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Sap flow system EMS81

Installation guide

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The following paragraphs will guide you through the installation procedure. Please note that proper installation of the measuring point is essential for acquiring the reliable results.

1. Tools

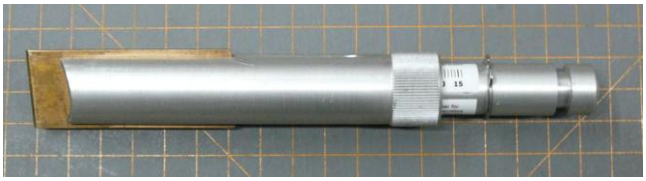
Installation tools (and also some consumables) are placed in a suitcase:

The items stored here are mainly:

1/ main tool assembly

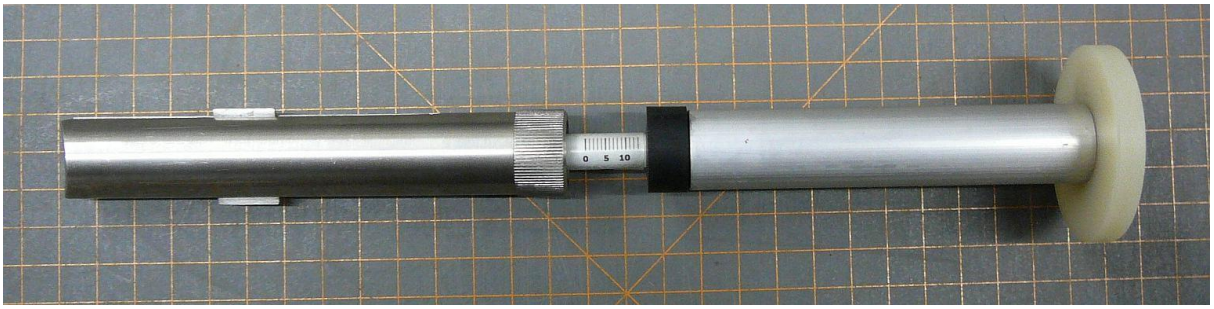
2/ bark & phloem thickness gauge

3/ lateral electrodes pointer



(asymmetrically sharpened!)

4/ electrode bumper

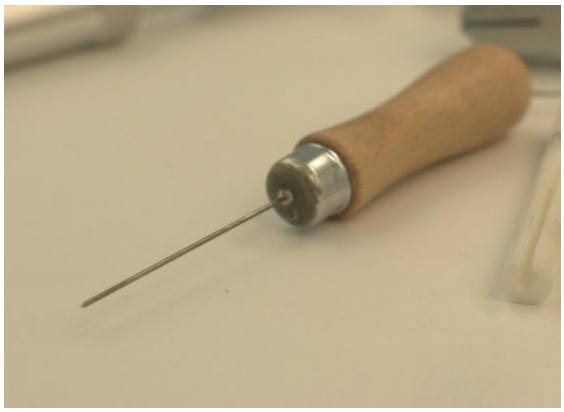


5/ electrode extractor

6/ needle guide

7/ needle extractor

7/ tiny rasp for cleaning slots in electrodes



and also a hammer, straps, pocket tape measure, electrodes and thermosensors (if they are not stored in separate boxes).

2. Installation procedure

2.1. Sensor location on tree trunk

Sap flow sensors SF 81 may be installed on trunks with diameter larger than 12 cm. Fundamental criteria for location of measuring points on tree trunk are the homogeneity of tissue and height above ground. Highest temperature gradient which may interfere with the measurement occurs close to ground surface. Therefore, measuring points should be placed at least at the height 1 m above ground but still below the living crown. Stem tissues in the place of future measuring point should be homogeneous enough, i.e., with no irregularities such as knobs, mechanical or biotic injuries, or anything else that may affects normal xylem water flow. All possible circumstances should be considered at this point. Take into account the necessary space around the measuring point where the weather shield should be fastened.

In order to reduce the influence of natural variability of sap flow along the circumference of large or irregular tree trunks, two measuring points on opposite sides of tree trunks could be installed. This might be also useful in stands with complex soil conditions, in trees growing on slopes, etc. The whole tree sap flow is calculated as an average from sap flow values measured on both sides. However, with respect to the often limited budget, sap flow is usually measured only from one side of the trunk. Only when there are reasonable doubts about the regularity of sap flow along the stem circumference, two measuring points on one tree might be installed. When two measuring points on the opposite sides of tree trunk are installed, they should be either in the same height (large trunks) or vertically separated by more than 30 cm (especially for thin trunks) to avoid warming of reference electrode from the opposite measuring point and also to allow setting up the weather shield.

