

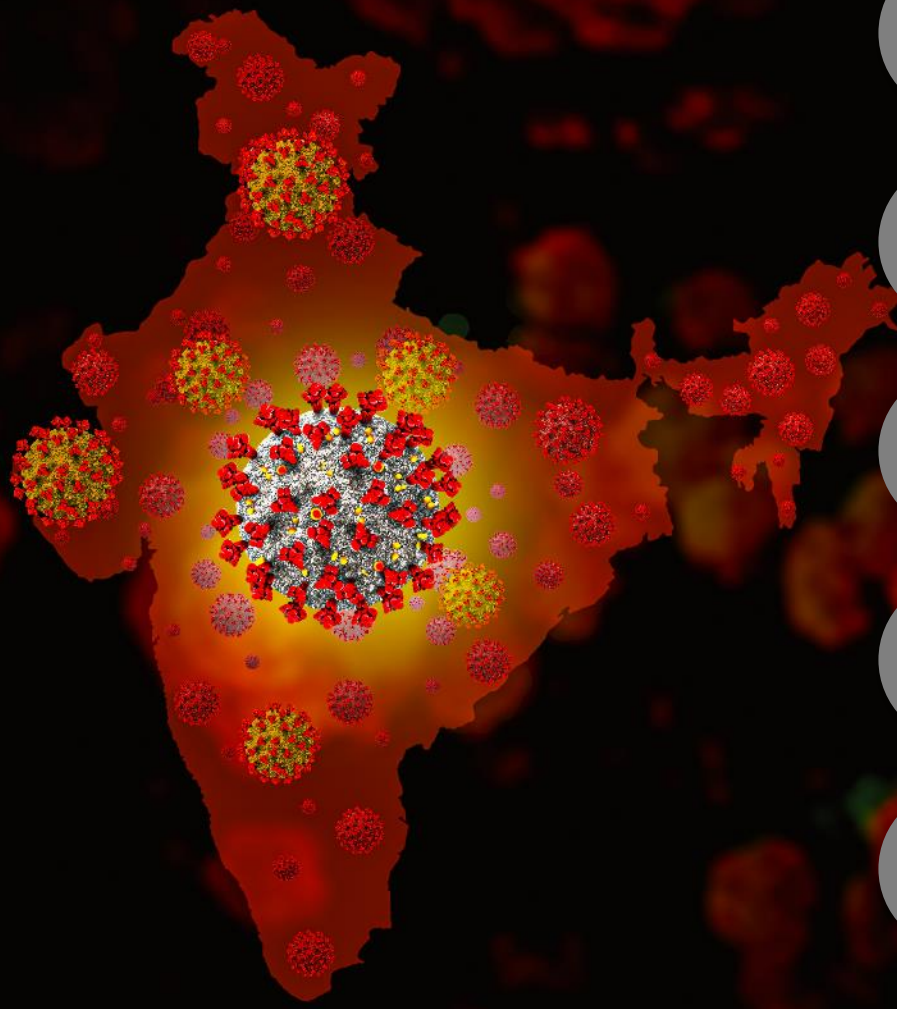


TATA CONSULTING ENGINEERS LIMITED

ENGINEERING A BETTER TOMORROW
OVER FIVE DECADES

Portable Oxygen Concentrator Using Oxikit Open Source For Make in India

Introduction



1

India is battling with the worst 2nd wave of Covid-19 Pandemic

2

Several big hospitals across India are relying on daily oxygen supplies but they are not getting enough to keep some as backup in case of emergency

3

The situation is worse still in small hospitals that don't have storage tanks and have to rely on big cylinders leading to Oxygen crises

4

The need of an hour is to develop portable oxygen concentrators to save lives

5

Tata Consulting Engineers (TCE) has prototyped an Indigenous portable O₂ Concentrator using opensource Oxikit design with 100% Indian components

6

TCE is open to assist MSME's who have regulatory approvals from authorities for mass manufacturing

About Oxygen Concentrators: Technology & Major Components

Oxygen Sources



Cylinders

- Very common
- Mobile but can be heavy
- Require high pressure compressor for filling
- Require supply chain



Manifold Systems

- Cylinder based
- Require supply chain
- Require facility to have piping
- Relatively low maintenance
- Difficult to repair

Pressure Swing Adsorption



Concentrators

- Mobile
- Do not require supply chain
- Require electricity
- Require maintenance



Oxygen Plants

- Do not require supply chain
- Require electricity
- Require maintenance
- May need piping
- Capable of filling cylinders



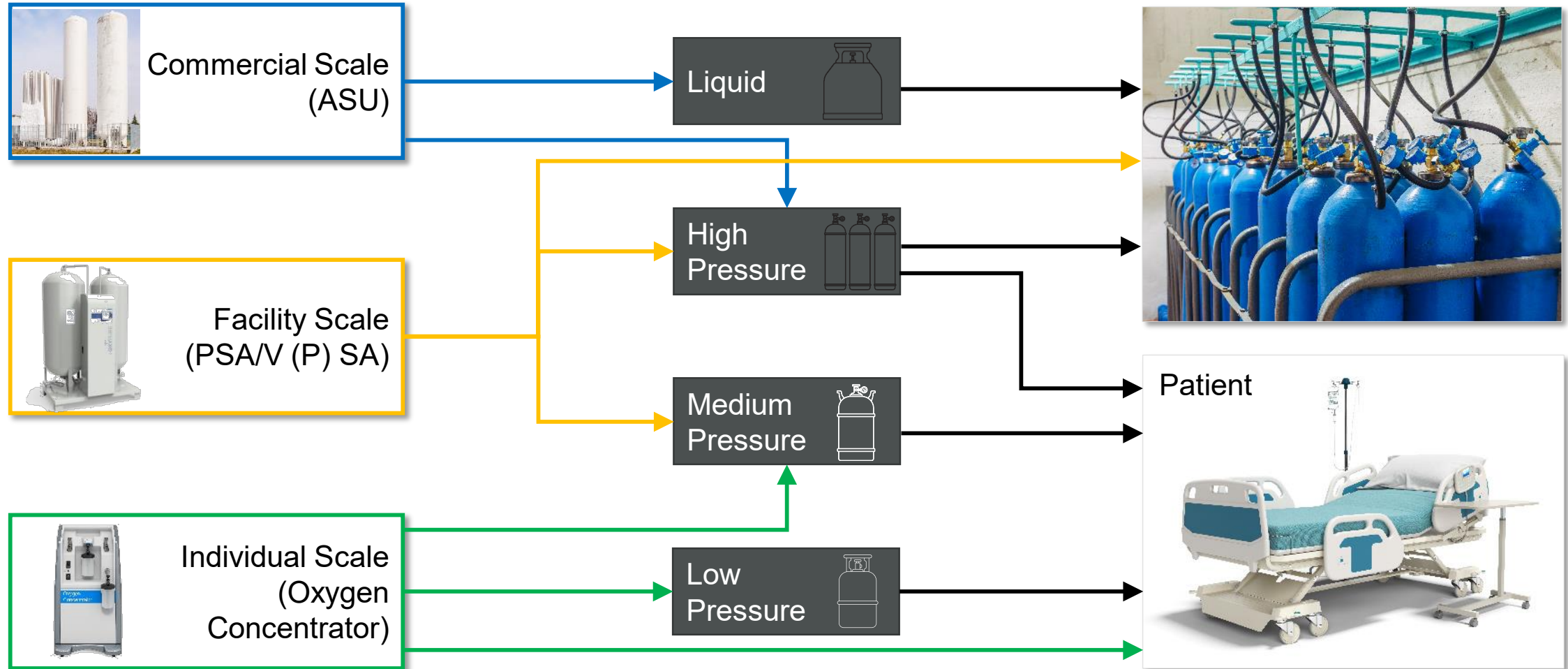
Liquid Oxygen

- Space requirements
- Requires facility to have piping
- Supply chain
- Suitable for larger facilities

