

SCUBALAB
SPECIAL
REPORT

MUSCLE REGS

WE WENT LOOKING
FOR THE OUTER
LIMITS OF REGULATOR
PERFORMANCE AND
FOUND IT IN 16
EXTREME BREATHERS.



ATOMIC AQUATICS
SPECIAL REPRINT
COURTESY OF
SCUBA DIVING
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ATOMIC AQUATICS T2

THE T2 HIT THE MARKET in May, easily earned a 2005 Testers' Choice in our June review of new regulators, and has had divers talking ever since. Both first and second stages are built with solid billet titanium components, creating a corrosion-free breathing system that weighs less than two pounds. The reg comes with an all-titanium version of Atomic's Comfort Swivel on its second stage, and uses the company's patented Automatic Flow Control, a depth-activated venturi control that automatically balances breathing performance and stability as depths increase.

In standard breathing simulator tests the T2 delivered a perfect score without breaking a sweat. In the muscle test the reg was able to attain a breathing rate of just under 91 RMV. In ocean tests the reg was rated excellent in all ergo categories but bubble interference, where it earned a very good.



ATOMIC AQUATICS T1X

REPLACED BY THE T2, the T1x (a 2002 Testers' Choice) is no longer in production for the U.S. market but was still available at the time of our test. It aced all of the standard breathing simulator tests, then handled a breathing rate of just under 85 RMV in the muscle test. It was also a test diver favorite in the water, earning an excellent rating for ease of breathing. It also scored well for dryness, clearing and overall comfort.



ATOMIC AQUATICS M1

THE M1 IS MANUFACTURED with Monel internal parts. Monel is high-grade stainless-steel known for its strength, corrosion resistance and oxygen compatibility. Like its Atomic brethren, the reg is equipped with Atomic's Automatic Flow Control, a depth-activated venturi control that automatically balances performance and stability as depth increases. Also like its brethren, this reg turned in **Excellent** performance on the breathing simulator, earning perfect work of breathing scores when subjected to our standard reg tests. In the muscle test, it reached a breathing rate of just over 81 RMV.

Past and present in-water tests have shown the M1, a 2002 Testers' Choice, to be a real easy breather in all positions. The reg has a very efficient purge system and minimal bubble interference. Test divers liked the mouthpiece and low-pressure port turret on the balanced piston first stage that simplifies hose routing.

DEFINING OUR TERMS

RMV. Or Respiratory Minute Volume. This is basically the amount of gas that can be ventilated through the lungs in one minute.

37.5 RMV represents how a physically fit recreational diver might breathe while swimming a long distance (for comparison, a relaxed diver making a drift dive will be breathing at about 22 RMV or less). A diver could theoretically maintain 37.5 RMV for only about five minutes without becoming significantly winded.

62.5 RMV is considered a standard "heavy work" breathing rate, what commercial divers might be breathing when active on a project. A recreational diver in excellent condition would be able to maintain this rate for only a couple of minutes.

75 RMV is considered an "extremely heavy work" breathing rate. A diver in excellent condition can breathe at 75 RMV for only about a minute, even at shallow depths. This rate can also provide a pretty good indication of a regulator's ability to support two divers breathing off the same first stage in an air-sharing situation.

WORK OF BREATHING. Also referred to as External Work of Breathing or EXT WOB. This is the sum of the inhalation and exhalation effort expressed on the breathing simulator in joules per liter, or j/l, as captured on a "breathing loop," a graphic representation of a regulator's total inhalation and exhalation performance.

TEST PARAMETERS. Following internationally accepted test standards, a regulator's work of breathing is measured in joules per liter (j/l) for each complete inhale/exhale cycle, during which the highest inhalation or exhalation pressure experienced by the "diver" should never exceed 25 millibars or a total WOB of 3 j/l. If a reg does exceed these parameters, it doesn't mean that it stops delivering air—only that the breathing resistance at some point in the cycle is higher than what is considered acceptable.



ATOMIC AQUATICS B2

ATOMIC'S B2 FEATURES a balanced piston first stage with a low-pressure port swivel turret to simplify hose routing. The second stage is built with titanium components and features Atomic's Comfort Swivel, which we consider the best second stage swivel around. This 2003 Testers' Choice breathed effortlessly on the simulator, delivering perfect scores on ScubaLab's standard tests. When pushed to its limits, the reg was able to achieve a breathing rate of just a tad over 75 RMV.

