Sizing Medical Gas Piping

By Mike Frankel

Here is the information on sizing methods for medical gas piping systems that NFPA 99 doesn't provide.

This article will discuss only the methods and criteria required for sizing medical gas piping distribution systems. Nothing downstream of the main shut-off valve of the facility, such as tanks, source arrangements, and equipment or system configurations such as valve locations, alarms, etc., will be presented.

The information provided is strictly the author's own and was developed after years of engineering for many hospital facilities, using the primary standard for the installation of medical gas systems, NFPA 99. The standard, however, does not provide any guidance for sizing.

This article will cover medical/surgical compressed air, high-pressure instrument compressed air, laboratory compressed air, dental compressed air, oxygen, nitrous oxide, carbon dioxide, nitrogen, surgical/medical vacuum, waste anesthesia gas disposal (WAGD), laboratory vacuum, vacuum pump exhaust, and finally, dental vacuum piping.

General Design Criteria

The typical design criteria are the same for most of the compressed gases except for instrument air. Vacuum is also considered a medical gas, and the same type of criteria is necessary. Note that the information presented here is for sizing purposes only.

All of the piping networks are sized using the following four items: total connected flow rate, the diversity factor, the allowable friction loss, and the equivalent length of piping. The equivalent length is found by using the actual measured run and adding 50% of the measured run to account for fittings. The total is the equivalent length.

Dividing the equivalent run of pipe (in hundreds of feet) by the allowable system loss will establish the allowable friction loss per 100 feet of pipe. As an example, 5 psig is allowed for total system loss with an equivalent length of 400 feet. Therefore, 4 divided into 5 equals 1.25 psi friction loss per 100 feet.

The final delivery pressure for all systems, except for instrument air and vacuum, is 50 psig. With a generally allowable friction loss of 10%, the source should be arranged to deliver 55 psig in order for the pressure loss through the piping to be 5 psig. For instrument air, the delivery pressure is higher, usually around 200 psig. The delivery pressure will vary based on the type of pneumatic instruments used, but will never exceed 200 psig because of the standards that are used for these systems. This means a system loss of 20 psig. The modern instruments developed use less pressure than the older instruments. It will be some time before a complete changeover will occur due to the cost involved. All vacuum systems should deliver 15" if mercury, with the source set to deliver 20" mercury. Any pressure adjustment shall be made at the point of use.

Oversizing some portions of the piping system will allow for future changes or expansion, while the cost of adding another pipe or replacing a smaller pipe with a larger one will be many times the cost of larger sizing during the initial construction. Good practice is to make the smallest size branch and drops to individual outlets for the compressed gases 1/2", sub-mains should be a minimum of 3/4" in size and main size no less than 1". This is to allow for future expansion and renovations without replacing piping. NFPA 99 requires that the minimum size of all mains and branches be 1/2" nominal size. The minimum size of vacuum piping shall be 3/4", with 1/2" drops to individual inlets permitted.

Medical/Surgical Compressed Air

The medical/surgical (low-pressure compressed air) system must be a dedicated system. It is not permitted to be used for any other purpose.

Table 1 gives the actual common usage in the medical facility and the diversity factor to adjust the total connected load to a level that approximates probable usage. Add all the outlets together to calculate a total connected load. Using the appropriate diversity factor, calculate the maximum adjusted flow rate for the entire branch, sub-main, main or project.

In **Table 2**, enter the adjusted scfm (standard cubic feet per minute) on one side and use the allowable friction loss to find the friction loss that most closely meets the allowable figure. Select the smallest correct size. If the exact figure for friction loss is not found, use the smallest size based on the scfm.

