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by

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Contents

1. Foreword

The aim of this technical report is to provide detailed information about the long-term stability of the thermometer ASL F200 (WIKA Instruments Limited [1]) that is used as temperature reference to calibrate other temperature sensors in the Laboratory of Building Energy and Indoor Environment at Aalborg University – Department of the Built Environment [2]. This ASL F200 thermometer is regularly sent for recalibration at the “Temperature Laboratory” of the Danish Technological Institute, which is a National Reference Laboratory [3].

In this report, the stability of the thermometer is assessed as the difference in the temperature reading of the instrument at a specific temperature over time. The latter is calculated as the yearly deviation (or stability) in between consecutive recalibrations, which is equivalent to the difference in the calibration correction term in between two consecutive recalibrations divided by the elapsed time in between these two consecutive recalibrations.

The long-term stability of the ASL F200 thermometer is only assessed here for the first channel “Chan 1” of the instrument.

All calculations of this technical report are based on calibrations reports from the National Reference Laboratory of the Danish Technological Institute [3]. The main results of those calibration reports can be found in the Appendix at the end of this document.

2. ASL F200 Thermometer Specifications

The precision thermometer ASL F200 has 2 measurement channels equipped with 2 RTD temperature probes Pt100. This report is only concerning the calibration and stability of the first channel denominated “Chan 1”. In addition, the thermometer is recalibrated and therefore used as a reference, in the temperature range from -20 °C to 100 °C. According to the manufacturer’s specifications, the yearly deviation (stability) of the ASL F200 precision thermometer should be better (lower) than 0.005 °C per year.

3. Long-Term Stability

One can see in *Figure 1* the different calibration correction curves of the ASL F200 reference thermometer that have been collected over the last years. One can observe that the calibration correction curves do not change much from one calibration to the other.

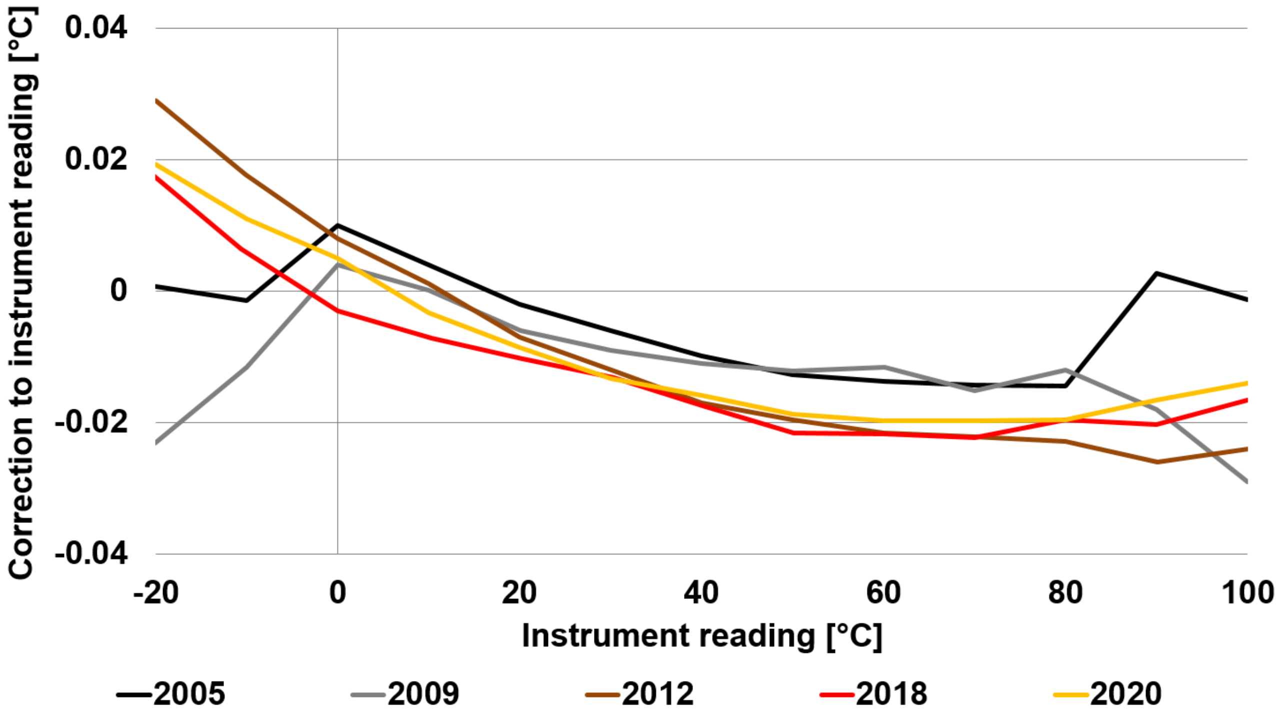

Figure 1: *The different calibration correction curves of the ASL F200 reference thermometer.*

