YORK® APPLICATION DATA

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668

Form 1505.25-AD

WATER PIPING

TABLE OF CONTENTS

GENERAL

Water lines should be selected for optimum size with respect to:

1. Initial Cost
2. Operation and Maintenance Cost
3. Water Velocity
4. Pressure Drop

It is desirable to have line sizes as small as possible from the standpoint of low initial cost. However, small pipe sizes produce high water velocity and pressure drop. High water velocity may result in noise problems as well as rapid erosion and early failure of the pipe. High pressure drop will increase pump operating cost and may require a larger size pump.

DEFINITIONS

1. APPROACH – Is the difference in degrees F. between the temperature of the water leaving the tower basin and the wet bulb temperature of the air entering the cooling tower.

2. BLEED-OFF – Is the wasting to the drain of a small part of the circulating water to control the buildup and concentration of scale forming chemicals in the water.

3. COOLING RANGE – Is the number of degrees F. which the water is cooled while passing through the cooling tower. It is the difference in temperature of the water entering the cooling tower and the water leaving the tower basin.

4. DRIFT – Is the amount of water lost in the form of droplets which is carried away by the circulating air. Drift is completely independent of evaporation loss.

5. EQUIVALENT FEET – Any component in a water piping system creates friction loss (Pressure Drop). Tests have established the rate of friction loss in terms of length of straight pipe. For example, an elbow with a rating of 5 equivalent feet has the same friction loss as 5 feet of straight pipe.

6. MAKE-UP – Is the water required to be added to the system to replace that which has been lost due to evaporation, drift, bleed-off or leakage.

ABBREVIATIONS

1. FPS – Feet Per Second, Velocity
2. GPM – Gallons Per Minute, Flow Rate
3. PSI – Pounds Per Square Inch, Pressure
4. EQ. FT. – Equivalent Feet

CONVERSION VALUES

1. Pressure drop may be given in feet of water or pounds per square inch. To convert:

   (a) Pounds per square inch to feet of water multiply by 2.31.

   (b) Feet of water to pounds per square inch multiply by .434.

2. 1 cubic foot of water = 7.48 Gallons
   = 62.4 Pounds

3. 1 gallon of water = 8.34 Pounds
   = 0.133 Cubic Feet

WATER PIPING CLASSIFICATION

There are two primary classifications of water piping systems:

1. Once through type where water flows from a reservoir through piping to the equipment and is relieved to a different reservoir.

2. Re-circulation type where water flows from a reservoir through piping to the equipment and is returned to the original reservoir for re-circulation.

Systems are further classified as:

1. Open – when water is brought in close contact with air in the reservoir.

2. Closed – when water does not come in close contact with air in the reservoir.

An Open Expansion Tank does not constitute an open system as the water contact with the air is very limited.

EXAMPLES:

1. Open once through type:

   (a) City water system.

   (b) Water cooled condenser of air conditioner with regulating value discharging water to drain.

2. Open re-circulation type:

   (a) Water cooled condenser of air conditioner operated with cooling tower.

3. Closed re-circulation type:

   (a) Water chiller with coil heat exchanger for cooling and de-humifying the air.

   (b) Hot water boiler with coil heat exchanger for heating the air.

All piping systems have at least one point where atmospheric pressure is exerted on the surface of the water. This is the reference point for determination of hydrostatic lift imposed on the pump. The hydrostatic lift is the vertical distance in feet between the water level on the suction side of the pump and the highest water level on the discharge side of the pump.

In an open system, the suction reservoir may be at a different elevation than the discharge reservoir. The pump must overcome the frictional losses of the system, plus the hydrostatic lift, or the difference in elevation between the two reservoirs. Refer to FIG. 1.

In a closed system a pump must overcome only the frictional resistance of the system. The discharge reservoir is also the suction reservoir so there is no difference in elevation and consequently no hydrostatic lift for the pump to overcome. See FIG. 2.

PIPE SIZING

The design of a piping system is limited by:

1. Maximum velocity permissible which is established by:

   (a) Noise generated by water flowing through piping.

   (b) Erosion of piping by water and entrained sand, air and other foreign particles.

2. Friction loss:

   (a) Once through systems must be sized to provide the required flow at a pressure loss within the pressure available after all other losses (Condenser Pressure Drop, Hydrostatic and Line, Valve and Fitting Losses) have been deducted.

   (b) Re-circulating pump systems are sized to provide a reasonable balance between increased pumping horsepower due to high friction loss and increased piping first cost due to larger pipe sizes.

DESIGN LIMITATIONS:

1. Velocity – between 3 and 10 feet per second.

2. Friction Loss – maximum 20 feet per 100 feet equivalent length.

The system should be laid out with valves, fittings, length of runs and water quantities shown for all mains and branches. The size of the mains should be determined first and tabulated as shown in Table 6. The pressure should be indicated at the points in the system where branch runouts are taken. It will then be possible to determine the available pressure drop across each unit being fed from the main system so that pipe, valves and fitting sizes may be determined. In this way, it may be possible to use smaller sizes of branch runouts than would normally be considered good practice. All available pressure drop should be used in the branch to require a minimum of adjustment to equalize pressures and volume of flow.

Each pipe size selection should include a comparison between the initial installation cost and the operation and maintenance cost. Good engineering practice may permit the selection of more than one size for a given rate of flow.

