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www.scuba-clinic.com service@scuba-clinic.com

Tech talk #4: "The Dupond-Dupont -Dilemma" of second stage features part I

Who doesn't remember from his childhood the Adventures of TinTin and the notorious detectives Dupond-Dopont (French) or Thomson and Thompson (English)? As there seems to be a little confusion around some second stage second feature functions: 'diver adjustable inhalation effort' and 'venturi effect', time to investigate and see what the effects of each feature are. This week we'll have an in-depth look at the adjustable inhalation effort.

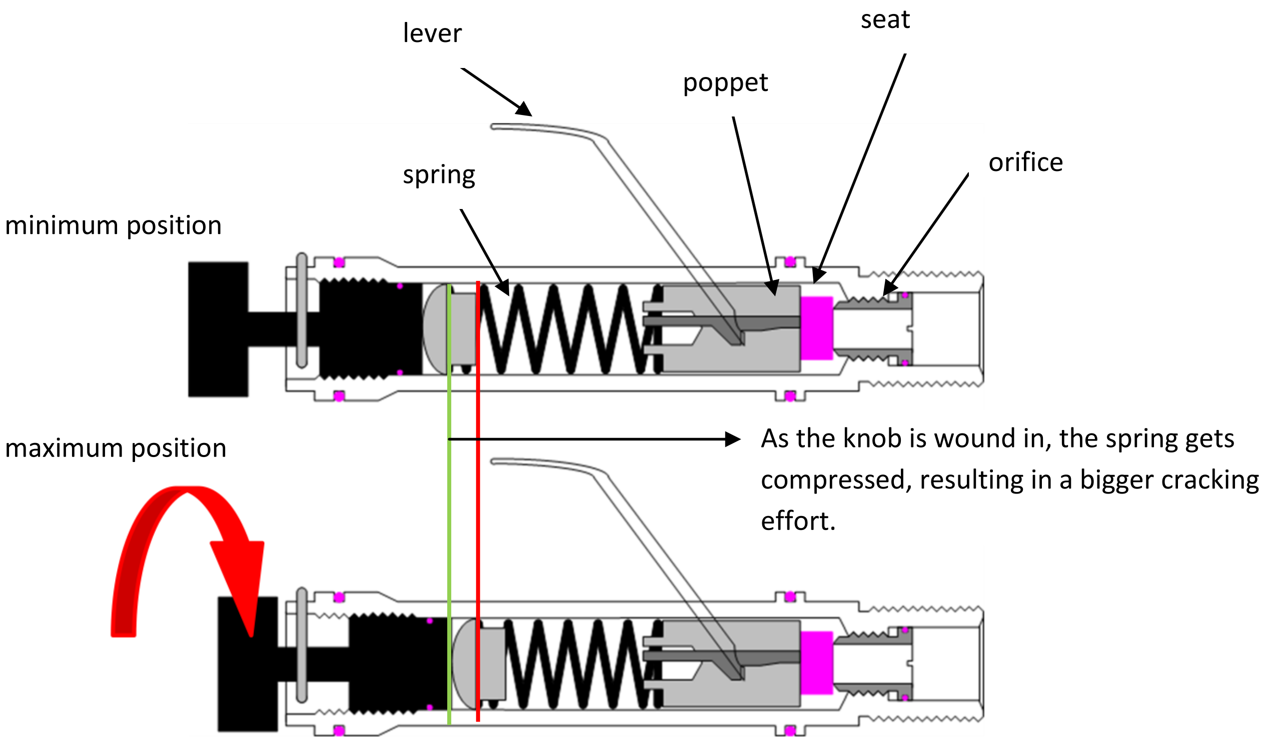
First things first, let's define cracking effort: cracking effort is the minimum amount of inhalation effort (vacuum) required to begin the airflow through a regulator. It can be measured by using a Magnehelic gauges and is most commonly expressed in inches of water. It is important to keep in mind that this 'static' parameter 'cracking effort' is measured with no flow through the second stage. However, this effort can also be measured during flow conditions and often also is referred to as inhalation effort. Under dynamic or flow condones this inhalation effort is the amount vacuum required to obtain a certain flow (e.g. 10 SCFM or 283 lpm).

The cracking effort is specified by the manufacturer and will be different for each regulator type. To give a very much generalized idea of the 'value' of the cracking effort, most second stages will have a cracking effort between 1 and 1.6 inches of water for primary first stages and up to 2" of water for secondary second stages (octopus). Furthermore the cracking effort will also be dependent on the intermediate pressure of the first stage, hence the importance of setting up a second stage with a specific first stage. Interchanging second stages between first stages could change the performance characteristics of the second stage. There always will be a minimum amount of cracking effort, if the latter was not the case, your regulator would free-flow as soon as you open the cylinder valve or enter the water.

