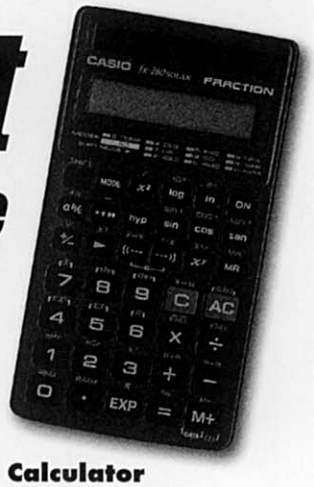
Gas Management

Running the Numbers for a Safer Dive



CURT BOWEN

No, this article has nothing to do with chili dogs or Mylanta. We're talking about planning extended range dives and making sure you have enough breathing gas to get back to the surface. Running out of bottom mix is bad business; it means aborting the dive early and at the very least, stressing out your dive buddy. Even worse, however, is coming up short on deco gas. If your buddy doesn't have enough for both of you, it's a sure-fire way to get bent. The secret to avoiding such perilous situations is to plan, plan, plan. Now get out your calculator, you're gonna' need it.

Many training agencies calculate gas consumption rates by pounds per square inch per minute (psim). This method is fine as long as a diver always uses the same size cylinder, such as a standard aluminum 80. But, when a diver switches to other cylinder sizes, the psim can change drastically since it's a measure of pressure, not volume (see gas volume chart below). This change can mislead the diver into thinking that an ample gas supply is available when in fact, it isn't. In technical diving, due to the variety of cylinder sizes used and their different working pressures, gas consumption rates should be calculated in cubic feet per minute (cfm). This method will provide the exact amount of gas available in each cylinder and allow the diver to calculate the estimated duration of use at depth according to their rate of air consumption.

First, let's define some terms:

Cylinder Rated Cubic Feet: the amount of gas the cylinder is rated to in cubic feet at its working pressure. For example, an OMS 112 at 2640 psi holds 112 cubic feet of gas.

Cylinder Working Pressure: The recommended maximum fill pressure for a cylinder. For example, both OMS and Pressed Steel have a working pressure of 2640 psi with their +10% overfill whereas standard aluminum 80s have a working pressure of 3000 psi. (Note: most steel cylinders are allowed a 10% overfill. Both OMS and Pressed Steel cylinders are rated for 2400 but with the 10% overfill the working pressure rises to 2640 psi.)

Atmospheres Absolute (ata): The total amount of pressure exerted on a diver. A diver at 100 feet is experiencing 4 ata. Use the following formula: ata = (depth / 33) +1.

Surface Consumption Rate (SCR): The rate of gas consumption for a diver during the working part of the dive as measured in cubic feet per minute.

Decompression Consumption Rate (DCR): The rate of gas consumption for a diver during decompression stops as measured in cubic feet per minute.

Fire Up the Calculator

To begin, the diver must calculate the cubic feet of gas in each cylinder using the following formula: (cylinder rating in cubic feet / cylinder working pressure) x psi in cylinder = cubic feet of gas in cylinder.

Example: To find the cubic feet of gas in an OMS steel 85 filled to 2200 psi calculate (85cf / 2640psi) x 2200psi = 70.8cf. We now know that the cylinder contains 85 cubic feet at 2640 psi but at 2200 psi it contains 70.8 cubic feet.

Second, each diver should know their surface gas consumption rate (SCR) in cubic feet per minute. This should be calculated for both bottom and decompression gas. Obviously the bottom gas consumption rate will be much higher than the decompression rate due to the physical activity during the deeper part of the dive. Gas consumption rates can be calculated over several dives and then averaged for a more accurate result. Use the following formula: (cylinder rated cubic feet / cylinder working pressure) x (beginning psi - ending psi) / bottom time or decompression time / ata.

Bottom Gas Example: Gas consumption rate for a diver using double OMS 112s to 200 feet for 25 minutes. The diver started the dive with 2700 psi and ended with 1400 psi. SCR = (112cf / 2640psi) x (2700psi - 1400psi x 2 for doubles) / 25 minutes / 7.06ata = 0.62 cubic feet per minute.

Decompression Gas Example: The diver switches to an OMS 46 cylinder of oxygen for decompression at 20 feet for 18 minutes then rises to 10 feet for an additional 38 minutes (these depths can be averaged to 15 feet for more accurate results). The diver started with 2300 psi and ended with 600 psi. DCR = (46cf / 2640psi) x (2300psi - 600psi) / 56 minutes / 1.45ata = 0.36 cubic feet per minute.

