User Guide 441 Revision E

Dimension Heater/Cooler

441.1 Introduction

The Dimension™ heater/cooler enables atomic force microscopy (AFM) at both reduced (down to -35ºC) and elevated temperatures (up to 250ºC) in a controlled environment. Primary components of the system include a heated probe holder, a heating element and/or a heating-cooling element and a Thermal Applications Controller (TAC).

This package is available as an option with the purchase of a new Dimension/Hybrid head, Dimension Icon or Dimension Edge series SPM, or as a system upgrade for these configurations.

Document Revision History: Dimension Heater/Cooler

Rev.	Date	Sections	Ref. DCR	Approval
Rev. E	5-Jan. 2011	Edge limit switch spacer, re-branded to Bruker		Vinson Kelley
Rev. D	22-July-2010	Updates for Dimension Edge		Vinson Kelley
Rev. C	27-May-2009	Updates for Dimension Icon with STM		Vinson Kelley
Rev. B	30-March-2009	Updates for Dimension Icon		Vinson Kelley
Rev. A	5-May-2008	Initial Release		Vinson Kelley

112 Robin Hill Road
Santa Barbara, CA 93117
805.967.1400

Part Number: 013-441-000

Product Names:
NanoScope®
Dimension Icon™
MultiMode™
Dimension™
Dimension® Icon®
BioScope™
BioScope™ Catalyst™
Atomic Force Profiler™ (AFP™)
Dektak®

Software Modes:
TappingMode™
Tapping™
TappingMode+™
LiftMode™
AutoTune™
TurboScan™
Fast HSG™
PhaseImaging™
DekMap 2™
HyperScan™
StepFinder™
SoftScan™
ScanAsyst™
Peak Force Tapping™
PeakForce™ QNM™

Hardware Designs:
TrakScan™
StiffStage™

Hardware Options:
TipX®
Signal Access Module™ and SAM™
Extender™
TipView™
Interleave™
LookAhead™
Quadrex™

Software Options:
NanoScript™
Navigator™
FeatureFind™

Miscellaneous:
NanoProbe®

This support note includes the following:

441.1.1 Scope of this Document

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

441.1.2 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**.

441.2 Safety Precautions

This section details safety requirements involved in the installation of the Dimension 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 Dimension AFM.

Table 2.0a 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 beschaedigen 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 elekrischen 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 Dimension Heaters and Heater/Coolers.

CAUTION: If you use the equipment in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

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 authorisierte 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 Dimension 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 DMHCKIT. 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.

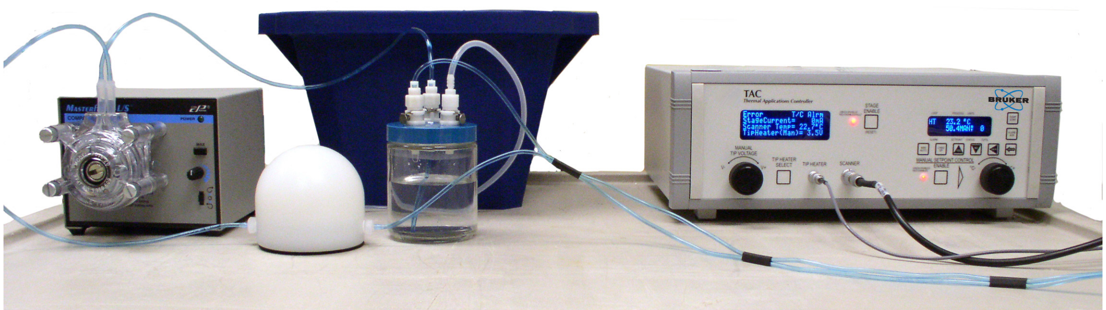
VORSICHT: Benutzen Sie nur de-ionisiertes (DI) Wasser mit dem Hoch-Temperatur System DMHCKIT. Vermeiden Sie Kontakt zwischen der Elektronik und dem Kühlmittel (DI Wasser). Füllen Sie das Kühlmittel nur in das Reservoir und auch nur nachdem Sie die Leitungen entsprechend der Anleitung angebracht haben.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

441.3 Heater/Cooler Components

The heater/cooler components, shown in Figure 3.0a, are used to heat or cool the sample to the desired temperature. Set the controlled temperature to a value within the range of -35ºC to 250ºC.

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

Figure 3.0a Heater/Cooler Components

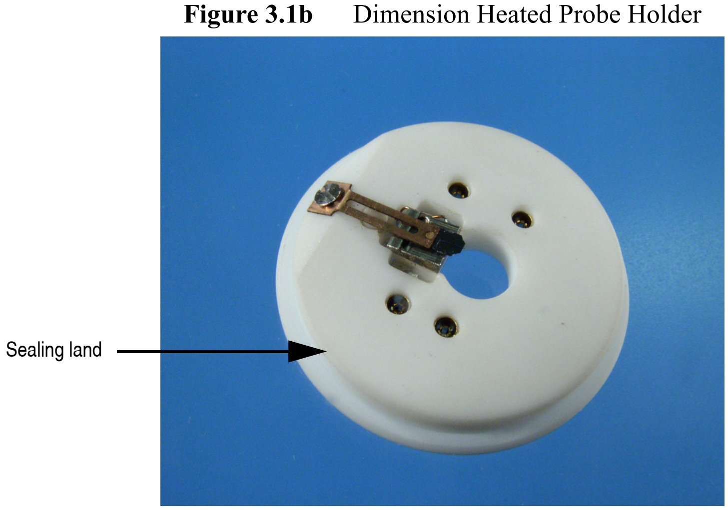


The Heater/Cooler and High Temperature Heater contain the following main components:

441.3.1 Heated TappingMode Probe Holder

The ceramic Dimension Heater/Cooler probe holder, shown in Figure 3.1b, allows for cantilever oscillation, tip heating, gas purging and insulates the thermally sensitive scan tube from the heating and cooling elements (see **Heating and Cooling Elements:** Section 441.3.3). Included with the probe holder is a silicone rubber seal that acts as a sealed sample chamber for controlled atmosphere AFM operations. The land on the bottom face of the holder seals the top end of the silicone rubber seal.

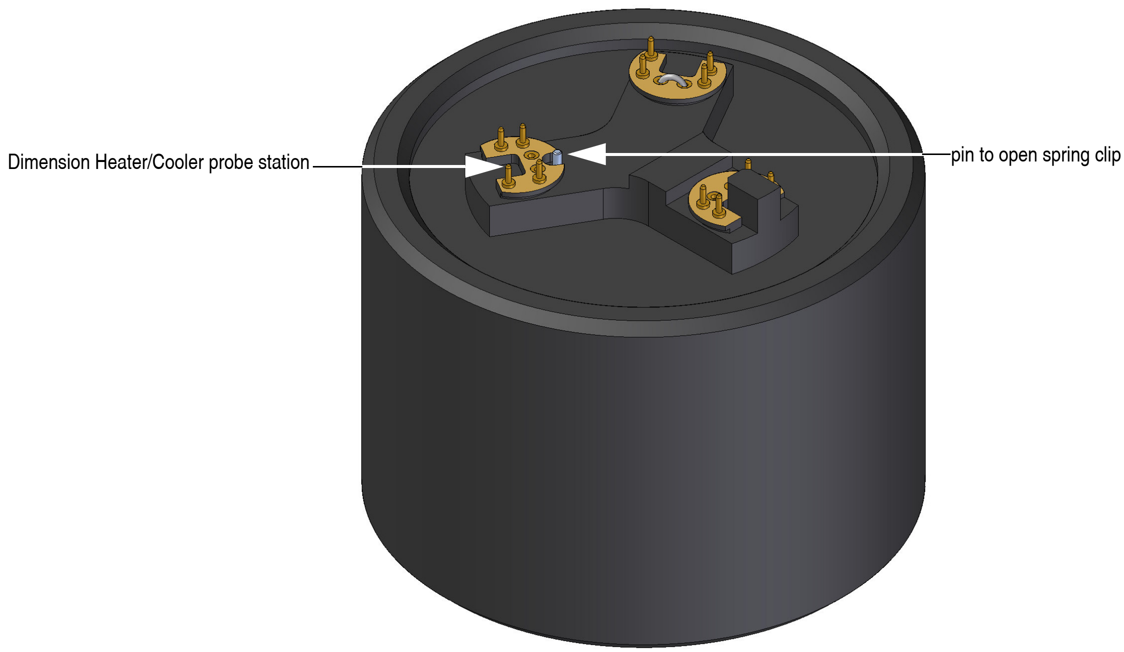
Figure 3.1b Dimension Heated Probe Holder



441.3.2 Dimension Heater/Cooler Probe Stand

The Dimension Heater/Cooler TappingMode probe holder requires its own station on the Dimension Heater/Cooler Probe Stand, shown in Figure 3.2c. This station incorporates an extra pin that opens the probe holder spring clip and allows the probe to be inserted into the probe holder.

Figure 3.2c Dimension Heater/Cooler Probe Stand

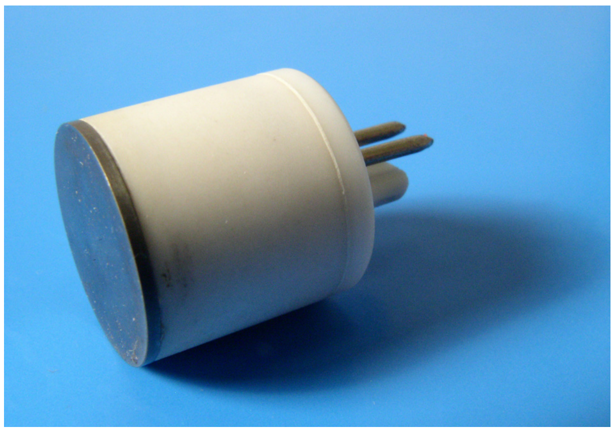


441.3.3 Heating and Cooling Elements

Two different heating and heating-cooling elements are available for the Dimension:

1. A 250ºC heater element, shown in Figure 3.3d. The High Temperature Heater element includes a ceramic body and tungsten cap. Internal components include a platinum resistive type heater, a "K-type" thermocouple and a magnet. The heater is located underneath the tungsten cap. This 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 3.3d High Temperature Heater: Ambient to 250ºC



2. A -35ºC to 100ºC heater/cooler, shown in Figure 3.3e. 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 "K-type" thermocouple. This thermocouple is located directly under the tungsten cap, approximately 0.5mm (0.020 inches) from the surface. The Heater/Cooler element does not incorporate a magnet.

Figure 3.3e Heater/Cooler: -35ºC to 100ºC

The high temperature heater and heater/cooler elements plug into the connector on top of the Dimension Heater/Cooler magnetic base, shown in Figure 3.6i, Figure 3.6j and Figure 3.6k. The five contact pins on the bottom of the heater and heater/cooler elements, shown in Figure 3.3f, 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).

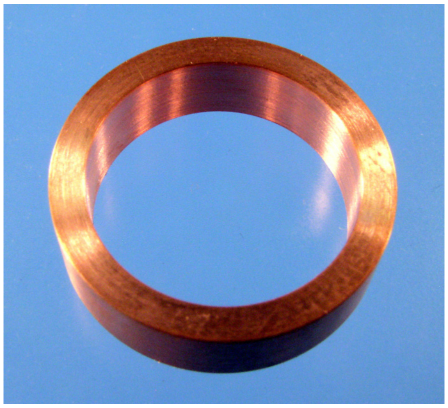
Figure 3.3f Contact Pins

Two heater/cooler elements are required to cover the full temperature range, -35ºC to 250ºC. Single experiments can be run from -35ºC to 100ºC and from room temperature to 250ºC.

441.3.4 Copper Ring

The copper ring, shown in Figure 3.4g, is used to extract heat from the heater/cooler during reduced temperature experiments.

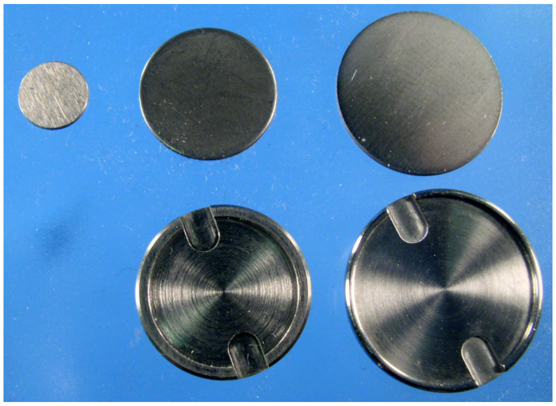
Figure 3.4g Copper Ring



441.3.5 Heater/Cooler Covers

The heater/cooler element is provided with two heater/cooler covers with matching sample pucks, shown in Figure 3.5h. Heater/cooler covers are designed to accommodate larger sample pucks and thus allow larger sample size. The added mass of these covers increases the minimum achievable temperature (reduces cooling capacity).

Figure 3.5h Heater/Cooler Covers with Matching Sample Pucks (top). Left: 6mm; Middle: 12mm; Right: 15mm



Sample Pucks

Three sample pucks, shown in Figure 3.5h, are available:

1. 6mm: Bruker P/N 130-006-121. To reach low temperatures using the -35ºC to 100ºC heater/cooler (< 0ºC), you must use this puck or no puck.

2. 12mm: Bruker P/N 130-000-011.

3. 15mm: Bruker P/N 130-011-010.

441.3.6 Dimension Heater/Cooler Base

The Dimension 3100/V and Dimension Icon Heater/Cooler magnetic bases, shown in Figure 3.6i and Figure 3.6j, contain three Neodymium Iron Boron magnets that attach the base to the Dimension chuck base. In addition to the three magnets holding the Heater/Cooler, two screws, shown in Figure 4.1c, also hold the heater/cooler to the Dimension Icon chuck base. Because the Dimension Edge chuck base in not magnetic, two screws are used to attach the heater/cooler base, shown in Figure 3.6k, to the Dimension Edge chuck base.

Three additional magnets attach the heater/cooler base to the magnetic stainless steel gas ring, shown in Figure 3.7l. An internal fluid reservoir coupled to an external cooling system is used to extract heat from the Peltier element in the heater/cooler. A thermocouple is used to monitor the reservoir fluid temperature.

