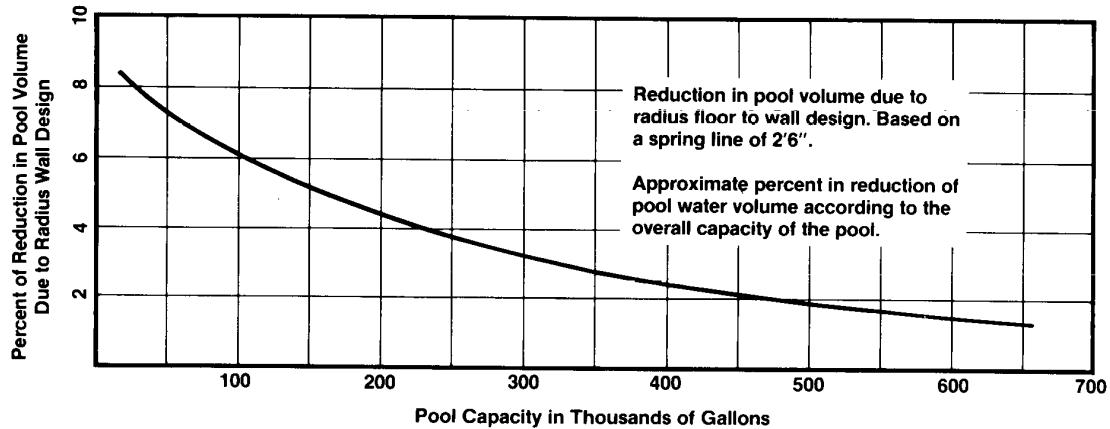


HYDRAULICS CALCULATION GUIDE

- I. **This guide is an aid for completing the required forms.** However, the person submitting the calculations is **Solely** responsible for insuring compliance with **all** applicable requirements and the Clark County Health District shall not be held liable for any errors or omissions contained herein nor for any damage or loss due to use of this guide.
- II. **Read Nevada Administrative Code Chapter 444 Public Bathing Places and/or Chapter 444 Public Spas** carefully for requirements. Copies of current codes are available from the Clark County Health District.
- III. **Calculations must be submitted on approved forms, using only the method described in the approved forms.** Copies of current, approved forms are available from the Clark County Health District.
- IV. **Determine pool/spa volume in gallons:**
 - A. **Determine surface area in square feet:**
 1. Area of a rectangle or square = length x width.
 2. Area of circle = $\pi \times \text{radius}^2$.
 3. Area of free form pool - use planimeter on scale drawing.
 - B. **Determine average depth:**
 1. Average depth for uniform slope = $\frac{\text{min. depth} + \text{max. depth}}{2}$
 2. For pools with different floor slopes - divide pool into sections with uniform slopes and determine average depth for each section, add these depths together and divide the sum by the number of sections.
 - C. **Determine volume in cubic feet:**
 1. Volume in cubic feet = surface area x average depth
 - D. **Determine volume in gallons:**
 1. Volume in gallons = volume in cubic feet x $\frac{7.48 \text{ gallons}}{\text{cubic foot}}$
 - E. **Reduce volume by gallonage taken up by steps, benches, and wall/floor radius:**
 1. Determine volume taken up by steps and benches (very important with spas) and subtract from volume determined in D above.

2. Determine the percent of reduction in pool volume due to radius wall design:



V. Refer to **CALCULATION OF TOTAL DYNAMIC HEAD IN POOL AND SPA RECIRCULATION SYSTEMS** for specific requirements for filling out that form and for determining minimum and design flows.

VI. Useful conversions, definitions, and formulas:

- A. 1 square foot = a square 12 inches wide and 12 inches long
- B. 1 cubic foot = a cube 12 inches wide by 12 inches long by 12 inches high
- C. 1 cubic foot of water contains 7.48 gallons
- D. $\pi = 3.14$
- E. radius = $\frac{1}{2}$ diameter
- F. 1 foot of head = .433 psi (pounds per square inch)
- G. 1 psi = 2.31 feet of head
- H. 1 inch of mercury = 1.13 feet of head
- I. "Total Dynamic Head" (TDH) is the sum of all resistance in a complete recirculation system when it is in operation. It is sometimes used as an equivalent to "friction head."
- J. "Turnover cycle" is the period of time required to completely recirculate the volume of water in a pool or spa through its filter and treatment systems.

