

STAGE GAS PLANNING - LINEAR

Plan for a single stage diver in a team of two using "Half Plus" planning
Comparing safety margin of thirds to "Half Plus"

Use the gas planning worksheet

Depth	Interval
2 ATA	
3 ATA	
4 ATA	

* Reminder: Stage bottle intervals are doubled *

KEY			
SP	Start Pressure	PI	Pressure In
UP	Usable Pressure	PO	Pressure Out
DP	Drop Pressure	TI	Time In
TP	Turn Pressure	TO	Time Out
		MG	Minimum Gas

STAGE	BG
SP:	
UP:	
DP:	X
TP:	X

Distance:

DP:

TI:

TP:

TI:

PO:

TO:

PO:

TO:

Distance:

Avg Depth:

Populate Intervals chart for reference from where it should be written down in wetnotes

Depth	Interval
2 ATA	100
3 ATA	150
4 ATA	200

Also populate anticipated Average Depth

PO:

TO:

Avg Depth:

At an average of 30' an interval of 100psi/5 minutes will be assumed for the rest of the example

Normal Dive

Starting with a full set of AL80s and a full stage bottle we can populate all the SP: 3000

Using "Half Plus" on the stage we determine DP on the stage

$$SP/2 + 200 = DP$$

$$3000/2 + 200 = 1700$$

$$SP - DP = UP$$

$$3000 - 1700 = 1300$$

	STAGE	BG
SP:	3000	
UP:	1300	
DP:	1700	X
TP:	X	

Distance:		
DP:		TP:
TI:		TI:

PO:		Distance:
TO:		

Now we set aside the volume used in the stage aside as a reserve in backgas

First we convert that pressure from the stage into volume

$$V = \text{Pressure} / 100 \times \text{Tank Factor}$$

$$V = 1300 / 100 \times 2.5$$

$$V = 13 \times 2.5$$

$$V = 32.5 \text{ cf}$$

Round to 33

$$V = P/100 \times TF$$

$$P = V/TF \times 100$$

Next we convert that volume back to pressure in doubles

$$P = \text{Volume} / \text{Tank Factor} \times 100$$

$$P = 33 / 5 \times 100$$

$$P = 6.6 \times 100$$

$$P = 660 \text{ psi}$$

Round to 700

Remember that single tank tank factors are 1/2

That 700psi is our safety reserve to be set aside from the rest of our UP calculation in doubles

Doubles are full to 3000 psi, subtract that safety margin

$$3000 - 700 = 2300$$

2300 is our Provisional Starting Pressure

Calculate thirds based on this Provisional Pressure

2300 drops down to 2100

$$2100/3 = 700$$

700psi is our UP

$$SP - UP = TP$$

$$3000 - 700 = 2300$$

Backgas numbers can be filled into the table

	STAGE	BG
SP:	3000	3000
UP:	1300	700
DP:	1700	X
TP:	X	2300

Distance:		
DP:		TP:
TI:		TI:

PO:	PO:	Distance:
TO:	TO:	

We expect to drop the stage at about minute 32
 $1300 \text{ psi usable pressure} / 200 \text{ psi intervals} \times 5 \text{ minute intervals} = \text{drop time}$
 $1300 / 200 \times 5 = 32.5$

We can further expect that at 30fpm our drop will be approximately 960 feet penetration
 $32 \text{ min} \times 30\text{fpm} = 960$

	STAGE	BG
SP:	3000	3000
UP:	1300	700
DP:	1700	X
TP:	X	2300

Distance:	960	
DP:	1700	TP:
TI:	32	TI:

PO:	PO:	Distance:
TO:	TO:	

From this point the dive continues to backgas TP of 2300

$700 \text{ psi used} / 100 \text{ psi interval} \times 5 \text{ minute intervals} = \text{time spent on backgas}$
 $700/100 \times 5 = 35 \text{ minutes}$

32 minutes to the drop, one minute for drop, plus 35 minutes swimming places us at minute 68

Additional 35 minutes swim multiplied by 30fpm gives us another 1050 feet or 2010 total

	STAGE	BG
SP:	3000	3000
UP:	1300	700
DP:	1700	X
TP:	X	2300

Distance:	960	
DP:	1700	TP:
TI:	32	TI:

