Temperature Control

User's Guide

Heated Microscope Incubators, Stages & Objective Heaters

- **Precise Temperature Control throughout the experiment**
- **Conditions similar to** *in vivo*
- **Compatible with Imaging systems**
- **Heating stages for any microscope**
- **No drift with 0.01°C stability**

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www.biosciencetools.com

Contents

CE

Specifications

Range -80 to 150ºC
Accuracy 0.1ºC
Stability 0.01ºC, required for sensitive applications: nano & piezo positioning, AFM, TIRF and so on
No noise suitable for electrophysiology
Automatic Cooling
No vibrations no external fans
Temperature sensors
built-in STAGE sensor
external BATH probes
Feedback
from STAGE or BATH sensors
self-tuning to adjust feedback gains

Analog Input
analog voltage to SET temperature: 10V/230ºC
Analog Output
To monitor temperature (10V/230ºC)
RS232 port
to set and monitor temperatures
Size (Controller) : 8W x 1.8H x 11D in.
Output:
max 4A per channel (140W with 35VDC input)
Power Supply
12-40VDC; 2.1mm pin positive polarity

Warranty

This product is warranted to be free from defects in material and workmanship for the duration of one year. Normal wear, or damage resulting from abuse, accident, alteration, misuse, service by an unauthorized party or shipping damage, are excluded from this warranty and are not covered. Bioscience Tools will repair or replace the defective product covered by this warranty free of charge if it is returned, postage prepaid, to Bioscience Tools, 4527 52nd Street San Diego, CA 92115, ph: 1-877-853-9755

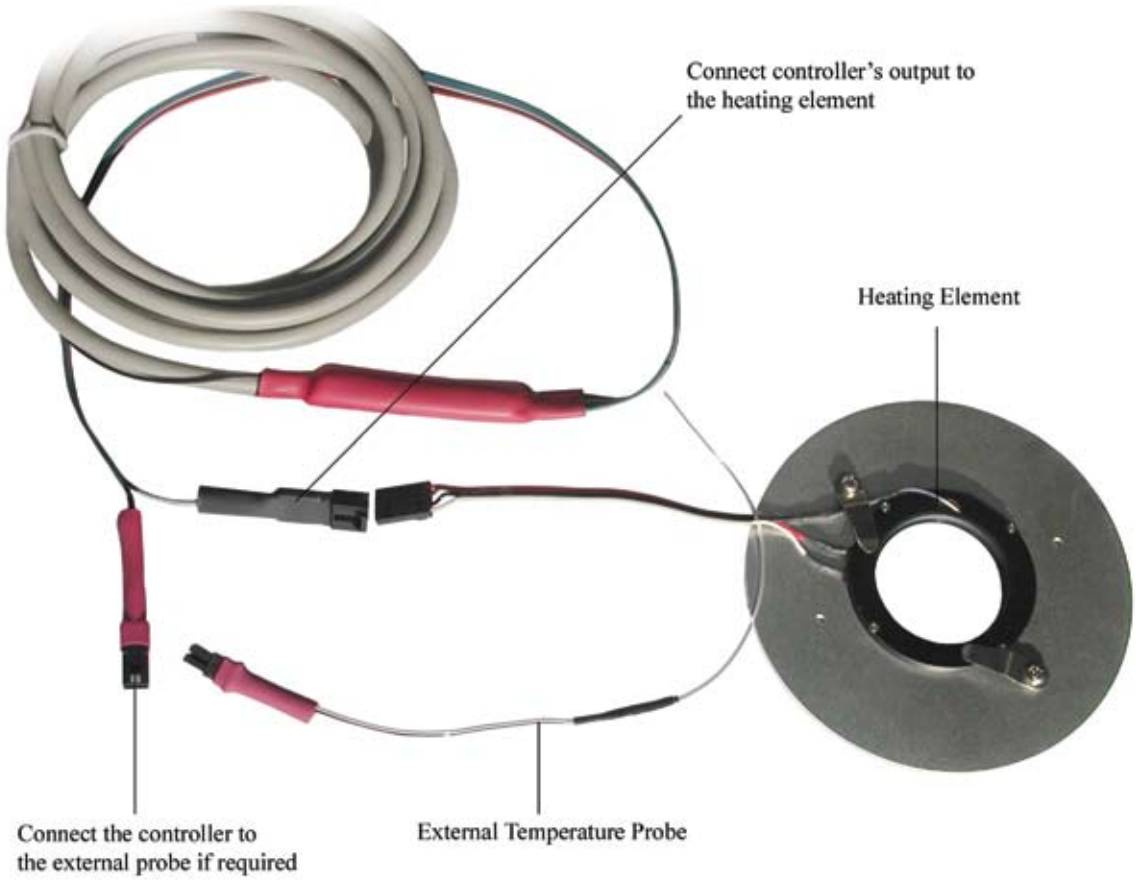
Introduction

The complete temperature control system comes with a controller, an external power adapter, external temperature probes, and connecting cables to heating elements. All heating elements incorporate a temperature sensor built inside - STAGE sensor. This internal sensor can be used for FEEDBACK. It is also used to prevent accidental overheating of the sample. Microscope adapters, MA or IMA type, are required to fit the heating elements to your microscope. Most heating elements can be used as inline pre-heaters, if connected to a perfusion systems. The following are an illustrated installation guide and example configurations of temperature controlled setups.

Installation Guide

1 Connect power cable to the external DC power adapter. Plug the power cable into the wall outlet. Plug the adapter to the power jacks on the back of the controller. Plug the heating stage cable into the output connector on the back of the controller. RED marker - channel I, ORANGE - channel II

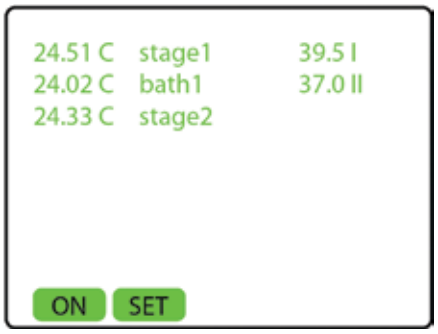
NOTE: The controller can be used with different power supplies, from 12V up to 40V. Larger heating stages, miniature incubators and large heating plates for example, require higher voltage for the controller to provide sufficient power to the heating stage. Small heating stages do not need more than 12V supply. In our experience, 18V power supply is needed for the miniature incubators TC-MI and TC-MIS, and 24V for cooling stages BTC-S/I/SL/S50.



2 Connect the output cable to the heating element/stage and external temperature probes, if used.

3 Prepare the sample chamber, petri dish for example, by filling the chamber with water. Using optional adjustable holders, MTH or MH type, position the external temperature probe inside the chamber - BATH probe. You do not have to do this initial setup procedure while the heating stage is on the microscope. Use a desktop instead. You can transfer the heating stage on the microscope after you are familiar with the system. Turn the controller ON.

4a



On the left of the graphical display, you will see temperature readings from STAGE and BATH sensors of different channels. On the right is a SET/ reference temperature. On the bottom are two buttons: ON and SET. Using any pointing tool, a stylus, hit the button ON.

4b

The button turns into down state and will say OFF. The power bars in the middle of the display will indicate power supplied to the heating elements. Initially, the controller will self adjust itself to the customer setup. After a few minutes, the temperature readings for STAGE sensors should stabilize around SET temperatures.

NOTE: Some heating elements can make readings from STAGE sensor fluctuate rapidly due to high sensor sensitivity. These fluctuations will not transfer to the sample, however, as can be observed from BATH sensor's readings if used.

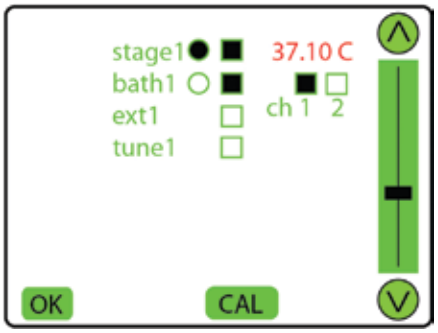
If BATH sensor does not show the required temperature, several degrees off for example, the SET temperature can be offset accordingly (set several degrees higher) to achieve the required temperature around the sample. In the following paragraphs we will explain how to change SET temperature and choose feedback from either STAGE or BATH sensors.

