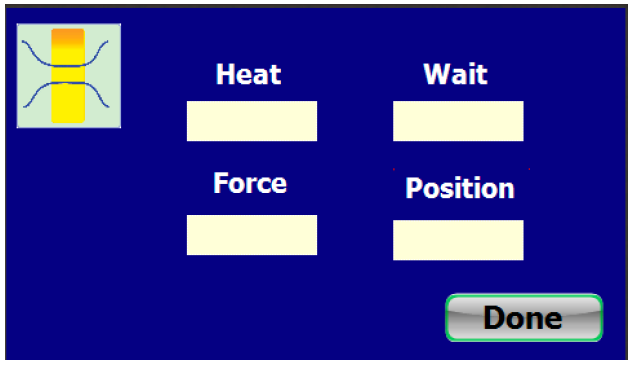
Pulling tips DB/v.01

Foreword:

In spite of several technical progresses pulling glass to make microelectrodes remains an empirical challenge. Thanks to the advantages offered by micro technology and electronics it is, however, possible to obtain reproducible conditions that will allow you to make good quality microelectrodes that are ready to use for patch clamp and do not require fire polishing.

The **Smart Pull** offers several advantages including simple or complex personalized programs, the parameters of which will be automatically saved and ready to use the next time you come in to pull your favorites microelectrodes. The aim of this document is to provide a few basic tips on how to organize and determine the parameters that will most suit your application.

To begin let start with the simplest program referenced as ***Injection Pipettes***. In this mode, the puller will execute a single cycle in which the four parameters that are respectively ***Heat, Wait, Force and Position*** will be used. To select this mode, press once on the corresponding icon. The **Icon**  which represents the program pulling step should be displayed and its corresponding parameters can be accessed by a touch of the icon. The following window should be displayed.



Pressing once on either ***Heat, Wait, Force and Position*** allows to display the current parameters and/or modify its value. The new parameter set for the selected user (or default when no user is selected) is automatically stored when the ***Done*** button is pressed.

The ***Heat*** value (ranging from 0-1500) corresponds to the voltage expressed in arbitrary units that will be applied to the filament. Typically, a heat value ranging between 800-950 provides adequate heating for borosilicate glass. Note that the higher the heat value, the brighter the filament will be when turned on.

The ***Wait*** corresponds to the waiting time **in seconds** during which the heat is applied before the pulling force is applied.

The parameters ***Force*** and ***Position*** (both in arbitrary units) determine the force that is applied by the motor (typically ranging between 200-900) to pull the clamps apart until the desired position is reached. The entire spanning displacement corresponds to 1000 units.

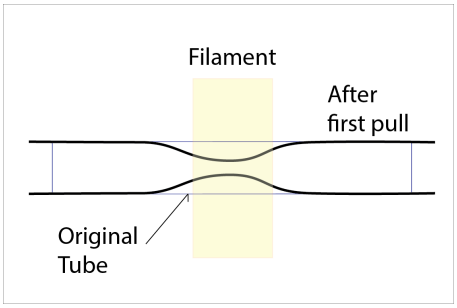
As a first step, it is interesting to explore the **Heat values** required to pull a given glass diameter and thickness. Typically, the **Force** and **Position** will be set at about 800 and 600 respectively. A **Wait** of 5-10 s should be sufficient for the glass to reach a steady condition.

Optimizing when modifying the parameters: when modifying the parameters remember that the fastest way to obtained the desired value is to use a binary approach. Typically, should you desire to reduce the ***Heat*** value and starting with an initial value of 850, it is suggested to decrease this number to 700. If this new value is too small, it should be increased by the half of the difference, which in this case will be 700 + 75. Successively, if this value is still to small, the next step will be to increase the value from 750 by half of the difference versus 850 or 750 + 50.

This sequence was designed for pulling micro-injection pipettes in which the glass is typically pulled to its maximal and the tip is subsequently obtained by breaking the tube at the desired diameter.

This mode was designed to pull the glass in two steps as exemplified by the icons that are displayed upon selection of this mode.

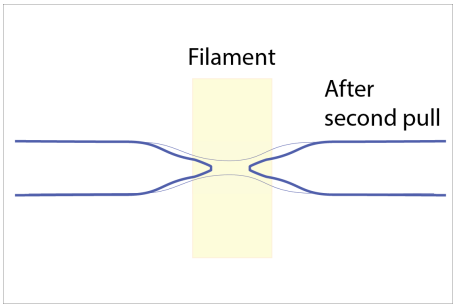
In the first step the four parameters ***Heat, Wait, Force and Position*** can be chosen and this first part of the sequence is aiming at reducing the external diameter of the glass capillary as schematized below:



Following this first step the glass is cooled down during the wait period symbolized by the icon.


The wait time (seconds) is typically set between 5-10 s which are sufficient for the glass to cool down before the next pulling sequence is applied.

Schematically, the action of the second pull can be represented as follows:



Note that the breaking of the electrode tip occurs within the filament position which provides enough heat for the fire polishing of the electrode tip.

Adjusting the parameters for a two steps pulling: Since the goal of the first step is elongate the glass capillary and decrease its outside diameter the most important parameters will be ***Heat and Position*****.** Typical values for ***Heat*** (850) and ***Position*** (130), these values can be explored in function of the glass that is used for making the electrodes, keeping in mind that the further pulling position, the less glass will remain available for the subsequent pulling and the next step might require a lower force to prevent breaking the glass.

To adjust the second step, it is recommended to explore two extremes for the ***Heat*** between conditions in which a long filament is observed or a break of the glass before the formation of the electrode tip. Using the optimized method described above an adequate tip fabrication is generally rapidly achieved.

This mode was designed for making short patch clamp pipettes. Shortening of the tip is rendered possible by a dual step procedure in which the glass is elongated twice before the final pull. The procedure is similar to the two steps and is adjusted using the same principles. Note that, again, the final step is done in the center of the filament which causes the automatic fire polishing.