Air-Therm H

Heater/Humidity Controller for Bioscience Laboratories

INSTRUCTION MANUAL

10/27/2011

CONTENTS

OPERATIONAL QUICK START

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

When the unit is turned on, after initialization, the home page appears on both controllers (Fig. 1). These are the default upon power up. The heat controller 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.

NOTE: The temperature display will alternate with AL.L (Alarm Low) until the temperature reaches 1°C below the setpoint. When the temperature rises 1°C above the setpoint, the temperature display alternates with AL.h (Alarm High). When the temperature is within ±1°C from the temperature setpoint, the humidity controller operates.

The humidity controller displays the actual relative humidity in large red numbers. The smaller green numbers on the right side of the display indicate the humidity setpoint.

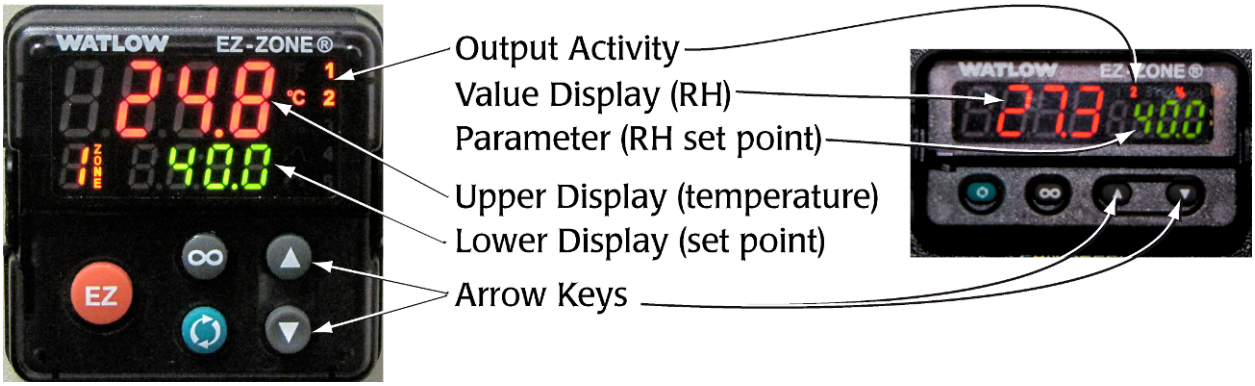

Fig. 1. The home page of the heat PID controller shows the probe temperature reading and the target setpoint. The home page of the humidity PID controller shows the relative humidity reading and the humidity setpoint.

NOTE: The small numbers in the upper right hand corner of the heat controller display and along the top of the humidity controller indicate the status of the controller outputs. The number 1 flashes on the heat controller when the process temperature information is sent to the BNC analog output on the back of the Air-Therm H. The number 2 illuminates when the heater is on. The 4 illuminates when the temperature is within one degree of the setpoint which then allows the humidity controller to deliver humidity, if needed. The number 2 illuminates on the humidity controller when the AirTherm H has turned on power to the humidifier.

Changing the Temperature Setpoint

The Air-Therm H is pre-programmed with a temperature setpoint of 37ºC. To change the setpoint, use the arrow keys on the heat controller (▲ and ▼).

Changing the Humidity Setpoint

The Air-Therm H is pre-programmed with a humidity setpoint of 40%. To change the setpoint, use the arrow keys on the humidity controller (▲ and ▼).

Heater

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

Humidifier

The humidifier (included with the system) has a 2 gallon daily output capacity and a half gallon tank. Use only distilled water in the tank to avoid contaminants in the chamber. The humidifier has a power switch on the front and two speeds. Do not turn the humidifier power on until the system has maintained the set-point temperature for one hour.

Fan Speed

Rotate the fan speed knob on the front of the AirTherm H 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.

INTRODUCTION

The Air-Therm H is a computer-controlled heating and humidification system designed to be used with microscopes that are built into a chamber that is usually acrylic (insulated). Humidification of the enclosed system reduces evaporation from cell culture dishes. The computer-controlled structure uses PID (proportional, integral, derivative) control to maintain a tightly controlled environment.

