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SHERWOOD MAXIMUS REGULATOR TEMPERATURE AND PERFORMANCE DURING ANTARCTIC DIVING

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In recent years, the Sherwood Maximus has become the predominant regulator in the U.S. Antarctic Research Diving Program. The purpose of this work was to evaluate the overall performance of this regulator and the effectiveness of an optional second stage exhaust valve heat retention plate made available in 1993. The Maximus failure rate, as reported by program divers between the 1991-92 and 94-95 seasons, was 1.7% (23 of 1341 dives). This contrasts a mean failure rate of 9.1% (50 of 551 dives) for all other regulators used during the same period (X^2 [1]=18.03, p<0.001). Maximus failure rates during the last two seasons when some of the regulators were equipped with heat retention plates were 2.3% (7/309) without the plate and 0.9% (6/633) with the plate (X^2[1]=2.76, p<0.10). Temperature data were collected during 18 dives during the 1994-95 season. Six divers were monitored during the course of three operational dives to a maximum depth of 122 fsw. Internal temperatures were sampled at one minute intervals in first stage, second stage without heat retention plate, or second stage with heat retention plate. Mean temperatures were -3.8±0.6 C (-5.6 to -2.2), 3.2±1.0 C (0.0 to 6.1) and 3.8±1.2 C (0.6 to 7.2), respectively. A Mann-Whitney U test confirmed that overall differences in second stage temperatures were significant (p<0.0001). Differences were significant across all but the shallowest of four 30 foot ranges. Regardless of the increased second stage temperature, it could not be concluded that addition of the plate augments the reliability of the regulator. However, because five of the six failures involving plate-equipped regulators may have resulted from user care problems unrelated to the regulator configuration, it is recommended that further trials be conducted.

Keywords: Antarctic diving; health and safety; polar; regulator performance; regulator temperature

INTRODUCTION

Open circuit scuba diving has been used as a research tool in the U.S. Antarctic Program's scientific research effort since at least 1961 (Peckham 1964). A large part of this diving has taken place in the vicinity of McMurdo Station (77° 51'S, 166° 40'E), where the sea water temperature ranges from -1.8 to -1.9 C (28.6-28.8 F). Historically, single-hose regulators have been prone to freezing and subsequent free flow failure. If the first stage is unprotected, ice may form around the pressure adjusting spring. In the second stage, moisture from the exhaled air of the diver (or any other fresh water contaminant) may freeze and cause regulator failure. Until recently, the U.S. Divers Royal Aquamaster (RAM) double-hose regulator was used almost exclusively for Antarctic diving. This practice was initiated following a series of open water evaluation dives off Point Barrow, Alaska in November of 1970 (water temperatures essentially constant at -1.7 C [28.9 F]). The double-hose regulator was so much more reliable than the available single-hose regulators that a U.S. Navy-wide policy was adopted that all scuba diving in water colder than 3.3 C (38 F) should be conducted with double-hose regulators (Bright 1972).

The fundamental advantage of the RAM regulator was primarily that its design kept both the first and second stages dry. Over time, however, as parts for the Antarctic RAM's became scarcer and the regulators themselves became old and battered, reports of failure became more common. A growing variety of single-hose regulators began to be used as substitutes for the aging stock.

Beginning in the 1989-90 austral summer season (August through February), a testing program was undertaken at McMurdo Station, Antarctica to measure the performance of specific regulators and quantify reliability. The testing program was expanded to include new regulators in 1990-91 (Bozanic and Mastro 1992).

The regulator currently used most extensively due to its demonstrated combination of reliability and ease of servicing is the Sherwood Maximus. The first stage of this regulator is isolated from the environment by means of a overpressure bleed valve. The second stage contains two mouthpiece fins which are designed to transfer the heat of exhaled air to the second stage mechanism. These fins are intended to help maintain the temperature of the second stage above ambient water temperature. This could reduce the risk of second stage freeze-up and subsequent free flow failure.

The manufacturer has suggested that the reliability and resistance to freezing of the Maximus could be further enhanced by the addition of another heat retention plate, this one placed over the exhaust valve. The goals of the present study were to determine, first, if the exhaust valve heat retention plate is effective in increasing second stage temperatures under polar diving conditions and, second, whether or not its presence improves overall reliability.

METHODS

Regulator Performance Assessment

Recent historical and current regulator performance was evaluated through review of a database constructed from dive log information submitted by all U.S. Antarctic Program divers operating out of McMurdo Station. Available information includes: dive location, partner(s), maximum depth, underwater time, safety stop information, repetitive dive status, dive computer used (if any), regulator model used, and details of any problems or regulator failures that occur. The latter includes depth of failure and elapsed time into the dive at which the failure occurred. Records of regulator configuration were maintained by the McMurdo-based Scientific Diving Coordinator. The divers were not aware of the presence or absence of the exhaust valve heat retention plate in regulators issued to them.

