



PERMA PURE
PROTECT LIFE

Baldwin™ -Series
Model 5210D
Thermo-Electric Cooler
User's Manual

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UNPACKING

Perma Pure has made every effort to ship you a high-quality product that has been thoroughly inspected and tested. It has been carefully packed to ensure that it arrives at your facility in good condition. Even though every effort has been made to prevent damage during the transportation process, damage can occur by the carrier. This is out of control of Perma Pure and is the responsibility of the carrier to ensure that your equipment arrives intact and undamaged.

- ❖ Inspect outside packaging. If there is any visible damage, inform the carrier at the time of deliver. ***This inspection is important! Once the package is signed for, responsibility for any visible damage then transfers to the consignee.***
- ❖ Unpack your equipment. Visually inspect the outside of your equipment for any damage. If there is any damage, ***contact the carrier immediately.*** Generally, a carrier must be notified within 24 hours of the delivery to make a hidden damage claim.

Items in the carton include:

- (1) Model 5210D thermo-electric cooler
- (1) User's Manual

Optional glass impingers will ship separately.

If any of the above parts are missing or damaged, call the helpline at **(800) 337-3762**.

INTRODUCTION

Thank you for purchasing this product from Perma Pure LLC. This manual has been assembled so that it can answer all questions regarding operation. Please keep the operators manual near the equipment for future reference. There may also be optional equipment available that was not ordered at the time of original purchase, which may be described and/or illustrated in this manual.

If you still have any questions regarding your equipment's operation, available options or technical support, please contact your purchasing dealer or contact Perma Pure directly.

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This equipment is to be installed and operated by trained personnel, with sufficient command of the English language to clearly understand the instructions and safety warnings.

PRINCIPLE OF OPERATION

One of the natural products of combustion (and other processes) is significant amounts of water in the form of vapor. Most measurement processes require this water to be removed for proper measurement and/or reliability of the system. The cooler rapidly lowers the temperature of the sample stream in the impinger to just above the freezing point of the water, thereby forcing water vapor to condense. Once condensed, it is collected and removed. The 5210D is a thermoelectric cooler, which utilizes TECs (also called Peltier elements) to provide active cooling. The cooler may include a passive stage, where the cold block is thermally mated directly to the heat sink. The Peltier element is a key element to this type of cooler. When powered, one side becomes cold and the other side becomes hot. The control system monitors the coldest point on the heat transfer block, and holds it to just above freezing, preventing the sample stream from icing up. The control system reacts to variations in temperature at the heat transfer block, maintaining the set point as the load or ambient conditions vary.

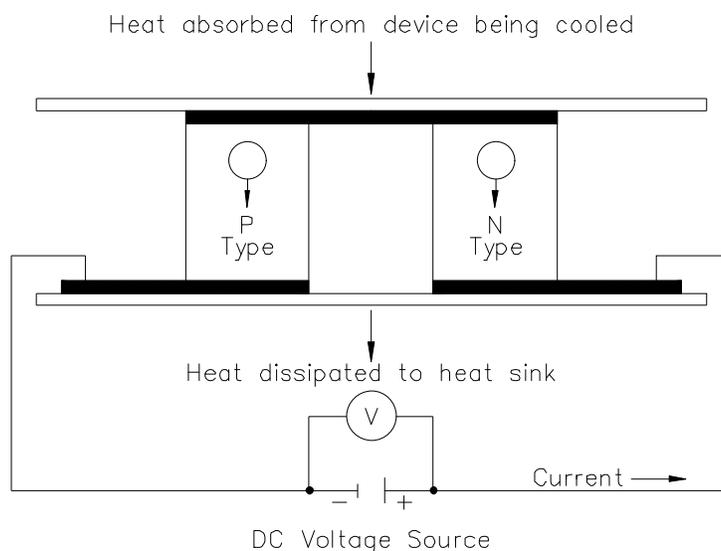


Figure 1: Thermo-electric element (Peltier)

LIMITATIONS:

There are limitations to what a thermoelectric cooler can do. The Peltier elements can only move so much heat. If more heat is applied to the channel than the element can move for a given set point, the element will be overwhelmed and the temperature will rise above the set point. The Peltier element generates a *differential* temperature for a given voltage and load. As the ambient temperature rises, the hot side heat sink rises with it. Should ambient conditions become too hot the element will no longer be able to maintain the set point for the applied load. Ambient conditions should be within specifications for proper operational characteristics. As mentioned above, a cooler lowers the temperature of the sample stream to just above freezing. This process may drop out other constituents of the sample stream with the water, some which may impact your measurements.

Perma Pure Provides Nafion-based sample conditioning systems which prevent loss of water soluble analyses using a permeation method for sample drying.

KEY COMPONENTS OF A THERMO-ELECTRIC COOLER:

- 1) **Peltier Element:** When DC voltage is applied to the Peltier element, one side of the element becomes cold, and the other hot. This heating and cooling effect at the junction of dissimilar metals is referred to as the Peltier effect, named after the physicist who discovered it in 1834. The Peltier elements used here are very powerful, and if not properly mated to a thermal sink will get extremely hot very quickly. **DO NOT POWER** these elements without proper connection to a heat sink! You may get burned, and will damage or destroy the element!
- 2) **Heat Sink:** The Peltier elements generate a significant amount of waste heat when in operation. This heat is conducted into a heat sink to be removed into the ambient environment by forced convection.
- 3) **Heat Sink Fan:** The above mentioned forced convection.
- 4) **Heat Transfer Block:** This is the mechanical and thermal interface between the cold side of the Peltier elements and the walls of the impinger. The heat transfer block provides a conductive path and mechanical interface between the long cylindrical impinger and the rectangular Peltier elements.
- 5) **Impinger:** Interface between the sample stream and the heat transfer block. Water vapor condenses along the outer wall and collects in the bottom for extraction. The sample stream travels through the impinger, so corrosion resistance must be considered.
- 6) **Power Supply:** AC to regulated DC to provide sufficient amperage for the Peltier elements configuration. Peltier elements have a very specific power to performance curve. Performance can be adversely affected by supplying too much power. The power supply provided is factory adjusted, and should not be altered!
- 7) **Control Thermistors:** Measures temperature of the heat transfer block at the Peltier element interface for feedback to control electronics. This is the temperature displayed, and is the coldest point on the heat transfer block.
- 8) **Control Electronics:** Regulates power supplied to Peltier elements to maintain a set temperature. The control electronics provides Pulse Width Modulated (PWM) power to the Peltier elements, regulated by a control loop.
- 9) **Peristaltic Pump (not covered here):** Removes condensate from the impinger without creating a path for outside air to enter the sample

