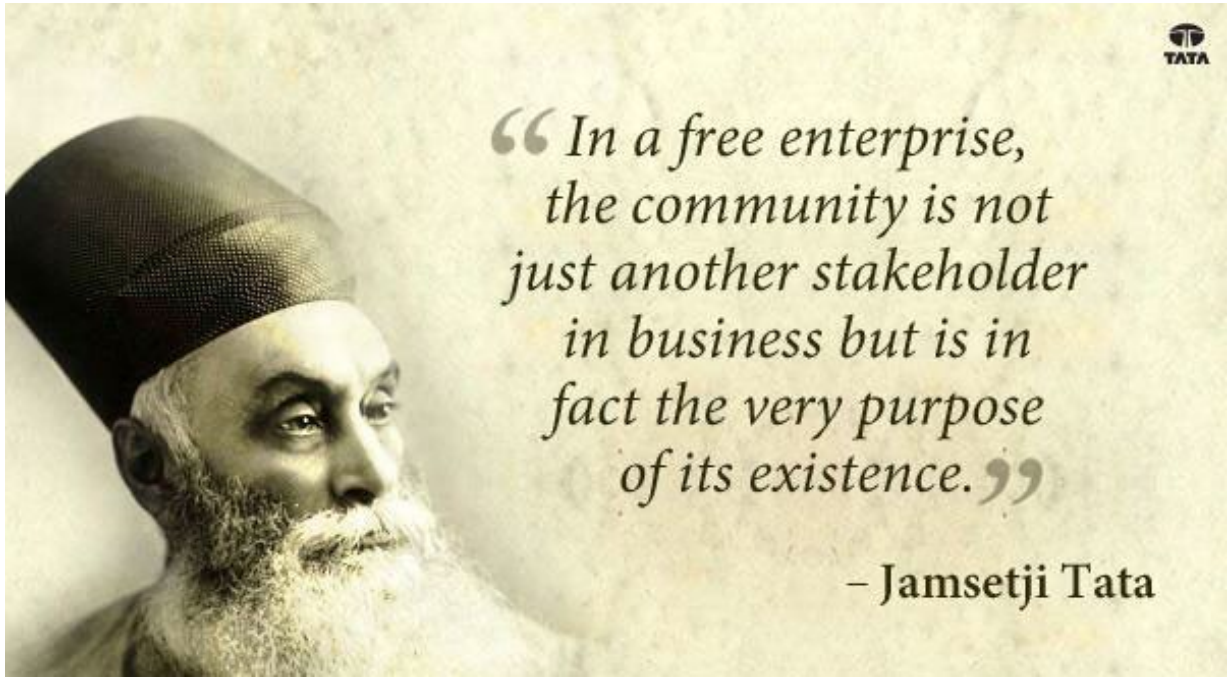
TATA CONSULTING ENGINEERS LIMITED

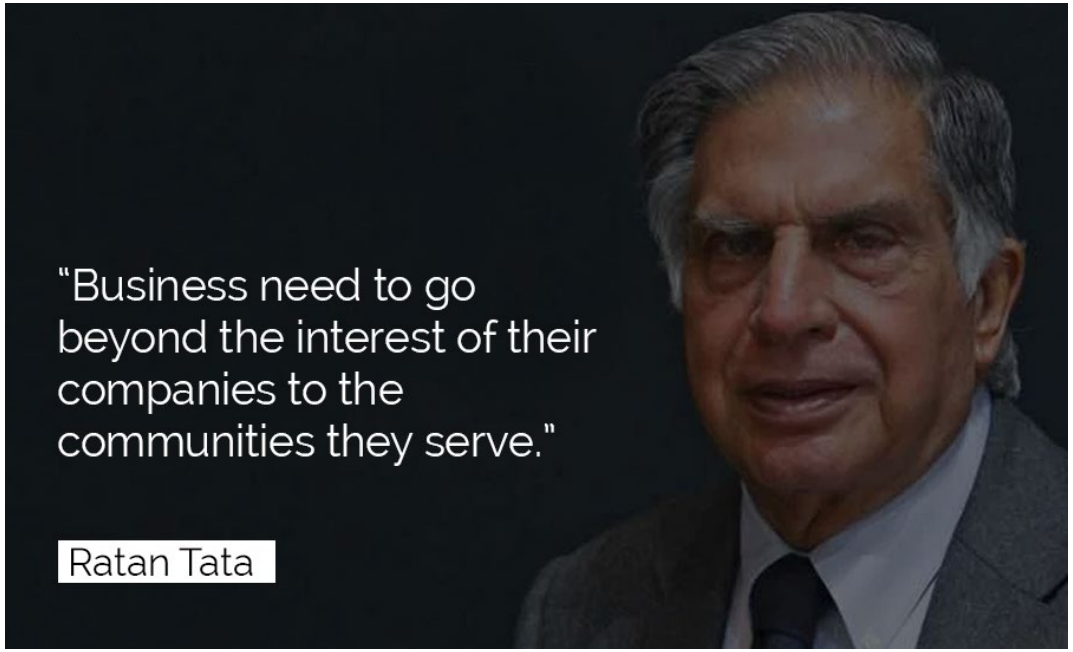
ENGINEERING A BETTER TOMORROW

SINCE 1962

TCE Emergency Response to FIGHT COVID

The Tata Group





The Tata Group

150+ years heritage.
started in **1868**

700+ MN
consumers in **150** countries

750,000+ employees
operating in **100+** countries

$21.3 BN brand value
among top **100** globally

$106+ BN group revenue
17x in 25 years

$242+ BN market cap
India's **LARGEST** business house

TCE: Engineering a Better Tomorrow

59+ YEARS
of Technical Excellence

$35+ BN WORTH PROJECTS
under management

10000+ PROJECTS
Delivered Globally

3000+ ENGINEERS
across all domains

33000+ MLD WATER & WASTEWATER
treatment done

15+ MN HOURS
3D engineering across businesses

170+ GW POWER PLANTS
engineered globally

SECTORS SERVED

POWER
- Thermal
- Nuclear
- Renewables
- Hydro
- Transmission & Distribution

RESOURCES
- **Hydrocarbons & Chemicals :** Oil & Gas, Petrochemicals & Refineries, Food & Pharma, Specialty Chemicals
- **Mining & Metallurgy:** Ferrous & Non-Ferrous, Geology & Mining, Beneficiation, Material Handling

INFRASTRUCTURE
- Water and Wastewater
- Environment & Buildings
- Sustainability
- Urban Development
- Industrial Facilities
- Urban Transport
- Ports & Harbours
- Project Management
- Safety
- Procurement Management

SERVICES OFFERED

EDPM – Engineering Design & Project Management

- DESIGN & ENGINEERING
- PROJECT MANAGEMENT & SAFETY
- PROCUREMENT MANAGEMENT
- DIGITAL & ADVANCED TECHNOLOGIES

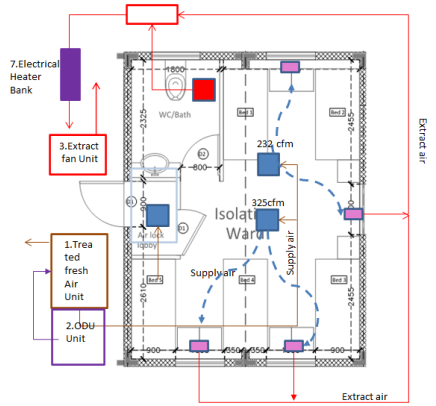
TCE Core Values

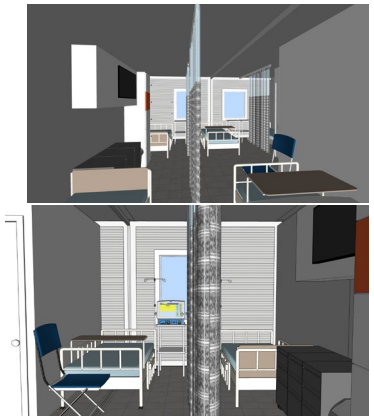
- Customer satisfaction and loyalty
- Responsibility to society
- Organisational and individual growth
- Technical excellence with professional ethics
- Employee dignity and self respect

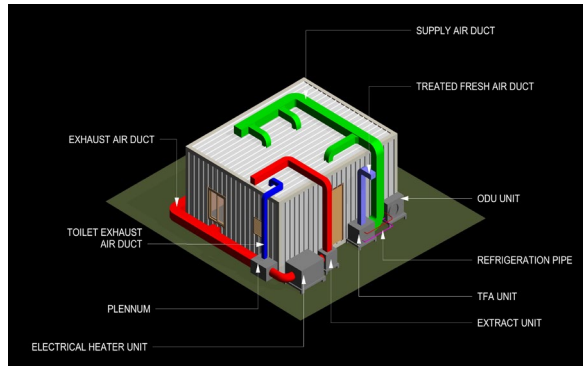
Covid Aid 2020 Efforts:

Engineering Consultancy by Tata Consulting Engineers (TCE)

COVID MODULAR Hospitals



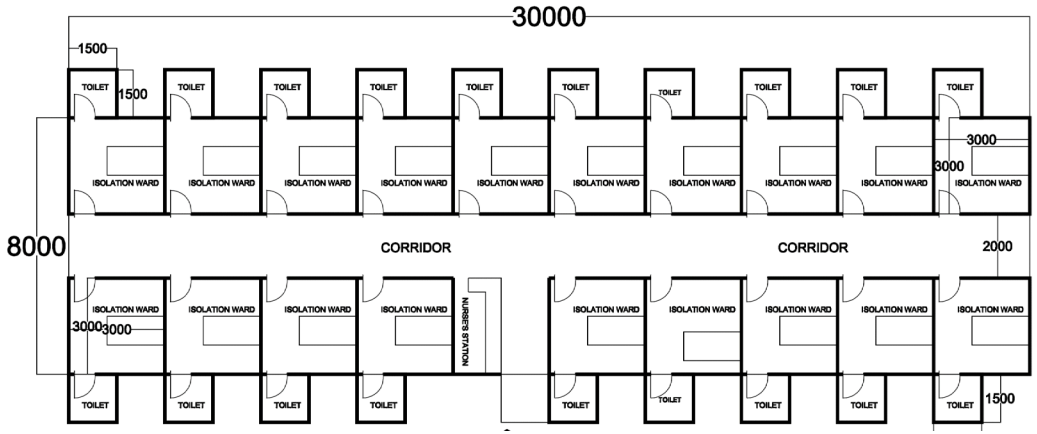


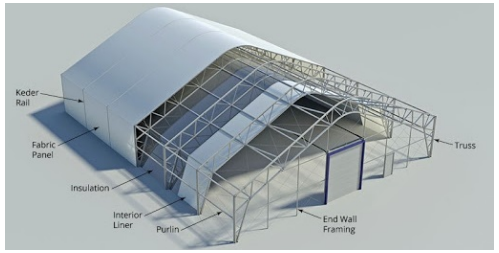


Opensource Ventilators

1. Multiple Ventilator design were studied feasibility under emergency conditions was evaluated (No prototypes were done only feasibility evaluations)
2. OpenSource Medtronics Ventilator was finally zeroed upon and manufacturing firms were conveyed to explore tie-up and manufacturing

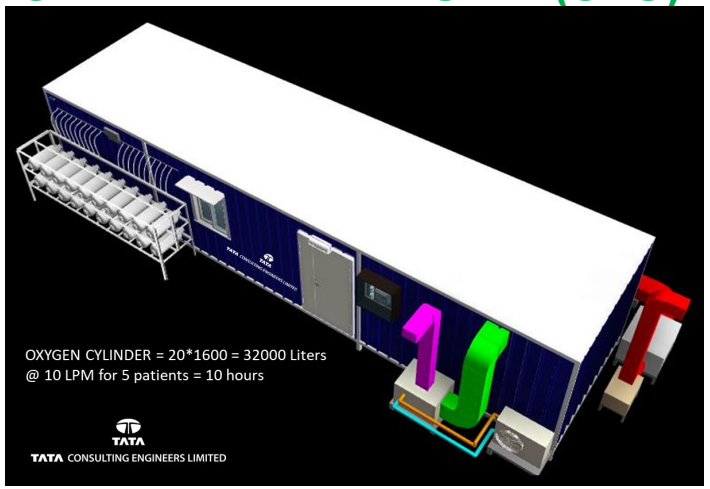
COVID JUMBO Hospitals





Covid Aid 2020 Efforts:

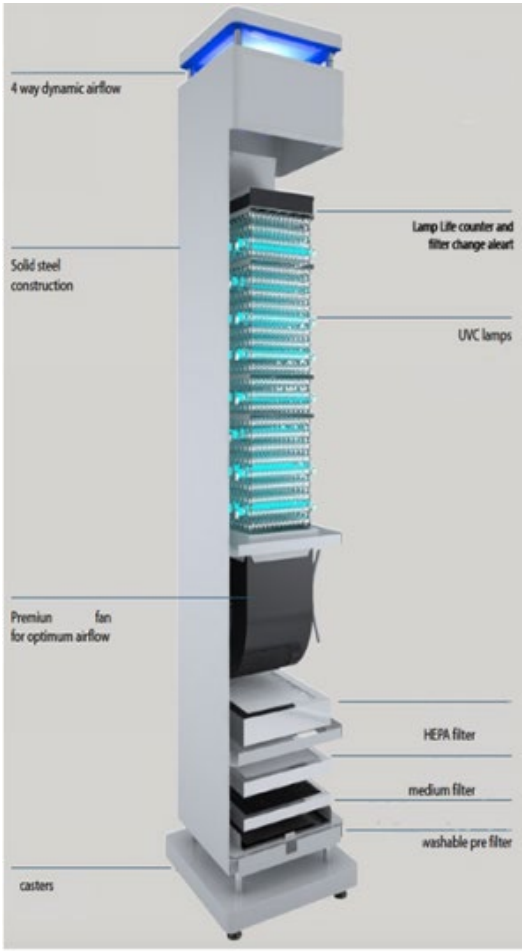
STANDARD TATA UNIT (STU)



Variants: STU (Vaccination), STU (Isolation) STU (ICU Units)

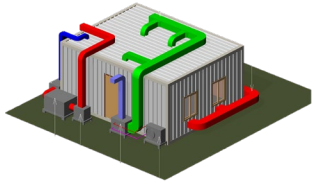
Modular solution, fully plug and play, can give 5 bed to 500 or more.

