CoVent Challenge Abstract

Team Name: Breathe Eazy

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CoVent-19 CHALLENGE

General description of your ventilator design (1-2 paragraphs):

The ventilator will be an electromechanical system that operates mainly by mechanical means which provides such benefits as simpler manufacturing ability. The initial and any subsequent altering of the design are further simplified with minimal and strategic use of electrical components, especially where they increase patient safety by narrowing the margins on the control range validation requirements. The system's operation will be regulated with pneumatic powered valves which reduce electrical power consumption should the main power supply go out the back up power be needed to run the alarm system for an extended period. The pump will be a single cylinder with a dual silicone sealed partition creating two chambers. One chamber has an inlet of conditioned low pressure air and oxygen mix that is used to expand the same chamber during the patient's expiratory cycle. The outlet pressure of this same chamber is precisely controlled via a relief valve opening at the correct threshold. The pressure is attained in the chamber via valves opening in the other chamber thus pressurizing it to a higher degree and moving the partition accordingly. The partition movement is controlled to an adjustable distance that correlates to the prescribed tidal volume. Any excess pressure is mitigated via a blow off valve.

The user interface will consist of analog components: only analog components will be used to simplify regulatory validation. The readouts for the user will also be presented on analog instruments such as pressure gauges and dials. The system will be fairly lightweight and have a small footprint. It will be as compact as possible so it is portable. It will have a handle or other attachment points to make it easy for the hospital to integrate into the room setup. Incorporated into the design is a rolling tripod supporting the vertical ventilator mounting rod situated at a height for easy adjustability by medical staff. Additionally on the vertical ventilator mounting rod is a platform for the humidifier. The non-disposable components will be easily identified as to assist with patient transfer and set up. The design is oriented around 3D printing for local manufacturability.

List of the parts in your design (does not need to be final):
Part, quantity, off-the-shelf or custom manufactured?
If custom manufactured, manufacturing plan (OTS, 3d print, mill, etc) and material

Pump: Pneumatically powered cylinder with medical grade silicone rings sealing the chamber that will provide the correct oxygen level to the patient. Certain ots parts like rods, bolts and nuts will be sourced. 3D printed parts will be enabling local production with the easily mentioned ots materials.

Control Panel: Incorporated into the housing unit to simplify the mechanical control and feedback system routing. The analog indicators will have the ability to be indexed via a sliding scale that will be locked in upon calibration.

Plexiglass enclosure that isolates the internal components from the patient and facilitates easy sanitizing.

Air Mixing: Something along the lines of this, whether it is an off the shelf component or something we design and produce.
https://www.sharn.com/respiratory-supplies/p/MaxFLO2Air-OxygenMixer/.

Gauges: Pressure gauge (Off the Shelf)

Venturi Valve (probably Off the Shelf)

Sliding scales with lockable components after calibration (as a means of indicating volume).

Needle valves: Inlet control for air and oxygen
Silicone tubing: Routing of ventilator internal air channels

Disposable filters: Low cost exhalation filters. Off the Shelf
https://mfimedical.com/products/allied-healthcare-ahp300-bacterial-exhalation-filter?variant=11898312786 06&gclid=CjwKCAjwvtX0BRAFEiwAGWJyZIdKoaIKCE04K7OCuMPSKjjd9qtT2m84PzK6EgthcQWAGKn6kWL2_RoCU6MQAvD_BwE

Noise Suppression and Exhaust Filters: A 3D printed set of baffles will be used to reduce the noise at the location where spent air powering the device is exhausted. This unit will be modular and will include disposable sections as a filter will stop and retain any lubricant from escaping.

Pipes - For Air and Oxygen travelling with specific colour. Blue pipe for Inhale and White for Exhale

Knobs and switches that easily withstand acceptable sterilization processes.

Y-Connector -It is used for connecting two pipes and a third exhaust outlet for patients. It has a one way valve and a plug

Thermometer - To measure mixture of air and oxygen

Support Arm - To hold circuit in place

Roller - For making Portable Ventilator and with roller locking system

Stage of development and testing:
Describe where you are in development. If already prototyped and/or testing, please describe the status briefly (1-2 paragraphs). ***You do not need to have a prototype at this point.***

The team has designed the main components and situated them accordingly. As mentioned, the design is using a pneumatic control system and power system. Ideas regarding materials that can be used from Stratasys for tubing such as Agilus 30, ABS-M30i, and PC-ISO, are being looked into as well. Overall, the design process is still ongoing, but a general idea of what the components may look like have been mentioned above.

Requirements compliance:
Does your system concept meet the initial system requirements? If not meeting specific requirements, please let us know what additional assistance you might need.

The proposed concept addresses the basic requirements of a ventilator including a power source to drive the ventilator, knobs to control variables like pressure and flow, and an air-oxygen mixing chamber. One requirement we are unsure of is the need for heat and moisture exchanger filters (HME). A study discovered the following, “when providing humidification to patients with low tidal volumes, such as when lung-protective ventilation strategies are used, HMEs are not recommended because they contribute additional dead space, which can increase the ventilation requirement and PaCO2” (Humidification During Invasive and Noninvasive Mechanical Ventilation: 2012)**.** In the Webinar Q&A doc, it was mentioned that “we create our system requirements with a positive pressure ventilator in mind. Nearly all of our data for treating ARDS is based on positive pressure ventilation with low tidal volumes (i.e. Lung Protective Ventilation)”. However, in the Webinar Q&A doc, it was also stated “we expect the use of a Heat & Moisture Exchanger (HME) filter in the ventilator circuit for the purpose of air humidification”. Therefore, is a HME required?

What prototyping tools would you need for developing (in addition to 3D printing) to create a functional prototype in Round 2?
List the prototype tools that your team would need assistance with for rapid prototyping

Pressure and volume sensors for testing and calibration. A 'dummy's load to test pressure and volume that is representative of realistic scenarios. Air pressure and volume that replicates what will be seen in the hospital setting.

Laser cutting for plexiglass case.