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Uncle Ricky

10-03-2005 09:33

### Regarding asymmetrical fills

The latest Eagle's Nest mishap involved a doubles fill with the isolator closed. It raised some questions as to what would happen if a mix were attempted with a closed isolator, and that isolator were later opened.

What would the analysis of such a set of doubles look like?

Would the two tanks mix through the now open manifold?

What are the potential problems?

So, I did a little experiment.

I drained a set of (nitrox) doubles and then, with the isolator closed I put 500 psi oxygen in one tank and 500 psi air in the other.

Then I analysed each tank.

Right post - 93.3%

Left post - 21.8%

I then opened the isolator and let it sit for two hours.

with the isolator still open,

Right post analysis was wildly erratic, values ranged from 40% to 70%. I let this go for five minutes and the swings did not steady out at all.

Left post initially swung from 56% to 60% a couple of times, then settled down at 56.8% steady.

Closed isolator

Right post - 93.3%

Left post - 22.0%

Opened isolator...

After 10 hours with isolator open...

Right post - after an initial spike to 62% and dip to 54%, settled at 59.0%

Left post - normal looking analysis at 58.8%

Closed isolator...

Right post - 93.1%

Left post - 22.4%

so...

After 10 hours with an open isolator, no appreciable mixing between the bottles has occurred.

Considering that, I am at a loss to explain why the open-isolator analyses are less erratic than they were at the two hour mark.

Isolator reopened...

After 26½ hours with the isolator open...

Left post - 57.7% after a little bit of erratic movement

Right post - 60.0% after quite a bit of erratic movement

Isolator closed:

Left post - 23.1%

Right post - 93.1%

Reopened isolator and tried to reanalyse - very erratic both posts...

After 44 hours with the isolator open...

At this point in the experiment it was brought to my attention that I may not be using a procedure that would guarantee an accurate analysis of each bottle when I had the isolator closed, because there may be residual gas in the crossbar, so...

Opened valve on right post for a few seconds. This filled the crossbar with the contents of the left tank.

Closed Isolator, analysed left post... 22.7%

Opened Isolator.

Opened valve on left post for a few seconds. This should have filled the crossbar with the contents of the right tank.

Close isolator, analysed right tank... 93.3%

Therefore... with the isolator open for 44 hours there has been zero measurable mixing between the contents of the two tanks!

Now I didn't think there'd be much, but I did think there'd be at least enough to measure after nearly two days.

Interesting...

So, I'm ready to draw the following conclusions

If you were to fill doubles with different gasses:

- (1) It would take weeks (if not years) for them to thoroughly mix through the manifold
- (2) The situation would probably be apparent during analysis by the erratic nature of the analysis, but it is possible to get a normal looking analysis.
- (3) Whether there would be adequate mixing during breathing such a set of bottles to avoid dangerously high or low O2 levels even with the isolator open is still uncertain.
- (4) If you did dive such a set thinking the gasses were mixed and you had to isolate you could be in deeeeeeep kimchee.

Rick

Tegg

10-03-2005 09:39

**Re: Regarding assymetrical fills**

Thanks for this info... Very intresting find indeed.

Should someone else also conduct the same thing to "verify" this?

Just a thought.

Intresting none the less...

henryville

10-03-2005 09:41

**Re: Regarding assymetrical fills**

Wow, there's nothing like empirical data. With a few years of Physical Chemistry lurking in my deep past, I thought the mixing would be slow, but nonetheless measurable over the time frame you studied.

Fascinating and verrrry instructive. Thanks for tinkering and sharing.

jadairiii

10-03-2005 10:08

**Re: Regarding assymetrical fills**

In your experiment, the tanks will never mix since they are equal pressure, therefore no movement of gas from one side to the other, when you gauge the mix with open isolator your pulling from both tanks

and mixing right in the tube where the "weight" of the gas will control the mix.

Here would be a real test, lets say you do a dive with EAN 36 in your doubles, next week you want to dive deep so you go to the shop to get 18/45 trimix, but some how the isolator gets closed. They drain just one tank thinking your draing two. Do the PP mix in just one of the tanks thinking its for two. At the end of the day you have say 1200 psi of EAN 36 in one tank and 3300 of 18/45 in the other. Your now on the dive boat and heading out, turn the isolator now mixing the tanks but you fail to hear the quick hiss. What's the mix, or how well would it mix in a short time?

Two years ago my buddy dropped his tanks off at the LDS that did mix fills, order 18/45 (same as the current gas mix in the tanks). Came back the day of the dive to pick them up, they were all taped and ready, he gauged the mix, right on! got on the boat, attached his regs and behold, same pressure as the week before, they never filled them. Lucky for him it just cost him the dive.

John

cat

10-03-2005 10:10

**Re: Regarding assymetrical fills**

I also did PhysChem way back when (and still mess with it a bit today) and also thought that they would show some signs of mixing over a diving-relevant time frame thanks to the laws of diffusion. That they clearly *\*don't\** mix, probably due to the orifice size and the length of the manifold joining the tanks and the relative low density gradient used in the experiment, is of more importance to divers than any theoretical voodoo that shows that they *\*should\** mix.

Next time my tanks get a pp fill when I am not standing over them, I will be analyzing from each post using the isolator closure protocol described in Uncle Ricky's 44 hour analysis. Respect for empirical science is key to a long and healthy life. If others wish to experiment further with other gas blends, differential pressures, etc., I am sure the results will be equally enlightening.

