



ATC1000

Animal Temperature Controller

INSTRUCTION MANUAL

Serial No. _____

010612

World Precision Instruments

www.wpiinc.com

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ABOUT THIS MANUAL

The following symbols are used in this guide:



This symbol indicates a CAUTION. Cautions warn against actions that can cause damage to equipment. Please read these carefully.



This symbol indicates a WARNING. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.



Fig. 1—Fig. 1—Animal Temperature Controller

INTRODUCTION

ATC1000 is a low noise heating system for maintaining animal body temperature during experimental procedures. The DC heater is extremely quiet in terms of electromagnetic radiation. This is essential in electrophysiological recordings which are very sensitive to electromagnetic interference.

The controller uses proportional, integral, and derivative (PID) technology in adjusting the DC voltage output. Compared with switched on/off type controllers, PID controllers provide a much more precise and stable control of temperature. The PID approach is also more immune to the variation of the experimental conditions such as change in animal size and unexpected disturbances.

The controller has dual temperature sensing inputs.

- The Probe input is used to monitor the rectal probe to control the animal temperature.
- The other input is labeled "Output," because it connects with the heater. It is used to monitor an internal temperature sensor in the heating plate (available separately) to prevent the localized hot spots under animal.

The **ATC** features an auto tuning function that utilizes a fuzzy-logic algorithm to optimize settings automatically. Parameters may also be set manually. The temperature resolution of the controller is 0.1°C. The rectal temperature probe has a 6-ft ultra-flexible shield cable and an RTD sensor.

Parts List

After unpacking, verify that there is no visible damage to the sensor. Verify that all items are included:

(1) **ATC1000** Animal Temperature Controller

(1) **502197** Rectal Probe, 2mm shaft diameter, 3.5mm ball tip or

503524 Mouse Rectal Probe, 1.8mm shaft diameter, 2.5mm ball tip

(1) Instruction Manual

NOTE: You need a heating plate to use the **ATC1000** and three varieties are available. For accessories, see "Accessories" on page 14.

An optional silicone pad (WPI #**503573**) is available for use with the **ATC1000**. It is composed of a thermally conductive rubber material that is used to enhance the heat transfer to the animal. Simply place the silicone pad on the **ATC1000** warming plate and place the animal on silicone pad.



Fig. 2—The 503573 Silicone Pad, an optional accessory, can be placed under the animal to enhance the heat transfer from the ATC1000 plate to the animal.

Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled “Claims and Returns” on page 19 of this manual. Please contact WPI Customer Service if any parts are missing at 941.371.1003 or customerservice@wpiinc.com.

Returns: Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI’s Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100mm (four inches) of shock absorbing material. For further details, please read the section entitled “Claims and Returns” on page 19 of this manual.

INSTRUMENT DESCRIPTION

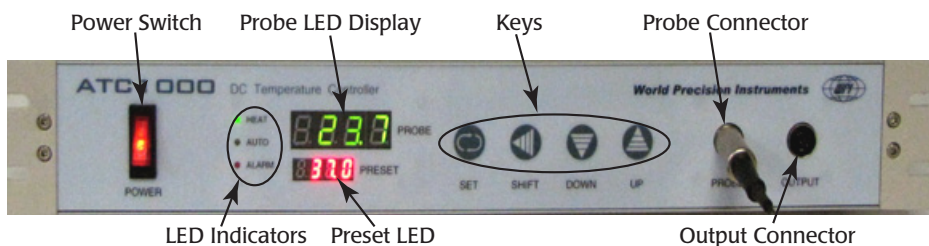


Fig. 3—Front panel of the ATC1000

Front Panel

LED Displays

Probe LED Display—The **Probe LED** display shows either the probe temperature in normal working mode or one of the setting modes. Press the **Set** key to enter the temperature setting mode as described in “Operating Instructions” on page 6. If the **Set** key is pressed for 5 seconds, the controller enters the PID setting mode, which is described in “Using the ATC1000 Controls” on page 7.

Preset LED Display—The **Preset LED** display shows the temperature setting in the normal working mode. It shows the parameter value when the controller is in setting mode.