With Air-Therm H, the temperature of the sample and optics can be controlled within 0.2°C. The humidity level (%) can be controlled at slightly below the dew point of the inner walls of the chamber to prevent condensation that might damage the microscope optics. During operation, air is drawn out of the chamber through the flexible hose, heated by the Air-Therm H heater, humidified and re-circulated to the chamber by the return hose.

The system is typically used in a closed loop configuration (Fig. 2).

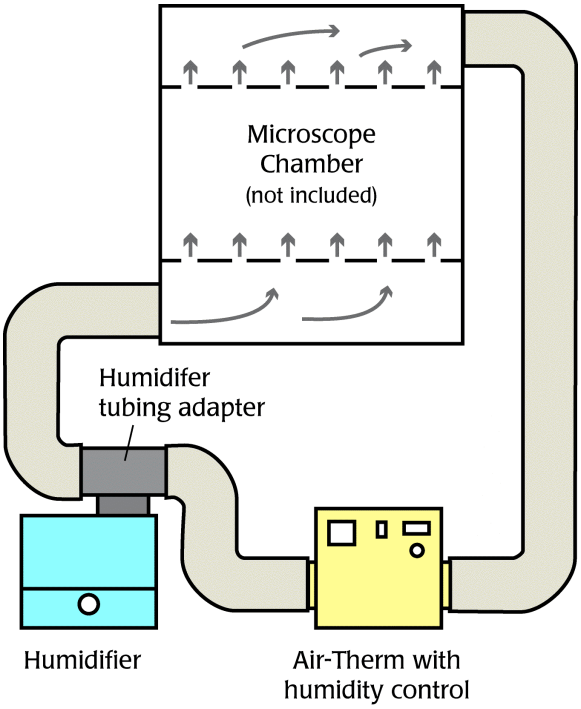

Fig. 2. A typical Air-Therm H installation places the moist, heated air inflow at the bottom and the cold air return at the top of the microscope chamber.

Cautions and Warnings

⚠ WARNING: DO NOT USE THE AIR-THERM H 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 H dry. For example, avoid condensation in a high humidity environment. Make sure the air outlet of the AirTherm H is connected to the humidifier. Connecting the humidifier to the air inlet to the humidifier will damage the AirTherm H.

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

Parts List

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

(1) Air-Therm H

(1) power cord

(1) 2 gallon daily output humidifier

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

(4) hose clamps (WPI #13208)

(1) temperature sensor (WPI #300276)

(1) humidity sensor (WPI #300418)

(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 loss or damage should be reported at once to the carrier and an inspection requested. Please read the section entitled "Claims and Returns" on page 29 of this manual. Please call WPI Customer Service if any parts are missing.

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 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. Please read the section entitled "Claims and Returns" of this manual.

INSTRUMENT DESCRIPTION

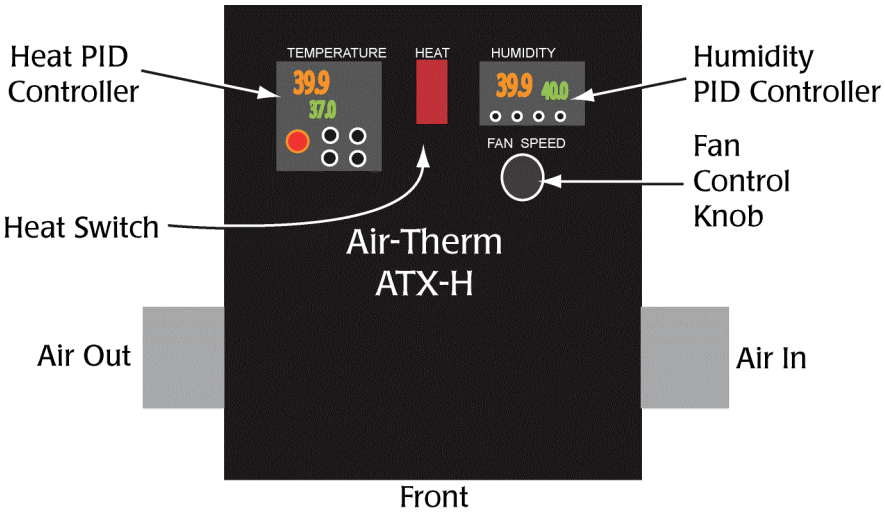

Fig. 3. The two PID controllers, heat switch and fan control are located on the front panel of the Air-Therm H.