K. Velocity Formula:

Mathematical Formula: $v = .4085 \frac{q}{d^2}$

In Computer Notation: $v = .4085(q/d^2)$

Where:

v = velocity of fluid in feet per second

q = flow in gallons per minute

d = actual (not nominal) inside diameter of pipe in inches

L. Head Loss Formula:

$$\text{Mathematical Formula: } h = .2083 \left(\frac{100}{c} \right)^{1.852} \frac{q^{1.852}}{d^{4.8655}}$$

In Computer Notation: $h = ((.2083)*(100/c)^{1.852})*(q^{1.852}/d^{4.8655})$

Where:

h = head in feet of water per 100 feet of pipe

c = constant for inside roughness of pipe

q = flow in gallons per minute

d = actual (not nominal) inside diameter of pipe in inches

VII. Determine Total Dynamic Head. (Provide a copy of acceptable manufacturer's head loss data to the Clark County Health District for any system components, piping, and fittings not provided below).

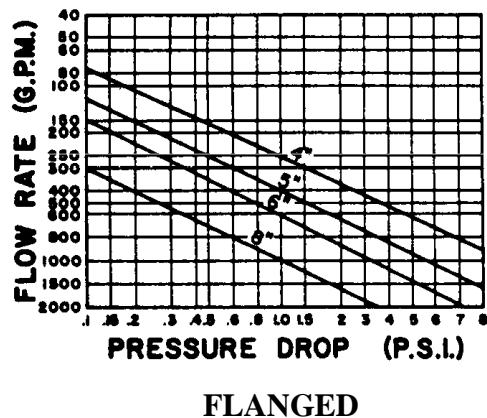
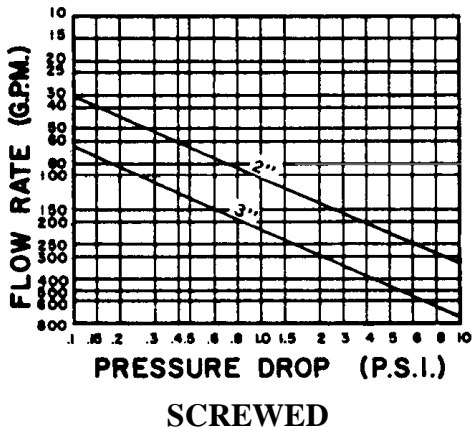
A. Main drain(s):

GPM	HEAD LOSS IN FEET	
	1 1/2" OUTLET	2" OUTLET
20	0.5	
30	1.0	
40	1.5	1.0
50	2.0	1.5
60	2.5	2.0
70		3.0
80		4.0

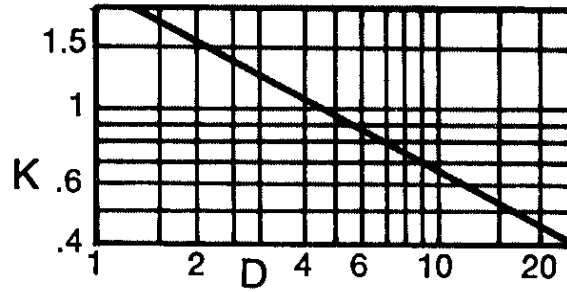
B. Skimmer(s):

GPM	HEAD LOSS IN FEET	
	1 1/2" OUTLET	2" OUTLET
20	1.0	0.5
30	2.0	1.0
40	3.0	2.0
50	4.0	3.0
60	5.5	4.0
70		5.0
80		6.0

C. Pump strainer inlets (nominal inlet size):



D. Pump strainer baskets:



$$h = K \frac{V^2}{2g}$$

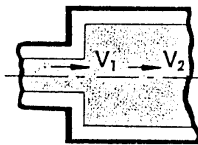
Where:
 h = head loss in feet
 K = resistance coefficient
 V = velocity in basket
 D = diameter of strainer basket
 g = 32.17 feet/sec²

