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[COVID-19] COVID-19 Emergency Response: Oxygen Supply Considerations [ECRI Exclusive User Experience Network]

Problem

1. COVID-19 treatments increase hospital oxygen consumption by two to five times the normal amount.
2. When this high demand for oxygen occurs:
    1. There is an increased risk of depleting reserves before deliveries may be available.
    2. Increased ice buildup on vaporizers at higher flows reduces vaporizer efficiency and maximum oxygen delivery rate from liquid oxygen tanks.
    3. Pressure may drop, especially in areas outside the intensive care unit (ICU), which are not plumbed for as high a demand.
    4. A pressure drop may cause device malfunctions.
    5. If oxygen cannot be maintained at a higher pressure than medical air, there is a potential for medical air to backflow into the oxygen supply resulting in reduction of life sustaining therapy.

ECRI Recommendations:

Risk Management/Quality Control/Nursing

1. Plan for care in areas with insufficient oxygen supply, such as med/surg rooms converted to intensive care, non-patient care areas converted to patient care, or off-site support.
2. Seek out sources of emergency oxygen supplies, such as mobile industrial oxygen concentrators and field multi-patient liquid oxygen delivery systems.
3. Consider the use of home care single-patient oxygen delivery systems, such as liquid oxygen tanks and concentrators.
4. Be aware that therapies with high oxygen consumption (e.g., high-flow nasal cannula with high FiO_2) may cause a pressure drop in other oxygen outlets.
5. Ensure that staff are familiar with low oxygen pressure alarms and procedures to address it (e.g., contact facilities).
6. To minimize oxygen waste:
    1. Turn off all flowmeters that are not in use.
    2. Ensure that patients' oxygen delivery masks do not excessively leak.
    3. If anesthesia units are being used as ventilators, consider modifying the units to use air as the driving gas instead of oxygen.

Facilities/Materials Management

1. Inform your primary liquid oxygen and bottled gas suppliers that:
    1. Usage will increase.
    2. You will need more frequent refills of liquid oxygen and that timely delivery is critical because your reserves will be depleted faster.
    3. You will need timely delivery of bottled oxygen.
    4. Inquire about the feasibility of preemptively adding an emergency source to the emergency oxygen supply connection.
    5. Inquire about raising main line pressure up to 55 psig.
    6. Inquire about ice buildup mitigation measures on existing liquid oxygen vaporizers; particularly, inquire about training staff to safely de-ice vaporizers.
    7. Maximize current inventory of bottled oxygen.
    8. Larger H and K sized tanks may be needed as auxiliary supplies.
2. Contact alternative suppliers if the primary supplier is unable to support anticipated needs.

3. Seek out locations near care units that may lose pressure that can accommodate several H and K sized tanks as an auxiliary oxygen source.
    1. Place them as close to care areas as possible.
    2. Tanks can supply pressure during surges if their regulators are set just under main pressure. This is especially important in ad-hoc ICUs.
4. Contact all current clinical users of bottled medical gases to obtain a current inventory and anticipated needs.
5. Know what the maximum flow from your liquid oxygen delivery system is and how to monitor it. The liquid oxygen vaporizer may limit flow more than piping diameter.

Background:

1. Anecdotal evidence from experience in Italy indicates hospitals in areas heavily affected by COVID-19 will require from two to five times the normal oxygen demand.
2. Respiratory care will have to be provided in areas not designed for it.
    1. Intensive care for COVID-19 patients may have to be given in general medical/surgical floors because of the lack of space in a standard ICU.
    2. Intensive care may be cohorted by COVID-19 status with one group outside a care area designed as an ICU.
    3. Lower acuity care may be conducted outside the facility's walls.
3. Oxygen outlets in lower acuity areas may not have the capacity to support certain respiratory treatments.
    1. As an example, the hospital building code in one state requires:
        1. General medical/surgical care rooms to have one oxygen outlet capable of 20 L/min per bed.
        2. A unit with multiple beds can be designed assuming that only 50% of the beds will be at that level.
    2. If a single med/surg unit is full of COVID-19 patients requiring oxygen, the unit may have only enough capacity to deliver 10 L/min per bed.
    3. Treatment using a high-flow nasal cannula (HFNC) may use up to 60 L/min at 100% O_2.
    4. According to some states' codes, maximum HFNC could use up to six times the designed oxygen allowance for general med/surg bed spaces.
    5. State codes may specify higher oxygen flow rates for intensive care and anesthesia locations. A space designated for anesthesia has 18 times the minimum and intensive care has 27 times the minimum limit per bed.
    6. Different states may have codes in which the difference is more pronounced.
    7. Older construction may also not meet this capacity.
4. High demand may exceed the systems total capacity.
    1. The limiting factor is often the liquid oxygen vaporizer. The efficiency of vaporizers is reduced as it operates because of ice buildup.
        1. The heat needed to vaporize liquid oxygen into gas is pulled from external ambient air.
        2. The vaporizer is basically a radiator built to maximize the surface area to ambient air and maximum circulation.
        3. Frost from the moisture in the ambient air builds up on the surface of the vaporizer impeding air flow and the transfer of heat, thus reducing the rate at which the vaporizer can convert O_2 from liquid to gas.
    2. Vaporizers are sometimes in pairs with one in operation while the other is de-icing.
        1. Many vaporizers are not be paired.
        2. Paired vaporizers can minimize icing by increasing the switching rate, thus minimizing the need for manual de-icing.
    3. Some vaporizers may use hot water or steam baths to allow the same heat transfer in a much smaller unit. These are more frequently encountered in urban areas where space is limited. Ice buildup in this design is generally not a concern.
    4. Higher oxygen demand increases the speed of ice buildup, which reduces efficiency faster.
    5. Factors affecting ice buildup rate besides demand are:
        1. Relative humidity.
        2. Temperature. Higher temperatures hold more moisture for the same relative humidity. High relative humidity and high temperature will build ice faster than low temperature and high relative humidity.
    6. Manual de-icing should not be attempted by untrained personnel.
        1. The tubing walls may be thin, making it is easy to damage the vaporizer.

