PUL-1000
Microprocessor-controlled 4-Step Micropipette Puller

Serial No.____________________
Other WPI Favorites

**Glass Capillaries**

*Clean, high quality glass for making micropipette electrodes and other research implements*

WPI offers a wide spectrum of high-quality glass capillaries. We take pride in our ability to ship your glass order within 48 hours. If you need a special glass that does not appear in our catalog, please call us. We will make every effort to provide it for you.

**MicroFil™**

Nonmetallic syringe needle for filling micropipettes

WPI’s MicroFil™ fills micropipettes easily and reliably. Its long and fine tip allows you to start the filling very close to the pipette tip, eliminating both air bubble formation and clogging due to the washing down of dust particles.

**Microforging, Micropipette Calibration and Microinjection—in single device!**

The DMF1000 is a microprocessor-controlled microforge designed for fabrication of both small patch clamp glass pipettes and larger injection pipettes. The DMF1000 is based on a design. The DMF1000 is powered by the latest digital signal processor (DSP) technology. A digital timer is used to precisely control the polish heating time. Ten memories can be used to store settings of the heating power and heating duration.

Filament Holder mounts directly to objective to provide precise control of heating element position.
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World Precision Instruments
QUICK START

1. Push the carriages together toward the center.

2. Mount the glass capillary onto the carriage, and secure it with the glass clamps.

3. On the LCD display, choose the correct sequence. If you do not have a sequence yet, choose one from the program storage.

   **NOTE**: Program sequence 00 is designed for OD 1.0mm borosilicate capillary glass (WPI# 1B100-4), and sequence 01 is designed for OD 1.14mm borosilicate capillary glass (WPI# 4878).

4. Close the cover.

5. Press **START**, and the puller will do the rest. Each pull results in two identical micropipettes.
ABOUT THIS MANUAL

The following symbols are used in this guide:

⚠️ This symbol indicates a CAUTION. Cautions warn against actions that can cause damage to equipment. Please read these carefully.

⚠️ This symbol indicates a WARNING. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.

Fig. 1  The PUL-1000 is programmable.

INTRODUCTION

PUL-1000 is a microprocessor controlled, four-stage, horizontal puller for making glass micropipettes or microelectrodes used in intracellular recording, patch clamp, microperfusion and microinjection. The puller was designed with tight mechanical specifications and precision electronics for complete control of the pulling process and accurate reproducibility. It offers programmable sequences of up to four steps with heating, force, movement and cooling time. This allows graduated cycles for a variety of applications.

NOTE: This is not a production puller designed for continual Use. If the puller stops in the middle of a pull, allow time for it to cool down.
When pulling glass tips finer than 1 µm, you should first wash the glass capillaries in filtered acetone (or filtered distilled water and filtered 95% alcohol) then allow the fluids to evaporate in a clean dust free environment. This assures that submicron tips are not immediately clogged with glass particles from the manufacturing of the capillaries.

A glass capillary is heated by a platinum/iridium filament and pulled by a controlled force. The PUL-1000 is capable of producing a vast array of pipette shapes. Pipettes—PUL-1000 can produce pipettes with tip diameters from less than 0.1µm to 10+ µm. Microprocessor settings control the pulling automatically.

Pulling pipettes is an art, and reliable results depend on factors like the operating environment, the type of glass used and your technique. Understanding how the puller works is critical to manufacturing the pipettes you want. Glass capillaries can even be slightly different for every lot. Each time you open a new vial of glass capillaries, recalibrate the puller heat parameters for the new glass.

Programming—The settings for a 4-stage pull may be stored in memory. Up to 95 user-selectable programs can be permanently be stored in memory for later recall. The instrument contains two factory installed and tested programs. Choose from the factory installed programs or create your own.

Construction—The cover of the pulling chamber is made with tempered glass to minimize the effects of humidity and air currents on the reproducibility of pulled pipettes.