Flow rate and Diversity Factor for Low-Pressure Medical Air Outlets

Air outlet/equipment	Design flow in scfm (free air) Per unit	Per room	Per bed	Per outlet	Simultaneous-use factor, %
Anesthetizing Locations:					
Special surgery and cardiovascular		0.5			100
Major surgery and orthopedic		0.5			100
Minor surgery		0.5			75
Emergency surgery		0.5			25
Radiology		0.5			10
Cardiac catheterization		0.5			10
Ventilators	5				100
Delivery rooms		0.5			100
Acute Care Locations:					
Recovery room/surgical (postanesthesia)			2		25
ICU/CCU			2		50
Emergency rooms			2		10
Neonatal ICU		1	1		100
Dialysis units			0.5		10
Recovery rooms/OB		2			25
Ventilators	3				90
Subacute Care Locations:					
Nursery			0.5		25
Patient rooms			0.5		10
Exam and treatment		1			10
Preop holding				1.5	20
Respiratory care		1			50
Pulmonary function lab, INCL. CPAP				1	50
EEG and EKG				1	50
Birthing and LDRP		1			50
Patient isolation room			0.5		25
Other:					
Anesthesia workroom		1.5			10
Respirator care workroom	1.5			10	
Nursery workroom		1.5			10
Equipment repair		1.5		1.5	10
Med. laboratory				1.5	25
Autopsy		1			100
Sterile supply		1			10
Plaster room		1			50
Pharmacy		1			10
Dental, high pressure (50 psig)		2 per chair		2	100
Dental, low pressure (30 psig)		1 per chair		3	100

Table 1

Compressed Air For Oxygen And Nitrogen Piping Also

SCFM	ACFM	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
5	1.1	0.15	0.04	.01						
10	2.2	0.51	0.13	0.04	0.01					
15	3.3	1.04	0.27	0.09	0.02	0.01				
20	4.3		0.45	0.14	0.04	0.02				
25	5.4		0.67	0.21	0.06	0.03	0.01			
30	6.5		0.93	0.29	0.08	0.04	0.01			
35	7.6			0.39	0.10	0.05	0.02	0.01		
40	8.7			0.49	0.13	0.06	0.02	0.01		
45	9.8			0.60	0.16	0.08	0.02	0.01		
50	10.9			0.73	0.20	0.09	0.03	0.01		
60	13.0			1.01	0.27	0.13	0.04	0.02	0.01	
70	15.2				0.36	0.17	0.05	0.02	0.01	
80	17.4				0.45	0.22	0.07	0.03	0.01	
90	19.5				0.56	0.27	0.08	0.03	0.01	
100	21.7				0.68	0.32	0.10	0.04	0.02	0.00
110	23.9				0.81	0.38	0.12	0.05	0.02	0.01
120	26.0				0.94	0.45	0.14	0.06	0.02	0.01
130	28.2				1.09	0.52	0.16	0.07	0.02	0.01
140	30.4					0.59	0.18	0.08	0.03	0.01
150	32.6					0.67	0.20	0.09	0.03	0.01
175	38.0					0.89	0.27	0.11	0.04	0.01
200	43.4					1.13	0.34	0.14	0.05	0.01
225	48.8						0.42	0.18	0.06	0.02
250	54.3						0.51	0.22	0.08	0.02
275	59.7						0.60	0.26	0.09	0.02
300	65.1						0.71	0.30	0.11	0.03
325	70.5						0.82	0.35	0.12	0.03
350	76.0						0.94	0.40	0.14	0.04
375	81.4						1.06	0.45	0.16	0.04
400	86.8							0.51	0.18	0.05
450	97.7							0.63	0.22	0.06
500	108.5							0.76	0.27	0.07
550	119.4							0.90	0.32	0.09
600	130.2							1.06	0.37	0.10
650	141.1								0.43	0.12
700	151.9								0.49	0.13
750	162.8								0.56	0.15
800	173.6								0.63	0.17
850	184.5								0.70	0.19
900	195.3								0.78	0.21
950	206.2									0.23
1000	217.0									0.25
1100	238.7									0.30
1200	260.4									0.35
1300	282.1									0.41
1400	303.8									0.47
1500	325.5									0.53

Note: Values in table are for flow velocities not exceeding 4000 feet per minute.

