K-STATE Kansas State University

IRRIGATION MANAGEMENT SERIES

Useful Conversions and Formulas

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Water Measurement

1 cubic foot = 7.48 gallons = 62.4 pounds of water
1 acre-foot = 43,560 cubic feet = 325,851 gallons = 12 acre-inches
1 acre-inch = 27,154 gallons
1 acre-foot is the volume of water that would cover 1 acre of land 1 foot deep
1 acre-inch per hour = 450 gallons per minute (gpm)
= 1 cubic foot per second (cfs)
1 cubic meter = 1,000 liters = 264 gallons
1 gallon = 128 ounces = 3,785 mililiters
1 ounce = 29.56 mililiters
1 liter = 1.06 quarts

Pressure

1 pound per square inch (psi) = 2.31 feet of water = 6.9 kpa (kilopascal)
= 0.0703 kilogram per square centimeter (kg/cm^2)
= 0.704 meters of water
A column of water 2.31 feet deep exerts a pressure of 1 psi at the bottom of the column.
Total dynamic head (TDH) = pumping lift + elevation change + friction loss + irrigation system operating pressure

Area/Length/Weight/Yield

1 acre = 0.405 hectare (ha) = 43,560 $feet^2$
1 hectare = 2.47 acres
1 mile = 5,280 feet = 1.61 kilometers
1 foot = 0.305 meter (m)
1 meter = 3.28 feet
1 inch = 2.54 centimeters
1 pound = 454 grams
1 kilogram per hectare (kg/ha) = 1 metric ton/ha (MT/ha)
= 0.0149 bushel (60 pounds) per acre

Temperature

°F = 1.8 (°C) + 32 °C = (°F - 32) / 1.8

°C	-40	-20	0	20	37	60	80	100
°F	-40	0	32	80	98.6	160		212
			(water freezes)		(body temperature)			(water boils)

Horsepower

1 horsepower = 0.746 kilowatts (kw) = 33,000 foot-pounds per minute

Water horsepower (WHP) is the power required to lift a given quantity of water against a given total dynamic head.
WHP = (Q × H) ÷ 3960, where Q = flow rate in GPM and H = total dynamic head in feet

Brake horsepower (BHP) is the required power input to the pump.
BHP = WHP/E, where E = pump efficiency

Power unit horsepower
Electric power units: approximate name plate horsepower = BHP ÷ 0.9
Internal combustion units:
Must derate 20 percent for continuous duty (= 80 percent efficiency)
5 percent for right-angle drive (= 95 percent efficiency)
3 percent for each 1,000 feet above sea level (= 91 percent for 3,000 feet)
1 percent for each 10° above 60°F (= 96 percent for 100°F)
Approximate engine horsepower required = BHP ÷ deratings
= BHP ÷ (0.80 × 0.95 × 0.91 × 0.96)

Nebraska Performance Criteria (NPC)

Energy source	WHp-hours per unit of fuel
Diesel	12.5 WHp-hrs per gallon
Propane	6.89 WHp-hrs per gallon
Natural gas:	
925 BTU/ft^3	61.7 WHp-hrs per 1,000 ft^3 (MCF)
1,000 BTU/ft^3	66.7 WHp-hrs per 1,000 ft^3 (MCF)
Electric	0.885 WHp-hrs per kilowatt-hour

Water Application

$D = Q \times T \div A$ *or* $T = D \times A \div Q$

D = average application depth (inches)
Q = flow rate (acre-inches per hour)
T = time of application (hours)
A = area irrigated (acres)

Acreage covered by rectangular set:

$$\text{acres} = \frac{\text{no. of rows} \times \text{row width} \times \text{length of run}}{43{,}560 \text{ feet}^2/\text{acre}}$$

(measure width and length in feet)

Acreage covered by center pivot:

$$\text{acres} = \frac{(\text{radius* of wetted area})^2 \times 3.14}{43{,}560 \text{ ft}^2/\text{acre}}$$

(measure radius in feet)

* Radius is the distance from the pivot point to the end of the area wetted by the system.

Nozzle discharge:

Flow rate (gpm) = $29.7 \times D^2 \times \sqrt{P}$

D = diameter of nozzles (inches)
P = pressure (psi)

Net irrigation = gross irrigation × system efficiency

Irrigation Delivery Rate* per Acre (gpm/acre)

Net irrigation application (inches/day)	System efficiency (percent) 50	60	70	80	90	100
	gpm/acre					
0.10	3.77	3.14	2.69	2.36	2.10	1.89
0.15	5.66	4.71	4.04	3.54	3.14	2.83
0.20	7.54	6.29	5.39	4.71	4.19	3.77
0.25	9.43	7.86	6.73	5.89	5.24	4.71
0.30	11.31	9.43	8.08	7.07	6.29	5.66
0.35	13.20	11.00	9.43	8.25	7.33	6.60
0.40	15.09	12.57	10.78	9.43	8.38	7.54
0.45	16.97	14.14	12.12	10.61	9.43	8.49
0.50	18.86	15.71	13.47	11.79	10.48	9.43

Field delivery rate = gpm/acre × acres irrigated

Plastic Pipe Friction Loss (psi loss per 100 feet of pipe) for C = 150

Pipe size (inches)	Flow rate (gpm) 10	25	50	75	100	150
	psi loss per 100 feet					
1½	0.26	1.40	5.50	——	——	——
2	0.09	0.52	1.90	4.10	——	——
2½	0.03	0.17	0.65	1.35	2.40	5.00
3	——	0.07	0.26	0.38	0.95	2.05
4	——	0.01	0.06	0.14	0.24	0.50

Pipe size (inches)	Flow rate (gpm) 200	400	600	800	1000	1200
	psi loss per 100 feet					
4	0.85	3.20	——	——	——	——
6	0.12	0.42	0.93	1.60	2.40	3.40
8	0.03	0.11	0.22	0.38	0.60	0.85
10	——	0.04	0.08	0.16	0.19	0.28
12	——	——	0.03	0.06	0.08	0.11

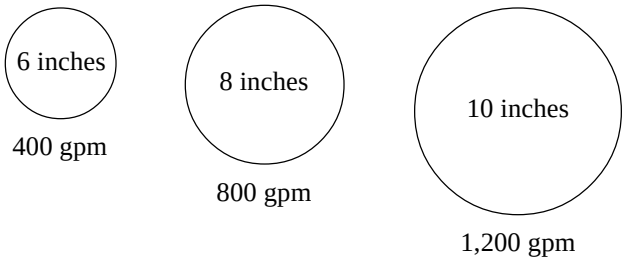
Economical Pipe Size Selection (flow in gpm)

Size (inches)	Aluminum *	Plastic *
	gpm	
4	200	275
6	450	620
8	800	1,100
10	1,250	1,720
12	1,800	2,480

* Aluminum pipe velocity limited to 5 ft/sec. Plastic pipe velocity limited to 7 ft/sec.

Maximum Economical Pipe-flow Capacities

A rule of thumb for coupled and gated pipe:



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