

NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

EVALUATION OF SCUBA PRO MARK I
AND
MARK V OPEN CIRCUIT SCUBA REGULATORS

LETTER REPORT 5-70

by

STEPHEN D. REIMERS

AD #760-285

Approved for public release; distribution unlimited.

Submitted



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EDU:SDR:mec

3960

Ser: 923

29 DEC 1970

From: Officer in Charge, Navy Experimental Diving Unit
To: Supervisor of Diving, NAVSHIPS OOC
Subj: Letter Report 5-70, Evaluation of SCUBA PRO MARK I
and MARK V Open Circuit SCUBA Regulators

Ref: (a) SCUBA PRO ltr 4123/24169 Ser 6604 3B1-1524
of 10 July 1969
(b) NAVXDIVINGU ltr JWS:dlm 3960/3 Ser 915 of
15 September 1969

Encl: (1) Exploded View, SCUBA PRO MARK I and MARK V
SCUBA Regulators
(2) EDU Breathing Resistance Test Apparatus for
Open Circuit SCUBA Regulators (Single-Hose)
(3) Breathing Resistance vs Depth Curves for
SCUBA PRO Regulator #910537
(4) Breathing Resistance vs Depth Curves for
SCUBA PRO Regulator #951809
(5) Breathing Resistance vs Depth Curves for
SCUBA PRO Regulator #910520
(6) Breathing Resistance vs Depth Curves for
SCUBA PRO Regulator #962966

1. Reference (a) requested qualification testing of the SCUBA PRO MARK I and MARK V single hose demand air regulators. Reference (b) granted the request and forwarded the appropriate qualification request forms to SCUBA PRO for completion. Two SCUBA PRO regulators, one MARK I serial number 910537 and one MARK V serial number 951809, were subsequently tested at the Navy Experimental Diving Unit in December 1969.

2. Enclosure (1) contains an exploded view of each regulator. The only difference between the two regulators is in their first stages; the MARK V first stage will take two second stages whereas the MARK I will take only one. The same second stage is used with both regulators. The inhalation resistance of the regulators can be altered by turning the adjustment knob (Enclosure (1), page 1, item 11) which changes the spring tension on the second stage poppet (Enclosure (1), page 1, item 15). Both regulators were tested in the conditions of maximum inhalation resistance (identified as regulator valve closed in Enclosures (3) through (6)) and minimum inhalation resistance (identified as regulator valve open).

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3. The test apparatus used and the method used for interpreting the data are described in enclosure (2). The regulators were tested in the "wet" mode only.

4. The test results are contained in enclosures (3) and (4). The measured resistances were found to be unaffected by the supply pressure so long as it remained above 500 psi.

5. Due to high exhalation resistance and, under certain settings, high inhalation resistance these regulators were deemed satisfactory and returned to SCUBA PRO.

6. In May 1970 two additional regulators, one MARK I serial number 910520 and one MARK V serial number 962966, were received from SCUBA PRO. When the regulator test apparatus was set up in August 1970 to test another regulator (Evaluation Report 3-70), these additional SCUBA PRO regulators were also tested. On this occasion the regulators were tested both wet and dry. The results are contained in enclosures (5) and (6).

7. The exhalation resistance characteristics of the second set of regulators tested were satisfactory. However, the inhalation resistance characteristics continued to be unsatisfactory when the adjustment knob was screwed all the way in.

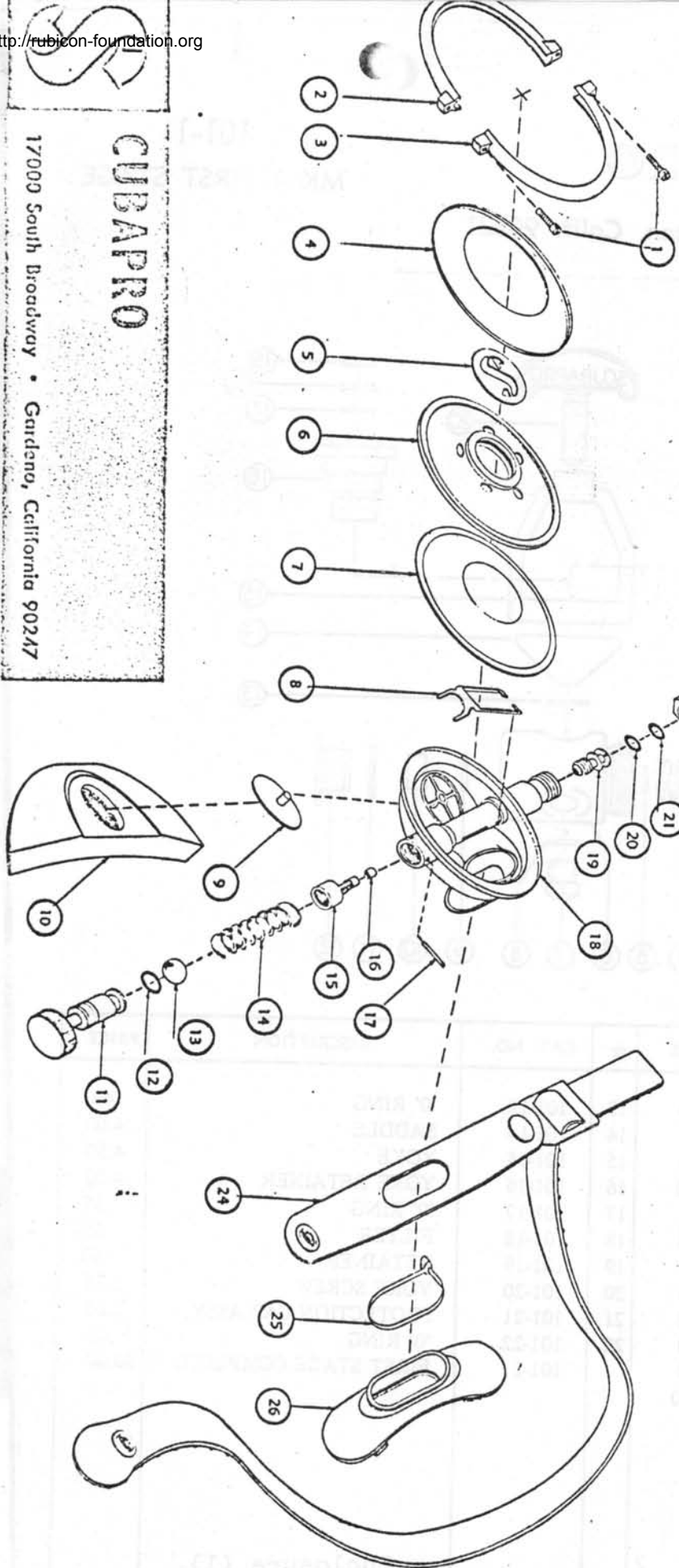
8. Since the inhalation resistance of all the regulators tested becomes unsatisfactory within a portion of the range of regulator adjustments that can be made by a diver in the water, the regulators, SCUBA PRO MARK I and MARK V, are considered unacceptable at this time.


J. H. BOYD, JR.



CUBAPRO

17000 South Broadway • Gardena, California 90247



CAT. NO.	DESCRIPTION	PRICE
109-51	Second Stage Complete	50.00
108-73	Screw (2 Req.)	.15
108-71	Threaded Clamp	1.50
108-72	Unthreaded Clamp	1.50
108-70	Cover Ring	3.00
108-69	Insignia Plate	.75
109-63	Cover	1.80
109-62	Diaphragm	3.00
109-61	Demand Valve Lever	3.00
109-64	Exhaust Valve	.50
109-65	Exhaust Tee	3.50
109-59	Adjustment Knob	2.00
109-58	'O' Ring	.35
109-58	Spring Pod	.50

#	CAT. NO.	DESCRIPTION	PRICE
14	109-57	Spring	1.80
15	109-56	Poppet	1.00
16	109-55	Seat Assembly	1.00
17	109-60	Stop Pin	.30
18	109-52	Case Assembly	10.00
19	109-54	Adjustable Orifice	2.50
20	109-53	'O' Ring	.40
21	101-6	'O' Ring	.35
22	108-61	Hose	6.50
23	101-9	'O' Ring	.35
24	108-62	Neck Strap Assembly	3.00
25	108-63	Mouthpiece Strap	.25
26	108-64	Mouthpiece	1.50

(Prices Subject to change without notice.)

