50-271
F

VERMONT YANKEE NUCLEAR POWER CORPORATION

SEVENTY SEVEN GROVE STREET
RUTLAND, VERMONT 05701

B.3.2.1

REPLY TO:
ENGINEERING OFFICE
TURNPIKE ROAD
WESTBORO, MASSACHUSETTS 01581
TELEPHONE 617-366-9011

WVY 78-104

December 20, 1978

United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Office of Nuclear Reactor Regulations
Division of Operating Reactors
Thomas A. Ippolito, Chief
Operating Reactors Branch #2

References: (a) License No. DPR-28 (Docket No. 50-271)
(b) USNRC Letter, K. R. Goller to VYNPC, R. H. Groce, dated January 13, 1978, Amendment No. 43 to Facility Operating License
(c) VYNPC Letter, D. E. Moody to USNRC, T. A. Ippolito, dated August 14, 1978, Fire Protection Systems Additional Information

Dear Sir:

Subject: Hose Station Hydraulic Calculations

The fire protection Safety Evaluation Report (SER) enclosed with Reference (b) requested additional design information pertaining to various portions of the Vermont Yankee fire protection system. In particular, Section 3.1.3 of the SER requested that we perform calculations or flow tests to verify that sufficient pressure would be provided to the most hydraulically remote hose stations. At the time of our letter, Reference (c), the results of this study were unavailable. We have since concluded our review of the hose station hydraulic design and have enclosed the calculations and results as Attachment 1.

We trust this information is satisfactory; however, should you have any questions with regard to this material, please contact us.

Very truly yours,

VERMONT YANKEE NUCLEAR POWER CORPORATION

D. E. Moody

D. E. Moody
Manager of Operations

DEM/em

Enclosure

ATTACHMENT I

REACTOR BUILDING FIRE HEADER AND

STANDPIPE SYSTEM HYDRAULIC CALCULATIONS

CALCULATION OF HEAD LOSS IN

REACTOR BUILDING FIRE HEADER AND STANDPIPE SYSTEMS

PDCR 78-4

By [signature] / 8/30/78
Date

Checked By [signature] / 9/5/78
Date

Discussion

This calculation was made to verify ASCOA's line sizing and calculations for the Reactor Building standpipe. I have used some of the information from ASCOA's calculations where necessary. Their calculations are based on sizing the standpipe to the requirements of NFPA-14.

This calculation is based solely on sizing the system to the requirements of the NRC (that the system be designed to provide 65 psig at the nozzle at the most remote hose station). I have assumed that both hose stations at ele. 345' are in use simultaneously.

References

1. PDCR 78-4
2. PDCR 78-7
3. ASCOA Reactor Building Standpipe Plans; Sheet 1, Rev. 0, Sheet 2, Rev. 0 and Sheet 3, Rev. 0
4. Crane Technical Paper No. 410 (appropriate pages attached)
5. NFPA Fire Protection Handbook (appropriate pages attached)
6. ASCOA Hydraulic Calculations, dated 7/17/78
7. G191197, Rev. 6
8. G191163, Rev. 8
9. Cameron Hydraulic Data, 15th edition (appropriate pages attached)
10. G191230, Rev. 3
11. G191233, Rev. 7

Assumptions/Bases

1. Wilco (manufacturers of our fire hose nozzles) has indicated their nozzles are rated for 68 gpm at 65 psi.

2. The SER for the fire systems requires 65 psi at the nozzles at the most remote hose station in the Reactor Building.

3. Equivalent length (L/D) of fittings and valves are found from Crane 410 as follows:

fully open gate	L/D = 13
90° elbow	L/D = 30
45° elbow	L/D = 16

flow thru run tee (R Tee) L/D = 20
flow thru branch tee (B Tee) L/D = 60
flow alarm L/D (estimated) = 30
22 1/2° elbow L/D = 13 (from ASCOA calculations)
angle valve L/D = 145
swing check L/D = 135

4. From NFPA Handbook, the friction loss in 100 ft. of 1 1/2" good quality hose at 68 gpm is 11.7 psi. The loss for 75 feet of hose is 8.8 psi x 2.31 ft/psi = 20.3 ft.

5. Equivalent length of fittings in feet (L) is calculated from L/D and the pipe diameter using Crane 410, page A-31.

6. Friction loss in feet per 100 ft. (hf) is taken from Table ST-1 of Crane 410 and pages 3-20 through 3-25 of Cameron.

7. Equivalent length of reducers (L/D) is found using A-23 of Crane 410 for the friction factor of commercial steel pipe and the L/D vs. D1/D2 chart attached.

8. Pressure drop is calculated from the diesel fire pump (furthest pump from the hose stations).

Results

1. The pressure required at the diesel fire pump is 141.5 psi.

2. The attached pump curves show that the diesel fire pump has a lower head available at 136 gpm than the electric fire pump. The diesel fire pump head available is 380 feet = 164.5 psi. This is greater than the required pressure of 141.5 psi.

3. This calculation shows that the standpipe system is conservatively sized to meet the pressure and flow requirements of the NRC.

SAV/jh

PRESSURE DROP CALCULATION

FIRE HEADER AND STANDPIPE SYSTEM

PDCR 78-4

LINE	FLOW (gpm)	SIZE (in)	# FITTINGS	L/D (Pipe Dia.)	TOTAL L (feet)	LENGTH OF RUN (feet)	TOTAL LENGTH (feet)	h_f (feet/100')	FRICTION LOSS (feet)	STATIC HEAD LOSS (feet)	TOTAL LOSS (feet/psi)	REMARKS
SE Hose el 345'	68	1½	–	–	–	75	–	11.7(psi)	20.3	0	20.3/8.8	65 psi required at the nozzle at el. 345'
1½" line to 4" SE standpipe el. 348'-11"	68	1½	1- angle valve 1- 90°el	145 30	18 4 22	5.5	27.5	29.5	8.1	0	8.1/3.5	
4" SE Standpipe el. 348'-11" to 6" SE Standpipe el. 282'-0"	68	4"	1 -B Tee 9 -90°el 2 - 45°el 1- gate valve 6 -R Tee	60 30 16 13 20	20 90 11 4.5 39 164.5	88.3	252.8	.31	.78	67	67.8/29.3	65 psi @ nozzle + 8.8 + 3.5 + 29.3 = 106.6 psi available at the MG set foam system (92 psi required)
6" SE standpipe el 282'-0" to 6" torus header	68	6"	1 - B Tee 11 - 90°el 2 - R Tee	60 30 20	30 165 20 215	135	350	.043	.15	67	67.15/29.1	
6" torus header to 6" supply lines	68	6"	2 - B Tee 2 - R Tee 8 - 22½°el 1- gate valve	60 20 13 13	60 20 56 2 143	113	256	.043	.1	0	.1/0.0	Use longest run around header
6" supply line @ el. 215' to 4" line @ turb. bldg. wall	68	6"	2 - 45°el 2 - B Tee 8 - 90°el 1- gate valve	16 60 30 13	16 60 120 7 203	98.3	301.3	.043	.1	-26.3	-26.2/-11.3	Use supply line with largest loss
4" line @ turb. wall to turb. loop tie-in	68	4"	4 - 90°el 1- Flow alarm 1- gate valve	30 30 13	40 10 4.5 54.5	24	78.5	.31	.2	6	6.2/2.7	Pressure required @ turb loop tie-in = 65 + 8.8 + 3.5 + 29.3 + 29.1 + 0 - 11.3 + 2.7 = 127.1 psi

PRESSURE DROP CALCULATION

PDCR 78-4

LINE	FLOW (gpm)	SIZE (in)	# FITTINGS	L/D (Pipe Dia.)	TOTAL L (feet)	LENGTH OF RUN (feet)	TOTAL LENGTH (feet)	h_f (feet/100')	FRICTION LOSS (feet)	STATIC HEAD LOSS (feet)	TOTAL LOSS (feet/psi)	REMARKS
NW Hose el. 345	68	1½	—	—	—	75	—	11.7 (psi)	20.3	0	20.3/8.8	65 psi required at the nozzle at el. 345'
1½" line to NW el 345 floor penetration (2½" line)	68	1½	1-angle valve 10-90° el	145 30	18 40 58	57.8	115.8	29.5	34.2	-1.5	32.7/14.1	
2½" line el 351'-10" to 4" line el. 324'-0"	68	2½"	1-1½"x2½" Red 1-R Tee 4-90° el	14 20 30	3 4 24 31	60.9	91.9	3.4	3.1	27.9	31.0/13.4	
4" line el. 324'-0" to turb. loop tie-in	68	4"	1-2½"x4" Red 8-R Tee 18-90° el 2-gate valve 2-B Tee	16 20 30 13 60	5.5 56 180 9 40 290.5	194.3	485.3	.31	1.5	88	89.5/38.7	Pressure required at turb loop tie-in = 65 + 8.8 + 14. + 13.4 + 38.7 = 140 psi ∴ NW stand-pipe has the larger pressure drop & w be used in the calcula
turb. loop tie-in @ el 324'-0" to 8" FP-7 @ el 230'6"	136	4	3-B Tee 2-gate valve 5-R Tee 10-90° el	60 13 20 30	60 9 35 100 204	205	409	1.08	4.4	6.5	10.9/4.7	140 psi required @ tur loop tie-in
8" FP-7 thru 8" FP-6 to 12" FP-1	136	8	2-B Tee 1-gate valve 4-90° el 1-45° el	60 13 30 16	80 8.5 80 9 177.5	113.5	291	.04	.1	-14.5	-14.4/-6.2	

