

	<h1 style="margin: 0;">DESIGN DATA</h1>	<h2 style="margin: 0;">HYDRAULIC FORMULAS AND TABLES METRIC UNITS</h2>
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I. CALCULATION OF SPRINKLER AND SPRAY NOZZLE WATER DISCHARGE

Water discharge is determined by the formula:

$$Q = K \sqrt{P}$$

Q = flow in gpm
where K = Constant for the specific Sprinkler or Nozzle (see specific data book page)
P = Pressure at the nozzle or sprinkler in psi.

Example: Find the flow (Q in gpm) of a Viking D2 90° spray nozzle operating at 40 psi.

$$Q = 4.97 \sqrt{40} = 31.4 \text{ gpm}$$

II. CALCULATION OF FRICTION LOSS, VELOCITY AND VELOCITY PRESSURE

A. Friction loss through pipe is based on Hazen & Williams formula which is:

$$P = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times d^{4.87}}$$

P = friction loss (psi/ft)
Q = flow in gpm
d = internal diameter of pipe in inches
C = constant

The fifth column of the pipe table gives the constant of $\frac{4.52}{C^{1.85} \times d^{4.87}}$

for various sizes and types of pipe. To determine the friction loss in one foot of pipe multiply this constant by $Q^{1.85}$

Example: Find the friction loss (p-psi/ft) with a flow (Q) of 10,000 gpm thru 10" Steel Pipe (Schedule 40) using C = 120.

$$p = 8.13 \times 10^{-9} \times Q^{1.85}$$

$$p = 8.13 \times 10^{-9} \times 25,119,000$$

$$p = 0.204 \text{ psi/ft}$$

Metric Friction Loss

$$P = 6.05 \times 10^5 \frac{Q^{1.85}}{C^{1.85} \times d^{4.87}}$$

where P = Friction Loss — Bars/Meter
Q = Flow—Liters/Minute
C = Constant
d = Inside dia. of Pipe — Millimeters

Effect of Valves & Fittings is commonly expressed as that length of pipe which produces the same friction loss as the valve or fitting. The equivalent pipe length table gives the equivalent length of C = 120 pipe. If the pipe to which the valve or fitting is being made equivalent is other than C = 120, then the equivalent length must be multiplied by the indicated factor.

Example: Find the length of 6" cast iron pipe, unlined class 150 (C = 100), which is equivalent to a 6" deluge valve.

$$33 \text{ Ft.} \times .713 = 23.5 \text{ Ft.}$$

B. Velocity of water in pipe may be found by formula:

$$V = \frac{0.485 Q}{d^2}$$

V = Velocity in feet per second
Q = Flow in gpm
d = Inside diameter of pipe in inches

The sixth column of the pipe table gives the constant of $\frac{0.4085}{d^2}$ for various sizes and types of pipe. Velocity (fps)

may be found by multiplying the constant by flow (Q in gpm).

Example: Find velocity (V-fps) in 10" Schedule 40 steel pipe with a flow (Q) of 10,000 gpm.

$$V = 0.004 \times Q$$

$$V = 0.004 \times 10,000 = 40.0 \text{ fps}$$

Metric Velocity of Water

$$V = 21.22 \frac{Q}{d^4}$$

where V = Meters/Second
Q = Liters/Minute
d = Millimeters

C. Velocity pressure is found by the following formula:

$$P_v = 0.001123 \frac{Q^2}{d^4}$$

P_v = Velocity pressure in psi
Q = Flow in gpm
d = Inside diameter of pipe in inches

The seventh column of the pipe table gives the Constant of $\frac{0.001123}{d^4}$ for various sizes and types of pipe.

Velocity pressure may be found by multiplying the square of the flow (Q² in gpm²) by this Constant.

Example: Find velocity pressure in 10" schedule 40 steel pipe with a flow of 10,000 gpm.

$$V.P. = 1.07 \times 10^{-7} Q^2$$

$$V.P. = 1.07 \times 10^{-7} \times 10,000^2 = 1.7 \text{ psi.}$$

Metric Velocity Pressure

$$P_v = 2.25 \frac{Q^2}{d^4}$$

where P = Bars
Q = Liters/Minute
d = Millimeters

<h1>VIKING</h1>	<h2>DESIGN DATA</h2>	<h3>HYDRAULIC FORMULAS AND TABLES (U.S. UNITS)</h3>
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EQUIVALENT PIPE LENGTH TABLE A
(For Common Fittings and Viking Valves expressed in equivalent feet of pipe C = 120)