About Oxygen Concentrators: Technology & Major Components



Oxygen Product Mix



Oxygen Production

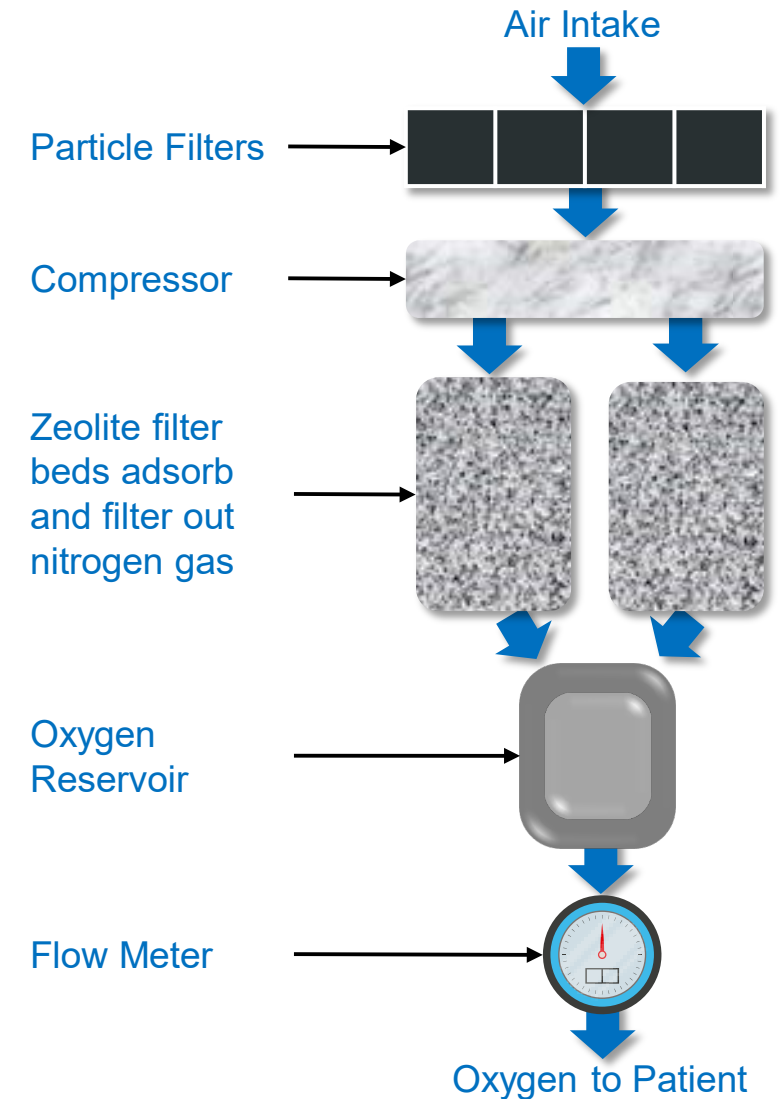
Oxygen Storage

Oxygen Delivery

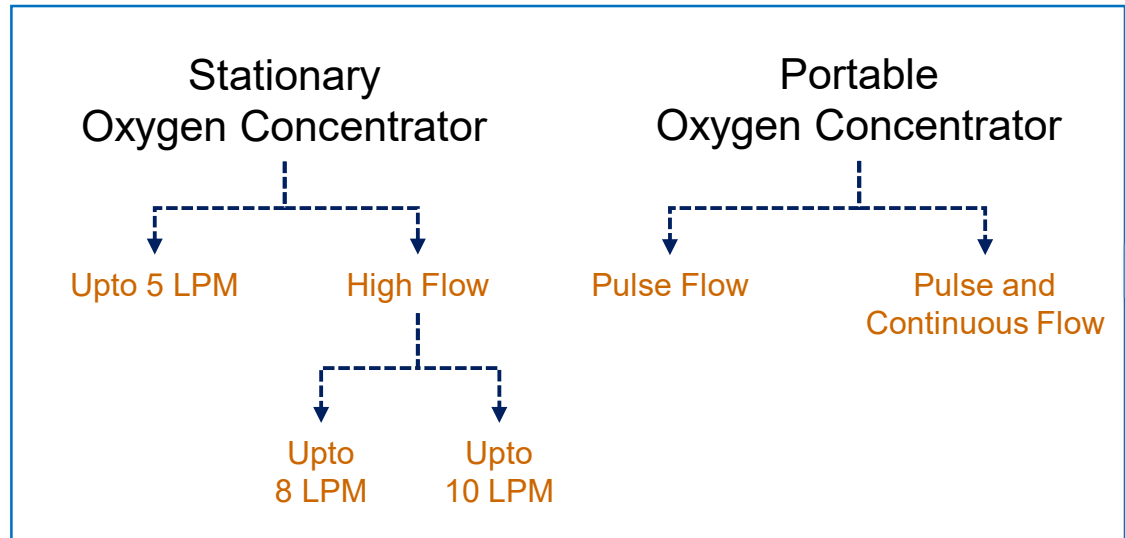
Oxygen Concentrators: How It Works?



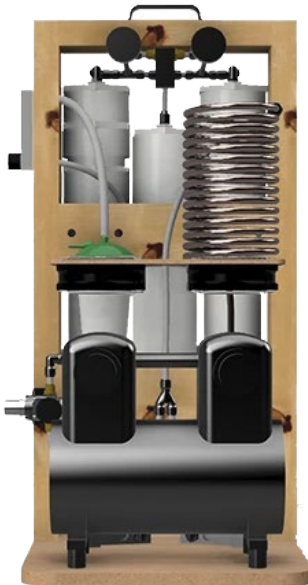
1. An oxygen concentrator is a self-contained, electrically powered device designed to concentrate oxygen from ambient air.
2. Utilising a process known as Pressure Swing Adsorption (PSA), an oxygen concentrator produces up to 95.5% concentrated oxygen.
3. Atmospheric air is drawn through a gross particle and intake filter before moving through a compressor.
4. The pressurised air passes through a heat exchanger to reduce the temperature before entering sieve beds that contain zeolite, a mineral material that preferentially adsorbs nitrogen gas (N₂) at high pressures.
5. As each sieve bed is depressurized, N₂ is released. Valves open to deliver concentrated oxygen into a reservoir where it accumulates, and from which a flowmeter can be used for measured and continuous release of oxygen to the patient at a specified flow rate



Oxygen Concentrators: Oxikit – Why?



