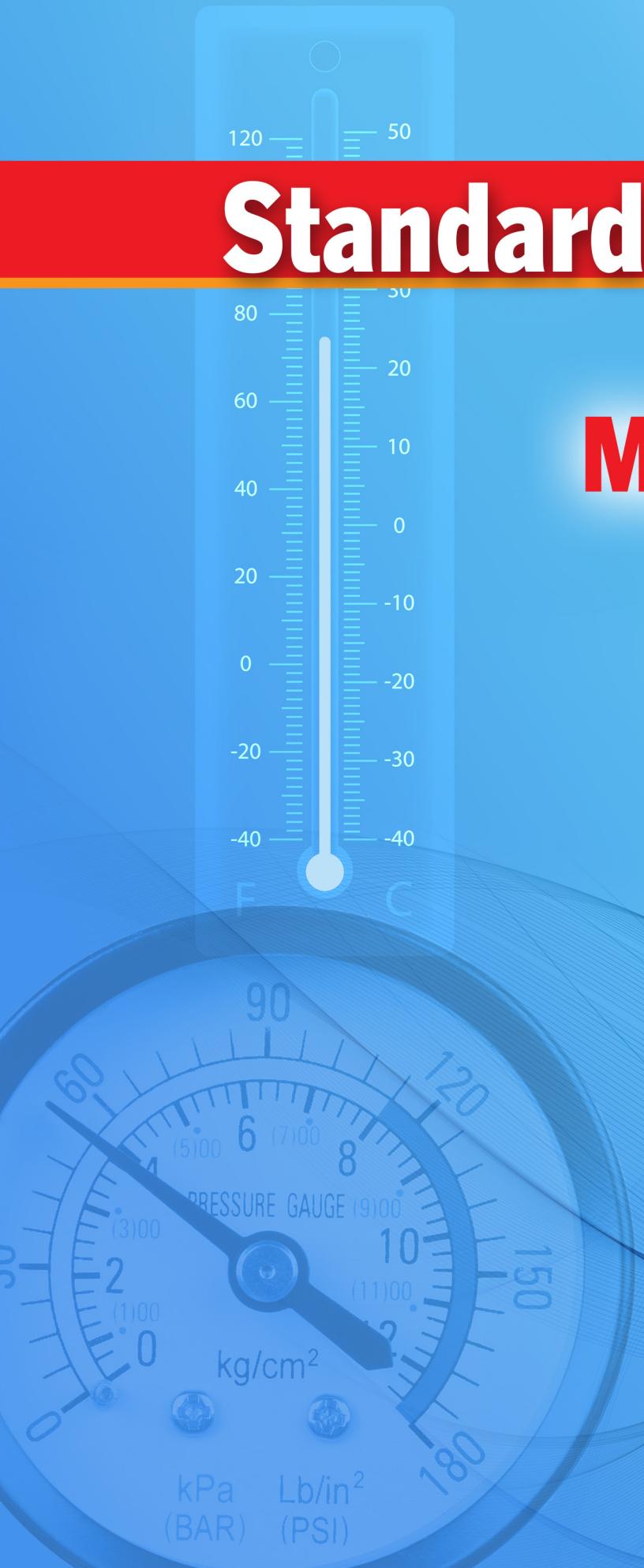


Understanding

Standard Conditions

In Flow Measurement



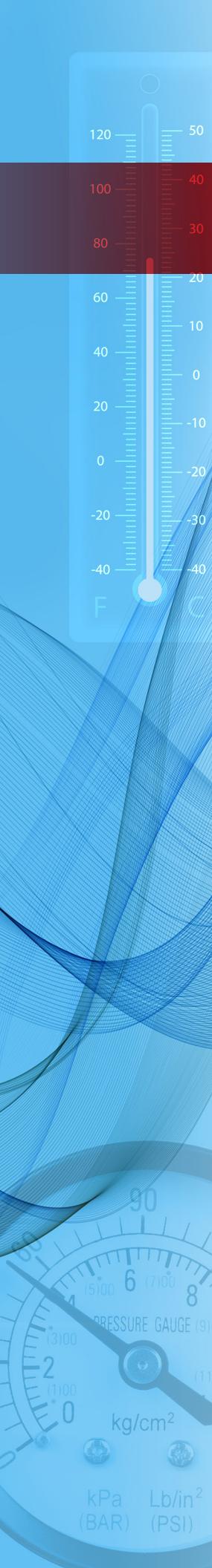
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Understanding

Standard Conditions

In Flow Measurement



Gas flow measurement is usually expressed in volumetric units such as cubic feet, cubic liters, or cubic centimeters per time. Since gases are compressible fluids, the total **mass** contained in a given volume varies with both the temperature and the pressure of the gas, as described by the Ideal Gas Law. To avoid lengthy descriptions of flow, such as 10 cubic feet of nitrogen at 114.7 psia and 70°F, science and industry have adopted “standard conditions” of pressure and temperature.

The key question is: what is the definition of “standard conditions?”

Standard Conditions

Volumetric expression of flow for compressible fluids is not sufficient to describe how much “stuff” has passed through a cross section of pipe or tubing. The density of gas changes as pressure and temperature change. In order to easily describe how much substance is flowing, the notion of a “standard” set of conditions has been defined. These standard conditions denote the pressure and temperature that exist in the volume. In units of measurement like SCFH, SLPM and SCCM, the “S” indicates standard. This transforms the expression of flow from a volumetric expression to a **mass flow rate**.

