AirTherm™

Heater controller for bioscience laboratories

INSTRUCTION MANUAL

Serial No._____

102711

World Precision Instruments

CONTENTS

OPERATIONAL QUICK START

The **Air-Therm** is controlled by the Watlow EZ-Zone controller. This controller is pre-configured at the factory and in many cases is ready to use without further adjustments. This quick start describes the basic operational features and adjustments of the **Air-Therm.** More specific operational details are described in later sections of the manual.

When the unit is turned on, after initialization, the home page appears (Fig. 1). This is the default upon power up and displays the probe temperature and the target setpoint temperature. The large red number in the upper display shows the active probe temperature. The small, green number in the lower display indicates the target temperature setpoint.

Fig. 1 The home page of the PID controller shows the probe temperature reading and the target setpoint.

The small numbers in the upper right hand corner of the display indicate the status of both the controller outputs. The number 1 flashes when the process temperature information is sent to the BNC analog output on the back of the **Air-Therm**. The number 2 illuminates when the heater is on.

Changing the Setpoint

The **Air-Therm** is pre-programmed with a setpoint of 37°C. To change the setpoint, use the arrow keys (▲ and ▼).

Heater

The heat switch on the front of the unit illuminates when the heater is enabled.

Fan Speed

Rotate the fan speed knob to set the desired air flow.

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.

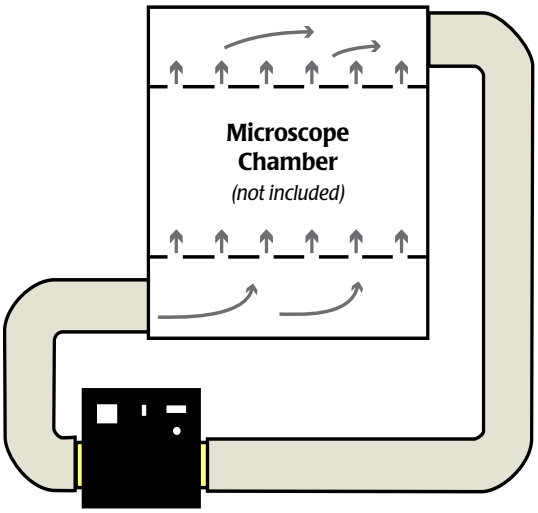
This symbol indicates a **WARNING**. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and **TIPS** contain helpful information.

Fig. 2 AirTherm ATX-SR is available as 110V or 220V.

INTRODUCTION

The **Air-Therm** is a computer-controlled heating system designed to be used with microscopes that are built into a chamber that is usually acrylic (insulated). The computer-controlled structure uses PID (proportional, integral, derivative) control to maintain a tightly controlled, heated environment. The system is typically used in a closed loop configuration (Fig. 3).



Air-Therm ATX

Fig. 3 A typical Air-Therm installation places the heated air inflow at the bottom and the cold air return at the top of the microscope chamber.

Cautions and Warnings

WARNING: DO NOT USE THE AIR-THERM IN AN OXYGEN ENHANCED ENVIRONMENT.

CAUTION: Avoid blocking the airflow. Although a built-in thermal cutoff switch is designed to reduce the hazard, a fan failure or obstruction in the airflow has the potential for overheating the system and damaging the instrument or even causing a fire.

CAUTION: Keep the Air-Therm dry. For example, avoid condensation in a high humidity environment.

CAUTION: Do NOT insert any object into the air in or air out ports of the **Air-Therm**.

Parts List

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

(1) **Air-Therm**

(1) power cord

(2) clear, coil-reinforced heater hose pieces, 4.5' (WPI #**15590**)

(4) hose clamps (WPI #**13208**)

(1) temperature sensor (WPI #**300276**)

(1) Instruction Manual

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 30 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 30 of this manual.

INSTRUMENT DESCRIPTION

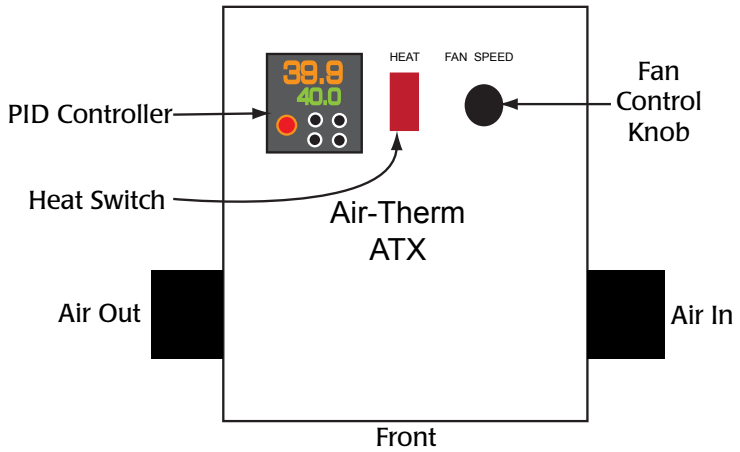


Fig. 4 The PID controller, heat switch and fan control are located on the front panel of the Air-Therm.