One can see in *Figure 2* the yearly deviation of the ASL F200 reference thermometer for different temperatures at the different recalibration times. One can observe that, apart from the negative temperatures in 2009 and 2012, and the 100 °C temperature in 2009, the yearly deviation of the ASL F200 thermometer is fairly stable and within the conformity limit of the manufacturer's documentation (±0.005 °C per year.), for the whole range of temperature measurement.

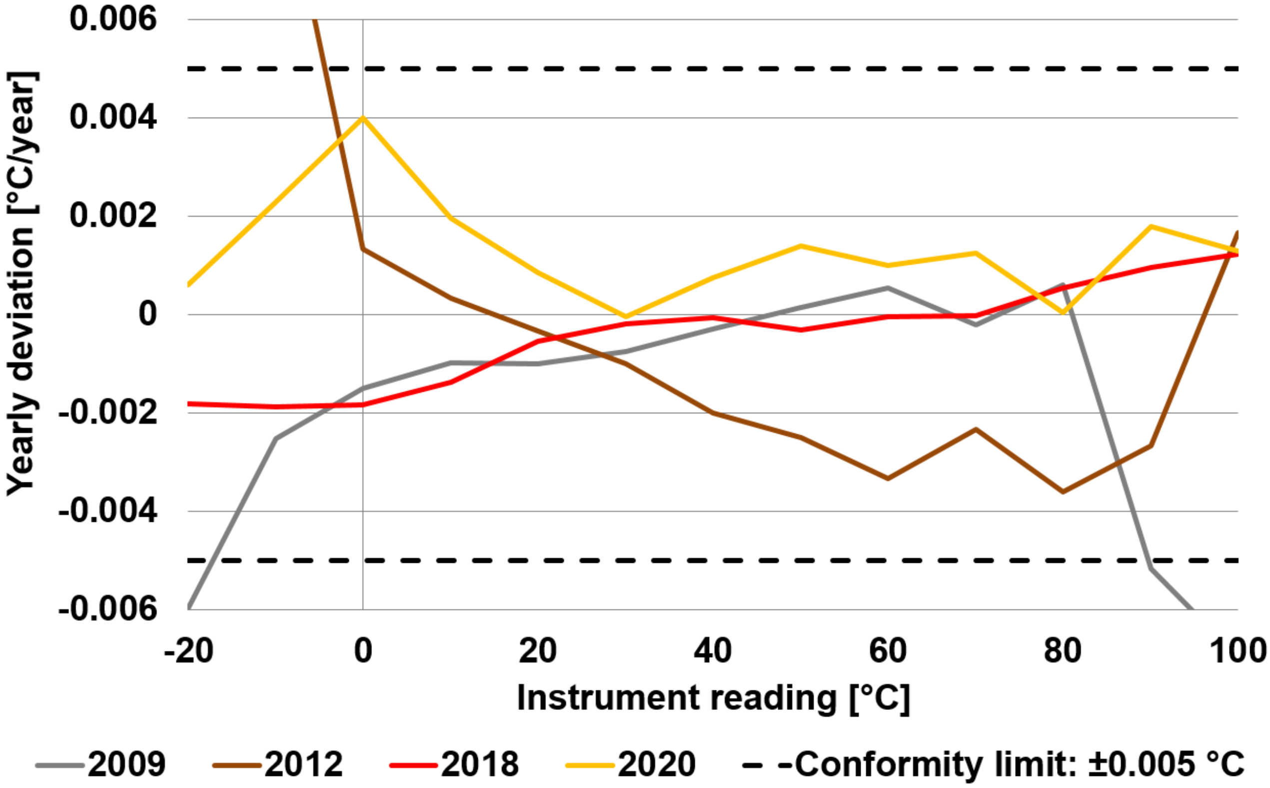

Figure 2: *Yearly deviation of the ASL F200 reference thermometer at the different recalibration times.*

