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MICROPIPETTE FABRICATION

The P-77 Puller was Sutter Instrument's founding product, and the first electronic pipette puller on the market. With 45 years of continual development, we've long been the undisputed leader in micropipette pullers.

Forming glass micropipettes at a nanoscale demands precision and sophisticated controls. From years of continued refinement of the micropipette puller, Sutter pullers represent the state-of-the-art in micropipette fabrication. From the ease of use of the P-1000 touch screen display, to the P-2000, one of the only pullers available that can fabricate pipettes from pure quartz tubing, Sutter's pullers have become the world standard.

The P-1000 is the latest evolution of the Flaming/Brown™ Style micropipette puller. This puller extends the features of the P-97 by incorporating a color touch screen and integrating new technology that simplifies programming. Unique features such as the safe heat mode, diagnostic testing,

line repeat mode, and jaw temperature sensor assist in creating the ideal pipette morphology. The pre-installed Sutter Pipette Cookbook, glossary and help topics, make it easy to access the extensive library of programs. Both pullers offer: microprocessor controlled programmability, constant current power supply, a self-contained precision air delivery system, and a patented velocity sensing system. These design elements have led to significant improvements in pipette reproducibility when compared to other micropipette pullers.

The current state-of-the-art in micropipette puller technology is the P-2000. It incorporates the mechanical design and programmability of the Flaming/Brown™ pullers, but uses a CO_2 laser as the heat source. With the addition of the laser,

quartz tubing can now be pulled along with other lower melting point glass compositions. Quartz pipettes have helped eliminate some technical barriers in electrophysiological studies and have enhanced microinjection procedures as well as near field scanning microscopy.

The P-30 is Sutter's lowest priced and simplest puller, based upon a National Institutes of Health (NIH) design from the 1950s. As a vertical puller, it is intended for basic micropipette fabrication, sharp electrode, and microinjection work.

The BV-10 micropipette beveler continues to be the state-of-the-art in micropipette beveling technology. For precision beveling of pipette tip diameters from fractions of a micron to tens of microns, it is the system of choice.
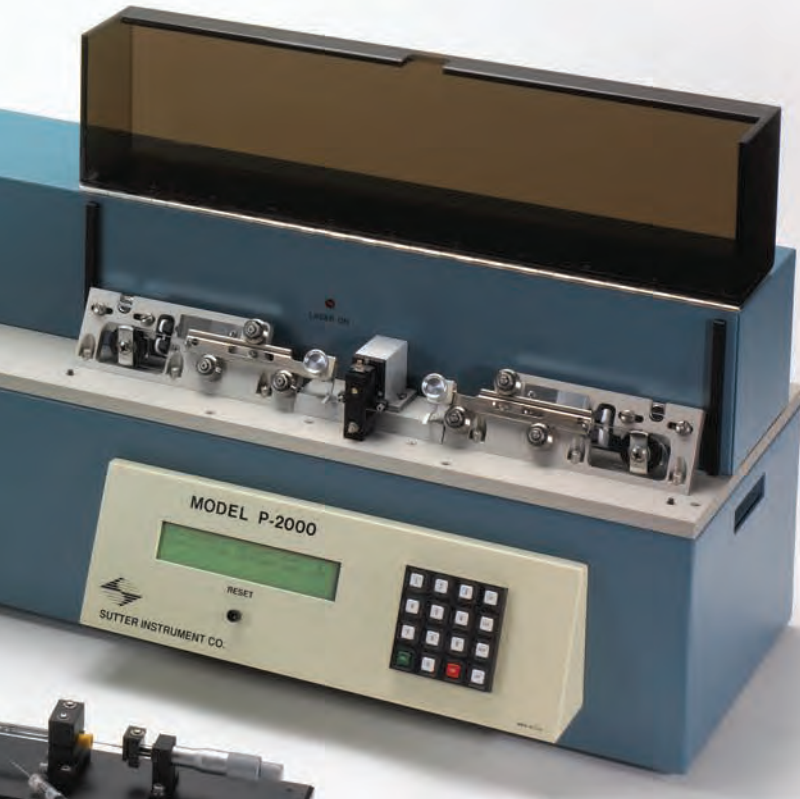
P-2000 LASER-BASED MICROPIPETTE PULLER

FEATURES   P-2000

- Capable of pulling quartz, borosilicate and aluminosilicate glass

- Fully programmable — including heating filament characteristics

- The laser has no melting point limit as with conventional metal filaments, and therefore, cannot be burned out

- Pulls electrodes with tip diameters that are less than 0.03 µm

- Optimized velocity sensing circuit for maximized sensitivity and reproducibility*

- Operating life of the CO_2 laser is expected to be in excess of ten years with normal use, after which the laser can be refurbished by Sutter Instrument for a fee

- Individual programs can be write-protected in order to secure them from inadvertent changes

- The total time that the heat is on during the pull is displayed for improved program development and troubleshooting

- A date and time stamp is displayed to show when the program was written and/or the last time a program was changed

- The P-2000/F is ideal for applications such as nanospray and NSOM

- Preprogrammed sample programs for intra-cellular and patch pipettes. The P-2000/F is also preprogrammed with an NSOM tip

  *Patent No.4,600,424

The P-2000 integrates a CO_2 laser-based heat source with the technology derived from our extensive experience with conventional pullers. This system offers capabilities unmatched by other pullers. A significant advance in the technology of fabrication of micropipettes, optical fiber probes, and nanospray tips, is offered with the P-2000 micropipette puller.

The use of laser heat allows the P-2000 to work with quartz glass (fused silica) as well as conventional glasses. Quartz offers superior material properties for a variety of research applications. Quartz is stronger than other glasses and can facilitate penetration through tough tissues which would normally break conventional pipettes[1]. For applications requiring a low noise glass, users will find that quartz is the lowest noise glass available[2,4]. Quartz contains none of the metals used in conventional glasses[3]. Optically, quartz is virtually free from fluorescence when illuminated.

A CO_2 laser was selected as the heat source for the P-2000 for several reasons:
1) The nominal emission wavelength of the laser approximates the resonant frequency of the SiO_2 lattice in glass. Thus, quartz and other conventional glasses can be melted when the appropriate laser power is supplied. 2) Laser heat is clean and leaves no metal residue on the pipette as do conventional heating filaments. 3) Laser heat can be turned off instantly, leaving no residual filament heat. 4) The user can program the amount and distribution of heat supplied to the glass. 5) No filaments to age or burn out.

The P-2000 can store up to 100 separate programs, with each program consisting of up to 8 command lines. Programmable parameters include: laser power level, scan width, trip velocity, delay/laser on time, and hard pull strength.

One important consideration for the use of the P-2000 is the diameter of the glass used. The optical design produces even heating on glass up to 1.2 mm in outside diameter. Larger diameter glass can be used with the P-2000/G (up to 1.5 mm quartz and 1.8 mm conventional glass), but the performance is best with glass that is 1.2 mm diameter or less.

The P-2000/F works well with small diameter glass such as optical fibers, and with small diameter fused silica capillary commonly used for the manufacture of nanospray tips. Smaller diameter glass with an outer diameter in the range of 0.125 mm to 0.6 mm, require special puller bars as well as an optical alignment optimized for the smaller diameter material. These modified components will be installed at the time of purchase.