— Pressure Drop (psi) per 100 Ft. in 55 psi Copper Tubing, Type L

Table 2

High Pressure Compressed Air Friction Loss Table

Pipe Size / SCFM	Pipe Size 1/2" at 125 psi	1/2" at 175 psi	1/2" at 250 psi	3/4" at 125 psi	3/4" at 175 psi	3/4" at 250 psi	1" at 125 psi	1" at 175 psi	1" at 250 psi	1 – 1/4" at 125 psi	1 – 1/4" at 175 psi	1 – 1/4" at 250 psi
6	.102	.075	.054	.023								
8	.181	.133	.096	.041	.030							
10	.283	.208	.149	.064	.047	.034	.017					
15	.636	.469	.336	.144	.106	.076	.038	.028				
20	1.131	.833	.597	.255	.188	.135	.067	.050	.036	.016		
25	1.768	1.302	.933	.399	.294	.211	.105	.078	.056	.025	.019	
30	2.546	1.875	1.344	.574	.423	.303	.152	.112	.080	.037	.027	
35	3.465	2.552	1.829	.782	.576	.413	.206	.152	.109	.050	.037	.026
40	4.526	3.333	2.388	1.021	.752	.539	.270	.199	.142	.065	.048	.034
45	5.728	4.218	3.023	1.292	.952	.682	.341	.251	.180	.083	.061	.044
50	7.071	5.208	3.732	1.596	1.175	.842	.421	.310	.222	.102	.075	.054
60	10.183	7.499	5.374	2.298	1.692	1.213	.607	.447	.320	.147	.108	.078
70	13.860	10.207	7.315	3.128	2.303	1.651	.826	.608	.436	.200	.147	.105
80		13.331	9.554	4.085	3.008	2.156	1.079	.794	.569	.261	.192	.138
90		16.872	12.092	5.170	3.807	2.729	1.365	1.005	.721	.330	.243	.174
100		20.830	14.928	6.383	4.700	3.369	1.685	1.241	.890	.408	.300	.215
125			23.325	9.973	7.344	5.263	2.633	1.939	1.390	.637	.469	.336
150				14.361	10.576	7.579	3.792	2.793	2.001	.918	.676	.484
175					14.395	10.316	5.162	3.801	2.724	1.249	.920	.659
200					18.801	13.474	6.742	4.965	3.558	1.632	1.202	.861
225						17.053	8.533	6.284	4.503	2.065	1.521	1.090
250						21.054	10.534	7.757	5.559	2.550	1.878	1.346
275						25.475	12.746	9.387	6.727	3.085	2.272	1.628
300						30.317	15.169	11.171	8.006	3.671	2.704	1.938
325								13.110	9.396	4.309	3.173	2.274
350								15.205	10.867	4.997	3.680	2.637
375								17.454	12.509	5.736	4.224	3.027
400								19.859	14.232	6.527	4.806	3.445
425								22.419	16.067	7.368	5.426	3.889
450									18.013	8.260	6.083	4.360

Table 3

Diversity Factor For Dental Compressed Air

No. of outlets	Simultaneous use factor, %
4	100
5–10	75
11–over	50

Table 4

Instrument Air

Instrument air is a higher pressure system because of the large variety of pneumatic tools used. The largest flow rate

Flow Rate and Diversity Factor for Oxygen Outlets

Location	Simultaneous use factor, %	Volume, Lpm
First OR (far end of a section of piping and all individual branches to ORs), MIS ROOMS	100	50 per OR
Each additional OR (on a section of piping)	100	30 per OR
Emergency rooms	100	Same as OR
Trauma rooms	100	Same as OR
LDRP rooms	100	20 per room
Delivery rooms	100	Same as OR
Cystoscopy and special procedures rooms	100	Same as OR
Recovery rooms (postanesthesia recovery)		30 per outlet ~~NORMAL USE~~
1–8 outlets	100	40 FOR VENTILATORS
9–12 outlets	60	
13–16 outlets	50	
additional outlets	45	
Intensive care (ICU) rooms	100	30 per outlet ~~NORMAL USE~~
Neonatal		40 FOR ALL VENTILATORS
Pediatric		
Medical-surgical		
Coronary care (CCU) rooms	100	30 per outlet NORMAL USE

Simultaneous Use Factors for Other Spaces*

The first outlet on the end section of piping is 20 Lpm, 100 percent use factor. For additional outlets on the section of piping, add 10 Lpm with the following use factors.