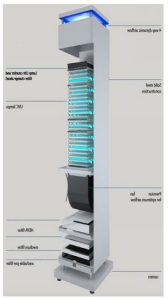
VLRU



UV Based Viral Load Reduction Unit @

ICIS (INTEGRATED COVID INFRASTRUCTURE SOLUTION)

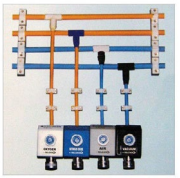


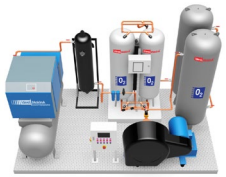


Vaccine Refrigerator

MOBILE GREEN POWER

Oxygen readiness





Covid Aid 2020 Efforts:

Engineering Consultancy by Tata Consulting Engineers (TCE)

PSAN2O2 & PSAO2

Innovative open source solution for Plant scale Oxygen generation

1. Conceptualised an innovative idea and engineered the conversion of existing PSA Nitrogen plants to PSA Oxygen plants
2. Implemented successful pilot with IIT Bombay in 03 days
3. Partnered with Tata Chemical for required sourcing of Zeolite from Europe
4. With the support of Min of Commerce, PSA, DSIR & CSIR received GOI – IAF support for urgent airlifting of a critical resource for the conversion
5. Ongoing program under Min of Environment, CPCB, TCE is project managing feasibility of more than 150+ plant (80,000 LPM) conversion across India, with 65 confirmed plants (35,000 LPM) as on date
6. and providing technical expertise, design guidance and consulting to 1500+ teams across India in their endeavour to solve the oxygen crisis
7. Technical Specs, zeolite procurement & assistance for NEW oxygen plants

C2O

Solutions for effective Oxygen supply chain

1. by proposing an innovative solution of using existing cylinders (LPG/CO_2) for Oxygen distribution
2. by leveraging the existing supply chain of LPG / CNG for Oxygen supply across the country

O2C

Solution for portable Oxygen generation

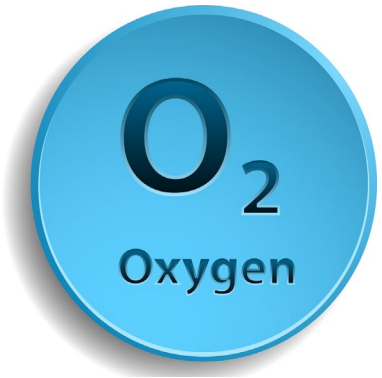
1. Supporting MSME across India for mass manufacture of Oxygen Concentrators
2. Working prototype of Portable Oxygen Concentrator with an open-source design created in 05 days
3. 100% indigenous concentrator supporting India's Atmanirbhar Vision
4. Prototype produces 20 LPM @ 94% oxygen purity

Consulting on Oxygen Generation supply chain and capacity enhancement

1. across various States, namely Rajasthan, Maharashtra, Uttar Pradesh, Odisha, Andhra Pradesh, Silvassa, Gujarat
2. to NGOs, hospitals including Tata Medical Centre for their Oxygen augmentation and readiness
3. Emergency Modular Units with Oxygen, AC and Medical support

Covid 2021 FOCUS : Response towards mitigating OXYGEN Crisis

1. **PSAN2O2** : PSA Nitrogen Plant to Oxygen Plant Conversion
2. **PSAO2:** PSA New Oxygen Plant Installation
3. **C2O**: Cylinder for Emergency Oxygen
4. **O2C** : Oxygen Concentrators



CONSULT - ENGINEER - ENABLE

GOAL ~10,000 MT / Day of OXYGEN !!!

TCE Teams Involvement – Consulting, Design, Sourcing other support

Conversion of Industrial Nitrogen Generation Units for Oxygen Generation

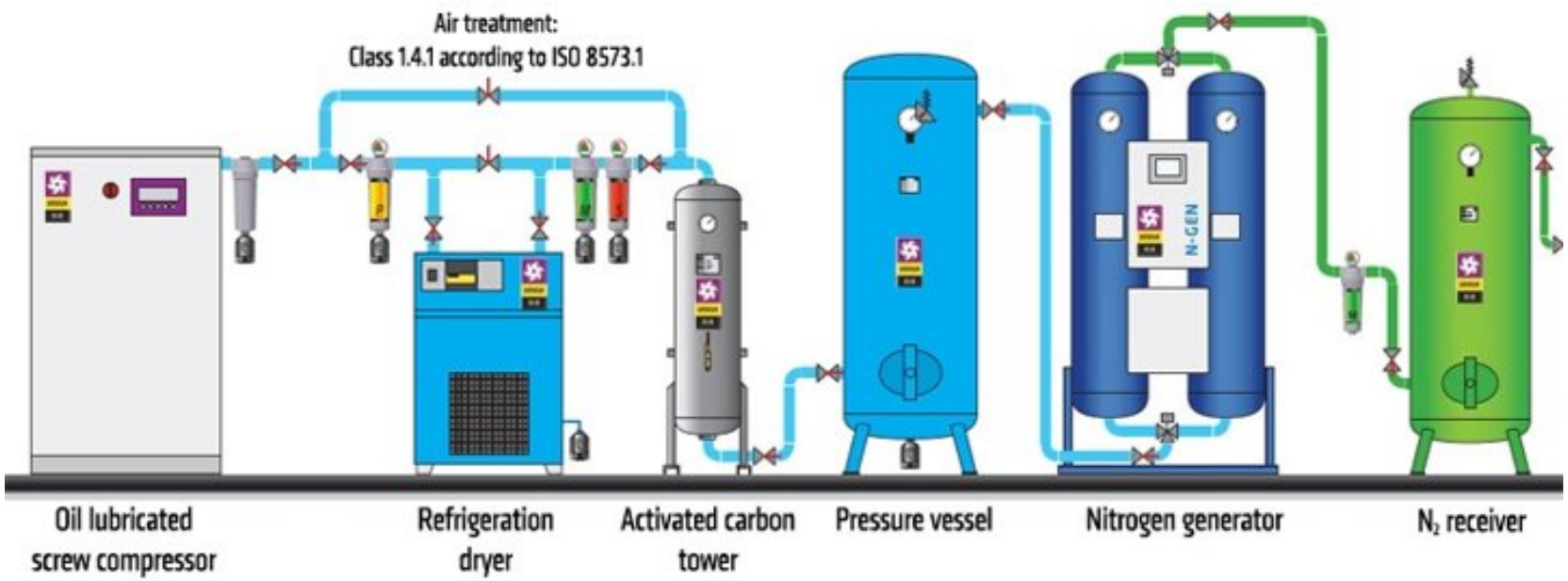
+

New PSA Oxygen Plants

PSA-N2O2 Conversions : CPCB as Anchor Body :
More than 65 Ongoing – 35,000 LPM (70 MT/Day) to be added in next few days

Supported PSA Oxygen Plants : More than 50 Ongoing – 25,000 LPM (50 MT/Day)

OUTCOME = 60,000 LPM = 120 MT/Day !!



Pressure Swing Adsorption (PSA) technology

Emergency Oxygen Storage and Distribution : Ongoing Efforts

PP Pilot Projects

Use of CO_2 Fire Extinguisher Cylinders for Storage of Oxygen

PP Pilot Projects

Use of LPG Cylinders for storage of Oxygen

PP Pilot Projects

Use of CNG Cylinders for storage of Oxygen

Involved Authorities

THESE CONVERSIONS CAN ONLY BE DONE BY GOVERNMENT AUTHORITIES.

All these methods INVOLVE Statutory, Legal and other APPROVALS. Proper cleaning and COLOUR coding of CYLINDERS is required for SAFETY reasons. A governance mechanism involving government officials, PESO, Controller of Explosives, Fire Department, Medical Department (Min. of Health) and administrative authorities is required for related compliances and approvals.

OUTCOME = 8000 MT of Oxygen Storage addition

1. 80 Lacs LPG Cylinders* (average O2 600 litres /cylinder)
2. 7200 MT

1. 3 Lacs CO2/CNG Cylinders (average O2 1600 litres /cylinder)
2. 600 MT

*India has ~40 Cr Household LPG Cylinders

This Conversion Program needs to be executed at a NATIONAL Scale to realize above numbers

Focus on Oxygen Concentrator : O2C

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 O_2 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

TARGETED OUTCOME = 1,00,000 O2C = 20,00,000 LPM = 4000 MT/Day

Manufacture Up to 1,00,000 Oxygen Concentrators IN 100 DAYS

Our Opensource Approach to help GLOBAL Fight against COVID

UN goals for Sustainable Development

While our Efforts were triggered due to INDIAN Crisis – We believe these efforts will help countries and communities worldwide

The Opensource movement is to enable global communities to get access to basic element – OXYGEN – and that's a step towards aligning with the UN Sustainable development goals

TATA CONSULTING ENGINEERS LIMITED

ENGINEERING A BETTER TOMORROW
SINCE 1962

Portable Oxygen Concentrator
Using Oxikit Open Source
For Make in India

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

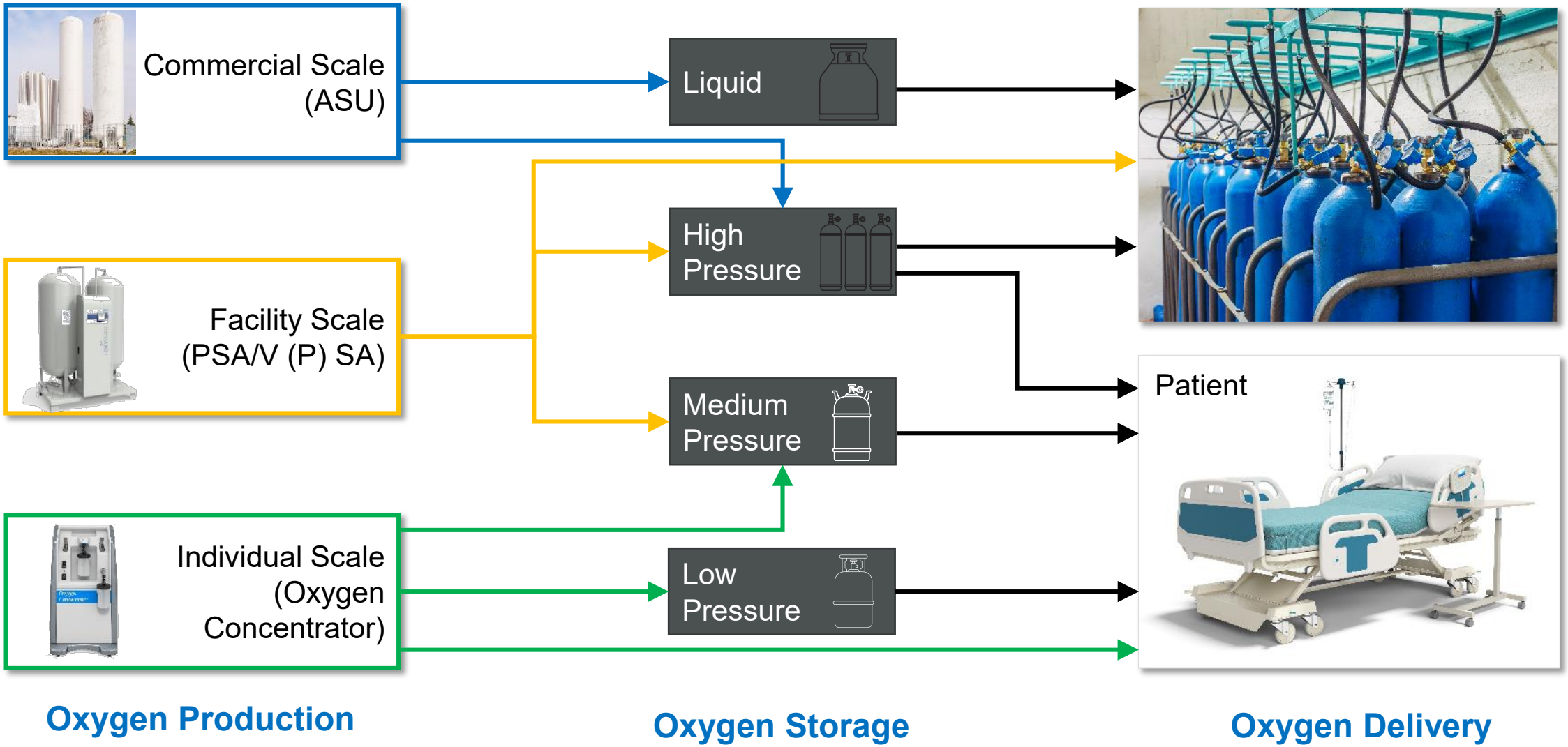
- Do not require supply chain
- Require electricity
- Require maintenance
- May need piping
- Capable of filling cylinders

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 Concentrators: How It Works?

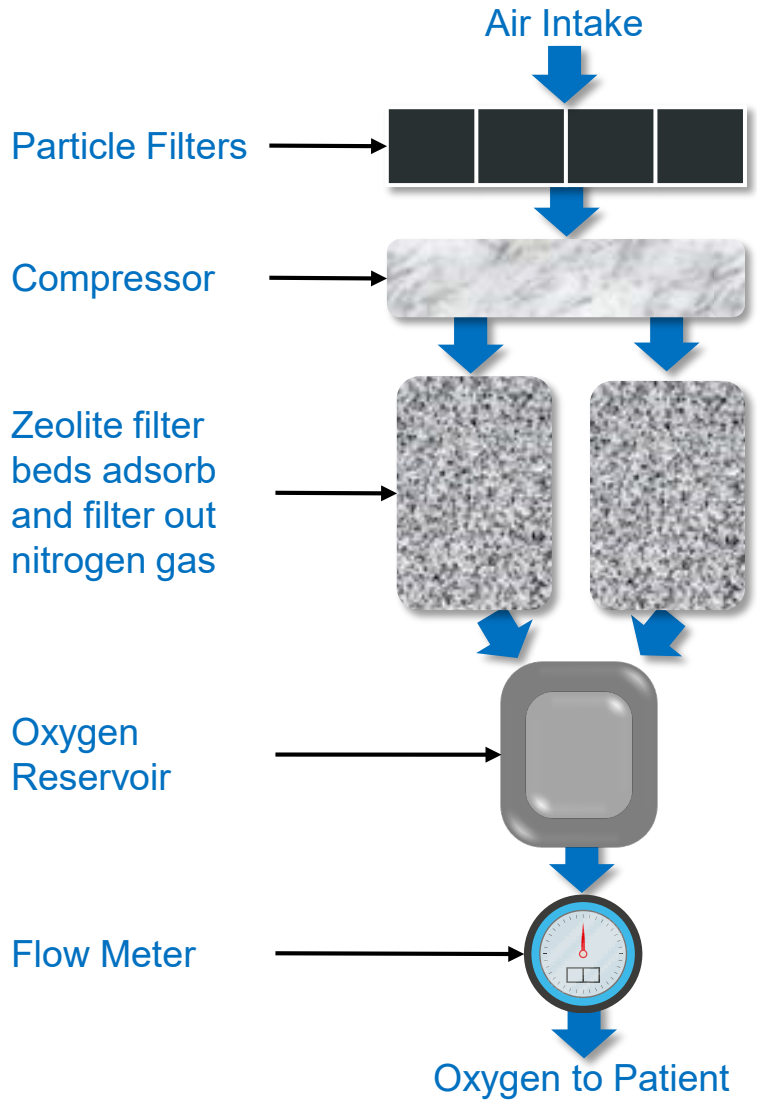
1. An oxygen concentrator is a self-contained, electrically powered device designed to concentrate oxygen from ambient air.

2. Utilising a process known as Pressure Swing Adsorption (PSA), an oxygen concentrator produces up to 95.5% concentrated oxygen.

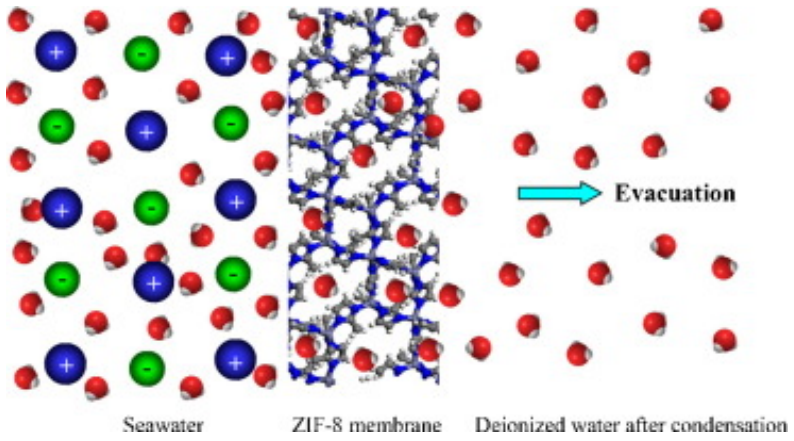
3. Atmospheric air is drawn through a gross particle and intake filter before moving through a compressor.

