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भारत सरकार
गृह मंत्रालय
राष्ट्रीय आपदा प्रबंधन प्राधिकरण
Government of India
Ministry of Home Affairs
National Disaster Management Authority

D. O.5-95/2020/Mitigation

Dated: 23rd April 2021.

Sub-: Guidelines on Safe Storage, Transportation and Handling of Liquid Oxygen for Medical Use

Dear Colleague,

As you are aware that on 21 April 2021 a preventable accident resulting in leakage of oxygen from the installed 13 Kilolitre Oxygen Tank occurred at Dr Zakir Husain Hospital at Nasik, Maharashtra, leading to drop in pressure in the piped oxygen supply which resultant in death of 22 patients.

2. Rapid rise in COVID-19 cases and resultant rapid demand of medical oxygen is posing high pressure on its transportation, storage infrastructure and handling at COVID-19 hospitals. Towards ensuring seamless, accident free optimal supply of medical oxygen National Disaster Management Authority has issued numerous advisories which are relevant for "Hazardous Chemicals: Safe Manufacture, Transportation and Handling", from time to time. A few of them are listed as under: -

I. Guidelines on Chemical Disasters 2007.
II. Guidelines on Management of Chemical (Terrorism) Disasters 2009.
III. Strengthening of Safety and Security for Transportation of POL Tankers 2010.
IV. Guidelines on Hospital Safety 2016.
V. Medical Preparedness and Mass Casualty Management 2007

3. In addition to that , The Manufacture, Storage and Import of Hazardous Chemical Rules, 1957; Environment Protection Act, 1986; The Petroleum Act 1934, The Explosives Act 1884, The Static and Mobile Pressure Vessel (Unfired) Rules 1981, The Gas Cylinder Rules, 2004 and various rules framed by states, provide the statutory requirements.

4. However despite all the existing Guidelines and SoP's incidences/ accidents as quoted above do happen which are actually preventable. In view of There is a need to revisit the existing information on Storage, Transportation and handling of Medical Oxygen Supply. In order to minimize the risk and to encourage smooth functioning broad "Guidelines on Safe Storage, Transportation and Handling of Liquid Oxygen for Medical Use" are enclosed as Appendix (A).

5. State Governments should ensure that these guidelines are disseminated to all the hospitals in the state for compliance. SDMA/DDMA/AAPADMITRAS to be roped in for dissemination of these guidelines on ground level with the aim to prevent a repeat of the such accident in future.

Regards,

Yours sincerely

(Sanjeeva Kumar)

Encl: As above

Chief Secretaries of States /
Administrators of UTs
(As per the list attached)

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Appendix-A

Guidelines on Safe Storage, Transportation and Handling of Liquid Oxygen for Medical Use

I. End Use Medical Equipment for Liquid Oxygen

- **Oxygen cylinders** - These are primarily used in hospitals where Medical Gas pipeline (MGps) has not been laid, however many hospitals use cylinders connected in series to supply oxygen to the wards through a manifold. The Jumbo cylinders are used in critical areas like operation Theatres, ICUs, HDUs, etc. Smaller cylinders (B Type) are used for stretchers, ambulances, general wards, etc. The use of oxygen cylinders requires three times the inventory of cylinders consumed in a hospital in a day (one set of cylinders in use, one set as backup and one set in refilling station). It is labour intensive, logistically challenging, unsafe, unhygienic (chances of carrying infection from hospital) and expensive method' However this is the most easily adaptable method in short term and emergency situations.

- **Oxygen Concentrators** - An oxygen concentrator is a self-contained, electrically powered medical device designed to concentrate oxygen from ambient air. This is used on the bedside without MGpS and caters to 1-2 patients at a time.

- **Oxygen Pipeline Systems**- These supply oxygen at high pressure to equipment such as anaesthetic machines and ventilators. A key advantage of pipeline systems is that they obviate the need for handling and transporting heavy cylinders between hospital wards. The high cost of installing centralized oxygen sources with copper pipelines and the high level of specialized maintenance required currently make these systems of oxygen delivery unsuitable for many district-level.