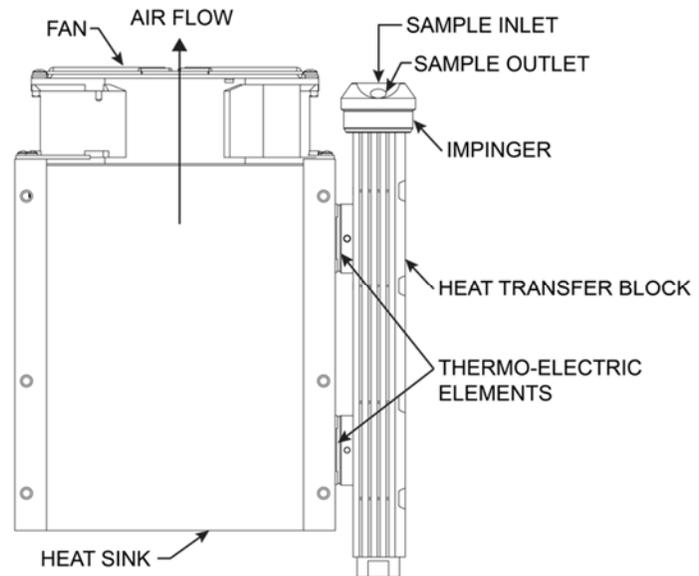


Figure 2: Heat Exchanger, Impinger and Heat Sink stream.

PHYSICAL DESCRIPTION

- Single (Series) or Dual (Parallel) stream system
- 1 x 10" heat exchanger connected in series; actively cooled to the temperature set point
- 1 x 10" heat exchanger connected in series; passively cooled by direct contact with the heat sink
- LCD temperature display
- Dimensions: 14.5" x 11" x 10.5" HWD (37 x 28 x 26.5 cm)
- Weight: 35 lbs (16 kg)

SPECIFICATIONS

| | |
|------------------------------------|---|
| Sample gas flow range | Up to 8 LPM (Up to 17 SCFH) |
| Avg. inlet dew point at rated flow | 20% H ₂ O (60°C DP) @ 5 LPM |
| Maximum cooling rate | 440 BTU/hr (464 kJ/hr) |
| Maximum inlet sample temp. | 400°F (205°C) for SS or glass impingers 280°F (138°C) for Kynar™ impingers |
| Maximum inlet pressure | 15 psig (1 bar; 760 mmHg) |
| Maximum pressure drop | <+1 in H ₂ O |
| Ambient temperature range | 33-104°F (0.6-40°C) |
| Outlet sample gas dew point | 39°F (4°C) |
| Voltage | 115 OR 230 VAC (Verify before energizing equipment) 50/60 Hz |
| Power supply | 600 Watt |
| Cooling down time | Less than 6 minutes |

CONNECTIONS

- Sample gas inlet: Kynar, 3/8" tube compression fitting
- Sample gas outlet: Kynar, 1/4" tube compression fitting
- Drain tubing connection: Kynar, 1/4" barbed tube fitting

An automatic condensate drain, dual-head peristaltic drain pump is recommended (not included) for water removal, Perma Pure part number 3KPB-003; size 17 tubing.

Always use factory supplied fittings; Perma Pure cannot warrant against damage to the Peltier elements or heat exchangers if our fittings are not used.

IMPORTANT SAFETY WARNINGS

Please be sure to review the following basic safety procedures. These procedures represent the **MINIMUM** requirements to operate the equipment safely. It is the ultimate responsibility of the operator to ensure that proper safety practices are utilized at the point of operation.

- **NEVER** attempt to operate this equipment in an explosive or otherwise hazardous area.
- **NEVER** exceed any specified rating for the equipment. Voltage, temperature and pressure ratings must be closely observed and not exceeded. Voltage rating of the equipment **MUST** match the rating on the data label. Please make sure that it matches before powering up the equipment.
- This equipment is **NOT** designed to be used in an explosive environment.
- This equipment is **NOT** designed to operate in a wet environment.
- **Condensate is potentially dangerous. NEVER** handle drain lines, impingers or any other item that may have come into contact with the gas stream or any hazardous material, without adequate personal protective equipment. **ALWAYS** assume that any liquid present is hazardous.
- **Sample gas is potentially dangerous.** A leak test is recommended at initial startup and as often as necessary to maintain a safe working environment around the equipment. The gas stream exhaust must exit away from all personnel to prevent dangerous exposure.
- **NEVER operate the equipment with any part of the enclosure unsecured.** All operating doors and covers must be in place and secured prior to operation. Electrical current may be present behind covers or doors, even if tools are not necessary to access these components.
- **NEVER** attempt service on this equipment without first disconnecting all energy sources. Repair of this equipment should only be done by properly trained personnel that are familiar with the potential risks involved with servicing of the equipment.
- **NEVER** replace fuses with types other than the sample specification of type and current. Do not bypass this or any other safety device.
- **NEVER** operate this equipment if it is visibly damaged or the possibility exists that it may have been damaged.
- The use of components that have not been purchased through an authorized Perma Pure dealer or directly from Perma Pure may compromise the safety of the operator. Additionally, use of non-authorized components may change the operating characteristics of this equipment. Any changes to the equipment, that modify its operation in any way, are dangerous, and are strictly prohibited.
- Read the entire operating manual before attempting to set up or operate the equipment.
- Please heed all warning labels that are on the equipment. They are there to remind you of possible hazardous conditions.
- Verify the integrity of any mechanical and/or electrical connections that are made to the unit.
 - Verify that the unit is connected to the proper rated power for the system
 - Verify that the unit is plumbed properly to operate effectively

INSTALLATION

Hardware required for installation

- (4) ¼-20 mounting screws
- For stainless steel sample lines, 2 inches of 3/8" Teflon tube
- Peristaltic drain pump, dual head

Mounting

The Classic Model 5210D Thermo-Electric Cooler should be installed away from heat sources in a well vented area.

NOTE: The operational stability of the cooler dew point is influenced by the stability of the ambient temperature.

For proper operation, the ambient temperature cannot exceed 40°C (104°F). At, or close to the maximum ambient temperature, the cooler will not be able to control the temperature to reduce the dew point of the sample gas to the 4°C set point. This will result in compromised operation and water slip or carryover, possibly into the analyzer. Also, at or near this temperature, the cooler will be running "full on" and Peltier life will be greatly reduced.

CONNECTIONS

Sample and Drain

1. Connect the sample inlet to the 3/8" tube fitting shown in figure 3 below.

NOTE: If using heated stainless steel sample line, add 2 inches of Teflon tubing at the heat exchanger inlet fitting, and connecting it to the heated line. This isolates the heated line from the heat exchanger and prevents excessive heating of the heat exchanger, possibly overloading the cooler.

2. Connect the sample outlet to the 1/4" tube fitting shown in the figure.
3. Connect the peristaltic pumps to the ¼" barbed tube fittings at the base of the impinger.

NOTE: Do not reduce the size of the condensate tubing since doing so restricts water flow resulting in water carryover into the sample.

