ORIFICES

PRACTICAL INFORMATION

In the design of any gas burning equipment some means must be provided for metering the flow of fuel. This usually takes the form of a nozzle commonly called an orifice. The ideal orifice would be an opening with an approach and discharge conforming to the perfect nozzle formula. This would provide maximum energy with a minimum of noise for the injection of primary air. Practically, however, orifices are usually selected from a standard stock with due regard for size and cost.

The most commonly used orifice consists of a threaded brass plug in which the upstream approach is made at an angle of 60 degrees to the line of gas flow and the discharge is made through a wall perpendicular to the line of discharge. The latter is often varied by making the discharge side conical in shape with apex pointed downstream.

Since an orifice is a nozzle it is prone to all the problems of a nozzle. As most orifices are not perfect nozzles they are noisy. The amount of noise depends on the shape of the orifice, the size of the discharge opening, the type of gas and the pressure differential. Most standard orifices are not noisy at pressures generally used but when used at low pressures (less than two inches of equivalent water column) they are liable to whistle. This condition can be cured by changing the shape of the orifice so that noise is produced at conditions under which the orifice is not going to be used. Usually the lower pressure differential the more streamlining will be necessary to reduce the noise level.

The generally accepted relationship between rate of gas flow and orifice size is expressed by the formula:

$$Q = 1658.5\ A\ K\sqrt{\frac{h}{d}}$$

Where Q = Rate of flow in cu. ft./hr.

A = Area of orifice opening in sq. in.

K = Constant

h = Pressure differential in In. H_2O

d = Specific gravity of gas (Air = 1)

It is readily apparent that the rate of flow varies directly as the square root of the gas pressure and inversely as the square root of the specific gravity. The only real problem is in determining the value of "K". This will usually be somewhere between 0.8 and 0.85. As the size of the hole increases in relation to the length of the orifice opening the value of "K" will rise until some other factor becomes large enough to overshadow the length to diameter ratio. Since the value of "K" is affected by such a wide variety of factors it is suggested that a manifold and orifice be set up and the rate checked at approximately the rate to be used. The value of "K" can then be accurately determined and used to calculate the exact orifice sizes needed.

On appliances where exact input ratings are not needed or where variable conditions make ready adjustment essential it is sometimes possible to use an adjustable orifice. This type of orifice follows the same laws as the fixed variety when the adjusting means is set for maximum flow. However, once the adjusting means starts to restrict the flow, performance as regards to gas flow and air entrainment varies widely depending on the adjusting method used. The following methods are in common use

1. The iris type which, when turned, opens and closes the discharge opening. This method adjusts the flow rate with a minimum of distortion to the gas stream.

2. The needle type which has either a fixed needle and movable orifice or an orifice fixed in position and a movable needle. Both systems are widely used at low rates of gas flow. As flow rates rise into the hundreds of feet per hour noise becomes a problem and the discharge pattern is distorted so that air entrainment is impaired. Since air entrainment on larger burners is liable to pose a problem under the best conditions, this type of orifice is not recommended at high flow rates. The latter problem is aggravated as the specific gravity of the gas increases so that this type of orifice may cause undesirable effects when used on gases which are heavier than air. (Specific gravity greater than one (1)).

Properly designed and used an orifice can do more than just meter the flow of gas. The shape of the discharge side of the orifice can be used to control primary air injection and mixing of gas and air.

At one design extreme is the conical discharge face with the apex pointing downstream. This allows a streamlined flow of air which minimizes the retarding vacuum usually found around discharge openings. This allows the gas to flow freely at a high velocity and thus entrain a large amount of primary air.

At the other extreme is the countersunk orifice which has the orifice opening down in and concentric with a larger opening in the downstream face of the orifice. By increasing the depth and diameter of the larger or countersunk bore it is possible to control the velocity of gas flow and subsequent air entrainment over quite a wide range. Usually the larger and deeper the countersunk hole the greater the retarding action. Also the greater the pressure differential the greater the retarding action. This latter characteristic is particularly useful where large variations in pressure are encountered. Small appliances and pilots use this principle to advantage. Another use for this type of orifice is in the control of flow velocities of the heavier gases. These gases traveling at high speeds represent considerable energy and can entrain a large amount of air at a high velocity. By using an appropriately designed countersunk orifice these gases can be slowed to the point where air entrainment can be easily controlled. Otherwise a primary air shutter may be unable to control the air gas mixture. Other methods of using orifices for both gas flow and air control are as follows:

1. Double orifice consisting of one orifice inside another with the space between either fixed or adjustable.
2. Angle orifice where the discharge opening is drilled at an angle to the centerline of the orifice body so that the gas stream tends to impinge on the mixing tube wall thus decreasing the velocity.
3. Double orifices consisting of two orifices drilled at an angle so that the gas streams impinge on each other. This method is usually confined to small burners (pilots) because of the noise problem.
4. Multiple drilled orifices where several small openings are drilled in one large orifice. While not generally recommended this is one method of eliminating burning at the orifice on extinction.