Regulator Temperature Assessment

The manufacturer provided exhaust valve heat retention plates and newly engineered second stage housings designed to accommodate them. Small holes were drilled in two first stage bodies and in two lever supports, the internal part through which air flows into the second stage. A small hole was also drilled through the second stage housing to allow passage of a thermocouple wire. Two Maximus regulators were assembled using these parts. Intermediate pressure was set at 125 psig, within the range of the manufacturer's specifications.

A thermocouple was inserted into either the first stage body or through the second stage housing and into the lever support. The thermocouple tip was held in place with silicone cement. The hole through the second stage housing was also sealed with silicone cement. The thermocouple was attached to an electronic, digital thermometer contained in a clear acrylic, submersible housing.

The submersible housing was attached to the back of a set of twin 71.2 ft^3 cylinders with duct tape. A Dacor Omnimax console computer was attached contiguous to the thermometer, also with duct tape. Elapsed time, temperature, depth, and cylinder pressure were recorded manually on an underwater slate at one minute intervals. Measurements were made by an accompanying diver swimming above the subject diver, with no physical contact between the two.

Regulator temperatures were assessed during a total of 18 operational dives. Six male scientific divers were monitored during three dives. A summary of subject characteristics is found in Table 1. Four subjects had multi-year experience diving in the Antarctic, two were first year polar divers.

Table 1. Summary of characteristics of scientific divers used in testing regulator temperatures.

	Age (years)	Height (cm)	Weight (kg)	BMI# (kg*m-2)
Mean	34.8	177	77.1	24.6
SD	5.6	4.7	6.9	2.0
Range	26-41	170-180	72.0-90.7	22.8-28.0

- Body Mass Index

Measurement of first stage, second stage without the exhaust valve heat retention plate and second stage with the plate were each dedicated to a single dive. Subjects were aware as to whether first or second stage temperatures were being monitored, but typically unaware as to which of the two second stage conditions they were under.

Differences in regulator failure rates were tested with Chi-square tests ($\mathbf{X}^2$) for contingency tables. Differences between second stage temperatures were tested with a Mann-Whitney U test, a rank sum test for comparing two sets of data. Significance for all tests was accepted at $p<0.05$.

RESULTS

Regulator Performance

Regulator performance records from the 1989-90 through 1994-95 seasons are summarized in Table 2. Regulators are ranked according to the total number of dives completed. Of those regulators accumulating at least 100 dives, the Poseidon Thor and Sherwood Maximus demonstrate the lowest failure rates of 1.1 and 1.7%, respectively. The RAM regulator has the highest failure rate of 17.4%. Little can be said about regulators that have accumulated only small numbers of dives. Normally, given the risks associated with under-ice diving, divers will not continue to use a regulator that has failed during one or more of its initial trials. This practice is evident in the typically high failure rates seen in the lower portion of Table 2. The notable exception to this rule may be the AGA mask. This full face mask is infrequently used within the scientific diving community for reasons unrelated to failure rate.

Failure information should be considered incomplete for the 1989-90 season. The formalization of dive log submission was initiated during this season. While a generic space for "comments" was included in the form, there was no specific request made for the reporting of regulator failures. It is believed that the information for 1990-91 and beyond do represent comprehensive reporting.

The failure rates of Maximus and non-Maximus regulators within the U.S. Antarctic Research Diving Program at McMurdo Station are summarized in Table 3. The difference in cumulative failure rates (1.7% and 9.1%, respectively) is substantial ($\mathbf{X}^2$ [1]=18.03, $p<0.001$).

Table 2. Regulator performance summary: number of dives, (number of failures), percentage failure.

Regulator	89-90*	90-91	91-92	92-93	93-94	94-95	Total
Sherwood Maximus			54 (0) 0%	345 (10) 2.9%	642(12) 1.9%	300 (1) 0.3%	1341 (23) 1.7%
Poseidon Cyklon 300	226 (4) 1.8%	201 (13) 6.5%	218 (17) 7.8%	48 (3) 6.3%	16 (3) 18.8%	1 (0) 0%	710 (40) 5.6%
Poseidon Odin	164 (8) 4.9%	99 (6) 6.1%	3 (1) 33%		4 (0) 0%		270 (15) 5.6%
USD Ram	133 (10) 7.5%	126 (35) 27.8%					259 (45) 17.4%
Poseidon Thor		87 (1) 1.1%			48 (1) 2.1%	47 (0) 0%	182 (2) 1.1%
DSI EXO-26			5 (4) 80%	30 (3) 10%	6 (0) 0%	65 (4) 6.2%	106 (11) 10.4%
Scubapro Mk10/G200		27 (13) 48.1%					27 (13) 48.1%
Dacor Extreme Ice					25.(4) 16.0%		25 (4) 16.0%
Scubapro Mk 10/D350		14 (2) 14.3%		3 (1) 33.3%			17 (3) 17.6%
AGA	3 (0) 0%	0%		2 (0)	7 (0) 0%	0%	12 (0)
Scubapro Mk200/G200	1 (1) 100%	7 (7) 100%					8 (8) 100%
USD Conshelf Supreme	5 (2) 40%		2 (2) 100%				7 (4) 57.1%
Scubapro Mk10/D400					7 (1) 14.3%		7 (1) 14.3%
Scubapro Mk10/Polar				1 (1) 100%	5 (1) 20%		6 (2) 33.3%
USD Arctic Supreme					4 (0) 0%		4 (0) 0%
USD Pro Diver		3 (2) 66.7%					3 (2) 66.7%
Sherwood Blizzard					2 (2) 100%		2 (2) 100%