Figure 3.6i Dimension 3100/V Heater/Cooler magnetic base

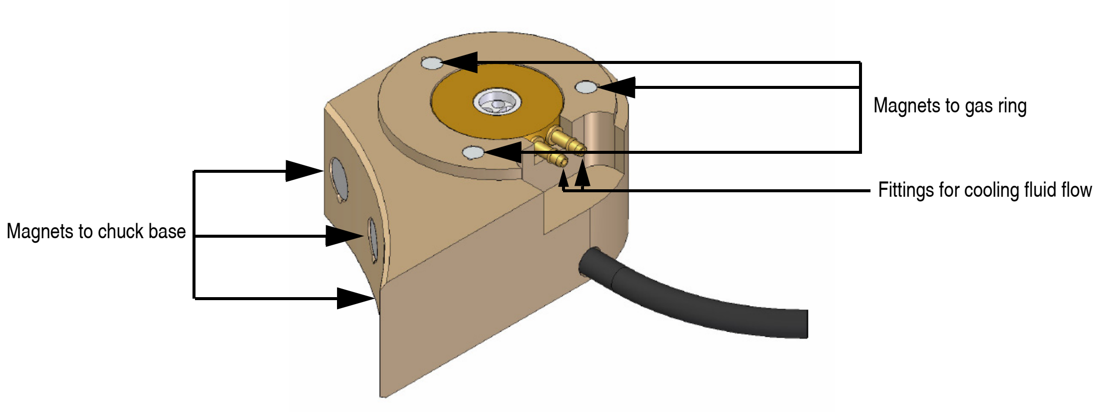


Figure 3.6j Dimension Icon Heater/Cooler magnetic base

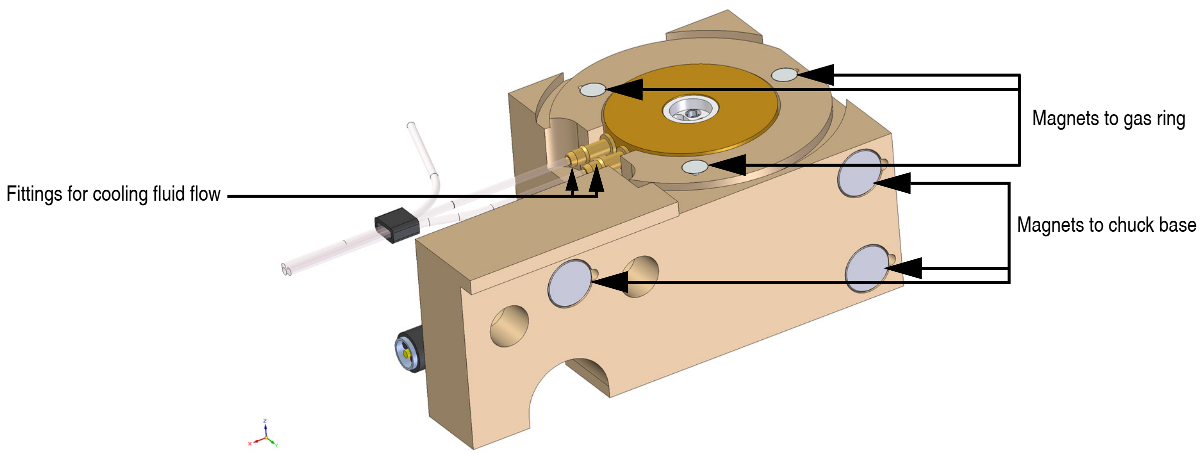
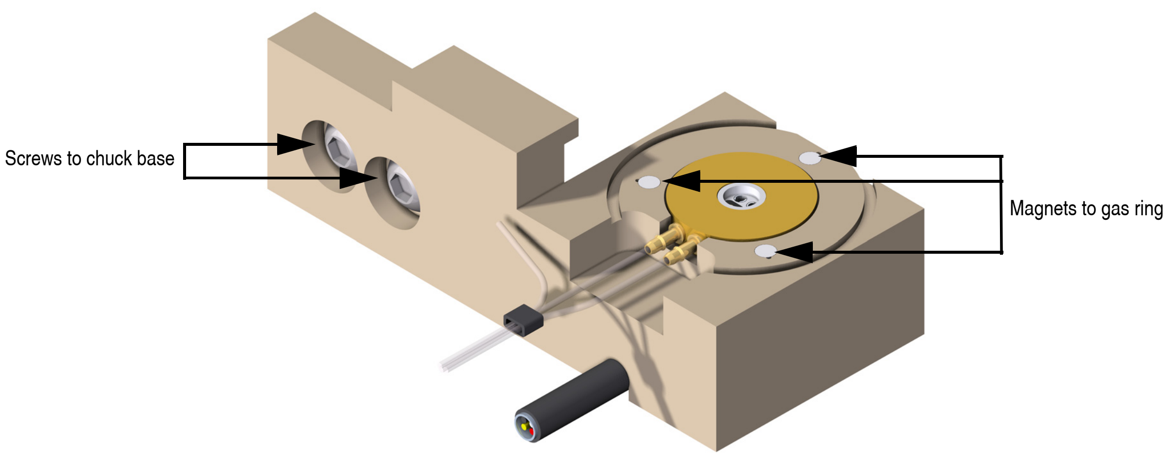


Figure 3.6k Dimension Edge Heater/Cooler base



441.3.7 Gas Ring

The gas ring, shown in Figure 3.7l, with associated silicone rubber seal, shown in Figure 3.7m, is used to provide an inert, dry or reducing atmosphere at the sample. This is used to prevent ice formation during cooler use or oxidation when heating.

Figure 3.7l The heater/cooler gas ring

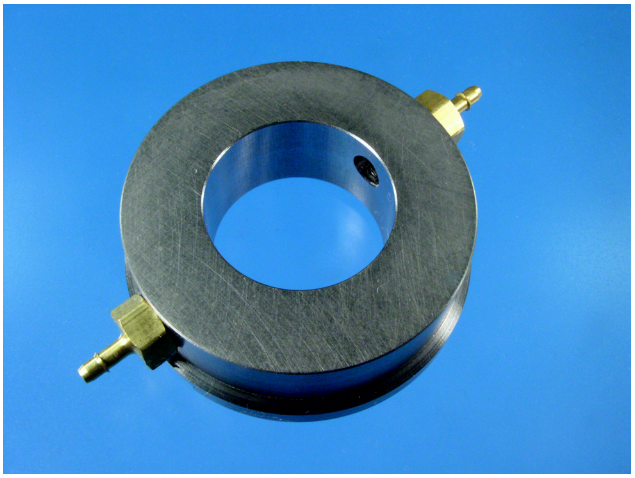


Figure 3.7m Silicone rubber seal

441.3.8 Manifold

The gas/fluid manifold, shown in Figure 3.8n and Figure 3.8o, attaches to the side of the D3100/V electronics box or the air table of the Dimension Icon or Dimension Edge and is used to simplify gas and cooling water routing. The manifold includes a valve and flow meter to control the purge gas flow.

Figure 3.8n Dimension 3100/V Manifold

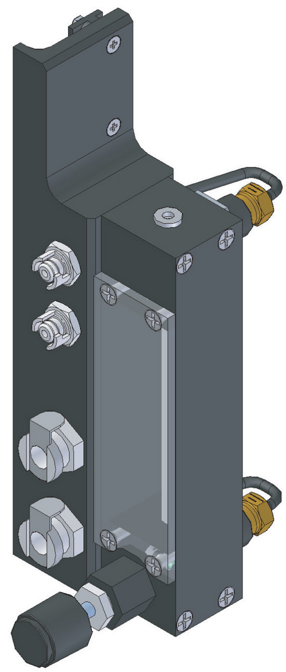
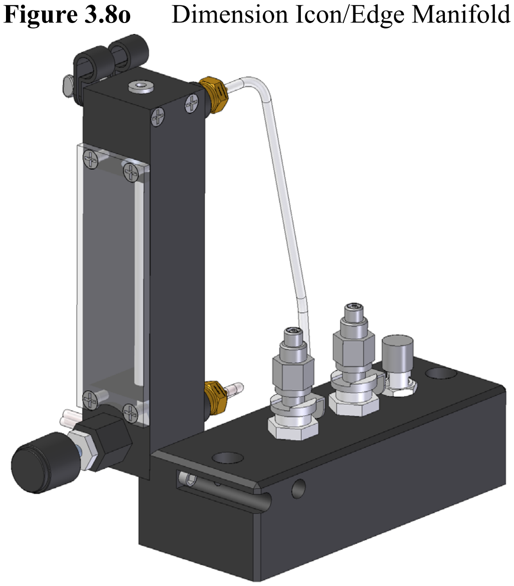


Figure 3.8o Dimension Icon/Edge Manifold



441.3.9 Thermal Applications Controller

Set and control the sample temperature by regulating the heater or heater/cooler element and tip heater voltage with the Thermal Applications Controller (TAC), shown in Figure 3.9p.

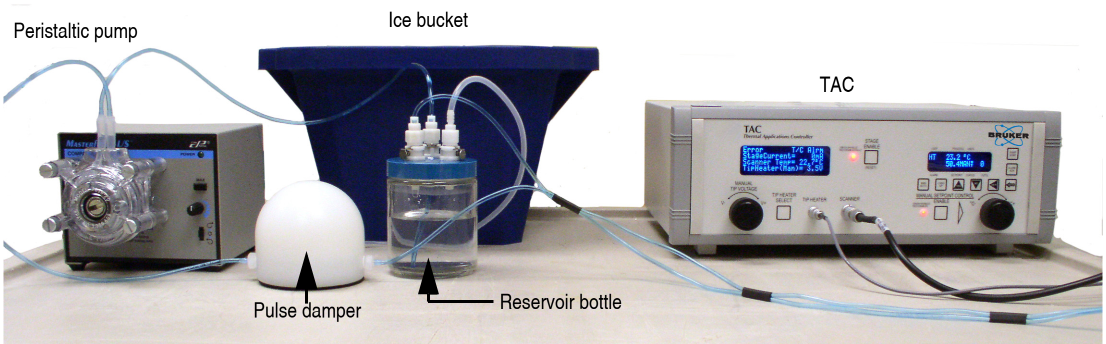
Figure 3.9p The Thermal Applications Controller (TAC)

441.3.10 Thermoelectric Cooling system

The fluid cooling system, shown in Figure 3.10q, cools the reservoir inside the Dimension Heater/ Cooler base to remove heat from the thermoelectric device during sub-ambient operation. The following components comprise the cooling system:

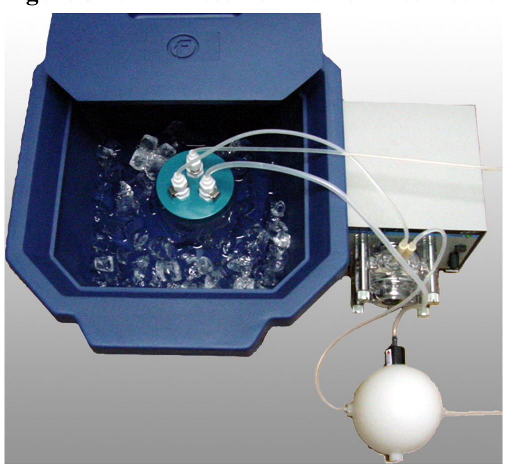
- Peristaltic pump
- Reservoir bottle and tubing
- Pulse damper
- Ice bucket

Figure 3.10q Fluid Cooling System



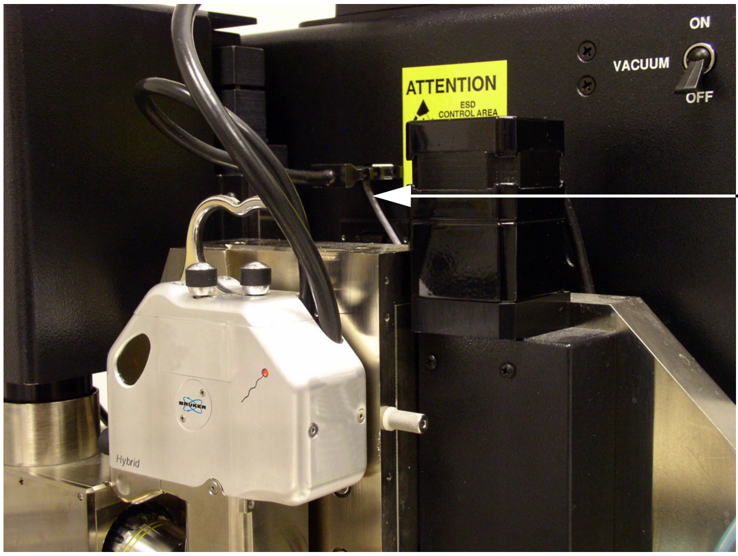
- **Reservoir Bottle and Tubing**: The fluid cooling system includes a reservoir bottle and tubing. The cooling water flows from the reservoir bottle to the pump, through the reservoir inside the Dimension Heater/Cooler base and back to the reservoir bottle. The pump-side of the bottle includes a fitting with the suction tube inside the bottle. The tubing is standard 1/16" (1.59mm) ID x 1/8" (3.2mm) OD polyurethane tubing.

Figure 3.10r Reservoir Bottle in Ice Bucket



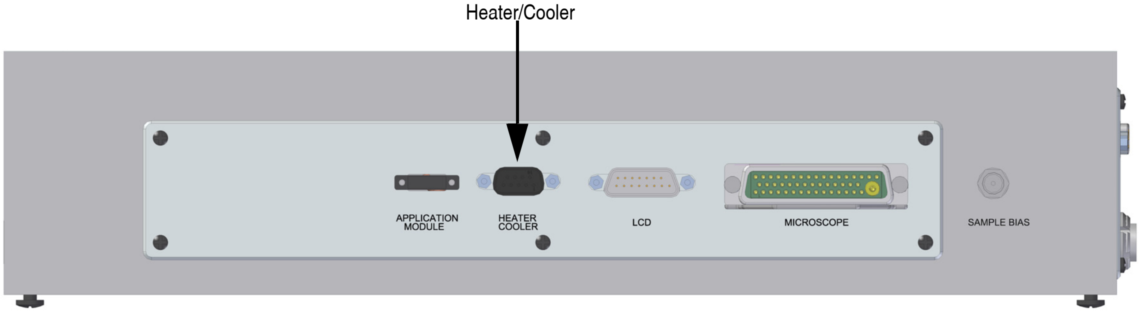
- **Dimension 3100/V Heater Extension and Tip Heater Cables**: The heater extension and tip heater cables attach to the two Lemo connectors on the front panel of the control box. The heater cable connects to the 7-pin connector (labeled SCANNER on the TAC) and the tip heater cable connects to the 4-pin connector (labeled TIP HEATER on the TAC). The opposite end of the tip heater cable acts as a required adapter between the Dimension head and Dimension SPM cable (see Figure 3.10s).

Figure 3.10s Inline Adapter: Dimension head to Head Cable



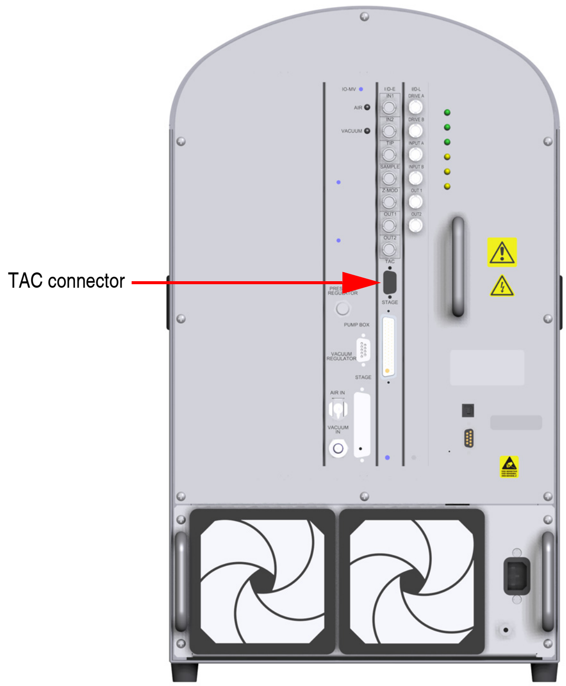
- **Dimension Icon Heater Extension and Tip Heater Cables**: The heater extension cable attaches to the 9 pin D-sub connector labeled HEATER/COOLER on the top of the Dimension Icon electronics box, shown in Figure 3.10t and connects heater cable on the 4-pin connector (labeled TIP HEATER on the TAC), shown in Figure 4.1j.

Figure 3.10t Dimension Icon Microscope Electronics Box (top view)



- **Dimension Edge Heater Extension and Tip Heater Cables**: The heater extension cable attaches to the 9 pin D-sub connector labeled TAC on the IO-E board of the NanoDrive controller, shown in Figure 3.10u and connects heater cable on the 4-pin connector (labeled TIP HEATER on the TAC), shown in Figure 4.1j.

