Repair

Poor response may indicate a faulty photocell. If other possible causes have been eliminated (blocked atomizer, failed dilutor, old tubes, faulty power connections), then replace the photocell.

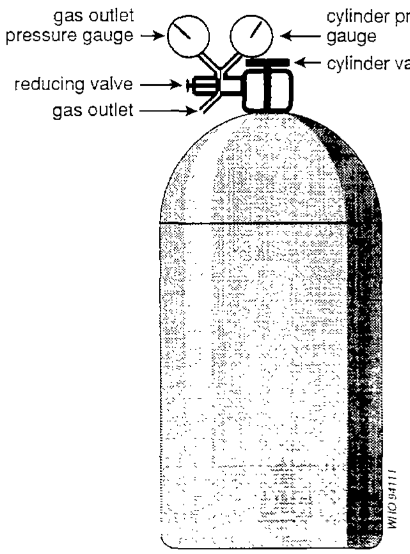
Calibration

Flame emission photometry is a comparative technique; therefore calibrators must be prepared and assayed simultaneously with the samples.

Gas cylinders and gases

It is assumed that hospital laboratories, theatres, and other departments that use gas cylinders will be using cylinders owned by the vendor. The problems of refilling will therefore not be considered. Cylinders are intrinsically simple devices (Fig. 2.17) requiring little or no maintenance. However, they are potentially highly dangerous because of the pressure of the contained gas. The pressure within a fully charged cylinder may be governed by local requirements, but can be as high as 20 MPa. For this reason, cylinders should be treated and maintained with care to avoid damage.

Fig. 2.17. Gas cylinder assembly.



Many gases are flammable, giving rise to an additional hazard. Even "harmless" gases, such as carbon dioxide and nitrogen, are potentially dangerous if allowed to escape into the atmosphere in high concentration, as they can cause asphyxiation by oxygen deprivation.

Gases, such as butane, that are liquid under storage conditions will exert vapour pressure within the cylinders all the time there is liquid present.

Procedures for the safe use and maintenance of cylinders

The name of the gas should be stamped or stencilled on the cylinder. Colour coding is also used for identification, but this may vary from country to country.

Labelling of cylinder caps is not acceptable as a means of identification, as these are interchangeable.

Cylinders should be kept in a purpose-built store and the gas piped to the area of utilization. Gas lines should be of an appropriate material for the safe distribution of the gas. Brass and steel pipes and fittings should **never** be connected together, since accelerated oxidation of the metals will occur, causing leaks. The lines should be clearly labelled.

Cylinders should not be subjected to extreme temperatures. (It is especially important that those containing flammable gases are not exposed to high temperatures.) This must be borne in mind when selecting the sites for gas stores.

Incompatible gases should not be stored together. Flammable gases (e.g., hydrogen, propane, butane) should not be stored with non-flammable gases (carbon dioxide, nitrogen, oxygen).

If a dedicated gas store is not available, and cylinders have to be stored in the working area, they must be fastened to the wall or bench with purpose-designed clamps. Flat-bottomed cylinders should not be used or stored free-standing, and purpose-designed or innovative stands should not be used as an alternative to clamping. Cylinders must be stored in a cool area away from sunlight. Oxygen cylinders used on the wards and other public areas should always be kept in a cylinder carrier.

Cylinders should never be emptied to below a pressure of 170 kPa. Empty cylinders should be clearly marked.

The main valve on an empty cylinder should not be left open. This will enable moisture to enter the cylinder, ultimately causing corrosion. It will also allow air to enter, which could create an explosive mixture with some flammable gases when the cylinder is refilled.

Cylinders must be fitted with the correct reducing-valve equipment. The operator must be familiar with the manufacturer's recommendations and adhere to these. Valve equipment should fit easily on to the cylinder, and should never be forced. If force is required, the fitting is probably inappropriate. Force may damage the valve and the cylinder.

Whenever a gas cylinder is to be connected to a regulator or piping system, the cylinder valve should be quickly "cracked" open and reclosed, in order to clear any debris accumulated in the valve outlet. Failure to do this can lead to plugged regulating valves and other disturbances. The cylinder should be clamped to the wall or bench before "cracking".