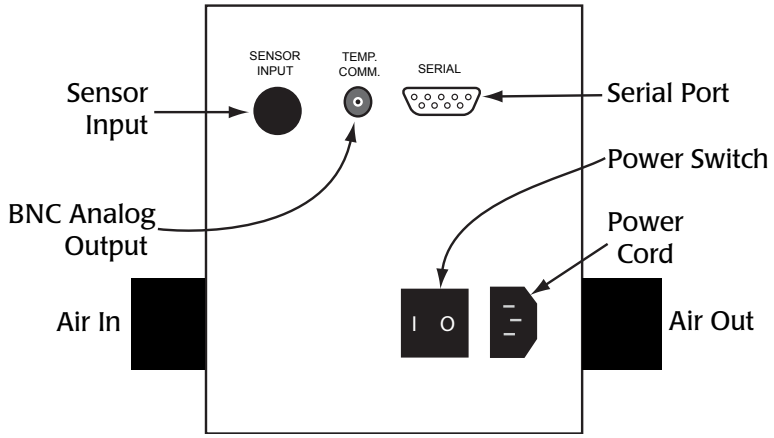


Fig. 5 The master power switch, BNC analog output connector, serial port and temperature sensor input are located on the back panel.

Power–The power switch on the back panel controls the main power for the fan, heater and microprocessor controller.

Heat Switch–The heat switch on the front panel illuminates when it is powered on. It controls only the heater. When the heater switch is off and the power is on, the controller and fan are powered.

Fan Control Knob–The fan control knob on the front panel adjusts the airflow rate from 20–50 ft^3/minute (CFM). For safety reasons, the fan cannot be turned off unless the instrument is off.

TIP: A lower flow rate offers a quiet operation and is suitable for most applications. However, the higher flow rate can generate more turbulence, so that the temperature in the chamber is more uniform. The higher air flow speeds up the heating process and makes it possible to heat larger chambers.

CAUTION: Avoid blocking the airflow. Although a built-in thermal cutoff switch is designed to reduce the hazard, a fan failure or obstruction in the airflow has the potential for overheating the system and damaging the instrument or even causing a fire.

Sensor Input–The RTD temperature sensor plugs into this port.

Sensor (not shown)–The sensor is shielded and grounded with a stainless steel sleeve. The sensor can be directly inserted near sites that involve electric recording without introducing any interference from the heating unit. It can be safely placed in water, but it will ground the system unless a electrically insulated coating is applied. If an electrically insulated coating is necessary, we recommend using silicone or epoxy to coat the stainless steel portion of the sensor. The coating should not be applied unless it is necessary, since it will slow the response time.

Analog Output–This BNC output is used to connect the **Air-Therm** with a data acquisition system (Data-Trax, or other recording device). The range of the output is 0–10V, representing 0 to 100ºC.

Serial Port–The RS-232 serial port connection is made available for user designed software to allow the **Air-Therm** to interface with a computer or peripheral device. The port uses pins 2 (Receive), 3 (Transmit) and 5 (Common).

NOTE: The **Air-Therm** does not include any software for use with the serial port. This output is provided for users with custom applications who may require it. In most cases the port will not be used and is covered.

PID Controller–By adjusting the parameters of the PID controller, the **Air-Therm** can be configured for different applications. However, we recommend using the preset parameters in the controller first. These parameters are set to control a regular size acrylic chamber that covers a microscope for live cell imaging. To properly use **Air-Therm** for other applications, some basic PID control knowledge is useful. See "Appendix A: Understanding PID Control" on page 23.

PID Controller Description

Fig. 6 On startup, the PID controller shows the home page with both the current temperature reading from the probe (active process value) and the setpoint.

Upper Display –During normal operations (home page displayed) this value shows the actual temperature reading from the temperature sensor. When configuring the controller, the parameter value is displayed here.

Zone Display–The **Air-Therm** uses only one zone, Zone 1.

Home Page Key–When you are navigating through the configuration menus, press this key to back up one level. Or, hold this key for two seconds to return to the home page. The home page shows the actual temperature and the setpoint.

EZ Key–This key is user-configurable, and it is not generally used with the **Air-Therm**.

Advance Key–Use this key to access the main menu.

Information Icons –These icons include ºF and ºC to indicate the units for the temperature display and % which illuminates when the open loop setpoint is displayed (manual mode).

Output Activity Indicators–The **Air-Therm** only uses outputs 1 and 2. Flashing numbers indicate output activity.