SECOND STAGE MARK I & MARK V SCUBA PRO REGULATOR

Enclosure (1)

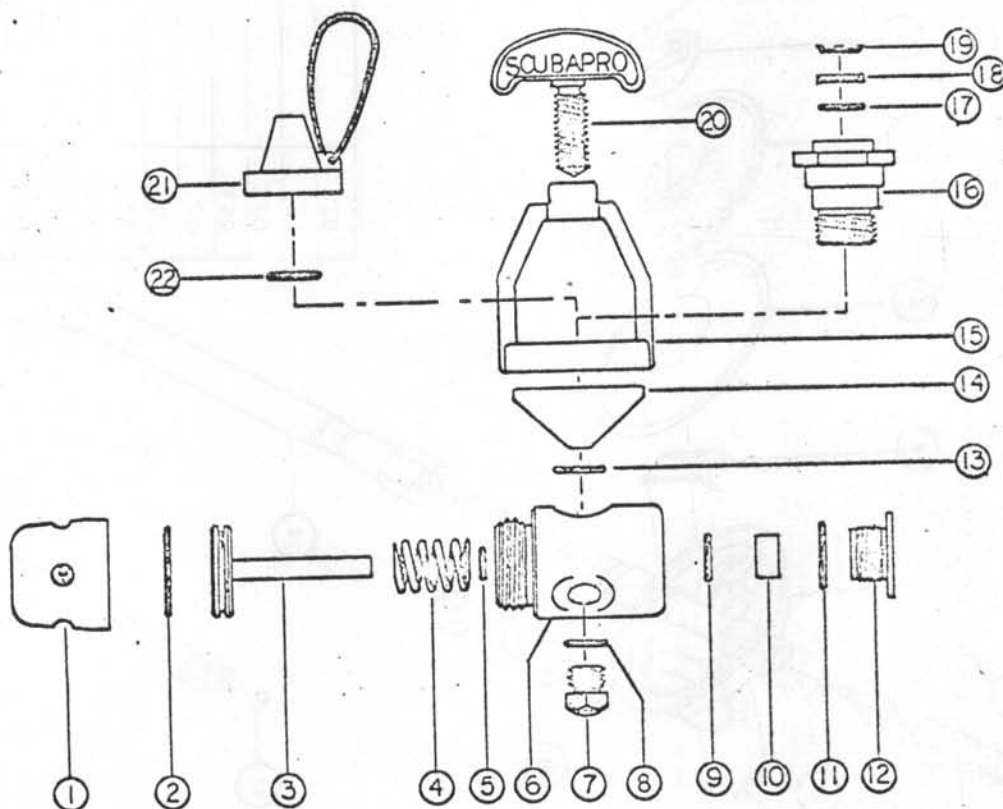


SCUBAPRO

3105 E. Harcourt St./Compton, Calif. 90221

101-1

MK 1 FIRST STAGE



#	CAT. NO.	DESCRIPTION	PRICE	#	CAT. NO.	DESCRIPTION	PRICE
1	101-2	CAP	6.00	13	101-12	'O' RING	.40
2	101-3	'O' RING	.40	14	101-14	SADDLE	4.00
3	101-4	PISTON	20.00	15	101-15	YOKE	4.50
4	101-5	SPRING	3.00	16	101-16	YOKE RETAINER	4.00
5	101-6	'O' RING	.35	17	101-17	'O' RING	.35
6	101-7	BODY	9.00	18	101-18	FILTER	.65
7	101-8	PLUG	.75	19	101-19	RETAINER	.40
8	101-9	'O' RING	.35	20	101-20	YOKE SCREW	1.75
9	101-10	'O' RING	.40	21	101-21	PROTECTION CAP ASSY.	1.00
10	101-11	SEAT	2.50	22	101-22	'O' RING	.40
11	101-12	'O' RING	.40		101-1	FIRST STAGE COMPLETE	50.00
12	101-13	SEAT RETAINER	3.00				
				2		Enclosure (1)	

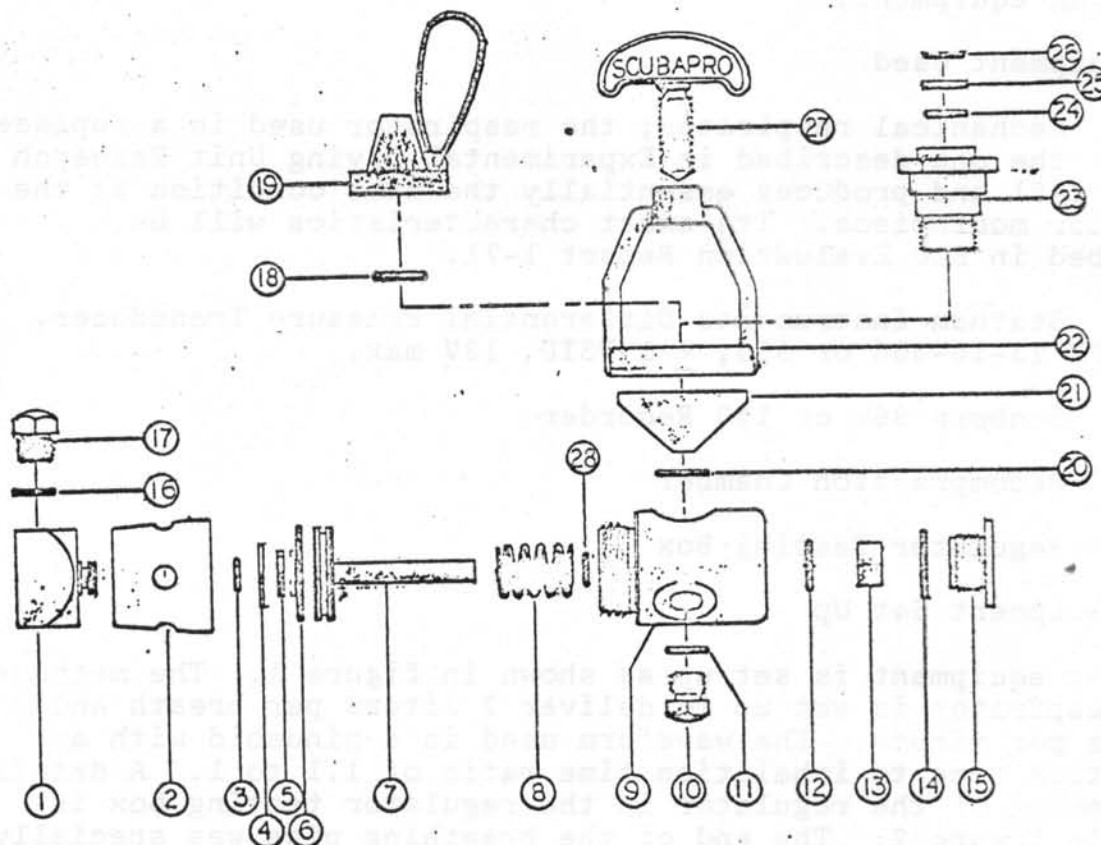


SCUBAPRO

3105 E. Harcourt St./Compton, Calif. 90221

105-1

MK 5 FIRST STAGE



#	CAT. NO.	DESCRIPTION	PRICE	#	CAT. NO.	DESCRIPTION	PRICE
1	105-2	SWIVEL	8.00	16	101-9	'O' RING	.35
2	105-3	CAP	6.00	17	101-8	PLUG	.75
3	101-17	'O' RING	.35	18	101-22	'O' RING	.40
4	105-5	WASHER	.35	19	101-21	PROTECTION CAP ASSY.	1.00
5	105-6	SWIVEL RETAINER	.50	20	101-12	'O' RING	.40
6	101-3	'O' RING	.40	21	101-14	SADDLE	4.00
7	101-4	PISTON	20.00	22	101-15	YOKE	4.50
8	101-5	SPRING	3.00	23	101-16	YOKE RETAINER	4.00
9	101-7	BODY	9.00	24	101-17	'O' RING	.35
10	101-8	PLUG	.75	25	101-18	FILTER	.65
11	101-9	'O' RING	.35	26	101-19	RETAINER	.40
12	101-10	'O' RING	.40	27	101-20	YOKE SCREW	1.75
13	101-11	SEAT	2.50	28	101-6	'O' RING	.35
14	101-12	'O' RING	.40		105-1	FIRST STAGE COMPLETE	60.00
15	101-13	SEAT RETAINER	3.00				
				3		Enclosure (1)	

EDU BREATHING RESISTANCE TEST APPARATUS FOR OPEN CIRCUIT SCUBA REGULATORS (SINGLE-HOSE)

Breathing resistance studies are conducted on open circuit SCUBA regulators supplied to the Navy Experimental Diving Unit in accordance with the following procedures and utilizing the following equipment.

I. Equipment Used

a. Mechanical respirator; the respirator used is a replacement to the one described in Experimental Diving Unit Research Report 2-61 and produces essentially the same condition at the regulator mouthpiece. Its exact characteristics will be described in EDU Evaluation Report 1-71.

b. Statham Instruments Differential Pressure Transducer, model PR 23-ID-300 or 350, ± 1 PSID, 13V max.

c. Sanborn 964 or 150 Recorder

d. Recompression Chamber

e. Regulator Testing Box

II. Equipment Set Up

The test equipment is set up as shown in figure 1. The mechanical respirator is set up to deliver 2 liters per breath and 20 breaths per minute. The waveform used is a sinusoid with an exhalation time to inhalation time ratio of 1.1 to 1. A detailed arrangement of the regulator in the regulator testing box is shown in figure 2. The end of the breathing pipe was specially formed to fit tightly into the mouthbit without creating any flow restrictions. The differential pressure transducer is connected to the mouthpiece so that it indicates the pressure difference between the mouthpiece and ambient pressure in the chamber.