4c

During operation the heating stage can accidently overheat. This can happen if you choose BATH feedback, but do not place the external probe inside the sample, or do not put the sample inside the heating element. In this case the controller will try to heat an empty space excessively. The controller is shipped set for 150ºC shut-off level. Different thresholds can be set on request.

If the controller shuts itself OFF, no power will be provided to heating stages. You need to hit the button OFF and set your sample and temperature probes correctly before starting the controller again.

4d



To adjust SET temperatures and other settings hit button SET. The controller should be in the idle mode for this button to be visible. If the controller is in ON mode, for example, you need to hit button OFF before adjusting the setting.

In SET mode, the display shows:

feedback radio-buttons to choose STAGE or BATH sensors for feedback,

show/hide check-boxes to select which readings to show during operation, STAGE and BATH,

external EXT check-box to use external signal to SET temperature,

slider to adjust SET temperature and calibrate the sensors,

increment/decrement buttons to change settings by a 10 points,

tune check-box to perform self-tuning during operation (NOTE: the controller ships tuned);

CAL button to perform re-calibration procedure (NOTE: the controller ships calibrated);

channel check-boxes to select settings for different channels (this is also used to turn the channels I or II off during operation - if un-checked).

Use radio-buttons to choose a feedback sensor. NOTE: STAGE sensor feedback provides the most stable operation. Use slider on the right and increment buttons to adjust SET temperature shown, RED for channel I. Hit button OK after all settings are adjusted.

The HIDE/SHOW check-boxes are used to show or hide temperature readings during operation. If planning to use an external signal to SET the temperature, EXT check-box needs to be selected.

Although the controller ships with sensors calibrated, you can re-calibrate the sensors if required. Usually two containers with hot and cold waters, and a precision temperature meter are required to perform calibration (NOTE: the controller ships calibrated). To start calibration procedure hit button CAL.

1. Choose a radio-button according to the sensor calibrated. Put the sensor into cold water. Hit the name of the sensor (stage1 for example) to turn it to show LOW/HIGH. Usually you need to start with LOW settings first. After the name turns LOW, the display will show the current temperature readings from the sensor. If different from your own readings, you can adjust readings using INCREMENT/DECREMENT buttons or/and the slider. Adjusted reading will appear next time you hit LOW/HIGH or INCREMENT/DECREMENT buttons (at least one sec. is required, however, for new settings to start showing on the screen, so do not hit the screen too fast).

2. Put the sensor into hot water, and hit the name to show HIGH. Use INCREMENT/DECREMENT buttons or/and the slider to adjust readings. Repeat if necessary. After calibration is completed, choose another radio-button to select appropriate sensor, or hit button SAVE.

4e

Tuning might be performed, if a different heating stage is used, for example. To go through self-tuning procedure, check TUNE box for the appropriate channel. Next time you hit button ON, the controller starts tuning itself to determine optimal settings for the required set temperatures. If self-tuning operation takes too long to finish, it does not have to be performed in the beginning of every experiment. To bypass self-tuning and to use stored settings instead, un check TUNE check-box. Note: the controllers are shipped tuned already; tuning is usually done only once until some changes in the customer's setup happened.

Manual Tune-up procedures

Since samples in the petri dish are located at some distance from the heating element, the temperature of the sample will be different from the temperature inside the heating element - this is called “temperature gradient”. The display will show that BATH temperature readings are usually several degrees lower than STAGE temperature, provided you connected an external temperature probe and placed it inside the sample chamber.

You can achieve the required temperature in the sample chamber by increasing SET reference level to compensate the temperature difference between the heating element and solution inside sample chambers.

Using an objective heater with oil or water immersion objectives will eliminate this temperature gradient. The second channel of the controller is usually used to regulate the temperature of the objective heater, which has a built-in temperature sensor and does not require too much of fine tuning.

NOTE: The chambers with uniformly heated bottom, TC-HB for example, usually do not generate undesirable temperature gradient.

Objective Heater

Uniformly Heated Bottom

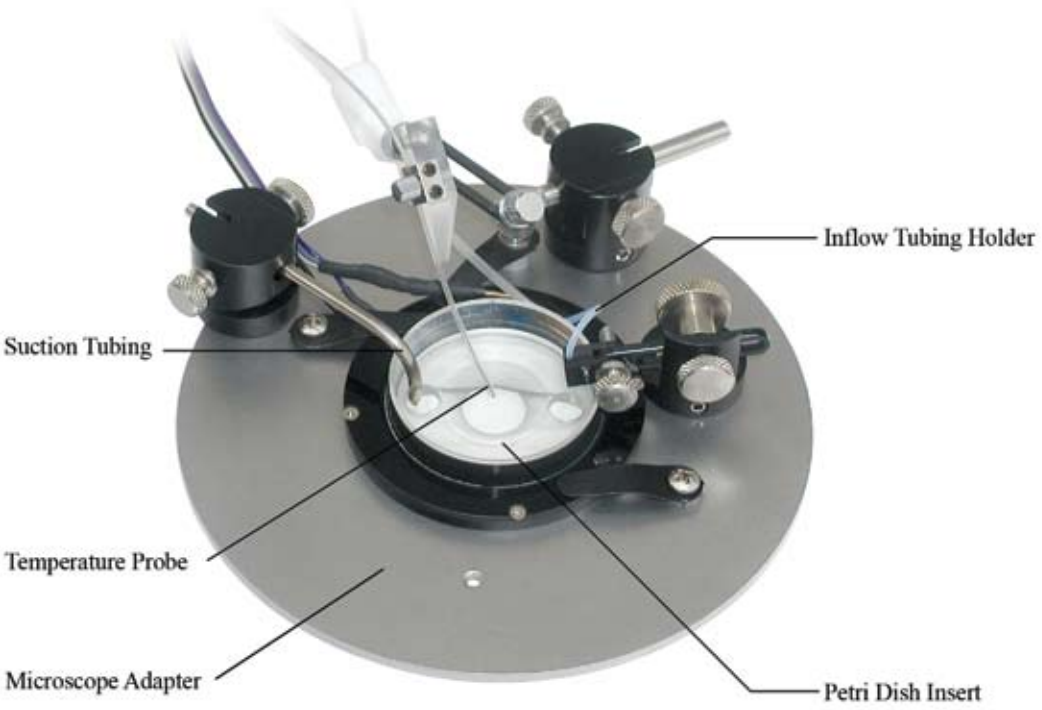
Another way to achieve the correct temperature around your sample is to switch the feedback of the controller to BATH temperature probe. This might result to temperature fluctuations, however.

The setup procedure needs to be done only once before using the system. Changing the sample configuration, like volume of solution, might require settings adjustments. One way to readjust the system is to use the controller in self-TUNE mode. Another is to change SET reference level.

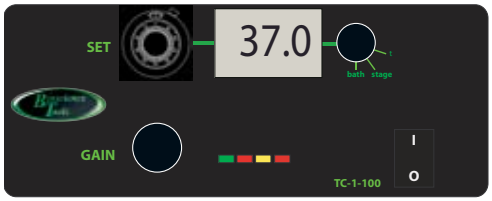
NOTE 1: More stable operation is achieved by switching to STAGE feedback and increasing SET temperature to off-set the temperature gradient.

NOTE 2: If self-tuning takes too long to complete, stop the procedure by hitting button OFF. Go to SET mode, and un check TUNE box. Next time you hit button ON, the controller will use the stored settings, and will not go through self-tuning procedure again.

NOTE 3: Using continuous perfusion of your sample helps to eliminate the undesirable temperature gradient in the system. If flow rate in the system does not change, better temperature stability might be achieved by switching the controller feedback to the heating element sensor STAGE, and adjusting SET temperature to a higher level, so that the BATH temperature is still at the correct point. This trick of using STAGE sensor for feedback might be used without perfusion as well. Using STAGE sensors for feedback usually provides more stable configuration with minimum temperature fluctuations around your sample.