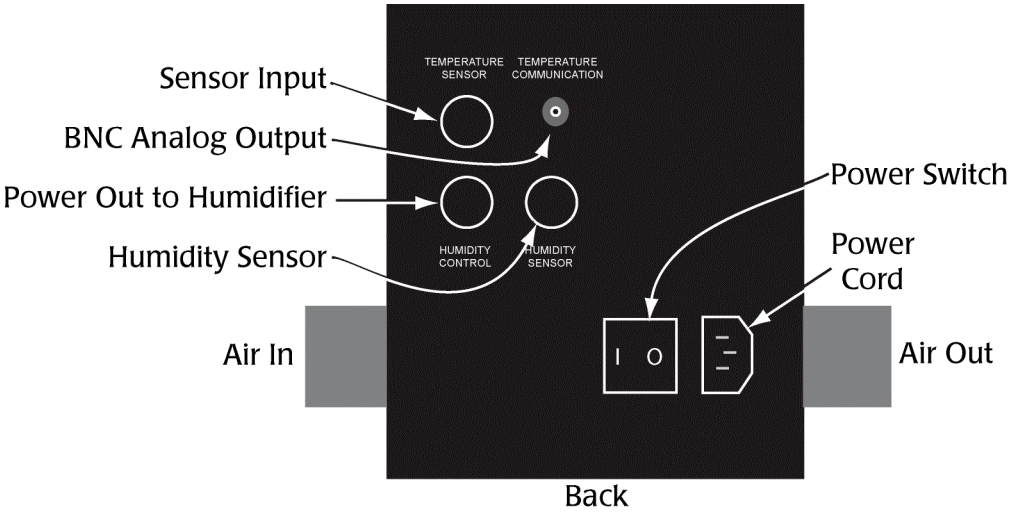

Fig. 4. The master power switch, BNC analog output connector, temperature sensor input, humidity sensor input and humidifier supply voltage are located on the back panel.

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

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.

Temperature 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 an 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.

Humidity Sensor Input – The humidity sensor plugs into this port.

Humidity Sensor (not shown) – The sensor is included. The sensor should be shielded from bright light. Do NOT expose the sensor to condensing environments. Exposure to condensing environments will cause the sensor output to indicate 0% relative humidity.

Humidity Control – The humidity power cord connect to this circular, panel mount, 4 pin connector.

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

Heat PID Controller–By adjusting the parameters of the PID controller, the Air-Therm H 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 H for other applications, some basic PID control knowledge is useful. See "Appendix A: Understanding PID Control on page 26."

Humidity PID Controller – The PID parameters of this control determine how the humidity in the chamber is regulated. See "Appendix A: Understanding PID Control on page 26."

Humidifier

The humidifier uses ultrasonic sound waves to turn water into a fine mist. This has the advantage of being very efficient and easy to control. The drawback is that particles dissolved in the water can end up floating around in the air after the mist evaporates.

CAUTION: Make sure the humidifier is clean before each use and only use distilled water in order to keep dust from being deposited inside the chamber.

Air temperature drops as water mist from the humidifier evaporates. Conversely, relative humidity drops as air temperature rises. As a result, humidity and temperature control compete when both are increased simultaneously. Therefore, humidity regulation in the Air-Therm H is automatically deactivated when the temperature is more than one degree from the set point. If the temperature setpoint is 37°C, the humidity controller operates when the temperature is between 36 and 38°C.

NOTE: The temperature display will alternate with AL.L (Alarm Low) until the temperature reaches 1°C below the setpoint. When the temperature rises 1°C above the setpoint, the temperature display alternates with AL.h (Alarm High).

Heat PID Controller Description

Fig. 5. 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 H 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 H.

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–Flashing numbers indicate output activity. The 4 illuminates when the temperature is within one degree of the setpoint which then allows the humidity controller to deliver humidity, if needed.

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.

Humidity PID Controller Description

Fig. 6. On startup, the PID controller shows the relative humidity and the humidity setpoint.

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

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 humidity and the setpoint.

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

Output Activity Indicators–Flashing numbers indicate output activity. When the 2 illuminates, power is delivered to the humidifier. Humidity is only delivered to the system when the humidifier power switch is in the one of the on positions.

Parameter 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.