Lower Display–During normal operations (home page) this value indicates the setpoint. When configuring the controller, this display shows the menu or the parameter being configured.

Arrow Keys– During normal operations (home page), use the arrow keys to adjust the setpoint. On configuration pages, use the arrow keys to toggle through the submenus or parameter settings.

OPERATING INSTRUCTIONS

Basic Use of the Air-Therm

1. Connect the temperature sensor to the Sensor Input port on the back of the **Air-Therm**. Position the temperature sensor at the location where the temperature is to be controlled.
2. Turn the **Air-Therm** power switch on. It is located on the back panel.
3. Use ▲ and ▼ keys on the PID controller to adjust the temperature setpoint (lower display) to the desired target value. The upper display shows the temperature reading from the sensor.
4. Adjust the fan speed to control the air flow rate using the knob on the front of the unit.
5. Turn on the **Air-Therm** heater switch located on the front panel. If the temperature reading is below the setpoint, the heater turns on and output number 2 begins to flash.

Understanding the PID Controller

A PID control algorithm is comprised of three primary control factors: **P**roportional, **I**ntegral and **D**erivative. The controller monitors the difference between the actual temperature reading and the setpoint. This is the "error" value (ΔT). The error value is processed by each of the P, I and D algorithms. The algorithms are then summed to produce a final control output. You have access to three parameters that affect the algorithms, heat proportional band (h.Pb), integral time (ti) and derivative time (td).

- **Proportional** (P)–The proportional control factor offers a response proportional to the error. Once the actual temperature climbs past the heat proportional band threshold, the proportional band control factor scales down the heat output of the controller to avoid overshooting the setpoint. A larger P value gives a faster response, but too large a value makes the system oscillate around the setpoint. If it is too low, the system will not respond fast enough, and the temperature will never reach the setpoint.
- **Integral** (I)–Measured in seconds/repeat, the integral control factor is set based on the recent changes in the error value. It is proportional to the size and duration of the error. Together the P and I control factors, bring the system closer to the setpoint more quickly. When the I is added, though, there is the possibility that the temperature will overshoot the setpoint if the integral time (ti) parameter is set too high.
- **Derivative** (D)–This control factor is set based on the rate that the error has changed over time. As the temperature approaches the setpoint, the D value slows the rate of

change of the heater output, dampening the overshoot of the I value. To decrease the overshoot of the I value, increase the D value. Larger D values will slow the system response.

NOTE: For information on the inner operations of PID controller and the logic behind PID control, see "Appendix A: Understanding PID Control" on page 23.

Display Character Set

The **Air-Therm** uses a simple 7-segment display, shown below.

1 = 1	8 = 8	E = E	L = L	S = S
2 = 2	9 = 9	F = F	M = M	t = T
3 = 3	0 = 0	G = G	n = N	U = U
4 = 4	A = A	h = H	o = O	u = V
5 = 5	b = B	i = I	P = P	uu = W
6 = 6	c, C = C	J = J	q = Q	y = Y
7 = 7	d = D	H = K	r = R	2 = Z

Viewing and Adjusting Parameters from the Main Menu

When you are on the home page, press the key to toggle through the main menu of **Air-Therm** parameters. Some parameters are read-only, and others can be manipulated. After cycling through all the parameters, you return to the home page.

Name	Description	Default Value	Options	Notes
AC.Pu	Active Process Value	none	Read only–temperature probe reading	Shows in the upper display on the home page
AC.SP	Active Set Point	37.0 °C	Use ▲ and ▼ keys to change the setpoint	Shows in the lower display on the home page
h.Pr	Heat Power Output	none	Read only–actual heat output of the controller (%)	Real-time heat output of the controller. See "Viewing the Heater Power Output" on page 10.
h.Pb	Heat Proportional Band	3.0	Use ▲ and ▼ keys to change.	Proportional parameter in the PID controller. See"Viewing the Heater Power Output" on page 10.

Name	Description	Default Value	Options	Notes
ti	Time Integral	150 seconds/ repeat	Use ▲ and ▼ keys to change.	Integral parameter in the PID controller. See"Setting the Integral Time" on page 11.
td	Time Derivative	96 seconds	Use ▲ and ▼ keys to change.	Derivative parameter in the PID controller. See "Setting the Derivative Time" on page 12.
CM	Control Mode	AUto	AUto, Automatic MAn, Manual oFF, No heat Use ▲ and ▼ keys to change.	See "Control Modes" on page 14.
C_F	Temperature Units	C	C, Celsius F, Fahrenheit Use ▲ and ▼ keys to change.	
AUt	Auto Tune Request	oFF	no, Auto tune off YES, Set the system to auto tune Use ▲ and ▼ keys to change.	See "Auto Tuning the System" on page 12.