Figure 3.10u NanoDrive Controller rear panel



441.4 Installation

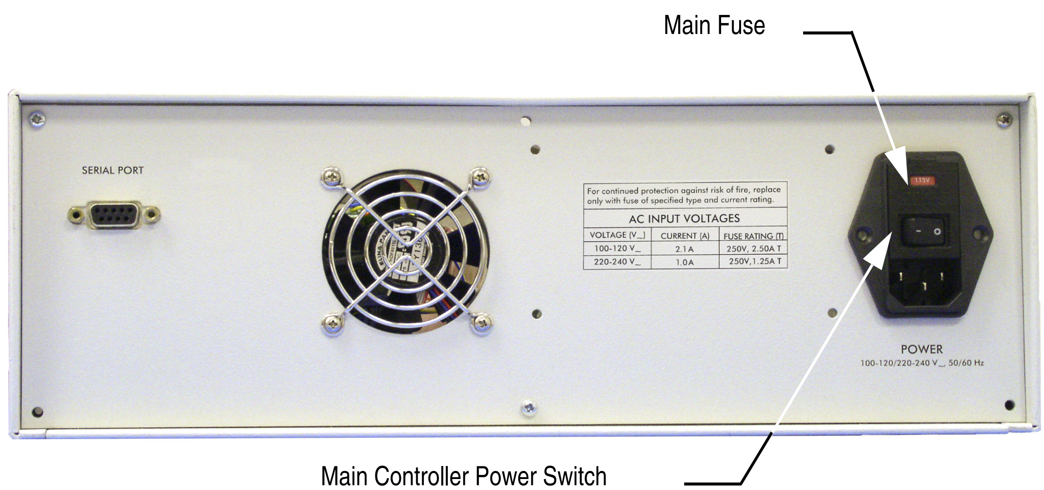
441.4.1 General Setup

1. Unpack the system and verify that the following items are included:
    - All Systems
        - Heated TappingMode Probe Holder
        - Heating Element and/or Heating/Cooling Element
        - Thermal Applications Controller
        - Tip Heater Cable
        - Heater extension cable
        - Silicone rubber seals
        - Manifold
        - Heater/Cooler Base
        - Gas Ring
        - Dimension Heater/Cooler probe Stand
    - Systems with Sample Cooling
        - Reservoir Bottle and Tubing
        - Ice Bucket
        - Peristaltic pump
        - Pulse damper
        - Copper ring
2. Verify that the controller is set to the appropriate voltage configuration for the regional power supply (see Figure 4.1a).

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 Thermal Applications Controller and into the power supply (see Figure 4.1a).

Figure 4.1a Thermal Applications Controller (Rear Panel)



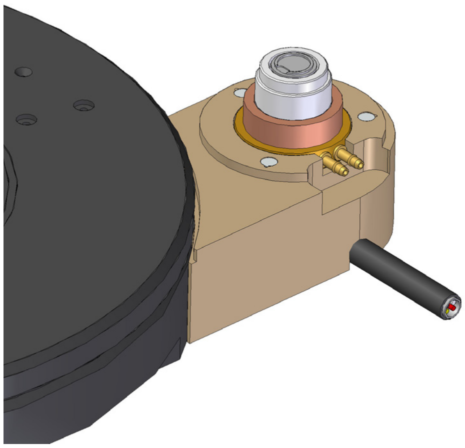
4. Verify that the power disconnect device is readily accessible.

5. Set the **MAIN CONTROLLER POWER** switch to **ON** (see Figure 4.1a), and verify that the controller has power.

6. Mount the Heater/Cooler magnetic base to the Dimension chuck base:

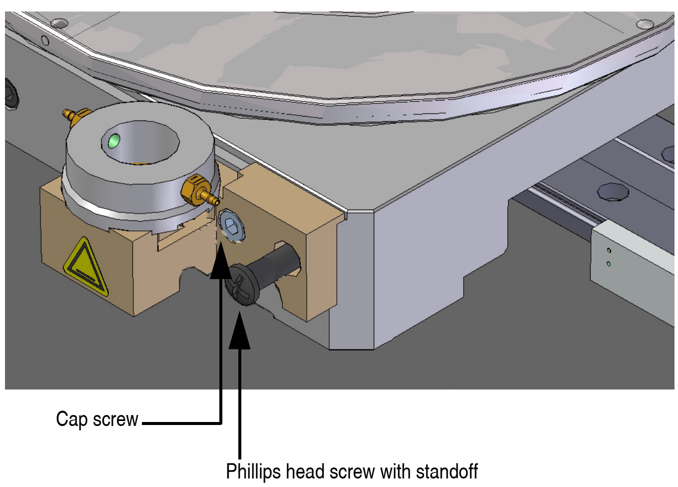
   a. **Dimension 3100/V**: Place the Heater/Cooler magnetic base against the brass air fitting (not shown) on the rear of Dimension chuck base as shown in Figure 4.1b. The magnets in the base will hold it in place.

Figure 4.1b Heater/Cooler Magnetic base attached to Dimension 3100/V chuck base



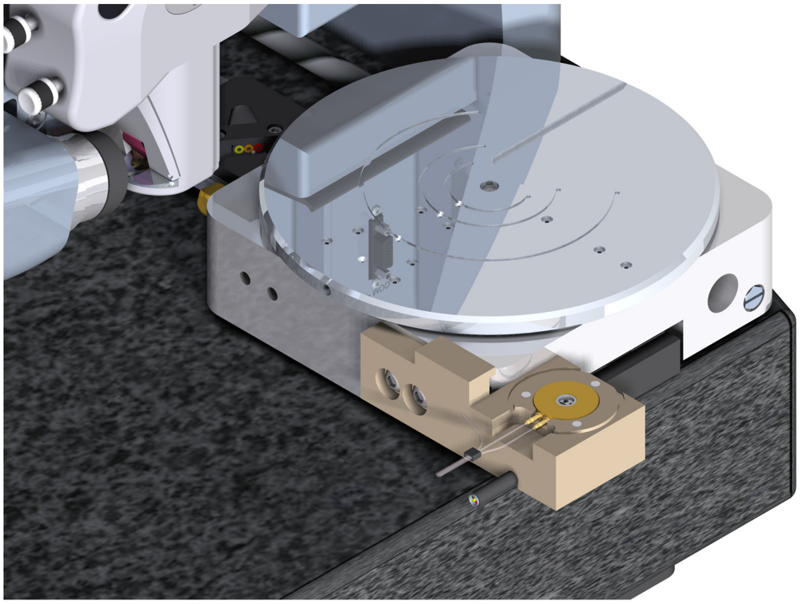
   b. **Dimension Icon**: Place the heater/cooler base against the Dimension Icon chuck base so that the lip overlaps the shelf in the chuck base. Although the magnets in the heater/cooler base will hold the heater/cooler base, firmly secure the heater/cooler base using the supplied cap and Phillips head screws with a standoff on the Phillips head screw. This standoff will be used to support the heater/cooler hoses and cable. See Figure 4.2p.

Figure 4.1c Heater/Cooler attached to the Dimension Icon chuck base.



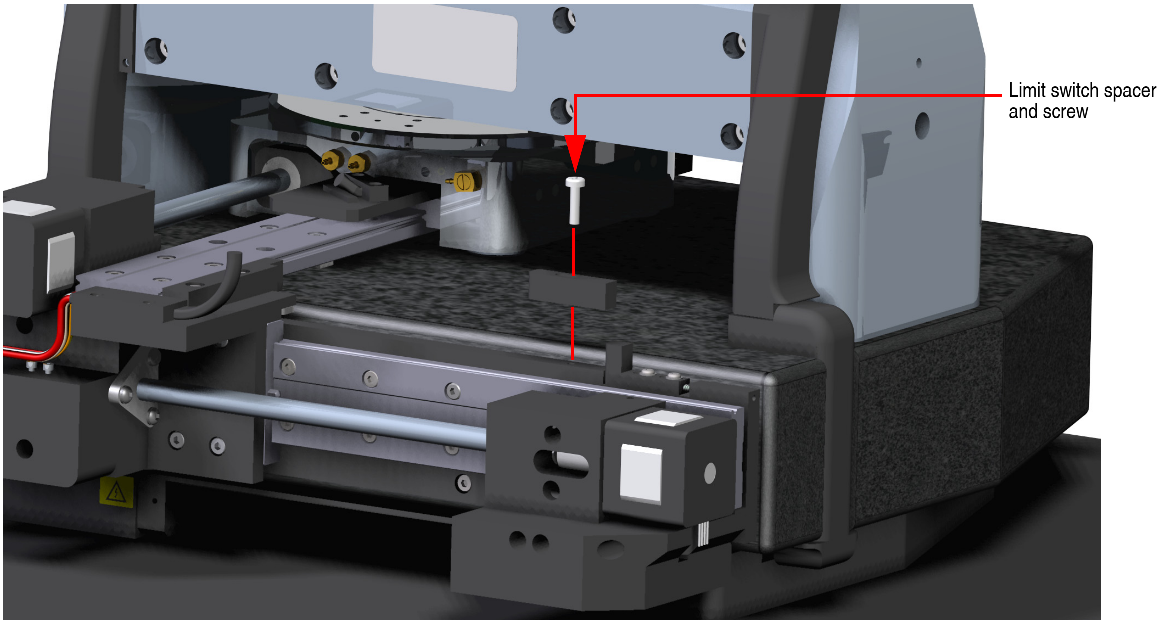
c. **Dimension Edge**: Place the heater/cooler base against the Dimension Edge chuck base so that the lip overlaps the shelf in the chuck base. Firmly secure the heater/cooler base using the two supplied M6 x 12mm button head cap screws. See Figure 4.1d.

Figure 4.1d Heater/Cooler attached to the Dimension Edge chuck base.



7. **Dimension Edge**: Install the stage X-limit switch spacer block shown in Figure 4.1e.

Figure 4.1e X-limit switch spacer

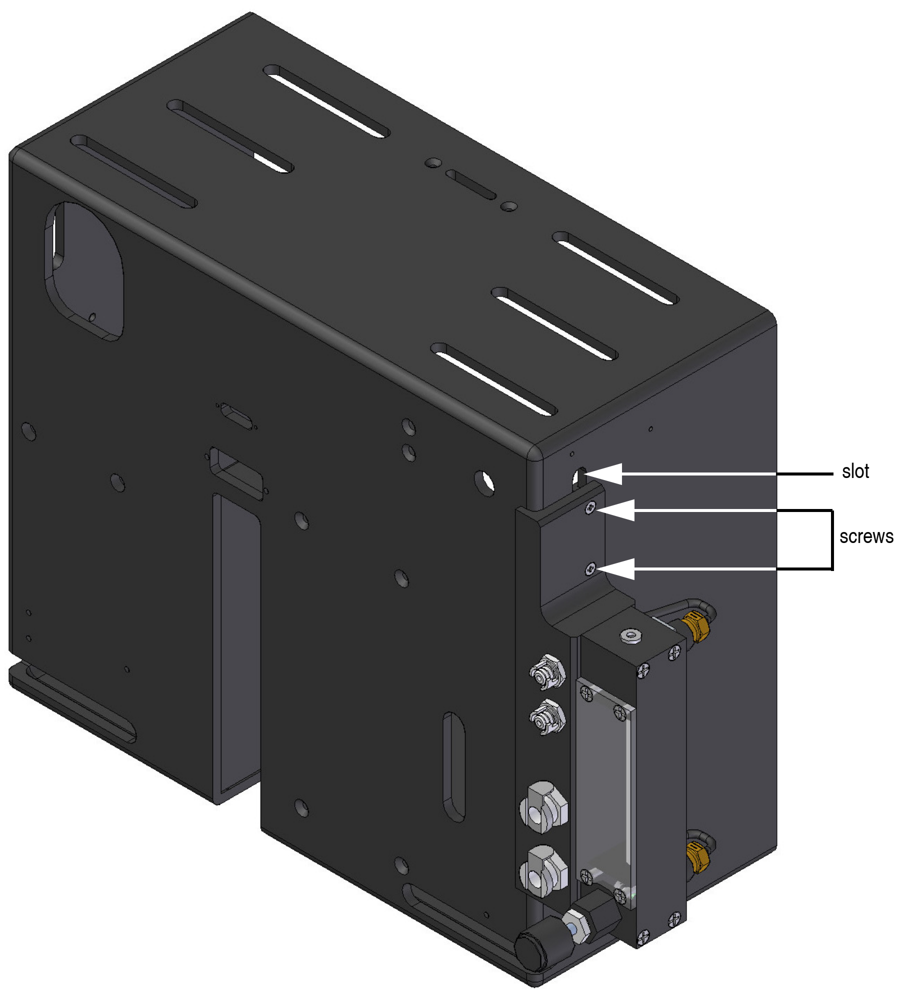


8. Install the manifold:

   a. **D3100/V**: Install the gas/water manifold on the side of the Dimension electronics box, shown in Figure 4.1f.

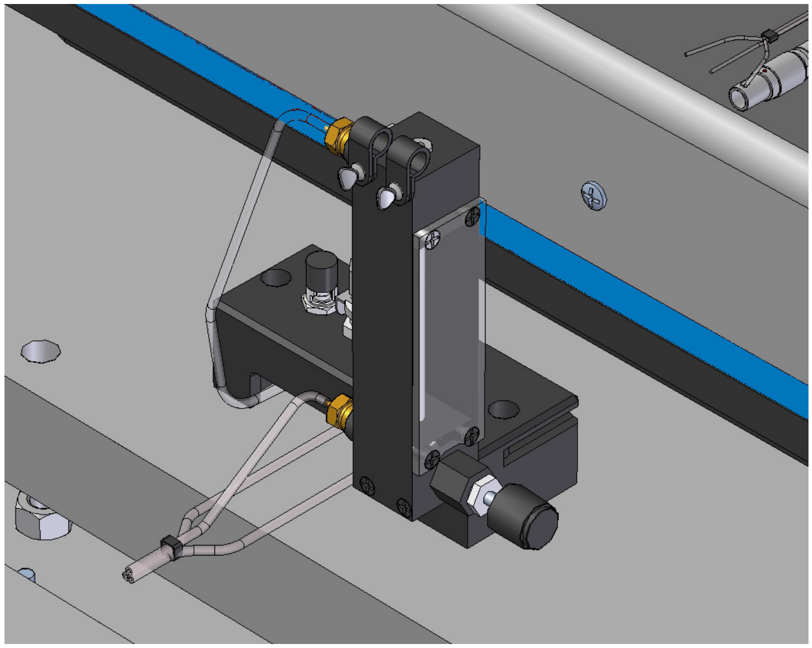
      - Place the manifold on the right side of the Dimension electronics box.
      - Push the screws with “T-nuts” through the slots on the right side of the Dimension electronics box.
      - Tighten the screws. The “T-nuts” will grab the inside of the of the Dimension electronics box.

Figure 4.1f Manifold installed on the Dimension electronics box



b. **Dimension Icon**: Using two cap screws, bolt the manifold to the air table on the left side of the microscope. See Figure 4.1g.

Figure 4.1g Manifold attached to the air table of the Dimension Icon.



c. **Dimension Edge**: Using two cap screws, bolt the manifold to the manifold support block. See Figure 4.1h. Place the manifold on the air table to the left of the microscope. Loosen the thumbscrews on the side of the support block and pull the “L” brackets firmly to the bottom of the air table and tighten the thumbscrews. See Figure 4.1i.