Take the B2 into the water and it breathes easily in all positions and is dry as a bone. It is equipped with a resistance knob and Atomic's Automatic Flow Control instead of a dive/pre-dive switch. According to Atomic, this depth-activated venturi control automatically balances performance and stability as depth increases. Its dual compound mouthpiece was a favorite among test divers, along with the second-stage swivel.



ATOMIC AQUATICS Z2

THE Z2 ONLY RECENTLY hit dive stores, but already it is developing a reputation as a superb breather. When subjected to ScubaLab's standard simulator test protocols, the Z2 delivered perfect simulator scores. When pressed to the limit, it was able to achieve one of the best breathing rates of this group, just over 87 RMV. This superior performance carries into the water as well, where test divers found the reg a very easy and dry breather in all positions with an excellent purge.

The Z2 has a new high-flow second stage casing similar to what's on the new T2. Like all Atomic regs, the Z2 also uses Atomic's patented Automatic Flow Control and comes with a great dual composite mouthpiece. The first stage is available with either seven fixed low-pressure ports of five low-pressure ports on swivel.



ATOMIC AQUATICS Z1

THE Z1 (so-named for the zirconium/nickel coating on the brass valve body of the second stage) is the least expensive model in Atomic's line, yet it features all of Atomic's design innovations and can stand up with the priciest of them when it comes to performance. Earning perfect simulator scores under normal test conditions, this budget reg, which received a Testers' Choice in 2002, achieved a maximum breathing rate of over 81 RMV at 198 feet.

In the water, the Z1 offers very good breathing performance in all positions. It also breathes dry and clears easily due to a very powerful purge. With a compact balanced piston first stage offering seven low-pressure ports and a lightweight second stage, this regulator is efficient and comfortable and has been a consistent favorite among test divers, although its standard mouthpiece tends to be a bit too small for many divers' tastes.

SO WHAT MAKES THESE REGS DIFFERENT?

THE 16 MODELS THAT met or exceeded our muscle reg threshold are a diverse lot. They range in price from \$375 to \$1,596. Seven have balanced piston first stages, nine have balanced diaphragm first stages. All but one have balanced second stages. All but one have some kind of user adjustment, and all but three of these user adjustments include breathing resistance knobs on their second stages.

So what's the secret to their extreme capabilities? Is it in the first stage? The second stage? Parts or materials or maybe machining? We put these questions to manufacturers. The answer: All of the above. The devil, they say, is in the details.

Unfortunately, that's about all they were willing to say, although it's understandable that they wouldn't be eager to share their secrets. But we couldn't help but notice these regs have a few things in common.

ACCESS TO BREATHING MACHINES DURING THE DESIGN PROCESS. The manufacturers of these muscle regs either own, or have access to, an ANSTI breathing simulator. This ability to test design modifications takes the guesswork out of engineering breathing performance.

A ROCK-SOLID FIRST STAGE. Muscle regs tend to have really solid first stages, built upon generation after generation of successful designs. Past ScubaLab tests have shown that a weak second stage powered by a solid first stage will rise to the occasion. But put a well-performing second stage on a poorly performing first stage, and you'll get a poorly performing reg. Of course, these muscle regs have solid first and second stages, or they simply couldn't do what they can do.

THE ABILITY TO BALANCE SHALLOW AND DEEP WATER PERFORMANCE. Having a reg that goes to the extremes is great, but all of the muscle reg manufacturers agree: You can't ignore the primary function, which is to deliver gas efficiently at standard recreational diving depths.

REPEATABLE PERFORMANCE. One manufacturer claimed that it is relatively easy for a good engineer to make one super-performing reg. The challenge is to make a thousand of them and have them all perform the same. Repeatability requires quality parts and tight manufacturing tolerances.

CHARTING THE OUTER LIMITS OF REG PERFORMANCE

First, a quick refresher course on our terms:

RMV.

Stands for Respiratory Minute Volume. This is basically the amount of gas that is ventilated through the lungs in one minute.

WORK OF BREATHING.

Also referred to as External Work of Breathing, or EXT WOB. This is the sum of the inhalation and exhalation measured by the breathing simulator in joules per liter, or *j/l*.

TEST PARAMETERS.

Following internationally accepted test standards, a regulator's work of breathing is measured in joules per liter (*j/l*) for each complete inhale/exhale cycle, during which the highest inhalation or exhalation pressure experienced by the diver should never exceed 25 millibars or a total EXT WOB of 3 *j/l*. Note: If a reg does exceed these parameters, it doesn't mean that it stops delivering air—only that the breathing resistance at some point in the cycle is higher than what is considered acceptable.

SIMULATOR TESTS DEFINED

TEST A (37.5 RMV @ 132 FSW).