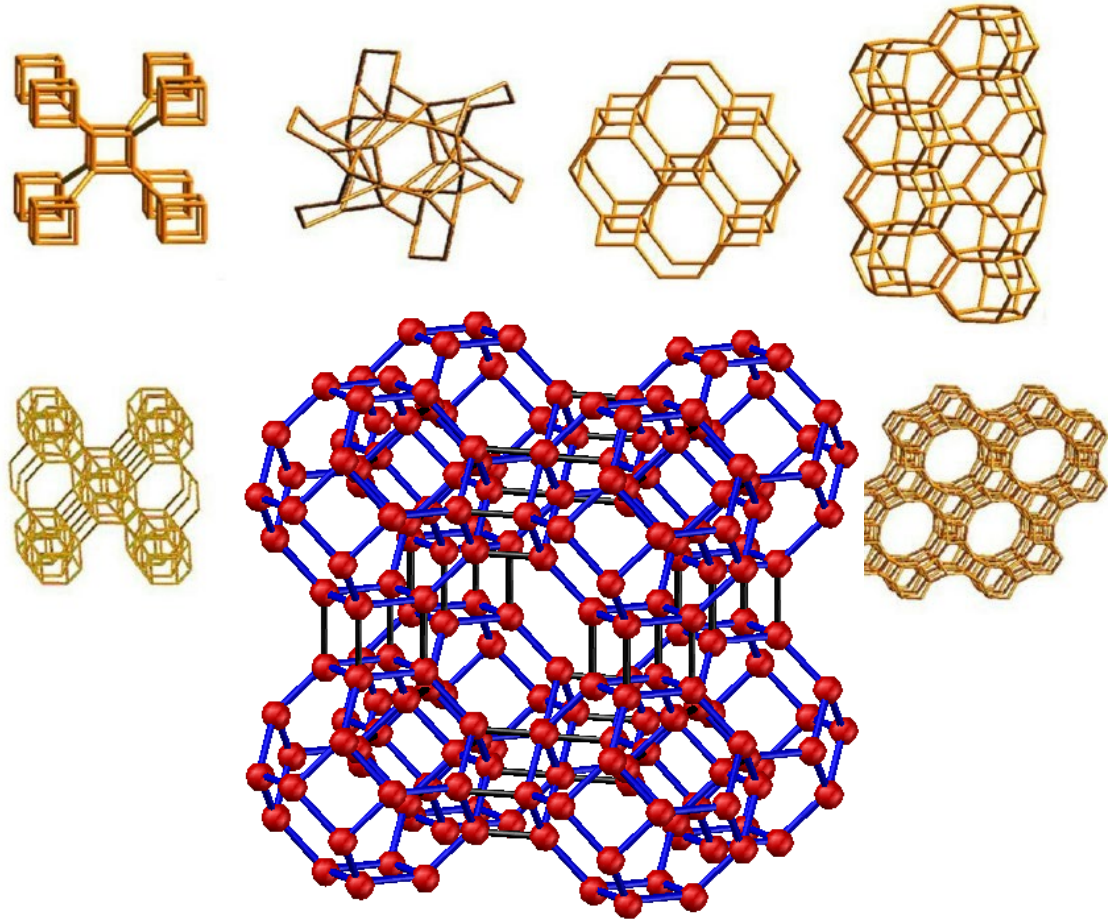
4. The pressurised air passes through a heat exchanger to reduce the temperature before entering sieve beds that contain zeolite, a mineral material that preferentially adsorbs nitrogen gas (N2) at high pressures.

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



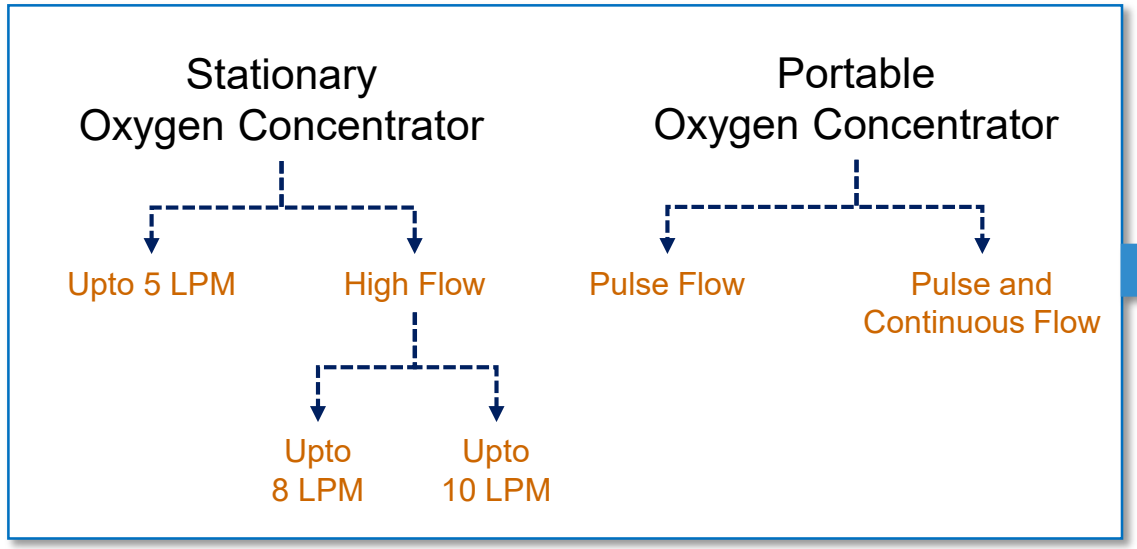
Zeolite Molecular Sieve





1. Type of Zeolite
2. Ambient Temperature, Pressure, Humidity of Zeolite environment
3. Pressure and Flow rate of Medium (to be processed)

Oxygen Concentrators: Oxikit – Why?

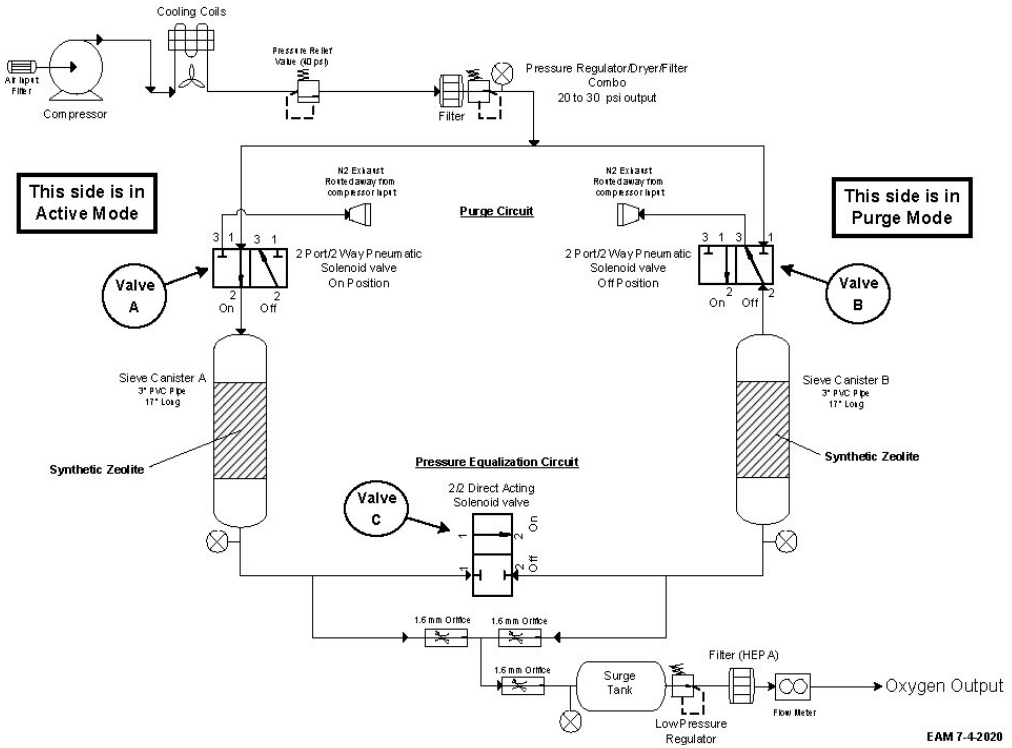


5 -10 LPM Concentrators are available in the market. Concentrators with **higher output flow (more tha15 LPM) will help to reduce pressure on existing Oxygen supplies**

https://oxikit.com

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

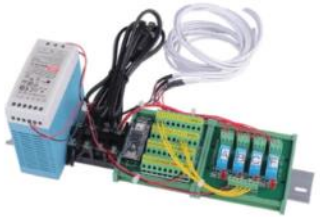
Oxikit – DIY Concentrator



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)

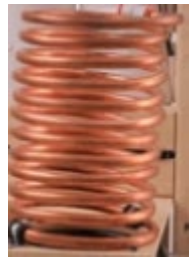
Oxikit – Main Components



Arduino Uno Board

Solenoid Valves/Tubing/Fittings

Pressure Gauges/Flow meters etc.



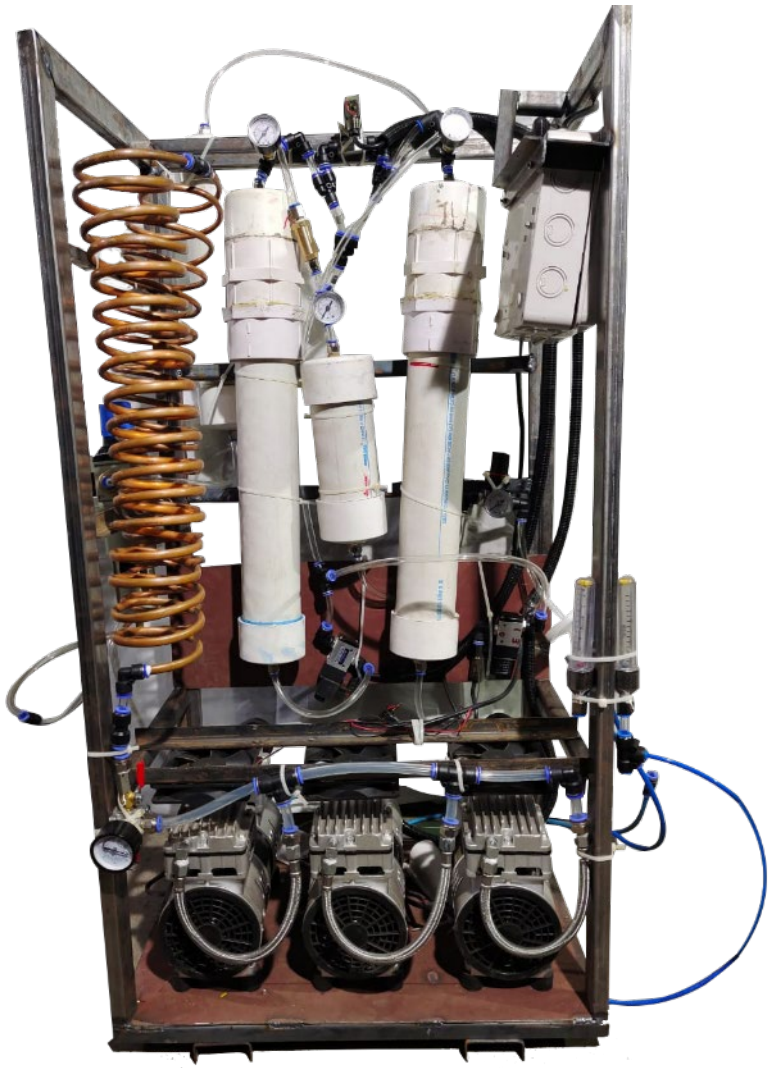
Cooling Coil
1 no.

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

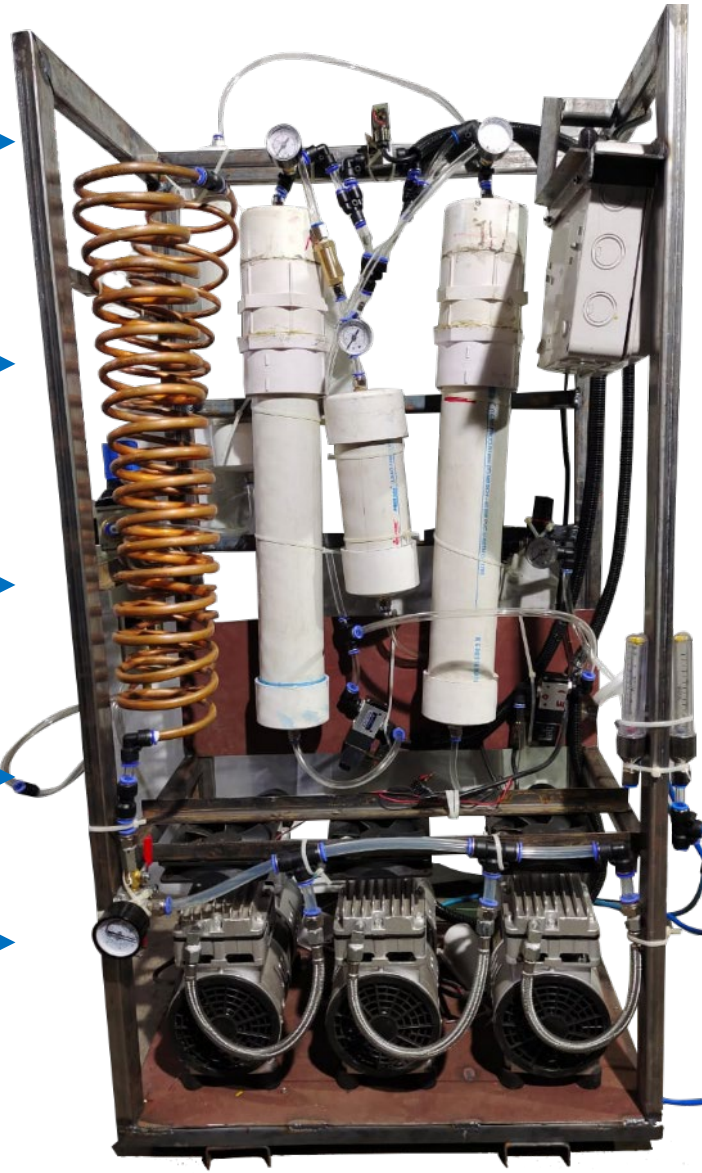
Arduino Uno Board

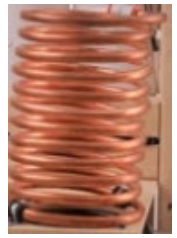
HEPA Filter

Solenoid Valves/Tubing/Fittings

Cooling fan

Pressure Gauges / Flow meters, regulators etc.





Cooling Coil
2 no.

Zeolite Sieve Beds – 2 nos.

Silica gel Dryer Tank – 1 no.

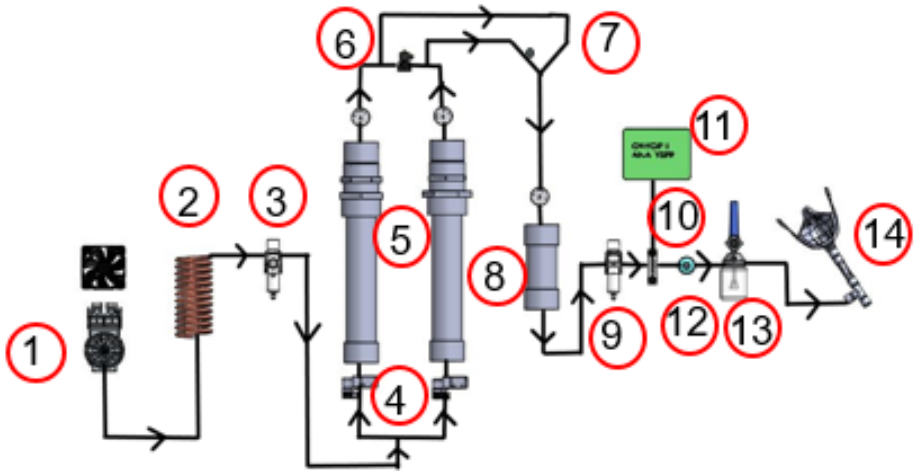
Surge Tank
1 no.

