

Planning a Flow Gas Experiment

Planning an experiment involving a gas flowing in a sample tube should include the selection of the best gas velocity, direction of flow, tube diameter, tube length and pan diameter. Each of these factors may affect the sample reaction time or noise level or both.

First, consider gas velocity. Obviously, the needed velocity depends upon the sample. 10 to 50 cm/mm is usually enough velocity to purge gases evolved from most samples or to deliver needed reactive gases to the sample. Keep the velocity as low as possible to reduce possible loss of sample from the pan and to reduce aerodynamic noise. Be careful of velocities above 100 cm/mm, though we have some Thermo Scientific papers with flow velocities much higher.

Though the term velocity (cm/min) is used when discussing gas flow in a sample tube, flow meters are calibrated in volume (cc/mm). Table 1 allows the conversion from volume to velocity. Example: a gas volume of 100 cc/min in a 19 mm tube will have a velocity of 35 cm/mm past the sample. Also note that there can be different velocities in different sections of the system (see Fig. 1). The small diameter tube in the condensing jacket restricts the vapors from entering the balance chamber. The velocity of the gas in this section would be very high. However, the same volume of gas would have a low velocity in the body of the wider sample tube.

Generally, higher gas velocities require longer sample tubes to produce a noiseless, streamlined gas flow. Longer tubes are also called for when using a furnace in order to keep the heat source away from the balance chamber. A furnace also affects gas velocity. As the temperature increases, the gas velocity will increase due to

the thermal expansion of the gas. This expansion can cause some back pressure which can slightly reduce the input flow volume. Table 2 is useful in estimating the heated gas velocities, assuming constant input flow volume. Example: a gas flowing at 25 cm/mm at 20 °C will flow at 33.5 cm/min at 120 °C.

Pan and sample tube diameters are also very critical in Figure 1: Different Velocities in Sample Tube containing the noise level. The cross sectional area of the pan should not be more than one-third the cross sectional area of the sample tube (see Fig. 2). Larger pan ratios produce much more noise and can start causing a "piston" effect in the tube. However, to hold the noise to the

minimum level, use the smallest sample tube and pan combination possible. Besides less noise, a small diameter tube will allow better temperature control of the sample, less temperature gradients in the sample and requires less reactive or purge gas. A 9 mm pan in a 16 mm tube will produce very little noise, even with gas velocities near 100 cm/min.

Another reason for using a small pan is to reduce the "drag" or apparent weight change due to the flowing gas. A 5 mm diameter sample pan in a 25 cm/mm ambient air flow will show less than 1 mg drag. The drag will be steady and repeatable as long as the gas flow is steady and repeatable. As the gas temperature rises, the flow velocity will increase, but the

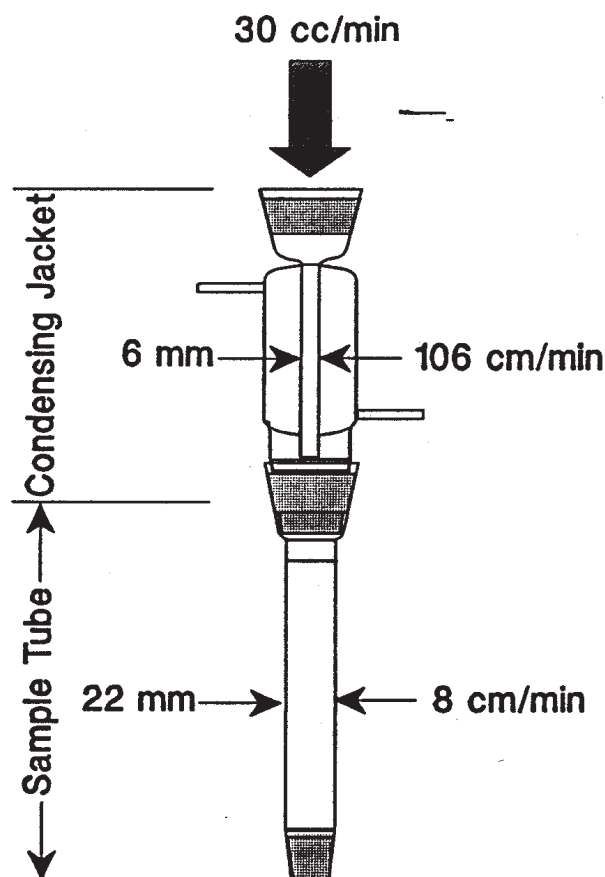
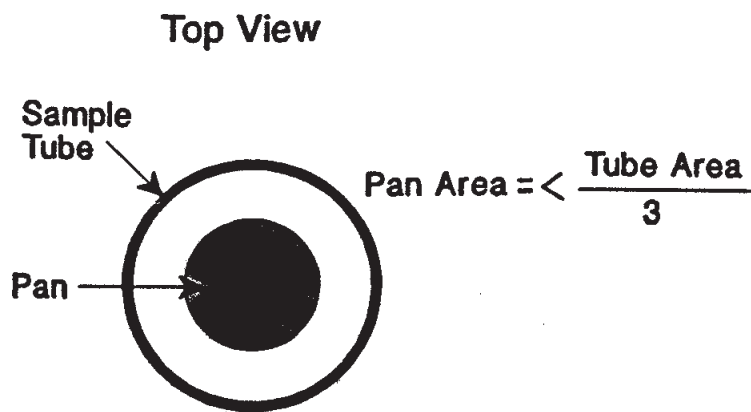


