



# MultiMode Heater/Cooler

## 392.1 Introduction

The MultiMode™ heater/cooler enables atomic force microscopy (AFM) at both reduced (down to -35°C) and elevated temperatures (up to 250°C) in a controlled environment. Primary components of the system include a heated probe holder, a heating element and/or a heating-cooling element, a specialized Heater/Cooler scanner with heat exchanger, Thermal Applications Controller (TAC), spacer block and silicone rubber seal.

This package is available as an option with the purchase of a new MultiMode AFM Microscope, or as a system upgrade. The system is compatible with the Bruker top-view microscopes (models OM2 and OMV).



**Document Revision History: MultiMode AFM Heater/Cooler**

Rev.	Date	Sections	Ref. DCR	Approval
F	01-20-2011	Re-branded		Ruth Wishengrad
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MultiMode™  
Dimension™  
BioScope™  
Atomic Force Profiler™ (AFP™)  
Dektak®

**Software Modes:**

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Tapping™  
TappingMode+™  
LiftMode™  
AutoTune™  
TurboScan™  
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**Miscellaneous:**

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- **Operation:** [page 36](#)
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### 392.1.1 Scope of this Document

This support note is a guide to the heating and heating/cooling accessories available for MultiMode Scanning Probe Microscopes. Additional information may be found in the Watlow *CLS200 Series User's Guide*, the Cole Parmer *Operating Manual: Masterflex L/S<sup>TM</sup> Compact Pump Drives* and the Cole Parmer *Masterflex L/S<sup>TM</sup> Standard Pump Heads* supplied with the Thermal Applications Controller.

### 392.1.2 Conventions and Definitions

**Note:** In the interest of clarity, certain nomenclature is preferred. A SPM *probe* comprises a *tip* affixed to a *cantilever* mounted on a *base*, which is inserted in a *probe holder*.




Three font styles distinguish among contexts. For example:

**Window or Menu Item** / **BUTTON OR PARAMETER NAME** is set to **VALUE**.


## 392.2 Safety Precautions

This chapter details safety requirements involved in the installation of the MultiMode Heater/Cooler. Specifically these safety requirements include all safety precautions, conditions and equipment safety applications. Training and compliance with all safety requirements are essential during installation and operation of the MultiMode AFM.

**Table 392.2a** Safety Symbols Key

Symbol	Definition
	This symbol identifies conditions or practices that could result in damage to the equipment or other property, and in extreme cases, possible personal injury.
	Ce symbole indique des conditions d'emploi ou des actions pouvant endommager les équipements ou accessoires, et qui, dans les cas extrêmes, peuvent conduire à des dommages corporels.
	Dieses Symbol beschreibt Zustaende oder Handlungen die das Geraet oder andere Gegenstaende beschadigen koennen und in Extremfaellen zu Verletzungen fuehren koennen.
	This symbol identifies conditions or practices that involve potential electric shock hazard.
	Ce symbole indique des conditions d'emploi ou des actions comportant un risque de choc électrique.
	Dieses Symbol beschreibt Zustaende oder Handlungen die einen elektrischen Schock verursachen koennen.
	This symbol identifies a thermal hazard. Touching could result in skin burns upon contact.
	Ce symbole indique un risque lié à des hautes températures. Un contact peut entraîner des brûlures de la peau.
	Dieses Symbol bedeutet "Heiße Oberfläche" Berührung kann zu Hautverbrennungen führen.

To avoid operator injury and equipment damage, observe the following cautions regarding MultiMode Heaters and Heater/Coolers.

	<p><b>CAUTION:</b> If you use the equipment in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.</p>
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**CAUTION:** *Only* qualified personnel aware of the hazards involved may perform service and adjustments.

**ATTENTION:** Toute réparation ou étalonnage doit être effectué par des personnes qualifiées et conscientes des dangers potentiels.

**VORSICHT:** Service- und Einstellarbeiten sollten nur von qualifizierten Personen, die sich der auftretenden Gefahren bewußt sind, durchgeführt werden.



**CAUTION:** Follow company and government safety regulations. Keep unauthorized personnel out of the area when working on equipment.

**ATTENTION:** Il est impératif de suivre les prérogatives imposées tant au niveau gouvernemental qu'au niveau des entreprises. Les personnes non autorisées ne peuvent rester près du système lorsque celui-ci fonctionne.

**VORSICHT:** Befolgen Sie die gesetzlichen Sicherheitsbestimmungen Ihres Landes. Halten Sie nicht autorisierte Personen während des Betriebs fern vom Gerät.



**WARNING:** Voltages supplied to and within certain areas of the system are potentially dangerous and can cause injury to personnel. Power-down everything and unplug from sources of power before doing ANY electrical servicing. (Bruker personnel, *only*).

**AVERTISSEMENT:** Les tensions utilisées dans le système sont potentiellement dangereuses et peuvent blesser les utilisateurs. Avant toute intervention électrique, ne pas oublier de débrancher le système. (Réservé au personnel de Bruker Group seulement).

**WARNUNG:** Die elektrischen Spannungen, die dem System zugeführt werden, sowie Spannungen im System selbst sind potentiell gefährlich und können zu Verletzungen von Personen führen. Bevor elektrische Servicearbeiten irgendwelcher Art durchgeführt werden ist das System auszuschalten und vom Netz zu trennen. (Nur Bruker Personal).



**CAUTION:** Use only de-ionized (DI), filtered water with the MultiMode Heating/Cooling system. Avoid contact between the electronics and the coolant (DI water). Only add coolant to the reservoir bottle, and only after setting up the coolant tubing according to the instructions. Avoid overfilling the reservoir as leakage could damage the electronics.

**ATTENTION:** Utiliser seulement de l'eau déionisée avec le système MMHCKIT. Eviter tout contact entre les composantes électroniques et le système de refroidissement (eau déionisée). N'ajouter de l'eau déionisée que dans le réservoir et seulement après avoir installé les tubulures selon les instructions. Eviter de faire déborder le réservoir car les fuites pourraient endommager les parties électroniques.

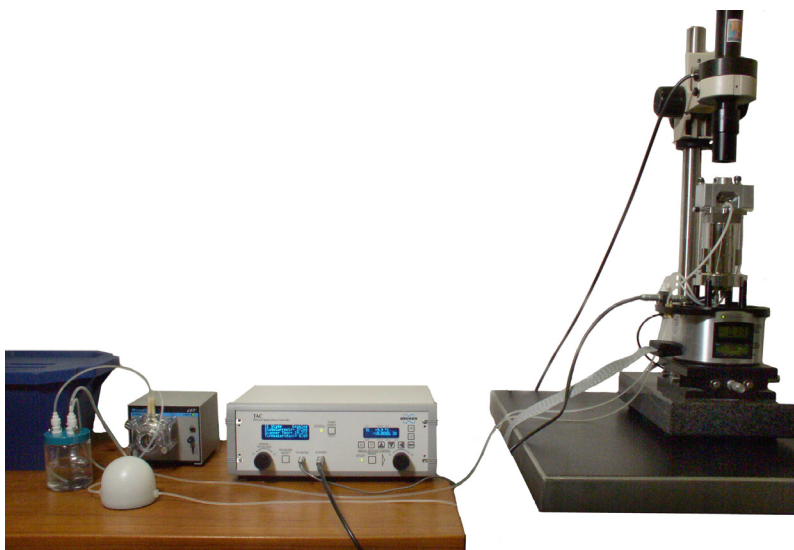
**VORSICHT:** Benutzen Sie nur de-ionisiertes (DI) Wasser mit dem Hoch-Temperatur System MMMCKIT. Vermeiden Sie Kontakt zwischen der Elektronik und dem Kühlmittel (DI Wasser). Füllen Sie das Kühlmittel nur in das Reservoir und auch nur nachdem Sie die Leitungen entsprechend der Anleitung angebracht haben. Vermeiden Sie, das Reservoir zu ueberfüllen, weil auslaufendes Wasser die Elektronik beschädigen kann.

### 392.3 Heater/Cooler Components

The heater/cooler components (see [Figure 3a](#)) are used to heat or cool the sample to the desired temperature. Set the controlled temperature to a value within the range of -35°C to 250°C.

**Note:** The temperature range depends on which heating element is installed and is discussed in **Heating and Cooling Elements:** [page 11](#).

**Figure 392.3a** Heater/Cooler with MultiMode Scanning Probe Microscope (SPM)



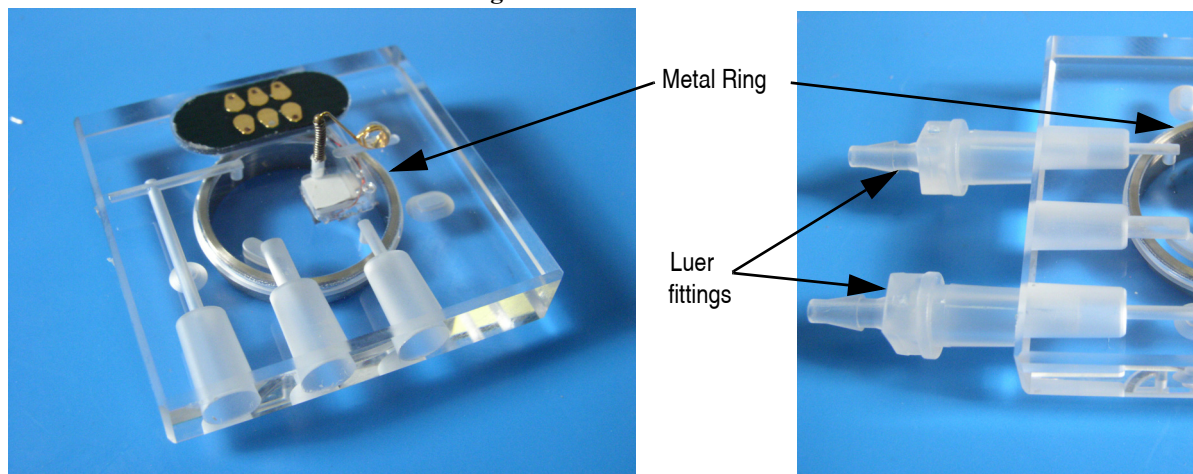
The Heater/Cooler and High Temperature Heater contain the following main components:

#### 392.3.1 Heated TappingMode (Air) Probe Holder, also called the Gas Cell

The heated TappingMode (air) probe holder is specifically designed for this application (US Patent No. 6,185,992, “Method and System for Increasing the Accuracy of a Probe-based Instrument Measuring a Heated Sample”). The holder allows for cantilever oscillation, tip heating, gas purging and external sensor access. Included with the probe holder is a silicone rubber seal acting as a sealed sample chamber for controlled atmosphere AFM operations. The transparent body of the probe holder is made of fused silica for optical clarity and low coefficient of thermal expansion.

Three Luer™ fittings connect to the front face of the probe holder. The two outside openings are for purge gas, and the middle opening (with larger diameter) acts as the optional sensor input (see [Figure 3b](#)). The metal ring on the bottom face of the holder seals the top end of the silicone rubber seal.

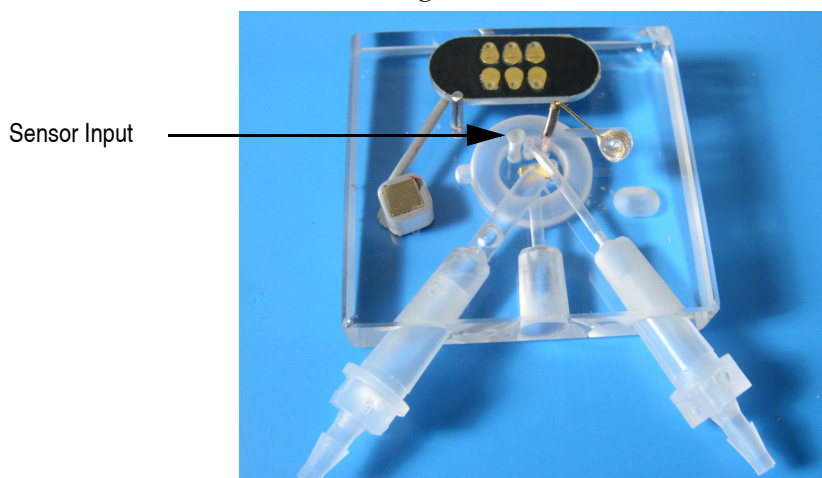


**Figure 392.3b** Gas Cell

### 392.3.2 Fluid Cell

The fluid cell, shown in [Figure 3c](#), allows for cantilever oscillation, fluid flow and external sensor access. The transparent body of the probe holder is made of glass for optical clarity.

