

DRAFT GUIDANCE NOTE ON
LIQUID MEDICAL OXYGEN (LMO) STORAGE TANKS

1. Rapid rise in COVID-19 cases and resultant rapid demand of medical oxygen has provided a window of opportunity for re-visiting the SOP available on oxygen transportation, storage infrastructure and safe handling for patient use at the healthcare facilities. In this regard GoI MHA, NDMA has issued guidelines on safe storage, transportation, and handling of liquid medical oxygen (LMO) for medical use vide DO.5-95/2020/Mitigation dated 23rd April 2021 which needs to be followed to minimize the inherent risk involved. Medical oxygen is an important drug for saving lives, both for COVID – 19, as well as for other critical illnesses. Medical Oxygen is available in gaseous form in cylinders, or in liquid form (Kept in cryogenic state, cooled to -183 degree centigrade), stored in cryogenic tanks.

2. Liquid Medical Oxygen (LMO) is a preferred source of medical oxygen, because of the following reasons:

(a) The purity of oxygen from this source as per **IP 2018** is 99% v/v of oxygen. Moreover, the purity is constant, and does not vary with flow etc. This also makes it ideal for use with ventilators and at critical ICU beds.

(b) There are no operational costs associated with Liquid Medical Oxygen (LMO) administration. Once it is filled into the tank inside the hospital premises, it flows into the Medical Gas Pipeline System (MGPS) of the hospital, on its own, (once the valve is opened). No extra manpower, no electrical power, no maintenance, is required.

(c) LMO has no limitation of Flow Rate. It simply supplies at whatever flow rate is required by the hospital, at any given point in time. Other sources of Oxygen may fail, or shut down, if the flow required by the hospital at any given time, exceeds the flow rating of the oxygen source.

(d) The storage capacity of LMO is large. One liter of Liquid Medical Oxygen is equivalent to approx. 870 liters of gaseous Oxygen.

3. Healthcare facilities can be equipped with large bulk cryogenic liquid oxygen tanks that are refilled periodically by a truck from supplier. The liquid oxygen tank supplies a centrally piped system (MGPS) throughout the health facility independent of power supply. Liquid Medical Oxygen (LMO) demands a MGPS. A safe, open, unhindered space in a hospital premise. It also demands installation of a storage tank which needs a PESO license and a third-party supply dependence. It also demands as a best practice of having 1 to 2 days oxygen supply through cylinders as backup (Reserve). Liquid oxygen is a far better, economical, safer method than supply through cylinders or PSA plants but is a supplier dependent method.

4. Cryogenic liquids are liquefied gases that have a boiling point between -150 degree centigrade to -270 degree centigrade. Liquid oxygen is in a cryogenic form at -183 degree centigrade. A typical liquid oxygen storage system consists of a cryogenic storage tank, vaporizers, and a pressure control system. The LMO tank is a double walled vacuum insulated vessel (Maximum Allowable Working Pressure of 16 to 18 Kg/square cm with certified standards as per ASME/EN/Equivalent – **ASME Sec.VIII/EN-13458-2/Equivalent**), the capacity of which can ranges from 2 Kilo Liters to 20 Kilo Liters. The walls are made of stainless steel designed for a positive pressure at cryogenic temperature, with a vacuum between them (**Filled with perlite under vacuum**), to insulate the contents from ambient heat.

5. Liquid oxygen is stored, transported, and handled in several types of containers, depending upon the quantity required by the user. The types of containers in use include the

Dewar, cryogenic liquid cylinder and cryogenic storage tanks. All tanks are vacuum insulated and equipped with various circuits to control product fill, pressure build up, pressure relief, product withdrawal, and tank vacuum. Liquid transfer or withdrawal lines are insulated to minimize the loss of liquid product to gas and is used to safely remove liquid product from either Dewars or cryogenic liquid cylinders.