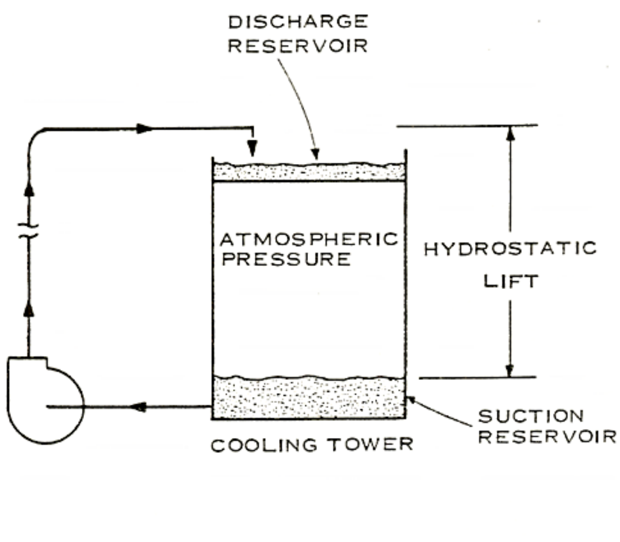


FIG. 1— Hydrostatic Lift

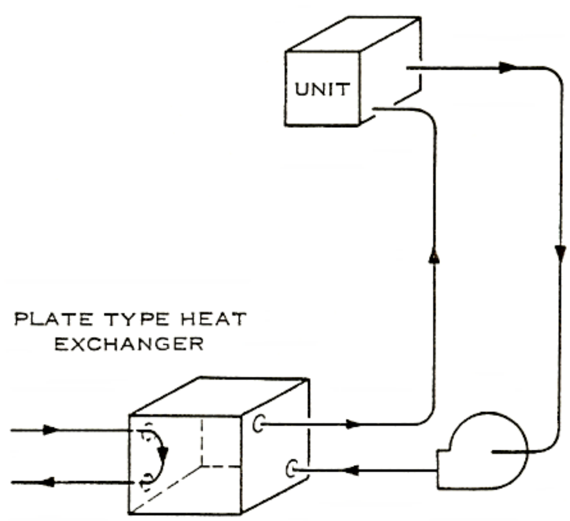


FIG. 2— Closed Water System

TABLE 1— STANDARD SCHEDULE 40 PIPE

Nominal Size Inches	External Diameter Inches	Internal Diameter Inches	Cross-Sectional Internal Area		Volume
			Sq. In. (In^2)	Sq. Ft. (Ft^2)	Gallon Per Foot Length
1/2	0.840	0.622	0.304	0.00211	.0158
3/4	1.050	0.824	0.533	0.00370	.0277
1	1.315	1.049	0.864	0.0060	.0449
1-1/4	1.660	1.380	1.50	0.0104	.0777
1-1/2	1.900	1.610	2.04	0.0142	.1058
2	2.375	2.067	3.36	0.0233	.174
2-1/2	2.875	2.469	4.79	0.0333	.249
3	3.500	3.068	7.39	0.0513	.384
3-1/2	4.000	3.548	9.89	0.0686	.514
4	4.500	4.026	12.7	0.0883	.661
5	5.563	5.047	20.0	0.139	1.04
6	6.625	6.065	28.9	0.2005	1.50

TABLE 2— SEAMLESS COPPER TUBING

Size Inches O. D.	Nominal Pipe Size Inches	External Diameter Inches	Type	Internal Diameter Inches	Thickness of Metal Inches	Cross-Sectional Internal Area		Volume
						Sq. In. (In^2)	Sq. Ft. (Ft^2)	Gallon Per Foot Length
3/8	1/4	.375	K	0.305	0.035	0.073	.000507	.00379
			L	0.315	0.030	0.078	.000540	.00404
1/2	3/8	.500	K	0.402	0.049	0.127	.000882	.00660
			L	0.430	0.035	0.145	.00101	.00753
5/8	1/2	.625	K	0.527	0.049	0.218	.00151	.0113
			L	0.545	0.040	0.233	.00162	.0121
3/4	5/8	.750	K	0.652	0.049	0.334	.00232	.0174
			L	0.666	0.042	0.348	.00242	.0181
7/8	3/4	.875	K	0.745	0.065	0.436	.00302	.0227
			L	0.785	0.045	0.484	.00336	.0250
1-1/8	1	1.125	K	0.995	0.065	0.778	.00540	.0405
			L	1.025	0.050	0.825	.00573	.0442
1-3/8	1-1/4	1.375	K	1.245	0.065	1.22	.00847	.0634
			L	1.265	0.055	1.26	.00875	.0655
1-5/8	1-1/2	1.625	K	1.481	0.072	1.72	.0119	.0894
			L	1.505	0.060	1.78	.0124	.0925
2-1/8	2	2.125	K	1.959	0.083	3.01	.0209	.157
			L	1.985	0.070	3.10	.0215	.161
2-5/8	2-1/2	2.625	K	2.435	0.095	4.66	.0324	.242
			L	2.465	0.080	4.77	.0331	.247
3-1/8	3	3.125	K	2.907	0.109	6.64	.0461	.345
			L	2.945	0.090	6.81	.0473	.354
3-5/8	3-1/2	3.625	K	3.385	0.120	9.00	.0624	.468
			L	3.425	0.100	9.21	.0640	.478
4-1/8	4	4.125	K	3.857	0.134	11.7	.0812	.607
			L	3.905	0.110	12.0	.0834	.623
5-1/8	5	5.125	K	4.805	0.160	18.1	.126	.940
			L	4.875	0.125	18.7	.130	.971
6-1/8	6	6.125	K	5.741	0.192	25.9	.179	1.35
			L	5.845	0.140	26.8	.186	1.39

TABLE 3— VELOCITY (FPS) & PRESSURE DROP (Ft. of Water Per 100 Ft.) OF FAIRLY ROUGH PIPE

	Nominal Pipe Diameter, Inches											
	1/2		3/4		1		1-1/4		1-1/2		2	
GPM	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop
	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water
1	1.7	4.1										
2	3.2	15.5										
3	4.9	34.6	2.2	4.6								
4	6.5	57.8	2.9	8.3								
5	8.2	90.1	3.8	13.2	2.1	3.1						
10			7.5	48.5	4.2	11.8	2.7	4.2				
15			11.5	106	6.3	23.3	4.0	9.0	2.8	3.5		
20					8.4	46.2	5.4	15.5	3.7	6.0		
25					11.0	69.3	6.8	23.1	4.6	9.2	2.7	2.3
30							8.0	33.5	5.6	13.4	3.1	3.2
40							11.0	55.5	7.2	22.0	4.1	5.3
50									9.2	35.0	5.2	8.7
60									11.0	48.5	6.2	12.0
70											7.3	16.2
80											8.3	21.3
90											9.4	27.8
100											11.0	34.5

	Nominal Pipe Diameter, Inches											
	2-1/2		3		3-1/2		4		5		6	
GPM	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop
	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water
40	2.7	1.8										
50	3.3	2.9										
60	4.0	4.0	2.8	1.8								
70	4.6	5.4	3.2	2.3								
80	5.3	6.9	3.8	3.0								
90	6.0	8.7	4.2	3.7	3.0	1.7						
100	6.7	11.0	4.7	4.6	3.5	2.1	2.7	1.1				
150	10.0	23.1	7.0	10.2	5.1	4.6	3.9	2.3	2.6	.8		
200	13.0	40.4	9.3	16.7	6.8	8.1	5.1	3.9	3.4	1.4		
250			12.0	25.4	8.5	14.3	6.4	6.0	4.2	2.2		
300					10.0	16.4	7.5	8.3	5.0	3.0	3.4	1.1
400					13.5	30.0	10.0	14.3	6.7	5.2	4.7	2.1
500							13.0	22.4	8.4	8.1	5.8	3.2
600									10.0	11.3	6.9	4.4
700									12.0	14.8	8.0	6.0
800									13.5	19.2	9.1	7.9
900									15.0	24.2	10.5	9.7
1000											11.5	11.6
1500											17.5	25.4

