CAPACITY OF RETURNS WITH VARIOUS GRADES

In general return lines when installed follow the contour of the land, and Table 3 gives sizes of return pipes for various grades. It is evident that at points where the grade is great, smaller pipes can be installed.

Table 4 gives the number of pounds of steam condensed to water for various steam pressures which can be used in determining the size of steam main or return line.

CAPACITY OF SUPPLY MAINS

Table 5 gives the capacity of various sizes of pipes under various steam pressures, based on a velocity of 10,000 ft. per minute. The pipe loss will not vary under other velocities. For other velocities, at the same pressure drop, the capacity may be determined by dividing by 10,000 and multiplying by the actual velocity.

Present practice in the design of underground lines is towards higher velocities, and 10,000 ft. per minute may be considered as a minimum. Velocities as high as 35,000 ft. per minute are becoming quite common. As an example, at a velocity of 35,000 ft. per minute, the capacities would be three and one-half times the values given in the table. In assuming the higher velocities, the corresponding pressure drop should be checked.

As already stated, with a maximum load, the pressure drop in a line will be such that a fixed pressure can be held at a distant point to meet definite requirements of a customer. For this reason, the practice has been quite well established among district heating companies for using pressure drop as the determining factor for fixing pipe sizes in order to give proper service at the end of any line. Following this practice velocities ranging from 25,000 to 50,000 ft. per minute are in use.

The formula generally accepted for the flow of steam in pipes is that using Babcock's constant of $K = 0.0027$. Table 6, derived from this formula, is taken from *Steam*, and gives the amount of steam passing per minute that will flow through straight smooth pipes having a length of 240 diameters, for various initial pressures with 1 lb. difference between the initial and final pressures.

To apply this table for other lengths of pipe and pressure losses than those assumed, let L = the length and d the diameter of the pipe, both in inches; l the loss in pounds; Q the weight under the conditions assumed in the table; and Q_1 the weight for the changed conditions.

For any length of pipe, if the weight of steam passing is the same as given in the table, the loss will be:

$$l = \frac{L}{240d}$$

If the pipe length is the same as assumed in the table, but the loss is different, the quantity of steam passing per minute will be:

$$Q_1 = Q l^{1/2}$$

For any assumed pipe length and loss of pressure, the weight will be:

$$Q_1 = Q \left(\frac{240dl}{L}\right)^{1/2}$$

Table 5. Pipe Sizes for Underground Supply Mains Based on a Velocity of 10,000 Ft. per Minute

Gage Pressure Lb.	Lb. Steam per Minute	Total B.t.u. above 200 Deg. Fahr. per Hr.	Pipe Loss B.t.u. per Hour, per Ft. Length		Lb. Steam Condensed per Hour per Ft. Length
			Bare	Covered (10% of Bare)	
		1 in. Pipe			
0	2.23	131,100	116	11.6	0.0119
10	3.65	217,200	143	14.3	0.015
20	4.98	298,200	168	16.8	0.0179
40	7.68	461,400	206	20.6	0.0224
60	10.3	627,000	236	23.6	0.0262
80	12.8	780,000	260	26.0	0.0292
100	15.3	936,000	284	28.4	0.0322
120	18.1	1,110,000	304	30.4	0.0349
140	20.6	1,272,000	322	32.2	0.0374
160	23.0	1,416,000	337	33.7	0.0395
180	26.0	1,608,000	355	35.5	0.0420
200	28.5	1,764,000	373	37.3	0.0445
		2 in. Pipe			
0	8.70	512,400	209	20.9	0.0216
10	14.2	846,000	258	25.8	0.0270
20	19.4	1,158,000	306	30.6	0.0327
40	29.8	1,794,000	372	37.2	0.0406
60	40.0	2,436,000	426	42.6	0.0472
80	49.7	3,030,000	471	47.1	0.0529
100	59.8	3,660,000	513	51.3	0.0582
120	70.5	4,338,000	548	54.8	0.0631
140	80.4	4,950,000	582	58.2	0.0675
160	89.6	5,520,000	608	60.8	0.0714
180	101.0	6,240,000	641	64.1	0.0760
200	111.0	6,888,000	674	67.4	0.0804
		3 in. Pipe			
0	19.2	1,129,200	309	30.9	0.0319
10	31.3	1,860,000	380	38	0.0399
20	42.8	2,562,000	451	45	0.0480
40	65.5	3,588,000	549	55	0.0600
60	87.5	5,280,000	628	63	0.0693
80	108	6,588,000	694	69	0.0775
100	130	7,980,000	756	76	0.0864
120	153	9,420,000	809	81	0.0931
140	174	10,740,000	857	86	0.0999
160	194	11,940,000	897	90	0.1058
180	220	13,560,000	945	94	0.1110
200	240	14,880,000	993	99	0.1180
		4 in. Pipe			
0	33.0	1,944,000	397	39.7	0.0404
10	54.0	3,210,000	489	48.9	0.0514
20	73.8	4,422,000	579	57.9	0.0617
40	113	6,840,000	705	70.5	0.0769
60	153	9,300,000	806	80.6	0.0895
80	189	11,520,000	891	89.1	0.1000
100	227	13,920,000	971	97.1	0.110
120	268	16,440,000	1039	103.9	0.119
140	305	18,780,000	1101	110.1	0.128
160	340	21,000,000	1152	115.2	0.135
180	384	23,760,000	1214	121.4	0.144
200	420	25,440,000	1275	127.5	0.152