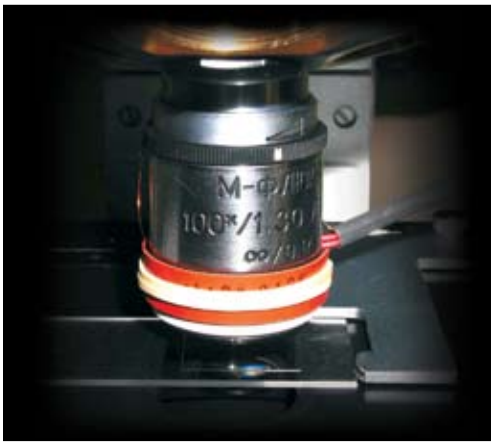


Complete Temperature Controlled System

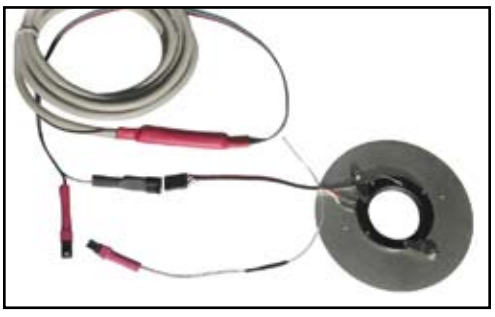


The complete functional temperature controlled setup includes the following components:

1 The main component of the system is a controller, which regulates the temperature of your sample by providing appropriate amount of energy to the heating/cooling elements. The controller uses sensors to get the temperature feedback from the sample and compares these readings with required settings. There are two types of feedback: one is determined by the volume or thermal mass of solution around your sample, and the second is determined by difference between required temperature and the actual temperature of the sample. The first type is responsible for providing steady amount of power to the system to compensate thermal energy dissipation due to temperature gradient between your sample and environment. It is regulated by DC GAIN. The second type is regulated by AC GAIN, and traditionally called FEEDBACK GAIN.



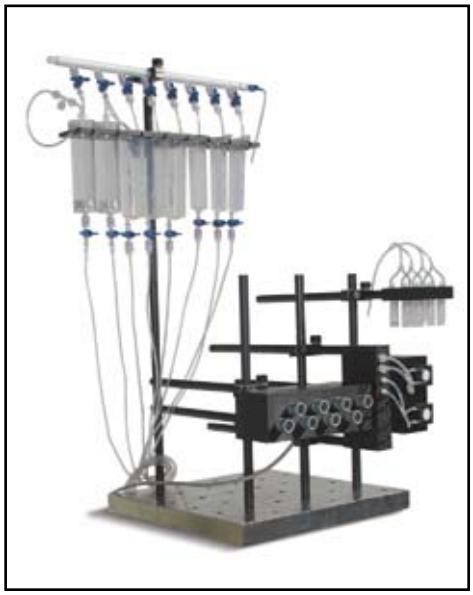
If heated bottom chambers TC-HB are used in the system, the sample is heated uniformly. The traditional chambers like petri dishes, however, are usually heated from sides, along the outer walls of the dish. This inevitably creates temperature gradient inside the dish with temperature being higher along the walls of the dish than temperature in the middle, where your sample is usually located. Using oil or water immersion objectives with regulated objective heaters effectively eliminates this undesirable gradient. Another way to eliminate the temperature gradient in the system is to use continuous perfusion, or flow of solution, which is preheated by passing through the heating element. Most of our heating elements can be used as solution pre heaters.



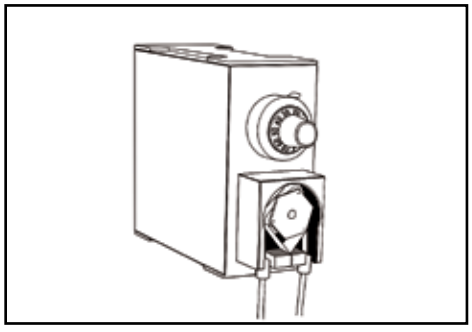
2 Each system includes a set of connecting cables and temperature probes. The heating elements might require microscope adapters, The heating element incorporate a built-in temperature sensors.

3 Closed controlled environment systems not only define gas composition and preserve moisture inside the system, but also help to prevent heat dissipation. In combination with heated top and heated immersion objectives, they provide effective way to control environment around your sample during long term experiments, time lapsed imaging for example. The closed systems also include a set of accessories to configure solution exchange, test substance application, or continuous perfusion of the sample. Petri dishes, chambers for coverslips, and chambered cover glasses can be used with these systems.

4 A set of perfusion accessories, from heated zero-dead volume manifolds to automatic solution switches, allow you to manipulate media around your sample and keep stable temperature control at the same time. Automatic flow controllers and simple gravity driven systems can be combined to switch and mix up to 320 different solutions. Computerized packages with software to program any solution exchange protocols will create flexible experimental environment to perform not only test substance applications during imaging, but staining your sample while still under the microscope.

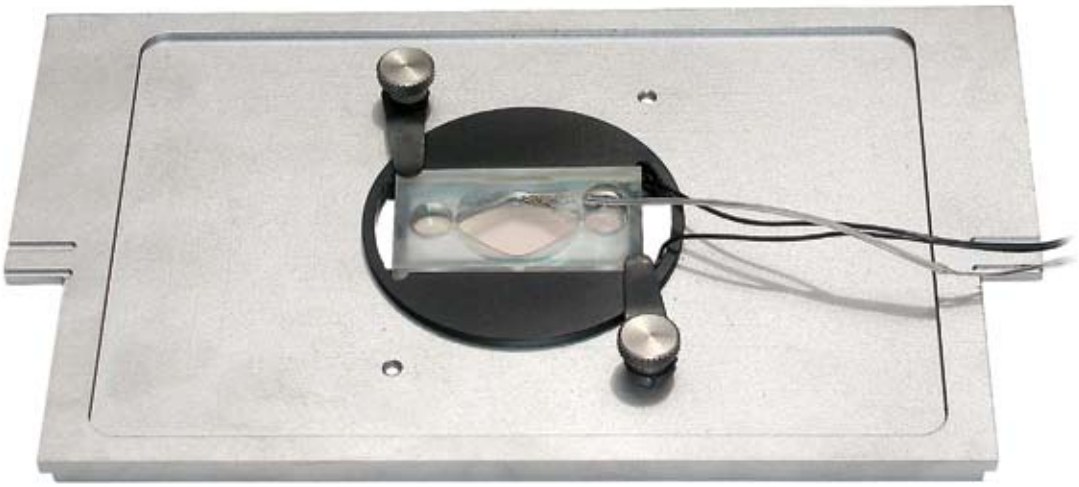


To complete the heated perfusion system you need to configure solution outflow, which is required for most systems - petri dish heaters, for example. The controlled flow unit CFPS-1U66 can handle up to 22ml/min. Outflow starts automatically, every time perfusion is ON, to prevent accidental solution overflow in the system. Multiple flow control units can be used to control inflow rate as well.



Uniformly Heated Glass Bottom Chambers

Uniformly heated chambers incorporate glass heaters on the bottom to provide uniform temperature distribution without gradient. Below are small and large volume chambers.



Introduction

The transparent indium tin oxide (ITO) coated heated chambers can be used with inverted or upright microscopes. The electrically conductive coating is on one surface only, with opposite clean surface contacting your sample media.

TC-HB Chamber This is an open chamber to perform uniform heating of samples while applying substances though miniature manifolds or/and recording with electrodes/patch pipettes. The dimensions of the working compartment (14x20mm diamond) allow you to use the chamber with water immersion objectives as well.

TC-WI Chamber This is a larger volume open chamber that provide optical clearance to accommodate water immersion objectives of upright microscopes.

