Pump Sizing Made Easy

HYDROMATIC®

HWP-81 covers the steps that need to be taken to accurately select the correct sump pump, sewage pump, effluent pump and applicable systems for use in:

- Basement sumps
- Septic tank effluent
- Wastewater
- Flooded basements
- Sewage ejectors

The system is selected first, and in sizing a system, you need to work through five steps to determine:

1. System Capacity (GPM required)
2. Total Dynamic Head (TDH)
3. Solid Size
4. Basin Size
5. Type (Simplex or Duplex)

Figure A — FIXTURE UNIT VALUES

Fixture Description	Unit Value
Bathroom group, consisting of lavatory, bathtub or shower and (direct flush) water closet.	8
Bathroom group, consisting of lavatory, bathtub or shower and (flush tank) water closet.	6
Bathtub with 1-1/2" trap	2
Bathtub with 2" trap	3
Bidet with 1-1/2" trap	3
Dental unit or cuspidor	1
Drinking fountain	1/2
Dishwasher, domestic type	2
Kitchen sink, domestic	2
Kitchen sink, domestic with waste grinder	3
Lavatory with 1-1/2" waste plug	1
Lavatory, barber or beauty shop	2
Laundry tray, 2-compartment	2
Shower stall	2
Shower (group) per head	3
Sink (direct flush valve)	8
Sink (service type with floor drain)	3
Sink (scullery)	4
Sink (surgeons)	3
Urinal (with flush valve)	8
Urinal (with flush tank)	4
Water closet (flush valve)	8
Water closet (flush tank)	4
Swimming pools (per 1000 gal. capacity)	1
Unlisted fixture with 1-1/4" trap size	1
Unlisted fixture with 1-1/2" trap size	2
Unlisted fixture with 2" trap size	3
Unlisted fixture with 2-1/2" trap size	4
Unlisted fixture with 3" trap size	5
Unlisted fixture with 4" trap size	6
Water softener (domestic)	4
Washing machine	2

NOTE! To the installer: Please make sure you provide this manual to the owner of the pumping equipment or to the responsible party who maintains the system.

In sizing a pump, you need to determine:

1. Solid Size Required
2. Pump Capacity (GPM available)
3. Total Dynamic Head (TDH)

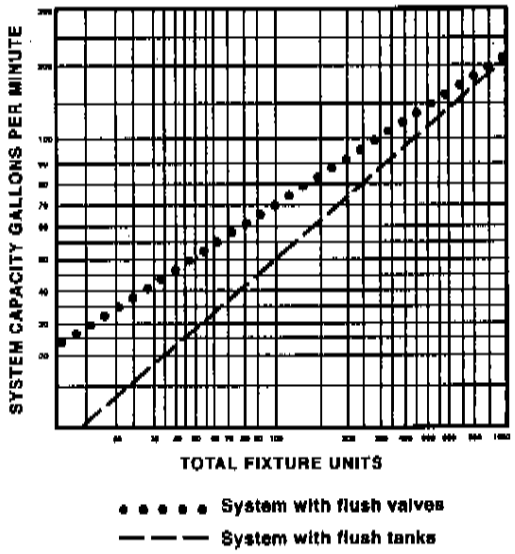
Sizing the System:

STEP 1: System Capacity refers to the rate of flow in gallons per minute (GPM) necessary to efficiently maintain the system. The "Fixture Unit" method is suggested for determining this figure. This approach assigns a relative value to each fixture or group of fixtures normally encountered. Determination of the required SYSTEM CAPACITY is as follows:

A. List all fixtures involved in the installation, and using Figure A assign a Fixture Unit value to each. Add to obtain total.

B. Referring to Figure B, locate the total Fixture Unit amount along the horizontal axis of the graph and follow vertically until intersecting one of the two plotted lines. Select the correct line as a function of using flush valves or flush tanks. Read the SYSTEM CAPACITY in GPM along the vertical axis.

Figure B – SYSTEM CAPACITY BASED ON TOTAL VALUE OF FIXTURE UNITS



STEP 2: Total Dynamic Head (TDH) is a combination of Static Head and Friction Head and is expressed in feet.

