Predicting Surge Requirements for Medical Gas Consumption

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Disclosure

- **I am a paid consultant for**
  - IngMar Medical
  - Hillrom
  - Vyaire Medical

Disclaimer

- **I have no experience in the area of facilities engineering**
- **I do have 40+ years of experience as a medical scientist**

Goal of this talk

- To improve the communication between Medical Gas Professionals and Healthcare Professionals to better prepare for emergency surges in oxygen consumption

Overview

- **Gas consumption concerns during a surge**
- **Facilities design issues**
  - Limitations on O_2 consumption due to facility design
  - Potential problems with design tolerances
- **Crash course on medical consumption of oxygen**
  - Medical terms
  - Device descriptions
- **Crash course on statistics**
- **How to predict medical consumption**
  - Misconceptions about data needed
  - Where to get the data
  - How to use the calculators
- **Practical suggestions**

Caveat

- **The late management guru Peter Drucker considered hospitals to be**
  – “*The most complex human organization ever devised* ”
- **According to complex systems theory, chaos theory, graph theory and network theory**
  – The behavior of complex systems is highly sensitive to changes in initial conditions
  – Complex systems are essentially unpredictable
- **You better have a backup plan in case your predictions fail**

COVID-19 Epidemic Concerns

- **Increased usage of mechanical ventilators**
  - Increased usage of current inventory
    - *Invasive & non-invasive mechanical ventilators*
  - Rapid increase in new ventilator purchases
- **Increased usage of other oxygen delivery equipment**
  - Conventional and high flow nasal cannulas
- **The limiting factor may not be the number of ventilators but the medical gas supply to operate them**

Facilities Design Issues

Facilities Design – Storage and Use

- **Limitations on medical oxygen stored in liquid form**
  - Maximum flow due to plumbing resistance
  - Maximum zone and total facility storage capacity
  - Reduced heat exchange due to icing on evaporation coils

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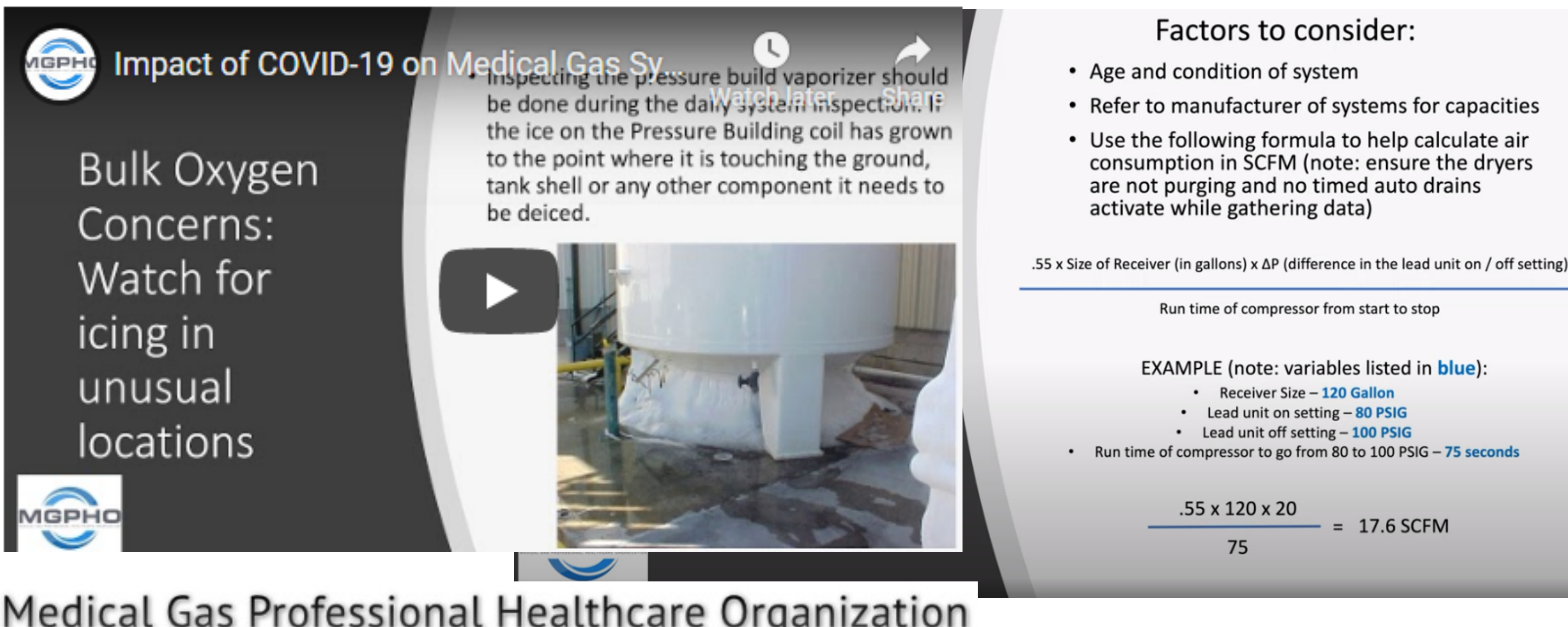
Facilities Design – Medical Air

- **Air is supplied by huge air compressors with dryers to remove water vapor**
  – Failure of dryers will lead to water in plumbing that can damage ventilators



https://mgpho.org/

Facilities Design – Tolerance Limits

- **No standard design procedure for medical gas sizing**
  - Tolerance limits set by engineering experience
  - Clinical expectations may be misunderstood or not considered
- **System design surge tolerances may not be adequate**
  - Tolerances may be based on average normal oxygen usage
  - Surge oxygen use may be based on unexpected use of medical equipment (types and numbers)
- **Tolerances must be based on clear communication between clinicians and engineers**
  - Data from current COVID-19 surge should be used to improve prediction accuracy

Crash Course

in

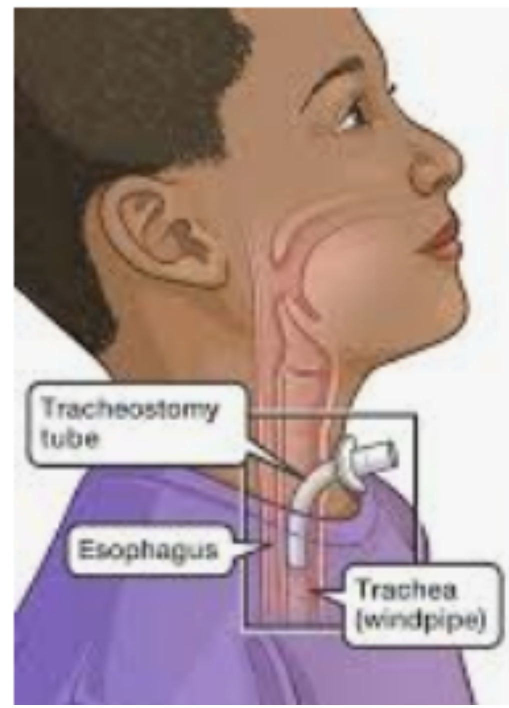
Medical Terminology

Crash Course in Medical Terminology

- **Ventilator**
  - Automatic machine use to perform some portion of the work of breathing to assure gas exchange
- **Ventilator-day**
  - Metric for ventilator usage recorded in EMR
  - One ventilator used for 24 hrs = 1 vent day
  - One ventilator used for 2 days = 2 vent days
  - Two ventilators used for 1 day = 2 vent days