Basic System Setup

1. Clean the humidifier and fill it with distilled water.
   NOTE: If distilled water is not used, contaminants in tap water may end up inside the microscope chamber.
2. Connect the humidifier to the plumbing connection where the humidity input ports come into the system. A PVC T-shaped tubing adapter in the hole on the top of the humidifier can be used for this purpose.
3. Connect tubing with the included clamps as shown in Fig. 7. Make sure the air outlet of the AirTherm H connects to the humidifier before going on to the microscope chamber.

CAUTION: Connecting the humidifier to the air inlet to the humidifier will damage the AirTherm H.

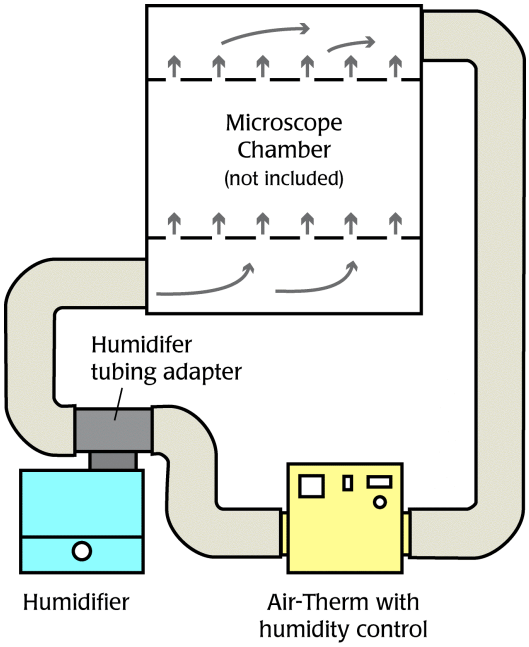

Fig. 7. System setup

4. Connect the humidifier power cable to the humidity control outlet on the back panel of the Air-Therm H. Line up the pins, push the plug into the humidity control port, and rotate the outer collar of the plug clockwise until the cable locks in place.
5. Connect the humidity sensor to the humidity sensor 8-pin DIN input port on the back of the Air-Therm H. Line up the pins, push the plug into place and screw the collar finger tight.
6. Connect the temperature sensor to the temperature sensor 8-pin DIN input port on the back panel of the Air-Therm H.
7. Place the sensors inside the microscope chamber.

OPERATING INSTRUCTIONS

Basic Use of the Air-Therm H

1. Setup the system as described in Basic System Setup on page 10.
2. Position the temperature sensor and humidity sensor at the location where the temperature and humidity will be controlled.
3. Turn the Air-Therm H power switch on. It is located on the back panel.
4. Use ▲ and ▼ keys on the heat PID controller to adjust the temperature setpoint (lower display on the heat controller) to the desired target value. The upper display shows the temperature reading from the sensor.
5. Use ▲ and ▼ keys on the humidity PID controller to adjust the humidity setpoint to the desired target value.
6. Adjust the fan speed to control the air flow rate using the knob on the front of the unit.
7. Turn on the Air-Therm H 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.
8. Allow the temperature to reach the setpoint and wait one hour.
9. Turn on the humidifier power switch located on the humidifier.

Understanding the Heat PID Controller

A PID control algorithm is comprised of three primary control factors: Proportional, Integral and Derivative. 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 (t I) and derivative time (t d).

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 (t I) 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 26.”

Display Character Set

The Air-Therm H 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	V = V
5 = 5	b = B	I = I	P = P	W = W
6 = 6	c , C = C	J = J	Q = Q	Y = Y
7 = 7	d = D	K = K	R = R	Z = Z

Viewing and Adjusting Heat Parameters from the Main Menu

When you are on the home page of the heat controller, press the key to toggle through the main menu of Air-Therm H 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 14.
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 14.
td	Time Derivative	96 seconds	Use ▲ and ▼ keys to change.	Derivative parameter in the PID controller. See "Setting the Derivative Time" on page 15.

Name	Description	Default Value	Options	Notes
t1	Time Integral	150 seconds/repeat	Use ▲ and ▼ keys to change.	Integral parameter in the PID controller. See "Setting the Integral Time" on page 15.
C_F	Temperature Units	C	C, Celsius F, Fahrenheit Use ▲ and ▼ keys to change.	
Ain1	Process Value	none	Read only– temperature probe reading	
AUt	Auto Tune Request	no	no, Auto tune off YES, Set the system to auto tune Use ▲ and ▼ keys to change.	See "Auto Tuning the Heat System" on page 16.

