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EVALUATION OF POSEIDON CYKLON SUPER 300 OPEN CIRCUIT SCUBA REGU--ETC(U)
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NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 7-77

EVALUATION OF POSEIDON CYKLON SUPER 300 OPEN CIRCUIT SCUBA REGULATOR

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UNITED STATES NAVY

PANAMA CITY, FLORIDA 32407

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
Panama City, Florida 32407

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REPORT NO. 7-77
EVALUATION OF POSEIDON CYKLON SUPER 300
OPEN CIRCUIT SCUBA REGULATOR

by
James R. Middleton

May 1977

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Submitted by:	Reviewed by:	Approved by:
J. R. MIDDLETON Test Engineer	J. G. MALEC LCDR, RN T & E Department Head	C. A. BARTHOLOMEW CDR, USN Commanding Officer

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The Poseidon Cyklon Super 300 open circuit scuba regulator was tested by the Navy Experimental Diving Unit in accordance with mil spec MIL-R-24169A. Test results indicate that this regulator meets mil spec requirements and it is recommended for placement on the list of equipment authorized for Navy use.

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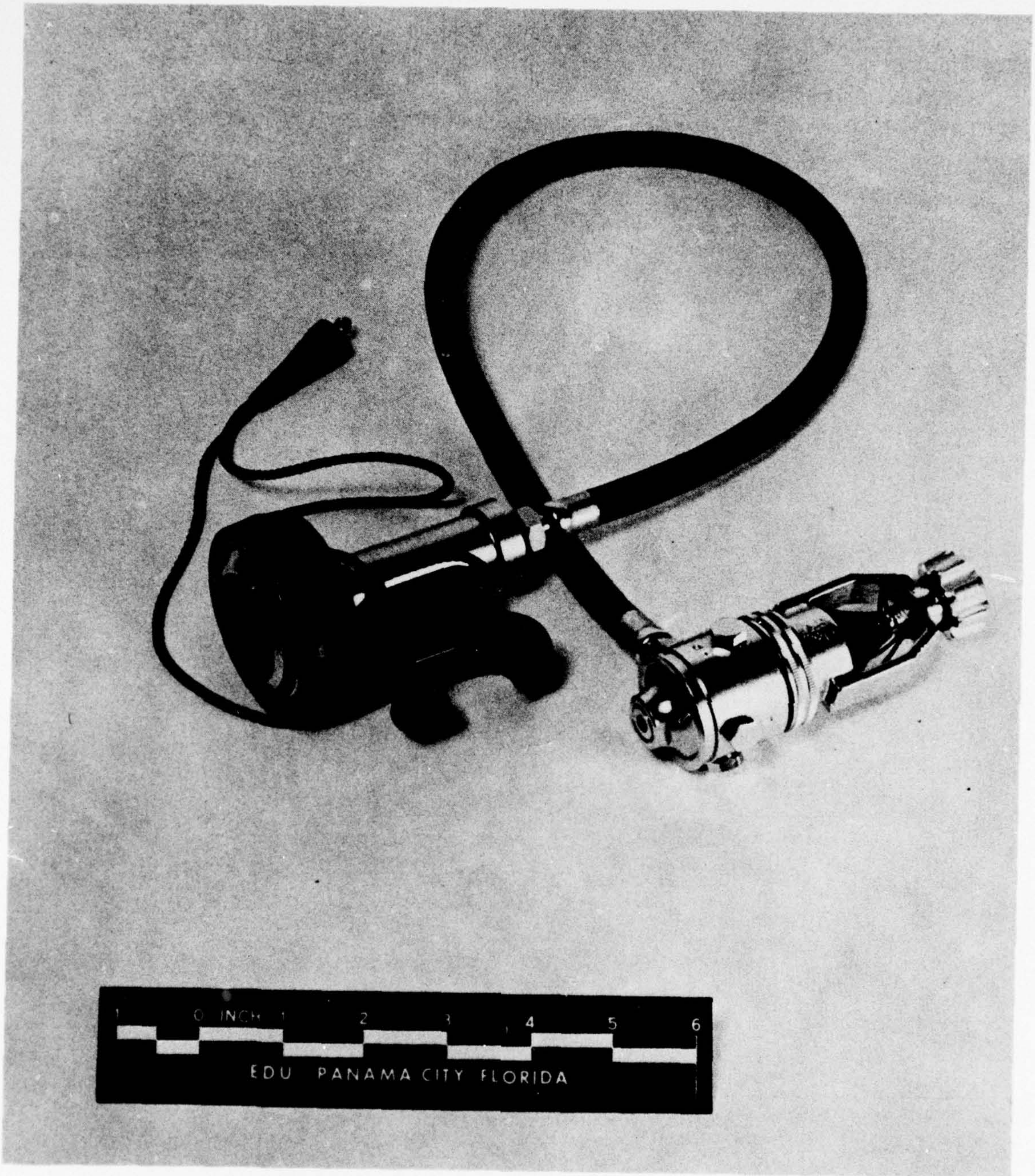
LIST OF ABBREVIATIONS

ABBREVIATION	DEFINITION
BPM	breaths per minute
cm H_2O	centimeters of water pressure (differential)
fsw	feet of seawater
kg·m/l	breathing work in kilogram meters per liter ventilation
mil spec	military specification MIL-R-24169A
NEDU	Navy Experimental Diving Unit
O/B	over bottom pressure
psig	pounds per square inch gauge
ΔP	pressure differential
RMV	respiratory minute volume in liters per minute

ABSTRACT

The Poseidon Cyklon Super 300 open circuit scuba regulator was tested by NEDU in accordance with mil spec MIL-R-24169A. Test results indicate that this regulator meets mil spec requirements, and it is recommended for placement on the list of equipment authorized for Navy use. The second-stage demand-valve ejector sleeve effectively reduces breathing resistance when the sleeve is pointed directly toward the mouthpiece, and breathing resistance stays within mil spec limits when the sleeve is rotated no more than 45 degrees from the mouthpiece. However, this regulator should generally not be operated with the sleeve pointed at greater than a 45-degree angle from the mouthpiece because of potential diver discomfort from excessive breathing work requirements.



POSEIDON CYKLON SUPER 300 REGULATOR

INTRODUCTION

In October 1976, NEDU, by direction of the Supervisor of Diving (Reference 1), tested a single hose demand scuba regulator produced in Sweden and marketed by the Poseidon Systems Division of Parkway Fabricators, 291 New Brunswick Avenue, Perth Amboy, New Jersey 08861. The regulator tested was model Cyklon Super 300.