GRF

10-03-2005 10:25

**Re: Regarding assymetrical fills**

With the isolator open and different mixes in each of the tanks would there be sufficient mixing in the second stage hose to provide a consistent mix at the second stage or would there be a delay in response from the left tank due to the constriction of the isolator which would result in a mix leaning towards the contents of the right tank.

Uncle Ricky

10-03-2005 10:50

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **GRF**

*With the isolator open and different mixes in each of the tanks would there be sufficient mixing in the second stage hose to provide a consistent mix at the second stage or would there be a delay in response from the left tank due to the constriction of the isolator which would result in a mix leaning towards the contents of the right tank.*

---

My gut feeling is that you'd get adequate mixing. But that sure isn't shown in the analysis, which swings

all over the place. The difference is that when breathing you're dealing with much higher flow rates and much more gas. Still, it is uncertain from my limited little experiment that you'd get "safe" gas. The big deal is that if you had to isolate then either tank could be dangerous. Personally I'm thinking about some kind of lock for the isolator with one of those big red "Remove before Flight" flags on it that I can put on my open isolator any time I let the doubles get filled by any shop. Or at least some kind of frangible tape that would break if the valve were moved from the full open position.

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**Muzz**

10-03-2005 10:52

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**Re: Regarding assymetrical fills**

Uncle Ricky

Would you try it with 500psi on 1 side and 1000 on the other?

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**Uncle Ricky**

10-03-2005 11:26

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**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **Muzz***Uncle Ricky**Would you try it with 500psi on 1 side and 1000 on the other?*

---

I suppose I could, but all that would change would be the initial gasses once the isolator was opened and you got the pressures equalized... you'd only get mixing on the low-pressure side until equalization, then mixing would essentially stop... and if the original gasses were markedly different you'd still have a hazardous situation if you ever had to isolate on a dive.

Rick

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**GaryNJ**

10-03-2005 11:30

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**Re: Regarding assymetrical fills**

Very informative, Rick--thanks for taking the time to run the experiment and post the results.

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**Muzz**

10-03-2005 11:33

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**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **Uncle Ricky***all that would change would be the initial gasses once the isolator was opened and you got the pressures equalized... you'd only get mixing on the low-pressure side until equalization, then mixing would essentially stop... Rick*

---

Your statement makes perfect sense. I just wanted to make sure.  
note: Only if you have the time and feel like playing with it.

Raydar

10-03-2005 11:37

**Re: Regarding asymmetrical fills**

Sorta related but potential verging OT:

Do people normally close their isolators when not diving and why?

In my case, it's always open. I never close my isolator for anything other than a functionality test.

Just wondering if I'm missing something important here.

chimie007

10-03-2005 11:51

**Re: Regarding asymmetrical fills**

Quote:

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Originally Posted by **GaryNJ**

*Very informative, Rick--thanks for taking the time to run the experiment and post the results.*

---

Ditto

dta

10-03-2005 11:57

**Re: Regarding asymmetrical fills**

Shake well before use. ;)

Uncle Ricky

10-03-2005 12:03

**Re: Regarding asymmetrical fills**

Quote:

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Originally Posted by **Raydar**

*Do people normally close their isolators when not diving and why?*

---

No. The isolator should remain open during mixing/filling. The problem comes when "someone" closes an isolator (usually a shop rat who has "check all valves closed before filling" on the brain) and you get an asymmetrical fill - it should never happen, but as the Eagle's Nest mishap so tragically illustrates, it can.

Rick

SCoach

10-03-2005 12:45

**Re: Regarding asymmetrical fills**

In the interest of my personal education, when a person analyzes the tanks after a fill, is it customary

to check on BOTH sides of the isolator, or just one? It seems to me, that if the isolator was closed during the fill, and the isolator was left closed, the tanks should read quite differently.

So if one takes the to me, it would be prudent to check BOTH sides of the manifold before giving the ok on the tanks.

Also, is there anyone here who uses mixed gas but does not have their own analyzer? I know the analyzers are expensive, but it would seem to me that it would be fairly cheap insurance against getting a bad fill. And do you guys analyze EAN fills as well since they can be potentially lethal at depth? I mean, I would HATE to think I'd asked for 28% and planned a dive on that, when some shop guy had put 40% in the tank.

Thanks,

-P

David Swift

10-03-2005 13:03

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **SCoach**

*... It seems to me, that if the isolator was closed during the fill, and the isolator was left closed, the tanks should read quite differently...*

---

See post #1, you are right.

Quote:

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Originally Posted by **SCoach**

*...Also, is there anyone here who uses mixed gas but does not have their own analyzer?...*

---

I presume you mean their own O2 analyzer. Few of us can afford (and argueably need) an HE analyzer. If you are mixing and don't have your own O2 analyzer you are asking for trouble. O2 analyzers don't have to be expensive or complicated, there is plenty of DYI information here on TDS and other sites.

Spectre

10-03-2005 13:03

**Re: Regarding assymetrical fills**

Hmm. After you get the results of the 'mobile vibration' test... if it doesn't mix at all, it might be really interesting to see how it mixes if gas isn't equal. e.g. blow out some of the gas in the air side, open the isolator and see if that's enough activity to get them fully mixed.

Scuba\_Vixen

10-03-2005 13:22

**Re: Regarding assymetrical fills**

Depends on which analyser you're asking about.

I'm sure everyone who's at the trimix level has at least one, and likely two O2 analysers.

Very few individual divers have helium analysers, by contrast. Most shops do, and probably a number of instructors do though.

If you blend yourself, and have good protocols for doing so, then all a helium analyser does is further confirm your results.