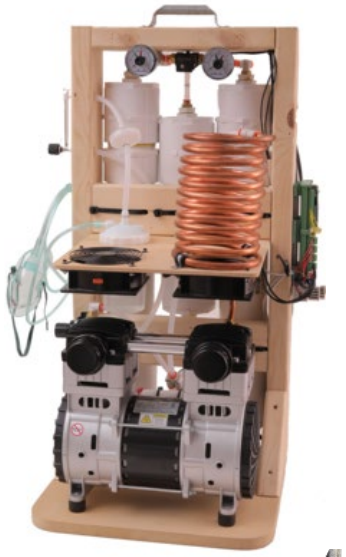
Compressor

O_2 analyzer

TCE Prototype - Enhancements

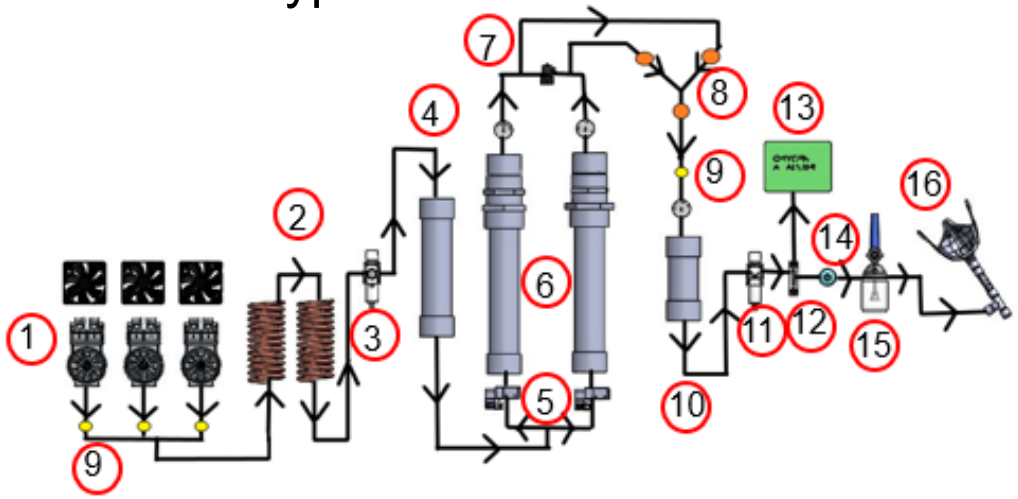
Oxikit oxygen generator

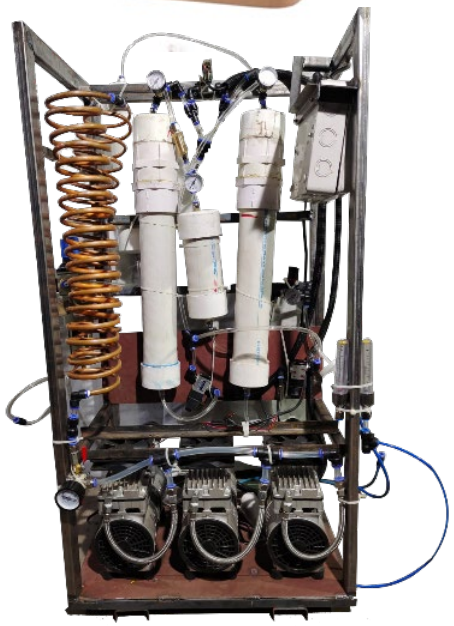




1. Air compression
2. Air cooling coil
3. Air Filtration and Regulation
4. 3/2 Charge/purge valve
5. Adsorbing tower A
   Adsorbing tower B
6. Pressure equivalisation valve
7. Orifice
8. Surge Tank
9. Low pressure regulator
10. Oxygen flow meter
11. Oxygen analyser
12. HEPA Filter
13. Humidifier
14.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

TCE Prototype





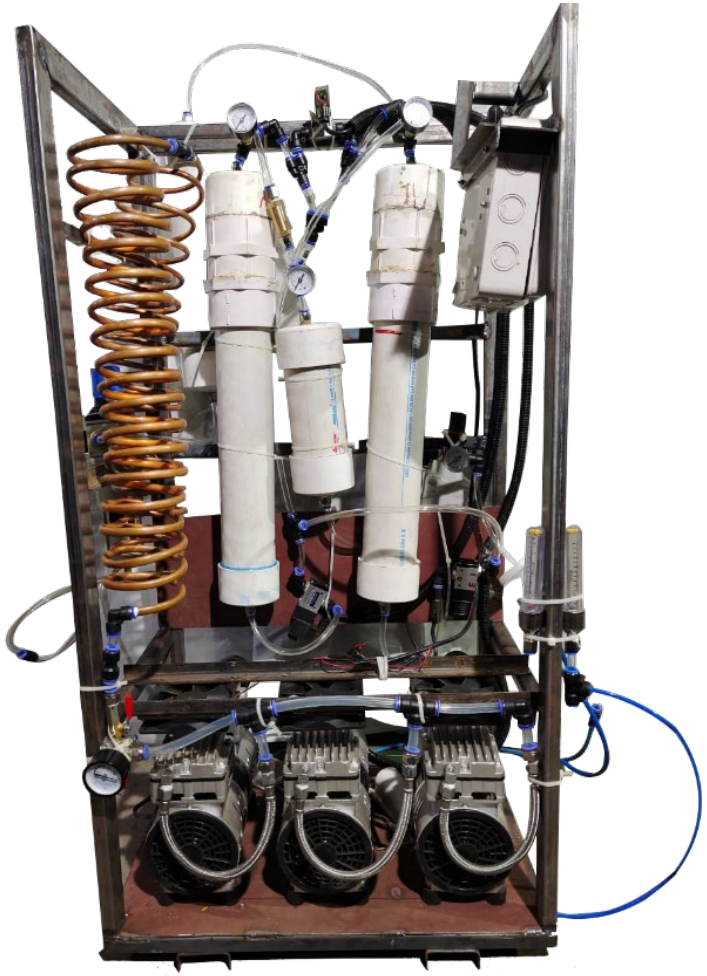
1. Air compression
2. Air cooling coil
3. Air Filtration and Regulation
4. Air Drying (Silica gel dryer)
5. 3/2 Charge/purge valve
6. Adsorbing tower A
   Adsorbing tower B
7. Pressure equivalisation valve
8. Orifice
9. Non return valve
10. Surge Tank
11. Low pressure regulator
12. Oxygen flow meter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

Prototype

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.

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

Key Points Considered for Prototype

1. TCE has studied several open source designs available for construction of the oxygen concentrators. Based on simplicity, Ease of assembly, Oxygen Capacity and technical specifications, the design provided by OXIKIT was selected for prototype development
2. It was decided to build Proto with the components available locally in India
3. Proto is built considering the impact of Indian ambient condition on the performance and accordingly technical enhancements were considered. During sourcing of the components time limitation & strict lockdown restrictions in Maharashtra where this protype was built were also considered.

OIL FREE COMPRESSSOR : One of the critical parameter is availability of suitable capacity oil free air compressor. The air compressors used for dental applications are oil free type and was readily available. The required capacity was divided in three compressors to reduce total cost of compressor and also time for delivery. The prototype was run for upto 5-6 hrs without any interruption (as per the rated application of selected compressor in this prototype). **However, It is important to select compressor suitable for running continuously for 24hrs without any heating issue.**

Brand: GAHL
Model:GA750-3-70L
Power: 2.25KW/3HP ; Voltage: 240V/50Hz
Exhaust Volume: 450L/Min / 14.3 CFM
Maximum Working Pressure: 8 Bar / 116 Psi
Noise ≤70dB ; Tank Capacity: 70L

Analyser used for checking O2 Concentrator is given below.

ACCURRA-S 3130 Paramagnetic Oxygen Analyser
(M/s Sarvesh Analytics Pvt. Ltd.)
Measurement Range : 0 – 100%
Sensor Technology: Paramagnetic
Display Resolution: 0.01 %
Response Time T90: < 5 sec

The prototype design and performance can be further suitably enhanced by considering appropriate changes during its commercial development by the innovators, developers

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.

Performance & Results

Started Work on 06.05.2021

As of 10.05.2021 (Readings at a given instant)
a) Achieved 18-24 LPM ambient temperature
b) Oxygen Concentration between 60% to 85%

As of 11.05.2021 (Readings at a given instant)
a) Achieved 18-24 LPM ambient temperature
b) Oxygen Concentration between 88% to 95.5%

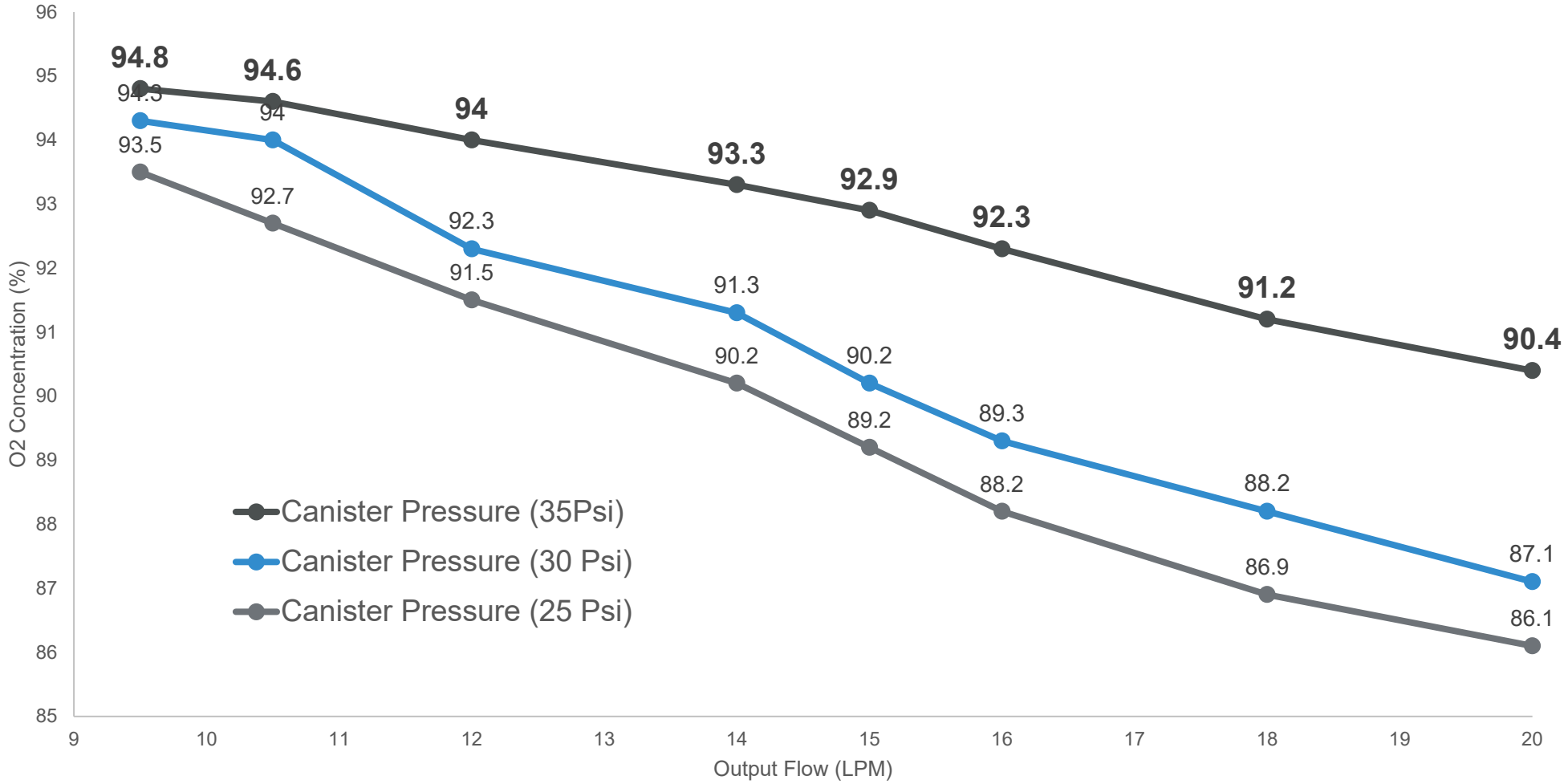
As of 12.05.2021 (Continuous Operations)
a) Achieved 22 LPM ambient temperature
b) Oxygen Concentration between 94% to 95.5%
c) Machine under continuous running for 3-6 hours

As of 14.05.2021 (Continuous Operations)
a) Achieved 22-25 LPM ambient temperature
b) Oxygen Concentration between 92% to 95.5%
c) Machine under continuous running for 3-6 hours
d) 3-4 masks checked for flow rate

As of 19.05.2021 (Continuous Operations)
a) Ambient Temp = 34-35°C
b) Temperature at inlet of Canister = 29-30°C
c) O2 Concentration (range) – 94 – 90%

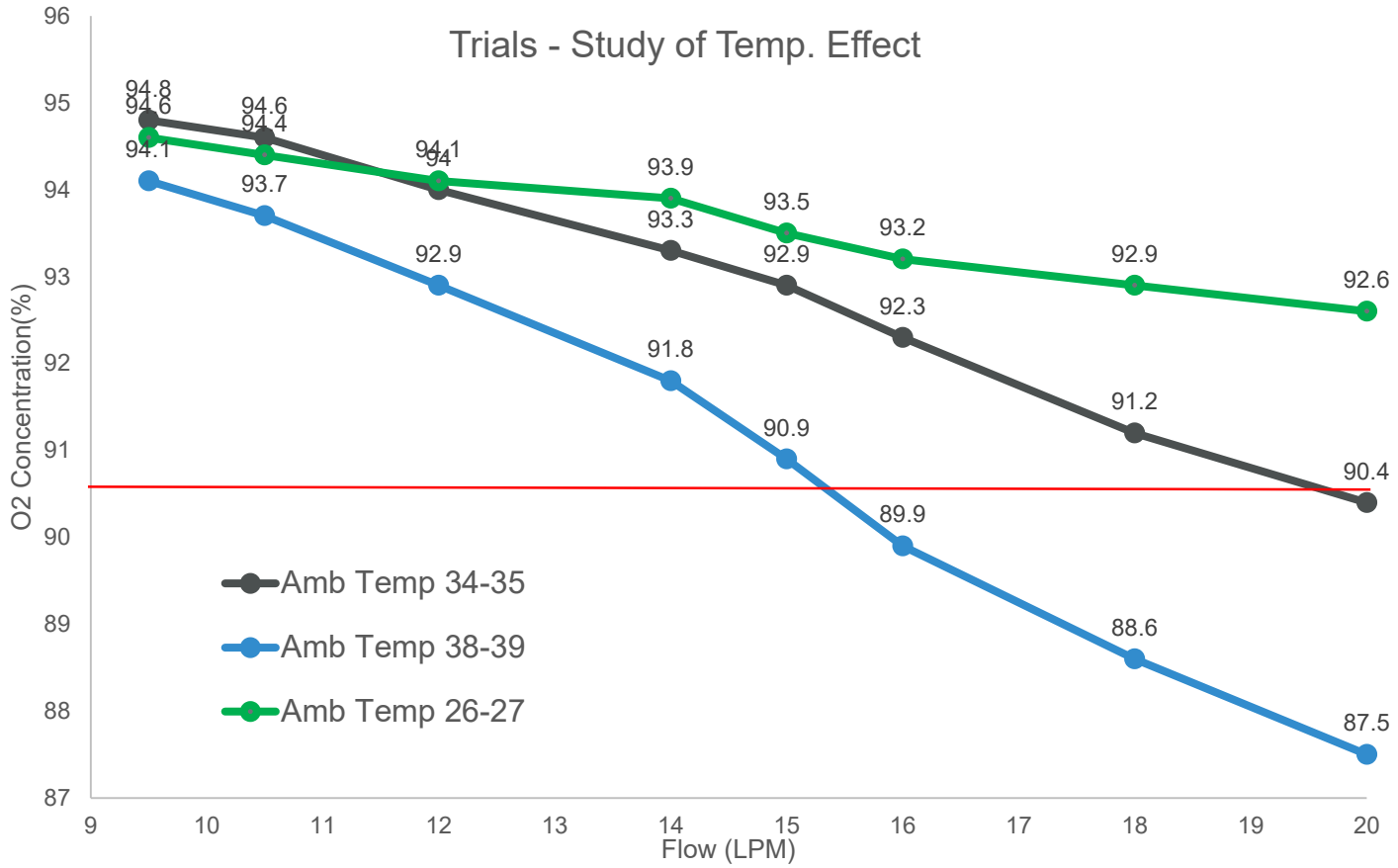
As of 20.05.2021 (Continuous Operations)
a) Ambient Temp = 38-39°C
b) Temperature at inlet of Canister = 34-33°C
c) O2 Concentration (range) – 94 – 87%