In summing up, it should be remembered that orifices should always be drilled in the direction of gas flow. Any burrs, striations, or other extraneous impedances to gas flow should be removed.

The following tables show the rate of flow of gases thru orifices at various pressures.

TABLE No. I

DECIMAL EQUIVALENTS AND AREAS

of Wire Gauge, Letter and Fractional Size Drills

Fractional Wire Gauge or Letter Size Drills	Decimal Equivalent in Inches	Area Square Inches	Fractional Wire Gauge or Letter Size Drills	Decimal Equivalent in Inches	Area Square Inches	Fractional Wire Gauge or Letter Size Drills	Decimal Equivalent in Inches	Area Square Inches
4/1000	.004	.0000126	35	.1100	00950	9/32	.2813	.06215
8/1000	.008	.0000503	34	.1110	.00968	L	.29	.06605
12/1000	.012	.0001131	33	.1130	01003	M	.295	.06835
80	.0135	.000143	32	.1160	.01057	19/64	.2969	.06922
79	.0145	.000165	31	.1200	.01131	N	.302	.07163
1/64	.0156	.000191	1/8	.1250	.01227	5/16	.3125	.07670
78	.016	.000201	30	.1285	.01296	O	.316	.07843
77	.018	.000254	29	.1360	.01453	P	.323	.08194
76	.020	.000314	28	.1405	.01549	21/64	.3281	.08456
75	021	.000346	9/64	.1406	.01553	Q	.332	.08657
74	.0225	.000398	27	.1440	.01629	R	.339	.09026
73	.024	.000452	26	.1470	.01697	11/32	.3438	.09281
72	.025	.000491	25	.1495	.01755	S	.348	.09511
71	.026	.000531	24	.1520	.01815	T	.358	.1006
70	.028	.000616	23	.1540	.01863	23/64	.3594	.1014
69	.0292	.000670	5/32	.1563	.01917	U	.368	.1064
68	.031	.000755	22	.1570	.01936	3/8	.375	.1104
1/32	.0313	000765	21	.1590	.01986	V	.377	.1116
67	.032	.000804	20	.1610	.02036	W	.386	.1170
66	.033	.000855	19	.1660	.02164	25/64	.3906	.1198
65	.035	.000962	18	.1695	.02256	X	.397	.1238
64	.036	.001018	11/64	.1719	.02320	Y	.404	.1282
63	.037	.001075	17	.1730	.02351	13/32	.4063	.1296
62	.038	.001134	16	.1770	.02461	Z	.413	.1340
61	.039	.001195	15	.1800	.02545	27/64	.4219	.1398
60	.0400	.001257	14	.182	.02602	7/16	.4375	.1503
59	.0410	.001320	13	.185	.02688	29/64	.4531	.1613
58	.0420	.001385	3/16	.1875	02761	15/32	.4688	.1726
57	.0430	.001452	12	.189	.02806	31/64	.4844	.1843
56	.0465	001698	11	.191	.02865	1/2	.5000	.1963
3/64	.0469	.00173	10	.1935	.02940	17/32	.5312	.2217
55	.0520	.00212	9	.196	.03017	9/16	.5625	.2485
54	.0550	.00238	8	.199	.03110	19/32	.5937	.2769
53	.0595	.00278	7	.201	.03173	5/8	.6250	.3068
1/16	.0625	.00307	13/64	.2031	03241	21/32	.6562	.3382
52	.0635	.00317	6	.204	.03269	11/16	.6875	.3712
51	.0670	.00353	5	.2055	.03317	23/32	.7187	.4057
50	.0700	.00385	4	.209	.03431	3/4	.7500	.4418
49	.0730	.00419	3	.213	.03563	25/32	.7812	.4794
48	.0760	.00454	7/32	.2188	.03758	13/16	.8125	.5185
5/64	.0781	.00479	2	.221	.03836	27/32	.8437	.5591
47	.0785	.00484	1	.228	.04083	7/8	.8750	.6013
46	.0810	.00515	A	.234	.04301	29/32	.9062	.6450
45	.0820	.00528	15/64	.2344	.04314	15/16	.9375	.6903
44	.0860	.00581	B	.238	.04449	31/32	.9687	.7371
43	.0890	.00622	C—	.242	.04600	1	1.0000	.7854
42	.0935	.00687	D	.246	.04753	1 1/16	1.0625	.8866
3/32	.0938	.00690	E 1/4	.250	.04909	1 1/8	1.1250	.9940
41	.0960	.00724	F	.257	.05187	1 3/16	1.1875	1.1075
40	.0980	.00754	G	.261	.05350	1 1/4	1.2500	1.2272
39	.0995	.00778	17/64	.2656	.05542	1 3/8	1.3750	1.485
38	.1015	.00809	H	.266	.05557	1 1/2	1.5000	1.767
37	.1040	.00849	I	.272	.05811	1 5/8	1.625	2.074
36	.1065	.00891	J	.277	.06026	2	2.0000	3.142
7/64	.1094	.00940	K	.281	.06202			

