RAIN BIRD

Tech Tip

Sprinkler and Micro Irrigation Engineering Formulas - U.S. Units

System Capacity Requirements

$$\text{System Capacity (gpm)} = \frac{453\ AC\ D}{I\ T\ E_s}$$

AC = Area to be irrigated (acres)
D = Net depth irrigated (in)
I = Irrigation interval (days)
T = Operating time per day (hr)
E_s = Irrigation system efficiency (decimal)

Trees and Vines Daily Requirement

$$\text{Daily Requirement} = \frac{.623\ S_t\ S_r\ ET_p}{E_a}$$

S_t = Tree spacing (ft)
S_r = Row spacing (ft)
ET_p = Crop peak evapotranspiration (in/hr)
E_a = Application efficiency (decimal)

Precipitation Rate

$$\text{Precipitation Rate (in/hr)} = \frac{96.3\ Q}{S_p\ S_l}$$

Q = Sprinkler flow (gpm)
S_p = Sprinkler spacing (ft)
S_l = Lateral spacing (ft)

Nozzle Discharge

$$\text{Discharge (gpm)} = 29.82\ \sqrt{P}\ D^2\ C_d$$

P = Nozzle pressure (psi)
D = Nozzle orifice diameter (in.)
C_d = Nozzle discharge coefficient
(tapered ≅ .96 to .98)

Emitter Discharge

$$\text{Emitter Discharge (gph)} = k\ p^x$$

κ = Emitter flow constant
p = Emitter pressure (psi)
x = Emitter exponent

Emitter Exponent

$$\text{Emitter Exponent } x = \frac{\log(\frac{Q_1}{Q_2})}{\log(\frac{P_1}{P_2})}$$

P_1 = First emitter test pressure (psi)
Q_1 = Emitter flow at P1 pressure (gph)
P_2 = Second emitter test pressure (psi)
Q_2 = Emitter flow at P2 pressure (gph)

Pipe Friction Loss (Hazen-Williams)

$$\text{Pressure Loss (psi)} = 4.55\frac{\left(\frac{Q}{C}\right)^{1.852}}{ID^{4.87}}\ L$$

Q = Pipe flow (gpm)
C = Roughness coefficient (PVC = 150, Aluminum w/ couplers = 120)
ID = Pipe inside diameter (in.)
L = Pipe length (ft)

Drip Tubing Friction Loss (Blasius)

$$\text{Pressure Loss (psi)} = .000576\frac{Q^{1.75}}{ID^{4.75}}L$$

Q = Flow in the lateral (gpm)
ID = Lateral inside diameter (in)
L = Length of the lateral (ft)

Emitter Obstruction Loss

Emitter Loss (psi) = .0359 K_d v^2

K_d = emitter obstruction factor
V = flow velocity in the lateral (fps)

Pipe Velocity

$$\textbf{Velocity (fps)} = \frac{.4085\,Q}{ID^2}$$

Q = Pipe flow (gpm)
ID = Pipe inside diameter (in.)

Brake Horsepower Required

$$\textbf{Brake Horsepower} = \frac{Q\ TDH}{3960\ E_p}$$

Q = System flow (gpm)
TDH = Total Dynamic Head (ft)
E_p = Pump efficiency (decimal)

Electrical Horsepower

$$\textbf{Electrical Horsepower} = \frac{BHP}{E_m}$$

BHP = Brake horsepower required
E_m = Electrical motor efficiency (decimal)

Water Hammer Pressure Surge

Surge Pressure (psi) = .01345 c V

$$\textbf{Wave veloc. c (fps)} = \frac{4660}{\sqrt{1+\frac{K\,(SDR-2)}{E}}}$$

c = Surge wave velocity (fps)
V = Instantaneous velocity change (fps)
K = Bulk modulus (300,000 psi for water)
SDR = Standard Dimension Ratio of the pipe (OD/ wall thickness)
E = Modulus of elasticity of the pipe (400,000 psi for PVC)

Conversion Factors

1 psi = 2.31 feet of water column
1 acre-inch = 27,154 gallons
1 cfs = 449 gpm
1 acre = 43560 sq. feet
1 cu. foot = 7.48 gal.
1 acre-in / hr = 453 gpm
1 million gal. per day (mgd) = 694.4 gpm
1 horsepower = .746 kilowatts

For further information contact:

Rain Bird Agri-Products Co.
633 W. Foothill Blvd.
Glendora, CA 91741-5624
Phone: (800) 435-5624
Fax: (626) 852-7310

Rain Bird International, Inc.
145 N. Grand Ave.
Glendora, CA 91741-2469
Phone: (626) 963-9311
Fax: (626) 963-4287