RSI Technical Note 047

Why Calibrate the FP07 Thermistor

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1 The Question

How do you choose between ordering an FP07 thermistor *with* or *without* calibration?

The FP07 is offered by RSI without calibration. It is also available with an optional calibration over the 0 to 35 °C range. Here are the reasons for choosing between these two options.

2 The Answer

The answer depends upon your particular circumstances. You will certainly need the coefficients to convert your raw data collected with an FP07 into physical units of °C and to derive the gradient of temperature in $°C\,m^{-1}$.

A calibration of the FP07 by RSI provides the coefficients for the conversion of your data into physical units, and this calibration is accurate to better than 0.01 °C at atmospheric pressure. But this is not the only way to obtain the coefficients.

2.1 FP07 Fundamentals

You must consider that the FP07 is not designed to be an *accurate* thermometer, such as you might find on a CTD. It is designed to be a *fast* thermometer. One that can respond very quickly to rapid changes of temperature along a profile. It is also designed to resolve very minute fluctuations of temperature (down to $\sim$10 µ°C). Neither of these two characteristics are provided by any thermometer on a CTD.

The fast response of the FP07 thermistor is achieved by leaving its metal-oxide sensing element completely unprotected from the pressure of its environment, save for a very thin ($\sim$25 µm) layer of glass to isolated it electrical from seawater. This means that the thermistor will compress with increasing depth, and this compression induces a positive bias to the reported temperature. This bias has not been properly quantified but appears to be $\sim 1 \times 10^{-4}\,°C\,dbar^{-1}$ (Shang et al., 2017).

The high resolution of temperature is achieved by electronics that are optimized for noise and not long-term stability. The noise level of the electronics that support the FP07 is very close to the theoretical limits imposed by thermodynamics – the so called Johnson noise due to the thermal agitation of electrons within a resistive lattice. The stability of the electronics is roughly equivalent to 0.010 °C over the oceanic temperature range.

The raw thermistors supplied to RSI are accurate to 50 % but their temperature coefficient of resistance has a far tighter tolerance of 1 %. This means if you use nominal coefficients to convert your data into physical units, the reported temperature could be shifted by as

much as 12 °C from its true value, but the variations of temperature will be reported quite accurately.

2.2 User calibration

Many instruments provided by RSI carry a CTD-quality thermometer (usually a Sea-Bird SBE3F, or a JAC-CT) which can be used to calibrate the FP07 using *in situ* data collected during a profile. The RSI Library of processing function supports this method of calibration using the function `cal_FP07_in_situ.m`[1]. This option spares you the expense of a calibration at RSI, but it is slightly inferior because the ocean is not homogeneous (like a calibration bath) and the reference thermometer and your FP07 are physically separated. That is the CTD-quality thermometer and your FP07 are not profiling through exactly the same water. The *in situ* calibration function compensates for the delay of a physical separation and this works well on vertical profilers. On gliders, the lateral separation of the two sensors can be considerable (∼0.3 m) and the calibration may be slightly biased by this separation. However, even on a glider, the FP07 temperature readings are within ∼0.1 °C after *in situ* calibration.

If your instrument does not carry a CTD-quality thermometer, then calibration at RSI is highly recommended. Otherwise you will be restricted to adjusting the T_0 coefficient (while keeping the β_1 coefficient at its nominal value) until your FP07 data agrees semi-quantitatively with profiles obtained from an independent source, such as a ship-lowered CTD.

References

Shang, X., Y. Qi, G. Chen, C. Liang, R. G. Lueck, B. Prairie, and H. Li, 2017: An expendable microstructure profiler for deep ocean measurements. *Journal of Atmospheric and Oceanic Technology*, **34 (1)**, 153 – 165, doi:10.1175/JTECH-D-16-0083.1.

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[1] See RSI Technical Note 039 for details.