WORK OF BREATHING AND BREATHING RESISTANCE OF DEEP LIFE OPEN REVOLUTION REBREATHERS AND THEIR COMPLIANCE WITH INTERNATIONAL SAFETY STANDARDS AND GUIDELINES

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Revision History

A correction to the revision sequencing has been made to this document. In addition to the normal tabulation, the description below is provided.

This document was originally created as DV_OR_WOB_Respiratory_(datecode).doc and .pdf

On 20th October 2009 it was split into two documents:

1. Measurements on the O.R. rebreathers for submission to SGS. SGS required that there be no reference to any performance of any third party product. This document was DV_OR_WOB_Respiratory_REV_(datecode).doc and .pdf
2. ALARP Benchmark Cases for Functional Safety purposes (establishing the performance of the state of the art in the market before setting ALARP targets). SIRA were provided this data. This is DV_OR_WOB_Respiratory_FULL_VERSION_(datecode).pdf

Review in June 2010 found the revision traceability confusing. The appropriate action should have been to either change the name of the files completely when restarting revision sequencing, or to increment the revision history to the next series. This document corrects this situation by moving to revision C0. There is no other change to the document DV_OR_WOB_Respiratory_A3_100228.doc in this document.

The second document above following the split is renamed as DV_ WOB_ ALARP_Benchmarks _(datecode).doc and .pdf with revision sequencing set to A0.

For clarity, this declaration and the full revision history of the document sources are shown below.

Revision History of DV_OR_WOB_Respiratory_(datecode).doc Post Document Split

Revision	Date	Description
A1	20th Oct 2009	Report extracted from full report for Deep Life Ltd, DV_OR_WOB_Respiratory_090212.pdf (Revision B6) to remove ALARP benchmark cases. High resolution version of plots used. Document revision sequence restarted as it was treated as a separate document on SVN (Source Control).
A2	28th Nov 2009	Reviewed and accepted for release
A3	28th Feb 2010	All CE test points added. All relevant calibration data added on request of N.B. Repeat of CE tests on iCCR and Incursion. Repeat of DRB CE tests with injected breathing manifold, due to design change. All DRB results deeper than 100m are retired as these will be presented for the extension certification, retested using the injection moulded breathing manifold.
C0	24th June 2010	Correction of revision numbering anomaly. No other change.
C1	11th Nov 2010	Edits limited to Addition in Section 8.13 of additional cases where ALVBOV sets loop volume, with that test data witnessed by the Notified Body 15-20th Feb 2010, and Sections 11, 12 and 13.

Revision History of DV_OR_WOB_Respiratory_(datecode).doc

Revision	Date	Description
A	27th Mar 2007	Test using CNC prototypes to EN14143 and NORSOK U101.
A1, A2	30th Mar 2008	Complete update and retest using samples of production units of single and dual scrubber configurations (A1, 13th Dec 2007), due to design changes, US Navy procurement limits added (A2, 30th March 2008)
A3	13th May 2008	Repeat tests using production batch of 5 DRB units and samples of SRB units out of a production batch.
A4	28th May 2008	ALARP Benchmarks started: CCR Ltd Ouroboros test results added
A5	24th June 2008	Draeger Dolphin test results and Deep Life DRB mouthpiece test result added. Comparative figures for the benchmark units.
A6	19th Dec 2008	Tests repeated and replaced for Deep Life DRB with helmet version mouthpiece, Deep Life DRB helmet mouthpiece, modified Deep Life SRB mouthpiece, Deep Life SRB Incursion and Apocalypse result added. APD Evolution 2007 test results added. Pelagian results added.
B1	20th Jan 2009	SRB test results replaced by most recent retests after design changes to mouthpiece (DL Mod 2 ALVBOV), added intermediate results for standard compliance purposes. Reordered benchmarks results.
B2	4th Feb 2009	DRB test results added intermediate results for standard compliance purposes. Added intermediate results in accordance with gas densities and depths.
B3	6th Feb 2009	Detailed results for DRB heliox depths beyond recommended operational depths removed to a separate “Exceptional dive risk assessment” document.
B4	9th Feb 2009	Proof reading of English text, removing typos.
B5	10th Feb 2009	Summary of plots or extreme depths using heliox reinstated in conclusion.
B6	12th Feb 2009	Relative peak pressures according to EN14143 definition reinstated for all test results: the relative resistance script was combined with the physiological resistance script and issued as Rev 3.0 E, so both sets of data are in this one report.

Table of Contents

1. PURPOSE AND SCOPE

This document is a verification report covering the respiratory performance of Deep Life's Open Revolution Family of Rebreathers, in particular:

- OR_Umbilical Bell Diver's Dual Scrubber eCCR
- OR_Incursion Single Scrubber eCCR
- OR_Apocalypse Type IV Single Scrubber iCCR
- OR_Apocalypse Type IV Single Scrubber O2-CCR

The report considers the measurement and compliance of the Work of Breathing (WOB) and Breathing Resistance, to six sets of standards or guidelines:

- EN14143:2003
- NORSOK U-101:1999
- NATO STANAG 1410:2006
- DEEP LIFE HUMAN RESPIRATORY SAFETY LIMITS
- US NAVY 1994 TM 01-94
- NEDU 2007 TA 05-12 LIMITS

This edition of this report focuses on the CE EN limits, and NORSOK limits.

Hydrostatic imbalance is not determined here for these rebreathers: it is the subject of a separate verification report: *DV_DLOR_HydroImbal_091008.pdf.*

The document is a Design Verification and Validation Report in terms of BAI Quality Procedure QP-20 (Safety Critical Systems).

The scope of this report is to cover comprehensively five areas for the standards and guidelines listed above:

1. The interpretation of the standards as they relate to WOB and Breathing Resistance.
2. The sources of error in measuring respiratory parameters in accord with the standards.
3. Description of the method applied and equipment used to make the reported measurements.
4. The empirical values of respiratory parameters measured in accord for the Deep Life Open Revolution series of rebreathers, including compliance information in respect of the Respiratory parameters tests in each of the standards and guidelines listed.
5. Identify any issues in the standards which the body responsible for the standard may wish to consider when making their next revision.

In selecting plots to reproduce here in full, all results required in EN 14143 are chosen, plots of worst case diver orientation at maximum depth, and intermediate points of interest.

2. SOURCE DOCUMENTATION

The following documentation was provided:

- European Normative Standard EN 14143:2003. September 2003
- Norwegian Technology Standards Institution Standard NORSOK U-101:1999 Rev.1 Aug.1999
- NATO Standardisation Agency Standard STANAG 1410:2006. 20 October 2006; 2nd edition
- NEDU Technical Manual, "US NAVY UNMANNED TEST METHODS AND PERFORMANCE GOALS FOR UNDERWATER BREATHING APPARATUS", Navy experimental Diving Unit TM 01-94:1994, June 1994.
- NEDU Technical Report by D. E. Warkander, "COMPREHENSIVE PERFORMANCE LIMITS FOR DIVERS' UNDERWATER BREATHING GEAR: OF ADOPTING CONSEQUENCES DIVER-FOCUSED LIMITS, Navy experimental Diving Unit TA05-12,15 January 2007
- Deep Life human respiratory limits as recorded on their Mantis requirement tracking system
- Full Bill of Materials and Exploded drawings of the rebreathers under test, Rev B16, to confirm that the products tested are representative of the design.

Deep Life requested results with both the separate ALV+BOV and the combined ALVBOV.

The separate ALV and BOV was fitted to the OR_Umbilical and both separate and the combined ALVBOV was fitted to the SRB models (OR_Incursion and OR_Apocalypse).

The loop volume was swept in each test, so the ALV function had no gas supply. CE audit tests were performed by the Notified Body with the ALV function on, and these results also fall within the compliance requirements.

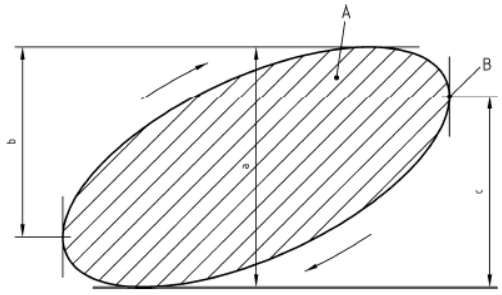
3. REQUIREMENT FOR LIMITS OF PERFORMANCE

3.1. EN14143:2003 Respiratory Requirements

EN14143:2003 defines WOB and respirator pressure as follows:

> **EN14143:2003 Section 3: Definition of Terms**
>
> **3.5 respiratory pressure**: the differential pressure in the facepiece relative to the no flow pressures in the facepiece at the end of inhalation and exhalation (see Figure 1)
>
> **3.12 work of breathing:** the work expended during one breathing cycle measured in Joule per litre. This work is proportional to the area bounded by the pressure volume diagram (see Figure 1)

The figure refered to in EN14143:2003 as Fig 1, is a pressure volume diagram reproduced below (Figure 3-1).



Key

a) peak to peak respiratory pressure

b) peak expired respiratory pressure (end inhalation to peak exhalation)

c) peak inspired respiratory pressure (end exhalation to peak inhalation)

A WOB

B Reference point of hydrostatic imbalance; end of exhalation ("no flow")

Figure 3-1: Reproduction of Figure 1 Lissajou in EN14143:2003 for WOB calculation

The calculation defines WOB as the area contained within the Lissajou.

WOB requirements in EN14143:2003 is split over several sections and figures, starting with EN14143 Section 5.6.1.2 and Section 5.6.1.3 , which reads as follows:

> **EN14143:2003 Section 5.6.1.2 General:** Work of breathing shall not exceed a value of:
>
> WOB = 0,5+0,03*RMV[J/l] related to an RMV from 10 l/min to 75 l/min
>
> NOTE The WOB specified is considered to be a physiological maximum level and the manufacturers should endeavour to keep the WOB as low as possible.
>
> Testing shall be done in accordance with 6.3.2.

The WOB maximum values related to an RMV are denoted in Table 4 of EN14143:2003. Measurement of the respiratory pressure is performed by means of a Breathing simulator (respirator).

Table 1 Reproduction of Table 4 in EN14143:2003 for a Breathing simulator (respirator) settings

Tidal volume at BTPS l	Breathing frequency min^{-1}	Ventilation rate at BTPS l min^{-1}	Carbon dioxide injection rate at STPD l min^{-1}	Oxygen consumption rate at STPD l min^{-1}	Maximum WOB J l^{-1}
1,0	10	10,0	0,40	0,44	0,80
1,5	15	22,5	0,90	1,00	1,18
2,0	20	40,0	1,60	1,78	1,70
2,5	25	62,5	2,50	2,78	2,38
3,0	25	75,0	3,00	3,33	2,75

> **EN14143:2003 Section 5.6.1.3 General:** Peak to peak and inspired and expired respiratory pressures shall be determined as shown in Figure 1. The peak to peak respiratory pressure shall not exceed 50 mbar. The inspired and expired respiratory pressures shall not exceed 25 mbar each.
>
> Testing shall be done in accordance with 6.3.2.

Sections 5.6.1.2 and 5.6.1.3 of EN14143:2003 refer to Section 6.3.2 for the specific WOB and respiratory pressures tests procedures:

> **EN14143:2003 Section 6.3.2 :** Set the Breathing simulator at the ventilation rates in Table 4.
>
> Measure the respiratory pressure at the mouth and determine performance from the pressure-volume diagram generated by plotting the low (respiratory) pressure against the displaced volume. Analyse the pressure-volume diagram in accordance with figure 1.
>
> Simulate the diver in both the vertical and horizontal orientation (+ 90° and 0° pitch - see figure 4).

The diver positions are illustrated at the Figure 3-2.

EN 14143:2003 does not stipulate what depths and pressures shall be measured, nor even the RMVs (it does not require testing at every single depth, or depth, merely that sufficient tests shall be performed to ensure that the limits set by the standard are met. This would require a test at minimum RMV and a test at the maximum RMV, with intermediate points to establish the curve, using points taken from Table 4 at the test depths.

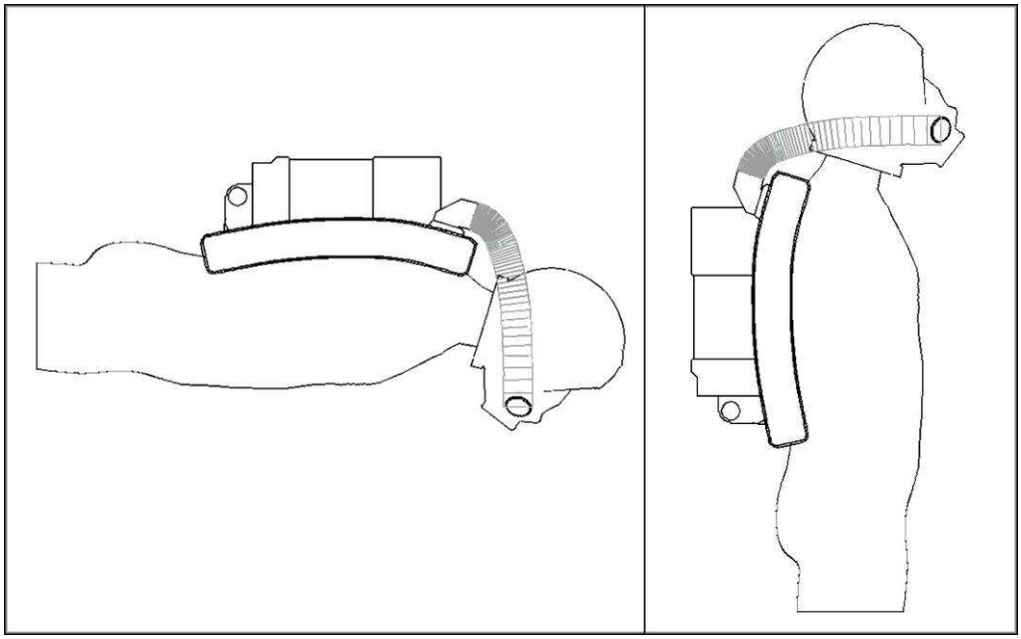


Figure 3-2: The WOB and respiratory pressures tests diver positions: 0° (left) and +90° pitch (right)

3.1.1. Test Conditions

The general measurement conditions in EN14143:2003 are as follows:

> **EN14143:2003 Section 6.3.1 General test conditions:** The apparatus shall be fully rigged on a mannequin according to the information supplied by the manufacturer.
>
> The breathing performance of the apparatus shall be determined using a sinusoidal gas flow from a Breathing simulator with an allowable variation of ± 3 % in both the frequency and the amplitude.
>
> Completely immerse the apparatus in water at a depth sufficiently deep to preclude surface effects. The gas supply shall be switched on and any adjustable relief valve set to a mechanical midpoint or the manufacturers recommended setting.
>
> For apparatus that do not add gas during tests the breathable volume shall be optimised before starting each measurement.
>
> Record the performance of the apparatus at test pressures of 5 bar with oxygen in nitrogen gas mixtures and at 11 bar with oxygen in helium based mixtures or a reduced pressure specified by the manufacturer Stabilise the temperature of the water in the test chamber at 4 ± 1 °C, or lower if specified by the manufacturer.

The apparatus adds gas when there is a change of depth, via the ALV. The test does not consider a change of depth, therefore the apparatus shall be optimised. In practise, the diver will optimise the loop volume by taking a deeper breath or a minor depth change to achieve a comfortable loop volume that does not trigger the ALV, but then during ascent, the loop volume expands and is less than optimal. To cover all these situations, the loop volume is swept during the test from maximum to minimum and the point selected that is as close as possible to the diver optimised volume: a mid point of ten lowest breathing cycles is used – this provides an average optimisation point not the most optimal point.

The rest of the EN general test conditions require that the respiratory parameters are measured at the following pressures, gases and temperatures:

Table 2 EN14143:2003 tests conditions

Tests pressures	Tests gases	Ambient area
5 bar absolute	Nitrox	Water at temperature 4 ± 1℃ OR lower if specified by the manufacturer.
11 bar absolute OR reduced pressure specified by the manufacturer	Heliox	

3.1.2. Scrubber Conditions

The worst case conditions for measuring respiratory parameters are those with an expired scrubber, as the scrubber swells during use. Therefore all tests on the Deep Life rebreathers are carried out with an scrubber fitted to the unit that has had 3 hours of scrubber use, (two scrubbers in the case of the dual version of the unit).

In comparative benchmarks, the scrubbers with granular material were filled with dry used granules to ensure the results are easily repeatable. The condition where the scrubber is wet was tested separately[1]. Rebreathers that use granular scrubbers exhibit a very marked increase in breathing resistance after the scrubber has absorbed small quantities of water: tests found a four fold increase in scrubber resistance from just 100ml of water in a 2.5kg scrubber. The Deep Life rebreathers use Micropore EACs, which do not swell beyond the amount found in the expired state, when immersed in water for reasonable intervals.

3.2. NORSOK U-101 Respiratory Requirements

NORSOK U-101 defines WOB and respiratory pressure differently to EN14143, namely:

NORSOK U-101 Section 3.1: Definition of Terms

> **Respiratory pressure:** Differential pressure measure in the diver's mouth during inhalation and exhalation, in relation to the reference pressure (Measured in kPa).
>
> **Work of Breathing:** Additional external work required in order to use the breathing apparatus (Measured in Joules per litre). Ref. Section 5.2.1 of this standard.

The difference between EN14143 and NORSOK U-101 definitions of the term "respiratory pressure" is the points and the method of measurements. EN14143 is a relative measurement, but NORSOK U101 is an absolute measurement. This is because EN14143 defines respiratory pressures only at no-flow points of the volume pressure diagram (Figure 3-1) against NORSOK U-101 use of the peak pressure during breathing cycle. Both standards require measurement of the respiratory pressure at the diver's mouth (Section 6.3.2). If the measurements are taken using the NORSOK method, the result is the same as using the EN14143 relative method, but only the relative measurements are taken then the NORSOK compliance data cannot be derived from it. For this reason, this report uses absolute measurements throughout, taking particular care with the position of the equipment on the mannequin to be representative of a diver's use of that equipment.

The term "additional work" is taken to mean the work imposed by the equipment: that is it is additional to the work the diver has of pumping gas into and out of his lungs by respiration in a dry and open environment containing the same gas at the same pressure. The Base WOB that this assumes, means that the Breathing simulator should be calibrated such that the effect of the hoses and structures of the Breathing simulator are excluded from the test, just as the dynamics of the diver's trachea are excluded.

[1] Report available on www.deeplife.co.uk/or_dv.php with a capture date concurrent with the issue of this report.

The WOB calculation method in NORSOK U-101 reads as follows:

> **NORSOK U101 5.2.1 Calculation of work of breathing:** The work of breathing (W) carried out during testing of breathing apparatus is determined on the basis of pressure and volume measurements. The area inside the pressure-volume diagram represents the work of breathing according to this standard.
>
> Additional work of breathing may occur in very special cases. This is represented by the area (B) between the pressure-volume diagram and the volume axis, cf. the figure below. This work is associated with possible positive pressures during inhalation and is subtracted from the total work of breathing in this standard. In practice this means that the area B is not included in the calculation of the work of breathing in this standard.
>
> The respiratory system will only gain from positive assistance during inhalation to a certain degree. Therefore if the defined work of breathing (A) inside the pressure-volume diagram or the respiratory parameters is close to the upper limit, the magnitude of this additional work (B) shall be taken into consideration. Positive or negative contributions during inhalation as well as exhalation should similarly be described if they contribute significantly to the calculation of the total work of breathing.

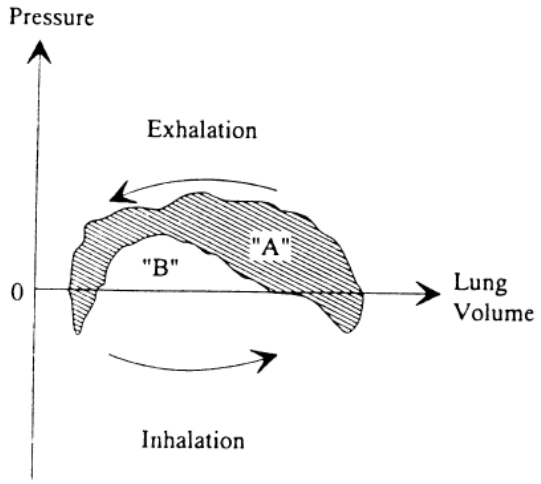


Figure 1: **Graphic illustration showing the work of breathing as a function of the breathing pressure and the tidal volume.**

Area «A» = Work of breathing (W)
Area «B» = Additional work normally not included in the definition of work of breathing in these guidelines.

Figure 3-3: NORSOK U101 Lissajou. Not the definitions are the same as EN14143 but the data is plotted counterclockwise instead of clockwise.

NORSOK U-101 considers the case where the inhale motion includes a positive pressure: see the above figure. Other than this, the calculation of WOB as the area within a Lissajou is the same as for EN14143:2003.

NORSOK U101 requirements to WOB are defined in the 5.2.2 and 5.3 sections:

> **NORSOK U101 5.2.2 Relation between work of breathing and respiratory minute volume:** The work of breathing when breathing apparatus is in use may vary with the respiratory minute volume.

Work of breathing should be as low as possible. Figure 2 indicates work of breathing at respiratory minute volumes between 7.5 and 90.0 l BTPS min

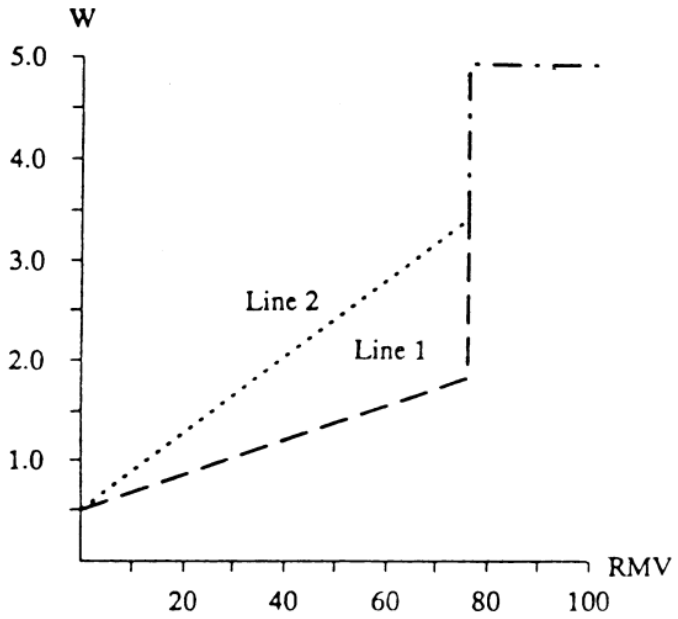


Figure 2: Relation between the work of breathing and the respiratory minute volume

Line 1 represents preferred values for work of breathing (W). In the case of deep diving (depths exceeding 180 m) line 1 will represent maximum values. Line 1 is derived from the equation:

$$W = k + (f \cdot RMV)$$

when k = 0.5 J/l , f = 0.02, RMV= 7.5 -75 l BTPS / min .

Line 2 represents maximum values for work of breathing (W) at diving depths less than 180 m, and is derived from the equation:

$$W = k + (f \cdot RMV)$$

when k = 0.5 J/l , f = 0.04, RMV = 7.5 -75 l BTPS / min .

Work of breathing in the range RMV = 75-90 l BTPS/min or equivalent upper RMV-range for equipment other than the primary underwater BA, shall be less than 5 J/l.

In the assessment of types of equipment other than primary underwater breathing apparatus, such as emergency breathing equipment, modified acceptance criteria for work of breathing may be considered (see clause 5.3).

NORSOK U101 5.3 Respiratory minute volume: The breathing apparatus shall function satisfactorily within the maximum and minimum limits stipulated by these guidelines, at a respiratory minute volume from 15 to 75 l BTPS / min.

Maximum work of breathing for the interval 75 to 90 l BTPS / min shall be less than 5 J/l . For other breathing equipment than the primary modified requirements may be applied as follows: For BIBS corresponding RMV ranges are 7.5 to 40 l BTPS / min and 40 to 62.5 l BTPS / min; For welding mask and escape equipment corresponding RMV ranges are 15 to 40 l BTPS / min and 40 to 62.5 l BTPS / min . For lung powered survival equipment corresponding RMV ranges are 7.5 to 22.5 l BTPS / min.

NORSOK U-101 tidal volumes for different RMVs are shown in Section 6.3.4 as follows (Table 3):

Table 3 NORSOK U-101 6.3.4 Tidal volume

RMV ($l\ BTPS \cdot min^{-1}$)	Tidal Volume ($l\ BTPS$)	Breathing Rate ($n\ min^{-1}$)
7.5	0.75	10
15.0	1.0	15
22.5	1.5	15
40.0	2.0	20
62.5	2.5	25
75.0	3.0	25
90.0	3.0	30

Taking into account the table above, appropriate values of maximum WOB for primary breathing apparatus can be calculated for each rated RMV (Table 4):

Table 4 Maximum WOB values according to NORSOK U-101

Depth, m	RMV, l(BTPS)/min	Maximum WOB, J/l
>180	7.5	0.65
	15.0	0.80
	22.5	0.95
	40.0	1.30
	62.5	1.75
	75.0	2.00
≤180	7.5	0.8
	15.0	1.1
	22.5	1.4
	40.0	2.1
	62.5	3.0
	75.0	3.5
-	90	5

The requirements to test at 90l/min RMV are reasonable: this is the same as for an athlete running a marathon in 3 hours 15 minutes. It can therefore clearly be sustained for a long period, and in any case, can occur to divers for a short period: unless the WOB is within reasonable limits, then there will be an increase in blood carbon dioxide levels, and the

resulting hypercapnia will cause run-away increases in RMV. NORSOK standard is much more satisfactory as a safety standard than EN14143:2003 in this regard.

The respiratory pressure requirements are in Section 5.5 of the standard:

> **NORSOK U101 5.5Respiratory pressure:** The respiratory pressure (P) should ideally be limited to ± 1.5 kPa and shall not exceed ± 2.5 kPa relative to the reference pressure (Pr) during a breathing cycle.

Note, the WOB and respiratory pressures tests are carried out in isolation from the hydrostatic tests: these are different tests. This means that equipment can comply with the WOB and respiratory pressures requirements, simply by varying the pressure in the loop until the minimum of the differential pressures are reached. It is understood that this was correct as the standard acknowledges that a diver adjusts the loop volume so it is as comfortable as possible, so the measurement should be taken with the loop volume optimised for WOB and respiratory pressures. In this case the minimum WOB does not occur at the point of minimum hydrostatic imbalance , but are measured in the normal diver positions. The details of the hydrostatic imbalance tests are described in a separate document: *DV_DLOR_HydroImbal_091008.pdf*

NORSOK U-101 defines more strict requirements than EN14143 to the Breathing simulator (respirator) this can be found at Section 6.2 of the standard.

The amplitude of the Breathing simulator is accurate to within 1%: that is the peak to peak amplitude, and the frequency is accurate to a tiny fraction of that unless the machine encounters enough resistance to trigger the safety systems: these are set to 200mbar. There is an error in the waveform, common to most Breathing simulators: this has been examined in detail and a full compensation determined for that error. The error causes the result to appear worse than it is until the error compensation is switched in.

The respirator has a response of 10mS and has no damping. The requirement is to measure with an accuracy of 0.1 kPa, which is 1mbar. The report *Cal_Breathing_Simulator_Assessment_090707.pdf* shows the equipment is accurate to well within 1mbar, and the Rev C machine produces a true sine flow.

NORSOK U-101 WOB and respiratory pressures tests procedures reads as follows:

> **NORSOK U101 Section 6.3.7 Work of breathing:** Work of breathing is to be determined at each RMV tested.
>
> **NORSOK U101 Section 6.3.3 Respiratory minute volume:** The tests are to be carried out at a respiratory minute volumes that are relevant (see 5.3) of 7.5,15.0, 22.5, 40.0, 62.5, 75.0 and 90.0 l BTPS / min.
>
> Tests at the highest RMV will indicate whether the equipment is functioning during extreme ventilation. The equipment shall be tested at a lower respiratory minute volume after the RMV test to see that the apparatus still functions satisfactorily. It is important to include this in the total evaluation of the breathing apparatus.

3.2.1. Test Conditions

General test conditions are described in Sections 6.2 and 6.3 of the standard, which are:

> **NORSOK U-101 Section 6.2.2 Test environment:** The equipment shall be tested with the gas and in the environment in which it is intended to be used (e.g. heliox, water, air etc.) as documented by manufacturer. When tested in water, the equipment shall be immersed to a depth sufficient to preclude surface effects. It shall be ensured that the conditions during testing reflect the most unfavourable operational conditions of the equipment.
>
> The reference to "the environment in which it is intended to be used" means the equipment is tested in sea water: artificial sea water for the purposes of testing, as local sea water has an unusually low salinity. This is reinforced by Section 6.2.7, below.
>
> **NORSOK U-101 Section 6.2.7 Ambient test temperature:** The temperature of the water surrounding the equipment in the test chamber shall be kept at 5°C ± 2°C.
>
> The temperature and the relative humidity of the breathing gas affect the freezing properties of the breathing apparatus when in use.
>
> **NORSOK U-101 Section 6.3.1 Test depths:** Tests are to be performed at ambient pressures corresponding to the test depths stipulated below.
>
> - With air or corresponding breathing gas preferred test depths are: 0, 10, 30 and 60 m.
> - With heliox or corresponding breathing gas preferred test depths are: 0, 50,100, 200, 300 and 400m.
>
> Testing of the equipment shall include tests at:
>
> - a depth equal to or less than the minimum depth at which the equipment is intended to be used.
> - a depth in excess of the maximum depth at which the equipment is intended to be used.
>
> Tests at intermediate depths shall be carried out if the test results show that interpolation is not possible between them. The following test depths should then preferably be selected: 3, 20, 40, 50, 150, 250, 350 and 450 m.

This means that the respiratory parameters are measured at the following pressures, gases and temperatures:

Table 5 NORSOK U-101 tests conditions

Test depths, m	Additional intermediate depths (if interpolation is impossible), m	Test gases	Test Environment
0	3 20 40 50	Air	Artificial sea water at a temperature (5 ± 2)℃
10			
30			
60			
0	150 250 350 450	Heliox	
50			
100			
200			
300			
400			

Interpolation is possible, so only the test depths on the left need to be used.

3.3. NATO STANAG 1410:2006 Requirements

NATO STANAG 1410:2006 requires that the WOB is under the following limit:

> At ventilation rates from 10 to 90 l/min ATP:
>
> Equipment only to be used at depths <20m shall have a WOB <= 2.2 J/L
>
> All other equipment shall have a WOB <= 1.7 J/L.
>
> Respiratory Pressures within 2KPa at ventilatoin rates from 10 to 90L/min ATP.

STANAG 1410 does not contain elastance limits for the equipment under test: it merely defines elastance as part of a calibration procedure for the Breathing simulator. The definition of elastance in STANAG 1410 is not clear, but the application of the word in the standard means it is a difference in pressure due to changes in the the height of water pressure expressed in mbar under the influence of the tidal volume: in a rebreather this is the vertical movement of the gas centroid in the counterlungs across the breathing cycle.

The acceptance criteria lists a Work of Breathing Limit, but not a hydrostatic imbalance or elastance limit. The standard does include the diagrams showing the different diver attitudes needed to measure hydrostatic imbalance and elastance.

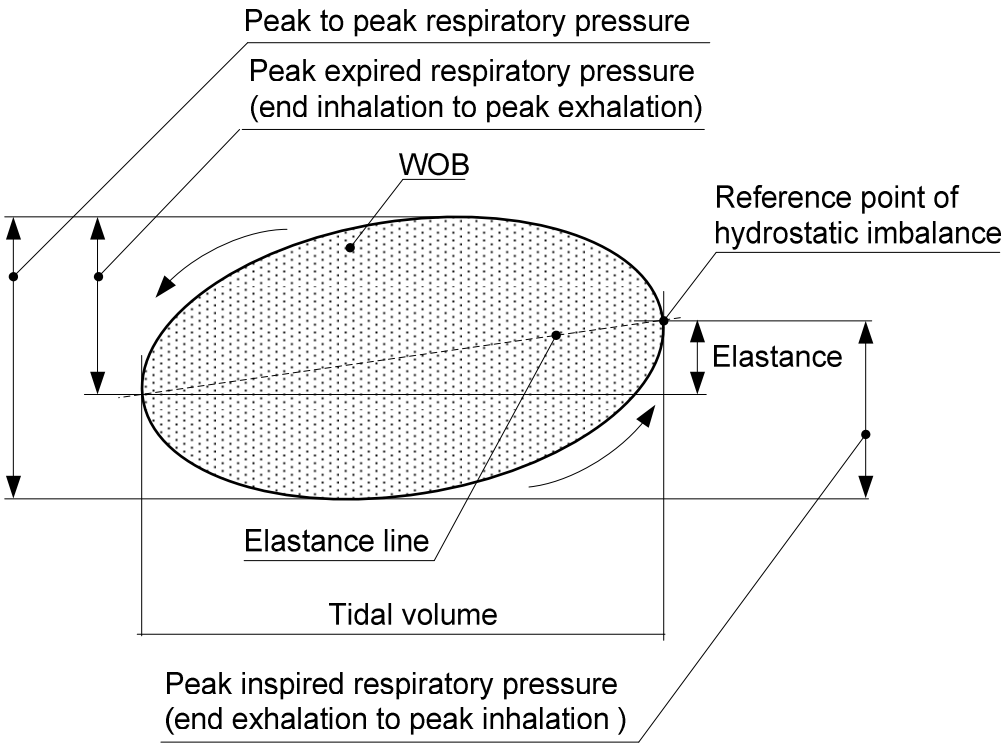


Figure 3-4: Lissajou showing terms used in NATO STANAG 1410:2006. Note the direction of the Lissajou is the opposite to that in EN14143:2003. STANAG use the term "elastance" to refer to the hydrostatic change of the counterlung centroid.

3.4. DEEP LIFE HUMAN RESPIRATORY LIMITS

Deep Life have carried out a careful review of the safety data behind EN14143:2003 limits and conclude that those limits may be unsafe because it does not take into account the Work of Breathing of the diver, which increases with depth. That is, Deep Life consider the total breathing load a diver can maintain as being constant, which means that as depth increases, the load that can be placed on the diver externally, has to reduce.

The Work of Breathing for the human was determined by Deep Life by using a Breathing simulator with dead space and restrictions comparable to an average adult male. The results were compared with the medical research results available and a reasonable degree of correlation was found.

The Work Of Breathing of the Breathing simulator is shown below using air. This indicates that the WOB limit for air should be the 2.75J/L stated in EN14143:2003, reducing by 0.12J/L every 10m, so at 150m the WOB limit would be 0.95J/L, and at 230m it is zero (i.e. it is not possible to dive using air from Work of Breathing limits alone, ignoring all narcosis issues).

In helium, there is a 5.5 fold reduction in the human WOB, so in helium the WOB limit should reduce by 0.022J/L every 10m, giving a depth limit where external WOB is zero of 1250m: this is deeper than the limit of human physiology (considered to be 701m due to effects of pressure in humans on the action of neurological enzymes, particularly GABA[2].[3]).

[2] S.C. Gilman, J Colton, J. Hallenbeck, "Effect of pressure on [3H]GABA release by synaptosomes isolated from cerebral cortex", J Appl Physiol 61: 2067-2073, 1986.

[3] J. Rastain, N. Balon, "Diving: barometric pressure and neurochemical mechanisms". J. Soc. Biol. 2006; 200(3) 257-63, and "Recent neurochemical basis of inert gas narcosis and pressure effects" by same authors, Undersea Hyperb Med, 2006; 33(3) 197-204.

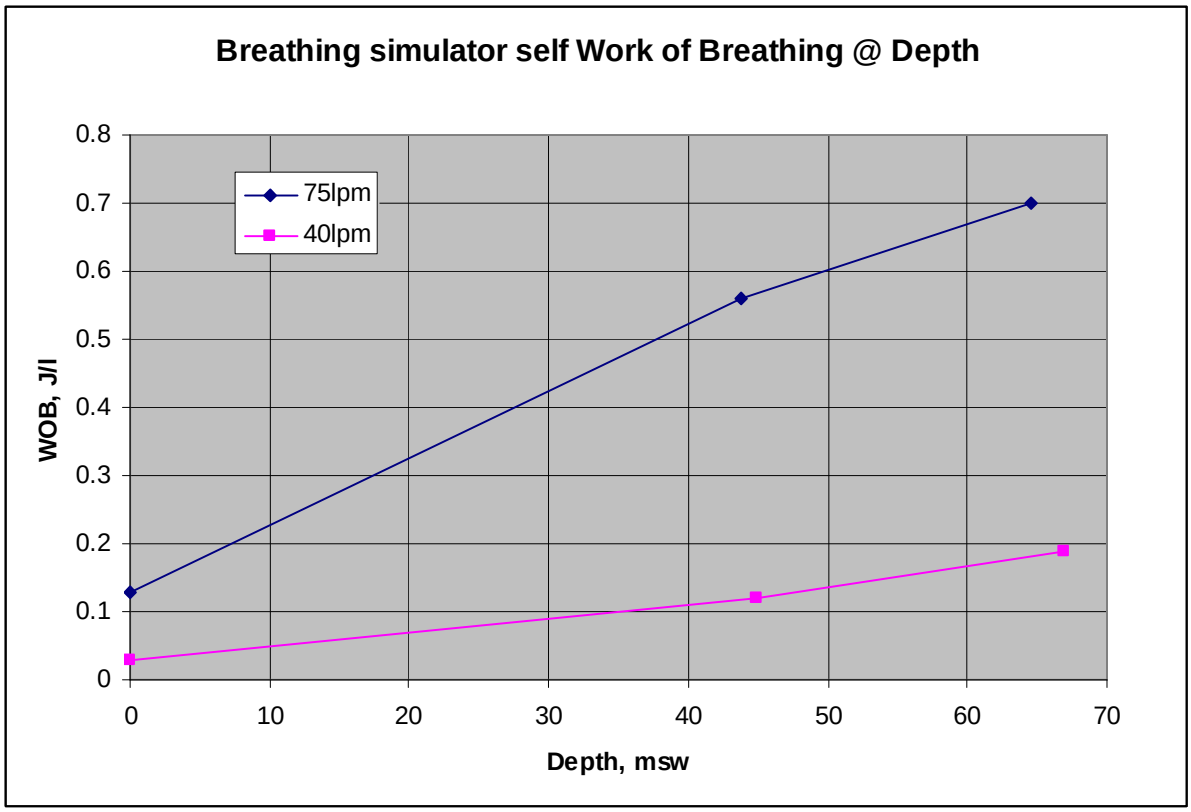
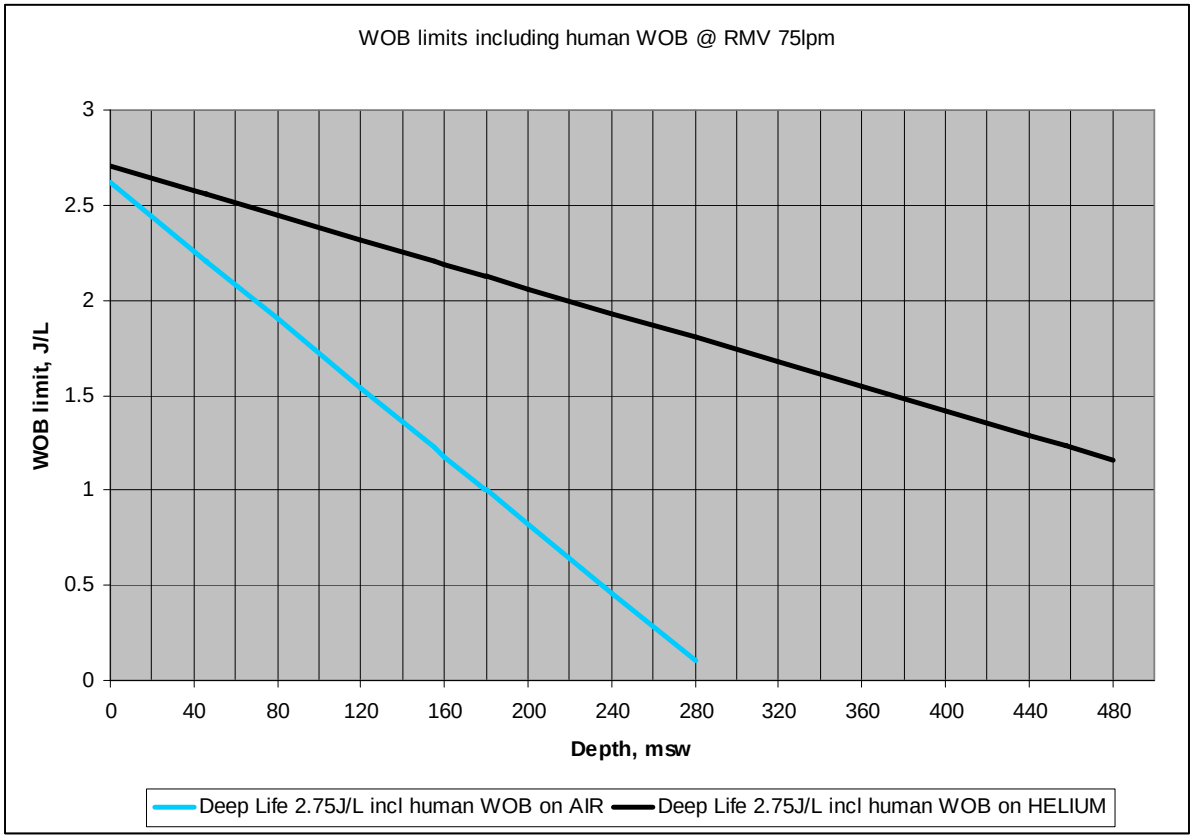


Figure 3-5: Work of breathing for a Breathing simulator modelling human physiology using air as the breathing gas.



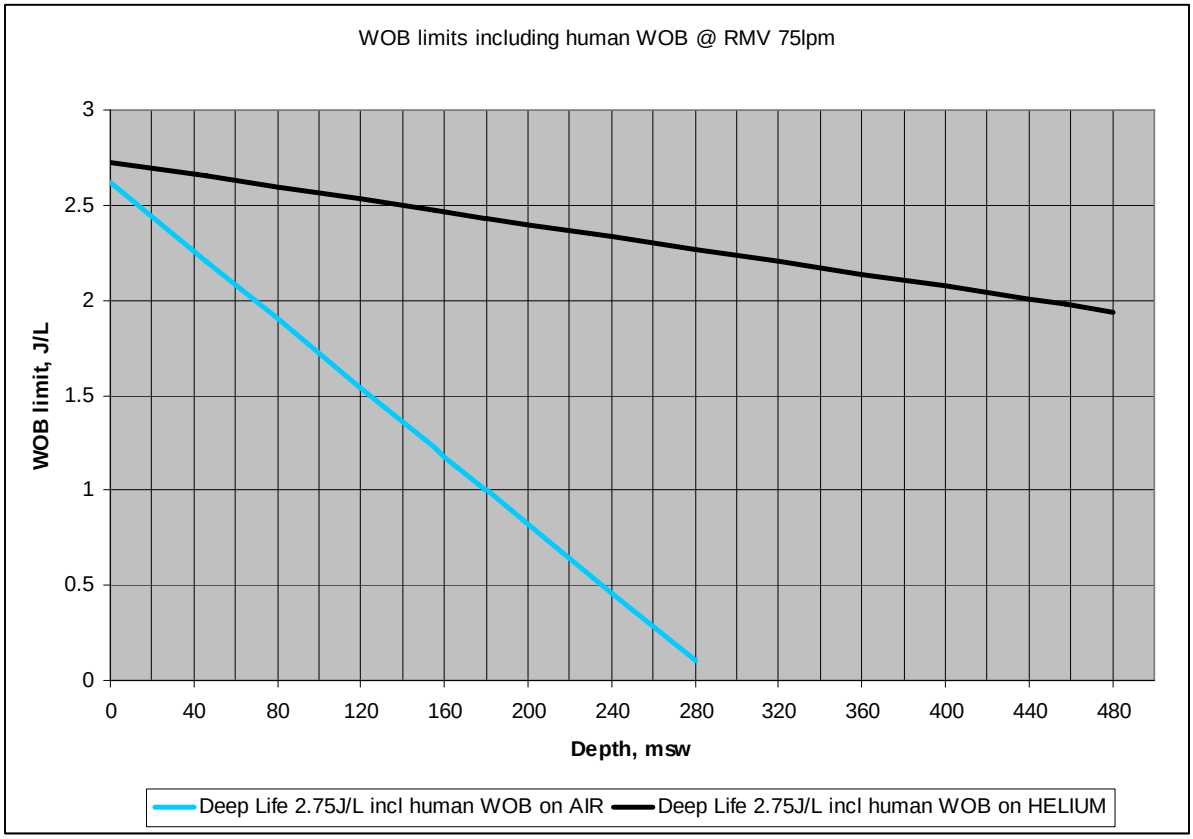


Figure 3-6: Modifing EN14143:2003 work of breathing limit for RMV of 75 lpm with human physiology using air and Helium as the breathing gas.

The 0.12J/L reduction every 10m in air, and the 0.022J/L reduction in helium does not account for the fact that the breathing loop will not be optimised during ascent, and often even during static depth portions of the dive. It is known that human metabolism is significantly less efficient under these circumstances, from observations of expired CO2 levels. It is prudent therefore to reduce the WOB limit more aggressively to reflect these facts, and a 50% increase in human WOB was considered by Deep Life to be a reasonable error band given the information available at this time. The resulting WOB limits adopted by Deep Life for diver safety are:

- Air diving: 2.75J/L minus 0.18J/L for every 10m
- Heliox diving: 2.75J/L minus 0.033J/L for every 10m

This work was carried out prior to publication of human test data by NEDU in TR 07-02, covering the same subject. The two sets of limits are compared in Chapter 3.6, where reasonable correlation is found but NEDU consider only air diving.

3.5. US Naval TM 01-94:1994 WOB Objectives

The figure below shows the goals for WOB set by the US Navy, for Underwater Breathing Equipment, in 1994, in document TM N01-94.

					CATEGORY 1 DEPTH 0 to 198 fsw AIR		CATEGORY 2 0 to 198 fsw AIR 0 to 1000 fsw HeO_2		CATEGORIES 3 & 5 0 to 200 fsw AIR 0 to 1500 fsw HeO_2			CATEGORY 4 0 to 150 fsw AIR			CATEGORY 4 0 to 1500 fsw HeO_2		
$\dot{V}O_2$ (L/min)	RMV (L/min)	V_T (L)	f (BPM)	PEAK FLOW RATE (L/sec)	RESISTIVE EFFORT		RESISTIVE EFFORT		$\Delta P^{(3)}$ (kPa)	RESISTIVE EFFORT		$\Delta P^{(3)}$ (kPa)	RESISTIVE EFFORT		$\Delta P^{(3)}$ (kPa)	RESISTIVE EFFORT	
					kg·m/L	kPa (J/L)	kg·m/L	kPa (J/L)		kg·m/L	kPa (J/L)		kg·m/L	kPa (J/L)		kg·m/L	kPa (J/L)
0.90	22.5	1.5	15	1.18	0.14[1]	1.37[1]	0.18[1]	1.76[1]	0.147	0.024	0.231	0.108	0.017	0.170	0.147	0.024	0.231
1.60	40.0	2.0	20	2.09	0.14[1]	1.37[1]	0.18[1]	1.76[1]	0.393	0.063	0.617	0.324	0.052	0.509	0.393	0.063	0.617
2.50	62.5	2.5	25	3.27	0.14[1]	1.37[1]	0.18[1]	1.76[1]	0.982	0.157	1.542	0.746	0.120	1.172	0.982	0.157	1.542
3.00	75.0	2.5	30	3.93	(2)	(2)	(2)	(2)	1.375	0.220	2.159	1.080	0.173	1.696	1.375	0.220	2.159
3.60	90.0	3.0	30	4.71	(2)	(2)	(2)	(2)	1.964[4]	0.315	3.085	1.610[4]	0.258	2.529	1.964[4]	0.315	3.085

3.6. NEDU Jan 2007 WOB Recommendations

The NEDU report by D. E. Warkander, "COMPREHENSIVE PERFORMANCE LIMITS FOR DIVERS' UNDERWATER BREATHING GEAR: OF ADOPTING CONSEQUENCES DIVER-FOCUSED LIMITS, Navy experimental Diving Unit TA 05-12 , 15 January 2007" recommends a lower WOB limit and also gives elastance limits for rebreathers. This was a ground breaking piece of work in relating Work of Breathing limits to measured diver physiometric response. The NEDU TA 05-12 recommendations are expected to be adopted by NATO in STANAG 1410:2008.

The principle of the NEDU report TA 05-12 , is to determine what Work of Breathing causes the diver's RMV to increase by 50%. This is a function of depth, gas and equipment configuration. Whilst the report considers primarily Work of Breathing, there are references to hydrostatic limits, and the introduction of a new limit for elastance.

The TA 05-12 NEDU report contains recommendations on "ELASTANCE AND HYDROSTATIC IMBALANCE" that are measured and reported in the Hydrostatic report for this equipment: the equipment complies in all orientations even with the worst case counterlungs fitted (a long, thin counterlung).

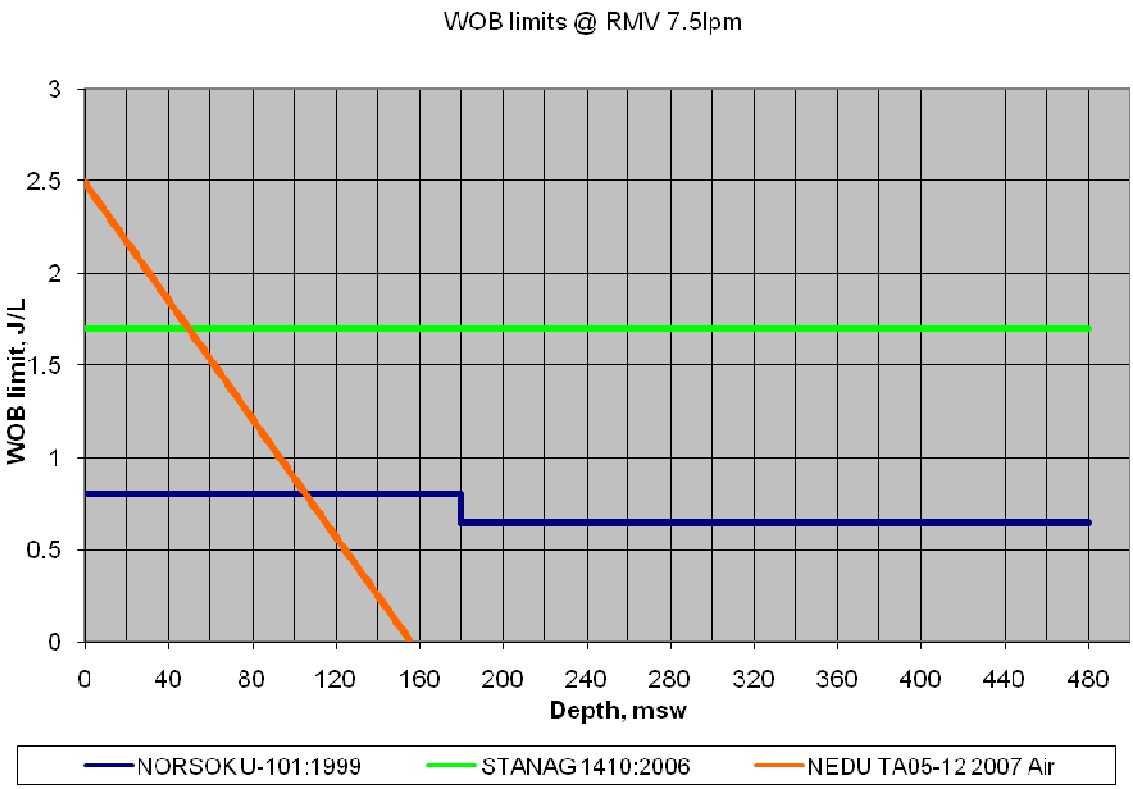
NEDU use the same WOB figure and Lissajou as in NATO STANAG 1410: see Figure Figure 3-4.

The limits proposed by TA 05-12 are:

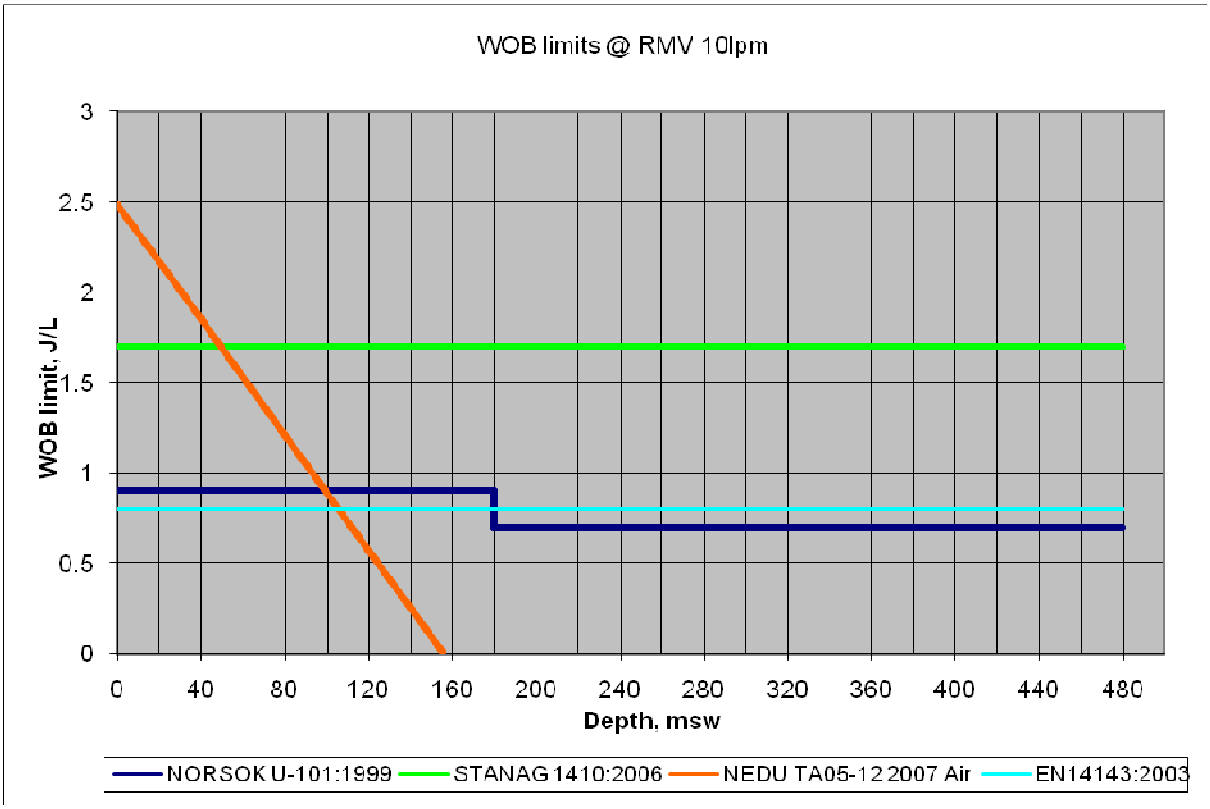
> The resistive effort (WOB/VT) should not exceed:
>
> WOB/VT < 2.49 -0.016 *depth (depth in m, effort in kPa)
>
> WOB/VT < 2.49 -0.00485 * depth (depth in fsw, effort in kPa)
>
> The elastance should not exceed 0.7 kPa/L independent of depth and ventilation. The maximum tolerable hydrostatic imbalances, relative to the suprasternal notch, should be in the range +0.4 to +2.9 kPa for a vertical diver and in the range -0.3 to +1.7kPa for a horizontal diver.

The total acceptable respiratory load can be calculated by adding the relative value for each load.

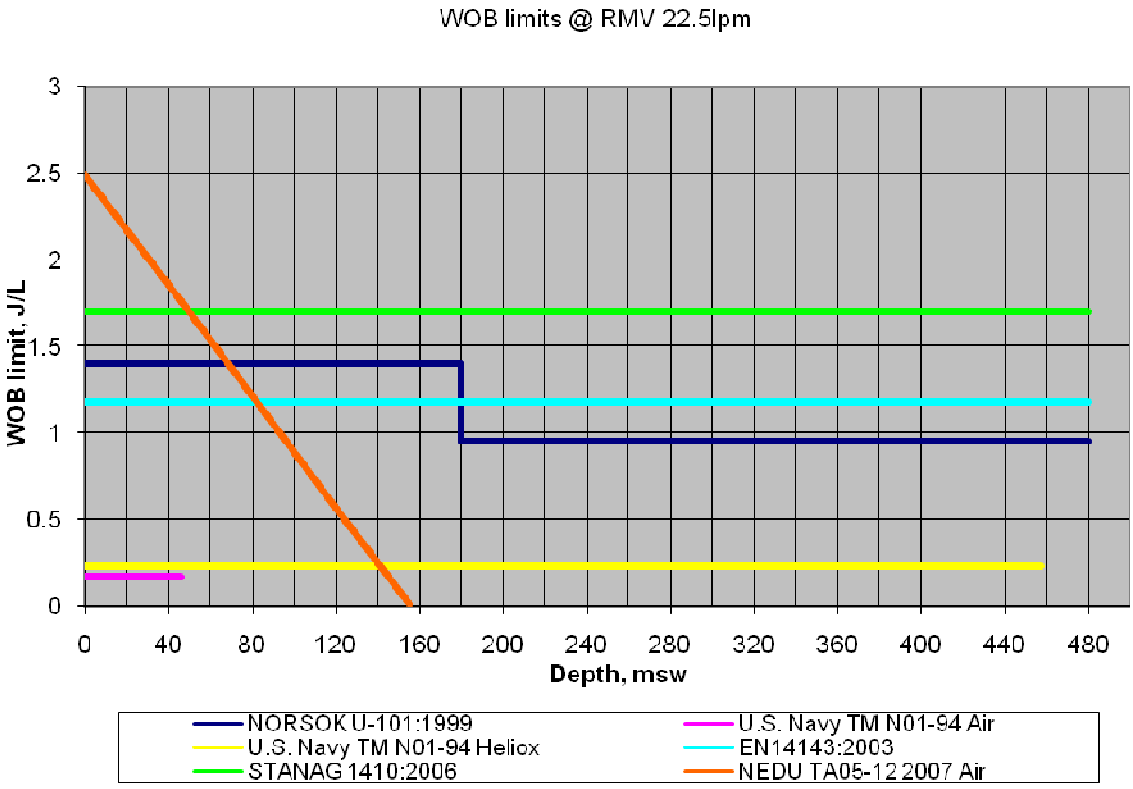
3.7. Combined plots of compliance requirements



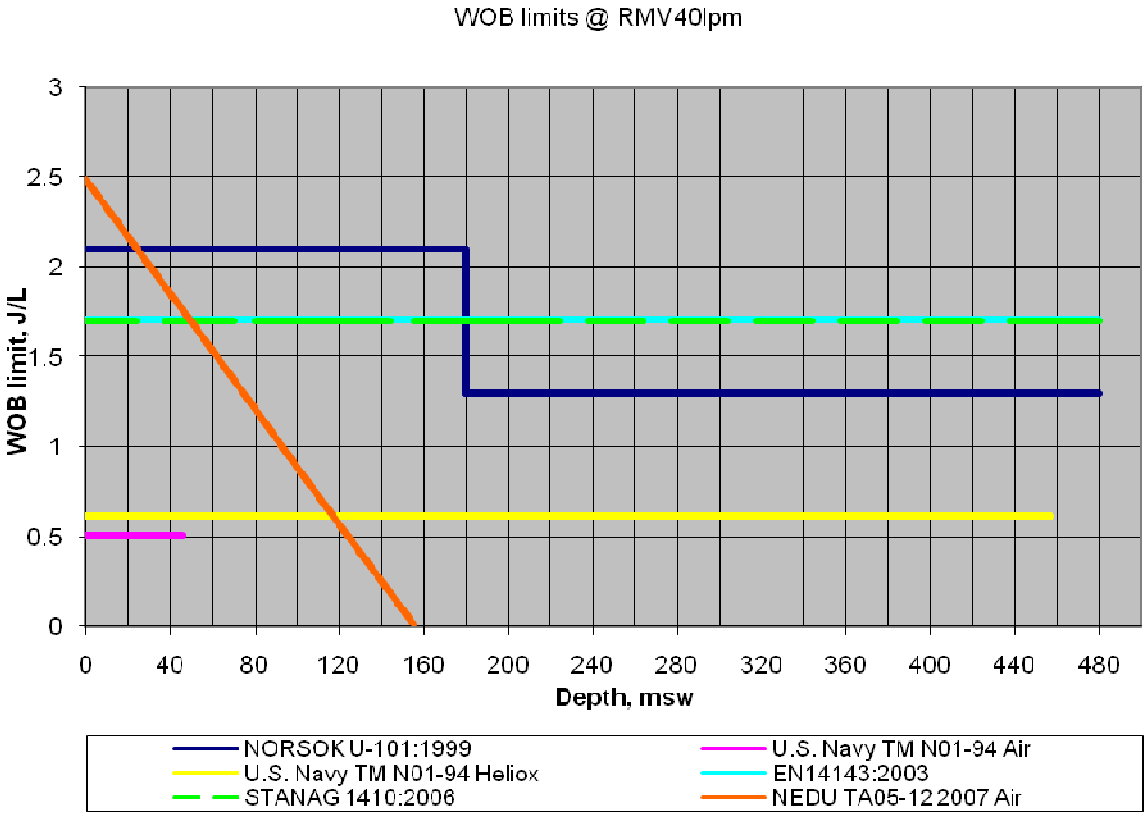
Work of breathing limits of different standards for RMV of 7.5 lpm at depth.



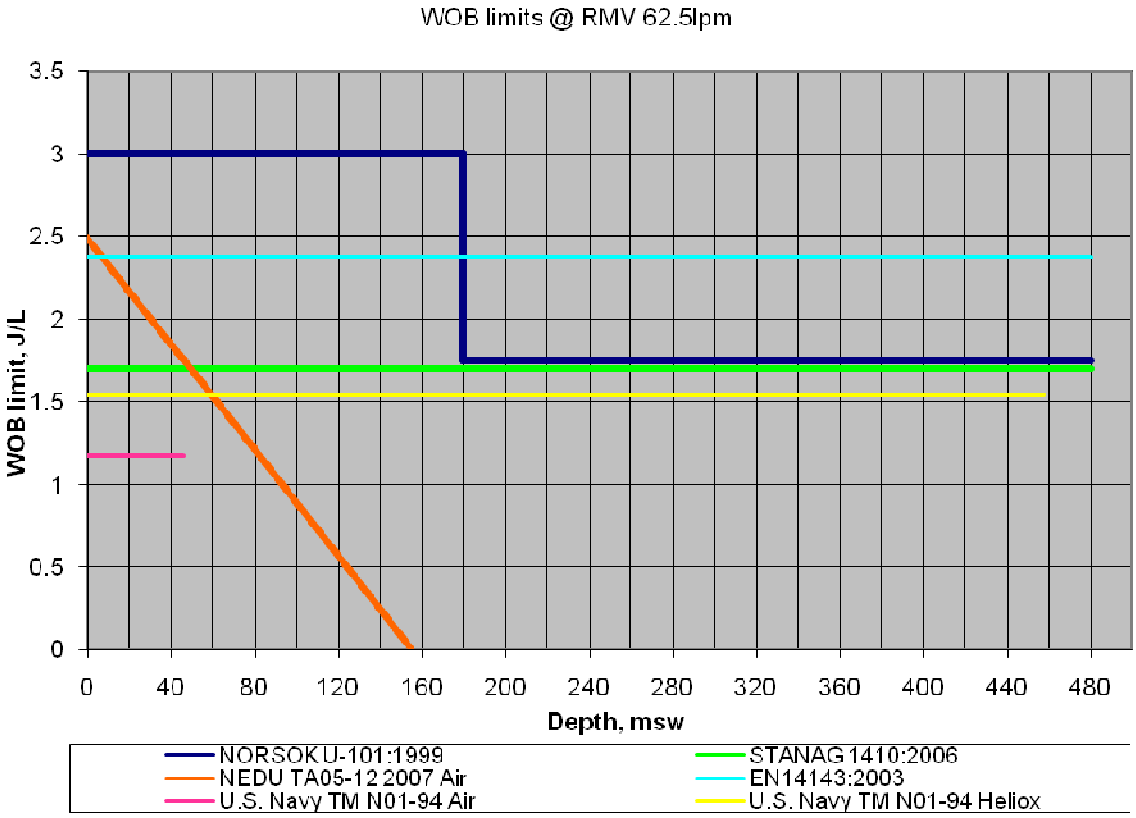
Work of breathing limits of different standards for RMV of 10 lpm at depth.



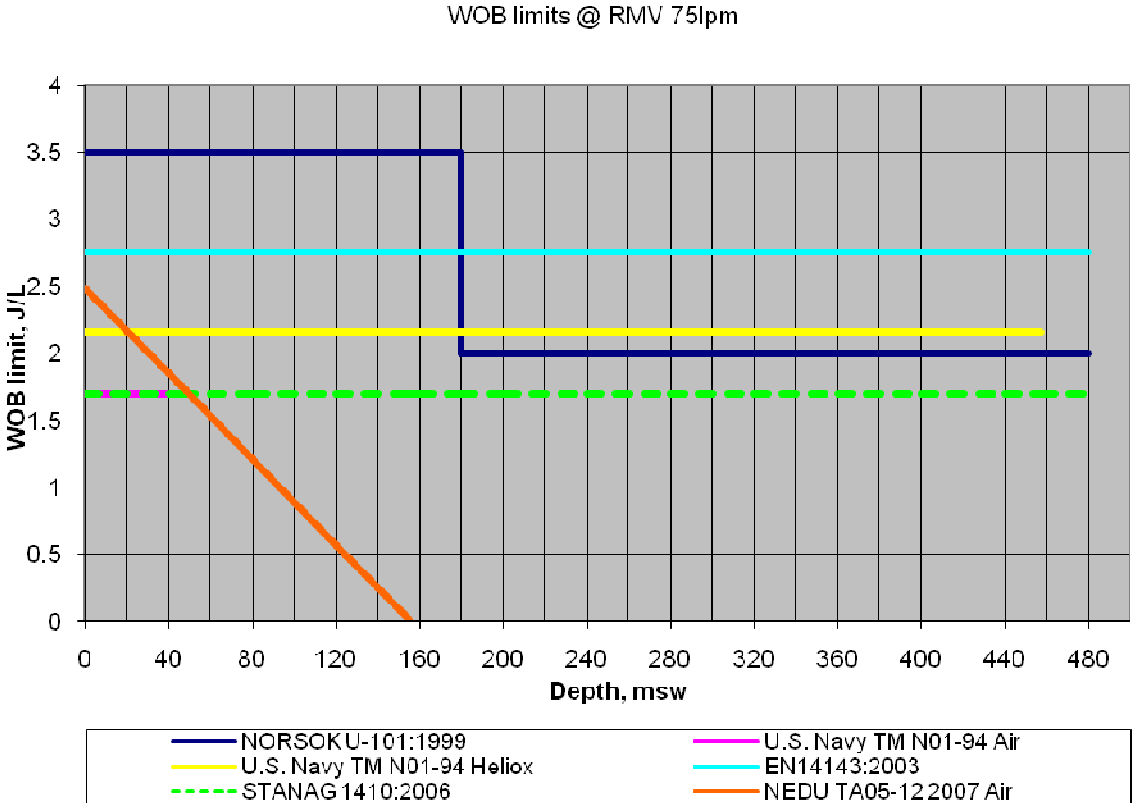
Work of breathing limits of different standards for RMV of 22.5 lpm at depth.



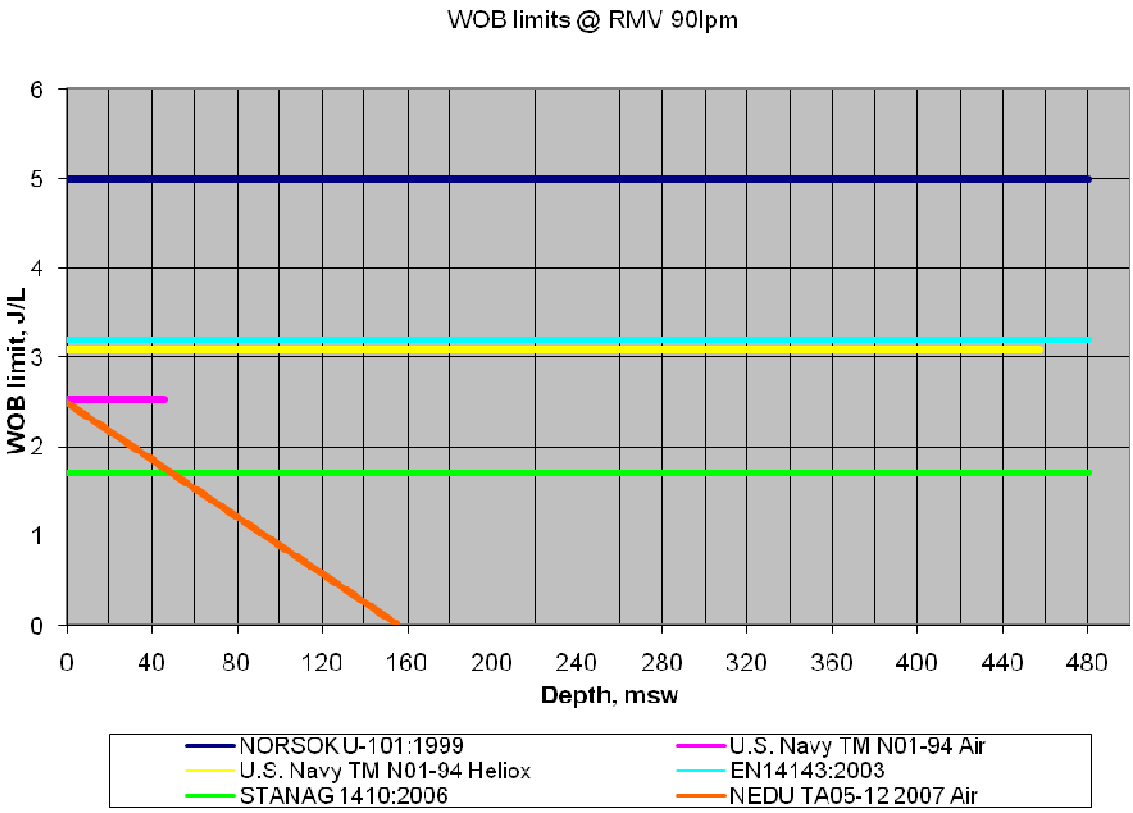
Work of breathing limits of different standards for RMV of 40 lpm at depth.



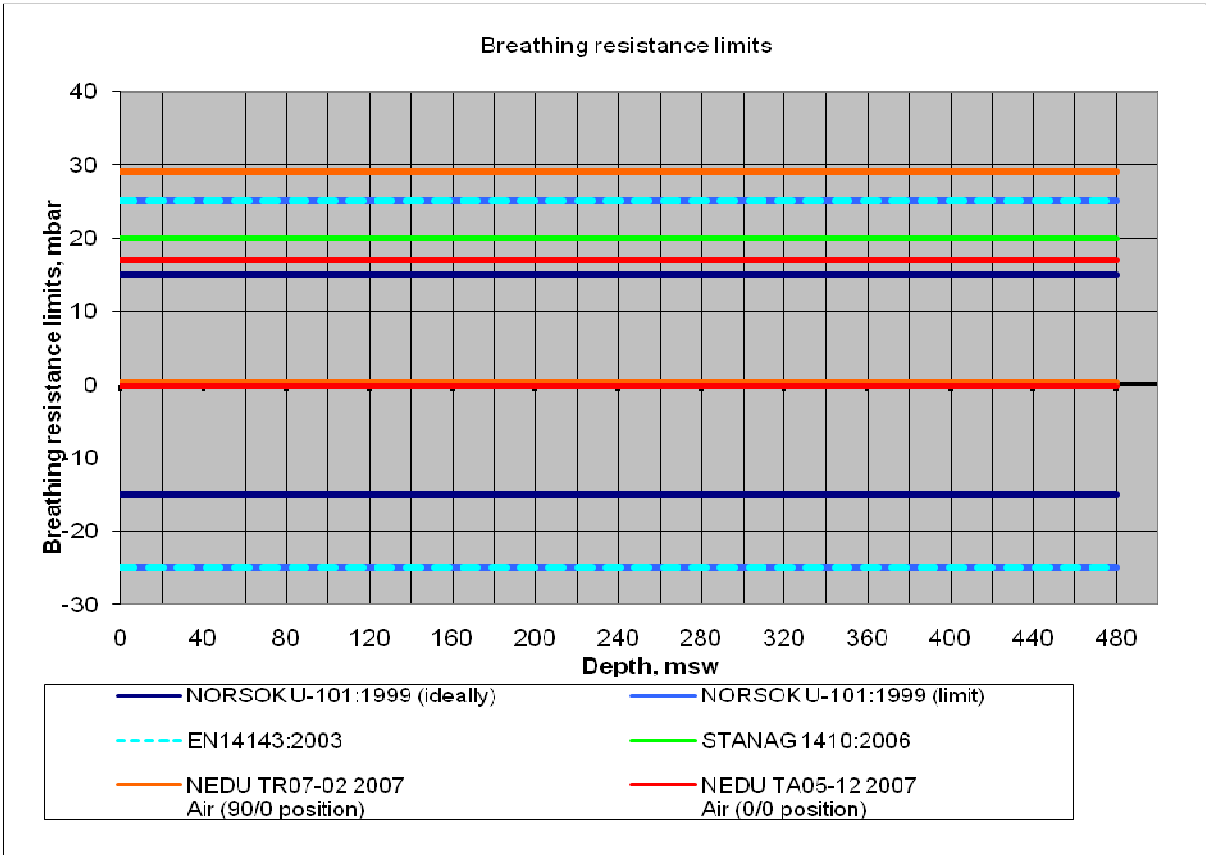
Work of breathing limits of different standards for RMV of 62.5 lpm at depth.



Work of breathing limits of different standards for RMV of 75 lpm at depth.



Work of breathing limits of different standards for RMV of 90 lpm at depth.



Breating resistance limits of different standards. Note: STANAG 1410:2006 contains only relative values of the respiratory pressure.

4. EQUIPMENT USED

The test equipment is listed below.

Equipment	Serial Number	Calibration Log Number	Calibration Next Due
DL, Human Respiratory Emulator (Breathing simulator) DL Rev C2	DL 001	See below	July 2010 and Check cal prior to test
Differential pressure sensor. Druck lpm9381	2393261	D22	Aug 2010
Test chamber high pressure sensor Keller ECO1	004630	M03	August 2010
Test chamber reference pressure sensor, Keller LEO1 0-700 bar, +/-0.01 bar accuracy	24137,	L36	August 2010
High pressure sensor ME 705	DL 004	M02	August 2010
National Instruments Data Capture System PCI-6014	HA4375847	L15	Against TTi 1906, Serial Number 111474 Prior to test
Power supply GPR – 1850	033624	N/A	N/A
Deep Life 600x800 mm chamber, with environmental control, rotateable	CH03	N/A	Next hydrostatic Sept 2009
Thermometer, high accuracy. Protek D610 and probe	D61000013	L61	Dec 2009

Note 1: The Druck differential sensor provides very high quality results, and works dry:wet, so all tests are carried out with the reference anatomically correct to the suprasternal notch. The sensor offset is zeroed where the test method is described as ABSOLUTE, and is not zeroed when the test is described as RELATIVE.

Differential sensors fail rapidly in helium. For each set of helium results, multiple calibration runs are carried out, before and after, to ensure the accuracy of these results. This means that each helium test takes several times longer than each air test. The helium tests are

monitored using absolute pressure variations in the loop to detect the onset of differential pressure failure. Using the sensors wet:wet does not overcome the helium ingress issue.

Note 2: the Breathing Simulator is a complex measurement system and contains additional sensors not listed in the table above. This information is provided at Breathing Simulator Calibration report *Cal_Breathing_Simulator_Assessment_090707.pdf*.

4.1. Calibration references and means

- NEDU Small Calibration Orifice (S/N DL 008), sample of calibration data reproduced herein
- EN14143 Calibration Orifice (S/N DL 009), sample of calibration data reproduced herein
- NATO STANAG 1410:2006 Elastance test fixture, sample of calibration data reproduced herein

Calibration orifices, calibration weight set, calibrated graduated volume are not subject to annual calibration, but are inspected for wear on each use.

4.2. Mannequin Measurements in NORSOK U-101 and TA05-12 NEDU report compared to EN14143 and BAI's test lab mannequin

A mannequin forms part of the test frame, with dimensions shown on the right below.

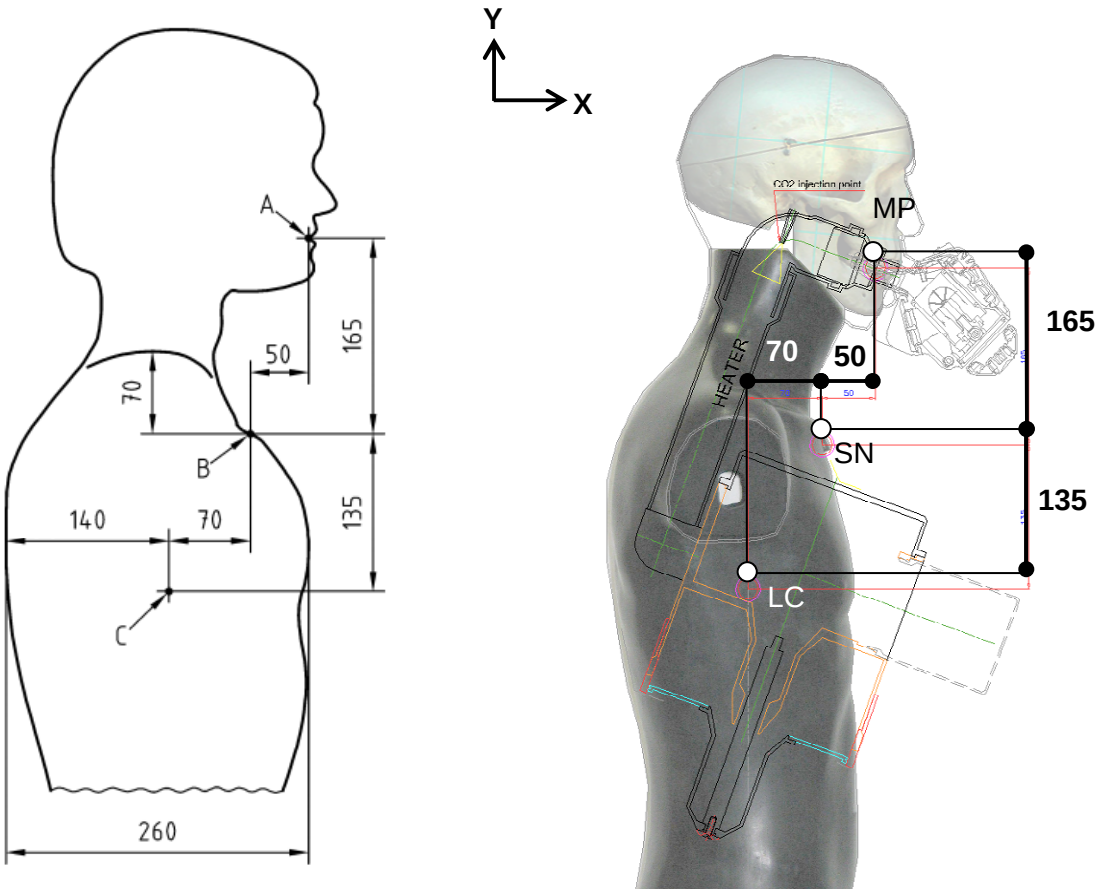


Figure 4-1: The Figure 2 from EN14143:2003 giving mannequin measurements, alongside BAI's test mannequin with Breathing Simulator installed.

In cases where the mannequin and equipment under test does not fit within the chamber, a wire mannequin is used and the Breathing simulator then occupies part of the internal space of the mannequin. The wire mannequin is set up to the same dimensions as the solid mannequin, for consistency.

The mannequin measurements determine the respiratory pressures as much as the rebreather geometry. The mannequin measurements differ between each standard.

BAI's mannequin reference points are compensated to correspond to EN14143:2003 mannequin dimensions, therefore there is no need for any offset for the test results. The dimension values are shown in the table below.

	Vertical dimensions, mm			**Horizontal dimensions, mm**			
Mannequin Dimensions	**From mouth to SN**	**From SN to LC**	**From Top of shoulder to SN**	**From Back to LC**	**From LC to SN**	**From SN to mouth**	**From chest to back**
In EN14143:2003	165	135	70	140	70	50	260
In NORSOK U-101	160	124	-	-	70	70	-
In NEDU TA05-12	-	140	-	-	70	-	-
Test Mannequin	165	135	-	-	70	50	-

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5. CALIBRATION

For standards compliance work, it is necessary to perform a traceable calibration of the Breathing Simulator. For Breathing Simulator calibration, the standards specify the performance using test orifices and an elastance test fixture. There are two orifices used: one is the NEDU orifice, the second is the EN14143 orifice. The elastance test fixture is described in the NATO STANAG 1410 edition 2 Figure D-3.

