Notes on Biosystems Non-Magnetic Twin Hose Regulators
Jack Burt

I have been involved in the design and manufacture of various types of diving equipment since 1966. Most of this activity involved mixed gas closed circuit equipment. I designed the electronic control systems for the US Navy's Mark 10 Closed Circuit Rebreather when I worked at General Electric's Missile and Space Division.

In 1969 because of the downturn in the Aerospace business, those of us who worked at the Missile and Space Division were worried about our future job prospects. (Diving was a very tiny portion of GE's revenues). I joined 6 other GE Engineers in forming a new company called BioMarine Industries, Inc. BioMarine intended to make commercial diving equipment and medical electronics devices. In fact, BioMarine was never very successful in its commercial diving ventures, but our CCR-1000 mixed gas closed circuit diving apparatus became the standard for Navy SEAL and Army Green Beret dive teams.

An interesting offshoot of this was meeting members of the Navy's Explosive Ordinance Disposal (EOD) teams. EOD divers are very brave guys who defuse mines. These mines can be activated by magnetic or acoustic signals. BioMarine received a contract to modify its equipment to eliminate any magnetic materials and to make the operation as quiet as possible. This equipment eventually became the Navy Mark 16 Diving Apparatus.

Before the development of the Mark 16, EOD divers used specially manufactured versions of US Divers Two Hose Regulators. All of the metal parts were made of specially tested brass (to be sure that there were no impurities which would impart a magnetic signature) and were either painted or gold plated. Gold plating was necessary because any other plating medium would have been magnetic. In fact, all of the internal parts of the regulators may be replaced by standard US Divers parts as long as the regulators aren't to be used for Mine Disposal.

US Divers is located in Santa Ana, California. The Navy's EOD Technical center is located in Indian Head, Maryland. All of the regulators and parts had to be tested at Indian Head and, if the parts were non-magnetic, they would be marked with the "Low Mu" symbol (the Capital letter L superimposed upon the Greek Letter mu) and the date of testing. There were so many problems in passing the magnetic tests that the management of US Divers threw up their hands and decided that they could no longer supply equipment, particularly as the Mark 16 was soon coming.

In 1981 I left BioMarine and started Biosystems, Inc. in my basement workshop in suburban Philadelphia. I intended to design and manufacture electronic instruments, not diving equipment. However, some of my old friends in the Navy Diving community knew that I had contacts who could manufacture all kinds of weird parts and they asked if Biosystems could supply replacement parts to keep their Non-Mag US Divers regulators working. Fortunately, the Navy had paid US Divers to develop complete drawings of the regulators. These drawings were the property of the Naval Sea Systems Command (NAVSEA). For several years in the early 80's I would spend a day every couple of months working at the EOD Tech center's magnetometer testing both raw material and

finished parts. The pass rate ranged from 0% to 99%, about 85% was pretty average. Every spare parts contract went out for competitive bids, Biosystems was the only company either crazy enough or desperate enough to bid on the contracts. It should be noted that the rubber parts and plastic parts were never a problem and the standard US Divers parts always passed the magnetometer.

By 1983 the Mark 16 project was behind schedule and the Navy wanted to purchase some complete regulators. US Divers again declined to quote on the business, as did everyone but Biosystems. Over the next few years we may have manufactured up to 75 regulators, as well as making replacement parts.

In 1985, the Navy decided that they wanted to purchase 52 complete sets of Non Magnetic open circuit diving equipment, including twin air cylinders, reserve air valves, bands and harness assemblies. The cylinders were a very long lead time item and hugely expensive. They were made of Aluminum and were not strictly Non-Magnetic. When the cylinders were moved during magnetic testing, eddy currents would be generated in a magnetic field, these currents would be sufficient to cause a failure. The Navy recognized this and created a waiver for eddy currents for cylinders only.

Obviously, the open circuit diving equipment was noisy and, because of the eddy current problem, was not truly non-magnetic. The Mark 16 uses Inconel spheres for gas storage. Inconel has no eddy currents. Because the Mark 16 is a rebreather there are no bubbles and operation is silent.