III. Procedure

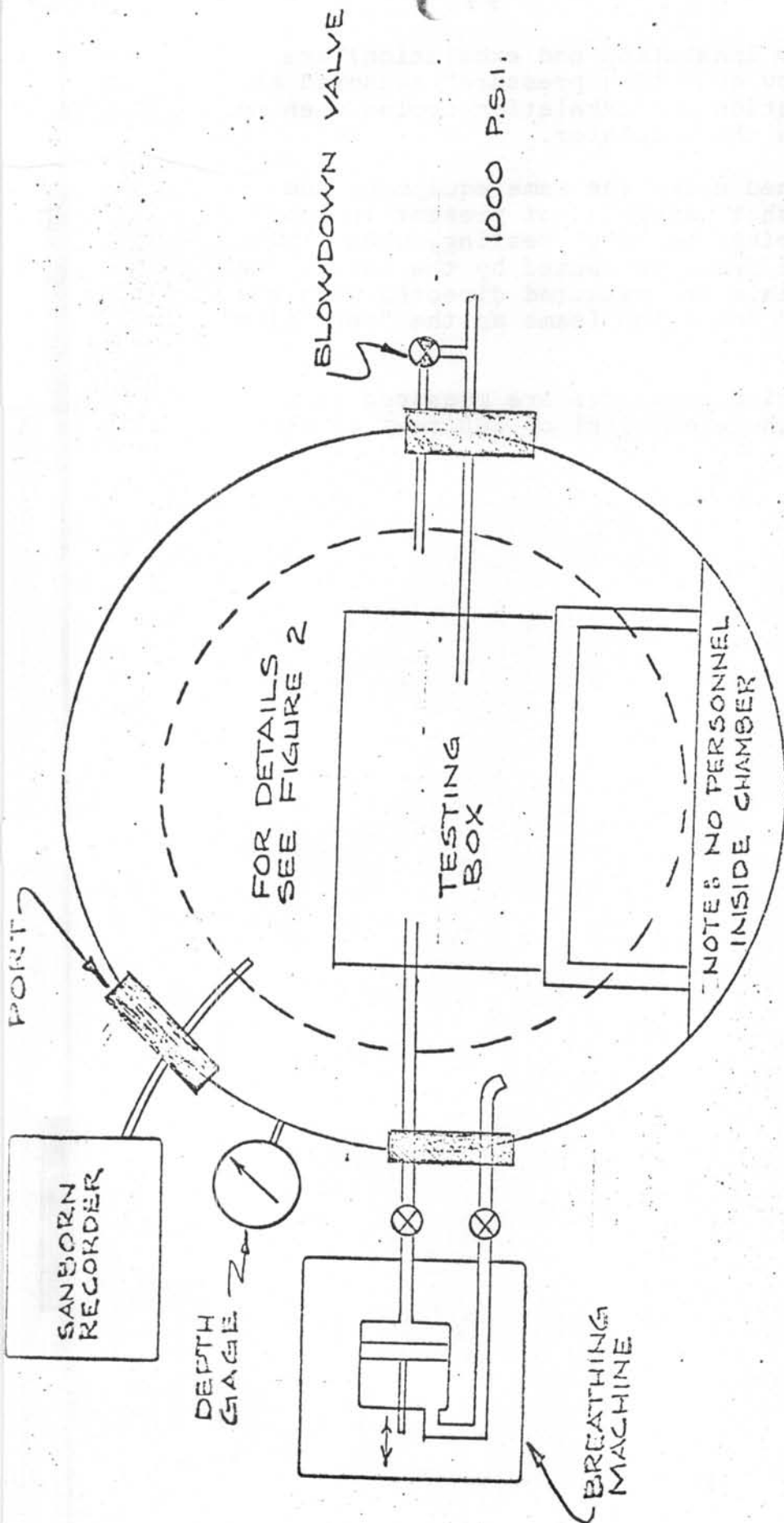
The test equipment shown in figure 1 is used to test the regulators in a "wet" or a "dry" environment.

The "wet" environment is produced by adding water to the regulator testing box to the level shown; allowing the regulator to be tested while immersed in water. The pressure differentials between the mouthpiece and ambient during inhalation and exhalation are recorded with the transducer and Sanborn recorder. During "wet" testing, the differential pressure readings from the transducer contain a component due to the weight of the water above the regulator. During these tests the maximum

pressure differentials (for inhalation and exhalation) are measured from the "zero flow condition pressure" measured at the time between the inhalation and exhalation cycles when no net flow is passing through the regulator.

"Dry" testing is accomplished using the same equipment and set up with the exception that water is not present in the regulator testing box. During the "dry" testing, when there is no inherent differential pressure caused by the water, the maximum pressure differentials are measured directly from the transducer "0 differential" condition (same as the "zero flow" condition above).

Peak inhalation and exhalation pressures are measured at 25 foot increments from 0 to the equivalent of 200 feet of sea water.



HYPERBARIC CHAMBER AT E.D.U.

BREATHING RESISTANCE TESTING APPARATUS

FIGURE 1

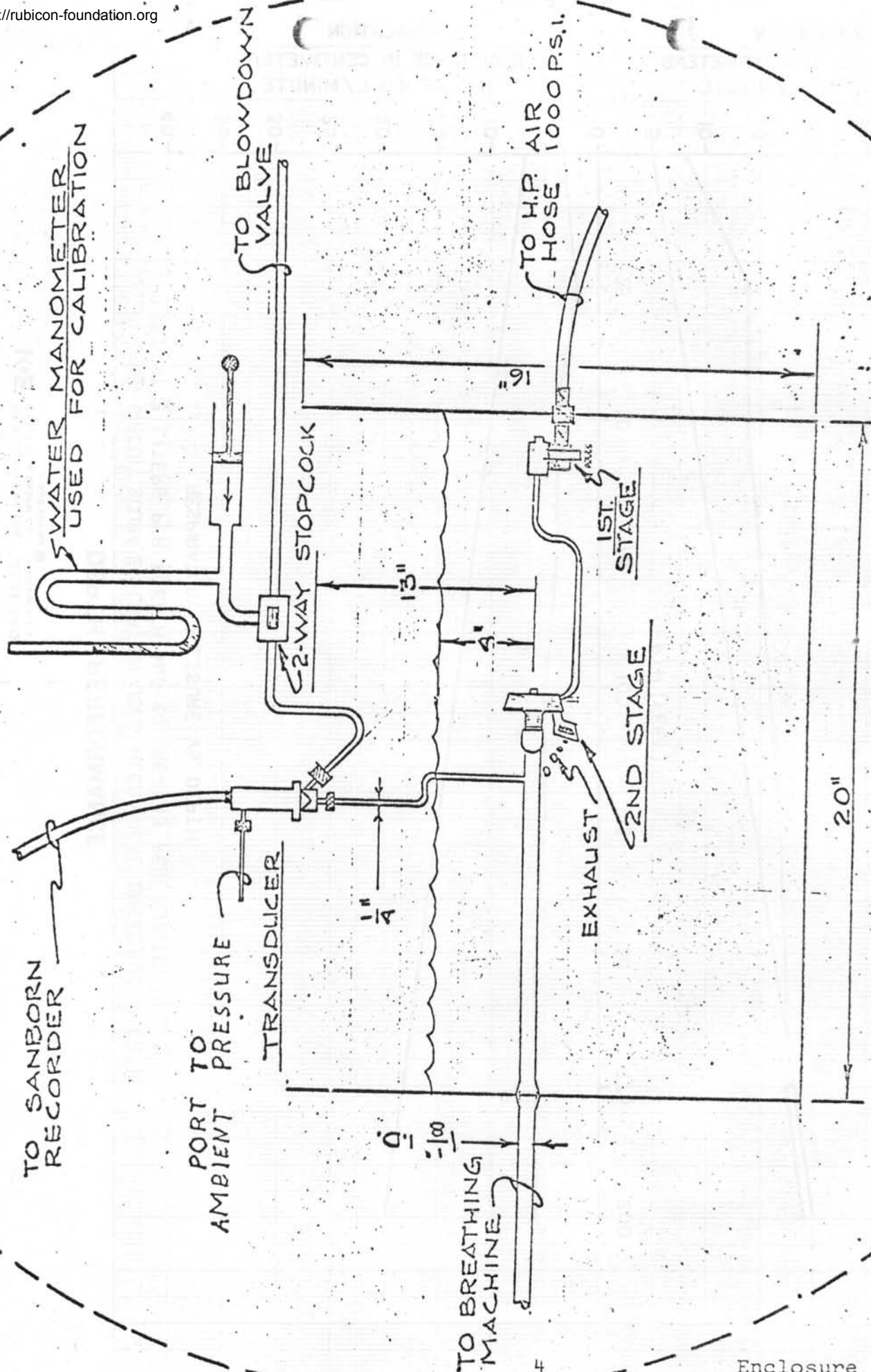
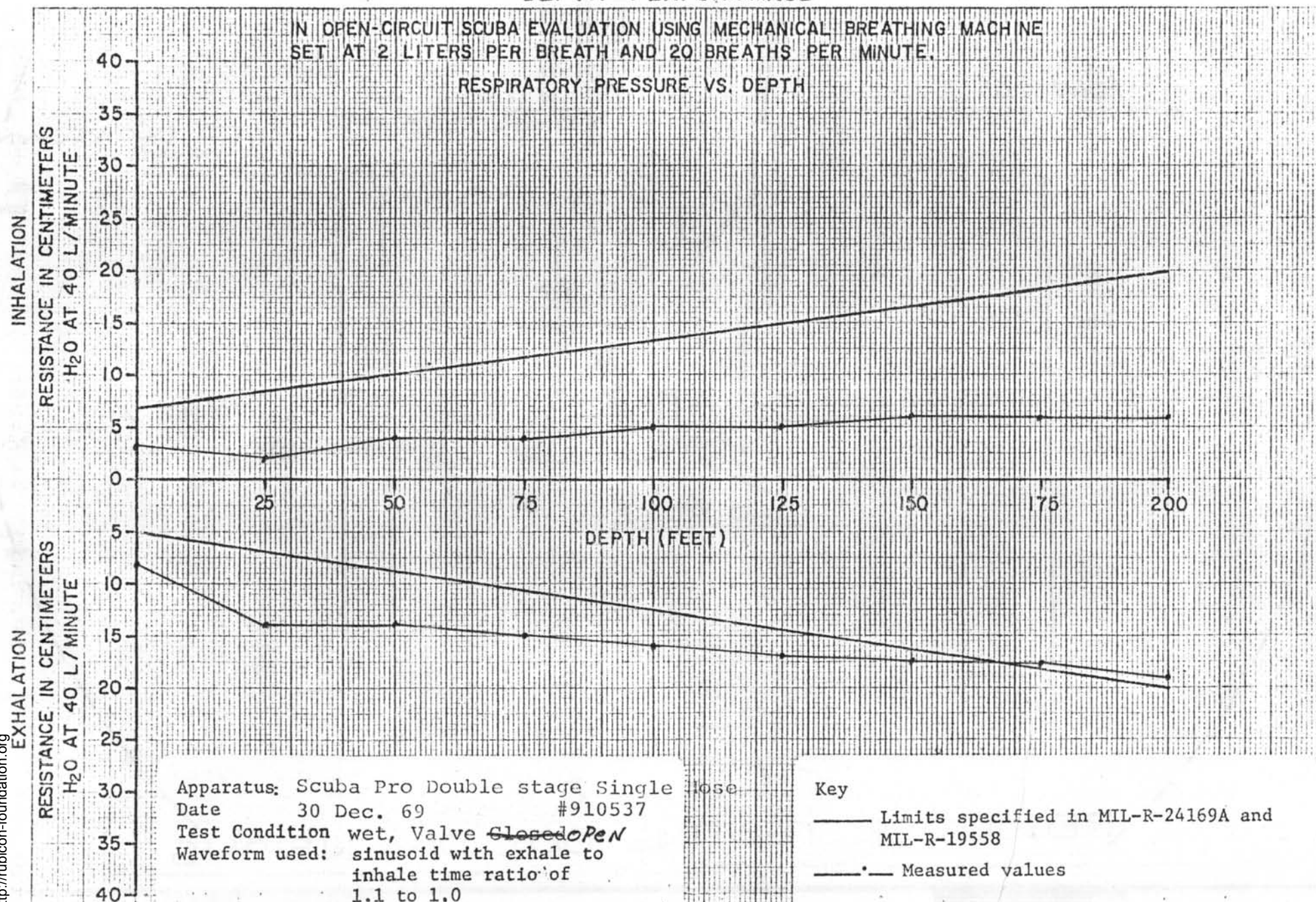


