Calibration of Pressure Instruments

Part-3: Calibration Procedures

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Content

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Comprehensive calibration procedure

- comprehensive calibration procedure in accordance with EURAMET calibration guideline 17 (CG-17)
  - there are three procedures according to the client's requirements
  - the procedure depends on the target uncertainty of the instrument and can limit the lowest achievable uncertainty

  - the procedure of calibration shall allow the evaluation of at least
    - the hysteresis,
    - and the repeatability

  of the instrument to be calibrated

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Comprehensive calibration procedure

- the calibration results shall allow the user of the calibrated measuring instrument to gain knowledge about linearity from the calibration results, if necessary

- basic calibration procedure
    - the expanded measurement uncertainty ($k = 2$) of the calibrated instrument may not be reported smaller than 0.2 % FS (FS = full scale)

$$1100 \text{ hPa} * 0,2 \text{ %} \geq 2.2 \text{ hPa}$$

Comprehensive calibration procedure

- standard calibration procedure
  - the expanded measurement uncertainty ($k = 2$) of the calibrated instrument may not be reported smaller than 0.05 % FS

$$1100 \text{ hPa} * 0{,}05 \text{ \%} \quad \geq \quad 0.55 \text{ hPa}$$

- comprehensive calibration procedure
  - the expanded measurement uncertainty ($k = 2$) of the calibrated instrument may be reported smaller than 0.05 % FS

$$1100 \text{ hPa} * 0{,}05 \text{ \%} \quad < \quad 0.55 \text{ hPa}$$

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Comprehensive calibration procedure

- comprehensive calibration procedure
  - at least two pre-loadings to the upper pressure limit
    - keep the pressure for at least 60 seconds
    - the time between the pre-loadings should be at least 60 seconds