Power Supply—PUL-1000 has a switching power supply for use anywhere in the world without worry about the line voltage differences. Pulling reproducibility is unaffected by line voltage fluctuation. Heating voltage can be controlled to within 0.1% accuracy even when line voltage fluctuates from 100–240VAC.

Features
• Microprocessor controlled
• Program sequences up to four pulling steps
• Produce micropipettes with a tip diameter less than 0.1µm or greater than 10µm
• Store up to 95 programs in memory
• Two factory programs installed
• Tempered glass cover reduces the effects of humidity and air currents on puller reproducibility
• Switchable power supply for any line voltage 100–240VAC ensures that line voltage fluctuations don’t affect reproducibility

Parts List
After unpacking, verify that there is no visible damage to the instrument. Verify that all items are included:
(1) PUL-1000 Puller
(1) TW100-4 - Thin Wall Glass Capillaries, 4 in., 1 / 0.75 OD/ID, package of 500
(1) MF34G-5 package of MicroFil
(1) Instruction Manual
Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled “Claims and Returns” on page 15 of this manual. Please contact WPI Customer Service if any parts are missing at 941.371.1003 or customerservice@wpiinc.com.

Returns: Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI’s Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100mm (four inches) of shock absorbing material. For further details, please read the section entitled “Claims and Returns” on page 15 of this manual.

INSTRUMENT DESCRIPTION

Tempered Glass Lid
Capillary Glass Clamps
Heating Filament
V-Shaped Glass Groove
Carriage
Keypad

Fig. 2  The parts of the puller are identified.

Tempered Glass Lid—For safety, the lid should be closed whenever you are pulling glass.
Capillary Glass Clamps—These two clamps securely hold the glass when you are pulling pipettes.

Heating Filament—The PUL-1000 comes with a platinum/iridium box filament, which may be easily replaced, as needed. (See “Accessories” on page 10.)

V-Shaped Glass Groove—Slide a single piece of capillary glass into the groove from one side or the other. The groove helps line up the glass to slide easily through the filament and hold it in the proper position during pulling.

Carriage—The carriage should move freely. It slides apart as the glass is pulled. Then, you can manually slide the two ends of the carrier together before the next pull.

LCD Display—This display shows the programming sequence and the defined parameters. If you press the Stop key on the keypad, you can toggle to the Glass Capillary Softening Test display.

![Fig. 3](image.png) The front panel has an intuitive keypad.

Keypad—The keypad has the following keys:

- **Arrows**—Press the arrow keys to move the cursor in Edit mode. The Up or Down arrow keys increment or decrement the last digit by 1. Press the Left and Right arrow keys to increment or decrement the last number by 10. For example, when you are in Edit mode, you could press the Right arrow to increase the distance from 0.50 to 0.60 or to increase the force from 200 to 210.
- **ENTER**—Press to enter or exit the Edit mode.
- **START/PAUSE**—Press to begin running a pulling program. Press it again to pause the program.
- **STOP**—Press to switch between windows or to terminate the pulling program and return to the main window while the puller is running.
Program Sequence
A saved program can be loaded into the PUL-1000 microprocessor. When the LCD cursor is flashing next to the entry “LOAD” on the display, use the arrows on the keypad to select a program.

**NOTE:** The puller is shipped with programs saved in memory locations 00 – 01. See “Appendix A: Example Sequences” on page 12 for a list of recommended program settings for WPI glass capillaries. You can start from these settings to get your own ideal program setting.

For other types of glass capillaries, the first step is to do a Glass Capillary Softening Test. (See “Glass Capillary Softening Test” on page 8.) This helps you find the required heating power setting for that glass. Then, you can choose a sequence to match. Finding the right sequence to get the desired glass pipette requires experimentation.

