Oxygen Calculator Formulas and Assumptions

PaO2 Imputation Calculation :

SaO_2 = user input range 0 to 100%
FiO_2 = user input range 0 to 100%

Imputed PO_2 =
(11700 / ((1/SaO_2) - 1) + (50^3 + (11700 / ((1/SaO_2) - 1))^2) ^1/2) ^ ⅓

Imputed P:F = Imputed PO_2 / FiO_2
S:F = (SaO_2 * 100) / FiO_2

i. The non-linear equation utilized by this calculator is derived in Brown et al Chest 2016.

$$PO_2 = \left\{ \frac{11{,}700}{\left({}^{1}/_{S} - 1\right)} + \left[50^3 + \left(\frac{11{,}700}{{}^{1}/_{S} - 1}\right)^2\right]^{1/2} \right\}^{1/3} + \left\{ \frac{11{,}700}{\left({}^{1}/_{S} - 1\right)} - \left[50^3 + \left(\frac{11{,}700}{{}^{1}/_{S} - 1}\right)^2\right]^{1/2} \right\}^{1/3}$$

Non-linear*

Cylinder Duration Calculations:

Cylinder constants used in duration calculations:

'Size C': 0.085
'Size D': 0.17
'Size E': 0.34
'Size F': 0.68
'Size G': 1.7
'Size J': 3.40
'Size K': 3.55

Remaining Supply = cylinder constant * (gauge pressure - residual pressure)
Remaining Time = Remaining Supply / Flow Rate

Pressure in psi and Flow in LPM

* Of note: cylinder size terminology and volumes are not universally standard. You must check with the local manufacturer for cylinder capacity and size/capacity.
*Service pressure for aluminum cylinders is approximately 2000-2200 psi, while service pressure for steel cylinders may vary more widely. Always check with the manufacturer for specifications.

Cylinder Size Calculations:

The cylinder capacity calculator uses volumetric calculations based on height, circumference (or width), and wall thickness to estimate volume of the cylinder (see formulas below). This calculator assumes the shape of a cylinder which will vary from the actual shape of a gas cylinder - see ISO 7866 and ISO 9809 for details. Steel and aluminum cylinders have different wall thicknesses and knowing which type of cylinder you have is necessary for accurate estimations.

Calculated cylinder volume may vary from actual or manufacturer reported cylinder volume due to differences between the entered and actual wall thickness, shape of the bottom or top of the cylinder, or the fill pressure used to define capacity, among other potential factors. See ISO7866 and ISO9809

***Gaseous oxygen volume** = (Cylinder pressure in PSI/2000) x (cylinder pressure in psi/14.696) x pi [(outer diameter - 2(wall thickness))/2]^2 x [(height without valve)-(wall thickness) / 1000 / 1000*

***Liquid water volume capacity** = pi [(outer diameter - 2(wall thickness)/2)]^2 x [(height without valve)-(wall thickness) / 1000 / 1000*

Oxygen Supply Calculations:

Conversion factors

1 Gallon = 3.79 Liters
1 Cubic Meter = 1000 Liters

Cylinder Supply:

User inputs size of cylinder and number of cylinders. We use the following constants in Liters * number of cylinders.

'Size C': 170	Tank Constant 0.085
'Size D': 340	Tank Constant 0.17
'Size E': 680	Tank Constant 0.34
'Size F': 1360	Tank Constant 0.68
'Size G': 4100	
'Size H': 6600	Tank Constant 3.14
'Size J': 6800	Tank Constant 3.4
'Size K': 7100	Tank Constant 3.55
'7500L': 7500	

* Of note: cylinder size terminology and volumes are not universally standard. You must check with local manufacturer's for cylinder capacity and size/capacity.

Duration = (Tank Constant)(Gauge pressure - residual pressure) / Flow
Pressure in psi and Flow in LPM

Plant and Concentrator Supply:

User inputs quantity per unit of time and we convert to Liters per day * % day safely run * leakage factor

per minute Quantity * Liter Conversion * 60 * 24 * % day safely run * leakage factor
per hour Quantity * Liter Conversion * 24 * % day safely run * leakage factor
per day Quantity * Liter Conversion * % day safely run * leakage factor

For concentrators, user inputs number of concentrators and calculator multiplies above by number of concentrators.

Liquid (VIE) Supply:

User inputs total quantity in gallons or Liters (note we eliminated height as an option since we could not find a reliable calculation or constant).