Three Luer™ fittings connect to the front face of the probe holder. The two outside openings are for fluid flow, and the middle and top openings act as the optional electrode or sensor inputs (see [Figure 3c](#)).

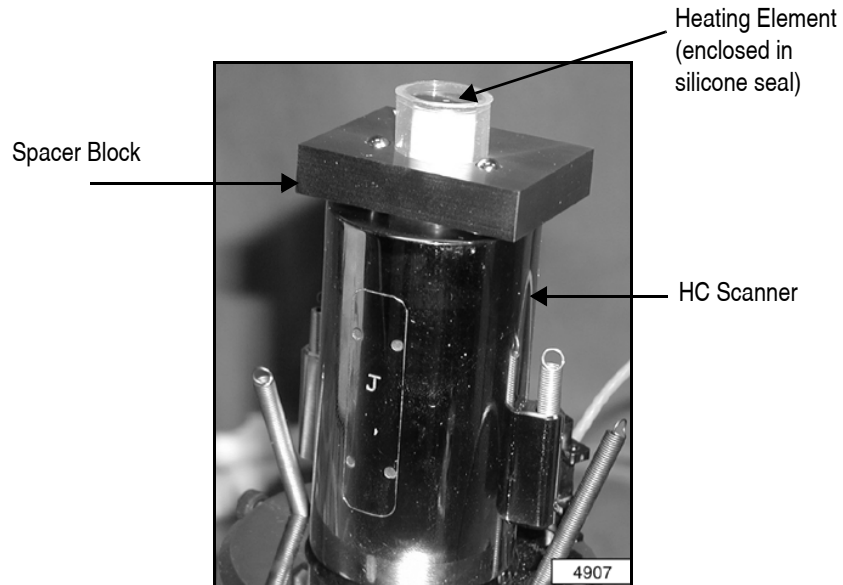
**Figure 392.3c** Fluid Cell

### 392.3.3 Spacer Block

The spacer block, located between the scanner and the head, adjusts the vertical height of the head in relation to the scanner (see [Figure 3d](#)). This allows for heating element insertion. The spacer block (in conjunction with the piezo guard on the scanner) also seals the bottom end of the silicone

seal. Form this seal by lightly compressing the bottom lip of the silicon seal between the piezo guard and spacer block.

**Figure 392.3d** High Temperature Heater Components

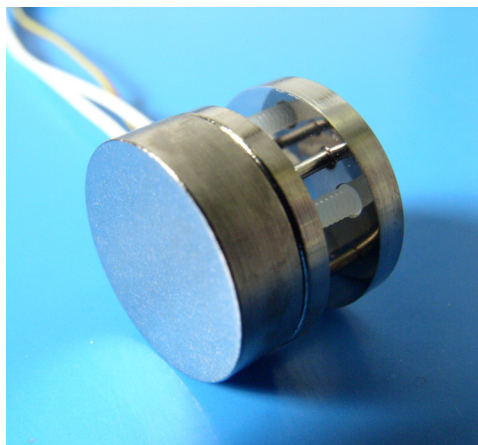


### 392.3.4 Heating and Cooling Elements

Three different heating and heating-cooling elements are available for the MultiMode:

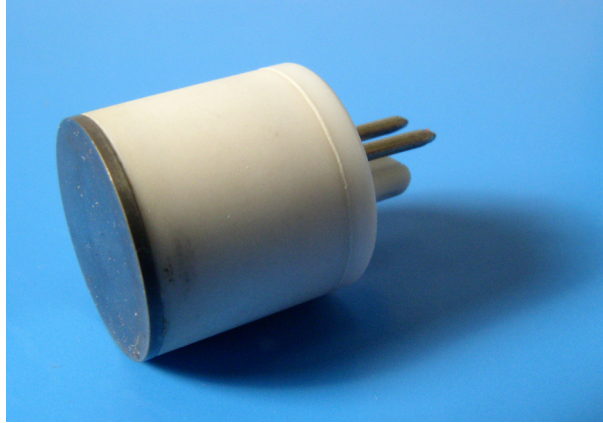
1. A 60°C heater element, shown in [Figure 3e](#). The Air/Fluid heater, also called a Bio-Heater, has a nickel-plated copper cap on top of a platinum resistive heater. A thermocouple sits between the copper cap and heater. An internal magnet is used to hold both the heater to the scanner and also holds a sample puck to the heater.

**Figure 392.3e** Air/Fluid Heater: Ambient to 60°C



2. A 250°C heater element, shown in [Figure 3f](#). The High Temperature Heater element includes a ceramic body and tungsten cap. Internal components include a platinum resistive type heater, a thermocouple and a magnet. The heater is located underneath the tungsten cap. The thermocouple is located inside the tungsten cap at the center of the heater approximately 0.1mm (0.004 inches) beneath the surface. The magnet is located inside the heater body.

**Figure 392.3f** High Temperature Heater: Ambient to 250°C



3. A -35°C to 100°C heater/cooler, shown in [Figure 3g](#). The Heater/Cooler element includes a Delrin body with a tungsten base and cap. Internal components include a multi-stage Peltier (thermoelectric) element and a thermocouple. The thermocouple is located directly under the tungsten cap at the center of the heater, approximately 0.5mm (0.020 inches) from the surface. The Heater/Cooler does not incorporate a magnet.

**Figure 392.3g** Heater/Cooler: -35°C to 100°C



The high temperature heater and heater/cooler elements plug into the connector on top of the specialized Heater/Cooler scanner with the fluid heat exchanger (see [Figure 3d](#)). The five contact pins on the bottom of the heater and heater/cooler elements, shown in [Figure 3h](#), include: two

thermocouple leads (large pins), two heater leads (two outer small brass pins), and one bias voltage lead to the cap (center small brass pin).

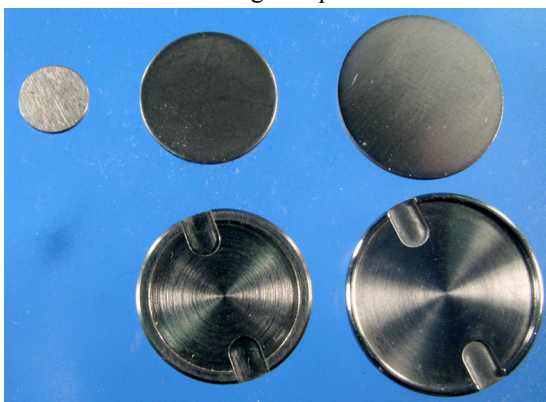
**Figure 392.3h** Contact Pins



### 392.3.5 Heater/Cooler Covers

The heater/cooler element is provided with two heater/cooler covers with matching sample pucks, shown in [Figure 3i](#). These allow larger sample size and are required for use with the fluid cell. Heater/cooler covers are designed to accommodate larger sample pucks and seal with the fluid cell. The added mass of these covers increases the minimum achievable temperature (reduces cooling capacity).

**Figure 392.3i** Heater/Cooler Covers with Matching Sample Pucks. Left: 6mm; Middle: 12mm; Right: 15mm



### **Sample Pucks**

Three sample pucks, shown in [Figure 3i](#), are available:

1. 6mm: Bruker P/N 130-006-121. To reach low temperatures using the -35°C to 100°C heater/cooler (< 0°C), you must use this puck or no puck.
2. 12mm: Bruker P/N 130-000-011.
3. 15mm: Bruker P/N 130-011-010.

### **392.3.6 Heater/Cooler Scanner with Cooling**

This specialized scanner is a modified version of a standard AS-130V scanner (see [Figure 3d](#)). Modifications include internal cabling and the addition of a water-fluid cooling system to remove heat from the Peltier or heating elements and protects the piezo scanner from overheating. The cooling system uses a thermocouple located at the top of the piezo crystal to provide an over-temperature safety control. The inlet and outlet fluid lines for the cooling system attach to the pump and reservoir bottle through the Luer fittings on the bottom of the scanner. Because the cooling system is a straight pass-through design, inlet and outlet ports are interchangeable.

In addition to the water-fluid cooling system, the cabling for the heating/cooling element is inside the scanner. The electrical power and the thermocouple outputs generated from the heating element and the fluid cooling system route to the controller via a 7-pin cable extending from the bottom of the scanner.

A second set of larger springs (MultiMode base springs) is provided with the scanner. We recommend using these springs (which attach from the base to the head) in addition to the springs on the scanner for better mechanical stabilization.

### **392.3.7 Stages**

A heater or heater/cooler element that is plugged into a scanner is referred to as a stage.

### 392.3.8 Thermal Applications Controller

#### Front Panel

Set and control the sample temperature by regulating the heater or heater/cooler element and tip heater voltage with the Thermal Applications Controller (TAC). This controller includes an over-temperature alarm mode that turns the heater off when the scanner temperature exceeds a factory setpoint. The Thermal Applications Controller front panel (see [Figure 3j](#)) consists of the following components:

- **Watlow™ Controller:** Use the **MANUAL SETPOINT ENABLE/DISABLE SWITCH** to enable/disable the **MANUAL SETPOINT CONTROL KNOB** on the Thermal Applications Controller which is used to set the target temperature.



**CAUTION:** This controller is pre-programmed at Bruker to provide easy and optimal control of the heater and heater/cooler element temperature. However, you may choose to re-program the controller for a particular application using the Watlow manual that is provided.

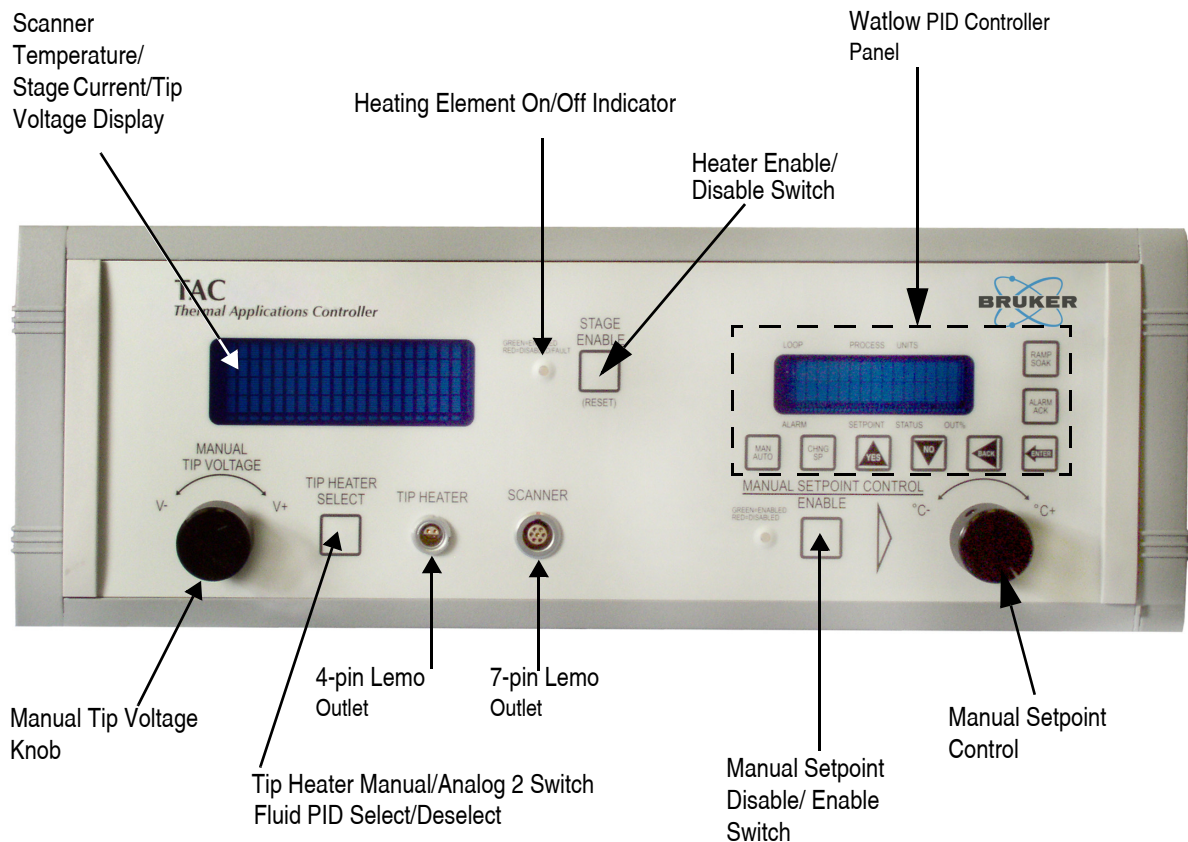
Bruker does not warranty the performance of the high temperature heater or heater/cooler at parameters different from those pre-programmed at the factory.

