

# Portable Oxygen Distribution System: Enhancement of Capacity as COVID-19 Preparedness

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## ABSTRACT

**Introduction:** The symptomatic treatment of COVID-19 patients involves timely supply of oxygen. Exponential rise in the number of patients has put extreme stress on the existing oxygen supply system in the hospitals necessitating the need to improvise and find a portable, easy to use, simple to fabricate, robust system capable of optimizing the utility of oxygen cylinders by supplying oxygen to multiple patients simultaneously.

**Aim:** To implement and illustrate an innovative device so that oxygen need of multiple patients can be achieved.

**Methodology:** When there is no piped gas supply system in the isolation wards, it becomes a big challenge to meet the oxygen requirements of COVID-19 patients. The oxygen cylinders have to be changed or shifted quite often as per patients' need which becomes cumbersome and undesirable. To bit the crisis, capacity enhancement was done by process design and engineering effort. In this paper, we present a simple and efficient system which has been validated at two hospitals and which uses the parts of pneumatic systems of different heavy motor vehicles (readily available in the commercial market) to mitigate this requirement.

**Result:** The innovative process design was applied here to have the system of multiple patients with connectivity of oxygen from a single cylinder. The gas mechanics with regulatory control and flow diagrams have been well depicted in the article. This prototype has been widely appreciated in the current environment.

**Conclusion:** The study is a hallmark of capability building by innovation which could achieve praise-worthy outcome in pandemic situation with support of engineers.

**Keywords:** COVID-19, Oxygen, Portable oxygen distribution system (PODS).

*International Journal of Research Foundation of Hospital and Health Care Administration (2020): 10.5005/jp-journals-10035-1118*

## INTRODUCTION

A tertiary care providing super speciality hospital was actively involved in COVID management of clientele. Apart from managing tertiary care support, the administration has to manage COVID-related cases in tandem by rendering assistance to civil authorities when requisitioned. It calls for detailed planning and streamlining of resources for handling the resources.

During the time of COVID-19 preparedness, many in-patient facilities had to be converted as COVID isolation wards.<sup>1</sup> There was no facility of piped oxygen supply in these isolation wards and cylinders were used as source of oxygen to the patient (in the existing system, one cylinder is used per patient). Many of the COVID patients would require ventilator support with oxygen connection. The oxygen cylinders have to be changed/shifted repeatedly depending on the place of requirement and this task is both labor intensive and time-consuming. Moreover, due to frequent change of cylinders, the regulator undergoes excessive wear and tear. A suitable mechanical modification was devised and successfully tested using two oxygen cylinders on a mobile platform connected to the contraption system for streamlined oxygen delivery to four patients simultaneously, thereby splitting one source of oxygen into four consumer points.

## CAPACITY ENHANCEMENT

To fight the pandemic COVID-19 ideas and innovations from across the board have been forthcoming. The ingenuity and creativity of this is indeed praiseworthy. One of the most noteworthy of these is enhancing the capability of oxygen supply system. In traditional

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**How to cite this article:** Naik BAK, Chandra MR. Portable Oxygen Distribution System: Enhancement of Capacity as COVID-19 Preparedness. *Int J Res Foundation Hosp Healthc Adm* 2020; XX(X):1–3.

**Source of support:** EME, Department of Anaesthesia, CHNC

**Conflict of interest:** None

method, the oxygen cylinder has been used to supply O<sub>2</sub> to multiple patients at hospitals using fixed copper lines (rigid, non-portable, and expensive) or using one cylinder per patient.

As of now, symptomatic treatment of COVID-19 involves giving patients oxygen at the rate of approximately 02–06 L/minute in critical cases. Cases are known to have responded well in case of timely administration of requisite oxygen.<sup>2</sup> However, anticipating an exponential rise in the requirements, there is likely to be added burden on existing limited oxygen supply infrastructure.

As a solution to tide over the pandemic situation, multiple oxygen feed pump contraptions were devised for the COVID-19 wards with the help of engineers. The main feature of this design is the concept of utilizing high pressure pneumatic system of heavy motor vehicles to deliver oxygen to multiple patients from the cylinders simultaneously.<sup>3</sup>

## DESIGN AND DESCRIPTION

The various parts used in the system are shown in Figure 1.