The gases supplied have supply certificates recording their purity.

The calibration of the respirator (DL-BM-Rev.C2) is described in the following document: *Cal_Breathing_Simulator_Assessment_090707.pdf.*

The respirator does not support the lowest tidal volume (TD) of 0.75l referred to in NORSOK U-101: the minimum is 1 litre. The equivalent RMV but with a 1 litre TD can be achieved with a breathing rate calculated as follows:

BR_equivalent = RMV_NORSOK / TD_DL_BM = 7.5l/min / 1l = 7.5 cycles/min

The slower BR is a worse case for PPO2 control than a high rate with a lower TD, so this method of carrying out NORSOK test for a 7.5l/min RMV will produce a wide error in the PPO2 control than the same test with a 0.75l stroke.

A safety assessment for these specific tests was carried out in addition to a general assessment for all of EN14143 and NORSOK U101 tests. Safety provisions in use of compressed gases were observed. Tests were overseen by a qualified Advanced Gas Technician. All tests were carried out by qualified and experienced graduate engineers.

5.1. Non-Applicable Fields in Calibration Result Tables

In the Lissajou tables of calibration results, the following fields are marked Not Applicable (N.A.):

- WOB OF BREATHING SIMULATOR
- TOTAL WORK OF BREATHING (WOB)
- TOTAL POS / NEG WORK

These three fields are additional to the work of breathing of the apparatus under test. That is, the WORK OF DEVICE UNDER TEST is determined from the data, and then the three extra fields above are computed – they are the corresponding figures for the diver's internal respiratory resistance as approximated by the breathing simulator, and then the sum of that physiological resistance and the apparatus resistance.

These three extra parameters are generated for each test because Deep Life's own safety requirements have a total budget for WOB, which is split between the rebreather and the diver. The breathing simulator has dimensions that provide an estimate of the physiological WOB that is additional to the measured WOB of the equipment. These additional fields allow the limits described in Chapter 3.4 to be monitored.

The additional fields for diver physiological losses do not form part of NATO STANAG, EN 14143 or NORSOK U-101 measurements because the calibration is not calibrating the diver, it is calibrating the ability of the breathing simulator to provide the correct waveform and measurements of the apparatus under test only

5.2. Calibrations using the NEDU Orifice

The Breathing simulator was calibrated using the NEDU TM01-94 calibration orifice (Figure 4.1 of NEDU TM01-94), under all conditions described by NEDU in TM01-94, by EN14143:2003 orifice (Figure 5-2) and test conditions. Samples of those calibrations, which were repeated with each series of tests, are reproduced along with the test results.

Figure 5-1: NEDU TM01-94 Test Orifice.

Table 14. Reproduction of Table 4-1 of NEDU TM01-94 (p.4-2) "CLM Orifice Calibration Values (Daily Calibration)"

RMV (L/min)	minimum $\overline{P}_v$ (kPa or J/L)	maximum $\overline{P}_v$	mean $\overline{P}_v$
22.5	0.17	0.31	0.24
40.0	0.70	0.82	0.76
62.5	1.58	1.84	1.71
75.0	2.17	2.45	2.31
90.0	3.10	3.43	3.26

The Breathing simulator was calibrated using the NEDU TM01-94 calibration orifice (Figure 4.1 of NEDU TM01-94), under all conditions described by NEDU in TM01-94. List of those calibrations, which are repeated with each series of tests, is reproduced below.

It is BAI's procedure to run the NEDU orifice calibration each time the breathing simulator stroke is changed, before starting the sequence of tests. The EN 14143:2003 orifice is run less frequently: weekly during periods when WOB tests are performed.

Tests are bracketed by calibrations: that is before tests are performed and at the end of the series of tests. Where the breathing machine fails a calibration, all work since the previous calibration is examined. Unless an obvious and distinct cause for the failure is identified, e.g. a cable becoming unplugged, all tests in the interval that finishes with the unsatisfactory calibration, are repeated.

For tests below 22.5 lpm RMV, a higher setting is used for calibration, because the amplitude of the calibration signal is otherwise too small.

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration (NEDU N01-94 orifice)	
TEST METHOD	:	NEDU TM N01-94	SINE FLOW
DATE AND TIME	:	04.02.2010	
TEST CARRIED OUT BY	MS	WITNESS:	

CONDITIONS OF TEST

ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	0.0	m
ROOM / WATER TEMPERATURE	:	18.0 / -	℃
EHXALE GAS TEMPERATURE	:	-	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/30.0bpm/90.1 lpm	metric

RESULTS

PRESSURE@START INHALE / EXHALE	=	-0.6 / -0.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-23.5 / 25.9	mbar
PEAK TO PEAK PRESSURE	=	49.5	mbar
EN14143 RELATIVE PEAK PRESSURES	=	22.9 / 26.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A.	J/l
WOB OF BREATHING SIMULATOR	=	N.A.	J/l
WOB OF DEVICE UNDER TEST	=	3.37	J/l
TOTAL POS / NEG WORK	=	N.A.	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.76 / 1.61	J/l

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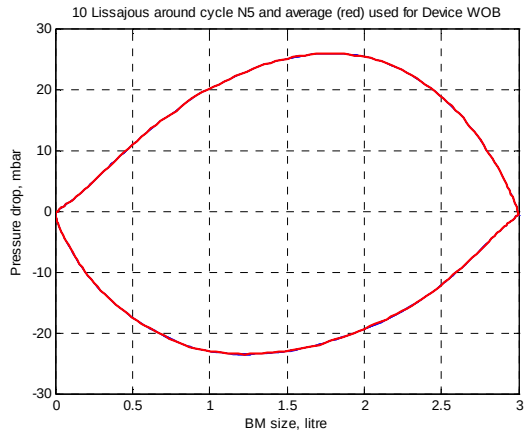
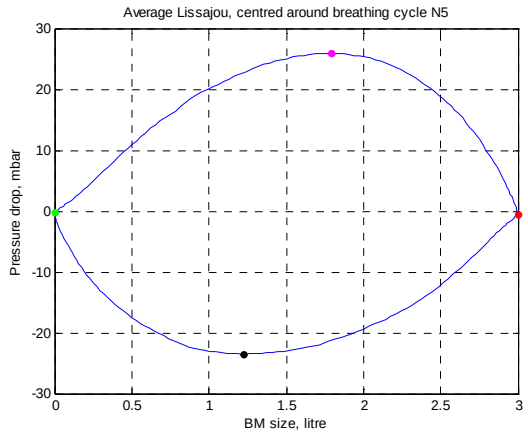
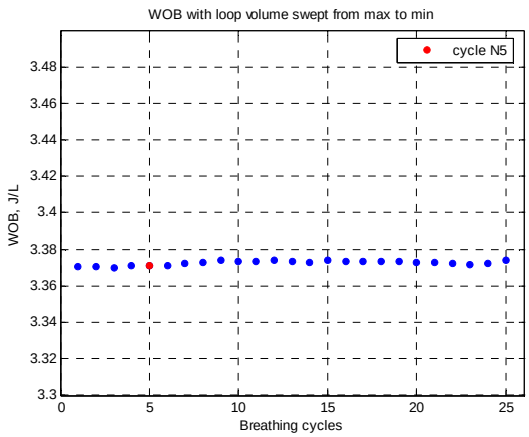
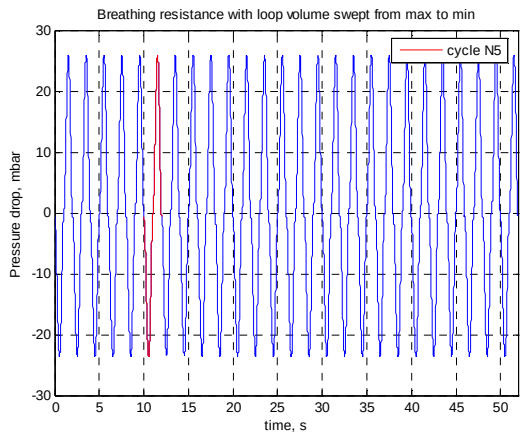








RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration (NEDU N01-94 orifice)	
TEST METHOD	:	NEDU TM N01-94	SINE FLOW
DATE AND TIME	:	24.02.2010	
TEST CARRIED OUT BY	MS	WITNESS:	

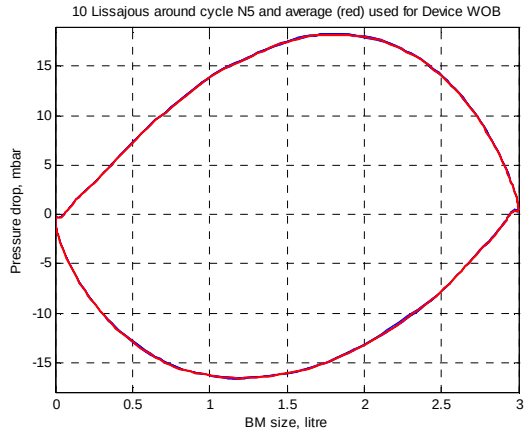
CONDITIONS OF TEST

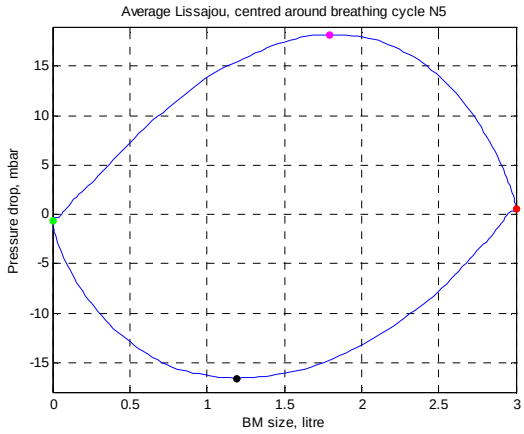
ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	0.0	m
ROOM / WATER TEMPERATURE	:	18.0 / -	℃
EHXALE GAS TEMPERATURE	:	-	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

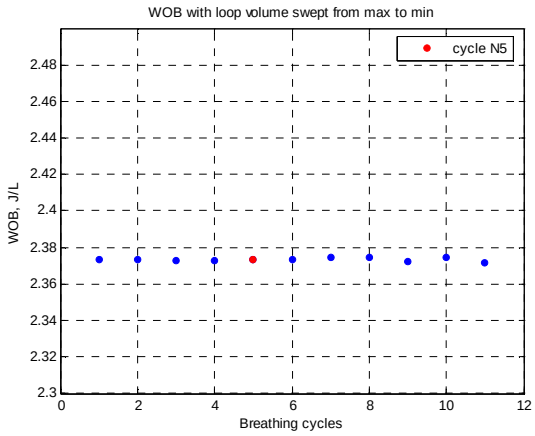
RESULTS

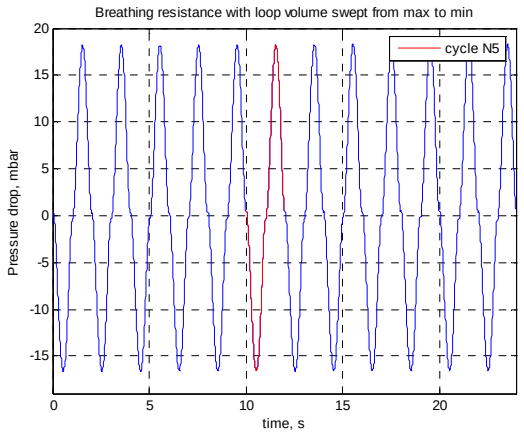
PRESSURE@START INHALE / EXHALE	=	0.6 / -0.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-16.6 / 18.2	mbar
PEAK TO PEAK PRESSURE	=	34.8	mbar
EN14143 RELATIVE PEAK PRESSURES	=	17.2 / 18.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A	J/l
WOB OF BREATHING SIMULATOR	=	N.A	J/l
WOB OF DEVICE UNDER TEST	=	2.37	J/l
TOTAL POS / NEG WORK	=	N.A	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.23 / 1.15	J/l

ALL DATA STORED AS # (DATA FILE): WOB_NEDUcal_90d_0m_75 lpm_air_100224_1









RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration (NEDU N01-94 orifice)	
TEST METHOD	:	NEDU TM N01-94	SINE FLOW
DATE AND TIME	:	23.02.2010	
TEST CARRIED OUT BY	MS	WITNESS:	

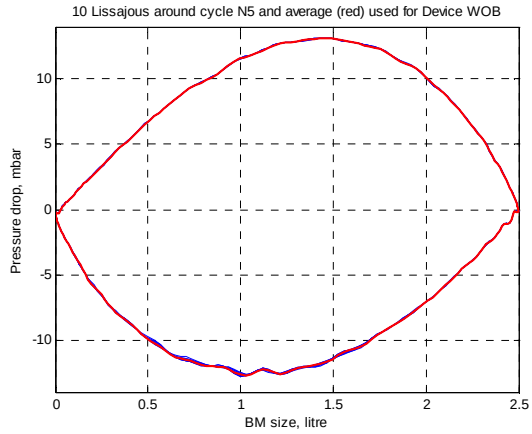
CONDITIONS OF TEST

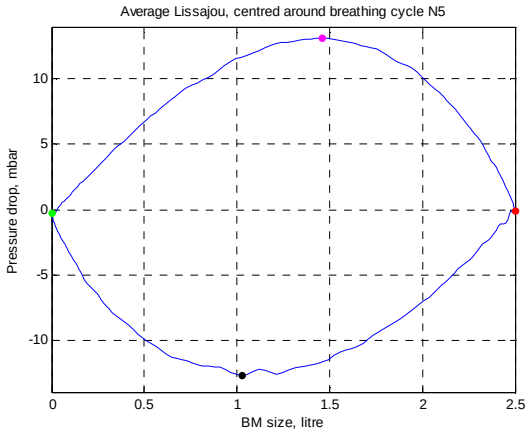
ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	0.0	m
ROOM / WATER TEMPERATURE	:	18.0 / -	℃
EHXALE GAS TEMPERATURE	:	-	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5 lpm	metric

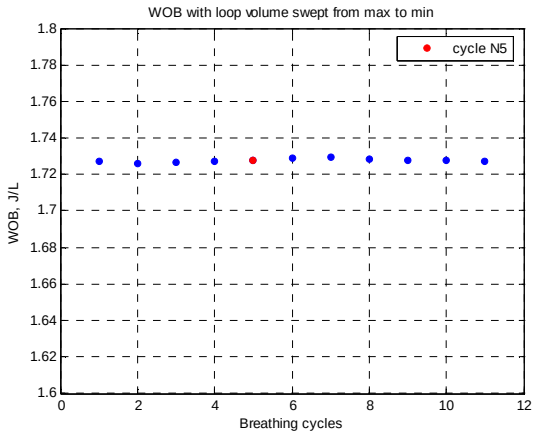
RESULTS

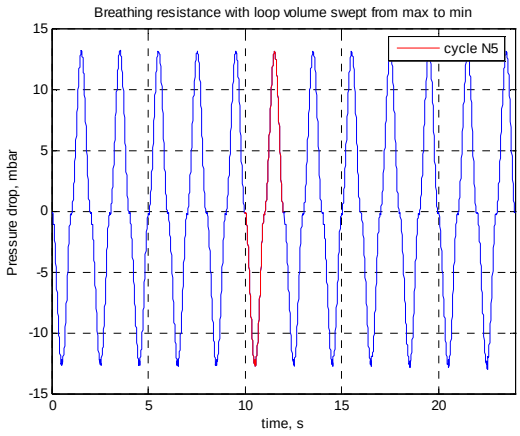
PRESSURE@START INHALE / EXHALE	=	-0.1 / -0.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-12.8 / 13.2	mbar
PEAK TO PEAK PRESSURE	=	25.9	mbar
EN14143 RELATIVE PEAK PRESSURES	=	12.6 / 13.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A.	J/l
WOB OF BREATHING SIMULATOR	=	N.A.	J/l
WOB OF DEVICE UNDER TEST	=	1.73	J/l
TOTAL POS / NEG WORK	=	N.A.	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.89 / 0.84	J/l

ALL DATA STORED AS # (DATA FILE): WOB_NEDUcal_90d_0m_62.5 lpm_air_100223_1









RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration (NEDU N01-94 orifice)	
TEST METHOD	:	NEDU TM N01-94	SINE FLOW
DATE AND TIME	:	18.02.2010	
TEST CARRIED OUT BY	MS	WITNESS:	

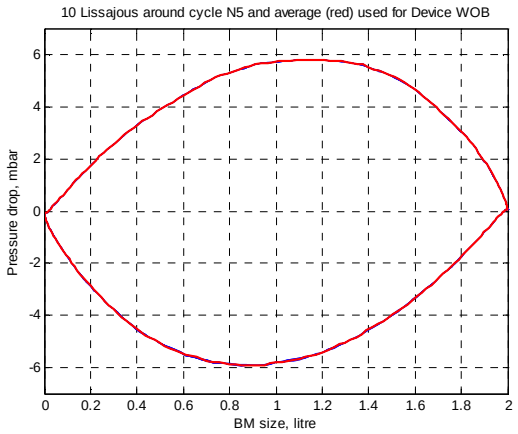
CONDITIONS OF TEST

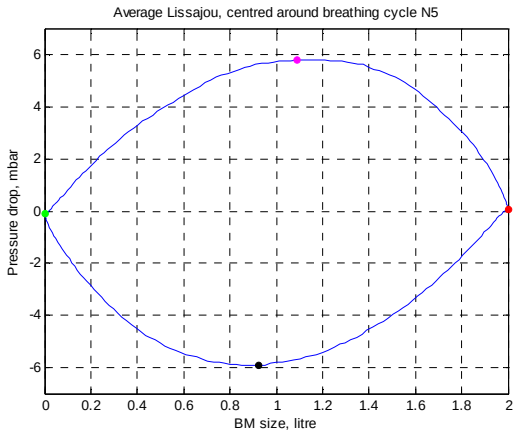
ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	0.0	m
ROOM / WATER TEMPERATURE	:	18.0 / -	℃
EHXALE GAS TEMPERATURE	:	-	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

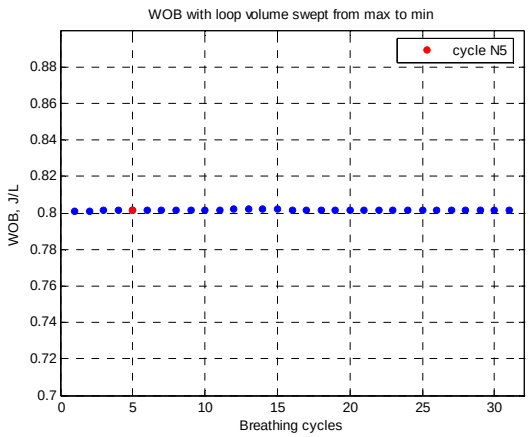
RESULTS

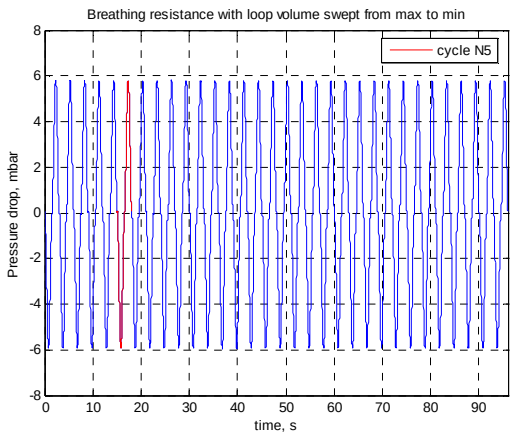
PRESSURE@START INHALE / EXHALE	=	0.1 / -0.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-5.9 / 5.8	mbar
PEAK TO PEAK PRESSURE	=	11.7	mbar
EN14143 RELATIVE PEAK PRESSURES	=	6.0 / 5.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A.	J/l
WOB OF BREATHING SIMULATOR	=	N.A.	J/l
WOB OF DEVICE UNDER TEST	=	0.80	J/l
TOTAL POS / NEG WORK	=	N.A.	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.40 / 0.40	J/l

ALL DATA STORED AS # (DATA FILE): WOB_NEDUcal_90d_0m_40 lpm_air_100218









RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration (NEDU N01-94 orifice)	
TEST METHOD	:	NEDU TM N01-94	SINE FLOW
DATE AND TIME	:	13.02.2010	
TEST CARRIED OUT BY	MS	WITNESS:	

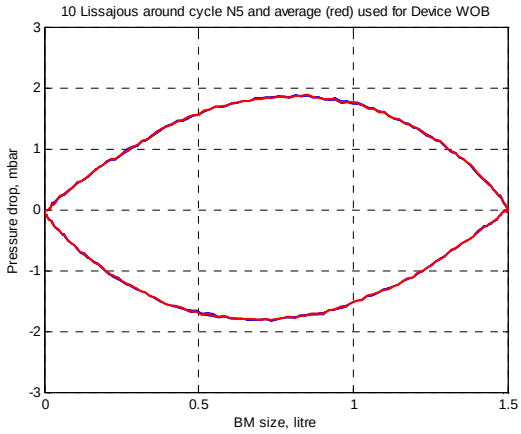
CONDITIONS OF TEST

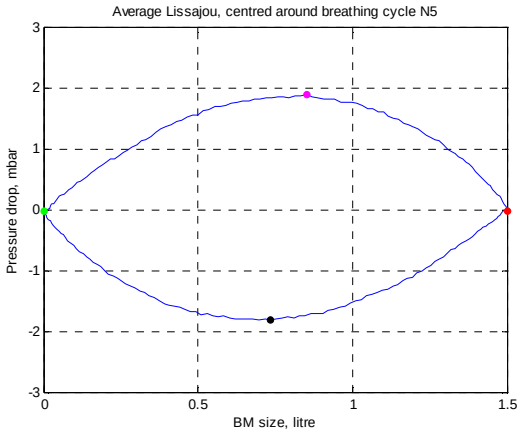
ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	0.0	m
ROOM / WATER TEMPERATURE	:	18.0 / -	℃
EHXALE GAS TEMPERATURE	:	-	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5 lpm	metric

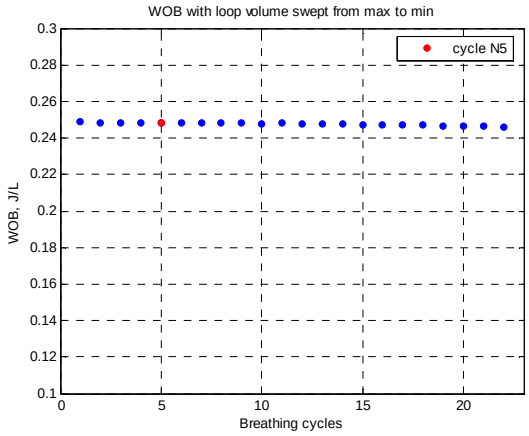
RESULTS

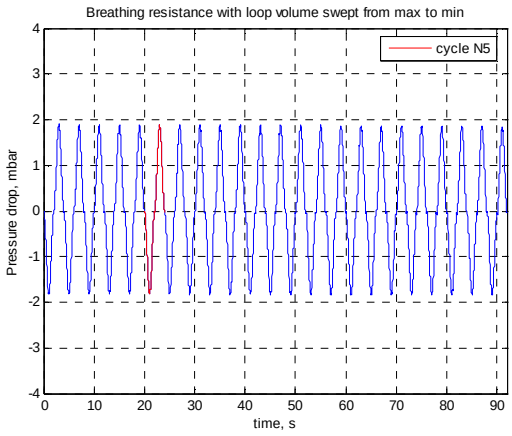
PRESSURE@START INHALE / EXHALE	=	-0.0 / -0.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-1.8 / 1.9	mbar
PEAK TO PEAK PRESSURE	=	3.7	mbar
EN14143 RELATIVE PEAK PRESSURES	=	1.8 / 1.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A.	J/l
WOB OF BREATHING SIMULATOR	=	N.A.	J/l
WOB OF DEVICE UNDER TEST	=	0.25	J/l
TOTAL POS / NEG WORK	=	N.A.	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.13 / 0.12	J/l

ALL DATA STORED AS # (DATA FILE): WOB_NEDUcal_90d_1m_22.5 lpm_air_100213_1









5.2.1. Table of NEDU orifice calibrations performed during the execution of the respiratory measurements within the scope of EN 14143

N	Date	File name	RMV [LPM]	WOB [J/L]	Pressure (mbar)
1.	10.01.2009	BM_NEDUcalibration_1ATA_75 lpm_090110.mat	75.0	2.41	-17.0…17.9
2.	10.01.2009	BM_NEDUcalibration_1ATA_90 lpm_090110.mat	89.7	3.29	-25.1…25.1
3.	01.04.2009	BM_NEDUcalibration_1ATA_75 lpm_090401.mat	74.7	2.44	-17.8…17.4
4.	01.04.2009	BM_NEDUcalibration_1ATA_90 lpm_090401.mat	89.3	3.40	-24.9…25.4
5.	26.06.2009	BM_NEDUcalibration_62.5 lpm_090626.mat	62.5	1.70	-11.5…12.9
6.	16.09.2009	CAL_BM001RC2_NEDUcal_1ATA_ 62_5 lpm_090916.mat	62.5	1.64	-11.8…12.5
7.	21.09.2009	CAL_BM001RC2_NEDUcal_1ATA_ 40 lpm_090921.mat	39.5	0.64	-4.6…4.8
8.	21.09.2009	CAL_BM001RC2_NEDUcal_1ATA_ 22_5 lpm_090921.mat	22.5	0.23	-1.7…1.7
9.	22.09.2009	CAL_BM001RC2_NEDUcal_1ATA_ 62_5 lpm_090922_2.mat	62.5	1.71	-12.4…12.9
10.	17.12.2009	CAL_BM001RC2_NEDUcal_1ATA_75 lpm_091217.mat	75.0	2.40	-16.9…18.1
11.	21.12.2009	WOB_BM001RC2_NEDUcal_1ATA_90d _0m_62.5 lpm_air_091221.mat	62.5	1.61	-11.7…11.9
12.	14.01.2010	WOB_NEDUcal_90d_0m_62.5 lpm_air_100114_1.mat	62.3	1.65	-11.9…12.1
13.	15.01.2010	WOB_NEDUcal_90d_0m_62.5 lpm_air_100115_1.mat	62.1	1.64	-11.9…12.0
14.	26.01.2010	WOB_NEDUcal_90d_0m_62.5 lpm_air_100126.mat	62.4	1.69	-12.0…12.9
15.	04.02.2010	WOB_NEDUcal_90d_0m_75 lpm_air_100204.mat	75.0	2.38	-16.8…17.3
16.	04.02.2010	WOB_NEDUcal_90d_0m_90 lpm_air_100204.mat	90.1	3.39	-23.5…25.1
17.	05.02.2010	WOB_NEDUcal_90d_0m_90 lpm_air_100205_postHe.mat	90.0	3.48	-23.6…26.8
18.	09.02.2010	WOB_NEDUcal_90d_0m_75 lpm_air_100209.mat	74.7	2.45	-17.3…18.4

19.	09.02.2010	WOB_NEDUcal_90d_0m_40 lpm_air_100209.mat	40.0	0.76	-5.3…5.8
20.	10.02.2010	WOB_NEDUcal_90d_-1m_22.5 lpm_air_100210.mat	22.5	0.23	-1.8…1.8
21.	13.02.2010	WOB_NEDUcal_90d_1m_22.5 lpm_air_100213_1.mat	22.5	0.25	-1.8…1.9
22.	13.02.2010	WOB_NEDUcal_90d_0m_22.5 lpm_air_100213_2_postHe.mat	22.5	0.27	-1.7…2.2
23.	13.02.2010	WOB_NEDUcal_90d_1m_40 lpm_air_100213_1.mat	40.0	0.81	-5.9…5.8
24.	13.02.2010	WOB_NEDUcal_90d_1m_62.5 lpm_air_100213_1.mat	62.5	1.78	-12.9…13.0
25.	16.02.2010	WOB_NEDUcal_90d_0m_62.5 lpm_air_100216_1.mat	62.4	1.76	-12.7…13.4
26.	18.02.2010	Hydr_NEDUcal_62.5 lpm_0_45_100218_opt_2nd.mat	62.4	1.75	-13.6…12.6
27.	18.02.2010	WOB_NEDUcal_90d_0m_40 lpm_air_100218.mat	40.0	0.80	-5.9…5.8
28.	20.02.2010	Hydr_NEDUcal_62.5 lpm_0_-90_100220_corrected.mat	62.5	1.76	-12.5…13.9
29.	23.02.2010	WOB_NEDUcal_90d_0m_62.5 lpm_air_100223_1.mat	62.5	1.73	-12.6…13.1
30.	24.02.2010	WOB_NEDUcal_90d_0m_75 lpm_air_100224_1.mat	74.9	2.41	-16.9…18.0

5.3. Calibrations using the EN14143 orifice

The Breathing simulator was calibrated using the EN14143:2003 orifice, (the EN orifice), before starting each sequence of tests, and at the end of the sequence. Where the sequence involves multiple weeks of continuous testing, the Breathing simulator is calibrated weekly using the EN orifice.

The EN orifice is suitable for use only in air at a depth of 50m, using a 62.5 lpm RMV. It is cumbersome to set up on Breathing simulators that require the chamber to be opened and a crank pin changed, such as the Deep Life simulator. For these reasons, the NEDU orifice is used for check the calibration at RMVs other than 62.5 lpm.

The EN orifice produces a breathing resistance of 50mbar at 5 ATM at an RMV of 62.5l/min. Sample of those calibrations, which were repeated with each series of tests, is reproduced along with the test results, along with a tabulation of the past year of EN calibrations that relate to the Work of Breathing measurements that fall within the scope of EN 14143:2003.

Figure 5-2: EN14143:2003 Test Orifice.

The first calibration on 14th was outside specification. All tests from the 12th to 14th Feb 2010 were examined, with comparison to the same tests a year earlier and the latest test immediately prior to 14th was repeated with a good calibration.

Cal failure was due to either a residual water level in the chamber being displaced by the breathing simulator piston or water in the measurement reference hose (as the calibration is carried out dry, unlike the WOB tests. The water was cleared and the recalibration result shown overleaf was obtained. As the cause was related purely to the calibration process, results were accepted. This fault has occurred twice in 2010 with a good calibration.

Actions have now been taken to eliminate the fault, including direct measurement of the water depth in the chamber during calibration processes, and replication of the differential sensor outside the chamber(i.e. two differential sensors in use for redundant data). The operational Checklist for the WOB procedures have been updated accordingly.

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration calibration orifice)	(EN14143:2003
TEST METHOD		EN14143:2003 Breathing Simulator calibration method	SINE FLOW
DATE AND TIME		07/04/2009 15:56:31	
TEST CARRIED OUT BY	VD	WITNESS: MS	

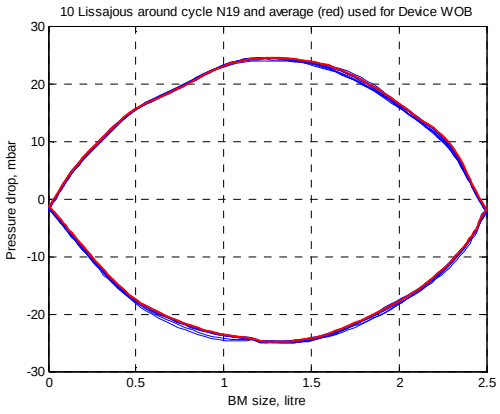
CONDITIONS OF TEST

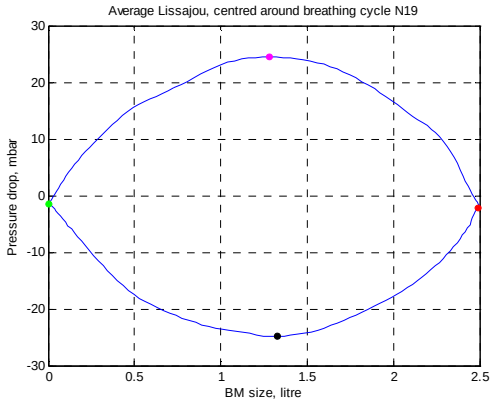
ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	50.2	m
ROOM / WATER TEMPERATURE	:	19.7 / -	℃
EHXALE GAS TEMPERATURE	:	21.2	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5 lpm	metric

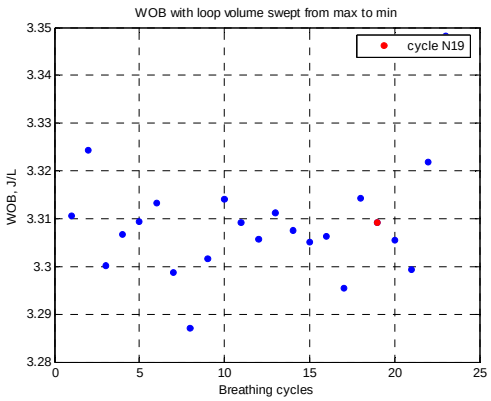
RESULTS

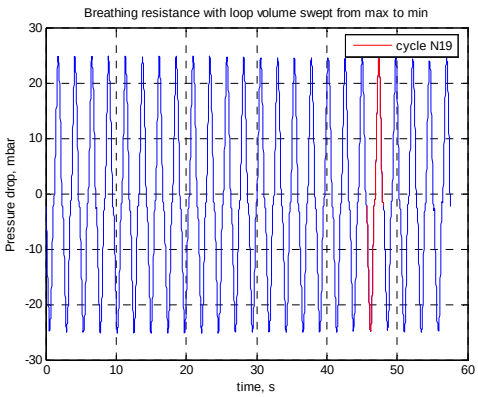
PRESSURE@END EXHALE / INHALE	=	-0.5 / -0.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-25.0 / 24.8	mbar
PEAK TO PEAK PRESSURE	=	49.8	mbar
INHALE/EXHALE RESP PRESSURES	=	24.5 / 25.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A.	J/l
WOB OF BREATHING SIMULATOR	=	N.A.	J/l
WOB OF DEVICE UNDER TEST	=	3.31	J/l
TOTAL POS / NEG WORK	=	N.A.	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.67 / 1.64	J/l

ALL DATA STORED AS # (DATA FILE): BM_EN14143calibration_6ATA_62_5 lpm_090407

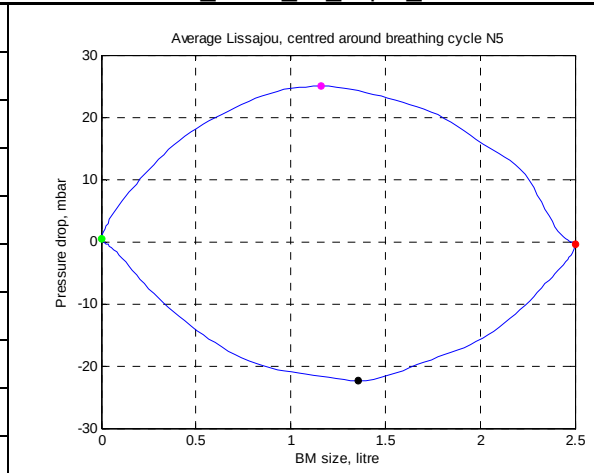
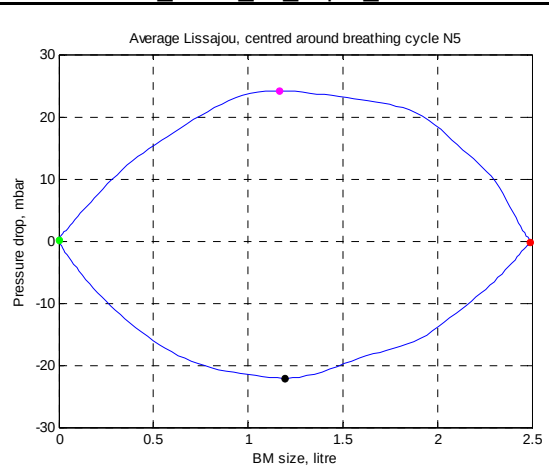
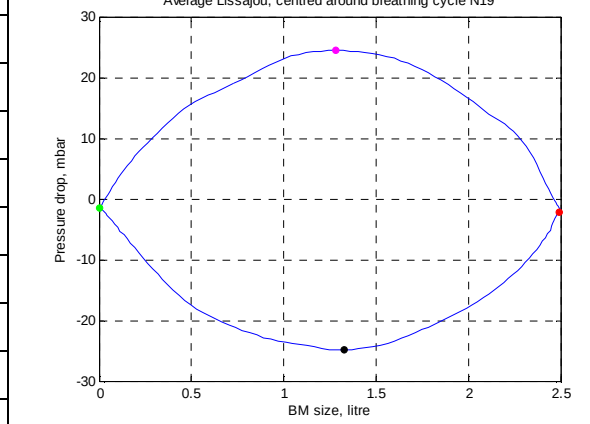
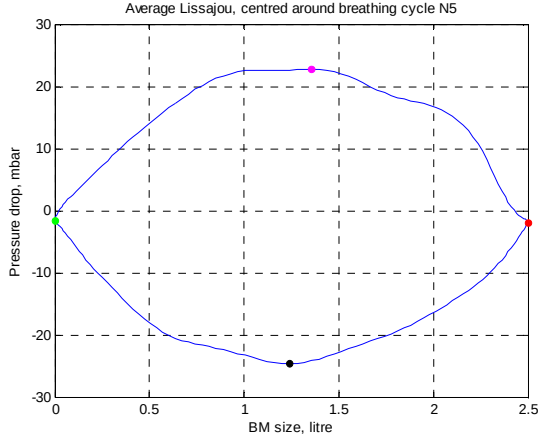


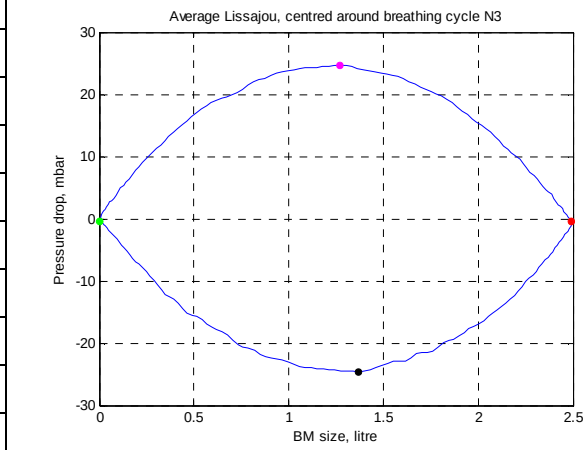


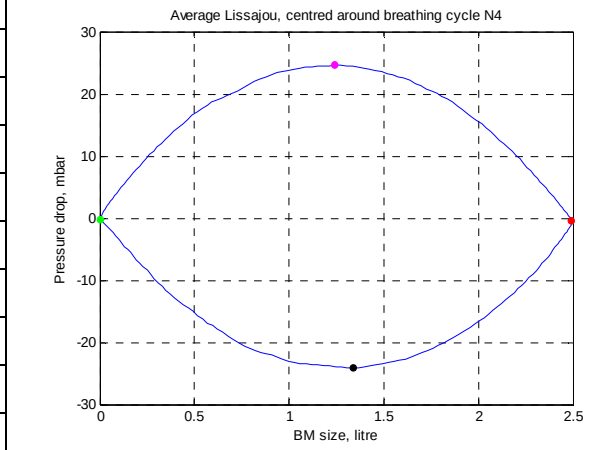


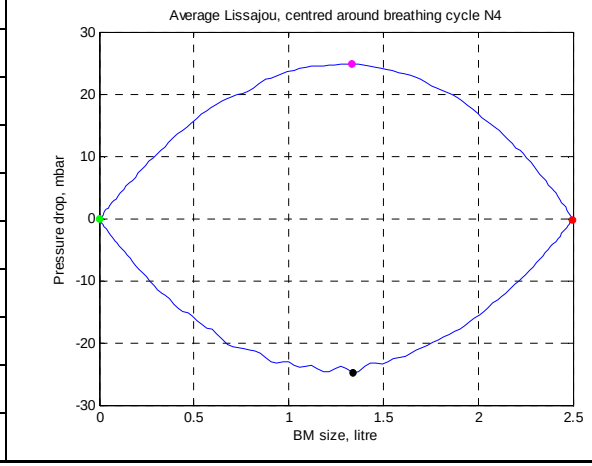


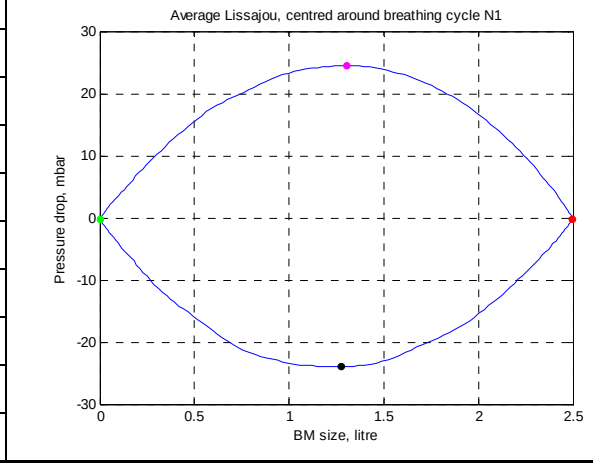
5.3.1. Table of EN orifice calibrations performed during the execution of the respiratory measurements within the scope of EN 14143

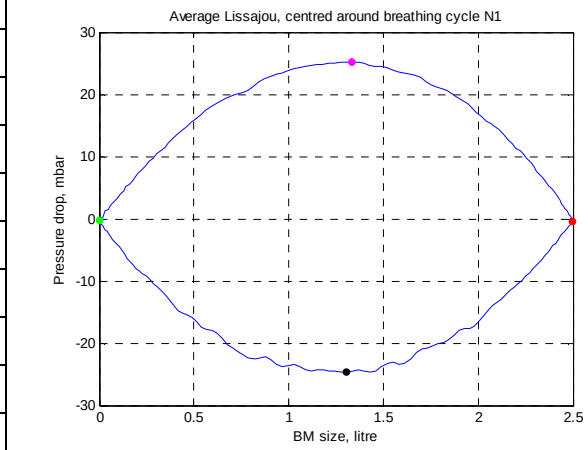
File name: BM_EN14143calibration_6ATA_62_5 lpm_090115.mat		**File name:** BM_EN14143calibration_6ATA_62_5 lpm_090401.mat	
Date [dd.mm.yyyy]		**Date [dd.mm.yyyy]**	
15.01.2009		01.04.2009	
Deth [m]		**Deth [m]**	
49.9		49.8	
Pressure (min) [mbar]		**Pressure (min) [mbar]**	
-23.9		-23.1	
Pressure (max) [mbar]		**Pressure (max) [mbar]**	
25.1		25.8	
WOB [J/L]		**WOB [J/L]**	
3.28		3.34	
File name: BM_EN14143calibration_6ATA_62_5 lpm_090407.mat		**File name:** BM_EN14143calibration_6ATA_62_5 lpm_090413.mat	
Date [dd.mm.yyyy]		**Date [dd.mm.yyyy]**	
07.04.2009		13.04.2009	
Deth [m]		**Deth [m]**	
50.2		50.0	
Pressure (min) [mbar]		**Pressure (min) [mbar]**	
-25.0		-25.5	
Pressure (max) [mbar]		**Pressure (max) [mbar]**	
24.8		24.5	
WOB [J/L]		**WOB [J/L]**	
3.31		3.29	

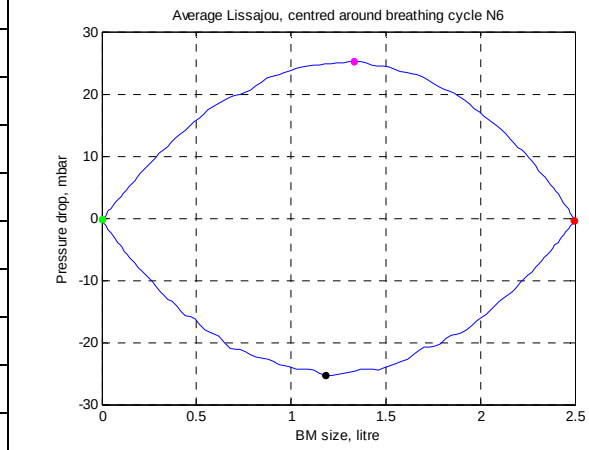
File name: BM_ENcalibration_62.5 lpm_090626.mat	
Date [dd.mm.yyyy]	
26.06.2009	
Deth [m]	
50.4	
Pressure (min) [mbar]	
-24.6	
Pressure (max) [mbar]	
24.9	
WOB [J/L]	
3.31	

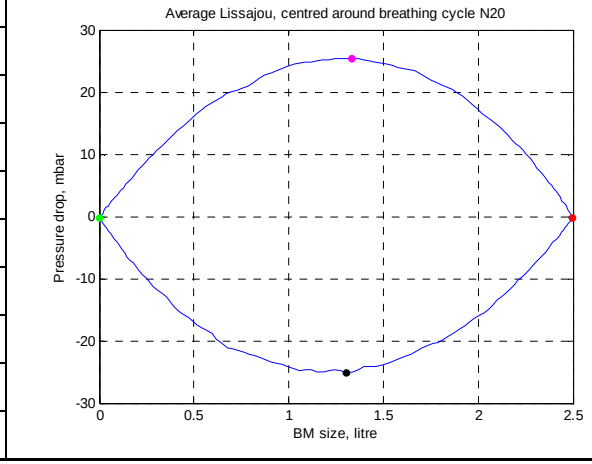
File name: BM_ENcalibration_62.5 lpm_090723.mat	
Date [dd.mm.yyyy]	
23.07.2009	
Deth [m]	
50.5	
Pressure (min) [mbar]	
-24.1	
Pressure (max) [mbar]	
24.9	
WOB [J/L]	
3.29	

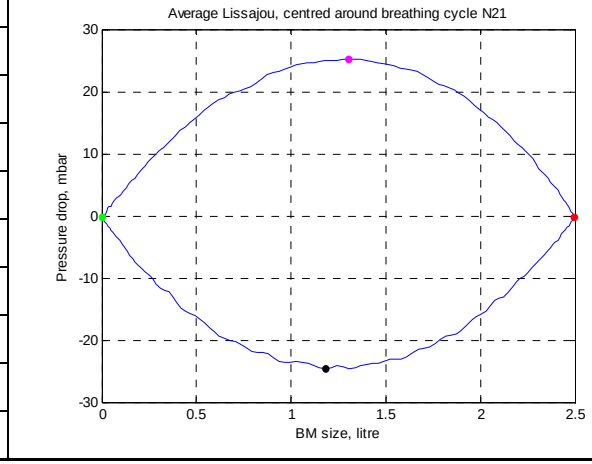
File name: CAL_BM001RC2_ENcal_6ATA_62.5 lpm_090916.mat	
Date [dd.mm.yyyy]	
16.09.2009	
Deth [m]	
50.6	
Pressure (min) [mbar]	
-24.8	
Pressure (max) [mbar]	
24.9	
WOB [J/L]	
3.31	

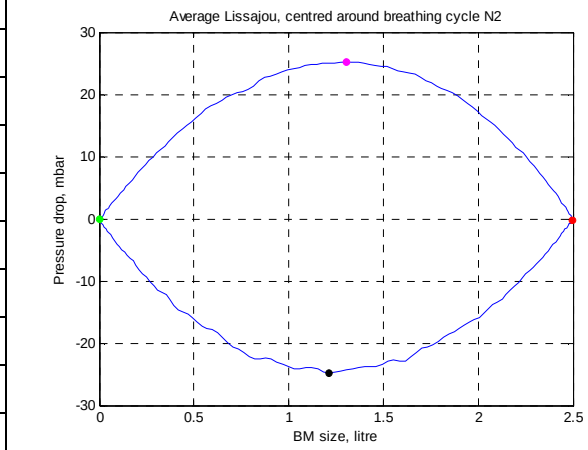
File name: CAL_BM001RC2_ENcal_6ATA_62.5 lpm_091217.mat	
Date [dd.mm.yyyy]	
17.12.2009	
Deth [m]	
50.2	
Pressure (min) [mbar]	
-24.0	
Pressure (max) [mbar]	
24.7	
WOB [J/L]	
3.29	

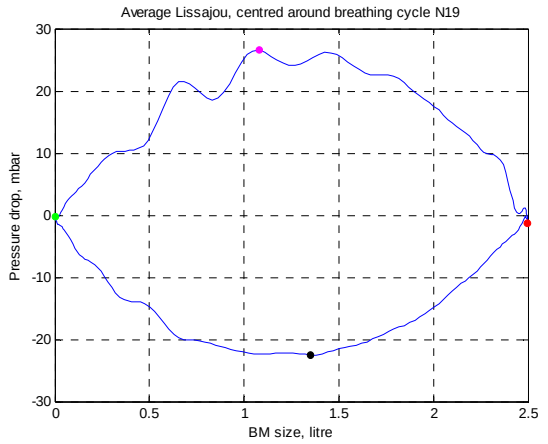
File name: WOB_ENcal_90d_51m_62.5 lpm_air_100115_1_.mat	
Date [dd.mm.yyyy]	
15.01.2010	
Deth [m]	
51.2	
Pressure (min) [mbar]	
-24.7	
Pressure (max) [mbar]	
25.2	
WOB [J/L]	
3.36	

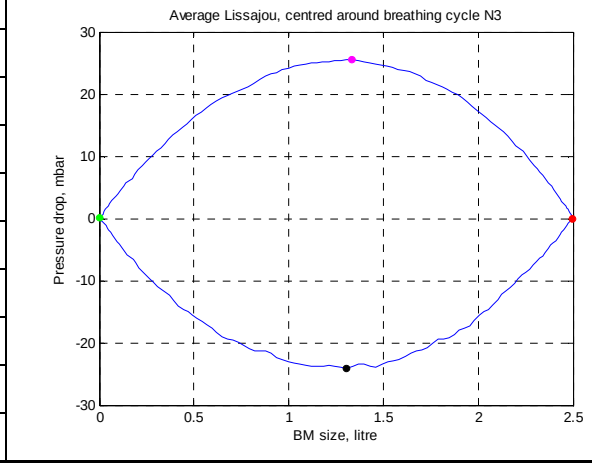
File name: WOB_ENcal_90d_50m_62.5 lpm_air_100126_1.mat	
Date [dd.mm.yyyy]	
26.01.2010	
Deth [m]	
50.3	
Pressure (min) [mbar]	
24.9	
Pressure (max) [mbar]	
25.5	
WOB [J/L]	
3.37	

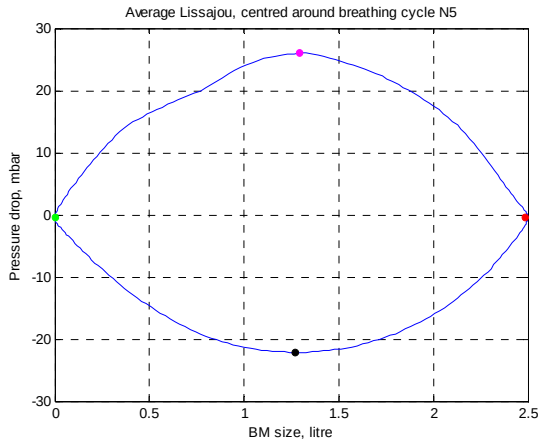
File name: WOB_ENcal_90d_51m_62.5 lpm_air_100201_1.mat	
Date [dd.mm.yyyy]	
01.02.2010	
Deth [m]	
51.4	
Pressure (min) [mbar]	
25.4	
Pressure (max) [mbar]	
-25.2	
WOB [J/L]	
3.40	

File name: WOB_ENcal_90d_51m_62.5 lpm_air_100205_1.mat	
Date [dd.mm.yyyy]	
05.02.2010	
Deth [m]	
51.1	
Pressure (min) [mbar]	
-24.7	
Pressure (max) [mbar]	
25.2	
WOB [J/L]	
3.36	

File name: WOB_ENcal_90d_51m_62.5 lpm_air_100212_1.mat	
Date [dd.mm.yyyy]	
12.02.2010	
Deth [m]	
51.3	
Pressure (min) [mbar]	
24.8	
Pressure (max) [mbar]	
25.2	
WOB [J/L]	
3.35	

File name: WOB_ENcal_90d_50m_62.5 lpm_air_100214_1.mat	
Date [dd.mm.yyyy]	
14.02.2010	
Deth [m]	
50.0	
Pressure (min) [mbar]	
-22.5	
Pressure (max) [mbar]	
26.5	
WOB [J/L]	
3.25	

File name: WOB_ENcal_90d_51m_62.5 lpm_air_100216_correction_.mat	
Date [dd.mm.yyyy]	
16.02.2010	
Deth [m]	
51.4	
Pressure (min) [mbar]	
24.1	
Pressure (max) [mbar]	
25.5	
WOB [J/L]	
3.34	

File name: WOB_ENcal_90d_51m_62.5 lpm_air_100223_1.mat	
Date [dd.mm.yyyy]	
23.02.2010	
Deth [m]	
51.0	
Pressure (min) [mbar]	
-23.1	
Pressure (max) [mbar]	
26.0	
WOB [J/L]	
3.29	

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	Br.sim. calibration (EN14143:2003 calibration orifice)	
TEST METHOD	:	EN14143:2003 Breathing Simulator calibration method	SINE FLOW
DATE AND TIME	:	14/02/2010 19:25:26	
TEST CARRIED OUT BY	MS	WITNESS:	

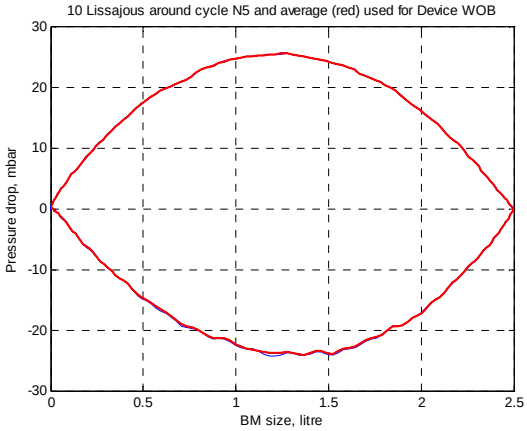
CONDITIONS OF TEST

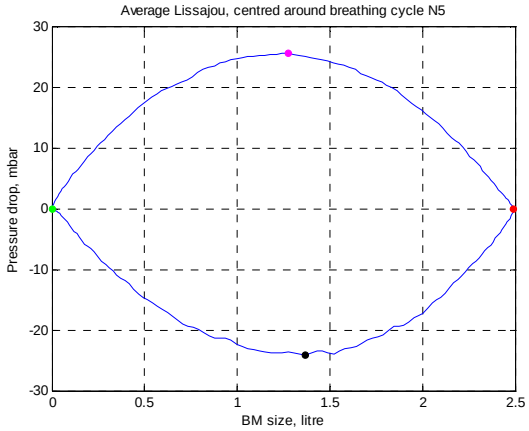
ATTITIDE: PITCH & ROLL	:	-/-	Deg.
GAS MIXTURE	:	Air	
DEPTH	:	50.0	m
ROOM / WATER TEMPERATURE	:	18.0 / -	℃
EHXALE GAS TEMPERATURE	:	12.6	℃
GAS SUPPLY PRESSURE	:	-	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.4 lpm	metric

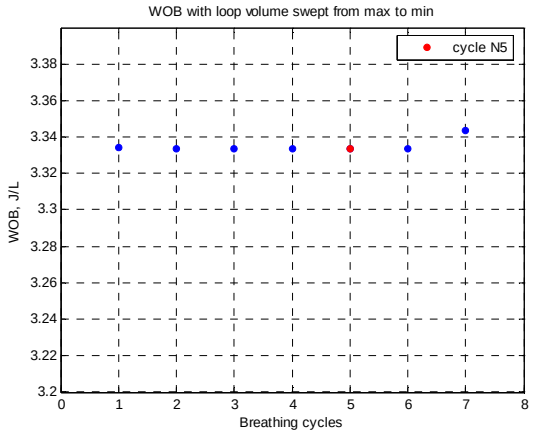
RESULTS

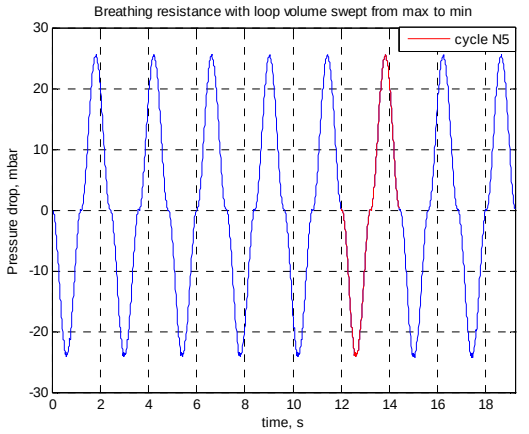
PRESSURE@START INHALE / EXHALE	=	-0.0 / -0.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.1 / 25.5	mbar
PEAK TO PEAK PRESSURE	=	49.6	mbar
EN14143 RELATIVE PEAK PRESSURES	=	24.1 / 25.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	N.A.	J/l
WOB OF BREATHING SIMULATOR	=	N.A.	J/l
WOB OF DEVICE UNDER TEST	=	3.33	J/l
TOTAL POS / NEG WORK	=	N.A.	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.71 / 1.61	J/l

ALL DATA STORED AS # (DATA FILE): WOB_ENcal_90d_51m_62.5 lpm_air_100216 _correction









5.4. NATO STANAG 1410:2006 Elastance test fixture

NATO STANAG 1410:2006 stipulates the following demand on the elastence:

> The pressure difference between the end exhalation point and the end inhalation point shall be 5 kPa for each litre of tidal volume.

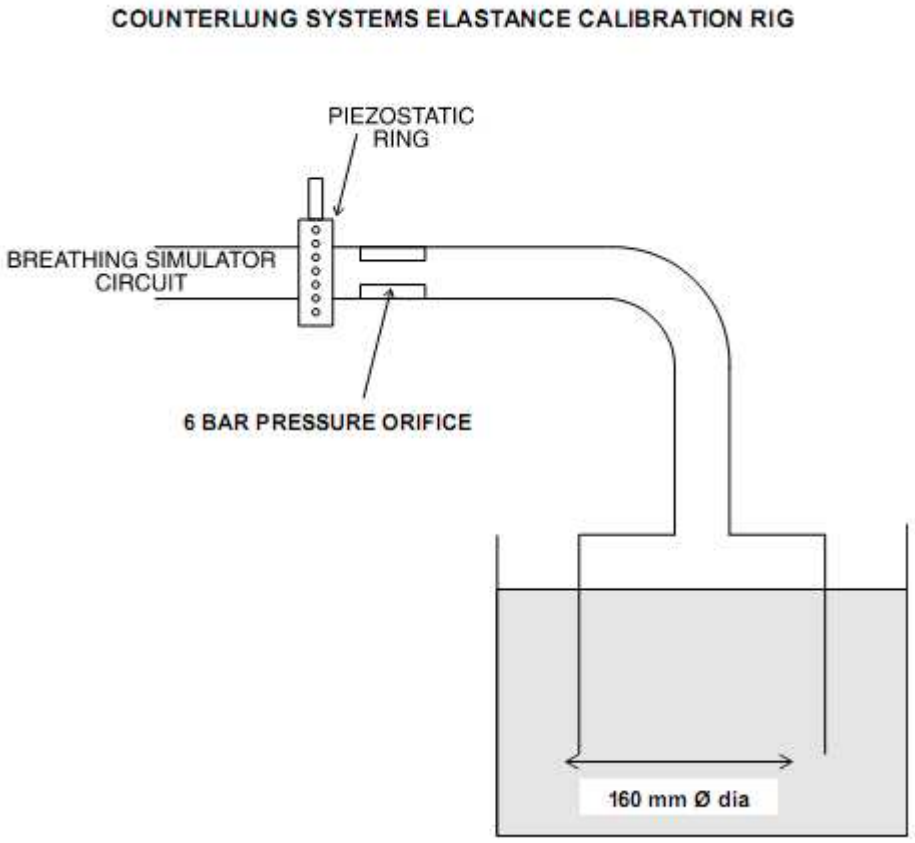


Figure 5-3: Reproduction of Figure D3 (NATO STANAG 1410:2006). Elastence test fixture

The elastance was measured and was within 0.05 mbar of the required value: that is, within 1%.

6. METHOD

The breathing loop of the apparatus under test matched that described in drawings, in Exploded Drawings and 2D Drawings directory “DL SGS Set 2”, except as stated relating to the helmet, DSV and side cylinders.

The OR_Incursion and the OR_Apocalypse have identical geometry and breathing loops, other than the Incursion has a different plastic moulding at the inlet to the scrubber: this is a the same as the OR_Apocalypse scrubber inlet moulding except for providing an enclosed space outside the breathing loop to house electronics. The moulding is rigid, so cannot effect Hydrostatic Imbalance, and the geometry in the breathing loop is the same as for the OR_Apocalypse. The two models, OR_Incursion and OR_Apocalypse will be treated as one product for the purposes of these tests: the test will be performed with the OR_Apocalypse scrubber head fitted. Similarly, it is noted that the OR_Apocalypse Type IV has two submodels, one is the O2-CCR and the other is the iCCR: the breathing loops are identical for respiratory performance purposes.

The test rig used for these tests is shown in Figure 6-1, comprising a 600mm x 800mm thermally controlled pressure chamber filled with artificial sea water, connected to a gas supply system, Breathing simulator (respirator) and PC with Matlab RT control model. The Breathing simulator was inside the chamber, such that water displacement by the Breathing simulator piston compensates for counterlung displacement, as would be the case for a human diver's lungs. The test chamber is an automatically controlled system, and a script was set up for these tests. Running a test involves performing the calibration using test orifices and a water column for elastance, connecting the correct gases, executing the script and checking the results as they are produced, then calibrating again after the test to ensure there has been no significant change to the measurement equipment during the duration of the test.

The gas supply system comprises a chamber gas supply, a buffer chamber, a flow controller, digital pressure sensors and shut-off valves.

Both single and dual scrubber configurations of the rebreathers were tested. These systems were complete, production samples in every respect, including the outer-housing. Back mounted counterlungs were fitted to each unit. No separate test of the effect of the different counterlung configurations was made, as this information is reported separately in the Hydrostatic Imbalance report for the equipment.

For each test, the following steps are taken:

1. The 600mm x 800mm ID chamber is pressurised to the desired test pressure through the In/Out port. During pressurisation, the volume loop adjustment valve that can feed and bleed gas to and from the breathing loop, is open. Thus the OPV is used to pressurize the chamber through the breathing loop. After reaching the desired test pressure an initial set of measurements are then taken from the respirator to check for maximum starting loop volume.

2. The next step is to optimise the volume of the breathing loop. To accomplish this, the loop volume adjustment valve is turned on and the breathing loop is depressurized with step of 1mbar mean loop pressure for 15 breathing cycles to negative loop pressure. During each gas ejection, the controller stabilizes chamber internal pressure, compensating loop volume varying. 15 breathing cycles are enough for the loop pressure stabilizing and getting clear view of the WOB for the current loop volume. Then the controller subscribe the next portion of gas.

3. When the breathing loop pressure is near the ADV trigger pressure, the ADV starts to injecting gas: this is detected by the dynamic pressure waveform and levelling off of the breathing loop pressure. After the ADV triggers, the chamber moves to the next pressure and during this process the data log from the respirator is used to create Lissajou graphs at

different loop volumes, the lowest WOB of which represents the optimal loop volume. When the optimal loop volume point is reached, the results for the current pressure and RMV are recorded.

4. When series of the tests for the current RMV, different pressures and diver's positions is completed then the chamber is depressurised.

Changing the TD involves depressuring the chamber and changing the crank position on the the DL Rev.C2 breathing respirator manually that was made available for these tests.

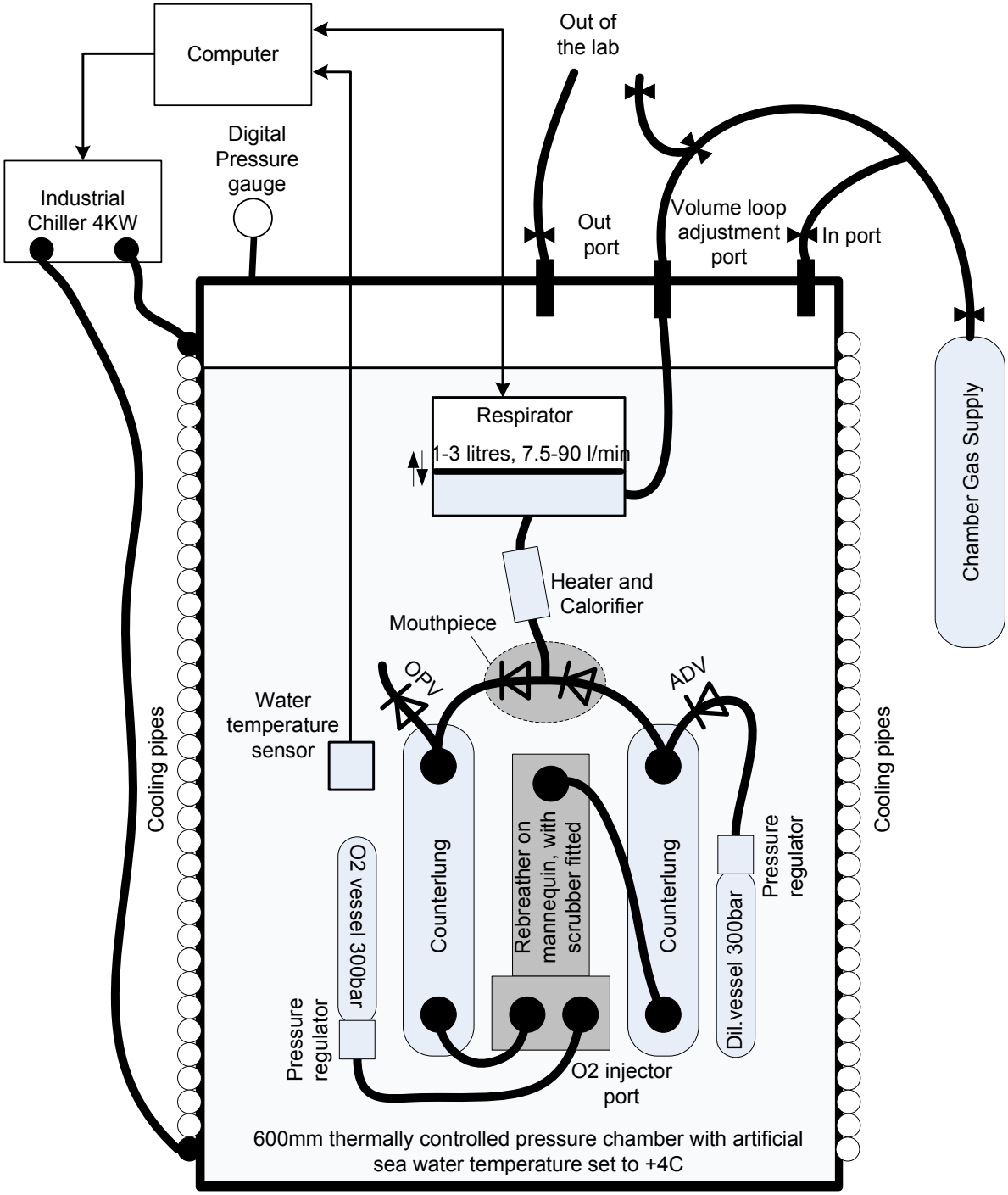


Figure 6-1: The test fixture used for WOB and respiratory pressure measurements.

7. TEST PLAN

EN14143 and NORSOK U-101 defines different conditions for respiratory parameter tests. The combined table is presented below:

Table 6 Tests conditions combining all requirements of EN14143 and NORSOK U-101 standards.

<table>
<tr><th rowspan="2">Standard</th><th rowspan="2">Test pressures</th><th colspan="4">Requirements</th><th rowspan="2">Diver's position</th><th rowspan="2">Test gases</th><th rowspan="2">Environment</th></tr>
<tr><th>RMV, l/min</th><th>Max. WOB, J/l</th><th>TD, l</th><th>Resp. press.</th></tr>
<tr><td rowspan="2">EN14143:2003</td><td>5 bar = 40m</td><td rowspan="2">10.0
22.5
40.0
62.5
75.0</td><td rowspan="2">0.80
1.18
1.70
2.38
2.75</td><td rowspan="2">1.0
1.5
2.0
2.5
3.0</td><td rowspan="2">Respiratory pressures: inspired and expired pressures not more than 25mbar; peak-to-peak pressure not more than 50mbar</td><td rowspan="2">+ 90° and 0° pitch</td><td>Air</td><td rowspan="2">Artificial sea water at temperature 4 ± 1℃ OR lower if specified by the manufacturer: this is -4℃ with counterlung heating.</td></tr>
<tr><td>11 bar = 100m</td><td>Heliox</td></tr>
<tr><td rowspan="14">NORSOK U-101</td><td>1 atm = 0 m</td><td rowspan="7">7.5
15.0
22.5
40.0
62.5
75.0
75-90</td><td rowspan="7">0.65
0.80
0.95
1.30
1.75
2.00
5.00</td><td rowspan="7">1.0*
1.0
1.5
2.0
2.5
3.0
3.0</td><td rowspan="14">Respiratory pressures not more ±1.5kPa and shall not exceed ±2.5kPa</td><td rowspan="14">not stated</td><td rowspan="7">Air</td><td rowspan="14">Water at temperature (5 ± 2)℃</td></tr>
<tr><td>2 atm = 10 m</td></tr>
<tr><td>4 atm = 30 m</td></tr>
<tr><td>7 atm = 60 m</td></tr>
<tr><td>1 atm = 0 m</td></tr>
<tr><td>6 atm = 50 m</td></tr>
<tr><td>11 atm = 100 m</td></tr>
<tr><td>21 atm = 200 m</td><td rowspan="7">7.5
15.0
22.5
40.0
62.5
75.0
75-90</td><td rowspan="7">0.8
1.1
1.4
2.1
3.0
3.5
5.0</td><td rowspan="7">1.0*
1.0
1.5
2.0
2.5
3.0
3.0</td><td rowspan="7">Heliox</td></tr>
<tr><td>31 atm = 300 m</td></tr>
<tr><td>41 atm = 400 m</td></tr>
<tr><td>51 atm = 500 m</td></tr>
<tr><td>61 atm = 600 m</td></tr>
</table>

* See Section 5 for the information about the respirator tidal volume.

Note that NORSOK U-101 does not describe the diver's position for the respiratory paramter tests. It states only that the equipment shall be tested as realistically as possible (Section 6.2.1). Also it is mentioned that the Breathing simulator shall allow the breathing apparatus

to be tested in different positions. Therefore it is assumed that EN14143 test requirements for diver's position can be used.

According to the above comments a list of test is compiled (see Table 7).

Table 7 Full list of respiratory parameter tests for EN14143 and NORSOK U-101 compliance.

Test num.	Test pressures	Diver's position	Test gases	Environment	Requirements	
					RMV, l/min	TD, l
1.	1 atm = 0 m	+ 90° pitch	Air	Artificial sea water at 4 ±1℃	7.5	0.75
2.	2 atm = 10 m					
3.	4 atm = 30 m					
4.	5 bar = 40m					
5.	7 atm = 60 m					
6.	1 atm = 0 m		Heliox			
7.	6 atm = 50m					
8.	11 atm = 100 m					
9.	21 atm = 200 m					
10.	31 atm = 300 m					
11.	41 atm = 400 m					
12.	51 atm = 500 m					
13.	61 atm = 600 m					
14.	1 atm = 0 m	0° pitch	Air			
15.	2 atm = 10 m					
16.	4 atm = 30 m					
17.	5 bar = 40m					
18.	7 atm = 60 m					
19.	1 atm = 0 m		Heliox			
20.	6 atm = 50m					
21.	11 atm = 100 m					
22.	21 atm = 200 m					
23.	31 atm = 300 m					
24.	41 atm = 400 m					
25.	51 atm = 500 m					
26.	61 atm = 600 m					
27.	1 atm = 0 m	+ 90° pitch	Air		10	1.0
28.	2 atm = 10 m					
29.	4 atm = 30 m					
30.	5 bar = 40m					
31.	7 atm = 60 m					
32.	1 atm = 0 m		Heliox			
33.	6 atm = 50m					
34.	11 atm = 100 m					
35.	21 atm = 200 m					
36.	31 atm = 300 m					
37.	41 atm = 400 m					
38.	51 atm = 500 m					
39.	61 atm = 600 m					
40.	1 atm = 0 m	0° pitch	Air			
41.	2 atm = 10 m					
42.	4 atm = 30 m					
43.	5 bar = 40m					

44.	7 atm = 60 m					
45.	1 atm = 0 m		Heliox			
46.	6 atm = 50m					
47.	11 atm = 100 m					
48.	21 atm = 200 m					
49.	31 atm = 300 m					
50.	41 atm = 400 m					
51.	51 atm = 500 m					
52.	61 atm = 600 m					
53.	1 atm = 0 m		Air			
54.	2 atm = 10 m					
55.	4 atm = 30 m					
56.	5 bar = 40m					
57.	7 atm = 60 m					
58.	1 atm = 0 m	+ 90° pitch	Heliox			
59.	6 atm = 50m					
60.	11 atm = 100 m					
61.	21 atm = 200 m					
62.	31 atm = 300 m					
63.	41 atm = 400 m					
64.	51 atm = 500 m					
65.	61 atm = 600 m				15	1.0
66.	1 atm = 0 m		Air			
67.	2 atm = 10 m					
68.	4 atm = 30 m					
69.	5 bar = 40m					
70.	7 atm = 60 m					
71.	1 atm = 0 m	0° pitch	Heliox			
72.	6 atm = 50m					
73.	11 atm = 100 m					
74.	21 atm = 200 m					
75.	31 atm = 300 m					
76.	41 atm = 400 m					
77.	51 atm = 500 m					
78.	61 atm = 600 m					
79.	1 atm = 0 m		Air	Artificial sea water at 4 ±1℃	22.5	1.5
80.	2 atm = 10 m					
81.	4 atm = 30 m					
82.	5 bar = 40m					
83.	7 atm = 60 m					
84.	1 atm = 0 m	+90° pitch	Heliox			
85.	6 atm = 50m					
86.	11 atm = 100 m					
87.	21 atm = 200 m					
88.	31 atm = 300 m					
89.	41 atm = 400 m					
90.	51 atm = 500 m					
91.	61 atm = 600 m					
92.	1 atm = 0 m	0° pitch	Air			
93.	2 atm = 10 m					
94.	4 atm = 30 m					
95.	5 bar = 40m					
96.	7 atm = 60 m					

97.	1 atm = 0 m		Heliox			
98.	6 atm = 50m					
99.	11 atm = 100 m					
100.	21 atm = 200 m					
101.	31 atm = 300 m					
102.	41 atm = 400 m					
103.	51 atm = 500 m					
104.	61 atm = 600 m					
105.	1 atm = 0 m		Air			
106.	2 atm = 10 m					
107.	4 atm = 30 m					
108.	5 bar = 40m					
109.	7 atm = 60 m					
110.	1 atm = 0 m	+90° pitch	Heliox			
111.	6 atm = 50m					
112.	11 atm = 100 m					
113.	21 atm = 200 m					
114.	31 atm = 300 m					
115.	41 atm = 400 m					
116.	51 atm = 500 m					
117.	61 atm = 600 m				40.0	2.0
118.	1 atm = 0 m		Air			
119.	2 atm = 10 m					
120.	4 atm = 30 m					
121.	5 bar = 40m					
122.	7 atm = 60 m					
123.	1 atm = 0 m	0° pitch	Heliox			
124.	6 atm = 50m					
125.	11 atm = 100 m					
126.	21 atm = 200 m					
127.	31 atm = 300 m					
128.	41 atm = 400 m					
129.	51 atm = 500 m					
130.	61 atm = 600 m					
131.	1 atm = 0 m		Air		62.5	2.5
132.	2 atm = 10 m					
133.	4 atm = 30 m					
134.	5 bar = 40m					
135.	7 atm = 60 m					
136.	1 atm = 0 m	+90° pitch	Heliox			
137.	6 atm = 50m					
138.	11 atm = 100 m					
139.	21 atm = 200 m					
140.	31 atm = 300 m					
141.	41 atm = 400 m					
142.	51 atm = 500 m					
143.	61 atm = 600 m					
144.	1 atm = 0 m	0° pitch	Air			
145.	2 atm = 10 m					
146.	4 atm = 30 m					
147.	5 bar = 40m					
148.	7 atm = 60 m					
149.	1 atm = 0 m		Heliox			

150.	6 atm = 50m					
151.	11 atm = 100 m					
152.	21 atm = 200 m					
153.	31 atm = 300 m					
154.	41 atm = 400 m					
155.	51 atm = 500 m					
156.	61 atm = 600 m					
157.	1 atm = 0 m	+90° pitch	Air	Artificial sea water at 4 ±1℃	75.0	3.0
158.	2 atm = 10 m					
159.	4 atm = 30 m					
160.	5 bar = 40m					
161.	7 atm = 60 m					
162.	1 atm = 0 m		Heliox			
163.	6 atm = 50m					
164.	11 atm = 100 m					
165.	21 atm = 200 m					
166.	31 atm = 300 m					
167.	41 atm = 400 m					
168.	51 atm = 500 m					
169.	61 atm = 600 m					
170.	1 atm = 0 m	0° pitch	Air			
171.	2 atm = 10 m					
172.	4 atm = 30 m					
173.	5 bar = 40m					
174.	7 atm = 60 m					
175.	1 atm = 0 m		Heliox			
176.	6 atm = 50m					
177.	11 atm = 100 m					
178.	21 atm = 200 m					
179.	31 atm = 300 m					
180.	41 atm = 400 m					
181.	51 atm = 500 m					
182.	61 atm = 600 m					
183.	1 atm = 0 m	+90° pitch	Air		90	3.0
184.	2 atm = 10 m					
185.	4 atm = 30 m					
186.	5 bar = 40m					
187.	7 atm = 60 m					
188.	1 atm = 0 m		Heliox			
189.	6 atm = 50m					
190.	11 atm = 100 m					
191.	21 atm = 200 m					
192.	31 atm = 300 m					
193.	41 atm = 400 m					
194.	51 atm = 500 m					
195.	61 atm = 600 m					
196.	1 atm = 0 m	0° pitch	Air			
197.	2 atm = 10 m					
198.	4 atm = 30 m					
199.	5 bar = 40m					
200.	7 atm = 60 m					
201.	1 atm = 0 m		Heliox			
202.	6 atm = 50m					

203.	11 atm = 100 m					
204.	21 atm = 200 m					
205.	31 atm = 300 m					
206.	41 atm = 400 m					
207.	51 atm = 500 m					
208.	61 atm = 600 m					

In EN14143, three samples are tested. This multiplies what is already a large number of runs by a factor of three. NORSOK require 5 units to be tested. Thus Dual Scrubber rebreather require 1040 tests (208 x 5) and Single Scrubber rebreather – 640 (128 x 5) tests. It is necessary to reduce the number of these tests to a practical number. The samples are identical: they are produced using mass production techniques of injection moulding and plastic forming. One test was performed on each sample to confirm the samples are the same, then a single sample was used for all tests.

This updated list is presented below (Table 8 for SRB rebreather and Table 9 for DRB rebreather). All tests are carried out at 4C.

Table 8 Reduced list of respiratory parameter tests for EN14143 and NORSOK U-101 compliance (Single Scrubber).

Test num.	Test pressures	Diver's position	Test gases	Environment	Requirements	
					RMV, l/min	TD, l
1.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	10	1.0
2.		0° pitch				
3.	5 atm = 40 m	+ 90° pitch	Heliox			
4.	11 atm = 100 m					
5.	5 atm = 40 m	0° pitch				
6.	11 atm = 100 m					
7.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	22.5	1.5
8.		0° pitch				
9.	5 atm = 40 m	+ 90° pitch	Heliox			
10.	11 atm = 100 m					
11.	5 atm = 40 m	0° pitch				
12.	11 atm = 100 m					
13.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	40.0	2.0
14.		0° pitch				
15.	5 atm = 40 m	+ 90° pitch	Heliox			

16.	11 atm = 100 m					
17.	5 atm = 40 m	0° pitch				
18.	11 atm = 100 m					
19.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	62.5	2.5
20.		0° pitch				
21.	5 atm = 40 m	+ 90° pitch	Heliox			
22.	11 atm = 100 m					
23.	5 atm = 40 m	0° pitch				
24.	11 atm = 100 m					
25.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	75.0	3.0
26.		0° pitch				
27.	5 atm = 40 m	+ 90° pitch	Heliox			
28.	11 atm = 100 m					
29.	5 atm = 40 m	0° pitch				
30.	11 atm = 100 m					
31.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	90.0	3.0
32.		0° pitch				
33.	5 atm = 40 m	+ 90° pitch	Heliox			
34.	11 atm = 100 m					
35.	5 atm = 40 m	0° pitch				
36.	11 atm = 100 m					

Table 9 Reduced list of respiratory parameter tests for EN14143 and NORSOK U-101 compliance (Dual Scrubber).