- **Liquid Oxygen**- Facilities can be equipped with large bulk liquid oxygen tanks that are refilled periodically by a truck from a supplier. The liquid oxygen tank supplies a centrally piped system throughout the health facility by self-vapourization, meaning that a power supply is not required. Liquid Medical Oxygen demands a MGPS, a safe, open, unhindered space upto 9M x1'5M 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 one day of oxygen supply through cylinders as a backup. But this is a far better, cheaper, safer method than supply through cylinders, however this is again a supplier dependent method. Although currently an economical option in some locations, liquid oxygen requires high technical knowledge and large, well-ventilated spaces, and can introduce risks in settings with extreme temperature and humidity. It is best practice to also have cylinders as a backup supply.

- **Oxygen Plant (Central Oxygen Supply System)**- An oxygen plant is a large, onsite, central source of oxygen that is piped directly to terminal units within patient areas. Plants can also be set up to refill cylinders for oxygen distribution or backup oxygen supply; these cylinders can be connected to sub-central manifold systems at the health facility or transported to neighbouring health facilities. Oxygen plants require a reliable source of power. It is best practice to also have cylinders as a backup supply.

II. Liquid Oxygen

Oxygen is the second largest component of the atmosphere, comprising 20.8% by volume. Liquid oxygen is pale blue and extremely cold. Although nonflammable, oxygen is a strong oxidizer. Oxygen is necessary to support life. Oxygen will react with nearly all organic materials and metals, usually forming an oxide. Materials that burn in air will burn more vigorously in oxygen. Equipment used in oxygen service must meet stringent cleaning requirements, and systems must be constructed of materials that have high ignition temperatures and that are nonreactive with oxygen under the service conditions. Vessels should be manufactured and designed to withstand the process temperatures and pressures.

Liquid oxygen is a cryogenic liquid. Cryogenic liquids are liquefied gases that have a normal boiling point below –130°F (–90°C). Liquid oxygen has a boiling point of –297°F (–183°C). Because the temperature difference between the product and the surrounding environment is substantial—even in the winter—keeping liquid oxygen insulated from the surrounding heat is essential. The product also requires special equipment for handling and storage.

Oxygen is often stored as a liquid, although it is used primarily as a gas. Liquid storage is less bulky and less costly than the equivalent capacity of high-pressure gaseous storage. A typical storage system consists of a cryogenic storage tank, one or more vaporizers and a pressure control system. The cryogenic tank is constructed, in principle, like a vacuum bottle. There is an inner vessel surrounded by an outer vessel. Between the vessels is an annular space that contains an insulating medium from which all the air has been removed. This space keeps heat away from the liquid oxygen held in the inner vessel. 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. Vessels used in liquid oxygen service should be designed for the pressure and temperatures involved. Piping design should follow similar design and conform to national standards and codes.

III. Medical Uses

Oxygen is generally liquefied so that it can be more effectively transported and stored in large volumes. However, most applications use oxygen after it is vaporized to the gaseous form. The primary uses of oxygen relate to its strong oxidizing and life-sustaining properties. Oxygen is commonly relied upon in health and medical applications.

IV. Health effects

Normally, air contains 21% oxygen, and oxygen is essentially nontoxic. No health effects have been observed in people exposed to concentrations up to 50% at 1 atmosphere for 24 hours or longer. The inhalation at 1 atmosphere of 80% oxygen for more than 12 hours can cause irritation of the respiratory tract, progressive decrease in vital capacity, coughing, nasal stuffiness, sore throat, and chest pain, followed by trachea-bronchitis and later by pulmonary congestion and/or edema. Inhalation of pure oxygen at atmospheric pressure or less can cause pulmonary irritation and edema after 24 hours.