TC-PH Heated Plates These are transparent glass heaters with large working surface to accommodate large objects like standard glass slides, petri dishes, or our ultra-thin imaging chambers. The heater will provide uniform temperature distribution throughout the whole surface. A set of flat clamps will keep the samples in place. The imaging chambers can be formed directly on the glass surface of the heater using our ultra-thin silicone gaskets.

TC-GSH Uniformly Heated Glass Slides These are standard size 3x1 in. glass slides coated with ITO transparent layer on one side only. A sealed imaging chambers can be formed on a coverslip using our adhesive silicone gaskets. The heated glass slide attaches from the top and provides uniform temperature distribution. Recommended for inverted microscopes. Use MTC-PH and MTC-GS for upright microscopes.

TC-DIS Miniature Water Bath/Dissecting Chamber is a large (54x54x8mm) volume chamber for different applications, including dissecting of tissue. Can be used as a miniature water bath. The chamber has glass bottom, which is used as a heater to provide uniform temperature distribution throughout the whole surface. Optical clearance is 42x42mm.

Instructions for TC-HB Chamber

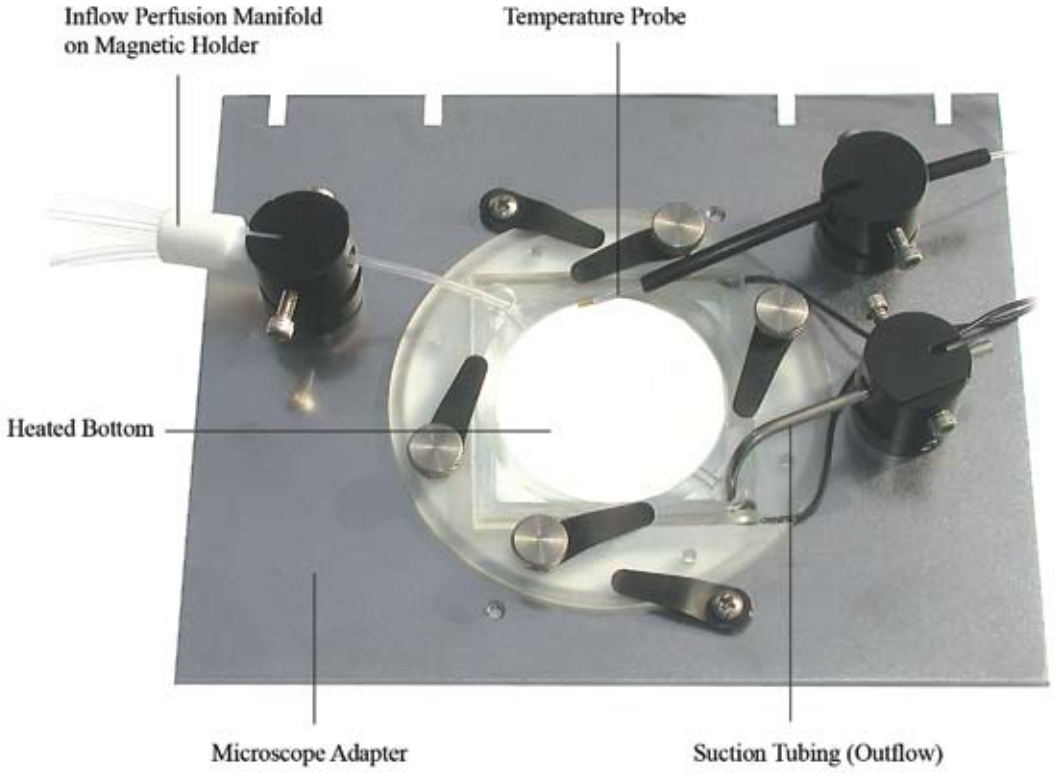
1. Position the glass heater (coated site on the bottom) inside the black metal holder. Fix the heater with flat springs. Position the holder with stainless suction tubing so that the tip of the suction tubing is inside the outflow compartment. Position the holder with inflow tubing so that the tubing is inside the inflow compartment.

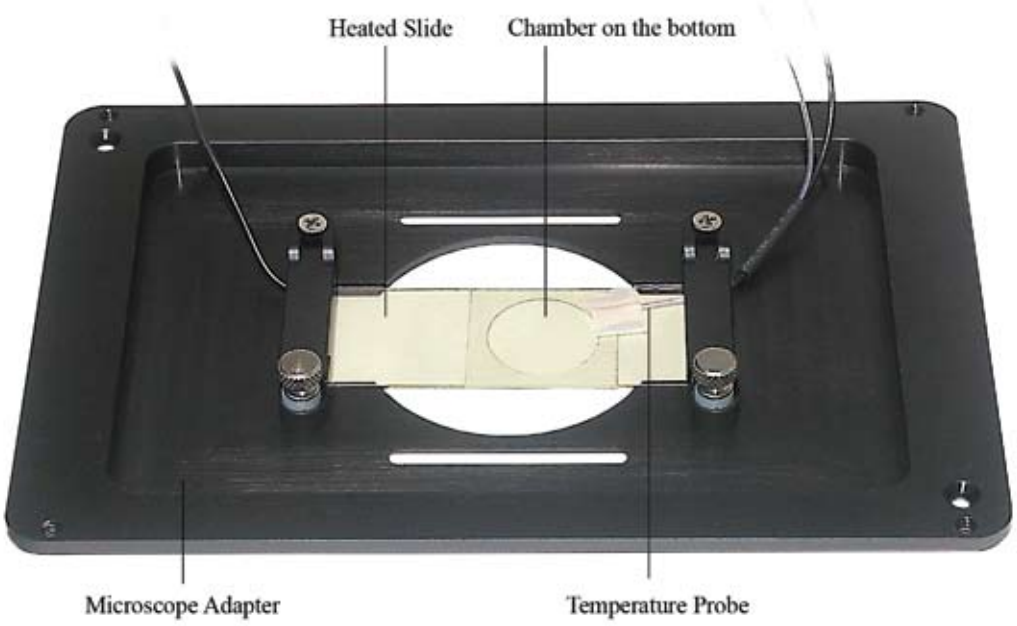
2. Connect the heater to the controller using cables provided. The heater incorporates a temperature sensor, so the controller should be switched to display STAGE/BLOCK temperature and read STAGE/BLOCK temperature feedback.

3. To clean the heater lay the heater on a flat surface and wipe gently using a tissue or Q-tip with 70% ethanol solution or any other cleaning solution. Do not soak the heater in ethanol or other solvents.

CAUTIONS: ITO Heaters can be OVERHEATED! Maximum operating temperature is approx. 70°C. If using an external temperature probe to provide feedback to the controller, position the probe close to the midline of the heater if possible.

TC-WI chamber (top) for upright water immersion optics, and TC-GSH uniformly heated slides to form sealed chambers for inverted microscopes (bottom).


Inflow Perfusion Manifold
on Magnetic Holder
Temperature Probe
Heated Bottom
Microscope Adapter
Suction Tubing (Outflow)


Heated Slide
Chamber on the bottom
Microscope Adapter
Temperature Probe

Heater for *in vivo* experiments

A temperature controlled heater to keep exposed organs at animal body temperature. This heater can be adjusted to position next to or above a small animal. Live attached organs can be placed into a silicone chamber attached to the glass surface of the heater. Easy to clean after use. Custom chambers of any shape are available. Adjustable miniature tubing holders can be used for solution exchange or to apply test compounds (the holders can be also used to fix electrodes and sensors). Magnetic stands provide solid support on the microscope table. The stands are adjustable for easy elevation change during experiments.

Specifications:

Dimensions: 1x 3 in. transparent glass heater

Temperature stability: better than 0.01°C, built-in sensor

Adjustable elevation: Flexible, up to 2in. Can be custom modified

Miniature Heated Zero-Dead Volume Manifolds, ZMMT

1. The zero-dead volume manifolds come 2 ft. long Teflon connecting tubing. Teflon tubing fits directly to Small Volume Reservoir System, SVDS1. To connect to a perfusion system, PS-KIT luer-locks and barbs fitting set can be used to fit to different size soft Tygon and polyethylene perfusion tubing.

