Specifying compressed air for healthcare

Providing medical gases for hospitals requires a system that is optimised to meet demand and utilises the appropriate technology to enable a cost effective and energy-efficient solution for administrators.

Designing a compressed air system for use in a hospital is a complex and challenging task. Not only does it have to meet a plethora of demanding regulations that cover medical devices and medicines, but it must also be energy efficient, cost effective and, above all, totally reliable. These are the challenges facing suppliers but they must be met because only a highly reliable source of absolutely pure breathing air is suitable for hospital patients.

There are two very distinct compressed air systems in hospitals that are governed by different standards and regulations around the world. First, there is the medical air used for patients and medical equipment and then there is the technical air that is used for maintenance around the facility. One of the prime requirements of medical devices directive 93/42/EC is that these systems must be separate, which means the air produced by compressors for use in facility tasks cannot be used for patients, and vice versa.

Safety first

The highest priority for medical air and its use in hospitals is the safety of the patient. This means that breathing air needs to be available 24 hours a day, seven days a week. At the core of this reliability is redundancy. The 93/42/EEC and related regulation stipulates that there needs to be multiple sources of compressed air to ensure that if one compressor is under maintenance and a second fails at the same time then there is a back-up of one or more sources that is able to provide 100 per cent of a hospital's maximum air requirements. Therefore, it is common practice for installations to have triple or even quadruple systems in place, with each compressor able to feed 100 per cent of the demand.

When designing a system for a hospital, one of the main challenges is to calculate the hospital's 100 per cent compressed air demand. This is defined as the amount of air that would be required if every conceivable application was being used at the same time – even though this is a situation that would never actually occur. Whether for patient beds or operating theatres, medical compressed air is used in all areas of hospitals and must be readily available at all times. By designing compressed air systems with at least triple redundancy, the risk of failure is virtually ruled out.

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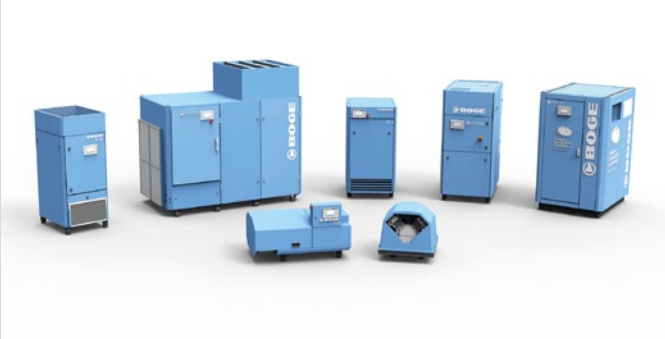
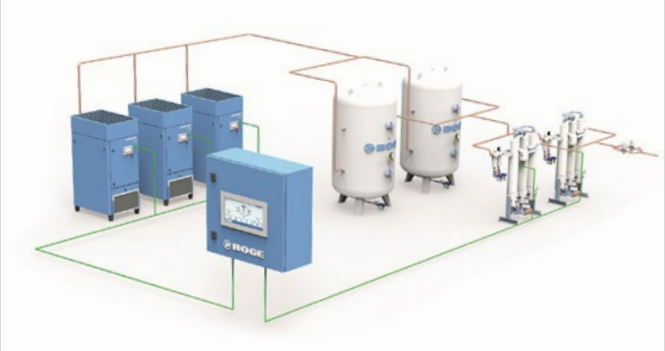
Compressor choice

When it comes to the choice of the compressors themselves, there is very little difference between those used for medical air or general air within hospitals. The main variance will be in the specific software that is required to control the medical compressors.

These compressors themselves are not classified as medical devices, which means the same compressors can be used for all compressed air requirements within a hospital.

The components of a compressed air system would usually comprise at least three compressors, a control system that co-ordinates their operation, together with all the delivery mechanisms. The system itself is a medical device rather than the individual components and the gas that it delivers is classified as a medicine. As such, they are subject to their respective standards.





Medical gas in use

There are numerous uses for medical gas within the health services, all covered by the medical devices directive 93/42/EC

Artificial respiration: Only a highly reliable source of absolutely pure breathing air is suitable for supplying to patients. In BOGE treatment units the compressed air is dried, purified and treated in seven stages to obtain medical compressed air that complies with DIN EN ISO 7396-1.