Unfortunately, the definition of “standard conditions” varies slightly among technical disciplines and industry groups. **Standard temperature** ranges from 32°F to 70°F (0°C to 21°C). **Standard pressure** is generally average atmospheric pressure at sea level: 14.7 psia.

A **mass flowmeter** is a common type of instrument used to measure gas flow relatively independent of gas pressure or barometric pressure

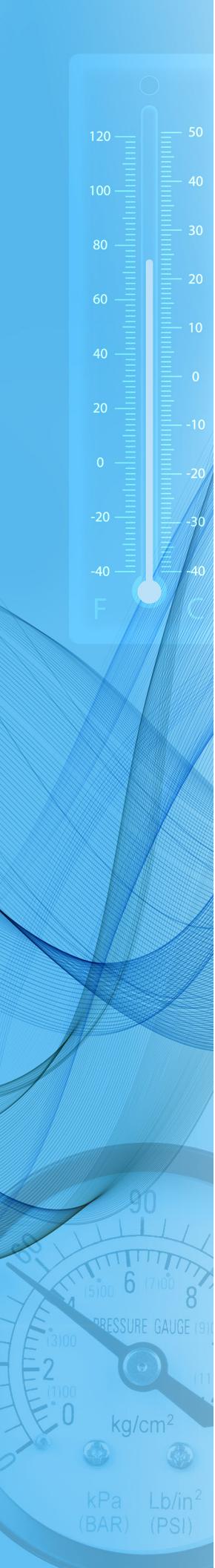
conditions. In models using the thermal measurement principle, mass flow is calculated either by introducing a known amount of heat to a gas and measuring the temperature change, or by keeping a probe at a certain temperature and measuring the amount of energy needed to maintain that temperature. Typically, they are calibrated for the following standard conditions:

- Nitrogen
- 32°F (0°C)
- 14.7 psia

A **rotameter** is another instrument used for measurement of air or other gas flows that must be used for the specific conditions for which they are calibrated. Typically, they are calibrated for the following standard conditions:

- Air
- 70°F (21°C)
- 14.7 psia

Rotameters can be calibrated for other gas flows or other outlet pressure conditions, or correction factors can be applied.



Factors to Consider

In comparing flow measurements taken at different locations and with different measuring equipment, the following factors should be considered:

1. Definition of Standard Conditions

Standard temperatures of 32°F or 70°F generate an almost 8% difference in mass flow rate.

2. Temperature of the Gas

A 10°F deviation causes about 1% error in a rotameter reading. More or less deviation occurs in other type flow measuring instruments. The deviations are predictable and the flow measurement is correctable.

Industry Examples

As discussed, flow measurement conditions vary due to application requirements across different industries. **In many applications, errors of $\pm 10\%$ in flow rate are unimportant.** In this case, corrections for standard conditions, barometric pressure, and temperature are not required.

HVAC Industry

Due to the pressure generally being fairly low on the equipment used, it's common for pressure measurement instruments to indicate pressure in inches of water. There are 27.68 inches of water in 1 psi.



3. Barometric Pressure

Normal atmospheric pressure variations of $\pm 1/2"$ Hg. can cause more than 1% error in rotameters. Altitude is also an important factor, since the barometric pressure decreases rapidly with increasing altitude. At an elevation of 2,000 ft. above sea level, rotameter scale readings are in error by 3 1/2%. These errors can be corrected quite easily with predictable correction factors, and accurate knowledge of barometric pressure.



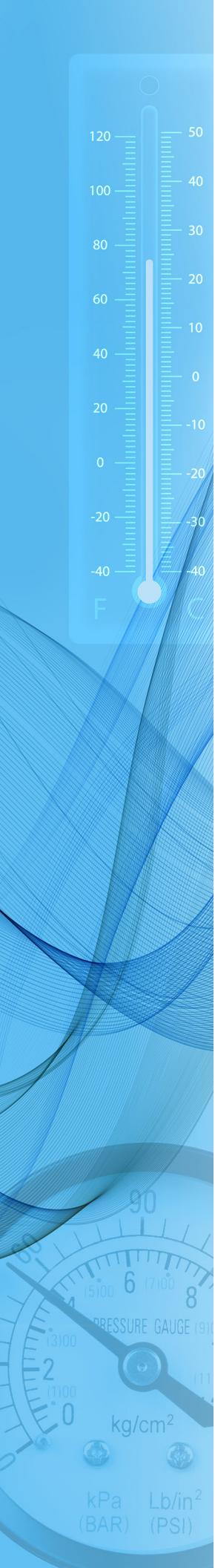
Meteorology

Meteorologists report atmospheric pressure as forewarnings of oncoming storms or changes in weather. They often refer to this as barometric pressure because of the instrument developed to measure atmospheric pressure, the barometer. Oftentimes the units of measurement used are Inches of mercury ("Hg) because of the liquid used in the barometer. One standard atmosphere, 14.7 psia is equivalent to 29.92" Hg.

Medical Devices

In medical devices, such as artificial lung ventilators, precision gas flow is necessary, and accurate flow measurement is critical. Using the correct standard conditions allows users to precisely specify the correct orifice sizes to create a reliable, consistent air flow for life-saving purposes.





