
Calibration

Calibration of the stem psychrometer is accomplished by preparing a range of standard sodium chloride (NaCl) solutions of known molality in the range 0.1, 0.2, 0.3, 0.4, 0.5 and 1.0 Molal. The exact NaCl volumes per 50ml volume of water are provided in [Preparation of Calibration Solutions](#). These concentrations are derived from the work of Lang, A.R.G, *Osmotic Coefficients and Water Potentials of Sodium Chloride Solutions from 0 to 40°C*, 1967. Australian Journal of Chemistry, 20, 2017-23. This range of concentrations correspond well to the typical range of water potentials experienced by crop plants and trees (-0.642, -0.915, - 1.368, -1.823, -2.281 and -4.640 MPa).

Saturated filter paper disks (Watman's No.1) are used for calibration purposes. These are supplied by ICT already cut to the correct 6mm diameter size required for the calibration lid holder. Replacements are conveniently obtained using a standard paper punch. Measurement of thermocouple output in the suggested range is essentially linear at a given temperature.

NOTE: Always use freshly made NaCl calibration solutions. If you are making calibration solutions for the first time, we recommend watching: VIDEO 16 – Making Calibration Solutions

Pre-Calibration Cleaning

The slope and intercept will be different for each psychrometer as the thermocouples are hand made using a very thin 25 μm wire. The thermocouple surface will have a natural variation that may have more or less dimpling providing different physics for the condensation of water. This is further impacted by the cleanliness of the thermocouple hence, it is imperative that the chamber is cleaned prior to calibration.

NOTE: When the chambers are cleaned and calibrated at 25°C using fresh Molal calibrations solutions the calibration protocol reliably returns R^2 of 0.999 to 0.9999.

It is advisable to enhance the vapour seal between the faces of the chamber and the calibration disk holder with a small amount of silicon grease. It is also helpful if calibration is carried out in a stable thermal environment or temperature controlled chamber.

Watch a demonstration: VIDEO 17 – [Sealing the Calibration Lid to the Psychrometer to perform a calibration measurement](#)

Calibration Temperature

Calibration is usually done at, or corrected to, 25°C. Temperature correction for Psychrometric measurements is given by:

$$\text{Corrected Reading} = \text{Reading} / (0.027T + 0.325) \quad \text{Equation 3}$$

Where: T is chamber temperature in °C.

The calibration routine should be carried out in a temperature controlled chamber if possible. However, if you can only manage crude temperature control, then this is often worse than none at all. Rapid cycling of temperature caused by heating and cooling systems initiates transient gradients in the instrument and confound accurate calibration procedures. The relatively stable temperature of a large room is preferable. Corrections for ambient conditions can be made using the formula above.

Calibration Chamber

Here is a simple and effective means to achieve stable temperature control: You will require a good quality circulating water bath, preferably with proportional control of water temperature. This eliminates the typical "sawtooth" temperature control of less sophisticated baths. Circulate the water through a flexible copper tube (1-2 cm diameter and 2-3 m long) which is then coiled and placed inside a box close to the inside edges. Construct the box of dense styrofoam (eg. 5 cm. thickness, Styrofoam SM) and line all inside surfaces with a reflective foil (eg. aluminium foil). The dimensions of the box should accommodate the number of psychrometers you intend to calibrate as well as one or two small electric fans to facilitate air mixing. Internal dimensions of approximately 50x50x50 cm are appropriate. Suspend a light plastic grid in the centre of the box to serve as a platform for the psychrometers. This allows air movement around the instruments and eliminates temperature gradients from conductive surfaces. Normal equilibration times for salt solutions are quite brief but it is safest to allow between 30 to 60 minutes for each solution to equilibrate depending upon how intensively the psychrometer was handled while loading the calibration solution.

VIDEO 18: A demonstration detailing the components used in the construction and use of a simple [calibration chamber for psychrometers](#).

Calibration Protocol

Prior to attempting a calibration of the psychrometer for the first time it is recommended that you watch VIDEO 19: [Calibration Protocol](#), this video clearly details all the practical steps involved in the successful calibration of the PSY1 Stem Psychrometer. An additional video, VIDEO 20, demonstrates the software [Calibration Function](#), used to initiate a measurement and process the calibration data.

The calibration routine is designed to be semi-automated and all inclusive within the PSY1 software, from making measurements of calibration solutions to plotting the data, generating a slope and intercept and storing the calibration in the firmware of the PSY1 Instrument for real time data processing.

Start Calibration

To begin a calibration, connect to the PSY1 instrument, go to Configuration and then Launch PSY Calibration.