Respiratory symptoms can occur in two to six hours at pressures above 1 atmosphere. One of the earliest responses of the lung is accumulation of water in its interstitial spaces and within the pulmonary cells. This can cause reduced lung function, which is the earliest measurable sign of toxic- ity. Other symptoms include fever and sinus and eye irritation.

When pure oxygen is inhaled at pressures greater than 2 or 3 atmo- spheres, a characteristic neurological syndrome can be observed. Signs and symptoms include nausea, dizziness, vomiting, tiredness, light-headedness, mood changes, euphoria, confusion, incoordination, muscular twitching, burning/tingling sensations (par- ticularly of the fingers and toes), and loss of consciousness. Characteristic epileptic-like convulsions, which may be preceded by visual disturbances such as loss of peripheral vision, also occur. Continued exposure can cause severe convulsions that can lead to death. The effects are reversible after reduction of oxygen pressure.

Premature infants placed in incuba- tors to breathe oxygen in concentra- tions greater than in air can develop irreversible eye damage. Within six hours after an infant is placed in a high-oxygen atmosphere, vasocon- striction of the immature vessels of the retina occurs, which is reversible if the child is immediately returned to air, but irreversible if oxygen-rich therapy is continued. Fully developed blood vessels are not sensitive to oxygen toxicity.Extensive tissue damage or cryogenic burns can result from exposure to liquid oxygen or cold oxygen vapors.

V. Containers

Liquid oxygen is stored, shipped, 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 Tank. Storage quantities vary from a few liters to many thousands of litrs. Since heat leak is always present, vaporization takes place continuously. Rates of vaporization vary, depending on the design of the container and the volume of stored product. Containers are designed and manufactured according to the applicable codes and specifications for the temperatures and pressures involved.

Tanks may be spherical or cylindrical in shape and are mounted in fixed locations as stationary vessels or on railcar or truck chassis for easy transportation. Sizes range from 1,893 – 1,589,873 Litres . All tanks are powder- and vacuum-insulated in the annular space and equipped with various circuits to control product fill, pressure build up, pressure-relief, product withdrawal, and tank vacuum. Tanks are designed to national specifications for the pressures and temperatures involved.

Liquid transfer line is used to safely remove liquid product from dewars or cryogenic liquid cylinders. A typical transfer line for dewars is connected to a bayonet that provides a means of using product vapor pressure buildup or an external pressure source to remove the liquid. For cryogenic liquid cylinders, the transfer line is connected to the cylinder's liquid withdrawal valve. Liquid product is typically removed through insulated withdrawal lines to minimize the loss of liquid product to gas. Insulated flexible or rigid lines are used to withdraw product from stor-age tanks. Connections on the lines and tanks vary by manufacturer.

VI. <u>Safety considerations</u>

The hazards associated with liquid oxygen are exposure to cold temperatures that can cause severe burns; 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; 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 vapors it releases not only pose a serious burn hazard to human tissue, but can also cause many materials of construction to lose their strength and become brittle enough to shatter.

It is important to note that fire chemistry starts to change when the concentration of oxygen increases. Materials easily ignited in air not only become more susceptible to ignition but also burn with added violence in the presence of oxygen. These materials include clothing and hair, which have air spaces that readily trap the oxygen. Elevated oxygen levels can be reached very quickly, and all personnel must be aware of the hazard.

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.

Do not permit smoking or open flames in any areas where liquid oxy- gen is stored or handled. Do not permit liquid oxygen or oxygen-enriched air to come in contact with organic materials or flammable or combustible substances of any kind. Some of the organic materials that can react violently with oxygen when ignited by a spark or even a mechanical shock are oil, grease, asphalt, kerosene, cloth, tar, and dirt that may contain oil or grease. If liquid oxygen spills on asphalt or other surfaces contaminated with combustibles, do not walk on or roll equipment over the area of the spill. Keep sources of ignition away for 30 minutes after all frost or fog has disappeared.