As with larger diameter glass, a wide range of tip sizes and taper geometries can be produced with this modified P-2000/F and small diameter glass. We have drawn optical fiber tips ranging from less than 10 nm to more than 5 µm. Please consult our technical staff for further information.

[1, 2, 3, 4] References listed on the next page.

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COMMON APPLICATIONS   P-2000

P-2000/G

■ Patch clamp — single isolated and whole cell
■ Intracellular recording
■ Microinjection
■ Nanoprobe research
■ SECM

P-2000/F

■ Nanospray mass spectrometry
■ NSOM
■ Tapering optical fibers

SPECIFICATIONS   P-2000

■ **Dimensions**   30 in x 14.25 in x 13.25 in
76 cm x 36 cm x 33.5 cm
■ **Weight**   90 lbs
41 kg
■ **Electrical**   115/230 Volts
50/60 Hertz power line

CE

■ **CLASS I LASER PRODUCT**

REFERENCES   P-2000

1. Munoz, J.L. and Coles, J. Quartz micropipettes for intracellular voltage microelectrodes and ion selective microelectrodes. Journal of Neuroscience Methods: 22:57-64, 1987.

2. Rae, J.L. and Levis, R. A. A method for exceptionally low noise single channel recordings. European Journal of Physiology - Pflügers Archive: 420:618-620, 1992.

3. Zuazaga, C. and Steinacker, A. Patch-clamp recording of ion channels: Interfering effects of patch pipette glass. News in Physiological Science: 5:155-59, 1990.

4. Levis, R. A. and Rae, J. L. The use of quartz patch pipettes for low noise single channel recording. Biophysical Journal: 65:1666-1677, 1993.

P-2000

*U.S. prices available at **www.sutter.com**. International prices vary by country. Contact a distributor or Sutter Instrument for a quotation. Prices subject to change without notice.*

■ **P-2000/G**   Laser-based puller, outfitted for use with glass
GREATER than 0.6 mm outer diameter

■ **P-2000/F**   Laser-based puller, outfitted for use with glass
LESS than 0.6 mm outer diameter

(Pullers include a glass stop, sample box of Q100-70-7.5 glass, mirrored tile and manual)

ACCESSORIES   P-2000

■ **FPS**   Spacer for special procedures
■ **GS-I**[1]   Glass stop (Imperial)
■ **GLA**[1]   Glass loading aid
■ **CTS**   Ceramic tile for scoring glass
■ **PET**   Pipette examining tile
■ **BX10**[2]   Pipette storage box (holds 10)
4 3/4 in x 3 5/8 in x 3/4 in
■ **BX20**[2]   Pipette storage box (holds 20)
7 in x 3 5/8 in x 3/4 in
■ **O730350**   Mirrored tile
■ **PR**[3]   Protective ruler (used with P-2000/F)
■ **PBS**   Puller bar hard stop

[1] *Installs on either puller bar*
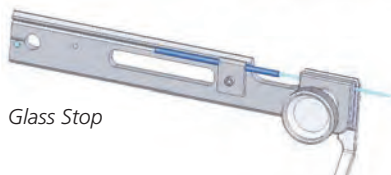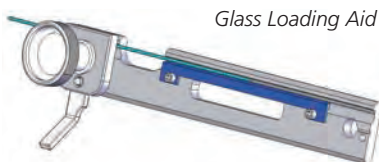
[2] *Minimum order of any 2 boxes*

[3] *Allows user to burn coating off HPLC tubing without damaging tubing. Acts as a guide to allow repeatable location control of burn site.*

Protective Ruler

Glass Stop

Glass Loading Aid

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P-1000 NEXT GENERATION MICROPIPETTE PULLER

FEATURES   P-1000

- Color touch screen display

- Safe heat mode to protect and extend filament life

- Pipette Cookbook program directory

- Pre-heat mode improves stability

- Line repeat mode simplifies multi-line programming

- Help topics and error detection

- Glossary defines micropipette and puller terminology

- Copy & paste function for writing new programs

- Jaw temperature sensor helps define ideal pulling conditions

- Record of last two pull results

- Ramp test more easily accessed and is stored and referenced within each program. Helps to establish program heat settings and protect filament.

- Two symmetrical pipettes with each pull

- Self-contained air supply with filtration system and humidity control chamber

- Memory storage for up to 100 programs

- Two cooling modes: Time and Delay

- Use with single or multi-barrel glass

Developed through years of experience with the Flaming-Brown™ style micropipette pullers, and infused with leading-edge technology, Sutter is proud to offer the P-1000 micropipette puller. The most obvious new feature is the color touch screen display that provides an intuitive and full-featured interface.

The extensive library of programs found in the popular Sutter Pipette Cookbook has been incorporated into the P-1000 puller and is available to the user. You need only specify the glass, filament, and type of pipette you require, and a suitable program is identified and available for installation. This takes the guesswork out of pipette pulling and simplifies programming.

The Pre-heat mode actively heats and controls the jaw temperature and assures that the jaws have reached a specific temperature before the glass is pulled. This can increase the stability of the program from pull to pull. Copy and Paste functions assure that programs can be easily written and the line repeat mode simplifies multi-line programming. A safe heat mode is an additional feature that helps the user avoid using heat settings that might damage or burn out the filament. When the safe heat mode is turned on, the puller will "check" the installed heat and alert the user when a given heat value is too low or too high in relation to the ramp value. User notes can be added to each program for annotating important information.

New features for the P-1000 include: diagnostic testing of all puller components, built-in error detection of air pressure loss or filament burnout, easy access to ramp test, measurement of jaw temperature, and access to previous pull results with the heat-on times for each cycle of the program. Help topics are preloaded to assist with on-site troubleshooting, and the built-in glossary includes text, pictures, and diagrams explaining the terms used in micropipette fabrication. A rotary dial is offered as an alternative to the touch pad for numerical entry.

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COMMON APPLICATIONS   P-1000

- Patch pipettes
- Sharp electrodes
- Pronuclear injection

- Zebrafish injection
- Insect Egg microinjection
- Aspiration pipettes

SPECIFICATIONS   P-1000

- **Dimensions** 21 in x 14 in x 12 in
  53 cm x 36 cm x 30 cm
- **Weight** 41 lbs
  18.59 kg
- **Electrical** 115/230 Volts
  50/60 Hertz power line

$C\,\epsilon$

P-1000

*U.S. prices available at **www.sutter.com**. International prices vary by country. Contact a distributor or Sutter Instrument for a quotation. Prices subject to change without notice.*

- **P-1000** Flaming/Brown™ type micropipette puller, glass stop, manual, hard copy of Sutter Pipette Cookbook. *Each puller comes with a FB255B filament and a sample box of BF100-50-10, BF150-110-10, and BF150-86-10 glass. Sutter pre-programs the P-1000 with a 2.5 mm x 2.5 mm box filament (FB255B) unless an alternative filament is requested.*

