



## Method of Reference Measurements

Equipment used: Reference thermometer SBE35 SN 078  
Gallium Fixpoint cell, Isotech, SN 516 and 543  
Water triple point cell, Isotech, model B13. Sorry SN 1084 and 1143  
Fluke temperature calibration bath 7340

The readings from the Antares Miniaturized Temperature Loggers (MTLs) are compared against readings from a Sea-Bird Electronics SBE35 reference thermometer in a calibration bath. The reference thermometer has been recalibrated in a Gallium fix point cell and a water triple point cell shortly before the comparison. Four melt cycles have been performed in the Gallium cell, 24h each. The water triple point cell is stress annealed for a couple of days before using it. Residence time of the reference thermometer in the water triple point cell is greater than 10h. Resulting errors in the fix points are below 10 mK.

Comparison measurements are performed in a Fluke 7340 precision temperature calibration bath at 8 temperature points. These points are concentrated around 0°C (2°C steps) to ensure maximum accuracy in this range. Fluctuations in the bath are below 5mK. Antares thermometer raw data readings are fitted to the reference values by a 3<sup>rd</sup> order Steinhart-Hart polynomial. Final calibration uncertainty is below 10 mK.

The reference measurements have been performed by establishing distinct temperature plateaus in rising temperatures and for control reasons also in decreasing temperatures.

## Document of Calibration

Type: Miniature Temperature Logger (MTL)  
Manufacturer: Antares Datensysteme GmbH

LoggerID: 1854634C

### Standard High Precision Calibration

The reference measurements were performed by Dr. Gereon Budéus at the temperature calibration laboratory of the Alfred-Wegener-Institute Helmholtz Centre for Polar and Marine Research in Bremerhaven, Germany. The calculation of the resulting calibration coefficients was done by FIELAX GmbH. The final calibration uncertainty is below 10 mK.

Date of Calibration: 15.11.2017  
Temperature range: -2 ... 30°C

Date / Signature

27.11.17



## Results of Calibration

The calibration coefficients are determined by fitting the resistance by the Steinhart and Hart equation of 3<sup>rd</sup> order:

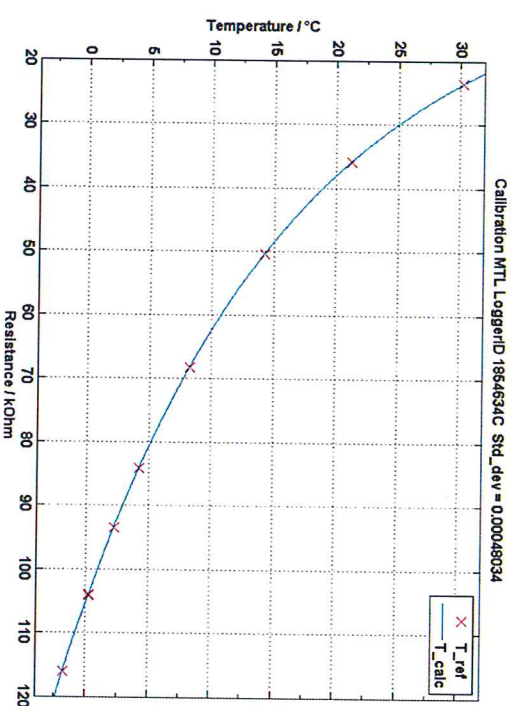
$$T(^{\circ}\text{C}) = \frac{1}{\sum_{i=0}^3 A[i](\ln X)^i} - 273.15$$

(X = raw data / digits) with the resulting coefficients

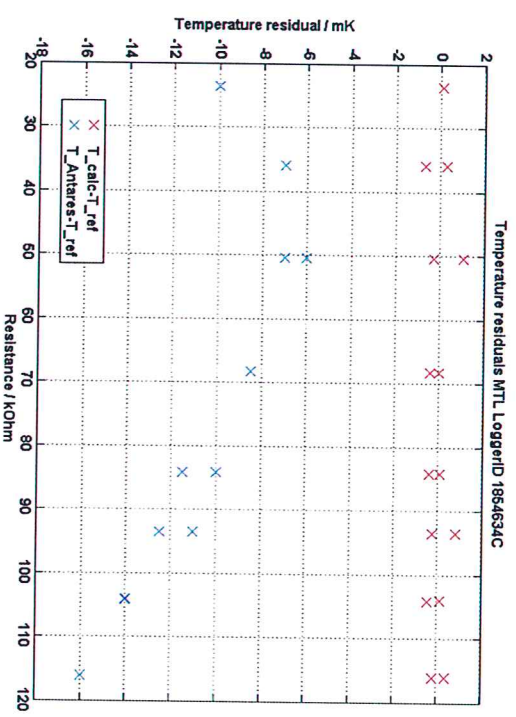
A[0] = 2.564497e-003  
A[1] = 2.242152e-004  
A[2] = 2.093151e-006  
A[3] = 6.708270e-008

Resistance / kOhm	Reference / °C	Calculated / °C	Residuals / °C
116.1604	-1.7920	-1.79223	0.00023
104.1151	0.2250	0.22456	0.00044
93.5569	2.2185	2.21825	0.00025
84.1707	4.2135	4.21307	0.00043
68.3563	8.2105	8.21009	0.00041
50.4494	14.2180	14.21771	0.00029
35.8909	21.2100	21.20929	0.00071
23.6185	30.2000	30.20008	-0.00008
35.8909	21.2090	21.20929	-0.00029
50.4511	14.2160	14.21704	-0.00104
68.3584	8.2095	8.20949	0.00001
84.1707	4.2130	4.21307	-0.00007
93.5540	2.2180	2.21882	-0.00082
104.1119	0.2250	0.22513	-0.00013
116.1568	-1.7920	-1.79166	-0.00034

Standard Deviation: 0.000480°C



Reference temperatures from the Sea-Bird Electronics SBE35 reference thermometers in the calibration bath and fitted data according to Steinhart and Hart equation.



Temperature residuals for fitted data (red) and original Antares calibration (blue)