Viewing the Heater Power Output

The **Air-Therm** is a variable heat controller. The heater output (% of total output) changes based on the value of the PID algorithm. The heat power output is the real-time percentage of heat output of the controller.

Fig. 7 The Watlow controller displays the heat power output.

1. To view the heat power output from the home page, press the key.
2. Press the key to return to the home page.

NOTE: Even if the heater switch is off, a percentage may display for this parameter. As the PID controller executes its program, it sends commands to set the heat power output.

Setting the Heat Proportional Band (P)

The heat proportional band (h.Pb) is the "P" parameter of the PID algorithm. The default value is 3.0.

Fig. 8 The Watlow controller displays the heat proportional band parameter.

1. To view the heat proportional band parameter from the home page, press the key twice.
2. Use the or keys to adjust the parameter.

   NOTE: If this value is set too high, they temperature will oscillate around the setpoint. If it's too low, the response is sluggish.
3. Press the key to return to the home page.

Setting the Integral Time

The integral time (t1) is the "I" parameter of the PID algorithm. The default value is 150 seconds/repeat.

Fig. 9 The Watlow controller displays the time integral parameter.

1. To view the integral time from the home page, press the key three times.
2. Use the or keys to adjust the parameter.
3. Press the key to return to the home page.

Setting the Derivative Time

The derivative time (td) is the "D" parameter of the PID algorithm. The default value is 96 seconds.

Fig. 10 The Watlow controller displays the derivative time parameter.

1. To view the derivative time value from the home page, press the key four times.
2. Use the or keys to adjust the parameter.
3. Press the key to return to the home page.

Tuning the System

The system may be tuned automatically or manually.

Auto Tuning the System

Auto tuning allows the PID controller to automatically find the heater proportional band, integral time and derivative time necessary to reach and maintain the temperature setpoint. The controller evaluates the process and selects the PID values to maintain optimal control. Once you initiate the learning process, the controller lets the temperature fluctuate across the setpoint line five times until ideal PID parameters are established. After auto tuning, the controller immediately begins regulating the temperature using these values.

NOTE: If the controller does not complete the auto tuning process within 60 minutes, it will time out, and the original programming will prevail.

Fig. 11 The Watlow controller displays the auto tune request.

To invoke the auto tuning request:

1. From the home page, press the key seven times to display the auto tune request (AUt).
2. Use the or keys to set the parameter to YES.
3. Press the key to return to the home page. Once auto tuning is initiated, the upper display (home page) flashes tUn 1 alternately with the actual temperature, and the lower display flashes Attn (Fig. 12).

Fig. 12 When the controller is auto tuning, tUn 1/Attn flashes alternately with the temperature display on the home page.

Manual Tuning

You can manually adjust the PID parameters. See "Understanding the PID Controller" on page 8. Typically, the system is auto tuned first, so that only minor adjustments are needed during manual tuning. Here are some examples of PID parameters:

	h.Pb	ti	td
Slow response process	7	600	100.2
Normal response process	4	210	34.8
Fast response process	3	90	15
Defaults	3	150	96

TIP: If the accuracy is too low, reduce the h.Pb.

If the time needed to reach the set temperature is too long, decrease ti .

If the system is very unstable, reduce td.

Control Modes

The PID controller has two modes, automatic (AUto) and manual (mAn). If the mode is set to oFF, the system will not heat. The default setting is AUto.

Fig. 13 The Watlow controller displays the control mode parameter.

Automatic–Typically the controller operates in Auto mode (closed loop control). In this mode, the actual temperature reading and the setpoint are used in the control of the **AirTherm**.

Manual–Manual mode uses open loop control where you directly set the output power level of the heater to a fixed output value (%). No adjustment is made to the output based on either the temperature reading or the setpoint. This mode is normally reserved for troubleshooting.

NOTE: If you set the controller to manual mode, the lower display in the home page shows the output in percent instead of displaying a temperature setpoint.

Switching Between Control Modes

1. From the home page, press the key five times to display the control mode (CrM) parameter.
2. Use the or keys to set the parameter:
   - mAn for manual
   - AUto for automatic
   - oFF for no heat.
3. Press the key to return to the home page.

Changing the Temperature Display Units

The temperature is configured to display in degrees Celsius. You may also view the temperature in degrees Fahrenheit.

Fig. 14 The Watlow controller displays the temperature display parameter.

1. From the home page, press the key six times to view the temperature display mode (C_F) parameter.
2. Use the or keys to set the parameter:
   - C for Celsius
   - F for Fahrenheit
3. Press the key to return to the home page.

Analog Temperature Read-out

The BNC connector on the back panel of the **Air-Therm** is an analog output for the temperature read-out. The range of the output is 0.0–10.0V and represents 0 to 100°C. For example, at 40°C, the read-out is 4.0V. The accuracy is ±1% of the range. If greater accuracy is desired, adjust the sensitivity and offset of the recording device to match the reading on the **Air-Therm** panel.