TABLE No. II

RATE OF FLOW OF GASES THROUGH ORIFICES AT VARIOUS PRESSURES

*DISCHARGE IN CUBIC FEET PER HOUR OF 0.65 S. G. GAS

ORIFICE SIZES			GAS PRESSURE at orifice in inches of water								
Drill Designation	Diameter Inch	Area Square Inch	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0
80	0.0135	0.000143	.341	.381	.418	.451	.482	.512	.539	.591	.638
79	0.0145	0.000165	.394	.440	.482	.521	.557	.590	.622	.682	.736
1/64	0.0156	0.000191	.456	.509	.558	.603	.644	.683	.720	.789	.852
78	0.0160	0.000201	.479	.536	.587	.634	.678	.719	.758	.831	.897
77	0.0180	0.000254	.606	.677	.742	.802	.857	.909	.958	1.049	1.134
76	0.0200	0.000314	.749	.837	.917	.991	1.059	1.124	1.184	1.297	1.401
75	0.0210	0.000346	.825	.923	1.011	1.092	1.167	1.238	1.305	1.430	1.544
74	0.0225	0.000398	.949	1.062	1.163	1.256	1.343	1.424	1.501	1.644	1.776
73	0.0240	0.000452	1.078	1.206	1.321	1.426	1.525	1.617	1.705	1.868	2.017
72	0.0250	0.000491	1.171	1.310	1.435	1.550	1.656	1.757	1.852	2.029	2.191
71	0.0260	0.000531	1.267	1.416	1.551	1.676	1.791	1.900	2.003	2.194	2.370
70	0.0280	0.000616	1.469	1.643	1.800	1.944	2.078	2.204	2.324	2.545	2.749
69	0.02925	0.000670	1.598	1.787	1.958	2.114	2.260	2.397	2.527	2.768	2.990
68	0.0310	0.000755	1.801	2.014	2.206	2.383	2.547	2.702	2.848	3.120	3.369
1/32	0.0313	0.000765	1.825	2.040	2.235	2.414	2.581	2.737	2.886	3.161	3.414
67	0.0320	0.000804	1.918	2.144	2.349	2.537	2.712	2.877	3.033	3.322	3.588
66	0.0330	0.000855	2.040	2.280	2.498	2.698	2.885	3.059	3.225	3.533	3.816
65	0.0350	0.000962	2.295	2.566	2.811	3.036	3.246	3.442	3.629	3.975	4.293
64	0.0360	0.001018	2.428	2.715	2.974	3.213	3.434	3.643	3.840	4.206	4.543
63	0.0370	0.001075	2.564	2.867	3.141	3.392	3.627	3.847	4.055	4.442	4.797
62	0.0380	0.001134	2.705	3.025	3.313	3.579	3.826	4.058	4.277	4.686	5.061
61	0.0390	0.001195	2.851	3.187	3.491	3.771	4.032	4.276	4.508	4.938	5.333
60	0.0400	0.001257	2.999	3.353	3.673	3.967	4.241	4.498	4.741	5.194	5.609
59	0.0410	0.001320	3.149	3.521	3.857	4.166	4.453	4.723	4.979	5.454	5.891
58	0.0420	0.001385	3.304	3.694	4.047	4.371	4.673	4.956	5.224	5.723	6.181
57	0.0430	0.001452	3.464	3.873	4.242	4.582	4.899	5.196	5.477	5.999	6.480