ACCESSORIES   P-1000

- **FPS**   Fire polishing spacer
- **GS-M**   Glass stop (Metric)
- **GC-M**   Glass clamps with grips (Metric set of 2)
- **CTS**   Ceramic tile for scoring glass
- **PET**   Pipette examining tile
- **BX10**[1]   Pipette storage box (holds 10)
                 4 3/4 in x 3 5/8 in x 3/4 in
- **BX20**[1]   Pipette storage box (holds 20)
                 7 in x 3 5/8 in x 3/4 in
- **V400103**   Replacement Drierite (1 lb)

BOX FILAMENTS
- **FB215B**   2.0 mm square box filament, 1.5 mm wide
- **FB220B**   2.0 mm square box filament, 2.0 mm wide
- **FB230B**   2.0 mm square box filament, 3.0 mm wide
- **FB255B**   2.5 mm square box filament, 2.5 mm wide
- **FB245B**[1] 2.5 mm square box filament, 4.5 mm wide
- **FB315B**   3.0 mm square box filament, 1.5 mm wide
- **FB320B**   3.0 mm square box filament, 2.0 mm wide
- **FB330B**   3.0 mm square box filament, 3.0 mm wide

TROUGH FILAMENTS
- **FT315B**   1.5 mm wide trough filament
- **FT320B**   2.0 mm wide trough filament
- **FT330B**   3.0 mm wide trough filament
- **FT345B**   4.5 mm wide trough filament

CUSTOM FILAMENT
- **FILAMENT**   Custom platinum/iridium filament
                 (phone Sutter for assistance)

[1] Minimum order of any 2 boods

Pipette storage box

Glass Stop

SPACER

CUTTER BAR

SET SCREW

Fire Polishing Spacer

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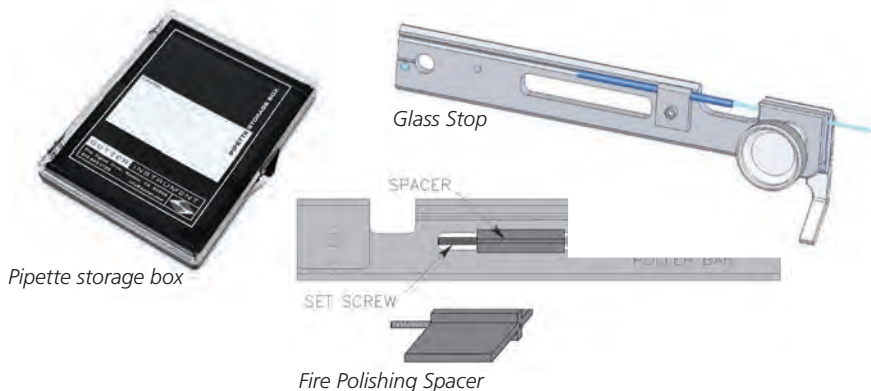
P-97 FLAMING/BROWN™ MICROPIPETTE PULLER

FEATURES   P-97

- Environmental chamber for humidity control

- Programmable air pressure

- Memory storage for up to 100 programs

- Write protection and date stamp for each program

- Two symmetrical pipettes with each pull

- Two cooling modes: time and delay

- Pre-programmed sample programs for intracellular and patch pipettes. Special programming on request

- Ramp test to establish program heat settings when a new filament or glass is introduced

- Vacuum fluorescent display

- Constant current power supply for filament and pull solenoid

- Looping pull cycle for fabrication of patch type micropipettes

- Self-contained air supply with filtration system and humidity control

- Consistent and reliable electrodes with tip diameters less than 0.1 μm

- Control over the time and pressure at which the air is delivered

- Optimized velocity sensing circuit for maximized sensitivity and reproducibility

- Quality control, SEM photograph of a tip pulled with each puller; criterion is tip measurement less than 0.1 μm and typically is ~0.06 μm

The P-97 Flaming/Brown™ type micropipette puller is ideal for fabricating micropipettes, patch pipettes and microinjection needles. While retaining many of the features of earlier models, the P-97 offers improvements in mechanical, electronic and software design. The result is better control of the pulling process and a higher degree of reproducibility. The P-97 combines a proven mechanical system with a sophisticated, programmable microprocessor controller. This programmable control of the pulling parameters allows the investigator to design application specific pipettes from a wide range of glass compositions and sizes.

A number of other features have been incorporated in the design of the P-97. Most apparent is the environmental chamber which surrounds the heating filament. This environmental chamber is designed to minimize the effect of changing humidity on the reproducibility of pulled pipettes. A 25% increase in power over previous versions allows for the use of larger heating filaments, larger diameter glass and multi-barrel glass. The metal jaws that clamp the heating filament have also been redesigned to minimize heat retention. There are two modes of cooling: time and delay. The delay mode provides extended cooling for large diameter and multi-barrel glass. A spring-loaded clamping mechanism has been added for easier loading of glass. A vacuum fluorescent display has been added that allows easy viewing.

Software improvements on the P-97 include a display of the total heat-on time to assist in program development and troubleshooting. Up to 100 programs can now be written and stored in memory, which makes the P-97 suitable for multiple users. These programs can now be write-protected, adding security to prevent programs from being changed or altered inadvertently. The display shows the last date and time the program was written or edited. In addition, the air pressure is a programmable parameter.

Patent No. 4,600,424

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COMMON APPLICATIONS   P-97

- Patch pipettes
- Sharp electrodes
- Pronuclear injection

- Zebrafish injection
- Insect egg microinjection
- Aspiration pipettes

SPECIFICATIONS   P-97

- **Dimensions** 21 in x 16 in x 12 in
  53 cm x 40.6 cm x 30 cm
- **Weight** 50 lbs
  23 kg
- **Electrical** 115/230 Volts
  50/60 Hertz power line

REFERENCES   P-97

These references describe the Flaming/Brown™ series of pullers and contain valuable information applicable to the P-97.

1. Brown, K.T. and Flaming, D.G. *Neurosciences Journal*: 2:813-827, 1977.

2. Flaming, D.G. and Brown, K.T., *Journal of Neuroscience Methods*: 6:91-102, 1982.

3. Brown, K.T. and Flaming, D.G., *Advanced Micropipette Techniques for Cell Physiology.* John Wiley and Sons. Great Britain, 1986.
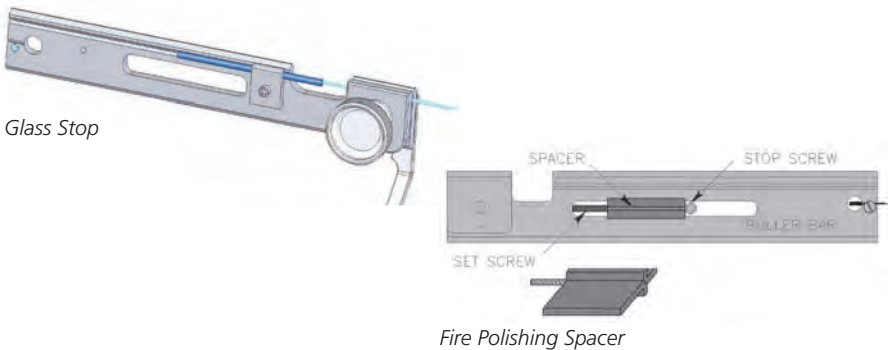
Glass Stop

Fire Polishing Spacer

P-97

■ **P-97** Flaming/Brown™ type micropipette puller, glass stop, manual, hard copy of Sutter Pipette Cookbook.

