CHAPTER 2: The Plumbing System

SECTION I: SIZING REQUIREMENTS

Establish building dimensions

- Building height can be determined either by architectural drawings or # of floors times height/floor. (ex: 10 floors x 10 feet/floor = 100' Tall)
- Convert feet of water column to PSI by using the following formula:

H x .433 = PSI

where H = Static Head;
.433 is the mathematical reciprocal of 2.31, therefore,
you will arrive at the same condition by dividing TDH by 2.31)

	TDH	PSI
A. STATIC HEAD - BUILDING HEIGHT		
B. FRICTION HEAD - FRICTION LOSS		
C. RESIDUAL PRESSURE REQUIRED (@ TOP)		
D. SYSTEM REQUIRED PRESSURE (A + B + C)		
E. MINIMUM SUCTION PRESSURE (SUBTRACT)		
F. SYSTEM BOOST PRESSURE (D - E)		
G. PRV LOSSES (5 -10 PSI)		
H. PUMP HEAD REQUIRED (F + G)		

The table to the left indicates the various requirements in establishing system pressure rating. Typically, all figures are expressed in PSI using the Feet/PSI conversion formula and are then converted back to TDH to select the pumps.

Establish building flow capacity (see fig. #3 & 4)

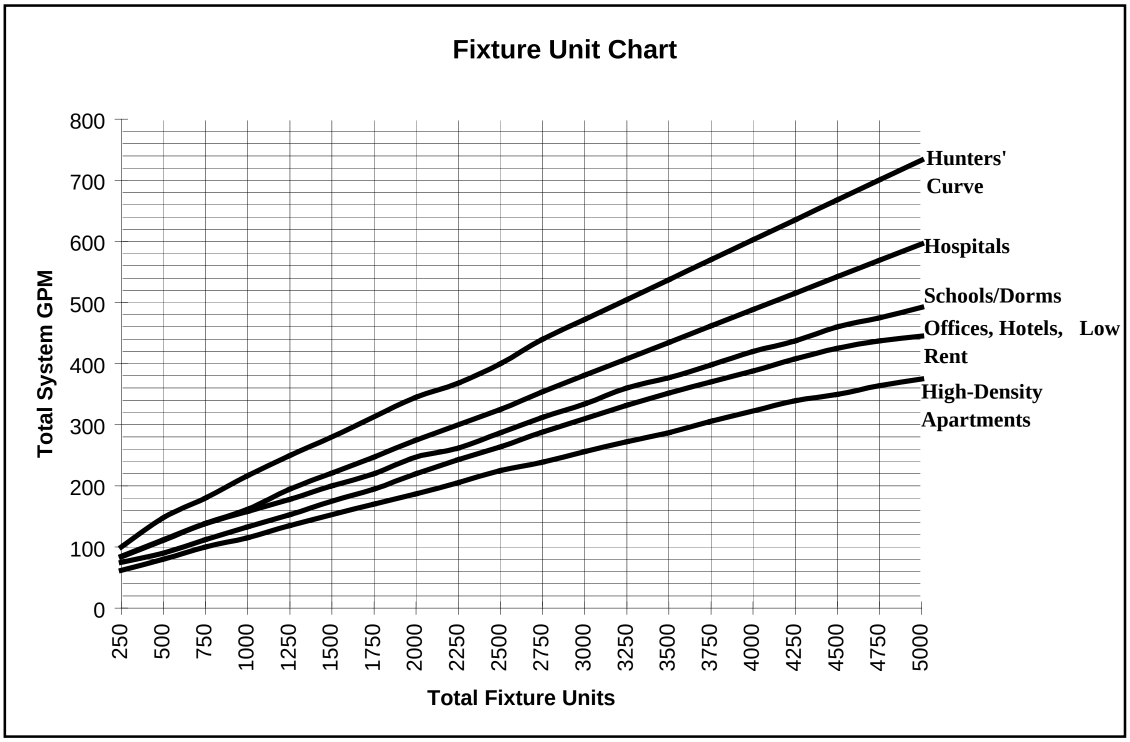
- Count the number of fixtures which use domestic water. Bear in mind that different fixtures use water differently. (ex: 1.6 GPF Water Closet, 3.5 GPF Water Closet, Flush Valve, etc.)
- Determine the "type" of building from the flow chart which will indicate maximum required GPM.
- Be careful when selecting systems with a constant load, these systems will not benefit from a drawdown tank and system shutdown. (ex: Cooling tower, commercial laundry facilities, restaurants, night clubs, hydronic water make-up, etc.)