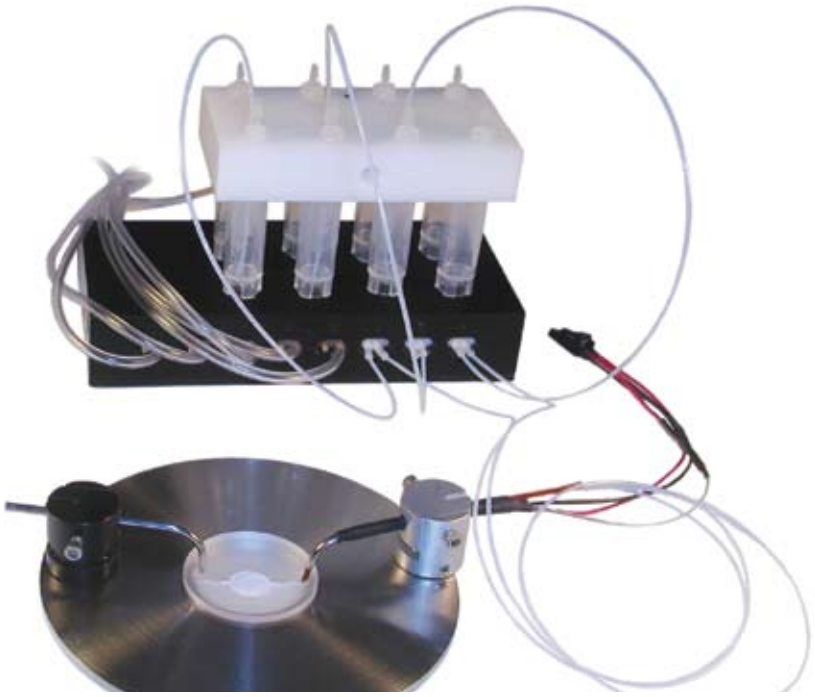
2. Both Teflon and Polyimide tubing are washable.

3. The polyimide 360/250 micron I.D. tubing inside the manifolds will provide adequate solution flow with regular gravity driven perfusion systems. If higher solution flow rate through the manifold are required, the solutions can be pressurized or elevated (elevation is used with gravity driven systems). Pressurized cylinders PC and SVDS1 system, for example, require external pressure application to drive the solutions from the reservoirs. Controlled flow units CFPS-1U can also provide enough pressure to drive the solutions through the manifold.

4. Always wash the manifold with DISTILLED water after use.

5. The manifolds incorporate a temperature sensor. Switch to controller to display STAGE/BLOCK temperature and read STAGE/BLOCK temperature feedback. Connect the manifold to the controller using cables provided.

6. Zero-dead volume manifolds not only facilitate solution exchange around your sample, but preheat solution to provide stable temperature control.

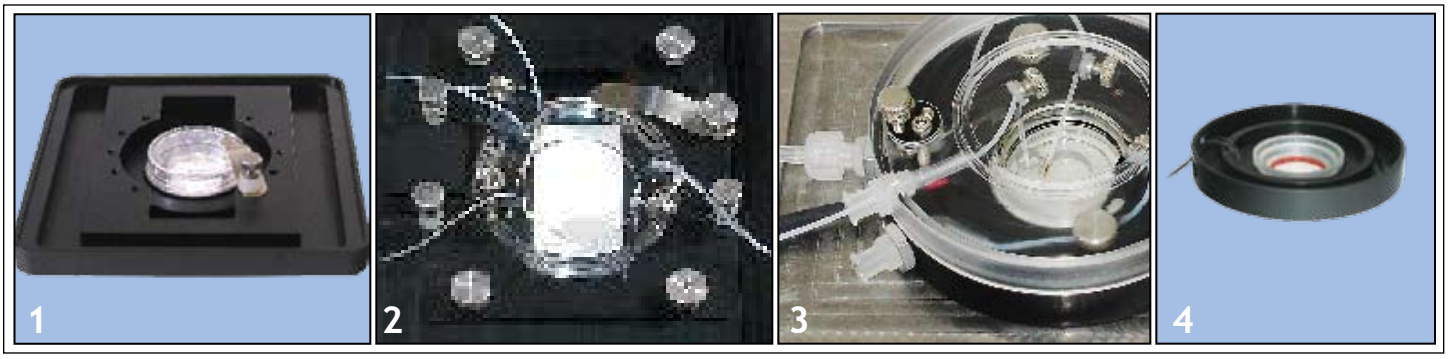


Miniature Incubators

Incubator for motorized stages TC-MI with chambered cover glass inside.

The closed controlled environment setup can provide conditions around your sample similar to those obtained inside incubators. At the same time it allows you to position the sample on microscope stages to perform imaging while keeping the samples in controlled environment. The incubators can be used with coverslip holders the same way as with petri dishes and cover glasses.

Catalog #	Features:
TC-MIS	Incubator for petri dishes and cover glasses.
TC-MI	Incubator for motorized stages.
TC-CIC	Light-weight incubator for 35mm petri dishes and coverslip holders



1. Place the dish inside the heating element. Use petri dish adapters to fit different brand dishes. 50mm reducing adapter can be used with TC-MI and TC-MIS.

If water evaporation and condensation is an issue, a heated cover can be used. If you are doing short-term imaging experiments, you do not need to fill the incubator with water. If you are concerned about evaporation of media, however, you might fill the reservoir (groove on the side of the incubator) with distilled water to keep certain level of moisture in the incubator and to prevent evaporation of your media. The water can be refilled through one of the ports on the side of the incubator.

2. The setup also allows you to exchange media inside the dish or chamber. To make a perfusion setup, you need to

configure your system to provide solution flow/exchange using PS15 perfusion systems or controlled flow systems CFPS-1U, CFPS-2. The solution outflow can be provided by using additional CFPS-1U, or one of the channels in CFPS-2. Using provided tubing holders, adjust inflow tubing so that it goes inside one of the compartments in your dish or chamber. A luer-lock connectors can be used to attach the inflow solution to the incubator. After opening the port, feed thin Teflon tubing through the port inside the incubator. Another luer-lock tubing fitting should be attached to the outflow port. Similarly, using another holder, adjust the suction tubing so that the outflow/suction tubing goes inside another compartment in your dish or chamber. Before closing the incubator, make sure the inflow and outflow tubing are positioned inside the dish or chamber.

The tubing holders are adjustable and allow you to position the tubing at any angle (tilt), and can be rotated to bring the tubing closer to the center of the dish/chamber. First, rotate the holder so that tubing/probe is positioned above the right compartment inside the dish/chamber (you might use provided glass bottom dish insert with different inflow and outflow compartments to facilitate perfusion of the dish). Then, adjust tilt & length so that the tubing goes to the right depth. Note: after the experiment, the sequence is opposite. First, pull out the tubing from the dish/chamber, and then, rotate the holder to clear the dish/chamber.

Note: if perfusion is used, the media can be saturated with gases (CO2/O2, for example) before it enters the dish; in this case, using the cover and connecting the setup to a source of the gas mixture might be unnecessary, unless perfusion can be stopped during the experiment.

3. You can use an External Temperature Probe inside the dish similar to perfusion setups below. Since solution perfusion will effectively eliminate temperature gradient inside the dish, you can also attach the temperature probe to the heated base. This will make the system more stable, but you might need to offset the reference temperature, if the actual temperature in the dish is different from the required temperature. Or simply use FEEDBACK from a sensor inside the base - STAGE/BLOCK. To use incorporated inside the base temperature sensor, switch the controller to display STAGE temperature, and read STAGE/BLOCK temperature feedback. Refer to setting reference temperature procedure in the manual.

The source of CO2 mixture connects to one of the ports in the cover or in the base and should provide a very slow continuous stream – enough to replace the residual gases inside the incubator (the incubator is not sealed).

4. The incubators can be used with coverslip holders the same way as with petri dishes and cover glasses.

5. The heated cover of TC-MI and TC-MIS incubators can be connected in parallel with heating base. Use the cable-adapter to connect both the cover and the base to the same channel of a temperature controller. Usually, the thinner outlet connects to the cover, and the wider - with four wires - connects to the base to provide feedback from the sensor inside the base.