Figure 4.1h Attach the manifold to the support block.

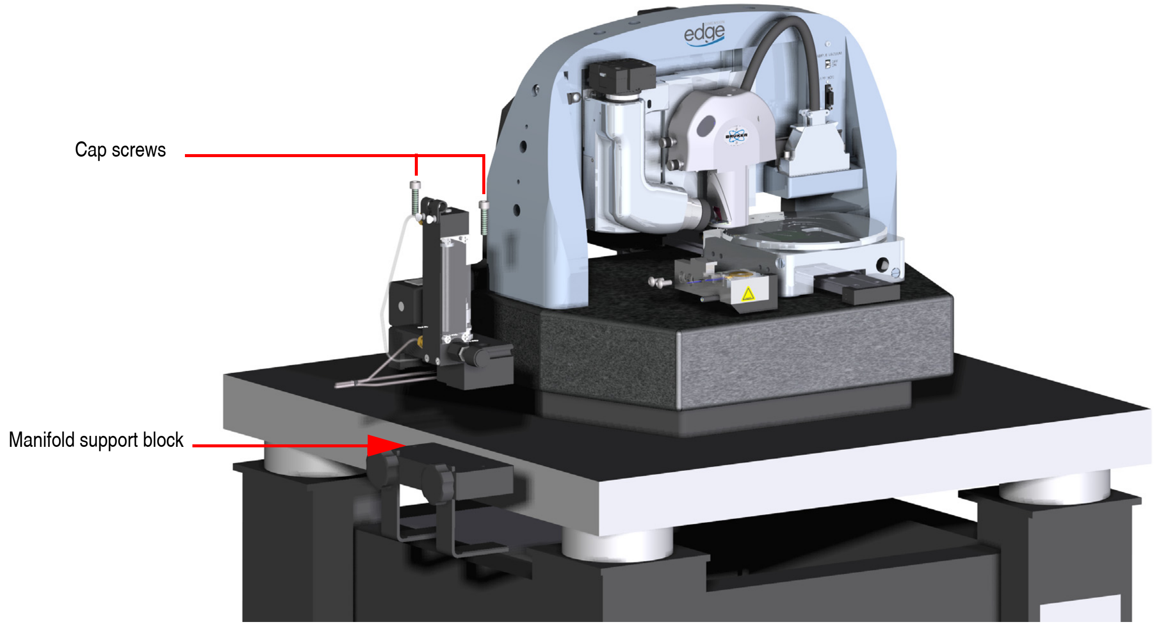


Figure 4.1i Manifold attached to the air table of the Dimension Edge.

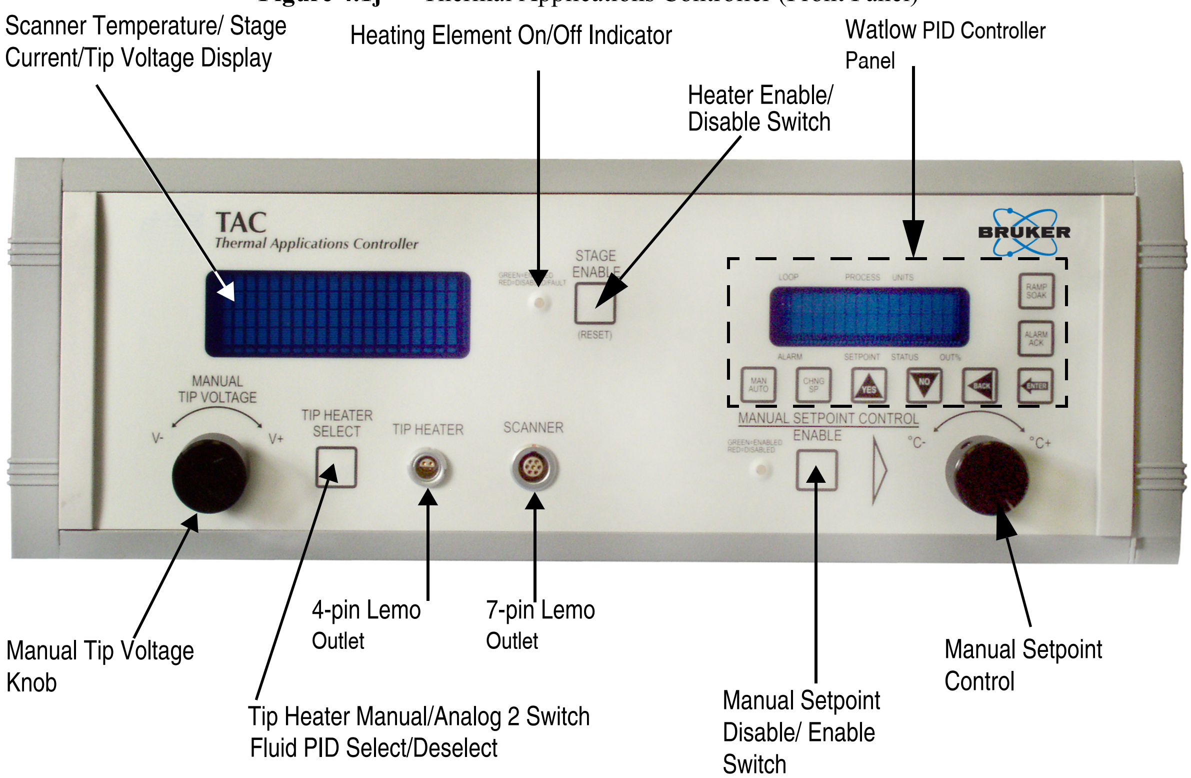
9. Plug the 7-pin Lemo connector on the cable from the heater/cooler magnetic base into the 7-pin receptacle of the heater extension cable.

10. Connect the heater extension cable: Plug the 7-pin Lemo connector on the heater extension cable into the 7-pin SCANNER receptacle on the front panel of the Thermal Applications Controller (see Figure 4.1j).

11. Tip heater:

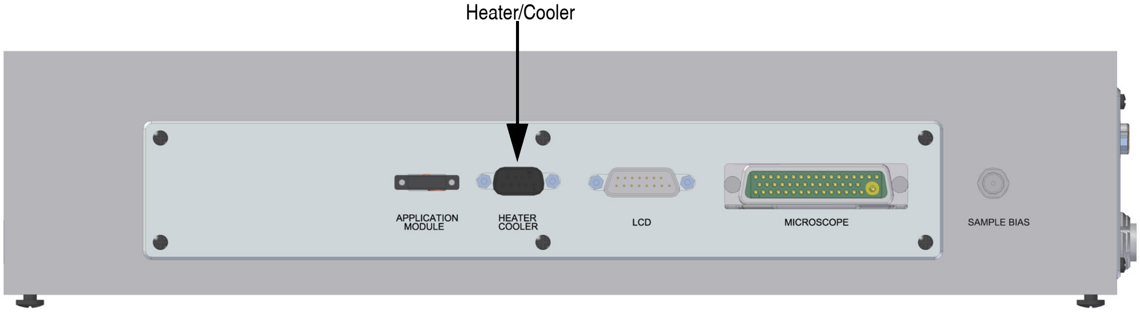
    a. **Dimension 3100/V**: Plug the 4-pin tip heater cable into the 4-pin TIP HEATER receptacle on the front panel of the Thermal Applications Controller (see Figure 4.1j). Use the other end of the cable as a connector between the Dimension head cable and the Dimension electronics box base receptacle (see Figure 3.10s).

Figure 4.1j Thermal Applications Controller (Front Panel)



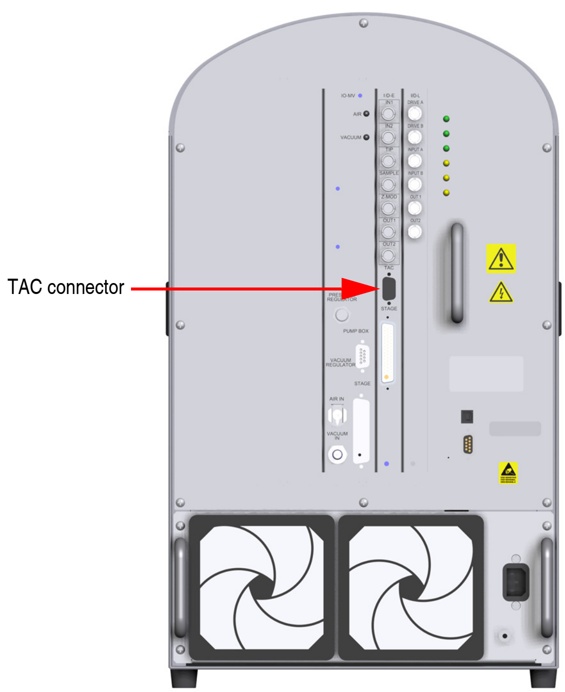
b. **Dimension Icon**: Connect the one end of the tip heater cable into the 4-pin Lemo connector labeled TIP HEATER on the front panel of the Thermal Applications Controller and the other end into the 9-pin D-sub connector labeled HEATER/ COOLER on the top of the Dimension Icon electronics box, shown in Figure 4.1k.

Figure 4.1k Dimension Icon Microscope Electronics Box (top view)



c. **Dimension Edge**: Connect the one end of the tip heater cable into the 4-pin Lemo connector labeled TIP HEATER on the front panel of the Thermal Applications Controller and the other end into the 9-pin D-sub connector labeled TAC on the IO-E board of the NanoDrive controller, shown in Figure 4.1l.

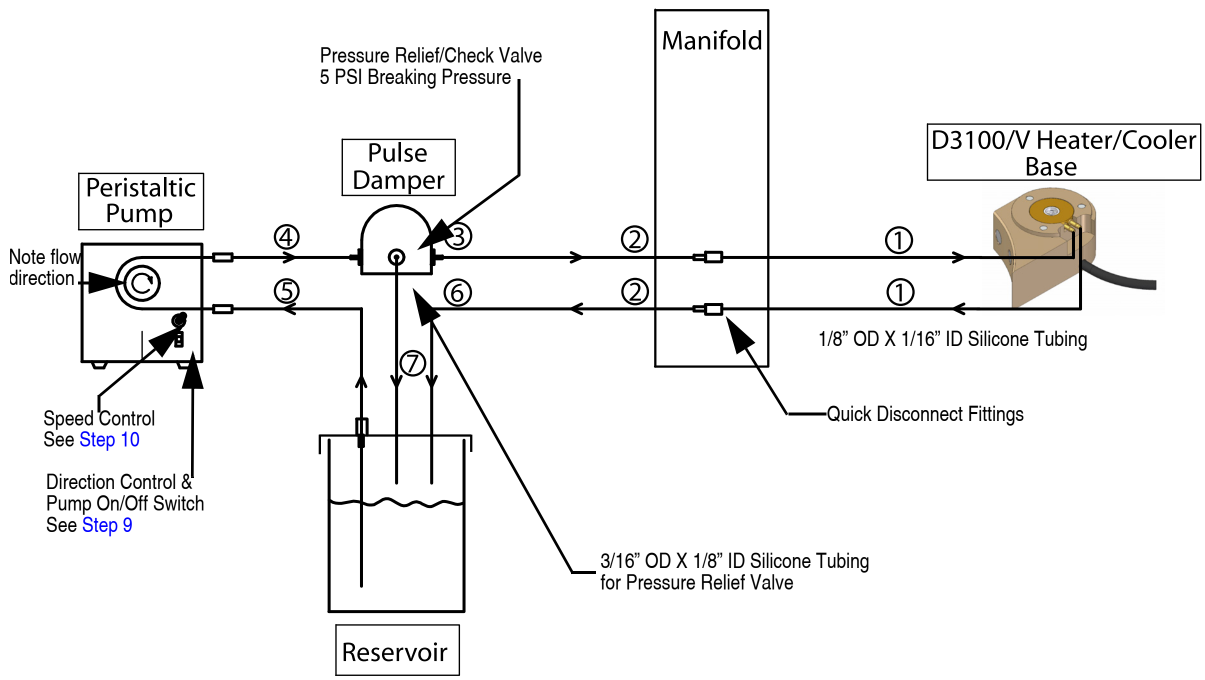
Figure 4.1l NanoDrive Controller rear panel



441.4.2 Assemble the Cooling System (Sample Cooling Only)

A block diagram of the cooling system is shown in Figure 4.2m.

Figure 4.2m Sample Cooling System. D3100/V base shown. Numbers correspond to steps below.



Connect the cooling system as follows (see Figure 4.2m):

1. Install the shorter dual tubing assembly from the two fluid quick-disconnect couplings on the front of the manifold to the barb fittings on the magnetic base as shown in Figure 4.2m.

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

   a. **Dimension Icon/Edge**: Route the hoses through the clamps (attached with thumb screws) on the top of the manifold to provide a service loop, shown in Figure 4.2n and Figure 4.2o. Ensure that sufficient slack exists to provide travel to all four corners of the stage travel. The two markers on the tubes should be on each side of the cable clamps on the top of the manifold.

Figure 4.2n Run water and gas cables through clamps on top of manifold to provide a service loop.

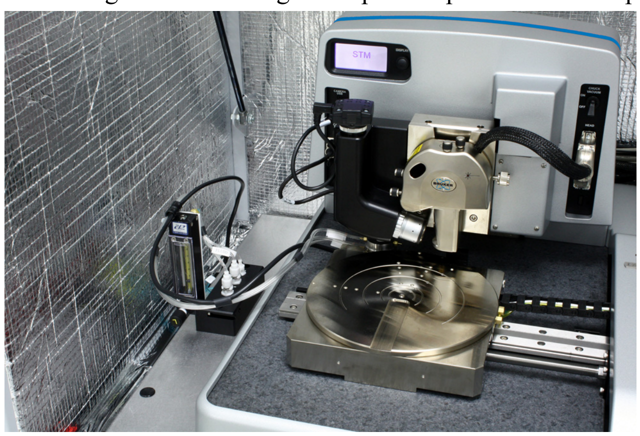
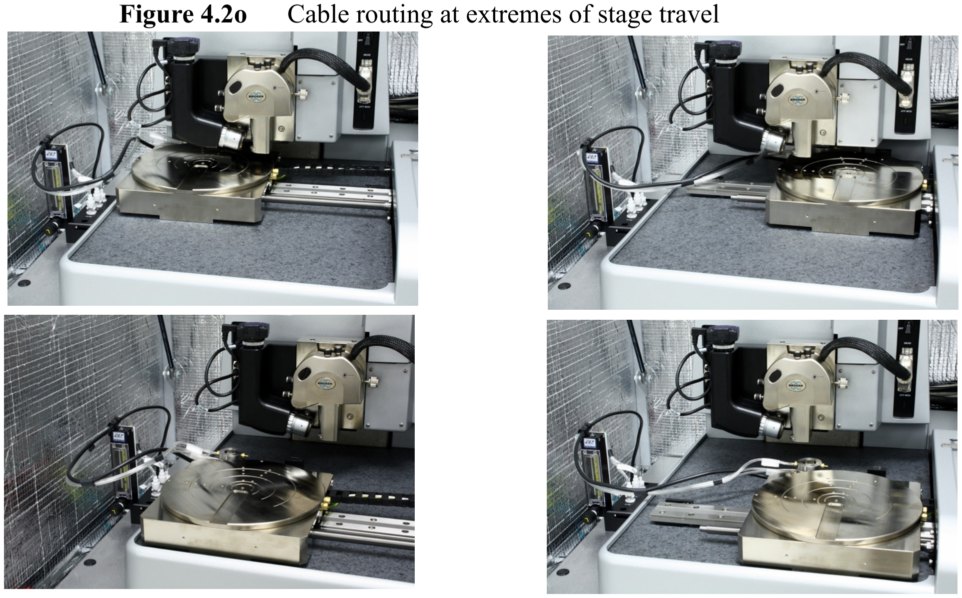
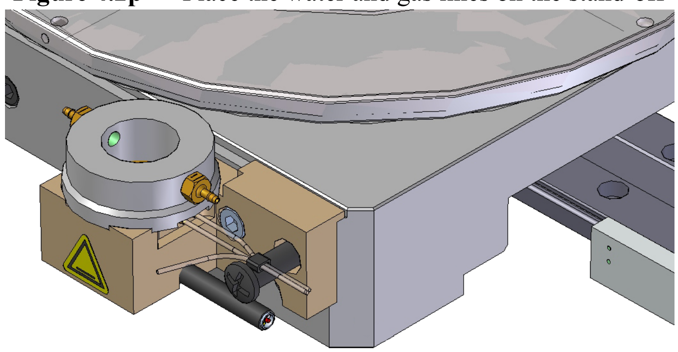


