RM&C
for good measure

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Temperature • Pressure • Flow • Level • Calibration and Repair

Variable Area Flowmeter Sizing

To select the proper size Variable Area flowmeter for a specific application - liquid or gas service, it is necessary to convert the flow to be measured to an equivalent air or water flowrate. The nearest standard range VA flowmeter can then be found in the RM&C flow catalogue.

Sizing For Liquids

For Volumetric Flow at Standard Reference Condition of 20°C

Definition of Sizing Factor (K)

· Water equivalent flowrate Q_1 = Sizing Factor (K) x max flow Liquid Q_2 i.e. $Q1 = K \times Q_2$

· Max Flow liquid $Q_2 = \frac{Q_1 \text{ (water equiv. flow)}}{K \text{ (sizing factor)}}$ Sizing Factor $K = \sqrt{\frac{6.96 \times X_2}{7.96 - X_2}}$

Where X_2 = Liquid density at working conditions (g/cm3)

Example 1.

To establish water equivalent flowrate and tube float combination for:

1.5 L/min paraffin, working density 0.80 g/cm3

- Sizing factor (K) $= \sqrt{\frac{6.96 \times 0.80}{7.96 - 0.80} = 0.882}$
- Water equivalent Q1 = 0.882 x 1.5 = 1.323 L/min
- Nearest standard range = 200 to 1500 cm3/min using GTF 2ASS Tube & Float
- Equivalent paraffin flowrate = $\frac{200 \text{ (min)}}{0.882}$ to $\frac{1500 \text{ (max)}}{0.882}$

i.e 227 to 1700 cm^3/min paraffin

- Select meter type from VA Flowmeter section of catalogue.
- The flowmeter can then be supplied calibrated for 0.2 to 1.7 L/min of paraffin.

Liquid Density Corrections For VA Flowmeters

Liquid density (g/cm3)	For Volumetric units (e.g. L/min) multiply scale reading of water flow rate (in same units) by factor:	For Gravimetric units (e.g. g/min) multiply scale reading of water flow rate (in same units) by factor:
0.60	1.328	0.797
0.65	1.271	0.826
0.70	1.221	0.855
0.75	1.175	0.881
0.80	1.134	0.907
0.85	1.096	0.932
0.90	1.062	0.955
0.95	1.030	0.978
1.00	1.000	1.000
1.05	0.972	1.021
1.10	0.947	1.041
1.15	0.922	1.061
1.20	0.900	1.080
1.25	0.878	1.098
1.30	0.858	1.115
1.35	0.839	1.132
1.40	0.821	1.149
1.45	0.803	1.165
1.50	0.787	1.180
1.55	0.771	1.195
1.60	0.756	1.209
1.65	0.741	1.223
1.70	0.727	1.237
1.75	0.714	1.250
1.80	0.701	1.262
1.85	0.689	1.274
1.90	0.677	1.286
1.95	0.665	1.298
2.00	0.654	1.309

Sizes for Gases

For Volumetric Flow At Standard Reference Conditions Of 20°C And 1.013 bar abs. (ATP)

Definition of Sizing Factor (K)

· Air equivalent flowrate (F1) = Sizing factor (K) x Max gas flow (F2)

Note: F2 MUST BE EXPRESSED IN FREE VOLUMES OF GAS (ie MEASURED AT ATP)

Sizing factor (K) $= \sqrt{r \times \frac{T_2}{P_2} \times \frac{1.013}{293}}$

Where: r = Relative density of gas to be measured
P_2 = Absolute operating pressure (bar)
T_2 = Gas temperature (kelvin)

Example 2

To establish equivalent air flowrate and suitable tube and float combination for 15 l/min acetylene (free volume measured at ATP) working at 5 barg and 40°C.

$P_2 = 1.013 + 5 = 6.013$ bar Abs, $T_2 = 273 + 40 = 313$ K, r = 0.898 (from reference table)

- Sizing factor (K) $= \sqrt{0.898 \times \frac{313}{6.013} \times \frac{1.013}{293}} = 0.402$
- Equivalent Air Flow F1 = 15 x 0.402 = 6.03 L/min
- Nearest standard range = 1 to 10 L/min Air tube for G Series Flowmeter, GTF 2BHS Tube & Float.
- Equivalent Acetylene Flowrate = $\frac{1 \text{(min)}}{0.402}$ to $\frac{10 \text{ (max)}}{0.402}$ = 2.29 to 24.88 L/min
- Select meter type from VA Flowmeter section of catalogue
- The flowmeter can then be supplied calibrated for 2 to 25 L/min of acetylene at 40°C and 5 bar G