FIGURE 2
REGULATOR TESTING BOX DIMENSIONS

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

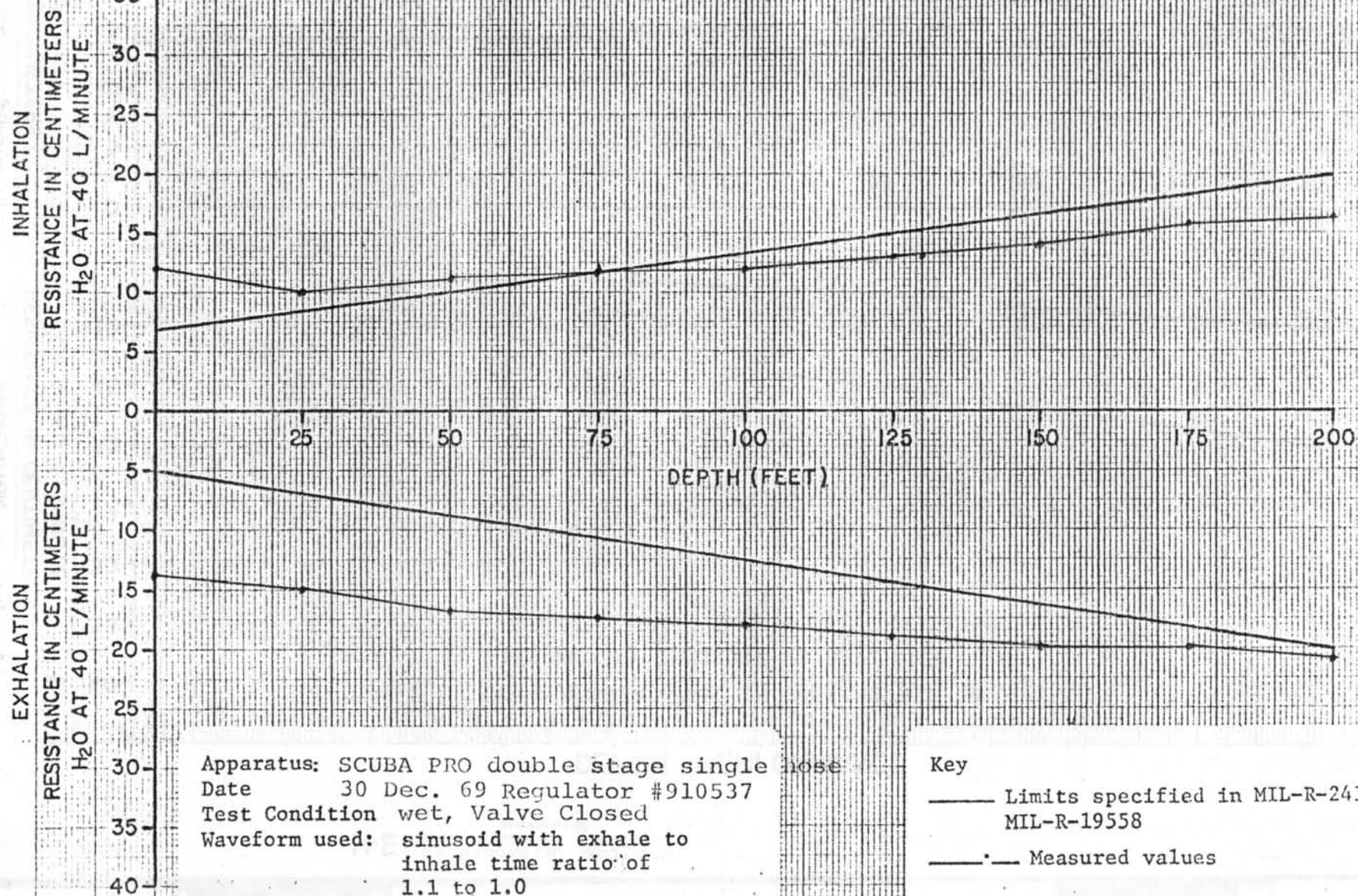


ENCLOSURE

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

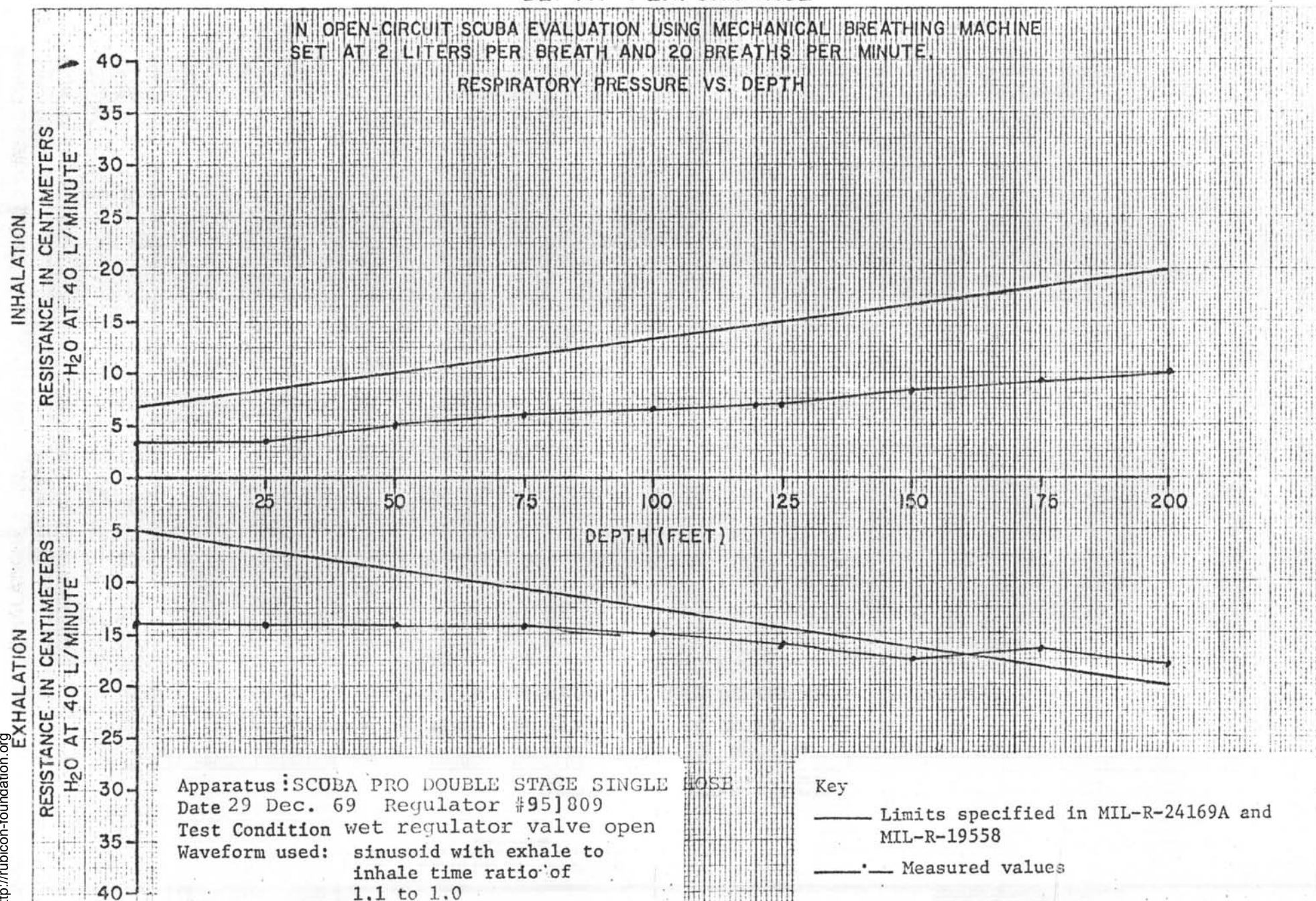
RESPIRATORY PRESSURE VS. DEPTH



DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

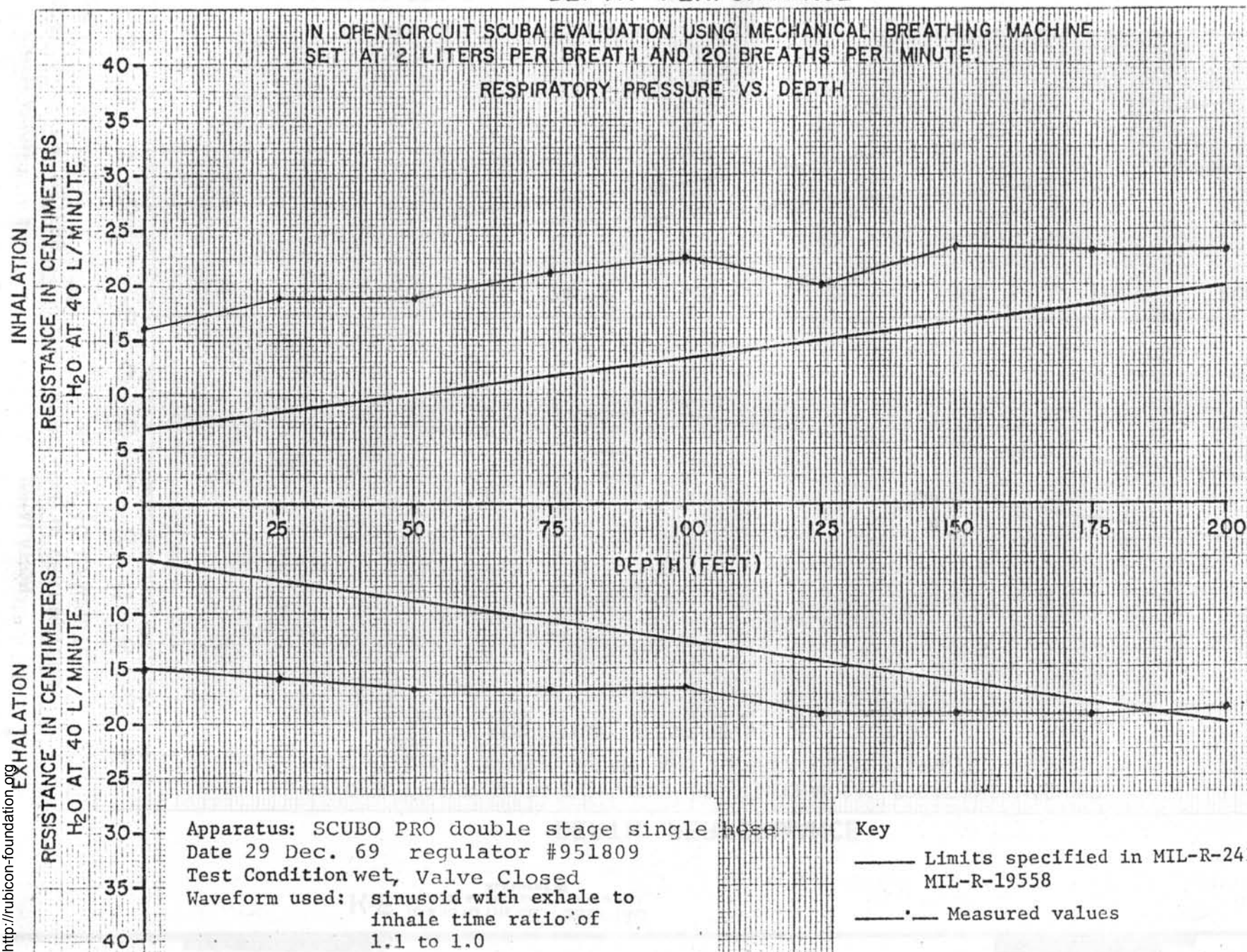
RESPIRATORY PRESSURE VS. DEPTH



DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