- 66 calibration points are required, each in three upward and downward rows of 11 points, covering as large a range as possible
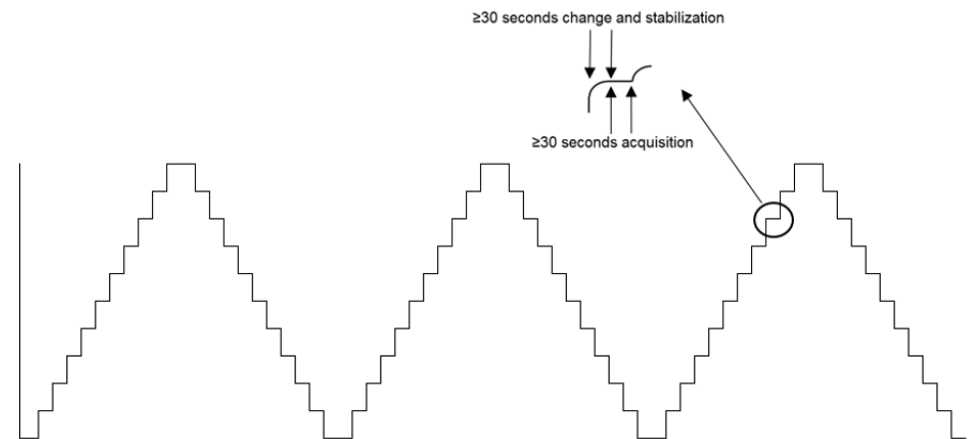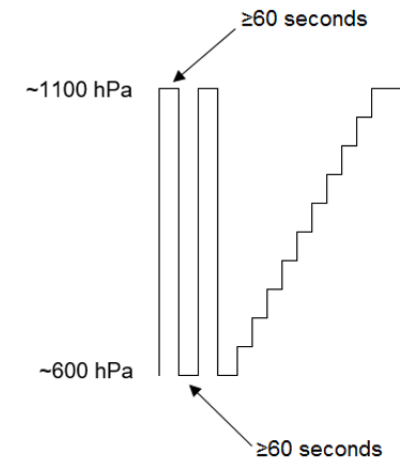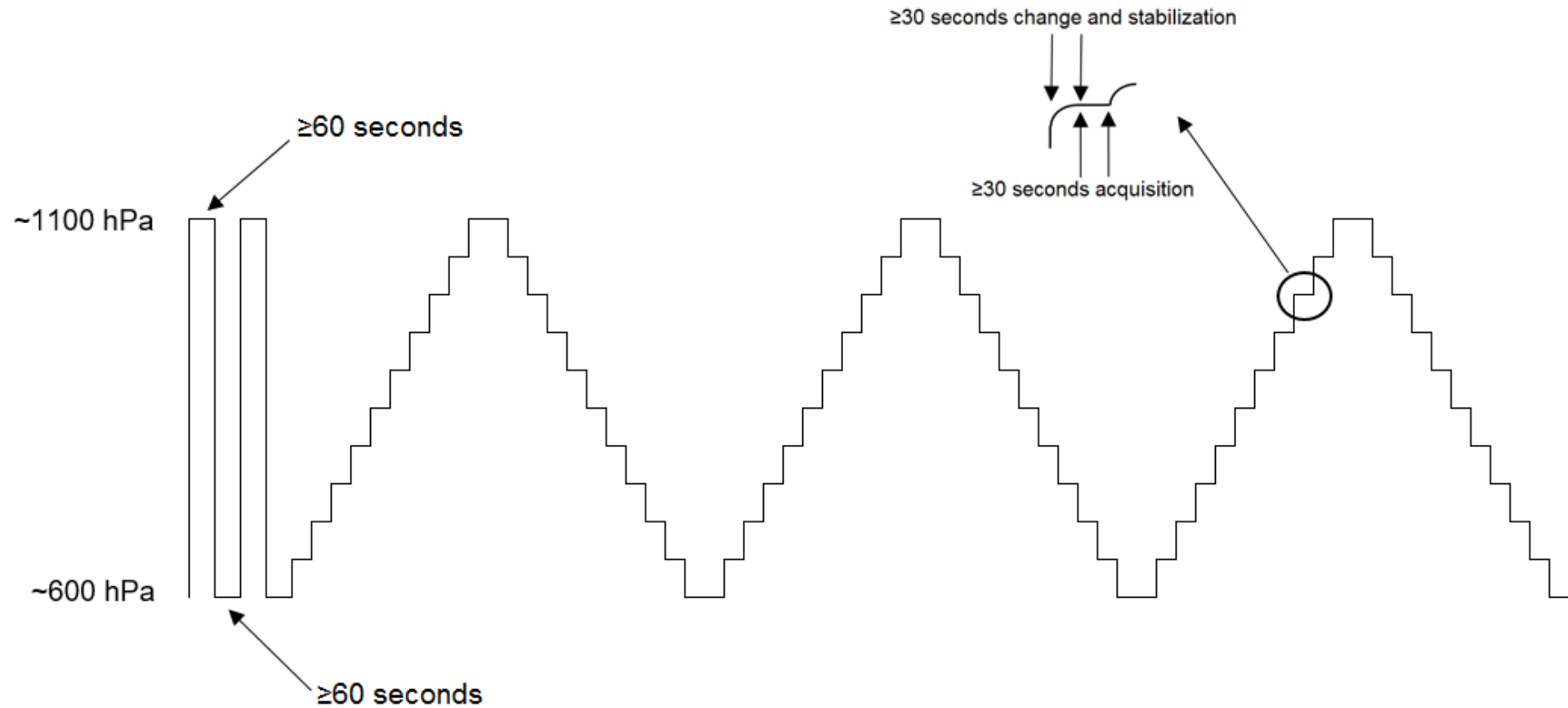
Comprehensive calibration procedure

- for the variation of the pressure points in a measurement series, the time
  - between two successive pressure points should be the same and should not be shorter than 30 seconds
  - the reading should be made 30 seconds after the end of the pressure change at the earliest

- the adjustment of the pressure during the repeated measuring series should be as close as possible to the values of the individual pressures of the first measuring series

- the difference between the reference pressures in the repeated measuring series shall not be bigger than 1 % of the calibration range

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Comprehensive calibration procedure