Heat LED Indicator (green)—The green LED indicates that the unit is heating. It toggles on and off during normal use. The amount of time the LED is illuminated is proportional to the output voltage. Continuous illumination means the heater is on full power.

Auto Tuning LED Indicator (orange)—The yellow LED flashes when auto-tuning is on.

Alarm LED Indicator (red)—The red LED lights up when the measured temperature of the probe exceeds the user-programmed upper limit (the set temperature plus the deviation limit). An audible alarm is also turned on to indicate overheating.

Switches and Keys

Power Switch—This turns the temperature controller on and off.

Set Key—Press the **Set** key to set the control parameters.

Shift Key—When the controller enters the setting mode, press the **Shift** key to save the current digit value (flashing digit), move to the next digit and make the new digit ready to change.

Animal Temperature Controller (ATC1000)

Down Key—Press the **Down** key to decrease the displayed digit by 1 if it is not 0, otherwise it changes to 9.

Up Key—Press the **Up** key to increase the displayed digit by one if it is not 9, otherwise it changes to 0.

Connectors



Fig. 4—ATC1000 connectors

Probe Connector—Connect the temperature sensor to the **Probe** connector.

Output Connector—Connect the heating device to the **Output** connector.

Back Panel

The BNC connector on the rear panel provides the temperature sensor output with a voltage corresponding to temperature — $20 \text{ mV}/^{\circ}\text{C}$.

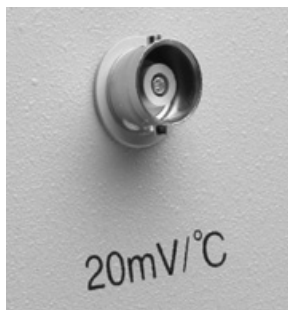


Fig. 5—BNC connector on the rear panel of the ATC1000

The power input module, also on the rear panel, contains a fuse.

OPERATING INSTRUCTIONS

The temperature controller provides electrically quiet control over the heating plate. Place the animal directly onto the heating plate.

1. Connect the heating device to the **Output** connector.
2. Connect the rectal temperature probe to the **Probe** input on the **ATC1000**.

The controller's PID algorithm compares the measured temperature to the preset (setpoint) temperature to determine the correct heater power output. When the instrument is turned on, the control parameters last used are loaded. The probe (animal) temperature is shown on the **Probe LED** display. (Fig. 5)



Fig. 6—Temperature Control display

TIP: It may be useful to allow the heating plate to warm up before placing the animal on it. After the plate reaches the setpoint, position the animal and insert the rectal probe.

Alarms

The **ATC1000** has two alarm conditions that trigger the audible alarm:

- **DEVIATION LIMIT ALARM**—When the animal's temperature (monitored with the rectal probe) exceeds the upper temperature limit, an audible alarm sounds, the red LED flashes, and the heater shuts off. The upper temperature limit is the target temperature plus the user-defined deviation limit. The deviation limit can be adjusted up or down to change the sensitivity of this alarm.
- **SAFETY ALARM**—An internal sensor monitors the plate temperature. When the temperature of the plate exceeds 45°C, a safety alarm sounds. The heater, however, remains on. When this alarm sounds, turn the **ATC1000** off to avoid injury to the animal. See "Troubleshooting" on page 15 for information on correcting the alarm condition before turning the heating plate back on.

TIP: If this alarm becomes a nuisance, set the deviation limit a little higher. See "Setting the Temperature Deviation Limit" on page 9.



WARNING: WHEN THE SAFETY ALARM SOUNDS (THE PLATE TEMPERATURE EXCEEDS 45°C), TURN THE ATC1000 OFF TO ALLOW THE HEATING PLATE TO COOL FOR A FEW MINUTES BEFORE TURNING IT BACK ON.

Turning the ATC1000 On/Off

When the **Power** key is set to on (I), it takes several seconds for the controller to initialize and come to a normal working condition. The parameters loaded are the same as those last used. The **Probe LED** display shows the temperature measured by the sensor. The **Preset LED** display shows the temperature setting (setpoint). If any connection is loose, the controller alarm sounds.

Set the Power key to off (O) to turn the temperature controller off.



CAUTION: After the power is switched off, wait at least 30 seconds before turning the unit on again or the controller may not initiate the control parameters correctly.