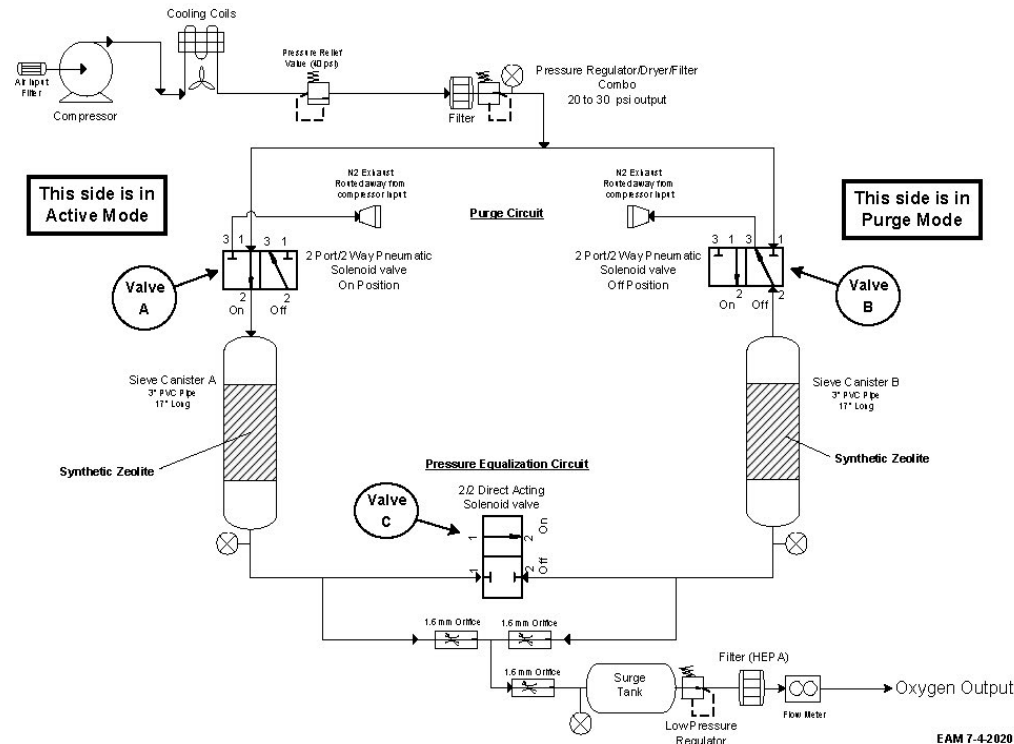
5 -10 LPM Concentrators are available in the market. Concentrators with **higher output flow (more than 15 LPM)** will help to reduce pressure on existing Oxygen supplies



<https://oxikit.com>

Offers **24 liters per minute (LPM)** of O₂ with **92% concentration**

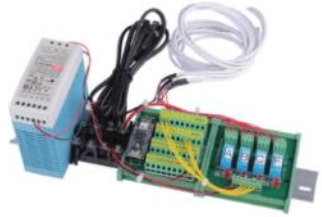
Oxikit – DIY Concentrator



1. An open-source Oxygen concentrator anyone can build.
2. Offers **24 LITERS PER MINUTE (LPM) OF O₂ WITH 92% CONCENTRATION.**
3. Easy to build design
4. ARDUINO UNO BOARD – Open Code
5. Assembly procedure / videos available for ease of assembly
6. **OUTPUT - 20 LPM+ AT 90%+ CONCENTRATION**

Oxikit's Specifications compelled TCE to build prototype with localised parts (Make In India)

Oxikit – Main Components



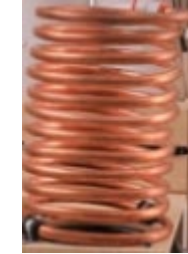
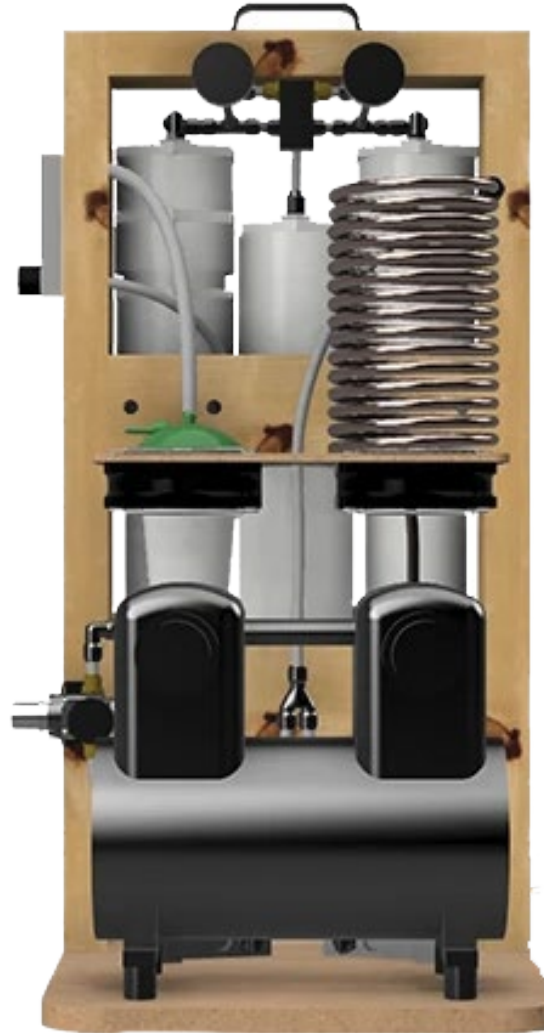
Arduino Uno Board



Solenoid Valves/Tubing/Fittings



Pressure Gauges/Flow meters etc.



Cooling Coil
1 no.



Zeolite Sieve
Beds – 2 nos.



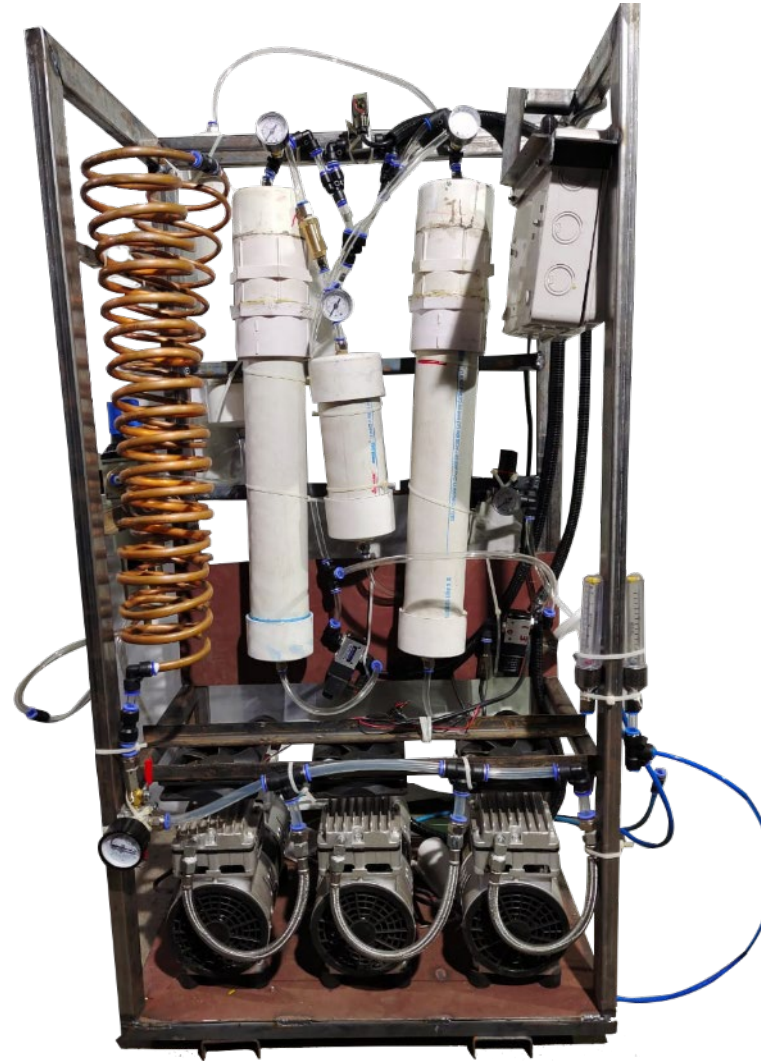
Surge Tank
1 no.