- The **MANUAL SETPOINT CONTROL ENABLE/DISABLE SWITCH** enables (green LED indicator)/disables (red LED indicator) the **MANUAL SETPOINT CONTROL KNOB**. The default setting is disabled. Enabling the **MANUAL SETPOINT CONTROL** transfers control of the Watlow controller from the **WATLOW CONTROL BUTTONS** (see [page 21](#)) to the **MANUAL SETPOINT CONTROL KNOB** and TAC firmware.

**Note:** For normal operation, switch the **MANUAL SETPOINT CONTROL** to **ENABLED** (green) before enabling the stage. The **MANUAL SETPOINT CONTROL** knob, rather than the Watlow control buttons, is then used to adjust the setpoint. When the **MANUAL SETPOINT CONTROL** is **DISABLED** (red), the Bruker-preset PID parameters are inactive. You may then use the **Watlow control buttons:** [page 21](#), to adjust setpoint and PID parameters.

- The **MANUAL SETPOINT CONTROL KNOB** is used to set the desired heater/cooler temperature, displayed on the second line of the right display, shown in [Figure 3n](#).
- The **STAGE ENABLE/DISABLE/RESET** switch on the front panel of the control box controls the power to the heating/cooling element. The indicator light turns **GREEN** when the heater/cooler output is enabled, and **RED** when the heater/cooler output is disabled.

**Figure 392.3j** Thermal Applications Controller (Front Panel)



- **Over-Temperature Alarm Shutdown:** The controller includes an over-temperature alarm independent of the Watlow controller. When in alarm mode, the indicator light turns red and power turns off to both the tip and sample heaters. The indicator light is located in the middle of the front panel of the control box. The factory programs the over-temperature setpoint.
- **Manual Tip Voltage:** The temperature of the tip heater inside the probe holder is controlled by the tip voltage.

There are three MultiMode system configuration options; the method of applying tip voltage depends on system configuration.

1. **Standard (Unextended) MultiMode:** Set the **TIP HEATER SELECT** switch to **MANUAL** (MAN on left display). The **ANALOG 2** switch setting is not functional in this system configuration. Adjust tip voltage with the **MANUAL TIP VOLTAGE KNOB**.
2. **Extended MultiMode, Extender Electronics Module and a NanoScope III or IIIA Controller:** Manual operation is the same as for the standard system configuration. To adjust tip voltage through NanoScope software, set the **TIP HEATER** switch to **ANALOG 2** (AN2 on the left display), set the **TIP OR SAMPLE VOLTAGE** switch on the Extender Module to **ANALOG 2**. Click the DI logo in the upper left of the Realtime window and select **Microscope Select > Edit > Advanced... > ANALOG 2**. Click **USER DEFINED**. **ANALOG 2** becomes a



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parameter in the **Feedback Controls** panel; enter numerical values to adjust it. If **ANALOG 2** does not appear as a parameter in the **Feedback Controls** panel, open its drop-down menu by clicking the dark hyphen in the grey box in the upper left corner of the panel. Click on **SHOW ALL ITEMS**. Select **ANALOG 2** for parameter **IMAGEMAINGROUP TIP BIAS CTL**.

3. **Extended MultiMode with a NanoScope IIIa Controller with Quadrex or a NanoScope IV Controller:** Manual operation is the same as for the other two system configurations. If **ANALOG 2** does not appear as a parameter in the **Feedback Controls** panel, open its drop-down menu by clicking the dark hyphen in the grey box in the upper left corner of the panel. Click on **SHOW ALL ITEMS**. Select **ANALOG 2** for parameter **IMAGEMAINGROUP TIP BIAS CTL**.

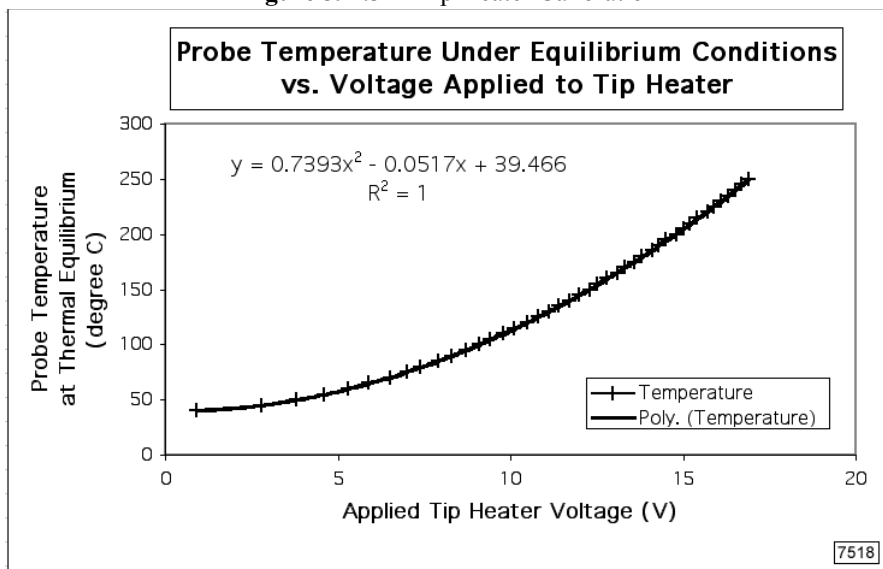
**Note:** In **MANUAL** mode the digital readout above the knob indicates the applied voltage. In **ANALOG 2** mode the digital readout indicates the voltage applied by the controller to the probe holder. This voltage is double the voltage set in **ANALOG 2**.

A calibration of temperature as a function of tip voltage appears in Figure 3k. Data points are indicated by crosses; the line is a second order polynomial fit to them. Use this table to set the tip voltage for the desired temperature.

Temperature as a Function of Tip Voltage Data  
(Plotted in Figure 3k)

Voltage (V)	Temp (deg.C)	Voltage (V)	Temp (deg.C)	Voltage (V)	Temp (deg.C)
0.9	40	10.1	115	14.3	190
2.8	45	10.5	120	14.5	195
3.8	50	10.8	125	14.8	200
4.6	55	11.1	130	15	205
5.3	60	11.4	135	15.2	210
5.9	65	11.7	140	15.4	215
6.5	70	12	145	15.7	220
7	75	12.3	150	15.9	225
7.4	80	12.5	155	16.1	230
7.9	85	12.8	160	16.3	235
8.3	90	13.1	165	16.5	240
8.7	95	13.3	170	16.7	245
9.1	100	13.6	175	16.9	250
9.4	105	13.8	180		
9.8	110	14.1	185		

Figure 392.3k Tip Heater Calibration



**Note:** Although a TIPHEATER voltage is shown on the front panel, the voltage to the tip heater is disabled when the TAC STAGE ENABLE switch is set to DISABLED. The STAGE ENABLE switch must be set to ENABLED to apply a voltage to the tip heater.

## Left Display

The left display panel, shown in [Figure 3l](#), shows, in order:

**Figure 392.3l** Left Display



1. Heater type (**TE STAGE** - ThermoElectric heater/cooler, **HEAT STAGE** - High Temperature heater or **LOW T STAGE** - Air/Fluid heater), **PID** parameters (air or fluid) and state (**ENABLED**, **DISABLED**, **ERROR**).
  - **FLUID PID SELECT:** Pushing the **TIP HEATER SELECT** button for more than 2 seconds changes the PID (Proportional, Integral, Derivative) control loop parameters of the Watlow controller from those appropriate for air operation to those appropriate for fluid operation. This is indicated by a message **-F**, shown in [Figure 3m](#), in the first line of the left display. When fluid PID parameters have been selected, pushing the **TIP HEATER SELECT** button for more than 2 seconds changes the PID control loop parameters of the Watlow controller back to those appropriate for air operation. No symbol is displayed for air PIDs.

**Figure 392.3m** PID set for Fluid



**Note:** **ERROR** messages include:

- **PID ALARM:** An alarm in the Watlow PID controller has been activated. The PID controller will give an alarm when the heater connection or thermocouple sensor connection have been disconnected. The PID controller will also give an alarm when a process variable hits a limit.

**Note:** A PID alarm will occur every time that a heater or heater/cooler element is unplugged from the scanner. After installing a new element onto the scanner, press the **STAGE ENABLE** button once to **RESET** the alarm. Press the **STAGE ENABLE** button a second time to enable the output of the Thermal Applications Controller.

- **SCANNER:** The thermocouple in the scanner which measures the piezo temperature has been disconnected. Usually it means the scanner is unplugged from the TAC. Press the **STAGE ENABLE** button once to **RESET** the alarm.
- **SCN TEMP:** The thermocouple that measures the scanner temperature reads 65°C. This protects the piezo scanner.

2. **STAGE** (heater or heater/cooler) **CURRENT**.

3. **SCANNER TEMPERATURE**.

**Note:** The **SCANNER TEMPERATURE** displays the air temperature and is not valid when using the Air/Fluid (Bio) Heater.

**Note:** The output of the TAC is disabled when the piezo scanner temperature exceeds 65°C. If using the Air/Fluid (Bio) Heater, the output of the TAC is disabled when the stage temperature reaches 65°C.

4. **TIP HEATER** Voltage and source (**MANUAL** or **ANALOG 2**).

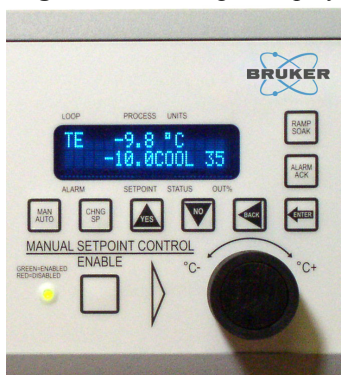
### Right Display

The right display panel, shown in [Figure 3n](#), shows, in order:

1. Control loop type (**TE** - ThermoElectric or **HT** - Heat Type) and stage temperature.
2. Stage set point, PID loop and output percentage.

**Note:** PID loops of **COOL**, **HEAT** or **AUTO** indicate that the output is **ON**. **MAN** with 0 percent output indicates that the output is **OFF**.

Figure 392.3n Right Display



### Watlow control buttons

The touch pad controls adjacent to the right display, shown in Figure 3n, provide full access to the Watlow controller features. Because the Watlow controller has been pre-programmed at Bruker, few users will need to use these controls. Information about them may be found in the Watlow *CLS200 Series User's Guide*, supplied with the Thermal Applications Controller. This *User's Guide* may also be downloaded from [http://www.watlow.com/literature/pti\\_search.cfm](http://www.watlow.com/literature/pti_search.cfm). The file is [http://www.watlow.com/literature/prodtechinfo/files/controllers/cls2e\\_c.pdf](http://www.watlow.com/literature/prodtechinfo/files/controllers/cls2e_c.pdf).



**CAUTION:** The temperature setpoint is limited by Bruker-supplied Watlow firmware to values shown in Table 3o. These minimum and maximum setpoint and the high temperature alarm, which turns off the stage current, values must never be changed.

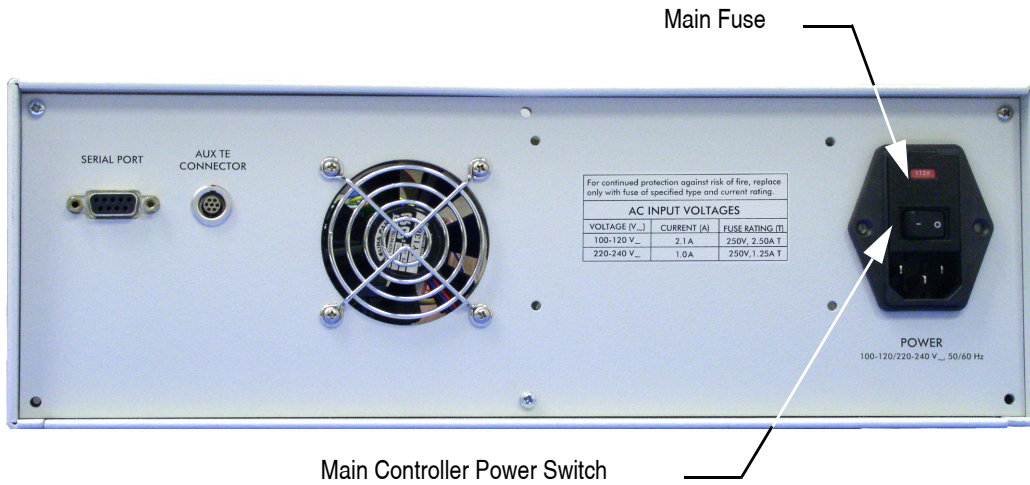
Table 392.3o Stage Values


Stage Type	Minimum Setpoint	Maximum Setpoint	High Temperature Alarm
HEAT STAGE	0°C	250°C	275°C
TE STAGE	-40°C	100°C	110°C
LOW T STAGE	0°C	62.5°C	65°C

Rear Panel

- **Controller Power:** The **POWER** plug, **SWITCH** and main fuse are located on the back of the control box.
- The **SERIAL PORT** and **AUX TE CONNECTOR** are, at present, not used.

