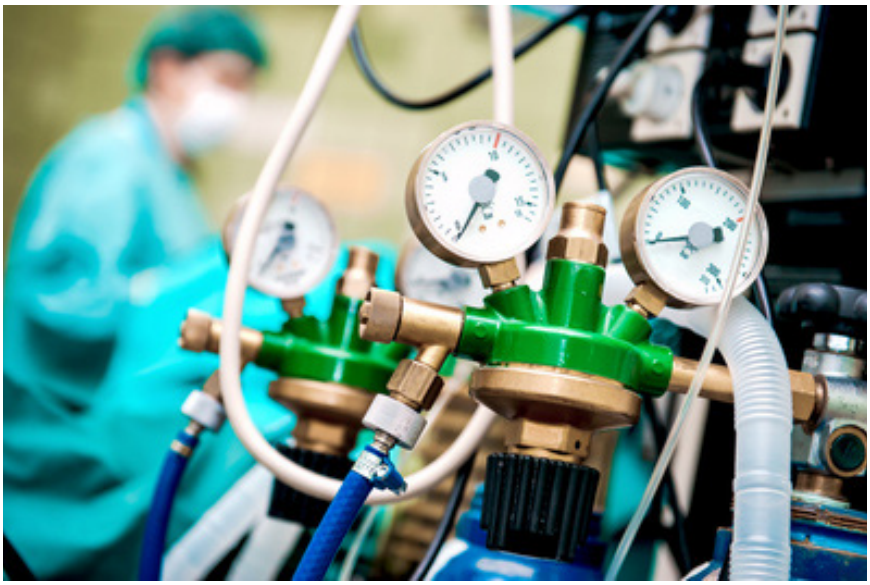
Key Instrumentation Considerations in Medical Gas Delivery Systems

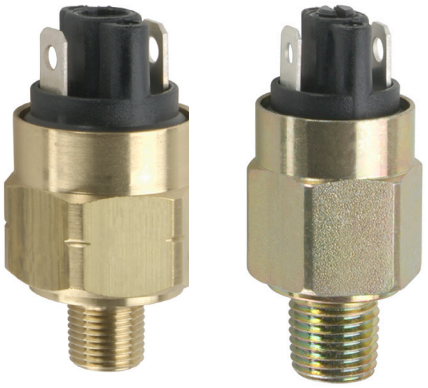
The provisioning of medical gases to hospitals, mobile health providers and in-patient care environments requires absolute conformance to stringent industry standards. As a result, manufacturers, distributors and facility safety managers must have complete confidence in supply quality and continuity. It is important to note that, whilst accredited governing bodies do set critical industry health and safety guidelines, they neither evaluate nor inspect medical gas equipment, facilities, pipelines, nor other infrastructure. Compliance is therefore the direct responsibility of the medical gas OEM or integrator, along with the individual facility into which such gases are delivered. To achieve required high-accuracy monitoring and control, design engineers typically specify pressure sensors, switches and isolation valves within finished system designs. For larger or more complex projects, they also outsource the design of bespoke manifolds. These integrate sensors, switches, valves and other components into a single control module. For over 20 years, the ISO13485 certified Gems Sensors & Controls (www.gemssensors.co.uk) has helped OEMs to address the often-complex instrumentation requirements of medical gas delivery systems. Successful applications include the monitoring of oxygen, helium, xenon, carbon dioxide and nitrous oxide; medical and surgical air; compressed air; or vacuum systems. Typical requirements can range anywhere from a few dozen pressure switches and valves; to custom OEM volume manufacturing of fully degreased, oxygen compatible sensors; to full medical gas distribution pipeline instrumentation. Regardless of requirement, a distinct advantage exists for medical gas OEMs in the capability to specify a broad range of instrumentation, in multiple ranges and types, from a single source. This paper shall examine, by application, several key considerations for medical gas delivery systems.



