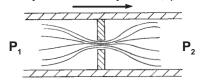
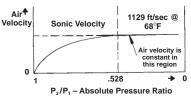
The Basic Concept

A greatly misunderstood and misapplied notion is that of "choked flow", also referred to as "critical flow".

In gas flow through an orifice there is an occasion where the gas velocity reaches sonic conditions. This occurs for air flow when the <u>absolute</u> pressure ratio is .528, i.e. when the downstream absolute pressure (P_2) is 52.8% of the upstream absolute pressure (P_1) .



Sonic velocity occurs for air flow when $P_2/P_1 \le .528$.

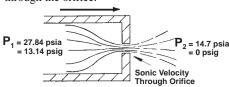


The air flow velocity is limited once the absolute pressure ratio is $\leq .528$.

For air flow through an orifice with an inlet air temperature of 68°F the choked (sonic) velocity is 1129 ft/sec.

The Misconception!

Once sonic velocity is achieved in orifice air flow $(P_2/P_1 = .528)$, it is easy to "assume" that the mass flow rate is constant for all pressure ratios less than .528; i.e. $P_2/P_1 \le .528$. For example, when P_2 is 14.7 psia and P_1 is 27.84 psia, sonic velocity occurs through the orifice. As P_1 further increases there is no further increase in the <u>velocity</u> of the air flowing through the orifice.



Conditions for the onset of sonic velocity in orifice air flow.

Consider all the Factors!

The mass flow rate through an orifice is a function of three basic parameters.

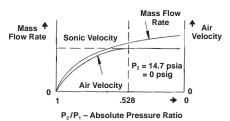
Q (flow) is a function of

- Velocity
- Density
- Orifice Area

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When the air velocity reaches sonic velocity $(P_2/P_1 \le .528)$ further increases in P_1 (upstream pressure) do not cause any further increase in the air velocity through the orifice. Consequently it is <u>wrongly concluded</u> that the mass flow rate also does not increase.

As the air pressure (P_1) increases, the density of the air also increases; and since the mass flow rate is also a function of density, the mass flow rate increases linearly with pressure (P_1) .

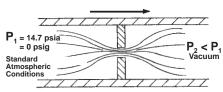


Even though the air velocity through the orifice is limited to the speed of sound, the mass flow rate continues to increase as the absolute pressure (P_1) increases.

What is Choked?

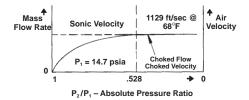
The parameter that becomes "choked" or "limited" is the velocity of the air. It is more accurate to use the term "choked velocity" rather than "choked flow" when the absolute pressure ratio of air through an orifice is $\leq .528$.

Vacuum Conditions



Air at atmospheric pressure enters the orifice and flows to a downstream vacuum pump.

In the case of vacuum conditions on the outlet of an orifice and where the inlet is at ambient atmospheric pressure, both the air velocity and the mass flow rate become choked (limited) when sonic velocity is achieved through the orifice.



For atmospheric inlet pressure and downstream vacuum, both the air velocity and mass flow rate are limited.

The reason for the mass flow rate limitation is the fixed inlet density combined with the fixed velocity. The flow charts on pages 16-18 show the choked mass flow effect for vacuum conditions. At vacuum levels between 15-30" Hg the mass flow rate is fixed.

Choked Flow for Positive Pressure Conditions

As in the case of the above vacuum conditions there are certain situations in which choked flow does occur for positive (above atmospheric) pressure. By maintaining a <u>fixed</u> inlet pressure to the orifice and allowing the outlet pressure (back pressure) to vary, there is a range of outlet pressures over which the mass flow rate is fixed.

For example (see chart below).

- With an inlet pressure of 80 psig, the mass flow rate is choked (limited) for all outlet pressures less than 35.30 psig (including vacuum conditions).
- The actual flow rate is constant for the outlet pressure range of 35.30 psig to as low as a complete vacuum. The flow rate can be obtained from the charts on pages 16-18; e.g. for an orifice of .010" diameter and with 80 psig inlet pressure, the choked flow rate is 8.4 scfh (page 16). This flow rate will be constant for all outlet pressure conditions between 35.30 psig and full vacuum.

Sonic Vo	elocity Con	ditions – A	ir Flow
Inlet P	ressure		Pressure ic Velocity
Gage Pressure	Absolute Pressure	Absolute Pressure	Gage Pressure
psig	psia	psia	psig
100	114.7	≤ 60.56	≤ 45.86
90	104.7	≤ 55.28	≤ 40.58
80	94.7	≤ 50.00	≤ 35.30
70	84.7	≤ 44.72	≤ 30.02
60	74.7	≤ 39.44	≤ 24.74
50	64.7	≤ 34.16	≤ 19.46
40	54.7	≤ 28.88	≤ 14.18
30	44.7	≤ 23.60	≤ 8.90
20	34.7	≤ 18.32	≤ 3.62
15	29.7	≤ 15.68	≤ .98
14.7	29.4	≤ 15.52	≤ .82
10	24.7	≤ 13.08	≤ -1.62
5	19.7	≤ 10.40	≤ -4.30
1	15.7	≤ 8.29	≤ -6.47
0	14.7	≤ 7.76	≤ -6.94

