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## 10 Cleaning the Psychrometer

The need for cleaning the stem psychrometer may not always be obvious from visual observation even under a 20x dissection microscope. The Stem Psychrometer consists of two very small welded thermocouples using very fine wire only 25  $\mu\text{m}$  in diameter. This makes the sensor very sensitive to measuring water potential but equally as sensitive to dirt and even mild oxidation. It is recommended that before starting any measurements you clean the thermocouples.

**NOTE 10** - This should even be done upon receipt of new instruments from ICT or at the commencement of a field campaign, especially if they have been stored for any length of time.

**WARNING 4** – NEVER store the stem psychrometer without first cleaning it.

Diagnosing a dirty thermocouple that is not visually obvious is done by plotting the Peltier cooling curve and interpreting psychrometric plateau and the thermocouple response as it returns to zero microvolts within the measurement period. This is covered in detail in section [diagnosing a dirty thermocouple](#).

Conversely, badly contaminated and dirty psychrometers can easily be identified from visual observation, in some cases even without the use of a 20 x dissection microscope.



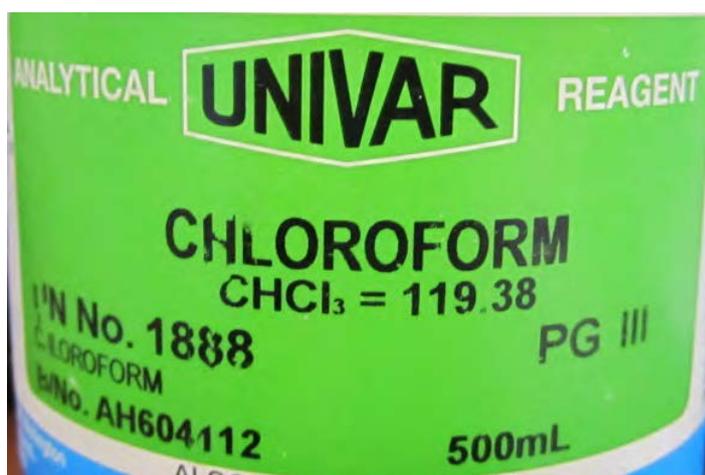
**Photo 9:** A heavily contaminated stem psychrometer in which the chamber well has been filled with vacuum grease and plant tissue or callus, this type of contamination is clearly obvious from visual observation.

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## 10.1 Cleaning routine

The stem psychrometer requires a strong organic solvent to clean dirt and/or organic matter that may have entered and contaminated the chamber and thermocouples. The organic solvent will dissolve the contaminants, but both the organic solvent and dissolved contaminants must be flushed from the chamber using distilled water. Failure to do so will result in the dissolved contaminants precipitating out of solution as the solvent dries (evaporates) and the thermocouples being recoated with a film of contamination and not being cleaned.

The organic solvent recommended for cleaning the psychrometer is Chloroform ( $\text{CHCl}_3$ ). This is a standard analytical reagent available in most laboratories; however it is regulated under strict safety controls that may make it difficult to access and definitely difficult to transport safely in the field. An alternative cleaning agent that may be substituted for Chloroform is electrical contact cleaner. Recommended electrical contact cleaners and cleaning procedures for cleaning the psychrometer using both options are documented below.



**Photo 10: Analytical Reagent Chloroform ( $\text{CHCl}_3$ ) Cleaner.**



**Photo 11: CRC - QD Electronic.**

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### 10.1.1 Cleaning the psychrometer using Chloroform

#### VIDEO 12 - [Watch how to clean the Psychrometer](#) using Chloroform

- a. Invert the psychrometer chamber and flood the chamber well with the organic solvent, (chloroform). This is done using an eye dropper to deliver several drops of Chloroform directly onto the thermocouples. Let stand for between 5 to 10 seconds (longer if severely contaminated) ensuring not to allow the chloroform to evaporate.

**WARNING 5** - If chloroform is allowed to evaporate while in the chamber well of the Psychrometer it will further contaminate the thermocouples. Any and all of the organic compounds dissolved by the chloroform must be washed out with distilled water. Failure to do so results in these dissolved contaminants being evenly distributed and coating the thermocouple further exacerbating the original contamination. This contamination will be visible as a fine white film.