Crash Course in Medical Terminology

- **Invasive ventilation**
  - Intubation with endotracheal tube or tracheostomy tube



Crash Course in Medical Terminology

- **Non-Invasive ventilation**
  - Use of mask or helmet

Classification of Ventilators

- **By Application**
  - General purpose ICU
  - Homecare/transport
  - Pediatric/neonatal
  - High frequency ventilators
  - Noninvasive ventilators

Dräger Evita XL

Classification of Ventilators

- **By Application**
  - General purpose
  - Homecare/transport
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Covidien PB 540

Classification of Ventilators

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Dräger Babylog VN500

Classification of Ventilators

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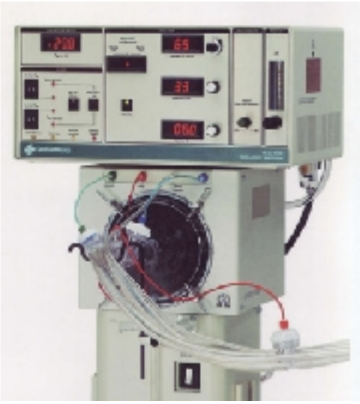


Sensormedics 3100

Bunnell Life Pulse

Classification of Ventilators

- **By Application**
  - – General purpose
  - – Homecare/transport
  - – Pediatric/neonatal
  - – High frequency ventilators
  - – Noninvasive ventilators

Philips Respironics V60

Some Ventilators Use Blowers

Miniature turbine avoids use of medical air supply

Noninvasive

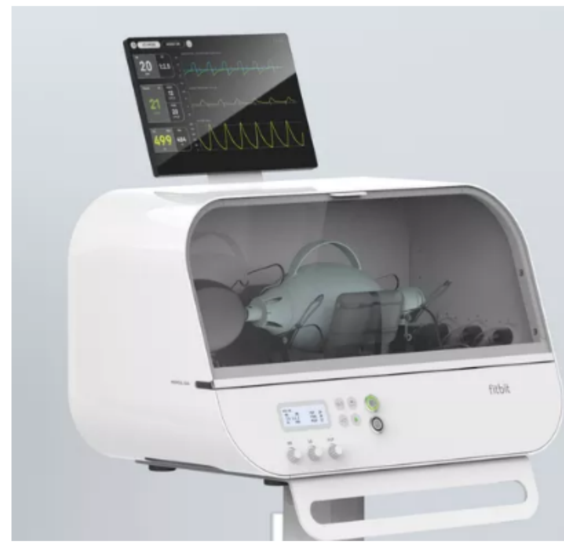
Invasive

Unexpected examples

VOCSN

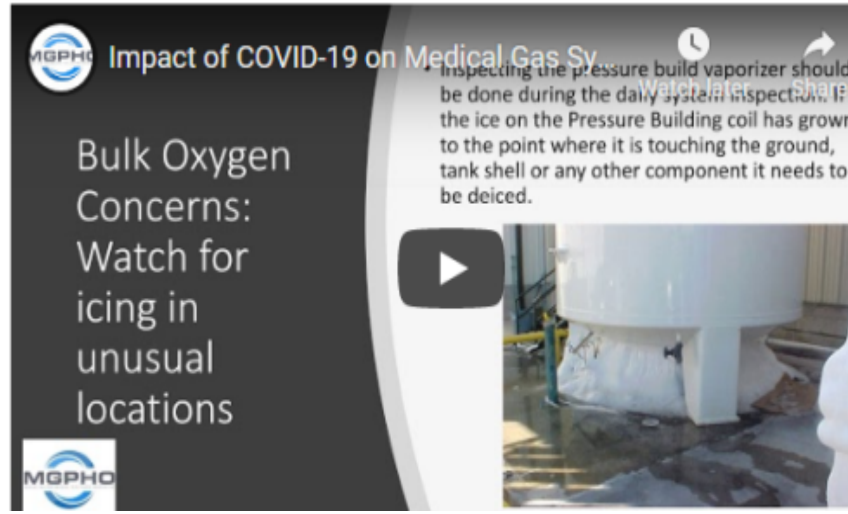
Ventilation
Oxygen
Cough
Suction
Nebulization

Fitbit's ventilator gets emergency FDA approval



Huge variability among ventilators

Oxygen Only	Oxygen & Med Air
Philips Respironics BiPAP V60 • Max Flow 175 LPM • Low 40, High 87	GE Carescape R860 • Max Flow 160 LPM • Low 35, High 94
Respironics Esprit • Max Flow 300 LPM • Low 40, High 90	Carefusion Avea • Low 20, High 80
Allied Healthcare AutoVent 3000 • Flow listed between 16-48 LPM • Low 40, High 60	Carefusion LTV1200 • Low 40, High 80
Allied Healthcare EPV200 • Spec says an oxygen D cylinder will last 65 minutes • Low 40, High 87	Tecme Advance • Low 41, High 87
Respironics Vision BiPAP • Max Flow 120 LPM • Low 50, High 100	Drager Evita XL • Max flow 120 LPM • Low 39, High 87
Trilogy Ventilator • Max Flow 200 LPM • Low 40, High 87	Maquet Servo I • Low 29, High 94
Newport HT70 Transport Ventilator • Max Flow 100 LPM • Low 35, High 90	PB 840 • Flow to 200 LPM • Low 35, High 100



Medical Gas Professional Healthcare Organization

- **Need to consult with clinical representatives to account for ventilator models**
  – Consider constant bias flow (0 – 30 L/min)
  – Consider huge leaks during noninvasive ventilation

Crash Course in Medical Terminology

- **Minute Ventilation (L/min)**
  - Flow of fresh gas through the lungs to achieve adequate elimination of carbon dioxide
  - Minute ventilation = tidal volume x respiratory rate
- **Tidal Volume (mL)**
  - The volume of gas inhaled/exhaled during ventilation
- **Respiratory Rate (breaths/min)**
  - Number of breaths per minute during ventilation
- **Inspiratory flow (L/min)**
  - Peak flow into the lungs during inspiration

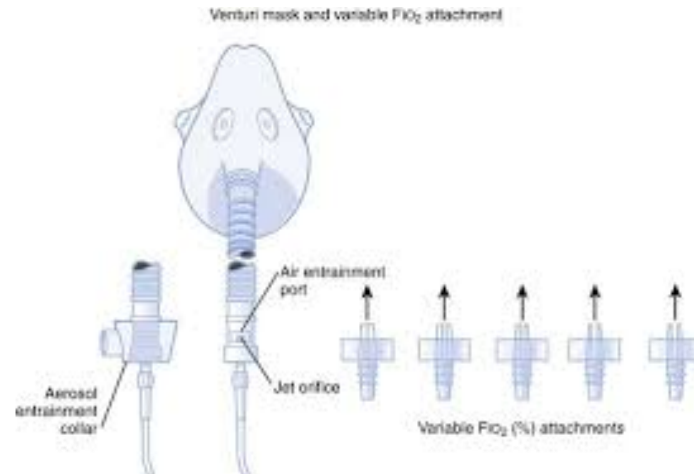
Oxygen Delivery Devices

Simple Oxygen Mask
(5-10 L/min)

Non-Rebreathing Mask
(10 - 15 L/min)

Oxygen Delivery Devices

Entrainment (Venturi) Oxygen Mask
(4-15 L/min)



Entrainment Large Volume Nebulizer
(15 L/min)

Oxygen Delivery Devices

Standard Nasal Cannula
(1-6 L/min)

