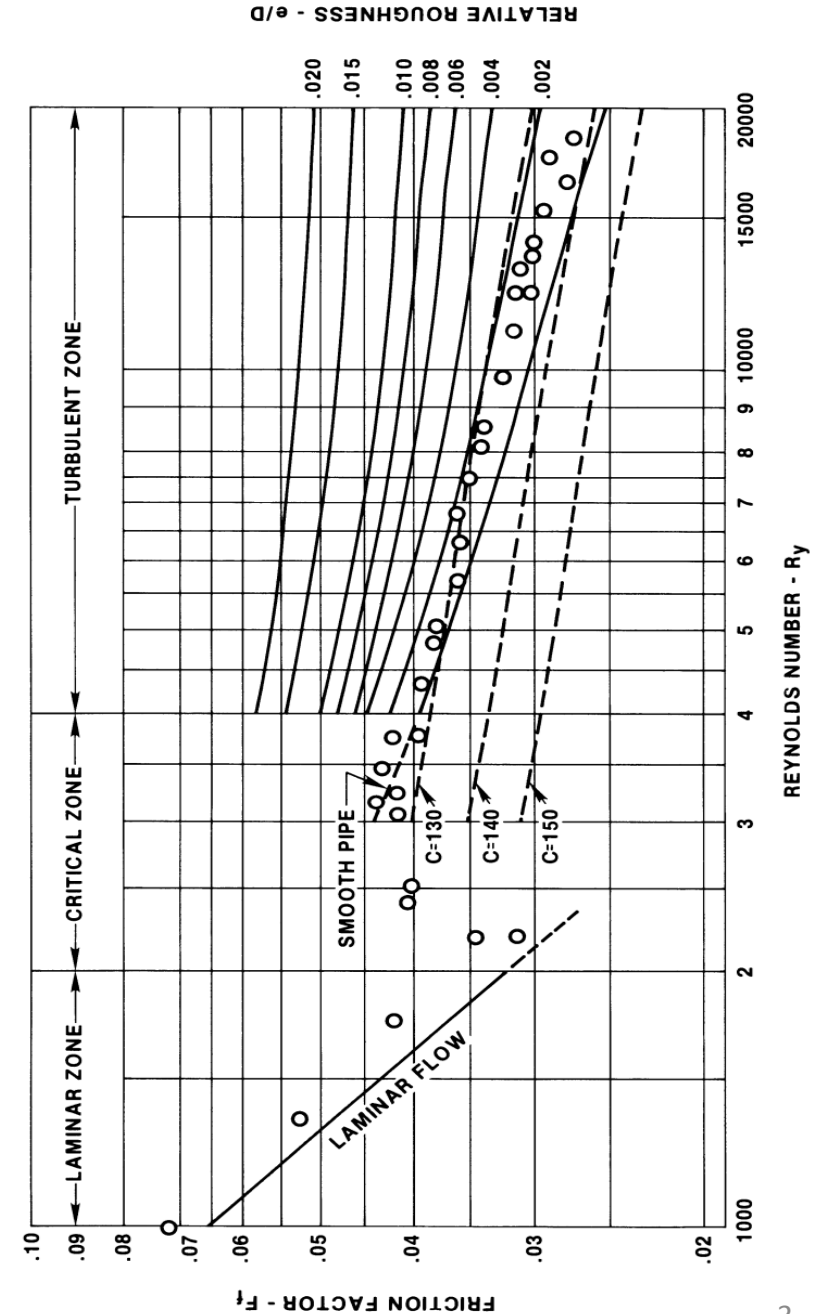
- In an Irrigation system, the head consists of following components
 - *Static head*: simply the difference in elevation between the highest discharge point in the system and that point
 - *Pressure head*: pressure at that point divided by unit weight of water.
 - *Velocity head*: head required to accelerate the water from rest to the velocity at that point.
 - *Friction head*: energy required for water to flow between two points at same elevation.
 - *Elevation above datum*: distance of a given point in the system above some arbitrary datum.



Calculation of Pipe Friction

Darcy-Weisbach equation

- $h_f = F_f \frac{L V^2}{D 2g}$
 - h_f = head loss due to pipe friction (m)
 - F_f = Darcy-Weisbach pipe friction factor
 - V = velocity of flow in the pipe (m/s)
 - g = acceleration due to gravity (m/s²)
 - D = inside pipe diameter (m)
- $F_f = \frac{64}{R_y}$ for $R_y < 2000$
- $F_f = 0.32R_y^{-0.25}$ for $2000 \leq R_y \leq 10,000$
 - R_y = Reynold's number



Friction Factors for 13-Millimeter (1/2-Inch) Plastic Irrigation Tubing (Small Circles) and Hazen-Williams (Dashed Curves) versus Darcy-Weisbach (Solid Curves) Friction Coefficients in the Low Reynolds Number Range.