Figure 4.2o Cable routing at extremes of stage travel



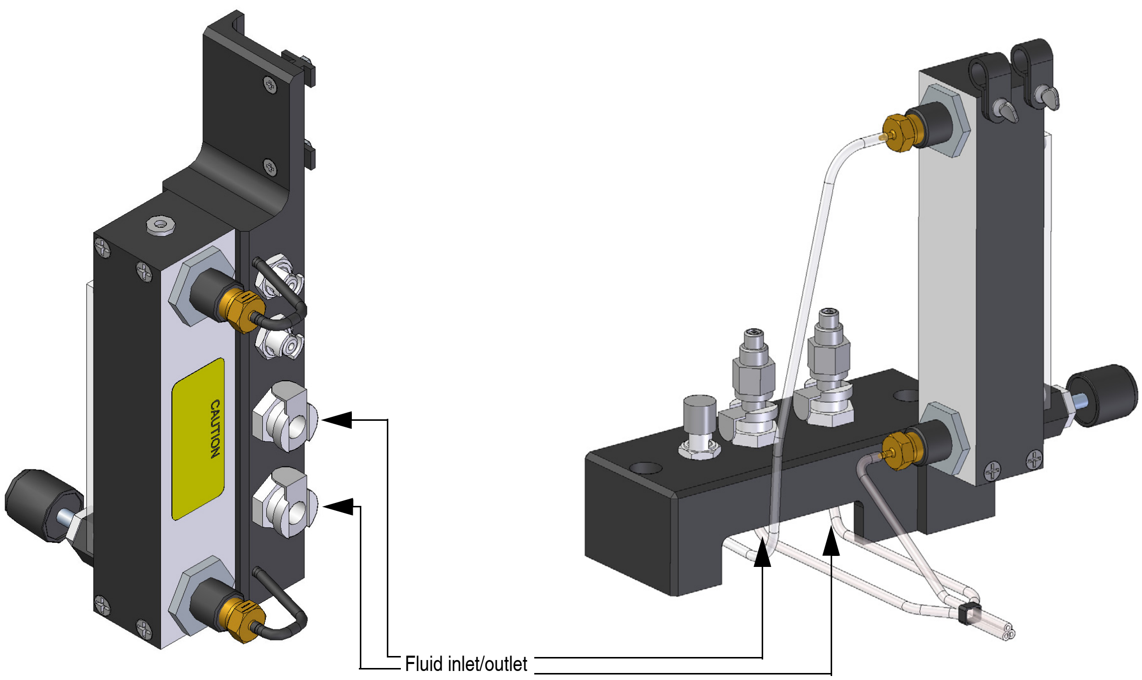
b. **Dimension Icon**: Place the water and gas lines on the stand-off holding the heater/cooler to the Dimension Icon chuck base. See Figure 4.2p.

Figure 4.2p Place the water and gas lines on the stand-off



2. Install the longer dual tubing assembly from the two (fluid) quick-disconnect couplings on the back of the manifold.

Figure 4.2q Manifold - rear view. **D3100/V**, left; **Dimension Icon, Dimension Edge**, right.



3. Connect one of the tubes in Step 2 to one end of the pulse damper, shown in Figure 3.10q and Figure 4.2m.

4. Connect a short line at the opposite end of the pulse damper to the peristaltic pump.

5. Connect the other short line from the peristaltic pump to the CPC quick-disconnect fitting on the reservoir bottle labeled **PUMP**.

6. Connect the other long line from the back of the manifold to the reservoir bottle.

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.

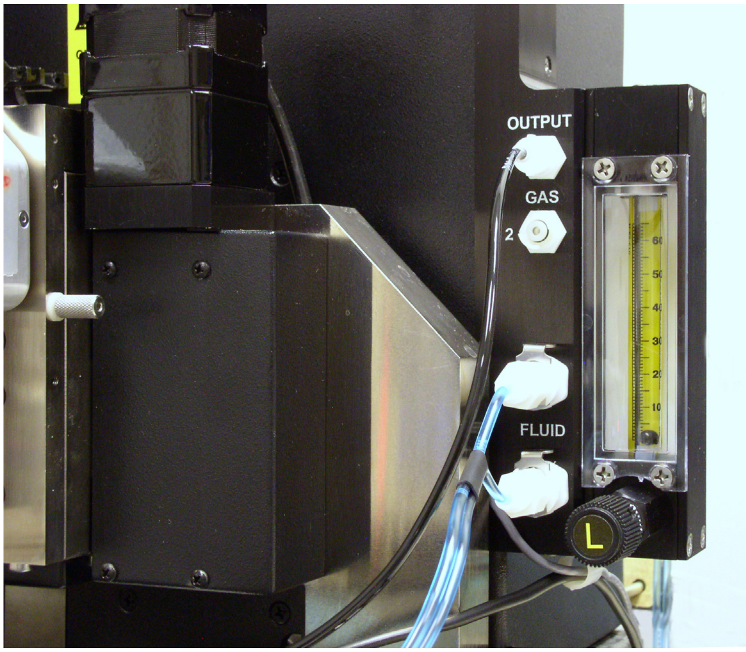
9. Toggle the pump switch to **ON**, as shown in Figure 4.2m, so that the fluid flows from the reservoir to the pump, through the pulse damper and into the magnetic base. Allow the pump to run until all the lines are filled with water and drips appear on the output side of the reservoir bottle connector. 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 about half full once the circuit is full.

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

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

    Note: Speeds greater than 1/3 maximum generally do not improve sample cooling but only add noise to the system.

Figure 4.2r Tubing from manifold



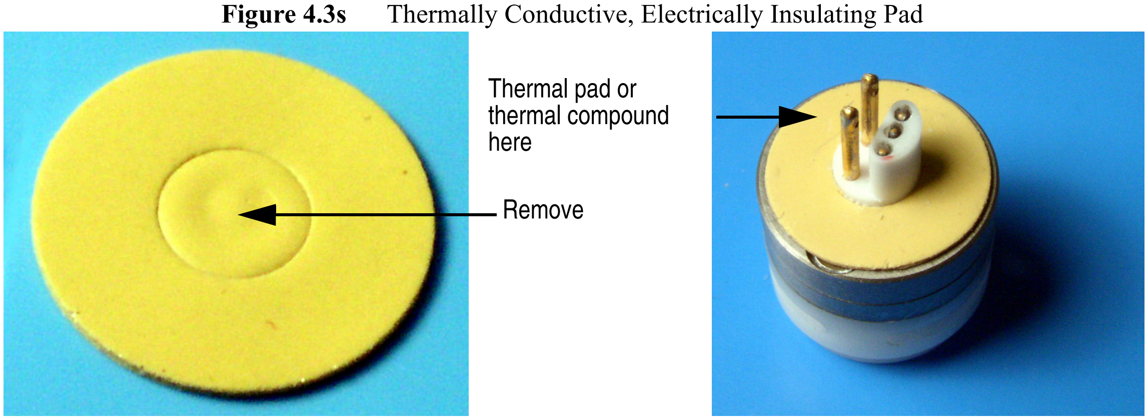
441.4.3 Installation of the High Temperature Heater or Heater/Cooler Element

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 reservoir. Bruker provides thermally conductive, electrically insulating pads, shown in Figure 4.3s, (reorder Bruker part number 499-000-261) to accomplish this task. You may also use Wakefield Engineering Thermal Compound, Wakefield Engineering (www.wakefield.com) part number 120-2, but because it is messier, thermal pads are generally preferred. Wakefield Engineering Thermal Compound is required to reach temperatures below -20°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 4.3s. If you are using thermal compound on the base of the heater, also spread some thermal compound onto the mating surface of the magnetic base.

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

Figure 4.3s Thermally Conductive, Electrically Insulating Pad



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

.

CAUTION:	Use the thermally conductive pads only on the heater/cooler element. They are not needed with the high temperature heater element.

2. Insert the heating element into the connector on the top of the Dimension heater/cooler base.

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

CAUTION: The heating element must be plugged in and unplugged in a straight orientation (no side-to-side motion).

CAUTION: 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.

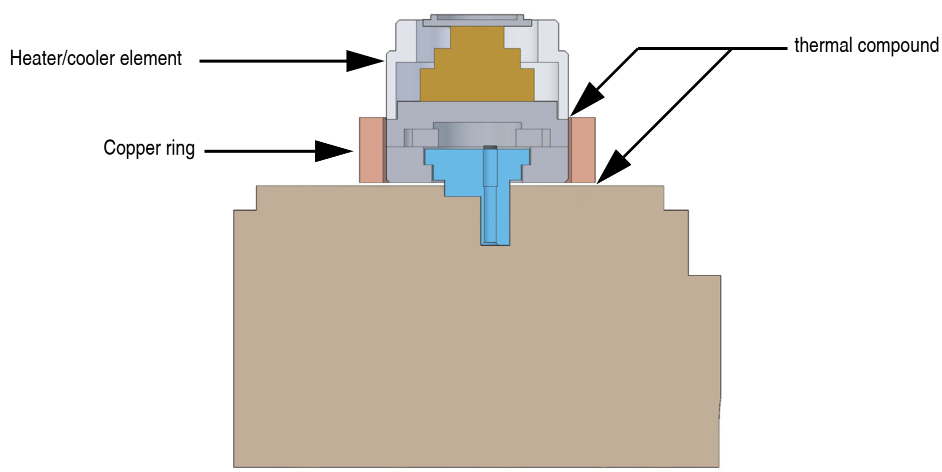
3. Coat the side of the heater/cooler element with thermal compound.

4. Coat the inside and base of the copper ring with thermal compound. Figure 4.3t.

5. Side the copper ring over the heater/cooler element.

Note: Use the copper ring for temperatures < 20°C. It is not needed for temperatures > 20°C.

Figure 4.3t Apply thermal compound to the copper ring

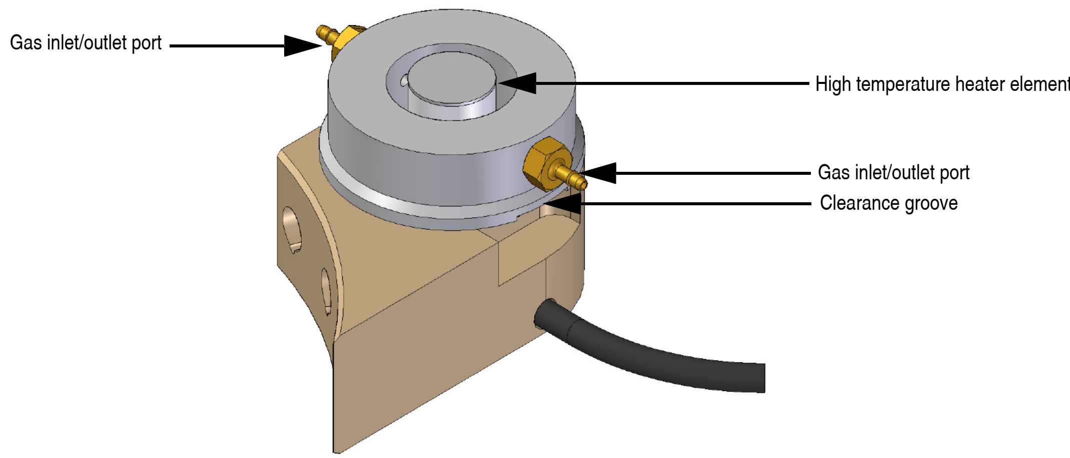


441.4.4 Install the Gas Ring

1. Install the gas ring by placing it around the heater element on the Dimension Heater/Cooler base as shown in Figure 4.4u. Orient the clearance groove in the bottom of the gas ring over the barb cooling water fittings. The magnets will hold it in place.

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

Figure 4.4u The heater/cooler gas ring attached to the heater/cooler base. Dimension 3100/V shown.



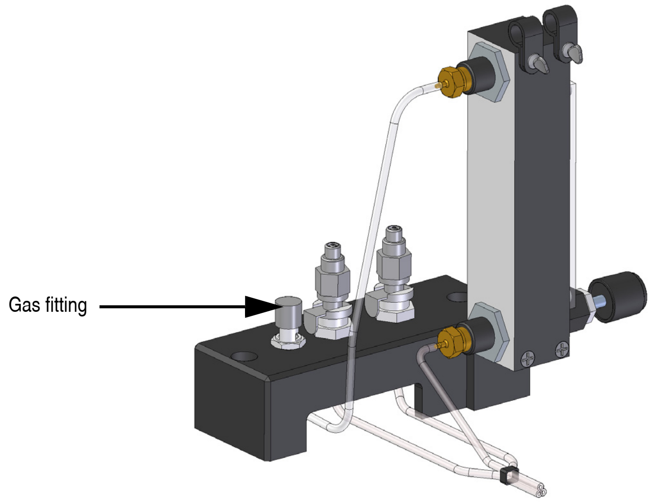
2. Connect the gas inlet:

   a. **D3100/V**: Using the small in-line mating fitting, connect the short (approximately 30 cm) black polyurethane tubing to the top (Gas) quick-disconnect coupling on the front of the manifold.

   b. **Dimension Icon**: Using the small in-line mating fitting, connect the short (approximately 30 cm) black polyurethane tubing to the gas quick-disconnect coupling on the manifold. See Figure 4.4v.

   c. **Dimension Edge**: Using the small in-line mating fitting, connect the short (approximately 30 cm) black polyurethane tubing to the gas quick-disconnect coupling on the manifold. See Figure 4.4v.

