MEDICAL GRADE COMPRESSED AIR

Professor Rebecca Jacob M.D.,D.A., Kumaresh V. D.A. Senior Registrar, Department of Anaesthesia
Christian Medical College Hospital, Vellore, India

Compressed air is required in hospitals to operate surgical instruments such as pneumatic drills and saws. Air is also used to run ventilators and may be used as a carrier gas in anaesthesia. Although oxygen may also be used it is very expensive. In small hospitals oxygen concentrators with air compressors are used which are capable of driving ventilators. The amount of compressed air produced is however insufficient for use in larger hospitals.

In our hospital we decided to produce our own supplies of compressed air. Initially we bought cheap, commercially available oil lubricated compressors. There were no dryers (or dessicators) incorporated and mild steel pipelines were used to transport the compressed air to the operating rooms. Contamination of the air unfortunately occurred very rapidly with oil and dust, along with rust from the mild steel pipelines, and caused frequent problems. The ventilators got clogged, needed frequent cleaning and servicing, the drills seized and neonatal ventilators failed.

Specification of medical air

Medical grade air should be free from toxic products, flammable or toxic vapours, and odours at all points in the pipeline system. Although it is not sterile medical grade air is clean and at STP(standard temperature and pressure) should not contain more than:

- 0.5mg of particulate oil mist /cubic metre of air
- 5.5mg of carbon monoxide/ cubic metre of air
- 900 mg carbon dioxide/ cubic metre of air
- no moisture
- no bacterial contamination

Surgical instruments require compressed air at 7.2bar or 105psi

Anaesthetic ventilators require compressed air at 4.1 bar or 60psi

Components of compressed air system

The system consists of various parts which include the air inlet, compressors, reservoirs, dryers or dessicators, coolers, filters, conduits and pipelines.

Air inlets (air intake) for a compressor producing medical grade air should be located in such a way that it will minimise contamination from internal combustion engines' exhausts, discharge from hospital vacuum pumps and other sources of contamination. They should ideally be located outdoors and protected from rain, dust and fumes. This is not easy in the centre of a city with heavy vehicular traffic. Therefore if the quality of air is unreliable it is better to filter the air at the inlet. Filters may be dry medium filters or paper element filters. More than one may be required. These filters may add to the initial expense but this is small compared to the greater costs which will be incurred by the use of unfiltered air.

Air compressors are of different types. Ideally two or more compressors should be available. Each one must be capable of handling 100% of the estimated peak flow demand. Oil lubricated compressors are cheaper but it is very difficult to filter out the oil mist which may be produced. Oil free compressors are best, but it must be remembered that they are oil free only as long as the seals to their oil lubricated parts remain effective. The material from which the sealing rings are made is also important. Carbon releases carbon monoxide and carbon dioxide on overheating, PTFE releases toxic gases on overheating. Water sealing is not suitable if the water is hard or contains solids in suspension.

Air pressure in the compressor air receiver acts as a reservoir and should always be higher than that required for instruments and should allow for pressure loss occurring downstream in pipelines, dryers and filters. Pressure regulators should always be downstream from the dryers.

Aftercoolers During compression air gets heated and cools during its transit and delivery to the operating rooms. It is during this time that condensation occurs leading to the corrosion of mild steel pipelines which results in malfunction of equipment. Compressed atmospheric air contains water vapour which may be removed by a cooling process. This may be done by air, water, or a refrigeration medium. This process must be efficient to keep the subsequent condensation to the minimum. The humidity should be such that the dew point of air supplied is $< 40^0$C. (Dew point is the temperature at which condensation occurs when a gas mixture cools).

The Air Receiver acts as a reservoir for the compressed air. It maintains a constant pressure and ensures that an uninterrupted non-pulsatile air flow is delivered. Ideally each compressor should have its own reservoir or receiver. Air receivers should be supplied with test certificates stating that they can withstand twice the normal working pressure. Air receivers should be fitted with automatic drain traps with valves which allow condensed water to drain away to an outside drain. Each receiver should also be fitted with safety valves, a pressure gauge and an inspection window to check that the drain is working. They should also be fitted with non return and isolation valves. The receiver must be provided with a bypass to permit servicing without shutting down the piped air system.

Dryers and dessicators may be of two types - the refrigerator type or the heatless dessicant type. The dessicants may be silica gel, activated alumina or a molecular seive. They should be two to a unit and the change over from one to the other when the first one is exhausted should be automatic.

The separator trap and filter assembly is required to finally filter out the residual water, oil mist or droplets and other particulate matter. It should have a trap with an automatic or manual drain and a manual bypass. Ideally this bypass should lead to an alternate filter. Filters should have an efficiency of not less than 95% and a filter penetration of 0.5%. These filters are very expensive.

Pipelines should be of copper and not mild steel which is prone to rust.

It is sensible to have a 'testing' outlet from the compressed air pipeline just prior to its entering the operating room complex so that a quality check may be made of the air.

It is always preferable to have a duplex system with interconnecting compressors, air receivers and dryers of similar capacity connected by a bypass or isolation valves which allows the servicing of a compressor, air receiver or dryer at any time whilst ensuring an uninterrupted supply of compressed air.

Audiovisual alarm systems are an option which may be used to monitor the line pressure. They may be fitted at vantage points such as nursing stations etc.

Although initially expensive, with proper care and maintenance, a relatively simple set up will provide supplies of medical grade compressed air for the running of surgical instruments and ventilators for many years.

References

1. Conely JIM, Railton R, Mackenzie AI. Ventilator problems caused by humidity in the air supplied from simple compressors. British Journal of Anaesthesia. 1981;53;549

2. Dorsch JA. Understanding anaesthesia equipment. Publisher. Williams and Wilkins 3rd ed.. Pages 29-30

3. Parbrook GD, Davis PD, Kenny GNC. Basic physics and measurement in anaesthesia Publisher. Butterworth Heinemann 4th Ed. 1995. Pages 146-9 and 273-4

4. Mushin WW. Physics for the anaesthetist. Publisher. Blackwell Scientific Publications, 2nd Ed. Pages 73-5