E. **Multiport valves**—refer to manufacturer's head loss data.

F. **Filters**—refer to manufacturer's or NSF's head loss data.

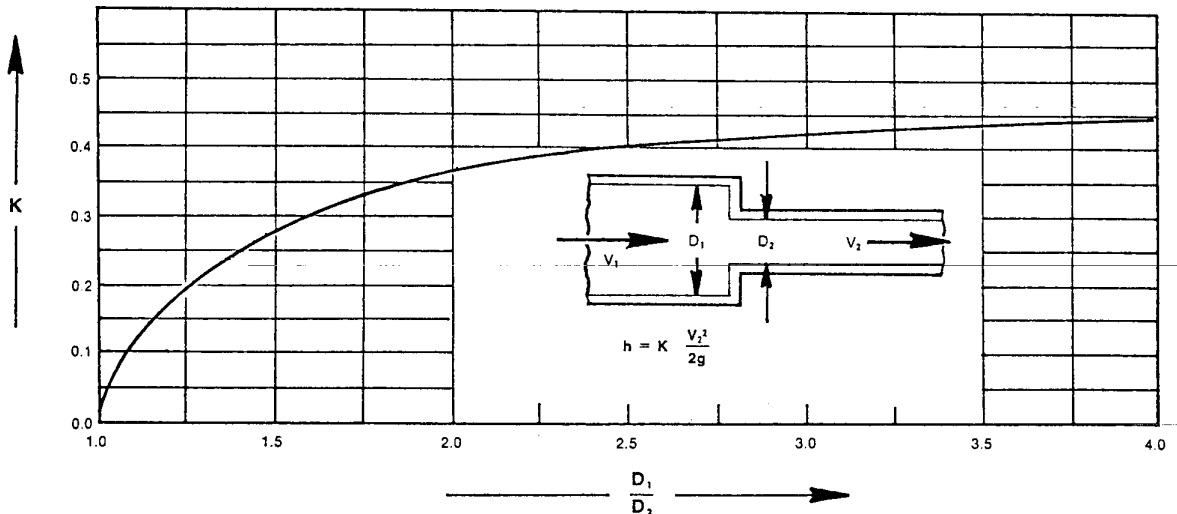
G. **Heaters**—refer to manufacturer's head loss data.

H. Sudden enlargements:



$$h = \frac{(V_1 - V_2)^2}{2g}$$

I. Reducers:



RESISTANCE COEFFICIENTS FOR REDUCERS

J. Notes for enlargements and reducers:

h = head loss in feet

K = resistance coefficient

V₁ = velocity in smaller pipe for enlargements, in larger pipe for reducers

V₂ = velocity in larger pipe for enlargements, in smaller pipe for reducers

D₁ = diameter of larger pipe

D₂ = diameter of smaller pipe

g = 32.17 feet/sec²

K. Wall inlet fittings (nominal orifice size):

HEAD LOSS IN FEET OF HEAD					
GPM	3/8"	1/2"	3/4"	7/8"	1.0"
1	.13				
2	.53				
3	1.18				
4	2.10				
5	3.28	1.04	.21		
6	4.72	1.49	.30		
7	6.43	2.03	.41		
8	8.40	2.66	.53		
9	10.63	3.36	.67		
10	13.12	4.15	.82	.44	
11		5.02	.99	.54	
12		5.98	1.18	.64	
13		7.02	1.39	.75	
14		8.14	1.61	.87	
15		9.34	1.85	1.00	.58
16		10.63	2.10	1.13	.66
17		12.00	2.37	1.28	.75
18		13.45	2.66	1.43	.84
19		14.99	2.96	1.60	.94
20		16.61	3.28	1.77	1.04
21			3.62	1.95	1.14
22			3.97	2.14	1.26
23			4.34	2.34	1.37
24			4.72	2.55	1.50
25			5.13	2.77	1.62

HEAD LOSS IN FEET OF HEAD					
GPM	3/8"	1/2"	3/4"	7/8"	1.0"
26			5.54	2.99	1.75
27			5.98	3.23	1.89
28			6.43	3.47	2.03
29			6.90	3.72	2.18
30			7.38	3.98	2.34
31				4.25	2.49
32				4.53	2.66
33				4.82	2.83
34				5.11	3.00
35				5.42	3.18
36				5.74	3.36
37				6.06	3.55
38				6.39	3.75
39				6.73	3.95
40				7.08	4.15
41					4.36
42					4.58
43					4.80
44					5.02
45					5.25
46					5.49
47					5.73
48					5.98
49					6.23
50					6.49

L. Floor inlet fittings (amount open):

		HEAD LOSS IN FEET OF HEAD			
GPM	1/4	1/2	3/4	FULL	
1	.05				
2	.29				
3	.46				
4	.58				
5	.87	.04			
6	1.01	.08			
7	1.16	.13			
8	1.59	.18			
9	1.73	.22			
10	2.02	.27	.14		
11	2.16	.31	.15		
12	2.31	.36	.17		
13	2.60	.51	.20		
14	2.89	.62	.23		
15	3.18	.66	.29		
16	3.41	.72	.35		
17	3.61	.87	.40		
18	3.90	1.01	.46		
19	4.19	1.07	.52		
20	4.18	1.16	.58		
21	4.62	1.27	.63		
22	5.05	1.39	.69		
23	5.20	1.44	.75		
24	5.63	1.59	.81		
25	6.06	1.73	.87	.58	