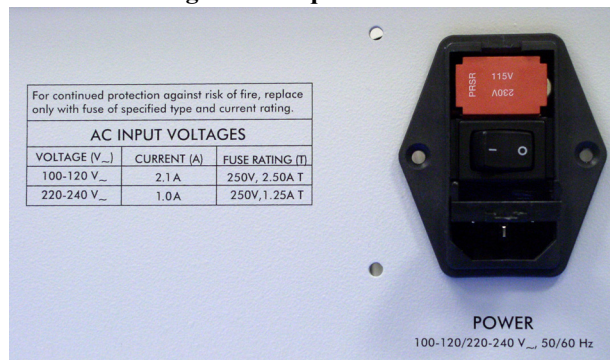
Figure 392.3p Thermal Applications Controller (Rear Panel)



 **CAUTION:** Assure that the voltage configuration is set to the appropriate regional power supply. An incorrect setting may cause equipment damage (i.e., a blown fuse).

Using a small screwdriver, change the operating voltage by opening the fuse box cover from the top, shown in Figure 3q, and removing and rotating the fuse holder.

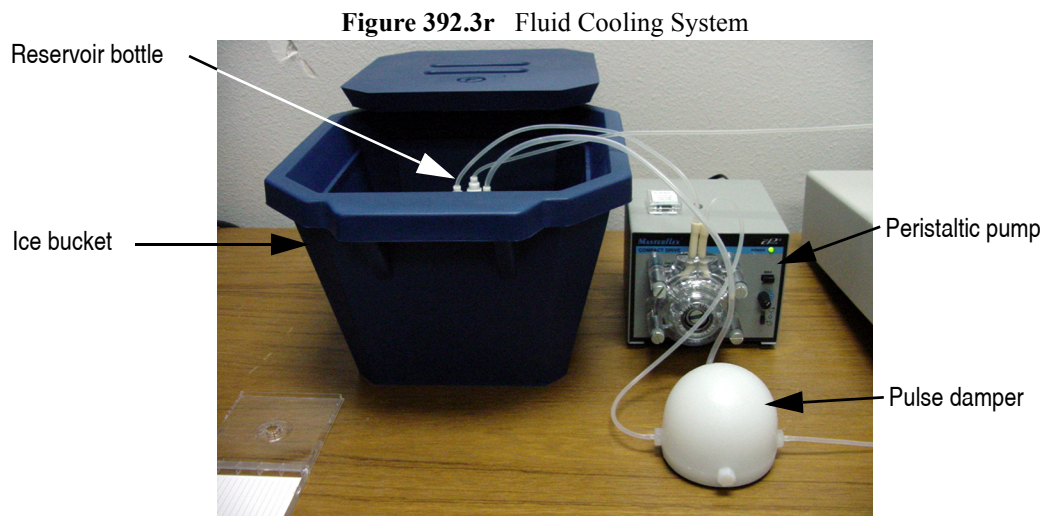
Figure 392.3q Fuse Holder



### 392.3.9 Scanner Cooling system

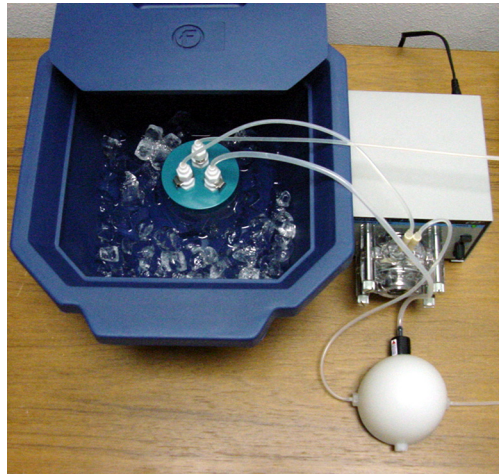
The fluid cooling system, shown in [Figure 3r](#), cools the piezo crystal inside the scanner from the heat generated (or transferred) by the heater or heater/cooler and removes heat from the thermoelectric device during sub-ambient operation. The following components comprise the scanner cooling system:

- Peristaltic pump
- Reservoir bottle and silicone tubes
- Fluid safety sleeve
- Pulse damper
- Ice bucket
- Manifold ring



- **Reservoir Bottle and Silicone Tubes:** The fluid cooling system includes a reservoir bottle and silicone tubes (see bottom of [Figure 3s](#)). The cooling fluid flows from the reservoir bottle to the pump, through the scanner, and back to the reservoir bottle. The pump-side of the bottle includes a fitting with the silicone suction tube inside the bottle. The tubing is standard 1/16" (1.59mm) ID x 1/8" (3.2mm) OD silicone tubing.

**Figure 392.3s** Reservoir Bottle in Ice Bucket



- **Fluid Safety Sleeve:** The MultiMode scanner and its base are protected from water leakage at the scanner/hose interface by the fluid safety sleeve. The sleeve is a 1.5" (3.8cm) wide, 1.5 mil (0.038mm) thickness, 5' (1.524m) long piece of poly-tubing. A 6" (15.2cm) length of the tubing is fitted over the bottom of the scanner and around the connecting hoses.
- **Scanner Extension and Tip Heater Cables:** The scanner extension and tip heater cables attach to the two Lemo connectors on the front panel of the control box. The scanner cable connects to the 7-pin connector and the tip heater cable connects to the 4-pin connector. The opposite end of the tip heater cable acts as a required adapter between the MultiMode base and head cable (see [Figure 3t](#)).

**Figure 392.3t** Inline Adapter: MultiMode Base to Head Cable





## 392.4 Installation

### 392.4.1 General Setup

1. Unpack the system and verify that the following items are included:
  - All systems:
    - Heated TappingMode (Air) Probe Holder and/or Fluid Tip Probe Holder
    - Spacer Block
    - Heating Element and/or Heating/Cooling Element
    - Thermal Applications Controller
  - Systems with a High Temperature Heater and/or a Heater/Cooler:
    - Heating/Cooling Scanner
    - Tip Heater Cable
    - Reservoir Bottle and Silicone Tubes
    - Fluid Safety Sleeve
    - Ice Bucket
    - Manifold ring
    - Scanner extension cable
2. Verify that the controller is set to the appropriate voltage configuration for the regional power supply (see [Figure 3p](#)).

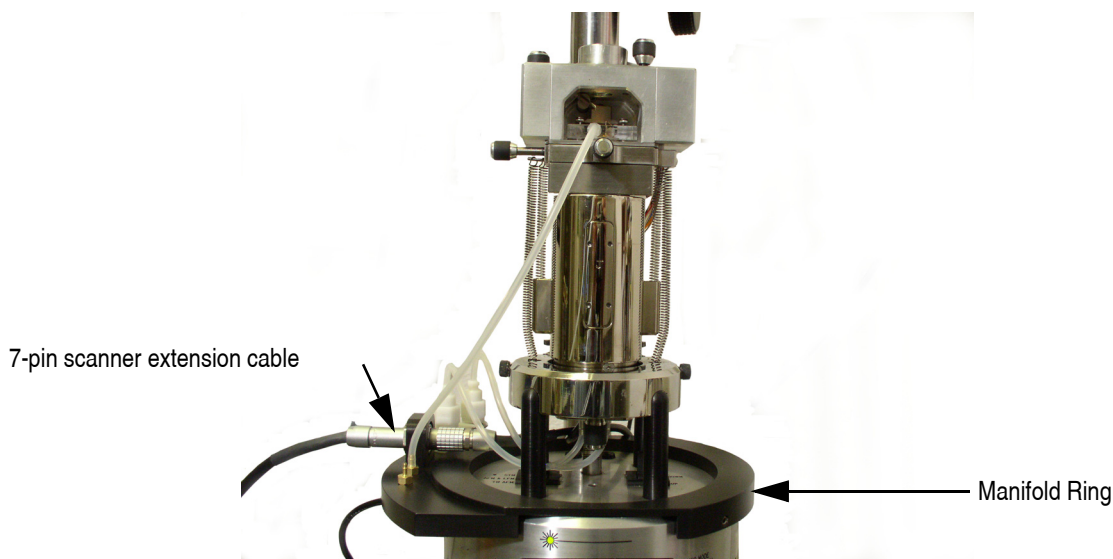


**CAUTION:** Do not obstruct the ventilation slots of the Thermal Applications Controller.

3. Set the **MAIN CONTROLLER POWER** switch to **OFF**. Plug the power cord into the rear panel of the controller and into the power supply (see [Figure 3p](#)).
4. Verify that the power disconnect device is readily accessible.
5. Set the **MAIN CONTROLLER POWER** switch to **ON** (see [Figure 3p](#)), and verify the controller has power (see [Figure 3j](#)).

6. If you are installing a 60°C heater element (“BioHeater”), skip to **Installation of the 60°C heater element**: [Section 392.4.3](#).
7. Install the MultiMode base springs (see [Figure 3a](#) and [Figure 4i](#)).
8. Place the manifold ring on the MultiMode base with the cables and connectors on the left side as shown in [Figure 4a](#). Tighten the two set screws to secure it to the MultiMode base with the supplied 5/64” Allen wrench (hex key).

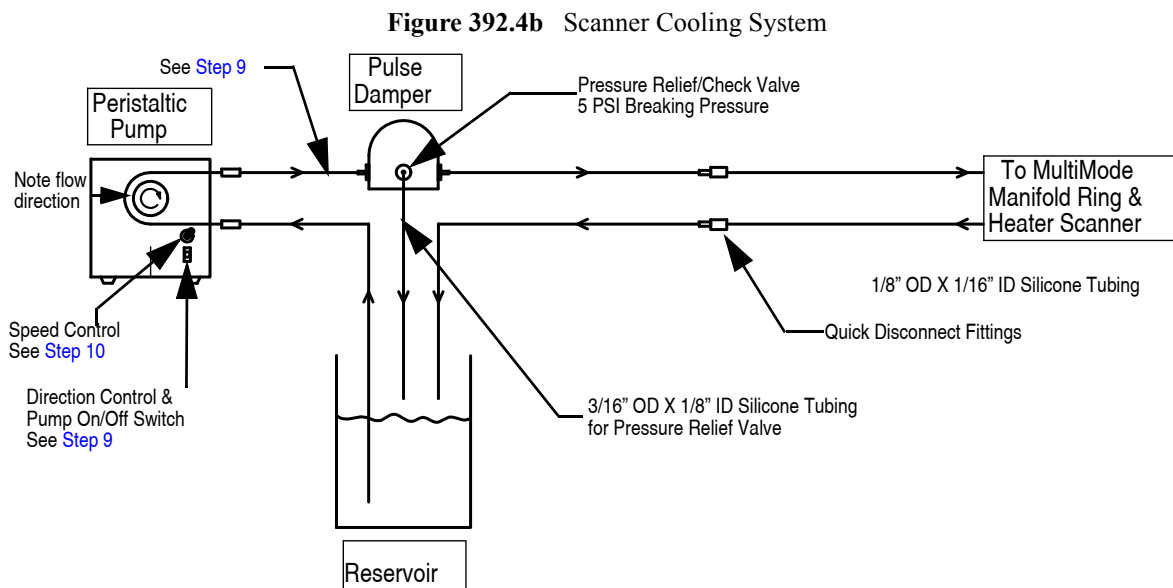
**Figure 392.4a** Manifold Ring



9. Mount the scanner to the MultiMode base by completing the following:
  - a. Route the scanner cable and silicone tubes through the opening in the base.
  - b. Secure the scanner mechanically with the stabilizing screw.
10. Plug the 9-pin cable of the scanner into the 9-pin receptacle on the MultiMode base.
11. Plug the 7-pin Lemo connector on the cable from the scanner base into the 7-pin receptacle on the manifold ring, shown in [Figure 4a](#).
12. Plug the 7-pin Lemo connector on the scanner extension cable, attached to the manifold ring, into the 7-pin scanner receptacle on the front panel of the Thermal Applications Controller (see [Figure 3j](#)).
13. Plug the 4-pin tip heater cable into the 4-pin receptacle on the front panel of the Thermal Applications Controller (see [Figure 3j](#)). Use the other end of the cable as a connector between the MultiMode head cable and the corresponding base receptacle (see [Figure 3t](#)).