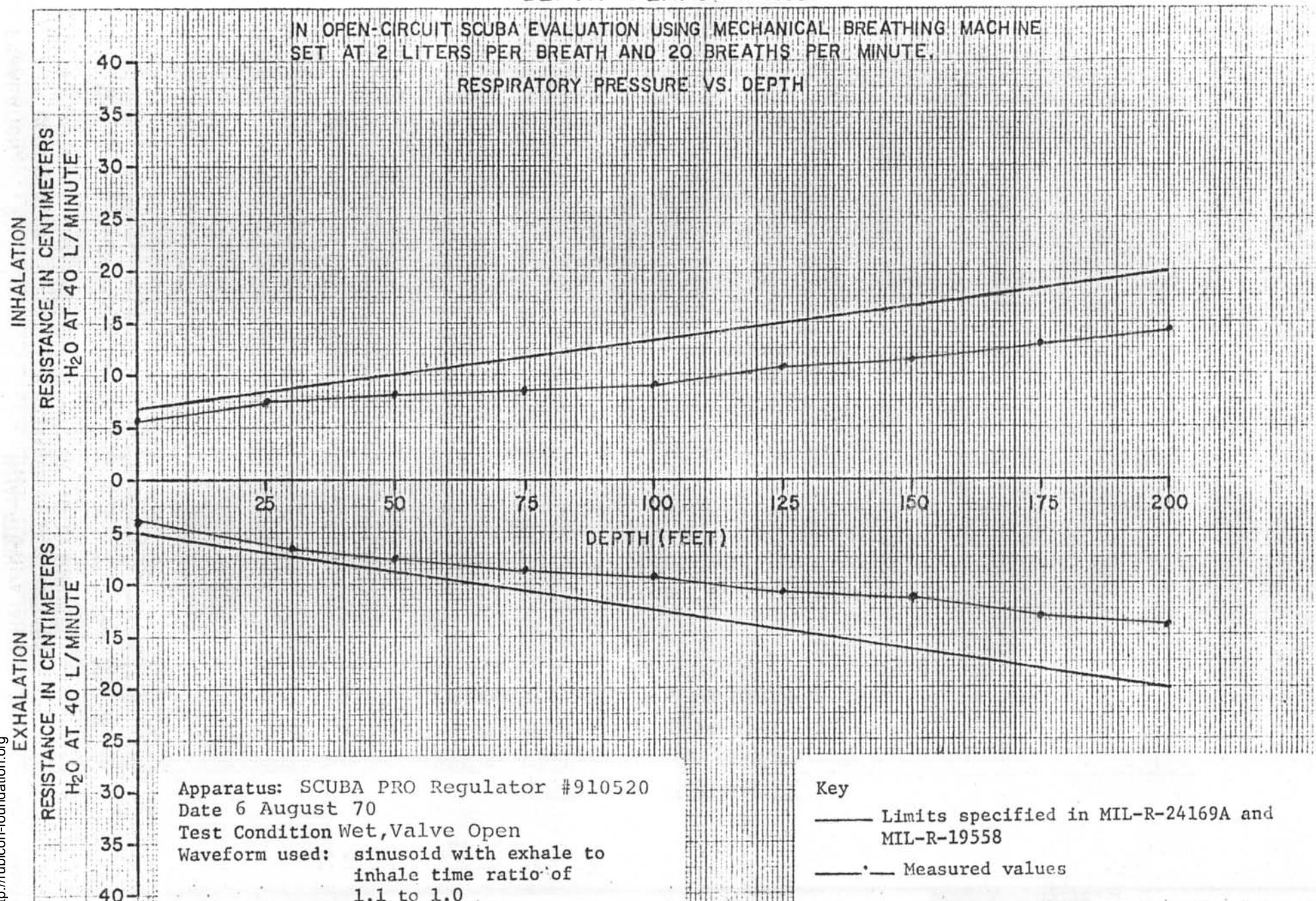
RESPIRATORY PRESSURE VS. DEPTH



DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

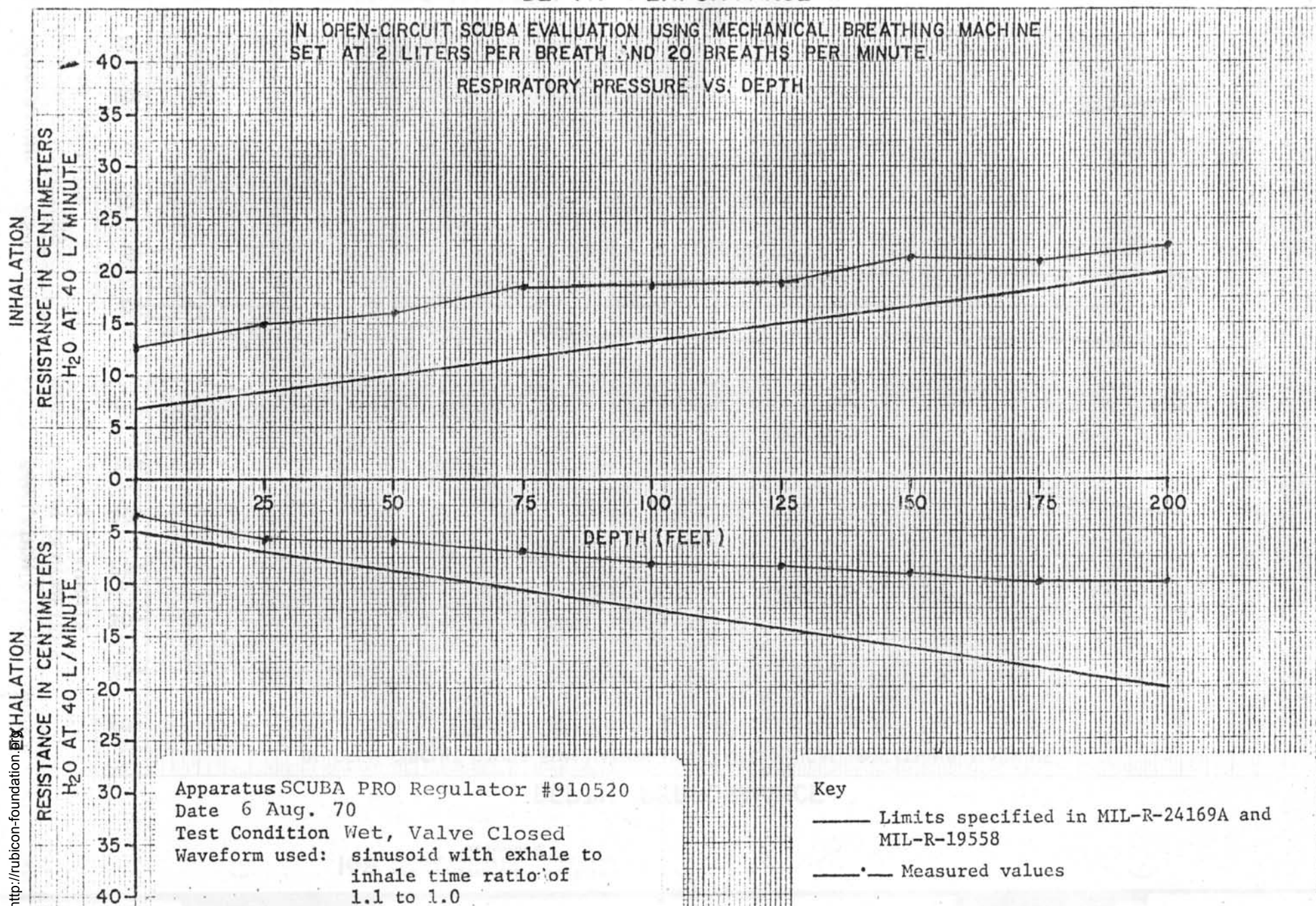


ENCL # 5

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH



ENCL # 5

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

INHALATION

RESISTANCE IN CENTIMETERS

H₂O AT 40 L/MINUTE

EXHALATION

RESISTANCE IN CENTIMETERS

H₂O AT 40 L/MINUTE

DEPTH (FEET)

Apparatus: SCUBA PRO #910520