Table 2. (con'd).

Regulator	89-90*	90-91	91-92	92-93	93-94	94-95	Total
Mares Mr-3				2 (2) 100%			2 (2) 100%
Scubapro Mk10/G250		1 (1) 100%					1 (1) 100%
Total**	532 (25) 4.7%*	565 (80) 14.2%	282 (24) 8.5%	431 (20) 4.6%	766 (24) 3.1%	413 (5) 1.2%	2989 (178) 6.0%

* failure data are considered incomplete for the 1989-90 season
** dives conducted with surface supplied systems are not included in this assessment

Table 3. Summary of Maximus and non-Maximus regulator failures: number of dives, (number of failures), percentage failures.

Season	Total Dives	Maximus Dives	Non-Maximus Dives
1991-92	282 (24) 8.5%	54 (0) 0%	228 (24) 10.5%
1992-93	431 (20) 4.6%	345 (10) 2.9%	86 (10) 11.6%
1993-94	766 (24) 3.1%	642 (12) 1.9%	124 (12) 9.7%
1994-95	413 (5) 1.2%	300 (1) 0.3%	113 (4) 3.5%
Total	1892 (73) 3.9%	1341 (23) 1.7%	551 (50) 9.1%

($\mathbf{X}^2$ [1]=18.03, p<0.001 for Maximus *vs.* non-Maximus failures)

The exhaust valve heat retention plate was first tested in the Maximus during the 1993-94 season. A total of 302 dives without the plate (seven failures) and 340 dives with the plate (five failures) were made. During the 1994-95 austral season, seven dives were made without the plate (no failures); 293 dives with the plate (one failure). The combined data for both seasons appear in Table 4. The difference in the failure rates (2.3% without the plate versus 0.9% with the plate) did not achieve statistical significance ($\mathbf{X}^2$ [1]=2.76, p<0.10).

The intermediate pressure on the Maximus is adjustable from 120 to 150 psig, but it is normally set to 140 psig at the factory. Additionally, the second stage spring tension is set at the factory so that the regulator free flows when the diver-accessible adjustment knob is turned fully open (counter-clockwise). This adjustment is made subjectively.

Table 4. Dive and failure data for similarly adjusted Sherwood Maximus regulators with and without the exhaust valve heat retention plate.

Second Stage Configuration	Number of Dives	Number of Failures	Percent Failures
Without Plate	309	7	2.3
With Plate	633	6	0.9

(X^2 [1]=2.76, p<0.10)

In 92-93, all regulators were issued as supplied, with no modifications. From 93-94 on, all regulators were adjusted according to the manufacturer's recommendations for use in cold water; the intermediate pressure was set to 125 psig and the second stage spring tension increased. The increase in second stage spring tension was measured, subjectively, by a reduction in the volume of free flow when the adjustment knob was turned fully open. The intent of these adjustments was to increase the ability of the second stage to positively close against any nascent ice forming around the internal mechanism.

The relative contribution of cold water adjustment to reliability is difficult to ascertain with failure rates as low as those seen for the Maximus (Table 5). The 1992-93 failure rate for unadjusted Maximus regulators was 2.9% (10 out of 345 dives). This was not significantly different from the 1993-94 season rate of 2.3% (7 of 302 dives) for Maximus regulators that were cold water adjusted (X^2 [1]=0.21, p<0.70).

Table 5. Dive and failure data for unmodified Maximus regulators (*i.e.*, without the exhaust valve heat retention plate) with standard or cold water adjustment.