- b. Then, using a wash bottle of distilled water, immediately rinse away the dissolved contaminants by squirting a steady stream of water into the chamber well, rinsing continuously for approx 3-5 seconds.
- c. Next use a Kim Wipe or other such lint free tissue, and place a corner of the tissue in the outer edge of the chamber well. This will wick the bulk of the water up out of the chamber well.

**WARNING 6** - Be extremely careful not to touch the thermocouples with the tissue and do not attempt to rub the tissue within the chamber. The intention is merely to absorb the bulk of the free water not to completely dry the chamber well.

- d. Finally, blow dry with a controlled stream of compressed air (20 to 30 psi). The drying phase is important as residual water must be removed from the chamber well. Stubborn drops may reside around the copper posts and sustained streams of compressed air may be required to remove all the water.

This cleaning process may be required to be performed several times to achieve a thorough cleaning of the stem Psychrometer depending upon the severity of the contamination. Once satisfied that the stem Psychrometer is clean, connect the unit to the PSY1 and perform a verification test, see ([Appendix 1](#)).

At this point you should also visually check the position of Thermocouple-S using a 20 x dissection microscope. If Thermocouple-S requires adjustment follow the instructions in the [Setup Procedure](#). The stem psychrometer is now clean and ready for deployment.

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### 10.1.2 Cleaning the psychrometer using Electronic Contact Cleaner

Electrical Contact Cleaners are available from a number of commercial outlets. Whilst these are all intended for the same basic purpose, that being to clean electrical contacts leaving no residue for high electrical conduction, they utilise a variety of organic solvents at varying concentrations. Therefore, not all electrical contact cleaners will perform to the same level of efficacy in cleaning the stem psychrometer. ICT has evaluated a range of Electronic Contact Cleaners and provided a list of recommended options. Appendix 22.2 [Electronic Contact Cleaners](#), lists manufacturer web sites and MSDS links to enable you to source a cleaner locally.

**WARNING 7** – Do not use a De-greaser Spray or a contact cleaner that is oil based.

**NOTE 11:** Not all electronic cleaners may be available in your country.

#### VIDEO 13 - [Watch how to clean the psychrometer](#) using Electrical Contact Cleaner

- a. In an open well-ventilated area (preferably outdoors), invert and hold the psychrometer chamber at 45° to the ground facing away from your body. Shake the can well (following the manufacturer's directions) and spray a steady stream of electronic contact cleaner into the chamber well for approx 2 seconds ensuring the chamber well is fully saturated. Repeat this process at least twice leaving the chamber well fully saturated.

**WARNING 8** – the physical pressure of the propellant used in the electronic cleaner will aid in dislodging contamination, but will not fully remove the dissolved organics that will invariably remain in the chamber well in solution. This contaminated solution must be flushed with distilled water prior to it evaporating.

- b. Then, using a wash bottle of distilled water, immediately rinse away the dissolved contaminants by squirting a steady stream of water into the chamber well, rinsing continuously for approx 3-5 seconds.
- c. Next use a Kim Wipe or other such lint free tissue, and place a corner of the tissue in the outer edge of the chamber well. This will wick the bulk of the water up out of the chamber well.

**WARNING 9** - Be extremely careful not to touch the thermocouples with the tissue and do not attempt to rub the tissue within the chamber. The intention is merely to absorb the bulk of the free water not to completely dry the chamber well.

- d. Finally, blow dry with a controlled stream of compressed air (20 to 30 psi). The drying phase is important as residual water must be removed from the chamber well. Stubborn drops may reside around the copper posts and sustained streams of compressed air may be required to remove all the water.

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This cleaning process may be required to be performed several times to achieve a thorough cleaning of the stem Psychrometer depending upon the severity of the contamination. Once satisfied that the stem Psychrometer is clean, connect the unit to the PSY1 and perform a verification test ([Appendix 1](#)).