Separate reducing-valve equipment is required for flammable and non-flammable gases. These are specially designed, usually with a right-hand thread for non-flammable gases and a left-hand thread for flammable gases. However, this is not always the case, and the operator needs to be familiar with the manufacturer's practice and local requirements.

Reducing valves should always be used on cylinders that have a pressure greater than 700 kPa when full. Careful attention should be paid to the units on the manometer. Otherwise, misreading may lead to inappropriate handling of a gas cylinder.

The main cylinder valve should be opened slowly to avoid damaging the reducing valve. It should never be necessary to open the main valve fully, except with cylinders that are designed to operate with the valve fully open.

Oil should never be used to lubricate reducing valves, or any other part of the system.[1]

Only those tools provided, or recommended, by the manufacturer should be used for opening and shutting the main valve and for fitting or removing reducing valves. Undue force should not be required, as it is likely to damage the cylinder or the valve.

Cylinders should be transported with care to avoid fracture. They should not be dropped or rolled, and should be transported in an upright position on purpose-designed trolleys.

The operator must ensure that the cylinder and gas lines are leakproof. A leak of flammable gas is potentially explosive. Gases, such as hydrogen, that have a high diffusion rate, will escape from connections that would be leakproof for more dense gases. Connections should be checked regularly by dispensing a dilute soap solution on the fitting. A leak is indicated by the formation of bubbles.

Special requirements for the use of hazardous gases

As a general rule, it is strictly forbidden to smoke in the vicinity of gas cylinders.

Oxygen

Oxygen (O_2) is a normal constituent of the atmosphere, comprising 20–21% by volume. Oxygen is not flammable, but supports combustion, and in high oxygen concentrations almost everything will burn.

Valves, plumbing, and all fitments of oxygen gas cylinders must be scrupulously cleaned to remove all traces of organic material. Even new piping must be thoroughly cleaned before use. No equipment that is to be used in connection with oxygen should be touched with oily hands or gloves. Systems used for oxygen should never be used for any other gas.

Cylinders must be stored away from any combustible material.

Hydrogen

Hydrogen (H_2) is the lightest known gas, and therefore has a high diffusion rate. It will burn in oxygen in almost any concentration ratio, with a non-luminous flame which makes it difficult to see. It is fast burning, and fire spreads rapidly. Hydrogen is unique in that its temperature increases on expansion, with the risk of self-ignition if it is released too quickly from the cylinder. The main valve and reducing valve of a hydrogen gas cylinder should be opened slowly to avoid self-ignition.

All systems using hydrogen should be checked especially carefully for leaks.

Carbon dioxide

Carbon dioxide (CO_2) is a colourless, odourless, non-combustible, water-soluble gas. It is available in the form of a compressed liquid in gas cylinders, and in solid

[1] See also the recommendations for anaesthetic equipment, pp. 70–100.

form (dry ice). In the laboratory, it is used for the incubation of certain microbes, in the measurement of blood gases, and for other scientific purposes. In medicine, it is used as a respiratory stimulant. The liquid form is used in fire-extinguishers. Solid CO_2 is used primarily as a temporary laboratory coolant.

Carbon dioxide can accumulate at high concentrations in closed compartments, such as in closed rooms that are used for fermentation processes, or in wells, silos, mines, etc., where it diffuses to the bottom since it is more dense than air. A concentration of 5% carbon dioxide in the air will produce headaches and shortness of breath. A concentration of more than 10% can produce unconsciousness and death from oxygen deficiency. Such hazards can be easily avoided by appropriate room ventilation.

Nitrogen

Nitrogen (N_2) is the main component of air, comprising 78–79% by volume. It does not support the chemical reactions needed to maintain life. It can cause medical problems by displacing oxygen, leading to hypoxic asphyxia.

Compressed nitrogen is provided in gas cylinders, and is generally used in combination with oxygen gas, for better control of burning processes. In medicine, liquid nitrogen, which has a temperature of − 195 °C, is used for quick freezing and storage of tissues and microorganisms.