2.2. Necessary measurements

There are three important dimensions that should be measured:

- DBH, measured at 1.3 m [cm]. It is usually used for scaling purposes.
- Circumference at the measuring point level [cm]. Measuring point is usually located at the height of ca 1.5 m for comfortable manipulation and also because sap flow variability around the trunk circumference decreases with the height aboveground.
- Bark and phloem thickness [mm]. This value is important for (i) assessment of xylem (cambium) circumference, which is necessary for exact calculation of the whole tree sap flow rate, (ii) for estimation of proper depth of electrodes. Each electrode used for xylem heating has an insulated part that has to fit to above cambium layers in order to avoid passing the electric current by high conductive phloem tissue *(Cermak et al., 2004)*.

Both circumferences are measured by a common pocket tape measure, bark and phloem thickness needs a special tool and it is measured later after the main tool assembly has been fitted to the stem.

2.3. Main tool assembly installation

Clean the bark surface by hand or by a blunt tool like hammer, piece of wood or a similar stuff. Some tree species (pine) require removing the upper rough bark by a special sharp tool (drawknife). The remaining bark and phloem layer should not exceed thickness 15 mm.

Find the best position for tool inside the brushed area. Think also about the space necessary for weather protection shield; avoid old knots and all kind of irregularities.

Wrap the strap around the trunk, thread it through the clip and tighten it firmly.

2.4. Bark & phloem thickness measurement

With respect to the formula for calculation of the whole tree sap flow:

$Q_{tree} = Q*(A - 6.28*B)$; $[kg\ hr^{-1}]$

Two values has to be measured:
A - trunk circumference *[cm]*
B - bark & phloem thickness *[cm]*.

In contrast to easy measurement of circumference, the bark and phloem thickness needs a special gauge (see the figures below). It should be inserted into the hole for central or reference electrode and hammered gently until the change in sound indicates the cambium layer. Than, the bark & phloem thickness value shows on the scale.

2.5. Lateral electrodes pointer

By smaller trunks up to ca 20 cm in diameter the lateral electrodes tend to slide along the tree rings and turn aside. This can be reduced by a special tool – lateral electrodes pointer. Its knife-edge is sharpened asymmetrically. When it is hammered prior to the electrode into the same place, it helps to point the electrode to the 'right' direction.

Please note the sign on the moving part – it must always point to central electrode!

Note: Both last mentioned tools sometimes have to be drawn out by the tool used mainly for extracting of electrodes and thermosensor needles:

Watch your fingers!

2.6. Inserting electrodes

Inserting electrodes require the most important tool - electrode bumper. The tool has flexibly fixed hammering rod that considerably eliminates accidental side strokes sideways the tool axis. Using of the tool is clear, however, **hammering needs forceful strokes**.

The hammering has to be stopped when the bark and phloem thickness value is reached on the scale. This way assures the proper depth of insulated part of electrode in the stem with respect to the phloem.

The good job is indicated by easy removing of main tool assembly from electrodes. Protruding parts of the electrodes have to be parallel to each other. Invisible parts of white insulation cover the phloem and living parts of the bark in order to avoid their heating by electric current passing between electrodes.

Important: the reference electrode is not used as an electric terminal. Therefore it is not insulated.

After the installation of electrodes, slots have to be cleaned by rasp from the rests of wood and in order to prepare enough space for tiny thermosensor needles.

2.7. Installation of sensor SF 81

The sensor needles are to be pushed into slots of the electrodes. Therefore, needle installation does not need any drilling. For easy inserting, using of needle guide is recommended in order to avoid an accidental needle bending. The metal cup of needles inserted into 70 and 80 mm long electrodes should touch their upper edge, while it sticks out by ca 4 mm in 60 mm long electrodes.

The thermosensor assembly with the electrode terminals should be hanged firstly on the central electrode. Than insert the needles to the slots in electrodes (using the needle guide) and finally set up the terminals.

Red needles belong to upper electrodes in the order as it is displayed. The blue needle is pushed in the reference bare electrode.

After all needles have been properly inserted, the heating terminals can be put on the electrodes. Set the **blue one on the central electrode**, the white ones on both lateral electrodes. Finally, the cable connector is hooked to the MicroSet8X sensor.

