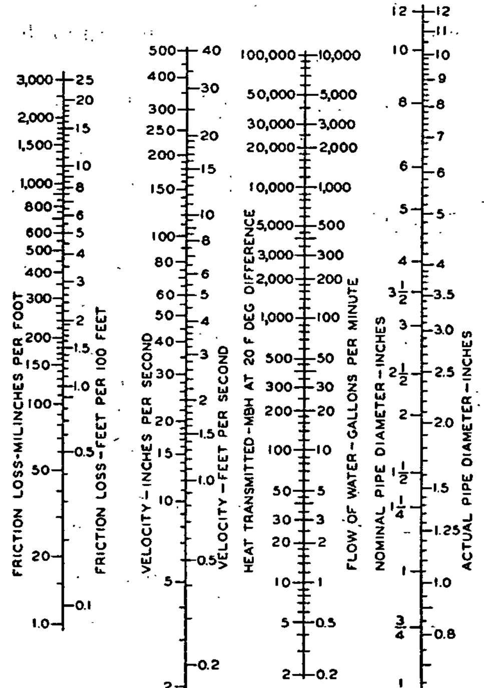
of pump used and the economics of small pipe size and high pump head versus large pipe and low pump head. Noise is also an important factor. Velocites are usually limited to a maximum of 4 fps for pipe sizes less than 2-in. to reduce the possibility of noise. Velocities up to 10 fps are frequently used in piping larger than 6-in. Average friction drops of 1.0 to 4.0 ft of water per 100 ft of pipe (120 to 480 milinches per ft of pipe) are commonly used in sizing piping systems. The actual friction loss for a particular section of pipe may vary considerably from the average loss for the



BASED ON CLEAN PIPE WITH 140 F WATER

FIG. 3. FRICTION LOSS DUE TO FLOW OF WATER IN IRON PIPE[2, 3]
(Based on clean pipe and 140 F water)

system due to the limitations of commercial pipe sizes. For example, if the average friction loss is 2.0 ft of water per 100 ft of pipe (240 milinches per ft), the actual friction loss in particular sections of pipe may vary from 1.0 to 3.0 ft per 100 ft (120 to 360 milinches per ft).

One method of sizing pipe is based on preliminary selection of a pump. The head which the pump can produce is divided by the equivalent length of the longest circuit to obtain an average design friction loss.

The equivalent length of a system or circuit is the length of pipe in series flow in the circuit, plus the length of pipe equivalent in resistance to the fittings and also the equipment in series flow in the circuit. For preliminary calculation the equivalent length is sometimes assumed to be 1.5 times the measured length.

TABLE I. CARRYING CAPACITY OF STANDARD BLACK PIPES WITH TEMPERATURE DROP OF 20 F DEG[a]