Portable Medical Gas Cylinder Changeover Devices

European Pharmacopoeia sets forth stringent definitions for the maximum allowable and stability concentrations of delivered patient oxygen. Without exception, medical gas OEMs and integrators must specify instrumentation in strict conformance with these standards. Smaller and more mobile healthcare environments, such as ambulances and temporary triage centres, rely upon portable, replaceable supply cylinders for patient inhaled oxygen delivery. Due to the wide external temperature ranges over which portable changeover systems must operate, cylinder setups are also instrumented with safety alarms. High-pressure alarms signal higher temperatures and increased risk of gas store depletion caused by evaporation. Low-pressure alarms can signal pending cylinder changeover requirements. Pressure monitoring ranges vary, depending upon medical gas type. Thus, careful attention to proper sensor selection criteria is essential. Specified instrumentation, such as Gems 3100 Series pressure transducers, can accurately monitor the cylinder pressure levels of oxygen, nitrous oxide, and other medical gases. Typically installed between the cylinders and gas delivery system, they also help to determine proper cylinder supply changeover criteria and timing. One transducer is used to measure incoming delivered gas supply pressure. Another measures supply feed pressure to the distribution system. This process ensures that consistent pressure levels are maintained within a specified range.

Medical grade pressure switches, such as the Gems PS61, are installed on cylinder alarms to provide effective early warning of possible supply system risks, as well as leaks or blockages. They are also used to facilitate the switch of cylinders from standby to on-duty modes. Gems also designs and manufactures complete pressure manifolds for these applications. Here, several medical gas cylinder banks are monitored simultaneously. The pressure manifolds consist of a Gems PS31 pressure switch, incorporating special Kapton® Polyimide diaphragms, and various isolation valves. The pressure switch diaphragm design allows it to maintain its physical properties and performance stability over a wide operating temperature range. Due to its high chemical resistance and with no known organic solvents, the switch is also compatible with a variety of medical gases. In addition, Gems pressure sensing instrumentation is used to monitor cylinders, alarms and inhaled nitrous oxide supplies. Inhaled nitrous oxide has proven effective within neonatal intensive care units for the treatment of newborn hypoxemic respiratory failure.



Medical Air Generation Compressors and Vacuum Systems

Surgical and medical air are essential for safe operating theatre, patient hospital ward and intensive care unit functionality. Compressed air helps medical professionals to deliver proper surgical anaesthesia and inhaled patient oxygen concentrations. It also powers diagnostic and surgical equipment, dental drills, and other non-critical medical devices. Medical and surgical air is typically produced via specialty water- or air-cooled compressor systems. In order to remain effective, a compressor must be clean and dry, as well as dust-, mould- and oil-free, throughout its operation. It also must reliably perform to varying set pressure levels. To ensure this, compressors are instrumented with both an automatic manifold panel and a manifold reserve, each programmed to a predefined set buffer pressure range. In the event that an automatic manifold is exhausted, a secondary emergency reserve manifold engages, ensuring uninterrupted airflow. Both manifolds require accurate, continuous pressure level monitoring. The Gems 3100 Series, a family of rugged stainless steel pressure sensors, is often specified within these generator systems. The sensors form part of a control circuit that activates and deactivates the compressor, allowing it to automatically monitor supply pressure. In doing so, the 3100 Series helps to ensure that buffer pressure remains within its predefined set range. These sensors can reliably operate over a variety of pressure settings, with low thermal errors and a wide temperature compensation range. Sensors may also be customised with application-specific pressure ranges, ports, connectors, cables and electrical outputs. In addition, the 3100 Series acts as an alarm, should levels fall below acceptable values. Data from these sensors also provide important overall compressor health assessments. Medical vacuum systems, like compressed air, operate from a centrally controlled source. The systems are essential for surgical suction, as well as for generating negative pressure conditions within environmental chambers. Here, pressure transducers are used for critical level monitoring, alarm activation, and support of the central vacuum generator control circuit. The Gems 3500 Series pressure transducer presents a unique advantage within these applications. In its compound form, it can accurately cover a range of -1 bar to +1 bar. This allows for the specification of one pressure transducer model for the effective support of a multitude of vacuum systems.

Distributed Medical Gas Pipeline Systems (MGPS)

Medical gas pipeline systems (MGPS) are used to transport a variety of often-combustible medical gases, including oxygen, medical air, and anaesthesia, from central and secondary stores into designated areas. Standards for these systems are maintained and installed as set forth in “UK Health Technical Memorandum 02-01: Medical gas pipeline systems.” In North America, medical gas pipelines are also designed for conformance to National Fire Protection Association (NFPA) guidelines. Typically constructed of copper, MGPS support high- and low-pressure medical gas delivery within hospitals, laboratories and other clinical environments.