Using the ATC1000 Controls

Using the keys on the front panel of the ATC1000, you can:

- Set the desired temperature (page 9)
- Set the deviation limit, auto tuning preference and other detailed parameters of the PID algorithm (page 9)
- Lock the parameters (page 12)
- Calibrate the sensor (page 9)

The flow chart (**Fig. 5**) provides a visual overview of **ATC1000** operations. After turning the power on, you may enter the Temperature Setting Mode or the Advanced Setting Mode depending on how long you hold down the Set key. Specific instructions for adjusting parameters are detailed on the next few pages.

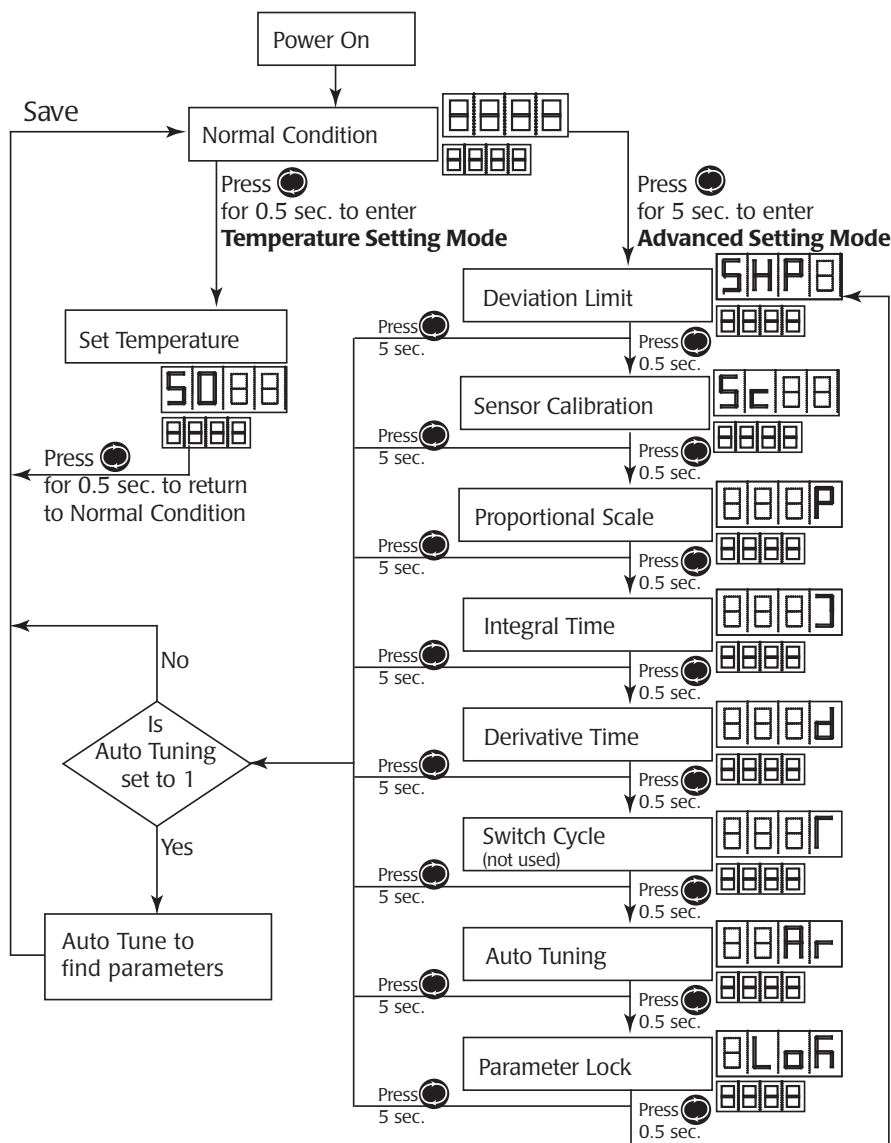


Fig. 7—Overview of ATC1000 functions available from the front panel

NOTE: A time limit applies when you are working with the functions of the **ATC1000**. If no key is pressed for 30 seconds, the controller returns to the normal condition without saving the data.