At this point you should also visually check the position of Thermocouple-S using a 20x dissection microscope (or a 10x pocket hand lens if in the field). If Thermocouple-S requires adjustment follow the instructions in Chapter 9 [Setup Procedure](#). The stem Psychrometer is now clean and ready for deployment.

**NOTE 12:** A pre-packaged pressurised can of pure, moisture free, compressed air is recommended to ensure sufficient pressure to drive out microscopic beads of water from around the copper posts and is a convenient tool in the field.



**Photo 12 CRC Air Brush Compressed Air**



**Photo 13 Dick Smith Air Jet Spray**

## 10.2 Diagnosing a Dirty Thermocouple

Detection and diagnosis of a contaminated thermocouple is easily accomplished with the PSY1 in Manual mode.

Place a known water potential sample (1.0 Molal NaCl solution) on a filter paper disk in the calibration lid of the Psychrometer. Set the PSY1 to Manual mode and perform a measurement.

If the thermocouple is very dirty the measured result will clearly indicate a problem. This can be seen in the “Dialogue box” where the results of the manual measurement are immediately displayed upon completion of the measurement. The key factor to review is the Wet Bulb Depression. If water had been able to be condensed on the thermocouple it would have cooled generating a  $\mu\text{V}$  output in the range of 19  $\mu\text{V}$  for a 1.0 Molal solution. In this example, there is effectively no change from the Electronic Dry Bulb Offset (measured prior to each measurement), remaining at  $-0.15 \mu\text{V}$ .

In less obvious cases the Psychrometric plateau will show a less crisp and clean response with a typical, long slow drift back to zero reference or perhaps even fail to reach zero within the measurement window.

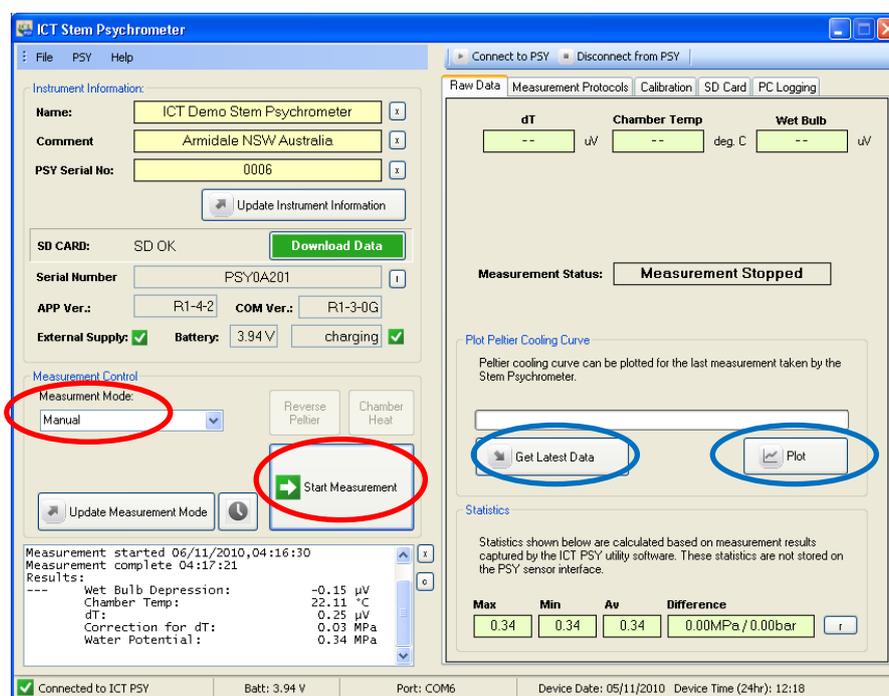
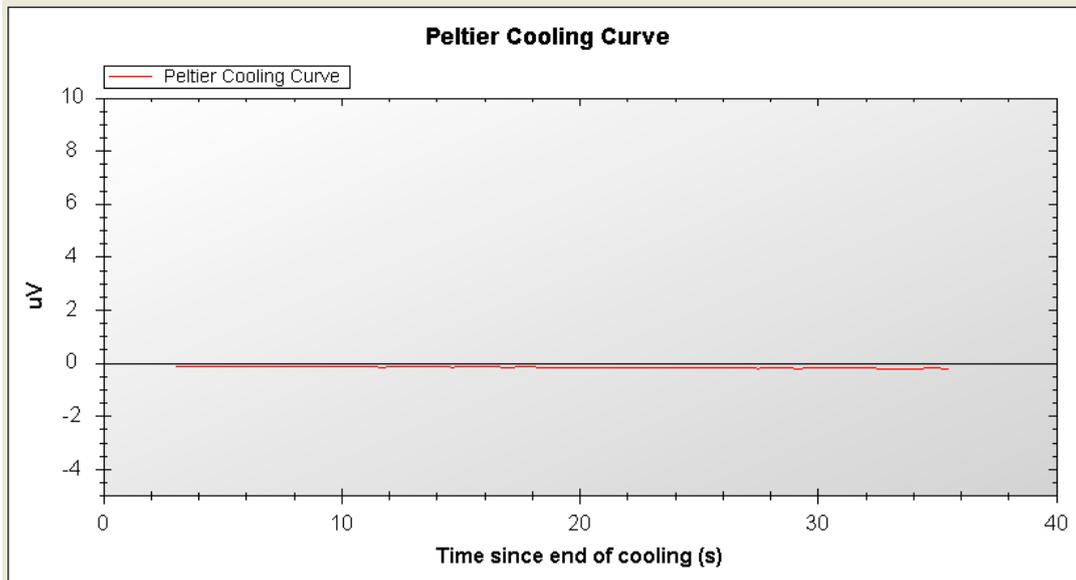