I had access to a He analyser for a while, (buddy visiting) and we regularly checked each mix. (more as an experiment)

What we found was that every mix was within 5% (typically less) on the helium, and predictably, always on the high side. ( I always add a bit more than called for, since you're better high than low)

Being able to analyse the He is great if you need to have others mix your gas, or you're in a liability situation, .. mixing for others or teaching.

As far as analysing both sides, if you have your tanks filled, it's probably a good idea for sure.

If you fill yourself, it's less of an issue.

I usually do the analysis off the opposite side I filled from.

One thing that wasn't mentioned yet, the filler in the original incident was a CCR diver, I wonder if he was used to filling doubles, or just his RB and bailout bottles?

Darlene

Bishop

10-03-2005 16:56

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**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **SCoach**

*In the interest of my personal education, when a person analyzes the tanks after a fill, is it customary to check on BOTH sides of the isolator, or just one? It seems to me, that if the isolator was closed during the fill, and the isolator was left closed, the tanks should read quite differently.*

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*Thanks,*

*-P*

---

How about instead of doing all of that you just twist the isolator to ensure that it is open before you fill it. Fix the problem - don't add steps and make it worse.

ScubaPeo

10-03-2005 18:26

**Re: Regarding assymetrical fills**

He-he, since the fill station I'm using have multiple fill whips on a manifold, I've picked up the habit of hooking up both posts when I do my fills (of course still with the manifold valve open). I've found that it reduces heating during the fill a bit. Now I have another reason to continue doing so, especially since I almost never drain my tanks in between fills...

/Peo

Uncle Ricky

10-03-2005 22:37

**Bouncing/heating/cooling**

Just for grins and giggles, and because Spectre suggested it, the set of doubles is in the back of the Suburban right now, riding around with me and getting unevenly heated and cooled by the sun/shade, and bounced around on rough roads. With the isolator open.

I don't think the bouncing around will cause much mixing through that manifold, but the uneven heating and cooling ought to get at least something mixing.

Analysis scheduled for Wednesday afternoon.

After that they get drained, and filled for the weekend

Rick

Matt Reed

10-04-2005 05:13

**Re: Regarding assymetrical fills**

Very interesting, and certainly different to what I would have imagined.

I don't want to hijack, but I think it comes in the same topic so- who has experience with mixing and has found a difference whether the tank is laid down after filling or not.?

I have been told that the chemistry(physics?) of it all says it shouldn't make any difference - but in my experience it clearly does.

Anyone?

Cheers,

Matt.

caverkevin

10-04-2005 07:11

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **Matt Reed**

*I don't want to hijack, but I think it comes in the same topic so- who has experience with mixing*



*and has found a difference whether the tank is laid down after filling or not.?*

*I have been told that the chemistry(physics?) of it all says it shouldn't make any difference - but in my experience it clearly does.*

---

Would you expand on the differences you have witnessed between filling in the different positions. Which position is more effective? How much error are you producing when filling in the other position? This is only the second time I have heard of there being a difference. In the process of producing my own mixtures, the cylinders have always been vertical.

TIA

KLJ

RickGonzalez

10-04-2005 08:27

**Re: Regarding asymmetrical fills**

The method I employ when mixing trimix is to mix the gas at least two days prior to diving. I then place my doubles in the back of my truck afterwards and drive around with them in order to promote mixing. It might be better to employ a vibration set up similar to what is used for paint but I know of no one who has such a set up. Normally gas when mixed will not stratify in the cylinders but this could happen depending on the method used for mixing in the first place. For example, if on day one gas A is placed in the tank then on day two, the second gas is placed in the cylinder. Although you wouldn't think that mixing occurs through the manifold I would venture to say it does because of the high tank pressure, especially during the mixing process since the gas molecules would be most active due to heating. However if the isolator valve is shut off during the mixing process then reopened I could see that some problems could occur then. I do know of a scuba shop where I live that has a rotating table set up that they use when mixing trimix. They spin the tanks in different directions so that mixing is facilitated. However, I do not think that there would be any difference in mixing if the tanks are vertical or horizontal. The only time that stratification could take place is if the tanks are stored for a long period of time, especially in a cold environment, where the gases would have time to diffuse.

chimie007

10-04-2005 12:11

**Re: Regarding asymmetrical fills**

Quote:

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Originally Posted by **Matt Reed**

*I have been told that the chemistry(physics?) of it all says it shouldn't make any difference - but in my experience it clearly does.*

---

Matt, not exactly. At low pressure (low density) gases diffuse very fast and the shape/orientation of the container should not make any difference. At high pressure, gases behave more like liquids since their densities are very high. If I remember correctly the density of air at 3000 PSI is about 1/4 to 1/3 the density of water. As density increases, the effect of gravity increases.

If one assumes that high pressure gases behave somewhat like liquids then filling tanks in vertical or horizontal position should make a difference. Think of it as filling a tall narrow glass with syrup and water versus filling a short wide glass with the same thing. Come back in an hour and the syrup/water

in the short glass will be better mixed for 2 reasons. First, there is a larger surface of contact between the syrup and the water for molecules to exchange. Second, these molecules don't have to go as far to mix since the layer of water and syrup are thinner.

The same logic can perhaps "explain" why trimix PP fills take longer to mix than nitrox PP fills. Helium as a significantly lower density than that of O2 or air. One would expect liquids having different densities to layer better in the tanks and be harder to mix than liquids with similar densities.

Obviously gases aren't liquids but considering them as liquids helps making sense of all this.