PO:	PO:	Distance:
TO:	TO:	2010

A thumb is deployed and the dive is turned

All things being equal the team arrives back at the drop bottles 35 minutes later at minute 103

Diver has breathed 700psi out and 700psi back leaving 1600psi in backgas

	STAGE	BG
SP:	3000	3000
UP:	1300	700
DP:	1700	X
TP:	X	2300

Distance: 960

DP: 1700

TI: 32

TP: 2300

TI: 68

PO:

TO:

PO: 1600

TO: 103

Distance: 2010

Stage bottles still containing 1700psi are collected

A minute or so is added on to runtime as everyone gets their stages sorted

At minute 104 everyone is back underway towards the exit.

It took 32 minutes to swim in, it should take 32 minutes out

This places the surface time at minute 136

It took 1300psi in, it should take 1300psi out

This places the stage bottle gauge at 400psi

	STAGE	BG
SP:	3000	3000
UP:	1300	700
DP:	1700	X
TP:	X	2300

Distance: 960

DP: 1700

TI: 32

TP: 2300

TI: 68

PO: 400

TO: 136

PO: 1600

TO: 103

Distance: 2010

Between the remaining 400psi (10cf) in the stage and 1600psi (80cf) in backgas we are still surfacing with a ton of gas

Which is not a terrible bother because it has been more than 2 hours and everyone is hungry anyway

But why reserve so much gas?

OOG Emergency

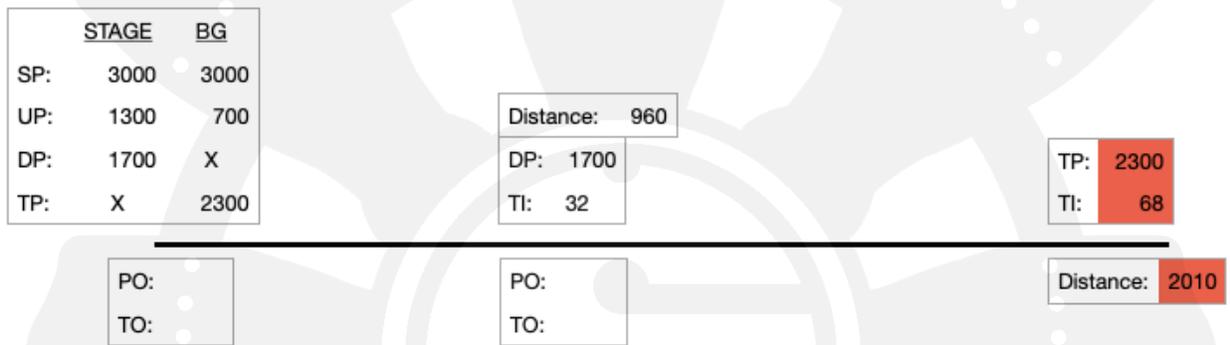
We can skip over the failure of OOG during the backgas portion of the dive
 We've planned within thirds, obviously enough for two to share back to the stage bottles

We can also skip over the potential failure of a retrieved stage bottle
 We went through the whole reserved gas exercise, right?

If you want to do the math on each of these possible losses of gas, be my guest

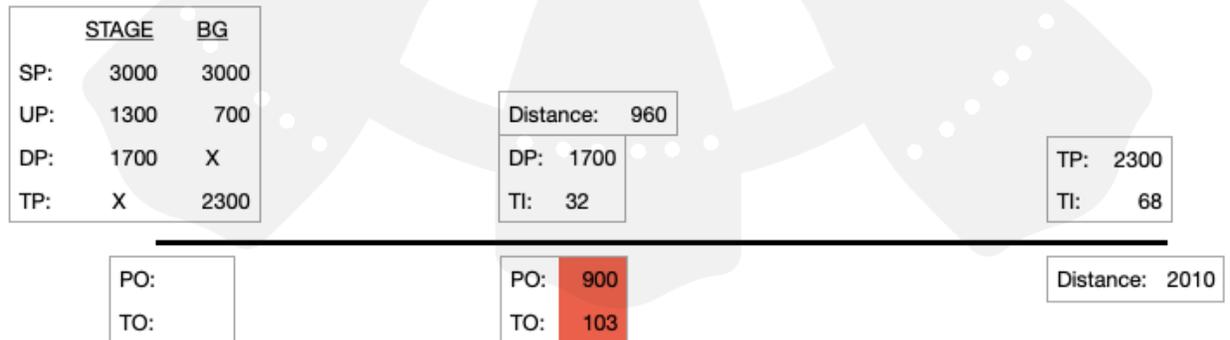
What we should explore is a dual failure:
 OOG at maximum point of penetration AND discovering a failed stage

