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Short Communication

Refilling USAID oxygen cylinders, indigenous solution to a foreign challenge

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The Oxygen cylinders are the most common source of oxygen storage and supply in the health care setting.[1] The oxygen cylinders require a special valve or regulator to reduce the pressure inside the cylinder in a controlled way and a flow meter for calibrating the flow. It is extremely dangerous to use an oxygen cylinder without a regulator, and the high pressures can damage the delicate and critical equipment downstream to the cylinder. As per regulations of the country, cylinders specifications vary with at least five different types in use and each cylinder has a different type of regulator.[2]

Safety features in the cylinder include Color coding, pin index, pressure relief device, Bodok seal, and label attached and guidelines for the storage, installation, and use of cylinders to ensure the safety of patients, hospital personnel, and the environment.[3] Problems of oxygen cylinders include leaking oxygen from improper connections, contact with incompatible materials and gases causing a fire and explosion hazard, incorrect use of oxygen gas, careless handling of oxygen cylinders leading to workplace injuries.[4] Hazards include incorrect cylinder being connected despite the pin index system, and incorrect contents when due diligence at filling cylinders is not followed.[5] Other issues with cylinders include incorrect valve, incorrect color, incorrect labeling, inoperable valve, and damaged valve.[6] Major complications occur due to asphyxia when a nitrous oxide cylinder has been accidentally connected in place of oxygen.[7] If equipment is contaminated with dirt, grease, oil, hand cream, paraffin, or other combustible substances, explosive rupture and burning of components may occur.[8] Explosion can also occur if the cylinder is improperly filled and the pressure relief device does not function properly.

An international color code to aid in the identification of gas cylinders was adopted by the medical gas industry in 1949. Unfortunately, this has not been adopted by many countries, US uses green and Germany uses blue color for oxygen cylinders.

Each gas cylinder has a unique connection assigned to it by the central gas association (CGA) in the United States of America, where the large oxygen cylinder is green in color and has a CGA 540 connection. In India the cylinders are black with white shoulders as per the medical gas cylinder color code Indian standard IS 3933.[9]

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The sudden surge in the Covid pandemic overwhelmed the existing infrastructure with a deluge of patients needing hospitalization and oxygen requirement. The delivery of 50 Oxygen cylinders by the Government of India which were a part of the US AID to our Institute helped in increasing the oxygen supply. The US-AID oxygen cylinders proved to be challenging due to, incompatibility with the available flow meters, the manifold connections, and the refilling nozzles at the refilling gas center making the utilization a hurdle.

The full oxygen cylinders have pressures of 13 400 kPa {132 atmospheres (atm), 2000 psi.} which has to be reduced around 5 atm, and the reducing valve or control valve reduces the cylinder pressure to this working pressure. Oxygen gas flow meters are used to deliver oxygen to patients directly from the oxygen cylinders or the central gas pipeline system in hospitals. The flow meters connected to the central outlets are different from those connected to the oxygen cylinder mainly because of the outlet pressures. The oxygen flow meter connected to the pipeline outlets operates at 4 to 5 atm, while the flow meter connected to the oxygen cylinders has a pressure reducing valve attached to reduce the cylinder pressures of 132 atm to 5 atm.

The combination of a flowmeter with a reducing valve is being referred to as the oxygen flow regulator. The components of the flow regulators for delivering oxygen from an oxygen cylinder include a pressure regulator with a Bourdon pressure gauge, Thorpe tube flow meter, and a bubble humidifier which together form the complete unit. Care has to be taken with Thorpe tubes as they are fragile. Their accuracy can be altered with exposure to static electricity or a magnetic field, and also secondarily to a mechanical shock or when the vertical position cannot be maintained.

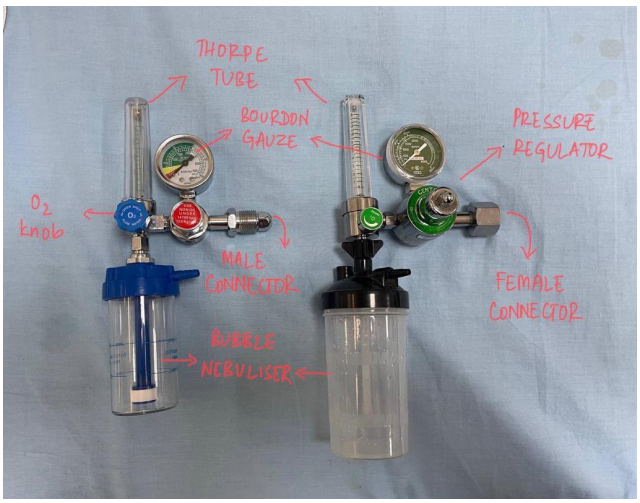

Fig. 1: Flow regulators differing in the design of connectors

Different types of Oxygen Flow regulators (blue with a male connector on the left, green flow regulator with a female connector on the right) for use with Oxygen cylinders as seen in Figure 1. The USAID Cylinders required the flow regulator on the right(green) with a female connector to utilize the oxygen.

Technical Problem: The US Oxygen Cylinder outlet was a 5/8" male outlet with 14 National Gas Outlet thread (NGO)

Fig. 2: Difference in cylinder outlets Male (left) and female (right)

The process for changing the cylinder valve requires a certified vendor and permission from both BIS (Bureau of Indian standards) and PESO (Petroleum and Explosive Safety Organisation of India). The certification process is prolonged and was not implementable during the lockdown.[10]

To immediately use these cylinders, especially during peak pandemic conditions where oxygen demand was very high, an adaptor was designed which fitted to the male outlet of US Oxygen cylinder and the other end 5/8" British Standard Pipe right-handed threaded female connection without changing the oxygen valve by a senior engineer (Figure 3). The first adaptor was tested, for functionality by doing a leak test after connecting to a flow meter, and by refilling oxygen without a problem. Successful utilization of the adaptor solved the different problems of connection to the available flow regulators, refilling of the cylinders with oxygen, and connections to the manifold, thereby providing a solution to the immediate use of cylinders.

This small indigenous adaption made a major improvement in oxygen delivery during the peak pandemic. This was an interim solution in a grim situation, with improvement in the covid situation, all the cylinders received from USAID were sent for change in the valve, painting as per guidelines and PESO certification, and added to the cylinder bank.

Oxygen cylinders are a vital component and a primary source of oxygen in a hospital, the safe management of the cylinders includes strict adherence to safety measures as well as having correct and compatible accessories as per government regulations. Oxygen flow regulators are important in delivering oxygen in a safe and regulated

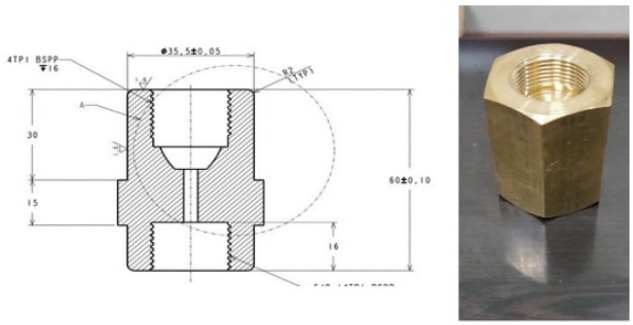

Fig. 3: Adaptor design and actual product

manner from an oxygen cylinder and due diligence should be taken regarding their compatibility and quality.

Conflicts of interest

None.

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