Maximizing Medical Gas Flow Capacity

SURGING VENTILATOR USAGE DURING THE COVID-19 PANDEMIC MEANS HEALTH CARE FACILITIES NEED TO ENSURE THEIR MEDICAL GAS SUPPLY SYSTEMS CAN DELIVER LARGER AMOUNTS OF OXYGEN AND AIR

The immediate push for more ventilators in US hospitals may have subsided for now as suppliers have ramped up production. But more hurdles lie ahead for some hospitals working to align their existing medical gas supply systems with the increased oxygen and air capacity required to run additional ventilators for longer periods of time.

"The design requirements for oxygen and medical air systems have changed over time, providing more capacity in newer installations. But some older units are not capable of handling high flow needs," says Bobby Baird, SASHE, CHFM, CHSP, CHC, director of facility operations, University of Florida Health in Gainesville, and a member of the *EC News* Customer Advisory Board.

In intensive care units, ventilators are usually connected to oxygen and air outlets at 50 pounds per square inch gauge (psig), according to the American Association for Respiratory Care. These outlets are linked by plumbing to liquid oxygen storage tanks and air compressors to provide both flow and pressure. Medical gas supply lines are typically designed to handle 150% of average usage, calculated by average annual air or oxygen usage per square foot of floor space or per bed.[1]

When average usage exceeds design by far more than 50%, however, problems can develop in delivering the needed flow of oxygen and air to ventilators, says Baird. Lines that are not large enough for optimal delivery of needed medical gas capacity can experience high pressure drops that don't allow the required flow or pressures.

"A common result of high consumption in medical gas lines is a reduction in pressure," says Baird. "Under high-flow conditions, a drop in pressure is one of the first indicators that the system is approaching maximum delivery."

An overloaded system can also result in ventilator damage and even failure. If the air compressor and dehumidifying systems are overloaded, for example, moisture can get into the air lines and then reach the ventilators, resulting in ventilator failure.

Evaluating the medical gas system

Conscientious capacity assessment and monitoring can help health care facilities stay on top of medical oxygen and air flow capacity, even when resources are strained by a surge in ventilator needs.

"At a minimum, facility operators should know the rated capacity of their medical gas systems as designed," advises Baird. Then, the facility needs to determine the

SHUTTERSTOCK

Medical gas lines are usually designed to handle 150% of average usage, not the unprecedented surge from increased ventilator use during the COVID-19 pandemic.

expected boost in demand for oxygen, based on flow and pressure required for the numbers and types of patient breathing-assist devices to be added.

Baird recommends beginning this evaluation process at the source, including pressure regulator and vaporizer capacity, and then tracking supply lines through the facility to the outlet on the headwall.

"Recognizing the 'choke points' is key for deciding where surge patients requiring high consumption of medical gases should be located," he says. "Recognize that the 'choke point' could be in the distribution system, since the design of medical gas systems for standard patient rooms does not anticipate full flow at every outlet."

At hospitals, the bulk oxygen system vaporizer size is a common limiting factor for the number of ventilators and other breathing devices that can safely be accommodated, reports Kaiser Permanente, although some smaller facilities may be limited by the size of their incoming oxygen pipes.[2]

"At UF Health, we started at the bulk oxygen pad and medical air pumps, and evaluated the capacity of each device in the path," Baird says. "We then made recommendations to our administration on which units had the available capacity to deliver the flows necessary. As expected, the ICUs had the greatest capacity for surge medical gas delivery. We were surprised to learn, however, that in our older operating rooms, there was not sufficient capacity to handle a surge from a single patient to multiple patients in a room."

Timothy Markijohn, MBA-MHA, CHFM, CHE, field director–surveyor management and support for The Joint Commission, suggests keeping an eye on vaporizers for excessive icing and the potential need to manually deice them. "One thing I'm seeing from the increased use of oxygen during the pandemic is vaporizers becoming excessively iced over, with the potential for liquid O_2 getting past the vaporizers," he explains.

Reducing oxygen flow needs

Here are some recommendations from the American Association for Respiratory Care for conserving oxygen usage overall[1]:

- Turn on oxygen to manual resuscitators only when needed.
- Use the required oxygen concentration only.
- Lessen the use of high-flow nasal cannula delivery of oxygen.
- If possible, consider reducing ventilator bias (the continuous flow of a gas), or use a pressure trigger rather than a flow trigger.

Thomas E. Kinman, PE, BSME, CHFM, CHSP, CLSS-HC, a consultant with Joint Commission Resources, points out that the National Fire Protection Association (NFPA) *Health Care Facilities Code* (NFPA 99-2012), in Section 5.1.14.4.3, requires an annual review of bulk oxygen system capacity. "This analysis could be done by the bulk oxygen supplier," he says.

When hospitals evaluate their own medical gas capacity, Kinman suggests an alternate path to that offered by Baird. "Start at the patient room and work back to the bulk oxygen system or the medical air compressors," he says. "The Clinical Engineering Department has a total of all medical devices consuming oxygen or medical air from its equipment inventory. The library of information on these pieces of inventory includes medical air and/or oxygen consumption. Calculations can determine if there is enough system capacity to operate the equipment listed on the inventory."

If there isn't excess system capacity, handling a surge could be challenging, Kinman says. If there is excess capacity and the hospital is required to handle a surge, the organization should determine exactly how many more patients could be served by that extra capacity and what could be done to compensate for a capacity shortfall.

Finding solutions

Hospitals that determine they need more medical gas capacity have a number of options, depending on where in the system they are coming up short. Temporary supplemental supply lines, piped from the existing supply system or from a temporary supplemental system, are one possible solution. Keep in mind that any temporary supply systems still have the same NFPA performance requirements as those for permanent supply systems.

Adding equipment such as storage tanks, regulators, or vaporizers can also boost capacity. If adding a vaporizer isn't an option, the Compressed Gas Association recommends considering ice-buildup monitoring and regular deicing. Vaporizers that are running at top capacity do not have an opportunity to defrost, which can lower the oxygen gas temperature inside and disturb the regulators controlling oxygen flow.

In addition, hospitals may be able to increase medical oxygen flow by increasing storage tank pressure or by increasing the regulator set points and monitoring pressure at the farthest use point with oxygen flowing.[3] When there are two parallel final line regulators, operating both simultaneously to boost capacity may be possible, depending on a risk analysis and approval by the authority having jurisdiction (AHJ) due to the deviation from code requirements.

Resources for determining medical gas flow needs

Medical Gas Consumption Calculator
American Association for Respiratory Care
http://www.aarc.org/wp-content/uploads/2020/04/calculator-medical-gas-consumption.xlsx

Sizing Medical Gases for COVID-19
BeaconMedaes LLC
https://www.ashe.org/system/files/media/file/2020/04/MedGasSizing-updated.pdf

References

1. American Association for Respiratory Care. Additional Ventilators May Pose a Risk to Hospital Gas Systems Guidance Document. Apr 14, 2020. Accessed Jun 8, 2020. https://www.aarc.org/additional-ventilators-may-pose-risk-to-hospital-gas-systems/
2. Kaiser Permanente National Facilities Services, Facilities Strategy Planning and Design. Medical Air and Oxygen Capacity. Apr 5, 2020.
3. Compressed Gas Association. Medical Oxygen Supply System Issues during the COVID-19 Crisis Safety Alert. 2020. Accessed Jun 8, 2020. https://portal.cganet.com/Publication/Details.aspx?id=SA-37