Improving Measurement Accuracy

In cases where precise gas flow rate is critical, the following formulas can be used to ensure measurement accuracy.

1. Definition of Standard Conditions

The data on pages 5-7 is for standard conditions of 70°F and 14.7 psia. To reconcile data taken from instruments which are referenced to different standard conditions, use the following formula:

$$Q_s = Q_m \times \frac{P_m}{P_s} \times \frac{T_s}{T_m}$$

Q_m = measured volumetric flow (SCFH) or (SLPM).

Q_s = volumetric flow corrected to 70°F and 14.7 psia.

P_m = standard barometric pressure referenced by the manufacturer (psia). This is generally 14.7 psia.

P_s = standard barometric pressure = 14.7 psia.

T_m = standard absolute temperature referenced by the manufacturer (°Rankine).

T_s = standard absolute temperature = 530°R.

Example: A mass flowmeter manufacturer uses the following standard conditions: 14.7 psia, 32°F (492°R).

To convert to standard conditions of 70°F (530°R) and 14.7 psia, apply the following:

$$Q_s = Q_m \times \frac{P_m}{P_s} \times \frac{T_s}{T_m} = Q_m \times \frac{14.7}{14.7} \times \frac{530}{492}$$
$$= 1.077 Q_m$$

The volumetric flow Q_s is larger than Q_m by 7.7%. Consult the manufacturer of your flow measuring equipment to insure that you know exactly the standard conditions which apply to your equipment.

2. Temperature Effects

Consult your instrument manufacturer for temperature correction factors. There are two temperature considerations:

1. Effect of ambient temperature on the flow measuring instrument
2. Effect of gas temperature on the flow measuring instrument

3. Barometric Pressure Effects

Consult your instrument manufacturer for pressure correction factors. There are two pressure considerations:

1. Effect of barometric pressure on the flow measuring instrument
2. Effect of gas pressure on the flow measuring instrument

Table of Average Barometric Pressure

Altitude Above Sea Level Feet	Barometer Reading Inches Mercury	Atmospheric Pressure PSIA
0	29.92	14.696
500	29.38	14.43
1000	28.86	14.16
1500	28.33	13.91
2000	27.82	13.66
2500	27.32	13.41
3000	26.82	13.17
3500	26.33	12.93
4000	25.84	12.69
4500	25.37	12.46
5000	24.90	12.23
5500	23.99	11.78
7000	23.10	11.34
8000	22.23	10.91

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"Standard conditions" used in measuring the flow of gases have definitions that vary based on industry. Understanding why standard conditions vary and what can be done to improve measurement accuracy is essential to specifying the correct precision orifice sizes for your application.

Precision orifices manufactured by O'Keefe Controls Co. are designed to ensure accurate, repeatable, and exact flow through the orifice, enabling us to help companies worldwide when precision is most needed in flow control — whether liquid or gas. Our precision orifices pass stringent quality control testing to ensure they operate exactly as specified, with consistent performance. As an ISO 9001:2015 certified company, all processes are held to the highest standards of quality. But perhaps of even greater benefit to our customers, the engineers at O'Keefe Controls are technical experts in the field — knowledgeable about not only our products, but also the science behind their use. As such, we are able to assist customers in diverse practical applications across the industrial landscape. In all we do, we stand proudly by our tagline:

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Call us if you have questions about a flow control application and talk to one of our engineers. We're happy to help you achieve success in your endeavors.

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P.O. Box 316
Monroe, CT 06468
info@okeefecontrols.com
www.okeefecontrols.com