Regulator Tuning	Number of Dives	Number of Failures	Percent Failures
Standard Adjustment	345	10	2.9
Cold Water Adjustment	302	7	2.3

(X^2 [1]=0.21, p<0.70)

Regulator Temperature

All dives were initiated from heated dive huts located near McMurdo Station, Ross Island or New Harbor, 80 km west of McMurdo Station (77° 34'S, 163° 35'E). Huts were positioned directly over holes through two to three meters of sea ice. Water temperature remained constant between -1.8 and -1.9 C. The dive profiles and activities of individual divers were similar during each of the three dives monitored. Three divers conducted benthic sampling with an stationary airlift device that delivered sediment and invertebrates to the surface (Pollock and Bowser, in press). Two divers conducted photographic survey dives. One diver conducted localized free-swimming excursions to collect small sediment core samples. Air consumption rates, standardized to surface equivalent values, indicate that all dives were low intensity (Table 6).

Table 6. Test dives (mean±SD).

Dive Mission	Number of Dives	Max Depth (fsw)	Bottom Time (min)	Air Consumption (scfm)
Air Lift	9	72.7±1.2	27.0±3.3	0.48±0.03
Photographic Survey	6	117.5±4.2	21.7±2.6	0.49+0.03
Sediment Coring	3	79.7±8.7	31.7±1.5	0.57±0.06
Total	18	88.7±21.4	26.0±4.5	0.50±0.05

Temperature profiles for two individual divers are found in Figures 1 and 2. First stage temperatures are generally similar for the two divers. While mean second stage temperatures with the exhaust valve heat retention plate in place are higher for both divers, the effectiveness of the plate was markedly greater for subject B. The higher air consumption of subject B (0.51 *vs.* 0.48 scfm) provides at least partial explanation of this difference. Figure 3 graphically displays the variability of mean temperature patterns among the six subjects.

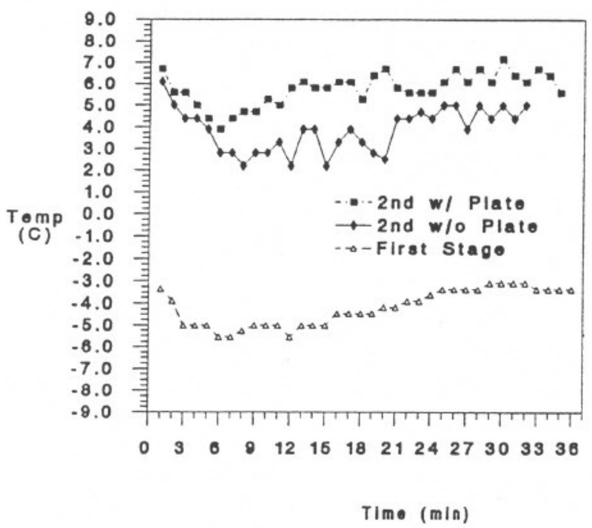

Figure 1. Regulator temperature during photographic survey dives (Subject B). Mean air consumption 0.51 scfm.

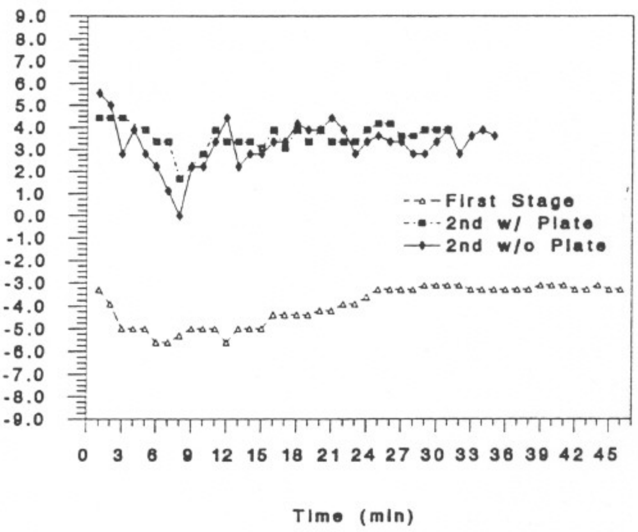

Figure 2. Regulator temperature during photographic survey dives (Subject A). Mean air consumption 0.48 scfm.