Medical systems: Medical compressed air is subject to the European Pharmacopoeia, which defines stringent purity requirements for the air. To ensure this purity, sterile filters provide an eighth treatment stage to all medical air whatever its final use is, for artificial respiration of patients or for delivering air to anaesthetic systems.

Medical staff: Whether for use by patients or in operating theatres, medical compressed air must be readily available at all times. By designing its compressed air generation systems with at least triple redundancy, BOGE virtually rule out the risk of failure.

Surgical instruments: Numerous surgical instruments and tools operate with compressed air. In addition, medical devices need to be inspected or dried at repeated intervals, all this utilises medical
compressed air.

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Compressors – modular systems

One of the key factors to consider when planning a medical system is that it not only has to deliver the appropriate redundancy and availability for breathing air. It also has a second priority, which is to keep the total cost of ownership, with maintenance and energy consumption, as low as possible for the owner.

To achieve this it is important to select the right technologies from those available. A modular system has the benefit of bringing efficiencies both in initial cost of investment and throughout the system's lifecycle.

Knowing what the hospital's total demand of air will be is vital to attaining the greatest efficiency and to keeping costs as low as possible. This is because the size of the hospital and the minimum and maximum compressed air demand influences the running characteristics – and therefore the associated running costs – of the chosen compressors. When it comes to energy usage, some compressors may have advantages depending on their loading and use characteristics.

The BOGE advantage

BOGE has an extensive portfolio of compressors that provides the right technology for every use – whether oil-lubricated or oil-free. All principal components comply with the relevant standards. The spectrum ranges from screw and piston compressors right up to scroll compressors. There is also a choice of models for use in sensitive applications that deliver outstanding efficiency, super silencing or whisper-quiet low-vibration operation. These are all features that predestine BOGE compressors for use in hospitals. With this range of models, a tailor-made medical compressed air system can be configured to satisfy any hospital's requirements.

PO Series:
The PO (Piston Oil-free) range of modular, oil-free piston compressors, which cover the power rating spectrum of 2.2 to 5.5kW for 10 and 15 bar, are extremely economical in use and offer numerous options for adapting to specific applications. The new piston compressors have a compact design, are absolutely oil-free, provide the highest degree of reliability, and ensure the simplest possible maintenance.

EO Series:
The whisper-quiet and ultra-low vibration compressors of the BOGE EO (Eccentric Oil-free) series feature integrated compressed air treatment and supply Class 0 oil-free compressed air. Being completely oil-free is a must, especially in sensitive work environments. The scroll compressors operate extremely quietly with ultra-low vibration. A modular concept with one to four air ends systematically matches compressor use to demand and also offers maximum versatility - no matter whether it is used on receivers, with refrigeration dryers, as a duplex unit or with a cyclone separator. The compressors of the EO series come with a drive power of 16.5 kW (triple system) and 22 kW (quadruple system) and variable free air delivery from 625 up to 2500 ltr/min and have been launched on the market in 2015.

HST Series:
With the development of its new high-speed turbo (HST) technology, BOGE is ushering in a new era in compressed air. BOGE has radically reduced the number of components and introduced an extremely intelligent design principle. With innovative turbo drive, the HST compressors produce 100 per cent Class 0 oil-free compressed air - at the highest degree of efficiency and with minimal maintenance effort.
Cost savings of up to 30 per cent compared with conventional oil-free screw compressors are realistic.

