

## Granier's probes assembling

Granier's sensors are composed of 2 **needles** containing each one a **thermocouple**. On the outside, probes have a **heating winding**. Every probe is positioned in the xylem, inside a **metal sleeve**.

### Setting the needles

#### Materials

Hypodermic stainless steel needles 20G, dimensions 0,9 x 40 mm



#### Tools

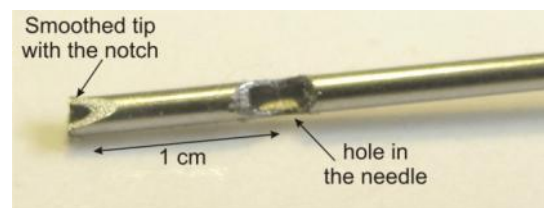
Electric abrasive rotary tool (or a metal file)  
Drill (diameter 1-1.5 mm)



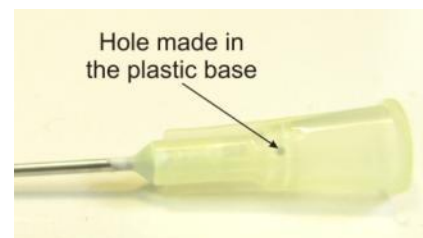
#### Operations

With the rotary tool (or a metal file):

- smooth the tip, leaving a small notch
- cut a hole at the distance of 1 cm from the tip notch (or 5 mm for probes 10 cm long).



With a drill make a hole (1-1.5 mm in diameter) in the plastic base of the needle



### Making the thermocouples

#### Materials

Insulated copper wire 0.07 mm (0.003") in diameter  
Insulated constantan wire 0.07 mm in diameter



*Fine wires for thermocouples*

## Tools

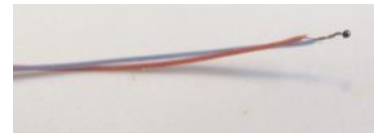
Thermocouple welder;  
cutting tools



*Thermocouple welder*

## Operations

Cut 15 cm long pieces of copper and constantan wire; using wire strippers or a blade, strip off about 1 cm of insulation from one end of the wires to put out the copper and constantan metals; join the exposed copper and constantan wires twisting them together; merge the metals with the thermocouple welder<sup>1</sup>.



*The thermocouple*

## The wire for the heating winding

### Materials

Insulated constantan wire 0.12 mm (0.05") in diameter  
Cutting tools



### Operations

Cut 30 cm of constantan wire; using wire strippers or a blade, strip off about 1 cm of insulation from the two ends of the wires to put out the constantan metal.



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<sup>1</sup> Without a special welder, it could be possible to build the thermocouple just twisting the wires tightly together and soldering the junction with a soldering iron, using as solder a commercial combination of tin and lead. However, the solder could alter the junctions introducing an error to the measure. This error can be accepted if it is systematic (not always true) since the sensor output comes from the temperature difference measured with 2 thermocouples.

## Assembling and cabling the probes

### Materials

Cianocrylate glue or epoxy resin;  
some fine copper wire;  
hot melt glue;  
heat-shrink rubber tubing (1.6 mm in diameter).



### Operations

#### Assembling

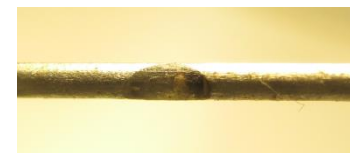
Insert the two lead wires of thermocouple and the single constantan heating wire into the tip of the needle and gently push until they come out through the needle base;  
pull all three wires from the base until the thermocouple junction is visible at the hole;  
move the lead wire of the constantan heating wire in order it has a length of 3-4 cm from the needle base;  
apply a small drop of cianocrylate glue in the hole to fix the thermocouple;  
fill the hole with cianocrylate gel glue or epoxy resin;  
after the glue or resin will be hardened, smooth it with a rotary tool or fine glass paper until the needle surface will be flat.  
Apply a little quantity of cianocrylate glue on the needle surface and starting at the tip (the tip notch should stuck the wire), wrap the constantan heating wire around the needle for 2 cm (or 1 cm) keeping on it a steady tension. The wraps must adhere together;  
block the heating wire at the base of the wraps with a fine copper wire wrapping it on the rest of the needle;  
insert the end of the heating wire in the hole of the plastic base and trim it at the same length of the other end (4-5 cm);  
fill the plastic base of the needle with hot-melt adhesive.



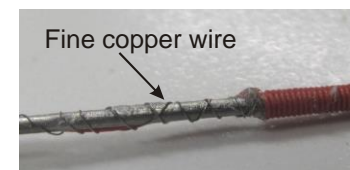
*Thermocouple positioned in the hole*



*The hole filled with cianocrylate gel glue*



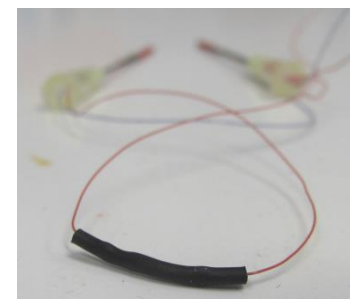
*The hole after the glue smoothing*



Fine copper wire

#### Cabling

Cut 5 pieces (length 2 cm) of heat-shrink rubber tubing ;  
insert in one piece of heat-shrink tubing one of the constantan wires (red insulation) coming from the thermocouples;  
connect the two constantan wires from the thermocouples together by twisting them and then merge the metal with the thermocouple welder (if you don't have the welder you can solder them but twist them very tight because solder could add metals to the junctions introducing an error to the measure);  
cover the exposed connections with the heat-shrink rubber tubing and shrink it with heat;  
take a 4-wires cable (24 AWG for instance) of appropriate length (from the tree to the datalogger or a junction box) and expose the wires for



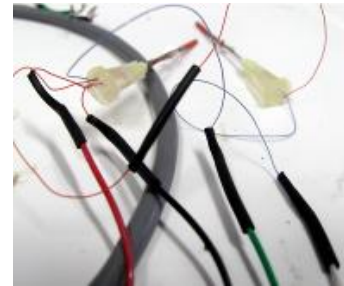
10 cm;

insert in the other 4 pieces of heat-shrink tubing the 4 wires of the cable;

connect the copper wires (blue color) from the thermocouples to two wires of cable by soldering;

connect the two heating wires (red color) from the heated probe, to two wires of cable by soldering;

insulate all exposed connections covering them with heat-shrink rubber tubing.



## The metal sleeves

### Materials

Aluminum or copper tubes (outer diameter 2 mm, inner diameter 1.6 mm);

rotary tool or glass paper;

cutter.

### Operations

Cut the tube with a cutter blade in order to get pieces of 21 mm for 20 mm probes (or 11 mm for 10 mm probes);

smooth their tip with a rotary tool or the glass paper (this will make easier putting the tubes in the xylem pushing it with a rounded pointed tool after having bored the wood with a drill of 2.1 mm in diameter).

