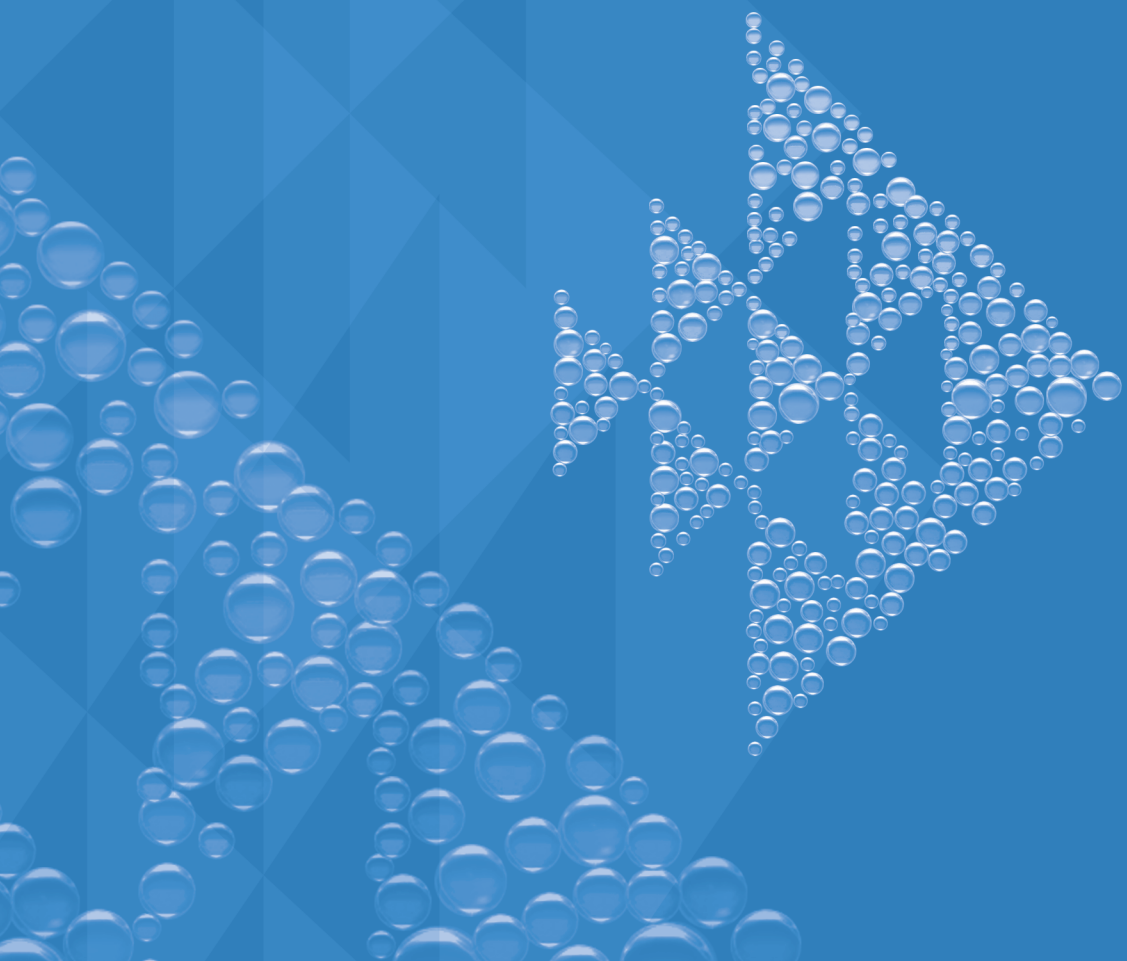
Distributed By

LeeJOSEPH

Pool Supplies, Service & Certification

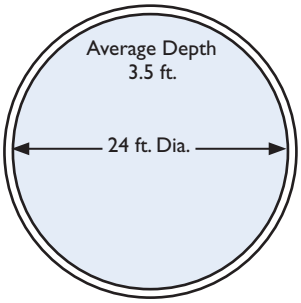
Engineering Data

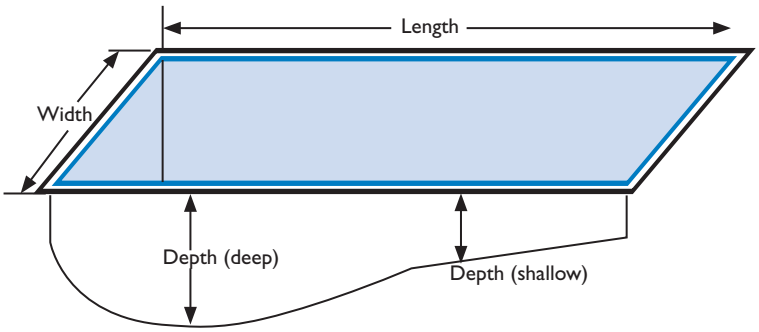
Engineering Data for Swimming Pools and Spas



