Repairs

If electrodes are stored incorrectly the membrane may dry out. It is sometimes possible to restore performance by removing the outer layer of the membrane with a smooth flat file.

Hazards

If electrodes are used for measuring biological fluids, they must be cleaned and disinfected according to the manufacturer's recommendations.

Packing

Electrodes are very fragile and must therefore be packed correctly, following the manufacturer's instructions. Care is needed in removing the packaging.

Flame photometers

Flame photometers are used routinely for the measurement of lithium (Li), sodium (Na), and potassium (K) in body fluids. More sophisticated instruments can also measure calcium (Ca).

In flame photometry, an aqueous salt solution is dispersed in air. The salt in the dispersed droplets is transferred into a gaseous state by heating with a flame, and then quickly disintegrates into gaseous atoms. Above a critical temperature the atoms absorb energy, which excites the electrons into higher energy states. When the excited electrons return to their original state, they emit the absorbed energy as light. The wavelength of the light emitted by each metal is characteristic for that element. The intensity of the light emitted at the given wavelength is proportional to the number of excited metal atoms and can be measured with a suitable optical filter and photodetector.

This principle—also called flame emission photometry—can be used to measure more than 50 elements. However, it is mainly used for determination of the alkali metals, the excitation of which requires only a low energy input from a low-temperature flame (propane/air or butane/air).

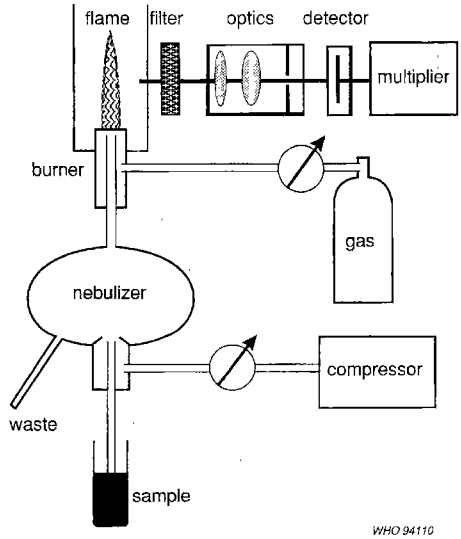
Under ideal circumstances, there is a linear correlation between the concentration of the element in dispersion and the light intensity at a specific wavelength. However, in practice, there will be some degree of ionization, depending on the concentration of the element. Additionally, the presence of other elements may suppress ionization. Both atoms and ions of an element in the gaseous state can be excited, but the emission spectra from atoms and ions are different. Therefore, it is necessary to choose conditions of measurement in which only atom emission spectra are obtained. The optimal conditions must be defined for each element. When measuring potassium in a specimen, for example, the addition of another element, such as lithium, to the solution not only suppresses potassium ionization, but can at the same time provide internal calibration, if the lithium concentration is measured with a reference detector. A flame photometer with a reference detector for lithium therefore compensates for fluctuations in the energy input from the flame.

A flame photometer consists of the following essential parts (Fig. 2.16):

- nebulizer
- burner

– filter and optics
– detector and multiplier
– air compressor
– gas supply.

Fig. 2.16. Flame photometer assembly.



The specimen solution is mixed with a diluent which may contain a lithium salt at a defined concentration. Many flame photometers have a dilutor as an integral part of the instrument. This diluted solution is dispersed by compressed air in the nebulizer chamber, and heated in a gas flame. The emitted light passes through the optical system to the detector.

The filter wavelengths for measurement are:

Li—671 nm
Na—589 nm
K—768 nm

With a well maintained flame photometer, the coefficient of variation in measurement can be as low as 1.5% for Li and 0.5% for Na and K.

Services required

In addition to a reliable electricity supply, flame photometers require:

– compressed air at a pressure of about 100 kPa, from either an electrically powered air compressor or a gas cylinder (but this is expensive);
– a gas cylinder connected to the flame photometer through an air filter, or a gas supply (city gas, butane, or propane), as specified by the manufacturer;
– distilled water;
– drainage point.

Unpacking, siting, installation

1. Read the manufacturer's instructions carefully.
2. Remove the instrument from its packing and wipe the external surfaces with a cloth. Keep the packing for possible future use.

