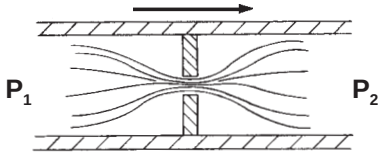
# Choked Flow of Gases

TUTORIAL

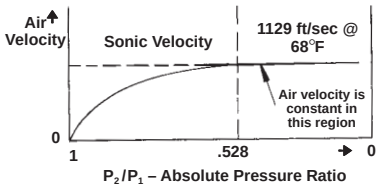
## The Basic Concept

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 absolute 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 $P_2/P_1 \leq .528$.*

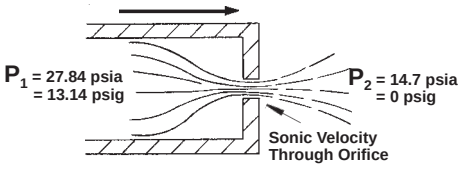



*The air flow velocity is limited once the absolute pressure ratio is ≤ .528.*

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. $P_2/P_1 \leq .528$. 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 velocity of the air flowing through the orifice.




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

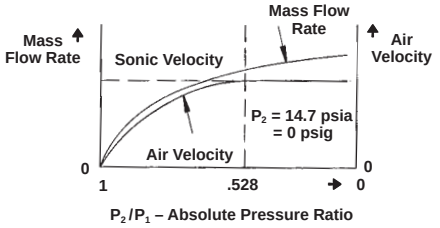
## Consider all the Factors!

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

Q (flow) is a function of
- Velocity
- Density
- Orifice Area

When the air velocity reaches sonic velocity ($P_2/P_1 \leq .528$) further increases in $P_1$ (upstream pressure) do not cause any further increase in the air velocity through the orifice. Consequently it is wrongly concluded 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 ($P_1$).

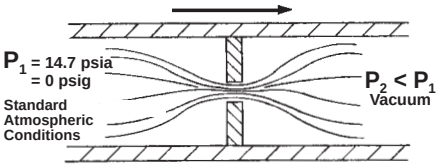



*Even though the air velocity through the orifice is limited to the speed of sound, the mass flow rate continues to increase as the absolute pressure ($P_1$) increases.*

## What is Choked?

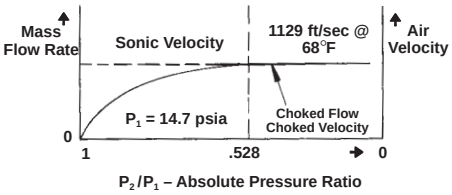
The parameter that becomes "choked" or "limited" is the velocity of the air. It is more accurate to use the term "choked velocity" rather than "choked flow" when the absolute pressure ratio of air through an orifice is ≤ .528.

## 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 fixed 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 Velocity Conditions – Air Flow**

| Inlet Pressure | | Outlet Pressure For Sonic Velocity | |
|---|---|---|---|
| Gage Pressure psig | Absolute Pressure psia | Absolute Pressure psia | Gage Pressure 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

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# Metal Orifice Air Flow – SCFH