MAINTENANCE

Calibrating a Temperature Sensor

Air-Therm's temperature sensor, a Pt 100 DIN RTD, has been matched with the controller. If the sensor must be replaced, the system should be re-calibrated to get accurate temperature control.

1. Fill a beaker with distilled water and ice made of distilled water. It should be at least half filled with ice.
2. Place a magnetic stirrer bar in the beaker and stir the ice water on a magnetic stirrer.
3. Connect the temperature probe to the sensor input port on the back of the instrument.
4. Firmly attach a thermometer to the sensor with a rubber band.
5. Suspend the sensor in the beaker of water, and wait for 15 minutes or until the temperature reading on the instrument stabilizes.
6. The reading on the **Air-Therm** should equal the thermometer reading ±0.1°C. If it doesn't match, change the input offset calibration parameter.

CAUTION: Do not make changes to any other parameter in this menu. If you require assistance, please contact Technical Support

a. From the home page, press and hold down both the ▲ and ▼ keys for three seconds to enter the operations menu. You are in the A1 (Analog Input) submenu (Fig. 15).

Fig. 15 The first submenu on the operations menu is analog input (A1).

b. Press the key several times to scroll to the i.CA (Input Calibration) parameter (Fig. 16).

Fig. 16 The default setting for the input calibration parameter is 0.0.

c. Use the ▲ or ▼ keys to set the parameter to the negative of the difference between the controller reading and the thermometer value. For example, if the

controller reads 2.6ºC, and the thermometer reads 0.4ºC, set the input calibration offset value to −2.2.

Fig. 17 Use the arrow keys to set the calibration offset value.

d. Hold the key for two seconds to return to the home page.

Changing a Fuse

A spare fuse is provided in the fuse housing (Fig. 18).

1. Turn the main power switch off (I).
2. Unplug the power cord from the power cord socket on the back of the **Air-Therm** (Fig. 18).

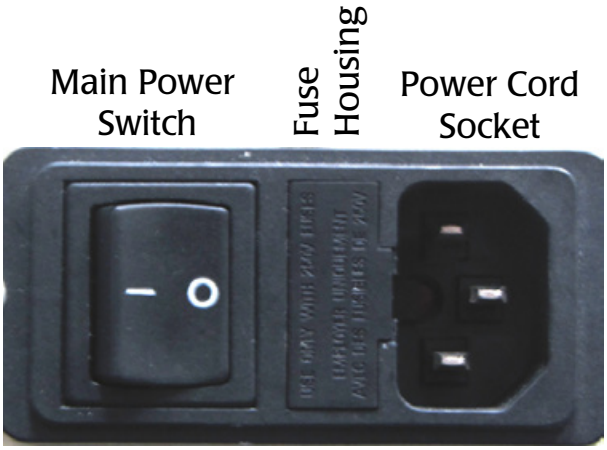


Fig. 18 Unplug the power cord to access the fuse housing release.

3. Insert a small flat blade screwdriver under the lip on the right side of the fuse housing cover (Fig. 19).

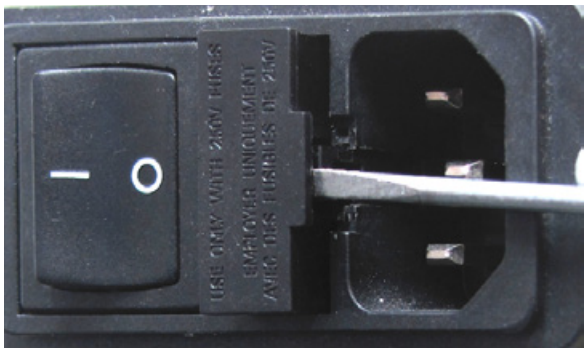


Fig. 19 Insert the screw driver under the fuse housing lip and pry the housing open.

4. Pull the fuse housing out as far as it will go and rotate it to the right. There is a catch to keep the housing from coming completely out (Fig. 4).

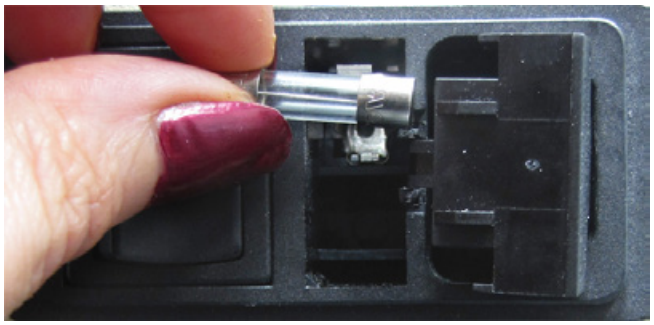


Fig. 20 Open the fuse housing and rotate it right to remove the fuse.