Unmanned tests of the regulator were performed in accordance with mil spec MIL-R-24169A (Reference 2). In order to simulate light and heavy diver work rates, the regulator was tested at two RMV's other than the one required by the mil spec (40 RMV). The position of the second stage adjustable sleeve was varied to determine its effect on breathing resistance, and measurements of the breathing work required to operate the regulator were obtained and were used as supplementary guides for evaluation.

Normally, intermediate pressure between the first and second stages is monitored, but the metric fittings on the Cyklon Super 300 first stage high-pressure port prevented interfacing with NEDU test equipment.

TEST PROCEDURE

TEST PLAN

In the plan followed during testing of the Cyklon Super 300 regulator, a breathing machine was used to simulate respiration at three RMV's, representing light, moderate and heavy diver work rates. The chamber was pressurized at various depth increments to 200 fsw, and ΔP measurements were taken between the mouthpiece and ambient pressure with the ejector sleeve wide open (pointing straight into the mouthpiece) and pointing 45 and 180 degrees from the mouthpiece. The various data and parameters that were controlled, measured, computed, and plotted are detailed below. The actual steps followed during the tests are presented in Appendix A, while the test equipment used is shown in the test setup in Figure 1 and is listed in Appendix B.

CONTROLLED PARAMETERS

The following parameters were controlled during the test.

1. Breathing rate/tidal volume
   a. 15 BPM/1.5 liters   22.50 RMV
   b. 20 BPM/2.0 liters   40.0 RMV
   c. 25 BPM/3.0 liters   75.0 RMV

2. Exhalation/inhalation time ratio: 1.10/1.00
3. Breathing waveform: modified sinusoid
4. Air supply pressure to first stage: 1000 psig at all depths except 0 fsw and 200 fsw where data was taken at 1000 psig, 500 psig O/B and 200 psig O/B

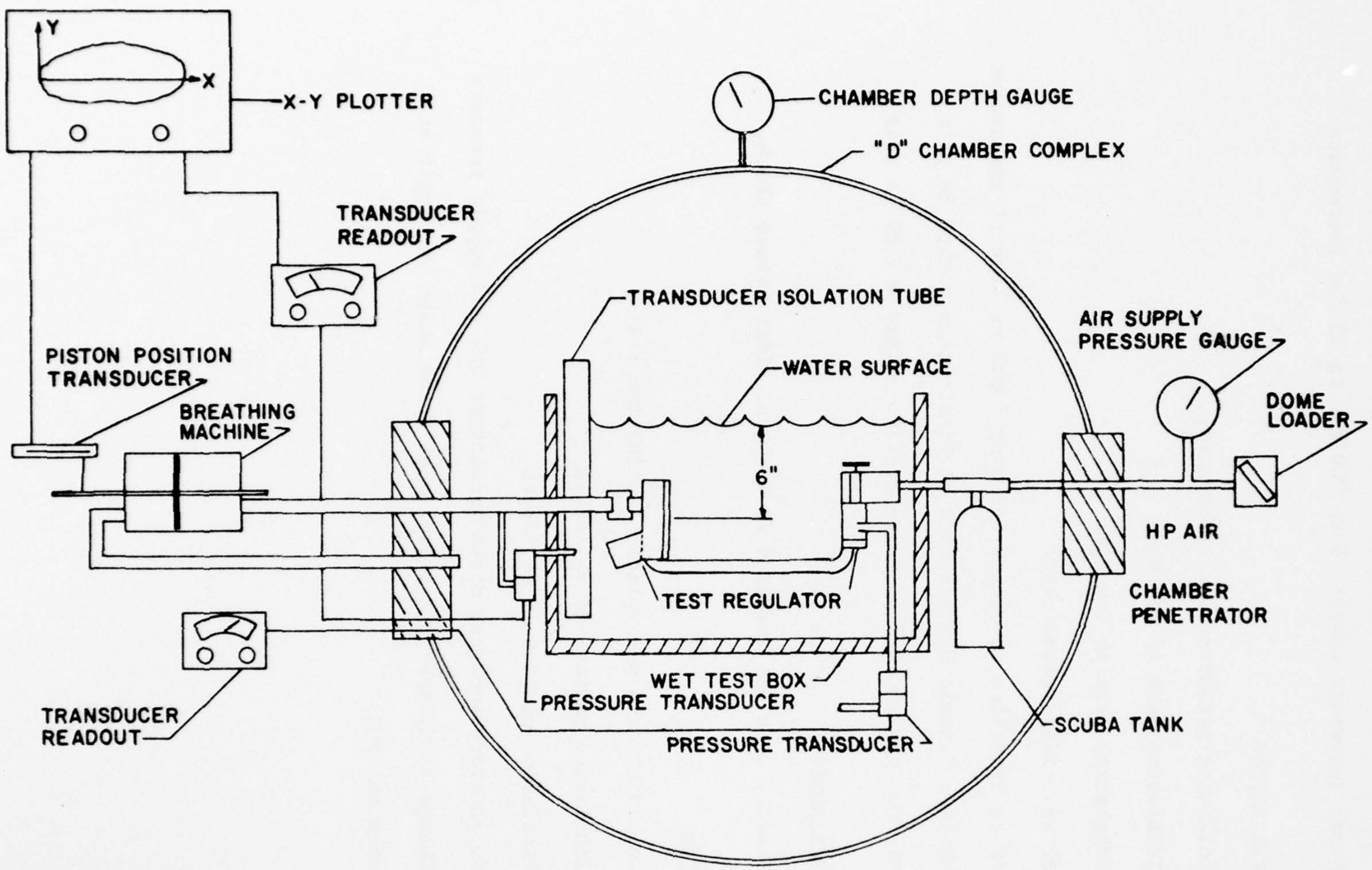


FIGURE 1. TEST SETUP
(SEE APPENDIX B FOR A COMPLETE DESCRIPTION OF EQUIPMENT.)

5. Depth increment stops: 0 to 200 fsw in 33 fsw increments

MEASURED PARAMETERS

The following parameters were measured.

