Understanding SCUBA Compressors and Filtration
by Ted Green

Since there are a number of people on this list who have their own compressor for their own consumption or run a small operation or club, I thought it might be useful to offer some information on compressors and filtration. As mentioned in the previous thread I have been playing with this stuff for 25+ years while working in and owning a dive store. The information is deemed very reliable; however pressures, components and designs may very from manufacturer to manufacturer and from model to model. Please keep this in mind as your compressor may be slightly different. For the purpose of this discussion I am referring to oil lubricated 6 to 9 cfm (cubic feet per minute) at 5,000 psi pumps (compressors) commonly made by Poseidon, Mako, Bauer, etc. While Rix pumps are not oil lubricated much of the information will apply to them as well. Most of these pumps are 3 stages of compression, if electric 5 to 7 horsepower single phase, air cooled, and continuous duty rated for 8 hours. What does all that mean? Lets look at it a piece at a time. In this first post I will explain how your 3 stage pump works.

The Compressor

In very basic terms, here is how your $8,000 toy works. The fist stage (largest piston maybe 5" in diameter) pulls in air through an intake filter and compresses it to around 100 to 140 psi as it pushes it out. A byproduct of compressing air is heat. If we don't get rid of the heat before the air goes into the second stage, our pump won't live very long! Each time we compress the air (after each piston or "stage") we have an inter cooler or coil to dissipate the heat. The inter cooler is a tube wound in a coil that goes between the 1st stage and the second stage. The inter cooler is cooled by the flywheel; more on that later. Air is compressed in the first staged to around 140 psi, cooled in the inter cooler coil and then goes into the second stage (middle sizes piston maybe 2" in diameter) where the air is compressed again to around 800 to 1,000 psi. As you have probably guessed, there is another inter cooler after the second stage. Before the air goes into the third stage we have a moisture separator which separates moisture from the air. Here is how the separator works: The air at 1,000 psi has been compressed in a ratio of about 68:1. Think of 68 boxes of air 1' by 1' by 1' compressed in to 1 box. While the air compresses, the water vapor (humidity) in the air does not. There is

68 times as much water vapor in the box or about 1 ounce of water (on a humid day). When the air leaves the second stage the water is suspended in the air because of the heat. As the air goes through the inter cooler the temperature drops and fog or dew forms in the air. In the moisture separator the dew coalesces in the bottom and the air goes out the top. The moisture separator is a vertical pipe where the air enters in the middle the water collects and drains from the bottom and the air comes out from near the top. Air is compressed in the first stage to around 140 psi, cooled in the inter cooler coil, compressed in the second stage to around 1,000 psi, cooled in the inter cooler coil, dehumidified in the moisture separator and then compressed in the third stage (smallest piston less than 1" in diameter) to as much as 5,000 psi. From the third stage we go through another inter cooler coil and another moisture separator. The compression ratio is now as much as 340:1 resulting in more dew forming when the air is cooled. Most small compressors have 2 moisture separators after the third stage. The last moisture separator usually has a small filter (mine is 1" in diameter by 5" long) in the top of the separator. After the separator there may be more filters or the filters may be mounted separately from the pump. Generally the last think on the pump before air distribution is the back pressure valve. The back pressure valve provides a head pressure against which the pump must push. This valve is normally set between 2,700 and 3,300 psi. Back pressure serves 2 purposes. First it forces the compressor to run balanced. You ask, " what do you mean balanced?" Ok, visualize this. Each piston is connected to the crank shaft (an irregular shaped shaft that pushes the pistons up and down as it rotates) Each piston has a counter weight built into the crank shaft to offset the weight, force and drag of the piston. So for each piston we have an offsetting counter weight. Now in the compressor we have 3 pistons equal distance from each other in the rotation. When piston #1 is all the way up (12 o'clock), piston #2 will be 2/3 down (4 o'clock) and piston #3 will be 1/3 up (8 o'clock). So when the pump is running at 3,000 psi each piston's force is offset 120 degrees from the next piston and all the pistons' forces are equal to each other. When the pump is running at around 1,000 rpm (revolutions per minute) and all the piston forces are equal, we say that the compressor is balanced. But it is not always so. When you start the pump there is no force or resistance on any of the pistons. The first stage develops all of it's pressure first. The pump becomes unbalanced because there is resistance at one point on each revolution of the pump.