PRESSURE DROP CALCULATION

PDCR 78-4

LINE	FLOW (gpm)	SIZE (in)	# FITTINGS	L/D (Pipe Dia.)	TOTAL L (feet)	LENGTH OF RUN (feet)	TOTAL LENGTH (feet)	h_f (feet/100')	FRICTION LOSS (feet)	STATIC HEAD LOSS (feet)	TOTAL LOSS (feet/psi)	REMARKS
12" FP-1 @ inner loop tie-in to 12" FP-1 @ intake structure wall	136	12"	3- BTee 2- RTee 3- 90° el. 1- gate valve 1- 45° el.	60 20 30 13 16	180 40 90 13 16 339	725	1064	.004	0.0	3	3.0/1.3	
12" FP-1 @ intake structure wall to diesel fire pump discharge	136	12	7- 90° el 4- RTee 3- gate valve 1- check valve	30 20 13 135	210 80 39 135 464	79.3	543.3	.004	.02	4	4.02/1.7	Pressure required at diesel fire pump discha = 140+4.7-6.2+1.3+1. = 141.5 psi

Schedule (Thickness) of Steel Pipe Used in Obtaining Resistance Of Valves and Fittings of Various Pressure Classes by Test*

Valve or Fitting ANSI Pressure Classification			Schedule No. of Pipe Thickness
Steam Rating		Cold Rating	
250-Pound and Lower		500 psig	Schedule 40
300-Pound to 600-Pound		1440 psig	Schedule 80
900-Pound		2160 psig	Schedule 120
1500-Pound		3600 psig	Schedule 160
2500-Pound	½ to 6"	6000 psig	xx (Double Extra Strong)
	8" and larger	3600 psig	Schedule 160

*These schedule numbers have been arbitrarily selected only for the purpose of identifying the various pressure classes of valves and fittings with specific pipe dimensions for the interpretation of flow test data; they should not be construed as a recommendation for installation purposes.

Representative Equivalent Length‡ in Pipe Diameters (*L/D*) Of Various Valves and Fittings

Description of Product				Equivalent Length In Pipe Diameters (*L/D*)
Globe Valves	Stem Perpendicular to Run	With no obstruction in flat, bevel, or plug type seat	Fully open	340
		With wing or pin guided disc	Fully open	450
	Y-Pattern	(No obstruction in flat, bevel, or plug type seat)		
		– With stem 60 degrees from run of pipe line	Fully open	175
		– With stem 45 degrees from run of pipe line	Fully open	145
Angle Valves		With no obstruction in flat, bevel, or plug type seat	Fully open	145
		With wing or pin guided disc	Fully open	200
Gate Valves	Wedge, Disc, Double Disc, or Plug Disc		Fully open	13
			Three-quarters open	35
			One-half open	160
			One-quarter open	900
	Pulp Stock		Fully open	17
			Three-quarters open	50
			One-half open	260
			One-quarter open	1200
Conduit Pipe Line Gate, Ball, and Plug Valves			Fully open	3**
Check Valves	Conventional Swing		0.5† . . Fully open	135
	Clearway Swing		0.5† . . Fully open	50
	Globe Lift or Stop; Stem Perpendicular to Run or Y-Pattern		2.0† . . Fully open	Same as Globe
	Angle Lift or Stop		2.0† . . Fully open	Same as Angle
	In-Line Ball		2.5 vertical and 0.25 horizontal† . . Fully open	150
Foot Valves with Strainer		With poppet lift-type disc	0.3† . . Fully open	420
		With leather-hinged disc	0.4† . . Fully open	75
Butterfly Valves (8-inch and larger)			Fully open	40
Cocks	Straight-Through	Rectangular plug port area equal to 100% of pipe area	Fully open	18
	Three-Way	Rectangular plug port area equal to 80% of pipe area (fully open)	Flow straight through	44
			Flow through branch	140
Fittings	90 Degree Standard Elbow			30
	45 Degree Standard Elbow			16
	90 Degree Long Radius Elbow			20
	90 Degree Street Elbow			50
	45 Degree Street Elbow			26
	Square Corner Elbow			57
	Standard Tee	With flow through run		20
		With flow through branch		60
	Close Pattern Return Bend			50
Pipe	90 Degree Pipe Bends			See Page A-27
	Miter Bends			See Page A-27
	Sudden Enlargements and Contractions			See Page A-26
	Entrance and Exit Losses			See Page A-26

**Exact equivalent length is equal to the length between flange faces or welding ends

†Minimum calculated pressure drop (psi) across valve to provide sufficient flow to lift disc fully

‡For limitations, see page 2-11. For effect of end connections, see page 2-10

For resistance factor "K", equivalent length in feet of pipe, and equivalent flow coefficient "C_v", see pages A-31 and A-32.

FIRE PROTECTION HANDBOOK
14th Edition - NFPA

Table 9-5D. Friction Losses in Rubber-Lined Fire Hose

(Pounds per square inch per 100 ft of hose)

2½-In.*	2¾-In.† (3-In. couplings)	3-In.‡ (2½-In. couplings)	3-In. (3-In. couplings)	Flow in Gpm	2½-In.*	2¾-In.† (3-In. couplings)	3-In.‡ (2½-In. couplings)	3-In.* (3-In. couplings)
2.5	1.7	1.2	1.2	290	19.9	11.9	8.4	7.7
3.2	2.1	1.4	1.4	300	21.2	12.7	9.0	8.2
3.9	2.4	1.6	1.6	310	22.5	13.5	9.7	8.7
4.5	2.8	1.9	1.8	320	23.8	14.3	10.3	9.3
5.2	3.1	2.1	2.0	330	25.3	15.2	10.9	9.9
5.8	3.6	2.5	2.3	340	26.9	16.2	11.6	10.5
6.6	4.0	2.9	2.6	350	28.4	17.1	12.3	11.0
7.4	4.5	3.2	2.9	360	30.0	18.0	13.0	11.5
8.3	5.0	3.6	3.2	370	31.5	18.9	13.7	12.2
9.2	5.6	3.8	3.5	380	33.0	19.8	14.4	12.8
10.1	6.1	4.0	3.8	390	34.6	20.7	15.2	13.4
11.1	6.7	4.4	4.2	400	36.2	21.7	16.0	14.1
12.0	7.2	4.5	4.6	420	39.9	24.0	17.7	15.4
13.0	7.8	5.3	5.0	440	43.2	25.9	19.4	16.8
14.1	8.5	5.8	5.4	460	46.8	28.1	21.3	18.2
15.3	9.2	6.2	5.9	480	50.8	30.5	23.1	19.7
16.4	9.9	6.8	6.3	500	55.1	33.1	25.0	21.2
17.5	10.5	7.3	6.7	—	—	—	—	—
18.7	11.2	7.8	7.2	—	—	—	—	—

* Losses shown for nominal 2½-in. hose (actual 2 5/8-in. waterway) and for 3-in. hose are based upon tests conducted in 1909 by the National Board of Fire Underwriters.

† Losses for 2¾-in. hose with 3-in. couplings are based upon tests by the Oakland, California, Fire Department. The 2¾-in. hose with 3-in. couplings, formerly used in the San Francisco Bay area, is not a nationally recognized standard fire hose. Three-inch hose should be equipped with 2½-in. outlets to be considered a standard size.

‡ Losses for 3-in. hose with standard 2½-in. couplings are based upon tests by the NFPA Fire Service Department in cooperation with the Boston Fire Department.

Table 9-5E. Friction Losses in Small Diameter Rubber or Rubber-Lined Fire Hose

(Pounds per square inch per 100 ft of hose)

Flow in Gpm	¾-In. (Booster)	1-In. (Booster)	1½-In. (Lined standpipe & lined forestry)	1½-In. (Good quality fire dept. hose)	2-In.*
10	13.5	3.5	0.5	0.3	0.1
15	29.0	7.2	1.0	0.7	0.3
20	50.0	12.3	1.7	1.2	0.4
25	75.0	18.5	2.6	1.9	0.6
30	105.0	26.0	3.6	2.5	0.9
35	140.0	35.0	4.8	3.4	1.2
40	180.0	44.0	6.1	4.3	1.5
45	—	55.0	7.6	5.4	1.9
50	—	67.0	9.2	7.1	2.3
60	—	—	13.0	9.2	3.2
70	—	—	17.3	12.3	4.3
80	—	—	22.0	15.6	5.4
90	—	—	27.3	19.5	6.9
100	—	—	33.0	25.5	8.3
120	—	—	47.0	33.0	11.7
150	—	—	70.0	50.0	17.5
200	—	—	—	—	29.9