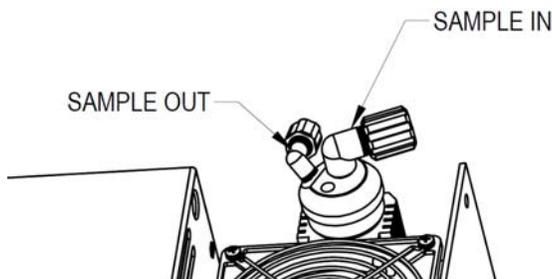
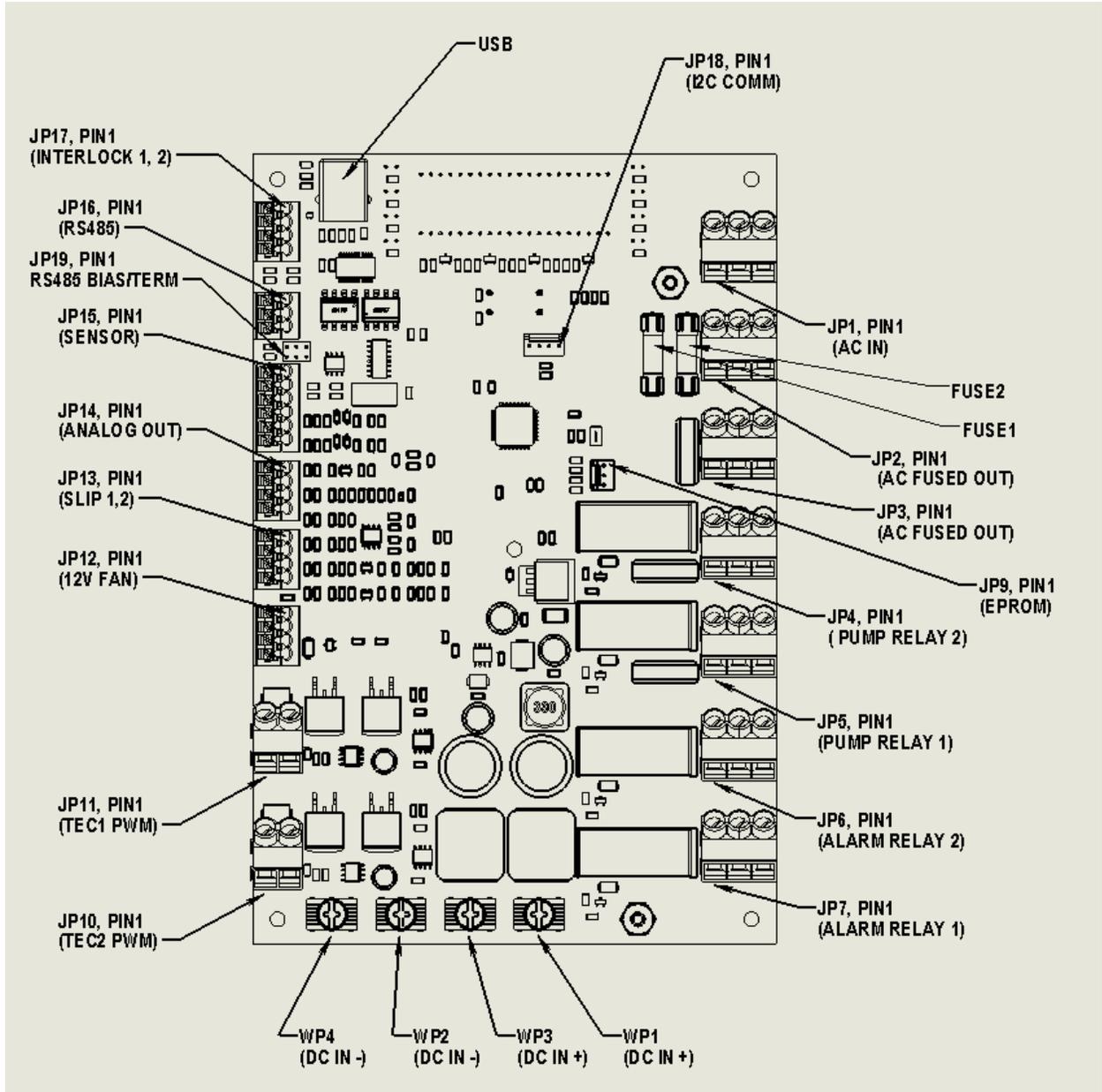
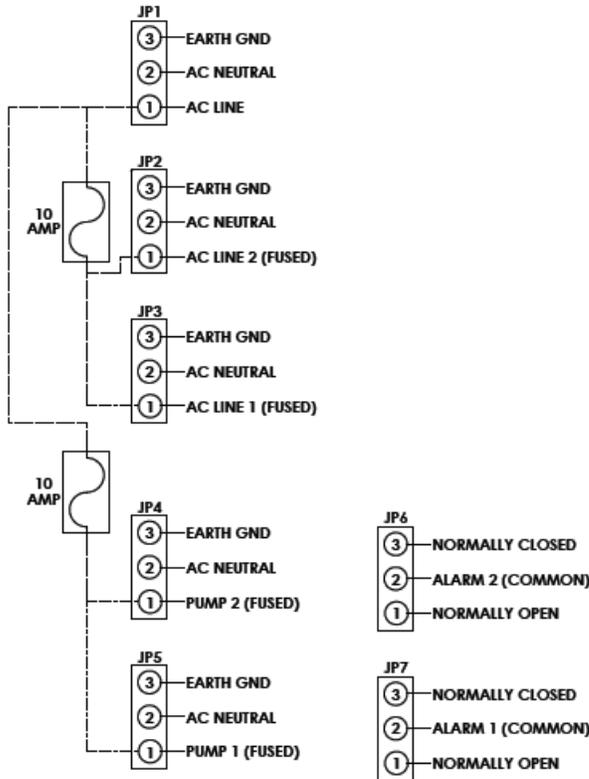