800.533.3285

Metal Orifice Air Flow — SCFH

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Orifice Diameter Inches	0.004	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.033	
Size Number	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	31	32	33	
C _v	0.00035	0.00061	0.00086	0.0012	0.0015	0.0019	0.0025	0.0028	0.0034	0.0038	0.0043	0.0050	0.0055	0.0067	0.0073	0.0080	0.0088	0.0096	0.011	0.012	0.013	0.014	0.016	0.017	0.018	0.019	0.022	0.024	0.025	
Supply Pressure - psig	1	0.075	0.136	0.182	0.269	0.360	0.479	0.593	0.653	0.843	0.962	1.11	1.30	1.40	1.64	1.82	2.03	2.22	2.39	2.73	2.99	3.26	3.54	4.05	4.13	4.68	5.06	5.62	6.10	6.42
	5	0.18	0.33	0.45	0.64	0.85	1.10	1.37	1.51	1.94	2.25	2.56	2.99	3.26	3.73	4.20	4.70	5.23	5.62	6.29	6.87	7.48	8.12	9.20	9.41	10.5	11.3	12.4	13.6	14.4
	10	0.25	0.47	0.65	0.91	1.21	1.57	1.97	2.14	2.73	3.14	3.56	4.13	4.26	4.79	5.38	6.00	6.70	7.48	9.17	10.1	11.0	11.8	13.0	13.6	15.2	16.6	18.3	19.9	21.1
	15	0.34	0.59	0.82	1.14	1.53	1.97	2.48	2.67	3.43	3.92	4.45	5.17	5.30	6.04	6.84	7.56	8.50	9.34	11.3	12.6	13.6	14.7	16.1	16.8	18.6	20.3	22.5	24.6	26.1
	20	0.40	0.70	0.97	1.38	1.80	2.33	2.92	3.16	4.07	4.64	5.28	6.08	6.29	7.20	8.18	9.03	10.3	11.1	13.5	14.7	16.1	17.3	18.9	19.7	21.8	23.7	26.3	28.6	30.3
	25	0.47	0.82	1.12	1.59	2.08	2.69	3.37	3.62	4.66	5.30	6.06	6.95	7.25	8.31	9.43	10.4	11.8	12.7	15.5	16.8	18.3	19.9	21.6	22.7	24.8	27.1	30.1	32.6	34.5
	30	0.53	0.92	1.26	1.80	2.37	3.03	3.81	4.09	5.23	5.98	6.80	7.82	8.20	9.39	10.7	11.8	13.4	14.4	17.4	19.0	20.7	22.5	24.4	25.4	28.0	30.5	33.7	36.7	39.0
	40	0.64	1.15	1.56	2.22	2.92	3.75	4.68	5.02	6.44	7.31	8.33	9.56	10.1	11.6	13.2	14.5	16.5	17.8	21.4	23.3	25.4	27.5	29.9	31.1	34.1	37.1	41.1	44.7	47.7
	50	0.76	1.37	1.86	2.67	3.50	4.45	5.55	5.93	7.59	8.62	9.83	11.3	12.1	13.8	15.7	17.3	19.6	21.2	25.2	27.5	30.1	32.6	35.2	36.7	40.3	43.9	48.5	53.0	56.4
	60	0.89	1.59	2.16	3.09	4.05	5.13	6.40	6.84	8.75	10.0	11.3	13.0	14.0	16.0	18.2	20.0	22.7	24.6	29.2	31.8	34.7	37.5	40.7	42.4	46.4	50.4	55.9	61.0	65.0
	70	1.02	1.82	2.46	3.54	4.60	5.83	7.27	7.76	9.92	11.3	12.8	14.7	16.0	18.2	20.7	22.9	25.9	28.0	33.1	36.0	39.2	42.6	46.0	48.1	52.5	57.2	63.6	69.3	73.9
	80	1.14	2.04	2.75	3.96	5.15	6.53	8.12	8.67	11.1	12.6	14.3	16.5	17.9	20.5	23.3	25.6	29.0	31.6	37.1	40.3	43.9	47.7	51.3	53.6	58.7	64.0	71.2	77.8	82.6
	90	1.27	2.27	3.05	4.41	5.70	7.20	8.96	9.56	12.2	13.9	15.9	18.3	19.9	22.7	25.9	28.4	32.2	35.0	40.9	44.5	48.5	52.8	56.8	59.3	65.0	71.0	78.8	86.0	91.5
	100	1.40	2.48	3.35	4.83	6.25	7.88	9.81	10.5	13.4	15.3	17.4	20.0	21.8	25.0	28.4	31.1	35.2	38.1	44.7	48.7	53.2	58.1	62.3	65.3	71.4	78.0	86.7	94.5	101
Vacuum Level In. Hg.	5	0.113	0.203	0.273	0.405	0.536	0.703	0.860	0.953	1.23	1.40	1.64	1.90	2.07	2.41	2.70	2.99	3.28	3.60	4.03	4.45	4.87	5.25	5.81	6.00	6.70	7.23	8.01	8.73	9.15
	10	0.145	0.263	0.356	0.521	0.687	0.892	1.10	1.20	1.55	1.77	2.06	2.37	2.62	2.99	3.35	3.79	4.15	4.62	5.17	5.68	6.12	6.63	7.29	7.59	8.48	9.11	10.1	10.9	11.5
	15	0.158	0.284	0.392	0.568	0.744	0.964	1.20	1.30	1.68	1.91	2.26	2.59	2.86	3.28	3.71	4.11	4.64	4.92	5.53	6.04	6.61	7.08	7.73	8.01	8.90	9.56	10.7	11.5	12.1
	20	0.158	0.284	0.392	0.568	0.744	0.964	1.20	1.30	1.68	1.91	2.26	2.59	2.86	3.28	3.71	4.11	4.64	4.92	5.53	6.04	6.61	7.08	7.73	8.01	8.90	9.56	10.7	11.5	12.1
	30	0.158	0.284	0.392	0.568	0.744	0.964	1.20	1.30	1.68	1.91	2.26	2.59	2.86	3.28	3.71	4.11	4.64	4.92	5.53	6.04	6.61	7.08	7.73	8.01	8.90	9.56	10.7	11.5	12.1

