# Breathpal Reproducibility over Time and after Repeated Connection

© 2023 Ben Bulsink

Version 1.0-March 17, 2023

## Content



## Background

The Breathpal RIP sensor can be used to measure the breathing movements of the body.

To use the sensor over a longer time and between separated sessions, it is important to know the stability of the reading over time and between separate attachments. This document describes the method of investigation of this stability and the results.

## RIP Measuring principle

The RIP measuring method actually measures the surface (cm2) within the circumference of the strap that is spanning the body. This surface is related with the tidal volume (cm3) of the breathing, with a beforehand unknown factor, and with various unknown stable and less stable errors. See https://breathpal.nl/wp-content/uploads/2021/12/Breathpal-measurement-quality-report-vs-1.4.pdf for an overview of errors in the translation from tidal volume to surface.

## Test setup

The tests are executed by using the Plastic Lung, a device supplied by MST (Figure 1). It allows to put straps around two halfpipes, and precisely vary the distance between the halfpipes, and so change the surface within the strap loop with a reproducibility (scale division) of 0,16 cm2.

The sensitivity of the sensor is set to be 4.6 Arbitrary Units (AU) per cm2 surface change (Plastic lung reading: 17,5 cm., enclosed surface 472,5 cm2)

## Measurements

The sensor is set up, using the plastic lung, as in below picture. The distance between the half pipes is locked to a fixed value of 17.0 cm.

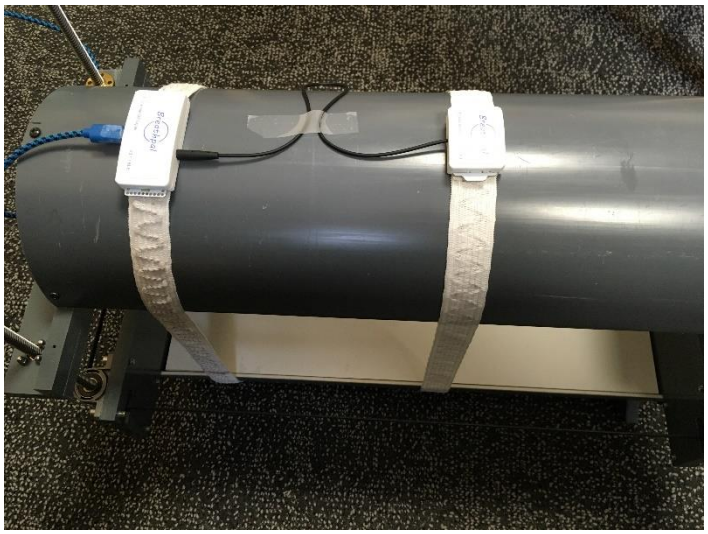

*Figure 1: Setup of long term stability measurement*

Between each measurement, the USB powering and the abdominal strap had to be disconnected while the battery runs empty over one day, which causes that repowering does not initialize USB connecting well then.
Below the (AU) readings over a time span of three weeks.

Four strap are used:

A: 74 cm length, in rest
B: 76 cm length, in rest
C: 72 cm length, in rest
D: 68 cm length, in rest

*Table 1: Readings over longer time*

| | Thorax reading strap A (AU) | Abdominal reading strap B (AU) |
|---|---|---|
| 16-2-2023 11:48 | 7418 | 2958 |
| 17-2-2023 13:00 | 7417 | 2960 |
| 09-03-2023 10:40 | 7420 | 2961 |

Now, on date 17-03-2023, repeatedly both straps are disconnected and reconnected, sometimes with some manipulation. The remarks and readings are listed in below table.

*Table 2: readings after reconnections*

| Measurement number and remarks | Thorax reading strap A (AU) | Abdominal reading s trap B (AU) |
|---|---|---|
| 1 | 7428 | 2970 |
| 2 | 7428 | 2970 |
| 3a | 7426 | 2969 |
| 3b after some shifting and stretching | 7428 | 2967 |
| 4 | 7429 | 2966 |

Now, on 17-03-2023, the readings are taken, and the straps are exchanged and changed by two others.

*Table 3: Readings with different straps*

| Measurement number and remarks | Thorax reading (AU) | Abdominal reading (AU) |
|---|---|---|
| After power-up and connecting | 7411 strap A | 2956 strap B |
| After powerdown and reconnecting | 7412 strap A | 2955 strap B |
| Exchange straps | 7440 strap B | 2926 strap A |
| Use other straps | 7409 strap C | 2676 strap D |
| And exchange these | 7151 strap D | 2921 strap C |

# Discussion

## Long term stability

The long term stability of Breathpal is very good. For making readings over a longer time, it was decided to switch the computer off, which made it necessary to disconnect and the straps before each reading (in order to avoid improper USB enumeration, due to technical choices in Breathpal). With as little manipulation of the textile straps as possible, the readings had a maximum deviation over 3 weeks of only 3 AU (0.65 cm2). A better procedure would be to keep the reading computer up and running over the long time, which would give a more precise and reliable figure of the long term stability. However, in practical use, this situation is unlikely to appear.

## Disconnection and reconnection

The disconnection and reconnection of the Breathpal straps also causes different readings on the same mechanical situation. Actually, the readings in Table 1 also needed disconnection and reconnection of the straps. Table 2 lists these effects where more manipulation is done. Some mechanical shifting and stretching of the straps does not have much influence.

## Changing of straps

The effect of changing straps by other versions (same material, but slightly different lengths, is listed in Table 3. Changes of 250 AU are found, just by a few cm strap rest length difference. If absolute value readings need to be compared over some sessions, it is necessary to use the same straps for these sessions.

## Conclusions

The Breathpal electronics show very good stability over time. The strap material is based on soft tissue, which can easily change the surface within the copper wire connector which it supports. Therefor slight manipulations of the straps can change the sensor reading. The readings do largely change between straps that have different length in rest.