Viewing the Heater Power Output

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

Fig. 8. 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 (hPb) is the "P" parameter of the PID algorithm. The default value is 3.0.

Fig. 9. 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 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 three times.
2. Use the or keys to adjust the parameter.
3. Press the key to return to the home page.

Setting the Integral Time

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

Fig. 11. The Watlow controller displays the time integral parameter.

1. To view the integral time 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.

Changing the Temperature Display Units

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

Fig. 12. The Watlow controller displays the temperature display parameter.

1. From the home page, press the key five 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.

Tuning the Heat System

The system may be tuned automatically or manually.

Auto Tuning the Heat System

Auto tuning allows the heat PID controller to automatically find the heater proportional band, integral time and derivative time necessary to reach and maintain the humidity (RH) 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 humidity fluctuate across the setpoint line five times until ideal PID parameters are established. After auto tuning, the controller immediately begins regulating the humidity 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. 13. 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 tUn1 alternately with the actual temperature, and the lower display flashes AtEn (Fig. 14).

Fig. 14. When the controller is auto tuning, tUn1/AtEn flashes alternately with the temperature display on the home page.

Manual Tuning

You can manually adjust the PID parameters. See “Understanding the Heat PID Controller” on page 12. Typically, the system is auto tuned first, so that only minor adjustments are needed during manual tuning. Here are some examples of PID parameters:

	HPb	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 hPb.

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

If the system is very unstable, reduce td.

Analog Temperature Read-out

The BNC connector on the back panel of the Air-Therm H 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. The Ain parameter displays the value being sent to the analog output.

Viewing and Adjusting Humidity Parameters from the Main Menu

When you are on the home page of the humidity controller, press the key to toggle through the main menu of Air-Therm H 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.Pv	Active Process Value	none	Read only–humidity probe reading	Shows in the Value display on the home page
AC.SP	Active Set Point	40.0 %	Use ▲ and ▼ keys to change the setpoint	Shows in the parameter display on the home page
AUt 1	Auto Tune Request	no	no, Auto tune off YES, Set the system to auto tune Use ▲ and ▼ keys to change.	See "Auto Tuning the Heat System" on page 16.
ti	Time Integral	120 seconds/repeat	Use ▲ and ▼ keys to change.	Integral parameter in the PID controller. See "Setting the Integral Time" on page 15.
td	Time Derivative	0 seconds	Use ▲ and ▼ keys to change.	Derivative parameter in the PID controller. See "Setting the Derivative Time" on page 15.

Auto Tuning the Humidity System

Auto tuning allows the humidity 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 humidity 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. 15. The Watlow controller displays the auto tune request.

To invoke the auto tuning request:

1. From the home page, press the key twice 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 value display (home page) flashes tUn1 alternately with the actual temperature, and the parameter display flashes AtEn

Manual Tuning

You can manually adjust the PID parameters. See "Appendix A: Understanding PID Control" on page 26. Typically, the system is auto tuned first, so that only minor adjustments are needed during manual tuning. The size of the chamber, length of the hoses, room temperature and humidity all affect the optimal P, I and D settings. Typically the integral time is the only value that will need adjusting.

For this controller, the P parameter (hPb) is set at the factory, and the derivative time (td) is set at 0. If the time needed to reach the set temperature is too long, decrease the integral time (ti).

Setting the Integral Time

The integral time (ti) is the "I" parameter of the PID algorithm. The default value is 120 seconds/repeat.

Fig. 16. 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 0 seconds.

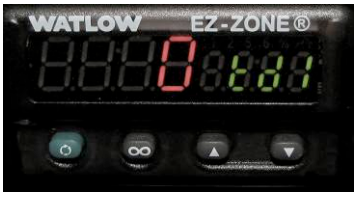

Fig. 17. The Watlow controller displays the derivative time parameter.

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.

MAINTENANCE

Preventing Condensation on Microscope Chamber Walls

Chambers designed for microscope temperature regulation are not as well insulated as incubation systems. Because the inside of the chamber can be significantly warmer than room temperature, condensation can form inside the chamber when the humidity is too high. This condensation can cause damage to the microscope and equipment inside the chamber. To prevent this, start by setting the relative humidity to 40%. Gradually increase the humidity until condensation begins to form. Then, reduce the humidity setpoint by 10%.