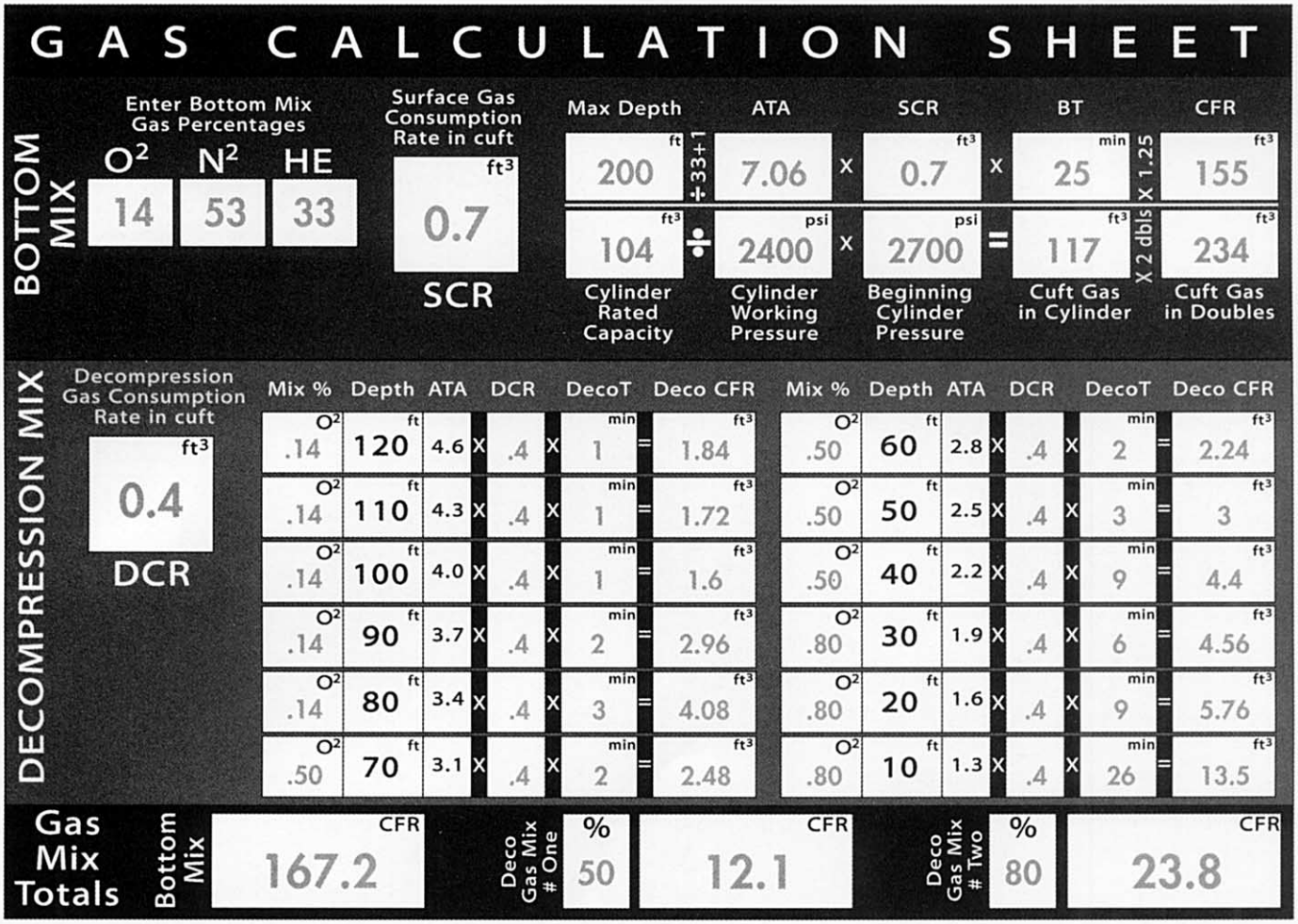
Note: Steel cylinders have a tendency to lose several hundred psi once immersed in cool water. For better results, record the starting psi after the cylinders have cooled.