Date 6 Aug. 70
Test Condition dry, Valve open
Waveform used: sinusoid with exhale to
inhale time ratio of
1.1 to 1.0

Key

— Limits specified in MIL-R-24169A and
MIL-R-19558

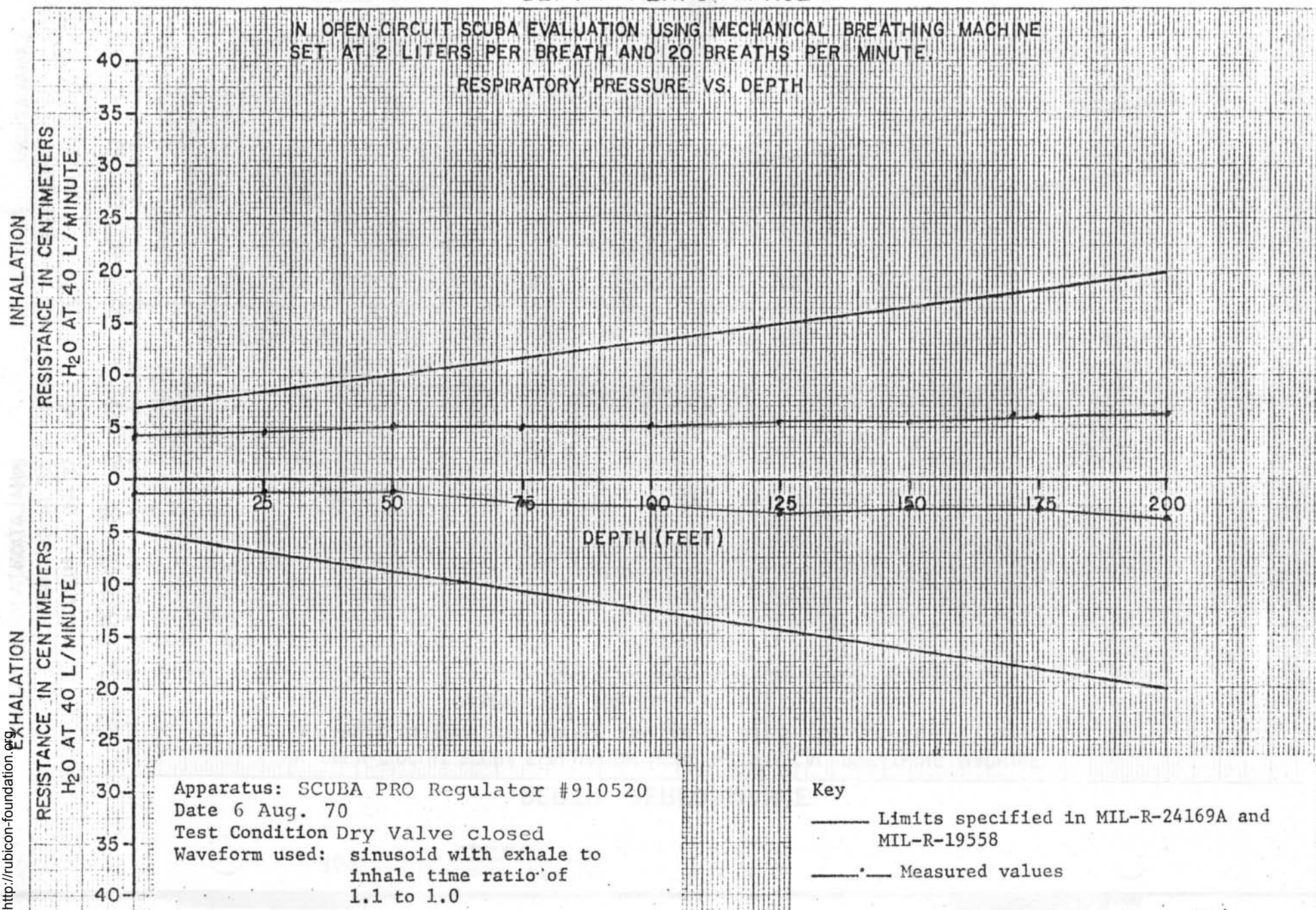
— Measured values

ENCLOSURE

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH



Apparatus: SCUBA PRO Regulator #910520
Date 6 Aug. 70
Test Condition Dry Valve closed
Waveform used: sinusoid with exhale to
inhale time ratio of
1.1 to 1.0