This is the breathing rate/depth combination that most closely represents recreational diving. A breathing rate of 37.5 RMV represents how a physically fit recreational diver might breathe while swimming a long distance. A typical diver could theoretically maintain 37.5 RMV for only about five minutes without becoming significantly winded. For comparison, a relaxed diver making a drift dive will be breathing at about 22 RMV or less.

STANDARD TEST SCORES

Tests A, B, C and D are the standard ScubaLab breathing machine tests and are scored on a 2 to 5 scale that represents the EXT WOB expressed in *j/l* as follows:

5 = EXCELLENT

The regulator can achieve the breathing rate/depth category with a EXT WOB of 1.05 *j/l* or less.

4 = VERY GOOD

The regulator can achieve the breathing rate/depth category with a EXT WOB of 1.06 to 1.55 *j/l*.

3 = GOOD

The regulator can achieve the breathing rate/depth category with a EXT WOB of from 1.56 to 2.25 *j/l*.

2 = FAIR

Any regulator that can achieve the breathing rate/depth category with a EXT WOB of 2.26 to 3.0 *j/l* which is the EN 250 limit.



MANUFACTURER/ Product/Contact	PRICE	MADE IN	WARRANTY	FEATURES				SIMULATOR TESTS					
				1st STAGE	PORTS	2nd STAGE	2nd STAGE ADJUSTMENTS	FACTORY-READY NITROX CAPABLE	A (37.5 RMV @ 132 fsw)	B (75 RMV @ 132 fsw)	C (62.5 RMV @ 165 fsw)	D (62.5 RMV @ 198 fsw)	Maximum RMV @ 198 fsw within test parameters **
ATOMIC AQUATICS T2 www.atomicaquatics.com	\$1,395	USA	Ltd. Lifetime	Balanced piston	2 HP 5 LP	Balanced	Resistance Knob	Up to 40%	5	5	5	5	90.8
ATOMIC AQUATICS T1x* www.atomicaquatics.com	\$1,596	USA	Ltd. Lifetime	Balanced piston	2 HP 5 LP	Balanced	Resistance Knob	Up to 40%	5	5	5	5	84.8
ATOMIC AQUATICS Z2 www.atomicaquatics.com	\$429	USA	Ltd. Lifetime	Balanced piston	7 HP 5 LP	Balanced	Resistance Knob	Up to 40%	5	5	5	5	87.2
ATOMIC AQUATICS Z1 www.atomicaquatics.com	\$379	USA	Ltd. Lifetime	Balanced piston	2 HP 7 LP	Balanced	Resistance Knob	Up to 40%	5	5	5	5	81.5
ATOMIC AQUATICS B2 www.atomicaquatics.com	\$699	USA	Ltd. Lifetime	Balanced piston	2 HP 4 LP	Balanced	Resistance Knob	Up to 40%	5	5	5	5	75.3
ATOMIC AQUATICS M1 www.atomicaquatics.com	\$699	USA	Ltd. Lifetime	Balanced piston	2 HP 5 LP	Balanced	Resistance Knob	Up to 80%	5	5	5	5	81.1

* No longer manufactured for the U.S. market, but available at the time of initial testing. ** See explanation of test meters on page 100.

* No longer manufactured for the U.S. market, but available at the time of initial testing. ** See explanation of test parameters on page 100.

TEST B (75 RMV @ 132 FEET).

For a single diver, this is an "extremely heavy work" breathing rate. A diver in excellent condition can breathe at 75 RMV for only about a minute, even at shallow depths. This rate also tests a regulator's ability to support two divers breathing off the same first stage in an air-sharing situation.

TEST C (62.5 RMV @ 165 FEET).

This is the EN250 test. In addition to going beyond the traditional depth limit of recre-

ational diving, this test uses an RMV of 62.5—a standard "heavy work" breathing rate similar to what commercial divers might be breathing when active on a project. A recreational diver in excellent condition would be able to maintain this rate for only a couple of minutes.

TEST D (62.5 RMV @ 198 FEET).

This is the U.S. Navy's basic regulator test, representing a standard "heavy work" breathing rate similar to what commercial divers might be breathing when active on a project and con-

ducted well beyond traditional recreational diving depth limits.

MUSCLE POINT.

This is not a standard ScubaLab breathing machine test and is used in this special report only to gauge the outer limits of regulator performance. We set a threshold of 75 RMV @ 198 fsw. If a reg could meet that standard within the 25 millibar or 3 *j/l* parameters, we gradually increased the RMV to see where each reg fell out.