NATO STANDARD

ADivP-05

STANDARD UNMANNED TEST PROCEDURES AND ACCEPTANCE CRITERIA FOR UNDERWATER BREATHING APPARATUS

Edition A Version 1

FEBRUARY 2015

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED DIVING OPERATIONS PUBLICATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

5 February 2015

1. The enclosed Allied Diving Operations Publication ADivP-05, Edition A, Version 1, STANDARD UNMANNED TEST PROCEDURES AND ACCEPTANCE CRITERIA FOR UNDERWATER BREATHING APPARATUS, which has been approved by the nations in the Military Committee Maritime Standardization Board (MCMSB), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 1410.

2. ADivP-05, Edition A, Version 1, is effective upon receipt.

3.

4. This publication shall be handled in accordance with C-M(2002)60.

Edvardas MAŽEIKIS
Major General, LTUAF
Director, NATO Standardization Office

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RESERVED FOR NATIONAL LETTER OF PROMULGATION

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
General	POL
Annex A	FRA
Annex F	FRA

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
FRA	France has the following two reservations on implementation of STANAG 1410 (ADivP-05): - Annex A, Table A-1 and Annex F: The maximum ventilation rate taken into account when testing French Navy diving equipment is 62.5 $l \cdot min^{-1}$ instead of 90 $l \cdot min^{-1}$; - Annex F: In France, the maximum permitted work of breathing (WOB) is 3.0 $J \cdot l^{-1}$ for equipment to be used at depths < 60 m, whereas ADivP-05 limits the acceptance criteria to a maximum of 2.0 $J \cdot l^{-1}$ for equipment to be used at depths of < 25 m and to ≤ 1.7 $J \cdot l^{-1}$ for all other equipment.
POL	STANAG 1410 (ADivP-05) will be implemented only with reference to new diving breathing apparatus.

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CHAPTER 1 INTRODUCTION

1.1. AIM

The aim of this agreement is to provide for the assessment and acceptance of underwater breathing apparatus, used within NATO, against a standard set of test procedures and performance criteria.

1.2. AGREEMENT

Participating nations agree to use the following details as standard test procedures and acceptance criteria for underwater breathing apparatus.

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CHAPTER 2 DETAILS OF AGREEMENT

2.1. GENERAL

All equipment shall be primarily specified and dimensioned in Standard International Units (SI).

2.2. TESTING

1. The Breathing Apparatus (BA) shall be assessed in accordance with the test procedures contained at Annex A.

3. The test equipment, where applicable, shall conform to the requirements specified at Annex B.

4. The measuring instruments, where applicable, shall meet the range and uncertainty of measurement specified at Annex C.

5. The test system and instrumentation shall be calibrated in accordance with the requirements specified at Annex D.

6. Data recording, analysis and display shall be in accordance with the requirements specified at Annex E.

2.3. ACCEPTANCE CRITERIA

The apparatus performance shall be compared with the acceptance criteria specified at Annex F.

2.4. REPORTING

Details of the BA under assessment, major parameters defining the conditions of test and the results shall be recorded in accordance with the test records specified at Annex G.

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ANNEX A

TEST PROCEDURES

A.1. BREATHING PERFORMANCE

1. The dynamic performance of the breathing apparatus shall be tested at appropriate ventilation rates, shown in Table A-1, with the apparatus immersed.

2. The ventilation rates shall be measured under Actual Temperature, Pressure and humidity (ATP) conditions. All relevant data should be included to allow ventilation rates to be corrected for Body Temperature Pressure Saturated (BTPS) conditions, by calculation, after testing.

A.2. CARBON DIOXIDE ABSORBENT CANISTER

The duration of the carbon dioxide absorbent canister shall be determined with heated and humidified exhaled gas, at a ventilation rate of 40 $l \cdot min^{-1}$ (ATP) and a carbon dioxide injection rate of 1.6 $l \cdot min^{-1}$ (STPD). In addition it may be determined at any other appropriate ventilation rate stated in Table A-1. Canister duration is defined as the time taken for the carbon dioxide level, measured in the inhaled gas, to reach 0.5 kPa.

A.3. ORAL NASAL FACEMASK/HELMET CARBON DIOXIDE LEVELS

Breathing apparatus utilising oral nasal masks and or helmet systems shall be tested for inspired carbon dioxide. The gas sample for the measurement of inspired carbon dioxide shall be taken at the mouth of the test mannequin.

A.4. COUNTER-LUNG VOLUME

The collapsible volume of any counter-lung, incorporated into the breathing apparatus under test, shall be measured.

A.5. NUMBER OF EQUIPMENT FOR TEST

The minimum number of equipment tested shall be five and ideally a greater number should be tested to give statistically valid test data.