1. Inhalation peak ΔP (cm H_2O)
2. Exhalation peak ΔP (cm H_2O)
3. ΔP vs. tidal volume plots
4. ΔP at zero flow condition for each depth on descent and ascent
5. Maximum dynamic O/B pressure at first-stage outlet in psig
6. Minimum dynamic O/B pressure at first-stage outlet in psig

COMPUTED PARAMETERS

Respiratory work was computed from ΔP vs. tidal volume plots.

DATA PLOTTED

The following data were plotted during the test.

1. Inhalation maximum ΔP vs. depth
2. Exhalation maximum ΔP vs. depth
3. Respiratory work vs. depth at constant RMV and supply pressure
4. Change in dynamic O/B pressure at first stage vs. depth at constant RMV

RESULTS AND DISCUSSION

DESCRIPTION

The Cyklon Super 300 regulator has an unbalanced diaphragm-type first stage with three low-pressure ports, and one high-pressure port for a submersible pressure gauge.

The regulator second stage has a balanced demand valve with an adjustable sleeve which directs the air flow from the second-stage valve seat toward the mouthpiece. The extent of the vortex effect created is proportional to the angle of the ejector sleeve to the mouthpiece. When the sleeve directs air straight into the mouthpiece, the least amount of breathing resistance occurs. As the sleeve is rotated away from the mouthpiece, inhalation resistance increases, reaching the maximum when the sleeve is at a 180-degree angle to the mouthpiece. When used properly, the sleeve can be easily adjusted according to diver preference to achieve the most comfortable inhalation response.

BREATHING RESISTANCE

During the test of the Cyklon Super 300 regulator, breathing resistance was measured at three RMV's to simulate light, moderate and heavy work rates. Light work was measured at 22.5 RMV with a 1.5 liter tidal volume and 15 BPM; moderate work was measured at 40 RMV with a 2.0 liter tidal volume and 20 BPM; heavy work was measured at 75 RMV with a 3.0 liter tidal volume and 25 BPM. The mil spec calls for only a 40 RMV at 1000 psig supply pressure (Reference 2). However, the other RMV's were measured to obtain information on the full spectrum of regulator performance.

Breathing resistances plotted in Figures 2 through 8 are the maximum resistances measured, excluding cracking pressure, during one complete inhalation/exhalation cycle at a given depth and RMV. Air supply pressure to the first stage is 1000 psig. Resistance measurements were also taken at 500 psig O/B and 200 psig O/B supply pressure on the surface and at 200 fsw at each RMV.

The Cyklon Super 300 regulator was tested with the ejector sleeve in three positions: wide open (pointing straight into the mouthpiece) at a 45-degree angle to the mouthpiece and at 180 degrees from the mouthpiece. The pressures at all three RMV's were measured with the ejector sleeve at 45 degrees and at 180 degrees. However, pressures were measured only at the standard mil spec condition (40 RMV) when the ejector sleeve was wide open. Some figures do not have complete data to 200 fsw because tests were terminated at the maximum indicated depth because of excessive breathing resistance.

The following table lists equivalent depth densities for air vs. HeO_2 down to 200 fsw on air. This table is a means of comparing regulator performance on HeO_2 mixes at depths greater than 200 fsw.

Air Depth (fsw)	Equivalent HeO_2 Depth (fsw)
50	230
100	625
150	1000
200	1350

Ejector Sleeve Wide Open

Inhalation Characteristics. Figure 2 shows that the maximum inhalation pressure usually occurred immediately after flow began. As the inhalation

