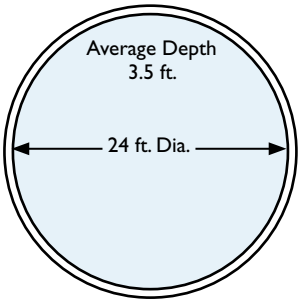
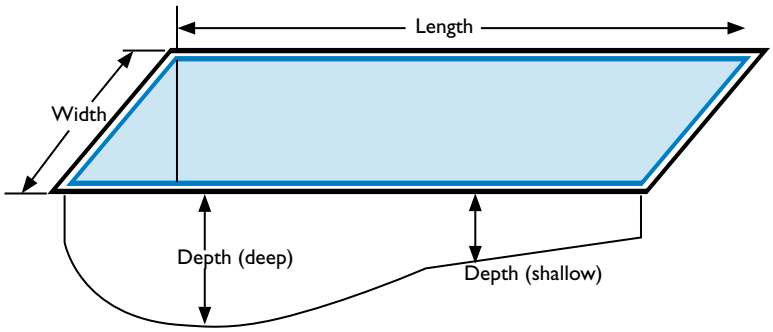
Engineering Data

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.

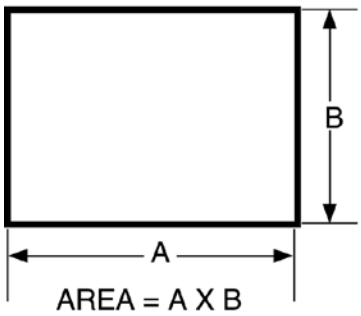
Gal.cu.ft.	
Rectangle:	7.5
Oval:	6.7
Kidney:	7.0

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

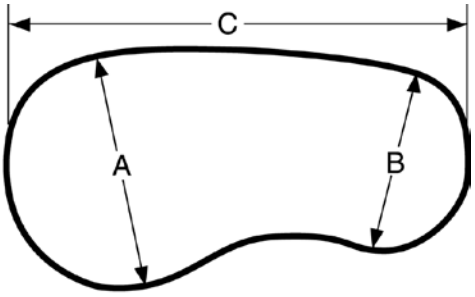
Example:

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

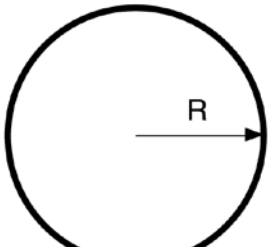
Using formula A: 40 X 20 = 800 sq. ft., 800 X 5.5 = 4,400 cubic ft., 4,400 X 7.5 = 33,000 gallons



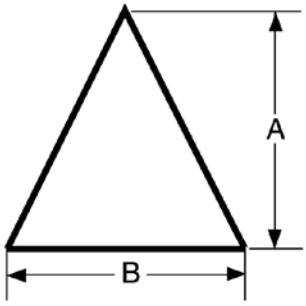
AREA = A X B



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	$\frac{\text{H.P. OUTPUT}}{\text{K.W. INPUT}}$
PUMP EFFICIENCY	$\frac{\text{G.P.M x TOTAL HEAD (F.T.)}}{3960 \times \text{B.H.P.}}$
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.

MINIMAX HEATER REQUIRED TO HEAT POOL IN 24 HOURS

	Desired Temperature Rise					
Pool Capacity in Gallons	5° F	10° F	15° F	20° F	25° F	30° F
10000	200	200	200	200	200	200
12000	200	200	200	200	200	250
14000	200	200	200	200	250	250
16000	200	200	200	250	250	300
18000	200	200	200	250	300	400
20000	200	200	200	300	400	400
22000	200	200	200	300	400	400
24000	200	200	250	400	400	525
26000	200	200	250	400	400	525
28000	200	200	250	400	525	525
30000	200	200	300	400	525	750
32000	200	200	300	525	525	750
34000	200	200	300	525	525	750
36000	200	250	400	525	750	750

MiniMax model needed	200	250	300	400
Commercial Series MiniMax model needed			525	750

{These heater model numbers are represented within the tables.}

MINIMAX HEATER REQUIRED FOR MAINTENANCE HEATING

	Desired Temperature Rise				
Pool Surface Area (sq. ft.)	10° F	15° F	20° F	25° F	30° F
200	200	200	200	200	200
300	200	200	200	200	200
400	200	200	200	200	250
500	200	200	200	250	300
600	200	200	250	300	400
700	200	200	250	400	400
800	200	250	300	400	525
900	200	250	400	400	525
1000	200	300	400	525	525