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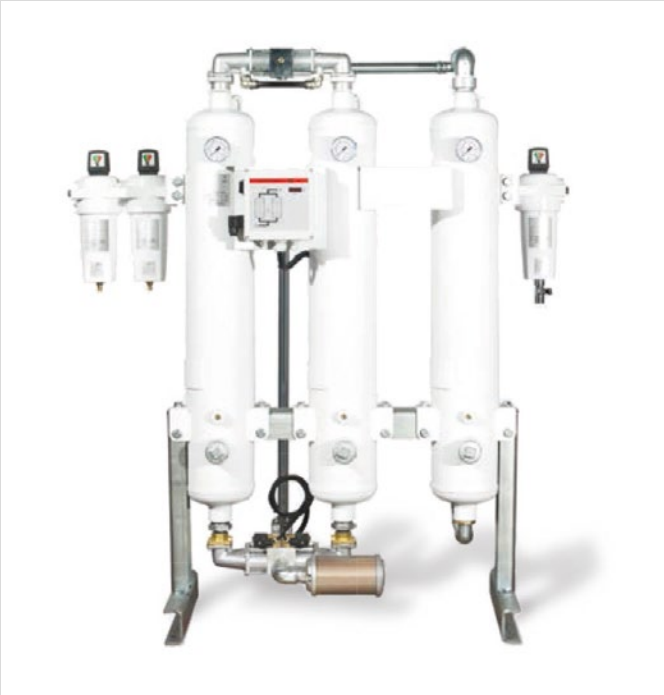
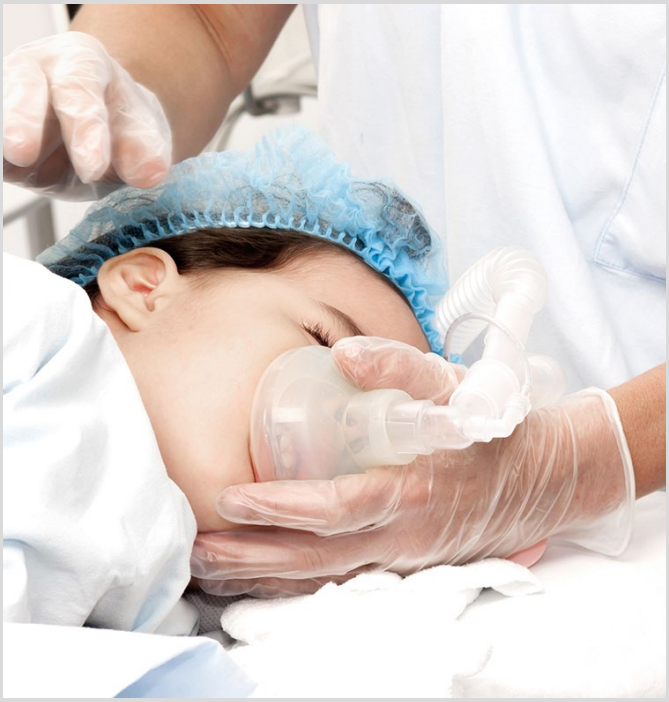
The filtration process

To deliver 100 per cent medically pure air, effective filtration is an essential part of the process. BOGE's systems, for example, operate a seven-stage filtration process with two chambers that are used to dry the compressed air in a pressure swing process and remove harmful substances. Integrated filter and purification/catalytic stages treat the compressed air efficiently and reliably according to the stringent specifications for medical compressed air.



The filtration has to have two redundancies to make sure that the output of medical air is delivered to a defined purity even if one stream is offline for maintenance or has a fault. The filtration process must ensure that any residual oil, dust, and humidity is removed as well as limiting the ambient concentration of carbon monoxide.

Although a seven stage filtration process may seem excessive, it is critical to achieving the required purity of compressed air for use in medical applications. The first two stages occur in the inlet of the filtration unit where there are two filters - a micro filter and a sub-micro filter - which filter out water, oil and dust.



The third stage is two columns that are a special kind of desiccant air dryer unit for medical purposes that will reduce humidity down to minus 40 degrees Celsius and will also remove any sulphur dioxide and nitric oxide out of the incoming air.

The fourth filtration stage, which takes place in a third column, features active carbon, the fifth stage will be catalyst material to reduce the amount of carbon monoxide, and then there is another special type of active carbon for the sixth stage. Finally, for the seventh stage there is a filter to remove any dust that could potentially be produced from all these cleaning processes. This entire process is monitored by sensors that enable accurate control over the dew point.

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Three of the Best: Staying in control

With high quality compressed air and filtration taken care of, the next requirement is efficient and reliable control, and once again BOGE ticks all the boxes

Focus Control 2.0: Right from the basic model, the modular control is one of the most modern in the industry. With focus control 2.0, BOGE has an intelligent compressor control system, which in the age of Industry 4.0 can be integrated into modern, networked production. The new machine control system allows up to four compressors to be connected. Information can be read comfortably via the high-resolution colour display and with touchscreen capabilities it makes it extremely easy to use. An RFID interface allows authorised operating personnel to remotely log in to the controller.

Airtelligence Plus: The BOGE airtelligence plus is able to control up to six compressors of the same or different outputs in a combined system. The selectable cyclic basic load switching ensures balanced utilisation of all compressors, thus reducing service costs and simultaneously increasing compressed air supply – this is how simple and cost effective efficiency can be.