Setting the Temperature

1. Press the **Set** key to enter the Temperature Setting Mode.
2. When **50.0** displays, use the **Shift** and the **Up** or **Down** key to change the temperature. The controlled temperature range can be adjusted up to 45°C.
3. Press the **Set** key again to save the temperature and exit to the normal condition.

Setting the Temperature Deviation Limit

The standard deviation limit is 2°C. DO NOT SET THE DEVIATION LIMIT TO ZERO.

NOTE: The temperature controller can maintain the temperature within less than $\pm 0.3^{\circ}\text{C}$ in most situations, so the deviation limit should be larger than 0.3°C. Otherwise, the alarm may be triggered unnecessarily.

To set the deviation limit:

1. Press and hold the **Set** key for 5 seconds.
2. When **5HP** is shown in the upper LED display, use the **Shift**, **Up** and **Down** keys to change the setting. (For example, 2°C is the standard setting.)
3. Press and hold the **Set** key for 5 seconds to save the setting and exit to normal working condition.

Sensor Calibration

The instrument is calibrated before shipping. It does not need calibration before use. However, if a new sensor is replaced or the accuracy of the reading needs to be confirmed, the user can calibrate the system with an equilibrated ice and water mixture. The controller provides a calibration function.

1. Set the **Preset** temperature at 0.0°C to avoid a heating output.
2. Immerse the probe in the ice water. The ratio of ice and water should be 2:1 and be stirred by a magnetic stirrer.
3. After at least 10 minutes, take a reading.
4. Press and hold the **Set** key for 5 seconds.
5. Press the **Set** key briefly seven times or until **5T** is shown in the **Probe LED** display.
6. When **5T** is shown, use the **Shift**, **Up** and **Down** keys to change the setting. The last digit also changes the calibration temperature above zero or below zero. For example, the probe measures 0.5°C in the ice water, enter -0.5°C in the calibration to correct the reading to zero. The maximum calibration range is $\pm 9.9^{\circ}\text{C}$.
7. Again, press and hold the **Set** key for 5 seconds to save the setting and exit to normal working condition.

PID Controller Parameters

If auto-tuning does not adequately stabilize the system or the ideal settings for a particular heater are already known, you can manually adjust the PID parameters. WPI doesn't recommend changing these parameters manually unless you are familiar with the functions of each PID parameter. See "Auto-tuning" on page 13.

Proportional Scale

When the plate temperature falls within the range of the proportional band, the proportional control algorithm of the PID controller is invoked.

Actual Temperature	Heating Power Output
Below proportional band range	Maximum output
Rising in proportional band range	Power diminishing proportionally
Falling in proportional band range	Power increasing proportionally
Above the proportional band range	Zero

The proportional control limits the amount of fluctuation of the temperature around the setpoint value as the controller stabilizes. However, if the proportional control is used alone after the temperature has stabilized, then the actual temperature approaches the setpoint, but never quite reach it. **Fig. 6** shows a graphically representation of how the temperature rises compared with the heater output over time.