TABLE 4— VELOCITY (FPS) & PRESSURE DROP (Ft. of Water per 100 Ft.) OF TYPE L SMOOTH COPPER TUBING

	Seamless Tubing O.D. Inches											
	5/8		7/8		1-1/8		1-3/8		1-5/8		2-1/8	
GPM	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop
	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water
1	1.4	2.8										
2	2.7	8.3										
3	4.2	16.4	2.0	3.0								
4	5.6	27.7	2.7	4.9								
5	7.0	39.2	3.4	7.4								
10			6.7	24.3	3.9	6.7						
15			10.0	48.5	5.9	13.4	3.8	5.1				
20					7.8	21.7	5.1	8.3	3.6	3.7		
25					9.7	32.4	6.4	12.5	4.5	5.7		
30					11.7	44.0	7.7	16.9	5.4	7.5	3.1	2.1
40							10.2	27.8	7.2	12.5	4.2	3.5
50							12.8	40.5	9.1	18.5	5.2	5.1
60									10.8	24.7	6.2	6.9
70									12.6	32.4	7.2	9.3
80											8.3	11.5
90											9.3	13.9
100											10.4	16.7

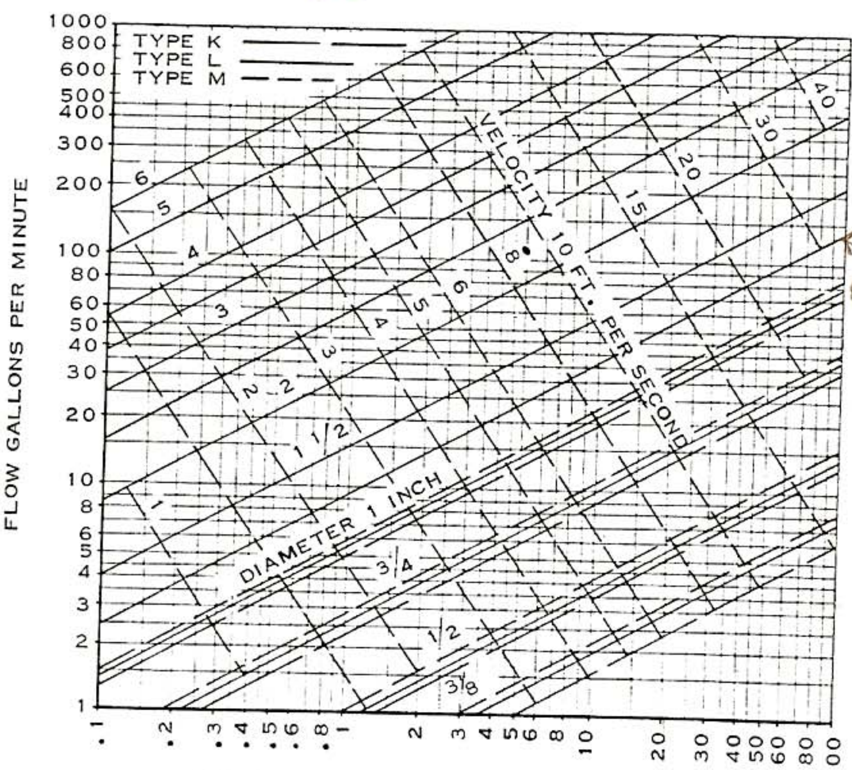
	Seamless Tubing O. D. Inches											
	2-5/8		3-1/8		3-5/8		4-1/8		5-1/8		6-1/8	
GPM	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop	Vel.	Pres. Drop
	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water	FPS	Ft. Water
50	3.4	1.7										
60	4.1	2.5										
70	4.7	3.2	3.3	1.4								
80	5.4	3.9	3.8	1.7								
90	6.0	4.9	4.3	2.2								
100	6.8	6.0	4.7	2.8	3.5	1.3						
150	10.1	11.8	7.1	5.3	5.2	2.7	4.0	1.4				
200	13.5	19.2	9.5	8.6	7.0	4.2	5.4	2.3	3.5	.8		
250			11.8	13.2	8.7	6.5	6.7	3.5	4.3	1.2		
300					10.6	8.8	8.0	4.4	5.2	1.6	3.6	.7
400					14.0	14.4	10.8	7.6	7.0	2.8	4.8	1.2
500							13.4	11.1	8.6	3.9	6.0	1.7
600									10.4	5.5	7.2	2.5
700									12.0	7.2	8.4	3.2
800									13.7	9.3	9.6	3.9
900											10.8	4.9
1000											12.0	5.8
1500											18.0	12.5

TABLE 5— RESISTANCE OF VALVES AND FITTINGS, EQUIVALENT LENGTH STRAIGHT PIPE IN FEET

Nominal Pipe Size Inches	Inside Diameter, Inches Schedule 40 Pipe	Gage Valve Full Open	Globe Valve Full Open	Angle Valve Full Open	Swing Check Valve Full Open	Standard 45° Elbow	Standard 90° Elbow	Long Sweep 90° Elbow or Run Through Tee	Standard Tee Thru Side Outlet
1/2	0.622	.3	16	8	4.3	.8	1.5	1.0	3.0
3/4	0.824	.5	21	11	5.5	1.0	2.0	1.5	4.5
1	1.049	.6	26	14	7.0	1.3	2.5	2.0	5.5
1-1/4	1.380	.8	35	18	9.3	1.6	3.5	2.5	7.5
1-1/2	1.610	.9	43	20	11.0	2.0	4.5	3.0	9.0
2	2.067	1.2	54	25	14.0	2.5	5.0	3.5	12.0
2-1/2	2.469	1.4	65	31	17.0	3.0	6.5	4.0	14.0
3	3.068	1.7	80	40	21.0	3.8	8.0	5.0	17.0
3-1/2	3.548	2.0	95	45	24.0	4.5	10	6.0	20.0
4	4.026	2.5	110	51	28.0	5.0	11	7.0	22.0
5	5.047	3.0	140	70	35.0	6.0	14	9.0	26.0
6	6.065	3.5	160	80	42.0	8.0	16	10.0	33.0

↑ flow rate & FPM
FPM ↓ drop ↑ ? Inc

total stim length + 25%
to add for fittings



what is type L the only spec pipe for over 1"?

- How is velocity an issue?

