

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: $(cylinder\ rating\ in\ cubic\ feet / cylinder\ working\ pressure) \times psi\ in\ cylinder = cubic\ feet\ of\ gas\ in\ cylinder$.

Example: To find the cubic feet of gas in an OMS steel 85 filled to 2200 psi calculate $(85cf / 2640psi) \times 2200psi = 70.8cf$. 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: $(cylinder\ rated\ cubic\ feet / cylinder\ working\ pressure) \times (beginning\ psi - ending\ psi) / bottom\ time\ or\ decompression\ time / ata$.

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. $SCR = (112cf / 2640psi) \times (2700psi - 1400psi) \times 2\ for\ doubles / 25\ minutes / 7.06ata = 0.62\ cubic\ feet\ per\ minute$.

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. $DCR = (46cf / 2640psi) \times (2300psi - 600psi) / 56\ minutes / 1.45ata = 0.36\ cubic\ feet\ per\ minute$.

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.

CYLINDER VOLUMES IN CUBIC FEET

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

G A S C A L C U L A T I O N S H E E T

BOTTOM MIX	Enter Bottom Mix Gas Percentages			Surface Gas Consumption Rate in cuft		Max Depth		ATA		SCR		BT		CFR	
	O ²	N ²	HE	ft ³		ft		psi		ft ³		min		ft ³	
	14	53	33	0.7		200		7.06		0.7		25		155	
				SCR											
				ft ³		ft ³		psi		psi		ft ³		ft ³	
				104		2400		2700		117		234			
				Cylinder Rated Capacity		Cylinder Working Pressure		Beginning Cylinder Pressure		Cuft Gas in Cylinder		Cuft Gas in Doubles			

DECOMPRESSION MIX	Decompression Gas Consumption Rate in cuft		ft ³		DCR													
	0.4																	
	DCR																	
	Mix %	Depth	ATA	DCR	DecoT	Deco CFR	Mix %	Depth	ATA	DCR	DecoT	Deco CFR	Mix %	Depth	ATA	DCR	DecoT	Deco CFR
	.14	120	4.6	.4	1	1.84	.50	60	2.8	.4	2	2.24	.50	50	2.5	.4	3	3
	.14	110	4.3	.4	1	1.72	.50	40	2.2	.4	9	4.4	.50	30	1.9	.4	6	4.56
	.14	100	4.0	.4	1	1.6	.80	20	1.6	.4	9	5.76	.80	10	1.3	.4	26	13.5

Gas Mix Totals	Bottom Mix	CFR	Deco Gas Mix # One	%	CFR	Deco Gas Mix # Two	%	CFR
	167.2	50	12.1	80	23.8			

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

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. $0.75 \times 25 \text{ minutes} \times 7.06 \text{ ata} = 132 \text{ cubic feet bottom gas required}$. 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, there 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.