Test num.	Test pressures	Diver's position	Test gases	Environment	Requirements	
					RMV, l/min	TD, l
1.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	10	1.0
2.		0° pitch				

3.	5 atm = 40 m	+ 90° pitch	Heliox			
4.	11 atm = 100 m					
5.	21 atm = 200 m					
6.	31 atm = 300 m					
7.	41 atm = 400 m					
8.	51 atm = 500 m					
9.	61 atm = 600 m					
10.	5 atm = 40 m	0° pitch				
11.	11 atm = 100 m					
12.	21 atm = 200 m					
13.	31 atm = 300 m					
14.	41 atm = 400 m					
15.	51 atm = 500 m					
16.	61 atm = 600 m					
17.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1°C	22.5	1.5
18.		0° pitch				
19.	5 atm = 40 m	+ 90° pitch	Heliox			
20.	11 atm = 100 m					
21.	21 atm = 200 m					
22.	31 atm = 300 m					
23.	41 atm = 400 m					
24.	51 atm = 500 m					
25.	61 atm = 600 m					
26.	5 atm = 40 m	0° pitch				
27.	11 atm = 100 m					
28.	21 atm = 200 m					
29.	31 atm = 300 m					

30.	41 atm = 400 m					
31.	51 atm = 500 m					
32.	61 atm = 600 m					
33.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	40.0	2.0
34.		0° pitch				
35.	5 atm = 40 m	+ 90° pitch	Heliox			
36.	11 atm = 100 m					
37.	21 atm = 200 m					
38.	31 atm = 300 m					
39.	41 atm = 400 m					
40.	51 atm = 500 m					
41.	61 atm = 600 m					
42.	5 atm = 40 m	0° pitch				
43.	11 atm = 100 m					
44.	21 atm = 200 m					
45.	31 atm = 300 m					
46.	41 atm = 400 m					
47.	51 atm = 500 m					
48.	61 atm = 600 m					
49.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	62.5	2.5
50.		0° pitch				
51.	5 atm = 40 m	+ 90° pitch	Heliox			
52.	11 atm = 100 m					
53.	21 atm = 200 m					
54.	31 atm = 300 m					
55.	41 atm = 400 m					
56.	51 atm = 500 m					

57.	61 atm = 600 m					
58.	5 atm = 40 m	0° pitch				
59.	11 atm = 100 m					
60.	21 atm = 200 m					
61.	31 atm = 300 m					
62.	41 atm = 400 m					
63.	51 atm = 500 m					
64.	61 atm = 600 m					
65.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	75.0	3.0
66.		0° pitch				
67.	5 atm = 40 m	+ 90° pitch	Heliox			
68.	11 atm = 100 m					
69.	21 atm = 200 m					
70.	31 atm = 300 m					
71.	41 atm = 400 m					
72.	51 atm = 500 m					
73.	61 atm = 600 m					
74.	5 atm = 40 m	0° pitch				
75.	11 atm = 100 m					
76.	21 atm = 200 m					
77.	31 atm = 300 m					
78.	41 atm = 400 m					
79.	51 atm = 500 m					
80.	61 atm = 600 m					
81.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	90.0	3.0
82.		0° pitch				
83.	5 atm = 40 m	+ 90° pitch	Heliox			

84.	11 atm = 100 m					
85.	21 atm = 200 m					
86.	31 atm = 300 m					
87.	41 atm = 400 m					
88.	51 atm = 500 m					
89.	61 atm = 600 m					
90.	5 atm = 40 m	0° pitch				
91.	11 atm = 100 m					
92.	21 atm = 200 m					
93.	31 atm = 300 m					
94.	41 atm = 400 m					
95.	51 atm = 500 m					
96.	61 atm = 600 m					

Table 10 Breathing performance data points needed for EN 14143:2003 (Single Scrubber).

Test num.	Test pressures	Diver's position	Test gases	Environment	Requirements	
					RMV, l/min	TD, l
1.	5 atm = 40 m	0° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	10	1.0
2.	5 atm = 40 m	+ 90° pitch	Heliox			
3.	11 atm = 100 m					
4.	5 atm = 40 m	0° pitch				
5.	11 atm = 100 m					
6.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	22.5	1.5
7.		0° pitch				
8.	5 atm = 40 m	+ 90° pitch	Heliox			
9.	11 atm = 100 m					
10.	5 atm = 40 m	0° pitch				
11.	11 atm = 100 m					

12.	5 atm = 40 m	+ 90° pitch	Heliox	Artificial sea water at a temperature 4 ± 1℃	40.0	2.0
13.	11 atm = 100 m					
14.	5 atm = 40 m	0° pitch				
15.	11 atm = 100 m					
16.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	62.5	2.5
17.		0° pitch				
18.	5 atm = 40 m	+ 90° pitch	Heliox			
19.	11 atm = 100 m					
20.	5 atm = 40 m	0° pitch				
21.	11 atm = 100 m					
22.	5 atm = 40 m	0° pitch	Heliox	Artificial sea water at a temperature 4 ± 1℃	75.0	3.0
23.	11 atm = 100 m					
24.	5 atm = 40 m	0° pitch	Heliox	Artificial sea water at a temperature 4 ± 1℃	90.0	3.0
25.	11 atm = 100 m					

Table 11 Breathing performance data points needed for EN 14143:2003 (Dual Scrubber).

Test num.	Test pressures	Diver's position	Test gases	Environment	Requirements	
					RMV, l/min	TD, l
1.	5 atm = 40 m	0° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	10	1.0
2.	5 atm = 40 m	+ 90° pitch	Heliox			
3.	11 atm = 100 m					
4.	21 atm = 200 m					
5.	31 atm = 300 m					
6.	41 atm = 400 m					
7.	51 atm = 500 m					
8.	61 atm = 600 m					
9.	5 atm = 40 m	0° pitch				

10.	11 atm = 100 m					
11.	21 atm = 200 m					
12.	31 atm = 300 m					
13.	41 atm = 400 m					
14.	51 atm = 500 m					
15.	61 atm = 600 m					
16.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	22.5	1.5
17.		0° pitch				
18.	5 atm = 40 m	+ 90° pitch	Heliox			
19.	11 atm = 100 m					
20.	21 atm = 200 m					
21.	31 atm = 300 m					
22.	41 atm = 400 m					
23.	51 atm = 500 m					
24.	61 atm = 600 m					
25.	5 atm = 40 m	0° pitch				
26.	11 atm = 100 m					
27.	21 atm = 200 m					
28.	31 atm = 300 m					
29.	41 atm = 400 m					
30.	51 atm = 500 m					
31.	61 atm = 600 m					
32.	5 atm = 40 m	+ 90° pitch	Heliox	Artificial sea water at a temperature 4 ± 1℃	40.0	2.0
33.	11 atm = 100 m					
34.	21 atm = 200 m					
35.	31 atm = 300 m					
36.	41 atm = 400 m					

37.	51 atm = 500 m					
38.	61 atm = 600 m					
39.	5 atm = 40 m	0° pitch				
40.	11 atm = 100 m					
41.	21 atm = 200 m					
42.	31 atm = 300 m					
43.	41 atm = 400 m					
44.	51 atm = 500 m					
45.	61 atm = 600 m					
46.	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	62.5	2.5
47.		0° pitch				
48.	5 atm = 40 m	+ 90° pitch	Heliox			
49.	11 atm = 100 m					
50.	21 atm = 200 m					
51.	31 atm = 300 m					
52.	41 atm = 400 m					
53.	51 atm = 500 m					
54.	61 atm = 600 m					
55.	5 atm = 40 m	0° pitch				
56.	11 atm = 100 m					
57.	21 atm = 200 m					
58.	31 atm = 300 m					
59.	41 atm = 400 m					
60.	51 atm = 500 m					
61.	61 atm = 600 m					
62.	5 atm = 40 m	+ 90° pitch	Heliox	Artificial sea water at a temperature	75.0	3.0
63.	11 atm = 100 m					

64.	21 atm = 200 m			4 ± 1℃		
65.	31 atm = 300 m					
66.	41 atm = 400 m					
67.	51 atm = 500 m					
68.	61 atm = 600 m					
69.	5 atm = 40 m	0° pitch				
70.	11 atm = 100 m					
71.	21 atm = 200 m					
72.	31 atm = 300 m					
73.	41 atm = 400 m					
74.	51 atm = 500 m					
75.	61 atm = 600 m					
76.	5 atm = 40 m	+ 90° pitch	Heliox	Artificial sea water at a temperature 4 ± 1℃	90.0	3.0
77.	11 atm = 100 m					
78.	21 atm = 200 m					
79.	31 atm = 300 m					
80.	41 atm = 400 m					
81.	51 atm = 500 m					
82.	61 atm = 600 m					
83.	5 atm = 40 m	0° pitch	Heliox			
84.	11 atm = 100 m					
85.	21 atm = 200 m					
86.	31 atm = 300 m					
87.	41 atm = 400 m					
88.	51 atm = 500 m					
89.	61 atm = 600 m					

Besides the lists in the Table 8 and Table 9 additional tests are carried out to show SRB types differences do not adversely affect Breathing performance. These differences concern appearence of CO2 and O2 monitors for Apocalypse IV iCCR in the breathing loop and replacing the rebreather heads for Incursion relative to Apocalypse xCCRs.

The following conditions are applied for these comparative tests of Apocalypse IV iCCR, Apocalypse IV O2-CCR and Incursion: 40m depth, +90° pitch, air as make-up gas and RMV of 75 lpm (see **Table 12**)

Table 12 List of comparative tests for Single Scrubber series of the Open Revolution rebreathers.

Test num.	DUT	Test pressures	Diver's position	Test gases	Environment	Requirements	
						RMV, l/min	TD, l
1.	Apocalypse IV iCCR	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	75.0	3.0
2.	Apocalypse IV O2-CCR						
3.	Incursion						

8. WOB AND RESISTANCE RESULTS FOR SINGLE SCRUBBER CONFIGURATION

All tests were carried out on the rebreather models with eCCR heads fitted unless otherwise stated.

The iCCR head as a 0.8% lower breathing resistance based on computer flow modelling: but when tested no difference was found – any difference is well within the error margin of the Breathing simulator, and conduct of the test (variations in depth, temperature and loop volume sweep profile). The head resistance has only a minor contribution to the overall breathing performance of the loop.

The instrumented and dumb 90 degree ports for the iCCR and Incursion/O2-CCR: flow modelling shows them the same, and testing could find no measureable difference.

A difference was found between single and dual scrubber configurations, so these are reported separately.

There is a fluttering of the Lissajou at very low breathing rates, shallow, and also at higher gas densities: this has been traced to the physical phenomenon of the counterlung positive bias, and material movements in the counterlung. At 4C the counterlung is noticeably stiffer than when warm, so the positive boas is not entirely even.

8.1. Comparative WOB test on Incursion and iCCR

The sole difference in the breathing loop between the Incursion and Apocalypse is that the Incursion has oxygen cells and an injector in the scrubber head, whereas the Apocalypse models have a flow cone. The effect on the open flow area is less than that of a 15mm stretch of the breathing hoses. It is not surprising therefore, that there is no consistent measurable difference in any breathing parameter between the Incursion and iCCR.

When respiratory parameters are measured, there are differences between successive runs, especially over long period of time. The factors include:

1. The age of the counterlungs; all plastics harden with age, and the counterlungs become less pliable. This results in a snap effect that can be seen clearly on many of the Lissajous in this report (the plots use counterlungs that are a year old, and have been used extensively).
2. The rate at which the breathing volume is swept: it is swept manually by venting the breathing loop.
3. Differences in depth: successive runs are not exactly the same depth.

Sample depths are reproduced herein on both Incursion and Apocalypse iCCR models, to enable a comparison to be made. These are:

8.3.9 SRB (Incursion), Air, 40m, 75 lpm RMV, 90° Pi tch, compare with Section 8.3.10

8.9.9 SRB (iCCR), Heliox, 100m, 75 lpm RMV, 90° pi tch, comparing with 8.9.10.

8.2. SRB. Air, Depth < 6m

8.2.1. SRB (iCCR), Air, <3m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 1 with ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	29.11.2008 12:49	
TEST CARRIED OUT BY	VD	WITNESS: MS	

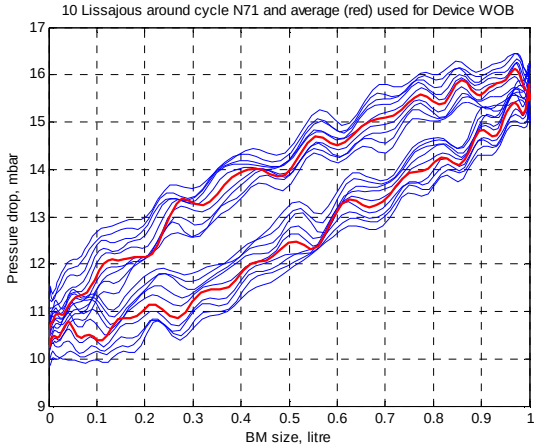
CONDITIONS OF TEST

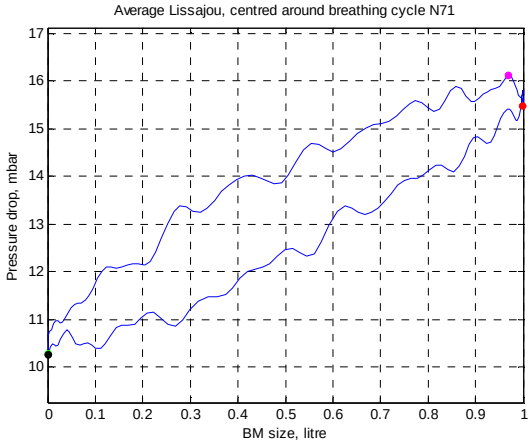
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	0.98	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.7	℃
EHXALE GAS TEMPERATURE	:	18.1	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/9.9bpm/9.9 lpm	metric

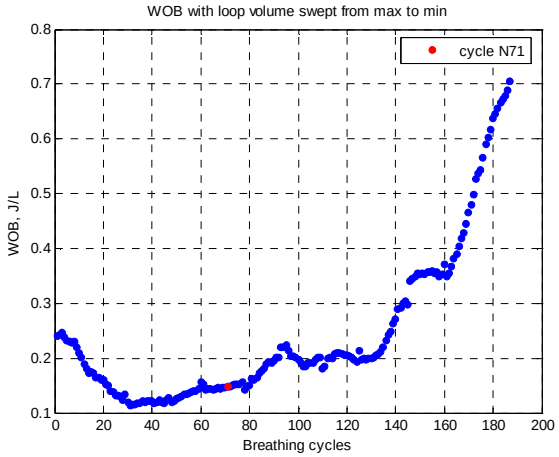
RESULTS

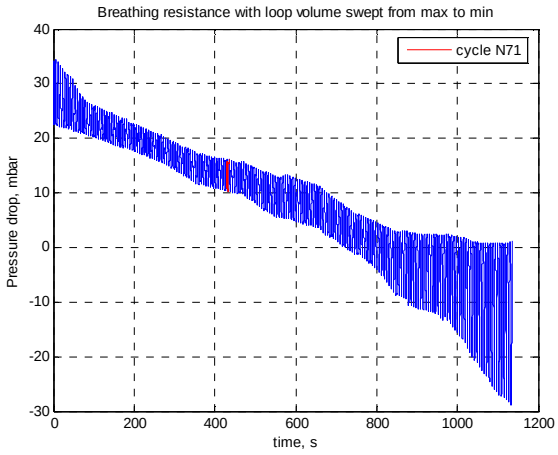
PRESSURE@END EXHALE / INHALE	=	15.5 / 10.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	10.3 / 16.1	mbar
PEAK TO PEAK PRESSURE	=	5.9	mbar
INHALE/EXHALE RESP PRESSURES	=	5.2 / 5.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.15	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.15	J/l
TOTAL POS / NEG WORK	=	0.10 / 0.03	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.10 / 0.03	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 00m_10 lpm_081129_01









8.2.2. SRB (iCCR), Air, <3m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		28/11/08 10:44	
TEST CARRIED OUT BY	VD	WITNESS: MS	

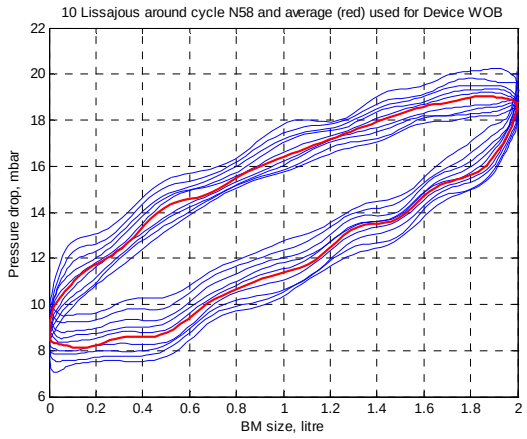
CONDITIONS OF TEST

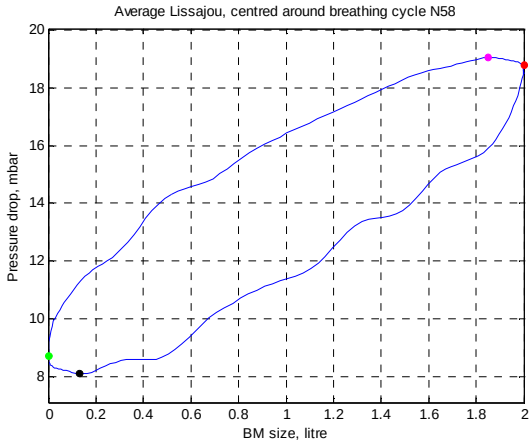
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	0.98	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.3	℃
EHXALE GAS TEMPERATURE	:	17.4	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/39.9 lpm	metric

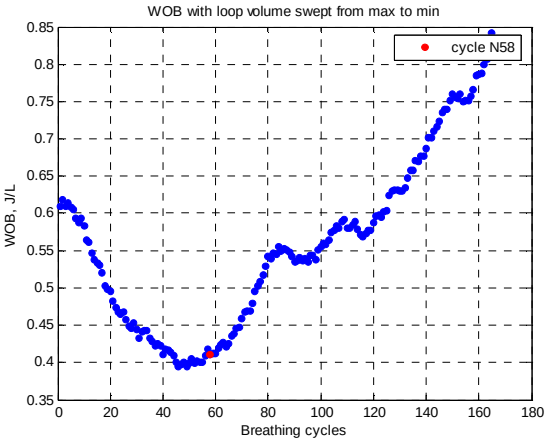
RESULTS

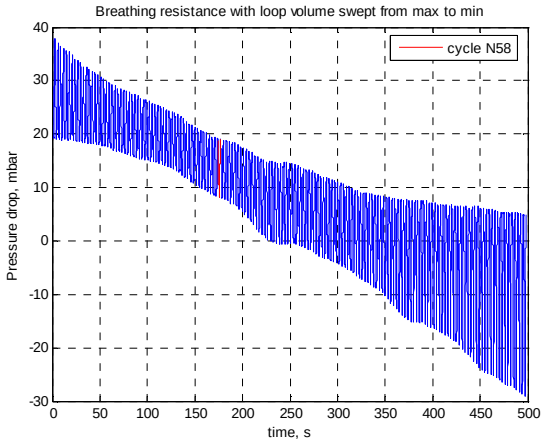
PRESSURE@END EXHALE / INHALE	=	18.8 / 8.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	8.1 / 19.1	mbar
PEAK TO PEAK PRESSURE	=	10.9	mbar
INHALE/EXHALE RESP PRESSURES	=	10.7 / 10.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.44	J/l
WOB OF BREATHING SIMULATOR	=	0.03	J/l
WOB OF DEVICE UNDER TEST	=	0.41	J/l
TOTAL POS / NEG WORK	=	0.24 / 0.20	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.22 / 0.19	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 00m_40 lpm_081128_01









8.2.3. SRB (iCCR), Air, <3m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		28/11/08 12:40	
TEST CARRIED OUT BY	VD	WITNESS: MS	

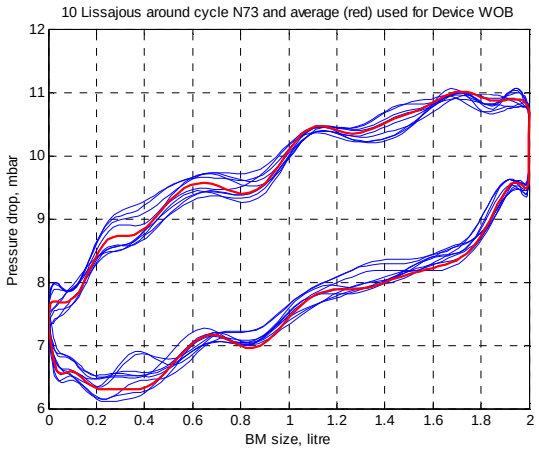
CONDITIONS OF TEST

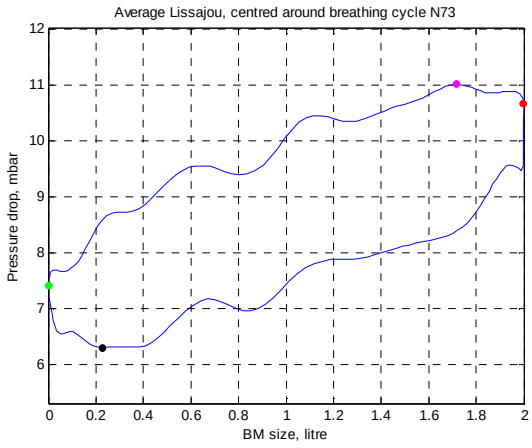
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	1.65	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.6	℃
EHXALE GAS TEMPERATURE	:	17.7	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

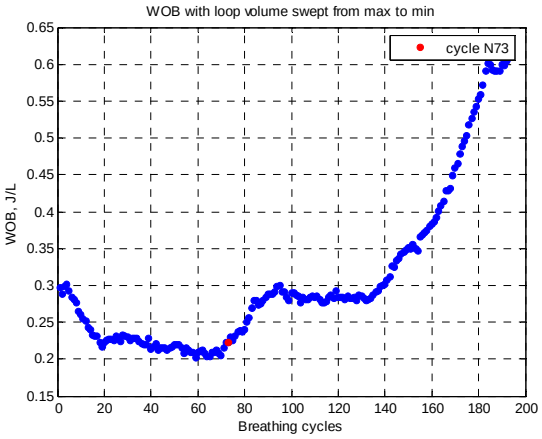
RESULTS

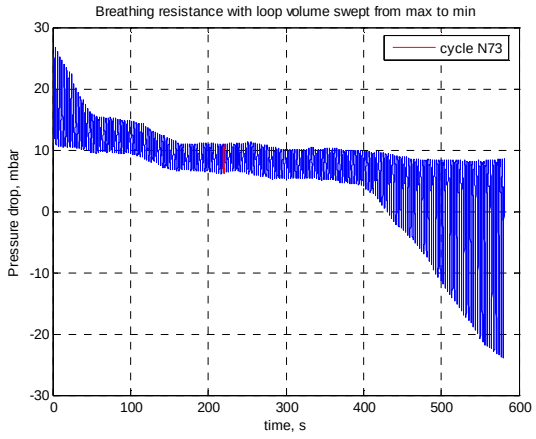
PRESSURE@END EXHALE / INHALE	=	10.7 / 7.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	6.3 / 11.0	mbar
PEAK TO PEAK PRESSURE	=	4.7	mbar
INHALE/EXHALE RESP PRESSURES	=	4.4 / 3.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.25	J/l
WOB OF BREATHING SIMULATOR	=	0.03	J/l
WOB OF DEVICE UNDER TEST	=	0.22	J/l
TOTAL POS / NEG WORK	=	0.09 / 0.16	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.08 / 0.15	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_00d_ 00m_40 lpm_081128_01









8.2.4. SRB (iCCR), Air, <3m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		10/01/09 14:42	
TEST CARRIED OUT BY	VD	WITNESS: MS	

CONDITIONS OF TEST

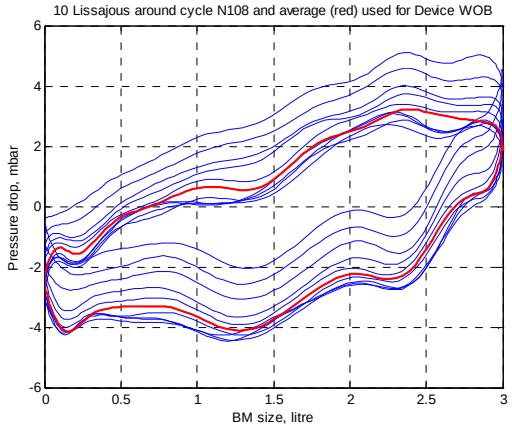
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	2.08	m
ROOM / WATER TEMPERATURE	:	18.7 / 4.5	℃
EHXALE GAS TEMPERATURE	:	18.6	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

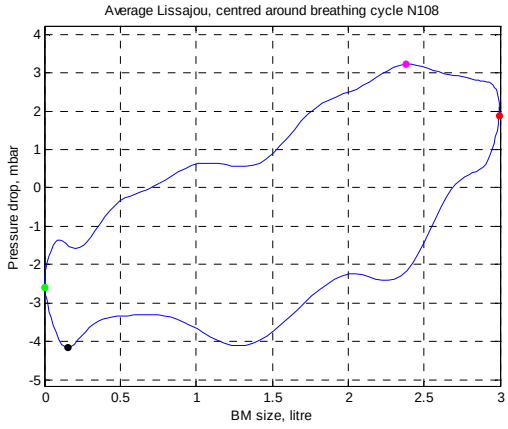
RESULTS

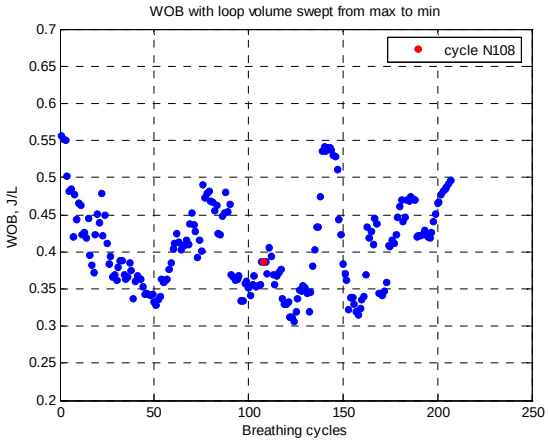
PRESSURE@END EXHALE / INHALE	=	1.9 / -2.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-4.2 / 3.2	mbar
PEAK TO PEAK PRESSURE	=	7.4	mbar
INHALE/EXHALE RESP PRESSURES	=	6.0 / 5.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.54	J/l
WOB OF BREATHING SIMULATOR	=	0.15	J/l
WOB OF DEVICE UNDER TEST	=	0.39	J/l
TOTAL POS / NEG WORK	=	0.23 / 0.30	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.15 / 0.22	J/l

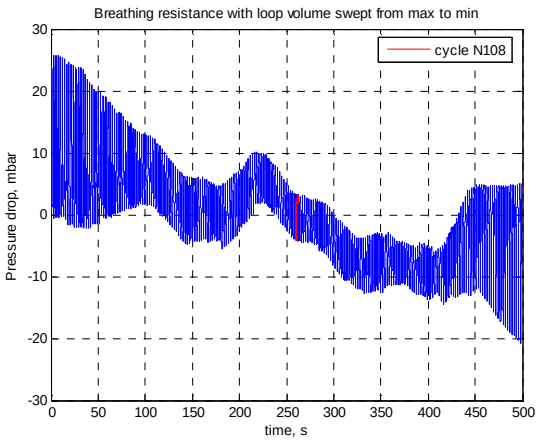
ALL DATA STORED AS # (DATA FILE):

WOB_SRB_helmMTHPCmod2_00d_ 00m_75 lpm_090110_01









8.2.5. SRB (iCCR), Air, <3m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 13:20	
TEST CARRIED OUT BY	VD	WITNESS: MS	

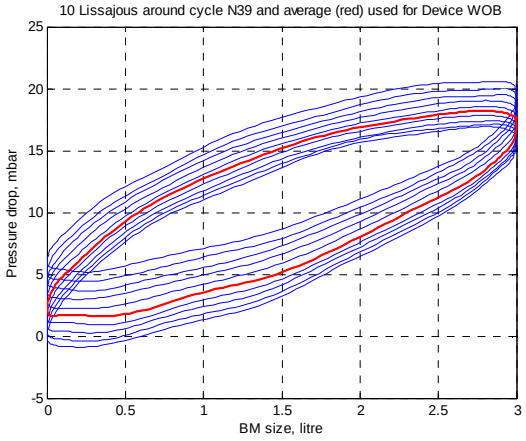
CONDITIONS OF TEST

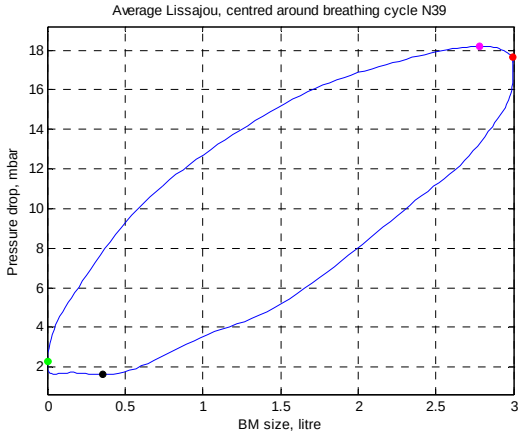
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	0.67	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.7	℃
EHXALE GAS TEMPERATURE	:	15.4	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.9bpm/89.7 lpm	metric

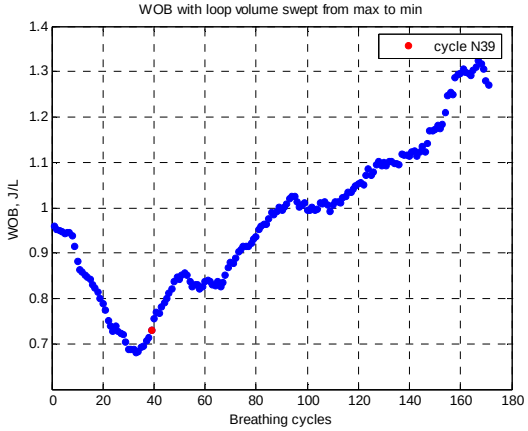
RESULTS

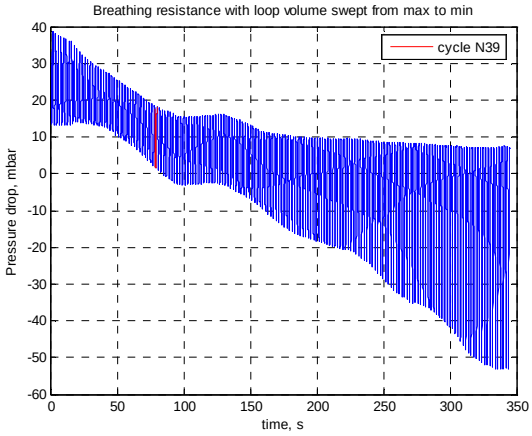
PRESSURE@END EXHALE / INHALE	=	17.7 / 2.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.6 / 18.2	mbar
PEAK TO PEAK PRESSURE	=	16.6	mbar
INHALE/EXHALE RESP PRESSURES	=	16.0 / 15.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.89	J/l
WOB OF BREATHING SIMULATOR	=	0.16	J/l
WOB OF DEVICE UNDER TEST	=	0.73	J/l
TOTAL POS / NEG WORK	=	0.48 / 0.41	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.40 / 0.33	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 00m_90 lpm_081127_01









8.2.6. SRB (iCCR), Air, 4m, 90 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		10/01/09 14:51	
TEST CARRIED OUT BY	VD	WITNESS: MS	

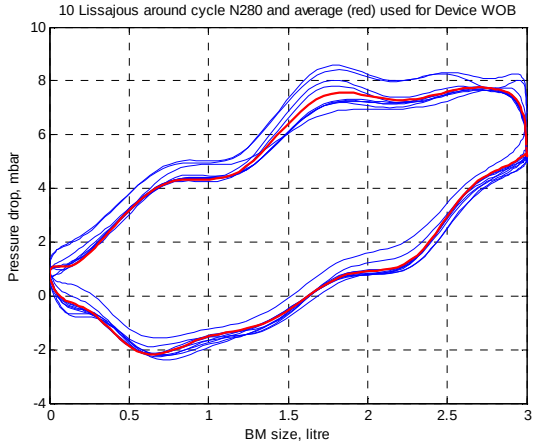
CONDITIONS OF TEST

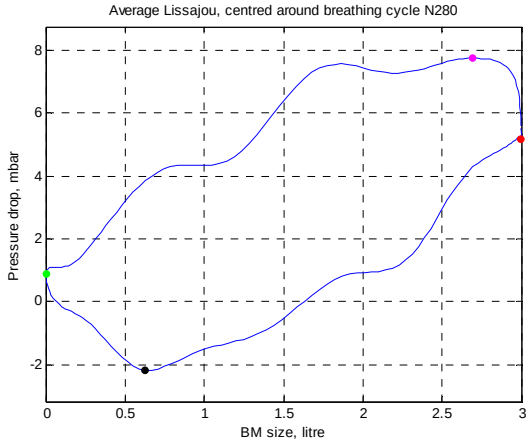
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	4.21	m
ROOM / WATER TEMPERATURE	:	18.8 / 4.2	℃
EHXALE GAS TEMPERATURE	:	18.8	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/30.0bpm/89.9 lpm	metric

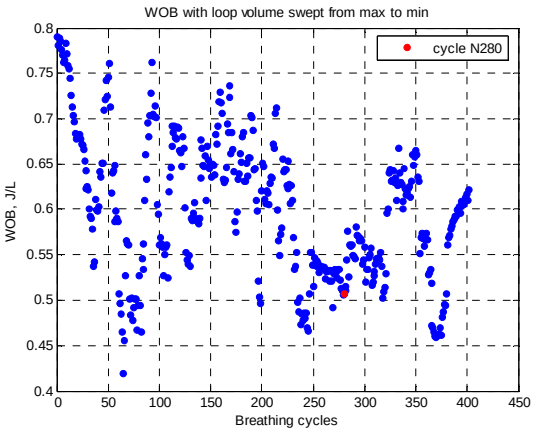
RESULTS

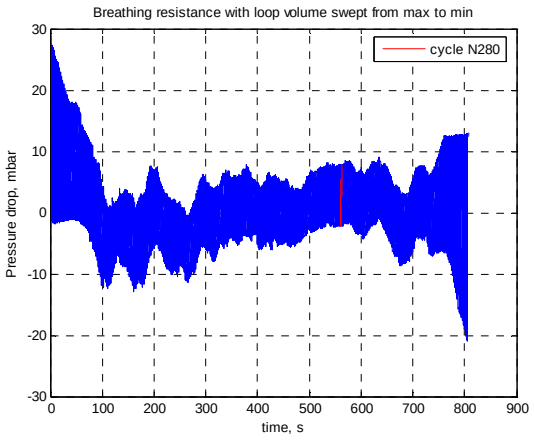
PRESSURE@END EXHALE / INHALE	=	5.2 / 0.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-2.2 / 7.8	mbar
PEAK TO PEAK PRESSURE	=	9.9	mbar
INHALE/EXHALE RESP PRESSURES	=	7.4 / 6.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.71	J/l
WOB OF BREATHING SIMULATOR	=	0.20	J/l
WOB OF DEVICE UNDER TEST	=	0.51	J/l
TOTAL POS / NEG WORK	=	0.33 / 0.35	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.23 / 0.25	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_00d_ 00m_90 lpm_090110_01









8.3. SRB. Air, Depth 40m

8.3.1. SRB (iCCR), Air, 40m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

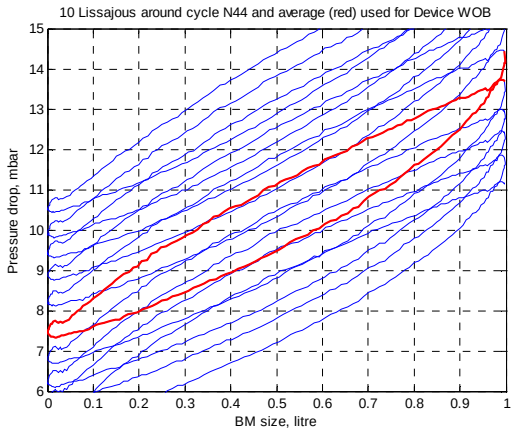
CONDITIONS OF TEST

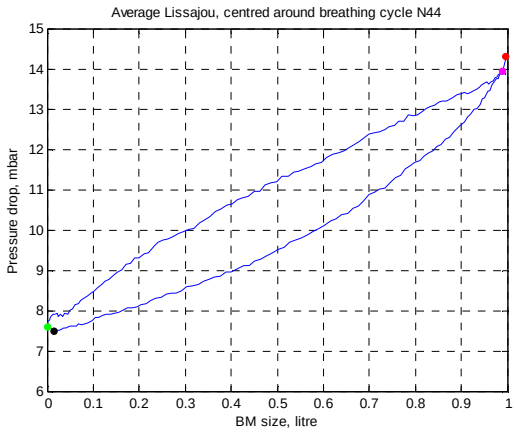
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	39.4	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	13.7	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0 lpm	metric

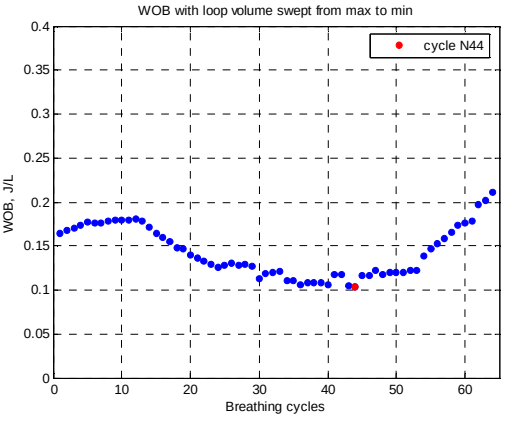
RESULTS

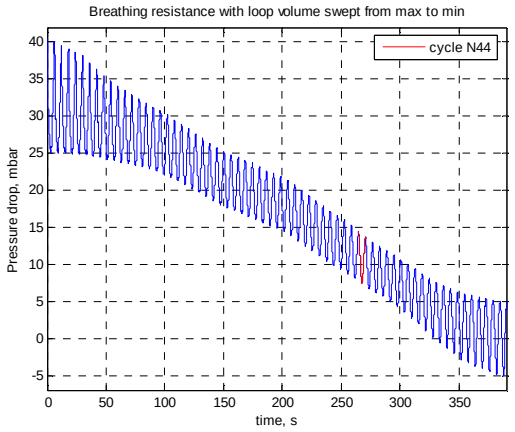
PRESSURE@END EXHALE / INHALE	=	14.2 / 7.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	7.3 / 13.7	mbar
PEAK TO PEAK PRESSURE	=	6.4	mbar
INHALE/EXHALE RESP PRESSURES	=	6.8 / 6.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.10	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.10	J/l
TOTAL POS / NEG WORK	=	0.03 / 0.10	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.03 / 0.10	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_10 lpm_air_100211_1









8.3.2. SRB (iCCR), Air, 40m, 10 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

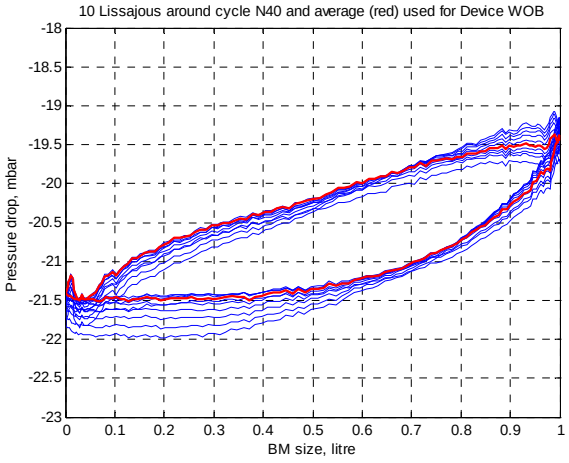
CONDITIONS OF TEST

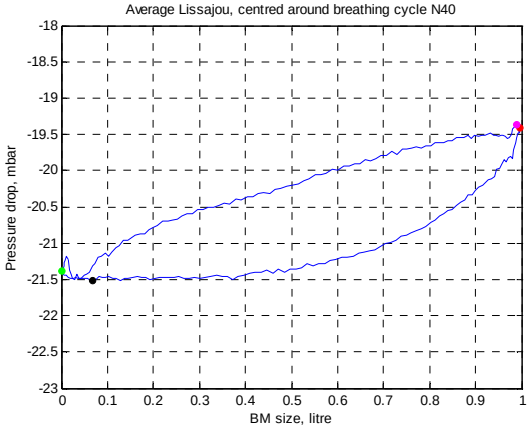
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.5	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	12.3	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/9.9bpm/9.9 lpm	metric

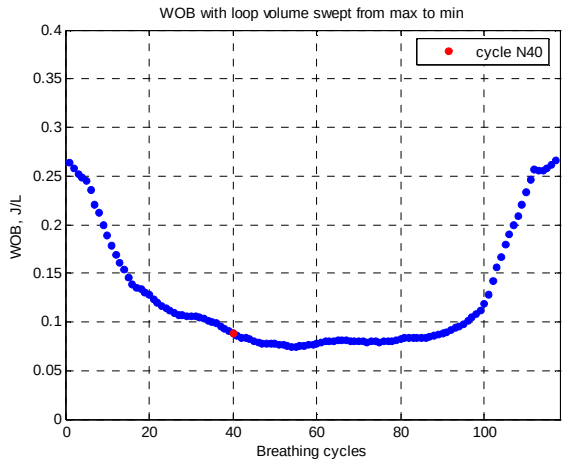
RESULTS

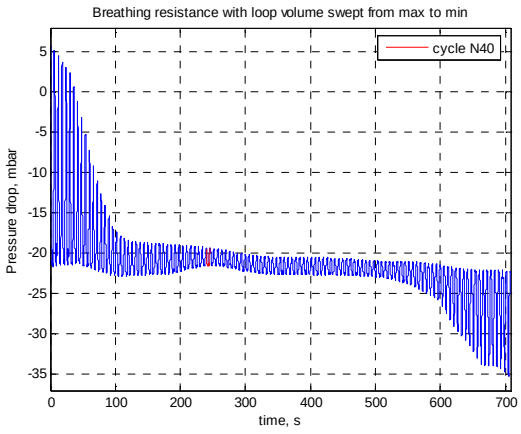
PRESSURE@END EXHALE / INHALE	=	-19.4 / -21.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-21.5 / -19.4	mbar
PEAK TO PEAK PRESSURE	=	2.2	mbar
INHALE/EXHALE RESP PRESSURES	=	2.1 / 2.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.09	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.09	J/l
TOTAL POS / NEG WORK	=	0.02 / 0.07	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.02 / 0.07	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_41m_10 lpm_air_100211_1









8.3.3. SRB (iCCR), Air, 40m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	10.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

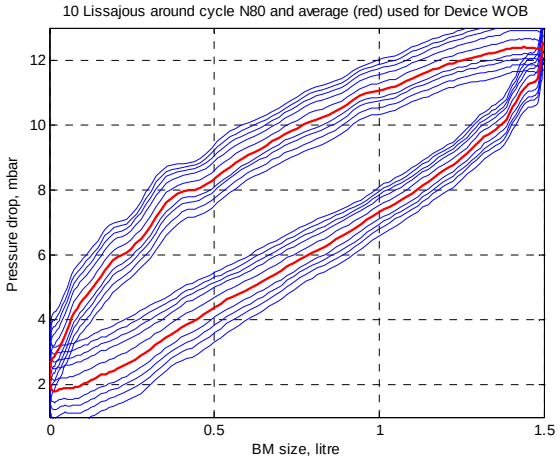
CONDITIONS OF TEST

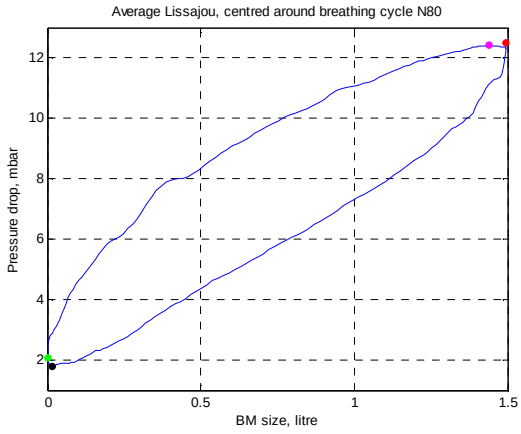
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	39.0	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	20.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5 lpm	metric

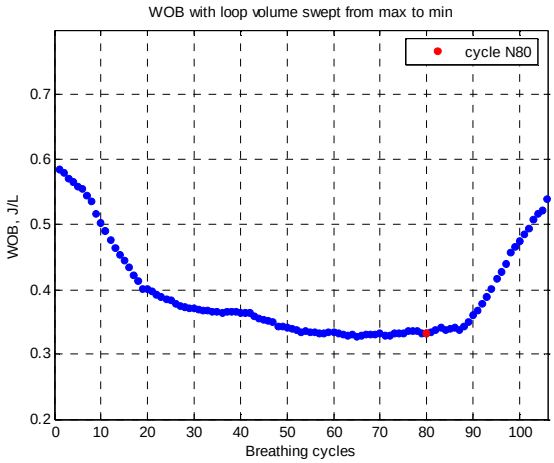
RESULTS

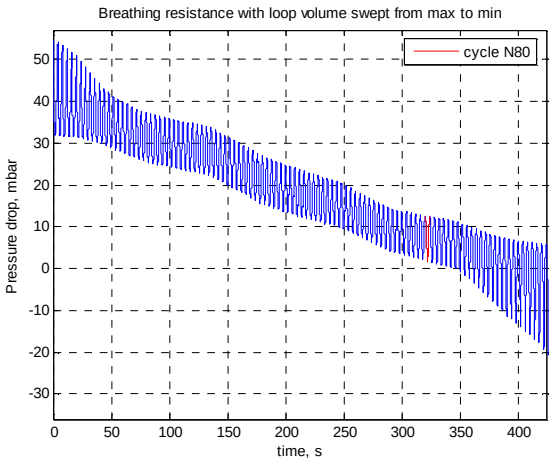
PRESSURE@END EXHALE / INHALE	=	12.5 / 2.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.8 / 12.4	mbar
PEAK TO PEAK PRESSURE	=	10.6	mbar
INHALE/EXHALE RESP PRESSURES	=	10.7 / 10.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.33	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.33	J/l
TOTAL POS / NEG WORK	=	0.19 / 0.13	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.19 / 0.13	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_22.5 lpm_air_100210









8.3.4. SRB (iCCR), Air, 40m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	10.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

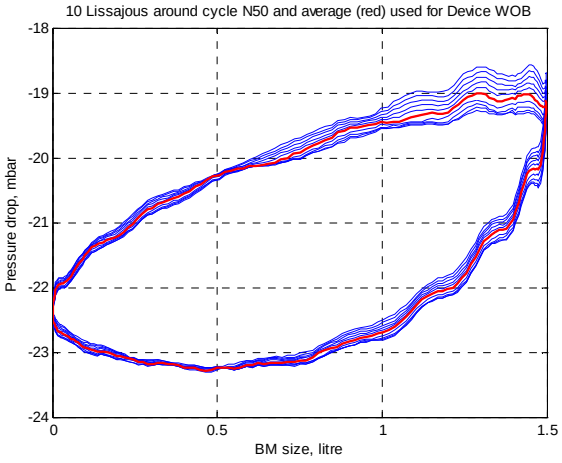
CONDITIONS OF TEST

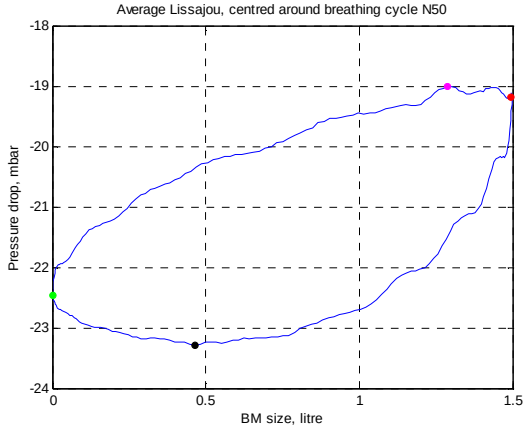
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	38.5	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5 lpm	metric

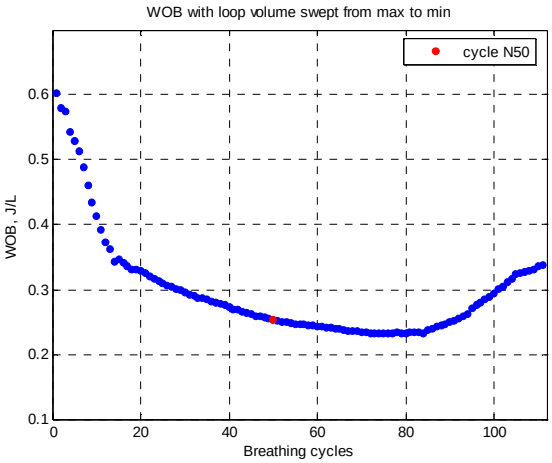
RESULTS

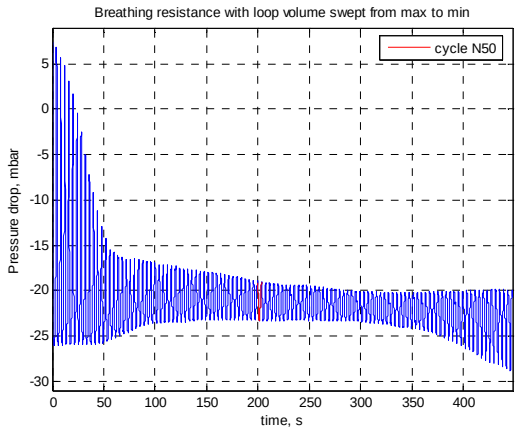
PRESSURE@END EXHALE / INHALE	=	-19.2 / -22.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-23.3 / -19.0	mbar
PEAK TO PEAK PRESSURE	=	4.3	mbar
INHALE/EXHALE RESP PRESSURES	=	4.1 / 3.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.25	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.25	J/l
TOTAL POS / NEG WORK	=	0.07 / 0.17	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.07 / 0.17	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_39m_22.5 lpm_air_100210_1









8.3.5. SRB (iCCR), Air, 40m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

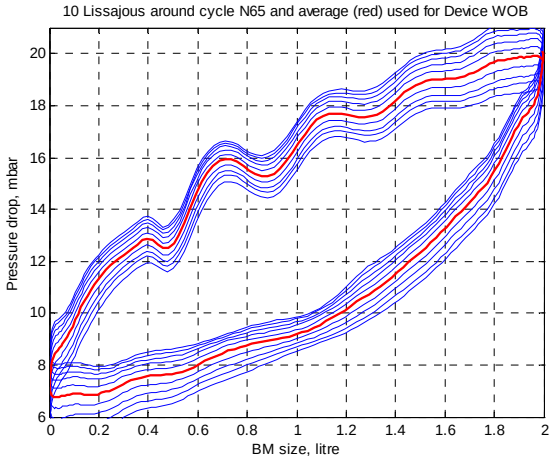
CONDITIONS OF TEST

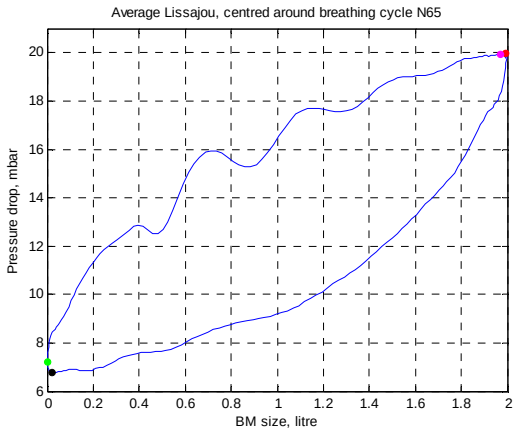
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.2	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	12.8	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

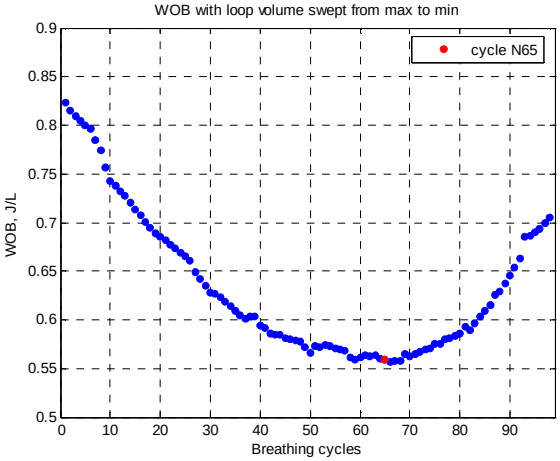
RESULTS

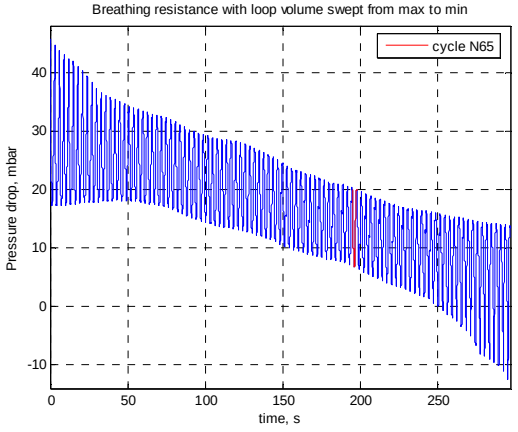
PRESSURE@END EXHALE / INHALE	=	20.0 / 7.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	6.8 / 19.9	mbar
PEAK TO PEAK PRESSURE	=	13.2	mbar
INHALE/EXHALE RESP PRESSURES	=	13.2 / 12.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.59	J/l
WOB OF BREATHING SIMULATOR	=	0.04	J/l
WOB OF DEVICE UNDER TEST	=	0.56	J/l
TOTAL POS / NEG WORK	=	0.25 / 0.34	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.23 / 0.32	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_40 lpm_air_100209









8.3.6. SRB (iCCR), Air, 40m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

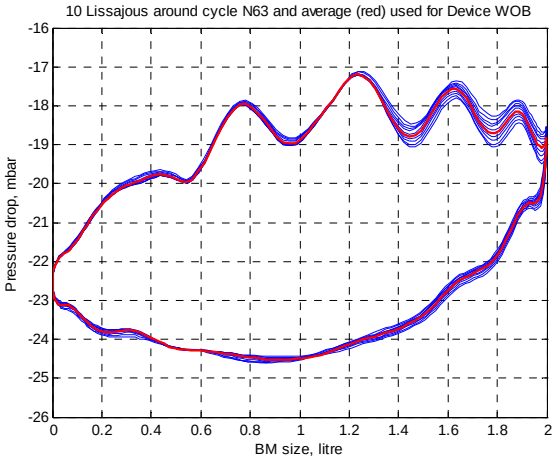
CONDITIONS OF TEST

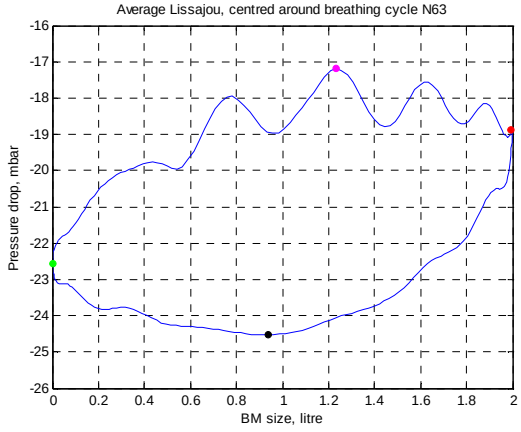
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.2	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.2	℃
EHXALE GAS TEMPERATURE	:	13.7	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

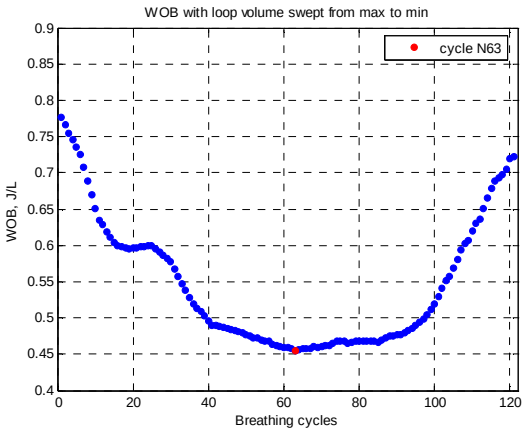
RESULTS

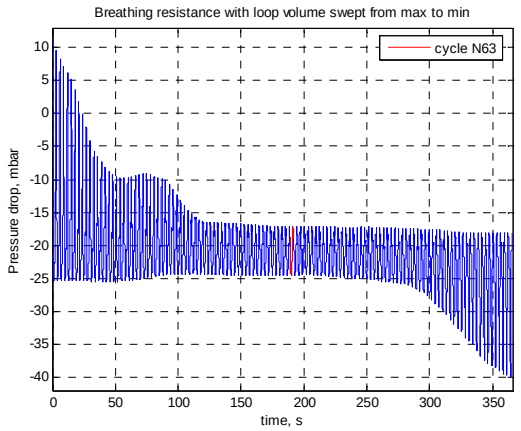
PRESSURE@END EXHALE / INHALE	=	-18.9 / -22.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.5 / -17.2	mbar
PEAK TO PEAK PRESSURE	=	7.3	mbar
INHALE/EXHALE RESP PRESSURES	=	5.6 / 5.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.49	J/l
WOB OF BREATHING SIMULATOR	=	0.04	J/l
WOB OF DEVICE UNDER TEST	=	0.46	J/l
TOTAL POS / NEG WORK	=	0.19 / 0.29	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.18 / 0.28	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_40m_40 lpm_air_100209









Ripple above is a feature of the counterlung. Compare with following page in 2008: the only difference is a rotation in the seam position of the counterlung.

8.3.7. SRB (iCCR), Air, 40m, 62.5 lpm RMV, 90° Pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	02.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

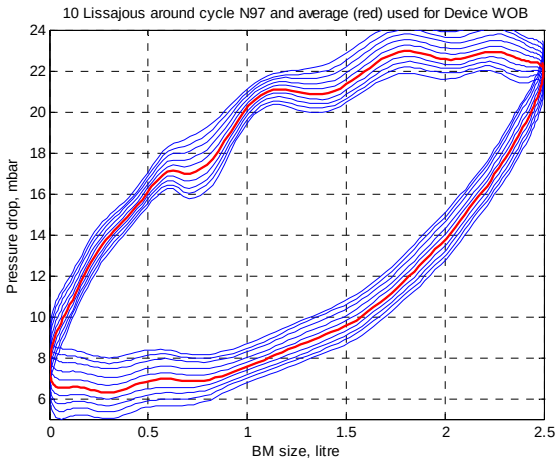
CONDITIONS OF TEST

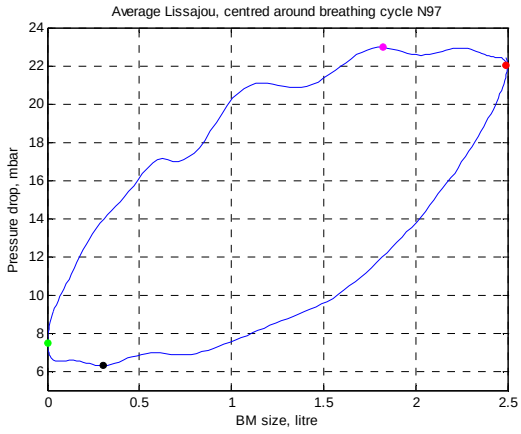
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	41.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.0	℃
EHXALE GAS TEMPERATURE	:	8.4	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/24.9bpm/62.3 lpm	metric

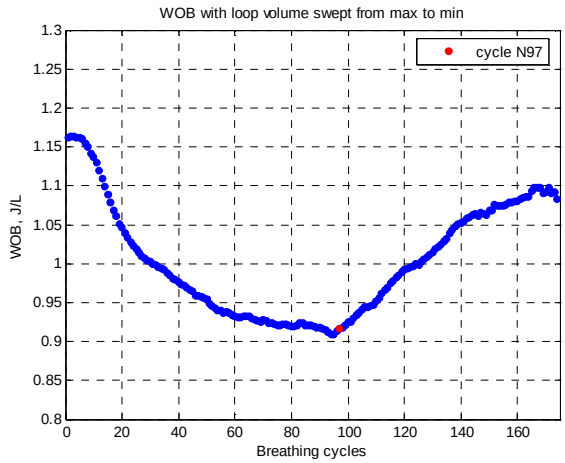
RESULTS

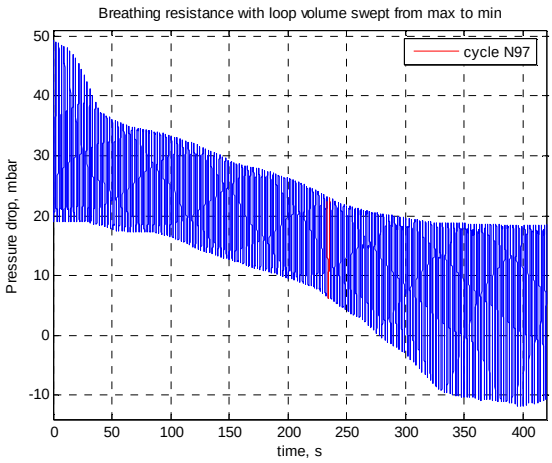
PRESSURE@END EXHALE / INHALE	=	22.0 / 7.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	6.3 / 23.0	mbar
PEAK TO PEAK PRESSURE	=	16.7	mbar
INHALE/EXHALE RESP PRESSURES	=	15.7 / 15.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.92	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.92	J/l
TOTAL POS / NEG WORK	=	0.43 / 0.46	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.43 / 0.46	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_62.5 lpm_air_100202_1









8.3.8. SRB (iCCR), Air, 40m, 62.5 lpm RMV, 0° Pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	23.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

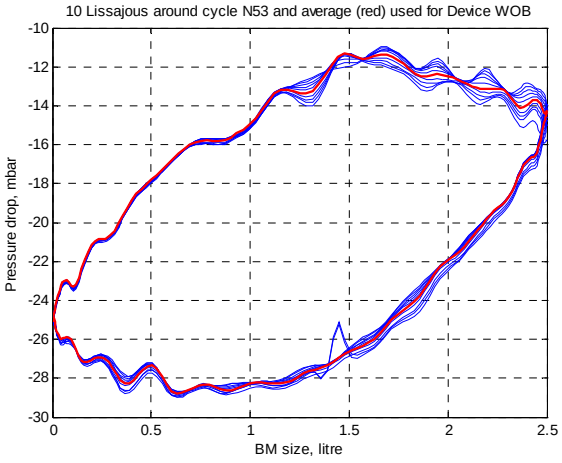
CONDITIONS OF TEST

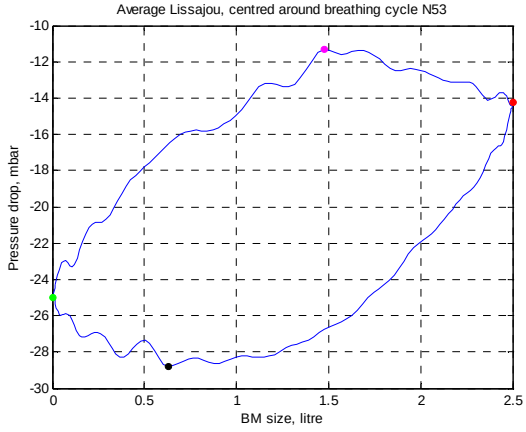
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	39.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.0	℃
EHXALE GAS TEMPERATURE	:	16.0	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.4bpm/62.4 lpm	metric

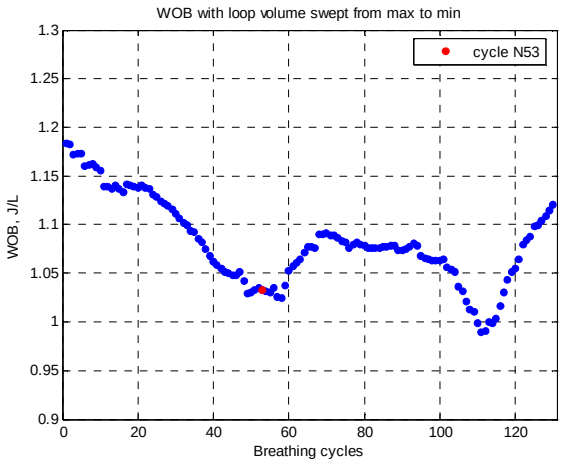
RESULTS

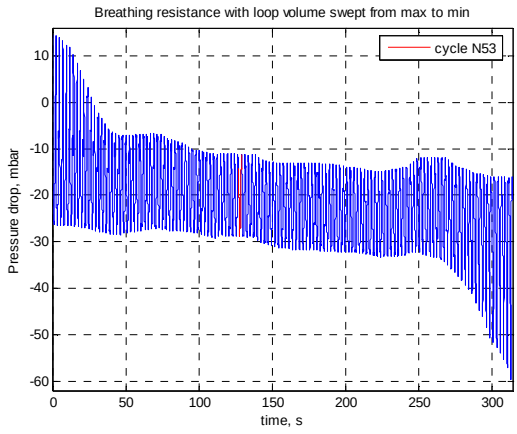
PRESSURE@END EXHALE / INHALE	=	-14.3 / -25.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-28.8 / -11.3	mbar
PEAK TO PEAK PRESSURE	=	17.5	mbar
INHALE/EXHALE RESP PRESSURES	=	14.5 / 13.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.03	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	1.03	J/l
TOTAL POS / NEG WORK	=	0.46 / 0.58	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.46 / 0.58	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_S1_0d_40m_62.5 lpm_air_100223_1









8.3.9. SRB (Incursion), Air, 40m, 75 lpm RMV, 90° Pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR Incursion S1 with ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

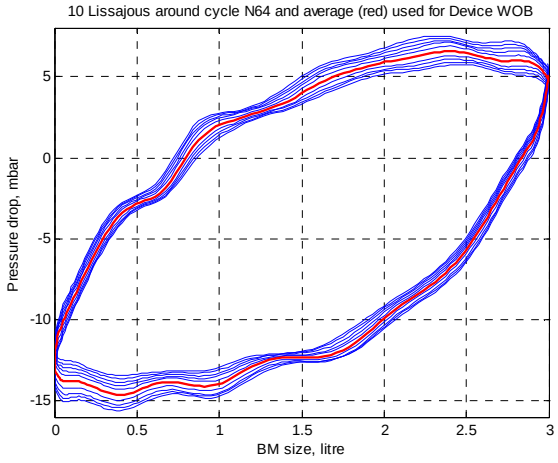
CONDITIONS OF TEST

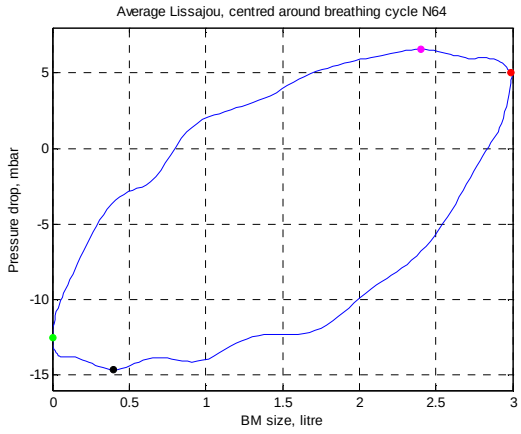
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.4	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.8	℃
EHXALE GAS TEMPERATURE	:	12.4	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

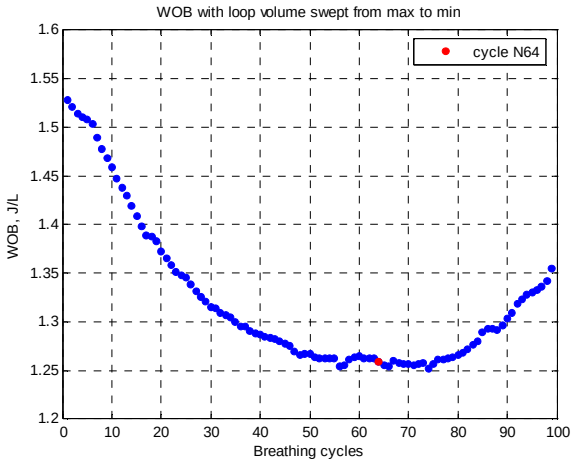
RESULTS

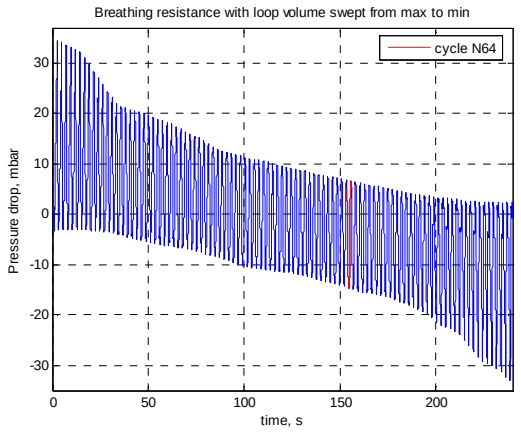
PRESSURE@END EXHALE / INHALE	=	5.0 / -12.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-14.6 / 6.6	mbar
PEAK TO PEAK PRESSURE	=	21.2	mbar
INHALE/EXHALE RESP PRESSURES	=	19.7 / 19.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.42	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	1.26	J/l
TOTAL POS / NEG WORK	=	0.66 / 0.75	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.59 / 0.67	J/l

ALL DATA STORED AS # (DATA FILE): WOB_iCCR_90d_40m_75 lpm_air_100209.mat









8.3.10. SRB (iCCR), Air, 40m, 75 lpm RMV, 90° Pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

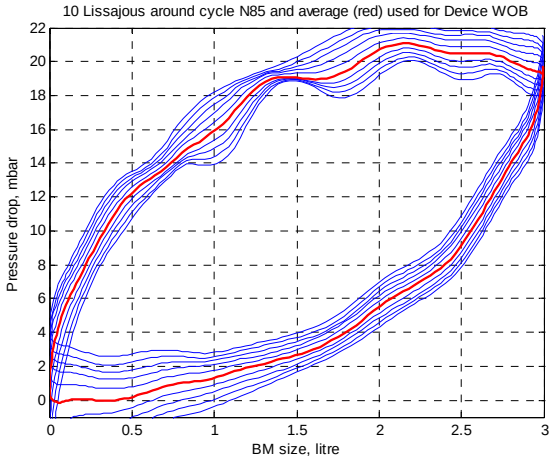
CONDITIONS OF TEST

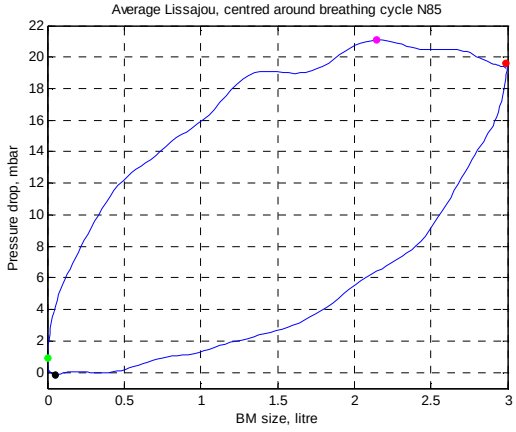
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	39.6	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	15.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/24.9bpm/74.8 lpm	metric

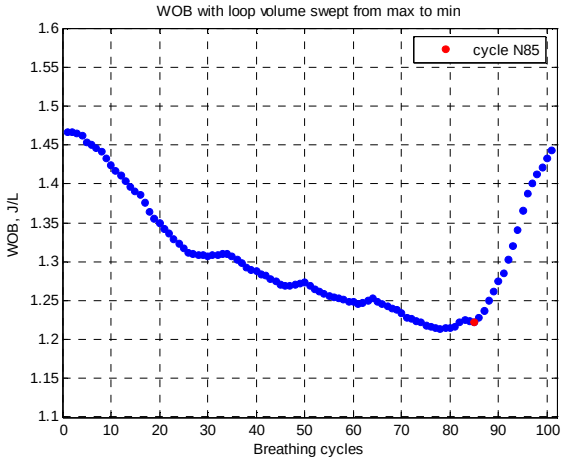
RESULTS

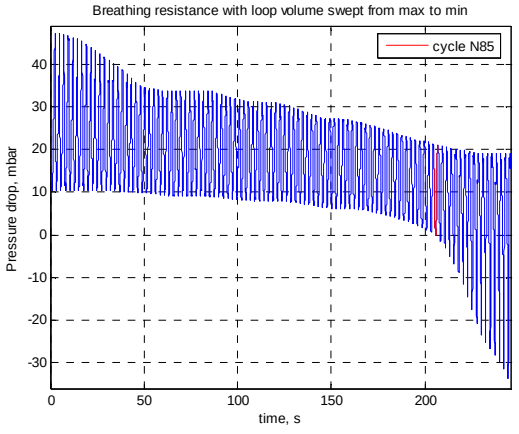
PRESSURE@END EXHALE / INHALE	=	19.6 / 0.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-0.1 / 21.1	mbar
PEAK TO PEAK PRESSURE	=	21.2	mbar
INHALE/EXHALE RESP PRESSURES	=	19.7 / 20.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.39	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	1.22	J/l
TOTAL POS / NEG WORK	=	0.73 / 0.66	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.65 / 0.58	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_75 lpm_air_100205









8.3.11. SRB (iCCR), Air, 40m, 75 lpm RMV, 0° Pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

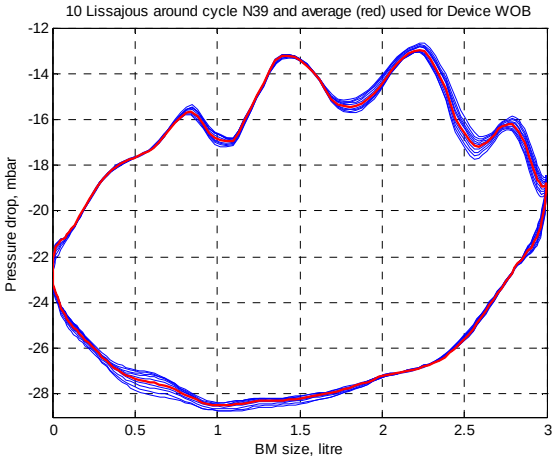
CONDITIONS OF TEST

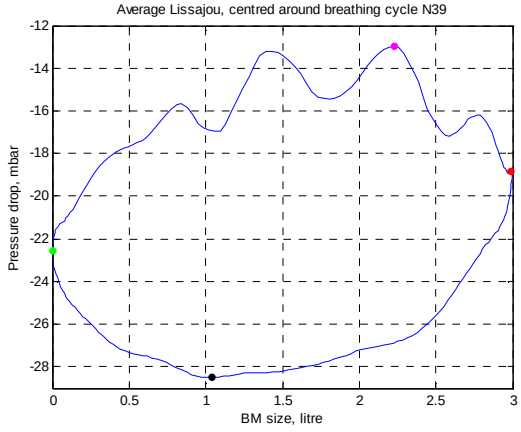
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	12.6	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.1bpm/75.1 lpm	metric

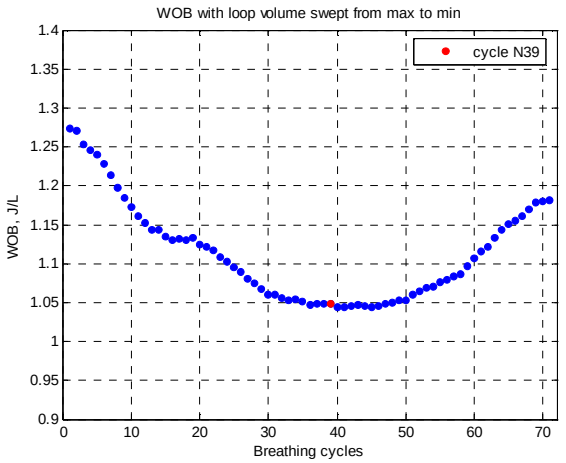
RESULTS

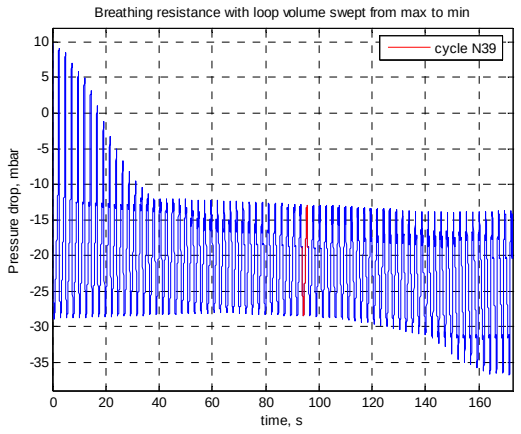
PRESSURE@END EXHALE / INHALE	=	-18.8 / -22.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-28.5 / -12.9	mbar
PEAK TO PEAK PRESSURE	=	15.6	mbar
INHALE/EXHALE RESP PRESSURES	=	9.7 / 9.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.21	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	1.05	J/l
TOTAL POS / NEG WORK	=	0.53 / 0.67	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.45 / 0.59	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_41m_75 lpm_air_100205_1









8.3.12. SRB (iCCR), Air, 40m, 90 lpm RMV, 0° pitch

Following plots are noisy due to movement of gas in horizontal counterlungs.