Systems used in oxygen service must meet stringent cleaning requirements to eliminate any incompatible contaminants. . Also, review the Material Safety Data Sheet (MSDS) and follow all recommendations.

VII. <u>Buildings</u>

Because of the large expansion ratio of liquid-to-gas, it is very important to provide adequate ventilation in areas where liquid oxygen is in use. A minimum of six air changes per hour is suggested. The definition of an oxygen-enriched atmosphere is one containing more than 23.5% oxygen. Remember, oxygen has no warning properties!

VIII. Storage

- Store and use liquid containers with adequate ventilation. Do not store containers in a confined area or in area unprotected from the extremes of weather.
- Cryogenic containers are equipped with pressure relief devices de- signed 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 20 feet or a half-hour fire wall. Post "No Smoking" and "No Open Flames" signs.
- Liquid containers should not be left open to the atmosphere for extend-ed periods. Keep all valves closed and outlet caps in place when not in use. If restriction results from freezing moisture or foreign material present in openings and vents, contact the vendor for instructions. Restrictions and blockages may result in dangerous over pressurization. Do not attempt to remove the restriction without proper instructions. If possible, move the cylinder to a remote location.

IX. Handling

- 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 for moving smaller containers. Move larger containers by pushing, not pulling. Avoid mechanical and thermal shock.
- Never allow any unprotected part of the body to come in contact with uninsulated pipes or equipment containing cryogenic product. The extreme cold will cause flesh to stick fast and potentially tear on withdrawal.
- Use only oxygen-compatible materials and lubricants.
- If there is any difficulty in operating the container valve or container connections, discontinue use and contact the vendor. Do not remove or interchange connections. Use only the properly assigned connections. Do not use adapters.
- Use only transfer lines and equipment designed for use with cryogenic liquids. Some elastomers and metals, such as carbon steel, may become brittle at extremely low temperatures and may easily fracture. These materials must be avoided in cryogenic service.
- It is recommended that all vents be piped to the exterior of the building.
- On gas withdrawal systems, use check valves or other protective apparatus to prevent reverse flow into the container.
- On liquid systems, pressure relief devices must be used in lines where there is the potential to trap liquid between valves.

X. Personal Protective Equipment (PPE)

Personnel must be thoroughly familiar with properties and safety considerations before being allowed to handle liquid oxygen and its associated equipment. The eyes are the most susceptible to the extreme cold of the liquid and vapours of liquid oxygen. The recommended PPE is a full face shield over safety goggles; clean, loose-fitting thermal-insulated or leather gloves; long-sleeved shirts; and pants without cuffs. Wear this PPE when handling or using liquid oxygen, or whenever the possibility of exposure due to a spill exists. In addition, safety shoes are recommended for those involved with the handling of containers.

In emergency situations, self- contained breathing apparatus (SCBA) must be used. Clothing that is fire- resistant in air may be readily ignitable in oxygen-enriched atmospheres. Only trained and certified emergency responders should respond to emergency situations.

XI. First aid

For skin contact with liquid oxygen, remove any clothing that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. As soon as practical, place the affected area in a warm water bath with a temperature not exceed- ing 105°F (40°C). Never use dry heat. Call a physician as soon as possible. Frozen tissue is painless and appears waxy with a possible yellow color. It will become swollen, painful, and prone to infection when thawed. If the frozen part of the body has been thawed, cover the area with a dry sterile dressing with a large bulky protective covering, pending medical care. In case of massive exposure, remove clothing while showering the victim with warm water. Call a physician immediately. If the eyes are exposed to the extreme cold of the liquid or vapors, immediately warm the frostbite area with warm water not exceeding 105°F (40°C) and seek medical attention. Since oxygen is nonflammable but supports combustion, fire-fighting actions require shutting off the source of oxygen, if possible, then fighting the fire according to the material involved.