Each puller comes with a FB255B filament and a sample box of BF150-110-10, BF100-50-10, and BF150-86-10 glass. Sutter pre-programs the P-97 with a 2.5 mm box filament unless an alternative filament is requested.

ACCESSORIES   P-97

■ **FPS** Fire polishing spacer
■ **GS-M[1]** Glass stop (Metric)
■ **GS-I[1]** Glass stop (Imperial)
■ **GC-M[1]** Glass clamps with grips (Metric)
■ **GC-I[1]** Glass clamps with grips (Imperial)
■ **CTS** Ceramic tile for scoring glass (large tips 20 - 200 microns)
■ **PET** Pipette examining tile
■ **BX10[2]** Pipette storage box (holds 10) 4 3/4 in x 3 5/8 in x 3/4 in
■ **BX20[2]** Pipette storage box (holds 20) 7 in x 3 5/8 in x 3/4 in
■ **V400103** Replacement Drierite (1 lb)

BOX FILAMENTS
■ **FB215B** 2.0 mm square box filament, 1.5 mm wide
■ **FB220B** 2.0 mm square box filament, 2.0 mm wide
■ **FB230B** 2.0 mm square box filament, 3.0 mm wide
■ **FB255B** 2.5 mm square box filament, 2.5 mm wide
■ **FB245B[1]** 2.5 mm square box filament, 4.5 mm wide
■ **FB315B** 3.0 mm square box filament, 1.5 mm wide
■ **FB320B** 3.0 mm square box filament, 2.0 mm wide
■ **FB330B** 3.0 mm square box filament, 3.0 mm wide

TROUGH FILAMENTS
■ **FT315B** 1.5 mm wide trough filament
■ **FT320B** 2.0 mm wide trough filament
■ **FT330B** 3.0 mm wide trough filament
■ **FT345B** 4.5 mm wide trough filament

CUSTOM FILAMENT
■ **FILAMENT** Custom platinum/iridium filament (phone Sutter for assistance)

[1] *Installs on either puller bar. Order Metric for serial numbers that include a "M" and Imperial for all others.*

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P-30 VERTICAL MICROPIPETTE PULLER

FEATURES   P-30

- Pulls electrodes with tip diameters down to 0.3 μm, consistently and reliably

- A micrometer allows precise reproducibility of trip point settings in producing fine microelectrodes

- Full three digit digital controls for accurate setting of heat and pull values

- Constant current power supplies for filament and pull solenoid

- Enclosed front to reduce variability caused by drafts

- Dual (manually) switched heat settings for patch pulling or two different types of micropipettes

- All working parts are made from corrosion resistant material

- Two heating assemblies available: platinum/iridium (recommended) or Nichrome coil

- Built-in RFI filter and dual voltage/dual frequency operation

- Rubber padded jaws to minimize breakage of capillary tubing

- Designed to take up minimal bench space

- Slope of the front panel aids in preventing glass from entering cabinet/solenoid mechanism

The model P-30 vertical micropipette puller is designed for the fabrication of basic micropipettes and patch-type pipettes. It will pull micropipettes with tip diameters as small as 0.3 µm and moderate taper lengths (6 mm to 10 mm). By using an included patching attachment, the P-30 will pull a patch-type pipette. But, for those needing very short tapers, high cone angles, and advanced reproducibility, one should consider the P-97 or the P-1000 micropipette pullers. Using thin or standard walled capillaries, the P-30 will generate suitable pipettes for microinjection studies. The P-30 is also ideal for student laboratories and other situations which call for an economical, reliable pipette pulling device.

The P-30 is available with either a platinum/iridium or a Nichrome filament. The Nichrome filament is suitable for many applications and is not prone to damage. The platinum filament is more efficient at heating and cooling, and, although it is more prone to damage than the Nichrome filament, the platinum filament is recommended for thick wall and aluminosilicate glass and applications requiring shorter taper lengths.

COMMON APPLICATIONS   P-30

- C. elegans
- Xenopus
- Drosophila microinjection

SPECIFICATIONS   P-30

- **Dimensions**   18 in x 10 in x 9 in
  46 cm x 25 cm x 23 cm
- **Weight**   35 lbs
  16 kg
- **Electrical**   115/230 Volts
  50/60 Hertz power line

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P-30

U.S. prices available at www.sutter.com. International prices vary by country. Contact a distributor or Sutter Instrument for a quotation. Prices subject to change without notice.

- **P-30/P**   Vertical micropipette puller with platinum/iridium filament
- **P-30/N**   Vertical micropipette puller with Nichrome filament

  Each puller comes with a sample box of BF100-50-10 glass, and manual. The P-30/P also comes with an additional filament.

MICROPIPETTE FABRICATION

- **PF30T15** — 1.5 mm wide trough filament
- **PF30T20** — 2.0 mm wide trough filament
- **PF30T30** — 3.0 mm wide trough filament
- **PF30N[1]** — Nichrome filament (3 turns)
- **PF30N-4[1]** — Nichrome filament (4 turns)
- **P-30-NFL/M[2]** — Nichrome filament block assembly
- **P-30-PFL/M[2]** — Platinum/iridium filament block assembly
- **PET** — Pipette examining tile
- **BX10[3]** — Pipette storage box (holds 10)
  4 3/4 in x 3 5/8 in x 3/4 in
- **BX20[3]** — Pipette storage box (holds 20)
  7 in x 3 5/8 in x 3/4 in

[1] *P-30/N pullers (serial number lower than P-30-680) came with a P30N filament installed. You can now select either the P30N or P30N-4 filament. With the P30N-4 you can 1) use lower heat settings, 2) pull longer tapers (2-3 cm) and 3) use aluminosilicate glass. If you need to pull very short tapers, the P30N is recommended.*

[2] *Only necessary when changing filament configuration*

[3] *Minimum order of any 2 boxes*

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MICROPIPETTE PULLER COMPARISON CHART

Features	P-1000	P-97	P-2000	P-30
Heat Source				
Platinum Filament with Safe Heat Mode	■			
Platinum Filament		■		
CO_2 Laser			■	
Platinum or Nichrome Filament				■
Glass Type				
Borosilicate and Aluminosilicate	■	■	■	■
Quartz Glass or Fiber[1]			■	
Max. Glass Size (OD)				
4 mm	■	■		
2 mm				■
1.65 mm Quartz, 1.8mm Borosilicate			■	
Tip Size				
0.06 μ–3 μ	■	■		
0.01 μ–5 μ			■ (Fiber)	
0.03 μ–5 μ			■ (Glass)	
0.30 μ–2 μ				■
Max. Taper Length				
1 cm				■
1.8 cm			■	
2 cm	■	■		
Program Lines				
8		■	■	
1 Stage or 2 Stage with manual adjustment				■
4 plus Line Repeat Mode	■			
Type of Cooling				
Compressed Dry Air with Humidity Control Chamber	■	■		
NA (Laser On/Off)			■	
None				■
Usable Pipettes/Pull	2	2	2	1