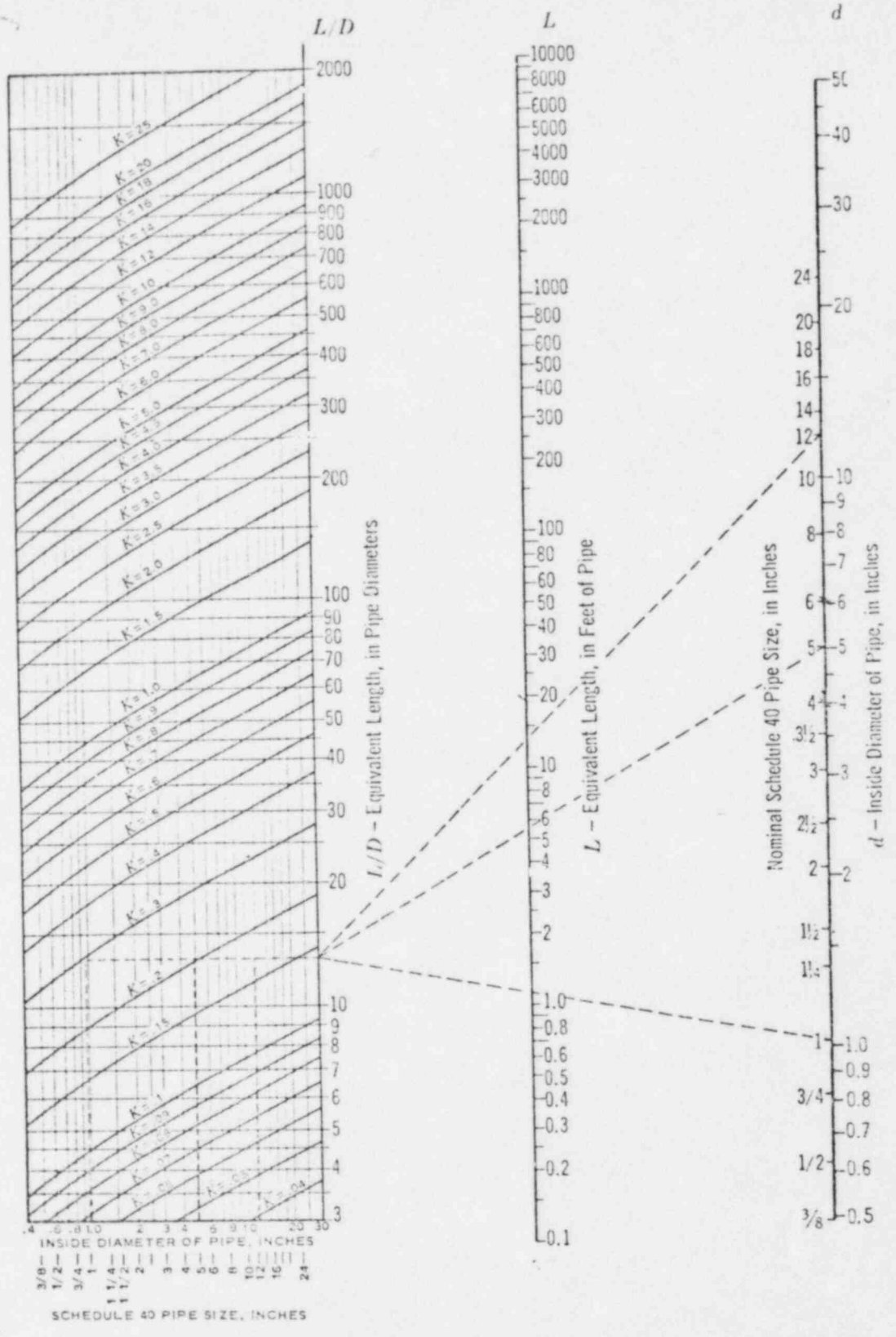
* The 2-in. hose is not recognized as a standard size but is used in some fire departments as a "leader line" because it is relatively easy to handle and carries more water at a given pressure than 1½-in. hose.

C. Large Diameter Hose

With the introduction of lightweight, large diameter hose, fire departments have been able to move large quantities of water with greater efficiency. The reason for the increased efficiency is based on the principle that as the diameter of the hose increases the loss due to friction becomes less. Table 9-5F shows the inside diameter vs. the area in square inches of various sizes of hose. Note that one 5-in. hose line has the same area as four 2½-in. lines.

Table 9-5G illustrates the friction loss of large diameter hose at various flows. Note that the friction loss for 100 ft

*Equivalent Lengths *L* and *L/D* and Resistance Coefficient *K*



Problem: Find the equivalent length in pipe diameters and feet of Schedule 40 pipe, and the resistance factor *K* for 1, 5, and 12-inch fully-opened gate valves.

*For limitations, see page 2-11.

Solution

Valve Size	1"	5"	12"	*Refer to*
Equivalent length, pipe diameters	13	13	13	Page A-30
Equivalent length, feet of Sched. 40 pipe	1.1	5.5	13	Dotted lines on chart.
Resist. factor *K*, based on Sched. 40 pipe	0.30	0.20	0.17	

SCHEDULE 40 STEEL PIPE — FRICTION LOSS FOR WATER IN FEET PER 100 FEET

TABLE ST-1 These ΔP/100 figures are based on C = 140 (i.e., they are the same as the Cazenovia tables but in ft. instead of psi/ft.)

U.S. Gallons per Minute	¼ In.		⅜ In.		½ In.		¾ In.		U.S. Gallons per Minute	1 In.		1¼ In.		1½ In.	
	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.		V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.
0.6	2.47	12.7							6	2.23	2.68				
1.0	3.08	19.1							8	2.97	4.51				
1.2	3.70	26.7							10	3.71	6.80				
1.4	4.32	35.3	2.35	7.85					12	4.45	9.62	2.52	2.48		
1.6	4.93	45.1	2.68	10.1					14	5.20	12.8	2.80	3.28		
1.8	5.55	56.4	3.02	12.4					16	5.94	16.5	3.13	4.20	2.38	1.96
2.0	6.17	69.0	3.35	15.0	2.11	4.78			18	6.68	20.6	3.86	5.23		
2.5	7.71	105.9	4.20	22.6	2.64	7.15			20	7.42	25.1	4.29	6.38	3.02	2.42
3.0	9.25	148.9	5.01	31.8	3.17	10.0			22	8.17	30.2	4.72	7.58		
3.5	10.79	200.0	5.88	42.6	3.70	13.3			24	8.91	35.6	5.15	8.96	3.65	3.42
4.0	12.33	259.0	6.72	54.9	4.22	17.1	2.41	4.21	26	9.65	41.6	5.58	10.4	4.10	4.01
5	15.42	390	8.40	83.5	5.28	25.8	3.01	6.32	28	10.39	47.9	6.01	11.9	4.41	5.51
6			10.08	118	6.34	36.5	3.61	8.85	30	11.1	54.6	6.44	13.6	4.73	6.28
7			11.8	158	7.39	48.7	4.21	11.8	35	13.0	73.3	7.53	18.2	5.52	8.42
8			13.4	205	8.45	62.4	4.81	15.0	40	14.8	93.0	8.59	23.1	6.30	10.6
9			15.1	258	9.50	78.3	5.42	18.8	45	16.7	119.0	9.65	29.4	7.09	13.4
10			16.8	316	10.56	95.9	6.02	23.0	50	18.6	146	10.7	36.0	7.88	16.4
12					12.7	134	7.22	32.6	55			11.8	44.0	8.66	19.9
14					14.8	184	8.43	43.5	60			12.9	51.8	9.45	23.8
15					16.9	235	9.63	56.3	65			13.9	59.6	10.2	27.8
18							10.8	70.3	70			15.0	68.2	11.03	31.8
							12.0	86.1	75			16.1	76.7	11.8	35.8
							13.2	104	80					12.6	40.0
							14.4	123	85					13.4	44.6
							15.6	143	90					14.2	49.2
							16.8	164	95					15.0	53.5
									100					15.8	60.2

U.S. Gallons per Minute	2 In.		2½ In.		3 In.		4 In.		U.S. Gallons per Minute	5 In.		6 In.		8 In.	
	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.		V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.	V Ft./Sec	hf Fric.
25	2.39	1.22							160	2.57	0.487				
30	2.87	1.69							180	2.89	0.608				
35	3.35	2.23	2.35	1.00					200	3.21	0.739				
40	3.82	2.86	2.68	1.28					220	3.53	0.892				
45	4.30	3.55	3.02	1.59					240	3.85	1.05	2.41	0.356		
50	4.78	4.37	3.35	1.94	2.17	0.662			260	4.17	1.20	2.60	0.410		
60	5.74	6.59	4.02	2.72	2.60	0.928			300	4.81	1.58	3.33	0.623		
70	6.69	8.83	4.69	3.63	3.04	1.23			330	5.61	2.11	3.89	0.821		
80	7.65	11.4	5.36	4.66	3.47	1.57			400	6.41	2.73	4.44	1.09	2.54	0.274
90	8.60	14.2	6.03	5.82	3.91	1.96			450	7.22	3.41	5.00	1.36	2.86	0.342
100	9.56	17.4	6.70	7.11	4.34	2.39	2.62	0.662	500	8.02	4.16	5.55	1.66	3.21	0.417
120	11.5	24.7	8.04	10.0	5.21	3.37	3.02	0.877	600	9.62	5.88	6.66	2.34	3.85	0.589
140	13.4	33.2	9.38	13.5	6.08	4.51	3.53	1.17	700	11.2	7.83	7.77	3.13	4.49	0.786
160	15.3	43.0	10.7	17.4	6.94	5.81	4.03	1.49	800	12.8	10.02	8.88	4.00	5.13	1.00
180			12.1	21.9	7.81	7.24	4.54	1.86	900	14.4	12.9	9.99	5.06	5.77	1.26
200			13.4	26.7	8.68	8.90	5.04	2.27	1000	16.0	15.8	11.1	6.17	6.41	1.55
220			14.7	32.2	9.55	10.7	5.54	2.72	1100			12.2	7.41	7.05	1.87
240			16.1	38.1	10.4	12.6	6.05	3.23	1200			13.3	8.72	7.69	2.21
260					11.3	14.7	6.55	3.77	1300			14.4	10.1	8.33	2.58
280					12.2	16.9	7.06	4.39	1400			15.5	11.8	8.97	2.99
300					13.0	19.2	7.56	4.89	1500					9.62	3.42
320					13.9	21.8	8.07	5.55	1600					10.3	3.88
340					14.8	24.5	8.57	6.24	1700					10.9	4.36
360					15.6	27.3	9.08	6.95	1800					11.5	4.86
380					16.5	30.2	9.58	7.69	1900					12.2	5.38
400					17.4	33.3	10.1	8.47	2000					12.8	5.93
420							10.6	9.27	2100					13.5	6.49
440							11.1	10.1	2200					14.1	7.08
460							11.6	10.9							
480							12.1	11.8							
500							12.6	12.8							
520							13.1	13.8							
540							13.6	14.8							
560							14.1	15.8							

NOTE: The above table shows average values of pipe friction for new pipe. For commercial installations it is recommended that 15% be added to the above values. No allowance for aging of pipe is included.