Nitrous oxide/oxygen mixtures

A 50/50 mixture of nitrous oxide and oxygen (N_2O/O_2) is often used for anaesthesia. If cylinders containing a nitrous oxide/oxygen mixture are stored at temperatures below 10 °C, the nitrous oxide can separate out. Therefore, the bottles must be warmed and shaken before use. Otherwise, the oxygen will be used first resulting in very high concentrations of nitrous oxide being delivered at a later stage, which will be hazardous to the patient.

Butane/propane

Butane (C_4H_6) and propane (C_3H_8) are colourless, odourless, flammable gases, and are usually mixed with foul-smelling additives to permit recognition of their presence. Although no special precautions are required in handling, the operator must be aware of their flammability. They are often supplied in small cylinders designed to fit on the back of analytical equipment. It must be remembered that, even in this quantity, these gases are explosive and potentially dangerous.

Butane and propane are stored as liquids under pressure. Therefore, cylinders must be kept upright, to prevent the liquids being forced into the piping system. In the laboratory, butane and propane are used for flame photometry.

Acetylene

Acetylene (C_2H_2) is a colourless gas with a faint ethereal odour. It is the most unstable compound any hospital worker is likely to encounter. Acetylene is used for atomic absorption spectroscopy, and also for the brazing, welding, cutting, and heating of metals. It will ignite explosively in air, over a wide concentration range. It is stabilized by the presence of certain other organic compounds, and is usually dissolved in acetone in commercially available cylinders. Acetylene reacts with many metals including copper, silver, and lead to form explosive acetylides.

Metal gas lines should not be used for acetylene, except at the express recommendation of the gas supplier. Stainless steel is acceptable, whereas copper pipes and soldered joints are not. Narrow-bore lines should be used, as acetylene is less stable in wide-bore pipes.

Operating gas pressure should not exceed 100 kPa. Only reducing valves that are specifically approved for acetylene should be used.

Special care must be taken with the storage and transportation of cylinders.

Acetylene is so dangerous that it should not be used in the hospital environment unless there is no alternative available.

Anaesthetic gases

There is no common standard for the identification of anaesthetic gas cylinders. For example, in North America, oxygen cylinders are usually green, those in Commonwealth countries are black with white shoulders, whereas in Switzerland and in France the cylinders are blue. Gas should not be administered to the patient unless the anaesthetist is absolutely certain of the contents of the cylinders.

When anaesthetic vapours are present in the operating room there is a risk of fire or explosion. It is important to distinguish between gas mixtures that are flammable and those that are explosive; the latter are much more dangerous to both staff and patients.

- Ether can be either flammable or explosive in the concentrations used for clinical purposes.
- 10% trichloroethylene will burn in oxygen.
- Mixtures of ether and air are flammable.
- Mixtures of ether and oxygen (or ether and nitrous oxide) are explosive.
- Oxygen and mixtures of oxygen and air are explosive.

There is a potential risk of explosion if diathermy equipment or other electrical apparatus is used in conjunction with flammable anaesthetic gases. Static electricity may also trigger an explosion if explosive gas mixtures are present. No potential source of combustion or electrical discharge should be allowed within 50 cm of an expiratory valve through which an explosive gas mixture is passing (e.g., ether/oxygen). Diathermy should be avoided altogether if a flammable gas mixture is in use, and vice versa.

Precautions

- The operating room and equipment should be rendered anti-static (it is worth remembering that moisture gives anti-static protection).
- Electrical sockets and switches should be either spark-proof, or situated at least 1 metre above floor level.
- The patient's expired gases should be carried away from the expiratory valve down a wide-bore tube at least to the floor (ether is heavier than air), or out of the operating room. Ensure that the tube is not kinked or blocked, and that there are no fire sources near its exit point.

Microscopes

Microscopes are used in medical laboratories to magnify images of light-transmitting or light-reflecting specimens. There are two main types of microscope: light microscopes and electron microscopes.