56	0.0465	0.001698	4.051	4.529	4.961	5.359	5.729	6.076	6.405	7.016	7.578
3/64	0.0469	0.00173	4.13	4.61	5.06	5.46	5.84	6.19	6.53	7.15	7.72
55	0.0520	0.00212	5.06	5.65	6.19	6.69	7.15	7.59	8.00	8.76	9.46
54	0.0550	0.00238	5.68	6.35	6.95	7.51	8.03	8.52	8.98	9.83	10.62
53	0.0595	0.00278	6.63	7.42	8.12	8.77	9.38	9.95	10.49	11.49	12.41
1/16	0.0625	0.00307	7.32	8.19	8.97	9.69	10.36	10.99	11.58	12.69	13.70
52	0.0635	0.00317	7.56	8.46	9.26	10.00	10.70	11.34	11.96	13.10	14.15
51	0.0670	0.00353	8.42	9.42	10.31	11.14	11.91	12.63	13.32	14.59	15.75
50	0.0700	0.00385	9.18	10.27	11.25	12.15	12.99	13.78	14.52	15.91	17.18
49	0.0730	0.00419	10.00	11.18	12.24	13.22	14.14	14.99	15.81	17.31	18.70
48	0.0760	0.00454	10.83	12.11	13.26	14.33	15.32	16.25	17.13	18.76	20.26
5/64	0.0781	0.00479	11.43	12.78	14.00	15.12	16.16	17.14	18.07	19.79	21.38
47	0.0785	0.00484	11.55	12.91	14.14	15.27	16.33	17.32	18.26	20.00	21.60
46	0.0810	0.00515	12.29	13.74	15.05	16.25	17.38	18.43	19.43	21.28	22.98
45	0.0820	0.00528	12.60	14.08	15.43	16.66	17.81	18.89	19.92	21.82	23.56
44	0.0860	0.00581	13.86	15.50	16.98	18.34	19.60	20.79	21.92	24.01	25.93
43	0.0890	0.00622	14.84	16.59	18.17	19.63	20.98	22.26	23.46	25.70	27.76
42	0.0935	0.00687	16.39	18.32	20.07	21.68	23.18	24.58	25.91	28.39	30.66
3/32	0.0938	0.00690	16.46	18.40	20.16	21.78	23.28	24.69	26.03	28.51	30.79
41	0.0960	0.00724	17.27	19.31	21.15	22.85	24.43	25.91	27.31	29.92	32.31
40	0.0980	0.00754	17.99	20.11	22.03	23.80	25.44	26.98	28.44	31.15	33.65
39	0.0995	0.00778	18.56	20.75	22.73	24.55	26.25	27.84	29.35	32.15	34.72
38	0.1015	0.00809	19.30	21.58	23.64	25.53	27.29	28.95	30.52	33.43	36.10
37	0.1040	0.00849	20.25	22.64	24.81	26.79	28.64	30.38	32.02	35.08	37.89
36	0.1065	0.00891	21.26	23.76	26.03	28.12	30.06	31.88	33.61	36.82	39.76
7/64	0.1094	0.00940	22.42	25.07	27.46	29.67	31.71	33.64	35.46	38.84	41.95
35	0.1100	0.00950	22.66	25.34	27.76	29.98	32.05	33.99	35.83	39.25	42.40
34	0.1110	0.00968	23.09	25.82	28.28	30.55	32.66	34.64	36.51	40.00	43.20
33	0.1130	0.01003	23.93	26.75	29.30	31.65	33.84	35.89	37.83	41.44	44.76

TABLE No. II [Continued]