WATER SUPPLY FIXTURE UNITS - WSFU

TYPE OF FIXTURES	Individual Dwelling Units	Serving Three or more Dwelling Units	Other than Dwelling Units	Heavy Use Assembly
Bathroom Group, 1.6 GPF Gravity Tank Water Closet	5.0	3.5		
Bathroom Group, 1.6 GPF Pressure-Tank Water Closet	5.0	3.5		
Bathroom Group, 3.5 GPF Gravity Tank Water Closet	6.0	5.0		
Bathroom Group, 1.6 GPF Flushometer Valve	6.0	4.0		
Bathroom Group, 3.5 GPF Flushometer Valve	8.0	6.0		
Kitchen Group (Sink and Dishwasher)	2.0	1.5		
Laundry Group (Sink and Clothes Washer)	5.0	3.0		
INDIVIDUAL FIXTURES				
Bathtub or Combination Bath/Shower	4.0	3.5		
Bidet	1.0	0.5		
Clothes Washer, domestic	4.0	2.5	4.0	
Dishwasher, domestic	1.5	1.0	1.5	
Drinking Fountain or Watercooler			0.5	0.75
Hose Bibb (1/2" Supply Pipe)	2.5	2.5	2.5	
Hose Bibb, each additional (1/2" Supply Pipe)	1.0	1.0	1.0	
Kitchen Sink, domestic	1.5	1.0	1.5	
Laundry Sink	2.0	1.0	2.0	
Lavatory	1.0	0.5	1.0	1.0
Service Sink or Mop Basin			3.0	
Shower	2.0	2.0	2.0	
Shower, continous use			5.0	
Urinal, 1.0 GPF			4.0	5.0
Urinal, greater than 1.0 GPF			5.0	6.0
Water Closet 1.6 GPF Gravity Tank	2.5	2.5	2.5	4.0
Water Closet 1.6 GPF Pressure Tank	2.5	2.5	2.5	3.5
Water Closet 1.6 GPF Flushometer Valve	5.0	5.0	5.0	8.0
Water Closet 3.5 GPF Gravity Tank	3.0	3.0	5.5	7.0
Water Closet 3.5 GPF Flushometer Valve	7.0	7.0	8.0	10.0
Whirlpool Bath or Combination Bath/Shower	4.0	4.0		

1995 Change to the National Standard Plumbing Code adopted at NSPC Public Hearing - August 1994

Typical Fixture Unit Chart showing various types of fixtures and their relational fixture unit assignment. This is typically used by consultants to determine a fixture unit "load" which is interpreted on the building profile curves (fig. #4). This chart is taken from the National Plumbing Code, August 1994.



The plumbing designer must consider the activities of the occupants and the building usage. Since this does not consider the human element, we rely on operating data and records compiled over the years by users, manufacturers and trade associations. The graph above is a representation of this information. This is typically what system flows are based on.

The National Bureau of Standards published report BMS-65, "Methods of Estimating Loads in Plumbing Systems", by the late Dr. Roy B. Hunter. This report provided tables of load-producing characteristics (fixture unit weighting) of commonly used domestic water fixtures as well as probability curves to estimate the capacity of the system. These curves are the basis for all manufacturers selection of Pressure Booster Systems. Over the years, the industry has further defined the "Hunters Curve" changing the probability of maximum flow in accordance with the type of building, since all structures do not use water in the same manner and frequency.

Special Services

Don't forget that there are sometimes other systems which rely on the plumbing pumps for water make-up, service load, etc. These must be added in after you have determined the domestic fixture load. Examples of this are:

- Cooling Tower make-up water valve
- On-Site commercial laundry facility (Hospitals, Hotels, Dorms, etc.)
- HVAC System make-up load
- Boiler water make-up load
- Swimming pools

Add these services in addition to the GPM arrived at from the charts.

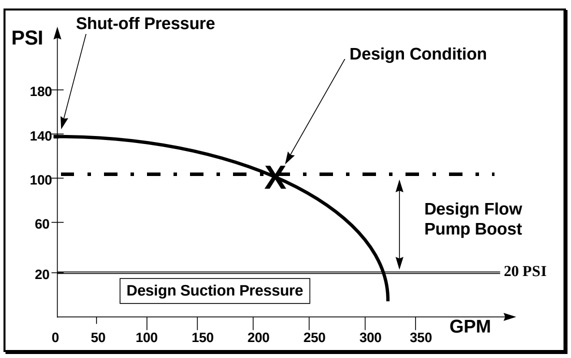
TIP: Remember that when you add for special services, you will not have fixture unit references. You must add in the additional flow rate in gallons per minute AFTER you have used the fixture unit method to arrive at a total system flow rate. When this step is complete, simply add the additional GPM to the total system capacity for the extra services.

SECTION II: SYSTEM CONDITIONS

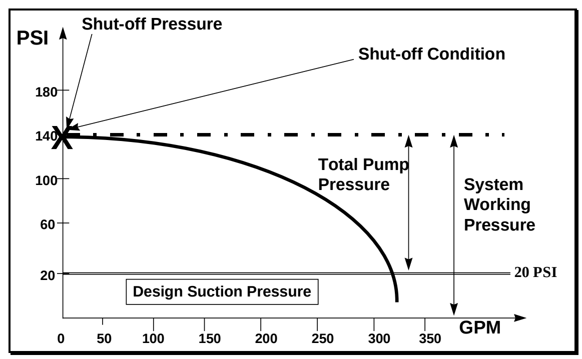
Establish current water system conditions

- Minimum suction pressure; this can typically be found on the Fire Flow Test, which is done on all buildings which require a fire system. Use the maximum design flow based on the flow condition calculated from fixture unit count. **DO NOT ASSUME A MINIMUM SUCTION PRESSURE!** Get this information from consultant or contractor.
- On "cistern" systems, be careful when you have a low NPSH. Suction lift is not recommended for a pressure booster system.
- Figure #5 through #7 explains the potential problems which can arise when an accurate suction pressure is not used to size the booster package.