A. Static Head is the actual vertical distance ("lift") measured from the minimum water level in the BASIN to the highest point in the discharge piping. (Fig. D)

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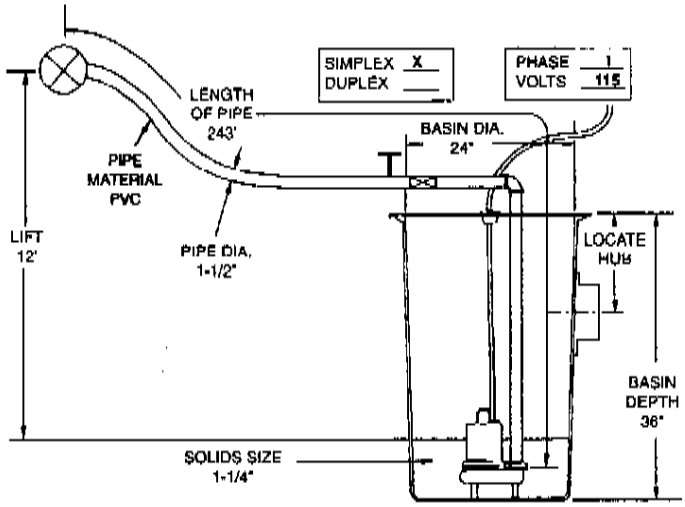


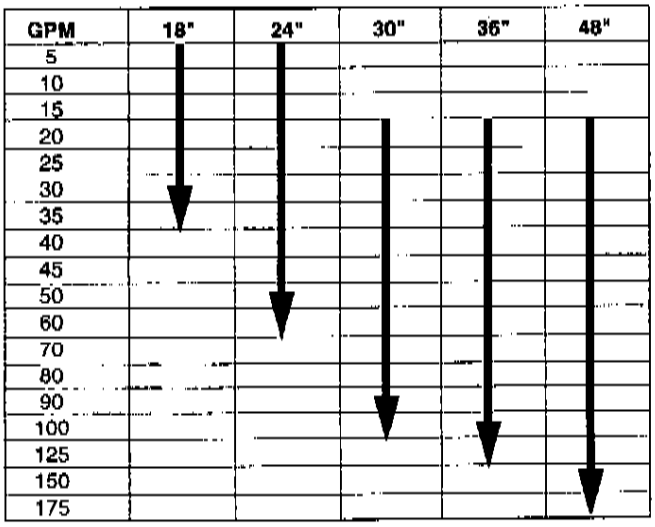
B. Friction Head is the additional head created in the discharge system due to resistance to flow within its components. (Fig. C and F) It should be kept to 2 feet per second for maximum efficiency.

Figure C – FRICTION FACTORS FOR PIPE FITTINGS IN TERMS OF EQUIVALENT FEET OF STRAIGHT PIPE

Nominal Pipe Size	90° Elbow	45° Elbow	Tee (Thru-Flow)	Tee Branch Flow	Swing Check Valve	Gate Valve
1-1/4"	3.5	1.8	2.3	6.9	11.5	.9
1-1/2"	4.0	2.2	2.7	8.1	13.4	1.1
2"	5.2	2.8	3.5	10.3	17.2	1.4
2-1/2"	6.2	3.3	4.1	12.3	20.6	1.7
3"	7.7	4.1	5.1	15.3	25.5	2.0

STEP 3: Solids-Handling requirements may be determined by local codes and/or by the type of application and types of solids anticipated. Unless otherwise stated by codes, a sewage pump should have the capability of handling spherical solids of at least 2" in diameter in installations involving water closets, and at least 1/2" in installations without water closets.

Figure E — RECOMMENDED BASIN DIAMETERS



STEP 4: Basin selection is best accomplished by relating to required SYSTEM CAPACITY as determined by the Fixture Unit method. Figure E shows recommended basin diameters, assuming the normal pump differential (distance in inches between turn-on and turn-off), and running time range of from 15 seconds to 4 minutes. BASIN depth, however, should be at least 24" below basin inlet for most pumps and deeper where greater pumping differentials are anticipated.

NOTE: Since basin size is directly related to frequency of pump operation, it is important to select a basin of sufficient size to insure that the pump does not short cycle. Short cycling causes premature pump failure.

STEP 5: A Simplex or Duplex System depends on the type of installation and/or local codes. Generally, a determination can be made using the following guidelines:

A. Domestic — SIMPLEX System is usually adequate.

B. Commercial — OPTIONAL, depending on the type of business and the need for uninterrupted sanitary drainage facilities.

FORMULA FOR VOLUME PER FOOT OF WATER

$$\frac{\pi \cdot R2 \cdot \text{Depth of Basin} = \text{volume}}{231}$$

Pump should run a minimum of 2 minutes.
Basin diameter gallons per foot/per inch

24" = 23.5/foot / 1.95/inch - 30" = 36/foot / 3.00/inch
36" = 52.9/foot / 4.41/inch - 48" = 94/foot / 7.83/inch
60" = 147/foot / 12.25/inch - 72" = 211.5/foot /17.625/inch

