Pneumatics breathe life into battlefield casualties

When soldiers are injured in combat, critical-care medical equipment, under the worst conditions, must work reliably.

When a field-portable ventilator was needed by the U.S. Army, engineers at Oceanic Medical Products, Atchison, Kansas, designed a pneumatic control system. With over 20 years of service around the world, a unit has never failed.

Transport ventilators assist seriously injured soldiers who can't breathe efficiently on their own. The devices deliver a precise, adjustable, volume of oxygen with each breath until patients reach a hospital or medical facility.

The Army demanded a small, light, ultra-reliable ventilator that could withstand the rigors of the battlefield, says William Gates, Oceanic Vice President for Innovation and Development. In those terms, there was no better choice than pneumatics.

"Electronic controls would have a hard time operating in harsh, remote environments," says Gates. "The units routinely face physical

The Magellan ventilator features a pneumatic control system. It's simpler than electronic controls and is more dependable in harsh environments.

abuse, extreme cold and heat, and sand and snow. And though electronics have greatly improved over the last 20 years, they still aren't quite suited for this kind of machine."

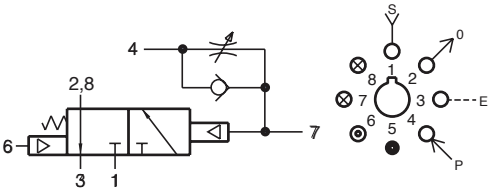
A pneumatic-control system also lets Oceanic use compressed oxygen gas for power. This eliminates the need for a battery and charger when electricity is not readily available.

"Pneumatics offered simplicity, that's part of the key to success," says Gates. The heart of the system is R-331 timing valves from Clippard Instrument Laboratory, Cincinnati. "They run flawlessly," he explains, and adjust to set the duration of each cycle.

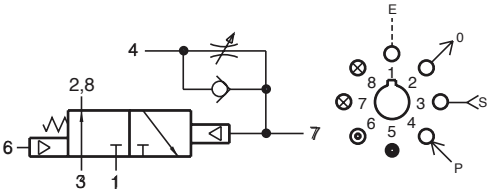
"Clippard has made these valves for a long time, and we liked their history. They have a mean time between failure of about 20 million cycles. That was gold to us," says Gates. It eliminated the need for endurance testing, he explains, which would have been expensive and delayed the launch by years.

Careful design and meticulous manufacturing allows Clippard's R-331 timing valves to run with little internal friction, resulting in a 20 million cycle life.

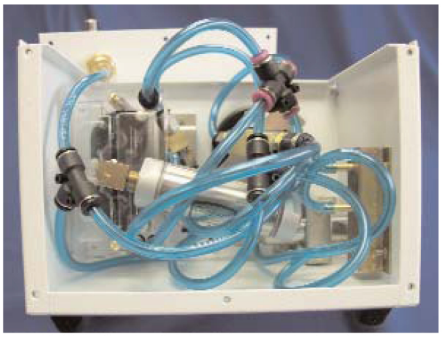
Delayed in Normally-Closed



Delayed in Normally-Open



In practical terms, a 20 million MTBF means the respirator can cycle every 6 seconds for about 10 years before a timing valve would be statistically likely to fail. And because the units see intermittent use, actual life is much longer. "Since 1986, the FDA has never had a reported failure of one of our ventilators, worldwide. That's absolutely unprecedented for a mechanical ventilator," says Gates.



Clippard's R-331 timing valve, behind the tubing.

The valve's reliability results from careful design and meticulous manufacturing, says Rich Humason, a Clippard Engineer. "We do a number of things inside the valve to reduce friction which, in turn, makes them last longer." One is what the company calls microgap construction. Instead of moving a seal across an orifice to control flow, as is the case with some pneumatic valves, the R-331 shifts an o-ring back and forth across a tiny annular opening. The gap is only about 0.010", so the seal travels just a short distance with little friction or wear. Yet the annular shape permits up to 9 scfm flow at 100 psi, says Humason.

Precision manufacturing techniques maintain tight gap tolerances to ensure consistent flow, he adds. They roller-burnish internal sealing surfaces and ball peen the gap edges to round off corners and eliminate burrs. This ensures the O-ring travels on a smooth, low-friction surface, with no asperities that could snag the seal.

Internally-lubed o-rings are another detail. Solid lubricant, such as molybdenum disulfide, is encapsulated in the seal. While this adds a bit of cost, combined with conventional lubrication it gives extra lubricity that further extends life. Special oxygen-compatible, medical-grade lubricants are used in the Oceanic unit.

Finally, the valves sit in a tough, Delrin® case that can handle abuse without damage. Clippard also supplies flow valves and an acrylic manifold for the ventilator. The latter eliminates several fluid connectors and lengths of tubing which boosts reliability.

The Army and Air Force have tested the ventilator rigorously. It saw extreme heat, subzero temperatures, fine sand, and severe vibration. Units dropped 50' from a helicopter survived. A simulated loss of cabin pressure at 30,000' didn't affect Oceanic's device. In contrast, electronic-controlled units that needed a reference atmospheric pressure signal shut down instantly.

The ventilator can be sterilized with ethylene-oxide gas and disinfected with alcohol or general cleaning agents, with no ill effects. In addition to military service, it sees widespread civilian use in ambulances, as well as in veterinary hospitals. It also goes on Oceanic's field-portable anesthesia machine, introduced a few years ago for the Army. The compact unit is simple to operate and technicians and doctors can maintain either machine with just a screwdriver and standard wrenches.

Clippard Minimatic®