High Flow Nasal Cannula
(1-40 L/min)

Oxygen Delivery Devices

Small Volume Nebulizer
(6-8 L/min)

Note: there could be hundreds of treatments per day at perhaps 10 minutes/treatment

Oxygen Hood
(10-15 L/min)

Oxygen Metering Devices

Oxygen Flow Meter
(0-15 L/min)

Oxygen Blender
(2 - 120 L/min)

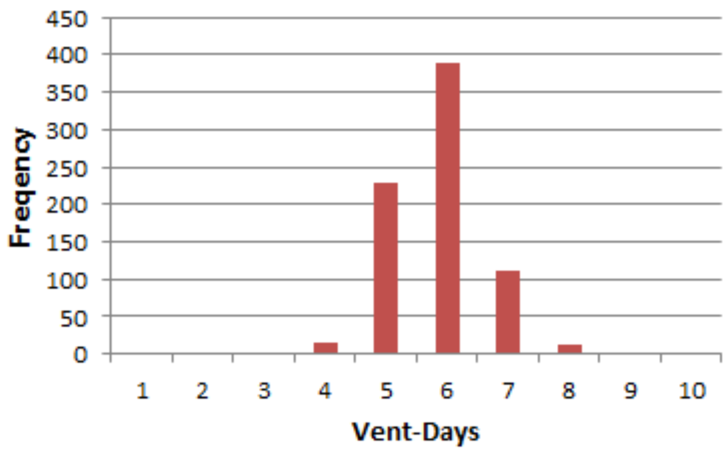
Crash Course in Statistics

Turning Date Into Information

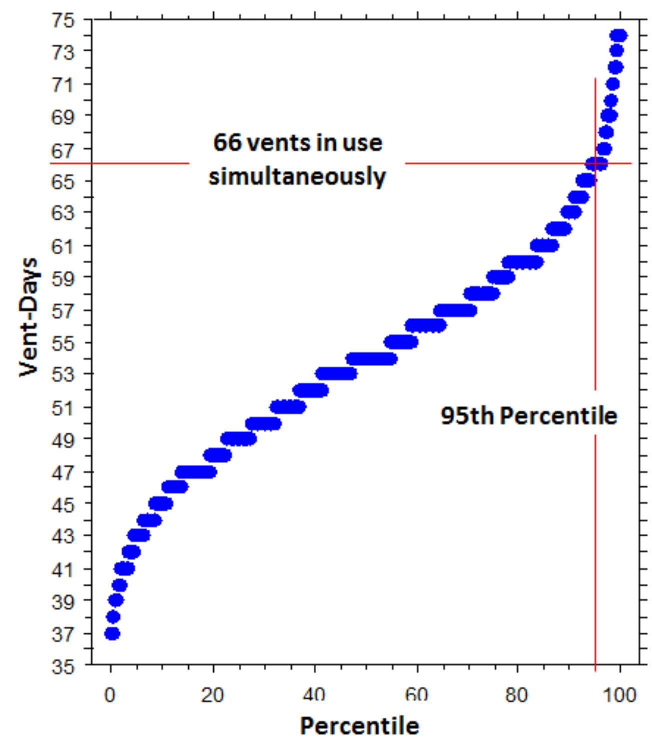
Raw Data

	A
1	Ven-Days
2	48
3	51
4	47
5	50
6	55
7	59
8	60
9	62
10	57
11	48
12	52

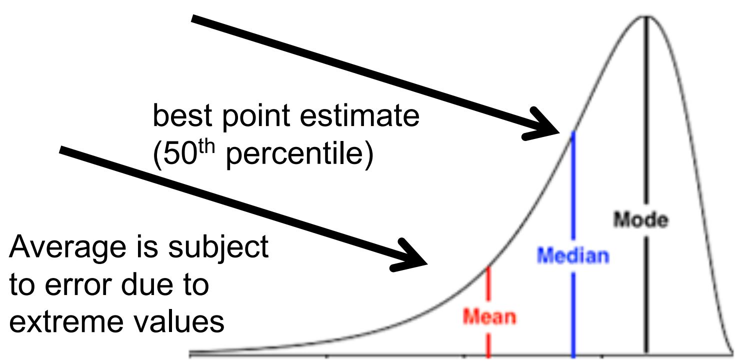
Histogram (frequency distribution)



Percentile Plot



Summary Data for Distribution

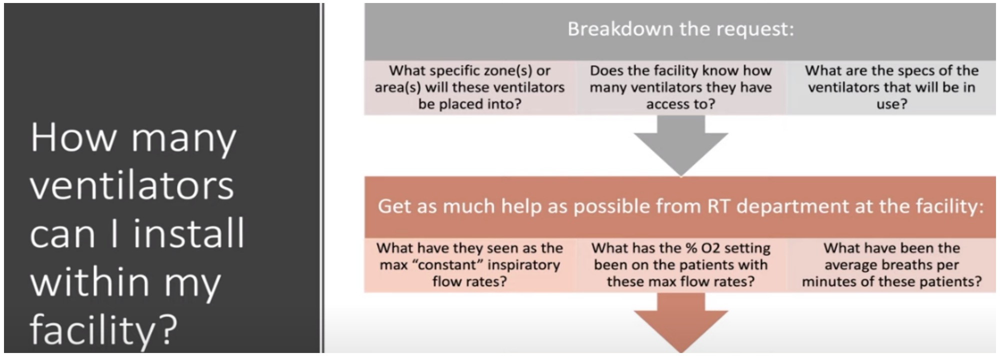


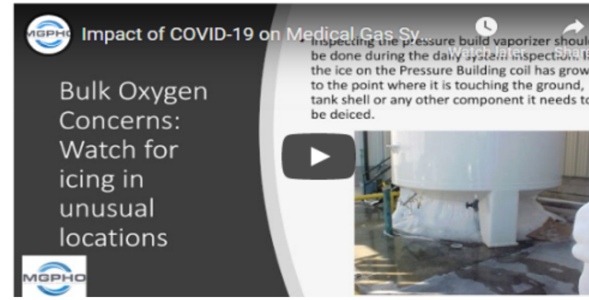
Predicting Oxygen Consumption

The Basic Problem:

- **What data do we need?**
  - Peak flow of oxygen to a hospital zone
    - *Total flow from ventilators in simultaneous use*
    - *Total flow from oxygen delivery devices in simultaneous use*
    - *Predictive model for turning random usage into probable peak usage*
- **Where will we get it?**
  - Hospital Electronic Medical Record
    - *System for associating billing codes to O_2 devices*
- **How do we analyze it?**
  - Oxygen usage calculator