C. Public or Industrial — DUPLEX System is essential.

While you are sizing the system and before you select the pump, you will need to know — and consider — or make allowances for the following:

- Volts/Phase/Hertz — What is available?
- Will the pump share a circuit?
- Does the home, business, etc. have circuit breakers or fuses?
- What is the breaker or fuse amp rating? Make sure it is enough.
- Check local or state codes for: (1) Solid Size requirements; (2) Amp ratings/circuit-cord size/ratings or type; (3) Pipe material/size/depth to bury; (4) Tank size/location.
- Are there plans for future expansion, i.e. added upstairs bath, basement plumbing, washing machine, etc.

Use the simple sketch of a typical system in Figure D to determine the answers for the items included.

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Example Problem:

A customer requests a recommendation for a domestic, simplex sewage system. The tank is to be fiberglass, and installed in the basement of a four bedroom, two and one-half bath home which includes the following: 2 bathroom groups (flush tank), 1 half bath (sink and water closet), 1 dishwasher, 1 washing machine, 1 two compartment laundry tray, 1 kitchen sink with waste grinder and 1 bar sink.

The house is equipped with 10, 15, and 20 amp separate circuit breakers at 1/60/115 volts. Local codes allow 1-1/4" solid size, plastic PVC pipe, but the customer wants a minimum tank retention volume of 30 gallons. The customer is also planning to add a basement shower, water softener, and service sink with floor drain.

Solution:

I. GPM REQUIRED — Determine the Fixture Units (Fig. A).

Qty.	Fixture	Total Fixture Units
2	Bathroom groups (flush tank)	12
1	Half bath — lavatory sink w/1-1/2" plug, water closet (flush tank) (1 + 4)	5
1	Dishwasher — domestic	2
1	Washing machine	2
1	Laundry tub	2
1	Kitchen sink with waste grinder	3
1	Bar sink (unlisted 1-1/4")	1
	FUTURE EXPANSION	
1	Shower stall	2
1	Water Softener	4
1	Service sink w/drain	3
	TOTAL	36

Since the bathroom group has flush tanks, select the lower plotted line (Fig. B) and determine GPM capacity as a function of 36 Fixture Units.

The SYSTEM CAPACITY is approximately 19 GPM. Note that if we didn't consider future expansion, the Fixture Units would be 27 and the system capacity 17 GPM.

II. TDH REQUIRED — Refer to layout sketch (Fig. D). The static head or lift in this example problem is 12 feet. Depending on the GPM flow, pipe size and pipe material, all straight pipe, fittings, valves, etc. have a friction factor which must also be considered. These friction factors are converted to, and expressed as, equivalent feet of straight pipe. These are then totalled and translated to Fraction head. This reduces to four basic steps:

A. Determine the discharge pipe size. In order to ensure sufficient fluid velocity to carry solids, (generally accepted to be 2 feet per second), flows should be at least:

9 GPM through 1-1/4" pipe
13 GPM through 1-1/2" pipe
21 GPM through 2" pipe
30 GPM through 2-1/2" pipe
46 GPM through 3" pipe

In this example problem, we will use the 1-1/2" diameter pipe (due to solid size and relatively short length).

B. The length of the discharge piping is measured from the discharge opening of the pump to the point of final discharge, following all contours and bends. In this example, total pipe length is 243 feet of 1-1/2" pipe.

Figure F — FRICTION HEAD IN FEET PER 100' OF SCHEDULE 40 PIPE

GPM	1-1/4"		1-1/2"		2"		2-1/2"		3"	
	PLASTIC	STEEL	PLASTIC	STEEL	PLASTIC	STEEL	PLASTIC	STEEL	PLASTIC	STEEL
4	.34	.35								
6	.71	.72	.33	.34						
8	1.19	1.20	.56	.57						
10	1.78	1.74	.83	.85						
12	2.48*	2.45*	1.16	1.18	.34	.35				
14	3.29	3.24	1.54	1.51	.45	.46				
16	4.21	4.15	1.97*	1.93*	.58	.59				
18	5.25	5.17	2.41*	2.40*	.72	.73				
20	6.42	6.31	2.96	2.92	.88	.88				
25	10.39	9.61	4.80	4.80	1.38	1.39				
30	13.6	13.0	6.27	6.23	1.81	1.82	.75	.77		
35	19.2	18.2	8.82	8.82	2.4*	2.4*	1.01	.99		
40			10.7	10.80	3.12	3.10	1.28	1.3		
45			14.0	14.0	3.8	3.8	1.5	1.6	.55	.56
50			16.5	16.5	4.7	4.7	1.9*	1.9*	.66	.68
60					6.5	6.6	2.7*	2.7*	.94	.91
70					8.6	8.8	3.7	3.6	1.2	1.2
80					11.1	11.4	4.7	4.6	1.6	1.6
90					13.8	14.3	5.8	5.8	2.0*	2.0*
100					16.8	17.5	7.1	7.1	2.4	2.4
125							10.9	10.9	3.7	3.6
150							15.9	15.9	5.2	5.1
175									6.9	6.9