Orifice Diameter Inches	0.035	0.037	0.038	0.039	0.040	0.041	0.042	0.043	0.047	0.052	0.055	0.060	0.063	0.067	0.070	0.073	0.076	0.079	0.081	0.086	0.089	0.094	0.096	0.100	0.104	0.109	0.113	0.120	0.125			
Size Number	35	37	38	39	40	41	42	43	47	52	55	60	63	67	70	73	76	79	81	86	89	94	96	100	104	109	113	120	125			
C _v	0.028	0.031	0.032	0.033	0.036	0.038	0.039	0.041	0.048	0.059	0.068	0.081	0.088	0.10	0.11	0.12	0.13	0.14	0.15	0.17	0.18	0.20	0.21	0.23	0.25	0.27	0.31	0.34	0.37			
Supply Pressure - psig	1	7.37	8.12	8.75	9.45	9.75	9.90	10.6	11.4	13.6	17.0	19.9	23.7	25.9	30.1	33.6	35.9	39.3	43.0	46.0	49.7	53.7	60.2	63.7	69.8	75.2	83.9	91.4	101	106		
	5	16.3	18.0	19.3	20.6	21.6	22.5	23.9	25.6	30.1	37.3	43.0	50.6	55.3	64.2	71.6	76.5	83.5	91.3	97.5	108	116	131	138	150	162	180	195	216	229		
	10	22.5	25.0	26.5	28.8	30.5	31.4	33.1	35.6	41.0	51.9	57.4	68.2	74.6	86.2	96.6	103	112	121	131	144	153	172	181	196	216	237	250	286	314	345	377
	15	27.8	30.7	32.6	35.4	37.5	38.6	40.5	43.2	50.0	62.9	69.7	82.6	90.3	104	117	125	136	147	158	174	185	207	218	235	261	286	303	345	377		
	20	32.4	36.0	38.4	41.5	44.3	45.3	47.7	50.9	58.7	74.2	82.0	97.3	106	123	138	146	160	172	185	203	216	242	256	275	305	335	354	403	445		
	25	37.5	41.5	44.1	47.9	50.9	52.3	54.9	58.5	67.6	85.4	94.5	112	122	141	158	168	183	198	212	233	248	278	292	316	347	381	405	464	511		
	30	42.4	47.0	50.0	54.2	57.6	59.3	62.3	66.3	76.3	96.6	107	126	138	160	179	190	206	222	239	265	280	314	331	356	392	432	458	525	578		
	40	52.5	58.1	67.2	67.0	71.2	73.3	76.9	82.0	94.3	119	132	156	170	196	220	233	254	273	295	324	343	384	405	439	483	532	566	648	714		
	50	62.5	69.1	73.7	79.7	85.0	87.5	91.7	97.5	112	142	157	185	202	233	261	278	301	324	347	384	407	456	481	523	576	634	771	850			
	60	72.7	80.5	86.0	92.8	99	102	107	113	130	165	182	214	233	269	301	320	347	375	400	445	473	530	559	606	667	735	780	894	985		
	70	83.1	91.7	98.1	106	113	117	122	129	148	187	207	244	267	307	343	362	394	428	458	509	538	604	638	693							

Metal Orifice Air Flow — SLPM

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Orifice Diameter Inches	0.004	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027	0.028	0.029	0.031	0.032	0.033	
Size Number	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	31	32	33	
C _v	0.00035	0.00061	0.00086	0.0012	0.0015	0.0019	0.0025	0.0028	0.0034	0.0038	0.0043	0.0050	0.0055	0.0067	0.0073	0.0080	0.0088	0.0096	0.011	0.012	0.013	0.014	0.016	0.017	0.018	0.019	0.022	0.024	0.025	
Supply Pressure - psig	1	0.035	0.064	0.086	0.127	0.170	0.226	0.280	0.308	0.398	0.45	0.52	0.61	0.66	0.77	0.86	0.96	1.05	1.13	1.29	1.41	1.54	1.67	1.91	1.95	2.21	2.39	2.65	2.88	3.03
	5	0.09	0.16	0.21	0.30	0.40	0.52	0.65	0.71	0.92	1.06	1.21	1.41	1.54	1.76	1.98	2.22	2.47	2.65	2.97	3.24	3.53	3.83	4.34	4.44	4.94	5.31	5.86	6.42	6.80
	10	0.12	0.22	0.31	0.43	0.57	0.74	0.93	1.01	1.29	1.48	1.68	1.95	2.01	2.26	2.54	2.83	3.16	3.53	4.33	4.75	5.18	5.55	6.15	6.43	7.18	7.83	8.63	9.40	9.98
	15	0.16	0.28	0.39	0.54	0.72	0.93	1.17	1.26	1.62	1.85	2.10	2.44	2.50	2.85	3.23	3.57	4.01	4.41	5.35	5.93	6.43	6.95	7.58	7.95	8.78	9.58	10.6	11.6	12.3
	20	0.19	0.33	0.46	0.65	0.85	1.10	1.38	1.49	1.92	2.19	2.49	2.87	2.97	3.40	3.86	4.26	4.84	5.22	6.35	6.95	7.58	8.15	8.90	9.28	10.3	11.2	12.4	13.5	14.3
	25	0.22	0.39	0.53	0.75	0.98	1.27	1.59	1.71	2.20	2.50	2.86	3.28	3.42	3.92	4.45	4.91	5.59	6.01	7.30	7.95	8.65	9.38	10.2	10.7	11.7	12.8	14.2	15.4	16.3
	30	0.25	0.44	0.60	0.85	1.12	1.43	1.80	1.93	2.47	2.82	3.21	3.69	3.87	4.43	5.03	5.56	6.33	6.81	8.23	8.98	9.75	10.6	11.5	12.0	13.2	14.4	15.9	17.3	18.4
	40	0.30	0.54	0.74	1.05	1.38	1.77	2.21	2.37	3.04	3.45	3.93	4.51	4.78	5.47	6.21	6.85	7.81	8.42	10.1	11.0	12.0	13.0	14.1	14.7	16.1	17.5	19.4	21.1	22.5
	50	0.36	0.65	0.88	1.26	1.65	2.10	2.62	2.80	3.58	4.07	4.64	5.31	5.70	6.51	7.40	8.15	9.26	10.0	11.9	13.0	14.2	15.4	16.6	17.3	19.0	20.7	22.9	25.0	26.6
	60	0.42	0.75	1.02	1.46	1.91	2.42	3.02	3.23	4.13	4.70	5.34	6.13	6.61	7.56	8.58	9.46	10.7	11.6	13.8	15.0	16.4	17.7	19.2	20.0	21.9	23.8	26.4	28.8	30.7
	70	0.48	0.86	1.16	1.67	2.17	2.75	3.43	3.66	4.68	5.32	6.05	6.96	7.53	8.61	9.77	10.8	12.2	13.2	15.6	17.0	18.5	20.1	21.7	22.7	24.8	27.0	30.0	32.7	34.9
	80	0.54	0.96	1.30	1.87	2.43	3.08	3.83	4.09	5.23	5.95	6.77	7.79	8.46	9.67	11.0	12.1	13.7	14.9	17.5	19.0	20.7	22.5	24.2	25.3	27.7	30.2	33.6	36.7	39.0
	90	0.60	1.07	1.44	2.08	2.69	3.40	4.23	4.51	5.78	6.58	7.49	8.62	9.38	10.7	12.2	13.4	15.2	16.5	19.3	21.0	22.9	24.9	26.8	28.0	30.7	33.5	37.2	40.6	43.2
	100	0.66	1.17	1.58	2.28	2.95	3.72	4.63	4.94	6.33	7.22	8.21	9.46	10.3	11.8	13.4	14.7	16.6	18.0	21.1	23.0	25.1	27.4	29.4	30.8	33.7	36.8	40.9	44.6	47.5
Vacuum Level In. Hg.	5	0.053	0.096	0.129	0.191	0.253	0.332	0.406	0.450	0.582	0.661	0.773	0.899	0.977	1.14	1.28	1.41	1.55	1.70	1.90	2.10	2.30	2.48	2.74	2.83	3.16	3.41	3.78	4.12	4.32
	10	0.069	0.124	0.168	0.246	0.324	0.421	0.519	0.564	0.730	0.834	0.972	1.12	1.24	1.41	1.58	1.79	1.96	2.18	2.44	2.68	2.89	3.13	3.44	3.58	4.00	4.30	4.77	5.16	5.43
	15	0.075	0.134	0.185	0.268	0.351	0.455	0.566	0.614	0.792	0.902	1.07	1.22	1.35	1.55	1.75	1.94	2.19	2.32	2.61	2.85	3.12	3.34	3.65	3.78	4.20	4.51	5.05	5.45	5.72
	20	0.075	0.134	0.185	0.268	0.351	0.455	0.566	0.614	0.792	0.902	1.07	1.22	1.35	1.55	1.75	1.94	2.19	2.32	2.61	2.85	3.12	3.34	3.65	3.78	4.20	4.51	5.05	5.45	5.72
	30	0.075	0.134	0.185	0.268	0.351	0.455	0.566	0.614	0.792	0.902	1.07	1.22	1.35	1.55	1.75	1.94	2.19	2.32	2.61	2.85	3.12	3.34	3.65	3.78	4.20	4.51	5.05	5.45	5.72