Raphael

el-ninio

10-04-2005 13:05

**Re: Regarding assymetrical fills**

the water analog is good. Air at 200 AT is about 5 pounds (~2.3kg) per al12l (AL80), while water is 11kg (the tank is about 11l volue) for the same volume, so the air is about 1/5 the density of water. At this density, one could expect mixing times to be simular to what we can see in liquids - if one tank was filled with water and the other with vodka, how long would it take for the diffusion to even things out through the pinhole size opening in the manifold? I would assume it would take quite some time.

It's worth noting that when the only force pushing the tanks to equalize are diffusion related, the bottleneck is, well, the bottleneck. A manifold, which is thin and long, has just the right shape to slow diffusion out.

an interesting experiment would be to PP fill a single tank very slowly, and then see how long it takes the tank to reach a good mix without miving it around. my guess is that it should take something around half a day.

I tried to work out the physics of this some monthes ago, I'll look for the post. I was very surprised at the original result which suggested that mixing time was inversly proportional to pressue. If this is the case, a 500psi fill, as described above, would mix six times faster then an actual 3000psi one.

el-ninio

10-04-2005 13:10

**Re: Regarding assymetrical fills**

the water analog is good. Air at 200 AT is about 5 pounds (~2.3kg) per al12l (AL80), while water is 11kg (the tank is about 11l volue) for the same volume, so the air is about 1/5 the density of water. At this density, one could expect mixing times to be simular to what we can see in liquids - if one tank was filled with water and the other with vodka, how long would it take for the diffusion to even things out through the pinhole size opening in the manifold? I would assume it would take quite some time.

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EDIT: found it - <http://thedecostop.com/forums/showth...ghlight=mixing>

chimie007

10-04-2005 13:17

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **el-ninio**

**I tryed to work out the physics of this some monthes ago, I'll look for the post. I was very surprised at the original result which suggested that mixing time was inversly proportional to pressue. If this is the case, a 500psi fill, as described above, would mix six times faster then an actual 3000psi one.**

**EDIT: found it - [url**

[http://thedecostop.com/forums/showthread.php?t=10556&highlight=mixing\[/url\]](http://thedecostop.com/forums/showthread.php?t=10556&highlight=mixing[/url])

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Actually. Graham's law states that "The rate of diffusion of a gas is inversely proportional to the **square root** of its density under given conditions of temperature and pressure."

Assuming that the change in density of air from 500 PSI to 3000 PSI is about 6 times. The change in diffusion would be about 2.5 not 6 since Diffusion =  $1 / (6)^{0.5}$

runawaylobster

10-04-2005 13:55

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **chimie007**

*Actually. Graham's law states that "The rate of diffusion of a gas is inversely proportional to the **square root** of its density under given conditions of temperature and pressure."*

*Assuming that the change in density of air from 500 PSI to 3000 PSI is about 6 times. The change in diffusion would be about 2.5 not 6 since Diffusion =  $1 / (6)^{0.5}$*

---

Raphael...

here is something you can have fun with :)...

<http://www.falstad.com/gas/>

Les

lamont

10-04-2005 14:51

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **ScubaPeo**

*He-he, since the fill station I'm using have multiple fill whips on a manifold, I've picked up the habit of hooking up both posts when I do my fills (of course still with the manifold valve open). I've found that it reduces heating during the fill a bit. Now I have another reason to continue doing so, especially since I almost never drain my tanks in between fills...*

/Peo

---

That doesn't sound like a bad idea. The viscosity of ideal gases goes in proportion to the pressure, which is why air through the reg gets thicker the deeper you go. At 200+ times atmospheric pressure those gases are going to be a bit syrupy.

And recently I did some calculations (verified by similar calculations in my old stat mech text) that showed that it took days to smooth out even very small features in gas under such high pressure via diffusion alone.

---

David Swift

10-04-2005 16:02

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **chimie007**

*...The same logic can perhaps "explain" why trimix PP fills take longer to mix than nitrox PP fills. Helium as a significantly lower density than that of O2 or air...*

---

So I presume that the order of the PP fill gasses also effect the mixing speed. Putting the lower density HE in first and the heavier O2 second would force them to mix faster I would presume.

Interesting thought experiment. But I find in the real world that stratification within each tank doesn't last very long.

---

Wreck

10-04-2005 23:51

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **ScubaPeo**

*He-he, since the fill station I'm using have multiple fill whips on a manifold, I've picked up the habit of hooking up both posts when I do my fills (of course still with the manifold valve open). I've found that it reduces heating during the fill a bit.*

/Peo

---

This sounds impossible. Adiabatic heating is directly related to how fast the tanks are being pressurized. Since the pressure increases equally in both cylinders (across the manifold) they will pressurize equally and heat equally.

There should be no measurable temperature differences around the midsection of each cylinder, unless they are somehow different from each other. The manifold and valves can get cool sometimes from gas flowing through it, and may absorb some heat from the tank necks, but that's different.

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ScubaPeo

10-05-2005 00:27

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**Re: Regarding assymetrical fills**

I haven't done the math, nor have I put it through a rigorous test. It seems to help a bit, and I can't see how it would make any harm (in fact I can only see advantages), so I'll just continue my habit and if it so happens that the tanks are a bit colder than otherwise, I'll just take that as an extra bonus. ;-)

/Peo

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Gary

10-05-2005 02:46

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**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **Wreck**

*Adiabatic heating is directly related to how fast the tanks are being pressurized.*

---

Frictional heating from turbulent flow through a narrow pipe/orifice (manifold/valve) or even the fill hoses and wips could be in addition to Adiabatic heating. Head loss/friction would be proportional to the square of the rate of flow. Putting a whip on both sides while keeping the rate of fill constant (thus half on each side and none through the manifold) would reasonably reduce frictional heating (however much it contributed) or allow filling nearly twice as fast while making the frictional heating it no worse.