Available Head-Feet: 30	25	22	20	18	16	15	14	13	12	11	10	9	8	7	6	5	Friction Loss: Ft/100 Ft	Mi/Ft	Flow	Pipe Size—Nominal Inches: ½	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12
Equivalent Length of System, Feet																																		
6000	5000	4400	4000	3600	3200	3000	2800	2600	2400	2200	2000	1800	1600	1400	1200	1000	½	60	GPM	0.57	1.3	2.3	4.8	7.5	14	24	42	64	88	165	270	570	1080	1800
																			FPS	0.6	0.8	0.9	1.1	1.2	1.4	1.6	2.0	2.1	2.3	2.7	3.1	3.7	4.3	5.0
4000	3330	2940	2660	2400	2130	2000	1870	1730	1600	1470	1330	1200	1070	935	800	665	¾	90	GPM	0.72	1.6	2.9	6.3	9.8	18	29	54	78	110	205	340	730	1350	2200
																			FPS	0.75	0.92	1.1	1.3	1.5	1.8	2.0	2.3	2.6	2.8	3.3	3.8	4.7	5.5	6.3
3000	2500	2200	2000	1800	1600	1500	1400	1300	1200	1100	1000	900	800	700	600	500	1	120	GPM	0.8	1.8	3.4	7.3	11	21	32	63	93	130	240	400	850	1600	2600
																			FPS	0.92	1.1	1.3	1.5	1.8	2.1	2.3	2.8	3.0	3.3	3.8	4.4	5.5	6.3	7.3
2400	2000	1760	1600	1440	1280	1200	1120	1040	960	880	800	720	640	560	480	400	1¼	150	GPM	0.9	2.0	3.8	8.3	12.3	24	38	71	110	145	270	460	950	1800	2900
																			FPS	1.0	1.3	1.4	1.8	1.9	2.3	2.7	3.1	3.4	3.8	4.4	5.2	6.2	7.3	7.5
2000	1666	1470	1330	1200	1070	1000	935	866	800	735	667	600	535	467	400	333	1½	180	GPM	1.1	2.2	4.3	9.0	13	27	44	77	115	165	300	500	1100	2000	3300
																			FPS	1.2	1.3	1.6	1.9	2.2	2.6	2.9	3.4	3.8	4.2	4.8	5.7	6.7	8.2	9.3
1715	1430	1260	1140	1030	915	856	800	745	680	628	572	515	457	400	343	275	1¾	210	GPM	1.2	2.4	4.6	9.7	14.5	29	47	85	130	180	340	550	1170	2200	3600
																			FPS	1.3	1.5	1.8	2.1	2.3	2.8	3.2	3.8	4.2	4.5	5.3	6.2	7.5	9.0	10.2
1500	1250	1100	1000	900	800	750	700	650	600	550	500	450	400	350	300	250	2	240	GPM	1.2	2.6	5.0	11	16	32	52	92	140	190	360	580	1300	2400	3800
																			FPS	1.3	1.6	1.9	2.3	2.5	3.0	3.4	4.0	4.5	4.8	5.8	6.7	8.2	9.7	10.8
1333	1110	980	890	800	712	666	623	577	533	490	445	400	356	312	267	222	2¼	270	GPM	1.3	2.8	5.5	11	17	34	54	97	145	200	380	630	1350	2550	4200
																			FPS	1.4	1.7	2.0	2.4	2.7	3.2	3.7	4.3	4.8	5.2	6.2	7.6	8.5	11.4	11.9
1200	1000	880	800	720	640	600	560	520	480	440	400	360	320	280	240	200	2½	300	GPM	1.4	2.9	5.7	12	18	36	57	105	155	210	400	670	1400	2700	4400
																			FPS	1.5	1.8	2.1	2.6	2.8	3.4	3.8	4.5	5.0	5.5	6.5	7.7	9.2	12.0	12.5
1090	904	800	727	655	582	546	510	473	437	400	364	328	291	254	218	182	2¾	330	GPM	1.5	3.1	5.9	13	19	38	60	110	165	230	420	700	1480	2800	4600
																			FPS	1.6	1.9	2.2	2.7	3.0	3.6	4.0	4.7	5.2	5.8	6.8	7.8	9.5	12.5	13.0
1000	833	733	667	600	534	500	467	433	400	367	333	300	267	234	200	167	3	360	GPM	1.5	3.2	6.3	14	20	39	64	112	170	240	440	750	1600	3000	4800
																			FPS	1.7	2.0	2.3	2.8	3.2	3.8	4.3	5.0	5.5	6.2	7.3	8.3	10.2	13.4	13.6
924	767	677	615	573	493	462	430	400	369	338	308	277	246	215	185	154	3¼	390	GPM	1.6	3.4	6.5	14	21	40	66	120	175	250	460	770	1650	3200	5000
																			FPS	1.8	2.1	2.4	2.9	3.3	3.9	4.4	5.2	5.8	6.3	7.5	8.7	10.6	14.3	14.2
858	715	628	572	514	457	429	400	372	343	314	286	257	228	200	171	143	3½	420	GPM	1.7	3.6	6.8	15	22	42	70	125	180	260	480	800	1700	3300	5500
																			FPS	1.9	2.2	2.6	3.1	3.4	4.1	4.7	5.5	6.1	6.7	7.9	9.1	10.9	14.7	15.6
800	666	587	533	480	427	400	373	347	320	293	267	240	214	187	160	133	3¾	450	GPM	1.7	3.7	7.0	15	23	45	73	130	190	270	500	840	1800	3400	5700
																			FPS	1.9	2.3	2.7	3.3	3.5	4.3	4.8	5.7	6.3	7.0	8.3	9.5	11.5	15.2	16.1
750	625	550	500	450	400	375	350	325	300	275	250	225	200	175	150	125	4	480	GPM	1.8	3.8	7.3	16	24	46	75	135	200	280	520	870	1850	3500	5800
																			FPS	1.9	2.3	2.8	3.4	3.7	4.4	5.0	5.8	6.7	7.2	8.5	9.8	11.8	15.6	16.4
705	588	517	470	423	376	353	329	306	282	259	235	212	188	165	141	118	4¼	510	GPM	1.8	4.0	7.5	16	25	47	77	140	210	290	540	900	1900	3600	6000
																			FPS	2.0	2.4	2.8	3.4	3.8	4.5	5.2	6.1	6.8	7.5	8.8	10.0	12.2	16.1	17.0
666	555	479	444	400	355	333	311	290	267	244	222	200	178	155	133	111	4½	540	GPM	1.9	4.1	7.7	17	25	48	79	145	215	300	560	930	2000	3800	6200
																			FPS	2.0	2.4	2.9	3.5	3.9	4.7	5.3	6.3	7.0	7.7	9.0	10.3	12.8	17.0	17.5
631	526	463	421	379	337	316	295	274	253	232	210	190	168	147	126	105	4¾	570	GPM	1.9	4.2	8.0	17	26	50	80	150	220	310	580	970	2050	3900	6400
																			FPS	2.1	2.5	3.0	3.6	4.0	4.8	5.5	6.4	7.2	7.8	9.3	10.8	13.1	17.4	18.1
600	500	440	400	360	320	300	280	260	240	220	200	180	160	140	120	100	5	600	GPM	2.0	4.3	8.3	18	27	52	85	155	225	320	600	1000	2100	4000	6600
																			FPS	2.2	2.6	3.1	3.8	4.2	5.0	5.7	6.7	7.4	8.9	9.7	11.1	13.4	17.8	18.7

[a] May be Used for Preliminary Sizing of Type L Copper Tube.