The table below is provided to show some basic guidelines when setting up a sequence.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Increase (↑)</th>
<th>Decrease (↓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat</td>
<td>Longer Taper</td>
<td>Shorter Taper</td>
</tr>
<tr>
<td>Force</td>
<td>Smaller Tips, Longer Taper</td>
<td>Larger Tips, Shorter Taper</td>
</tr>
<tr>
<td>Distance</td>
<td>Smaller Tips</td>
<td>Larger Tips</td>
</tr>
<tr>
<td>Delay</td>
<td>Shorter Taper</td>
<td>Longer Taper</td>
</tr>
</tbody>
</table>

**OPERATING INSTRUCTIONS**

When heat is applied, and the glass becomes soft, the carriages pull outward, drawing the tube into a micropipette. A position sensor in the carriage assembly monitors the movement. When the movement exceeds the programmed distance, the heating stops.

**Load the Glass in the Carriages**

The glass capillary is held by clamps mounted on two movable carriages. Both carriages synchronously slide as a program is executed. Manually slide them back together when you are loading the glass.

1. To open the clamps, place your thumb under the clamp and depress the release button with your index finger.
Press the Release Button to open the clamp.

2. Slide the glass capillary into the V-Shaped Groove from one side. Slide it through the center of heating filament onto the other side. If you want two equivalent length micropipettes, be sure to center the glass in the filament.

3. Secure the glass capillary with the clamps.

**CAUTION**: The carriage has a narrow clearance above the body of the puller. If foreign material such as broken glass becomes wedged underneath the carriages, it can cause a bind between the carriage and the body. Remove foreign material from this area using vacuum only. Use of compressed air may drive particles deeper, making them more difficult to remove.

**Program Run Sequence**

The heating element uses a platinum/iridium filament that provides enough heat to melt all common glasses except quartz. After starting the program, the filament begins to glow and heats the glass. A solenoid gradually applies a moderate tension to the glass. The small section of the glass capillary in the filament is heated until it is soft. When the glass is soft enough, it begins to narrow and stretch longer and thinner. The carriages move because of the solenoid’s pulling force, and at some point, the two halves separate, forming two micropipettes.

**Programs**

The temperature, tensile force, distance of movement and delay time between steps are all programmable parameters. Each of these parameters is user-defined for each step in a four-step sequence. A total of 95 sequences may be stored for recall by program number. When the unit is powered on, the LCD screen displays the last used sequence in the window. **PUL-1000** is designed to form the pipette in four steps. A basic program step (called a line) consists of four entries:
1. The first stage is to pull a thin section on the capillary. The heating power, pulling force and pulling length determine the taper shape and length.

2. The thin section is pulled again in the second stage to reach a preset length. When the glass capillary is pulled thinner and longer, the waist of pulled section is proportional to pulled length. The capillary outside diameter is dependent on the properties of the glass, heating power and pulling force.

3. The third stage is used to control the glass temperature.

4. If necessary, the program repeats until the glass capillary is ready to break. In the fourth stage, the capillary breaks at a lower temperature to form the tip. The puller can produce pipettes with tip diameters from less than 0.1 μm to tens of microns.

**Program Parameters**

![Fig. 5](image)

The main display shows the parameters which may be controlled.

For each step of a four-step sequence, the four primary parameters may be set. A description of each follows:

**HEAT**—The HEAT parameter determines the amount of heat produced by the filament. The units represent the amount of current to be passed through the filament. Values range from 0 to 999. The useful range of values depends upon the filament and glass type. Usually the value used is close to the value determined in the Glass Capillary Softening Test (below). During execution of a program line, the puller gradually establishes a moderate pulling force, and then the filament current is turned on.

**FORCE**—The FORCE parameter determines the amount of force delivered to the carriage by the solenoid. The units are arbitrary (ranging from 50–400g) with the maximum value set to prevent overheating of the solenoid. The value of the FORCE determines the solenoid force at the maximum for the pulling stage. The force ramps from zero to the setting.