Results – Prototype Trials



Suggested Zeolite Bed Pressure = Above 35Psi

Results – Prototype Trials – Study of Temp Effect



1. Trial Date – 19-05-2021
   - **Ambient Temp = 34-35°C**
   - Temperature at inlet of Canister = 29-30°C
   - O2 Concentration (range) – 94 – 90%
2. Trial Date – 20-05-2021
   - **Ambient Temp = 38-39°C**
   - Temperature at inlet of Canister = 34-33°C
   - O2 Concentration (range) – 94 – 87%
3. Trial Date – 21-05-2021
   - **Ambient Temp = 26-27°C**
   - Temperature at inlet of Canister = 23-24°C
   - O2 Concentration (range) – 94 – 92%

Zeolite Bed Pressure = 35Psi

Observations:

1. Ambient temperature has an effect on O2 concentration at higher flow output

Observations based on Prototype Trials

1. Ambient Conditions: Ambient conditions (temperature/ humidity/ moisture content in the air) plays major role in achieving desired O2 concentration. Sustaining higher O2 concentration at higher ambient temperatures may be difficult.
2. Compressor – Pressure : It is important to select compressor suitable for running continuously for 24hrs without any heating issue. Small amount of pressure drop from compressor or overheating resulting into discharge of air at higher temperature may affect performance of the machine during continuous running.
3. Cooling / Drying of Air : Proper cooling / drying arrangement may help to achieve higher O2 concentration at higher flow rates.
4. Leak Tightness : As the machine contents no. of joints / tubing/ copper coils etc., leak tightness of all joints must be ensured. Any small amount of leakage leads to reduction in O2 concentration and overall performance of the machine.
5. Valve Timing : Arriving at proper valve timings to suit Indian ambient conditions need to be worked by trial & error. The valve timings may differ depending upon the prevailing ambient conditions.
6. Flow rate vs. concentration : It is observed that sustaining higher O2 concentration at higher flow rate (>15 LPM) may be difficult due to fluctuations in the ambient conditions.
7. Operating conditions : Performance of the machine during operating conditions such as cyclone/ heavy monsoon/ extreme cold needs to evaluated.
8. Test Conditions : For better and accurate test results, testing of the machine shall be done in stable test conditions and not in controlled test conditions to capture effect of ambient conditions on the machine performance.

Conclusion based on Prototype Trials

1. It is observed that O2 purity varies (+/- 3-4%) due to ambient conditions and it varies (+/- 2-3%) by reducing valve timings. It is also seen that purity increases at higher inlet canister pressure of approx. 40 Psi.

2. Trend of the results shows low temp, high press, low cycle time help to achieve higher O2 purity.

3. By using combination of higher pressure (40 Psi), proper cooling arrangement (increased surface area of copper coils/ heat exchanger) & reduced valve timings may give 93% purity at 20 LPM.

Business Case : Guidance for MSME / Entrepreneurs

Key Components – Local India Sourcing	Single Prototype*	Bulk*
Oil Free Compressor (2.5 HP Min 24 hrs continuous operation rating)	₹25,000 – 20,000	₹15,000 - 10,000
Electronics + Sensor (Oxygen, Temperature, Humidity, Digital Display, Relays, IC Control board)	₹12,000 – 10,000	₹7000 – 5000
Zeolite (0.4 MM Sodium ZMS) – 100% imported	₹7000 – 5000	₹4000 – 5000
Others (valves, pipes, fittings etc)	₹20,000 – 15,000	₹12,000 – 10,000
Structure / Frame / External	₹10,000 – 8000	₹7500 – 5000
ONLY MATERIAL COST RANGE	**₹80,000 – 60,000**	**₹45,000 - 35000**

** Approximate Indicative material cost pricing ONLY – Scarcity and freight constraints during crisis times may significantly impact prices and availability*

Further Enhancements - Critical for BULK Manufacturing

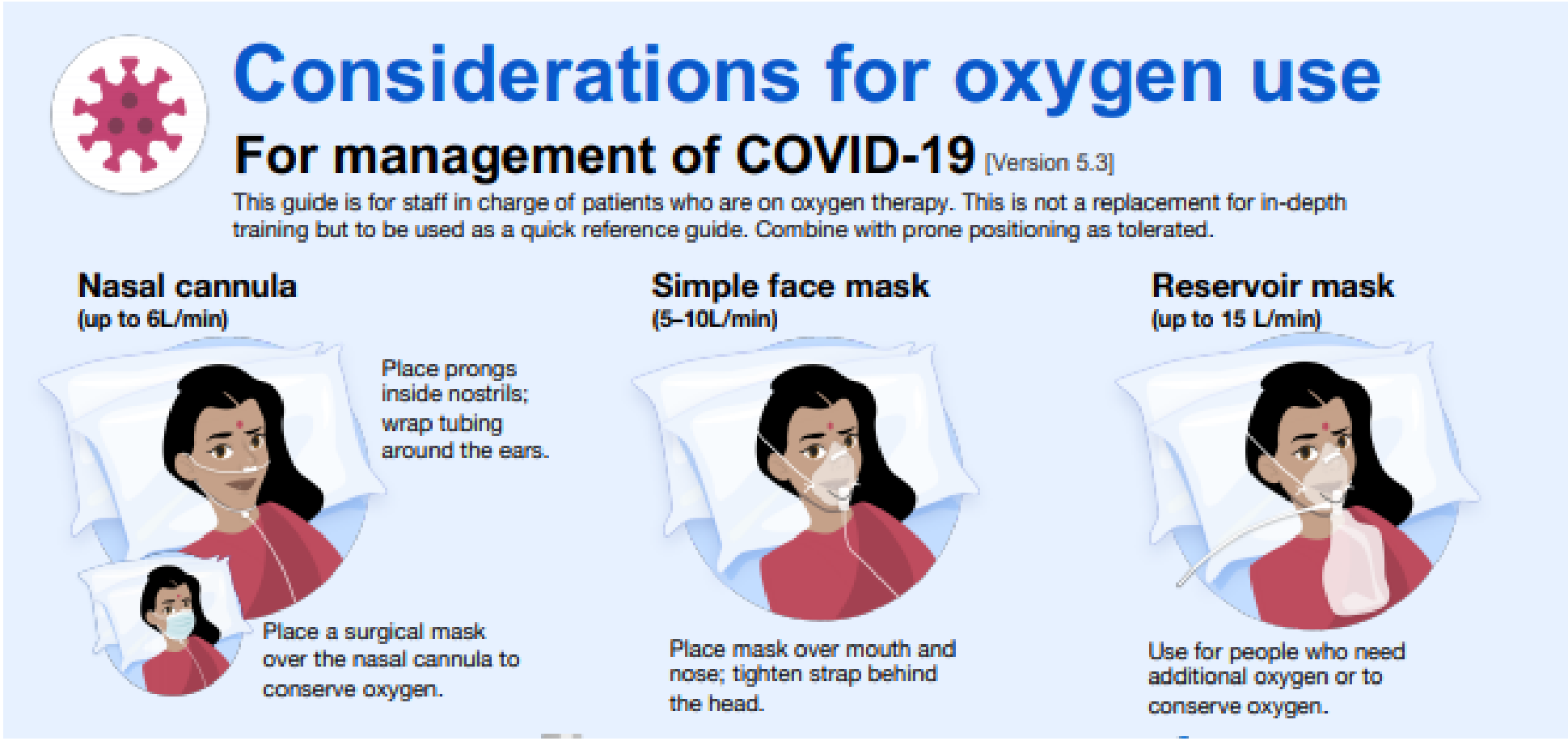
1. Ensure OIL Free compressor has rating of min 24 hours continuous operations – One may use 3 (of 0.75 HP or 2 (of 1.5 HP) or 1 (of 2.5 HP) in parallel configuration
2. Zeolite must be 0.4 MM Sodium ZMS from reputed global firms (100% imported no Indian option)
3. Integrated Controller should be designed locally to take care of IC Module, Relay, Sensors (Oxygen, Temperature, Pressure) along with Digital display
4. Careful design, engineering and valve timing to be simulated and carefully tested for continuous operations for 5-10 days with few initial protypes before final design is finalized
5. All regulatory, statutory, manufacturing setup approvals etc. must be ensured
6. Please ensure all advisories are studied carefully – Latest Advisory Government of INDIA

Suggestions – To MSMEs

1. Machine shall be tested at varying ambient conditions to evaluate effect of these conditions.
2. Selection of oil free compressor capable of delivering air at desired pressure must be ensured.
3. Considering Indian ambient conditions, it is suggested that proper cooling arrangement (increasing copper tubing/ using fins/ arrangement like radiator/ etc.) shall be worked out.
4. Sustaining O2 concertation at higher flow rates (> 15 LPM) may be difficult due to fluctuating ambient conditions.
5. Zeolite bed shall be checked periodically for its conditions due to moisture content and humidity levels prevailing at ambient cognitions.
6. It is suggested to arrive at optimised O2 concentration and Flow rate based on tests carried out at varying ambient conditions.

Things to READ and Keep in Mind

https://www.indiacovidsos.org/oxygen1



OXYGEN CONCENTRATOR CHECKLIST: https://www.indiacovidsos.org/oxygenchecklist

OXYGEN CONCENTRATOR EVALUATIONS: Evaluation of oxygen concentrators for use in countries with limited resources - Peel - 2013 - Anaesthesia - Wiley Online Library

Study / Reference Material

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=PL4O1RQEiLpHBJ0i1zqe-CZk1p_NTtGl76 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

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SINCE 1962

Frequently Asked Questions:

1) Question: What are main components of this Oxygen concentrator?
Answer: The main components of this oxygen concentrator are Air Compressor (Oil free) with min 24 hours of continuous operations (refer ratings), Zeolite Sieve Cannister, Zeolite (imported), cooling coils, silica bed dryer, IC Control unit OR Arduino Uno Board (Electronic circuit), solenoid valves, fittings, pressure gauges and oxygen flow meter.

2) 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.

3) Question: What is the maximum concentration of oxygen that can be achieved with the concentrator?
Answer: Up to 90 – 94.6%

4) 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 ARKEMA Nitroxy5 (0.4 mm Sodium Zeolite) which was Zeolite used in this concentrator. Other brands that may be explored UOP-Honeywell, ZeoChem etc

5) Question: Is specification of main components available?
Answer: Please refer BOM giving specifications of main components. TCE oxygen concentrator Proto BOM

6) Question: Is assembly of this concentrator complex?
Answer: No. Assembly is very simple but needs planning, careful process adherence and basic knowledge of mechanical and electronic assembly. Refer animation file showing assembly of 3D model. TCE Prototype - 3D Model Drawing

Frequently Asked Questions:

7) 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, as Zeolite performance is sensitive to pressure, temperature, and humidity. Silica bed air dryer is used due to its low cost and ease of availability.

8) Question: Can I use any Zeolite for this concentrator?

Answer: NO the Zeolite must be for Medical Grade Zeolite (ZMS) only from reputed global brands. The Zeolte used in our prototype was 13X Sodium based zeolite of 0.3 – 0.6 mm grade (diameter). Higher grade (diameter) **SHOULD NOT** be used for this concentrator. Lithium Zeolite of similar size may be explored, but it is scarce and expensive.

9) 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. These may be locally fabricated and use such electronic control units. 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

10) 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 Component suppliers and fabricate at your end.

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

Answer: some of the precautions to be considered are: Refer guidelines

- 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

Frequently Asked Questions:

12) Question: What are the enhancements aligned to Indian ambient conditions

Answer: Following enhancement were done by TCE team for the prototype

1. addition and Use of low-cost silica gel Desiccant dryer to improve oxygen concentration
2. approx double length of cooling coils used. 2 nos. of cooling coils used.
3. addition of non return valves (NRV)
4. use of Arkema 0.4 mm Nitroxy-5 zeolite
5. 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)
6. zeolite packaging in the adsorption containers must be done carefully / and to ensure better packaging of zeolite proper spring selection is needed
7. other than above exact specifications, dimensions and design has been carefully adhered to from standard oxikit specification.
8. Output of 20-22 LPM @ 92-95% Oxygen concentration is at 25 PSI (1.7 bar)
9. 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:

13) 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

14) : 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:

15) Question: Any suggestions for preparation of Zeolite Sieve beds?

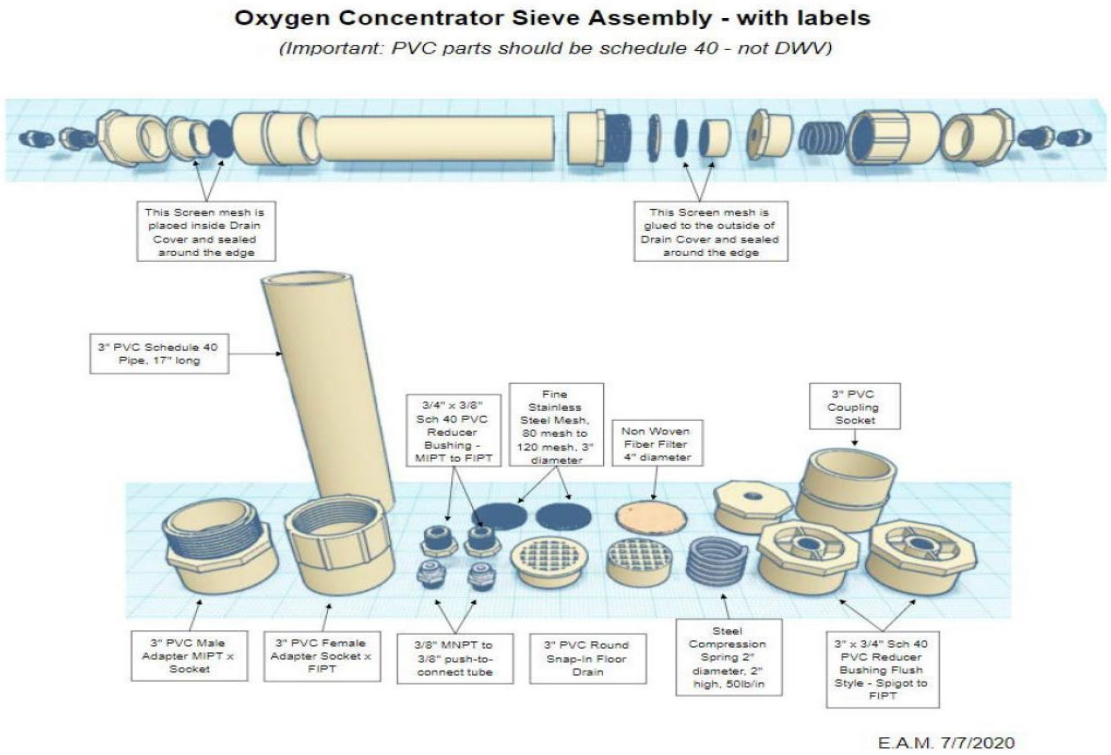
Answer: Suggestive steps for preparation of Zeolite bed are given below:

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.

