PUMP SIZING

The purpose of this presentation is to explain about the methodology used in pump sizing and pump selection.

Written By Ir. Tan Yoke Lee

MIEM, Mi-FIRE E

yokeleetan71@gmail.com

PUMP SIZING

METHODS FOR PUMP SIZING

1. CALCULATE THE FLOW RATE.
   - Flow rate is either given to us by the client or from the demand flow rate calculated. For example, say you want to fill up a tank Q litres in certain t,mins. The flow rate is Q/t in litres/min. Or Q can be the maximum demand for water flow rate, ie peak flow rate of all connected devices.

PUMP SIZING

METHODS FOR PUMP SIZING

2. CALCULATE THE FRICTION LOSS, Pf.
   - Friction loss is the loss of pressure experienced due to the friction experienced by the liquid flowing from the suction tank to the elevated tank, etc.
   - Use the Hazen William equation for friction loss if the medium is water.

$$p = \frac{6.05 \times 10^5}{C^{1.85} \times d^{4.87}} \times L \times Q^{1.85}$$

where

p is the pressure loss in the pipe, in bar;

Q is the flow through the pipe, in litres per minute;

d is the mean internal diameter of the pipe, in millimetres;

C is a constant for the type and condition of the pipe (see Table 22); and

L is the equivalent length of pipe and fittings, in metres.

   - Be careful of the units input into the Hazen William equation. Do not use imperial formula when you intend to key in input in S.I and vice versa.

PUMP SIZING

METHODS FOR PUMP SIZING

Table 22. *C* values for various types of pipe

Type of pipe	Value of *C*
Cast iron	100
Ductile iron	110
Mild steel	120
Galvanized steel	120
Spun cement	130
Cement lined cast iron or ductile iron	130
Cement lined mild steel	130
Stainless steel	140
Copper	140
Reinforced glass fibre	140

NOTE. The list is not exhaustive.

PUMP SIZING

METHODS FOR PUMP SIZING

Table 23. Equivalent length of fittings and valves

Fittings and valves	Equivalent length of steel straight pipe for a *C* value of 120[a] (m)										
	Nominal diameter (mm)										
	20	25	32	40	50	65	80	100	150	200	250
90° Screwed elbow (standard)	0.76	0.77	1.0	1.2	1.5	1.9	2.4	3.0	4.3	5.7	7.4
90° Welded elbow (r/d = 1.5)	0.30	0.36	0.49	0.56	0.69	0.88	1.1	1.4	2.0	2.6	3.4
45° Screwed elbow (standard)	0.34	0.40	0.55	0.66	0.76	1.0	1.3	1.6	2.3	3.1	3.9
Standard screwed Tee or cross (flow through branch)	1.3	1.5	2.1	2.4	2.9	3.8	4.8	6.1	8.6	11.0	14.0
Gate valve - straight way	-	-	-	-	0.38	0.51	0.63	0.81	1.1	1.5	2.0
Alarm or non-return valve (swinging type)	-	-	-	-	2.4	3.2	3.9	5.1	7.2	9.4	12.0
Alarm or non-return valve (mushroom type)	-	-	-	-	12.0	19.0	19.7	25.0	35.0	47.0	62.0
Butterfly valve	-	-	-	-	2.2	2.9	3.6	4.6	6.4	8.6	9.9
Globe valve	-	-	-	-	16.0	21.0	26.0	34.0	48.0	64.0	84.0

[a] These equivalent lengths may be converted as necessary for pipes with other C values by multiplying by the following factors:

C value	100	110	120	130	140
Factor	0.714	0.85	1.00	1.16	1.33

Total length of pipe to be input into Hazen William is summation of straight pipe length and equivalent length of fittings.