Returning to the maximum point of penetration....
 A teammate suffers a catastrophic gas loss mandating gas-sharing



We'll assume, for the exercise, that all divers precisely share an RMV
 Each diver used 700psi (35cf) to get to this point after dropping the stage bottles
 Two divers will require 70cf (1400psi) to return to that point

35 minutes back to the stages place us at minute 104 (adding a minute for gas share)
 1400psi gas shared from tanks starting at 2300psi TP = 900psi remaining in backgas



And this is when calamity strikes again...

The OOG diver's stage is also malfunctioning

The OOG diver remains on donated backgas while the donating diver gas switches

Each diver used 1300psi from a single bottle (33cf) to make it to this point
 Each diver requires 33cf to get home

The donating diver is breathing their stage as normally and, therefore, we know has plenty of gas

The OOG diver continues to have access to 900psi (45cf) of denotable gas from the donating diver's back

33cf in redundant gas supply = ~700psi

We add yet another minute for the stage pickup kerfuffle and a 32 minute swim out
 Our divers surface at minute 137

After more than an hour of swimming very close together

	STAGE	BG
SP:	3000	3000
UP:	1300	700
DP:	1700	X
TP:	X	2300

Distance: 960

DP: 1700
 TI: 32

TP: 2300
 TI: 68

STAGE
 PO: 400
 TO: 137

PO: 900
 TO: 104

Distance: 2010

BACKGAS
 PO: 300
 TO: 137

But there is still gas in everyone's reg so everyone can go home for tea and cookies

****NOTE****

The above accident management plan sharing gas all the way to the exit assumes doubles.

In sidemount configuration the OOG diver should remain on whatever functional stages are available for as long as possible to allow for independence and speed/efficiency of exit.

Why Not Straight Thirds?

This is the most common mistake applied to stage bottle gas planning

Without going step-by-step, all other parameters are the same, this is the way such a dive would play out if all goes well

	STAGE	BG			
SP:	3000	3000		Distance: 750	
UP:	1000	1000		DP: 2000	TP: 2000
DP:	2000	X		TI: 25	TI: 76
TP:	X	2000			
<hr/>					
	PO: 1000		PO: 1000		Distance: 2250
	TO: 152		TO: 126		

Drop was made at 25 minutes and 750 feet penetration
 Compared to 32 minutes and 960 feet penetration using "Half Plus" - 7 minutes later

Turn is at 75 minutes and 2250 feet penetration
 Compared to 68 minutes and 2010 feet penetration using "Half Plus" - 7 minutes earlier

Total run time of 152 minutes compared to 136
 Dive time difference of 16 minutes and 200 feet of penetration

Is losing that dive time and penetration worth the frustration of all the extra math?

	STAGE	BG			
SP:	3000	3000		Distance: 750	
UP:	1000	1000		DP: 2000	TP: 2000
DP:	2000	X		TI: 25	TI: 75
TP:	X	2000			
<hr/>					
	PO:		PO:		Distance: 2250
	TO:		TO:		

Same failure as before - total OOG at maximum point of penetration

One diver used 1000psi going in, two divers will use 2000psi coming out

	STAGE	BG
SP:	3000	3000
UP:	1000	1000
DP:	2000	X
TP:	X	2000

Distance:	750
DP:	2000
TI:	25

TP:	2000
TI:	75

PO:	
TO:	

PO:	0
TO:	125

Distance:	2250
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Without even adding in a minute here or there for stage handling or dealing with the OOG
Our divers just barely make it back to their stage bottles

If they discover, in this moment, that one of the stages is dead...

Well... so is one of the divers.

Sure, each breathed 1000psi to get there and there's 2000psi left in their one working stage

But there's only one reg

Are they gonna buddy breath for 25 minutes as they exit?

Breathing the very last gasp just as they surface?

And that's why not straight thirds