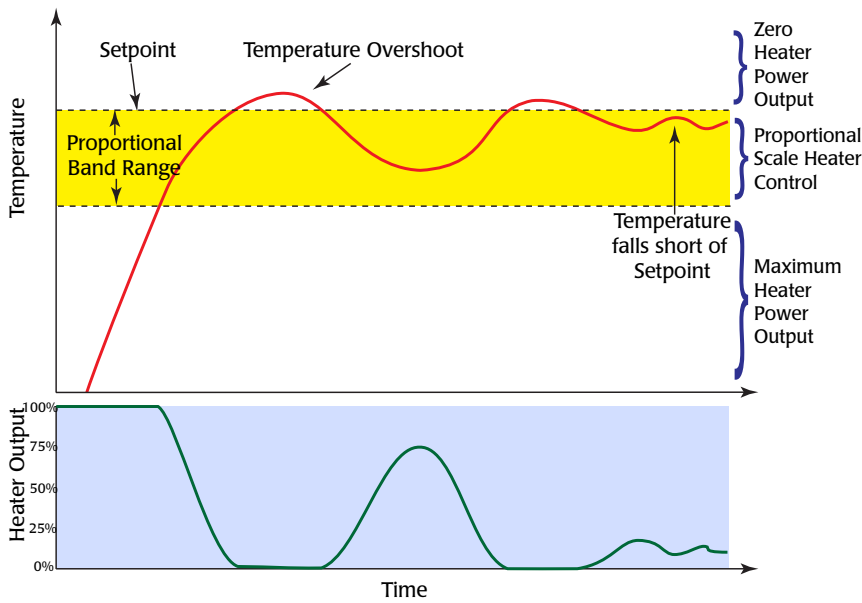


Fig. 8—Heater power output is compared with the actual temperature over time. Notice that with proportional control alone, the temperature falls short of the setpoint as it stabilizes.


Animal Temperature Controller (ATC1000)

The proportional algorithm can be expressed mathematically.

Heater Output Power = (Temperature Setpoint – Actual Temperature) * 100 / (Proportional Scale Value)

The power output is inversely proportional to the proportional scale value and directly proportional to the temperature deviation. A smaller scale value means higher gain, faster response and tighter temperature control. However, the system can become unstable if the value is too small. The scale range is between 1-999. The default value is 5.

NOTE: NEVER set the proportional scale value to zero.

1. Press and hold the **Set** key for 5 seconds to enter advanced setting mode.
2. Press the **Set** key briefly to change the setting mode. This setting is the second one in the advanced setting mode.
3. When  is shown in the upper LED display, use the **Shift** key and the **Up** or **Down** keys to change the setting.
4. Again, press and hold the **Set** key for 5 seconds to save the setting and exit to normal working condition.


Integral Time

Adding integral control to the proportional control corrects the temperature shortfall experienced with proportional control alone, bringing the actual temperature closer to the setpoint. The value set for the integral determines the speed of the correction. The integral value is only applied when the actual temperature falls within the range of the proportional band. At startup or when the setpoint is changed, the actual temperature may overshoot the setpoint. The integral value is seconds/repeat. A low integral value causes rapid action, but too much action makes the system unstable.

The integral function eliminates the residual difference between the set temperature and measured temperature.

Controller Output = (Error Time) / (Integral Time)

The controller output is proportional to the amount of time the error is present and inversely proportional to the integral time. The integral time range is 0-3600 seconds. The default is 7. The smaller the integral time, the stronger the integral effect. When the integral time is set to zero, the integral function shuts off.

1. Press and hold the **Set** key for 5 seconds to enter advanced setting mode.
2. Press the **Set** key briefly to switch between the different settings. This setting is the third one in the advanced setting mode.
3. When  is shown in the **Probe LED** display, use the **Shift** key and the **Up** or **Down** keys to change the setting.
4. Again, press and hold the **Set** key for 5 seconds to save the setting and exit to normal working condition.

Derivative Time

The derivative control minimizes the setpoint overshoot of proportional/integral control. It is the rate control mechanism. The derivative adjusts the temperature output based on the rate of the actual temperature change. If the derivative value is set too high, the system becomes less responsive.


The derivative parameter has two main functions.

- Provides fast action when the system has a large disturbance
- Reduces oscillation in the system

$$\text{Controller Output} = (\text{Derivative Time}) \times dT / dt$$


T = temperature of the animal

The controller output is proportional to both the rate of the error change and the derivative time. The derivation time range is 0-3600 seconds. The default value is 3. The larger the derivative time, the stronger its effect. Zero derivative time has no effect.

1. Press and hold the **Set** key for 5 seconds to enter advanced setting mode.
2. Press the **Set** key briefly to switch between the different settings. This setting is the fourth one in the advanced setting mode.
3. When  is shown in the **Probe LED** display, use the **Shift** key and the **Up** or **Down** keys to change the setting.
4. Again, press and hold the **Set** key for 5 seconds to save the setting and exit to normal working condition.


Parameter Lock

Two parameter lock options are available. If you do not want to leave the parameters adjustable, you may set the ATC1000 so that only the temperature can be modified or so that none of the parameters can be modified.