No. of outlets	Simultaneous use factor, %	Volume, minimum Lpm
1–3	100	—
4–12	75	45
13–20	50	115
21–40	33	125
40 and over	25	155

*"Other spaces" include the following: patient rooms (medical and surgical) (bedside outlets), labor rooms, nurseries, examination and treatment rooms, OR bed holding areas, surgical preparation rooms, blood donor rooms, anesthesia workrooms, plaster (fracture) rooms, cardiac and heart catheterization rooms, deep therapy rooms, inhalation therapy rooms, electroencephalogram (EEG) rooms, electrocardiogram (ECG) rooms, electromyogram (EMG) rooms, fluoroscopy rooms, high-level radioisotope rooms, low-level radiation rooms, x-ray rooms, and endoscopy rooms.

Table 5

(generally between 6 and 15 scfm) will be used in facilities that do orthopedic, thoracic and neurosurgical procedures. The connected load is a matter of the scfm used by the appropriate tool(s) and the pressure required that the tools use. The type of tools used must be found from the facility. A 100% diversity factor is used. Use **Table 3** for sizing purposes. 175 psig is the most often-used figure.

Flow rate and Diversity Factor for Nitrous Oxide Outlets

Location	Volume, Lpm
First OR (far end of piping and all individual branches to ORs)	30 per OR
Second OR (on a section of piping)	20 per OR
Each additional OR (on a section of piping)	15 per room
Delivery rooms	20 per room
Emergency rooms	20 per room
Trauma rooms	20 per room
Anesthesia workrooms	15 per room
Plaster (fracture) rooms	20 per room
Endoscopy rooms	15 per room
Dental surgery	5 per room

Table 6

Data for Sizing Nitrous-Oxide Supply-Piping And Carbon Dioxide Piping

SCFM @ 68°F	ACFM @ 68°F 55 psig	Nominal Pipe Size (inches) 1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2½"	3"
		Measured Pressure Drop per 100 ft of Pipe, psig (Velocity in ft/sec)							
							Type "L"		
1	0.21	0.02(2.2)							
2	0.42	0.08(4.3)							
3	0.63	0.18(6.5)							
4	0.84	0.30(8.7)	0.05(4.2)						
5	1.05	0.46(10.8)	0.07(5.2)						
6	1.27	0.65(13.0)	0.10(6.3)						
7	1.48	0.89(15.2)	0.14(7.3)	0.04(4.3)					
8	1.69	1.13(17.4)	0.18(8.4)	0.05(5.0)					
9	1.90	1.40(19.5)	0.22(9.4)	0.06(5.5)					
10	2.11	1.70(21.7)	0.27(10.5)	0.07(6.1)					
15	3.16	3.80(32.5)	0.59(15.7)	0.15(9.2)					
20	4.22		1.02(20.9)	0.26(12.3)					
25	5.27		1.57(26.1)	0.40(15.3)	0.14(10.1)	0.06(7.1)			
30	6.33		2.24(31.4)	0.57(18.4)	0.19(12.1)	0.08(8.5)			
40	8.43			1.00(24.5)	0.34(16.1)	0.14(11.4)			
50	10.54				0.52(20.1)	0.21(14.2)	0.05(8.2)		
75	15.81				1.14(30.2)	0.47(21.3)	0.11(12.3)		
100	21.09				2.00(40.3)	0.81(28.4)	0.20(16.4)	0.07(10.6)	
200	42.17					3.16(56.9)	0.76(32.7)	0.25(21.2)	0.10(14.9)
300	63.26						1.70(49.1)	0.55(31.8)	0.22(22.3)
400	84.34						3.00(65.4)	0.96(42.4)	0.39(29.7)
500	105.43						4.59(81.8)	1.49(53.0)	0.60(37.1)
600	126.52							2.14(63.6)	0.85(44.6)
700	147.60							2.90(74.2)	1.16(52.0)
800	168.69							3.78(84.8)	1.50(59.4)
900	189.77								1.90(66.9)
1000	210.86								2.33(74.3)