So the pump starts to vibrate because of this imbalance. Next the second stage develops all of it's pressure. The vibration becomes worse because there are 2 points of resistance 120 degrees apart and then an absence of resistance. Finally the third stage comes on line. The three pistons have similar forces being required; the compressor becomes balanced and much of the vibration goes away. The vibration when the compressor is unbalanced, leads to premature wear and failure of the bearings and other moving parts. The back pressure valve maintains pressure on the compressor regardless of what pressure is in the scuba tank being filled. This forces the pressures on the pistons to be similar allowing the compressor to be near balanced most of the time. The third stage starts working when the compressor reaches about 800 psi. Somewhere between 2,500 and 3,300 psi the pump becomes the most balanced. As you go above 3300 psi the pump starts to become unbalanced the other way. Pumps run above 4,000 psi all the time live short unhappy lives! The back pressure valve also affects how the filtration works; more on that when I get to filtration. That's it for the basics of how the compressor works. In the next segment I will finish up the basic description explanation and give you pearls of wisdom on care and feeding. The last segment will be on filtration.

The compressor system plus care and feeding

In this segment I will finish up the basic description explanation and give you pearls of wisdom on care and feeding. When last we talked our 3 stage pump was happily turning at 1,000 rpm producing 7 ½ cfm at 3,000 psi (or at least that's what mine does). In my description I described it as oil lubricated. The oil does 2 things. First it lubricates and reduces wear on the pistons, piston rings, bearings, seals and other moving parts inside the pump.

Side note: On many of these compressors the third stage piston is actually a rod sliding up and down in a sleeve. The rod is pushed up by a piston beneath it and pushed down by air coming in from the second stage. This is called a floating piston because it is not physically connected to the crank shaft. There are no piston rings on this piston. The rod and sleeve have an incredible close fit. What actually makes the seal between the rod and the sleeve is the oil. Said another way, what keeps 5,000 psi of air pressure from going between a sleeve and a rod that is going up and down 1,000 times per minute, is a really close fit and some very special oil!

Secondly, the oil helps to remove heat from the hottest parts of the pump, the pistons and cylinder walls. The oil is the life blood of your pump. How often should you change it? Unlike in a car engine, it doesn't turn black with use. If the oil has turned black in your pump, you have serious problems. The black in car engine oil is carbon from combustion. It's bad when you say carbon, combustion, and Pumping Nitrox through your compressor, all in the same sentence. The oil in your compressor does brake down over run time, even though it doesn't significantly change color. We say it looses its lubricity (yes that's actually a word) or it's ability to lubricate. When this happens the parts start to wear more! The third stage piston and sleeve comes to mind first, see above. My original compressor manual said to change the oil every 200 hours. The dealer who sold me the pump said 400 hours, but then he wanted to sell me parts in the future. I change my oil every 50 hours which is probably excessive. The dealer said I could expect to replace the third stage piston and sleeve after 1,000 hours. One of my two pumps still has the original third stage after 20 years and 4,000+ hours. Go figure! An oil change with synthetic oil costs me about $8. For those of you who would rather not change the oil that often remember: You can pick when and how often to change your oil, not when to repair the pump!

In the description I talked about a 5,000 psi pressure rating. This is an intermittent rating and not what the pump is designed to do all the time. At over 3,500 psi the pump is running somewhat unbalanced the wrong way. The higher the pressure, the more unbalanced it gets. A lot of heat is being generating in the third stage because of the high compression ratio of the third stage (5:1) and the high density of the gas being compressed. If you are pumping air with a proper storage bank system (see previous thread), you can expect to have 15 to 30% of your pump time above 3,000 psi. Percentages will vary depending on your banks, the fill pressure of the tanks you are filling, and the average amount of air left in the tank from the previous use. When you start mixing Trimix, the percentages will go up as the lower pressures in the tank are achieved through transfilling helium etc. While your percentage will go up, the total hours will diminish for the same number of tanks.