| 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 |
| Choked Flow | 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** |
| 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 |
| 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 |
| | 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 | 672 | 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 | 763 | 839 | 892 | 1021 | 1125 |
| | 80 | 93 | 103 | 110 | 119 | 127 | 131 | 137 | 145 | 167 | 210 | 231 | 273 | 298 | 343 | 384 | 405 | 443 | 481 | 513 | 570 | 604 | 678 | 716 | 778 | 856 | 943 | 1000 | 1146 | 1263 |
| | 90 | 106 | 115 | 122 | 132 | 141 | 146 | 151 | 161 | 185 | 231 | 256 | 303 | 331 | 379 | 424 | 447 | 489 | 532 | 568 | 631 | 670 | 750 | 792 | 860 | 947 | 1042 | 1106 | 1267 | 1398 |
| | 100 | 114 | 126 | 135 | 146 | 156 | 164 | 167 | 177 | 203 | 254 | 282 | 331 | 362 | 415 | 468 | 496 | 540 | 587 | 627 | 697 | 739 | 831 | 875 | 951 | 1047 | 1153 | 1225 | 1403 | 1545 |
| Vacuum Level In. Hg. | 5 | 10.4 | 11.4 | 12.3 | 13.3 | 14.3 | 14.5 | 15.4 | 16.3 | 19.2 | 23.9 | 26.4 | 31.4 | 36.2 | 42.4 | 47.7 | 50.6 | 55.1 | 60.0 | 64.0 | 70.3 | 76.1 | 84.9 | 88.6 | 96.1 | 104 | 114 | 123 | 138 | 150 |
| | 10 | 13.1 | 14.4 | 15.4 | 16.6 | 17.6 | 18.0 | 19.2 | 20.3 | 23.6 | 29.4 | 32.7 | 38.6 | 44.9 | 51.7 | 57.6 | 63.4 | 68.9 | 74.8 | 79.9 | 87.9 | 94.9 | 106 | 110 | 120 | 130 | 142 | 153 | 173 | 187 |
| Choked Flow | 15 | 13.8 | 15.2 | 16.2 | 17.4 | 18.3 | 18.8 | 20.0 | 21.1 | 24.5 | 30.5 | 33.7 | 39.4 | 46.8 | 54.0 | 60.2 | 66.1 | 71.8 | 78.0 | 83.5 | 91.7 | 99.0 | 110 | 115 | 125 | 135 | 148 | 160 | 180 | 195 |
| | 20 | 13.8 | 15.2 | 16.2 | 17.4 | 18.3 | 18.8 | 20.0 | 21.1 | 24.5 | 30.5 | 33.7 | 39.4 | 46.8 | 54.0 | 60.2 | 66.1 | 71.8 | 78.0 | 83.5 | 91.7 | 99.0 | 110 | 115 | 125 | 135 | 148 | 160 | 180 | 195 |
| | 30 | 13.8 | 15.2 | 16.2 | 17.4 | 18.3 | 18.8 | 20.0 | 21.1 | 24.5 | 30.5 | 33.7 | 39.4 | 46.8 | 54.0 | 60.2 | 66.1 | 71.8 | 78.0 | 83.5 | 91.7 | 99.0 | 110 | 115 | 125 | 135 | 148 | 160 | 180 | 195 |

Standard Conditions 70°F, 14.7 psia are

SCFH – Standard Cu. Ft. Per Hour

SLPM – Standard Liters Per Minute

Above data obtained with Type B restrictor. Flow rates for other metal restrictors essentially the same as for Type B. Above data supercedes previous publications.

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# Metal Orifice Air Flow – SLPM