Friction of Water

4 Inch—Asphalt-dipped cast iron and new steel pipe

Flow U S gal per min	Asphalt-dipped cast iron 4.0" inside dia			Std wt steel sch 40 4.026" inside dia			Extra strong steel sch 80 3.826" inside dia			Schedule 160—steel 3.438" inside dia		
	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft
20	.511	.004	.038	.504	.004	.035	.56	.00	.045	.691	.007	.074
30	.766	.009	.076	.756	.009	.072	.84	.01	.092	1.04	.017	.154
40	1.02	.016	.128	1.01	.016	.120	1.12	.02	.153	1.38	.030	.258
50	1.28	.025	.194	1.26	.025	.179	1.40	.03	.230	1.73	.046	.387
60	1.53	.037	.273	1.51	.036	.250	1.67	.04	.320	2.07	.067	.540
70	1.79	.050	.365	1.76	.048	.330	1.95	.06	.424	2.42	.091	.691
80	2.04	.065	.470	2.02	.063	.422	2.23	.08	.541	2.77	.119	.885
90	2.30	.082	.588	2.27	.080	.523	2.51	.10	.649	3.11	.150	1.10
100	2.55	.101	.719	2.52	.099	.613	2.79	.12	.769	3.46	.185	1.34
110	2.81	.123	.862	2.77	.119	.732	3.07	.15	.943	3.80	.224	1.61
120	3.06	.146	1.02	3.02	.142	.861	3.35	.17	1.11	4.15	.267	1.89
130	3.32	.171	1.19	3.28	.167	1.00	3.63	.20	1.29	4.49	.313	2.20
140	3.57	.199	1.37	3.53	.193	1.15	3.91	.24	1.48	4.84	.363	2.53
150	3.83	.228	1.57	3.78	.222	1.31	4.19	.27	1.69	5.18	.417	2.89
160	4.08	.259	1.77	4.03	.253	1.48	4.47	.31	1.91	5.53	.475	3.26
170	4.34	.293	1.99	4.28	.285	1.66	4.75	.35	2.14	5.88	.536	3.66
180	4.60	.328	2.23	4.54	.320	1.85	5.02	.39	2.38	6.22	.601	4.09
190	4.85	.368	2.47	4.79	.356	2.05	5.30	.44	2.64	6.57	.669	4.53
200	5.11	.406	2.73	5.04	.395	2.25	5.58	.48	2.91	6.91	.742	5.00
220	5.62	.490	3.29	5.54	.478	2.70	6.14	.59	3.49	7.60	.897	6.00
240	6.13	.583	3.90	6.05	.569	3.19	6.70	.70	4.13	8.30	1.07	7.09
260	6.64	.685	4.55	6.55	.667	3.72	7.26	.82	4.81	8.99	1.25	8.27
280	7.15	.794	5.26	7.06	.774	4.28	7.82	.95	5.54	9.68	1.45	9.55
300	7.66	.912	6.02	7.56	.888	4.89	8.38	1.09	6.33	10.37	1.67	10.9
320	8.17	1.04	6.84	8.06	1.01	5.53	8.94	1.24	7.17	11.06	1.90	12.4
340	8.68	1.17	7.70	8.57	1.14	6.22	9.50	1.40	8.06	11.75	2.14	13.9
360	9.19	1.31	8.61	9.07	1.28	6.94	10.0	1.6	9.00	12.44	2.40	15.5
380	9.70	1.46	9.58	9.58	1.43	7.71	10.6	1.7	9.99	13.13	2.68	17.3
400	10.2	1.62	10.6	10.1	1.58	8.51	11.2	1.9	11.0	13.82	2.97	19.1
420	10.7	1.79	11.6	10.6	1.74	9.35	11.7	2.1	12.1	14.52	3.27	21.0
440	11.2	1.96	12.8	11.1	1.91	10.2	12.3	2.3	13.3	15.21	3.59	22.9
460	11.7	2.14	13.9	11.6	2.09	11.2	12.8	2.5	14.5	15.90	3.92	25.0
480	12.3	2.33	15.2	12.1	2.27	12.1	13.4	2.8	15.7	16.59	4.27	27.2
500	12.8	2.53	16.4	12.6	2.47	13.1	14.0	3.0	17.0	17.28	4.64	29.5
550	14.0	3.06	19.8	13.9	2.99	15.8	15.3	3.6	20.5	19.00	5.61	35.5
600	15.3	3.65	23.6	15.1	3.55	18.7	16.7	4.3	24.3	20.74	6.67	42.1
650	16.6	4.28	27.6	16.4	4.17	21.7	18.1	5.1	28.4	22.46	7.83	49.2
700	17.9	4.96	32.0	17.6	4.84	25.3	19.5	5.9	32.8	24.19	9.08	57.0
750	19.1	5.70	35.6	18.9	5.55	28.9	20.9	6.8	37.6	25.92	10.4	65.2
800	20.4	6.48	41.6	20.2	6.32	32.8	22.3	7.7	42.7	27.65	11.7	74.1
850	21.7	7.32	45.9	21.4	7.13	37.0	23.7	8.7	48.1	29.38	13.4	83.4
900	23.0	8.20	52.6	22.7	8.00	41.4	25.1	9.8	53.8	31.10	15.0	93.4
950	24.3	9.14	58.5	23.9	8.91	46.0	26.5	10.9	59.8	32.83	16.7	104
1000	25.5	10.1	64.8	25.2	9.87	50.9	27.9	12.1	66.2	34.56	18.5	115
1100	28.1	12.3	78.3	27.7	11.9	61.4	30.7	14.6	79.8	38.02	22.4	139

Friction of Water

5 Inch—New Steel Pipe
Ft per 100 ft

Flow U S gal per min	Standard wt steel—sch 40 5.047" inside dia			Extra strong steel—sch 80 4.813" inside dia			Schedule 160—steel 4.313" inside dia		
	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft
30	.481	.004	.024	.53	.00	.030	.659	.007	.051
40	.641	.006	.040	.71	.01	.051	.878	.012	.086
50	.802	.010	.060	.88	.01	.075	1.10	.019	.128
60	.962	.014	.083	1.06	.02	.105	1.32	.027	.178
70	1.12	.020	.110	1.23	.02	.138	1.54	.037	.235
80	1.28	.026	.140	1.41	.03	.176	1.76	.048	.301
90	1.44	.032	.173	1.59	.04	.218	1.98	.061	.373
100	1.60	.040	.210	1.76	.05	.265	2.20	.075	.453
120	1.92	.058	.293	2.11	.07	.370	2.64	.108	.612
140	2.25	.078	.389	2.47	.09	.491	3.07	.147	.816
160	2.57	.102	.480	2.82	.12	.607	3.51	.192	1.05
180	2.89	.129	.598	3.17	.16	.757	3.95	.243	1.31
200	3.21	.160	.728	3.52	.19	.922	4.39	.299	1.60
220	3.53	.193	.870	3.84	.23	1.10	4.83	.362	1.91
240	3.85	.230	1.03	4.23	.28	1.30	5.27	.431	2.25
260	4.17	.270	1.19	4.58	.33	1.51	5.71	.506	2.63
280	4.49	.313	1.37	4.94	.38	1.74	6.15	.587	3.02
300	4.81	.360	1.56	5.29	.43	1.99	6.59	.674	3.45
320	5.13	.409	1.77	5.64	.49	2.25	7.03	.766	3.91
340	5.45	.462	1.98	5.99	.56	2.52	7.47	.865	4.39
360	5.77	.518	2.21	6.35	.63	2.81	7.91	.970	4.90
380	6.09	.577	2.45	6.70	.70	3.12	8.35	1.08	5.43
400	6.41	.639	2.71	7.05	.77	3.44	8.78	1.20	6.00
420	6.74	.705	2.97	7.40	.85	3.78	9.22	1.32	6.59
440	7.06	.774	3.25	7.76	.94	4.13	9.66	1.45	7.21
460	7.38	.846	3.54	8.11	1.02	4.50	10.10	1.58	7.85
480	7.70	.921	3.84	8.46	1.11	4.88	10.54	1.73	8.53
500	8.02	.999	4.15	8.82	1.21	5.28	10.98	1.87	9.23
550	8.82	1.21	4.99	9.70	1.46	6.35	12.08	2.26	11.1
600	9.62	1.44	5.90	10.6	1.7	7.51	13.18	2.70	13.1
650	10.4	1.69	6.89	11.5	2.1	8.77	14.27	3.16	15.4
700	11.2	1.96	7.95	12.3	2.4	10.1	15.37	3.67	17.8
750	12.0	2.25	9.09	13.2	2.7	11.6	16.47	4.21	20.3
800	12.8	2.56	10.3	14.1	3.1	13.1	17.57	4.79	23.0
850	13.6	2.89	11.6	15.0	3.5	14.8	18.67	5.41	25.9
900	14.4	3.24	13.0	15.9	3.9	16.5	19.76	6.06	29.0
950	15.2	3.61	14.4	16.7	4.3	18.4	20.86	6.76	32.3
1000	16.0	4.00	15.9	17.6	4.8	20.3	21.96	7.49	36.7
1100	17.6	4.84	19.2	19.4	5.8	24.5	24.16	9.06	43.0
1200	19.2	5.76	22.7	21.1	6.9	29.0	26.35	10.78	51.0
1300	20.8	6.75	26.6	22.9	8.2	34.0	28.55	12.65	59.8
1400	22.5	7.83	30.7	24.7	9.5	39.3	30.74	14.67	69.2
1500	24.1	8.99	35.2	26.4	10.8	45.0	32.94	16.84	79.2
1600	25.7	10.2	40.0	28.2	12.4	51.1	35.14	19.16	90.0
1700	27.3	11.6	45.1	30.0	14.0	57.6	37.33	21.63	101