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	OR SRB iCCR S1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		10/01/09 15:08	
TEST CARRIED OUT BY	VD	WITNESS: MS	

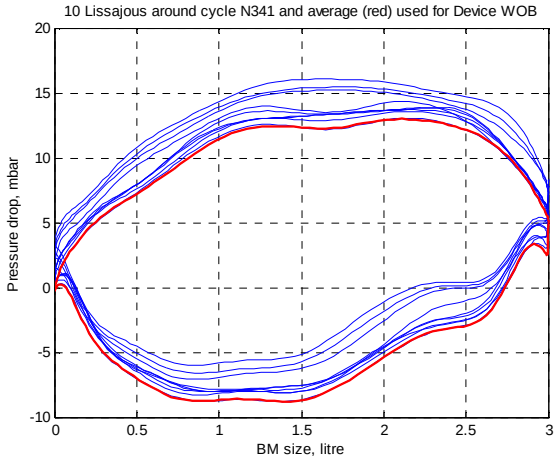
CONDITIONS OF TEST

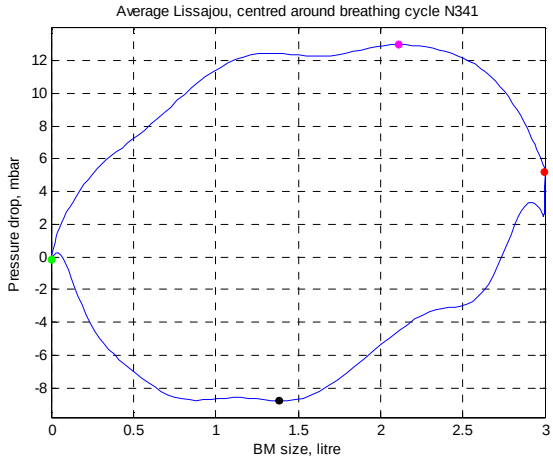
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	38.15	m
ROOM / WATER TEMPERATURE	:	18.8 / 4.3	℃
EHXALE GAS TEMPERATURE	:	19.1	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.8bpm/89.3 lpm	metric

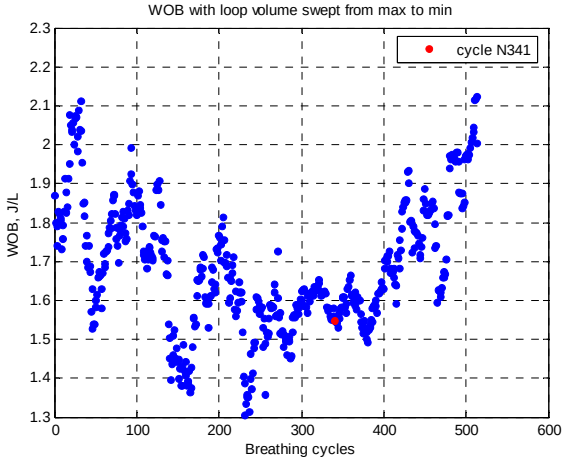
RESULTS

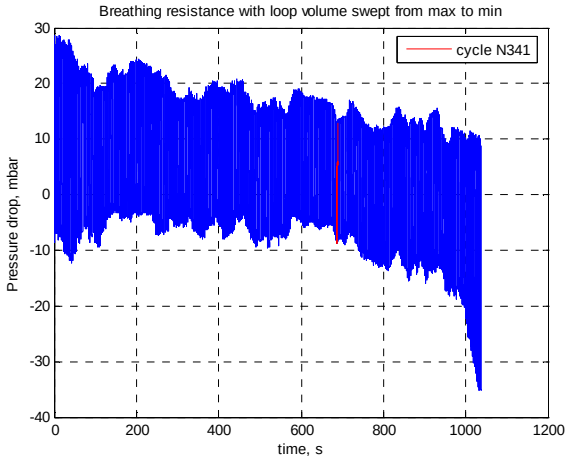
PRESSURE@END EXHALE / INHALE	=	5.7 / 0.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-8.1 / 13.7	mbar
PEAK TO PEAK PRESSURE	=	21.7	mbar
INHALE/EXHALE RESP PRESSURES	=	13.7 / 12.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	2.14	J/l
WOB OF BREATHING SIMULATOR	=	0.59	J/l
WOB OF DEVICE UNDER TEST	=	1.55	J/l
TOTAL POS / NEG WORK	=	1.08 / 1.04	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.79 / 0.74	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_00d_ 40m_90 lpm_090110_01









8.4. SRB. Air, Depth 60m

8.4.1. SRB (iCCR), Air, 60m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	OR SRB iCCR S1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		28/11/08 11:34	
TEST CARRIED OUT BY	VD	WITNESS: MS	

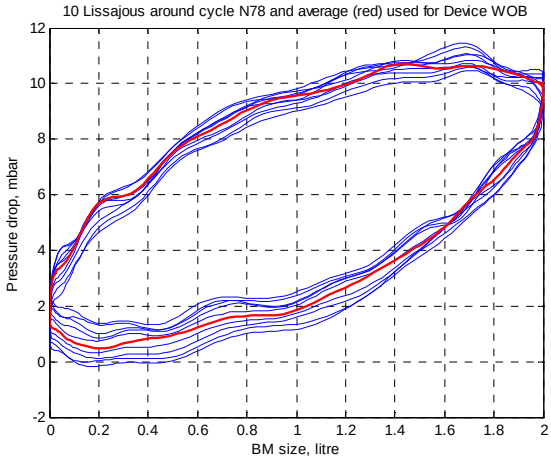
CONDITIONS OF TEST

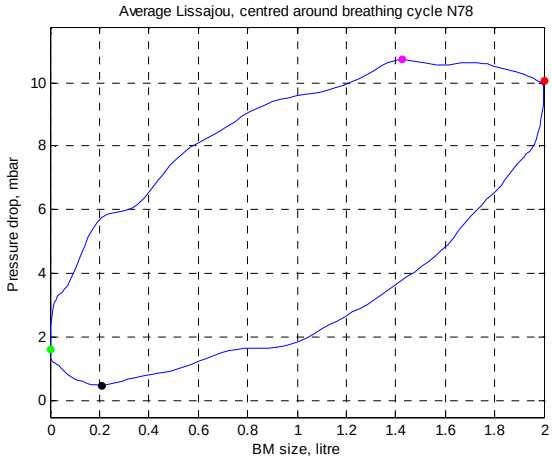
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	60.36	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.3	℃
EHXALE GAS TEMPERATURE	:	17.8	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/19.9bpm/39.9 lpm	metric

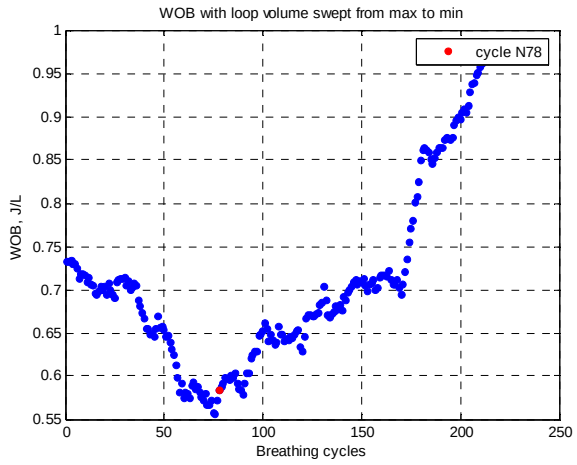
RESULTS

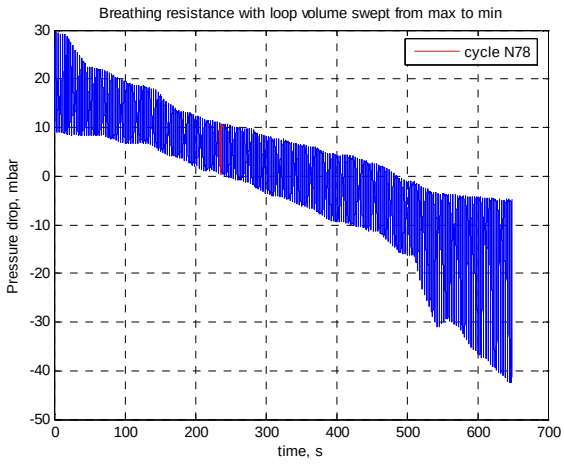
PRESSURE@END EXHALE / INHALE	=	9.2 / 0.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-0.3 / 10.1	mbar
PEAK TO PEAK PRESSURE	=	10.5	mbar
INHALE/EXHALE RESP PRESSURES	=	9.5 / 9.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.76	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	0.60	J/l
TOTAL POS / NEG WORK	=	0.38 / 0.37	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.30 / 0.29	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 60m_40 lpm_081128_01









8.4.2. SRB (iCCR), Air, 60m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	OR SRB iCCR S1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 11:58	
TEST CARRIED OUT BY	VD	WITNESS: MS	

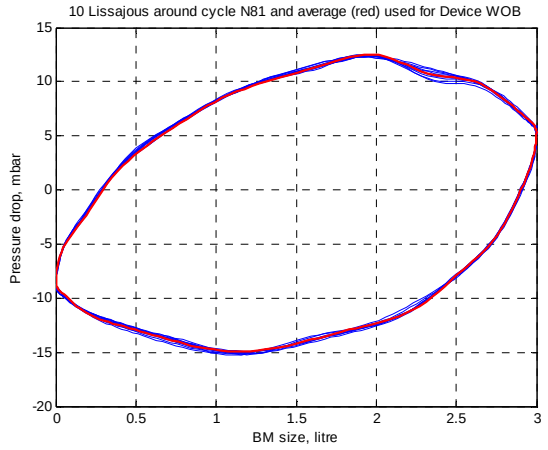
CONDITIONS OF TEST

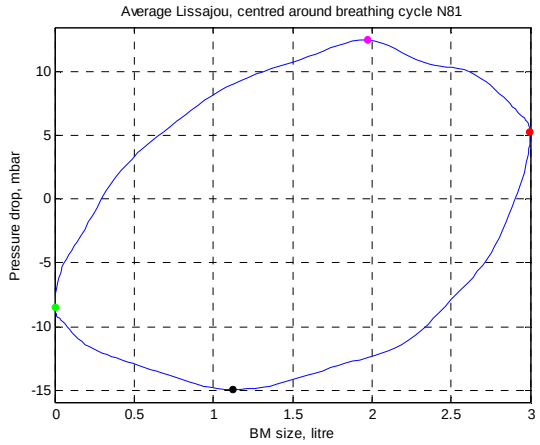
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	59.94	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.3	℃
EHXALE GAS TEMPERATURE	:	15.5	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/24.9bpm/74.7 lpm	metric

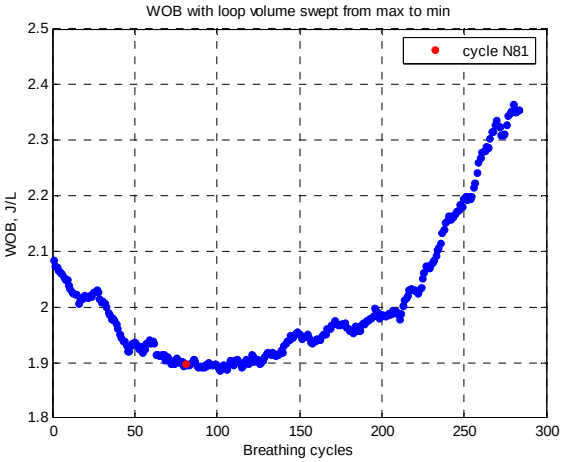
RESULTS

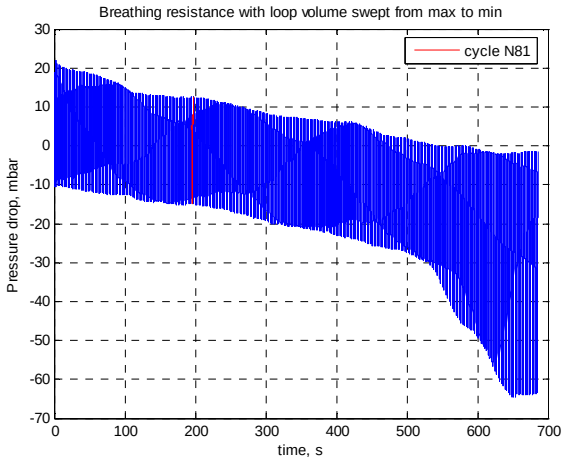
PRESSURE@END EXHALE / INHALE	=	5.3 / -8.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-14.9 / 12.5	mbar
PEAK TO PEAK PRESSURE	=	27.5	mbar
INHALE/EXHALE RESP PRESSURES	=	20.3 / 21.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	2.57	J/l
WOB OF BREATHING SIMULATOR	=	0.67	J/l
WOB OF DEVICE UNDER TEST	=	1.90	J/l
TOTAL POS / NEG WORK	=	1.24 / 1.27	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.91 / 0.93	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 60m_75 lpm_081127_02









8.4.3. SRB (iCCR), Air, 60m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	OR SRB iCCR S1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 12:57	
TEST CARRIED OUT BY	VD	WITNESS: MS	

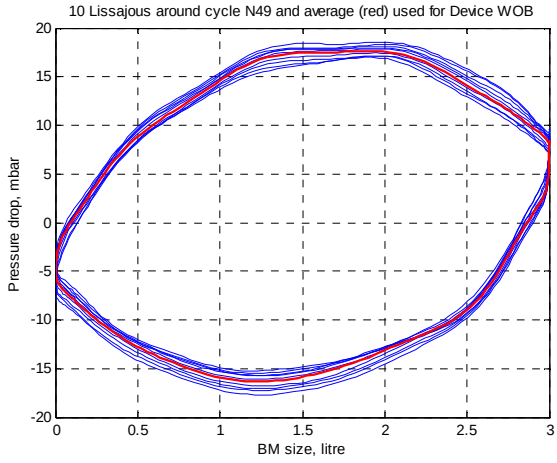
CONDITIONS OF TEST

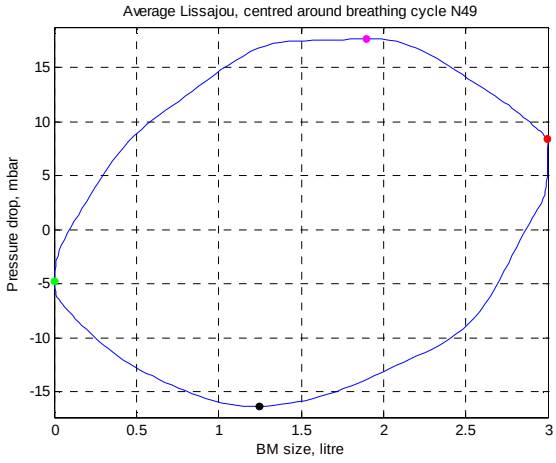
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	60.00	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.3	℃
EHXALE GAS TEMPERATURE	:	15.6	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.8bpm/89.3 lpm	metric

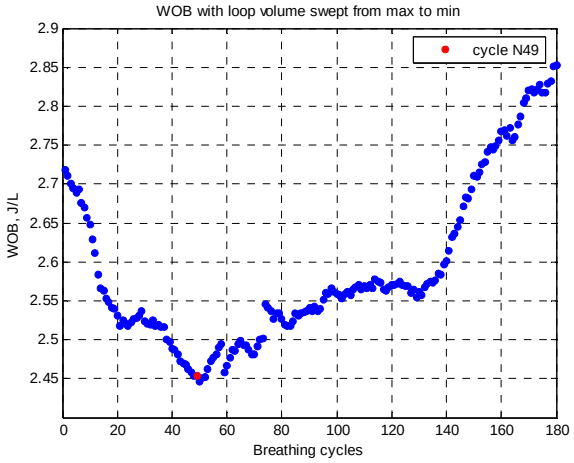
RESULTS

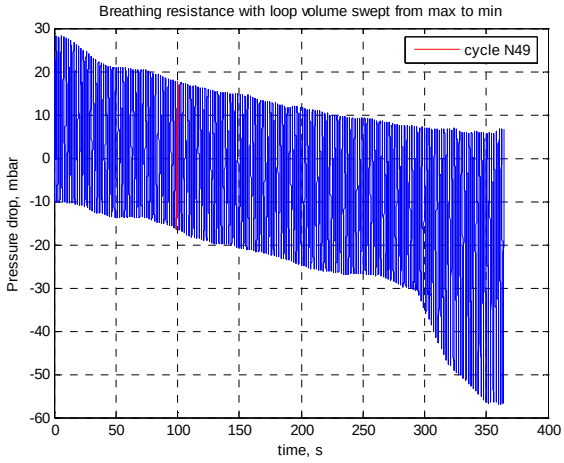
PRESSURE@END EXHALE / INHALE	=	8.4 / -4.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-16.3 / 17.6	mbar
PEAK TO PEAK PRESSURE	=	34.0	mbar
INHALE/EXHALE RESP PRESSURES	=	24.8 / 22.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	3.30	J/l
WOB OF BREATHING SIMULATOR	=	0.84	J/l
WOB OF DEVICE UNDER TEST	=	2.45	J/l
TOTAL POS / NEG WORK	=	1.53 / 1.73	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.11 / 1.31	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 60m_90 lpm_081127_01









8.5. SRB. Air, Depth 80m

8.5.1. SRB (iCCR), Air, 80m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	OR SRB iCCR S1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 12:13	
TEST CARRIED OUT BY	VD	WITNESS: MS	

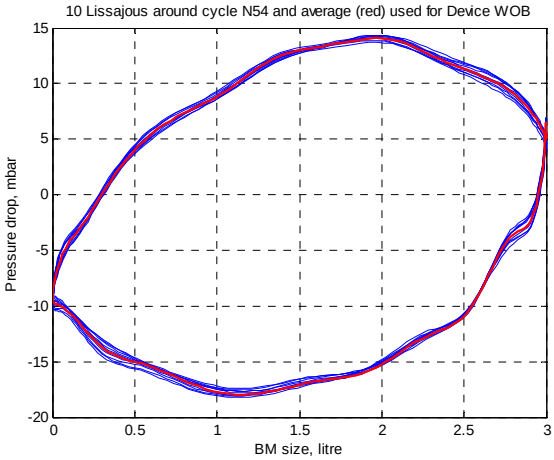
CONDITIONS OF TEST

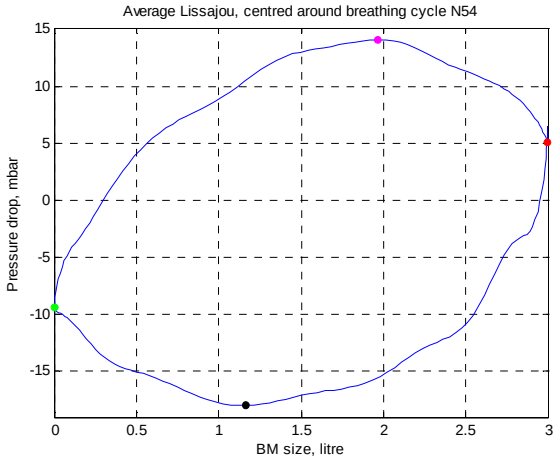
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	80.02	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.3	℃
EHXALE GAS TEMPERATURE	:	15.6	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/24.9bpm/74.7 lpm	metric

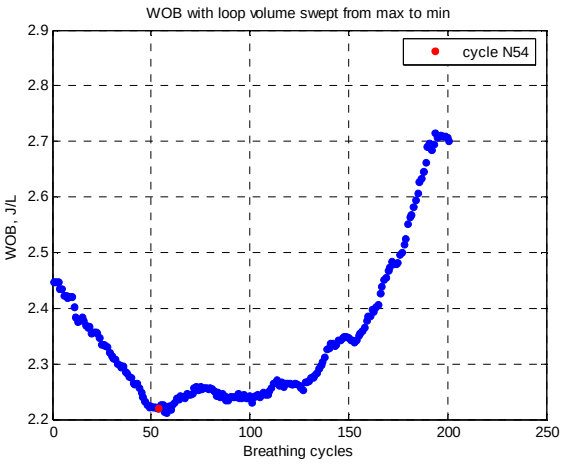
RESULTS

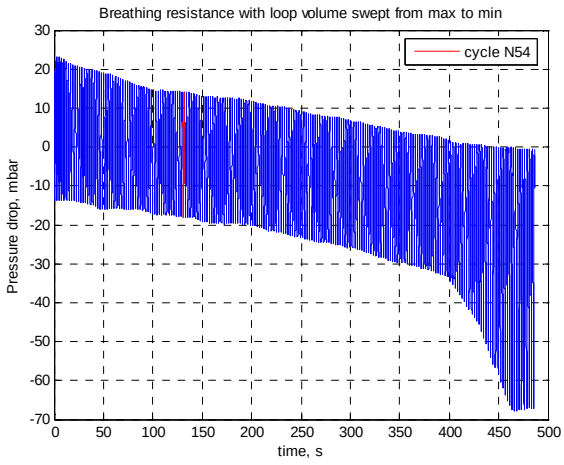
PRESSURE@END EXHALE / INHALE	=	5.1 / -9.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-18.0 / 14.1	mbar
PEAK TO PEAK PRESSURE	=	32.1	mbar
INHALE/EXHALE RESP PRESSURES	=	23.1 / 23.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	3.07	J/l
WOB OF BREATHING SIMULATOR	=	0.85	J/l
WOB OF DEVICE UNDER TEST	=	2.22	J/l
TOTAL POS / NEG WORK	=	1.51 / 1.52	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.09 / 1.10	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 80m_75 lpm_081127_02









8.5.2. SRB (iCCR), Air, 80m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	OR SRB iCCR S1 with ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 12:49	
TEST CARRIED OUT BY	VD	WITNESS: MS	

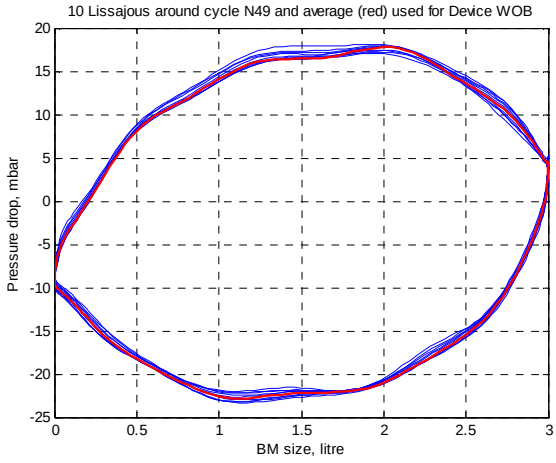
CONDITIONS OF TEST

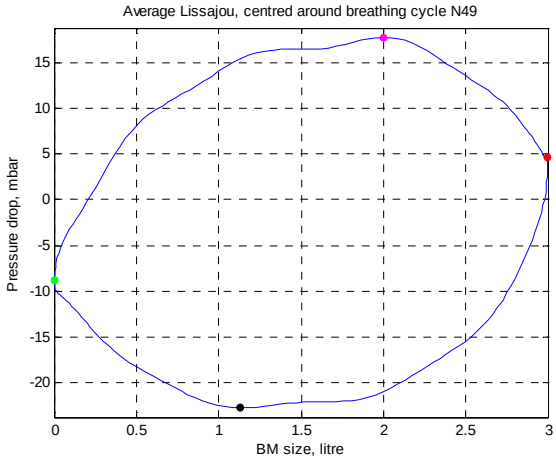
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	80.08	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.4	℃
EHXALE GAS TEMPERATURE	:	15.6	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/30.0bpm/90.0 lpm	metric

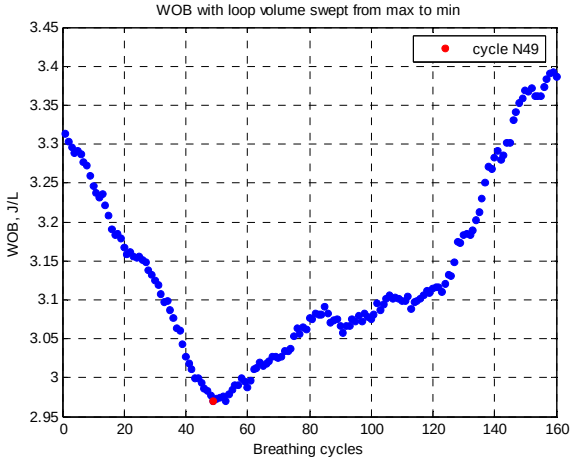
RESULTS

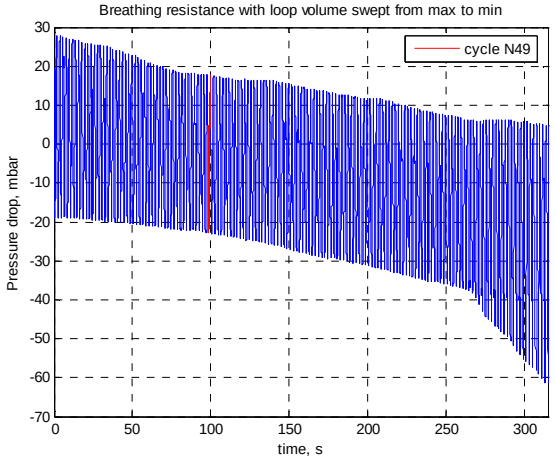
PRESSURE@END EXHALE / INHALE	=	4.6 / -8.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.8 / 17.8	mbar
PEAK TO PEAK PRESSURE	=	40.6	mbar
INHALE/EXHALE RESP PRESSURES	=	27.4 / 26.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	4.05	J/l
WOB OF BREATHING SIMULATOR	=	1.08	J/l
WOB OF DEVICE UNDER TEST	=	2.97	J/l
TOTAL POS / NEG WORK	=	1.93 / 2.08	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.41 / 1.54	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 80m_90 lpm_081127_01









8.6. SRB. Air, Depth 100m

8.6.1. SRB (iCCR), Air, 100m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB SN1 with DL Mod 2 ALVBOV EN14143:2003	
TEST METHOD		RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 12:25	
TEST CARRIED OUT BY	VD	WITNESS: MS	

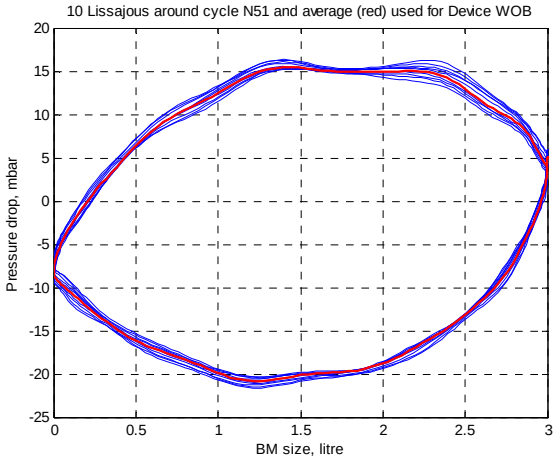
CONDITIONS OF TEST

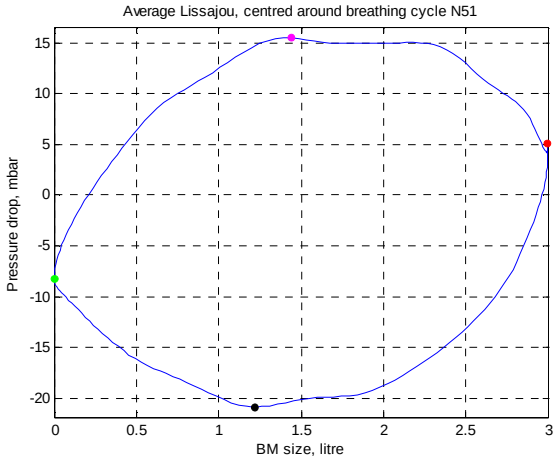
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	100.04	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.0	℃
EHXALE GAS TEMPERATURE	:	15.7	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0 lpm	metric

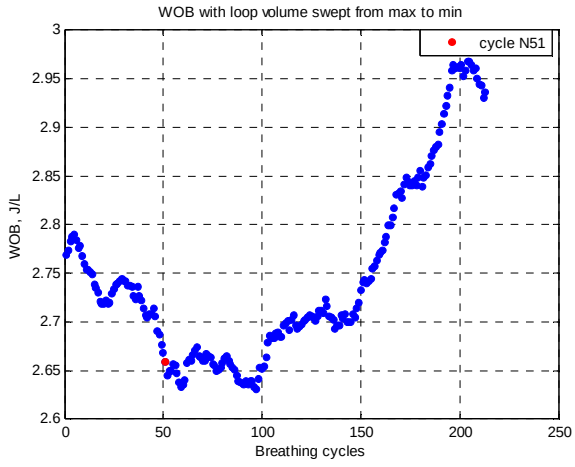
RESULTS

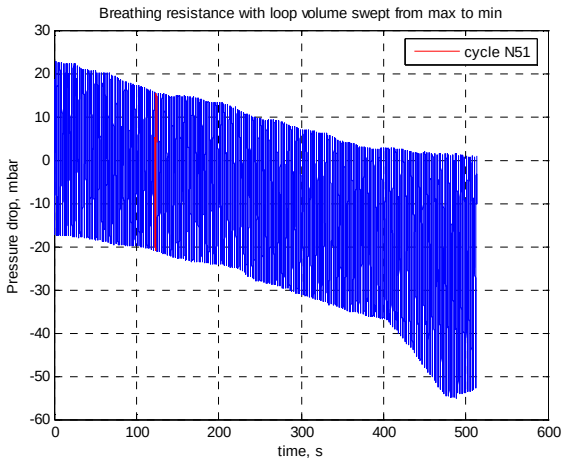
PRESSURE@END EXHALE / INHALE	=	5.1 / -8.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-20.8 / 15.5	mbar
PEAK TO PEAK PRESSURE	=	36.3	mbar
INHALE/EXHALE RESP PRESSURES	=	25.9 / 23.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	3.69	J/l
WOB OF BREATHING SIMULATOR	=	1.03	J/l
WOB OF DEVICE UNDER TEST	=	2.66	J/l
TOTAL POS / NEG WORK	=	1.76 / 1.89	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.25 / 1.38	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 100m_75 lpm_081127_02









8.6.2. SRB (iCCR), Air, 100m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB SN1 with DL Mod 2 ALVBOV	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		27/11/08 12:39	
TEST CARRIED OUT BY	VD	WITNESS: MS	

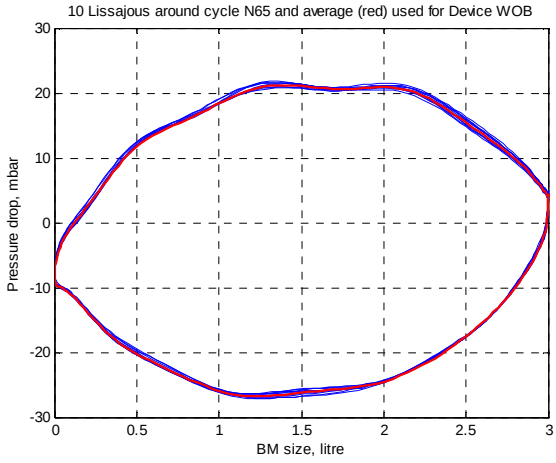
CONDITIONS OF TEST

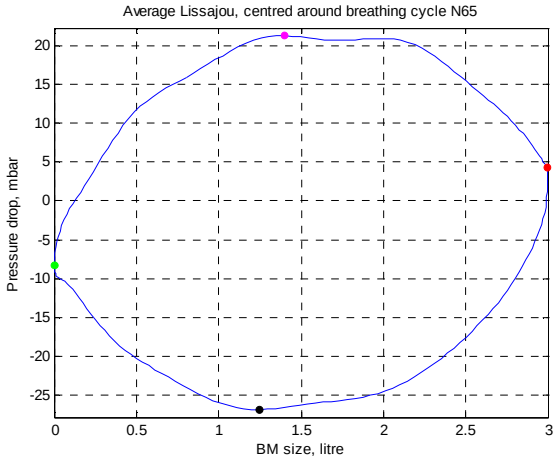
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	99.92	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.4	℃
EHXALE GAS TEMPERATURE	:	15.7	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/30.0bpm/89.9 lpm	metric

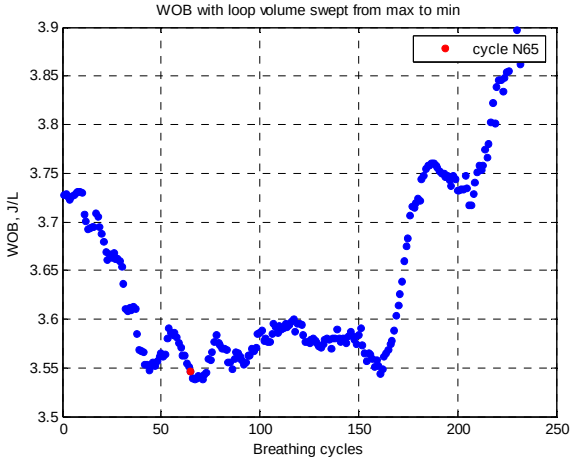
RESULTS

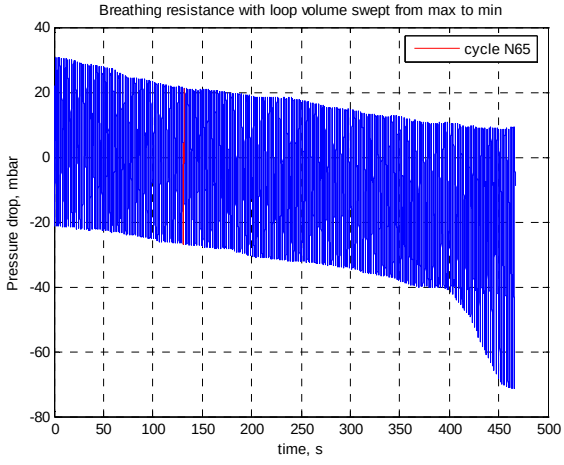
PRESSURE@END EXHALE / INHALE	=	4.4 / -8.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-26.8 / 21.2	mbar
PEAK TO PEAK PRESSURE	=	48.0	mbar
INHALE/EXHALE RESP PRESSURES	=	31.1 / 29.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	4.85	J/l
WOB OF BREATHING SIMULATOR	=	1.30	J/l
WOB OF DEVICE UNDER TEST	=	3.55	J/l
TOTAL POS / NEG WORK	=	2.35 / 2.45	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.71 / 1.81	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 100m_90 lpm_081127_01









90 lpm on air at 100m (> double maximum depth limit on air) exceeds NORSOK limits.

8.7. SRB. Heliox, Depth < 3m

8.7.1. SRB (Incursion), Heliox, <3m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV EN14143:2003	
TEST METHOD		RELATIVE	SINE FLOW
DATE AND TIME		10/01/09 18:00	
TEST CARRIED OUT BY	VD	WITNESS: MS	

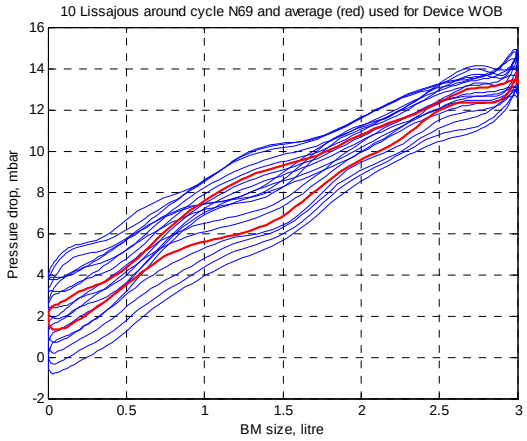
CONDITIONS OF TEST

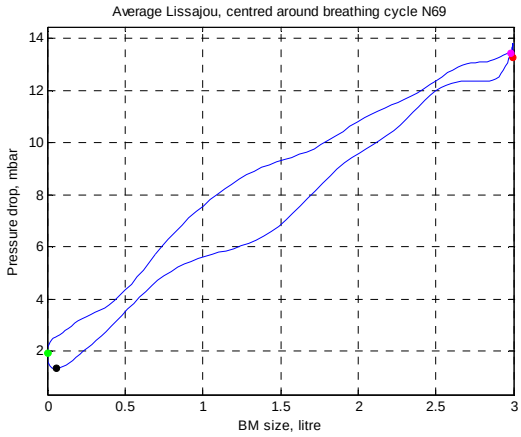
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	1.95	m
ROOM / WATER TEMPERATURE	:	19.0 / 4.8	℃
EHXALE GAS TEMPERATURE	:	19.3	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

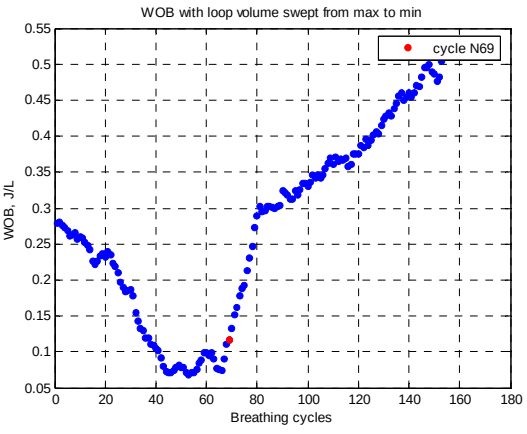
RESULTS

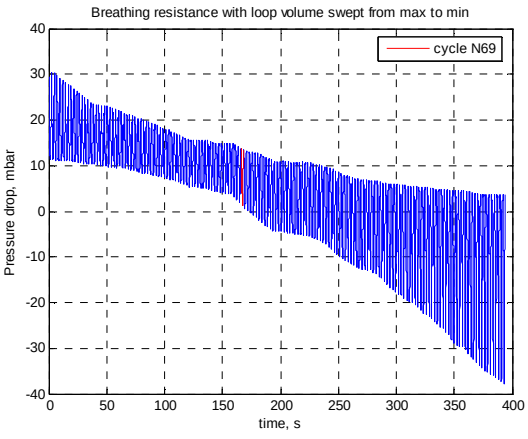
PRESSURE@END EXHALE / INHALE	=	13.3 / 1.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.3 / 13.4	mbar
PEAK TO PEAK PRESSURE	=	12.1	mbar
INHALE/EXHALE RESP PRESSURES	=	11.9 / 11.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.17	J/l
WOB OF BREATHING SIMULATOR	=	0.05	J/l
WOB OF DEVICE UNDER TEST	=	0.12	J/l
TOTAL POS / NEG WORK	=	0.13 / 0.02	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.11 / 0.00	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_mod2_90d_ 00m_75 lpm_090110_01He









8.8. SRB. Heliox, Depth 40m

8.8.1. SRB (Incursion), Heliox, 40m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

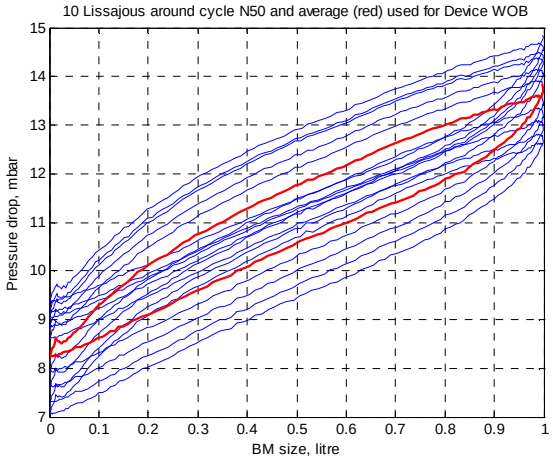
CONDITIONS OF TEST

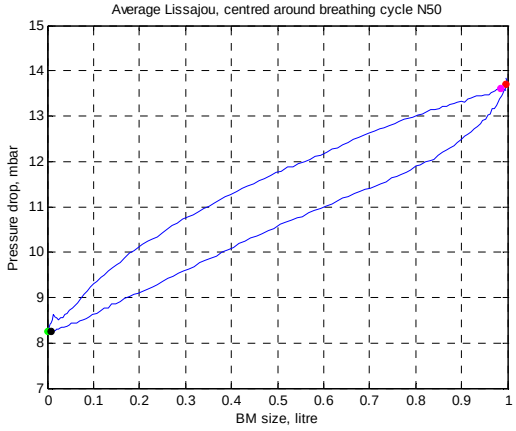
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.3	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	17.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0 lpm	metric

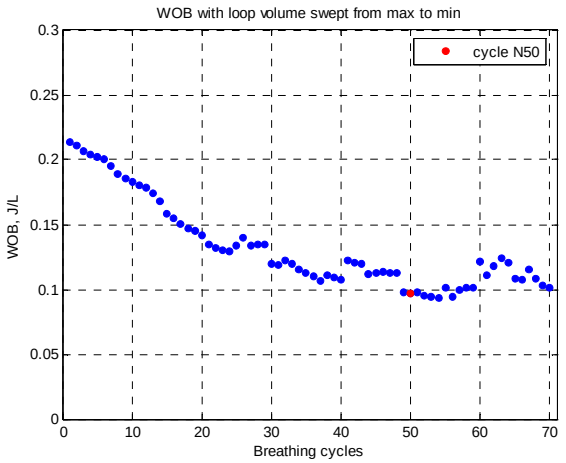
RESULTS

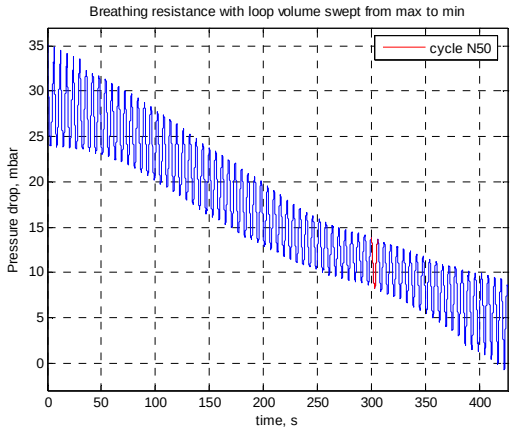
PRESSURE@END EXHALE / INHALE	=	13.7 / 8.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	8.2 / 13.6	mbar
PEAK TO PEAK PRESSURE	=	5.4	mbar
INHALE/EXHALE RESP PRESSURES	=	5.5 / 5.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.10	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.10	J/l
TOTAL POS / NEG WORK	=	0.06 / 0.04	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.06 / 0.04	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_10 lpm_HeOx_100211_2









8.8.2. SRB (Incursion), Heliox, 40m, 10 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

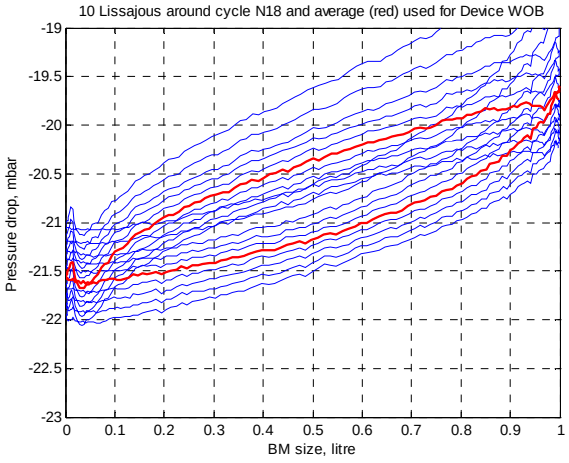
CONDITIONS OF TEST

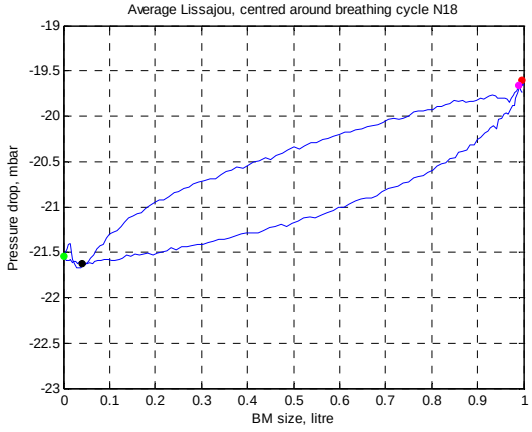
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.7	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	21.6	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0 lpm	metric

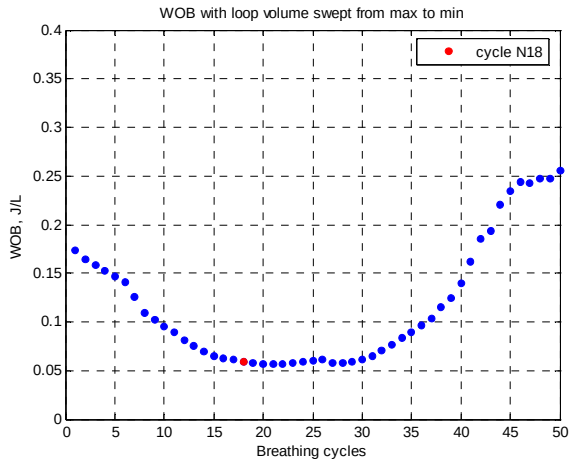
RESULTS

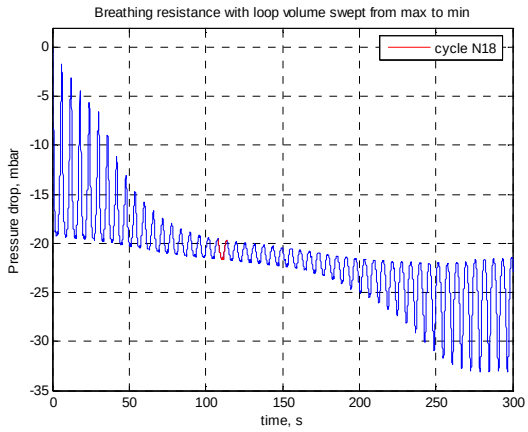
PRESSURE@END EXHALE / INHALE	=	-19.6 / -21.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-21.6 / -19.7	mbar
PEAK TO PEAK PRESSURE	=	2.0	mbar
INHALE/EXHALE RESP PRESSURES	=	2.0 / 1.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.06	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.06	J/l
TOTAL POS / NEG WORK	=	0.02 / 0.05	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.02 / 0.05	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_41m_10 lpm_HeOx_100211_1









8.8.3. SRB (Incursion), Heliox, 40m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	10.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

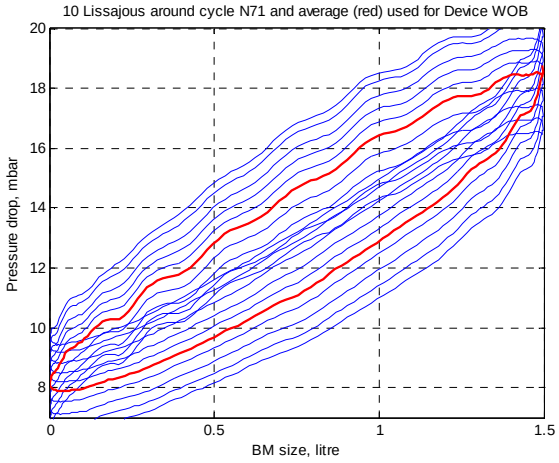
CONDITIONS OF TEST

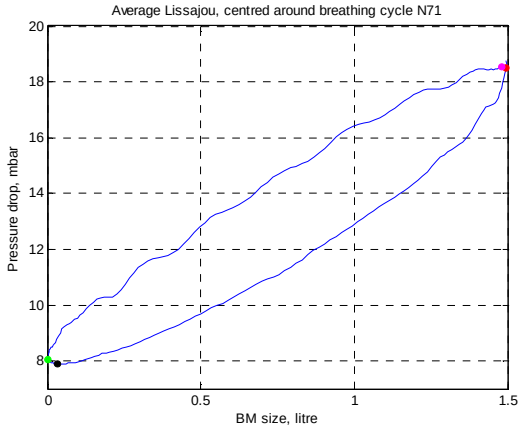
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	38.4	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	20.3	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/14.9bpm/22.4 lpm	metric

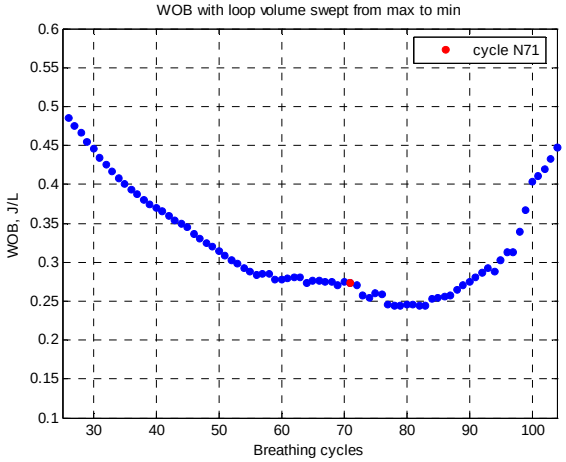
RESULTS

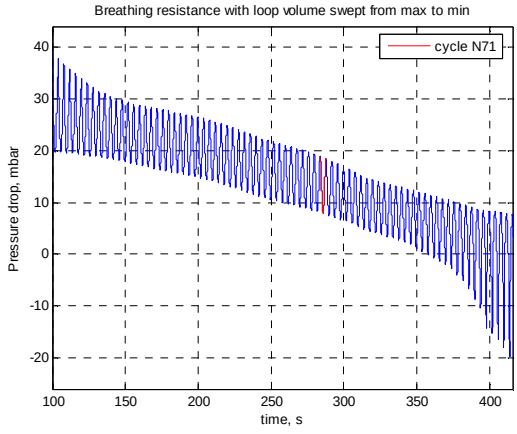
PRESSURE@END EXHALE / INHALE	=	18.5 / 8.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	7.9 / 18.5	mbar
PEAK TO PEAK PRESSURE	=	10.6	mbar
INHALE/EXHALE RESP PRESSURES	=	10.6 / 10.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.27	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.27	J/l
TOTAL POS / NEG WORK	=	0.09 / 0.17	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.09 / 0.17	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_38m_22.5 lpm_HeOx_100210_1









8.8.4. SRB (Incursion), Heliox, 40m, 22.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	10.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

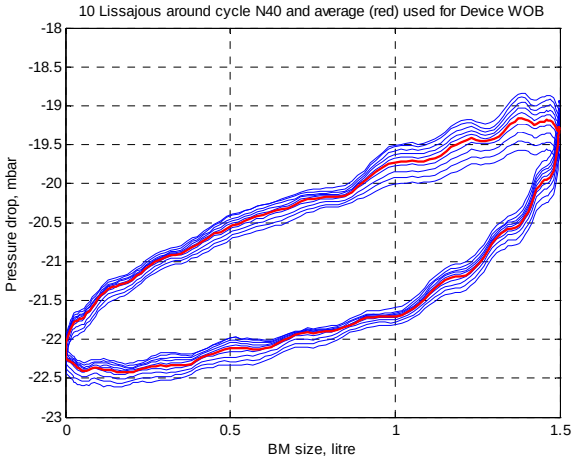
CONDITIONS OF TEST

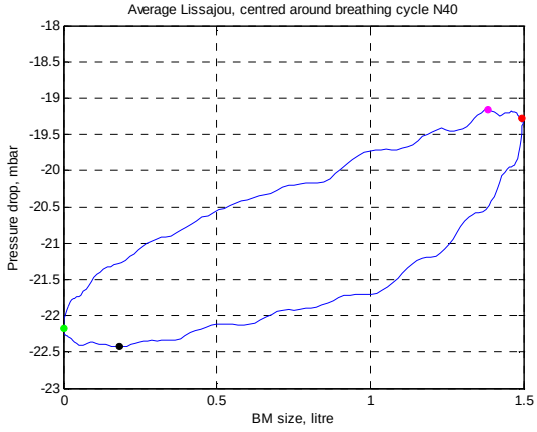
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	38.7	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	6.9	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5 lpm	metric

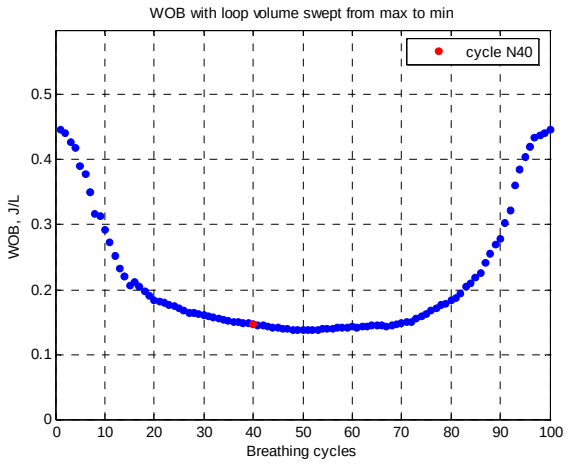
RESULTS

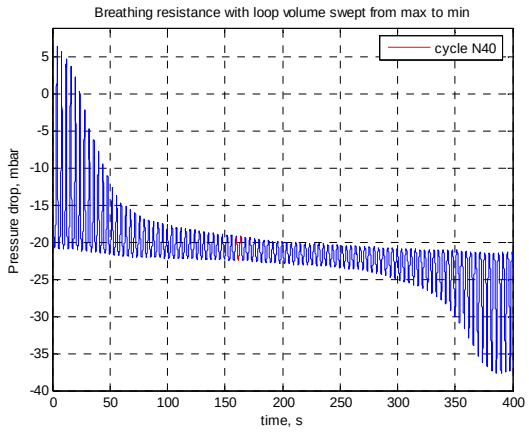
PRESSURE@END EXHALE / INHALE	=	-19.3 / -22.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.4 / -19.2	mbar
PEAK TO PEAK PRESSURE	=	3.3	mbar
INHALE/EXHALE RESP PRESSURES	=	3.2 / 3.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.15	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.15	J/l
TOTAL POS / NEG WORK	=	0.04 / 0.10	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.04 / 0.10	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_39m_22.5 lpm_HeOx_100210_1









8.8.5. SRB (Incursion), Heliox, 40m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

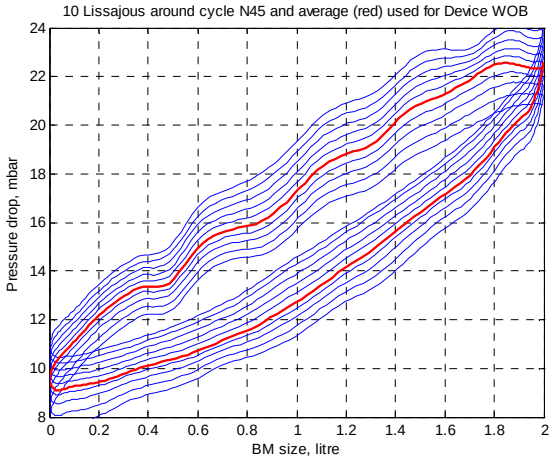
CONDITIONS OF TEST

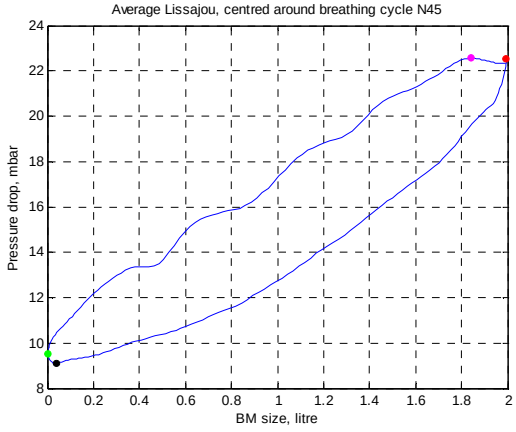
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.2	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	12.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

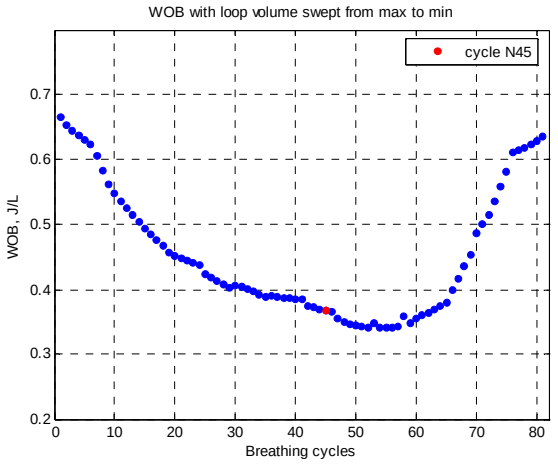
RESULTS

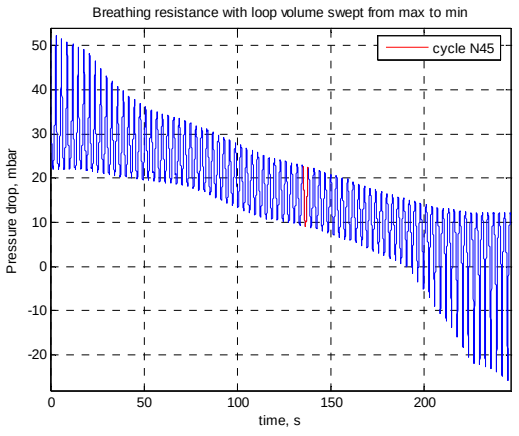
PRESSURE@END EXHALE / INHALE	=	22.5 / 9.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	9.1 / 22.6	mbar
PEAK TO PEAK PRESSURE	=	13.5	mbar
INHALE/EXHALE RESP PRESSURES	=	13.4 / 13.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.38	J/l
WOB OF BREATHING SIMULATOR	=	0.01	J/l
WOB OF DEVICE UNDER TEST	=	0.37	J/l
TOTAL POS / NEG WORK	=	0.12 / 0.25	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.12 / 0.25	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_40 lpm_HeOx_100209









8.8.6. SRB (Incursion), Heliox, 40m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

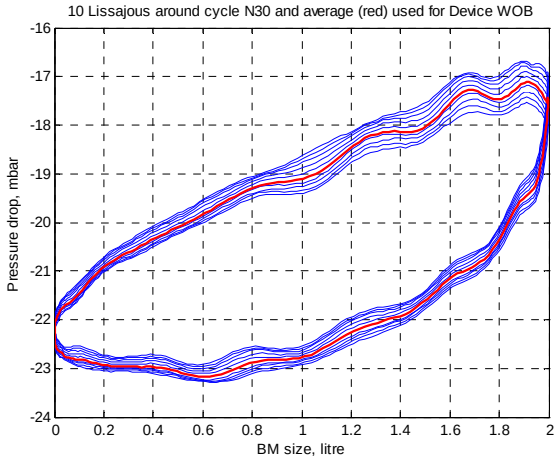
CONDITIONS OF TEST

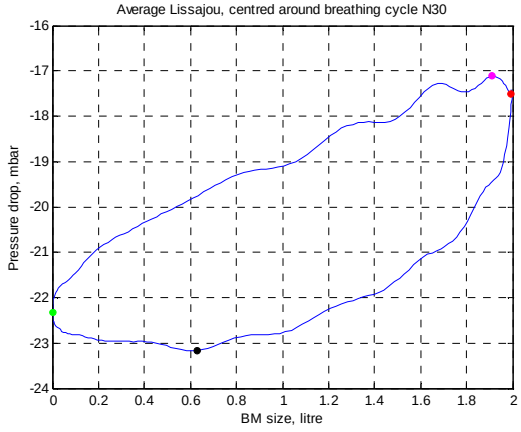
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.4	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	11.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

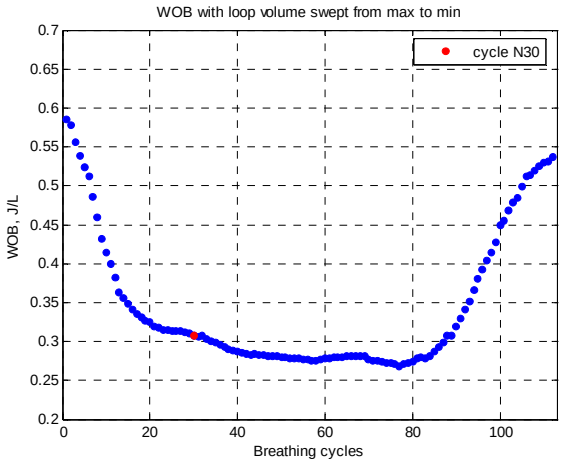
RESULTS

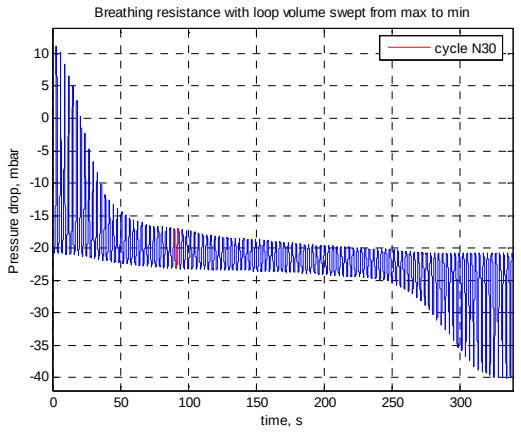
PRESSURE@END EXHALE / INHALE	=	-17.5 / -22.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-23.2 / -17.1	mbar
PEAK TO PEAK PRESSURE	=	6.1	mbar
INHALE/EXHALE RESP PRESSURES	=	5.7 / 5.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.32	J/l
WOB OF BREATHING SIMULATOR	=	0.01	J/l
WOB OF DEVICE UNDER TEST	=	0.31	J/l
TOTAL POS / NEG WORK	=	0.09 / 0.23	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.08 / 0.22	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_40m_40 lpm_HeOx_100209









8.8.7. SRB (Incursion), Heliox, 40m, 62.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	23.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

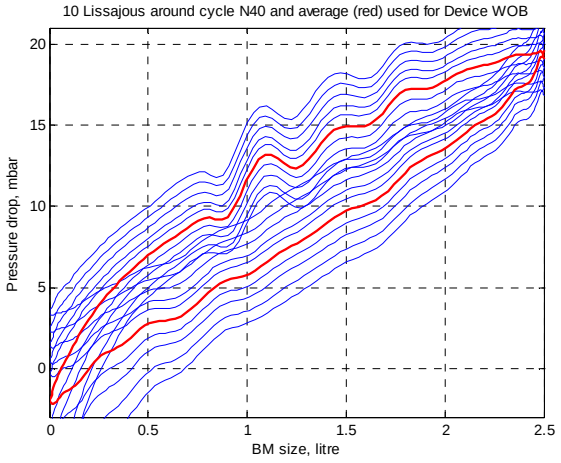
CONDITIONS OF TEST

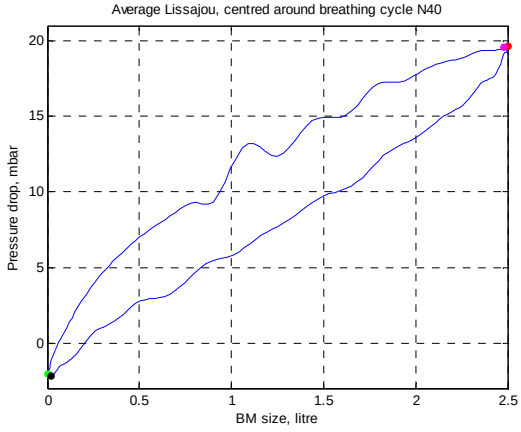
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.5	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	12.0	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5 lpm	metric

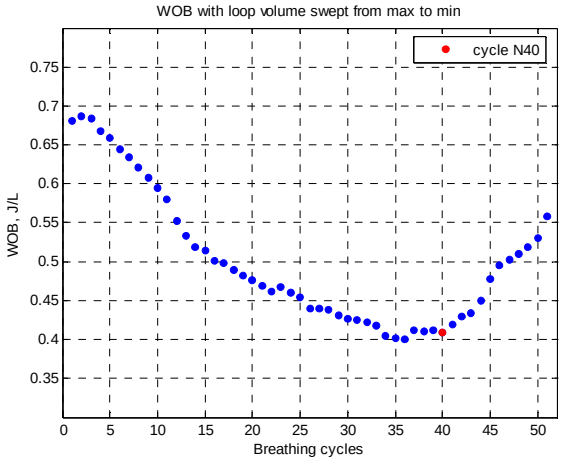
RESULTS

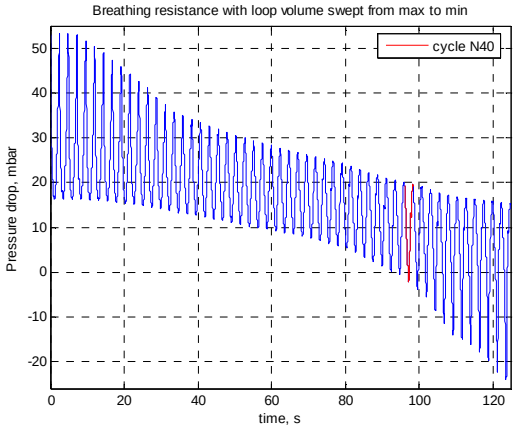
PRESSURE@END EXHALE / INHALE	=	19.6 / -2.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-2.2 / 19.5	mbar
PEAK TO PEAK PRESSURE	=	21.8	mbar
INHALE/EXHALE RESP PRESSURES	=	21.8 / 21.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.41	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.41	J/l
TOTAL POS / NEG WORK	=	0.37 / 0.08	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.37 / 0.08	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_S1_90d_41m_62.5 lpm_HeOx_100223_2









8.8.8. SRB (Incursion), Heliox, 40m, 62.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	23.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

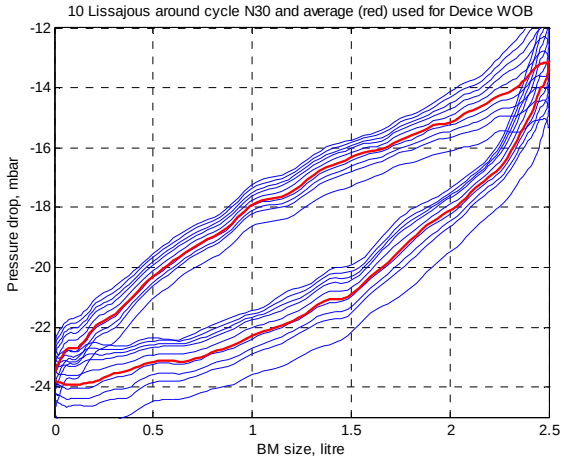
CONDITIONS OF TEST

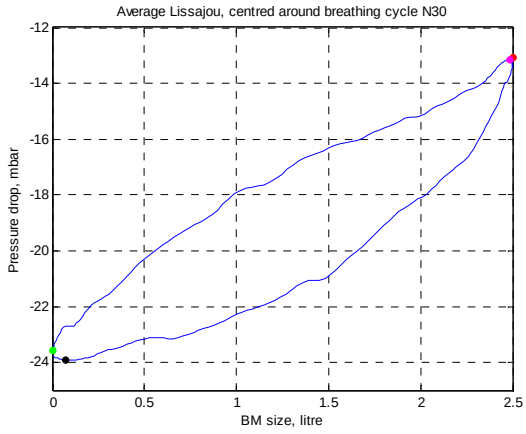
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.4	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.9	℃
EHXALE GAS TEMPERATURE	:	16.1	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.4 lpm	metric

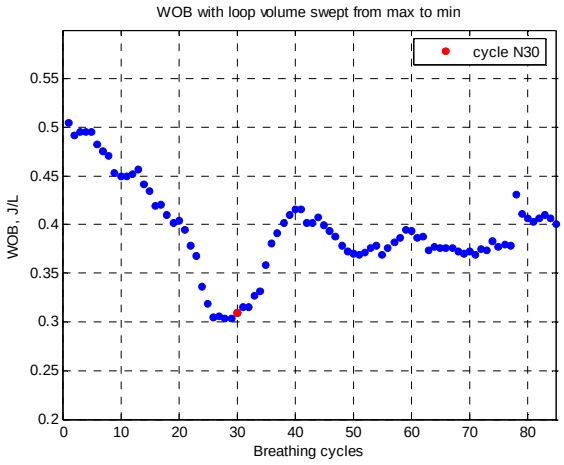
RESULTS

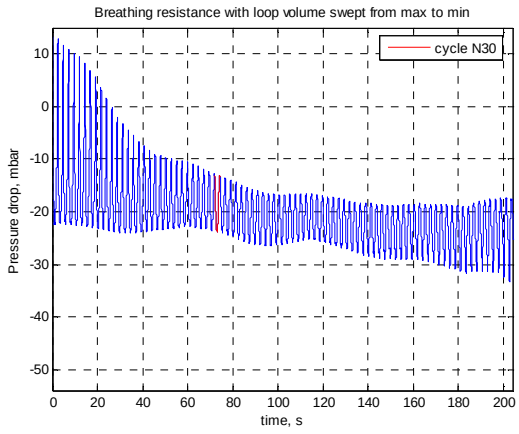
PRESSURE@END EXHALE / INHALE	=	-13.1 / -23.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-23.9 / -13.2	mbar
PEAK TO PEAK PRESSURE	=	10.8	mbar
INHALE/EXHALE RESP PRESSURES	=	10.9 / 10.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.31	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.31	J/l
TOTAL POS / NEG WORK	=	0.09 / 0.25	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.09 / 0.25	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_S1_0d_40m_62.5 lpm_HeOx_100223_1









8.8.9. SRB (iCCR), Heliox, 40m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR SRB iCCR Sample 2	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

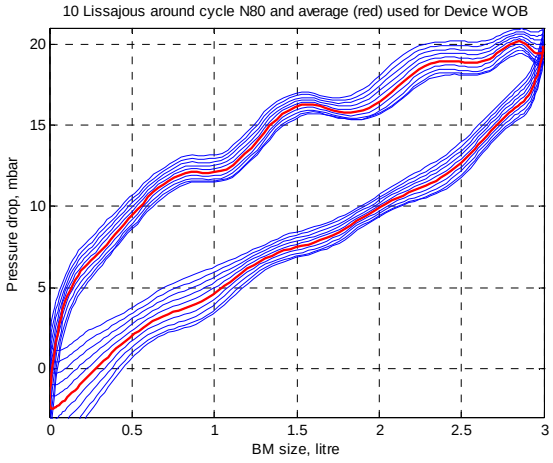
CONDITIONS OF TEST

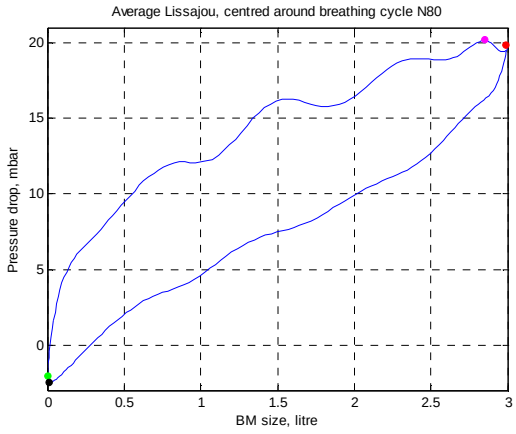
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	39.6	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	15.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.1bpm/75.1 lpm	metric

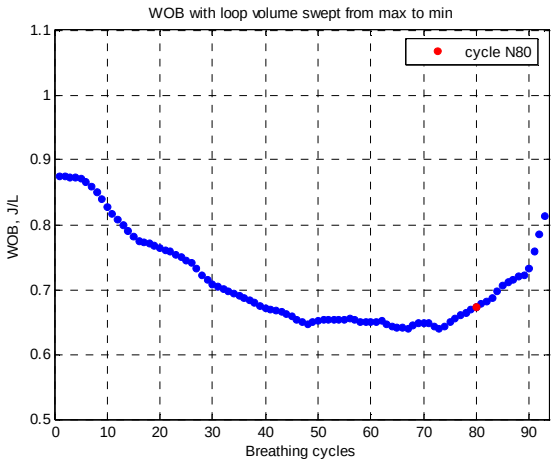
RESULTS

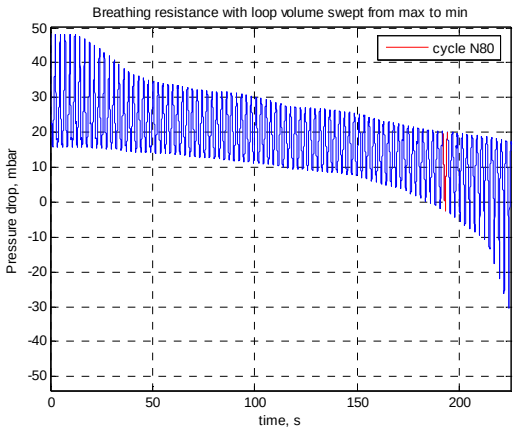
PRESSURE@END EXHALE / INHALE	=	19.8 / -2.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-2.5 / 20.2	mbar
PEAK TO PEAK PRESSURE	=	22.6	mbar
INHALE/EXHALE RESP PRESSURES	=	22.3 / 22.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.73	J/l
WOB OF BREATHING SIMULATOR	=	0.06	J/l
WOB OF DEVICE UNDER TEST	=	0.67	J/l
TOTAL POS / NEG WORK	=	0.55 / 0.18	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.52 / 0.15	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_40m_75 lpm_HeOx_100205









8.8.10. SRB (Incursion), Heliox, 40m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

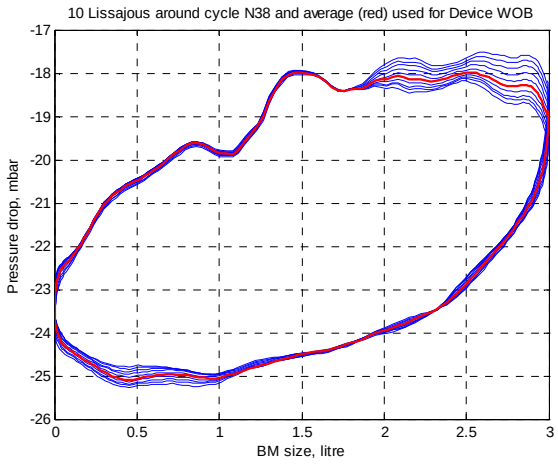
CONDITIONS OF TEST

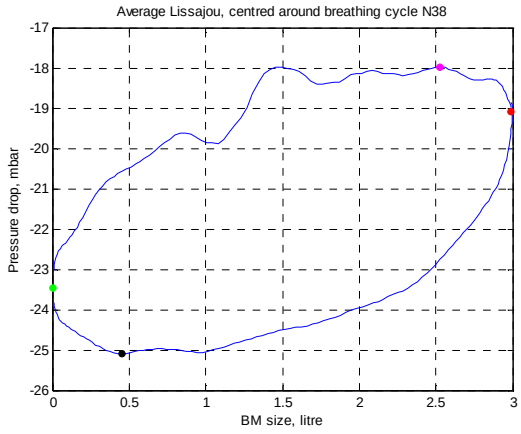
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	12.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.8bpm/77.4 lpm	metric

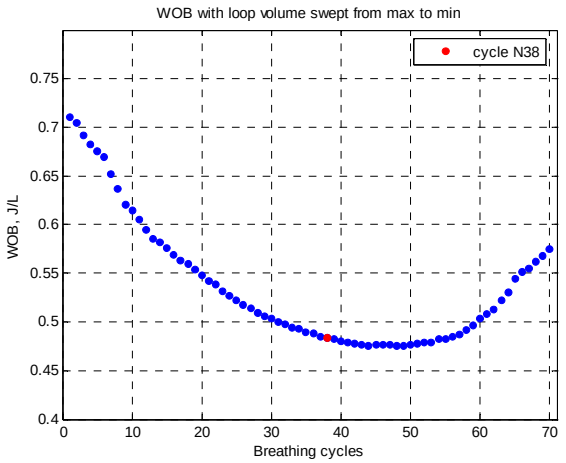
RESULTS

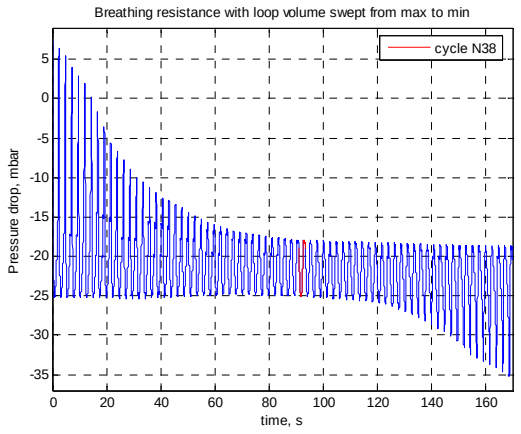
PRESSURE@END EXHALE / INHALE	=	-19.1 / -23.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-25.1 / -18.0	mbar
PEAK TO PEAK PRESSURE	=	7.1	mbar
INHALE/EXHALE RESP PRESSURES	=	6.0 / 5.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.54	J/l
WOB OF BREATHING SIMULATOR	=	0.06	J/l
WOB OF DEVICE UNDER TEST	=	0.48	J/l
TOTAL POS / NEG WORK	=	0.22 / 0.30	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.20 / 0.27	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_41m_75 lpm_HeOx_100205_1









8.8.11. SRB (Incursion), Heliox, 40m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11/01/09 13:49	
TEST CARRIED OUT BY		VD WITNESS: MS	

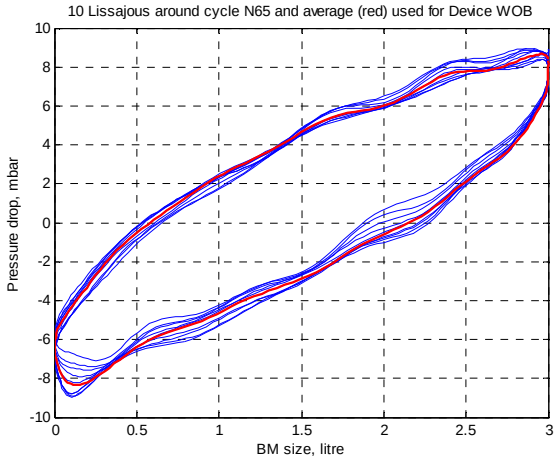
CONDITIONS OF TEST

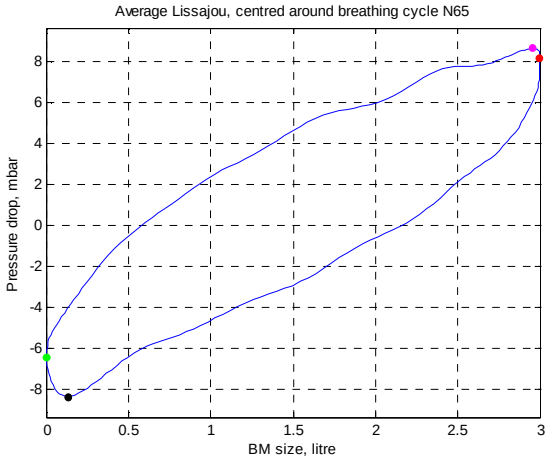
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	39.25	m
ROOM / WATER TEMPERATURE	:	18.7 / 4.3	℃
EHXALE GAS TEMPERATURE	:	20.2	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.1 lpm	metric

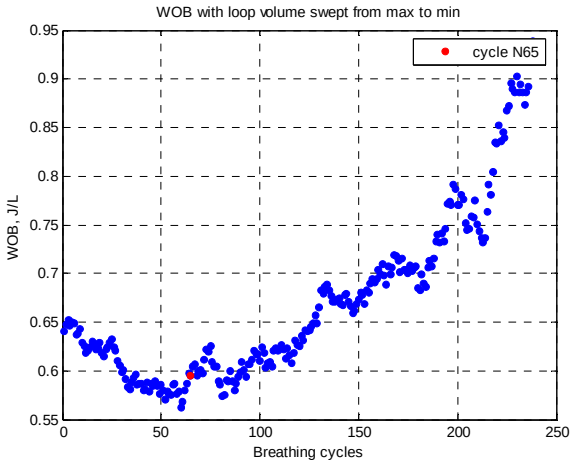
RESULTS

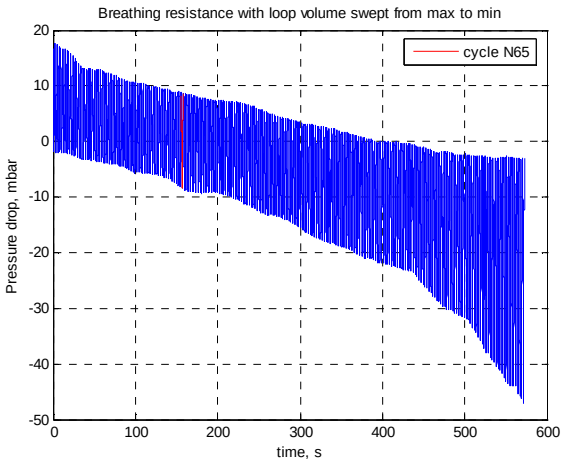
PRESSURE@END EXHALE / INHALE	=	8.2 / -6.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-8.4 / 8.7	mbar
PEAK TO PEAK PRESSURE	=	17.0	mbar
INHALE/EXHALE RESP PRESSURES	=	16.5 / 15.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.76	J/l
WOB OF BREATHING SIMULATOR	=	0.16	J/l
WOB OF DEVICE UNDER TEST	=	0.59	J/l
TOTAL POS / NEG WORK	=	0.35 / 0.37	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.27 / 0.29	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 40m_75 lpm_090111_01He









8.8.12. SRB (Incursion), Heliox, 40m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	27/11/08 13:11	
TEST CARRIED OUT BY		VD WITNESS: MS	

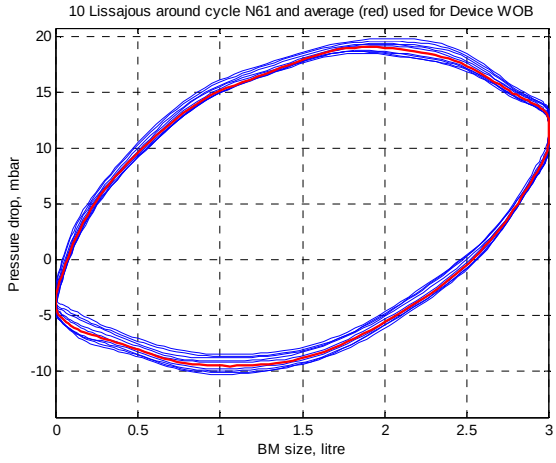
CONDITIONS OF TEST

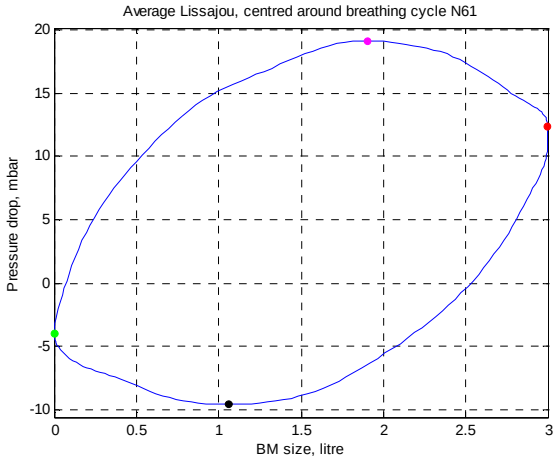
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	39.98	m
ROOM / WATER TEMPERATURE	:	20.7 / 3.7	℃
EHXALE GAS TEMPERATURE	:	15.7	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.9bpm/89.7 lpm	metric

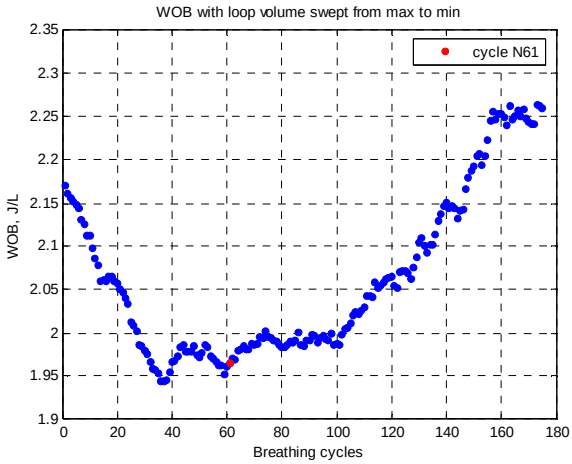
RESULTS

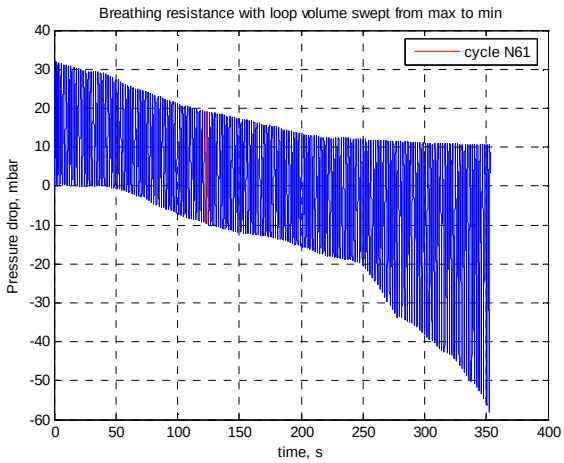
PRESSURE@END EXHALE / INHALE	=	12.4 / -4.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-9.6 / 19.1	mbar
PEAK TO PEAK PRESSURE	=	28.7	mbar
INHALE/EXHALE RESP PRESSURES	=	21.9 / 23.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	2.58	J/l
WOB OF BREATHING SIMULATOR	=	0.61	J/l
WOB OF DEVICE UNDER TEST	=	1.97	J/l
TOTAL POS / NEG WORK	=	1.31 / 1.20	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.01 / 0.90	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 40m_90 lpm_081127_02