### 392.4.2 Assemble the Cooling System

A block diagram of the cooling system is shown in [Figure 4b](#).

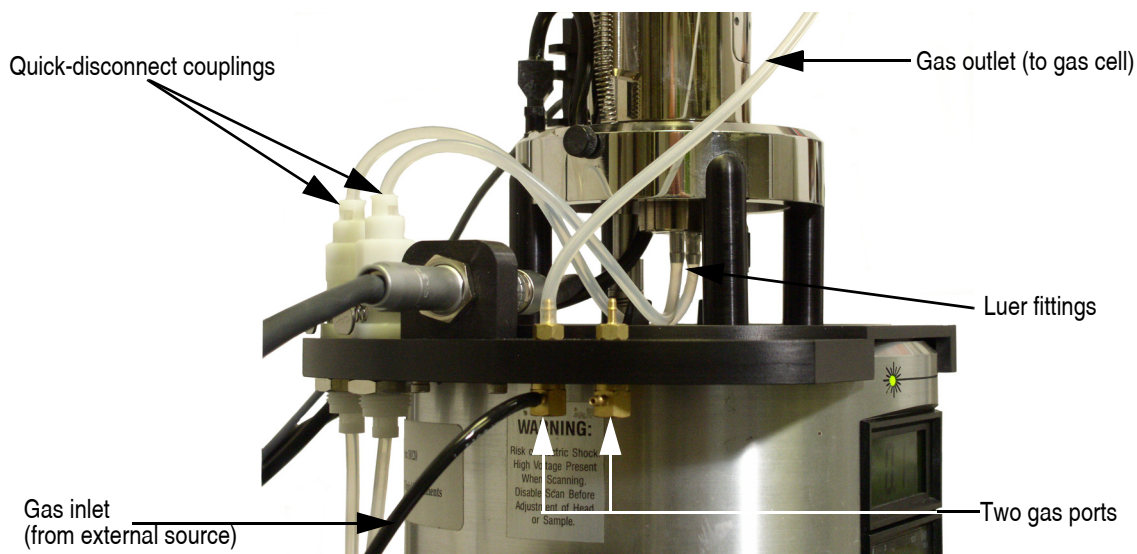


Connect the cooling system as follows (see [Figure 4b](#)):

1. Cut two short lengths of tubing and route them from the top of the quick-disconnect couplings on the manifold ring to the Luer fittings on the bottom of the scanner as shown in [Figure 4c](#).

**Note:** These Colder Products Company (CPC) quick-disconnect couplings are both fluid and gas-compatible and include a spring-operated 316 SS valve that seals the flow path when fitting halves are disengaged.

**Figure 392.4c** Connections Using the Manifold Ring



2. Connect (either) one of the lines from the quick-disconnect fittings on the manifold ring to one end of the pulse damper, shown in [Figure 3r](#) and [Figure 4a](#).
  3. Connect a line at the opposite end of the pulse damper to the peristaltic pump.
  4. Connect the other line from the peristaltic pump to the quick-disconnect fitting on the reservoir bottle labeled **PUMP**.
  5. Cut a short (approximately 2" (5cm)) length of silicone tubing and connect it to the bottle side of the **PUMP** quick-disconnect fitting on the reservoir bottle.
- Note:** This ensures that fluid is pulled from the reservoir bottle for scanner cooling.
6. Connect the other line from the manifold ring to the reservoir bottle connection labeled **SCANNER**.
  7. Connect a 3/16" OD line from the unlabeled reservoir bottle connection to the pulse damper.
  8. Fill the reservoir bottle approximately 3/4 full with distilled, filtered water.
  9. Toggle the pump switch to **ON**, as shown in [Figure 4b](#), so that the fluid flows from the reservoir to the pump, through the pulse damper and into the MultiMode AFM. Allow the pump to run until all the lines are filled with water and drips appear on the scanner side of the reservoir bottle connector. This takes a few minutes. The reservoir bottle fluid level should remain at a constant height once the cooling circuit has been primed. The reservoir bottle remains half full once the circuit is full.

**Note:** The pulse damper greatly reduces mechanical noise from the peristaltic pump.

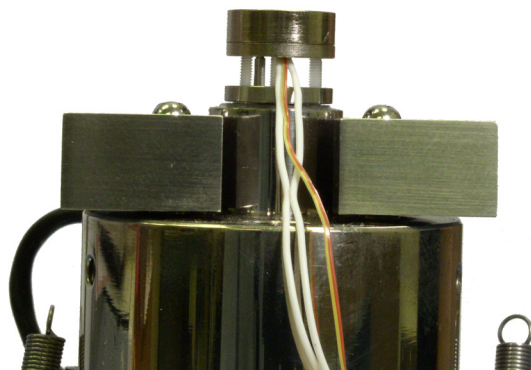
10. Use the lowest speed (full counter-clockwise knob setting) for heating. Increase the pump speed, as needed, to keep the scanner temperature low. Sample cooling, which transfers heat from the sample to the scanner, will generally require higher pump speeds than heating.

**Note:** The maximum pump speed during normal operation must be limited to 1/3 of the full, clockwise, range. Higher flow rates may cause leakage over time.

### 392.4.3 Installation of the 60°C heater element

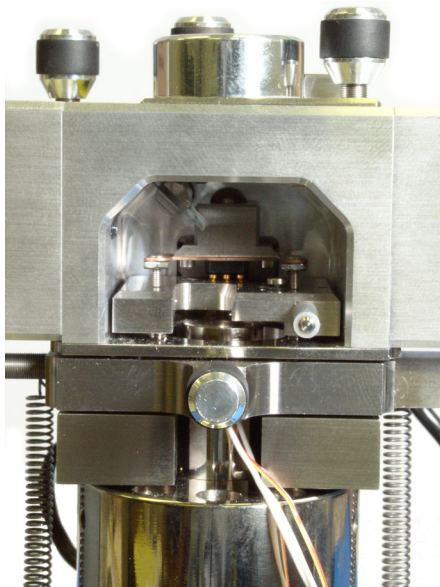
1. Remove the springs holding the head to the scanner
2. Unplug and remove the head from the MultiMode base.
3. Install the spacer block by completing the following:
  - a. Slide the spacer block straight down.
  - b. The spacer block should be centered and level.
  - c. Verify that the grooves on the bottom of the spacer block align with the positioning balls on the top of the scanner and that the spacer block is sitting flat.
4. Place the heater, as shown in [Figure 4d](#), on the scanner. The magnet will hold it in place. You may wish to tape the wires to the scanner.

**Figure 392.4d** 60°C Heater Element and Spacer



5. Replace the head and secure it to the scanner with the springs, shown in [Figure 4e](#).

**Figure 392.4e** Head, 60°C Heater Element and Spacer



6. Connect the 7-pin Lemo to DB9 adapter cable to the heater, shown in [Figure 4f](#).

**Figure 392.4f** Adapter Cable, Head, 60°C Heater Element and Spacer



7. Plug the 7-pin Lemo connector on the adapter cable into the 7-pin scanner receptacle on the front panel of the Thermal Applications Controller (see [Figure 3j](#)).
8. Select a probe holder typically a Fluid Cell, shown in [Figure 3c](#), or a MultiMode air probe holder, shown in [Figure 3b](#). Refer to the *MultiMode Manual* for more information.
9. Install a probe in the probe holder if you haven't already.

10. Load the sample.
11. Insert the probe holder into the head.
12. For Fluid Cell operation, refer to Support Note 290, *Guidelines for Fluid Operation with a MultiMode AFM*. Use an O-ring to prevent fluid evaporation.
13. Tighten the middle knob on the back of the head to lower the clamp onto the probe holder to secure it in place.
14. Align the laser beam to reflect into the photodetector from the tip-end of the cantilever (refer to the *MultiMode Scanning Probe Microscope Instruction Manual*, Chapter 5 for detail).

**Note:** The system is now ready for use.



**CAUTION:** The surface of the heating element can be hot. Touching could result in burns on contact.

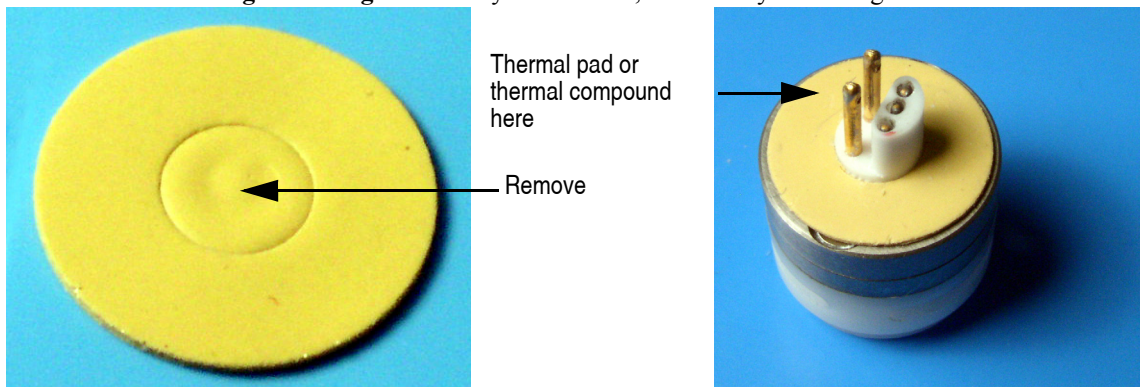
#### 392.4.4 Installation of the High Temperature Heater or Heater/Cooler Element

The thermoelectric heater/cooler element transfers heat from one side of the element to the other side. Thus it requires good thermal conduction between the heater/cooling element and the cooling water in the scanner. Bruker provides thermally conductive, electrically insulating pads, shown in [Figure 4g](#), (reorder Bruker part number 499-000-261) to accomplish this task. You may also use Wakefield Engineering Thermal Compound, Wakefield Engineering ([www.wakefield.com](http://www.wakefield.com)) part number 120-2, but because it is messier, thermal pads are generally preferred. Wakefield Engineering Thermal Compound may be required to reach temperatures below  $-20^{\circ}\text{C}$ .

1. If you are using a heater/cooler element, place a thermally conductive, electrically insulating pad or spread thermal compound on the base of the heater/cooler element. See [Figure 4g](#). If you are using thermal compound on the base of the heater, also spread some thermal compound onto the mating surface of the scanner.

**Note:** Remove the center section to place the pad on the heater/cooler element.

**Figure 392.4g** Thermally Conductive, Electrically Insulating Pad



**Note:** The shelf life of the thermal pads is 1 year.

	<p><b>CAUTION:</b> Use the thermally conductive pads only on the heater/cooler element. Do not use them with the high temperature heater element. The high temperature heater element is designed to be thermally insulated from the scanner.</p>
--	---

2. Insert the heating element into the connector on the top of the scanner (see [Figure 4h](#), image a). You may place the sample puck and sample on the heating element as shown or wait until step 5.

**Note:** Spread a small amount of thermal compound under the sample puck if you are using the heater/cooler element.

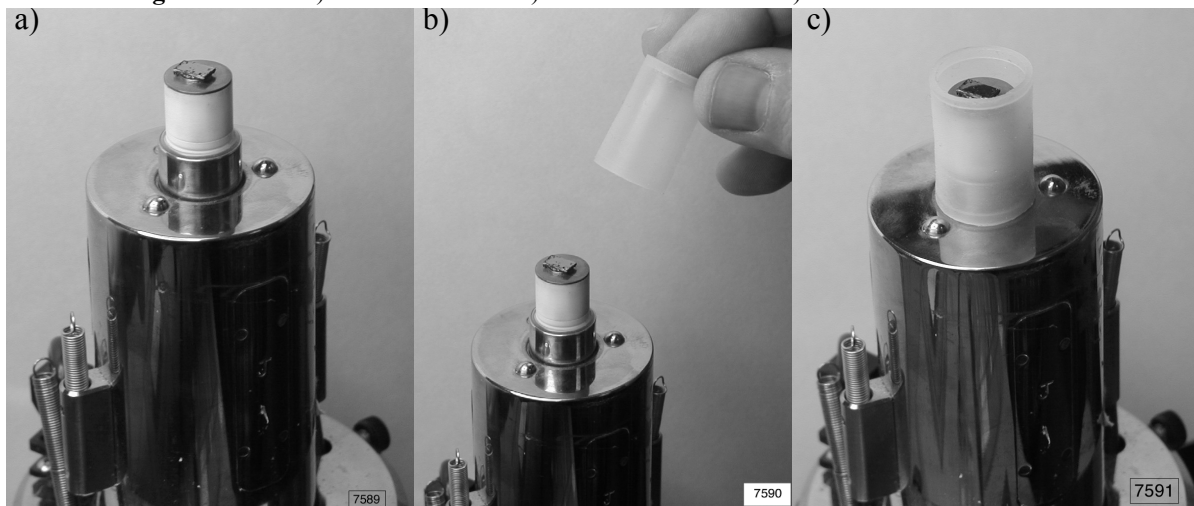
	<p><b>CAUTION:</b> The heating element must be plugged in and unplugged in a straight orientation (no side-to-side motion). Failing to do so can cause damage to the piezo crystal.</p>
--	---

	<p><b>CAUTION:</b> The heater/cooler element is extremely delicate. Always handle it with care. Do not drop it. The top of the element is particularly delicate. Do not set it on a table with the top side facing down. When not in use, keep it in its protective foam box. Clean the element gently with a cotton swab and isopropyl alcohol.</p>
--	--



3. If needed to facilitate installation, lubricate the silicone seal and piezo guard with the provided silicone grease.
4. Place the silicone seal around the heating element and scanner piezo guard. Press down on the seal until it rests against the top of the scanner body (see [Figure 4h](#), images b and c).

