Gas Mixing

SECTION THREE

Why mix it?

On large worksites, most gas is pre-mixed. If you want 4%, you just order it and next week it turns up on the supply boat.

Sometimes, though, you still have to mix it. Maybe there's been a sudden change of plan, maybe you have a lot of 4% left over and now you need 6%. Anything can happen during a diving operation.

All you have to do (in theory) is take two gases, call them Mix 1 and Mix 2, and mix them together to give the Final Mix.

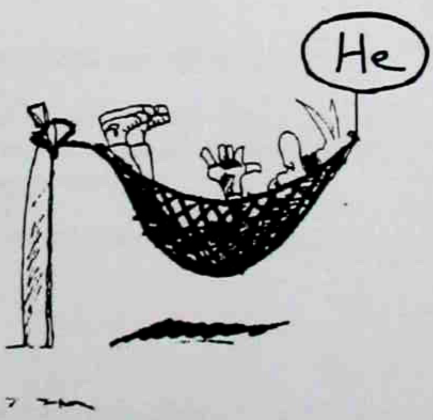
The percentage of the Final Mix, by the way, must lie between the percentages of Mix 1 and Mix 2. It sounds obvious, but some divers have had a heartbreaking time trying to make 7% out of 3% and 4%.

In the ideal world, you'd pump the right amount of Mix 1 into an empty quad, pump the right amount of Mix 2 on top, wait until tomorrow and you've got the Final Mix.

$$\text{Pressure of Mix 1} = \text{Final Pressure} \times \frac{(\%\ \text{Final Mix} - \%\ \text{Mix 2})}{(\%\ \text{Mix 1} - \%\ \text{Mix 2})}$$

Old diver's tales

Mix 1 is the richest mix (most oxygen). Wise old divers will shake their heads if you pump the richest first. They'll tell you that it won't mix as well.



That may be true, but it's safer. If you're dealing with anything over 21%, there's a fire risk associated with high pressure pumping. Whenever possible, get it in first when the pressure is low.

Wise old divers will also tell you that the gases will separate into layers of helium and oxygen if you leave them - rather like oil and water.

This is real claptrap. Once gas is mixed, it stays mixed, unless one of them starts to liquefy. It's got to be really cold for that to happen - helium liquefies at about -269oC

Example 14

You want to make 200 bar of 8%, using 4% and 23%. What pressure of each gas do you need?

$$\text{Pressure of Mix 1} = \frac{\text{Final Pressure} \times (\text{\% Final Mix} - \text{\% Mix 2})}{(\text{\% Mix 1} - \text{\% Mix 2})}$$

Final Pressure = 200 bar
% Final Mix = 8
% Mix 1 = 23 (richest)
% Mix 2 = 4

$$\text{Pressure of Mix 1} = \frac{200 \times (8 - 4)}{(23 - 4)} \text{ bar}$$

$$= \frac{200 \times 4 \text{ bar}}{19}$$

$$= 42.1 \text{ bar}$$

Round it to 42 bar.

You need 42 bar of 23% and 158 bar of 4%

You'd start off by pumping ~~53~~ 42 bar of 23% into your empty quad, then pumping 4% on top until the pressure came up to 200 bar. In practice, you'd go a little over 200 bar to allow for cooling.

That was easy, wasn't it. And you only had to pump the 23% up to ~~53~~ 42 bar - no fire risk.

Turning it round

Usually of course, you don't have an empty quad. You have 70 bar of 10% and you need to turn it into 6%, by using some of the 2%.

In this case, you need to turn the formula round.

$$\textbf{Final Pressure} = \frac{\textbf{Pressure of Mix 1} \times (\textbf{\% Mix 1} - \textbf{\% Mix 2})}{(\textbf{\% Final Mix} - \textbf{\% Mix 2})}$$

You can't assume that Mix 1 is the richest mix. Mix 1 is whatever you have in the quad. If it's actually the weakest mix, you'll find negative numbers appearing. Don't panic! If you get two of them, they cancel out. If they don't cancel, you're making a mistake.

Example 15

You have 70 bar of 4% and you want to turn it into 6%, by pumping in 10%. What will the final pressure of the mixture be?

$$\textit{Final Pressure} = \frac{\textit{Pressure of Mix 1} \times (\textit{\% Mix 1} - \textit{\% Mix 2})}{(\textit{\% Final Mix} - \textit{\% Mix 2})}$$

$$\begin{aligned}
\textit{Pressure of Mix 1} &= 70 \\
\textit{\% Mix 1} &= 4 \\
\textit{\% Mix 2} &= 10 \\
\textit{\% Final Mix} &= 6
\end{aligned}$$

$$\textit{Final pressure} = \frac{70 \times (4 - 10)}{(6 - 10)} \text{ bar}$$

$$= 70 \times \frac{-6}{-4} \text{ bar}$$

$$= 70 \times \frac{6}{4} \text{ bar} \quad \textit{(the minus signs cancel out)}$$

$$= 105 \text{ bar}$$

The final pressure is 105 bar

All you have to do, is pump in 10% until the pressure reaches 105 bar.

Pure gases

If you ever find yourself using pure helium, remember that the percentage is 0.

If you ever find yourself using pure oxygen, think of another way to do it. It's dangerous stuff, things burn very easily. The higher the pressure, the easier they burn.

Just opening a valve too fast can cause an explosion. If pure oxygen flows quickly into pipework or a cylinder at a lower pressure, the heat of compression can raise the temperature by several hundred degrees.

Any plastic materials can breakdown or melt and may ignite. Any traces of oil or grease will ignite spontaneously. Once ignition has occured, the steel cylinder itself will start to burn, fed by the high pressure oxygen flow.

If there really is no alternative, the percentage for the calculation is 100. Make sure that the oxygen goes in first, at low pressure and be very careful. An oxygen explosion is not something you want to experience. It's often fatal.

Three way mixing

Finally, by popular request, here's a gas mixing equation of limited use. If you ever want to use left over gases to make a mix using 3 mixes:

Final pressure =

$$\frac{\text{Pressure Mix 1(\%Mix 1-\%Mix 3)+Pressure Mix 2(\%Mix 2-\%Mix 3)}}{\text{(\%Final Mix - \% Mix 3)}}$$

Example 16

You have 50 bar of 2%, 40 bar of 4% and you want to mix them together and add 23% to make the mix up to 8%. What will the final pressure be?

Final pressure =

$$\frac{\text{Pressure Mix 1(\% Mix 1 - \% Mix 3) + Pressure Mix 2(\% Mix 2 - \% Mix 3)}}{\text{(\%Final Mix - \% Mix 3)}}$$

Pressure of Mix 1 = 50 bar
Pressure of Mix 2 = 40 bar
% Mix 1 = 2
% Mix 2 = 4
% Mix 3 = 23

$$\text{Final pressure} = \frac{50(2 - 23) + 40(4 - 23)}{(8 - 23)} \text{ bar}$$

$$= \frac{50(-21) + 40(-19)}{(-15)} \text{ bar}$$

$$= \frac{-1050 - 760}{-15} \text{ bar}$$

$$= \frac{-1810}{-15} \text{ bar}$$

$$= \frac{1810}{15} \text{ bar} \quad \text{(the minus signs cancel out)}$$

$$= 120.67 \text{ bar}$$

The final pressure will be 121 bar

You would mix the 2% and 4% together, then pump in 23% until the pressure came up to 121 bar.