Figure 4: Manual mode Configuration and operation

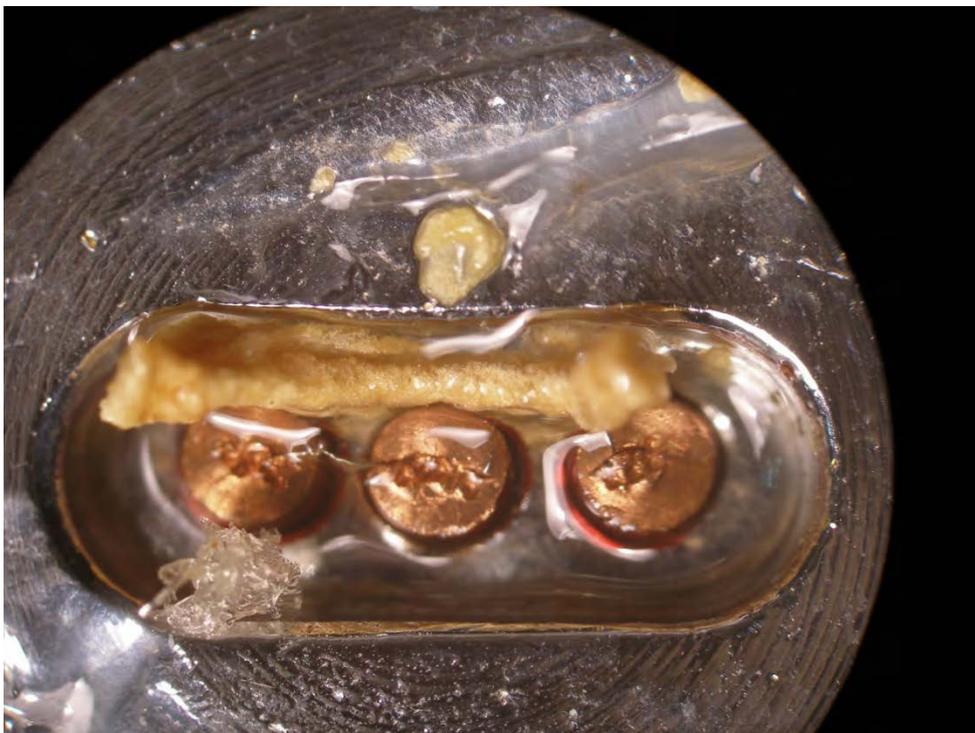
Click on the “Get Latest Data” icon and then plot the data by clicking on the “Plot” icon. The Peltier cooling pulse is graphed and can be reviewed to illustrate the numerical results from the “Dialogue box”.