Chambers for replaceable coverslips - CSC

Example of using CSC chamber in a perfusion setup. Magnetic holders are arranged on a microscope adapter MA to provide solution inflow and outflow.

1. Position the bottom part of the 2-parts chamber on a flat surface. Put a cover slip inside the groove in the bottom part. Put the top part inside the bottom part.

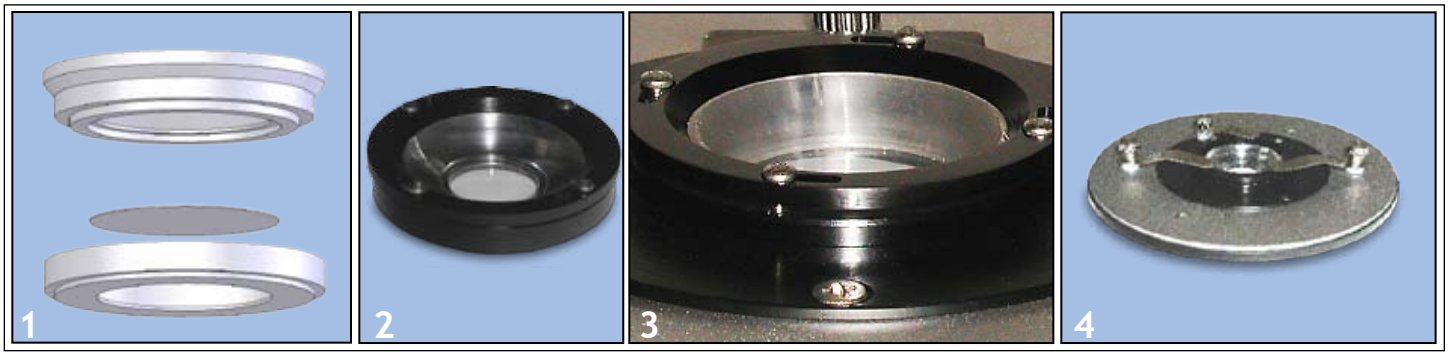
2. Fix the plastic insert with a metal ring from the top.

3. Put the assembled chamber inside microscope adapter or the temperature controlled stage.

4. Use provided clamps to fix the chamber in place, this is especially useful if oil immersion objective is used with an inverted microscope.

Arrange magnetic holders with inflow manifold and

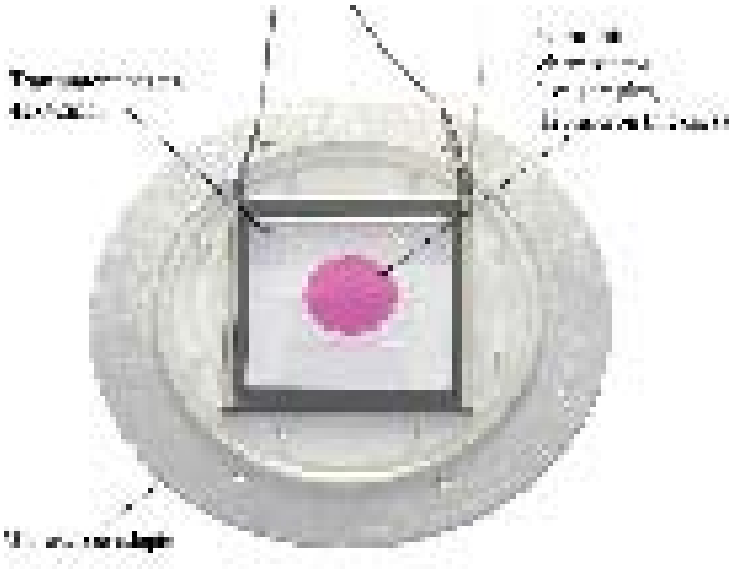
Catalog #	Features:
CSC	Chamber for replaceable round coverslips. Simply put a coverslip inside and seal by a snap-in action.
	Choose the right diameter to fit your coverslips.



suction tubing around the chamber. While using the cover slips with cultured cells, excess of solution on the cover slip might result in bad seal and cause leakage. Try to leave only a minimum amount of liquid on the cover slip before assembling the chamber.

Note: Although the plastic CSC-10P chamber is tight enough, you can further improve the seal against solution leak by putting a thin layer of silicone grease or mineral oil (or Vaseline) inside the bottom part of the chamber, especially along the edges of the groove for the cover slip. Using provided clamps helps to seal the chamber as well.

Ultra-thin imaging chambers - UTIC



Ultra-thin chamber formed on top of a heated glass plate TC-HP50x50. Heated slides TC-GS can be also used.

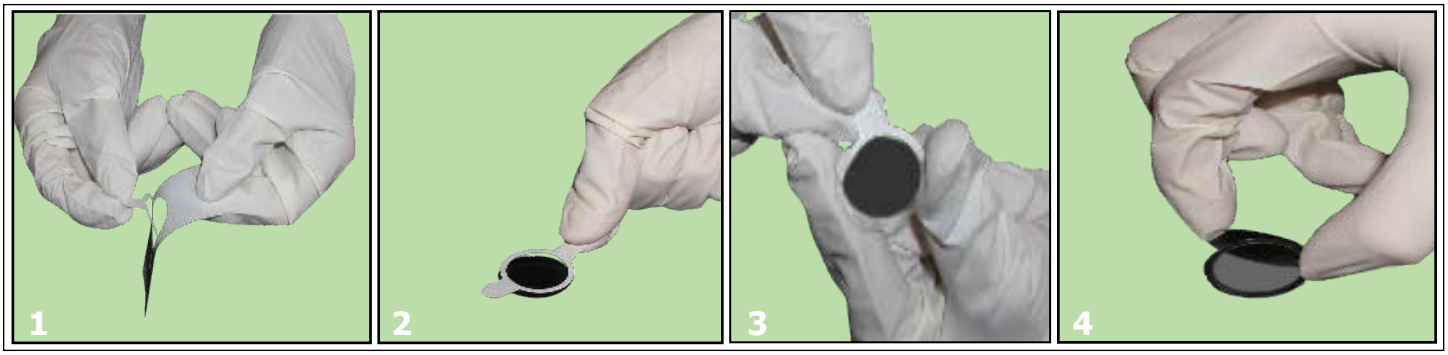
1. Remove protective liner from the bottom surface to expose the adhesive.

2. Apply the adhesive side down onto the surface of a coverslip, glass slide, or on the bottom of a chamber. Press gently to seal.

3. Remove the remaining protective liner. Aliquot a small amount of media into the chamber, or place your sample inside and fill the chamber with additional medium.

4. Place another coverslip on the top. Press gently but firmly to seal the chamber.

Catalog #	Features:
UTIC-21 UTIC-11D UTIC-20-24x24 UTIC-13-24x24	Ultra-thin self adhesive chambers for high resolution imaging. Can be used with coverslips, and on any glass or plastic surface.
quantity	Pack of 100 layers.



5. Place the sealed chamber into metal holder UTIC-25, which fits microscope adapters MA and heating stages, TC-E35. An open chamber can be also formed using a plastic holder, PCCS1 for example.

6. The holder and glass surface can be cleaned after use by removing residual adhesive with a scalpel. Adhesive Removal solutions are also helpful.

Objective Heaters, TC-HLS

The Objective Heater is wrapped around a microscope objective. An incorporated temperature sensor is used to regulate and monitor the objective temperature. Switch the controller to display STAGE/BLOCK temperature and to read temperature feedback from STAGE/BLOCK sensor.

Attaching Heater to Lens

If possible remove the lens from the microscope. Use included Velcro tape to fix the heater securely around the objective.