1. Press and hold the **Set** key for 5 seconds to enter advanced setting mode.
2. Press the **Set** key briefly to switch between the different settings. This setting is the seventh one in the advanced setting mode.
3. When  is shown in the **Probe LED** display, use the **Shift** key and the **Up** or **Down** keys to change the setting.
 - 0—All parameters are adjustable
 - 1—Only temperature is adjustable
 - 2—No parameter changes allowed, including auto-tuning
4. Again, press and hold the **Set** key for 5 seconds to save the setting and exit to normal working condition.

Auto-tuning

The controller is shipped with PID parameters that work in most conditions. However, when changing heating plates or trying to warm a subject that is significantly different from a regular sized animal, the current setting of the controller might not hold the temperature as stable. To solve this problem, use the Auto-tuning feature. This lets the controller find the best parameters for the system. The Auto-tuning program heats the subject and lets it cool several times. Based on the heating and cooling speed, the program optimizes the PID parameters for the system. Auto-tuning is the sixth setting mode in the advanced setting mode.

1. Press and hold the **Set** key for 5 seconds to enter advanced setting mode.
2. Press the **Set** key briefly to switch between the different settings.
3. When  is shown in the **Probe LED** display, use the **Shift** key along with the **Up** and **Down** keys to change the setting to either 0 or 1.


NOTE: When auto-tuning is set to 1, the controller erases all existing parameters, finds the optimal parameters and saves these parameters to memory. When auto-tuning is set to 0, the parameters can be changed manually as described above.

Parameter Values

Parameter	Upper Limit	Lower Limit	Default	Range
Deviation Limit	9.9	0.3	2.0	0.5–3.0
Sensor Calibration	9.9	-9.9	0.0	-1.5–1.5
Proportional Scale	999	0	5	2–10
Integral Time	3600	0	7	1–100
Derivative Time	3600	0	3	1–500
Auto Tuning			0	0, 1
Parameter Lock			1	0, 1, 2

MAINTENANCE


Cleaning the Heating Plate

 **CAUTION:** Do not immerse in liquids.
Do not autoclave.
Do not use acids or strong bases.

Clean the heating plate with mild soap and water and rinse with water. Be careful to keep water away from the cord, especially where the cord connects with the heating plate. If desired, use enzymatic cleaners to wash the heating plate.

Sterilize with alcohol, if needed.

Cleaning the Rectal Probe Tip

 **CAUTION:** Do not immerse in liquids.
Do not autoclave.
Do not use acids or strong bases.

To clean the rectal probe, use an enzymatic detergent like Enzol (WPI #7363-4). Soak the tip of the probe in Cidex Plus (WI #7364) for 20-45 minutes to disinfect it.

ACCESSORIES

Table 1: Accessories

Part Number	Description
7363-4	Enzol enzymatic detergent, gallon
7364-4	Cidex Plus biocide, gallon
502195	Small Heating Plate with built-in RTD sensor, 10x15cm
502196	Medium Heating Plate with built-in RTD sensor, 15x25cm
502197	Rectal Temperature Probe, 2 mm shaft diameter, 3.5mm ball tip
503524	Mouse Rectal Temperature Probe, 1.8mm shaft diameter, 2.5mm ball tip
503567	Mouse Adaptor Heating Plate with built-in RTD sensor, 4x15cm (for use with 502063 Stereotaxic Adaptor)
503573	Silicone pad for ATC1000 (10x15cm)

TROUBLESHOOTING

Issue	Possible Cause	Solution
No power	Poor connection	Check the power cable connection.
	Fuse is blown	Check the fuse, which is inside the power input module. Change the fuse if it is blown.
"-LLL" or "-HHH" displays	Poor probe connection	Disconnect and properly re-connect the probe to the ATC1000 .
Animal cannot reach set temperature	Insufficient heating power	The maximum power output on the heating device is 30W. In most situations, the power is sufficient to keep the animal warm up to 40°C. To minimize heating loss, insulate the bottom of heating plate and cover the animal with a small blanket to keep it warm.
Control of temperature is unstable	Environmental temperature fluctuations	<p>Since the heating output of the ATC1000 is automatically PID-controlled, the temperature can swing back and forth if the environmental temperature varies dramatically. Set the deviation limit to a small value so that the temperature swing is minimized.</p> <p>NOTE: The deviation limit alarm may be triggered more frequently (each time the temperature reaches the upper limit).</p>
Alarm is sounding	<p>Poor transfer of heat from the heating plate to the animal. (The plate is hot, but the animal has not warmed up.) You may use these solutions independently or together to solve this issue.</p>	Improve the thermal coupling from the heating plate to the animal. Place a heat-conductive, conformal material (like cotton wadding) between the animal and the plate.
		Adjust the PID parameter to slow the plate heating process. To do this, increase the proportional scale (P parameter) incrementally. A value between 3 and 8 is normal. See "Proportional Scale" on page 10.
	Poor connection to heating plate and probe	Disconnect both the heating plate and probe and reinsert them properly. If nothing is plugged into the ATC, an alarm will sound.

