TOTAL GAS PRESSURE INFORMATION SHEET
Point Four Systems Inc.
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Gas Bubble Disease (aka Gas Bubble Trauma)

Figure 1: Bubble formation in Zebra Fish due to supersaturation.

"Gas Bubble Disease" can result when the water is supersaturated with gas (bottom of a waterfall or overactive aquarium aerator).

Both oxygen and nitrogen enter the fish via the gills, where it is rapidly distributed via the bloodstream to the tissues. At this juncture, supersaturated gases come out of solution and form gas bubbles, thus leading to the condition known as "gas bubble disease".

Supersaturation by nitrogen is generally the culprit, but oxygen alone (i.e., in systems using oxygen injection) may cause GBD. With zebrafish research systems, the cause is often a leaky pipe on the suction side of the pump, which causes air injection.

Unfortunately, many cases of GDB do not present specific clinical or pathological changes – i.e., fish die without visible bubbles in the tissues.

The main symptoms are:

- Bubbles (emboli) visible in the lateral line, gill filaments, gill covers and fins
- Exophthalmia (bulging eyes)
- No visible signs

Results in:

- Damage to blood capillaries
- Impaired organ development and function, particularly in relation to the gills
- An increased susceptibility to disease
- Behavioural effects (more vulnerable to predation)
- Etc.

Definitions

a) Barometric Pressure:
The "weight" of the air above the water surface.

b) Hydrostatic Pressure:
The "weight" of the water.
1 atm = 760 mmHg = 34 ft freshwater = 33 ft saltwater

c) Total Dissolved Gas Pressure:
The sum of the pressures exerted by the dissolved gases in the water.

TGP Calculations

$\mathbf{P_{TG}}$ = Total Dissolved Gas Pressure

$$\mathbf{P_{TG}} = pO_2 + pN_2 + pCO_2 + pH_2O + p\ldots$$

or $$\mathbf{P_{TG}(\%)} = (P_{TG} / P_{BP}) \times 100$$

Where:

pO_2 = partial pressure of oxygen
pN_2 = partial pressure of nitrogen
pCO_2 = partial pressure of carbon dioxide
pH_2O = partial pressure of water vapour
p… = all other partial pressures present (from dissolved gases)

$P_{TG}(\%)$ = TGP expressed as percent saturation
P_{BP} = Barometric Pressure at water surface

Therefore,
If the water is in equilibrium with air:
TGP = BP and % sat = 100%
If the water is supersaturated:
TGP > BP and % sat ≥100%

TGP can also be expressed as Delta P:

Delta P = TGP – BP

How to calculate N_2?

If we assume that the dissolved CO_2 and Ar are negligible, then we can use the measure of TGP and Dissolved Oxygen to determine the value of dissolved N_2.

$$TGP = pO_2 + pN_2$$

where

pO_2 is the partial pressure of Oxygen

pN_2 is the partial pressure of Nitrogen

To facilitate the equation, both the TGP and DO measurement should be expressed as a percentage.

$$TGP\ (\%sat) = [DO\ (\%sat) \times 0.2095] + [N_2\ (\%sat) \times 0.7808)]$$

Solve for N_2:

$$N_2\ (\%sat) = [TGP - (0.2095 \times DO)] / 0.7808$$

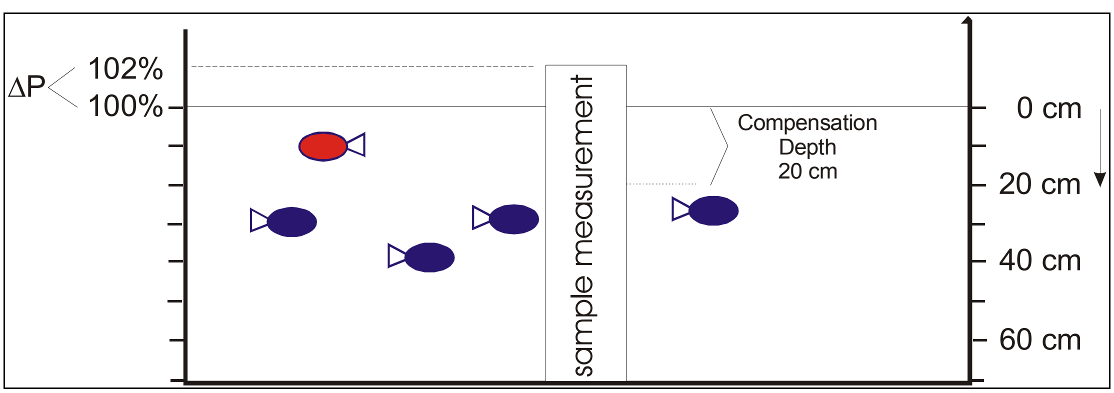
Compensation Depth

When TDG is at 110% at the surface of a water body, the TDG saturation one meter (3 feet) below the surface is 100%. For each meter you go down in the water, because the water pressure goes up (hydrostatic pressure), the TDG saturation actually experienced by the fish drops by 10%. Therefore, when the surface TDG is 120%, a fish two meters down is exposed to a TDG level of only 100%.