Compressor



TCE Prototype

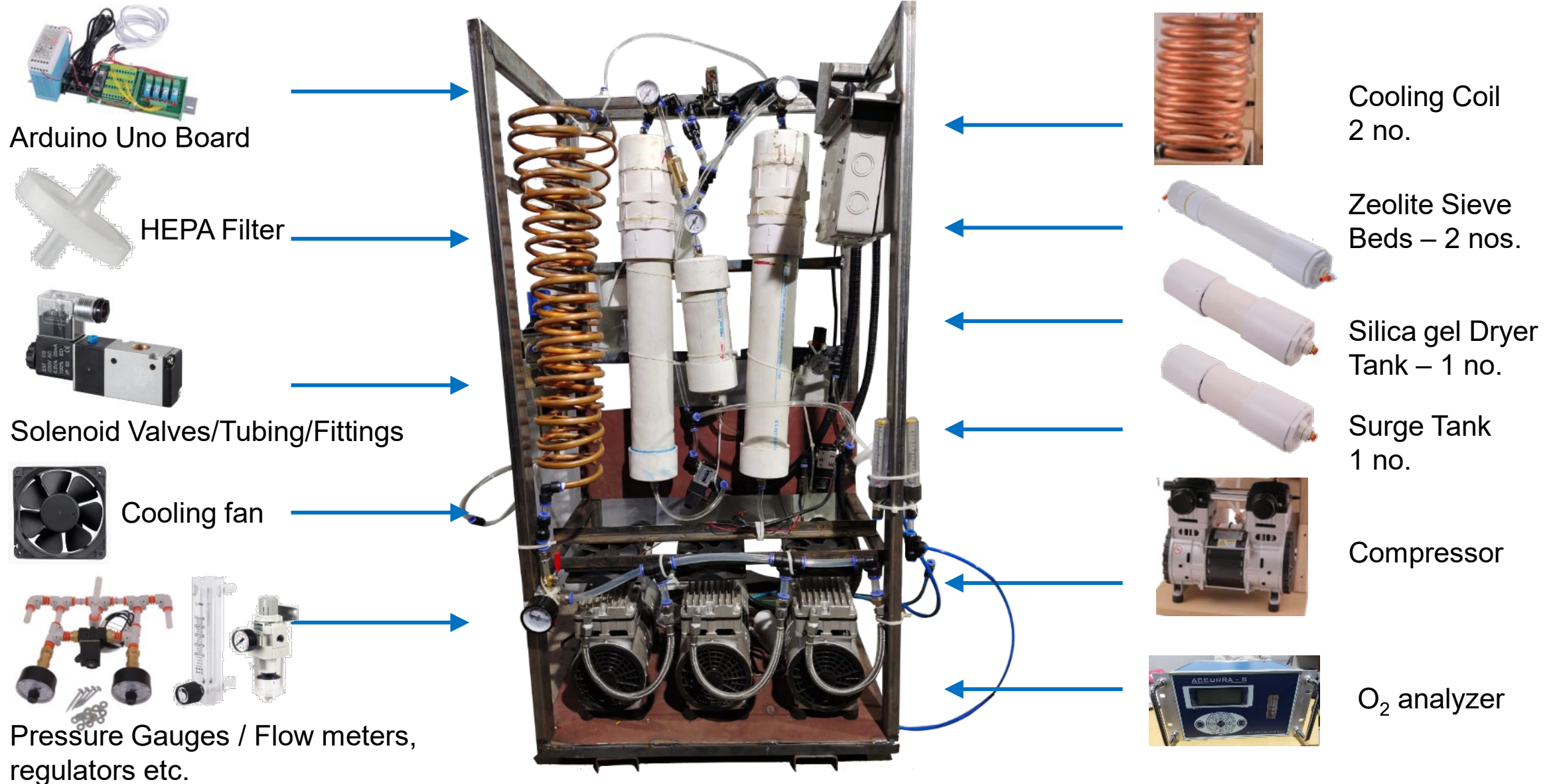


**Output Flow
18 - 22 LPM**

**O₂ Concentration
92 - 95%+**

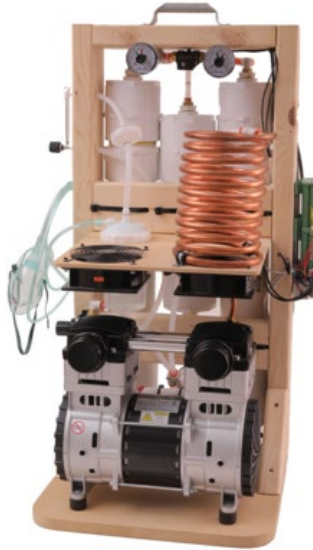
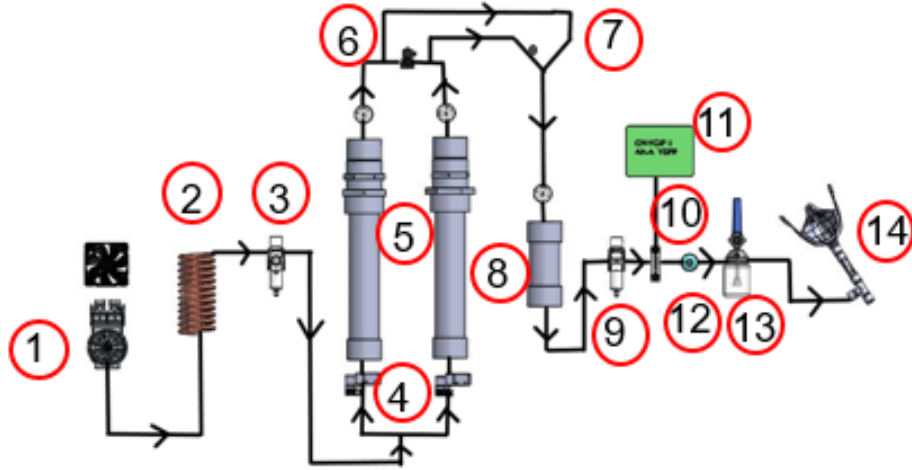
**Molecular Sieves Sodium
based Zeolite @3.2 kg**