Figure 3: Model 5210D Cooler

BOARD CONNECTIONS

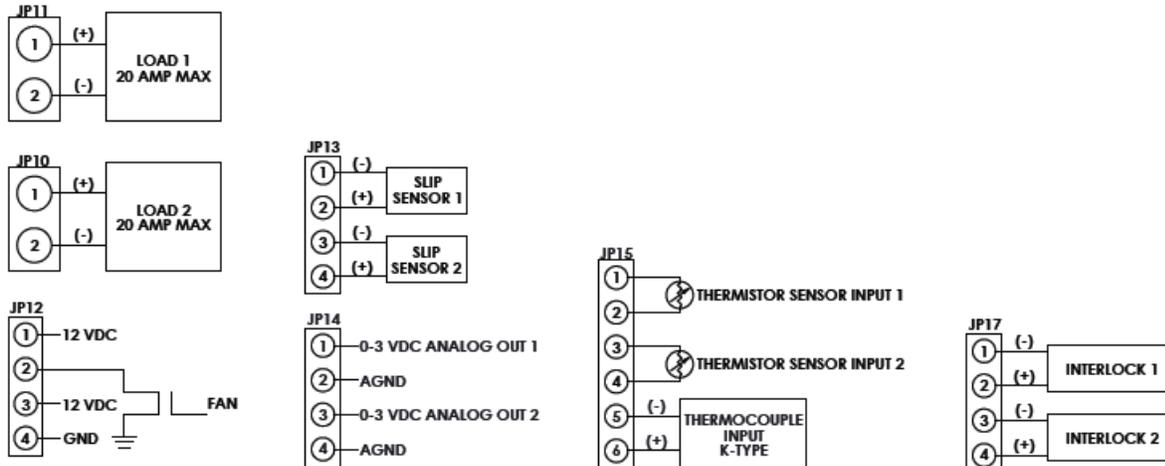


AC side (right side)



- JP1:** AC line in for accessory control.
- JP2:** Fused power out from JP1, currently heatsink fan.
- JP3:** Fused power out from JP1
- JP4:** Fused pump relay for Channel 2. Relay applies power to circuit when temperature is below “ready” temperature. Circuit will open when temperature is above the ready temperature. This avoids passing vapor exceeding the “ready temperature” dew point. JP4 and JP5 operate independently of each other.
- JP5:** Fused pump relay for Channel 1. Relay applies power to the circuit when temperature is below “ready” temperature. Circuit will open when temperature is above the ready temperature. This avoids passing vapor exceeding the “ready temperature” dew point. JP4 and JP5 operate independently of each other.
- JP6-L** Channel 2 alarm relay. Isolated relay which can be wired Normally Open (N.O.) or Normally Closed (N.C.). JP6 and JP7 operate independently of each other. A sensor failure (short or open) will trip the relay.
- JP7:** Channel 1 alarm relay. Isolated relay which can be wired NC or NO (normally open or normally closed). JP6 and JP7 operate independently of each other. NOTE: The board is incorrectly physically labeled.
- FUSE1:** 10Amp fuse between JP1 and JP2 and JP3
- FUSE2:** 10 Amp fuse between JP1 and JP4 and JP5 (pump relay controlled)

DC Side (left side):



- JP8:** Not Used
- JP9:** EPROM flash. For factory use only.
- JP10:** Outputs for Peltier element channel 2. Pulse width modulated (PWM) with DC input voltage.
- JP11:** Outputs for Peltier element channel 1. Pulse width modulated (PWM) with DC input voltage.
- JP12:** 12VDC regulated out for fans. 2 Circuits, steady on and thermostatically controlled provided. Thermostat control is for enclosure fan only
- JP13:** Slip sensor inputs. When resistive threshold is exceeded, pump relays open. Settings are configurable via software.
- JP14:** Analog out, 0-3VDC. 2 channels are available. Each output can be configured to telemeter CH1 temp, CH2 temp, or TC temp, via manufacturer's configuration software at time of purchase. 0VDC and 3VDC temperatures (for scaling) are selectable via configuration software.
- JP15:** Temperature sensor inputs for CH1 and CH2 thermistors and Type K thermocouple. NJTC MUST be enabled via software. (Negative lead wire is red)
- JP16:** RS485 output. Not supported at this time.
- JP17:** Interlock inputs. When enabled in software, opening the interlock circuit disables the pump on that channel. That is, the pump will not run unless the circuit is closed.
- JP18:** Expansion port. Not supported at this time.
- JP19:** RS485 bias and termination. Not supported at this time.

BASIC OPERATION

Your cooler comes from the factory ready to go, preset to operate at 4°C, and to close the sample pump relays at 10°C. Closing the pump relays illuminates the READY status LED, near the temperature display. See the interconnection diagram for a typical installation that includes water slip sensing, using cooler controlled pump relays, interlock input and alarm relays. Your cooler can be operated without using any of these on-board features.

CONTROLLER:

This cooler is controlled by a digital control board.

Throughout this manual, channel 1 refers to the left channel when facing the display, and channel 2 to the right.

This board regulates power to the Peltier elements to maintain the set point temperature regardless of the thermal load on the channel (within the specified ranges). The board is capable of independently controlling two separate channels. The board provides a pulse width modulated power output to the Peltier elements as determined by a temperature control loop.

In addition, this board includes fused sample pump relays, alarm relays, 0-3V analog output, New Jersey thermocouple input and output, and slip sensor electronics.

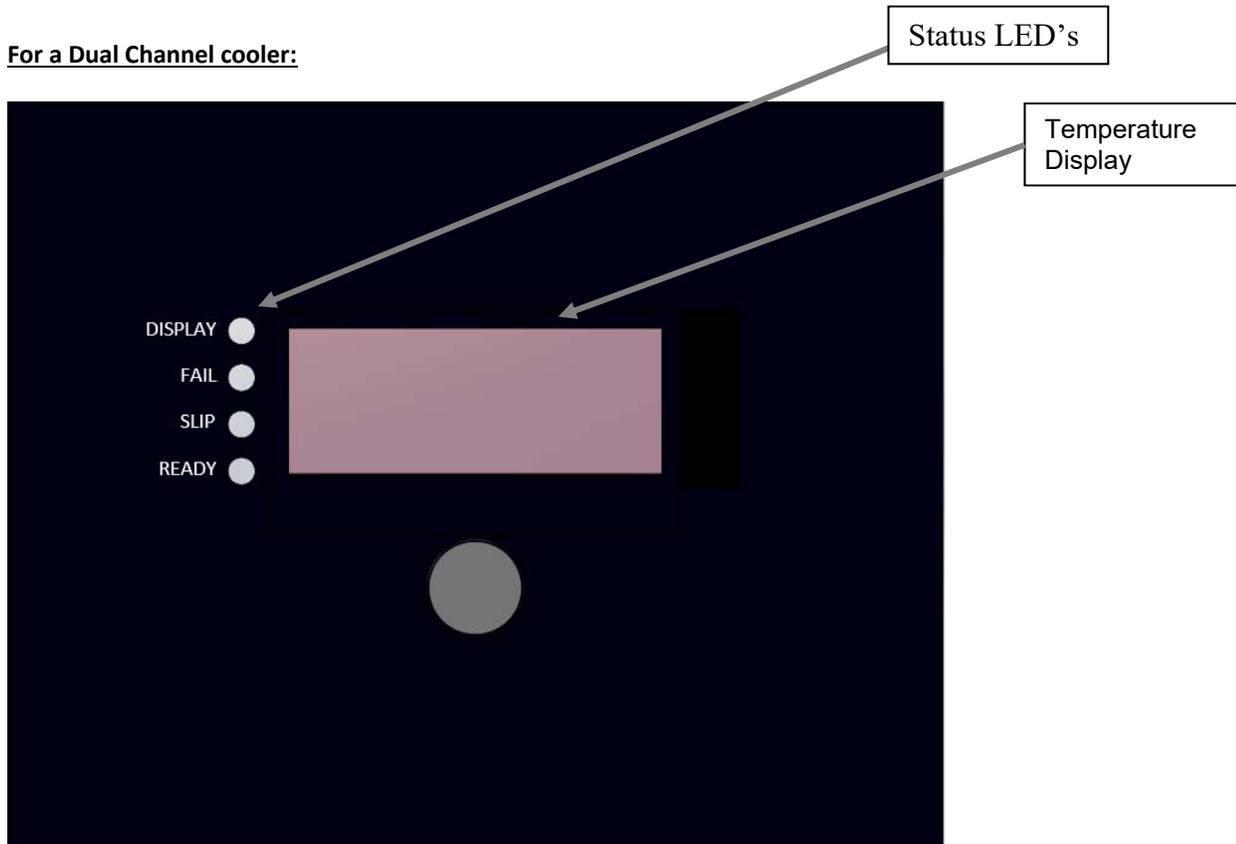
This controller is digitally controlled and configured using a PC via USB and proprietary software.