PUMP SIZING

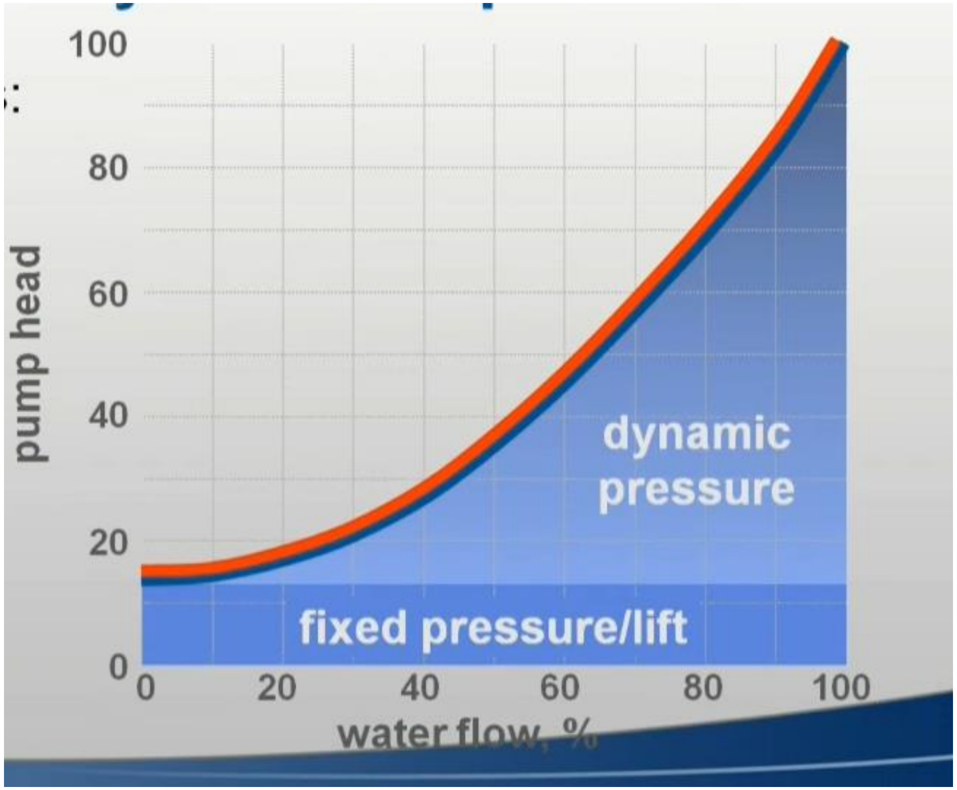
METHODS FOR PUMP SIZING

3. CALCULATE THE STATIC LOSS (H is negative for static gain and positive for static loss)
   - Static loss is the difference in height between the delivery point to the suction tank low level in meters divide by 10 to get static loss in **bar**. H in bar is static gain if the delivered point is lower than the suction tank.
4. CALCULATE RESIDUAL PRESSURE REQUIREMENT (Pr) FOR FURTHEST DEVICE AND CONTROL VALVE PRESSURE DROP.
   - For example, for a shower, the residual pressure requirement is 2 bar for rain water shower. For a water closet, it is 0.3bar to fill up the cistern.
5. APPLY SAFETY FACTOR TO CATER FOR UNCERTAINTY OF FRICTION LOSS
   - The factor of safety to be applied depends on the uncertainty, for long pipe, the Pf calculated in step 2 is quite high, so we can apply a lower factor say 1.2.

PUMP SIZING

METHODS FOR PUMP SIZING

6. WHEN DRAWING SYSTEM CURVE APPLY AFFINITY LAW ONLY TO THE FRICTION COMPONENT.



Head requirement at operation point is Pf x F.S + H + Pr in bar calculated from the previous section for Q l/min .

To draw the entire system curve, first calculate the dynamic pressure requirement for every water flow rate using the formula

$P1/ P2 = (Q1/ Q2)^2$

Then add back the H static loss component and Pr.

PUMP SIZING

METHODS FOR PUMP SIZING

7. UNDERSTAND WHETHER THE FLOW IS FIXED OR VARIES.
8. FOR FIXED FLOW RATE AND FIXED PUMP HEAD SUCH AS WATER TRANSFER FROM TANK TO TANK, USE CONSTANT SPEED PUMP WITH LEVEL SWITCH CONTROL.
    - Note that operating point may not be exact to calculation due to selection of pump unless we can trim the impeller to exact dimension.