NOTE: If you have a problem/issue with that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at 941.371.1003 or technicalsupport@wpiinc.com.

SPECIFICATIONS

The **ATC1000** conforms to the following specifications:

Temperature Range	up to 45°C
Resolution	0.1°C
Accuracy	± 0.3°C
Rat Sensor	RTD, OD 2.0mm tube with 3.5mm ball head (Optional mouse sensor is available)
Maximum DC Output	32V, 1A
Proportion Scale (P)	1 ~ 999, default setting: 5 (normal: 3-8)
Integral Time (I)	0 ~ 3600 seconds, default setting: 7
Derivative Time (D)	0 ~ 3600 seconds, default setting: 3
Power	90 - 240V, 50 - 60 Hz
Dimensions	45x30x7 cm (17.7 x 11.8 x 2.76 in.)
Weight	5 kg (11 lb)
Fuse	For 110V, 2A For 220V, 1A

APPENDIX A: APPLICATION NOTE

If desired, the RTD temperature sensor inside the heating plate can be used to control the warming. In this case the rectal probe is not used. Instead the temperature monitored is the plate temperature, not the animal's temperature. To do this, plug the heating plate into the **Probe** connector and set the Preset temperature about 5°C higher than normal. When the plate temperature falls below the setpoint to the value defined in the PID algorithm, the plate will begin to heat. This may take several minutes, depending on the sensitivity or your algorithm settings.

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DECLARATION OF CONFORMITY



WORLD PRECISION INSTRUMENTS, INC.

175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

Telephone: (941) 371-1003 Fax: (941) 377-5428
e-mail wpi@wpiinc.com

DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota FL 34240-9258
USA

as the distributor of the apparatus listed, declare that the product:

Title: ATC-1000 Temperature Controller

to which this declaration relates is in conformity with the following standards or other normative documents:

Safety: EN 61010-1: 2001, EN 61010-2-010: 2003


EMC: EN 61326-1: 2006
EN 55011: 1998 + A2: 2002
EN 61000-3-2: 2000
EN 61000-3-3: 2001
EN 61000-6-2: 2001

and therefore conforms with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility and Council Directive 73/23/EEC amended by Council Directive 93/68/EEC relating to safety requirements.

Issued on: January 18, 2007


Mr. Cliff Bredenberg
General Manager

World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA


Mr. Glen Carlquist
Vice President of Manufacturing
World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

WARRANTY

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of 30 days* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

Repairs

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*



World Precision Instruments, Inc.

USA

International Trade Center, 175 Sarasota Center Blvd., Sarasota FL 34240-9258

Tel: 941-371-1003 • Fax: 941-377-5428 • E-mail: sales@wpiinc.com

UK

1 Hunting Gate, Hitchin, Hertfordshire SG4 0TJ

Tel: 44 (0)1462 424700 • Fax: 44 (0)1462 424701 • E-mail: wpiuk@wpi-europe.com

Germany

Zossener Str. 55, 10961 Berlin

Tel: 030-6188845 • Fax: 030-6188670 • E-mail: wpide@wpi-europe.com

China & Hong Kong

WPI Shanghai Trading Co., Ltd.

Rm 20a, No8 Dong Fang Rd., Lu Jia Zui Financial District, Shanghai PRC

Tel: +86 688 85517 • E-mail: chinasales@china.wpiinc.com

Internet

www.wpiinc.com • store.wpiinc.com • www.wpichemistry.com

www.wpi-europe.com • www.wpiinc.cn