THE DISPLAY

The display operation varies depending on as shipped configuration. When the unit powers on, it will briefly display R-XX (r-01, r-02, etc.). This is the revision of the control software loaded into the on-board memory.

LED SUMMARY

For a Dual Channel cooler:



Single channel cooler (5210)

- 1) **Numeric Display:** Four digit LED display can show temperature in degrees Celsius of CH1 or NJTC.
- 2) **Status LED's:** Indicate operational status of the system.
 - a. **DISPLAY (Display state):** GREEN indicator, flashing indicates cold block temperature, solid indicates that NJTC is displayed.
 - b. **FAIL (Failure):** RED indicates that the controller has detected an internal system failure.
 - c. **SLIP:** GREEN indicates that the Water Slip sensor (if installed) has NOT detected water in the sample stream. GREEN indicates that the slip controller has not disabled the sample pump(s).
 - d. **READY:** GREEN indicates the system has reached its cold ready point and has closed the pump relays.
- 3) **DISPLAY-SELECT Button:** Sets the display state. Pushing this button will toggle the display between (flashing) CH1, NJTC (solid). The controller will not respond to features that are not enabled. For example, if a NJTC is not enabled, the unit will not allow NJTC display as an option, it will instead display the revision status. Enabling features in software that are not physically installed may cause unexpected / unpredictable results.

START-UP

1. Verify AC power matches operating voltage that is specified on serial number data label.
2. Plug power cord into a properly grounded main circuit. Green "Slip" LED will come on.
3. Wait for the green "Ready" LED light to come on. This will indicate the impinger temperature is below 10°C and the sample gas flow can begin.
4. Afterwards the factory set-point of +4°C (41°F) will be reached.

The SLIP Green LED is always on unless;

- Moisture is detected by the water slip sensor
- There is a malfunction (e.g. Shorted water slip sensor leads or a defective relay)

TROUBLESHOOTING AND MAINTENANCE GUIDE

Troubleshooting and repair should only be attempted by qualified personnel;

Review Safety Warnings Page for more complete details of potential hazards

Inside the enclosure there are lethal AC voltages, 15VDC power at 12 amps, as well as exposed rotating fan blades and other potentially hazardous components.

ALWAYS USE CAUTION! DEENERGIZE EQUIPMENT PRIOR TO ATTEMPTING SERVICE!

The status board will indicate what the on-board computer *thinks* is happening.

Verify that the unit has commanded the response before going in to verifying hardware. For example, verify the board indicates that the pump relay is closed before physically pulling the relay.

Peltier Elements

Troubleshooting Peltier elements can be difficult at the part level without specialized equipment. A conventional Ohm Meter will not provide useful information. Peltier failure or degradation can be indicated by current measurement. The measurement should be made during the first few minutes of start-up. For a 5210D, the Peltier elements are wired in parallel, with each drawing between 6 and 9 amps. Unit-to-unit variation, such as exact voltage, wire run length, ambient temperature, and cooler temperature, can generate some variation. This test can also be performed by placing a DC inductive ammeter around the black or white leads coming off JP10 or JP11.

12VDC Cooling Fan

There are two regulated outputs for the 12VDC cooling fans, one is thermostatically controlled by the control board for enclosure component cooling. The 12VDC cooling fans on a 5210D should be wired to the designated 12VDC output of the board. Care should always be taken to avoid rotating blades!

| Symptom | Diagnostic | Fix |
|--|--|---|
| No LED(s) and no fan. | <p>AC power input.</p> <p>10A DC fuse on Control Board</p> <p>15A AC Input fuse on Power Supply</p> <p>Verify 15VDC at output terminals on Power Supply</p> | <p>Ensure that AC power is connected. Replace fuse as necessary.</p> <ul style="list-style-type: none"> Verify current draw is not close to or exceeding fuse rating Verify current draw of Peltier Elements Replace control board if Peltier elements test properly and current is excessive <p>Replace fuse as necessary.</p> <ul style="list-style-type: none"> Verify current draw is not close to or exceeding fuse rating Replace power supply if current is excessive If reading lower than 15VDC, carefully disconnect wiring and measure voltage If not 15VDC, within 1.0VDC adjust and/or replace defective Power Supply |
| LED(s) on and heatsink fan does not run. | <p>Check fan for blockage (power off). Check for power at JP1 (AC power input, unfused), JP2 (AC power for fan, fused) on control board</p> <p>Verify voltage at terminal JP2 of control PCB; Should be line voltage</p> | <p>Clear any blockage, replace fuse or repair wiring as required</p> <p>Check fuses on control PCB-</p> <ul style="list-style-type: none"> If fuses are good and voltage is not equal to line voltage, replace control board. If fuse1 is blown (open), disconnect JP2 wiring for heat sink fan and replace fuse; Retest; reconnect wiring if fuse does not blow If fuse blows again, Fan or wiring may be defective |
| F1 on control PCB keeps blowing. | <p>Disconnect JP2 wiring for heat sink fan; Replace fuse</p> | <p>Energize cooler and see if fuse blows-</p> <ul style="list-style-type: none"> Fuse blows-Replace control PCB Fuse does not blow-verify heat sink fan wiring condition If wiring is good, fan likely defective |