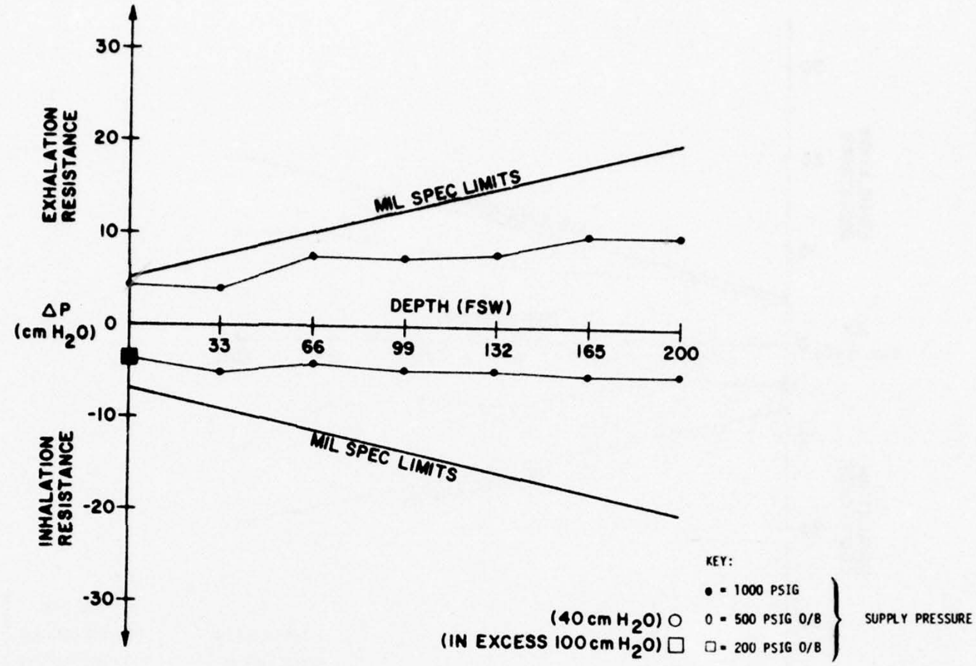


FIGURE 2. BREATHING RESISTANCE VS. DEPTH AT 20 BPM, 2.0 TIDAL VOLUME, 40 RMV WITH EJECTOR SLEEVE WIDE OPEN

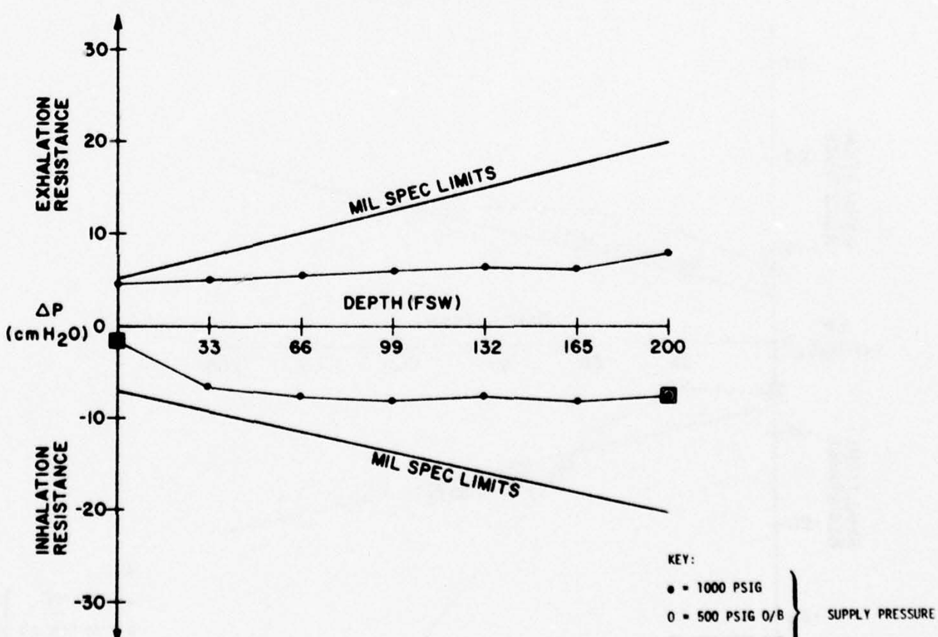


FIGURE 3. BREATHING RESISTANCE VS. DEPTH AT 15 BPM, 1.5 TIDAL VOLUME, 22.5 RMV WITH EJECTOR SLEEVE AT 45 DEGREES

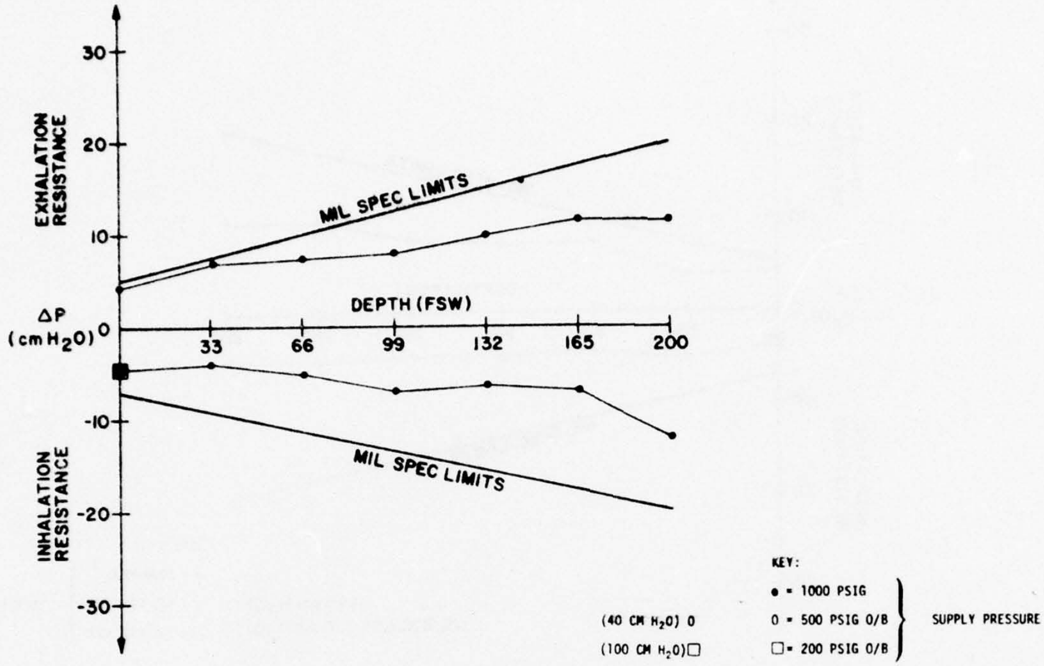


FIGURE 4. BREATHING RESISTANCE VS. DEPTH AT 20 BPM, 2.0 TIDAL VOLUME, 40 RMV WITH EJECTOR SLEEVE AT 45 DEGREES

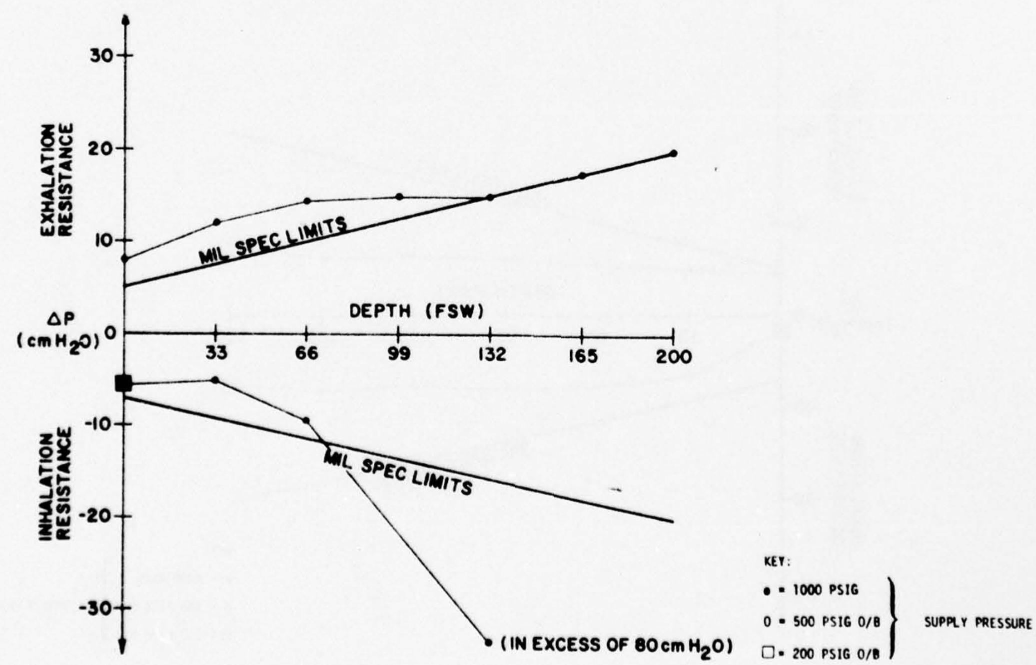


FIGURE 5. BREATHING RESISTANCE VS. DEPTH AT 25 BPM, 3.0 TIDAL VOLUME, 75 RMV WITH EJECTOR SLEEVE AT 45 DEGREES

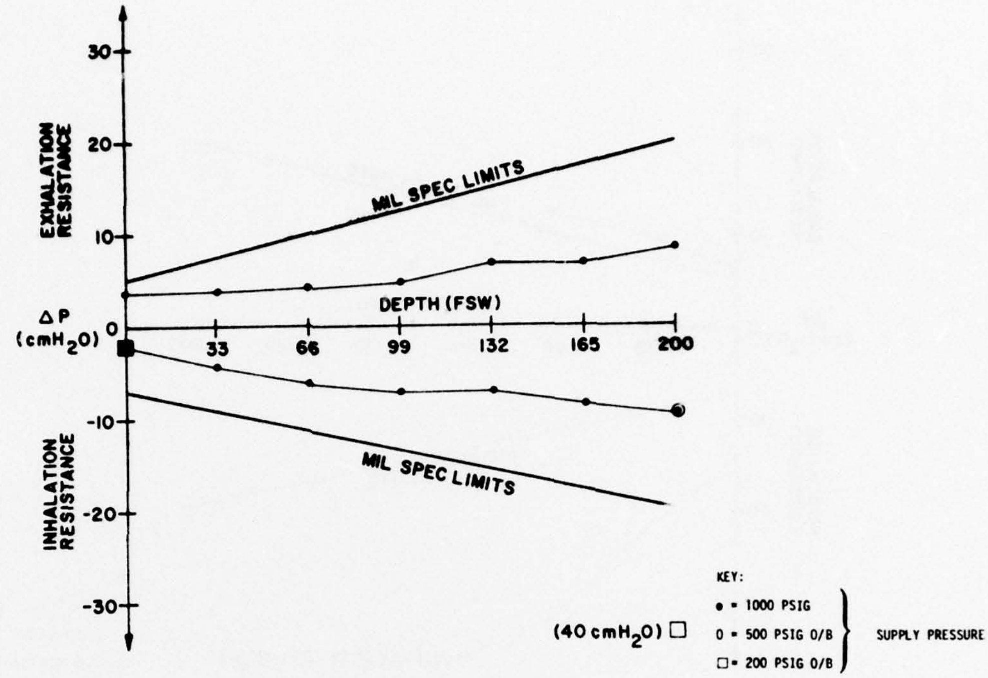


FIGURE 6. BREATHING RESISTANCE VS. DEPTH AT 15 BPM, 1.5 TIDAL VOLUME, 22.5 RMV WITH EJECTOR SLEEVE AT 180 DEGREES

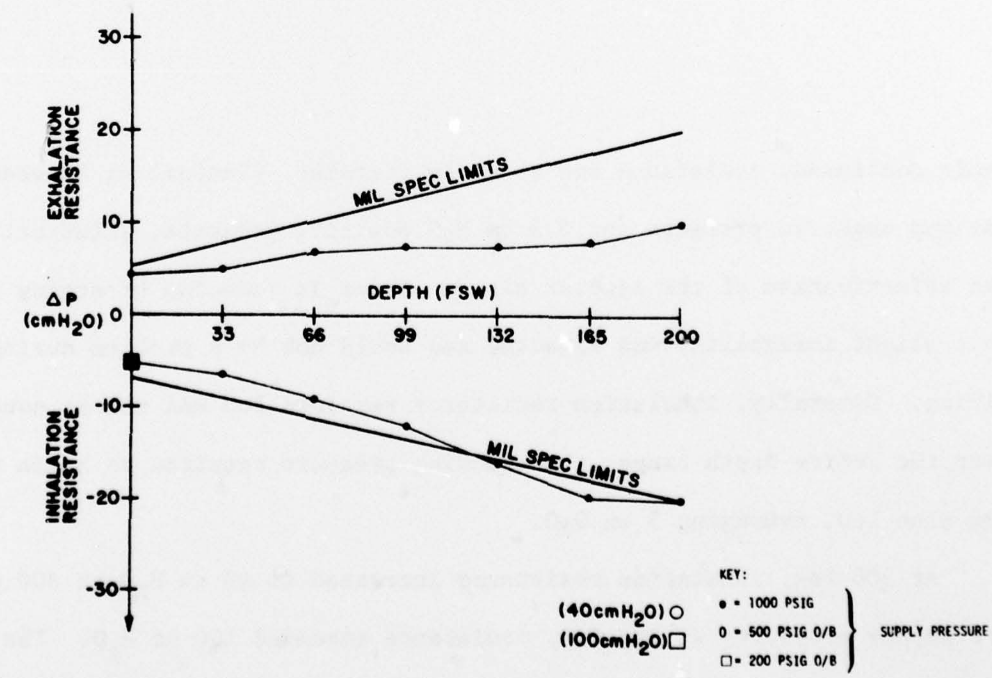


FIGURE 7. BREATHING RESISTANCE VS. DEPTH AT 20 BPM, 2.0 TIDAL VOLUME, 40 RMV WITH EJECTOR SLEEVE AT 180 DEGREES

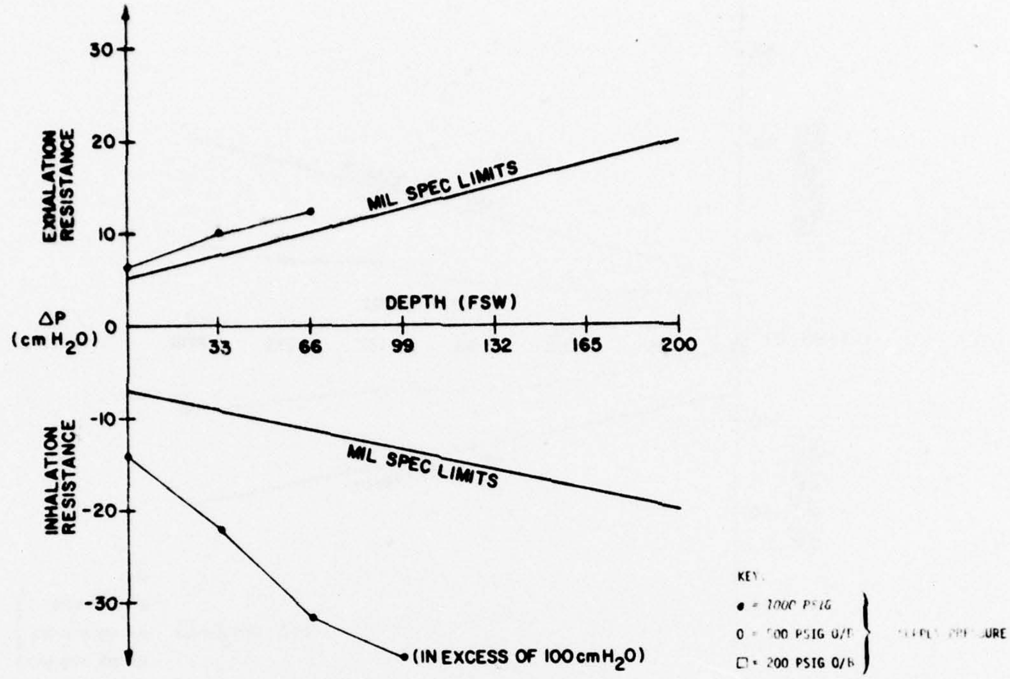


FIGURE 8. BREATHING RESISTANCE VS. DEPTH AT 25 BPM, 3.0 TIDAL VOLUME, 75 RMV WITH EJECTOR SLEEVE AT 180 DEGREES

cycle continued, resistance was slightly unstable, fluctuating between maximum negative pressure and 3.5 cm H_2O positive pressure, illustrating the effectiveness of the ejector sleeve vortex in reducing breathing resistance. This slight instability was expected and would not be a problem during actual diving. Generally, inhalation resistance remained low and almost constant over the entire depth range; the cracking pressure required to begin flow was also low, averaging 3 cm H_2O.

At 200 fsw, inhalation resistance increased to 40 cm H_2O at 500 psig O/B supply pressure; at 200 O/B, resistance exceeded 100 cm H_2O. The regulator second stage is balanced with almost constant resistance at all depths. Therefore, the increase in breathing effort required at low supply pressures is probably a result of the unbalanced diaphragm first stage.

Exhalation Characteristics. As Figure 2 shows, the exhalation resistance measured with the ejector sleeve wide open was well within the requirement of the mil spec. The exhaust pressure was stable, varying only 5 cm H_2O over the entire depth range. This stability is probably a result of the unique exhaust valve design of the Cyklon Super 300, which includes a series of small exhaust ports rather than one large exhaust port.