- comprehensive calibration procedure

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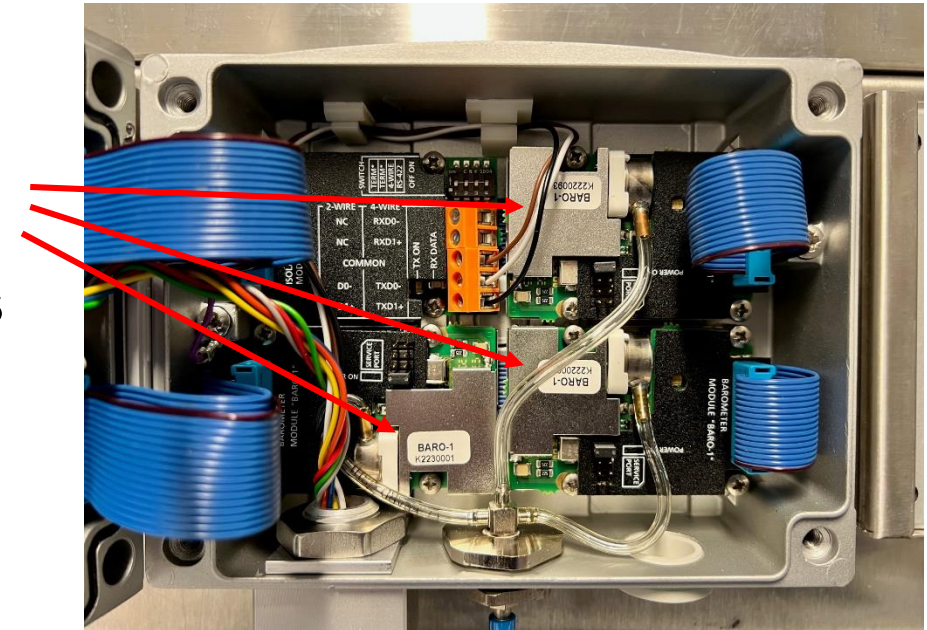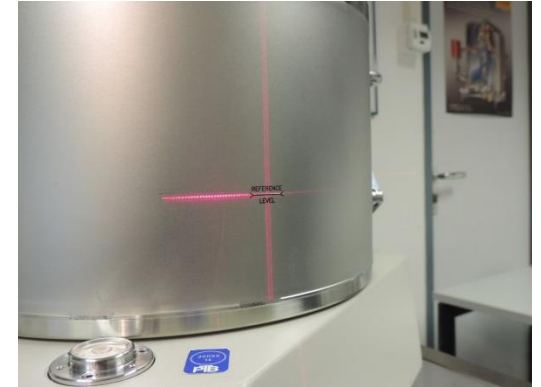# Calibration equipment and data acquisition

- Examples: calibration with a pressure balance (left) and calibration with a pressure controller and standard (down)

- all data is read and stored at regular short intervals, typically 1 to 5 seconds
- if the DUT has more than one pressure module, the measurement data from each module shall be read and saved separately

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Calibration equipment and data acquisition

- alignment of the device under test (DUT)
  - in general SB and DUT should be at the same height

  - the reference height is normally indicated

  - often the exact height, e.g. within the enclosures, is not known
    - example barometer with three modules
    - what is the reference height?

Calibration equipment and data acquisition

- alignment of the device under test (DUT)
  - therefore reference points are defined; for example, the transition between the pressure connection and the enclosure can be defined as a reference point
  - this information is also documented in the calibration certificate
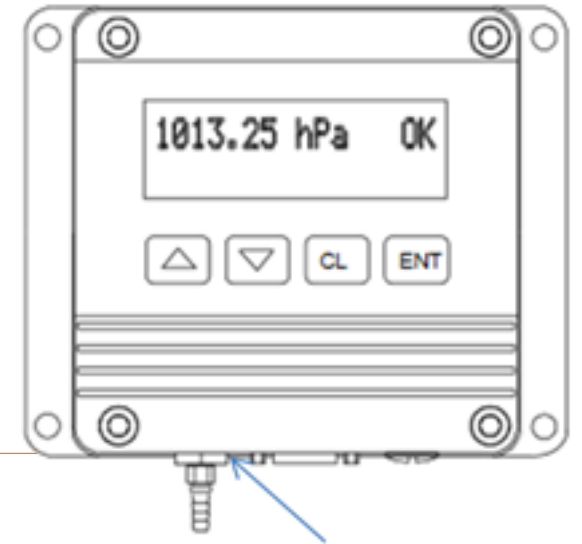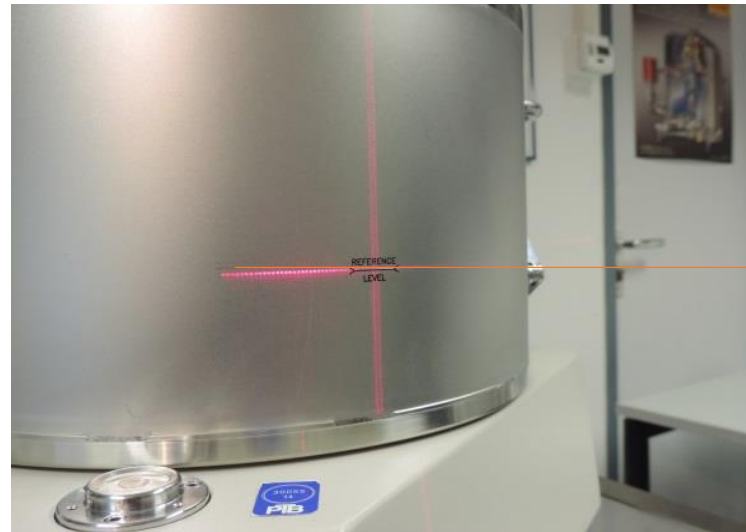
Calibration equipment and data acquisition