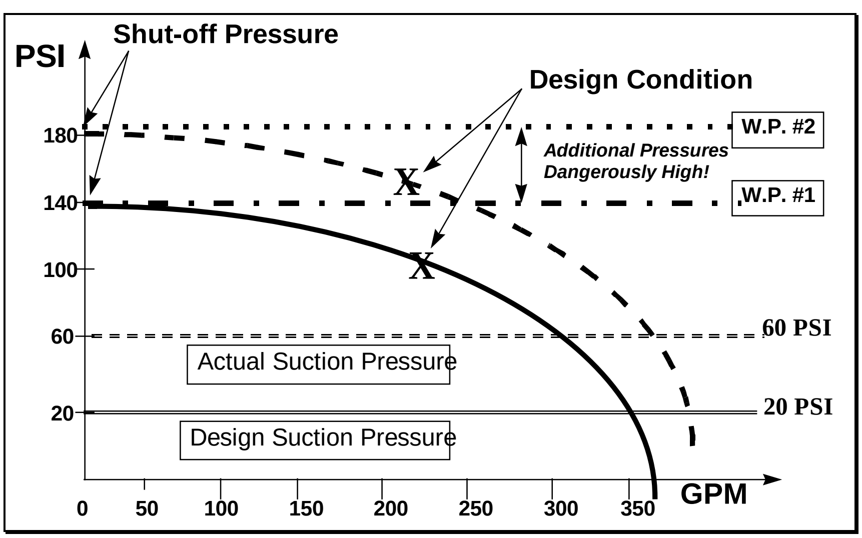
TIP: In some cases, an incorrect suction pressure can contribute to potential problems. For example: If a system is designed using a minimum suction pressure of 20 PSI and a potential pump shutoff pressure of 140 (@ 0 GPM Flow), the capacity of the system could exceed minimum ratings if the suction pressure exceeds 40 PSI! In this case, the system will now EXCEED the 175 PSI working pressure, thereby, requiring a HIGH PRESSURE system design.



Pump design head is based on the minimum available (worst case) suction pressure plus the pump boost



Additional head is achievable when pump moves to shut-off. Although the PRV's will regulate downstream, upstream pressures can rise.



In a worst case scenario as shown in the graphic to the left, when suction pressures are under-estimated, there is a potential that the pressure could exceed the system rated working pressure.

SECTION III: FLOW SPLIT

Select the best capacity split for the GPM capacity.

- In some cases, it is best to use an un-equal split rather than an equal capacity split. Much of this can be determined by either flow analysis (flow recorder mounted on system for a period of time in order to develop a usage pattern) or by some other less technical means. (i.e.: Typical load does not exceed 20% of system capacity for 70% of the day)

Select a system manifold suited for the conditions and maximum flow
Armstrong offers a number of different manifold materials to suit nearly every domestic water need. They are as follows:

- Cast Iron Flanged on either end. (includes (2) blind flange caps)
- Type “K” Copper Manifolds on Series 6500 (due to pump weight)
- Type “L” Copper Manifolds available on all other models
- Type 304 Schedule 10 Stainless Steel fabricated
- Schedule 40 Galvanized Steel fabricated

Size manifolds according to the total system flow rate.

- See Figure #7 below for maximum recommended flows for system headers:

Manifold Size	Maximum Flow (GPM)
3”	300
4”	500
6”	1000
8”	2000
10”	3000

Fig. 7: The above chart represents the maximum recommended flow rates through the Pressure Booster System headers for various manifold sizes.

Rule of Thumb:

Duplex Systems - Un-equal split (33%/67%) becomes more cost effective at 200 GPM or higher.

Triplex Systems - Un-equal split (20%/40%/40%) is more cost effective at 300 GPM or higher.

PROBLEM 1:

1. Apartment building: 15 stories, 10'/story = __________ X .433 = __________ PSI
2. Minimum suction pressure available is 30 PSI.
3. System is a "retro-fit" constructed in 1975 utilizing 3.5 GPF Water Closets.
4. There are 2.5 Baths/Unit, 5 Units per floor, each with a laundry room & kitchen.
5. Total # of Flow units = _______ Based on High Density Apartment Profile = _______ GPM.
6. There is a cooling tower on the roof which has a constant "make-up" demand of 30 GPM.
7. Available voltage is 208/3/60.
8. There is sufficient area at the top floor to mount a drawdown tank if required.
9. There are no special services on site.

System Flow Capacity = __________ GPM

System Output Pressure = __________ PSI

System Header Size is _____________"