6. The LMO storage tank should have pressure valve, safety devices, two separate liquid withdrawal valves with dual parallel regulator system for uninterrupted supply, 3-way gauge valve for isolation of line pressure with manual control. The tank should be PESO certified and **outer shell** material used should conform to EIGA IGC 73/08/E/**IS2062/SA36**. A typical system requirement for hospital installation is as follows:

- LMO Storage Tank
- Ambient Air Vaporizer – should provide ambient air heat exchange which is able to vaporize **300-600** N cu M per hour LMO into vapours.
- Pressure regulation skid
- Interconnecting pipe between tank and vaporizer.
- Foundation bolts for tank and vaporizer

7. LMO tanks are installed vertically in open space in the hospital premises. The selection of location should comply with PESO regulations. Allocated space should be 9M (W) X **16 M (L)** at ground level and should be accessible for smooth movement of LMO tanker from/to the site. The supply of liquid medical oxygen shall conform to specified codes (latest edition): **Medical Oxygen IP 2018** and subsequent revisions. Avoid installation of LMO tank in the indoor environment or near drain or pits. The site should not have overhead power or other utility cable. The site should be fenced having a gate for entry/exit. Fire extinguishers & water connection, lighting, safety warnings, earthing pit etc.

8. Vaporizers convert the liquid oxygen into a gaseous state. A pressure control manifold then controls the gas pressure that is fed to the process or application. The atmospheric vaporizer should be of suitable material (Non-ferrous) for operation at low pressure. Oxygen converts from a liquid to gaseous state in contact with the ambient temperature as it expands over approx. 860 times. The tank has a built-in evaporator so that the liquid oxygen keeps on evaporating into Oxygen gas (Natural evaporation rate should be less than 1% of net volume per day). Vessels used in liquid oxygen service should be designed for the pressure and temperature involved. Piping design should follow similar design and conform to national standards and codes.

9. Some important points to be kept in mind, while planning installation of LMO tanks at the healthcare facility are appended below (General Specifications of LMO Tank is placed at Annexure C):

- (a) The tank should be located in open space (open to sky)
- (b) Vacant space should be provided within a radius of 5 meters around the tank.
- (c) Suitable distance from any combustible substance should be maintained. Liquid oxygen in itself is not an explosive but facilitates combustion easily.
- (d) Easy approach of truck which comes to fill the tank.
- (e) Permission from Chief Controller of Explosives, Nagpur (Regional offices available across the country).

(f) Existence of a Medical Gas Pipeline System (MGPS) network in the hospital is a pre-requisite for any source of Medical Oxygen, including LMO for delivery till individual bedside.

(g) The back up or secondary source of oxygen, mandatory as per MGPS norms and standards, remains the high-pressure Oxygen cylinders (Type D), connected to the gas manifold.

10. The norms for setting up of PSA Plants and LMO tanks have been issued by Ministry vide letter dated 6th July 2021 (Annexure A).

11. **Safety Considerations:** The hazards associated with liquid oxygen are exposure to cold temperatures that can cause severe burn injury, over pressurization due to expansion of small amounts of liquid into large volumes of gas in inadequately vented equipment, oxygen enrichment of the surrounding atmosphere (defined as atmosphere containing more than 23.5% oxygen), and the possibility of a combustion reaction if the oxygen is permitted to contact a non-compatible material. The low temperature of liquid oxygen and the vapours it releases not only pose a serious burn hazard to human tissues but can also cause materials or construction to lose their strength and become brittle enough to shatter. Any clothing that has been splashed or soaked with liquid oxygen or exposed to high oxygen concentrations should be removed immediately and aired for at least an hour. Personnel should stay in a well-ventilated area and avoid any source of ignition until their clothing is completely free of any excess oxygen. Clothing saturated with oxygen is readily ignitable and will burn vigorously.