NOTE: Since relative humidity changes by about 5% per degree Celsius in high humidity environments, the setpoint should be reduced even further if there is significant drop in the laboratory temperature at night.

The microscope warms up much slower than air. Allow the microscope to warm up to the temperature setpoint for at least one hour before starting humidity control. This prevents condensation from forming on the optics.

Calibrating a Temperature Sensor

The Air-Therm H temperature sensor, a 100Ω platinum 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 H should equal the thermometer reading ±0.1ºC. 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

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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. 18).

Fig. 18. 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. 19).

Fig. 19. The default setting for the input calibration parameter is 0.0.

c. Use the and 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. 20. 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 H (Fig. 21).

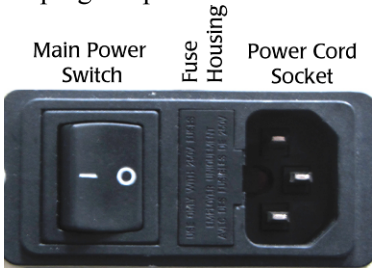


Fig. 21. Unplug the power cord to access the fuse housing release.

3. Insert a small flat blade screwdriver under the lip on the right side of the fuse housing cover (Fig. 22).

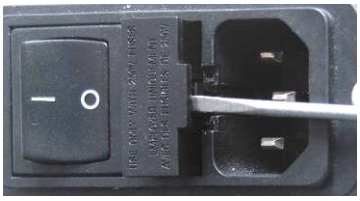


Fig. 22. Insert the screw driver under the fuse housing lip and pry the housing open.

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. 23).

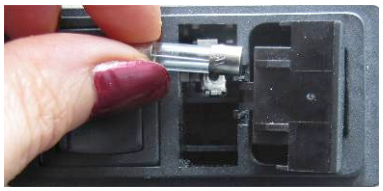


Fig. 23. Open the fuse housing and rotate it right to remove the fuse.

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 H has power again.

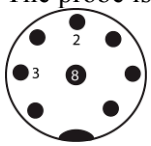
ACCESSORIES

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)
300418	Replacement humidity probe

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 20. 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.
Er1 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.  *8-pin DIN connector looking into the end*	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.
Chamber heats inconsistently	The PID parameters are improperly adjusted.	See "Appendix A: Understanding PID Control" on page 26.
	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.

Issue	Possible Cause	Solution
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 hPb is too low, and it is overshooting the setpoint. The hPb should be at least 3.0. See "Setting the Heat Proportional Band (P)" on page 14.
	The factory default parameters may be corrupt.	Contact technical support for instructions on resetting the default parameters.
Humidity control fails	The humidifier is out of water.	Turn off power to the system. Add water to the humidifier reservoir. See the humidifier manual for instructions.
	The humidifier power switch is off.	Set the humidifier power switch to one of the two on settings.

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 m3/minute)
Control Temperature Range	Ambient to 60°C
Temperature Resolution	0.1°C
Temperature Accuracy	0.2°C
Humidity Control Range	Ambient–90%
Humidity Resolution	0.1%
Humidity Accuracy	5%
Humidity Repeatability	0.5%
Heat 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
Temperature Sensor Type	Platinum RTD 100Ω
Humidifier Type	Ultrasonic
Humidifier Tank Capacity	0.5 gallons
Humidifier Daily Output	2 gallons
AirTherm H Fuse	For 120VAC, 8A 250V 5x20mm metric For 230VAC, 4A 250V 5x20mm metric
AirTherm H Power	450W, 95–135V or 220–240V, 50/60Hz
AirTherm H Dimensions	6½ x 8 x 7½" (15.5 x 21 x 19cm)
Humidifier Dimensions	9½ x 5 x 9" (24 x 12 x 22cm)

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.