Ejector Sleeve at 45 Degrees

Inhalation Characteristics. Generally, no pressure fluctuations were observed while the regulator was operated with the ejector sleeve in positions other than wide open. When the ejector sleeve was at a 45-degree angle to the mouthpiece, inhalation resistances measured at 22.5 RMV (Figure 3) and 40 RMV (Figure 4) were low and stable, remaining almost constant over the entire depth range.

At 75 RMV (Figure 5), breathing resistance increased and exceeded limits at all depths greater than 66 fsw. Inhalation resistance was in excess of 80 cm H_2O at depths greater than 132 fsw. Cracking pressure remained low, reaching a maximum of only 6 cm H_2O at 75 RMV; this low cracking pressure is unusual and was probably a result of the balanced second-stage valve.

At 22.5 RMV, decreasing supply pressures did not affect regulator performance, while at 40 RMV in 200 fsw, pressures of 500 and 200 psig O/B produced breathing resistances of 40 and 100 cm H_2O, respectively. Reduced supply pressure at 75 RMV produced ΔP greater than 100 cm H_2O at 200 fsw.

Exhalation Characteristics. At 225 RMV (Figure 3), the exhalation resistance remained almost constant at all depths measured and reached a maximum of only 8 cm H_2O at 200 fsw. Exhaust pressures at 40 RMV (Figure 4) increased approximately 4 cm H_2O more at each depth than the exhaust pressures measured at 22.5 RMV. However, all measurements remained within mil spec limits. At 75 RMV (Figure 5) exhalation resistance was greater than mil spec limits at all depths. However, none of the recorded pressures exceeded 20 cm H_2O, which is low for this extreme RMV.

Ejector Sleeve at 180 Degrees

Inhalation Characteristics. At 22.5 RMV (Figure 6), inhalation pressures were stable and did not differ significantly from the measurements obtained at a breathing rate of 22.5 RMV when the ejector sleeve was at 45 degrees. At 40 RMV (Figure 7), breathing resistance increased substantially but remained within mil spec limits. At 75 RMV (Figure 8), resistance exceeded limits at all depths, reaching over 100 cm H_2O at 99 fsw.