8.9. SRB. Heliox, Depth 100m

8.9.1. SRB (Incursion), Heliox, 100m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

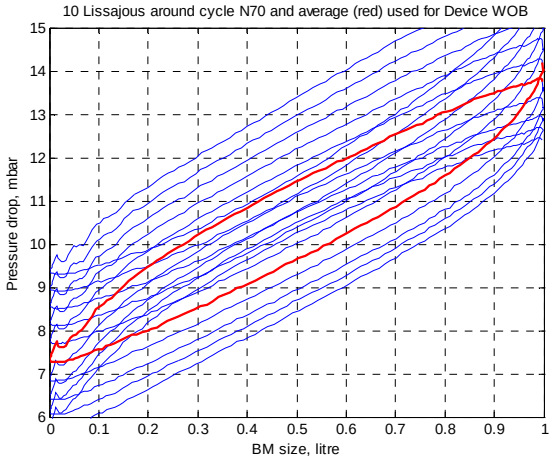
CONDITIONS OF TEST

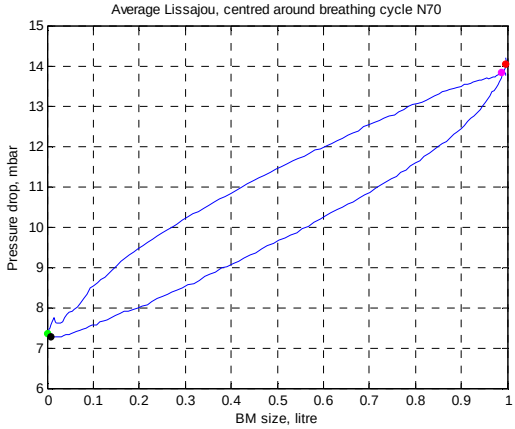
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.6	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	18.2	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0 lpm	metric

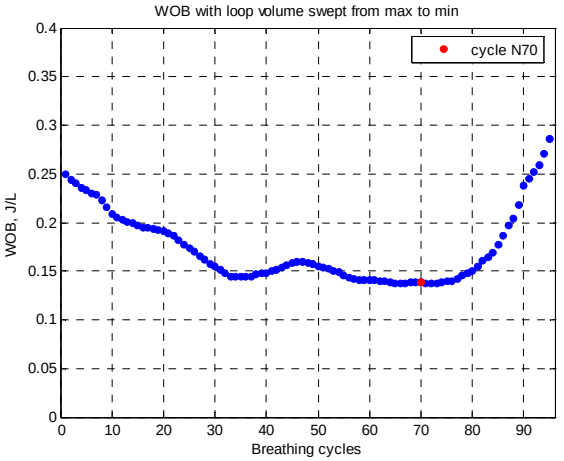
RESULTS

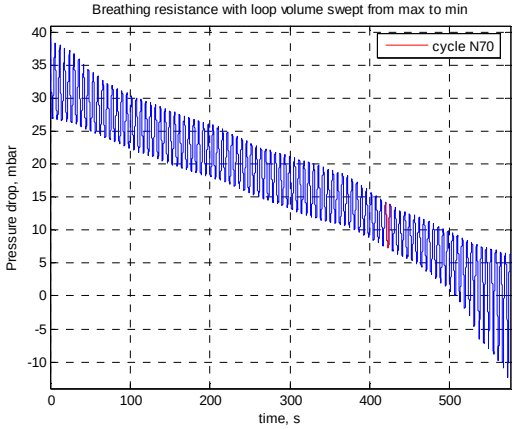
PRESSURE@END EXHALE / INHALE	=	14.0 / 7.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	7.3 / 13.8	mbar
PEAK TO PEAK PRESSURE	=	6.6	mbar
INHALE/EXHALE RESP PRESSURES	=	6.8 / 6.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.14	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.14	J/l
TOTAL POS / NEG WORK	=	0.06 / 0.09	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.06 / 0.09	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_101m_10 lpm_HeOx_100211_1









8.9.2. SRB (Incursion), Heliox, 100m, 10 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

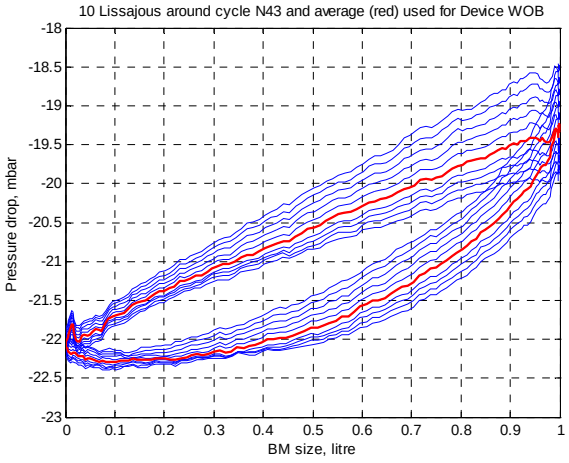
CONDITIONS OF TEST

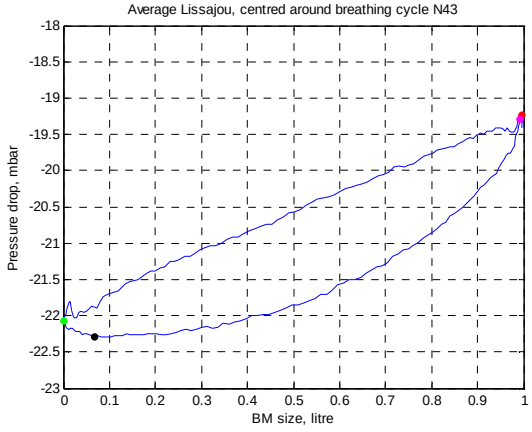
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.4	℃
EHXALE GAS TEMPERATURE	:	16.9	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0 lpm	metric

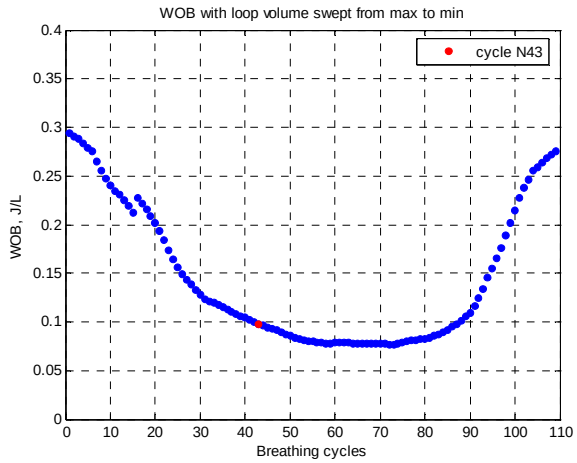
RESULTS

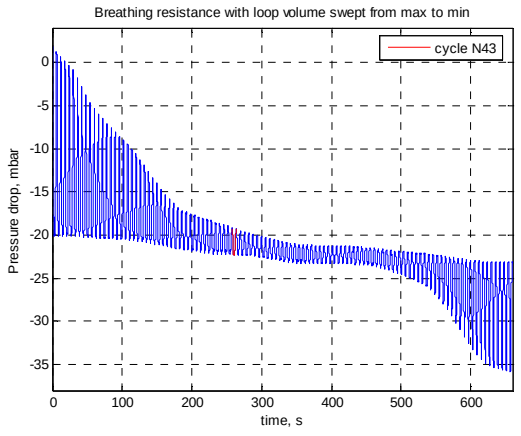
PRESSURE@END EXHALE / INHALE	=	-19.2 / -22.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.3 / -19.3	mbar
PEAK TO PEAK PRESSURE	=	3.0	mbar
INHALE/EXHALE RESP PRESSURES	=	3.1 / 2.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.10	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.10	J/l
TOTAL POS / NEG WORK	=	0.01 / 0.09	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.01 / 0.09	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_101m_10 lpm_HeOx_100211_1









8.9.3. SRB (Incursion), Heliox, 100m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	10.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

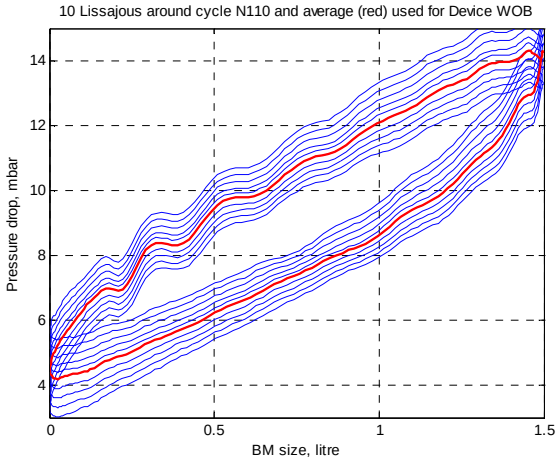
CONDITIONS OF TEST

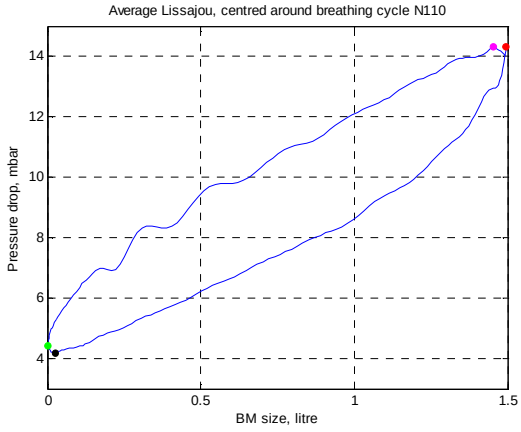
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	97.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	15.3	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5 lpm	metric

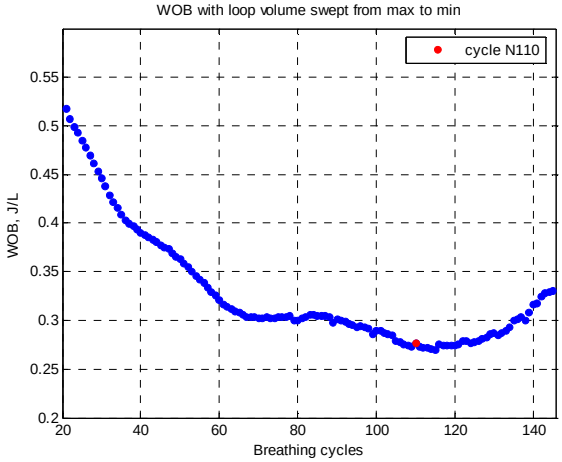
RESULTS

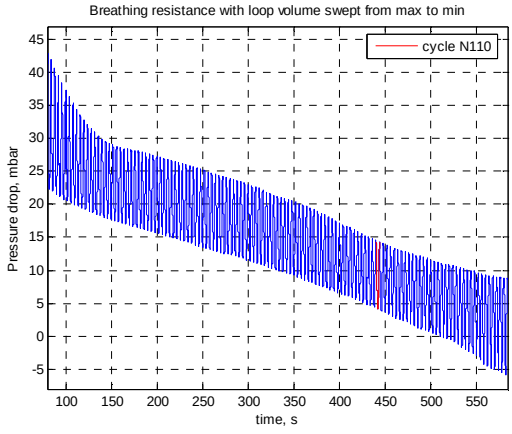
PRESSURE@END EXHALE / INHALE	=	14.3 / 4.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	4.2 / 14.3	mbar
PEAK TO PEAK PRESSURE	=	10.1	mbar
INHALE/EXHALE RESP PRESSURES	=	10.1 / 9.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.28	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.28	J/l
TOTAL POS / NEG WORK	=	0.11 / 0.16	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.11 / 0.16	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_98m_22.5 lpm_HeOx_100210_1









8.9.4. SRB (Incursion), Heliox, 100m, 22.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	10.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

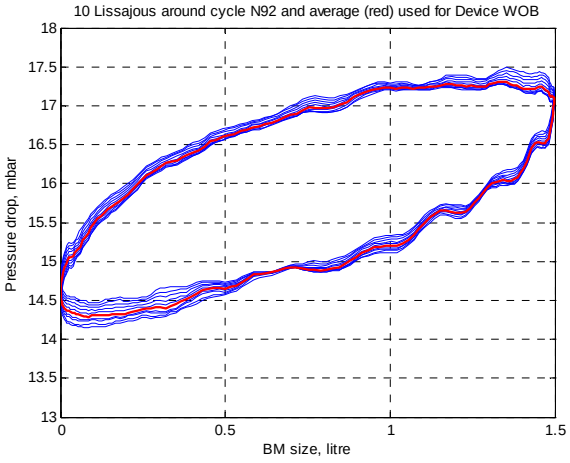
CONDITIONS OF TEST

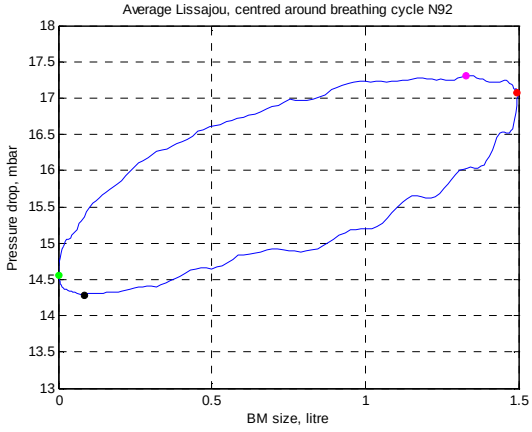
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	98.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.2	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5 lpm	metric

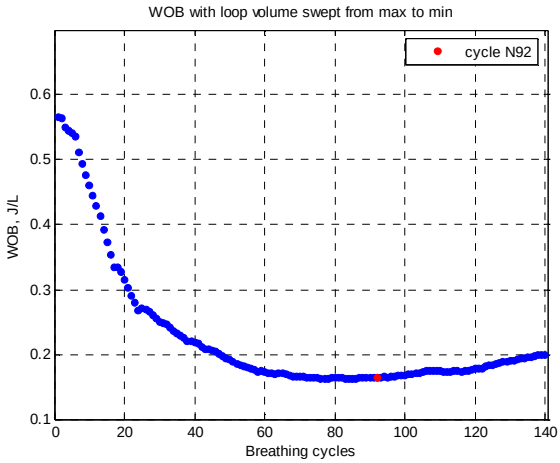
RESULTS

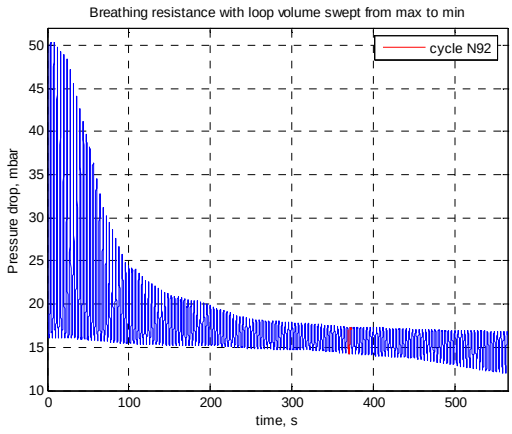
PRESSURE@END EXHALE / INHALE	=	17.1 / 14.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	14.3 / 17.3	mbar
PEAK TO PEAK PRESSURE	=	3.0	mbar
INHALE/EXHALE RESP PRESSURES	=	2.8 / 2.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.16	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.16	J/l
TOTAL POS / NEG WORK	=	0.08 / 0.08	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.08 / 0.08	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_99m_22.5 lpm_HeOx_100210_1









8.9.5. SRB (Incursion), Heliox, 100m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

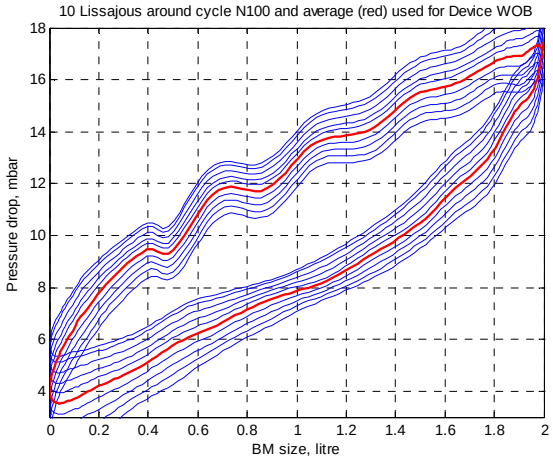
CONDITIONS OF TEST

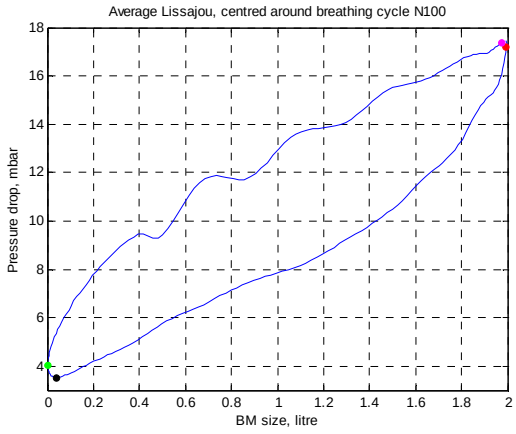
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.3	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	11.6	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

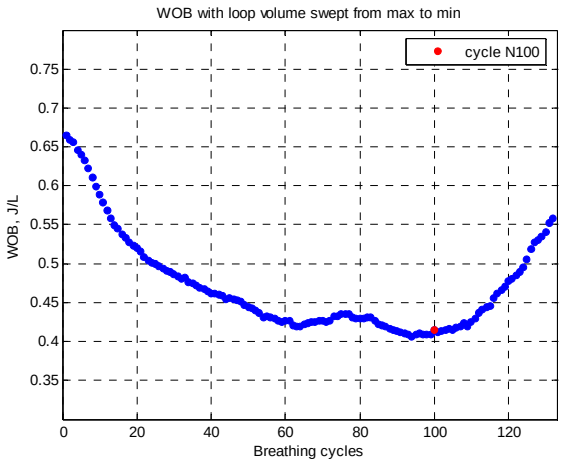
RESULTS

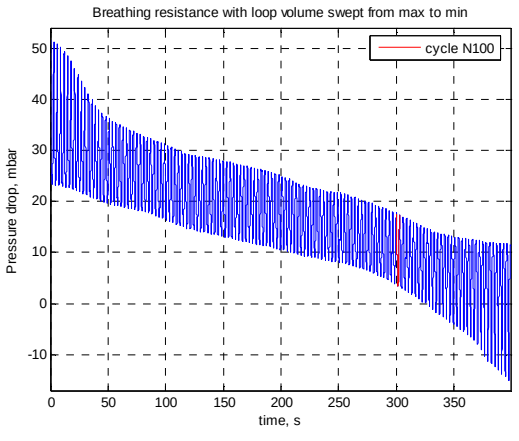
PRESSURE@END EXHALE / INHALE	=	17.2 / 4.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	3.5 / 17.3	mbar
PEAK TO PEAK PRESSURE	=	13.8	mbar
INHALE/EXHALE RESP PRESSURES	=	13.7 / 13.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.43	J/l
WOB OF BREATHING SIMULATOR	=	0.02	J/l
WOB OF DEVICE UNDER TEST	=	0.42	J/l
TOTAL POS / NEG WORK	=	0.18 / 0.23	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.18 / 0.23	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_100m_40 lpm_HeOx_100209









8.9.6. SRB (Incursion), Heliox, 100m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	09.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

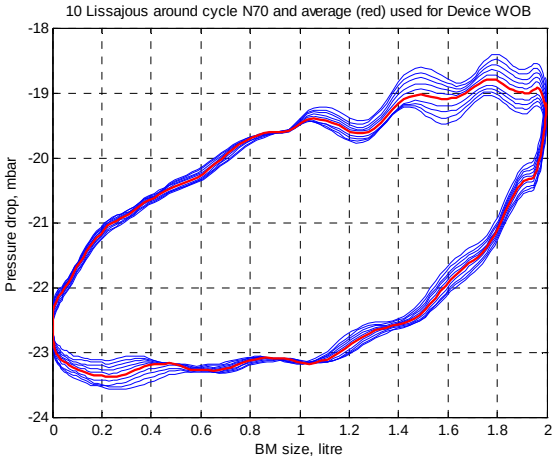
CONDITIONS OF TEST

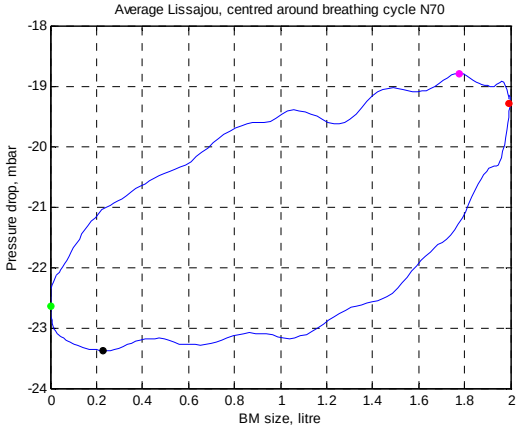
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.4	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	11.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

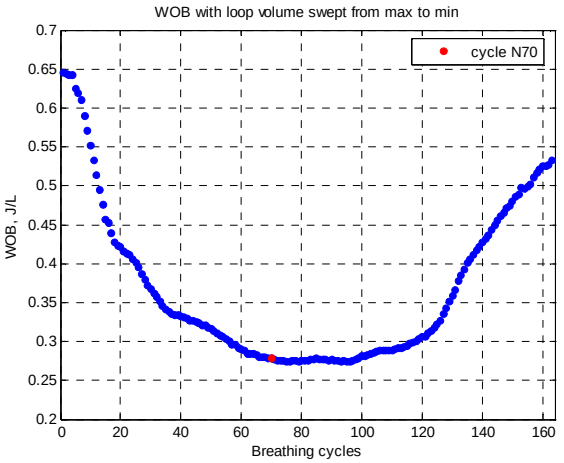
RESULTS

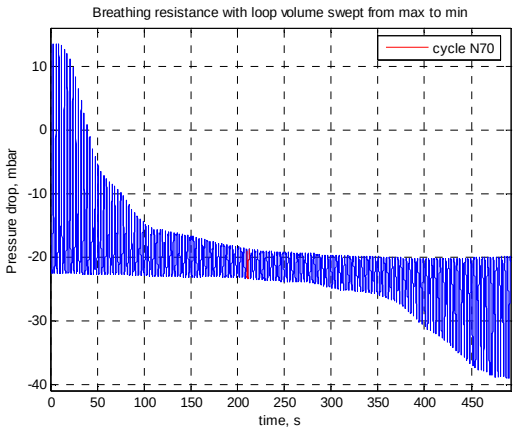
PRESSURE@END EXHALE / INHALE	=	-19.3 / -22.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-23.4 / -18.8	mbar
PEAK TO PEAK PRESSURE	=	4.6	mbar
INHALE/EXHALE RESP PRESSURES	=	4.1 / 3.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.29	J/l
WOB OF BREATHING SIMULATOR	=	0.02	J/l
WOB OF DEVICE UNDER TEST	=	0.28	J/l
TOTAL POS / NEG WORK	=	0.11 / 0.17	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.10 / 0.17	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_100m_40 lpm_HeOx_100209









8.9.7. SRB (Incursion), Heliox, 100m, 62.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	23.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

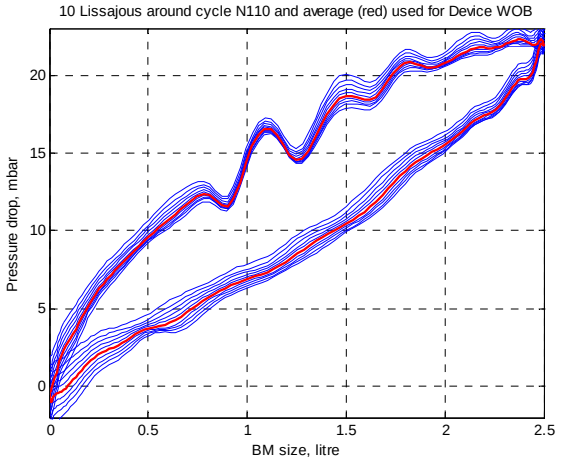
CONDITIONS OF TEST

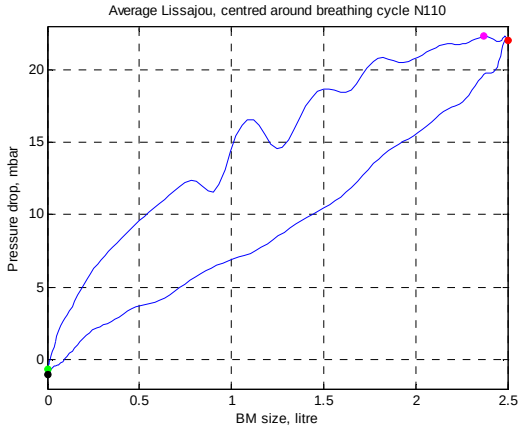
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.3	℃
EHXALE GAS TEMPERATURE	:	11.8	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5 lpm	metric

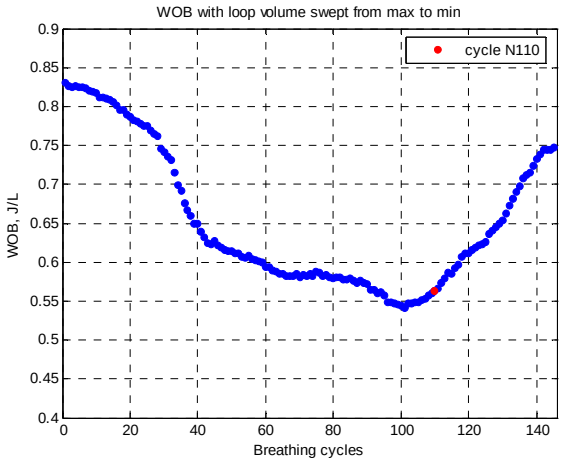
RESULTS

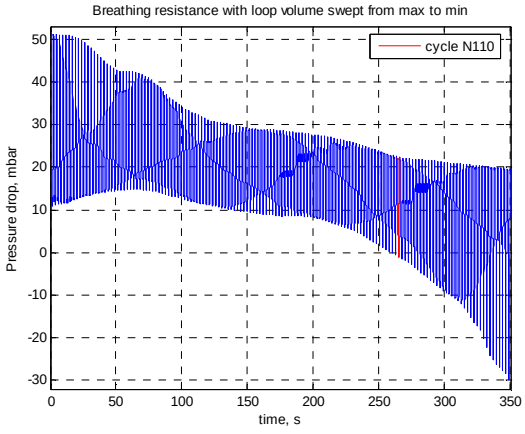
PRESSURE@END EXHALE / INHALE	=	22.0 / -0.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-1.0 / 22.3	mbar
PEAK TO PEAK PRESSURE	=	23.3	mbar
INHALE/EXHALE RESP PRESSURES	=	23.1 / 23.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.56	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.56	J/l
TOTAL POS / NEG WORK	=	0.45 / 0.14	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.45 / 0.14	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_S1_90d_101m_62.5 lpm_HeOx_100223_1









8.9.8. SRB (Incursion), Heliox, 100m, 62.5 lpm RMV, 00° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	23.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

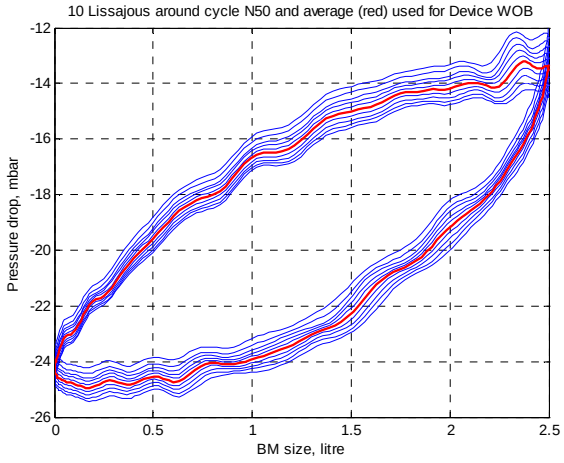
CONDITIONS OF TEST

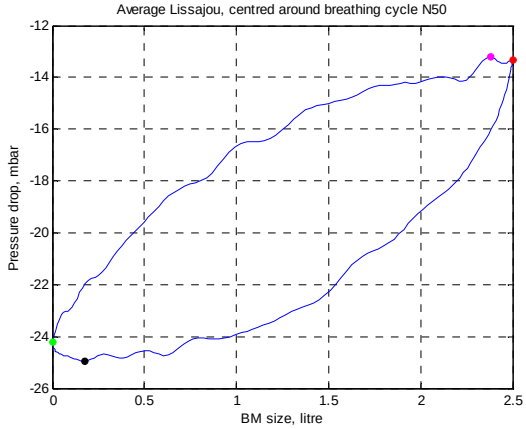
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	14.2	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5 lpm	metric

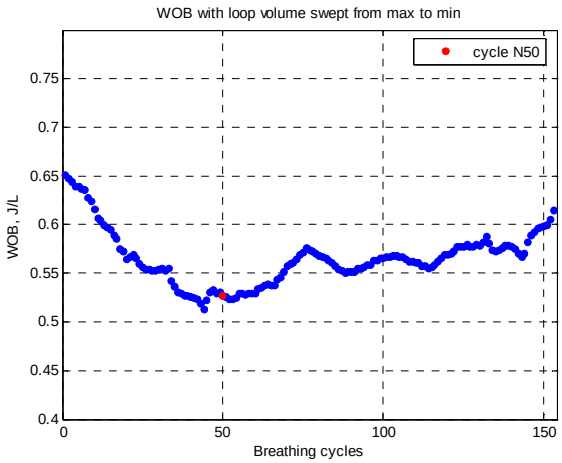
RESULTS

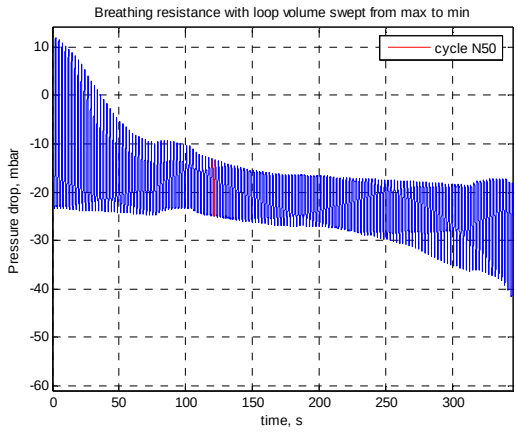
PRESSURE@END EXHALE / INHALE	=	-13.3 / -24.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.9 / -13.2	mbar
PEAK TO PEAK PRESSURE	=	11.7	mbar
INHALE/EXHALE RESP PRESSURES	=	11.6 / 11.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.53	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.53	J/l
TOTAL POS / NEG WORK	=	0.21 / 0.33	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.21 / 0.33	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_S1_0d_101m_62.5 lpm_HeOx_100223_1









8.9.9. SRB (iCCR), Heliox, 100m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB iCCR with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	11/01/09 14:30	
TEST CARRIED OUT BY	VD	WITNESS: MS	

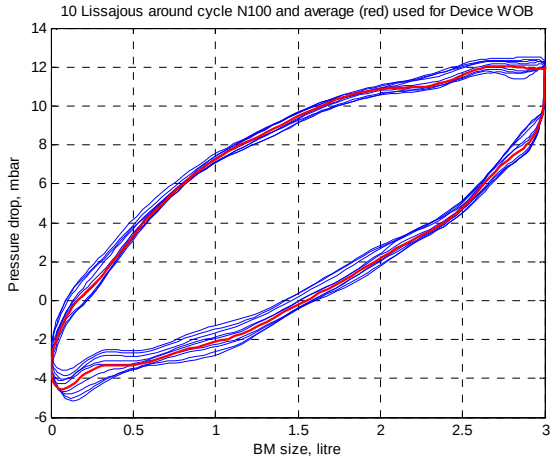
CONDITIONS OF TEST

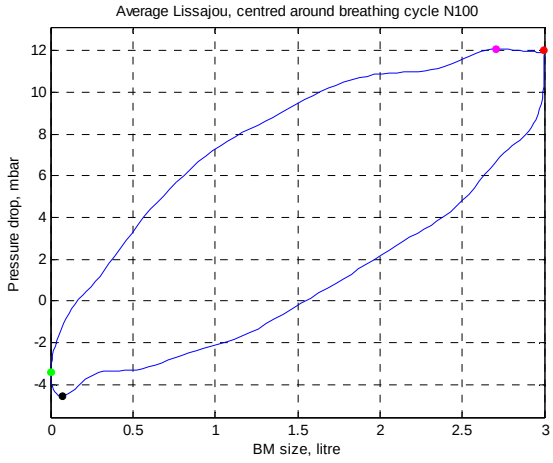
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	99.67	m
ROOM / WATER TEMPERATURE	:	18.7 / 4.5	℃
EHXALE GAS TEMPERATURE	:	19.9	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

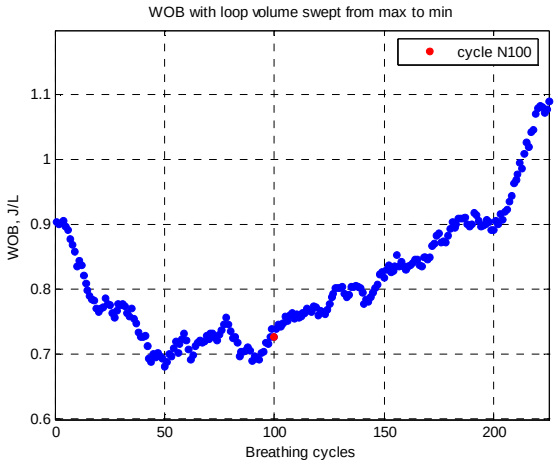
RESULTS

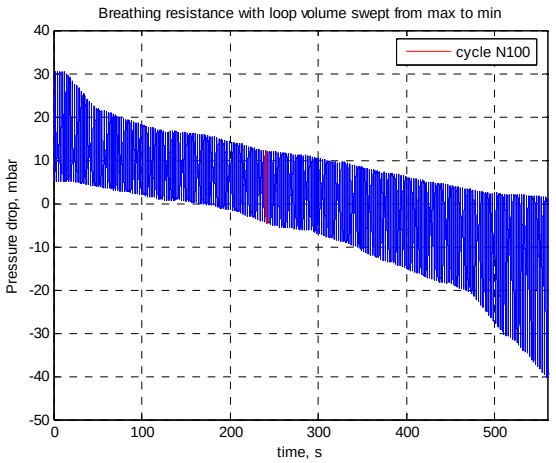
PRESSURE@END EXHALE / INHALE	=	12.0 / -3.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-4.6 / 12.1	mbar
PEAK TO PEAK PRESSURE	=	16.6	mbar
INHALE/EXHALE RESP PRESSURES	=	16.6 / 15.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.07	J/l
WOB OF BREATHING SIMULATOR	=	0.34	J/l
WOB OF DEVICE UNDER TEST	=	0.73	J/l
TOTAL POS / NEG WORK	=	0.53 / 0.51	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.37 / 0.33	J/l

ALL DATA STORED AS # (DATA FILE): WOB_SRB_helmMTHPCmod2_90d_ 100m_75 lpm_090111_01He









8.9.10. SRB (Incursion), Heliox, 100m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

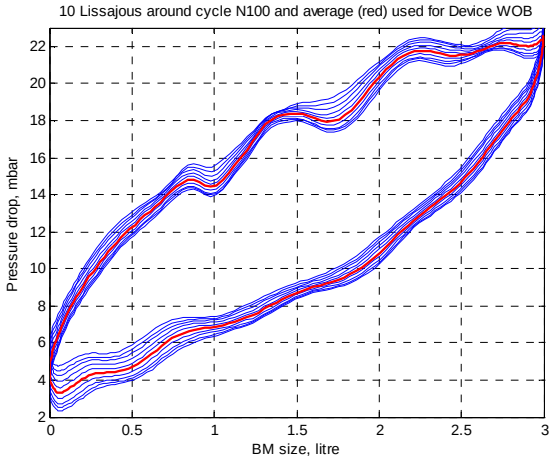
CONDITIONS OF TEST

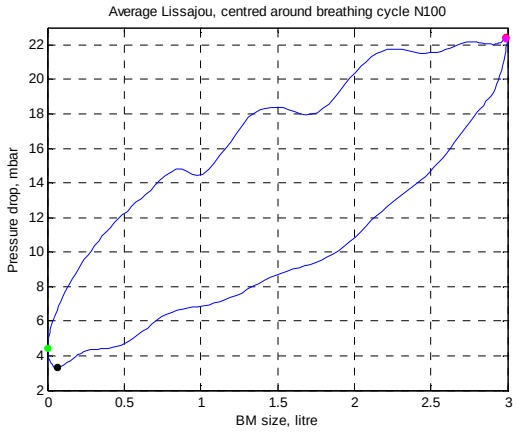
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	99.1	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	13.9	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.7bpm/77.1 lpm	metric

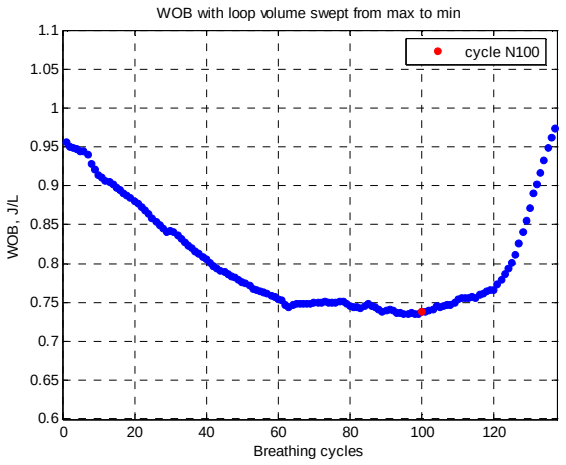
RESULTS

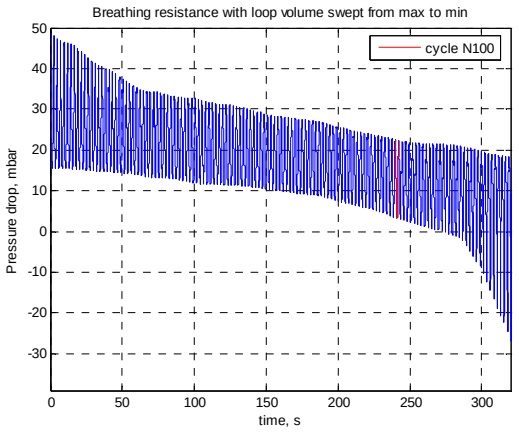
PRESSURE@END EXHALE / INHALE	=	22.4 / 4.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	3.3 / 22.4	mbar
PEAK TO PEAK PRESSURE	=	19.1	mbar
INHALE/EXHALE RESP PRESSURES	=	19.1 / 17.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.81	J/l
WOB OF BREATHING SIMULATOR	=	0.07	J/l
WOB OF DEVICE UNDER TEST	=	0.74	J/l
TOTAL POS / NEG WORK	=	0.38 / 0.43	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.34 / 0.39	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_100m_75 lpm_HeOx_100205









8.9.11. SRB (Incursion), Heliox, 100m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

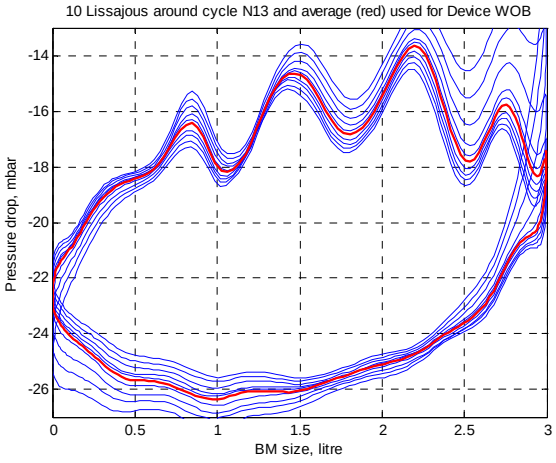
CONDITIONS OF TEST

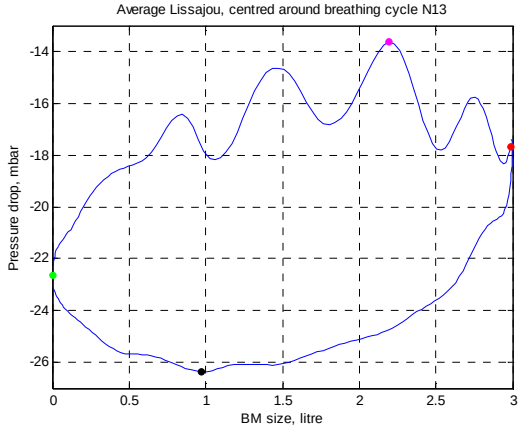
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	102.0	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	11.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.8bpm/77.3 lpm	metric

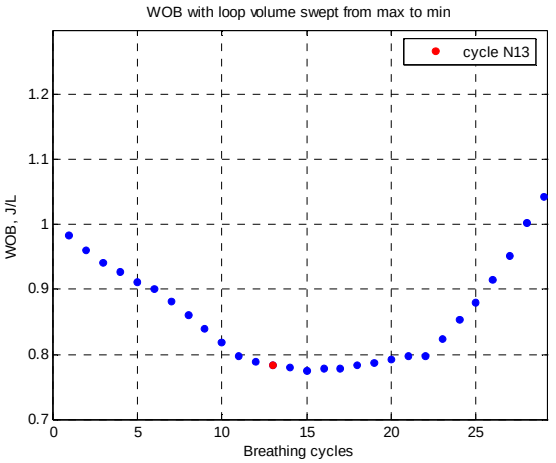
RESULTS

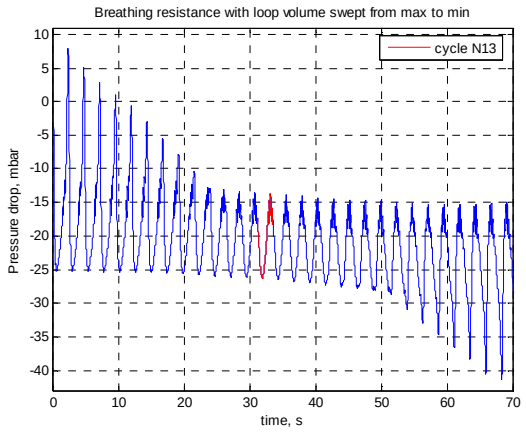
PRESSURE@END EXHALE / INHALE	=	-17.7 / -22.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-26.4 / -13.7	mbar
PEAK TO PEAK PRESSURE	=	12.7	mbar
INHALE/EXHALE RESP PRESSURES	=	8.7 / 9.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.86	J/l
WOB OF BREATHING SIMULATOR	=	0.07	J/l
WOB OF DEVICE UNDER TEST	=	0.78	J/l
TOTAL POS / NEG WORK	=	0.35 / 0.50	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.32 / 0.46	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_102m_75 lpm_HeOx_100205_1









8.9.12. SRB (Incursion), Heliox, 100m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

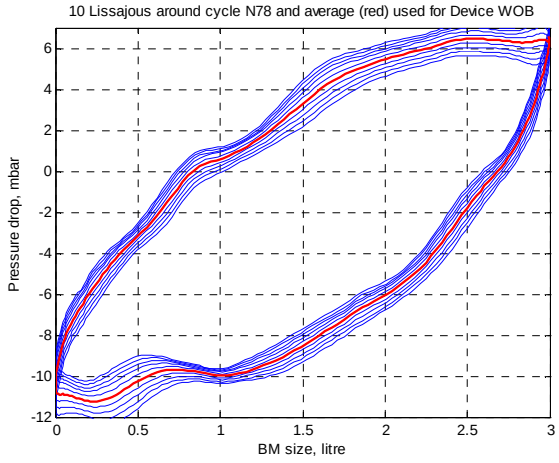
CONDITIONS OF TEST

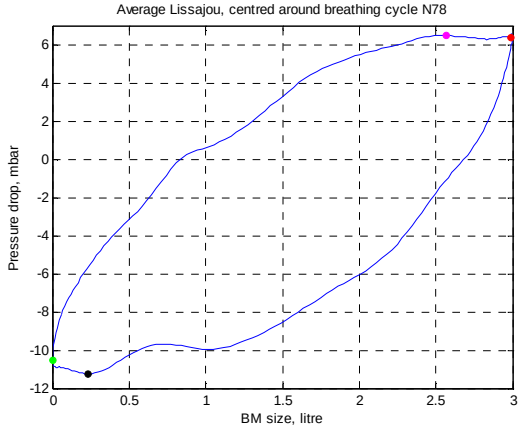
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	99.1	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	13.2	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/30.1bpm/90.2 lpm	metric

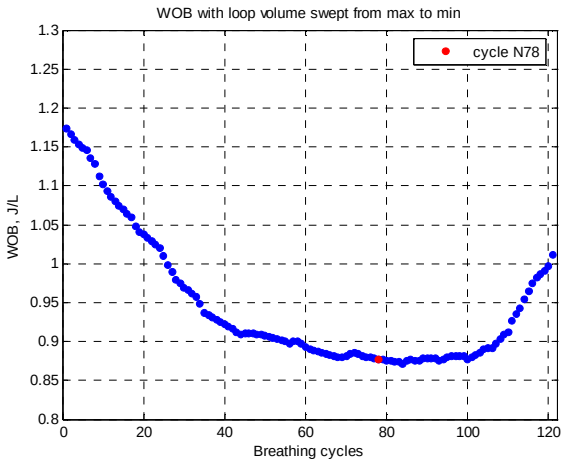
RESULTS

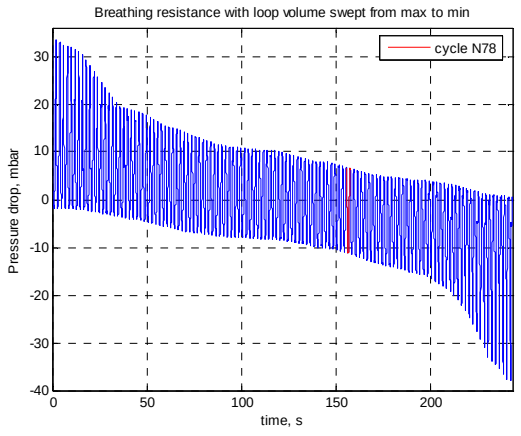
PRESSURE@END EXHALE / INHALE	=	6.4 / -10.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-11.2 / 6.5	mbar
PEAK TO PEAK PRESSURE	=	17.7	mbar
INHALE/EXHALE RESP PRESSURES	=	17.6 / 17.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.97	J/l
WOB OF BREATHING SIMULATOR	=	0.09	J/l
WOB OF DEVICE UNDER TEST	=	0.88	J/l
TOTAL POS / NEG WORK	=	0.43 / 0.51	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.39 / 0.47	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_99m_90 lpm_HeOx_100205









8.9.13. SRB (Incursion), Heliox, 100m, 90 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

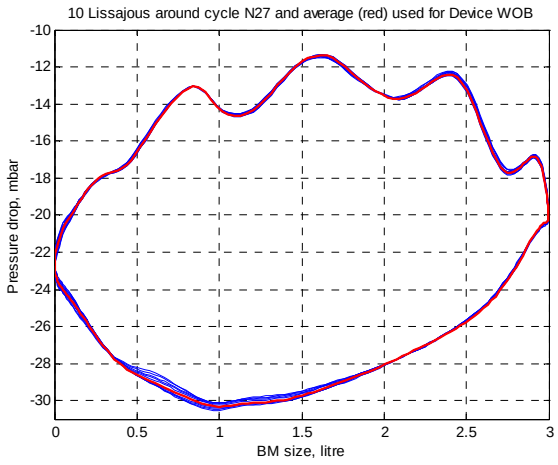
CONDITIONS OF TEST

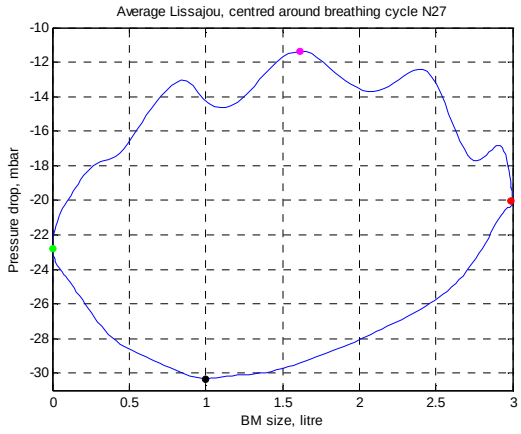
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	102.0	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	11.2	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.7bpm/89.0 lpm	metric

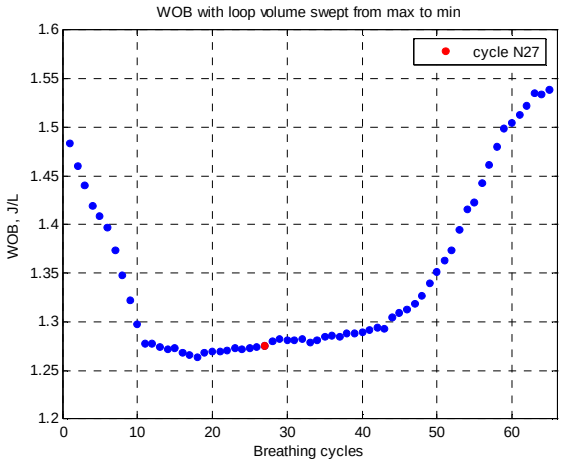
RESULTS

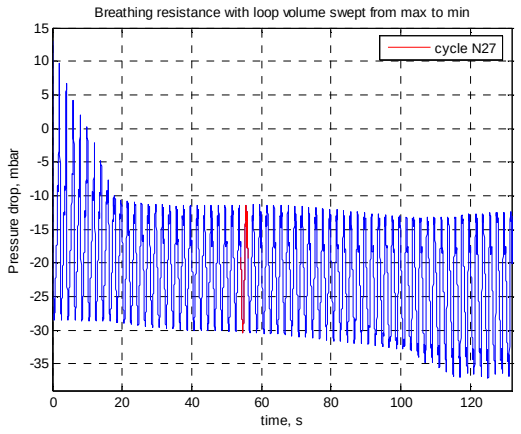
PRESSURE@END EXHALE / INHALE	=	-20.0 / -22.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-30.3 / -11.4	mbar
PEAK TO PEAK PRESSURE	=	19.0	mbar
INHALE/EXHALE RESP PRESSURES	=	10.3 / 11.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.37	J/l
WOB OF BREATHING SIMULATOR	=	0.09	J/l
WOB OF DEVICE UNDER TEST	=	1.27	J/l
TOTAL POS / NEG WORK	=	0.67 / 0.66	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.63 / 0.61	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_102m_90 lpm_HeOx_100205_1









8.10. SRB. Heliox, Depth 200m

8.10.1. SRB (Incursion), Heliox, 200m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

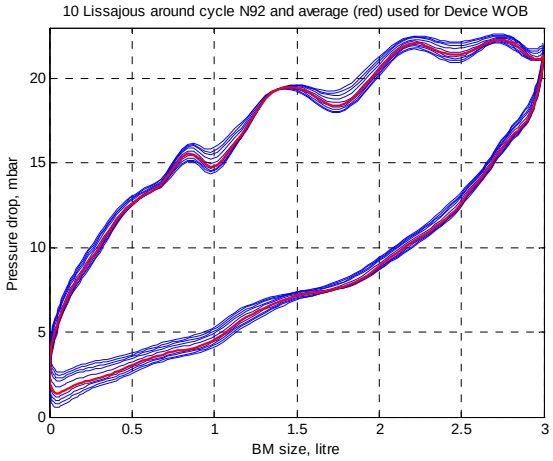
CONDITIONS OF TEST

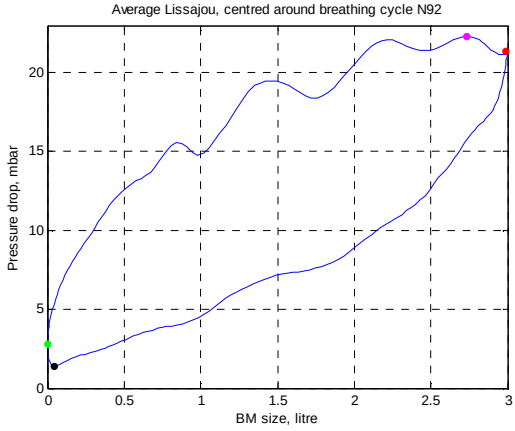
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	200.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	13.2	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

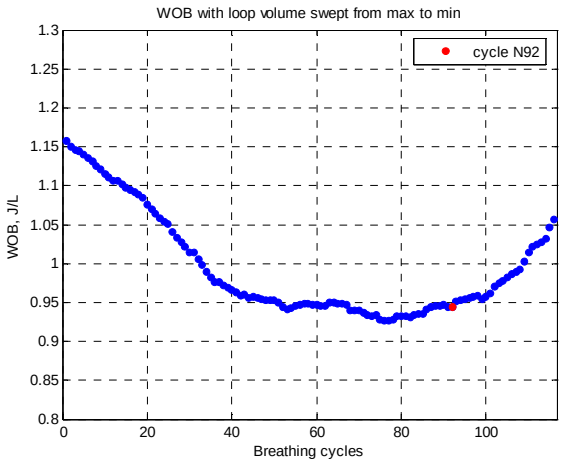
RESULTS

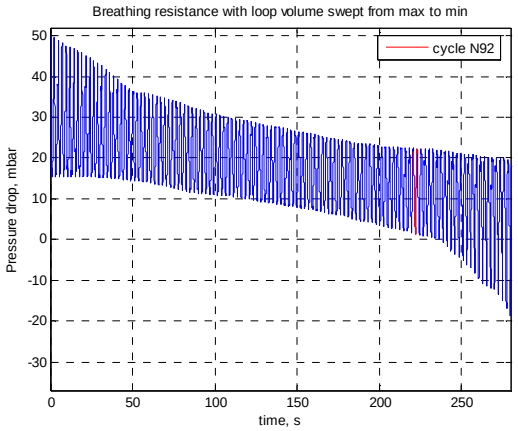
PRESSURE@END EXHALE / INHALE	=	21.3 / 2.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.4 / 22.3	mbar
PEAK TO PEAK PRESSURE	=	20.9	mbar
INHALE/EXHALE RESP PRESSURES	=	20.0 / 19.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.05	J/l
WOB OF BREATHING SIMULATOR	=	0.10	J/l
WOB OF DEVICE UNDER TEST	=	0.94	J/l
TOTAL POS / NEG WORK	=	0.55 / 0.49	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.51 / 0.44	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_200m_75 lpm_HeOx_100205









8.10.2. SRB (Incursion), Heliox, 200m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

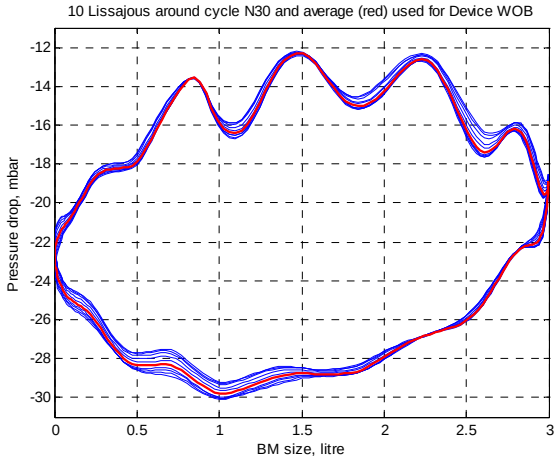
CONDITIONS OF TEST

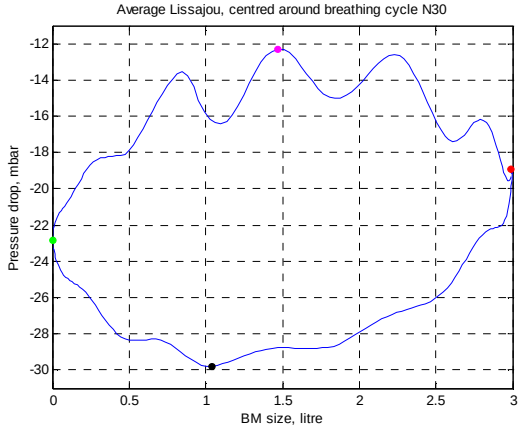
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	201.1	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	11.2	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.7bpm/77.2 lpm	metric

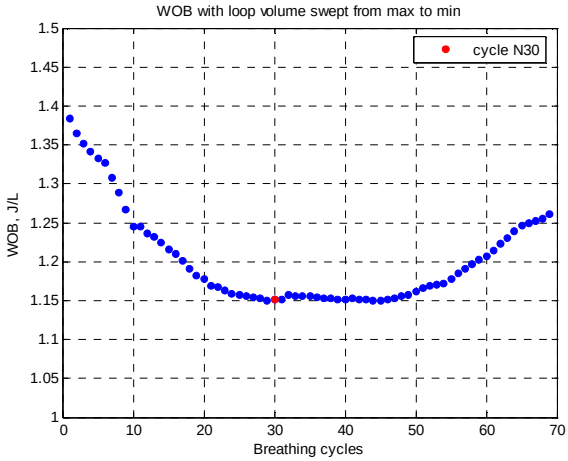
RESULTS

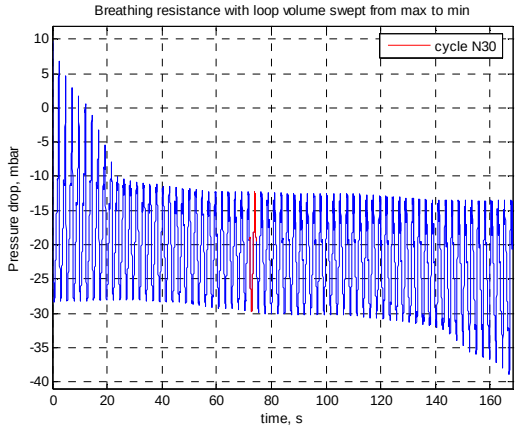
PRESSURE@END EXHALE / INHALE	=	-18.9 / -22.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-29.8 / -12.3	mbar
PEAK TO PEAK PRESSURE	=	17.5	mbar
INHALE/EXHALE RESP PRESSURES	=	10.9 / 10.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.25	J/l
WOB OF BREATHING SIMULATOR	=	0.10	J/l
WOB OF DEVICE UNDER TEST	=	1.15	J/l
TOTAL POS / NEG WORK	=	0.58 / 0.68	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.54 / 0.63	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_201m_75 lpm_HeOx_100205_1









8.10.3. SRB (Incursion), Heliox, 200m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

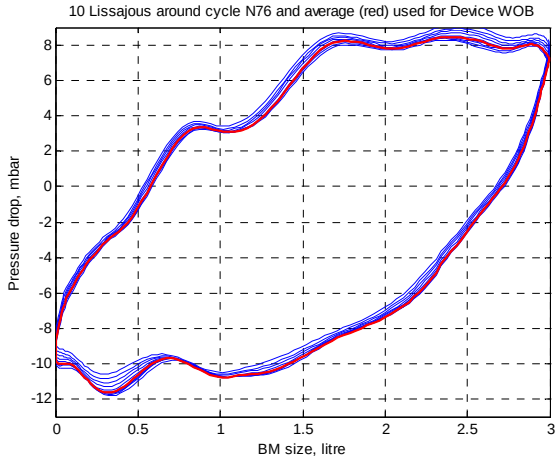
CONDITIONS OF TEST

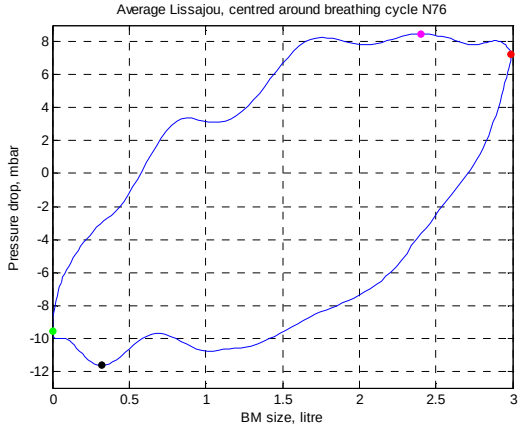
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	200.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	12.6	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.4bpm/88.2 lpm	metric

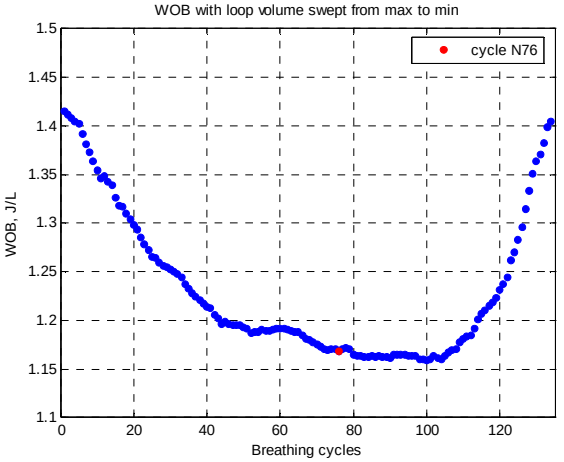
RESULTS

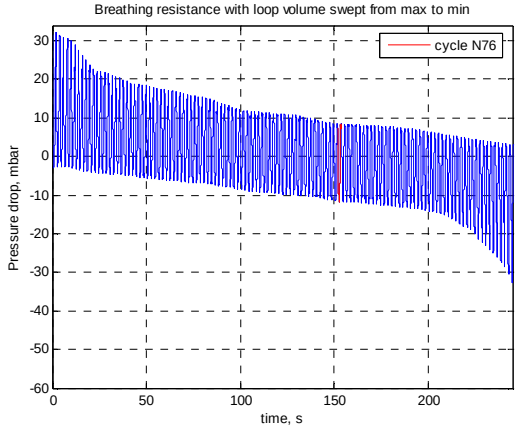
PRESSURE@END EXHALE / INHALE	=	7.2 / -9.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-11.6 / 8.5	mbar
PEAK TO PEAK PRESSURE	=	20.1	mbar
INHALE/EXHALE RESP PRESSURES	=	18.9 / 18.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.30	J/l
WOB OF BREATHING SIMULATOR	=	0.13	J/l
WOB OF DEVICE UNDER TEST	=	1.17	J/l
TOTAL POS / NEG WORK	=	0.59 / 0.68	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.52 / 0.62	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_201m_90 lpm_HeOx_100205









8.10.4. SRB (Incursion), Heliox, 200m, 90 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

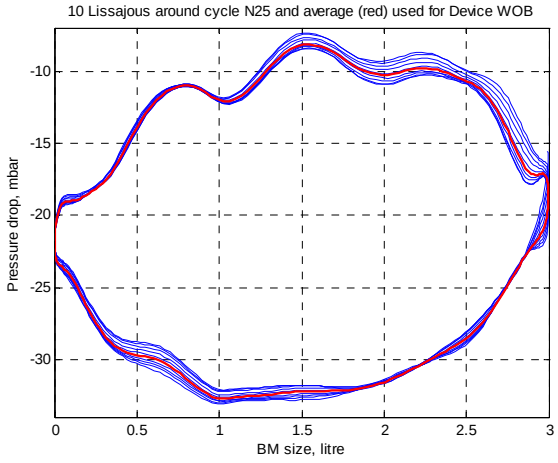
CONDITIONS OF TEST

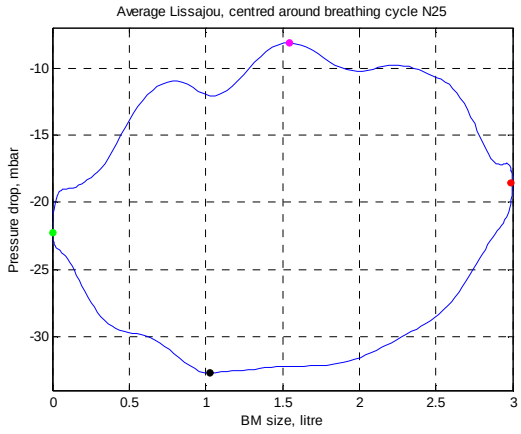
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	201.8	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	10.8	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.9bpm/89.7 lpm	metric

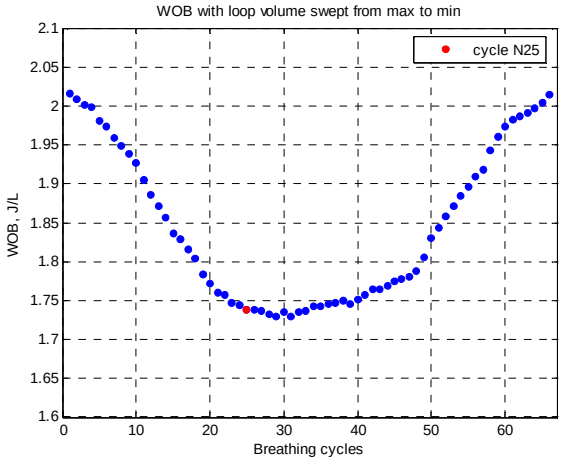
RESULTS

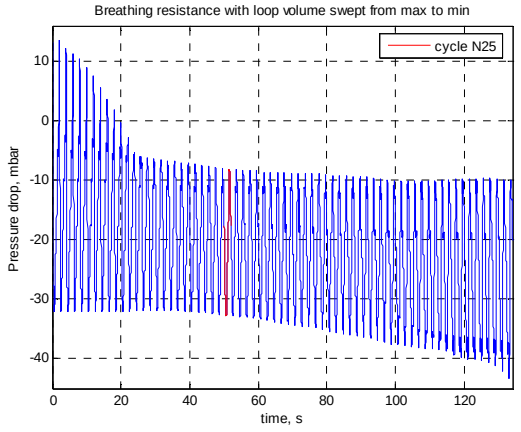
PRESSURE@END EXHALE / INHALE	=	-18.6 / -22.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-32.7 / -8.1	mbar
PEAK TO PEAK PRESSURE	=	24.6	mbar
INHALE/EXHALE RESP PRESSURES	=	14.2 / 14.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.87	J/l
WOB OF BREATHING SIMULATOR	=	0.13	J/l
WOB OF DEVICE UNDER TEST	=	1.74	J/l
TOTAL POS / NEG WORK	=	0.83 / 0.98	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.77 / 0.91	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_202m_90 lpm_HeOx_100205_1









8.11. SRB. Heliox, Depth 300m

8.11.1. SRB (Incursion), Heliox, 300m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

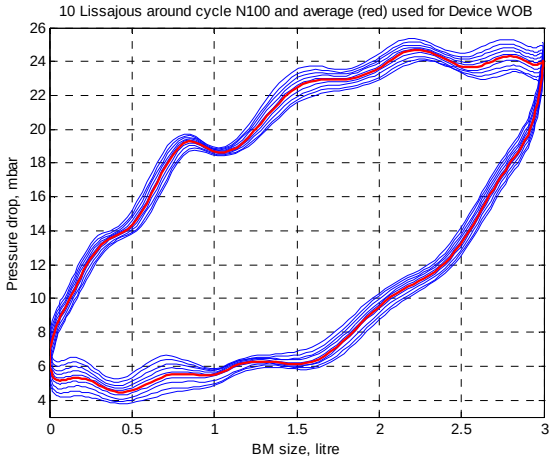
CONDITIONS OF TEST

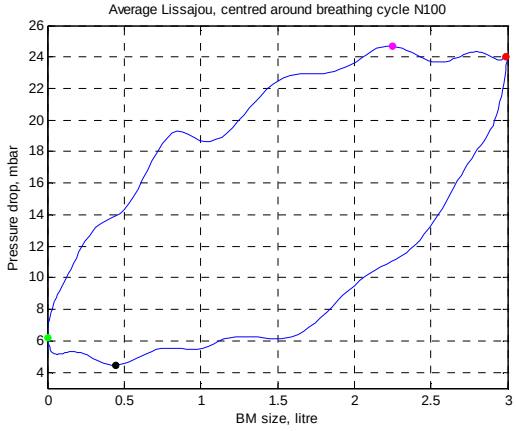
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	301.1	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	12.3	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/24.9bpm/74.8 lpm	metric

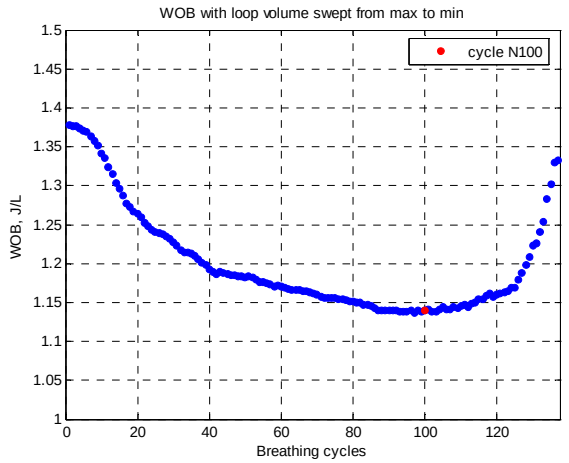
RESULTS

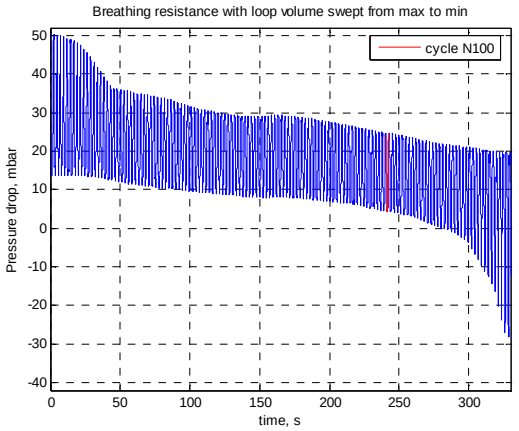
PRESSURE@END EXHALE / INHALE	=	24.0 / 6.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	4.4 / 24.7	mbar
PEAK TO PEAK PRESSURE	=	20.2	mbar
INHALE/EXHALE RESP PRESSURES	=	19.6 / 18.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.27	J/l
WOB OF BREATHING SIMULATOR	=	0.13	J/l
WOB OF DEVICE UNDER TEST	=	1.14	J/l
TOTAL POS / NEG WORK	=	0.55 / 0.71	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.48 / 0.64	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_300m_75 lpm_HeOx_100205









8.11.2. SRB (Incursion), Heliox, 300m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

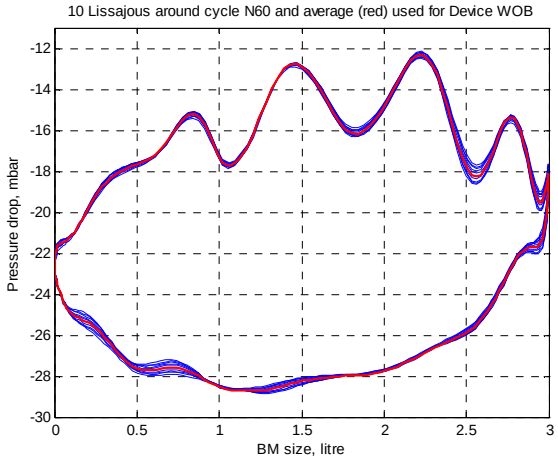
CONDITIONS OF TEST

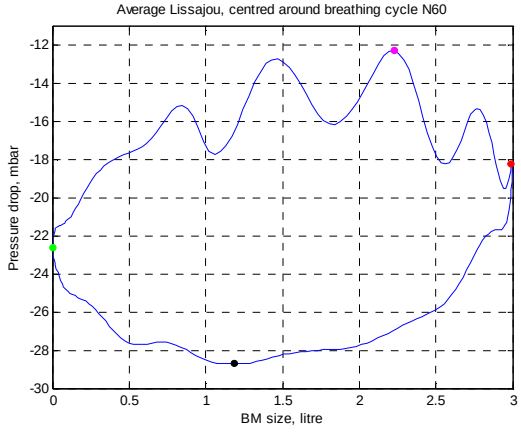
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	302.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	10.8	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.7bpm/77.1 lpm	metric

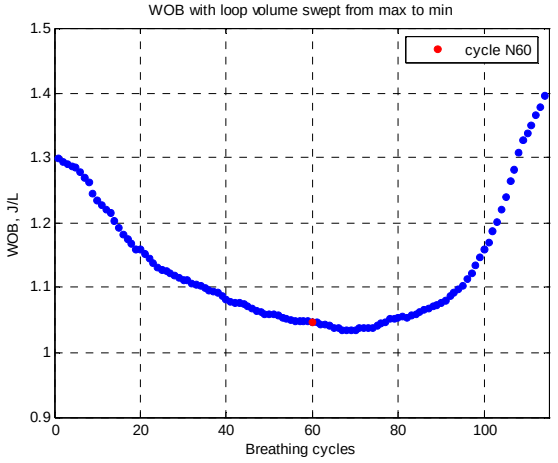
RESULTS

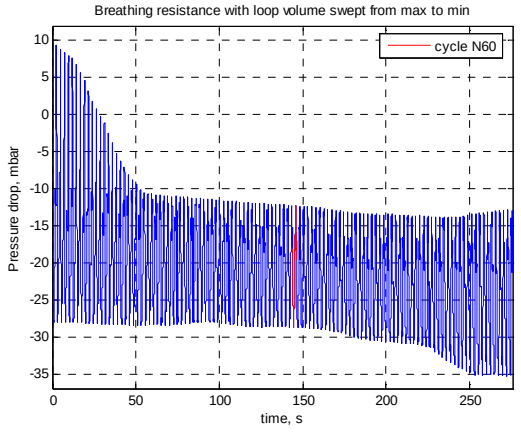
PRESSURE@END EXHALE / INHALE	=	-18.2 / -22.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-28.7 / -12.3	mbar
PEAK TO PEAK PRESSURE	=	16.4	mbar
INHALE/EXHALE RESP PRESSURES	=	10.5 / 10.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.20	J/l
WOB OF BREATHING SIMULATOR	=	0.15	J/l
WOB OF DEVICE UNDER TEST	=	1.05	J/l
TOTAL POS / NEG WORK	=	0.49 / 0.70	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.42 / 0.63	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_302m_75 lpm_HeOx_100205_1









8.11.3. SRB (Incursion), Heliox, 300m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

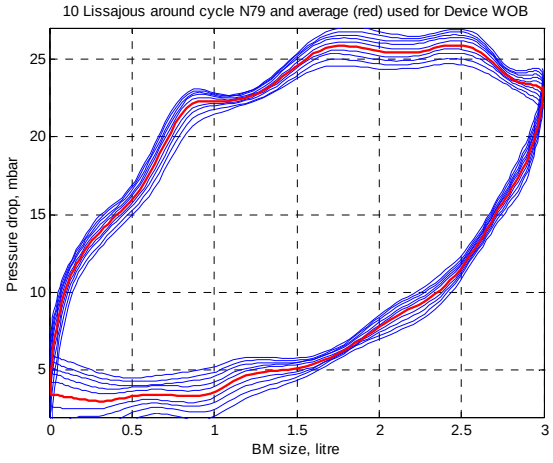
CONDITIONS OF TEST

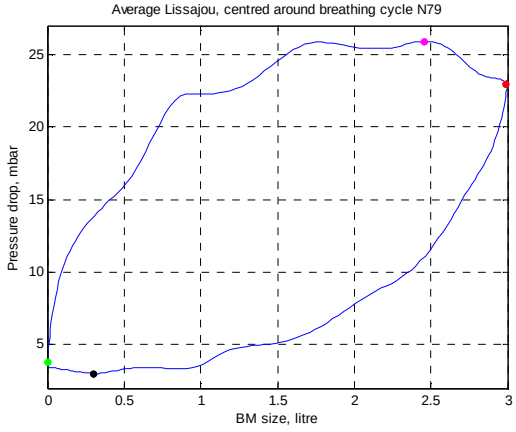
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	301.1	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	11.9	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.9bpm/89.8 lpm	metric

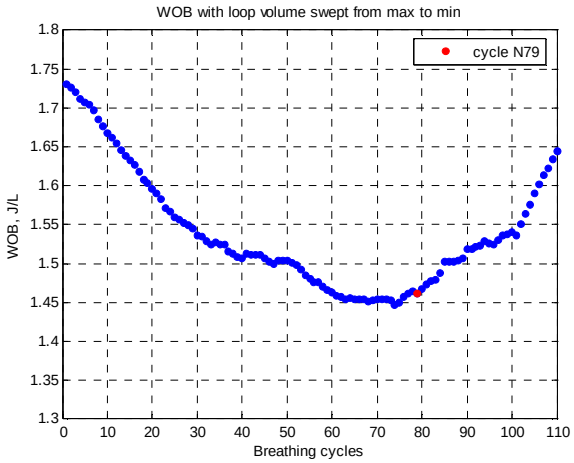
RESULTS

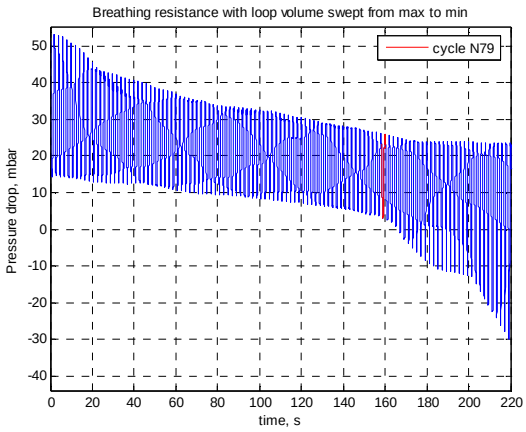
PRESSURE@END EXHALE / INHALE	=	22.9 / 3.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	3.0 / 25.9	mbar
PEAK TO PEAK PRESSURE	=	22.9	mbar
INHALE/EXHALE RESP PRESSURES	=	19.9 / 22.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.63	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	1.46	J/l
TOTAL POS / NEG WORK	=	0.90 / 0.71	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.82 / 0.63	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_301m_90 lpm_HeOx_100205









8.12. SRB. Heliox, Depth 350m

8.12.1. SRB (Incursion), Heliox, 350m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

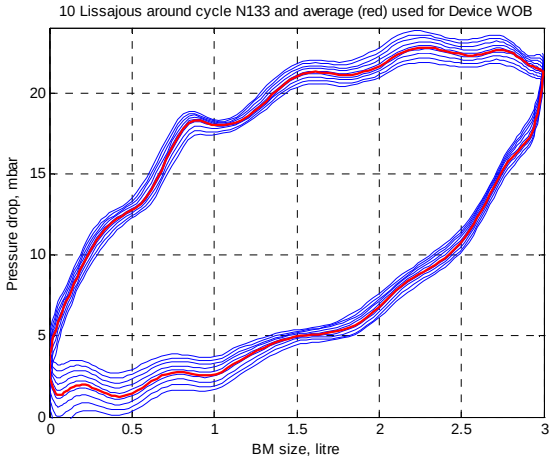
CONDITIONS OF TEST

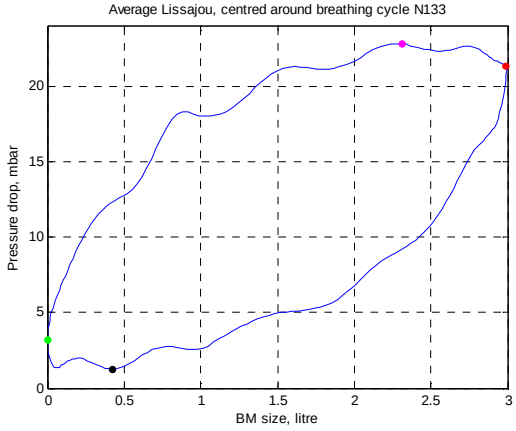
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	351.7	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	10.8	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

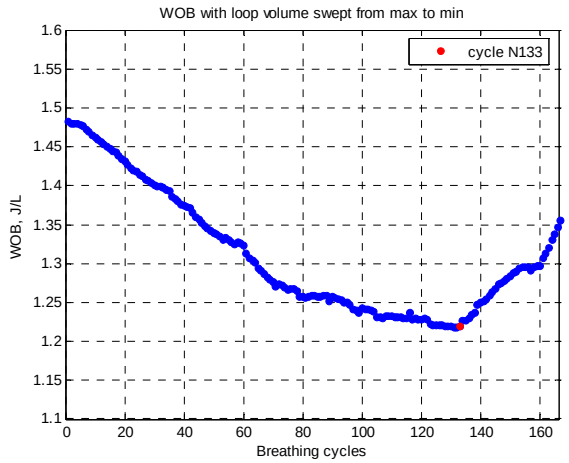
RESULTS

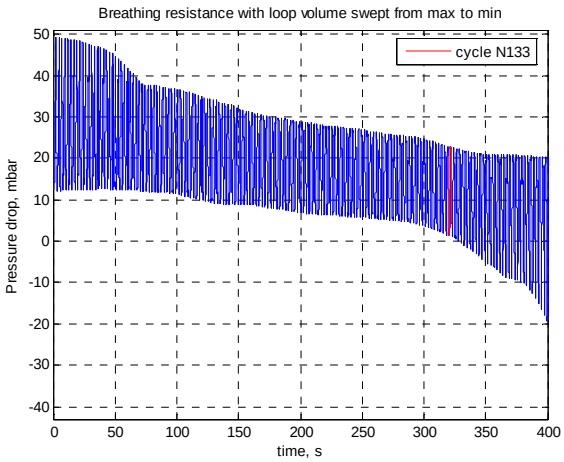
PRESSURE@END EXHALE / INHALE	=	21.3 / 3.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.3 / 22.8	mbar
PEAK TO PEAK PRESSURE	=	21.5	mbar
INHALE/EXHALE RESP PRESSURES	=	20.0 / 19.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.37	J/l
WOB OF BREATHING SIMULATOR	=	0.15	J/l
WOB OF DEVICE UNDER TEST	=	1.22	J/l
TOTAL POS / NEG WORK	=	0.67 / 0.69	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.60 / 0.61	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_350m_75 lpm_HeOx_100205