Mass + Volume

To convert	into	multiply by	Reciprocal
Imp. Gallons	Litres	4.5460	0.21997
U.S. Gallons	Litres	3.7854	0.26417
Imp. Pint	Litres	0.56826	1.7598
Cubic feet	Litres	28.316	0.035315
Cubic Centimetre	Millilitres	0.999973	1.000027
Cubic Inch	Millilitres	16.387	0.061024
Imp. fluid ounce	Millilitres	28.413	0.035195
Cubic Metre	Litres	1000	0.001
Pound	Kilogrammes	0.45359	2.2046
Ounce	Kilogrammes	0.028349	35.274
Imp. Ton	Tonne	1.01605	0.98421

Pressure

To convert	into	multiply by	Reciprocal
inch H2O	millibar	2.491	0.4015
psi	millibar	68.95	0.014504
inch Hg	millibar	33.86	0.02953
KPa (KN/m2)	millibar	10	0.1
Atm	bar	1.0132	0.9869
Kg/cm2	bar	0.9807	1.0197
Kg/cm2	psi	14.22	0.07031
psi	Atm	0.06805	14.696
psi	inch H2O	27.68	0.03613
N/cm2	KPa (KN/m2)	10	0.1

Ingress Protection (IP) Codes *(IEC/EN 60529)*

First Numeral SOLID BODIES	Second Numeral LIQUIDS	
No protection	0	0 No protection
Objects greater than 50mm	1	1 Vertically dripping water
Objects greater than 12mm	2	2 Angled dripping water -75° to 90°
Objects greater than 2.5mm	3	3 Sprayed water
Objects greater than 1.0mm	4	4 Splashed water
Dust-protected	5	5 Water jets
Dust-tight	6	6 Heavy seas
		7 Effects of immersion
		8 Indefinite immersion

Example: IP65 equipment is dust-tight and protected against water jets

Flowrates

To convert	into	multiply by	Reciprocal
Imp. Gal/hr	L/min	0.07577	13.20
U.S. Gal/hr	L/min	0.06308	15.85
Cu. Ft/hr	L/min	0.4719	2.119
Imp. Pint/hr	ml/min	9.471	0.1056
Barrels/hr	m3/hr	0.1637	6.110
Imp. Fluid Oz/hr	ml/min	0.4735	2.112
Pounds/hr	g/min	7.560	0.1323
Imp. Gal/min	m3/hr	0.2728	3.666
U.S. Gal/min	m3/hr	0.2271	4.403
Cu. Ft/min	m3/hr	1.699	0.5886
Pounds/min	kg/hr	27.22	0.03674
Litres/min	m3/hr	0.06	16.67
Litres/sec	m3/hr	3.6	0.278

Gas Density Corrections For VA Flowmeters

Flowmeter scales can be infinite in variety due to the differing physical properties of gases and their operating conditions. Standard tubes for gases are calibrated for atmospheric pressure at the flowmeter outlet. If the working outlet pressure (P) is different, the scale reading (expressed at ATP) should be corrected by using the formulae:-

Actual flow rate (@ATP) $= \sqrt{\frac{P \text{ (Bar Abs.)}}{1.013}} \times$ Scale reading

Actual flow rate (@ working pressure P) $= \sqrt{\frac{1.013}{P \text{ (Bar Abs.)}}} \times$ Scale reading

Notes:
1. Density and pressure correction factors should not be applied to the lowest flowrate tubes (Frame Size 1) - consult RM&C sales.
2. Tubes with scales for different operating pressures and calibration conditions are available to order.

To convert ATP air flow rates to ATP flow rates of the selected gas, divide by sizing factor K:

Gas	Chemical Formula	Relative Density (Air = I)	Sizing Factor K
Acetylene	C_2H_2	0.898	0.948
Ammonia	NH_3	0.588	0.767
Argon	A	1.380	1.175
Butane	C_4H_{10}	2.007	1.417
Carbon Dioxide	CO_2	1.520	1.233
Carbon Monoxide	CO	0.967	0.983
Chlorine	CL_2	2.450	1.565
Cyclopropane	C_3H_6	1.453	1.205
Ethane	C_2H_6	1.038	1.019
Ethylene	C_2H_4	0.968	0.984
Helium	He	0.138	0.371
Hydrogen	H_2	0.0695	0.264
Hydrogen Chloride	HCL	1.259	1.122
Hydrogen Sulphide	H_2S	1.177	1.085
Methane	CH_4	0.554	0.744
Neon	Ne	0.697	0.835
Nitrogen	N_2	0.968	0.984
Nitrus Oxide	N_2O	1.520	1.233
Oxygen	O_2	1.105	1.051
Propane	C_3H_8	1.522	1.234
Sulphur Dioxide	SO_2	2.210	1.487

Notes:
1. RM&C standards express gas volumes at 1.013 bar absolute and 20°C (ATP).
2. Density of air at 1 atmosphere and 20°C = 1.204 g/l.