Basic medical gas pipeline infrastructure consists of a main line, connecting the gas media supply to the risers; risers, which connect the main line to lateral pipelines; and lateral pipelines, which feed into a branch room, or set of rooms, within the medical care environment. These pipes are installed in plain view within the healthcare setting.

All MGPS must be extensively tested prior to use. This is to ensure adequate gas delivery pressure, supply regulation and control. Particularly, gas supplies to anesthesia ventilators are most critical, as those rely upon sufficiently high pressure levels for proper functionality. To ensure such functionality, MGPS must also be continuously monitored for pressure and temperature variations and extremes. Sensors implemented within these environments are used to provide critical early warning of impending pressure drops or overpressures.

The highly corrosive nature of certain gas media makes MGPS prone to corrosion, moisture, mould, pressure stresses and other mechanical damages. Over time, these factors can contribute to pipe leakages. Within an oxygen delivery environment, such leaks can pose an especially high risk of fire or combustion, as well as patient health damage caused by depleted oxygen stores. Any cross-leakage can further increase patient hypoxia risks.

Main MGPS supplies are controlled via manifolds. The manifolds allow for the manual or automatic switching of primary and secondary supplies between alternating stores. Gas is then transported through the main line. These systems also include a manual shutoff function, in the event of an emergency.

Instrumentation requirements call for the monitoring of individual pipelines, with their specifications based upon the type of measured gas media and untapped emergency stores. Vacuum air pressures are also monitored. Pressure switches and transducers are the key safety components to alarm for any leaks or overpressures, as well as to monitor general pressure levels. The main trunk system from the source often operates at 400 bar or 200 bar, with typical step-down distribution channels to 25 bar and 16 bar at a room level (sometimes as low as 10 bar). Pressure transducers and switches are placed strategically within the system to monitor pressure levels and alarm for any unusual conditions.

Selected instrumentation must be able to withstand higher-than-typical pressure levels. Pressure sensors typically would operate at 12V or 24V, with 4-20 mA or 0.5 to 4.5V output. An IP67 rating ensures continued sensor reliability within possible splash environments.

Gems 3500 and 3100 Series pressure transducers, as well as associated switches, are recommended for MGPS applications. Their versatility and interchangeability effectively support a wide range of MGPS points. Gems is also able to customise individual sensor settings for specific gas media compatibility, as well as other requirements.

Both 3500 and 3100 Series sensors feature high-accuracy and reliability with low thermal errors and a wide temperature compensation. Their compact size facilitates ease of installation within the space constraints of a typical MGPS environment. All sensors are degreased prior to shipment, ensuring their compatibility with specialty monitored gases. In addition, Gems pressure switches are offered with a variety of pressure ranges, from miniature vacuum switches to units over 400 bar. Their highly favourable size-to-pressure ratio allows them to effectively monitor pipeline infrastructure within confined spaces. All switches are also available with custom set points.

All Gems standard catalogue products are available for immediate customer order. Standard OEM volumes can be produced within just a few business days. The rapid customisation of medical gas sensors and switches is also possible, as well as close customer collaboration on custom manifold designs to help meet specific regulatory compliance standards.

Ensuring Absolute Compliance

The specialty nature of medical gas delivery systems, along with their critical end use, creates often-complex requirements. As the burdens of stringent regulatory compliance are left to the OEMs, integrators, and health care facilities themselves, effective system monitoring is essential. Specified sensors and switches must be fully gas media compatible, as well as highly robust, accurate, and compact. Instrumentation must be free of contamination risks. It must also have the option for rapid customisation. Gems, with their longtime proven expertise, unique technical capabilities and rapid customer response, can serve as highly competent partners.

Gems™ Sensors & Controls

Gems Sensors & Controls
+44 (0) 1256 320244
sales@gems-sensors.co.uk
www.gems-sensors.co.uk

facebook.com/GemsSensors
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linkedin.com/company/gems-sensors