Symbol Pipe Size	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	5	6	8	10	12
E Standard Elbow	2	2	3	4	5	6	7	8	10	12	14	18	22	27
MtE Medium Turn Elbow	2	2	3	3	4	5	6	6	8	10	12	16	19	22
LtE Long Turn Elbow	1	2	2	2	3	4	5	5	6	8	9	13	16	18
EE 45° Elbow	1	1	1	2	2	3	3	3	4	5	7	9	11	13
T Tee-Flow Turned 90°	4	5	6	8	10	12	15	17	20	25	30	35	50	60
GV Gate Valve					1	1	1	1	2	2	3	4	5	6
Cr Cross-Flow Turned 90°	4	5	6	8	10	12	15	17	20	25	30	35	50	60
AL V Alarm Valve						10			20		18	35		
DP V Dry Pipe Valve							10		10		19	27		
Del V Deluge Valve					18		29		35		33			
CV Swing Check Valve									10		11	14		
Dk V Detector Check Valve									14		36	55	45	
FL V *Flow Control					18		29		35		33			

NOTE: Use above values with C-120. For other values of "C" multiply the above by the following factors:

Value of C	100	120	140	150
Factor	0.713	1.0	1.33	1.51

*If Pressure Regulator is not used.

PIPE TABLE B

Size (IN.)	O.D. (IN.)	Wall Thickness (IN.)	I.D. (IN.)	p (psi/Lin. Ft.) Multiply Q ^{1.85} By		V (fps) Multiply Q By	P _v (psi) Multiply Q ² By
Steel Pipe — 1/2-6 Sch 40							
8-12 Sch 30							
				For C = 120	For C = 100		
1/2	0.840	0.109	0.622	6.50 x 10 ⁻³	9.11 x 10 ⁻³	1.056	7.50 x 10 ⁻³
3/4	1.050	0.113	0.824	1.65 x 10 ⁻³	2.32 x 10 ⁻³	0.602	2.44 x 10 ⁻³
1	1.315	0.133	1.049	5.10 x 10 ⁻⁴	7.14 x 10 ⁻⁴	0.371	9.27 x 10 ⁻⁴
1-1/4	1.660	0.140	1.380	1.34 x 10 ⁻⁴	1.88 x 10 ⁻⁴	0.215	3.10 x 10 ⁻⁴
1-1/2	1.90	0.145	1.610	6.33 x 10 ⁻⁵	8.87 x 10 ⁻⁵	0.158	1.67 x 10 ⁻⁴
2	2.375	0.154	2.067	1.87 x 10 ⁻⁵	2.63 x 10 ⁻⁵	0.096	6.15 x 10 ⁻⁵
2-1/2	2.875	0.203	2.469	7.89 x 10 ⁻⁶	1.11 x 10 ⁻⁵	0.067	3.02 x 10 ⁻⁵
3	3.500	0.216	3.068	2.74 x 10 ⁻⁶	3.84 x 10 ⁻⁶	0.0434	1.27 x 10 ⁻⁵
3-1/2	4.000	0.226	3.548	1.35 x 10 ⁻⁶	1.89 x 10 ⁻⁶	0.0325	7.09 x 10 ⁻⁶
4	4.500	0.237	4.026	7.29 x 10 ⁻⁷	1.02 x 10 ⁻⁶	0.0252	4.27 x 10 ⁻⁶
5	5.563	0.258	5.047	2.43 x 10 ⁻⁷	3.40 x 10 ⁻⁷	0.0160	1.73 x 10 ⁻⁶
6	6.625	0.280	6.065	9.91 x 10 ⁻⁸	1.39 x 10 ⁻⁷	0.0111	8.30 x 10 ⁻⁷
8	8.625	0.277	8.071	2.47 x 10 ⁻⁸	3.45 x 10 ⁻⁸	0.0063	2.65 x 10 ⁻⁷
10	10.75	0.307	10.136	8.13 x 10 ⁻⁹	1.14 x 10 ⁻⁸	0.0040	1.06 x 10 ⁻⁷
12	12.75	0.330	12.090	3.45 x 10 ⁻⁹	4.83 x 10 ⁻⁹	0.0028	5.26 x 10 ⁻⁸
Steel Pipe — 1-3 1/2 Sch. 10 S							
4-8 .188 Wt.							
				For C = 120	For C = 100		
1	1.315	0.109	1.097	4.10 x 10 ⁻⁴	5.75 x 10 ⁻⁴	0.339	7.75 x 10 ⁻⁴
1-1/4	1.660	0.109	1.442	1.08 x 10 ⁻⁴	1.52 x 10 ⁻⁴	0.196	2.60 x 10 ⁻⁴
1-1/2	1.900	0.109	1.682	5.12 x 10 ⁻⁵	7.17 x 10 ⁻⁵	0.144	1.40 x 10 ⁻⁴
2	2.375	0.109	2.157	1.52 x 10 ⁻⁵	2.13 x 10 ⁻⁵	0.088	5.19 x 10 ⁻⁵
2-1/2	2.875	0.120	2.635	5.75 x 10 ⁻⁶	8.05 x 10 ⁻⁶	0.059	2.33 x 10 ⁻⁵
3	3.500	0.120	3.260	2.04 x 10 ⁻⁶	2.86 x 10 ⁻⁶	0.0384	9.94 x 10 ⁻⁶
3-1/2	4.000	0.120	3.760	1.02 x 10 ⁻⁶	1.43 x 10 ⁻⁶	0.0289	5.62 x 10 ⁻⁶
4	4.500	0.188	4.124	6.49 x 10 ⁻⁷	9.09 x 10 ⁻⁷	0.0240	3.88 x 10 ⁻⁶
5	5.563	0.188	5.187	2.12 x 10 ⁻⁷	2.98 x 10 ⁻⁷	0.0152	1.55 x 10 ⁻⁶
6	6.625	0.188	6.249	8.57 x 10 ⁻⁸	1.20 x 10 ⁻⁷	0.0105	7.36 x 10 ⁻⁷
8	8.625	0.188	8.249	2.22 x 10 ⁻⁸	3.11 x 10 ⁻⁸	0.0060	2.43 x 10 ⁻⁷



