Frequently Asked Questions

(1) **Question:** Our project is to look at how oak wilt affects sap flow in infected trees. It is difficult to predict, which trees will be attacked each summer and we were looking for mobile sensors that we could easily move around upon finding an infected tree.

Answer: The SFM1 is definitely a mobile sensor! I could not imagine trying to deploy the old style sap flow sensors of the past which require so much added inconvenient infrastructure to house the logger, wiring of the sensors and separate power supplies to power them. The SFM1 is a dream for your application.

(2) **Question:** We are heading toward summer when daytime temperatures will reach more than 35°C. Perhaps I should bump up the heat pulse of the Sap Flow Meter. Do you have a recommended setting for air temperatures in the upper 30°Cs (probably similar to subtropical Costa Rica).

Answer: The ambient daytime temperatures typically do not affect the HRM measurement because the Heat Pulse raises the temperature above ambient. In air, if you dare to hold the heater during a heat pulse (not recommended I might add) the temperature will momentarily reach approx. 90°C This is typically sufficient to increase the temperature in the xylem by anything up to 1°C, of course with different wood densities, water content and thermal diffusivities this will vary. The biggest affect will of course be the sap velocity so if the sap velocity is quite high then the heat field can be flushed away too quickly to be measured hence an artificially low value recorded. This is automatically identified and a message to the effect of temperature rise insufficient is included in the data file. So ambient temperatures of 35 °C should not directly affect the required heat pulse. I almost always use 20 Joules heat pulses. This is adequate across all day time temperatures and night time. In our Mediterranean winter experiment the day time temperatures were in the low to mid 20's down to night time temperatures approaching zero. In the Costa Rican rainforest experiments I believe the PhD student used only 20 Joule pulses for all his research.

(3) **Question:** Based on my previous experience with other types of sap flow sensors, I had placed the sensors on the north side of the trunk and insulated them with aluminium-lined insulation.

Answer: The HRM principle should not require insulation with aluminium foil because it is a heat pulse technique and not continuously heated, therefore does not suffer the same issues of Natural Thermal Gradients (NTG's) that continuously heated techniques like the Granier Thermal Dissipation Probes. I expect we will have a paper published in Tree Physiology soon that discusses this topic. **Influence of Stem Temperature changes on Heat Pulse Sap Flux Density Measurements** MAURITS W. VANDEGEHUCHTE, STEPHEN S.O. BURGESS, ALEC DOWNEY, KATHY STEPPE,

Again this is research I did with Prof Steve Burgess where we showed that even in some instances where NTG's have the potential to impact HRM readings ICT has automatically corrected for this in the way in which we handle the raw data in Sap Flow Tool Software to ensure that we eliminate this potential (and it is only a

potential) for ambient temperatures to affect HRM data.

The only time insulation is required is as I mentioned in our experiment when the needles are partially exposed to incident radiation. In this case yes, insulation is required because the incident radiation is conducted along the aluminium needles resulting in an external heat source that is unregulated, or indeed unmeasured, that confounds the measurement through thermal saturation of the measurement system.

(4) **Question:** If I lower the pulse power (e.g., 20J) to save power, what difference does it make on the measurements? The sap flow measurements don't seem much different from when pulse was at 50J.

Answer: Your results confirm the application note I did (see SFM1 Manual) Appendix O - Chapter 22.15.1 SFM1 External Battery Operation Test (without Solar Panel) where I tested the small 12 V DC, 7 Ah Lead Acid rechargeable motorcycle battery for a scientist who wanted to use them in the rainforest in Costa Rica.

You ask a great question about the impact of the Heat Pulse on the measurement.

I have done research with Prof Steve Burgess and we looked at the impact of this. We hope there is a paper being published with the results soon. But in summary, having a dedicated SFM1 instrument with a dedicated high resolution microprocessor and A/D circuit where data is processed at the point of measurement without any signal loss utilising the very low noise threshold, the quality of the data has advanced so much that we can now accurately measure sap flow with even lower heat inputs. We tested this by increasing the needle spacing from 5 mm to 10 mm distance between each needle and the central heater whilst simultaneously reducing the heat Pulse from 20 Joules to 10 Joules. The data was still GREAT! We then further tested the instrument by placing it in direct sun with the needles partially exposed to the sun. At this point we still got results, but not always guaranteed and with more noisy data. This is as we had expected because the external heat load from incident radiation was greater than the 10 Joules heat input from the heater, not surprisingly when the needles are separated by 10 mm. We then insulated the installation and found that noise in the data reduced and we were able to obtain acceptable quality data once more.

I must highlight, all of this research was performed without replication, on a single species, on a potted plant under a single transpiration condition, being low transpiration in a Mediterranean winter climate. We should really expand the experiment to include high transpiration conditions and extend beyond a single species as no doubt this will change the results significantly. Nevertheless, the outcome is that, YES a 10 Joule heat pulse is definitely suitable for obtaining high accuracy, low noise sap flow data when using the SFM1 dedicated sap flow meter.

This is also shown in a short application note we did. The resolution of the SFM1 is an order of magnitude greater than other commercially available loggers reducing from +/- 0.25 cm hr to +/- 0.025 cm hr resolution.

I make the recommendation of reducing the Heat Pulse energy input with the caveat that an initial reconnaissance experiment should always be performed when measuring a new species for the first time to ensure that the Heat Pulse is adequately

matched to the conditions and the thermal diffusivity of the species. In the experiment I outlined, we observed temperature rises of as low as 0.2 °C instead of the 0.7 to 1 °C we have previously recommend as necessary to obtain good results, which were based on the original discovery research by Prof Steve Burgess when he was developing the HRM principle back in the late 1990's using the available analogue technology at the time. Being able to obtain high accuracy, low noise sap flow data with such a small temperature increase has significant implications for reduced wounding as a result of less heating of the vascular tissues, and of course power consumption as well.