TIDAL VOLUME (litres) ATP	BREATHS PER MINUTE (BPM)	VENTILATION (litre per minute) ATP	CARBON DIOXIDE FLOW (litre per minute) STPD	OXYGEN REMOVAL (litre per minute) STPD
1.0	10	10.0	0.4	0.44
1.5	15	22.5	0.9	1.00
2.0	20	40.0	1.6	1.78
2.0	25	50.0	2.0	2.22
2.5	25	62.5	2.5	2.78
3.0	25	75.0	3.0	3.33
3.0	30	90.0	3.6	4.00

Standard Temperature and Pressure Dry (STPD) 0 °C, 1.013 bar

Actual Temperature and Pressure (ATP)

Table A-1: Breathing simulator settings

ANNEX B

TEST EQUIPMENT

B.1. GENERAL

Minimum Test Equipment shall conform to the following requirements:

B.2. NOMINAL VALUES AND TOLERANCES

1. Unless otherwise specified, the values shall be subjected to a maximum deviation of ± 5 %. Unless otherwise specified, the room temperature for testing shall be 22 ± 5 °C and at a relative humidity of at least 50 %. Temperature limits shall be subject to a maximum deviation of ± 1 °C.

2. Where depth is presented in metre (m) it shall be related to absolute pressure in bar such that a depth change of 10.00 m is equal to a pressure change of 1.000 bar (this assumes a water density of 1.01972 at 4 °C).

3. Where depth is presented in feet of sea water (fsw), the relationship between fsw and absolute pressure in bar shall be stated.

B.3. BREATHING SIMULATOR

1. The breathing simulator shall be adjustable to the tidal volumes and breathing rates shown at Annex A, Table A-1.

2. The breathing simulator shall provide a sinusoidal breathing waveform with a harmonic distortion of less than or equal to 5 % and shall be capable of generating the ventilation specified in Annex A, Table A-1 with an error of less than or equal to 1 %.

3. The breathing simulator shall be connected to the breathing apparatus by a rigid pipe system, the volume of which shall be as low as possible and shall be stated.

B.4. TEMPERATURE AND HUMIDIFICATION SYSTEM

If fitted, the heating and humidification system shall be capable of maintaining temperature and Relative Humidity (RH) with the range of 25-30 °C and 95-100 % RH, respectively, when measured at the mouth.

B.5. OXYGEN REMOVAL

If fitted, the system shall be capable of removing oxygen from the breathing apparatus circuit at the rates specified at Annex A, Table A-1.

B.6. CARBON DIOXIDE INJECTION SYSTEM

1. If fitted, the system shall be capable of injecting carbon dioxide at the rates specified in Annex A, Table A-1.

2. The breathing simulator should also include a carbon dioxide absorbent system prior to the injection point to prevent carbon dioxide accumulation during non-endurance tests.

B.7. TEST CHAMBER

The test chamber shall be designed to appropriate National Codes and shall allow the diving equipment to be tested, completely immersed, at pressures equivalent to the maximum depth that it is intended to be used. During testing the pressure variation, occurring within the test chamber, shall be as low as possible and shall not exceed ± 0.5 m of the test depth (pressure). The water temperature should be maintained within ± 1 °C of the set temperature, appropriate for the intended conditions of use.

ANNEX C

MEASURING INSTRUMENTS

C.1. MOUTH PRESSURE

The mouth pressure sensor shall measure, differentially, the pressure variations occurring at the inlet to the mouth or mouthpiece. It may be referenced to the air space above the immersed equipment provided the dynamic range of the mouth pressure sensor is not exceeded either by the sum of the depth plus 2.5 kPa or the sum of the depth plus the maximum positive pressure variation recorded during dry testing. The sensor must have a minimum frequency and amplitude response of 50 Hz and ± 6.0 kPa respectively.

C.2. VOLUME/DISPLACEMENT MEASUREMENT

It is preferable that tidal volume be measured directly via a suitable non-invasive sensing system or, if not practical, indirectly via measurement of the linear displacement of the breathing simulator piston.

C.3. TEMPERATURE SENSORS

The temperature of the water in which the equipment is immersed shall be measured with an accuracy of ± 0.5 °C. Where necessary the inspired and expired gas temperature shall be measured as close to the mouth as practicable. The time constant of the temperature sensor shall be stated.

C.4. GAS ANALYSIS

1. Breath by breath gas analysis: Where used, breath by breath gas analysis shall be undertaken with an analyser response time of better than 150 ms to 95 % of the step change. The sampling tube between the breathing apparatus and the analyser shall flow sufficient gas to minimise lag time and gas mixing. The sample flow shall not alter, unduly, the gas concentrations normally maintained within the breathing apparatus.

2. Canister breakthrough analysis: Canister breakthrough may be monitored with a lower response but suitably ranged analyser.