DESIGN DATA

**HYDRAULIC FORMULAS
AND TABLES
METRIC UNITS**

PIPE TABLES

Size (IN.)	O.D. (IN.)	Wall Thickness (IN.)	I.D. (IN.)	p (psi/Lin. Ft.) Multiply Q ^{1.85} By	V (fps) Multiply Q By	P _v (psi) Multiply Q ² By
Cast Iron Pipe— Unlined Class 150						
				For C = 100		
4	4.80	0.35	4.10	9.35 x 10 ⁻⁷	0.024	3.97 x 10 ⁻⁶
6	6.90	0.38	6.14	1.31 x 10 ⁻⁷	0.011	7.90 x 10 ⁻⁷
8	9.05	0.41	8.23	3.14 x 10 ⁻⁸	0.006	2.45 x 10 ⁻⁷
10	11.10	0.44	10.22	1.09 x 10 ⁻⁸	0.0039	1.03 x 10 ⁻⁷
12	13.20	0.48	12.24	4.55 x 10 ⁻⁹	0.0027	5.00 x 10 ⁻⁸
14	15.30	0.51	14.28	2.15 x 10 ⁻⁹	0.0020	2.70 x 10 ⁻⁸
16	17.40	0.54	16.32	1.12 x 10 ⁻⁹	0.0015	1.58 x 10 ⁻⁸
18	19.50	0.58	18.34	6.34 x 10 ⁻¹⁰	0.0012	9.93 x 10 ⁻⁹
20	21.60	0.62	20.36	3.81 x 10 ⁻¹⁰	0.00099	6.54 x 10 ⁻⁹
24	25.80	0.73	24.34	1.60 x 10 ⁻¹⁰	0.00069	3.20 x 10 ⁻⁹
Cast Iron Pipe— Enameline Class 150						
				For C = 140		
4	4.80	0.41	3.98	5.80 x 10 ⁻⁷	0.026	4.48 x 10 ⁻⁶
6	6.90	0.44	6.02	7.73 x 10 ⁻⁸	0.011	8.55 x 10 ⁻⁷
8	9.05	0.47	8.11	1.81 x 10 ⁻⁸	0.006	2.60 x 10 ⁻⁷
10	11.10	0.50	10.10	6.22 x 10 ⁻⁹	0.004	1.08 x 10 ⁻⁷
12	13.20	0.54	12.12	2.56 x 10 ⁻⁹	0.0028	5.20 x 10 ⁻⁸
14	15.30	0.60	14.09	1.23 x 10 ⁻⁹	0.0021	2.85 x 10 ⁻⁸
16	17.40	0.64	16.13	6.36 x 10 ⁻¹⁰	0.0016	1.66 x 10 ⁻⁸
Cast Iron Pipe— Cement Lined—Class 150						
				For C = 140		
4	4.80	0.48	3.85	6.82 x 10 ⁻⁷	0.0276	5.11 x 10 ⁻⁶
6	6.90	0.50	5.89	8.60 x 10 ⁻⁸	0.0118	9.33 x 10 ⁻⁷
8	9.05	0.54	7.98	1.96 x 10 ⁻⁸	0.0064	2.77 x 10 ⁻⁷