Friction of Water

6 Inch—Asphalt-dipped cast iron and new steel pipe
Ft per 100 ft

Flow U S gal per min	Asphalt-dipped cast iron 6.0" inside dia			Std wt steel sch 40 6.065" inside dia			Extra strong steel sch 80 5.761" inside dia			Schedule 160—steel 5.187" inside dia		
	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft
50	.57	.005	.027	.56	.005	.025	.62	.01	.032	.759	.009	.053
60	.68	.007	.038	.67	.007	.034	.74	.01	.044	.911	.013	.073
70	.79	.010	.048	.78	.009	.045	.86	.01	.058	1.06	.018	.096
80	.91	.013	.062	.89	.012	.057	.98	.01	.074	1.22	.023	.123
90	1.02	.016	.077	1.00	.016	.071	1.11	.02	.091	1.37	.029	.152
100	1.13	.020	.094	1.11	.019	.086	1.23	.02	.110	1.52	.036	.184
120	1.36	.029	.132	1.33	.028	.120	1.48	.03	.154	1.82	.052	.256
140	1.59	.039	.176	1.55	.038	.158	1.72	.05	.203	2.13	.070	.340
160	1.82	.051	.226	1.78	.049	.202	1.97	.06	.260	2.43	.092	.435
180	2.04	.065	.283	2.00	.062	.251	2.22	.08	.323	2.73	.116	.522
200	2.27	.080	.346	2.22	.077	.304	2.46	.09	.392	3.04	.143	.635
220	2.50	.097	.415	2.44	.093	.363	2.71	.11	.451	3.34	.173	.760
240	2.72	.115	.490	2.66	.110	.411	2.96	.14	.530	3.64	.205	.895
260	2.95	.135	.571	2.89	.130	.477	3.20	.16	.616	3.95	.242	1.04
280	3.18	.157	.658	3.11	.150	.548	3.45	.19	.708	4.25	.281	1.20
300	3.40	.180	.752	3.33	.172	.624	3.69	.21	.807	4.56	.322	1.36
320	3.63	.205	.851	3.55	.196	.705	3.94	.24	.911	4.86	.366	1.54
340	3.86	.231	.957	3.78	.222	.790	4.19	.27	1.02	5.16	.414	1.73
360	4.08	.259	1.07	4.00	.240	.880	4.43	.31	1.14	5.47	.464	1.93
380	4.31	.289	1.19	4.22	.277	.975	4.68	.31	1.26	5.77	.517	2.14
400	4.54	.320	1.31	4.44	.307	1.07	4.93	.38	1.39	6.07	.572	2.36
450	5.10	.403	1.65	5.00	.388	1.34	5.54	.48	1.74	6.82	.725	2.95
500	5.67	.500	2.02	5.55	.479	1.64	6.16	.59	2.13	7.59	.894	3.61
550	6.24	.605	2.44	6.11	.580	1.97	6.77	.71	2.55	8.35	1.08	4.34
600	6.81	.720	2.89	6.66	.690	2.33	7.39	.85	3.02	9.11	1.29	5.13
650	7.37	.845	3.38	7.22	.810	2.71	8.00	.99	3.52	9.87	1.51	5.99
700	7.94	.980	3.90	7.77	.939	3.13	8.63	1.16	4.05	10.63	1.75	6.92
750	8.51	1.12	4.47	8.33	1.08	3.57	9.24	1.33	4.64	11.39	2.01	7.91
800	9.08	1.28	5.07	8.88	1.23	4.04	9.85	1.51	5.25	12.15	2.29	8.96
850	9.64	1.44	5.72	9.44	1.38	4.55	10.5	1.7	5.90	12.91	2.59	10.1
900	10.2	1.62	6.40	9.99	1.55	5.08	11.1	1.9	6.59	13.67	2.90	11.3
950	10.8	1.80	7.11	10.5	1.73	5.64	11.7	2.1	7.33	14.42	3.23	12.5
1000	11.3	2.00	7.87	11.1	1.92	6.23	12.3	2.4	8.09	15.18	3.58	13.8
1100	12.5	2.42	9.50	12.2	2.32	7.49	13.5	2.8	9.74	16.71	4.33	16.7
1200	13.6	2.88	11.3	13.3	2.76	8.87	14.8	3.4	11.5	18.22	5.15	19.8
1300	14.7	3.38	13.2	14.4	3.24	10.4	16.0	4.0	13.5	19.74	6.05	23.1
1400	15.9	3.92	15.3	15.5	3.76	12.0	17.2	4.6	15.6	21.26	7.01	26.7
1500	17.0	4.50	17.5	16.7	4.31	13.7	18.5	5.3	17.8	22.78	8.05	30.6
1600	18.2	5.12	19.9	17.8	4.91	15.6	19.7	6.0	20.3	24.29	9.16	34.7
1700	19.3	5.78	22.4	18.9	5.54	17.5	20.9	6.8	22.8	25.81	10.34	39.1
1800	20.4	6.48	25.1	20.0	6.21	19.6	22.2	7.7	25.5	27.33	11.59	43.8
1900	21.6	7.22	28.0	21.1	6.91	21.8	23.4	8.4	28.4	28.85	12.92	48.7
2000	22.7	8.00	31.0	22.2	7.67	24.1	24.6	9.4	31.4	30.37	14.31	53.9
2200	25.0	9.68	37.4	24.4	9.27	29.1	27.1	11.4	37.9	33.40	17.32	65.0
2400	27.2	11.5	44.5	26.6	11.0	34.5	29.6	13.6	44.9	36.44	20.61	77.2

Friction of Water

8 Inch—Asphalt-dipped cast iron and new steel pipe
Ft per 100 ft

Flow U S gal per min	Asphalt-dipped cast iron 8.0" inside dia			Std wt steel sch 40 7.981" inside dia			Extra strong steel sch 80 7.625" inside dia			Schedule 160—steel 6.813" inside dia		
	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft
130	.83	.011	.037	.83	.011	.036	.91	.01	.045	1.14	.020	.079
140	.89	.012	.042	.90	.013	.042	.98	.01	.052	1.23	.024	.090
150	.96	.014	.048	.96	.014	.047	1.05	.02	.059	1.32	.027	.102
160	1.02	.016	.054	1.03	.016	.053	1.12	.02	.066	1.41	.031	.115
170	1.08	.018	.060	1.09	.018	.059	1.19	.02	.074	1.50	.035	.128
180	1.15	.021	.067	1.15	.021	.066	1.26	.02	.082	1.58	.039	.142
190	1.21	.023	.074	1.22	.023	.073	1.33	.03	.091	1.67	.043	.157
200	1.28	.025	.082	1.28	.026	.080	1.41	.03	.099	1.76	.048	.172
220	1.40	.031	.098	1.41	.031	.095	1.55	.04	.118	1.94	.058	.205
240	1.53	.037	.115	1.54	.037	.111	1.69	.04	.139	2.11	.069	.241
260	1.66	.043	.134	1.67	.043	.128	1.83	.05	.161	2.29	.081	.279
280	1.79	.050	.154	1.80	.050	.147	1.97	.06	.184	2.46	.094	.320
300	1.91	.057	.175	1.92	.058	.167	2.11	.07	.209	2.64	.108	.350
350	2.23	.077	.235	2.24	.089	.222	2.46	.09	.278	3.08	.147	.467
400	2.55	.101	.303	2.57	.102	.284	2.81	.12	.343	3.52	.192	.601
450	2.87	.128	.380	2.89	.129	.341	3.16	.15	.428	3.96	.243	.750
500	3.19	.158	.465	3.21	.160	.416	3.51	.19	.522	4.40	.301	.916
550	3.51	.191	.559	3.53	.193	.497	3.86	.23	.625	4.84	.364	1.10
600	3.83	.228	.661	3.85	.230	.586	4.22	.28	.736	5.28	.433	1.30
650	4.15	.267	.772	4.17	.271	.682	4.57	.32	.857	5.72	.508	1.51
700	4.47	.310	.891	4.49	.313	.785	4.92	.38	.986	6.16	.589	1.74
750	4.79	.356	1.02	4.81	.360	.895	5.27	.43	1.13	6.60	.676	1.98
800	5.11	.405	1.16	5.13	.409	1.01	5.62	.49	1.27	7.04	.769	2.24
850	5.42	.457	1.30	5.45	.462	1.14	5.97	.55	1.43	7.48	.869	2.52
900	5.74	.513	1.45	5.77	.518	1.27	6.32	.62	1.59	7.92	.974	2.81
950	6.06	.571	1.61	6.09	.577	1.40	6.67	.69	1.77	8.36	1.09	3.12
1000	6.38	.633	1.78	6.41	.639	1.55	7.03	.77	1.95	8.80	1.20	3.45
1100	7.02	.766	2.15	7.05	.773	1.86	7.83	.95	2.34	9.68	1.46	4.14
1200	7.66	.911	2.55	7.70	.920	2.20	8.43	1.10	2.77	10.56	1.73	4.91
1300	8.30	1.07	2.98	8.34	1.08	2.56	9.13	1.30	3.23	11.44	2.03	5.73
1400	8.93	1.24	3.45	8.98	1.25	2.96	9.83	1.5	3.73	12.32	2.36	6.62
1500	9.57	1.42	3.95	9.62	1.44	3.38	10.5	1.7	4.26	13.20	2.71	7.57
1600	10.2	1.62	4.48	10.3	1.64	3.83	11.2	2.0	4.83	14.08	3.08	8.58
1800	11.5	2.05	5.65	11.5	2.07	4.81	12.6	2.5	6.07	15.84	3.90	10.8
2000	12.8	2.53	6.95	12.8	2.56	5.91	14.1	3.1	7.46	17.60	4.81	13.3
2200	14.0	3.06	8.40	14.1	3.09	7.11	15.5	3.7	8.98	19.36	5.82	16.0
2400	15.3	3.65	9.98	15.4	3.68	8.43	16.9	4.4	10.6	21.12	6.92	19.0
2600	16.6	4.28	11.7	16.7	4.32	9.85	18.3	5.2	12.4	22.88	8.13	22.2
2800	17.9	4.96	13.5	18.0	5.01	11.4	19.7	6.0	14.4	24.64	9.43	25.7
3000	19.1	5.70	15.5	19.2	5.75	13.0	21.1	6.9	16.5	26.40	10.82	29.4
3500	22.3	7.70	21.1	22.4	8.9	17.6	24.6	9.4	22.3	30.80	14.73	39.8
4000	25.5	10.1	27.4	25.7	10.2	22.9	28.1	12.3	29.0	35.20	19.23	51.8
4500	28.7	12.8	34.7	28.9	12.9	28.9	31.6	15.5	36.6	39.60	24.34	65.4
5000	31.9	15.8	42.7	32.1	16.0	35.6	35.1	19.1	45.0	44.00	30.05	80.6
5500	35.1	19.1	51.7	35.3	19.3	43.0	38.6	23.2	54.4	48.40	36.36	97.3