Temperature 68°F

Metal Orifice Air Flow – SCFH

0.033	33	0.025	6.42	14.4	21.1	26.1	30.3	34.5	39.0	47.7	56.4	0.59	73.9	82.6	91.5	101	9.15	11.5	12.1	12.1	12.1
0.032 0.	32	0.024 0.	6.10 6	13.6 1	19.9 2	24.6 2	28.6 3	32.6 3	36.7 3	44.7 4	53.0 5	61.0 6	69.3 7	77.8 8	86.0	94.5 1	8.73 9	10.9	11.5 1	11.5 1	11.5 1
0.031 0.	31	0.022 0.	5.62	12.4	18.3	22.5	26.3 2	30.1	33.7	41.1 4	48.5 5	55.9	63.6	71.2 7	78.8	86.7	8.01	10.1	10.7	10.7	10.7
0.029 0.	59	0.019 0.	5.06 5	11.3	16.6	20.3 2	23.7 2	27.1 3	30.5	37.1 4	43.9 4	50.4 5	57.2 6	64.0 7	71.0 7	78.0 8	7.23 8	9.11 1	9.56 1	9.56	9.56 1
0.028 0.	78	0.018 0.	4.68 5	10.5 1	15.2 1	18.6 2	21.8 2	24.8 2	28.0 3	34.1 3	40.3 4	46.4 5	52.5 5	58.7 6	65.0 7	71.4 7	6.70 7	8.48	8.90	8.90	8.90
0.027 0.	27	0.017 0.	4.13 4	9.41	13.6 1	16.8 1	19.7 2	22.7 2	25.4 2	31.1 3	36.7 4	42.4 4	48.1 5	53.6 5	59.3 6	65.3 7	9 00.9	7.59 8	8.01 8	8.01 8	8.01 8
0.026 0.	26	0.016 0.	4.05 4	9.20	13.0 1	16.1	18.9 1	21.6 2	24.4 2	29.9	35.2 3	40.7 4	46.0 4	51.3 5	56.8 5	62.3 6	5.81	7.29 7	7.73 8	7.73 8	7.73 8
0.025 0	25	0.014 0	3.54 4	8.12 9	11.8	14.7	17.3	19.9	22.5	27.5	32.6	37.5 4	42.6 4	47.7 E	52.8	58.1 (5.25 5	6.63	7.08 7	7.08 7	7.08 7
0.024 0	24	0.013 0	3.26	7.48	11.0	13.6	16.1	18.3	20.7	25.4	30.1	34.7	39.2	43.9 4	48.5	53.2	4.87	6.12	6.61 7	6.61	6.61 7
0.023	23	0.012	2.99	28.9	10.1	12.6	14.7	16.8	19.0	23.3	27.5	31.8	36.0	40.3	44.5	48.7	4.45	5.68	6.04	6.04	6.04
0.022 0.0	52	0.011 0.0	2.73 2	6.29 6	9.17	11.3	13.5	15.5 1	17.4	21.4 2	25.2 2	29.2	33.1	37.1 4	40.9	44.7 4	4.03 4	5.17 5	5.53 6	5.53 6	5.53 6
0.021 0.	21	0.0096 0.	2.39 2	5.62 6	7.48 9	9.34 1	11.1	12.7 1	14.4	17.8 2	21.2 2	24.6 2	28.0 3	31.6 3	35.0 4	38.1 4	3.60 4	4.62 5	4.92 5	4.92 5	1.92 5
0.020 0.	20	0.0088 0.0	2.22	5.23 5	6.70 7	8.50 9	10.3	11.8 1	13.4	16.5 1	19.6	22.7 2	25.9 2	29.0	32.2	35.2	3.28 3	4.15 4	4.64 4	4.64 4	4.64 4
0.019 0	19	0.0080 0.	2.03	4.70 E	9 00.9	3 95.7	9.03	10.4	11.8	14.5	17.3	20.02	22.9	25.6 2	28.4	31.1	2.99	3.79 4	4.11 4	4.11 4	4.11 4
0.018 0	8	0.0073 0.	1.82	4.20	5.38	. 48.9	8.18	9.43	10.7	13.2	15.7	18.2	20.7	23.3	25.9	28.4	2.70	3.35	3.71	3.71	3.71
0.017	17	0.0067 0	1.64	3.73	4.79	6.04	7.20	8.31	9.39	11.6	13.8	16.0	18.2	20.5	22.7	25.0	2.41	2.99	3.28	3.28	3.28
0.016	16	0.0055 0	1.40	3.26	4.26	5.30	6.29	7.25	8.20	10.1	12.1	14.0	16.0	17.9	19.9	21.8	2.07	2.62	2.86	2.86	2.86
0.015	15	0.0050 0	1.30	2.99	4.13	5.17	80.9	6.95	7.82	9.56	11.3	13.0	14.7	16.5	18.3	20.0	1.90	2.37	2.59	2.59	2.59
0.014	41	0.0043	1.11	2.56	3.56	4.45	5.28	90.9	08.9	8.33	9.83	11.3	12.8	14.3	15.9	17.4	1.64	2.06	2.26	2.26	2.26
0.013	13	0.0038	0.962	2.25	3.14	3.92	4.64	5.30	5.98	7.31	8.62	10.0	11.3	12.6	13.9	15.3	1.40	1.77	1.91	1.91	1.91
0.012	12	0.0034	0.843	1.94	2.73	3.43	4.07	4.66	5.23	6.44	7.59	8.75	9.92	11.1	12.2	13.4	1.23	1.55	1.68	1.68	1.68
0.011	=	0.0028	0.653	1.51	2.14	2.67	3.16	3.62	4.09	5.02	5.93	6.84	7.76	8.67	9.56	10.5	0.953	1.20	1.30	1.30	1.30
0.010	9	0.0025	0.593	1.37	1.97	2.48	2.92	3.37	3.81	4.68	5.55	6.40	7.27	8.12	96.8	9.81	0.860	1.10	1.20	1.20	1.20
0.009	6	0.0019	0.479	1.10	1.57	1.97	2.33	5.69	3.03	3.75	4.45	5.13	5.83	6.53	7.20	7.88	0.703	0.892	0.964	0.964	0.964
0.008	∞	0.0015	0.360	0.85	1.21	1.53	1.80	2.08	2.37	2.92	3.50	4.05	4.60	5.15	5.70	6.25	0.536	0.687	0.744	0.744	0.744
0.007	7	0.0012	0.269	0.64	0.91	1.14	1.38	1.59	1.80	2.22	2.67	3.09	3.54	3.96	4.41	4.83	0.405	0.521	0.568	0.568	0.568
900.0	9	0.00035 0.00061 0.00086 0.0012	0.182	0.45	0.65	0.82	0.97	1.12	1.26	1.56	1.86	2.16	2.46	2.75	3.05	3.35	0.273	0.356	0.392	0.392	0.392
0.005	52	0.00061	0.136	0.33	0.47	0.59	0.70	0.82	0.92	1.15	1.37	1.59	1.82	2.04	2.27	2.48	0.203	0.263	0.284	0.284	0.284
0.004	4	0.00035	0.075	0.18	0.25	0.34	0.40	0.47	0.53	0.64	92.0	0.89	1.02	1.14	1.27	1.40	0.113	0.145	0.158	0.158	0.158
<u></u>			-	2	10	15	20	25	30	40	20	09	70	80	06	100	2	10	15	20	30
Orifice Diameter Inches	Size Number	♂				6	sd	– ə.	ıns	res	Y YI	ddı	าร				lə	γeν J·	βH.		