NOTE: DIAMETERS ARE EXPRESSED AS NOMINAL PIPE SIZE
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FIG. 3— Resistance to Flow of Water Through Smooth Copper Tubing

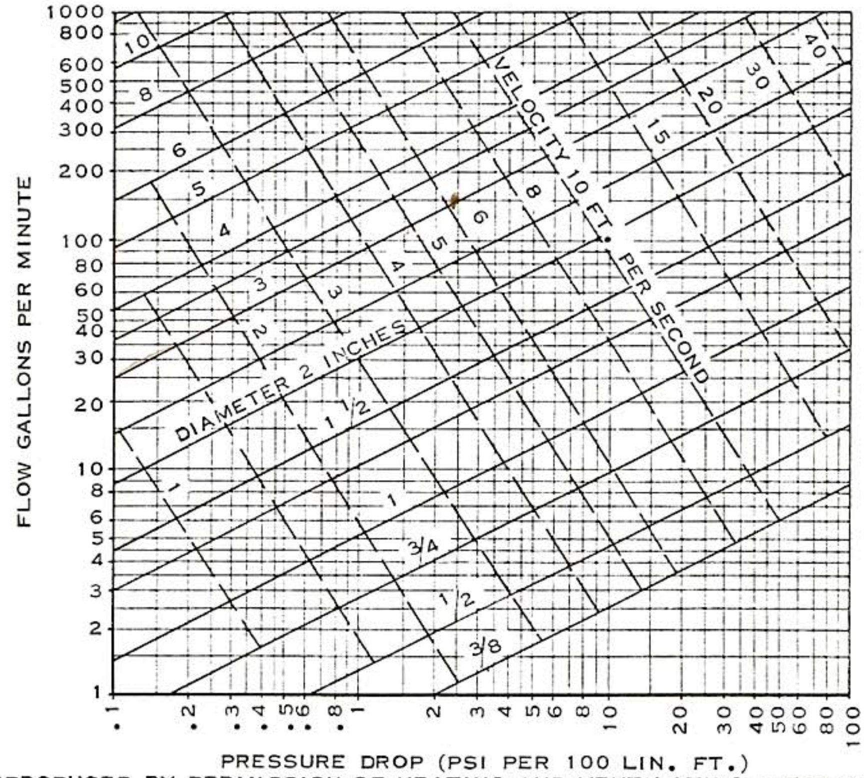


FIG. 4— Resistance to Flow of Water Through Fairly Smooth Pipe

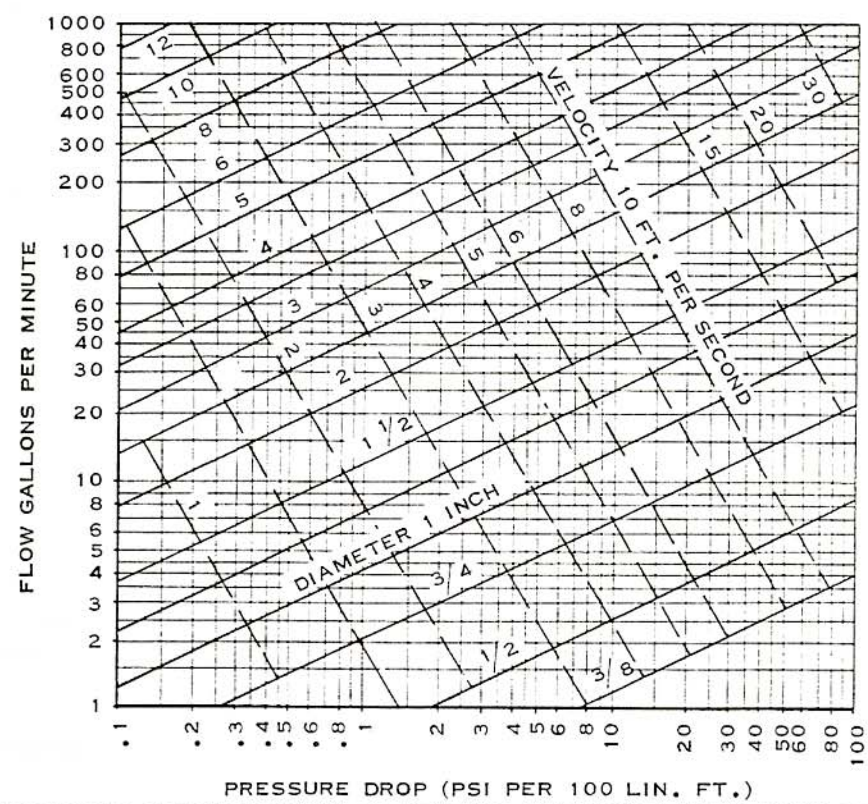


FIG. 5— Resistance to Flow of Water Through Fairly Rough Pipe

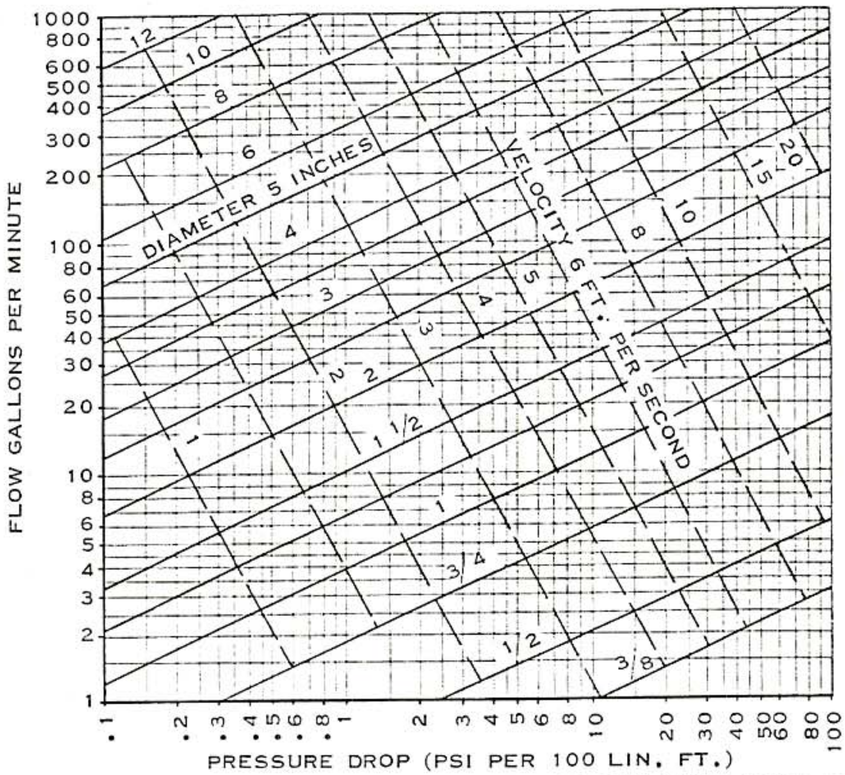


FIG. 6— Resistance to Flow of Water Through Rough Pipe

* Is there a loss per 100' that can be used for fitting's ?

WATER PIPING FOR COOLING TOWER SYSTEM

To select the proper water piping for a cooling tower system, the following information must be available:

1. Gallons of water per minute to be circulated.
2. Total length of piping.
3. Pressure drop across condenser (this varies widely and must be obtained from equipment manufacturer).
4. Hydrostatic lift of tower.
5. Number of valves, fittings and any other resistances in piping system.
6. Type of pipe used (Copper Tubing or Iron Pipe).