		HEAD LOSS IN FEET OF HEAD			
GPM	1/4	1/2	3/4	FULL	
26	6.29	1.87	.92	.69	
27	6.64	2.02	.98	.81	
28	6.93	2.19	1.04	.92	
29	7.36	2.31	1.10	1.04	
30	7.65	2.60	1.16	1.10	
31	8.09	2.74	1.44	1.22	
32	8.37	2.89	1.55	1.28	
33	8.95	3.03	1.59	1.34	
34	9.24	3.18	1.73	1.40	
35	9.67	3.41	1.88	1.46	
36	10.11	3.61	2.05	1.52	
37	10.69	3.75	2.19	1.59	
38	11.12	3.98	2.25	1.65	
39	11.55	4.04	2.31	1.85	
40	12.13	4.33	2.37	2.04	
41	12.56	4.50	2.42	2.08	
42	12.99	4.76	2.48	2.14	
43	13.57	4.91	2.51	2.19	
44	14.15	5.34	2.60	2.25	
45	14.44	5.49	2.66	2.31	
46	15.01	5.63	2.71	2.37	
47	15.59	5.78	2.77	2.43	
48	16.17	6.06	2.83	2.48	
49	16.60	6.35	2.89	2.54	
50	17.18	6.64	2.94	2.60	

M. Pipe velocities and friction losses (see also Velocity and Head Loss Formulas on pages 2-3):

GPM	1" Schedule 40 PVC—1.049 in. i.d.		1" Type L Copper—1.025 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=140	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
2	0.74	0.32	0.78	0.41
3	1.11	0.68	1.17	0.87
4	1.49	1.15	1.56	1.48
5	1.86	1.75	1.95	2.23
6	2.23	2.45	2.34	3.13
8	2.97	4.16	3.11	5.35
10	3.71	6.31	3.89	8.08
12	4.46	8.85	4.67	11.30
14	5.20	11.80	5.45	15.00
16	5.94	15.10	6.22	19.20
18	6.68	18.70		
20	7.43	22.80		
25	9.29	34.60		
30	11.10	48.10		

GPM	1¼" Schedule 40 PVC—1.380 in. i.d.		1¼" Type L Copper—1.265 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=140	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
4	0.86	0.30	1.02	0.52
6	1.29	0.65	1.53	1.12
8	1.72	1.10	2.04	1.92
10	2.15	1.67	2.55	2.90
12	2.57	2.33	3.06	4.04
14	3.00	3.10	3.57	5.35
16	3.43	3.96	4.08	6.85
18	3.86	4.93	4.59	8.52
20	4.29	6.00	5.10	10.40
25	5.36	9.06	6.38	15.70
30	6.43	12.70		
40	8.58	21.60		
50	10.70	32.60		
60				

GPM	1½" Schedule 40 PVC—1.610 in. i.d.		1½" Type L Copper—1.505 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=140	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
6	0.95	0.31	1.08	0.49
8	1.26	0.52	1.44	0.82
10	1.58	0.79	1.80	1.24
12	1.89	1.10	2.16	1.73
15	2.36	1.59	2.70	2.62
20	3.15	2.83	3.60	4.46
25	3.94	4.26	4.51	6.74
30	4.73	6.00	5.41	9.44
40	6.30	10.20	7.21	16.10
50	7.88	15.40		
60	9.46	21.60		
70	11.00	28.70		
80				
90				

GPM	2" Schedule 40 PVC—2.067 in. i.d.		2" Type L Copper—1.985 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=140	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
10	0.96	0.23	1.07	0.35
15	1.44	0.50	1.60	0.75
20	1.91	0.84	2.13	1.24
25	2.39	1.27	2.66	1.87
30	2.87	1.78	3.19	2.62
40	3.82	3.03	4.26	4.48
50	4.78	4.57	5.32	6.76
60	5.74	6.44	6.39	9.47
70	6.69	8.53		
80	7.65	10.90		
90	8.61	13.60		
100	9.56	16.50		
120	11.50	23.10		
150				

GPM	2½" Schedule 40 PVC—2.469 in. i.d.		2½" Type L Copper—2.465 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=140	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
20	1.34	0.35	1.38	0.43
30	2.01	0.75	2.07	0.91
40	2.68	1.27	2.76	1.55
50	3.35	1.92	3.45	2.34
60	4.02	2.69	4.14	3.28
70	4.69	3.58	4.82	4.36
80	5.36	4.59	5.51	5.58
90	6.03	5.72	6.20	6.95
100	6.70	6.90		
115	7.70	9.00		
130	8.71	11.30		
150	10.00	14.70		
200	13.40	25.00		
250				