| | 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 (Choked Flow) | 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 (Choked Flow) | 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 (Choked Flow) | 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** |
| | 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 |
| Supply Pressure – psig | 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 | 422 | 465 |
| | 70 | 39.2 | 43.3 | 46.3 | 50.0 | 53.3 | 55.0 | 57.4 | 61.0 | 70.0 | 88.4 | 97.6 | 115 | 126 | 145 | 162 | 171 | 186 | 202 | 216 | 240 | 254 | 285 | 301 | 327 | 360 | 396 | 421 | 482 | 531 |
| | 80 | 44.0 | 48.7 | 52.1 | 56.2 | 60.0 | 61.9 | 64.5 | 68.5 | 78.6 | 99.1 | 109 | 129 | 141 | 162 | 181 | 191 | 209 | 227 | 242 | 269 | 285 | 320 | 338 | 367 | 404 | 445 | 472 | 541 | 596 |
| | 90 | 50.0 | 54.2 | 57.8 | 62.4 | 66.7 | 68.9 | 71.5 | 76.0 | 87.2 | 109 | 121 | 143 | 156 | 179 | 200 | 211 | 231 | 251 | 268 | 298 | 316 | 354 | 374 | 406 | 447 | 492 | 522 | 598 | 660 |
| | 100 | 53.9 | 59.6 | 63.7 | 68.7 | 73.5 | 77.3 | 78.6 | 83.5 | 95.8 | 120 | 133 | 156 | 171 | 196 | 221 | 234 | 255 | 277 | 296 | 329 | 349 | 392 | 413 | 449 | 494 | 544 | 578 | 662 | 729 |
| Vacuum Level In. Hg. | 5 | 4.92 | 5.40 | 5.81 | 6.29 | 6.76 | 6.82 | 7.29 | 7.67 | 9.08 | 11.3 | 12.4 | 14.8 | 17.1 | 20.0 | 22.5 | 23.9 | 26.0 | 28.3 | 30.2 | 33.2 | 35.9 | 40.1 | 41.8 | 45.3 | 49.0 | 53.9 | 57.9 | 65.3 | 70.9 |
| | 10 | 6.18 | 6.78 | 7.29 | 7.85 | 8.31 | 8.50 | 9.08 | 9.58 | 11.1 | 13.9 | 15.4 | 18.2 | 21.2 | 24.4 | 27.2 | 29.9 | 32.5 | 35.3 | 37.7 | 41.5 | 44.8 | 50.0 | 52.1 | 56.6 | 61.2 | 67.2 | 72.2 | 81.4 | 88.4 |
| | 15 (Choked Flow) | 6.50 | 7.17 | 7.63 | 8.22 | 8.66 | 8.87 | 9.46 | 10.0 | 11.6 | 14.4 | 15.9 | 18.6 | 22.1 | 25.5 | 28.4 | 31.2 | 33.9 | 36.8 | 39.4 | 43.3 | 46.7 | 52.1 | 54.4 | 59.0 | 63.8 | 70.1 | 75.3 | 84.9 | 92.2 |
| | 20 (Choked Flow) | 6.50 | 7.17 | 7.63 | 8.22 | 8.66 | 8.87 | 9.46 | 10.0 | 11.6 | 14.4 | 15.9 | 18.6 | 22.1 | 25.5 | 28.4 | 31.2 | 33.9 | 36.8 | 39.4 | 43.3 | 46.7 | 52.1 | 54.4 | 59.0 | 63.8 | 70.1 | 75.3 | 84.9 | 92.2 |
| | 30 (Choked Flow) | 6.50 | 7.17 | 7.63 | 8.22 | 8.66 | 8.87 | 9.46 | 10.0 | 11.6 | 14.4 | 15.9 | 18.6 | 22.1 | 25.5 | 28.4 | 31.2 | 33.9 | 36.8 | 39.4 | 43.3 | 46.7 | 52.1 | 54.4 | 59.0 | 63.8 | 70.1 | 75.3 | 84.9 | 92.2 |

Standard Conditions 70°F, 14.7 psia are

SCFH – Standard Cu. Ft. Per Hour

SLPM – Standard Liters Per Minute

Above data obtained with Type B restrictor. Flow rates for other metal restrictors essentially the same as for Type B. Above data supercedes previous publications.



O'Keefe Controls Co.

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# Sapphire Orifice Air Flow – 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 | 3.50 | 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 | 1.69 | 1.91 | 2.19 | 2.52 | 2.84 | 3.19 | 3.96 | 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 | 16.0 | 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 |
| Choked Flow | 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 |