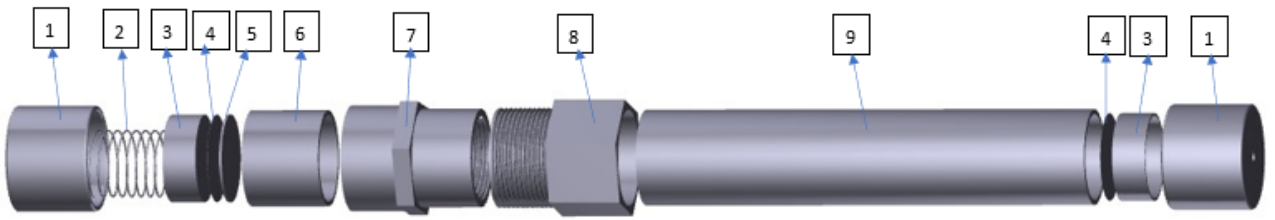
Frequently Asked Questions:

16) 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.



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:

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

Answer: 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.

Frequently Asked Questions:

18) Question: Are main components of this Oxygen concentrator prototype readily available?

Answer: As mentioned earlier main components of this prototype oxygen concentrator are Oil free Air Compressor (Oil free & suitable for min 24 hours of continuous operations, refer ratings), Zeolite (imported) and Arduino Uno Board (Electronic circuit) etc. MSMEs/ Manufacturers should set up their own supply chain for availability of these components mainly Oil free air compressor and Zeolite.

19) Question: Can we use any Zeolite or locally available Zeolite for this concentrator?

Answer: We have used ARKEMA Nitroxy5 0.4 -0.8 mm Sodium based Zeolite in this concentrator and hence it is suggested to use 0.4-0.8 mm Sodium ZMS equivalent to ARKEMA Nitroxy5 such as OXYSIV 5XP or OXYSIV HP 5XP supplied by reputed global firms.

20) Question: Is the Bill of Materials and their specifications are as per IS standards?

Answer: At present there are no IS standards for O2 concentrators BOM. This prototype is built based Oxikit open-source design as per BOM and specifications mentioned in Oxikit design documentation.

21) Question: Is this prototype full proven, frozen & functionally/clinically tested as per the Bureau of Indian/ International standards?

Answer: Please note that the intention was to build prototype with local available parts in shortest possible time to assess performance of Oxikit design and share Technical knowhow with MSMEs/ Manufacturers. All regulatory, statutory, manufacturing setup approvals etc. must be ensured by MSMEs/ Manufacturers'. Also, it is suggested that few initial protypes must be carefully tested for continuous operations for 5-10 days at different ambient conditions before final design is finalized.

Frequently Asked Questions:

22) Question: Is it permitted to use the Arduino boards (Which is used in the TCE Design) for commercial/ Industrial grade systems?

Answer: Arduino board is used as we are developing prototype. It is suggested that MSMEs/ Manufacturers to use board suitable for commercial/ Industrial use compiling to any regulatory or statuary or certification requirement.

23) Question: Is it necessary to develop more prototype say 5 nos of prototypes?

Answer: As mentioned earlier, this prototype was built based on Oxikit open-source design and performance was checked for continuous running for 3-6 hours. It was observed that O2 purity varies due to ambient conditions. Hence, considering varying Indian ambient conditions it is suggested to build few prototypes which shall be carefully tested for continuous operations (24 Hrs) for 5-10 days before finalising design for mass manufacturing.

24) Question: Can we use any other connectors than specified in BOM?

Answer: Connectors are generally available in market. However, you can use suitable connectors having pressure rating as specified.

25) Question: Any suggestion for Testing of this concentrator?

Answer: It is observed that O2 purity varies due to ambient conditions such as temperature / humidity etc. Hence, it is suggested to test your prototype/s for continuous operations (24 Hrs) for 5-10 days in ambient conditions and not in controlled conditions.

26) Question: Any precautions to be taken while preparation of ZMS canister?

Answer: As we are aware that adsorption capabilities of Zeolite may be affected by ambient conditions and particularly in moist environment. Hence, it is suggested that the ZMS canister assembly shall be carried out in dry environment to avoid moisture contact with ZMS. Also, it is suggested to use hand gloves while ZMS canister assembly and store Zeolite in dry condition.

Frequently Asked Questions:

27) Question: Any key points to be considered or suggestions while working on the prototype or for mass manufacture of this concentrator ?

Answer: We suggest to consider following points while working on the prototype or for mass manufacture of this concentrator

1) It was observed that O2 purity varies due to ambient conditions. Hence, considering varying Indian ambient conditions it is suggested to build prototype/s which shall be carefully tested for continuous operations (24 Hrs) for 5-10 days before finalising design for mass manufacturing.

   It is suggested that testing of prototype/s for continuous operations (24 Hrs) for 5-10 days shall involve events such as abrupt switching OFF & ON (power failure), switching OFF for machine cool down/ compressor overheating/ high ambient temperature/ cyclonic conditions/ heavy rains-thunderstorms with lightening etc. In such events provision for auxiliary Oxygen cylinder or capacity of surge tank shall be evaluated for ensuring continuous Oxygen supply to patient/s. Please note that events mentioned above are for guidance only and MSMEs/ Manufacturers must prepare their comprehensive test plan for testing prototype/s, for finalsing assembly procedures, for finalising packaging & transportation schemes etc. before finalising design for mass manufacturing

2) MSMEs/ Manufacturers keen to mass manufacture must ensure all approvals and clearances if any

3) MSMEs/ Manufacturers must carefully study and align themselves with required advisory or guidance issued from time to time by GOI related to oxygen concentrators.

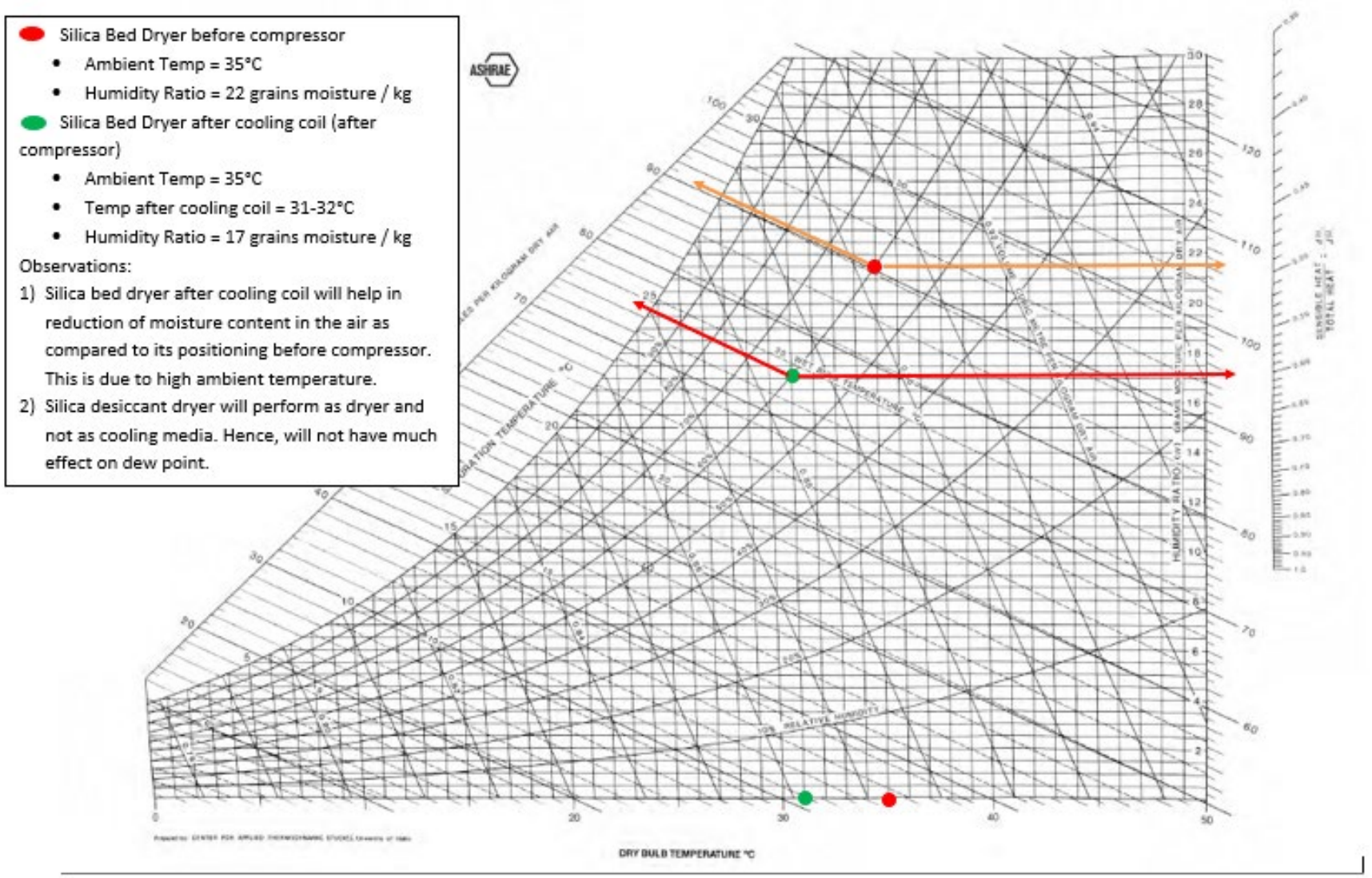
4) MSMEs/ Manufacturers must carefully evaluate and ensure proper sourcing, manufacturing, testing, quality control and after sales service aligned with their planned business and market strategy.

5) It is also suggested to study and establish source for zeolite of correct grade, size and quality for ensuring continuous supply.

Frequently Asked Questions:

28) Question: Can we position Silica bed dryer at the Compressor inlet instead as shown in the process diagram ?

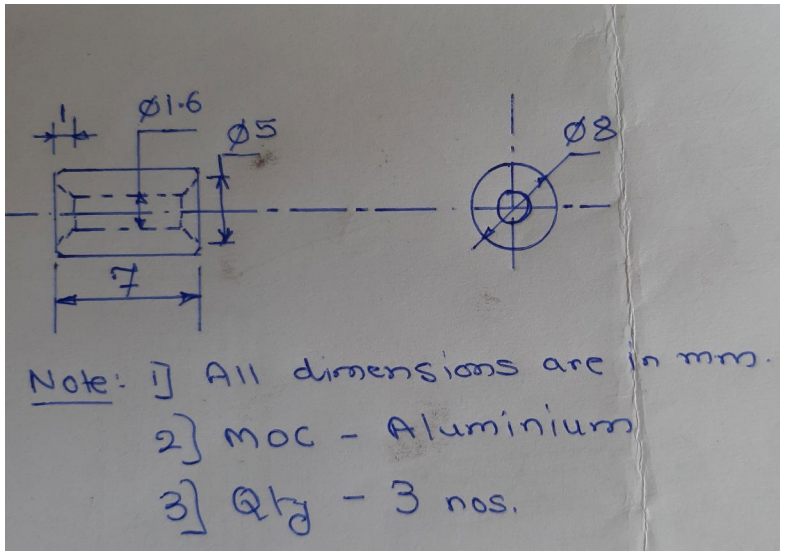
Answer: As we are aware that Silica gel is an amorphous and porous form of silicon dioxide that adsorb moisture. It is nontoxic, inert and stable. We have positioned Silica bed dryer after cooling coils to adsorb more moisture from the air considering Indian ambient conditions like temperature/ relative humidity. The psychometric chart prepared for two potions (at the inlet of the compressor & after cooling coil) of Silica bed dryer to assess its performance is given herewith for your ready reference. MSMEs/ Manufacturers should take decision based on such studies.



Frequently Asked Questions:

29) Question: What are dimensional details of Orifice? Can you provide any supplier list for this Orifice?

Answer: Dimension details for the Orifice are given below. This orifice is manufactured in house by machining operation. MSMEs/ Manufacturers to develop their suppliers for supplying this Orifice.



30) Question: Can you provide details of NRV used and its suppliers?

Answer: NRV details used in this prototype are given below.

a) Model – GV 161
b) Make – M/s Janatics
c) Pressure Range – 0.4 -10 bar

Suggested Suppliers:

M/s SMC; / M/s FESTO; /M/s LEGRIES; M/s PNEUMAX; M/s PARKER; M/s Janatics

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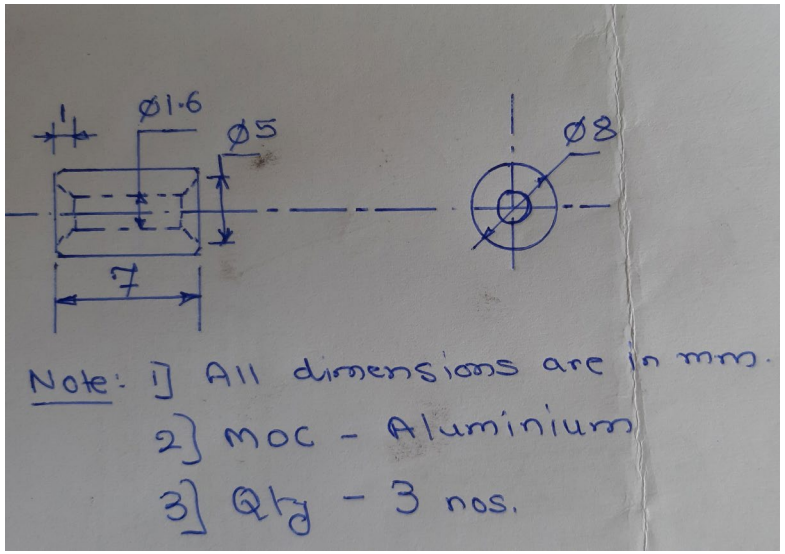

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Answer: NRV details used in this prototype are given below.

a) Model – GV 161
b) Make – M/s Janatics
c) Pressure Range – 0.4 -10 bar

Suggested Suppliers:

M/s SMC; / M/s FESTO; /M/s LEGRIES; M/s PNEUMAX; M/s PARKER; M/s Janatics

Frequently Asked Questions:

31) Question: Can you provide us what approvals are needed for this Oxygen Concentrator? Can you any contact details for obtaining approvals?

Answer: At present there are no existing IS standards for such O2 concentrators. We suggest to follow guidelines of GOI and other regulatory/ approving authorities for obtaining necessary approvals.