The line diagram of portable O<sub>2</sub> distribution system and the circuit diagram of portable oxygen distribution system (PODS) are as shown in Figures 2 and 3, respectively.

The pressure of standard oxygen cylinder ranges from 130 to 200 kg/cm<sup>2</sup>. The oxygen is then fed to a double-stage reducer which measures the pressure both at cylinder and at the pipeline end. A pressure of range 4–6 kg/cm<sup>2</sup> is sufficient to maintain desired flow rates at patient end. This volume of gas is then fed to a quadruple system protection valve (suitably modifying the kit) to sustain same pressure at inlet and outlet. A high pressure pneumatic line with rating of up to 25 kg/cm<sup>2</sup> is used to maintain/sustain pressure in the system. A standard oxygen flow meter (hospital grade) has been attached with the help of adapter to monitor/control flow to the patients. A trolley is used to ensure portability and easy carriage of

the system. A cabinet to enclose the system and display the visual/ audio alarm in case of high/low pressure is also incorporated in the design for ease of use and installation.

Features: The key features of the system include the following:

- Four-level safety features:
  - Primary safety at the O<sub>2</sub> cylinder regulators.
  - Secondary safety at double-stage regulator.
  - Tertiary safety at flow meter regulator.
  - Audio/visual alarm if pressure is not within 2–6 kg/cm<sup>2</sup> in the pipeline.
- Flexibility of size: The system allows use of any size of the oxygen cylinder due to use of high pressure pipes. The cylinders in parallel can be of different sizes at the same time without any change in design.<sup>4</sup>
- Flexibility in distance between patients: The design allows varying the length of O<sub>2</sub> pipes going from the contraption