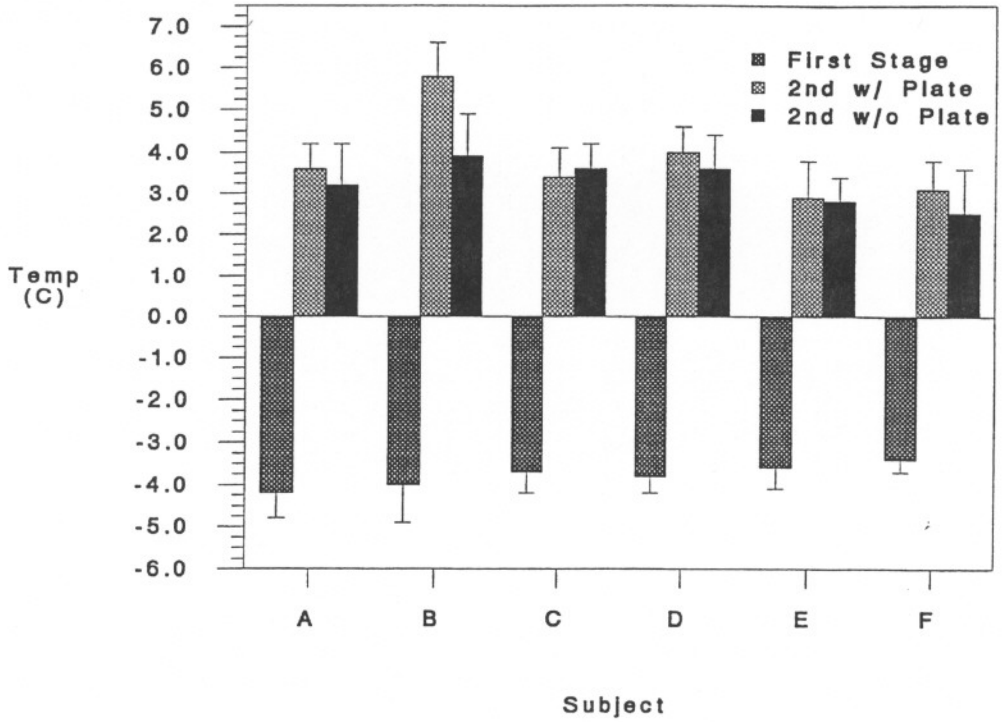

Figure 3. Mean regulator temperatures for six subjects (with standard error).

Pooled mean regulator temperatures are summarized in Table 7 and shown graphically in Figure 4. First stage temperatures remained below the freezing level with a mean of -3.8 C across all depths. First stage temperature also tended to decrease with increasing depth. Second stage temperatures remained well above freezing with or without the presence of the exhaust valve heat retention plate. Addition of the plate resulted in an increased mean second stage temperature of 0.6 C (1.1 F) ($p<0.0001$). Separating the measures into 30 fsw ranges, the difference is significant across all but the shallowest range. The effect of the plate, however, was most marked in the deepest depth range where the mean temperature was 1.4 C (2.5 F) higher with the plate ($p=0.0016$). While second stage temperatures without the additional plate stabilized, they climbed substantially when the plate was in place.

Table 7. Regulator temperatures (mean±SD).

Depth Range	First Stage Temperature	Second Stage w/ Heat Plate	Second Stage w/o Heat Plate	Mann-Whitney Contrast
0-30	-3.4±0.5	4.5±1.1	4.2±0.8	p=0.1680
31-60	-3.8±0.7	4.0±1.2	3.3±0.9	p=0.0350
61-90	-3.9±0.5	3.2±1.0	2.8±0.8	p=0.0005
91-122	-5.0±0.5	4.1±1.1	2.7±1.1	p=0.0016
Overall	-3.8±0.6	3.8±1.2	3.2±1.0	p=<0.0001

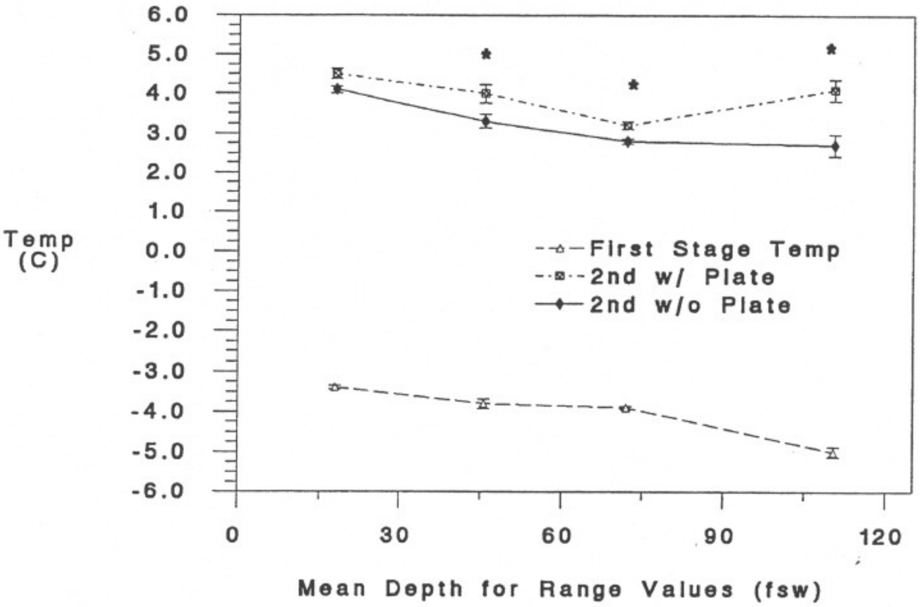

Figure 4. Mean and standard error for regulator temperatures pooled in 30 foot depth ranges (six subjects) (* $p<0.05$ for comparison of second stage temperatures).