**VIDEO 14: [Diagnosing Dirty Thermocouples](#) provides explanation and examples of the effect of a dirty thermocouple on the shape of the Psychrometric plateau.**

The flat line (shown in Figure 5) with no evidence of Peltier cooling, which would generate a positive  $\mu\text{V}$  response, is an extreme example of a dirty thermocouple and clearly shows that water has not been able to be condensed on the thermocouple due to severe contamination probably by silicon grease or perhaps plant material.



**Figure 5:** Shows an extreme response of a dirty Thermocouple-C that requires cleaning as no water could be condensed on the thermocouple.



**Photo 14:** The corresponding contamination of the thermocouples that results in no Wet Bulb Depression being generated as water vapour could not be condensed on Thermocouple-C.

The second example (Figure 6 below) is less extreme showing a more subtle response yet still indicating a dirty thermocouple. The thermocouple output is lower than expected (approx only 13  $\mu\text{V}$  at 6 seconds after the end of cooling), and instead of the cooling curve dropping sharply to zero, as the thermocouple warms quickly due to the condensed water evaporating, it has a slow drift back towards zero. In fact even 30 seconds after the completion of the measurement all of the condensed water has yet to fully evaporate, trapped by the organic contamination of the thermocouple resulting in the failure of the thermocouple to warm back to zero or the starting reference temperature (zero  $\mu\text{V}$ ).