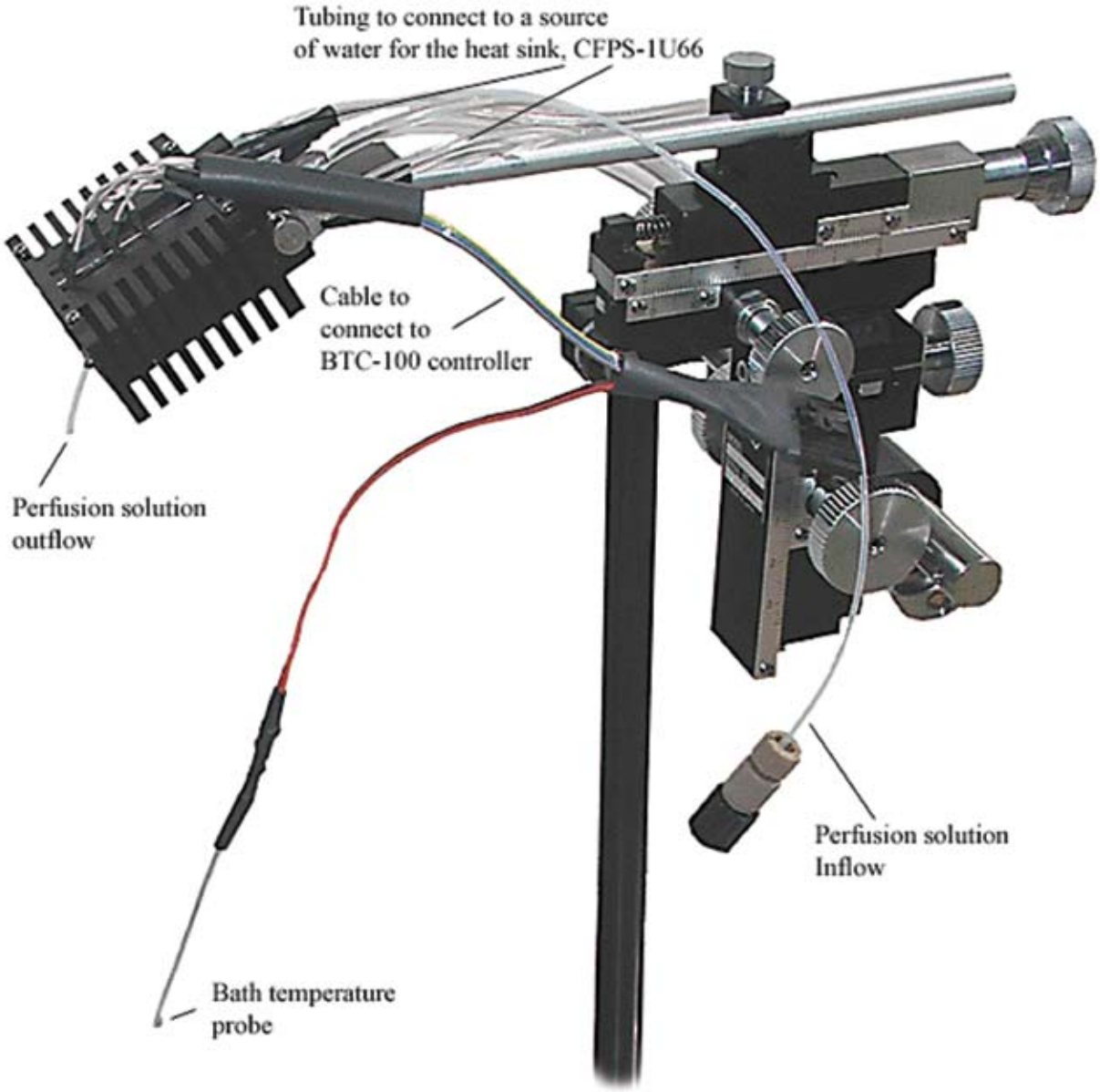
DIMENSIONS: Specify the size of the heater required. The default/standard size is 1x4 in. The heater should be long enough to cover the hole perimeter of the objective. The height of the objective can be limited by the space available on your objective. Usually the heater is attached to the end of the objective close to your sample. The minimum height is 0.25 in.

Flexible silicone objective heaters can be used with any objective and are easy to install. Using objective heaters provide an effective way to stabilize the temperature around your sample.

Cooling stages BTC-S/I, BTC-SL/I, BTC-S50, TC-RD

The controller will automatically detects if SET temperature is below ambient level and starts cooling your sample, provided a cooling/heating stage is connected. If SET temperature is very low an additional sink cooling might be required. Each cooling stage incorporates four ports to connect to a source of water. Two ports in a horizontal row need to be connected together to form a closed loop. Two ports in another horizontal row can be used as in and outflow ports. You can use CFPS-1U66 miniature flow unit, which can provide up to 22ml/min water flow to cool the sink.

If the controller detects the cooling stage, it will actively control the temperature by heating and cooling the stage alternatively. This feature can be used to generate linear temperature changes ("ramp") by providing an EXT temperature level, or sending software commands through RS232 computer port.


Tubing to connect to a source
of water for the heat sink, CFPS-1U66
Cable to
connect to
BTC-100 controller
Perfusion solution
outflow
Perfusion solution
Inflow
Bath temperature
probe

Syringe Heaters, SYR-T8

The Syringe Heaters were designed to heat 60cc (or smaller) syringe barrels of perfusion systems for degassing solutions or maintaining solutions at temperatures above ambient. They can be used, however, with any syringes or containers, or any other object.

Flexible heaters can be wrapped around any size syringes (or any other containers) to keep solutions at temperatures above ambient. The heaters are easy to install and remove. If possible, the heaters should be positioned on the syringes so that the level of solutions remains visible when near the bottom. Multiple heaters can be attached to the same syringe

Instructions

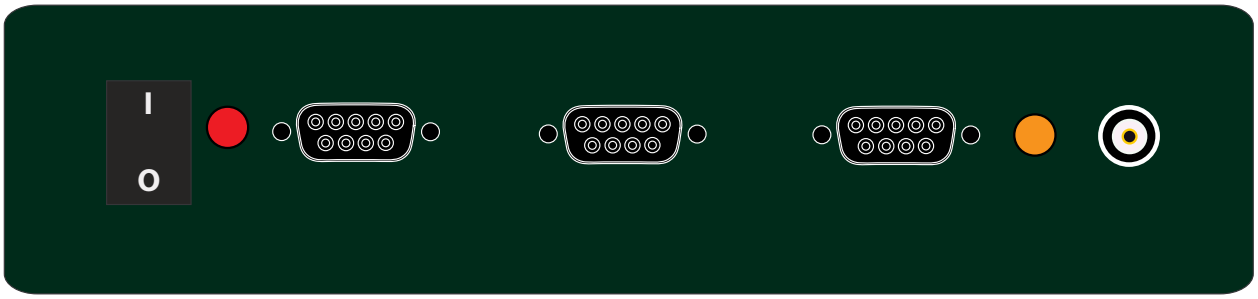
1. Before connecting to cables, the heater should be wrapped around the syringe barrel and Velcro Tape applied to hold it against the barrel. Two (or more) heaters can be attached to the same syringe.
2. One of the heaters incorporates a temperature sensor to use with any temperature controller: TC-1, TC-1-100, BTC-100 or even TC2-80-150.
3. This Heater has a 4-pin connector and should be attached to a cable included with temperature controllers.
4. This heater also provides splitter connector to attach another heater (with 2-pin connectors), and a (color coded) splitter to attach the remaining six heaters.
5. The heaters should be always used in pairs as no power will provided to a single heater.

Caution

1. At least one extra heater should be attached to the splitter cable coming from the temperature sensing heater.
2. If the temperature sensing heater is not positioned on a syringe, the temperature of the solution can not be controlled properly.
3. Use color coded splitters and matching connectors to attach multiple heaters: 2-pin black connectors are used to attach heaters, and color coded connectors are used to attach splitter cables.

Outputs and Controls

Outputs & Inputs	
OUTPUTS I & II	RED connector - channel I, ORANGE - channel II; Connect to STAGE cables to provide power to the heating elements and to provide temperature readings to the controller.
	The same cable provides readings from temperature sensors.