        2. Liquid oxygen is extremely cold, physical contact is extremely hazardous.
        3. Injuries have occurred from large sections of falling ice.
5. The supply chain is robust.
    1. Vendors have reciprocal agreements so customers can be supplied even if a plant were to become inoperative.
    2. Trucking does not seem to be a problem.
    3. Medical oxygen is a small portion of the overall industrial oxygen generation, but manufacturers are now focused on medical supply.
    4. The only raw materials needed to supply a plant are electricity and access to air.
6. Limitations in the supply chain.
    1. The most limiting factor in supplying oxygen to patients is likely to be vaporizer limitations because of icing.
        1. The number of gas company technicians and contractors to de-ice a vaporizer is less than 1,000. Rural areas are a greater concern.
        2. ECRI has not yet heard of gas manufacturers training hospital staff to safely de-ice a vaporizer.
        3. No special tools needed to de-ice vaporizers.
    2. There are limited numbers of backup generators or storage. Most are purchased to enable service.

Manufacturer's Perspectives or Comments:

1. Air Products statement on COVID-19 is available at: http://www.airproducts.com/APNews.aspx. Highlights include:
    1. Air Products remains committed, and is still at normal production.
    2. The firm is helping facilities to improve infrastructure, such as installing tanks.
    3. The firm is improving delivery and working with the U.K. Ministry of Defence to train more drivers.
2. Air Liquide/Airgas statements on COVID-19 are available at:
    1. https://www.airliquide.com/group/air-liquide-committed-fight-covid-19
    2. https://www.airliquide.com/shareholders/stock-share/our-relationship/covid-19-message-benoit-potier-shareholders
    3. https://www.airgas.com/alerts
    4. Highlights include:
        1. Fully mobilized to respond to COVID-19.
        2. Producing ventilators.
        3. Ramping up production.
        4. Airgas has built-in redundancy in its production facilities.
3. Linde/Praxair statements on COVID-19 are available at:
    1. https://www.linde.com/customers/covid-19-statement
    2. http://www.praxair.ca/-/media/corporate/praxair-canada/documents-en/brochures-and-specification-sheets/customer-letters-covid-all-business-units-eng.pdf?rev=a1af99b5c6154d0e981eefd4f61c6ca6
    3. Highlights include prioritizing and increasing oxygen delivery.
4. FDA's Enforcement Policy for Ventilators and Accessories and Other Respiratory Devices During the Coronavirus Disease 2019 (COVID-19) Public Health Emergency, available at: https://www.fda.gov/media/136318/download, states: "*FDA does not intend to object to modifications to the FDA-cleared indications, claims, or functionality of these devices, without prior submission of a premarket notification where the modification will not create an undue risk in light of the public health emergency. Examples of circumstances where FDA currently believes a modification would not create such undue risk include…… The use of oxygen concentrators for primary supply when medically necessary and clinically appropriate."*
5. American Society of Healthcare Engineers (ASHE) published Sizing Medical Gases for COVID 19 available at: https://www.ashe.org/system/files/media/file/2020/04/MedGasSizing-updated.pdf. It includes:
    1. Estimates of oxygen demand both peak and averaged over one minute for various therapies
        1. Standard nasal Cannula – 8L/min peak, 0.9 L/min average
        2. Reservoir and Venturi masks - 151 L/min peak (flushing), 1.5 to 5.5 L/min average.
        3. Standard Invasive Ventilators – 12 L/min peak, 4.4 L/min average
        4. HFNC – 50 L/min peak, 24.7 L/min average
        5. High frequency oscillatory ventilators – 80 L/min peak, 50.5 L/min average.

    1. Assessment worksheets for bulk liquid storage flow and storage capacity

2. Assessment worksheets for individual branch flow capacity

UMDNS Term(s)

Alarms, Central Gas System, Oxygen Depletion [26592]
Alarms, Environmental Emergency, Oxygen Depletion [26614]
Liquid Oxygen Containers [16536]
Liquid Oxygen Units, Individual [16853]
Medical Gas Cylinders [16501]
Oxygen Canisters [12868]
Oxygen Concentrators [12873]
Oxygen Delivery Units, Controlled [18076]

Geographic Region(s)

Worldwide

Suggested Distribution

Clinical/Biomedical Engineering, Critical Care, Emergency/Outpatient Services, Nursing, Pulmonology/Respiratory Therapy, Facilities/Building Management

Comment

- This alert is a living document and may be updated when ECRI receives additional information.

Miscellaneous

References:

- BeaconMedaes. Medical gases for Covid 19 [online]. MedGas Insights [online]. 2020 Apr [cited 2020 Apr 10]. Available from Internet: Click here.