Airtelligence Provis 2.0: The BOGE energy efficient controller simply sets new standards for cost effectiveness and maintenance reduction. The controller automatically determines the net capacity and potential leakage. It co-ordinates and harmonises up to 16 compressors of different makes. The intelligent master control is designed to configure the compressed air station for the best possible efficiency along with smooth and low maintenance operation. At the same time, airtelligence provis 2.0 assumes control of all operational functions.

Staying in control

In the standard control configuration, each compressor will have its own compressor control that governs its operation. This is intelligent in regards to energy saving. If, for example, a compressor needs to run even when it has reached maximum pressure, it features technology which unloads internal systems.

Traditionally, this would take time to achieve and mean 40-50 seconds of idle time while it unloaded. Modern control systems are more intelligent so are able to monitor the internal pressure and as soon as this is unloaded the compressor can be switched off. This saves money as running idle costs 30 per cent of the rated power even when no compressed air is produced.

When it comes to medical systems, BOGE uses a master control system that can control the entire compressor system. By monitoring the system and understanding the demand for compressed air, this system can decide how many compressors are required, and which of these compressors needs to be running. It can also adjust performance if one compressor is offline for maintenance or through a fault and compensate for that.

Additionally, each single compressor control monitors the master control system and will take over in the event that the master control fails or reacts too late. All this information is provided to the monitoring system of the hospital.

Energy efficiency

Energy efficiency for the whole system can be achieved in various manners. It is a well-known fact in the industrial arena that reducing pressure will save five to six per cent of the energy demand per bar, but this is not possible to do it in the medical system.

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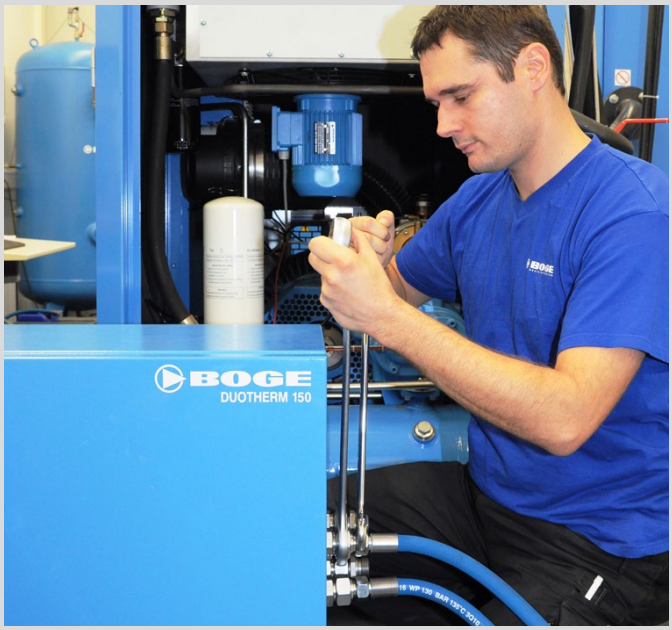
Another way to help reduce energy consumption is to the reduce the idle time of screw compressors, which means proper sizing of the system combined with the use of inverter-driven units. When you save 10 to 15 per cent of the idle time you save both money and energy.

For example, a system without inverter-drive units will switch on at eight bar and switch off at ten bar, running an average energy consumption at nine bar. An inverter-driven unit will switch on at eight bar and start to control the speed of the compressor at 8.2 bar, which means stable pressure at just above minimum pressure and lower energy consumption in comparison with the sustained compressor.

Another option, which is well-established in the industry, is heat recovery and it is a very interesting system for hospitals. Due to high thermal energy emission, it could be said, the compressor is actually a heater that produces compressed air. In total, almost 100 per cent of electrical energy consumed by a compressor will become heat. Using a heat recovery device such as the BOGE DuoTherm with a screw compressors can recover up to 80 per cent of this heat energy easily and is able to provide hot water up to 70°C to feed to heating systems of the facility.



Compressed air needs drying and that process is energy hungry so it is vital that it is fully optimised. Intelligent load-dependent controlling of the medical dryers means that up to 50 per cent of the regeneration energy can be saved. This works by continuously adapting the ratio of drying and regeneration to the current moisture status.

Building the right system

BOGE's vast experience of compressed air systems in the medical sector has taught us that if the total cost of owning a compressed air system is considered over a period of 10 years then 80 per cent of these costs will be energy consumption, while only ten per cent is the initial purchase cost of the equipment and ten per cent is maintenance. With those figures in mind, it is crucial that the right system – with the most suitable technologies - is specified.