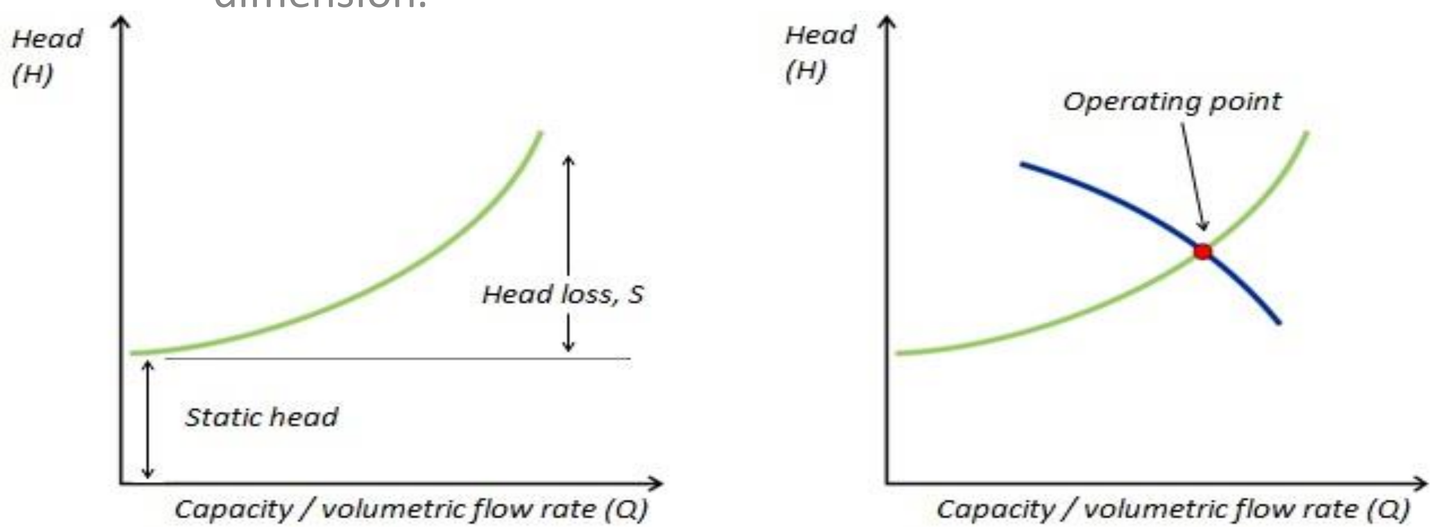
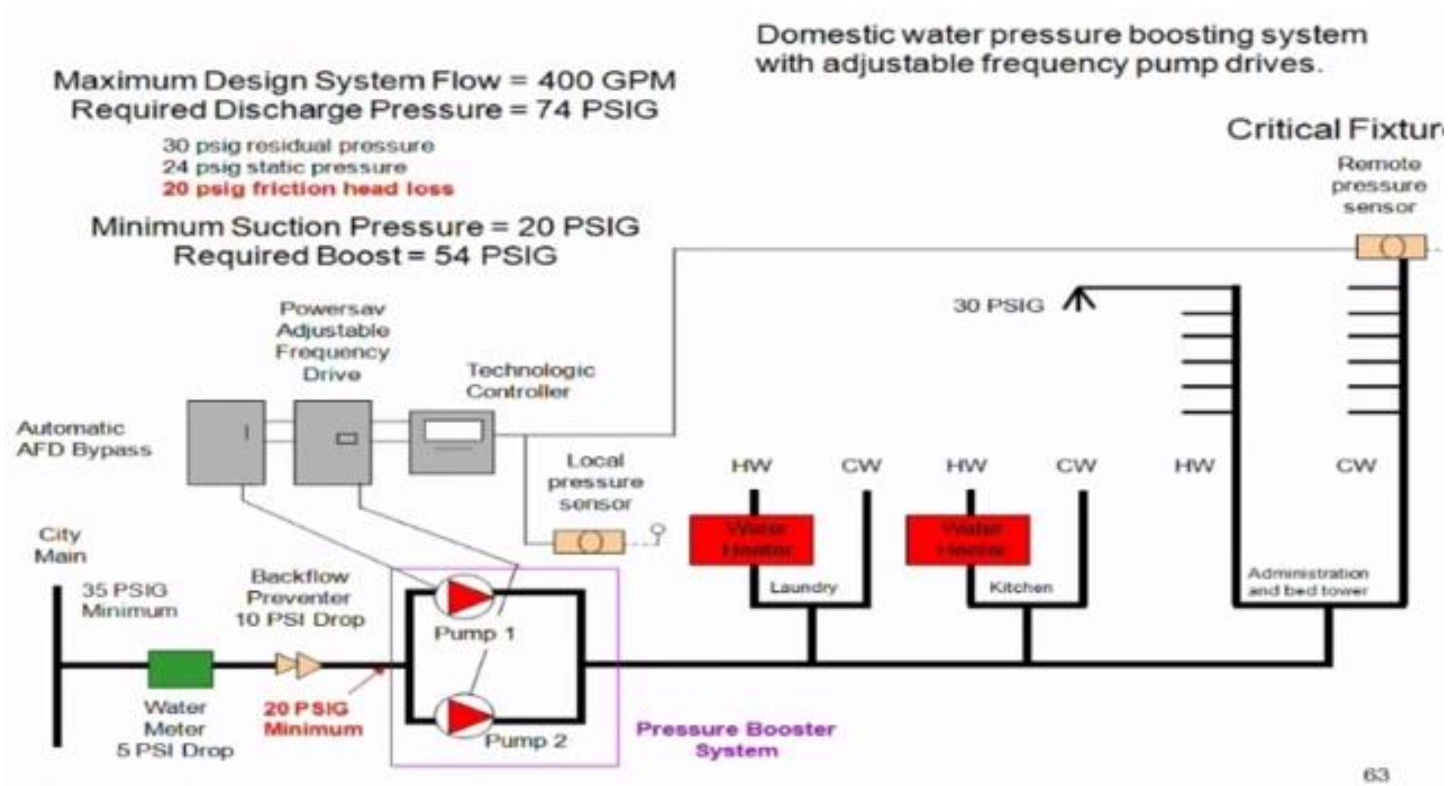


