Chapter 24

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BREATHING GAS CONTAMINATION

The supply of uncontaminated breathing gas (air) is of vital importance to the diver because of the magnifying effect on contamination by the partial pressure rise with increasing depth. For example, 5% contamination of gas at atmospheric pressure is equivalent to 20% at 30 metres depth (4 ATA).

Contamination usually arises either from impurities in the air taken into the compressor or from contaminants generated by the compressor itself.

PREPARATION OF COMPRESSED AIR

Atmospheric air is taken into the compressor and is compressed by one of two methods. Most dive shops use a piston and cylinder compressor which raises the pressure of the gas in several stages. A more advanced compressor uses a diaphragm pump similar in principle to that in a refrigerator.

Ideally the compressed air should be treated by passing it through several purifying cartridges (or filters) to remove contaminants. Silica gel is used to remove **water** vapour, activated charcoal removes **oil** and **hydrocarbons**, a molecular sieve removes **water droplets and dust particles** and a catalyst converts **carbon monoxide** to carbon dioxide, which can be absorbed. Less scrupulous air suppliers have been known to substitute women's sanitary pads, instead of filters.

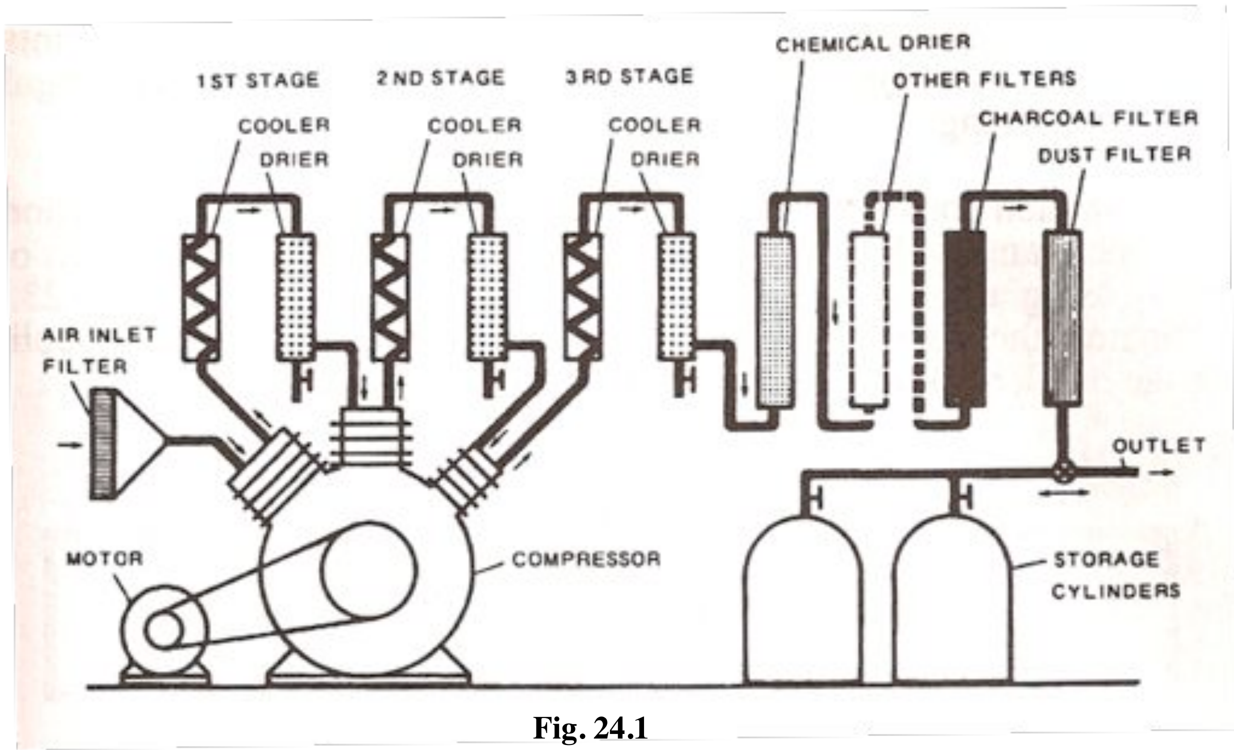

Fig. 24.1
Schematic diagram of a compressor system with filters.

GAS PURITY STANDARDS

Authorities such as the US Navy, NOAA and Standards Australia specify minimum standards of purity for breathing gas.