Friction of Water

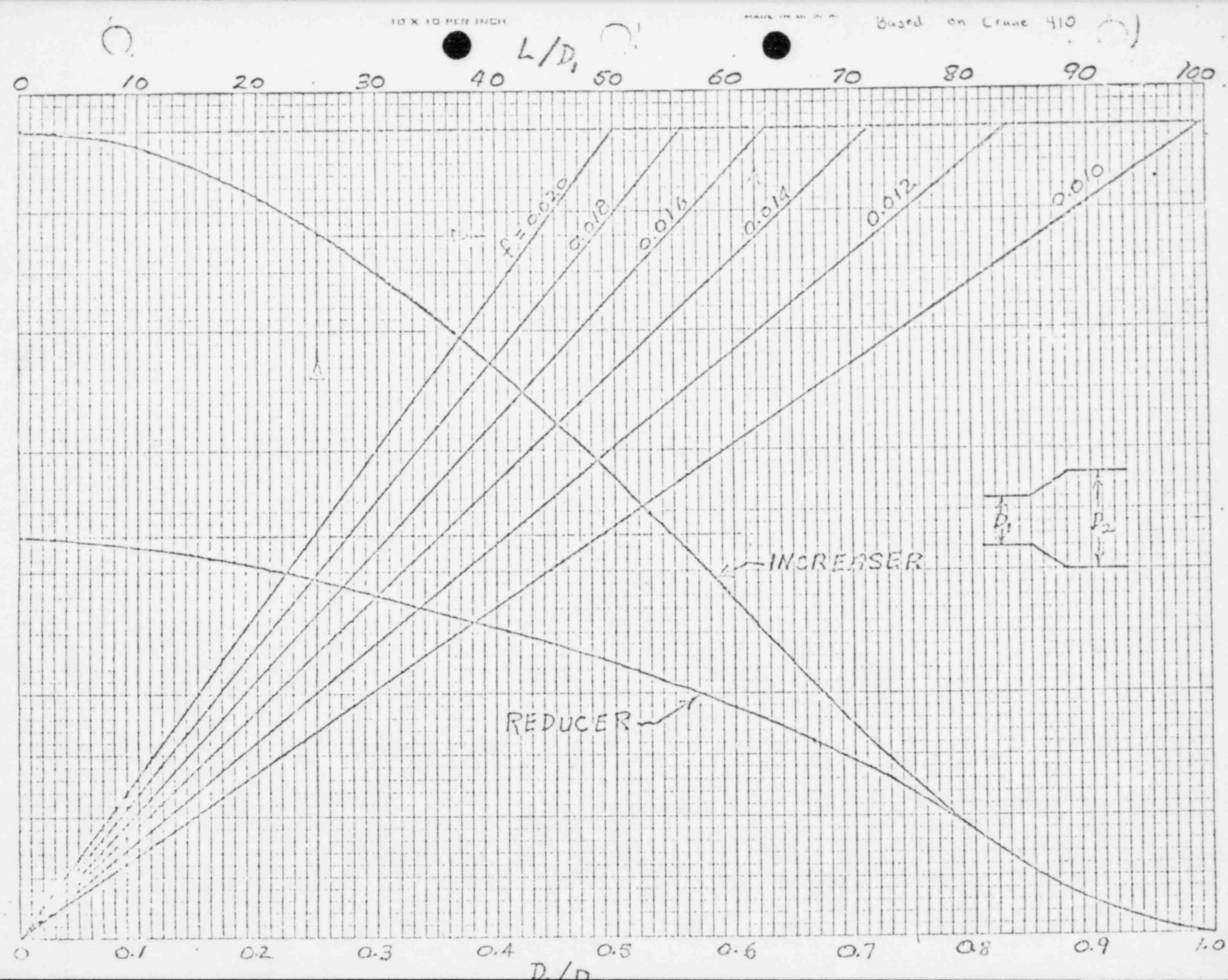
10 Inch—Asphalt-dipped cast iron and new steel pipe
Ft per 100 ft

Flow U S gal per min	Asphalt-dipped cast iron 10.0" inside dia			Std wt steel sch 40 10.020" inside dia			Schedule 80 steel 9.562" inside dia			Schedule 160—steel 8.500" inside dia		
	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft
180	.74	.008	.023	.73	.008	.022	.804	.010	.027	1.02	.016	.048
200	.82	.010	.028	.81	.010	.026	.894	.012	.033	1.13	.020	.059
220	.90	.013	.032	.90	.013	.031	.983	.015	.039	1.24	.024	.070
240	.98	.015	.038	.98	.015	.037	1.07	.018	.046	1.36	.029	.082
260	1.06	.018	.044	1.06	.017	.042	1.16	.021	.053	1.47	.034	.094
280	1.14	.020	.051	1.14	.020	.049	1.25	.024	.061	1.58	.039	.108
300	1.23	.073	.057	1.22	.023	.055	1.34	.028	.069	1.70	.045	.123
320	1.31	.032	.077	1.30	.032	.073	1.56	.038	.092	1.98	.061	.163
400	1.63	.042	.099	1.63	.041	.093	1.79	.050	.117	2.26	.079	.208
450	1.84	.053	.123	1.83	.052	.116	2.01	.063	.145	2.54	.100	.259
500	2.04	.065	.150	2.03	.064	.140	2.34	.077	.177	2.83	.124	.304
550	2.25	.079	.180	2.24	.078	.167	2.46	.094	.211	3.11	.150	.364
600	2.45	.093	.213	2.44	.093	.197	2.68	.112	.239	3.39	.179	.428
650	2.66	.110	.248	2.64	.109	.228	2.90	.131	.277	3.68	.210	.498
700	2.86	.127	.286	2.85	.126	.263	3.13	.152	.319	3.96	.243	.573
800	3.27	.166	.370	3.25	.165	.325	3.57	.198	.410	4.52	.318	7.38
900	3.68	.210	.464	3.66	.208	.405	4.02	.251	.512	5.09	.402	9.23
1000	4.09	.259	.569	4.07	.257	.494	4.47	.310	.625	5.65	.496	1.13
1100	4.49	.314	.685	4.48	.311	.592	4.92	.375	.749	6.22	.600	1.35
1200	4.90	.373	.811	4.88	.370	.699	5.36	.446	.884	6.79	.714	1.60
1300	5.31	.438	.947	5.29	.435	.814	5.81	.524	1.03	7.35	.839	1.66
1400	5.72	.508	1.09	5.70	.504	.938	6.26	.607	1.19	7.92	.972	2.15
1500	6.13	.584	1.25	6.10	.579	1.07	6.70	.697	1.35	8.48	1.12	2.46
1600	6.54	.664	1.42	6.51	.659	1.21	7.15	.793	1.53	9.05	1.27	2.78
1700	6.94	.749	1.60	5.92	.745	1.36	7.60	.895	1.72	9.61	1.43	3.13
1800	7.35	.840	1.79	7.32	.834	1.52	8.04	1.00	1.92	10.18	1.61	3.49
1900	7.76	.936	1.99	7.73	.929	1.68	8.49	1.12	2.13	10.74	1.79	3.88
2000	8.17	1.04	2.20	8.14	1.03	1.86	8.94	1.24	2.36	11.31	1.99	4.29
2200	8.99	1.26	2.65	8.95	1.25	2.24	9.83	1.50	2.83	12.44	2.40	5.15
2400	9.80	1.49	3.15	9.76	1.48	2.64	10.72	1.79	3.35	13.57	2.86	6.11
2600	10.6	1.75	3.68	10.6	1.74	3.09	11.62	2.09	3.92	14.70	3.35	7.14
2800	11.4	2.03	4.26	11.4	2.02	3.57	12.51	2.43	4.52	15.83	3.89	8.25
3000	12.3	2.33	4.88	12.2	2.32	4.08	13.40	2.79	5.17	16.96	4.47	9.44
3200	13.1	2.66	5.54	13.0	2.63	4.62	14.30	3.17	5.87	18.09	5.08	10.7
3400	13.9	3.00	6.25	13.8	2.97	5.20	15.19	3.58	6.60	19.22	5.74	12.1
3600	14.7	3.36	6.99	14.6	3.33	5.81	16.08	4.02	7.38	20.35	6.43	13.5
3800	15.5	3.74	7.79	15.5	3.71	6.46	16.98	4.47	8.21	21.49	7.17	15.0
4000	16.3	4.15	8.62	16.3	4.12	7.14	17.87	4.96	9.07	22.62	7.94	16.6
4500	18.4	5.25	10.9	18.3	5.21	8.99	20.11	6.27	11.4	25.44	10.05	20.9
5000	20.4	6.48	13.4	20.3	6.43	11.1	22.34	7.75	14.1	28.27	12.40	25.7
5500	22.5	7.85	16.2	22.4	7.78	13.3	24.57	9.37	17.0	31.10	15.01	31.1
6000	24.5	9.34	19.2	24.4	9.26	15.8	26.81	11.15	20.1	33.92	17.86	36.9
6500	26.6	11.0	22.6	26.4	10.9	18.5	29.04	13.09	23.6	36.75	20.96	43.2
7000	28.6	12.7	26.1	28.5	12.6	21.4	31.28	15.18	27.3	39.58	24.31	50.0
7500	30.6	14.6	30.0	30.5	14.5	24.5	33.51	17.43	31.2	42.41	27.91	57.3