Key

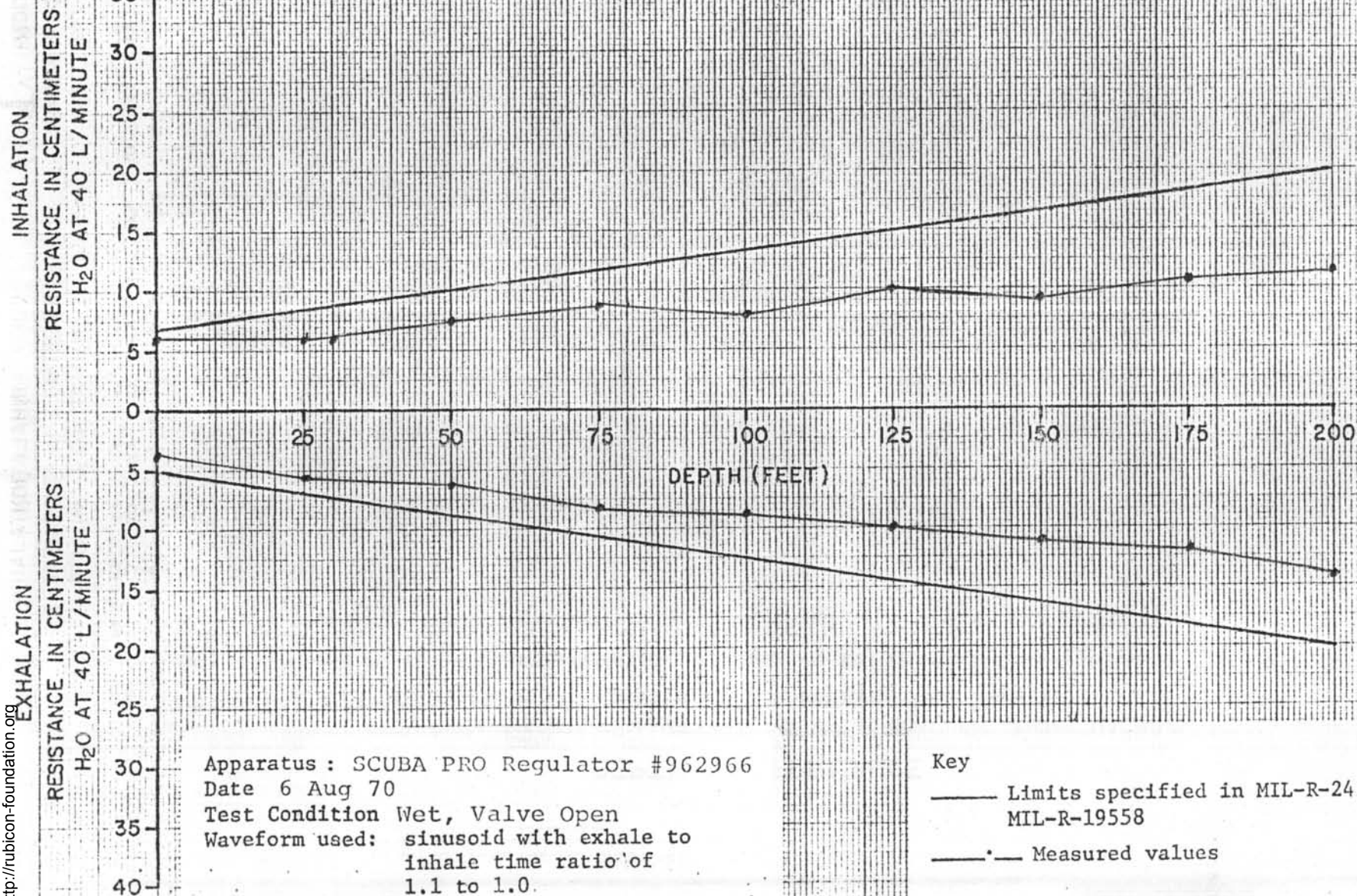
- Limits specified in MIL-R-24169A and MIL-R-19558
- - - Measured values

ENCLOSURE

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

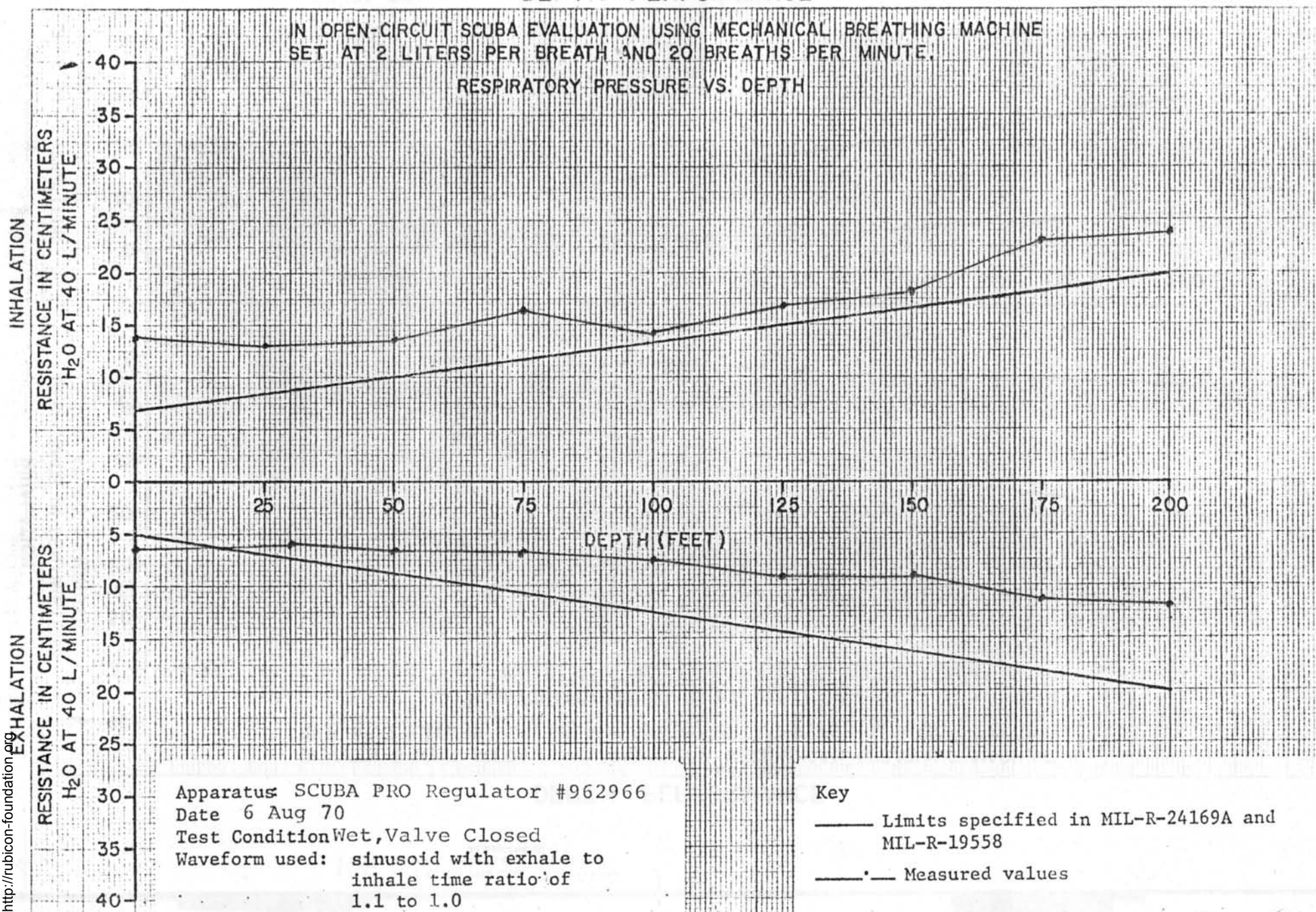


Enc 1 (6)