1. Outer diameters < 600 μm require P-2000/F.

P-1000 / P-97 COMPARISON CHART

Features	P-1000	P-97	Notes
Tip Size Range	0.06 µm–3 µm	0.06 µm–3 µm	Two identical pipettes with the same taper length and same tip size.
Taper Length Range	3 mm–15 mm	3 mm–15 mm	For longer or shorter tapers, contact Sutter Technical Support.
Two Identical Pipettes	Yes	Yes	To make overall length identical, please purchase and install the optional Glass Stop (part # GS) onto your puller bar.
Program Looping	Yes	Yes	4–5 loops is ideal for thick walled glass, while 2–3 loops is ideal for thin walled glass.
Multi-line Programming	Yes	Yes	The P-1000 has an additional feature "Line Repeat" (see below).
Humidity Control Chamber	Yes	Yes	This chamber is purged with dry air before and after the pull to remove humidity and control for the ambient conditions in the lab.
100 Program Spots	Yes	Yes	Ideal for labs with multiple users.
Two Cooling Modes: Time & Delay	Yes	Yes	Delay mode is recommended when making patch pipettes with thick walled glass.
Program Lock	Yes	Yes	On the P-1000, the PROGRAM LOCK feature is on the Menu Screen of the program.
Safe Heat Mode	Yes	No	The SAFE HEAT mode helps prevent filament burn-out.
Pipette Cookbook	Yes	No	The PIPETTE COOKBOOK can be used to search for a program that is appropriate for the filament installed in your puller, the glass dimension you are using, and your application.
Programming Touch Screen Display	Yes	No	The color TOUCH SCREEN DISPLAY provides an intuitive interface that allows more information to be displayed.
Temperature Sensor	Yes	No	The JAW TEMPERATURE SENSOR helps define ideal pulling conditions.
Pre-heat Mode	Yes	No	The ThermoLock™ technology in the PRE-HEAT mode assures that the jaws have reached a specific temperature before the glass is pulled. This can increase the stability of the program from pull to pull.
Copy & Paste Function	Yes	No	The COPY & PASTE feature simplifies writing and editing a program.
Line Repeat	Yes	No	The LINE REPEAT feature simplifies writing multi-line programs.
Ramp Test Specific to Each Program	Yes	No	The RAMP TEST VALUE is linked and specific to each program.
Diagnostics	Yes	No	The DIAGNOSTIC feature can be used to check the Heat, Pull, Velocity Sensor, and Air/Cooling System functions of the puller.
Error Messages & Warnings	Yes	No	The P-1000 will alert the user if a system error occurs when pulling a pipette (filament burn-out, air leak, failed to melt glass, etc).
Pull Results	Yes	No	The PULL RESULTS feature displays the heat-on times line by line for the last two pulls.
Glossary	Yes	No	The GLOSSARY is a built-in dictionary of terms associated with the pipette puller.

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FILAMENTS / ACCESSORIES

There is a minimum purchase of 4 filaments.

Appropriate filament selection depends on your research application, but a general guideline for filaments is as follows:

Box Filaments are recommended for small to large diameter borosilicate glass, double barreled, or aluminosilicate glass. Box filaments are particularly suitable for patch pipettes, slice preparations, and for sharp electrodes and microinjection pipettes where gradual parallel walls would aid cell penetration. When using a box filament, the size of the square box should be approximately 1.0 mm to 1.5 mm larger than the outside diameter of the glass that you will be using.

For IVF and ICSI applications, a 2.5 mm x 4.5 mm box filament (FB245B) is recommended. For pronuclear injection work, we recommend a 2.5 mm x 2.5 mm box filament (FB255B). Call for more specific advice or to request a combination of settings, filaments, and glass for your application.

Trough Filaments are excellent general purpose filaments and are recommended for creating longer slice patch pipettes and sharp electrodes. The trough filament is not ideal for making patch pipettes or when using glass over 1.2 mm OD. If very short tapers are required for patch electrodes or for microinjection, a 2.5 mm or 3mm box filament is recommended.

Sutter pre-programs the P-1000 and P-97 with a 2.5 mm x 2.5 mm box filament unless an alternative filament is requested.

For either shape of filament (box or trough), increasing the filament width tends to increase the length of the pipette taper. If there are specific questions as to the filament type needed, please call and our technical support staff will guide you in your choice.

BOX FILAMENTS
P-1000, P-97, P-87, P80PC, P80C, PC-84, P-77B

FB215B	2.0 mm square box filament, 1.5 mm wide
FB220B	2.0 mm square box filament, 2.0 mm wide
FB230B	2.0 mm square box filament, 3.0 mm wide
FB255B	2.5 mm square box filament, 2.5 mm wide
FB245B[1]	2.5 mm square box filament, 4.5 mm wide
FB315B	3.0 mm square box filament, 1.5 mm wide
FB320B	3.0 mm square box filament, 2.0 mm wide
FB330B	3.0 mm square box filament, 3.0 mm wide

TROUGH FILAMENTS
P-1000, P-97, P-87, P80PC, P80C, PC-84, P-77B

FT315B	1.5 mm wide trough filament
FT320B	2.0 mm wide trough filament
FT330B	3.0 mm wide trough filament
FT345B	4.5 mm wide trough filament

P-30 FILAMENTS

PF30T15	1.5 mm wide trough filament
PF30T20	2.0 mm wide trough filament
PF30T30	3.0 mm wide trough filament
PF30N[2]	Nichrome filament (3 turns)
PF30N-4[2]	Nichrome filament (4 turns)

P-77A LOOP FILAMENTS
(Serial number 160 and above)

FL315A	3.0 mm loop filament, 1.5 mm wide
FL320A	3.0 mm loop filament, 2.0 mm wide
FL325A	3.0 mm loop filament, 2.5 mm wide

(Serial number below 160)

FL315X	3.0 mm loop filament, 1.5 mm wide
FL320X	3.0 mm loop filament, 2.0 mm wide
FL325X	3.0 mm loop filament, 2.5 mm wide

ACCESSORIES

FILAMENT	Custom platinum/iridium filament
FPS	Fire polishing spacer (P-2000, P-97, P-87)
FS1875	Platinum/iridium sheet, 18 mm x 75 mm x 0.05 mm (40 µ)
CTS	Ceramic tile for scoring glass (large tips 20-200 microns)
BX10	Pipette storage box (holds 10) 4 3/4 in x 3 5/8 in x 3/4 in
BX20	Pipette storage box (holds 20) 7 in x 3 5/8 in x 3/4 in

[1] For P-87, please contact Sutter.

[2] P-30/N pullers (serial number lower than P-30-680) came with a P30N filament installed. You can now select either the P30N or P30N4 filament. With the P30N4 you can 1) use lower heat settings, 2) pull longer tapers (2-3 cm) and 3) use aluminosilicate glass. If you need to pull very short tapers, the P30N is recommended.