Note: A calibration can only be performed in Manual mode. If you attempt to “Start a Calibration” while in Live Mode or while the instrument is logging, an error message is displayed.

Loading the Calibration Filter Paper

Place a known calibration solution on a filter paper inside the calibration lid of the Psychrometer. Place the Psychrometer into an isothermal calibration chamber ideally set and regulated to 25°C and leave for at least 30 minutes to preferably 1 hour to equilibrate before making the measurement.

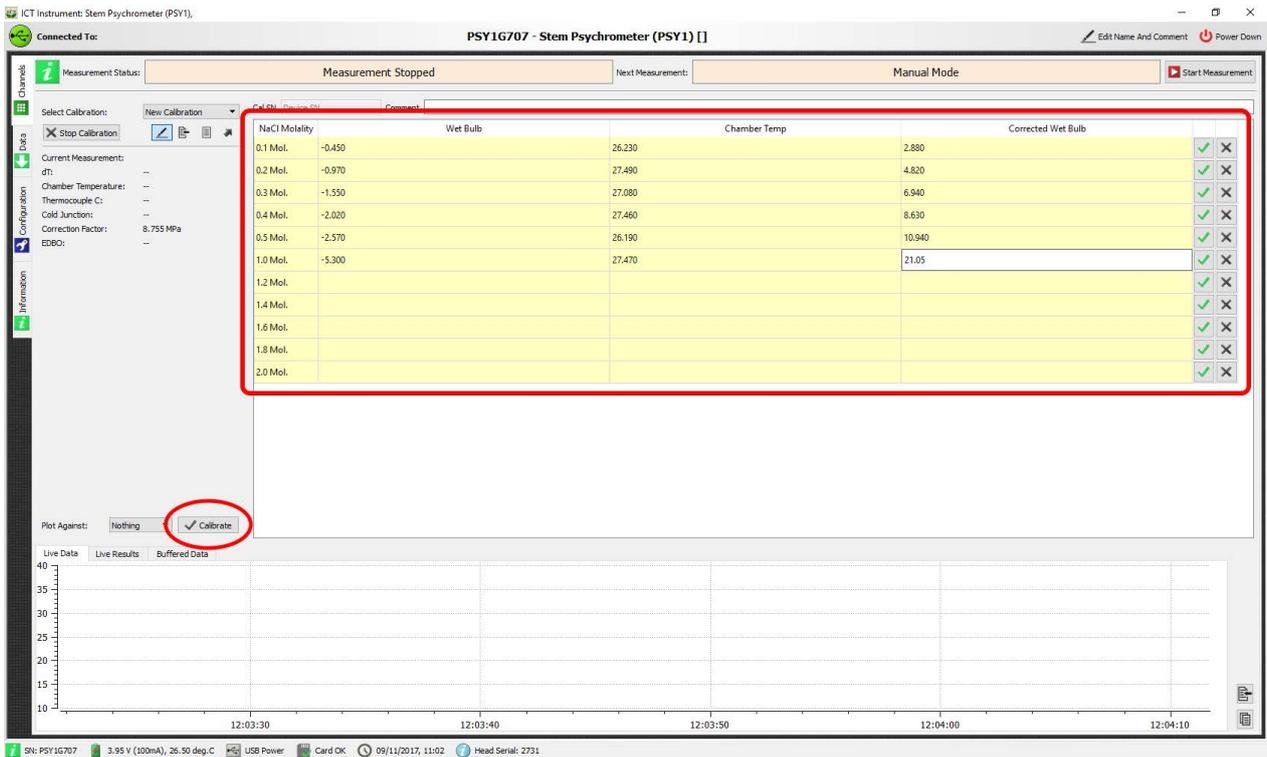
Selecting the Calibration Range

Click the Edit button to enter calibration values:

The screenshot shows the software interface for the PSY16707 - Stem Psychrometer (PSY1). The 'Measurement Status' is 'Measurement Stopped' and 'Next Measurement' is 'Manual Mode'. A table lists NaCl Molality from 0.1 to 2.0. Columns include Wet Bulb, Chamber Temp, and Corrected Wet Bulb. A red circle highlights the 'New Calibration' button in the 'Select Calibration' dropdown menu.