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ORIFICE SIZES			GAS PRESSURE at orifice in inches of water								
Drill Desig-nation	Diameter Inch	Area Square Inch	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0
32	0.1160	0.01057	25.22	28.19	30.88	33.36	35.66	37.82	39.87	43.67	47.17
31	0.1200	0.01131	26.98	30.17	33.04	35.69	38.16	40.47	42.66	46.73	50.47
1/8	0.1250	0.01227	29.27	32.73	35.85	38.72	41.40	43.91	46.28	50.70	54.76
30	0.1285	0.01296	30.92	34.57	37.87	40.90	43.72	46.38	48.89	53.55	57.84
29	0.1360	0.01453	34.66	38.75	42.45	45.85	49.02	51.99	54.81	60.04	64.84
28	0.1405	0.01549	36.95	41.31	45.26	48.88	52.26	55.43	58.43	64.00	69.13
9/64	0.1406	0.01553	37.05	41.42	45.37	49.01	52.39	55.57	58.58	64.17	69.30
27	0.1440	0.01629	38.86	43.45	47.59	51.41	54.96	58.29	61.45	67.31	72.70
26	0.1470	0.01697	40.48	45.26	49.58	53.55	57.25	60.72	64.01	70.12	75.73
25	0.1495	0.01755	41.87	46.81	51.28	55.38	59.21	62.80	66.20	72.51	78.32
24	0.1520	0.01815	43.30	48.41	53.03	57.28	61.23	64.95	68.46	74.99	81.00
23	0.1540	0.01863	44.44	49.69	54.43	58.79	62.85	66.66	70.27	76.98	83.14
5/32	0.1563	0.01917	45.73	51.13	56.01	60.50	64.67	68.60	72.31	79.21	85.55
22	0.1570	0.01936	46.18	51.64	56.56	61.10	65.32	69.28	73.03	79.99	86.40
21	0.1590	0.01986	47.38	52.97	58.03	62.67	67.00	71.07	74.91	82.06	88.63
20	0.1610	0.02036	48.57	54.30	59.49	64.25	68.69	72.85	76.80	84.13	90.86
19	0.1660	0.02164	51.62	57.72	63.23	68.29	73.01	77.44	81.63	89.41	96.57
18	0.1695	0.02256	53.8	60.2	65.9	71.2	76.1	80.7	85.1	93.2	100.7
11/64	0.1719	0.02320	55.3	61.9	67.8	73.2	78.3	83.0	87.5	95.9	103.5
17	0.1730	0.02351	56.1	62.7	68.7	74.2	79.3	84.1	88.7	97.1	104.9
16	0.1770	0.02461	58.7	65.6	71.9	77.7	83.0	88.1	92.8	101.7	109.8
15	0.1800	0.02545	60.7	67.9	74.4	80.3	85.9	91.1	96.0	105.2	113.6
14	0.1820	0.02602	62.1	69.4	76.0	82.1	87.8	93.1	98.1	107.5	116.1
13	0.1850	0.02668	63.6	71.2	78.0	84.2	90.0	95.5	100.6	110.2	119.1
3/16	0.1875	0.02761	65.9	73.6	80.7	87.1	93.1	98.8	104.1	114.1	123.2
12	0.1890	0.02806	66.9	74.8	82.0	88.6	94.7	100.4	105.8	115.9	125.2
11	0.1910	0.02865	68.3	76.4	83.7	90.4	96.7	102.5	108.1	118.4	127.8
10	0.1935	0.02940	70.1	78.4	85.9	92.8	99.2	105.2	110.9	121.5	131.2
9	0.1960	0.03017	72.0	80.5	88.1	95.2	101.8	108.0	113.8	124.7	134.6
8	0.1990	0.03110	74.2	82.9	91.0	98.1	104.9	111.3	117.3	128.5	138.8
7	0.2010	0.03173	75.7	84.6	92.7	100.1	107.0	113.5	119.7	131.1	141.6
13/64	0.2031	0.03241	77.3	86.4	94.7	102.3	109.3	116.0	122.3	134.0	144.6
6	0.2040	0.03269	78.0	87.1	95.5	103.2	110.3	117.0	123.3	135.1	145.9
5	0.2055	0.03317	79.1	88.5	96.9	104.7	111.9	118.7	125.1	137.1	148.0
4	0.2090	0.03431	81.8	91.5	100.2	108.3	115.8	122.8	129.4	141.8	153.1
3	0.2130	0.03563	85.0	95.0	104.1	112.4	120.2	127.5	134.4	147.2	159.0
7/32	0.2188	0.03758	89.6	100.2	109.8	118.6	126.8	134.5	141.8	155.3	167.7
2	0.2210	0.03836	91.5	102.3	112.1	121.1	129.4	137.3	144.7	158.5	171.2
1	0.2280	0.04083	97.4	108.9	119.3	128.9	137.7	146.1	154.0	168.7	182.2
A	0.2340	0.04301	102.6	114.7	125.7	135.7	145.1	153.9	162.2	177.7	191.9
15/64	0.2344	0.04314	102.9	115.1	126.0	136.1	145.5	154.4	162.7	178.2	192.5
B	0.2380	0.04449	106.1	118.7	130.0	140.4	150.1	159.2	167.8	183.8	198.5
C	0.2420	0.04600	109.7	122.7	134.4	145.2	155.2	164.6	173.5	190.1	205.3
D	0.2460	0.04753	113.4	126.8	138.9	150.0	160.4	170.1	179.3	196.4	212.1
E 1/4	0.2500	0.04909	117.1	130.9	143.4	154.9	165.6	175.7	185.2	202.8	219.1