12. **Safety** while storage and handling liquid oxygen:

- Store and use liquid containers with adequate ventilation. Do not store containers in a confined area or in area unprotected from extremes of weather.
- Cryogenic containers are equipped with pressure relief devices designed to control the internal pressure. Under normal conditions these containers will periodically vent product. Do not plug, remove or tamper with any pressure relief device.
- Oxygen must be separated from flammables and combustibles by **at least 5 M or 2.5 M** fire wall. Post 'No Smoking' and 'No Open Flames' signages.
- Cryogenic containers must be stored, handled and transported in the upright position. When moving, never tip, slide or roll containers on their side. Use a suitable hand truck or trolley for moving smaller containers. Avoid mechanical & thermal shock while moving cryogenic oxygen cylinders
- Use only transfer lines and equipment designed for use with cryogenic liquids. should be well insulated.
- Personnel must be thoroughly familiar with properties and safety considerations before being allowed to handle liquid oxygen and its associated equipment. The eyes are most susceptible to the extreme cold liquid and vapours of liquid oxygen.
- A diffuser to be attached to the transfer hose to reduce turbulence & release of gas while filling up from tanker.
- Use phase separator or funnel for the inlet of the receiving hose pipe.
- Never dispose-off liquid cryogenics down the drain or sink. Allow cryogenic liquids to evaporate in a 'Fume Hood' in open space.

13. **Regulatory requirement**

- All statutory requirements of the Chief Controller of Explosives of India and SMPV rules need to be followed; besides all regulations and guidelines put forward by the State/UT competent authority.
- Civil work & PESO approval (Online application)

- PESO approval for filling & operation of the LMO installation
- Fencing & gate around the installation.
- Fire extinguisher, water connection, lighting, safety signages, earthing pit for lightening arrestor.
- Allocated space for installation should be 9M(W) X **16M(L)**
- Site should be selected at ground level, outdoor, without overhead power or other utility cable.
- Should have assigned space for smooth movement of LMO tanker from/to the installation.
- Display of liquid oxygen level and outlet gas pressure should be provided.
- Automatic change over should be provided between the LMO tank and existing oxygen manifold in the health facility premises.

14. **Submittals:**

- Approval letter from CCOE along with approved drawing from CCOE.
- Approval letter from CCOE for use of cryogenic vessel(s) at site.
- Certificate from the authorized inspection agency.
- Heat chart for pressure parts.
- Dimensions check report.
- Dished End report.
- Mechanical properties test report for production test coupon.
- Visual inspection report.
- Radiography examination report
- Liquid penetrant examination report
- Cleaning inspection report.
- Hydro-pressure test report.

15. **Maintenance and Training**

- The vendor/supplier should organize satisfactory on-site training to the health facility staff designated by the authority for a period of 2 weeks
- Refresher training shall be provided by the vendor/supplier at the time of scheduled preventive maintenance visit by service engineer.
- Maintenance, repair, and safety of the whole installation and LMO related to liquid oxygen vessel will be the responsibility of the supplier and monitored by the hospital management committee.
- The oxygen tank and associated equipment, control panel, pipeline etc should be placed under CAMC for 5 years. On-line helpline support/complaint system shall be provided by the vendor/supplier.

Encl: 1. Annexure A – Letter from MoHFW dated 6th July 2021.
 2. Annexure B – Layout diagram.
 3. Annexure C – Draft General Technical Specifications of LMO Tank



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भारत सरकार
स्वास्थ्य एवं परिवार कल्याण विभाग
स्वास्थ्य एवं परिवार कल्याण मंत्रालय
Government of India
Department of Health and Family Welfare
Ministry of Health and Family Welfare

D.O.No.S.12035/26/2021-Proc.I/Oxygen/EG
6th July, 2021

Dear Colleague,

Please refer to my earlier D.O. letter dated 4th May, 2021 (copy enclosed) regarding establishment of Pressure Swing Adsorption (PSA) plants in public and private health facilities. From the Government of India's side, 1452 PSA plants are being installed. In addition, States/UTs are also setting up PSA plants from their own sources. It is important to establish PSA plants in all the concerned health facilities, especially in those health facilities which do not have access to liquid oxygen or gaseous oxygen refilling, so as to make them self-sufficient in medical oxygen.