Important note: If your pump is always running at 3,500 psi and above, start setting money aside now for your next pump or overhaul!

Let's talk about electric motors for a minute. Some of you may use gasoline or diesel motors to drive your pumps and that's fine. Most pumps though are driven by electric motors and even if I was going to make a portable system (which I wouldn't) it would still be electric. The modern design HP compressor (since early 1980's) generates 1 ½ cfm per horsepower of electric motor. This is a rough ratio. If your pump cfm to motor horsepower has a ratio of 1:1, well……can you say dinosaur.

Most of the pumps (6 to 9 cfm) we are using will have a single phase 220 or 240 volt electric motor. What does single phase 220 or 240 volt mean? This refers to the power feeding the motor. Don't worry about the difference between 220 and to 240 volts. In a normal house in the USA the wall outlet has 2 slots and 1 hole for each plug. One slot is hot with 110 volts ac power. The other slot is neutral no power. The round hole is ground. This is a 110 ac receptacle. If you have an electric clothes dryer, the receptacle is a little different. You still have 2 slots and a hole. However both of these slots have 110 volts ac. The round hole is still a ground. The two legs of power as they are referred to are not of the same phase (don't worry about what it means, just understand that there not the same). This receptacle is referred to single phase 220 volt ac. This is the electric power that most of our compressors use. When the pump size gets much larger than 8cfm the electric motor required gets larger than 5 horsepower. Almost all electric motors over 5 horsepower require 3 phase 220 volts. Instead of 2 hot legs there are now 3. This is commercial power not found in residential areas. Are there exceptions to this? Yes, but there rare. Most compressors over 8 or 9 cfm require 3 phases electric found in commercial locations. As a result most of our homebrew electric pumps are 8 cfm or below. So here is what you need to know about these motor. If you have to buy one, get a commercial duty single phase 220 volt ball bearing (not sleeve bearing) unit. Keep it clean on the outside; run it in an environment compatible with your pump and it will generally out live your compressor with zero maintenance. Many of these electric pumps can be run from an electric clothes dryer receptacle. On several trips that I have been on a house was rented to stay in. The portable compressor was plugged into a dryer receptacle with a special extension cord (not found premade at the Home Depot). Not all dryer receptacles will have enough amperage for these motors, check in advance. I prefer to have enough tanks and a trailer to avoid the need for the portable compressor. But if I had to have one, it would be electric with a long extension cord. 5 minutes after I find the circuit breaker panel, we'll be pumping air. It's not that I hate gasoline or diesel driven compressors..................yes it is!

What does air cooled mean? The pulley on the compressor is actually called a fly wheel. The fly wheel serves several purposes. First it has 1 or more grooves (like a pulley) for drive belts to turn the compressor crank shaft. Second it has a significant centrifugal mass designed to smooth out the compression peak forces (when the piston reaches the top of the stroke) on each stage. Finally the spokes or blades of the fly wheel act as a fan to push air across the inter cooler coils, piston cylinders, moisture separators, and the compressor block. It is the air flow that keeps the operating temperatures of the different parts of the pump tolerable. The reason that I mention this is that when the compressor becomes dirty and the inter cooler coils become fouled, the operating temperatures of the compressor will rise. This will result in oil break down, varnishing of the pistons, and poor moisture separation which is bad for your filters. The easiest way I have found to clean the compressor is to plug the inlet, take the pump outside, and spay it down with several cans of automotive carburetor cleaner. Let it sit outside for the rest of the day until all the smell is gone. On the subject of air cooled, my compressors are on wheels and are rolled outside to run. There is a receptacle on the wall that they plug into and a hose with a high pressure quick disconnect to hook them to my filter system inside. The air outside is often cooler and my air conditioner doesn't have to fight the compressor. I try to only pump above 3,300 psi early in the morning, late at night, or when the outside temperature is below 65 degrees. Did I mention that I have had the same two compressors for the last 20 years?