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BV-10
MICROELECTRODE BEVELER

(BV-10-D with optional 40X stereo microscope)

FEATURES   BV-10

- Vibration-free, magnetically coupled beveling surface

- Abrasive surface optically flat to a half wave (250 nm)

- Finest abrasive surface commercially available

- Synchronous clock motor insures stable rotation rate

- 7 pound steel baseplate adds additional dampening

- Integrated LED lamp

- Robust micromanipulator controls bevel angle and advancement

COMMON APPLICATIONS   BV-10

- Deep brain injections

- ES cell and ICSI procedures

- C. elegans injections

- Fish and insect egg injections

Elegant and simple to use, the BV-10 offers precision beveling of micropipette tips between 0.1 μm and 100 μm. The unique abrasive plate drive system is vibration free for greater control of the beveling process. Beveling can be accomplished very rapidly and produces consistent tip diameters using the techniques as described by Brown and Flaming, *Science*, August 1974, Vol. 185.

Intracellular recording electrodes can benefit from beveling because of 1) a reduction in the tip diameter by creation of the sharp point on the electrode and 2) a lowered electrical resistance of the electrode due to the larger cross sectional area of the lumen. This greatly facilitates penetrating and holding very small or difficult cells. Microinjection needles also benefit from beveling by promoting entry into cells with minimal damage while at the same time enhancing the flow of material through the needle.

The basic beveling system consists of a stationary pedestal, optically flat to a half wave (250 nm), surface mounted on a heavy baseplate. This serves as a bearing for an abrasive coated glass grinding plate, which is also flat to half a wave. The flat abrasive plate is coupled to a low vibration, slow-speed motor by means of magnetic fields to provide a wobble-free flat grinding surface. The abrasive plates are fabricated with a proprietary process which insures a consistent abrasive coating.

A 2-axis micromanipulator holds the pipette to be beveled and permits controlled advancement onto the abrasive surface. The bevel angle and speed of advancement are adjustable. An integrated LED lamp with a gooseneck enhances the beveling operation by providing sharp illumination of the abrasive plate and pipette.

The basic system comes with two abrasive plates of your choice, a wick with holder (for wet beveling), pedestal oil, degreasing fluid, and manual.

Two *options* are available for monitoring the beveling process: an 40X stereo microscope, and an electrode impedance meter. Depending on your research application, one or both of these options may be desirable. For all micropipette applications, the swing mounted microscope enhances your control of pipette advancement onto the abrasive plate and allows for viewing of the beveling operation (scope resolution is not sufficient for viewing the actual bevel except in the case of very large tips). For microelectrode applications, the impedance meter is used to monitor the tip resistance during the beveling operation. The meter is an analog design, offering three resistance ranges (0–10 MOhm, 0–100 MOhm, 0–500 MOhm). Measurements are made at 12 Hz to minimize capacitive contributions to the impedance measured and provide a near-true DC resistance value. A rapid roll-off is used to reduce 50/60 Hz interference, allowing operation in a laboratory environment without screening.

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SPECIFICATIONS   BV-10

■ **Bevel Range**   0.1 µm through 100 µm finished electrodes depending on abrasive plate used

■ **Grinding Surface Variation**   Less than 1.0 µm

■ **Grinding Speed**   60 RPM

■ **Bevel Angle Range**   5–90 degrees — adjustable

■ **Micromanipulator**   Course drive: 0.075 in / dial revolution
Fine drive: 0.0004 in / dial revolution

■ **Dimensions Speed**   19 in x 9 in x 8 in
48 cm x 22 cm x 20 cm

■ **Weight**   Approx. 45 lbs / 20 kg

■ **Electrical**   100/120 or 200/240 Volts
50/60 Hz power line

CE

OPTIONS

40X stereo microscope

Impedance meter for real-time measurement of tip impedance

(Shown: BVM-CE)

BV-10

*U.S. prices available at **www.sutter.com**. International prices vary by country. Contact a distributor or Sutter Instrument for a quotation. Prices subject to change without notice.*

BV-10   SYSTEM

- ■ **BV-10-B***   Micropipette beveler basic system
- ■ **BV-10-C**   BV-10-B with electrode impedance meter
- ■ **BV-10-D**   BV-10-B with 40X stereo microscope
- ■ **BV-10-E**   BV-10-B with impedance meter and 40X stereo microscope

  * Includes BV-10 beveler, micromanipulator, reference wick, reference wick holder, pedestal oil, degreaser, manual, and two abrasive plates of your choice.

ACCESSORIES   BV-10

- ■ **BVM-CE**   Electrode impedance meter with active and reference lead
- ■ **BV-10S**   40X stereo microscope
- ■ **104C**   Diamond abrasive plate – coarse (5.0 µm to 50 µm tip sizes)
- ■ **104D**   Diamond abrasive plate – fine (2.0 µm to 20 µm tip sizes)
- ■ **104E**   Diamond abrasive plate – very fine (0.7 µm to 2.0 µm tip sizes)
- ■ **104F**   Diamond abrasive plate – extra fine (0.2 µm to 1.0 µm tip sizes)
- ■ **007**   Degreaser (bottle)
- ■ **008**   Beveler pedestal oil
- ■ **O740125**[1]   20X eyepieces (pair)
- ■ **O740130**   Reticle grid for BV-10S scope 5 mm scale / 100 divisions

  [1] *Useful for higher magnification and for working with tips under 5 microns.*

REPLACEMENT PARTS   BV-10

- ■ **101**   6-inch reference lead (body to meter)
- ■ **102**   2-inch active lead (platinum to pipette)
- ■ **X050300**   Reference wick
- ■ **M100019**   Reference wick holder
- ■ **H906100**   Drive belt
- ■ **PEDESTAL**   Pedestal plates (top and bottom)

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MICROPIPETTE TECHNIQUES
ADVANCED MICROPIPETTE TECHNIQUES FOR CELL PHYSIOLOGY

KENNETH T. BROWN

University of California at San Francisco

DALE FLAMING

Sutter Instrument Company, Novato, CA.

Fine glass micropipettes are extensively used in intra- and extracellular physiology as a means of recording electrical activity in cells and as channels for injecting a variety of substances for experimental purposes. In 1973, the authors began a course of systematic studies designed to help them improve the capabilities and efficiency of intracellular research using the micropipette technique. Here, they present for the first time their theory of how micropipette tips are formed, their methods of reducing tip size, and the implications of their work for research on small cells of all kinds, especially cells within the central nervous system. This text not only incorporates this new work, but reviews and analyzes existing publications on micropipette methodology, including patch-clamping, in order to present as complete an account as possible of how micropipettes can be used efficiently and effectively in a wide variety of experimental situations. The information presented here should prove helpful to anyone performing research with micropipettes, from a graduate student conducting a first project to the most experienced investigator.

CONTENTS

BOOK

■ **BOOK**   *Advanced Micropipette Techniques
For Cell Physiology*

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GLASS CAPILLARY TUBING

Sutter Instrument Company, in addition to the finest micropipette pullers available, offers a wide selection of high quality capillary glasses in various sizes and materials. Though there are many types and sizes of capillary glass available, we have carefully selected only those that pass our strict criteria for precision and quality.

We offer capillary glass tubing in three different compositions; quartz, borosilicate and aluminosilicate. Each composition has its own unique properties and the selection will be determined by your application and your puller's capabilities. Please refer to the Pipette Cookbook for recommendations on which glass to consider for specific applications. It should also be noted that quartz glass (fused silica) can only be pulled using the P-2000 laser-based micropipette puller.