2. In order to make a health facility self-sufficient in oxygen, either it needs to have sufficient LMO storage facility to store liquid oxygen or it needs to have a PSA plant. The Government has examined the issue of establishment of PSA plants vis-a-vis LMO storage tanks in health facilities with more than 30 beds and developed certain indicative norms. These may be useful to the States/UTs in estimating the requirements and prioritizing such infrastructure in the health facilities.

3. These indicative norms are as follows:-

- (a) PSA Plants should be the mainstay in the health facilities of all such States/UTs which are geographically difficult to reach (including the North Eastern States, tribal States, hill States and Island UTs)
- (b) In other States, PSA plants can be prioritized in those health facilities which have a bed capacity of 30 to 120 beds and are located at a distance of more than 200 km from the nearest LMO Manufacturing plants.
- (c) For bigger hospitals, which have a bed capacity of more than 120, installation of LMO tanks may be preferred, along with at least one PSA plant.
- (d) For hospitals which are geographically closer to LMO facility - i.e. less than 200 km distance from LMO Manufacturing facility, LMO tanks can be a preferred option in those hospitals which have 50 to 120 beds, whereas in hospitals with 30-50 beds, oxygen cylinders can be the mainstay of providing oxygen.

4. The States/UTs may examine these indicative norms in the context of local requirements and take up establishment of PSA plants and LMO tanks in all the balance public health facilities. Similarly, using the same norms they may facilitate the establishment of these critical health infrastructure in private health facilities also.

Harm Regards

Yours sincerely

(Rajesh Bhushan)

Encls. : A/a

To : Chief Secretaries/Administrators of all States/UTs

Copy to : Additional Chief Secretary/Principal Secretary/Secretary, Health - All States/UTs

2235756/2021/O/O JS(NV)



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भारत सरकार
स्वास्थ्य एवं परिवार कल्याण विभाग
स्वास्थ्य एवं परिवार कल्याण मंत्रालय
Government of India
Department of Health and Family Welfare
Ministry of Health and Family Welfare

D.O. No. S-12035/16/2021-Procl/Addl.PSAPlants
4th May, 2021

Dear Colleague,

In the wake of COVID-19 pandemic, the need for each health facility to have a dedicated oxygen generation plant has been acutely felt. An oxygen generation plant provides the respective hospital with an assured medical oxygen supply that is of critical need during any health emergency. The Liquid Medical Oxygen (LMO) tanks can only be a top-up source for oxygen supply in the hospital and can only supplement such dedicated oxygen generation facility.

2. In view of their immense utility, the Central Government had earlier sanctioned 162 Pressure Swing Adsorption (PSA) oxygen generation plants in 32 States/UTs in public health facilities. Subsequently, the Central Government has sanctioned additional PSA Plants (500 to be executed by DRDO and another 551 by the Ministry of Health and Family Welfare) in public health facilities. In addition, 93 PSA plants are being done in government hospitals by the Ministry of Petroleum and Natural Gas through their CSR funds. All these plants are to be commissioned within the next three months and the Ministry is coordinating closely with the States/UTs and the respective implementing agency for their quick installation.

3. Even with all these efforts, there may be some public health facilities which do not get covered under the above categories. The private hospitals may also remain left out of this endeavor. In view of the same, the States are requested to take up at their end, on priority basis, establishment of such oxygen generation plants in all the remaining public health facilities that are not included in the sanctioned list and take immediate steps for setting up such plants. Simultaneously, the private health facilities may also be persuaded to establish similar plants at the earliest.