Engineering Data

Estimating Total Gallons in a Pool or Spa





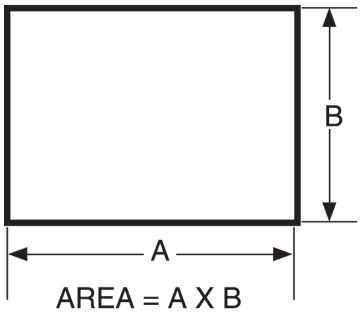
Radius2 x 3.14 x A.D. x 7.5 = Gallons
12 x 12 x 3.14 x 3.5 x 7.5 = 11,869 Gals.
Dia. x Dia. x Av Dp x 5.9 = Gallons
24 x 24 x 3.5 x 5.9 = 11,894 Gals.

Gal.cu.ft.	
Rectangle:	7.5
Oval:	6.7
Kidney:	7.0

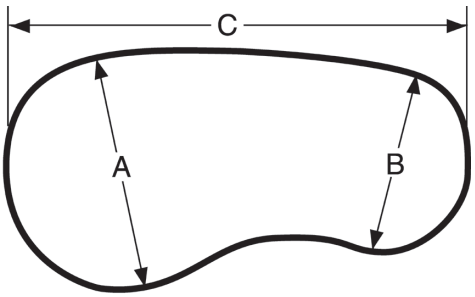
Formula A: Length X Width X Average Depth X Gal.cu.ft. = Gallons

Example:	Pool Length	=	40 ft.
	Pool Width	=	20 ft.
	Shallow Depth	=	3 ft.
	Deep Depth	=	+8 ft.
	Total Depth	=	11 ft.

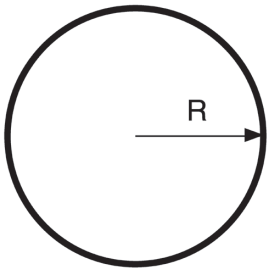
Using formula A: 40 X 20 = 800 sq. ft., 800 X 5.5 = 4,400 cubic ft., 4,400 X 7.5 = 33,000 gallons



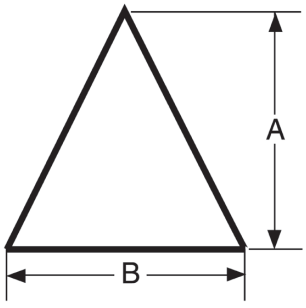
AREA = A X B



AREA = .45 X (A + B) C



AREA = 3.14 X R X R



AREA = A X B ÷ 2

The area in square feet for pools and spas can be determined by using one or more of the above formulas.

Engineering Data
Units of Measure

UNITS OF LENGTH

UNIT	INCH	FOOT	YARD	METER
INCH	1.0	.0833	.0278	.0254
FOOT	12.0	1.0	.333	.305
YARD	36.0	3.0	1.0	.9144
METER	39.37	3.281	1.094	1.0

UNITS OF AREA

UNIT	SQUARE INCH	SQUARE FOOT	SQUARE YARD	SQUARE METER
SQUARE INCH	1.0	.00694	.000772	.000645
SQUARE FOOT	144.0	1.0	.1111	.0929
SQUARE YARD	1,296.0	9.0	1.0	.836
SQUARE METER	1,550.0	10.76	1.196	1.0

UNITS OF VOLUME

UNIT	U.S. GALLON	IMPERIAL GALLON	CUBIC FEET	POUNDS OF WATER	CUBIC METERS
U.S. GALLON	1.0	.833	.1337	8.33	.003785
IMPERIAL GALLON	1.2	1.0	.1605	10.0	.004546
CUBIC FEET	7.481	6.232	1.0	62.37	.0283
POUNDS OF WATER	.12	.09996	.0160	1.0	.00045
CUBIC METERS	264.2	220.0	35.31	2,204.0	1.0