Please refer Advisory notice dated 16th May 2021 issued by CDSCO –GOI- Ministry of Health and Family welfare regarding Advisory regarding oxygen Concentrators suitable for COVID-19 case management in Home settings. The link for the same is given below.

https://cdsco.gov.in/opencms/resources/UploadCDSCOWeb/2018/UploadPublic_NoticesFiles/Advisory%20on%20Oxygen%20Concentrators.pdf

Alternatingly, you may refer standards mentioned below and decide on the necessary steps to be taken for protype development / mass manufacture of Oxygen concentrator.

a) IS 23485 - Medical Devices Quality Management Systems with Essential Principles of Safety and Performance

- This Indian Standard specifies requirements for a quality management system that can be used by an organization involved in one or more stages of the life-cycle of a medical device, including design and development, production, storage and distribution, installation, servicing and final decommissioning and disposal of medical devices, and design and development, or provision of associated activities (for example, technical support).
- The requirements in this Indian Standard can also be used by suppliers or other external parties providing product (for example, raw materials, components, subassemblies, medical devices, sterilization services, calibration services, distribution services, maintenance services) to such organizations.
- This Indian Standard can also be used by internal and external parties, including certification bodies, to assess the organization's ability to meet customer and regulatory requirements applicable to the quality management system and the organization's own requirements. It is emphasized that the quality management system requirements specified in this Indian Standard are complementary to the technical requirements for product that are necessary to meet customer and applicable regulatory requirements for safety and performance.

b) IS/ISO 13485 - Medical Devices Quality Management Systems (MDMS) Certification Scheme

- This standard specifics requirements for a quality management :system where an organization needs to demonstrate its ability to provide medical devices and related services that consistently meet customer requirements and regulatory requirements applicable to medical devices and related service and supports essential requirements of directives on medical devices.
- It is the most accepted standard internationally for medical devices producers.
- ISO 13485 sustains the reduction of unexpected risks for companies that build, manufacture, or use medical products and services, both during the manufacturing process and after. The primary objective of ISO 13485 is to facilitate harmonization of medical devices regulatory requirements for medical devices with quality management system requirements.

Frequently Asked Questions:

32) Question: Any additional information which we can refer for mass manufacturing of Oxygen Concentratos?

Answer: Please refer links mentioned below giving additional information for reference.

a) https://indianexpress.com/article/india/govt-nod-to-oxygen-concentrators-from-iit-kanpur-startup-7315633/

b) https://dst.gov.in/government-invites-rd-proposals-critical-components-and-innovations-oxygen-concentrators

c) https://dst.gov.in/startups-offering-medical-equipments-aids-catering-doctors-needs-during-pandemic-new-normal

d) https://www.business-standard.com/article/current-affairs/covid-govt-invites-r-d-proposals-on-innovations-in-oxygen-concentrators-121052200928_1.html

e) http://www.pharmabiz.com/NewsDetails.aspx?aid=138693&sid=1

f) https://www.republicworld.com/india-news/general-news/union-ministry-invites-applications-from-startups-to-develop-new-tech-to-tackle-covid-wave.html

g) https://timesofindia.indiatimes.com/india/indian-tech-cos-join-hands-to-make-open-source-based-oxygen-concentrators-to-be-priced-at-around-rs-40000/articleshow/82879978.cms

h) https://www.theweek.in/news/biz-tech/2021/05/23/indian-tech-cos-join-hands-to-make-cheaper-open-source-oxygen-concentrators.html

i) https://health.economictimes.indiatimes.com/news/medical-devices/indian-tech-cos-join-hands-to-make-open-source-based-oxygen-concentrators-to-be-priced-at-around-rs-40k/82897647

Frequently Asked Questions:

33) Question: Any checklist or datasheet that we can use while building prototype?

Answer: You can use attached checklist / datasheet while building your prototype. Please use this checklist as reference only and not as any standard or compliance sheet.

Please share with us this filled checklist / datasheet in case you need any technical help or assistance from us.

CHECKLIST - DATASHEET FOR OXYGEN CONCENTRATOR PROTOTYPE-V2

Frequently Asked Questions:

34) Question: Have you conducted any trials with Lithium (Li) based ZMS ?

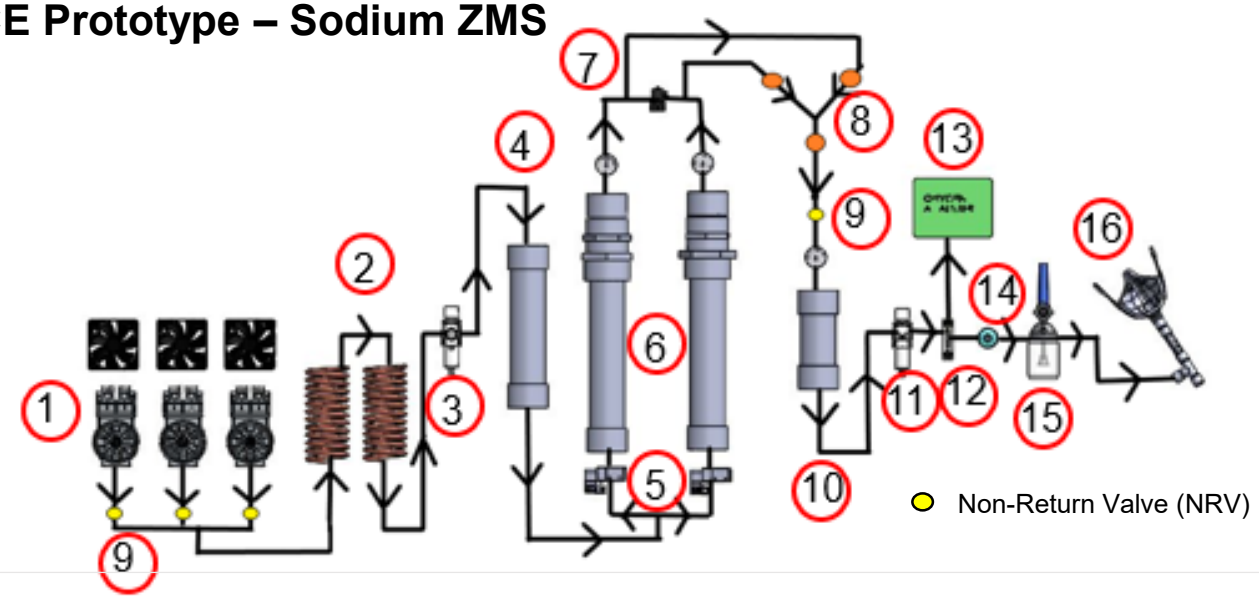
Answer: Yes…we have conducted trials with Lithium based ZMS to compare results obtained with Sodium based ZMS. Comparison of key parameters with Li & Sodium ZMS is tabulated below.

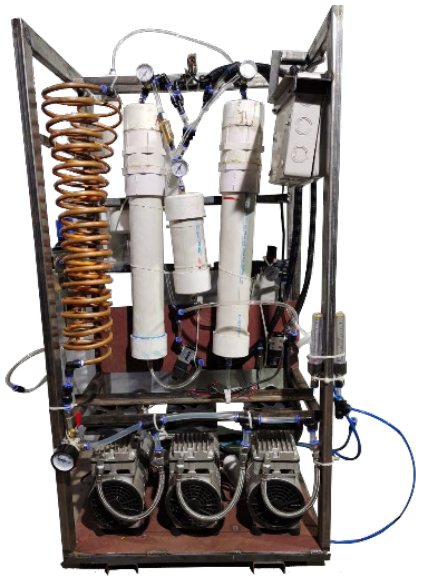
Sl.No	Parameters	ZMS Type	
		Sodium ZMS Prototype	**Li ZMS Prototype**
1	Make	Arkema	Jalon
2	Trade Name	**NITROXY® 5**	**JLOX- 101**
3	Particle size	above 0.4 mm (0.4 – 0.6 mm)	above 0.4 mm (0.4 – 0.6 mm)
4	No. of ZMS beds used	2	2
5	Height of ZMS bed (mm)	490mm	630mm
6	Internal Diameter of ZMS bed (mm)	77mm	52mm
7	Quantity of ZMS used	3.5 Kg	1.6 Kg
8	**Price per kg (INR) (Excluding Taxes and P&F)**	**1800/-**	**3037/-**
9	**Total Price of ZMS used in Prototype (INR) (Excluding Taxes and P&F)**	**6300/-**	**4860/-**

Please refer subsequent slides for details about trials conducted with Li ZMS

Frequently Asked Questions: Set up Comparison

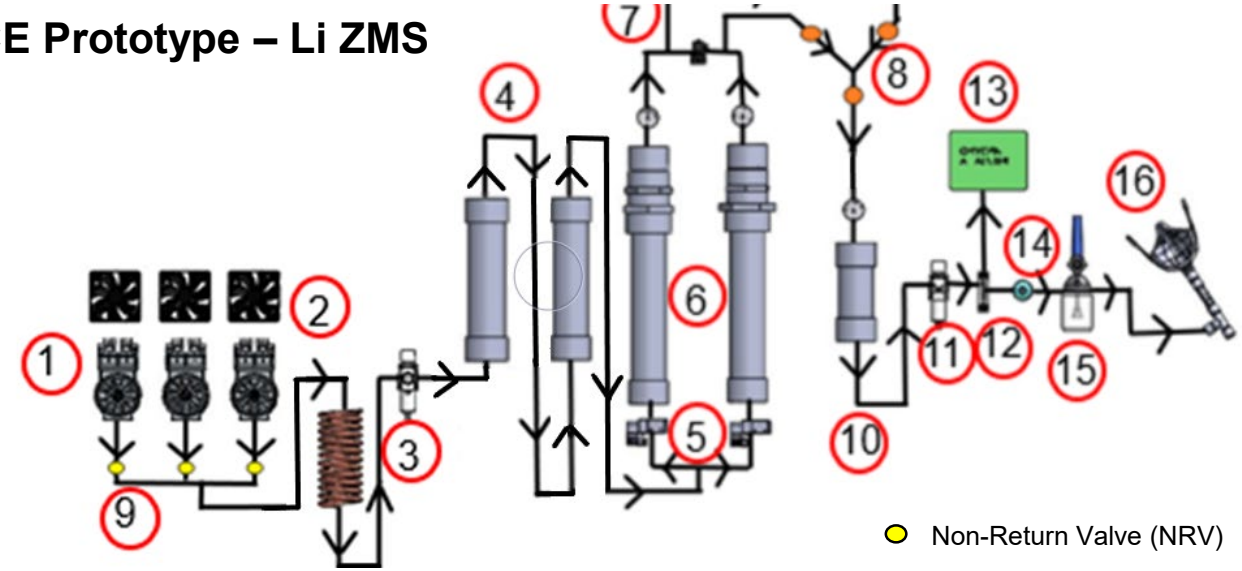
TCE Prototype – Sodium ZMS





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 equivalisation 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

TCE Prototype – Li ZMS

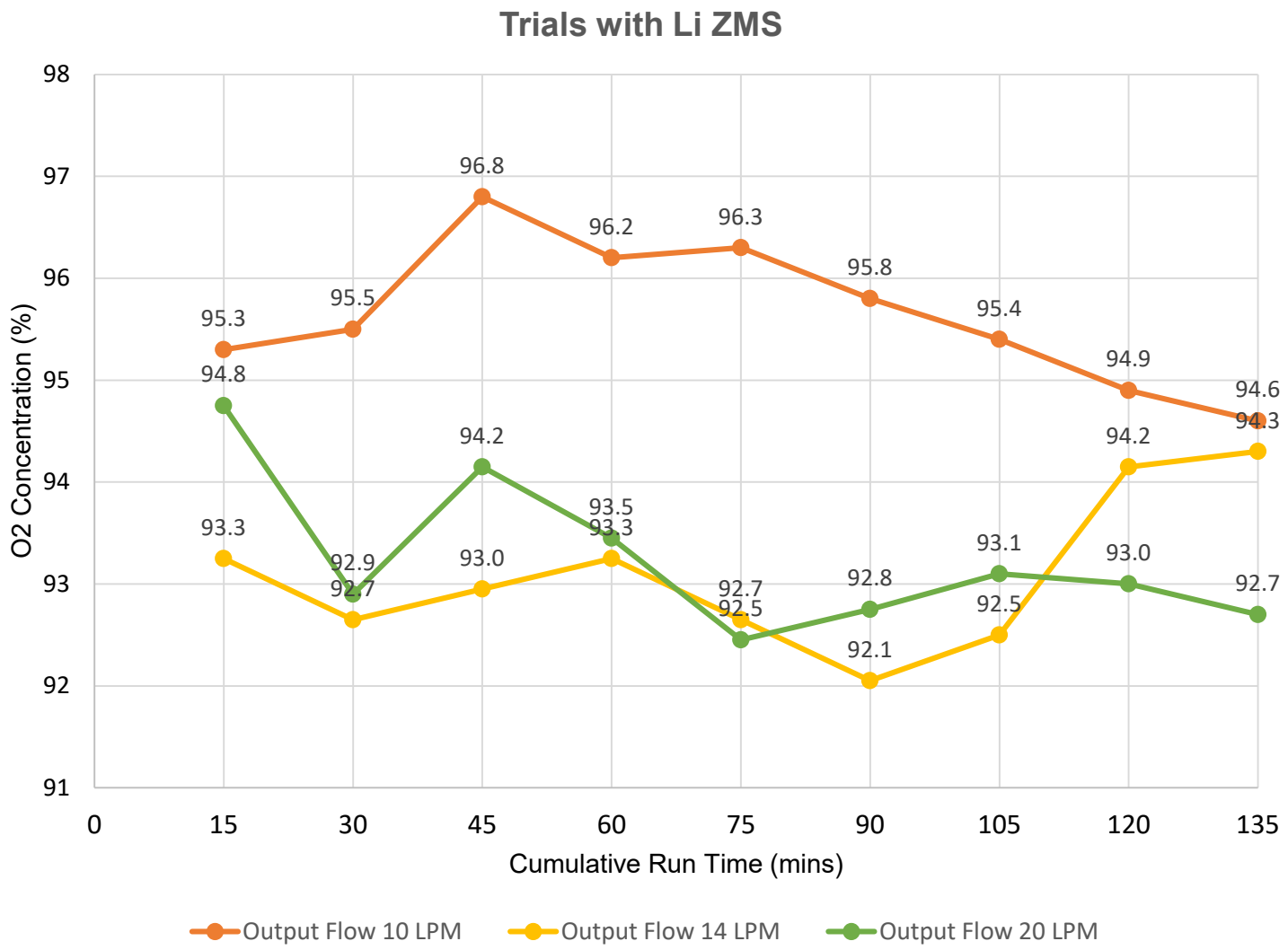


1. Air compression
2. Air cooling coil
3. Air Filtration and Regulation
4. Air Drying (Silica gel dryer)-2no.s
5. 3/2 Charge/purge valve
6. Adsorbing tower A
   Adsorbing tower B
7. Pressure equivalisation valve
8. Orifice
9. Non return valve
10. Surge Tank
11. Low pressure regulator
12. Oxygen flow meter
13. Oxygen analyser
14. HEPA Filter
15. Humidifier
16. Oxygen mask

Frequently Asked Questions: Set up Comparison-Key Points

Sl.No	Item / Components	ZMS Type		Remarks
		Sodium ZMS Prototype	Li ZMS Prototype	
1	Cooling Coils used	2 nos.	1 no.	It is observed that with Li ZMS only one Cooling coil is sufficient obtain consistent results
2	Air Drying (Silica gel dryer) Desiccant dryer beds used	1 no.	2 nos.	2 nos. of dryer beds are used in Li ZMS set up to ensure moisture free air.
4	No. of ZMS beds used	2	2	
5	Quantity of ZMS used	3.5 Kg	1.6 Kg	Half quantity of Li ZMS gives better and more consistent results in caparison with Sodium based ZMS
6	Size of ZMS Bed used (mm)	ID77 x 490 Ht.	ID52 x 630 Ht.	
7	Input canister pressure (psi)	35	35	
8	Valve Timing	6150 Millisecond	5150 Millisecond	
9	Ambient Temperature (°C)	33 - 35	25 - 31	