0.035	m	5 0.037	7 0.038	0.039	0.040	0.041	0.042	0.043	0.047	0.052 0	0.055 0.	0.060 0.0	0.063 0.	0.067 0.0	0.070 0.0	0.073 0.0	0.076 0.0	0.079 0.0	0.081 0.0	0.086 0.	0.089 0.	0.094 0.0	0.096 0.1	0.100 0.	0.104 0.	0.109 0.113	13 0.120	20 0.125
, r	35	37	88	39	04	14	42	43	47	52	55	09	63	. 29	02	23	7 97	8 62	8	98	68	94	96	100	104	109	113 120	0 125
	0.028	0	0	0	0.036	0.038	0.039	_	φ	0.059 0		_			_		_	4	2		_		_					
	7.37	7 8.12	2 8.75	9.45	9.75	9.90	10.6	11.4	13.6	17.0	19.9	23.7 2	25.9 3	30.1	33.6	35.9 3	39.3 43	43.0 4	46.0 49	49.7 5	53.7 6	60.2 6	63.7 69	69.8 7	75.2 83	83.9	91.4 101	1 106
	16.3	3 18.0	19.3	20.6	21.6	22.5	23.9	25.6	30.1	37.3	43.0 5	50.6 58	55.3 6	64.2 7	71.6 7	76.5 8%	83.5 9	91.3 97	97.5 10	108 1	116 1	131 1	138 15	150 1	162 1	180 19	195 216	5 229
	22.5	5 25.0	0 26.5	28.8	30.5	31.4	33.1	35.6	41.0	51.9	57.4 6	68.2 74	74.6 8	86.2 9	96.6	103	112 12	121 13	131 14	144	153 1	172 1	181 18	196 2	216 2	237 25	250 286	9 314
	27.8	8 30.7	7 32.6	35.4	37.5	38.6	40.5	43.2	20.0	62.9	8 2.69	82.6 90	90.3	104 1	117 1	125 1	136 14	147 1	158 17	174 1	185 2	207 2	218 23	235 2	261 2	286 3	303 345	5 377
	32.4	4 36.0	38.4	41.5	44.3	45.3	47.7	50.9	58.7	74.2	82.0 9	97.3	106 1	123 1	138 1	146 1	160 17	172 1	185 2	203 2	216 2	242 2	256 27	275 3	305	335 38	354 403	3 445
	37.5	5 41.5	5 44.1	47.9	50.9	52.3	54.9	58.5	9.79	85.4	94.5	112 1	122 1	141 1	158 1	168 1	183 18	198 2	212 23	233	248 2	278 2	292 3	316 3	347 3	381 40	405 464	4 511
	42.4	4 47.0	0.09	54.2	9.75	59.3	62.3	66.3	76.3	9.96	107	126 1	138 1	160 1	179 1	190 2	206 22	222 2	239 26	265	280 3	314 3	331 35	356 3	392 4	432 4	458 525	5 578
	52.5	5 58.1	1 67.2	0.79	71.2	73.3	6.97	82.0	94.3	119	132 1	156 1	170 1	196 2	220 2	233 2	254 27	273 23	295 33	324 3	343 3	384 4	405 43	439 4	483 5	532 56	566 648	8 714
	62.5	5 69.1	1 73.7	79.7	85.0	87.5	91.7	97.5	112	142	157 1	185 2	202 2	233 2	261 2	278 3	301 32	324 3	347 38	384 4	407 4	456 4	481 52	523 5	9 929	634 67	672 771	1 850
	72.7	7 80.5	5 86.0	92.8	66	102	107	113	130	165	182	214 2	233 2	269 3	301 3	320 3	347 37	375 40	400 4	445 4	473	530 5	226 60	9 909	2 299	735 78	780 894	4 985
	83.1	1 91.7	7 98.1	106	113	117	122	129	148	187	207	244 2	267 3	307 3	343 3	362 3	394 42	428 4	458 5	209	538 (604 6	638 69	693 7	763 8	839 8	892 1021	1125
	83	103	110	119	127	131	137	145	167	210	231	273 2	298 3	343 3	384 4	405 4	443 48	481 5	513 5	9 029	604 (678 7	716 77	778 8	856 9	943 10	1000 1146	1263
	106	3 115	122	132	141	146	151	161	185	231	256	303 3	331 3	379 4	424 4	447 4	489 53	532 5	568 63	631 6	670 7	750 7	792 86	6 098	947 10	1042 11	1106 1267	1398
	114	126	135	146	156	164	167	177	203	254	282	331 3	362 4	415 4	468 4	496 5	540 58	587 6	627 69	. 269	739	831 8	875 9	951 10	1047 11	1153 12	1225 1403	3 1545
	10.4	4 11.4	12.3	13.3	14.3	14.5	15.4	16.3	19.2	23.9	26.4	31.4 3	36.2 4	42.4 4	47.7 5	50.6 5	55.1 60	9 0.09	64.0 70	70.3 7	76.1 8	84.9 88	98.6	96.1	104 1	114 12	123 138	8 150
	13.1		15.4	16.6	17.6	18.0	19.2	20.3	23.6	29.4		38.6 4	44.9 5	51.7 5	9 9.73	63.4 68	68.9 74	74.8 79	79.9 87	87.9	94.9	106 1	110 12	120 1	130 1	142 15	153 173	3 187
	13.8	8 15.2	2 16.2	17.4	18.3	18.8	20.0	21.1	24.5	30.5	33.7 3	39.4 46	46.8 5	54.0 6	60.2 6	66.1 7	71.8 78	78.0 83	83.5 91	91.7 9	99.0	110 1	115 12	125 1	135 1	148 16	160 180	0 195
	13.8	8 15.2	2 16.2	17.4	18.3	18.8	20.0	21.1	24.5	30.5	33.7 3	39.4 46	46.8 5	54.0 6	60.2 6	66.1 7	71.8 78	78.0 8%	83.5 91	91.7 9	99.0	110 1	115 12	125 1	135 1	148 16	180	0 195
	13.8	8 15.2	2 16.2	17.4	18.3	18.8	20.0	21.1	24.5	30.5	33.7 3	39.4 46	46.8 5	54.0 6	60.2 6	66.1 7	71.8 78	78.0 8%	83.5 97	91.7 9	99.0	110 1	115 12	125 1	135 1	148 16	160 180	0 195

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SLPM - Standard Liters Per Minute

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O'Keefe Controls Co.

essentially the same as for Type B. Above data supercedes previous publications.