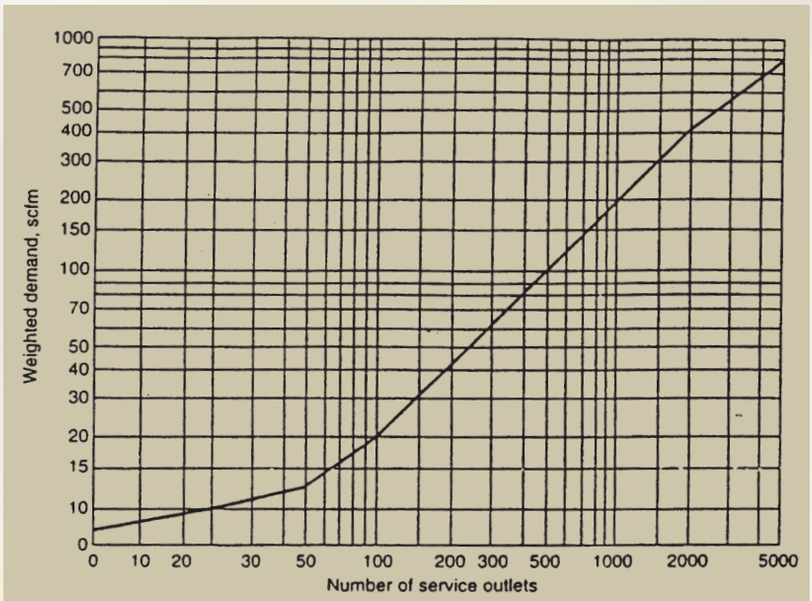
Table 7

Laboratory Compressed Air

The basis of sizing shall be **Figure 1**, which is direct reading. Enter the chart with the number of connected outlets and read the adjusted scfm. With the friction loss calculated, size the system using **Table 2**.

Dental Compressed Air

Dental tools are available that use both high- and low-pressure air. High-pressure tools such as drills use a pressure of 50 psig (345 kPa) and a flow rate of 2 scfm. Low-pressure handpieces used for cleaning and by hygienists use 30 psig (210 kPa) and a flow rate of 3 scfm. Auxiliary outlets use 1 scfm. For diversity factors for dental compressed air, refer to **Table 4**. Use **Table 2** to size the piping network.



General laboratory demand for compressed air.

Figure 1

Pressure Drop (psi) per 100 ft. of 160 psi Nitrogen Piping

Nominal Pipe Size (inches) TYPE "L" COPPER TUBING

C.F.M.	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
5	.11	.01	--	--	--	--
10	.43	.07	.02	.01	--	--
15	.96	.12	.04	.01	--	--
20	1.70	.26	.07	.02	.01	--
25	2.66	.42	.11	.03	.01	--
30		.59	.17	.04	.02	--
35		.81	.22	.05	.02	--
40		1.06	.29	.07	.03	--
45		1.34	.37	.09	.04	.01
50		1.65	.46	.11	.05	.01
60		2.37	.66	.15	.07	.02
70			.90	.21	.09	.02
80			1.17	.27	.12	.03
90			1.48	.34	.15	.04
100			1.83	.43	.19	.05
110			2.21	.51	.23	.06
120				.62	.27	.07
130				.72	.32	.09
140				.83	.37	.10
150				.96	.42	.11

4. The minimum size for risers shall be 3/4".
The minimum size for branches shall be 1/2".

Table 8

Oxygen

Use **Table 5**, using the flow rate in lpm and a diversity factor for the outlet or equipment used. Size the piping system using **Table 2**, entering it with the adjusted scfm on one side and using the allowable friction loss to find the friction loss that most closely meets the allowable figure. Select the smallest correct size. If the exact figure for friction loss is not found, use the smallest size based on the scfm.

Nitrous Oxide

See **Table 6** for room or outlet usage in lpm and a diversity factor to be used. Size the piping system using **Table 7**.

Carbon Dioxide

The use of carbon dioxide is very limited. When used, it is normally supplied from cylinders and not from centrally piped systems. The connected load and usage shall be confirmed from the facility. Diversity shall be 100% to be on the safe side. A central system is sized using **Table 7**. The difference