*The above table was calculated using an orifice coefficient of discharge of 0.82 and for gases having a specific gravity of 0.65. For gases of other gravities multiply the figures shown in above table by the following factors:

Specific Gravity	Multiplying Factor	Specific Gravity	Multiplying Factor	Specific Gravity	Multiplying Factor	Specific Gravity	Multiplying Factor
0.35	1.363	0.55	1.087	0.75	0.9309	0.95	0.8272
0.40	1.275	0.60	1.041	0.80	0.9014	1.00	0.8062
0.45	1.202	0.65	1.000	0.85	0.8745	1.55 Propane	0.6476
0.50	1.140	0.70	0.9636	0.90	0.8498	2.0 Butane	0.5701

TABLE No. III

FLOW RATE OF GAS THROUGH ORIFICES

RATE OF FLOW OF NATURAL GAS THROUGH ORIFICES

Pressure at orifice 7" water column
Heating value of gas 1120 b. t. u./cu. ft.
Specific Gravity of gas 0.65
Average coefficient of discharge assumed as 0.82

Orifice Size D.M.S. or Inches	Area of Orifice	*Natural Gas Flow Rate	
		Cu. Ft. /hr.	B.T.U. /hr.
60	.001257	5.6	6270
59	.001320	5.9	6610
58	.001385	6.2	6940
57	.001452	6.5	7280
56	.001698	7.6	8510
3/64	.00173	7.7	8620
55	.00212	9.5	10640
54	.00238	10.6	11870
53	.00278	12.4	13890
1/16	.00307	13.7	15330
52	.00317	14.2	15900
51	.00353	15.7	17580
50	.00385	17.2	19260
49	.00419	18.7	20940
48	.00454	20.3	22740
5/64	.00479	21.4	23970
47	.00484	21.6	24190
46	.00515	23.0	25760
45	.00528	23.6	26430
44	.00581	25.9	29010
43	.00622	27.8	31140
42	.00687	30.7	34380
3/32	.00690	30.8	34500
41	.00724	32.3	36180
40	.00754	33.6	37630
39	.00778	34.7	38860
38	.00809	36.1	40430
37	.00849	37.9	42450
36	.00891	39.8	44580
7/64	.00940	41.9	46930
35	.00950	42.4	47490
34	.00968	43.2	48380
33	.01003	44.8	50180
32	.01057	47.2	52860
31	.01131	50.5	56560
1/8	.01227	54.8	61380
30	.01296	57.8	64740
29	.01453	64.8	72580
28	.01549	69.1	77390
9/64	.01553	69.3	77620
27	.01629	72.7	81420
26	.01697	75.7	84780
25	.01755	78.3	87700
24	.01815	81.0	90720
23	.01863	83.1	93070
5/32	.01917	85.5	95760
22	.01936	86.4	96770
21	.01986	88.6	99230
20	.02036	90.9	101810
19	.02164	96.6	108190
18	.02256	100.7	112780
11/64	.02320	103.5	115920
17	.02351	104.9	117490
16	.02461	109.8	122980
15	.02545	113.6	127230

RATE OF FLOW OF MANUFACTURED GAS THROUGH ORIFICES

Pressure at orifice 3.5" water column
Heating value of gas 550 b. t. u./cu. ft.
Specific Gravity of gas 0.38
Average coefficient of discharge assumed as 0.82