Figure 2. (a) System curve; (b) combining system and pump curves

PUMP SIZING

METHODS FOR PUMP SIZING

9. FOR VARIABLE FLOW AND HIGH FRICTION LOSS AS COMPARED TO STATIC LOSS, USE VSD AND POSITION PRESSURE SENSOR AT MOST CRITICAL FITTING. SENSORS TO BE WIRED DIRECTLY BACK TO CONTROL OR THE REMOTE SENSOR CAN PIGGY BACK ON LOCAL SENSOR NEAR THE PUMP. THE LOCAL SENSOR WILL UPDATE REGULARLY.



PUMP SIZING

METHODS FOR PUMP SIZING

10. FOR VARIABLE FLOW AND ALMOST CONSTANT HEAD, IE VERY LOW FRICTION LOSS, USE FLAT PUMP CURVE WITH CYCLE STOP VALVE, IE THROTTLING. BUT CHECK WHETHER IT IS AGAINST REGULATION IN YOUR COUNTRY. HOWEVER TO ENSURE THAT THE OPERATION POINT IS CLOSE TO BEP (80% TO 110%), MAY NEED TO HAVE 2 OR MORE PUMPS SUCH THAT THE PUMPS ARE SIZED SMALLER TO CATER FOR LOWER FLOW RATE.

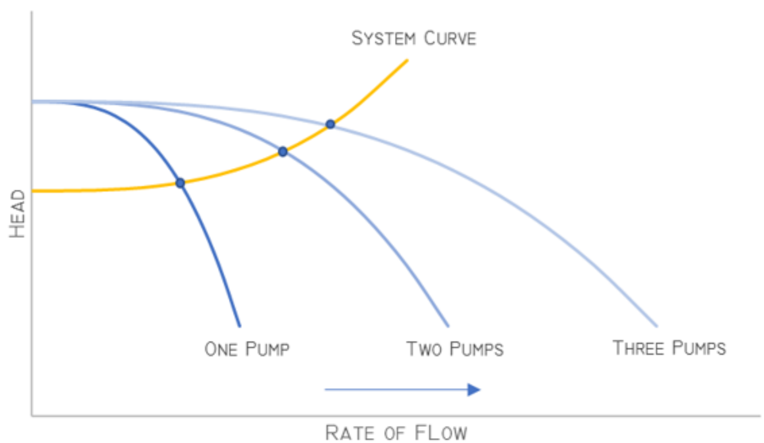
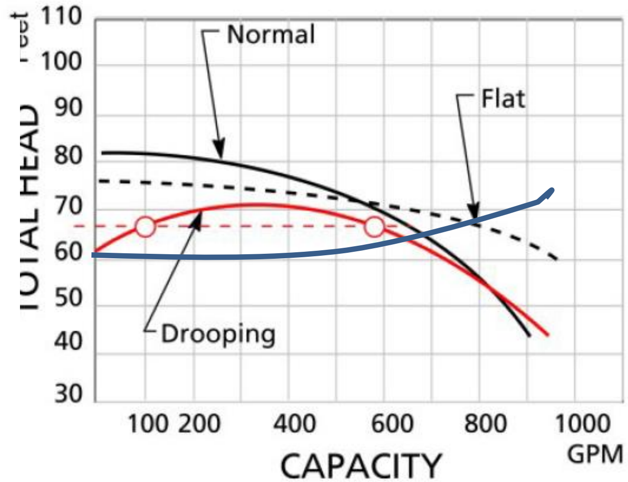


Figure 2. A shallow system curve superimposed on a composite pump curve (parallel). As each additional pump is brought online, the flowrate increases significantly.