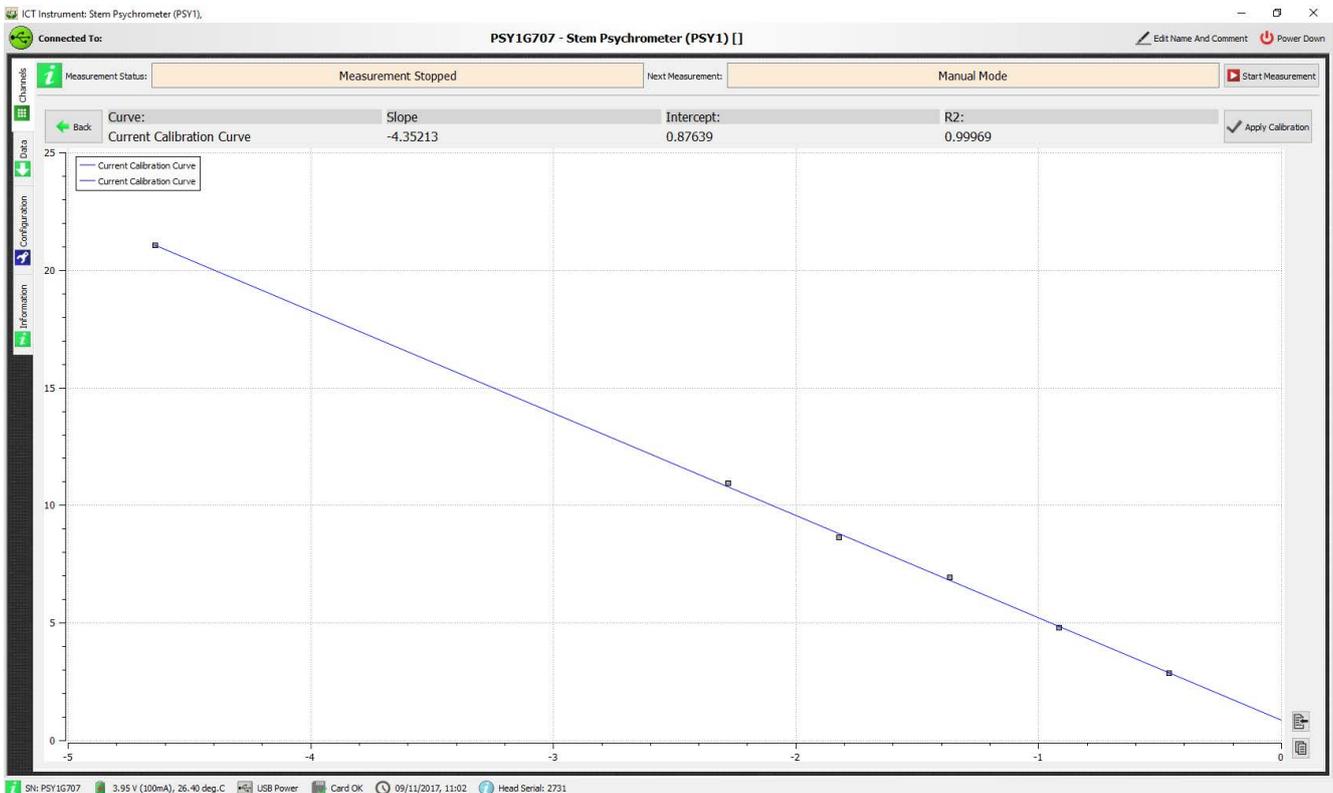
NaCl Molality	Wet Bulb	Chamber Temp	Corrected Wet Bulb		
0.1 Mol.				✓	✗
0.2 Mol.				✓	✗
0.3 Mol.				✓	✗
0.4 Mol.				✓	✗
0.5 Mol.				✓	✗
1.0 Mol.				✓	✗
1.2 Mol.				✓	✗
1.4 Mol.				✓	✗
1.6 Mol.				✓	✗
1.8 Mol.				✓	✗
2.0 Mol.				✓	✗

After you have recorded measurements for each different molarity, enter the Wet Bulb, Chamber Temp and Corrected Wet Bulb values for each molarity.



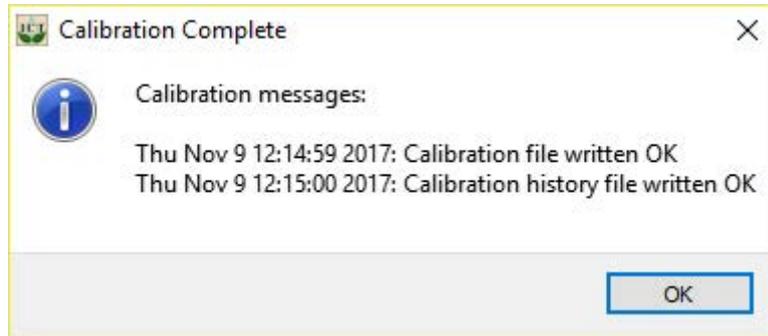
Generate Calibration Curve

When the data points have been entered, click on the Calibrate button. The data points will be automatically plotted, a regression line fitted, the slope, intercept and R² calculated. If the calibration is of suitable accuracy, an R² of at least 0.999, preferably 0.9999, should be possible and the slope should be within the general range of -3.8 to -4.2 μV/MPa with an intercept of between 0 to 1 μV.