Calculation of Pipe Friction

Watters and Keller (1978)

- $J = \frac{100h_f}{L} = K \frac{Q^{1.75}}{D^{4.75}}$ for use with smooth pipes less than 125 mm \emptyset
 - K = conversion constant (7.89×10^7 , for metric units)
- $J = \frac{100h_f}{L} = K \frac{Q^{1.83}}{D^{4.83}}$ for use with smooth pipes more than 125 mm \emptyset
 - K = conversion constant (9.58×10^7 , for metric units)

Friction losses for pipes with outlets

- More frictional loss in a closed pipeline of given length, than that with a pipe having equally spaced outlets.
- This is because the volume of flow decreases each time an outlet is passed

Calculation of Pipe Friction

Friction losses for pipes with outlets

- A method developed by Christiansen (1942), for computing head or pressure loss in multiple outlet pipeline.
- Involves computing the friction loss in the line without outlet and then multiplying a factor F .
- Thus head loss becomes: $h_f = J F \frac{L}{100}$

Reduction coefficient, F , for multiple-outlet pipelines

Number of outlets	F		Number of outlets	F	
	(end) ¹	(mid) ²		(end)	(mid)
1	1.00	1.00	8	0.42	0.38
2	0.64	0.52	9	0.41	0.37
3	0.54	0.44	10-11	0.40	0.37
4	0.49	0.41	12-15	0.39	0.37
5	0.46	0.40	16-20	0.38	0.36
6	0.44	0.39	21-30	0.37	0.36
7	0.43	0.38	≥ 31	0.36	0.36

¹Where the first outlet is a full space from the pipe inlet, i.e., at the end of the first pipe.

²When the first outlet is one-half space from the pipe inlet, i.e., at the middle of the first pipe.

Lateral Inlet Pressure

- The general equation for the lateral inlet pressure (pressure required at the mainline end) is:

- $P_l = P_a + \frac{3}{4}P_f + \frac{1}{2}\Delta P_e + P_r$

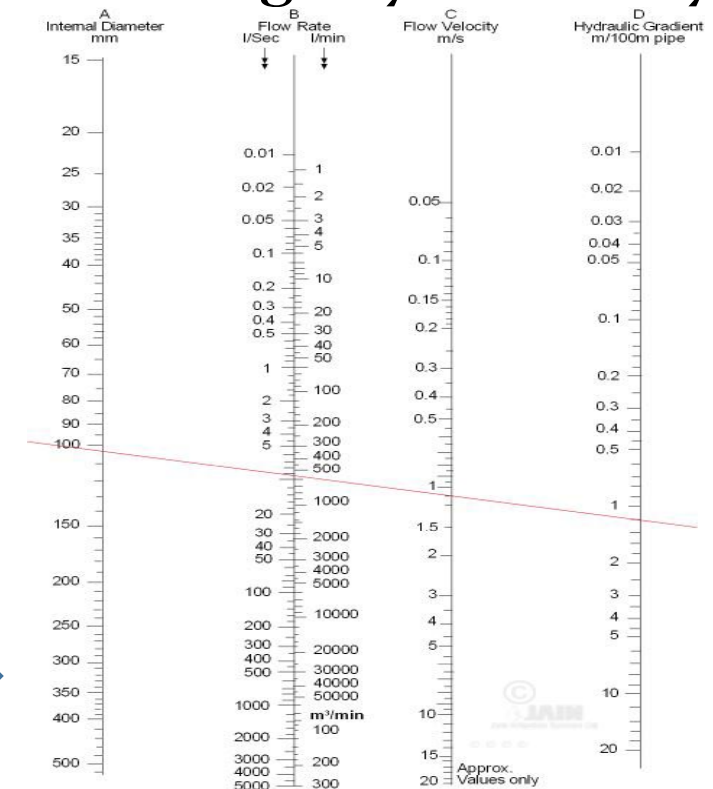
And

- $H_l = H_a + \frac{3}{4}h_f + \frac{1}{2}\Delta H_e + H_r$

- P_l = lateral inlet pressure (kPa)
- P_f = pressure loss due to pipe friction (kPa)
- P_r = pressure required to lift the water up the riser (9.8kPa/m)
- H_l = lateral inlet pressure head (m)
- H_a = average sprinkler operating pressure head (m)
- h_f = head loss due to pipe friction (m)
- ΔH_e = static pressure difference between the inlet and closed ends due to elevation difference
- H_r = height of riser (m)

Main Line Pipe Size

- The function of mainline and sub-mains is to convey the required quantity of water at desired pressure to all laterals under maximum pressure conditions.
- Friction loss of 3m for small system and 12m for large system may be allowed.



A nomograph showing hydraulic gradient in m/100m length →

Pumps and Power Units

- In selecting a suitable pump, it is necessary to determine the maximum total head against which the pump is working.
- This may be determined by:
- $H_t = H_n + H_m + H_j + H_s$
 - H_t = total design head against which the pump is working
 - H_n = maximum head required at the main to operate the sprinkler
 - H_m = maximum friction loss in the main and in the suction line
 - H_j = elevation difference between the pump and the junction of lateral and the main
 - H_s = elevation difference between the pump and source of water after drawdown

!!!-Thank you-!!!