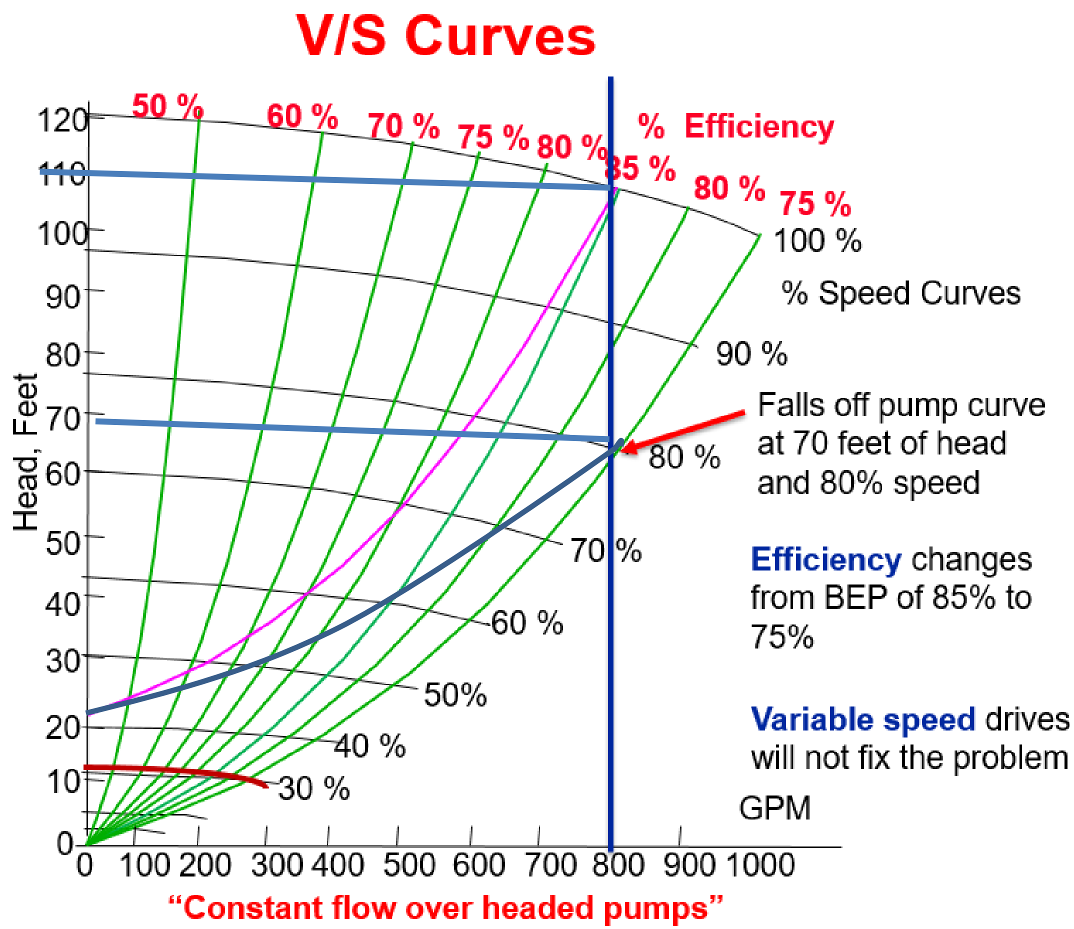


ure 12 Different types of radial pump characteristic ..ve profiles.

PUMP SIZING

METHODS FOR PUMP SIZING

11. CHOOSE PUMP WITH CURVE SUCH THAT SYSTEM OPERATES MOST OF THE TIME BETWEEN 80- 110% BEP FOR VARIABLE FLOW. IF PUMP IS OVERHEADED, OPERATE ONLY AT 80-90% OF BEP TO AVOID PUMP CAVITATION AT LOW SPEED.



Make sure that system curve stays away from end of pump curves at all operation speed.
For eg, if design operation is 800gpm at 70 feet but we overheaded by 50% to 110feet, when we run at 800gpm, we will actually fall into the cavitation zone.

PUMP SIZING

METHODS FOR PUMP SIZING

11. CHOOSE PUMP WITH CURVE SUCH THAT SYSTEM OPERATES MOST OF THE TIME BETWEEN 80- 110% BEP FOR VARIABLE FLOW. IF PUMP IS OVERHEADED, OPERATE ONLY AT 80-90% OF BEP TO AVOID PUMP CAVITATION AT LOW SPEED.