The cracking effort will be affected by numerous factors such as: the intermediate pressure from the first stage, the spring tension of the poppet assembly, alignment of hard and soft seats, flaws in the seating surfaces, lever height, position of the orifice in the second stage housing... It is the technician's job to balance these variables carefully and ensure your regulator is set to the manufacturers' specified cracking effort. However over time, due to wear and tear, this cracking effort can change.

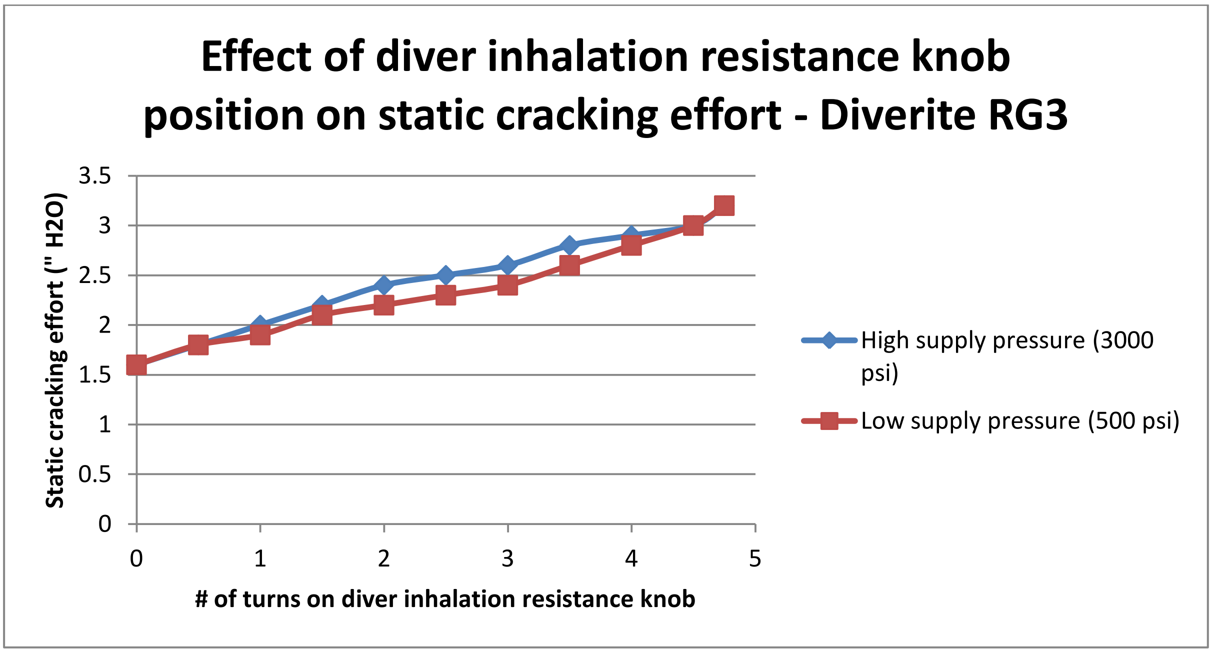
Looking at some basic regulators, for example the Aqualung Calypso or a Scubapro R295 the cracking effort is 'fixed'. Under certain conditions like surf, or strong currents it could happen that the erratic water flow could 'trigger' the second stage and supplied the diver with some 'unwanted' air. Therefore, on high-end regulators manufacturers have incorporated a 'diver adjustable inhalation effort'. Examples hereof are the Scubapro S600, Apeks XTX50. By incorporating an external feature (knob) the diver has the possibility to stiffen the spring load on the poppet hence increasing the inhalation effort. Stiffening the spring load will assist in dampening the water surges to match the diving conditions. Each manufacturer will have its unique design on how to achieve this from very simple mechanisms to complicated 'Matryoshka Dolls'. In most cases, with the knob fully wound out, the cracking effort will be at its minimum. However, in some designs, with the knob in its minimum position, there will be a slight air leak (some Oceanic models).