3. Install the instrument on a vibration-free bench, away from direct sunlight and draughts.
4. Place the air compressor on the floor, or on a purpose-built shelf, as compressors cause much vibration (and noise).
5. Ensure that the operating voltage of the flame photometer and compressor is the same as the local supply.
6. Following the manufacturer's instructions, connect the gas supply, the compressed air supply, and the drainage tube to the flame photometer.
7. If the instrument has removable optical filters, put these in place. **Never** use the flame photometer without the filters in place.
8. Some instruments with meters have a locking device. Unlock this before use.

Operation and maintenance

Since the degree of dilution of the specimen and the gas pressure are critical, it is advisable to follow the operating instructions for the instrument supplied by the manufacturer.

For most instruments, measurements can be made on serum. However, serum protein may precipitate in the tubes and dilution chamber. Similarly, the burner, the burning chamber (chimney), and the filter can become contaminated by such particles if the gas and air mixture does not provide complete combustion.

The following precautions should be noted:

- Samples should be homogeneous, and not highly viscous.
- Check the performance of the instrument with a calibrator and a quality control serum prior to each series of measurements on unknown specimens. Calibrators and samples must be diluted with the same diluent.
- Check the gas bottles daily.
- Adjust the air supply from the compressor as recommended by the manufacturer.
- Clean the tubing and nebulizer system by suction of distilled water after each series of measurements. Leakage in the system can be checked by use of a soap solution; this may also clean precipitates from tubing. Dilutors with a pumping system, using rubber tubing, must be checked routinely at frequent intervals, since the tubing will soften after prolonged use, leading to problems in measurement due to erratic dilution of the specimen.
- Turn off the gas supply after each run.
- Empty the waste container daily.
- Clean the tubing of the dilutor and nebulizer weekly, and rinse with distilled water.
- Clean the burner, glass chimney, and filters every 6 months with a lint-free cloth, a cleaning solution, and methanol.

Remember: Optical filters must be handled only by the edges.

Good working practices

Follow the manufacturer's operating instructions:

- Check that the gas cylinder is sufficiently full.
- Check that the working pressure of the gas cylinder is correct.
- Never operate the photometer without the optical filters in place.

Clean the flame photometer by aspirating distilled water through the atomizer after each series of measurements.

When switching off:

1. Turn off the gas.
2. Wait for extinction of the flame.
3. Turn off the air.
4. Remove the distilled water from the aspiration line.
5. Switch off the instrument and the compressor.
6. Allow to cool.
7. Cover with plastic cover to keep out dust.

Hazards

If good working practices are observed then the service personnel are not exposed to any special biological hazards. Be careful to follow the manufacturer's procedure when lighting and turning off the flame.

Tools

A general tool kit is satisfactory.

Spares

Atomizer
Capillary tubing (plastic)
Capillary tube (metal)
Wire for cleaning capillary tubes
Gas cylinder
Photocell
Bulbs (when fitted)
Glass chimney (when fitted)

Maintenance

1. Remove the atomizer from the instrument and flush water through it.
2. Clean the metal capillary tube with thin wire to remove fibrin, dried serum, or plasma. Flush with water again.
3. If there is a built-in diluting pump, check the condition of the pump tubes and replace if necessary. Check that the dilution is correct (approximately) by preparing a calibrator, appropriately diluted using volumetric glassware, and comparing it with the dilution prepared by the pump. When the display is erratic, a volumetrically diluted calibrant will help to differentiate between a faulty pump and nebulizer/flame stability problems.

Service

1. Clean lenses, filters, and mirrors (if fitted) with a soft cloth to remove dust or carbon.
2. Clean the photocell with a soft cloth.
3. Clean the glass chimney.
4. Atomizers made of acrylic resin should be inspected for cracks. Replace as necessary.

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.

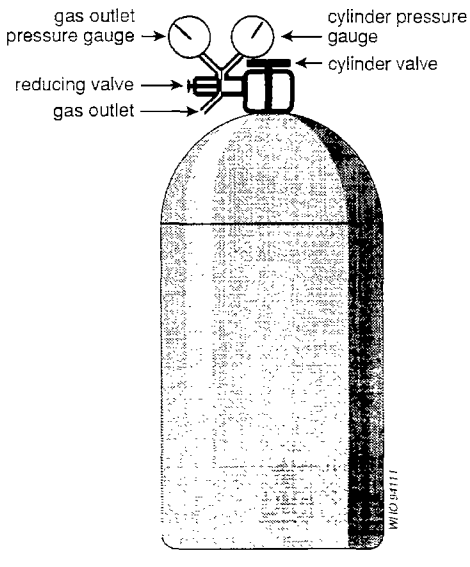
Calibration

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.