The lowest first stage temperature recorded during any man-dive was -5.6 C (subject B). Figure 5 displays this dive with an overlay of the depth profile. As expected, minimal temperatures correspond with the deepest depths. To get an estimate of the minimum temperature a first stage might achieve, the test regulator was used to provide the air supply for the stationary air lift. Figure 6 contrasts the first stage temperatures while the regulator is supplying a diver working at 74 fsw (subject F) with temperatures when the regulator is supplying the air lift at 70 fsw. The lowest temperature recorded in supplying the diver was -3.9 C (25.0 F); the lowest in supplying the air lift was -8.9 C (16.0 F). Even under the demands of supplying the air lift, the regulator appeared to be perform without problem throughout the dive. The progressive rise in temperature during the latter portion of the air lift dive reflects a decrease in gas expansion as the tank pressure declined.

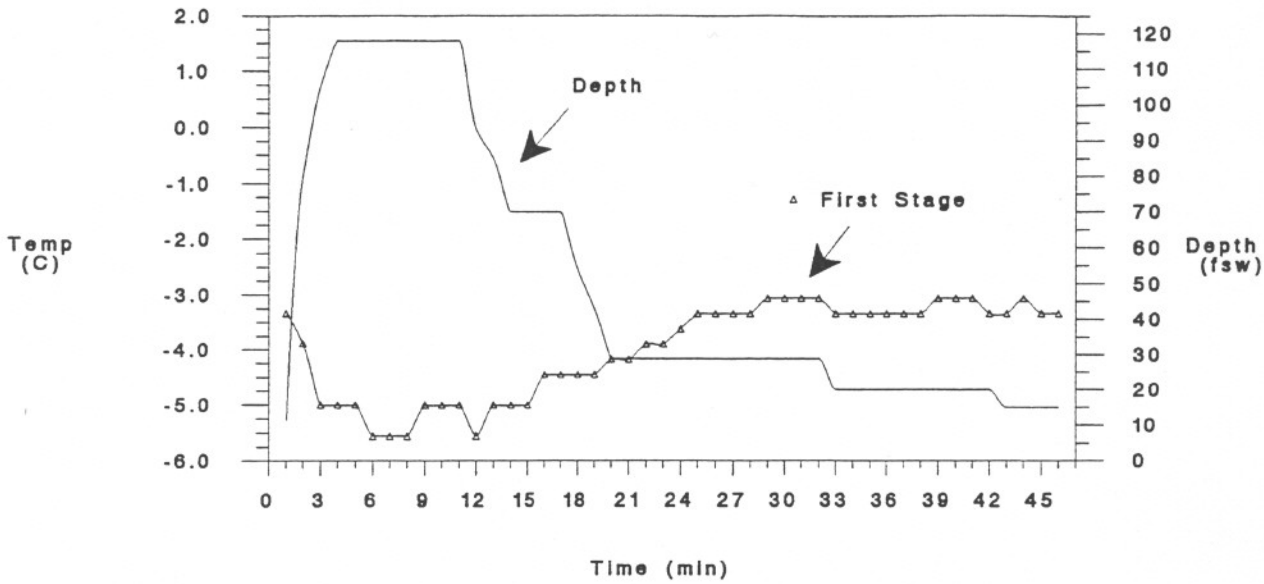

Figure 5. Dive profile and first stage temperature during a typical photographic survey dive (Subject B).