# Sapphire Orifice Air Flow – 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 |
| $C_v$ | | 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 | 0.007 | 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 | 15.0 |
| | 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 | 4.66 | 5.25 | 6.44 | 7.71 | 9.24 | 10.7 | 11.3 | 13.9 | 17.6 |
| | 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 | 7.42 | 8.88 | 10.7 | 12.3 | 12.9 | 16.0 | 20.2 |
| | 30 | 0.046 | 0.072 | 0.152 | 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 | 3.58 | 4.05 | 4.64 | 5.34 | 6.02 | 6.76 | 8.39 | 10.1 | 12.1 | 13.9 | 14.6 | 18.0 | 22.7 |
| | 40 | 0.057 | 0.091 | 0.189 | 0.258 | 0.345 | 0.430 | 0.544 | 0.680 | 0.826 | 0.966 | 1.15 | 1.34 | 1.56 | 1.79 | 1.86 | 2.20 | 2.50 | 3.11 | 4.28 | 4.47 | 4.98 | 5.66 | 6.50 | 7.33 | 8.26 | 10.4 | 12.4 | 14.9 | 17.2 | 18.0 | 22.0 | 27.8 |
| | 50 | 0.068 | 0.110 | 0.225 | 0.311 | 0.413 | 0.511 | 0.648 | 0.811 | 0.981 | 1.15 | 1.38 | 1.60 | 1.85 | 2.13 | 2.22 | 2.63 | 2.99 | 3.71 | 5.06 | 5.30 | 5.89 | 6.69 | 7.69 | 8.64 | 9.72 | 12.4 | 14.7 | 17.7 | 20.4 | 21.4 | 26.1 | 32.8 |
| | 60 | 0.079 | 0.129 | 0.261 | 0.362 | 0.481 | 0.593 | 0.754 | 0.943 | 1.14 | 1.33 | 1.59 | 1.85 | 2.14 | 2.46 | 2.61 | 3.07 | 3.47 | 4.30 | 5.87 | 6.12 | 6.78 | 7.69 | 8.83 | 9.94 | 11.2 | 14.3 | 17.2 | 20.5 | 23.5 | 24.8 | 30.1 | 37.9 |
| | 70 | 0.089 | 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 | 6.95 | 7.67 | 8.73 | 10.0 | 11.3 | 12.7 | 16.3 | 19.6 | 23.3 | 26.9 | 28.2 | 33.9 | 42.8 |
| | 80 | 0.100 | 0.168 | 0.335 | 0.424 | 0.619 | 0.756 | 0.960 | 1.21 | 1.45 | 1.70 | 2.03 | 2.37 | 2.72 | 3.13 | 3.33 | 3.94 | 4.43 | 5.49 | 7.44 | 7.75 | 8.56 | 9.75 | 11.2 | 12.6 | 14.2 | 18.3 | 22.0 | 26.1 | 30.3 | 31.4 | 37.9 | 47.9 |
| | 90 | 0.111 | 0.188 | 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 | 8.58 | 9.47 | 10.7 | 12.4 | 13.9 | 15.7 | 20.3 | 24.4 | 29.0 | 33.3 | 34.7 | 41.7 | 52.8 |
| | 100 | 0.122 | 0.208 | 0.409 | 0.570 | 0.754 | 0.922 | 1.17 | 1.47 | 1.76 | 2.07 | 2.47 | 2.88 | 3.30 | 3.81 | 4.07 | 4.81 | 5.40 | 6.67 | 9.03 | 9.41 | 10.4 | 11.8 | 13.5 | 15.2 | 17.2 | 22.5 | 26.7 | 31.8 | 36.4 | 38.1 | 45.8 | 57.8 |
| Vacuum Level In. Hg. | 5 | 0.007 | 0.013 | 0.029 | 0.043 | 0.059 | 0.076 | 0.100 | 0.121 | 0.154 | 0.180 | 0.212 | 0.246 | 0.290 | 0.331 | 0.358 | 0.422 | 0.485 | 0.587 | 0.799 | 0.850 | 0.956 | 1.08 | 1.25 | 1.43 | 1.62 | 2.08 | 2.46 | 2.92 | 3.41 | 3.47 | 4.51 | 5.53 |
| | 10 | 0.009 | 0.018 | 0.039 | 0.057 | 0.076 | 0.098 | 0.128 | 0.155 | 0.197 | 0.231 | 0.271 | 0.316 | 0.371 | 0.424 | 0.460 | 0.536 | 0.619 | 0.746 | 1.02 | 1.07 | 1.18 | 1.35 | 1.56 | 1.76 | 2.02 | 2.67 | 3.19 | 3.81 | 4.36 | 4.47 | 5.40 | 6.76 |
| Choked Flow | 15 | 0.012 | 0.020 | 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 | 0.826 | 1.11 | 1.17 | 1.33 | 1.51 | 1.73 | 1.95 | 2.26 | 2.95 | 3.50 | 4.22 | 4.89 | 5.06 | 5.87 | 7.37 |
| | 20 | 0.012 | 0.020 | 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 | 0.826 | 1.11 | 1.17 | 1.33 | 1.51 | 1.73 | 1.95 | 2.26 | 2.95 | 3.50 | 4.22 | 4.89 | 5.06 | 5.87 | 7.37 |
| | 30 | 0.012 | 0.020 | 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 | 0.826 | 1.11 | 1.17 | 1.33 | 1.51 | 1.73 | 1.95 | 2.26 | 2.95 | 3.50 | 4.22 | 4.89 | 5.06 | 5.87 | 7.37 |

Standard Conditions 70°F, 14.7 psia

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

Above data obtained with Type S restrictor. Flow rates for Type A, BTF, BWF, F, J, L, P, and SF restrictors are essentially the same as for Type S.
Above data supercedes previous publications.

O'Keefe Controls Co.

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