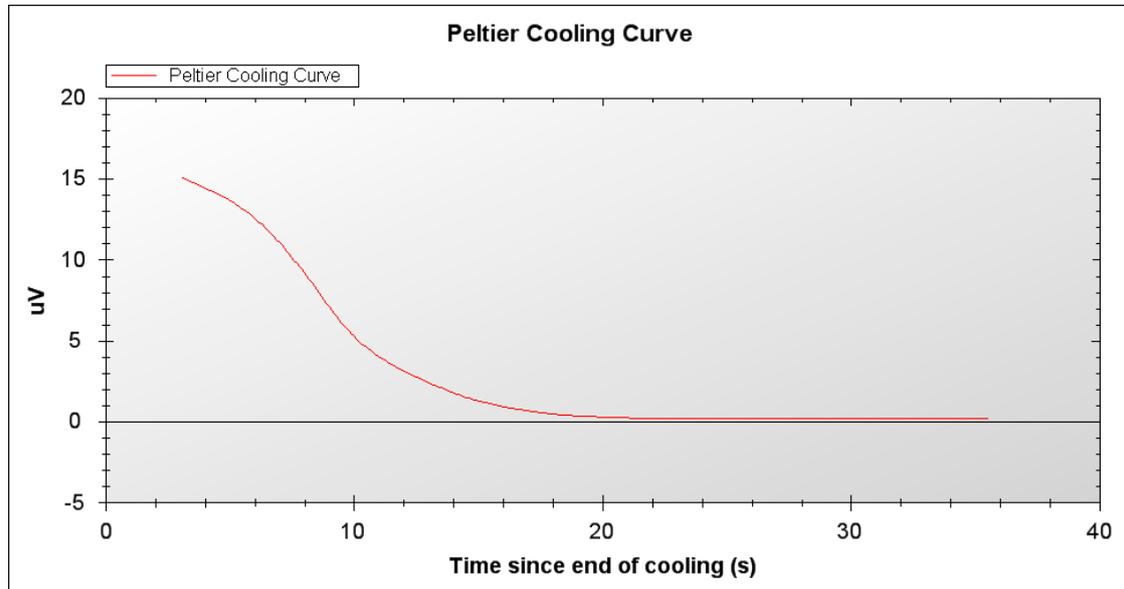


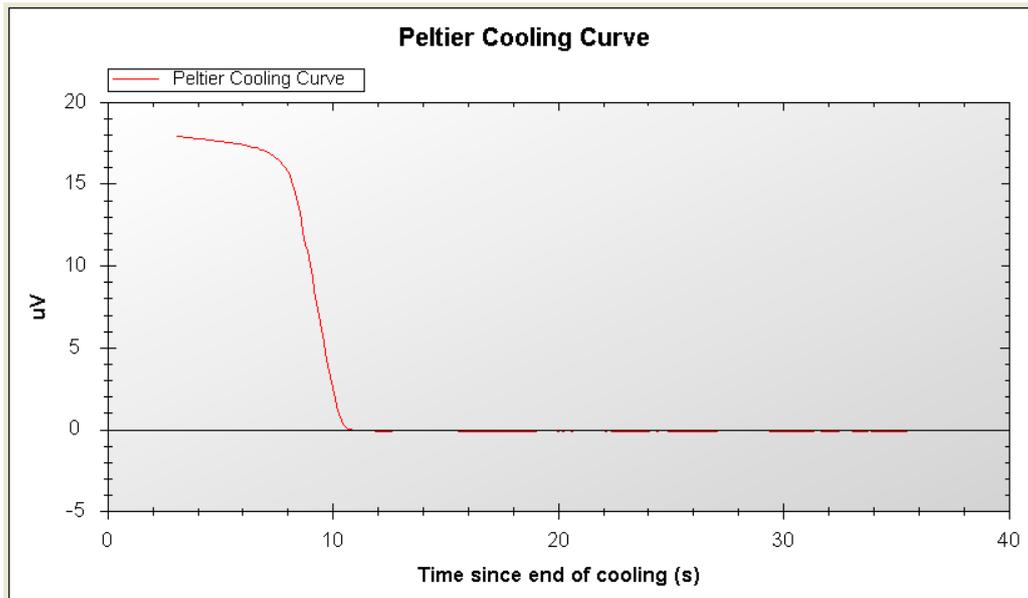
Figure 6: The characteristic response of a dirty Thermocouple-C that requires cleaning.



Photo 15: The corresponding psychrometer that generated the Peltier cooling curve in Figure 6. Note there is no visually obvious dirt or contamination. This is why it is important to clean and test with a 1.0 Molal NaCl solution before deployment

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Figure 7 shows the results after the chamber was cleaned. The results are now as expected; a Wet Bulb Depression in the range of approx 19  $\mu\text{V}$ , producing a Water Potential of -4.64 MPa for a 1.0 molal solution. The thermocouple had been dirtied by a small amount of organic material and mild oxidation of the thermocouples. This disrupted the process of condensation and evaporation of water on the thermocouple. Once the contamination had been cleaned water could fully condense on the surface of the thermocouple and fully evaporate from the thermocouple leaving it completely dry and rapidly returning to zero. No microscopic beads of water remained trapped on the thermocouple by organic contaminants disrupting the evaporation process and causing a thermal offset or interference.