8.12.2. SRB (Incursion), Heliox, 350m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

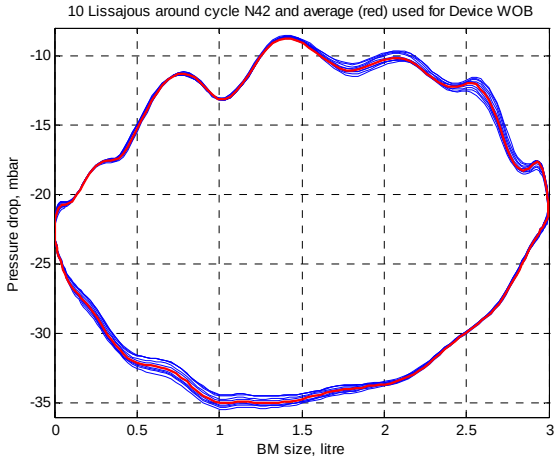
CONDITIONS OF TEST

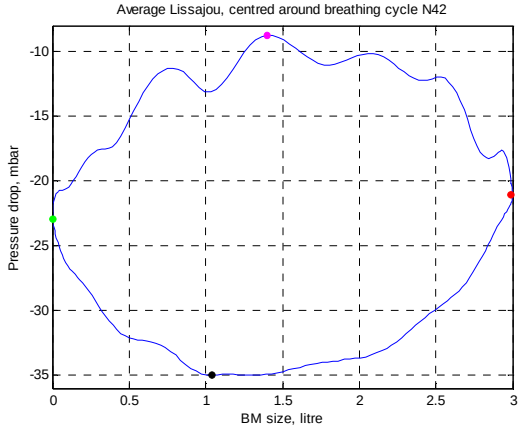
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	352.2	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	10.6	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.7bpm/77.0 lpm	metric

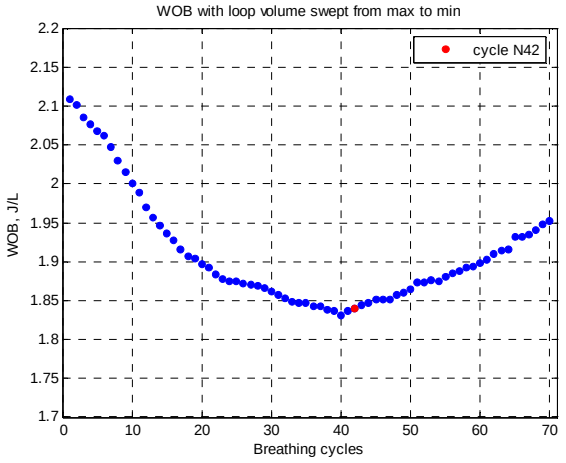
RESULTS

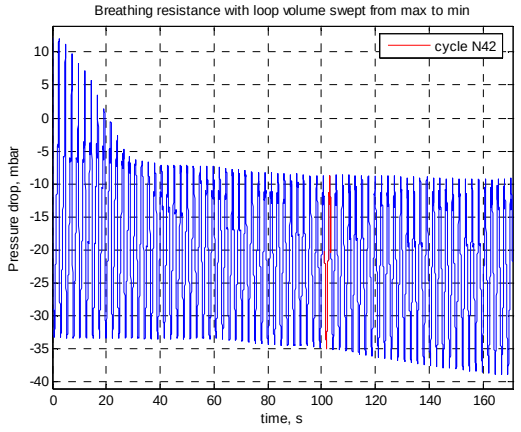
PRESSURE@END EXHALE / INHALE	=	-21.0 / -22.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-35.0 / -8.7	mbar
PEAK TO PEAK PRESSURE	=	26.3	mbar
INHALE/EXHALE RESP PRESSURES	=	14.0 / 14.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.97	J/l
WOB OF BREATHING SIMULATOR	=	0.13	J/l
WOB OF DEVICE UNDER TEST	=	1.84	J/l
TOTAL POS / NEG WORK	=	0.90 / 1.03	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.84 / 0.96	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_350m_75 lpm_HeOx_100205









8.12.3. SRB (Incursion), Heliox, 350m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

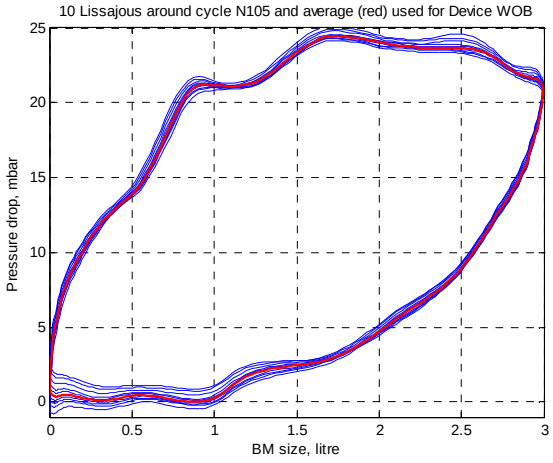
CONDITIONS OF TEST

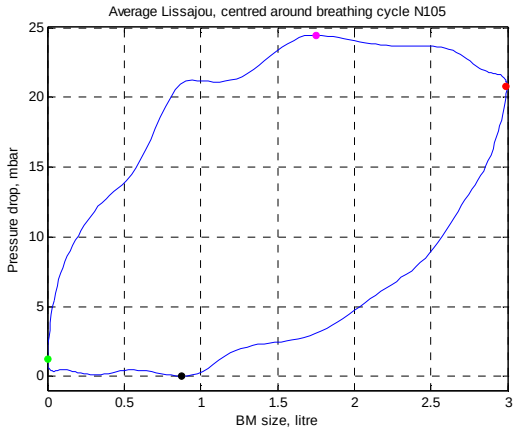
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	351.7	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.5	℃
EHXALE GAS TEMPERATURE	:	10.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.9bpm/89.8 lpm	metric

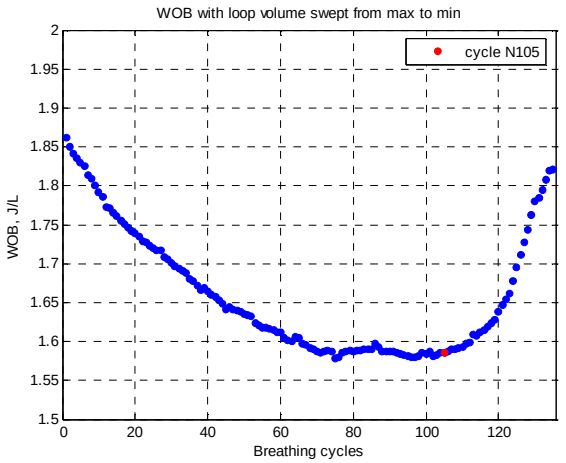
RESULTS

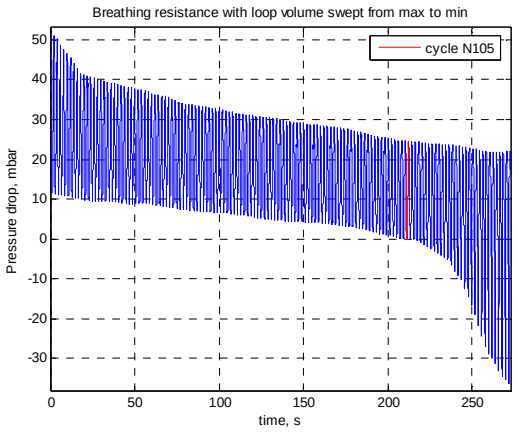
PRESSURE@END EXHALE / INHALE	=	20.8 / 1.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	0.0 / 24.5	mbar
PEAK TO PEAK PRESSURE	=	24.4	mbar
INHALE/EXHALE RESP PRESSURES	=	20.7 / 23.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.77	J/l
WOB OF BREATHING SIMULATOR	=	0.19	J/l
WOB OF DEVICE UNDER TEST	=	1.59	J/l
TOTAL POS / NEG WORK	=	0.96 / 0.78	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.87 / 0.68	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_90d_352m_90 lpm_HeOx_100205









8.12.4. SRB (Incursion), Heliox, 350m, 90 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	SRB Incursion with DL Mod 2 ALVBOV	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	05.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

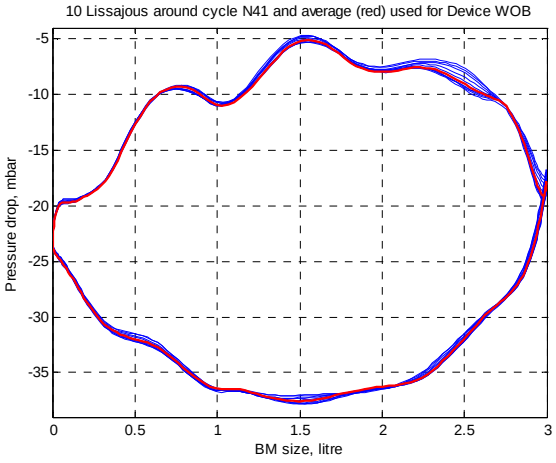
CONDITIONS OF TEST

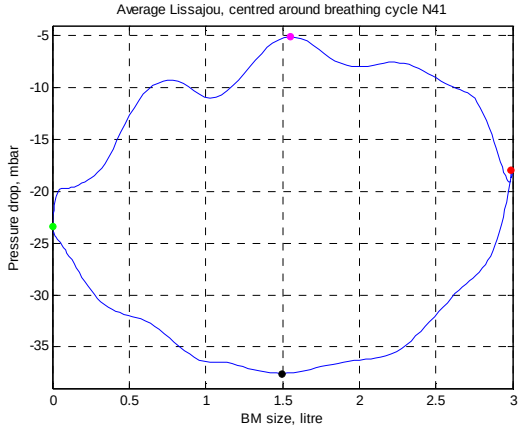
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	352.2	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.6	℃
EHXALE GAS TEMPERATURE	:	11.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.8bpm/89.5 lpm	metric

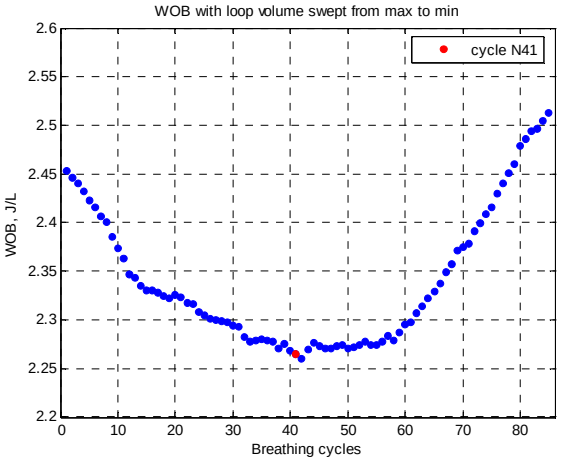
RESULTS

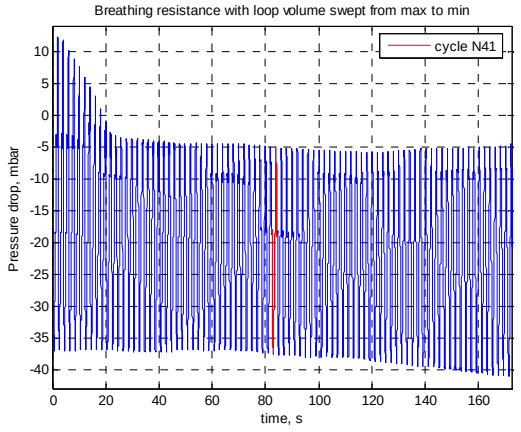
PRESSURE@END EXHALE / INHALE	=	-18.0 / -23.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-37.6 / -5.1	mbar
PEAK TO PEAK PRESSURE	=	32.5	mbar
INHALE/EXHALE RESP PRESSURES	=	19.6 / 18.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	2.45	J/l
WOB OF BREATHING SIMULATOR	=	0.19	J/l
WOB OF DEVICE UNDER TEST	=	2.27	J/l
TOTAL POS / NEG WORK	=	1.14 / 1.34	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.05 / 1.25	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Apoc_S1_0d_301m_90 lpm_HeOx_100205









8.13. SRB with ALV setting loop volume

8.13.1. SRB (iCCR), Air, 44m, 75 lpm RMV, 90° Pitch (Audit, ALV fixes loop vol)

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR iCCR (SRB sample 1)	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	15.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

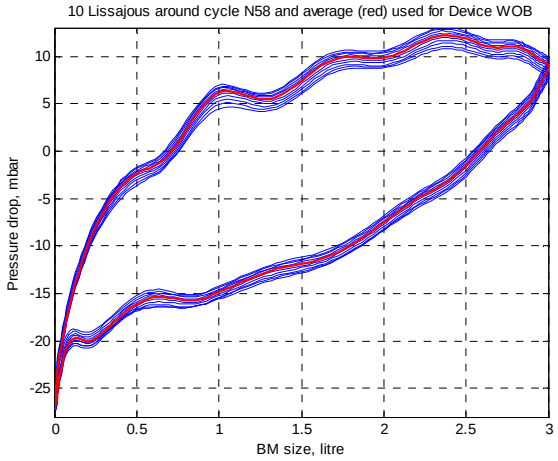
CONDITIONS OF TEST

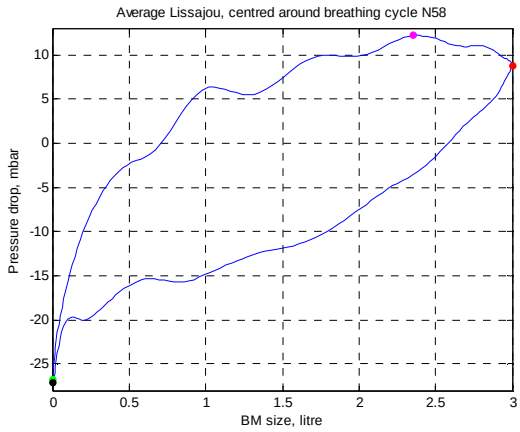
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	43.9	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.1	℃
EHXALE GAS TEMPERATURE	:	9.1	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0 lpm	metric

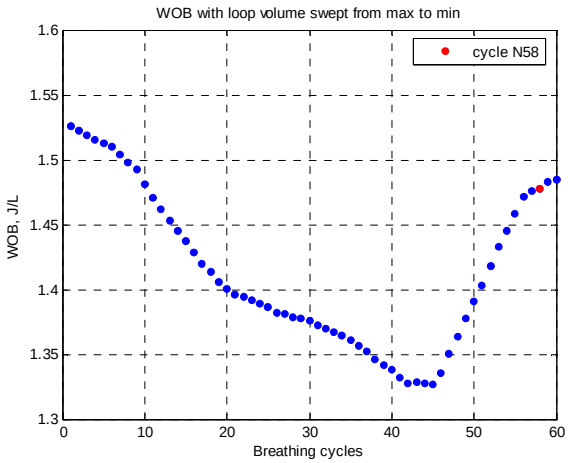
RESULTS

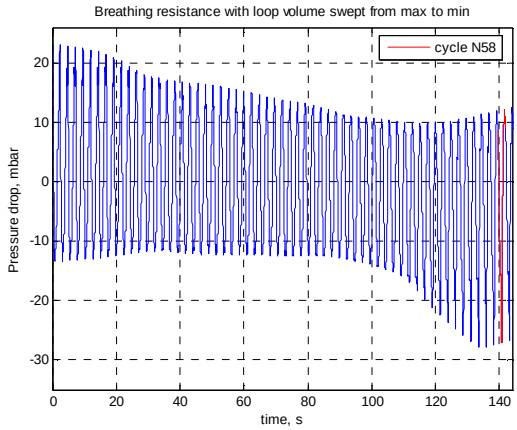
PRESSURE@END EXHALE / INHALE	=	8.8 / -26.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-27.1 / 12.2	mbar
PEAK TO PEAK PRESSURE	=	39.3	mbar
INHALE/EXHALE RESP PRESSURES	=	35.9 / 38.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.65	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	1.48	J/l
TOTAL POS / NEG WORK	=	1.47 / 0.19	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.39 / 0.10	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Inc_S1_90d_44m_75 lpm_Air_100215_1









8.13.2. SRB (iCCR), Heliox, 102m, 75 lpm RMV, 90° Pitch (Audit, ALV fixes loop vol)

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR iCCR (SRB sample 1)	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	15.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

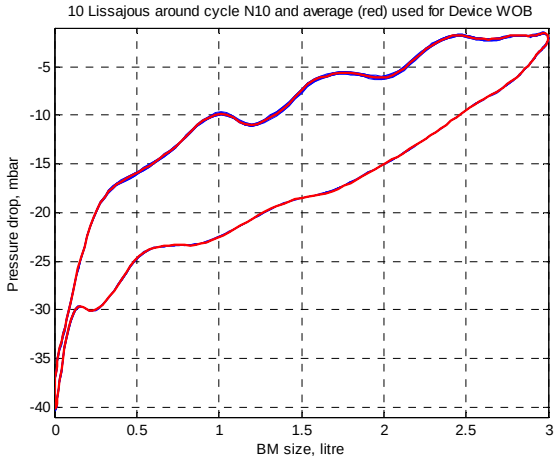
CONDITIONS OF TEST

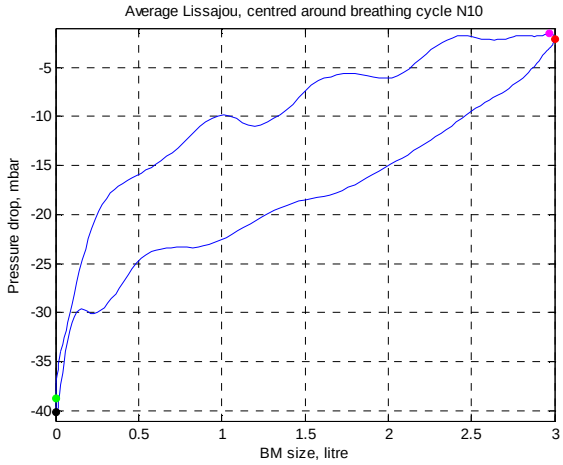
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	HeOx	
DEPTH	:	102.3	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.1	℃
EHXALE GAS TEMPERATURE	:	9.1	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0 lpm	metric

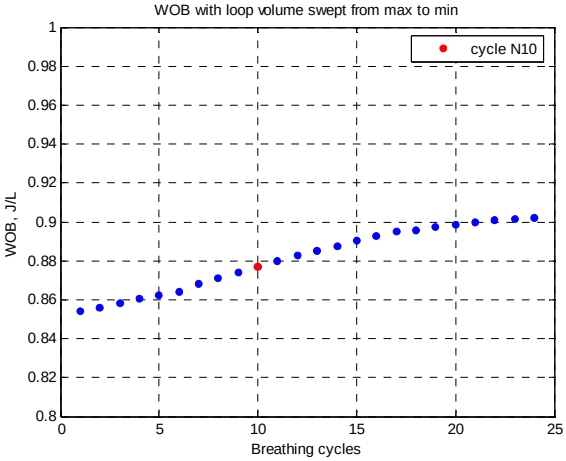
RESULTS

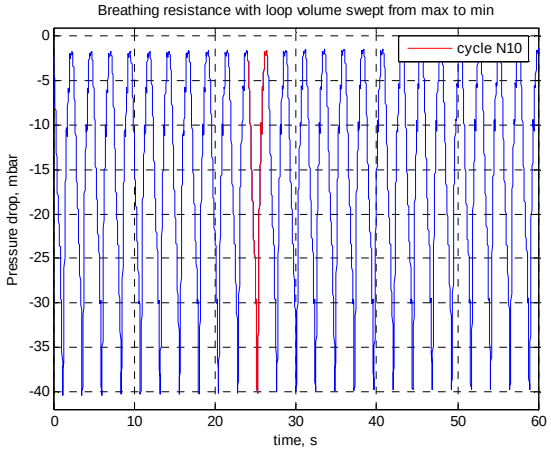
PRESSURE@END EXHALE / INHALE	=	-2.1 / -38.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-40.1 / -1.5	mbar
PEAK TO PEAK PRESSURE	=	38.6	mbar
INHALE/EXHALE RESP PRESSURES	=	38.1 / 37.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.95	J/l
WOB OF BREATHING SIMULATOR	=	0.07	J/l
WOB OF DEVICE UNDER TEST	=	0.88	J/l
TOTAL POS / NEG WORK	=	1.14 / 0.17	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.11 / 0.21	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Inc_S1_90d_102m_75lpm_Trimix_100215_1









8.13.3. SRB (iCCR), Air, 42m, 10 lpm RMV, 90° Pitch (Audit, ALV fixes loop vol)

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR iCCR (SRB sample 1)	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	16.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

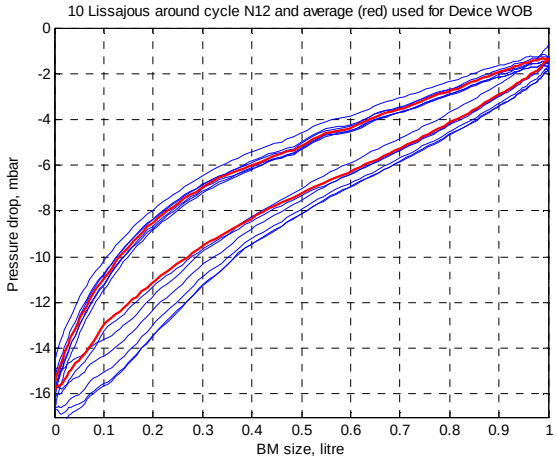
CONDITIONS OF TEST

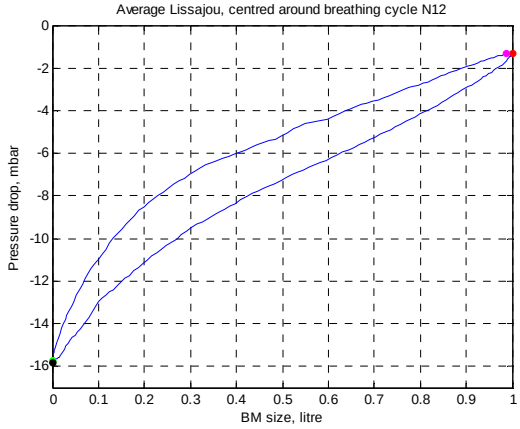
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	41.6	m
ROOM / WATER TEMPERATURE	:	18.0 / 3.6	℃
EHXALE GAS TEMPERATURE	:	6.5	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0lpm	metric

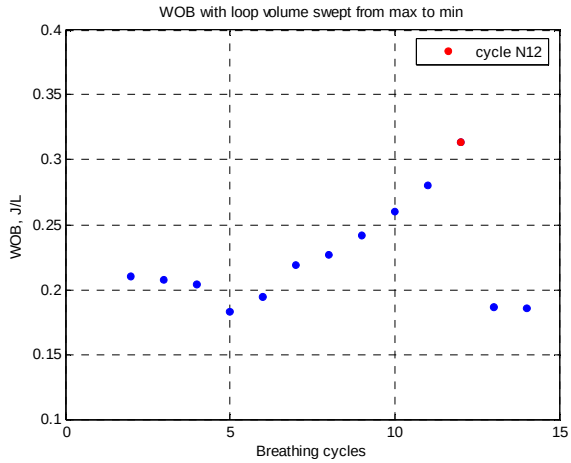
RESULTS

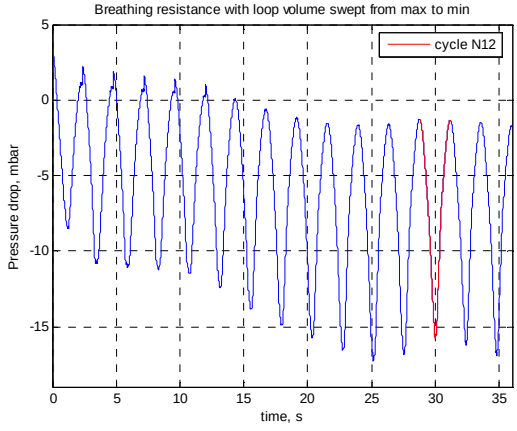
PRESSURE@END EXHALE / INHALE	=	-1.3 / -15.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-15.8 / -1.3	mbar
PEAK TO PEAK PRESSURE	=	14.5	mbar
INHALE/EXHALE RESP PRESSURES	=	14.5 / 14.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.31	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.31	J/l
TOTAL POS / NEG WORK	=	0.28 / 0.09	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.28 / 0.09	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Inc_S1_90d_42m_10lpm_air_100216_1









8.13.4. SRB (iCCR), Air, 42m, 10 lpm RMV, 0° Pitch (Audit, ALV fixes loop vol)

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR iCCR (SRB sample 1)	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	16.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

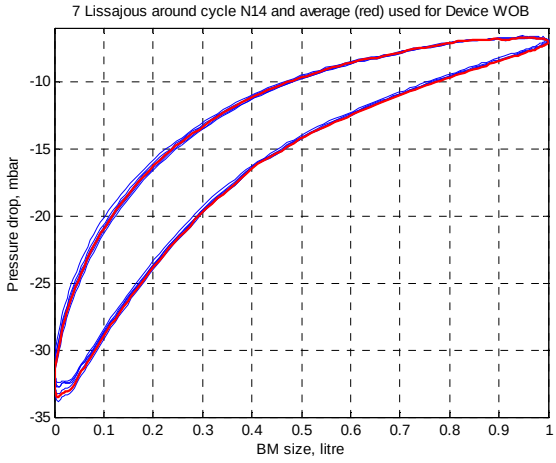
CONDITIONS OF TEST

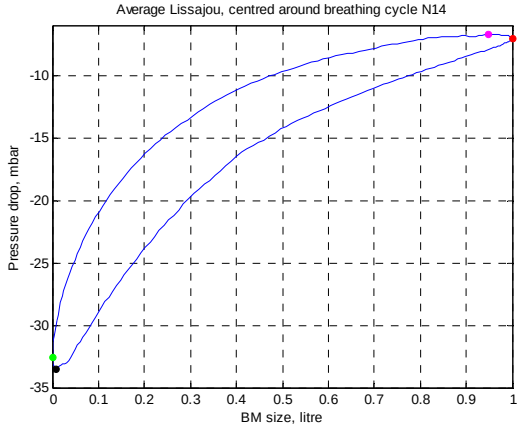
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	41.5	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.1	℃
EHXALE GAS TEMPERATURE	:	4.6	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/9.6bpm/9.6lpm	metric

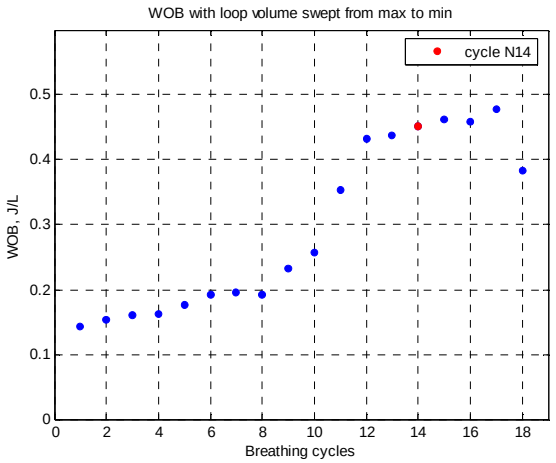
RESULTS

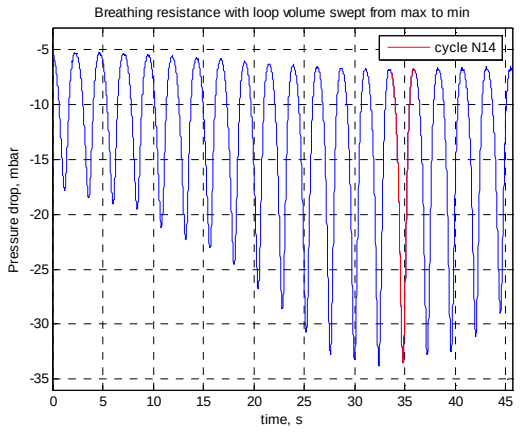
PRESSURE@END EXHALE / INHALE	=	-1.3 / -15.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-15.8 / -1.3	mbar
PEAK TO PEAK PRESSURE	=	14.5	mbar
INHALE/EXHALE RESP PRESSURES	=	14.5 / 14.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.31	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.31	J/l
TOTAL POS / NEG WORK	=	0.28 / 0.09	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.28 / 0.09	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Inc_S1_0d_41m_10lpm_air_100216_1









8.13.5. SRB (iCCR), Heliox, 102m, 10 lpm RMV, 0° Pitch (Audit, ALV fixes loop vol)

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR iCCR (SRB sample 1)	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	16.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

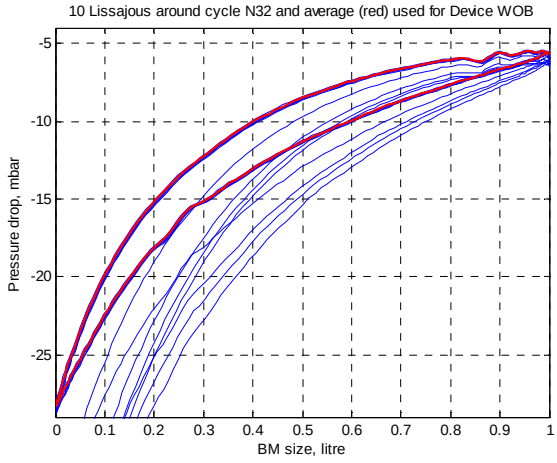
CONDITIONS OF TEST

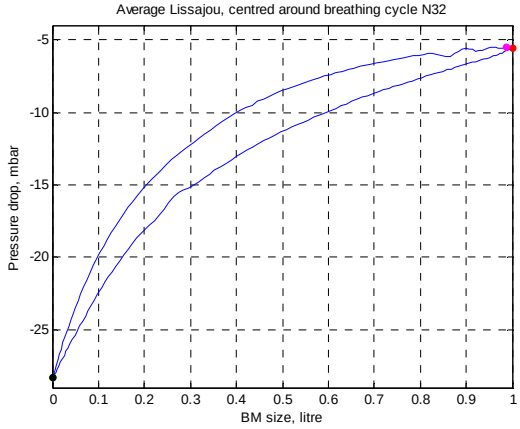
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	HeOx	
DEPTH	:	102.1	m
ROOM / WATER TEMPERATURE	:	18.0 / 4.7	℃
EHXALE GAS TEMPERATURE	:	5.0	℃
GAS SUPPLY PRESSURE	:	11.5	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/9.6bpm/9.6lpm	metric

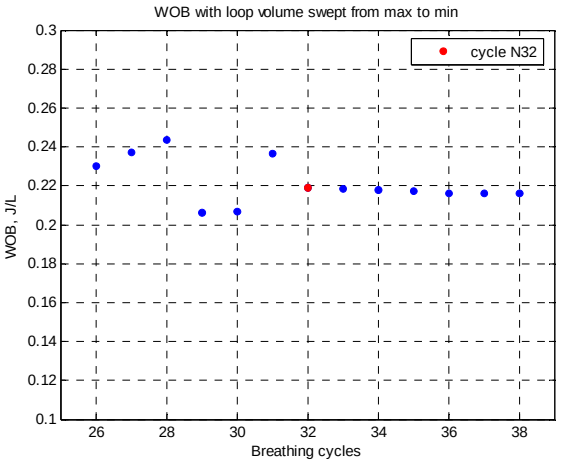
RESULTS

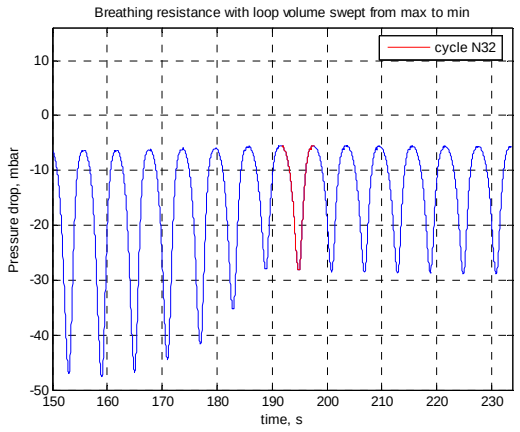
PRESSURE@END EXHALE / INHALE	=	-5.6 / -28.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-28.3 / -5.5	mbar
PEAK TO PEAK PRESSURE	=	22.8	mbar
INHALE/EXHALE RESP PRESSURES	=	22.8 / 22.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.22	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.22	J/l
TOTAL POS / NEG WORK	=	0.61 / 0.40	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.61 / 0.40	J/l

ALL DATA STORED AS # (DATA FILE): WOB_Inc_S1_0d_102m_10lpm_Trimix_100216_1









8.14. Summary of Results

Table 13 Results of respiratory parameter tests for Standards compliance (Single scrubber).

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, m	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
1.	40	10	+ 90°	Air	0.8	+/-25	0.9	+/-15 idealy (+/-25 limit)	1.7	20	-	-	1.85	0.4 / 29	0.10	6.8 / 6.3	PASS ALL
2.			0°											-0.3 / 17	0.09	2.1 / 2.0	PASS ALL
3.	40		+ 90°	Heli ox										0.4 / 29	0.10	5.5 / 5.4	PASS ALL
4.	100												0.89		0.14	6.8 / 6.5	PASS ALL
5.	40		0°										1.85	-0.3 / 17	0.06	2.0 / 1.9	PASS ALL
6.	100												0.89		0.10	3.1 / 2.8	PASS ALL
7.	40	22.5	+ 90°	Air	1.18	+/-25	1.4	+/-15 idealy (+/-25 limit)	1.7	20	0.17	-	1.85	0.4 / 29	0.33	10.7 / 10.3	PASS ALL
8.			0°											-0.3 / 17	0.25	4.1 / 3.5	PASS ALL
9.	40		+ 90°	Heli ox							0.231			0.4 / 29	0.27	10.6 / 10.5	PASS ALL
10.	100												0.89		0.28	10.1 / 9.9	PASS ALL

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, m	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
11.	40		0°										1.85	-0.3 / 17	0.15	3.2 / 3.0	PASS ALL
12.	100												0.89		0.16	2.8 / 2.8	PASS ALL
13.	40	40.0	+ 90°	Air	1.7	+/-25	2.1	+/-15 idealy (+/-25 limit)	1.7	20	0.509	-	1.85	0.4 / 29	0.56	13.2 / 12.7	PASS ALL
14.			0°											-0.3 / 17	0.46	5.6 / 5.4	PASS ALL
15.	40		+ 90°	Heli ox							0.617			0.4 / 29	0.37	13.4 / 13.1	PASS ALL
16.	100												0.89		0.42	13.7 / 13.3	PASS ALL
17.	40		0°										1.85	-0.3 / 17	0.31	5.7 / 5.2	PASS ALL
18.	100												0.89		0.28	4.1 / 3.8	PASS ALL
19.	40	62.5	+ 90°	Air	2.38	+/-25	3.0	+/-15 idealy (+/-25 limit)	1.7	20	1.172	-	1.85	0.4 / 29	0.92	15.7 / 15.5	PASS ALL
20.			0°											-0.3 / 17	1.03	14.5 / 13.7	PASS ALL
21.	40		+ 90°	Heli ox							1.542			0.4 / 29	0.41	21.8 / 21.6	PASS ALL

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, m	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
22.	100												0.89		0.56	23.1 / 23.0	PASS ALL
23.	40		0°										1.85	-0.3 / 17	0.31	10.9 / 10.4	PASS ALL
24.	100												0.89		0.53	11.6 / 11.0	PASS ALL
25.	40	75.0	+ 90°	Air	2.75	+/-25	3.5	+/-15 idealy (+/-25 limit)	1.7	20	1.696	-	N.A.	0.4 / 29	1.22	19.7 / 20.2	PASS ALL
26.			0°											-0.3 / 17	1.05	9.7 / 9.6	PASS ALL
27.	40		+ 90°	Heli ox							2.159			0.4 / 29	0.67	22.3 / 22.2	PASS ALL
28.	100												N.A.		0.74	19.1 / 17.9	PASS ALL
29.	200												-		0.94	20.0 / 19.5	PASS ALL
30.	300														1.14	19.6 / 18.5	PASS ALL
31.	350														1.22	20.0 / 19.6	PASS ALL
32.	40		0°										N.A.	-0.3 / 17	0.48	6.0 / 5.5	PASS ALL

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, m	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
33.	100												N.A.		0.78	8.7 / 9.0	PASS ALL
34.	200														1.15	10.9 / 10.6	PASS ALL
35.	300												-		1.05	10.5 / 10.3	PASS ALL
36.	350														1.84	14.0 / 14.2	PASS ALL
37.	100	90.0		Heli ox	3.2	+/-25	5.0	+/-15 idealy (+/-25 limit)	1.7	20	2.529	-	N.A.		0.88	17.6 / 17.0	PASS ALL
38.	200		+ 90°											0.4 / 29	1.17	18.9 / 18.0	PASS ALL
39.	300												-		1.46	19.9 / 22.1	PASS ALL
40.	350														1.59	20.7 / 23.2	PASS ALL
41.	100		0°										N.A.	-0.3 / 17	1.27	10.3 / 11.4	PASS ALL
42.	200												-		1.74	14.2 / 14.2	PASS EN+NO +USN FAIL NATO

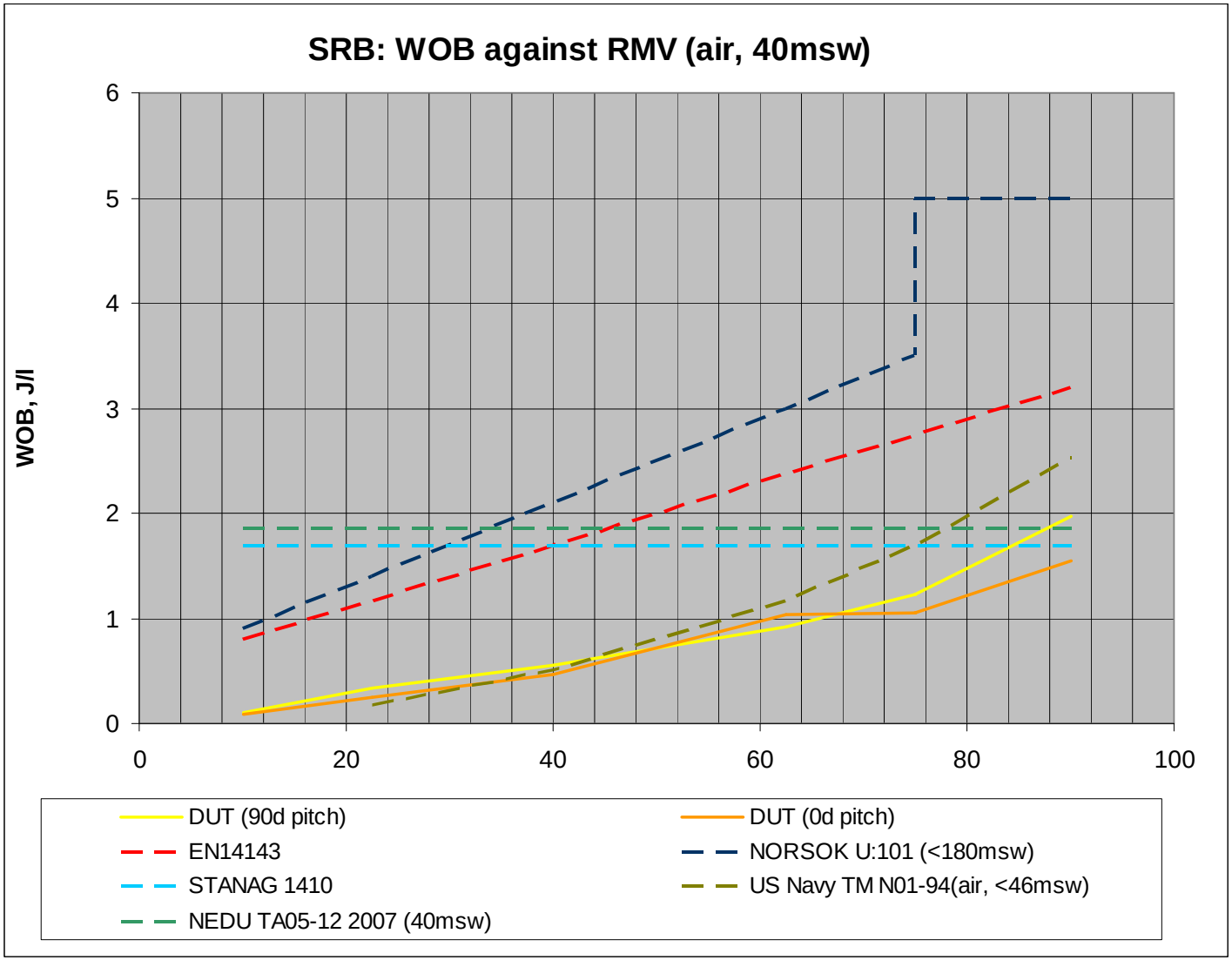
Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, m	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
43.	300														2.27	19.6 / 18.3	PASS EN+NO +USN FAIL NATO
44.	350														2.67	21.2 / 20.8	PASS EN+NO +USN FAIL NATO

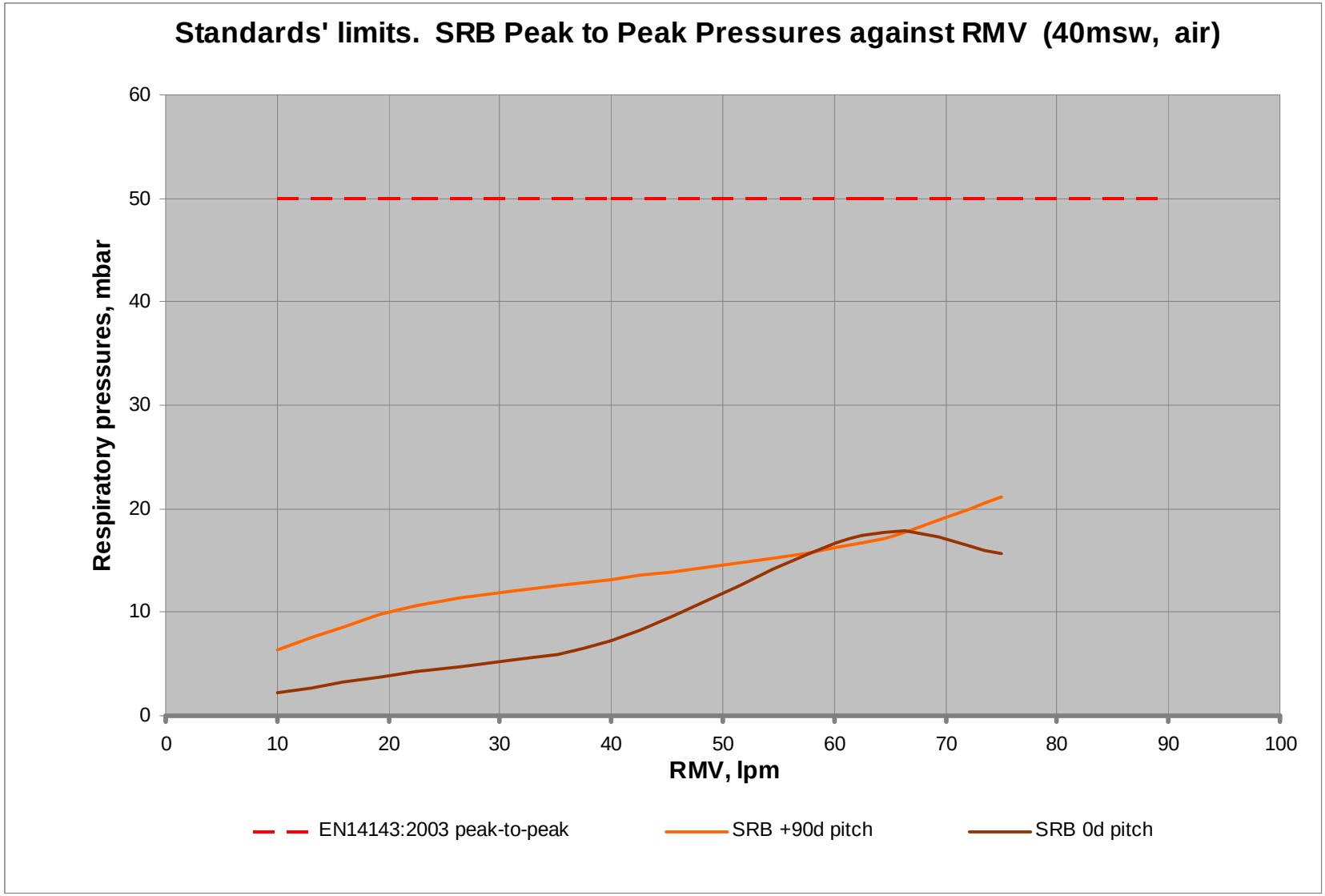
Table 14 Comparative WOB tests resluts for Single Scrubber series of the Open Revolution rebreathers.

Test num.	DUT	Test pressures	Diver's position	Test gases	Environment	Requirements		Test Result	
						RMV, l/min	TD, l	WOB	BR
1.	Apocalypse IV iCCR	5 atm = 40 m	+ 90° pitch	Air	Artificial sea water at a temperature 4 ± 1℃	75.0	3.0	1.22	19.7 / 20.2
2.	Incursion							1.26	19.7 / 19.1

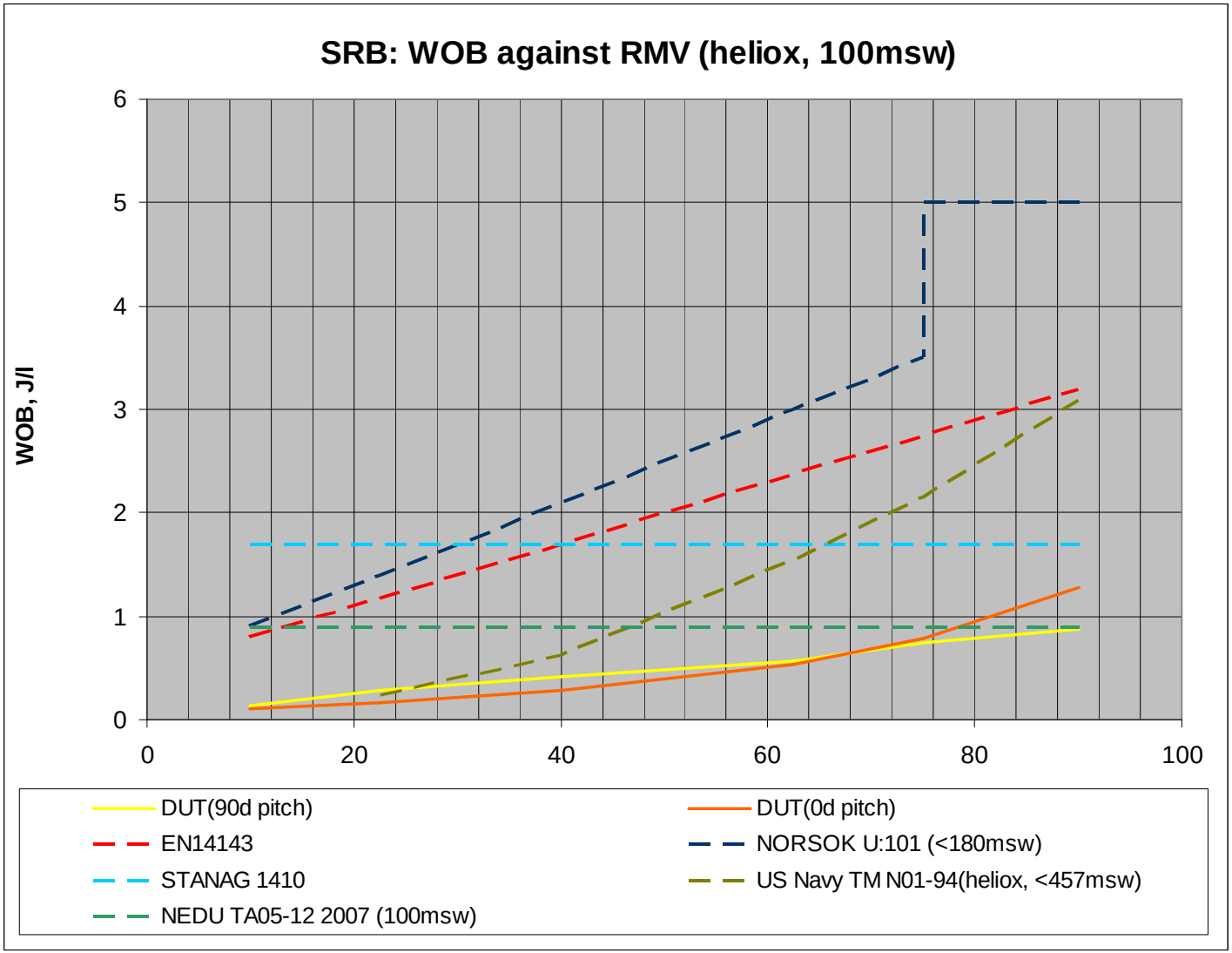
The breathing loop is also within the EN 14143:2003 compliance limits when the ALVBOV is setting the loop volume: this is not a normal operating mode – no diver should be breathing for more an a couple of breaths at the ALVBOV cracking pressure. The normal use of the ALVBOV is to take a deeper than normal inhale when the loop is empty, to add enough volume to be comfortable during normal respiration.

8.15. SRB. WOB and Breathing Resistance comparison air at 40m





8.16. SRB. WOB and Breathing Resistance Heliox at 100m, with PPO2 of 1.0



9. WOB AND RESISTANCE RESULTS FOR DUAL SCRUBBER CONFIGURATION

Figure 9-1. DL DRB Rebreather for Commercial Diving, shown here operating, with back cover removed. Counterlungs are in the same position as for the single scrubber configuration, and of the same construction, but the scrubber fixed body is further out from the diver: it is connected by a rigid manifold. The corrugated hose is the same, but there is an additional run of stainless steel tube around the helmet, and a gas heater.

Observation: All tests reported herein were performed with the short CL springs as per BOM B13 & B17. Comparison with the same tests performed in 2008 using full length CL springs reveal that the short springs have a higher elastance, hence higher respiratory peak pressures. Future design improvement to use full length springs should be considered: this will require retest of the respiratory parameters reported herein.

9.1. DRB. Air, <6m

9.1.1. DRB, Air, <6m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece EN14143:2003	
TEST METHOD		RELATIVE	SINE FLOW
DATE AND TIME		15/01/09 12:21	
TEST CARRIED OUT BY	VD	WITNESS: MS	

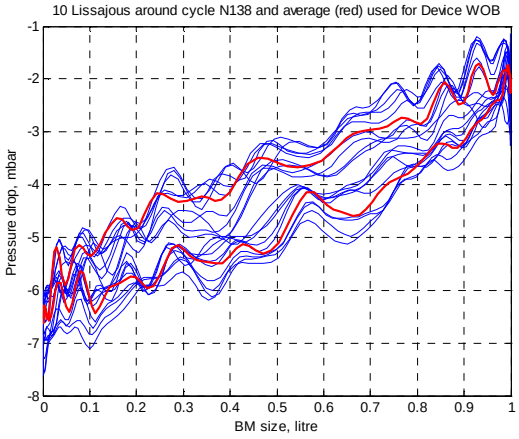
CONDITIONS OF TEST

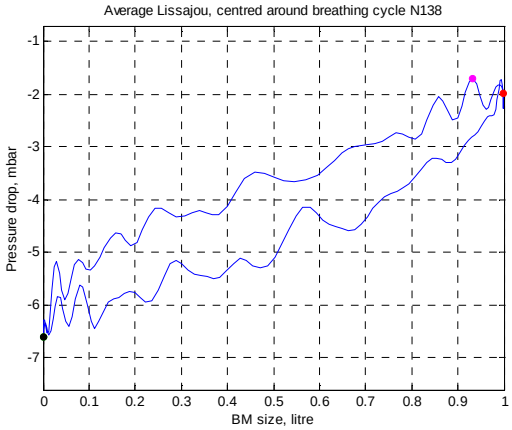
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	2.44	m
ROOM / WATER TEMPERATURE	:	19.5 / 4.1	℃
EHXALE GAS TEMPERATURE	:	15.6	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0 lpm	metric

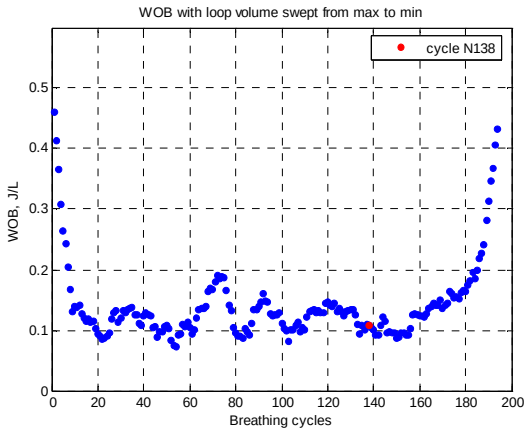
RESULTS

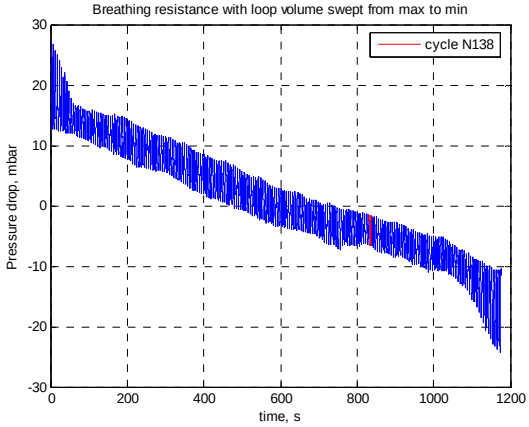
PRESSURE@END EXHALE / INHALE	=	-2.0 / -6.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-6.7 / -1.6	mbar
PEAK TO PEAK PRESSURE	=	5.1	mbar
INHALE/EXHALE RESP PRESSURES	=	4.8 / 4.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.11	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.11	J/l
TOTAL POS / NEG WORK	=	0.05 / 0.05	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.05 / 0.05	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 00m_10 lpm_090115_01









9.1.2. DRB, Air, <6m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece EN14143:2003	
TEST METHOD		RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 14:12	
TEST CARRIED OUT BY	VD	WITNESS: MS	

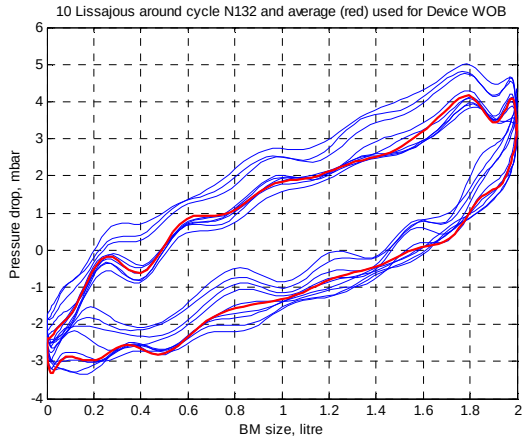
CONDITIONS OF TEST

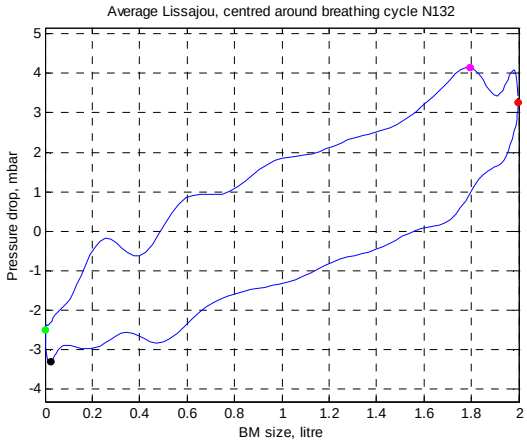
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	1.71	m
ROOM / WATER TEMPERATURE	:	19.5 / 4.2	℃
EHXALE GAS TEMPERATURE	:	15.5	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0 lpm	metric

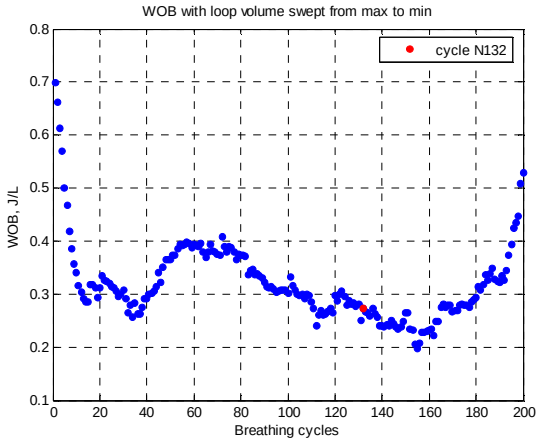
RESULTS

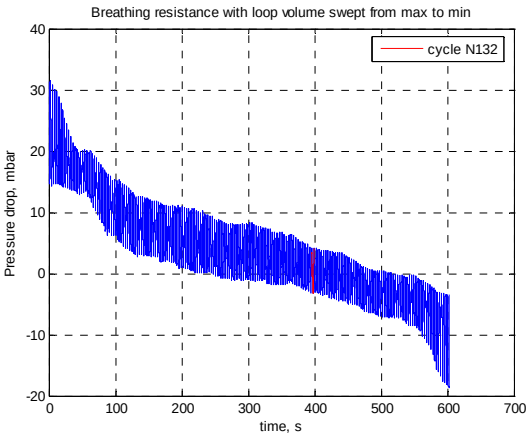
PRESSURE@END EXHALE / INHALE	=	3.3 / -2.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-3.3 / 4.2	mbar
PEAK TO PEAK PRESSURE	=	7.5	mbar
INHALE/EXHALE RESP PRESSURES	=	6.6 / 6.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.30	J/l
WOB OF BREATHING SIMULATOR	=	0.03	J/l
WOB OF DEVICE UNDER TEST	=	0.27	J/l
TOTAL POS / NEG WORK	=	0.12 / 0.17	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.10 / 0.16	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 00m_40 lpm_090114_01









9.1.3. DRB, Air, <6m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece EN14143:2003	
TEST METHOD		RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 15:11	
TEST CARRIED OUT BY		VD WITNESS: MS	

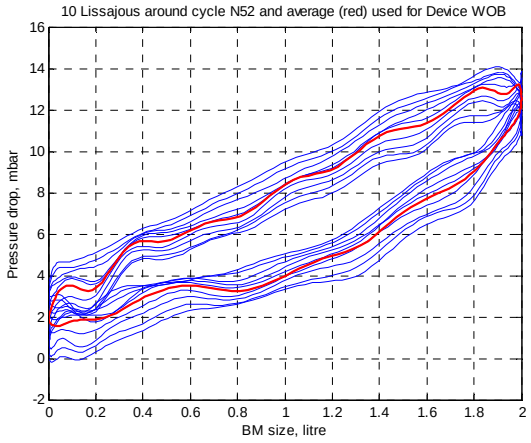
CONDITIONS OF TEST

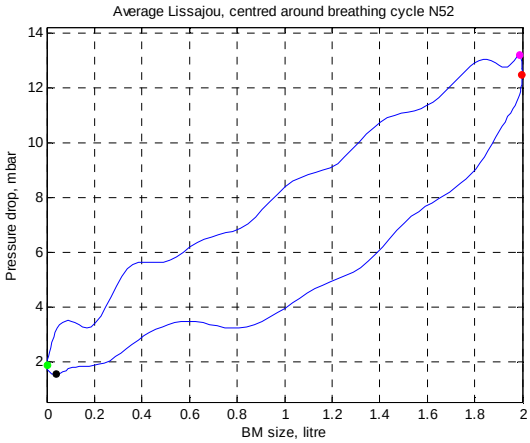
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	3.11	m
ROOM / WATER TEMPERATURE	:	20.3 / 4.2	℃
EHXALE GAS TEMPERATURE	:	14.4	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/39.9 lpm	metric

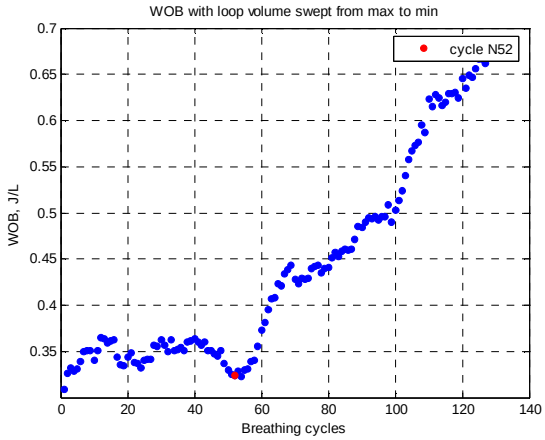
RESULTS

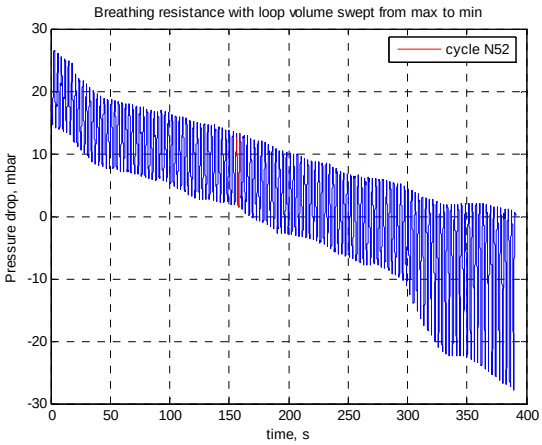
PRESSURE@END EXHALE / INHALE	=	12.3 / 1.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.2 / 13.0	mbar
PEAK TO PEAK PRESSURE	=	11.8	mbar
INHALE/EXHALE RESP PRESSURES	=	11.1 / 11.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.36	J/l
WOB OF BREATHING SIMULATOR	=	0.03	J/l
WOB OF DEVICE UNDER TEST	=	0.33	J/l
TOTAL POS / NEG WORK	=	0.15 / 0.21	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.13 / 0.19	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_00d_ 00m_40 lpm_090114_01









9.1.4. DRB, Air, <6m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13/01/09 15:50	
TEST CARRIED OUT BY	VD	WITNESS: MS	

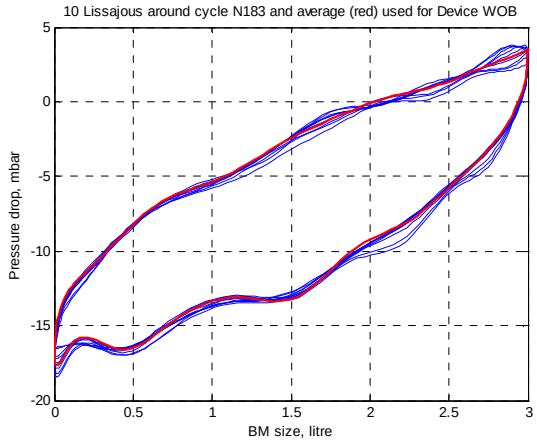
CONDITIONS OF TEST

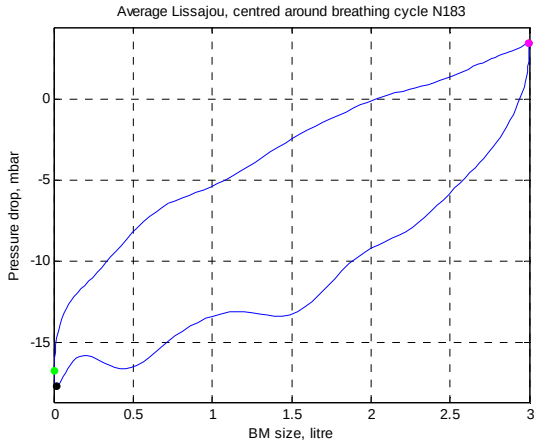
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	3.42	m
ROOM / WATER TEMPERATURE	:	20.4 / 3.9	℃
EHXALE GAS TEMPERATURE	:	19.3	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

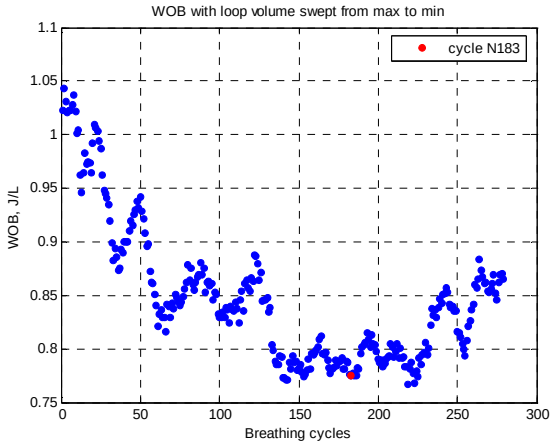
RESULTS

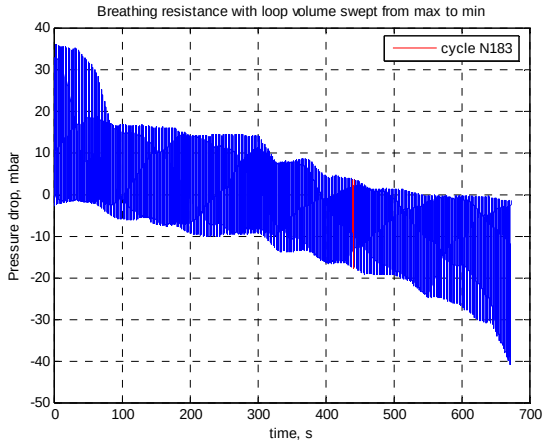
PRESSURE@END EXHALE / INHALE	=	3.5 / -16.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-17.7 / 3.4	mbar
PEAK TO PEAK PRESSURE	=	21.1	mbar
INHALE/EXHALE RESP PRESSURES	=	21.1 / 20.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.94	J/l
WOB OF BREATHING SIMULATOR	=	0.16	J/l
WOB OF DEVICE UNDER TEST	=	0.77	J/l
TOTAL POS / NEG WORK	=	0.42 / 0.48	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.34 / 0.39	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 00m_75 lpm_090113_01









9.1.5. DRB, Air, <6m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 11:16	
TEST CARRIED OUT BY	VD	WITNESS: MS	

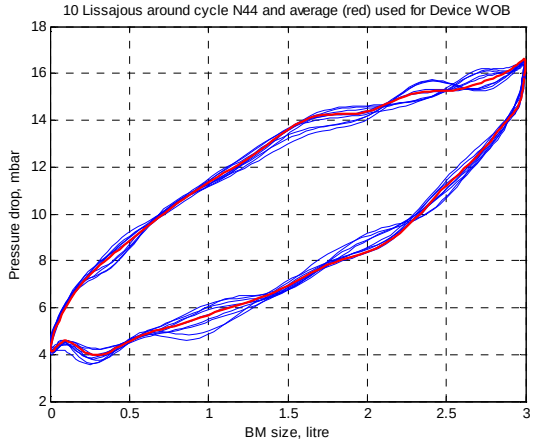
CONDITIONS OF TEST

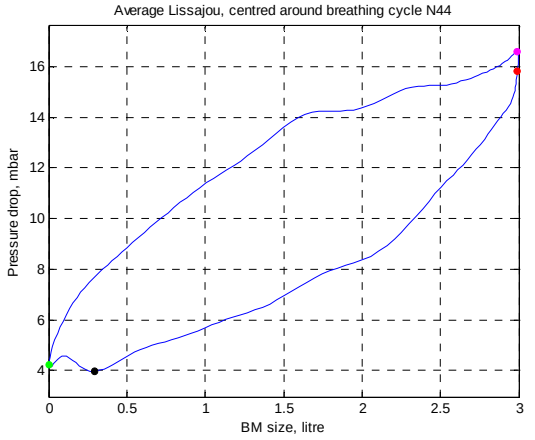
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	3.91	m
ROOM / WATER TEMPERATURE	:	19.6 / 3.8	℃
EHXALE GAS TEMPERATURE	:	19.7	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

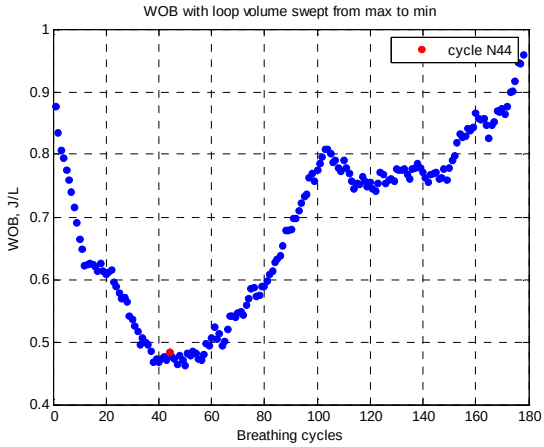
RESULTS

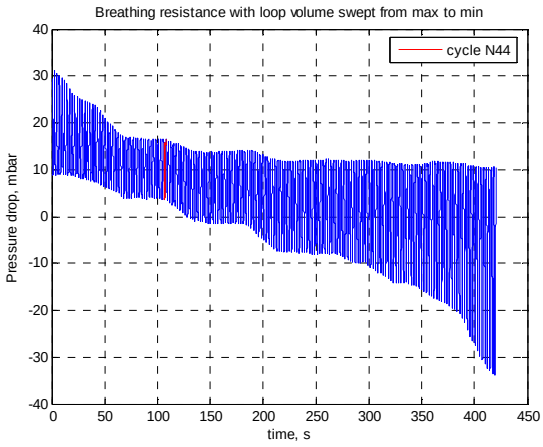
PRESSURE@END EXHALE / INHALE	=	15.8 / 4.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	4.0 / 16.6	mbar
PEAK TO PEAK PRESSURE	=	12.6	mbar
INHALE/EXHALE RESP PRESSURES	=	11.8 / 12.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.65	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	0.48	J/l
TOTAL POS / NEG WORK	=	0.37 / 0.30	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.28 / 0.23	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_00d_ 00m_75 lpm_090114_01









9.1.6. DRB, Air, <6m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		13/01/09 16:03	
TEST CARRIED OUT BY	VD	WITNESS: MS	

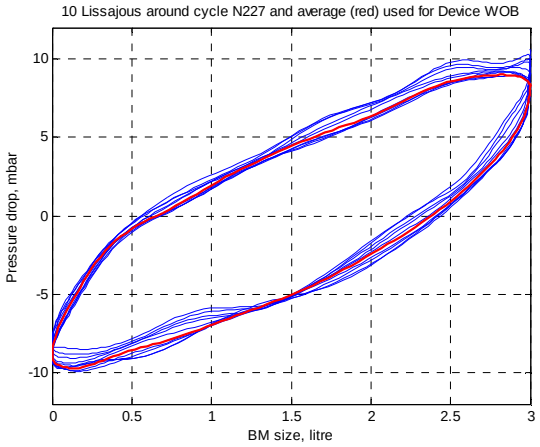
CONDITIONS OF TEST

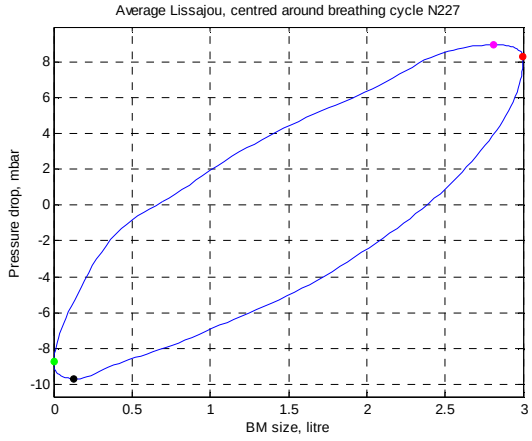
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	2.56	m
ROOM / WATER TEMPERATURE	:	20.5 / 3.8	℃
EHXALE GAS TEMPERATURE	:	18.4	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/30.0bpm/89.9 lpm	metric

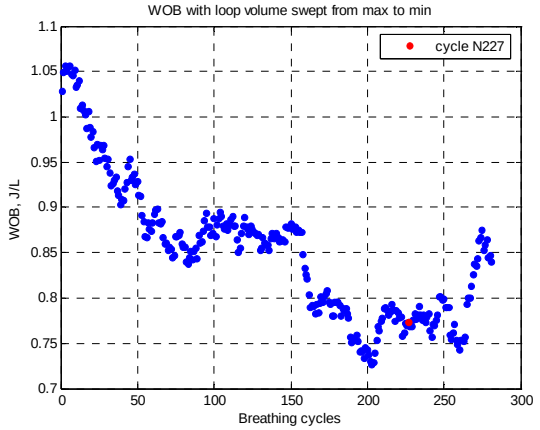
RESULTS

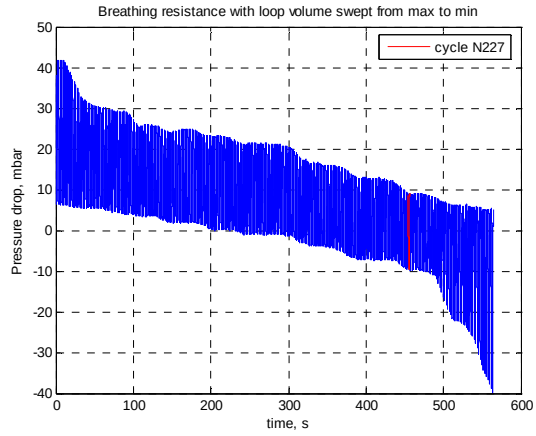
PRESSURE@END EXHALE / INHALE	=	8.3 / -8.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-9.7 / 9.0	mbar
PEAK TO PEAK PRESSURE	=	18.7	mbar
INHALE/EXHALE RESP PRESSURES	=	18.1 / 17.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.96	J/l
WOB OF BREATHING SIMULATOR	=	0.18	J/l
WOB OF DEVICE UNDER TEST	=	0.77	J/l
TOTAL POS / NEG WORK	=	0.49 / 0.45	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.40 / 0.35	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 00m_90 lpm_090113_01









9.2. Air, 40m

9.2.1. DRB, Air, 40m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	12.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

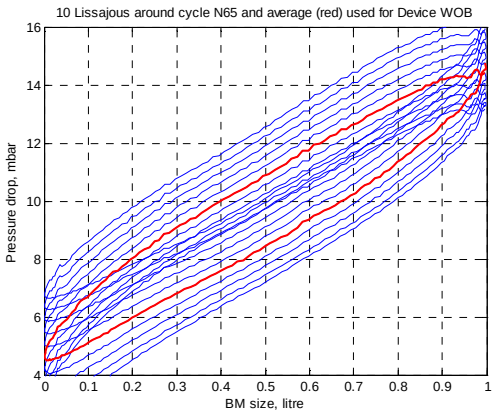
CONDITIONS OF TEST

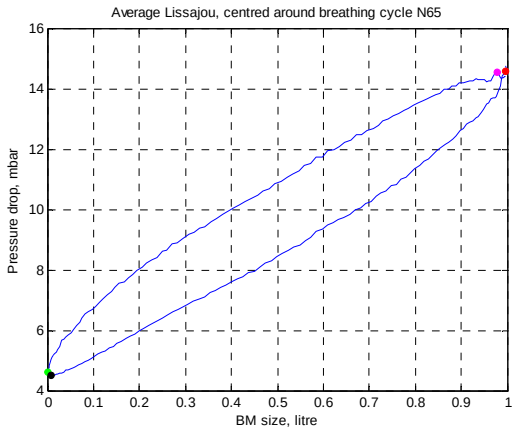
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.3	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	12.6	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0lpm	metric

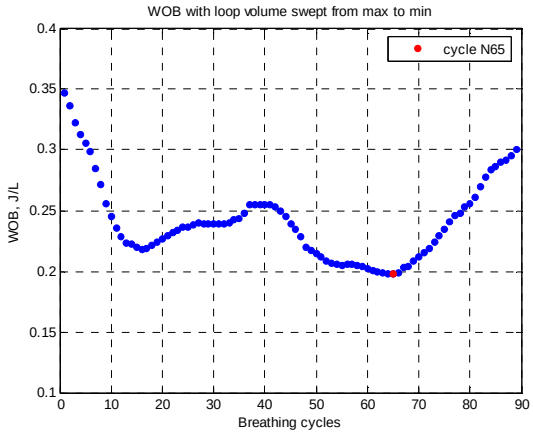
RESULTS

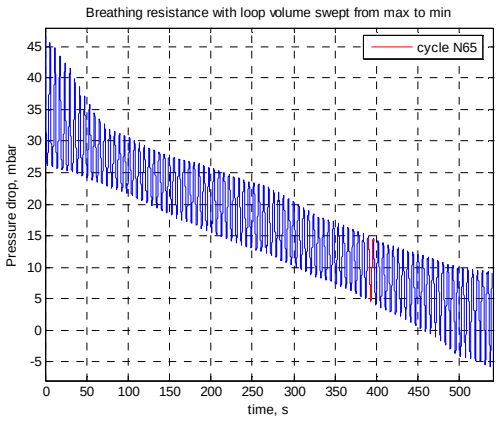
PRESSURE@END EXHALE / INHALE	=	14.6 / 4.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	4.5 / 14.5	mbar
PEAK TO PEAK PRESSURE	=	10.0	mbar
INHALE/EXHALE RESP PRESSURES	=	10.1 / 9.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.20	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.20	J/l
TOTAL POS / NEG WORK	=	0.10 / 0.09	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.10 / 0.09	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_40m_10lpm_air_100212_2









9.2.2. DRB, Air, 40m, 10 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	12.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

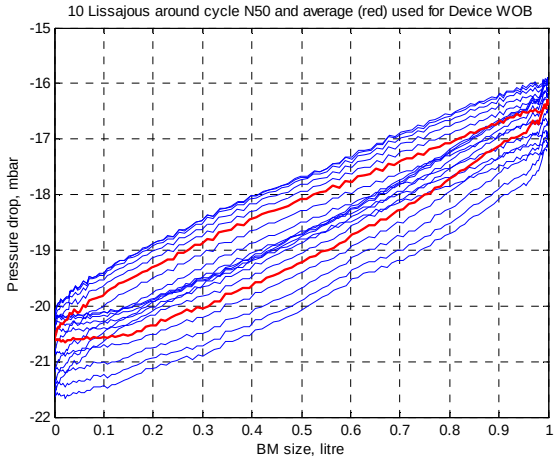
CONDITIONS OF TEST

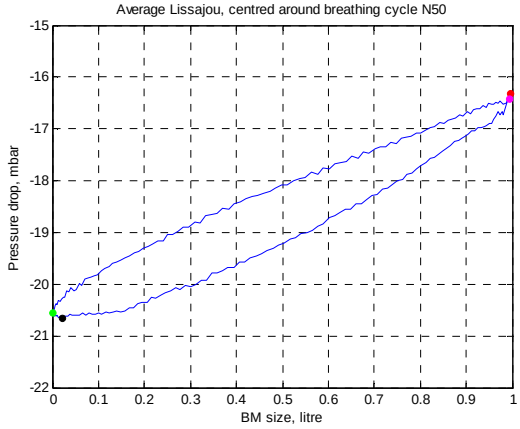
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.2	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0lpm	metric

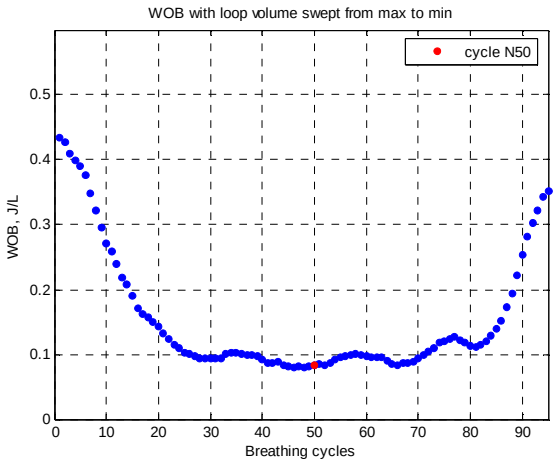
RESULTS

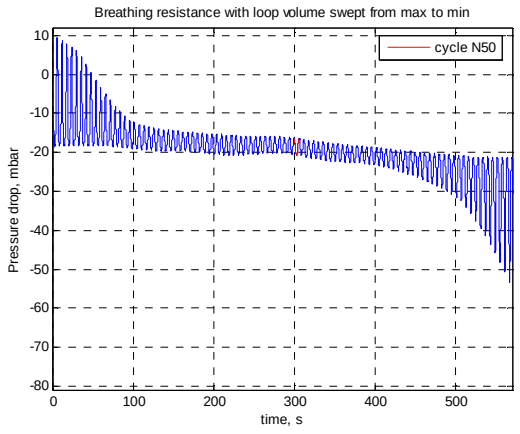
PRESSURE@END EXHALE / INHALE	=	-16.3 / -20.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-20.7 / -16.4	mbar
PEAK TO PEAK PRESSURE	=	4.2	mbar
INHALE/EXHALE RESP PRESSURES	=	4.3 / 4.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.08	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.08	J/l
TOTAL POS / NEG WORK	=	0.03 / 0.06	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.03 / 0.06	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_40m_10lpm_air_100212_1