10	11.10	0.56	9.97	6.62 x 10 ⁻⁹	0.0041	1.14 x 10 ⁻⁷
12	13.20	0.60	11.99	2.70 x 10 ⁻⁹	0.0028	5.43 x 10 ⁻⁸
14	15.30	0.70	13.90	1.31 x 10 ⁻⁹	0.0021	3.01 x 10 ⁻⁸
16	17.40	0.73	15.94	6.74 x 10 ⁻¹⁰	0.0016	1.74 x 10 ⁻⁸
Copper Tube—Type "K"						
				For C = 150		
3/4	0.875	0.065	0.745	1.79 x 10 ⁻³	0.736	3.65 x 10 ⁻³
1	1.125	0.065	0.995	4.36 x 10 ⁻⁴	0.413	1.15 x 10 ⁻³
1-1/4	1.375	0.065	1.245	1.47 x 10 ⁻⁴	0.264	4.67 x 10 ⁻⁴
1-1/2	1.625	0.072	1.481	6.29 x 10 ⁻⁵	0.186	2.33 x 10 ⁻⁴
2	2.125	0.083	1.959	1.61 x 10 ⁻⁵	0.106	7.63 x 10 ⁻⁵
2-1/2	2.625	0.095	2.435	5.59 x 10 ⁻⁶	0.069	3.19 x 10 ⁻⁵
3	3.125	0.109	2.907	2.36 x 10 ⁻⁶	0.0483	1.57 x 10 ⁻⁵
3-1/2	3.625	0.120	3.385	1.12 x 10 ⁻⁶	0.0357	8.55 x 10 ⁻⁶
4	4.125	0.134	3.857	5.95 x 10 ⁻⁷	0.0275	5.07 x 10 ⁻⁶
Copper Tube—Type L						
				For C = 150		
3/4	0.875	0.045	0.785	1.38 x 10 ⁻³	0.663	2.96 x 10 ⁻³
1	1.125	0.050	1.025	3.78 x 10 ⁻⁴	0.389	1.02 x 10 ⁻³
1-1/4	1.375	0.055	1.265	1.36 x 10 ⁻⁴	0.255	4.39 x 10 ⁻⁴
1-1/2	1.625	0.060	1.505	5.82 x 10 ⁻⁵	0.180	2.19 x 10 ⁻⁴
2	2.125	0.070	1.985	1.51 x 10 ⁻⁵	0.1037	7.23 x 10 ⁻⁵
2-1/2	2.625	0.080	2.465	5.26 x 10 ⁻⁶	0.0672	3.04 x 10 ⁻⁵
3	3.125	0.090	2.945	2.21 x 10 ⁻⁶	0.0471	1.49 x 10 ⁻⁵
3-1/2	3.625	0.100	3.425	1.06 x 10 ⁻⁶	0.0348	8.16 x 10 ⁻⁶
4	4.125	0.110	3.905	5.60 x 10 ⁻⁷	0.0268	4.83 x 10 ⁻⁶

<h1>VIKING</h1>	<h2>DESIGN DATA</h2>	<h3>HYDRAULIC FORMULAS AND TABLES METRIC UNITS</h3>
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PIPE TABLES