Cracking pressure did not exceed 8 cm H_2O at any RMV while the ejector sleeve was at 180 degrees. In 200 fsw at 22.5 RMV, a resistance of 40 cm H_2O was measured with a supply pressure of 200 psig O/B; no change occurred at 500 psig O/B. In 200 fsw at 40 RMV, resistances were 40 and 100 cm H_2O at 500 and 200 psig O/B, respectively. Limited data was obtained at 75 RMV because of poor regulator performance.

Exhalation Characteristics. When the ejector sleeve was at a 180-degree angle to the mouthpiece, exhaust pressures were almost identical to those measured at the other ejector settings because ejector position does not affect the exhaust valve. For a complete discussion, see the section on the exhalation characteristics of Cyklon Super 300 regulator with the ejector sleeve at 45 degrees.

WORK OF BREATHING

All underwater breathing apparatus is tested to specifications which use peak inhalation and peak exhalation pressures as the standard for evaluation (Reference 3). However, recent research has shown that the measure of external respiratory work performed by the diver to operate his breathing apparatus is useful in equipment evaluation (Reference 4). Breathing work is defined as the area enclosed by a typical pressure-volume loop generated during one complete breathing cycle. In breathing apparatus other than open circuit demand, breathing work is probably the most valid measure of equipment performance. With open circuit scuba, breathing work provides a useful supplementary guide to regulator performance. A standard of 0.170 kg·m/l ventilation (liter ventilation is defined as the tidal volume at a given RMV) has been proposed as the maximum external respiratory work allowable (Reference 4). In this report, .17 kg·m/l is used for comparative purposes only.

Ejector Sleeve Wide Open

Figure 9 shows that the Cyklon Super 300 regulator operates most efficiently with the ejector sleeve wide open; in this position, breathing work is low and remains almost constant from the surface to 200 fsw.