9.2.3. DRB, Air, 40m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

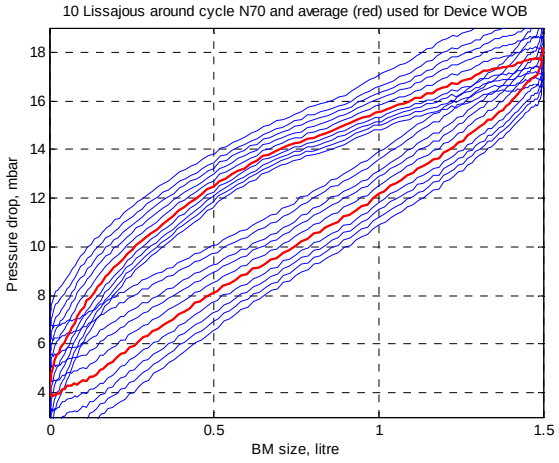
CONDITIONS OF TEST

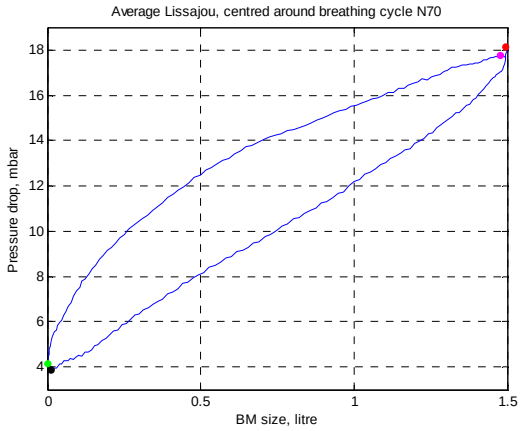
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.8	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	14.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5lpm	metric

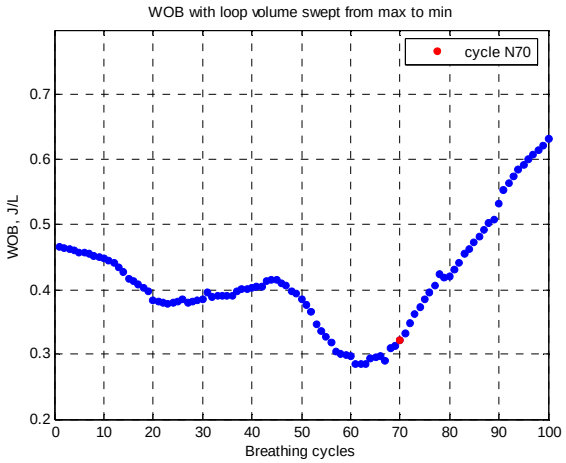
RESULTS

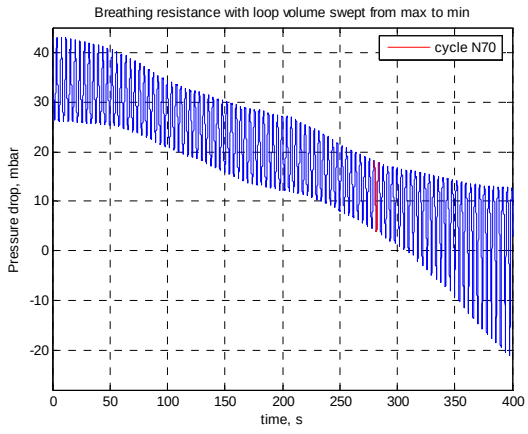
PRESSURE@END EXHALE / INHALE	=	18.1 / 4.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	3.8 / 17.8	mbar
PEAK TO PEAK PRESSURE	=	13.9	mbar
INHALE/EXHALE RESP PRESSURES	=	14.3 / 13.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.32	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.32	J/l
TOTAL POS / NEG WORK	=	0.23 / 0.10	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.23 / 0.10	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_41m_22.5lpm_air_100213_1









9.2.4. DRB, Air, 40m, 22.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

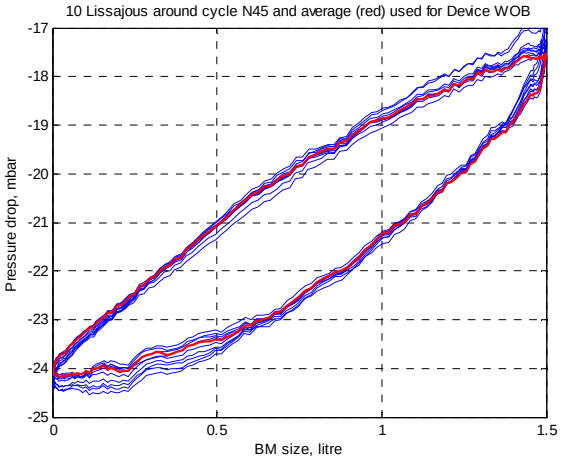
CONDITIONS OF TEST

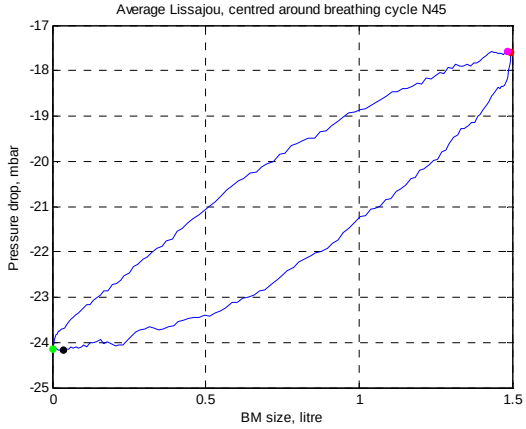
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	8.5	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5lpm	metric

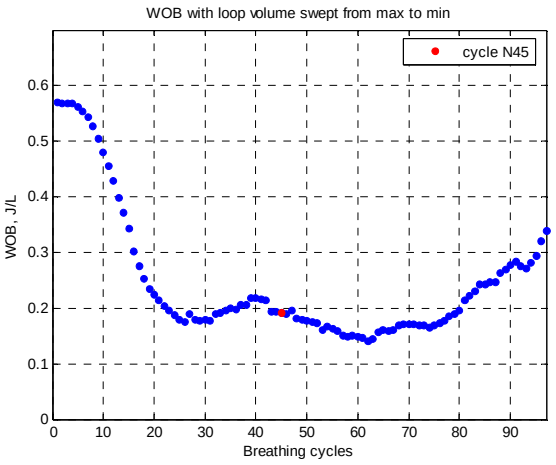
RESULTS

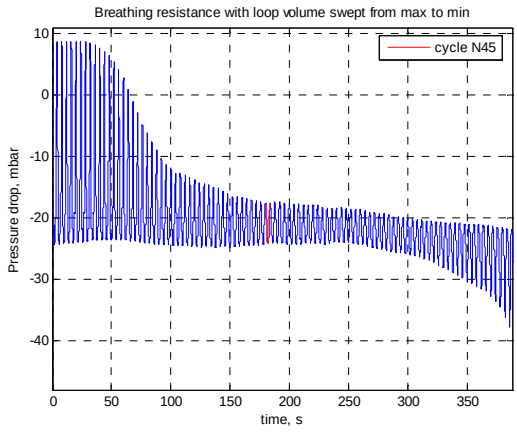
PRESSURE@END EXHALE / INHALE	=	-17.6 / -24.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.2 / -17.6	mbar
PEAK TO PEAK PRESSURE	=	6.6	mbar
INHALE/EXHALE RESP PRESSURES	=	6.6 / 6.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.19	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.19	J/l
TOTAL POS / NEG WORK	=	0.06 / 0.12	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.06 / 0.12	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_22.5lpm_air_100213_1









9.2.5. DRB, Air, 40m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

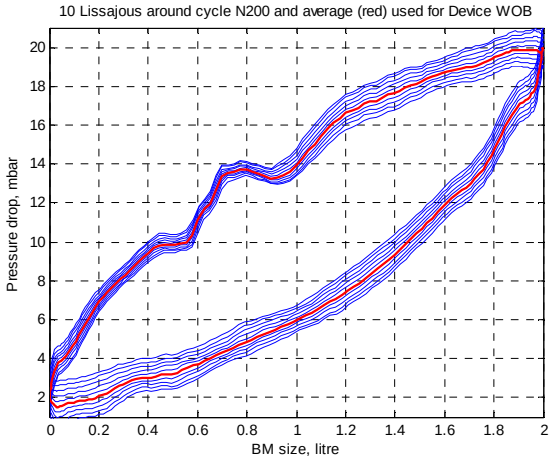
CONDITIONS OF TEST

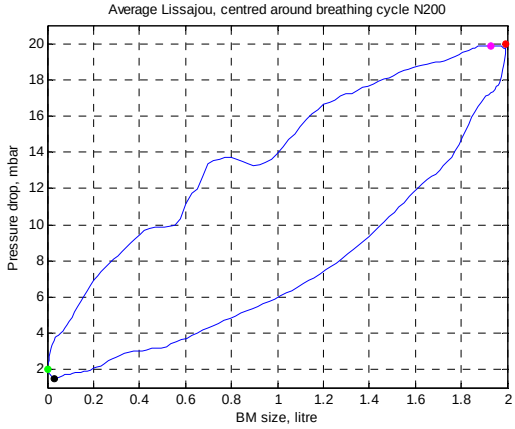
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.5	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0lpm	metric

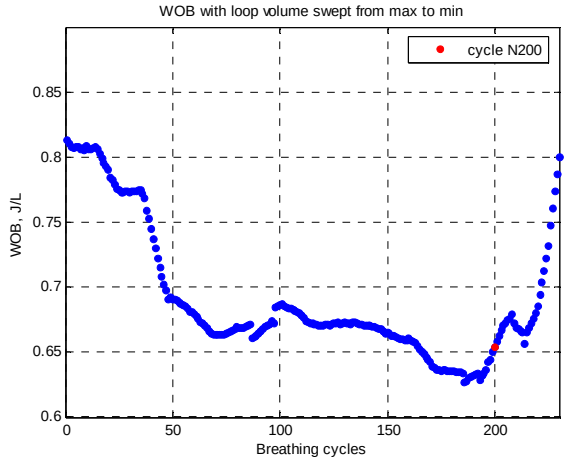
RESULTS

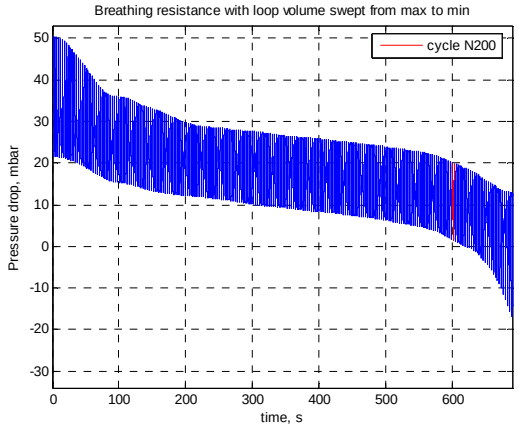
PRESSURE@END EXHALE / INHALE	=	20.0 / 2.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	1.5 / 19.9	mbar
PEAK TO PEAK PRESSURE	=	18.4	mbar
INHALE/EXHALE RESP PRESSURES	=	18.4 / 17.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.69	J/l
WOB OF BREATHING SIMULATOR	=	0.04	J/l
WOB OF DEVICE UNDER TEST	=	0.65	J/l
TOTAL POS / NEG WORK	=	0.30 / 0.39	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.28 / 0.37	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_41m_40lpm_air_100213_1









9.2.6. DRB, Air, 40m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

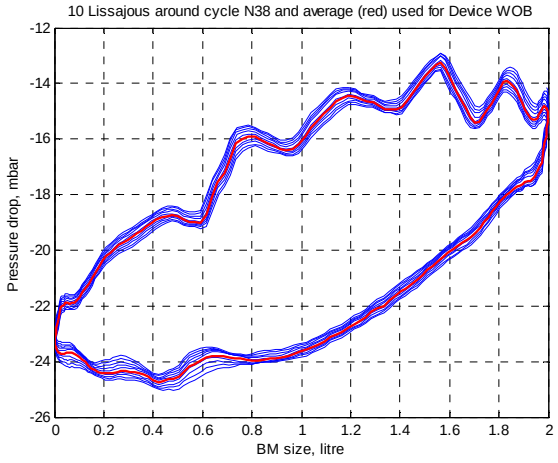
CONDITIONS OF TEST

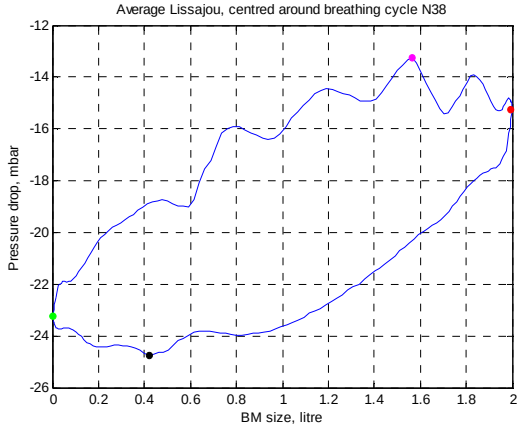
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.7	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.1	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0lpm	metric

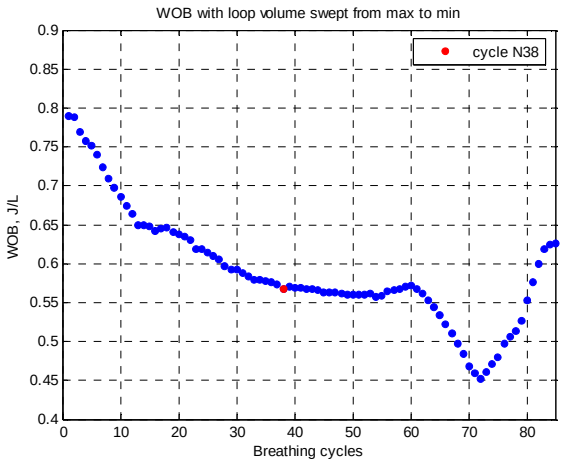
RESULTS

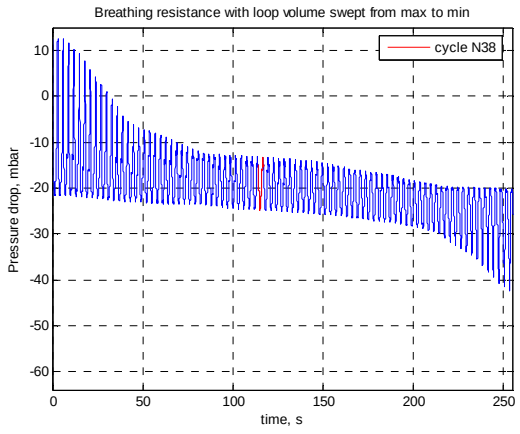
PRESSURE@END EXHALE / INHALE	=	-15.3 / -23.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.7 / -13.2	mbar
PEAK TO PEAK PRESSURE	=	11.5	mbar
INHALE/EXHALE RESP PRESSURES	=	9.5 / 10.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.60	J/l
WOB OF BREATHING SIMULATOR	=	0.04	J/l
WOB OF DEVICE UNDER TEST	=	0.57	J/l
TOTAL POS / NEG WORK	=	0.25 / 0.33	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.23 / 0.31	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_40lpm_air_100213_1









9.2.7. DRB, Air, 40m, 62.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

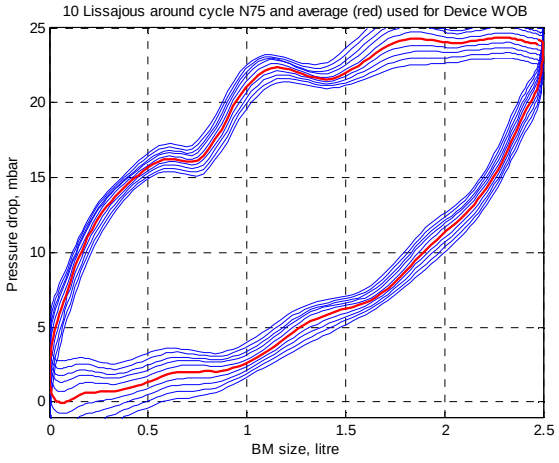
CONDITIONS OF TEST

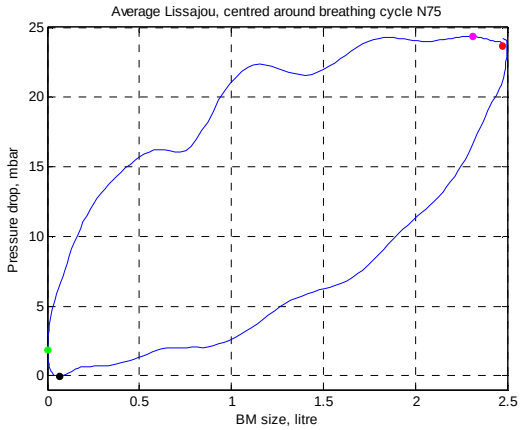
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.4	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5lpm	metric

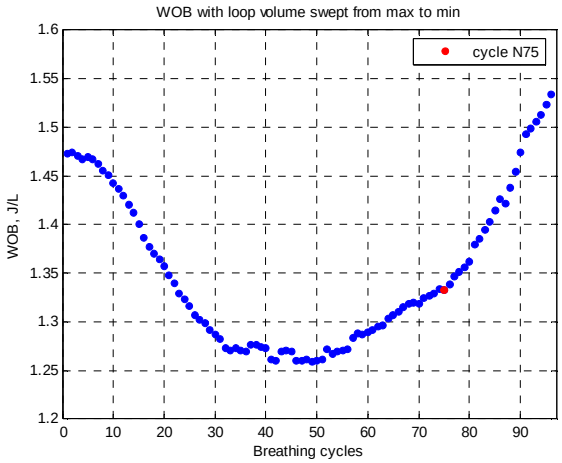
RESULTS

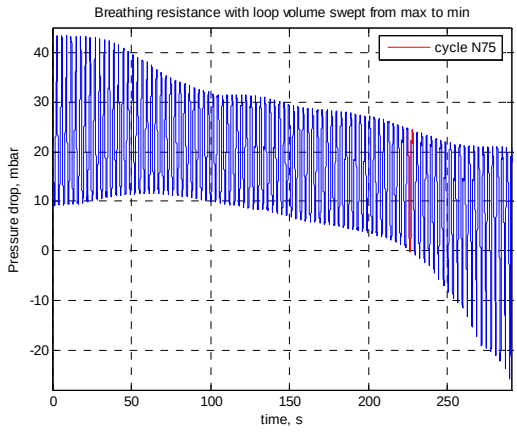
PRESSURE@END EXHALE / INHALE	=	23.7 / 1.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-0.0 / 24.4	mbar
PEAK TO PEAK PRESSURE	=	24.4	mbar
INHALE/EXHALE RESP PRESSURES	=	23.8 / 22.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.33	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	1.33	J/l
TOTAL POS / NEG WORK	=	0.61 / 0.66	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.61 / 0.66	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_41m_62.5lpm_air_100213_1









9.2.8. DRB, Air, 40m, 62.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

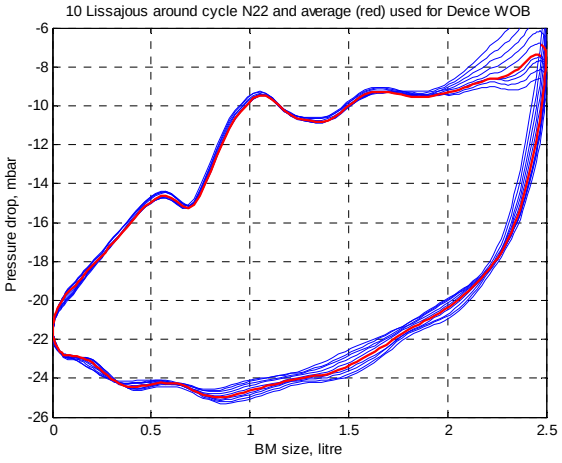
CONDITIONS OF TEST

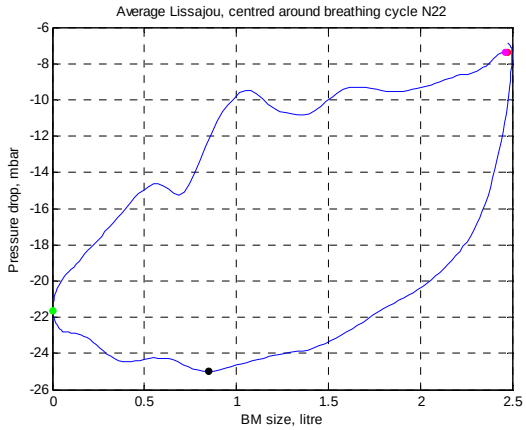
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.3	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	8.6	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5lpm	metric

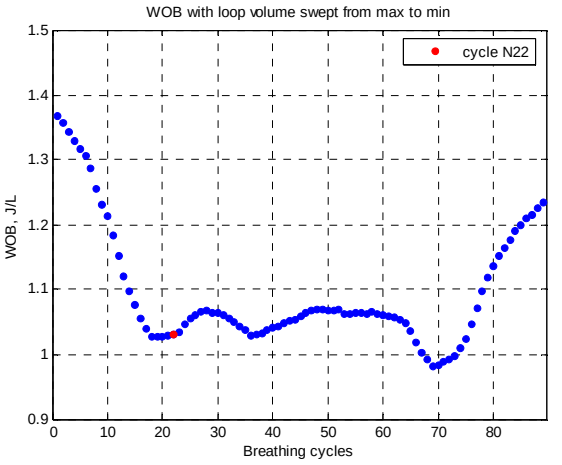
RESULTS

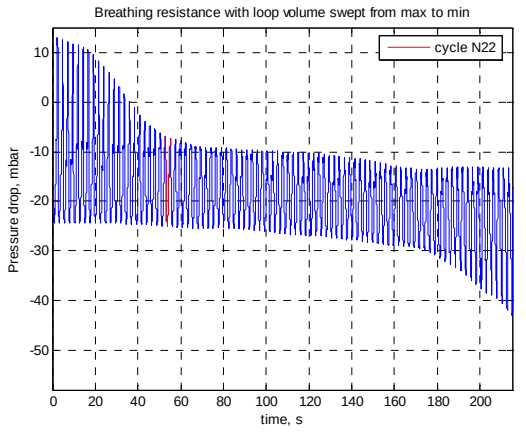
PRESSURE@END EXHALE / INHALE	=	-7.4 / -21.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-25.0 / -7.4	mbar
PEAK TO PEAK PRESSURE	=	17.6	mbar
INHALE/EXHALE RESP PRESSURES	=	17.6 / 14.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.03	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	1.03	J/l
TOTAL POS / NEG WORK	=	0.22 / 0.77	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.22 / 0.77	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_62.5lpm_air_100213_1









9.2.9. DRB, Air, 40m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	14.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

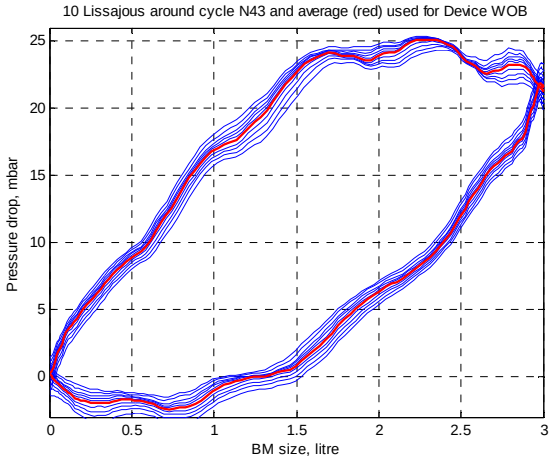
CONDITIONS OF TEST

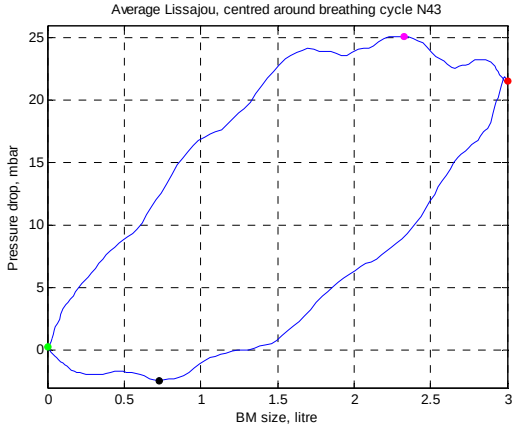
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.1	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0lpm	metric

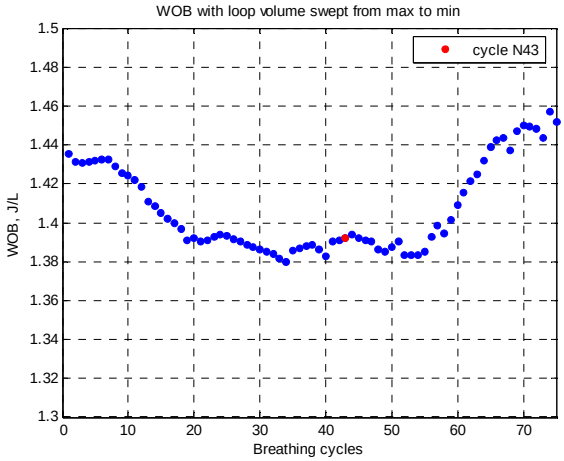
RESULTS

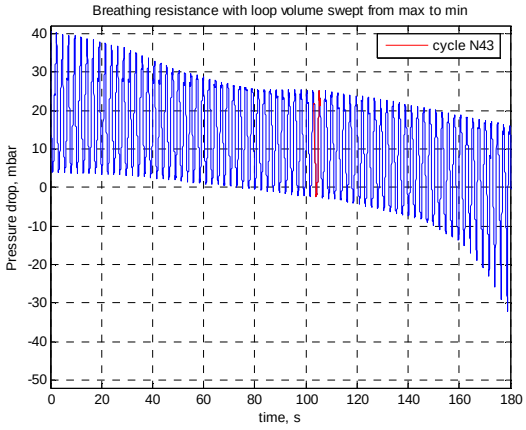
PRESSURE@END EXHALE / INHALE	=	21.6 / 0.2	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-2.4 / 25.1	mbar
PEAK TO PEAK PRESSURE	=	27.6	mbar
INHALE/EXHALE RESP PRESSURES	=	24.0 / 24.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.52	J/l
WOB OF BREATHING SIMULATOR	=	0.13	J/l
WOB OF DEVICE UNDER TEST	=	1.39	J/l
TOTAL POS / NEG WORK	=	0.80 / 0.73	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.74 / 0.67	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_40m_75lpm_air_100214_1









9.2.10. DRB, Air, 40m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	14.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

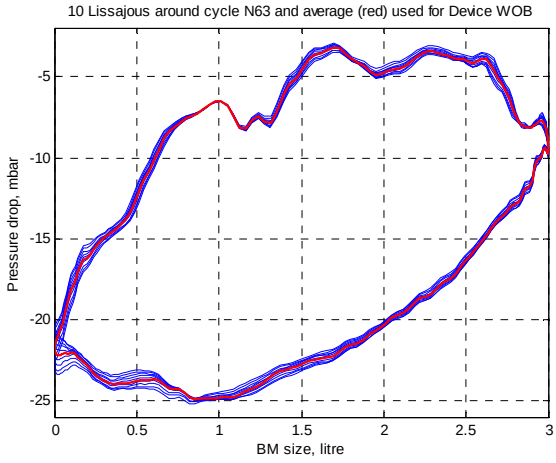
CONDITIONS OF TEST

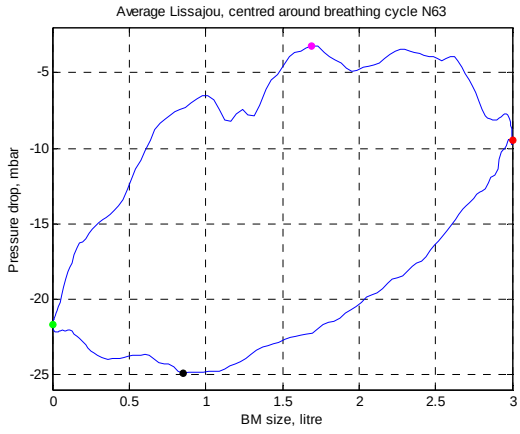
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	40.6	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0lpm	metric

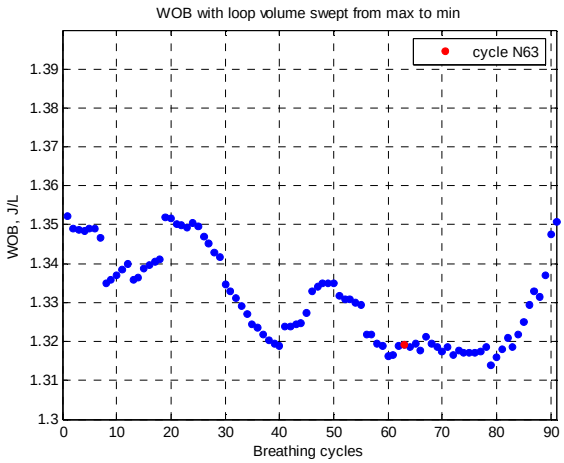
RESULTS

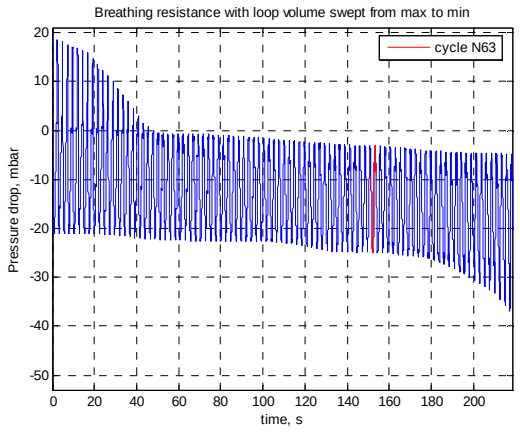
PRESSURE@END EXHALE / INHALE	=	-9.5 / -21.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.9 / -3.2	mbar
PEAK TO PEAK PRESSURE	=	21.7	mbar
INHALE/EXHALE RESP PRESSURES	=	15.4 / 18.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.49	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	1.32	J/l
TOTAL POS / NEG WORK	=	0.88 / 0.61	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.80 / 0.53	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_42m_75lpm_air_100214_1









9.3. DRB, Air, 60m

9.3.1. DRB, Air, 60m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece
TEST METHOD		EN14143:2003 RELATIVE SINE FLOW
DATE AND TIME		15/01/09 13:03
TEST CARRIED OUT BY	VD	WITNESS: MS

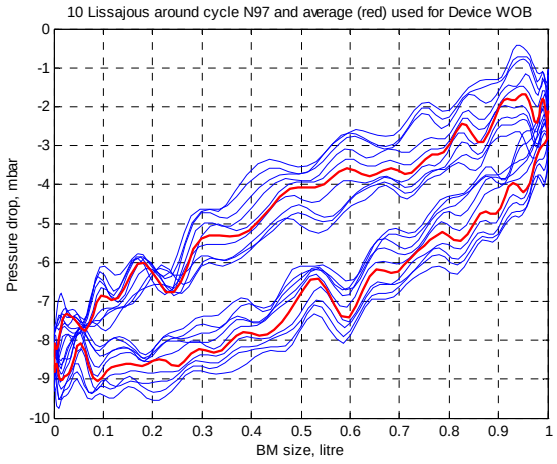
CONDITIONS OF TEST

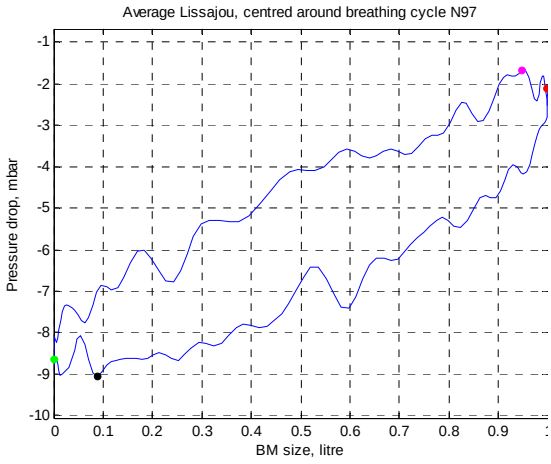
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	59.94	m
ROOM / WATER TEMPERATURE	:	19.5 / 4.2	℃
EHXALE GAS TEMPERATURE	:	15.8	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/9.9bpm/9.9 lpm	metric

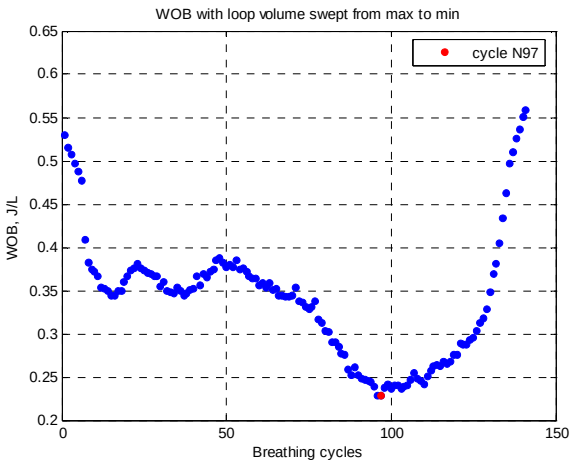
RESULTS

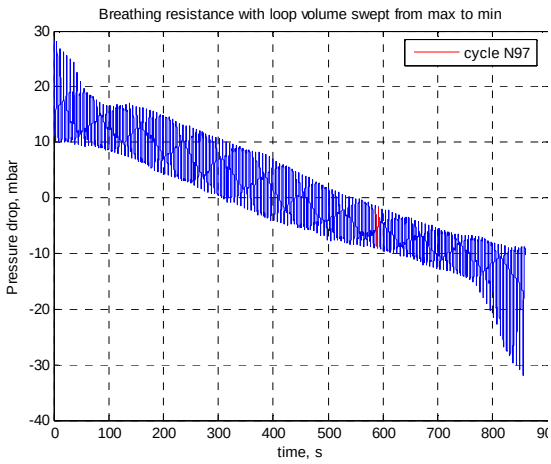
PRESSURE@END EXHALE / INHALE	=	-2.1 / -8.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-9.1 / -1.7	mbar
PEAK TO PEAK PRESSURE	=	7.4	mbar
INHALE/EXHALE RESP PRESSURES	=	6.9 / 7.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.23	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.23	J/l
TOTAL POS / NEG WORK	=	0.10 / 0.15	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.10 / 0.15	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 60m_10 lpm_090115_01









9.3.2. DRB, Air, 60m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 14:48	
TEST CARRIED OUT BY	VD	WITNESS: MS	

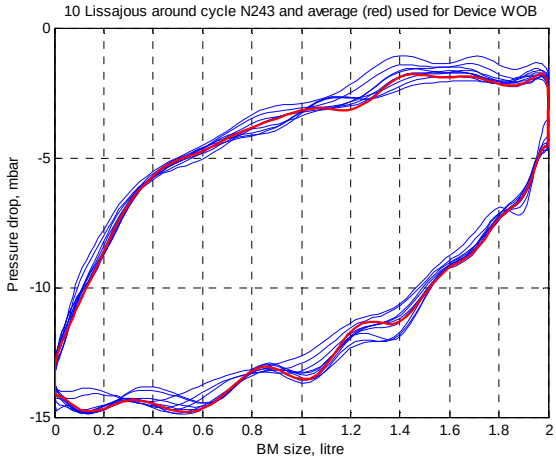
CONDITIONS OF TEST

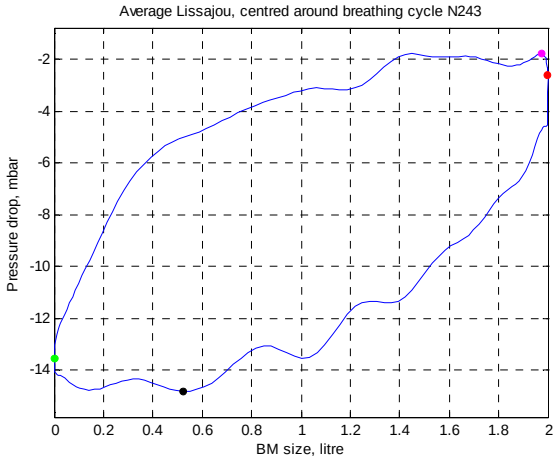
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	60.55	m
ROOM / WATER TEMPERATURE	:	20.3 / 4.1	℃
EHXALE GAS TEMPERATURE	:	14.5	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/19.9bpm/39.7 lpm	metric

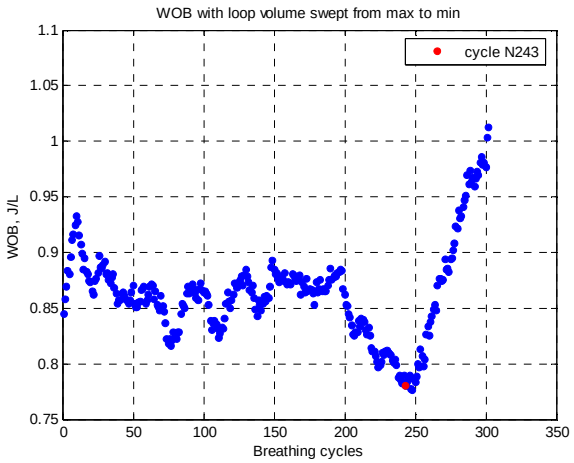
RESULTS

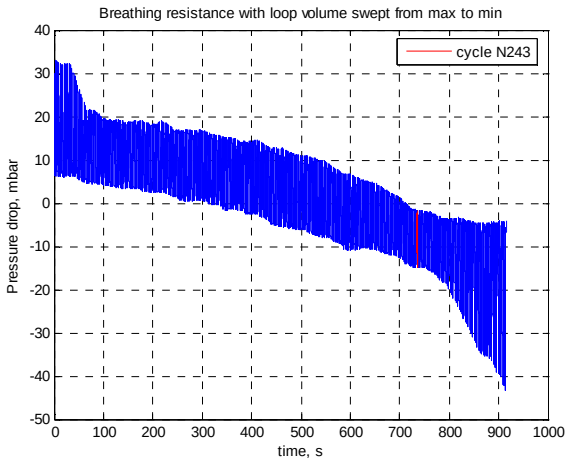
PRESSURE@END EXHALE / INHALE	=	-2.6 / -13.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-14.8 / -1.8	mbar
PEAK TO PEAK PRESSURE	=	13.0	mbar
INHALE/EXHALE RESP PRESSURES	=	12.2 / 11.8	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.95	J/l
WOB OF BREATHING SIMULATOR	=	0.17	J/l
WOB OF DEVICE UNDER TEST	=	0.78	J/l
TOTAL POS / NEG WORK	=	0.49 / 0.44	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.41 / 0.36	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 60m_40 lpm_090114_01









9.3.3. DRB, Air, 60m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece EN14143:2003	
TEST METHOD		RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 15:35	
TEST CARRIED OUT BY		VD WITNESS: MS	

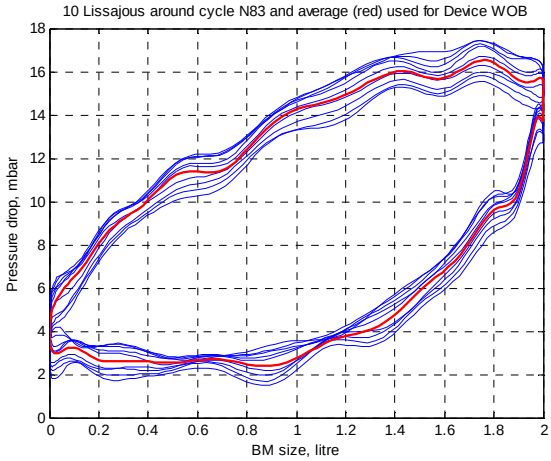
CONDITIONS OF TEST

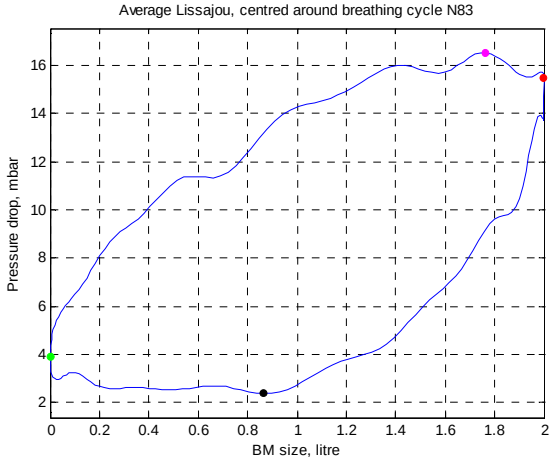
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	59.57	m
ROOM / WATER TEMPERATURE	:	20.3 / 4.2	℃
EHXALE GAS TEMPERATURE	:	14.8	℃
GAS SUPPLY PRESSURE	:	8.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/19.9bpm/39.7 lpm	metric

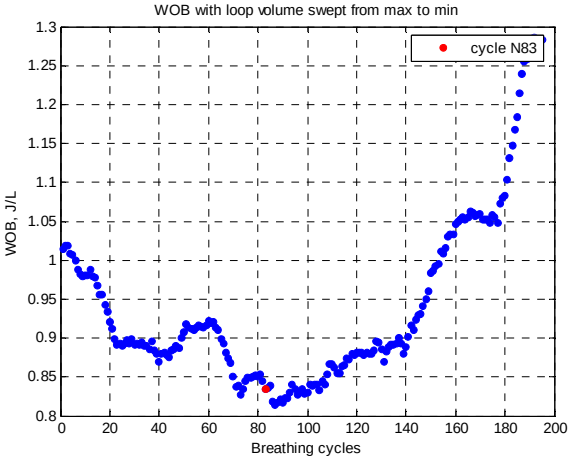
RESULTS

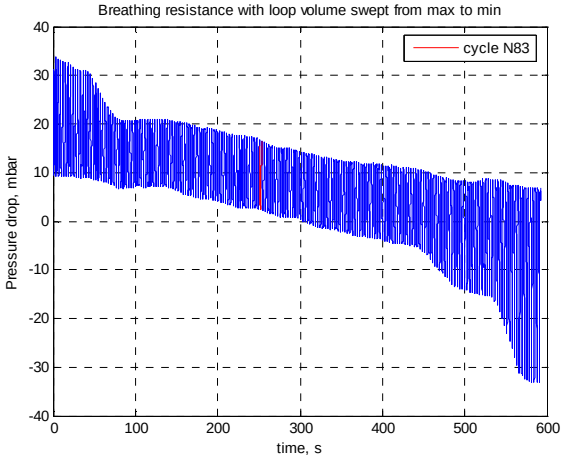
PRESSURE@END EXHALE / INHALE	=	15.6 / 4.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	2.5 / 16.7	mbar
PEAK TO PEAK PRESSURE	=	14.3	mbar
INHALE/EXHALE RESP PRESSURES	=	13.1 / 12.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.01	J/l
WOB OF BREATHING SIMULATOR	=	0.16	J/l
WOB OF DEVICE UNDER TEST	=	0.85	J/l
TOTAL POS / NEG WORK	=	0.42 / 0.57	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.34 / 0.48	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_00d_ 60m_40 lpm_090114_01









9.3.4. DRB, Air, 60m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		13/01/09 16:43	
TEST CARRIED OUT BY	VD	WITNESS: MS	

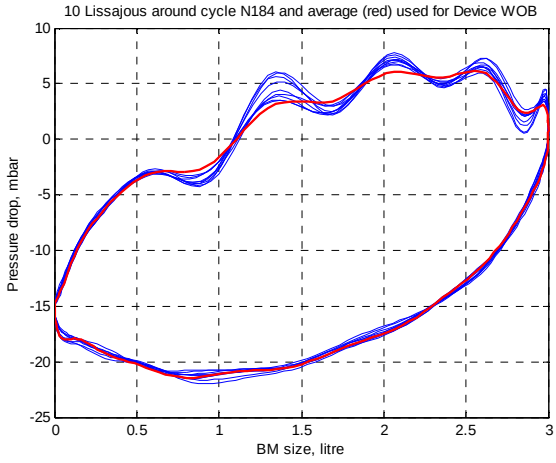
CONDITIONS OF TEST

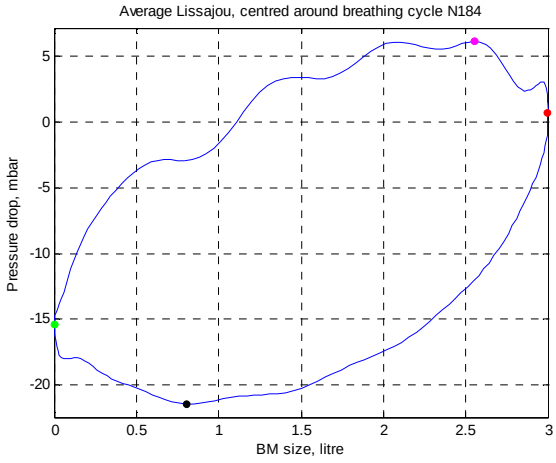
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	60.49	m
ROOM / WATER TEMPERATURE	:	20.5 / 3.8	℃
EHXALE GAS TEMPERATURE	:	19.0	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/24.9bpm/74.6 lpm	metric

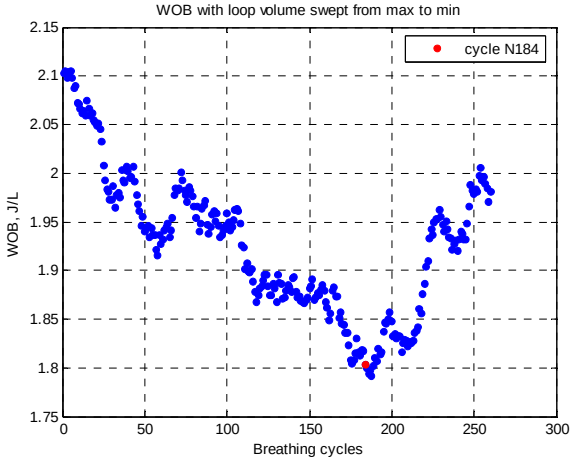
RESULTS

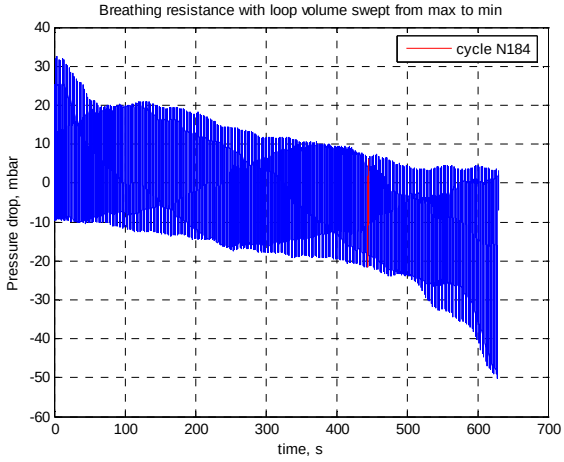
PRESSURE@END EXHALE / INHALE	=	0.7 / -15.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-21.5 / 6.1	mbar
PEAK TO PEAK PRESSURE	=	27.6	mbar
INHALE/EXHALE RESP PRESSURES	=	22.2 / 21.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	2.48	J/l
WOB OF BREATHING SIMULATOR	=	0.67	J/l
WOB OF DEVICE UNDER TEST	=	1.80	J/l
TOTAL POS / NEG WORK	=	1.15 / 1.26	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.81 / 0.93	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_90d_ 60m_75 lpm_090113_01









9.3.5. DRB, Air, 60m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 11:44	
TEST CARRIED OUT BY	VD	WITNESS: MS	

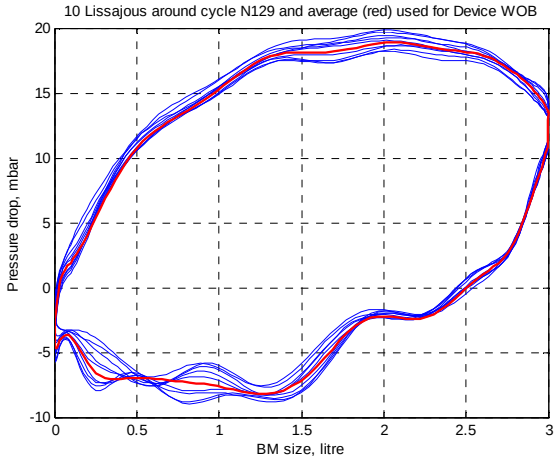
CONDITIONS OF TEST

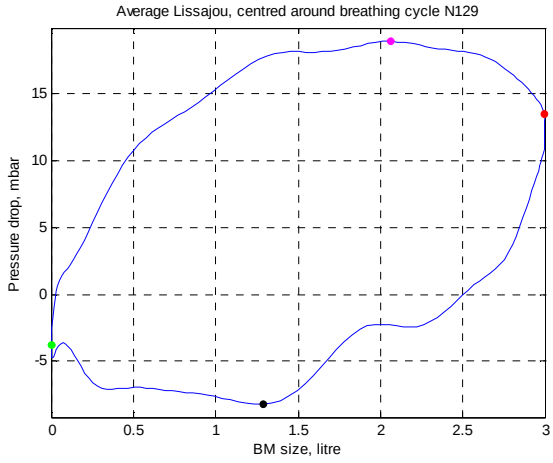
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	55.73	m
ROOM / WATER TEMPERATURE	:	19.6 / 3.8	℃
EHXALE GAS TEMPERATURE	:	17.7	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/74.9 lpm	metric

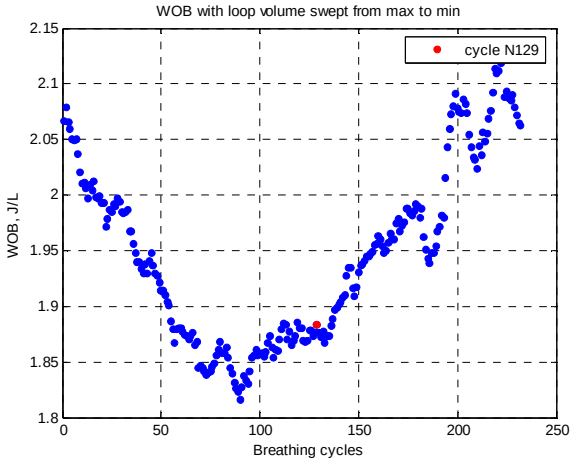
RESULTS

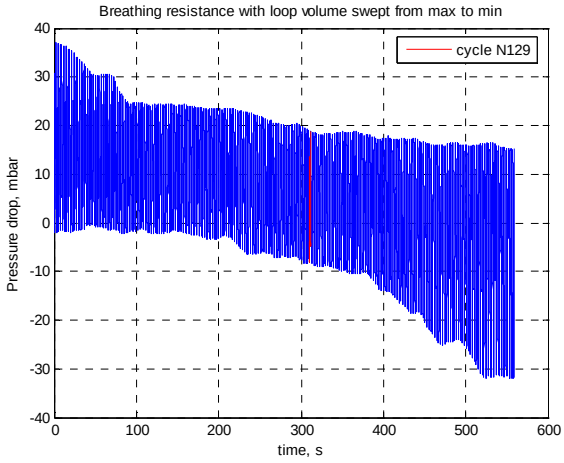
PRESSURE@END EXHALE / INHALE	=	13.5 / -3.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-8.2 / 18.9	mbar
PEAK TO PEAK PRESSURE	=	27.1	mbar
INHALE/EXHALE RESP PRESSURES	=	21.7 / 22.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	2.52	J/l
WOB OF BREATHING SIMULATOR	=	0.63	J/l
WOB OF DEVICE UNDER TEST	=	1.88	J/l
TOTAL POS / NEG WORK	=	1.31 / 1.15	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.00 / 0.88	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_00d_ 50m_75 lpm_090114_01









9.3.6. DRB, Air, 100m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DRB SN1112 with DL Helmet Mouthpiece	
TEST METHOD		EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME		14/01/09 12:05	
TEST CARRIED OUT BY	VD	WITNESS: MS	

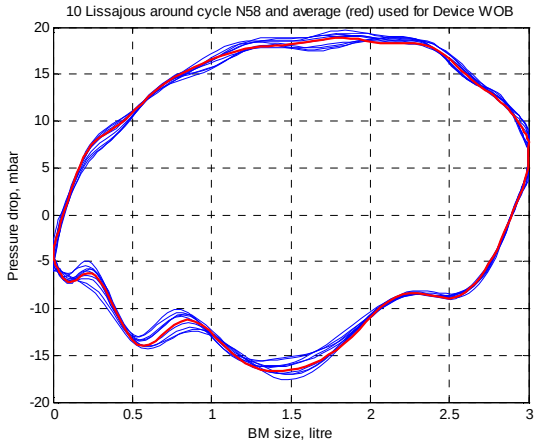
CONDITIONS OF TEST

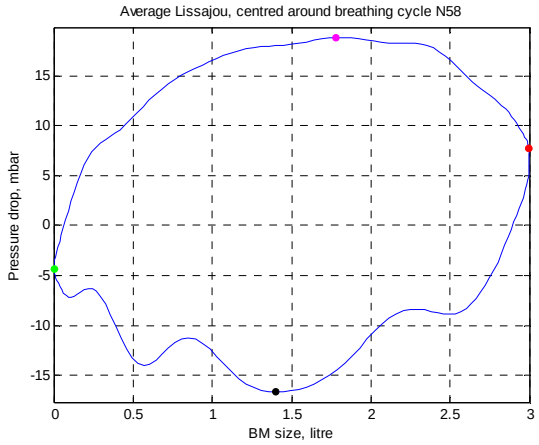
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	air	
DEPTH	:	99.67	m
ROOM / WATER TEMPERATURE	:	19.6 / 3.8	℃
EHXALE GAS TEMPERATURE	:	20.1	℃
GAS SUPPLY PRESSURE	:	8	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/24.9bpm/74.8 lpm	metric

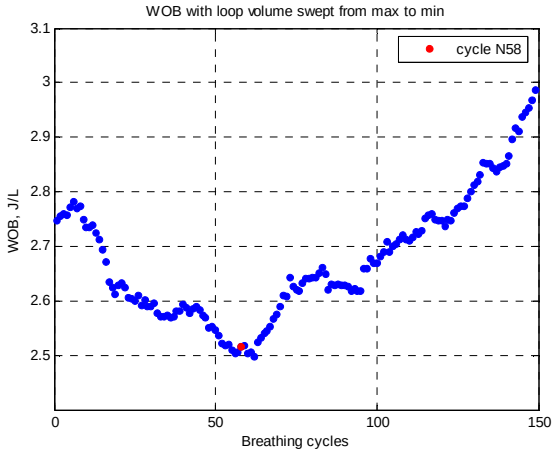
RESULTS

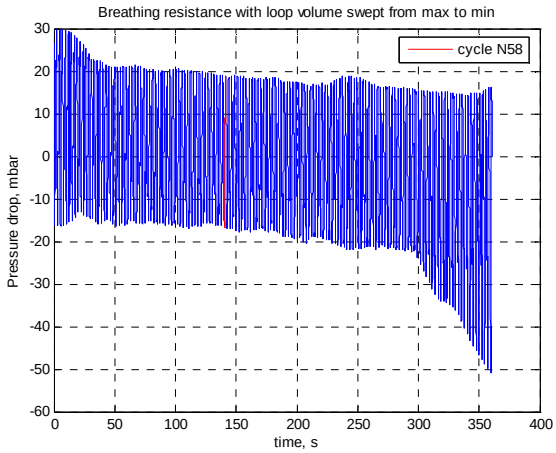
PRESSURE@END EXHALE / INHALE	=	7.7 / -4.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-16.7 / 18.9	mbar
PEAK TO PEAK PRESSURE	=	35.6	mbar
INHALE/EXHALE RESP PRESSURES	=	24.4 / 23.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	3.54	J/l
WOB OF BREATHING SIMULATOR	=	1.03	J/l
WOB OF DEVICE UNDER TEST	=	2.52	J/l
TOTAL POS / NEG WORK	=	1.80 / 1.72	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	1.29 / 1.20	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_helmMTHPC_00d_ 100m_75 lpm_090114_01









9.4. DRB, Heliox, 40m

9.4.1. DRB, Heliox, 40m, 10 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	12.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

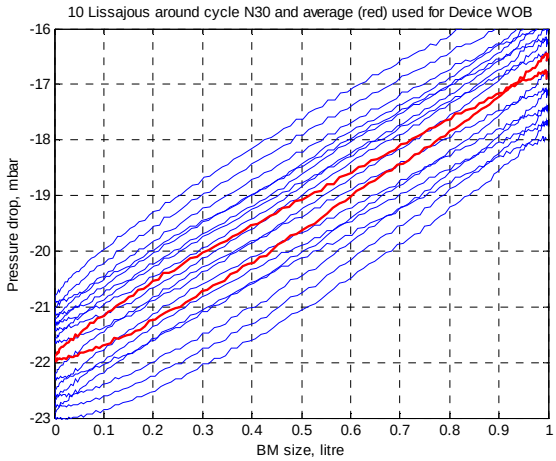
CONDITIONS OF TEST

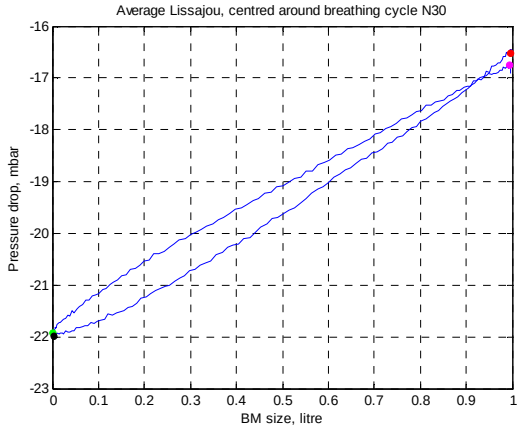
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.5	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0lpm	metric

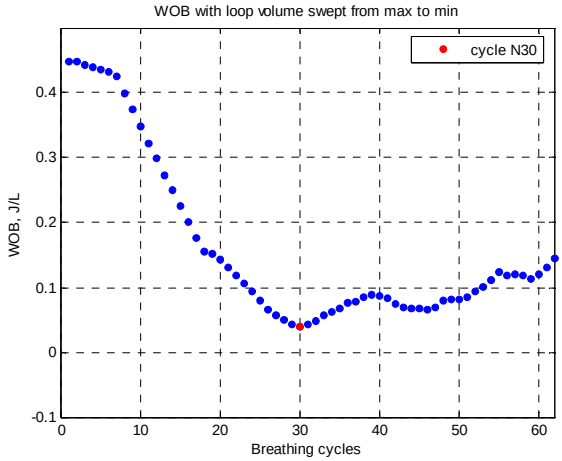
RESULTS

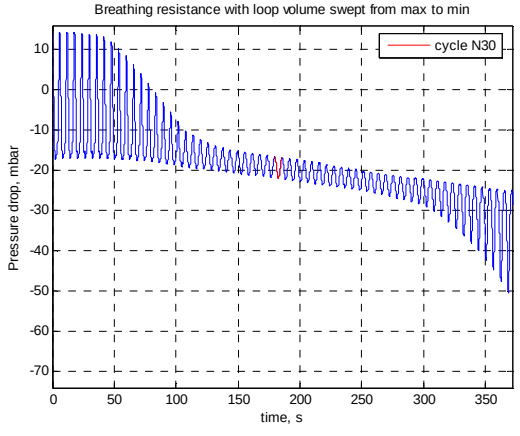
PRESSURE@END EXHALE / INHALE	=	-16.5 / -21.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.0 / -16.7	mbar
PEAK TO PEAK PRESSURE	=	5.2	mbar
INHALE/EXHALE RESP PRESSURES	=	5.5 / 5.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.04	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.04	J/l
TOTAL POS / NEG WORK	=	0.02 / 0.03	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.02 / 0.03	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_10lpm_HeOx_100212_1









9.4.2. DRB, Heliox, 40m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

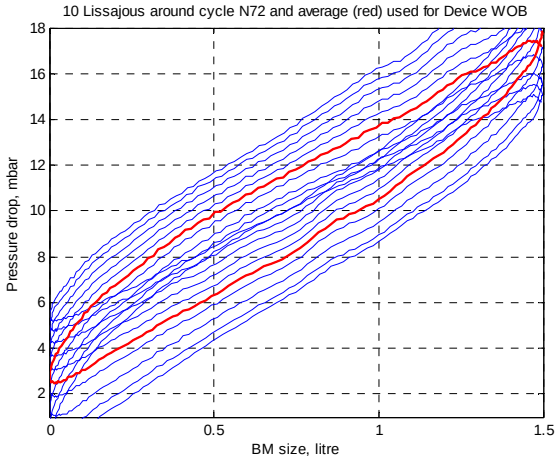
CONDITIONS OF TEST

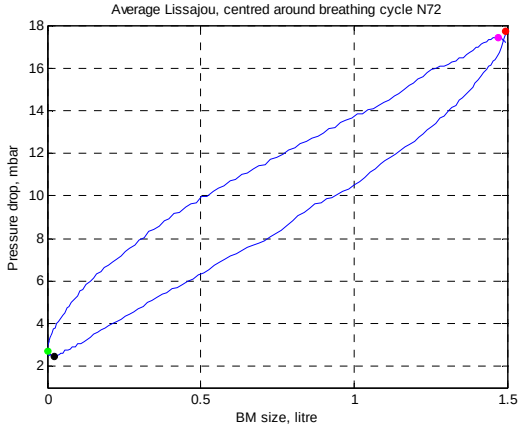
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	12.2	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5lpm	metric

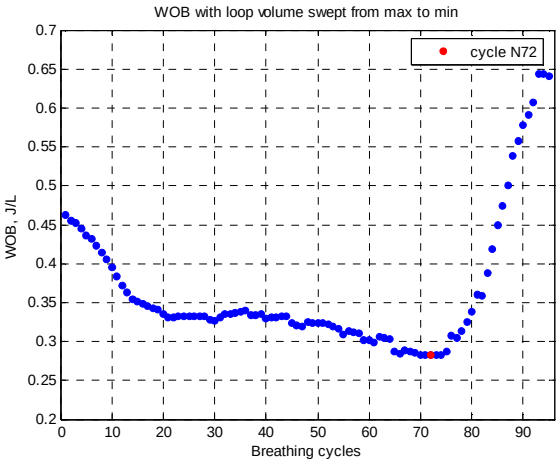
RESULTS

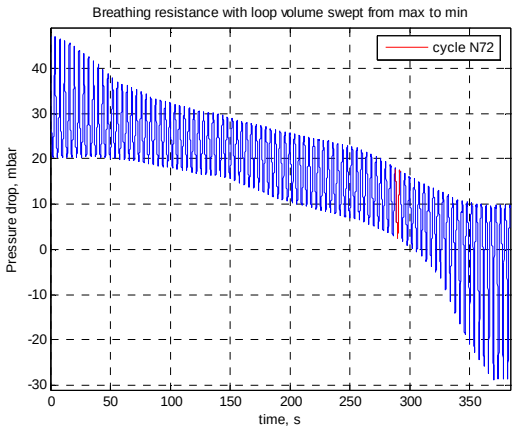
PRESSURE@END EXHALE / INHALE	=	17.7 / 2.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	2.5 / 17.5	mbar
PEAK TO PEAK PRESSURE	=	15.0	mbar
INHALE/EXHALE RESP PRESSURES	=	15.3 / 14.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.28	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.28	J/l
TOTAL POS / NEG WORK	=	0.14 / 0.15	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.14 / 0.15	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_40m_22.5lpm_HeOx_100213_1









9.4.3. DRB, Heliox, 40m, 22.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

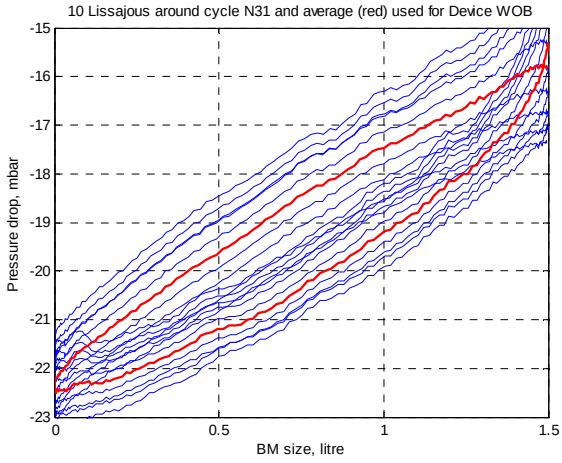
CONDITIONS OF TEST

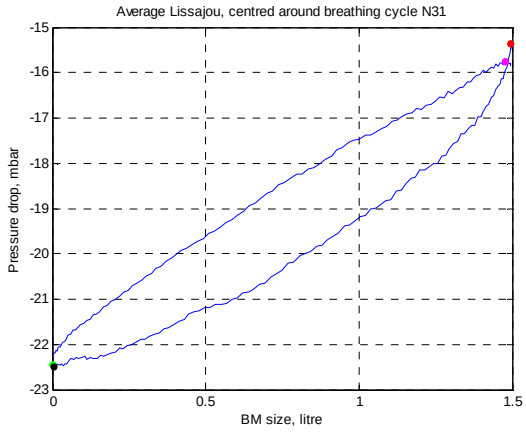
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.9	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.4	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5lpm	metric

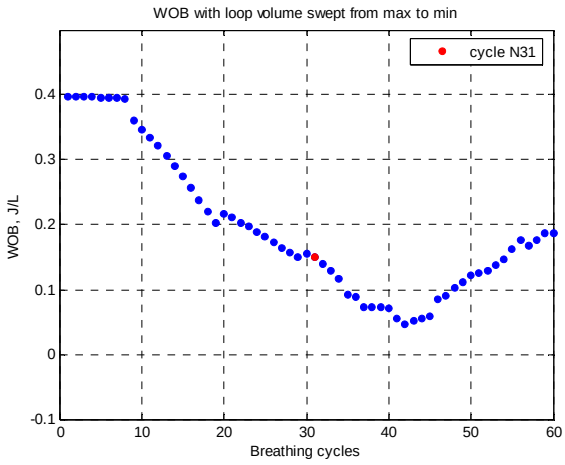
RESULTS

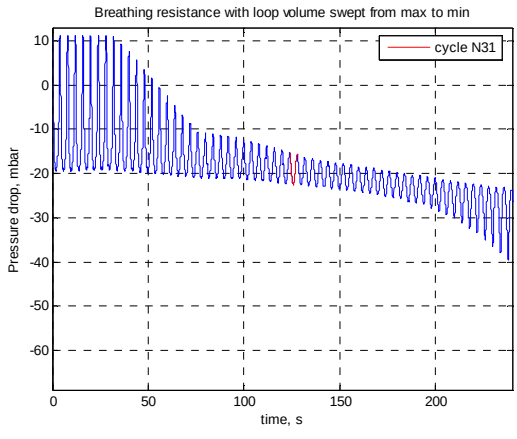
PRESSURE@END EXHALE / INHALE	=	-15.4 / -22.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.5 / -15.8	mbar
PEAK TO PEAK PRESSURE	=	6.7	mbar
INHALE/EXHALE RESP PRESSURES	=	7.1 / 6.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.15	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.15	J/l
TOTAL POS / NEG WORK	=	0.04 / 0.11	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.04 / 0.11	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_22.5lpm_HeOx_100213_1









9.4.4. DRB, Heliox, 40m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

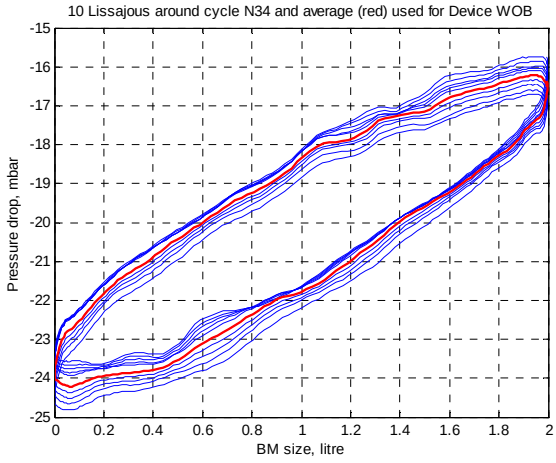
CONDITIONS OF TEST

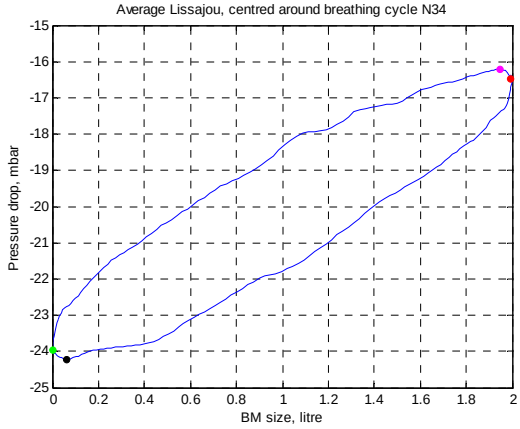
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	41.1	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	6.7	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0lpm	metric

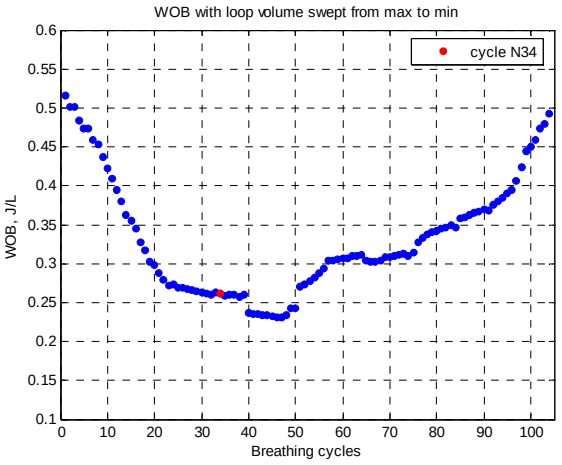
RESULTS

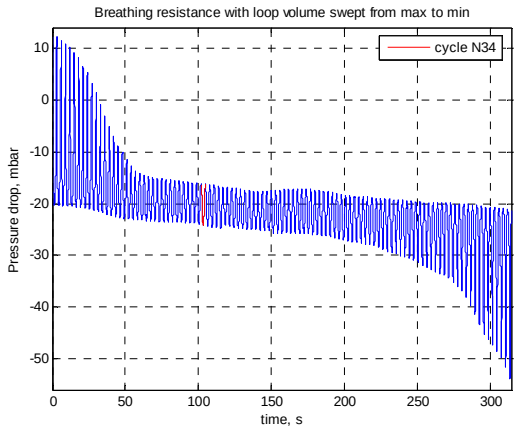
PRESSURE@END EXHALE / INHALE	=	-16.5 / -24.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.2 / -16.2	mbar
PEAK TO PEAK PRESSURE	=	8.0	mbar
INHALE/EXHALE RESP PRESSURES	=	7.8 / 7.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.27	J/l
WOB OF BREATHING SIMULATOR	=	0.01	J/l
WOB OF DEVICE UNDER TEST	=	0.26	J/l
TOTAL POS / NEG WORK	=	0.13 / 0.13	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.13 / 0.12	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_40lpm_HeOx_100213_1









9.4.5. DRB, Heliox, 40m, 62.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

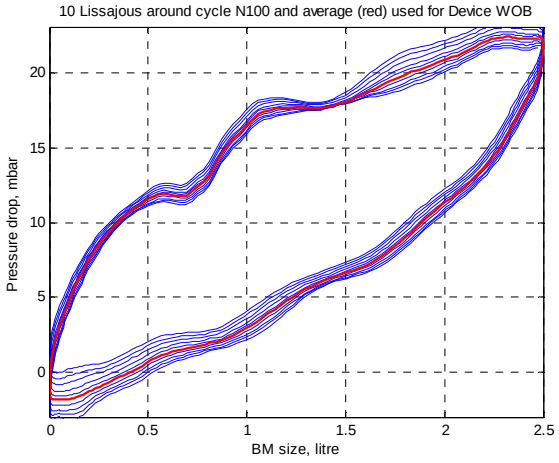
CONDITIONS OF TEST

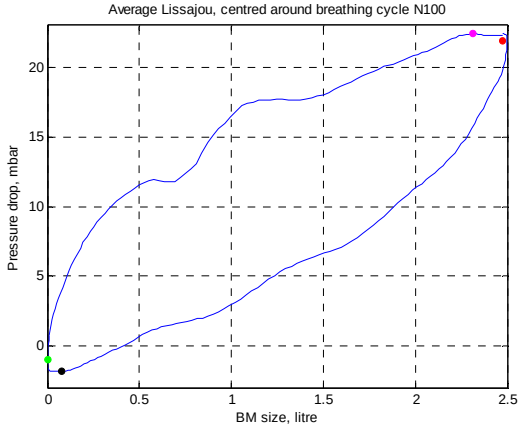
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	8.7	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5lpm	metric

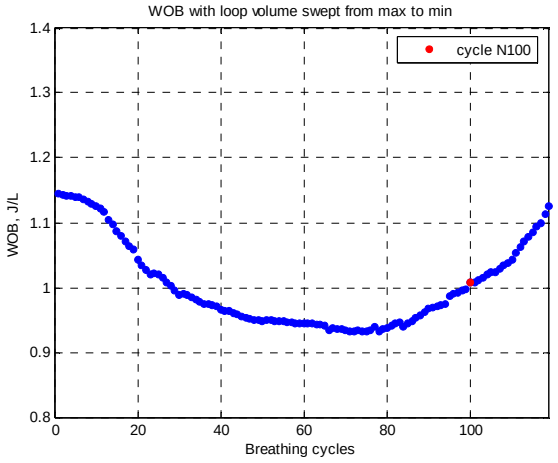
RESULTS

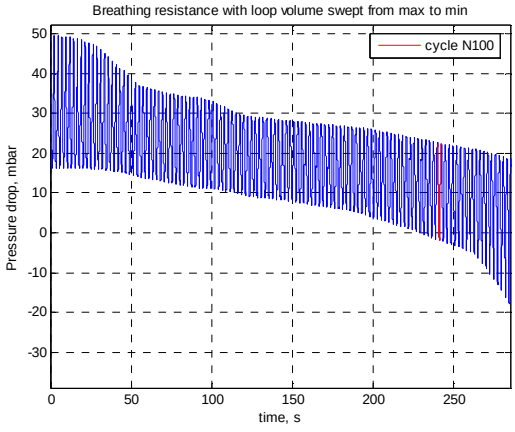
PRESSURE@END EXHALE / INHALE	=	21.9 / -1.0	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-1.9 / 22.4	mbar
PEAK TO PEAK PRESSURE	=	24.3	mbar
INHALE/EXHALE RESP PRESSURES	=	23.7 / 23.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.01	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	1.01	J/l
TOTAL POS / NEG WORK	=	0.46 / 0.46	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.46 / 0.46	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_41m_62.5lpm_HeOx_100213_1









9.4.6. DRB, Heliox, 40m, 62.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

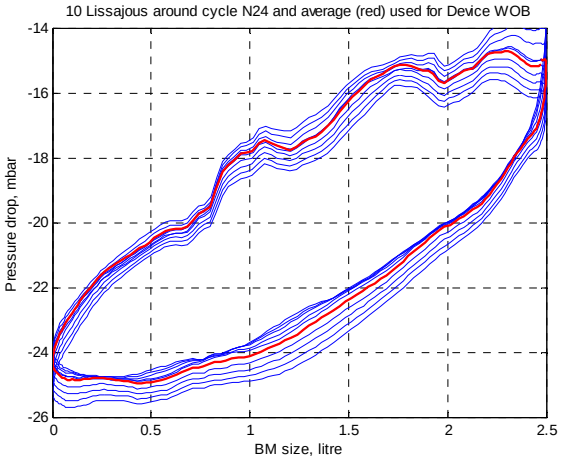
CONDITIONS OF TEST

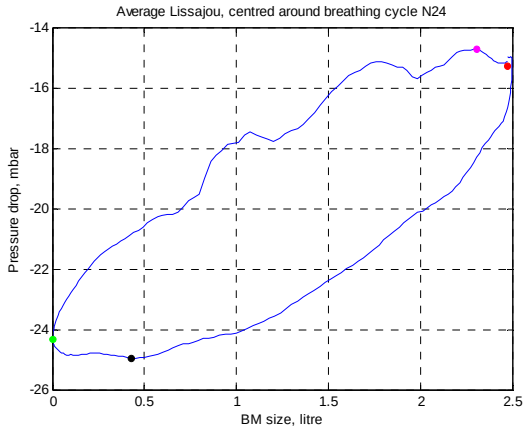
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	41.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	8.1	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/24.9bpm/62.5lpm	metric

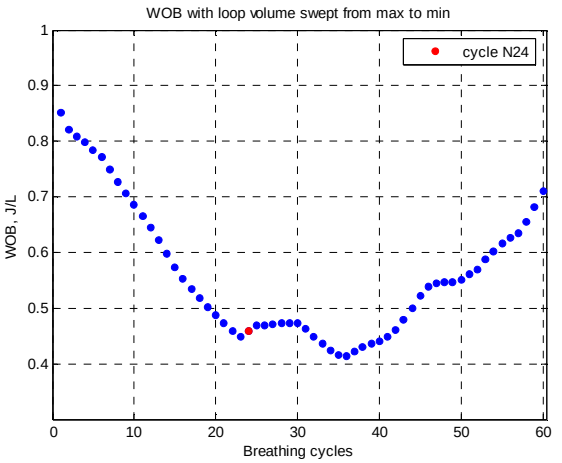
RESULTS

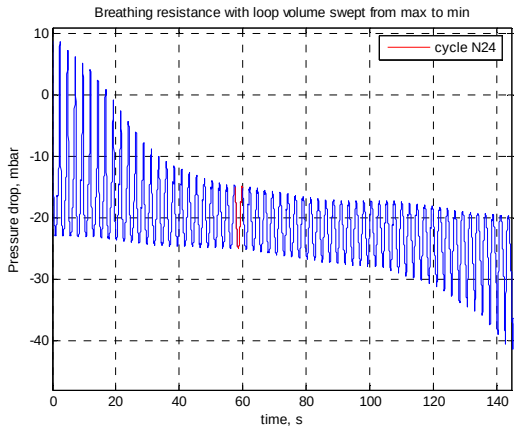
PRESSURE@END EXHALE / INHALE	=	-15.3 / -24.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-25.0 / -14.7	mbar
PEAK TO PEAK PRESSURE	=	10.2	mbar
INHALE/EXHALE RESP PRESSURES	=	9.7 / 9.6	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.46	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.46	J/l
TOTAL POS / NEG WORK	=	0.16 / 0.27	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.16 / 0.27	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_42m_62.5lpm_HeOx_100213_1









9.4.7. DRB, Heliox, 40m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	14.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

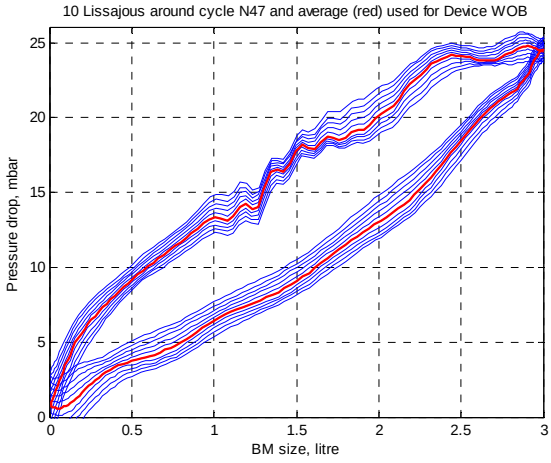
CONDITIONS OF TEST

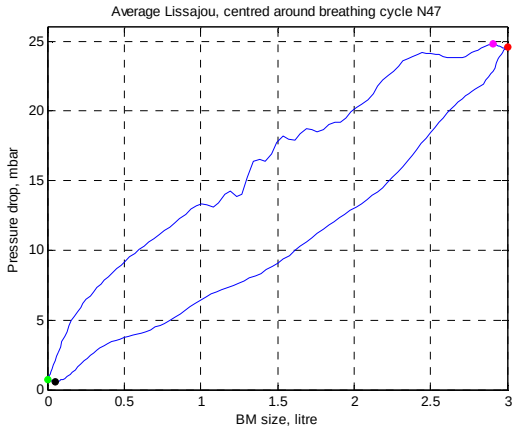
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.1	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.9	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0lpm	metric