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ANNEX D

CALIBRATION REQUIREMENTS

D.1. INSTRUMENTATION

Measuring instruments shall be calibrated against traceable standards.

D.2. DIFFERENTIAL (MOUTH) PRESSURE TRANSDUCER

The differential pressure transducer shall be calibrated along with the recording system against a water column manometer, or other certified device, in the positive and negative directions. Additionally, the transducer system must have a linear response less than or equal to 0.5 % of the intended dynamic range.

D.3. PRESSURE TRANSDUCERS (GENERAL PURPOSE)

1. Pressure transducers used to measure supply or intermediate pressures should be calibrated against a standard test gauge or instrument.

2. Where transducers display depth in metre (m) the density of the water/seawater shall be equivalent to 1.01972 (*i.e*. 10.00 m being equivalent to 1.000 bar).

D.4. CALIBRATION GASES

Gases used to calibrate analysers shall be certified.

D.5. CARBON DIOXIDE INJECTION

1. Ideally the carbon dioxide injection system shall be calibrated immediately prior to the test against a suitable standard at a pressure equivalent to the test depth. Alternatively the system may be calibrated prior to a fixed series of runs at a given test depth, the carbon dioxide injection rate must then be verified during each test by determining the mass change of the carbon dioxide supply.

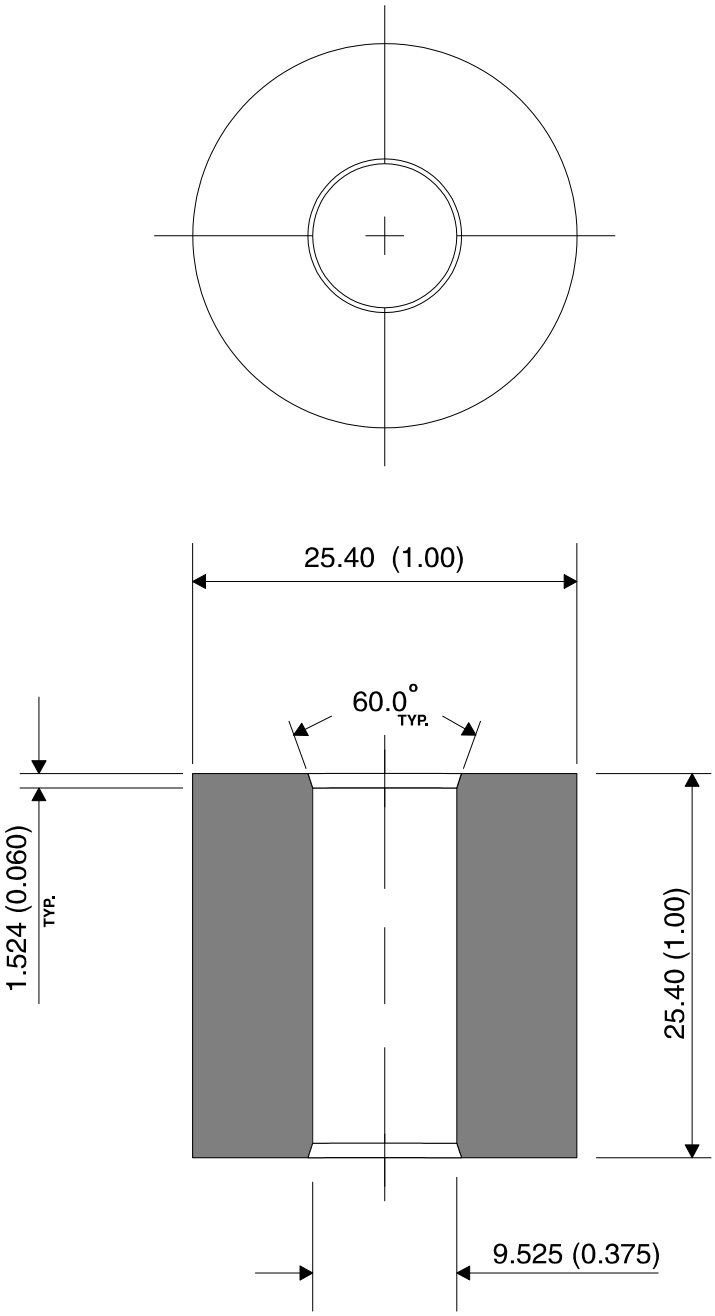
2. The performance of the volume weighted inspired carbon dioxide test equipment shall be defined by the use of calibration tubes. The calibration tube shall be attached to the output of the breathing simulator, have an internal diameter of 30 ± 0.2 mm and a length of 150 ± 1 mm. It shall be tested at atmospheric pressure with air and a ventilation rate of 62.5 $l \cdot min^{-1}$ and associated carbon dioxide injection of 2.5 $l \cdot min^{-1}$. A 0.2 $m \cdot s^{-1}$ forced ventilation shall be provided across the open end of the tube to remove the exhaled carbon dioxide. The value for the volume weighted inspired carbon dioxide shall be 0.42 ± 0.02 kPa.