Metal Orifice Air Flow – SLPM

Orifice Diameter Inches	Size Number	ο̈́	-	2	10	9i	Sd ·	- 5 2	e ins	res 40	7 V I	⊗ ddr	0/ 1 S	80	06	100	(S)	79.	βH.	ked i	
0.004 0	4	0.00035 0.00061 0.00086 0.0012	0.035 0	0.09	0.12	0.16	0.19	0.22	0.25	0.30	0.36	0.42	0.48	0.54	09.0	99.0	0.053 0	0.069	0.075 0	0.075 0	0.075 0
0.005	5	00061 0.	0.064 (0.16	0.22	0.28	0.33	0.39	0.44	0.54	0.65	0.75	98.0	96.0	1.07	1.17	0.096	0.124 (0.134 (0.134 (0.134
0.006 0.	9	00086 0.	0.086 0.	0.21 0	0.31 0	0.39 0	0.46 0	0.53 0	0.60	0.74 1	0.88 1	1.02	1.16 1	1.30 1	1.44	1.58 2	0.129 0.	0.168 0.	0.185 0.	0.185 0.	0.185 0.
0.007 0.	7		0.127 0.	0.30 0	0.43 0	0.54 0	0.65 0	0.75 0	0.85 1	1.05 1	1.26 1	1.46 1	1.67 2	1.87 2	2.08 2	2.28 2	0.191 0.	0.246 0.	0.268 0.	0.268 0.	0.268 0.
0.008 0.0	8	0.0015 0.00	0.170 0.2	0.40 0.9	0.57 0.7	0.72 0.9	0.85 1.7	0.98	1.12 1.4	1.38	1.65 2.	1.91 2.4	2.17 2.7	2.43 3.0	2.69 3.4	2.95 3.7	0.253 0.3	0.324 0.4	0.351 0.4	0.351 0.4	0.351 0.4
0.009 0.0	9 10	0.0019 0.00	0.226 0.280	0.52 0.6	0.74 0.9	0.93 1.1	1.10 1.3	1.27 1.5	1.43 1.8	1.77 2.21	2.10 2.6	2.42 3.0	2.75 3.4	3.08 3.8	3.40 4.2	3.72 4.6	0.332 0.4	0.421 0.5	0.455 0.5	0.455 0.5	0.455 0.5
0.010 0.011	10 11	0.0025 0.0028	280 0.308	0.65 0.71	0.93 1.01	1.17 1.26	1.38 1.49	1.59 1.71	1.80 1.93	21 2.37	2.62 2.80	3.02 3.23	3.43 3.66	3.83 4.09	4.23 4.51	4.63 4.94	0.406 0.450	0.519 0.564	0.566 0.614	0.566 0.614	0.566 0.614
11 0.012	1 12	028 0.0034	08 0.398	71 0.92	1.29	26 1.62	1.92	71 2.20	33 2.47	37 3.04	30 3.58	23 4.13	36 4.68	9 5.23	51 5.78	94 6.33	50 0.582	64 0.730	14 0.792	14 0.792	14 0.792
12 0.013	13	34 0.0038	98 0.45	1.06	9 1.48	1.85	2 2.19	0 2.50	.7 2.82	3.45	8 4.07	3 4.70	8 5.32	3 5.95	78 6.58	33 7.22	32 0.661	30 0.83	92 0.90	32 0.902	32 0.90
3 0.014	4	38 0.0043	5 0.52	5 1.21	8 1.68	5 2.10	9 2.49	0 2.86	2 3.21	5 3.93	7 4.64	0 5.34	2 6.05	5 6.77	8 7.49	2 8.21	1 0.773	4 0.972	1.07	1.07	1.07
4 0.015	15	13 0.0050	0.61	1.41	3 1.95	2.44	9 2.87	3.28	3.69	3 4.51	5.31	6.13	96.9	7.79	9 8.62	9.46	3 0.899	2 1.12	7 1.22	1.22	1.22
0.016	16	0 0.0055	99.0	1.54	2.01	2.50	2.97	3.42	3.87	4.78	5.70	6.61	7.53	8.46	9.38	10.3	9 0.977	1.24	1.35	1.35	1.35
0.017	17	5 0.0067	0.77	1.76	2.26	2.85	3.40	3.92	4.43	5.47	6.51	7.56	8.61	9.67	10.7	11.8	1.14	1.41	1.55	1.55	1.55
0.018	18	0.0073	0.86	1.98	2.54	3.23	3.86	4.45	5.03	6.21	7.40	8.58	9.77	11.0	12.2	13.4	1.28	1.58	1.75	1.75	1.75
0.019	19	0.0080	96.0	2.22	2.83	3.57	4.26	4.91	5.56	6.85	8.15	9.46	10.8	12.1	13.4	14.7	1.41	1.79	1.94	1.94	1.94
0.020	20	0.0088	1.05	2.47	3.16	4.01	4.84	5.59	6.33	7.81	9.26	10.7	12.2	13.7	15.2	16.6	1.55	1.96	2.19	2.19	2.19
0.021	21	9600.0	1.13	2.65	3.53	4.41	5.22	6.01	6.81	8.42	10.0	11.6	13.2	14.9	16.5	18.0	1.70	2.18	2.32	2.32	2.32
0.022 0	22	0.011 0	1.29	2.97	4.33	5.35	6.35	7.30	8.23	10.1	11.9	13.8	15.6	17.5	19.3	21.1	1.90	2.44	2.61	2.61	2.61
0.023	23	0.012	1.41	3.24	4.75	5.93	6.95	7.95	8.98	11.0	13.0	15.0	17.0	19.0	21.0	23.0	2.10	2.68	2.85	2.85	2.85
0.024	24	0.013	1.54	3.53	5.18	6.43	7.58	8.65	9.75	12.0	14.2	16.4	18.5	20.7	22.9	25.1	2.30	2.89	3.12	3.12	3.12
0.025 (25	0.014	1.67	3.83	5.55	6.95	8.15	9.38	10.6	13.0	15.4	17.7	20.1	22.5	24.9	27.4	2.48	3.13	3.34	3.34	3.34
0.026 0	26	0.016 0	1.91	4.34	6.15	7.58	8.90	10.2	, 211.5	14.1	, 9.91	19.2	21.7	24.2	26.8	29.4	2.74	3.44	3.65	3.65	3.65
0.027 0	27	0.017 0.	1.95	4.44 4	6.43 7	7.95	9.28	10.7	12.0 1	14.7	17.3 1	20.02	22.7 2	25.3 2	28.0	30.8	2.83 3	3.58 4	3.78 4	3.78 4	3.78 4
0.028 0.	78	0.018 0.	2.21 2	4.94 5	7.18 7	8.78	10.3	11.7 1	13.2 1	16.1	19.0 2	21.9 2	24.8 2	27.7 3	30.7 3	33.7 3	3.16 3	4.00 4	4.20 4	4.20 4	4.20 4
0.029 0.	29 ;	0.019 0.	2.39 2	5.31 5	7.83 8	9.58	11.2	12.8	14.4	17.5 1	20.7 2	23.8 2	27.0 3	30.2	33.5 3	36.8 4	3.41 3.	4.30 4.	4.51 5.	.51 5.	4.51 5
0.031 0.032	31 3	0.022 0.0	2.65 2.	5.86 6.	8.63 9.	10.6 11	12.4 13	14.2 15	15.9 17	19.4 21	22.9 25	26.4 28	30.0	33.6 36	37.2 40	40.9 44	3.78 4.	4.77 5.	5.05 5.	5.05 5.	5.05 5.45
32 0.033	32 33	0.024 0.025	2.88 3.03	6.42 6.80	9.40 9.98	11.6 12.3	13.5 14.3	15.4 16.3	17.3 18.4	21.1 22.5	25.0 26.6	28.8 30.7	32.7 34.9	36.7 39.0	40.6 43.2	44.6 47.5	4.12 4.32	5.16 5.43	5.45 5.72	5.45 5.72	15 5.72

Standard Conditions 70°F, 14.7 psia

SLPM - Standard Liters Per Minute SCFH - Standard Cu. Ft. Per Hour

essentially the same as for Type B. Above data supercedes previous publications.

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Above data obtained with Type B restrictor. Flow rates for other metal restrictors

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Sapphire Orifice Air Flow - SLPM