Isn't this part of the reason for limiting the rate of fills for O2? Reducing impingement of high flow rate O2 through the angles and restrictions of the valves and manifolds to help prevent combustion?

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ScubaPeo

10-05-2005 09:51

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**Re: Regarding assymetrical fills**

Thinking about frictional heating was exactly why I picked up this habit. I don't know how much of the heat generated is because of frictional heating as opposed to adiabatic heating though.

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Uncle Ricky

10-05-2005 15:57

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**Final analysis**

After 116 hours with the isolator open, 3 days of which were riding in the back of the Suburban getting heated & cooled with the sun and the night...

Left tank: 23.1%

Right tank: 92.4%

I attribute that little bit of mixing to the temperature changes more than the ride, but the bottom line remains that if you get an assymetrical fill it's going to stay assymetrical, and it could be dangerous. The isolator must remain open for all mixing ops.

Rick

---

Triton

10-05-2005 16:15

**Re: Regarding assymetrical fills**

Well thats a good one ! We was always told the gases would mix in the long run.

Thanks for going to the trouble to check this out  
... and have great dives this weekend :)

rgds

**Albion**

10-06-2005 04:56

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **el-ninio**

*if one tank was filled with water and the other with vodka, how long would it take for the diffusion to even things out through the pinhole size opening in the manifold?*

---

What you really need is some kind of stick which passes through the tank valve that would enable you to jiggle the contents about. The outer end of the stick could hold a small colourful paper umbrella to keep your tanks cool, while sat in the sun, as well :D also possibly a slice of lemon.

Its an interesting discussion and has got me thinking about the PP fills we do locally, where the fill to dive time is only around an hour. How much mixing has actually occurred? I might do a few closed isolator checks next time

**Wreck**

10-06-2005 13:44

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **Albion**

*Its an interesting discussion and has got me thinking about the PP fills we do locally, where the fill to dive time is only around an hour. How much mixing has actually occurred? I might do a few closed isolator checks next time*

---

I'm trying to recall what the exact trend was, but trimix analysis is typically 10% different (in helium) after the first twelve or so hours when it has stabilized. I notice this most for richer mixes (~55% He) and chalk the mixing speed up to the vastly different atomic sizes between helium and the other gases. 10% does have an affect the deco plan, but the O2 content seems like it remains more stable than the helium content in the analysis.

200' for 25 mins, and picking arbitrary numbers out of my head for mixes and corresponding total deco time:

23/32 - 37 minutes

21/32 - 38 minutes

19/36 - (target mix) 43 mins

17/40 - 47 minutes

15/40- 51 minues

This is just another good reason why we use conservatism factors to cover unknowns.

It's a shame something so simple ended up in a death. as a rule I always check the isolator before PP filling my tanks, just for fear of this very thing. This accident reinforces the reasoning for that, although I never close my isolators for anything but a valve drill. Then there are those on here who swear they will never use an isolator valve manifold.. I guess this puts a feather in their caps.

The lesson I get from all of this is if the isolator is open when we analyze a mix, the reading's instability should alert us that something is very wrong.

All times are GMT -6. The time now is 10:07.

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**The Deco Stop** (<http://thedecostop.com/forums/index.php>)

- **Diving Accidents and Incidents** (<http://thedecostop.com/forums/forumdisplay.php?f=36>)
- **Regarding assymetrical fills** (<http://thedecostop.com/forums/showthread.php?t=15615>)

## FreeFloat

10-06-2005 14:02

### Re: Final analysis

Quote:

Originally Posted by **Uncle Ricky**

*After 116 hours with the isolator open, 3 days of which were riding in the back of the Suburban getting heated & cooled with the sun and the night...*

Somehow I now have visions of shop tank fillers rolling tanks around on the floor to 'mix' them.....

## Wreck

10-06-2005 14:11

### OT: double-whip filling

Quote:

Originally Posted by **Gary**

*Frictional heating from turbulent flow through a narrow pipe/oriface (manifold/valve) or even the fill hoses and wips could be in addition to Adiabatic heating. Head loss/friction would be proportional to the square of the rate of flow. Putting a whip on both sides while keeping the rate of fill constant (thus half on each side and none through the manifold) would reasonably reduce frictional heating (however much it contributed) or allow filling nearly twice as fast while making the frictional heating it no worse.*

*Isn't this part of the reason for limiting the rate of fills for O2? Reducing impingement of high flow rate O2 through the angles and restrictions of the valves and manifolds to help prevent combustion?*

I think it's probably very insignificant when countered by the cooling effect of expanding gas in the conduits it's traveling in. I didn't consider the frictional heat aspect through the manifold. When I feel my manifold during a fill, it gets cooler, not warmer.

I think this deserves some empirical experimentation and measurement. One benefit to using two whips is that it's less potential wear and tear on the isolator valve seat.

## Wreck

10-06-2005 14:23

### Re: Final analysis



Quote:

---

Originally Posted by **FreeFloat**

*Somehow I now have visions of shop tank fillers rolling tanks around on the floor to 'mix' them.....*

---

Ironically if you search around on the board here, people have posted doing this very thing when mixing trimix in singles. I just fill the tanks several days in advance and let them sit.

And another (albeit obscure) use for tank tumblers.