Orifice Diameter Inches	0.035	0.037	0.038	0.039	0.040	0.041	0.042	0.043	0.047	0.052	0.055	0.060	0.063	0.067	0.070	0.073	0.076	0.079	0.081	0.086	0.089	0.094	0.096	0.100	0.104	0.109	0.113	0.120	0.125	
Size Number	35	37	38	39	40	41	42	43	47	52	55	60	63	67	70	73	76	79	81	86	89	94	96	100	104	109	113	120	125	
Supply Pressure - psig	Cv	0.028	0.031	0.032	0.033	0.036	0.038	0.039	0.041	0.048	0.059	0.068	0.081	0.088	0.10	0.11	0.12	0.13	0.14	0.15	0.17	0.18	0.20	0.21	0.23	0.25	0.27	0.31	0.34	0.37
	1	3.48	3.83	4.13	4.46	4.60	4.67	4.99	5.36	6.43	8.04	9.40	11.2	12.2	14.2	15.9	16.9	18.5	20.3	21.7	23.5	25.4	28.4	30.1	32.9	35.5	39.6	43.1	47.8	50.1
	5	7.67	8.48	9.09	9.70	10.2	10.6	11.3	12.1	14.2	17.6	20.3	23.9	26.1	30.3	33.8	36.1	39.4	43.1	46.0	51.1	54.9	61.9	65.0	70.8	76.6	84.8	92.1	102	108
	10	10.6	11.8	12.5	13.6	14.4	14.8	15.6	16.8	19.4	24.5	27.1	32.2	35.2	40.7	45.6	48.5	52.9	57.3	61.6	67.9	72.3	81.0	85.5	92.3	102	112	118	135	148
	15	13.1	14.5	15.4	16.7	17.7	18.2	19.1	20.4	23.6	29.7	32.9	39.0	42.6	49.3	55.3	58.8	64.0	69.4	74.5	82.1	87.3	97.8	103	111	123	135	143	163	178
	20	15.3	17.0	18.1	19.6	20.9	21.4	22.5	24.0	27.7	35.0	38.7	45.9	50.1	58.0	65.0	69.0	75.3	81.4	87.3	95.6	102	114	121	130	144	158	167	190	210
	25	17.7	19.6	20.8	22.6	24.0	24.7	25.9	27.6	31.9	40.3	44.6	52.8	57.7	66.7	74.7	79.3	86.4	93.5	100	110	117	131	138	149	164	180	191	219	241
	30	20.0	22.2	23.6	25.6	27.2	28.0	29.4	31.3	36.0	45.6	50.4	59.7	65.2	75.4	84.3	89.5	97.4	105	113	125	132	148	156	168	185	204	216	248	273
	40	24.8	27.4	31.7	31.6	33.6	34.6	36.3	38.7	44.5	56.3	62.2	73.6	80.3	92.7	104	110	120	129	139	153	162	181	191	207	228	251	267	306	337
	50	29.5	32.6	34.8	37.6	40.1	41.3	43.3	46.0	52.9	66.9	74.0	87.4	95.4	110	123	131	142	153	164	181	192	215	227	247	272	299	317	364	401
	60	34.3	38.0	40.6	43.8	46.7	48.1	50.3	53.5	61.5	77.7	85.8	101	110	127	142	151	164	177	189	210	223	250	264	286	315	347	368	42	