7 8 9 10 11 12 13 14 15 16 17 18 20 22 24 26 22 24 26 26 28 30 0.0028 0.0031 0.0047 0.0056 0.0056 0.0059 0.0069 0.0067 0.0071 0.0076 0.0076 0.0068 0.0068 0.0068 0.0069 0.0069 0.0069 0.0069 0.0069 0.0069 0.0069 0.0076 0.0099 0.1069 0.0076 0.0099 0.0076 0.0099 0.0076 0.0099 0.0076 0.0099 0.0076 0.0099 0.0076 0.0099 0.0076 0.0099 0.0076 0.0099<	12 13 14 15 16 17 18 20 22 24 26 28 30 32 12 13 14 15 16 17 18 20 22 24 26 28 30 32 0.00 1.0 1.0 1.0 1.0 1.0 1.0 2.0 22 24 26 28 30 32 0.00	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.006 0.008 0.0001 0.0001 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.002 0.003 0.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 0.002 0.003 0.000	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 0.002 0.003 0.000	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 0.0043 0.0051 0.0055 0.0059 0.0067 0.0094 0.0102 0.0110 0.0118 0.0126 0.0134 0.0126 0.0134 0.0126 0.0134 0.0126 0.0136 0.0126 0.0136 0.0146 0.01	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 10 </th <th>12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 1000000000000000000000000000000000000</th>	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 1000000000000000000000000000000000000
12 13 14 15 16 17 18 20 22 24 26 28 30 12 13 14 15 16 17 18 20 22 24 26 28 30 0.005 0.006 0.007 0.006 0.007	12 13 14 15 16 17 18 20 22 24 26 28 30 30 12 13 14 15 16 17 18 20 22 24 26 28 30 30 0.05 0.00	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.001 0.026 0.0020 0.0024 0.002 0.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10.00 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 0.00 1.02 0.00	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100048 0.0026 0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0	4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000
12 13 14 15 16 17 18 20 22 24 26 28 30 12 13 14 15 16 17 18 20 22 24 26 28 30 0.0058 0.0068 0.0000 0.0073 0.0004 0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 12 13 14 15 16 17 18 20 22 24 26 28 30 32 0.006 0.007 0.0005 0.0007 0.0004 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.002 0.003	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.00 1.0 1.0 1.0 1.0 1.0 1.0 1.0 2.0 2.2 24 26 28 30 32 34 0.00 1.0 </td <td>12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10.00 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 0.00 1.02 0.00</td> <td>12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100048 0.0026 0</td> <td>12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0</td> <td>4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0</td> <td>12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000</td>	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10.00 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 0.00 1.02 0.00	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100048 0.0026 0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0	4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000
12 13 14 15 16 17 18 20 22 24 26 28 30 12 13 14 15 16 17 18 20 22 24 26 28 30 0.006 0.008 0.000 0.009 0.000 0.001 0.001 0.002 0.002 0.010	12 13 14 15 16 17 18 20 22 24 26 28 30 32 12 13 14 15 16 17 18 20 22 24 26 28 30 32 0.005 0.006 0.0007 0.0005 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.002 0.002 0.003 <	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.001 0.026 0.0020 0.0024 0.002 0.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 0.000	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 1.00 1.	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0	4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000
12 13 14 15 16 17 18 20 22 24 26 28 30 12 13 14 15 16 17 18 20 22 24 26 28 30 0.0068 0.0080 0.0095 0.0064 0.0001 0.0007 0.0002 0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 12 13 14 15 16 17 18 20 22 24 26 28 30 32 0.005 0.006 0.0007 0.0005 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.002 0.002 0.003 <	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.001 0.026 0.0020 0.0024 0.002 0.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 0.000	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 1.00 1.	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0	4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000
12 13 14 15 16 17 18 20 22 24 26 28 30 12 13 14 15 16 17 18 20 22 24 26 28 30 0.0068 0.0080 0.0095 0.0064 0.0001 0.0007 0.0002 0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 12 13 14 15 16 17 18 20 22 24 26 28 30 32 0.005 0.006 0.0007 0.0005 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.002 0.002 0.003 <	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.001 0.026 0.0020 0.0024 0.002 0.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 0.000	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 1.00 1.	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0	4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000
12 13 14 15 16 17 18 20 22 24 26 28 30 12 13 14 15 16 17 18 20 22 24 26 28 30 0.0068 0.0080 0.0095 0.0064 0.0001 0.0007 0.0002 0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 12 13 14 15 16 17 18 20 22 24 26 28 30 32 0.005 0.006 0.0007 0.0005 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.002 0.002 0.003 <	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 0.001 0.026 0.0020 0.0024 0.002 0.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 0.000	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 10005 1.00 1.	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 100045 0.0005 0.0007 0.0006 0.0007 0	4.2 4.2 4.2 4.2 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 4.0 4.4 4.8 5.2 1.2 1.3 1.4 1.5 1.6 1.7 1.8 2.0 2.2 2.4 2.6 3.4 3.6 4.0 4.4 4.8 5.2 1.00 1.0	12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 30 12 13 14 15 16 17 18 20 22 24 26 28 30 32 34 36 40 44 48 52 54 0.000
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		34 0.0040 0.446 1.06 1.45 1.85 2.20 2.20 2.20 2.22 2.24 3.46 4.69 4.69 4.69 6.56 6.56	34 36 0.0040 0.0046 0.406 1.20 1.06 1.20 1.85 2.09 2.20 2.48 2.52 2.84 2.52 2.84 2.54 3.19 3.46 3.90 4.08 4.59 5.31 5.99 5.31 6.69 6.56 7.41 7.18 8.12	34 36 0.0040 0.0046 0.406 1.20 1.06 1.20 1.85 2.09 2.20 2.48 2.52 2.84 2.52 2.84 3.46 3.90 4.69 4.59 4.69 4.59 5.31 6.69 6.56 7.41 7.18 8.12	34 36 0.0040 0.0046 0.446 0.499 1.06 1.20 1.45 1.63 1.85 2.09 2.20 2.48 2.52 2.84 2.52 2.84 3.46 3.90 4.69 4.59 5.31 6.69 6.56 7.41 7.18 8.12	34 36 40 44 48 52 0.044 0.049 0.075 0.080 0.099 0.446 0.489 0.677 0.082 0.965 1.10 1.06 1.20 1.51 1.81 2.46 2.50 1.45 1.63 2.01 2.43 2.90 3.32 1.85 2.09 2.56 3.08 3.69 4.26 2.20 2.48 3.04 3.64 4.36 5.09 2.22 2.48 3.50 4.19 5.03 5.81 2.84 3.19 3.64 4.36 5.06 5.81 2.84 3.19 3.66 4.75 5.69 6.57 3.46 3.90 4.89 5.89 4.59 5.81 4.89 5.83 6.89 8.35 9.63 4.81 5.31 5.93 6.89 8.55 9.63 4.13 5.36 5.93 6.89 1.27	34 36 40 44 48 52 54 0.044 0.049 0.677 0.080 0.090 0.071 0.046 0.057 0.066 0.091 0.010 1.06 1.20 1.51 1.81 2.16 2.50 2.57 1.45 1.63 2.01 2.43 2.90 3.32 3.45 2.20 2.66 3.08 3.69 4.26 4.43 2.20 2.48 3.04 3.64 4.36 5.06 5.31 2.20 2.48 3.04 3.64 4.36 5.06 5.31 3.45 2.20 2.48 3.04 3.64 4.36 5.06 5.31 5.32 5.45 5.32 5.45 5.32 5.45 5.32 5