2.8. Weather protection

In comparison with former THB arrangements the version described in this manual is much less sensitive to external disturbing factors as stem flow and all types of ambient temperature gradients. However, good protection against solar irradiation is always necessary. The weather protection consists of two parts – a 'hat' covering the measuring point in order to keep relatively homogeneous environment inside and a 'skirt' protecting the part of tree trunk below the measuring point and its surrounding against direct sunshine.

The hat has to be put symmetrically over the measuring point. The correct vertical position is indicated by lower corner of the hat covering yellow mark on the cable. See following pictures:

The skirt is fixed to the hat by Velcro and fastened down to trunk against wind by a string with ordinary binder clips. Never tight the skirt to tree trunk – the free space under the skirts is important for ventilation necessary for good heat exchange.

Note the small "doors" in skirt intended for fast approach to the module.

3. Powering of sensors

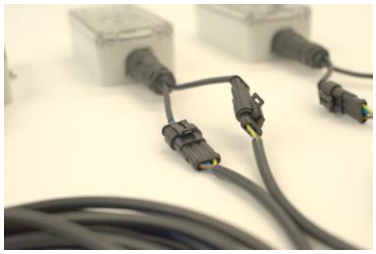
The main advantage of EMS 81 system is the spatial flexibility. Individual sensors can be used independently running from small battery or they can be connected in a powering network. Each sensor has two power cables of opposite sex. Therefore, the sensors can be connected in a chain from one sensor to another. This arrangement suits when the measured trees are selected in a row.

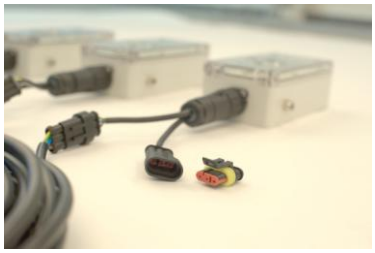
Yet, because of resistance of cables, the number of chain links is limited. The limit depends on more factors like cable length (12 m or 8 m), tree species with respect to expected sap flow magnitude etc. The reasonable number of chain links might be six but it is matter of experience.

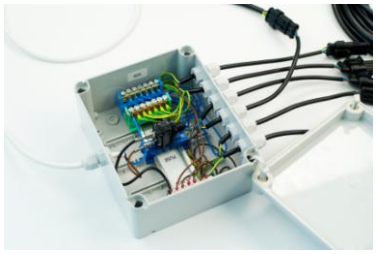
When the more branches of chains is expected, simple splitting box or more power cables with battery clips (intended for individual powering) can be used.

Sensors on trees located in star arrangement can be powered with more chains connected to splitting box. If those trees are situated relatively close to each other, some chains can be closed on splitting box.

The connecting cables are available in two standard lengths 8 m and 12 m. They are equipped with *Superseal* connectors (approved by automotive industry) what makes cables cheap and sturdy. The cost of one cable is roughly equal to the price of one industrial connector. In case of cable damage by animals they can be easily and quickly replaced.





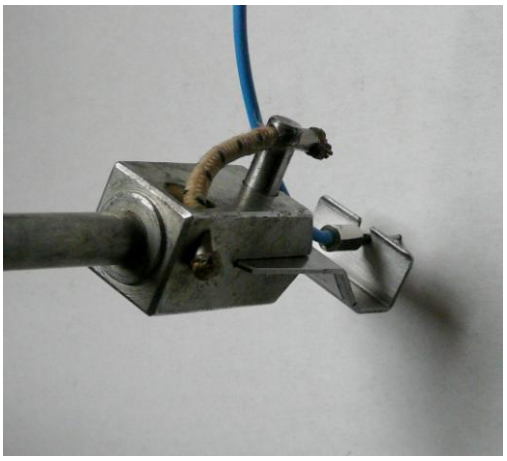


4. Sensor removal

After removing the weather protection, thermosensors and electrodes have to be pulled out by special extractors.

4.1. Extracting of thermosensor needles

Use the same extracting tool as for electrodes (see below) completed with a special adapter. Pull out needles with gently hits to upper backstop:

4.2. Extracting of electrodes:

Fix the tool to the electrode with the pin. Check the pin position carefully. Apply strong hits to backstop.


Important: For safety reasons always stand sideways the tool axis in order to avoid the harm of your face. Also, watch your fingers!