Medical Air and Oxygen Capacity

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BACKGROUND

The COVID-19 pandemic has caused hospitals to look at ways to increase the number of patient beds and ventilators. This has caused a concern that existing medical air and oxygen systems may be overtaxed. This document provides simple criteria to assess existing medical air and oxygen systems ability to support additional ventilators.

VENTILATOR CAPACITY

Below are quick reference charts for how many ventilators can be supported by various pipe sizes. The typical pipe size to med surge patient rooms is ¾". The ventilator flow capacity is typically set at 40 LPM to 60 LPM. A flow rate of 55 LPM was used for the main evaluation. The flow is blended with oxygen based on the percentage setting, so the oxygen flow rate could range from 20% up to 100%.

Medical Air – Patient Floors

Pipe Size	Pressure Drop/100 Ft (PSIG)	Capacity (LPM)	No. of Ventilators @55 LPM	No. of Ventilators @40 LPM
½"	0.96	260	5	7
¾"	1.06	700	13	18
1"	1.04	1,500	27	38

Note: This represents the maximum number of ventilators on a patient floor or wing served by the pipe sizes shown.

Medical Air – Hospital Mains and Risers

Pipe Size	Pressure Drop/100 Ft (PSIG)	Capacity (LPM)	No. of Ventilators @55 LPM	No. of Ventilators @40 LPM
1 ¼"	1.02	2,700	49	68
1 ½"	1.02	4,300	78	108
2"	0.64	7,000	127	175
2 ½"	0.60	12,000	218	300
3"	0.53	18,000	327	450

Note: This represents the maximum number of ventilators for a given section of the hospital served by the pipe sizes shown.

Oxygen – Patient Floors

Pipe Size	Pressure Drop/100 Ft (PSIG)	Capacity (LPM)	No. of Ventilators @55 LPM	No. of Ventilators @10 LPM
½"	1.06	260	5	26
¾"	1.06	660	12	66
1"	1.01	1,400	25	140

Note: This represents the maximum number of ventilators on a patient floor or wing served by the pipe sizes shown.

Oxygen – Hospital Mains and Risers

Pipe Size	Pressure Drop/100 Ft (PSIG)	Capacity (LPM)	No. of Ventilators @55 LPM	No. of Ventilators @10 LPM
1 ¼"	1.05	2,600	47	260
1 ½"	0.99	4,000	73	400
2"	0.90	8,000	145	800
2 ½"	0.66	12,000	218	1,200
3"	0.58	18,000	327	1,800
4"	0.33	28,000	509	2,800

Note: This represents the maximum number of ventilators for a given section of the hospital served by the pipe sizes shown.

DISCUSSION

The limiting factor regarding how many ventilators can be placed on a patient floor or wing are the flow settings and oxygen percentage. Treating patients with COVID-19 requires a lot of oxygen so that is really the limiting factor. Clinical staff reports using oxygen flow settings of 80% to 100% for the critical patients.

In emergency scenarios, pressure at the outlet *can* drop below 50 PSIG. The Hamilton G5 Ventilator has a minimum pressure requirement of 41 PSIG for medical air and 29 PSIG for oxygen. Respiratory therapist and ventilator vendors should be consulted.

We also evaluated hospital campuses on bulk oxygen storage capacity and found out that, most hospitals are limited by the bulk oxygen system vaporizer size. Ways to increase oxygen capacity are adding a second vaporizer, replacing the existing vaporizer or bringing in a portable large vaporizer on a trailer. We suggest working with the bulk O2 vendor on this.

ASSESSING MEDICAL AIR COMPRESSOR CAPACITY

Medical air compressors are sized for full load, with one (1) compressor as a back-up. When assessing the system, consider the existing and anticipated new ventilator loads. The table below shows compressor capacity required, based on ventilator quantity.