Sapphire Orifice Air Flow

O'Keefe Controls Co.

If it's about precision, it's O'Keefe.

SLPM

Orifice Diameter Inches	0.0012	0.0016	0.0020	0.0024	0.0028	0.0031	0.0035	0.0039	0.0043	0.0047	0.0051	0.0055	0.0059	0.0063	0.0067	0.0071	0.0079	0.0087	0.0094	0.0102	0.0110	0.0118	0.0126	0.0134	0.0142	0.0157	0.0173	0.0189	0.0205	0.0213	0.0228	0.0252	
Size Number	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30	32	34	36	40	44	48	52	54	58	64	
C _v	0.000030	0.000053	0.000090	0.00012	0.00017	0.00022	0.00028	0.00035	0.00042	0.00050	0.00061	0.00071	0.00084	0.00094	0.0011	0.0012	0.0015	0.0018	0.0021	0.0024	0.0028	0.0032	0.0036	0.0040	0.0046	0.0057	0.0067	0.0080	0.0091	0.010	0.011	0.013	
Supply Pressure - psig	1	0.003	0.005	0.010	0.014	0.020	0.025	0.034	0.040	0.050	0.058	0.068	0.080	0.095	0.106	0.120	0.139	0.161	0.194	0.259	0.275	0.300	0.340	0.393	0.446	0.499	0.677	0.822	0.965	1.10	1.12	1.38	1.69
	5	0.009	0.013	0.027	0.036	0.047	0.059	0.076	0.093	0.108	0.136	0.159	0.192	0.223	0.256	0.273	0.313	0.350	0.430	0.584	0.623	0.695	0.800	0.933	1.06	1.20	1.51	1.81	2.16	2.50	2.57	3.26	4.06
	10	0.010	0.016	0.036	0.049	0.065	0.082	0.107	0.132	0.164	0.193	0.228	0.264	0.308	0.357	0.382	0.430	0.480	0.590	0.830	0.868	0.968	1.09	1.27	1.45	1.63	2.01	2.43	2.90	3.32	3.45	4.43	5.58
	15	0.014	0.021	0.046	0.062	0.082	0.104	0.134	0.166	0.205	0.240	0.285	0.329	0.386	0.443	0.482	0.535	0.613	0.755	1.05	1.11	1.24	1.42	1.63	1.85	2.09	2.56	3.08	3.69	4.26	4.43	5.55	7.08
	20	0.016	0.025	0.055	0.074	0.099	0.125	0.159	0.197	0.243	0.284	0.337	0.390	0.457	0.525	0.569	0.635	0.730	0.910	1.25	1.32	1.48	1.70	1.95	2.20	2.48	3.04	3.64	4.36	5.06	5.31	6.55	8.33
	25	0.019	0.030	0.063	0.087	0.115	0.144	0.184	0.229	0.280	0.327	0.389	0.450	0.526	0.605	0.654	0.733	0.843	1.05	1.44	1.52	1.70	1.95	2.24	2.52	2.84	3.39	4.19	5.03	5.81	6.11	7.53	9.55
	30	0.022	0.034	0.072	0.098	0.132	0.164	0.208	0.260	0.317	0.370	0.440	0.511	0.595	0.685	0.710	0.838	0.958	1.19	1.63	1.89	2.19	2.52	2.84	3.19	3.66	4.75	5.69	6.57	6.90	8.48	10.7	
	40	0.027	0.043	0.089	0.122	0.163	0.203	0.257	0.321	0.390	0.456	0.543	0.632	0.734	0.845	0.880	1.04	1.18	1.47	2.02	2.11	2.35	2.67	3.07	3.46	3.90	4.89	5.86	7.02	8.10	8.50	10.4	13.1
	50	0.032	0.052	0.106	0.147	0.195	0.241	0.306	0.383	0.463	0.542	0.652	0.753	0.872	1.00	1.05	1.24	1.41	1.75	2.39	2.50	2.78	3.16	3.63	4.08	4.59	5.83	6.96	8.35	9.63	10.1	12.3	15.5
	60	0.037	0.061	0.123	0.171	0.227	0.280	0.356	0.445	0.536	0.630	0.751	0.875	1.01	1.16	1.23	1.45	1.64	2.03	2.77	2.89	3.20	3.63	4.17	4.69	5.29	6.77	8.10	9.69	11.1	11.7	14.2	17.9
	70	0.042	0.070	0.141	0.195	0.259	0.318	0.403	0.507	0.609	0.717	0.855	0.996	1.15	1.32	1.40	1.66	1.87	2.31	3.14	3.28	3.62	4.12	4.72	5.31	5.99	7.71	9.23	11.0	12.7	13.3	20.2	
	80	0.047	0.080	0.158	0.200	0.292	0.357	0.453	0.569	0.683	0.804	0.959	1.12	1.28	1.48	1.57	1.86	2.09	2.59	3.51	3.66	4.04	4.68	5.28	5.93	6.69	8.65	10.4	12.3	14.3	14.8	17.9	22.6
	90	0.053	0.089	0.175	0.244	0.324	0.396	0.502	0.632	0.757	0.891	1.06	1.24	1.42	1.64	1.75	2.06	2.32	2.87	3.89	4.05	4.47	5.07	5.83	6.56	7.41	9.60	11.5	13.7	15.7	16.4	19.7	24.9
	100	0.058	0.098	0.193	0.269	0.356	0.435	0.551	0.692	0.830	0.978	1.17	1.36	1.56	1.80	1.92	2.27	2.55	3.15	4.26	4.44	4.89	5.57	6.38	7.18	8.12	10.6	12.6	15.0	17.2	18.0	21.6	27.3
Vacuum Level In. Hg.	5	0.003	0.006	0.014	0.020	0.028	0.036	0.047	0.057	0.073	0.085	0.100	0.116	0.137	0.156	0.169	0.199	0.229	0.277	0.377	0.401	0.451	0.510	0.591	0.673	0.764	0.982	1.16	1.38	1.61	1.64	2.13	2.61
	10	0.004	0.008	0.018	0.027	0.036	0.046	0.061	0.073	0.093	0.109	0.128	0.149	0.175	0.200	0.217	0.253	0.292	0.352	0.482	0.503	0.556	0.638	0.734	0.833	0.955	1.26	1.51	1.80	2.06	2.11	2.55	3.19
	15	0.006	0.010	0.021	0.030	0.040	0.050	0.065	0.079	0.100	0.117	0.138	0.159	0.188	0.214	0.235	0.269	0.320	0.390	0.525	0.554	0.626	0.711	0.818	0.921	1.07	1.39	1.65	1.99	2.31	2.39	2.77	3.48
	20	0.006	0.010	0.021	0.030	0.040	0.050	0.065	0.079	0.100	0.117	0.138	0.159	0.188	0.214	0.235	0.269	0.320	0.390	0.525	0.554	0.626	0.711	0.818	0.921	1.07	1.39	1.65	1.99	2.31	2.39	2.77	3.48
	30	0.006	0.010	0.021	0.030	0.040	0.050	0.065	0.079	0.100	0.117	0.138	0.159	0.188	0.214	0.235	0.269	0.320	0.390	0.525	0.554	0.626	0.711	0.818	0.921	1.07	1.39	1.65	1.99	2.31	2.39	2.77	3.48