FILAMENT GLASS
Filamented glass has a small rod of glass annealed to the inner wall and this rod (filament of glass) creates the capillary action required to back-fill the pipette with solution. If the resulting pipette tip is under 1 µl and being used for microinjection or recording, we recommend "filamented-glass." The filament in the glass not only provides capillary action for quick filling of the micropipette, it also helps to reduce the incidence of air bubbles when introducing solution into the pipette. If you have any additional concerns, please contact Sutter for technical support.

FIRE POLISHING

All borosilicate and aluminosilicate capillary glass offered by Sutter Instrument has fire-polished ends. This process eliminates any sharp edges, making it easier to insert into holders, and does not affect the electrical or mechanical properties of the glass. Unpolished glass capillary is available upon request.

CUSTOM PIPETTES

Sutter Instrument can make custom pipettes and microtools not commonly available from other pipette manufacturers. For example, we make custom pre-pulled beveled pipettes for microinjection. The custom pipettes are considered non-sterile and are manufactured for research applications and non-human use. Please contact Sutter Instrument for further details.

BOROSILCATE (CORNING 7740)

The most commonly used glass is borosilicate. Sutter Instrument offers only TYPE I-CLASS A borosilicate as described by ASTM Standard 3.1.2[1]. This glass softens at 821 degrees Celsius and, as it is pulled, maintains its ratio of inside diameter to outside diameter over the total taper length. Borosilicate softens at a lower temperature than our other glasses and has a wider working range. These unique properties allow for a greater variety of shapes used in microelectrodes, patch pipettes, microinjection needles and, in the case of solid rod, chromosome dissection tools.

ALUMINOSILICATE (SCHOTT 8252)

Aluminosilicate softens at a higher temperature (935 degrees Celsius) than borosilicate and is workable over a much narrower range. It has a tendency to continuously thin out as it is drawn which allows extremely fine tips with very short tapers. For example, we have pulled aluminosilicate tips in the 20 – 30 nanometer range with taper lengths of 5 mm to 6 mm. Its resistivity is several orders of magnitude higher than borosilicate, thus reducing leakage currents when used in ion-selective micropipettes. Aluminosilicate is harder than borosilicate which results in a pipette that is more suitable for penetrating tough tissues.

QUARTZ (HERAEUS HSQ300)

The finest and purest glass available is quartz. It is superior to all other glasses in its mechanical, electrical and optical qualities. It has the lowest dielectric constant, the lowest loss factor and the highest volume resistivity making it ideal for investigators needing extremely low noise recording conditions. Its chemical purity virtually eliminates leakage of ions[2] and by using quartz in single channel patch clamp recordings the lowest background noise levels have been achieved[3]. Due to its high melting point, it cannot be pulled on conventional pullers, but can be easily pulled with the Sutter CO_2 laser-based P-2000 micropipette puller.

SIZES

Sutter Instrument capillary glass can be broadly divided into 2 categories based on the ratio of the inner diameter (I.D.) to the outer diameter (O.D.). Thick-walled capillaries are those having an approximate I.D to O.D ratio of 1:2, while thin-walled capillaries have an I.D. to O.D. ratio near 3:4. All other factors being equal, thicker walled capillaries produce pipettes with longer tapers and smaller tips, making them better suited for intracellular microelectrodes. Additionally, pipette capacitance decreases as the wall thickness increases so thicker walled capillaries contribute less capacitive noise during patch-clamp recording. Thinner walled capillary glass allows for larger tip openings which make it ideal for microinjection applications and low resistance microelectrodes.

[1] *ASTM Designation E438-90 - April 1990.*

[2] *Zuazaga C., Steinacker A. Patch-clamp recording of ion channels: Interfering effects of patch pipette glass. News in Physiological Sciences: International Union of Physiological Sciences and the American Physiological Society: 5:155-158, August 1990.*

[3] *Rae, James L., Levis Richard A. A Method for exceptionally low noise single channel recordings. Pflügers Archive; European Journal of Physiology:420:618-620, Springer-Verlag 1992.*

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THICK / STANDARD WALLED BOROSILICATE GLASS

WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
BF100-50-7.5	1.00 mm	0.50 mm	7.5 cm	225
BF100-50-10	1.00 mm	0.50 mm	10 cm	225
BF100-50-15	1.00 mm	0.50 mm	15 cm	225
BF100-58-10	1.00 mm	0.58 mm	10 cm	250
BF100-58-15	1.00 mm	0.58 mm	15 cm	250
BF120-60-10	1.20 mm	0.60 mm	10 cm	225
BF120-69-7.5	1.20 mm	0.69 mm	7.5 cm	250
BF120-69-10	1.20 mm	0.69 mm	10 cm	250
BF120-69-15	1.20 mm	0.69 mm	15 cm	250
BF150-75-7.5	1.50 mm	0.75 mm	7.5 cm	225
BF150-75-10	1.50 mm	0.75 mm	10 cm	225
BF150-86-7.5	1.50 mm	0.86 mm	7.5 cm	250
BF150-86-10	1.50 mm	0.86 mm	10 cm	250
BF150-86-15	1.50 mm	0.86 mm	15 cm	250
BF200-100-10	2.00 mm	1.00 mm	10 cm	225
BF200-116-10	2.00 mm	1.16 mm	10 cm	250
BF200-116-15	2.00 mm	1.16 mm	15 cm	250

WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
B100-20-10[1]	1.00 mm	0.20 mm	10 cm	225
B100-50-10	1.00 mm	0.50 mm	10 cm	225
B100-50-15	1.00 mm	0.50 mm	15 cm	225
B100-58-10	1.00 mm	0.58 mm	10 cm	250
B100-58-15	1.00 mm	0.58 mm	15 cm	250
B114-53-10NP[2]	1.14 mm	0.53 mm	10 cm	225
B120-69-8	1.20 mm	0.69 mm	8 cm	250
B120-69-10	1.20 mm	0.69 mm	10 cm	250
B120-69-15	1.20 mm	0.69 mm	15 cm	250
B150-86-7.5	1.50 mm	0.86 mm	7.5 cm	250
B150-86-10	1.50 mm	0.86 mm	10 cm	250
B150-86-15	1.50 mm	0.86 mm	15 cm	250
B200-116-10	2.00 mm	1.16 mm	10 cm	250
B200-116-15	2.00 mm	1.16 mm	15 cm	250

[1] *The ends are not fire-polished. Special order minimum of 2.*

[2] *Nanoinjection glass. Ends are not fire-polished.*

HEAVY POLISHED THICK / STANDARD AND THIN WALLED GLASS[1]

WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
BF150-86-7.5HP	1.50 mm	0.86 mm	7.5 cm	250
BF150-86-10HP	1.50 mm	0.86 mm	10 cm	250
BF150-110-7.5HP	1.50 mm	1.10 mm	7.5 cm	225
BF150-110-10HP	1.50 mm	1.10 mm	10 cm	225

WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
B100-30-7.5HP	1.00 mm	0.30 mm	7.5 cm	225
B100-50-7.5HP	1.00 mm	0.50 mm	7.5 cm	225
B150-86-7.5HP	1.50 mm	0.86 mm	7.5 cm	250
B150-86-10HP	1.50 mm	0.86 mm	10 cm	250
B150-110-7.5HP	1.50 mm	1.10 mm	7.5 cm	225
B150-110-10HP	1.50 mm	1.10 mm	10 cm	225

[1] Useful for added protection of gaskets and wire in headstages.