5. Remove the bad fuse. It is the one on the top. A spare fuse is stored in the bottom slot of the fuse housing.
6. Use the spare fuse provided to replace the bad fuse. Slide it into the top slot of the fuse housing.
7. Rotate the fuse housing and slide it back into position.
8. Reinstall the power cord.
9. Turn the power switch on to verify that the **Air-Therm** has power again.

ACCESSORIES

Table 1: Accessories

Part Number	Description
3301	European power cord
3302	UK power cord
3006	US power cord
3491	5' (1.5m) probe extension cable
13208	Hose clamps
13972	4A Fuse (for 220V)
14088	Australian power cord
15590	Clear hose, 2.5" diameter, 4.5'
300276	Replacement platinum temperature probe
800668	8A Fuse (for 110V)

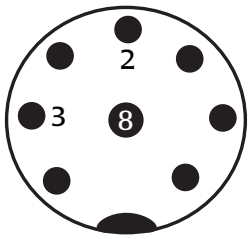
Optional Accessories

Table 2: Optional Accessories

Part Number	Description
FD35-100	Fluorodish Sterile Culture Dish, clear wall, 35mm, 23mm well, box of 100
FD35COL-100	Fluorodish Sterile Culture Dish, collagen coated, clear wall, 35mm, 23mm well, box of 100
FD35PDL-100	Fluorodish Sterile Culture Dish, Poly-D-Lysine coated, clear wall, 35mm, 23mm well, box of 100
FD3510-100	Fluorodish Sterile Culture Dish, clear wall, 35mm, 10mm well, low sidewall, box of 100
FD5040-100	Fluorodish Sterile Culture Dish, clear wall, 50mm, 35mm well, box of 100

TROUBLESHOOTING

Issue	Possible Cause	Solution
No power	Fuse is blown.	Check the fuse. See "Changing a Fuse" on page 17. The fuse is a 5x20mm metric fuse. 4A 250V for 230VAC service and 8A 250V for 120VAC service. A spare fuse is included in the fuse housing.
	Power cord is improperly connected	Verify that the power cord is securely connected and plugged into a live wall socket.
No heat	One of the switches is not turned on. The power switch on the back of the unit must be on (I), and the heat switch on the front of the unit must be on. When it is on, the heat switch is illuminated. When the heater is engaged, the #2 output indicator lights.	Verify that both the power switch and the heat switch are turned on.
No fan	If the power is on and the fan is not running, the airflow may be inhibited.	Check for an obstruction to the fan. This typically occurs in the air in port. If no obstruction can be found, return the unit for servicing.
Er.1 flashes on the display	The probe is loose, disconnected or missing.	Verify that the probe is securely connected. If not, reconnect the probe.
	The probe is defective.	Replace the probe (WPI #**300276**). You can confirm that a probe is defective by taking a resistance reading between the center pin (pin 8) and pin 2 or 3 of the sensor connector (8-pin DIN). (See the figure in the margin.) A reading between 90~110Ω indicates a working probe.



8-pin DIN connector looking into the end.

Issue	Possible Cause	Solution
Chamber heats inconsistently	The PID parameters are improperly adjusted.	See "Understanding the PID Controller" on page 8.
	The air hose is blocked.	Unplug the air out hose and verify that air is flowing through the system. If no air is flowing, locate and remove the blockage.
	The factory default parameters may be corrupt.	Contact technical support for instructions on resetting the default parameters.
Chamber never reaches setpoint	The chamber is too large or not insulated well enough.	Reduce the chamber size or insulate it.
	The probe is improperly located.	Check the position of the temperature probe.
	The factory default parameters may be corrupt.	Contact technical support for instructions on resetting the default parameters.
Chamber overheats	PID parameters are incorrectly set.	The h.Pb is too low, and it is overshooting the setpoint. The h.Pb should be at least 3.0. See "Setting the Heat Proportional Band (P)" on page 11.
	The factory default parameters may be corrupt.	Contact technical support for instructions on resetting the default parameters.

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

SPECIFICATIONS

This instrument conforms to the following specifications:

Air Flow Rate	20–50 CFM (0.55–1.4 m^3/minute)
Control Temperature Range	Ambient to 60°C
Temperature Resolution	0.1°C
Temperature Accuracy	0.2°C
Control Modes	Auto (PID control, both auto tuned and manually tuned) or Manual Control (% Heat output)
Analog Output For Chart Recorder	0.5°C resolution; 0–10V represents 0–100°C
Heating Volume	Less than 50 CF (1400L), re-circulating
Sensor Type	Platinum RTD 100Ω
Fuse	For 120VAC, 8A 250V 5x20mm metric For 230VAC, 4A 250V 5x20mm metric
Power	450W, 95–135V or 220–240V, 50/60Hz
Dimensions	6½ x 8 x 7½" (15.5 x 21 x 19cm)
Shipping Weight	10 lb. (4.5kg)