Understanding filtration part 1

In this segment I'm going to start to explain how filtration works.

First we need to understand some basic principles of air compression, gas movement, and gas analysis. Lets start with gas density. If I have a filter that is 4 feet tall and holds 1 cuft of air at ambient pressure (14.7 psi) and I have a 1 cfm (cubic foot per minute) air compressor, it will take 1 minute (theoretically) to push all the air in the filter through. Everybody still with me? Ok, now I have a back pressure valve at the discharge end of the filter. The back pressure valve makes the pressure in the filter stay at whatever I set it for. Only air in excess of that can get by. If I set the back pressure valve to 14.7 psi , the pressure in the filter will double (14.7 psi + the ambient pressure [14.7 psi] =29.4 psi absolute) and so will the cuft of gas. Even though the space in the filter hasn't changed the cuft of gas has doubled because the pressure has doubled. I don't see any blank stares, so I guess you all are still with me. Now if we are still using that same 1 cfm compressor it will take 2 minutes (theoretically) to push all the air in the filter through. Ok, now if I set the back pressure valve to 2,925.3 psi the pressure in the filter will be 200 times the ambient pressure and there will be 200 cuft of gas in the filter. With our 1 cfm compressor it will take 3 hours and 20 minutes (theoretically) to push all the air in the filter through. You ask," ok math man, what's your point?" Filtration works by air coming in contact with filter media and the media absorbing or trapping impurities. How well the media works is partly dependent on how long the air is in contact with the media. In the first example the air was in contact with the media for 1 minute. In the last example the air was in contact with the media for 3 hours and 20 minutes. Obviously, the last example was filtered better than the first. We refer to the time that the air is in contact with the filter media as dwell time. The longer the dwell time, the better the filtration (to a point). In this example, the only thing we did to improve the filtration of the air was to slow the flow down (increase the dwell time) by increasing the pressure in the filter with the back pressure valve. I'll talk more about the back pressure valve later. Ok, we now understand air compression and gas movement as it refers to filters. We understand that filter media absorbs impurities that it comes in contact with and the longer the dwell time (to a point) the more impurities will be absorbed. Now let's talk about gas analysis and how contaminants kill you. Well that quieted the room down. Gas analysis is done at ambient pressure. So most contaminants appear to be in very small amounts. Let me give you an example using water. In my filter Q media absorbs water moisture down to 40%. If I run the air through the filter at ambient pressure, the air exiting the filter will have 40% moisture by percentage. If I double the air pressure the air exiting the filter will still have 40% moisture by percentage but only

20% by cuft. Because water is not compressible, more moisture is absorbed to maintain the same percentage leaving the filter. When the pressure after the filter is reduced back to ambient there will be twice as much volume of air for the same amount of moisture. Thus at ambient pressure the air will now have 20% moisture by volume, cuft and percentage. If we run air though the same filter at 2,925.3 psi, the percentage in the filter is still 40% but when the air expands back at ambient pressure the percentage of moisture will be down to .2 % (theoretically). This is how we get .2% moisture content in our air analysis. Does this work for all contaminants? No, only non compressible ones like oil and water. This is the theory, actual numbers very a bit. Now to the part that can kill you. Contaminant levels that you can tolerate at the surface may kill you at depth. For this example let's use oxygen (O2). Let's assume that after the air goes through the filter the level of O2 is 21% by percentage and volume regardless of what pressure is in the filter. Because it's a compressible gas the percentage and volume of O2 will remain the same (21%) when the air is returned to ambient pressure. We know that 21% O2 is safe to breath at ambient pressure; the partial pressure of the O2 (PO2) is .21 ata. Suppose we decided to use this air at 297 fsw (feet sea water)? While the percentage of O2 in the air is still 21%, the PO2 is now 2.1 ata. Most people would consider this toxic and life threatening. Now I realize you all know this. I did this to make a point. It's not the percentage of a gas that will kill you but the partial pressure of the gas. Still don't get my point do you? Ok, what are the max exposures for PCO (partial pressure of carbon monoxide) and PCO2 (partial pressure of carbon dioxide)? Well look at that; the lights just came on! If an air analysis showed an acceptable percentage for each of these odorless, colorless, and tasteless gasses in your air mixture, the air might be fine at the surface, but toxic at extreme depth. Deep air divers beware!