D.6. BREATHING SIMULATOR SYSTEM

1. Non counter-lung equipment – Atmospheric pressure orifice test: The resistance posed by a standard orifice, shown in Figure D-1, shall be recorded at the outlet of the breathing machine test circuit.

2. Non counter-lung equipment – 6 bar (50 m) pressure orifice test: When tested with air at a ventilation rate of 62.5 $l \cdot min^{-1}$, and at a pressure of 6 bar (50 m), a standard pressure test orifice, shown in Figure D-2, shall give values recorded at the outlet of the breathing machine test circuit of 3.3 ± 0.05 $J \cdot l^{-1}$ for WOB and ± 2.5 kPa for respiratory pressures.

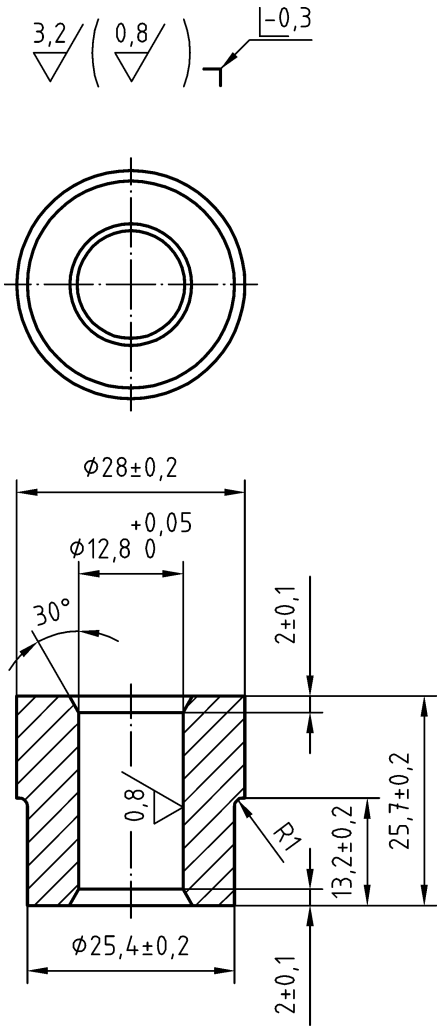
3. Counter-lung equipment - Elastance/orifice test: The resistance posed by a water-column and orifice, shown in Figure D-3, shall be recorded at the outlet of the breathing machine test circuit. The pressure difference between the end exhalation point and the end inhalation point shall be $\leq 5 \pm 0.05$ kPa for each litre of tidal volume.



DIMENSIONS IN MM (INCHES)