Harm Regards

Yours sincerely

(Rajesh Bhushan)

To : Chief Secretaries/Administrators of States/UTs

Copy to: ACS/Principal Secretaries/Secretaries (Health) of States/UTs

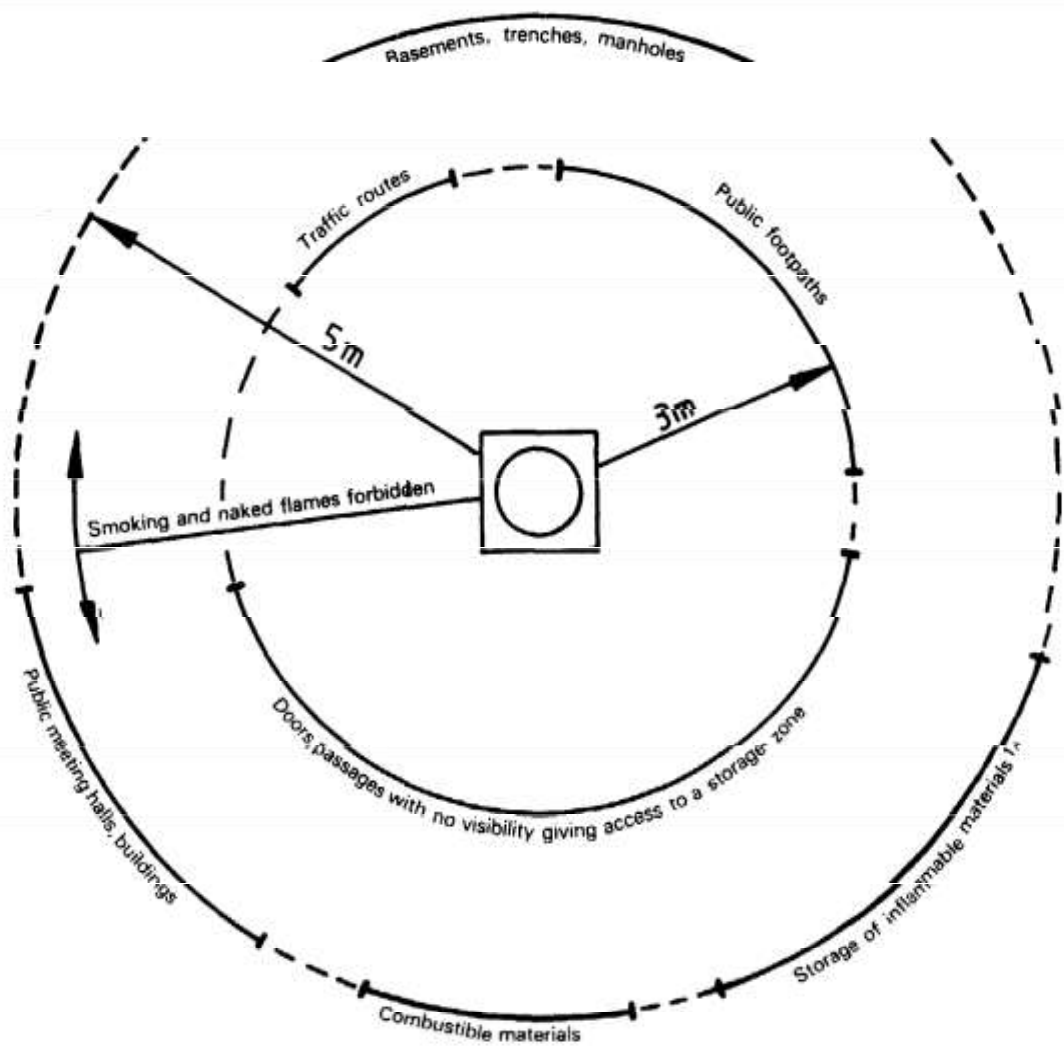


Figure 13 – Recommended minimum distances for the siting of stationary cryogenic oxygen vessels

- 1) Except where a separate firebreak wall exists with a minimum height of 2,5 m.

DRAFT TECH SPECS OF LIQUID MEDICAL OXYGEN STORAGE TANK


The double walled Vacuum Insulated Evaporator (VIE) shall be constructed of stainless-steel inner vessel contained within a carbon steel outer vessel. The annular space between the vessels shall be filled with non-inflammable perlite insulation material to insulate under vacuum. The VIE should be self-pressurizing type by partial evaporation of liquid oxygen through a pressure building coil by a non-ferrous imported pressure regulator.