Understanding filtration part 2

In this segment I'm going to continue to explain how filtration works. In the last segment we left off with Skippy the deep air diver wondering what the max exposure was for PCO (partial pressure of carbon monoxide). Good news Skippy, it's probably not CO that's going to kill you. In this segment I'm going to address the contaminants that were trying to remove and give you some tips on doing it better.

First on the list is water.

On an analysis for Scuba air (grade E) and OCA (Oxygen Compatible Air) water is expressed as a dew point and should be -50 degrees Fahrenheit or below or 67 ppm (parts per million). For those not familiar with the term dew point, this is the temperature at which moisture in the air condenses to water droplets. If you can visualize 67 parts per million of anything, your doing better than me. In the last segment, I explained that water was not compressible and there are filter media that will reduce the percentage in the air. We will talk about which media to use later. For now the important thing to understand is that we must remove as much moisture as possible before it gets to the filters.

The first step is to force the air through the last moisture separator at as high a pressure as is practical. The higher the pressure, the more moisture will separate out in the separator for a given temperature. How high should we go? When we run air through the separator at 58.8 psi (5:1 compression), the air will have near 100% humidity since some moisture will have fallen out. At ambient pressure this air will have 20% humidity. In a house this would be considered dry. If we crank the back pressure valve up to 279.3 psi (20:1 compression), after the separator we will still have 100% humidity, but the ambient pressure humidity has dropped to 5%. You're off the scale as far as houses are concerned. If we crank the back pressure valve up to 1,455.3 psi (100:1 compression), the ambient pressure humidity has dropped to 1%. The Sahara desert would be envious. At a back pressure of 2,925.3 psi (200:1 compression), the ambient pressure humidity has dropped to 1/2%. Nothing in nature is this dry. At a back pressure of 4,395.3 psi (300:1 compression), the ambient pressure humidity has dropped to 1/3%. While 1/3% humidity is impressive, it's not worth running your compressor at 4,395 psi all the time to achieve. In my book ½% of anything is nothing. So my back pressure valve is set at 3,000 psi and has been for the last 20 years (8,000+ compressor hours). If you want to set you valve at 1,455.3 psi, go ahead, but your filter will have more moisture to contend with and your compressor runs more than 60% of the time above this pressure anyway.

The second step is to reduce the dew point in the separator. A lower dew point means more moisture condensing and falling out in the separator. The best possible scenario would be to submerge the third stage inter cooler coil in a bucket of ice water. This unfortunately isn't practical. So, keep your compressor clean. Run it outside in open air. Pump high pressures if you can, when the temperature is coolest, early morning and late evening. Fill your banks completely on cool days. Enough about water.

Let's talk about oil.

Scuba air (grade E) requires 5 or less milligrams per cubic meter of oil and particles. OCA (Oxygen Compatible Air) requires .1 or less milligrams per cubic meter of oil and particles. I can't come up with a good comparison for how small an amount this is. So we will say that it is slightly more than nothing. The good news is that almost everything I said about water removal applies to oil. Add to that, change your oil regularly and use a top quality synthetic. If you use top quality filter media and follow my other tips, you to should be able to achieve less than 1 milligrams per cubic meter of oil and particles with standard filters. More about filter media later.

Time to deal with CO (Carbon Monoxide).