Figure 4.4v Dimension Icon/Edge manifold, rear view



3. Connect the other end of this tubing to one of the barb fittings on the gas ring.

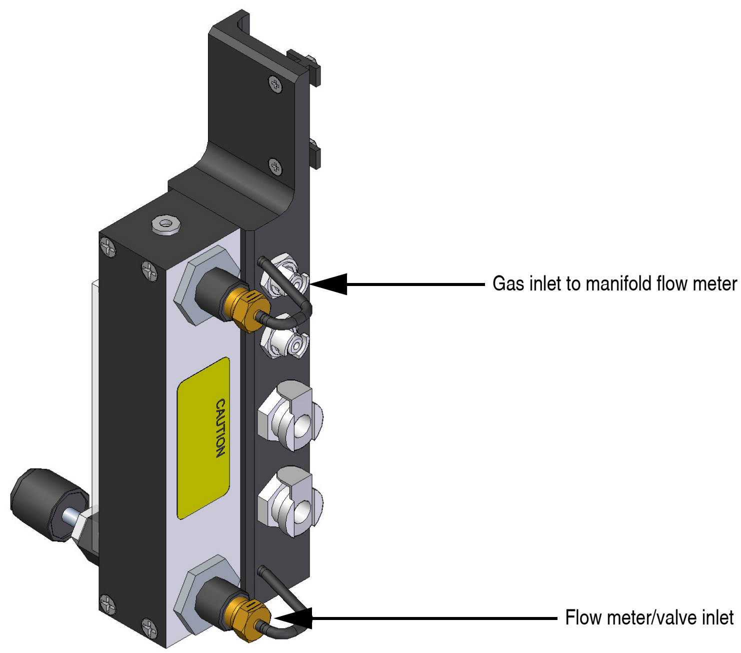
   a. Dimension Icon: Run this tubing, along with the water tubing, through the clamps on the top on the gas flow meter as shown in Figure 4.2n.

4. Supply the gas to the flow meter:

   a. **Dimension 3100/V**: Run the long (approximately 275 cm) length of (supplied) black polyurethane tubing from your regulated gas supply to the top, rear fitting on the manifold, shown in Figure 4.4w and connect it using the small in-line mating fitting.

   Note: The gas is internally routed from the top inlet (rear) port of the manifold to enter the flow control valve (bottom rear), and exit from the top front outlet to the gas ring.

Figure 4.4w Manifold - rear view



   b. **Dimension Icon/Edge**: Run the long (approximately 275 cm) length of (supplied) black polyurethane tubing from your regulated gas supply to the bottom, rear fitting on the flow meter, shown in Figure 4.4v and connect it using the small in-line mating fitting.

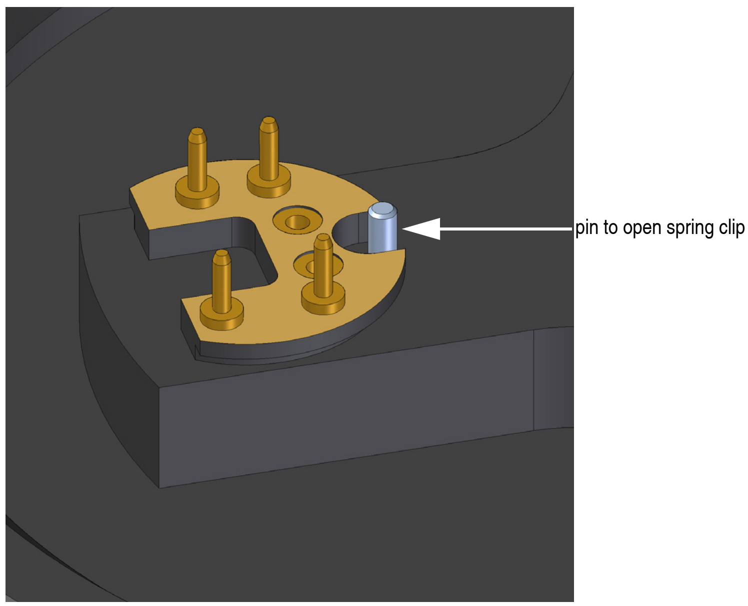
441.4.5 Install the sample and align the laser

1. Place the sample puck (with the sample pre-mounted) on top and centered on the heating element.

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

2. Place the probe holder in the appropriate socket of the Dimension heater/cooler probe stand, shown in Figure 4.5x, to actuate the spring clip.

Figure 4.5x Dimension Heater/Cooler TappingMode probe station



3. Load the probe into the probe holder.

4. Install the probe holder on the end of the scanner tube of the Dimension head.

5. Fit the silicone rubber seal on the probe holder. See Figure 4.5y. You may find it easier to use two hands to fit the seal on the probe holder.

Figure 4.5y Silicone rubber seal installed on the probe holder

6. Align the laser beam to reflect into the photodetector from the tip-end of the cantilever (refer to the appropriate *Dimension Scanning Probe Microscope Instruction Manual* 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.

441.5 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.

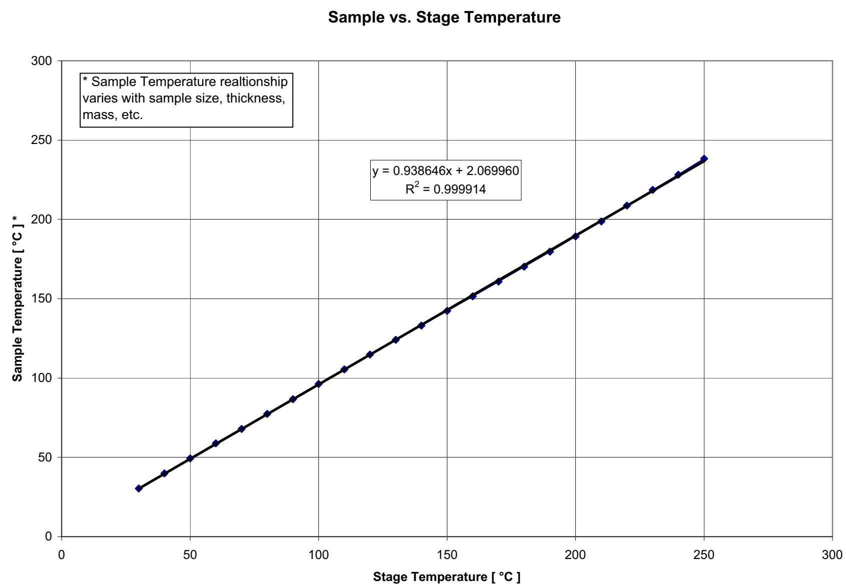
441.5.1 Probes

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

441.5.2 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, the sample temperature is closer to 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. Figure 5.2a shows a typical comparison of sample vs. stage temperature.

Figure 5.2a Sample temperature vs. stage temperature



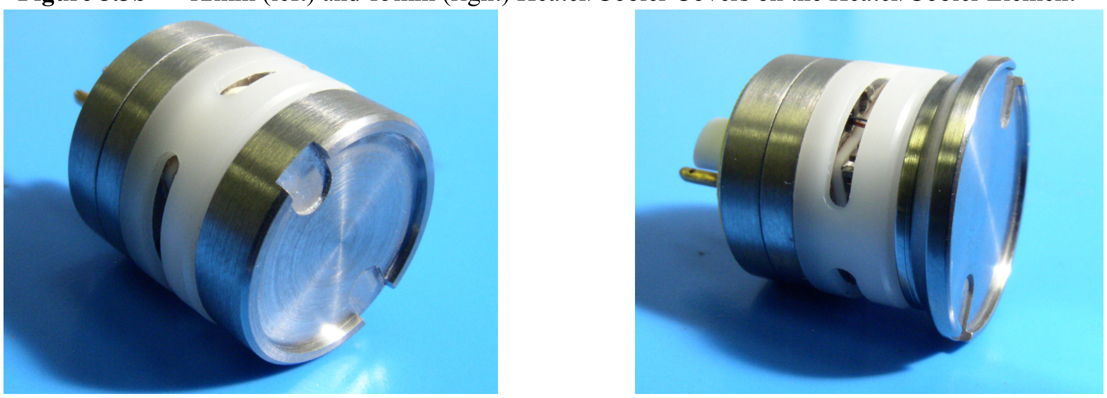
A magnet incorporated in the heater element holds the metallic sample puck to the heater surface. Samples consisting of a film on a flat substrate (such as mica, a silicon wafer, graphite, etc.) or a small block of material with a flat top surface, should be glued to the puck. Choice of glue can be quite 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 window of the heater/probe holder 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, 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).

Note: You may need to clean the probe holder if material has condensed onto it.

441.5.3 Larger Samples

Larger samples require that a heater/cooler cover, with matching sample puck be placed on top of the heater/cooler element as shown in Figure 5.3b. Smear Wakefield Thermal Compound on the mating surfaces (small tungsten cap and small surface under the covers) before putting them together.

Figure 5.3b 12mm (left) and 15mm (right) Heater/Cooler Covers on the Heater/Cooler Element



441.5.4 Thermal Applications Controller

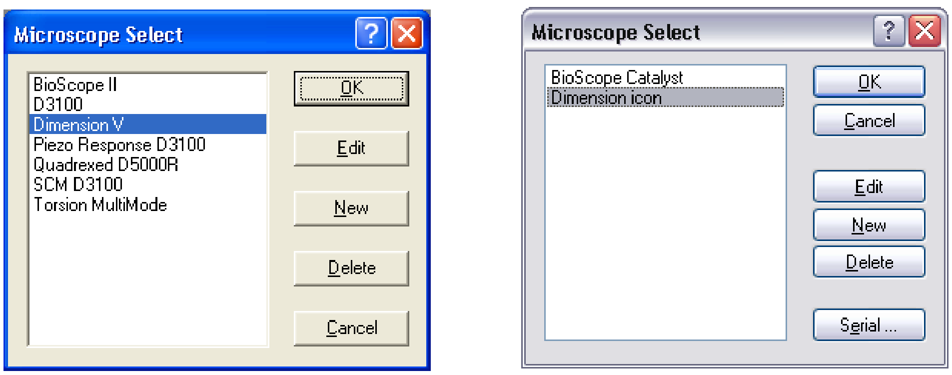
If you have a NanoScope V Controller and NanoScope 7.30 or later software, the Thermal Applications Controller can be controlled by NanoScope software. Earlier NanoScope or NanoDrive software requires front panel control, discussed in **Front Panel Control:** page 49.

Configure the NanoScope Software

Start version 7.30 or later NanoScope software by clicking on the desktop microscope icon.

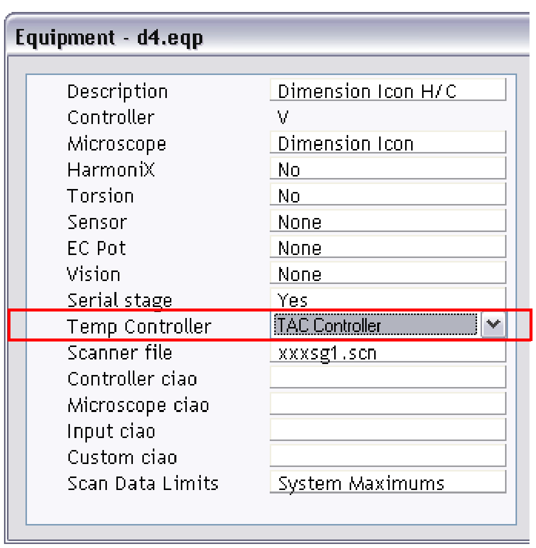
1. Set the microscope configuration by selecting **Tools > Select Microscope...** to open the **Microscope Select** window, shown in Figure 5.4c and select **DIMENSION V** or **DIMENSION ICON**.

Figure 5.4c **Microscope Select** Prompt. NanoScope 7.30, left; NanoScope 8.0, right.



2. Click **EDIT** > **ADVANCED** to open the **Equipment** window, shown in Figure 5.4d.

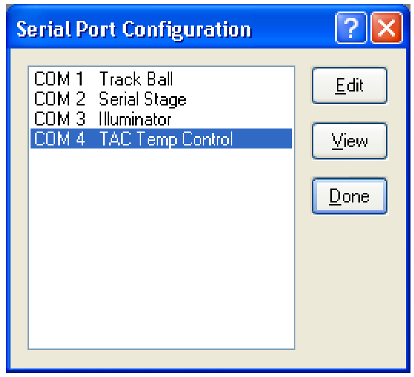
Figure 5.4d System component designation



3. Select the **TAC CONTROLLER** in the **Temp Controller** field.

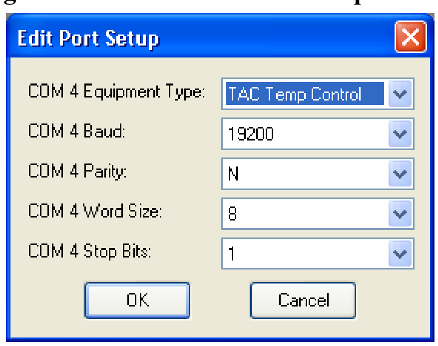
4. Configure the serial ports by clicking **SERIAL** in the **Equipment** (version 7.30) or in the **Microscope Select** (version 8.0) window. This will open the **Serial Port Configuration** window, shown in Figure 5.4e.

Figure 5.4e The **Serial Port Configuration** window



5. Highlight appropriate port and click **EDIT** in the **Serial Port Configuration** window to open the **Edit Port Setup** window, shown in Figure 5.4f.

Figure 5.4f The **Edit Port Setup** window



6. Use the drop-down menu to select the **TAC CONTROLLER** in the **Equipment Type** field and click **OK** to close the **Edit Port Setup** window for that port.

7. Click Done to close the **Serial Port Configuration** window.

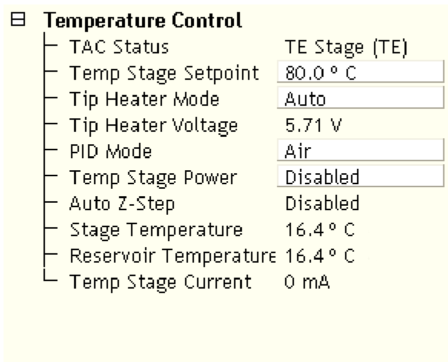
8. Click **OK** to close the **Equipment** window.

9. Click **OK** to close the **Microscope Select** window.

Software Control

Sample and tip heater temperatures can be controlled through the **Temp** panel, shown in Figure 5.4g. The **Temp** panel is available in either the **Scan Parameters List** or the **Scan-Single** (version 7.30) window.

Figure 5.4g The **Temp** panel



Temp Panel Parameters:

TAC Status	Status of the TAC Controller. Identifies stage type, errors. *Settings:* **Heat Stage/TE Stage**
Temp Stage Setpoint	User choice *Range:* **0°C** to **250°C** (Heat Stage) **-40°C** to **100°C** (TE Stage) *Default Setting:* **25°C**
Tip Heater Mode	*Settings:* **Auto/Manual** *Default Setting:* **Auto**
Tip Heater Voltage	*Range:* **0V** to **20V**
PID Mode	*Settings:* **Air/Fluid**
Temp Stage Power	*Settings:* **Disabled/Enabled** *Default Setting:* **Disabled**
Auto Z-Step	Specifies if auto z-stepping function is active (enable). If the NanoScope software detects that the z-scanner is nearly out of range (perhaps from thermal drift) and auto z-step is enabled, the step motor will reposition the scanner. *Settings:* **Disabled/Enabled** *Default Setting:* **Disabled**
Stage Temperature	Reports the stage temperature measured by the thermocouple.
Reservoir Temperature	Reports the reservoir temperature measured by the thermocouple.
Temp Stage Current	Reports the output current of the TAC. *Range:* **0mA** to **650mA** Heater stage **0mA** to **1350mA** Thermoelectric cooling stage

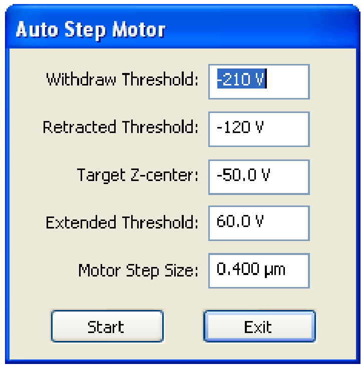
Auto Z-Stepper Motor Control

Z-drift can be a significant problem for heating (and cooling) due to thermal expansion. The purpose of the **AUTO Z-STEP** function is to keep the Z-center position from becoming extended or retracted, as a result of z-drift.