UNITS OF FLOW

UNIT	U.S. G.P.M.	IMPERIAL G.P.M.	CUBIC FEET/ SECOND	CUBIC FEET/ HOUR	LITERS/ SECOND
U.S. G.P.M.	1.0	.833	.00223	8.02	.0631
IMPERIAL G.P.M.	1.2	1.0	.00268	9.63	.0757
CUBIC FT. PER SECOND	448.8	374.0	1.0	3.600	28.32
CUBIC FT. PER HOUR	.1247	.104	.00028	1.0	.0078
LITERS PER SECOND	15.85	13.21	.0353	127.13	1.0

Engineering Data
Units of Measure

UNITS OF PRESSURE

UNIT	INCHES OF WATER	FEET OF WATER	POUNDS PER SQUARE INCH	INCHES OF MERCURY
INCHES OF WATER	1.0	.0833	.0361	.0736
FEET OF WATER	12.0	1.0	.433	.883
POUNDS PER SQUARE INCH	27.72	2.31	1.0	2.04
INCHES OF MERCURY	13.596	1.133	.4906	1.0

PRESSURE AND EQUIVALENT FEET HEAD OF WATER

$$H = \frac{\text{pressure (psi)} \times 144}{62.4}$$

Lbs. per Sq. In.	Feet Head	Lbs. per Sq. In.	Feet Head	Lbs. per Sq. In.	Feet Head	Lbs. per Sq. In.	Feet Head
1	2.31	20	46.18	120	276.42	225	519.23
2	4.62	25	57.72	125	288.46	250	576.92
3	6.93	30	69.27	130	300.00	275	634.62
4	9.24	40	92.36	140	323.08	300	692.31
5	11.54	50	115.38	150	346.15	325	750.00
6	13.85	60	138.46	160	369.23	350	807.69
7	16.16	70	161.53	170	392.31	375	865.38
8	18.47	80	184.62	180	415.38	400	923.08
9	20.78	90	207.69	190	438.46	500	1153.85
10	23.09	100	230.77	200	461.54	1000	2307.69
15	34.63	110	253.85				

Engineering Data
Units of Measure

EQUIVALENT VALUES OF PRESSURE

1 in. of Mercury (hg) = 1.13 ft. of water

Inches of Mercury	Feet of Water	Pounds per Sq. In.	Inches of Mercury	Feet of Water	Pounds per Sq. In.	Inches of Mercury	Feet of Water	Pounds per Sq. In.
1	1.13	0.49	11	12.45	5.39	21	23.78	10.3
2	2.26	0.98	12	13.57	5.87	22	24.88	10.8
3	3.39	1.47	13	14.70	6.37	23	26.00	11.28
4	4.52	1.95	14	15.82	6.86	24	27.15	11.75
5	5.65	2.44	15	16.96	7.35	25	28.26	12.25
6	6.78	2.93	16	18.09	7.84	26	29.40	12.73
7	7.91	3.42	17	19.22	8.33	27	30.52	13.23
8	9.04	3.91	18	20.35	8.82	28	31.65	13.73
9	10.17	4.40	19	26.47	9.31	29	32.80	14.22
10	11.30	4.89	20	22.60	9.80	29.929	33.947	14.6969

WEIGHT
1 U.S. GALLON OF WATER = 8.33 LBS.
1 CUBIC FOOT OF WATER = 62.35 LBS.
1 KILOGRAM (LITRE) = 2.2 LBS.
1 IMPERIAL GALLON = 10.0 LBS.

CURRENT CAPACITY (AMPS) OF WIRE*
Three wires in cable, ambient temp. 86°F

WIRE SIZE	AMPERES	
	COPPER	ALUMINIUM
14	20	–
12	25	20
10	30	25
8	40	30
6	55	40
4	70	55
3	85	65
2	95	75
1	110	85
0	125	100

*Wire size is minimum for amperes listed.