Temperature

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-40	-40.0	0	32.0	30	86.0	100	212	250	482	400	752	1000	1832
-38	-36.4	1	33.8	31	87.8	105	221	255	491	405	761	1050	1922
-36	-32.8	2	35.6	32	89.6	11å0	230	260	500	410	770	1100	2012
-34	-29.2	3	37.4	33	91.4	115	239	265	509	415	779	1150	2102
-32	-25.6	4	39.2	34	93.2	120	248	270	518	420	788	1200	2192
-30	-22.0	5	41.0	35	95.0	125	257	275	527	425	797	1250	2282
-28	-18.4	6	42.8	36	96.8	130	266	280	536	430	806	1300	2372
-26	-14.8	7	44.6	37	98.6	135	275	285	545	435	815	1350	2462
-24	-11.2	8	46.4	38	100.4	140	284	290	554	440	824	1400	2552
-22	-7.6	9	48.2	39	102.2	145	293	295	563	445	833	1450	2642
-20	-4.0	10	50.0	40	104.0	150	302	300	572	450	842	1500	2732
-19	-2.2	11	51.8	41	105.8	155	311	305	581	455	851	1550	2822
-18	-0.4	12	53.6	42	107.6	160	320	310	590	460	860	1600	2912
-17	1.4	13	55.4	43	109.4	165	329	315	599	465	869	1650	3002
-16	3.2	14	57.2	44	111.2	170	338	320	608	470	878	1700	3092
-15	5.0	15	59.0	45	113.0	175	347	325	617	475	887	1750	3182
-14	6.8	16	60.8	46	114.8	180	356	330	626	480	896	1800	3272
-13	8.6	17	62.6	47	116.6	185	365	335	635	485	905	1850	3362
-12	10.4	18	64.4	48	118.4	190	374	340	644	490	914	1900	3452
-11	12.2	19	66.2	49	120.2	195	383	345	653	495	923	1950	3542
-10	14.0	20	68.0	50	122.0	200	392	350	662	500	932	2000	3632
-9	15.8	21	69.8	55	131.0	205	401	355	671	550	1022	2050	3722
-8	17.6	22	71.6	60	140.0	210	410	360	680	600	1112	2100	3812
-7	19.4	23	73.4	65	149.0	215	419	365	689	650	1202	2150	3902
-6	21.2	24	75.2	70	158.0	220	428	370	698	700	1292	2200	3992
-5	23.0	25	77.0	75	167.0	225	437	375	707	750	1382	2250	4082
-4	24.8	26	78.8	80	176.0	230	446	380	716	800	1472	2300	4172
-3	26.6	27	80.6	85	185.0	235	455	385	725	850	1562	2350	4262
-2	28.4	28	82.4	90	194.0	240	464	390	734	900	1652	2400	4352
-1	30.2	29	84.2	95	203.0	245	473	395	743	950	1742	2450	4442

$°C = \frac{(°F - 32)}{1.8}$ $°F = 1.8°C + 32$

Thermocouple Guide

Type	Useful operating range	Maximum T/C grade range	EMF over maximum range	Standard limits of error	UK	USA	IEC 584-3
E	T/C grade -200 to 900°C Ext grade 0 to 200°C	-270 to 1000°C	-9.835 to 76.373mV	1.7°C or 0.5% whichever is greater			
J	T/C grade 0 to 750°C Ext grade 0 to 200°C	-210 to 1200°C	-8.095 to 69.553mV	2.2°C or 0.75% whichever is greater			
K	T/C grade -200 to1250°C Ext grade 0 to 200°C	-270 to 1372°C	-6.458 to 54.886mV	2.2°C or 0.75% whichever is greater			
N	T/C grade -270 to 1300°C Ext grade 0 to 200°C	-270 to 1300°C	-4.345 to 47.513mV	2.2°C or 0.75% whichever is greater			
T	T/C grade -250 to 350°C Ext grade -60 to 100°C	-270 to 400°C	-6.258 to 20.872mV	1.0°C or 0.75% whichever is greater			
U	Ext grade 0 to 50°C						
V	Ext grade 0 to 80°C						

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