Sapphire Orifice Air Flow – SCFH

Size 3	0.0055 0.0059 0.0063 0.0067	0.00 7900.0	971 0.0079	0.0087 0		Ċ	0.0102 0.		0.0110 0.0118	0.0110 0.0118 0.0126	0.0110 0.0118 0.0126 0.0134	0.0110 0.0118 0.0126 0.0134 0.0142 0.0157	0.0110 0.0118 0.0126 0.0134 0.0142 0.0157 0.0173	0.0110 0.0118 0.0126 0.0134 0.0142 0.0157 0.0173 0.0189	0.0110 0.0118 0.0126 0.0134 0.0142 0.0157 0.0173 0.0189	0.0110 0.0118 0.0126 0.0134 0.0142 0.0157 0.0173
Size 3																
C, 0.000030 0.0000058 0.00001 0.0001 0.00002 0.000020 0.000058 0.0000059 0.00002 0.00002 0.000030 0.000059 0.000000000000000000000000000	15				72			24 26 28	24 26	24 26 28 30	24 26 28 30 32	24 26 28 30 32 34	24 26 28 30 32 34 36	24 26 28 30 32 34 36 40 44 48	24 26 28 30 32 34 36 40 44 48 52	24 26 28 30 32 34 36 40 44 48
1 0.007 0.011 0.021 0.026 0.045 0.056 0.075 0.086 0.016 0.123 0.144 0.169 0.201 0.255 0.254 0.294 0.341 2 0.019 0.027 0.056 0.075 0.100 0.124 0.161 0.187 0.228 0.288 0.337 0.407 0.471 0.542 0.575 0.563 0.740 3 0.021 0.023 0.076 0.014 0.013 0.114 0.227 0.280 0.347 0.403 0.483 0.559 0.663 0.756 0.890 0.911 1.02 4 0.021 0.023 0.147 0.157 0.101 0.125 0.280 0.347 0.441 0.551 0.663	.00071 0.00084 0.00094	l	l	1	ı	0.0021	0.0021 0.0024	0.0021 0.0024 0.0028	0.0021 0.0024 0.0028 0.0032	0.0021 0.0024 0.0028 0.0032 0.0036	0.0021 0.0024 0.0028 0.0032	0.0021 0.0024 0.0028 0.0032 0.0036 0.0040	0.0021 0.0024 0.0028 0.0032 0.0036 0.0040 0.0046 0.0057 0.0067	0.0021 0.0024 0.0028 0.0032 0.0036 0.0040 0.0046 0.0057 0.0067 0.0080	0.0021 0.0024 0.0028 0.0032 0.0036 0.0040 0.0046 0.0057 0.0067 0.0080 0.0091	0.0021 0.0024 0.0028 0.0032 0.0036 0.0040 0.0046 0.0057 0.0067 0.0080
5 0.0019 0.0027 0.056 0.075 0.100 0.124 0.161 0.187 0.228 0.238 0.337 0.407 0.471 0.542 0.577 0.663 0.740 0.991 0.991 0.992 0.994 0.992 0.994 0.992 0.994 0.993 0.994 0.995 0.995	0.201 0.225				10		0.583	0.583 0.636	0.583 0.636 0.720	0.583 0.636 0.720 0.833 0	0.583 0.636 0.720	0.583 0.636 0.720 0.833 0.945	0.583 0.636 0.720 0.833 0.945 1.06 1.43 1.74	0.583 0.636 0.720 0.833 0.945 1.06 1.43 1.74 2.04	0.583 0.636 0.720 0.833 0.945 1.06 1.43 1.74 2.04 2.33	0.583 0.636 0.720 0.833 0.945 1.06 1.43 1.74 2.04
10 0.021 0.034 0.076 0.104 0.138 0.174 0.227 0.280 0.347 0.408 0.483 0.559 0.653 0.569 0.691 0.109 0.1091 0.107 0.157 0.120 0.284 0.385 0.347 0.494 0.586 0.894 0.584 0.589 0.694 0.684	0.471				-		1.32	1.32 1.47	1.32 1.47 1.70	1.32 1.47 1.70 1.98	1.32 1.47 1.70	1.32 1.47 1.70 1.98 2.25	1.32 1.47 1.70 1.98 2.25 2.53 3.20 3.83	1.32 1.47 1.70 1.98 2.25 2.53 3.20 3.83 4.58	1.32 1.47 1.70 1.98 2.25 2.53 3.20 3.83 4.58 5.30	1.32 1.47 1.70 1.98 2.25 2.53 3.20 3.83 4.58
15 10.030 10.044 10.097 10.114 10.120 10.284 10.385 10.494 10.59	0.653				1.7		1.84	1.84 2.05	1.84 2.05 2.31	1.84 2.05	1.84 2.05 2.31 2.69	1.84 2.05 2.31 2.69 3.07	1.84 2.05 2.31 2.69 3.07 3.45 4.26 5.15	1.84 2.05 2.31 2.69 3.07 3.45 4.26 5.15 6.14	1.84 2.05 2.31 2.69 3.07 3.45 4.26 5.15 6.14 7.03	1.84 2.05 2.31 2.69 3.07 3.45 4.26 5.15 6.14
5 0.034 0.054 0.117 0.147 0.265 0.347 0.515 0.605 0.714 0.826 0.968 1.11 1.21 1.35 1.55 1.99 5 0.040 0.064 0.133 0.184 0.244 0.365 0.645 0.657 1.11 1.28 1.39 1.55 1.79 2.22 6 0.046 0.072 0.152 0.268 0.140 0.267 0.048 0.344 0.657 0.784 0.866 1.15 1.34 1.26 1.39 1.55 1.79 1.25 1.79 1.25 1.79 1.25 1.79 1.25 1.79 1.25 1.79 1.25 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.79 1.75 1.75 1.75 1.75 1.75 1.75 1.75 1.75<	0.818		_		2.22	•	2.35	2.63	2.63 3.01	2.63	2.63 3.01 3.45	2.63 3.01 3.45 3.92	2.63 3.01 3.45 3.92 4.43 5.42 6.53	2.63 3.01 3.45 3.92 4.43 5.42 6.53 7.82	2.63 3.01 3.45 3.92 4.43 5.42 6.53 7.82 9.03	2.63 3.01 3.45 3.92 4.43 5.42 6.53 7.82
25 0.040 0.064 0.133 0.184 0.24 0.305 0.390 0.485 0.593 0.693 0.824 0.953 1.11 1.28 1.39 1.55 1.79 2.22 40 0.057 0.015 0.225 0.341 0.245 0.245 0.481 0.551 0.672 0.784 0.925 1.08 1.15 1.34 1.56 1.79 1.86 2.20 2.50 3.11 50 0.008 0.110 0.225 0.341 0.481 0.541 0.681 0.821 1.15 1.38 1.60 1.85 1.79 1.86 2.20 2.50 3.11 50 0.008 0.110 0.225 0.341 0.481 0.541 0.681 0.811 0.981 1.15 1.38 1.60 1.85 2.14 2.46 2.61 3.07 3.14 3.14 60 0.079 0.129 0.228 0.431 0.549 0.674 0.824 1.07 1.29 1.52 1.81 2.46 2.81 3.73 3.47 4.30 70 0.008 0.149 0.229 0.413 0.549 0.674 0.864 0.144 1.43 1.84 1.44 1.34 1.44	0.968	`	_		2.65	•	2.80	3.14	3.14 3.60	3.14 3.60 4.13	3.14 3.60	3.14 3.60 4.13 4.66	3.14 3.60 4.13 4.66 5.25 6.44 7.71	3.14 3.60 4.13 4.66 5.25 6.44 7.71 9.24	3.14 3.60 4.13 4.66 5.25 6.44 7.71 9.24 10.7	3.14 3.60 4.13 4.66 5.25 6.44 7.71 9.24
