Instructions for the SHM Series Multi-line Solution Heaters

General

In-line solution heating is a simple and effective method of providing warmed perfusion solutions to a bath.

The removable, minimal dead space manifold at the heater output allows the **SHM Series Multi-line Solution Heaters** to be used in applications where from 2 to 8 perfusion lines are connected to a chamber or other device.

SHM Series Solution Heaters are designed for use with the Warner **TC-324** and **TC-344** Heater Controllers (all models). The compact design of the heater makes it possible to install the device immediately adjacent to the input port of a perfusion chamber insuring minimum heat loss. Heaters can accommodate flow rates up to 5 ml/min.

Each heater is supplied with a **TA-29** thermistor cable assembly (which allows for monitoring of the actual bath temperature; T2 output on the heater controller), a 3-way valve, rubber o-rings and 3 meters of **PE-160** tubing.

Tubing Connections

PE-160 tubing (or any other tubing with a 1/16" (1.5 mm) OD is used to connect **SHM Series** heaters to both the solution reservoir and the perfusion chamber.

Connections are made by press fitting the tubing onto the 18 gauge stainless steel hypodermic tubes. Cap plugs are supplied to block unused inputs.

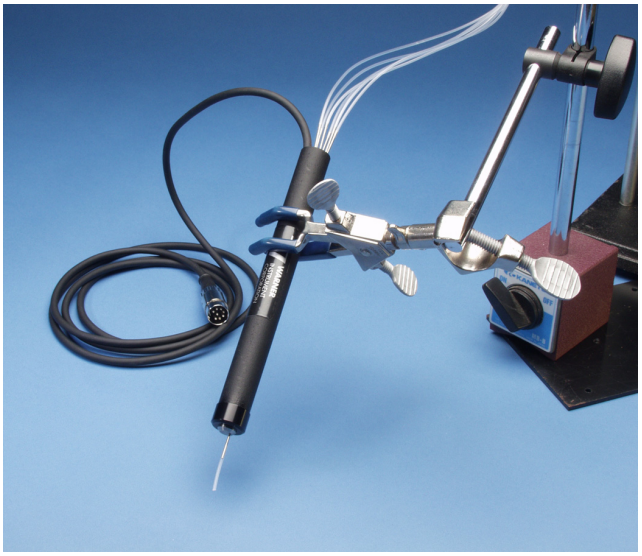
Assembly

1. Attach your solution reservoirs to the input ports of the inline heater using **PE-160** or equivalent tubing.

2. **All flow lines within the heater must be fluid-filled prior to use. A 3-way valve is supplied to facilitate filling of these lines.**

   Using a short length of **PE-160** tubing, attach the 3-way valve to the output end of the heater. Attach a vacuum line to the side port of the stopcock.

3. Sequentially fill all input ports on the device with fluid.



   Begin by filling unused input ports with distilled water. Block each port using the supplied plugs.

   Next fill each solution input port with perfusion solution.

4. Remove the 3-way valve and connect the output port of the heater to a perfusion chamber using **PE-160** tubing or equivalent.

5. Place the outboard tubing from the chamber into a collection reservoir such as a paper cup.

   Use a short length of PE tubing between the heater output and perfusion chamber to minimize heat loss during delivery.

6. Connect the power cable from the **SHM Series** heater to the output terminal of your heater controller.

   If using a Warner Heater Controller, connect the **TC-29** thermistor cable assembly to the rear panel input of the heater channel being used on the controller.

Operation

1. Start the solution flow and set the flow rate to the desired level.

   Typical flow rates are 5 ml/min or less and the heater can sustain temperatures up to 50°C under these conditions. Faster flow rates are supported but the output temperature will not be maintained.

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2. Turn the power to the heater *on* and adjust the heater controller to the desired temperature. Allow a few minutes for the system to stabilize.
3. If using a Warner heater controller, place the **TA-29** thermistor in the output flow path near the sample. Read the working solution temperature by selecting *T2* on the controller. Adjust the SET TEMP on the controller to compensate for heat loss from the heater to the bath.
4. Additional adjustment of the heater voltage may be required if any of the following change substantially during the experiment. Efforts to minimize these factors will be rewarded.
   - Solution flow rate
   - Temperature of solution entering the heater
   - Ambient (room) temperature
   - Air currents around chamber

Cleaning

The **SHM output manifold** is removable to facilitate cleaning of the output path. (*See* image to the right.) Gently unscrew the retaining cap to reveal the manifold assembly. Replacement rubber o-rings (2) are supplied to extend the life of the instrument.

Maintenance

Salt solutions can be corrosive to metal components and can shorten the life of the heater if left in the unit during storage.

The heater should be flushed with distilled water and blown dry after each use to eliminate the effects of salt and moisture.

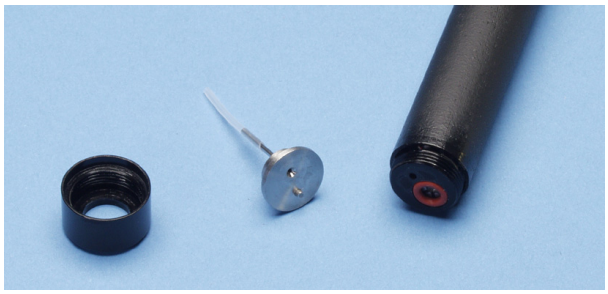
Outgassing

A common problem with rapid heating of solutions is outgassing. The bubbles formed can often cause blockages or disruptions to the flow in the chamber bath. An effective solution to this problem is to pre-warm the perfusate at the reservoir. Warner Instruments carries a full line of Solution Reservoir Heaters designed to work in concert with the **SHM Series** In-Line Solution Heaters.

Specifications

Heater resistance	10 Ω
Voltage requirement maximum	variable to 12 V
Maximum temperature	50 °C
Manifold dead volume	30 µl
Maximum flow rate	5 ml/min *

* See table next page



Physical Dimensions

Body	16.5 mm diameter x 16.5 cm long
Weight	104 g
Cable length	1.9 m
Warranty	1 year

Accessories

TA-29	Replacement cable with bead thermistor
TA-30	Replacement cable with glass thermistor
PE-160/10	Polyethylene tubing 3 meter
MB/B	Magnetic base
U9404	3-Prong clamp

Actual temperature at device outflow port as a function of flow rate.

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Set temp = 35 °C

Flow rate (ml/min)	Monitored temp (°C)	Output voltage (V)
1	34.0	4.44
2	33.4	5.20
3	32.5	5.72
4	31.7	6.10
5	31.0	6.86

Set temp = 37 °C

Flow rate (ml/min)	Monitored temp (°C)	Output voltages (V)
1	35.9	4.85
2	35.6	5.53
3	34.6	6.31
4	34.1	7.03
5	33.2	7.46

Set temp = 40 °C

Flow Rate (ml/min)	Monitored Temp (°C)	Output voltages (V)
1	38.9	5.22
2	38.2	6.13
3	37.3	6.87
4	36.3	7.45
5	36.7	7.52

Set temp = 45 °C

Flow Rate (ml/min)	Monitored Temp (°C)	Output voltages (V)
1	43.2	6.15
2	42.4	6.88
3	41.9	7.72
4	41.4	8.37
5	40.9	8.75

Set temp = 50 °C

Flow Rate (ml/min)	Monitored Temp (°C)	Output voltages (V)
1	47.9	6.89
2	47.4	7.85
3	47.2	8.95
4	46.2	9.69
5	44.6	10.3

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