Figure 1: Different Velocities in Sample Tube

gas density will decrease. The two effects cancel out each other at temperatures under 150 °C, but the drag will increase as the temperature continues to rise above 150 °C. The value of the drag is very dependent upon the shape of the pan, with semispherical bottom pans producing less drag than flat bottom pans. All of the above assumes that the pan is less than one-third the cross sectional area of the tube. At larger ratios, the drag will increase rapidly.

The direction of gas flow is also an important consideration. Normally, the gas should enter the side port at the top of the sample tube and flow down past the sample (see Fig. 3A). This direction gives the best aerodynamic results as the streamlined flow would be at the bottom of the tube where you would normally place the sample and furnace. Downward flow also allows you to use higher flow velocities. If you are using a reactive gas, however, you will also be using a purge gas from the balance chamber. A downward flow would then be a mixture of both the reactive and purge gases. In many cases, the mixing of the two gases is acceptable.

Figure 2: Cross Sectional Areas



Sometimes, a pure reactive gas flowing past the sample is needed. In this situation, flow the reactive gas up the tube see Fig. 3B). The purge gas protecting the balance flows down and both gases exit through the side port of the sample tube. To further protect the balance, place a baffle (disk with a small hole) in the balance chamber port. With the gas flowing up the sample tube, the streamlined flow, and sample, will be near the top of the tube. This arrangement would require using a

furnace close to the balance chamber which could cause a temperature drift in the balance. This arrangement also limits the flow velocity to prevent the sample pan being lifted off the extension wire.

These are the basic factors to be considered when designing your system. If you have any questions, please call upon us.