**Figure 392.4h** c) Placement of the b) Silicone Seal Around a) the Heater on the Scanner



5. Install the spacer block by completing the following:
  - a. Slide the spacer block straight down and around the silicone seal.

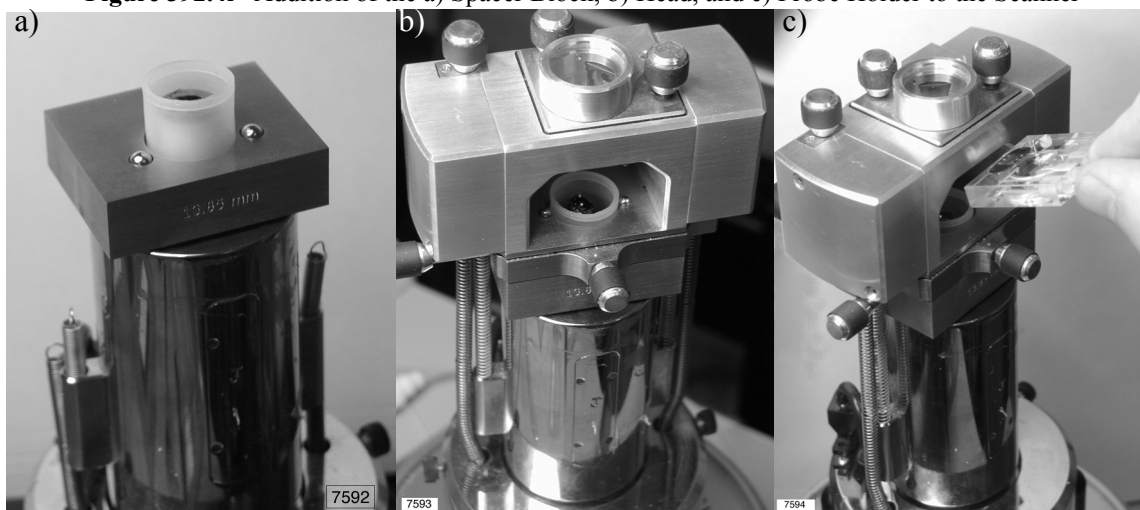


**CAUTION:** Do not hit the heater/cooler element. It is fragile.

**Note:** Initial setup may require the use of the silicone lubricant provided.

- b. Verify that the fit between the seal and the block is tight. The spacer block should be centered and level.
- c. Verify that the grooves on the bottom of the spacer block align with the positioning balls on the top of the scanner (see [Figure 4h](#) and [Figure 4i](#), image a) and that the spacer block is sitting flat.

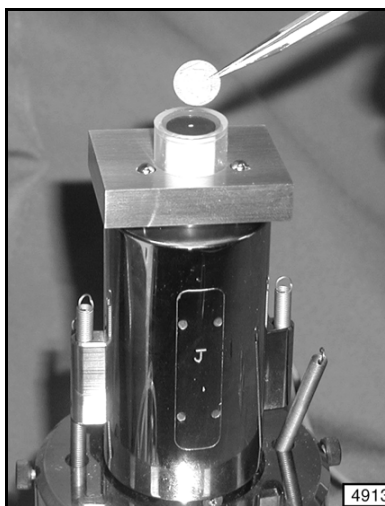
**Figure 392.4i** Addition of the a) Spacer Block, b) Head, and c) Probe Holder to the Scanner



6. Place the sample puck (with the sample pre-mounted) on top and centered on the heating element (see [Figure 4j](#)) if you haven't done so already.

**Note:** Spread a small amount of thermal compound under the sample puck if you are using the heater/cooler element.

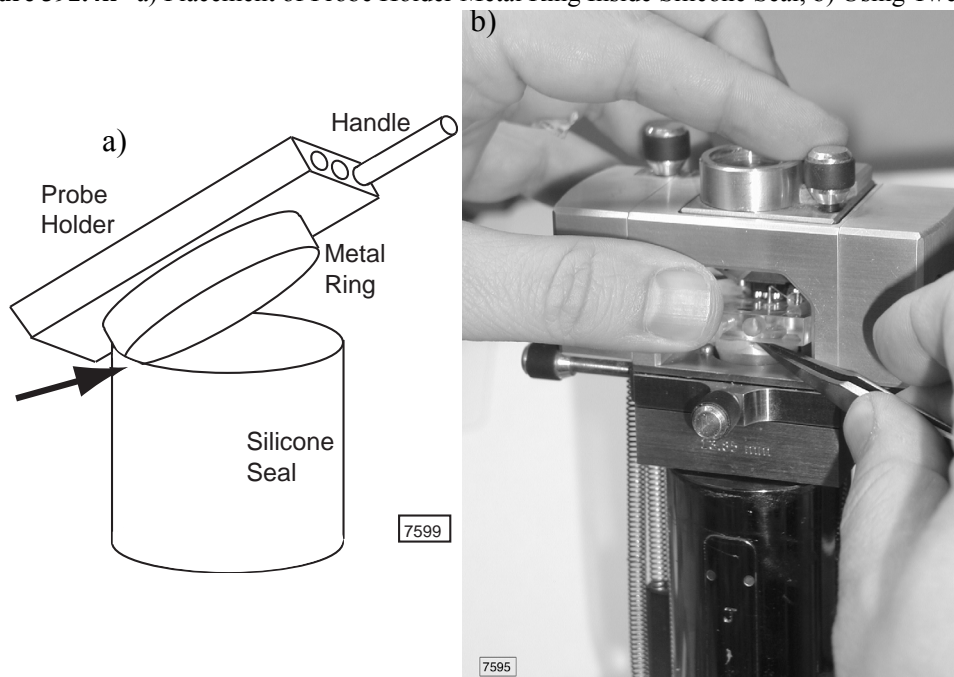
**Figure 392.4j** Positioning a Sample Puck



7. Position the MultiMode head on the spacer block (see [Figure 4i](#), image b). Secure the head to the scanner with the four springs.
8. Use the **TIP UP** switch on the MultiMode base to move the head and spacer block upward with respect to the sample. This will help to avoid damage to the sample when inserting the probe holder.

9. Insert a spare Luer fitting (see [Figure 3b](#))—to be used as a handle—into one of the three openings on the front face of the probe holder (see [Figure 4k](#), image a). Fully raise the probe holder clamp inside the head to get it out of the way for probe holder placement.
10. Install a probe in the probe holder if you haven't already.
11. Holding the probe holder by its Luer handle, tilt it up while approaching the head (see [Figure 4i](#), image c).
12. Insert the probe holder into the head so the outer edge of the metal ring on the base of the probe holder presses against the inside of the silicone seal (see [Figure 4k](#), image a). Using *blunt* tweezers to avoid puncturing the silicone seal, gently lift the silicone seal around the metal ring while lowering the probe holder onto the silicone seal (see [Figure 4k](#), image b).

**Figure 392.4k** a) Placement of Probe Holder Metal Ring Inside Silicone Seal, b) Using Tweezers



**Note:** Because the probe holder is transparent, you can verify that the seal encloses the entire metal ring and touches the body of the probe holder all the way around the ring.

13. Tighten the middle knob on the back of the head to lower the clamp onto the probe holder to secure it in place.
14. Align the laser beam to reflect into the photodetector from the tip-end of the cantilever (refer to the *MultiMode Scanning Probe Microscope Instruction Manual*, Chapter 5 for detail).

**Note:** The system is now ready for use.



**CAUTION:** The surface of the heating element can be hot. Touching could result in burns on contact.

## 392.5 Operation

The High Temperature Heater and Heater/Cooler have been extensively tested imaging polymer samples in TappingMode, but can also be applied to studies of other materials and in other modes.

**Note:** Adjustment of the tip heater (**TIP VOLTAGE**) varies with system configuration (standard MultiMode versus Extended MultiMode with NanoScope III/IIIA Controller versus Extended MultiMode with NanoScope IV Controller, see Tip Voltage, [page 16](#))

### 392.5.1 Probes

Uncoated etched silicon probes work best for heating/cooling in a gas environment. Bi-metallic or coated probes may produce unwanted heat-induced bending.

### 392.5.2 Fluid Cell Operation

The fluid cell requires that a heater/cooler cover, with matching sample puck be placed on top of the heater/cooler element as shown in [Figure 5a](#). Smear Wakefield Thermal Compound on all mating surfaces before putting them together.

**Figure 392.5a** 12mm (left) and 15mm (right) Heater/Cooler Covers on the Heater/Cooler Element



### 392.5.3 Samples

Thin films on a small (1/4 inch, or 6.3mm diameter) metallic puck are most suitable for AFM studies at elevated temperature. In such cases, sample temperature is within 1°C of that measured by the heater thermocouple. Larger pucks and thick samples can be placed on the heater surface, but keep in mind the limited power output of the heater and the possibility of the sample temperature being less than that indicated by the heater thermocouple.

A magnet incorporated in the heater element holds the metallic sample puck to the heater surface. Samples consisting of a film on a flat substrate (such as mica, a silicon wafer, graphite, etc.) or a small block of material with a flat top surface, should be glued to the puck. Choice of glue can be quite significant for imaging at temperatures above 100°C. Epoxy-based glues may contain volatile components or may decompose in the heat. An exuded material condensed on inner surfaces of the heater/probe holder chamber can reduce transparency, thus disturbing the laser beam. (Heating the probe prevents condensation of volatile material on the cantilever itself.) Low molecular weight materials, which are often added to industrial polymers, may rise to, and thereby alter, the polymer surface being imaged. For example, industrial polypropylene contains a constituent which appears as large droplets on the polymer surface at high temperatures (but below the polymer melting point).



**CAUTION:** Exercise caution handling sample pucks or performing other manipulations in the vicinity of the heater element installed in its socket. Lateral forces applied to the heater can damage the expensive scanner tube.

### 392.5.4 Experimentation

Prior to imaging samples at non-ambient temperatures, inspect the cooling lines for air bubbles. Bubbles can destabilize temperature control of the sample. A few minutes of pumping prior to heating is sufficient to eliminate bubbles from the coolant. This is always advisable after the system has been off for several hours. Verify that fluid flows at the output of the reservoir.

In a typical experiment, a sample is examined at room temperature before its temperature is changed to a target value.



**CAUTION:** Disengage the probe from the sample prior to heating to avoid unwanted contact as the sample and heater components expand with temperature. Only small (5-10°C) temperature increases can be performed safely without tip withdrawal. By the same logic, large (>30°C) temperature rises require further removal of the probetip from the sample.

When the target temperature is reached and the sample has had 3-5 minutes to reach equilibrium, it is essential to check the resonant frequency of the cantilever, which decreases slightly with elevated temperature. It is worth watching the cantilever amplitude sweep during heating to confirm sample temperature stabilization at the target because cantilever resonance is a sensitive function of temperature. Retune the cantilever drive frequency after the temperature has stabilized.

**Note:** In imaging polymers at elevated temperatures, higher probe (tapping) drive amplitude may be required to overcome increased sample stickiness.

Measurements at temperatures up to 75°C can be performed without powering the probe heater. However, when operating at higher temperatures, it is advised to use the Tip Heater to avoid condensation of moisture or the deposition of volatile sample components on the cantilever. These contaminants can destabilize the cantilever resonance and reduce the optical reflectivity to the laser beam.