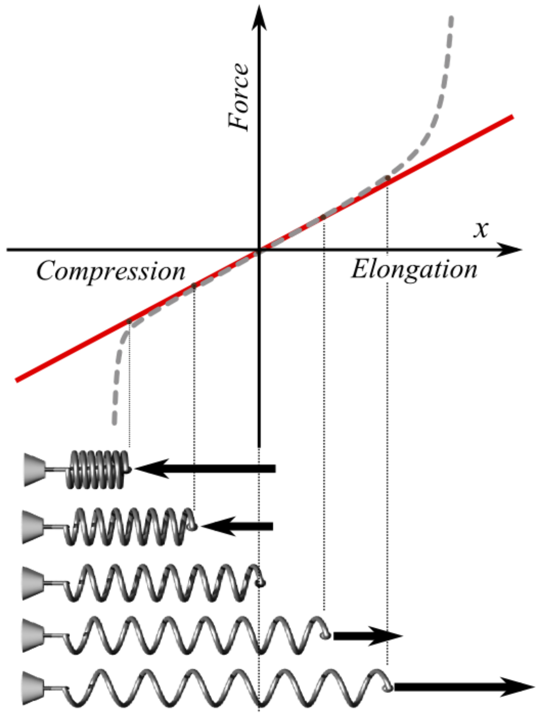
In order to visualize exactly what happens, I quickly drew this cross section of a simplified barrel type second stage with an externally adjustable inhalation effort feature. The top drawing is a cross section with the knob fully wound out (minimum position), the bottom drawing a cross-section with the knob fully wound in (maximum position). It can be observed that with turning the knob in, it shifts to the right, compressing the spring.



So said all the above, we took a Diverite RG3 first and second stage and put it on the test bench to see how turning the inhalation resistance knob affects the cracking effort. On this particular regulator, we could achieve 4 ¾ turns. With the knob in its minimum position the cracking effort is 1.6” of water and in its maximum position (fully turned in) the cracking effort is 3.2” of water. There was barely any change between low or high supply pressures. To make it more interesting, we turned the knob in ½ turn increments and plotted this out on a graph. You can observe a nice linear increase as the knob is turned in due to the increase in spring tension (spring compression). This shouldn’t be a surprise as the spring force will linearly increase within its working range (Hooke’s law).

Diverite RG3 1st and 2nd stage		
	Low supply pressure (500 psi)	High supply pressure (3000 psi)
# of turns	static cracking effort (" H2O)	static cracking effort (" H2O)
0	1.6	1.6
0.5	1.8	1.8
1	1.9	2
1.5	2.1	2.2
2	2.2	2.4
2.5	2.3	2.5
3	2.4	2.6
3.5	2.6	2.8
4	2.8	2.9
4.5	3.0	3
4.75	3.2	3.2

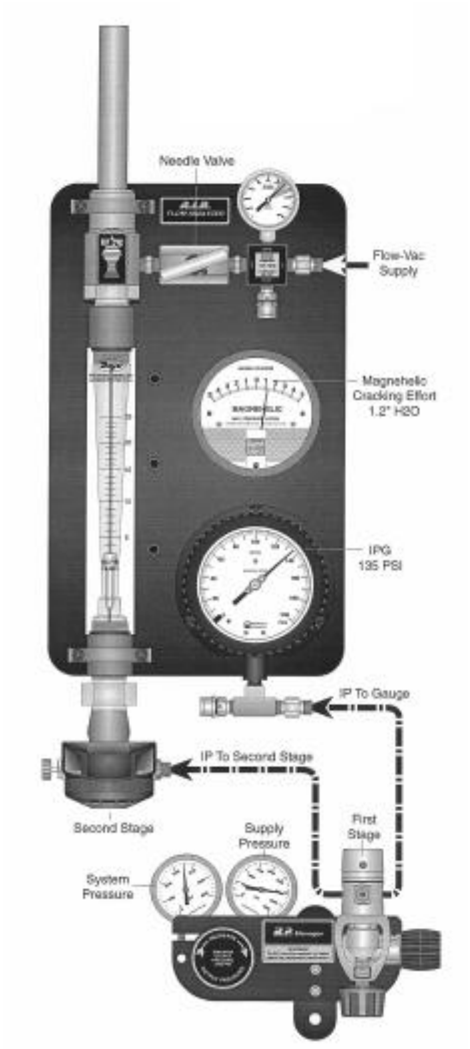




Tales from the bench: quite often we see high end regulators in the shop with the control knob fully wound in. I agree its personal preference as to where the adjustable inhalation effort it set at, however I find it a bit hard to understand why you'd turn it in so hard that the cracking effort might reach 4 to 5" of water so you nearly have to suck the air out of the regulator. That's not called nice and easy breathing any more for a high-end regulator. However, it most often masks an underlying problem: in these cases turning the inhalation resistance to its minimum position, the regulator is free-flowing. As mentioned above, unless the regulator is designed to do so, this is not an OK situation and most likely your regulator is due for a service.

In the end, the choice what to do with this information is yours, we're not the 'Scuba Police', but each one of you can surely make informed decisions. This article does not favour any brands nor claims performance comparisons between brands or condemns brands, it's just an experiment.

Test set-up:


Needle Valve
Flow-Vac Supply
Magnehelic Cracking Effort 1.2" H2O
IPG 135 PSI
IP To Gauge
IP To Second Stage
Second Stage
First Stage
Supply Pressure
System Pressure