The vessel shall be supplied as a functional whole with all materials of construction & the cleaning regime suitable for medical grade liquid oxygen. Material used (including lubricants) should conform to EIGA IGC 73/17/E (Revised version of Doc 73/08).

The LMO tank should have Liquid outlet & Gas Outlet along with all the necessary valves and accessories. There is constant display of the level of LMO and pressure etc. inside the vessel. The output from the tank is connected through a copper pipe of suitable diameter to the MGPS network at the MGPS Manifold.

Quantity: 10 KL x 1 No.

Installation: Outdoor

Type : Double walled, vertical 

Capacity : Minimum 20,000 liters water capacity

Design code: ASME Sec.VIII Div.I latest Edition / EN - 13458-2 Annexure-C/ AD2000 MARKBLATTER 2004 Edition

Max. working pressure: 17 Bar G

Design temperature: -196 to +50 degrees Centigrade

Hydraulic Test Pressure: 26 Bar G

Type of Insulation: Vacuum , perlite filled

Safety Valve Set pressure valve : 17 Bar G (Dual safety valve with three way diverter valve)

Bursting Disc Set Pressure : 23 Bar G

Standard fittings : Pressure rising coils capacity and size, dual safety valve with imported three way diverter valve, bursting disc., pressure gauges, liquid over flow line, Liquid level gauge and adequate numbers of extended spindle glove valve etc.

The pressure regulator installed should be made of suitable material (Non ferrous) with bonnet & trim parts. Inlet pressure max. 20 Kg/sq cm., outlet pressure range within 0.5 to 10 kg per sq cm (adjustable).

Maximum Evaporation Rate: <1% of net value.

Material of Construction: Inner shell and wetted parts of SS 304 Outer shell of CS ASTM A 516 Gr. 70 / CGA 341 2002 EN13455 S275/S355

Joint Efficiency: 100%

Radiography :100% for inner, for outer spot

External piping: From LMO Tank to Vaporizer SS304. From Vaporizer to inlet of Pressure Reducing Station SS304 From Outlet of Pressure Reducing Station to Main header Copper

Cryogenic Valves: Non-ferrous

Cryogenic Safety Valves: Non ferrous

Pressure Building regulator: Non ferrous with standard specifications.

Leak Detection test: Helium Leak detection

Inspection: By 3rd party (SGS/LLOYDS/TUV)

Cleaning Nitrogen: with degreasing for Service and Pressurize

Withdrawal rate: 1000 cum per hr. at 12 bar G

Should have safety features in line with Global Safety as part of installation The minimum safety (Alarm) features for LMO installation are as follows:

- Alarm VIE (Vacuum Insulated Evaporator)
 - For low content level (audio-visual) and
 - Low pressure alarm (audio-visual) and backup at manifold room.
- Alarm VIE low pressure alarm (audio-visual) low pressure in pipeline system. Deviation or fall in pipeline pressure by more than plus minus 10% from nominal distribution

pressure (The nominal distribution pressure should be within the range of 400kPa to 500 kPa).

- Alarm for changeover from primary to secondary supplies.
- Alarm for secondary or reserve supply below minimum pressure.
- Dual parallel regulator system for uninterrupted supply in case of regulator has to change for repair. One regulator is set at 4.2 bar and the other at 3.8 bar as per international practice.
- Three-way gauge valve for isolation of line pressure with manual manoeuvre.
- Remote monitoring telemetry-continuous monitoring of VIE stock based on daily consumption (automatic modification of tank replenishment).

Pressure Reducing Station

- The healthcare facility supply pipeline reducing station which reduces supply pressure must consist of dual parallel regulator system.
 - Both regulators must be online, and all isolation valves and regulators must be kept in the open position.
 - The nominal distribution pressure should be maintained within the range of 400kPa to 500kPa.
 - Pressure relief Valve – Medical oxygen pipeline system should be provided with a pressure relief device downstream of the line pressure regulator connected by means of a 3-way valve.
 - Material used should conform to (including lubricants) EIGA IGC 73/17/E
 - The control equipment should be protected from weather.
-