GPM	3" Schedule 40 PVC—3.068 in. i.d.		3" Type L Copper—2.945 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=150	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
40	1.74	0.39	1.88	0.62
60	2.60	0.81	2.82	1.31
80	3.47	1.39	3.76	2.22
100	4.24	2.10	4.70	3.35
120	5.21	2.94	5.64	4.70
140	6.08	3.90	6.58	6.25
160	6.94	5.00		
180	7.81	6.25		
200	8.68	7.60		
250	10.80	11.50		
300				
350				
400				
450				

GPM	4" Schedule 40 PVC—4.026 in. i.d.		4" Type L Copper—3.905 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=150	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
50	1.26	0.16	1.34	0.24
75	1.89	0.34	2.01	0.50
100	2.52	0.58	2.68	0.85
125	3.15	0.87	3.35	1.27
150	3.78	1.22	4.01	1.80
200	5.05	2.08	5.35	3.05
250	6.30	3.12	6.70	4.60
300	7.57	4.41		
350	8.82	5.82		
400	10.10	7.52		
500				
600				
700				
800				

GPM	6" Schedule 40 PVC—6.065 in. i.d.		6" Type L Copper—5.845 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=150	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
100	1.11	0.07	1.19	0.12
150	1.67	0.16	1.79	0.25
200	2.22	0.28	2.39	0.43
250	2.77	0.42	2.98	0.65
300	3.33	0.58	3.58	0.91
400	4.44	0.99	4.79	1.55
500	5.55	1.50	5.98	2.34
600	6.66	2.10	7.17	3.28
700	7.78	2.79		
800	8.90	3.60		
900	10.00	4.46		
1000	11.10	5.44		
1200				
1400				

GPM	8" Schedule 40 PVC—7.981 in. i.d.		8" Type L Copper—7.725 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=150	Velocity ft./sec	ft. of head/100 ft. of pipe—C=130
200	1.28	0.07	1.37	0.11
300	1.92	0.16	2.05	0.23
400	2.57	0.26	2.74	0.40
500	3.21	0.40	3.42	0.60
600	3.85	0.56	4.10	0.84
700	4.37	0.66	4.78	1.12
800	4.99	0.82	5.46	1.43
900	5.64	1.06	6.84	2.17
1000	6.25	1.28		
1200	7.51	1.79		
1400	8.77	2.37		
1600	10.00	3.01		
1800	11.27	3.78		
2000				

GPM	10" Schedule 40 PVC—10.02 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=150
500	2.03	0.13
600	2.44	0.19
700	2.85	0.25
800	3.25	0.32
900	3.66	0.39
1000	4.07	0.48
1200	4.88	0.67
1400	5.70	0.89
1600	6.51	1.04
1800	7.32	1.42
2000	8.14	1.72
2200	8.95	2.06
2400	4.76	2.42
2600	10.58	2.80

GPM	12" Schedule 40 PVC—11.938 in. i.d.	
	Velocity ft./sec	ft. of head/100 ft. of pipe—C=150
1000	2.84	0.20
1200	3.40	0.28
1400	3.97	0.37
1600	4.54	0.47
1800	5.11	0.59
2000	5.67	0.72
2200	6.24	0.86
2400	6.81	1.00
2600	7.38	1.17
2800	7.94	1.34
3000	8.51	1.52
3200	9.08	1.71
3400	9.65	2.13
3600	10.21	2.13

N. Fittings (losses expressed as equivalent length of pipe in feet):

Fitting	Material	1"	1¼"	1½"	2"	2½"	3"	4"	6"	8"	10"	12"
90° Elbow	Plastic	6	7	8	9	10	14	17	25	33	42	50
	Copper	3	4	4	5	6	8	10	15	20	25	30
45° Elbow	Plastic	2.5	3	4	5	6	7	9	13	13	22	26
	Copper	1.3	1.7	2.1	2.6	3	3.6	4.7	7.1	9.4	12	14
Standard Tee w/Branch Flow	Plastic	9	12	13	17	20	23	29	45	58	74	88
	Copper	6	8	9	11	14	16	20	31	40	51	61
Standard Tee	Plastic	3	4	5	7	8	10	12	17	24	29	34
	Copper	1.7	2.3	2.8	3.6	4.2	5.2	6.8	10	14	17	20
Adapt./Coupling/ Fitting to Thread	Plastic	3	3	3	3	3	3	3	3	3	3	3
	Copper	1	1	1	1	1	1	1	1	1	1	1
Gate Valve	-	0.60	0.80	0.95	1.15	1.4	1.6	2.1	3.2	4.3	5.3	6.4
Sw. Check Valve	-	7	9	11	13	16	20	26	39	52	67	77
Ord. Entrance	-	1.5	2.0	2.4	3.0	3.7	4.5	6.0	9.0	12	15	17