Oxikit – Main Components



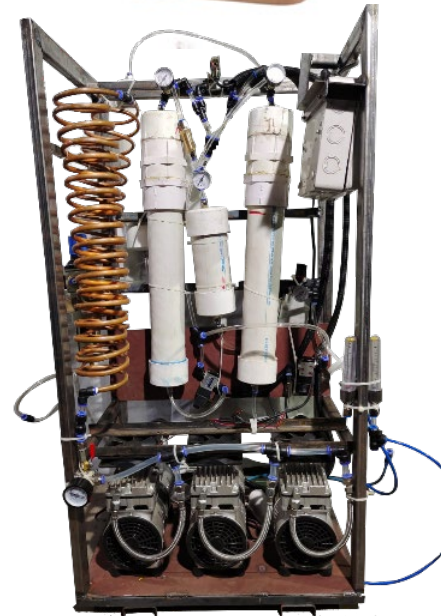
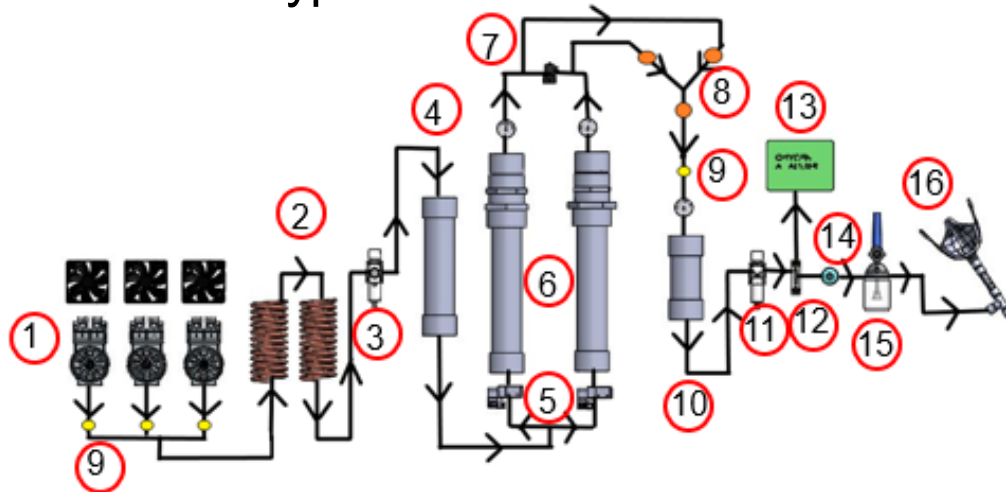
TCE Prototype - Enhancements

Oxikit oxygen generator



1. Air compression
2. Air cooling coil
3. Air Filtration and Regulation
4. 3/2 Charge/purge valve
5. Adsorbing tower A
Adsorbing tower B
6. Pressure equalisation valve
7. Orifice
8. Surge Tank
9. Low pressure regulator
10. Oxygen flow meter
11. Oxygen analyser
12. HEPA Filter
13. Humidifier
14. Oxygen mask

TCE Prototype



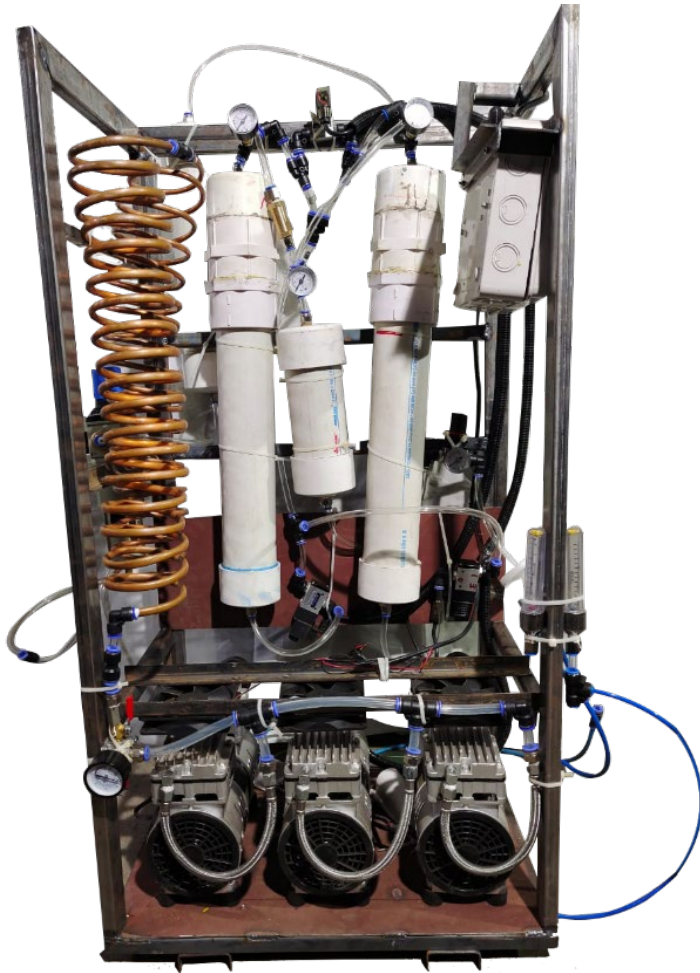
1. Air compression
2. Air cooling coil
3. Air Filtration and Regulation
4. Air Drying (Silica gel dryer)
5. 3/2 Charge/purge valve
6. Adsorbing tower A
Adsorbing tower B
7. Pressure equalisation valve
8. Orifice
9. Non return valve
10. Surge Tank
11. Low pressure regulator
12. Oxygen flow meter
13. Oxygen analyser
14. HEPA Filter
15. Humidifier
16. Oxygen mask

● Non-Return Valve (NRV)

TCE's Value Addition

1. Use of Compressor head without tank to reduce overall weight and cost of compressor
2. 2 nos. of cooling coils considering ambient temperature in India
3. Low-cost Silica Gel Dryer bed to improve O2 Concentration
4. Non return valve at input of surge tank to maintain the pressure in surge tank.
5. Modification of Absorbing tower assembly to suit locally available parts

Prototype to Mass-Production



400 x 600 x 1000 mm
Width x length x height
Prototype



Can be compacted to
300 x 500 x 750 mm
Production



Illustrative image – manufacturer to decide as per marketing strategy



TCE Prototype - Components



Component	Other names	Function
Enclosure	Cabinet, interior	Encases internal components of the concentrator
Compressor	Not applicable	Pressurizes and pumps air into the system
Filter Regulator	Air treatment unit	To filter out dust and moisture from input air
Fan	Cooling fan	Circulates air on compressor heads to cool them.
Cooling Coil	Heat exchanger	Dissipates heat created by gas compression
Arduino Uno Board	Control circuit, PCB, Printed Circuit assembly	Analyses the system state and controls the valves and compressor
Silica gel dryer	Silica gel dryer, De-humidifier	To absorb moisture from the input air.
Valve assembly	Solenoid, check, rotary valves	Controls the flow process for the sieve and exhaust
Molecular sieve beds	Sieve column, Zeolite sieves columns/ bed	Adsorbs nitrogen from air
Exhaust muffler	N2 exhaust muffler, silencer	Expels and quiets the N2 rich air released back into the room
Surge tank	Product tank, accumulator tank, mixing tank, Reservoir tank	Gas accumulator for providing a steady and continuous flow
Flowmeter	Flow selector	Controls the delivered flow rate
HEPA filter	-	Removes the particulates from the product stream
Oxygen analyzer	Oxygen purity analyzer	Displays the oxygen concentration in output
Humidifier	Bubble humidifier, bubbler	Humidifies the delivered gas before inhalation.