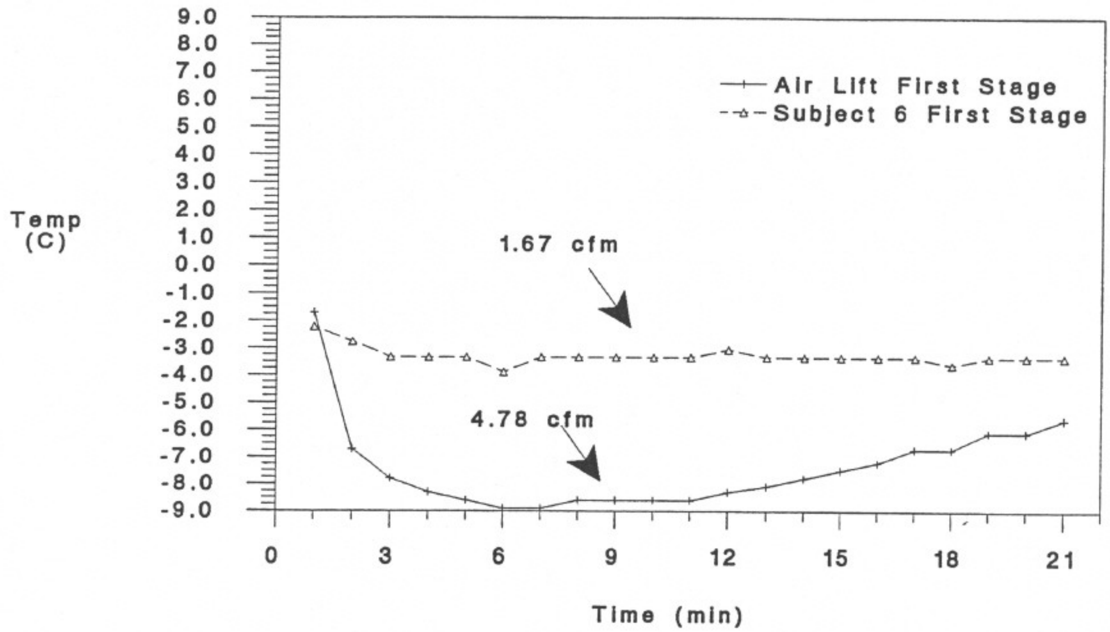

Figure 6. First stage temperatures and air flow rates of regulator supplying air lift (74 fsw) and supplying air lift operator (70 fsw) (Subject F).

DISCUSSION

Regulator Performance

There has been a general trend toward greater reliability in the Maximus between the 1992-93 and 1994-95 seasons (Table 2). (The small number of Maximus dives in 1991-92 make it difficult to draw conclusions for that season). This improvement does not seem to be explained by efforts at cold water adjustment. Instead, it is likely a function of improved diver awareness and regulator handling. The reliability of the Maximus, like any regulator, is dependent on user care. As might be expected, this is a chronic problem unchanged from the earliest cold water trials (Bright 1972). The available records indicate that all reported Maximus failures in this study were associated with water inside the regulator mechanism, whereas non-failing regulators were dry. More important to this study, five of the six failures involving regulators with the exhaust valve heat retention plate (Table 4) were experienced by a single diver who experienced chronic problems introducing water into the regulator mechanism. It is believed that these failures were likely due to poor user care and unrelated to the presence or absence of the plate. It is recommended that plate effectiveness be reviewed again once more data have accumulated.

Fundamental regulator maintenance does not require extensive facilities. Even field groups unable to regularly rinse their regulators because of a potable water shortage experienced no problems, as long as the workings of the regulators remain dry. Methods to reduce the impact of intruded water should be considered in future cold water regulator design.

The Poseidon Thor appears to exhibit a reliability comparable to the Maximus under polar conditions (Table 2), though more testing is required to confirm this assessment because over 90% of the dives were conducted by two individuals. Like all Poseidon regulators used in cold water, the Thor requires a rubber environmental cap and antifreeze solutions for the first stage. More careful handling is required, as well as a greater overall maintenance effort. Because of these factors and others, the Thor is little used in the U.S. Antarctic program.

Regulator Temperature

Several factors affect the internal temperatures of the regulator, in both the first and second stages: ambient temperature, air flow and expansion rates, and heat retention capability. Throughout these tests, ambient water temperature remained relatively constant between -1.8 and -1.9 C. Air flow and expansion rates were dependent upon both depth and the air consumption rates of the individual divers.

The internal pressure of the scuba cylinder (2250 to 3000 psig initial pressure) must be reduced to an intermediate pressure by the first stage (125 psig for the Maximus regulators used in this study). This represents an 18 to 24 fold reduction in pressure, and therefore a substantial expansion and subsequent adiabatic heat loss. To supply the diver with air, the second stage pressure must only be reduced to meet ambient pressure (69 psia at 122 fsw, the deepest point reached in this study, less than a two fold reduction).

It is no surprise, then, that the first stage experiences the most dramatic temperature drop during the course of the dive. This effect increases with depth, presumably due to the increased volume of air passing through the regulator and the increased cooling capacity of the denser air. The effect of this cooling is immediately obvious by the end of the dive: the first stage is entirely encapsulated by ice. However, as demonstrated by the air lift operation, the Maximus first stage seemed capable of tolerating temperatures as low as -8.9 C without apparent functional compromise.

Sherwood regulators employ an overpressure bleed system to isolate the first stage from the surrounding fluid medium. This system keeps the internal first stage mechanism dry. However, when water is inadvertently introduced into the interior of the first stage, such as during careless post-dive rinsing, it will freeze quickly during a subsequent dive and likely impede the action of the mechanism, causing regulator failure.

No temperature measurements were made of a Maximus second stage without the mouthpiece fins, because the airflow characteristics of the regulator were designed with them in place. However, it is reasonable to assume that the second stage mechanism would remain closer to ambient temperature if no heat retention components were present. The higher failure rate of almost all other regulators in the McMurdo environment is consistent with this hypothesis. In fact, many divers have complained of ice crystals being ejected from the second stages of other regulators during dives, ice presumably formed from the condensed and frozen moisture of exhaled breath.