30 0.046 0.072 0.162 0.208 0.280 0.347 0.441 0.551 0.672 0.784 0.932 1.08 1.26 1.45 1.50 1.78 2.03 2.52 3.45 40 0.057 0.018 0.225 0.341 0.433 0.544 0.880 0.846 1.15 1.34 1.56 1.79 1.86 2.20 2.50 3.11 4.28 40 0.057 0.008 0.110 0.225 0.341 0.433 0.544 0.880 0.841 1.15 1.38 1.50 1.85 2.14 2.46 2.61 3.07 3.47 4.30 5.44 40 0.009 0.119 0.225 0.341 0.433 0.544 0.881 0.784 1.15 1.38 1.59 1.85 2.14 2.46 2.61 3.07 3.47 4.30 5.87 40 0.009 0.149 0.225 0.341 0.549 0.544 0.881 1.45 1.75 1.81 2.13 2.22 2.63 2.99 3.71 5.06 40 0.009 0.149 0.225 0.441 0.585 0.986 1.24 1.45 1.24 1.24 2.46 2.61 3.07 3.47 4.30 5.87 40 0.010 0.168 0.335 0.442 0.686 0.980 1.24 1.45 1.70 1.89 2.25 2.62 3.01 3.47 4.36 4.85 5.49 6.65 40 0.010 0.018 0.029 0.049 0.051 0.059 0.045 0.009 0.018 0.029 0.045 0.009 0.018 0.009 0.01	1.11				3.05	٠,	3.22	3.60	3.60 4.13	3.60	3.60 4.13 4.75	3.60 4.13 4.75 5.34	3.60 4.13 4.75 5.34 6.02 7.42 8.88	3.60 4.13 4.75 5.34 6.02 7.42 8.88 10.7	3.60 4.13 4.75 5.34 6.02 7.42 8.88 10.7 12.3	3.60 4.13 4.75 5.34 6.02 7.42 8.88 10.7
40 0.057 0.094 0.189 0.258 0.345 0.430 0.544 0.680 0.826 0.366 1.15 1.34 1.56 1.79 1.86 2.20 2.50 3.11 4.28 3.69 3.70 3.40 3.69 3.69 3.70 3.69 3.70 3.69 3.70	1.26				3.45			4.05	4.05 4.64	4.05	4.05 4.64 5.34	4.05 4.64 5.34 6.02	4.05 4.64 5.34 6.02 6.76	4.05 4.64 5.34 6.02 6.76 8.39 10.1 12.1	4.05 4.64 5.34 6.02 6.76 8.39 10.1 12.1 13.9	4.05 4.64 5.34 6.02 6.76 8.39 10.1 12.1
50 0.006 0.11 0.225 0.311 0.413 0.511 0.426 0.811 0.981 1.15 1.38 1.60 1.85 2.13 2.22 2.63 2.99 3.71 5.06 5.0 50 0.0079 0.129 0.261 0.362 0.431 0.581 0.574 0.582 1.14 1.33 1.59 1.85 2.14 2.46 2.61 3.07 3.47 4.30 5.87 5.06 50 0.0079 0.149 0.299 0.413 0.549 0.674 0.854 1.07 1.29 1.52 1.81 2.11 2.43 2.80 2.97 3.52 3.96 4.89 6.65 50 0.010 0.168 0.335 0.443 0.549 0.674 0.854 1.07 1.45 1.70 2.03 2.37 2.72 3.13 3.33 3.94 4.43 5.49 5.44 50 0.011 0.188 0.371 0.541 0.686 0.890 1.21 1.45 1.70 2.03 2.37 2.72 3.13 3.33 3.94 4.43 5.49 5.44 50 0.012 0.029 0.041 0.674 0.692 0.413 0.414 1.47 1.47 1.47 1.48 1.40 2.48 2.80 2.91 3.41 4.36 4.95 6.67 9.03 50 0.001 0.012 0.029 0.045	1.56							4.98	4.98 5.66	4.98 5.66 6.50	4.98 5.66	4.98 5.66 6.50 7.33	4.98 5.66 6.50 7.33 8.26	4.98 5.66 6.50 7.33 8.26 10.4 12.4 14.9	4.98 5.66 6.50 7.33 8.26 10.4 12.4 14.9 17.2	4.98 5.66 6.50 7.33 8.26 10.4 12.4 14.9
Column C	1.85					100		5.89	5.89 6.69	5.89	5.89 6.69 7.69 8	5.89 6.69 7.69 8.64	5.89 6.69 7.69 8.64 9.72	5.89 6.69 7.69 8.64 9.72 12.4 14.7 17.7	5.89 6.69 7.69 8.64 9.72 12.4 14.7 17.7 20.4	5.89 6.69 7.69 8.64 9.72 12.4 14.7 17.7
50 70 0.089 0.149 0.599 0.413 0.549 0.674 0.854 1.07 1.29 1.52 1.81 2.11 2.43 2.80 2.97 3.52 3.89 3.99 4.89 6.674 0.854 1.07 1.29 1.52 1.81 2.11 2.43 2.80 2.97 3.75 3.72 3.13 3.33 3.94 4.43 5.49 7.44 90 0.010 0.188 0.371 0.517 0.686 0.890 1.21 1.46 1.70 2.03 2.37 2.72 3.13 3.33 3.94 4.43 5.49 7.44 100 0.011 0.118 0.371 0.517 0.184 1.70 2.07 2.07 2.81 3.70 3.47 3.71 4.93 4.83 5.94 7.44 7.44 7.84 6.87 7.44 7.84 7.44 7.44 7.44 7.44 7.44 7.44 7.45 7.44 7.44 7.44	2.14					(C)		6.78	69.7 87.9	6.78	6.78 7.69 8.83	6.78 7.69 8.83 9.94	6.78 7.69 8.83 9.94 11.2 14.3 17.2	6.78 7.69 8.83 9.94 11.2 14.3 17.2 20.5	6.78 7.69 8.83 9.94 11.2 14.3 17.2 20.5 23.5	6.78 7.69 8.83 9.94 11.2 14.3 17.2 20.5
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	2.43					(C)		79.7	7.67 8.73	7.67 8.73 10.0	7.67 8.73	7.67 8.73 10.0 11.3	7.67 8.73 10.0 11.3 12.7 16.3 19.6	7.67 8.73 10.0 11.3 12.7 16.3 19.6 23.3	7.67 8.73 10.0 11.3 12.7 16.3 19.6 23.3 26.9	7.67 8.73 10.0 11.3 12.7 16.3 19.6 23.3
100 0.112 0.108 0.371 0.517 0.686 0.839 1.06 1.34 1.60 1.89 2.25 2.62 3.01 3.47 3.71 4.36 4.92 6.08 8.24 8.24 8.24 8.25 8.24 8.25 8.25 3.05 3.05 3.05 3.05 9.25 9.	2.72				7.44	7.7		8.56	8.56 9.75	8.56 9.75 11.2	8.56 9.75	8.56 9.75 11.2 12.6	8.56 9.75 11.2 12.6 14.2 18.3 22.0	8.56 9.75 11.2 12.6 14.2 18.3 22.0 26.1	8.56 9.75 11.2 12.6 14.2 18.3 22.0 26.1 30.3	8.56 9.75 11.2 12.6 14.2 18.3 22.0 26.1
	3.01					m.		9.47	9.47 10.7	9.47 10.7 12.4	9.47 10.7	9.47 10.7 12.4 13.9	9.47 10.7 12.4 13.9 15.7 20.3 24.4	9.47 10.7 12.4 13.9 15.7 20.3 24.4 29.0	9.47 10.7 12.4 13.9 15.7 20.3 24.4 29.0 33.3	9.47 10.7 12.4 13.9 15.7 20.3 24.4 29.0