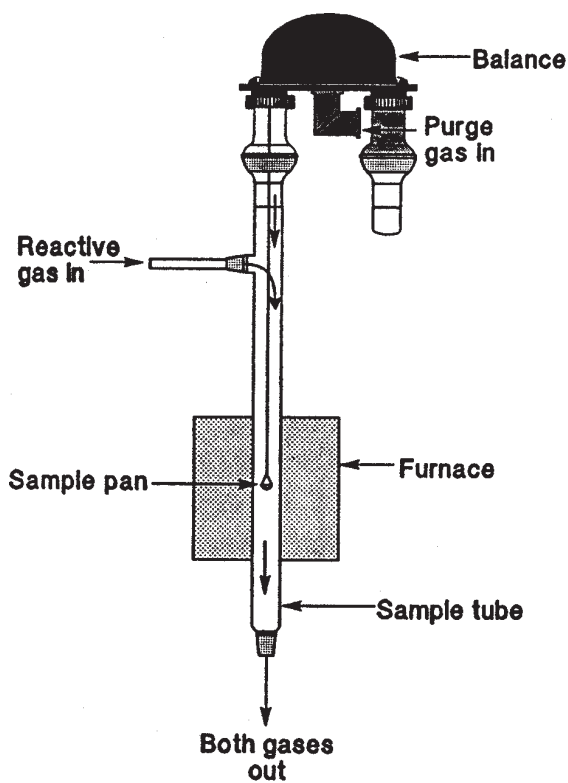


Figure 3A: Downward Gas Flow

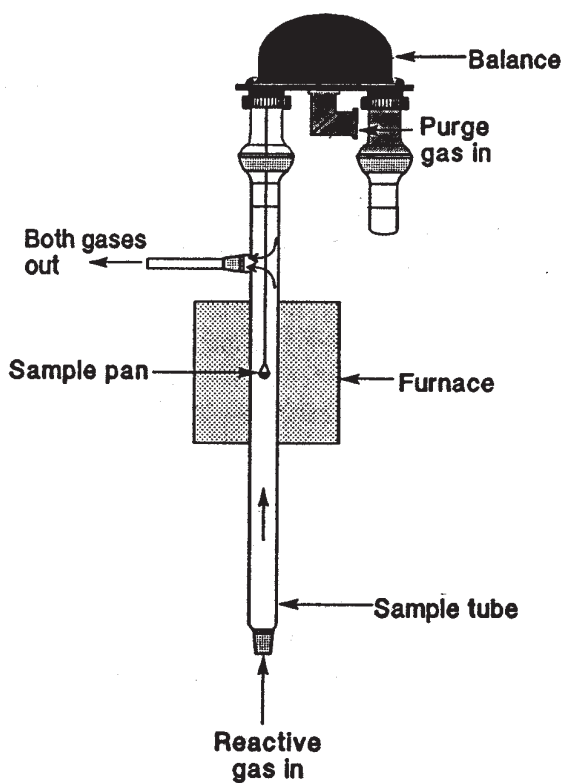


Figure 3B: Upward Gas Flow

Gas Volume to velocity

Gas Volume	Sample Tube I.D. (mm)										
	6	8	16	18	19	22	35	41	45	48	54
2	7	4	1	1	1	1	0.2	0.2	0.1	0.1	0.1
4	14	8	2	2	1	1	0.4	0.3	0.3	0.2	0.2
7	25	14	3	3	2	2	0.7	0.5	0.4	0.4	0.3
10	35	20	5	4	4	3	1	0.8	0.6	0.6	0.4
15	53	30	7	6	5	4	2	1	0.9	0.8	0.7
20	71	40	10	8	7	5	2	2	1	1	0.9
25	88	50	12	10	9	7	3	2	2	1	1
30	106	60	15	12	11	8	3	2	2	2	1
35	124	70	17	14	12	9	4	3	2	2	2
40	141	80	20	16	14	11	4	3	3	2	2
45	159	90	22	18	16	12	5	3	3	2	2
50	177	99	25	20	18	13	5	4	3	3	2
60	212	119	30	24	21	16	6	5	4	3	3
70	248	138	35	28	25	18	7	5	4	4	3
80	283	159	40	31	28	21	8	6	5	4	3
100	354	199	50	39	35	26	10	8	6	6	4
150	531	298	75	59	53	39	16	11	9	8	7
200		398	100	79	71	53	21	15	13	11	9
250		497	125	98	88	66	26	19	16	14	11
300			150	118	106	79	31	23	19	17	13
350			175	138	123	92	36	27	22	19	15
400			200	157	141	105	42	30	25	22	17
500			250	196	176	132	52	38	31	28	22
600			300	236	212	158	62	45	38	33	26
700			350	275	247	184	73	53	44	39	31
800			400	314	282	210	83	61	50	44	35
1000			497	393	353	263	104	76	63	55	44
1500				589	529	395	156	114	94	83	65
2000						526	208	151	126	111	87
3000							312	227	189	166	131
4000							416	303	252	221	175

Table 1

Temperature vs. velocity increase

Temperature above 20 °C	% Velocity increase
50	17
100	34
200	68
300	102
400	137
500	171
600	205
700	239
800	273
900	307
1000	341

Table 2

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