**NOTE:** The force applied may be set as a constant force or a gradient force. The constant force applies the same amount of force throughout the entire program. A gradient force allows the force to slowly taper off as the program runs. When the...
force gradually diminishes in the fourth stage, the tip breaks more smoothly. To toggle between constant and gradient force, move the cursor to the number under force and press STOP.

**DISTANCE**—DISTANCE in millimeters (ranging from 0-9.99mm) is the change in distance between the two movable carriages.

**DELAY**—DELAY values may range from 0 to 999 and are in units of 0.1 seconds. After one stage is done, the glass is allowed to cool for the DELAY time before the next stage begins.

# Glass Capillary Softening Test

Run the Softening Test when:

- You change the filament
- Lot numbers or capillary types change
- You create or modify a program

1. Press the STOP key to quit any running program. The following window displays (Fig. 6).

**NOTE:** A force of 150g is the factory set value for testing borsilicate glass capillaries using a 2.5mm square box filament (WPI #13834).

![Fig. 6](image)

*Fig. 6  The window displays when you press the STOP key.*

2. Mount a glass capillary on the carriage. See “Load the Glass in the Carriages” on page 5.

3. Press the START key to run the Glass Capillary Softening Test. The heating power increases gradually. The heating stops when the glass begins to move.

4. Record the heating power. This is the baseline heating value for the glass type tested. It is a good starting point for the first stage of your program.
# MAINTENANCE

## Replacing a Filament

The filament support blocks are located between the two carriages in the middle of the mechanical unit. The filament clamps are attached to the support blocks. The filament clamps are held to their supports by set screws. You may adjust the filament position by loosening the set screw, repositioning the filament and tightening the set screw.

![Image of filament support block, filament clamp, and set screw](image)

**Fig. 7** *The set screw secures the Filament Clamp to the Filament Support Block.*

If the filament wears out or is damaged, it must be replaced. To replace the filament:

1. Loosen the set screws that secures the Filament Clamp on the Filament Support Block.
2. Remove the old filament or its remaining pieces. Be careful not to drop any material into the mechanical unit.
3. Then, position the new filament and tighten down the set screws. It is best to approximate the position of the previous filament with the new one. The box filament should be positioned so that when the glass is clamped in place, it runs through the center of the box filament. If the filament is not square, or if it is off center, the glass will not heat evenly.

![Image of filament support block and glass centered through filament](image)

**Fig. 8** *Position the filament so the capillary glass runs through the center of the filament.*
If you are using a filament with a different shape or are pulling a different diameter of glass, be sure to test the placement of the glass capillary to verify that it remains in the center of the filament. When you are pulling larger diameter glass, you will need a larger filament. Typically, a larger filament has a greater offset from the Filament Support Block to compensate for the change of the glass position when you are using glass with a larger diameter.

**Choosing a Filament**

Appropriate filament selection depends on your research application, but generally Box Filaments are recommended. This configuration is particularly suitable for slice preparations where long, parallel walls will aid penetration. If you are using a box filament, the size of the square box should be approximately 1.0mm to 1.5mm larger than the outside diameter of the glass to be pulled.

**ACCESSORIES**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>13834</td>
<td>Replacement box filament, 2.5mm square, platinum iridium, 2.5mm wide</td>
</tr>
<tr>
<td>14074</td>
<td>Replacement box filament, 3mm square, platinum iridium, 2mm wide</td>
</tr>
</tbody>
</table>

**SPECIFICATIONS**

This unit conforms to the following specifications:

- **Heater Element**: Platinum/Iridium Filament
- **Pulling Force**: (50–400) Solenoid, adjustable
- **Taper Length**: 1–10mm
- **Capillary OD Range**: 1.0–2.0mm
- **Maximum Capillary Length**: 170mm
- **Minimum Capillary Length**: 55mm
- **Permanent Memory Set**: 95
- **Auto Shut-off Time**: 90 s
- **Power Input**: 100-240VAC 1.5A 50-60Hz
- **Power Output**: 19V DC at 4.74A (5.5x2.5 barrel connector with positive tip)
- **Dimensions**: 37 x 24 x 15cm
- **Shipping Weight**: 16 lb.