5 0.007 0.013 0.029 0.043 0.059 0.047 0.050 0.070 0.012 0.154 0.180 0.212 0.246 0.290 0.331 0.358 0.422 0.485 0.587 0.799 0.799 0.799 0.009 0.018 0.057 0.076 0.098 0.128 0.155 0.197 0.231 0.271 0.316 0.371 0.424 0.450 0.536 0.619 0.746 1.02 0.029 0.045 0.065 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.012 0.045 0.045 0.065 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.012 0.045 0.045 0.063 0.085 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.012 0.045 0.045 0.065 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.045 0.045 0.063 0.085 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.045 0.045 0.063 0.085 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.045 0.045 0.063 0.085 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.885 1.11 0.045	3.30					Ci.		10.4	10.4 11.8	10.4 11.8 13.5	10.4 11.8	10.4 11.8 13.5 15.2	10.4 11.8 13.5 15.2 17.2 22.5 26.7	10.4 11.8 13.5 15.2 17.2 22.5 26.7 31.8	10.4 11.8 13.5 15.2 17.2 22.5 26.7 31.8 36.4	10.4 11.8 13.5 15.2 17.2 22.5 26.7 31.8
H 2 15 0.009 0.018 0.029 0.017 0.0218 0.021 0.231 0.271 0.316 0.316 0.038 0.128 0.155 0.197 0.231 0.271 0.316 0.346 0.356 0.049 0.078 0.0197 0.128 0.128 0.128 0.128 0.128 0.128 0.128 0.128 0.248 0.292 0.337 0.398 0.453 0.678 0.079 0.078 0.079 0.078 0.079 0.078 0.079 0.078 0.079 <td>0.290</td> <td>l</td> <td>l</td> <td> </td> <td></td> <td>lω</td> <td></td> <td>0.956</td> <td>0.956 1.08</td> <td>0.956 1.08 1.25</td> <td>0.956 1.08</td> <td>0.956 1.08 1.25 1.43</td> <td>0.956 1.08 1.25 1.43 1.62 2.08 2.46</td> <td>0.956 1.08 1.25 1.43 1.62 2.08 2.46 2.92</td> <td>0.956 1.08 1.25 1.43 1.62 2.08 2.46 2.92 3.41</td> <td>0.956 1.08 1.25 1.43 1.62 2.08 2.46 2.92</td>	0.290	l	l			lω		0.956	0.956 1.08	0.956 1.08 1.25	0.956 1.08	0.956 1.08 1.25 1.43	0.956 1.08 1.25 1.43 1.62 2.08 2.46	0.956 1.08 1.25 1.43 1.62 2.08 2.46 2.92	0.956 1.08 1.25 1.43 1.62 2.08 2.46 2.92 3.41	0.956 1.08 1.25 1.43 1.62 2.08 2.46 2.92
E 3 0.012 0.0202 0.045 0.0645 0.065 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.486 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.486 0.826 1.11 3 0 0.012 0.0245 0.063 0.085 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.487 0.826 1.11	0.371			0.746	1.02	0.		1.18	1.18 1.35	1.18 1.35 1.56	1.18 1.35	1.18 1.35 1.56 1.76	1.18 1.35 1.56 1.76 2.02	1.18 1.35 1.56 1.76 2.02 2.67 3.19 3.81	1.18 1.35 1.56 1.76 2.02 2.67 3.19 3.81 4.36	1.18 1.35 1.56 1.76 2.02 2.67 3.19 3.81
E 3 0.012 0.020 0.045 0.0645 0.065 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.486 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.486 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.577 0.678 0.826 1.11	0.398			0.826	1.11	1.	Ì	1.33	1.33 1.51	1.33	1.33 1.51 1.73 1	1.33 1.51 1.73 1.95	1.33 1.51 1.73 1.95 2.26 2.95 3.50	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22 4.89	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22
S 30 0.012 0.020 0.045 0.063 0.086 0.107 0.138 0.168 0.212 0.248 0.292 0.337 0.398 0.453 0.498 0.570 0.678 0.826 1.11	0.398				1.11	1.7	Ì	1.33	1.33 1.51	1.33 1.51 1.73 1	1.33 1.51	1.33 1.51 1.73 1.95	1.33 1.51 1.73 1.95 2.26 2.95 3.50	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22 4.89	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22
	0.398 0.453				1.11	1.1		1.33	1.33 1.51	1.33 1.51 1.73	1.33 1.51	1.33 1.51 1.73 1.95	1.33 1.51 1.73 1.95 2.26 2.95 3.50	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22 4.89	1.33 1.51 1.73 1.95 2.26 2.95 3.50 4.22
Standard Conditions 70°F, 14.7 psia SCFH – Standard SLPM – Standard		12 13 14 15 16 42 0.00050 0.00061 0.00071 0.00084 0.00094 66 0.123 0.144 0.169 0.201 0.225 73 0.409 0.483 0.559 0.653 0.756 74 0.508 0.604 0.697 0.818 0.899 75 0.602 0.714 0.826 0.968 1.11 78 0.693 0.824 0.953 1.11 1.28 78 0.693 0.824 0.953 1.11 1.28 79 0.784 0.932 1.08 1.26 1.45 79 0.784 0.932 1.08 1.26 1.45 79 0.784 0.932 1.08 1.26 1.45 79 0.784 0.932 1.03 1.10 2.43 2.80 79 1.52 1.81 2.11 2.43 2.80 79 1.52 1.81 2.11 2.43 2.80 79 1.52 1.81 2.11 2.43 2.80 79 1.52 1.81 2.11 2.43 2.80 79 1.52 1.81 2.11 2.43 2.80 79 1.52 1.81 2.11 2.43 2.80 79 0.248 0.292 0.337 0.398 0.453 70 0.248 0.292 0.337 0.398 0.453 70 0.248 0.292 0.337 0.398 0.453 70 0.248 0.292 0.337 0.398 0.453 70 0.248 0.292 0.337 0.398 0.453 70 0.248 0.292 0.337 0.398 0.453	17 0.0011 0.254 0.057 1.02 1.39 1.50 1.50 1.50 2.26 2.26 2.26 2.27 2.97 3.33 3.33 3.71 0.358 0.498 0.498	17 0.0011 0.254 0.057 1.02 1.39 1.50 1.50 1.50 2.26 2.26 2.26 2.27 2.97 3.33 3.33 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