With **Auto Z-Step ENABLED** (Figure 5.4g) and **START**ed**,** NanoScope software automatically steps the z-stage up or down whenever the z-center voltage drifts too far towards the fully retracted or fully extended position. These two z-positions are user defined by **Retracted Threshold** and **Extended Threshold**, shown in Figure 5.4h. When the z-center voltage is less than **Retracted Threshold**, then the z-stage is stepped "up" (by the **Motor Step Size**) until the z-center is at the **Target Z-Center**.

The **Withdraw Threshold,** for the retracted side only, protects against feedback errors, which cause the Z piezo to fully retract. If the Z-center is less than the **Retracted Threshold**, the probe is automatically withdrawn.

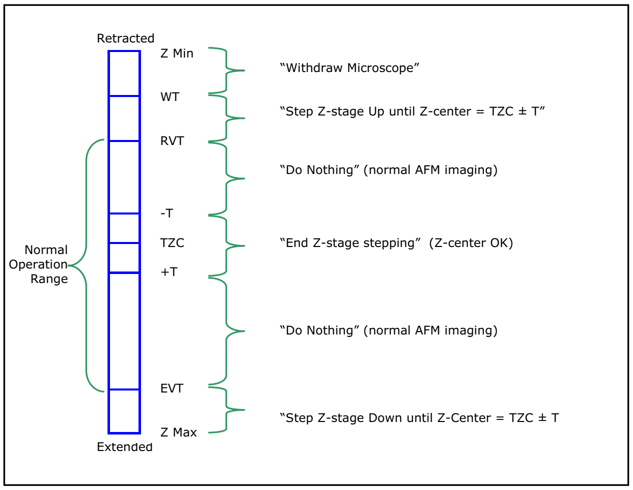
Figure 5.4h **Auto Step Motor** window



Auto Z-Step logic is shown in Figure 5.4i with the **Auto Step Motor** functions and symbols (for Figure 5.4i) are defined below.

Retracted Voltage **Threshold** (RVT)	*Range:* **Withdraw Threshold + 20V** to **Target Z-Center - 20V** *Default Setting:* **-210V**
Extended Voltage **Threshold** (EVT)	*Range:* **Target Z-Center + 20V** to ZMax (hybrid head: 110V, other heads 220V). *Default Setting:* **60V**
Target Z-Center (TZC)	*Default Setting:* **-50V** (hybrid head) **0V** (other heads)
Withdraw Threshold (WT)	*Range:* **Withdraw Threshold - 20V** to ZMax (hybrid head: 110V, other heads: 220V). *Default Setting:* **-210V**
Motor Step Size	*Range:***0µm** to **0.5µm** *Default Setting:* **0.4µm**
Start	Starts the Auto Step Motor function.
Stop	Stops the Auto Step Motor function.
Exit	Closes the **Auto Step Motor** window.
Target ± **tolerance** (T)	Not user adjustable *Default Setting:* **10V**

Figure 5.4i Auto Z-Step logic



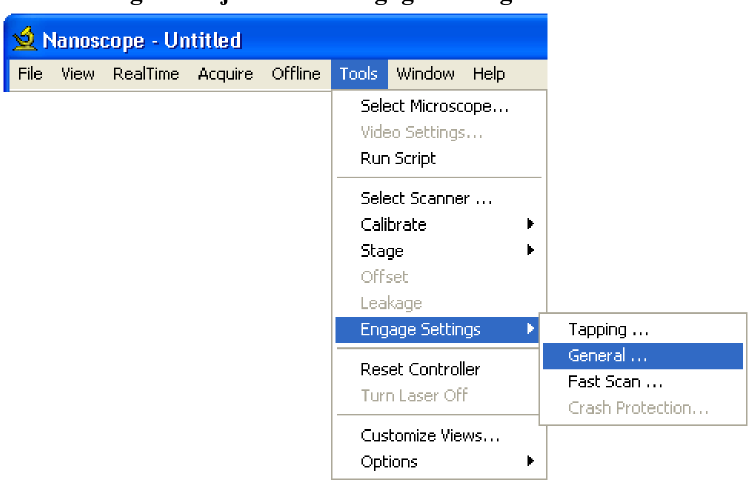
Short Withdraw

The purpose of the short withdraw function is to provide you with a safe means to change temperature, adjust the detector and feedback settings, tune the cantilever tune, etc. in close proximity to the surface so that the temperature of the tip and sample remain stable and the gas seal is maintained.

To change the short withdraw distance (the factory default is 20µm):

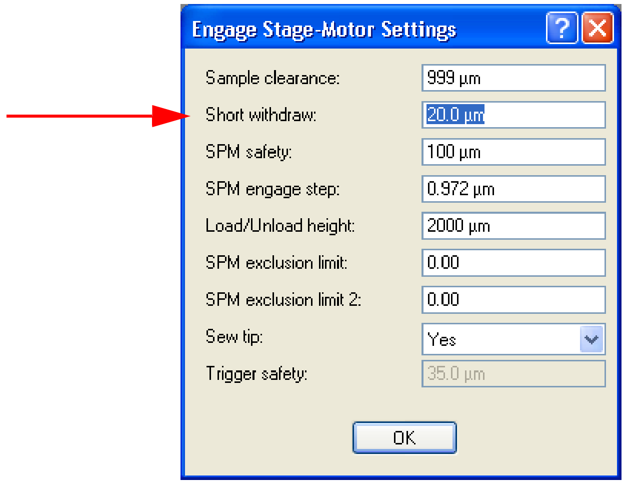
1. Click **TOOLS** (version 7.30) or **MICROSCOPE** (version 8.0) > **ENGAGE SETTINGS** > **GENERAL**, shown in Figure 5.4j.

Figure 5.4j Select **Engage Settings** > **General**

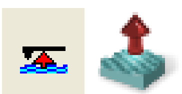


2. This opens the **Engage Stage - Motor Settings** window, shown in Figure 5.4k.

Figure 5.4k Engage Stage - Motor Settings



3. Modify the **Short withdraw** distance (range is 0 to 999µm) and click **OK.**



Click the **SHORT WITHDRAW** icon on the top (7.30) or workflow (8.0) toolbar to perform a short withdraw.

Click the **ENGAGE** icon on the top (7.30) or workflow (8.0) toolbar to re-engage the sample.

Front Panel Control

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 reservoir temperature exceeds a factory setpoint. The Thermal Applications Controller front panel (see Figure 5.4l) 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.

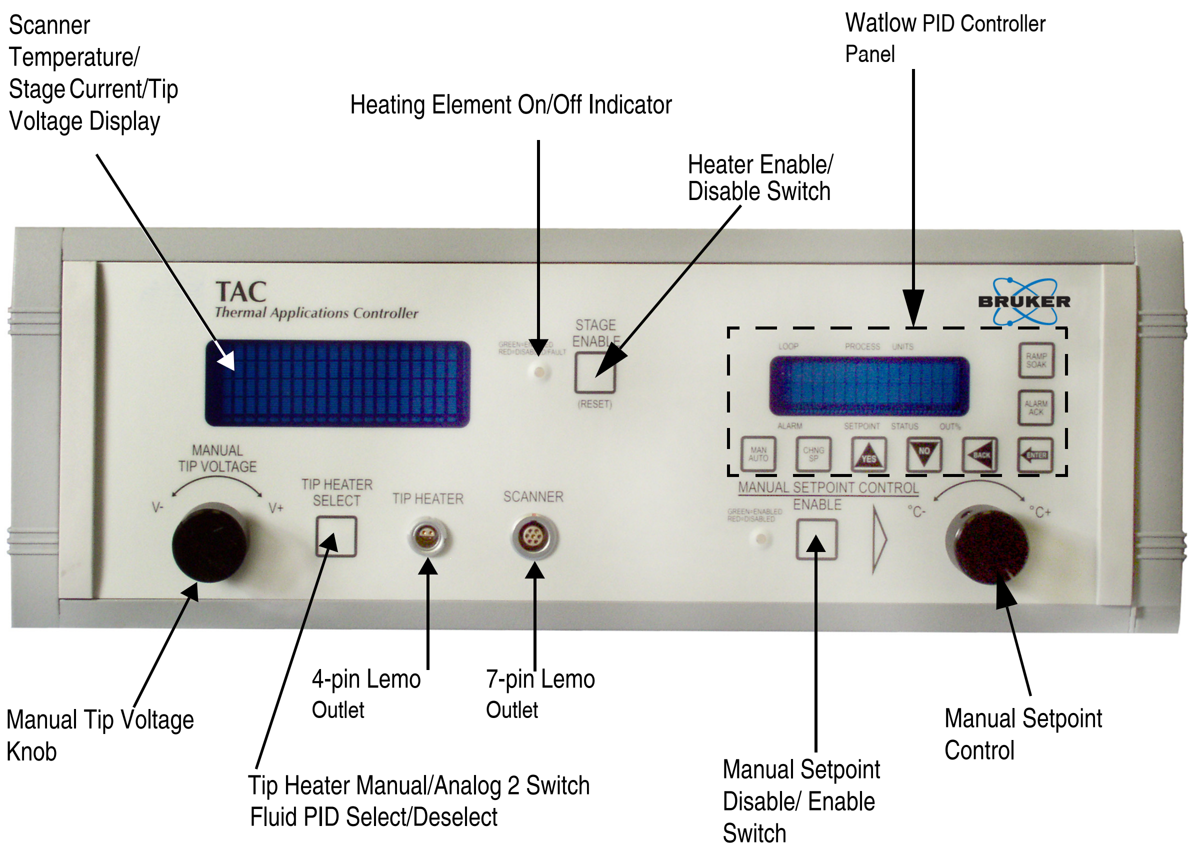
- The **Manual Setpoint Control Enable/Disable switch** enables (green LED indicator)/disables (red LED indicator) the **Manual Setpoint Control** knob. The factory default setting is **Disabled**. Enabling **Manual Setpoint Control** transfers control of the Watlow controller from the **Watlow control buttons** (see page 55) 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 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 55, 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 5.4p.

- 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 5.4l 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.

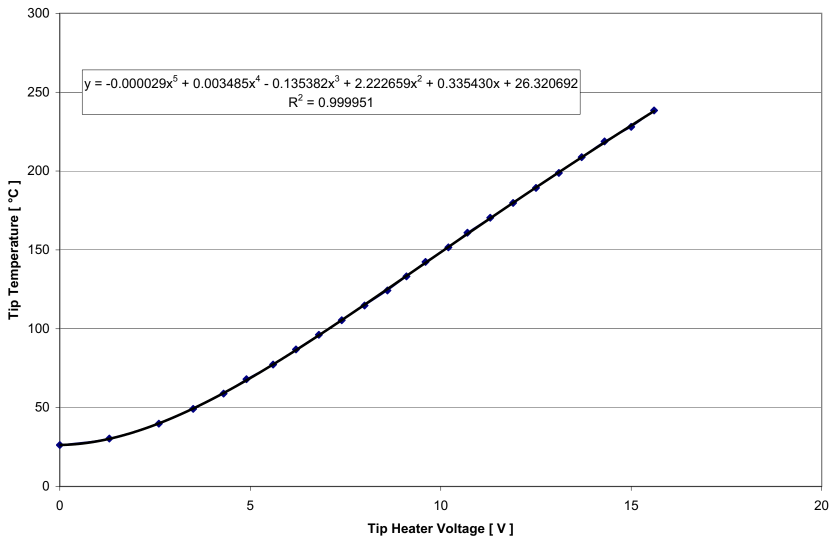
- **Manual Tip Voltage**: The temperature of the tip heater inside the probe holder is controlled by the tip voltage.

A calibration of temperature as a function of tip voltage appears in Figure 5.4m. Data points are indicated by diamonds; the line is a fifth order polynomial fit to them. Use this table to set the tip voltage for the desired temperature if you using manual, rather than software, control of the TAC.

Temperature as a Function of Tip Voltage Data
(Plotted in Figure 5.4m)

Stage Temperature [°C]	Sample Temperature [°C]	Tip Temperature [°C]	Tip Heater Voltage [Volts]	Time	Heater Output [%]
25.1	25.7	26.3	0.0	1:06 PM	0%
30.0	30.4	30.4	1.3	1:20 PM	9%
40.0	39.8	39.8	2.6	1:40 PM	14%
50.0	49.3	49.2	3.5	1:50 PM	19%
60.0	58.8	58.9	4.3	2:00 PM	23%
70.0	67.9	68.0	4.9	2:10 PM	27%
80.0	77.4	77.3	5.6	2:20 PM	30%
90.0	86.7	86.9	6.2	2:30 PM	34%
100.0	96.2	96.2	6.8	2:40 PM	37%
110.0	105.4	105.4	7.4	2:50 PM	40%
120.0	114.8	114.8	8.0	3:00 PM	44%
130.0	124.1	124.3	8.6	4:10 PM	47%
140.0	133.1	133.2	9.1	4:20 PM	51%
150.0	142.3	142.4	9.6	4:30 PM	54%
160.0	151.5	151.6	10.2	4:40 PM	57%
170.0	160.8	160.9	10.7	4:50 PM	61%
180.0	170.2	170.4	11.3	5:00 PM	64%
190.0	179.7	179.8	11.9	5:10 PM	67%
200.0	189.2	189.3	12.5	5:20 PM	71%
210.0	198.7	198.8	13.1	5:30 PM	74%
220.0	208.7	208.8	13.7	5:40 PM	77%
230.0	218.6	218.8	14.3	5:50 PM	81%
240.0	228.2	228.0	15.0	6:00 PM	84%
250.0	238.3	238.4	15.6	7:00 PM	88%

Figure 5.4m Tip Heater Calibration

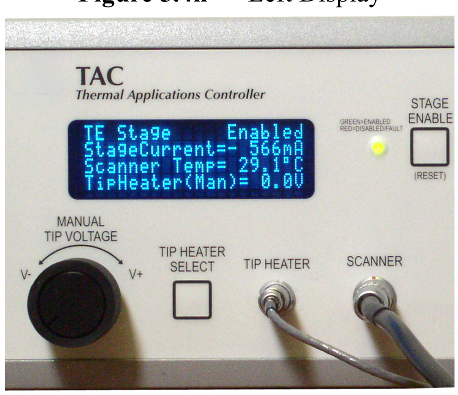


Note: Although a **TIPHEATER** voltage is shown on the front panel, the voltage to the tip heater is disabled when the TAC **STAGE ENABLE** switch is set to **DISABLED**. The **STAGE ENABLE** switch must be set to **ENABLED** to apply a voltage to the tip heater.

Left Display

The left display panel, shown in Figure 5.4n, shows, in order:

Figure 5.4n Left Display



1. Heater type (**TE STAGE** - ThermoElectric heater/cooler, **HEAT STAGE** - High Temperature heater or **LOW T STAGE** — Air/Fluid heater — MultiMode only), **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 5.4o, 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 5.4o 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 Dimension heater/cooler base which measures the reservoir temperature has been disconnected. Usually it means the Dimension heater/cooler base is unplugged from the TAC. Press the **STAGE ENABLE** button once to **RESET** the alarm.

- **SCN TEMP**: The thermocouple that measures the reservoir temperature reads 65ºC. This protects the thermoelectric cooler.

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

Note: The maximum **STAGE CURRENT** is 650mA for the heater stage and 1350mA for the thermoelectric cooling stage.

3. **Scanner Temp**: The temperature of the reservoir in the magnetic base.