EFFICIENCY	
EFFICIENCY	$\frac{\text{POWER OUTPUT}}{\text{POWER INPUT}}$
MOTOR EFFICIENCY	$\frac{\text{HP OUTPUT}}{\text{K.W. INPUT}}$
PUMP EFFICIENCY	$\frac{\text{G.P.M x TOTAL HEAD (F.T.)}}{3960 \times \text{BHP}}$
OVERALL PLANT EFFICIENCY (OPE)	$\frac{\text{G.P.M x TOTAL HEAD (F.T.)}}{5310 \times \text{K.W. INPUT}}$

Amperage =	$\frac{\text{Watts}}{\text{Volts}}$
Watts =	Volts x Amperage
WHP =	Water Horsepower (output HP of pump) = $\frac{\text{g.p.m x total head}}{3960}$
HP input (to motor) =	KW input x 1.341
Total Head =	Discharge head + Pumping water level (ft)
Discharge Head =	Discharge Pressure (PSI) x 2.31 ft. of head

Engineering Data
Heater Sizing Information

Pool heaters can be sized by the volume method for maintenance heating or for spot heating. For many days during the swimming season, the sun maintains a desirable pool temperature of 78–80°F. and the pool requires no supplemental heating. However, during cooler periods a pool will usually lose 2–4°F. per day.

To get the water to the desired temperature, you could choose a smaller heater and run it during the daily filter cycle of 4–6 hours every day. This would be sufficient to overcome a slight temperature drop between filter cycles, but it would mean leaving the heater on every day. If you don't use the pool daily, it's more economical to spot heat the pool, say for the weekend. In this case, you could choose a larger heater which will heat the pool faster, and then can be turned off between uses. With either, maintenance heating or spot heating, you need to determine the size of heater to select and the time it will require to heat the pool.

MASTERTEMP AND MAX-E -THERM MODEL REQUIRED TO HEAT POOL IN 24 HOURS

Pool Sizing*

°F Temperature Change/ 24 Hrs.	Heater Size					Heater Size				
	Model 175	Model 200	Model 250/250HD	Model 300	Model 400/400HD	Model 175	Model 200	Model 250/250HD	Model 300	Model 400/400HD
	Pool Capacity in Gallons					Pool Surface Area in Sq. Ft. at 5.5' Depth				
5	85,210	97,383	121,729	146,075	194,766	2,069	2,364	2,955	3,546	4,727
10	42,605	48,691	60,864	73,037	97,383	1,034	1,182	1,478	1,773	2,364
15	28,403	32,461	40,576	48,692	64,922	690	788	985	1,182	1,576
20	21,303	24,346	30,433	36,519	48,691	517	591	739	887	1,182
25	17,042	19,477	24,346	29,216	38,953	414	473	591	710	945
30	14,201	16,230	20,288	24,345	32,461	345	394	493	591	788
35	12,173	13,912	17,390	20,868	27,824	296	338	423	507	675
40	10,651	12,173	15,216	18,260	24,346	259	295	369	443	591

MASTERTEMP AND MAX-E -THERM MODEL REQUIRED TO HEAT THE SPA 30°F IN A GIVEN TIME PERIOD

Spa Sizing*

Model	Spa Volume (Gallons)								
	200	300	400	500	600	700	800	900	1,000
	Minutes for 30°F Temperature Rise (Heater Input in 1000 BTU/HR)								
175	21.0	31.0	40.0	50.0	61.0	71.0	81.0	91.0	102.0
200	18.0	27.0	35.0	44.0	53.0	62.0	71.0	80.0	89.0
250/250HD	15.8	23.5	30.8	38.5	46.5	54.3	62.0	70.0	77.8
300	13.5	20.0	26.5	33.0	40.0	46.5	53.0	60.0	66.5
400/400HD	9.0	13.0	18.0	22.0	27.0	31.0	35.0	40.0	44.0

Note: The chart is based on a 30°F (16.6°C) temperature rise, discounting losses and only based on heat required to raise temperature in minutes. Two-year limited warranty. See warranty for details.

*ASME models available. See your Pentair Water Pool and Spa representative for details.

* For Commerical Heaters 500,000 BTU/hr and over please contact factory for sizing.

TIME IN HOURS POOL & SPA = $\frac{\text{Vol. in Gal. x 8.34 lb./gal. x temprise}}{\text{Heater BTUH input x efficiency of heater}}$

TIME IN MINUTES SPA = $\frac{\text{Vol. in Gal. x 8.34 lb./gal. x temprise x 60 min}}{\text{Heater BTUH input x efficiency of heater}}$

Engineering Data

Heater Gas Supply and Pipe Sizing Information

When installing any Pentair Pool Products pool or spa heater, it is very important to have the proper amount of gas supplied to all Pentair Pool heaters. Below, for your information, is a table which will assist you in selecting the correct size of piping for the installation.