Medical Air Compressor Verification

No. of Ventilators @55 LPM	Total Capacity (LPM)	Equivalent Compressor Capacity Required (SCFM)
1	55	2
5	275	10
10	550	19
50	2,750	96
100	5,500	193

Medical Air Compressor Verification

No. of Ventilators @40 LPM	Total Capacity (LPM)	Equivalent Compressor Capacity Required (SCFM)
1	40	1
5	200	7
10	400	14
50	2,000	70
100	4,000	140

Notes:

1. Based on the ventilator flows indicated with 100% medical air.
2. For compressor capacity multiply LPM by 0.035 to obtain SCFM.

ASSESSING OXYGEN CAPACITY

Oxygen systems are sized for oxygen load. They are also required to have back-up reserve capacity. System source can be a bulk cryogenic (liquid O2) tank or a series of cylinders. Reserve capacity can be a secondary tank and a bank of cylinders. There must be an automatic changeover manifold. When assessing the system, consider the existing and anticipated new ventilator loads. The table below shows oxygen cylinder capacity required based on the number of ventilators. Bulk systems must be evaluated on a case by case basis. Normally, distribution piping is the limiting factor.

Oxygen Capacity Verification – Max Flow Estimate 100% O2 @55 LPM

No. of Ventilators on 100% O2 @55 LPM	Total Capacity (LPM)	Bulk Oxygen Consumption per Day (gallons)	Equivalent # of Oxygen Consumption per Day (K Type Cylinders)
1	55	24	11
2	110	48	23
5	275	120	57
10	550	241	115
50	2,750	1,205	574
100	5,500	2,409	1,148

Oxygen Capacity Verification – Min Flow Estimate @ 10 LPM

No. of Ventilators O2 Flow @10 LPM	Total Capacity (LPM)	Bulk Oxygen Consumption per Day (gallons)	Equivalent # of Oxygen Consumption per Day (K Type Cylinders)
1	10	4	2
2	20	9	4
5	50	22	10
10	100	44	21
50	500	219	104
100	1,000	438	209

Notes:

1. One (1) H or K type O2 cylinder contains 6,900 liters of O2

TEMPORARY SYSTEMS

Temporary facilities, shelled spaces, “MASH” units, tents, etc will need medical air and oxygen systems. Distribution piping may not be possible. Cylinders set by a bed may be a simple solution. However, the cylinders may have to be replaced frequently.

A portable rental unit could be a temporary source of medical air. Flexible distribution piping could be used for quick installation, but must be rated for medical air use. Cylinders could, too. Cylinders might be depleted *very quickly*, so capacity needs to be evaluated prior to deployment.

Cylinders could also be temporary sources of oxygen. Again, usage and capacity need to be carefully evaluated. There are also portable bulk oxygen systems on trailers, which could be parked nearby. Flexible distribution piping could be used for quick installation, but must be rated for oxygen use.

BACKGROUND ON SYSTEM SIZING

For system sizing, engineers use data from professional organizations (ASPE, NFPA, Vendors), then apply healthy safety factors. As such, many systems are oversized. Historically, engineers have used 100 LPM/outlet for medical air sizing and 20 LPM/outlet for oxygen. Diversity is 100% for operating rooms, 50% for ICU's, and 10% to 25% for patient rooms.

The California Plumbing Code (CPC) requires each medical air and oxygen outlet be designed for 20 LPM. A footnote states, *"A room designed for a permanently located respiratory ventilator or anesthesia machine shall have an outlet capable of a flow rate of 6.36 CFM (3.0 L/s) at the station outlet."* This is equal to 180 LPM.

Pipe sizing is based on estimated max flow, length of pipe run and allowable system pressure drop. The source pressure of medical air and oxygen systems is 55 PSIG. Allowable pressure drops between the source and outlet is 5 PSIG. A good benchmark is to size the piping, at a pressure drop of 1 PSIG/100 feet of equivalent pipe run (including elbows, valves and other devices). In large facilities with long pipe runs the, pressure drop/100 Ft would have to be lower, i.e. 0.50 PSIG/100 Ft.