Sample Selection: (Refer to Fig. 7)

1. 30 GPM of water to be circulated.
2. 80 Ft. of total piping.
3. 11.4 PSI pressure drop across condenser at 30 GPM.
4. 5 Ft. hydrostatic lift of tower.
5. 6 standard 90° elbows
   2 gate valves
   1 standard tee thru side outlet
   1 standard tee straight thru
6. Schedule 40 Pipe (Assume to have "Fairly Rough" interior surface)

Solution:

Make preliminary selection of 1-1/2" standard schedule 40 pipe as Table 3 gives 5.6 feet per second velocity at flow rate of 30 GPM.

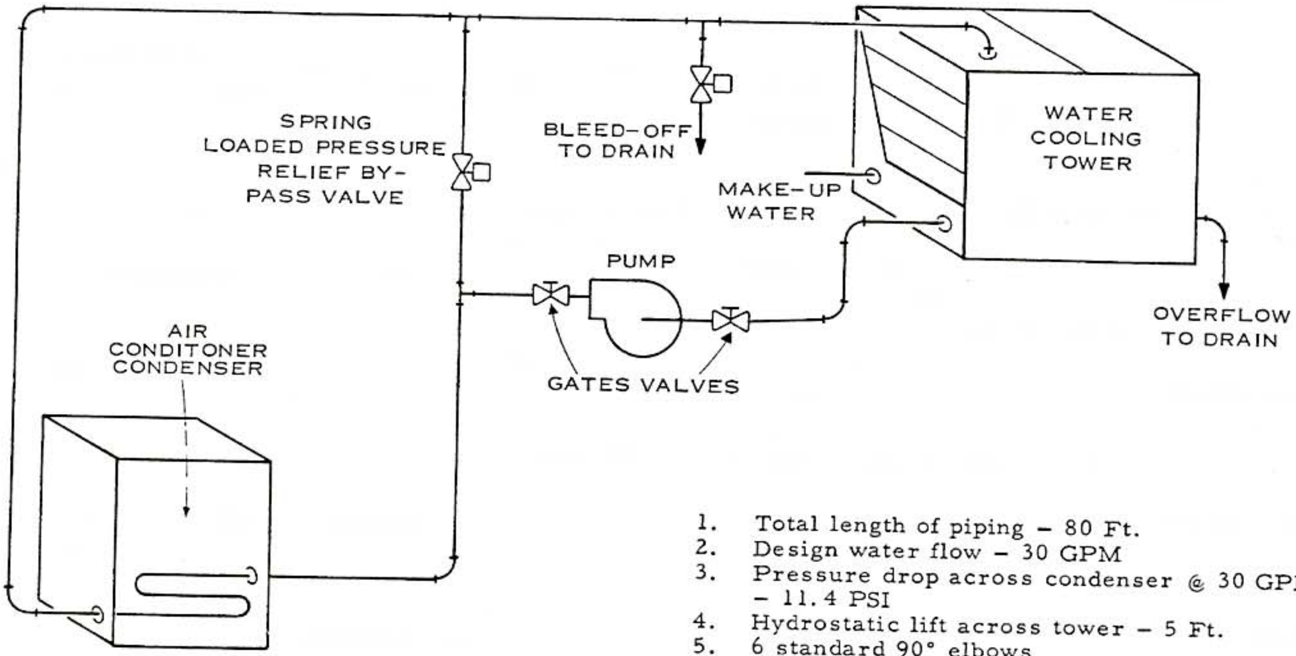
80 feet of 1-1/2" standard pipe	= 80.0
6 standard 90° elbows @ 4.5 Ft. (Table 5)	= 27.0
2 gate valves @ .9 Ft. (Table 5)	= 1.8
1 standard tee side outlet @ 7.5 (Table 5)	= 7.5
1 standard tee straight thru @ 3.0 (Table 5)	= 3.0
TOTAL EQUIVALENT FEET	119.3

From Table 3 the pressure drop for 30 GPM of water flowing thru 1-1/2" standard pipe is 13.4 feet per 100 feet of pipe.

1598.62 15.98

$$\frac{13.4 \text{ Ft. of water} \times 119.3 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 16.0 \text{ Ft. of water}$$

↑ Explain wht 13.4 x 119.3 occurs !



1. Total length of piping – 80 Ft.
2. Design water flow – 30 GPM
3. Pressure drop across condenser @ 30 GPM – 11.4 PSI
4. Hydrostatic lift across tower – 5 Ft.
5. 6 standard 90° elbows
6. 2 Gates valves
7. 1 standard tee thru side outlet
8. 1 standard tee straight thru

FIG. 7 — Typical Water Cooling Tower Arrangement

Pressure drop due to pipe and fittings	= 16.0 Ft.
Pressure drop due to cond. (11.4 psi × 2.31 Ft./psi)	= 26.3 Ft.
Pressure drop due to hydrostatic lift	= 5.0 Ft.
TOTAL Head for selection of pump	= 47.3 Ft

Select a pump to circulate 30 GPM of water operating against a total head of 48 feet.

The 1-1/2" pipe is satisfactory since the velocity and friction loss are within recommended limits.

If a 2" pipe had been selected, the water velocity and friction loss would be less with corresponding lower pump horsepower requirement but with greater initial cost due to the larger size pipes, valves and fittings. (Would require a pump capable of circulating 30 GPM of water operating against a total head of 36 feet.)

If a 1-1/4" pipe had been selected, the water velocity and friction loss would be greater with corresponding higher pump horsepower requirement but with lower initial cost due to the smaller size pipes, valves and fittings. (Would require a pump capable of circulating 30 GPM of water operating against a total head of 69 feet.) It is quite probable that the total operating head pressure difference between 48 feet with 1-1/2" pipe and 69 feet with 1-1/4" pipe would require a larger pump motor.

Refer to Table 7 which is a typical pump selection table. Using the above figures, 30 GPM of water with a 48 foot head would require a model 1/2P100 pump but with a 69 foot head, a model 1P100 pump is required. This indicates the same size pump would be used but mated with a larger motor.

PREVAILING WINDS

Locate tower so prevailing winds are in same direction as tower discharge air. A strong wind blowing into the tower discharge can greatly reduce air flow thru the tower.

COOLING TOWER PUMP

Locate pump so that it discharges to the condenser.

To assure pump priming, the suction level to the pump must be lower than the water level in the tower basin.

VALVES

Install service or shutoff valves where needed to perform maintenance or service. Should be gate type to minimize pressure drop penalty on system.

Balancing valves should be installed to regulate the flow of water in the system. Required where the pressure from pump or main is sufficient to cause excessive flow. Recommend globe valve or square-head plug cock which provides pressure loss in proportion to valve opening.

Check valves are used to prevent reversal of flow during the off cycle. Swing check valves recommended.