Current Performance & Results

As of 12.05.2021

- a) Achieved 22 LPM ambient temperature
- b) Oxygen Concentration between 94% to 95.5%
- c) Machine under continuous running to be extended to 24-48 hours – currently measured for 3-6 hours of continuous running

As of 14.05.2021

- a) Achieved 22-25 LPM ambient temperature
- b) Oxygen Concentration between 92% to 95.5%
- c) Machine under continuous running to be extended to 24-48 hours – currently measured for 3-6 hours of continuous running
- d) 3-4 masks checked for flow rate



TEAMS are working on the prototype to gather data under varying conditions and duration – the output of these runs shall be shared in coming days

TCE Prototype – Specification of Main Components



Component	Specification	Make Used in Prototype
Air compressor	Brand: GAHL Model:GA750-3-90L Power: 2.25KW/3HP ; Voltage: 240V/50Hz Exhaust Volume: 405L/Min / 14.3 CFM Maximum Working Pressure: 8 Bar / 116 Psi Noise ≤70dB ; Tank Capacity: 90L	M/s NIPB Industrial Brushes India Private Limited, Chakan, Pune
Cooling coil	2 nos. , Material = Copper Dia of Coil = OD 10 mm ID = 100 mm Height = 570 mm	
Dryer	Silica gel Dryer Silica weight = 2 kg	M/s Royal Tools & Hardware Dow Corning Dealer India, Pune M/s CILICANT CHEM PRIVATE LIMITED for large quantities
Molecular sieve / Zeolite	Zeolite 13X: Brand – Nitroxy5 (ARKEMA) Diameter : 0.4-0.9mm Sodium based zeolite Quantity – 3.2 Kg	Similar make of Sodium Zeolite may be used after studying their specification sheet.
Solenoid Valves	As per BOM	M/s Aeroflex

TCE Prototype – Assembly Procedure



1. Prepare Support structure.
2. Prepare molecular sieve (Zeolite) bed 2 no's and keep for PVC bond curing for 12 hrs.
3. Prepare surge tank and silica gel dryer bed and keep for PVC bond curing for 12 hrs.
4. Assemble 3 compressor heads and Colling fan onto support structure
5. Prepare cooling coils and Position the 2 cooling coils
6. After curing, the 2 molecular bed, Surge tank and Silica gel dryer are mounted on the structural frame.
7. Mount the filter and flow meter.
8. Prepare the electrical circuit.
9. Prepare the pneumatic connection as per pneumatic circuit diagram.
10. Prepare Electronic connection and logic circuit.
11. Run the Equipment.

1. Main Website: <https://oxikit.com/>
2. Bill of Material (US Parts) :
https://cdn.shopify.com/s/files/1/0518/9671/3414/files/Oxikit_Documentation_V.4.pdf?v=1619411248

Important Videos:

1. https://youtube.com/playlist?list=PL4O1RQEIpHBJ0i1zqe-CZk1p_NTtGI76 OxiKit: How to Build DIY Oxygen Concentrator 15 LPM at 98% Concentration – All Videos
2. <https://youtu.be/hJ9agj3yWJc>
3. <https://youtu.be/8fDJ30SG4NA> - OxiKit How to Build: Principles of the DIY Oxygen Concentrator - 15 LPM 98 Percent O2 Concentration
4. <https://youtu.be/2U1sdMwJ1gE> - OxiKit How to Build: Sieve Canister Assembly Part 1 - 15 LPM 98% High Flow DIY Oxygen Concentrator

Frequently Asked Questions:



Question: What are main components of this Oxygen concentrator?

Answer: The main components of this oxygen concentrator are Compressor (Oil free), Zeolite Sieve beds, cooling coils, silica bed dryer, Arduino Uno Board (Electronic circuit), solenoid valves, fittings, pressure gauges and oxygen flow meter.

Question: Can I use any compressor for this concentrator?

Answer: You must select **Oil Free (DENTAL Air Compressor)** for this concentrator. It is suggested to use only compressor heads to reduce cost and overall weight of the equipment.

Question: What is the maximum concentration of oxygen that can be achieved with the concentrator?

Answer: Up to 94%

Question: Are all components used in this concentrator are available locally?

Answer: All components used this concentrator are available locally and are made in India components except for Zeolite Sieves. You may contact Zeolites & Allied Products Pvt. Ltd. for supply of Nitroxy5 Zeolite used in this concentrator.

Question: Is specification of main components available?

Answer: Please refer BOM giving specifications of main components. [TCE oxygen concentrator Proto BOM](#)

Question: Is assembly of this concentrator complex?

Answer: No. Assembly is very simple. Refer animation file showing assembly of 3D model. [Prototype-3D assembly](#)

Frequently Asked Questions:



Question: Is Silica bed dryer necessary?

Answer: You can use any suitable dryer in the circuit. The dryer is necessary to confirm flow of dry air which will help in achieving desired O₂ concentration. Silica bed air dryer is used due to its low cost and ease of availability.

Question: Can I use any Zeolite for this concentrator?

Answer: You must use 13X Sodium/ Lithium based zeolite sieves of 0.3 – 0.6 mm grade (diameter). Higher grade (diameter) shall not be used for this concentrator.

Question: Is use of Arduino Uno Board for electronics compulsory ? And related Code?

Answer: Concentrator uses simple electronic circuit required to open and close solenoid valves. Hence you can use any electronic circuit available with you. Arduino Uno Board open source boards are also easily available. The valve timing code may be downloaded from Oxikit website – but will need to be refined aligned with your device / pressure / volume rate / ambient conditions – minor tweaking required

Question: Can you supply these concentrators?

Answer: Please note that we do not fabricate any equipment, we have built working prototype using local available parts as mentioned above. For actual supply of the unit, you will need to contact MSME who have regulatory approvals.

Question: What are the Precautions during usage of the oxygen concentrator?

Answer: some of the precautions to be considered are:

- The concentrator should be placed as far away from the window as possible to avoid dust and moisture
- It should be kept far away from open flames
- When a flow-splitter is being used, the total flow should not exceed more than 7 liters per minute or the concentration of oxygen will decrease. This should be checked frequently to confirm desired O₂ concentration.

Frequently Asked Questions:



Question: What are the enhancements aligned to Indian ambient conditions

Answer: Following enhancement were done

- addition and Use of low-cost silica gel Desiccant dryer to improve oxygen concentration
- approx double length of cooling coils used. 2 nos. of cooling coils used.
- addition of non return valves (NRV)
- use of Arkema 0.4 mm Nitroxy-5 zeolite
- use of 3 compressor of 1 HP in parallel (Power: 2.25KW/3HP ; Voltage: 240V/50Hz, Exhaust Volume: 405L/Min / 14.3 CFM, Maximum Working Pressure: 8 Bar / 116 Psi)
- zeolite packaging in the adsorption containers must be done carefully / and to ensure better packaging of zeolite proper spring selection is needed
- other than above exact specifications, dimensions and design has been carefully adhered to from standard oxikit specification.
- Output of 20-22 LPM @ 92-95% Oxygen concentration is at 25 PSI (1.7 bar)
- Note that this design is for Oxygen Concentration output from 7-22 LPM for 92-95% Oxygen concentration. Any range outside of this 7-22 LPM may result in reduction of Oxygen Concentration.