One important tool that we can employ to ensure that a system is sized correctly is visualisation. Usually the customer will either come to us and give us an idea of the size of hospital they require compressed air for - along with the characteristics of the compressed air demand they need us to fulfil – or they will ask for a Medical AirAudit to gather the information. We can input these figures into advanced simulation software and, based on the profile that this software delivers, we are able to compare different systems and technologies against each other and select the best system for each customer.

Simulation software provides a well-proven and effective strategy for designing a system that is fit for purpose. It can meet the customer's needs with the correct compressor technology in the right size system that delivers an optimum solution, particularly when it comes to energy consumption.

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For example, when a system has a small general demand of around 500 litres per minute of medical air and at the same time the need can fluctuate greatly to up to 1000 litres per minute and down to just 150 litres per minute, a screw compressors with 1.5 cubic metres per minute may be most appropriate.

Living and Breathing Regulations

BOGE medical compressed air systems, installed and certified by reputable hospital equippers and medical device manufacturers, comply with all the relevant standards and requirements, including:

- Medical devices directive 93/42/EC
- DIN EN ISO 7396-1
- DIN EN ISO 9001/13485
- HTM 02-01

The European Medical Device Directives 93/42/EC: Any medical device placed on the European market must comply with relevant legislation. Manufacturers' products meeting 'harmonised standards' have a presumption of conformity to the Directive. Products conforming with the Directive must have a CE mark applied. Where available, relevant standards may be used to demonstrate compliance with the essential requirements defined in the Directives' list of harmonised standards.

[Source: http://www.bsigroup.com/en-GB/medical-devices/our-services/european-mdd/]

DIN EN ISO 7396-1: ISO 7396-1 specifies requirements for design, installation, function, performance, documentation, testing and commissioning of compressed medical gas and vacuum pipeline systems in health care facilities to ensure continuous delivery of the correct gas from the pipeline system. It includes requirements for supply systems, pipeline distribution systems, control systems, monitoring and alarm systems and non-interchangeability between components of different gas systems. It is applicable to: oxygen; oxygen-enriched air; nitrous oxide; air for breathing; carbon dioxide; oxygen/nitrous oxide mixtures; air for driving surgical tools; nitrogen for driving surgical tools; and to vacuum pipeline systems.

[Source: http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_detail_ics.htm?csnumber=25795]

DIN EN ISO 9001/13485: ISO 13485:2003 specifies requirements for a quality management system where an organisation needs to demonstrate its ability to provide medical devices and related services that consistently meet customer requirements and regulatory requirements applicable to medical devices and related services. The primary objective of ISO 13485:2003 is to facilitate harmonised medical device regulatory requirements for quality management systems. As a result, it includes some particular requirements for medical devices and excludes some of the requirements of ISO 9001 that are not appropriate as regulatory requirements. Because of these exclusions, organisations whose quality management systems conform to this International Standard cannot claim conformity to ISO 9001 unless their quality management systems conform to all the requirements of ISO 9001.

[Source: https://www.iso.org/obp/ui/#iso:std:iso:13485:ed-2:v1:en]

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However, the average hospital use is only 50 to 60 per cent of the 100 per cent calculated hospital demand, which means that the system would be forced to idle because the screw compressor would have to switch off when it had reached maximum pressure to unload then switch back on when there was demand. In this example, therefore, a hospital could instead install a piston compressor, which has the advantage that it does not need to have the idle run time because it switches completely off after reaching the maximum pressure. Therefore, a piston compressor system may be more efficient than a same size screw compressor system and be a more suitable option than screw compressors.

Take another scenario where the hospital is much bigger or the air demand is flat in demand with little fluctuation. In this case, the screw compressors may be more appropriate because during operation times screw compressors deliver better efficiency. As soon as it is possible to avoid idle run time the screw compressors may become more advantageous than piston compressors. This is why it is key to look at the individual demands.

When human lives are at stake safety must come first. But even in such a highly regulated environment a compressed air system must be cost effective. The key factors to achieve this are that it is a properly sized and controlled system that gives the maximum availability and minimum energy consumption and maintenance costs. It is important to choose the right components and create the right systems from these.

The use of highly-efficient energy-saving technologies in conjunction with modern control, monitoring and visualisation concepts ensures the system will meet all requirements whether from a regulatory or operational perspective.

To find out more about BOGE Compressors and specialist gas generators, please contact us or visit our website:
www.boge.com/uk

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