WATER REGULATING VALVE

A water regulating valve normally is not needed with a cooling tower but may be used when it is desirable to maintain close control of the condensing pressure. When used, the pressure drop across the valve must be included when calculating the system pressure drop.

hen a water regulating valve is included, a spring loaded pressure relief bypass valve must be installed between the pump discharge and the inlet to the tower (See Fig. 7). This maintains a constant head on the pump as the water regulating valve opens and closes.

BLEED-OFF

Bleed-off is absolutely necessary to control the concentration of scale forming minerals in the water system unless make-up water treatment is able to eliminate the need. The bleed-off line should be installed in the hot water line near the top of the tower. This will permit bleed-off only when the pump is operating.

A valve or controller should be installed in the bleed-off line to regulate the amount of flow. The line should be routed to a drain or to tower overflow pipe.

The amount of bleed-off required depends upon the cooling range, rate of water circulation and the local water conditions. It is impossible to provide a specific bleed-off rate due to the variables involved. A suggested bleed-off rate for 10° to 15° cooling range is 1/2 percent of circulation rate (.005 × GPM circulated).

WATER PIPING FOR CLOSED RE-CIRCULATION SYSTEM

o select the proper water piping for a closed re-circulation system, the following information must be available:

1. Total gallons per minute of water to be circulated as well as gallons per minute to be circulated in each branch run.
2. Layout of system showing lengths of all runs with location of units, valves and fittings.
3. Pressure drop across condensers and heat exchanger (this varies widely and must be obtained from equipment manufacturer).
4. Type of pipe to be used.

Sample Selection: (Refer to Fig. 8)

1. 60 GPM total water to be circulated.
2. Length of runs with units, valves and fitting as shown in Fig. 8.
3. Pressure Drop.
   (a) 11.3 feet of water each unit condenser at 10 GPM flow rate.
   (b) 15.0 feet of water for plate type heat exchanger at 60 GPM flow rate.
4. Schedule 40 pipe (assume to have "fairly rough" interior surface).

Solution: (Refer to Fig. 8)

1. Select pipe sizes for most remote run which will determine pressure drop of system. In this example, circuit a-d-g-h-k-l.

   For fairly rough pipe, the velocity and pressure drop may be obtained from Table 3. For copper tubing or other roughness of pipe, refer to Fig. 3 thru 6.

   (a) Run (a-b) 60 GPM; try 2" pipe as this gives a velocity of 6.2 FPS which is within recommended limits.

Length of pipe	= 3.0	EQ. FT.
1 gate valve (Table 5)	= 1.2	
TOTAL EQUIVALENT FT	= 4.2	

From Table 3, at 60 GPM with 2" pipe, the pressure drop is 12.0 feet of water per 100 feet of length.

$$\frac{12.0 \text{ Ft. of water} \times 4.2 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = .5 \text{ Ft. of water}$$

Record this and following calculations in tabulation form as illustrated in Table 6.

(b) Run (b-c) at 60 GPM flow rate, pressure drop is 15.0 feet of water for plate type heat exchanger as given as data in sample selection section.

(c) Run (c-d) 60 GPM; use 2" pipe as selected for run (a-b).

Length of pipe	= 15.0	EQ. FT.
1 gate valve (Table 5)	= 1.2	
TOTAL EQUIVALENT FT	= 16.2	

$$\frac{12.0 \text{ Ft. of water} \times 16.2 \text{ EQ. FT}}{100 \text{ Linear Ft.}} = 1.9 \text{ Ft. of water}$$

(d) Run (d-e) 30 GPM; Try 1-1/2" pipe as this gives a velocity of 5.6 FPS which is within recommended limits.

Length of pipe	= 28.0	EQ. FT.
Std. tee thru run (Table 5)	= 3.0	
Std. 90° elbow (Table 5)	= 4.5	
TOTAL EQUIVALENT FT	= 35.5	

From Table 3, at 30 GPM with 1-1/2" pipe, the pressure drop is 13.4 feet of water per 100 feet of length.

$$\frac{13.4 \text{ Ft. of water} \times 35.5 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 4.8 \text{ Ft. of water}$$

(e) Run (e-f) 20 GPM; try 1-1/4" pipe as this gives a velocity of 5.4 FPS which is within recommended limits.

Length of pipe	= 8.0	EQ. FT.
Std. tee thru run (Table 5)	= 2.5	
TOTAL EQUIVALENT FT	= 10.5	

From Table 3, at 20 GPM with 1-1/4" pipe, the pressure drop is 15.5 feet of water per 100 feet of length.