One can see in *Figure 3* the evolution of the thermometer's yearly deviation (average of the absolute deviation and maximum of the absolute deviation over the full range of temperature measurement) as a function of time. One can observe that the average of the absolute deviation of the thermometer's measurement is always below the manufacturer's conformity limit. However, for the years 2009 and 2012, the maximum deviation over the full range of measurement is larger than the conformity limit. As mentioned before, this is due to some extreme deviations restricted to the far ends of the range of measurement below 0 °C and at 100 °C. Fortunately, since 2018, the yearly deviation of the ASL F200 thermometer over the entire range of temperature measurement is always better than the conformity limit.

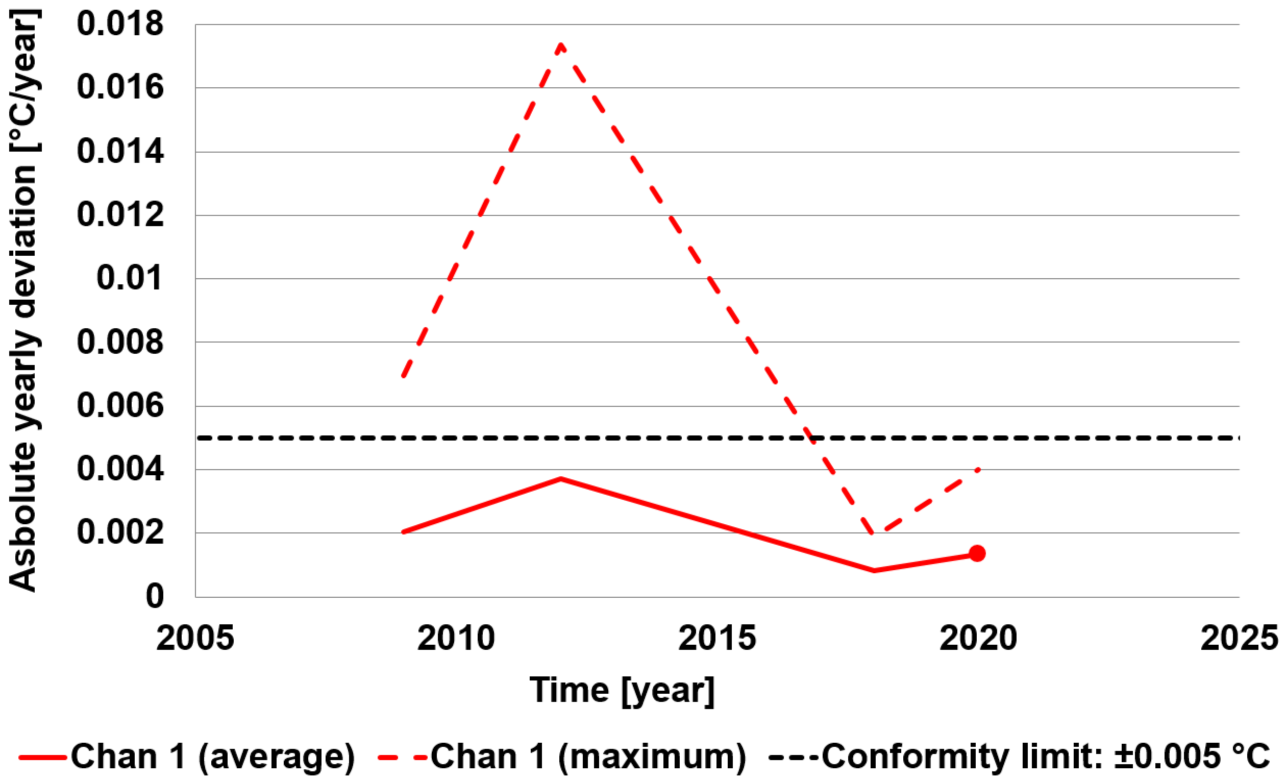

Figure 3: *Evolution of the yearly deviation (average of the absolute deviation and maximum of the absolute deviation) as a function of time.*

