SCUBA REGULATOR PERFORMANCE FOR UNDER-ICE SCIENTIFIC DIVING OPERATIONS

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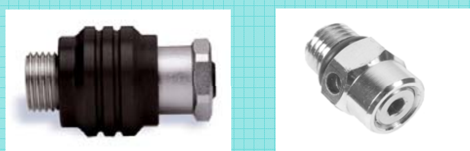
Background

Single-hose scuba regulators dived in very cold water have a probability of experiencing first- or second-stage malfunction yielding complete occlusion of air flow or massive free flow that rapidly expends a diver's air supply, both conditions referred to as regulator "freeze-up". Principal factors contributing to ice crystallization in the regulator second stage include manufacturer's design, materials, and quality control, exhalant breath of diver, adiabatic gas expansion, mass flow, time, and temperature. Operational diving safety concerns for exposures in an overhead ceiling environment include availability of independent back-up regulator system, free-flowing regulator shut-off capability, and sufficient air supply to reach exit or safety hole.

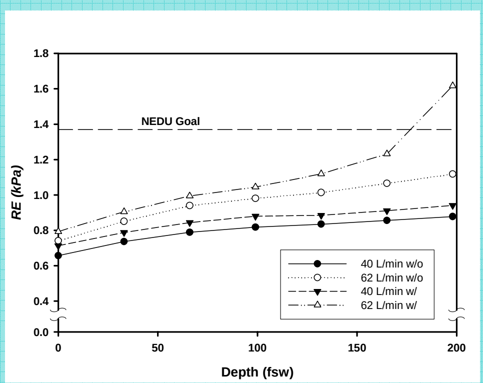
Methods

11 divers (mean height 180.1 cm, mean weight 84.6 kg) logged a total of 133 dives in -1.86ºC sea water under 6-m thick Antarctic fast ice. Dive profiles had an average depth of 38 msw and dive time of 29 min, including a mandatory 3 min safety stop at 6 msw. Twenty-seven commercially available, unmodified regulator units from 9 different manufacturers underwent standardized pre-dive regulator care and were randomly assigned to divers. Depths and times of onset of second-stage regulator free-flow were recorded.

Isolation Valve

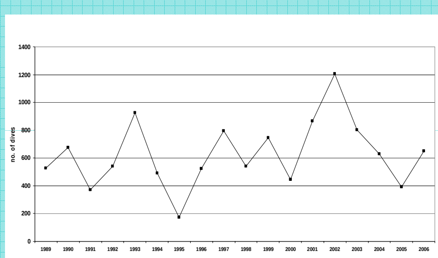


Zeagle isolation valve (free-flow shut-off device; product no. 333-0233) on the regulator second stage (left) used in conjunction with a first-stage overpressure relief valve (product no. 330-4905; right).



Effect of the isolation valve on resistive effort of an Apeks TX50 scuba regulator at respiratory minute volumes of 40 and 62.5 L/min. Tests were conducted under ambient temperature (~20° C). The triangle symbols indicate tests with the isolator valve in place, and the circles indicate regulator tests without the isolator valve.

USAP Scientific Diving Data



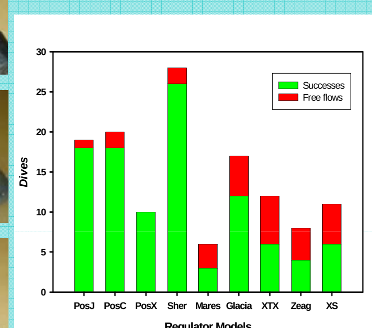
Results

In 133 dives, there were 28 free flows. The free flows were not evenly distributed across the regulator brands. The regulators classified for the purpose of the test as "better" suffered only 5 free-flows out of 77 exposures (6% combined incidence), and the others suffered 23 out of 56 exposures (41% free-flow incidence). Testing on three regulators was aborted when free flow incidence reached 50%. Differences between regulator free-flow incidences were tested by the Chi-square test. The pooled incidences for the four best performing regulators were compared to the five remaining regulators. The differences between the groupings was significant at P<0.001.

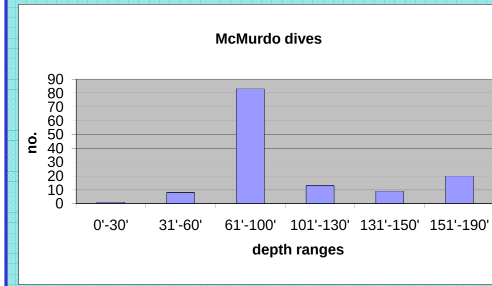
Conclusions

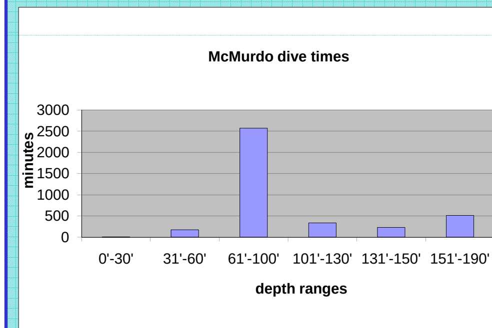
- Regulator freeze-up is a probabilistic event; even the best regulators can fail under polar conditions. Combined laboratory and field-testing, proper pre-dive regulator care, depth-dependent gas density control, breathing rate, and diver experience can influence freeze-up incidence.
- This field study narrowed the number of regulator models being considered for the rigorous conditions of the U.S. Antarctic Diving Program from 9 models to two: the Poseidon Xstream and the Sherwood Maximum SRB7600.
- Within 4 weeks after concluding this series of evaluation dives, two dive team members logged another 20 dives (13 Poseidon Xstream dives and 7 Sherwood SRB7600) experiencing zero free-flow incidents. Dive times averaged 35.5 minutes (range 29-51 mintues) in the following depth ranges 31-60 fsw (4), 61-100 fsw (8), 101-130 fsw (4), 131-150 fsw (2) and 151-190 fsw (2).
- Finally, the 1991 Sherwood SRB3600 regulators must follow the path of the Royal Aquamaster double-hose ice-diving regulators that were retired from the USAP in 1990. There are better breathing and more reliable regulators for ice diving available that meet scientific under-ice diving and military needs.

Regulator Test Units

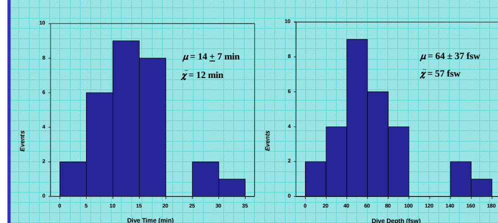


Test dive summary





Free-flow onset time and depth



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