Some Misconceptions

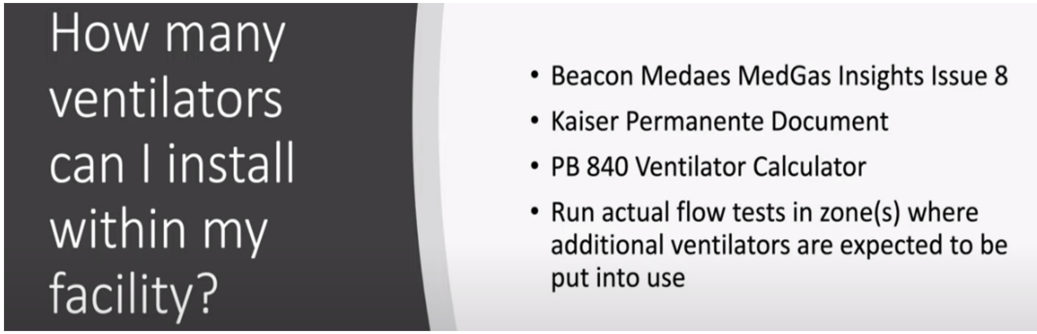


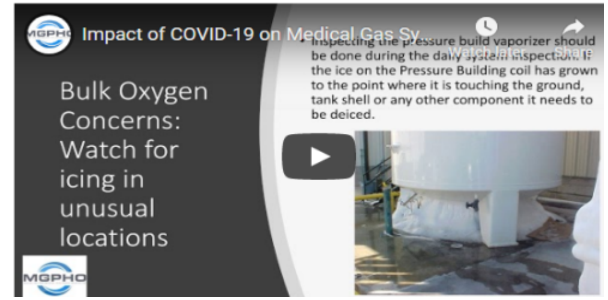


Medical Gas Professional Healthcare Organization

- **What is max inspiratory flow rate?**
  - This is irrelevant, what you want is minute ventilation
- **What is average breaths per minute**
  - Incomplete data, what you need is:
  - Minute Ventilation = Breath Rate x Tidal Volume
- **What is % O_2 on max flow settings**
  - Inadequate data
  - Better to use O_2 consumption calculator
- **The average respiratory therapist cannot supply the information you need**
  - What you need is a task force and EMR data mining

Some Good Advice





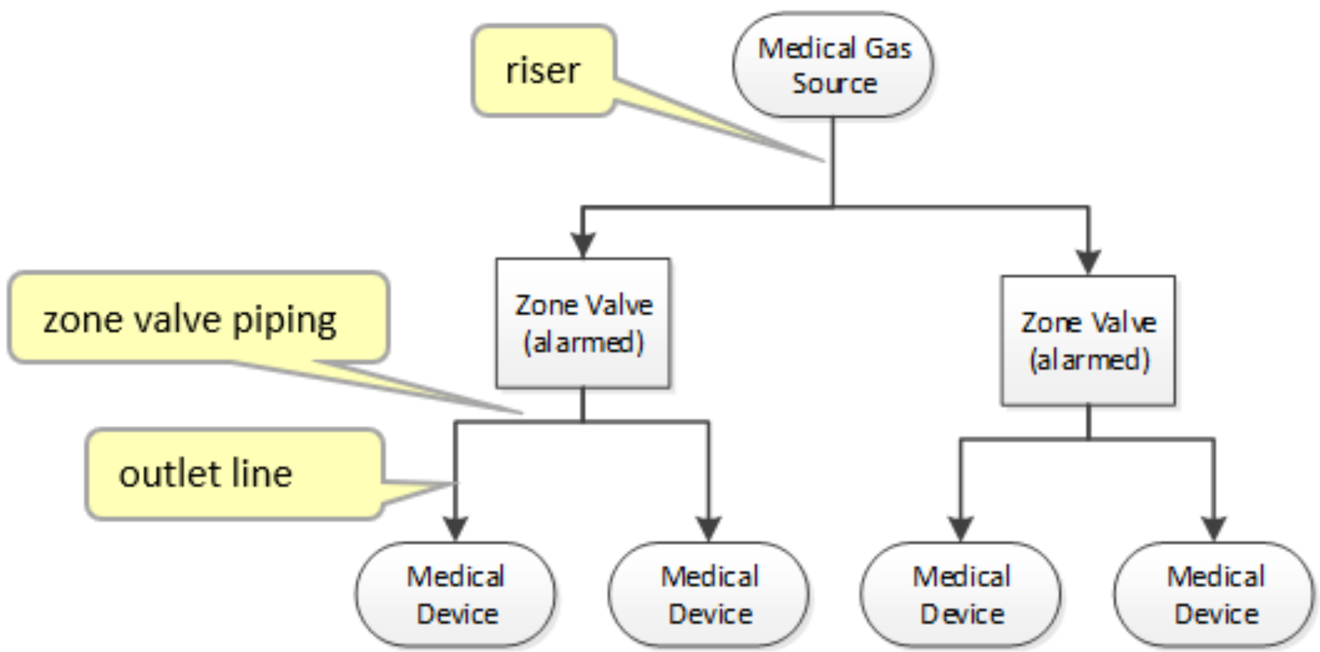
Medical Gas Professional Healthcare Organization

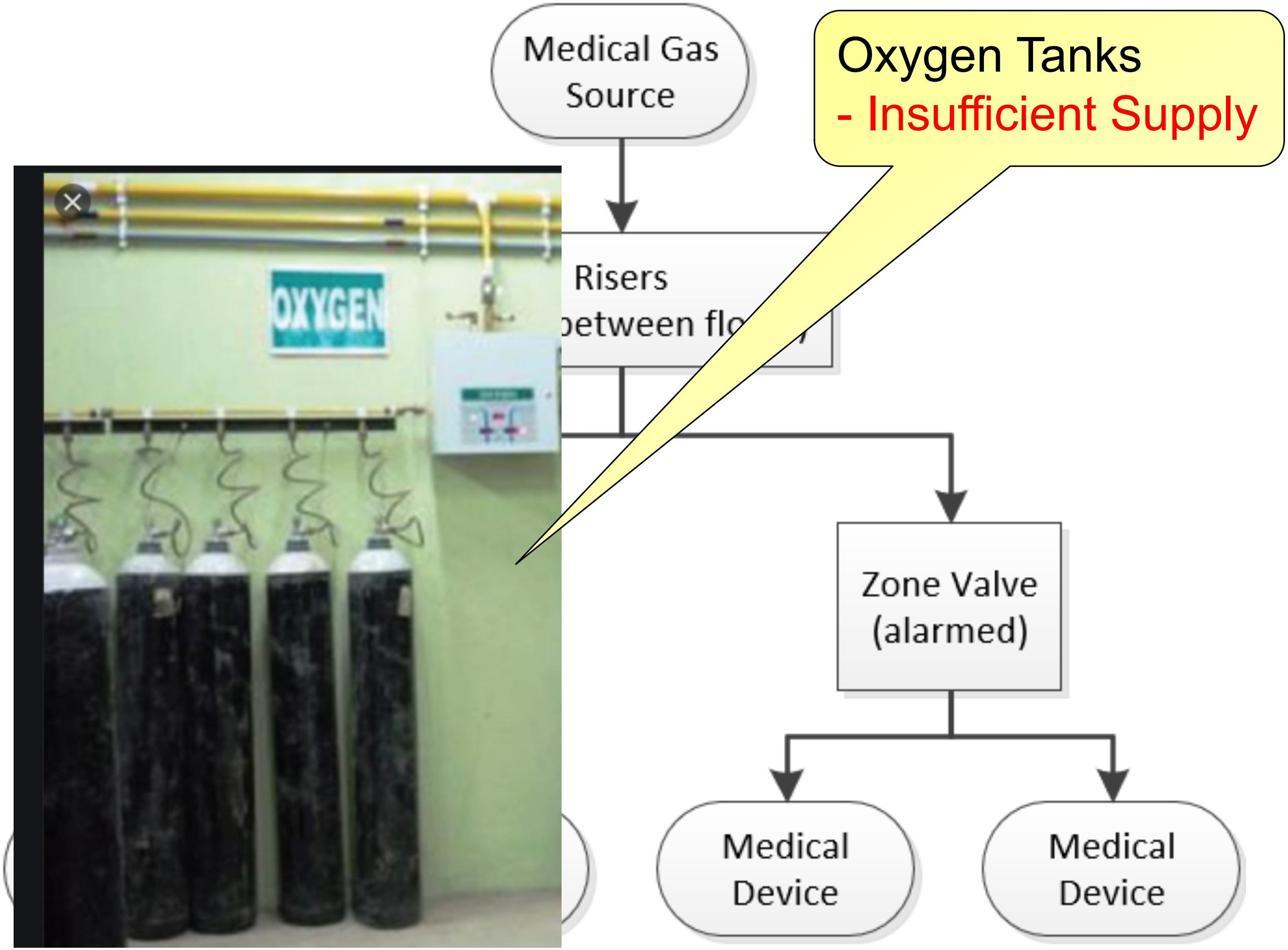
- **Beacon Medaes**
  - Point estimates – not applicable for zone usage
- **Kaiser Permanente**
  - Good distinction between invasive/noninvasive vents vs high flow nasal cannula
- **PB 840 calculator**
  - Ventilators differ radically in oxygen consumption for same settings: need to consult operator's manuals
- **Run actual flow tests**
  - Perhaps the best advice if you can get enough vents for the simulation and know what settings to use