Frequently Asked Questions: Trials – Li ZMS



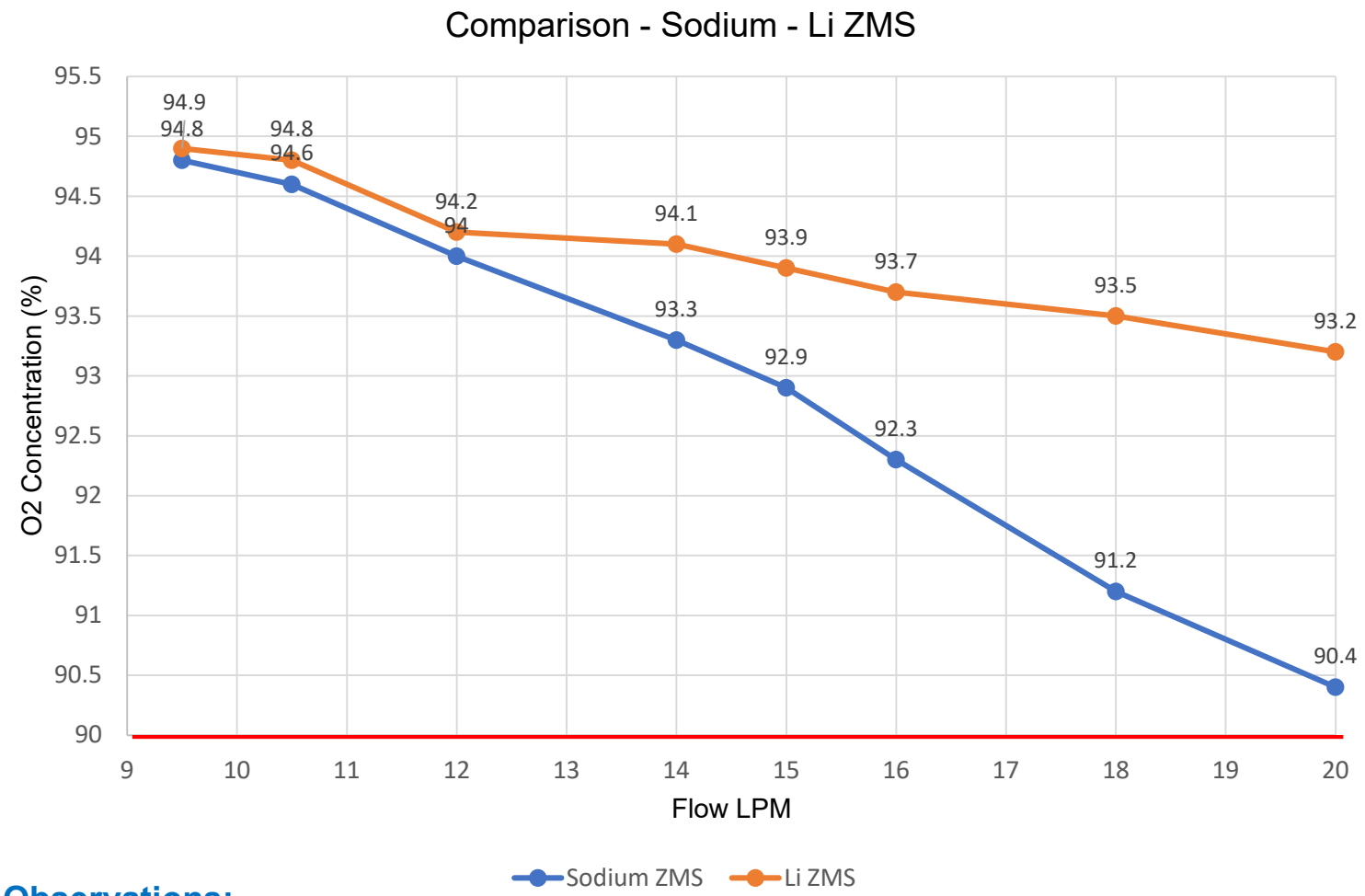
Proto Details :

1. ZMS Used = Lithium based ZMS
   JALON's JLOX-101
2. Particle Size = 0.4 mm
3. ZMS Bed Pressure = 35 Psi
4. No. of ZMS beds = 2 nos.
5. Quantity of ZMS = 1.6 Kg (for 2 beds)
6. No. Cooling coils = 2 nos.
7. No. of desiccant dryer beds = 2 nos.
8. Desiccant dryer used = Silica gel
9. Total Quantity of Desiccant dryer = 4 Kg

Ambient conditions / O2 Concentration observed:

1. Trial Date – 13-06-2021 To 18-06-2021
   - Ambient Temp = 34-35°C
   - Temperature at inlet of Canister = 29-30°C
   - O2 Concentration (range) – 92 – 94%

Frequently Asked Questions: Results – Comparison – Sodium ZMS & Li ZMS



Observations:

1. O2 Concentration (range) of 92 – 94% with Li ZMS was observed (results were consistent through out 3 days trial)
2. O2 Concentration (range) - 90 – 94% with Sodium ZMS

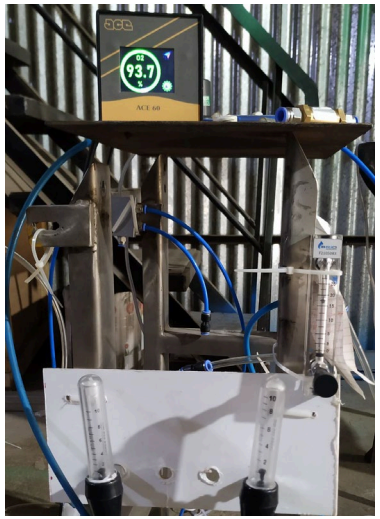
Proto set up details - A

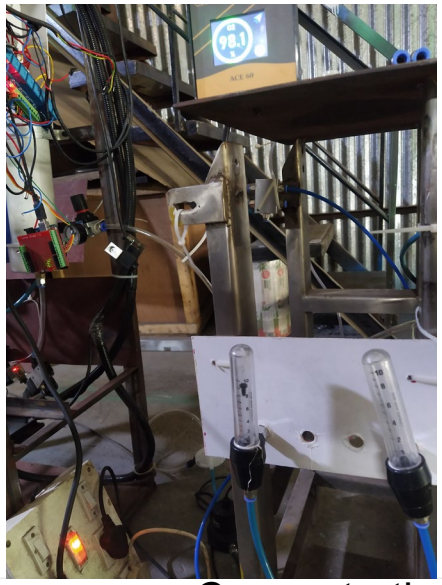
1. **ZMS Used = Sodium based ZMS ARKEMA's NITROXY 5**
2. Particle Size = 0.4 mm
3. ZMS Bed Pressure = 35 Psi
4. No. of ZMS beds = 2 nos.
5. Quantity of ZMS = 3.5 Kg (for 2 beds)
6. No. Cooling coils = 2 nos.
7. No. of desiccant dryer beds = 1 no.
8. Desiccant dryer used = Silica gel
9. Quantity of Desiccant dryer = 2 Kg
10. Trial duration = 3 – 5 Hrs
11. O2 Concentration (range) – 90– 94%

Proto Set up details - B

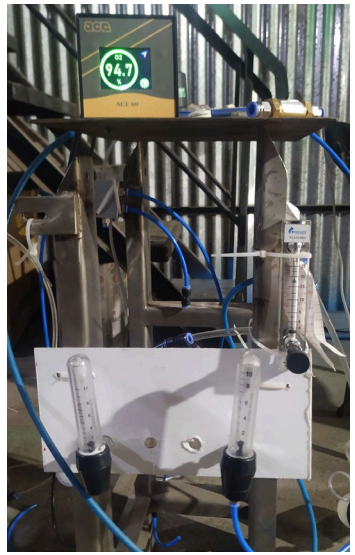
1. **ZMS Used = Lithium based ZMS JALON's JLOX-101**
2. Particle Size = 0.4 mm
3. ZMS Bed Pressure = 35 Psi
4. No. of ZMS beds = 2 nos.
5. Quantity of ZMS = 1.6 Kg (for 2 beds)
6. No. Cooling coils = 1 nos.
7. No. of descant dryer beds = 2 nos.
8. Descant dryer used = Silica gel
9. Total Quantity of Descant dryer = 4 Kg
10. Trial duration = 6 – 8 Hrs
11. O2 Concentration (range) – 92– 94%

Frequently Asked Questions: Trials – Li ZMS

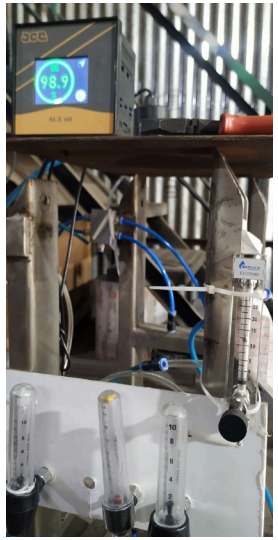




O_2 Concentration – 10 LPM



O_2 Concentration – 20 LPM



O_2 Concentration – 14 LPM

Frequently Asked Questions: Conclusion based on Prototype Trials – Sodium & Li ZMS

1. It is observed that half quantity of Li ZMS (1.6 kg) against Sodium ZMS (3.5 kg) gives better O_2 purity at output flow of 10 LPM and 20 LPM.

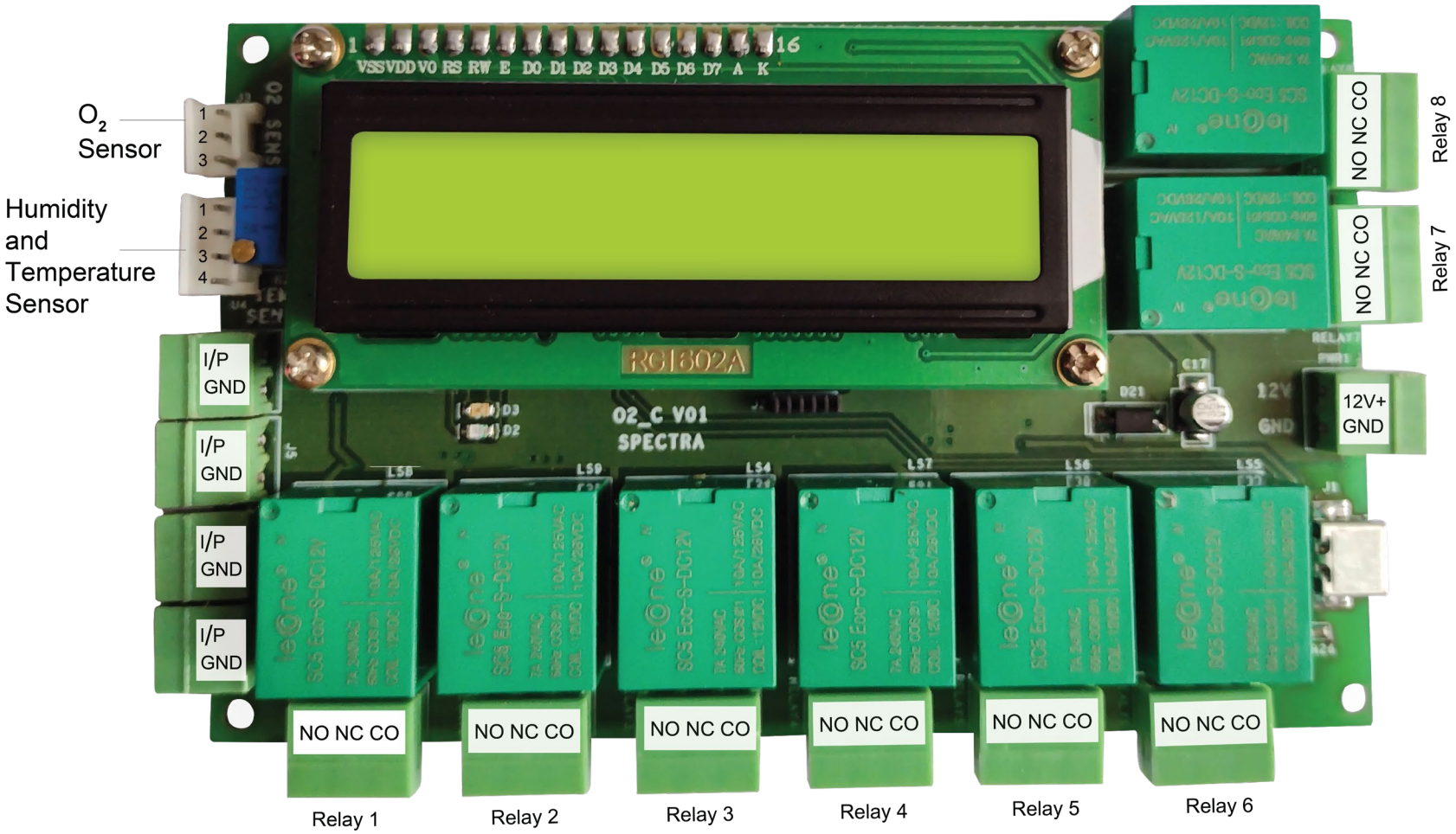
2. Trend of the results shows consistent O_2 purity (92 – 94%) with Li ZMS during continuous running, during intermittent stopping and starting , during 3-4 days trials and in varying ambient temperature.

3. It is observed that the Canister size (Internal diameter, Height) plays important role in providing optimum flow and O_2 purity with Li ZMS.

4. Valve timing needs adjustment to achieve required O_2 purity with Li ZMS.

5. By using Li ZMS with combination of proper valve timings, desiccant dryer beds & proper ZMS bed size gives 93% O_2 purity at 20 LPM consistently.

FAQ - Indigenous electronic control board for Oxygen concentrator



[FOR MORE DETAILS CLICK HERE]

Study / Reference Material

1. **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=PL4O1RQEiLpHBJ0i1zqe-CZk1p_NTtGl76 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

Important Links: Click to Download

1) TCE Oxygen Concentrator Proto BOM

2) Prototype 3D Assembly Animation

3) TCE Prototype - 3D Model Drawing

4) Sample Arduino Code @ Oxikit Website

5) Project additional documentation : https://hackaday.io/project/178334-oxikit-oxygen-concentrator

Additional Supplier Links

1. **Oil Free Compressor**
   a. https://www.industrybuying.com/ - Buy Orbit 30 L 2.5 HP Oil Free Compressor - OG 30L Online in India at Best Prices (industrybuying.com)
   b. https://dir.indiamart.com/impcat/oil-free-compressors.html
   c. https://www.nipbindustrial.in/oil-free-air-compressors.html
   d. https://store.compressorwale.com/products/3-hp-single-phase-oil-free-reciprocating-piston-type-air-compressor/8686290000000850003
   e. https://www.deltaautomations.co.in/air-compressors.html
   f. https://www.tradeindia.com/fp4984264/Oil-Free-Air-Compressor-3HP-TFS-30-Anest-Iwata-.html
   g. Search for other sources also

2. **Oxygen Sensor**
   a. https://www.exploremedical.co.in/
   b. https://www.exploremedical.co.in/envitec-oxygen-sensor.html#oxygen-sensor-oom204
3. https://www.industrykart.com/
4. https://www.moglix.com/
5. https://my.indiamart.com/
6. https://www.amazon.in/
7. https://www.technocart.com/
8. https://www.auzaro.com/list/all
9. https://www.smeshops.com/
10. https://in.misumi-ec.com/
11. https://www.tradeindia.com/
12. https://www.eleczo.com/
13. https://www.indiamart.com/utopiatechnology/profile.html

Additional Supplier Links

ONLINE at Oxikit

https://oxikit.com/collections/all-products

CHINA SOURCES
https://www.alibaba.com/product-detail/Oil-Free-Motor-For-Air-Compressor_60757842499.html?spm=a2700.themePage.1022141619731.3.332a233dB4jhQq

https://www.alibaba.com/product-detail/Air-Compressor-Oil-Free-Air-Compressor_1600100959314.html?spm=a2700.galleryofferlist.normal_offer.d_image.34733f4c0uphSc&s=p

Supplier of Instrumentation components such as Sensors, Transmitters, etc.
https://wa.me/c/919760547671

TATA CONSULTING ENGINEERS LIMITED

ENGINEERING A BETTER TOMORROW
SINCE 1962

THANK YOU

For any questions and details please write to

SUBJECT: O2 Concentrator

tceconnect@tce.co.in