DIAGRAM NOT TO SCALE

Figure D-1: Atmospheric pressure calibration orifice



DIMENSIONS IN MM
DIAGRAMME NOT TO SCALE

Figure D-2: 6 bar (50 m) Pressure calibration orifice

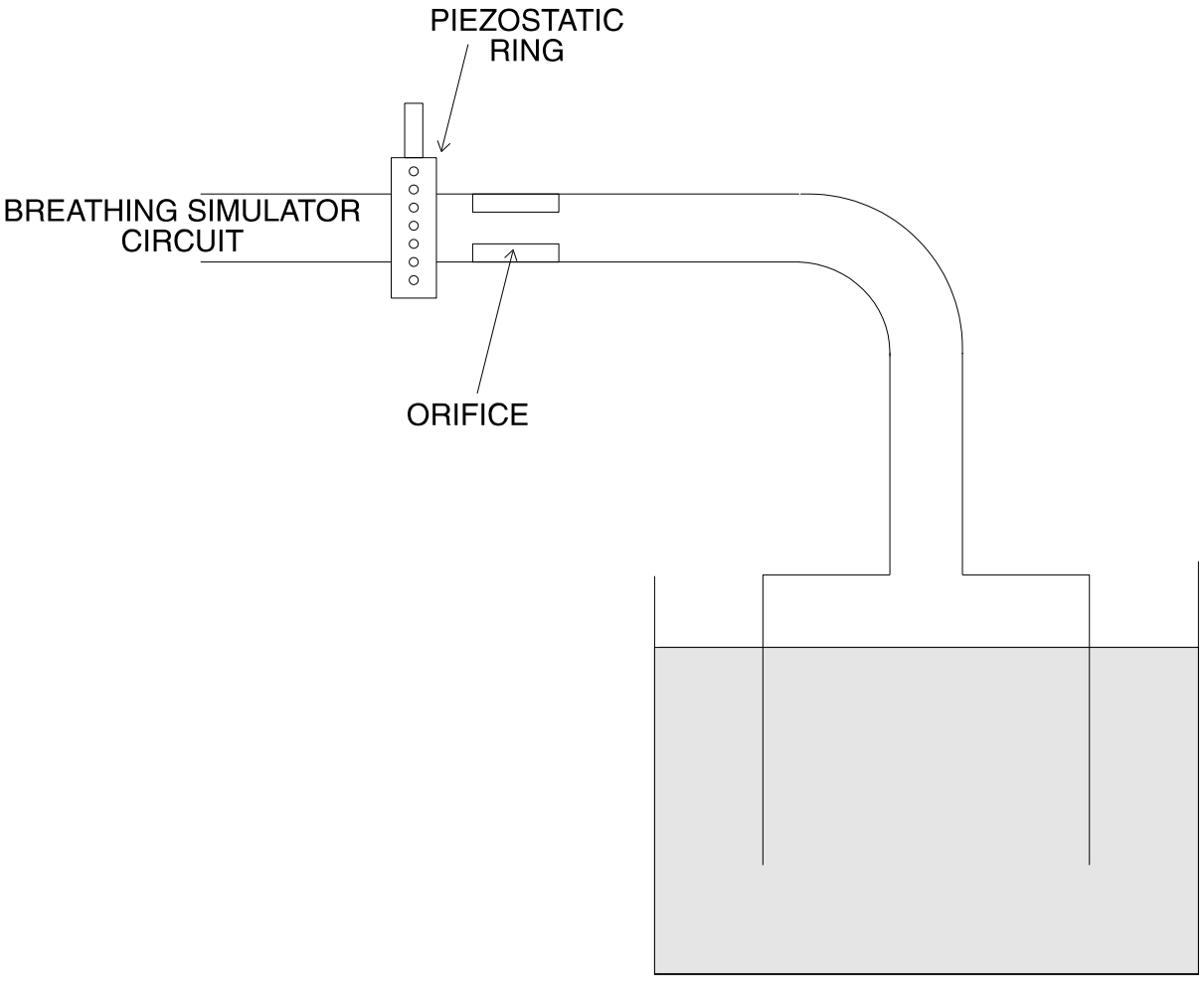


DIAGRAM NOT TO SCALE

Figure D-3: Counterlung systems elastance calibration rig

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ANNEX E

DATA CAPTURE, ANALYSIS AND DISPLAY

E.1. GENERAL

The basic standard for displaying information will be in the form of a Pressure (mouthpiece) - Volume diagram (PV Loop). Pressure and volume will be recorded on the Y and X axis, respectively, and the scales clearly labelled.

E.2. COMPUTERISED DATA CAPTURE SYSTEM

If a computerised data capture system is used it shall have a digital sampling rate ≥ 50 Hz for each channel of data.

E.3. DATA DISPLAY AND ANALYSIS

1. Non counter-lung equipment: The maximum values for inspired/expired pressures shall be recorded along with the calculated value for work of breathing and Root Mean Square (RMS) pressure, for a range of ventilation rates, including 62.5 $l \cdot min^{-1}$, as shown in Figure E-1.

2. Counter-lung equipment: The maximum values for peak to peak respiratory pressure along with the calculated value for work of breathing shall be recorded and measured, for a range of ventilation rates, in accordance with the diagram shown in Figure E-2.

E.4. BA ORIENTATION

The test orientation of the BA, in respect of pitch, shall be as defined in Figure E-3 and roll, as defined in Figure E-4.