A Procedure for Risk Prediction

Procedure Overview

1. Create list of ICU with number of beds in each unit
2. Obtain medical gas piping data from facilities engineering
3. Understand location of choke points





Oxygen Tanks
- Insufficient Supply
Medical Gas Source
Risers
Zone Valve (alarmed)
Medical Device
Medical Device
OXYGEN

Liquid Oxygen
- Insufficient Supply
- Icing
- De-Ice at 50%

Medical Gas Source

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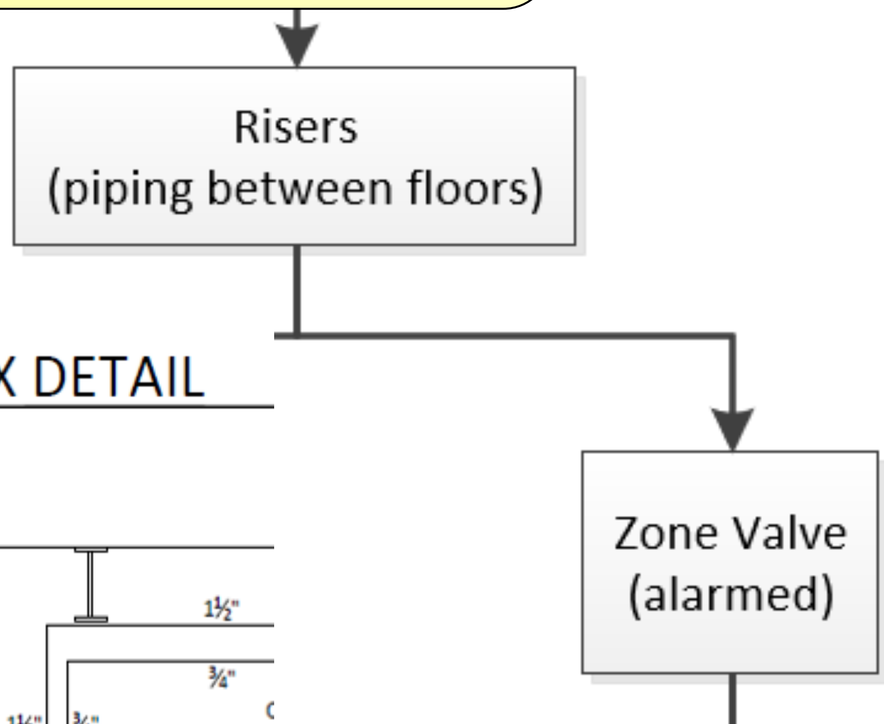
Piping
- Flow limited by diameter
- Pressure drop is flow dependent

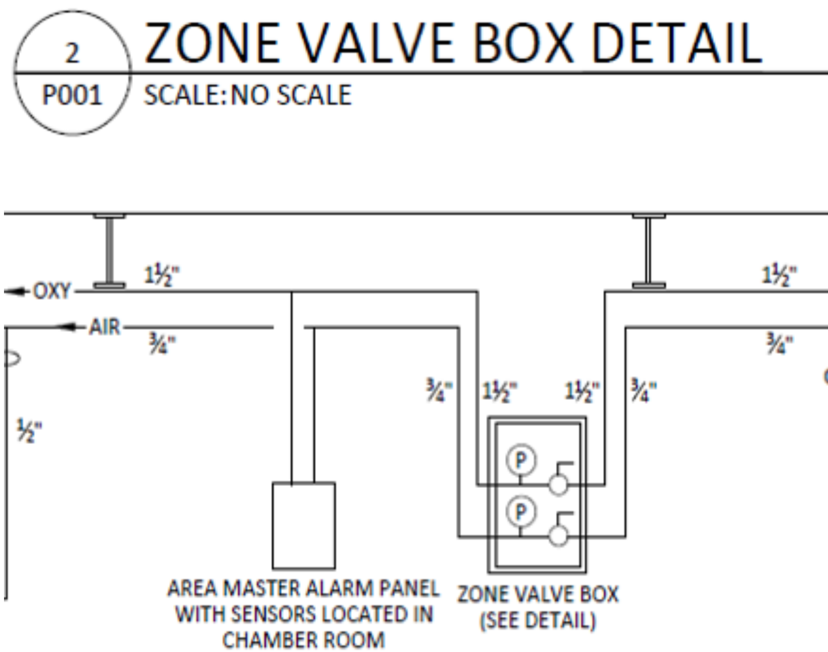
Risers
(piping between floors)

Medical Air – Hospital Mains and Risers

Pipe Size	Pressure Drop/100 Ft (PSIG)	Capacity (LPM)
1 ¼"	1.02	2,700
1 ½"	1.02	4,300
2"	0.64	7,000
2 ½"	0.60	12,000
3"	0.53	18,000

Zone Valve
- Choke point in system
- Alarms for pressure drop > 5 psi





Pipe Size	Pressure Drop/100 Ft (PSIG)	Capacity (LPM)
½"	0.96	260
¾"	1.06	700
1"	1.04	1,500

Calculator -Medical Gas Flow Limitation

Riser	South			Middle		North		
Unit	G60	G50	G51	G61	G52	G62	G53	G54
Number of beds per unit	8	10	11	17	10	18	10	10

Minute Ventilation (LPM)/Ventilator 10 FiO₂ 0.45

Air (LPI	O_2 (LPM)
7.0	3.0

Assumed Air flow per bed (L/min) 10 d Oxygen flow per bed (L/min) 60

Medical Air								
Target Pressure (PSI) at Zone Valve Box Inlet	50	50	50	50	50	50	50	50
Riser Pipe Size (inches)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Riser served from	South	South	South	Middle	Middle	North	North	North
Maximum Capacity in Riser (LPM)	2700	2700	2700	2700	2700	2700	2700	2700
Maximum Number of Beds per Riser	**270**	**270**	**270**	**270**	**270**	**270**	**270**	**270**
Zone Valve Pipe Size (inches)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Maximum Capacity through Zone Valve (LPM - 1.06 PSI pressure drop)	700	700	700	700	700	700	700	700
Maximum Number of Beds per Zone Valve from Riser	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**
Outlet Pipe Size (inches)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Maximum Capcity Through Outlet Pipe (LPM - 1.06 PSI pressure drop)	260	260	260	260	260	260	260	260
Maximum Number of Beds per Outlet Pipe from Zone Valve	**26**	**26**	**26**	**26**	**26**	**26**	**26**	**26**
Number of beds in Unit	8	10	11	17	10	18	10	10
Percentage of Beds supported at 49 PSI	**325%**	**260%**	**236%**	**153%**	**260%**	**144%**	**260%**	**260%**
Number of beds in Unit	8	10	11	17	10	18	10	10
Total flow at assumed flow/bed	480	600	660	1020	600	1080	600	600
Outlet pressure (PSIG) at Zone Valve	**49**	**49**	**49**	**48**	**49**	**48**	**49**	**49**
Outlet pressure (PSIG) at bed	**47**	**47**	**46**	**44**	**47**	**44**	**47**	**47**