Because Biosystems made so few of the regulators and other parts it was never possible to tool up and everything was made one at a time. Even though the negotiated contracts had a very slim profit margin (about 10%), costs were quite high. I would guess that a complete regulator assembly sold for about $2000 and a complete diving apparatus for about $5000 (In 1985 dollars!). Unfortunately Biosystems has no records going back that far.

biosystems
A Division of Bacou USA Safety, Inc.
651 South Main Street
Middletown, CT 06457
Phone: (860) 344-1079
Fax: (860) 344-1068
http://www.biosystems.com

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Dr. Samuel Miller
971 Fresno Street
Pismo Beach, CA 93449

Dear Dr Miller:

It was a real pleasure to get your letter today. You are completely correct, the Biosystems regulators which are now hitting the government surplus market are US Divers types and are non-magnetic. The date of manufacture was in the early 1980's.

These regulators were made for the US Navy's Explosive Ordinance Disposal (EOD) teams. These guys defuse mines, many of which are triggered by magnetic fields. Therefore, all of the parts in the regulators are non-magnetic. You will see that the regulators have a "low mu" mark engraved onto them.

After the regulators were made (of special non-magnetic brass) they were sent to the Navy's EOD headquarters in Indian Head Maryland for testing on a magnetometer. After they passed this testing they were sent into the field. The regulators were used with non-magnetic twin Aluminum cylinders which also had a non-magnetic valve and reserve assembly.

The regulators are identical in form fit and function with late US Divers double hose regulators. US Divers provided prints to the Navy so that other sources could make the parts. John Cronin, who was President of US Divers at that time did not want the hassle of making these parts, not knowing until magnetometer testing if they would be acceptable. At Biosystems we found that the hassle was too great also, we got out of the non-mag SCUBA business over 10 years ago.

The Navy has since replaced all of these open circuit apparatus with Mark 16 Closed Circuit SCUBA, designed by BioMarine (a company of which I was a co-founder). The big advantage of the closed circuit Mark 16 is that there are no bubbles. The sound of the bubbles could trigger a sensitive mine. The other difficulty with the Aluminum twin cylinders is that if the diver moved quickly the cylinders would cause a magnetic effect due to Eddy currents. Gas storage in the Mark 16 is in two cylinders (one for Oxygen the other for diluent gas) made of Inconel which has no magnetic signature.

Speaking of BioMarine, that company had a pretty interesting history. It was founded by six engineers who were formerly employed by General Electric's Missile and Space Division in Valley Forge PA.

At GE back in 1966 the company wanted to do zero-gravity simulations of Astronaut extra-vehicular activities. Astronaut Scott Carpenter said that his experiences in space were very similar to those which he had when SCUBA diving. GE had the idea of building a full-scale mock up of the Saturn S-IV-B fuel tank (which was to become Skylab) in the warm clear and calm waters off of Little Buck Island in the US Virgin Islands. Test subjects wearing pressurized space suits would then perform the tasks which NASA expected the astronauts to perform.

In order to determine how hard the test subjects were working the project manager at GE, Fred Parker, decided that he needed a BioMedical Engineer to design a Physiological Monitoring system to be incorporated into the life support system. I was recruited from a Graduate program at Drexel University and Temple Medical School in Philadelphia to do the job. When Fred told me that I would be trained in SCUBA diving and would be spending half of my time diving in the Islands I gladly gave up the academic grind and joined his team.

The apparatus we developed was really great. Because all of our tests were done in shallow water we developed a pure O2 rebreather which performed the additional task of pressurizing the test subject's space with water suit to 3.7 psi. A closed circuit system was desirable because with a breathing bag as a reservoir for the subject's breath there was no change in buoyancy with inhalation and exhalation. We instrumented the apparatus to measure the test subject's O2 consumption, recorded his EKG, and measured his respiration rate and tidal volume. We could really quantify just how hard a guy was working.

As we got more experience at GE and met more members of the diving community we decided that a mixed gas closed circuit diving application which could be used to depths in excess of 1000 feet would be a neat project for us to work on. GE approved the project and we developed this product which became the US Navy Mark 10. Although Alan Krassberg at Westinghouse had designed a sensor controlled deep diving rebreather previous to the Mark 10, it was never put into full production. We tested Mark 10's at simulated depths of over 1000 feet (naturally using Helium as a diluent) both the Navy Experimental Diving Unit (which at that time was still in the Washington DC Navy Yard) an at Duke University's hyperbaric facility. We did a lot of sport diving with the prototypes too. Without the limitation to 30 feet inherent in a pure Oxygen rebreather and with a duration of 8 hours without recharging we really had a lot of fun. We electronically controlled PPO2 to 0.8 atmospheres. Determining decompression schedules was always a challenge back in those days.