Flow Rate & Diversity Factor For Medical/Surgical Vacuum

	Minimum number of station inlets, REQUIREMENT	Usage group	Demand in scfm
Anesthetizing Locations			
Operating room	4/rm	A	1.5 PER OUTLET ADDITIONAL DEMAND OF 4.0 PER OR
Cystoscopy/Endoscopy	3/rm	A	
Delivery	3/rm	A	
Special procedures	3/rm	A	
Other anesthetizing locations	3/rm	A	
Acute Care Locations (Nonanesthetizing Locations)			
Neonatal	4/bed	A	1 PER INLET
Recovery room (postanesthesia)	1/bed	A	
Critical care	2/bed	A	
Special procedures	2/rm	A	
Emergency rooms	1/bed	A	
Emergency rooms—cardiac	2/bed	A	
Cardiac ICU (CCU)	2/bed	A	
Catheterization lab	3/rm	B	
Surgical excision rooms	1/rm	B	
Dialysis unit	(½)/bed	B	0.25 per INLET
Birthing rooms (LDRP or LDR)	3/rm	A	
Subacute Care Areas (Nonanesthetizing Locations)			
Nurseries	1/bed	B	
Patient rooms	1/bed	B	
Exam and treatment rooms	1/bed	B	
Respiratory care	Convenience		
Other			
Autopsy	1/table	B	
Central supply	Convenience	B	
Equipment repair, calibration, and teaching	Convenience	B	
Laboratory			1.0

Table 9

in size between nitrous oxide and carbon dioxide falls well within acceptable limits.

Nitrogen

There is no general consensus of opinion as to the quantity of nitrogen that might be used over an extended period of time in a typical facility, because of the constantly changing requirements of tools using nitrogen, the desire of medical staff to use specific instruments and the degree of use for inhalation therapy, if any. The largest flow rate (generally between 6 and 15 scfm) will be used in facilities that do orthopedic, thoracic and neurosurgical procedures. Size piping for this system using **Table 8**.

Medical Surgical Vacuum

Each individual station inlet, except WAGD (waste anesthesia gas disposal), must provide a minimum flow rate for proper functioning of connected equipment under design conditions. The various inlets are separated into usage groups based on the expected usage. Group A is heavy usage; Group B is a lesser usage. For a separation of various areas into suggested use groups to find the actual cfm, flow rate for various station and service inlets, and diversity group, refer to **Table 9**. For convenience, **Table 10** has been prepared to give a direct reading for the actual adjusted scfm for both A and B types.

For sizing the piping system, use **Table 11**. Using the cfm from inlet types A and B added together and finding the allowable friction loss similar to that previously explained using a 5" vacuum loss, select the pipe size using the lowest friction loss in the table based on the adjusted scfm.

Waste Anesthesia Gas Disposal (WAGD)

WAGD means Waste Anesthesia Gas Disposal and is used to remove the waste anesthesia gas from any anesthetic location. In the past, this has caused problems for facility personnel after they breathed it in.

The vacuum pressure is the same as the surgical/medical system and uses a 5" vacuum loss for the piping system. The usage of each inlet is 1 scfm and uses a 100% diversity factor. After adding the total scfm from the system, use **Table 11** for sizing.

Laboratory Vacuum

This system is intended only for laboratories within a health care facility, but it can actually be used for laboratories of all types. Use 1 scfm for each inlet and see **Figure 2**. **Figure 2** is a direct reading figure that uses the number of inlets and the (weighted) adjusted sfcm.

Vacuum Pump Exhaust

The exhaust piping for vacuum pumps are sized using the total scfm for the system (both lead and lag pumps) and the equivalent length of run.