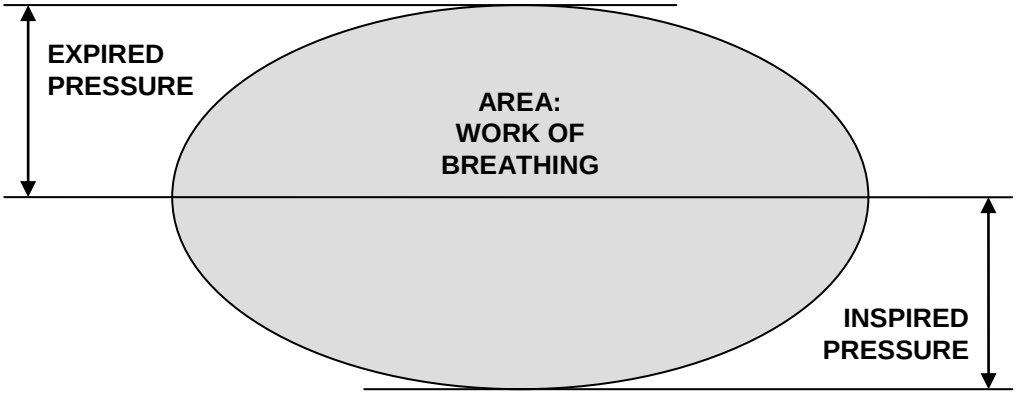

**Figure E-1: Non-counterlung equipments –
Measurement of work of breathing and respiratory pressures**

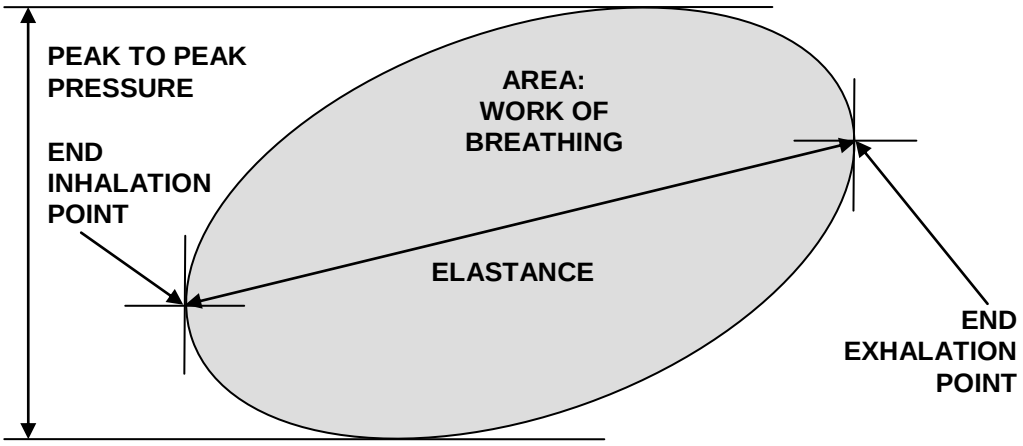

**Figure E-2: Counterlung equipments -
Measurement of work of breathing and respiratory pressure**

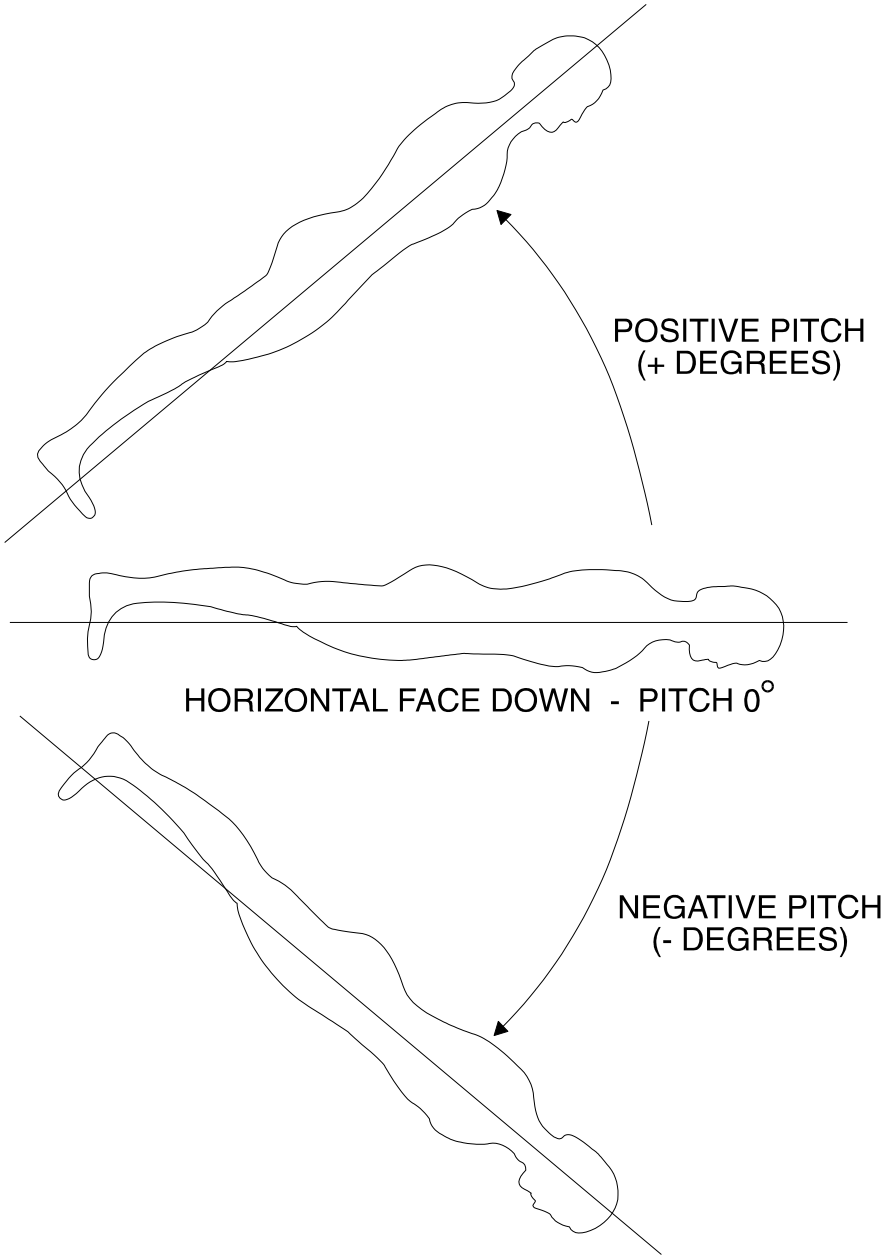

Figure E-3: Measurement and presentation of BA orientation - Pitch

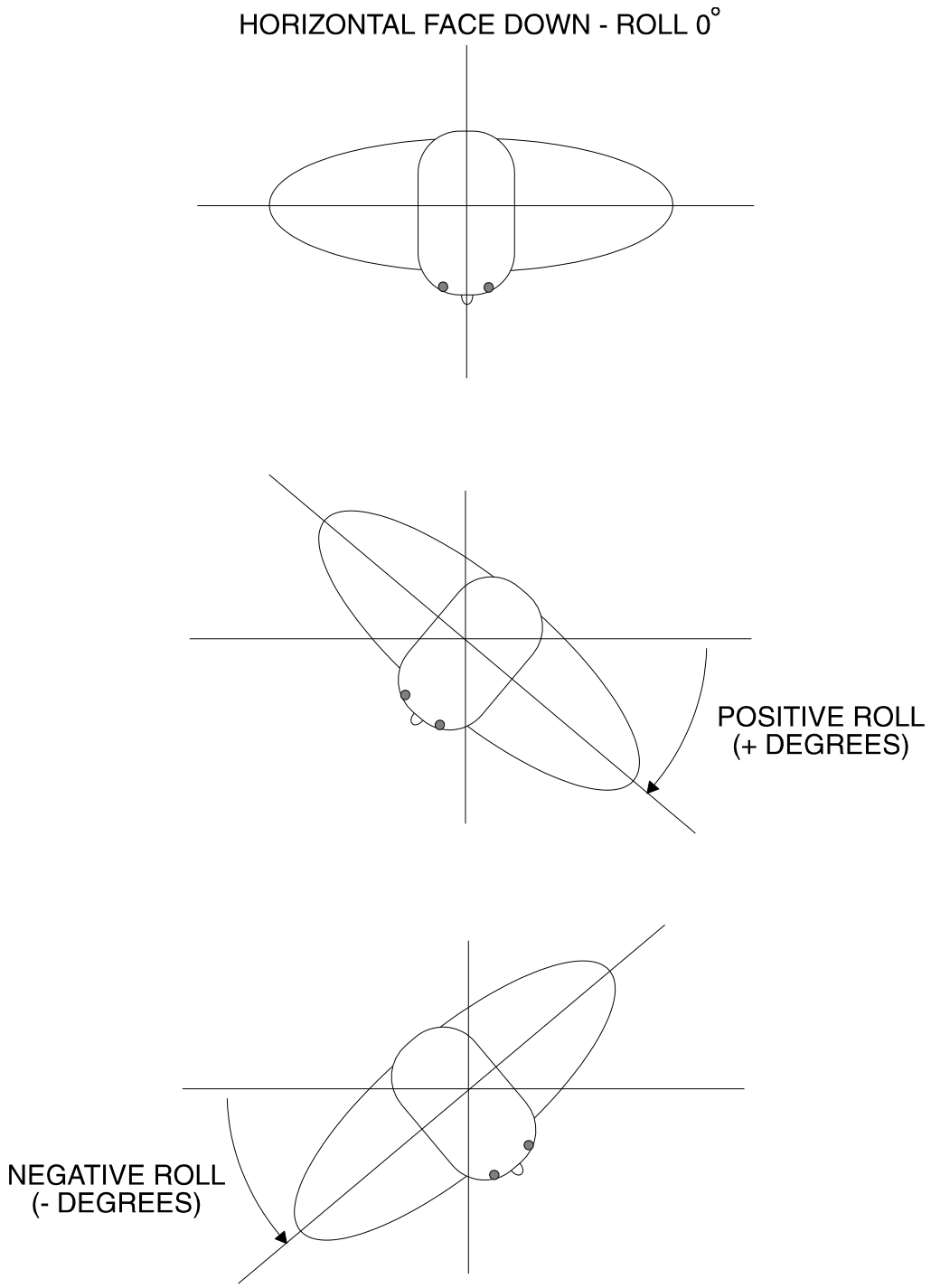

Figure E-4: Measurement and presentation of BA orientation – Roll Viewed from the top of the head of the diver/mannequin

ANNEX F

DIVING BREATHING APPARATUS - ACCEPTANCE CRITERIA

F.1. STATISTICS

1. For work of breathing (WOB) (*i.e.* volume weighted pressure – kPa), respiratory pressures and volume weighted average inspired carbon dioxide the mean test value shall not exceed $\alpha = 0.05$ for the criteria below.