* Recommended loss in friction head per 100'.

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C. To determine the equivalent of discharge piping represented by fittings and valves, refer to Figure C and total all values. Add this to the measured length of discharge pipe. Although not specifically shown in Figure D, the discharge piping has the following:

	Equivalent Pipe Length
(1)1-1/2" check valve (swing type)	13.4 feet
(1)1-1/2" gate valve	1.1
(3)90° elbows — (3 x 4)	12.0
(2)45° elbows — (2 x 2.2)	4.4
Total Equivalent Pipe Length =	30.9 feet

Summary:

Total Pipe Length	243.0
Total Equivalent Pipe Length	30.9
Total Equivalent Length =	273.9 feet

D. Refer to Figure F and find the required System Capacity in GPM in the left column. Follow across to the number below the pipe size being used, which represents the friction Head per 100 feet of pipe. Multiply this number by the total equivalent length of pipe in feet. Using 20 GPM, 1-1/2" plastic pipe, we read 2.96 feet of friction loss per 100 feet of pipe.

Therefore (2.96 feet/100 x 273.9 feet) = 8.10 feet friction loss. Add the Static and Friction Head to determine TOTAL DYNAMIC HEAD.

Static Head	12.0 feet
Friction Head	8.1 feet
Total TDH =	20.1 feet

The system design requirements are:
19 GPM at 20' TDH

III. **SOLID SIZE** — Normally select 2-inch, however this example problem allowed 1-1/4".

IV. **BASIN SIZE and TYPE OF SYSTEM** — This example problem is for a domestic application and therefore a simplex, 18-inch diameter tank would seem adequate. There is the requirement for 30 gallons storage, so it is necessary to determine whether the 18" tank is large enough.

A standard 18-inch tank is 30 inches deep. Total tank volume can be calculated from the formula $\pi R2H$:

$\pi = 3.1416$
R = Tank Radius (inches)
H = Tank Depth (inches)

$3.1416 \times 92 \times 30 = 7634$ cubic inches

1728 cubic inches = 1 cubic foot

$7634 \div 1728 = 4.42$ cubic feet

1 Gallon = .1337 cubic feet

$4.42 \div .1337 = 33$ gallons (in 18" x 30" tank)

The 18-inch tank is marginal as it must hold 30 gallons **plus** the pump and the piping. The selection should be a 24-inch tank, which has a volume of 70.49 gallons, as computed by the above formula.

Pump Selection:

SYSTEM CAPACITY is the calculated flow in GPM you want to pump. When the pump pushes this flow through the discharge piping, you determine the total pressure (HEAD) in feet required. This is called the DESIGN CONDITION. It is measured in ____GPM at ____TDH.

Every centrifugal pump has a unique performance curve. This curve illustrate the relationship of flow (GPM) to pressure (TDH) at any point. The pump will operate at any point along this performance curve.

Pump capacity is therefore the flow the pump will generate at any specific pressure. The object is to select a pump whose performance curve passes either through or close to the design condition, preferably above.

STEP 1: Start with the smallest pump horsepower size that will pass the required solid size. If the solid size is not required or mentioned, go to Step 2 and check performance.

STEP 2: With the pump selected in Step 1, check performance curve(s) to see that it passes **above** or through the design condition.

In this example problem the pump has to handle a 1-1/4" solid and meet or exceed the design condition of 19 GPM at 20' TDH.

SELECTION — Use your Hydromatic Pump Catalog, "Sewage Ejectors" section.

SOLUTION — SP40

The SP40 is the smallest horsepower pump that will pass a 1-1/4" solid. The SP40 performance curve passes **above** the design condition.

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USA
740 East 9th Street Ashland, Ohio 44805
Tel: 419-289-3042 Fax: 419-281-4087

www.hydromatic.com

CANADA
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Tel: 519-896-2163 Fax: 519-896-6337

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