Frequently Asked Questions:

Question: Can you provide details of spring used?

Answer: Spring details are given below (Refer attached image for complete details)

OD = 70mm ; ID = 64mm ; Mean Diameter = 67mm

Spring Index = 22.33

Units:	mm
Outer Diameter (OD):	70
Inner Diameter (ID):	64
Mean Diameter (D):	67
Load @ Solid Height:	20.02
Solid Height (H):	33
Total Coils (N or Nt):	11
Active Coils (n or Na):	9
Free Length (L):	110
Wire Diameter (d):	3
Rate (R):	0.26
Deflection (F1):	77
Index (C):	22.33
Wahl Factor (K):	1.06
Part Weight:	0.1317
Tensile Strength:	1595
Max % Allowed of Tensile:	35

Question: what are details of Silica dryer?

Answer: Details of Silica dryer are given below

OD = 80mm ; ID = 40mm ;

Total Length of canister = 410mm (End to End)

Quantity of Silica used = approx. 2 kg



Frequently Asked Questions:



Question: Any suggestions for preparation of Zeolite Sieve beds?

Answer: Suggestive steps for preparation of Zeolite bed are given below:

- 1) Assemble all parts of the Canister and conduct dry run using air to check for any leakages from joints.
- 2) Ensure that 13X Sodium/ Lithium based zeolite sieves of 0.3 – 0.6 mm grade (diameter) is used.
- 3) Prepare assembly of canister without Zeolite. Remove top end cap assembly (including spring/SS mesh/mesh cap etc.) and do marking of level upto which Zeolite should be filled.
- 4) Start filling Canister with small quantities of Zeolite. Vibrate canister after every 2-3 filling using hand vibrating machines (low intensity). Take appropriate care while using vibrator so as not damage PVC pipes.
- 5) Fill Canister with Zeolite upto marking.
- 6) Vibrate Canister using hand vibrating machines (low intensity) 5-6 times. Repeat this step after 5-10 mins.
- 7) Fill the Zeolite into Canister till it reaches marking. This will ensure proper height of Zeolite bed in the canister
- 8) Assemble End cap including spring/SS mesh/mesh cap etc.
- 9) Keep Canister filled with Zeolite for settling for 15-30 mins.

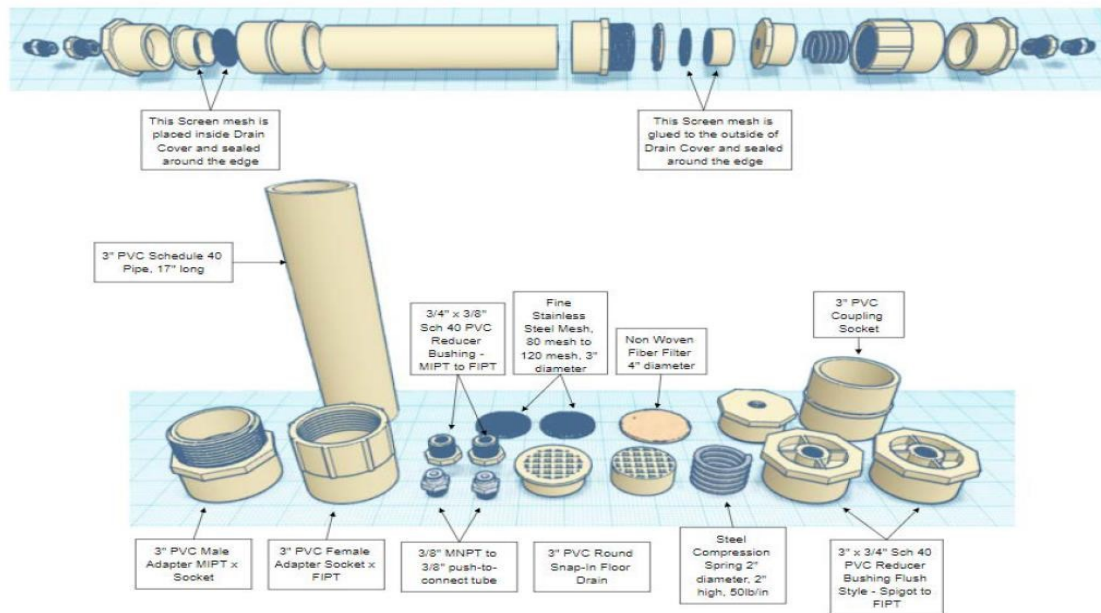
Frequently Asked Questions:

Question: Any other suggestions or modifications in canister carried out?

Answer: Canister design is slightly modified considering availability of parts in local market. Please refer images given below showing all necessary details. Refer 3D model for more details.

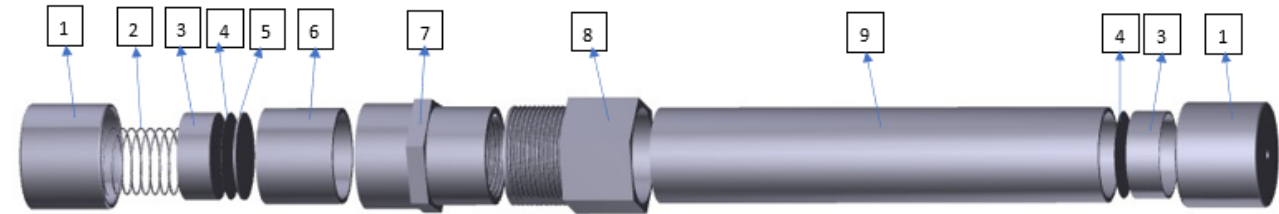
Oxygen Concentrator Sieve Assembly - with labels

(Important: PVC parts should be schedule 40 - not DWV)



E.A.M. 7/7/2020

Canister - Oxikit



BOM :

- 1 - End Cap 3" SCH 40 Pipe
- 2 - 2.8" Diameter x 3" Tall - Compression Springs - 50 lb per inch tension
- 3 - SS 304 mesh guide U Cup
- 4 - 304 Stainless Steel Woven 100 Mesh
- 5 - Non-woven Filter Material - Vent Register Filter
- 6 - 3" PVC SCH 40 Pipe Small section (Approx. 3.5")
- 7 - 3" Schedule 40 PVC Female Adapter - Socket to FIPT
- 8 - 3" Schedule 40 PVC Male Adapter - MIPT to Socket
- 9 - 3" PVC SCH 40 Pipe Small section (Approx. 15")

Canister - Prototype

Frequently Asked Questions:

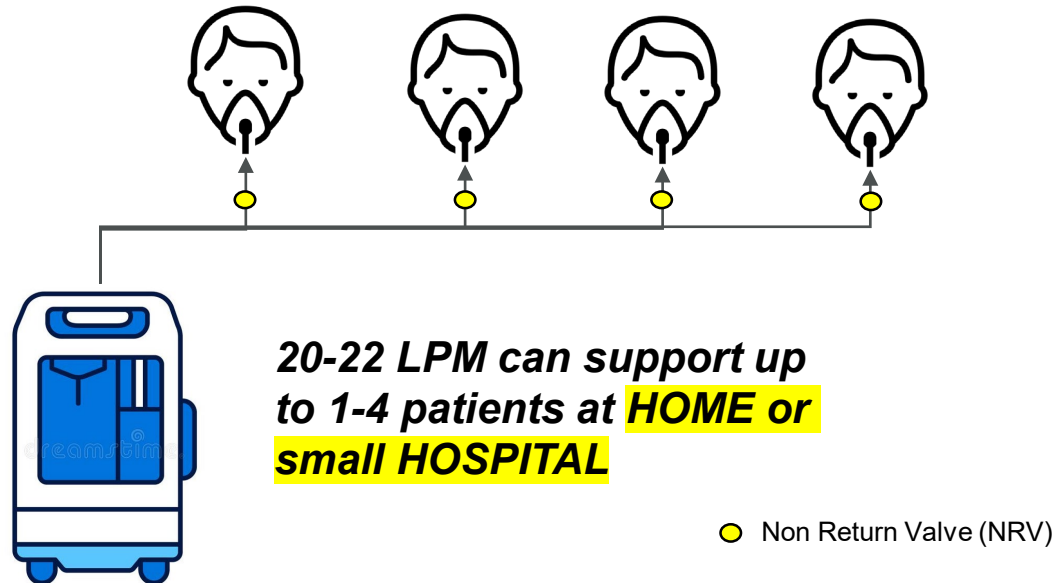


OXYGEN Generation using O2 Concentrator: Rollout of an Opensource Oxygen concentrator design for use by start-ups, entrepreneurs and MSME across India.

- a. Prototype leveraging opensource design (www.oxikit.com), has been accomplished in less than five (05) working days, with complete local parts as available in India (except Zeolite) and with benchmark results of 20-22 LPM of 94-95% Oxygen concentration.
 - i. Critical design changes and process refinements were incorporated to ensure benchmarked results under Indian conditions
 - ii. We have used Sodium Zeolite and avoided Lithium-Zeolite keeping in mind the Indian ambient conditions, Zeolite availability, and to ensure a competitive price point advantage.
 - iii. Our refined prototype uses 3.2 Kg (7 pounds) Sodium Zeolite (0.4mm) to produce 20+ LPM of 94-95% Oxygen concentration.
 - iv. Except the Zeolite, we have used locally available Indian parts for the prototype.
 - v. With patients requiring between 10-20 LPM and keeping in mind need for such devices in villages and interior parts of the country, we have kept the specification at 20 LPM and above.
 - vi. We have calculated (pure material cost approx. 50-60k) and a benchmarked competitive price of INR 75k (+/-10%) for the specification designed, which can be further optimized based on mass-manufacturing and bulk procurement strategies.
- b. Oxikit teams approached us and informed that TCE has been the first team in India to achieve this milestone – we humbly thank them – true success will be when we enable and ensure that 1000 more achieve this milestone in INDIA at the earliest – with actual products coming out of manufacturing facilities in lacs soon, and with that vision we have shared everything online with the link and details

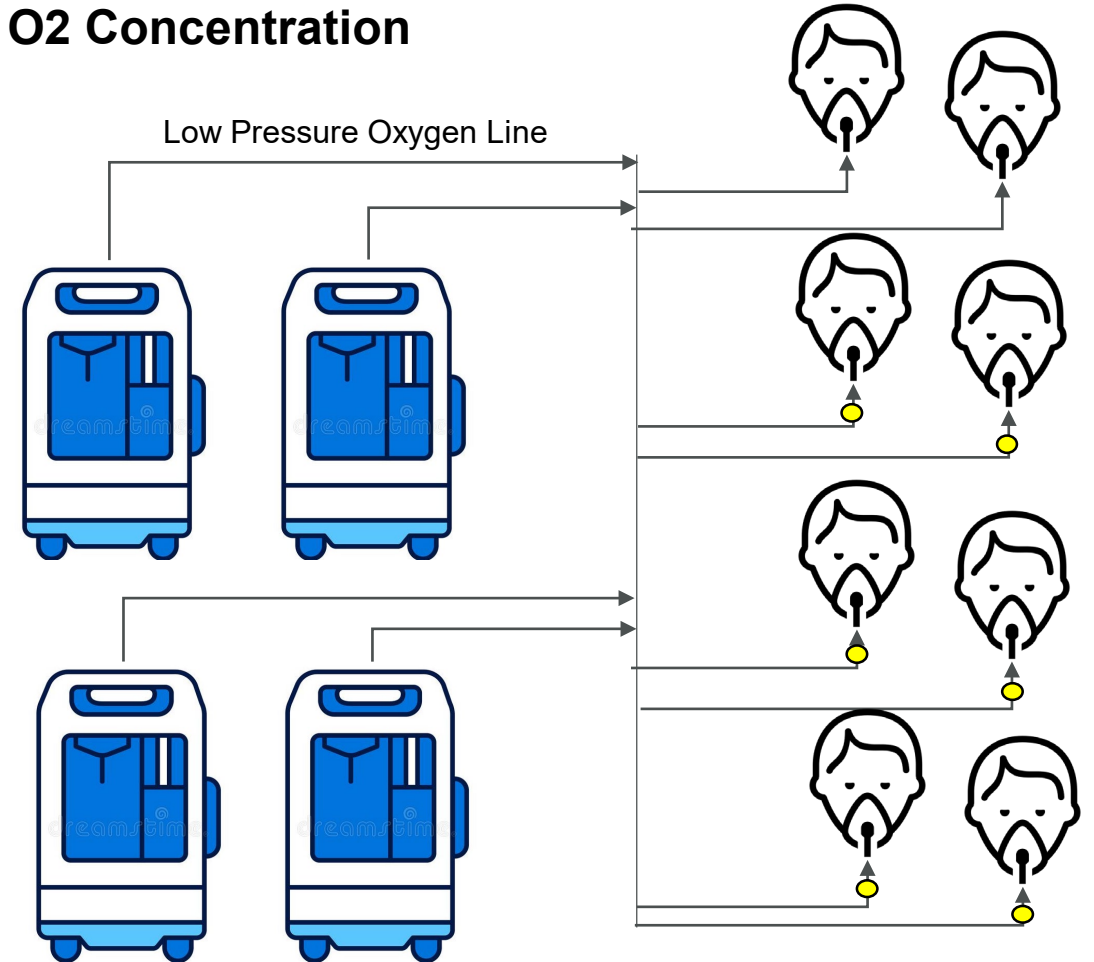
Some Metrics and application

1. 3.2 KG (7 lb) Sodium Zeolite
2. Range of optimal performance 7-22 LPM for 92-95% Oxygen concentration.
3. Possible Price point INR 60-90k



NOT SUITABLE FOR VENTILATOR which requires 4-4.5 Bar as the O2 Concentrator produces 1.5-1.7 Bar output for 20-22 LPM @ 92-95% oxygen concentration

20-22 LPM @ 92-95% O2 Concentration



4-10 Machines connected can support a **HOSPITAL in rural India or villages – 10 Machines for 200 LPM**

Important Links: Click to Download



- 1) [TCE Oxygen Concentrator Proto BOM with Suppliers](#)
- 2) [Prototype 3D Assembly Animation](#)
- 3) [TCE Prototype - 3D Model Drawing](#)
- 4) [Sample Arduino Code](#)

Thank You

For any questions and details please write to

SUBJECT: O2 Concentrator

tceconnect@tce.co.in