SCFH

Orifice Diameter Inches	0.0012	0.0016	0.0020	0.0024	0.0028	0.0031	0.0035	0.0039	0.0043	0.0047	0.0051	0.0055	0.0059	0.0063	0.0067	0.0071	0.0079	0.0087	0.0094	0.0102	0.0110	0.0118	0.0126	0.0134	0.0142	0.0157	0.0173	0.0189	0.0205	0.0213	0.0228	0.0252			
Size Number	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30	32	34	36	40	44	48	52	54	58	64			
Supply Pressure - psig	1	0.007	0.011	0.021	0.030	0.042	0.053	0.072	0.085	0.106	0.123	0.144	0.169	0.201	0.225	0.254	0.294	0.341	0.411	0.549	0.583	0.636	0.720	0.833	0.945	1.06	1.43	1.74	2.04	2.33	2.37	2.92	3.58		
	5	0.019	0.027	0.056	0.075	0.100	0.124	0.161	0.197	0.228	0.288	0.337	0.407	0.471	0.542	0.577	0.663	0.740	0.911	1.24	1.32	1.47	1.70	1.98	2.25	2.53	3.20	3.83	4.58	5.30	5.44	6.90	8.60		
	10	0.021	0.034	0.076	0.104	0.138	0.174	0.227	0.280	0.347	0.409	0.483	0.559	0.653	0.756	0.809	0.911	1.02	1.25	1.76	1.84	2.05	2.31	2.69	3.07	3.45	4.26	5.15	6.14	7.03	7.31	9.39	11.8		
	15	0.030	0.044	0.097	0.131	0.174	0.220	0.284	0.352	0.434	0.508	0.604	0.697	0.818	0.939	1.02	1.13	1.30	1.60	2.22	2.35	2.63	3.01	3.45	3.92	4.43	5.42	6.53	7.82	9.03	9.39	11.8	15.6		
	20	0.034	0.053	0.117	0.157	0.210	0.265	0.337	0.417	0.515	0.602	0.714	0.826	0.968	1.11	1.21	1.35	1.55	1.93	2.65	2.80	3.14	3.60	4.13	4.75	5.34	6.02	6.76	8.39	10.1	12.1	13.9	14.6	18.0	22.7
	25	0.040	0.064	0.133	0.184	0.244	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	3.05	3.22	3.60	4.13	4.75	5.34	6.02									