MINIMAX HEATER REQUIRED TO HEAT SPA IN ONE HOUR

	Desired Temperature Rise				
Spa Capacity in Gallons	10° F	15° F	20° F	25° F	30° F
200	200	200	200	200	200
300	200	200	200	200	200
400	200	200	200	200	200
500	200	200	200	200	200
600	200	200	200	200	250
700	200	200	200	250	250
800	200	200	200	250	300
900	200	200	250	300	400
1000	200	200	250	300	400

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 B.T.U. per Cubic Foot														
Propane Gas at 2500 B.T.U. per Cubic Foot														
MODEL	½"		¾"		1"		1-¼"		1-½"		2"		2-½"	
	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO	NAT	PRO
100 & 75	20'	50'	50'	150'	150'	600'	-	-	-	-	-	-	-	-
150	10'	40'	50'	150'	150'	600'	-	-	-	-	-	-	-	-
200	-	20'	30'	80'	125'	250'	450'	600'	-	-	-	-	-	-
250	-	10'	20'	50'	70'	150'	250'	500'	600'	-	-	-	-	-
300	-	-	10'	30'	50'	100'	200'	350'	400'	600'	-	-	-	-
350	-	-	10'	20'	30'	70'	125'	250'	250'	500'	500'	-	-	-
400	-	-	-	10'	20'	60'	100'	150'	200'	450'	400'	-	-	-
525	-	-	-	5'	15'	35'	65'	150'	130'	360'	390'	700'	-	-
750	-	-	-	-	-	20'	35'	80'	75'	180'	260'	600'	-	-
900	-	-	-	-	-	15'	20'	45'	45'	100'	150'	360'	400'	-

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 B.T.U. Per CU. FT.			
MAXIMUM EQUIVALENT PIPE LENGTH			
Model	**0 to 50 Feet**	**50 to 100 Feet**	**100 to 150 Feet**
75 through 400	½ in.	½ in.	½ in.

→

Stage Two "Low Pressure" Gas Pipe Sizing		
Stage 2 set at 14" W.C.		
MAXIMUM EQUIVALENT PIPE LENGTH		
Model	**0 to 10 Feet**	**10 to 20 Feet**
75 through 400	¾ in.	¾ 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 B.T.U. Per CU. FT.			
MAXIMUM EQUIVALENT PIPE LENGTH			
Model	**0 to 20 Feet**	**20 to 90 Feet**	**90 to 200 Feet**
75 through 400	¾ in.	1 in.	1-¼ in.

→

Stage Two "Low Pressure" Gas Pipe Sizing		
Stage 2 set at 7" W.C.		
MAXIMUM EQUIVALENT PIPE LENGTH		
Model	**0 to 5 Feet**	**0 to 15 Feet**
75 through 300	¾ in.	1 in.
350 & 400	1 in.	1 in.

Stage One "High Pressure" Gas Pipe Sizing			
5 PSI @ 1000 B.T.U. Per CU. FT.			
MAXIMUM EQUIVALENT PIPE LENGTH			
Model	**0 to 50 Feet**	**50 to 100 Feet**	**100 to 200 Feet**
75 through 400	¾ in.	¾ in.	¾ in.

→

Stage Two "Low Pressure" Gas Pipe Sizing		
Stage 2 set at 7" 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 H.P.	120V	6.6	35"	5-10
1-½ H.P.	120V	7.4	45"	9-15
2 H.P.	120V	9.3	55"	12-17
1 H.P.	240V	3.9	30"	4-9
1-½ H.P.	240V	4.3	40"	8-13
2 H.P.	240V	5.0	50"	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 ½ 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" hole = .0123 sq. in.	3/16" hole = .0276 sq. in.
5/32" hole = .0192 sq. in.	1/4" hole = .0491 sq. in.

Engineering Data, Friction Flow

FRICTION/FLOW CHART FOR SCHEDULE 40 RIGID PVC PIPE*

U.S. Gal.per min.	¾" pipe		1" pipe		1 ¼" pipe		1 ½" pipe		2" pipe		2 ½" pipe		3" pipe		4" pipe		5" pipe		6" 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.