2. The standard absorbent canister endurance shall be the mean test value minus two standard deviations or values derived from comparable statistical methods (*e.g.* 95 % prediction limits).

F.2. WORK OF BREATHING (WOB)

At ventilation rates from 10 to 90 $l \cdot min^{-1}$ ATP:

a. Equipment only to be used at depths <25 m shall have a WOB ≤ 2.0 $J \cdot l^{-1}$.

b. All other equipment shall have a WOB ≤ 1.7 $J \cdot l^{-1}$.

F.3. RESPIRATORY PRESSURES

1. Non-counterlung apparatus:

   Inspired and expired within ± 2.0 kPa at ventilation rates from 10 to 90 $l \cdot min^{-1}$ ATP.

2. Counterlung apparatus:

   a. Peak to peak within < 4.0 kPa at ventilation rates from 10 to 90 $l \cdot min^{-1}$ ATP.

   b. Elastance < 1 $kPa \cdot l^{-1}$ for each litre of the tidal volume.

F.4. VOLUME WEIGHTED AVERAGE INSPIRED CARBON DIOXIDE

1. ≤ 2.0 kPa.

2. This shall be fulfilled during the full endurance of the apparatus and include up to 0.5 kPa of carbon dioxide exhausting through the absorbent canister.

F.5. STANDARD ABSORBENT CANISTER ENDURANCE

1. Immersed at; 4 °C.
2. Ventilation rate; 40 $l \cdot min^{-1}$.
3. Carbon dioxide injection rate; 1.6 $l \cdot min^{-1}$.
4. Standard endurance time to 0.5 kPa carbon dioxide.

ANNEX G

TEST RECORDS

G.1. PRESENTATION

1. Ideally the test records should be presented in a standard format with the data in a tabular form, it shall include, where applicable, the information outlined in this Annex. However, where dictated by the complexity of the tests and requisite statistical analysis a more descriptive presentation may be used to report the results of the testing.

2. The test records and data may also be presented in a standard computer format (*e.g.* ASCII text with Comma Separated Variables, CSV) accompanied by a hard copy description of the data format.

G.2. REFERENCE

- Unique identifier
- Date
- Time

G.3. BREATHING APPARATUS

- BA model
- Serial number
- Carbon dioxide absorbent Type
    - Manufacturer
    - Batch number
    - Activity time (minutes)
- Gas composition
    - BA with fixed gas composition in cylinders

      (% by volume)
    - BA with variable gas composition in breathing circuit

(Partial pressure of oxygen, PO_2 bar, followed by statement of diluent gas or where relevant state partial pressures of diluent/other gases in bar)

- Cylinder pressures (bar)
- BA Orientation
    - Pitch (° [degree rotation], see Figure E-3)
    - Roll (° [degree rotation], See Figure E-4)
- Immersed depth Mouthpiece (m)

G.4. TEST CONDITIONS

- Test depths (m)
- Water temperature (°C)

G.5. BREATHING SIMULATOR SYSTEM

- Tidal volume (l [litre])
- Breaths Per Minute (BPM)
- Ventilation rate ($l \cdot min^{-1}$ [litre/minute])
- Inhale/exhale temperatures (°C min - °C max)
- Humidity (% RH min - % RH max)
- Carbon dioxide injection rate ($l \cdot min^{-1}$ STPD)
- Oxygen removal rate ($l \cdot min^{-1}$ STPD)

Configuration details:

- Non-compliant pipe volume (l)
- Pipework maximum pressure drop at 90 $l \cdot min^{-1}$ (kPa)

  (measured between piston outlet and mouthpiece)
- Inhale/exhale temperature sensors time constant (ms)
- Calibration orifice/compliance: Work of breathing (J [Joules])

  Volume average work ($J \cdot l^{-1}$)

Peak inhale pressure (kPa [kiloPascal])

Peak exhale pressure (kPa)

G.6. RESULTS

- Peak inhale pressure (kPa [kiloPascal])
- Peak exhale pressure (kPa)
- Work of breathing (J [Joule])
- Volume average work ($J \cdot l^{-1}$)
- RMS pressure (kPa)
    - RMS inhale pressure (kPa)
    - RMS exhale pressure (kPa)
- Elastance ($kPa \cdot l^{-1}$)
- Absorbent canister duration to: 0.5 kPa (minutes)
- Pressure volume diagram.

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