- the comparison of the data of the reference and the calibration object is carried out by means of time stamps

- environmental data P, T, U

```
00378724                    00137901
PTB                         HC2-USB
20220309                    20220309
09:30:01;1021.68            09:30:00; 22,73; 18,97
09:30:11;1021.68            09:30:10; 22,74; 18,95
09:30:21;1021.68            09:30:20; 22,72; 18,90
09:30:31;1021.68            09:30:30; 22,73; 18,86
09:30:41;1021.68            09:30:40; 22,71; 18,84
09:30:51;1021.68            09:30:50; 22,71; 18,84
```

- data of DUT

```
09.03.2022;09:45:42;1021.80;DUT1_1;00385393
09.03.2022;09:45:43;1021.81;DUT1_1;00385393
09.03.2022;09:45:44;1021.79;DUT1_1;00385393
09.03.2022;09:45:45;1021.80;DUT1_1;00385393
09.03.2022;09:45:46;1021.80;DUT1_1;00385393
09.03.2022;09:45:47;1021.80;DUT1_1;00385393
```

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Calibration equipment and data acquisition

- data of reference

  - these time stamps indicate here the end of the measuring point

  - period of the acquisition always took place over 60 seconds

    - for example `#12 945.8380 hPa`

    - data collection period: `10:34:15 – 10:35:14`

```
[TEST PRESSURE CYCLE]
01;20220309;09:56:09; 602,6390
02;20220309;09:59:36;1095,9660
03;20220309;10:03:12; 602,6385
04;20220309;10:06:55;1095,9660
05;20220309;10:10:22; 602,6383
06;20220309;10:13:38; 653,0831
07;20220309;10:18:16; 703,6640
08;20220309;10:21:37; 754,5533
09;20220309;10:24:53; 794,9102
10;20220309;10:28:23; 845,4911
11;20220309;10:31:50; 895,4629
12;20220309;10:35:14; 945,8380
13;20220309;10:38:28; 996,3460
14;20220309;10:41:43;1045,5199
15;20220309;10:44:58;1095,9646
```

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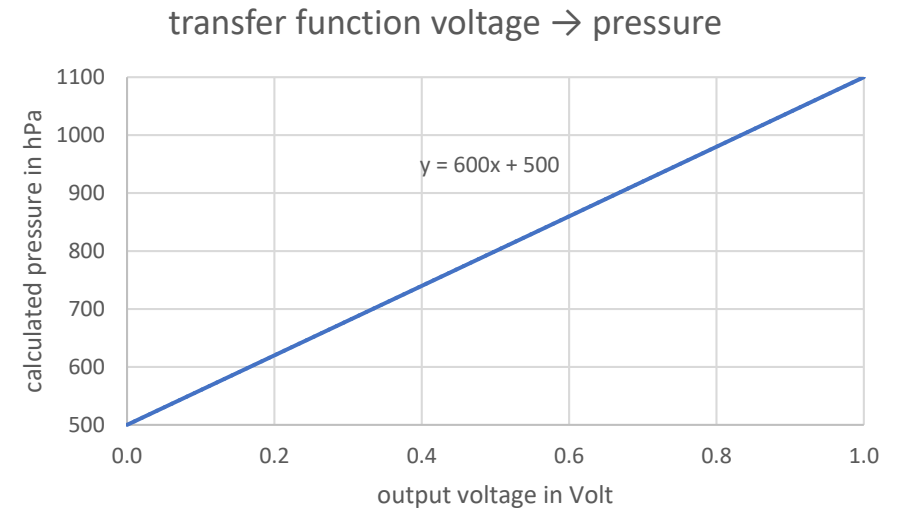ORGANIZATION

Calibration equipment and data acquisition

- all data from the reference and the DUT, each recorded for 60 seconds, are used to calculate the mean value and the type A measurement uncertainty

Calibration equipment and data acquisition

- in case a barometer has an analogue output, e.g. voltage, then the pressure value shall be calculated from the voltage measurement

$$p = U * \frac{600 \; hPa}{V} + 500 \; hPa$$

transfer function voltage → pressure

- both the voltage measurement and the conversion are subject to some uncertainties
  - drift, repeatability, resolution, …
  - all these points shall be examined and also taken into account
  - the measurement uncertainty will always increase

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End of Part 3

Thank you.

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