illustration: Curt Bowen

CYLINDER VOLUMES IN CUBIC FEET

DeepTech	OMS 46	OMS 66	OMS 85	OMS 98	OMS 112	OMS 125	OMS 131	PST 95	PST 104	PST 120
Weight	17.6 lbs	25 lbs	31 lbs	38 lbs	41 lbs	45 lbs	47 lbs	41 lbs	46 lbs	52 lbs
3600 psi	63 cuft	90 cuft	116 cuft	134 cuft	153 cuft	170 cuft	179 cuft	129 cuft	142 cuft	164 cuft
3400 psi	59 cuft	85 cuft	109 cuft	126 cuft	144 cuft	161 cuft	169 cuft	122 cuft	134 cuft	155 cuft
3200 psi	56 cuft	80 cuft	103 cuft	118 cuft	136 cuft	151 cuft	159 cuft	115 cuft	126 cuft	145 cuft
3000 psi	52 cuft	75 cuft	96 cuft	111 cuft	127 cuft	142 cuft	149 cuft	108 cuft	118 cuft	136 cuft
2800 psi	49 cuft	70 cuft	90 cuft	104 cuft	119 cuft	133 cuft	139 cuft	101 cuft	110 cuft	127 cuft
2640 psi	46 cuft	66 cuft	85 cuft	98 cuft	112 cuft	125 cuft	131 cuft	95 cuft	104 cuft	120 cuft
2400 psi	42 cuft	60 cuft	77 cuft	89 cuft	102 cuft	113 cuft	119 cuft	86 cuft	94 cuft	109 cuft
2200 psi	39 cuft	56 cuft	72 cuft	83 cuft	95 cuft	106 cuft	112 cuft	81 cuft	89 cuft	102 cuft
2000 psi	35 cuft	50 cuft	64 cuft	74 cuft	85 cuft	95 cuft	99 cuft	72 cuft	79 cuft	91 cuft
BUOYANCY	N	-1.7	N	N	-1	N	+0.75	-1.75	-1	N

OMS - Ocean Management Systems 914-457-1617 Weight empty with valve
PST - Pressed Steel / US Divers 714-540-8010 Weight empty without valve



Use this chart to calculate gas requirements for both bottom mix and decompression gas. An example is provided in light print.

illustration: Curt Bowen

Calculating Gas Volumes

Now that you know how much gas is in each cylinder and what your consumption rates are, you can calculate the volume of gas required for both your bottom mix and decompression gas. This will tell you the minimum amount of gas needed in each cylinder to safely complete the dive. Use the following formula: SCR x minutes at depth x ata = cubic feet of gas required.

Example: A diver plans a dive to 200 feet for 25 minutes, he has calculated his surface consumption rate at 0.75 cubic feet per minute. 0.75 x 25 minutes x 7.06ata = 132 cubic feet bottom gas required. This number can then be multiplied by 1.25 to add an additional 25% safety factor.

For the decompression section of the dive, each stop will need to be calculated using the same formula as above but with the lower DCR rate and the time at each depth. Once you know how much gas you need, compare that with how much gas you are carrying and plan the dive accordingly.

Gas Rules

After you calculate the amount of gas required and amount of gas you can carry, it is wise to follow an applicable guideline for gas management. For cave divers, the Rule of Thirds has been set for many years. Use one-third of your gas supply going into the cave and save two-thirds for the return trip. This allows a safety factor in case of an equipment failure leading to a major gas loss or a buffer supply in case the diver becomes lost in the cave.

No such standards have been set for wreck diving but many wreckers go by the One-Half Rule, one-half of the gas supply is used on the wreck, one-half is left for emergency use. If penetration into the wreck is planned or if the wreck is extremely large, the Rule of Thirds should be implemented.

For decompression gas, the amount needed depends on the deco schedule planned. However, the diver should calculate the amount of gas needed at every depth using the longest possible decompression table planned with a safety margin added.

Safety Gas

When planning a decompression dive, it's a good idea to have additional bottom and decompression cylinders available. These cylinders should be staged in the appropriate places in the cave, wreck or on the decompression line, and of course, contain the same mixes as the diver is already carrying. When possible, safety divers carrying extra gas cylinders can be strategically placed in the water column to provide extra gas or personal assistance to the dive team. Safety divers can also relay messages to the surface on the condition and position of the divers.

Regulator Standardization

Finally, when diving with multiple cylinders, their is an increased chance of regulator failure. If a regulator fails, the contents of the cylinder may be lost or at least become inaccessible. To avoid the latter, all first stage regulators should be identical, either DIN or standard yoke styles. This will provide first stage redundancy and allow the diver to switch regulators from one tank to the next while underwater. DT

Curt Bowen is associate publisher of DeepTech. He can perform gas calculations in his head faster than the rest of us could using a calculator, slide rule and abacus.