Case History 24.1 In an area subject to tidal currents an experienced diver planned to dive at slack water. He anchored his boat almost at low tide. The hookah compressor he used was correctly arranged with the air inlet upwind of the exhaust and the dive commenced. After 90 minutes at 10 metres the diver felt dizzy and lost consciousness but was fortunately pulled aboard by his attendant and resuscitated.
Diagnosis — Carbon monoxide poisoning.
Explanation — as the tide turned, so did the boat. This put the compressor **air inlet downwind of the motor exhaust** and carbon monoxide from the exhaust was breathed under pressure by the diver.

Compressors can also generate some lethal contaminants internally. The compressor piston requires lubrication and this is usually achieved by the use of special **oils**. In some circumstances, such as where there is excessive wear of the compressor, high temperatures can be generated and this may decompose the lubricating oil into toxic products such as **oxides of nitrogen** or **carbon monoxide**, which are then pumped into the diver's air tank. Poor maintenance of the compressor can also lead to an **oil** and **hydrocarbon** mist escaping into the air supply.

If the compressor is operated in an unclean environment, **dust** (and chemical vapours) can find its way into the diver's air causing abnormal wear on the moving parts of both the compressor and the regulator.

Fig. 24.2 A modern air compressor

Water vapour must be removed from the air delivered from the compressor or it can condense in the scuba cylinder causing rust, or allow the regulator to freeze up during diving in cold conditions.

Most compressors have a **filtration system** both on the inlet side to prevent the intake of dust, and on the outlet side to filter out oil and water vapour. Their efficiency depends on regular maintenance and the absence of over-loading.

Occasionally contamination comes from the destruction of the filters and lubrication systems. Non-hydrocarbon based lubricants with high "flash points' are preferable. The problems of oil lubrication can be overcome by using a compressor which is lubricated with water or dry Teflon materials. Unfortunately the expense of these is beyond the reach of many air suppliers. Diaphragm pumps also avoid the problem of oil lubrication but are also very expensive.

CLINICAL FEATURES

Contaminated air may have an unusual taste or smell, or alternately, it may appear quite normal.

As many of the divers may obtain their air supply from the same source, it is not uncommon for similar symptoms to be spread amongst the diving group. As only the most serious case may present, the other divers should be interrogated for similar but less severe symptoms.

- **Oxides of nitrogen** cause lung damage, which is likely to cause coughing, wheezing, shortness of breath and/or tightness in the chest.

- **Carbon monoxide** causes headache and unconsciousness – a detailed description can be found in Chapter 23.

- **Oil** can cause nausea, vomiting, chest pain, shortness of breath, coughing and pneumonia.

- **Trichloroethylene and other aliphatic halogens** can cause respiratory and gastrointestinal symptoms.

TREATMENT

If a diver is affected by breathing contaminated air he should be separated from the source, managed according to the **basic life support** principles outlined in Chapter 42, and gas from his scuba cylinder should be sent for analysis to a chemical or gas testing laboratory, as should that from others who used the same air compressors.

PREVENTION

The diver should breathe from his equipment before entering the water and should not use air which has an unusual taste or smell.

As the expertise of compressed air (and other breathing gases) suppliers vary, divers are well advised to obtain air fills only from a reputable supplier. Regular checks by local authorities on the quality of the air are advisable, and in many places are now mandatory. It can be tested by chemical detector tubes that determine the level of each specific contaminant. Drager (a gas and medical equipment company) supply these tubes in a Drager Gas Detection Kit. Many others are available.

Following any diving accident, suspect air can be tested by commercial gas suppliers and State Health authorities.

Case History 24.2

A diving club had for many years been filling their cylinders from an air bank made up of large cylinders, the source of which had been lost in the mists of time. It was decided to return the bank of cylinders to a major industrial gas supplier for testing. The cylinders had their original paint in good condition – black cylinders with a white collar. The gas company tested the cylinders, found them to be sound and refilled them according to the colour code on the cylinders. Unfortunately, this was the standard colour code for pure oxygen and that is what the company filled them with, having no idea that they would be ultimately used to fill scuba tanks.

A member of the dive club took delivery of the cylinders and reinstalled them in the bank. He did not know the significance of the colour coding and assumed that because he was using the cylinders to store air that the company would refill them accordingly. Because they were already full there was no need to fill them from the compressor and the bank was immediately used to fill several sets for a dive the following day. Two divers used tanks from this source on a dive to 20 metres. One abruptly convulsed 10 minutes into the dive and was fortunately rescued by his buddy before he too convulsed.

Some clever detective work performed by the rescuing diver, and the diving physician they consulted, established the cause of the problem as oxygen toxicity. Swift action by the police to round up all the contaminated scuba tanks before they could be used, averted a major disaster. In this case, breathing from the cylinder at the surface before the dive would not have disclosed any detectable difference from air.