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

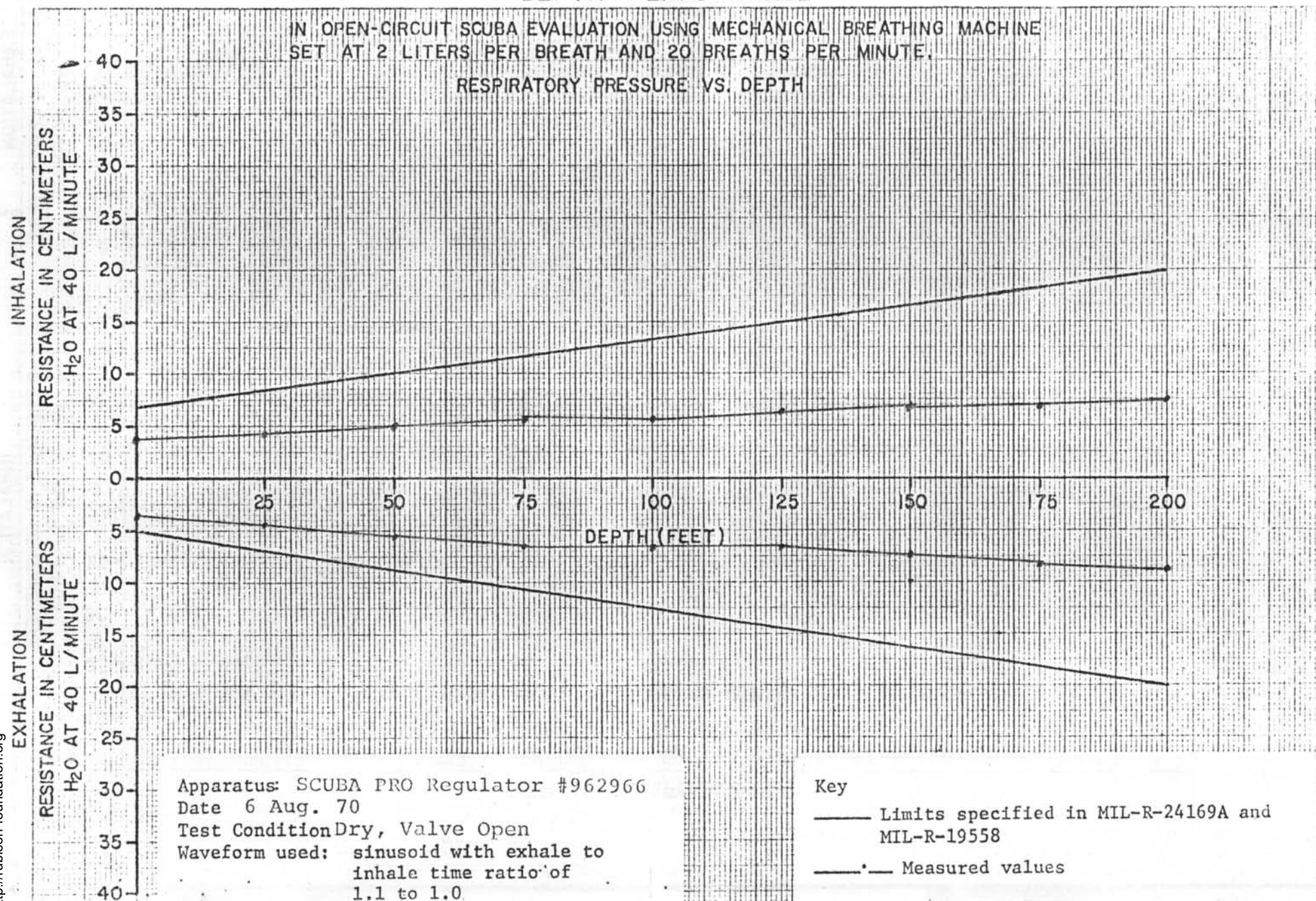


Enc 1 (6)

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH



Apparatus: SCUBA PRO Regulator #962966
Date 6 Aug. 70
Test Condition Dry, Valve Open
Waveform used: sinusoid with exhale to
inhale time ratio of
1.1 to 1.0

Key

- Limits specified in MIL-R-24169A and MIL-R-19558
- Measured values

Enc 1(6)

DEPTH PERFORMANCE

IN OPEN-CIRCUIT SCUBA EVALUATION USING MECHANICAL BREATHING MACHINE
 SET AT 2 LITERS PER BREATH AND 20 BREATHS PER MINUTE.

RESPIRATORY PRESSURE VS. DEPTH

INHALATION

RESISTANCE IN CENTIMETERS
 H_2O AT 40 L/MINUTE

RESISTANCE IN CENTIMETERS
 H_2O AT 40 L/MINUTE

EXHALATION

RESISTANCE IN CENTIMETERS
 H_2O AT 40 L/MINUTE

RESISTANCE IN CENTIMETERS
 H_2O AT 40 L/MINUTE

DEPTH (FEET)

Apparatus: SCUBA PRO Regulator # 962966
 Date 6 Aug. 70
 Test Condition Dry, Valve Closed
 Waveform used: sinusoid with exhale to
 inhale time ratio of
 1.1 to 1.0

Key

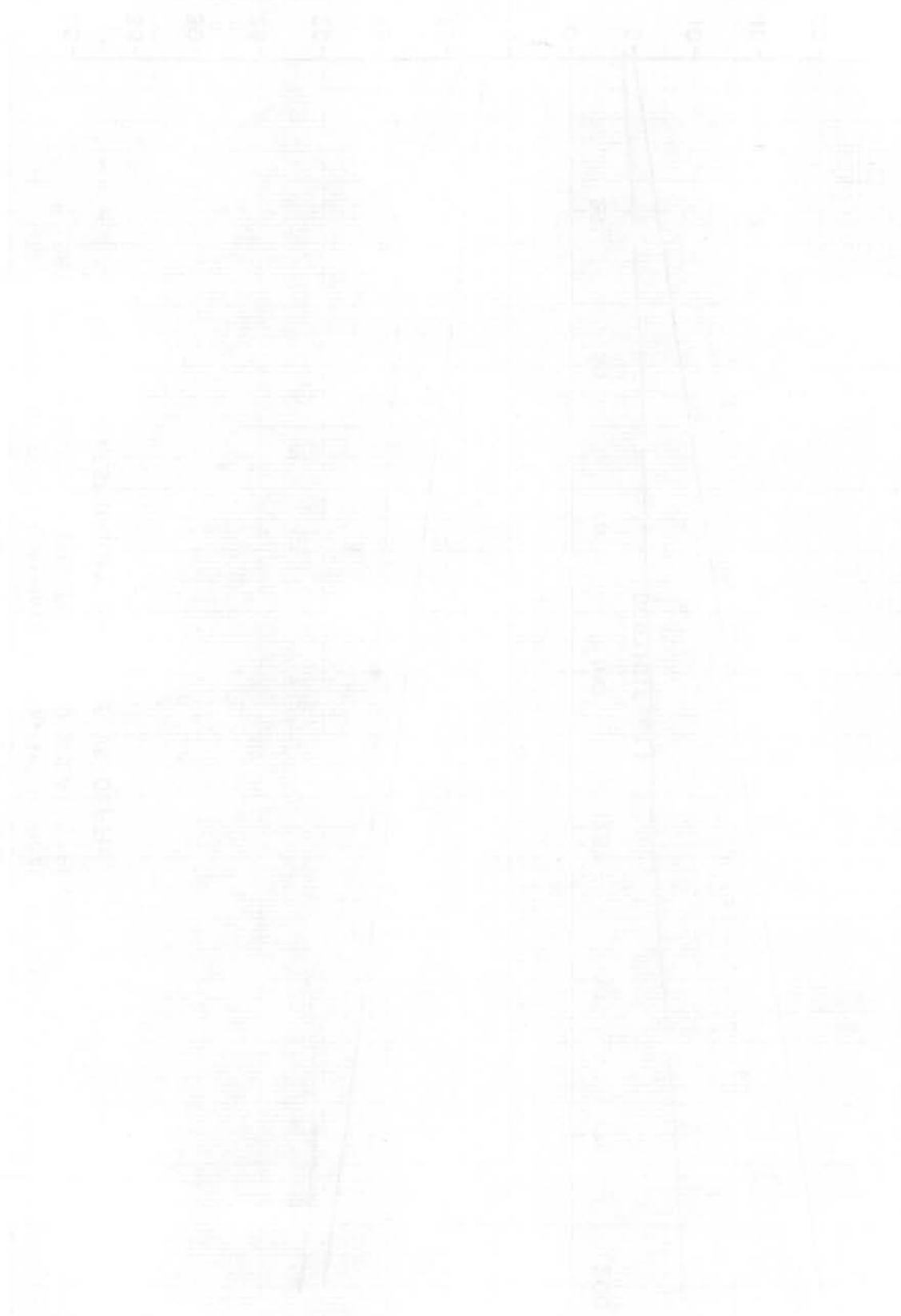
— Limits specified in MIL-R-24169A and
 MIL-R-19558

—*— Measured values

Encl(6)

STATION
MOUNTAIN
RECORDING
MOUNTAIN

STATION
MOUNTAIN
RECORDING
MOUNTAIN



DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Navy Experimental Diving Unit Washington Navy Yard, Washington, D.C.		2a. REPORT SECURITY CLASSIFICATION Unclassified	
		2b. GROUP	
3. REPORT TITLE Evaluation of SCUBA PRO MARK I and MARK V Open Circuit SCUBA Regulators			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Product Qualification Test			
5. AUTHOR(S) (First name, middle initial, last name) Stephen D. Reimers			
6. REPORT DATE 29 December 1970		7a. TOTAL NO. OF PAGES 21	7b. NO. OF REFS 2
8a. CONTRACT OR GRANT NO. None		9a. ORIGINATOR'S REPORT NUMBER(S) Letter Report 5-70	
b. PROJECT NO.			
c.		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) None	
d.			
10. DISTRIBUTION STATEMENT Statement Approved for public release; distribution unlimited.			
11. SUPPLEMENTARY NOTES None		12. SPONSORING MILITARY ACTIVITY NAVSHIPSYSKOM	
13. ABSTRACT The military specifications for open circuit SCUBA regulators provide a mechanism by which commercial vendors may submit their regulators to the Navy Experimental Diving Unit for testing for possible approval for U.S. Navy use. Accordingly, two SCUBA PRO single hose regulators, Models MARK I AND MARK V, were tested in December 1969. The inhalation resistance of the regulators was found under certain conditions to exceed the limits specified for single hose regulators in Mil-R-24169A. The regulators were, therefore, disapproved for U. S. Navy use.			

14

KEY WORDS

LINK A

LINK B

LINK C

[illegible]

WT

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WT

Breathing Apparatus
Underwater Life Support Systems
Diving