It is interesting to note that the effectiveness of the exhaust valve heat retention plate appears to increase in the deepest range evaluated. The declining first stage temperature is clearly associated with the increased absolute flow rate through the first stage. The extreme example in Figure 6 compares the first stage temperatures resulting from the diver's air consumption of 1.87 cfm with the air lift consumption rate of 4.78 cfm at a similar depth. The same conditions produce the opposite result in the second stage (Figure 4). An elevated respiration rate, possibly augmented by the increased heat capacity of denser expired gases, protects second stage temperature. The temperature stabilizes at increasing depths even without the exhaust valve heat retention plate. With the plate, a marked increase in second stage temperature is evident.

Despite the significant increase in housing temperature, the effect on inspired gas temperature is unclear. None of the subjects reported being aware of the presence of the exhaust valve heat retention plate. This may not be an important indicator, however, because previous research has demonstrated that respiratory heat loss is poorly sensed physiologically (Piantadosi and Thalmann 1980). It is possible that the presence of this type of heat retention device could have a measurable impact on total respiratory heat loss, particularly during deeper exposures. This is an area that deserves further investigation.

CONCLUSION AND RECOMMENDATIONS

Evidence accumulated from 1341 dives conducted over four seasons in the Antarctic indicate that the Sherwood Maximus regulator is effective under extremely cold diving conditions. Addition of a recently available exhaust valve heat retention plate does increase mean temperature within the second stage. However, likely due to a series of failures unrelated to the presence or absence of the plate, it can not be concluded that addition of the plate increases the regulator's overall reliability. This question should be reviewed again once more data have accumulated. On that theme, further regulator testing and assessment under polar field conditions should be encouraged to better appreciate the demands placed on the equipment, to quantify the performance of specific systems, and to determine how design changes will practically affect operational divers. It is believed that this information will be extremely useful in future development of underwater breathing equipment.

ACKNOWLEDGMENTS

The authors are indebted to Dr. Sam Bowser and the research divers of S-043 for their support of the regulator temperature trials, and all U.S. Antarctic Program divers for their diligence in contributing to the Antarctic diving database. Sherwood and Dacor Corporations are acknowledged for their provision of test and measurement equipment. This work was supported in part by National Science Foundation grant OPP9220146.

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ERRATA IN THE 15th ANNUAL AAUS SYMPOSIUM PROCEEDINGS

The following errors in the 1995 Symposium volume should be corrected. Most of these errors occurred because of difficulties translating computer files and having to retype the tables in which the errors occurred. The authors are not responsible for the errors.

SHERWOOD MAXIMUM REGULATOR TEMPERATURE AND PERFORMANCE DURING ANTARCTIC DIVING by J. G. Mastro and N. W. Pollock

Page 51 line 10 - Abstract: The first symbol in parentheses should be X^2, not √

Pages 54-55. Table 2: Regulator name should appear as USD RAM, not Ram

Poseidon Cyklon 300: 90-91 failures should read 13, not 1

USD RAM: 90-91 percentage failures should read 27.8%, not 27.85.

AGA: all four percentage values are shifted out of column alignment

Scubapro Mk10/G250: total failure percentage should read 100%, not 199%

Page 55. Table 3: 199% should be 100%

Page 56. Table 4. Without Plate: Percent Failures should read 2.3, not 3.3.

Page 56. Table 5. All values wrong. Table 4 values copied into Table 5. The correct table is as follows:

Regulator Tuning	Number of Dives	Number of Failures	Percent Failures
Standard Adjustment	345	10	2.9
Cold Water Adjustment	302	7	2.3

Page 57. Table 6. Sediment Coring: Bottom Time should read 31.7±21.4, 26.0±4.5 (copied from Total).

Sediment Coring: Max Depth should read 79.7±8.7, not 79.7±21.4.

Total: Max Depth should read 88.7, not 88,7±21.4.

Air consumption for Photographic Survey dives should read 0.49±0.03, not 0.49±0.49.

Page 58. Table 7: 31-60: Mann-Whitney Contrast should read p=0.035, not p=0.305.

0-30: 2nd stage with plate temperature should read 4.5, not -4.5.

SCUBA COLLECTION OF BENTHIC FORAMINIFERA IN EXPLORERS CAVE, ANTARCTICA: AN ACCESSIBLE MODEL OF THE DEEP OCEAN BENTHOS, by N. W. Pollock and S. S. Bowser.

Page 71. Table 2: Equipment Setup/Test/Inspection: 1990 dives should read 11, not 1.

SCIENTIFIC DIVING BY BRITISH ANTARCTIC SURVEY: 1962-1995, by Martin G. White

Page 139. Figure 2: The legend is correct, but the figure is Figure 3.

Page 142. Figure 3: The legend is correct, but the figure if Figure 2.