Controls	
RS232 middle	Optional connection to a serial RS232/USB computer port to read and set temperatures, and to turn temperature control ON/OFF.
left DB-9 connector	Provides EXT1 temperature settings (pin 1, 10V/230ºC, 0V = -80ºC) and INHIBIT signals (pin 2, +3-5V shut the channel OFF) for channel I, pin 9 - GROUND
right DB-9 connector	Provides EXT2 temperature settings (pin 1, 10V/230ºC, 0V = -80ºC) and INHIBIT signals (pin 2, +3-5V shut the channel OFF) for channel II, pin 9 - GROUND.

Software control and monitoring

Using a serial cable provided connect the controller (middle DB-9 connector) to a serial port of your computer. Set the serial port at 115,200 speed, 8 bits, 1 stop bit, NONE parity, and Hardware control. The following is the list of text commands supported. NOTE: Each command should follow by \n <CR> code:

T1<CR> returns temperature readings from STAGE1 sensor: T1 37.1 C

T2<CR> returns temperature readings from BATH1 sensor: T2 36.9 C

T3<CR> returns temperature readings from EXT1 setting (reads SET temperature if EXT is not used): T3 37.0 C

T4<CR> returns temperature readings from STAGE2 sensor: T1 37.1 C

T5<CR> returns temperature readings from BATH2 sensor: T1 36.9 C

T6<CR> returns temperature readings from EXT2 sensor: T1 37.0 C

ON<CR> turns temperature control ON

OFF<CR> turns temperature control OFF

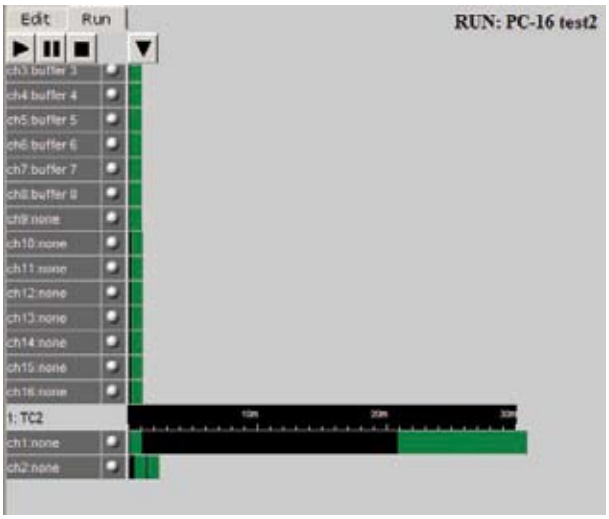
S1 0370<CR> sets reference temperature for channel I (NOTE: all four digits should be sent to the controller)

S2 0370<CR> sets reference temperature for channel II

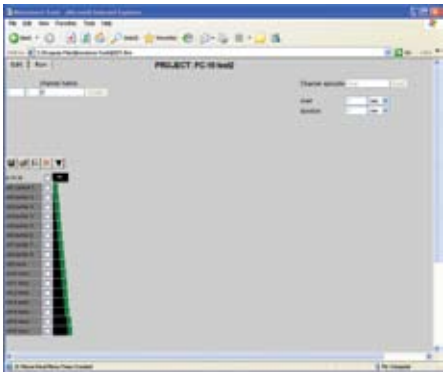
Using Protocol Automation Software

The Protocol Automation software package ships installed on a laptop computer. Connect the computer to the PC-16 controller using provided a regular DB-9 cable (no RS232 cable is needed). Turn the computer ON. Find and double-click BIOSCIENCE TOOLS icon, which is located in the middle of the Desktop. What you will see on the monitor is a sample protocol to activate all channels of the controller. Click the botton PLAY (black triangle) to start the protocol. The controller's channels will be activated in sequence. The indicators on the controller's front panel and manual buttons on the computer's monitor will be ON for the duration of the protocol. After the last channel is OFF, pop-up window will notify you that the protocol is completed.

Manual channel control can be achieved by clicking small round button located next to the name of the channel. This can be used during initial setup of your experiment.

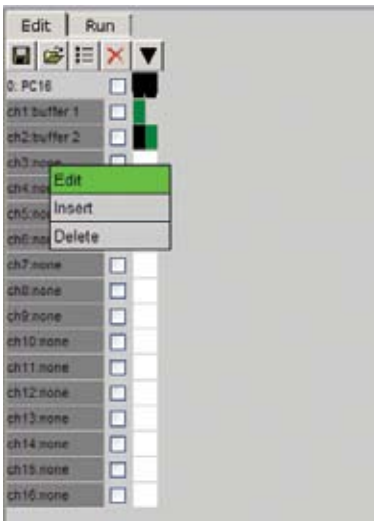


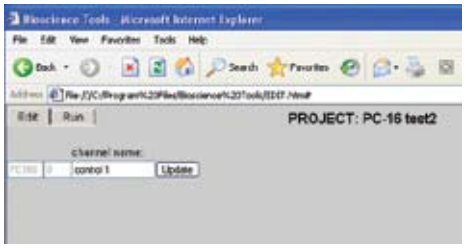
In order to edit or create a new protocol, click the tab EDIT. On the following screen click the button SAVE AS. The following screen will let you create another protocol under different name. After typing a new protocol name, click button SAVE.



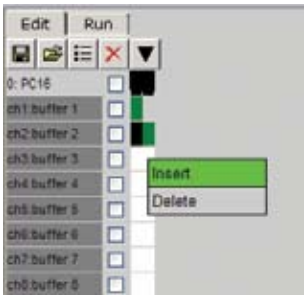
To delete the project, click icon SAVE AS, and clik button DELETE on the following screen. To open another project click icon OPEN and select a project from pull-down list. To insert devices into the project, click icon INSERT and select a device from pull-down list.

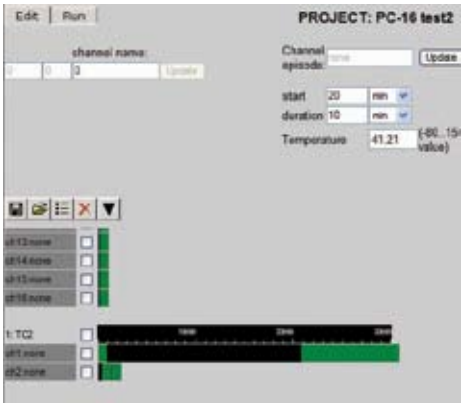
Each channel can be renamed to reflect different settings used during the protocol. In order to rename the channel, click on the channel name, and on the pop-up window select EDIT. In the top-left corner of the screen, type in a new name, and click button UPDATE.





Each channel can have an unlimited number of time episodes, during which it is changing SET temperature. If the channel does not have active episodes, it will be represented by an white square. In order to created an episode, click on the white square and select INSERT on the pop-up widow. In the top-right corner of the screen, type in start time and duration, SET temperature. and click button INSERT. Start time is calculated from the beginning of the protocol. The episode will be represented by a GREEN area. The duration of the episode is not important, as the temperature will not change until the start of another episode for the same channel.

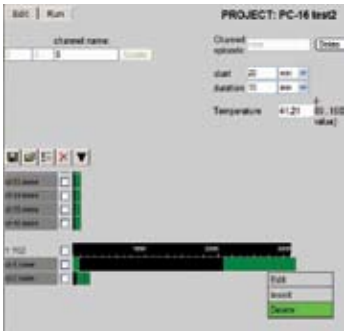




In order to change time settings or temprature for an episode, click on the episode and select EDIT on the pop-up. In the top-right corner of the window, type in new parameters and click button UPDATE.

An additional OPEN episode can be added after an existing episode for the same channel. Click on GREEN episode and select INSERT on the pop-up window. In the top-right corner, type in time parameters required and click button INSERT.

In order to DELETE an OPEN episode, click on the episode and select DELETE. Click button DELETE in the top-right corner to confirm. The episode and corresponding GREEN area will be removed from the screen.



In order to execute the protocol, click tab RUN. On the following screen, click button PLAY to start he protocol.