**NOTE**: This puller is designed for single barrel borosilicate glasses or patch glass, not quartz or aluminosilicate.
## TROUBLESHOOTING

<table>
<thead>
<tr>
<th>Issue</th>
<th>Possible Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puller stops in the middle of a pull. Unit beeps.</td>
<td>The unit is over heating</td>
<td>Allow the unit time to cool down before attempting to pull more glass</td>
</tr>
<tr>
<td></td>
<td>If program fails in the middle of a pull, you may have exceeded the parameters of the unit. For example, when you add up the distance of travel for all the stages, you may have exceeded the maximum range of travel.</td>
<td>Check your program. You may need to alter the heating or travel parameters to conform with the unit’s maximums.</td>
</tr>
<tr>
<td>New glass doesn’t pull well</td>
<td>Parameter are not set properly for the properties of the new glass</td>
<td>Run the Glass Softening Test to establish a new baseline heating parameter. See “Glass Capillary Softening Test” on page 8.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Install a new filament. See “Replacing a Filament” on page 9.</td>
</tr>
<tr>
<td>Cannot select a program</td>
<td>Puller may be in Edit mode. It will not execute a program until you exit the Edit mode.</td>
<td>Press the Exit key to exit the program editing mode without saving the program. Press Start to run your program.</td>
</tr>
<tr>
<td>Unit Beeps</td>
<td>If program fails to start, carriages may be too far apart.</td>
<td>Remove the glass, slide the carriages together and reposition the glass.</td>
</tr>
</tbody>
</table>

**NOTE:** If you have a problem/issue with that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at 941.371.1003 or technicalsupport@wpiinc.com.
**APPENDIX A: EXAMPLE SEQUENCES**

For WPI single-barrel standard borosilicate glass tubing:

OD: 1.0 mm, WPI # **1B100-4**

<table>
<thead>
<tr>
<th>STEP</th>
<th>HEAT</th>
<th>FORCE</th>
<th>DISTANCE</th>
<th>DELAY</th>
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<tbody>
<tr>
<td>1</td>
<td>400</td>
<td>200</td>
<td>2.00</td>
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<td>2</td>
<td>300</td>
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<td>4</td>
<td>200</td>
<td>100</td>
<td>0.30</td>
<td>20</td>
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OD: 1.14mm (WPI# **4878**).

<table>
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<th>FORCE</th>
<th>DISTANCE</th>
<th>DELAY</th>
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<tr>
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<td>700</td>
<td>350</td>
<td>3.00</td>
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<td>600</td>
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<td>1.00</td>
<td>60</td>
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<tr>
<td>4</td>
<td>350</td>
<td>120</td>
<td>0.30</td>
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**My Sequences**

Name: __________________________________________

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<th>STEP</th>
<th>HEAT</th>
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WORLD PRECISION INSTRUMENTS, INC.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA
Telephone: (941) 371-1003 Fax: (941) 377-5428
E-mail: wpil@wpilinc.com

DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

As the manufacture/distributor of the apparatus listed, declare under sole responsibility that the product(s):

PUL-1000

To which this declaration relates is/are in conformity with the following standards or other normative documents:

Safety:
EN 61010-1:2010

EMC:
EN 61326-1:2013
EN 61326-2-3:2013


Issued on: May 22, 2014

Cliff Brodemberg
Chief Technology Officer

S. Carlquist
Vice President of Manufacturing

F-QC-006
REV A
**WARRANTY**

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of 30 days* from the date of receipt. WPI’s obligation under this warranty shall be limited to repair or replacement, at WPI’s option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI’s approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

**Claims and Returns**

Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or piffed cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

**Repairs**

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

* Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.
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Germany
Zossener Str. 55, 10961 Berlin
Tel: 030-6188845 • Fax: 030-6188670 • E-mail: wpide@wpi-europe.com

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