| | | |
|---|--|---|
| <p><i>Failure LED is on.</i></p> | <p><i>Thermistor connection JP15 pins 1-4</i></p> | <p><i>Ensure proper connection. Try a good thermistor in place of old one</i></p> <ul style="list-style-type: none"> • <i>Mark wiring and connect to opposite channels at control PCB, if failure moves with change of wiring, thermistor has failed</i> • <i>If not, board is defective. Replace as required</i> |
| <p>Impinger frozen and cooler indicates ambient temperature.</p> | <p><i>Thermistor placement in heat exchanger block. Peltier element wiring</i></p> | <p><i>Verify placement of thermistor</i></p> <ul style="list-style-type: none"> • <i>Trace wiring to ensure wiring is not shorted to chassis ground due to pinched wires caught in covers</i> |
| <p>Impinger does not reach set temperature, but is below ready temperature.</p> | <p><i>System loading. Verify Peltier Element current draw</i></p> | <p><i>Ensure system loading is not exceeding cooler capacity. Review Specifications Peltier Elements should draw between 6 and 9 Amps</i></p> |
| <p>Ready LED does not come on when impinger is below 10°C.</p> | <p><i>Ready temperature adjustment.</i></p> | <p><i>Consult Factory</i></p> |
| <p>Water carryover in system.</p> | <p><i>Impinger temperature. Should be below 5°C.</i></p> | <p><i>Ensure system loading is not exceeding cooler capacity and ambient conditions are not exceeding specifications.</i></p> |
| <p>Slip LED does not come on.</p> | <p><i>Water carryover in system. Water slip sensor connections.</i></p> | <p><i>Ensure system loading is not exceeding cooler capacity and ambient conditions are not exceeding specifications.</i></p> <ul style="list-style-type: none"> • <i>Ensure that all water slip sensor connections are made.</i> • <i>Disconnect sensor; Clean tip of sensor.</i> • <i>Replace sensor as necessary.</i> |

| | | |
|---|--|---|
| <p>Pump does not start. Ready and slip LED(s) are on.</p> | <p><i>Pump electrical connections.</i></p> | <p><i>Ensure proper connections.</i></p> <p><i>Possible defective pump; Measure voltage at corresponding pump terminals.</i></p> <ul style="list-style-type: none"> • <i>If good, pump motor may be defective(open)</i> • <i>If bad, fuse may be blown on board; replace fuse with pump disconnected, reenergize and retest. If fuse blows, board is defective</i> • <i>Reconnect pump, if it blows pump motor likely defective (shorted or mechanical failure)</i> <p><i>Possible defective relay coil or relay contact- Visually check operation and condition. If O.K., check coil of relay with ohm meter; if O.K., possible bad relay contact; Replace with known good relay.</i></p> |
|---|--|---|

REPLACEMENT PARTS

Classic Model 5210D

| Part No. | Description |
|-----------|---|
| 3CCB-051 | Control Board: Dual Channel Board, Control, Cooler, Digital |
| 2FAN-005 | Fan: Muffin, 4" x 1", 12 VDC |
| 2FAN-004 | Fan, muffin, 4" x 1-1/2", 12VDC |
| 3CXD-022 | Impinger: 10" EZ-clean twist-apart Durinert® |
| 3CXD-024 | Impinger: 10" NJ, EZ-clean twist-apart Durinert coated |
| 3CXG-002 | Impinger: 10" Glass, threaded w/ fittings |
| 3CXK-003 | Impinger: 10" Kynar |
| 3CXS-022 | Impinger: 10" Stainless Steel, EZ-clean twist-apart |
| 3CXS-024 | Impinger: 10" NJ, Stainless Steel, EZ-clean twist-apart |
| 3KPE-004* | Peltier Element Kit, 40 mm |
| 1PSD-035* | Power Supply, 1PSD-008/009 Replacement |
| 103185* | Thermistor, Control |

