Supplementary oxygen

Most climbers use supplementary oxygen ('O_2'), carried in bottles and delivered through a face mask. Some feel that using O_2 is 'cheating' as it makes the ascent easier, others regard it as standard equipment, like crampons or gloves. About 4% have summited 'without O_2'. The death rate among them is only slightly higher than for 'O_2' climbers, but most of the 'non-O_2' climbers are far more experienced.

The decision is a personal one, but there are genetic factors to consider. Research shows that most people could not survive a climb of Everest without additional O_2. Most climbers start using it at about 7500m, though some start lower to conserve energy for summit day.

In the Death Zone you can't run around or wave your arms to keep warm: it costs too much energy and oxygen. One reason for using O_2 is that it helps to keep your body warm, preventing frostbite. On the other hand, each system weighs at least 4 kg, not counting spare bottles, so you will need extra energy (and oxygen), just to carry the kit, diminishing its net advantage.

Climbers' oxygen bottles are filled with almost 100% pure O_2. Two systems are in use: POISK which uses constant flow, and the newer Summit which delivers O_2 in pulses. The older POISK system has been tested over many years. It consists of an oxygen cylinder pressurized to several hundred bar and regulator, rubber hose and mask. The cylinder is made of Kevlar-reinforced metal to save weight, and is 3 or 4 litres in volume.

The metal regulator screws on top and it controls the gas flow, measured in litres per minute (l/min). This can be set from 0 to 4 l/min in ½- or 1-litre steps. The display shows pressure remaining. Many factors affect the flow and pressure display, including temperature changes and mechanical errors, so check regularly.

The rubber hose usually has a small flow indicator built in, useful because often it's impossible to check the flow and pressure on the regulator itself, with the display behind you inside your backpack.

The mask itself is held over your face with an elastic band. Although it protects your face against frostbite, it also limits your view and can fog your goggles. It has a rebreather bag on the side, which re-uses your exhaled CO_2 and some of the moisture you exhale.

The Summit system replaces the big POISK mask with small plastic tubes for your nose, leaving your mouth and vision free. Summit delivers oxygen in pulses, activated by the lower pressure when breathing in. A bottle will thus last much longer, so less weight has to be carried.

The disadvantage is that Summit depends on electronics and batteries which die quickly in the cold. It could still work as constant-flow, but you'd then have to bring extra bottles anyway. Also the plastic tubes may fill with mucus, may freeze and get blocked easily. Most climbers stick with POISK.

Whichever system you use, check that:

- the bottles are from a reputable supplier, preferably direct from the factory. Some organizations re-fill their bottles to save costs, but the oxygen content and quality could be compromised.
- Open the regulator fully before screwing it onto the bottle and close it only when the oxygen is flowing through it. Some regulators have broken because of sudden high pressure when attached 'closed' to a pressurized bottle.

POISK system

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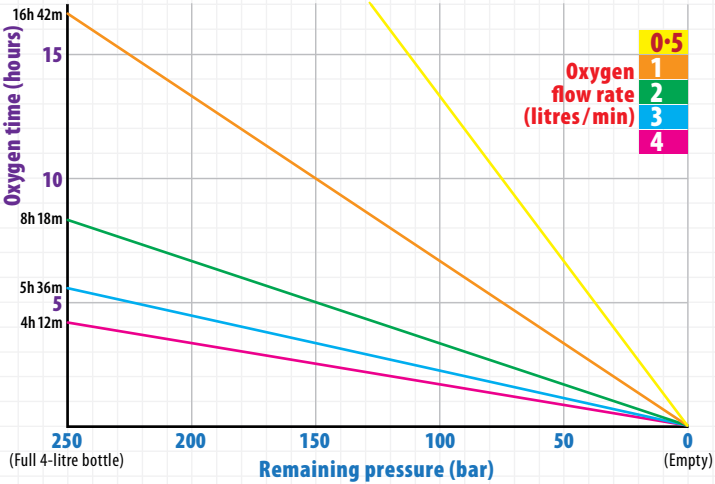
- Long before you need oxygen, test how the regulator and mask work together. Read the pressure, then let the oxygen flow at a fixed rate for several minutes, timed carefully. Check the remaining pressure and calculate the actual flow. Compare it with the flow rate shown on the gauge. You won't get 100% accuracy because temperature changes or defects can cause fluctuations. But knowing if your regulator under- or over-delivers means you can calculate your remaining O_2 time better.
- Ensure that you have enough. Although using O_2 can increase safety, if it runs out, the sudden shock can be deadly, especially if you were using a high flow rate.

Graph of remaining oxygen time (4-litre bottle)



Calculating remaining oxygen time

To find how much oxygen is in a bottle, multiply its volume in litres by its pressure in bar. The normal size is 4 litres, but 3-litre bottles also exist: check carefully and multiply by ¾ for the smaller size.

A 4-litre bottle at 250 bar ('full') effectively holds 1000 litres of O_2 at atmospheric pressure (1 bar). At 200 bar it hold holds 800 litres, and so on. Although bottles may be factory-filled to 300 bar, by the time they are ready to use, leakage and cold reduce this to about 250 bar. The pressure can vary by up to +/-15%, so always check the gauge.

How long the oxygen in your bottle will last depends on
a) how much it holds now (volume x pressure)
b) the flow rate you set, in litres per minute.

For example you'll set a flow of 0.5 l/min while sleeping or resting in high camps, but more, perhaps 2 to 3 l/min, when climbing. For short periods, e.g. the steepest parts of the Hillary or Second Step, you may need maximum flow (4 l/min). At that setting, a full 4-litre bottle would last only 1000/4=250 minutes – just over 4 hours.

Use the graph opposite to read off remaining oxygen time at a given flow rate (coloured lines) for a given pressure (horizontal axis).

To complicate things, temperature affects oxygen pressure. It can also affect the regulator flow rate unexpectedly. The most accurate measurement would be to weigh the bottle, since the mass of the oxygen it contains stays constant. Since weighing isn't feasible, you need to monitor your gauge and manage your supply carefully.

A higher flow rate means you feel better and climb faster. However, you need more bottles, and carrying extra loads increases your oxygen need. Each climber must find the best balance.

As a guideline, most people use at least 4-5 bottles per attempt:

- One bottle covers a night at Camp 2 and a move to High Camp, where you can start a second bottle if need be.
- A second bottle (perhaps partly used) stays in High Camp for emergency and descent.
- Summit day: maximum of three bottles, even if you have a personal sherpa to carry two of them for you. Reckon on up to 18 hours of oxygen time, either as 6 hours each with 3 bottles or 9 hours each with 2 bottles. Allowing for briefly increased flow for strenuous sections, that means a flow rate of either 2 l/min or 1.5 l/min depending on whether you have 3 bottles or 2. (This assumes that all bottles are 4 litres and filled to 250 bar. Use only full bottles on summit day.)

To save energy, many climbers start using O_2 from about 7000m, so they need at least one further bottle. Always mark your bottles clearly, with waterproof markers and stickers. This may prevent 'accidental' usage by other climbers, a growing problem on Everest.

If you feel really bad on a summit attempt, it's better to give up early. That way you can rest, recover and may be able to try again, whereas if you've used too much precious oxygen, your bid is over.

In summary, the benefits of O_2 are higher climbing speed and warmer body temperature. Its drawbacks are its weight and your dependency.

Climbers just above the Third Step, Tibet