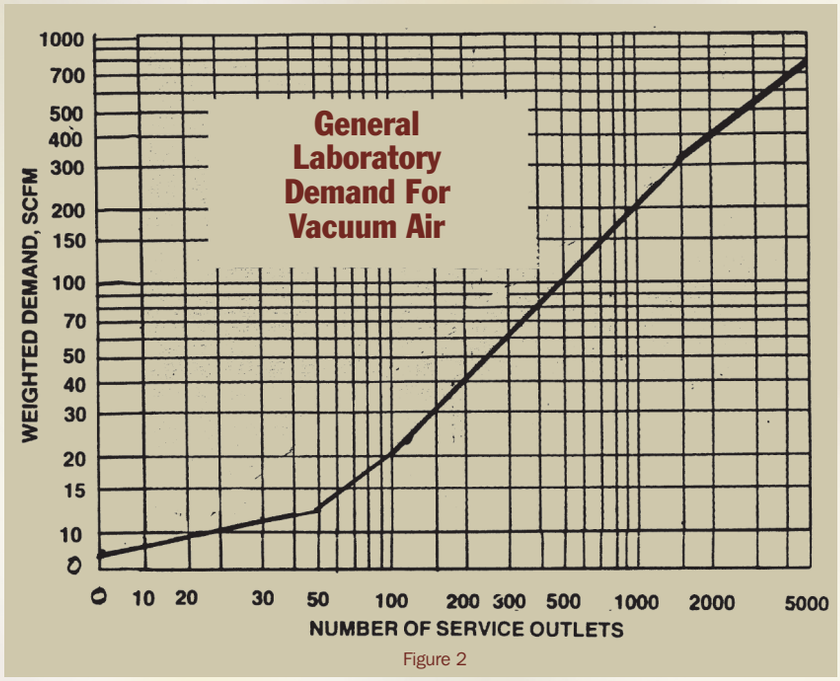


Figure 2

Dental Vacuum

The number of inlets shall be the same as dental chairs. The level of vacuum varies depending on the usage as follows:

- Dental surgery—12 to 17 inches of mercury.
- General dentistry—8 to 12 inches of mercury.
- Laboratory—5 to 9 inches of mercury.

Direct Reading of Simultaneous Use Factors for Health Care Facilities

No. of inlets	Diversity A	Diversity B
15	100	100
20	100	99
25	100	96
30	100	92
35	99	86
40	99	78
45	99	70
50	98	66
57	97	62
60	96	59
65	95	56
70	94	54
75	92	52
80	90	50
85	87	48
90	84	46
95	80	44
100	75	42
110	70	40
120	66	39
130	62	38
140	58	36
150	55	35
160	53	34
170	50	33
180	47	32
190	44	30
200	42	29
220	38	28
240	36	27
260	34	27
280	32	26
300	31	25
340	30	24
380	28	23
420	26	22
460	24	21
500	22	21
600	21	20
700	20	20
800	19	19
900	19	19
1000	18	18

Note: Diversities are based on an average hospital. Specialty hospitals may require higher diversity.