Ejector Sleeve at 45 Degrees

The breathing resistances measured with the ejector sleeve at 45 degrees did not significantly differ from those measured with the ejector sleeve wide open. However, Figure 10 shows that substantially more breathing work was required when the ejector sleeve was at a 45-degree angle to the mouthpiece than was required when the sleeve was in the wide open position. A higher work rate was needed at 22.5 RMV with the sleeve at 45 degrees than was needed at 40 RMV with the sleeve wide open, and the 40-RMV work rates with the sleeve at 45 degrees were almost double those measured when the sleeve was in the wide open position. However, measurements remained within the proposed limits. The breathing work required at 75 RMV exceeded the mil spec limits at 66 fsw and increased rapidly at greater depths.

Ejector Sleeve at 180 Degrees

Figure 11 shows that, at 22.5 RMV, breathing work rates remained within the proposed limit, reaching a maximum of .143 kg·m/l. At 40 RMV, the required breathing work increased rapidly with increasing depth. Although the 40-RMV breathing resistance pressures stayed within the mil spec limits at all depths to 200 fsw, the proposed breathing work limit was exceeded at 132 fsw. At 75 RMV, the proposed limit on breathing work was exceeded at less than 66 fsw. The test was terminated when work increased to .245 kg·m/l at 66 fsw.