Write Calibration to Firmware

Click Apply Calibration (top right hand corner of the plot). This will automatically write the calibration slope and intercept to the firmware of the PSY1.



Calibration Summary file (*.rdf)

The calibration summary file is attributed the name of the psychrometer chamber that was calibrated. The file consists of the calibration intercept and slope that was generated after performing the minimum 3-point calibration using known NaCl solutions. It also contains the basic reference information related to the calibration such as the serial number of the PSY1 instrument that the calibration was conducted with; the calibration comment and the date and time the calibration was completed.

0.88

-3.87

PSY1AB03

ICT Demo Calibration

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16.6.6 Calibration File

The *.cqs calibration file is simply a text (*.txt) file that records and stores the raw calibration values for every calibration solution measured for a specific calibration run of a psychrometer. This file is stored on the Micro SD card or can be saved to your computer to allow loading it to the psychrometer or editing it at a later date. This can be a useful feature if a calibration cannot be finished or the user wishes to save each data point for fear of the OS crashing and the calibration data being lost.

The first line of the *.cqs file is the header line or comment entered by the user. Then data is stored in a simple table. The left hand column is the Molal solution concentration: 0.1, 0.2, 0.3, 0.4, 0.5, and 1.0 Molal, the standard calibration concentration range. The column continues for 1.2, 1.4, 1.6, 1.8 and 2.0 Molal concentrations, or the Extreme environment calibration range. The subsequent 3 columns of the table refer to the direct measurements recorded during calibration process: Wet Bulb, Chamber Temp and Corrected Wet Bulb.

Values are only entered if measured by the PSY1. Because the data file can be edited, there may be instances where only 1 value appears in a column, most commonly this would be the far right column for corrected Wet Bulb if the user has entered a nominal value for the purpose of demonstrating the calibration function or has values from a previous calibration that were manually entered into the calibration file.

16.6.7 Calibration History File

The calibration history file maintains a chronological record of all the calibrations performed on the psychrometer over the life of the instrument. Every time a calibration is made and saved using the four digit serial number of the psychrometer, the raw data for each calibration solution is stored in the file, including:

- i. Wet bulb depression,
- ii. Chamber temperature at which the measurement was made
- iii. Corrected wet bulb depression
- iv. Serial Number of the PSY1
- v. Comment
- vi. Date & Time

This provides a good reference to check for calibration drift over time.

HCDATE_26/10/2012_14:47:49

CC_Check Calibration Drift

CS_PSYOAB03

01_2.45_25.00_2.45

02_4.55_25.00_4.55

03_6.40_25.00_6.40

04_7.90_25.00_7.90

05_9.80_25.00_9.80

10_19.00_25.00_19.00

12_ _ _

14_ _ _

16_ _ _

18_ _ _

20_ _ _

HCDATE_26/10/2012_14:41:30

CC ICT Demo Calibration

CS_PSYOAB03

01_2.60_25.00_2.60

02_4.50_25.10_4.49

03_6.20_24.90_6.22

04_7.90_24.80_7.94

05_9.60_24.80_9.65

10_18.80_24.90_18.85

12_ _ _

14_ _ _

16_ _ _

18_ _ _

20_ _ _

NOTE: If the thermocouple is broken and replaced, the relevance of the chronological calibration data is lost. A new thermocouple will have no correlation with the calibration history of a previous thermocouple. It is effectively now a different instrument.

Preparation of Calibration Solutions

Calibration over a range of water potentials is accomplished using sodium chloride (NaCl) solutions (the molecular weight of sodium chloride = 58.4428 g/mole).

The following Table represents a suitable range of molalities (i.e., mass of salt per unit mass of water) of salt solutions with the corresponding water potential equivalent at 25°C.

You can make these solutions yourself using sodium chloride and distilled water by carefully measuring the salt & water exactly on a minimum 4 decimal balance. An [instructional video](#) is available on the ICT International web site and the CD shipped with this instrument.

Alternatively, premixed calibration solutions can be purchased directly from ICT International or their distributor in your country.

NaCl Molality	Mass of NaCl (g)	Mass of Water (g)	Water Potential (MPa)
0.1	0.2922	50	- 0.462
0.2	0.5844	50	- 0.915
0.3	0.8766	50	-1.368
0.4	1.1688	50	- 1.823
0.5	1.4610	50	- 2.281
1.0	2.9221	50	- 4.640