Orifice Size D.M.S. or Inches	Area of Orifice	*Mfg. Gas Flow Rate	
		Cu. Ft. /hr.	B.T.U. /hr.
55	.00212	6.7	3690
54	.00238	7.5	4130
53	.00278	8.8	4840
1/16	.00307	9.7	5340
52	.00317	10.0	5500
51	.00353	11.1	6110
50	.00385	12.2	6710
49	.00419	13.2	7260
48	.00454	14.3	7865
5/64	.00479	15.1	8310
47	.00484	15.3	8420
46	.00515	16.3	8970
45	.00528	16.7	9190
44	.00581	18.3	10070
43	.00622	19.6	10780
42	.00687	21.7	11940
3/32	.00690	21.8	11990
41	.00724	22.9	12600
40	.00754	23.8	13090
39	.00778	24.6	13530
38	.00809	25.5	14030
37	.00849	26.8	14740
36	.00891	28.1	15460
7/64	.00940	29.7	16340
35	.00950	30.0	16500
34	.00968	30.6	16830
33	.01003	31.7	17440
32	.01057	33.4	18370
31	.01131	35.7	19640
1/8	.01227	38.7	21290
30	.01296	40.9	22500
29	.01453	45.9	25250
28	.01549	48.9	26900
9/64	.01553	49.0	26950
27	.01629	51.4	28270
26	.01697	53.6	29480
25	.01755	55.4	30470
24	.01815	57.3	31520
23	.01863	58.8	32340
5/32	.01917	60.5	33280
22	.01936	61.1	33610
21	.01986	62.7	34490
20	.02036	64.3	35370
19	.02164	68.3	37570
18	.02256	71.2	39160
11/64	.02320	73.2	40260
17	.02351	74.2	40810
16	.02461	77.7	42740
15	.02545	80.3	44170
14	.02602	82.1	45160
13	.02668	84.2	46310
3/16	.02761	87.1	47910
12	.02806	88.6	48730
11	.02865	90.4	49720
10	.02940	92.8	51040

For natural and manufactured gases having specific gravities and/or pressures other than those given above refer to table II.

*RATE OF FLOW OF PROPANE AND BUTANE THROUGH THE ORIFICES

(15° Angle of Approach and 11 In. of Water pressure at the Orifice)

Orifice Size D.M.S. or Dec. In.	Flow Rate			
	Propane		Butane	
	Cu. Ft. /hr.	B.T.U. /hr.	Cu. Ft. /hr.	B.T.U. /hr.
45	19.60	49000	18.0	57200
46	18.46	46150	17.35	55100
47	17.60	44000	16.15	51300
48	17.1	42750	15.18	48200
49	15.29	38230	13.32	42300
50	14.12	35300	12.48	39650
51	12.89	32220	11.43	36300
52	11.93	29820	10.01	31800
53	10.00	25000	8.87	28150
54	8.85	22130	7.61	24170
55	7.78	19450	6.76	21470
56	6.27	15680	5.43	17240
57	5.295	13240	4.635	14710
58	5.08	12700	4.45	14110
59	4.845	12120	4.19	13310
60	4.57	11420	4.02	12760
61	4.37	10920	3.83	12160
62	4.085	10210	3.59	11400
63	3.935	9850	3.41	10830
64	3.72	9300	3.26	10350
65	3.52	8800	3.06	9725
66	3.135	7840	2.74	8700
67	2.965	7420	2.585	8215
68	2.79	6980	2.39	7590
69	2.435	6090	2.125	6750
70	2.245	5615	1.968	6250
71	1.938	4845	1.685	5350
72	1.797	4490	1.559	4950
73	1.635	4090	1.422	4520
74	1.422	3555	1.23	3910
75	1.255	3140	1.09	3460
76	1.113	2825	.986	3130
77	.891	2230	.782	2485
78	.708	1770	.622	1975
79	.570	1425	.5045	1600
80	.495	1240	.412	1315
0.004	.0555	138	.0588	187
0.008	.1899	475	.188	598
0.009	.2482	621	228	724
0.010	.3185	797	.302	960
0.011	.368	930	.326	1036
0.012	.410	1025	.370	1175

NOTE

1. These values may not agree exactly with those computed from equation since the factor "K" is based on average data for all orifice types while these values are for results of tests on the particular type of orifice indicated.

2. B.T.U. rates based on heating values of 2500 and 3175 B.T.U. per cubic foot for propane and butane respectively. For other heating values multiply cubic foot rate by heating value.

3. Specific gravities of test gases were 1.53 and 2.0 for propane and butane respectively. For other specific gravities such as for propane-butane mixtures find cubic foot rate by interpolation, equation or use Table II.

*Excerpt from article by W. R. Teller in A.G.A. Monthly, October, 1938.