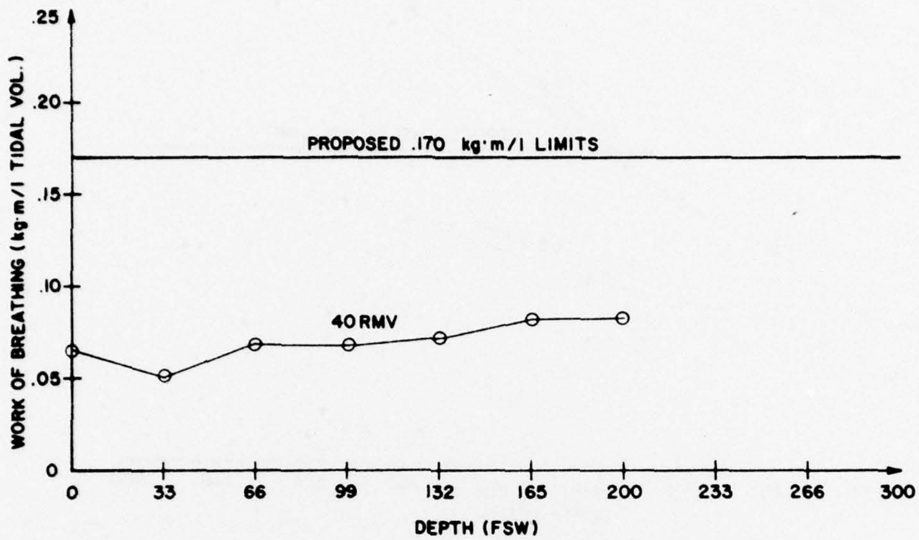


FIGURE 9. WORK OF BREATHING VS. DEPTH WITH EJECTOR SLEEVE WIDE OPEN

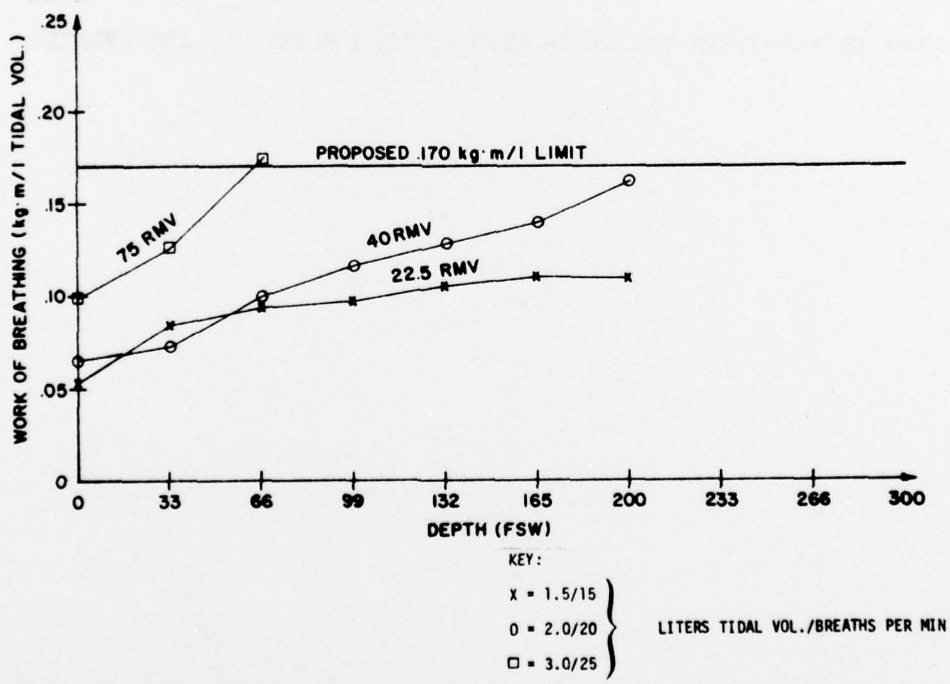


FIGURE 10. WORK OF BREATHING VS. DEPTH WITH EJECTOR SLEEVE AT 45 DEGREES

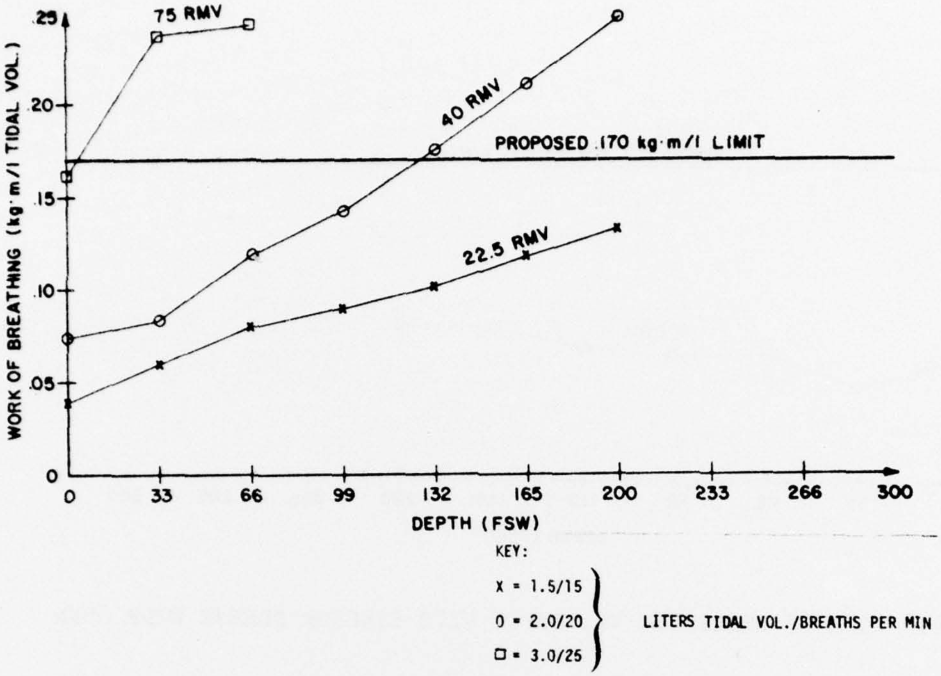


FIGURE 11. WORK OF BREATHING VS. DEPTH WITH EJECTOR SLEEVE AT 180 DEGREES

CONCLUSIONS AND RECOMMENDATIONS

The Poseidon Cyklon Super 300 regulator meets mil spec requirements and is recommended for placement on the list of equipment authorized for Navy use. Tests revealed that under normal conditions this regulator provides ease of breathing with smooth inhalation and exhalation characteristics. The ejector sleeve on the second-stage demand valve effectively reduces breathing resistance when the sleeve is in the wide open position (pointing directly toward the mouthpiece). Although breathing resistance approaches, but does not exceed, mil spec limits when the sleeve is rotated more than 45 degrees from the mouthpiece, more breathing work is required. Therefore, the sleeve should not be positioned at greater than a 45-degree angle from the mouthpiece.

The Cyklon Super 300 regulator performed poorly both at high RMV and at low supply pressures. Since the second stage is balanced and vortex-assisted, the regulator's problem appears to involve its first stage. Larger first-stage porting and a balanced valve mechanism could improve performance.

The regulator is made in Sweden and uses metric measurements, which could present difficulties involving maintenance, obtaining spare parts, and interfacing with auxiliary equipment. Submersible pressure gauges made in the U. S. will not interface with the regulator first stage without a special adapter which is available from Poseidon Systems.

REFERENCES

1. NAVSEA Letter OOC:WRB, 3960/2003, Serial 1037,23 June 1976.

2. Department of the Navy Military Specification MIL-R-24169A, Regulator, Air, Demand, Single Hose, Nonmagnetic, Divers, 22 March 1967.

3. Navy Experimental Diving Unit Report 23-73, U.S.N. Procedures for Testing the Breathing Characteristics of Open Circuit Scuba Regulators, by S. D. Reimers, p. 5, 11 December 1973.

4. Navy Experimental Diving Unit Report 19-73, Proposed Standards for the Evaluation of the Breathing Resistance of Underwater Breathing Apparatus, by S. D. Reimers, p. 36, 30 January 1974.

APPENDIX A

TEST PLAN

The test plan for examination of the Cyklon Super 300 regulator included the following steps.

1. Insure that the regulator is set to factory specifications and is working properly.
2. Insure that the chamber is on the surface.
3. Calibrate the transducers and zero the transducer by regulator position after water is added to the wet test box.
4. Open the air supply valve to test the regulator and set the supply pressure at 1000 psig.
5. Adjust the breathing machine to 1.5 liter tidal volume and 15 BPM and take readings.
6. Stop the breathing machine.
7. Establish zero flow ΔP position on the x-y plotter.
8. Adjust the air supply pressure to 500 psig O/B.
9. Repeat steps 5 through 7.
10. Adjust the air supply pressure to 200 psig O/B. (Be sure that the breathing resistance transducer stays within its range.)
11. Repeat steps 5 through 7.
12. Pressurize the chamber to 33 fsw.
13. Adjust the air supply to 1000 psig
14. Repeat steps 5 through 7.
15. Pressurize the chamber to 66 fsw.
16. Adjust the air supply to 1000 psig.
17. Repeat steps 5 through 7.
18. Pressurize the chamber to 99 fsw.

19. Adjust the air supply to 1000 psig.

20. Repeat steps 5 through 7.

21. Pressurize the chamber to 132 fsw.

22. Adjust the air supply to 1000 psig.

23. Repeat steps 5 through 7.

24. Pressurize the chamber to 165 fsw.

25. Adjust the air supply to 1000 psig.

26. Repeat steps 5 through 7.

27. Pressurize the chamber to 200 fsw.

28. Repeat steps 4 through 11.

29. Set the breathing machine to 2.0 liter tidal volume and 20 BPM. (This replaces step 5.)

30. Repeat steps 4 through 28 in reverse order (as chamber is being brought to surface making incremental stops in reverse order).

31. Set the breathing machine to 3.0 liter tidal volume and 25 BPM. (This replaces step 5.)

32. Repeat steps 4 through 28.

33. Bring the chamber to the surface (no stops).

34. Check the calibration on the transducers.

APPENDIX B

TEST EQUIPMENT

The following equipment was used in testing the Cyklon Super 300 regulator and is shown in Figure 1.

1. NEDU breathing machine
2. Validyne model DP-15 pressure transducer with 1 psid diaphragm
3. NEDU wet test box
4. Validyne model DP-15 pressure transducer with 250 psid diaphragm
5. MFE x-y plotter, model 715M, serial number 30925002
6. Validyne model CD-12 transducer readout, 2 each, serial numbers 12247 and 5538
7. 71.2-cu. ft. scuba tank
8. NEDU "D" chamber complex
9. Roylyn air supply pressure gauge, model 0-2000 psig with accuracy to 0.25 percent, calibration date August, 1976
10. Marotta dome loader
11. Roylyn chamber depth gauge, model 0-2300 fsw with accuracy to 0.25 percent, calibration date December, 1975
12. Test regulator (first and second stage) Poseidon Cyklon Super 300, serial number 35953
13. Bourns piston position transducer, model 2001764008
14. Transducer isolation tube

APPENDIX C

MAN-HOURS REQUIRED

The man-hours required for the test of the Cyklon Super 300 regulator are computed below.

	Men	Hours	Man-Hours
Test set-up	3	2	6
Test operation	3	2	6
Chamber operation	1	2	2
Post-test cleamup	2	1	2
Data reduction/report production	1	80	80
Duplicating	4	25	100
TOTAL			196