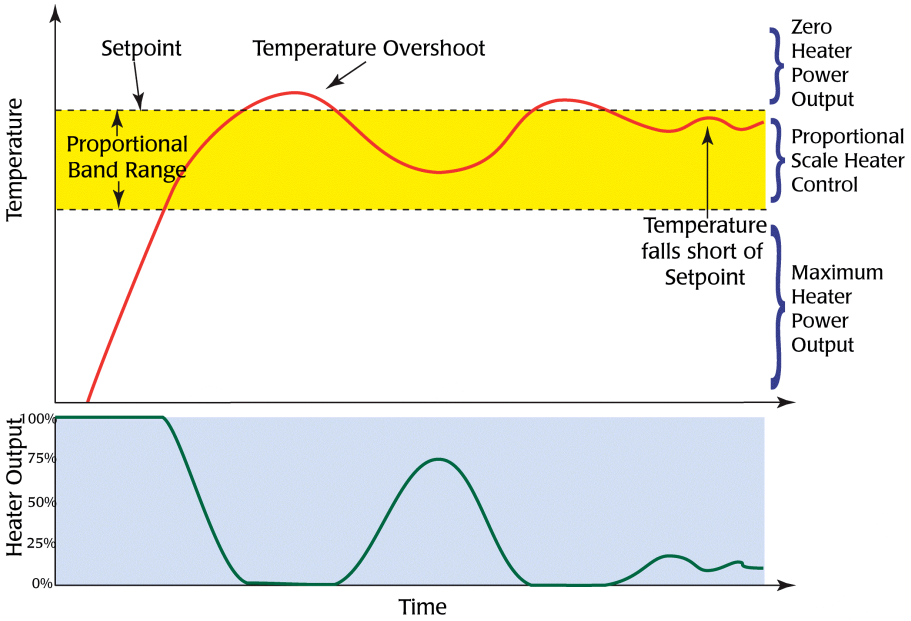


Fig. 24. Using proportional control alone, the temperature tends to droop just below the setpoint when the system stabilizes.

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 integral time parameter is set too high, the system can become unstable. The larger the integral time parameter (Ei), 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.

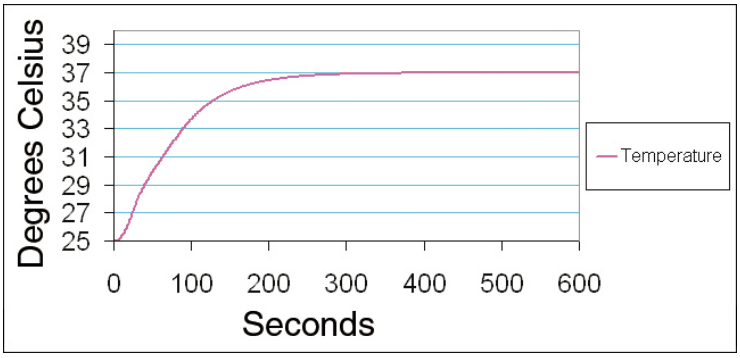
The larger the Ed value, the stronger the action.

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 Heat System” on page 16.) Then, you can fine tune the individual parameters to achieve the desired results.

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

The graphs (Fig. 25) show the theoretical action of the PID parameters in a well tuned system and the resulting heater output.



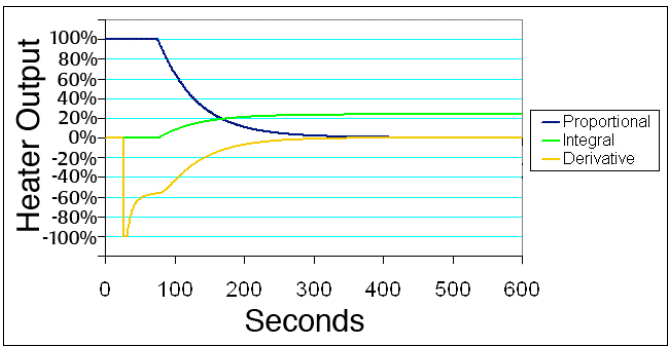


Fig. 25. Temperature is shown in the top graph, and the bottom graph shows the action of the PID parameters individually as the temperature approaches the setpoint.

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 one year* 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 10 days after receipt of shipment. Claims for lost shipments must be made within 30 days of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim settles. 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.
- 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.
- Do not return any goods to WPI without obtaining prior approval and instructions (RMA#) from our returns department. Goods returned unauthorized or by collect freight may be refused. The RMA# must be clearly displayed on the outside of the box, or the package will not be accepted. Please contact the RMA department for a request form.
- 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.