Size (IN.)	O.D. (IN.)	Wall Thickness (IN.)	I.D. (IN.)	p (psi/Lin. Ft.) Multiply Q ^{1.85} By	V (fps) Multiply Q By	P _v (psi) Multiply Q ² By
Copper Tube = Type M						
For C = 150						
3/4	0.875	0.032	0.811	1.18 x 10 ⁻³	0.621	2.60 x 10 ⁻³
1	1.125	0.035	1.055	3.28 x 10 ⁻⁴	0.367	9.07 x 10 ⁻⁴
1-1/4	1.375	0.042	1.291	1.23 x 10 ⁻⁴	0.245	4.04 x 10 ⁻⁴
1-1/2	1.625	0.049	1.527	5.42 x 10 ⁻⁵	0.175	2.07 x 10 ⁻⁴
2	2.125	0.058	2.009	1.43 x 10 ⁻⁵	0.101	6.89 x 10 ⁻⁵
2-1/2	2.625	0.065	2.495	4.96 x 10 ⁻⁶	0.0656	2.90 x 10 ⁻⁵
3	3.125	0.072	2.981	2.09 x 10 ⁻⁶	0.0460	1.42 x 10 ⁻⁵
3-1/2	3.625	0.083	3.459	1.01 x 10 ⁻⁶	0.0341	7.84 x 10 ⁻⁶
4	4.175	0.095	3.935	5.39 x 10 ⁻⁷	0.0264	4.68 x 10 ⁻⁶
Perma Stran—Class 150						
For C = 150						
4	4.50	.110	4.28	3.58 x 10 ⁻⁷	0.022	3.35 x 10 ⁻⁶
6	6.625	.153	6.32	5.37 x 10 ⁻⁸	0.010	7.04 x 10 ⁻⁷
8	8.625	.200	8.23	1.48 x 10 ⁻⁸	0.006	2.45 x 10 ⁻⁷
10	10.750	.259	10.23	5.14 x 10 ⁻⁹	0.0039	1.03 x 10 ⁻⁷
12	12.750	.313	12.12	2.25 x 10 ⁻⁹	0.0028	5.20 x 10 ⁻⁸
Cement Asbestos— Class 150 and 250						
For C = 140						
	*	*	†			
4	5.07	0.54	4.00	5.66 x 10 ⁻⁷	0.0255	4.39 x 10 ⁻⁶
6	7.17	0.66	5.85	8.89 x 10 ⁻⁸	0.0119	9.59 x 10 ⁻⁷
8	9.37	0.76	7.85	2.12 x 10 ⁻⁸	0.0066	2.96 x 10 ⁻⁷
10	11.92	0.96	10.00	6.53 x 10 ⁻⁹	0.0041	1.12 x 10 ⁻⁷
12	14.18	1.09	12.00	2.69 x 10 ⁻⁹	0.0028	5.42 x 10 ⁻⁸
14	16.48	1.24	14.00	1.27 x 10 ⁻⁹	0.0021	2.92 x 10 ⁻⁸
16	18.72	1.36	16.00	6.62 x 10 ⁻¹⁰	0.0016	1.71 x 10 ⁻⁸
18	21.30	1.65	18.00	3.73 x 10 ⁻¹⁰	0.00126	1.07 x 10 ⁻⁸
20	23.64	1.82	20.00	2.23 x 10 ⁻¹⁰	0.00102	7.02 x 10 ⁻⁹
24	28.32	2.16	24.00	9.19 x 10 ⁻¹¹	0.00071	3.38 x 10 ⁻⁹

*—O.D. and W.T. apply to Class 150 only.

†—I.D. same for Class 150 and 250.

CONVERSIONS HYDRAULIC FORMULAS U.S. TO METRIC

METRIC CONVERSIONS — U.S. to Metric

Area	— Square Feet (Ft ²)	x 0.093	=	Square Meters (M ²)
	— Square Inches (IN ²)	x 0.0006	=	Square Meters (M ²)
Volume	— Gallon (Gal)	x 3.79	=	Liters (L)
	— Cubic Feet (Ft ³)	x 0.028	=	Cubic Meters (M ³)
	— Gallons (Gal)	x 0.0378	=	Cubic Meters (M ³)
Length	— Feet (Ft)	x 0.3048	=	Meters (M)
Pressure	— Pounds/Sq Inch (PSI)	x 6.89	=	Kilopascals (kPa)
	— Pounds/Sq Inch (PSI)	x 6.894	=	Kilonewton/Meter ² (KN/m ²)
	— Pounds/Sq Inch (PSI)	x 0.06894	=	Bars
	— Feet of Water	x 0.021	=	Kilopascals (kPa)
Velocity	— Feet per second (FPS)	x 0.305	=	Meters/Second (M/Sec)
Density	— Gallons/Min/Sq Ft (GPM/Ft ²)	x 40.7	=	Liters/Min/Sq Mtr (L/M/M ²)
	— Gallons/Min/Sq Ft (GPM/Ft ²)	x 40.7	=	dm ³ /Min/m ²
	— Gallons/Min/Sq Ft (GPM/Ft ²)	x 40.7	=	mm/Min (Milimeter/min)
	— K-U.S.	x 14.4	=	K Metric
Force	— 1 Pound Force	x 4.448	=	Newton (N)
Temperature	— °Fahrenheit	5 (°F-32)	=	°Celsius (°C)