When installing any gas appliance, it is very important to have the proper size gas meter and home pressure regulator installed. Once you have selected the correct size heater for the pool or spa, contact the local utility which supplies the gas and request a field review of the installation and have them install the proper size meter and proper size pressure regulator.

LOW PRESSURE, SINGLE STAGE PIPE SIZING FOR GAS LINE CONNECTIONS

4														
Natural gas at 1000 BTU per Cubic Foot														
Propane Gas at 2500 BTU per Cubic Foot														
MODEL	1/2 in.		3/4 in.		1 in.		1-1/4 in.		1-1/2 in.		2 in.		2-1/2 in.	
	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO
100 & 75	20 ft.	50 ft.	50 ft.	150 ft.	150 ft.	600 ft.	-	-	-	-	-	-	-	-
150	10 ft.	40 ft.	50 ft.	150 ft.	150 ft.	600 ft.	-	-	-	-	-	-	-	-
200	-	20 ft.	30 ft.	80 ft.	125 ft.	250 ft.	450 ft.	600 ft.	-	-	-	-	-	-
250	-	10 ft.	20 ft.	50 ft.	70 ft.	150 ft.	250 ft.	500 ft.	600 ft.	-	-	-	-	-
300	-	-	10 ft.	30 ft.	50 ft.	100 ft.	200 ft.	350 ft.	400 ft.	600 ft.	-	-	-	-
350	-	-	10 ft.	20 ft.	30 ft.	70 ft.	125 ft.	250 ft.	250 ft.	500 ft.	500 ft.	-	-	-
400	-	-	-	10 ft.	20 ft.	60 ft.	100 ft.	150 ft.	200 ft.	450 ft.	400 ft.	-	-	-
525	-	-	-	5 ft.	15 ft.	35 ft.	65 ft.	150 ft.	130 ft.	360 ft.	390 ft.	700 ft.	-	-
750	-	-	-	-	-	20 ft.	35 ft.	80 ft.	75 ft.	180 ft.	260 ft.	600 ft.	-	-
900	-	-	-	-	-	15 ft.	20 ft.	45 ft.	45 ft.	100 ft.	150 ft.	360 ft.	400 ft.	-

Gas Pressure	Model	Natural	Propane
		Inches W. C.	
Gas Pressure Requirements Pentair Water Heaters			
Maximum Inlet	CH	10	14
	STD	10	14
	TSI	10	N/A
	LN	10	N/A
Minimum Inlet	CH	6	12
	STD	6	12
	TSI	4	N/A
	LN	6	N/A
Manifold	CH	4	11
	STD	4	11
	TSI	2	N/A
	LN	4	N/A

Gas Pressure	Natural	Propane
	Inches W. C.	
Gas Pressure Requirements for MiniMax 75 & 100 Pentair Water Heaters		
Normal Altitudes (0–2500 ft. above Sea Level)		
Maximum Inlet	10	14
Minimum Inlet	5	12
Normal Manifold	4	11
High Altitudes (2500–7000 ft. above Sea Level)		
Maximum Inlet	10	14
Minimum Inlet	5	12
Normal Manifold	3	7

Note: All readings must be taken while heater is operating. Any adjustments or readings made while heater is off will give incorrect readings and should not be used for evaluation of heater operation.

All Values are +/- 0.2 inch W. C.

Engineering Data

Heater Gas Supply and Pipe Sizing Information

"RESIDENTIAL" PROPANE GAS 2 STAGE REGULATION

In many Propane gas line installations, the gas supplier and or installer will utilize a two stage regulation process whereby, at the supply tank, they will install the first stage gas regulator, which would be at a higher pressure, usually 10 psi. This higher pressure allows for much longer distance and in a much smaller pipe size. Then, within a short distance from the pool heater, generally around 24 inches, a second regulator, which is the second stage, would be installed and set at the required inlet pressure of the heater.

SEE "GAS PRESSURE REQUIREMENT CHART."

Stage One "High Pressure" Gas Pipe Sizing			
10 PSI @ 2500 BTU Per CU. FT.			
MAXIMUM EQUIVALENT PIPE LENGTH			
Model	**0 to 50 Feet**	**50 to 100 Feet**	**100 to 150 Feet**
75 through 400	1/2 in.	1/2 in.	1/2 in.