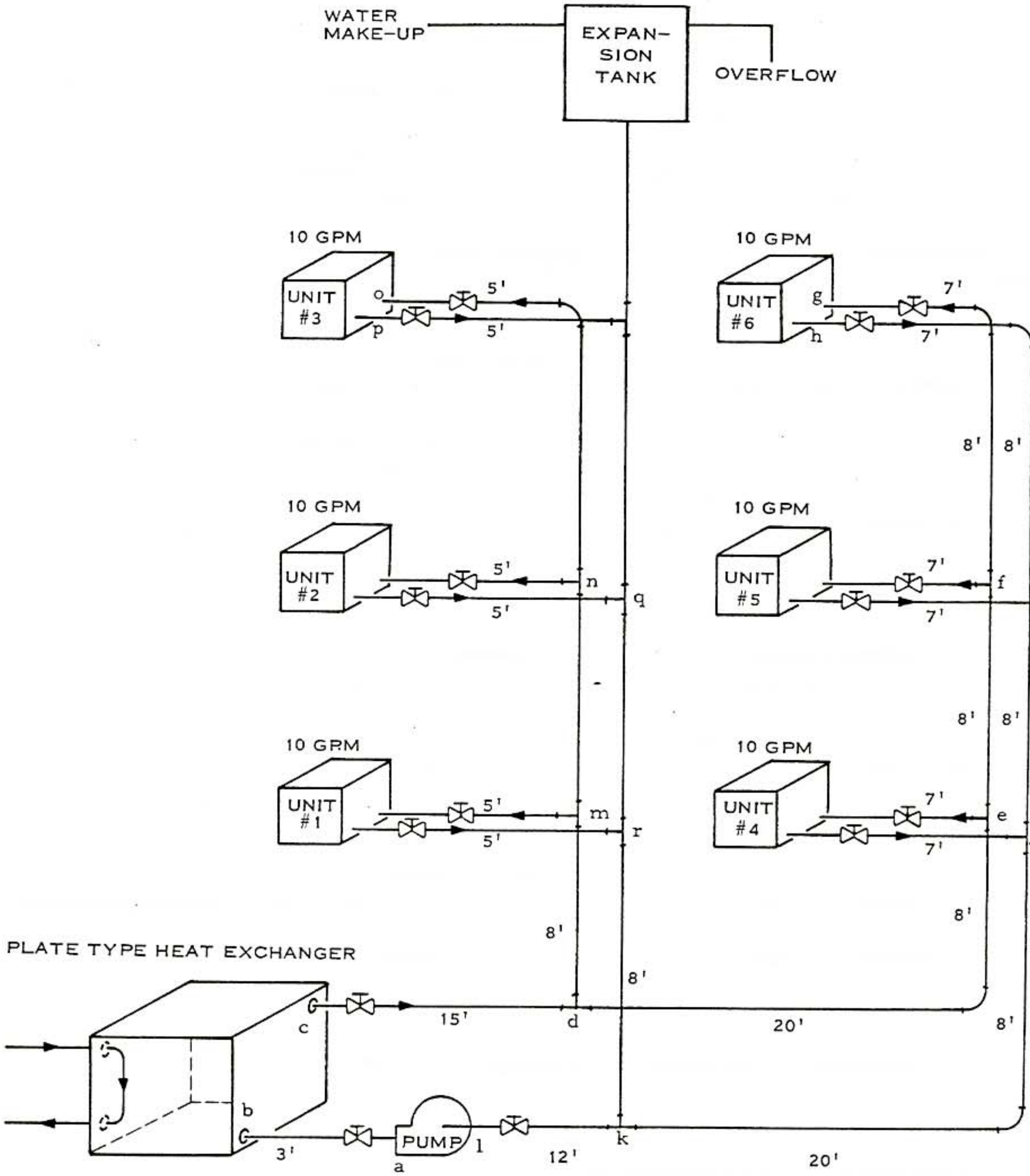


FIG. 8— Typical Closed Water Re-circulation System

$$\frac{15.5 \text{ Ft. of water} \times 10.5 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 1.6 \text{ Ft. of water}$$

(f) Run (f-g) 10 GPM; try 1" pipe as this gives a velocity of 4.2 FPS which is within recommended limits.

Length of pipe	= 15.0	EQ. FT.
1 gate valve (Table 5)	= 0.6	
1 std., 90° elbow (Table 5)	= 2.5	
1 std. tee thru run(Table 5)	= 2.0	
TOTAL EQUIVALENT FT	= 20.1	

From Table 3, at 10 GPM with 1" pipe the pressure drop is 11.8 feet of water per 100 feet of length.

$$\frac{11.8 \text{ Ft. of water} \times 20.1 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.4 \text{ Ft. of water}$$

(g) Run (g-h) at 10 GPM flow rate, pressure drop is 11.3 feet of water for unit condenser as given as data in sample selection section.

(h) Run (h-i) 10 GPM; use 1" pipe as selected for run (f-g).

Length of pipe	= 15.0	EQ. FT.
1 gate valve (Table 5)	= 0.6	
1 std. 90° elbow (Table 5)	= 2.5	
TOTAL EQUIVALENT FT	= 18.1	

$$\frac{11.8 \text{ Ft. of water} \times 18.1 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.1 \text{ Ft. of water}$$

(i) Run (i-j) 20 GPM; use 1-1/4" pipe as selected for run (e-f).

Length of pipe	= 8.0	EQ. FT.
1 std. tee thru run (Table 5)	= 2.5	
TOTAL EQUIVALENT FT.	= 10.5	

$$\frac{15.5 \text{ Ft. of water} \times 10.5 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.1 \text{ Ft. of water}$$

(j) Run (j-k) 30 GPM; use 1-1/2" pipe as selected for (d-e).

Length of pipe	= 28.0	EQ. FT.
1 std. tee thru run (Table 5)	= 3.0	
1 std. 90° elbow (Table 5)	= 4.5	
TOTAL EQUIVALENT FT.	= 35.5	

$$\frac{13.4 \text{ Ft. of water} \times 35.5 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 4.8 \text{ Ft. of water}$$

(k) Run (k-l) 60 GPM; use 2" pipe as selected for run (c-d).

Length of pipe	= 12.0	EQ. FT.
1 std. tee thru (Table 5)	= 3.5	
1 gate valve (Table 5)	= 1.2	
TOTAL EQUIVALENT FT.	= 16.7	

$$\frac{12.0 \text{ Ft. of water} \times 16.7 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.0 \text{ Ft. of water}$$

. Determine total pressure drop of system by adding the pressure drop of the sections making up the longest rún. Total pressure drop is 48.0 feet of water.

3. Select a pump which will produce a flow of 60 GPM against a total pressure drop of 48.0 feet of water.

4. The pressure at various points in the system can now be computed by assuming the total pressure drop of 48.0 ft. of water is available at the pump discharge. Starting at the pump discharge, subtract the pressure drop for each run of pipe to obtain the pressure at the other points. (Refer to last column in Table 6).

5. Determine pipe sizes for second circuit (Run d-o-p-k).

(a) Pressure at d = 30.6 Ft. of water
Pressure at k = 2.0 Ft. of water
28.6 Feet of water

available for pressure drop in circuit. Piping should be selected to use all available pressure drop. This will minimize the adjustment of valves for equalization of pressure drop and volume of flow.

(b) Run (d-m) 30 GPM; try 1-1/2" pipe which gives a velocity of 5.6 FPS which is within recommended limits.

Length of pipe	= 8.0	EQ. FT.
1 std. tee thru branch (Table 5)	= 9.0	
TOTAL EQUIVALENT FT.	= 17.0	

From Table 3 at 30 GPM flow rate, pressure drop is 13.4 feet of water per 100 feet of length.

$$\frac{13.4 \text{ Ft. of water} \times 17.0 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.3 \text{ Ft. of water}$$

(c) Run (m-n) 20 GPM; try 1-1/4" pipe which gives a velocity of 5.4 FPS which is within recommended limits.

Length of pipe	= 8.0	EQ. FT.
1 std. tee thru run (Table 5)	= 2.5	
TOTAL EQUIVALENT FT.	= 10.5	

From Table 3, at 20 GPM with 1-1/4" pipe, the pressure drop is 15.5 feet of water per 100 feet of length.

$$\frac{15.5 \text{ Ft. of water} \times 10.5 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 1.6 \text{ Ft. of water}$$

(d) Run (n-o) 10 GPM; try 1" pipe which gives a velocity of 4.2 FPS which is within recommended limits.

Length of pipe	= 13.0	EQ. FT.
1 gate valve (Table 5)	= 0.6	
1 std. 90° elbow (Table 5)	= 2.5	
1 std. tee thru run (Table 5)	= 2.0	
TOTAL EQUIVALENT FT.	= 18.1	

From Table 3 at 10 GPM with 1" pipe, the pressure drop is 11.8 feet of water per 100 feet of length.

$$\frac{11.8 \text{ Ft. of water} \times 18.1 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.1 \text{ Ft. of water}$$

(e) Run (o-p) 10 GPM flow rate, pressure drop is 11.3 feet of water for unit condenser as given as data in sample selection section.