Medical Oxygen								
Target Pressure (PSI) at Zone Valve Box Inlet	50	50	50	50	50	50	50	50
Riser Pipe Size (inches)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Riser served from	South	South	South	Middle	Middle	North	North	North
Maximum Capacity in Riser (LPM)	2600	2600	2600	2600	2600	2600	2600	2600
Maximum Number of Beds per Riser	**43**	**43**	**43**	**43**	**43**	**43**	**43**	**43**
Zone Valve Pipe Size (inches)	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Maximum Capacity through Zone Valve (LPM - 1.06 PSI pressure drop)	660	660	660	660	660	660	660	660
Maximum Number of Beds per Zone Valve from Riser	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**
Outlet Pipe Size (inches)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Maximum Capcity Through Outlet Pipe (LPM - 1.06 PSI pressure drop)	260	260	260	260	260	260	260	260
Maximum Number of Beds per Outlet Pipe from Zone Valve	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Number of beds in Unit	8	10	11	17	10	18	10	10
Percentage of Beds supported at 49 PSI	**50%**	**40%**	**36%**	**24%**	**40%**	**22%**	**40%**	**40%**
Number of beds in Unit	8	10	11	17	10	18	10	10
Total flow at assumed flow/bed	480	600	660	1020	600	1080	600	600
Outlet pressure (PSIG) at Zone Valve	**49**	**49**	**49**	**48**	**49**	**48**	**49**	**49**
Outlet pressure (PSIG) at bed	**47**	**47**	**46**	**44**	**47**	**44**	**47**	**47**

Air Riser	**South**	**Middle**	**North**
Number of beds in ICUs served by each Riser	29	27	38
Total Capacity of the Riser for Med Air	2700	2700	2700
Capacity of Beds that can be served per Med Air Riser at	**270**	**270**	**270**
Percentage of Beds that can be served per Med Air Riser :	**931%**	**1000%**	**711%**
Oxygen Riser			
Total Capacity of the Riser for Oxygen	2600	2600	2600
Capacity of Beds that can be served per Oxygen Riser at a	**43**	**43**	**43**
Percentage of Beds that can be served per Oxygen Riser a	**148%**	**159%**	**113%**

https://1drv.ms/x/s!AuFakBJODC3DgeFo4JcevHaMclp5aw?e=X4alo0

Procedure Overview

4. **Identify choke points (gas flow limitations calculator)**
   a. Enter riser diameter
   b. Enter zone valve pipe diameter
   c. Enter outlet pipe diameter
   d. Calculate
      - *% beds supported*
      - *Outlet pressure at zone valve*
      - *Outlet pressure at bed site*

Step 4a – Calculate Max Riser Capacity

Worst case scenario
All HFNC @ 60 LPM

Riser	South		
Unit	G60	G50	G51
Number of beds per unit	8	10	11

Assumed flow per bed (L/min) 60

Med Gas			
Pressure (lbs) at Zone Valve Box	50	50	50
Riser Pipe Size (inches)	1.25	1.25	1.25
Riser served from	South	South	South
Maximum Capacity in Riser (LPM)	2700	2700	2700

Step 4b – Calculate Zone Valve Capacity

Worst case scenario
All HFNC @ 60 LPM

Riser	South		
Unit	G60	G50	G51
Number of beds per unit	8	10	11

Assumed flow per bed (L/min) 60

Medical Air			
Target Pressure (PSI) at Zone Valve Box Inlet	50	50	50
Riser Pipe Size (inches)	1.25	1.25	1.25
Riser served from	South	South	South
Maximum Capacity in Riser (LPM)	2700	2700	2700
Maximum Number of Beds per Riser	**270**	**270**	**270**
Zone Valve Pipe Size (inches)	0.75	0.75	0.75
Maximum Capacity through Zone Valve (LPM - 1.06 PSI pressure drop)	700	700	700
Maximum Number of Beds per Zone Valve from Riser	**70**	**70**	**70**
Outlet Pipe Size (inches)	0.5	0.5	0.5
Maximum Capcity Through Outlet Pipe (LPM - 1.06 PSI pressure drop)	260	260	260
Maximum Number of Beds per Outlet Pipe from Zone Valve	**26**	**26**	**26**

Step 4c – Device Capacity

Determine risk of zone alarm

Number of beds in Unit	8	10	11
Percentage of Beds supported at 49 PSI	**325%**	**260%**	**236%**
Number of beds in Unit	8	10	11
Total flow at assumed flow/bed	480	600	660
Outlet pressure (PSIG) at Zone Valve	**49**	**49**	**49**
Outlet pressure (PSIG) at bed	**47**	**47**	**46**

Determine risk of ventilator alarm

Calculator – Medical Gas Consumption

Note Some ventilators have blowers and do not consume air from the wall outlet

Abbreviations BTPS = body temperature and pressure saturated with water vapor

STPD = standard temperature and pressure dry

conversion factor

Minute Ventilation (STPD) = Minute Ventilation (BTPS) x conversion fact $\frac{P_B - 47}{760} \times \frac{273}{310}$

DOV = duration of ventilation per patient

L (liter) = Dm³ (cubic decimeter)

Medical Gas Consumption Calculator v3.28.20

Created by Prof. Robert L. Chatburn, MHHS, RRT-NPS, FAARC 2020

BASIC ASSUMPTIONS (per ventilator)	units	High	Median	Low
Barometric Pressure	mmHg	760		
Atmospheric Temperature	°C	27		
Minute Ventilation	L/min/vent; BTPS	12.0	7.8	5.0
Minute Ventilation	L/min/vent; STPD	9.9	6.5	4.1
FiO_2		1.0	0.60	0.4
Oxygen Flow	L/min/vent; STPD	9.9	3.2	1.0
Oxygen Flow	L/hr/vent; STPD	595	192	60
Oxygen Flow	L/d/vent; STPD	14,276	4,605	1,431
Air Flow	L/min/vent; STPD	0.0	3.3	3.1
Air Flow	L/hr/vent; STPD	0	197	188
Air Flow	L/d/vent; STPD	0	4,723	4,518

$$O_2 \text{ flow} = \frac{\text{total flow} \times (FiO_2 - 0.21)}{0.79}$$

$$\text{airflow} = \text{total flow} - O_2 \text{ flow}$$

CRITICAL ASSUMPTIONS	units	High	Median	Low
Daily Ventilator Census	vents	800	500	100
Duration of Ventilation	days	14	12	10
Total vent-days	vent-days	11,200	6,000	1,000
Capacity of Oxygen H-Tanks	L/tank	7,080		
Capacity of Air H-Tanks	L/tank	7,080		