Fish sense high gas pressures, and like a diver, will go deeper in the tank to compress the gases and thereby prevent bubble formation. When water is at 102% gas saturation (*figure 2*), for example, the compensation depth (or depth at which bubbles will not form) is 20 cm (8 inches).

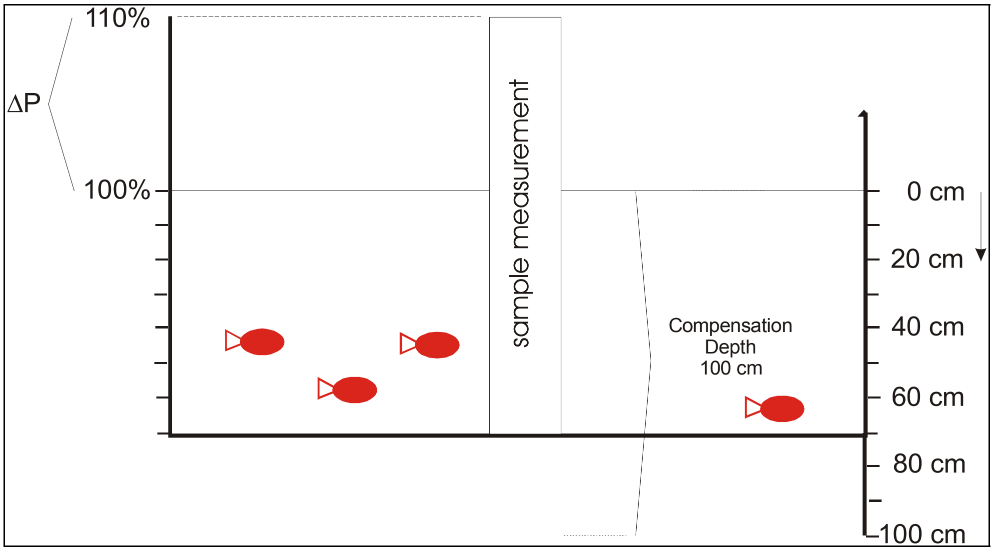
As a guide, for every 1% increase in gas pressure, the fish have to swim 10 cm (4 inches) deeper in the water to equilibrate. If the total gas pressure increases to 110% and the depth of the tank is only 50 cm (20 inches), the fish cannot escape and the consequences will be 100% mortality in about 30 minutes (*figure 3*).

<u>*Figure 2*</u>: Compensation depth with proper tank depth.



DP = 0.02 atm (2%), compensation depth is: 2 x 10cm = 20 cm (8”)

Figure 3: Compensation depth with tank not allowing for minimum depth required.



DP = 0.10 atm (2%), compensation depth is: 10 x 10cm = 100cm (40")

Current Guidelines

British Columbia Ministry of Water, Land and Air Protection (MWLAP) Guidelines:

Freshwater & Marine Aquatic Life
Max. DP ≤ 76 mmHg (or **110%** at sea level)

Hatchery Environments
Max. DP = 24 mmHg (or **103%** at sea level)
DP = 0 mmHg when pO_2 is ≤ 100 mmHg

Visit http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/tgp/tgp_over.html for more details.

PT4 Tracker with TGP Smart Probe: Features

- Known as a TGP Meter (aka Saturometer or Tensionometer)
- 2 pressure sensors: TGP and BP
- Response time is 5 to 10 minutes (this is reduced by keeping the probe in movement while taking a measurement)
- Datalogging capable with user defined time intervals and logged parameters.

- Calibration is simple:
  - Probe must be dry (leave in air for at least 30 minutes)
  - Check with the local airport or weather station (internet) for the latest Barometric Pressure.
- Note: the accuracy is increased by using this meter for in-situ measurements or for large samples (> 10 litres) as there would be a loss of dissolved gases due to agitation of the sample or contact with the air over time)