* Recommended Spares

APPENDIX A: COOLER DRAWINGS

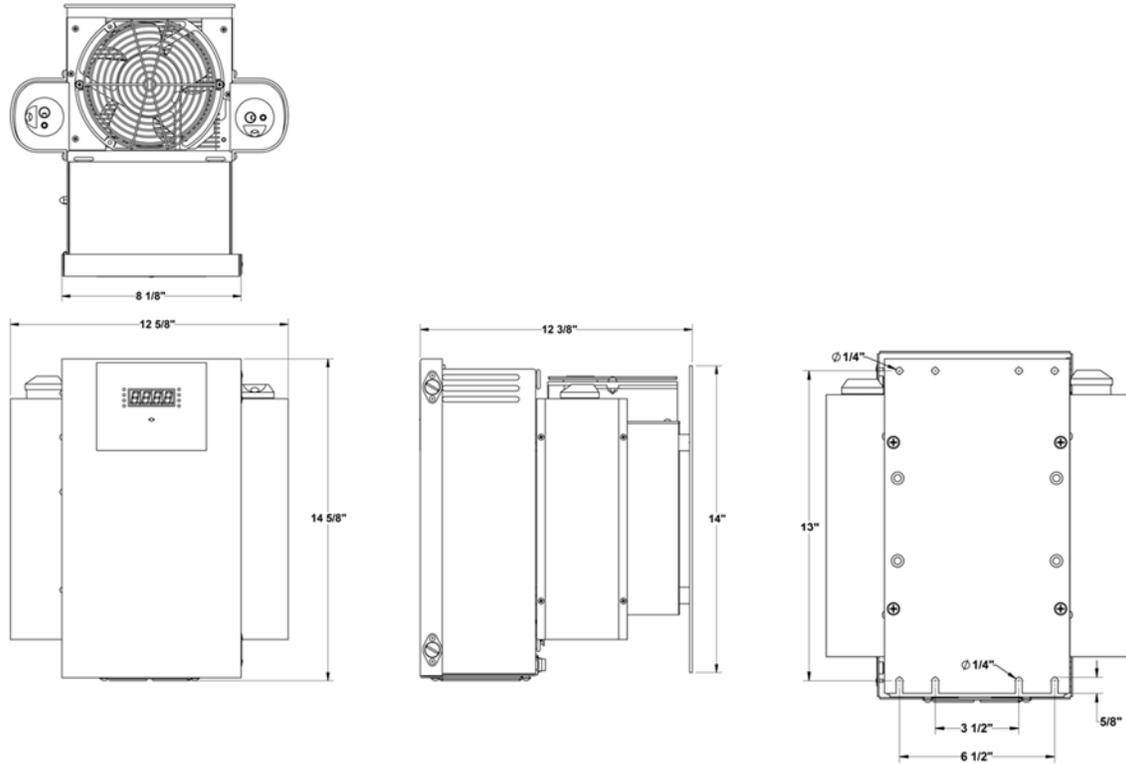


Figure A1: Model 5210D Dimensional Drawing

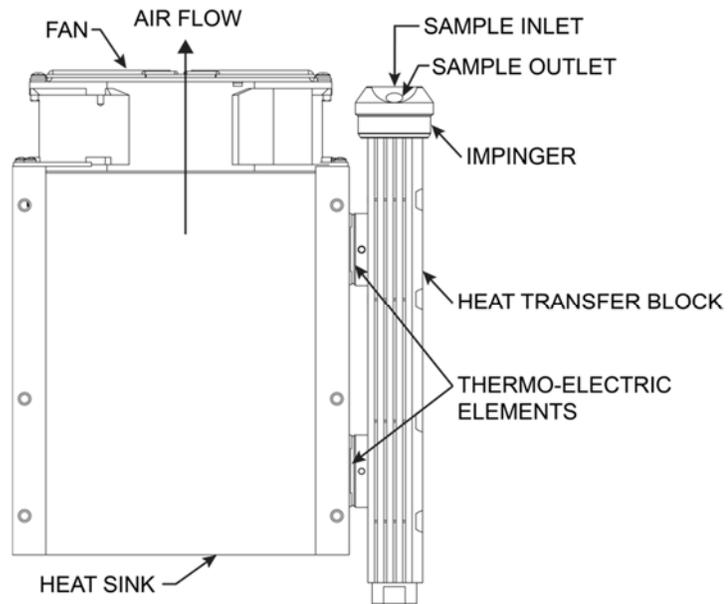
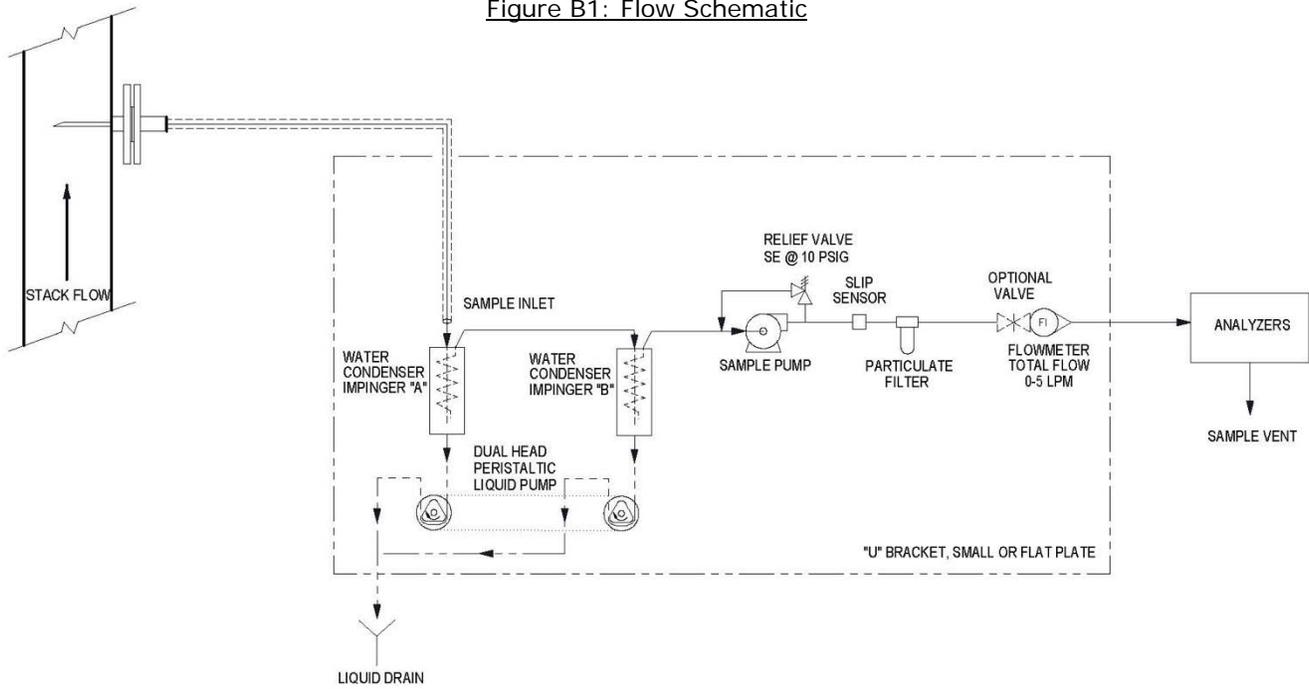


Figure A2: Impinger Diagram

APPENDIX B: SAMPLE

CONDITIONING SYSTEM DRAWINGS

Figure B1: Flow Schematic



APPENDIX C: CONVERSION TABLES

CHART OF VOLUME PERCENT WATER CONCENTRATIONS AT SATURATION FOR VARIOUS TEMPERATURES AT STANDARD PRESSURE (ATMOSPHERIC PRESSURE)

| DEGREES C | DEGREES F | VOLUME % | DEGREES C | DEGREES F | VOLUME % |
|-----------|-----------|----------|-----------|-----------|----------|
| +100 | +212 | 100.00 | + 2 | + 36 | 0.696 |
| + 90 | +194 | 69.20 | + 1 | + 34 | 0.649 |
| + 80 | +176 | 46.70 | 0 | + 32 | 0.602 |
| + 75 | +167 | 38.70 | -1 | + 30 | 0.555 |
| + 70 | +158 | 30.70 | -2 | + 28 | 0.510 |
| + 65 | +149 | 25.20 | -3 | + 27 | 0.469 |
| + 60 | +140 | 19.70 | -4 | + 25 | 0.431 |
| + 55 | +131 | 15.50 | -5 | + 23 | 0.396 |
| + 50 | +122 | 12.20 | -6 | + 21 | 0.363 |
| + 45 | +113 | 9.45 | -7 | + 19 | 0.333 |
| + 40 | +104 | 7.25 | -8 | + 18 | 0.305 |
| + 35 | + 95 | 5.55 | -9 | + 16 | 0.281 |
| + 30 | + 86 | 4.19 | -10 | + 14 | 0.256 |
| + 29 | + 84 | 3.95 | -11 | + 12 | 0.234 |
| + 28 | + 82 | 3.73 | -12 | + 10 | 0.214 |
| + 27 | + 81 | 3.62 | -13 | + 9 | 0.196 |
| + 26 | + 79 | 3.32 | -14 | + 7 | 0.179 |
| + 25 | + 77 | 3.13 | -15 | + 5 | 0.163 |
| + 24 | + 75 | 2.94 | -16 | + 3 | 0.148 |
| + 23 | + 73 | 2.77 | -17 | + 1 | 0.135 |
| + 22 | + 72 | 2.61 | -18 | 0 | 0.123 |
| + 21 | + 70 | 2.46 | -19 | -2 | 0.112 |
| + 20 | + 68 | 3.31 | -20 | -4 | 0.102 |
| + 19 | + 66 | 2.17 | -22 | -8 | 0.084 |
| + 18 | + 64 | 2.04 | -24 | -11 | 0.069 |
| + 17 | + 63 | 1.91 | -26 | -15 | 0.057 |
| + 16 | + 61 | 1.79 | -28 | -18 | 0.046 |
| + 15 | + 59 | 1.68 | -30 | -22 | 0.038 |
| + 14 | +57 | 1.58 | -32 | -26 | 0.031 |
| + 13 | + 55 | 1.48 | -34 | -30 | 0.025 |
| + 12 | + 54 | 1.38 | -36 | -34 | 0.019 |
| + 11 | + 52 | 1.29 | -38 | -37 | 0.016 |
| + 10 | + 50 | 1.21 | -40 | -40 | 0.013 |
| + 9 | + 48 | 1.13 | -42 | -44 | 0.011 |
| + 8 | + 46 | 1.03 | -44 | -47 | 0.008 |
| + 7 | + 45 | 0.988 | -46 | -51 | 0.006 |
| + 6 | + 43 | 0.922 | -48 | -54 | 0.005 |
| + 5 | + 41 | 0.861 | -50 | -58 | 0.004 |
| + 4 | + 39 | 0.803 | -52 | -62 | 0.003 |
| + 3 | + 37 | 0.751 | -54 | -65 | 0.002 |