→

Stage Two "Low Pressure" Gas Pipe Sizing		
Stage 2 set at 14 in. W.C.		
MAXIMUM EQUIVALENT PIPE LENGTH		
Model	**0 to 10 Feet**	**10 to 20 Feet**
75 through 400	3/4 in.	3/4 in.

"RESIDENTIAL" NATURAL GAS 2 STAGE REGULATION

In many Natural gas line installations, the gas supplier and or installer will utilize a two stage regulation process whereby, at the street's main gas supply, they will install the first stage gas regulator, which would be at a higher pressure. This higher pressure is usually set at 2 psi or 5 psi and can be run for long distances and in a much smaller pipe size. Then, within a short distance from the pool heater, generally around 24 inches, they will install a second regulator, which is the second stage. This second stage regulator would be set at the minimum operating pressure for the heater. For "Natural Gas Pentair Pool Heaters" the minimum is 7 inches W.C.

Stage One "High Pressure" Gas Pipe Sizing			
2 PSI @ 1000 BTU Per CU. FT.			
MAXIMUM EQUIVALENT PIPE LENGTH			
Model	**0 to 20 Feet**	**20 to 90 Feet**	**90 to 200 Feet**
75 through 400	3/4 in.	1 in.	1-1/4 in.

→

Stage Two "Low Pressure" Gas Pipe Sizing		
Stage 2 set at 7 in. W.C.		
MAXIMUM EQUIVALENT PIPE LENGTH		
Model	**0 to 5 Feet**	**0 to 15 Feet**
75 through 300	3/4 in.	1 in.
350 & 400	1 in.	1 in.

Stage One "High Pressure" Gas Pipe Sizing			
5 PSI @ 1000 BTU Per CU. FT.			
MAXIMUM EQUIVALENT PIPE LENGTH			
Model	**0 to 50 Feet**	**50 to 100 Feet**	**100 to 200 Feet**
75 through 400	3/4 in.	3/4 in.	3/4 in.

→

Stage Two "Low Pressure" Gas Pipe Sizing		
Stage 2 set at 7 in.W.C.		
MAXIMUM EQUIVALENT PIPE LENGTH		
Model	**0 to 5 Feet**	**0 to 15 Feet**
75 through 300	3/4 in.	1 in.
350 & 400	1 in.	1 in.

Engineering Data
Blower Sizing

HORSEPOWER

To Get This	Divide This	By This
Horsepower	Kwatts	0.746
Horsepower	Watts	746
Horsepower	Torque (ft. lbs.) X RPM	33000
Horsepower	Torque (ft. lbs.) X RPS	550
Horsepower required to pump water at a given rate to a given Height, assuming 100% eff. AKA Water Horsepower	GPM x TDH (ft.)	3960
	GPH X TDH (psi)	103000
Brake HP	Water HP	Pump eff.

AIR BLOWER SIZING GUIDE

BLOWER MOTOR SIZE	VOLTS	AMPS	MAXIMUM INCHES OF WATER DEPTH	JETS ONLY RECOMMENDED NUMBER OF JETS
1 HP	120V	6.6	35 in.	5–10
1-1/2 HP	120V	7.4	45 in.	9–15
2 HP	120V	9.3	55 in.	12–17
1 HP	240V	3.9	30 in.	4–9
1-1/2 HP	240V	4.3	40 in.	8–13
2 HP	240V	5.0	50 in.	12–17

BLOWER SIZING FORMULA	
Measure total depth of water in spa (not total spa depth)	
Add - 1 in. water for each 10 ft. of 2 in. air pipe	Add 1/2 in. water for each 90 deg. 2 in. elbow
Compare your total with maximum inches of water column and select that size or the next size higher blower than your total, in your selected voltage.	
The number of holes in the air channel (both floor and seat) should be approximately 1.6 sq. in. total plus or minus .5	
1/8 in. hole = .0123 sq. in.	3/16 in. hole = .0276 sq. in.
5/32 in. hole = .0192 sq. in.	1/4 in. hole = .0491 sq. in.