---

Gary

10-06-2005 14:30

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**Re: OT: double-whip filling**

Quote:

---

Originally Posted by **Wreck**

*I think it's probably very insignificant when countered by the cooling effect of expanding gas in the conduits it's traveling in. I didn't consider the frictional heat aspect through the manifold. When I feel my manifold during a fill, it gets cooler, not warmer.*

---

While you are probably right about the contribution of friction to heating - the coolness of the manifold itself could be caused by quite a different effect. In fact the greater the friction across the manifold the greater the pressure drop and the MORE cooling that would be evident at the manifold (as in pressure drop across an orifice) while still adding heat to the total process.

Filling with both whips *might* make the manifold feel less cooled and yet the tanks still less warm - depending on a lot of factors.

After all the air coming from the tanks is already cooled and pressurized - it's the air already in the tanks that is getting compressed and causing most of the heating.

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ScubaPeo

10-06-2005 15:33

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**Re: OT: double-whip filling**

Quote:

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Originally Posted by **Wreck**

*I think it's probably very insignificant when countered by the cooling effect of expanding gas in the conduits it's traveling in. I didn't consider the frictional heat aspect through the manifold. When I feel my manifold during a fill, it gets cooler, not warmer.*

*I think this deserves some empirical experimentation and measurement. One benefit to using two whips is that it's less potential wear and tear on the isolator valve seat.*

---

But, but ...

Doing a fill from banks where all storage tanks are at a pressure above my end fill pressure, the gas in my doubles after filling is still warm (hmm, actually to be very precise, I should say my DOUBLES are warm). As you point out, the cooling effect of the EXPANDING gas should actually lower the temperature, unless I'm missing something here. That means the heat generated somewhere must be adiabatic heating and friction, right?

jeffkruse2000

10-06-2005 15:50

**Re: Regarding assymetrical fills**

If I walked into a shop and saw someone filling twins with two whips I would walk back out. :D

Please, stop the silliness. :p

Peo, the gas coming from the banks is expanding and getting colder. Run that through many feet of tubing and it will try to warm up to room temp thus increasing the temp of the gas. The more tubing the more heat transfer.

Now your compressing it back into your tank and the adiabatic heating that occurs is almost equal to the cooling that occurred. Frictional heating IMO is negligible and probably the same for (one whip/more gas through it) or (two whips/less gas through each).

Your bank has more mass then your tanks, so the banks might drop 20 degrees but your tanks may rise 60 degrees.

Now if you were filling directly from the compressor, the longer the whip/s the more the hot gas coming from the compressor will cool before it gets into your tanks and heats up again, thus lowing the over all temperature of the tanks.

NEwreckdiver

10-06-2005 17:36

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **Uncle Ricky**

*I drained a set of (nitrox) doubles and then, with the isolator closed I put 500 psi oxygen in one tank and 500 psi air in the other.*

*Then I analysed each tank.*

*Right post - 93.3%*

*Left post - 21.8%*

*I then opened the isolator and let it sit for two hours.*

*Rick*

---

Hi Rick,

Interesting experiment. I am not sure if I misread something or not, but I just had a quick question.... was your baseline O2 measurement coming out at 93.3% (ie before you opened the isolator) or was this a measurement taken immediately after opening the isolator? If I understood correctly, this was a measurement taken before opening the iso. My O2 typically analyzes at >99% ... just curious.

Thanks

Heather

Albion

10-07-2005 00:49

**Re: Final analysis**

Quote:

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Originally Posted by **FreeFloat**

*Somehow I now have visions of shop tank fillers rolling tanks around on the floor to 'mix' them.....*

---

I prefer to toss them end over end :eek: :eek:

Uncle Ricky

10-07-2005 06:52

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **NEwreckdiver**

*Hi Rick,*

*Interesting experiment. I am not sure if I misread something or not, but I just had a quick question.... was your baseline O2 measurement coming out at 93.3% (ie before you opened the isolator) or was this a measurement taken immediately after opening the isolator? If I understood correctly, this was a measurement taken before opening the iso. My O2 typically analyzes at >99% ... just curious.*

*Thanks  
Heather*

---

Hi Heather,

Before opening the isolator - but this wasn't an oxygen tank to start with, not drained to absolute zero and I only filled it to 500 psi. So 93.3 is right. I was just shooting for a marked difference between the tanks to start with so I could make decent measurements and come up with a "real world" conclusion on the consequences of filling with a closed isolator.

---

As for the discussions of in-tank mixing, I want to emphasize we are talking apples and oranges; gasses mix well and easily when they're all in the same container, and any stratification that occurs during PP filling with an open isolator is just not a problem by the time the tanks get hauled to the dive site. (I guess if your dive site were next to your mixing station it could be a problem, but any significant time - two hours or so - or movement - loading into the truck and hauling 'em to the site - should take care of that). But they will not mix at all - at least not measurably - through an isolator and so it is imperative that PP fills be made with the isolator open.

Rick :)

Simon Richards

10-07-2005 08:46

**Re: Regarding assymetrical fills**

Quote:

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Originally Posted by **Uncle Ricky**

---

*As for the discussions of in-tank mixing, I want to emphasize we are talking apples and oranges; gasses mix well and easily when they're all in the same container, and any stratification that occurs during PP filling with an open isolator is just not a problem by the time the tanks get hauled to the dive site. (I guess if your dive site were next to your mixing station it could be a problem, but any significant time - two hours or so - or movement - loading into the truck and hauling 'em to the site - should take care of that). But they will not mix at all - at least not measurably - through an isolator and so it is imperative that PP fills be made with the isolator open.*

*Rick :)*

---

You can do some rough calculations assuming that the diffusive flux is proportional to the cross sectional area (i.e. the square of the diameter) and inversely proportional to the length. Those will probably convince you that the gases in a tank will mix 1000 or more times as fast as via the isolator. And as someone else has pointed out, its very very easy to measure this effect anyway, so there is generally no need for voodoo activities. When possible, it makes a lot more sense to mix the day before, then just analyse on the morning of the dive.