| MOISTURE CONVERSION TABLE | | | | | |
|---------------------------|-----------------|-------------------------|---------------|----------------------------|-------------------------|
| DEW POINT °F | DEW POINT °C | VAPOR PRESSURE Mm Hg | ppm by VOLUME | RELATIVE HUMIDITY @70°F | ppm by WEIGHT in air |
| -110 | -166 | .000010 | .00132 | .000053 | 0.00082 |
| -108 | -162 | .000018 | .00237 | .000096 | .0015 |
| -106 | -159 | .000028 | .00368 | .00015 | .0023 |
| -104 | -155 | .000043 | .00566 | .00023 | .0035 |
| -102 | -152 | .000065 | .00855 | .00035 | .0053 |
| -100 | -148 | .000099 | .0130 | .00053 | .0081 |
| -98 | -144 | .00015 | .0197 | .00080 | .012 |
| -96 | -141 | .00022 | .0289 | .0012 | .018 |
| -94 | -137 | .00033 | .0434 | .0018 | .027 |
| -92 | -134 | .00048 | .0623 | .0026 | .039 |
| -90 | -130 | .0007 | .0921 | .0037 | .057 |
| -88 | -126 | .0010 | .132 | .0054 | .082 |
| -86 | -123 | .0014 | .184 | .0075 | .11 |
| -84 | -119 | .0020 | .263 | .0107 | .16 |
| -82 | -116 | .0029 | .382 | .0155 | .24 |
| -80 | -112 | .0040 | .562 | .0214 | .33 |
| -78 | -108 | .0056 | .737 | .0300 | .46 |
| -76 | -105 | .0077 | 1.01 | .0410 | .63 |
| -74 | -101 | .0105 | 1.38 | .0559 | .86 |
| -72 | -98 | .0143 | 1.88 | .0762 | 1.17 |
| -70 | -94 | .0194 | 2.55 | .104 | 1.58 |
| -68 | -90 | .0261 | 3.43 | .140 | 2.13 |
| -66 | -87 | .0349 | 4.59 | .187 | 2.84 |
| -64 | -83 | .0464 | 6.11 | .248 | 3.79 |
| -62 | -80 | .0614 | 8.08 | .328 | 5.01 |
| -60 | -76 | .0808 | 10.6 | .43 | 6.59 |
| -58 | -72 | .106 | 13.9 | .565 | 8.63 |
| -56 | -69 | .138 | 18.2 | .735 | 11.3 |
| -54 | -65 | .178 | 23.4 | .948 | 14.5 |
| -52 | -62 | .230 | 30.3 | 1.23 | 18.8 |
| -50 | -58 | .295 | 38.8 | 1.57 | 24.1 |
| -48 | -54 | .378 | 49.7 | 2.02 | 30.9 |
| -46 | -51 | .481 | 63.3 | 2.57 | 39.3 |
| -44 | -47 | .609 | 80.0 | 3.25 | 49.7 |
| -42 | -44 | .768 | 101 | 4.10 | 62.7 |
| -40 | -40 | .966 | 127 | 5.16 | 78.9 |
| -38 | -36 | 1.209 | 159 | 6.44 | 98.6 |
| -36 | -33 | 1.507 | 198 | 8.04 | 122.9 |
| -34 | -29 | 1.873 | 246 | 1.00 | 152 |
| -32 | -26 | 2.318 | 305 | 1.24 | 189 |
| -30 | -22 | 2.859 | 376 | 1.52 | 234 |
| -28 | -18 | 3.51 | 462 | 1.88 | 287 |
| -26 | -15 | 4.30 | 566 | 2.30 | 351 |
| -24 | -11 | 5.26 | 692 | 2.81 | 430 |
| -22 | -8 | 6.40 | 842 | 3.41 | 523 |
| -20 | -4 | 7.76 | 1020 | 4.13 | 633 |
| -18 | 0 | 9.39 | 1240 | 5.00 | 770 |
| -16 | +3 | 1.132 | 1490 | 6.03 | 925 |
| -14 | +7 | 1.361 | 1790 | 7.25 | 1110 |
| -12 | +10 | 1.632 | 2150 | 8.69 | 1335 |
| -10 | +14 | 1.950 | 2570 | 10.4 | 1596 |
| -8 | +18 | 2.326 | 3060 | 12.4 | 1900 |
| -6 | +21 | 2.765 | 3640 | 14.7 | 2260 |
| -4 | +25 | 3.280 | 4230 | 17.5 | 2680 |
| -2 | +28 | 3.880 | 5100 | 20.7 | 3170 |
| 0 | +32 | 4.579 | 6020 | 24.4 | 3640 |
| +2 | +36 | 5.294 | 6970 | 28.2 | 4330 |
| +4 | +39 | 6.101 | 8030 | 32.5 | 4990 |
| +6 | +43 | 7.013 | 9230 | 37.4 | 5730 |
| +8 | +46 | 8.045 | 10590 | 42.9 | 6580 |
| +10 | +50 | 9.029 | 12120 | 49.1 | 7530 |
| +12 | +54 | 10.52 | 13840 | 56.1 | 8600 |
| +14 | +57 | 11.99 | 15780 | 63.9 | 9800 |
| +16 | +61 | 13.63 | 17930 | 72.6 | 11140 |
| +18 | +64 | 15.48 | 20370 | 82.5 | 12650 |
| +20 | +68 | 17.54 | 23080 | 93.5 | 14330 |
| +22 | +71 | 19.827 | 26088 | | 16699 |
| +24 | +75 | 33.377 | 29443 | | 18847 |
| +26 | +79 | 25.209 | 33169 | | 21232 |

APPENDIX D: WARRANTY AND DISCLAIMER

Perma Pure LLC

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