CO is an odorless colorless gas most often produced by gasoline and diesel engines. It is toxic and fatal in extremely small amounts. Scuba air (grade E) allows 10 ppm. OCA allows 2 ppm. This is some bad chit hombre. The good news is, it's easy to get rid of. There is a manganese dioxide based catalysts called Monoxycon (another name brand is Hopcalite 300) that oxidizes CO (carbon monoxide) into CO_2 (carbon dioxide). I flunked chemistry, so don't ask me how it works. It is advertised to handle concentrations up to 300 ppm. I use it in my system and achieve less than 1 ppm on air analysis. Note: you must have drying agent before it and have a dew point of –50 degrees as moisture neutralizes the catalysts. After the catalysts you should have CO_2 absorbent. More on this in a minute. Monoxycon ads $19 to the cost of a prepackaged 36" filter cartridge. I can not understand why anyone would not spend the extra money to eliminate the CO!

Reducing CO_2 (Carbon Dioxide)

The good news is it takes a lot more CO_2 to kill you. The bad news is CO_2 will kill you! Scuba air (grade E) and OCA both allow 1,000 ppm of CO_2. CO_2 is absorbed to some extent by Activated Carbon and Molecular Sieve 13X. In my system I normally have CO_2 values below 200 ppm.

T.H.C. (Total HydroCarbons) (Methane)

This is the stuff you don't want to partial pressure blend with oxygen. Scuba air (grade E) and OCA both allow 25 ppm of T.H.C. Molecular Sieve 13X will absorb most of it. In my system I normally have T.H.C. values below 5 ppm.

That's it for the contaminants and substances we are trying to reduce.

Understanding filtration part 3

In this the third and final segment I'm going to talk about the different filter media, what I use, how my filtration is configured, and hopefully give you some useful tips.

Filtration Media

Desiccants

These are a group of filter media that are designed to absorb water vapor. In addition some will absorb other contaminants such as oil vapor, hydrocarbons, CO_2 (carbon dioxide), and other organics. I'm not sure what there referring to with "other organics", but I'm glad there being filtered out. Certainly don't want anything organic in my body. Some of these desiccants that have been, and are being used include: Activated Alumina, Silica gel, Sorbead, Molecular Sieve 13X, and women's sanitary napkins. I know it sounds hard to believe, but as recently as the late 1970's some dive shops still used women's sanitary napkins as desiccants. Thankfully most dive stores take air filtration more seriously now. I won't waste any time discussing the relative merits of each product and which cost less. From what I have read there is one product, Molecular Sieve 13X (13X) that works significantly better than the rest, and correspondingly costs the most. 13X is described as follows: highest grade desiccant, up to 4 times more powerful than other desiccants – especially at elevated (up to 120 degrees Fahrenheit) temperatures, can absorb up to 23% of it's own weight in water, can produce –102 degree Fahrenheit dew points, and with added capacities for hydrocarbons, carbon dioxide, and other organics. I have used this product for the better part of 20 years with outstanding results. More about this product later.

Manganese Dioxide based Catalysts

I have already mentioned Monoxycon and Hopcalite 300. These catalysts oxidize CO (carbon monoxide) into CO2 (carbon dioxide). While some may question it's merit, in reviewing the last 10 air analysis for my dive store, the CO content was either "none detected" or "less than 1 ppm (part per million)". My store was in a retail business district. I can't believe there wasn't any CO in the air before it went through my compressor! Enough said.

Activated Carbon

By description it absorbs both condensable and vaporous hydrocarbons (lubricants), effective in cornering odors, organics, and halogenated solvents. Well I don't know about you, but I for one am glad to here that if we can't absorb all the organics, at least we can keep them in the corner! Anyway, as you can tell from the description activated carbon is an absorbent targeting most contaminants other than water, CO, and CO2. For something as simple and natural as carbon, it does a tremendous filtering job. Now it's time to put all the components together into a filtration system.

The Filter system

The short description: A filter tower or towers with either cartridge or loose filter media, a back pressure (priority) valve, one or more pressure gauges, and maybe a separator (coalescer). Here is how the system works. As you will remember from the discussion on air compressors, air leaves the third stage of the compressor and goes through the final inter cooler coil. From there it goes through 1 or 2 separators to remove condensed water droplets. I haven't seen a compressor made in the last 20 years that didn't have a moisture separator after the final inter cooler coil. But if yours doesn't, a separator (coalescer) will be the first tower in your filter system. They are usually about 12" tall and 4" in diameter. As on the air compressor they separate the water and oil droplets from the air. There is a drain on the bottom just as on the compressor separators, to periodically drain the condensate out. Having removed as much water and oil as possible through mechanical separation, it's time to filter through bonding and absorption.