Engineering Data, Friction Flow

FRICTION/FLOW CHART FOR SCHEDULE 40 RIGID PVC PIPE*

U.S. Gal.per min.	3/4 in. pipe		1 in. pipe		1-1/4 in. pipe		1-1/2 in. pipe		2 in. pipe		2-1/2 in. pipe		3 in. pipe		4 in. pipe		5 in. pipe		6 in. pipe		U.S. Gal.per min.
	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	Velocity feet per second	Loss in feet	
1	.71	.40	.40	.10	0.26	0.03															1
2	1.43	1.44	.80	.35	.51	.12	.36	.05													2
3	2.14	3.05	1.20	.75	.77	.25	.53	.10													3
4	2.85	5.19	1.60	1.28	1.03	.43	.71	.18													4
5	3.56	7.85	2.00	1.94	1.28	.65	.89	.27	.50	.07	.32	.02	.22	.01							5
6	4.28	11.01	2.41	2.71	1.54	.92	1.07	.38	.60	.09	.38	.03	.27	.01							6
8	5.70	18.75	3.21	4.62	2.05	1.56	1.43	.64	.80	.16	.51	.05	.36	.02							8
10	7.13	28.34	4.01	6.99	2.57	2.36	1.78	.97	1.00	.24	.64	.08	.45	.03							10
15	10.69	60.06	6.01	14.81	3.85	5.00	2.67	2.06	1.50	.51	.96	.17	.67	.07							15
20			8.02	25.24	5.13	8.52	3.56	3.51	2.00	.87	1.28	.29	.89	.12	.50	.03					20
25			10.02	38.16	6.41	12.88	4.45	5.31	2.51	1.31	1.60	.44	1.11	.18	.63	.04					25
30			12.03	53.48	7.70	18.06	5.34	7.44	3.01	1.83	1.92	.62	1.34	.26	.75	.06	.48	.02			30
35					8.98	24.03	6.24	9.89	3.51	2.44	2.24	.82	1.56	.34	.88	.08	.56	.03			35
40					10.26	30.77	7.13	12.67	4.01	3.13	2.57	1.06	1.78	.43	1.00	.11	.64	.04			40
45					11.54	38.27	8.02	15.76	4.51	3.89	2.89	1.31	2.00	.54	1.13	.13	.72	.05			45
50					12.83	46.51	8.91	19.16	5.01	4.72	3.21	1.60	2.23	.66	1.25	.16	.80	.05	.56	.02	50
60							10.69	26.85	6.01	6.62	3.85	2.24	2.67	.92	1.50	.23	.96	.08	.67	.03	60
70									7.01	8.81	4.49	2.98	3.12	1.23	1.75	.30	1.12	.10	.78	.04	70
80									8.02	11.28	5.13	3.81	3.56	1.57	2.00	.39	1.28	.13	.89	.05	80
90									9.02	14.03	5.77	4.74	4.01	1.95	2.25	.48	1.44	.16	1.00	.07	90
100									10.02	17.06	6.41	5.76	4.45	2.37	2.51	.59	1.60	.20	1.11	0.08	100
125											8.02	8.71	5.57	3.59	3.13	.88	2.00	.30	1.39	.12	125
150											9.62	12.20	6.68	5.03	3.76	1.24	2.41	.42	1.67	.17	150
175													7.79	6.69	4.38	1.65	2.81	.56	1.95	.23	175
200													8.91	8.56	5.01	2.11	3.21	.71	2.23	.29	200
225													10.02	10.65	5.64	2.63	3.61	.89	2.51	.37	225
250													11.13	12.95	6.26	3.19	4.01	1.08	2.78	.44	250
275															6.89	3.81	4.41	1.29	3.06	.53	275
300															7.52	4.48	4.81	1.51	3.34	.62	300
325															8.14	5.19	5.21	1.75	3.62	.72	325
350															8.77	5.95	5.61	2.01	3.90	.83	350
375															9.39	6.77	6.01	2.28	4.18	.94	375
400															10.02	7.63	6.41	2.57	4.45	1.06	400
425																	6.81	2.88	4.73	1.19	425
450																	7.22	3.20	5.01	1.32	450
475																	7.62	3.54	5.29	1.46	475
500																	8.02	3.89	5.57	1.60	500
550																	8.82	4.64	6.12	1.91	550
600																	9.62	5.46	6.68	2.25	600
650																			7.24	2.61	650
700																			7.79	2.99	700
750																			8.35	3.40	750
1000																			11.13	5.79	1000

* Friction loss of water in feet per 100 feet length of pipe. Based on Williams & Hazen formula using constant 150.
* Recommended operating flow velocities indicated by boxed areas.