   Note: The output of the TAC is disabled when the reservoir temperature exceeds 65ºC.

4. **Tip Heater** Voltage and source (**Manual** or **Analog 2**).

Right Display

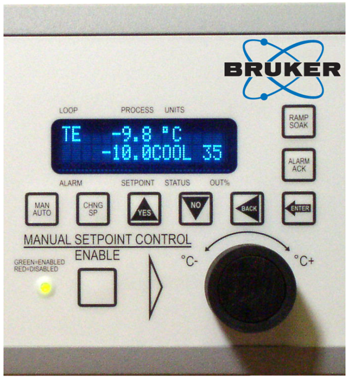
The right display panel, shown in Figure 5.4p, shows, in order:

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 5.4p Right Display



Watlow control buttons

The touch pad controls adjacent to the right display, shown in Figure 5.4p, provide full access to the Watlow controller features. Because the Watlow controller has been pre-programed 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. The file is 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 7.0g. These minimum and maximum setpoint and the high temperature alarm, which turns off the stage current, values must never be changed.

Table 5.4q Stage Values

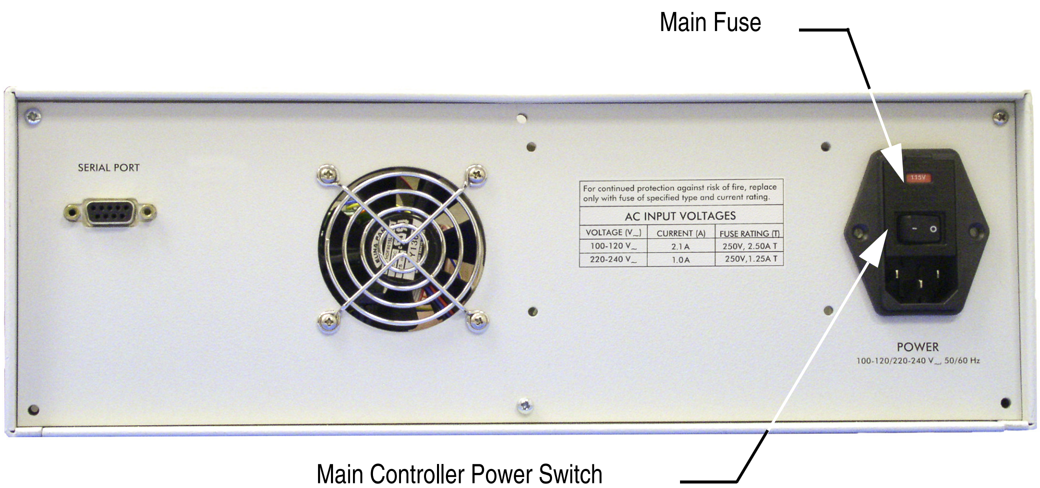
Stage Type	Minimum Setpoint	Maximum Setpoint	High Temperature Alarm
HEAT STAGE	20°C	250°C	275°C
TE STAGE	-40°C	100°C	110°C

Rear Panel

- **Controller Power**: The **POWER** plug, **SWITCH** and main fuse are located on the back of the control box.
- The **SERIAL PORT** is connected to a serial port connection, usually COM4, of the PC controlling the Dimension microscope.

  Note: The serial port is used only for NanoScope (software) control of the TAC. Connection is unnecessary for manual control.

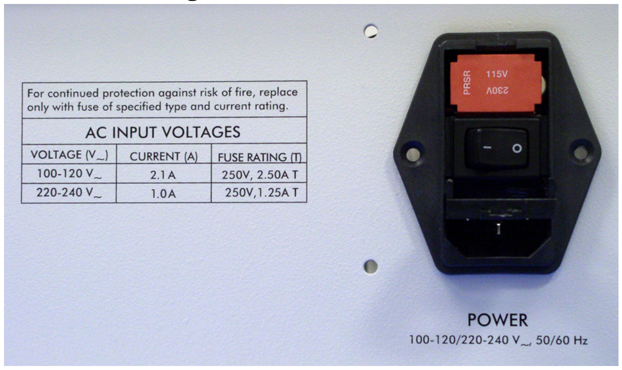
Figure 5.4r Thermal Applications Controller (Rear Panel)



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 5.4s, and removing and rotating the fuse holder.

Figure 5.4s Fuse Holder



441.5.5 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 ≤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.

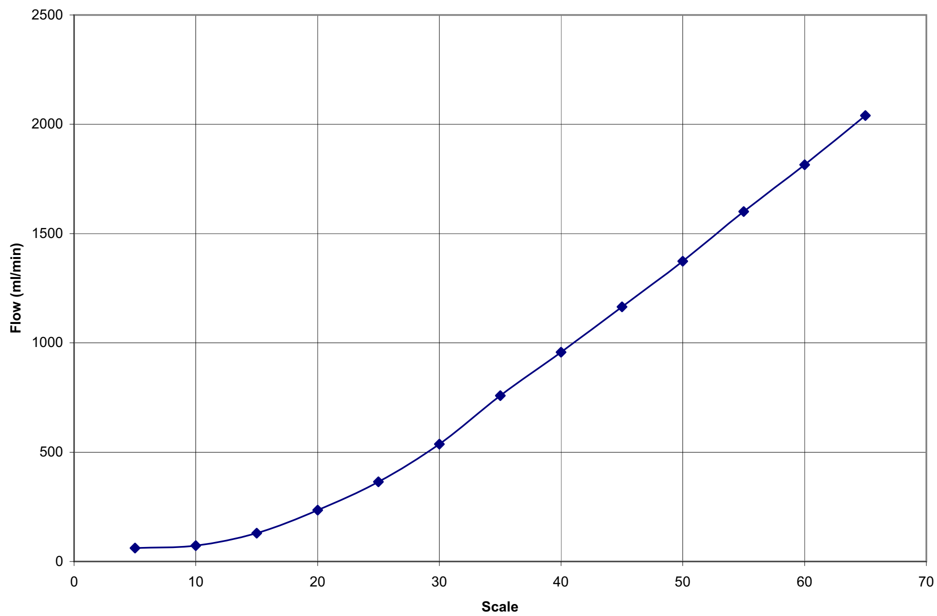
441.5.6 Gas Purging

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.).

Because of the possibility of material oxidation at high temperature, the 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 1-2 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.

The flow meter calibration curve, shown in Figure 5.6t, shows flow rate, in ml/min vs. the scale markings on the flow meter.

Figure 5.6t Flow meter calibration curve



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

Dry nitrogen gas purging, at 50 - 500 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 500 ml/min. will heat the sample or cause noise. 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 (www.chartbiomed.com)
   E-mail: 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
   E-mail: 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.wessingtoncrygenics.com
   E-mail: 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.

441.5.7 Thermoelectric Element 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 Dimension scanner. Periodically monitor the cooling system for leaks during operation. Replace leaky tubing.

When the pump is first started, the pulse damper (see Figure 3.10q) 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 polyurethane 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.

441.5.8 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.

441.6 Maintenance

441.6.1 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 5.4s).

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.

441.6.2 Pump Tube Replacement

If the cooling pump fails to draw water, the persitaltic pump tube inside the cooling pump housing may have become blocked, pinched or leaky. The persitaltic 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. The peristaltic pump works by squeezing the outside of the tube to move the contents within the tube. With the persitaltic 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 persitaltic pump tube:

1. Using a flat blade screwdriver, remove the four cap screws which hold the cooling pump end bells to the pump motor.

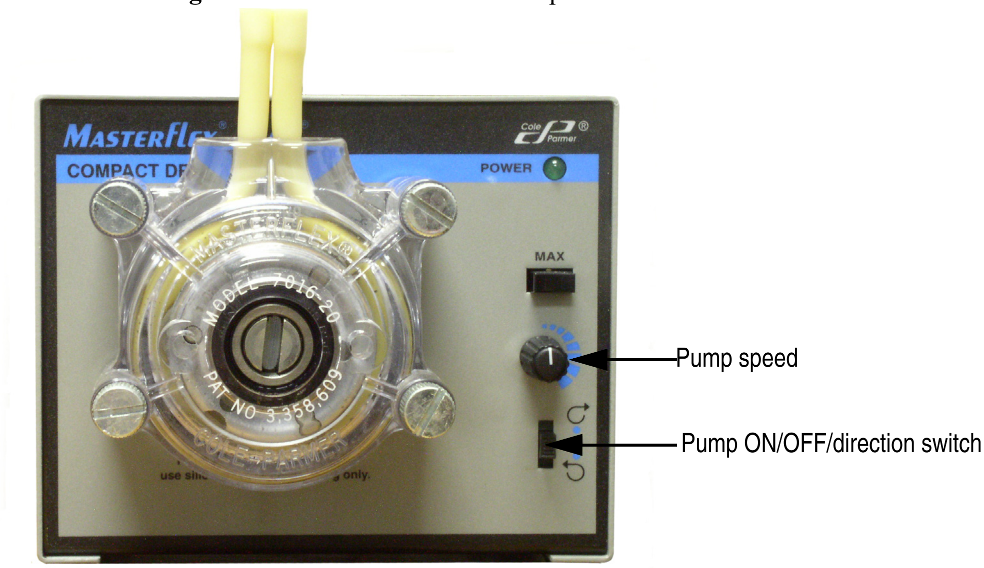
2. Separate the end bells and gently pull the peristaltic pump tube free of the pump.

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 6.2a Masterflex L/S Pump Drive and Head



441.6.3 Tube Replacement

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

441.6.4 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.

441.7 Specifications

See Table 7.0a for characterization of the Dimension Heater/Cooler capabilities and Table 7.0c for conditions associated with its controller.

Table 7.0a Specifications for the Dimension Heater/Cooler

Parameter	High Temperature Heater Specification	Heater/Cooler Specification
Maximum Heater Temperature (Air)[1]	250º C	100º C
Maximum Heater Temperature (Fluid)[1]		50º C
Minimum Heater Temperature (Air)[1]	Ambient	-35º C [5, 6]
Minimum Heater Temperature (Fluid)[1]	Ambient	< 4º C
Pressure	Ambient	Ambient
Resolution	0.1°C	0.1°C
Accuracy	3.0%	3.0%
Temperature Drift[1]	< 0.5°C, 0.2°C typical	< 0.5°C, 0.2°C typical
Overshoot[1]	<1.0°C[2]	<1.0°C typical, <2.5°C max[3]
Heating Rate Nominal[1]	> 10°C/min.	> 20°C/min.
Cooling Rate Nominal[1]	n/a	> 20°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) ≤50°C.
[3] Temperature step (change) ≤10°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 7.0b shows the PID zones.
[4] Temperature step (change) ≤10°C.
[5] With dry nitrogen gas flow of 50 - 500 ml/min. No sample puck or 6mm sample puck.
[6] A temperature of -35º C is sustainable for a limited time. Typical times at this temperature range from 30 to 90 minutes.

Table 7.0b 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 7.0c 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 7.0d through Table 7.0h 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 7.0d 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	**19200**
Communications Protocol	**Mod** (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 7.0e 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	**K T/C**	**K T/C**	**Skip**
Loop Name	**TE**	**HT**	03 to 05
Input Units	**°C**	**°C**	°F
Input Reading Offset	**0°C**	**0°C**	0°F
Reversed T/C Detection	Off	Off	Off
Input Filter	**Varies***	**Varies***	3 Scans

* Dynamically controlled by the TAC processor.

Table 7.0f 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 7.0g 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 7.0h 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.

441.8 Compatibility

Table 8.0a lists known compatibility issues with the Dimension Heater/Cooler. Many of these can be worked around by using front panel (manual) rather than NanoScope software control of the TAC as discussed in Note 1.

Table 8.0a Dimension Heater/Cooler Compatibility

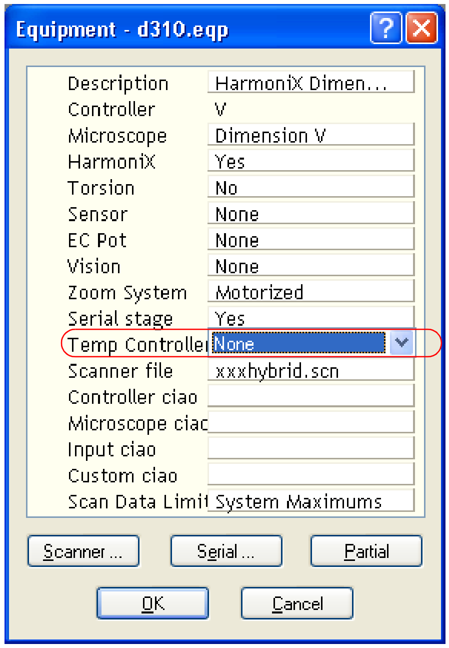
Mode/Application	Compatibility	Compatibility Issue
Active Tip/Fast Scan	No	Fast Scan requires a special probe holder.
Dark Lift	Yes	None.
Harmonic Drive (w/ generic lock-in)	Limited	Ana2 required for Harmonic Drive. See Note 1.
HarmoniX	Limited	A Force Modulation probe holder is required for HarmoniX. See Note 2.
MFM	Yes	
Piezo Response	Yes Limited	Compatible using sample bias only. Ana2 available for tip bias. See Note 1.
SCM	Limited	SCM probe holder is required. See Note 2.
SSRM	Limited	SSRM probe holder is required. See Note 2.
STM	No	STM and Heater/Cooler are mutually exclusive. Moreover, the Heater/Cooler cable to the Icon Electronics box needs (see Figure 4.1k) to be disconnected when in STM mode. Otherwise, the Current Signal will not route back to the NS V controller.
Surface Potential (EFM)	Yes Limited	Compatible using sample bias only. Ana2 available for tip bias. See Note 1.
TR mode	Limited	TRmode probe holder is required. See Note 2. STM line required. See Note 3.
TUNA	Limited	TUNA probe holder is required. See Note 2.

Notes:

1. Ana2 is available for other uses if the **Temp Controller** parameter in the **Equipment** window is set to **NONE**, shown in Figure 8.0b. Control of the TAC is then (manual) from the TAC front panel, see **Front Panel Control:** page 49.

2. The Dimension Heater/Cooler probe holder provides tip heating to prevent condensation on the probe tip. It, along with matching seal, provides a sealed environment micro-environment to control condensation and oxidation. These will both be given up if other probe holders are used.

Figure 8.0b Set **Temp Controller** to **NONE** to make Ana2 available.



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.

No one is authorized to extend or alter these warranties on Seller's behalf without the written authorization of Seller.

THE ABOVE WARRANTIES ARE EXPRESSLY IN LIEU OF ANY OTHER EXPRESS OR IMPLIED WARRANTIES (INCLUDING THE WARRANTY OF MERCHANTABILITY), AND OF ANY OTHER OBLIGATION ON THE PART OF SELLER. SELLER DOES NOT WARRANT THAT ANY EQUIPMENT OR SYSTEM CAN BE USED FOR ANY PARTICULAR PURPOSE OR WITH ANY PARTICULAR PROCESS OTHER THAN THAT COVERED BY THE APPLICABLE PUBLISHED SPECIFICATIONS.

NO CONSEQUENTIAL DAMAGES. LIMITATION OF LIABILITY. Seller shall not be liable for consequential damages, for anticipated or lost profits, incidental, indirect, special or punitive damages, loss of time, loss of use, or other losses, even if advised of the possibility of such damages, incurred by Buyer or any third party in connection with the equipment or services provided by Seller. In no event will Seller's liability in connection with the equipment or services provided by Seller exceed the amounts paid to Seller by Buyer hereunder.