Friction of Water

12 Inch—Asphalt-dipped cast iron and new steel pipe
Ft per 100 ft

Flow U S gal per min	Asphalt-dipped cast iron 12.0" inside dia			Std wt steel sch 40 11.938" inside dia			Schedule 80 steel 11.374" inside dia			Schedule 160 steel 10.126" inside dia		
	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft	Velocity ft per sec	Velocity head ft	Head loss ft per 100 ft
200	.57	.005	.011	.57	.005	.011	.632	.006	.014	.797	.010	.025
250	.71	.008	.017	.72	.008	.017	.789	.010	.021	.996	.015	.038
300	.85	.011	.024	.86	.012	.024	.947	.014	.030	1.20	.022	.052
350	.99	.015	.031	1.00	.016	.031	1.11	.019	.039	1.39	.030	.069
400	1.13	.029	.040	1.15	.020	.040	1.26	.025	.050	1.59	.039	.088
450	1.28	.025	.049	1.29	.026	.049	1.42	.031	.062	1.79	.050	.110
500	1.42	.031	.060	1.43	.032	.060	1.58	.039	.076	1.99	.062	.133
550	1.56	.038	.072	1.58	.039	.071	1.74	.047	.090	2.19	.075	.159
600	1.70	.045	.085	1.72	.046	.083	1.90	.056	.106	2.39	.089	.187
700	1.99	.061	.114	2.01	.063	.111	2.21	.076	.140	2.79	.121	.240
800	2.27	.080	.147	2.29	.082	.142	2.53	.099	.180	3.19	.158	.308
900	2.55	.101	.184	2.58	.103	.176	2.84	.125	.216	3.59	.200	.384
1000	2.84	.125	.225	2.87	.128	.207	3.16	.155	.263	3.98	.246	.469
1100	3.12	.151	.271	3.15	.154	.247	3.47	.187	.315	4.38	.298	.562
1200	3.40	.180	.320	3.44	.184	.291	3.79	.223	.371	4.78	.355	.663
1300	3.69	.211	.374	3.73	.216	.339	4.11	.262	.432	5.18	.416	.772
1400	3.97	.245	.431	4.01	.250	.390	4.42	.303	.497	5.58	.483	.889
1500	4.26	.281	.493	4.30	.287	.444	4.73	.348	.566	5.98	.554	1.02
1600	4.54	.320	.558	4.59	.327	.502	5.05	.396	.640	6.37	.631	1.15
1700	5.11	.405	.702	5.16	.414	.629	5.68	.501	.802	7.17	.798	1.44
2000	5.67	.500	.862	5.73	.511	.769	6.32	.619	.981	7.97	.985	1.76
2200	6.24	.605	1.04	6.31	.618	.923	6.95	.749	1.18	8.77	1.19	2.12
2400	6.81	.720	1.23	6.88	.735	1.09	7.58	.891	1.39	9.56	1.42	2.51
2600	7.38	.845	1.44	7.45	.863	1.27	8.21	1.05	1.62	10.76	1.67	2.93
2800	7.94	.980	1.67	8.03	1.00	1.47	8.84	1.21	1.87	11.16	1.93	3.38
3000	8.51	1.13	1.91	8.60	1.15	1.68	9.47	1.39	2.14	11.95	2.22	3.86
3500	9.93	1.53	2.58	10.0	1.55	2.26	11.05	1.90	2.89	13.94	3.02	5.22
4000	11.3	2.00	3.36	11.5	2.04	2.92	12.63	2.48	3.74	15.94	3.94	6.77
4500	12.8	2.53	4.24	12.9	2.59	3.68	14.21	3.13	4.71	17.93	4.99	8.52
5000	14.2	3.13	5.21	14.3	3.19	4.52	15.79	3.87	5.78	19.92	6.16	10.5
5500	15.6	3.78	6.30	15.8	3.86	5.44	17.37	4.68	6.97	21.91	7.45	12.6
6000	17.0	4.50	7.43	17.2	4.60	6.45	18.95	5.57	8.26	23.90	8.87	15.0
6500	18.4	5.28	8.76	18.6	5.39	7.54	20.53	6.54	9.66	25.90	10.41	17.5
7000	19.9	6.13	10.1	20.1	6.26	8.72	22.10	7.58	11.2	27.89	12.07	20.3
7500	21.3	7.03	11.6	21.5	7.18	9.98	23.68	8.71	12.8	29.88	13.86	23.3
8000	22.7	8.00	13.2	22.9	8.17	11.3	25.26	9.90	14.5	31.87	15.77	26.4
8500	24.1	9.04	14.9	24.4	9.22	12.8	26.84	11.18	16.4	33.86	17.80	29.8
9000	25.5	10.1	16.7	25.8	10.3	14.3	28.42	12.54	18.3	35.86	19.95	33.3
9500	26.9	11.3	18.6	27.2	11.5	15.9	30.00	13.97	20.4	37.85	22.23	37.1
10,000	28.4	12.5	20.6	28.7	12.8	17.6	31.58	15.48	22.6	39.84	24.64	41.0
11,000	31.2	15.1	24.9	31.5	15.4	21.2	34.73	18.73	27.2	43.82	29.81	49.6
12,000	34.0	18.0	29.6	34.4	18.3	25.2	37.89	22.29	32.3	47.81	35.47	58.7
13,000	36.9	21.1	34.7	37.3	21.6	29.5	41.05	26.15	37.9	51.79	41.63	69.0
14,000	39.7	24.5	40.2	40.1	25.0	34.2	44.21	30.33	43.8	55.78	48.28	79.9
15,000	42.6	28.1	46.1	43.0	28.7	39.2	47.37	34.82	50.3	59.76	55.43	91.6


10 X 10 PER INCH
Based on Crane 410
L/D1
0
10
20
30
40
50
60
70
80
90
100
f = 0.020
0.018
0.016
0.014
0.012
0.010
INCREASER
REDUCER
D1
D2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
D2/D1