Ricky's excellent demonstration leads to the well known rule that you need to keep the isolator open when filling. You should also check it is open when analysing (and frankly whenever you touch the manifold/valves for any reason). Isolator locks wouldn't work - I wouldn't fill a set of doubles if I couldn't check the isolator. I think the bottom line is that there is no safe way for someone who will not reliably follow these rules to mix breathing gases. There is a lot of merit in restricting yourself to just a few standard breathing gases, so you can print out and laminate up the fill PPs and you are always doing the same thing.

You should never base a decision to dive a gas just on what an analyser says - they can do strange things when wet and when the cell is expiring. If it reads 21% on air and near 100% on O2 then its probably OK. But really the purpose of an analyser should be to confirm that the gas you have in the tanks is what you expected. If it doesn't analyse to near that, then you need to be asking yourself why, and you either need a second analyser or you need to check what your analyser is doing on two different known gases whose contents are either side of the unknown gas (e.g. air and 100% for nitrox/normoxic trimixes) rather than just one.

I find it strange that most people don't analyse air, because its air. How do you know that without analysing it? I have analysed air tanks at 38%. I have seen people not analysing nitrox because it came from a bank, and I can't say anything positive about those people.

I'm also impressed when I see someone with an O2 bottle that has probably only ever been used for O2 and it is marked with an analysis like "97.3%". What do they think the other 2.7% is and how did it get in there?

Regards,

Simon Richards

---

Albion

10-10-2005 03:36

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **Uncle Ricky**

*I guess if your dive site were next to your mixing station it could be a problem, but any significant time - two hours or so*

---

This is precisely my problem. My tanks will be sat on back deck of dive boat, so dive site is about two steps from the filling station. Come up from dive, remove first stage then PP fill. Typically with a two hour surface interval, I would be looking at around 1 hour of 'mixing time'

Uncle Ricky

10-10-2005 10:33

**Re: Regarding assymetrical fills**

Quote:

Originally Posted by **Albion**

*This is precisely my problem. My tanks will be sat on back deck of dive boat, so dive site is about two steps from the filling station. Come up from dive, remove first stage then PP fill. Typically with a two hour surface interval, I would be looking at around 1 hour of 'mixing time'*

---

Are y'all experiencing any odd analyses or other indication of stratification problems? If you are, the only immediate solution that leaps to mind is having a spare set of tanks so you can alternate them, diving one while the other's mixing.

Rick

Dave

10-10-2005 12:26

**Re: Regarding assymetrical fills**

Very interesting topic, thanks for the work Rick.

Simple solution....continuous blending, gods gift to blenders ;)

mike king

10-10-2005 12:35

**Re: Regarding assymetrical fills**

good job thanks Rick:D

Mike

Albion

10-10-2005 23:32

**Re: Regarding assymetrical fills**

Quote:

Originally Posted by **Uncle Ricky**

*Are y'all experiencing any odd analyses or other indication of stratification problems? If you are, the only immediate solution that leaps to mind is having a spare set of tanks so you can alternate them, diving one while the other's mixing.*

*Rick*

---

i've not noticed it, but then until i started reading this thread hadn't considered the possibilities :eek: , it might not be a problem at all, but it wont hurt to monitor the fills a bit more closely, thanks for flagging this up

abowie

10-15-2005 17:23

**Re: Regarding assymetrical fills**

This is interesting.

From first principles I would have expected the gases to mix given that there is a partial pressure difference for both N2 and O2 across the manifold.

A physical pressure differential across the manifold will encourage mixing, but only by forcing gas through the manifold and by producing turbulence.

Flow through a tube is proportional, among other things, to the fourth power of the radius of the tube. I guess the manifold tube ID is such that it just takes a long, long time. You can sort of imagine those little molecules of O2 and N2 bashing into each other in the manifold as they try to travel in opposite directions....

I have problems with stratification with nitrox fills; I have a very slow air compressor. These usually sort themselves out if I leave the tanks lying on their side overnight. In any event agitation in the car on the way to the dive site would encourage adequate mixing. A good argument for checking your mix just prior to diving, and probably one for a He analyser too.

phreaticus

10-15-2005 17:52

**Re: Regarding assymetrical fills**

This is the most interesting thread I have seen in years on this forum, as back in the early days of "mix" diving (early80's) we used to roll/rotate the filled tanks after adding He and O2, to get the gasses "mixed".

This was all based on "theoretical/anecdotal" methods...probably totally incompetant, but we survived.....I'm extremely interested in determining (if that is within our current capabilities) the truly accurate ways to blend disparete gasses.

Come on you educated newbies (newbie to me is less than 10 years and 1000 cave/tech-wreck +mix/deco dives)..lets hear some accurate, scientifically proven gas-mixing methods!

Old-dog....wanting to keep learning new tricks here...as you should be if you ever get there!

BTW, Ricky, I'm the Dive Rite rep for the SE...did we meet back in the summer, your avatar and the perception seem familiar?

abowie

10-16-2005 02:33

**Re: Regarding assymetrical fills**

Having thought more about it and discussed it with dteubner who can remember more physics than me, I am less surprised. The only process facilitating equilibration between the two cylinders is Brownian motion. Only increasing temperature or actual gas flow will make them mix faster.