THIN WALLED BOROSILICATE GLASS

WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
BF100-78-10	1.00 mm	0.78 mm	10 cm	250
BF100-78-15	1.00 mm	0.78 mm	15 cm	250
BF120-94-8	1.20 mm	0.94 mm	8 cm	250
BF120-94-10	1.20 mm	0.94 mm	10 cm	250
BF120-94-15	1.20 mm	0.94 mm	15 cm	250
BF150-110-7.5	1.50 mm	1.10 mm	7.5 cm	225
BF150-110-10	1.50 mm	1.10 mm	10 cm	225
BF150-117-10	1.50 mm	1.17 mm	10 cm	250
BF150-117-15	1.50 mm	1.17 mm	15 cm	100
BF150-120-10	1.50 mm	1.20 mm	10 cm	250
BF165-120-7.5	1.65 mm	1.20 mm	7.5 cm	225
BF165-120-10	1.65 mm	1.20 mm	10 cm	225
BF200-156-10	2.00 mm	1.56 mm	10 cm	250
BF200-156-15	2.00 mm	1.56 mm	15 cm	100

WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
B100-75-10	1.00 mm	0.75 mm	10 cm	225
B100-75-15	1.00 mm	0.75 mm	15 cm	225
B120-90-8	1.20 mm	0.90 mm	8 cm	225
B120-90-10	1.20 mm	0.90 mm	10 cm	225
B120-90-15	1.20 mm	0.90 mm	15 cm	225
B150-110-7.5	1.50 mm	1.10 mm	7.5 cm	225
B150-110-10	1.50 mm	1.10 mm	10 cm	225
B150-117-10	1.50 mm	1.17 mm	10 cm	250
B200-156-10	2.00 mm	1.56 mm	10 cm	250
B200-156-15	2.00 mm	1.56 mm	15 cm	100

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MULTI-BARREL BOROSILICATE[1] GLASS
WITH FILAMENT

catalog number	number of barrels	outside/inside diameter	overall length	pieces per package
2BF100-50-10	2 barrels	1.00/0.50	10 cm	75
2BF100-75-10	2 barrels	1.00/0.75	10 cm	75
2BF150-86-10	2 barrels	1.50/0.86	10 cm	100
2BF150-86-15	2 barrels	1.50/0.86	15 cm	100
3BF100-50-10	3 barrels	1.00/0.50	10 cm	75
3BF100-75-10	3 barrels	1.00/0.75	10 cm	75
3BF120-69-10	3 barrels	1.20/0.69	10 cm	100
3BF120-69-15	3 barrels	1.20/0.69	15 cm	100

WITHOUT FILAMENT

catalog number	number of barrels	outside/inside diameter	overall length	pieces per package
3B100-75-10	3 barrels	1.00/0.75	10 cm	75
4B100-75-10	4 barrels	1.00/0.75	10 cm	75

[1] *Multibarrel borosilicate requires a custom filament . Please contact Sutter Instrument for more information when ordering.*

QUARTZ GLASS
WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
QF100-50-7.5	1.00 mm	0.50 mm	7.5 cm	100
QF100-50-10	1.00 mm	0.50 mm	10 cm	100
QF100-60-7.5	1.00 mm	0.60 mm	7.5 cm	100
QF100-60-10	1.00 mm	0.60 mm	10 cm	100
QF100-70-7.5	1.00 mm	0.70 mm	7.5 cm	100
QF100-70-10	1.00 mm	0.70 mm	10 cm	100
QF100-70-15	1.00 mm	0.70 mm	15 cm	100
QF120-60-7.5	1.20 mm	0.60 mm	7.5 cm	100
QF120-60-10	1.20 mm	0.60 mm	10 cm	100
QF120-90-10	1.20 mm	0.90 mm	10 cm	100
QF150-75-7.5	1.50 mm	0.75 mm	7.5 cm	100
QF150-75-10	1.50 mm	0.75 mm	10 cm	100

WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
Q100-30-7.5	1.00 mm	0.30 mm	7.5 cm	100
Q100-30-15	1.00 mm	0.30 mm	15 cm	100
Q100-50-7.5	1.00 mm	0.50 mm	7.5 cm	100
Q100-50-10	1.00 mm	0.50 mm	10 cm	100
Q100-70-7.5	1.00 mm	0.70 mm	7.5 cm	100
Q100-70-10	1.00 mm	0.70 mm	10 cm	100
Q114-53-10NP*	1.14 mm	0.53 mm	10 cm	100
Q120-40-7.5	1.20 mm	0.40 mm	7.5 cm	100
Q120-60-7.5	1.20 mm	0.60 mm	7.5 cm	100
Q120-90-7.5	1.20 mm	0.90 mm	7.5 cm	100
Q120-90-10	1.20 mm	0.90 mm	10 cm	100
Q150-50-7.5	1.50 mm	0.50 mm	7.5 cm	100
Q150-75-7.5	1.50 mm	0.75 mm	7.5 cm	100
Q150-75-10	1.50 mm	0.75 mm	10 cm	100
Q150-110-10	1.50 mm	1.10 mm	10 cm	100
Q165-115-10	1.65 mm	1.15 mm	10 cm	100

* The ends are not fire-polished. Nanoinjection glass.

SOLID QUARTZ ROD

catalog number	outside diameter	inside diameter	overall length	pieces per package
QR-100-7.5	solid	1.00 mm	7.5 cm	100
QR-100-10	solid	1.00 mm	10 cm	100
QR-100-15	solid	1.00 mm	15 cm	100

QUARTZ THETA GLASS

catalog number	outside diameter	inside diameter	overall length	pieces per package
QT120-90-7.5	1.20/0.9 mm	0.15 mm	7.5 cm	50

MULTI-BARREL GLASS

catalog number	number of barrels	outside/inside diameter	overall length	pieces per package
7Q033-16-10	7 barrel	1.00/[.33/.16 ea]	10 cm	50

ALUMINOSILCATE GLASS

WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
AF100-64-10	1.00 mm	0.64 mm	10 cm	100
AF120-77-10	1.20 mm	0.77 mm	10 cm	100
AF120-87-10	1.20 mm	0.87 mm	10 cm	100
AF150-100-10	1.50 mm	1.00 mm	10 cm	100

WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package
A100-64-10	1.00 mm	0.64 mm	10 cm	100
A120-77-10	1.20 mm	0.77 mm	10 cm	100
A120-87-10	1.20 mm	0.87 mm	10 cm	100
A150-100-10	1.50 mm	1.00 mm	10 cm	100

BOROSILICATE THETA GLASS

catalog number	outside diameter	inside diameter	overall length	pieces per package
BT-150-10	1.50/1.17 mm	0.165 mm	10 cm	100

SOLID BOROSILICATE ROD

catalog number	outside diameter	inside diameter	overall length	pieces per package
BR-100-10	solid	1.00 mm	10 cm	250
BR-100-15	solid	1.00 mm	15 cm	250