Commercial Wrought Steel Pipe Data

Schedule Wall Thickness—Per ASA B36.10-1950

	Nominal Pipe Size	Outside Diameter	Thickness	Inside Diameter		Inside Diameter Functions (In Inches)				Transverse Internal Area	
				d	D					a	A
	Inches	Inches	Inches	Inches	Feet	d^2	d^3	d^4	d^5	Sq. In.	Sq. Ft.
Schedule 10	14	14	0.250	13.5	1.125	182.25	2460.4	33215.	448400.	143.14	0.994
	16	16	0.250	15.5	1.291	240.25	3723.9	57720.	894660.	188.69	1.310
	18	18	0.250	17.5	1.4583	306.25	5359.4	93789.	1641309.	240.53	1.670
	20	20	0.250	19.5	1.625	380.25	7414.9	144590.	2819500.	298.65	2.074
	24	24	0.250	23.5	1.958	552.25	12977.	304980.	7167030.	433.74	3.012
	30	30	0.312	29.376	2.448	862.95	25350.	744288.	21864218.	677.76	4.707
Schedule 20	8	8.625	0.250	8.125	0.6771	66.02	536.38	4359.3	35409.	51.85	0.3601
	10	10.75	0.250	10.25	0.8542	105.06	1076.9	11038.	113141.	82.52	0.5731
	12	12.75	0.250	12.25	1.021	150.06	1838.3	22518.	275855.	117.86	0.8185
	14	14	0.312	13.376	1.111	178.92	2393.2	32012.	428185.	140.52	0.9758
	16	16	0.312	15.376	1.281	236.42	3635.2	55894.	859442.	185.69	1.290
	18	18	0.312	17.376	1.448	301.92	5246.3	91156.	1583978.	237.13	1.647
	20	20	0.375	19.250	1.604	370.56	7133.3	137317.	2643352.	291.04	2.021
	24	24	0.375	23.25	1.937	540.56	12568.	292205.	6793832.	424.56	2.948
	30	30	0.500	29.00	2.417	841.0	24389.	707281.	20511149.	660.52	4.587
Schedule 30	8	8.625	0.277	8.071	0.6726	65.14	525.75	4243.2	34248.	51.16	0.3553
	10	10.75	0.307	10.136	0.8447	102.74	1041.4	10555.	106987.	80.69	0.5603
	12	12.75	0.330	12.09	1.0075	146.17	1767.2	21366.	258304.	114.80	0.7972
	14	14	0.375	13.25	1.1042	175.56	2326.2	30821.	408394.	137.88	0.9575
	16	16	0.375	15.25	1.2708	232.56	3546.6	54084.	824801.	182.65	1.268
	18	18	0.438	17.124	1.4270	293.23	5021.3	85984.	1472397.	230.30	1.599
	20	20	0.500	19.00	1.5833	361.00	6859.0	130321.	2476099.	283.53	1.969
	24	24	0.562	22.876	1.9063	523.31	11971.	273853.	6264703.	411.00	2.854
	30	30	0.625	28.75	2.3958	826.56	23764.	683201.	19642160.	649.18	4.508
Schedule 40	⅛	0.405	0.068	0.269	0.0224	0.0724	0.0195	0.005242	0.00141	0.057	0.00040
	¼	0.540	0.088	0.364	0.0303	0.1325	0.0482	0.01756	0.00639	0.104	0.00072
	⅜	0.675	0.091	0.493	0.0411	0.2430	0.1198	0.05905	0.02912	0.191	0.00133
	½	0.840	0.109	0.622	0.0518	0.3869	0.2406	0.1497	0.09310	0.304	0.00211
	¾	1.050	0.113	0.824	0.0687	0.679	0.5595	0.4610	0.3799	0.533	0.00371
	1	1.315	0.133	1.049	0.0874	1.100	1.154	1.210	1.270	0.864	0.00600
	1¼	1.660	0.140	1.380	0.1150	1.904	2.628	3.625	5.005	1.495	0.01040
	1½	1.900	0.145	1.610	0.1342	2.592	4.173	6.718	10.82	2.036	0.01414
	2	2.375	0.154	2.067	0.1722	4.272	8.831	18.250	37.72	3.355	0.02330
	2½	2.875	0.203	2.469	0.2057	6.096	15.051	37.161	91.75	4.788	0.03322
	3	3.500	0.216	3.068	0.2557	9.413	28.878	88.605	271.8	7.393	0.05130
	3½	4.000	0.226	3.548	0.2957	12.59	44.663	158.51	562.2	9.886	0.06870
	4	4.500	0.237	4.026	0.3355	16.21	65.256	262.76	1058.	12.730	0.08840
	5	5.563	0.258	5.047	0.4206	25.47	128.56	648.72	3275.	20.006	0.1390
	6	6.625	0.280	6.065	0.5054	36.78	223.10	1352.8	8206.	28.891	0.2006
	8	8.625	0.322	7.981	0.6651	63.70	508.36	4057.7	32380.	50.027	0.3474
	10	10.75	0.365	10.02	0.8350	100.4	1006.0	10080.	101000.	78.855	0.5475
	12	12.75	0.406	11.938	0.9965	142.5	1701.3	20306.	242470.	111.93	0.7773
	14	14.0	0.438	13.124	1.0937	172.24	2260.5	29666.	389340.	135.28	0.9394
	16	16.0	0.500	15.000	1.250	225.0	3375.0	50625.	759375.	176.72	1.2272
	18	18.0	0.562	16.876	1.4063	284.8	4806.3	81111.	1368820.	223.68	1.5533
	20	20.0	0.593	18.814	1.5678	354.0	6659.5	125320.	2357244.	278.00	1.9305
	24	24.0	0.687	22.626	1.8855	511.9	11583.	262040.	5929784.	402.07	2.7921
Schedule 60	8	8.625	0.406	7.813	0.6511	61.04	476.93	3725.9	29113.	47.94	0.3329
	10	10.75	0.500	9.750	0.8125	95.06	926.86	9036.4	88110.	74.66	0.5185
	12	12.75	0.562	11.626	0.9688	135.16	1571.4	18268.	212399.	106.16	0.7372
	14	14.0	0.593	12.814	1.0678	164.20	2104.0	26962.	345480.	128.96	0.8956
	16	16.0	0.656	14.688	1.2240	215.74	3168.8	46544.	683618.	169.44	1.1766
	18	18.0	0.750	16.500	1.3750	272.25	4492.1	74120.	1222982.	213.83	1.4849
	20	20.0	0.812	18.376	1.5313	337.68	6205.2	114028.	2095342.	265.21	1.8417
	24	24.0	0.968	22.064	1.8387	486.82	10741.	236994.	5229036.	382.35	2.6552
Schedule 80	⅛	0.405	0.095	0.215	0.0179	0.0462	0.00994	0.002134	0.000459	0.036	0.00025
	¼	0.540	0.119	0.302	0.0252	0.0912	0.0275	0.008317	0.002513	0.072	0.00050
	⅜	0.675	0.126	0.423	0.0353	0.1789	0.0757	0.03200	0.01354	0.141	0.00098
	½	0.840	0.147	0.546	0.0455	0.2981	0.1628	0.08886	0.04852	0.234	0.00163
	¾	1.050	0.154	0.742	0.0618	0.5506	0.4085	0.3032	0.2249	0.433	0.00300
	1	1.315	0.179	0.957	0.0797	0.9158	0.8765	0.8387	0.8027	0.719	0.00[illegible]
	1¼	1.660	0.191	1.278	0.1065	1.633	2.087	2.6667	3.409	1.283	0.00891

(continued on the next page)

HYDRAULIC PERFORMANCE WARRANTY

Guaranteed at design rated point only and is contingent on

1. Proper and adequate flow to pump suction.
2. Proper submergence and NPSH available.
3. Fluid free of gas, air and abrasive matter.
4. Impeller with proper lateral adjustment.

PEERLESS PUMP

HYDRODYNAMICS DIVISION

Los Angeles 31, Calif. • Indianapolis 8, Ind.

FOR _____

CURVE NO 2895866

PUMP TYPE 16 HXB

COLUMN 12" STD. x 1 15/16"

BOWL 2619682E STAGES 3

RPM 1760 IMPELLER NO 2617215

PUMP NO 382953 s/o NO 822197

2-IMP. DIAS. 10 13/16 x 11 3/16

1-IMP. DIA. 11 3/4 x 12

FIRE DIESEL

TOTAL DYNAMIC HEAD IN FEET

EFFICIENCY

HORSEPOWER

EFFICIENCY

HEAD-CAPACITY

B.H.P.

400 300 200 100

90 80 70 60 50 40

380

300 200 100 0

0 130 600 1600 2400 3200 4000 4800

GALLONS PER MINUTE

HYDRAULIC PERFORMANCE WARRANTY

Guaranteed at designated point only and is contingent on

1. Proper and adequate line to pump suction.
2. Proper submergence and NPSH available.
3. Fluid free of gas, air and abrasive matter.
4. Impeller with proper lateral adjustment.

PEERLESS PUMP

HYDRODYNAMICS DIVISION

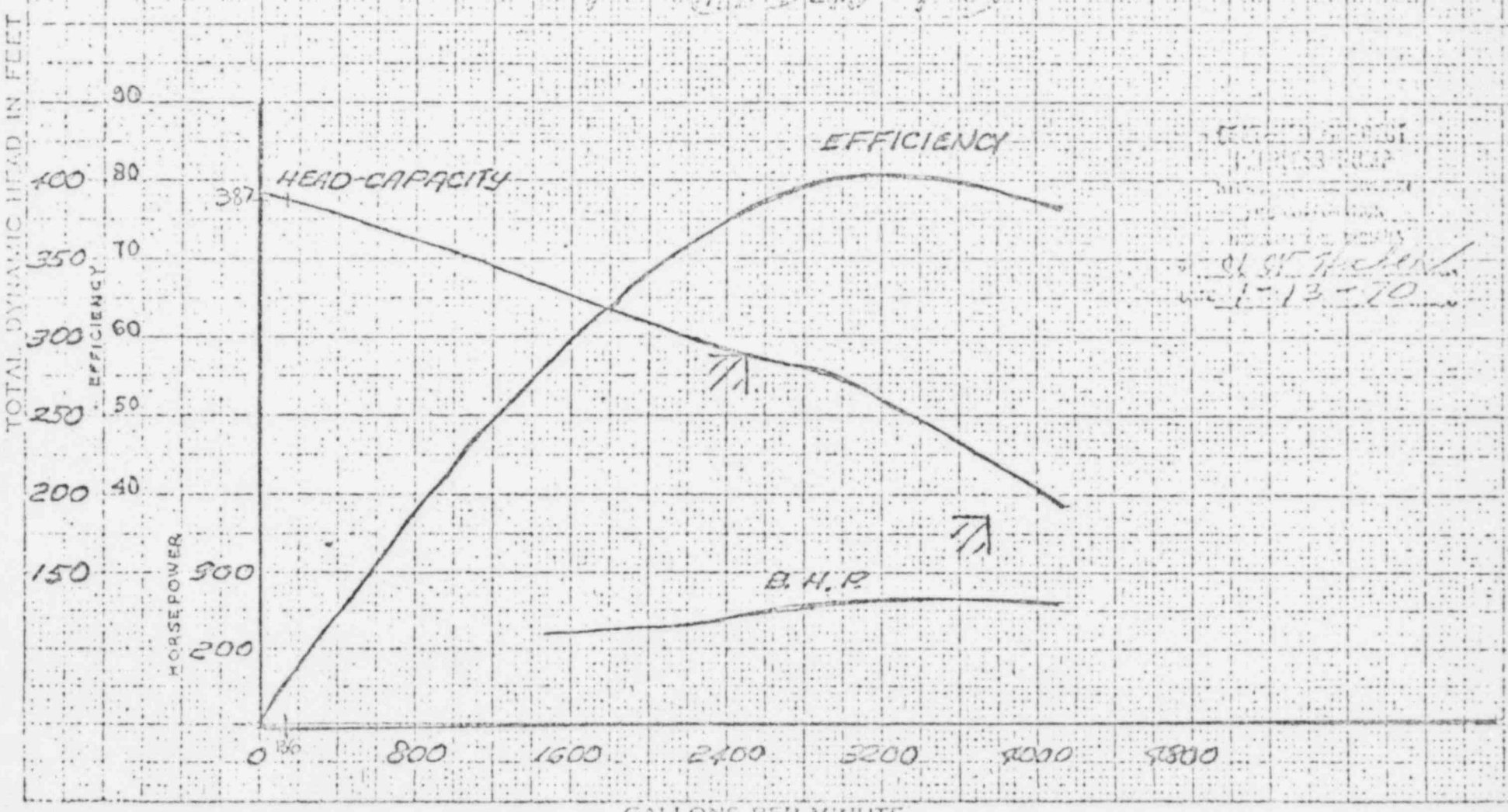
Los Angeles 31, Calif. • Indianapolis 8, Ind.

FOR _____

CURVE NO. 2896145
PUMP TYPE 16 HXB
COLUMN 12 x 1 1/8 OLS
BOWL 2614968-E STAGES 3
RPM 1760 IMPELLER NO 2617216
PUMP NO 362952 S/O NO 82215

C-12 FIRE MOTOR DRIVEN
P-60 Bay-1 B

IMP. DIA. 10 3/4 x 11 1/2



PLOTTED BY CHERYL FROM TEST NO. 134353 DATE 1-14-70

FORM E-1