4. Current Calibration Correction

In order to perform an accurate temperature measurement with the ASL F200 reference thermometer, it is necessary to correct the readings of the instrument with the adequate correction term. This correction term depends on the temperature reading of the thermometer. The temperature-dependent correction terms (calculated from the recalibration report) are shown in *Figure 4* and can be found in Appendix *Table 5*. The correction term corresponding to the instrument's reading must be added to the instrument's reading:

$$Corrected\ measurement = Instrument\ reading + Correction$$

Because the recalibration report comprises only correction terms at every 10 °C, it is recommended to use a linear interpolation or a cubic Hermite spline interpolation function to calculate the correction term at the specific temperature corresponding to the reading of the instrument. Alternatively, for very smooth and regular calibration correction curves such as the one from the 2020 recalibration (see *Figure 4*), one can use a polynomial fitting function on the entire set of recalibration data to interpolate the correction term at the specific temperature.

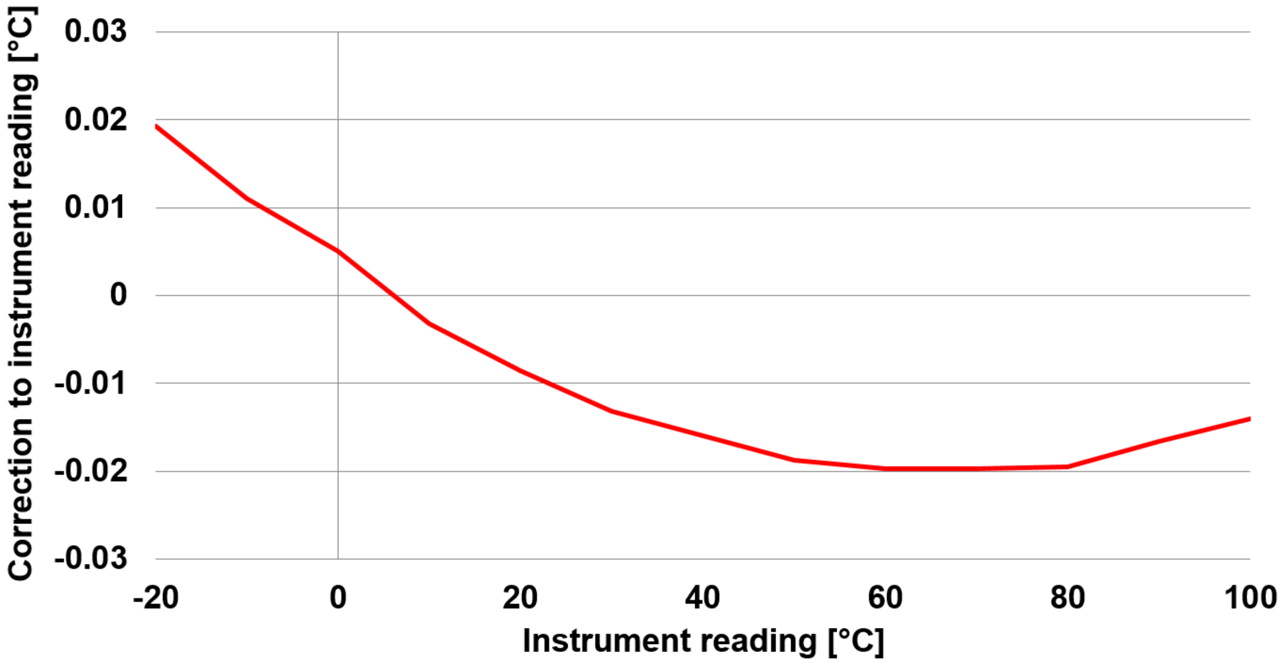

Figure 4: *Current calibration correction curve for the ASL F200 reference thermometer to be used from 2020 onwards.*

5. Conclusion

From the evolution of the thermometer’s yearly deviation presented in *Figure 3*, one can conclude that the ASL F200 thermometer presents a very good long-term stability over the last 2 years and can thus be trusted as a reference thermometer for the calibration of other temperature sensors.