Stable imaging in TappingMode is the main purpose of the Tip Heater. Due to difficulties in measuring probe temperature, its heating is regulated by a voltage applied to the heater, which is installed in direct contact with the probe substrate. An increase of 1 volt raises substrate temperature approximately 10°C. It has been demonstrated that the application of  $\delta 7V$  is sufficient for stable imaging in the range of 75-140°C. The applied voltage needed gradually increases for imaging at higher temperatures. However, long-term operation at voltages above 15V may diminish the life of the piezostack-activated probe tapping oscillator.

**Note:** Use of the probe heater may lead to a slight change in the average level of the probe, causing a shift of the reflected laser beam away from the center of the position-sensitive detector. Therefore, during high temperature operation, watch the differential (A-B) signal from the vertical segments of the detector and adjust manually as needed. Also, the heater can influence the coupling between the piezostack and the cantilever, requiring a different drive amplitude to generate, for instance, 2V RMS oscillation of the cantilever at a different temperature. Again, it is worth monitoring the cantilever amplitude sweep (cantilever Tune) and retuning the cantilever to a target oscillation amplitude after the amplitude-vs.-frequency curve has stabilized following a temperature adjustment.

### **392.5.5 X, Y, Z Calibration**

The Heater/Cooler scanner provides modified parameters including: an increased scanning range and decreased bow characteristics (less than 100nm in 100 $\mu$ m). This is due to the extended length of the scanner. Bruker calibrates the modified scanner using the standard gratings (10 micron pitch and 1 micron pitch). As a result of repeated use, the scanner may require additional calibration. You may obtain a new set of calibration parameters at specific elevated temperature measurements from the *Auto Calibration* procedure using a calibration reference (refer to *Support Note 217, Calibration Procedures*).

**Note:** The Heater/Cooler scanner includes a factory calibration for X, Y and Z at room temperature. Recalibration is not typically required at elevated temperatures because the scanner crystal remains at near ambient temperatures.

### 392.5.6 Gas Purging

The heated TappingMode (air) probe holder in combination with the silicone rubber seal provides the option to control the atmosphere around the heated sample by purging with inert, dry, non-corrosive gases (e.g., nitrogen, argon, helium, etc.). The inlet and outlet purge ports connect to the two outside Luer ports on the probe holder. The middle Luer port is for an optional sensor.

Because of the possibility of material oxidation at high temperature, the gas-tight heater/sample chamber can be purged of oxygen with an inert gas (e.g. nitrogen, argon, helium, etc.). The small volume of the sample enclosure allows purging to be accomplished in 2-3 minutes at a rate of 5-10 ml/min. Gas replacement verification is easily checked using helium as a substitute for air because, in helium, the resonant frequency of the cantilever is slightly raised while its quality factor increases markedly.

Purging the sample chamber with inert gas leads to an increase in heat consumption and thus can reduce the maximum attainable sample temperature.

Dry nitrogen gas purging, at 50 - 250 ml/min., may not be required for sub-ambient operation in air, but will be required for temperatures near and below 0 °C. Flow rates less than 50 ml/min. are generally too low to prevent ice formation while flow rates greater than 250 ml/min. will heat the sample. Dry nitrogen from a high-pressure gas cylinder may not be dry enough to prevent ice formation on the sample surface at low temperatures. In this case, Bruker recommends the use of dry nitrogen from a gas vent on a low-pressure liquid nitrogen container. Minimize the nitrogen gas flow to prevent sample heating by the relatively warm gas while preventing ice formation on the sample surface. Bruker has found several suitable sources for liquid nitrogen storage:

1. MVE Bio-Medical Systems, Chart Industries, Inc.  
3505 County Road 42 West  
Burnsville, MN 55306-3803 USA  
Web: [www.chart-ind.com](http://www.chart-ind.com) ([www.chartbiomed.com](http://www.chartbiomed.com))  
E-mail: [storagesystems@chart-ind.com](mailto:storagesystems@chart-ind.com)  
United States: 800-400-4683 Fax: 952-882-5191  
Worldwide: 952-882-5090 Fax: 952-882-5008  
Chart Europe GmbH: +49 (0)212-700 570, Fax: +49 (0)212-700 577  
Chart Asia Inc.: 65-838-5209, Fax: 65-235-3680

Product Information:

Storage Vessel Model: # CryoCyl 35 (35 Ltr, 22 psi) or CryoCyl 50 (50 Ltr, 22 psi)  
Transfer Hose: 4 or 6 Foot Transfer Hose  
Gas Vent Connection: Check with vendor.

2. CryoFab  
540 Michigan Avenue  
P.O. Box 485  
Kenilworth, NJ 07033 USA  
Web: [www.cryofab.com](http://www.cryofab.com)  
E-mail: [sales@cryofab.com](mailto:sales@cryofab.com)

Product Information:

Storage Vessel Model: # CLPB25 (25 Ltr, 20 psi) or # CLPB50 (50 Ltr, 20 psi).  
Transfer Hose: 4 or 6 foot transfer hose, non-insulated or vacuum insulated, can be purchased.  
Gas Vent Connection: 3/8 NPT Male Connector on gas vent.

3. Wessington Cryogenics  
Building 9, Philadelphia Complex  
Houghton-le-Spring, Tyne & Wear  
DH4 4UG, ENGLAND  
Web: [www.wessingtoncryogenics.com](http://www.wessingtoncryogenics.com)  
E-mail: [info@wessingtoncryogenics.co.uk](mailto:info@wessingtoncryogenics.co.uk)

Product Information:

Storage Vessel Model: # PV-30 (30 Ltr, 1.5 bar) or # PV-60 (60 Ltr, 1.5 bar).  
Transfer Hose: May be required for filling vessel.  
Gas Vent Connection: Check with vendor.

### 392.5.7 Scanner Cooling

Room temperature water, with the coolant reservoir, is sufficient for heating and also sufficient for cooling to approximately -20°C.

Reaching the lowest specified operating temperature requires the use of ice water as the coolant directly from the ice bucket. Remove the silicone tubes from the reservoir and insert them into the ice water bucket. Reaching the lowest specified operating temperature also requires that no sample puck or the smallest sample puck, 6mm, be used.

Each time the pump system is started the user should inspect for leaks, particularly near the base of the MultiMode scanner. Periodically monitor the cooling system for leaks during operation. Replace leaky tubing.

When the pump is first started, the pulse damper (see [Figure 3r](#)) will take a few minutes to fill before cooling water starts to flow back into the reservoir. Furthermore, coolant flow will not stop immediately when the pump is turned off because the coolant inside the pulse damper will continue to flow for several minutes.

Because the silicone tubing is transparent, you can visually monitor the filling process. Verify that coolant is flowing freely into the reservoir. You should see a drip/stream from the **SCANNER** side of the reservoir cap.

The heater/cooler stage (element) should not be **ENABLED** until the cooling system is completely filled.



### **392.5.8 Temperature Calibration**

The factory sets the heater and temperature sensors, which do not normally require recalibration. The temperature measured and controlled by the heater controller is that of the heating/cooling element, not the sample. For the most accurate sample temperature measurement, measure the sample temperature independently using an optional temperature sensor. Temperature sensors directly contact the sample through an access port in the heated TappingMode-in-air probe holder.

## 392.6 Maintenance

### 392.6.1 Fuse Replacement

If nothing happens after turning on the Thermal Applications Controller, check the fuse located in the rear of the unit. To check the fuse complete the following:

1. Unplug the controller from the AC power supply.
2. Using a small screwdriver, open the fuse box cover from the top and remove the fuse holder from the main fuse compartment (see [Figure 3q](#)).
3. Remove the fuse that looks damaged.
4. Check the fuse with an ohmmeter. The reading is less than 0.5 ohms if the fuse is OK. Check the second fuse if the first one selected is undamaged.
5. Replace the blown fuse with an undamaged 250V rated fuse and press the cap/fuse holder back onto the main fuse compartment. The fuse rating for 100-120V is 2.5A and the rating for 220-240V is 1.25A.

**Note:** If the heater or heater/cooler is not functioning properly, contact Bruker.

### 392.6.2 Pump Tube Replacement

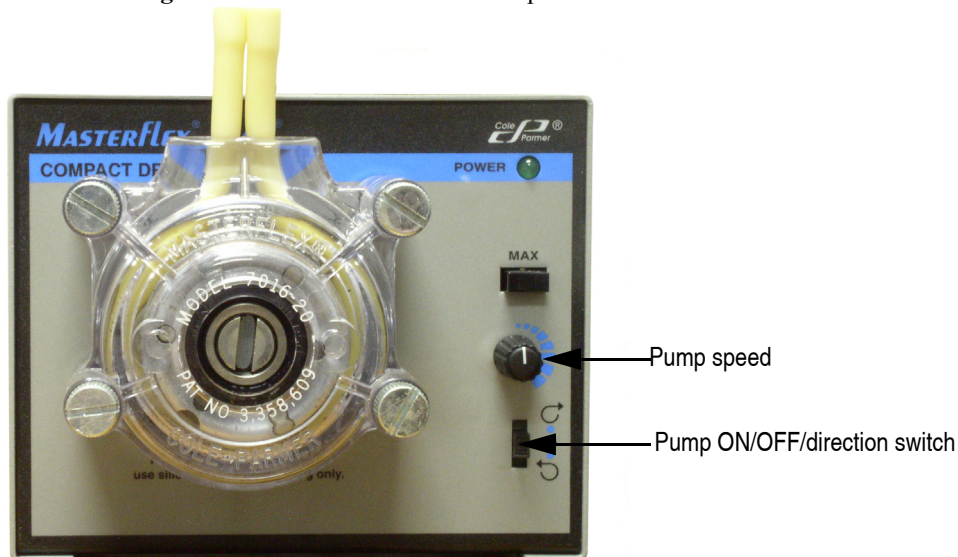
If the cooling pump fails to draw water, the peristaltic pump tube inside the cooling pump housing may have become blocked, pinched or leaky. The peristaltic pump tube is a consumable component and may be replaced by ordering Cole-Parmer Silicone Tubing (Peroxide Cured), 25 Feet, Size 16 Tubing, part number 96400-16, at [www.ColeParmer.com](http://www.ColeParmer.com). The peristaltic pump works by squeezing the outside of the tube to move the contents within the tube. With the peristaltic pump tube in place, but the pump turned off for a prolonged time, the tube may become permanently deformed in a constricting configuration, hindering flow when the pump is started again. After prolonged use, the peristaltic tube may also wear and leak.

To replace the peristaltic pump tube:

1. Using a flat blade screwdriver, remove the four cap screws which hold the cooling pump end bells to the pump motor.
2. Separate the end bells and gently pull the peristaltic pump tube free of the pump.
3. Inspect the tube for pinching/blockage. Massage the tube to attempt to restore its shape.
4. If the tube recovers functionality, reinstall it on the pump, rotating the tube relative to its former position to prevent recollapse of the same area.

5. If the tube cannot be reused, cut a new 15" (38cm) length from the tubing supply and, following the instructions in the *Masterflex L/S Standard Pump Head* manual, install it in the pump. Install the pump cover and secure it with the screws removed in step 1.

**Figure 392.6a** Masterflex L/S Pump Drive and Head



### 392.6.3 Tube Replacement

Replace the silicone tubing between the pump and the scanner if it has yellowed, appears dirty or is leaking.

### 392.6.4 Emptying the Cooling System

You may wish to empty the cooling system if it will be unused for a period of time, say several days. To do this:

1. Turn off the pump.
2. Unplug the **PUMP** quick-disconnect fitting on top of the fluid reservoir. This disconnects fluid input to the pump.
3. Unplug the silicone tube from the **PUMP** quick-disconnect fitting to allow air to enter the pump. The check valve in the quick-disconnect fitting is closed when not connected.
4. Vent the reservoir by removing the (larger diameter) tubing from the pressure relief port (unlabeled) on the fluid reservoir.

**Note:** Do not remove the quick-disconnect fitting from this port. Removing a quick-disconnect fitting closes a check valve causing the reservoir not to be vented to atmosphere.

5. Turn on the pump, in the same direction as before, so that it is pushing coolant into the reservoir. Because the silicone tube has been disconnected from the Pump side of the reservoir, the pump will no longer pull coolant from the reservoir. Increase the pump speed to 1/4 of the full, clockwise, range to speed up the purging process.
6. Turn off the pump after verifying that all fluid has been pumped from the tubing.
7. To empty the pulse damper completely, tilt the pulse damper placing the input side above the output side, removing the remaining coolant. Return the pulse damper to a level position and, if necessary, repeat.