(f) Run (p-q) 10 GPM; use 1" pipe as selected for run (n-o).

Length of pipe	= 13.0	EQ. FT.
1 gate valve (Table 5)	= 0.6	
1 std. tee thru branch (Table 5)	= 5.5	
TOTAL EQUIVALENT FT.	= 19.1	

From Table 3 at 10 GPM with 1" pipe, the pressure drop is 11.8 feet of water per 100 feet of length.

$$\frac{11.8 \text{ Ft. of water} \times 19.1 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 2.3 \text{ Ft. of water}$$

(g) Run (g-r) 20 GPM; use 1-1/4" pipe as selected for run (m-n).

Length of pipe	= 8.0	EQ. FT.
1 std. tee thru run (Table 5)	= 2.5	
TOTAL EQUIVALENT FT.	= 10.5	

From Table 3 at 20 GPM with 1-1/4" pipe the pressure drop is 15.5 feet of water per 100 feet of length.

$$\frac{15.5 \text{ Ft. of water} \times 10.5 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = 1.6 \text{ Ft. of water}$$

(h) Run (r-k) 30 GPM; try 1-1/4" pipe to use the available pressure drop.

Length of pipe	= 8.0	EQ. FT.
1 std. tee thru run (Table 5)	= 2.5	
1 std. tee thru branch (Table 5)	= 7.5	
TOTAL EQUIVALENT FT.	= 18.0	

From Table 3 at 30 GPM with 1-1/4" pipe the pressure drop is 33.5 feet of water per 100 feet of length.

$$\frac{33.5 \text{ Ft. of water} \times 18.0 \text{ EQ. FT.}}{100 \text{ Linear Ft.}} = \begin{matrix} 6.0 \text{ Ft.} \\ \text{of water} \end{matrix}$$

6. Determine total pressure drop of run (d-o-p-k) by adding the pressure drop of the individual runs. Total pressure drop is 27.2 feet of water. From paragraph 5a, there was 28.6 feet of water pressure drop available. Therefore, 28.6 minus 27.2 equals 1.4 feet of water which is the available pressure drop which was not used. This 1.4 feet of water pressure drop must be taken up by valve adjustment to obtain a balanced system at calculated flow rate.

7. Size branch lines from main supply to units #1, #2, #4 and #5. Use as much of available pressure drop as possible to minimize valve adjustment.

TABLE 6— TABULATION OF DATA FOR CLOSED WATER SYSTEM SAMPLE PROBLEM

Runs	Gallons per Minute	Nominal Pipe Size, Inches	Length of Pipe Feet	Fittings, Equivalent Feet of Pipe				Total Equivalent Feet	Press. Drop Ft. Water Per 100 Lin. Ft.	Total Press. Drop Feet Water	Actual Press. at Various Points in Feet Water
				Gate Valve	Std. Tee Thru Run	Std. Tee Thru Branch	Std. 90° Elbow				
a -b	60	2	3	1.2							a 48.0
b -c	60							4.2	12.0	.5	b 47.5
c -d	60	2	15	1.2						15.0	c 32.5
d -e	30	1-1/2	28		3.0			16.2	12.0	1.9	d 30.6
e -f	20	1-1/4	8		2.5		4.5	35.5	13.4	4.8	e 25.8
f -g	10	1	15	.6	2.0			10.5	15.5	1.6	f 24.2
g -h	10					Unit #6	2.5	20.1	11.8	2.4	g 21.8
h -i	10	1	15	.6						11.3	h 10.5
i -j	20	1-1/4	8		2.5		2.5	18.1	11.8	2.1	i 8.4
j -k	30	1-1/2	28		3.0			10.5	15.5	1.6	j 6.8
k -l	60	2	12	1.2	3.5		4.5	35.5	13.4	4.8	k 2.0
a -l								16.7	12.0	2.0	l 0
			Total Pressure Drop (Ft. of water) in Longest Run							48.0	
d -m	30	1-1/2	8			9.0					d 30.6
m-n	20	1-1/4	8		2.5			17.0	13.4	2.3	m 28.3
n -o	10	1	13	.6	2.0			10.5	15.5	1.6	n 26.7
o -p	10					Unit #3	2.5	18.1	11.8	2.1	0 24.6
p -q	10	1	13	.6		5.5				11.3	p 13.3
q -r	20	1-1/4	8			2.5		19.1	11.8	2.3	q 11.0
r -k	30	1-1/4	8		2.5	7.5		10.5	15.5	1.6	r 9.4
d -k								18.0	33.5	6.0	k 3.4 *
			Total Pressure Drop (Ft. of water) in Shorter Run							27.2	

* The pressure at point k is 2.0 ft. of water as determined by the longest run and this is the system controlling pressure drop. In order to have a balanced system with a minimum adjustment of valves, the branch runs should be sized so the available pressure drop between the supply main and return main is used in the branch run. The 3.4 ft. of water is close to the 2.0, so the difference of 1.4 ft. of water must be taken up by valve adjustment.

TABLE 7— TYPICAL RATINGS FOR PUMP SELECTION

PM	Total Head in Feet								
	20	30	40	50	60	70	80	90	100
10	1/3 P100	1/3 P100	1/3 P100	1/2 P100	1/2 P100	3/4 P100	1 P100	1 P100	1-1/2P200
20	1/3 P100	1/3 P100	1/3 P100	1/2 P100	3/4 P100	3/4 P100	1 P100	1 P100	1-1/2P200
30	1/3 P100	1/3 P100	1/2 P100	1/2 P100	3/4 P100	1 P100	1 P100	1-1/2P200	2 P200
40	1/3 P100	1/2 P100	1/2 P100	3/4 P100	1 P100	1 P100	1-1/2P200	1-1/2P200	2 P200
50	1/2 P100	3/4 P100	3/4 P100	1 P100	1 P100	1-1/2P200	1-1/2P200	2 P200	2 P200
60	1-1/2P200	1-1/2P200	1-1/2P200	1-1/2P200	1-1/2P200	1-1/2P200	2 P200	2 P200	3 P200
70	1-1/2P200	1-1/2P200	1-1/2P200	1-1/2P200	1-1/2P200	2 P200	2 P200	3 P200	3 P200
80	2 P200	2 P200	2 P200	2 P200	2 P200	2 P200	2 P200	3 P200	3 P200
90	2 P300	2 P300	2 P300	2 P300	2 P300	3 P300	3 P300	3 P300	5 P300
100	2 P300	2 P300	2 P300	2 P300	2 P300	3 P300	3 P300	5 P300	5 P300

Motor Horsepower
Motor Pump Assembly
Pump Size Designation

1/3 P 100

ble 7 is a Typical Pump Selection Table but should not be used for an actual pump selection. Refer to a np Manufacturers Ratings for a specific selection as a number of pump size/motor combinations are possible.

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