In the autumn of 1968 GE's management believed (correctly) that there was a very limited commercial market for mixed gas closed circuit diving equipment (which carried

a $10K price tag back then). GE also believed that the military market was very small. GE was looking to down-size our operation.

We stupid engineers were determined to prove GE's management wrong. The entire engineering team of GE's small diving operation left GE to form BioMarine Industries. In the first 3 years of BioMarine's existence we sold a grand total of 10 rebreathers, the CCR-1000. The company ran out of money.

Fortunately, we had been able to spin off the gas measuring technology developed for diving and we made instruments for measuring Oxygen levels in Anesthesia machines, Respiratory Therapy devices, and Neo-natal incubators. With this commercial business in place, we were able to raise money from outside investors to keep the company going. Unfortunately, the outside investors took over control of the company. Later we expanded to include instruments for measuring atmospheres in potentially hazardous workplaces like mines and confined spaces.

Because of the Vietnam War, in the mid 1970's the Navy SEAL teams and Army Special Forces (the Green Berets) standardized on the CCR-1000 for use in covert diving operations. The CCR-1000 became the Navy Mark 15. Over 1000 units were in service during the 1970's.

A non-magnetic version of the Mark 15 called the Mark 16 was designed for EOD forces. This was by no means a trivial exercise and took over five years of full time work by an Engineering team which had grown to 10 persons. During this time, in 1980, the outside investors sold what was now a profitable little company to Rexnord, a $2 billion/year company headquartered in Milwaukee.

Rexnord made it clear that they had little interest in the diving part of the business. Immediately after the sale I left the BioMarine division of Rexnord and became a consulting engineer. I incorporated as Biosystems, Inc. One of my first clients was the Navy for whom I worked on an electronic decompression computer. I also developed a line of gas monitors for Industrial Safety applications and Biosystems became a manufacturing company. When one of my friends in the Navy Diving community mentioned that US Divers didn't want to supply any more non-mag open circuit equipment I offered to supply the parts. In those days I would have done anything to turn a buck.

Unfortunately, Rexnord didn't have a clear vision for the BioMarine division and sales started to decline. A few years ago, the company which was down to about 10% of its previous size was sold to Neutronics, Inc. of Exton PA. Neutronics sold the tooling for the Mark 15 and Mark 16 to Carleton Controls of Florida who now supply spares for BioMarine diving equipment to the Navy. There never was a commercial market. Several companies have tried to introduce closed circuit mixed gas SCUBA but to my knowledge nobody has been commercially successful.

Fortunately, Biosystems has continued to grow. While we presently do almost nothing at all in the diving business, our gas detection products have a significant market share in the US. Last year I sold Biosystems to Bacou USA, a sister company of the French company Bacou SA. Among the divisions of the French Bacou company are three companies with an important contribution to Diving Technology: Commeines, Fenzy, and Fernez. Like Biosystems, these three companies have mostly left Diving for strictly commercial business in the Industrial Safety field.

Congratulations on your retirement. If you wish to do some more research on the history of mixed gas closed circuit SCUBA, you really should talk to the grand old man of the field, Fred Parker. I haven't seen Freddie for a few years. When he's not cruising on his sailboat he lives in Gwynned, PA a suburb of Philadelphia.

If there is anything I can do to help in your research, please let me know. Just writing this letter has revived many happy memories.

Sincerely,

Jack Burt

Jack Burt
President

Various notes from E-mails I have been copied on. E-mails were not address to me.

Biosystems Produced 52 units while I was still there. The 2 tanks per unit were 90 cubic ft aluminum. We, not only made the regulator but the crossover manifold between the tanks. All the the brass used required samples forwarded to Indianhead MD for magnatometer testing. The brass with tin coated and painted flat black so not to shine in the water. We also produced a set of working drawings for the Navy. These units were very expensive (approx $3000ea) and the project took about 2 years to complete. These "Twin 90's" which were actually quite outmoded and a whole pile of the latest and greatest rebreathers.....I guess it takes a while to invoke change on the Military. That's about the long and short of it as far as I recall. Not much excitement surrounding the old clunkers.

Gil Knott 2002

I was surprised to see this rig on E-bay. I guarantee that I assembled this piece originally. I worked for Biosystems for eight years as an engineer and machine shop manager. We built 52 complete units back in 1984-1985. We had them all tested at Indianhead, MD. They were supplied to the navy with 2-90 cubic ft aluminum cylinders.

Gill Knott 2002