### 392.6.5 Cleaning the Gas and Fluid Cells

You can clean various pieces of the AFM gas and fluid cell assembly and attachments (such as the glass piece and Luer fittings) in an ultrasonic bath by immersing them in deionized water in a container *made of Teflon or other soft material*. Do not place the glass piece of the fluid cell directly in contact with the metal bath because the glass may be damaged or scratched during cleaning. Make sure the glass piece rests on the Teflon container with the cantilever side facing up. This prevents the gold-coated clip from rubbing against the container bottom during cleaning. Do not use abrasive cleaning solutions to clean the glass piece, for you may damage the anti-reflective coating on the bottom surface of the glass piece.

### 392.6.6 Shipping the Heater/Cooler Scanner



**CAUTION:** The heating element must be unplugged from the scanner before shipping. Failing to do so can cause damage to the piezo crystal.

## 392.7 Specifications

See [Table 7a](#) for characterization of the MultiMode Heater/Cooler capabilities and [Table 7c](#) for conditions associated with its controller.

**Table 392.7a** Specifications for the MultiMode Heater/Cooler

Parameter	High Temperature Heater Specification	Heater/Cooler Specification	Bio Heater
Maximum Heater Temperature (Air) <sup>1</sup>	250° C	100° C	62.5° C
Maximum Heater Temperature (Fluid) <sup>1</sup>		50° C	50° C
Minimum Heater Temperature (Air) <sup>1</sup>	Ambient	-35° C <sup>5</sup>	Ambient
Minimum Heater Temperature (Fluid) <sup>1</sup>	Ambient	< 4° C	Ambient
Pressure	Ambient	Ambient	Ambient
Resolution	0.1° C	0.1° C	0.1° C
Accuracy	3.0%	3.0%	3.0%
Temperature Drift <sup>1</sup>	< 0.5° C, 0.2° C typical	< 0.5° C, 0.2° C typical	< 0.5° C
Overshoot <sup>1</sup>	<1.0° C <sup>2</sup>	<1.0° C typical, <2.5° C max <sup>3</sup>	<1.0° C <sup>4</sup>
Heating Rate Nominal <sup>1</sup>	> 10° C/min.	> 20° C/min.	1 - 2° C/min.
Cooling Rate Nominal <sup>1</sup>	n/a	> 20° C/min.	1 - 2° C/min.

[1] These parameters depend on many variables including purge gas flow, sample size and material, temperature change, coolant temperature...

[2] Temperature step (change)  $\leq 50^{\circ}\text{C}$ .

[3] Temperature step (change)  $\leq 10^{\circ}\text{C}$ . The maximum overshoot of 2.5° C occurs when crossing PID zone boundaries. Temperature overshoot can be minimized by crossing these PID zones using small temperature steps. [Table 7b](#) shows the PID zones.

[4] Temperature step (change)  $\leq 10^{\circ}\text{C}$ .

[5] With dry nitrogen gas flow of 50 - 250 ml/min. No sample puck or 6mm sample puck.

**Table 392.7b** TAC Zones

Zones	Stage Type	Medium	Temperature Range	Gain		
				P	I	D
1	High T Heat	Air	Ambient to 250°C	102	80	3
3	Low T Heat	Air	Ambient to 62.5°C	78	85	3
5	ThermoElectric Stage	Air	50°C to 100°C	102	42	3
6	ThermoElectric Stage	Air	35°C to 50°C	126	42	3
7	ThermoElectric Stage	Air	25°C to 35°C	150	42	3
8	ThermoElectric Stage	Air	15°C to 25°C	150	42	3
9	ThermoElectric Stage	Air	0°C to 15°C	102	25	3
10	ThermoElectric Stage	Air	-40°C to 0°C	82	20	3
11	Heat Stage	Fluid	Ambient to 250°C	102	80	3
13	Low T Heat	Fluid	Ambient to 62.5°C	78	70	13
15	ThermoElectric Stage	Fluid	50°C to 100°C	60	40	0
16	ThermoElectric Stage	Fluid	35°C to 50°C	60	40	0
17	ThermoElectric Stage	Fluid	25°C to 35°C	30	25	0
18	ThermoElectric Stage	Fluid	15°C to 25°C	30	25	0
19	ThermoElectric Stage	Fluid	0°C to 15°C	30	25	0
20	ThermoElectric Stage	Fluid	-40°C to 0°C	30	25	0

**Table 392.7c** Specifications for High Temperature Heater Controller Electronics

Parameter	Specification
Range of Environmental Conditions for Designed Operation	5°-55°C, Relative Humidity 5%-90%, non-condensing
Range of Environmental Conditions for Safe Storage	5°-70°C
Rated Voltage	100, 120, 230 or 240 volts AC (V~)
Maximum Rated Current	1.6A @ 100, 120V, 50/60Hz 0.6A @ 230, 240V, 50/60Hz

Tables [Table 392.7d](#) through [Table 392.7h](#) list TAC default settings. Settings that differ from Watlow CLS200 default values are shown in **bold**. See the Watlow CLS200 Series User's Guide for detailed setup instructions.

**Table 392.7d** Setup Global Parameters Default Values

Global Parameters	TAC Default Value (All Loops)
Load Setup from Job	1
Save Setup to Job	1
Job Select Digital Inputs	None
Job Select Digital Inputs Active	Low
Output Override Digital Input	None
Override Digital Input Active	Low
Startup Alarm Delay	0 min.
Keyboard Lock Status	Off
Power Up Output Status	Off
Process Power Digital Input	None
Controller Address	1
Communications Baud Rate	<b>19200</b>
Communications Protocol	<b>Mod</b> (Modbus RTU)
AC Line Frequency	60Hz
Digital Output Polarity on Alarm	Low
EPROM information: CLS 200 model number, firmware rev.	Varies*

\* Dynamically controlled by the TAC processor.

**Table 392.7e** Setup Loop Input Default Values

Setup Loop Input	TAC Default Value (vs. Loop)		
	Loop = 01 (TE)	Loop = 02 (HT)	Loop = 03, 04, 05
Input Type	<b>K T/C</b>	<b>K T/C</b>	<b>Skip</b>
Loop Name	<b>TE</b>	<b>HT</b>	03 to 05
Input Units	°C	°C	°F
Input Reading Offset	<b>0°C</b>	<b>0°C</b>	0°F
Reversed T/C Detection	Off	Off	Off
Input Filter	<b>Varies*</b>	<b>Varies*</b>	3 Scans

\* Dynamically controlled by the TAC processor.

**Table 392.7f** Setup Loop Control Parameters Default Values

Setup Loop Control Parameters	TAC Default Value (vs. Loop)		
	Loop = 01 (TE)	Loop = 02 (HT)	Loop = 03, 04, 05
Heat Control PB (Proportional Band)	Varies*	Varies*	50°F
Heat Control TI (Term Integral)	Varies*	Varies*	180 Sec./R
Heat Control TD (Term Derivative)	Varies*	Varies*	0 Sec.
Heat Control Output Filter	3	3	3
Cool Control Proportional Band	Varies*	Varies*	50°F
Cool Control TI (Term Integral)	Varies*	Varies*	60 Sec./R
Cool Control TD (Term Derivative)	Varies*	Varies*	0 Sec.
Cool Control Output Filter	3	3	3
Spread	0.5	0.5	0.5
Restore PID Digital Input	None	None	None

\* Dynamically controlled by the TAC processor.

**Table 392.7g** Setup Loop Outputs Default Values

Setup Loop Control Outputs	TAC Default Value (vs. Loop)		
	Loop = 01 (TE)	Loop = 02 (HT)	Loop = 03, 04, 05
Heat Control Output	Enabled*	Enabled*	Enabled
Heat Output Type	DZC	DZC	TP
Heat Output Action	Reverse	Reverse	Reverse
Heat Output Limit	100%	100%	100%
Heat Output Limit Time	Continuous	Continuous	Continuous
Sensor Fail Heat Output	0%	0%	0%
Heat T/C Break Output Average	Off	Off	Off
Heat Output	Linear	Linear	Linear
Cool Control Output	Enabled*	Disabled	Disabled
Cool Output Type	DZC	-	-
Cool Output Action	Direct	-	-
Cool Output Limit	100%	-	-
Cool Output Limit Time	Continuous	-	-



Setup Loop Control Outputs	TAC Default Value (vs. Loop)		
Sensor Fail Cool Output	0%	-	-
Cool T/C Break Output Average	Off	-	-
Cool Output	Linear	-	-

\* Dynamically controlled by the TAC processor.

**Table 392.7h** Setup Loop Alarms Default Values

Setup Loop Alarms	TAC Default Value (vs. Loop)		
	Loop = 01 (TE)	Loop = 02 (HT)	Loop = 03, 04, 05
High Process Alarm Setpoint	Varies*	Varies*	1000
High Process Alarm Type	Alarm	Alarm	Off
High Process Alarm Output Number	None	None	None
Deviation Alarm Value	0.5°C	0.5°C	0.5°C
High Deviation Alarm Type	Off	Off	Off
High Deviation Alarm Output Number	None	None	None
Low Deviation Alarm Type	Off	Off	Off
Low Deviation Alarm Output Number	None	None	None
Low Process Alarm Setpoint	-45°C	0	0
Low Process Alarm Type	Alarm	Off	Off
Low Process Alarm Output Number	None	None	None
Alarm Deadband	5.0°C	5.0°C	0.2°C
Alarm Delay	0 seconds	0 seconds	0 seconds

\* Dynamically controlled by the TAC processor.

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**WARRANTY INFORMATION**

This product is covered by the terms of the Bruker standard warranty as in effect on the date of shipment and as reflected on Bruker's Order Acknowledgement and Quote. While a summary of the warranty statement is provided below, please refer to the Order Acknowledgement or Quote for a complete statement of the applicable warranty provisions. In addition, a copy of these warranty terms may be obtained by contacting Bruker.

WARRANTY. Seller warrants to the original Buyer that new equipment will be free of defects in material and workmanship for a period of one year commencing (x) on final acceptance or (y) 90 days from shipping, whichever occurs first. This warranty covers the cost of parts and labor (including, where applicable, field service labor and travel required to restore the equipment to normal operation).

Seller warrants to the original Buyer that replacement parts will be new or of equal functional quality and warranted for the remaining portion of the original warranty or 90 days, whichever is longer.

Seller warrants to the original Buyer that software will perform in substantial compliance with the written materials accompanying the software. Seller does not warrant uninterrupted or error-free operation.

Seller's obligation under these warranties is limited to repairing or replacing at Seller's option defective non-expendable parts or software. These services will be performed, at Seller's option, at either Seller's facility or Buyer's business location. For repairs performed at Seller's facility, Buyer must contact Seller in advance for authorization to return equipment and must follow Seller's shipping instructions. Freight charges and shipments to Seller are Buyer's responsibility. Seller will return the equipment to Buyer at Seller's expense. All parts used in making warranty repairs will be new or of equal functional quality. The warranty obligation of Seller shall not extend to defects that do not impair service or to provide warranty service beyond normal business hours, Monday through Friday (excluding Seller holidays). No claim will be allowed for any defect unless Seller shall have received notice of the defect within thirty days following its discovery by Buyer. Also, no claim will be allowed for equipment damaged in shipment sold under standard terms of F.O.B. factory. Within thirty days of Buyer's receipt of equipment, Seller must receive notice of any defect which Buyer could have discovered by prompt inspection. Products shall be considered accepted 30 days following (a) installation, if Seller performs installation, or (b) shipment; unless written notice of rejection is provided to Seller within such 30-day period.

Expendable items, including, but not limited to, lamps, pilot lights, filaments, fuses, mechanical pump belts, V-belts, wafer transport belts, pump fluids, O-rings and seals ARE SPECIFICALLY EXCLUDED FROM THE FOREGOING WARRANTIES AND ARE NOT WARRANTED. All used equipment is sold 'AS IS, WHERE IS,' WITHOUT ANY WARRANTY, EXPRESS OR IMPLIED.

Seller assumes no liability under the above warranties for equipment or system failures resulting from (1) abuse, misuse, modification or mishandling; (2) damage due to forces external to the machine including, but not limited to, acts of God, flooding, power surges, power failures, defective electrical work, transportation, foreign equipment/attachments or Buyer-supplied replacement parts or utilities or services such as gas; (3) improper operation or maintenance or (4) failure to perform preventive maintenance in accordance with Seller's recommendations (including keeping an accurate log of preventive maintenance). In addition, this warranty does not apply if any equipment or part has been modified without the written permission of Seller or if any Seller serial number has been removed or defaced.

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