APPENDIX A: UNDERSTANDING PID CONTROL

In automatic control mode (AUto), the output power of the heater (hPr) is controlled by the PID (proportional, integral, derivative) control factors. The three PID control factors utilize an error value to generate a control output. The error value is the difference between the temperature reading from the probe (AC.Pu) and the setpoint (AC.SP), ΔT.

$$\Delta T = AC.Pu - AC.SP$$

If the auto tune request is not invoked, you can adjust three parameters (heat proportional band, time integral and time derivative) that influence the P, I and D control factor algorithms. The heater output power is directly proportional to the sum of the three values.

Proportional

The proportional control alone will typically bring the temperature within a few degrees of the setpoint. However, as the temperature approaches the setpoint, the proportional value gets closer and closer to zero. With proportional control alone, the temperature will never quite reach the setpoint, because the heat output gets so close to 0% just before reaching the setpoint.

The heat proportional band (hPb) parameter sets a temperature range below the setpoint called the proportional band. When the probe temperature is within the band, the heat output is proportionally adjusted down as the temperature approaches the setpoint. The closer the temperature is to the setpoint, the lower the heat power output (hPr) is set.

$$hPr = (\Delta T / hPb) * 100\%$$

The heat power output equals the error divided by the proportional parameter.

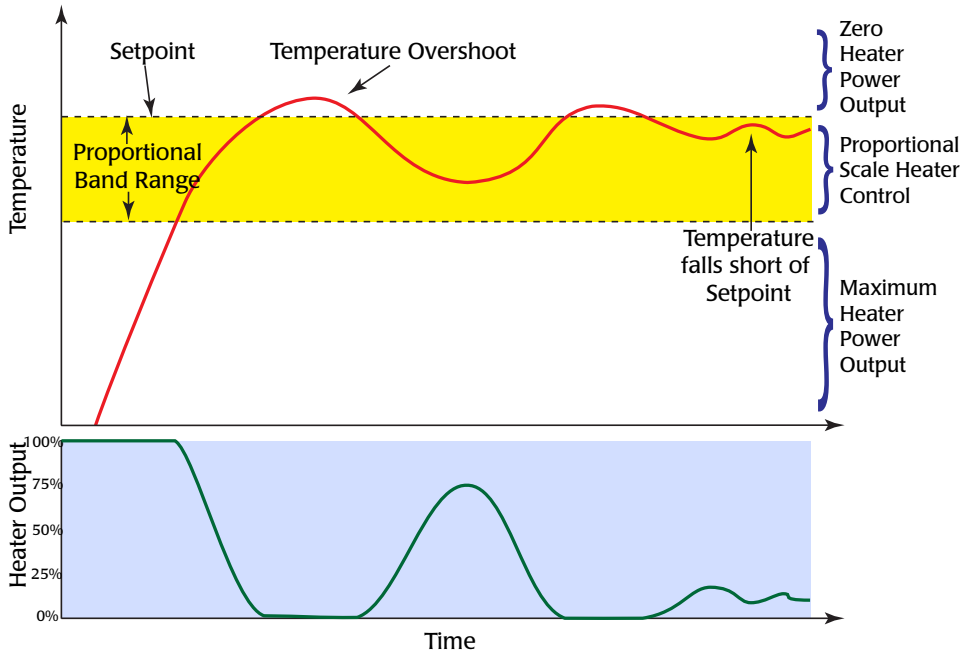


Fig. 21 Using proportional control alone, the temperature tends to droop just below the setpoint when the system stabilizes.

Example: Suppose only proportional action is turned on. If the setting is 37°C and hPb is set at 3°C. The heater is on 100% of the time when the temperature is below 34°C and is completely off when the temperature is above 37°C. Within the band, each degree of temperature difference between the set temperature and reading temperature corresponds to 33% (1/3) of the total output power change.

Integral

When the temperature is within the proportional band, the integral value comes into play to eliminate the droop of the proportional band. The integral control continuously increases at a rate proportional to ΔT. With integral control the temperature may overshoot the setpoint. If the time integral parameter is set too high, the system can become unstable. The larger the integral time parameter (ti), the slower the integral action. For small values of integral time, you are more likely to see an overshoot. If you set integral time to a larger value, the system approaches the setpoint more slowly with a smaller overshoot.

Derivative

When the derivative control is added to the system, it slows the rate of the temperature change, especially close to the setpoint. This minimizes the overshoot and increases the system stability. Derivative action helps the stability of the system in two ways:

- It slows the rate at which temperature is approaching the setpoint to prevent temperature overshoot. This is important to counteract a shorter integral time.
- It allows the system to respond quickly to any large changes. When the door of the chamber is opened, the derivative function detects the rapid loss of heat and quickly turns the heater to full power to prevent a dramatic temperature drop.