Think of this as an example. Someone lights a cigarette in the room next to the one you're in. The

adjoining door is closed, and there's only the keyhole for the smoke to get through. It's going to be a long time until any smoke particles get to you via the keyhole. It'll be a LOT longer before the smoke particles are equally distributed throughout both rooms ( it'll never happen; they'll all end up on the floor).

To make the smoke spread more quickly you can open the door or put a fan on to move the air around.

Putting the fan on is what you do with normal blending. By "squirting" some gas (He, air) in quickly, you hopefully end up encouraging mixing. Nevertheless I can see several situations where less than perfect mixing could occur and tank rolling be useful. As I mentioned I do my air top up from a very slow compressor (no air bank at home) and often have to wait 24 hours until my mix settles.

Now, as I tried to replicate Ricky's experiment at home, all I've got to do is work out what on earth I'm going to do with a set of twins that have 50 bar of air in one tank and 50 bar of O2 in the other. EAN40something anyone?

Scuba\_Vixen

10-16-2005 10:48

**Re: Regarding assymetrical fills**

Welcome to TDS, Andrew.  
Nice to have you here.

You could put ~100bar of Helium in them now and have a rather nice deco/bailout mix. :D

Darlene

plankton

10-16-2005 11:03

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **abowie**

*Now, as I tried to replicate Ricky's experiment at home, all I've got to do is work out what on earth I'm going to do with a set of twins that have 50 bar of air in one tank and 50 bar of O2 in the other. EAN40something anyone?*

---

I'm sure you'd figure it out yourself sooner or later. What were you smoking in that other room ;)

Close the isolator and blow off the air, fill your tires, whatever. Close that post and open the isolator. When the pressure balances, you should have 25 bar of O2 in each side. Top that up with air to 200 bar and you should have around ean31.

michael\_fisch

10-20-2005 11:38

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **abowie**

*Now, as I tried to replicate Ricky's experiment at home, all I've got to do is work out what on earth I'm going to do with a set of twins that have 50 bar of air in one tank and 50 bar of O2 in the other. EAN40something anyone?*

---

Would you believe EAN60?

$50\text{Bar O}_2 + .21 \times 50\text{Bar} = 60.5\text{Bar O}_2$

$60.5/100 = 60\% \text{ O}_2$

Michael

---

abowie

10-21-2005 06:12

---

**Re: Regarding assymetrical fills**

Yeah but if it ever mixes I'll only have 50 bar of it...

If I top it up to 220 bar I'll get 30% which is actually useful.

---

michael\_fisch

10-21-2005 06:50

---

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **abowie**

*Yeah but if it ever mixes I'll only have 50 bar of it...*

*If I top it up to 220 bar I'll get 30% which is actually useful.*

---

NO! not again!

$50\text{Bar O}_2 + .21 \times 170 \text{ Bar} = 39\% \text{ O}_2$

If you can't do the math you shouldn't be diving the mix.

Michael

---

caverkevin

10-21-2005 07:04

---

**Re: Regarding assymetrical fills**

Check you math..... filling with the given gas equals .299% Remember that the 50bar is in only one cylinder. So it is really like having 25bar in the set of doubles.

Ok! back to open water air diving for you Michael;)

Best!!

Kevin



Quote:

---

Originally Posted by **michael\_fisch**  
*NO! not again!*

*50Bar O2 + .21 x 170 Bar = 39% O2*

*If you can't do the math you shouldn't be diving the mix.*

*Michael*

---

michael\_fisch

10-21-2005 07:13

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **caverkevin**  
*Check you math..... filling with the given gas equals .299% Remember that the 50bar is in only one cylinder. So it is really like having 25bar in the set of doubles.*

*Ok! back to open water air diving for you Michael;)*

*Best!!*

*Kevin*

---

Outch!  
your right, I forgot that the 50Bar O2 was only in one tank!  
My apologies.

Michael

As a sign of shame, understanding my sins, I promise to do the next 10 dives OW, even though I have a wonderful RB 80 clone sitting in the garage for the next week or 2.

caverkevin

10-21-2005 07:21

**Re: Regarding assymetrical fills**

OK.....time for math class.

50bar in one cylinder is 25bar in two. So if you just open the isolator and try and mix the gas you get EAN73 [25bar o2 + (.21x25bar air)]/50bar total contents.

Then for topping with air to 220bar. [25bar o2 + (.21x195bar air)]/220bar you get EAN30 or 29.9 if you want to nit-pick

Man! I really need to go dive:D

KLJ

caverkevin

10-21-2005 07:24

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **michael\_fisch***Outch!**your right, I forgot that the 50Bar O2 was only in one tank!**My apologies.**Michael**As a sign of shame, understanding my sins, I promise to do the next 10 dives OW, even though I have a wonderful RB 80 clone sitting in the garage for the next week or 2.*

---

LOL!!!:D

Bet you made the mistake because you are too busy thinking about that breather!!

KLJ

Uncle Ricky

10-27-2005 10:25

**Re: Regarding assymetrical fills**

Quote:

---

Originally Posted by **phreaticus***BTW, Ricky, I'm the Dive Rite rep for the SE...did we meet back in the summer, your avatar and the perception seem familiar?*

---

We did. At Adventure Sports in Montgomery. I'm the short fat one with the hair and the beard :) (The owner was the short fat bald one)

Rick

All times are GMT -6. The time now is 10:08.

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