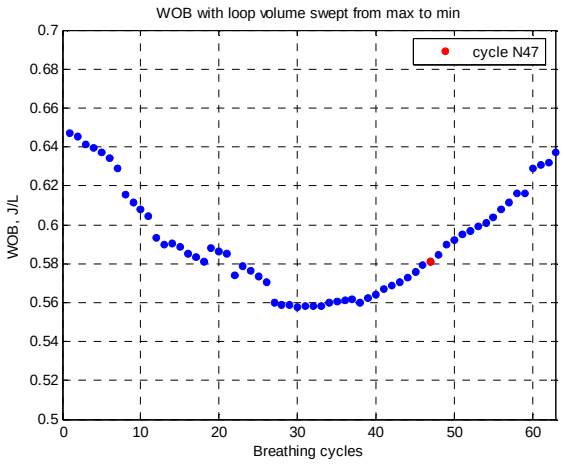
RESULTS

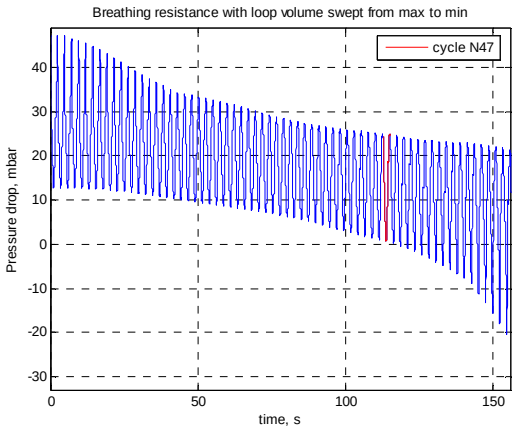
PRESSURE@END EXHALE / INHALE	=	24.6 / 0.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	0.6 / 24.8	mbar
PEAK TO PEAK PRESSURE	=	24.2	mbar
INHALE/EXHALE RESP PRESSURES	=	24.0 / 24.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.64	J/l
WOB OF BREATHING SIMULATOR	=	0.06	J/l
WOB OF DEVICE UNDER TEST	=	0.58	J/l
TOTAL POS / NEG WORK	=	0.40 / 0.26	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.37 / 0.23	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_41m_75lpm_HeOx_100214_1









9.4.8. DRB, Heliox, 40m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	14.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

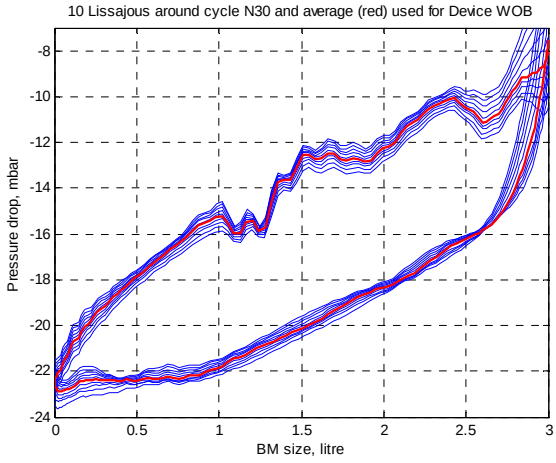
CONDITIONS OF TEST

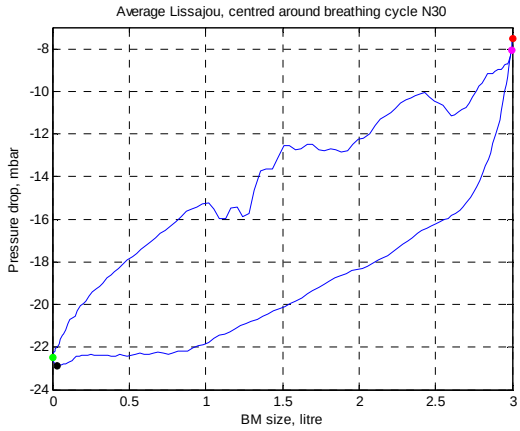
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	40.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0lpm	metric

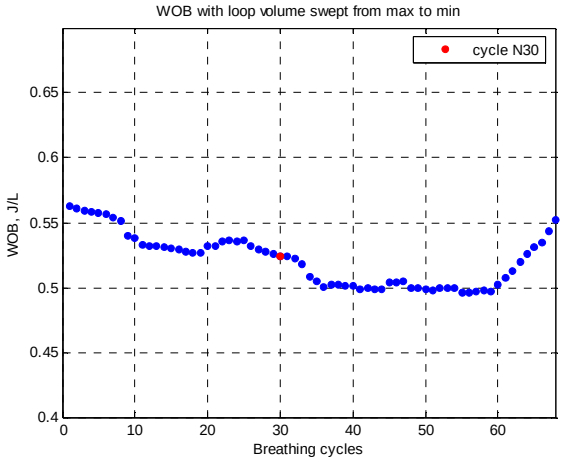
RESULTS

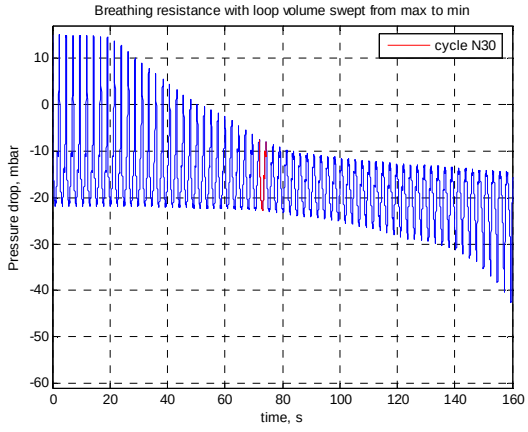
PRESSURE@END EXHALE / INHALE	=	-7.5 / -22.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.9 / -8.1	mbar
PEAK TO PEAK PRESSURE	=	14.8	mbar
INHALE/EXHALE RESP PRESSURES	=	15.3 / 14.4	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.58	J/l
WOB OF BREATHING SIMULATOR	=	0.06	J/l
WOB OF DEVICE UNDER TEST	=	0.52	J/l
TOTAL POS / NEG WORK	=	0.15 / 0.46	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.12 / 0.43	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_41m_75lpm_HeOx_100214_1









9.5. DRB, Heliox, 100m

9.5.1. DRB, Heliox, 100m, 10 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	12.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

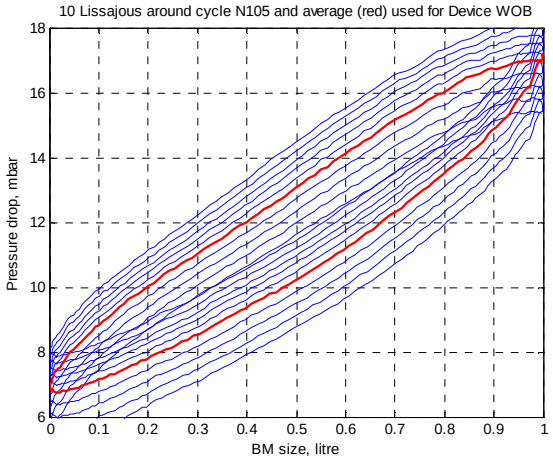
CONDITIONS OF TEST

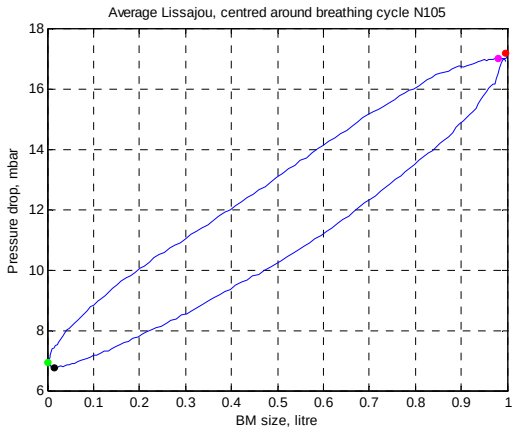
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.5	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0lpm	metric

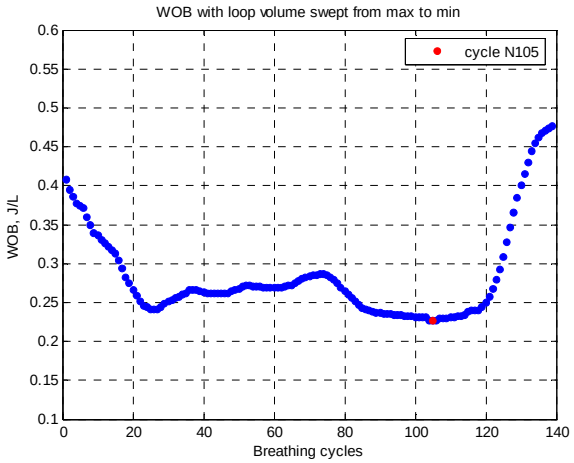
RESULTS

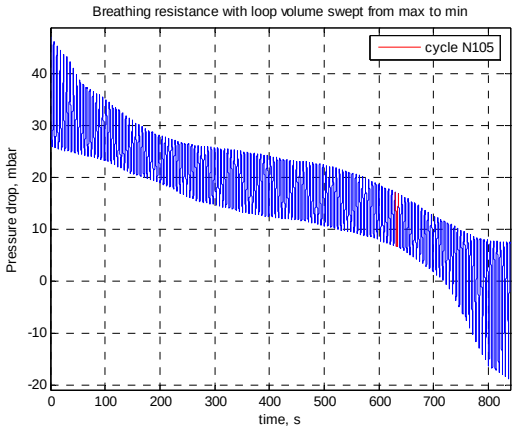
PRESSURE@END EXHALE / INHALE	=	17.2 / 6.9	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	6.7 / 17.0	mbar
PEAK TO PEAK PRESSURE	=	10.2	mbar
INHALE/EXHALE RESP PRESSURES	=	10.4 / 10.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.23	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.23	J/l
TOTAL POS / NEG WORK	=	0.09 / 0.14	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.09 / 0.14	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_100m_10lpm_HeOx_100212_1









9.5.2. DRB, Heliox, 100m, 10 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	12.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

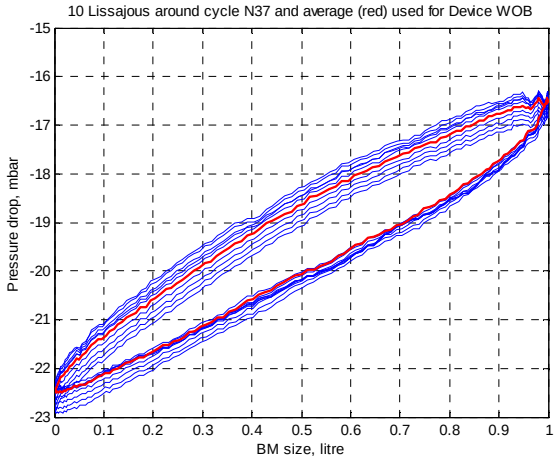
CONDITIONS OF TEST

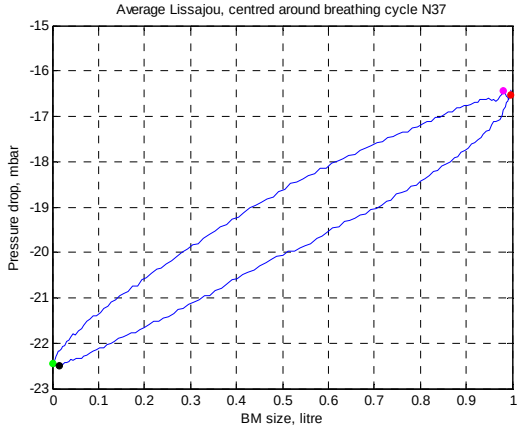
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.6	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.0L/10.0bpm/10.0lpm	metric

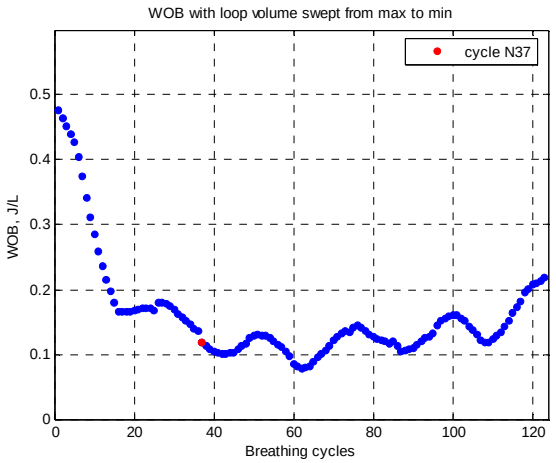
RESULTS

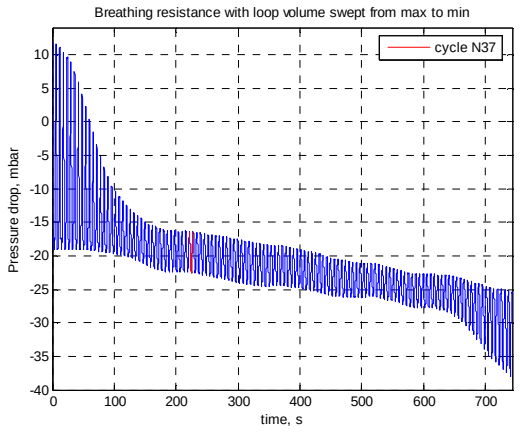
PRESSURE@END EXHALE / INHALE	=	-16.5 / -22.4	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.5 / -16.4	mbar
PEAK TO PEAK PRESSURE	=	6.1	mbar
INHALE/EXHALE RESP PRESSURES	=	6.0 / 6.0	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.12	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.12	J/l
TOTAL POS / NEG WORK	=	0.05 / 0.05	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.05 / 0.05	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_100m_10lpm_HeOx_100212_1









9.5.3. DRB, Heliox, 100m, 22.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

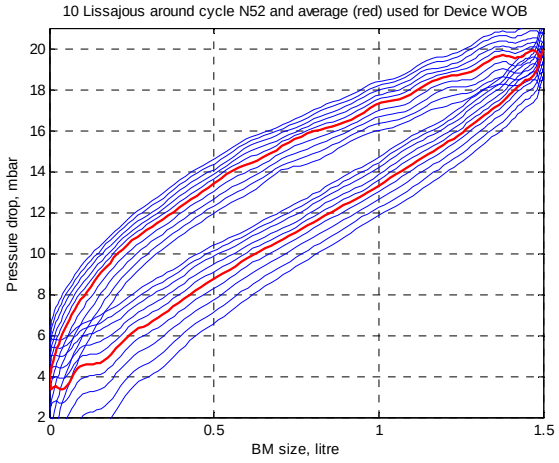
CONDITIONS OF TEST

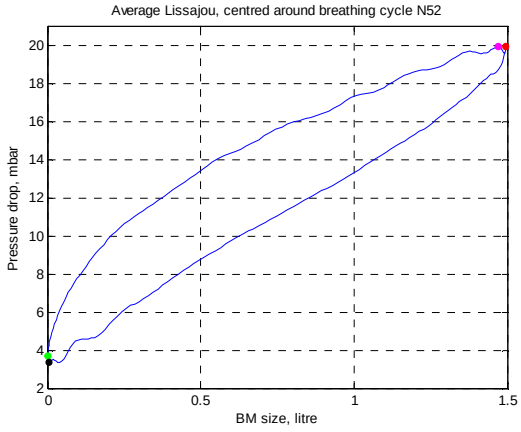
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.9	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	13.1	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5lpm	metric

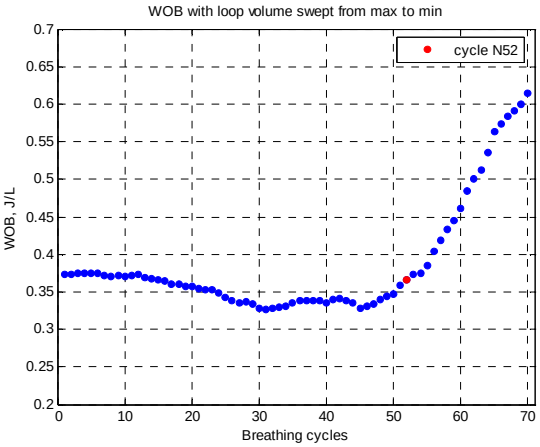
RESULTS

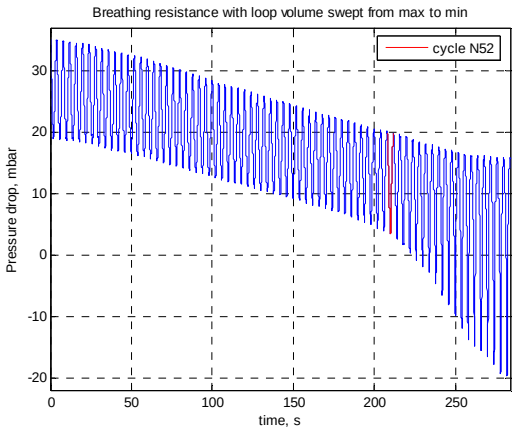
PRESSURE@END EXHALE / INHALE	=	19.9 / 3.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	3.4 / 19.9	mbar
PEAK TO PEAK PRESSURE	=	16.5	mbar
INHALE/EXHALE RESP PRESSURES	=	16.5 / 16.2	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.37	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.37	J/l
TOTAL POS / NEG WORK	=	0.29 / 0.08	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.29 / 0.08	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_101m_22.5lpm_HeOx_100213_1









9.5.4. DRB, Heliox, 100m, 22.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

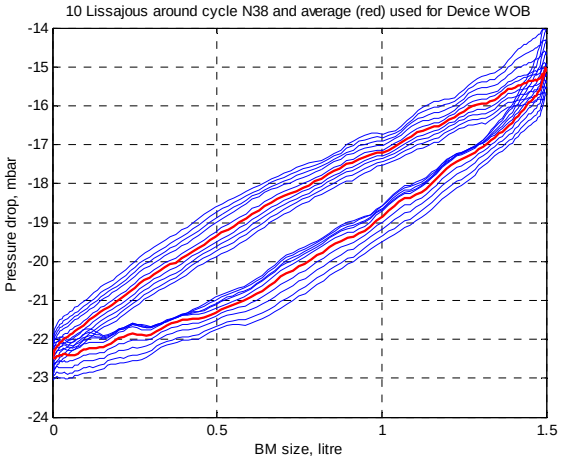
CONDITIONS OF TEST

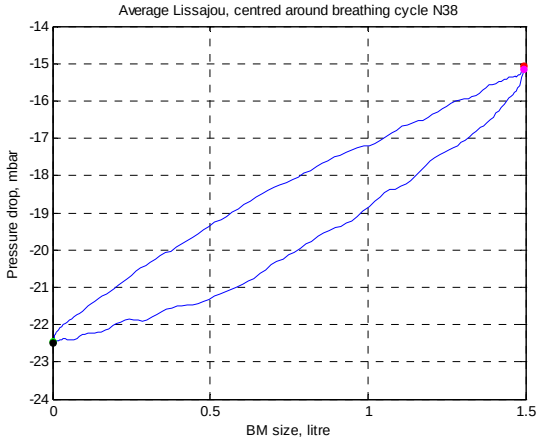
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.9	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	11.6	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	1.5L/15.0bpm/22.5lpm	metric

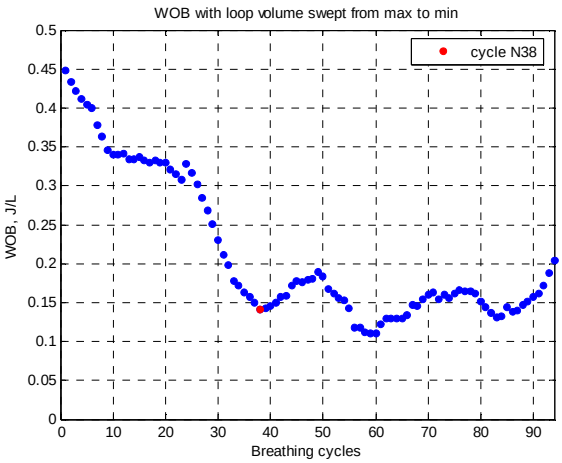
RESULTS

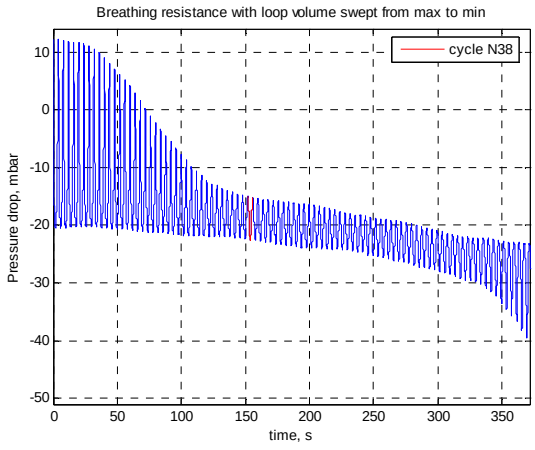
PRESSURE@END EXHALE / INHALE	=	-15.1 / -22.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-22.5 / -15.1	mbar
PEAK TO PEAK PRESSURE	=	7.4	mbar
INHALE/EXHALE RESP PRESSURES	=	7.4 / 7.3	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.14	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.14	J/l
TOTAL POS / NEG WORK	=	0.03 / 0.10	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.03 / 0.10	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_101m_22.5lpm_HeOx_100213_1









9.5.5. DRB, Heliox, 100m, 40 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

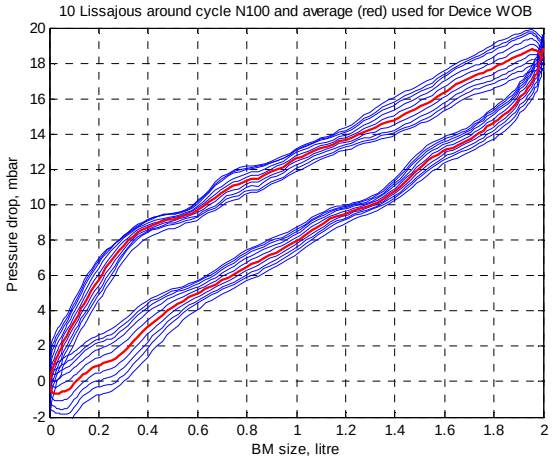
CONDITIONS OF TEST

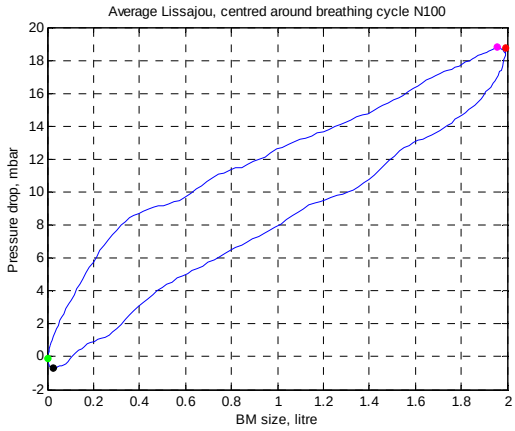
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	41.0	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	7.1	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0lpm	metric

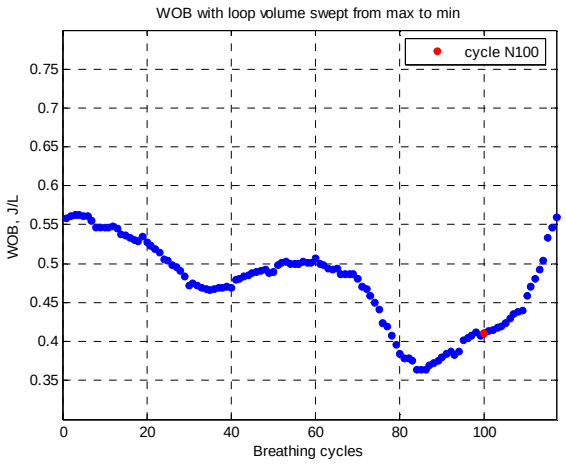
RESULTS

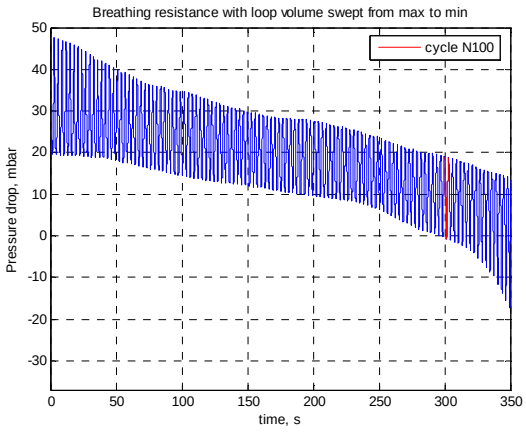
PRESSURE@END EXHALE / INHALE	=	18.8 / -0.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-0.7 / 18.8	mbar
PEAK TO PEAK PRESSURE	=	19.5	mbar
INHALE/EXHALE RESP PRESSURES	=	19.5 / 18.9	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.42	J/l
WOB OF BREATHING SIMULATOR	=	0.01	J/l
WOB OF DEVICE UNDER TEST	=	0.41	J/l
TOTAL POS / NEG WORK	=	0.27 / 0.15	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.27 / 0.14	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_41m_40lpm_HeOx_100213_1









9.5.6. DRB, Heliox, 100m, 40 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

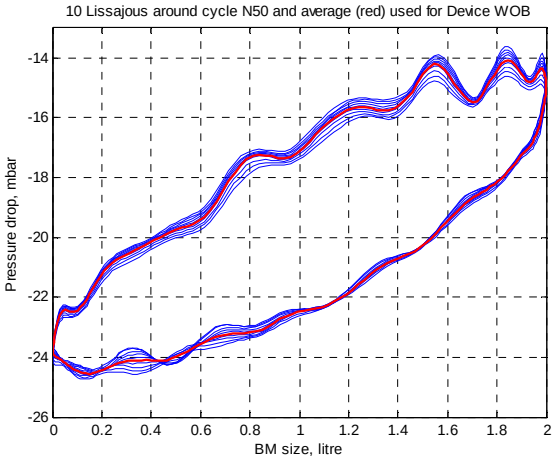
CONDITIONS OF TEST

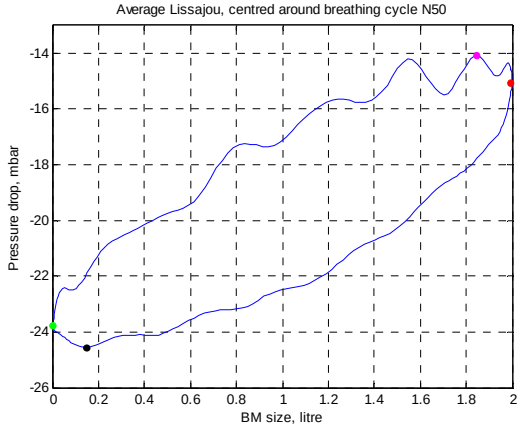
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	101.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	6.8	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.0L/20.0bpm/40.0lpm	metric

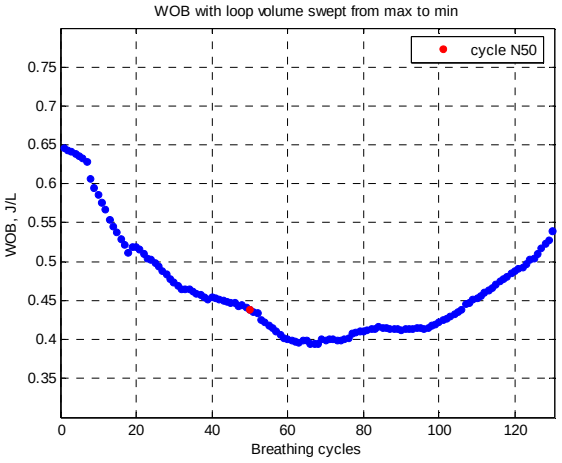
RESULTS

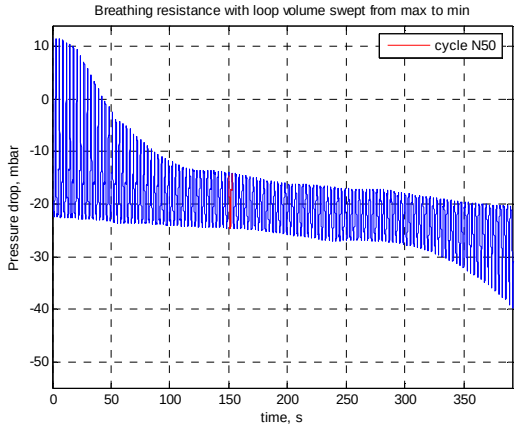
PRESSURE@END EXHALE / INHALE	=	-15.1 / -23.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.6 / -14.1	mbar
PEAK TO PEAK PRESSURE	=	10.5	mbar
INHALE/EXHALE RESP PRESSURES	=	9.5 / 9.7	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.46	J/l
WOB OF BREATHING SIMULATOR	=	0.02	J/l
WOB OF DEVICE UNDER TEST	=	0.44	J/l
TOTAL POS / NEG WORK	=	0.17 / 0.25	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.16 / 0.24	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_101m_40lpm_HeOx_100213_1









9.5.7. DRB, Heliox, 100m, 62.5 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

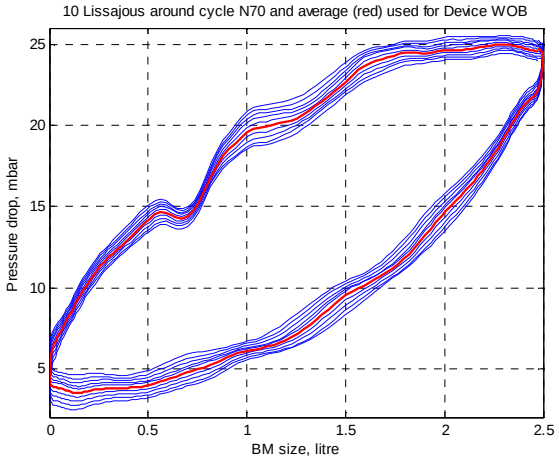
CONDITIONS OF TEST

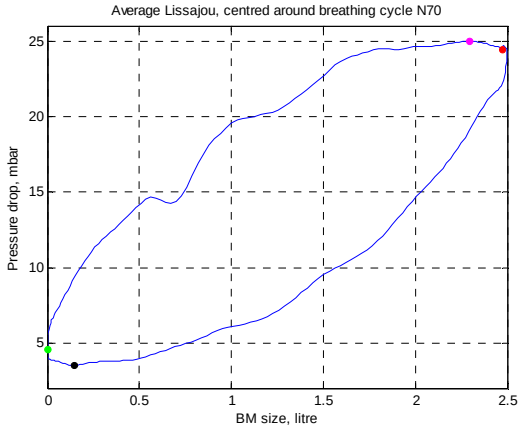
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	8.9	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5lpm	metric

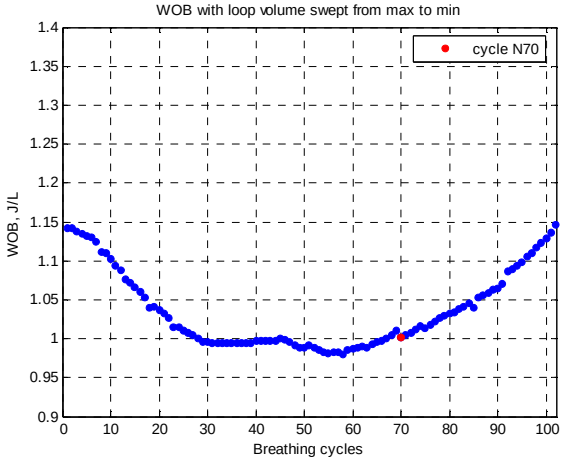
RESULTS

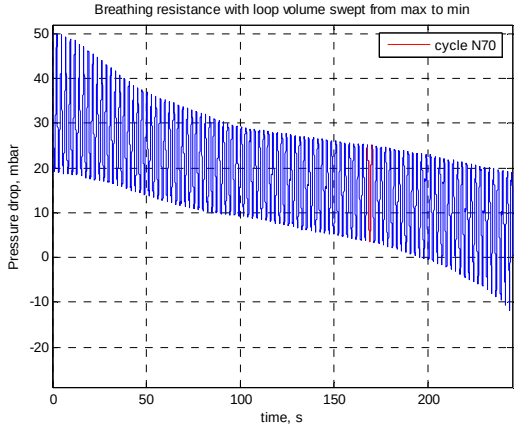
PRESSURE@END EXHALE / INHALE	=	24.4 / 4.5	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	3.5 / 25.0	mbar
PEAK TO PEAK PRESSURE	=	21.5	mbar
INHALE/EXHALE RESP PRESSURES	=	20.9 / 20.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.00	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	1.00	J/l
TOTAL POS / NEG WORK	=	0.41 / 0.53	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.41 / 0.53	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_101m_62.5lpm_HeOx_100213_1









9.5.8. DRB, Heliox, 100m, 62.5 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	13.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

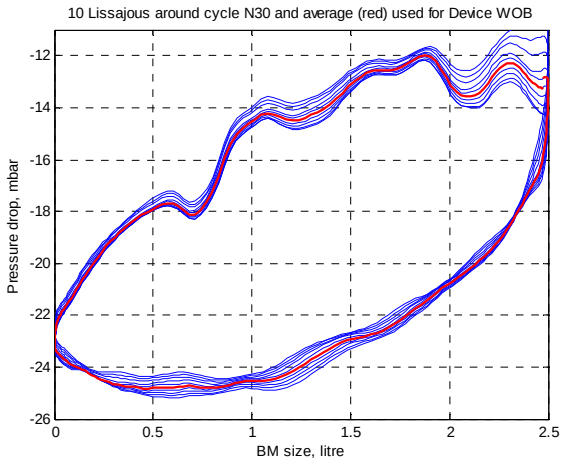
CONDITIONS OF TEST

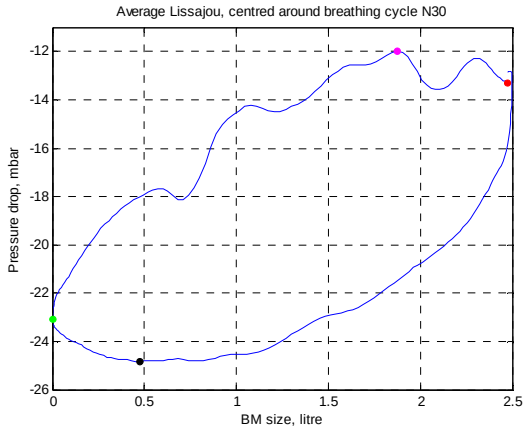
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	101.5	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	8.4	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	2.5L/25.0bpm/62.5lpm	metric

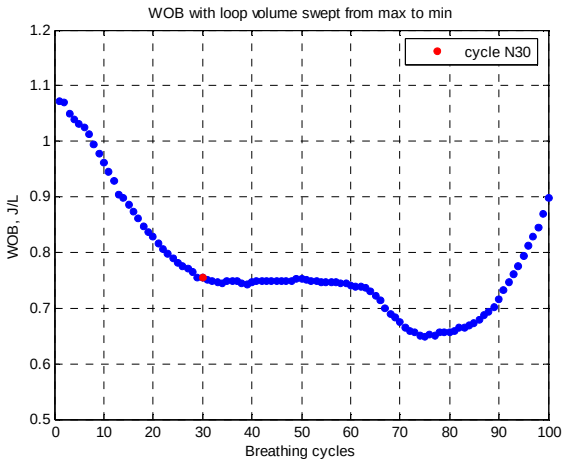
RESULTS

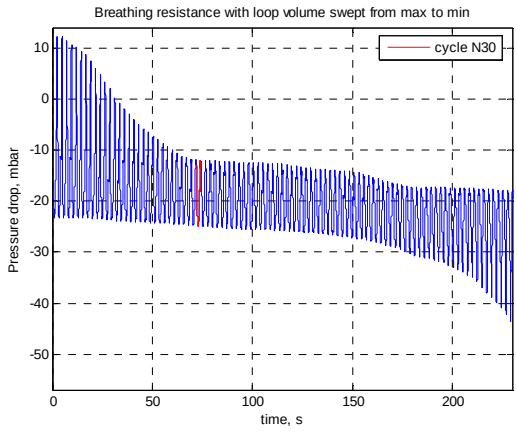
PRESSURE@END EXHALE / INHALE	=	-13.3 / -23.1	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.8 / -12.0	mbar
PEAK TO PEAK PRESSURE	=	12.8	mbar
INHALE/EXHALE RESP PRESSURES	=	11.5 / 11.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.75	J/l
WOB OF BREATHING SIMULATOR	=	0.00	J/l
WOB OF DEVICE UNDER TEST	=	0.75	J/l
TOTAL POS / NEG WORK	=	0.26 / 0.46	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.26 / 0.46	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_102m_62.5lpm_HeOx_100213_1









9.5.9. DRB, Heliox, 100m, 75 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	14.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

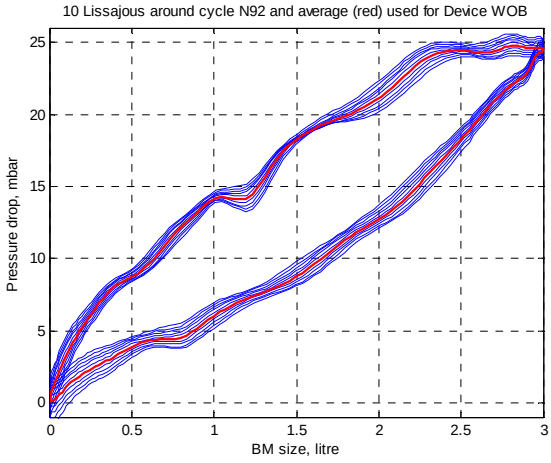
CONDITIONS OF TEST

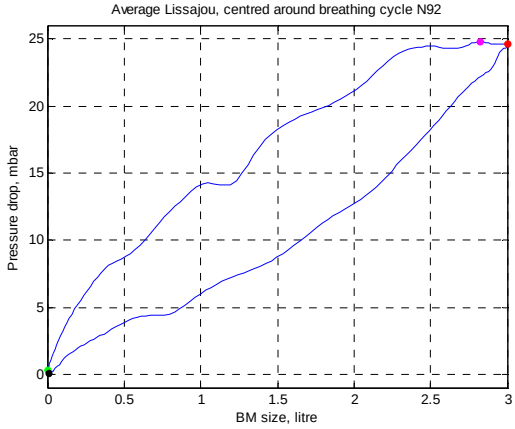
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0lpm	metric

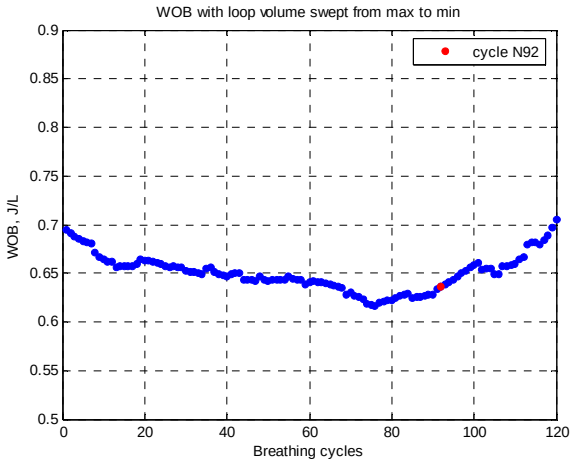
RESULTS

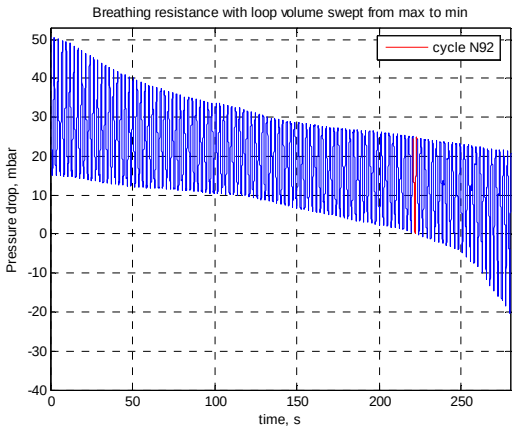
PRESSURE@END EXHALE / INHALE	=	24.6 / 0.3	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	0.1 / 24.8	mbar
PEAK TO PEAK PRESSURE	=	24.7	mbar
INHALE/EXHALE RESP PRESSURES	=	24.5 / 24.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.71	J/l
WOB OF BREATHING SIMULATOR	=	0.07	J/l
WOB OF DEVICE UNDER TEST	=	0.64	J/l
TOTAL POS / NEG WORK	=	0.47 / 0.26	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.43 / 0.22	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_101m_75lpm_HeOx_100214_1









9.5.10. DRB, Heliox, 100m, 75 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	14.01.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

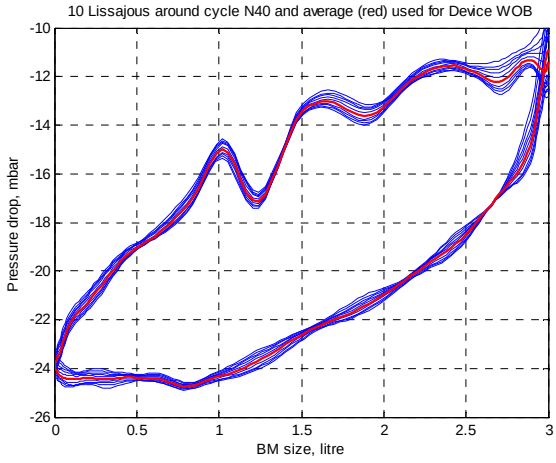
CONDITIONS OF TEST

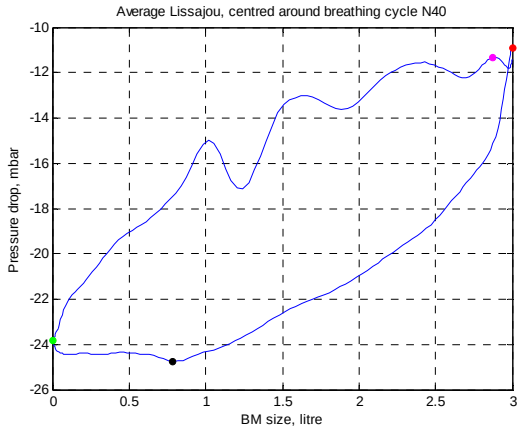
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	100.8	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.3	℃
EHXALE GAS TEMPERATURE	:	9.3	℃
GAS SUPPLY PRESSURE	:	0.0	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/25.0bpm/75.0lpm	metric

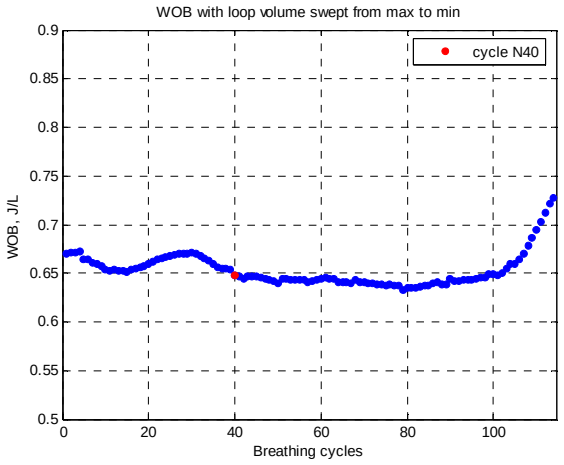
RESULTS

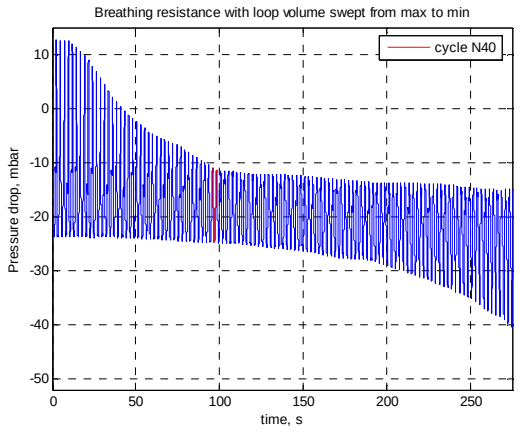
PRESSURE@END EXHALE / INHALE	=	-10.9 / -23.8	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-24.7 / -11.3	mbar
PEAK TO PEAK PRESSURE	=	13.4	mbar
INHALE/EXHALE RESP PRESSURES	=	13.9 / 12.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.72	J/l
WOB OF BREATHING SIMULATOR	=	0.07	J/l
WOB OF DEVICE UNDER TEST	=	0.65	J/l
TOTAL POS / NEG WORK	=	0.28 / 0.47	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.24 / 0.43	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_102m_75lpm_HeOx_100214_1









9.5.11. DRB, Heliox, 100m, 90 lpm RMV, 90° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	24.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

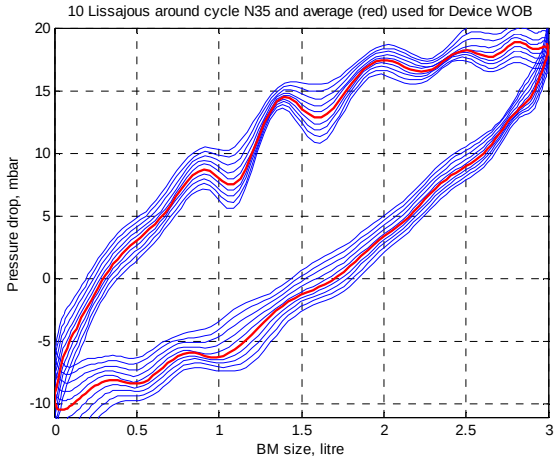
CONDITIONS OF TEST

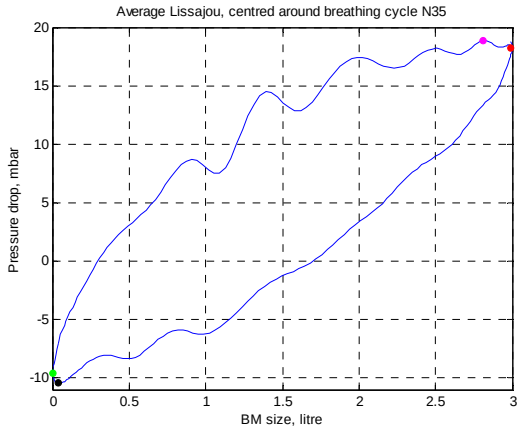
ATTITIDE: PITCH & ROLL	:	90/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	99.4	msw
ROOM / WATER TEMPERATURE	:	18.0 / 3.3	℃
EHXALE GAS TEMPERATURE	:	10.8	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.7bpm/89.1lpm	metric

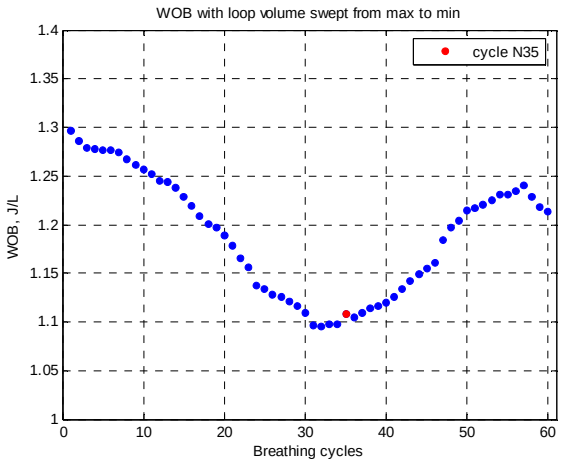
RESULTS

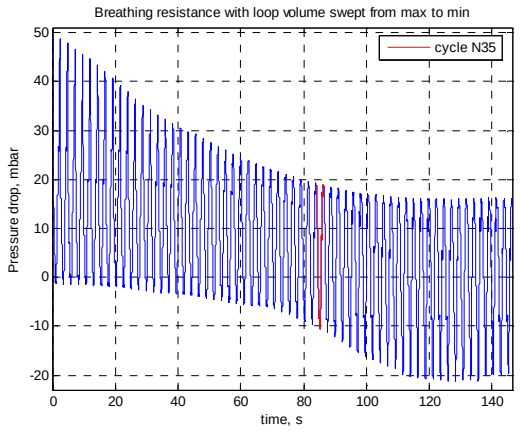
PRESSURE@END EXHALE / INHALE	=	18.2 / -9.6	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-10.5 / 18.9	mbar
PEAK TO PEAK PRESSURE	=	29.3	mbar
INHALE/EXHALE RESP PRESSURES	=	28.6 / 28.5	mbar
TOTAL WORK OF BREATHING (WOB)	=	1.20	J/l
WOB OF BREATHING SIMULATOR	=	0.09	J/l
WOB OF DEVICE UNDER TEST	=	1.11	J/l
TOTAL POS / NEG WORK	=	0.66 / 0.48	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.62 / 0.44	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_90d_99m_90lpm_HeOx_100224_1









9.5.12. DRB, Heliox, 100m, 90 lpm RMV, 0° pitch

RESPIRATORY WORK AND RESISTANCE MEASUREMENT

EQUIPMENT TYPE & SERIAL NUMBER	:	DL OR DRB sample 1	
TEST METHOD	:	EN14143:2003 RELATIVE	SINE FLOW
DATE AND TIME	:	25.02.2010	
TEST CARRIED OUT BY	MS	WITNESS: AD	

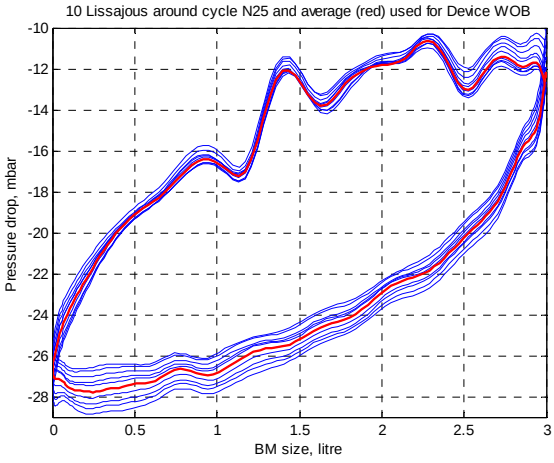
CONDITIONS OF TEST

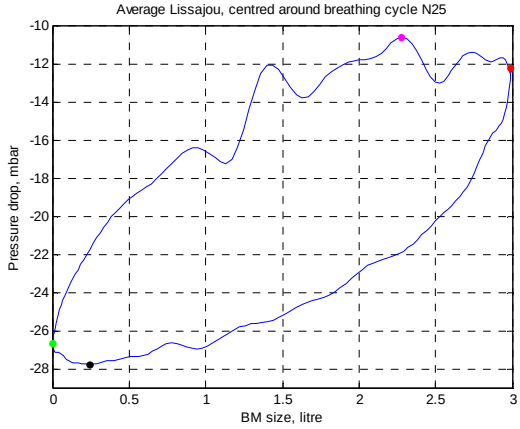
ATTITIDE: PITCH & ROLL	:	0/0	Deg.
GAS MIXTURE	:	Heliox	
DEPTH	:	99.9	msw
ROOM / WATER TEMPERATURE	:	18.0 / 4.6	℃
EHXALE GAS TEMPERATURE	:	16.3	℃
GAS SUPPLY PRESSURE	:	10.5	barg
TIDAL VOL, RESP RATE, RMV	:	3.0L/29.7bpm/89.0lpm	metric

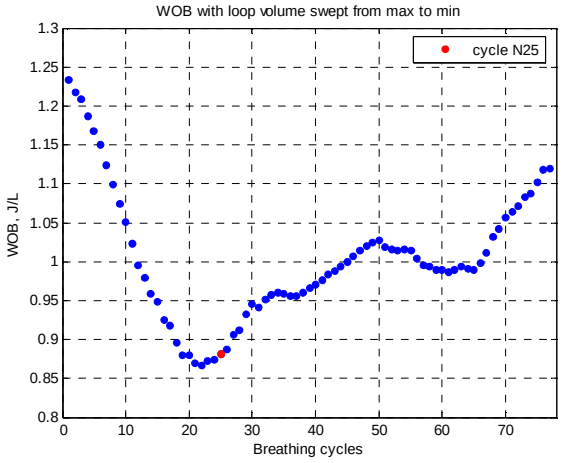
RESULTS

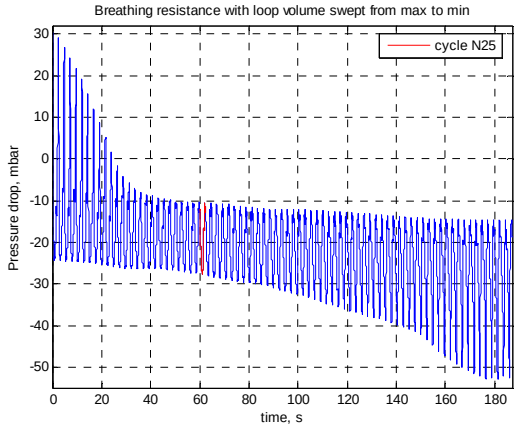
PRESSURE@END EXHALE / INHALE	=	-12.2 / -26.7	mbar
PHYSIOLOGICAL PEAK PRESSURES	=	-27.8 / -10.6	mbar
PEAK TO PEAK PRESSURE	=	17.2	mbar
INHALE/EXHALE RESP PRESSURES	=	15.5 / 16.1	mbar
TOTAL WORK OF BREATHING (WOB)	=	0.97	J/l
WOB OF BREATHING SIMULATOR	=	0.09	J/l
WOB OF DEVICE UNDER TEST	=	0.88	J/l
TOTAL POS / NEG WORK	=	0.47 / 0.50	J/l
POS / NEG WOB OF DEVICE UNDER TEST	=	0.43 / 0.46	J/l

ALL DATA STORED AS # (DATA FILE): WOB_DRB_S1_0d_100m_90lpm_HeOx_100225_1









9.6. Summary of Results

Table 15 Results of respiratory parameter tests for Standards compliance (Dual scrubber).

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, msw	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
1.	40	10	+ 90°	Air	0.8	+/-25	0.9	+/-15 idealy (+/-25 limit)	1.7	20	-	-	1.85	0.4 / 29	0.20	10.1 / 9.9	PASS ALL
2.			0°											-0.3 / 17	0.08	4.3 / 4.1	PASS ALL
3.	40		+ 90°	Heli ox										0.4 / 29	0.19	10.6 / 9.8	PASS ALL
4.	100												0.89		0.23	10.4 / 10.1	PASS ALL
5.	40		0°				0.9						1.85	-0.3 / 17	0.04	5.5 / 5.2	PASS ALL
6.	100												0.89		0.12	6.0 / 6.0	PASS ALL
7.	40	22.5	+ 90°	Air	1.18	+/-25	1.4	+/-15 idealy (+/-25 limit)	1.7	20	0.17	-	1.85	0.4 / 29	0.32	14.3 / 13.6	PASS ALL
8.			0°											-0.3 / 17	0.19	6.6 / 6.6	PASS ALL
9.	40		+ 90°	Heli ox							0.231			0.4 / 29	0.28	15.3 / 14.7	PASS ALL
10.	100												0.89		0.37	16.5 / 16.2	PASS ALL

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, msw	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
11.	40		0°				1.4				0.231		1.85	-0.3 / 17	0.15	7.1 / 6.7	PASS ALL
12.	100												0.89		0.14	7.4 / 7.3	PASS ALL
13.	40	40.0	+ 90°	Air	1.7	+/-25	2.1	+/-15 idealy (+/-25 limit)	1.7	20	0.509	-	1.85	0.4 / 29	0.65	18.4 / 17.9	PASS ALL
14.			0°											-0.3 / 17	0.57	9.5 / 10.0	PASS ALL
15.	40		+ 90°	Heli ox							0.617			0.4 / 29	0.41	19.5 / 18.9	PASS ALL
16.	100												0.89		0.56	19.6 / 19.5	PASS ALL
17.	40		0°				2.1				0.617		1.85	-0.3 / 17	0.26	7.8 / 7.7	PASS ALL
18.	100												0.89		0.44	9.5 / 9.7	PASS ALL
19.	40	62.5	+ 90°	Air	2.38	+/-25	3.0	+/-15 idealy (+/-25 limit)	1.7	20	1.172	-	1.85	0.4 / 29	1.33	23.8 / 22.5	PASS ALL
20.			0°											-0.3 / 17	1.03	17.6 / 14.3	PASS ALL
21.	40		+ 90°	Heli ox							1.542			0.4 / 29	1.01	23.7 / 23.4	PASS ALL

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures												Status
	Depths, msw	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12		Test Result		
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
22.	100												0.89		1.00	20.9 / 20.5	PASS ALL
23.	40		0°				3.0				1.542		1.85	-0.3 / 17	0.46	9.7 / 9.6	PASS ALL
24.	100														0.75	11.5 / 11.1	PASS ALL
25.	40	75.0	+ 90°	Air	2.75	+/-25	3.5	+/-15 idealy (+/-25 limit)	1.7	20	1.696	-	1.85	0.4 / 29	1.39	24.0 / 24.9	PASS EN+NO +USN FAIL NATO
26.			0°											-0.3 / 17	1.32	15.4 / 18.5	PASS ALL
27.	40		+ 90°	Heli ox							2.159			0.4 / 29	0.58	24.0 / 24.1	PASS EN+NO +USN FAIL NATO
28.	100												0.89		0.64	24.5 / 24.5	PASS EN+NO +USN FAIL NATO

Test num	Test conditions				Standards' limits for WOB in Joules per litre and Respiratory pressures										Test Result		Status
	Depths, msw	RMV, l/min	Diver's pitch	Gas	EN14143: 2003		NORSOK U101:1999		STANAG 1410:2006		US Navy TM01-94		NEDU TA 05-12				
					WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	WOB	BR	
29.	40		0°				3.5				2.159		1.85	-0.3 / 17	0.52	15.3 / 14.4	PASS ALL
30.	100												0.89		0.65	13.9 / 12.5	PASS ALL
31.	100	90.0	+ 90°	Heli ox	3.2	+/-25	5.0	+/-15 idealy (+/-25 limit)	1.7	20	3.085	-	0.89	0.4 / 29	1.11	28.6 / 28.5	PASS EN+NO +USN FAIL NATO
32.	100		0°								3.085		0.89	-0.3 / 17	0.88	15.5 / 16.1	PASS ALL

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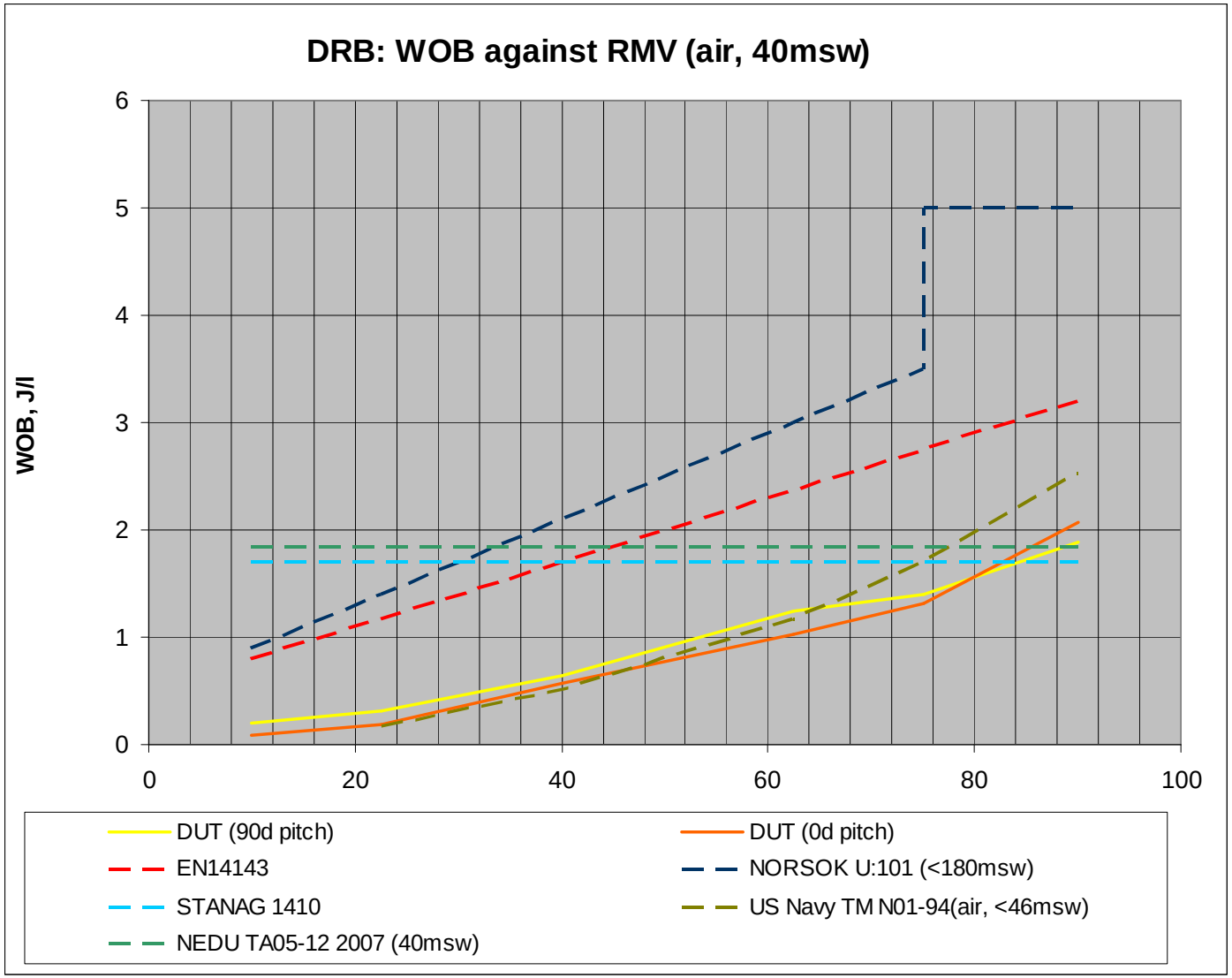
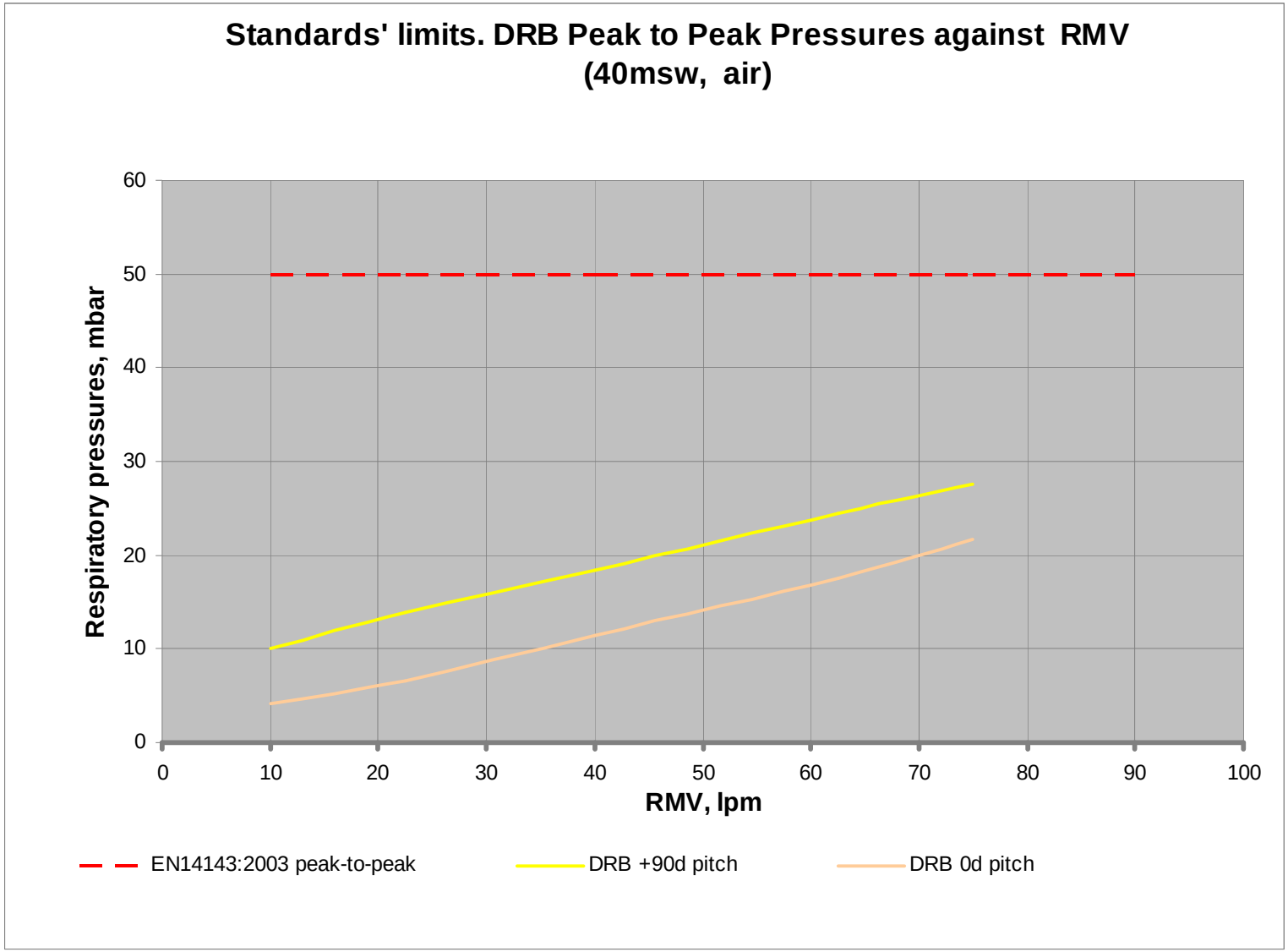
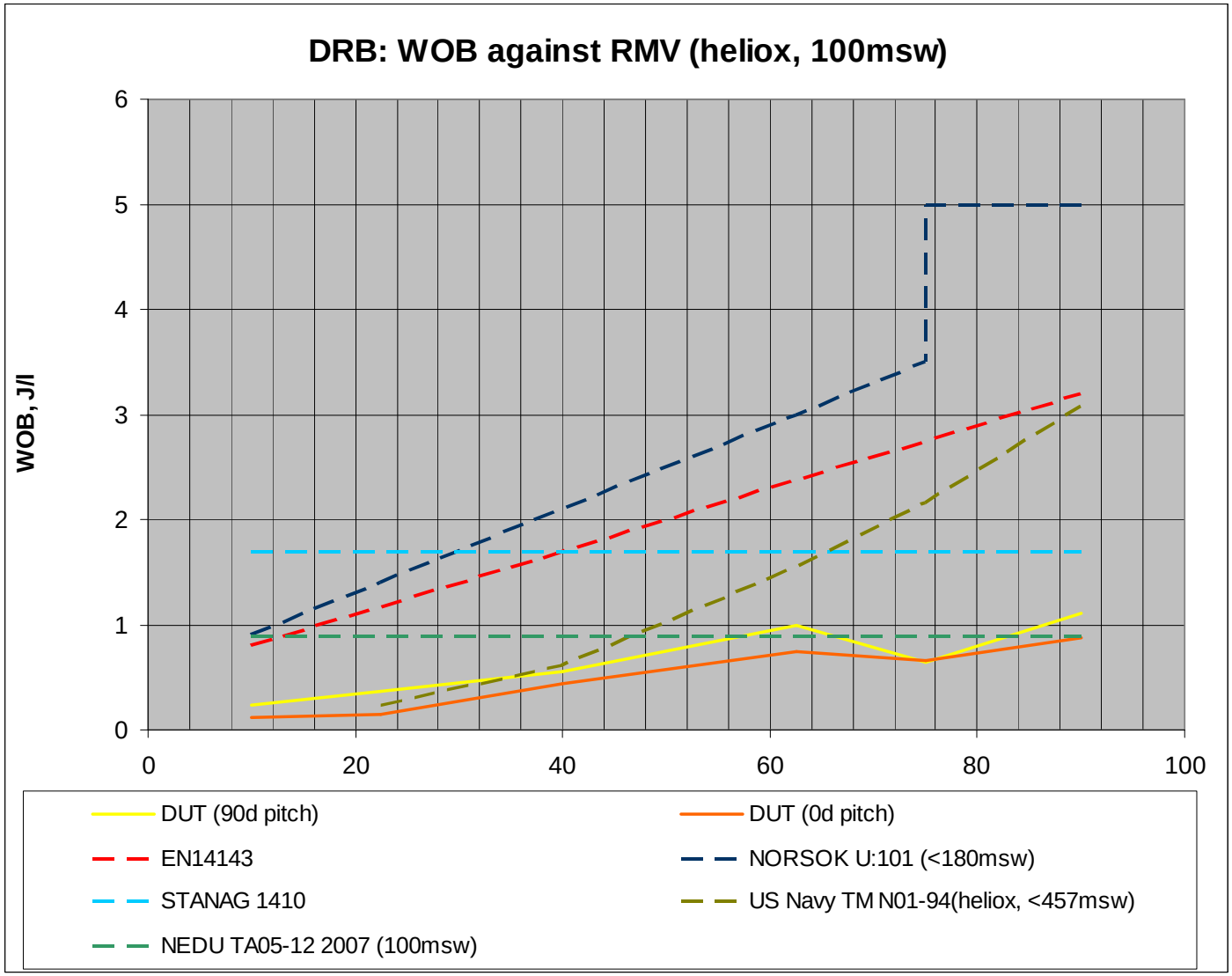
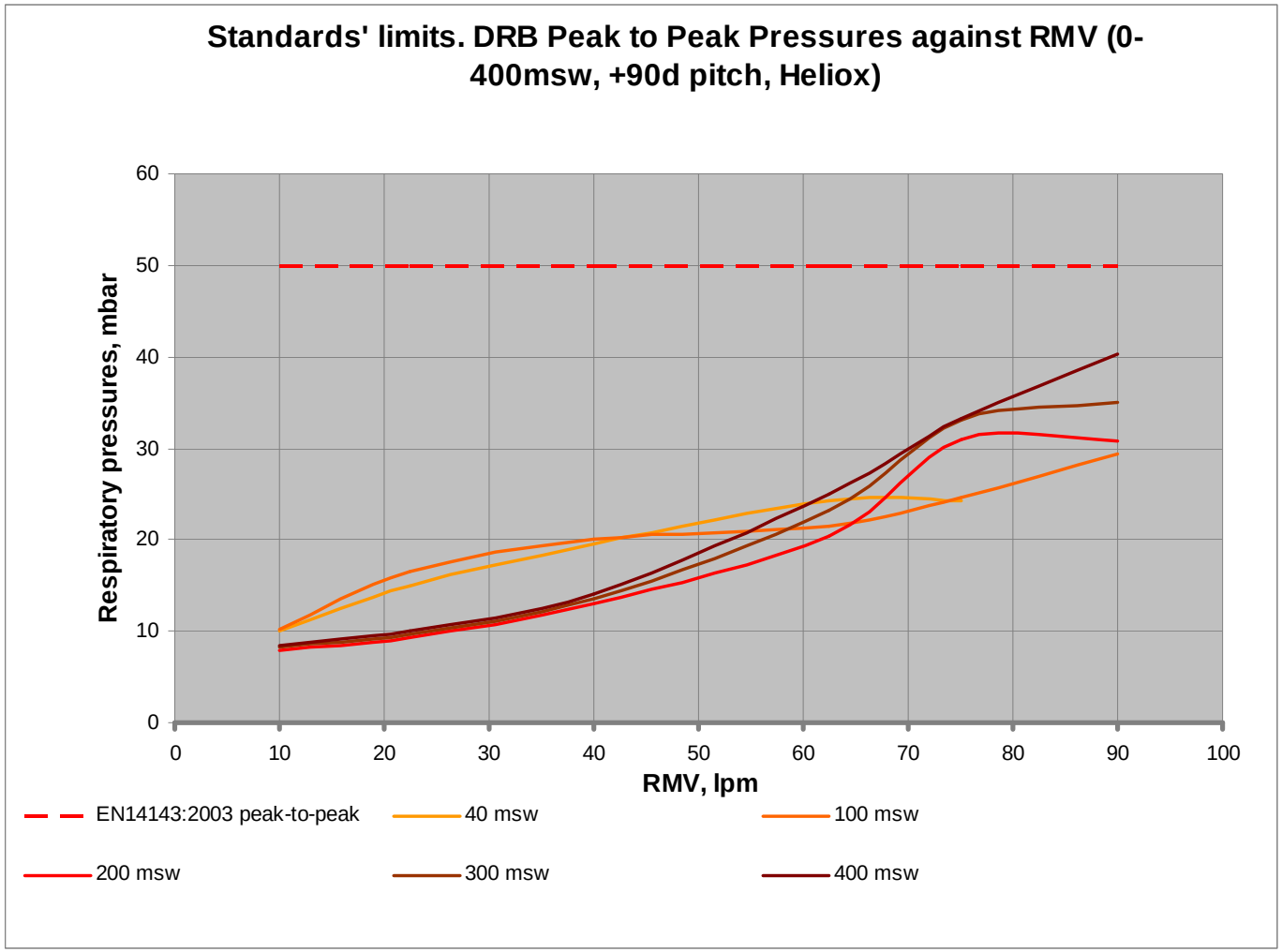
9.7. DRB. WOB and Breathing Resistance comparison over air diving range



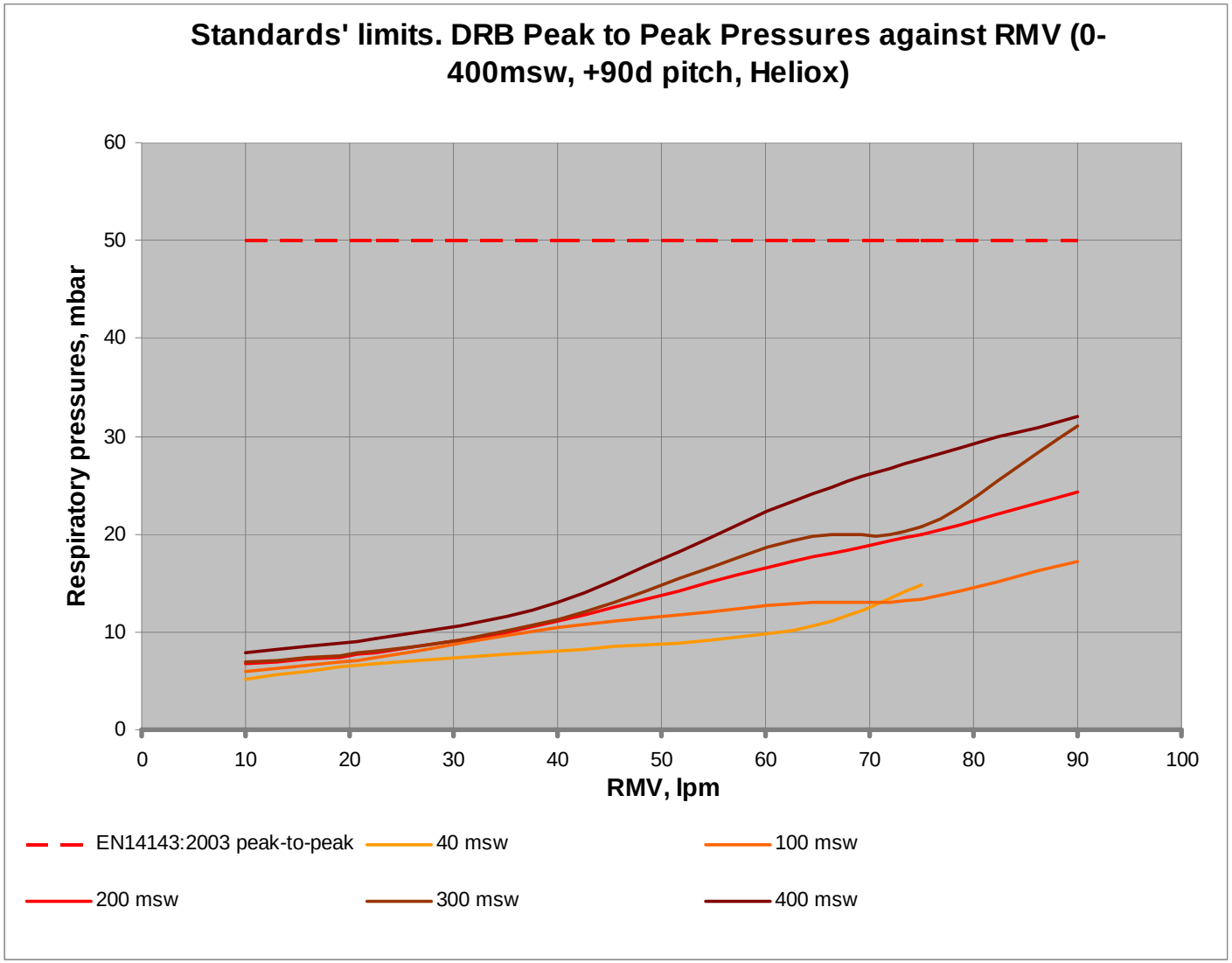


9.8. DRB. WOB over heliox diving range, with PPO2 of 1.0





Result deeper than 100msw for the DRB are indicative only, based on earlier tests using breathing manfold with narrower features. All results deeper than 100m for the DRB are retired: those tests will be repeated in due course as there has been a minor change to the breathing manifold (injection moulded), that may influence results. All results presented herein at 40m and 100m for CE purposes use the injection moulded manifold.



10. EFFECT OF REVERSED FLOW

It is not possible to reverse the flow through the single scrubber rebreather accidentially, because:

1. The Mushroom valve spiders cannot be swapped: they are of different diameters
2. The Mushroom valves cannot be installed on the spiders on the reverse side: there is a moulded ring preventing them engaging.
3. The hoses from the mouthpiece are on a length adjustment elbow which is angled so the hoses fan away from the mouthpiece, and the hoses are not long enough to enable the other end of the hoses to be swapped and the diver still breathe from the mouthpiece.
4. The mouthpiece is angled downwards, so trying to breathe from it reversed would block the majority of the diver's vision making it obvious the mouthpiece is not to be used in that position.

However, a person with wilful intent to reverse the flow could replace the mouthpiece with another. For this reason the WOB and breathing resistance was tested with reversed flow, in addition to tests in the normal flow, using a plain DSV mouthpiece.

There was no measurable difference in the WOB or breathing resistance from reversed flow.

It should be noted that reverse flow will cause the loop exhaust valve to be before the oxygen injection point, so an uncontrolled ascent will cause the majority of injected gas to flow away from the diver and out of the exhaust valve. Therefore, the state with reversed flow does not sustain life in an uncontrolled ascent from some depths.

11. ONE-WAY VALVES

The apparatus in the tests reported herein was fitted with silicone flapper valves, which have a maximum cracking pressure of 0.5mbar dry and 1.2mbar wet, pretensioned to 1mbar cracking pressure, fitted to an injection moulded 8 finger web. This produces a vertical rise in the Lissajou at each end of the respiratory cycle that can be seen in the results for each apparatus.

Tests were performed comparing 20 durometer, 30 durometer and 50 durometer Shore A flapper valves of a rimmed type, and comparison of a 50 durometer Shore A umbrella type, and no difference in breathing resistance was observed, but the cracking pressure varied up to 1mbar. This 1mbar difference did not change with depth or RMV: it was a cracking pressure. It is concluded therefore that there are no material differences between any of these combinations where the same pretension was used.

12. NOTES TO IMPROVE RESPIRATORY TESTING

The time taken in changing the stroke for the many repeats of these tests (each time the equipment is changed), has been analysed – it is substantial.

To reduce this in the future, Deep Life has two in-chamber breathing simulators in manufacturer and will provide these shortly to BAI with an electronically variable stroke, using a backlash free harmonic gear, with real time generation of the Lissajou results. These simulators are able to run any breathing waveform as they use a 4 Quadrant controller, and can strokes from 100ml to 3.5 litres, for RMVs from near zero to 120 lpm.

These simulators, after calibration, will be used to monitor the effect of all future updates to the rebreathers, and to provide comprehensive certification data to depth up to 600m.

13. CONCLUSIONS

The OR rebreathers have an exceptionally good Work of Breathing and respiratory performance.

There is no measureable difference in work of breathing or any respiratory parameter between the rebreather with O2/iCCR head and eCCR head.

There is no measureable difference in work of breathing or any respiratory parameter between the dumb 90 degree ports using on the OR_Incursion and OR_Apocalypse Type IV O2-CCR. The difference between the Incursion instrumented head and the instrumented ports used on the OR_Apocalypse Type IV iCCR is within the +/-3% limits of accuracy of the EN 14143:2003 test.

The dual scrubber model, OR_Umbilical, is measureably different to the single scrubber models (SRB models, OR_Incursion, OR_Apocalypse Type IV iCCR and O2-CCR), so results are reported separately for OR_Umbilical and SRB models. The DRB model (OR_Incusion) has a higher work of breathing and breathing resistance than for the SRB models, due to longer hoses to the diver. However the difference has no material effect on the depth limits of the DRB model.

This report is compiled with specific reference to the compliance requirements. The models tested meet WOB and breathing resistance requirements of the follow standards:

1. EN14143:2003 to 100m using air and 350m using heliox
2. NORSOK U-101:1999 to 100m using air and 350m using heliox
3. NATO STANAG 1410:2006 to 80m on the SRB. The umbilical rebreather does not comply with NATO limits in the form it was tested, due to the STANAG limit of +/-20mbar for respiratory pressures, rather than 25mbar for the other standards.
4. Deep Life HUMAN RESPIRATORY SAFETY LIMITS to 70m using air and 240m using heliox
5. US Navy 1994 TM 01-94 is met for Class 4 over the STANAG 1410 depth limits
6. NEDU 2007 TA 05-12 Limits to 80m using air (limit is only expressed for air)