The larger the td value, the stronger the action.

A Well Tuned System

If you prefer to avoid experimenting with manual adjustments, you can try auto tuning. If auto tuning is conducted under experimental conditions, the experimental conditions are taken into account, and the tuning process sets optimal PID parameters for you. (See "Auto Tuning the System" on page 12.) Then, you can fine tune the individual parameters to achieve the desired results.

TIP: If the integral action is too small (large ti) or the proportional band (hPb) is too big, the temperature will take a long time to reach the setpoint. However, making the values of ti or hPb too small may lead to overshoot of system instability.

The graphs (Fig. 22) below show the theoretical action of the PID parameters in a well tuned system and the resulting heater output.

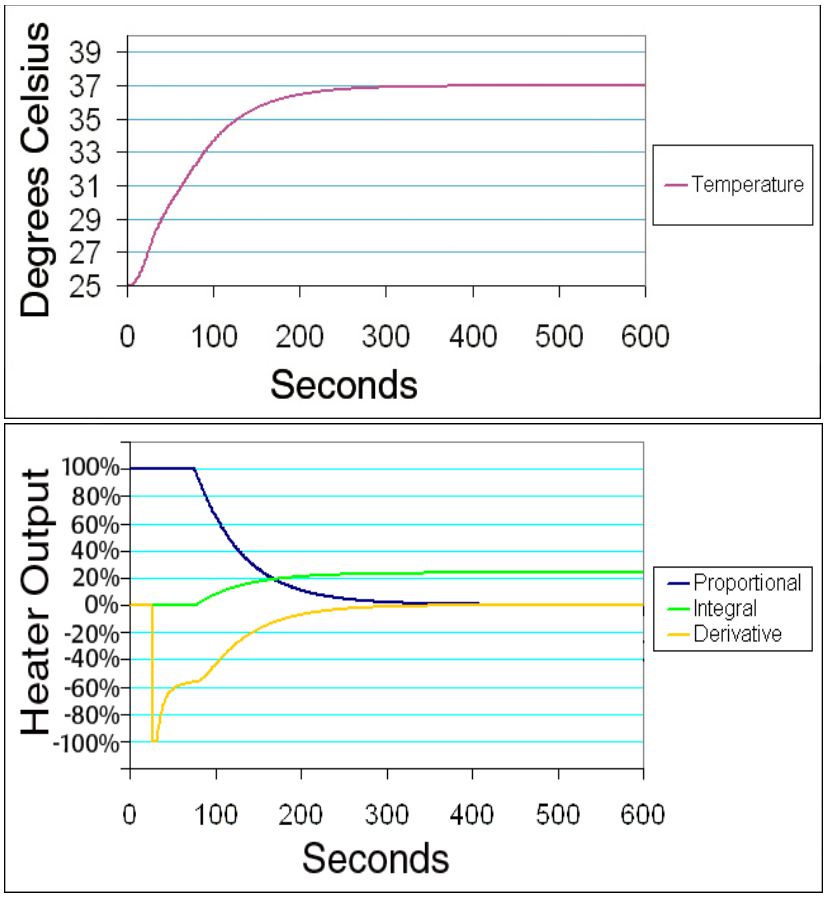


Fig. 22 Temperature is shown in the top graph, and the bottom graph shows the action of the PID parameters individually as the temperature approaches the setpoint.

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DECLARATION OF CONFORMITY

WORLD PRECISION INSTRUMENTS, INC.
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DECLARATION OF CONFORMITY

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

As the manufacture of the apparatus listed, declare under sole responsibility that the product(s):

AIR-THERM ATX

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

Safety: EN 61010-1:1993 (EC 1010-1:1990)

Emc: EN 50081-1: 1992
EN 50082-1: 1992

And therefore conform(s) with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility and Council Directive 73/23/EEC relating to safety requirements:

Issued on: May 11, 2005

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• WPI cannot be held responsible for items damaged in shipment en route to us. Please enclose merchandise in its original shipping container to avoid damage from handling. We recommend that you insure merchandise when shipping. The customer is responsible for paying shipping expenses including adequate insurance on all items returned.

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• Goods returned for repair must be reasonably clean and free of hazardous materials.

• A handling fee is charged for goods returned for exchange or credit. This fee may add up to 25% of the sale price depending on the condition of the item. Goods ordered in error are also subject to the handling fee.

• Equipment which was built as a special order cannot be returned.

• Always refer to the RMA# when contacting WPI to obtain a status of your returned item.

• For any other issues regarding a claim or return, please contact the RMA department

Warning: This equipment is not designed or intended for use on humans.

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

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