6. References

[1] WIKA Instruments Limited
https://www.wika.co.uk/

[2] Aalborg University, Department of Built Environment, Aalborg, Denmark.
https://www.build.aau.dk/

[3] Danish Technological Institute (DTI), The Temperature Laboratory.
https://www.dti.dk/testing/temperature/37566

7. Appendix

Table 1: *Results of the calibration report of 2005.*

Reference temperature [°C]	Instrument reading [°C]	Error [°C]	Correction [°C]
-20.0042	-20.0050	-0.0008	0.0008
-10.0089	-10.0075	0.0014	-0.0014
0.0000	-0.0100	-0.0100	0.0100
10.0100	10.0060	-0.0040	0.0040
20.0060	20.0080	0.0020	-0.0020
30.0070	30.0130	0.0060	-0.0060
40.0057	40.0155	0.0098	-0.0098
50.0078	50.0205	0.0127	-0.0127
60.0008	60.0145	0.0137	-0.0137
70.0037	70.0180	0.0143	-0.0143
80.0016	80.0160	0.0144	-0.0144
90.0127	90.0100	-0.0027	0.0027
100.0048	100.0060	0.0012	-0.0012

Table 2: *Results of the calibration report of 2009.*

Reference temperature [°C]	Instrument reading [°C]	Error [°C]	Correction [°C]
-20.1026	-20.0795	0.0231	-0.0231
-10.0195	-10.0080	0.0115	-0.0115
0.0000	-0.0040	-0.0040	0.0040
9.9906	9.9905	-0.0001	0.0001
20.0370	20.0430	0.0060	-0.0060
29.9930	30.0020	0.0090	-0.0090
39.9760	39.9870	0.0110	-0.0110
50.0159	50.0280	0.0121	-0.0121
60.0720	60.0835	0.0115	-0.0115
69.9874	70.0025	0.0151	-0.0151
80.0050	80.0170	0.0120	-0.0120
89.9920	90.0100	0.0180	-0.0180
99.9900	100.0190	0.0290	-0.0290

Table 3: *Results of the calibration report of 2012.*

Reference temperature [°C]	Instrument reading [°C]	Error [°C]	Correction [°C]
-20.0005	-20.0295	-0.0290	0.0290
-10.0583	-10.0760	-0.0177	0.0177
0.0000	-0.0080	-0.0080	0.0080
9.9981	9.9970	-0.0011	0.0011
19.9940	20.0010	0.0070	-0.0070
30.0330	30.0450	0.0120	-0.0120
39.9830	40.0000	0.0170	-0.0170
49.9774	49.9970	0.0196	-0.0196
59.9770	59.9985	0.0215	-0.0215
69.9764	69.9985	0.0221	-0.0221
79.9927	80.0155	0.0228	-0.0228
90.0480	90.0740	0.0260	-0.0260
100.0620	100.0860	0.0240	-0.0240

Table 4: *Results of the calibration report of 2018.*

Reference temperature [°C]	Instrument reading [°C]	Error [°C]	Correction [°C]
-20.6814	-20.6995	-0.0181	0.0181
-10.6286	-10.6350	-0.0064	0.0064
0.0000	0.0030	0.0030	-0.0030
10.3294	10.3365	0.0071	-0.0071
20.2992	20.3095	0.0103	-0.0103
30.2714	30.2845	0.0131	-0.0131
40.0836	40.1010	0.0174	-0.0174
50.0565	50.0780	0.0215	-0.0215
60.0318	60.0535	0.0217	-0.0217
70.0103	70.0325	0.0222	-0.0222
79.9909	80.0105	0.0196	-0.0196
90.0043	90.0245	0.0202	-0.0202
100.0124	100.0290	0.0166	-0.0166

Table 5: *Results of the calibration report of 2020.*

Reference temperature [°C]	Instrument reading [°C]	Error [°C]	Correction [°C]
-20.0117	-20.0310	-0.0193	0.0193
-10.0040	-10.0150	-0.0110	0.0110
0.0000	-0.0050	-0.0050	0.0050
10.0098	10.0130	0.0032	-0.0032
19.9999	20.0085	0.0086	-0.0086
29.9913	30.0045	0.0132	-0.0132
39.9901	40.0060	0.0159	-0.0159
50.0033	50.0220	0.0187	-0.0187
59.9993	60.0190	0.0197	-0.0197
69.9973	70.0170	0.0197	-0.0197
79.9885	80.0080	0.0195	-0.0195
89.9954	90.0120	0.0166	-0.0166
100.0025	100.0165	0.0140	-0.0140

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