THAT IS WHY IT IS IMPORTANT NOT TO APPLY SAFETY FACTOR TO STATIC PRESSURE LOSS ESPECIALLY WHEN IT IS VERY HIGH. MOST OF THE TIME, WE ARE QUITE SURE OF THE STATIC COMPONENT AND THERE IS NO REQUIREMENT TO APPLY SAFETY FACTOR. WHEN PUMP HEAD SPECIFICATION IS MUCH HIGHER THAN ACTUAL OPERATING HEAD, THE PUMP MAY RUN AT THE END OF PUMP CURVE AND GOES INTO CAVITATION.

MOREOVER, IF THE PUMP POWER REQUIREMENT INCREASES WITH FLOW, THE MOTOR PROVIDED MAY NOT BE SUFFICIENT, CAUSING THE PUMP MOTOR TO HAVE SHORTER SERVICE LIFE OR BURN OUT.

PUMP SIZING

CONTROL SYSTEM FOR PUMPS

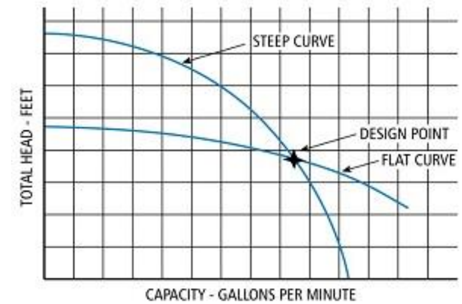
1. SUCTION TO ELEVATED TANK WATER TRANSFER:-
   - USE CONSTANT SPEED PUMP. AVOID VSD AS THE PRECISE FLOW RATE IS NOT IMPORTANT AND WE CAN ALLOW SYSTEM TO RIDE ON THE PUMP CURVE.
   - FOR LARGE PUMPS USE SOFT STARTER FOR STARTING.
   - IF MORE THAN 1 ELEVATED TANKS, PARALLEL ALL LEVEL SWITCHES FOR START CONTROL AND SERIES ALL LEVEL SWITCHES FOR STOP CONTROL.
   - PUMP WILL OPERATE ONCE ANY ELEVATED TANK IS LOW LEVEL.
   - PUMP WILL STOP ONCE ALL ELEVATED TANKS ARE FULL.

PUMP SIZING

CONTROL SYSTEM FOR PUMPS

2. SUCTION TO ELEVATED TANK WATER TRANSFER (**DISTANCE ELEVATED TANK**):-
   - USE CONSTANT SPEED PUMP. AVOID VSD.
   - FOR LARGE PUMPS USE SOFT STARTER FOR STARTING.
   - SINCE TANK IS FAR AWAY LEVEL SWITCH CONTROL WITH CABLING IS DIFFICULT TO IMPLEMENT.
   - INSTALL TIMER TO START PUMPS DURING OFF PEAK TARIFF. ALTERNATIVELY PUMP STARTS WHEN ALTITUDE VALVE OPENS AND PRESSURE SWITCH DETECTS LOW PRESSURE
   - WHEN ELEVATED TANK IS FULL, ALTITUDE VALVE CLOSES AND PUMP STOPS FROM PRESSURE SWITCH DETECTION NEXT TO PUMP.
   - DRY PROTECTION APPLIES AS USUAL.

PUMP SIZING



A Steep Curve and a Flat Curve Pump for a Given Design Condition
Figure 35

CONTROL SYSTEM FOR PUMPS

3. WATER BOOSTER APPLICATION:-
   - USE VARIABLE SPEED PUMP.
   - CHOOSE STEEP PUMP CURVE FOR THE VSD APPLICATION.
   - INSTALL PRESSURE SENSOR AT MOST REMOTE APPLICATION AND SET PUMP TO START TO MAINTAIN REQUIRED PRESSURE HEAD AT REMOTE SENSOR.
   - HYDROPNEUMATIC TANK AIR PRESSURE TO SET TO A PRESSURE 2PSI BELOW **START PRESSURE**
   - PUMP STARTS AT LOW PRESSURE. WILL PUMP TO TANK AND ALSO FITTINGS.
   - TANK WILL BE SLOWLY FILLED UNTIL PUMP STOPS AT CUT OFF PRESSURE.
   - PUMP WILL STOP WHEN HIGH PRESSURE IS DETECTED AT PRESSURE SWITCH.
   - DURING OFF PEAK, WATER IS DISCHARGED FROM TANK TO PREVENT FREQUENT START STOP OF PUMP.