Table 10

Wet/Dry Vacuum Pipe Sizing

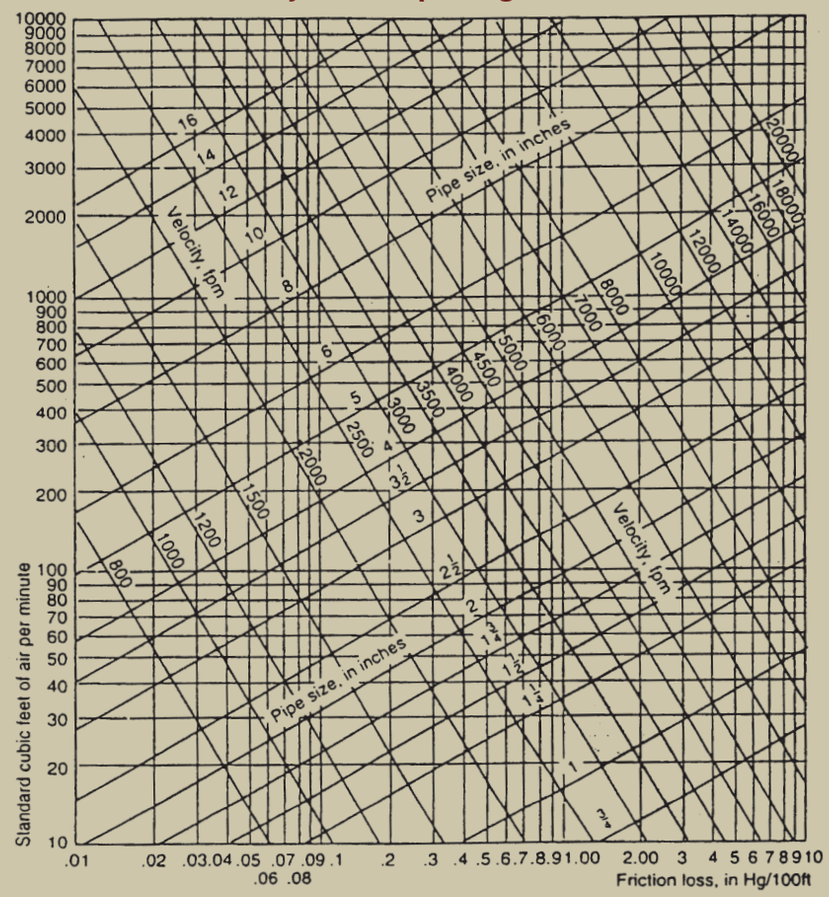


Figure 3

Vacuum Pipe Sizing Chart 15" Hg to 20" Hg

(Maximum velocity: 5000 fpm; pipe material: L tubing; pressure drop: inHg per 100 ft)

sLpm	scfm	Pipe diameter, in ¾	1	1¼	1½	2	2½	3	4
28.3	1	0.08							
56.6	2	0.27	0.08						
85.0	3	0.53	0.15						
113.3	4	0.88	0.25	0.09					
141.6	5	1.3	0.36	0.14					
169.9	6	1.8	0.50	0.19					
198.2	7		0.65	0.24	0.11				
226.6	8		0.82	0.30	0.13				
254.9	9		1.01	0.37	0.16				
283.2	10		1.22	0.45	0.20				
424.8	15			0.91	0.40	0.11			
566.4	20				0.66	0.18			
708.0	25					0.26	0.09		
850.0	30					0.36	0.13		
990.0	35					0.47	0.17		
1130.0	40						0.21	0.09	
1275.0	45						0.26	0.11	
1415.0	50						0.32	0.14	
1700	60						0.44	0.19	
2000	70							0.25	0.06
2250	80							0.31	0.08
2550	90								0.10
2830	100								0.12
3540	125								0.18
4250	150								0.25
4950	175								0.35
5665	200								0.44

Table 11

Experience has shown that a level of 10 to 12 inches of mercury has proven satisfactory at chairs for small dental practices or clinics.

Commonly used dental instruments use the following flow rate:

- Saliva ejector—2 to 3 scfm, depending on tip size.
- High volume ejector—5 to 10 scfm, depending on tip size.
- Hygienist—5 scfm.
- Dental chair—10 scfm.
- One dentist and one hygienist—15 scfm.
- Dental laboratory—20 scfm; 30 scfm for a fishmouth when grinding.

For clinics, use the following flow rates that include diversity:

- 2 chairs—15 scfm.

Vacuum Exhaust Pipe Sizing

Total vacuum plant capacity (scfm), all pumps	Equivalent pipe length, ft						
	50	100	150	200	300	400	500
10	2.00	2.00	2.00	2.00	2.00	2.00	2.00
50	2.00	2.50	3.00	3.00	3.00	3.00	3.00
100	3.00	3.00	3.00	4.00	4.00	5.00	5.00
150	3.00	4.00	4.00	4.00	5.00	5.00	5.00
200	4.00	4.00	4.00	5.00	5.00	5.00	5.00
300	4.00	5.00	5.00	5.00	6.00	6.00	6.00
400	5.00	5.00	6.00	6.00	6.00	8.00	8.00
500	5.00	6.00	6.00	6.00	8.00	8.00	8.00

Table 12

- 4 chairs—22 scfm.
- 5 chairs—30 scfm.
- 8 chairs—44 scfm.

The diversity factor varies as follows:

- 1 and 2 chairs—100%
- 3 and 4 chairs—75%
- 5 to 10 chairs—60%

Calculate the friction loss if there is much of a piping system. If it is under 25 feet, ignore it. Use **Figure 3** for pipe sizing because there is a good chance liquids will be mixed with vacuum. For the chart, use the friction loss for the project and the scfm. Use the larger pipe size when the point falls between lines. PME

Mike Frankel is president of Utility Systems Consultants in Boynton Beach, FL, and has more than 45 years experience in the design and engineering for a variety of facilities, including health care, nuclear, pharmaceutical, housing, commercial and chemical facilities. He is an ASSE member, has been an ASPE member for more than 20 years and is past president of the New Jersey ASPE chapter. He is the author of Utility Piping Systems Handbook, *published by McGraw-Hill. He is the ASPE representative on the NFPA 99 Health Care Facilities piping committee and can be reached at mfrankl@aol.com.*