Quantity converted to Liters * 861 * leakage factor

861 is the expansion factor of liquid oxygen to gaseous oxygen.
This comes from the ideal gas law, and we assume conditions of room temperature (typically from 20C-22C) and standard pressure (1 atm):

- Temperature assumption: 20 degrees [Celsius/Fahrenheit]
- Altitude: 0 [feet/meters] = 1 atm

Ideal gas law: PV = nRT
P = pressure (in atm)
V = volume (in Liters)
n = amount of substance (in moles)
R = ideal gas constant = 0.0821 (units are (Liters*atm)/(Kelvin*n))
T = absolute temperature (in Kelvin)

- To calculate volume (in Liters) of gaseous oxygen from liquid oxygen (in Liters), convert Liters of liquid oxygen to moles of oxygen.
- Multiply the Liters of liquid oxygen by 1000 to convert from Liters to mL, then multiply by its density, 1.14g/mL to obtain mass of oxygen. Divide mass of oxygen by its molecular mass (O_2 so 32g/mole) to obtain moles (n) of oxygen.
- Convert temperature to Kelvin (if Celsius, add 273.15).
- This input is entered into the ideal gas law:

$$\text{Liters of gaseous oxygen} = V = (nRT) / P$$

When sea level and room temperature are assumed, this simplifies to:

- Liters of liquid oxygen * 861 = Liters of gaseous oxygen.
- Leakage factor is then included to take into account leaks from equipment.

For demand (device consumption) calculations

User inputs number of devices and flow rate in LPM and we multiply the sum for usage in Liters per day.

Manufacturer specifications must always be referenced especially when using delivery devices with bias flow, turbines and compressors.

Device consumption does not include consideration for device leak or leak at the patient interface which may be commonly encountered.

Oxygen Consumption Calculations:

Consumption is liters per day of 100% O2 consumed, unless otherwise stated or set by the user. This calculator does not account for consumption of medical air, which may be required by some devices.

For the modeled ward scenario, users can manipulate the size of the ward and the severity of hypoxemia for patients. Some facilities may not have access to all listed delivery devices and the user must manually set those to zero. Estimates of oxygen consumption are derived from expert opinion. Although cross-sectional oxygen usage data have been published from early in the COVID-19 pandemic, the evolution of respiratory support practices—particularly the timing of intubation and the roles of non-invasive ventilation and high flow nasal oxygen—has limited the degree to which these data can be used to guide present-day estimates of oxygen demand.

Study author, journal year (url link)	Total # patients in study cohort	Location	0-5LPM (NC)	5-10LPM (FM)	10-15LPM (Non rebreather)	CPAP/BIPAP	High flow nasal cannula	Mechanical ventilation
Bellani et al, Annals ATS, 2021	8753	Milan, Italy	NA	NA	NA	10.4% (outside ICU); 6.2% in ICU. Mean FiO2 Also provides breakdown of CPAP vs NPPV	0.4%. Mean FiO2 59.2%	9.20%
Meyers et al, Kaiser Permanente	377	Northern CA	39.20%			2.10%	3.20%	29.20%

Northern California JAMA								
Ferguson et al, KP Northern California EID	72	Northern CA	30.60%	NA	8.30%	NA	2.80%	18.10%
Argenziano et al, NYP Columbia BMJ Open	1000	NYC	56%		36.50%	14%	4.1% (Venturi + HFNC)	23.30%

For nasal cannula, facemask, and non-rebreather

FiO2 is assumed to be 1.0 and flow rates are adjustable in liters per minute.

Liter per day consumption of O2 = device flow rate L/minute x 60 minutes/hr x 24 hr/day

For high flow nasal cannula

FiO2 is adjustable (defaulted to 1.0) and flow rate is adjustable in liters per minute.

Liter per day consumption of O2 = device flow rate L/minute x 60 minutes/hr x 24 hr/day; flow rate in LPM = device flow rate x (FiO2 - 0.21)/0.79

For ventilator, CPAP, BIPAP/NIPPV

FiO2 is adjustable (defaulted to 1.0) and flow rate is adjustable in liters per minute and dependent on multiple factors.

Liter per day consumption of O2 = device O2 consumption rate L/minute x 60 minutes/hr x 24 hr/day

Device O2 consumption rate in LPM = (Minute ventilation + (bias flow x RR x expiratory time/60) + leak) x (FiO2 - 0.21)/0.79