Mechanical Ventilator Milano

The MVM Ventilator: Particle physicists, National Labs and Industry

Presentation for: CAP Conference
June 9, 2021
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In 2020 many members of the DarkSide-20k International Liquid Argon Dark Matter Collaboration came together with Elemaster Italy and with companies and national labs in Canada and the US to build a new, inexpensive ventilator targeting intubated COVID-19 patients in ICUs. 10 countries: Phys. Fluids 33, 037132: 250 authors (Open source licence)
How the ventilator works
MVM was conceived as a low-cost, well controlled, and easy to operate electro-mechanical ventilator that could be produced quickly, at large scale, based on readily-available parts.

The basic principle is simple: Push oxygen enriched air into the lungs, and allow the elasticity of the lungs to exhale it.
Of course it ends up being much more complicated in the end:

- You need high precision controller to get the pressure profile correct
- It needs to measure the pressure at various points to do that control
- We also monitor for flow and leaks
- And the oxygen
- We also need to make sure that there are safety relief valves for high pressures, blockages etc
- We add a redundant independent cpu to monitor that there are no problems
- Add the ability to signal alarms
Pressure Control Ventilation: (PCV)

- Patient normally unable to breathe on their own, so machine is doing all the work.
- Regular pattern of breaths with profile and rate tuned to patient needs.

- New breath starts at the end of the previous, or if the patient tries to initiate a breath.
- PEEP: Positive end expiratory pressure: ensures alveoli in lungs do not collapse, improving oxygenation.
- Needed to introduce sighs, deal with coughs, recognize weak patient attempts to breathe...
Pressure Support Ventilation: (PSV)

- Patient able to breathe weakly, so machine is supporting their efforts.
- Regular pattern for each breath when patient demands a breath.
- Useful when patients are being weaned off the MVM to regain control of their own breathing
- Ventilator needs to recognize if they stop breathing and switch back to pressure control ventilation (and raise alarm)
Design Evolution:

• Medical: Enormous guidance from medical ventilator experts, including medical device designers, medical doctors, respiratory therapists, nurses, trainers, ..... To design the MVM to provide proper patient care for covid-19, be easy to use and learn, integrate with typical hospital infrastructure. Operational safety is key factor in all design considerations.

• Manufacture: Developed in very close cooperation with manufacturing companies in Italy/USA (Elemaster) and Canada (Vexos, JMP Solutions)

• Technical: 100’s of physicists and engineers with expertise in software development and safety, electronics, instrumentation, fluidics, project management, quality assurance, quality control

• Performance Standards: Designed to meet the required standards for certification as laid out by:
  • FDA Emergency Use Authorization
  • Health Canada Interim Order for medical devices
  • Canadian Standards Association certification, requiring a repeat of almost all of the testing

• Donations: Early support from Canadian donors to enable the purchase of critical parts in short supply and pieces of testing equipment.
8 months from idea to certified medical device

March 19/20 project initiated in Italy
March 23  First paper on archive
March 29  Prototype working on the bench
April 19  first series production units in Italy
May 1    US FDA Emergency Use Authorization
May 22   Govt. of Canada contract for VEXOS
July 30  Health Canada submission
Sept. 30 Health Canada Interim Order approval
Nov. 30  Canadian Standards Association (CSA) certification
Nov. 30  Canadian Production starts
Feb./2021 7300 ventilators delivered to Can. Govt.
Apr. 2021 Elemaster obtains CE mark
CURRENT STATUS

• Over 7300 units produced and accepted by Health Canada.
• Added to the stockpile for Canadian needs.
• Donation to developing countries in need has been considered from the beginning of this initiative. Donation is actively being pursued at the present time with assistance from the MVM group.