Both Monoxycon and activated carbon are neutralized by excessive moisture. In fact activated carbon when damp may dump the contaminants it has previously trapped and also produce small amounts of sulfuric acid. So the first tower if you have multiple towers, or first 60+% of your single tower is for desiccant. The desiccant must reduce the moisture to a dew point of below –50 degrees for the Monoxycon to work. As mentioned before, I am a big fan of 13X for desiccant. From what I have read it works better than all the rest and is still near 100% effective in temperature as high as 120 degrees. All other desiccants lose much of their effectiveness at or below 100 degrees. If your using a single tower or cartridge there will be a filter pad on top of the 13X to separate it from the Monoxycon. The Monoxycon is maybe 10% of the tower or cartridge. As previously mentioned the Monoxycon when kept dry, will convert up to 300 ppm CO into CO2. On top of the Monoxycon is another filter pad separating it from the activated carbon. The activated carbon makes up the balance of the tower or cartridge maybe 30%. After the activated carbon there is a final or series of filter pads to trap particles and filter media dust.

If you are using a multiple tower system the first 1 or 2 towers may be entirely desiccant with a 3 component cartridge after that. Still other multiple tower systems may use 1 desiccant and 2 multiple media cartridges. Shortly I will tell you what's in mine. After the tower(s) some systems have a 10 micron filter for trapping particles that get past the filter pads. Next is a pressure gauge (0 – 10,000 psi), and finally the back pressure (priority) valve. By now you know the back pressure valve is adjustable. The pressure gauge is used to set the valve. Some systems use a pressure gauge in front of the first tower. The idea is to be able to see a pressure differential caused by spent filter media. I think this is wishful thinking (they wish you would buy another pressure gauge). Towers come in 2 or 3 sizes. The tall ones hold 2 to 3 times more media for 10 to 30% more money. Kind of a no brainer if your building a stationary system.

My Filter system

Both of my compressors have 2 separators after the final inter cooler coil. In the last separator on each pump there is a repackable filter cartridge 1" in diameter by 5" long. The European manufacturer felt that you could adequately filter air with this cartridge 70% desiccant 30% activated carbon. Well at least filter repacks are cheap. Anyway, I fill that cartridge with 13X and repack it at least every 10 hours. I feel that 80 to 95% of my moisture and oil is trapped in those first 5". I repack it more frequently when the air is humid or I'm going to run the compressor for 5+ hours straight. I have 4 towers 36' tall by 4" in diameter and 1 filter 12" tall by 6" in diameter. The short tower is filled with loose 13X. The first 2 tall towers have cartridges filled with 13X. The last 2 towers have cartridges with 13x, Monoxycon and activated carbon. After the towers is a pressure gauge and a back pressure valve set at 3,000 psi. At 3,000 psi it takes 45 minutes for air to travel all the way through my filtration system. That's my idea of dwell time! How well does it work? 18 years ago when I only sold air and cartridges didn't have a 6 month or 1 year expiration, I ran those filters for 4 years straight. I did twice a year (I only ran the pumps April through October) air analysis and was still well with in grade E specs. After 4 seasons I figured it was time to change the filters. The last 2 cartridge litmus bands still hadn't changed color. Since I started blending nitrox 13 years ago, I change all the filters every year. If I were building a new system for only 1 to 4 divers and had the same compressor with the small repackable filter, I would have 2 tall towers each with 3 media cartridges. I would change the small filter as I do now. I would remove the cartridge from the first tower every year. Take the cartridge from the second tower, put it in the first, and put a new cartridge in the second tower. But that's just me!

This article is a compilation of posts from a discussion thread on The Deco Stop. The author, Ted Green, has over 25 years in the SCUBA diving industry and operates the charter boat; O.C. Diver.