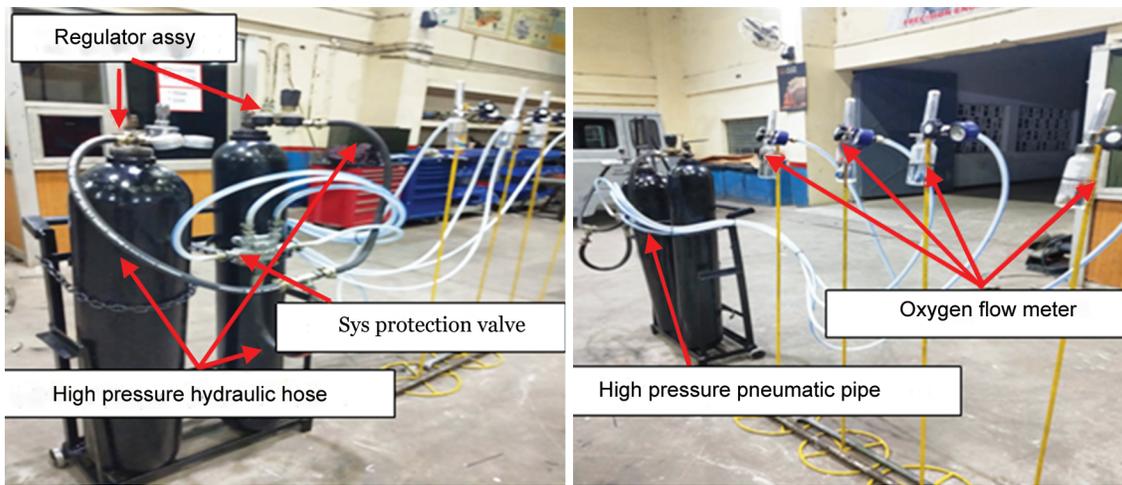


Fig. 1: Portable oxygen distribution system

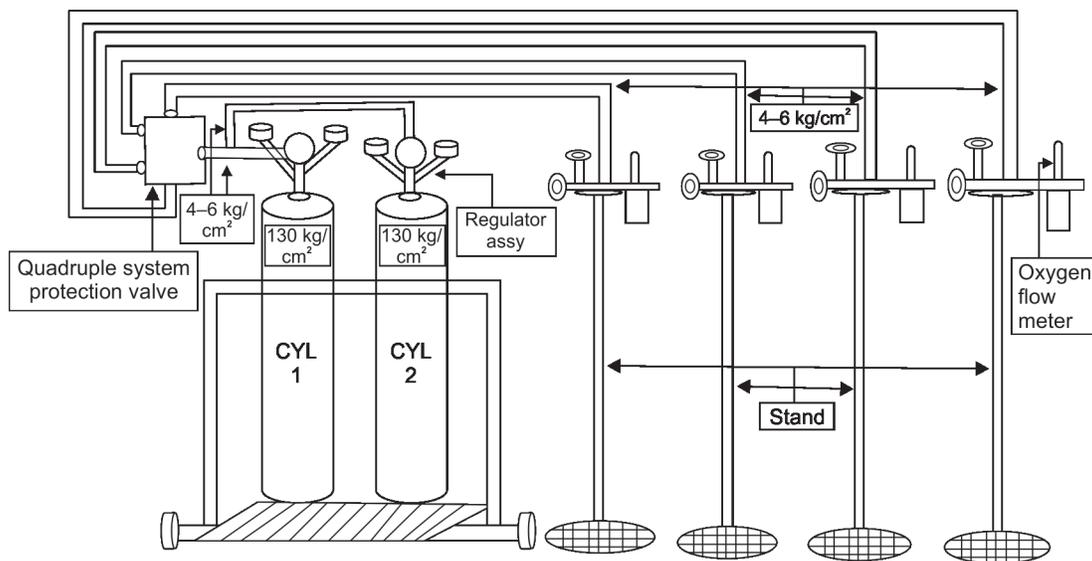


Fig. 2: Line diagram of portable oxygen distribution system

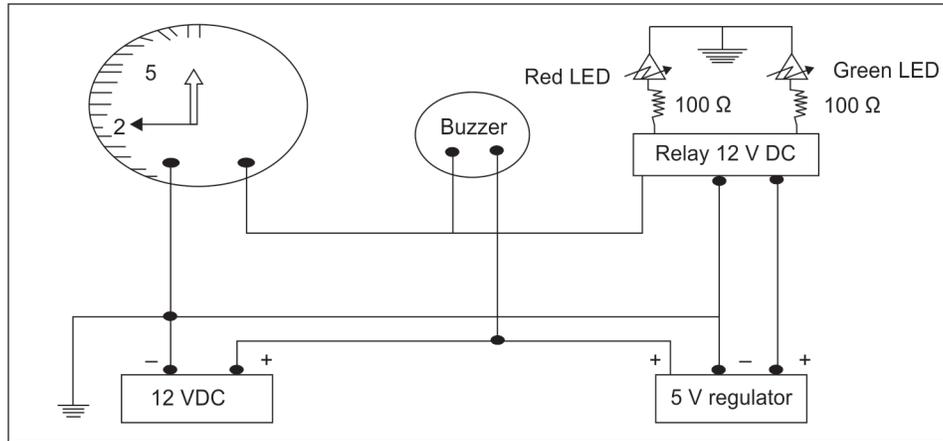


Fig. 3: Circuit diagram of alarm system of portable oxygen distribution system

device up to different patients, maintaining distance in COVID-19 scenario.

- **Portability:** The system is portable and based on a trolley for ease of use and flexibility. It can also be used to provide oxygen when the patients are transported in ambulance. The system is quite user-friendly.
- **Redundancy in O<sub>2</sub> cylinder:** To enable seamless shifting of oxygen cylinder without any stoppage of O<sub>2</sub> supply to the patients.
- **Patients with varying O<sub>2</sub> requirement** can be treated simultaneously as the rate of flow is controlled at the flow meter end.
- **Cost-effective solution:** By utilizing most of the commercially available automotive parts, the system is easy to fabricate.<sup>5</sup> There is no requirement of a separate designing process or manufacturing plant, which actually brings down the cost.

## CONCLUSION

In the time of COVID-19 pandemic, quite a few innovative works are being undertaken, but this PODS stands out because of its ability to save lives. For meeting the challenge and augment

infrastructure for oxygen supply in hospitals, this device has the potential of turning the fight against COVID-19 in our favor. The cost-effectiveness, readily available spare parts, ease of operation, and simplicity in assembling make it an asset which will have potential even in the post CORONA world. The modus operandi for capacity enhancement in such proactive and creative manner was well appreciated including its implementation at other hospitals as well.

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