RESULTS for PIPING SYSTEMS (STPD)	units	High	Median	Low
Oxygen Consumption Rate/min	cubic feet	280	56	4
Oxygen Consumption Rate/hr	cubic feet	16,806	3,388	211
Oxygen Consumption Rate/day	cubic feet	403,335	81,305	5,052
Air Consumption Rate/min	cubic feet	0	58	11
Air Consumption Rate/hour	cubic feet	0	3,475	665
Air Consumption Rate/day	cubic feet	0	83,390	15,955

○ cubic decimeters (L) ● cubic feet

RESULTS for TANK SYSTEMS (STPD)	units	High	Median	Low
Required Oxygen H-Tanks per Day	tanks	57	11	1
Required Oxygen H-Tanks per Population Duration of Ventilation	tanks	798	138	7
Required Air H-Tanks per Day	tanks	0	12	2
Required Air H-Tanks per Population Duration of Ventilation	tanks	0	141	23

https://1drv.ms/x/s!AuFakBJODC3DgeFm6t2Pc4mxBHcg-g?e=wCysro

Oxygen Budget

5. **Create oxygen use budget (medical gas consumption calculator)**
   a. Enter estimates for FiO_2 and ventilator census
      - *Can also be used for HFNC instead*
   b. Enter average duration of ventilation
   c. Enter capacity of compressed oxygen tanks
   d. Calculate
      - *Oxygen consumption*
      - *Air consumption*
      - *Required compressed gas tanks*

Step 5a – Recalculate Oxygen Budget

BASIC ASSUMPTIONS (per ventilator)	units	High	Median	Low
Barometric Pressure	mmHg	760		
Atmospheric Temperature	°C	27		
Minute Ventilation	L/min/vent; BTPS	12.0	7.8	5.0
Minute Ventilation	L/min/vent; STPD	9.9	6.5	4.1
FiO_2		1.0	0.60	0.4
Oxygen Flow	L/min/vent; STPD	9.9	3.2	1.0
Oxygen Flow	L/hr/vent; STPD	595	192	60
Oxygen Flow	L/d/vent; STPD	14,276	4,605	1,431
Air Flow	L/min/vent; STPD	0.0	3.3	3.1
Air Flow	L/hr/vent; STPD	0	197	188
Air Flow	L/d/vent; STPD	0	4,723	4,518

CRITICAL ASSUMPTIONS	units	High	Median	Low
Daily Ventilator Census	vents	800	500	100
Duration of Ventilation	days	14	12	10
Total vent-days	vent-days	11,200	6,000	1,000
Capacity of Oxygen H-Tanks	L/tank	7,080		
Capacity of Air H-Tanks	L/tank	7,080		

Step 5b – Recalculate Oxygen Budget

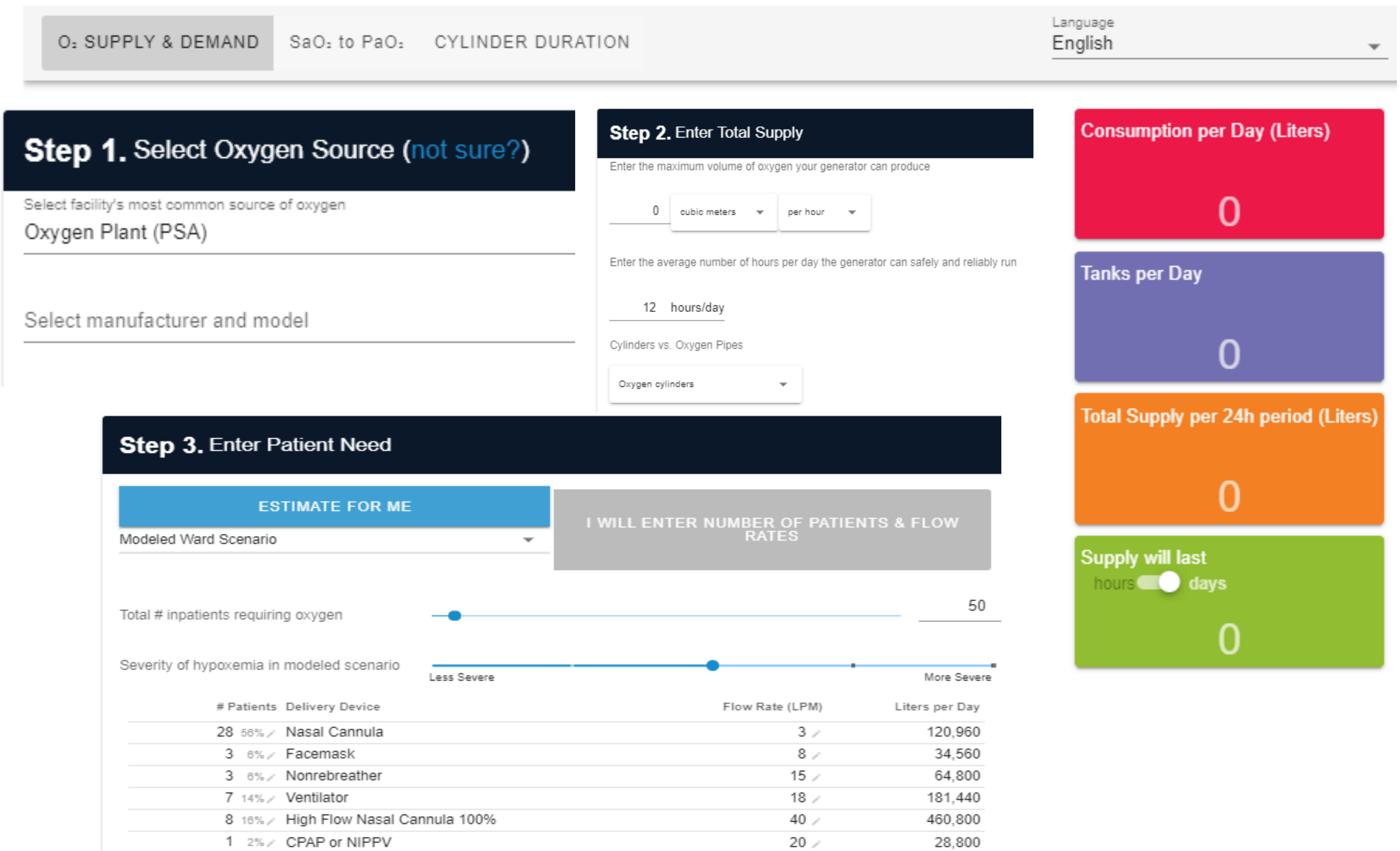
RESULTS for PIPING SYSTEMS (STPD)	units	High	Median	Low
Oxygen Consumption Rate/min	cubic feet	280	56	4
Oxygen Consumption Rate/hr	cubic feet	16,806	3,388	211
Oxygen Consumption Rate/day	cubic feet	403,335	81,305	5,052
Air Consumption Rate/min	cubic feet	0	58	11
Air Consumption Rate/hour	cubic feet	0	3,475	665
Air Consumption Rate/day	cubic feet	0	83,390	15,955

○ cubic decimeters (L) ● cubic feet

RESULTS for TANK SYSTEMS (STPD)	units	High	Median	Low
Required Oxygen H-Tanks per Day	tanks	57	11	1
H-Tanks per Population Duration of Ventilation	tanks	798	138	7
Required Air H-Tanks per Day	tanks	0	12	2
H-Tanks per Population Duration of Ventilation	tanks	0	141	23

Alternative Calculator

https://opencriticalcare.org/oxygen-supply-demand-calculator/



Practical Suggestions

1. **Consider simulation testing**
   – Place running ventilators with test lungs in each zone that might be used for critical care during surge
2. **Turn off oxygen to manual resuscitators until used**
   – Automatic shut-off devices are available
3. **Use minimal FiO_2 for adequate oxygenation**
4. **Reduce use of high flow nasal cannula for oxygen delivery**
5. **Find a way to monitor flow through zone valves**
   – Is it possible to use thermal probes across valves to represent flow?