**Figure 7: The good characteristic response of a clean Thermocouple-C.**

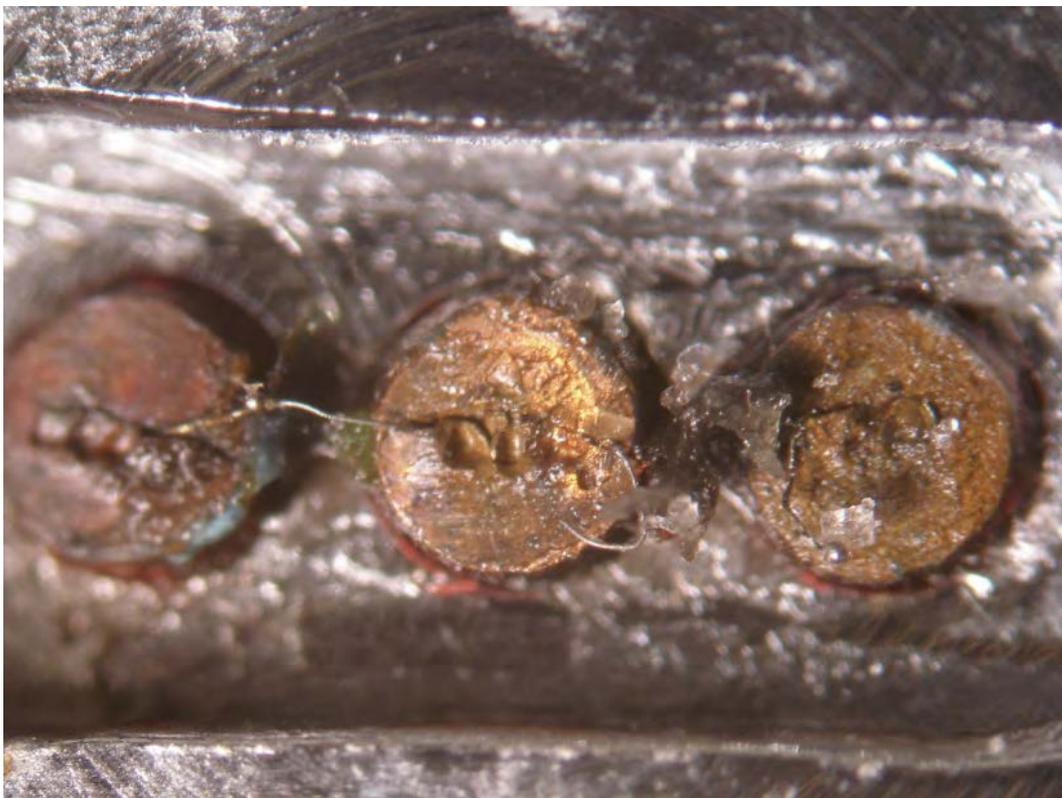
**CAUTION 1** Sometimes the process of cleaning can reposition thermocouples in awkward positions that make simple manipulations tricky when positioning Thermocouple-S for measurement. Be sure to take extra care and use a 20X dissection microscope to reposition the thermocouple. See [Handling the Instrument](#) and [adjusting thermocouples](#) for detailed instruction to minimise the possibility of damage to the thermocouples.

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### 10.3 Storing the Stem Psychrometers

It is not always practical to clean the stem psychrometers after de-installation whilst in the field. However, this does not mean that they can be left until you next need them for a future experiment. They must be cleaned upon return to the lab and prior to storage.

Oxidation of the copper posts within the chamber of the psychrometer may affect the measured water potential. If the chamber is not cleaned and the copper posts are corroded, the psychrometer may require factory repair. Corrosion is indicated by the green colouration on the copper posts. It may be necessary to make the observation of this corrosion using a 20X microscope to be sure that the electrodes are not corroded and are suitable for use.



**Photo 16: Corroded Copper posts and heavily contaminated psychrometer chamber well with broken thermocouple. DO NOT store a stem psychrometer that looks like this. Return it immediately to ICT for repair or replacement.**

**WARNING 10:** Failure to clean the psychrometers after use and prior to storage WILL result in damage to the very fine 25  $\mu\text{m}$  wires of the thermocouples and result in the instrument needing to be returned to ICT for factory repair.

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It is imperative that prior to storing the psychrometers you repeat the full cleaning process, ensuring that they are dry before sealing the chamber.

Use a small smear of vacuum grease on the mating surface of the chamber and the calibration lid for a good air tight seal for storage.

- a. Then use the label tape to provide a physical seal around the mating join of the chamber and the calibration lid.
- b. Use a #30 rubber band wrapped over the chamber from one handle of the calibration lid to the other to provide a second physical restraint for the calibration lid.
- c. Finally, wrap the psychrometer in a brown paper bag and store in a dry, safe and secure location ready for the next field campaign.

**NOTE 13** - Dow Corning high vacuum grease (150 gram tubes) is inert, heat stable, silicone grease and is recommended for use in sealing the psychrometer chamber and calibration lid. Products such as petroleum jelly or Vaseline cannot be used as they melt at a very low temperature and leak into the chamber. Application of several (2-3) small drops on the lid is all that is necessary to seal the calibration lid to the chamber. Apply 2-3 drops and then once the calibration lid is attached to the psychrometer, twist the two surfaces to spread the vacuum grease and form a seal.

**VIDEO 15** – [Watch how to apply the sealant to the calibration lid](#)