Additional Resources

American Association for Respiratory Care

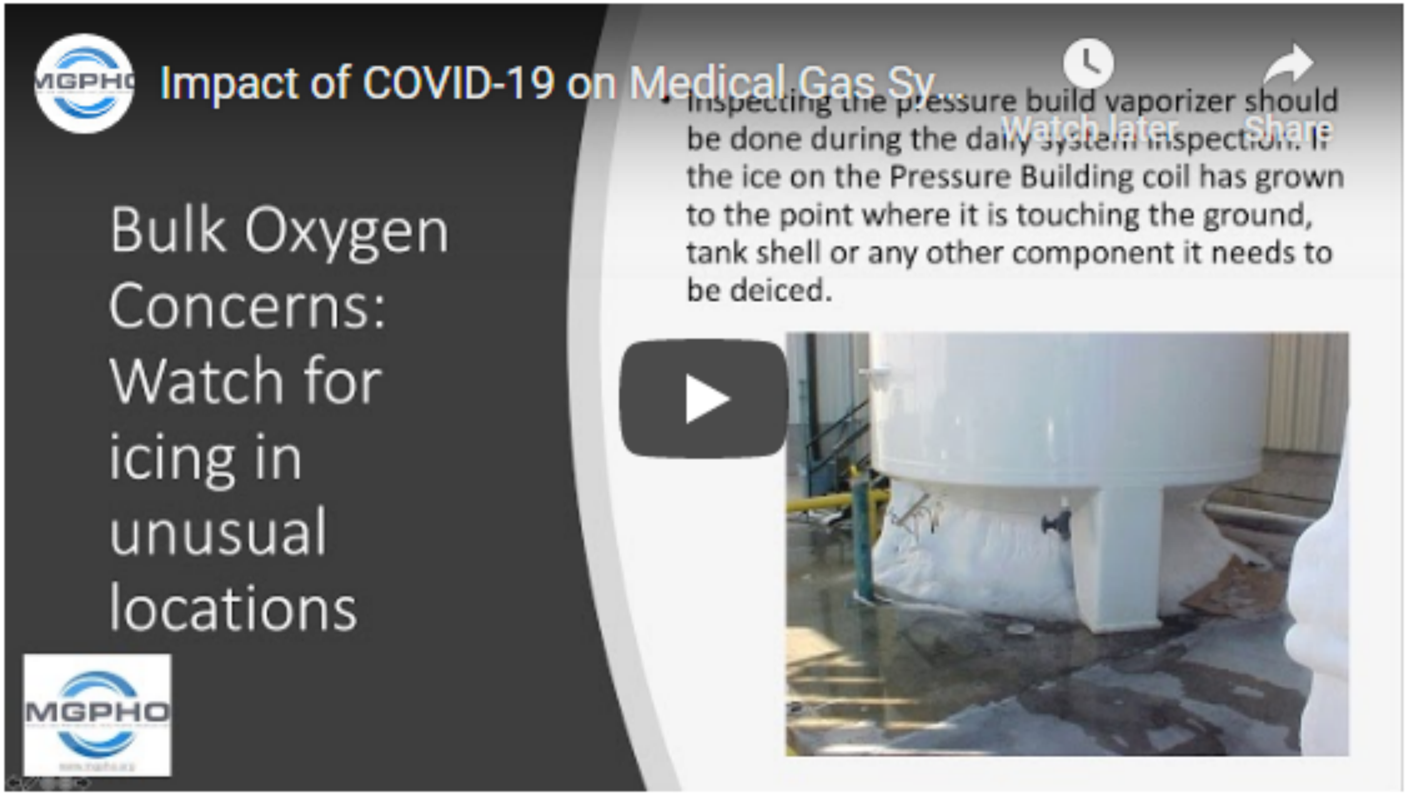
Guidance Document

Additional Ventilators May Pose a Risk to Hospital Gas Systems

https://www.aarc.org/additional-ventilators-may-pose-risk-to-hospital-gas-systems/

Medical Gas Professional Healthcare Organization

Leading through education, we save lives



https://mgpho.org/

MedGas Insights from BeaconMedæs

Issue 8, April 2020

Covid; Sizing Medical Gases

Sizing Medical Gases for Covid 19

https://www.ashe.org/system/files/media/file/2020/04/MedGasSizing-updated.pdf

KAISER PERMANENTE
National Facilities Services
Facilities Strategy Planning & Design

Medical Air and Oxygen Capacity

Medical Air and Oxygen Capacity

April 5, 2020

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https://www.dropbox.com/s/nbh6sitchxzbg36/KP%20White%20Paper%20Medical%20Air%20and%20Oxygen%20Capacity%20v3.pdf?dl=0

The Joint Commission

Maximizing Medical Gas Flow Capacity

SURGING VENTILATOR USAGE DURING THE COVID-19 PANDEMIC MEANS HEALTH CARE FACILITIES NEED TO ENSURE THEIR MEDICAL GAS SUPPLY SYSTEMS CAN DELIVER LARGER AMOUNTS OF OXYGEN AND AIR

https://www.jcrinc.com/-/media/jcr/jcr-documents/products/consulting/covid-recovery-services/max-medical-gas-ec-news.pdf

Compressed Gas Association

CGA Industry Toolkit for COVID-19 Response

(Last updated: June 26, 2020)

https://www.cganet.com/resources/cga-covid-19-toolkit/

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https://www.hamilton-medical.com/en_US/E-Learning-and-Education/Knowledge-Base/Knowledge-Base-Detail~2020-07-07~Calculating-oxygen-consumption-for-Hamilton-Medical-ventilators~c1b09f7f-3224-45b9-aa12-4cfd37e6d5ff~.html

This Lecture

Predicting
Surge Requirements
for
Medical Gas
Consumption

Robert L. Chatburn, MHHS, RRT-NPS, FAARC
Research Manager – Respiratory Institute
Cleveland Clinic
Professor – Department of Medicine
Lerner College of Medicine of Case Western Reserve University

https://1drv.ms/p/s!AuFakBJODC3DgqYHpES2jibCGaioTA?e=PCNHHz

Take-Home Messages

- **Medical oxygen and air supply systems may not be able to handle the increased usage during emergency surges (eg COVID-19)**
- **Accurate prediction of medical gas use during extreme surges requires a combination of both clinical and engineering information**
  - Simple questions to stakeholders will not suffice
  - Create a task force with content experts
    - *Facilities engineers*
    - *Respiratory therapists*
    - *Statistician*

Take-Home Messages

- **Calculators are available to make accurate estimates useful to engineers based on relevant ventilator usage data from clinical experience**
- **Other practical actions should be taken to assure adequate oxygen supplies**
- **Predicting the behavior of complex systems is extremely difficult**
  - Simplified models are tempting but may be misleading
  - This subject requires more study to improve our ability to cope with future surges